SUPERGENE ENRICHMENT PROFILE AT COPPER BASIN BATTLE MOUNTAIN, NEVADA

By

Maureen N. Moore-Roth

Submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology at New Mexico Institute of Mining and Technology

Earth and Environmental Sciences Department

Socorro, New Mexico

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ABSTRACT

Because mine planning requires detailed knowledge of ore types, especially the geometallurgical characteristics of ore mineralogy, this study emphasizes the identification of various copper ore minerals in the variably-developed supergene enrichment profile at Copper Basin.

The supergene copper deposit at Copper Basin is within the Battle Mountain District, Lander County, Nevada, and comprises disseminated pyrite and copper sulfides hosted primarily in clastic sedimentary rock units of the Cambrian-age Harmony Formation. The district has been mined historically for gold and copper, with current development focused on copper resources adjacent to the Contention open pit, previously mined in the 1970's by the Duval Corporation.

Previous studies (McComb, 2008, McComb, 2007, and McComb, 2006) have identified a series of supergene copper sulfides, including chalcocite, digenite, geerite, spionkopite, yarrowite, blaubleibender, and covellite; each of these copper species have metallurgically-

different copper recovery characteristics. Although the enrichment profile at Copper Basin is variably-developed, the copper sulfides display a general zoning pattern that reflects the deposition of copper minerals in response to oxidized copper availability, pyrite and chalcopyrite contents of the hostrock, the copper grade of the protolith, and geochemical maturity of the supergene profile.

Standard petrographic methods have been applied to drill core-derived composite samples representing logged vertical mineralogic variations in the Copper Basin geochemical stratigraphy, complemented through the use of microprobe and SEM-EDS analyses of mineral compositions. Paragenetic relationships establish that the enrichment profile adjacent to the Widow pit represents an immaturely-developed second cycle of supergene enrichment. The enrichment zones, generally, can be geochemically divided into three intensities of development based on mineralogic and paragentic relationships as strong, moderate, and weak enrichment.

The observation that enrichment is incipient in some areas of the Copper Basin System is reinforced by variations of the copper mineralogy present based on optical analyses and analytical analyses. Mineral phases identified include: chalcocite (Cu_2S), covellite (CuS), and intermediate mineral phases between chalcocite and covellite.

Through petrographic analyses of heavy concentrates derived from assay pulps it was found that although copper was present as copper sulfides in the heavy fractions and as encapsulated sulfide grains in the light fraction, copper is also adsorbed onto Fe-oxides, especially goethite, and on clays.

We conclude that copper recovery is influenced by the mineralogic and atomic forms of copper present within a given sample and by the occurrence of adsorbed Cu++ ions associated with ferric iron and clay minerals.

Keywords: supergene enrichment, geometallurgical, chalcocite

DEDICATION

To my father, who taught me that despite one's limitations in life, through hard work and passion, their destiny and dreams could be within reach.

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Discussions with the Copper Basin geological team and the Newmont mineralogical staff allowed me to review and truly understand the geochemical processes occurring at Copper Basin.

Although most of my family is far away their unconditional love and support through the past two years have provided me the encouragement to get through the difficult days and to appreciate the good days. I would lastly but most importantly like to acknowledge my husband, Trevor for allowing me to continuously move our family so that I can follow my dreams and ambitions.

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ABBREVIATIONS

Abbreviation	Description
RC	reverse circulation
CuOx	copper oxide (blue-green) mineral present
Cu_iron	neotosite
Enrich	enrichment chalcocite present
hypo	hypogene chalcopyrite present
Lch_cap	Leached cap, no copper present
Lo_Enr	lower enriched covellite present
Non_enr	non-enrichment, non-mineralized reduced rock
P_leach	partially leach rock +/- sulfides, copper will plate on nail with HCL
Ch	Cambrian Harmony Formation
Pbl	Pennslvanian Lower Battle Formation
Pbm	Pennslvania Middle Battle Formation
Pbu	Pennslvania Upper Battle Formation
Pap	Permian Edna Mountain Formation
Tag	Tertiary altered granite (Copper Canyon Stock)
Tb	Tertiary basalt
Qal	Quaterary alluvium
DSC	Devonian Scott Canyon Formation
Ki	Cretaceous igneous rock
Td	Tertiary diorite
Wd	Waste Dump
FZ	Fault Zone
ss	sandstone
slt	siltstone
ar	argillic
bh	biotite hornfels
ch	calc-silicate hornfels
gt	garnet skarn
kst	potassic
QSP	quartz-sercite pyrite (hypogene)
SPY	supergene phyllosilicates
SP	sericite + pyrite (hypogene)
QLT	Quick Leach Time
Tcm	Tuff of Cove Mine
SEM-EDS	Scanning Electron Microscope- Energy Dispersive Spectroscopy
NMS	Newmont Metallurgical Services
BSE	Back Scatter Electrons
ppm	parts per million
XRD	X-Ray Diffraction
EA	elemental analyzer

gt	goethite
hm	hematite
py	pyrite
jr	jarosite
cc	chalcocite
cv	covellite
→	replacing

INTRODUCTION

Mine planning requires detailed knowledge of ore types, especially the geometallurgical characteristics of ore mineralogy. This study focuses on identifying the copper ore mineralogy present in the variably-developed supergene enrichment profile at Copper Basin, Nevada. For this study, samples were collected near the Widow Pit, which was previously used as a waste dump and was formerly a site of small-scale underground mining.

The deposit is located within the Basin and Range physiographic province and is associated with numerous northerly-trending mountain ranges that are separated by broad valleys filled with alluvium (Lovering and McCarthy, 1977).

The property historically produced 308 million pounds of copper, 1.9 million ounces of silver, and 379,000 ounces of gold. Copper Basin switched from copper production to gold production due to the economic value of gold compared to copper in the 1980’s (Davenport & Keeler, 2011). Remaining resources comprise 1.7 billion pounds of copper and 1.8 million ounces of gold;

these resources are currently in the development stage of Newmont property assessment (Davenport & Keeler, 2011).

The Contention, Sweet Marie, and Widow pits are characterized by variably-developed supergene enrichment mineralization. Copper ores are dominantly hosted in the Cambrian-age Harmony Formation, with minor occurrences in numerous intrusions. The nature of Copper Basin intrusions and the ultimate source(-s) of copper are currently under investigation.

Newmont geologists have defined the following ore types based on mapped and logged mineralogy: leached capping, partially leached, copper oxide, enrichment, and hypogene. The complex mineralogy of Copper Basin ores makes accurate mineral identification through logging difficult, thus the geologic staff is using copper solubility values to aid in copper ore type classification. Samples are analyzed for acid and cyanide solubility, and are subjected to the following standard “quick leach test” (QLT) which tests copper solubility and potential copper leachability. This thesis study utilized the above information to estimate copper leachability of mineral assemblages in the supergene profile adjacent to the Widow deposit.

In a well-developed supergene enrichment profile, general zoning patterns reflect the deposition of the copper minerals in response to oxidized copper availability, pyrite and chalcopyrite contents of host rock, the copper grade of protolith, and geochemical maturity of the supergene profile. Previous studies at Copper Basin have identified chalcocite, digenite, geerite, spionkopite, yarrowite, blaubleibender, and covellite present as the dominant copper sulfide mineralogy within the enrichment zone (McComb, 2008; McComb, 2007; & McComb, 2006).

Several quantitative and qualitative analyses were used in this study to further identify copper mineralogy within the enrichment zone, and to help correlate copper solubility ranges identified. SEM-MLA and XRD analyses of samples from the supergene enrichment profile at Copper Basin have identified copper sulfide mineralogy ranging from chalcocite (Cu_2S), spionkopite ($Cu_{1.4}S$), roxybite ($Cu_{1.79}S$), and covellite (CuS).

Quantitative and qualitative analyses indicate that copper is also present adsorbed on goethite, as chalcocite and covellite inclusions in gangue minerals, and within the lattices of biotite and clays; these various hosts for copper significantly influence expected copper solubility and recovery values. The principal clay species identified are halloysite, kaolinite, and illite; notably, the amount of copper associated with these clays species varies considerably. Copper associated with illite ranged from 0 to 0.60 wt.%, and with kaolinite/halloysite ranging from 0 to 1.87wt.% Cu as adsorbed Cu^{++}.

Copper Mineralogy and paragenetic relationships indicate three distinct intensities of enrichment, classified as strong, moderate, and weak enrichment.

BACKGROUND

2.1 LOCATION

The Widow Pit is located within the Copper Basin property approximately 5 miles southwest of the town of Battle Mountain in north-central Nevada. This property is located approximately 10 miles north of Newmont's Phoenix mine (Copper Canyon). Both properties are located within the Battle Mountain Mining District (Davenport & Keeler, 2011; Roberts, 1964)

2.2 PHYSIOGRAPHY

The Battle Mountain Mining District is located within the Basin and Range physiographic province. The region is characterized by numerous northerly trending long contracted mountain ranges separated by broad valleys that have been filled with alluvium throughout geologic history (Lovering and McCarthy 1977).

No significant surface expression of the supergene enrichment deposit is present in the Widow deposit region and is generally covered by waste dump or Tertiary and Quaternary sediments. The Tertiary and Quaternary sediments consists of pediment gravel (Lovering and McCarthy, 1978). The vegetation present in the region is common to the Great Basin vegetation: sagebrush, shadscale, and sparse bunchgrass (Davenport & Keeler, 2011).

2.3 CLIMATE AND WATER SUPPLY

The elevation of the Battle Mountain property ranges from 4,500 feet near the toe of the previous Battle Mountain Gold Au leach pad, up to the 8,550 feet above sea level at North Peak, consisting of a mountainous terrain and semi-arid climate (Davenport & Keeler, 2011). Battle Mountain specifically has an average of 8.97 inches of rain and snowfall annually (Western Regional Climatic Center, August 2011).

The Battle Mountain mining district water supply comes both from surface and groundwater. The main sources of surface water in the region are the Humboldt River, local streams, tributaries, and natural springs (Roberts and Arnold, 1965). The average groundwater table elevation around the Widow deposit, the site of this study, ranges from 4900 to 5000 feet above sea level (Davenport and Keeler, 2011).

2.4 HISTORY AND PRODUCTION

The ore deposits within Copper Basin were discovered in 1866, and then in the late 1860’s small-scale mining started (Tippet, 1967). In 1897, ore shipments of copper began to the local smelter in Golconda, Nevada.

Production occurred soon after Glasgow and Western Exploration Co., Ltd merged numerous properties in the Copper Basin area, which occurred after 1897 (Blake, 1992). According to Newmont's Stage 1 report, Copper Basin's historical production totaled over 379,000 oz Au, 1.9 million oz Ag, and 308 million lbs Cu.

During the 1960's, the Duval Corporation took ownership of the property and conducted an extensive exploration program to identify the potential copper reserves (Blake, 1992). From their findings, an initial reserve of 22,657,000 tons of leach-grade material, averaging a grade of 0.41 wt% Cu, and 3,066,000 tons of mill-grade material, averaging a grade of 1.75 wt% Cu was identified (Sayers et al., 1968). Around the mid- 1960's the Copper Basin and Copper Canyon feasibility studies were approved and were identified as economical (Blake, 1992). The Sweet Marie, Carissa, Contention, and the Widow Mine were initially mined as underground operations. Table 1 summarizes the historical production of the four main mines at the Copper Basin property when they were run as underground operations (Blake, 1992). After small-scale underground mining, the deposits were identified to contain open-pit reserves. Open pit copper mining was in production from 1966 to 1981 (Davenport and Keeler, 2011). Battle Mountain Gold Company (BMG) obtained Copper Basin in 1985 and continued the operation until 1986; at which time the open pit operations were terminated. Although, the open pit mines at Copper Basin have been reclaimed there is still an estimated 1.7 billion lbs of Cu and 1.8 million oz of Au that have been identified using historic drill data and is currently in the initial stages of development (Davenport & Keeler, 2011).

Mine Name and years in operation	**Ore (tons)**	**Gold (oz/ton)**	**Silver (oz/ton)**	**Copper (wt. pct)**
Sweet Marie Mine, 1929 & prior years-1954	23038.1	0.006	0.27	9.22
Carissa Mine 1936-54	9104.3	0.499	2.15	2.96
Contention Mine 1927-54	8078.3	0.011	0.36	7.38
Widow Mine 1927-45	2741.8	0.005	0.23	8.48

Table 1: Underground production and metal grades from Roberts & Arnold, 1965, p. B65, B67-B68.

2.5 PREVIOUS MAPPING

Over the years, several regional and site-scale field mapping projects have characterized the geology at Copper Basin in detail (Robert, 1964; Roberts and Arnold, 1965; Tippett, 1967; Sayers *et al.*, 1968; Blake *et al.*, 1979; Schmidt *et al.*, 1988; Loucks and Johnson, 1992; Mckee, 1992; Theodore *et al.*, 1992; Blake, 1992; Hammerastorm, 1992, and Keeler, 2010). In addition to this research, past owners Duval, Climax, and Battle Mountain Gold, as well as the current owner Newmont have conducted their own investigations of the ore systems at Copper Basin.

2.6 REGIONAL GEOLOGY

The Dewitt and Golcanda faults are the main district regional thrust faults present in the Battle Mountain mining district. Figure 1 illustrates the thrust fault localities and the regional geology of the Antler Peak Quadrangle (Davenport & Keeler, 2011). The Antler sequence consists of formations from the Middle Pennsylvanian Battle Formation and Upper Pennsylvanian and Lower Permian Antler Peak Limestone Formation (Davenport & Keeler, 2011).

Through geologic studies, fifty different intrusive events can be identified within the Battle Mountain mining district ranging from the Cretaceous to Eocene age (Roberts, 1964; Steward, 1977). Out of the fifty different intrusive events two distinctive major intrusive rock episodes have been dated and are present locally within the district and specifically at Copper Basin. The two major episodes are the Late Cretaceous: 92–98 Ma (monazite porphyry), and Eocene, 38–41 Ma (Keeler, 2010). Previous studies identified the intrusive events to range from 39 - 89 Ma (granodiorite

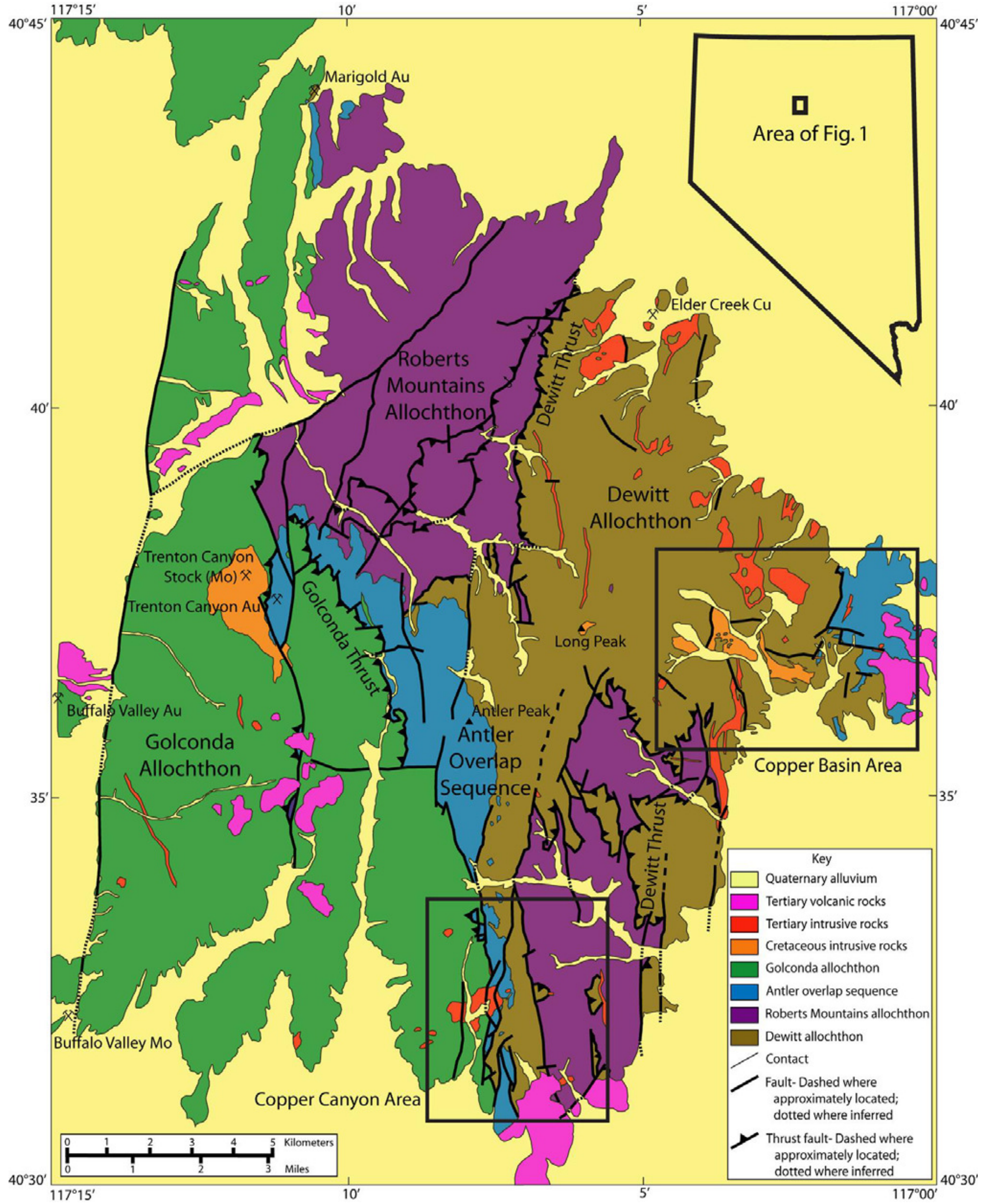


Figure 1. Map of North-Central Nevada illustrating all of the major stratigraphic rock units and structural components. The Copper Basin and Copper Canyon (Phoenix) site area are highlighted. Keeler, 2010

porphyry) (McKee, 1992; Theodore et al., 1992; McKee, 1992).

2.7 BATTLE MOUNTAIN MINING DISTRICT ORE DEPOSITS

Due to the favorable geologic setting, the Battle Mountain mining district hosts a variety of ore systems and thus, a range of economic mining developments. Specifically, the district hosts the following types of ore systems: porphyry Mo-Cu, porphyry-related Au ± Cu deposits hosted in skarn and silica-pyrite bodies, and supergene Cu deposits, which is the subject of this study.

The Buckingham porphyry molybdenum deposit is important ore system in the vicinity of the Copper Basin property. It has been explored throughout the years and is still considered a large lower grade molybdenum resource.

The Copper Basin property contains porphyry-related gold ± copper deposits hosted in sedimentary rocks as silica-pyrite ore bodies and supergene copper deposits. Examples of the former include Labrador, Empire, Northern Lights, Surprise, and Carissa which have been classified as porphyry-related gold ± copper deposits in skarn and silica-pyrite ore bodies by Blake (1992).

The current study focuses instead on the supergene copper deposits, Contention, Sweet Marie, and Widow. Figure 2 provides a view of the Battle Mountain mining district in the context of the regional geology of North-Central Nevada (Keeler, 2010).

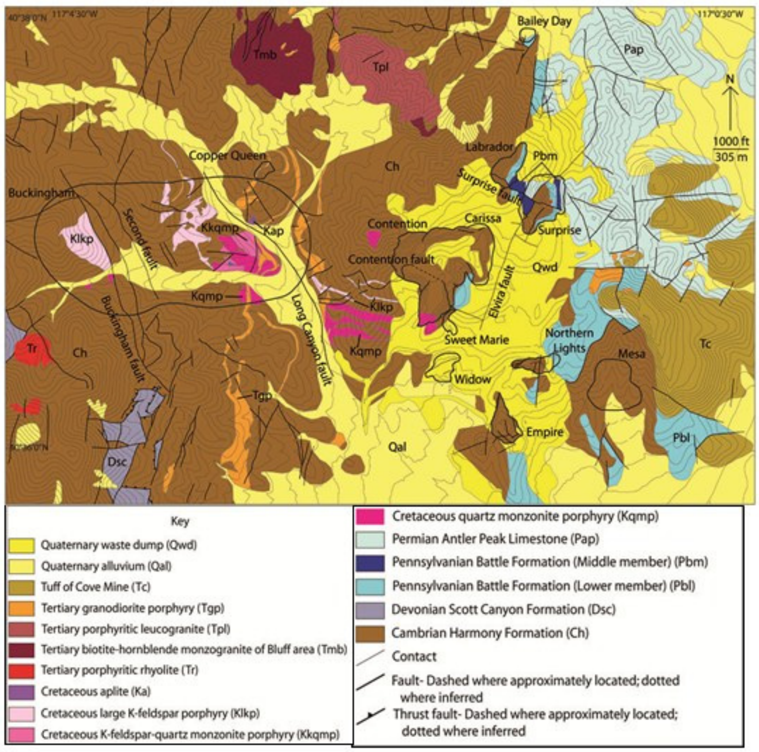


Figure 2. Geologic map of Copper Basin site illustrating all of the major stratigraphic rock units and structural components present within the area, Keeler, 2010 and Newmont Internal report, 2011.

3. COPPER BASIN GEOLOGY

3.1 STRATIGRAPHY

The Copper Basin area contains a simple suite of rocks that hosts Cu, Au, Mo, and Ag which includes the Devonian Scott Canyon formation, Cambrian Harmony formation, Lower, Middle, and Upper Battle Formation, and the Antler Peak Limestone, refer to Figure 2. The Cambrian Harmony Formation hosts the copper ore mineralization.

The oldest rock unit present at Copper Basin the *Devonian Scott Canyon Formation,* is characterized by thick allochthounous chert + argillite with basalt/greenstone, limestone, olistostrome with olistoliths of limestone, sandstone and chert and is greater than 1,300 feet thick (Davenport and Keeler, 2011 & Doebrich, 1995).

The *Cambrian Harmony Formation* overlies the *Scott Canyon Formation,* and is greater than 1,800 feet thick throughout the Copper Basin region (Davenport and Keeler, 2011). Its lithology is characterized by micaceous sandstone, feldspathic sandstone, arkose, shale, calcareous shale, and limestone. A classic feature of Harmony Formation is the presence of well-developed graded biostratigraphically useful fossils have been identified within bedding originally deposited by turbidity flows. No the *Harmony Formation* (Roberts, 1964). However, within the *Harmony Formation*, there is three different types of quartz fragments that indicate three different origins. The clear quartz fragments are thought to be from a single crystals, or possibly crystal aggregates. The source rock is likely a pegmatite, or possibly granitic (Roberts, 1964). Smoky quartz is found as microscopic opaque inclusions that are suspected to originate from veins. Milky quartz grains are also found within microscopic opaque inclusions, which is thought to come from veins, but range from finely granular to coarsely crystalline schistose quartzite (Roberts, 1964).

The *Harmony Formation* is commonly altered to biotite hornfels with associated quartz-sericite-pyrite (QSP), skarn(sk), and supergene phyllosilicate

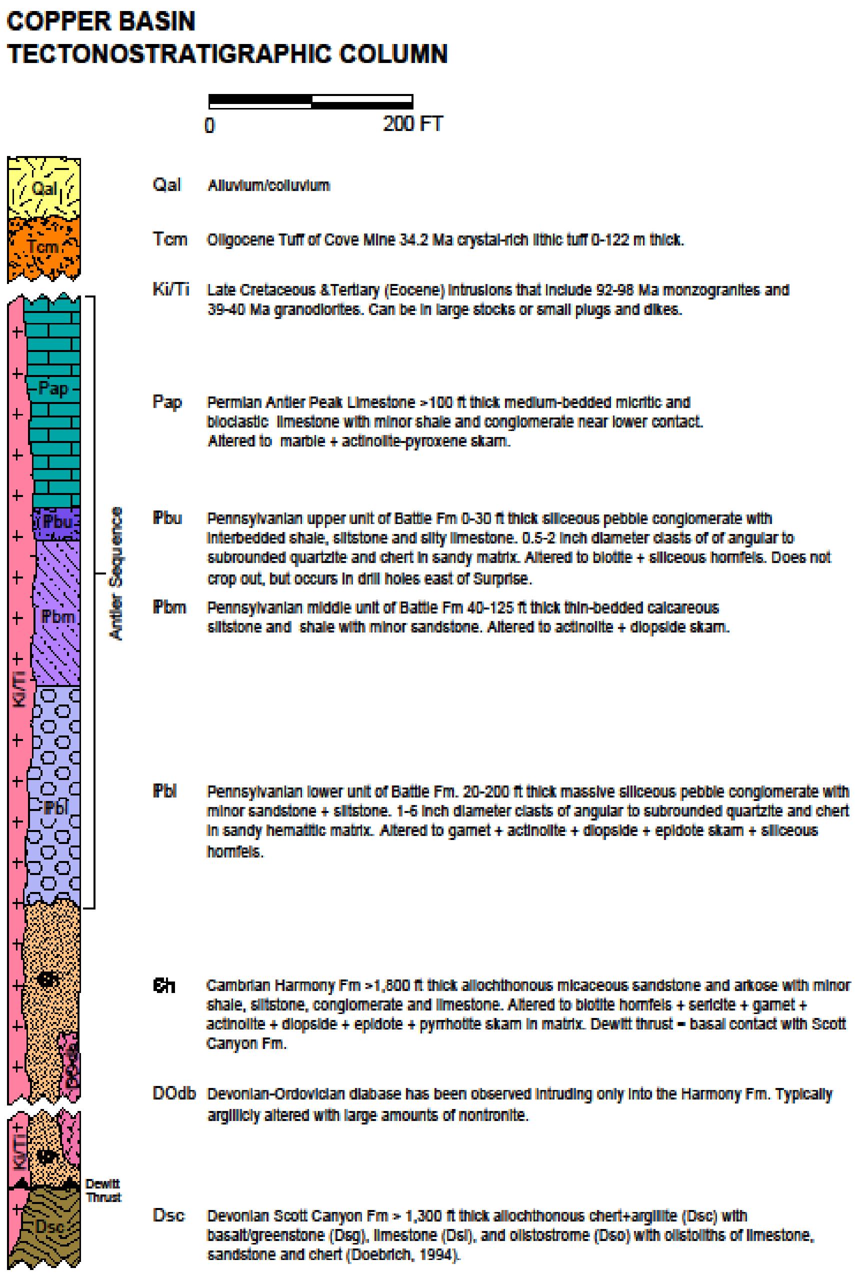


Figure 3: Generalized geologic map of Copper Basin site illustrating all of the major statigraphic rock units and structural components present within the area (Keeler, 2010).

alteration (SPY) (Davenport & Keeler, 2011). At Copper Basin it is more common to find altered Cambrian Harmony formation then unaltered.

Above this is the Middle Pennsylvanian *Battle Formation* which consists mostly of red to brown conglomerates with interbedded red sandstone, shale and thin limestone layers existing in the upper portions of the formation and ranges from approximately 40 to 125 feet thick (Davenport & Keeler, 2011). Crossbedding is common in this formation (Roberts, 1964). The *Battle Formation* has been subdivided into the three units; *Lower, Middle, and Upper*.

The *Lower Unit of the Battle Formation (Pbl)* is characterized by massive siliceous pebble conglomerates with minor interbedded sandstone and siltstone that ranges from 20 to 200 feet thick (Davenport and Keeler, 2011). A sandy hematitic matrix contains 1-6" -diameter clasts of angular to sub-rounded quartzite with chert (Roberts, 1964; Davenport & Keeler, 2011).

The *Middle Unit of the Battle Formation (Pbm)* contains of thin-bedded calcareous siltsone and shale with minor sandstone and ranges from approximately 40 to 125 feet thick (Davenport & Keeler, 2011). The only surface exposure of this unit is an outcrop near the Labrador and Surprise pit, which exhibits evidence of weathering and oxidation (Davenport & Keeler, 2011).

The *Upper Unit of the Battle Formation (Pbu)* is characterized as containing siliceous pebble conglomerates with interbedded shale, siltstone, and silty limestone beds that can be as thick as 30 feet thick (Davenport & Keeler, 2011). It is common to find 0.5-2" clasts of angular to sub- rounded quartzite and chert in the sandy matrix. There are no surface expressions of this rock unit within the Copper Basin area although it is found in the subsurface at the eastern edges of the property (Davenport & Keeler, 2011).

