

# Volcanogenic polymetallic massive sulfide deposits (VMS) of the Carolina Terrane in central North Carolina: New perspectives and historical reports and data from the files of Phelps Dodge Exploration East (1975-1982)

By

Robert J. Moye<sup>1</sup>

Jeffrey C. Reid<sup>2</sup>

David F. Lee<sup>3</sup>

<sup>1</sup>Consulting Geologist

<sup>2</sup>North Carolina Geological Survey

<sup>3</sup>Wake Stone Corporation

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# Volcanogenic polymetallic massive sulfide deposits (VMS) of the Carolina Terrane in central North Carolina: New perspectives and historical reports and data from the files of Phelps Dodge Exploration East (1975-1982)

By Robert J. Moyer<sup>1</sup>, Jeffrey C. Reid<sup>2</sup>, and David F. Lee<sup>3</sup>

## Foreword

This report documents the volcanogenic massive sulfide deposits (VMS) drilled during past exploration. It also documents the results of the Phelps Dodge Exploration East's exploration 1975-1982 program to make those results available to future exploration geologists interested in the potential for VMS discoveries in North Carolina's Piedmont. This report contains exploration reports, geologic maps and cross sections, results of diamond drill coring, core descriptions, and analytical data. **We gratefully acknowledge Freeport-McMoran's permission to publish these Phelps Dodge Exploration's data including that acquired from Conoco.** Open and use the embedded bookmarks to navigate this report.

For the Silver Shaft deposit, color photographs of Phelps Dodge Exploration East and Conoco 'skeletonized' core archived in the North Carolina Geological Survey's core repository are included as are photomicrographs and brief descriptions of polished ore thin sections. These add an important dimension to understanding these ore deposits. The drill cores available for this study are "skeletons" – meaning that they are sub-samples to represent the original cores. While geologic interpretations change, the rocks are a constant.

Contact the State Geologist for access to the drill cores and associated data from this study, and for information about other drill cores from related VMS deposits archived at the North Carolina Geological Survey's core facility in Raleigh, North Carolina.

The North Carolina Geological Survey is indebted to Robert J. Moyer for offering these reports, and for his efforts to bring them to Special Publication status and into the public domain. **Again, we thank Freeport-McMoran for permission to publish this information.**

Jeffrey C. Reid, PhD, PG, CPG  
Senior Geologist – Energy and Minerals  
North Carolina Geological Survey  
Raleigh, North Carolina

Robert J. Moyer <sup>1</sup> Consulting Geologist <a href="mailto:rjymoye@gmail.com">rjymoye@gmail.com</a>	David F. Lee <sup>3</sup> Wake Stone Corporation <a href="mailto:davidlee@wakestonecorp.com">davidlee@wakestonecorp.com</a>
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## 1.0. Introduction

## 1.1. Introduction to the NCGS Special Publication

Among the more distinctive and economically significant styles of mineralization present in the Carolina Terrane of central North Carolina are volcanogenic massive sulfide deposits (VMS). VMS mineralization is not widespread in the Carolina Terrane, and largely limited to occurrences in the Lincolnton-McCormick District of southwestern South Carolina and northeast Georgia and to the historic Cid and Gold Hill mining districts in central North Carolina. VMS deposits of the Cid and Gold Hill districts are latest Neoproterozoic to earliest Cambrian in age, and hosted by the Flat Swamp Member of the Cid Formation of the Albemarle Sequence. The association of VMS deposits with the Flat Swamp Member represents a specific metallogenic association and a well-constrained focus for future mineral deposit exploration.

Four deposits recognized as VMS mineralization have been identified to date; the Silver Hill and Silver Valley deposits of the historic Cid Mining District of Davidson County, and the Union Copper and Silver Shaft (McMakin) deposits of the Gold Hill District in Rowan and Cabarrus counties. All were largely mined out in the late 1800s to early 1900s, but the geographic extent of the host Flat Swamp Member suggests significant potential for additional discoveries. Exploration of this potential is facilitated by detailed knowledge of existing deposits, their geologic setting, character, and controls, and access to the insights gained from past exploration efforts.

Although known VMS deposits of the Albemarle Sequence are relatively small (< 0.5 Mt), the base metal content of the ore bodies is typically very high with significant gold and silver credits. Average run of mine for the Silver Hill ore body in the Cid District was 59.2% sphalerite, 21.9% galena, 17.1% pyrite, and 1.8% chalcopyrite (Pogue 1910), yielding 40% Zn and 19% Pb. The galena is argentiferous, and supergene Pb-carbonate was intergrown with plates of native Ag (Pogue 1910). The Union Copper ore body in the Gold Hill District produced five million pounds of Cu and almost 20,000 ounces Au, and ore from the nearby Silver Hill (McMakin) deposit assayed up to 11.4% Pb, 25.2% Zn, and 28.68 oz/t Ag. Clusters of similar VMS ore bodies or larger tonnage deposits would be highly desirable exploration targets.

## Background to the contents of this report

Exploration programs focused primarily on gold and polymetallic massive sulfide deposits were active intermittently in the Carolina Terrane in central North Carolina from the 1950s through the early 1970s. Major players included Conoco Minerals, Tennessee Copper, based at Ducktown, Tennessee, and Bear Creek Mining Company, the domestic exploration arm of Kennecott Copper Corporation. Interest in the exploration potential of the Proterozoic volcanic terranes of the southeastern piedmont intensified with the publication of the paper, *A suggested volcanogenic origin for certain gold deposits in the Slate Belt of the North Carolina piedmont* (Worthington and Kiff 1970) in *Economic Geology*.

Joe Worthington and Irv Kiff were exploration geologists working for the Bear Creek Mining Company in a regional evaluation of metallic mineral deposit potential in the Southeastern piedmont in 1965 and 1966. Although focused on gold deposits, their seminal paper suggested a regional potential for large tonnage volcanogenic gold and base metal deposits in the Carolina Terrane. This was given further significance by the end of Federal regulation on the price of gold in 1972. A chance meeting with Dr. William H. Spence of North Carolina State University at the Haile Mine in 1974 resulted in a long-term collaboration that contributed directly to the discovery of the Kennecott Ridgeway Gold deposit in South Carolina in 1979 and a new gold rush to the Carolinas thorough the late 1970s and early 1980s. Much of the history and circumstances of these developments are reviewed in Worthington (1993).

Evaluation of the exploration potential of the North Carolina piedmont was greatly facilitated by stratigraphic and structural studies of the Carolina Terrane in central North Carolina by the US Geological Survey (Stromquist and Sundelius 1969; Stromquist, Choquette, and Sundelius 1971; and Stromquist and Sundelius 1975) that built on the earlier work of Conley (1962). Publication in 1976 of North Carolina Geological Survey Bulletin 84, *Metallic mineral deposits of the Carolina Slate Belt, North Carolina* (Carpenter 1976) provided a catalogue of known metallic mineral occurrences and historic mines that, together with USGS Professional Paper 213, *Gold deposits of the southern Piedmont* (Pardee and Park 1948), served as a primary reference, locator, and framework for many prospect evaluations and exploration programs.

The Phelps Dodge Copper Company formed Phelps Dodge Exploration East in the mid-1970s, with offices in Bangor ME, Reston VA, and Raleigh NC. The Raleigh office of Phelps Dodge Exploration East, under the successive leadership of Ronald Luethe, Fausto

Cucchi, and William Smart, evaluated hundreds of precious and base metal sulfide prospects across North Carolina, South Carolina, and Georgia. Polymetallic VMS base metal sulfide deposits were an important exploration target for the program, including the historically mined deposits of the Cid and Gold Hill districts. The Cid District was extensively explored in the mid- to late-1970s, and a major drilling program completed at the Silver Hill deposit. The Silver Valley deposit in the Cid District and the Silver Shaft (McMakin) deposit of the Gold Hill District were evaluated and drilled in 1979-1981. Although no minable ore resources were identified, much useful information regarding the occurrence and character of these deposits was obtained.

### **The contents of this Special Publication**

The information contained in this Special Publication includes technical reports, geologic maps and cross-sections, drill hole core logs and assays, and geochemical and geophysical survey results from the files of Phelps Dodge Exploration East for the Silver Hill, Silver Valley, Union Copper, and Silver Shaft (McMakin) deposits. Portions of this material were donated by Robert J. Moye and David F. Lee, geologists with the Raleigh office of Phelps Dodge involved in the work at the Silver Shaft and Silver Valley prospects. Additional material was donated by Freeport-McMoRan Incorporated from the inherited files of Phelps Dodge. Permission to make this material available was kindly granted by Freeport-McMoRan Incorporated. Their assistance and cooperation are gratefully acknowledged, with special thanks to Michele A. Hughes and the personnel of Freeport-McMoRan Legal Administration.

Additionally, **this Special Publication includes two new papers by Robert J. Moye.** The first is a description and analysis of the Silver Shaft (McMakin) and Union Copper polymetallic base metal sulfide deposits, and intended to document the occurrence and character of VMS mineralization in the Gold Hill District. The second is an analysis of the metallogenic character and evolution of gold and base metal sulfide mineralization in the central Gold Hill District. It addresses the distribution and character of two separate and distinct mineral deposit types that characterize the district and the tectonic events and geologic environments in which they formed. Both reports originated with work in the district by Phelps Dodge Exploration East in the early 1980s, but benefit from hindsight and the accumulated knowledge and experience of a 35-year career in the industry.

Core from holes drilled at Silver Hill, Silver Valley, Union Copper, and Silver Shaft was donated to the North Carolina Geological Survey by Phelps Dodge and Conoco Minerals

at the termination of their exploration programs. These core holes are skeletonized, consisting of short core segments representing the major lithologies, alteration, and mineralization in each drill hole. They are stored in the core repository of the North Carolina Geological Survey in Raleigh, North Carolina and listed in the repository well and drill hole database.

Core from the Silver Shaft (McMakin) drill holes has been photographed and selectively sampled by Dr. Jeffrey C. Reid, Senior Geologist, Energy and Minerals, with North Carolina Geological Survey, Policy & Innovation Group – Office of the Secretary, N.C. Department of Environmental Quality. Plain, polarized, and reflected light microphotographs of polished thin sections of these samples were prepared, and are included in this Special Publication along with an initial description and analysis of their mineralogy and textures.

Regrettably, mineral exploration is a highly competitive and often secretive business. Extensive geological, geochemical, and geophysical data sets acquired through often large capital expenditures and insights by geologists are seldom made available to potential users outside the corporation. Exploration programs end, personnel are dispersed, and the information is too often relegated to eventually forgotten or discarded storage and lost.

The material contained in this Special Publication is an attempt to preserve the information and insights gained by the personnel of Phelps Dodge Exploration East regarding the occurrence and character of VMS deposits in the Carolina Terrane of central North Carolina, and to make that information freely available to all potential stakeholders to facilitate and encourage future mineral exploration efforts.

## **The volcanogenic massive sulfide (VMS) ore deposit model**

Volcanogenic massive sulfide deposits form in extensional tectonic regimes, typically in active rift environments. These include mid-ocean ridges, back-arc basins, intra-oceanic arc rifts, and continental arc rifts (e.g., Swinden 1991, Hannington et al. 1995, Scott 1997, Syme et al. 1999, Barrett et al. 2001, Piercey et al. 2001, Dusel-Bacon et al. 2004). VMS deposits are characteristically associated with extensional and trans-tensional grabens, calderas, and synvolcanic and synsedimentary faults (e.g. Gibson 1989, Allen 1992, McPhie and Allen 1992, Setterfield et al. 1995, Allen et al. 1996, Gibson et al. 1999, Stix et al. 2003, Gibson 2005).

Major VMS districts ranging in age from Archean to recent show characteristic geologic constraints on ore genesis, magmatic associations, and tectonic setting (Allen et al. 2002, Franklin et al. 2005, Galley et al. 2007):

1. VMS districts are not characteristic of typical volcanic arcs, but products of dramatic, often localized extensional tectonic-magmatic events superimposed on volcanic arcs or other convergent plate margin settings.
2. Crustal extension and thinning result in subsidence and transgression to deep marine graben environments, accompanied by the diapiric rise of asthenospheric mantle to the base of the crust with depressurization and partial melting, underplating of the crust by mafic and ultramafic magmas, and partial melting of hydrated lower crustal rocks at <15-kilometers depth to form anhydrous tonalite to trondhjemite melts.
3. The rise of mantle-derived mafic magmas and felsic crustal melts into the attenuated crust results in the characteristic bimodal volcanism associated with VMS environments.
4. VMS deposits are often specifically associated with a period of rapid, localized extension, subsidence, and felsic-dominated bimodal magmatism typically limited to a period of a few million years.
5. Associated felsic rocks are typically calc-alkaline or tholeiitic dacite-rhyolite. Associated mafic rocks are often mantle-derived, tholeiitic to transitional basalt and basaltic andesite.
6. Significant volumes of felsic volcanism may be associated with partial melting of evolved crust during extension of thickened oceanic crust, evolved oceanic arcs, oceanic arcs with continental basement, and continental margins.
7. Deposits in most districts occur within a specific time-stratigraphic interval, often associated with proximal rhyolite facies during the late stages in the evolution of a felsic magmatic center.
8. Deposits often form near the end of a major syn-rift felsic volcanic episode, followed by an abrupt change in the composition and intensity of volcanism and sedimentation.
9. The clustering of VMS deposits suggest possible formation in calderas, which may range from 1-2 kilometers to 5-10 kilometers (Noranda, Flin Flon) or up to 50 kilometers (Rosebery-Hercules, Tasmania; Bathurst, Canada; Hokuroku, Japan).

10. The mineralogy of VMS deposit is strongly related to the chemistry, temperature, pH, and sulfur activity of the fluids and the composition of the footwall sequence, with variable direct input from magmatic fluids.
11. Modern analogues include back-arc and intra-arc rifts and pull-apart basins such as the Miocene Japan arc system, the Okinawa trough, and the Lau and Manus basins in the southwest Pacific.

Various authors have classified VMS deposits into five categories based on host-rock assemblages (Barrie and Hannington 1999, Franklin et al. 2005, Piercey 2010):

1. **Mafic:** Mafic-dominated host assemblages, typically ophiolite (Cyprus, Oman, Newfoundland Appalachians).
2. **Bimodal-mafic:** Mafic-dominated sequences with up to 25% felsic rocks, which often directly host the deposits (Noranda, Flin Flon-Snow Lake, Kidd Creek camps).
3. **Mafic-siliclastic:** Sequences with subequal proportions of mafic  $\pm$  ultramafic and siliclastic rocks  $\pm$  minor felsic rocks (Besshi, Outokumpu, Windy Craggy).
4. **Felsic-siliclastic:** Fine-grained siliclastic dominated sequences with abundant felsic rocks and less than 10% mafic rocks (Bathurst, Iberian Pyrite Belt, Finlayson Lake).
5. **Bimodal-felsic:** Hosted by bimodal sequences where felsic rocks  $>$  mafic rocks and minor sedimentary rocks (Kuroko, Buchans, Skellefte).

Groups 1-3 are dominated by mafic material in juvenile magmatic environments with minimal input from continental crustal rocks. Felsic rocks are derived primarily from melting of hydrated mafic crust, and mafic rocks are predominantly sourced from asthenospheric mantle. VMS deposits are enriched in Cu + Zn with only minor Pb.

Groups 4-5 are associated with evolved magmatic environments dominated by continental rocks or sediments derived from them. Felsic rocks form by melting of continental crust or continent-derived rocks, with mafic rocks sourced from the lithosphere and asthenosphere. VMS deposits are typically dominated by Zn + Pb + Cu.

### **Ore deposit model constraints on VMS deposits of the Albemarle Basin**

Geologic constraints on the occurrence and composition of VMS deposits of the Cid and Gold Hill districts are consistent with those compiled (see 1-11 above) for the global

VMS model (Allen et al. 2002, Franklin et al. 2005, Galley et al. 2007). They formed during arc-rifting of the older Hyco Arc and Virgilina Sequence in the latest Proterozoic (1), proceeded by voluminous felsic-dominated Uwharrie magmatism (6) and characterized by rapid subsidence and the abrupt onset of strongly bimodal magmatism (2, 3, 5) associated with the upper Tillery Formation and the Cid Formation. The Cid and Gold Hill district VMS deposits are hosted by the Flat Swamp Member of the Cid Formation, a major syn-rift felsic volcanic episode followed by an abrupt change in the composition and intensity of volcanism and sedimentation represented by the Floyd Church Formation (8). The Union Copper and Silver Shaft VMS deposits of the Gold Hill District occur in a specific time-stratigraphic horizon (7), and the same may be true of the Silver Hill and Silver Valley deposits of the Cid District.

The ore composition and magmatic associations of the VMS deposits (Zn-Pb-Cu) of the Albemarle Basin are most consistent with an evolved tectonic-magmatic rift environment involving input from both continental crust and the asthenosphere (Barrie and Hannington 1999, Franklin et al. 2005, Piercey 2010). Average sulfide content of the Silver Hill ore body, based on 200 assays, was 59.2% sphalerite, 21.9% galena, 17.1% pyrite, and 1.8% chalcopyrite with trace gold and silver (Pogue 1910). The host Flat Swamp Member of the Cid Formation is consistent with the Bimodal-felsic association (Barrie and Hannington 1999, Franklin et al. 2005, Piercey 2010), similar to VMS deposits of the Kuroko District in Japan, the Buchans District in Canada, and the Skellefte District of Sweden. Considered in the context of the entire Cid Formation, the Albemarle VMS deposits may better fit the Felsic-siliclastic Class that includes deposits of the Bathurst camp and the Iberian Pyrite Belt.

The VMS deposits of the Cid and Gold Hill districts have not been related to the evolution of specific felsic volcanic centers, to recognized rift-related dike swarms, or to rift-related faults. The clustering of VMS deposits in the Flat Swamp Member may be related to an intra-rift caldera (9), as proposed by Butler (1995). Silicified rhyolite, vitrophyre and chert at the Silver Valley deposit suggest possible association with a small, localized eruptive center. The occurrence of the two largest, highest grade VMS deposits in the Albemarle Basin (Silver Hill and Union Copper) along the extreme western margin of the preserved Albemarle Group suggests the possibility that the Gold Hill Fault is, in part, a reactivated basin-bounding rift fault that may have been a focus for VMS-forming fluids.

## Arc-rifting and VMS deposits of the Carolina Terrane

The association with VMS deposits suggests that the Flat Swamp Member of the Cid Formation formed in an active rift environment, possibly an arc-rift or back-arc rift. A rift environment has frequently been proposed for part or all of the Albemarle Sequence. Moyer and Stoddard (1987) proposed deposition of the Albemarle Group in an arc-rift basin associated with sinistral strike-slip transtension. Harris and Glover (1988) suggest a possible intra-arc rift environment for deposition of the Virgilina Sequence, with the Uwharrie Formation representing renewed volcanism in a possible intra-arc transtensional basin. Feiss et al. (1993) proposed Neoproterozoic to Middle Cambrian arc-rifting of the Carolina Terrane based on whole-rock  $\delta^{18}\text{O}$  isotopic data.

Recent studies of the depositional history and tectonic setting of the Albemarle Group support an arc-rift or back-arc rift environment (Pollock 2007, Pollock et al. 2010, Hibbard et al. 2012, Hibbard et al. 2013), possibly related to the separation of Carolina and Gondwana with opening of the Rheic Ocean. Suggested modern analogues for the tectonic environment of the Albemarle Sequence include the Sea of Japan, Okinawa Trough, and Lau Basin (Pollock et al. 2010).

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## **2.0. VMS Deposits of the Gold Hill District, Rowan and Cabbarus counties, N.C.**

## **2.1. The Silver Shaft (McMakin) and Union Copper volcanogenic massive sulfide deposits, Gold Hill District, Rowan and Cabarrus counties, North Carolina**

By Robert J. Moyer

### **Introduction**

One of the more distinctive and economically significant styles of mineralization present in the Neoproterozoic Carolina Terrane in central North Carolina is volcanogenic massive sulfide (VMS) deposits. Feiss (1982) noted that these deposits are typically conformable with their host strata and often occur as complex, anastomosing lenses that pinch and swell. Individual VMS lenses may be up to 4.5 meters thick with lengths of 100-500 meters. Primary sulfide minerals include pyrite, sphalerite, galena, and chalcopyrite; with accessory minerals that may include pyrrhotite, magnetite, pentlandite, tetrahedrite, arsenopyrite, and bismuthinite (Feiss 1982).

Alteration and gangue minerals include quartz, chlorite, talc, biotite, sericite, siderite, ankerite, and calcite. Deposits may become lozenge shaped with deformation, and may pitch steeply in the noses of meso-scale folds or within shear zones (Feiss 1982). Ores are typically strongly recrystallized with loss of primary textures, and local-scale remobilization as veins along discordant structural fabrics and fractures is common.

Known VMS deposits of the Carolina Terrane in North Carolina appear to be restricted to the Albemarle Sequence, specifically to two clusters of deposits hosted by the Flat Swamp Member of the Cid Formation along the western side of the Carolina Terrane. These clusters are part of the historic Cid and Gold Hill mining districts (Figure 1). Polymetallic massive sulfide deposits of the Cid District include the Silver Hill and Silver Valley mines in Davidson County. The Union Copper and Silver Shaft mines are VMS deposits in the Gold Hill District of Rowan and Cabarrus counties.

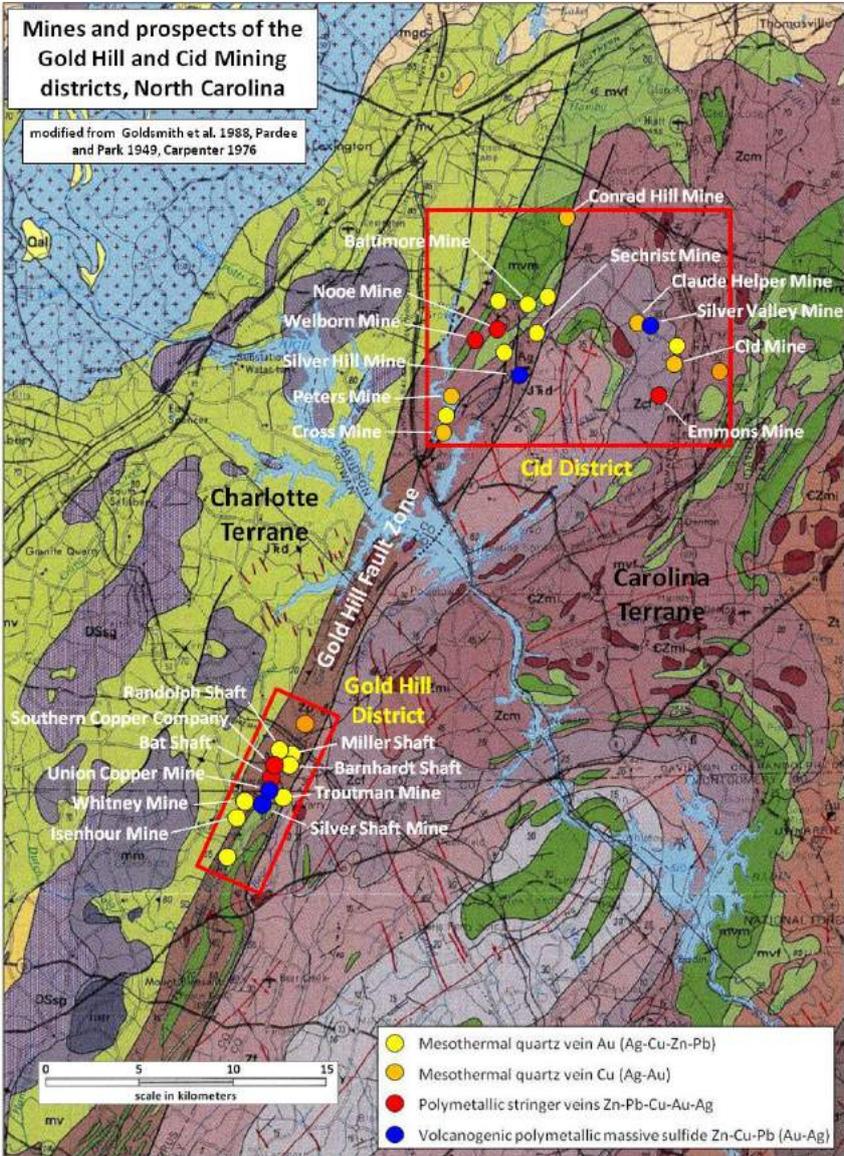
The present study is focused on the Silver Shaft (McMakin) VMS deposit in the Gold Hill District of Cabarrus and Rowan counties, North Carolina. The author was involved in an evaluation of the Silver Shaft prospect by Phelps Dodge Exploration East in 1980-1982, which defined the local stratigraphy, structure, and the style and distribution of alteration and mineralization. The Silver Shaft deposit is characterized by distinctive Zn-Pb-Ag mineralization with talc-carbonate-barite gangue (Smart and Moyer 1982), and is part of the larger Union Copper Cu-Zn-Au VMS deposit hydrothermal system (Unger 1982).

Hydrothermal alteration, disseminated and stringer base metal sulfide and precious metal mineralization, and local accumulations of massive to submassive sulfide extend along

strike for over a kilometer within a discrete 135-meter-thick, epiclastic siltstone-dominated stratigraphic interval that represents a hiatus in an extended period of highly explosive, felsic-dominated submarine volcanism.

**Acknowledgements**

The Silver Shaft project was part of the gold and base metal exploration program operated in the 1970s and 1980s by Phelps Dodge Exploration East, a subsidiary of the Phelps Dodge Corporation, through the regional office in Raleigh, North Carolina. The contributions of other PDEE personnel to the project are fondly remembered and gratefully acknowledged, especially those of Bob Ludden, Fausto Cucchi, Bill Smart, and David Lee. My gratitude goes to Freeport-McMoRan Incorporated for their kind permission to make this data available.



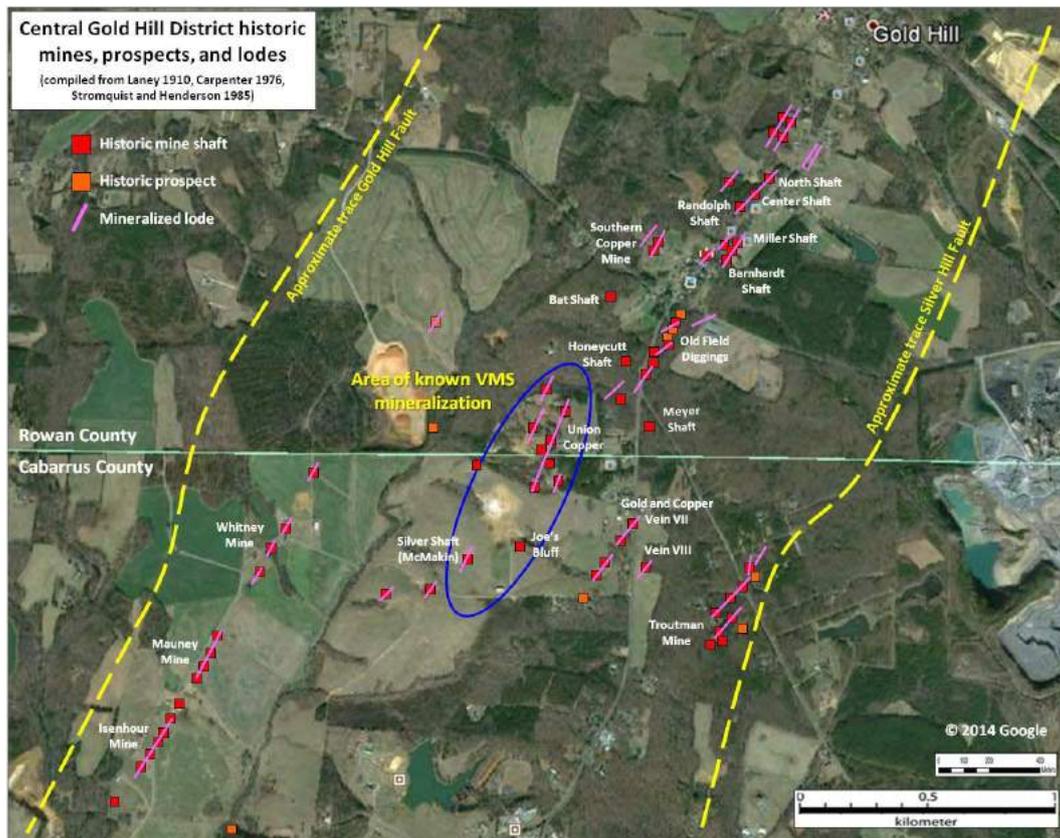
**Figure 1: Mines and prospects of the Gold Hill and Cid mining districts, central North Carolina**

## The Gold Hill District

The Union Copper and Silver Shaft (McMakin) VMS deposits are part of the Gold Hill Mining District. The Gold Hill District is one of several clusters of precious and base metal sulfide mineralization present within the Gold Hill Fault Zone at the western edge of the Carolina Terrane in central North Carolina (Figure 1). The mines of the Gold Hill District were active from 1842 until about 1915 (Pardee and Park 1948), producing gold, silver, and copper. The district was originally defined as a NNE-trending area measuring about 1 x 2.4 kilometers in south-central Rowan County and northeast Cabarrus County, characterized by a cluster of historic gold and base metal sulfide mines and prospects located immediately south of the town of Gold Hill (Kerr and Hanna 1888, Nitze and Hanna 1896). Laney (1910) expanded the term to encompass a 29 x 13 kilometers area, roughly centered on the town of Gold Hill.

The present study is focused on recognized occurrences of VMS mineralization, located within an area of about 1000 x 200 meters in the central portion of the Gold Hill District (Figure 2). The shafts of the Union Copper Mine are aligned north-northeast for about 400 meters across the Rowan-Cabarrus county line, with the Silver Shaft Mine located about a half kilometer to the southwest in Cabarrus County.

Two styles of mineralization are present in the central Gold Hill District, representing two separate and distinct metallogenic events; stratigraphically controlled polymetallic volcanogenic massive sulfide (VMS) deposits and structurally controlled orogenic gold-bearing lodes. The orogenic gold deposits are quartz + sulfide veins, silicic alteration zones, and vein stockworks along brittle-ductile shear zones associated with development of the Gold Hill Fault Zone during the Cherokee Orogeny in the late Ordovician (Hibbard et al. 2012). These include the classic Gold Hill lodes mined from the Randolph, Barnhardt, Honeycutt, and Southern Copper veins of the central Gold Hill District, as well as the Troutman and Isenhour-Whitney veins.



**Figure 2: Historic mines, prospects and lodes of the central Gold Hill mining district, Rowan and Cabarrus counties, North Carolina**

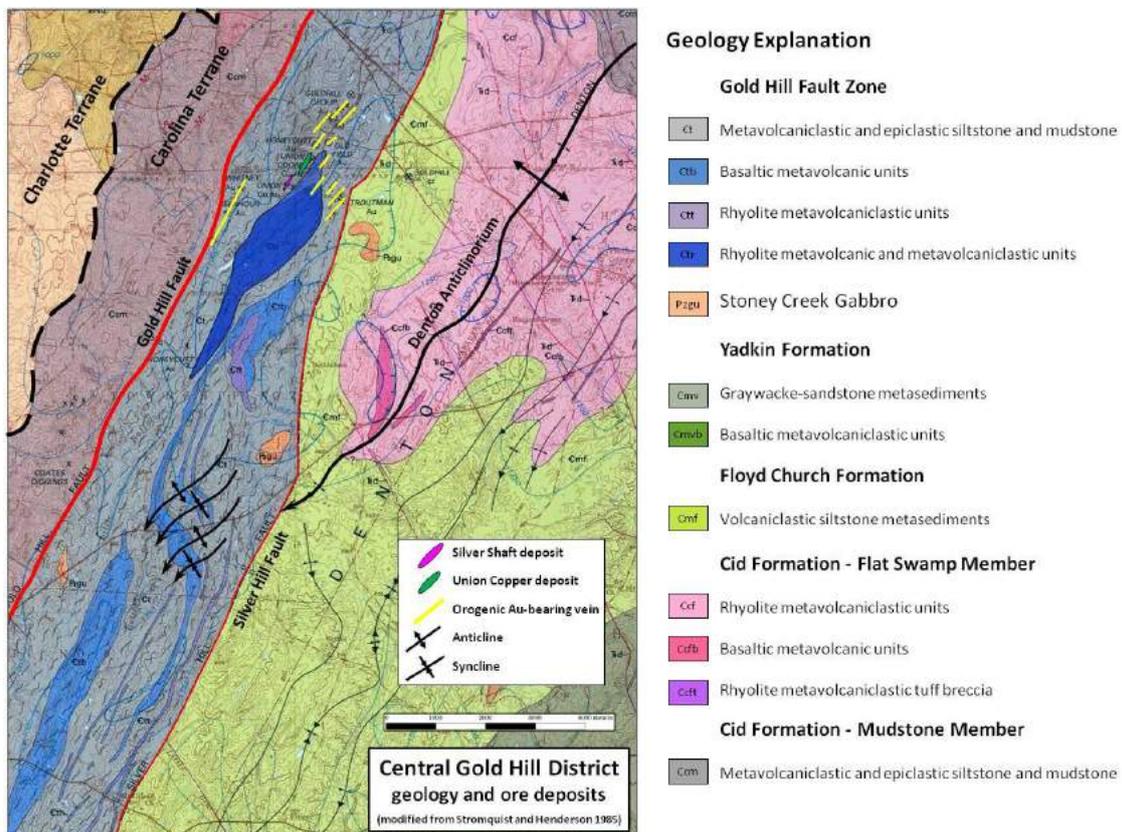
Polymetallic volcanogenic massive sulfide mineralization (VMS) of probable Neoproterozoic-early Cambrian age includes the Union Copper Mine and Silver Shaft deposits. The Union Copper Cu-Zn-Au deposit was the largest single mining operation in the Gold Hill District and an important producer of gold and copper. The Silver Shaft (McMakin) deposit to the southwest was a small Zn-Pb-Ag rich ore body higher in the same stratigraphic sequence. Both appear to be products of the same VMS hydrothermal event and are hosted by a metasilstone-dominated epiclastic sequence that represents a hiatus in the deposition of a thick, coarse-grained, largely felsic volcanoclastic sequence.

## Geologic setting

The precious and base metal deposits of the Gold Hill District are hosted by lithologies of the Albemarle Group within the Gold Hill Fault Zone, a domain of heterogeneous ductile-brittle strain about 120 kilometers long and up to 5 kilometers wide. Although long considered the faulted boundary between the Carolina and Charlotte Terranes (Butler and Fullagar 1978, Goldsmith et al. 1988, Butler and Secor 1991, Boland 1996, Hibbard et al. 2002), the Gold Hill Fault Zone is reinterpreted as a sinistral-reverse fault

duplex formed during docking of the Carolina superterrane with Laurentia in the late Ordovician (Hibbard et al. 2008, 2012).

Metavolcanic and metasedimentary units west of and hanging wall to the fault zone (Stromquist and Sundelius 1969, Standard 2003, Allen 2005) are consistent with the older Hyco Volcanic arc and dated to circa 613 Ma (Hibbard et al. 2008). The Charlotte-Carolina terrane suture may be located further west, possibly obscured by younger plutonic rocks.



**Figure 3: Geology and historically mined ore deposits of the central Gold Hill mining district, Rowan and Cabarrus counties, North Carolina**

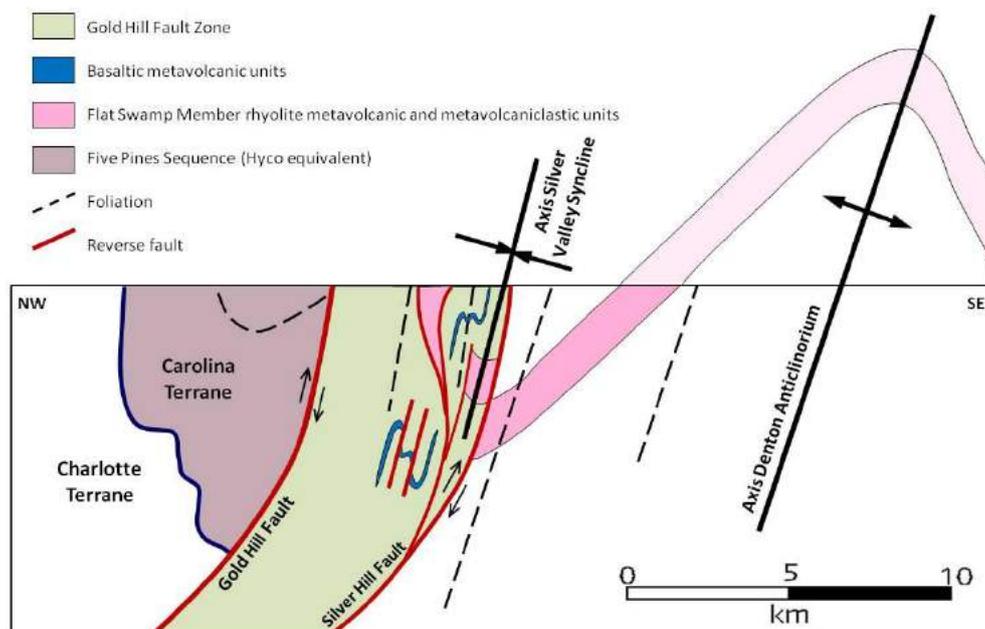
## The Gold Hill Fault Zone

Standard (2003) describes the Gold Hill Fault in central North Carolina as a discrete, relatively narrow, west-dipping, large displacement fault that separates lower strain Albemarle Group to the east (footwall) from higher strain rocks to the west (hanging wall). This fault and the broad zone of ductile-brittle strain in the footwall, bounded by the Silver Hill Fault, are defined as the Gold Hill Fault Zone (Standard 2003). Hibbard et al. (2008) suggest that the Gold Hill Fault Zone is an oblique thrust duplex between the Gold Hill roof fault and the Silver Hill floor fault. The Gold Hill Fault is a fundamental structure with an estimated stratigraphic offset of 12 kilometers (Hibbard et al. 2012), but the Silver Hill Fault

separates domains of differing deformation style in the same group of rocks and may be a largely brittle structure with significantly less displacement (Standard 2003).

In the Gold Hill area, the Gold Hill Fault Zone has a true thickness of about 2.2 kilometers that dips 70-75° northwest (Figure 3). There is a general increase in metamorphic grade, ductile strain, and meso-scale to micro-scale isoclinal to asymmetric folding approaching the Gold Hill Fault from the footwall (Laney 1910, Standard 2003). Laney (1910) interpreted the Gold Hill and Silver Hill faults in this area as SE-directed reverse faults, and noted the divergence of structural style across the Silver Hill Fault.

Albemarle Group rocks between the Gold Hill and Silver Hill Faults typically show extensive preservation of primary lithologies, textures and structures (Hibbard et al. 2008). Although ductile strain generally increases towards the Gold Hill Fault, high strain is typically restricted to narrow, discrete shear zones. Bedding and an earlier axial planar cleavage in Albemarle Group rocks are strongly transposed into a NNE-orientation parallel to the Gold Hill Fault, but stratigraphy is often well-preserved and intact over large areas.



**Figure 4: Schematic structural cross-section across the Gold Hill Fault Zone sinistral reverse duplex in the Gold Hill area, North Carolina (modified from Hibbard et al. 2012)**

The mines of the Gold Hill District lie along the western flank of the Denton Anticlinorium, about four kilometers northwest of the axis (Figures 3 and 4). Ductile strain on the Gold Hill Fault Zone post-dates formation of the Denton Anticlinorium and other large-scale *en echelon* folds in the Albemarle Sequence. These folds, earlier products of the Cherokee Orogeny, are consistent with sinistral strain; with axes and axial plane foliation oriented 25°-35° clockwise

to the Gold Hill Fault Zone and truncated by the younger shear fabric (Hibbard et al. 2008). White mica associated with the axial planar cleavage of the folds has  $^{40}\text{Ar}/^{39}\text{Ar}$  cooling ages of circa 445 Ma (Offield et al. 1995, Ayuso et al. 1997, Hibbard et al. 2008), and cleaved slate of the Tillery Formation has a  $^{40}\text{Ar}/^{39}\text{Ar}$  whole rock age of  $444 \pm 1$  Ma (Noel et al. 1988). However, it is important to note that these are cooling ages, and only represent a minimum possible age for the development of micas on cleavage surfaces.

## **The stratigraphy problem in the Gold Hill District**

The position of the felsic-dominated volcanoclastic host rocks for the Union Copper and Silver Shaft deposits within the established stratigraphy of the Albemarle Group is contentious. Stromquist and Sundelius (1969) and Stromquist et al. (1971) assigned the rocks within this portion of the Gold Hill Fault Zone to the Cid Formation, however Stromquist and Sundelius (1975) and Stromquist and Henderson (1985) assign the rocks to the Tillery Formation. Gibson and Huntsman (1988) and Standard (2003) suggest that the strata are similar to the Floyd Church Formation.

Stromquist and Sundelius (1969), Stromquist et al. (1971), Stromquist and Sundelius (1975), and Stromquist and Henderson (1985) suggest that the northern portion of the Gold Hill Fault Zone includes portions of both the Cid and Tillery Formations. Goldsmith et al. (1988) suggest that the fault zone may contain elements of both the Tillery Formation and the Mudstone Member of the Cid Formation, but their character is obscured by shearing and recrystallization. More recent studies (Standard 2003, Hibbard et al. 2012) classify all rocks between the Gold Hill and Silver Hill Faults as undivided Albemarle Group.

The Tillery Formation is largely composed of thin-bedded, fine-grained epiclastic metasedimentary rocks. They are characterized by laterally persistent 1-3 mm thick beds that typically grade from silt and clay, suggesting deep, quiescent marine deposition, with subordinate interbedded felsic and mafic metavolcanic rocks (Conley and Bain 1965, Seiders and Wright 1977, Gibson and Teeter 1984). Felsic volcanic units within the Tillery Formation are typically described as aphanitic, coherent, lenticular porphyritic flows or vitrophyres, some with flow banding (Conley 1962, Stromquist and Sundelius 1969).

Thick-bedded (30-60 centimeters) to massive mudstone dominates the lower Mudstone Member of the Cid Formation. Felsic and mafic volcanic units are increasing interbedded with mudstone into the middle of the sequence, but absent from the thinly laminated siltstone and mudstone in the upper part of the member (Stromquist and Sundelius 1969). Felsic volcanic units in the Mudstone Member are largely coherent aphanitic porphyry

and vitrophyre (Conley 1962, Stromquist and Sundelius 1969), similar to those in the Tillery Formation. These localized, lenticular felsic units contrast dramatically with the thick, widely distributed felsic pyroclastic and volcanoclastic units that characterize the Flat Swamp Member of the Cid Formation.

Flat Swamp Member felsic volcanic rocks include coarse-grained crystal-lithic tuff breccias, vitric tuffs, bedded volcanoclastic sequences, and tuffaceous breccia (Stromquist and Sundelius 1969). The crystal-lithic tuff breccias contain felsic clasts up to 3 centimeters across and lenticular aphanitic felsic fragments up to 5 centimeters long. These coarse-grained units appear to grade upwards and along strike into finer-grained vitric-crystal and vitric volcanoclastic units (Stromquist and Sundelius 1969). Variably fragmented crystals up to a millimeter in size are largely albite. Thinly bedded tuffaceous siltstone and mudstone at the top and base of the member contain pyrite and pyrrhotite as disseminated grains and bedding-parallel stringers or laminae (Stromquist and Sundelius 1969).

The Floyd Church Formation is characterized by greenish-grey metamudstone with local units of felsic and mafic metavolcanics (Stromquist and Sundelius 1969). Metasediments are typically moderately graded in the lower part of the sequence, but more massive and increasingly interbedded with minor volcanic epiclastic sandstone and siltstone in the upper portion. Lenses up to 30 meters thick of upward-fining argillaceous tuff breccia with scoured bases are present in the lower portion of the sequence, and contain clasts of primary and reworked felsic volcanic rocks and siltstone rip-up clasts (Stromquist and Sundelius 1969).

In western Davidson County, detailed geologic mapping by Phelps Dodge Exploration East in 1975-1976 suggests that the Flat Swamp Member of the Cid Formation hosts the Silver Hill deposit on the western limb of the Silver Valley Syncline, largely intact within the eastern margin of the Gold Hill Fault Zone. Ledger (1978), Unger (1982), and Smart and Moye (1982) conclude that the thick, coarse-grained, felsic-dominated volcanoclastic sequence in the Union Copper-Silver Shaft area of the Gold Hill District is also consistent with the Flat Swamp Member of the Cid Formation.

The Flat Swamp Member units hosting the Union Copper-Silver Shaft VMS system appear to be continuous with the elliptical rhyolite-dominated volcanic unit mapped by Stromquist and Henderson (1985) at the southern end of the Gold Hill District (Figure 3). The presence of the Flat Swamp Member within the Gold Hill Fault Zone duplex at Gold Hill suggests that it may have been structurally exhumed from the western limb of the Denton Anticlinorium at depth, possibly in southeast verging second-order folds or reverse faults

hanging wall to the Silver Hill Fault. Alternatively, it may be part of the southward continuation of the Silver Valley Syncline, which has been strongly appressed and dismembered within the fault zone (Figure 4).

### **Local lithologic and stratigraphic controls of VMS mineralization at Gold Hill**

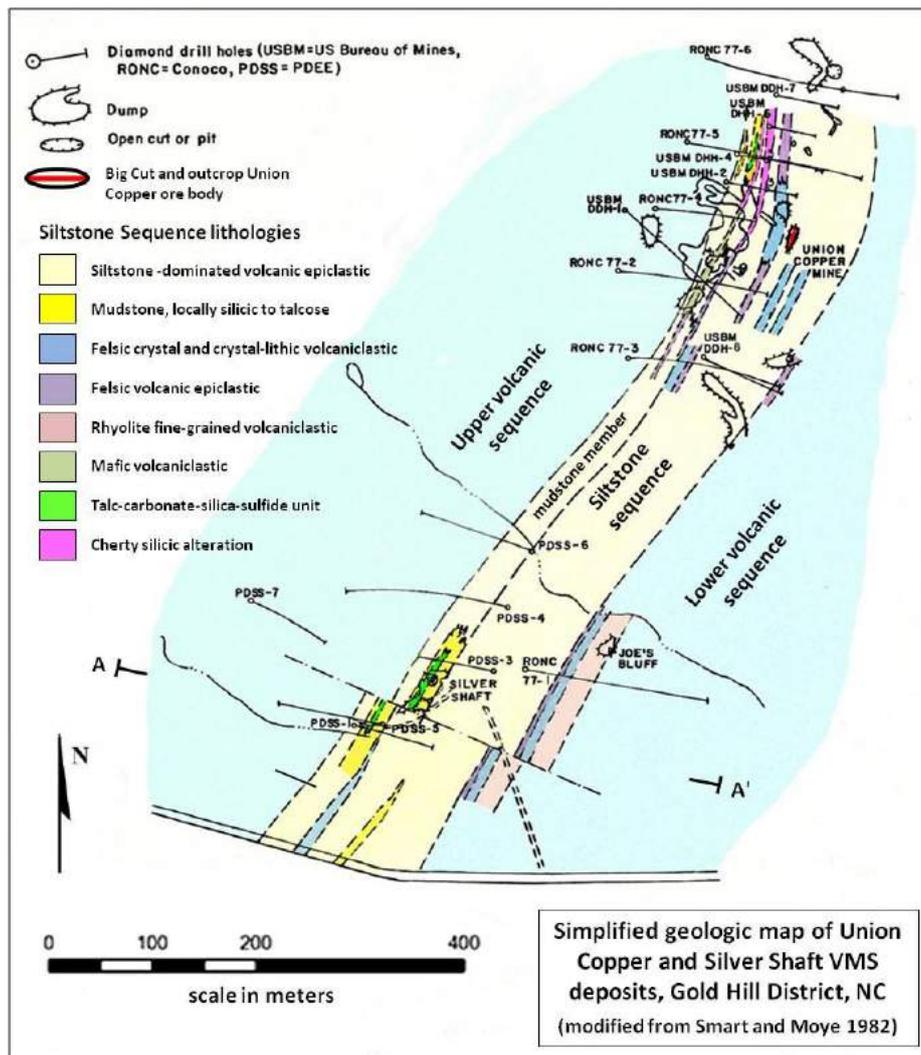
Three informal lithologic units form a continuous, northeast-striking, northwest dipping homoclinal sequence over 600 meters thick in the Silver Shaft-Union Copper Mine area, defined by detailed surface geologic mapping correlated with drill hole core logs (Unger 1982, Smart and Moyer 1982). These units (Figures 5, 6, 7, and 8) are:

- Upper Volcanic Sequence
- Siltstone Sequence (host to mineralization)
- Lower Volcanic Sequence

The Silver Shaft and Union Copper deposits are hosted by the Siltstone Sequence, a stratigraphic interval up to 135 meters thick dominated by massive to thinly bedded epiclastic siltstone, silty mudstone, and mudstone locally intercalated with thin units of felsic to intermediate volcanoclastic rocks (Figures 5 and 8). Significant lateral facies variations are observed, especially within finer-grained volcanoclastic and epiclastic sedimentary intervals. The Siltstone Sequence appears to become discontinuous farther south, and may be locally gradational into the overlying Upper Volcanic Sequence between Silver Shaft and the Union Copper Mine.

Stratigraphy in the Silver Shaft area strikes 025°, dips 70°NW, and is right side up, while cleavage strikes about 030°-045° and dips 75°-80°NW (Smart and Moyer 1982). At the Union Copper Mine to the north, bedding is also upright, strikes 020° and dips 70° NW; the dominant cleavage strikes 030°-045° and dips 75°-80°NW (Unger 1982). The sequence is metamorphosed to the lower to middle greenschist facies (Unger 1982, Smart and Moyer 1982).

Heterogeneous ductile-brittle strain associated with the Gold Hill Fault Zone is poorly developed in more massive volcanoclastic lithologies, but often strongly expressed in epiclastic siltstone and mudstones as an anastomosing phyllitic foliation and spaced to penetrative cleavage. Stratigraphic units extend without significant deflection or major fault offset for over a kilometer from Silver Shaft northward through the Union Copper Mine area, and appear continuously conformable, upright, and west-facing. However, the Silver Shaft mineralized zone appears to be offset about 30 meters to the west just south of the old mine shaft, although the fault is not directly observed at the surface or in drill holes (Figure 5).



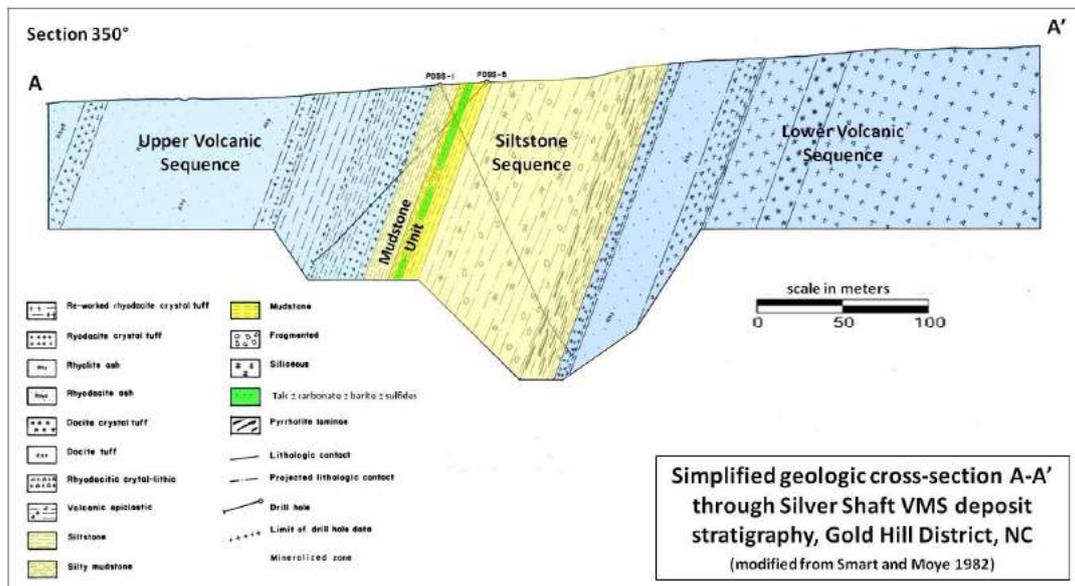
**Figure 5: Simplified geologic map of the sequence hosting the Union Copper and Silver Shaft VMS deposits, Gold Hill District, North Carolina**

### Lower Volcanic Sequence

The Lower Volcanic Sequence (Figures 5, 6, 7, and 8) is over 250 meters thick, and composed of usually thick, texturally variable units of feldspar phyric dacitic to rhyodacitic crystal and crystal-lithic volcaniclastic rocks that outcrop to the east of Joe's Bluff in the Silver Shaft area. The maximum size of lithic clasts in these rocks is about 2-3 centimeters. The rocks are locally silicified and contain fine-grained disseminated pyrite that ranges in volume from less than 1% to 3-5%, to locally 10-15%. In addition, reddish-brown sphalerite occurs as a trace to locally 3% disseminated grains scattered heterogeneously throughout the sequence. Disseminated chalcopyrite is locally present to 10% over narrow intervals in the lower part of the sequence, and trace galena is present locally in the upper part. There is an abrupt change from pyrite to pyrrhotite as the dominant disseminated Fe-sulfide phase in the upper 15 meters of the sequence.

A series of much finer-grained units, possibly vitric volcanoclastic or epiclastic siltstone, is present near the top of this sequence. The Joe's Bluff shaft is opened in a silicic, pyritic interval at the contact between two of these units. Conoco drill hole RONC-77-1 intersected intervals of up to 15% total sulfides at this position with anomalous Cu-Zn-Pb values. This horizon is footwall to the Union Copper Mine main ore body, and appears to have been prospected intermittently for at least a kilometer. At the top of the Lower Volcanic Sequence, fine-grained felsic volcanoclastic and epiclastic sediments are interbedded with thin dacitic to rhyodacitic crystal and crystal-lithic volcanoclastic units.

The Lower Volcanic Sequence corresponds to the Lapilli Tuff unit of Unger (1982) at the Union Copper Mine, composed largely of lapilli tuff and crystal-rich (to 30%) feldspar phyric lapilli-tuff with subordinate 5-15 meter thick intervals of lithic-vitric, vitric, and vitric-crystal tuff. Lapilli-sized clasts are composed of microcrystalline quartz + sericite, crystals are 0.5-3 millimeter grains of microcline and orthoclase, and the matrix is microcrystalline quartz, sericite, and biotite with accessory sulfides and chlorite (Unger 1982). The general homogeneity of this sequence suggests a sustained period of explosive submarine felsic volcanism.

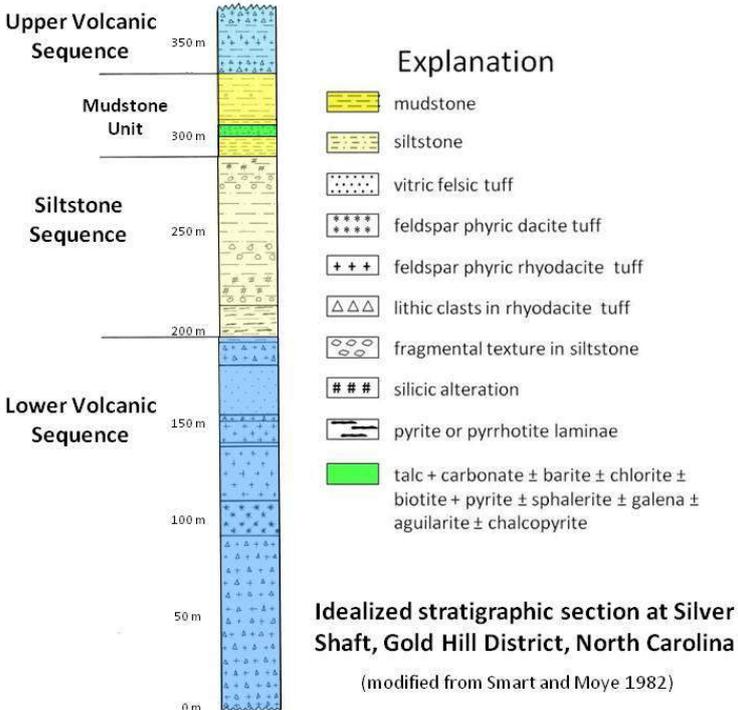


**Figure 6: Simplified geologic cross-section A-A' through the Silver Shaft deposit stratigraphic section, Gold Hill District, North Carolina**

## Siltstone Sequence

The Lower Volcanic Sequence appears to fine upward conformably into the Siltstone Sequence (Figures 5, 6, 7, and 8), which hosts the Union Copper Mine and Silver Shaft mineralization. This unit is about 137 meters thick at Silver Shaft and appears to vary significantly in thickness. It contains interbeds of coarser-grained felsic volcanoclastic rocks in

the Union Copper Mine area (Unger 1982, Smart and Moye 1982) that are absent to the south. The entire sequence generally fines upwards (west), and the upper 44 meters is informally designated the Mudstone Unit, characterized by localized, discontinuous, thinly bedded mudstone and silty mudstone intervals. The entire sequence shows extensive evidence of hydrothermal activity in the form of heterogeneous silicification, chloritization, Mg-metasomatism (talc), quartz ± carbonate ± sulfide veins, and disseminated sulfides.



**Figure 7: Idealized stratigraphic section hosting the Silver Shaft deposit, Gold Hill District, North Carolina**

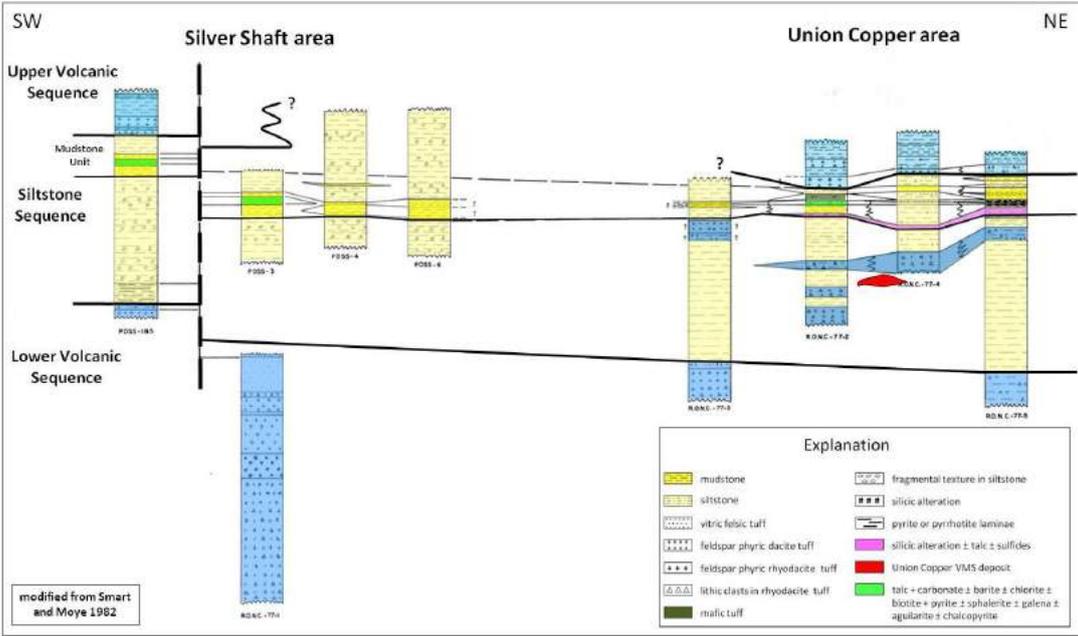
The base of the Siltstone Sequence in drill holes at Silver Shaft is characterized by about 15 meters of distinctive laminated volcanoclastic or epiclastic siltstones that contain 1-5% pyrrhotite as disseminated grains and thin (1-2 millimeters) lenses and laminae, locally increasing to 15% by volume with laminae up to a centimeter thick (Figures 6 and 7). This interval has a strong magnetic response in geophysical surveys.

Much of the rest of the sequence is composed of massive to poorly-bedded to streaky-textured siltstone interbedded with 30 centimeter to 4.5 meter thick intervals of silty mudstone. Fragmental textures are commonly observed, and generally characterized by elongate, often flattened fragments of dark siltstone in a lighter, more siliceous matrix. Portions of the sequence are chaotic mixtures of siltstone fragments, chert fragments, and occasional epiclastic volcanic rock fragments and crystals in a silty to siliceous matrix. The genesis of these fragmental textures is unclear. Some may be pseudo-breccia textures,

resulting from silicic alteration along fracture stockworks. Others may be the result of disruptive events during deposition, post-deposition hydrothermal processes, or deformation associated with deformation within the Gold Hill Fault Zone.

The rocks are generally siliceous and locally grade into partial to pervasive aphanitic (cherty) silicification. The sequence contains varying amounts of locally disseminated fine grained chlorite. Both pyrite and pyrrhotite occur as trace to 5% disseminated grains, lenses, and irregular laminae. Trace sphalerite occurs locally, and small quartz and quartz-carbonate veins, locally abundant in the sequence, occasionally contain streaks and blebs of sphalerite, galena, and pyrite.

The Siltstone Sequence at Silver Shaft appears to correspond to the Massive Vitric Tuff unit of Unger (1982) at the Union Copper Mine, ranging from 20-80 meters thick. It is described as fine-grained, generally massive, and siliceous to cherty. It is composed largely of microcrystalline quartz with minor sericite and accessory biotite, chlorite, and pyrite with <5% crystals of quartz, microcline, orthoclase, and albite (Unger 1982). Quartz micro-vein stockworks and pervasive cherty silicification are common. This unit hosts the Cu-Zn- Au ore body at the Union Copper Mine, as well as peripheral lenses of chlorite-biotite-talc-carbonate-sulfide schist (Unger 1982).



**Figure 8: Simplified schematic stratigraphic correlation longitudinal section through the Silver Shaft and Union Copper VMS deposits, Gold Hill District, North Carolina**

### Mudstone Unit

The upper 44 meters of the Siltstone Sequence at Silver Shaft is informally designated the Mudstone Unit, and hosts massive to disseminated Zn-Pb-Ag mineralization at the Silver

Shaft Mine and in the hanging wall of the Union Copper Mine ore body (Figures 5, 6, 7, and 8). The Mudstone Unit can be further divided into a lower mineralized interval and upper barren silty mudstone (Figure 7).

The lower mineralized interval of the Mudstone Unit is 19 meters thick at Silver Shaft, characteristically poorly-bedded to well-bedded, and contains locally abundant pyrite (10-15%) as disseminated grains, small lenses, and thin laminae. The mudstone becomes increasingly talcose upwards from the base of the unit. Streaky, irregular laminae of pyrite, pale yellow-brown sphalerite, and minor galena appear just below the Silver Shaft ore horizon, located about 11 meters above the base of the Mudstone Unit.