The uppermost unit, the Late Pennsylvanian to Early Limestone *Antler Peak Limestone* (Pap) consists mostly of light- to medium-gray, fine- to medium-grained limestone deposited in medium-to thick beds greater than 100 feet thick (Roberts, 1964 & Davenport & Keeler, 2011). Surface exposures of this rock unit can be found within the Labrador and Surprise Pits, as well as in the Elephant Head region (Davenport & Keeler, 2011).

3.2 INTRUSIVE ROCKS

Numerous intrusive rock units have been identified throughout the *Antler Peak Limestone, Battle, and Harmony Formations* in the form of dikes, sills, and irregular bodies. Although the majority of the intrusive rocks are felsic in composition and range from Late Cretaceous to

Tertiary in age (Keeler, 2010), different generations of diabase dikes and plugs have been identified in the area. Small extensively altered diabase dikes and plugs intrude the *Harmony Formation* and younger diabase dikes are located around the Labrador and Surprise deposits (Keeler, 2010). Due to their complexity, these intrusive rocks are poorly understood and are still being investigated.

3.3 STRUCTURE

There are several structural features at Copper Basin that control the hypogene and supergene mineralization, for example, the extensive NNW trending anticline formed by the *Harmony Formation* (Roberts & Arnold, 1965) and the fault-induced drag folds and the localized reversals (Sayers, et al. 1968). At Copper Basin, the sediments within the *Harmony Formation* strike N10° -30°E and generally dip to the east at 40-60° (Sayers, et al. 1968).

Within the site, there are five major fault zones that have greatly influenced the economic mineralization, all of which were mapped in the structural reconstruction of the Copper Basin region by Keeler (2010). The Contention fault has a strike of N55W dipping 15 to 35°, and exhibits offset up to 1,800 feet. Three younger parallel faults (Buckingham, Second, and Long Canyon

Faults) were mapped with a strike of N20–50°E dipping 55–77°W with an offset of approximately 1,000 feet. The Surprise Fault is an East to West strike and an 80–90° North–South dip, and field mapping did not identify any measurable offset.

3.4 ALTERATION ASSEMBLAGES

Several different alteration assemblages are present within Copper Basin that are hosted dominantly in the intrusive rock units and the Cambrian Harmony formation. Specifically, within the Widow Pit the dominant alteration types identified in this study are *argillic (AR), biotite hornfels (BH), quartz + sericite + pyrite (QSP), sericite + pyrite (SP), and supergene phyllosilicate (SPY).* These types of alteration are directly related to the occurrence and distribution of the ore mineralization present at the Widow Pit.

Argillic (AR) alteration is characterized by clay-rich minerals and is often localized along faults and fractures zones.

Biotite hornsfels (BH) alteration is characterized by a brownish-green fine-grained rock and is typically associated with hypogene ore types.

Quartz + sericite + pyrite (QSP) alteration is characterized by bleached sandstone intermixed with white phyllosilicate and pyrite grains.

Sericite + pyrite (SP) alteration is characterized by white phyllosilicates and pyrite grains.

Supergene phyllosilicate (SPY) alteration is characterized by fine-grained phyllosilicates.

Other minor assemblages present at Copper Basin are *potassic (KST)* and *skarn alteration (SK)*. *Potassic (KST)* alteration is characterized by potassium feldspar grains and is typically associated with biotite hornfels alteration types and intrusive rock units. *Skarn (SK)* alteration characterized by amphibole and pyroxene minerals and is typically found as lenses. Skarn alteration is associated with hypogene copper ore types and the lower and middle unit of the Battle formation. The unit comprises skarn alteration, which is typically found within the basal 30’ of the unit. (Roberts, 1964; Davenport & Keeler, 2011).

The main sedimentary rock units in the region undergo different alteration depending on whether they are calcareous and less calcareous rock units. Calcareous rock units commonly alter to skarn, calc-silicate hornfels, and supergene phyllosilicate alteration types, while less calcareous units alter to; biotite hornfels (BH), quartz-sericite-pyrite (QSP), or supergene phyllosilicate alteration (SPY) (Blake, 1992).

4. SUPERGENE ENRICHMENT

4.1 COPPER ORE TYPES

The main zones within a supergene enrichment profile are the leached capping, copper oxide, partial leach, enriched, and hypogene (Chavez, 2000). At the Widow deposit the main geochemical zones under study are those of Leached Cap, Partial Leach, Enriched, and Hypogene, as defined by Newmont geologists working in the district.

LEACHED CAP – ORE TYPE

The *Leached Cap* zone is the rock volume of the metal removal (Chavez, 2000). The extent of the Leach Cap is a good indication of the potential economic copper grades below, and is determined by the amount of acid-producing sulfides in the original rock volume, neutralizing capacity of the minerals present in the host rock, the amount of structural components that will provide fluid flow, and fluctuation of the phreatic zone (Anderson, 1982; Lopez and Titley, 1995; and Davenport & Keeler, 2011).

The iron oxide mineralogy present in the leached zone provides an indication of the geochemistry of the host rock and fluid. The presence of carmine hematite with box works, is an indication that there could be abundant steely-gray chalcocite in the enrichment zone, whereas a mix of goethite and hematite suggests that there will be less abundant chalcocite and possibly more covellite in the enrichment zone. Examples of hematite with box works can be seen at Northern Lights, which is a location of higher-grade chalcocite. Specifically, the *Leached Cap* at the Widow deposit consists mostly of goethite, hematite, and ± jarosite, which can be identified at the microscope level.

The iron oxides present in the *Leached Cap* zone typically exhibit replacement textures and associations, such as, micas and feldspars that are relic protore minerals still present in the rock. It is also common to find unreacted sulfides such as pyrite and trace amounts of copper sulfides with low total copper in this zone. The thickness of the *Leach Cap* zone varies throughout the Copper Basin site from “a few feet to greater than 300 feet” (Davenport & Keeler, 2011). Although it is more common to find the *Leached Cap* zone at or near the surface, Copper Basin contains multiple leach cap zones at various depths within the profile. The *Leached Cap* zone is typically associated with argillic alteration.

PARTIAL LEACH – ORE TYPE

As with most geochemical boundaries there are transitional zones in between the *Leached Cap* and the Enriched zone, this is referred to as the *Partial Leached* zone. Although this region has undergone leaching, not all of the sulfides within has been completely removed, therefore, a mix of abundant iron oxides and relic sulfides commonly characterizes this zone. In some cases, this region contains similar copper grades and recovery values as the enrichment zones. The *Partial Leach* zone is typically controlled by faults, varies in thickness, and can appear multiple times within one profile.

ENRICHMENT – ORE TYPE

The *Enriched zone* is the location where the metals leached from the leached cap region accumulate. Copper is mobile at lower pH levels and thus can be present as a cupric ion or as a copper sulfide and is enriched vertically with metal-bearing and acidic fluids (Chavez, 2000), once introduced to a reducing environment, the copper is no longer mobile and thus either precipitates or replaces existing sulfides.

In a well-developed enrichment profile chalcocite (Cu_2S) is more abundant in the upper portions of the enriched zone, and transitions into covellite (CuS) in the lower portions of the enrichment zone (Chavez, 2000). This relationship is directly related to the red/ox boundary between each zone (Leach Cap, Partial Leach, Enriched, and Hypogene) and the properties of the fluids that percolate throughout this zone. In other words, the fluids are initially richer in Cu but then become depleted as they flow through the reducing zone, losing copper as the fluid makes its way through the host rock. This is supported by the sequence of minerals phases that are present at Copper Basin; chalcocite, digenite, geerite, spinokopite, yarrowite, blaubleibender, and covellite (McComb, 2008; McComb, 2007; McComb, 2006).

HYPOGENE – ORE TYPE

The hypogene zone is the location of the original un-reacted ore mineralization. Originally classified by Blake (1992), the dominant *Hypogene* sulfide minerals originally present in the supergene copper deposits were: pyrite, pyrrhotite, chalcopyrite, galena, sphalerite, molybdenite, marcasite, and rare arsenopyrite. The samples collected from the Widow Pit include the following hypogene mineral assemblages: pyrite, pyrrhotite, and chalcopyrite.

4.2 STAGES OF MINERALIZATION AND CYCLES OF ENRICHMENT AT COPPER BASIN

The supergene enrichment profile developed at Copper Basin is considered to be incipient in maturity and erratic in development. The geochemical stratigraphy along the margins of the former Contention pit is not as well-developed as that in the previously-mined supergene enrichment, and the mineralogy and copper abundance suggests that it represents erratically-developed copper mobility and accumulation.

Outcrop-based studies of the leach capping at Copper Basin (Sayers *et al.* 1968) indicate that existing chalcocite enrichment is the product of previous supergene enrichment cycles, and is not derived directly from hypogene copper within the Cambrian-aged Harmony Formation. Copper Basin mineralogy and microtextures suggest that Copper Basin supergene enrichment underwent an incipiently-developed second cycle of enrichment. It is surmised that this second-cycle was interrupted by Miocene-age volcanism. This volcanism generated a sequence of quartz latite welded tuffs that covered the developing second-cycle geochemical stratigraphy (Sayers *et al.* 1968) and that the tuff acted as a cover for the previous supergene enrichment profile, concealing it from near-atmospheric conditions and meteoric water supply. Late Tertiary tectonic uplift prompted erosion of the tuff cover (Sayers *et al*. 1968) engendering a renewed cycle, but incipient, cycle of enrichment.

5. Assay Tests

An assay analytical test is used to determine the quantity of metals in a bulk rock sample. At Copper Basin, a standard set of assay tests are conducted for all of the samples collected during the drilling program. For this study the assay tests that will be reviewed will be total copper, CuOx, $CuCN_3$, and the Quick Leach Test (QLT).

The total copper assay indicates the total amount of copper in the bulk sample and the four acid near total digestion procedure is used, which includes the following acids: HNO_3, HCl, HF, $HClO_4$ (American Assay, 2011). If copper is greater than 10000ppm the two acid digestion procedure is used, which includes the following acids: HNO_3 and HCl (American Assay, 2011). This test alone is non-specific for mineralogy but if used in combination of CuOx, $CuCN_3$, and QLT values the bulk rocks potential leachability can be determined.

Acid solubility is a percentage value that is calculated by taking the CuOx value and dividing it by the total copper value. The CuOx assay test uses a mixture of H_2SO_4 and sodium sulfate (Davenport & Keeler, 2011). Overall, acid solubility values for copper sulfide mineralogy are not well documented in academia or industry.

Cyanide solubility is a percentage value that is calculated by taking the $CuCN_3$ value and dividing it by the total copper value. The $CuCN_3$ assay test uses a mixture of NaCN, and NaOH (Davenport & Keeler, 2011). Cyanide solubility values have been used for copper deposits to predict leachability of specific copper mineralogy. According to Lower and Booth (1965), who used similar assay methods identified chalcocite cyanide solubility values ranging from 54.4 to 92.6%, covellite cyanide solubility values ranging from 53.2 to 95.6%, and chalcopyrite cyanide solubility values around 5.8%. Historically, cyanide solubility values work best to identify chalcopyrite and copper oxides (except chrysocolla) (Davenport & Keeler, 2011).

The Morenci Leach Test now identified as the Quick Leach Test (QLT) was originally developed by the chemists at the Morenci Analytical Services Laboratory (Farquhar, 1993) and is currently conducted at Skyline Laboratory in Tucson, Arizona (William, et al, 1999). The cold Quick Leach Test is used in the current assay procedure with a mixture of H_2SO_4 and ferric Fe. Previous assay tests indicated the following as the typical range of leachability: copper oxides (100%), chalcocite (50%), and chalcopyrite (10%) (Davenport & Keeler, 2011).

The difficult part about using this data to predict leachability is that copper and iron impurities will affect the expected values and thus cause misleading values. In supergene copper deposits it is very common to have enrichment zones that still contain transitional zone that contain copper and iron impurities.

6. METHODOLOGY

6.1 ANALYTICAL BACKGROUND & SAMPLE COLLECTION

The main copper extraction methods that were used in this research were acid solubility, cyanide solubility, and the Quick Leach Test(QLT): acid solubility = (CuOX)/(total copper) and cyanide solubility = ($CuCN_3$)/(total copper). Since this data is collected for all reverse circulation (RC) and core samples drilled for the project, this analytical assay information was used to statistically identify the sample intervals. The data was collected by running a common data retrieval from the Newmont database based on the common assay tests: for total Cu, CuCN, CuOX, and QLT. For each copper ore type a lower, middle, and upper range was selected using a range of one standard deviation, except if the lower member started in the negative range.

Out of the three copper solubility tests, the acid solubility values illustrated a broader range fluctuation. Although on average, the copper solubility values were lower than the QLT and cyanide, the variation is assumed to reflect the complex mineralogy, which is the study of this project. The acid solubility was used to break up the sample intervals (refer to Table 4) in attempt to understand the complex mineralogy and connect to copper solubility values.

Acid and cyanide solubility data are from American Assay Laboratory in Reno, Nevada and the Quick Leach Test (QLT) are from Skyline Laboratory in Tucson, Arizona. The common data retrival pulled from the Newmont analytical assay database yields 6,131 sample intervals with a nominal length of 5 feet while the QLT extraction sample intervals have a nominal length of 20 feet. Frequencies of copper ore types from the common data retrieval are compiled in Figure 4 and Table 2.

Table 3 lists the drill holes collected, date of collection, and number of sample intervals chosen based on acid solubility ranges, which have been identified in Table 4. Since, there is potential for enrichment and hypogene classification overlap the ranges were modified slightly to compensate. Figure 15 illustrates the spatial relationship between all of the drill holes chosen for this study.

Pulp samples, representing composite drill hole intervals, were collected based on acid solubility ranges associated with logged copper ore types. An orthogonal cross section including north-south & east-west cross-sections intersecting the Widow pit were used to illustrate mineral relationships and associations across modeled ore zones (Figure 5). Fifteen drill holes, nine

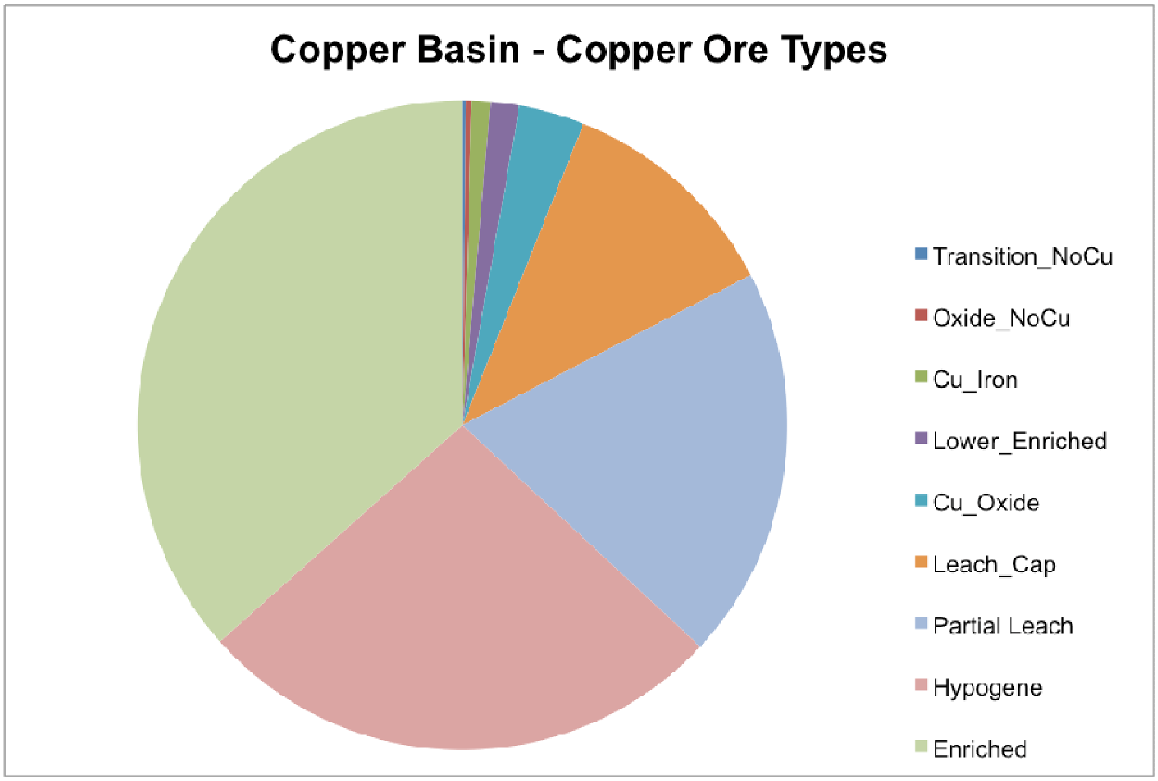


Figure 4: Frequencies of the different copper ore types that were a part of the common copper data extraction.

Copper Ore Type	# of Samples	Percentage Logged
Transition_NoCu	10	0.16%
Oxide_NoCu	18	0.29%
Cu_Iron	57	0.93%
Lower_Enriched	88	1.44%
Cu_Oxide	200	3.26%
Leach_Cap	691	11.27%
Partial Leach	1201	19.59%
Hypogene	1622	26.46%
Enriched	2244	36.60%
Total	6131	100.00%

Table 2: List of the different copper ore types that were a part of the common copper data extraction.

Ore Type	Acid Sol% Range	Code
Enriched	0-12.6%	Enr_1
	12.7-35.9%	Enr_2
	36.0-100%	Enr_3
Hypogene	0-12.6%	Hyp_1
	12.7-100%	Hyp_2
Partial Leach	0-13.6%	PL_1
	13.7-40.4%	PL_2
	40.5-100%	PL_3
Leach Cap	0-5.33%	LC_1
	5.34%-30.3%	LC_2
	30.4-100%	LC_3

Table 3: Acid solubility ranges with corresponding Copper Basin classified copper ore types.

Drill Hole	Date of Collection	Number of samples
PCB-04481	January, 2011	6
PCB-04482	January, 2011	7
PCB-04456	January, 2011	6
PCB-04618	January, 2011 / July-August, 2011	7
PCB-04451	July-August, 2011	8
PCB-04455	July-August, 2011	6
PCB-04465	July-August, 2011	3
PCB-04488	July-August, 2011	6
PCB-04499	July-August, 2011	6
PCB-04604D	July-August, 2011	9
PCB-04609	July-August, 2011	6
PCB-04691	July-August, 2011	11
PCB-04834	July-August, 2011	5
PCB-04836	July-August, 2011	8
PCB-04872	July-August, 2011	5

Table 4: List of drill holes and corresponding number of samples collected.

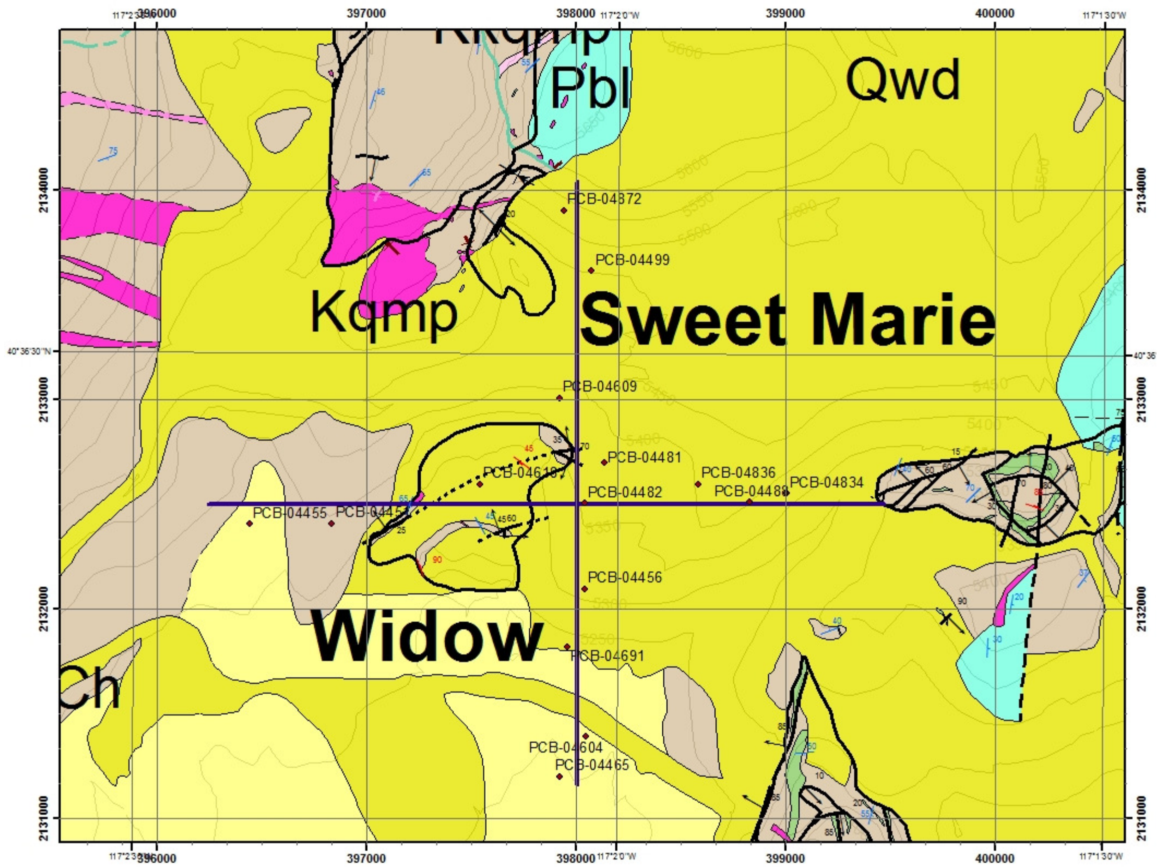


Figure 5: Generalized geologic mp of the Widow Pit showing the location of cross-section modified from Keeler, 2010.

from the north-south section and five from the east-west with PCB-04882 at the intersection of these, totally in 99 sample intervals were selected for pulp collection.

The sample pulps were collected from either reverse circulation (RC) chips and/or core that were pulverized. Initially, the samples were run through a jaw crusher such that approximately 95% passed 10 mesh. From that original sample, a 1000g sample is rotary split, with that sample pulverized until at least 85% passes through 200 mesh (Davenport, 2012).

6.2 HEAVY LIQUID SAMPLE SEPARATION OF PULP SAMPLES

New Mexico Institute of Mining and Technology Mineralogy Lab

A total of 99 samples were collected, representing the fifteen drill holes mentioned above. Thirty grams of 10 mesh composite pulp samples were mixed with non-toxic sodium polytungstate having a specific gravity of •2.85. The pulp-liquid slurry was mixed and agitated by hand for at least 30 seconds in a 250 ml centrifuge bottle. The mixture was subjected to centrifugation for at least 10 minutes at 700 rpm.

Following centrifugation, the bottles were placed in liquid nitrogen to freeze the heavy fraction of each sample. Once the heavy grains liquid mixture was frozen, the light grains are removed by rinsing with warm distilled water and poured through a quartz microfiber filter.

The centrifuge bottle containing the frozen heavy fraction is kept plugged to reduce airborne grain contamination, and the bottle is set aside to allow thawing of the heavy fraction. Once thawed, mineral grains are rinsed out of the bottle with warm distilled water and poured through a quartz microfiber filter. Heavy and light fractions are rinsed with warm distilled water until liquid rinses clear, and then samples are rinsed with acetone at least twice to ensure that all residual heavy liquid has been removed. Samples are then dried in an oven for at least six hours at 65°C; dried samples are mixed with epoxy at room temperature and poured into a Teflon© grain mount mold. The samples are left to cure in the oven at 89°C for at least 7 hours. Polished vertical settling columns so as to avoid bias due to grain density or size due to the sample preparation method.

6.3 MINERALOGICAL IDENTIFICATION

Samples are described using standard petrographic techniques (Schwartz, 1951 and Schwartz, 1932); in addition, electron microprobe, scanning electron microprobe (SEM), and X-ray diffraction analyses were performed as-needed so as to confirm or enhance mineral identification.

6.3.1 PETROGRAPHIC ANALYSES

All samples heavies and some light fractions underwent standard petrographic analyses in which copper sulfides and Fe-oxides were described by their mineralogy, mineral associations, and paragenetic relationships. Descriptions are summarized in the Analytical Results section, with details in the Appendix A.

6.3.2 SCANNING ELECTRON MICROSCOPE ANALYSES

Scanning Electron Microscope-Energy Dispersive Spectroscopy (SEM-EDS) analyses were completed at the Newmont Metallurgical Services (NMS) Laboratory using the X-ray backscattered electrons (XBSE) method to map and identify copper sulfide mineral phases. All spectra were analyzed using EDAX Genesis V6.04 software; theseback-scattered electrons (BSE) images were used to help identify between copper sulfides and iron oxides. For these analyses, the elemental detection limit for spot analyses is approximately 0.3wt. % (3000 ppm) for all elements. (Thogerson, 2011, Davenport & Keeler, 2011), with a spot size of approximately 3µ (Doerr, 2011). Analyses of crystalline phases will sum to 100% because this method was conducted without an internal standard and is considered standardless. This type of normalization is a requirement of software when not using a national standard.

6.4 ELECTON MICROPROBE ANALYSES- COPPER SULFIDES AND LIGHT SAMPLES

Using a Cameca Sx-50 Microprobe, quantitative point and traverse analyses were collected to quantify the relative abundances of Cu, Ag, Fe, S, O, and H to better identify the stoichiometric nature of the copper mineralogy. The analyses were performed at an accelerating potential of 20 keV, a beam current of 20ma, and each element was analyzed for a total of 10 seconds for the peak and another 10 seconds for background. A total of forty-eight analyses were performed with samples from two different drill holes; three chalcocite samples were collected from other supergene enrichment profiles of other ore deposits for stoichiometric comparison with Copper Basin copper sulfides.

6.5 XRD ANALYSES

A total of six samples from RC chips and six samples of light fraction material from the heavy liquid separation were analyzed using X-Ray Diffraction (XRD) on New Mexico Bureau of Geology's Panalytical X' Pert Pro. Samples were analyzed to understand the potential of copper being contained with the light material as inclusions of distinct copper minerals or hosted within the crystal lattice of phyllosilicates. The RC chips were collected to help identify black sooty mineral phases coating pyrite grains; this material commonly plates copper when attacked by sulfuric acid.

6.6 SULFUR ISOTOPE SURVEY

The purpose of this survey was to establish an isotopic baseline for the sulfur within the different zones within the supergene enrichment profile associated with copper mineralogy, specifically the partially leached and enrichment.

$\delta^{34}S$ analyses of pyrite were conducted using an Elemental Analyzer (EA) coupled with CFIRMS at the New Mexico Institute of Mining & Technology Stable Isotope Laboratory. A total of nine samples from RC chips were collected and analyzed. Each sample was weighted to approximately 0.7 ±0.2mg and poured into a small tin cup with the following dimensions; 3.5 x 5.0mm. A total of 3 different standards were prior to the sample run, during, and the end of the sample run to ensure laboratory quality standard protocol. Within the sample run three samples were run as duplicates as internal checks. Using the measured values and the expected values for the standards a corrected value was calculated.

7. RESULTS

7.1 PETROGRAPHIC ANALYSES

A total of 15 drill holes comprising 99 samples were reviewed from within and around the Widow Pit representing the area southeast of the former Contention Pit supergene chalcocite resource. Each sample interval was reviewed in the same systematic way and the findings as described in Figure 6 and are discussed in detail in Appendix A. All of the drill holes are located on either an east-west and/or the north-south cross section shown in Figure 36 and 37. Appendix A summarizes the petrographic observations comprising mineralogy, paragenetic relationships, and mineral textures, as well as assay results, field observations, and ore type classification from this study (as opposed to Newmont's geologists classification).

The following describe the drill hole intersections comprising this study. General ore and alteration mineralogy are given, with 97 samples from the Harmony Formation and 2 samples from the Kgmp intrusion. The flowchart of geochemical logging used in the petrographic analysis for this study is outlined in Figure 19. The flowchart describes how the geochemical ore

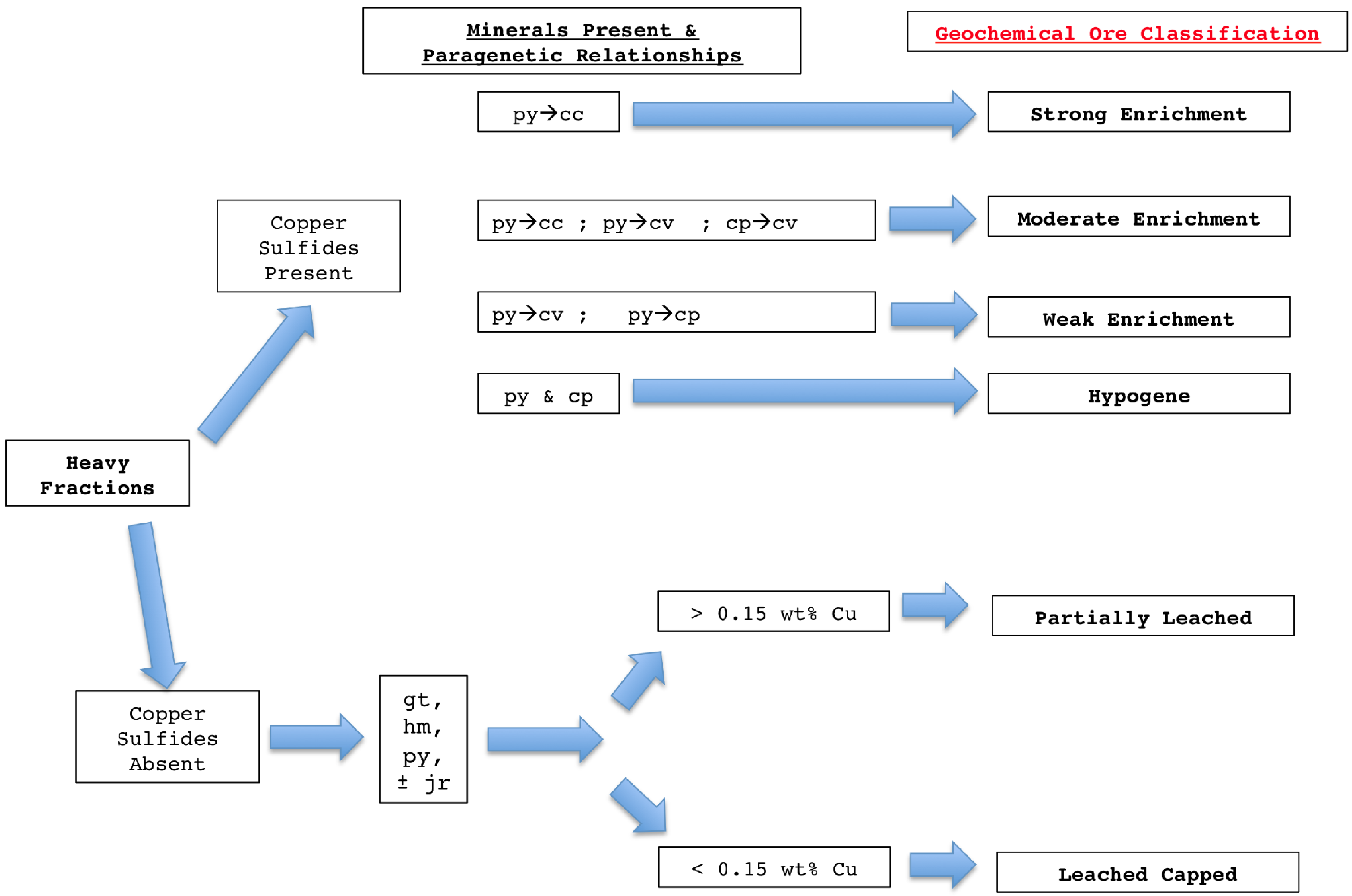


Figure 6: Flowchart of geochemical logging used in the petrographic analysis for the current study. (cc) chalcocite, (cp) chalcopyrite, (cv) covellite, (gt) goethite, (hm) hematite, (jr) jarosite, (py) pyrite, and (→) replaced by

classification was identified and was constructed after reviewing a smaller set of samples also included in this study.

7.1.1 Drill Hole PCB-04451

Drill hole **PCB-04451** is located on the east-west cross section (refer to figure 50), drilled as an RC hole to a depth of 360 feet and as core from a depth of 360 feet to 576.4 feet. A total of eight pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04451 459.5-470.1 feet

Petrographic Observations

- **Goethite**, is the dominant mineral and shows colloform textures.
- **Rutile**, is present as isolated grains indicating evidence for former biotite.
- **Hematite**, as trace isolated grains intergrown with goethite.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.1 wt% (pct)	24%	15%	None on file

The mineralogy, microtextures, and mineral paragensis indicated that this sample is representative of a leach capping environment, which supports the Copper Basin geologic classification as *Leached Cap.*

The presence of abundant rutile indicates the alteration and destruction of early alteration-derived biotite within the Harmony Formation. Microprobe data indicate that trace amounts of copper are associated with gangue minerals such as, white phyllosilicate grains. Note that when biotite is altered to white phyllosilicate during phyllic alteration, as noted in this study, it is common for rutile to be present as an alteration mineral derived from the trace amounts of Ti in the original magmatic biotite. If the biotite contained trace amounts of lattice-hosted copper, this copper would be liberated during the phyllic alteration event, and adsorbed to goethite during weathering (Meyer, 1967).

Copper Basin ore classification: *Leached Cap*

Geochemical Ore classification (from this study): *Leached Capping*

PCB-04451 470.1-474.1 feet

Petrographic Observation

- **goethite**, as dominant grains found as intergrowths with hematite.
- **Hematite**, less dominant grains than goethite and found as intergrowths with goethite.
- **Rutile**, is present as trace isolated grains associated with goethite.
- **jarosite**, as trace grains associated with goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.4 wt% (pct)	28%	16%	None on file

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partially leached zone, which supports the Copper Basin geologic classification as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified that fracture-hosted goethite plates copper when saturated with acid, associated with trace amounts of clay and residual biotite in the matrix of the sandstone.

The light material from the heavy liquid separation was analyzed using standard XRD practices and no copper sulfides were identified above the XRD detection limit. The main mineral phases identified are: quartz, orthoclase, muscovite, and kaolinite (Refer to table 8). With this information along with the petrographic observation it is assumed that the copper is adsorbed on the goethite grains.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

Partially Leached

PCB-04451 474.1-479.4 feet

Petrographic Observations

- **Goethite**, is the dominant mineral and shows colloform textures, which polishes very well indicating trace amounts of admixed silica.
- **Rutile**, is present as isolate grains.
- **Trace hematite**, as isolated grains intergrown with goethite.

Analytical Assay Data

Total Copper	Acid	Cyanide	QLT

	Solubility	**Solubility**	
0.17 wt% (pct)	26%	16%	None on file

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partially leach zone, which does not support the Copper Basin geologic classification as *Leach Cap.*

Copper Basin Ore Classification: Leached Cap

Geochemical Ore Classification (from this study):

Partially Leached

PCB-04451 479.4-483.7 feet

Petrographic Observations

- **Goethite**, is the dominant mineral, illustrating colloform texture, which polishes very well indicating trace amounts of admixed silica.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.14 wt% (pct)	40%	21%	None on file

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a leached capping zone, which supports the Copper Basin geologic ore classification as *Leached Cap*.

Copper Basin geologic team identified green clay that plates copper very well when saturated with acid: however, the total copper is not significant enough to be considered partially leached with a total copper of 14 wt%.

Copper Basin Ore Classification: *Leached Cap*

Geochemical Ore Classification (from this study): *Leached Capping*

PCB-04451 494.4-506.1 feet

Petrographic Observations

- **Goethite**, is the dominant mineral showing collofrom texture, which polished very well indicating admixed silica.
- **Trace rutile**, present as isolated grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.06 wt% (pct)	18%	95%	None on file

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a leached capping zone, which does not support the Copper Basin geologic ore classification as *Hypogene*.

Field observations noted by the Copper Basin geologic team identified biotite hornfels as the dominant alteration type.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Leached Capping

PCB-04451 506.1-509.6 feet

Petrographic Observations

- **Chalcocite**, as μ-scale patinas coating and replacing pyrite, representing typical supergene textures.
- **Chalcopyrite**, as relic grains inside a larger chalcocite grains.
- **Goethite**, as abundant isolated grains.

- **Pyrite**, as fine to medium-grains that are being replaced by chalcocite is the most dominant mineral phase.

<u>Analytical Assay Data</u>

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.38 wt% (pct)	25%	96%	None on file

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification as *Partial Leach.*

Field observation made by the Copper Basin geologic team noted biotite hornfels as the dominant alteration type, which could be the reason for the decreasing values of the copper solubilites values. It was also noted that fractures contain neostisite, chrysocolla, halloysite which plates copper when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04451 518.4-530.2 feet

Petrographic Observations

- **Chalcocite**, as μ-scale patinas coating and replacing pyrite representing typical supergene texture.
- **Chalcocite-covellite mixed mineral**, as μ-scale patinas coating and replacing pyrite representing typical supergene textures.
- **Hematite**, as abundant grains intergrown with goethite isolated grains.
- **Goethite**, less abundant than hematite as isolated grains.
- **Pyrite**, as fine to medium grains that are being replaced by chalcocite.
- **Rutile**, as isolated grains.
- **Pyrrhotite**, as isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.39 wt% (pct)	29%	96%	None on file

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations made by the Copper Basin geological team identified a fault zone from 521.8 to 526.6 feet, with clay and sericite as the dominant alteration minerals and chalcocite along bedding and joints. They also noted copper plating easily when saturated with acid and oxidation staining restricted to fracture zone consisting of red hematite and oxidizing pyrite. The low temperature clay mineral phase, halloysite, was identified along fractures and the matrix of regions of weaknesses.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Strong Enrichment

PCB-04451 530.2-576.4 feet

- **Goethite**, as less abundant grungy isolated grains.
- **Pyrite**, as fractured fine to medium grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.02 wt% (pct)	0%	45%	None on file

The mineralogy, microtextures, and mineral paragensis indicate a hypogene zone, which supports the Copper Basin Geologic classification as *Hypogene.*

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this stay): *Hypogene*

7.1.2 Drill Hole PCB-04455

Drill hole **PCB-04455** is located on the east-west cross section (refer to figure 50), drilled as an RC hole to a depth of 495 feet. The phreatic zone was identified at a depth of 490 feet. A total of six composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04455 150-155 feet

Petrographic Observations

- **Covellite** as a μ-scale patina coating and replacing pyrite.
- **Goethite** as abundant well-polished grains associated with silica mineral phases.
- **Hematite** is less abundant than goethite and comprises as grains associated with silica mineral phases.

- **Pyrite** replaced incipiently by covellite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
>1 wt% (pct)	23%	59%	59%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified chalcocite coating pyrite in clay-bearing intervals that plates copper easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04455 155-160 feet

Petrographic Observations

- **Chalcocite**, as μ-scale patinas coating and replacing pyrite, representing typical supergene textures.

- **Goethite**, as abundant well-polished grains coating silica.
- **Hematite**, less abundant than goethite, as grains coating darker silicate phases, and locally rimming and replacing chalcocite.
- **Pyrite**, as abundant fine to medium-grains that are being replaced by chalcocite.

<u>Analytical Assay Data</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.62 wt% (pct)	46%	93%	59%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified chalcocite coating pyrite in clay-bearing intervals that plates copper easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Strong Enrichment

PCB-04455 315-330 feet

Petrographic Observations

- **Chalcocite**, as coating and replacing pyrite, illustrating typical supergene textures.
- **Goethite**, as abundant grungy grains rimming darker silicate phases, pyrite, and chalcocite.
- **hematite** less abundant than goethite, found rimming silicates, pyrite, and chalcocite.
- **pyrite**, as dominant grains that are replaced by chalcocite.
- **covellite**, as trace isolated grains
- **enargite**, as trace intergrowths with chalcocite grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.37 wt% (pct)	24.6%	78.7%	44.7%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as enriched.

Field observations made by the Copper Basin geological team identified clay-bearing grains that were coating the RC chips and “black rounded chunks” (possibly chalcocite) from 315-320 feet. They also noted that the interval from 315-310 feet plates copper easily, but slower than the rest of the interval, which lacked clay.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Strong Enrichment

PCB-04455 330-335 feet

Petrographic Observations

- **Chalcocite**, is found in larger grains alone and associated as coatings on pyrite, illustrating typical supergene textures.
- **Pyrite**, as grains that are replaced by chalcocite.
- **Pyrrhotite**, as isolated grains.
- **Goethite**, less than trace isolated grains.
- **Chalcopyrite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid	Cyanide	QLT

	Solubility	Solubility	
0.21 wt% (pct)	40%	97%	50%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as an *Enriched* zone.

Field observations noted by the Copper Basin geologic team identified chalcocite coating pyrite as small clots within the matrix of the RC chips which plates copper easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Strong Enrichment*

PCB-04455 335-370 feet

<u>Petrographic Observations</u>

- **chalcocite**, as coating and replacing illustrating typical supergene texture.
- **pyrite**, as grains that are replaced by chalcocite.
- **covellite**, as trace isolated grains.
- **enargite**, as trace intergrowths with chalcocite grains.

- **goethite**, as trace isolated grungy grains.
- **pyrrhotite**, as trace isolated grains.

<u>**Analytical Assay Data**</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.23 wt% (pct)	26.4%	89%	45%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enrichment.* This sample interval contains less than five percent of iron oxides and by the Phoenix copper mill standard would be classified as “true enrichment”.

Field observations noted by the Copper Basin geologic team identified chalcocite coating pyrite that plates copper easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04455 370-395 feet

- **Pyrite**, as fractured fine to medium grains.
- **Trace goethite**, as grungy isolated grains.

<u>Analytical Assay Data</u>

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.03 wt.% (pct)	0%	58.8%	20%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene zone, which does not support the Copper Basin geologic ore classification, as an *Enriched* zone.

The field observations noted by the Copper Basin geologic team identified chalcocite coating pyrite grains within the RC chips, which plates copper easily when saturated with acid. Given that no chalcocite was identified in the heavy fractions it is assumed that the mineral previously identified as chalcocite is Cu++ adsorbed on the goethite grains. Biotite hornfels alteration was identified mixed within the sample interval of which does not plate copper easily when saturated with copper.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

7.1.3 Drill Hole PCB-04456

Drill hole **PCB-04456** is located on the south-north cross section (refer to figure 49) drilled as an RC hole to a depth of 525 feet. The phreatic zone was identified at a depth of 520 feet. A total of six composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04456 395-410 feet

Petrographic Observations

- **Chalcocite**, as coating and replacing pyrite and isolated grains, illustrating typical supergene textures.
- **Goethite**, as isolated grains and replacing pyrite.
- **Pyrite**, as grains being replaced by chalcocite and goethtie.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.2 wt% (pct)	22%	60%	42.8%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified chalcocite rimming pyrite in chips and plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Strong Enrichment*

PCB-04456 410-420 feet

Petrographic Observations

- **Goethite**, as intergrowths with hematite and as a patina rimming and replacing pyrite.
- **Hematite**, as intergrowths with goethite and as a patina rimming and replacing pyrite.
- **Pyrite**, as fractured isolated grains replaced Fe-oxides.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.03 wt% (pct)	0%	38%	40%

The mineralogy, microtextures, and mineral paragensis indicate a leach capping zone, which supports the Copper Basin geologic ore classification as *Leached Cap.*

Copper Basin Ore Classification: *Leach Cap*

Geochemical Ore Classification (from this study):

Leached Capping

PCB-04456 420-450 feet

Petrographic Observations

- **Chalcocite**, as μ-scale coating and replacing pyrite grains, illustrating typical supergene textures.
- **Covellite**, as isolated grains replacing chalcopyrite grains.
- **Goethite**, as abundant well-polished grains being replaced by hematite.
- **Hematite**, as trace grains rimming well-polished goethite indicating potential replacement.
- **Pyrite**, as fractured grains being replaced by chalcocite and Fe-oxides.
- **Chalcopyrite**, as trace grains being replaced by covellite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT

0.32 wt% (pct)	22%	69.3%	51.5%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basing geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified chalcocite coating pyrite and plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

PCB-04456 450-465 feet

Petrographic Observations

- **Chalcocite**, as a µ-scale coating and replacing pyrite grains, illustrating typical supergene textures.
- **Covellite**, as inclusions within pyrite.
- **Goethite**, as well-polished isolated grains and present as replacing pyrite.
- **Pyrite**, as fractured grains being replaced by chalcocite.

- **Chalcopyrite**, as trace amounts of inclusions within pyrite grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.6 wt% (pct)	24.7%	value on file potential typo	52.8%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified chalcocite coating pyrite, which plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04456 465-475 feet

Petrographic Observations

- **Chalcocite**, as a µ-scale coating and replacing fractured pyrite grains, illustrating typical supergene textures.
- **Goethite**, as intergrowths of hematite grains.

- **Hematite**, as intergrowths of goethite grains.
- **Pyrite**, as fractured grains being replaced by chalcocite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
1 wt%	13%	92%	52.6%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.*

Field observations noted by the Copper Basin geologic team identified that this zone plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Strong Enrichment*

PCB-04456 475-500 feet

Petrographic Observations

- **Chalcocite**, as trace isolated grains.
- **Covellite**, as trace isolated grains.
- **Goethite**, as well-polished grains as intergrowths of trace amounts of hematite.
- **Hematite**, as trace amounts as intergrowths with goethite grains.
- **Pyrite**, as isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.37 wt% (pct)	19%	Value on file potential typo	49.4%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which support the Copper Basin geologic ore classification, as *Enriched.*

Field observation noted by the Copper Basin geologic team identified that this zone plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

7.1.4 Drill Hole PCB-04465

Petrographic Observations

Drill hole **PCB-04465** is located on the south-north cross section (refer to figure 49), drilled as an RC hole to a depth of 400 feet and as core from 400 to 492 feet. The phreatic zone was identified at a depth of 400 feet. A total of three composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04465 220-245 feet

Petrographic Observations

- **Covellite**, as µ-scale patinas coating and replacing chalcopyrite.
- **Chalcopyrite**, as fine grains being replaced by covellite and medium grains present as isolated grains.
- **Pyrite**, as fractured fine to medium grains that are being replaced by covellite, present as the most dominant mineral phase.
- **Chalcocite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.4 wt% (pct)	42.3%	97.2%	45.1%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched*.

Field observations noted by the Copper Basin geologic team identified a fault zone from 240 to 245 feet and sooty chalcocite to be associated with pyrite and iron oxides; however no iron oxides were present in petrographic analyses.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Weak Enrichment*

PCB-04465 310-320′

<u>Petrographic Observations</u>

- **Chalcocite**, as coating and replacing pyrite, illustrating typical supergene textures.
- **Covellite**, as isolated grains.
- **Goethite**, as well polished medium grains dominantly the sample.
- **Hematite**, in trace amounts associated with goethite.
- **Pyrite**, as abundant fine to medium grains being replaced by chalcocite.
- **Chalcopyrite**, as trace grains being replaced by a covellite grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.09 wt% (pct)	24%	85.5%	28.6%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification, as a *Hypogene* zone.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04465 375-400'

Petrographic Observations

- **Chalcopyrite**, as fine to medium grains associated with pyrite illustrating hypogene textures.
- **Pyrite**, as fine to medium grains associated with chalcopyrite, as the dominant mineral phase.

Analytical Assay Data

Total Copper	**Acid**	**Cyanide**	**QLT**

	Solubility	Solubility	
0.22 wt% (pct)	4.2%	19.2%	1.8%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene zone, which supports the Copper Basin geological ore classification as a *Hypogene* zone.

Field observations noted by the Copper Basin geologic team identified RC chips illustrating synthetic chip oxidation and were magnetic, which suggests that there was originally abundant pyrrhotite that has oxidized since the samples were collected.

Copper Basin Ore Classification: *Hypogene*
Geochemical Ore Classification (from this study): *Hypogene*

7.1.5 Drill Hole PCB-04481

Drill hole **PCB-04481** is located on the south-north cross section (refer to figure 49), drilled as an RC hole to a depth of 505 feet. A total of seven composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04481 205-220 feet

Petrographic Observations

- **Covellite**, as fine grains replacing pyrite.
- **Chalcopyrite**, as relic isolated grains.
- **Goethite**, as abundant fine to medium grains filling in within between fractured pyrite. Also illustrating a banding texture and is very well polished.
- **Hematite**, as rimming goethite.
- **Pyrite**, as medium grains as isolated grains and being replaced by covellite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.31 wt% (pct)	26%	2%	20.8

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geological ore classification as an *Enriched* zone.

Field observations noted by the Copper Basin geologic team identified copper plating when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04481 220-230 feet

Petrographic Observations

- **Covellite**, as coating and replacing chalcopyrite.
- **Goethite**, is present as intergrowths with goethite.
- **Hematite**, is present as intergrowth with goethite.
- **Pyrite**, as fractured grains being replaced by Fe-oxides.
- **Chalcopyrite**, as trace amounts that are being replaced by covellite.
- **Jarosite**, as trace amounts associated with goethite and hematite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.19 wt% (pct)	value on file potential typo	1%	16.7%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone from 220-225 feet. They also noted that the unoxidized regions plates copper very well when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Weak Enrichment*

PCB-04481 230-255 feet

Petrographic Observations

- **Covellite**, as trace grains replacing chalcopyrite.
- **Goethite**, as abundant well-polished banded grains with hematite intergrowths and replacing pyrite grains.
- **Hematite**, as abundant intergrowths with goethite.
- **Pyrite**, replaced incipiently by covellite which is being replaced by goethite.
- **chalcopyrite**, as trace amount of grains being replaced by covellite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.04 wt% (pct)	0%	2%	30.6%

The mineralogy, microtextures, and mineral paragensis indicate an enrichment zone, which does not support the Copper Basin geological ore classification as *Leached Cap.*

Field observation noted by the Copper Basin geological team identified trace amounts of chalcocite, which plates copper weakly.

Copper Basin Ore Classification: *Leached Cap*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04481 255-270 feet

Petrographic Observations

- **Covellite**, as isolated grains.
- **Pyrite**, as fractured isolated grains, as the dominant mineral phase.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.18 wt% (pct)	62.7%	1.3%	45.4%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified chalcocite rimming pyrite and halloysite, and weakly plating copper when saturated with acid; however no chalcocite was identified in the petrographic study. This study assumes the sooty chalcocite really was covellite.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04481 270-305 feet

<u>Petrographic Observations</u>

- **Covellite**, as isolated grains filling in voids of fractured grains, illustrating typical supergene textures.
- **Pyrite**, as fractured isolated grains being replaced by covellite, as the dominant mineral phase.
- **Chalcopyrite**, trace grains associated with fractured pyrite grains.

<u>Analytical Assay Data</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.51 wt% (pct)	30%	1.7%	44.2%

The mineralogy, microtextures, and mineral paragensis indicate an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.* This sample interval contains less than five percent of iron oxides and by the Phoenix copper mill standard would be classified as “true enrichment”.

Field observations noted by the Copper Basin geologic team identified copper plating when saturated with acid.

Copper Basin Ore Classification*: Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04481 305-330 feet

Petrographic Observations

- **Covellite**, as isolated grains filling in voids of fractured grains, illustrating typical supergene textures.
- **Pyrite**, as fractured isolated grains being replaced by covellite.

- **Chalcocite**, as trace isolated grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.37 wt% (pct)	21.8%	1%	36.9%

The mineralogy, microtextures, and mineral paragensis indicate an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.* This sample interval contains less than five percent of iron oxides and by the Phoenix copper mill standard would be classified as “true enrichment”.

Field observation noted by the Copper Basin geologic team identified white sandstone in gooey white clay gouge brassy pyrite with chalcocite which plates copper well when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

7.1.6 Drill Hole PCB-04482

Drill hole **PCB-04482** is located on the both the south-north and the East-West cross section (refer to figure 49), drilled as an RC hole from 0-500 feet and then as a core 500-750 feet. A total of seven composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04482 410-430 feet

Petrographic Observations

- **Chalcocite**, as isolated grains.
- **Covellite**, as isolated grains.
- **Goethite**, as abundant grains intergrowths with hematite.
- **Hematite**, as abundant grains intergrowths with goethtie.
- **Pyrite**, as dominant fractured grains being rimmed and replaced by Fe-oxides.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.37 wt% (pct)	18%	94%	48.2%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone from 415 to 420 feet. From 410 to 415 feet they identified chalcocite plating copper well when saturated with acid and is associated with a white clay. From 415 to 430 feet they noted chalcocite present in the matrix of the sandstone and plates copper very well when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04482 430-450 feet

<u>Petrographic Observations</u>

- **Chalcocite**, as isolated grains being replaced by hematite and replacing pyrite grains.
- **Covellite**, as isolated grains being replaced by hematite and replacing pyrite grains.
- **Goethite**, as abundant grains intergrowths with hematite.
- **Hematite**, as abundant grains intergrowths with goethite and rimming chalcocite.

- **Pyrite**, as fractured grains being replaced by covellite and chalcocite, as the dominant mineral phase.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.56 wt% (pct)	31.8%	93.3%	48.9%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone between 435-445 feet and it plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

PCB-04482 598.4-615.6 feet

Petrographic Observations

- **Chalcocite**, as isolated grains being replaced by hematite and replacing pyrite grains.
- **Hematite**, as abundant grains intergrowths with goethite.
- **Goethite**, as abundant grains intergrowths with hematite.
- **Pyrite**, as fractured grains being Fe-oxides.
- **Covellite**, as trace isolated grains.
- **Chalcopyrite**, as trace isolated grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.19 wt% (pct)	43.5%	34.8%	None

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified a fault from 598.4 to 603 feet with neotisite on the joints and along vein margins with associated with iron oxides and black CuOx, which plates copper when saturated with acid. They also noted a fault zone from 603 to 606.6 feet, which contains iron oxide and chalcocite, which also plates copper easily, when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04482 615.6-639.8 feet

Petrographic Observations

- **Chalcocite**, as μ-scale coating and replacing pyrite grains.
- **Hematite**, as abundant well polished grains intergrowths with goethite and coating pyrite.
- **Goethite**, as abundant grains intergrowths with hematite and coating pyrite.
- **Pyrite**, as fractured grains being replaced chalcocite and Fe-oxides.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.15 wt% (pct)	38%	22.3%	None

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification, as a *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified a fault zone between 615.6 to 620.9 feet and from 635 to 639.8 feet. They also noted halloysite on joints and iron oxides plating copper when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Strong Enrichment*

PCB-04482 639.8-654.6′

Petrographic Observations

- **Chalcocite**, as μ-scale patina coating and replacing pyrite grains being replaced by goethite.
- **Goethite**, is rimming and replacing chalcocite, illustrating typical supergene textures and is well polished.
- **Pyrite**, as fractured grains being replaced by chalcocite and goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.22 wt% (pct)	33.7%	84.3%	None

The mineralogy, microtextures, and mineral paragensis indicated that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as an *Enriched* zone.

Field observations noted by the Copper Basin geologic team identified halloysite on joints with a brighter green clay and chalcocite abundant at 649 feet that plates copper when saturated with acid. Iron oxides are present on both sides of the contact and they identified chalcocite abundance to increase as approaching the contact.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Strong Enrichment

PCB-04482 654.6-666.2 feet

<u>Petrographic Observations</u>

- **Chalcocite**, as μ-scale patina coating and replacing pyrite grain being replaced by goethite, illustrating typical supergene texture.