In drill hole PDSS-3, the ore horizon is about 7-8 meters thick and consists of massive talc and talc-carbonate breccia with up to 15-20% pyrite, 5-10% sphalerite, minor galena, and about 1% aguilarite ( $\text{Ag}_4\text{SeS}$ ). Mineralization decreases upward through a short interval of talcose mudstone to the base of the barren mudstone interval. The barren upper 25 meters of the Mudstone Unit is massive to thinly-bedded silty mudstone with variable Mg-metasomatism (talc) and silicification with 1-5%, locally to 15%, pyrite as disseminations and irregular laminae. Trace sphalerite and galena are present locally.

Intervals of thinly-bedded mudstone appear to be discontinuous and lensoidal within the Mudstone Unit and much of the unit is composed of silty mudstone and siltstone difficult to distinguish from the rest of the Siltstone Sequence. Significant concentrations of Zn-Pb-Ag mineralization appear to be coincident with these lenses of thinly-bedded mudstone. The Mudstone Unit at Silver Shaft appears to be grouped with the Massive Vitric Tuff unit of Unger (1982) at the Union Copper Mine.

## Upper Volcanic Sequence

The Siltstone Sequence terminates abruptly at a rhyodacitic crystal-lithic volcanoclastic unit at the base of the Upper Volcanic Sequence (Figures 5, 6, 7, and 8). The sequence is probably over 250 meters thick and characterized by crystal and crystal-lithic dacitic to rhyodacitic volcanoclastic units alternating with vitric volcanoclastic or epiclastic siltstone, mudstone, and sandstone. Lithologies suggest a sporadic renewal of volcanic activity following a period of quiescence. Trace to 5% pyrite and pyrrhotite are present as disseminations and thin, irregular laminae, along with local trace red-brown sphalerite.

This sequence appears to correlate with the Sericite Phyllite unit of Unger (1982) at the Union Copper Mine. It is described as strongly foliated and locally bedded micro-crystalline quartz and sericite with 2-10% quartz and feldspar crystals 0.5 to 1.0 millimeters in

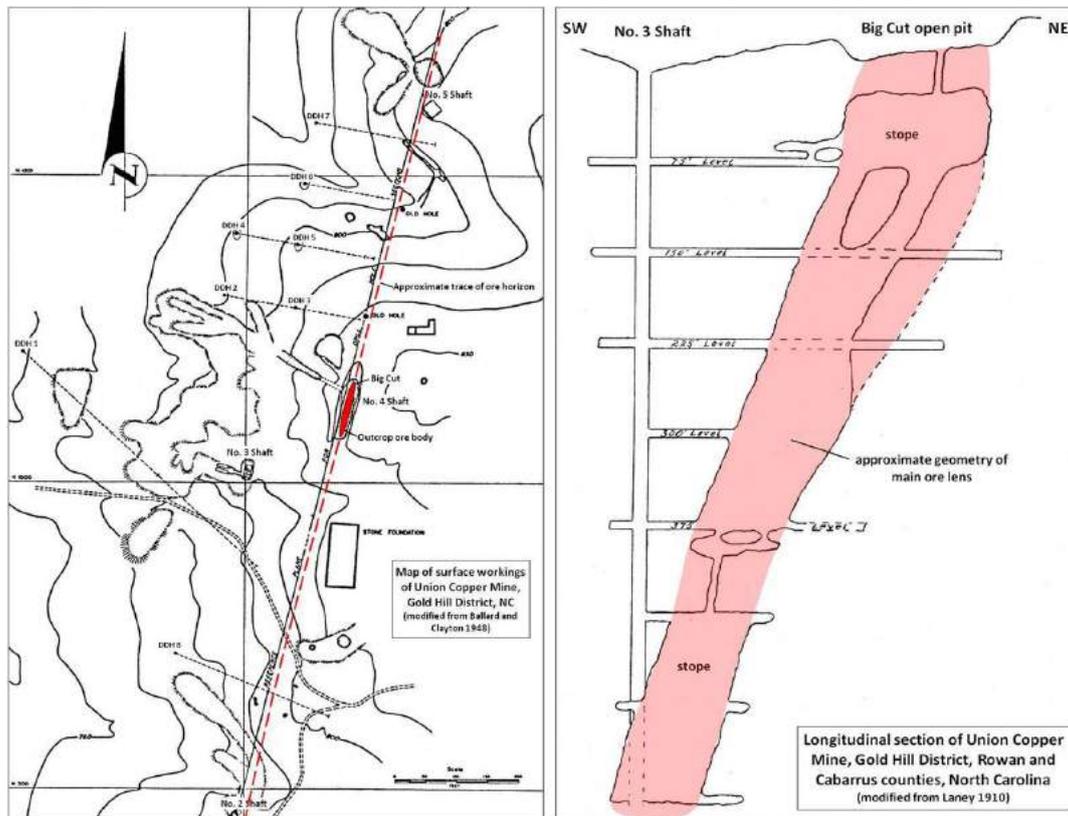
size. Pyrite as 0.5-3.0 millimeter grains is present as 1-5% disseminations and laminae, and often flattened into the foliation. Unger (1982) reports the presence of interbedded units and lenses of lapilli-tuff, lapilli-stone, lithic tuff, lithic-crystal tuff, and crystal-lithic tuff up to 25 meters thick in this sequence.

### **The Union Copper Mine deposit**

The Union Copper Mine is located on the Rowan-Cabarrus county line, 2.3 kilometers southwest of the town of Gold Hill (Figure 2). The deposit was discovered in 1842 and the oxidized surface gossan initially mined for gold from a shallow open pit known as the Big Cut. Secondary enriched Cu ores were encountered at a depth of 7.5 to 9 meters and the ore body named the “Big Cut copper vein” (Weed 1911). Copper minerals of the supergene enrichment zone include chalcocite, cuprite, native copper, malachite, and azurite (Weed 1911).

Five shafts were opened into the primary sulfide ores along a line trending 030° for around 400 meters (Figures 2 and 9). Most underground mining of the main ore lens was through shafts No. 3 and No. 4, with No. 3 reaching a depth of 183 meters and developed on five levels. The waste dumps from these shafts cover several acres on the surface. The open cut surrounding the No. 4 shaft marks the outcrop of the orebody at the surface and original mine site (Figure 9). An interesting historical note is the use of square set timbering in the upper portion of the mine, due to the incompetence of the rock (Laney 1910). The mine was most active from 1899 to 1906, and ceased operations in 1907. It produced 5,000,000 pounds of copper and \$375,000 in gold (18,142 ounces Au at \$20.67 per ounce), with most of the gold (\$300,000 from 14,514 ounces) recovered from the oxidized zone (Laney 1910).

Laney (1910) suggests that the Union Copper deposit was formed in a fault zone; however, it is more likely that a VMS deposit conformable within the stratigraphic section has been heterogeneously sheared and partially reoriented by ductile-brittle strain within the Gold Hill Fault Zone. Despite some degree of tectonic transposition, alteration and metal zonation studies by Unger (1982) suggest that the Union Copper deposit is largely intact and broadly preserves most elements of the original hydrothermal system architecture. The geometry of the Union Copper ore body is similar to that of the Silver Hill ore body in the Cid District to the north, and suggests similar tectonic modification of an existing VMS deposit within the Gold Hill Fault Zone during the Cherokee Orogeny (Hibbard et al. 2012).



**Figure 9: Surface map of historic mine workings (left) and longitudinal section through the main ore body (right), Union Copper Mine, Gold Hill District, North Carolina**

## Post-production exploration

The Union Copper deposit was drilled by the US Bureau of Mines in 1943 (Ballard and Clayton 1948). Eight diamond core holes totaling 762 meters tested the zone along 275 meters of strike (Figure 9). Six holes in four fences were drilled between shafts No. 4 and No. 5, one hole was drilled north of shaft No. 2, and a single deep hole tested the zone below and 30 meters south of the main stopes. Drilling encountered a generally lower-grade, strongly silicified mineralized zone 9-12 meters wide north and south of the old stopes, and containing pyrite and sphalerite with accessory chalcopyrite and galena (Ballard and Clayton 1948). The ore body appears to be zoned from a Cu-rich central zone to a more Zn-rich periphery. Gold mineralization appears to be closely associated with higher Cu-values.

The Tennessee Copper Company (Cities Service) drilled 7 core holes totaling 1675 meters at Union Copper in the early 1960s, and Conoco Minerals drilled an additional eight diamond core holes with a total of 1860 meters in 1977. Seven Conoco drill holes largely tested the down-dip extension of the same zone tested by the US Bureau of Mines without discovering significant mineralization. A single hole was drilled west-to-east beneath the old Joe's Bluff shaft, located south of the Union Copper Mine and east of Silver Shaft (Figure 5).

This collapsed shaft or pit is opened in a sulfidic zone footwall to the Union Copper ore body. A line of small prospects and shallow shafts follow this horizon north to the Union Copper Mine, but no significant production is indicated.

### Union Copper main Cu-Zn-Au ore body

The Union Copper main ore body (Figure 9) was up to 40 meters long and 12 meters thick near the surface, and 30 meters long and up to 5 meters thick at a depth of 114 meters below surface (Ballard and Clayton 1948, Pardee and Park 1948). The mineralization becomes attenuated and irregular at a depth of 152 meters. The upper part of the ore body, from the surface to the second underground level, strikes about  $025^\circ$  and plunges  $70^\circ$  SW, with slickenlines parallel to the plunge along the contacts (Laney 1910, Pardee and Park 1948). The dominant foliation in the host rocks strikes  $040^\circ$ . The ore body parallels the strike of the foliation on the third mine level, and other portions of the mineralized zone strike between  $035^\circ$  and  $065^\circ$ .

Mineralization is described as dominantly chalcopyrite + pyrite averaging about 1.5-3.0% Cu, with minor sphalerite and galena. Sulfides occur in a series of massive ( $\geq 50\%$ ) to sub-massive (30-50%) lenses containing fragments of country rock, surrounded by a lower-grade halo of quartz + sulfide stringers and veins and disseminated sulfide grains in a strongly silicified zone that extends along strike beyond the zone of known mineralization (Laney 1910, Unger 1982).

Primary ore minerals and accessories are pyrite, sphalerite, chalcopyrite, galena, pyrrhotite, barite, magnetite, and arsenopyrite (Unger 1982). Textures in the massive ore include banding, contorted banding, and chaotic textures (Unger 1982), probably in part of tectonic origin. Gangue and alteration minerals include, in decreasing abundance, chlorite, biotite, calcite, talc, and quartz (Unger 1982). Sub-massive sulfide lenses in the upper part of the system grade along strike into chlorite-biotite-talc-sulfide schist (Unger 1982).

### Hydrothermal alteration at Union Copper

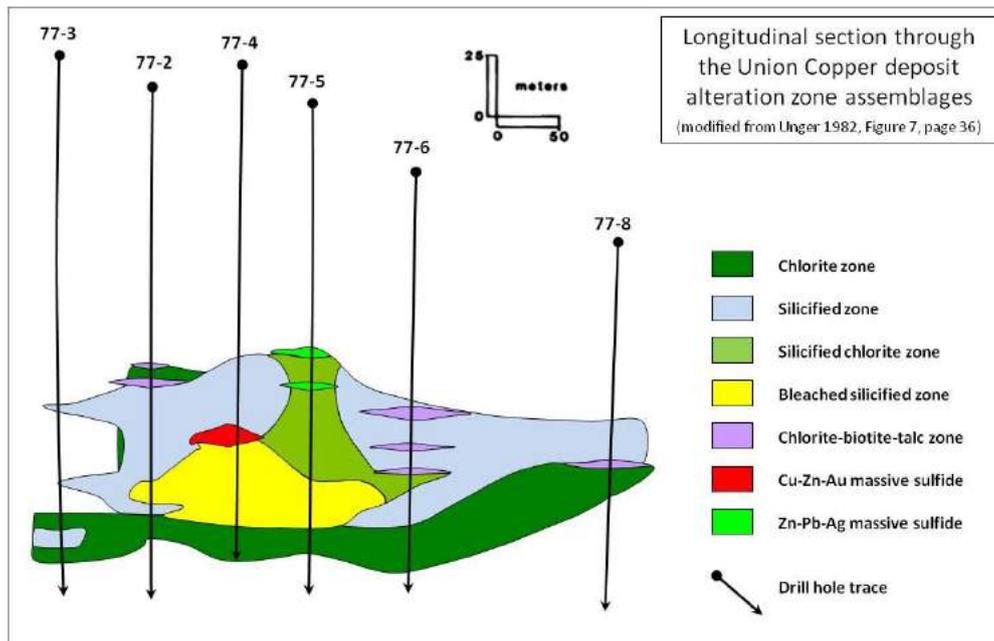
As mapped by Unger (1982), the Union Copper deposit is centered on an extensive area of compositionally zoned hydrothermal alteration developed for 300-500 meters along strike and around 100 meters stratigraphically (Figure 10). All alteration assemblages show some degree of local stratigraphic control, probably due to compositional or textural variations. Unger (1982) does not address alteration paragenesis, but there appears to be

widespread overprinting between strongly silicic and chlorite-biotite-talc-sulfide-carbonate assemblages.

The zone of most intense alteration forms a pipe about 100 meters wide across 30 meters stratigraphically in the immediate footwall of the sulfide ore body. A pipe of less intense alteration about 50 meters wide continues for another 400 meters into the hanging wall of the main Cu-Zn-Au ore body, footwall to a series of small lenses of Zn-Pb-Ag mineralization.

The alteration zone that surrounds the massive to sub-massive sulfide ore body is characterized by numerous stringer quartz-sulfide veins that contain 1-10% pyrite + sphalerite + chalcopyrite with minor galena and trace arsenopyrite (Unger 1982). This stringer mineralization is most extensively developed in the footwall (Unger 1982). It forms much of the mineralization present on the old mine dumps, but was not part of the ore body. Isolated stringer veins and disseminated pyrite, sphalerite, chalcopyrite and galena are widespread throughout much of the host sequence in the footwall and hanging wall of the deposit and along strike. There is a tacit assumption that all or most of the sulfide-bearing quartz veins peripheral and footwall to the main Union Copper ore body are hydrothermal in origin, and not products of subsequent deformation and metamorphism.

Pervasive silicification is the most common form of alteration associated with the Union Copper VMS deposit. It is strongly developed throughout the central and upper portions of the system, and often broadly coincident with chlorite alteration peripheral to the central core. It is composed of 75-95% fine-grained to cherty silica with minor to trace sericite (Unger 1982). The most intense hydrothermal alteration is represented by the "bleached silicified zone" footwall to the main Zn-Cu-Au ore lens (Unger 1982). Pale colored with a saccaroidal texture and strongly fractured or brecciated with stockwork quartz veins, the bleached silicic alteration is composed almost entirely of quartz + sericite + sulfides, mostly chalcopyrite, and appears to be central to the broad alteration zone surrounding the Union Copper main zone (Unger 1982). This style of alteration, coincident with or overprinting chloritic alteration also extends upward into the immediate footwall of several small hanging wall Zn-Pb-Ag ore lenses.



**Figure 10: Longitudinal cross-section through the Union Copper deposit alteration zone assemblages, Gold Hill District, North Carolina**

Chloritic alteration is less widespread than silicic, although it may be extensively overprinted in the core of the alteration zone, and characterized by 5% to over 50% chlorite (Unger 1982). It appears to extend throughout most of the system, but dominates the deep footwall and the periphery of the central silicic core. Unger (1982) reports the presence of at least six discontinuous 1-7 meter thick lenses of chlorite-biotite-talc-carbonate-sulfide schist in the Union Copper alteration zone (Figure 10). Some grade along strike into semi-massive sulfide mineralization. They show strong stratigraphic control and appear to flank the central silicic core of the alteration zone in the middle to upper portions of the host Siltstone Sequence.

Although not recognized as a discrete alteration zone, potassic alteration is present as biotite and as plagioclase altered to K-feldspar, especially in the footwall of the ore body where biotite is more abundant than chlorite in the matrix of the altered Lower Volcanic Unit (Unger 1982). Unger (1982) noted an alteration trend of progressive K-enrichment with depletion of Na within the Union Copper alteration zone, and an overall enrichment of Si, K, and Mg.

### Union Copper hanging wall Zn-Pb-Ag mineralization

Bureau of Mines drill holes DDH01 and DDH02 intersected a 5-meter thick zone of sphalerite and galena mineralization about 60 meters into the hanging wall of the Union Copper main ore body. Three of the Conoco drill holes intersected zones of Ag-Zn

mineralization in the hanging wall of the main Union Copper ore body. Drill hole RONC-77-2 intersected 3.7 meters (true thickness) of 4.91 opt Ag and 1.17% Zn. Drill hole RONC-77-5 intersected 2.7 meters of 1.02 opt Ag and 5.10% Zn within a 7.6 meter zone that averaged 3.59% Zn. Tennessee Copper drill hole No. 2 intersected 2.1 meters (true thickness) of 3.7 opt Ag and 1.74 % Zn.

Some of these hanging wall mineralized zones may be associated with discontinuous lenses of chlorite-biotite-talc-carbonate-sulfide schist described by Unger (1982) in the upper portions of the Union Copper alteration zone. The hanging wall Zn-Pb-Ag ore zones at the Union Copper Mine appear to be at the same approximate stratigraphic position as the mineralized zone at the Silver Shaft Mine to the south. Several small Union Copper Zn-Pb-Ag hanging wall ore lenses may have been exploited by a series of poorly known workings located west of the main line of lode at the Union Copper Mine, and may represent segments of the “Silver Vein” of Nitze and Hanna (1896, Plate VI).

### **The Silver Shaft (McMakin) deposit**

The Silver Shaft Mine, formerly the McMakin, is located approximately 550 meters south-southwest of the Union Copper Mine in Cabarrus County (Figures 2 and 5). The deposit is labeled the “Manganese” vein on the map of Emmons (1856). The McMakin Mine is commonly misidentified with the Whitney Mine (Laney 1910, Carpenter 1976); however, descriptions of the ore body in older publications (Kerr and Hanna 1888, Nitze and Hanna 1896) are not consistent with the geology of the Isenhour-Whitney lode. Nitze and Hanna (1896) make a clear distinction between the location of the McMakin Mine and the Isenhour-Whitney group of mines within the district.

Additionally, correlation of the “Big Cut” on the map of Emmons (1856) with the location of the “Standard-Open Cut-Copper Vein” on the map of Kerr and Hanna (1888) is consistent with the position of the Union Copper Mine. The location of the McMakin Mine relative to the Union Copper Mine on the same maps is consistent with the location of the Silver Shaft site. Confusion has probably arisen from the consolidation of a number of mining properties at Gold Hill as the Whitney Group during the later period of mining in the district. Only a single collapsed shaft and spoil pile remained of the McMakin Mine in the early 1980s, and the site was subsequently completely reclaimed.

The “McMakin Vein” is shown on the map of Nitze and Hanna (1896, Plate VI) as continuous with the “Silver Vein” to the southwest and the northeast over a strike of about 800 meters, mostly located in northern Cabarrus County. The “vein” is situated west and *en*

*echelon* to the “Copper Vein” and the “Standard” or “Open Cut Vein” of Nitze and Hanna (1896), representing the Union Copper Mine ore body. The McMakin-Silver Vein on this map may represent the Silver Shaft deposit and the series of small lenses of Zn-Ag rich VMS mineralization present in the hanging wall (west) of the Union Copper VMS deposit (Unger 1978, Smart and Moye 1982).

The McMakin Mine was active from sometime after 1842 until 1861. The “Main Vein” was worked by shallow pits for around 275 meters along strike (Nitze and Hanna 1896), and mined underground through three shafts over a length of 60 meters to a maximum depth of 55 meters with development levels at the bottom and at 20 meters depth (Kerr and Hanna 1888, Nitze and Hanna 1896). A smaller, parallel “West Vein” was stoped from the Whim Shaft to the surface (Kerr and Hanna 1888). The host rocks are described as talc-chlorite schist, with an argillaceous footwall and talcose hanging wall (Kerr and Hanna 1888).

Nitze and Hanna (1896) describe the “Main Vein” as bedding-parallel, striking 045°-060° and dipping 70°-75° southeast with the “West Vein” striking 050°-060° and dipping 35° southeast. However, the Silver Shaft sulfide ore body, as determined from geologic mapping correlated with core drill holes by Smart and Moye (1982), strikes 025° and dips 70°NW conformable with stratigraphy in the host Siltstone Sequence. The West Vein may be the faulted southern portion of the main ore body, as suggested by PDEE drilling.

In the “Main Vein” at the McMakin Mine, abundant manganese oxides (psilomelane, pyrolusite) were present from the surface to a depth of six meters, followed by abundant secondary Pb oxides, carbonates, and phosphates (pyromorphite, cerussite) to a depth of 18 meters (Kerr and Hanna 1888). Primary sulfides are yellow sphalerite, galena, Ag-bearing tetrahedrite, pyrite, and chalcopyrite, with a gangue of quartz, calcite, barite, rhodochrosite, and talc (Genth 1891, p. 90). Genth (1891) also reports the presence of small plates and reticulated masses of native silver, argentite, and possible proustite.

At a depth of 23 meters between the South and Whim shafts, the lode was described as 1-3 meters thick and composed largely of carbonate and barite with a zoned distribution of sulfides; disseminated grains and small masses (to 60 centimeters) of tetrahedrite near the hanging wall, a central zone with seams of tetrahedrite and yellow sphalerite, and yellow sphalerite and galena with numerous grains of tetrahedrite near the footwall (Kerr and Hanna 1888). The sulfide ore assayed around 14-53 opt Ag (Kerr and Hanna 1888) and Genth (1891) assayed tetrahedrite (freibergite) samples from the McMakin with 6.5-10.5 wt% Ag, equivalent to as much as 500 opt Ag.

## Phelps Dodge Exploration East exploration and evaluation

Phelps Dodge Exploration East evaluated the Silver Shaft deposit in 1980-1981, and the following discussion is largely based on in-house reports (Smart and Moye 1982). The area was mapped at a scale of 1 inch = 100 feet, extensive soil geochemical sampling and ground geophysical surveys were completed (magnetic, HLEM, SP, IP-Resistivity), and seven diamond core holes totaling 1345.1 meters were drilled (Figures 5, 6, 7, and 8).

The Silver Shaft mineralization was unresponsive to geophysical methods and no coherent soil geochemical anomaly could be established. The geochemical and geophysical response of the mineralization may have been masked by the widespread occurrence of up to 2-5% to locally 10-15% disseminated and laminar pyrite and pyrrhotite and widespread minor disseminated sphalerite, galena, and chalcopyrite throughout much of the host sequence.

The best drill hole result, from PDEE-3, was 7.3 meters averaging 8.88 opt Ag and 1.113% Zn, intersected 15 meters north of the old shaft at a vertical depth of 91.4 meters. The Silver Shaft ore body appears to be highly localized and elongated down-dip, similar to the geometry of the Union Copper deposit. Drilling outlined a mineralized zone measuring about 60 meters along strike, 120 meters down dip, and 7 meters thick with an estimated remaining resource of 190,000 tons of ore averaging 8-9 opt Ag and 1-2% Zn (Smart and Moye 1982). The historically mined portion of the ore body was apparently of substantially higher grade.

### Silver Shaft mineralization

Spoil from the single remaining shaft of the Silver Shaft Mine in 1980 included masses of variably foliated, medium to coarse-grained, massive or irregularly to colloform banded talc + carbonate + barite + sulfide rock that assayed up to 11.4% Pb, 25.2% Zn, and 28.68 opt Ag (Smart and Moye 1982). Sulfides are very fine-grained and consist largely of pyrite + sphalerite with trace galena and chalcopyrite. This style of mineralization appears localized and was not encountered in the PDEE drill holes.

Drill hole PDSS-3 intersected lower grade mineralization 15 meters north of the old shaft at a vertical depth of 91.4 meters, with 7.3 meters averaging 8.88 opt Ag and 1.113% Zn. The mineralization consists of 10 to 15% disseminations and laminae of pyrite and sphalerite with trace galena and 1% silver selenide identified as aguilarite ( $\text{Ag}_4\text{SeS}$ ). Sphalerite in the deposit is fine-grained, pale yellow to white, and extremely Fe-poor. Aguilarite was identified as the primary Ag-bearing phase and the tetrahedrite and argentite reported by Genth (1891) were not identified. The host rocks are interbedded massive talc, talc-carbonate breccia, and talcose mudstone. This interval occurs as a discrete zone near the

top of a 21-meter (true thickness) zone of talcose mudstones with disseminated mineralization that averages 3.62 opt Ag.

Significant mineralization was not encountered on the ore horizon in PDEE drill holes farther to the north along strike and at greater depth. Only low-grade mineralization was encountered immediately to the south. The Silver Shaft ore body appears to be highly localized and elongated down-dip, similar to the geometry of the Union Copper main zone. It appears that much of the higher-grade portion of the ore body, enriched near-surface by supergene processes, was extracted during the period of historic production.

### **Distribution of hydrothermal alteration and mineralization in the Silver Shaft-Union Copper VMS system**

The most widespread form of alteration in the Union Copper-Silver Shaft hydrothermal system is silicic alteration. It is heterogeneously developed throughout much of the observed stratigraphic section, but most strongly represented in the Siltstone Sequence. Given the broad distribution, it is uncertain whether silicic alteration is hydrothermal, authigenic, or a combination of the two. Work by Unger (1982) suggests that there is a focused area of hydrothermal silicic alteration centered on the Union Copper VMS deposit, with a bleached silicified zone at the core that represents the main fluid pathway (Figure 10). Widespread silicic alteration in the Siltstone Sequence at Silver Shaft shows no apparent relationship to mineralization, and may be largely authigenic. Although ubiquitous throughout the Lower Volcanic Sequence and Siltstone Sequence, silicic alteration does not appear to extend into the Upper Volcanic Sequence in the Union Copper or Silver Shaft areas.

Chlorite alteration centered on the Union Copper Mine ore body (Figure 10) extends through much of the Siltstone Sequence footwall to the uppermost Zn-Pb-Ag ore lens, and into the upper 15 meters of the Lower Volcanic Sequence (Unger 1982). Weak to moderate chlorite alteration is widespread in the Siltstone Sequence footwall to the ore body at Silver Shaft. Carbonate is not observed as a significant component of rock units or alteration assemblages in the Union Copper Mine section (Unger 1982), except as a minor component of quartz  $\pm$  sulfide veins. These veins are locally abundant peripheral and footwall to the Union Copper main ore zone and also present in the Siltstone Sequence footwall to the Silver Shaft deposit. However, carbonate is abundant in the Zn-Ag rich ore body at the Silver Shaft Mine. Unger (1982) also notes the occurrence of carbonate in 1-10 millimeter coarse-grained aggregates as gangue in massive sulfide ore at Union Copper.

Sulfidation in the form of minor disseminated Fe-sulfide is ubiquitous throughout the entire observed lithologic section in the Union Copper-Silver Shaft area. There is a distinct shift from pyrite to pyrrhotite as the dominant sulfide at the top of the Lower Volcanic Sequence, and prospecting along the Joe's Bluff horizon suggests that more abundant Fe-sulfides and minor base metal sulfides are present in this interval.

Pyrrhotite is especially abundant in the basal 15 meters of the Siltstone Sequence, and minor (1-5%) pyrite and pyrrhotite are present footwall to the Mudstone Unit of the Siltstone Sequence at Silver Shaft. Pyrite is the dominant Fe-sulfide present in the Mudstone Unit of the Siltstone Sequence, and both pyrite and pyrrhotite are trace to minor components of the Upper Volcanic Sequence. It is uncertain whether the widely dispersed disseminated sulfide formed by hydrothermal sulfidation of Fe-bearing minerals, as direct hydrothermal or authigenic precipitation, or a combination of processes. Local bedding-parallel laminae of pyrrhotite or pyrite suggest possible chemical sedimentation or selective replacement.

Base metal sulfides (sphalerite, chalcopyrite, and galena) are heterogeneously distributed throughout the defined stratigraphic section in the Union Copper-Silver Shaft area of the Gold Hill District. Base metal sulfides occur in three associations:

- as massive to semi-massive stratabound lenses
- as accessory minerals and aggregates in quartz veins
- as trace to minor disseminated grains throughout the section

Massive to semi-massive accumulations of base metal sulfides occur only within the Siltstone Sequence, and include the main Zn-Cu-Au ore body at the Union Copper Mine, the Zn-Pb-Ag lenses in the hanging wall at Union Copper, and the Zn-Pb-Ag ore body at the Silver Shaft Mine. These occurrences may be syngenetic exhalative horizons formed by hydrothermal fluids venting onto the ocean floor, or replacement mineralization formed at shallow depths below the sea floor. Semi-massive mineralization at Union Copper is locally gradational laterally into chlorite-biotite-talc-sulfide schist (Unger 1982), suggesting a stratigraphically controlled alteration or replacement origin.

Quartz ± carbonate ± sulfide veins form a stockwork (high density) to stringer (low density) zone surrounding the Union Copper main ore body, but are most strongly developed in the footwall (Unger 1982). Similar veins are present in the footwall of the Silver Shaft deposit, and both suggest formation by hydrothermal fluids within or peripheral to major fluid pathways footwall to the massive sulfide lenses. The formation of veins suggests brittle fracture, potentially hydraulic, of coherent rocks, possibly cemented during an earlier phase of alteration.

Disseminated base metal sulfides are scattered heterogeneously throughout the Lower Volcanic Sequence and Siltstone Sequence, and sphalerite is noted locally in the Upper Volcanic Sequence. Total disseminated base metal sulfide content is typically a trace to 2% by volume. Sphalerite, galena, or chalcopyrite may be locally dominant, but sphalerite is most common and chalcopyrite least abundant. Sphalerite is typically reddish-brown in the Lower Volcanic Sequence, the lower part of the Siltstone Sequence, and the Upper Volcanic Sequence. Pale yellow sphalerite appears only in the Mudstone Unit of the upper Siltstone Sequence, footwall to and within the Silver Shaft ore body.

Precious metal distribution in the Union Copper hydrothermal system is distinctly partitioned, with gold enriched in the higher temperature Cu-rich core of the Union Copper ore body and silver dominating the lower temperature Zn-Pb rich hanging wall sulfide zones. The mode of occurrence of gold in the Union Copper main ore body is uncertain, but appears closely associated with the distribution of chalcopyrite and higher copper grades. The occurrence of silver in small hanging wall lenses of Zn-Pb-Ag mineralization at the Union Copper Mine is uncertain, but much of the silver at the Silver Shaft deposit appears to reside in galena and Ag-sulfides and selenides. Aguilarite was identified by Phelps Dodge petrographers, and Genth (1891) reports the presence of Ag-bearing tetrahedrite, argentite, and proustite.

## **Conclusions**

The Union Copper and Silver Shaft ore bodies of the Gold Hill District are polymetallic volcanogenic massive sulfide (VMS) deposits, products of a large submarine hydrothermal system that was active synchronously with deposition of a portion of the host felsic volcanoclastic stratigraphic section. The hydrothermal system may have vented to the seafloor intermittently during deposition of the middle to upper portions of the Siltstone Sequence, forming the Union Copper and Silver Shaft polymetallic sulfide ore bodies. The hydrothermal system cooled and weakened but continued to operate during initial deposition of the Upper Volcanic Sequence.

The large area of intense alteration and mineralization centered at the Union Copper Mine (Figure 10) represents strongly focused hydrothermal discharge across the stratigraphic section. Alteration assemblages include bleached silicic (saccaroidal quartz + sericite + sulfide), silicic (cherty quartz ± quartz veinlets), sulphidic (pyrite and/or pyrrhotite), potassic (K-spar + biotite ± sulfide), and chloritic (chlorite + carbonate ± talc + sulfide + quartz).

These assemblages appear to be telescoped at the Union Copper Mine to produce a large, zoned alteration system with complex overprinting relationships.

Although strongly focused at Union Copper, the hydrothermal system operated heterogeneously over at least a kilometer of strike and across 300 meters of stratigraphic section. The almost ubiquitous occurrence of cherty silicic alteration and minor disseminated pyrite and/or pyrrhotite throughout the Lower Volcanic Sequence and Siltstone Sequence may be the result of authigenic processes in water saturated sediments. Alternatively, they may be peripheral to the focused VMS hydrothermal system at Union Copper.

The more localized, heterogeneous dissemination of sphalerite, galena, and chalcopyrite throughout the system, and the variable occurrence of these minerals in quartz  $\pm$  carbonate vein stringer zones, suggest association with hydrothermal processes. Both intensify towards the Union Copper footwall alteration zone and in the footwall of the Silver Shaft ore body. Potassic alteration and bleached silicic alteration appear to be strongly localized and centered on the Union Copper deposit, with potassic alteration extending from the deep footwall into the upper portion of the system. Bleached silicic alteration is strongly developed within the Siltstone Sequence footwall to the main Cu-Zn-Au ore body, but also extends upwards into the footwall of the stratigraphically higher Zn-Pb-Ag ore lenses at the top of the system, probably marking the main fluid conduit.

Chloritic alteration (chlorite  $\pm$  biotite  $\pm$  talc  $\pm$  carbonate  $\pm$  sulfide  $\pm$  quartz) appears to be most directly associated with base metal sulfide mineralization. In the absence of significant mafic rocks within the host stratigraphic section, Mg-rich assemblages appear to result from intense Mg-metasomatism. This produced strong, widespread chloritization peripheral to the primary fluid conduit at Union Copper, and more localized formation of talc. Talc at Union Copper appears to be largely restricted to thin, lensoidal units of chlorite + biotite + talc + carbonate + sulfide, where it may be the major component (Unger 1982). These units grade into semi-massive sulfide and appear to show distinct stratigraphic control, possibly due to favorable texture or composition.

Talc alteration of volcanoclastic mudstone occurs over an interval up to 25-30 meters thick at Silver Shaft, with disseminated to semi-massive Zn-Pb-Ag sulfide mineralization reaching ore grade over 7-8 meters near the top of the zone. The low-Fe character of the sphalerite, the presence of aguilarite, abundant carbonate, and locally abundant barite at Silver Shaft contrast with the higher temperature, more Fe-rich mineral assemblages at the Union Copper Mine. Although variable chlorite alteration and stringer quartz-carbonate-sulfide veins are present in the footwall of the Silver Shaft deposit, the intense, telescoped alteration zone

that characterizes Union Copper is absent. This perhaps suggests that Silver Shaft formed from a weaker, lower temperature, more diffuse hydrothermal flow peripheral to the main system.

Localized lenses of Zn-Pb-Ag mineralization in discontinuous intervals of thinly-laminated mudstone in the upper part of the Siltstone Sequence at Silver Shaft and Union Copper may suggest hydrothermal venting in local seafloor pools or seeps. Alternatively, the intimate association with talc alteration may indicate intense Mg-metasomatism and replacement below the water-sediment interface. Zones of fragmental or breccia textures in the Siltstone Sequence footwall to the Silver Shaft deposit may be the result of localized, possibly cyclic fluid overpressure and near-surface phreatic explosion or implosion events.

The character and thickness of the felsic crystal-lithic tuff of the Lower Volcanic Sequence in the Union Copper-Silver Shaft area of the Gold Hill District are not consistent with volcanic units described in the Tillery Formation, the Floyd Church Formation, or the Mudstone Member of the Cid Formation (Conley 1962, Stromquist and Sundelius 1969). These units are most consistent with lithologies of the Flat Swamp Member of the Cid Formation, in agreement with the interpretations of Ledger (1978), Unger (1982), and Smart and Moye (1982). The Siltstone Sequence, host for the Union Copper and Silver Shaft ore bodies, is consistent with the transition zones described by Stromquist and Sundelius (1969) at the top and base of the Flat Swamp Member.

The Flat Swamp Member also appears to be the host for the Silver Hill and Silver Shaft VMS deposits in the Cid District to the north. If correct, this interpretation suggests that all known polymetallic VMS deposits in the Albemarle Sequence are associated with the Flat Swamp Member of the Cid Formation. Additionally, known VMS deposits are also limited to the thickest sections of this formation in the north-western portion of the Albemarle Group outcrop area. It is possible that these VMS deposits occur exclusively within the northern nose and variably dismembered limbs of the Silver Valley Syncline.

Preservation of intact Flat Swamp Member stratigraphy within the Gold Hill Fault Zone in the Gold Hill District is consistent with observations concerning the character and distribution of ductile-brittle strain within the fault zone (Standard 2003, Hibbard et al. 2008, and Hibbard et al. 2012). It appears likely that preservation of the stratigraphic section within any given section of the Gold Hill Fault Zone is dependent on the degree of decoupling from the intact stratigraphic section in the footwall of the Silver Hill Fault. Stratigraphy is more likely to be intact over large areas in the lower portion of the Gold Hill Fault Zone, although potentially overturned or repeated by meso-scale folds and second order reverse faults.

Preservation of intact stratigraphic sections is probably reduced with proximity to the Gold Hill Fault.

The Union Copper and Silver Shaft VMS deposits in the Gold Hill District and the Silver Hill deposit in the Cid District are strongly elongated down-dip with a steep plunge to the southwest. This geometry is almost certainly due to largely ductile strain within the Gold Hill Fault Zone. However, there is no established evidence that this geometry is due to remobilization of VMS sulfides into meso-scale folds or shear zones. The generally intact hydrothermal architecture of the Union Copper and Silver Shaft VMS deposits suggests that alteration assemblages, and even massive sulfide mineralization, have not been preferentially deformed within the Gold Hill Fault Zone, nor have they acted as loci for initiation or partitioning of strain. The local partitioning of strain appears to be largely determined by lithology and rheological contrasts, with fine-grained volcanoclastic and sedimentary epiclastic units more strongly deformed relative to more massive, coarser-grained sequences.

### **Future exploration potential**

The Union Copper and Silver Shaft VMS deposits in the Gold Hill District are part of a large submarine hydrothermal system with a strike length of at least a kilometer and developed across over 100 meters of stratigraphic section. The host Siltstone Sequence represents a hiatus in a major episode of explosive, felsic-dominated submarine volcanism interpreted as part of the Flat Swamp Member of the Cid Formation. The full strike extent of the Siltstone Sequence is uncertain, but it may continue for hundreds or thousands of meters to the northeast and southwest.

The zoned, telescoped alteration pipe centered on the Union Copper Cu-Zn-Au ore body represents a conduit for focused, high volume hydrothermal fluid up-flow across the stratigraphic section. Lower intensity hydrothermal alteration footwall to the Silver Shaft Zn-Pb-Ag ore body over 500 meters to the south suggests lower temperature hydrothermal venting that was still sufficiently focused to produce a significant massive sulfide accumulation.

Stratabound base metal-bearing sulfide mineralization is present at Joe's Bluff at the top of the Lower Volcanic Sequence, and the zoned alteration pipe at the Union Copper Mine extends across the entire thickness of the Siltstone Sequence. This suggests that hydrothermal activity capable of producing VMS-type mineralization operated either continuously or episodically during deposition of over 100 meters of stratigraphy. The laterally extensive and long-lived character of VMS-associated hydrothermal activity during deposition of the

Siltstone Sequence suggests significant potential for further discovery of high-grade massive sulfide ore bodies within this unit, along strike or at depth below the surface.

Additionally, the Silver Hill Zn-Pb-Cu-Ag VMS deposit, located 25 kilometers to the north in the Cid District (Figure 1), is hosted by the Flat Swamp Member of the Cid Formation within the western limb of the Silver Valley Syncline, partially dismembered in the eastern portion of the Gold Hill Fault Zone. The segment of the Flat Swamp Member hosting VMS mineralization in the Gold Hill District may also be part of the Silver Valley Syncline, more extensively dismembered within the fault zone in the Gold Hill area. Additional intact portions of the Flat Swamp Member with potential for VMS mineralization may be present within the fault zone between the two districts and farther to the south of Gold Hill.

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## **2.2. Core photographs and selected petrography for the Silver Shaft (McMakin) VMS deposit, Gold Hill District, Rowan and Cabarrus counties, North Carolina**

By Jeffrey C. Reid

### **Overview**

These are skeletonized drill cores from the North Carolina Geological Survey's (NCGS) repository. Each drill hole was photographed wet to bring out textures. For each drill hole there is an: 1) identification slide showing the prospect name, county and drill hole number assigned by the exploration company, and 2) a word slide that provides a cross link between the exploration company's drill hole name and the NCGS' repository identification number. The second slide also contains (where known) collar elevation, bearing, inclination, total depth, drill hole completion date, and date of core photography. Subsequent slides present the contents of individual core boxes for the drill hole. Refer to Unger (1982) for core hole parameters.

Refer to portions of this report section (below) for core hole location map(s), core hole logs accompanied by exploration geochemical results, and cross sections containing these drill holes.

Organization of the core hole photographs and selected petrography for this report follows:

1. Phelps Dodge (PDSS) core holes,
2. Conoco (RONC) core holes,
3. HANC (unknown) core hole, and
4. Selected petrography – core hole PDSS-3 (NCGS ID CB-C-3-81) – organized by increasing depth.

# Silver Shaft Prospect

Cabarrus Co., N.C.

Core PDSS-1 (skeletonized)

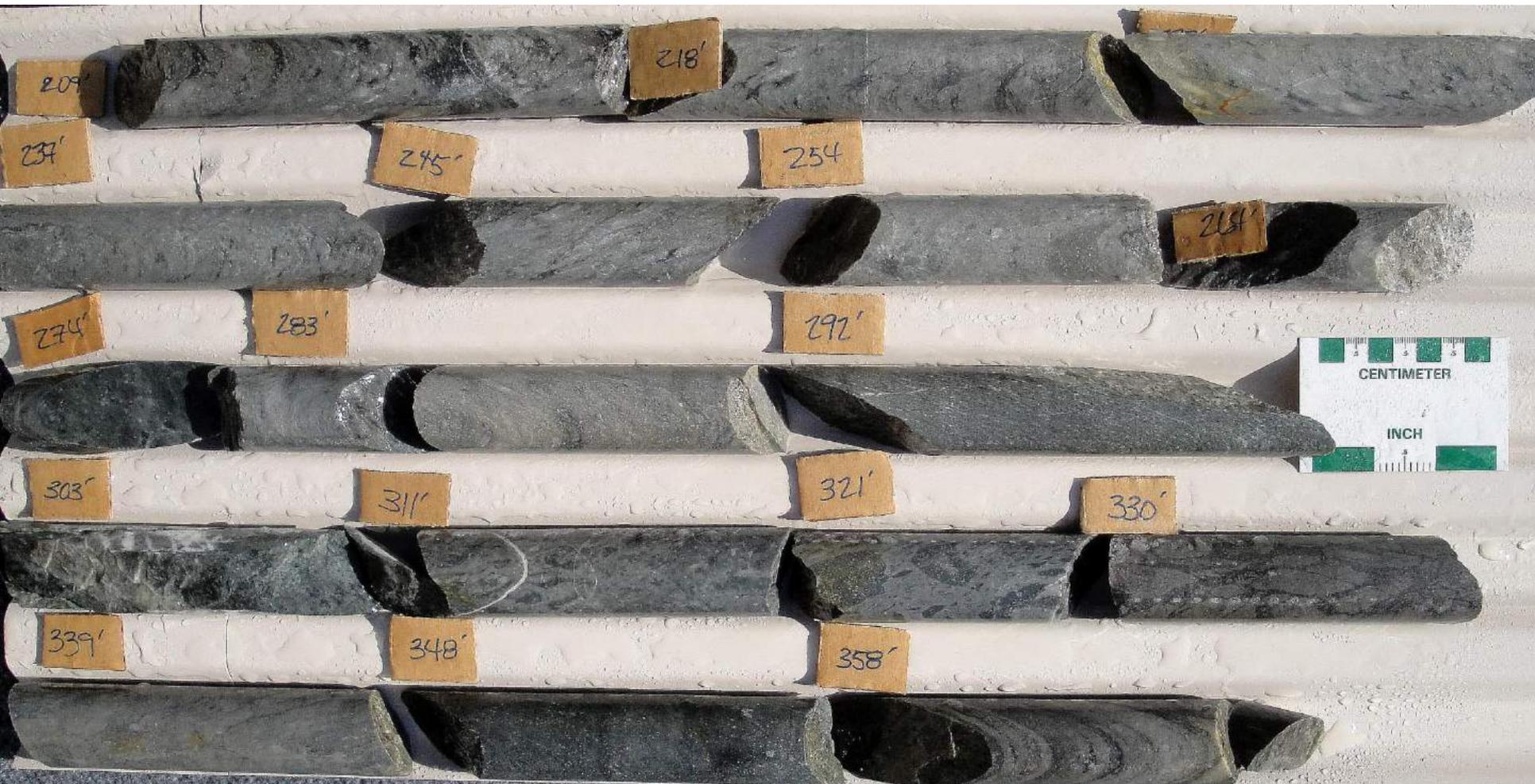
# Silver Shaft Prospect, Cabarrus Co., N.C.

- Phelps Dodge Exploration East core number: PDSS-1
- NC Geological Survey core ID: CB-C-01-81
- Other core name and ID: none
- Collar elevation: 720 feet
- Bearing: S 75° E
- Inclination: -67°
- Total depth: 604 feet
- Date core hole completed: October 1980
- Core photography date: March 1, 2016

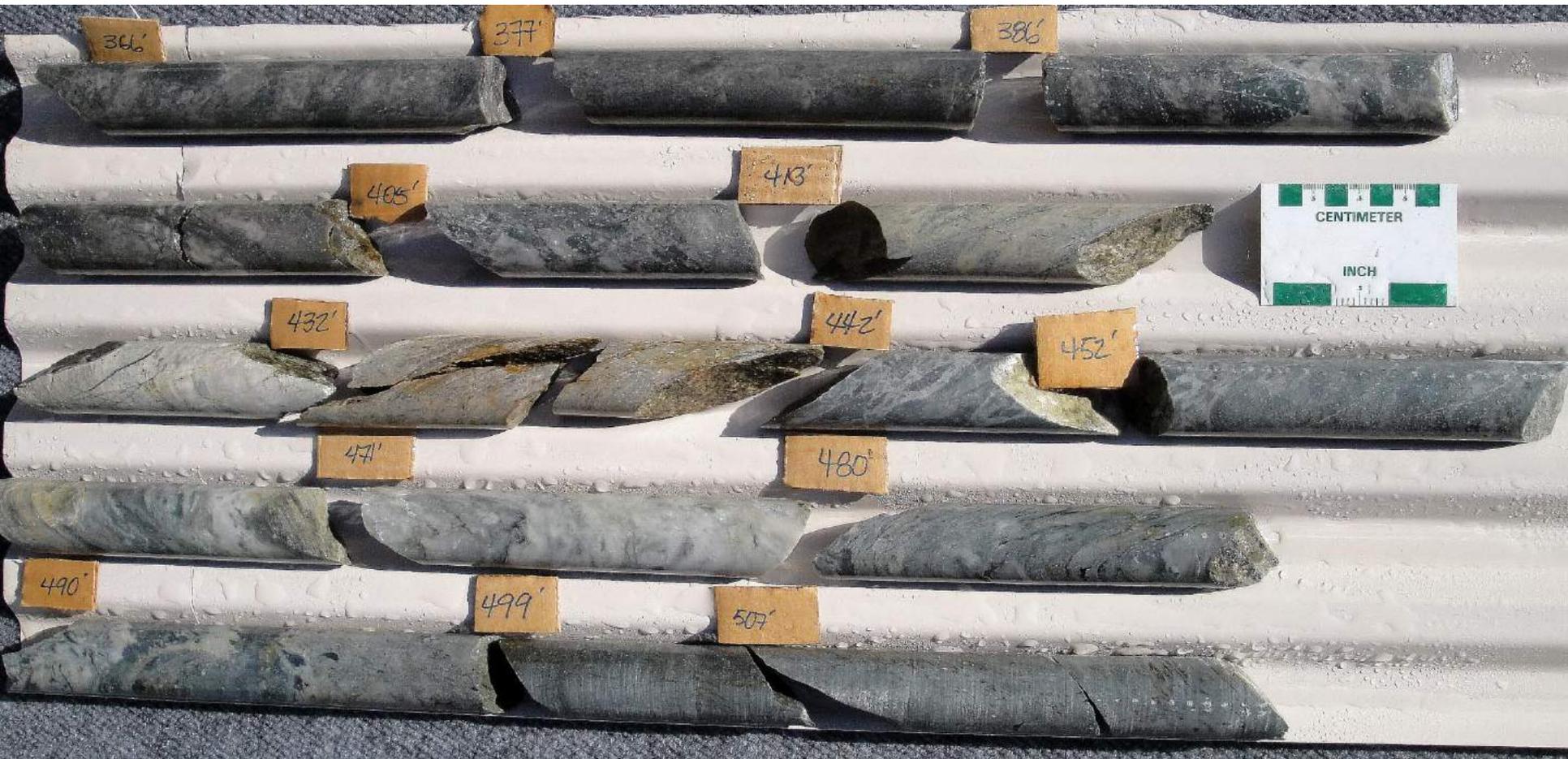
# 59-199 ft – Box 1 of 4 boxes



# 209-356 ft – Box 2 of 4 boxes



# 366-507 ft – Box 3 of 4 boxes



# 517-600 ft – Box 4 of 4 boxes



# Silver Shaft Prospect

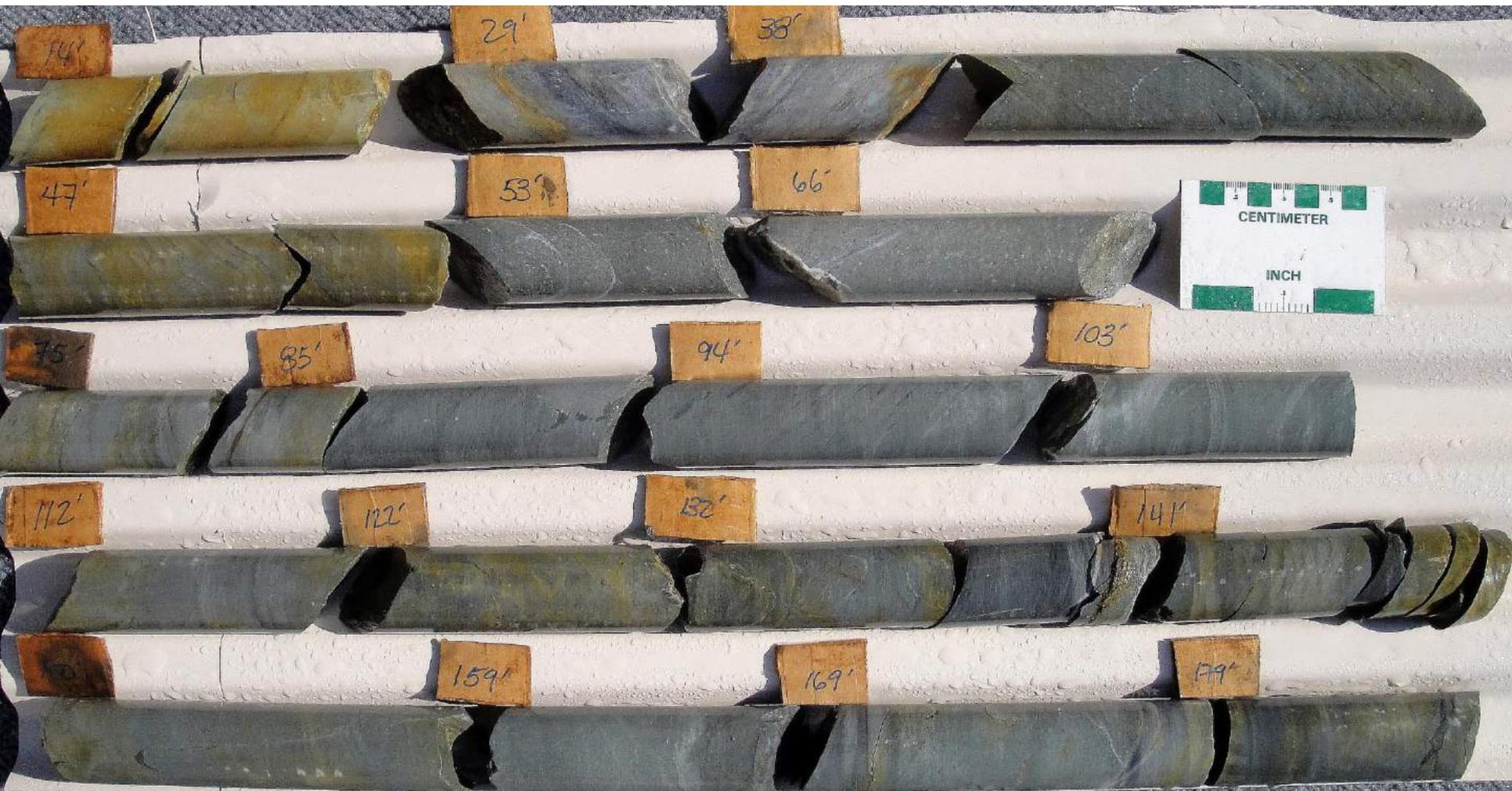
Cabarrus Co., N.C.

Core PDSS-2 (skeletonized)

# Silver Shaft Prospect, Cabarrus Co., N.C.

- Phelps Dodge Exploration East core number: PDSS-2
- NC Geological Survey core ID: CB-C-02-81
- Other core name and ID: none
- Collar elevation: 630 feet
- Bearing: S 70° E
- Inclination: -60°
- Total depth: 505 feet
- Date core hole completed: October-November 1980
- Core photography date: March 1, 2016

# 14-179 ft – Box 1 of 3 boxes



# 187-377 ft – Box 2 of 3 boxes



# 386-505 ft – Box 3 of 3 boxes



# Silver Shaft Prospect

Cabarrus Co., N.C.

Core PDSS-3 (skeletonized)

# Silver Shaft Prospect, Cabarrus Co., N.C.

- Phelps Dodge Exploration East core number: PDSS-3
- NC Geological Survey core ID: CB-C-03-81
- Other core name and ID: none
- Collar elevation: 730 feet
- Bearing: N 80° W
- Inclination: -50°
- Total depth: 574 feet
- Date core hole completed: November 1980
- Core photography date: March 1, 2016

# 61-262 ft – Box 1 of 3 boxes



# 272-416 ft – Box 2 of 3 boxes



# 424-568 ft – Box 3 of 3 boxes



# Silver Shaft Prospect

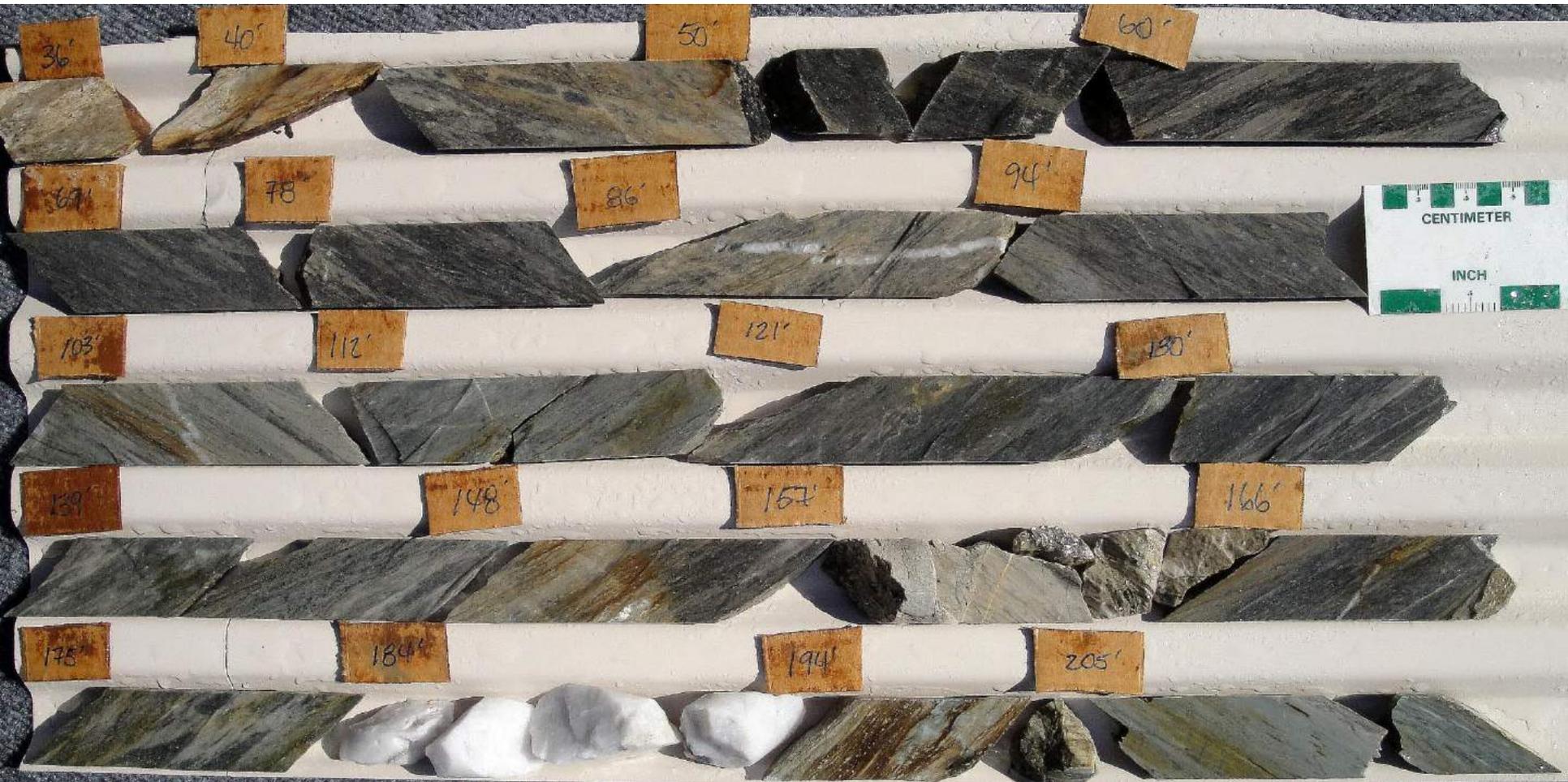
Cabarrus Co., N.C.

Core PDSS-4 (skeletonized)

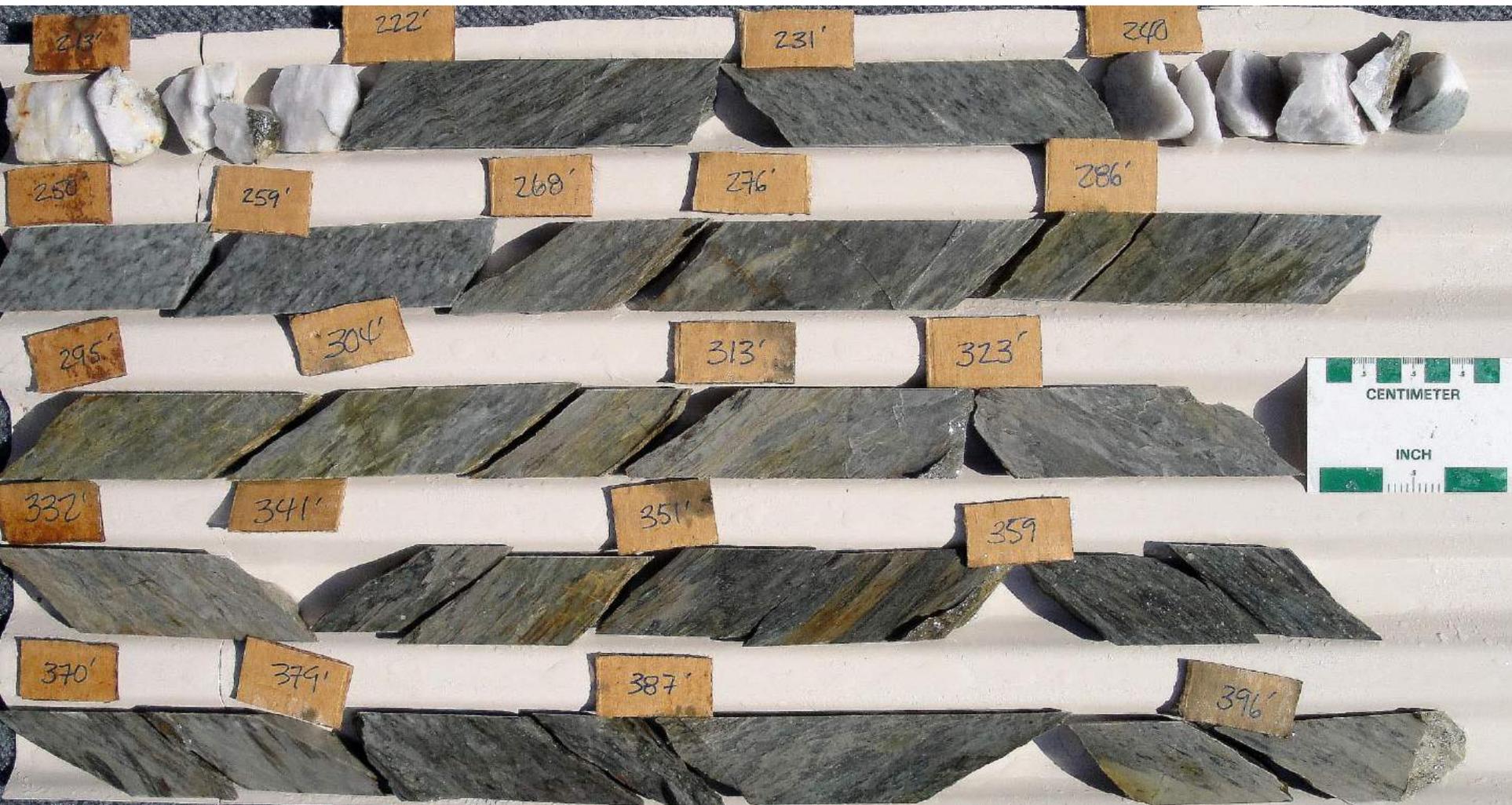
# Silver Shaft Prospect, Cabarrus Co., N.C.