- **Goethite**, is rimming and replacing chalcocite.
- **Pyrite**, as fractured grains being replaced by chalcocite and goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.27 wt% (pct)	44.5%	43.5%	None

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification, as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified a fault zone with clay and sericite alteration at 660.7 feet associated with chrysocolla on joints and fractures containing chalcocite.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Strong Enrichment*

PCB-04482 666.2-691.1 feet

Petrographic Observations

- **Chalcocite**, as μ-scale patina coating and replacing pyrite grains, illustrating typical supergene textures.
- **Pyrite**, as fractured grains being replaced by chalcocite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.31 wt% (pct)	29.4%	90.4%	None

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.*

Field observation noted by the Copper Basin geologic team identified Mo along edges of veins and chalcocite present in the matrix and on joints. They also identified halloysite along joints at 691 feet.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Strong Enrichment

7.1.7 Drill Hole PCB-04488

Drill hole **PCB-04488** is located on the south-north cross section (refer to figure 49), drilled as an RC hole to a depth of 580 feet. The phreatic zone was identified at a 520 feet. A total of six composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04488 270-280 feet

- **Chalcocite**, as µ-scale patinas coating replacing pyrite representing typical supergene texture.
- **Covellite**, as isolated grains.
- **Goethite**, as grungy fine grains replacing pyrite.
- **Pyrite**, as fine to medium grains being rimmed and replaced by chalcocite and covellite.
- **Pyrrhotite**, as inclusions within the pyrite grains.
- **Hematite**, as trace intergrowths with goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.59 wt% (pct)	34%	96%	51.9%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.* They also noted that copper plates when saturated with acid.

Field observations noted by the Copper Basin geologic team identified a fault zone associated with an argillic alteration type with clay and sericite as the main alteration minerals identified.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04488 280-290'

Petrographic Observations

- **Chalcocite**, as µ-scale patinas coating and replacing pyrite, illustrating typical supergene texture.
- **Covellite**, as coating and replacing pyrite illustrating typical supergene texture.
- **Pyrite**, as dominant fine to medium grains being replaced by covellite and chalcopyrite.
- **Chalcopyrite**, as trace inclusions in pyrite.
- **Goethite**, as trace grains rimming chalcocite.

Analytical Assay Data

Total Copper	Acid	Cyanide	QLT

	Solubility	**Solubility**	
0.62 wt% (pct)	39%	90%	54.5%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified chalcocite and pyrite disseminated throughout the sample interval and plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

PCB-04488 290-435'

Petrographic Observations

- **Chalcocite**, as coating and replacing pyrite, and chalcopyrite, illustrating typical supergene textures.
- **Covellite**, as coating and replacing chalcopyrite, illustrating typical supergene textures.

- **Pyrite**, as fine to medium grains being replaced by chalcocite.
- **Chalcopyrite**, as trace fine to medium grains being replaced by covellite and chalcocite.
- **Goethite**, as trace isolated grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.53 wt% (pct)	24%	91%	52.7%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as an *Enriched.* This sample interval contains less than five percent of iron oxides and by the Phoenix copper mill standard would be classified as “true enrichment”.

Field observations noted by the Copper Basin geologic team identified minor faults throughout the entire sample interval. They also noted that copper plates when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04488 435-500 feet

<u>Petrographic Observations</u>

- **Chalcocite**, as coating and replacing pyrite, illustrating typical supergene textures.
- **Chalcopyrite**, as a fine grains being replaced chalcocite.
- **Pyrite**, as fine to medium grains being replaced by chalcocite, as the dominant mineral phase.
- **Rutile**, as isolated grains.
- **Pyrrhotite**, as isolated grains.

<u>Analytical Assay Data</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.09 wt% (pct)	24%	87%	50%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.* This sample interval contains less than five percent of iron oxides and by the Phoenix copper mill standard would be classified as “true enrichment”.

Field observations noted by the Copper Basin geologic team identified copper plating when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

PCB-04488 500-505 feet

Petrographic Observation

- **Covellite**, as a coating and replacing pyrite, illustrating typical supergene texture.
- **Chalcopyrite**, as fine grains as inclusions in pyrite.
- **Goethite**, as trace isolated grains.
- **Pyrite**, as the dominant mineral phase being replaced by covellite and associated with chalcopyrite grains.
- **Rutile**, as isolated grains.
- **Pyrrhotite**, as isolated grains associated with pyrite.

Analytical Assay Data

Total Copper	**Acid**	**Cyanide**	**QLT**

	Solubility	Solubility	
0.09 wt% (pct)	30%	76%	33.3%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification, as a *Hypogene* zone. This sample interval contains less than five percent of iron oxides and by the Phoenix copper mill standard would be classified as “true enrichment”.

Field observations noted by the Copper Basin geologic team identified this zone to plates copper when saturated with acid.

The light material from the heavy liquid separation was analyzed using standard XRD practices and no copper sulfides were identified above the detection. The main mineral phases identified were; quartz, orthoclase, muscovite, and illite (Refer to table 8).

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04488 505-525 feet

Petrographic Observations

* **Pyrite**, as dominant fractured grains.
* **Rutile**, as isolated grains.
* **Chalcopyrite**, as trace isolated grains.
* **Hematite**, as trace isolated grains.
* **Goethite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.02 wt%	0%	15%	41.7%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene, which supports the Copper Basin geologic ore classification, as *Hypogene* zone.

Field observation noted by the Copper Basin geologic team identified a zone does not plate copper when saturated with acid.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Hypogene

7.1.8 Drill Hole PCB-04499

Drill hole **PCB-04499** is located on the south-north cross section (refer to figure 49), drilled as an RC hole to a total of 565 feet. A total of six composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04499 195-205 feet

- **Covellite**, as grains replacing pyrite, illustrating typical supergene texture.
- **Goethite**, as isolated grains.
- **Hematite**, as fine grains rimming and intergrowths within goethite.
- **Pyrite**, as abundant fine to medium grains being replaced by chalcocite.
- **Chalcopyrite**, as trace isolated grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.25 wt% (pct)	2.5%	81.5%	34,7%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone with moderate sericite and boxwork textures towards the lower portions of the interval.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04499 205-215 feet

<u>Petrographic Observations</u>

- **Goethite**, abundant well polished grains illustrating banded colloform textures.
- **Hematite**, as intergrowths with goethite.
- **Trace pyrite**, as isolated grains.

<u>Analytical Assay Data</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.03 wt% (pct)	0%	53.5%	44.4%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a leached capping zone, which does not support the Copper Basin geologic ore classification, as a *Partially Leach.*

Field observations noted by the Copper Basin geologic team identified copper plating when saturated with acid, and it is assumed that the copper is adsorbed on the goethite grains.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

Partially Leached

PCB-04499 215-230 feet

Petrographic Observations

- **Goethite**, as abundant well polished grains.
- **Hematite**, as intergrowths with goethite.
- **Pyrite**, as abundant fractured grains that are being replaced by Fe-oxides.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.13 wt% (pct)	18%	81.3%	44.4%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partial leach zone, which supports the Copper Basin geologic ore classification as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified a fault zone between 215 to 225 feet, less iron oxides associated with clay minerals, and copper plates when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

Partially Leach

PCB-04499 230-250 feet

Petrographic Observations

- **Chalcocite**, is present as replacing chalcopyrite.
- **Covellite**, as very fine isolated grains.
- **Goethite**, is abundant and associated with silica grains.
- **Pyrite**, as the dominant mineral phases associated with pyrrhotite.
- **Pyrrhotite**, as isolated grains.
- **Chalcopyrite**, as trace amounts being replaced by chalcocite.
- **Hematite**, as trace intergrowths.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.62 wt% (pct)	39%	90%	54.5%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone from 240 to 250 feet and classified clay and biotite as the main alteration minerals. They also noted copper plating when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04499 250-260 feet

Petrographic Observations

- **Chalcopyrite**, as inclusions within pyrite grains as isolated grains.
- **Pyrite**, as abundant grains.
- **Pyrrhotite**, as inclusions within pyrite grains.
- **Chalcocite**, as trace isolated grains.
- **Goethite**, as trace isolated grains.
- **Covellite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.85 wt%	11%	53%	22.2%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Field observation noted by the Copper Basin geologic team identified copper plating when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04499 435-475 feet

Petrographic Observations

- **Chalcopyrite**, as inclusions.
- **Pyrite**, as abundant fractured grains.
- **Rutile**, as trace isolated grains.
- **Goethite**, as trace well-polished grains.
- **Pyrrhotite**, as inclusions within pyrite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.02 wt% (pct)	0	11.8%	11.1%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene zone, which supports the Copper Basin geologic ore classification as *Hypogene.*

Field observations noted by the Copper Basin geologic team indicated biotite hornfels and chlorite as the dominant alteration type throughout this sample interval.

Copper Basin Ore Classification: *Hypogene*
Geochemical Ore Classification (from this study): *Hypogene*

7.1.9 Drill Hole PCB-04604D

Drill hole **PCB-04604D** is located on the south-north cross section (refer to figure 49), drilled as an RC hold to a depth of 400 feet. The phreatic zone was first identified at 380 feet. A total of nine composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04604D 140-145 feet

Petrographic Observations

- **Pyrite**, as abundant fractured grains with pyrrothotite and chalcopyrite as inclusions.
- **Pyrrhotite**, as trace inclusions in pyrite associated with chalcopyrite.
- **Goethite**, as isolated grains with intergrowths of well polished bands.
- **Chalcopyrite**, as trace inclusions in pyrite associated with pyrrhotite.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.18 wt% (pct)	16.7%	32.7%	24.9%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partially leached zone, which supports the Copper Basin geologic ore classification as *Partially Leached.*

Field observations made by the Copper Basin geologic team identified copper plating when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

PCB-04604D 145-160 feet

Petrographic Observations

- **Chalcocite**, as μ-scale patina coating and replacing pyrite grains, illustrating supergene textures.
- **Covellite**, as coating and replacing pyrite and chalcopyrite grains, illustrating supergene textures.
- **Chalcopyrite**, is found as an inclusion and being replaced by covellite.
- **Goethite**, abundant grains with trace amounts of hematite intergrowths.
- **Pyrite**, fractured grains that are being replaced by chalcocite and covellite.
- **Pyrrhotite**, as inclusions within pyrite.
- **Hematite**, as trace intergrowths within goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.57 wt% (pct)	26.7%	80.3%	51%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

an enrichment zone, which supports the Copper Basin geologic or classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone from 145 to 155 feet, which plates copper easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04604D 165-170 feet

Petrographic Observations

- **Goethite**, abundant grains with intergrowth of trace hematite.
- **Rutile**, as isolated grains.
- **Hematite**, as trace intergrowths with goethite.
- **Covellite**, as trace isolated grains.
- **Pyrite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.19 wt%	45%	17%	50%

(pct)			

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Field observation noted by the Copper Basin geologic team identified copper plating when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04604D 235-240 feet

Petrographic Observations

- **Chalcocite**, as μ-scale coating and replacing pyrite grains, illustrating supergene textures.
- **Covellite**, as flaky intergrowths within chalcocite.
- **Goethite**, abundant grains with trace amounts of hematite intergrowths.
- **Pyrite**, fractured grains that are being replaced by chalcocite and covellite.
- **Chalcopyrite**, as inclusions within pyrite.
- **Hematite**, as trace intergrowths within the goethite.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.38 wt% (pct)	25%	Value on file potential typo	50%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partially leached zone, which supports the Copper Basin geologic ore classification, as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified a fault zone, which plates copper easily when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04604D 240-250 feet

Petrographic Observations

- **Pyrite**, as fractured and is being replaced by covellite and found as isolated grains.

- **Chalcocite**, as thin wormy grains replacing pyrite grains, illustrating typical supergene textures.
- **Chalcopyrite**, as inclusions within pyrite that is also replacing pyrite.
- **Covellite**, as µ-scale coating and replacing pyrite grains, illustrating supergene texture.
- **Pyrrhotite**, as inclusions within pyrite grains.
- **Goethite**, as trace grains as isolated grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.1 wt% (pct)	25%	60.5%	37.5%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geological ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone, which plates copper easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

PCB-04604D 255-270 feet

Petrographic Observations

- **Pyrite**, fractured grains with inclusions of pyrrothite and chalcopyrite.
- **Pyrrothite**, as inclusions within pyrite and associated with chalcopyrite.
- **Chalcopyrite**, as inclusions within pyrite and associated with pyrrothite.
- **Covellite**, as fine-isolated grains.
- **chalcocite-covellite mixed mineral phase**, as coating and replacing pyrite.
- **goethite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.17 wt% (pct)	27	76.7%	28.8%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observation noted by the Copper Basin geologic team identified this interval to plate copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Weak Enrichment*

PCB-04604D 270-285 feet

Petrographic Observations

- **Chalcopyrite**, as fractured grains being replaced by covellite and goethite.
- **Covellite**, as fine-grains replacing chalcopyrite.
- **Goethite**, as grains replacing covellite.
- **Pyrrhotite**, as inclusion within pyrite grains.
- **Pyrite**, fractured grains with inclusions of pyrrhotite and chalcopyrite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.16 wt% (pct)	6.35	31%	20%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observation noted by the Copper Basin geologic team identified this interval plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Weak Enrichment*

PCB-04604D 360-375 feet

<u>Petrographic Observations</u>

- **Chalcopyrite**, as isolated fractured grains.
- **Pyrite**, as abundant isolated fractured grains.
- **Covellite**, as trace amounts of very fine grains.

<u>Analytical Assay Data</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.38 wt% (pct)	25%	Value on file potential typo	50%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative as a hypogene zone, which supports the Copper Basin geologic ore classification as *Hypogene.*

The light material from the heavy liquid separation was analyzed using standard XRD practices and trace amounts of covellite were identified. The main mineral phases identified were silicon oxides, orthoclase, muscovite, and pyrite (see Table 8).

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study): *Hypogene*

PCB-04604D 375-400 feet

Petrographic Observations

- **Chalcopyrite**, as coatings and replacing pyrite.
- **Pyrite**, as fractured grains and is being replaced by chalcopyrite.
- **Pyrrhotite**, as abundant isolated grains.
- **Covellite**, as trace amounts of isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.17 wt% (pct)	2%	9%	0%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene, which supports the Copper Basin geologic ore classification as *Hypogene* zone.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Hypogene

7.1.10 Drill Hole PCB-04609

Drill hole **PCB-04609** is located on the south-north cross section (refer to figure 49) drilled as an RC hole to a depth of 545 feet. A total of six composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04609 80-90 feet

Petrographic Observations

- **Goethite**, as abundant well polished grains with color variations.
- **Rutile**, as trace isolated grains.
- **Hematite**, as trace abundant intergrowths with goethite.
- **Pyrite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.29 wt% (pct)	50.3%	12.7%	57.1%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partially leach zone, which supports the Copper Basin geologic ore classification as *Partial Leach.*

Field observation noted by the Copper Basin geologic team identified this interval plates copper when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Partially Leach*

PCB-04609 100-115 feet

<u>Petrographic Observation</u>

- **Goethite**, as abundant well polished grains with trace hematite as intergrowths and rimming the grains.
- **Hematite**, as trace intergrowths with rimming goethite.

<u>Analytical Assay Data</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.23 wt% (pct)	4%	2.3%	5.3%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partially leached zone, which supports the Copper Basin geologic ore classification, as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified a fault zone from 105 to 115 feet.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Partially Leach*

PCB-04609 220-230 feet

- **Goethite**, as abundant well-polished grains with trace hematite grains as intergrowths and rimming the grains.
- **Hematite**, as trace intergrowths with and rimming goethite.

<u>Analytical Assay Data</u>

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.03 wt% (pct)	0%	5%	0%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a leach-capping zone, which supports the Copper Basin geologic ore classification as *Leached Cap.*

Copper Basin Ore Classification: *Leached Cap*

Geochemical Ore Classification (from this study):

Leach Capping

PCB-04609 275-290 feet

Petrographic Observations

- **Chalcocite**, as grains filling in fractures of pyrite, illustrating typical supergene textures.
- **Covellite**, as grains filling in around fractures in pyrite grains and as isolated grains, illustrating typical supergene textures.
- **Pyrite**, as fractured grains being replaced by chalcocite and covellite.
- **Goethite**, as abundant well polished banded grains with trace amounts hematite.
- **Hematite**, as trace amounts rimming goethite.
- **Rutile**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT

0.56 wt% (pct)	20%	65%	47.7%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of enrichment zone, which supports the Copper Basin ore classification as *Enriched.*

Field observation noted by the Copper Basin geologic team identified this interval plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04609 365-375 feet

Petrographic Observations

- **Chalcopyrite**, as coatings and replacing pyrite.
- **Pyrite**, as fractured grains being replaced by chalcocite and covellite.
- **Pyrrhotite**, as abundant isolated grains.
- **Goethite**, as abundant well-polished banded grains with trace amounts hematite.
- **Hematite**, as trace amounts associated with goethite.
- **Covellite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.23 wt%	10.5%	36%	33.3%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative as an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone from 370 to 375 feet.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04609 385-395 feet

Petrographic Observtion

- **chalcopyrite**, as inclusions within pyrite grains and is replacing pyrite.
- **Pyrite**, as fractured grains and is being replaced by chalcopyrite.

- **Pyrrhotite**, as isolated grains.
- **Goethite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.03 wt%	0%	30%	0%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an hypogene zone, which supports the Copper Basin geologic ore classification, as a *Hypogene.*

The light material from the heavy liquid separation was analyzed using standard XRD practices and trace amounts of copper sulfides were identified above the detection. The main mineral phases identified were quartz, orthoclase, muscovite, pyrite, and covellite (Refer to table 8).

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study): *Hypogene*

7.1.11 Drill Hole PCB-04618

Drill hole **PCB-04618** is located on the south-north cross section (refer to figure 49) drilled as an RC hole to a depth of 758.7 feet. A total of six composite pulp samples were collected and the heavy mineral separates were the medium analyzed.

PCB-04618 84.1-88.4 feet

Petrographic Observations

- **Goethite**, as well-polished banded grains.
- **Pyrite**, as trace isolated grains.
- **Covellite**, as isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.21 wt% (pct)	18%	33%	32.1%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified silification, clay, white phyllosilicate, chlorite, and epidote as the main alteration minerals. They also noted that copper plating easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04618 88.4-91.4 feet

Petrographic Observations

- **Covellite**, as isolated grains and being replaced by Fe-oxides.
- **Goethite**, as abundant intergrowths with goethite and filling in fractures of pyrite grains.
- **Pyrite**, as abundant fractured grains being replaced.
- **Pyrrhotite**, as inclusions within pyrite.
- **Hematite**, as intergrowths with goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.26 wt% (pct)	40%	99%	32.1%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.*

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

PCB-04618 91.4-96.3 feet

Petrographic Observations

- **Chalcocite**, as a μ-scale coating and replacing pyrite.
- **Chalcopyrite**, as inclusions with pyrite associated pyrrhotite grains.
- **Covellite**, as isolated grains.
- **Pyrite**, as fractured grains being replaced by chalcocite and chalcopyrite.
- **Pyrrhotite**, as inclusions within pyrite associated chalcopyrite grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.2 wt% (pct)	18%	91%	32.1%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified silification, clay, white phyllosilicate, chlorite, and epidote as the main alteration minerals. They also identified a minor fault in the middle of sample interval.

Field observations noted by the Copper Basin geologic team identified that copper plates easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

PCB-04618 142-153 feet

Petrographic Observations

- **Goethite**, as abundant well-polished grains.
- **Pyrite**, as trace fractured grains.
- **Hematite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.04 wt% (pct)	0%	20%	28.6%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a leached capping zone, which does not support the Copper Basin geologic ore classification as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified that copper plates easily when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Leached Capping*

PCB-04618 474.4-516.6′

- **Chalcocite**, is coating and replacing fractured pyrite grains.
- **Pyrite**, as trace fractured grains being replaced by chalcocite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.06 wt% (pct)	22%	92%	56.9%

The presence of copper sulfides, copper solubilities of 22% acid solubility, 92% cyanide solubility, and 56.9 QLT, indicates a strongly-developed enrichment zone, which supports the Copper Basin geologic classification.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Strong Enrichment

PCB-04618 516-523.6 feet

Petrographic Observations

- **Pyrite**, as abundant fractured grains.
- **Chalcocite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
1.43 wt% (pct)	16%	82%	56%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Copper Basin Ore Classification: Hypogene

Geochemical Ore Classification (from this study):

Strongly Enrichment

PCB-04618 523-664 feet

Petrographic Observations

- **Chalcocite**, as coating and replacing pyrite grains, illustrating typical supergene textures.
- **Chalcopyrite**, as an inclusion within a pyrite grians.
- **Covellite**, as μ-scale patina coating and replacing pyrite grains, illustrating typical supergene textures.
- **Pyrite**, as fractured grains being replaced by chalcocite and covellite.
- **Pyrrhotite**, as an inclusion within a pyrite grain.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.56 wt% (pct)	21%	91%	55.2%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geological ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified a fault zone from 531 to 546 feet.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

7.1.12 Drill Hole PCB-04691

Drill hole **PCB-04691** is located on the north-south cross section (refer to figure) drilled as an RC hole to a depth of 400 feet. The phreatic zone was first identified at 305 feet. A total of eleven composite pulp samples were collected and the heavy mineral separates were the medium analyzed.

PCB-04691 150-160 feet

Petrographic Observations

- **Goethite**, as well polished grains illustrating banding.
- **Hematite**, as trace amounts intergrowths with goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.19 wt% (pct)	25.5%	8.5%	29.9

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

a partially leached zone, which supports the Copper Basin geologic ore classification, as *Partially Leach.*

Field observations noted by the Copper Basin geologic team identified that copper plates easily when saturated with acid.

The light material from the heavy liquid separation was analyzed using standard XRD practices and no copper sulfides were identified above the detection. The main mineral phases identified were quartz and muscovite (Refer to table 8).

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Partially Leached*

PCB-04691 160-165 feet

<u>Petrographic Observations</u>

- **Goethite**, as well polished grains illustrating banding.
- **Hematite**, as trace amounts intergrowths with goethite.
- **Pyrite**, as isolated grains.

<u>Analytical Assay Data</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.21 wt% (pct)	46%	11%	27.8%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partially leached, which supports the Copper Basin geologic ore classification as *Partial Leach.* No copper sulfides were identified through the petrographic analyses; however it is assumed that the copper is adsorbed to the goethite grains.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Partially Leached*

PCB-04691 165-190 feet

<u>Petrographic Observation</u>

- **Covellite**, as isolated grains and present replacing fractured pyrite grains.
- **Pyrite**, as fractured grains being replaced by covellite and rimmed by Fe-oxides.
- **Goethite**, as abundant well-polished grains.

* **Hematite**, less abundant than goethite as intergrowths.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.14 wt% (pct)	18.8%	60.6%	36.5

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partially leached, which supports the Copper Basin geologic ore classification as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified copper plating easily when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Leached Capping*

PCB-04691 190-205 feet

Petrographic Observations

* **Chalcocite**, as isolated grains associated with pyrite grains.

- **Covellite**, as isolated grains associated with pyrite grains.
- **Chalcopyrite**, as inclusions within pyrite grains.
- **Pyrite**, as fractured grains associated with covellite and chalcocite.
- **Pyrrhotite**, as inclusions within pyrite grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.02 wt% (pct)	0%	8.5%	34.4

The mineralogy, microtextures, and mineral paragesnsis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified copper plating easily when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04691 205-290 feet

Petrographic Observations

- **Goethite**, as well polished grains with hematite intergrowths.
- **Hematite**, as intergrowths of goethite grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.27 wt% (pct)	24.9%	78.8%	37.5

The mineralogy, microtextures, and mineral paragensis indicate that this sample is a representative of a partial leach zone, which does not support the Copper Basin geologic ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified copper plating easily when saturated with acid.

The light material from the heavy liquid separation was analyzed using standard XRD practices and no copper sulfides were identified above the detection. The main mineral phases identified were quartz, muscovite, and illite (Refer to table 8).

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Partially Leach

PCB-04691 290-295 feet

Petrographic Observations

- **Chalcopyrite**, as isolated grains.
- **Pyrite**, as abundant fractured grains.
- **Covellite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.07 wt% (pct)	6%	21%	39.3

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene zone, which supports the Copper Basin geologic ore classification, as a *Hypogene* zone.

Field observations noted by the Copper Basin geologic team identified disseminated Mo.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Hypogene

PCB-04691 295-300 feet

Petrographic Observation

- **Pyrite**, as isolated grains.
- **Goethite**, as isolated grains.
- **Chalcopyrite**, as trace fine grains being replaced by covellite.
- **Covellite**, as trace fine grains replacing chalcopyrite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.1 wt% (pct)	24%	64%	39.3

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene zone, which supports the Copper Basin geologic ore classification as *hypogene.*

Field observations noted by the Copper Basin geologic team identified disseminated Mo.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04691 300-330 feet

Petrographic Observations

- **Chalcopyrite**, as inclusions within pyrite associated with pyrrhotite and isolated grains being replaced by covellite.
- **Pyrite**, as fractured grains with chalcopyrite and pyrrhotite inclusions, as the dominant mineral phase.
- **Pyrrhotite**, as inclusions within pyrite and associated with chalcopyrite grians.
- **Covellite**, as trace μ-scale patinas replacing chalcopyrite.
- **Rutile**, as isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.17 wt% (pct)	1.5%	16.3%	0

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

a hypogene zone, which supports the Copper Basin geologic ore classification as *hypogene.*

Field observations noted by the Copper Basin geologic field team noted biotite hornfels as the alteration type and that this interval plates copper easily when statured with acid.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04691 330-370 feet

<u>Petrographic Observations</u>

- **Pyrite**, as abundant isolated grains.

<u>Analytical Assay Data</u>

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.11 wt% (pct)	4%	16.1%	4.4

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene zone, which does not support the Copper Basin geologic ore classification as *Enriched.*

Field observations noted by the Copper Basin chalcocite identified abundant iron oxide staining from 330 to 350 feet and noted trace amounts of Mo and Cu, which plates easily from 350-370 feet.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Hypogene*

PCB-04691 370-375 feet

Petrographic Observations

- **Chalcopyrite**, as fractured grains being rimmed and replaced by covellite.
- **Covellite**, as a μ-scale patina coatings and replacing chalcopyrite.
- **Pyrite**, as fractured grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.28 wt% (pct)	16%	40%	13.2

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enriched zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified trace Mo, minor chalcopyrite, and plates copper easily when saturated with acid. Chalcocite was also noted in the field observations by the Copper Basin geologic team; however none was identified during the petrographic analyses. It is assumed that the sooty black chalcocite identified in the hand samples is oxidizing covellite.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

PCB-04691 375-400 feet

<u>Petrographic Observation</u>

- **Chalcopyrite**, is replacing pyrite grains and being replaced by covellite.
- **Covellite**, as a μ-scale coating and replacing chalcocpyrite and covellite.
- **Pyrite**, as fractured grains with pyrrhotite inclusions and is replaced by chalcocite and covellite.
- **Pyrrhotite**, as inclusions within pyrite grains.
- **Rutile**, as isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.14 wt% (pct)	3.4%	15.2%	27.4

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of enrichment zone, which does not support the Copper Basin geologic ore classification as *Hypogene.*

Field observations noted by the Copper Basin geologic team identified that copper plates easily when saturated with acid.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study):

Weak Enrichment

7.1.13 Drill Hole PCB-04834

Drill hole **PCB-04834** is located on the west-east cross section (refer to figure 50) drilled as an RC drilled to a depth of 500 feet. A total of five composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04834 210-215 feet

Petrographic Observations

- **Chalcocite**, as coatings and replacing fractured pyrite grains, illustrating typical supergene textures.
- **Covellite**, as coatings replacing chalcopyrite grains.
- **Hematite**, as abundant intergrowths with goethite.
- **Goethite**, as abundant intergrowths with goethite and as well polished grains.
- **Pyrite**, as grains being replaced by chalcocite.
- **Chalcopyrite**, as trace amounts being replaced by covellite.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.25 wt% (pct)	41%	80%	47.4%

The mineralogy, microtextures, and mineral paragensis indicate an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified this internal as a fault zone and is plating copper easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04834 220-240 feet

Petrographic Observations

- **Chalcocite**, as coating and replacing fractured pyrite grains, illustrating typical supergene textures.
- **Chalcopyrite**, as trace amounts being replaced by chalcocite.
- **Covellite**, as coatings replacing chalcopyrite.
- **Pyrite**, as grains replaced by chalcocite.
- **Possibly digenite**, as intergrowths within the chalcocite and covellite.
- **Goethite**, as trace isolated grains.
- **Hematite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.49 wt% (pct)	32.3%	83.3%	51.1%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified copper plating when saturate with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04834 285-295 feet

Petrographic Observations

- **Pyrite**, as dominant fractured grains.
- **Goethite**, as trace sole grains.
- **Covellite**, as trace very fine isolated grains.
- **Chalcopyrite**, as trace grains.
- **Jarosite**, as trace amounts.
- **Goethite**, as trace isolated grains.
- **Hematite**, as trace isolated grains

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.09 wt% (pct)	48.5%	73.5%	50%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification, as *Enriched.*

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Weak Enrichment*

PCB-04834 480-490 feet

Petrographic Observations

- **Chalcocite**, as a μ-scale patina coating and replacing pyrite, illustrating supergene textures.
- **Covellite**, as a μ-scale patina coating and replacing pyrite, illustrating supergene textures.
- **Chalcopyrite** is replacing pyrite grains and is being replaced by covellite.
- **Goethite**, as abundant grains rimming other grains.
- **Pyrite**, as dominant grains incipiently replaced by covellite.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.11 wt% (pct)	10%	9.9%	0%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enrichment.*

Field observations noted by the Copper Basin geologic team identified that copper plates when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

PCB-04834 490-495 feet

Petrographic Observations

- **Pyrite**, as abundant fractured grains.
- **Goethite**, as abundant grains associated with hematite.
- **Hematite**, less abundant than goethite and comprises as grains intergrown within goethite.
- **Covellite**, as trace isolated grains.
- **Chalcopyrite**, as trace isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.02 wt% (pct)	0%	33.3%	0%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a hypogene, which supports the Copper Basin geologic classification as *Hypogene.*

Field observations noted by the Copper Basin geologic team identified trace Mo present and copper plating when saturated with acid.

Copper Basin Ore Classification: *Hypogene*

Geochemical Ore Classification (from this study): *Hypogene*

7.1.15 Drill Hole PCB-04836

Drill hole **PCB-04836** is located on the east-west cross section (refer to figure 50), drilled as an RC hole to a total of 500 feet. The phreatic zone was first identified at 413 feet. A total of six composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04836 285-300 feet

Petrographic Observations

- **Chalcocite**, as coating and replacing pyrite and chalcopyrite grains, illustrating typical supergene textures.

- **Goethite**, is more abundant than hematite as isolated grains and replacing pyrite and coating chalcocite.
- **Hematite**, less abundant than goethite as coating and replacing sulfides.
- **Pyrite**, as grains being replaced by chalcocite and hematite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.4 wt% (pct)	62%	24.7%	None

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic classification as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified trace chalcocite disseminated within the RC chips.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study): *Strong Enrichment*

PCB-04836 300-310 feet

Petrographic Observations

- **Chalcocite**, as coatings and replacing pyrite grains, illustrating typical supergene textures.
- **Covellite**, as coatings and replacing pyrite grains, illustrating typical supergene textures.
- **Hematite**, more abundant than goethite as isolated grains.
- **Goethite**, less abundant than hematite as isolated grains.
- **Pyrite**, as abundant grains being replaced by chalcocite and covellite.
- **Chalcopyrite**, as trace amount of isolated grains and with inclusions of pyrite.
- **Pyrrhotite**, as trace amounts of inclusions of pyrite.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.34 wt% (pct)	33.5%	78.5%	50%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Field observation noted by the Copper Basin geologic team classified biotite hornfels as the dominant alteration type and identified abundant chalcocite throughout the sample interval that plates copper when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Moderate Enrichment

PCB-04836 310-325 feet

Petrographic Observations

- **Goethite**, as abundant grains and is found as well polished grains.
- **Hematite**, less abundant.
- **Pyrite**, as trace relic isolated grains.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.16 wt% (pct)	34.7%	19.7%	None

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of

a partially leach zone, which support the Copper Basin geologic ore classification, as *Partial Leach*.

Field observations noted by the Copper Basin geologic team identified that copper plating when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*

Geochemical Ore Classification (from this study):

Partially Leached

PCB-04836 325-360 feet

- **Chalcopyrite**, as inclusions within pyrite grain and being replaced by covellite.
- **Covellite**, as a coating and replacing chalcopyrite grains and filling in voids on fractured grains.
- **Pyrite**, as dominant fractured grains, with covellite filling in voids and chalcopyrite and pyrite as inclusions.
- **Pyrrhotite**, as inclusions within pyrite grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.22 wt% (pct)	62%	14.6%	None

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which does not support the Copper Basin geologic ore classification, as *Partial Leach.*

Field observations noted by the Copper Basin geologic team identified chalcocite that plates copper when saturated with acid.

Copper Basin Ore Classification: *Partial Leach*
Geochemical Ore Classification (from this study): *Weak Enrichment*

PCB-04836 360-430 feet

Petrographic Observations

- **Goethite**, as equally as abundant as hematite and found associated with hematite.
- **Hematite**, as equally as abundant as goethite, and found associated with goethite.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.19 wt% (pct)	22.4%	57.6%	35.7%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an partially leached zone, which supports the Copper Basin geologic ore classification, as *Partial Leach.*

The light material from the heavy liquid separation was analyzed using standard XRD practices and no copper sulfides were identified above the detection. The main mineral phases identified were; quartz, illite, and orthoclase.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Partially Leach*

PCB-04836 430-455 feet

<u>Petrographic Observation</u>

- **Chalcopyrite**, is filling in voids and fractures and replacing pyrite grains.
- **Covellite**, as trace isolated grains.
- **Pyrite**, as the abundant grains being replaced by chalcopyrite within fractures and voids.

* **Pyrrhotite**, as inclusions within pyrite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.18 wt%	16.7%	32.7%	24.9%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification as *Enriched.*

Field observation noted by the Copper Basin geologic team identified chalcocite that plates copper when saturated with acid during the logging process, however no chalcocite was identified during the petrographic analyses. It is assumed that the minerals identified during logging were covellite grains or potentially iron oxides rather than sooty chalcocite.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Weak Enrichment*

PCB-04836 455-470 feet

Petrographic Observations

- **Chalcocite**, as μ-scale patina coating and replacing pyrite grains, illustrating typical supergene textures.
- **Covellite**, as coating and replacing pyrite grains, illustrating typical supergene textures.
- **Chalcopyrite**, is filling in voids and fractures and replacing pyrite grains and is being replaced by covellite also as inclusions in pyrite.
- **Goethite**, as trace amounts of isolated grains.
- **Hematite**, as trace amounts of isolated grains.
- **Pyrite**, as grains being replaced by chalcocite, covellite, and chalcopyrite.
- **Pyrrhotite**, as inclusions with pyrite grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.16 wt% (pct)	23.7%	48.3%	None

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic ore classification, as *Enriched.*

Field observations noted by the Copper Basin geologic team identified that copper plates when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

PCB-04836 470-500 feet

Petrographic Observations

- **Chalcopyrite**, as inclusion in pyrite and isolated grains being replaced by covellite.
- **Covellite**, as μ-scale patinas coating and replacing chalcopyrite.
- **Pyrite**, as grains being replaced by chalcopyrite and covellite.
- **Pyrrhotite**, as inclusions in pyrite associated with chalcopyrite.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.13 wt% (pct)	16.7%	32.7%	24.9%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic classification as *Enriched.*

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

7.1.15 Drill Hole PCB-04872

Drill hole **PCB-04872** is located on the south-north cross section (refer to figure 49), drilled as an RC hole to a depth of 605 feet. A total of four composite pulp samples were collected and the heavy mineral separates were analyzed.

PCB-04872 205-210 feet

Petrographic Observations

- **Chalcocite**, as coating and replacing chalcopyrite and as isolated grains, illustrating typical supergene textures.
- **Goethite**, as isolated grains and rimming and replacing pyrite grains.
- **Pyrite**, as isolated grains being rimmed and replaced by goethite.

<u>Analytical Assay Data</u>

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.13 wt% (pct)	29%	88%	26.3%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geological ore classification as *Enriched.*

Field observation noted by the Copper Basin geologic team identified copper plating easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Strong Enrichment

PCB-04872 210-225 feet

<u>Petrographic Observation</u>

- **Chalcocite**, as isolated grains.
- **Chalcopyrite**, as isolated grains and present replacing fractured pyrite grains.

- **Goethite**, as more abundant than hematite isolated grains.
- **Hematite**, less abundant than geothite as isolated grains.
- **Pyrite**, as grains being replaced by chalcopyrite grains.

Analytical Assay Data

Total Copper	**Acid Solubility**	**Cyanide Solubility**	**QLT**
0.22 wt% (pct)	38.7%	88.3%	20.9%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geological ore classification as *Enriched.*

Field observation noted by the Copper Basin geologic team identified that copper plates when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Moderate Enrichment*

PCB-04872 310-315 feet

Petrographic Observation

- **Goethite**, as grains rimming and replacing pyrite grains.
- **Pyrite**, as fractured isolated grains replaced by goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.18 wt% (pct)	22%	93%	0%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of a partial leach zone, which does not support the Copper Basin geological ore classification as *Enriched.*

Field observations noted by the Copper Basin geologic team identified trace amounts of a sooty black mineral coating grains that is assumed to be goethite.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study): *Partially Leached*

PCB-04872 360-370 feet

Petrographic Observation

- **Covellite**, as isolated grains.
- **Goethite**, as grains rimming and replacing pyrite grains.
- **Pyrite**, as fractured isolated grains by goethite.

Analytical Assay Data

Total Copper	Acid Solubility	Cyanide Solubility	QLT
0.01 wt% (pct)	14.5%	74%	12.5%

The mineralogy, microtextures, and mineral paragensis indicate that this sample is representative of an enrichment zone, which supports the Copper Basin geologic as *Enrichment.*

Field observation noted by the Copper Basin geologic team identified that copper plates easily when saturated with acid.

Copper Basin Ore Classification: *Enriched*

Geochemical Ore Classification (from this study):

Weak Enrichment

7.2 Petrographic Findings Summary

Table 5 summarizes the mineralogy and leachability potential of the different geochemical copper ore types. As illustrated in Figure 6, the enrichment zone is broken up into three different levels based on enrichment intensities indicated by the mineral compositions and paragenetic relationships identified. It also should be noted that the majority of the sample intervals contains abundant pyrite.

The texture and mineral associations are very similar throughout all of the copper ore types, the only difference is the abundance of copper sulfides, pyrite, and iron oxides.

Geochemical Cu Ore Type		**Minerals Present**	**Paragentic Relationship**	**Ore Grade**	**Acid Sol%**	**CN Sol%**	**QLT**
Leached Cap		gt, hm, & relic py	None	< 0.15			
Partially Leach		gt, hm, & relic py	None	0.15-0.38	0-50.3	2.3-96	0-57.7
Enrichment	Strong	cc, py, gt, & hm	cc replaces pyrite	0.06-1.43	13-62	22.3-82	42.8-52.6
	Moderate	cc, cv, cp, py, gt, & hm	cc replaces py, cv replaces py, cv replaces cp	0.02-0.85	0-43.5	1-96.0	0-55.2
	Weak	cv, cp, py, gt, & hm	cp-->cv	0.04-1	0-62.7	1-99.0	0-64.9
Hypogene		cp, py, & trace cv	None	0.02-0.83	0-6	9-58.8	0-33.3

Table 5: Summary of the petrographic findings identified in this study.

Strong Enrichment is classified in this study as:

- the presence of chalcocite, pyrite, goethite, and hematite

- chalcocite rimming and replacing pyrite
    - paragenetic relationship indicating high Cu++ activity during weathering and copper mobility
    - textural relationship and mineral association as •illustrated in Figure 7

Moderate Enrichment is classified in this study as:

- the presence of chalcocite and covellite, with residual hypogene pyrite, chalcopyrite, goethite, and hematite
- chalcocite replacing pyrite, chalcopyrite replacing covellite, and covellite replacing pyrite
    - paragenetic relationships indicating a transition zone between a high and low Cu++ activity during weathering and copper mobility
    - textural relationships and mineral associations are shown in Figure 8

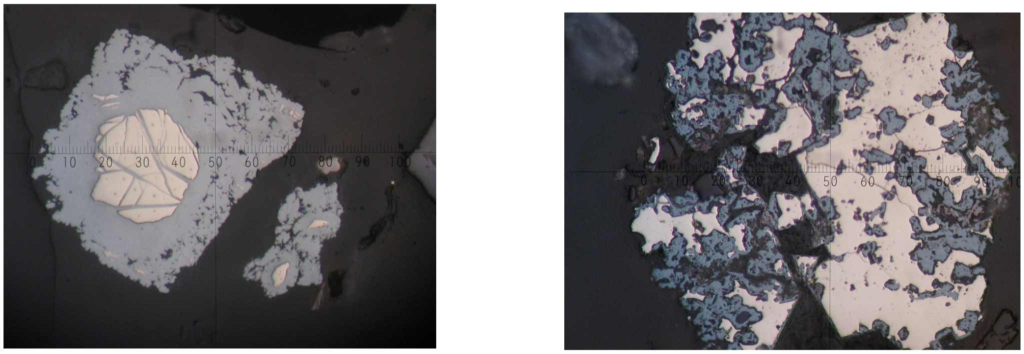
Weak Enrichment is classified in this study as:

- the presence of covellite, chalcopyrite, pyrite, goethite, and hematite
- covellite replacing chalcopyrite,
    - paragenetic relationship indicating that copper-bearing supergene solutions were

impoverished with respect to Cu++ activity.

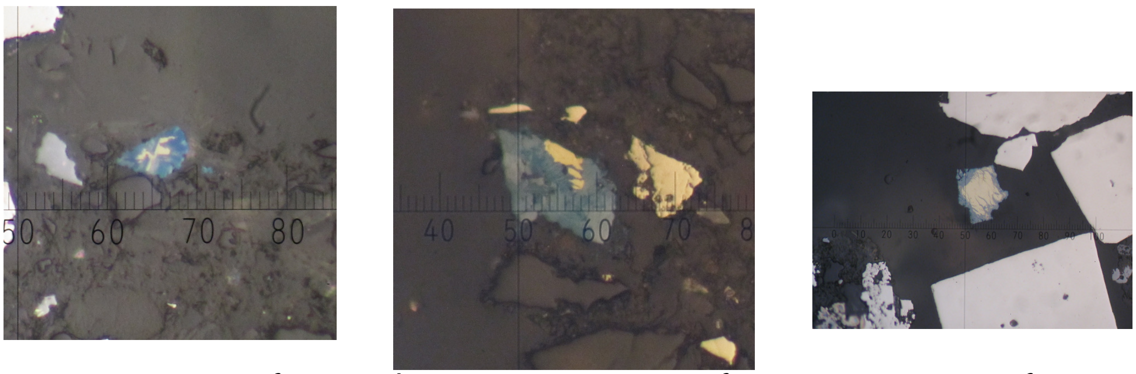
- textural relationships and mineral association are shown in Figure 9

Figures 10 to 12 illustrate varying copper sulfide percentages against different copper solubility tests to understand the control of specific copper sulfide mineralogy to leachability. Generally speaking, there is no correlation between increasing sulfide ratios and recovery values, except a correlation in Figure 10 between high ratios and higher recovery values. This lack of correlation is because copper is present in other copper-bearing mineral phases such as goethite, copper-bearing clays, and encapsulated copper sulfides, which are not considered during the line integration ratios.



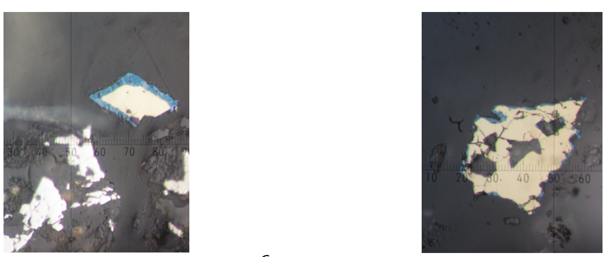
a. ___ 10µ b. __ 6µ

Figure 7. a. PCB-04551 506-509′ Fractured isotropic pyrite being replaced by pale blue-grey chalcocite illustrating a supergene texture that would be classified as strong enrichment. b. PCB-04455 315-330′ Blue-grey chalcocite replacing pale yellow isotropic pyrite with trace amounts of goethite replacing chalcocite illustrating a strong enrichment.



a. __ 6µ b. __ 6µ c. __ 6µ

Figure 8. a. PCB-04465 220-245′ A fine-grained chalcopyrite being rimmed and replaced by covellite and chalcocite demonstrating moderate enrichment. b. PCB-04465 310-320′ Fine-grained chalcopyrite being rimmed and replaced by covellite and chalcocite with an isolated pyrite grain demonstrating moderate enrichment. c. PCB-04488 435-500′ Chalcopyrite grain being replaced by an indigo blue covellite grain with isolated euhedral pyrite grains illustrating moderate enrichment.



a. _6µ b. _6µ

Figure 9. a. PCB-04691 375-400′ Brassy yellow chalcopyrite being replaced by an indigo-blue covellite grain with isolated pyrite grains demonstrating weak enrichment. b. PCB-04691 370-375′ Fractured brassy yellow chalcopyrite being replaced by an indigo-blue covellite.

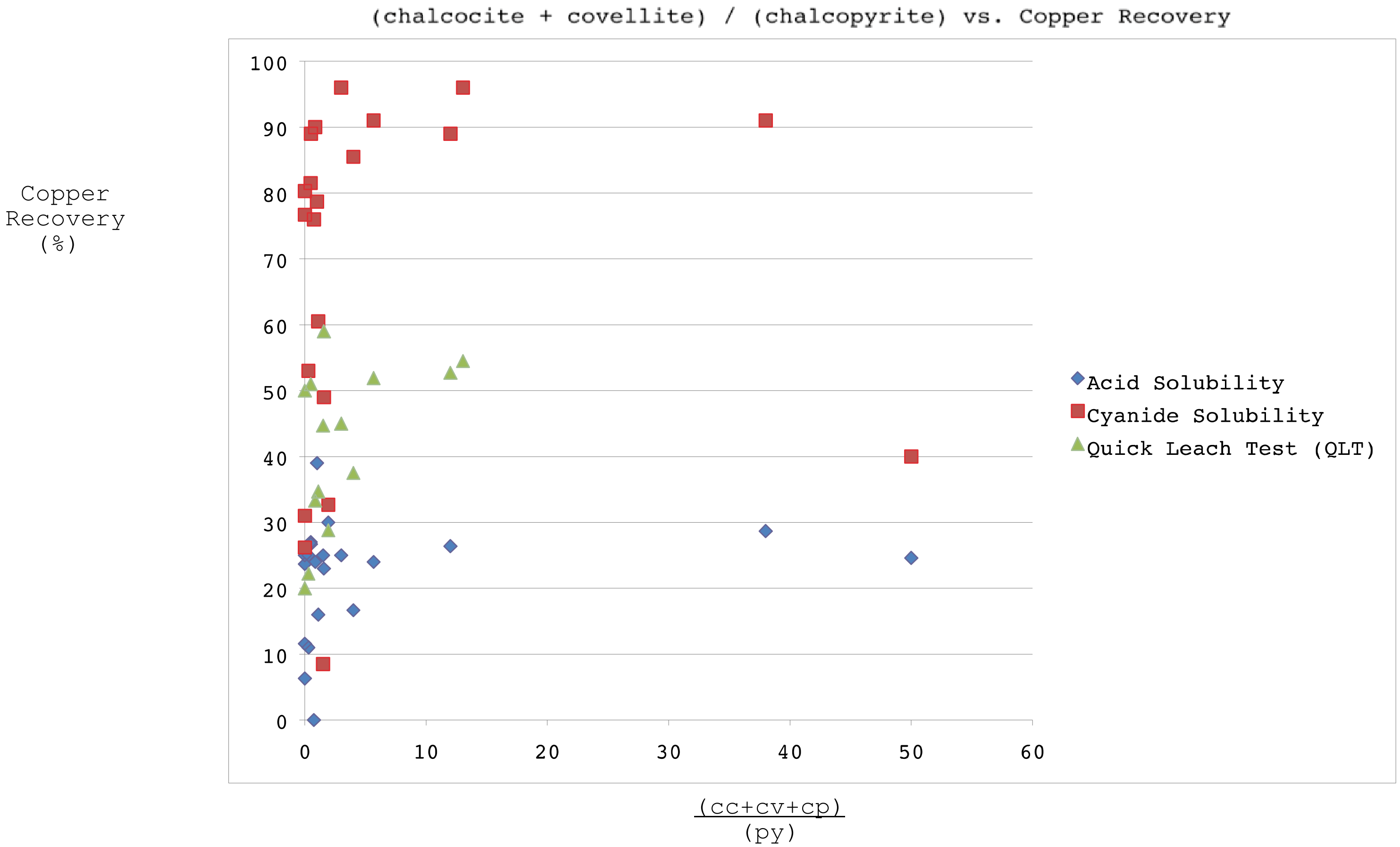


Figure 10: Scattergram illustrating chalcocite (cc) + covellite (cv) / chalcopyrite (cp) verses the three copper solubility tests used in this study. High ratios are associated with higher recovery values, where the lower ratios have varying recovery values. This lack of correlation is because copper is present in other copper-bearing mineral phases such as goethtite, copper-bearing clays, and encapsulated copper sulfides, which are not considered during the line integration ratios.

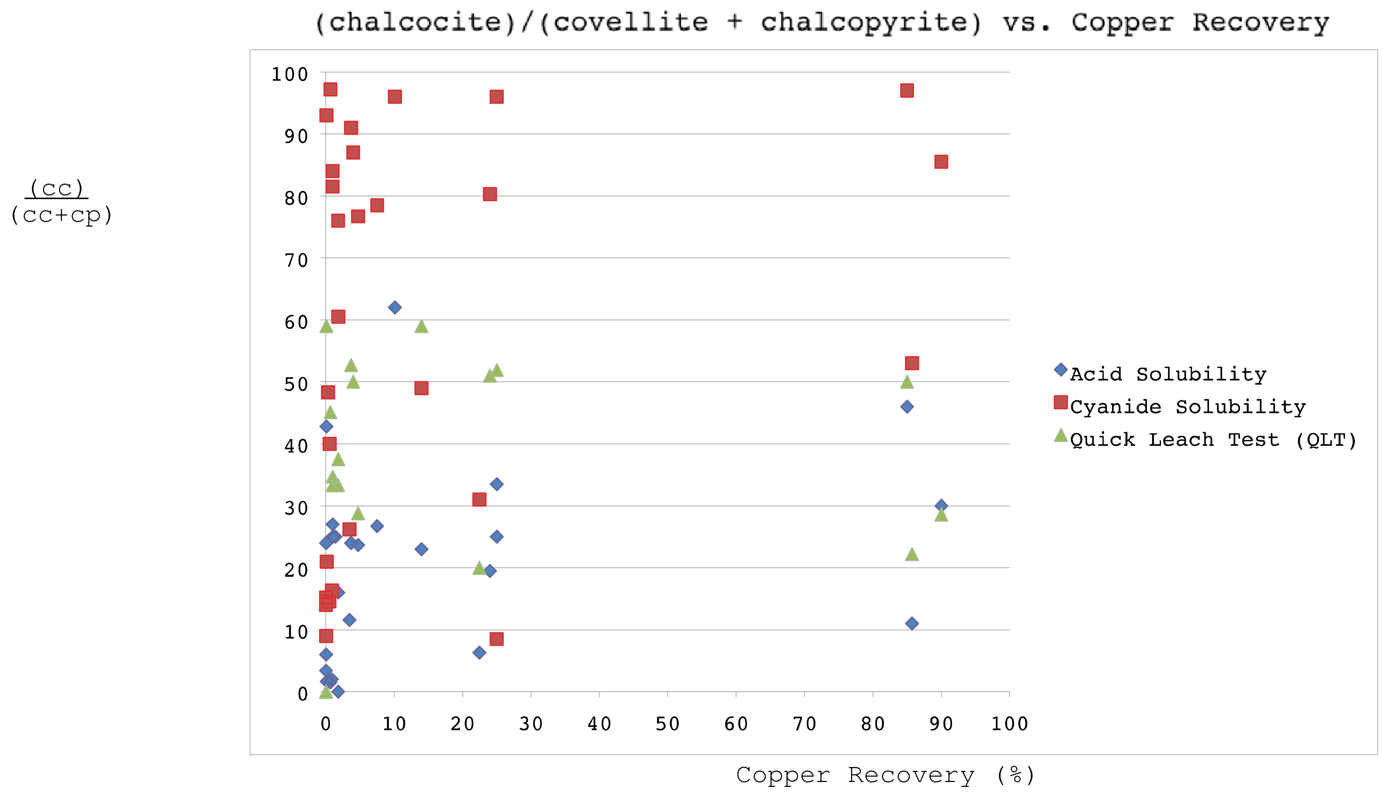
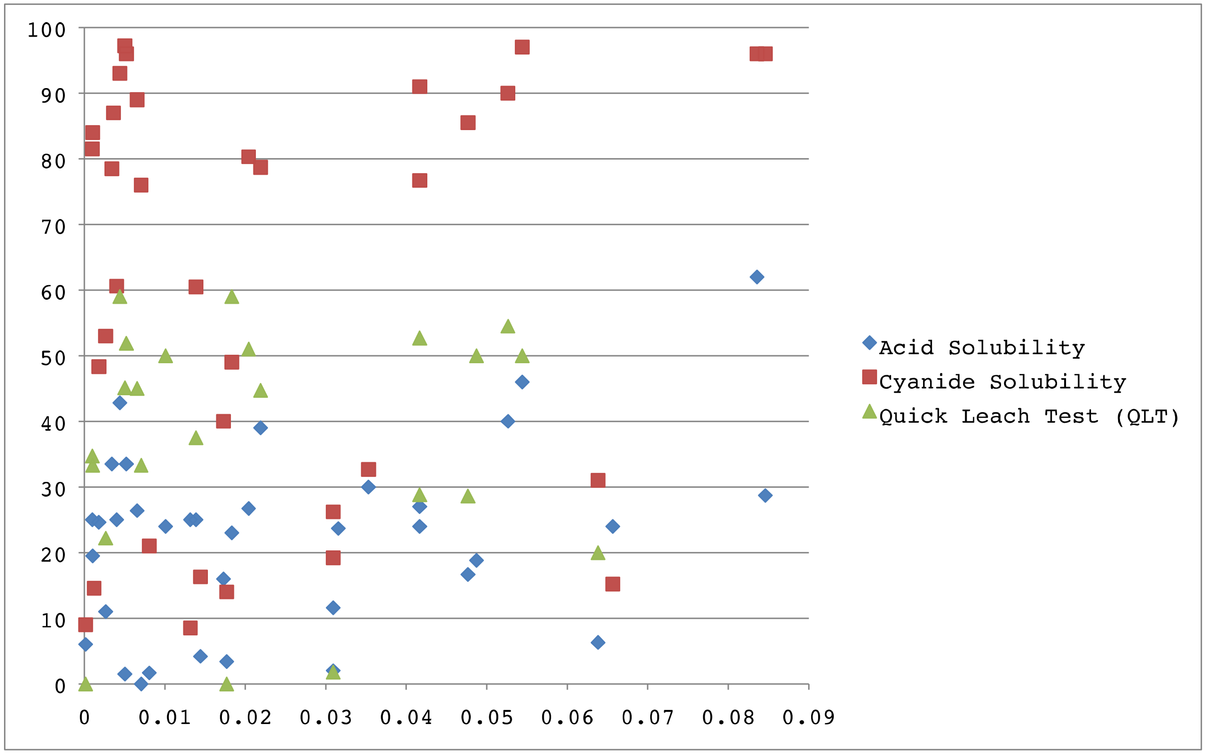


Figure 11: Scattergram illustrating chalcocite (cc) / covellite (cv) + chalcopyrite (cp) verses the three copper solubility tests used in this study. Generally speaking, there is no correlation between increasing sulfide ratios and recovery values. This lack of correlation is because copper is present in other copper-bearing mineral phases such as goethite, copper-bearing clays, and encapsulated copper sulfides, which are not considered during the line integration ratios.