- Phelps Dodge Exploration East core number: PDSS-4
- NC Geological Survey core ID: CB-04-81
- Other core name and ID: none
- Collar elevation: 710 feet
- Bearing: N 80° W
- Inclination: -45°
- Total depth: 706 feet
- Date core hole completed: April 1981
- Core photography date: March 1, 2016

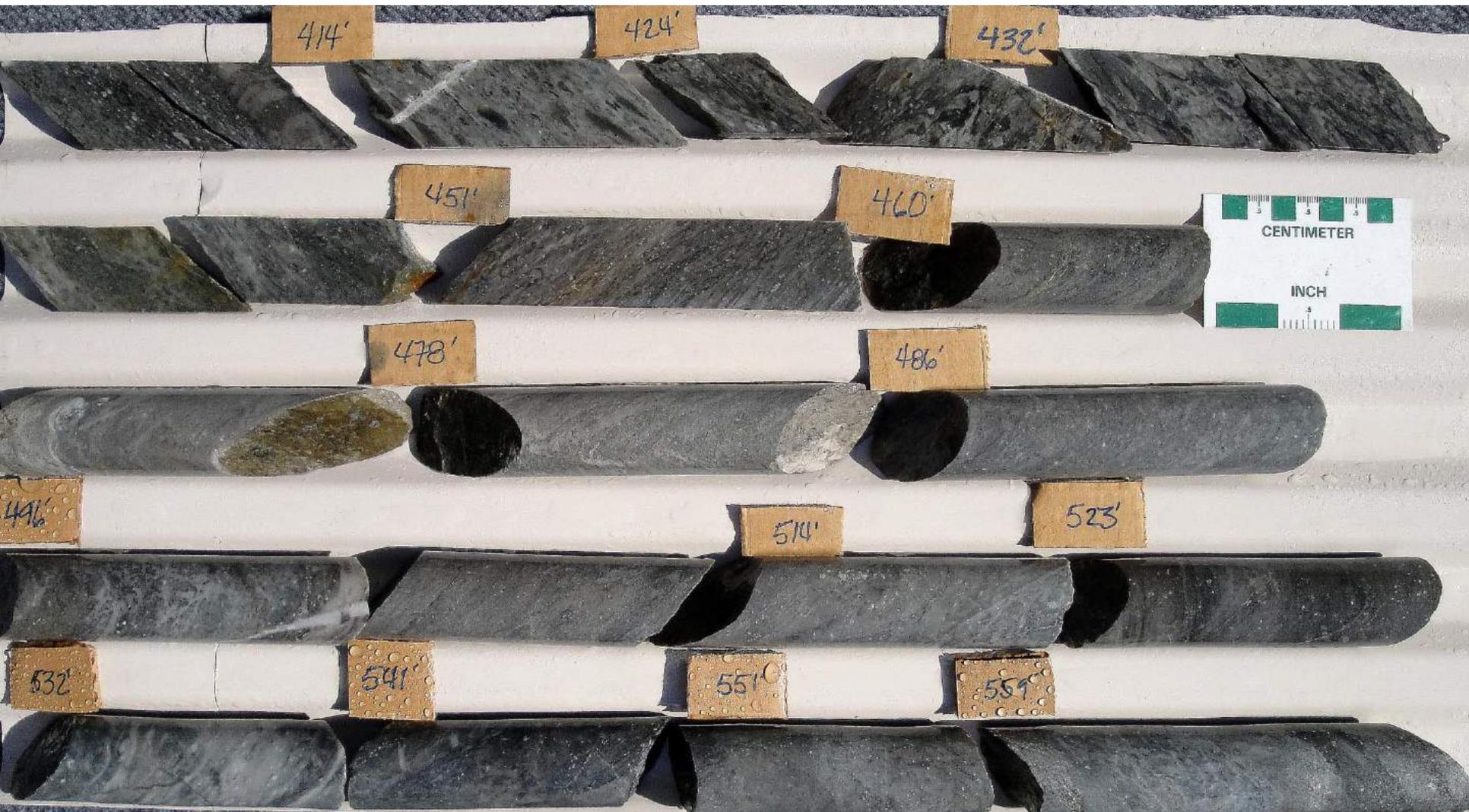
# 36-205 ft – Box 1 of 4 boxes



# 213-296 ft – Box 2 of 4 boxes



# 405-559 ft – Box 3 of 4 boxes



# 568-699 ft – Box 4 of 4 boxes



# Silver Shaft Prospect

Cabarrus Co., N.C.

Core PDSS-7 (skeletonized)

# Silver Shaft Prospect, Cabarrus Co., N.C.

- Phelps Dodge Exploration East core number: PDSS-7
- NC Geological Survey core ID: CB-C-05-81
- Other core name and ID: none
- Collar elevation: 720 feet
- Bearing: S 70° E
- Inclination: -65°
- Total depth: 1000 feet
- Date core hole completed: 1981
- Core photography date: March 1, 2016

# 46-209 ft – Box 1 of 6 boxes



# 219-391 ft – Box 2 of 6 boxes



# 400-551 ft – Box 3 of 6 boxes



# 560-712 ft – Box 4 of 6 boxes



# 721-915 ft – Box 5 of 6 boxes



# 925-999 ft – Box 6 of 6 boxes



# Union Copper Project

Rowan and Cabarrus Co., N.C.

Core RONC 77-1 (skeletonized)

# Union Copper project, Rowan and Cabarrus Co., N.C.

- Conoco core number: RONC 77-1
- NC Geological Survey core ID: CB-C-01-77
- Other core name and ID:
- Collar elevation: 670 ft
- Bearing: S 80° E
- Inclination: -45°
- Total depth: 754 ft
- Date core hole completed: 1977
- Core photography date: March 1, 2016

# 140-288 ft – Box 1 of 4 boxes



# 297-479 ft – Box 2 of 4 boxes



# 489-692 ft – Box 3 of 4 boxes



# 701-733 ft – Box 4 of 4 boxes



# Union Copper Project

Rowan and Cabarrus Co., N.C.

Core RONC 77-3 (skeletonized)

# Union Copper project, Rowan and Cabarrus Co., N.C.

- Conoco core number: RONC 77-3
- NC Geological Survey core ID: CB-C-01-77
- Other core name and ID:
- Collar elevation: 690 ft
- Bearing: S 80° E
- Inclination: -70°
- Total depth: 837 ft
- Date core hole completed: 1977
- Core photography date: March 1, 2016

# 108-283 ft – Box 1 of 3 boxes



# 292-526 ft – Box 2 of 3 boxes



# 536-828 ft – Box 3 of 3 boxes



# Union Copper Project

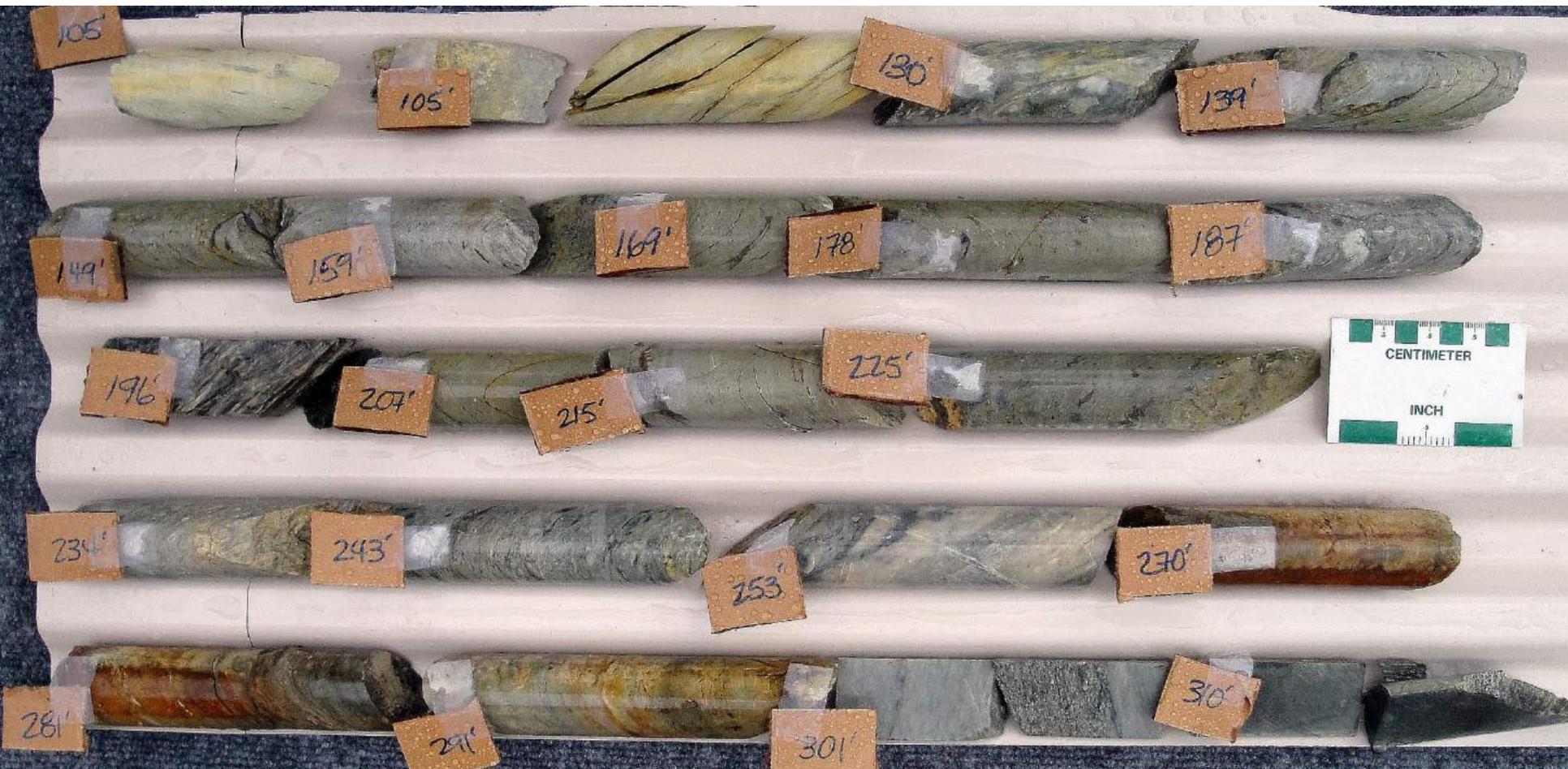
Rowan and Cabarrus Co., N.C.

Core RONC 77-5 (skeletonized)

# Union Copper project, Rowan and Cabarrus Co., N.C.

- Conoco core number: RONC 77-5
- NC Geological Survey core ID: RW-C-1-77
- Other core name and ID:
- Collar elevation: 720 ft
- Bearing: S 79° E
- Inclination: -70°
- Total depth: 896 ft
- Date core hole completed: 1977
- Core photography date: March 1, 2016

# 105-310 ft – Box 1 of 4 boxes



# 319-640 ft – Box 2 of 4 boxes



# 649-843 ft – Box 3 of 4 boxes



# 852-897 ft – Box 4 of 4 boxes



# Union Copper Project

Rowan and Cabarrus Co., N.C.

Core RONC 77-7 (skeletonized)

# Union Copper project, Rowan and Cabarrus Co., N.C.

- Conoco core number: RONC 77-7
- NC Geological Survey core ID: RW-C-2-77
- Other core name and ID:
- Collar elevation: 725 ft
- Bearing: S 75° E
- Inclination: -50°
- Total depth: 705 ft
- Date core hole completed: 1977
- Core photography date: March 1, 2016

# 48-259 ft – Box 1 of 2 boxes



# 278-704 ft – Box 2 of 2 boxes



# Union Copper Project

Rowan and Cabarrus Co., N.C.

Core RONC 77-8 (skeletonized)

# Union Copper project, Rowan and Cabarrus Co., N.C.

- Conoco core number: RONC 77-8
- NC Geological Survey core ID: RW-C-3-77
- Other core name and ID:
- Collar elevation: 700 ft
- Bearing: S 70° E
- Inclination: -55°
- Total depth: 796 ft
- Date core hole completed: 1977
- Core photography date: March 1, 2016

# 21-235 ft – Box 1 of 3 boxes



# 245-654 ft – Box 2 of 3 boxes



# 663-752 ft – Box 3 of 3 boxes



# Silver Shaft Prospect

Cabarrus Co., N.C.

Core HANC 77-1 (skeletonized)

# Silver Shaft Prospect, Cabarrus Co., N.C.

- Phelps Dodge Exploration East core number: HANC 77-1
- NC Geological Survey core ID: CB-C-02-77
- Other core name and ID: HANC 77-1 (Conoco)
- Collar elevation: 660 feet
- Bearing: S 80-85° E (estimate)
- Inclination: -\_\_° (unknown)
- Total depth: 394 feet
- Date core hole completed: 1977
- Core photography date: March 1, 2016

# 26-216 ft – Box 1 of 2 boxes



# 227-394 ft – Box 2 of 2 boxes



# Silver Shaft thin sections Drill hole PDSS-3

JC Reid – 20160316 – revised 20171129

Arranged in descending stratigraphic order from the surface

Selected petrography –core hole PDSS-3 (NCGS ID CB-C-3-81)

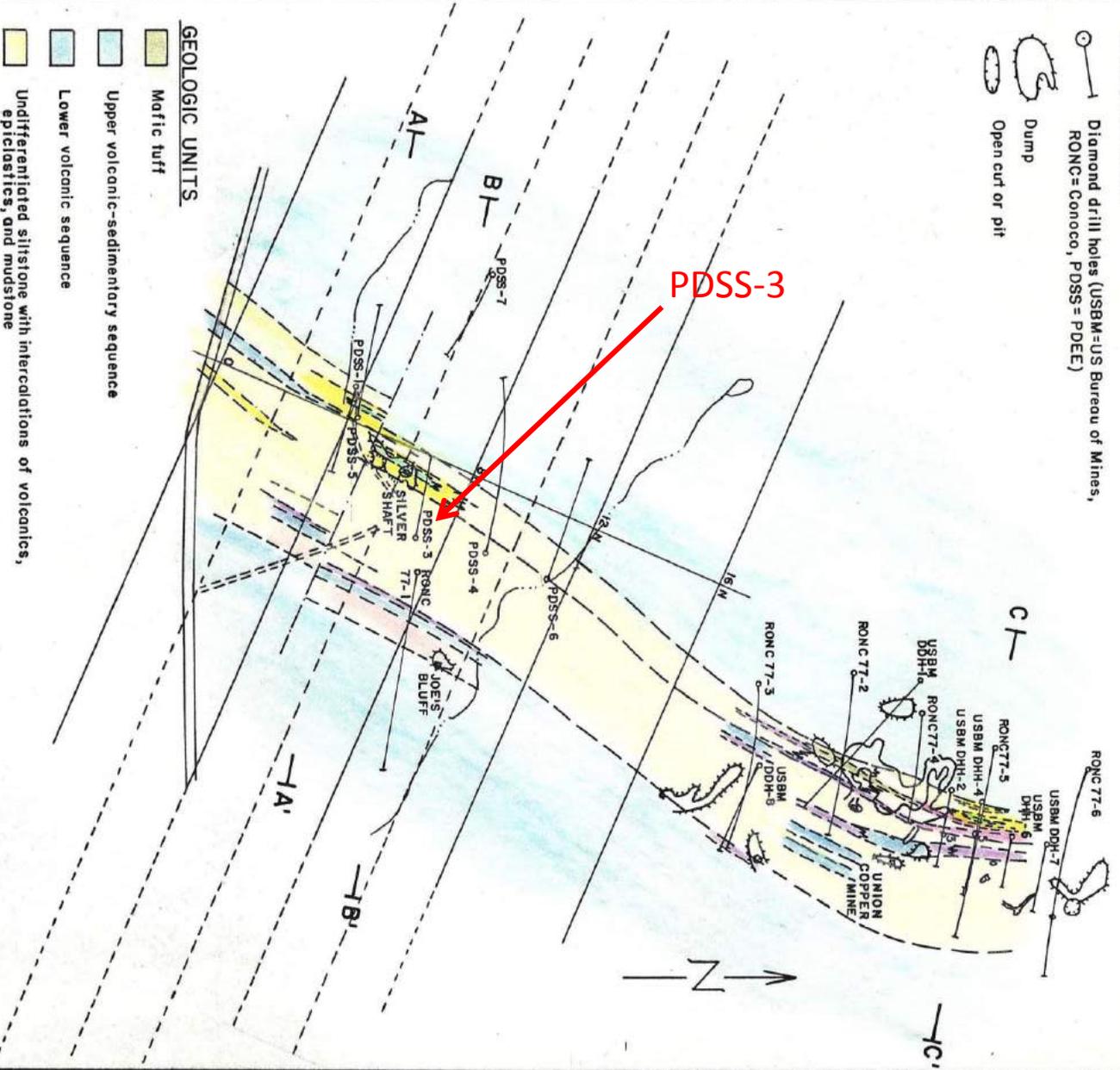
Arranged in descending stratigraphic order from the surface

## Summary of mineral and other abbreviations used.

- Tc = Talc
- Pyr rim = Pyrite rim
- Pyr core = Pyrite core
- Pyr = Pyrite (other as noted in caption)
- Qtz = Quartz
- Gal = Galena
- Sph = Sphalerite
- Carb = Carbonate
- Bar = Barite
- Cpy = Chalcopyrite
- Ser = Sericite
- FOV = Field of view (width)

**EXPLANATION**

-  Diamond drill holes (USBM-US Bureau of Mines, RONC=Conoco, PDSS=PDEE)
-  Dump
-  Open cut or pit



**GEOLOGIC UNITS**

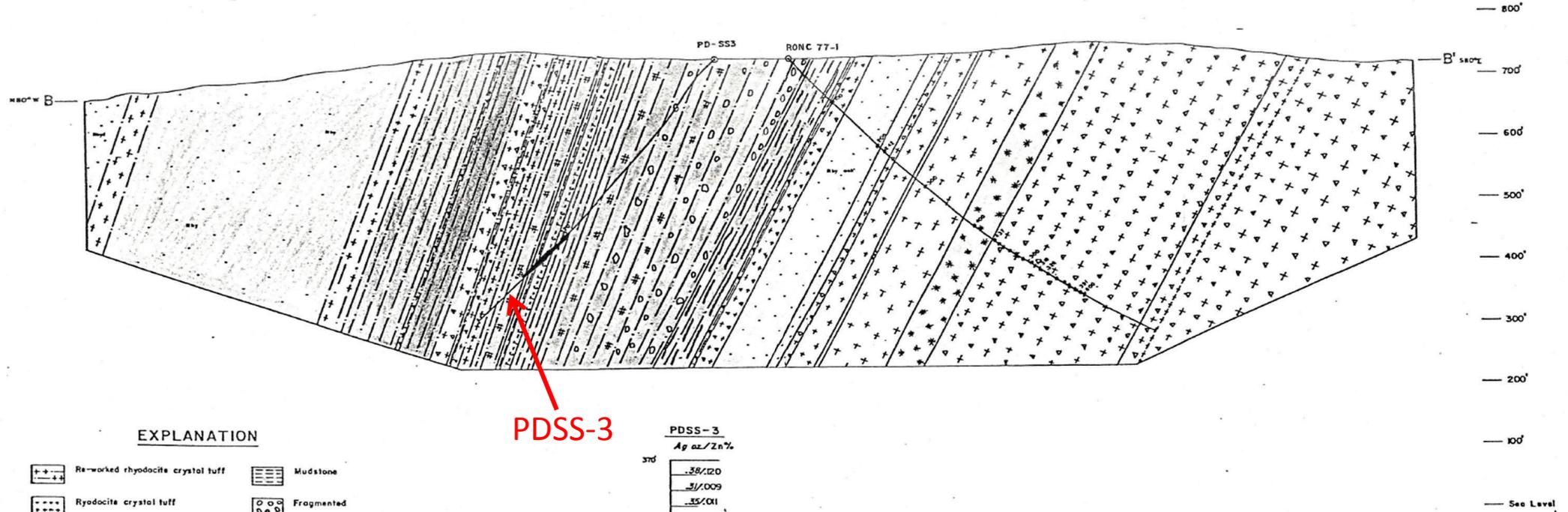
-  Mafic tuff
-  Upper volcanic-sedimentary sequence
-  Lower volcanic sequence
-  Undifferentiated siltstone with intercalations of volcanics, epiclastics, and mudstone
-  Mudstone, locally siliceous to talcose
-  Silver Shaft horizon: Talc-carbonate chert exhalites
-  Chert exhalite
-  Rhyodacitic crystal and crystal-tititic tuffs
-  Reworked rhyodacite tuffs/volcanic epiclastics
-  Rhyolite ash

*Phillips Dodge Exploration East, Inc.*

**GEOLOGIC MAP**  
of the  
**SILVER SHAFT MINE AREA**  
Cobarrus County, North Carolina

SCALE	H: 1" = 800'	CONTOUR INTERVAL:	REVISIONS
	V:	DATE: July, 1981	BY: R.J.M., D.F.L.
SHEET	OF	DRAWING NO:	FILE:

Looking North



EXPLANATION

- |  |  |  |                              |
|--|--|--|------------------------------|
|  | Re-worked rhyodacite crystal tuff          |  | Mudstone                     |
|  | Rhyodacite crystal tuff                    |  | Fragmented                   |
|  | Rhyolite ash                               |  | Siliceous                    |
|  | Rhyodacite ash                             |  | Talc-carbonate exhalite      |
|  | Dacite crystal tuff                        |  | Pyroxite laminae             |
|  | Dacite tuff                                |  | Lithologic contact           |
|  | Rhyodacite crystal and crystal-lithic tuff |  | Projected lithologic contact |
|  | Volcanic epiclastic                        |  | Drill hole                   |
|  | Siltstone                                  |  | Limit of drill hole data     |
|  | Silty mudstone                             |  | Mineralized zone             |

PDSS-3

PDSS-3  
Ag oz./Zn %

3rd	.38/120
	.31/009
	.35/001
	3.50/050
	.40/014
4th	.26/026
	.61/031
	.76/076
	1.40/280
	1.40/222
	6.13/148
	.35/164
	4.85/150
	13.89/2.48
40'	19.56/440
	344/540
40'	1.48/140
	.33/035
40'	.72/068
40'	.11/008

= 8.89 oz. Ag / 1.85% Zn

SCALE



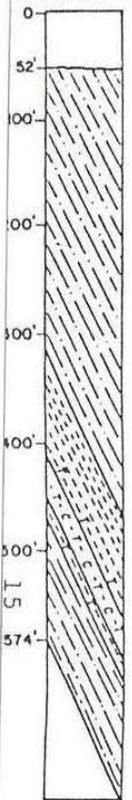
Figure 5

phelps dodge Exploration Co., Inc.

CROSS SECTION SS-B-B'  
SILVER SHAFT MINE AREA  
Cabarrus County, North Carolina

SCALE	H: 1" = 100'	CONTOUR INTERVAL:	REVISIONS	
	V:	DATE: JUNE, 1981	BY: R.J.M.	
SHEET	OF	DRAWING NO.:	FILE:	

Geologic Log



-  Siltstone
-  Mudstone
-  T.C.-T
-  Talc-Carbonates Exhalite
-  T-T Talcose

Sample Interval	Ag oz	Zn %	Pb %	Cu %	Co ppm	Au ppm
0-165		Not Assayed				
165-170	0.03	0.004	-0.01	-0.001	-5	-0.02
170-172	0.13	0.003	0.09	-0.001	-5	-0.02
172-175	0.008	0.004	-0.01	-0.001	5	-0.02
200-205	0.012	0.005	-0.01	-0.001	-5	0.02
225-230	0.012	0.006	-0.01	-0.001	-5	-0.02
250-255	0.044	0.008	-0.01	0.004	15	-0.02
255-260	0.035	0.005	-0.01	0.002	5	0.03
260-265	0.058	0.004	-0.01	0.001	-5	-0.02
265-270	0.268	0.046	0.01	0.004	5	0.10
270-275	0.087	0.013	-0.01	0.002	10	0.06
275-280	0.026	0.003	-0.01	0.001	5	-0.02
280-285	0.01	0.010	-0.01	0.001	10	-0.02
285-290	0.023	0.007	-0.01	-0.001	-5	-0.02
290-295	0.03	0.004	-0.01	-0.001	-5	-0.02
295-300	0.02	0.003	-0.01	-0.001	-5	-0.02
335-340	0.09	0.006	-0.01	0.002	5	0.02
340-345	0.24	0.011	-0.01	0.003	-5	0.02
370-375	0.38	0.12	-0.01	0.003	10	0.06
375-380	0.31	0.009	-0.01	0.002	5	-0.02
380-385	0.35	0.011	-0.01	0.003	10	-0.02
385-390	3.50	0.050	0.01	0.019	15	-0.02
390-395	0.40	0.014	-0.01	0.003	20	-0.02
395-400	0.26	0.026	-0.01	0.004	15	-0.02
400-405	0.61	0.031	0.01	0.005	10	0.04
405-410	0.76	0.076	0.02	0.003	10	-0.04
410-415	1.40	0.280	0.10	0.004	5	-0.04
415-420	14.0	2.22	0.71	0.035	5	-0.04
420-425	6.13	1.48	0.45	0.24	5	0.05
425-430	0.35	0.164	0.09	0.004	5	-0.04
430-435	4.85	1.50	0.38	0.017	5	0.02
435-440	13.89	2.48	0.68	0.036	20	0.06
440-445	19.56	0.440	0.55	0.055	15	0.05
445-450	3.44	0.540	0.11	0.010	10	0.03
450-455	1.48	0.140	0.04	0.004	5	-0.02
455-460	0.33	0.015	-0.01	0.001	-5	0.09
460-465	0.72	0.068	-0.02	0.004	10	-0.02
465-470	0.11	0.008	-0.01	0.002	5	-0.02
500-505	0.03	0.005	-0.01	-0.001	5	-0.02
540-545	0.05	0.010	-0.01	0.001	5	0.02

Summary of Geology

- 0- 52' Overburden.
- 52-314' Siltstone; massive to poorly bedded locally siliceous to fragmented. Trace to 5% pyrite as dissemination.
- 314-404' Mudstone; massive to well bedded, locally silty, siliceous or talcose. 3 to 5, locally 20 to 30% pyrite as disseminations and laminae.
- 404-445' Talc and talc-carbonate exhalite; locally brecciated. 1 to 5% pyrite as disseminated grains & laminae. Trace to 5% sphalerite. Trace to 1% aguilarite.
- 445-463' Mudstone; locally silty, siliceous or talcose. 1 to 3% pyrite, trace sphalerite and aguilarite.
- 463-574' Siltstone; massive to poorly bedded locally siliceous to fragmented. Trace to 3% pyrite.

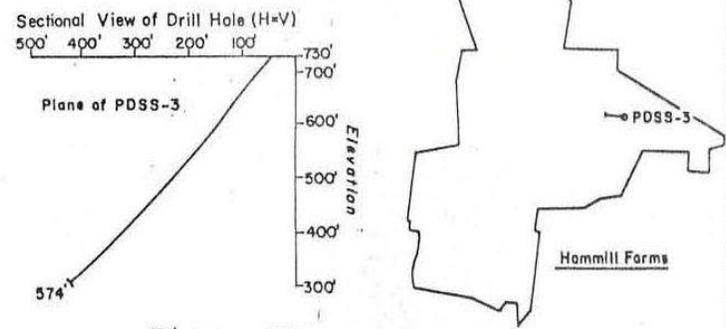
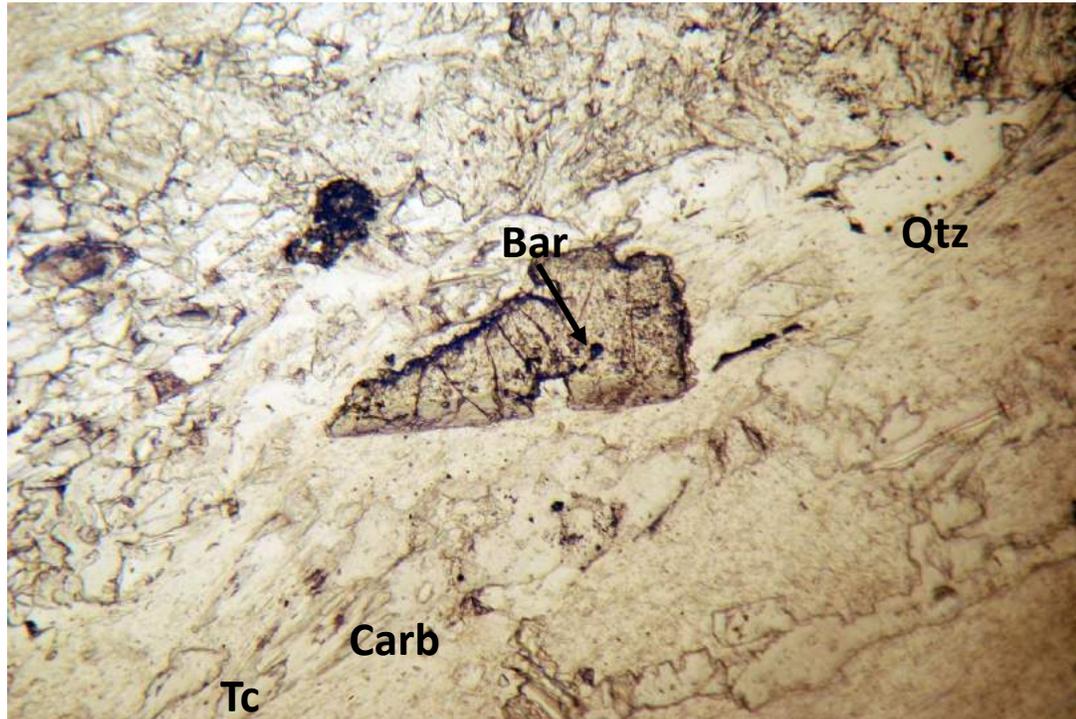


Figure 10

SILVER SHAFT PROJECT Hammill Farms, Cabarrus Co., N.C. Drill Hole PDSS-3 collar elevation = 730'			
SCALE	H:	CORRECTION INTERVAL:	REVISIONS:
	V:	DATE June, 81	BY R.J.M.

# Silver Shaft, Drill hole PDSS-3: depth 407-416 feet – 100x

Transmitted light.

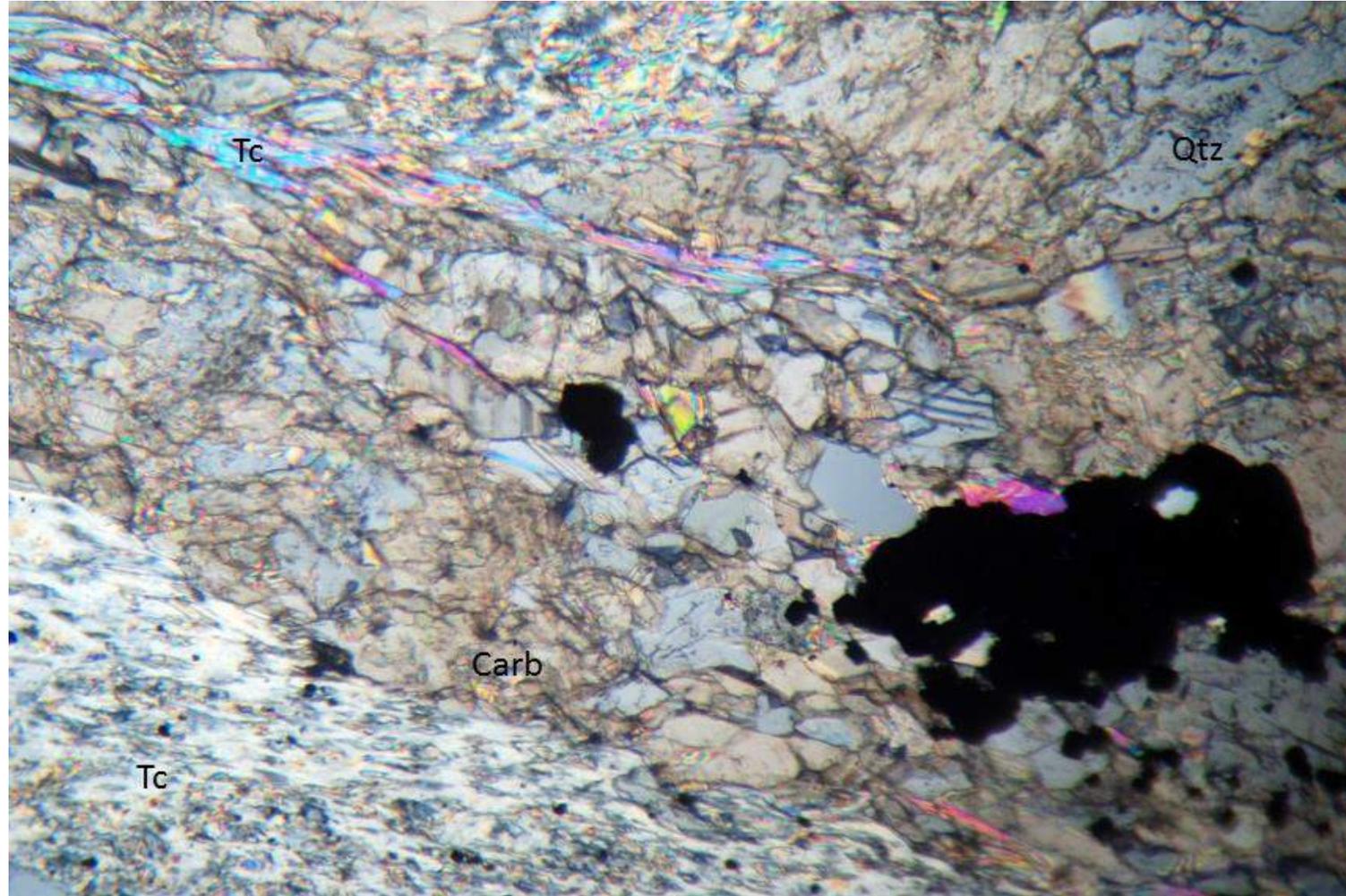


Cross polarized light.



This image illustrates the primary assemblage (carbonate+talc+sulfides [opaque]) plus barite (Bar) in the main mineralized horizon. The quartz flanking the barite may be a metamorphically recrystallized in a pressure shadow. Tc = talc, Carb = carbonate, Qtz = quartz, sulfides (opaque in this view). 100x viewed in cross polarized light. Width of field of view (FOV) ~1.2 mm.

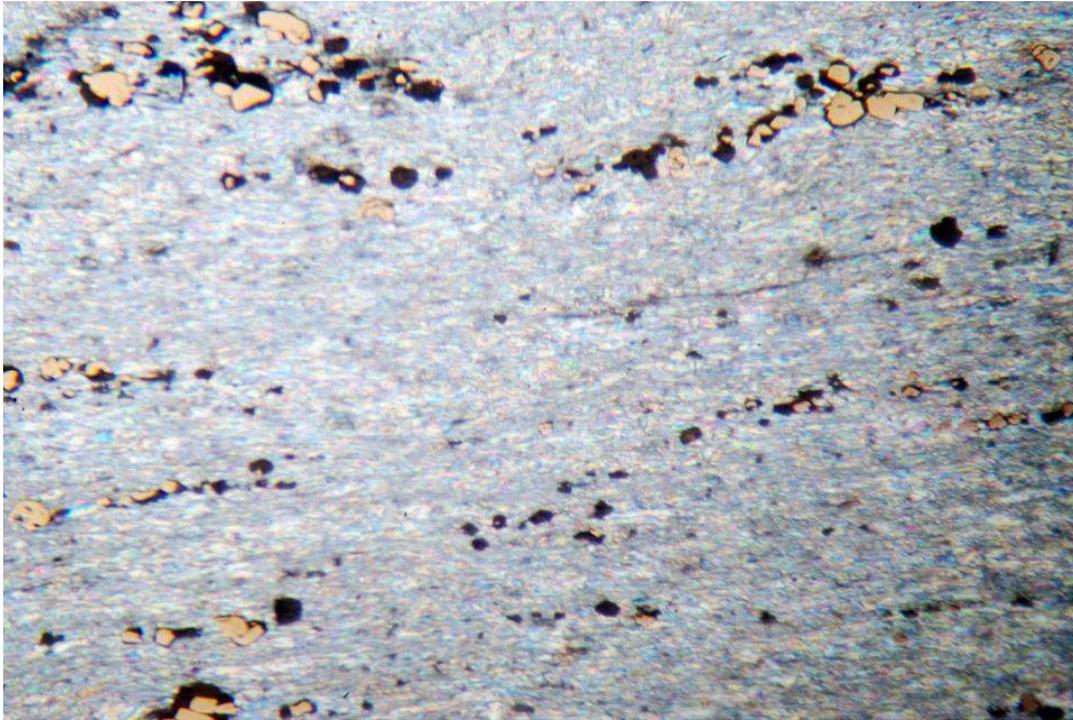
Silver Shaft, Drill hole PDSS-3: depth 407-416 feet – 100x



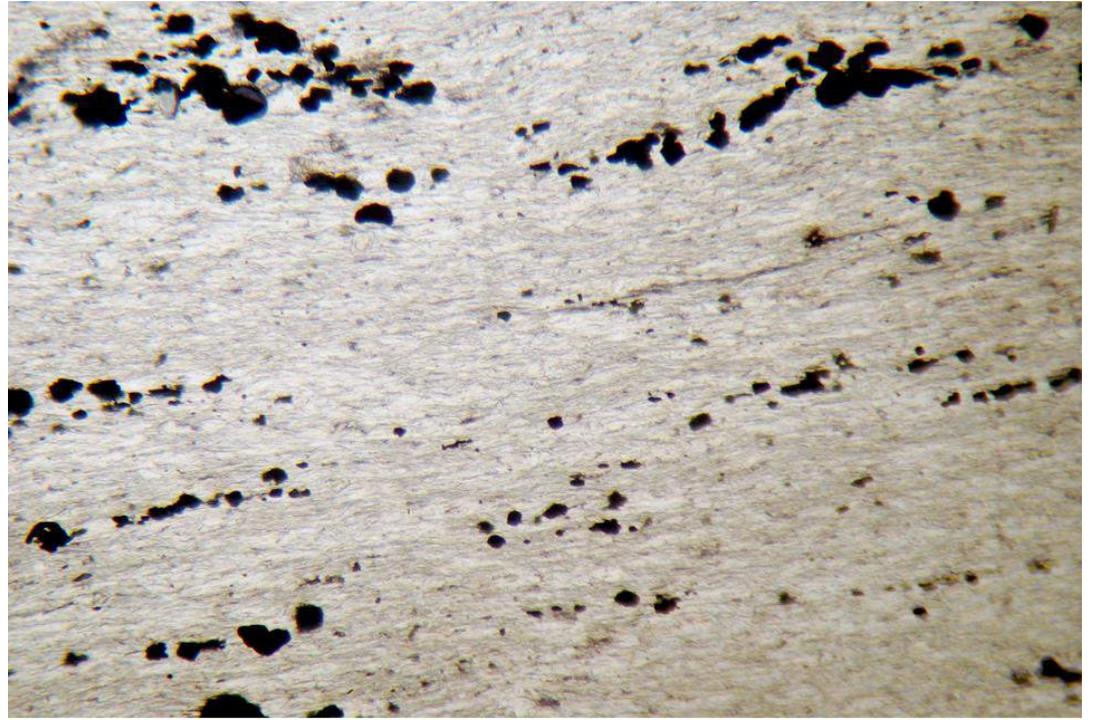
This image illustrates the primary assemblage (carbonate+talc+sulfides [opaques]) in the main mineralized horizon. Tc = talc, Carb = carbonate, Qtz = quartz, sulfides (opaque in this view). 100x viewed in cross polarized light. FOV ~1.2 mm.

## Silver Shaft, Drill hole PDSS-3: depth 416 feet -100x

Simultaneous reflected and cross-polarized light. FOV ~1.2mm.



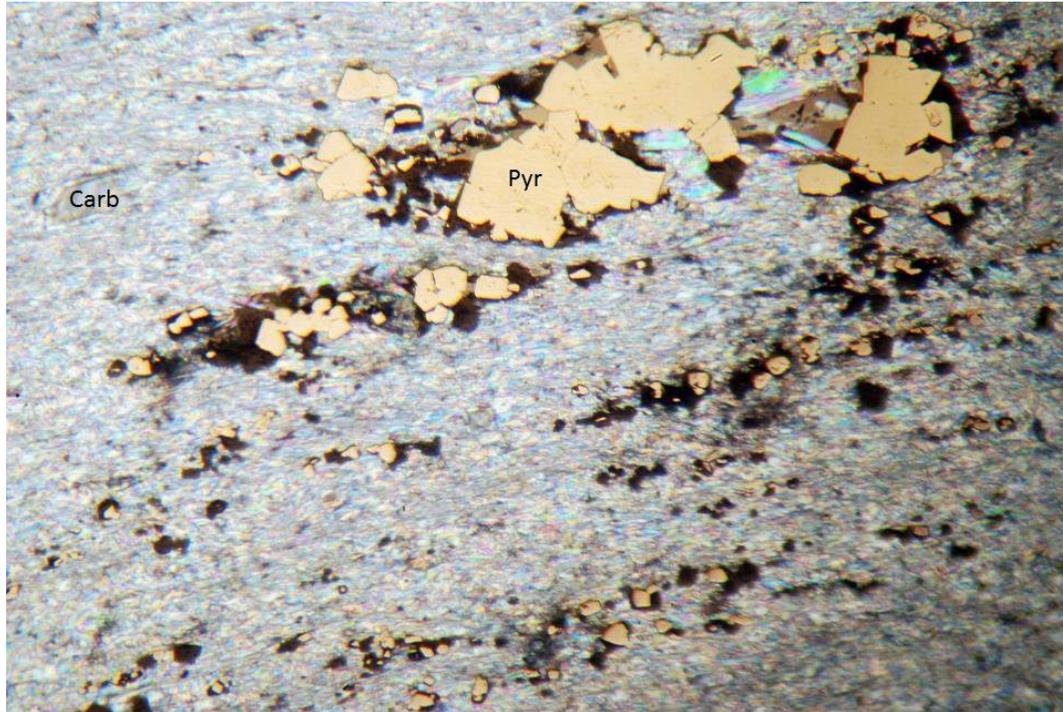
Transmitted light. FOV ~1.2mm.



Disseminated pyrite is strung out along the tectono-metamorphic fabric. This area is very strongly foliated and probably sheared. The Gold Hill Fault Zone shear fabric is very heterogeneous at all scales, from tens of meters to microscopic. This image illustrates the primary assemblage (carbonate+talc+sulfides) in the main mineralized horizon. Talc (Tc) comprises most of the matrix.

# Silver Shaft, Drill hole PDSS-3: depth 416 feet -100x

Simultaneous reflected and cross-polarized light. FOV ~1.2mm.



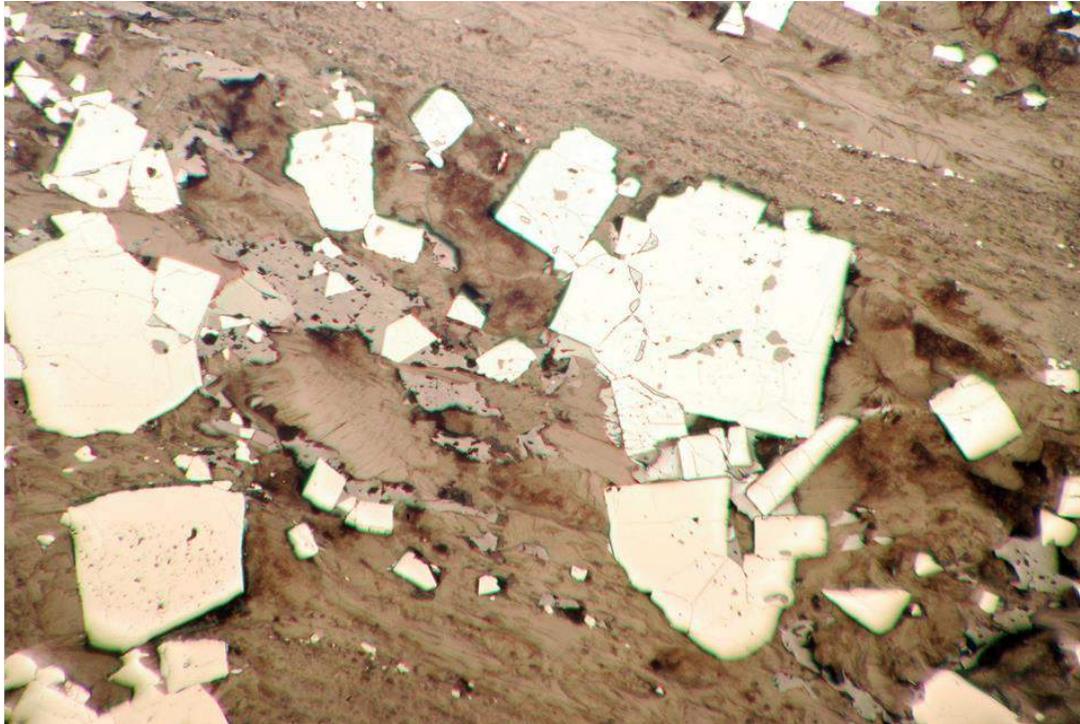
Transmitted light. FOV ~1.2mm.



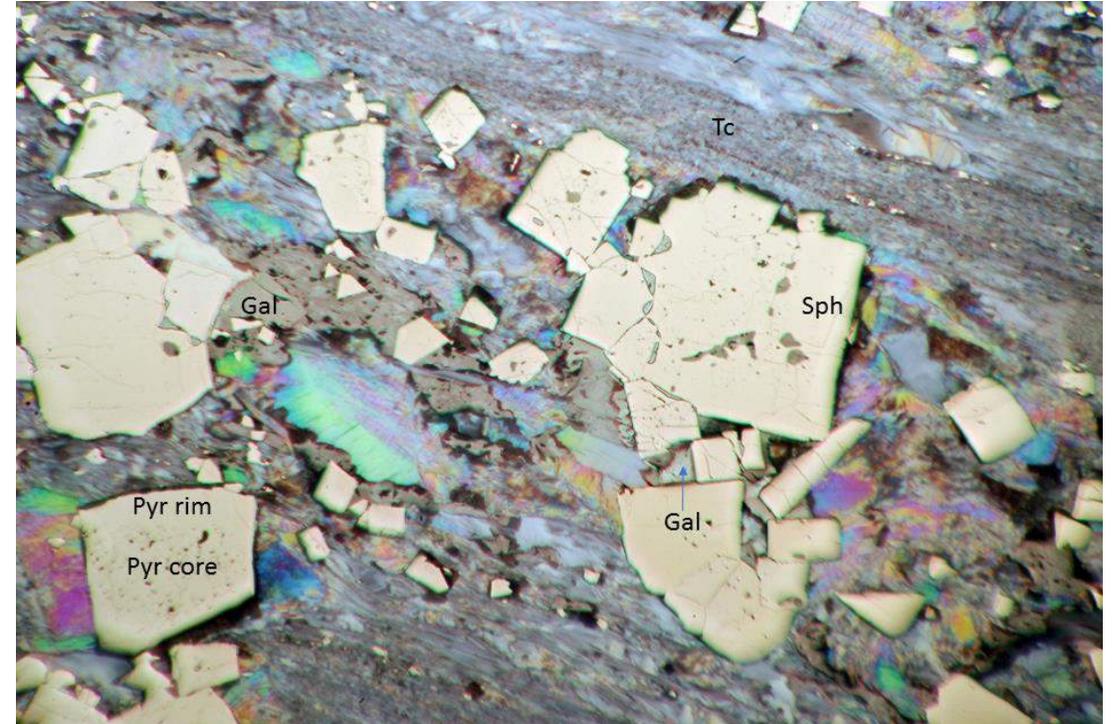
Talc dominates the matrix with minor quartz and carbonate. The larger pyrite grains are surrounded by pressure shadow growths of coarser-grained quartz, talc, and carbonate. Most of the pyrite is recrystallized metamorphic overgrowths; vestiges of a spongy core (primary ?) is present in some grains. This image illustrates the primary assemblage (carbonate+talc+sulfides) in the main mineralized horizon. Other recrystallized sulfides fringe the larger pyrite grains. Sericite and minor sphalerite form inclusions in one of the larger recrystallized pyrite grains.

# Silver Shaft, Drill hole PDSS-3: depth 424-426 feet – 40x

Reflected light.



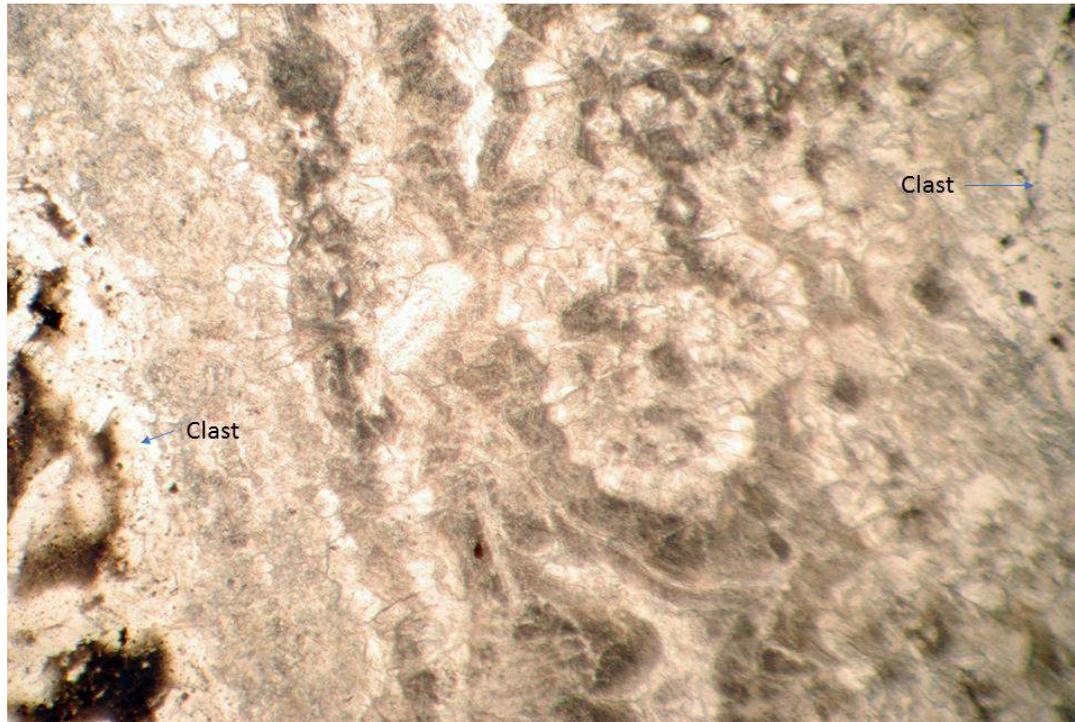
Cross polarized light and reflected light.



The primary assemblage (carbonate+talc+sulfides) with variable quartz forms the main mineralized horizon. With the possible exception of spongy poikiloblastic pyrite cores, these textures are not primary. Heterogeneous strain is characterized by narrow zones of intense foliation and shear enclosing lower strain domains. Galena and sphalerite are typically remobilized into low pressure sites (e.g., the lee of the pyrite crystals and fractures in the crystals). It is uncertain if the outer pyrite layers are overgrowing the foliation, or if they are being rotated and abraded by the shear. Width of field of view (FOV) ~2.9 mm.

# Silver Shaft, Drill hole PDSS-3: depth 426-446 feet – 40x

Transmitted light.



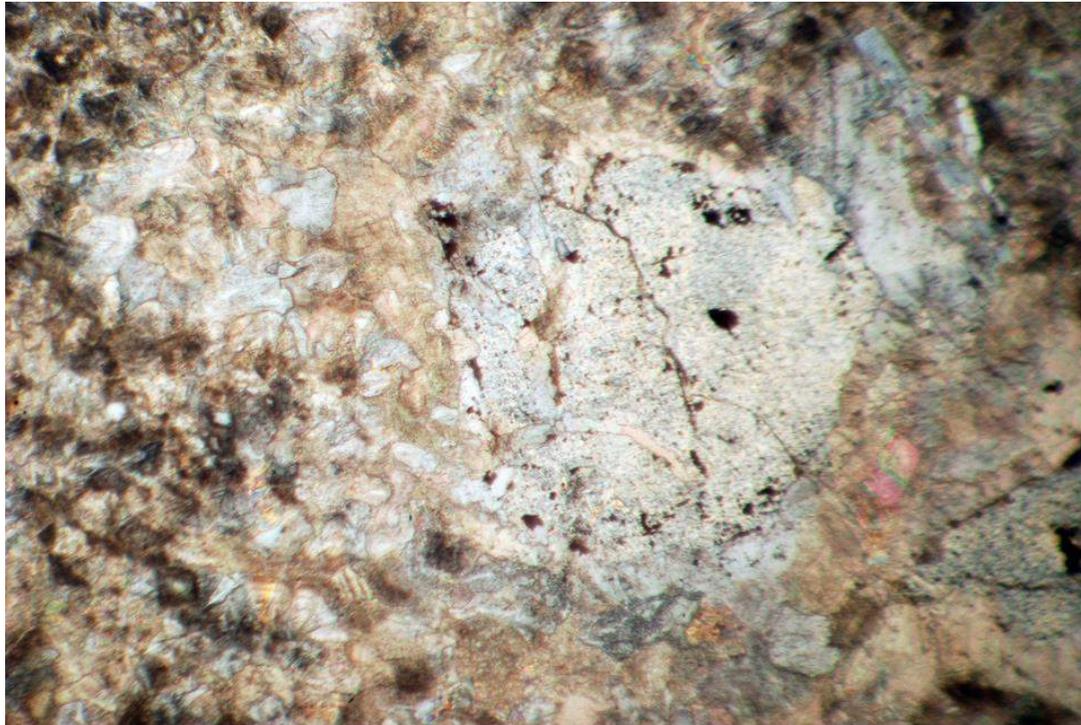
Simultaneous reflected- and cross-polarized light.



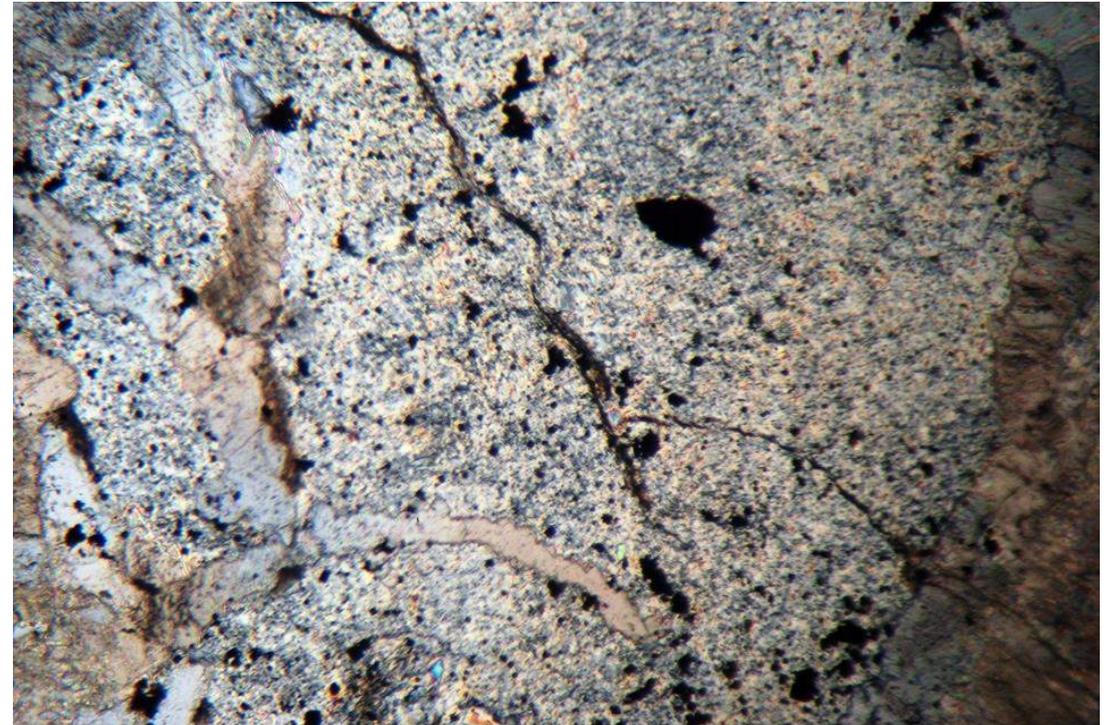
(Left) Possible primary textures consisting of banded and crustiform features – essentially all carbonate. Two clasts are present (one in the upper right corner, the other in the lower left corner), both enclosed by crustiform carbonate containing small amounts of barite (top right center). This may represent a portion of primary “sulfide mound” textures formed in channel ways at the base of a mound. (Right) The very-fine grained pyrite (opaque) may be primary. This is a view of the clast in the lower left corner of the transmitted light image. Field of view (FOV) ~2.9 mm.

## Silver Shaft, Drill hole PDSS-3: depth 426-446 feet

Simultaneous reflected and cross-polarized light –  
40x; FOV = 2.9mm.



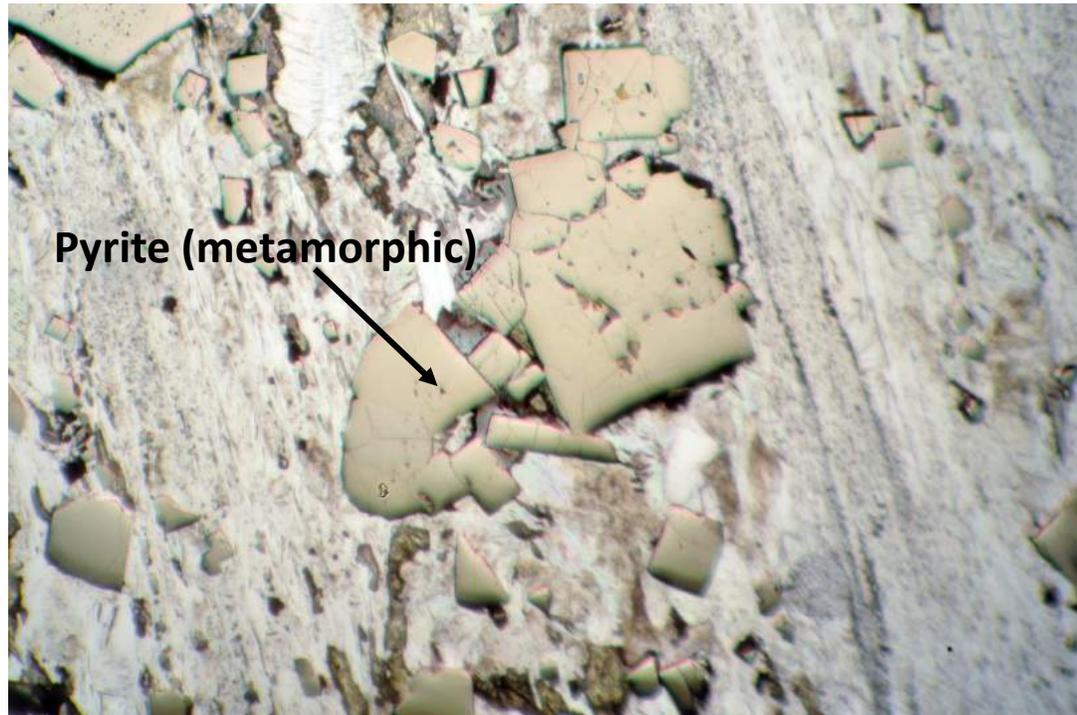
Simultaneous reflected and cross-polarized light –  
100x; FOV = 1.2mm.



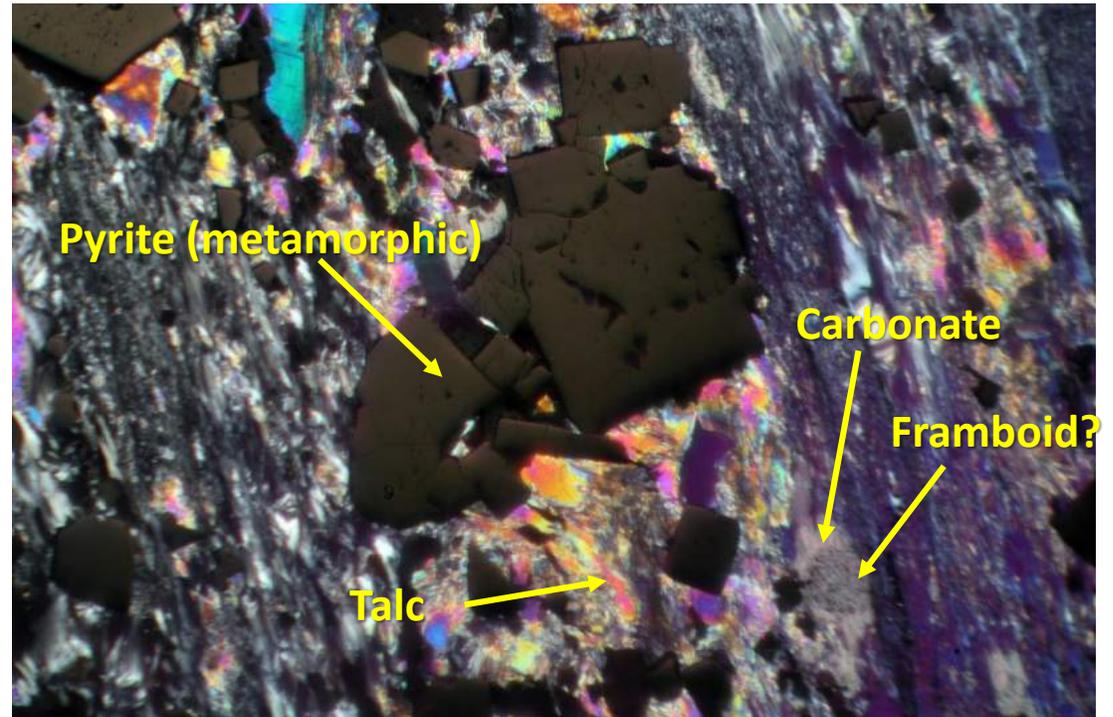
(Left) This clast (partly visible in the upper right corner of the previous slide) is enclosed by the crustiform, banded growths of carbonate. This may be a mineralized hydrothermal breccia formed at the vent site – see very fine banding in lower left. Fine-grained pyrite (opaque) may be primary. (Right) Magnified portion of the in the left image. It is enclosed by the crustiform, banded growths of carbonate. This may be a mineralized hydrothermal breccia formed at the vent site. Fine-grained pyrite (opaque) may be primary in a highly altered hydrothermal breccia clast with later syn-metamorphic fracture-filling carbonate and sulfide veins.

# Silver Shaft, Drill hole PDSS-3: depth 442-452 feet – 40x

Reflected light.