(chalcocite + covellite + chalcopyrite) / (pyrite) vs. Copper Recovery

(cc+cv+cp)
(py)



Copper Recovery (%)

Figure 12: Scattergram illustrating chalcocite (cc) + covellite (cv) + chalcopyrite (cp) / pyrite (py) verses the three copper solubility tests used in this study. Generally speaking, there is no correlation between increasing sulfide ratios and recovery values. This lack of correlation is because copper is present in other copper-bearing mineral phases such as goethite, copper-bearing clays, and encapsulated copper sulfides, which are not considered during the line integration ratios.

7.3 CLAY SAMPLES

A previous study of twenty-three core hand samples dominantly classified as containing clay minerals were collected from drill hole PCB-04621 and underwent XRD analysis specifically to identify the clay mineralogy present and the amount of copper contained within the clays. The most abundant clay mineral species identified in these clay samples were halloysite, kaolinite, and illite. The amount of copper with clay species varies substantially: illite varies from 0 to 0.60 wt.% Cu, kaolinite/halloysite from 0 to 1.87 wt.% Cu (Thogerson, 2011). Table 6 illustrates the summary of analytical results of selected clay samples that detected Cu++ within clays. Unfortunately, no quantitative analyses were conducted to better understand the abundance of clay

Copper Concentration by SEM/MLA and Semiquantitative XRD Analysis Results

Sample Interval (feet)	Copper Basin Ore Classification	Total Au	Total Ag	Total Cu	Acid Sol%	Cyanide Sol%	Avg. Cu Wt% in Clay (Kln)(1)	Avg. Cu Wt% in Clay (Ilt)(2)	Cu Wt% Range in Clay (Kln)(1)	Cu Wt% Range in Clay (Ilt)(2)	Notes
105.8	Enriched	<0.001	0.041	0.41	42	97	0.085	0.019	0–0.34	0–0.28	
120.9	Enriched	0.002	0.088	0.32	43	99	0.048	0.017	0–0.28	0–0.25	
132.9	Enriched	0.003	0.114	0.19	33	84	0.369	0.215	0–0.73	0–0.44	
172.7	Hypogene	0.026	0.289	0.12	22	66	0.015	0.093	0–0.23	0–0.65	
188.6	Enriched	0.065	0.045	0.14	28	80	0.185	0.149	0–0.35	0–0.6	
198.0	Enriched	<0.001	0.014	0.37	N/A	62	0.137	0.059	0.3	0.25	
205.7	Enriched	0.001	0.031	0.11	22	84	0.103	0.037	0–0.4	0–0.34	
212.2	Enriched	<0.001	0.19	0.32	26	81	0.371	0.153	0–1.87	0–0.66	cv(3) inclusion in kln
223.0	Hypogene	<0.001	0.081	0.09	33	80	0.026	0.031	0–0.39	0–0.24	

Table 6: Summary of copper concentration by SEM/MLA and Semiquantitative XRD Analysis of samples from Phoenix Copper Basin Drill Holes PCB-04621 (analytical data from Thogerson, 2011). (1)kaolinite, (2) illite, and (3) covellite

minerals present in the samples collected in this study. Thus, we are inferring that trace amounts of copper are attributed to copper bearing clays but further work is needed to quantify the significance within the samples collected from this study.

7.4 SCANNING ELECTRON MICROSCOPE ANALYSES

A total of fifty-nine spot and area scanning electron microscope analyses were collected and elementally quantified. Since this particular method was a standardless analysis it was used as qualitative examination, which confirmed copper sulfide mineral phases. The results indicated stoichiometries varying substantially from chalcocite to covellite.

7.5 ELECTRON MICROPROBE

A total of thirty-nine spot analyses of sulfides and oxide phases were qualitatively identified using electron microprobe analyses. The quantitative analyses located in Table 7 confirmed the following phases: chalcocite (Cu_2S), spionkopite ($Cu_{1.4}S$), pyrite (FeS_2) and a Fe-Cu composite oxide.

Drill Hole	Depth	Mineralogy Identified
PCB-04482	430-450'	Cu_2S and *$Cu_{1.4}S$
	598-615'	Cu_2S, $Cu_{1.4}S$, and *Fe Cu-oxides
	615-639'	Cu_2S and FeO_x
	639-654'	FeS_2
PCB-04456	395-410'	$Cu_{1.4}S$
	420-450'	Cu_2S

Table 7: Analytical results from microprobe analyses of heavy fraction separates.
*stoichmetric formula varies due to low total.

7.6 XRD ANALYSES

Qualitative analyses were conducted on pyrites picked from six RC grab samples. All of the samples are from intervals that contained significant total copper and plated copper when saturated with acid. The hand samples all contained a black sooty rind coating on pyrite grains, originally classified as chalcocite. Three of the six samples identified the black sooty rind to be a copper sulfide, chalcocite-roxybyite $Cu_{1.78}S$. Two of the six samples did not detect a coating on the pyrite, and one sample hosted a coating that consists of mixed aluminum silicate hydrate and aluminum silicate hydrate and aluminum silicate hydroxide, possibly $Al(OH)_3$. Table 8 summaries the full analytical results from the XRD analyses.

Qualitative analyses were conducted on six heavy liquid separated light fractions and the analytical results are in Table 9. Of the six samples, only one contained trace amounts of a copper sulfide; the other samples were a mix of quartz, muscovite, and illite. One interval contained kaolinite.

Drill Hole	From	To	Common Name	Minerals Identified	Summary
PCB-04456	420	425	Iron Sulfide & Copper Sulfide	Pyrite (FeS2) & Roxybyite (Cu7S4)	pyrite with roxybyite coating
PCB-04488	95	100	Iron Oxide Hydrate & Copper Sulfide	Fe2O3*H2O & Djurleite Cu1.97S	pyrite with trace djurleite possibly as a coating
PCB-04836	325	330	Iron Oxide & Copper Sulfide	Pyrite (FeS2) & Roxybyite (Cu7S4)- Chalcocite (Cu2S)	pyrite with a copper sulfide coating
PCB-04836	345	350	Iron Sulfide, Aluminum Silicate Hydrate, & Aluminum Silicate Hydroxide	Pyrite (FeS2), H4Al2Si2O9, Al4 (OH)8 (Si4O10)	pyrite, aluminum silicate hydrate, aluminum silicate hydroxide

Table 8: XRD analytical results of reverse circulation (RC) grab samples that detected a mineral phases coating the pyrite grain.

Drill Hole	From (feet)	To (feet)	Copper Basin Ore Classi-fication	Geochemical Ore Classi-fication	Assay Analytical Results				Minerals Identified in Light Fractions	Observations From Petrographic Analysis		
					Total Cu	Acid Sol%	CN Sol%	QLT		Copper Sulfides	Iron Oxides	Gangue
PCB-04691	150	160	Partial Leach	Partially Leached	0.19	25.5	8.5	29.9	quartz & muscovite	None Noted	gt >hm	None Noted
PCB-04691	205	290	Enriched	Partially Leached	0.27	24.9	78.5	37.5	quartz, muscovite, & illite	None Noted	gt >hm	None Noted
PCB-04451	470.1	474.1	Partial Leach	Partially Leached	0.24	28.0	16.0	N/A	quartz, orthoclase, muscovite, & kaolinite	None Noted	gt dominant	rt
PCB-04836	360	430	Enriched	Partially Leached	0.19	22.4	57.6	33.4	quartz, illite, & orthoclase	None Noted	gt = hm	None Noted
PCB-04488	435	500	Enriched	Moderate Enrichment	0.09	24.0	87.0	50	quartz, orthoclase, muscovite, & illite	cc, cp, & trace cv	gt	py and po
PCB-04604 D	360	375	Hypogene	Hypogene	0.83	1.7	14.0	0	quartz, orthoclase, muscovite, pyrite, & possibly covellite	cp & trace cv	None Noted	py

Table 9: XRD analytical results of the light fraction separates. (cp) chalcopyrite, (cc) chalcocite, (cc) covellite, (gt) goethite, (hm) hematite, (py) pyrite, (po) pyrrhotite, and (rt) rutile.

7.7 LIGHT SAMPLES

Twenty-four sample intervals from three drill holes were selected for repeat assays as an internal check, Table 10. Following petrographic observations and microprobe analyses of the light material noted in proceeding sections it is suspected that there is more copper contained within the light materials than originally anticipated. When comparing the bulk total copper and leachability values to the light fraction separates there is not a significant reduction in values, which indicates there is more recoverable copper within the light material than originally expected or equal amounts of copper in the light fractions as in the heavies.

7.8 SULFUR ISOTOPE STUDY

Nine pyrite $\delta^{34}S$ samples from four different drill holes were analyzed for $\delta^{34}S$ isotopic compositions. The purpose of this analyzes is to investigate the isotopic variation against magmatic values previously identified by Ohmoto and Rye, 1979. Table 11 complies the $\delta^{34}S$ isotopic values identified in this study and the corresponding

Drill Hole	From (feet)	To (feet)	Copper Basin Ore Classification	Cu wt% pct Bulk	Cu wt% Lights Fractions	Acid Sol% Bulk	Acid Sol% Light Fractions	Cyanide Sol% Bulk	Cyanide Sol% Lights	Cu Sulfides	Fe-Oxides
PCB-04451	518.4	530.2	Enriched	0.39	0.20	28.7%	27.9%	96.0%	99.9%	cc, dj, cc-cv (mix)	hm>gt
PCB-04691	370	375	Enriched	0.28	0.18	16.0%	14.5%	40.0%	43.7%	cp & cv	None
PCB-04836	325	360	Partial Leach	0.22	0.15	62.0%	19.1%	14.6%	61.9%	cp & cv	tr.gt &hm
PCB-04836	470	500	Enriched	0.16	0.14	16.7%	20.6%	32.7%	32.4%	cp & cv	None
PCB-04691	290	295	Hypogene	0.07	0.07	6.0%	14.9%	21.0%	28.1%	cp & tr.cv	None
PCB-04691	300	330	Hypogene	0.17	0.11	1.5%	7.2%	16.3%	18.1%	cp & tr.cv	None
PCB-04691	165	190	Partial Leach	0.14	0.11	18.8%	20.5%	60.6%	78.5%	cv	gt>hm
PCB-04691	150	160	Partial Leach	0.19	0.15	25.5%	31.0%	8.5%	12.2%	None	gt>hm
PCB-04691	160	165	Partial Leach	0.21	0.18	46.0%	46.3%	11.0%	15.2%	None	gt>>hm
PCB-04691	205	290	Enriched	0.27	0.01	24.9%	22.8%	78.5%	24.1%	None	gt>hm
PCB-04691	330	370	Enriched	0.11	0.07	4.0%	38.8%	16.1%	48.7%	None	None
PCB-04836	285	300	Partial Leach	0.33	0.13	62.0%	8.8%	24.7%	26.1%	None	gt & hm
PCB-04836	310	325	Partial Leach	0.16	0.15	34.7%	24.5%	19.7%	19.3%	None	gt & hm
PCB-04451	459.5	470.1	Leached Cap	0.10	0.08	22.5%	14.3%	14.5%	10.2%	None	gt (dom.)
PCB-04451	470.1	474.1	Partial Leach	0.24	0.21	28.0%	20.4%	16.0%	13.7%	None	gt (dom.)
PCB-04451	474.1	479.4	Leached Cap	0.17	0.09	26.0%	23.9%	16.0%	15.2%	None	gt (dom.)
PCB-04451	479.4	483.7	Leached Cap	0.14	0.14	40.0%	26.8%	21.0%	13.4%	None	gt (dom.)

Table 10: Assay analytical results from selected sample re-assayed. (cp) chalcopyrite, (cc) chalcocite, (cc) covellite, (gt) goethite, (hm) hematite, (py) pyrite, (po) pyrrhotite, and (rt) rutile.

protolith and alteration type logged by the Copper Basin geologic team as well as the geochemical ore classification identified in this study. The following results were identified:

- *Leached Capping* zone, as identified in this study has an isotopic signature of 2.7.
- *Partially Leached* zone, as identified in this study has a range of isotopic signatures of 2.7 to 5.2.
- *Weak Enrichment* zone, as identified in this study has an isotopic signature of 4.2.
- *Moderate Enrichment* zone, as identified in this study has a range of isotopic signatures of 3.9 to 6.3.

The isotopic signatures identified in this study are slightly heavier than the standard value of igneous sulfur ($\delta 34S$ of 0 +/- 3‰) identified by Ohmoto and Rye, 1979 but are within the range of sulfur from oxidized magmas. Further data would be needed to conclude the source of the sulfur within the supergene enrichment profile at Copper Basin.

Drill Hole	From	To	Copper Basin Ore Classification	Geochemical Ore Classification	Fm	Protolith	Alteration Type	Weight mg	$\delta^{34}S$ corrected	$\delta^{34}S$ Average
PCB-04872	365	370	Enriched	Weak Enrichment	Ch	ss	bh/spy	0.81mg	4.2	4.2
PCB-04604D	155	160	Enriched	Moderate Enrichment	Ch	ss	spy/sk	0.83	3.9	3.9
PCB-04488	305	310	Enriched	Moderate Enrichment	Ch	ss	spy	0.8 0.75	5.3 5.0	5.2
PCB-04488	310	315	Enriched	Moderate Enrichment	Ch	ss	spy	0.75 0.87	5.9 6.7	6.3
PCB-04691	250	255	Enriched	Partially Leached	Ch	ss	spy	0.75	4.8	4.8
PCB-04691	175	180	Partial Leach	Leached Capping	Ch	ss	spy	0.8	2.7	2.7
PCB-04691	170	175	Partial Leach	Leached Capping	Ch	ss	spy	0.81	2.7	2.7
PCB-04691	215	220	Enriched	Partially Leached	Ch	ss	spy;ar	0.85	2.7	2.7
PCB-04691	245	250	Enriched	Partially Leached	Ch	ss	sk	0.82 0.75	5.3 5.0	5.2

Ch	Harmony Formation
ss	sandstone
bh	biotite hornfels
spy	sericite-white phyllosilicate-pyrite
sk	skarn
ar	argillic

Table 11: Summary of $\delta^{34}S$ isotopic values of pyrite sample from the Copper Basin supergene enrichment profile.

8. DISCUSSION AND RECOMMENDATIONS

The main focus of this study was to identify the diverse copper ore mineralogy present in the variably-developed supergene enrichment profile of the Widow Pit area and to relate copper mineralogy and occurrence to leachability and recovery. Copper mineralogy is a controlling factor of copper recovery; however, petrographic analyses show that total contained copper is attributable to copper hosted by and in minerals other than copper sulfides; these other copper hosts make assessment of copper mineralogy and copper recovery relationships difficult.

8.1 TOTAL COPPER

Generally speaking, simple total copper assays do not indicate the soluble or insoluble nature of copper in leach solutions. Because of the mineralogic variability of copper occurrence, total copper assay values must be used with mineralogic considerations to understand the amount of leachable copper within the sample.

Figure 13 is a graphical representation of the geochemical zonation illustrating the varying copper grade with respect to copper ore type. Generally speaking at Copper Basin, as the metals are transported from the leached capping and partial leach rock volumes and travel downward they accumulate in an enrichment zone, increasing in total contained copper. As the copper-bearing solution transports through the rock it becomes impoverished in Cu++, which is indicated by lower copper grade and decreasing presence of copper sulfides. Figure 13 illustrates the geochemical zonation present in the variably-developed supergene enrichment profile at Copper Basin.

Petrographic, microprobe, SEM, XRD analyses show that copper is present in the form of:

- Copper sulfides
  - exposed sulfide grains in the heavy fraction separates
  - sulfide grains encapsulated in silicates or as only partially-liberated grains (present in the light fractions separates)
- Cu++ adsorbed and within the lattices of clays
- Cu++ adsorbed onto iron-oxides, especially goethite

Therefore, when comparing copper recovery to copper sulfide mineralogy at Copper Basin, a direct correlation is not always observed. The following sections will discuss the correlation or lack thereof between copper occurrence and copper leachability, and will try to unravel the geochemical development of the enrichment profile at Copper Basin.

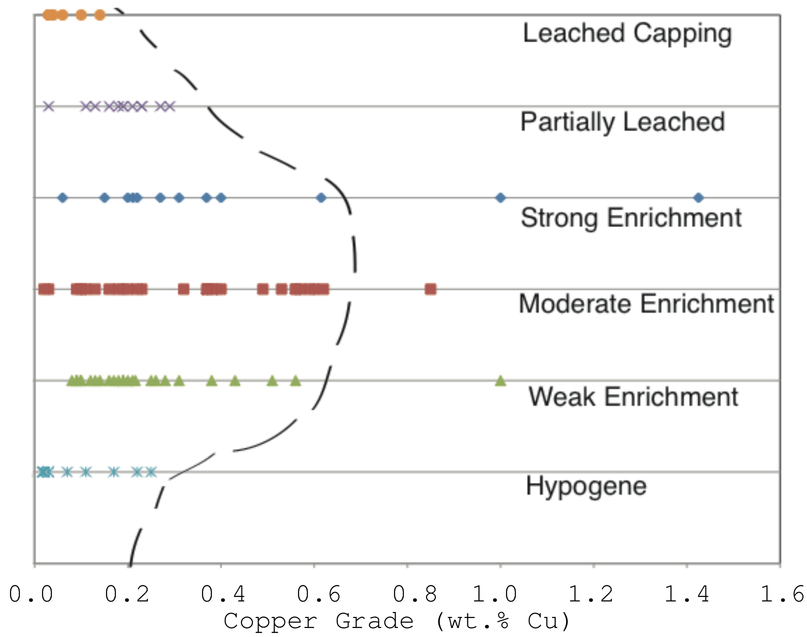


Figure 13: Graphical geochemical zonation representing the varying copper grade with respect to copper ore type. Copper grade increases at the Strong Enrichment zone and then diminishes with depth approaching the hypogene zone. Note protore average grade is 0.14% Cu with an approximate enrichment factor of 0.71.

8.2 COPPER SULFIDES

Prior to initiating this study, it was assumed that the majority of the copper was present as exposed disseminated or veinlet-hosted copper sulfide grains within the Cambrian-age Harmony Formation. Petrographic analyses indicate that the copper sulfides are present as exposed grains, but investigation of the light fraction separates confirm that the copper is also found as encapsulated sulfide grains trapped in silicates and as Cu++ adsorbed onto goethite, clays, and trace amounts of phyllosilicates. Petrographic analyses also confirm that the enrichment profile in the Widow Pit area represents an immaturely-developed second cycle of enrichment. Based on copper mineralogy and associated supergene mineral assemblages, this study identified that three distinct intensities of supergene development, classified here as *strong, moderate, and weak enrichment,* exist in the enrichment blanket.

8.2.1 COPPER SULFIDES IDENTIFIED IN HEAVY FRACTIONS

Figure 14 illustrates the copper sulfide mineralogic composition and paragentic relationships that comprise the different intensities and illustrates the significant mineralogic extent of enrichment. The data in Figure 14 is based on mineral count line integrations and the petrographic classification of enrichment intensity from the Copper Basin sample suite (Table 11). Figure 14 suggests that mineralogically, the moderate and weak enrichment is more extensive than strong enrichment for the weathering profile in the Widow Pit area. It should also be noted that weak enrichment extends the entire diagram except in samples with 100% chalcocite present.

Drill Hole	Interval (ft)		cc	cp	cv	en	py
PCB-04451	506	509.6	7%	0.69%			92%
PCB-04451	518.4	530.2	7.6%		0.2%		92.2%
PCB-04455	150	155	1.1%	0.12%	0.58%	trace	98.2%
PCB-04455	155	160	0.04%	0.4%			99.6%
PCB-04455	315	330	0.6%		0.7%	0.08%	98.62%
PCB-04455	330	335	5.1%	0.06%			94.84%
PCB-04455	335	370	0.6%		0.05%	0.05%	99.4%
PCB-04465	220	245		0.3%	0.20%		99.5%
PCB-04465	310	320	3%	0.05%	1.50%		95%
PCB-04465	375	400		3%			97%
PCB-04488	270	280		0.02%	0.5%		99.53%
PCB-04488	280	290	4%		1%		95%
PCB-04488	290	435	3.4%	0.2%	0.4%		96%
PCB-04488	435	500	0.8%	0.2%	tr		99%
PCB-04488	500	505	0.42%	0.25%	0.030%		99.3%
PCB-04499	195	205		0.05%	0.05%		99.90%
PCB-04499	230	250		0.05%	0.05%		99.90%
PCB-04499	250	260	0.06%	0.14%	0.06%		98.50%
PCB-04604D	145	160	1.5%	0.02%	0.48%		98%
PCB-04604D	235	240	4.3%	0.03%	0.3%	0.37%	95%
PCB-04604D	240	250	0.44%	0.48%	0.44%		98.1%
PCB-04604D	255	270	2.1%	0.70%	1.2%		96%
PCB-04604D	270	285		4.9%	1.10%		94%
PCB-04604D	360	375		1.7%	0.034%		98%
PCB-04604D	375	400		1.60%	0.04%		98% (po&py)
PCB-04618	88.4	91.4'			0.1%		99.9%
PCB-04618	91.4	96.3'	0.12%	0.15%	0.09%		99.55%
PCB-04618	523	664.6'	3%	0.03%	0.03%		96.94%
PCB-04618	664.6	686'	0.09%	0.09%			99.82%
PCB-04691	165	190			0.4%		99.9%
PCB-04691	190	205	0.3%	0.05%	0.95%		98.7%
PCB-04691	290	295		0.7%	0.1%		99.2%
PCB-04691	300	330		1.3%	0.12%		98.5%
PCB-04691	370	375		1.1%	0.6%		98.3%
PCB-04691	375	400		5.8%	0.37%		94%
PCB-04836	300	310	< tr.	0.04%	0.30%		99.75%
PCB-04836	325	360		0.08%	0.04%		99.88%
PCB-04836	430	455		2.9%	0.10%		97%
PCB-04836	455	470	0.04%		0.12%		99.84%
PCB-04836	470	500	3%		0.4%		96.3%

Table 12: Summary of petrographic line integration findings.

These observations support the classification of the Copper Basin enrichment profile as incipiently developed; conversely, in a well-developed enrichment system one would expect the intensities and extent of enrichment to be approximately distributed as in Figure 15.

- <u>Section 1:</u> represents the upper portion of the enrichment zone consisting of dominantly chalcocite, indicating a strong Cu++-rich mineralizing supergene solution.

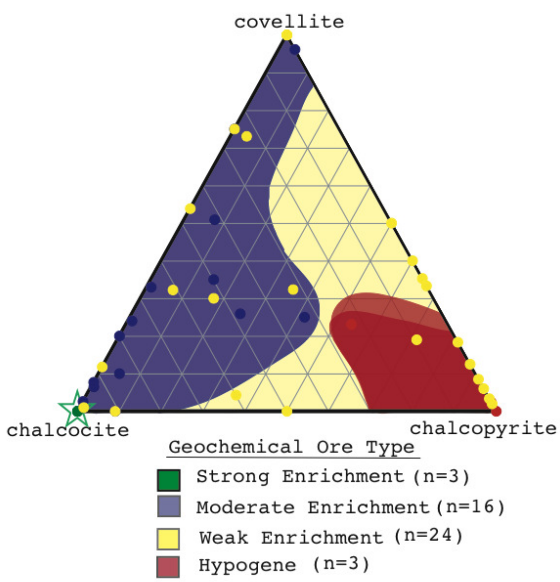


Figure 14: Ternary diagram illustrating the copper sulfide mineralogic composition and paragentic relationships that comprise the different intensities and the extent of enrichment. This diagram shows that moderate and weak enrichment is more extensive than strong enrichment. Dots show the petrographic and geochemical assay characterization of Copper Basin samples; the apparent overlap in sample classification is the result of paragenetic versus copper recovery considerations, but the overall classification scheme shows where samples would be placed based on copper mineral ratios. Note that weak enrichment extends the entire diagram except in samples with 100% chalcocite.

- <u>Section 2:</u> represents the middle portion of the enrichment zone consisting dominantly of chalcocite and covellite, indicating a moderately Cu++ - rich solution.

- Section 3: represents the lower portion of the enrichment zone consisting of covellite and hypogene chalcopyrite that transitions into the hypogene zone, indicating an impoverished Cu++ - bearing solution.

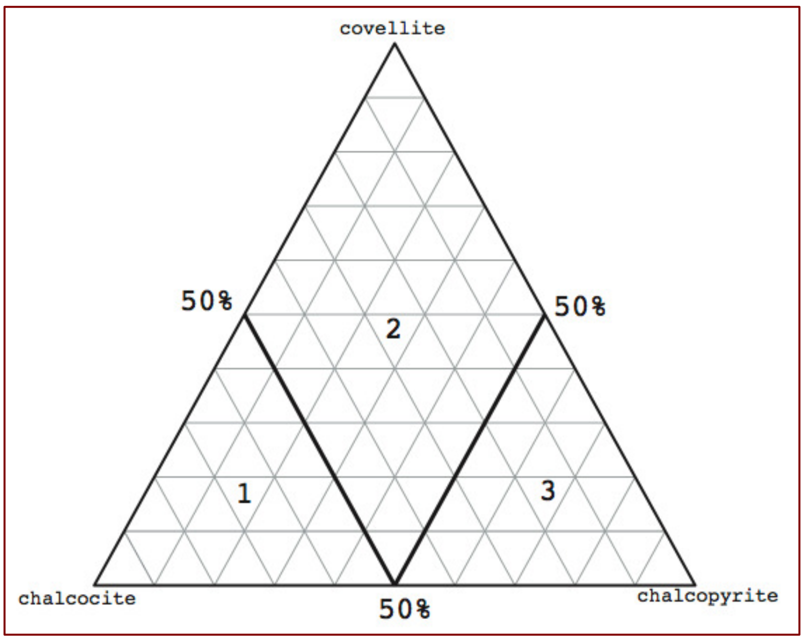


Figure 15: Ternary diagram illustrating the copper sulfide mineralogic composition that one would expect to reflect different intensities and extent of supergene enrichment. Section 1 describes the upper portion of the enrichment zone consisting of dominantly chalcocite, indicating a strong Cu++-rich solution. Section 2 describes the middle portion of the enrichment zone consisting dominantly of chalcocite and covellite, indicating a moderate Cu++ - rich solution. Section 3 describes the lower portion of the enrichment zone consisting of covellite and chalcopyrite that transitions into the hypogene zone, indicating an impoverished Cu++ - bearing solution.

Although chalcocite, covellite, and chalcopyrite were the main copper sulfides identified during this study, also identified within the supergene enrichment zone is spionkopite ($Cu_{1.4}S$). Copper sulfide species previously identified at Copper Basin are: chalcocite, digenite, geerite, spionkopite, yarrowite, and covellite (McComb, 2008; McComb, 2007, McComb, 2006).

8.2.2 COPPER SULFIDES IDENTIFIED IN LIGHT FRACTIONS

Petrographic and SEM analyses identified copper sulfides encapsulated in kaolinite, illite, and phyllosilicates grains, as illustrated in Figures 16; this encapsulation very likely influences the leachability of the copper sulfides by reducing the exposed surface area available to react with leach solutions, not allowing the Cu++ to be liberated from sulfides and gangue mineral(s). Through the six samples that were analyzed using XRD, SEM, and microprobe analyses, quartz, muscovite, illite, kaolinite, ± mixed layer clays were identified in the light fractions for the majority of the samples.

The light fractions of seventeen heavy liquid sample separates were re-assayed to determine whether the intervals contain leachable copper. Petrographic and analytical assay data indicate that copper sulfides remain as encapsulated inclusions that may not be available for liberation and thus reduce the overall leachability of the total copper.

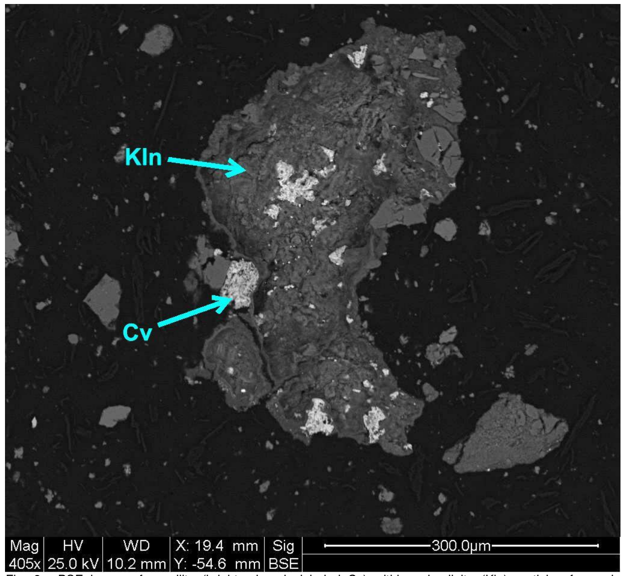


Figure 16: Backscatter electron image of covellite (bright minerals labeled Cv) within a kaolinite (Kln) particle of a sample from around the Widow Pit indicating copper sulfide encapsulation (Thogerson, 2012).

8.3. FE OXIDES – GOETHITE DOMINANT

Petrgraphic analyses suggest that several sample intervals originally classified by the Copper Basin geologic team as "Enriched" based on total contained copper, show no copper sulfides within heavy fractions separates. Although no copper sulfides were identified, there exist abundant iron oxides, specifically goethite within these sample intervals. With the help of microprobe, SEM, and petrographic analyses it is concluded that goethite contains adsorbed copper (e.g., Drever, 1997), representing the contained copper in these "Enriched" samples. Petrographic and assay results indicate that the copper adsorbed the goethite is significant and is leachable.

During petrographic analyses the iron oxides were identified as being dominant (>70% iron oxides), abundant (≈50% iron oxides), trace (<10% iron oxides) or "none noted". Figure 17 shows the varying abundance of iron oxides and copper grade as total contained copper wt.%. Generally speaking, the overlapping data values suggests the amount of iron oxides is not influencing overall copper grade, specifically for the enrichment and hypogene zone, because the main copper bearing phase influencing the copper grade is generally, copper sulfides. However, the main copper bearing mineral phase is iron oxides, especially goethite, in the partially leached zone and thus we would expect iron oxides to influence copper grade.

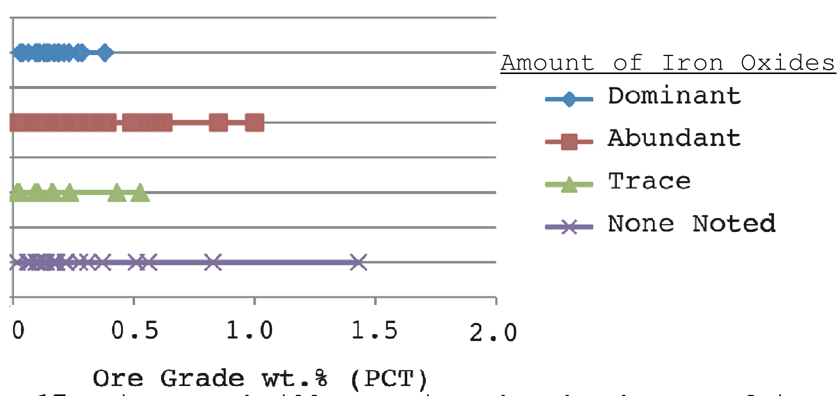
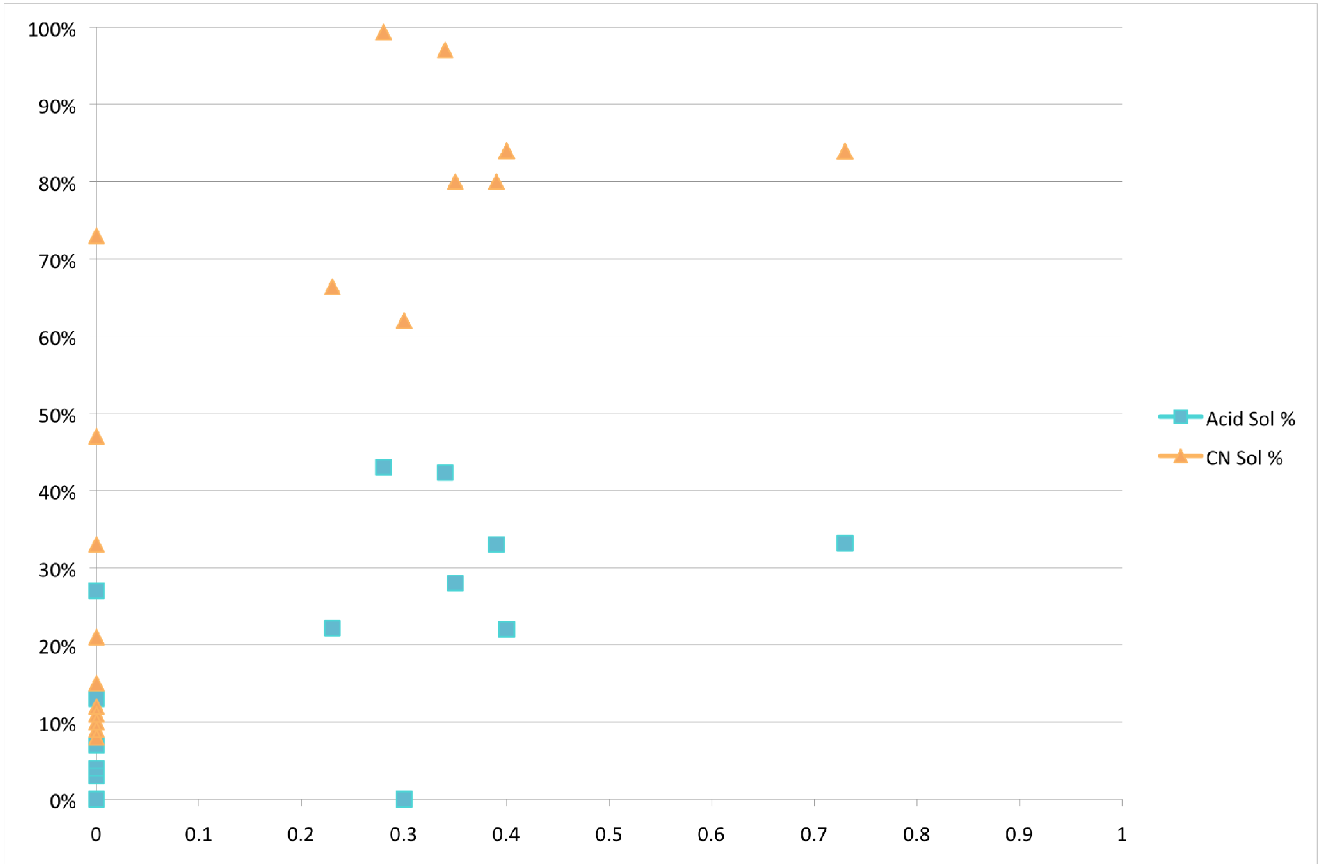


Figure 17: Line graph illustrating the abundances of iron oxides versus copper grade in heavy separates. It is observed that the amount of iron oxides does not influence overall copper grade. Dominant (n=19), Abundant (n=45), Trace (n=13), and none noted (n=21).

8.4 COPPER-BEARING CLAYS

Analytical tests found that kaolinite contains more total copper than illite, yet no correlation was shown between increasing amounts of kaolinite or illite with increasing copper leachability in the study of clay-dominant mineral samples conducted by NMS staff, as illustrated in Figure 18 and 19. However, further work is needed to quantify the significance of the copper-bearing clays to the overall bulk composite sample, because the previous study was conducted with core samples consisting dominantly of clay minerals not bulk composite samples like the current study. Using data from this previous study it is inferred that, in this study, no correlation would be found within increasing copper recovery and wt.% of copper within kaolinite or illite in the overall bulk composite sample because no correlation was found in the clay-dominant samples from the NMS study. This suggests it is less likely that there will be a correlation between the amount of copper-bearing clay minerals present in the bulk composite samples with copper grade and copper recovery.

Weight-% Cu Associated with Kaolinite



Copper Recovery (%)

Figure 18: Weight percentage of copper associated with kaolinite versus copper recovery. No apparent correlation is recognized that as total copper values increases so does copper recovery.

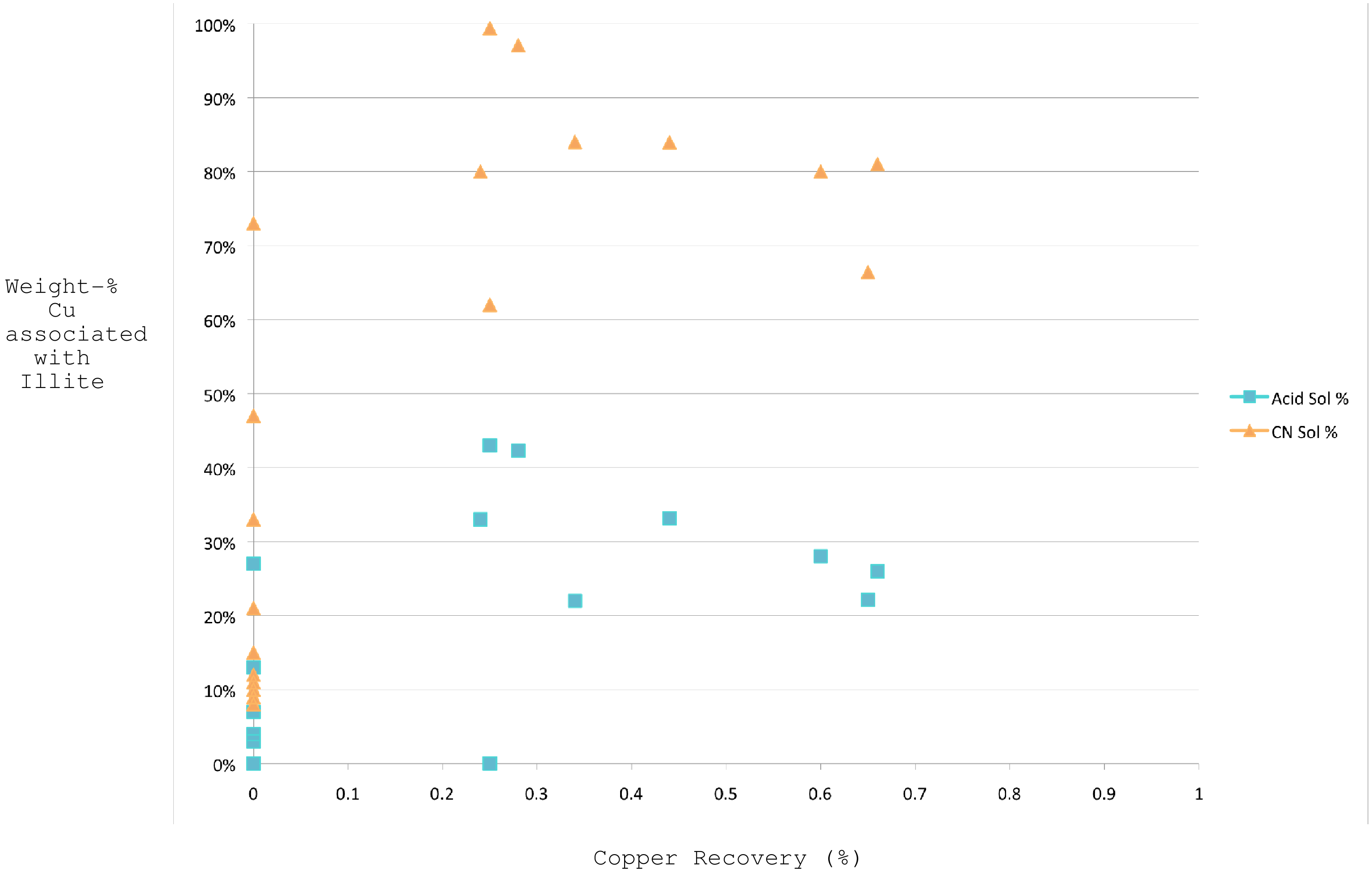


Figure 19: Weight percentage of copper associated with illite versus copper recovery. No correlation was identified that as total copper values increases so does copper recovery.

8.5 SOLUBLE COPPER ASSAY TESTS & LEACHABILITY

8.5.1 ACID SOLUBLILTY

Generally speaking, the leach solution used in the acid solubility analytical assay test was thought to dominantly dissolve copper sulfides (Dietrich, 2011). Acid solubility values are influenced by copper mineralogy, but the copper sulfide minerals quantified in this study are not the only copper present and thus does not greatly influence the acid solubility variation as originally anticipated. In this study and previous work it was concluded that copper attributed to goethite and copper-bearing clays are recoverable using the leach solution associated with acid solubility.

Figure 20 illustrates copper sulfide mineralogy corresponding to varying acid solubility values. The diagram shows us that chalcocite is not the most acid leachable copper sulfide as originally expected. On average the most abundant solubility range (20 to 29%) consists of abundant chalcocite and covellite, indicated by the yellow data points. As expected the chalcopyrite dominant sample had an acid solubility range of 0-9% as seen in Figure 20.

SEM/MLA work conducted by Mark McComb (2008) indicate that the variations in copper acid solubility values are attributed to the differences in copper distribution among copper-bearing phases, and are not necessarily attributable to variable copper sulfide minerals. He found that:

- *54% of kaolinite and muscovite-bearing samples* yielded an *acid solubility of 66%.*
- *33% of non-smectite clays* and 50% of the copper attributed to chalcocite and covellite reduced the *acid solubility to 38%.*
- *90% covellite and chalcocite* yielded an *acid solubility value of 21%*, this is similar to the average acid solubility and mineralogy in the Enrichment Zone at Copper Basin, as illustrated in Figure 23.
- *84% copper in chrysocolla and non-smectite clays* yields an *acid solubility of 81%*.
- 60% smectites yield a 3% acid solubility.
- copper was attributed in iron-oxides and muscovite with an acid solubility range of 27% (0.56% total Cu by MLA) to 59% (1.67% total Cu by MLA).

These results, along with the results from the current study suggest that other sources of copper may be providing greater copper recoveries than simply theses provided by copper sulfides.

The Partial Leach zone, comprising goethite hosting adsorbed copper, has similar acid solubility ranges to that of Enrichment Zone samples having variable total contained copper. The Partially Leach Zone nonetheless contains a significant amount of copper and thus is considered of economic interest.

Figure 21 illustrates the correlation between copper grade and copper acid solubility. The general correlation demonstrated is what is expected considering that Strong Enrichment is characterized by significant chalcocite, which generally leaches more rapidly and completely than covellite and chalcopyrite assemblages.

As illustrated in Figures 22 (Moderate Enrichment) and 23 (Weak Enrichment), copper grade appears to have no influence on copper acid leachability; this is likely because of the intermediate copper sulfide phases covellite and chalcopyrite and their varying acid solubility values, and possibly the masking by encapsulation, copper adsorbed on to goethite, and copper-bearing clays.

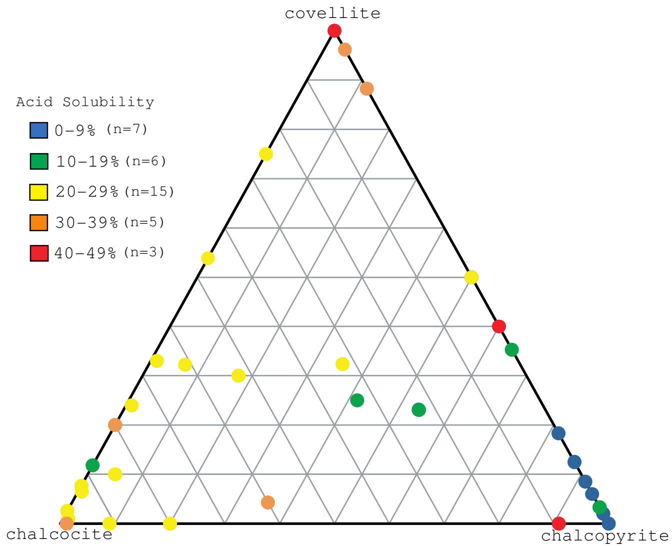
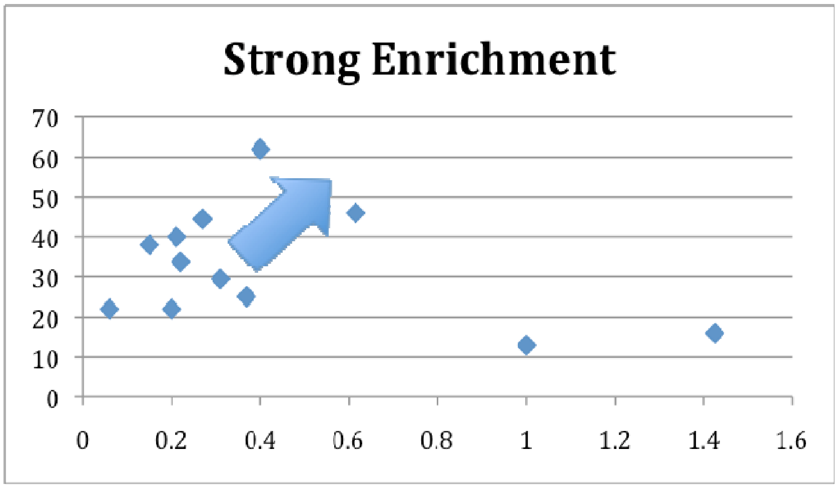


Figure 20: Ternary diagram illustrating copper sulfide compositions corresponding to varying acid solubilities. This figure illustrates copper sulfide mineralogy corresponding to varying acid solubility vales, which illustrates that chalcocite-bearing ores are not the most acid leachable copper sulfide as originally expected. On average, the mean acid solubility of ores containing significant chalcocite ranges from 20 to 29%. As expected the chalcopyrite dominant sample had an acid solubility range of 0-9%.

Figure 24 shows the varying abundance of copper content of iron oxides and acid solubility. The amount of iron oxides does not influence acid solubility, which is indicated by the overlapping values corresponding to varying abundances in Figure 25.

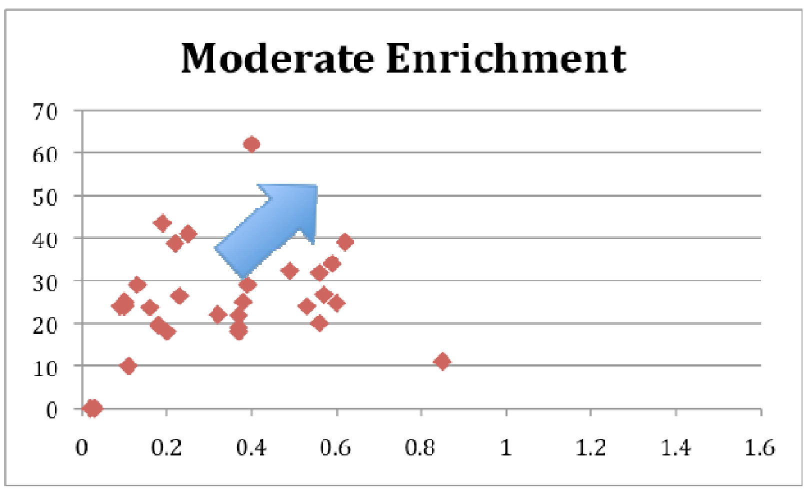
Copper
Acid
Solubility
(%)



Copper Grade (wt. % Cu)

Figure 21: Acid solubility versus copper grade representing data values from strong enrichment. As the copper grade increases so does the acid solubility.

Copper
Acid
Solubility
(%)



Copper Grade (wt. % Cu)

Figure 22: Acid solubility versus copper grade representing data values from moderate enrichment. The copper grade has no influence on acid leachability, which could be due to the intermediate copper sulfide phases covellite and chalcopyrite and their varying acid solubility values, and possibly the masking by encapsulation, copper adsorbed on to goethite, and copper-bearing clays.

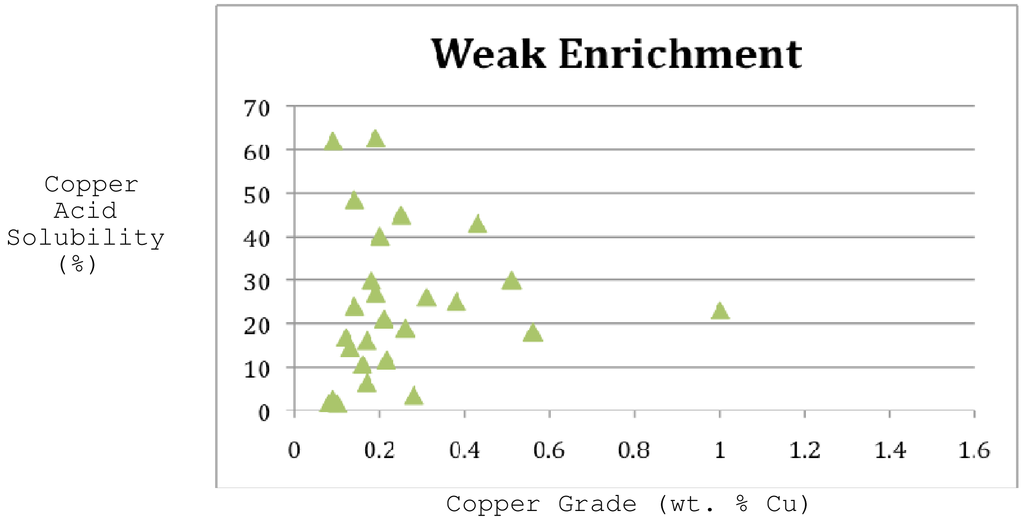


Figure 23: Acid solubility versus ore grade representing data values from weak enrichment. The ore grade has no influence on acid leachability, which could be due to the intermediate copper sulfide phases covellite and chalcopyrite and their varying acid solubility values, and possibly the masking by encapsulation, copper adsorbed on to goethite, and copper-bearing clays

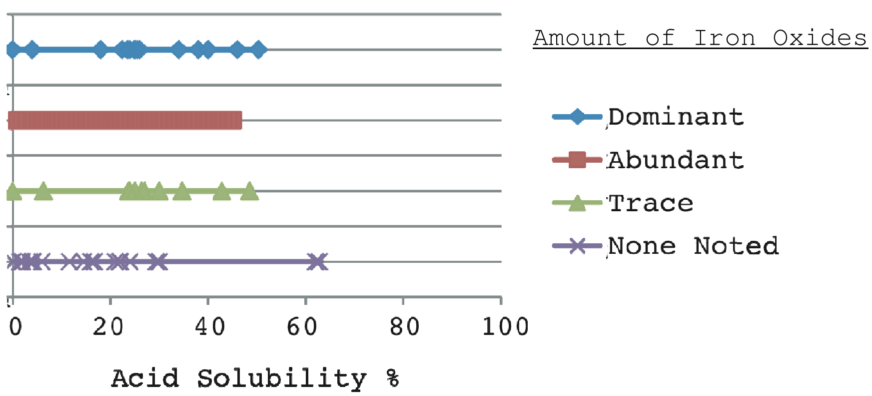


Figure 24: Line graph illustrating the abundances of iron oxides in correlation to copper acid solubility (%). The amount of copper content of iron oxides does not influence acid solubility, which is indicated by the over lapping values corresponding to varying abundances. Dominant (n=19), Abundant (n=45), Trace (n=13), and none noted (n=21).

8.5.2 CYANIDE SOLUBILITY

Although cyanide solubility values have been studied in greater detail when compared to acid solubility and

QLT, according to Baum, 1996, sodium cyanide is probably the worst lixivant that could be used as a diagnostic test for copper ores because the higher concentrations of cyanide solutions tend to solubilize a greater range of gangue, oxide, and sulfide minerals than the other tests. This can mislead the reviewer because it is not the best representation when trying to identify ferric leachable copper (oxidized sulfur) such as chalcocite and/or covellite (Baum, 1996). Even though it is not the best solubility test used to better understand the mineralogy within the sample it is often used in production to recovery copper.

Although there is some data clustering consisting of dominantly chalcopyrite ranging from 50 to 59% cyanide solubility indicated in blue, generally speaking, Figure 25 indicates that copper sulfide mineralogy does not influence cyanide leachability.

The lack of correlation illustrated in Figure 26 to 28 suggests that there is no relationship between increasing ore grade and cyanide solubility. Unfortunately, the current study is unable to provide a further geochemical explanation of why there is no correlation between increasing ore grade and cyanide solubility.

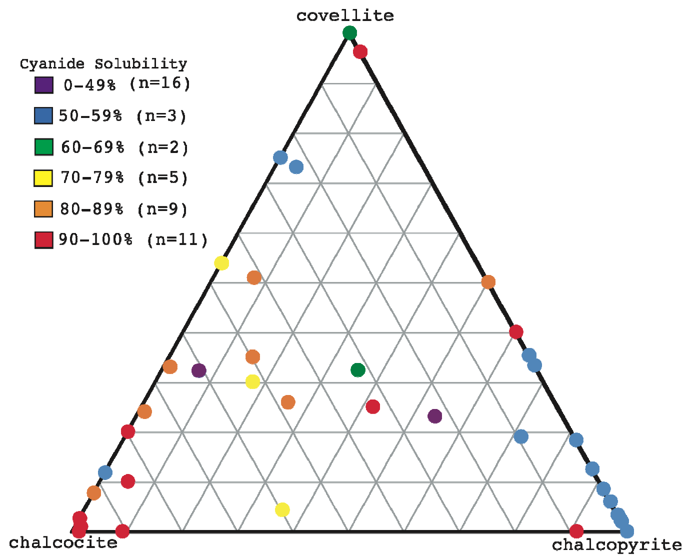


Figure 25: Ternary diagram illustrating the different copper sulfide composition corresponding to varying cyanide solubilities. Although there was some data clustering consisting of dominantly chalcopyrite overall, this figure indicates that copper sulfide mineralogy does not influence cyanide leachability.

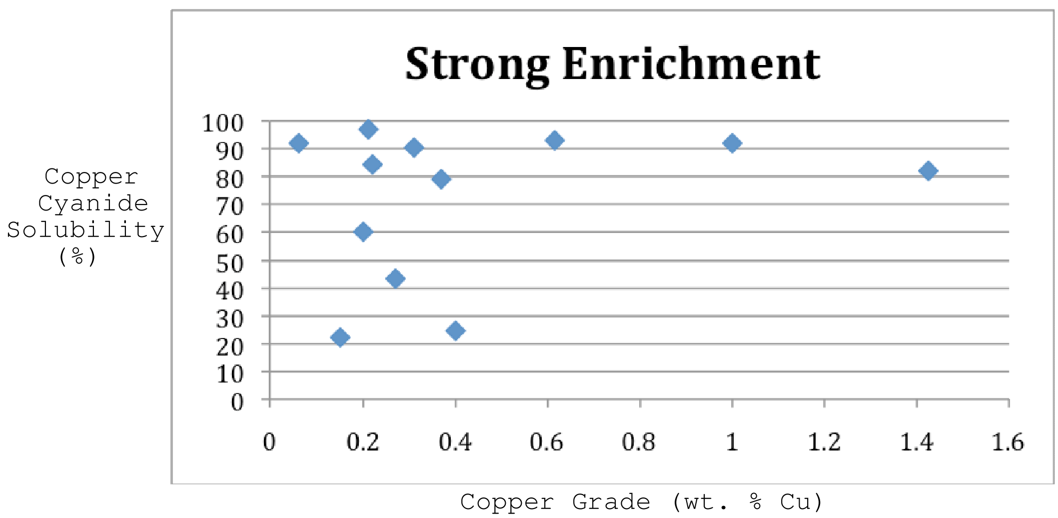


Figure 26: Cyanide solubility versus copper grade representing data values from strong enrichment. The copper grade has no influence on cyanide leachability.

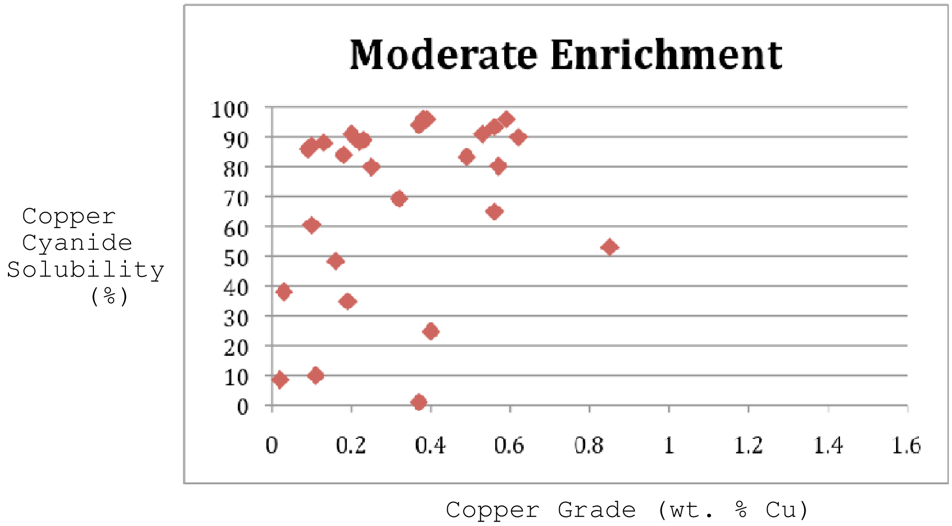


Figure 27: Cyanide solubility versus copper grade representing data values from moderate enrichment. The copper grade has no influence on cyanide leachability.