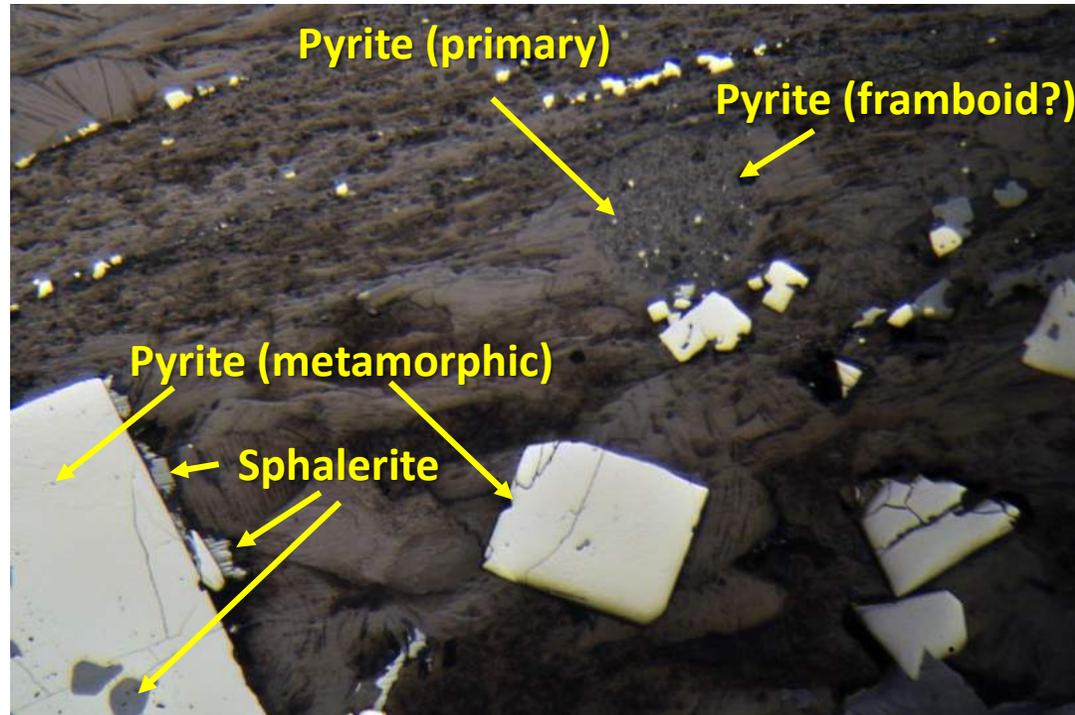
Simultaneous reflected light and cross polarized light.  
FOV ~2.9mm.



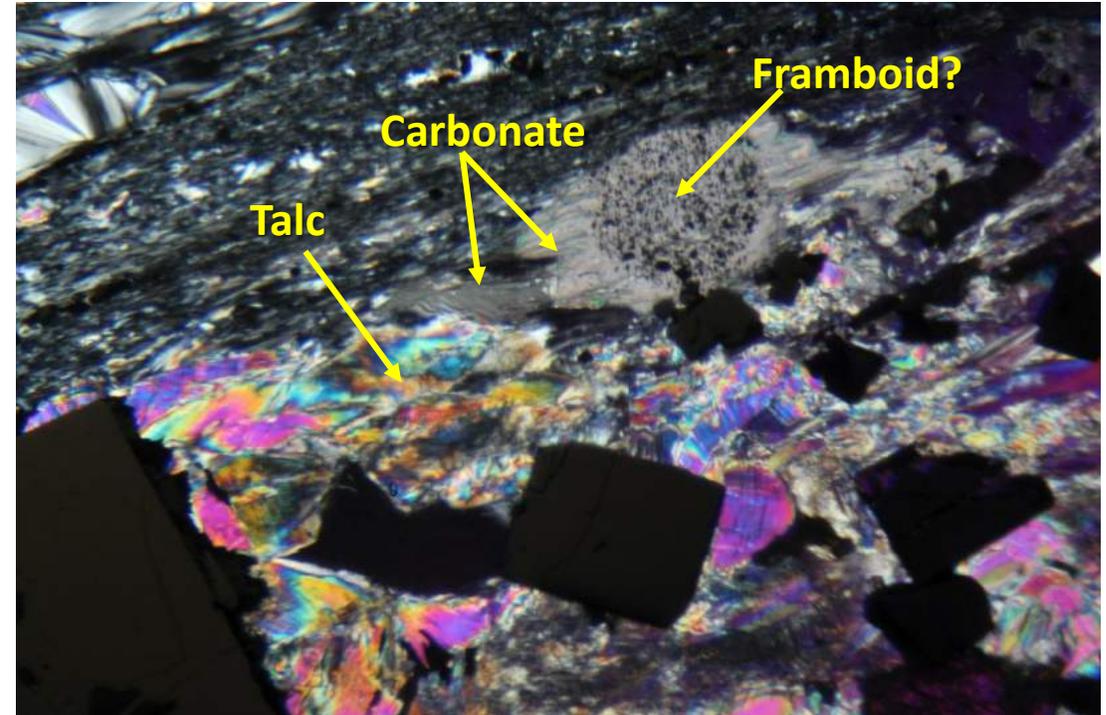
(Left). Recrystallized pyrite and transposition rock fabric with low-strain domains enclosed by high-strain zones of intense foliation and shearing. A few spongy, poikiloblastic pyrite cores remain, some containing inclusions of sphalerite. Talc and carbonate are common. Sericite and quartz comprise the matrix. See following image pair for sphalerite fringing the larger pyrite grain.

# Silver Shaft, Drill hole PDSS-3: depth 442-452 feet – 40x

Reflected light.



Cross polarized light.

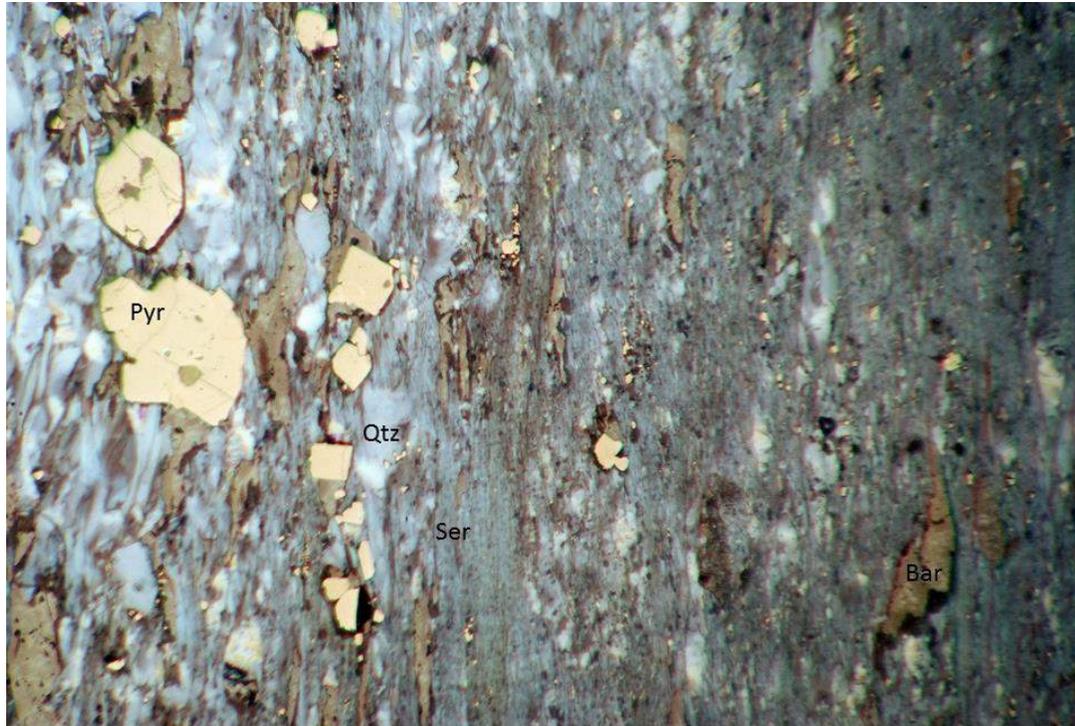


Detail of previous slide from near the base of the Silver Shaft mineralized horizon: talc+carbonate+pyrite assemblage with clean, coarse-grained, euhedral metamorphically recrystallized pyrite and a possible primary framboid composed of very fine-grained pyrite. Talc is coarsely recrystallized in pressure shadows around euhedral pyrite crystals.

# Silver Shaft, Drill hole PDSS-3: depth 442-452 feet – 40x

Simultaneous reflected light and cross polarized light.  
FOV ~2.9mm.

Transmitted light.



(Left). Metamorphically recrystallized euhedral to subhedral pyrite porphyroblasts cutting across high-strain, transposition rock fabric. A few possibly primary spongy pyrite cores remain, some containing inclusions of sphalerite. Sericite and quartz compose the matrix. (Right) This image shows that barite, the pale brown high-relief translucent mineral elongated within the foliation, is fairly common. Sulfides are opaque in this view.

# Silver Shaft, Drill hole PDSS-3: depth 442-452 feet – 40x

Simultaneous reflected light and cross polarized light.  
FOV ~2.9mm.

Transmitted light.



(Left). Clean, euhedral, metamorphic pyrite over-growths on spongy, poikiloblastic cores that cutting across a high-strain rock fabric. Pyrite and sphalerite are the dominant sulfides with barite common. Sericite and quartz with subordinate talc comprise the matrix. (Right). Opaque minerals are sulfides; barite is the pale brown, high relief mineral elongate parallel to the foliation.

# Silver Shaft, Drill hole PDSS-3: depth 442-452 feet – 40x

Reflected light. FOV ~2.9mm.

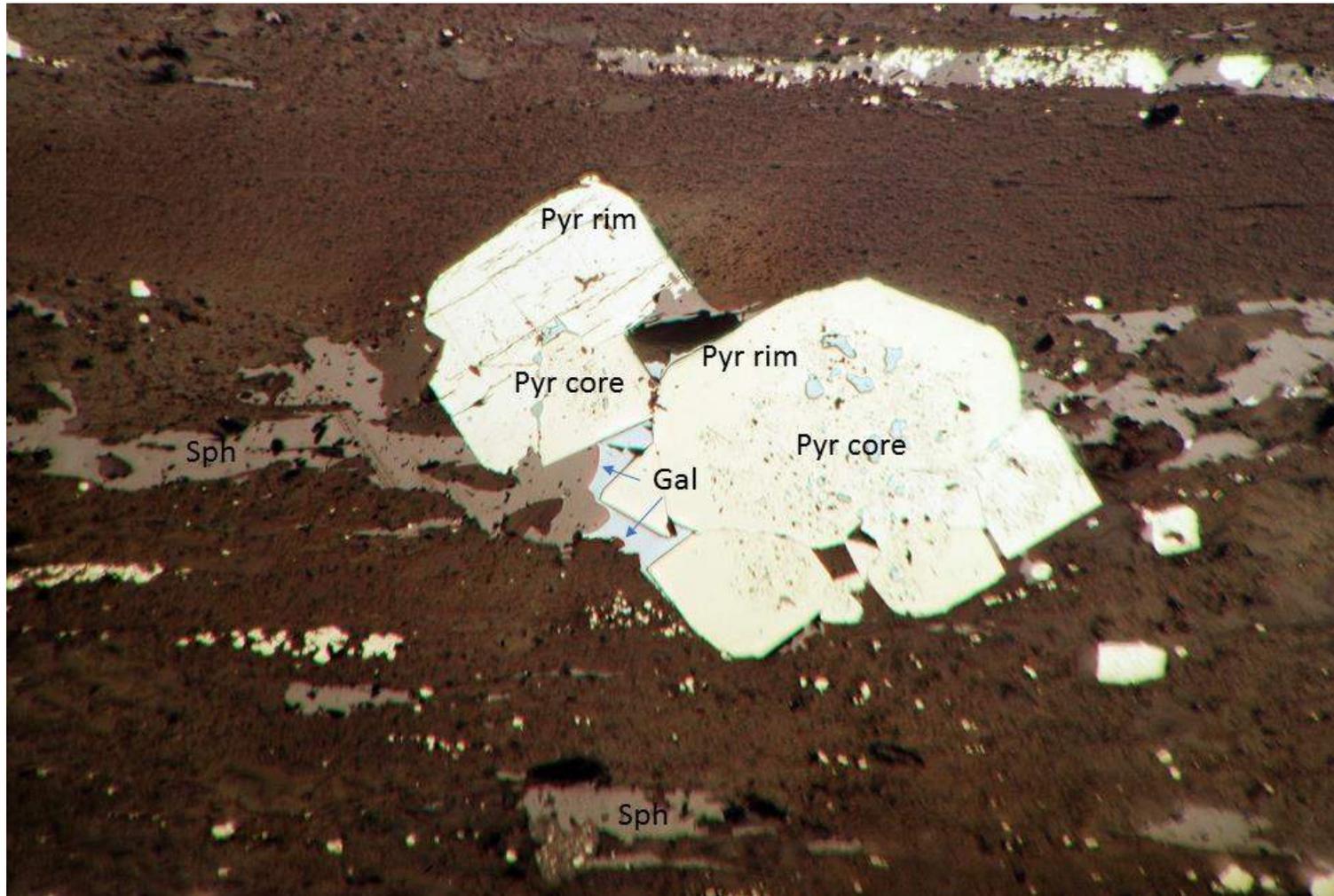


Simultaneous reflected light and cross-polarized light.



(Left). Strongly foliated, sheared, transposed, and recrystallized fabric in a metamudstone, overgrown by poikiloblastic pyrite metacrysts. The clean metamorphic rims appear to be post deformation. Remobilized galena fringes the clean pyrite rims, possibly in pressure shadows. Minute amounts of sphalerite were emplaced along fractures in the pyrite. The blue blobs in the spongy pyrite cores is blue-dyed epoxy. (Right). Same view, different lighting conditions.

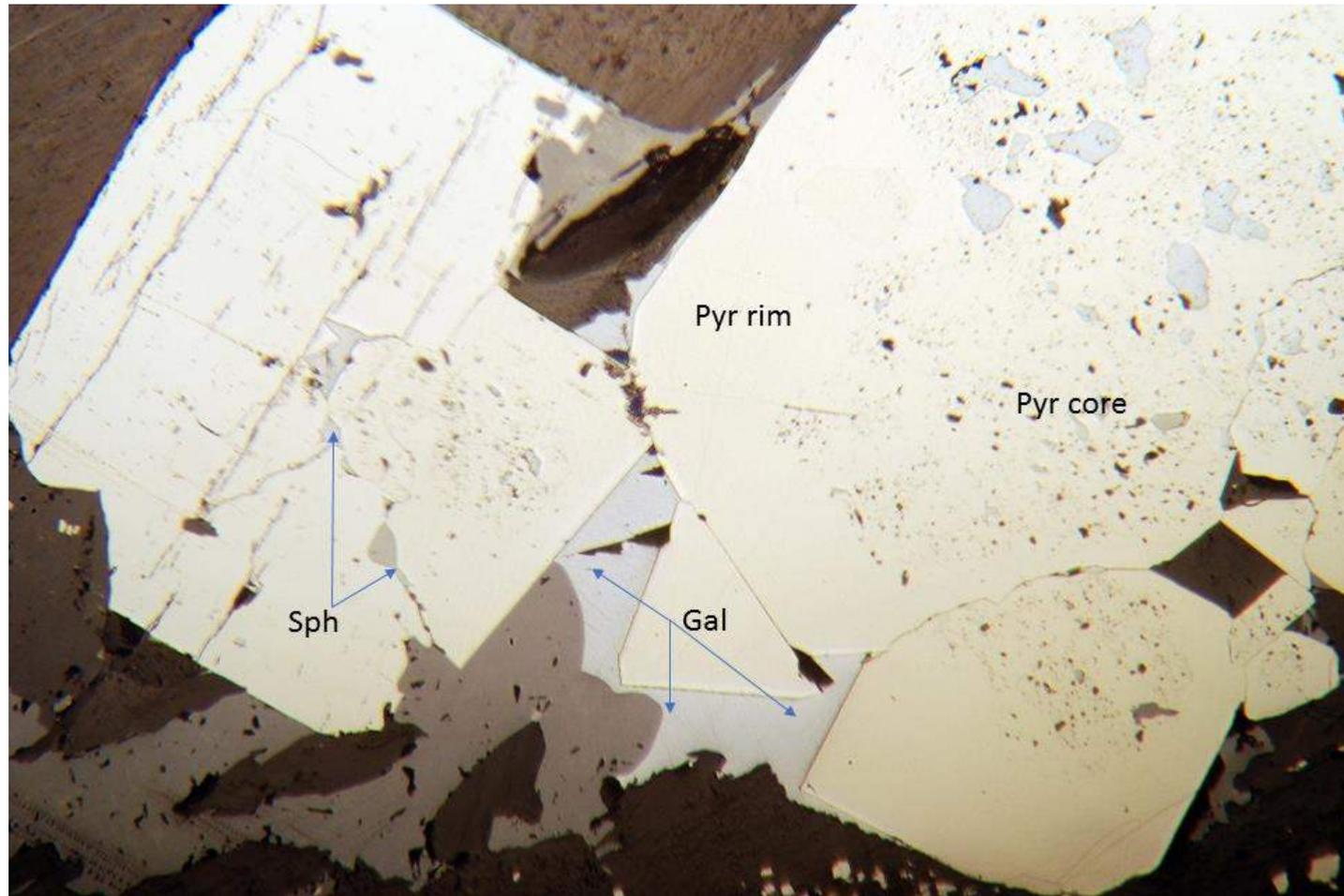
## Silver Shaft, Drill hole PDSS-3: depth 442-452 feet – 40x



Sphalerite forms anastomosing stringers within the foliation fabric in this image, while galena is present in the pressure shadows of pyrite metacrysts that cut across the fabric. Reflected light. FOV ~2.9 mm.

The laminar nature of the sph-gal-pyr assemblage parallel to cleavage and the recrystallization of the pyrite around spongy, possibly primary cores is revealed in this image.

## Silver Shaft, Drill hole PDSS-3: depth 442-452 feet – 100x



This detail of the previous image shows clean metamorphic pyrite rims overgrowing spongy, poikiloblastic, possibly primary pyrite cores and cutting across the foliation fabric, suggesting their growth is largely post deformation. Galena is strongly remobilized and fringes the clean pyrite rims, possibly in pressure shadows. Minute amounts of late recrystallized sphalerite were emplaced along fractures in the pyrite.

The blue blobs (previous images) in the spongy pyrite cores (primary pyrite) is blue-dyed epoxy; these appear gray in reflected light.

100x viewed in simultaneous reflected and cross-polarized light. FOV ~1.2 mm.

## Silver Shaft, Drill hole PDSS-3: depth 452-460 feet – 40x

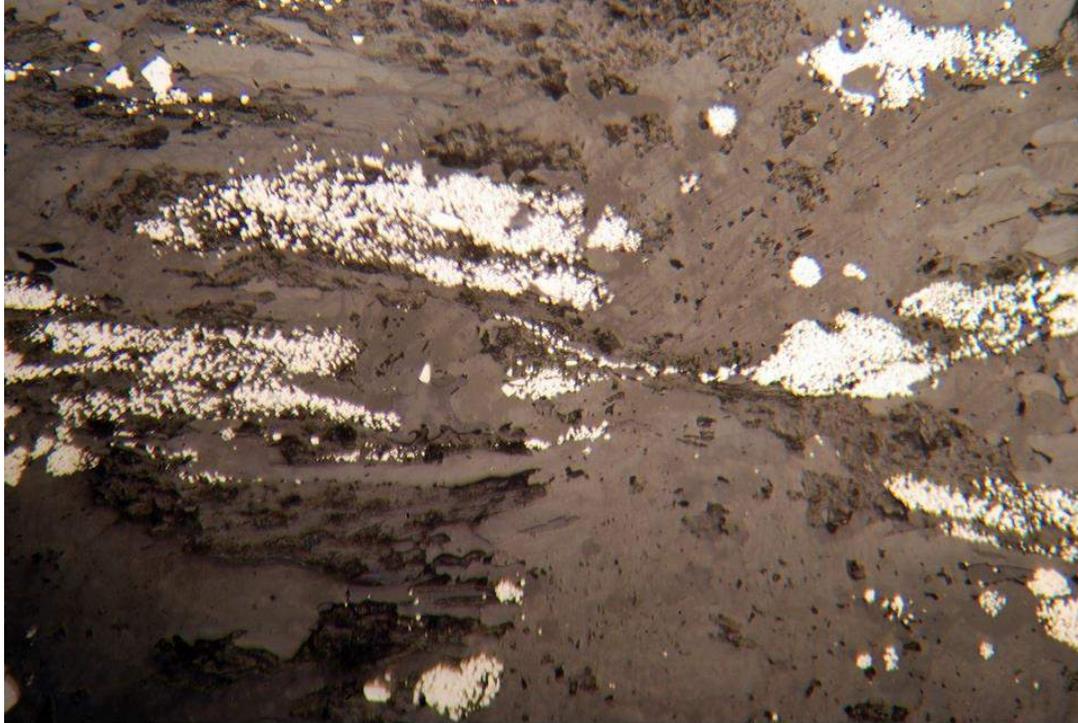


Possibly primary pyrite laminae or elongated framboids that are micro-folded and dismembered by shearing. The matrix is primarily carbonate.

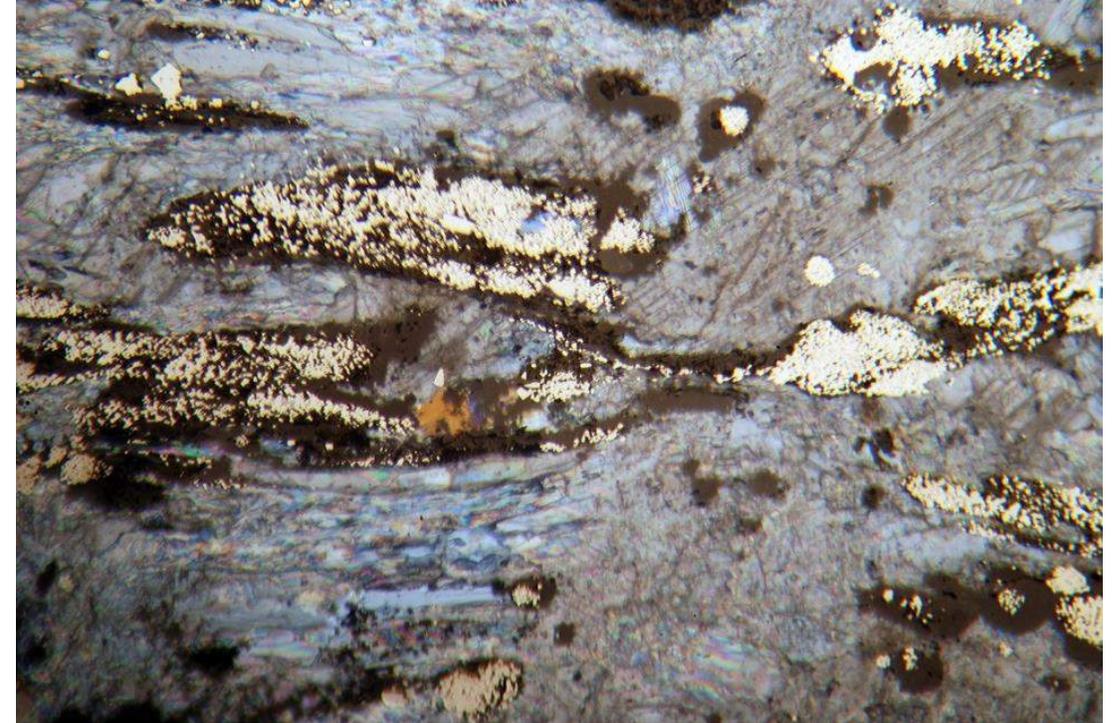
Viewed in simultaneous reflected and cross-polarized light. FOV ~2.9 mm.

# Silver Shaft, Drill hole PDSS-3: depth 452-460 feet – 100x

Reflected light. FOV ~ 1.2mm.



Simultaneous reflected and cross-polarized light. FOV ~ 1.2mm.

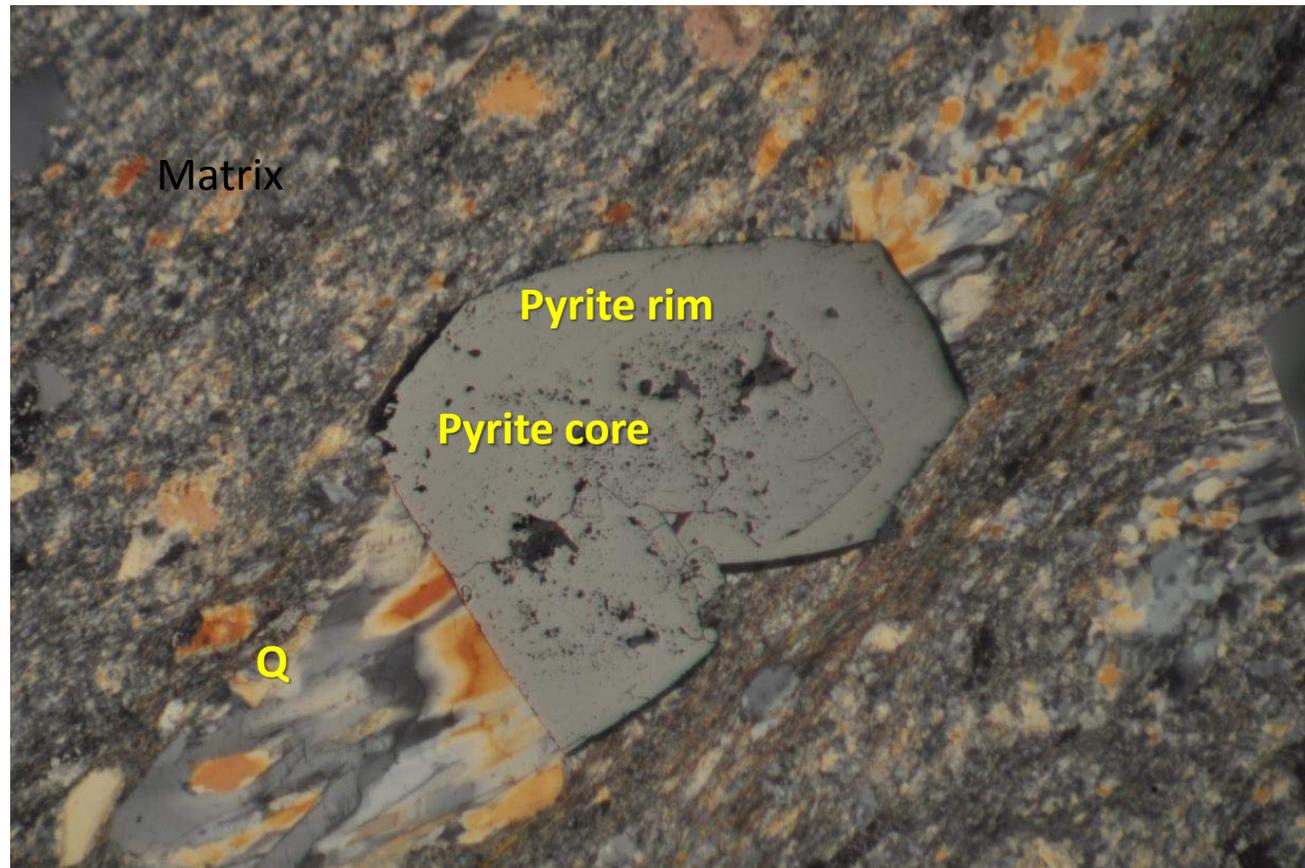


Detail of the previous image. (Left). Possibly primary pyritic laminae or pyrite framboids stretched, micro-folded and dismembered by shearing. The pyrite framboidal texture is distinct. The matrix is primarily carbonate. (Right). Same view in simultaneous reflected and cross-polarized light.

# Silver Shaft, Drill hole PDSS-3: depth 468-477 feet – 40x

Cross polarized light with incident reflected light.

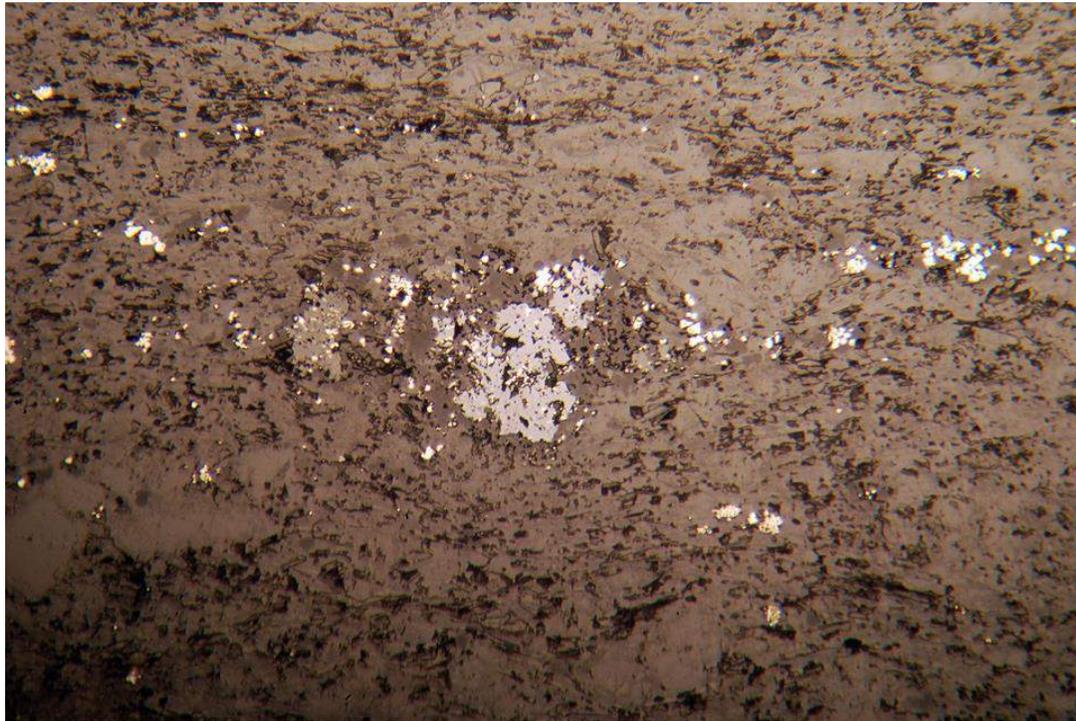
Comment.



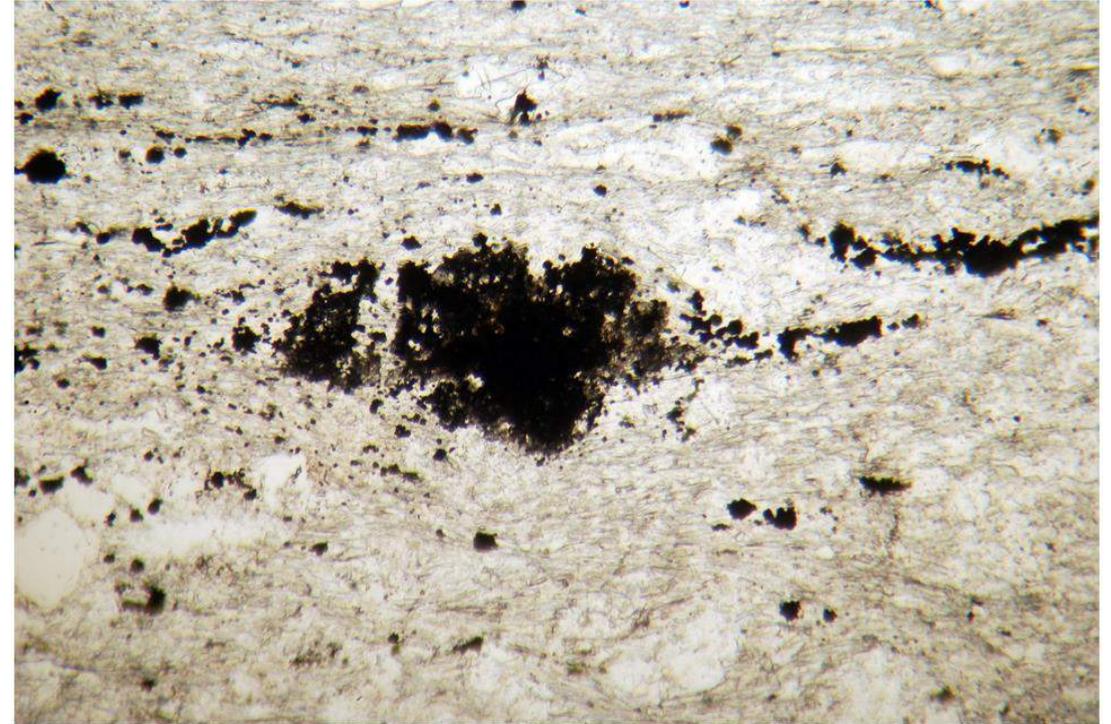
- The matrix is sericite and quartz. No talc nor carbonate is present.
- Pyrite rims (clean) envelope an earlier generation of pyrite (possibly primary ?) containing small sphalerite grains – some with red internal reflections.
- Some quartz may have recrystallized in pressure shadows (Q) around pyrite metacrysts.

# Silver Shaft, Drill hole PDSS-3: depth 468-477 feet – 100x

Simultaneous reflected and cross-polarized light. FOV ~1.2mm.



Transmitted light. FOV ~1.2mm.

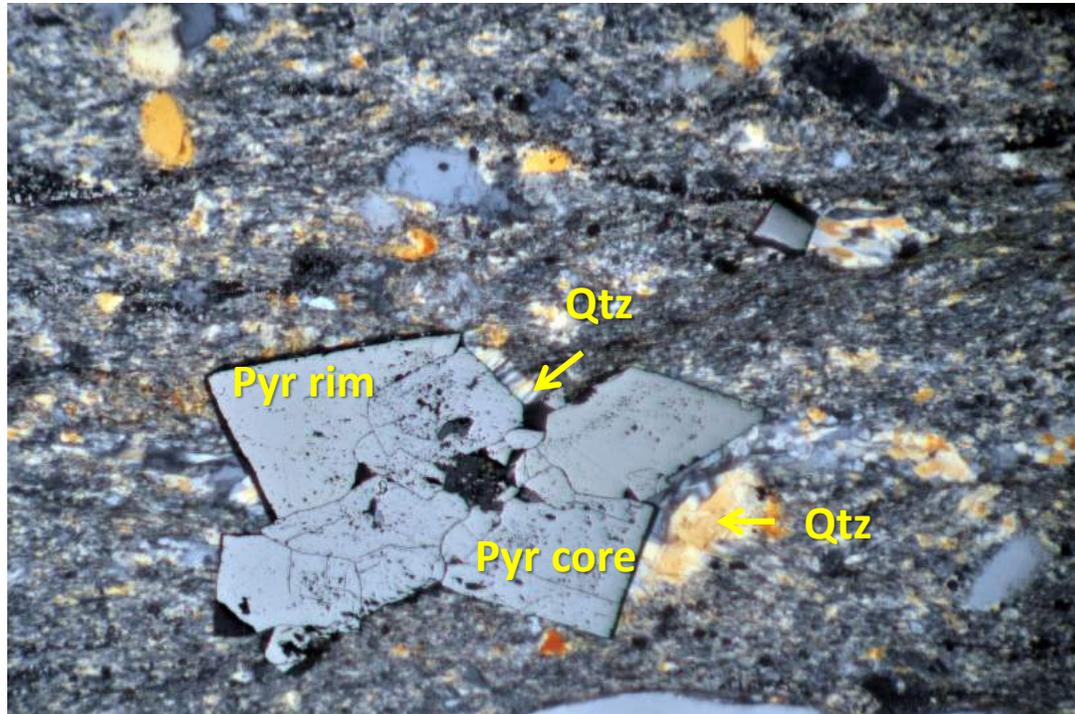


(Left). Rock not as strongly foliated may retain primary features and textures. “Near” pyrite framboids, lightly recrystallized (see previous images) Are composed of likely primary pyrite, sphalerite, and another unidentified mineral. Other “near” framboid pyrite patches occur in right center.  
(Right). Sulfide minerals are opaque and illustrate patches of “near” pyrite framboids.

# Silver Shaft, Drill hole PDSS-3: depth 464-477 feet – 40x

Cross-polarized light. FOV ~2.9mm.

Reflected and light. FOV ~2.9mm.

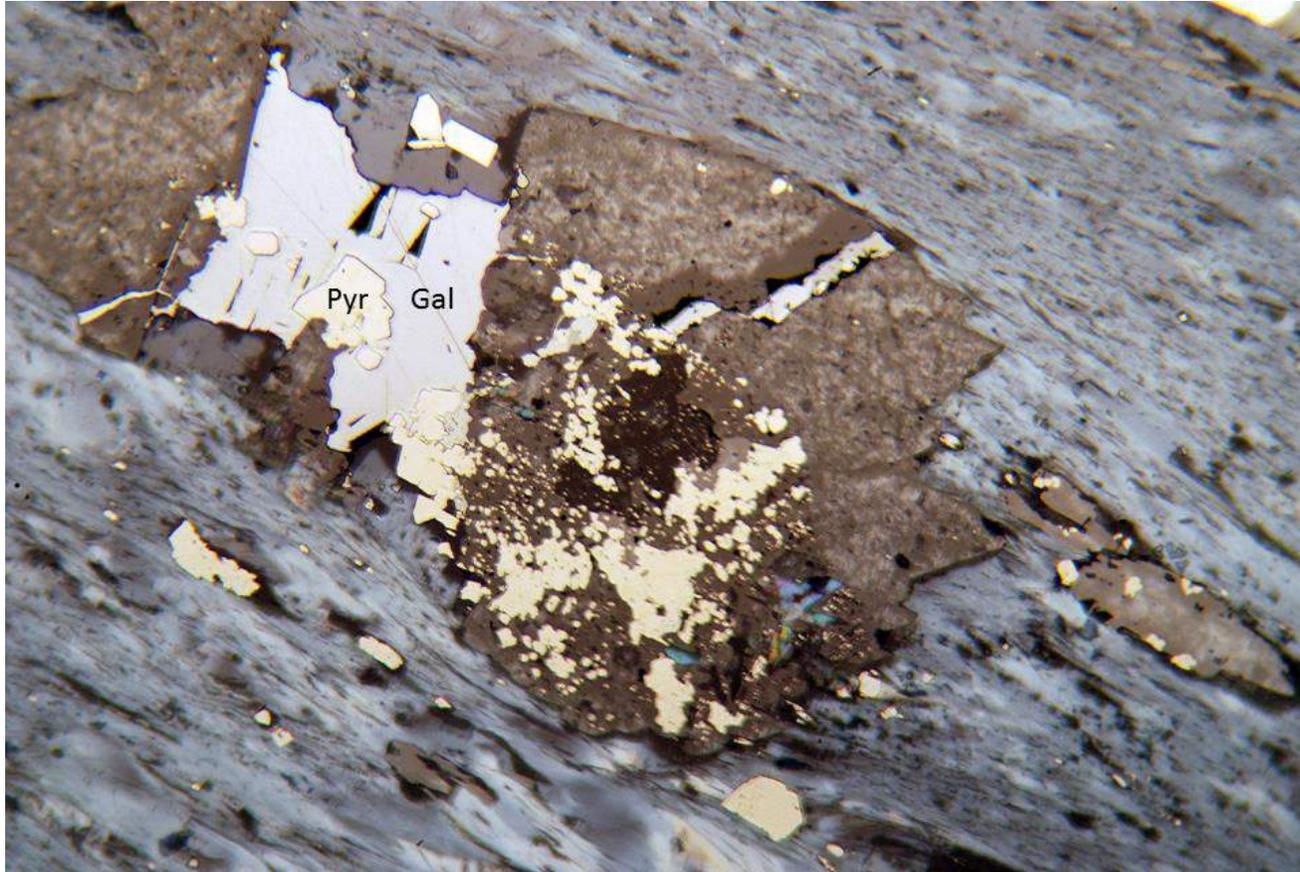


(Left). Quartz (Qtz) recrystallized in pressure shadows adjacent to clean, euhedral metamorphic pyrite overgrowths (Pyr rim) on spongy, poikiloblastic pyrite cores (Pyr core). (Right). Same view in reflected light.

# Silver Shaft, Drill hole PDSS-3: depth 468-477 feet – 100x

Simultaneous reflected and cross-polarized light.

Comment.

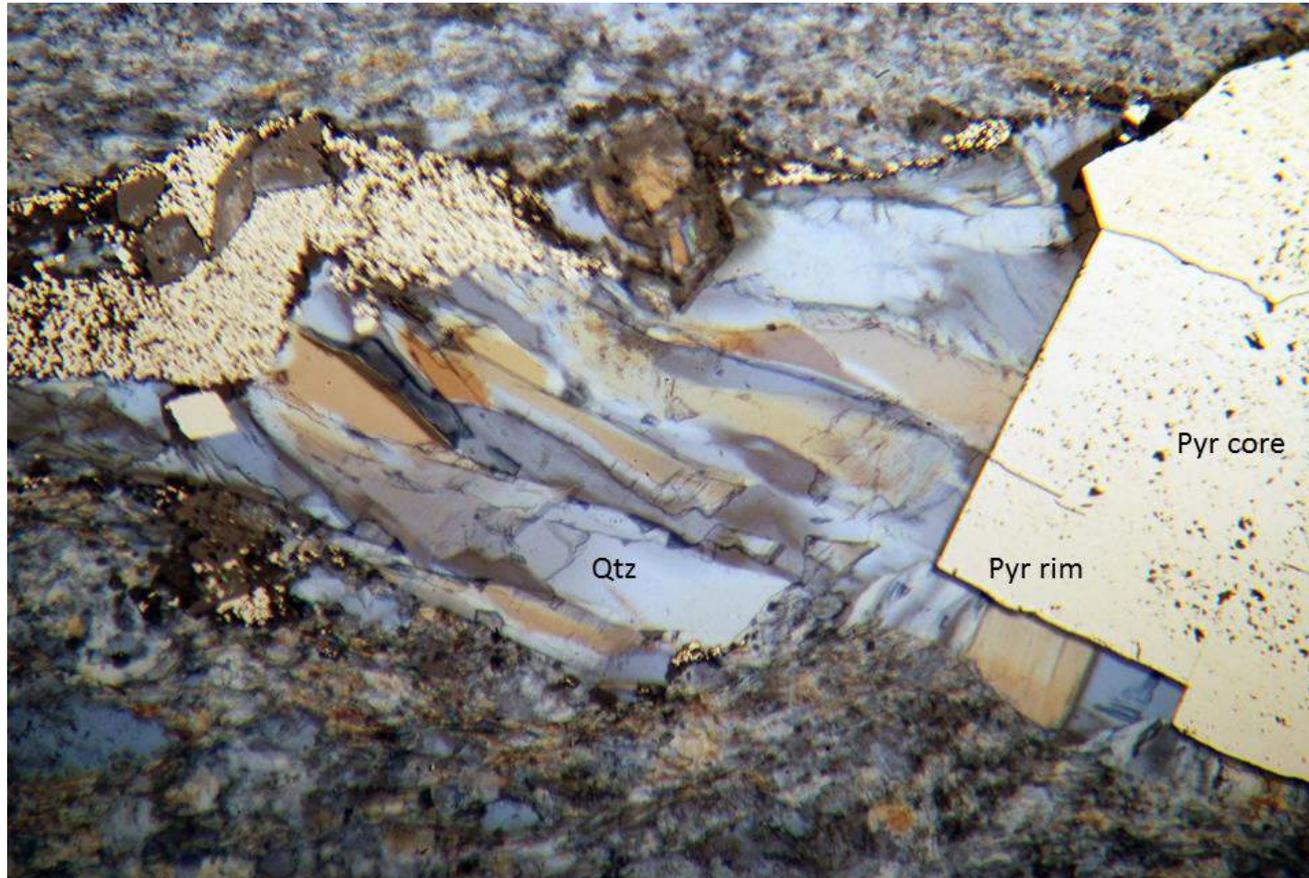


- This appears to be a clast of mudstone containing primary mineralization in the form of fine-grained aggregates or framboids of pyrite.
- The clast forms an augen in strongly a strongly foliated/sheared schistose matrix.
- The fracture-fill sulfides are metamorphic remobilizations.
- Width of field of view (FOV) ~1.2 mm.

# Silver Shaft, Drill hole PDSS-3: depth 468-477 feet – 100x

Simultaneous reflected and cross-polarized light.

Comment.

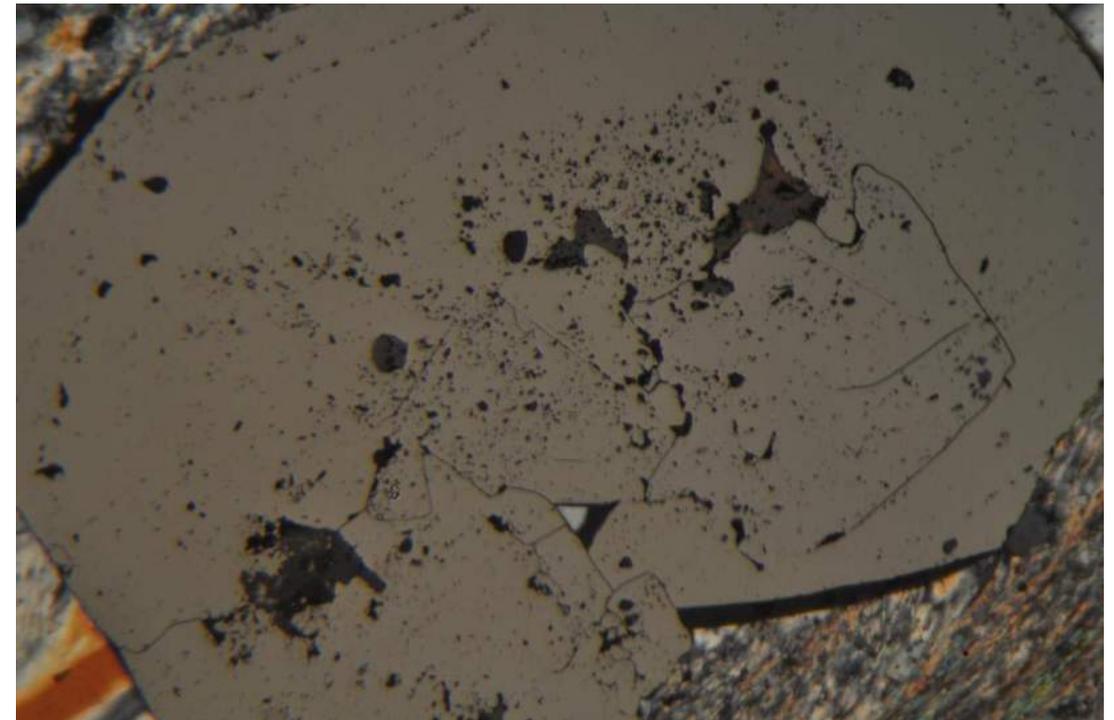
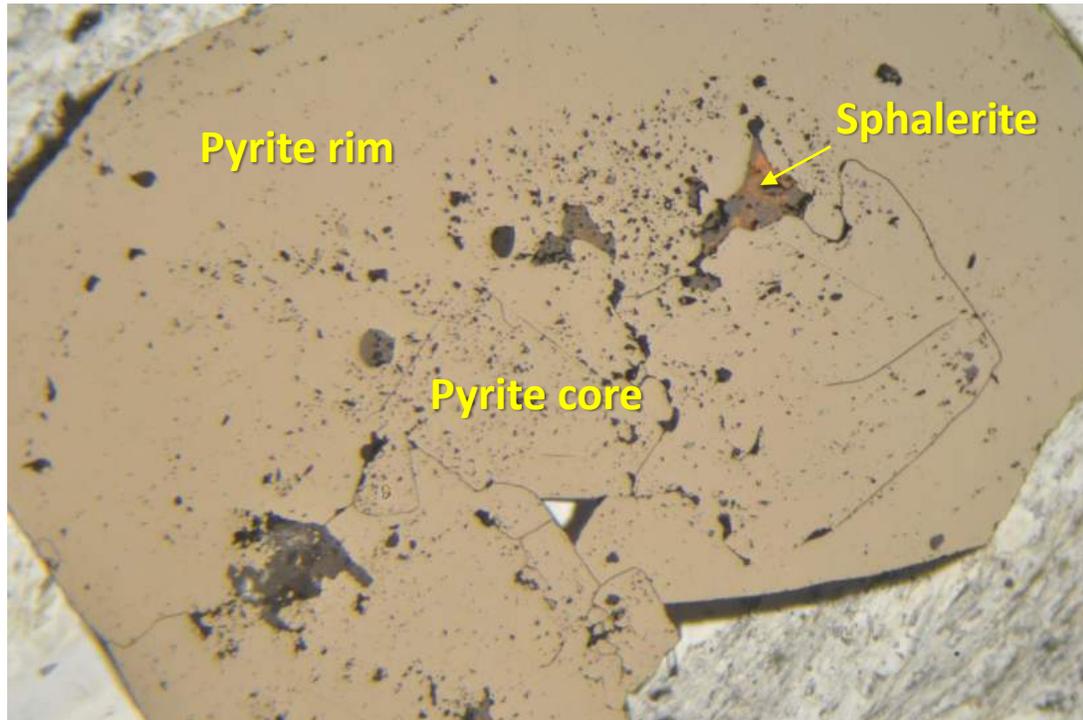


- The finer-grained, possibly framboidal pyrite in the upper left corner of this image resembles the fine-grained, spongy, poikiloblastic cores overgrown by clean, euhedral pyrite in the large pyrite metacryst to the right. Both may represent primary mineralization.
- The coarse-grained, elongated quartz grains are a pressure shadow growth and not of primary origin.
- Width of field of view (FOV) ~1.2 mm.

# Silver Shaft, Drill hole PDSS-3: depth 468-477 feet – 100x

Transmitted light with incident reflected light.

Cross polarized light with weak incident reflected light.



(Left). Fine-grained, spongy, poikiloblastic pyrite core overgrown by clean, euhedral metamorphic pyrite. The pyrite core and associated recrystallized sphalerite may represent primary mineralization. (Right). Same view under different lighting.

# Silver Shaft, Drill hole PDSS-3: depth 474-486 feet – 40x

Mudstone – footwall. Plane light.



Mudstone – footwall. Cross polarized light.



(Left). Unmineralized mudstone from the footwall of the Silver Shaft ore deposit. (Right). Same view in cross polarized light.

## **2.3. Metallogenesis of the central Gold Hill District of the Carolina Terrane, Rowan and Cabarrus Counties, North Carolina**

By Robert J. Moya

### **Introduction**

The Gold Hill District is one of several clusters of precious and base metal sulfide mineralization present within the Gold Hill Fault Zone in central North Carolina. The mines of the Gold Hill District were active from 1842 until about 1915 (Pardee and Park 1948), producing gold, silver, and copper. Early mining focused largely on relatively high-grade, supergene enriched free gold in the oxidized portions of lodes above the water table, but the primary sulfide ores of many bodies proved to be subeconomic. Successful underground mining continued at the central Gold Hill group of mines, including the Randolph and Barnhardt, the Southern Copper mines, and at the Union Copper Mine, but with limited success at other properties. Most gold and copper production from the district was restricted to an area of 1500 x 2500 meters centered immediately south of the town of Gold Hill.

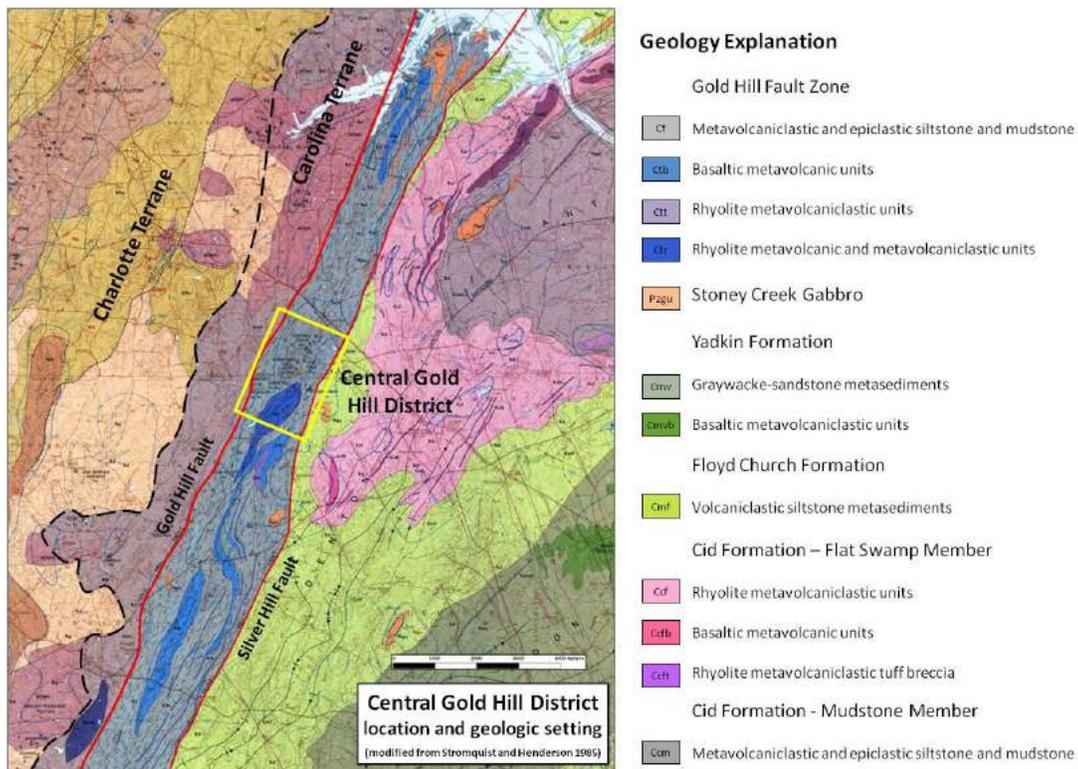
Two styles of mineralization are present in the central Gold Hill District, representing two separate and distinct metallogenic events; stratigraphically controlled polymetallic volcanogenic massive sulfide (VMS) deposits and structurally controlled orogenic gold-bearing veins. The major gold producing deposits are orogenic quartz + sulfide veins, silicic alteration zones, and vein stockworks along brittle-ductile shear zones associated with development of the Gold Hill Fault Zone during the Cherokee Orogeny in the late Ordovician (Hibbard et al. 2012). These include the classic Gold Hill lodes mined from the Randolph, Barnhardt, Honeycutt, and Southern Copper veins of the central Gold Hill District, as well as the Troutman and Isenhour-Whitney veins.

Polymetallic volcanogenic massive sulfide mineralization (VMS) of probable Neoproterozoic-early Cambrian age includes the Union Copper Mine and Silver Shaft deposits. The Union Copper Cu-Zn-Au deposit was the largest single mining operation in the Gold Hill District and an important producer of gold and copper. The Silver Shaft (McMakin) deposit to the southwest was a small Zn-Pb-Ag rich ore body higher in the same stratigraphic sequence. Both appear to be part of the same VMS hydrothermal event and are hosted by a metasilicite-dominated epiclastic sequence that represents a hiatus in the deposition of a thick, coarse-grained, largely felsic volcanoclastic sequence.

## Geologic setting

The central Gold Hill District is hosted by metasedimentary and metavolcanic rocks of the Albemarle Group within the Gold Hill Fault Zone near the western margin of the Carolina Terrane in central North Carolina (Figure 1). Stratigraphy, lithology, and structure are critical elements in the metallogenesis of ore deposits in the area. Orogenic Au-bearing veins of the central Gold Hill District are associated with development of the Gold Hill Fault Zone in the late Ordovician (Standard 2003, Hibbard et al. 2012). The fault zone is a complex sinistral reverse duplex structure in the Gold Hill area, and interaction with earlier-formed first order regional folds and Albemarle Group lithologies may be a factor in localizing gold mineralized structures.

The character and correlation of Albemarle Group metasedimentary and metavolcanic rocks within the Gold Hill Fault Zone is often uncertain and variably obscured by complex meso-scale folding and strongly developed but heterogeneous deformation fabrics, shear zones, and faults. However, large areas of relatively intact stratigraphy appear to be present, especially in the lower (eastern) portion of the fault duplex. Primary sedimentary structures are often preserved in



**Figure 1: Location and geologic setting of the central Gold Hill mining district, Rowan and Cabarrus counties, central North Carolina**

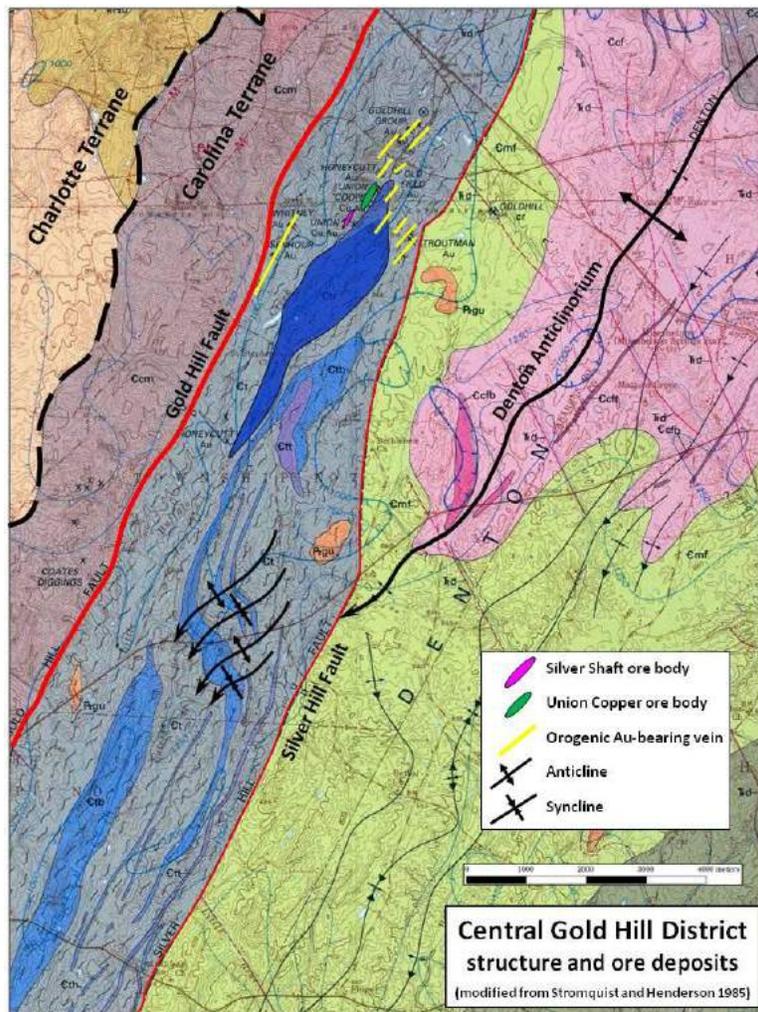
phyllitic metamudstone and metasilstone sequences, and volcanic textures are well preserved in the sequence of felsic-dominated coarse-grained volcanoclastic and fine-grained epiclastic units that host VMS mineralization in the central Gold Hill District.

## The Gold Hill Fault Zone in the Gold Hill area

The Gold Hill Fault Zone is about 120 kilometers long and up to 5 kilometers wide (Hibbard et al. 2012). In the Gold Hill area, the fault zone is about 2.5 kilometers wide and trends 025° (Figure 1), and characterized as a domain of heterogeneous ductile strain with a true thickness of about 2.2 kilometers that dips 70-75° northwest. There is a general increase in metamorphic grade, ductile strain, meso-scale to micro-scale isoclinal to asymmetric folding, shearing and transposition of primary fabrics approaching the Gold Hill Fault (Laney 1910, Standard 2003).

Long considered the faulted boundary between the Carolina and Charlotte Terranes (Butler and Fullagar 1978, Goldsmith et al. 1988, Butler and Secor 1991, Boland 1996, Hibbard et al. 2002), the Gold Hill Fault is more recently interpreted as a late Ordovician sinistral-reverse fault associated with docking of the Carolina Superterrane with Laurentia (Hibbard et al. 2012). Metavolcanic and metasedimentary units west of and hanging wall to the Gold Hill Fault (Stromquist and Sundelius 1969, Standard 2003, Allen 2005) are correlative with the Virgilina Sequence and dated to circa 613 Ma (Hibbard et al. 2008). The Charlotte-Carolina terrane suture is probably located further west, and possibly obscured by younger plutonic rocks.

Standard (2003) describes the Gold Hill Fault along the Davidson-Rowan county line in central North Carolina as a discrete, relatively narrow, west-dipping, large displacement fault that separates lower strain rocks of the Albemarle Group to the east (footwall) from higher strain rocks to the west (hanging wall). This fault and the broad zone of largely ductile strain in the footwall, bounded by the Silver Hill Fault, are defined as the Gold Hill Fault Zone. The Gold Hill Fault is a fundamental structural boundary between different groups of rocks, with a stratigraphic offset estimated at 12 kilometers (Hibbard et al. 2012). The Silver Hill Fault has significantly less displacement, separates domains of differing deformation style in the same group of rocks, and may be a largely brittle structure (Standard 2003). Hibbard et al. (2012) conclude that the Gold Hill Fault Zone is sinistral-reverse fault duplex between the Gold Hill Fault in the hanging wall and the Silver Hill Fault in the footwall.



**Figure 2: Structure and ore deposits of the central Gold Hill mining district, Rowan and Cabarrus counties, North Carolina**

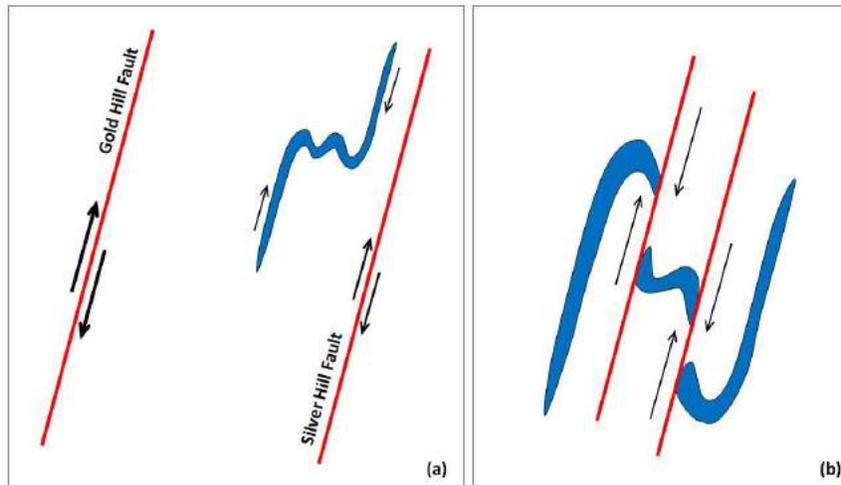
The mines of the central Gold Hill District also lie on the western flank of the Denton Anticlinorium, about four kilometers northwest of the axis (Figures 1 and 2). Ductile-brittle strain within the Gold Hill Fault Zone post-dates formation of the Denton Anticlinorium and other first-order, large-scale, en echelon folds affecting the Albemarle Sequence (Hibbard et al. 2012). These folds are consistent with sinistral strain; with axes and axial plane foliation oriented 025°-045°, clockwise to the Gold Hill Fault Zone. The fold limbs are appressed, transposed, and truncated by the younger shear fabric of the Gold Hill Fault Zone (Hibbard et al. 2008). White mica associated with the axial planar cleavage of the folds has  $^{40}\text{Ar}/^{39}\text{Ar}$  cooling ages of circa 445 Ma (Offield et al. 1995, Ayuso et al. 1997, Hibbard et al. 2008), and cleaved slate of the Tillery Formation has a  $^{40}\text{Ar}/^{39}\text{Ar}$  whole rock age of  $444 \pm 1$  Ma (Noel et al. 1988). Early regional

folding, cleavage development, and greenschist facies metamorphism of the Albemarle Group and subsequent ductile-brittle strain associated with formation of the Gold Hill Fault are all products of the late Ordovician Cherokee Orogeny (Hibbard et al. 2012).