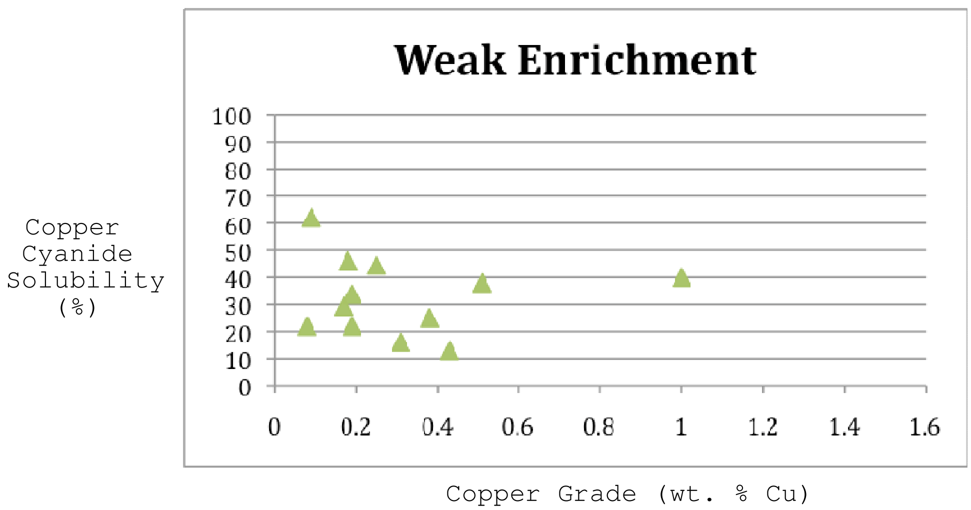


Figure 28: Cyanide solubility versus copper grade representing data values from weak enrichment. The copper grade has no influence on cyanide leachability.

Figure 29 shows the varying abundance of iron oxides and cyanide solubility. The overlapping data values indicates that the amount of copper content of iron oxides does not influence cyanide solubility, which for cyanide leach solution one would expect that the amount of iron oxides could influence cyanide solubility because the leach solution for this test.

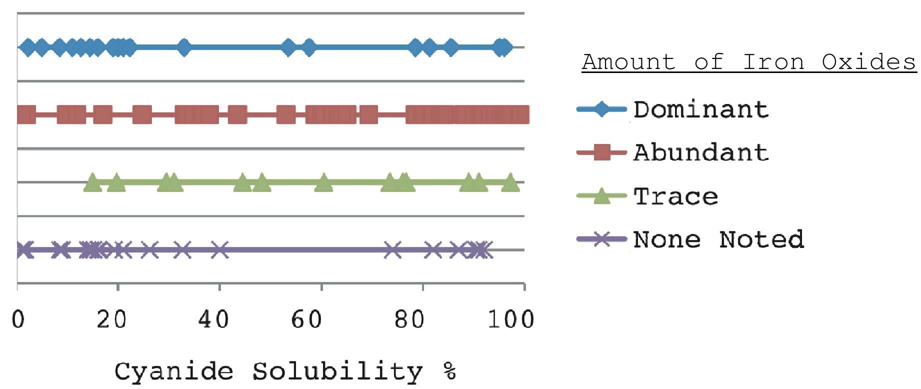


Figure 29: Line graph illustrating the abundances of iron oxides versus cyanide solubility (%). The overlapping values indicate that the amount of copper content of iron oxides does not influence cyanide solubility. Dominant (n=19), Abundant (n=45), Trace (n=13), and none noted (n=21).

8.5.3 QUICK LEACH TEST (QLT)

The Quick Leach Test (QLT) is used to estimate copper solubility in a dump leach environment, utilizing bacterial oxidation (Skyline, 2011). In this study, the classification of supergene enrichment is defined generally by copper sulfide mineralogy, supported by QLT data values, as illustrated in Figure 30. Figure 30 shows that higher QLT values are associated with dominant chalcocite and covellite samples, whereas lower QLT values represent samples containing greater covellite plus chalcopyrite. This suggests that as the amount of copper attributed to copper sulfides increases so does its leachability. Note that this is the only test out of the three to potentially provide a range for varying copper sulfides. Unfortunately, the current study is unable to provide a further geochemical explanation of why this test is better at predicting copper sulfide mineralogy when compared to the other tests.

Figure 31 shows that for Strong Enrichment, copper grade has no influence on recovery; thus, QLT values stay constant. Whereas, Figure 32 and 33 illustrates that moderate and weak enrichment is influenced by copper grade, thus QLT values increase.

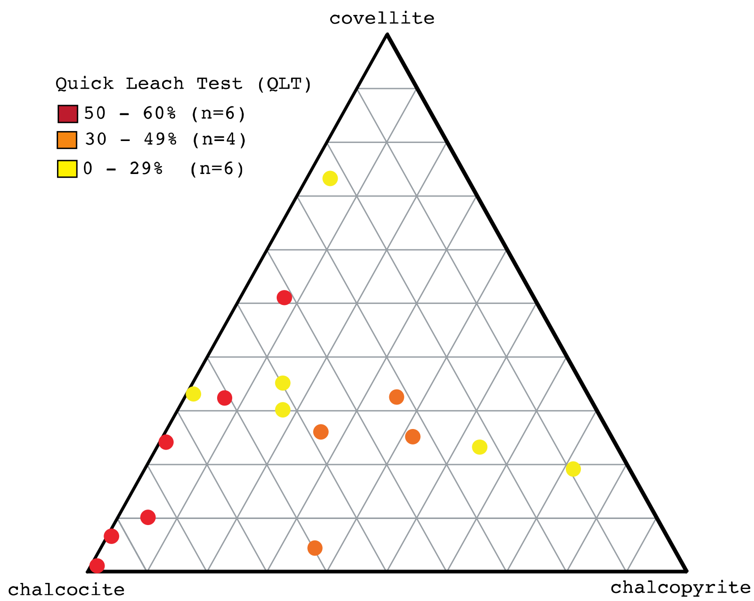


Figure 30: Ternary diagram illustrating copper sulfide composition corresponding to varying QLT values. This diagram shows that higher QLT values, ranging from 50 to 60% copper recovery consist of dominantly chalcocite and covellite, where as the lower QLT values ranging from 0 to 49% consist of more covellite and chalcopyrite than chalcocite. This indicates that as the amount of copper attributed to copper sulfides increases so does its leachability.

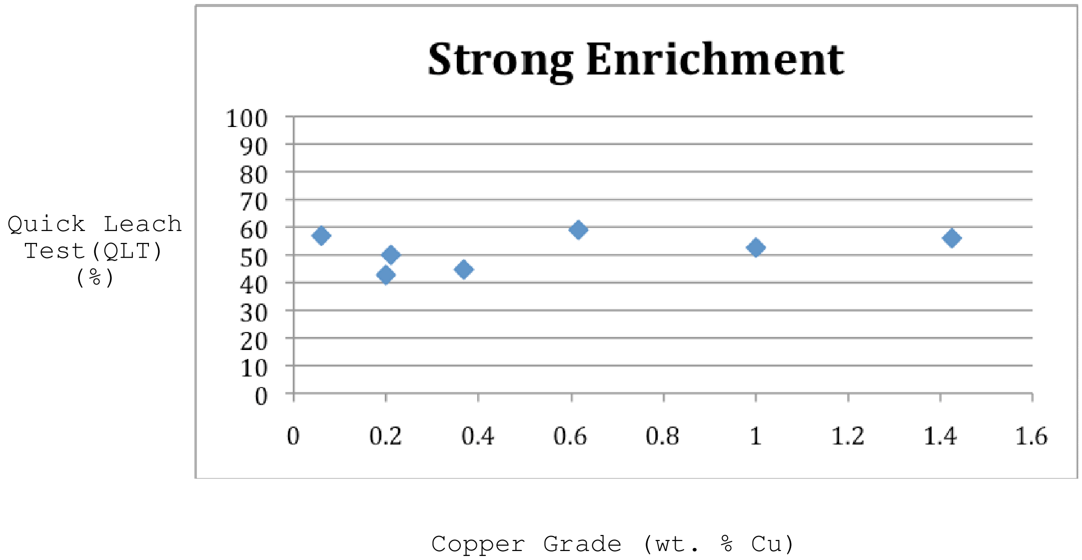


Figure 31: Quick Leach Test (QLT) solubility versus copper grade representing data values from strong enrichment. As the copper grade increases the leachability is constant.

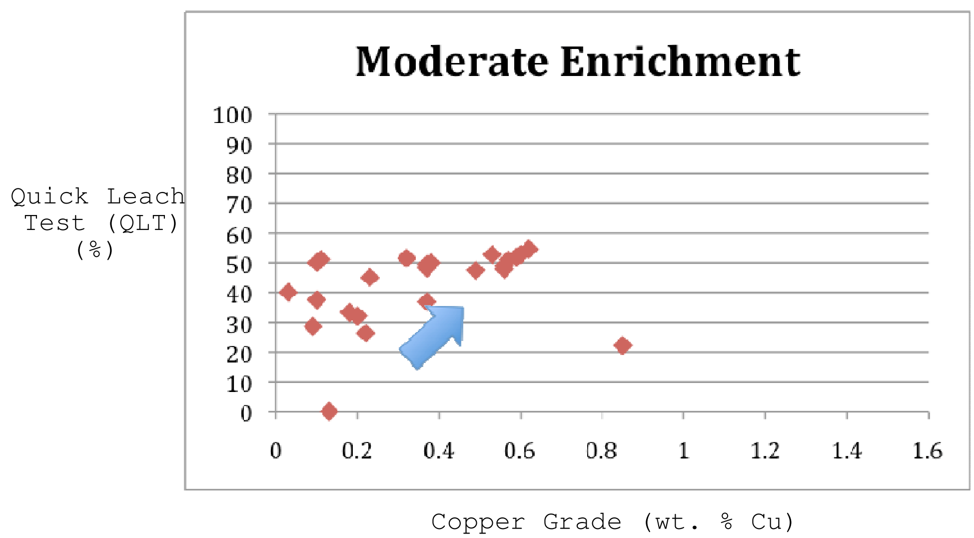


Figure 32: Quick Leach Test (QLT) solubility versus copper grade representing data values from moderate enrichment. As the copper grade increases so does the leachability.

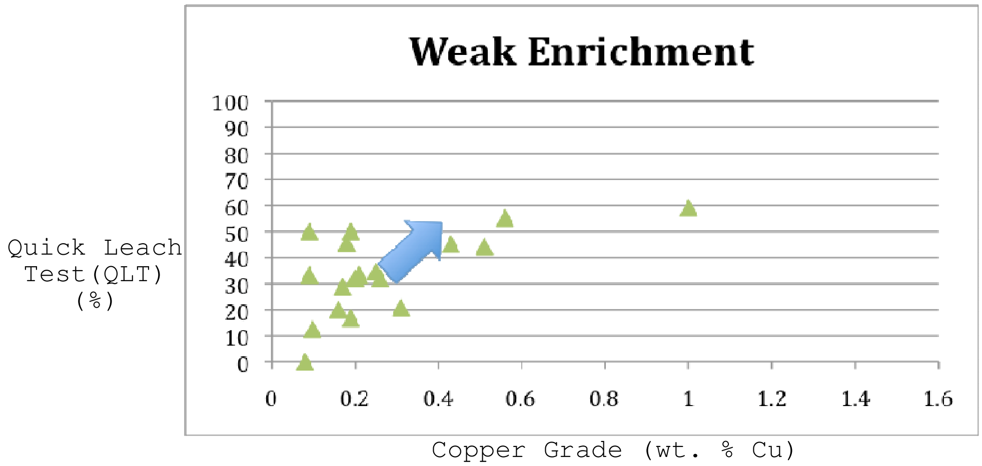


Figure 33: Quick Leach Time (QLT) solubility versus copper grade representing data values from weak enrichment. As the copper grade increases the leachability is constant.

Figure 34 shows the varying abundance of iron oxides and Quick Leach Test (QLT). The overlapping values indicate that the amount of copper content of iron oxides does not influence cyanide solubility.

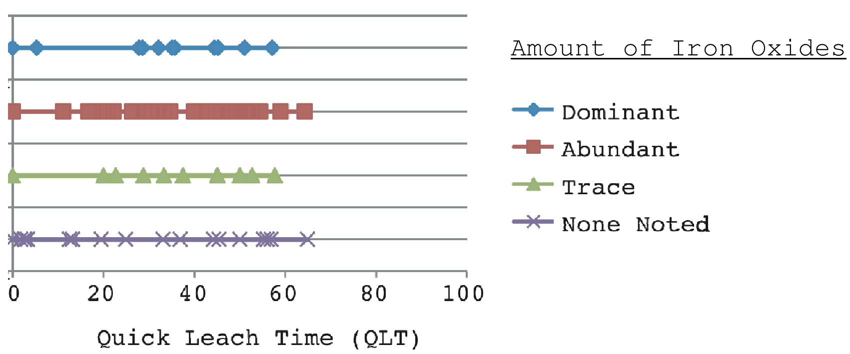


Figure 34: Line graph illustrating the abundances of iron oxides in correlation to Quick Leach Time (QLT). The overlapping values indicate that the amount of iron oxides does not influence QLT. Dominant (n=19), Abundant (n=45), Trace (n=13), and none noted (n=21).

8.6 CROSS-SECTIONS

Data from the petrographically determined ore classes were plotted on cross section to examine the spatial distribution of the supergene enrichment at Copper Basin.

Nine drill holes were selected which are located on the south-north cross-section illustrated in Figure 35. The Copper Basin geologic team identified several structural features between PCB-04691 and PCB-04482. After mapping out the copper ore zones it was noted in this study that this region represents a horst and graben structural feature. The cross-section indicates that the supergene enrichment profile is variably and weakly developed.

Six drill holes were selected which are located on the east-west cross section in Figure 36. The cross-section indicates that this supergene enrichment profile is weakly developed but illustrates less structural features as illustrated in the north-south cross-section.

When compared to the Copper Basin geologic model of the two-crossectional regions outlined in this study, the enrichment zone varied. On the South-North cross section the Copper Basin geologic team noted several perched enrichment zones where as, this study identified and interpreted this region as a horst and graben structural feature. On the West-East cross section the Copper Basin geologic team noted another perched enrichment zone between PCB-04451 and PCB-04482, but unfortunately no drill hole samples were collected within this region and thus, it was not identified in this study’s geological cross section.

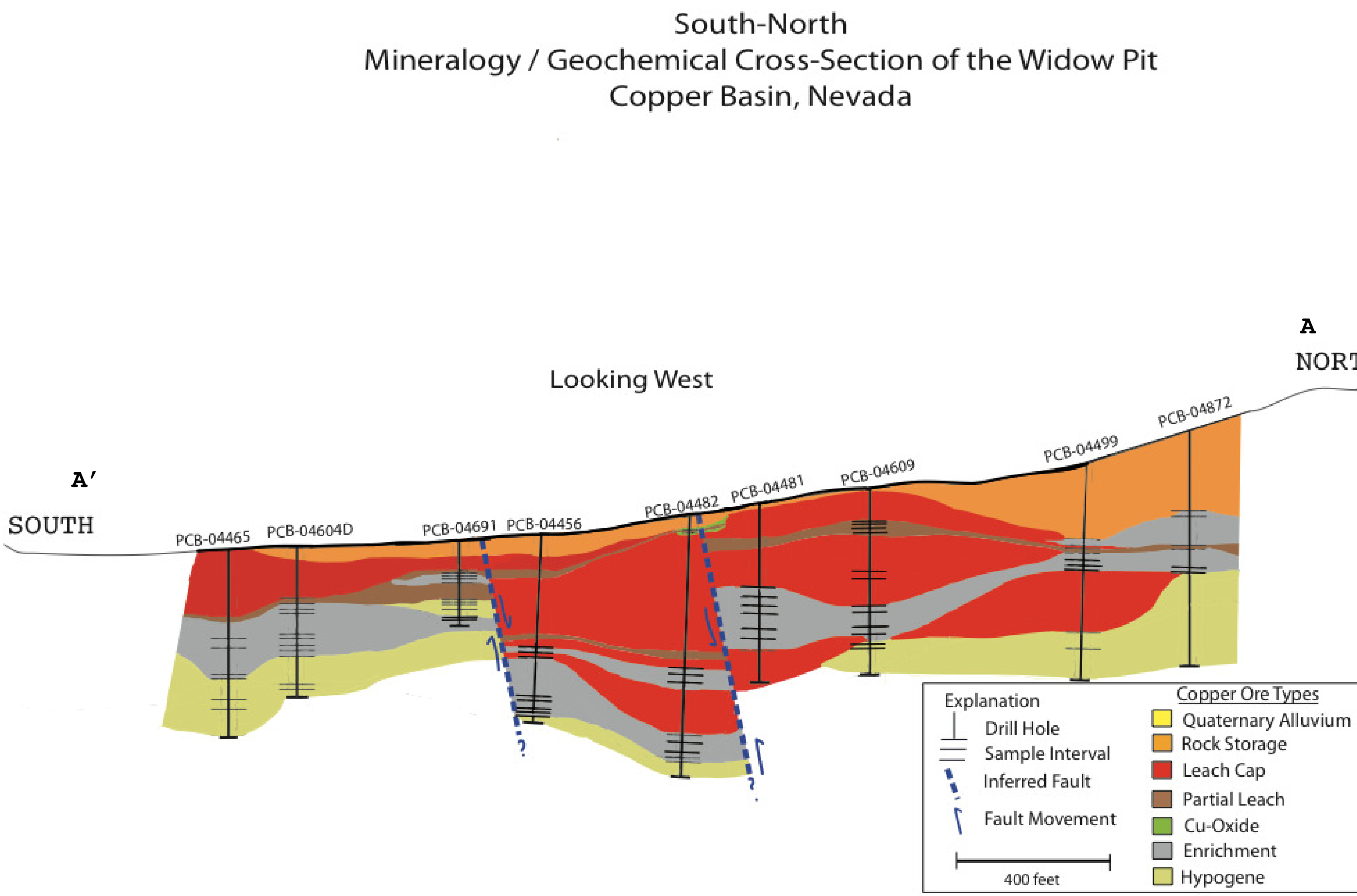


Figure 35: South-North cross section illustrating the mineralogy and geochemistry of the supergene enrichment profile of the Widow Pit, Copper Basin, Nevada.

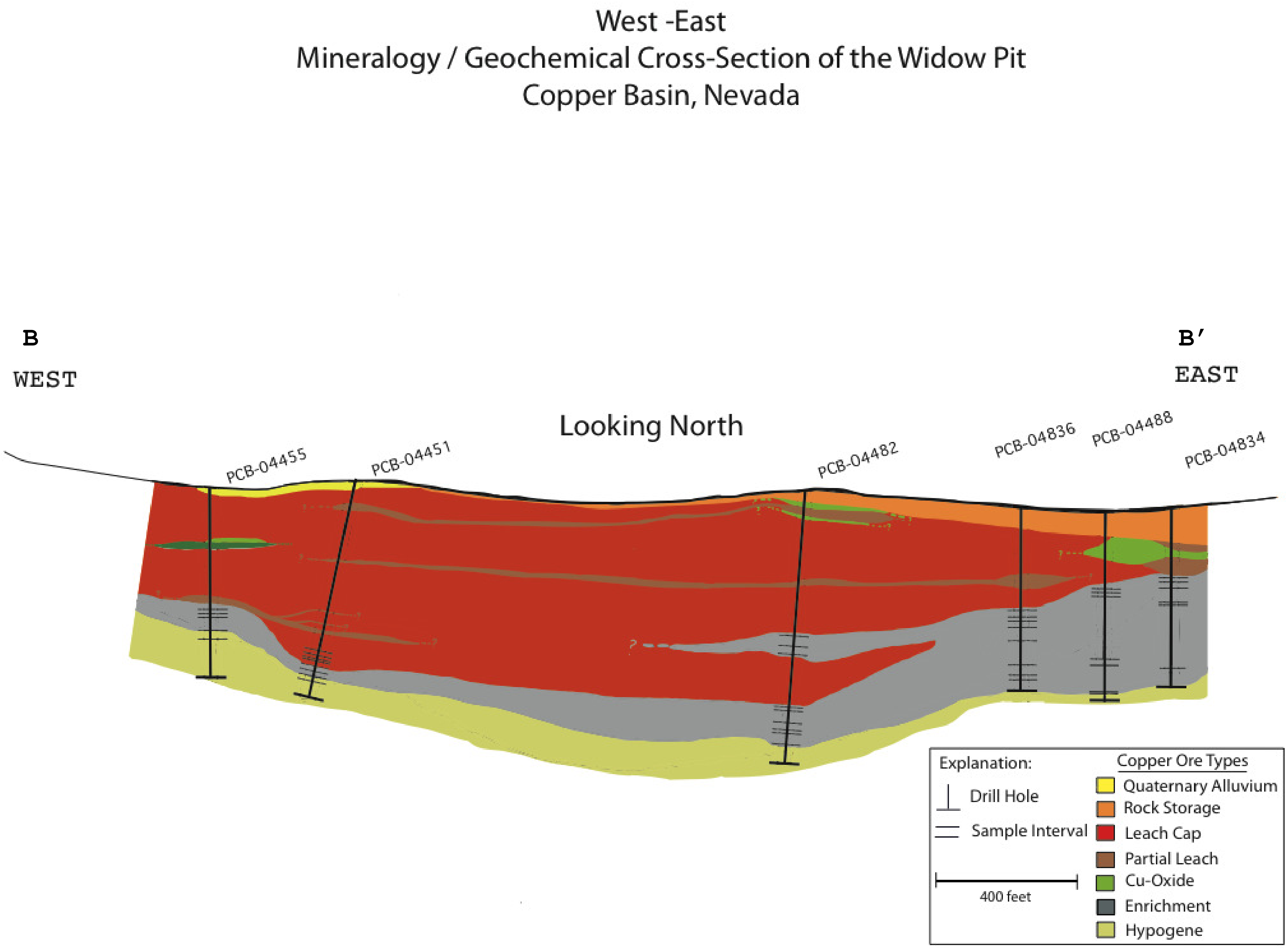


Figure 36: West-East cross section illustrating the mineralogy and geochemistry of the supergene enrichment profile of the Widow Pit, Copper Basin, Nevada

9. RECOMMENDATIONS

9.1 Connect current logging system to include new methodology.

Table 12 summaries the original copper ore classification and this studies geochemical ore classification. The main area where there was the most variation between the two ore classifications was the *Partially Leach and Enrichment* zone, which is expected considering the geochemical ore classification parameters have been slightly different for the current geochemical study.

Copper Basin Geologic Ore Classification		**Geochemical Ore Classification**	
Leached Cap	6	Leached Capping	7
Partial Leach	19	Partially Leached	13
Enriched	59	Strong Enrichment	14
		Moderate Enrichment	31
		Weak Enrichment	22
Hypogene	15	Hypogene	12
Total	99	*Total*	99

Table 13: Summary of the original copper ore classification and this studies geochemical ore classification.

Also, based on Newmont's Phoenix copper ore classification, *"True Enrichment"* has been identified at the Phoenix mill by the presence of chalcocite, significant total copper, and less than 5% iron oxides. Geochemically, the *Enrichment* ore mineralogy of the samples collected within Widow Pit is characterized by chalcocite replacing pyrite and +/- iron oxides greater than 5% iron oxides, which would be considered as leach-grade ore according to the Phoenix logging protocol. There are six samples that contained less than 5% iron oxides, which would be classified as “true” Enrichment according to the Phoenix copper ore classification and would be considered mill-grade ore.

Based on Newmont’s current copper ore classification, the partial leach zone is characterized by the presence of iron oxides, plating copper when saturated with acid, contains trace relic sulfides, and trace copper oxide. Petrographic analyses of the Partial Leach zones have concluded that geochemically they should be classified as an enrichment zone because of the abundant copper sulfides. This study reclassified the Partial Leach zone as containing significant total copper (>0.15%) that is present adsorbed to iron oxides dominantly as goethite.

With the conclusions made in the current study, it is recommended that the Copper Basin geologic team slightly modify their current ore classification to more specifically classify the geochemical difference between Partially Leached, Enrichment, and “true” Enrichment. This recommendation is contingent on the findings of the metallurgical column tests that are in the process of being analyzed. If the results come back without issues with the current logging procedure this recommendation may not be necessary.

9.2 Quantify the abundance and identify paragentic relationship of illite and kaolinite.

As discussed in previous sections, this study was unable to quantify the abundance of illite and kaolinite associated with the composite bulk sample to understand the significance of copper within the clay bearing phases. With the conclusion of this study it is recommended to conduct grain size analyses on bulk composite samples and a petrographic analyses study on a small sample set of five to ten thin sections. The purpose of the study would be to identify the paragentic relationships of illite, kaolinite, and other gangue minerals in the various ore zones hosting the minerals. The paragenetic sequence could potentially explain the timing and nature of the copper sulfide encapsulation. If the timing and nature of the encapsulation copper sulfides within the clay minerals is identified, they may be able to find a method that could increase the liberation of the copper from the encapsulation in the gangue minerals.

Grain size analyses will help identify the abundances of clays in the overall sample and a QEM scan analyses could help identify where within the clay material the copper is being held up within.

9.3 Isolate iron oxides and conduct small batch tests on the fractions to track and identify leachability patterns.

By isolating iron oxides from sample intervals that have been classified as geochemically *Partially Leach*ed to identify if and how the iron oxides (goethite) are influencing the leachability of the batch. During the assay tests it is recommended to track the pH levels during the test run, and any chemical changes of the minerals throughout the leaching process. Through ph-Eh studies we know that iron oxides should not be affecting the overall leach solution but there are additional geochemical processes occurring that can not be explained during the current study. An isolated batch test might be able to answer the unanswered questions in the current study.

9.4 Identify silicate gangue mineralogy for potential reagent consumption and leaching kinetics.

With the abundant amount of pyrite, overall leachability values should be much higher. No potential reagent consumers were identified in the samples collected in the Widow Pit that would explain potential acid consumption within the bulk composite samples, but a thin section study could provide a proper assessment of the silicate gangue mineralogy.

9.5 Investigate other potential factors that could be controlling copper leachability, such as host rock lithology, alteration assemblages, and/or structural components.

The affect of lithology, alteration assemblages, and/or structural components were reviewed in the current study but were not thoroughly quantified. It is recommended that a Newmont database-extraction be run to pull out all of the lithology, descriptions with corresponding sample interval assay analytical data. Separate data-extractions are recommended to also understand the control of varying alteration assemblages and structural components.

10. CONCLUSION

The original purpose of this study was to identify copper sulfide mineral phases in the enrichment profile at Copper Basin and outline the leachability ranges using the following analytical solubility tests: total copper, acid solubility, cyanide solubility, and Quick Leach Test (QLT). It was soon clear that although there is a simple mineralogy suite, relating the mineralogy to leachability became more complex, which hindered accuracy.

Results from this study have shown that copper is present adsorbed on goethite, copper sulfides as isolated grains and encapsulated as inclusions in gangue minerals, and within the lattices of clay minerals. The intergrowths, particle size, and encapsulation directly influence the previously expected copper solubility and recovery values.

In conclusion, the copper sulfide mineralogy present at Copper Basin alone can not be used to predict potential leachability because of the complex mineralogic relationships but by using assay analytical data and correctly identifying the mineralogy it is possible to better classify the complex copper ore mineralogy and corresponding copper ore types.

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