Albemarle Group rocks between the Gold Hill and Silver Hill Faults typically show extensive preservation of primary lithologies, textures and structures (Hibbard et al. 2008). Heterogeneous ductile strain generally increases towards the Gold Hill Fault, but high strain is typically restricted to narrow, discrete shear zones. Bedding and the earlier axial planar cleavage in Albemarle Group rocks are strongly transposed into a NNE-trending, steeply NW-dipping orientation parallel to the Gold Hill Fault, but stratigraphy is often well-preserved and intact over large areas. The prevalence of penetrative cleavage and foliation fabrics may have caused some studies to over-estimate the abundance of metamorphosed mudstones and siltstones within the fault zone (*e.g.* Kerr and Hanna 1888, Nitze and Hanna 1896, Laney 1910).

Mapping by Stromquist and Sundelius (1975) and Stromquist and Henderson (1985) suggests that the Gold Hill Fault Zone duplex narrows significantly through the Gold Hill area, with the Silver Hill floor fault displaced towards the Gold Hill roof fault (Figures 1 and 2). Eight kilometers southwest of Gold Hill, the fault zone is 3200-4000 meters wide and contains numerous, narrow, highly elongated and conformable mafic and felsic volcanic units (Stromquist and Henderson 1985). The fault zone narrows to about 2400 meters at the southern end of the central Gold Hill District (Figure 2).

This narrowing of the fault duplex is coincident with a series of low amplitude, southwest-plunging sigmoidal folds in the hanging wall of the Silver Hill Fault (Figure 2). The folds, defined by several narrow mafic volcanic units, have wavelengths of about 750 meters. This coincides with an abrupt northward deflection of the Silver Hill Fault that extends to the area of the Troutman Mine at the southeastern margin of the central Gold Hill Districts, where the fault resumes a northeast strike. Many of the elongate, conformable volcanic units within the Gold Hill Fault Zone may represent the limbs and axes of tightly folded, southeast verging, asymmetric folds, dismembered and detached by failure of the short limbs as reverse faults (Figures 3 and 4). These folds may be products of reverse shear within the fault zone or modified parasitic folds on the western limb of the Denton Anticlinorium.



**Figure 3: Schematic section for asymmetric folding (a) and dismembering (b) of volcanic units with the Gold Hill Fault Zone reverse duplex**

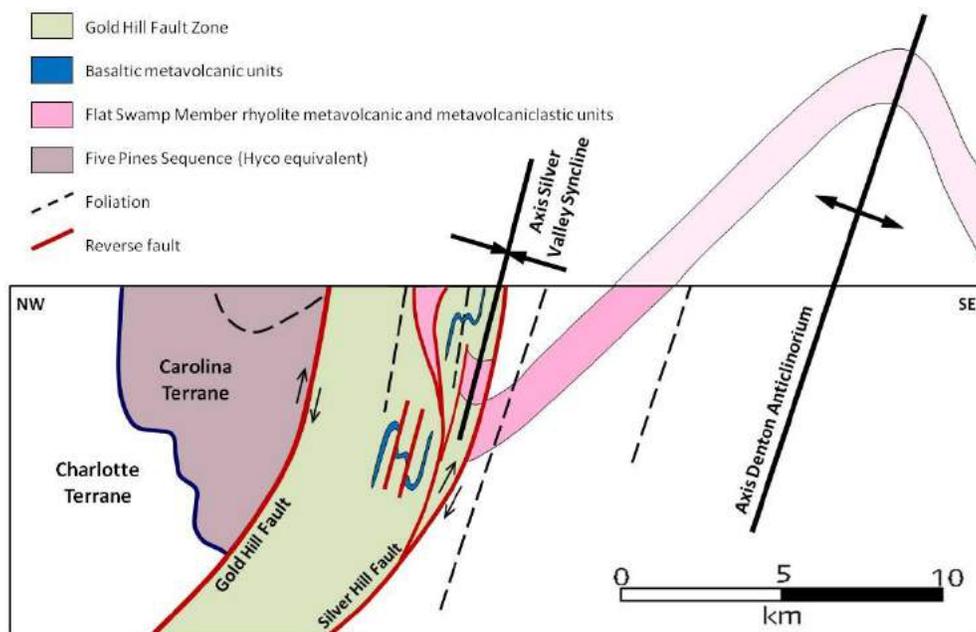
This narrowing and structural reorganization of the Gold Hill Fault Zone is broadly coincident with the presence of the Flat Swamp Member of the Cid Formation in the western limb of the Denton Anticlinorium footwall of the fault zone duplex (Figures 1 and 2). The fault zone widens again to the north as the duplex diverges from proximity to the Flat Swamp Member to the east. The Gold Hill Fault Zone duplex narrows and terminates farther north where the Flat Swamp Member is again present in the proximal footwall in the western limb of the Silver Valley Syncline (Stromquist and Sundelius 1975, Stromquist and Henderson 1985, Standard 2003).

The paucity of mapped volcanic units within the Gold Hill Fault Zone for a distance of 4-5 kilometers to the northeast of the Rowan-Cabarrus county line (Figure 1) may be due in part to difficulty of recognition rather than to the absence of these units, the result of more intense cleavage development within a zone of more strongly focused strain within this portion of the duplex. The orogenic gold deposits of the Gold Hill District may have formed in an area of the duplex with less focused strain to the southwest and more intense, strongly confined strain to the northeast.

Additionally, many of the auriferous lodes of the Gold Hill District appear to be distributed en echelon along the northeastern margin of the elliptical rhyolite-dominated volcanic unit mapped by Stromquist and Henderson (1985) at the southern end of the Gold Hill District (Figure 2). This unit may have acted as a rheological buttress that facilitated partitioning of strain and discharge of fluids through this area of the fault zone duplex. The felsic unit appears to be continuous with the thick sequence of felsic crystal-lithic volcanoclastic units present in the

footwall (east) of the Union Copper VMS deposit, correlated with the Flat Swamp Member of the Cid Formation (Ledger 1978, Unger 1982, LaPoint and Moye 2013).

The presence of Flat Swamp Member units within the Gold Hill Fault Zone duplex at Gold Hill suggests that they may have been structurally exhumed from the western limb of the Denton Anticlinorium at depth, possibly in southeast verging second-order folds or reverse faults hanging wall to the Silver Hill Fault (Figure 4). Alternatively, they are part of the southward continuation of the Silver Valley Syncline, strongly appressed and dismembered within the fault zone.



**Figure 4: Schematic structural section across the Gold Hill Fault Zone sinistral reverse duplex in the Gold Hill area, North Carolina**

### Stratigraphy and lithology in the Gold Hill area

The position of the host rocks of the Gold Hill District within the established stratigraphy of the Albemarle Group is contentious. Stromquist and Sundelius (1969) and Stromquist et al. (1971) assigned the rocks within this portion of the Gold Hill Fault Zone to the Cid Formation, however Stromquist and Sundelius (1975) and Stromquist and Henderson (1985) assign the rocks to the Tillery Formation. Gibson and Huntsman (1988) and Standard (2003) suggest that the strata are similar to the Floyd Church Formation.

Mapping by the USGS (Stromquist and Sundelius 1969, Stromquist et al. 1971, Stromquist and Sundelius 1975, and Stromquist and Henderson 1985) suggests that the northern

portion of the Gold Hill Fault Zone includes portions of both the Cid and Tillery Formations. Goldsmith et al. (1988) suggest that the fault zone may contain elements of both the Tillery Formation and the Mudstone Member of the Cid Formation, but their character is obscured by shearing and recrystallization. More recent studies (Standard 2003, Hibbard et al. 2012) classify all rocks between the Gold Hill and Silver Hill Faults as undivided Albemarle Group.

In western Davidson County, detailed geologic mapping by Phelps Dodge Exploration East in 1975-1976 suggests that the Flat Swamp Member of the Cid Formation hosts the Silver Hill VMS deposit on the western limb of the Silver Valley Syncline, largely intact but strongly appressed within the eastern margin of the Gold Hill Fault Zone. Ledger (1978), Unger (1982), and LaPoint and Moye (2013) suggest that the coarse-grained felsic volcanoclastic sequence in the footwall of the Union Copper and Silver Shaft deposits of the Gold Hill District is also consistent with the Flat Swamp Member of the Cid Formation.

Flat Swamp Member felsic units include coarse-grained crystal-lithic tuff breccias, vitric tuffs, bedded volcanoclastic sequences, and tuffaceous breccia (Stromquist and Sundelius 1969). The crystal-lithic tuff breccias contain felsic clasts up to 3 centimeters across and lenticular aphanitic felsite fragments up to 5 centimeters long. These coarse-grained units appear to grade upwards and along strike into finer-grained vitric-crystal and vitric volcanoclastic units (Stromquist and Sundelius 1969). Variably fragmented crystals up to a millimeter in size are largely albite. Thinly bedded tuffaceous siltstone and mudstone at the top and base of the member contain pyrite and pyrrhotite as disseminated grains and bedding-parallel stringers or laminae (Stromquist and Sundelius 1969).

Felsic volcanic units interbedded with largely fine-grained, thinly-bedded to massive metasedimentary rocks of the Tillery Formation and the Mudstone Member of the Cid Formation are typically described as aphanitic, coherent, lenticular porphyritic flows or vitrophyres, some with flow banding (Conley 1962, Stromquist and Sundelius 1969). Similar flows or vitrophyres are not recognized in the host sequence to the Gold Hill deposits. The felsic volcanoclastic sequence footwall to the Union Copper deposit is also inconsistent with volcanic units of the Floyd Church Formation (see Stromquist and Sundelius 1969).

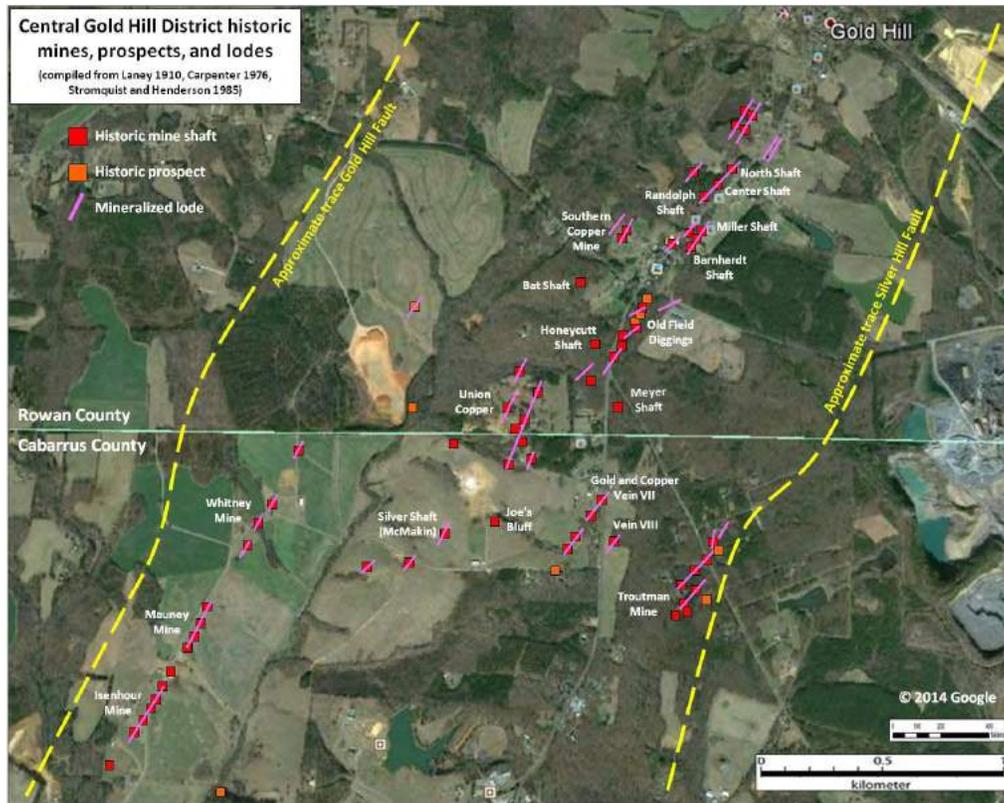
The elongate rhyolite volcanic unit mapped by Stromquist and Henderson (1985) within the Gold Hill Fault Zone immediately south of Gold Hill measures about 4.5 kilometers long and up to a kilometer wide, and appears to extend northward into the area between the Union Copper

and Troutman mines (Figure 2). This unit appears to be continuous with the volcanoclastic sequence mapped in the footwall of the Union Copper Mine deposit (Unger 1982, Smart and Moye 1982), interpreted as part of the Flat Swamp Member of the Cid Formation. This portion of the Flat Swamp Member may be a fault-bounded tectonic sliver, part of a 2<sup>nd</sup> or 3<sup>rd</sup> order fold limb detached from the western limb of the Denton Anticlinorium at depth, or part of a dismembered portion of the Silver Valley Syncline.

### **The Gold Hill mining district**

The Gold Hill District, as originally defined, covers a 1 x 2.4 kilometers area trending 025° in south central Rowan County and northeast Cabarrus County (Kerr and Hanna 1888, Nitze and Hanna 1896). The present study is largely focused on the central Gold Hill District; a northeast-trending area measuring about 1500 meters by 2500 meters within the Gold Hill Fault Zone that contains the largest and most historically productive mines (Figures 1, 2, and 5). Cleavage in the area strikes 025°-030° and generally dips about 75°-80° northwest (Nitze and Hanna 1896). Many mineralized veins, however, trend about 015°-020°, parallel to the strike of the Gold Hill Fault and at an acute angle to the dominant cleavage of the rocks. Kerr and Hanna (1888) note that the veins have not experienced any significant post-mineralization deformation or metamorphic overprint.

The central Gold Hill group of mines is developed along a series of up to a dozen narrow, subparallel mineralized trends (Kerr and Hanna 1888). The series of 8-10 veins depicted as continuous along strike for 1200 to 1800 meters on the maps of Kerr and Hanna (1896, Plate XVIII) and Nitze and Hanna (1896, Plate VI) is not consistent with geologic descriptions of the mines and veins (Figure 6). The map of Laney (1910, Plate XII) is probably more realistic (Figure 6), with shorter, more discontinuous veins and vein sets. Nitze and Hanna (1896) and Weed (1911) note the lack of outcrop along most veins, which makes along strike correlations problematic and contributed to the delayed discovery of these deposits until relatively late in the mining history of the area.



**Figure 5: Historic mines, prospects and lodes of the central Gold Hill mining district, Rowan and Cabarrus counties, North Carolina**

The major mineralized trends can be divided into a number of clusters or groupings that suggest similar local geologic controls (Figure 7). Most recorded gold production in the district is from the Main Gold Hill Group, which includes the Randolph and Barnhardt-Miller veins, the Honeycutt and Old Field veins, and those of the Southern Copper Mine. Veins in this cluster are relatively abundant and continuous along strike for around 600-900 meters across a 100-150 meter wide interval centered on the Randolph and Barnhardt veins, the most productive in the district. This association of mineralized veins appears to be part of a zone of focused but heterogeneous ductile-brittle shearing within the Gold Hill Fault Zone. Significant veins have not been traced more than a few hundred meters farther northeast, and vein continuity and orientation become more irregular to the southwest (Laney 1910, Plate XVIII).

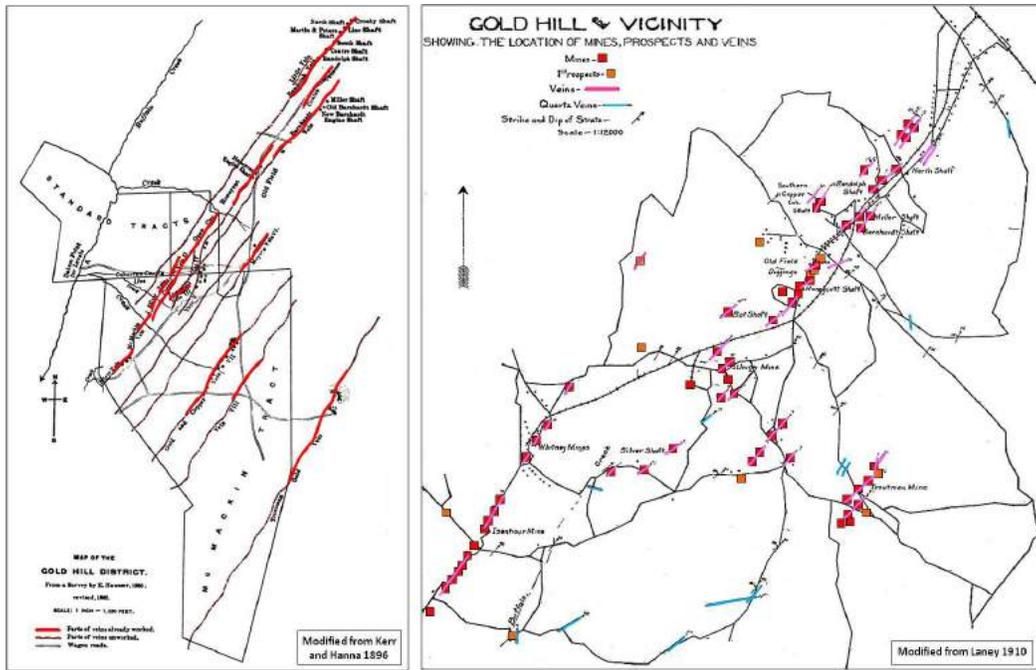


Figure 6: Location maps of mines, prospects, and major lodes of the central Gold Hill District by Kerr and Hanna 1888 (left) and Laney 1910 (right)

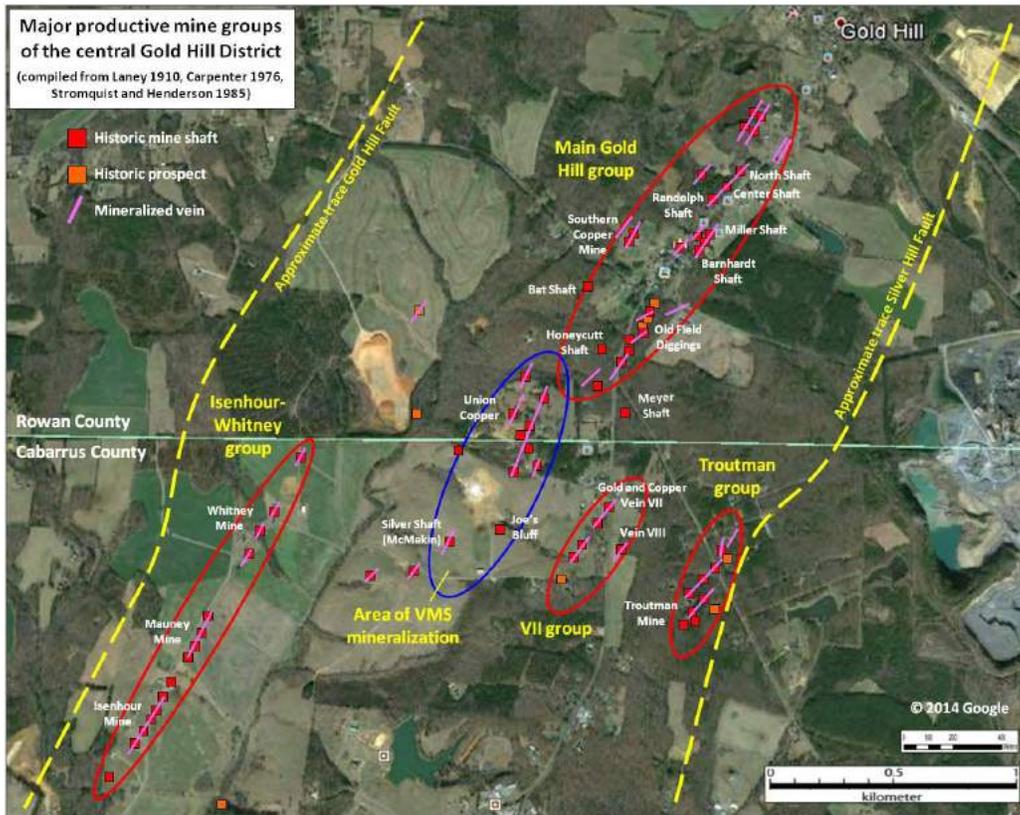
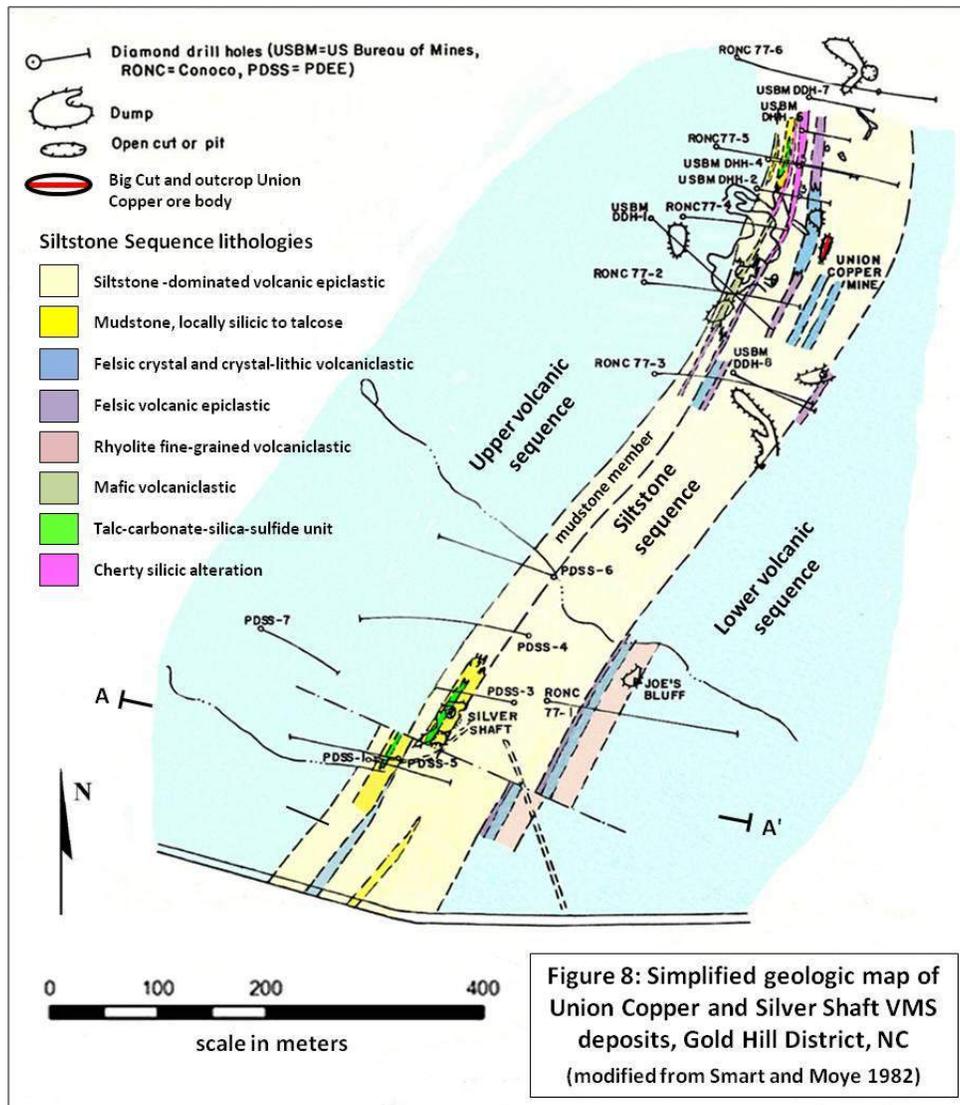


Figure 7: Major productive lode and mine groups of the central Gold Hill District

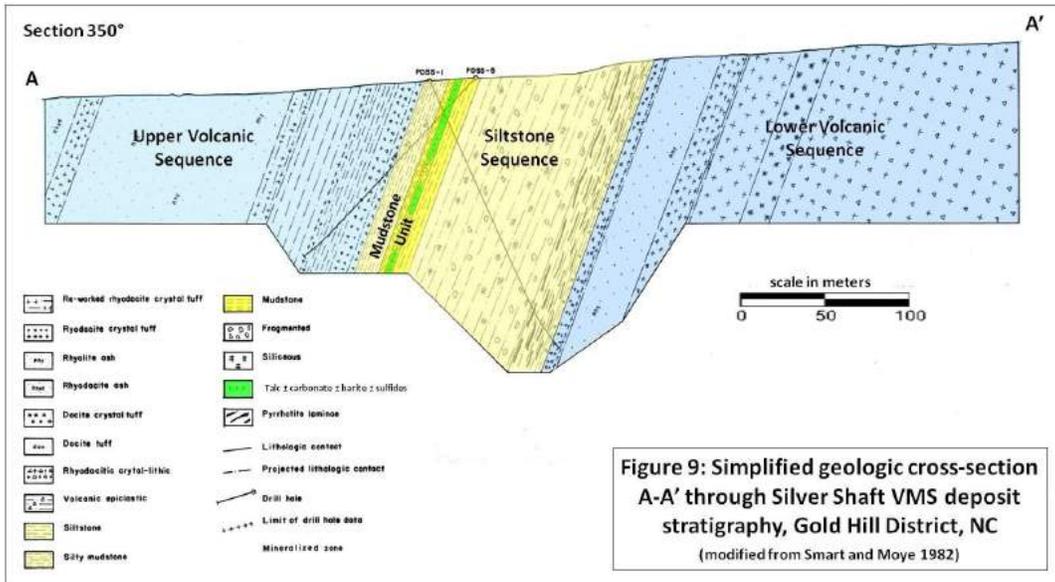
Additional clusters of auriferous veins in the district include the VII and VIII veins located en echelon to the south, the Troutman Group along the southeastern edge of the district, and the Isenhour-Whitney Vein along the southwestern margin (Figure 7). Little information is available regarding the VII and VIII veins, and the workings are probably shallow and production minor. The Troutman vein group, located about 1045 meters southeast of the Randolph Vein, is located in the hanging wall of the Silver Hill Fault. The Troutman Mine appears to exploit a series of possibly en echelon veins that mark the southeast boundary of the Gold Hill District. The Isenhour-Whitney vein appears to be a single continuous mineralized structure located a few hundred meters into the footwall of the Gold Hill Fault (Laney 1910). It is traced for 3200 meters at a strike of around 030° and dips steeply northwest.

The VMS deposits of the Gold Hill District are largely stratiform, stratabound polymetallic massive sulfide mineralization unrelated to the orogenic structurally-controlled auriferous quartz veins (Figures 7 and 8). They include the extensive workings of the Union Copper Mine, the small but high-grade Silver Shaft (McMakin) Zn-Pb-Ag deposit, and the Joe's Bluff prospect. Little information is available regarding workings immediately west of the main line of shafts opened along the Union Copper deposit, but they may have exploited the shallow levels of small Zn-Pb-Ag bodies similar to that at Silver Shaft.



## VMS deposits of the Gold Hill District

The VMS deposits of the Gold Hill District are hosted by a sequence of felsic to intermediate volcaniclastic rocks and massive to thin-bedded sedimentary units metamorphosed to the greenschist facies. The area lies within the central portion of the Gold Hill Fault Zone, with heterogeneous strain more strongly expressed in siltstone and silty mudstones as an anastomosing phyllitic foliation and spaced to penetrative cleavage. The dominant structural fabric strikes  $030^{\circ}$ - $045^{\circ}$  and dips  $75^{\circ}$ - $80^{\circ}$ NW, while bedding strikes  $020^{\circ}$  and dips about  $70^{\circ}$ NW (Unger 1982).



Volcanogenic sulfide mineralization is present locally over an approximately 150 meters wide stratigraphic interval that has been traced for about 900 meters from the Union Copper Mine area southwest beyond the Silver Shaft Mine (Figures 8, 9, and 10). The Union Copper deposit is a classic Cu-Au rich, pyrite-chalcopyrite dominated VMS deposit associated with a large zoned hydrothermal alteration system (Unger 1982). The Silver Shaft deposit is the southernmost of a series of Zn-Pb-Ag rich sulfide deposits associated with talc-barite-carbonate and hosted by mudstone units in the hanging wall (west) of the Union Copper deposit (Smart and Moye 1982).

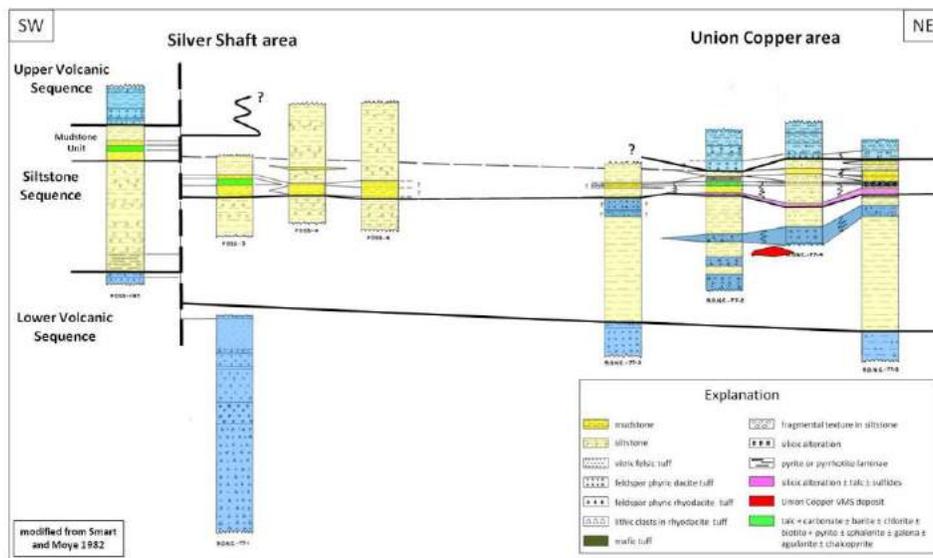


Figure 10: Longitudinal drill hole stratigraphic correlation diagram for the Silver Shaft-Union Copper Mine area, central Gold Hill District, Cabarrus County, North Carolina

The footwall Lower Volcanic Sequence is over 250 meters thick, and composed of usually thick, texturally variable, feldspar phyric, dacitic to rhyodacitic crystal and crystal-lithic volcanoclastic units formed by explosive felsic-dominated volcanism (Unger 1982, Smart and Moye 1982). The maximum size of lithic clasts in these rocks is about 2-3 centimeters. This sequence fines upward into the metasedimentary Siltstone Sequence, about 135 meters thick (Smart and Moye 1982) and dominated by felsic volcanoclastic and epiclastic siltstone and mudstone (Figures 8, 9, and 10).

The central portion of the Siltstone Sequence hosts the Union Copper Mine ore body. The sequence generally fines upwards (west), with discontinuous, thinly bedded mudstone units in the upper portion of the sequence that often host Zn-Pb-Ag sulfide mineralization, including the Silver Shaft ore body (Smart and Moye 1982). The entire sequence shows extensive evidence of hydrothermal activity in the form of silicification, chloritization, intense Mg-metasomatism (talc), and trace to locally economic concentrations of pyrite, sphalerite, galena, and chalcopyrite as disseminations, stringer veins, and bedding-parallel laminae. The Siltstone Sequence appears to have been deposited during a hiatus in an extended period of explosive felsic volcanism.

The metasedimentary Siltstone Sequence terminates abruptly at a rhyodacitic crystal-lithic volcanoclastic unit that forms the base of the hanging wall Upper Volcanic Sequence, representing renewed explosive volcanism. It is over 250 meters thick and characterized by crystal and crystal-lithic dacitic to rhyodacitic volcanoclastic units alternating with volcanic epiclastic sediments including siltstone, mudstone, and sandstone (Smart and Moye 1982).

### The Union Copper VMS deposit

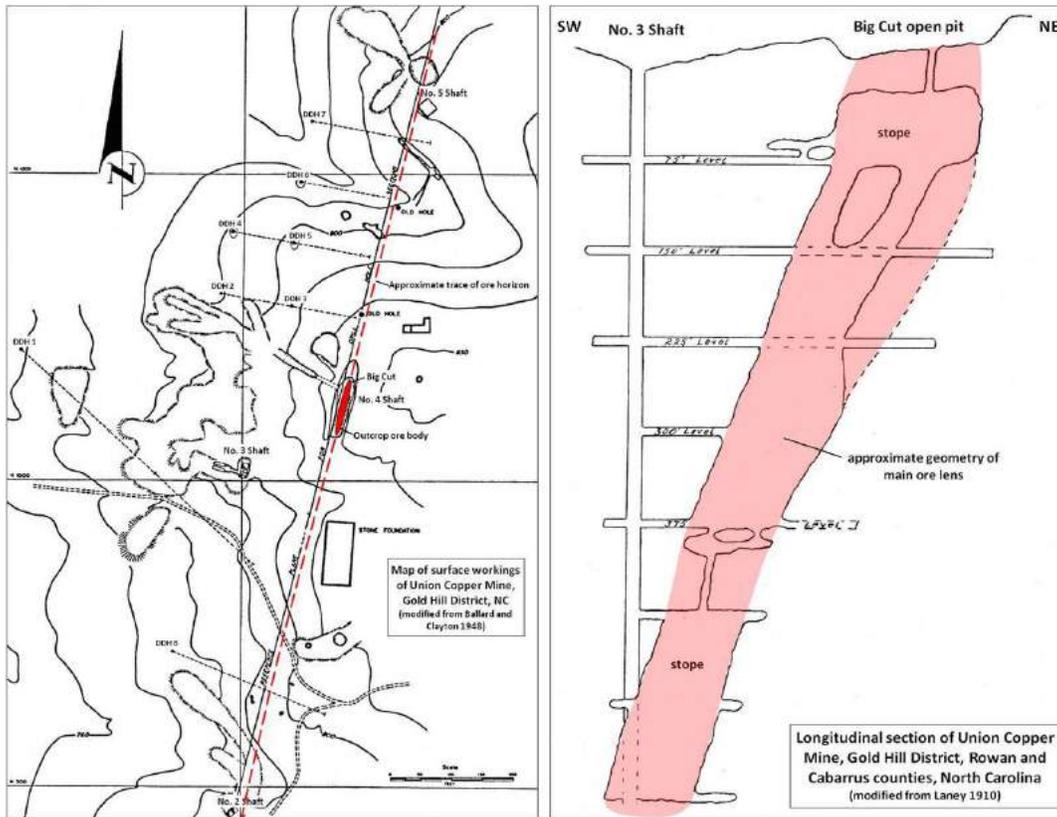
The deposit was discovered in 1842 and the oxidized gossan initially mined for gold from a shallow open pit known as the Big Cut. Secondary enriched Cu ores were encountered at a depth of 7.5 to 9 meters and the ore body named the “Big Cut copper vein” (Weed 1911). The workings are referred to as the “Big Cut” on the map of Emmons (1856) but as the “Open Cut” and “Copper” vein on the map of Nitze and Hanna (1896). Nitze and Hanna (1896) note that the Open Cut “vein” was a major copper resource and around ten meters thick. “Copper Vein” appears to be synonymous with “Big Cut copper vein”.

Five shafts were opened into the primary sulfide ores along a line trending 030° for about 400 meters (Figure 11). Most underground mining occurred on the main ore lens through shafts

No. 3 and No. 4, with No. 3 reaching a depth of 183 meters with development on five levels. The waste dumps from these shafts cover several acres on the surface. Shaft No. 4 was opened in the Big Cut open pit. The mine was most active from 1899 to 1906, ceasing operations in 1907. It produced 5,000,000 pounds of copper and \$375,000 in gold (18,142 ounces Au at \$20.67 per ounce), with most of the gold (about 14,514 ounces) recovered from the oxidized zone (Pardee and Park 1948).

The Union Copper main ore body (Figure 11) measured up to 40 meters along strike and 12 meters thick near the surface, and 30 meters long and up to 5 meters wide at a depth of 114 meters below surface (Ballard and Clayton 1948, Pardee and Park 1948). The mineralization becomes attenuated and irregular at a depth of 152 meters. The upper part of the ore body, from the surface to the second underground level, strikes about  $025^{\circ}$  and plunges  $70^{\circ}$  SW, with striations along the contacts parallel to the plunge (Laney 1910, Pardee and Park 1948). The dominant foliation in the host rocks strikes  $040^{\circ}$ . The ore body parallels the strike of the foliation on the third mine level, and other portions of the mineralized zone strike between  $035^{\circ}$  and  $065^{\circ}$ .

Mineralization is described as dominantly chalcopyrite + pyrite averaging about 1.5-3.0% Cu, with minor sphalerite and galena. Sulfides occur in a series of massive ( $\geq 50\%$ ) to sub-massive (30-50%) lenses containing fragments of altered country rock, surrounded by a lower-grade halo of quartz + sulfide stringers and veins and disseminated sulfides in a strongly silicified zone that extends along strike beyond the zone of known mineralization (Laney 1910, Unger 1982). Primary ore minerals are pyrite, chalcopyrite, sphalerite, galena, pyrrhotite, barite, magnetite, and arsenopyrite (Unger 1982). Gangue minerals include, in decreasing abundance, chlorite, biotite, calcite, talc, and quartz (Unger 1982). Sub-massive sulfide lenses in the upper part of the system grade along strike into chlorite-biotite-talc-sulfide schist (Unger 1982).

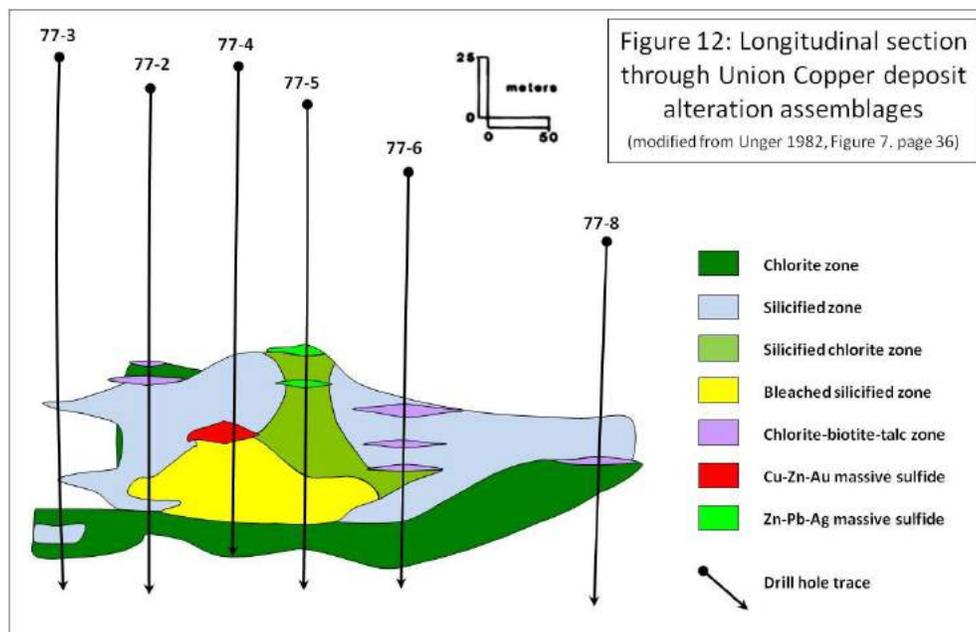


**Figure 11: Surface map of historic mine workings (left) and longitudinal section through the main ore body (right), Union Copper Mine, Gold Hill District, North Carolina**

The Union Copper deposit is at the center of an extensive area of compositionally zoned hydrothermal alteration developed over about 500 meters along strike and around 90 meters stratigraphically, located largely in the footwall and periphery of the deposit but extending into the hanging wall (Figure 12); and includes a footwall stringer quartz-sulfide vein zone that contains 1-10% pyrite + sphalerite + chalcopyrite with minor galena and trace arsenopyrite (Unger 1982). The alteration is zoned outward from an intensely silicic altered core with deep potassic alteration, overlapped and gradational with an outer zone of intense chloritic alteration (Unger 1982).

Drilling along strike and down dip from the deposit by the US Bureau of Mines in 1943, Tennessee Copper Company in the early 1960s, and Conoco Minerals in 1977 encountered a generally lower-grade, strongly silicified mineralized zone 9-12 meters wide north and south of the old stopes, consisting of pyrite and sphalerite with accessory chalcopyrite and galena. The ore body appears to be zoned from a Cu-rich central zone to a more Zn-rich periphery, with gold mineralization closely associated with higher Cu-values.

At least six discontinuous 1-7 meter thick lenses of chlorite-biotite-talc-carbonate-sulfide schist are present peripheral to the middle and upper portions of the Union Copper alteration zone, some gradational along strike into semi-massive sulfide mineralization (Unger 1982). Two Bureau of Mines drill holes intersected a 5-meter wide zone of sphalerite and galena mineralization about 60 meters into the hanging wall of the Union Copper main ore body. Three holes drilled by Conoco also intersected Ag-Zn mineralization in the hanging wall of the main Union Copper ore body, including 3.7 meters (true thickness) of 4.91 opt Ag with 1.17% Zn. These hanging wall Zn-Pb-Ag ore zones at the Union Copper Mine appear to be at the same stratigraphic position as the Silver Shaft Mine to the south.



### The Silver Shaft (McMakin) VMS deposit

The Silver Shaft Mine, formerly the McMakin, is located approximately on strike about 550 meters south-southwest of the Union Copper Mine in Cabarrus County (Figures 7 and 8). The deposit is labeled the “Manganese” vein on the map of Emmons (1856). The McMakin Mine is commonly misidentified with the Whitney Mine (Laney 1910, Carpenter 1976); however, descriptions of the ore body in older publications (Kerr and Hanna 1888, Nitze and Hanna 1896) are not consistent with the geology of the Isenhour-Whitney lode. Correlation of the “Big Cut” on the map of Emmons (1856) with the location of the “Standard-Open Cut-Copper Vein” on the map of Kerr and Hanna (1888) is consistent with the position of the Union Copper Mine. The

location of the McMakin Mine relative to the Union Copper Mine is consistent with the location of the Silver Shaft site.

Additionally, Nitze and Hanna (1896) make a clear distinction between the location of the McMakin Mine and the Isenhour-Whitney group of mines within the district. Confusion has probably arisen from the consolidation of a number of mining properties at Gold Hill as the Whitney Group during the later period of mining in the district. Only a single collapsed shaft and spoil pile remained of the McMakin Mine in the early 1980s, and the site was subsequently completely reclaimed.

The “McMakin Vein” is shown on the map of Nitze and Hanna (1896, Plate VI) continuous with the “Silver Vein” to the southwest and the northeast over a strike of about 800 meters, mostly located in northern Cabarrus County. The “vein” is situated west and en echelon to the “Copper Vein” and the “Standard” or “Open Cut Vein” of Nitze and Hanna (1896). The McMakin-Silver Vein on this map may represent the Silver Shaft deposit and the series of small lenses of Zn-Ag rich VMS mineralization present in the hanging wall (west) of the Union Copper VMS deposit (Unger 1982, Smart and Moye 1982).

The McMakin Mine was active from sometime after 1842 until 1861. The “Main Vein” was worked by shallow pits for around 275 meters along strike (Nitze and Hanna 1896), and mined underground through three shafts over a length of 60 meters to a maximum depth of 55 meters with development levels at the bottom and at 20 meters depth (Kerr and Hanna 1888, Nitze and Hanna 1896). The host rocks are described as talc-chlorite schist, with an argillaceous footwall and talcose hanging wall (Kerr and Hanna 1888). The smaller, parallel “West Vein” was stoped from the Whim Shaft to the surface (Kerr and Hanna 1888).

Kerr and Hanna (1888) and Nitze and Hanna (1896) describe the “Main Vein” of the McMakin Mine as bedding-parallel, striking  $045^{\circ}$ - $060^{\circ}$  and dipping  $70^{\circ}$ - $75^{\circ}$  southeast. The smaller, parallel “West Vein” strikes  $050^{\circ}$ - $060^{\circ}$  and dips  $35^{\circ}$  southeast (Kerr and Hanna 1888). This orientation contrasts with that determined by Phelps Dodge Exploration East surface mapping and diamond drilling, where the mineralization strikes  $025^{\circ}$  and dips  $70^{\circ}$ NW parallel to the host stratigraphy (Smart and Moye 1982). The West Vein may be the faulted southern portion of the main ore body, as suggested by PDEE drilling.

In the Main Vein, abundant manganese oxides (psilomelane, pyrolusite) were present from the surface to a depth of six meters, followed by abundant secondary Pb oxides, carbonates,

and phosphates (pyromorphite, cerussite) to a depth of 18 meters (Kerr and Hanna 1888). Primary sulfides are yellow sphalerite, galena, Ag-bearing tetrahedrite, pyrite, and chalcopyrite, with a gangue of quartz, calcite, barite, rhodochrosite, and talc (Genth 1891, p. 90). Genth (1891) also reports the presence of small plates and reticulated masses of native silver, argentite, and possible proustite.

At a depth of 23 meters between the South and Whim shafts, the lode is described as 1-3 meters thick and composed largely of carbonate and barite with a zoned distribution of sulfides; disseminated grains and small masses (to 60 centimeters) of tetrahedrite near the hanging wall, a central zone with seams of tetrahedrite and yellow sphalerite, and yellow sphalerite and galena with numerous grains of tetrahedrite near the footwall (Kerr and Hanna 1888). The sulfide ore assayed around 14-53 opt Ag (Kerr and Hanna 1888) and Genth (1891) assayed tetrahedrite (freibergite) samples from the McMakin with 6.5-10.5% Ag, equivalent to as much as 500 opt Ag.

Spoil from the single remaining shaft and dump in 1980 included masses of variably foliated, medium to coarse-grained, massive or irregularly to colloform banded talc + carbonate + barite + sulfide rock that assayed up to 11.4% Pb, 25.2% Zn, and 28.68 opt Ag (Smart and Moye 1982). Phelps Dodge Exploration East evaluated the Silver Shaft deposit in 1980-1981 and drilled seven diamond core holes along strike and down-dip from the old shaft. The best result was 7.3 meters averaging 8.88 opt Ag and 1.113% Zn, intersected 15 meters north of the old shaft at a vertical depth of 91.4 meters (Smart and Moye 1982). The Silver Shaft ore body appears to be highly localized and elongated down-dip, similar to the geometry of the Union Copper deposit. Drilling outlined an estimated resource measuring about 60 meters along strike, 120 meters down dip, and 7 meters thick with an estimated 190,000 tons of ore averaging 8-9 opt Ag and 1-2% Zn (Smart and Moye 1982).

The Silver Shaft deposit is hosted by discontinuous mudstone intervals in upper part of the Siltstone Sequence between the Upper and Lower felsic volcanoclastic sequences, interpreted as part of the Flat Swamp Member of the Cid Formation (Smart and Moye 1982). Stratigraphy strikes 025°, dips 70°NW, and is right side up, while cleavage strikes about 030°-045° and dips 75°-80°NW (Smart and Moye 1982). Foliation is most strongly developed in finer-grained units, and weakly expressed in coarser-grained, more massive rocks. The metamorphic grade appears to be lower to middle greenschist facies.

Talc alteration of volcanoclastic mudstone occurs over an interval up to 25-30 meters thick at Silver Shaft, with disseminated to semi-massive Zn-Pb-Ag sulfide mineralization reaching ore grade over 7-8 meters near the top of the zone. The low-Fe character of the sphalerite, the presence of aguilarite (Smart and Moye 1982), abundant carbonate, and locally abundant barite in the Silver Shaft deposit contrast strongly with the higher temperature Fe- and Cu-rich mineral assemblages at the Union Copper Mine. Although variable chlorite alteration and stringer quartz-carbonate-sulfide veins are present in the footwall of the Silver Shaft deposit, the intense, concentric zone of alteration that characterizes the Union Copper deposit is absent.

### Joe's Bluff

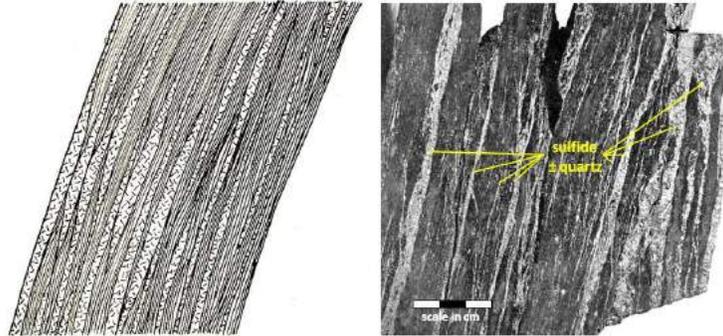
Joe's Bluff is a collapsed shaft or pit located 180 meters east of Silver Shaft (Figures 7 and 8), and is misidentified as the Silver Shaft Mine by Carpenter (1976). It is opened in a fine-grained, siliceous, pyritic unit near the top of the lower felsic-dominated Lower Volcanic Sequence. This horizon is footwall to the Union Copper Mine main ore body, and appears to have been prospected intermittently for at least a kilometer to the northeast. Conoco drill hole RONC-77-1 intersected intervals of up to 15% total sulfides in this unit with anomalous Cu-Zn-Pb values.

### Orogenic, shear zone hosted, gold-bearing vein deposits

Major gold production in the Gold Hill District was from generally narrow, discontinuous, often en echelon quartz vein sets, swarms, quartz and sulfide veinlet stockworks, and silicified zones along discrete, anastomosing shear zones associated with the latest phases of sinistral-reverse strain in the footwall of the Gold Hill Fault.

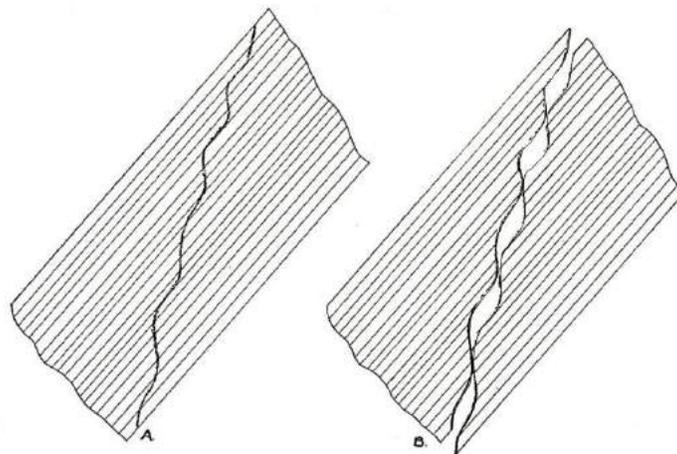
Laney (1910) noted three types of "veins" in the Gold Hill District. Type-1 is the most characteristic, and consists of anastomosing lenses and stockwork stringers of sulfide and sulfide + quartz without significant silicification of the adjacent host rocks (Figure 13). These veinlets and stringers are observed to cross-cut the dominant cleavage at an acute angle in small-scale steps (Figure 14), paralleling cleavage planes over short distances and breaking across to an adjacent plane in left-stepping en echelon geometry (Laney 1910). As a result, these veins often strike more northerly and dip more steeply or at shallower angles than the cleavage of the host

rocks (Laney 1910). Nitze and Hanna (1896) observed this geometry in the Randolph Vein, and noted that left-stepping, en echelon lenses of quartz and sulfides defined the vein.



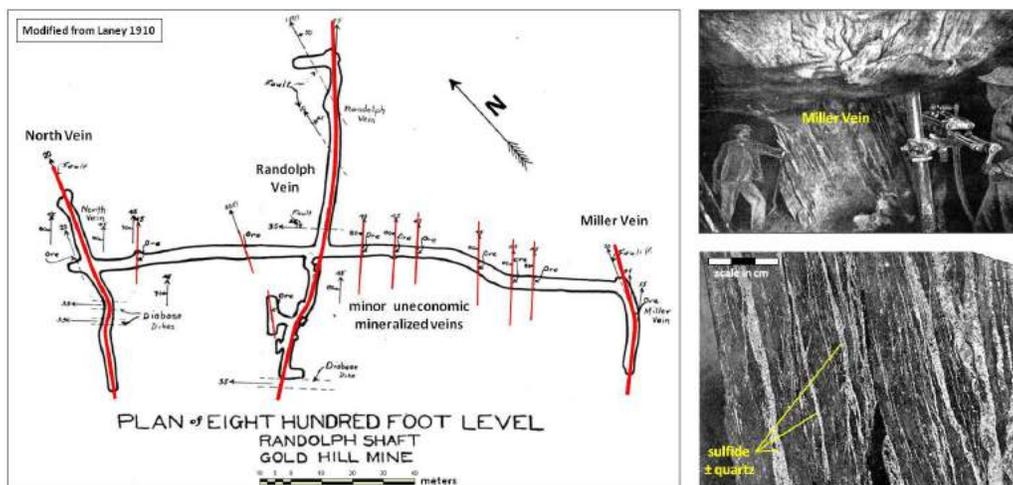
**Figure 13: Illustration of sulfide  $\pm$  quartz lenses and stringers in "rifted schist" (left) and example from Miller Vein (right) (modified from Laney 1910)**

Some Type-1 veins are Cu-rich with chalcopyrite as the dominant sulfide and little or no associated gold. Others are Au-rich with pyrite dominant and only minor chalcopyrite. Examples of this vein type include the Randolph and Barnhardt veins of the central Gold Hill area. The veins pinch-and-swell along strike and down dip, with economic mineralization typically present in steeply SW-plunging shoots (Laney 1910). These shoots commonly measure 6-30 meters along strike and 30 to over 250 meters down plunge (Figures 17 and 18), with heterogeneous variations in thickness and grade (Laney 1910). Slickenlines in the walls of the veins commonly plunge steeply southwest, parallel to the plunge of the ore shoots.



**Figure 14: Left-stepping geometry of veins in Gold Hill lodes (modified from Laney 1910)**

Additionally, Laney (1910) notes that numerous small, discontinuous mineralized veins are present within the host sequence peripheral to and between larger ore veins. At the 244 meter level of the Randolph Shaft, the Miller Vein is located about 110 meters east of the Randolph Vein, with at least six mineralized veins too small to work in between (Figure 15). This geometry appears to be repeated at scales of hundreds of meters to centimeters, with a few 1<sup>st</sup>-order veins (Randolph and Barnhardt) flanked by a series of less continuous parallel 2<sup>nd</sup>-order veins (Centre, Honeycutt, North), and numerous, highly discontinuous 3<sup>rd</sup>-, 4<sup>th</sup>-, and 5<sup>th</sup>-order veins present across the sequence. All orders of veins appear to be variably mineralized, with most production from the 1<sup>st</sup>- and 2<sup>nd</sup>-order veins.



**Figure 15: Plan map of cross-cut to North and Miller (Barnhardt) veins from 800 feet (244 meters) level of Randolph Shaft (left) with historic image of Miller Vein in drift (upper right, view south) and sample of Miller Vein sulfide ± quartz stringer stockwork in "rifted schist" (lower right) (all images modified from Laney 1910)**

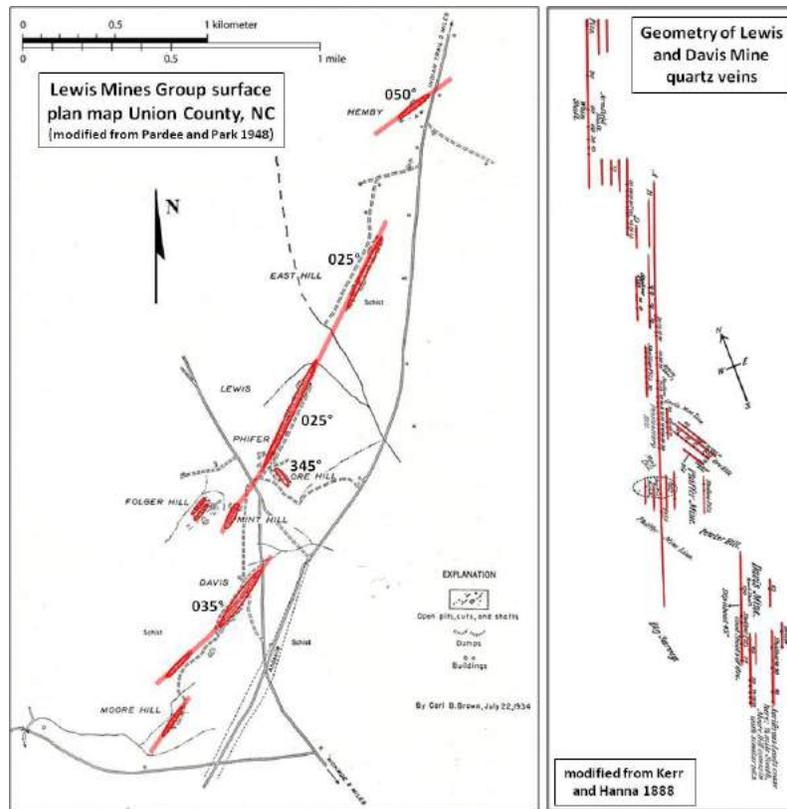
Type-2 veins are characterized by typically wider intervals of often intense silicic alteration, with locally ore-grade gold mineralization associated with pyrite and only minor copper. These zones are usually thicker and more laterally persistent than the Type 1 veins, with numerous, variably silicified, elongate clasts of host rock within the vein and a banded texture parallel to cleavage that may flow around screens of wall rock (Laney 1910). Silicic alteration ranges from abundant white quartz veins, to variable silicic alteration of clasts, to dense masses of blue-grey cherty silica with disseminated sulfides (Laney 1910). The Isenhour-Whitney Vein is the best example in the Gold Hill District.

The Type-1 and Type-2 lodes of the Gold Hill District are not true veins and typically have indefinite structural, alteration, and grade boundaries with the host rocks. Both types of

occurrence are present along several veins in the district, including the Randolph Vein and the Isenhour-Whitney Vein. Both styles have textures suggesting incremental development through repeated brittle fracture failure and punctuated fluid flow, consistent with seismogenic cycles along the host structures. Type-3 veins are true quartz veins with sharp contacts filling brittle fractures. Although widespread in the Gold Hill District, they seldom host significant mineralization.

A number of orogenic vein-type lodes in the Gold Hill District carry minor sphalerite and galena in addition to chalcopyrite, including the Troutman Mine and the mines of the Southern Copper and Gold Company (Figure 5). Gold Hill-type shear zone hosted veins, siliceous zones, and stockworks within the Gold Hill Fault Zone farther to the southwest also carry accessory base metal sulfides. Accessory galena  $\pm$  sphalerite is reported from the mines of the Lewis Group and Stewart Group in Union County. Both groups of mines are opened along shear zone hosted Gold Hill Type-1 and Type-2 veins that are typically semi-conformable with the ductile-brittle fabric of the Gold Hill Fault Zone.

The Lewis Mine Group of gold mines is located in southwest Union County, and extends for about 4 kilometers in a series of left-stepping en echelon segments 300 to 2000 meters long (Figure 16). The group trends about  $030^\circ$ , with individual vein structures at  $025^\circ$  to  $035^\circ$ . In the Lewis Group, argentiferous galena is reported in veins at the Davis, Phiffer, Lewis, and Hemby mines (Kerr and Hanna 1888).



**Figure 16: Left-stepping geometry of Lewis Group of orogenic Au-bearing quartz veins in the Gold Hill Fault Zone, Union County, NC**

The Stewart Group of 14 historic gold mines occupies a 12 kilometer long zone located at the western edge of Union County. Mineralization appears to be largely hosted by cleavage-parallel, variably silicified chloritic to sericitic schists, quartz veins, and quartz stringer zones (Pardee and Park 1948, Carpenter 1976). Many of the quartz veins carry appreciable base metal sulfides (chalcopyrite, galena, and sphalerite) and two, the Lemmonds and the Stewart, also carry accessory arsenopyrite. Argentiferous galena and sphalerite are especially noted in the Moore, Stewart, Lemmonds, Secrest, Smart, and Black mines.

The similar character, mineralogy, and apparent structural controls of vein-hosted gold mineralization in the Lewis Group, Stewart Group, and Central Gold Hill District suggest a similar origin. Additionally, all appear to be hosted by left-stepping en echelon ductile-brittle shear zones that parallel the orientation of the Gold Hill Fault and cross-cut earlier ductile foliation fabrics at an acute angle. These structural control for this style of mineralization is consistent with deformation associated with the Cherokee Orogeny in the late Ordovician (Hibbard et al. 2012).

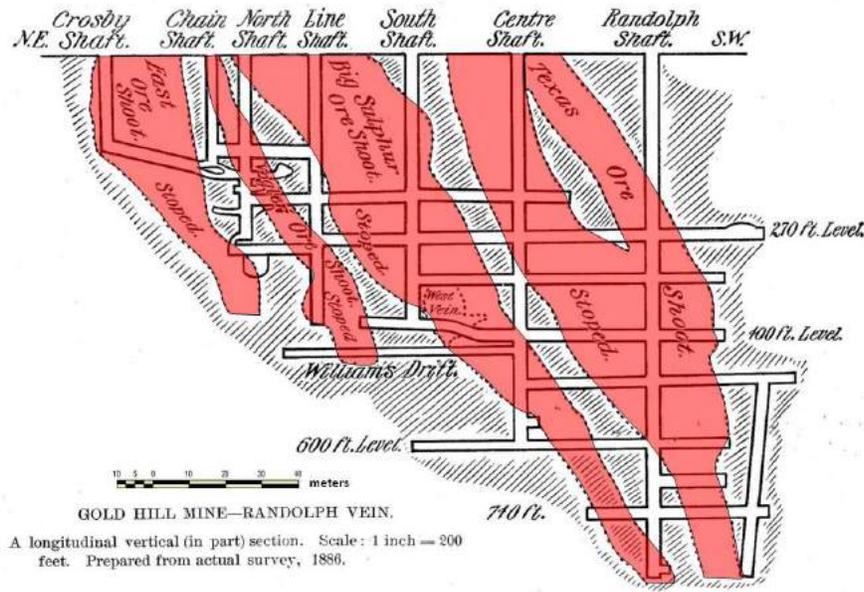
The pattern of well-constrained auriferous lodes present along the Randolph, Barnhardt, and Honeycutt veins of the central Gold Hill District is disrupted at the Rowan-Cabarrus County line, replaced by a series of irregular, discontinuous, possibly en echelon mineralized trends. These include the Vein 5, Open Cut-Standard Vein, Townsend Vein, and Silver Vein-McMakin Vein of Nitze and Hanna (1896, Plate XVIII). Rather than typical Gold Hill-type shear-hosted veins, some of these “veins” may be stratabound volcanogenic massive sulfide (VMS) deposits, formed synchronously with the host rocks and much older and genetically unrelated to the late Ordovician deformation event.

### The Gold Hill Group: North, Randolph (Earnhardt), Hunnicutt (Honeycut or Honeycutt), and Barnhardt (Miller) veins

This series of four major parallel “veins”, strike about  $015^{\circ}$  to  $030^{\circ}$ , dip steeply northwest, and are present in a zone with a width of about 150 meters for a distance of around 1500 meters at the core of the Gold Hill District (Figure 5). Of the estimated total gold production of 160,000 ounces from the district, around 122,000 ounces (~76%) was recovered from this set of structures; 115,000 ounces (72%) from the Randolph and Barnhardt Mines alone (Pardee and Park 1948). The Randolph and Barnhardt veins are the most continuous and productive in the Gold Hill District, with all significant production from the northeast ends.

The Randolph Vein (Figures 5 and 17) has been worked intensively for 460 meters along strike to a depth of 215 meters (Laney 1910). The host phyllite strikes about  $035^{\circ}$  and dips  $80^{\circ}$  northwest, and is locally bleached (phyllic alteration) with minor pyrite and chalcopyrite along cleavage surfaces (Carpenter 1976). Underground levels and stopes extend to a depth of 225 meters along a series of steeply SW-plunging shoots (Figure 17). From southwest to northeast they include the large Texas and Big Sulphur shoots and the smaller Vogler and East shoots (Nitze and Hanna 1896).

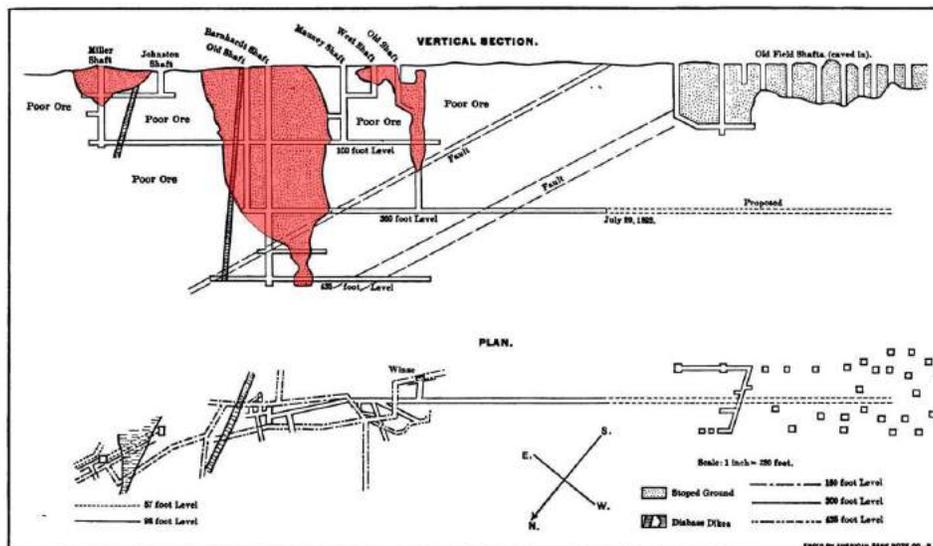
The lode pinches and swells from 15 to 120 centimeters thick and is locally up to 200 centimeters thick. Pyrite is predominant over chalcopyrite and mineralization is dominantly gold with only minor copper. An estimated 80,000 ounces of gold were recovered from the Randolph Mine (Pardee and Park 1948), dominating production from the Gold Hill District. Most production came from the Texas and Big Sulphur shoots, mined from three shafts (Randolph, Center, and South) over an area of about 100 meters by 100 meters in the plane of the vein.



**Figure 17: Longitudinal section of Randolph Vein from Crosby Shaft to Randolph Shaft illustrating distribution of steeply southwest-plunging ore shoots (red) (modified from Kerr and Hanna 1888)**

Cross-cuts normal to foliation from the 244 meter level of the Randolph Shaft (Figure 15) intersected the Barnhardt (Miller) Vein about 110-120 meters to the southeast and the North Vein 75 meters to the northwest (Laney 1910). An additional eight mineralized veins were intersected along this transect, six between the Randolph and Miller veins, but were too small to be mined profitably (Laney 1910). The Miller Vein appears to be the southern continuation of the Barnhardt Vein at depth. The North Vein does not appear to outcrop at the surface.

Most production from the Barnhardt (Miller) Vein comes from about 110 meters of strike accessed by the Miller, Middle (Johnson), and Barnhardt shafts. It was worked to a depth of 49 meters from the Miller Shaft and to 133 meters from the Barnhardt Shaft, both on separate ore shoots within the vein. The Barnhardt shoot plunges steeply southwest (Figure 18), with parallel slickenlines along the vein walls (Laney 1910). The Barnhardt Shaft measured 1.5 x 1.5 meters with working levels at 49, 91, 116, and 133 meters (Carpenter 1976). The strongly foliated host phyllites are oriented 040° with a subvertical dip (Carpenter 1976), but the lode strikes about 030° and dips steeply northwest.



**Figure 18: Longitudinal section of Barnhardt Vein illustrating distribution of steeply SW-plunging ore shoots (red); shallow Old Field workings on strike to southeast (modified from Nitze and Hanna 1896)**

The Barnhardt Vein trend continues about 100 meters to the southwest as the Old Field Workings, where it was mined to the water table (about 40 meters depth) from a series of shallow pits and shafts (Laney 1910). The lode structure appears to be less well constrained; with multiple parallel to en echelon veins only a few centimeters thick with discontinuous gold mineralization (Nitze and Hanna 1896, Laney 1910). Estimated gold production from the Barnhardt Vein is about 35,000 ounces (Pardee and Park 1948), most through the Barnhardt Shaft.

Where intersected at a depth of 244 meters by cross-cut from the Randolph Shaft (Figure 15), the Barnhardt (Miller) Vein was up to 3.7 meters wide and exposed for about 46 meters along a strike of  $015^{\circ}$ - $020^{\circ}$  (Laney 1910). Laney (1910) describes the vein as a series of anastomosing stringers of quartz and sulfide which form about 10% of the lode by volume. Genth (1891) reports the occurrence of small grains of bismuthinite associated with gold, chalcopyrite, and pyrite. The Barnhardt Vein is less copper-rich than the Randolph Vein (Kerr and Hanna 1888).

The Centre and Hunnicutt veins are located between the Randolph and Barnhardt (Miller) veins (Figure 5) and reported as 40-60 centimeters thick. The Centre Vein lies about midway between the Randolph and Barnhardt shafts. It was not recognized in the cross-cut at 244 meters depth between the Randolph and Barnhardt veins and is possibly correlated with one of the small subeconomic veins reported by Laney (1910).

The Hunnicutt Vein lies between the strike of the Randolph and Barnhardt veins to the south, but correlation with the Centre Vein is uncertain. West of the Old Field Workings, the Hunnicutt Vein was traced for around 365 meters (Nitze and Hanna 1896) and worked to a depth of about 56 meters from the Honeycutt (No. 12) Shaft (Laney 1910) with estimated production of around 6000 ounces of gold (Pardee and Park 1948). A vein located about 30 meters northwest of the Honeycutt Shaft was worked from Shaft No. 7 and carried mostly copper with little gold (Laney 1910).

The North Vein does not outcrop at the surface, and is 60-240 centimeters thick, averaging about a meter, and strikes  $015^{\circ}$ - $020^{\circ}$  (Laney 1910). Development along the vein suggests a SW-plunging ore shoot about 18 meters long on a strike more northerly than the cleavage in the host rocks. Quartz stringers locally follow cleavage away from the main shoot. Abundant free gold is reported (Laney 1910), and production was probably part of that reported for the Randolph Mine. Records for 1914-1915 production from the North Vein show 7250 tons of ore milled, yielding 3877 ounces Au (0.53 opt), 603 ounces Ag, and 23,112 pounds of Cu (Pardee and Park 1948).

### Southern Copper and Gold Mining Company Mine

Laney (1910) reports the presence of two shafts and two or three veins or lodes located on a hill a few hundred metres southwest of the Randolph Shaft, but not on the same line of lode (Figure 5). A shaft and pit near the mill are located in a siliceous, fine grained felsic rock along a Type 1 vein composed of narrow, anastomosing seams of sphalerite, galena, pyrite, and minor chalcopyrite with little associated alteration (Laney 1910).

The other shaft is located about 60 meters to the southeast in sheared, extensively silicified coarse-grained tuff along a Type 2 lode that carries auriferous pyrite and chalcopyrite with minor sphalerite and galena (Laney 1910). This shaft is up to 60 meters deep. Carpenter (1976) reports the presence of at least four shafts, some vertical and some inclined parallel to the dominant foliation, an adit, and numerous pits.

It is possible that some of the mineralized lodes at the Southern Copper and Gold Mine and the Bat Shaft to the southwest may be stringer or structurally remobilized VMS-type mineralization related to the Union Copper-Silver Shaft hydrothermal system.

## Bat Shaft

Carpenter (1976) reports that the Bat Shaft (Figure 5) was opened in a zone of siliceous phyllite containing pyrite, chalcocite, galena, and light yellow-brown sphalerite. This may represent a southwest continuation of the more westerly vein at the Southern Copper Mine.

## Meyer Shaft

The Meyer Shaft (Laney 1910) or Unnamed Shaft (Carpenter 1976) is a 3 x 4.5 collapsed shaft and a series of pits opened along sericite phyllite that strikes  $045^{\circ}$  and dips  $85^{\circ}$  northwest (Carpenter 1976). The character of the vein is uncertain.

## Townsend Vein

The Townsend Vein (Figure 6) is shown on the map of Nitze and Hanna (1896, Plate XVIII) as trending more easterly than the adjacent veins. It is shown as having a strike length of about 400 meters and was mined to a maximum depth of about 40 meters (Nitze and Hanna 1896). No further information is available.

## Troutman (Trautman) Mine (Au-Zn-Pb)

These veins form the southeastern edge of the Gold Hill group, and appear to be a series of en echelon veins rather than a single lode (Figure 5). Free gold was recovered from oxidized ore from the surface to a depth of about 6 meters, with ferruginous quartz and hematite with pyromorphite, cerussite, and other secondary lead minerals present from 8 to 18 meters depth (Nitze and Hanna 1896). Below 18 meters depth the vein was largely quartz and auriferous pyrite, with a 5-15 centimeter streak of pyrite + galena below 30 meters depth that increased in width with depth (Nitze and Hanna 1896).

Carpenter (1976) noted numerous shallow pits and trenches and a collapsed shaft along a low ridge. The host rocks are sericite and sericite-chlorite phyllites that strike  $010^{\circ}$  and dip  $75^{\circ}$  northwest. Abundant vein quartz detritus is present.

## Isenhour, Mauney, and Whitney Mines

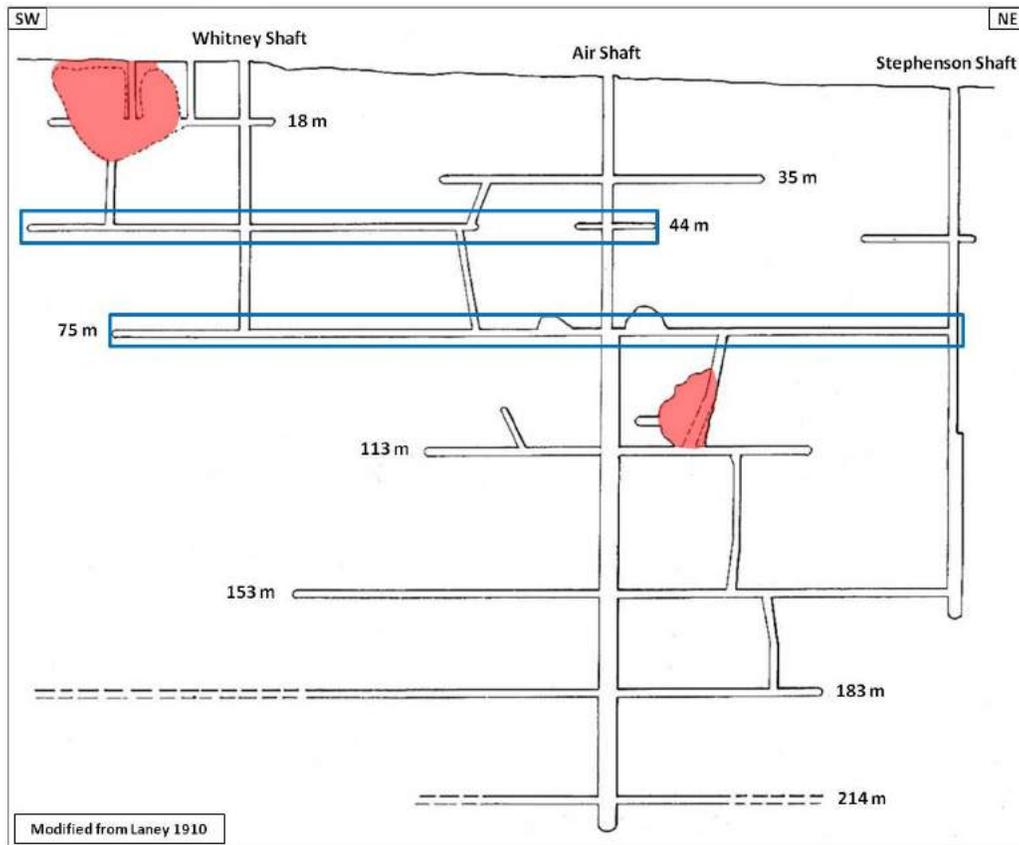
These mines were developed along the same line of lode (Figure 5) and consolidated as part of the Whitney Group in the late 1890s. This trend has been traced continually for around 3200 meters, and is located immediately west of Little Buffalo Creek and a few hundred meters

in the footwall of the Gold Hill Fault (Laney 1910). Despite the strike length and continuity of the lode and extensive underground development in the Whitney Mine at the northern end, total published gold production from the Whitney Group was only 3024 ounces (Pardee and Park 1948), mostly from shallow secondary enrichment zones and small underground shoots.

The vein at the Isenhour Mine at the southern end of the line of lode (Figure 5) varies from about a meter to 7.5 meters thick and averages about four meters, with shoots 15-30 meters long controlled by structural “floors” along the vein (Laney 1910). The Mauney Mine is located along the structure several hundred meters northeast of the Isenhour Mine (Nitze and Hanna 1896). The lode is about 1.2 meters thick with only minor quartz. It was worked from two shafts to a depth of about 21 meters; with oxidized ore that assayed up to 0.3 opt gold (Nitze and Hanna 1896). The lodes at the Isenhour and Mauney mines were reported to contain some small but rich shoots (Pardee and Park 1948).

The Whitney “vein” at the north end of the line of lode (Figures 5, 19, and 20) is described as a silicified shear zone from one meter to 15 meters wide that strikes 030°-035° and dips 75°-85° northwest, approximately parallel to the dominant foliation in the host rocks (Pardee and Park 1948). The lode is composed of alternating, discontinuous quartz stringers and intensely silicified slate, generally dark gray in color but with some cream colored laminae. Auriferous pyrite occurs as small disseminated grains, stringer, and small masses within the quartz veins (Pardee and Park 1948), and Laney (1910) reports the presence of minor chalcopyrite. Proximal silicic and phyllic alteration are reported in the wall rocks (Pardee and Park 1948).

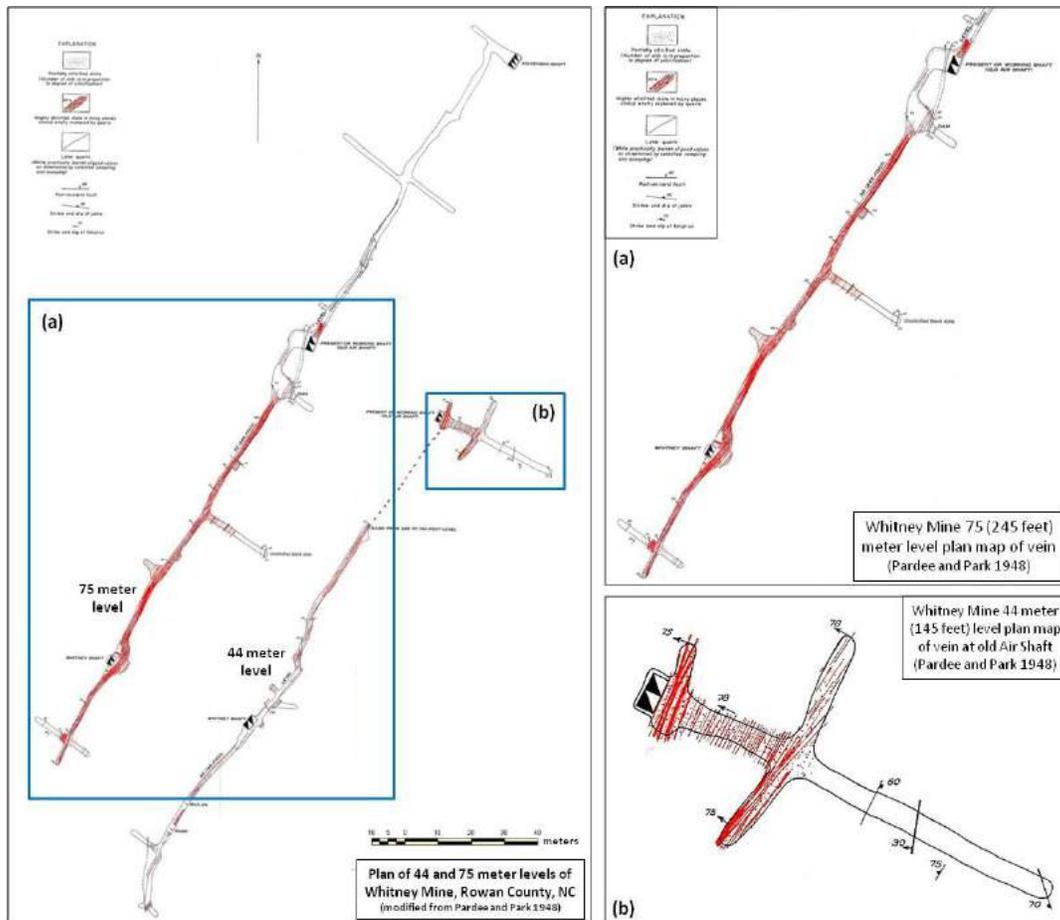
A zone of supergene enrichment extends from the surface to a depth of about 18 meters at the Whitney Mine (Pardee and Park 1948), marked by an almost continuous line of shallow workings. The Whitney Mine was extensively explored underground over a strike of around 145 meters on multiple levels through four shafts to a maximum depth of about 214 meters (Laney 1910, Pardee and Park 1948). Laney (1910) quotes a reported resource of 1.5 million tons of ore averaging about 0.12 opt Au. However, despite extensive underground development, production appears to have been limited to a few small shoots (Figure 19). Laney (1910) quotes reports of shoots 15-30 meters long with grades of 0.68-0.77 opt gold.



**Figure 19: Whitney Mine longitudinal section with ore shoots (red) and location of detailed geology level plans (blue boxes) from Pardee and Park (1948)**

The mine was partially dewatered to a depth of 75 meters in 1935 and the vein mapped and sampled in the upper workings (Pardee and Park 1948). Samples around the old stopes locally exceeded 0.125 opt Au, but high-grade mineralization is discontinuous and localized with the vein in the upper mine levels averaging  $\leq 0.05$  opt Au (Pardee and Park 1948). Variations in quartz vein thickness and abundance along strike and down dip within the host shear zone are well illustrated in the detailed maps of the 45 meter and 75 meter levels (Figure 20) published by Pardee and Park (1948).

Subparallel quartz veins and stringers are abundant over a zone about 10 meters wide between the Whitney Shaft and old Air Shaft on the 75 meter level, although little of this material appears to have been sufficiently high-grade for stoping. This same abundance of veins does not extend directly up-dip to the 44 meter level, although veins are abundant over a similar interval at the old Air Shaft (Figure 20). The abundance of quartz veins alone does not appear to show a strong correlation with ore-grade gold mineralization, and another control is indicated.



**Figure 20: Whitney Mine plans from 45 and 75 meters levels showing quartz veins and stringers comprising lode (modified from Pardee and Park 1948)**

## Discussion

Precious and base metal mineralization in the Gold Hill mining district of central North Carolina is not the product of a single geologic or metallogenic event, but the result of two separate and distinct events in the tectonic evolution of the Carolina Terrane. The juxtaposition of these two styles of mineralization is largely a coincidence. Latest Proterozoic VMS mineralization is stratabound within a specific litho-stratigraphic interval of the Albemarle Group and formed synchronously with deposition of the host rocks. Formation of late Ordovician orogenic gold deposits may be the result of interactions among heterogeneous ductile-brittle strain within the Gold Hill Fault Zone, pre-existing first-order folds, and the rheological properties of lithologies of the Albemarle Group.

## VMS mineralization and the Flat Swamp Member

Volcanogenic massive sulfide mineralization at the Union Copper Mine and Silver Shaft Mine, and possibly several smaller mines and prospects in the immediate area, appear to be products of seafloor hydrothermal activity during a hiatus in explosive submarine felsic-dominated volcanism that formed the Flat Swamp Member of the Cid Formation of the Albemarle Group, dated to around 547-540 Ma (Ingle et al. 2003, Pollock 2007, Hibbard et al. 2009).

The character and continuity of the Flat Swamp Member succession that hosts these deposits within the Gold Hill Fault Zone is uncertain. These units may be a fault-bounded fragment of the Flat Swamp Member from the western limb of the Denton Anticlinorium, detached and transported to a higher crustal level within the fault zone duplex. Alternatively, these units could lie within a portion of the strongly appressed, transposed, and partially dismembered Silver Valley Syncline.

The Silver Valley and Silver Hill VMS deposit in the Cid District of Davidson County to the north also appear to be hosted by the Flat Swamp Member of the Cid Formation within the Silver Valley Syncline. Like the Union Copper deposit at Gold Hill, the Silver Hill VMS deposit lies within the Gold Hill Fault Zone and is generally conformable with the Ordovician tectonic fabric and strongly elongated down-dip. However, studies of both deposits suggest that the basic VMS hydrothermal system architecture and zonation are largely intact (Unger 1982, Indorf 1981).

The Union Copper deposit is a large, complex VMS system with focused hydrothermal venting at or near the seafloor continuously or intermittently during deposition of over 30 meters of epiclastic and volcanoclastic material. The main Cu-Zn-Au ore body is centered on an extensive, roughly concentrically zoned footwall stringer sulfide halo and alteration system that includes chloritic, silicic, and potassic zones. Continued but diminished hydrothermal activity resulted in deposition of small lenses of massive to submassive Zn-Pb-Ag sulfides at higher stratigraphic levels, and overprinting of earlier mineralization and alteration assemblages by chloritic, silicic, and talcose assemblages.

The Silver Shaft Zn-Ag-Pb-Ba-Mn deposit around 550 meters to the southeast of the Union Copper Mine is mineralogically similar and at the same stratigraphic position as Zn-Pb-Ag sulfide lenses in the hanging wall of the main Union Copper ore body. All appear to be associated

with partial to pervasive talc-carbonate and silicic alteration. There is no well defined footwall alteration zone present at Silver Shaft, but silicic and intense Mg (talc) alteration and stringer and disseminated sulfide are widespread. Additional historic mines and prospects in the footwall and hanging wall of the main Union Copper Mine ore body and along strike to the northeast may also represent VMS-related mineralization.

Much of the value recovered from the Union Copper and Silver Shaft deposits was from the oxidized and secondary enrichment zones. The gossan of the Union Copper ore body was initially worked as a gold mine, with significant copper recovered from an underlying secondary enrichment zone. Although no production records are available, it is likely that significant native silver was recovered from the oxidized and secondary enrichment portions of the Silver Shaft (McMakin) deposit. Although the primary sulfide ore of the Union Copper deposit was mined profitably to a depth of over 180 meters, the primary sulfide ore of the Silver Shaft deposit may have presented significant metallurgical challenges, reflected in the relatively shallow extent of the workings.

The Union Copper VMS hydrothermal system in the Gold Hill District extends for at least 900 meters along strike, and probably much more. It is possible that mineralization at the Bat Shaft and Southern Copper Mines could be related to the Union Copper hydrothermal system, possibly as structurally modified stratabound horizons or as stratabound or cross-cutting stringer zones. Significant potential for additional high-grade VMS mineralization remains within this quiescent interval of the Flat Swamp Member of the Cid Formation, along strike and down-dip from the Union Copper deposit.

## Orogenic gold mineralization and the Gold Hill Fault Zone

The classic lode gold deposits of the central Gold Hill District are of orogenic origin, associated with formation of the Gold Hill Fault Zone during the Cherokee Orogeny in the late Ordovician (Hibbard et al. 2012). These deposits are not true veins, but narrow, anastomosing, discontinuous to en echelon ductile-brittle shear zones with heterogeneous development of quartz, quartz + sulfide, and sulfide veins, stringers, and stockworks with variable associated silicic, phyllic, and carbonate alteration. Mineralization is dominantly Au ± Cu associated with pyrite and chalcopyrite as disseminations, stringers, veins, and small masses. Some deposits also carry minor accessory galena, sphalerite, and other sulfides.

Free gold was widely recovered from the oxidized portions of many of the Gold Hill District orogenic lodes, but only a few were mined profitably below the water table. These include the Randolph, Barnhardt, Honeycutt, and possibly the Southern Copper Mine veins, where economic mineralization in primary sulfide ore was largely restricted to thickened ore shoots that plunge steeply southwest within the plane of the mineralized structures. Slickenlines in the wallrocks parallel to these shoots suggest that mineralization was synchronous with oblique strain late in the kinematic evolution of the host shear zones and consistent with reverse-sinistral strain within the Gold Hill Fault Zone duplex.

The elongate, steeply southwest-plunging geometry of the ore shoots may be a product of structural dilations formed in the plane of the shear zones where they intersect the older, more easterly striking regional cleavage. This is reflected in the left-steeping character of syn-mineralization veins noted by Laney (1910) and Nitze and Hanna (1896), and may be characteristic of many historic orogenic auriferous vein and shear zone deposits mined within the Gold Hill Fault Zone. However, the fault zone duplex architecture probably includes several orders of southeast-verging asymmetric shear folds and synthetic, antithetic, and conjugate shear zones that may locally control the development and geometry of mineralized structures.

The focus for ore-forming fluid flow and formation of appropriate host structures in the Gold Hill District may be associated with changes in the architecture of the Gold Hill Fault Zone duplex along the western flank of the Denton Anticlinorium, where the presence of the Flat Swamp Member of the Cid Formation may have been a contributing factor. The fault zone duplex narrows significantly at Gold Hill, with the Silver Hill floor fault deflected westward towards the Gold Hill roof fault. Orogenic mineralization in the Gold Hill District is located within the transition interval from the broader interval of less restricted heterogeneous strain to the southwest to more constricted, possibly more focused strain to the northeast.

Additionally, the possible presence of a large, intact segment of the Flat Swamp Member of the Cid Formation within the Gold Hill Fault Zone immediately southeast of Gold Hill may be a contributing factor in the localization of the auriferous lodes. Rheological contrasts between the coarse-grained felsic volcanoclastic rocks of the Flat Swamp Member and enclosing, more ductile metasedimentary units may have acted to focus strain and fluid flow along the northern and northeastern margins of this unit (main Gold Hill group). Additional shear strain and fluid flow

were partitioned along the proximal footwall of the Gold Hill Fault (Isenhour-Whitney structure) and the proximal hanging wall of the Silver Hill Fault (Troutman structure).

Similar rheological contrasts focused along the margins and structural lees of more competent buttress units have been suggested for other clusters of orogenic shear zone hosted gold ± base metal mineralization within the Gold Hill Fault Zone, including the Lewis Group and Stewart Group of historic gold mines in Union County, North Carolina (LaPoint and Moyer 2013). Similar rheological contrast controls appear to be important in the formation of some individual deposits, including the Reed Gold Mine (El Samani 1978).

The character and source of the fluids and metals that formed the orogenic gold deposits of the Gold Hill District are not well constrained. They could be sourced from metamorphic devolatilization reactions affecting rocks of the Carolina Terrane at depth within the Gold Hill Fault Zone, although magmatic contributions cannot be wholly discounted. Although many of the orogenic gold-bearing lodes of the Gold Hill District contain accessory chalcopyrite and some accessory galena and sphalerite, it is considered possible but unlikely that these metals were remobilized from older VMS-related mineralization (lateral secretion, *sensu stricto*). Accessory base metal sulfide mineralization in orogenic gold deposits is widespread along the Gold Hill Fault Zone, while VMS mineralization appears to be confined to specific areas and stratigraphic intervals.

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**2.4. Silver Shaft Project, Cabarrus County, North Carolina. Excerpt from 1980 Annual Report, Phelps Dodge Exploration East, Raleigh, N.C.**

By Robert J. Moye, and W. V. Smart

SILVER SHAFT PROJECT

CABARRUS COUNTY, NORTH CAROLINA

R. J. Moyer  
W. V. Smart

An agreement of assignment was concluded with Conoco, Inc. in June, 1980, on 2,234 acres of property covering the Silver Shaft Mine in Cabarrus County and the Silver Valley Mine in Davidson County, North Carolina.

Following completion of the agreement, an 80,000 foot grid was established over the Silver Shaft properties and adjacent areas (see Figure 2). Soil sampling, horizontal loop EM, and magnetometer surveys were completed over the grid, along with a detailed geologic map of the area.

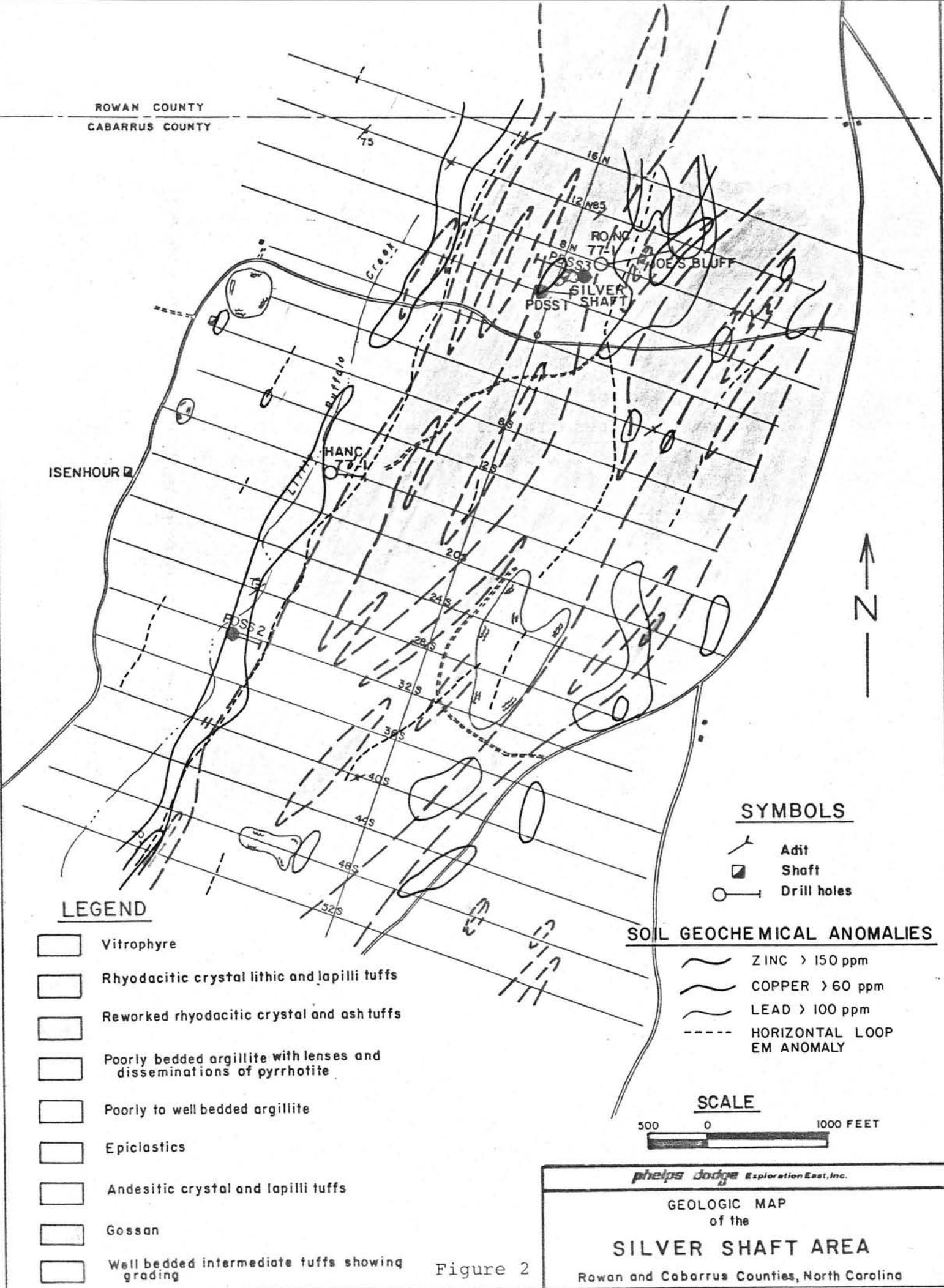
Geologic mapping indicated a local stratigraphic sequence of; mudstones and siltstones, dacitic to rhyodacitic crystalline tuffs and mixed clastic and chemical sedimentary facies.

Three viable target areas were defined on the basis of the geophysical and geochemical surveys and the geologic mapping:

1. A western geophysical/geochemical anomaly.
2. A geophysical/geochemical anomaly associated with the Joe's Bluff Mine.
3. The Silver Shaft Mine.

The western anomaly consists of a narrow, moderate strength EM response coincident with a magnetic high that follows the contact between the volcanic sequence and the pyrrhotitic siltstones to the west. The anomaly stretches for over 7,000 feet through the project area and is closely associated with a narrow, linear copper soil anomaly. The copper anomaly roughly follows Little Dutch Buffalo Creek and could be the result of contamination, but this zone lies within an environment of geologically favorable

ROWAN COUNTY  
CABARRUS COUNTY



**LEGEND**

- Vitrophyre
- Rhyodacitic crystal lithic and lapilli tuffs
- Reworked rhyodacitic crystal and ash tuffs
- Poorly bedded argillite with lenses and disseminations of pyrrhotite
- Poorly to well bedded argillite
- Epiclastics
- Andesitic crystal and lapilli tuffs
- Gossan
- Well bedded intermediate tuffs showing grading

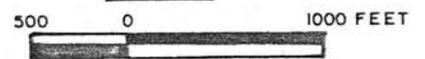
**SYMBOLS**

- Adit
- Shaft
- Drill holes

**SOIL GEOCHEMICAL ANOMALIES**

- ZINC > 150 ppm
- COPPER > 60 ppm
- LEAD > 100 ppm
- HORIZONTAL LOOP EM ANOMALY

**SCALE**



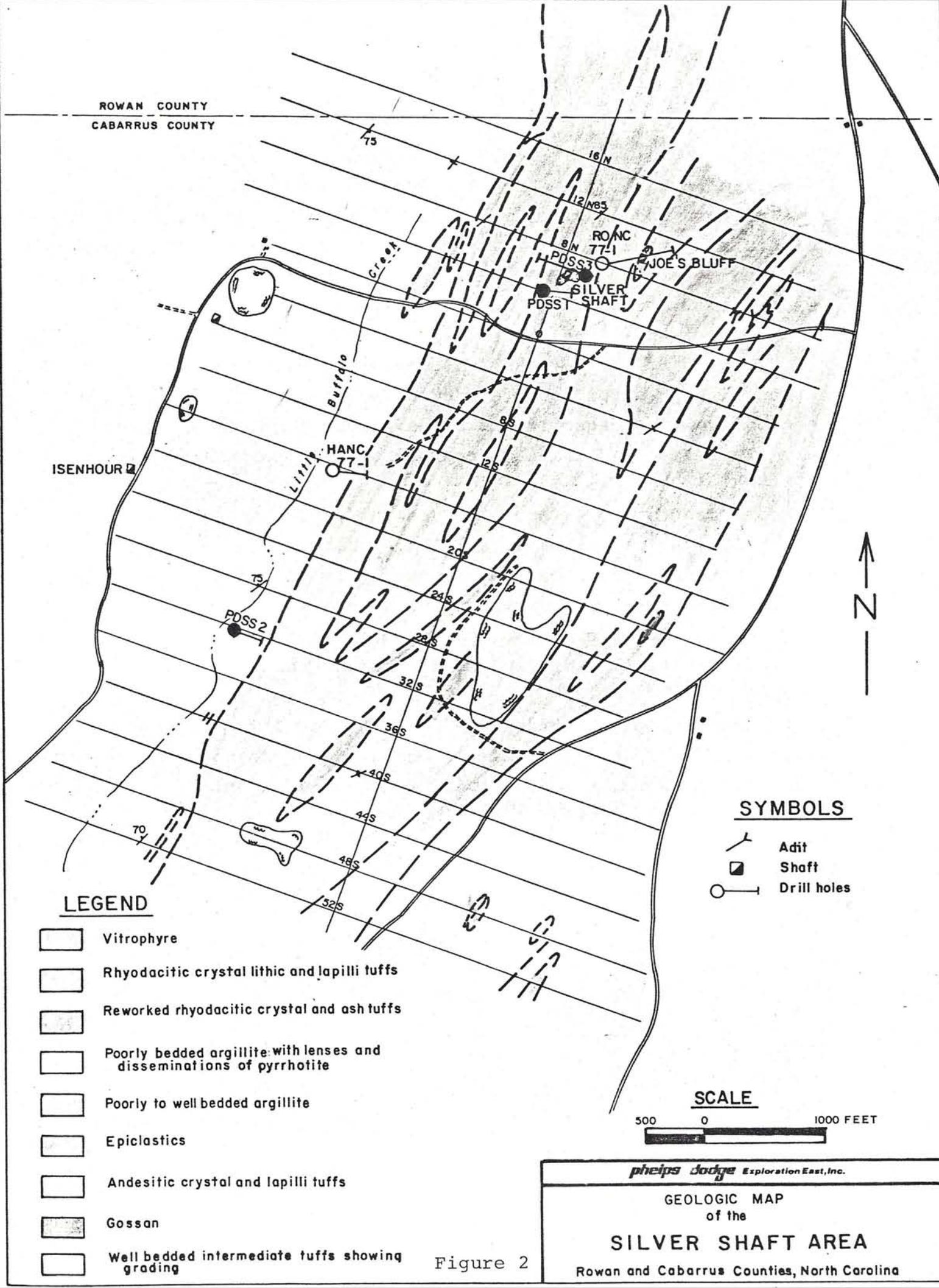
*phelps Dodge Exploration East, Inc.*

**GEOLOGIC MAP  
of the  
SILVER SHAFT AREA**

Rowan and Cabarrus Counties, North Carolina

Figure 2

ROWAN COUNTY  
CABARRUS COUNTY



**LEGEND**

-  Vitrophyre
-  Rhyodacitic crystal lithic and lapilli tuffs
-  Reworked rhyodacitic crystal and ash tuffs
-  Poorly bedded argillite with lenses and disseminations of pyrrhotite
-  Poorly to well bedded argillite
-  Epiclastics
-  Andesitic crystal and lapilli tuffs
-  Gossan
-  Well bedded intermediate tuffs showing grading

**SYMBOLS**

-  Adit
-  Shaft
-  Drill holes

**SCALE**



*pheips Dodge* Exploration East, Inc.

GEOLOGIC MAP  
of the  
**SILVER SHAFT AREA**

Rowan and Cabarrus Counties, North Carolina

Figure 2

massive sulfide mineralization.

Although Conoco drill hole HA-NC-77-1 tested a portion of the zone, the extreme lateral continuity of the anomaly appeared to preclude an effective evaluation based on a single drill hole. Therefore, drill hole PDSS-2 was collared to test the western anomalous zone 2,000 feet south of the Conoco hole. This drilling encountered a zone containing 1 - 5 mm thick laminae of pyrrhotite that locally forms up to 15% of the sequence at 270 to 310 feet downhole (see Figure 3). These laminae are highly conductive and appear capable of producing both the EM and magnetic responses. No further testing is planned for this zone.

A narrow moderate to weak EM anomaly, coincident with a magnetic high, passes through Joe's Bluff and is partially coincident with a broad copper, lead, and zinc soil anomaly. Though partially the result of surface contamination, much of the anomaly appears related to the Joe's Bluff mineralization and additional thin horizons of disseminated mineralization to the east.

Conoco drill hole RO-NC-77-1 tested the Joe's Bluff mineralization and encountered horizons with up to 15% sulfides. This mineralization appears sufficient to explain the geochemical and geophysical responses associated with Joe's Bluff. As a result, no further testing of the Joe's Bluff horizon is planned.

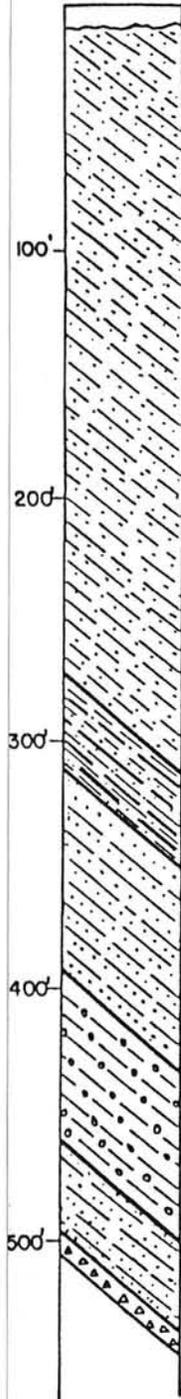
Ore from the dump of the Silver Shaft Mine has given assay results as high as 11.4% lead, 25.2% zinc, and 28.68 oz. per ton silver. Ore textures suggest rapid accumulation of sulfides in chaotic association with abundant talc and carbonate and locally abundant barite in a depositionally unstable environment.

Drill hole PDSS-1 (see Figure 4) was drilled from west of the shaft to intersect the mineralized horizon south of the mine along strike. Despite extension of the hole to 600 feet,

**GEOLOGIC LOG**

**SUMMARY OF GEOLOGY**

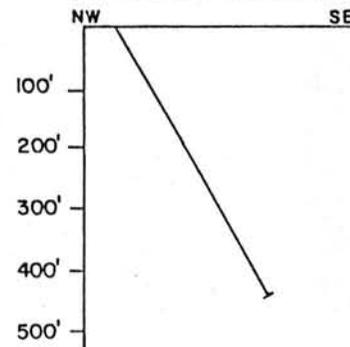
ZINC ppm    COPPER ppm    LEAD ppm    SILVER ppm



ASSAY RESULTS PENDING

- 0- 10' Overburden
- 10-272' Siltstone and silty mudstone locally mixed with minor siliceous chemical precipitate. Minor pyrrhotite as disseminations, lenses, and thin (2-5 mm) laminae.
- 272-310' Siltstone. Contains 3 to 5% (15% locally) pyrrhotite as fine disseminated grains, lenses, and thin (2 mm to 1 cm) laminae.
- 310-392' Siltstone and silty mudstone. Minor pyrrhotite.
- 392-460' Epiclastic siltstone with matrix supported volcanic rock fragments, interbedded with siltstone. Minor pyrrhotite.
- 460-498' Siltstone. Minor pyrrhotite.
- 498-505' Dacitic crystal-lithic tuff, locally reworked. Trace pyrite.

**SECTIONAL VIEW**



Collar elevation = 630'  
 Bearing = S70°E  
 Drilled 10/29/80 = 11/5/80

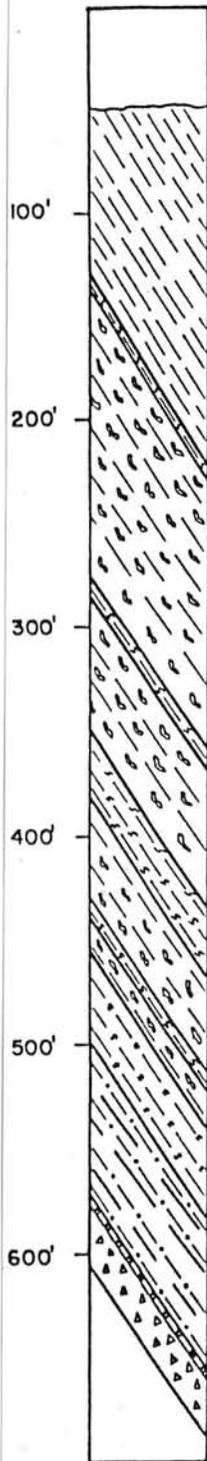
-  Siltstone
-  Pyrrhotite laminae
-  Epiclastic siltstone
-  Dacitic crystal-lithic tuff

Figure 3

<small>Phillips Shifting Exploration East, Inc.</small>			
SILVER SHAFT PROJECT Cabarrus County, North Carolina PDSS-2			
SCALE	H:	CONTOUR INTERVAL:	REVISIONS
	V:	DATE:	BY:
SHEET	OF	DRAWING NO:	FILE:

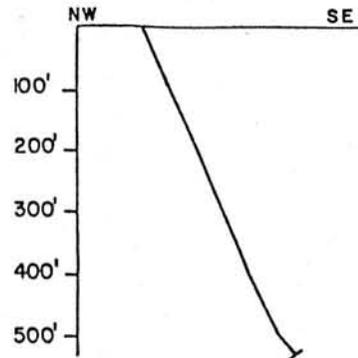
**GEOLOGIC LOG**

ZINC ppm    COPPER ppm    LEAD ppm    SILVER ppm



ASSAY RESULTS PENDING

**SECTIONAL VIEW**



Collar elevation = 720'  
Bearing = S75°E  
Drilled 10/20/80 - 10/29/80

-  Silty mudstone
-  Fragmented siltstone
-  Precipitate siltstone
-  Siltstone with pyrrhotite laminae
-  Volcanic epiclastics
-  Rhyodacitic crystal-lithic tuff

**SUMMARY OF GEOLOGY**

- 0- 50' Overburden
- 50-130' Silty mudstone. Pyrite 2 to 10% as disseminated grains and thin (1 - 2 mm) laminae.
- 130-138' Precipitate siltstone with varying content of silicic acid and talc precipitate in siltstone matrix. Trace pyrite.
- 138-274' Fragmented siltstone with varying content of siltstone fragments in silty matrix. Minor pyrite.
- 274-284' Precipitate siltstone. Trace pyrite.
- 284-347' Fragmented siltstone. Minor pyrite.
- 347-381' Precipitate siltstone. Trace pyrite.
- 381-429' Fragmented siltstone. Trace pyrite.
- 429-437' Precipitate siltstone. Trace pyrite.
- 437-455' Fragmented siltstone. Trace pyrite.
- 455-498' Precipitate siltstone. Minor pyrite.
- 498-571' Siltstone containing varying amounts of volcanic epiclastre fragments and crystals. Pyrrhotite increases from 1 - 2% at top to 5 - 7% at bottom as blebs, lenses, and thin (1 - 3 mm) laminae. Minor pyrite at base of unit.
- 571-574' Volcanic epiclastic sediments composed of clast-supported fragments and crystals, with a silty matrix. Minor pyrrhotite.
- 574-604' Rhyodacitic crystal-lithic tuff. Minor pyrite and pyrrhotite.

Figure 4

<i>Phillips Dodge Exploration-East Inc.</i>			
SILVER SHAFT PROJECT Cabarrus County, North Carolina PDSS-1			
SCALE	H	CONTOUR INTERVAL:	REVISIONS
	V	DATE:	BY:

neither base metal mineralization nor talc-carbonate precipitate facies like those observed in the dump were intersected.

The absence of mineralization in the PDSS-1 drill hole suggests that either the horizon does not extend to the south at depth or is not located directly below nor to the west of the shaft.

Diamond drill hole PDSS-3, collared 150 feet east and north of the shaft was drilled to confirm the stratigraphic position of the mineralization and test its thickness.

To date the hole has encountered an 18 foot void at a vertical depth of about 80 feet, probably a portion of the workings, as indicated by wall rock containing talc and minor base metal sulfides.

The main ore zone was intersected from 250 to 270 feet in the hole. This zone from preliminary logging indicates moderate concentrations of pyrite, galena, and/or tetrahedrite in a talc-carbonate rich matrix similar to that seen on the dump. A determination of the silver and lead content of this twenty foot zone is in progress. Drilling on PDSS-3 drill hole, now in progress, is planned to be terminated at 600 feet.

A decision concerning further drilling in the Silver Shaft Project area will be deferred until assay results are completed and the information acquired can be thoroughly evaluated.

#### GEOPHYSICS

J. P. Matthews, Jr.

Horizontal loop EM and magnetics were the two geophysical techniques used to evaluate the Silver Shaft area. A grid approximately 5,200 feet east-west by 6,800 feet north-south was surveyed for the geophysical work. This grid was also used in the geochemical sampling program and as an aid in the geologic mapping.

The EM and magnetics have defined two narrow sub-parallel

northerly-southerly trending conductive and magnetic zones approximately 2,000 feet apart, as well as a small closed magnetic high over a very weak conductor of limited strike extent about 300 feet west of the Silver Shaft.

Although Conoco drilled one hole in each of the two strongest geophysical conductors, it was decided to further test the western zone 2,000 feet to the south with a second drill hole. This hole intersected sulfides, mainly pyrrhotite, which occur as thin laminae locally comprising up to 15% of the sequence in an interval coincident with the axis of the anomaly. While the total sulfides are quite low, their mode of occurrence is such that they become relatively good conductors.

**2.5. Silver Shaft Project memo April 27, 1981. Phelps Dodge Exploration East, Raleigh, N.C.**

By Robert J. Moye



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TO: W. V. Smart

OFFICE:

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FROM: R. J. Moye

OFFICE:

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SUBJECT:

DATE: April 27, 1981

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Work has been completed on a detailed (1"=100") geologic/location map covering the area from the Silver Shaft Mine northward to the Union Copper Mine. In addition, drill hole PDSS-4 is complete and work has begun on PDSS-5.

As we have been unable to gain access to the northern properties, the locations of the Union Copper shafts and dumps are taken from a map prepared by the USBM, along with the positions of their drill holes. These locations are probably accurate to within about 25 feet. The locations of the Conoco drill holes are taken from their maps and are accurate to within about 50 feet at best.

Despite this uncertainty, the major stratigraphic and structural relationships between the Silver Shaft and Union Copper Mines have been established with some confidence, largely on the basis of the available drill hole data.

Correlation between Conoco's R.O.NC 77-1 and our PDSS-1 and 3 with the available surface outcrop is generally very good. We have firmly established that the sequence strikes  $N20^{\circ}-25^{\circ}E$  and dips  $70^{\circ}$  to  $80^{\circ}$  NW. The continuity of the EM, magnetic, and IP anomalies associated with the Joe's Bluff horizon and the outcrop pattern of the underlying volcanic unit suggest that there are no major faults or warps throughout the area of interest.

The lowermost portion of the stratigraphic sequence in this area is composed of usually thick, texturally variable units of dacitic to rhyodacitic crystal and crystal-lithic tuffs

that outcrop to the east of Joe's Bluff. These rocks are locally silicified and contain disseminated pyrite that ranges from less than 1% to 10-15% locally. In addition, reddish-brown sphalerite occurs as a trace to 3% disseminated grains scattered evenly through hundreds of feet of the sequence.

The maximum size of lithic fragments in these rocks is about 2 to 3 cm and these volcanics would appear to represent an accumulation of explosive products somewhat distal to the eruptive vent(s). The presence of disseminated sphalerite throughout much of the sequence suggests that, although base metal-forming processes were active, either their addition was too slow or the environment too dynamic to favor a massive accumulation.

The above sequence is overlain by a sequence of rhyolite ash tuffs. The contact between two ash units is exposed in the Joe's Bluff shaft. The upper few feet of the lower unit become increasingly more distinctly and more thinly bedded up to their contact with the more massive overlying ash. The ash contains abundant thin lenses and laminae of pyrite. The location of the Joe's Bluff shaft in the ash just above its contact with the underlying volcanics suggests that significant base metal sulfides may have accumulated between the waning of the more intermediate activity and deposition of the rhyolite ashes.

The rhyolite ashes are overlain by a relatively narrow unit of dacitic to rhyodacitic lithic-crystal tuff containing abundant disseminated pyrrhotite. They are gradational upward into pyrrhotitic epiclastics and siltstones containing abundant lenses and laminae of pyrrhotite. Both appear to be derived from the underlying volcanics. These units are

exposed in the bottom of PDSS-1 and possibly the top of R.O.NC 77-1.

These units are overlain by a thick sequence of texturally and compositionally variable siltstones that outcrop to the south of Silver Shaft. They are generally massive, brecciated, or chaotic but locally show faint bedding or a streaked texture. The rocks are generally siliceous and locally grade into chert. Brecciation is commonly observed and generally consists of elongate, often flattened fragments of dark siltstone in a lighter, more siliceous matrix. Portions of the sequence are chaotic mixtures of siltstone fragments, chert fragments, and occasional epiclastic volcanic rock fragments and crystals in a silty to siliceous matrix. In addition, the sequence locally contains varying amounts of fine grained chlorite.

Both pyrite and pyrrhotite occur as a trace to 5% disseminated grains, lenses, and irregular laminae. A trace of sphalerite occurs locally, and quartz and quartz-carbonate veins of metamorphic exudate origin, locally abundant in the sequence, occasionally contain streaks and blebs of recrystallized sphalerite, galena, and pyrite.

These siltstones appear to represent a rapidly accumulated sequence of silty sediments and siliceous precipitates on an unstable paleoslope; resulting in frequent slumping and possible large scale debris flows.

The siltstone sequence is gradational into an overlying sequence of mudstones. They are characteristically poorly to well bedded and contain locally abundant pyrite (10-15%) as disseminated grains, lenses and thin laminae.

The mudstones become increasingly talcose upwards through the section and pale yellow-brown sphalerite appears near the top of the sequence occurring with pyrite and minor galena as streaky, irregular horizons.

The mudstones grade upward into the ore sequence of massive talc and talc-carbonate breccia (intersected in PDSS-3) that carries as much as 15 to 20% pyrite, 5-10% sphalerite, minor galena, and about 1% aguilarite. Massive talc and talcose schist outcrop in the Silver Shaft and are abundant on the mine dump.

In addition, the presence of abundant massive carbonate, massive sulfide, and barite on the Silver Shaft dump and their absence from PDSS-3 suggest that these exhalative facies may occur as small discrete bodies within a dominantly talcose horizon.

The talc-carbonate horizon grades upward into silty talcose mudstones similar to those below the ore zone. Talc, base metal, and precious metal content decreases upward but pyrite is ubiquitous as disseminated grains and irregular laminae.

Gradation through this sequence from mudstone to talc-carbonate to mudstone suggests the growth, peak, and decline of an exhalative event during a quiescent period of deep water sedimentation. The dominance of talc and carbonate and the presence of barite and low-Fe sphalerite suggest that the temperature of the exhalative solutions were relatively low and of neutral to slightly acid pH.

The upper mudstones are abruptly terminated by a thin unit of dacitic to rhyodacitic crystal-lithic tuff, which is overlain by a sequence of frequently siliceous, locally

brecciated and chaotic siltstones similar to the lower siltstone unit.

The upper siltstones are overlain by a thick sequence of alternating units of dacitic to rhyodacitic crystal/crystal-lithic tuffs and rhyolite ash of varying thickness that outcrop to the NW and SW of Silver Shaft.

The uppermost rock unit in the core of PDSS-1 has been identified with some confidence as the lower portion of the mudstone sequence. The hole passes completely through the lower siltstone sequence and terminates in the underlying pyrrhotitic volcanic unit.

The location of the PDSS-1 collar 300' S60<sup>0</sup>W of the Silver Shaft indicates that the sequence has been displaced westwards about 100' as a result of transverse faulting, longitudinal warping, or possible paleotopographic variation.

Drill hole PDSS-5, presently active, is collared about 100' east of PDSS-1 and will be inclined-45<sup>0</sup> at a bearing of N80<sup>0</sup>W to overlap PDSS-1 and penetrate the ore horizon to the west.

The apparent absence of the ore horizon from PDSS-4 is a more puzzling matter. The hole is collared in the lower siltstone sequence and, although drilled to 700', remains in texturally variable siltstones throughout its length.

A survey of the hole showed that its bearing had changed from N80<sup>0</sup>W at the surface to S82<sup>0</sup>W at about 665' downhole. Although significant, much of this deflection probably occurred in the lower portion of the hole and should not have prevented an intersection. The thickness of siltstones

encountered is greater than that of the lower siltstone sequence, suggesting that the hole has passed through the lower sequence into the upper siltstone sequence and that the intervening mudstone and exhalative horizons are absent.

A facies change of this magnitude (60' to 0' in about 200') is unusual, but appears to be the most plausible explanation. Thin units of bedded mudstone are present in the PDSS-4 core from about 256' to 273' and the core will be assayed from about 375' to 475' to determine whether a horizon of anomalous mineralization is present. These relationships suggest a locally dynamic depositional environment that results in attenuations of the exhalative horizon of unknown extent.

The absence of the ore zone in PDSS-4 raises questions on the northward extension of the Silver Shaft horizon. However, correlation of the stratigraphy of the Silver Shaft area with that around the Union Copper Mine suggests a potential for additional Ag mineralization between the two.

The distribution of mine workings at the Union Copper and correlation between Conoco's drill holes suggest that at least two zones of mineralization are present. The No. 2 shaft is on strike with the Joe's Bluff shaft and appears to be opened in the uppermost portion of the dacitic to rhyodacitic crystal tuffs that underly the lower rhyolite ash to the south. Correlation of the mineralization in both is supported by the bearing and continuity of the IP, EM, and magnetic geophysical anomalies associated with the Joe's Bluff horizon.

The main ore body at Union Copper is a steeply plunging lens about 500 feet long, that measured 130 by 40 feet near the surface and 100 by 15 feet in the center. The body is stratabound, striking  $N25^{\circ}E$  with a dip of  $80^{\circ}NW$ , and pitches  $70^{\circ}SW$ .

The intersection of the ore horizon with the surface is marked by the open cut surrounding the No. 4 shaft. The Union Copper horizon appears to be somewhat higher stratigraphically than that intersected by the No. 2 and Joe's Bluff shafts.

Correlation between the stratigraphy of the Silver Shaft area and that of the Union Copper area, as shown in the Conoco drill core, show a similar stratigraphic progression with important facies changes, particularly in the lower portion of the sequence.

The lower rhyolite ash, exposed in the Joe's Bluff Shaft, has not been recognized in Conoco's Union Copper drill holes, however relogging is still in progress. The lower volcanic sequence appears to grade upward into the lower siltstone unit, which contains a markedly higher proportion of volcanic and volcanic-epiclastic material than it does to the south, particularly in the lower portions. In addition, the sequence is characterized by locally abundant chlorite in the matrix and silica, which forms numerous cherty exhalative horizons that are often gradational into the adjacent siltstones. This sequence locally contains 1 to 3% disseminated sphalerite with minor galena, particularly in the more chloritic and siliceous horizons, and 2 to 5% pyrite is ubiquitous.

The siltstone sequence grades upward into a variable sequence

of silty mudstones. The sequence is locally siliceous to chloritic and several horizons of exhalative chert are present. Talc appears in the central portion of the sequence and generally increases upward. Pyrite is ubiquitous throughout the sequence and sphalerite is locally present as 1-3% with minor galena.

The mudstone sequence to the north has a higher chemical and silt component and lacks the laminations indicative of a completely quiescent environment that are present to the south.

The silty mudstones grade into an exhalative sequence of locally silty massive talc and chert containing as much as 10 to 15% pyrite and sphalerite that appears to be correlative to the Silver Shaft horizon.

Although its location is not known, Tennessee Copper's No. 2 drill hole intersected this horizon at a vertical depth of about 750'. This intersection has an average grade of about 3.7 oz/ton Ag and 1.74% Zn over a true thickness of about 7 feet.

A review of Conoco's drill logs show at least 3 intersections with the Silver Shaft horizon.

The southernmost of the Union Copper holes, R.O.NC 77-3, probably intersects the sequence containing the Silver Shaft horizon but it is not evident from their logs and assay results are not available for the upper 2/3 of the hole.

Relogging of R.O.NC 77-2 identified the Silver Shaft horizon from 353 to 374 feet. Conoco assays show an average grade of 4.91% oz Ag/ton and 1.17% Zn over this interval.

From the Conoco logs, R.O.NC 77-4 appears to intersect the Silver Shaft horizon between 270' and 290' but relogging will be necessary to confirm this. Conoco's assays show Ag and Zn only slightly above background through this interval.

Drill hole R.O.NC 77-5 appears from the Conoco log to intersect the Silver Shaft horizon between 310' and 330', but Conoco appears never to have assayed this core.

Drill hole R.O.NC 77-7 and -8 appear to have been collared to the east to intersect the horizon.

The talc-chert horizon in the Union Copper area grades upward into increasingly less talcose mudstones and siltstones, which are overlain by the same thick sequence of alternating rhyolite ash and dacitic to rhyodacitic crystal and crystal-lithic tuffs noted to the south.

Correlation to the north is good, but all of the Conoco holes will be logged as soon as time permits to make our information more complete. In addition, the upper portion of drill holes R.O.NC 77-2 and -6 should be assayed to determine the grade of the Ag-bearing horizon in these intersections.

Stratigraphic correlation suggests that the Ag-bearing talcose horizon intersected by the Conoco holes is the northward extension of the Silver Shaft horizon. The horizon appears to be somewhat thinner and of lower grade in the Union Copper area, and may be attenuated in holes R.O.NC 77-3 and 77-4.

The Silver Shaft horizon thus appears to have a strike length of at least 2000' but lacks continuity, as demon-

strated by its absence from drill hole PDSS-4. Attenuations probably result from local variations in the conditions of deposition. The ore-forming exhalative solutions may have collected in paleotopographic basins or troughs of varying size along a single time-stratigraphic horizon.

Stratigraphic progression and facies changes along strike suggest that the Union Copper Mine area is somewhat more proximal to the eruptive vent(s), as evidenced by the greater abundance of volcanic and volcanic epiclastic rocks, and may be the source area for the exhalative solutions, as suggested by the local abundance of chlorite and the presence of numerous cherty horizons.

The southward facies change to a sequence characterized by less volcanic material and locally well developed bedding suggests that the Silver Shaft area is basinward of the Union Copper area. The often brecciated or chaotic textures in the siltstone units and rapid local facies changes suggest a periodically dynamic environment.

These relationships, together with the absence of coarse volcanoclastic facies or flows, suggest that the Union Copper mineralization was deposited proximal to an exhalative vent(s) or the unstable flank of the volcanic pile, somewhat distal to the eruptive vent(s).

The Joe's Bluff horizon probably formed during a period of relative quiescence that preceded the peak of exhalative activity, and is characterized by Zn and Pb with lesser Cu sulfides. The peak of activity resulted in the formation of the Union Copper lense and is characterized by Cu and Zn sulfides and the formation of abundant chlorite and chert. The Union Copper horizon appears to have formed during a time of depositional instability, as evidenced by the

enclosing siltstone sequence, which might explain its lack of continuity.

The Silver Shaft horizon is stratigraphically higher and may be considered to include the Ag-bearing talc horizon and the enclosing mudstones. This horizon appears to represent late stage, lower temperature exhalative activity during a period of relative quiescence. The facies change from talc-chert at the Union Copper to Talc-carbonate at Silver Shaft suggest that the Union Copper vents are the source of the exhalations that have filled local basins and/or troughs surrounding and downslope from the vents.

The Silver Shaft mine itself may represent one of the deeper basins or troughs downslope from the Union Copper area. Textures in the ore from the dump indicate rapid deposition and frequent slumping.

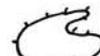
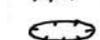
Although the horizon may not be continuous, the potential for an economic deposit is still good. The area between the Union Copper and Silver Shaft mines has not been tested and, as the horizon has no distinctive geophysical (or geochemical) signature (results are still pending on Ba in the soils, however), drilling appears to be the only reliable method of evaluation.

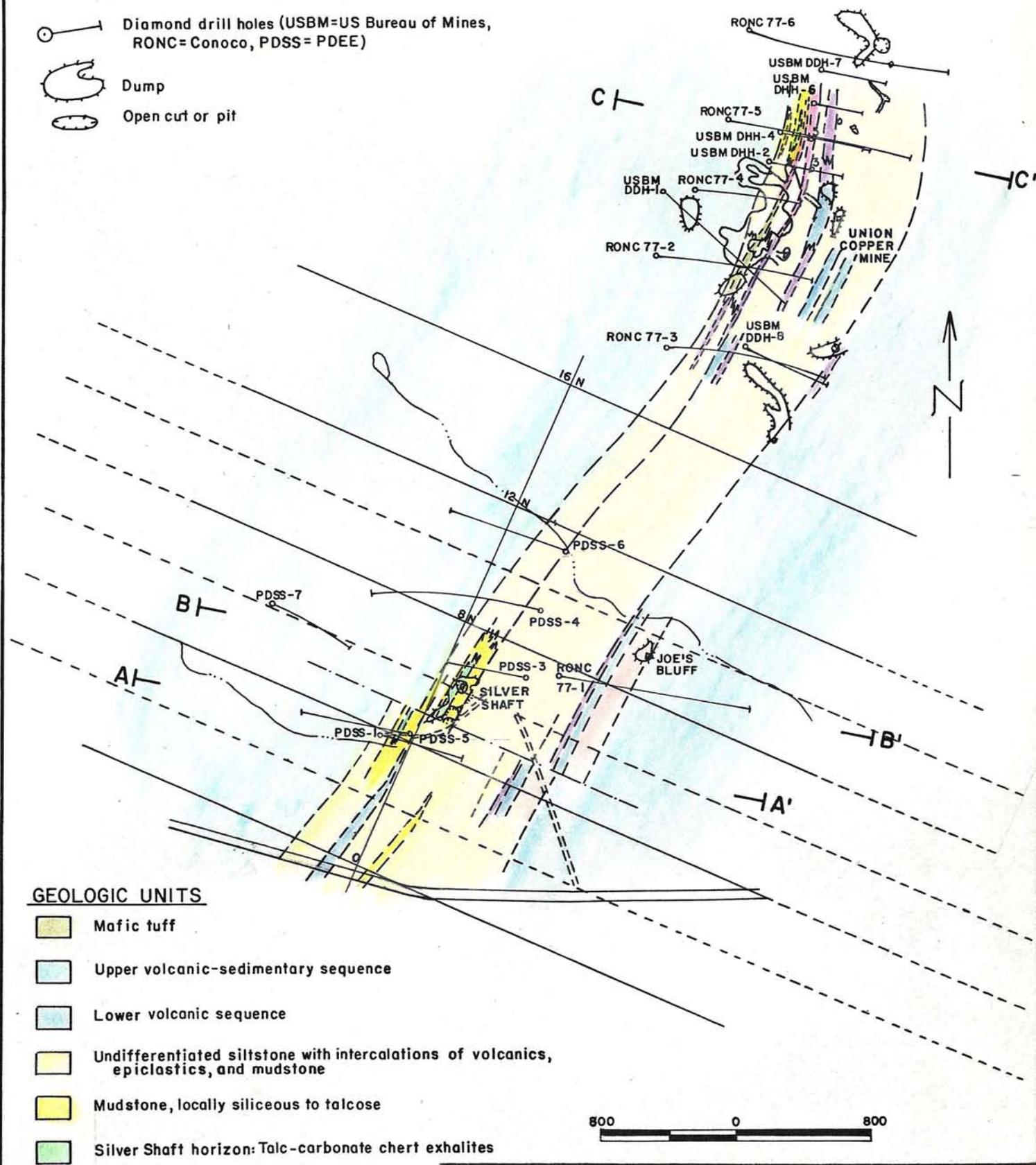
As this intervening area may be located along a paleoslope, the greatest potential for thicker, more continuous accumulations of the Silver Shaft horizon may lie basinward, i.e. to the south.

The presence of mudstones in the top of PDSS-1, the occurrence of talc float to the SW, and a weak to moderate IP response in the same area suggest that such may be the case.

The completion of PDSS-5, which overlaps PDSS-1 to the west, should test the accuracy of this hypothesis.

**EXPLANATION**

-  Diamond drill holes (USBM=US Bureau of Mines, RONC=Conoco, PDSS=PDEE)
-  Dump
-  Open cut or pit



**GEOLOGIC UNITS**

-  Mafic tuff
-  Upper volcanic-sedimentary sequence
-  Lower volcanic sequence
-  Undifferentiated siltstone with intercalations of volcanics, epiclastics, and mudstone
-  Mudstone, locally siliceous to talcose
-  Silver Shaft horizon: Talc-carbonate chert exhalites
-  Chert exhalite
-  Rhyodacitic crystal and crystal-lithic tuffs
-  Reworked rhyodacite tuffs/volcanic epiclastics
-  Rhyolite ash



*phelps dodge* Exploration East, Inc.

**GEOLOGIC MAP**  
of the  
**SILVER SHAFT MINE AREA**  
Cabarrus County, North Carolina

<b>SCALE</b>	H: 1" = 800'	CONTOUR INTERVAL:	<b>REVISIONS</b>
	V:	DATE: July, 1981	BY: R.J.M., D.F.L.
<b>SHEET</b>	<b>OF</b>	<b>DRAWING NO:</b>	<b>FILE:</b>

**2.6. Silver Shaft Project, October 1981. Excerpt from October 1981 Monthly Report, Phelps Dodge Exploration East, Raleigh, N.C.**

By Robert J. Moyer

CABARRUS COUNTY, NORTH CAROLINA

Drilling continued at the Silver Shaft Mine with the completion of 5 additional holes (see Figures 2 through 7) designed to test the continuity of the associated silver-bearing massive sulfide horizon.

Drill hole PDSS-3 encountered an ore grade intersection that assayed an average of 8.88 oz Ag/ton over a true thickness of 24 feet at a point 50 feet north of the shaft and at a vertical depth of 300 feet (Figure 3). In addition, the zone averages 1.113% Zn and has low Cu and Pb.

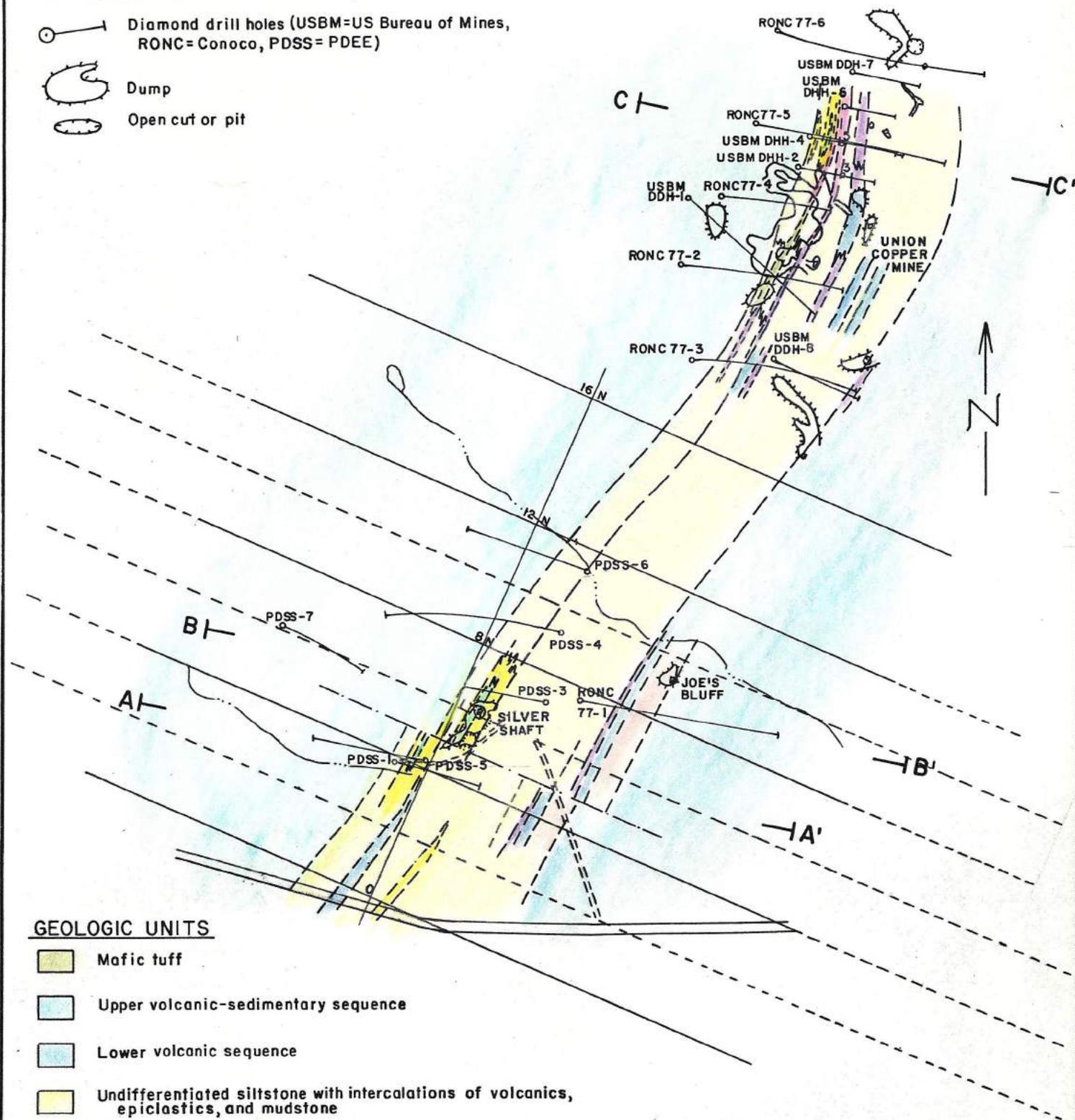
The mineralization consists of 10 to 15% disseminations and laminae of pyrite and sphalerite with a trace galena and 1% aguilarite, a silver selenide, identified by the Douglas Lab. The host rocks are interbedded massive talc, talc-carbonate breccia, and talcose mudstone that occur as a discrete zone of dominantly chemical exhalites near the top of a 70 foot (true thickness) zone of talcose mudstones with disseminated mineralization that averages 3.62 oz Ag/ton.

Drill holes PDSS-4 and PDSS-6 (see Figure 2) were located to test the northward extension of the ore horizon but both were barren. Drill hole PDSS-7 was designed to test the down-dip extension of the horizon at a vertical depth of 600 feet but no mineralization was encountered.

Correlation of stratigraphy between PDSS-3 and Conoco drill hole R.O.NC-77-1 (see Figure 8) suggested that PDSS-1 had been collared in the footwall of the ore horizon due to the presence of a blind 100 foot offset. This was confirmed by drill hole PDSS-5 (Figure 5), which intersected the talcose horizon at 54 feet. The horizon is interfingered with

**EXPLANATION**

-  Diamond drill holes (USBM=US Bureau of Mines, RONC=Conoco, PDSS=PDEE)
-  Dump
-  Open cut or pit



**GEOLOGIC UNITS**

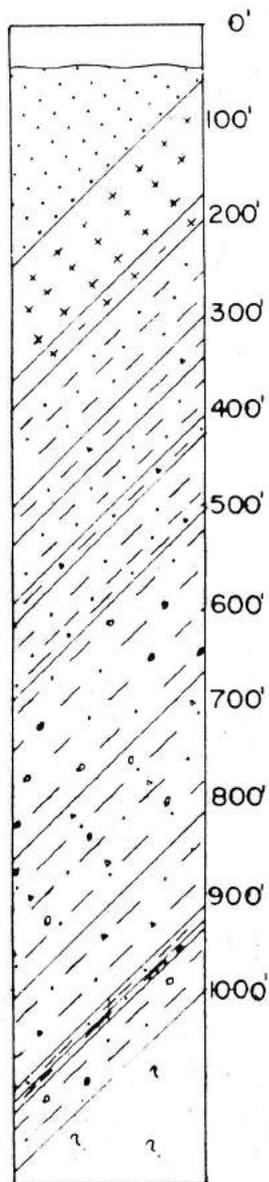
-  Mafic tuff
-  Upper volcanic-sedimentary sequence
-  Lower volcanic sequence
-  Undifferentiated siltstone with intercalations of volcanics, epiclastics, and mudstone
-  Mudstone, locally siliceous to talcose
-  Silver Shaft horizon: Talc-carbonate chert exhalites
-  Chert exhalite
-  Rhyodacitic crystal and crystal-lithic tuffs
-  Reworked rhyodacite tuffs/volcanic epiclastics
-  Rhyolite ash



<i>phelps dodge</i> Exploration East, Inc.			
GEOLOGIC MAP of the			
<b>SILVER SHAFT MINE AREA</b>			
Cabarrus County, North Carolina			
SCALE	H: 1" = 800'	CONTOUR INTERVAL:	REVISIONS
	V:	DATE: July, 1981	BY: R.J.M., D.F.L.
SHEET	OF	DRAWING NO:	FILE:

GEOLOGIC LOG

1" = 200"



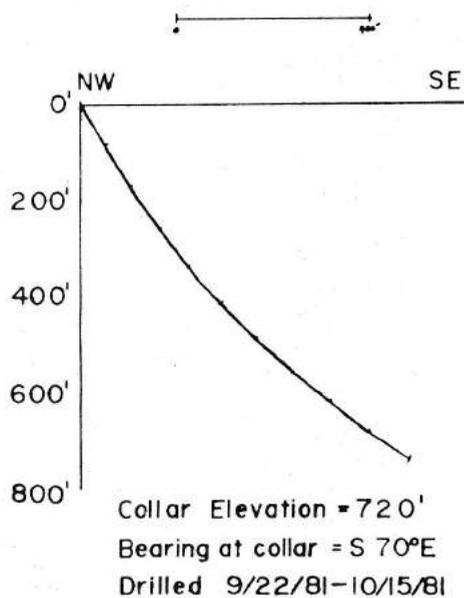
12

ASSAY RESULTS

INTERVAL ppmAg %Zn %Pb

RESULTS PENDING

SECTIONAL VIEW (r = 400')



- Rhyolite ash/felsic mudstone
- ⊕ Rhyolite/rhyodacite x-tal tuff
- ⊗ Reworked rhy/rhyodac x-tal tuff
- ▨ Siliceous epiclastic siltstone
- ▤ Siliceous siltstone
- ▧ Chloritic silty mudstone
- ⊞ Siliceous fragmented siltstone
- ⊠ Sil. fragmented epi. siltstone
- ▩ Mixed silty mudstone & frag. siltstone

SUMMARY OF GEOLOGY

- 0 - 43' Overburden
- 43 - 56' Rhyolite ash/felsic mudstone. Locally well laminated and locally silicified.
- 56 - 98' Rhyolite to rhyodacite crystal tuff. Locally variant degrees of silicification. Trace amounts of pyrite, galena, and sphalerite as masses within quartz veins.
- 98 - 175' Rhyolite to rhyodacite crystal tuff. Locally color variant due to biotite content of matrix. Trace to 1% total sulfides as masses of pyrite, galena, and sphalerite in quartz veins and disseminated pyrite.
- 175 - 202' Reworked equivalent of above rhyolite to rhyodacite crystal tuff. Trace to 1% total sulfides as disseminated pyrite and pyrrhotite masses to 2 mm along bdg/fol.
- 202 - 302' Siliceous siltstone with minor intercalations of reworked rhyolite to rhyodacite crystal tuff. Trace to 1% total sulfides as disseminated pyrite and pyrite + sphalerite veinlets locally.
- 302 - 346' Siliceous epiclastic siltstone. Reworked quartz and feldspar crystals in a silty matrix. Trace to 1% sulfides as pyrite and pyrrhotite disseminations.
- 346 - 407' Siliceous siltstone with low epiclastic component. Trace to 1% sulfides as disseminated pyrite, pyrite sprays along fractures and fine pyrrhotite blebs along foliation.
- 407 - 429' Epiclastic siltstone. Reworked crystals (qtz. and feld.) in a silty matrix. Epiclastic component decreases towards bottom interval. Trace to 1% pyrite as sprays along fractures. Trace pyrrhotite.
- 429 - 480' Dark grey siliceous siltstone locally containing cherty fragments. Trace pyrite as fine disseminations and sprays along fractures. Trace pyrrhotite as thin blebs.
- 480 - 484' Chloritic silty mudstone. Trace pyrite.
- 484 - 505' Siliceous siltstone with minor epiclastic component. Trace pyrite as disseminations and sprays along fractures. Trace pyrr.
- 505 - 543' Siliceous fragmented siltstone. Locally contains silty mdst fragments and ≤ 2' intercalations of silty mdst. Trace to 1% pyrite as disseminations. Trace to 1% pyrr.
- 543 - 672' Fragmented siltstone. Locally silicified and locally contains CO<sub>2</sub> healed fractures. Trace to 1% pyrite locally as fine disseminations and sprays along fractures.
- 672 - 815' Siliceous fragmented epiclastic siltstone. Locally silicified. Trace pyrite and pyrr. Locally contains intercalations of epi. siltstone.
- 815 - 912' Siliceous epiclastic siltstone. Trace py. as fine diss. and sprays. Trace pyrr.
- 912 - 924' Siliceous silty mudstone.
- 924 - 934' Intermixed silty mdst and fragmented siltst.
- 934 - 1000' Siliceous fragmented siltstone. Trace pyrr.

<b>SILVER SHAFT PROJECT</b>			
CABARRUS COUNTY, NORTH CAROLINA			
PDSS - 7			
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Figure 7

mudstones and barren of significant Ag mineralization, although values up to 17 ppm Ag were assayed in the overlying mudstones and siltstones.

The stratigraphy of the Silver Shaft area, illustrated in Figures 8 and 9 consists of 3 main formations:

1. Upper Volcanic Sequence
2. Siltstone Sequence
3. Lower Volcanic Sequence

The Lower Volcanic Sequence is composed primarily of dacitic to rhyodacitic crystal and lithic tuffs that often contain disseminated red-brown sphalerite. Waning volcanism resulted in the formation of local metalliferous horizons such as Joe's Bluff, which occurs in felsic ash at the top of the sequence.

The conformably overlying Siltstone Sequence represents a period of sedimentation with only minor volcanic activity characterized by siltstones and fragmented siltstones. These rocks are often highly siliceous due to the precipitation of dissolved silica during deposition and locally grade into chert. Rock textures suggest sedimentation accompanied by frequent local slumping on an unstable slope area. The Union Copper ore body, a steeply plunging lense of complex massive sulfide, occurs in the lower portion of the sequence. The Silver Shaft ore horizon and the enclosing mudstones occur near the top of the sequence.

The Siltstone Sequence is gradational upward into the Upper Volcanic Sequence, characterized by alternating siltstones, mudstones, epiclastics, and dacitic to rhyodacitic tuffs that indicate a sporadic renewal of volcanic activity.

The Silver Shaft exhalites and the enclosing mudstones are thought to have been deposited in a small, quiescent basin, indicated by drilling to be less than 100 meters in diameter. Ore textures indicate rapid deposition from an exhalative vent to which the massive sulfide-talc-carbonate-barite facies observed on the Silver Shaft dump are probably most proximal. Significant mineralization does not extend beyond the basin limits.

Review of previous drilling at the Union Copper Mine, located 1500 feet to the NE, identified 3 intersections of similar mineralization. Conoco drill hole R.O.NC-77-2 intersected about 12 feet (true thickness) of 4.91 oz/ton Ag and 1.17% Zn and R.O.NC-77-5 (Figure 10) intersected 9 feet of 1.02 oz/ton Ag and 5.10% Zn within a 25 foot zone of 3.59% Zn. Tennessee Copper drill hole Number 2 intersected a 7 foot (true thickness) zone of 3.7 oz/ton Ag and 1.74 % Zn at a vertical depth of about 750 feet.

Stratigraphic correlation (Figure 2 ) indicates that these intersections are laterally equivalent to the Silver Shaft mineralization and define a unique time-stratigraphic horizon characterized by widespread Ag-bearing exhalite mineralization localized by small depositional basins.

The high grade Ag-Zn mineralization of the Silver Shaft horizon offers considerable economic potential if a larger depositional basin can be located along strike or at depth. Unfortunately, the mineralization does not respond to conventional exploration methods.

Soil geochemistry, HLEM and magnetometer surveys conducted during 1980 and IP, SP, and VLF-EM surveys conducted during 1981 failed to detect the Silver Shaft mineralization.

A systematic program of core drilling along the horizon appears to be the only viable alternative. As the necessary expenditure associated with such a program is considerable, the possibility of a joint venture is under consideration.

**2.7. Review of exploration activity at the Silver Shaft Project, Cabarrus County, North Carolina. Termination report for the Silver Shaft Project, Phelps Dodge Exploration East, Raleigh, N.C.**

By W. V. Smart and Robert J. Moyer

REVIEW OF EXPLORATION ACTIVITY AT THE  
SILVER SHAFT PROJECT  
CABARRUS COUNTY, NORTH CAROLINA

W. V. Smart  
R. J. Moye  
March, 1982

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Review of Exploration Activity at the  
Silver Shaft Project  
Cabarrus, County, North Carolina

W. V. Smart  
R. J. Moye

March, 1982

Synopsis of Recent Exploration Activities

During initial testing at the Silver Shaft Mine in 1980 (See Figure 1), drill hole PDSS-3 encountered an ore grade intersection that assayed an average of 8.88 oz. Ag/ton over a true thickness of 24 feet, at a point 50 feet north of the shaft and at a vertical depth of 300 feet. In addition, the zone averages 1.113% zinc with minor copper and lead. The mineralization consists of 10-15% disseminations and laminae of pyrite and sphalerite with trace galena and 1% aguilarite, a silver selenide, identified by the Douglas Laboratory. The host rocks are interbedded massive talc, talc-carbonate breccia and talcose mudstone that occur as a discrete zone of predominantly chemical exhalites near the top of a 70 foot zone of talcose mudstones with disseminated mineralization that averages 3.62 oz. Ag/ton.

Drilling at the Silver Shaft Mine during 1981, consisted of completion of five holes, designed to test the continuity of the silver-bearing talc carbonate horizon. Drill holes PDSS-4 and PDSS-6 were located to test the northward extension of the ore horizon but failed to intersect the favorable horizon. Drill hole PDSS-7 was designed to test the down-dip extension of the horizon at a vertical depth of 600 feet, but again silver-bearing mineralization was not encountered.

Correlation of stratigraphy between PDSS-3 and Conoco drill hole RONC-77-1 suggested that PDSS-1 had been collared in the footwall of the ore horizon due to the presence of right lateral faulting, resulting in a 100 foot offset. This was confirmed



Figure 1

<i>phelps dodge</i> Exploration East, Inc.			
LOCATION MAP			
<b>SILVER SHAFT PROJECT</b>			
Cabarrus County, North Carolina			
SCALE	H:	CONTOUR INTERVAL:	REVISIONS
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by drill hole PDSS-5, which intersected the talcose horizon at 54 feet. The horizon is interfingered with mudstones, and contains low grade silver mineralization (For detailed drill hole information see Appendix).

### Geology and Mineralization

The stratigraphy of the Silver Shaft area consists of three major formations (See Figures 2 through 6):

1. The Lower Volcanic Sequence: Composed of dacitic to rhyodacitic crystal and lithic tuffs that often contain minor disseminated red-brown sphalerite. Waning volcanism resulted in the formation of local metalliferous horizons, such as Joe's Bluff, which occurs in felsic ash at the top of the sequence.
2. The conformably overlying Siltstone Sequence: This sequence represents a period of sedimentation with only minor volcanic activity characterized by siltstones. These rocks are often highly siliceous due to the precipitation of silica during deposition and, locally grade into chert. Rock textures suggest sedimentation accompanied by frequent local slumping on an unstable submarine slope area. The Union Copper ore body, a steeply plunging lense of complex massive sulfide, occurs in the lower portion of the sequence. The Silver Shaft ore horizon and the enclosing mudstones occur near the top of the sequence.
3. The Siltstone Sequence: This unit is gradational upward into the Upper Volcanic Sequence, characterized by alternating siltstones, mudstones, epiclastics and dacitic to rhyodacitic tuffs that indicate a sporadic renewal of volcanic activity.

Drilling indicates the Silver Shaft exhalatives and the enclosing mudstones are thought to have been deposited in a small, quiescent, submarine basin, less than 400 feet in diameter. Ore textures indicate rapid deposition from an exhalative vent to which the massive sulfide-talc-carbonate-barite facies observed

Outline of Silver Shaft Mine Area  
Map

ROWAN COUNTY  
CABARRUS COUNTY

UNION COPPER  
MINE

ISENHOUR

HANC  
77-1

16 N

12 N85

PDSS-6

PDSS-4

8 N

PDSS-3

PDSS-5

PDSS-7

PDSS-1

PDSS-2

PDSS-3

PDSS-4

PDSS-5

PDSS-6

PDSS-7

PDSS-8

PDSS-9

PDSS-10

PDSS-11

PDSS-12

PDSS-13

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PDSS-118

PDSS-119

PDSS-120

PDSS-121

PDSS-122

PDSS-123

PDSS-124

PDSS-125

PDSS-126

PDSS-127

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PDSS-129

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PDSS-209

PDSS-210

PDSS-211

PDSS-212

PDSS-213

PDSS-214

PDSS-215

PDSS-216

PDSS-217

PDSS-218

PDSS-219

PDSS-220

PDSS-221

PDSS-222

PDSS-223

PDSS-224

PDSS-225

PDSS-226

PDSS-227

PDSS-228

PDSS-229

PDSS-230

PDSS-231

PDSS-232

PDSS-233

PDSS-234

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PDSS-237

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PDSS-239

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PDSS-243

PDSS-244

PDSS-245

PDSS-246

PDSS-247

PDSS-248

PDSS-249

PDSS-250

PDSS-251

PDSS-252

PDSS-253

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PDSS-257

PDSS-258

PDSS-259

PDSS-260

PDSS-261

PDSS-262

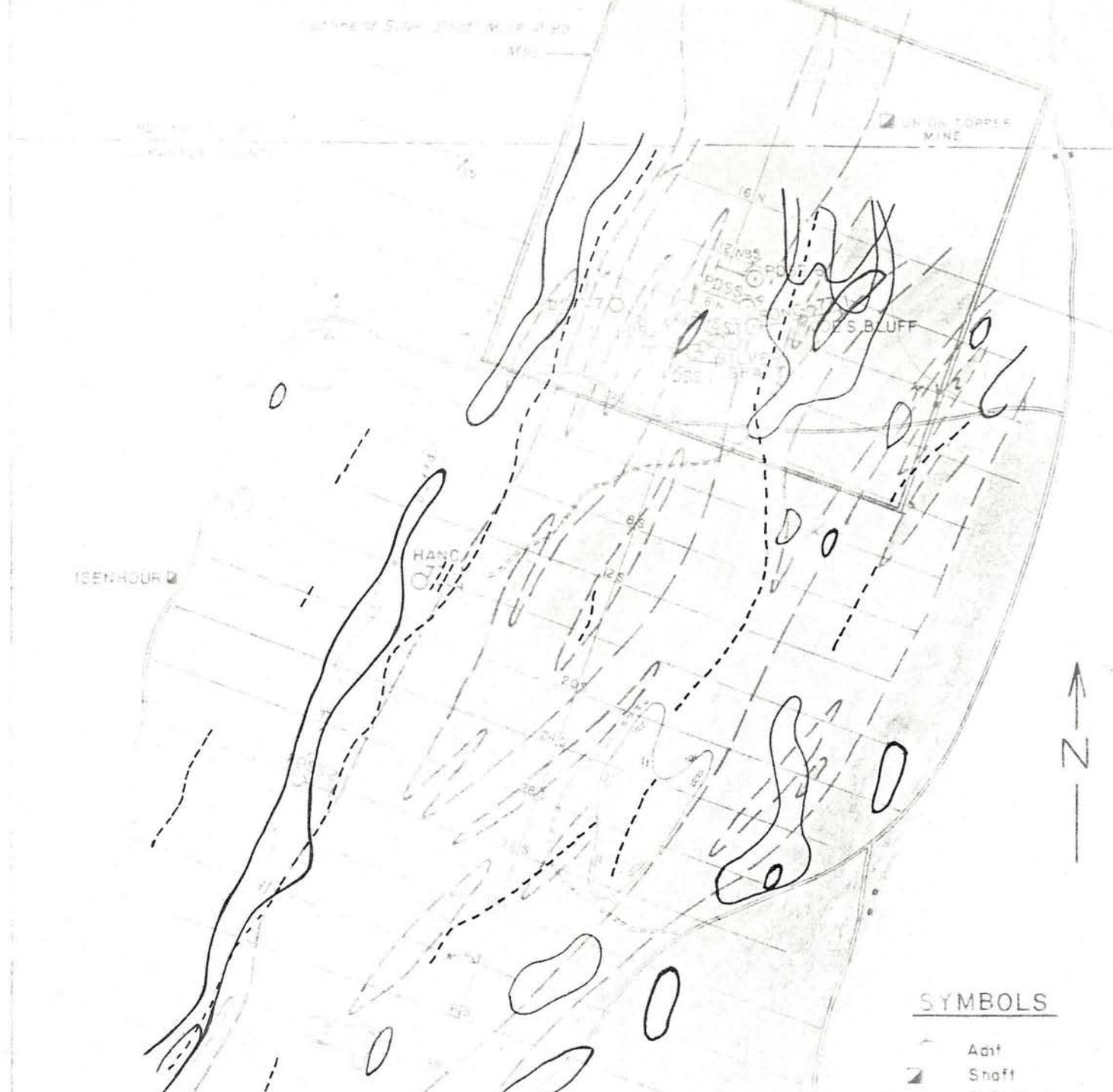
PDSS-263

PDSS-264

PDSS-265

PDSS-266

PDSS-267



**LEGEND**

- Vitriolite
- Rhynchonellidiferous (with chalcocite)
- Reworked rhynchonellidiferous (with chalcocite)
- Poorly bedded argillite with lenses and disseminations of pyrrhotite
- Poorly to well bedded argillite
- Epithermal
- Andesitic dykes and lapilli tuffs
- Basalt
- Unconsolidated

**SYMBOLS**

- Adit
- Shaft
- Drill holes

**SOIL GEOCHEMICAL ANOMALIES**

- ZINC > 150 ppm
- COPPER > 60 ppm
- LEAD > 100 ppm
- HORIZONTAL LOOP EM ANOMALY

**SCALE**



Figure 2

*phelps dodge* Exploration East, Inc.

GEOLOGIC MAP

SILVER SHAFT PROJECT

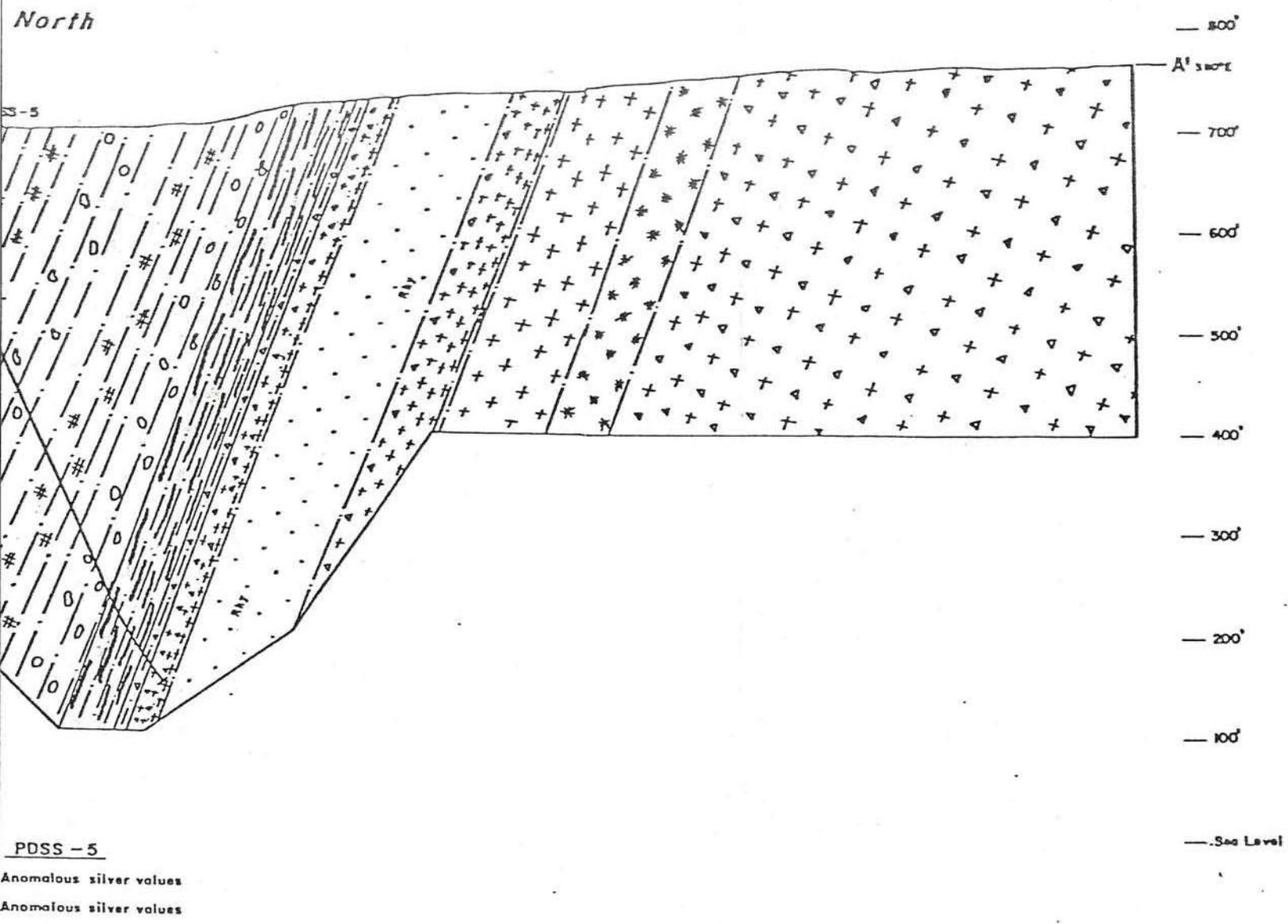


Figure 4

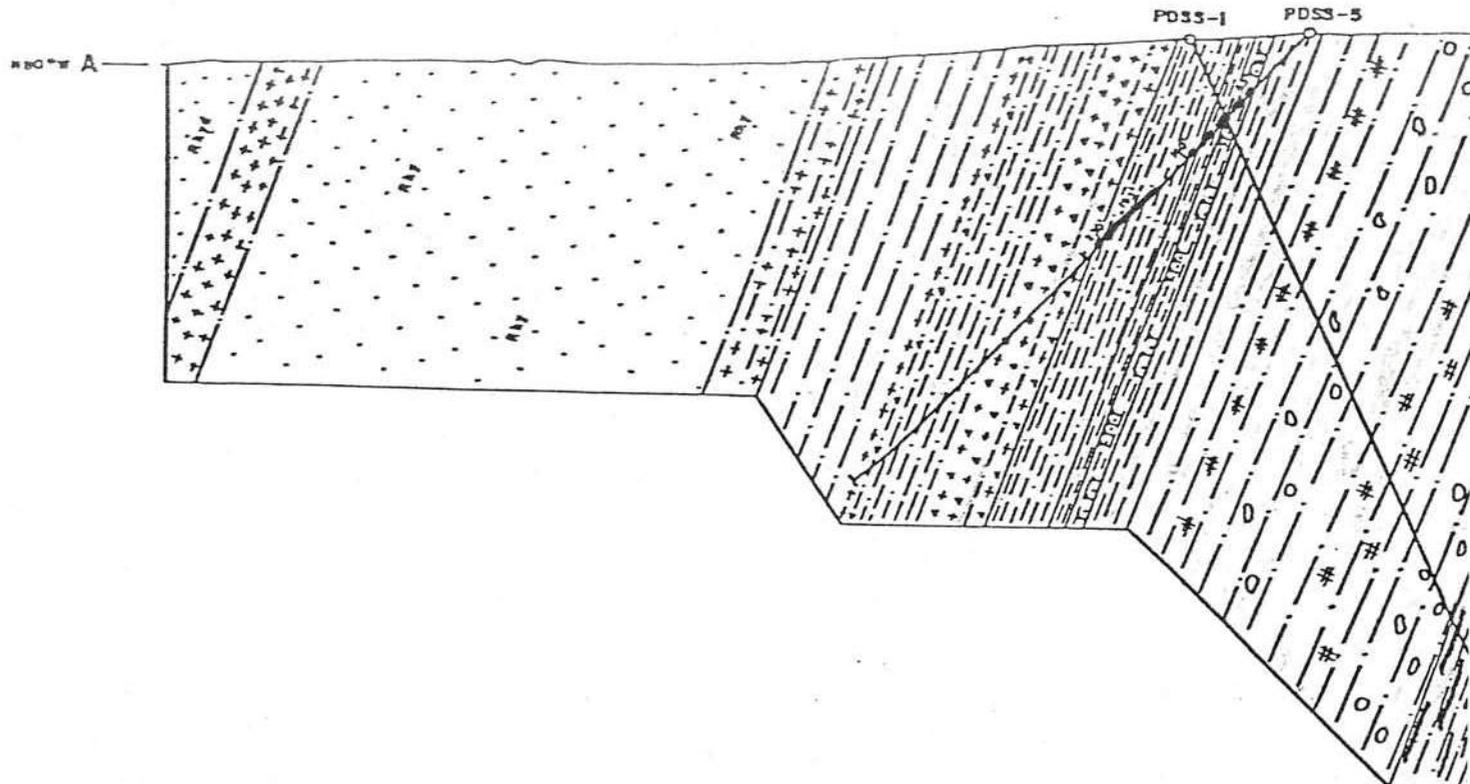
*phelps dodge* Exploration & Eng. Inc.

**CROSS SECTION SS-A-A'**  
**SILVER SHAFT MINE AREA**

Cabarrus County, North Carolina

SCALE		CONTOUR INTERVAL:		REVISIONS	
H:	1" = 100'				
V:		DATE: JUNE, 1981	BY: R. J. M.		
SHEET	OF	DRAWING NO.:		FILE:	

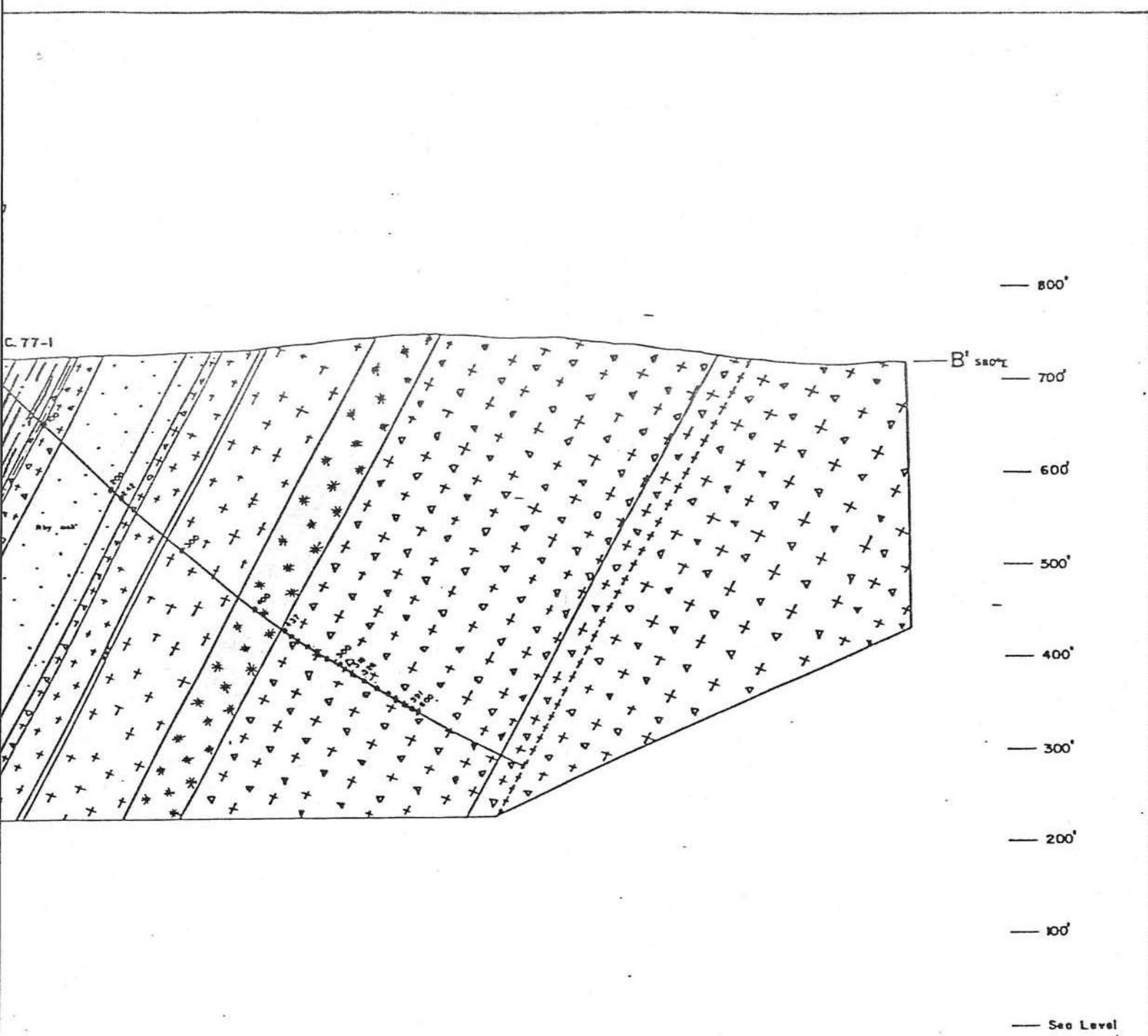
Looking North



**EXPLANATION**

- |   |  |
|---|--|
|  Re-worked rhyodacite crystal tuff |  Mudstone                     |
|  Rhyodacite crystal tuff           |  Fragmented                   |
|  Rhyolite ash                      |  Siliceous                    |
|  Rhyodacite ash                    |  Talc                         |
|  Dacite crystal tuff               |  Pyrrhotite laminae           |
|  Dacite tuff                       |  Lithologic contact           |
|  Rhyodacitic crystal-lithic        |  Projected lithologic contact |
|  Volcanic epiclastic               |  Drill hole                   |
|  Siltstone                         |  Limit of drill hole data     |
|  Silty mudstone                    |  Mineralized zone             |

**PDSS - 5**  
 65°-140° - Anomalous silver  
 195°-230° - Anomalous silver



SCALE



Figure 5

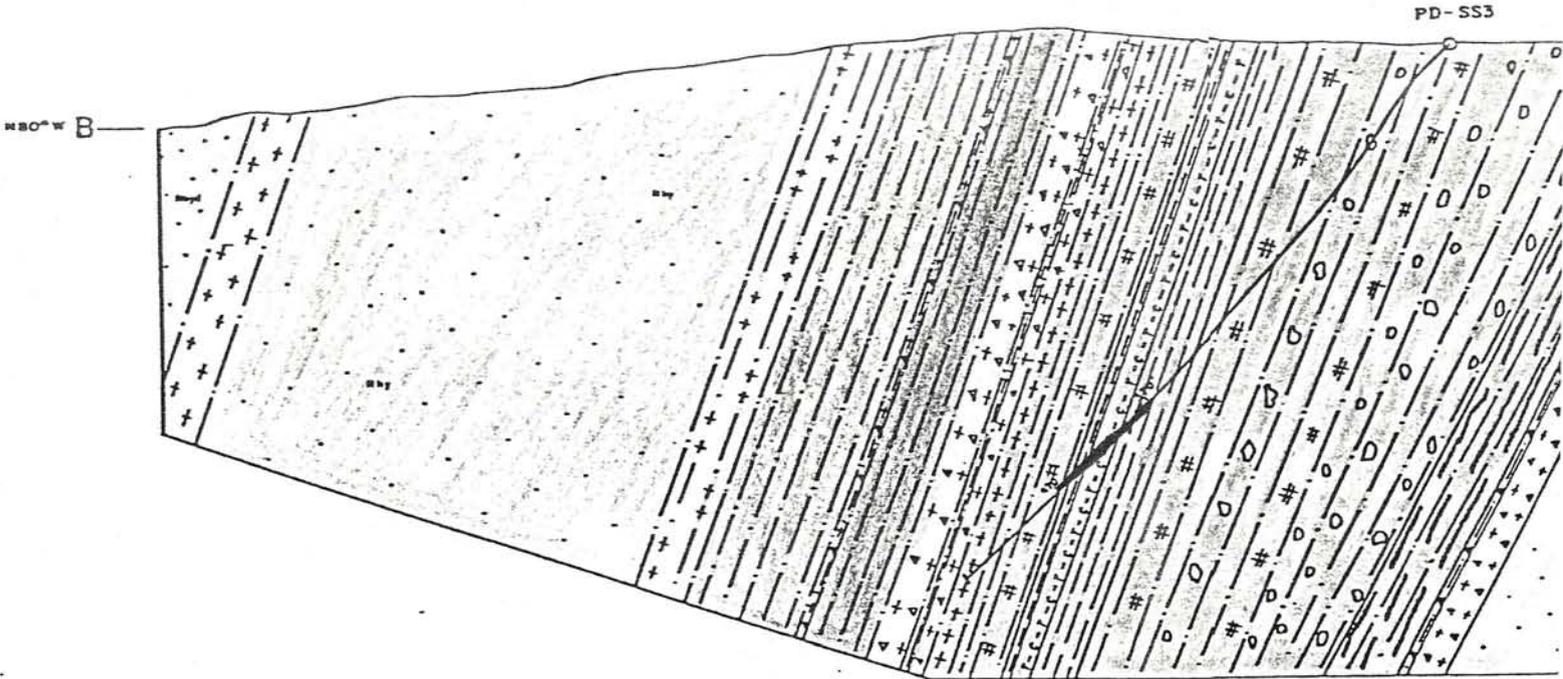
*phelps dodge* Exploration East, Inc.

CROSS SECTION SS-B-B'  
SILVER SHAFT MINE AREA

Cabarrus County, North Carolina

SCALE	H: 1" = 100'	CONTOUR INTERVAL:		REVISIONS	
	V:	DATE: JUNE, 1981	BY: R.J.M.		
SHEET	OF	DRAWING NO.:		FILE:	

Looking



**EXPLANATION**

- |  |  |  |                              |
|--|--|--|------------------------------|
|  | Re-worked rhyodacite crystal tuff          |  | Mudstone                     |
|  | Rhyodacite crystal tuff                    |  | Fragmented                   |
|  | Rhyolite ash                               |  | Siliceous                    |
|  | Rhyodacite ash                             |  | Talc-carbonate exhalite      |
|  | Dacite crystal tuff                        |  | Pyrrhotite laminae           |
|  | Dacite tuff                                |  | Lithologic contact           |
|  | Rhyodacite crystal and crystal-lithic tuff |  | Projected lithologic contact |
|  | Volcanic epiclastic                        |  | Drill hole                   |
|  | Siltstone                                  |  | Limit of drill hole data     |
|  | Silty mudstone                             |  | Mineralized zone             |

**PDSS-3**  
Ag oz./Zn%

370	.38/120
	.31/009
	.35/011
	3.50/050
	.40/014
400	.26/026
	.61/031
	.76/076
	1.40/280
	14.0/222
	6.13/148
	.35/164
	4.85/150
	13.89/248
	19.56/440
430	344/540
	1.48/140
	.33/005
	.72/068
470	.11/008

-8.89oz. Ag / 1.26% Zn -

Looking North

N.C.  
7-5

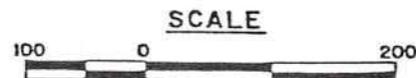
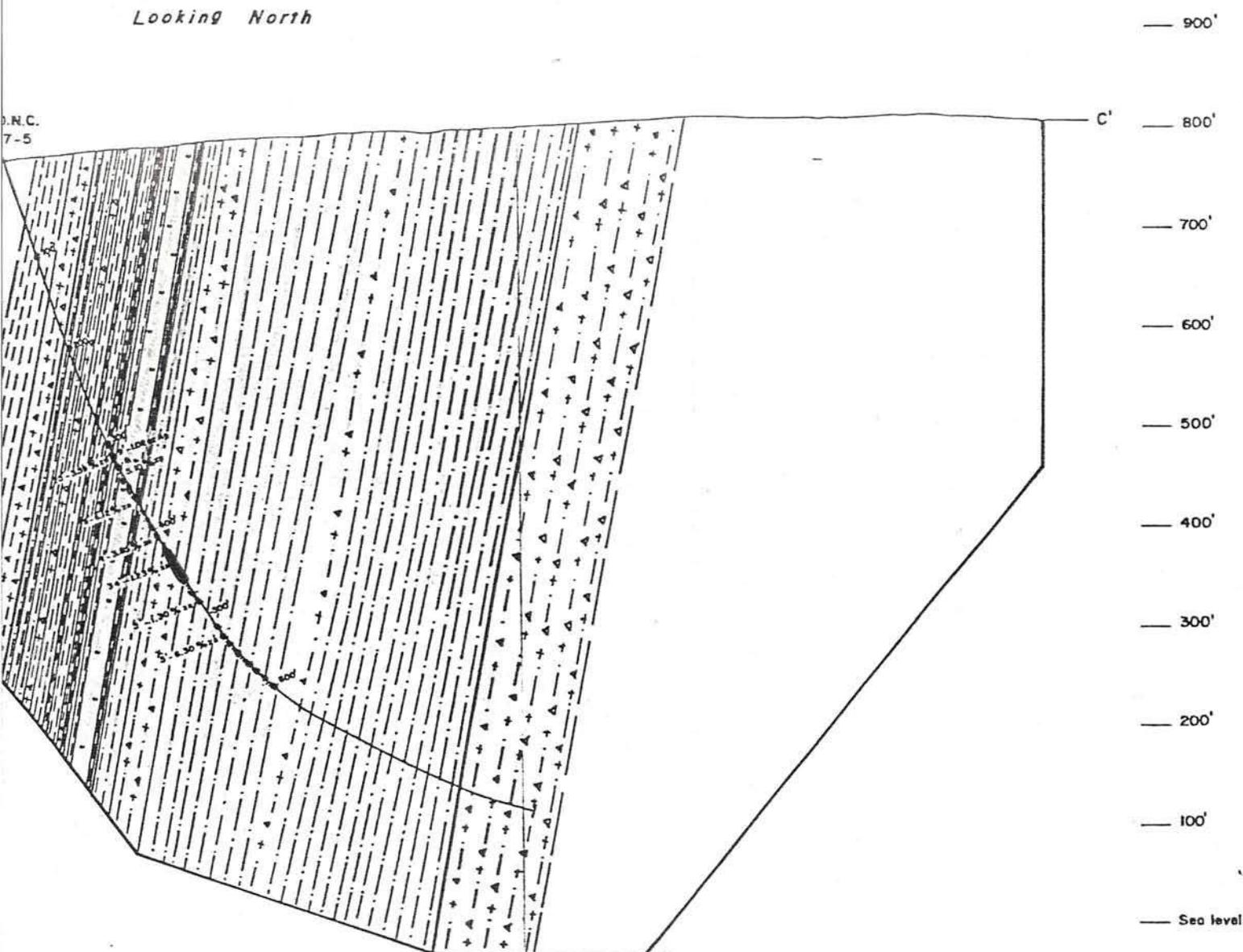


Figure 6

<i>phelps dodge</i> Exploration East, Inc.			
<b>CROSS SECTION C-C'</b>			
<b>UNION COPPER MINE AREA</b>			
Cobarrus County, North Carolina			
<b>SCALE</b>	H: 1" = 100'	CONTOUR INTERVAL:	
	V:	DATE: JULY, 1981	BY: R.J.M.
		REVISIONS	



on the Silver Shaft dump are probably most proximal. Significant mineralization probably does not exist beyond the basin limits.

Review of previous drilling at the Union Copper Mine, located 1,500 feet to the northeast identified three intersections of similar mineralization. Conoco drill hole RONC-77-2 intersected approximately 12 feet of 4.91 oz. Ag/ton and 1.17% zinc and RONC-77-5 intersected 9 feet of 1.02 oz. Ag/ton and 5.10% zinc within a 25 foot zone of 3.59% zinc. Tennessee Copper drill hole No. 2 intersected a seven foot (true thickness) zone of 3.7 oz. Ag/ton and 1.74% zinc at a vertical depth of about 750 feet.

Stratigraphic correlation indicates that these intersections are laterally equivalent to the Silver Shaft mineralization and define a unique time-stratigraphic horizon characterized by silver-bearing exhalative mineralization localized by small depositional basins.

#### Summary and Conclusions

Diamond drilling at the Silver Shaft Mine outlined a small silver-bearing talc lense of approximately 190,000 tons (200 feet by 400 feet by 24 feet) at 8-9 oz. Ag/ton and 1-2% zinc. In addition, the silver-bearing talc mineralization intersected at the Union Copper Mine probably represents a lense of somewhat similar proportions and grade.

The high grade silver-zinc mineralization of the Silver Shaft horizon offers considerable economic potential if a larger depositional basin can be located along strike or at depth. Unfortunately, the mineralization does not respond to conventional surveys conducted during 1980, and IP, SP and VLF-EM surveys conducted during 1981, failed to detect the known Silver Shaft mineralization.

A systematic program of core drilling along the mineralized silver-bearing horizon appears to be the only viable method of

continuing exploration in this area. Approximately six to eight shallow diamond drill holes would be required to continue the testing of the favorable zone. As the necessary expenditure associated with such a program is considerable, approximately \$60,000 to \$70,000, and the risk considered high, it is not possible to embark upon this undertaking within the current budgetary framework. Therefore, an attempt to farm the project out for joint venture will be made.

WVS:RJM:ph  
4/19/82

APPENDIX

ROWAN COUNTY  
CABARRUS COUNTY

PDSS-7 ●  
PDSS-5 ●  
PDSS-1 ●  
PDSS-6 ●  
PDSS-4 ●  
PDSS-3 ●

PDSS-2 ●



LEGEND

- — Completed Phelps Dodge diamond drill holes
- Property under lease by Phelps Dodge

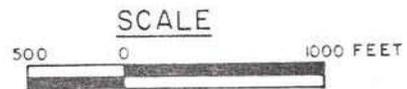


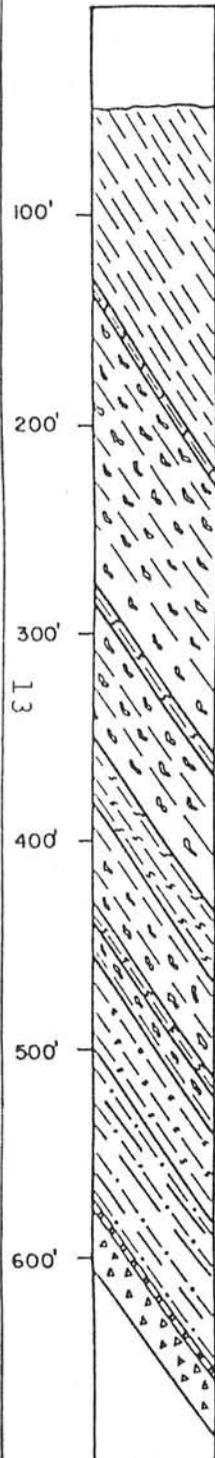
Figure 7

<b>phelps dodge</b> Exploration East, Inc.			
MAP SHOWING DRILL HOLE LOCATIONS			
<b>SILVER SHAFT PROJECT</b>			
Rowan and Cabarrus Counties, North Carolina			
SCALE	H: 1" = 1000'	CONTOUR INTERVAL:	
	V:	DATE: Nov, 1980	BY: RJM
SHEET	OF	DRAWING NO:	REVISIONS
			6/81 RJM
FILE:			

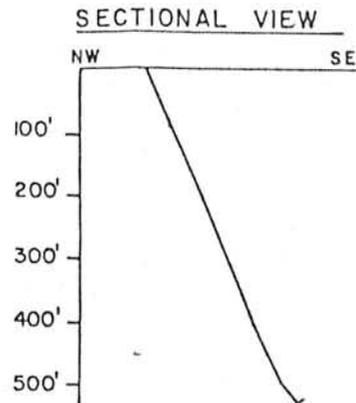
**GEOLOGIC LOG**

**ASSAY LOG**

**SUMMARY OF GEOLOGY**



Sample Interval	Ag ppm	Zn %
0 - 50 feet	Not Assayed	
50 - 55	.7	.035
55 - 60	.2	.012
60 - 65	.5	.010
65 - 70	.6	.008
70 - 75 feet	.6	.008
75 - 80	.3	.008
80 - 85	.5	.007
85 - 90	.3	.004
90 - 95	.4	.006
95 - 100 feet	.6	.008
100 - 105	.3	.006
105 - 110	.3	.008
110 - 115	.7	.006
115 - 120	.9	.005
120 - 125 feet	.5	.004
125 - 130	.2	.003
130 - 135	.2	.004
135 - 140	.2	.003
140 - 604 feet (Bottom)	Not Assayed	



Collar elevation = 720'  
 Bearing = S75°E  
 Drilled 10/20/80 - 10/29/80

- 0- 50' Overburden
- 50-130' Silty mudstone. Pyrite 2 to 10% as disseminated grains and thin (1 - 2 mm) laminae.
- 130-138' Precipitate siltstone with varying content of silicic acid and talc precipitate in siltstone matrix. Trace pyrite.
- 138-274' Fragmented siltstone with varying content of siltstone fragments in silty matrix. Minor pyrite.
- 274-284' Precipitate siltstone. Trace pyrite.
- 284-347' Fragmented siltstone. Minor pyrite.
- 347-381' Precipitate siltstone. Trace pyrite.
- 381-429' Fragmented siltstone. Trace pyrite.
- 429-437' Precipitate siltstone. Trace pyrite.
- 437-455' Fragmented siltstone. Trace pyrite.
- 455-498' Precipitate siltstone. Minor pyrite.
- 498-571' Siltstone containing varying amounts of volcanic epiclastre fragments and crystals. Pyrrhotite increases from 1 - 2% at top to 5 - 7% at bottom as blebs, lenses, and thin (1 - 3 mm) laminae. Minor pyrite at base of unit.
- 571-574' Volcanic epiclastic sediments composed of clast-supported fragments and crystals, with a silty matrix. Minor pyrrhotite.
- 574-604' Rhyodacitic crystal-lithic tuff. Minor pyrite and pyrrhotite.

- Silty mudstone
- Fragmented siltstone
- Precipitate siltstone
- Siltstone with pyrrhotite laminae
- Volcanic epiclastics
- Rhyodacitic crystal-lithic tuff

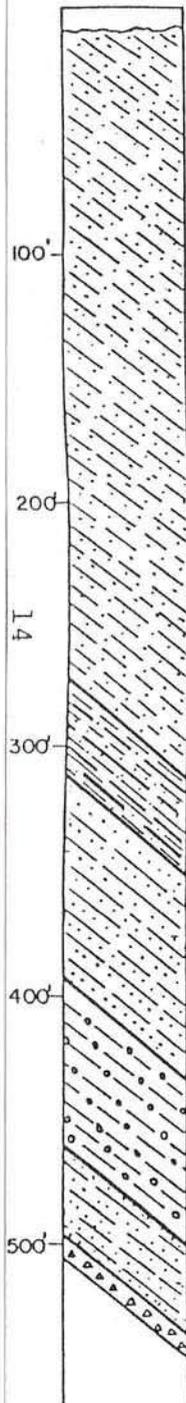
Figure 8

<i>prolog</i> <i>shaly</i> <i>Exploration</i> <i>Est.</i>			
SILVER SHAFT PROJECT Cabarrus County, North Carolina PDSS-1			
SCALE	H	CONTOUR INTERVAL:	REVISIONS
	V	DATE:	BY:
		DRAWING NO.	FILE

GEOLOGIC LOG

ASSAY LOG

SUMMARY OF GEOLOGY



Sample Interval	Ag ppm	Zn ppm	Pb ppm	Cu ppm
265 - 265.8 feet	85	127	15	-.2
267 - 268	63	85	8	-.2
306.5- 306.8	48	69	18	-.2
381 - 381.8	50	39	10	-.2
390.5- 391	48	63	33	-.2
418 - 418.7 feet	50	41	25	-.2
451.5- 452	43	51	23	-.2
463 - 463.2	40	64	10	-.2
492 - 492.2	63	80	18	-.2

0- 10' Overburden

10-272' Siltstone and silty mudstone locally mixed with minor siliceous chemical precipitate. Minor pyrrhotite as disseminations, lenses, and thin (2-5 mm) laminae.

272-310' Siltstone. Contains 3 to 5% (15% locally) pyrrhotite as fine disseminated grains, lenses, and thin (2 mm to 1 cm) laminae.

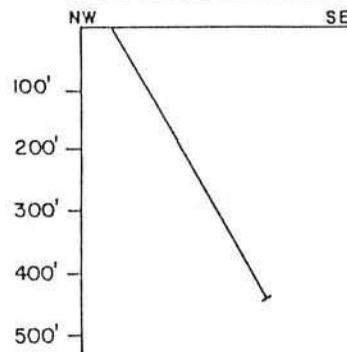
310-392' Siltstone and silty mudstone. Minor pyrrhotite.

392-460' Epiclastic siltstone with matrix supported volcanic rock fragments, interbedded with siltstone. Minor pyrrhotite.

460-498' Siltstone. Minor pyrrhotite.

498-505' Dacitic crystal-lithic tuff, locally reworked. Trace pyrite.

SECTIONAL VIEW



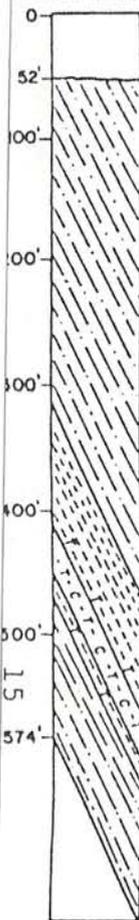
Collar elevation = 630'  
 Bearing = S70°E  
 Drilled 10/29/80 = 11/5/80

-  Siltstone
-  Pyrrhotite laminae
-  Epiclastic siltstone
-  Dacitic crystal-lithic tuff

Figure 9

<i>Principal Geology Exploration, Inc.</i>			
SILVER SHAFT PROJECT Cabarrus County, North Carolina PDSS-2			
SCALE	NO.	CONTOUR INTERVAL	REVISIONS
#:	DATE:	BY:	
SHEET	OF	DRAWING NO:	FILE:

Geologic Log



-  Siltstone
-  Mudstone
-  T.C.T  
Talc-Carbonate Exhalite
-  T-T  
Talcose

Assay Log

Sample Interval	Ag oz	Zn %	Pb %	Cu %	Co ppm	Au ppm
0-165		Not Assayed				
165-170	0.03	0.004	-0.01	-.001	-5	-0.02
170-172	0.13	0.003	0.09	-.001	-5	-0.02
172-175	0.008	0.004	-0.01	-.001	5	-0.02
200-205	0.012	0.005	-0.01	-.001	-5	0.02
225-230	0.012	0.006	-0.01	-.001	-5	-0.02
250-255	0.044	0.008	-0.01	0.004	15	-0.02
255-260	0.035	0.005	-0.01	0.002	5	0.03
260-265	0.058	0.004	-0.01	0.001	-5	-0.02
265-270	0.268	0.046	0.01	0.004	5	0.10
270-275	0.087	0.013	-0.01	0.002	10	0.06
275-280	0.026	0.003	-0.01	0.001	5	-0.02
280-285	0.01	0.010	-0.01	0.001	10	-0.02
285-290	0.023	0.007	-0.01	-.001	-5	-0.02
290-295	0.03	0.004	-0.01	-.001	-5	-0.02
295-300	0.02	0.003	-0.01	-.001	-5	-0.02
335-340	0.09	0.006	-0.01	0.002	5	0.02
340-345	0.24	0.011	-0.01	0.003	-5	0.02
370-375	0.38	0.12	-0.01	0.003	10	0.06
375-380	0.31	0.009	-0.01	0.002	5	-0.02
380-385	0.35	0.011	-0.01	0.003	10	-0.02
385-390	3.50	0.050	0.01	0.019	15	-0.02
390-395	0.40	0.014	-0.01	0.003	20	-0.02
395-400	0.26	0.026	-0.01	0.004	15	-0.02
400-405	0.61	0.031	0.01	0.005	10	0.04
405-410	0.76	0.076	0.02	0.003	10	-0.04
410-415	1.40	0.280	0.10	0.004	5	-0.04
415-420	14.0	2.22	0.71	0.035	5	-0.04
420-425	6.13	1.48	0.45	0.24	5	0.05
425-430	0.35	0.164	0.09	0.004	5	-0.04
430-435	4.85	1.50	0.38	0.017	5	0.02
435-440	13.89	2.48	0.68	0.036	20	0.06
440-445	19.56	0.440	0.55	0.055	15	0.05
445-450	3.44	0.540	0.11	0.010	10	0.03
450-455	1.48	0.140	0.04	0.004	5	-0.02
455-460	0.33	0.015	-0.01	0.001	-5	0.09
460-465	0.72	0.068	-0.02	0.004	10	-0.02
465-470	0.11	0.008	-0.01	0.002	5	-0.02
500-505	0.03	0.005	-0.01	-0.001	5	-0.02
540-545	0.05	0.010	-0.01	0.001	5	0.02

Summary of Geology

- 0- 52' Overburden.
- 52-314' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 5% pyrite as dissemination.
- 314-404' Mudstone; massive to well bedded, locally silty, siliceous or talcose. 3 to 5, locally 20 to 30% pyrite as disseminations and laminae.
- 404-445' Talc and talc-carbonate exhalite; locally brecciated. 1 to 5% pyrite as disseminated grains & laminae. Trace to 5% sphalerite. Trace to 1% aguilarite.
- 445-463' Mudstone; locally silty, siliceous or talcose. 1 to 3% pyrite, trace sphalerite and aguilarite.
- 463-574' Siltstone; massive to poorly bedded locally siliceous to fragmented. Trace to 3% pyrite.

Sectional View of Drill Hole (H=V)

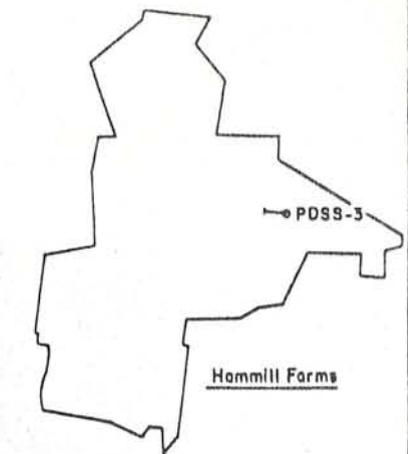
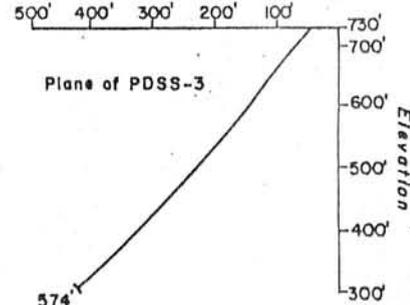
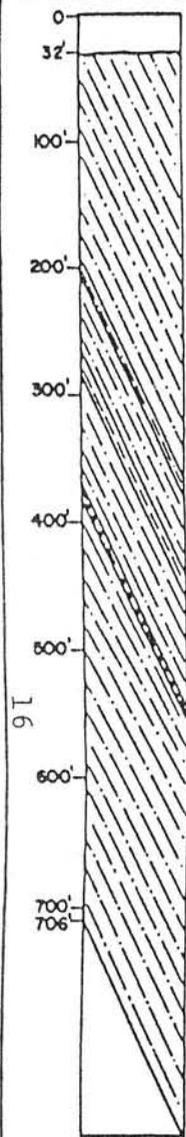


Figure 10

SILVER SHAFT PROJECT Hammill Farms, Cabarrus Co., N.C. Drill Hole PDSS-3 collar elevation = 730'			
SCALE	H: V:	CONTOUR INTERVAL:	REVISIONS
		DATE June, 81 BY: R.J.M.	

Geologic Log



Assay Log

Sample Interval	Ag ppm	Zn %	Pb %
0-350		Not Assayed	
350-355	.9	.005	-.01
355-360	.6	.006	-.01
360-365	.9	.006	-.01
365-370	.2	.005	-.01
370-375	.2	.004	-.01
375-380	.9	.004	-.01
380-385	.4	.003	-.01
385-390	.4	.006	-.01
390-395	.4	.003	-.01
395-400	.4	.003	-.01
400-405	.5	.004	-.01
405-410	.5	.003	-.01
410-415	.5	.003	-.01
415-420	.4	.003	-.01
420-425	.2	.003	-.01
425-430	(.2	.003	-.01
430-435	(.2	.003	-.01
435-440	.2	.003	-.01
440-445	(.2	.003	-.01
445-450	(.2	.002	-.01
450-706		Not Assayed	

Summary of Geology

- 0- 32' Overburden.
- 32-186' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 3% disseminated pyrite.
- 186-195' Silty mudstone; intimately mixed with siltstone. Trace pyrite.
- 195-256' Siltstone, massive to poorly bedded, locally siliceous to fragmented. Trace to 3% disseminated pyrite.
- 256-273' Mudstone; poorly to well bedded, chloritic in lower portion. Trace to 5% pyrite as disseminated and laminae.
- 273-364' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 3% disseminated pyrite.
- 364-370' Reworked rhyodacitic crystal-lithic tuff. Silty, chloritic matrix.
- 370-706' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 3% pyrite.

16

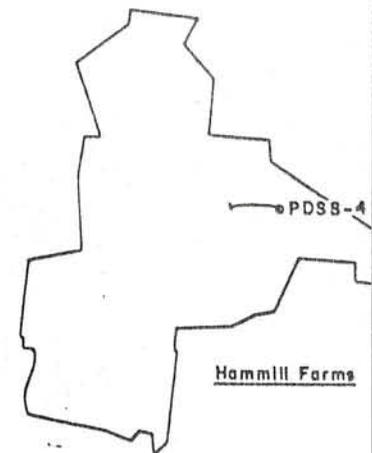
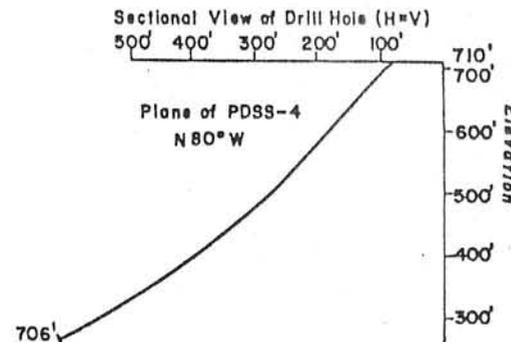
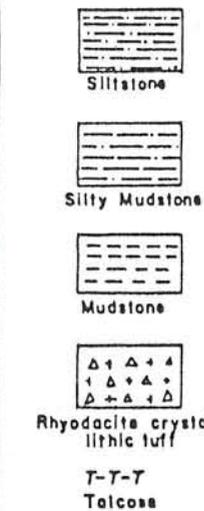
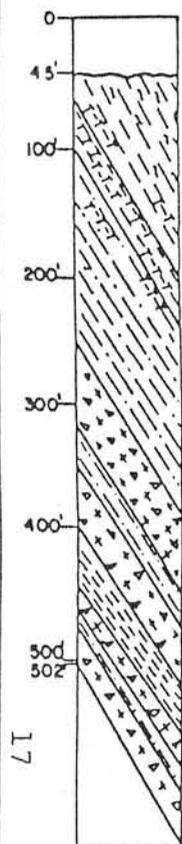


Figure 11

SILVER SHAFT PROJECT			
Hammill Farms, Cabarrus Co., N.C.			
Drill Hole PDSS-4			
collar elevation = 710'			
SCALE:	H:	CONTOUR INTERVAL:	BEYOND:
V:	DATE:	JUNE, 81	BY: R. J. M.

Geologic Log



Assay Log

Sample Interval	Ag ppm	Zn %	Pb %
0 - 45		Not Assayed	
45 - 50	.5	.009	(.01)
50 - 55	.7	.009	(.01)
55 - 60	.4	.007	(.01)
60 - 65	.5	.010	(.01)
65 - 70	1.0	.009	(.01)
70 - 75	1.0	.009	(.01)
75 - 80	.6	.009	(.01)
80 - 85	1.0	.013	(.01)
85 - 90	1.0	.021	(.01)
90 - 95	.3	.015	(.01)
95 - 100	2.0	.012	(.01)
100 - 105	1.5	.020	(.01)
105 - 110	1.3	.030	(.01)
110 - 115	2.0	.024	(.01)
115 - 120	1.7	.024	(.01)
120 - 125	1.9	.170	(.01)
125 - 130	1.4	.008	(.01)
130 - 135	2.2	.035	(.01)
135 - 140	1.1	.025	(.01)
140 - 145	.5	.013	(.01)
145 - 150	.7	.006	(.01)
150 - 155	.5	.005	(.01)
155 - 160	.8	.006	.01
160 - 165	.2	.004	(.01)
165 - 170	(.2	.002	(.01)
170 - 175	.7	.004	(.01)
175 - 180	.4	.006	(.01)
180 - 185	.3	.003	(.01)
185 - 190	.3	.005	(.01)
190 - 195	.6	.002	(.01)
195 - 200	1.0	.011	(.01)
200 - 205	.5	.006	(.01)
205 - 210	2.5	.006	(.01)
210 - 215	8.7	.006	(.01)
215 - 220	12.4	.006	.01
220 - 225	10.2	.006	.01
225 - 230	3.4	.004	(.01)
230 - 235	.3	.003	(.01)
235 - 240	(.2	.002	(.01)
240 - 502		Not Assayed	

Summary of Geology

0 - 45' Overburden.  
 45 - 61' Mudstone; talcose to sericitic 1-5% pyrite as disseminations and laminae.  
 61 - 100' Mudstone; talcose with locally abundant 1-5 cm thick talc horizons. 3-5% locally 10-15% pyrite as disseminations and laminae.  
 100 - 248' Mudstone; often silty, locally siliceous to talcose. 1-5% disseminated pyrite.  
 248 - 502' Alternating rhyodacitic crystalline tuff and silty mudstone/siltstone. 1-5% disseminated pyrite, trace sphalerite.

Sectional View of Drill Hole (H=V)

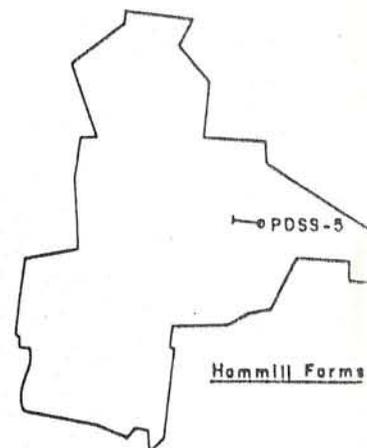
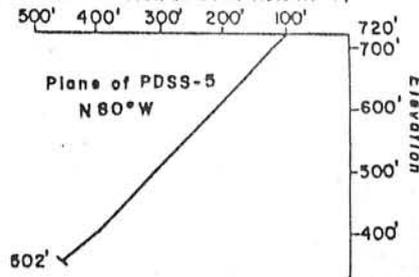


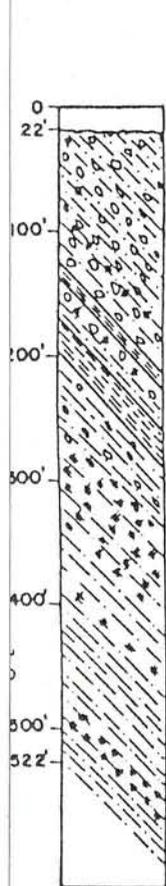
Figure 12

SILVER SHAFT PROJECT Hammill Farms, Cabarrus Co., N.C. Drill Hole PDSS-5 collar elevation = 720'		
SCALE	H: V:	CONTOUR INTERVAL: DATE: June, '81 BY: R.J.M.
		REVISED:

Geologic Log

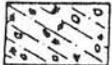
Assay Log

Summary of Geology



Sample Interval	Ag ppm	Zn %	Pb %
0- 50	Not Assayed	Assayed	
50- 55	.5	.114	-.01
80- 85	.5	.003	-.01
100-105	.5	.003	-.01
150-155	.5	.003	-.01
180-185	.5	.003	-.01
185-190	-.5	.003	-.01
190-195	.5	.002	-.01
195-200	.5	.002	-.01
200-205	.5	.003	-.01
205-210	.5	.008	-.01
250-255	.5	.003	-.01
300-305	.5	.005	-.01
350-355	-.5	.002	-.01
370-375	.5	.013	-.01
400-405	.5	.005	-.01
450-455	.5	.003	-.01
500-505	-.5	.004	-.01
505-522	Not Assayed	Assayed	

0- 22' Overburden  
 22-132' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 1% disseminated pyrite.  
 132-140' Mudstone; silty, chloritic. Trace pyrite.  
 140-183' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 1% disseminated pyrite.  
 183-207' Mudstone; silty to chloritic, moderately well bedded. 1 to 2% pyrite as lenses, laminae, and disseminated.  
 207-399' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 1% disseminated pyrite.  
 399-414' Silty mudstone; siliceous, finely bedded. Trace disseminated pyrite.  
 414-522' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 1% pyrite.

-  Siliceous Siltstone w/ fragments
-  Silty Mudstone
-  Well bedded Chloritic Mudstone
-  Massive siliceous Siltstone

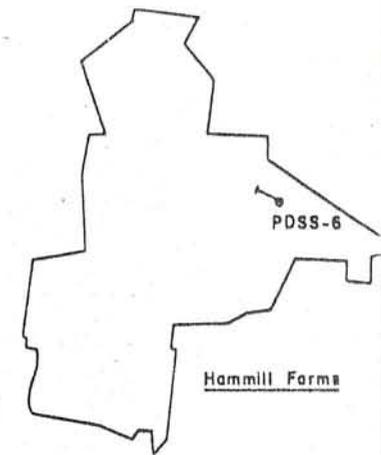
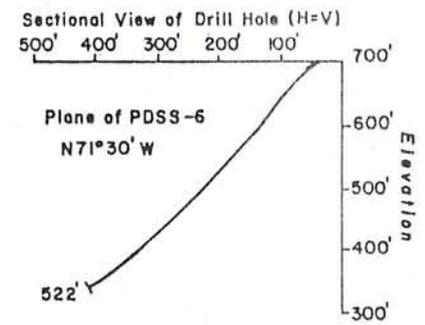


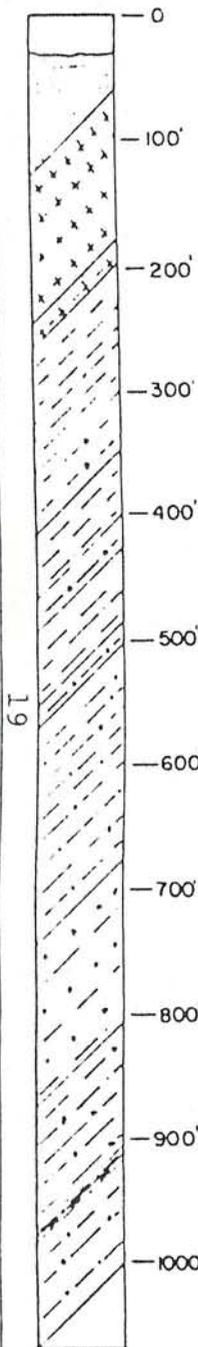
Figure 13

Geological Engineering & Exploration, Inc.

**SILVER SHAFT PROJECT**  
 Hammill Farms, Cabarrus Co., N.C.  
 Drill Hole PDSS-6  
 collar elevation = 700'

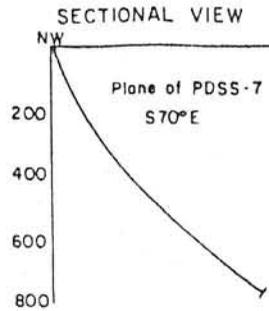
SCALE:	H:	CONTOUR INTERVAL:	REVISIONS:

Geologic Log



Assay Log

Sample Interval	Ag ppm	Zn %	Pb %
100 - 101 feet	(.5	.006	(.01
125 - 126	.5	.003	(.01
150 - 151	1.0	.037	(.01
175 - 176	2.0	.240	.11
200 - 201	(.5	.003	(.01
225 - 226 feet	2.0	.310	.03
250 - 251	.5	.004	(.01
275 - 276	(.5	.003	(.01
300 - 301	(.5	.003	(.01
325 - 326	(.5	.004	(.01
350 - 351 feet	.5	.003	(.01
375 - 376	.5	.004	(.01
400 - 401	.5	.004	(.01
425 - 426	.5	.002	(.01
450 - 451	.5	.004	(.01
475 - 476 feet	.5	.009	(.01
500 - 501	1.0	.026	.01
525 - 526	1.0	.004	(.01
550 - 551	.5	.006	(.01
575 - 576	.5	.004	(.01
600 - 601 feet	(.5	.007	(.01
625 - 626	(.5	.004	(.01
650 - 655	.5	.006	(.01
655 - 660	.5	.006	(.01
660 - 665	.5	.003	(.01
665 - 670 feet	(.5	.003	(.01
670 - 675	(.5	.004	(.01
675 - 680	.5	.003	(.01
680 - 685	(.5	.003	(.01
685 - 690	(.5	.004	(.01
690 - 695 feet	(.5	.004	(.01
695 - 700	(.5	.005	(.01
700 - 705	(.5	.004	(.01
705 - 710	.5	.004	(.01
710 - 715	(.5	.004	(.01
715 - 720 feet	(.5	.004	(.01
720 - 725	.5	.004	(.01
725 - 730	.5	.003	(.01
730 - 735	(.5	.004	(.01
735 - 740	(.5	.004	(.01
740 - 745 feet	(.5	.003	(.01
745 - 750	.5	.004	(.01
750 - 755	(.5	.002	(.01
755 - 760	(.5	.004	(.01
760 - 765	.5	.003	(.01
765 - 770 feet	.5	.004	(.01
770 - 775	.5	.003	(.01
775 - 780	(.5	.003	(.01
780 - 785	(.5	.004	(.01
785 - 790 feet	.5	.003	(.01
790 - 795	(.5	.005	(.01
795 - 800	.5	.003	(.01
800 - 805	(.5	.004	(.01
805 - 810	.5	.004	(.01
810 - 815 feet	(.5	.006	(.01
815 - 820	(.5	.005	(.01
820 - 825	.5	.005	(.01
825 - 830	.5	.005	(.01
830 - 835	(.5	.004	(.01
835 - 840 feet	.5	.005	(.01
840 - 845	1.0	.007	(.01
845 - 850	.5	.005	(.01
850 - 855	1.0	.007	(.01
855 - 860	1.0	.005	(.01
860 - 865 feet	.5	.005	(.01
865 - 870	(.5	.004	(.01
870 - 875	1.0	.005	(.01
875 - 880	.5	.006	(.01



	Rhyolite ash/felsic mudstone
	Rhyolite/rhyodacite x-tal tuff
	Reworked rhy/rhyodac x-tal tuff
	Siliceous epiclastic siltstone
	Siliceous siltstone
	Chloritic silty mudstone
	Siliceous fragmented siltstone
	Sil. fragmented epi. siltstone
	Mixed silty mudstone & frag. silt.

Sample Interval	Ag ppm	Zn %	Pb %
800 - 885 feet	.5	.006	(.01
885 - 890	.5	.006	(.01
890 - 895	1.0	.005	(.01
895 - 900	.5	.005	(.01
900 - 905	(.5	.003	(.01
905 - 910 feet	(.5	.004	(.01
910 - 915	(.5	.006	(.01
915 - 920	(.5	.004	(.01
920 - 925	.5	.003	(.01
925 - 930	.5	.002	(.01
930 - 935 feet	.5	.002	(.01
935 - 940	(.5	.002	(.01
940 - 945	.5	.003	(.01
945 - 1000	Not Assayed		

Summary of Geology

0 - 43'	Overburden.
43 - 56'	Rhyolite ash/felsic mudstone. Locally well laminated & locally silicified.
56 - 98'	Rhyolite to rhyodacite crystal tuff. Locally silicified. Trace amounts of pyrite, galena & sphalerite quartz veins.
98 - 175'	Rhyolite to rhyodacite crystall tuff. Trace to 1% pyrite, galena & sphalerite in quartz veins & disseminations.
175 - 202'	Reworked equivalent of above rhyolite to rhyodacite crystal tuff. Trace to 1% disseminated pyrite & pyrrhotite.
202 - 302'	Siliceous siltstone with minor intercalations of reworked rhyolite to rhyodacite crystall tuff. Trace to 1% disseminated pyrite & pyrite + sphalerite veinlets locally.
302 - 346'	Siliceous epiclastic siltstone. Reworked quartz & feldspar crystals in a silty matrix. Trace to 1% sulfides as pyrite & pyrrhotite disseminations.
346 - 407'	Siliceous siltstone with low epiclastic component. Trace to 1% sulfides as disseminated pyrite.
407 - 429'	Epiclastic siltstone. Reworked crystals (qtz. & feld.) in a silty matrix. Trace to 1% pyrite as sprays along fractures. Trace pyrrhotite.
429 - 480'	Dark grey siliceous siltstone locally containing cherty fragments. Trace pyrite as fine disseminations and sprays along fractures.
480 - 484'	Chloritic silty mudstone. Trace pyrite.
484 - 505'	Siliceous siltstone with minor epiclastic component. Trace pyrite as disseminations & sprays along frag.
505 - 543'	Siliceous fragmented siltstone. Trace to 1% pyr. as disseminations.
543 - 672'	Fragmented siltstone. Locally silicified & locally contains CO <sub>2</sub> healed fractures. Trace to 1% pyr.
672 - 815'	Siliceous fragmented epiclastic siltstone. Locally silicified. Trace pyrite & pyrrhotite.
815 - 912'	Siliceous epiclastic siltstone. Trace pyrite as fine disseminations and sprays. Trace pyrrhotite.
912 - 924'	Siliceous silty mudstone.
924 - 934'	Intermixed silty mudstone & fragmented siltstone.
934 - 1000'	Siliceous fragmented siltstone. Trace pyrrhotite.

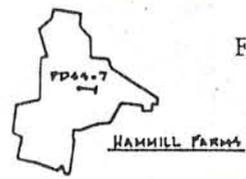


Figure 14

*Philip Dodge* Geotechnical Eng., Inc.

**SILVER SHAFT PROJECT**  
Hammill Farms, Cabarrus Co., N.C.  
Drill Hole PDSS - 7  
collar elevation\* 720'

SCALE	IN:	CONTOUR INTERVAL:	REVISIONS
	FT:	DATE: Oct. 81	BY: R.J.M
SHEET	OF	DRAWING NO.	PKT.

**2.8. Silver Shaft Mine area drill hole locations and cross sections with simplified logs and assays. Appendix from 1982 Termination Report, Phelps Dodge Exploration East, Raleigh, N.C.**

By W. V. Smart and Robert J. Moye

APPENDIX

ROWAN COUNTY  
CABARRUS COUNTY

PDSS-7 ●  
PDSS-5 ●  
PDSS-1 ●  
PDSS-6 ●  
PDSS-4 ●  
PDSS-3 ●

PDSS-2 ●



SCALE



LEGEND

- — Completed Phelps Dodge diamond drill holes
- Property under lease by Phelps Dodge

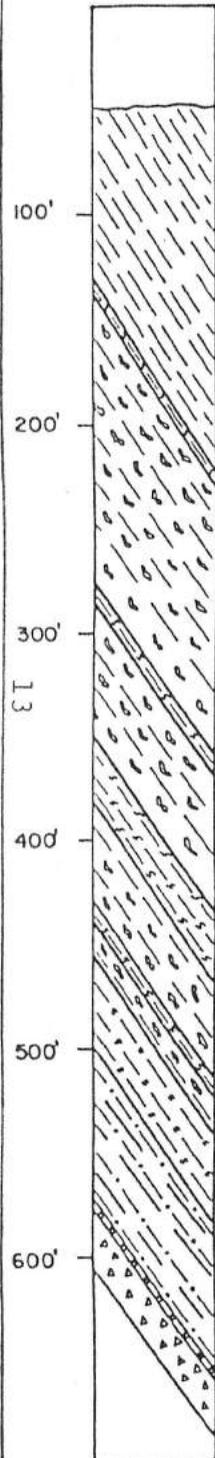
Figure 7

<b>phelps dodge</b> Exploration East, Inc.			
MAP SHOWING DRILL HOLE LOCATIONS			
<b>SILVER SHAFT PROJECT</b>			
Rowan and Cabarrus Counties, North Carolina			
SCALE	H: 1" = 1000'	CONTOUR INTERVAL:	
	V:	DATE: Nov, 1980	BY: RJM
SHEET	OF	DRAWING NO:	REVISIONS
			6/81 RJM
FILE:			

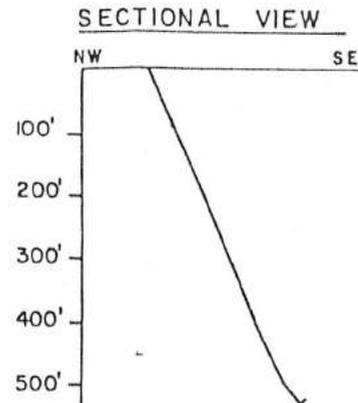
**GEOLOGIC LOG**

**ASSAY LOG**

**SUMMARY OF GEOLOGY**



Sample Interval	Ag ppm	Zn %
0 - 50 feet	Not Assayed	
50 - 55	.7	.035
55 - 60	.2	.012
60 - 65	.5	.010
65 - 70	.6	.008
70 - 75 feet	.6	.008
75 - 80	.3	.008
80 - 85	.5	.007
85 - 90	.3	.004
90 - 95	.4	.006
95 - 100 feet	.6	.008
100 - 105	.3	.006
105 - 110	.3	.008
110 - 115	.7	.006
115 - 120	.9	.005
120 - 125 feet	.5	.004
125 - 130	.2	.003
130 - 135	.2	.004
135 - 140	.2	.003
140 - 604 feet (Bottom)	Not Assayed	



Collar elevation = 720'  
 Bearing = S75°E  
 Drilled 10/20/80 - 10/29/80

- 0- 50' Overburden
- 50-130' Silty mudstone. Pyrite 2 to 10% as disseminated grains and thin (1 - 2 mm) laminae.
- 130-138' Precipitate siltstone with varying content of silica and talc precipitate in siltstone matrix. Trace pyrite.
- 138-274' Fragmented siltstone with varying content of siltstone fragments in silty matrix. Minor pyrite.
- 274-284' Precipitate siltstone. Trace pyrite.
- 284-347' Fragmented siltstone. Minor pyrite.
- 347-381' Precipitate siltstone. Trace pyrite.
- 381-429' Fragmented siltstone. Trace pyrite.
- 429-437' Precipitate siltstone. Trace pyrite.
- 437-455' Fragmented siltstone. Trace pyrite.
- 455-498' Precipitate siltstone. Minor pyrite.
- 498-571' Siltstone containing varying amounts of volcanic epiclastre fragments and crystals. Pyrrhotite increases from 1 - 2% at top to 5 - 7% at bottom as blebs, lenses, and thin (1 - 3 mm) laminae. Minor pyrite at base of unit.
- 571-574' Volcanic epiclastic sediments composed of clast-supported fragments and crystals, with a silty matrix. Minor pyrrhotite.
- 574-604' Rhyodacitic crystal-lithic tuff. Minor pyrite and pyrrhotite.

- Silty mudstone
- Fragmented siltstone
- Precipitate siltstone
- Siltstone with pyrrhotite laminae
- Volcanic epiclastics
- Rhyodacitic crystal-lithic tuff

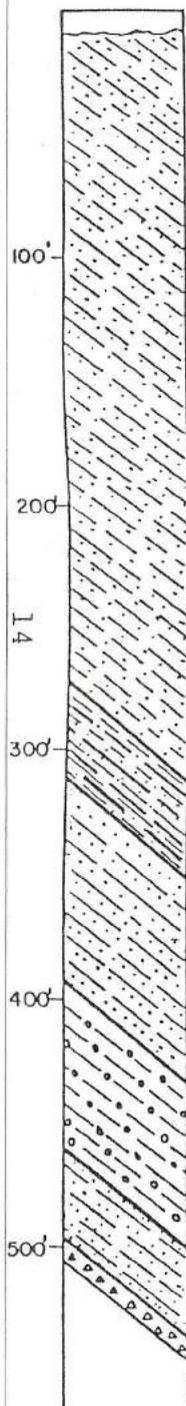
Figure 8

<i>phosphate shale</i>			
SILVER SHAFT PROJECT Cabarrus County, North Carolina PDSS-1			
SCALE	H	CONTOUR INTERVAL:	REVISIONS
	V	DATE:	BY:
		DRAWING NO.	DATE

GEOLOGIC LOG

A S S A Y L O G

SUMMARY OF GEOLOGY



Sample Interval	Ag ppm	Zn ppm	Pb ppm	Cu ppm
265 - 265.8 feet	85	127	15	-.2
267 - 268	63	85	8	-.2
306.5- 306.8	48	69	18	-.2
381 - 381.8	50	39	10	-.2
390.5- 391	48	63	33	-.2
418 - 418.7 feet	50	41	25	-.2
451.5- 452	43	51	23	-.2
463 - 463.2	40	64	10	-.2
492 - 492.2	63	80	18	-.2

0- 10' Overburden

10-272' Siltstone and silty mudstone locally mixed with minor siliceous chemical precipitate. Minor pyrrhotite as disseminations, lenses, and thin (2-5 mm) laminae.

272-310' Siltstone. Contains 3 to 5% (15% locally) pyrrhotite as fine disseminated grains, lenses, and thin (2 mm to 1 cm) laminae.

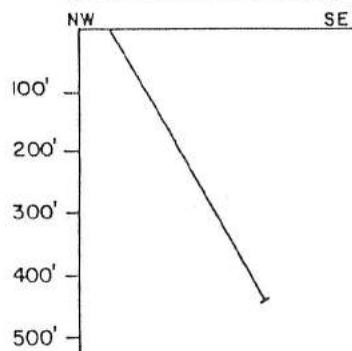
310-392' Siltstone and silty mudstone. Minor pyrrhotite.

392-460' Epiclastic siltstone with matrix supported volcanic rock fragments, interbedded with siltstone. Minor pyrrhotite.

460-498' Siltstone. Minor pyrrhotite.

498-505' Dacitic crystal-lithic tuff, locally reworked. Trace pyrite.

SECTIONAL VIEW



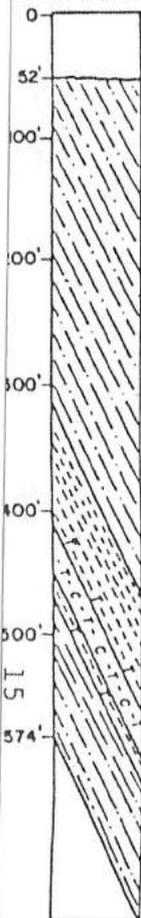
Collar elevation = 630'  
 Bearing = S70°E  
 Drilled 10/29/80 = 11/5/80

-  Siltstone
-  Pyrrhotite laminae
-  Epiclastic siltstone
-  Dacitic crystal-lithic tuff

Figure 9

<small>Geological Services Corporation</small>			
SILVER SHAFT PROJECT Cabarrus County, North Carolina PDSS-2			
SCALE:	H:	CONTOUR INTERVAL:	REVISIONS
:	:	DATE:	BY:
SHEET	OF	DRAWING:	FILE:

Geologic Log



-  Siltstone
-  Mudstone
-  T.C.-T
-  Talc-Carbonate Exhalite
-  T-T
-  Talcose

Assay Log

Sample Interval	Ag oz	Zn %	Pb %	Cu %	Co ppm	Au ppm
0-165		Not Assayed				
165-170	0.03	0.004	-0.01	-.001	-5	-0.02
170-172	0.13	0.003	0.09	-.001	-5	-0.02
172-175	0.008	0.004	-0.01	-.001	5	-0.02
200-205	0.012	0.005	-0.01	-.001	-5	0.02
225-230	0.012	0.006	-0.01	-.001	-5	-0.02
250-255	0.044	0.008	-0.01	0.004	15	-0.02
255-260	0.035	0.005	-0.01	0.002	5	0.03
260-265	0.058	0.004	-0.01	0.001	-5	-0.02
265-270	0.268	0.046	0.01	0.004	5	0.10
270-275	0.087	0.013	-0.01	0.002	10	0.06
275-280	0.026	0.003	-0.01	0.001	5	-0.02
280-285	0.01	0.010	-0.01	0.001	10	-0.02
285-290	0.023	0.007	-0.01	-.001	-5	-0.02
290-295	0.03	0.004	-0.01	-.001	-5	-0.02
295-300	0.02	0.003	-0.01	-.001	-5	-0.02
335-340	0.09	0.006	-0.01	0.002	5	0.02
340-345	0.24	0.011	-0.01	0.003	-5	0.02
370-375	0.38	0.12	-0.01	0.003	10	0.06
375-380	0.31	0.009	-0.01	0.002	5	-0.02
380-385	0.35	0.011	-0.01	0.003	10	-0.02
385-390	3.50	0.050	0.01	0.019	15	-0.02
390-395	0.40	0.014	-0.01	0.003	20	-0.02
395-400	0.26	0.026	-0.01	0.004	15	-0.02
400-405	0.61	0.031	0.01	0.005	10	0.04
405-410	0.76	0.076	0.02	0.003	10	-0.04
410-415	1.40	0.280	0.10	0.004	5	-0.04
415-420	14.0	2.22	0.71	0.035	5	-0.04
420-425	6.13	1.48	0.45	0.24	5	0.05
425-430	0.35	0.164	0.09	0.004	5	-0.04
430-435	4.85	1.50	0.38	0.017	5	0.02
435-440	13.89	2.48	0.68	0.036	20	0.06
440-445	19.56	0.440	0.55	0.055	15	0.05
445-450	3.44	0.540	0.11	0.010	10	0.03
450-455	1.48	0.140	0.04	0.004	5	-0.02
455-460	0.33	0.015	-0.01	0.001	-5	0.09
460-465	0.72	0.068	-0.02	0.004	10	-0.02
465-470	0.11	0.008	-0.01	0.002	5	-0.02
500-505	0.03	0.005	-0.01	-0.001	5	-0.02
540-545	0.05	0.010	-0.01	0.001	5	0.02

Summary of Geology

- 0- 52' Overburden.
- 52-314' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 5% pyrite as dissemination.
- 314-404' Mudstone; massive to well bedded, locally silty, siliceous or talcose. 3 to 5, locally 20 to 30% pyrite as disseminations and laminae.
- 404-445' Talc and talc-carbonate exhalite; locally brecciated. 1 to 5% pyrite as disseminated grains & laminae. Trace to 5% sphalerite. Trace to 1% aguilarite.
- 445-463' Mudstone; locally silty, siliceous or talcose. 1 to 3% pyrite, trace sphalerite and aguilarite.
- 463-574' Siltstone; massive to poorly bedded locally siliceous to fragmented. Trace to 3% pyrite.

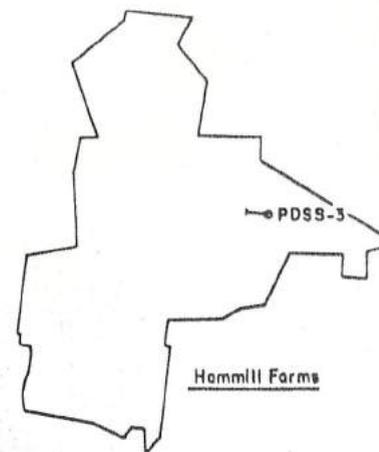
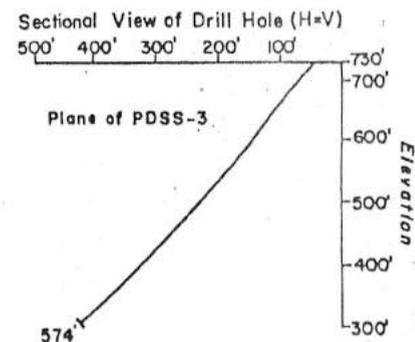
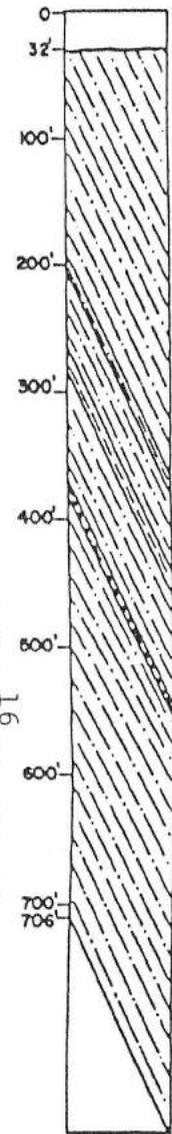


Figure 10

SILVER SHAFT PROJECT Hammill Farms, Cabarrus Co., N.C. Drill Hole PDSS-3 collar elevation = 730'			
SCALE:	H:	CONTOUR INTERVAL:	REVISIONS:
V:		DATE June, 81	BY: R.J.M.

Geologic Log



Siltstone  
Mudstone  
Reworked rhyodacite  
crystal-lithic tuff

Assay Log

Sample Interval	Ag ppm	Zn%	Pb%
0-350		Not Assayed	
350-355	.9	.005	-.01
355-360	.6	.006	-.01
360-365	.9	.006	-.01
365-370	.2	.005	-.01
370-375	.2	.004	-.01
375-380	.9	.004	-.01
380-385	.4	.003	-.01
385-390	.4	.006	-.01
390-395	.4	.003	-.01
395-400	.4	.003	-.01
400-405	.5	.004	-.01
405-410	.5	.003	-.01
410-415	.5	.003	-.01
415-420	.4	.003	-.01
420-425	.2	.003	-.01
425-430	(.2	.003	-.01
430-435	(.2	.003	-.01
435-440	.2	.003	-.01
440-445	(.2	.003	-.01
445-450	(.2	.002	-.01
450-706		Not Assayed	

Summary of Geology

0- 32' Overburden.  
 32-186' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 3% disseminated pyrite.  
 186-195' Silty mudstone; intimately mixed with siltstone. Trace pyrite.  
 195-256' Siltstone, massive to poorly bedded, locally siliceous to fragmented. Trace to 3% disseminated pyrite.  
 256-273' Mudstone; poorly to well bedded, chloritic in lower portion. Trace to 5% pyrite as disseminated and laminae.  
 273-364' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 3% disseminated pyrite.  
 364-370' Reworked rhyodacitic crystal-lithic tuff. Silty, chloritic matrix.  
 370-706' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 3% pyrite.

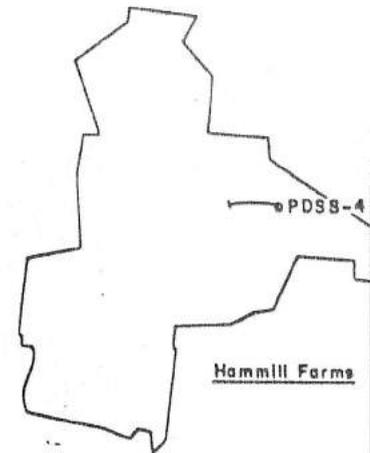
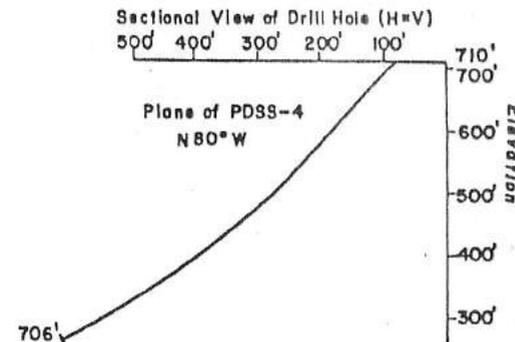


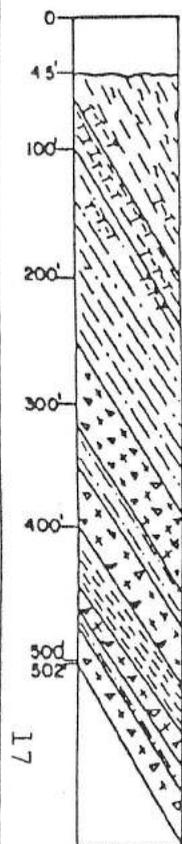
Figure 11

*Professional Geologist Registration No. 12345*

**SILVER SHAFT PROJECT**  
 Hammill Farms, Cabarrus Co., N.C.  
 Drill Hole PDSS-4  
 collar elevation = 710'

SCALE	NO.	CONTOUR INTERVAL:	REVISIONS
1"	1	10'	
DATE	JUN 81	BY	R. J. M.

Geologic Log



Assay Log

Sample Interval	Ag ppm	Zn %	Pb %
0 - 45		Not Assayed	
45 - 50	.5	.009	(.01)
50 - 55	.7	.009	(.01)
55 - 60	.4	.007	(.01)
60 - 65	.5	.010	(.01)
65 - 70	1.0	.009	(.01)
70 - 75	1.0	.009	(.01)
75 - 80	.6	.009	(.01)
80 - 85	1.0	.013	(.01)
85 - 90	1.0	.021	(.01)
90 - 95	.3	.015	(.01)
95 - 100	2.0	.012	(.01)
100 - 105	1.5	.020	(.01)
105 - 110	1.3	.030	(.01)
110 - 115	2.0	.024	(.01)
115 - 120	1.7	.024	(.01)
120 - 125	1.9	.170	(.01)
125 - 130	1.4	.008	(.01)
130 - 135	2.2	.035	(.01)
135 - 140	1.1	.025	(.01)
140 - 145	.5	.013	(.01)
145 - 150	.7	.006	(.01)
150 - 155	.5	.005	(.01)
155 - 160	.8	.006	.01
160 - 165	.2	.004	(.01)
165 - 170	(.2)	.002	(.01)
170 - 175	.7	.004	(.01)
175 - 180	.4	.006	(.01)
180 - 185	.3	.003	(.01)
185 - 190	.3	.005	(.01)
190 - 195	.6	.002	(.01)
195 - 200	1.0	.011	(.01)
200 - 205	.5	.006	(.01)
205 - 210	2.5	.006	(.01)
210 - 215	8.7	.006	(.01)
215 - 220	12.4	.006	.01
220 - 225	10.2	.006	.01
225 - 230	3.4	.004	(.01)
230 - 235	.3	.003	(.01)
235 - 240	(.2)	.002	(.01)
240 - 502		Not Assayed	

Summary of Geology

- 0 - 45' Overburden.
- 45 - 61' Mudstone; talcose to sericitic 1-5% pyrite as disseminations and laminae.
- 61 - 100' Mudstone; talcose with locally abundant 1-5 cm thick talc horizons. 3-5% locally 10-15% pyrite as disseminations and laminae.
- 100 - 248' Mudstone; often silty, locally siliceous to talcose. 1-5% disseminated pyrite.
- 248 - 502' Alternating rhyodacitic crystalline tuff and silty mudstone/siltstone. 1-5% disseminated pyrite, trace sphalerite.

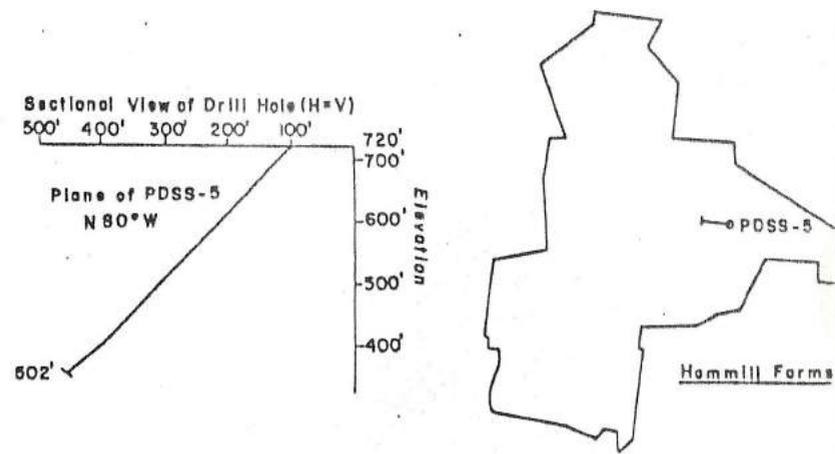


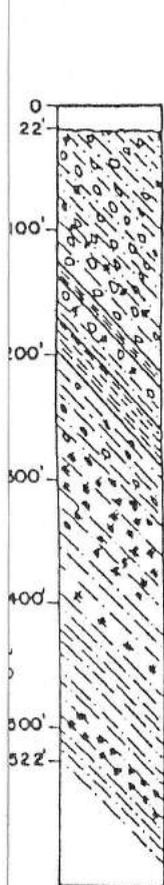
Figure 12

SILVER SHAFT PROJECT Hammill Farms, Cabarrus Co., N.C. Drill Hole PDSS-5 collar elevation = 720'		
SCALE	H: V:	CONTOUR INTERVAL: DATE: June, '81 BY: R.J.M.

Geologic Log

Assay Log

Summary of Geology



-  Siliceous Siltstone w/ fragments
-  Silty Mudstone
-  Well bedded Chloritic Mudstone
-  Massive siliceous Siltstone

Sample Interval	Ag ppm	Zn %	Pb %
0- 50	Not Assayed	Assayed	
50- 55	.5	.114	-.01
80- 85	.5	.003	-.01
100-105	.5	.003	-.01
150-155	.5	.003	-.01
180-185	.5	.003	-.01
185-190	-.5	.003	-.01
190-195	.5	.002	-.01
195-200	.5	.002	-.01
200-205	.5	.003	-.01
205-210	.5	.008	-.01
250-255	.5	.003	-.01
300-305	.5	.005	-.01
350-355	-.5	.002	-.01
370-375	.5	.013	-.01
400-405	.5	.005	-.01
450-455	.5	.003	-.01
500-505	-.5	.004	-.01
505-522	Not Assayed	Assayed	

0- 22' Overburden

22-132' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 1% disseminated pyrite.

132-140' Mudstone; silty, chloritic. Trace pyrite.

140-183' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 1% disseminated pyrite.

183-207' Mudstone; silty to chloritic, moderately well bedded. 1 to 2% pyrite as lenses, laminae, and disseminated.

207-399' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 1% disseminated pyrite.

399-414' Silty mudstone; siliceous, finely bedded. Trace disseminated pyrite.

414-522' Siltstone; massive to poorly bedded, locally siliceous to fragmented. Trace to 1% pyrite.

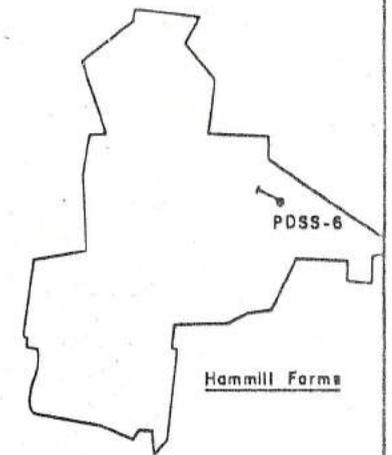
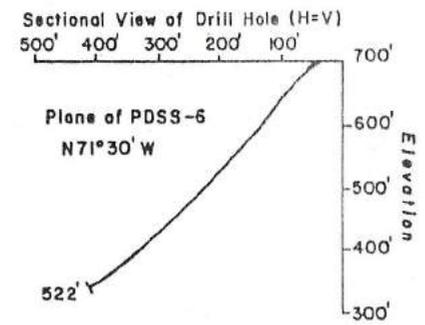
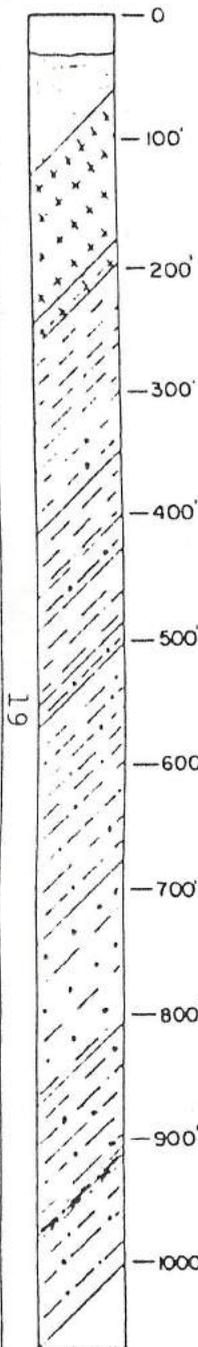


Figure 13

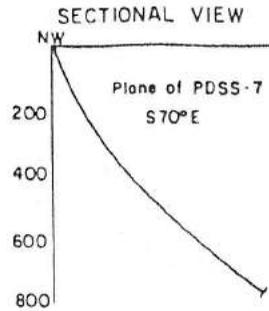
SILVER SHAFT PROJECT Hammill Farms, Cabarrus Co., N. C. Drill Hole PDSS-6 collar elevation = 700'		
SCALE	H'	CONTOUR INTERVAL
		REVISIONS

Geologic Log



Assay Log

Sample Interval	Ag ppm	Zn %	Pb %
100 - 101 feet	(.5	.006	(.01
125 - 126	.5	.003	(.01
130 - 151	1.0	.037	(.01
175 - 176	2.0	.240	.11
200 - 201	(.5	.003	(.01
225 - 226 feet	2.0	.310	.03
250 - 251	.5	.004	(.01
275 - 276	(.5	.003	(.01
300 - 301	(.5	.003	(.01
325 - 326	(.5	.004	(.01
350 - 351 feet	.5	.003	(.01
375 - 376	.5	.004	(.01
400 - 401	.5	.004	(.01
425 - 426	.5	.002	(.01
450 - 451	.5	.004	(.01
475 - 476 feet	.5	.009	(.01
500 - 501	1.0	.026	.01
525 - 526	1.0	.004	(.01
550 - 551	.5	.006	(.01
575 - 576	.5	.004	(.01
600 - 601 feet	(.5	.007	(.01
625 - 626	(.5	.004	(.01
650 - 655	.5	.006	(.01
655 - 660	.5	.006	(.01
660 - 665	.5	.003	(.01
665 - 670 feet	(.5	.003	(.01
670 - 675	(.5	.004	(.01
675 - 680	.5	.003	(.01
680 - 685	(.5	.003	(.01
685 - 690	(.5	.004	(.01
690 - 695 feet	(.5	.004	(.01
695 - 700	(.5	.005	(.01
700 - 705	(.5	.004	(.01
705 - 710	.5	.004	(.01
710 - 715	(.5	.004	(.01
715 - 720 feet	(.5	.004	(.01
720 - 725	.5	.004	(.01
725 - 730	.5	.003	(.01
730 - 735	(.5	.004	(.01
735 - 740	(.5	.004	(.01
740 - 745 feet	(.5	.003	(.01
745 - 750	.5	.004	(.01
750 - 755	(.5	.002	(.01
755 - 760	(.5	.004	(.01
760 - 765	.5	.003	(.01
765 - 770 feet	.5	.004	(.01
770 - 775	.5	.003	(.01
775 - 780	(.5	.003	(.01
780 - 785	(.5	.004	(.01
785 - 790 feet	.5	.003	(.01
790 - 795	(.5	.005	(.01
795 - 800	.5	.003	(.01
800 - 805	(.5	.004	(.01
805 - 810	.5	.004	(.01
810 - 815 feet	(.5	.006	(.01
815 - 820	(.5	.005	(.01
820 - 825	.5	.005	(.01
825 - 830	.5	.005	(.01
830 - 835	(.5	.004	(.01
835 - 840 feet	.5	.005	(.01
840 - 845	1.0	.007	(.01
845 - 850	.5	.005	(.01
850 - 855	1.0	.007	(.01
855 - 860	1.0	.005	(.01
860 - 865 feet	.5	.005	(.01
865 - 870	(.5	.004	(.01
870 - 875	1.0	.005	(.01
875 - 880	.5	.006	(.01



- Rhyolite ash/felsic mudstone
- Rhyolite/rhyodacite x-tal tuff
- Reworked rhy/rhyodac x-tal tuff
- Siliceous epiclastic siltstone
- Siliceous siltstone
- Chloritic silty mudstone
- Siliceous fragmented siltstone
- Sil. fragmented epi. siltstone
- Mixed silty mudstone & frag. silt.

Sample Interval	Ag ppm	Zn %	Pb %
800 - 885 feet	.5	.006	(.01
885 - 890	.5	.006	(.01
890 - 895	1.0	.005	(.01
895 - 900	.5	.005	(.01
900 - 905	(.5	.003	(.01
905 - 910 feet	(.5	.004	(.01
910 - 915	(.5	.006	(.01
915 - 920	(.5	.004	(.01
920 - 925	.5	.003	(.01
925 - 930	.5	.002	(.01
930 - 935 feet	.5	.002	(.01
935 - 940	(.5	.002	(.01
940 - 945	.5	.003	(.01
945 -1000	Not Assayed		

Summary of Geology

- 0 - 43' Overburden.
- 43 - 56' Rhyolite ash/felsic mudstone. Locally well laminated & locally silicified.
- 56 - 98' Rhyolite to rhyodacite crystal tuff. Locally silicified. Trace amounts of pyrite, galena & sphalerite quartz veins.
- 98 - 175' Rhyolite to rhyodacite crystall tuff. Trace to 1% pyrite, galena & sphalerite in quartz veins & disseminations.
- 175 - 202' Reworked equivalent of above rhyolite to rhyodacite crystal tuff. Trace to 1% disseminated pyrite & pyrrhotite.
- 202 - 302' Siliceous siltstone with minor intercalations of reworked rhyolite to rhyodacite crystall tuff. Trace to 1% disseminated pyrite & pyrite + sphalerite veinlets locally.
- 302 - 346' Siliceous epiclastic siltstone. Reworked quartz & feldspar crystals in a silty matrix. Trace to 1% sulfides as pyrite & pyrrhotite disseminations.
- 346 - 407' Siliceous siltstone with low epiclastic component. Trace to 1% sulfides as disseminated pyrite.
- 407 - 429' Epiclastic siltstone. Reworked crystals (qtz. & feld.) in a silty matrix. Trace to 1% pyrite as sprays along fractures. Trace pyrrhotite.
- 429 - 480' Dark grey siliceous siltstone locally containing cherty fragments. Trace pyrite as fine disseminations and sprays along fractures.
- 480 - 484' Chloritic silty mudstone. Trace pyrite.
- 484 - 505' Siliceous siltstone with minor epiclastic component. Trace pyrite as disseminations & sprays along frac.
- 505 - 543' Siliceous fragmented siltstone. Trace to 1% pyr. as disseminations.
- 543 - 672' Fragmented siltstone. Locally silicified & locally contains CO<sub>2</sub> healed fractures. Trace to 1% pyr.
- 672 - 815' Siliceous fragmented epiclastic siltstone. Locally silicified. Trace pyrite & pyrrhotite.
- 815 - 912' Siliceous epiclastic siltstone. Trace pyrite as fine disseminations and sprays. Trace pyrrhotite.
- 912 - 924' Siliceous silty mudstone.
- 924 - 934' Intermixed silty mudstone & fragmented siltstone.
- 934 -1000' Siliceous fragmented siltstone. Trace pyrrhotite.



Figure 14

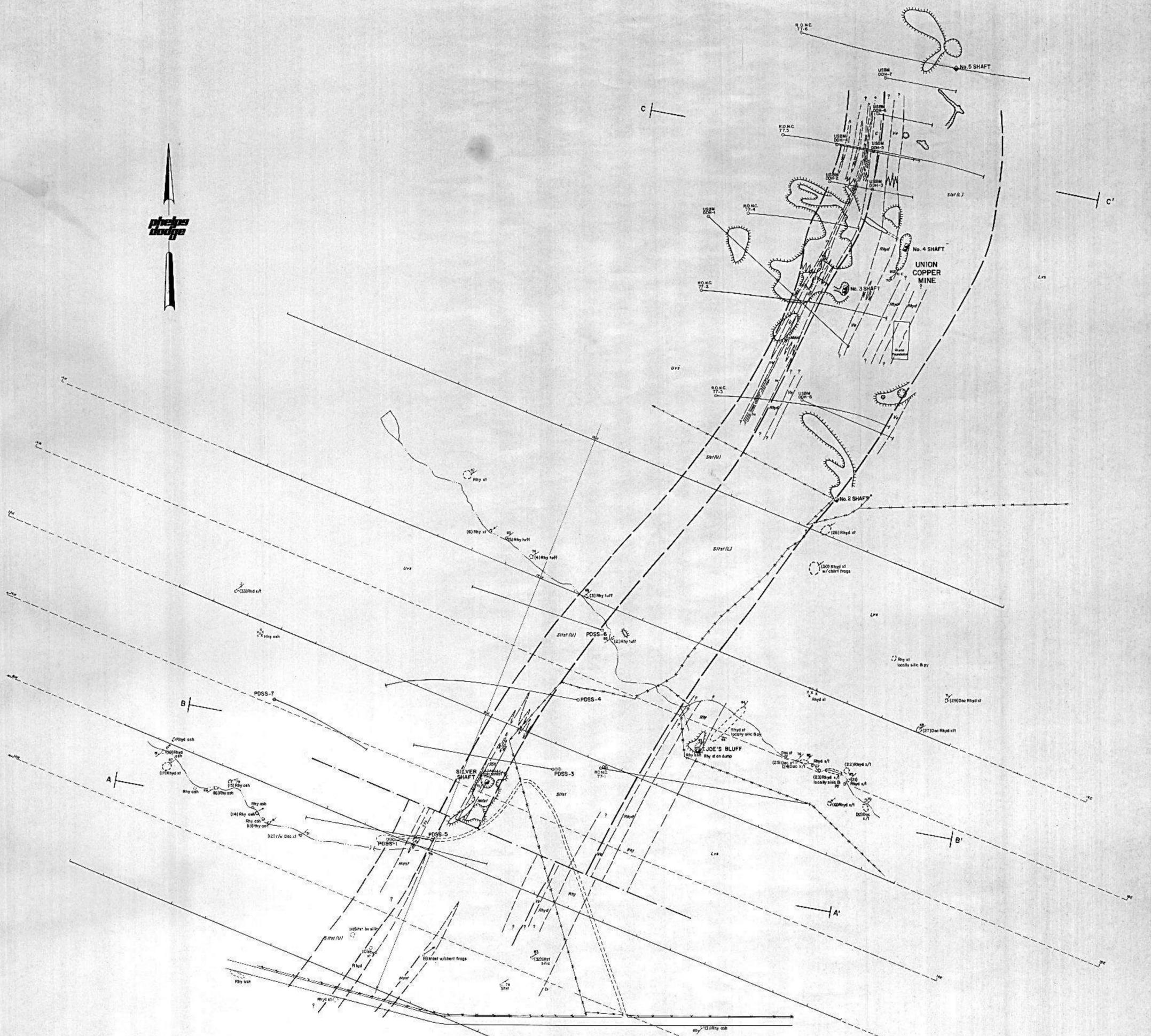
*phosphate analysis* Eastern Carolina State Univ.

**SILVER SHAFT PROJECT**  
Hammill Farms, Cabarrus Co., N.C.  
Drill Hole PDSS - 7  
collar elevation\* 720'

SCALE:	IN:	CONTOUR INTERVAL:	REVISIONS:
F:	DATE: Oct, 81	BY: R. J. M	
SHEET:	OF:	DRAWING NO:	FILE:

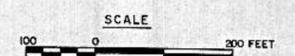
**2.9. Geological/location map, Silver Shaft Mine area, Cabarrus County, North Carolina. Phelps Dodge Exploration East, Raleigh, N.C., Scale 1 inch = 100 feet**

By Robert J. Moye, David F. Lee and R. B. Ludden



**EXPLANATION**

GEOLOGIC UNITS	OUTCROP LITHOLOGY	SYMBOLS
Mt Mafic tuff	Rhy Rhyolite	○ Limit of outcrop
Uvs Upper volcanic-sedimentary sequence	Rhyd Rhyodacite	✱ Float
Lvs Lower volcanic sequence	Dac Dacite	↘ Strike and dip of bedding
Slst Undifferentiated siltstone with intercalations of volcanics, epiclastics, and mudstone (U) Upper siltstone (L) Lower siltstone	And Andesite	↗ Strike and dip of foliation
Mdst Mudstone, locally siliceous to talcose	xt Crystal tuff	— Foliation strike trend
SSH Silver Shaft horizon Talc-carbonate chert exhalites	lt Lithic tuff	⊥ Vertical foliation
C Chert exhalite	Mdst Mudstone	↖ Strike and dip of joint
Rhyd Rhyodacitic crystal and crystal-lithic tuffs	Slst Siltstone	↗ Strike, dip, plunge of Union Copper ore body
Ve Reworked rhyodacite tuffs/volcanic epiclastics	Ve Volcanic epiclastic	⊠ Shaft
Rhy Rhyolite ash	Silic Siliceous	⊠ Dump
Formational contact	Py Pyrite	○ Open cut or pit
Unit contact	Pyrr Pyrrhotite (Pyrrhotitic)	○ Drill hole (USBM-US Bureau of Mines R.O.N.C. - Conoco)
Inferred fault	bx Breccia	⊠ Fence
	(10) Outcrop reference number	⊠ Gate



*Philip Dodge Exploration, Inc.*

**GEOLOGIC / LOCATION MAP**

**SILVER SHAFT MINE AREA**

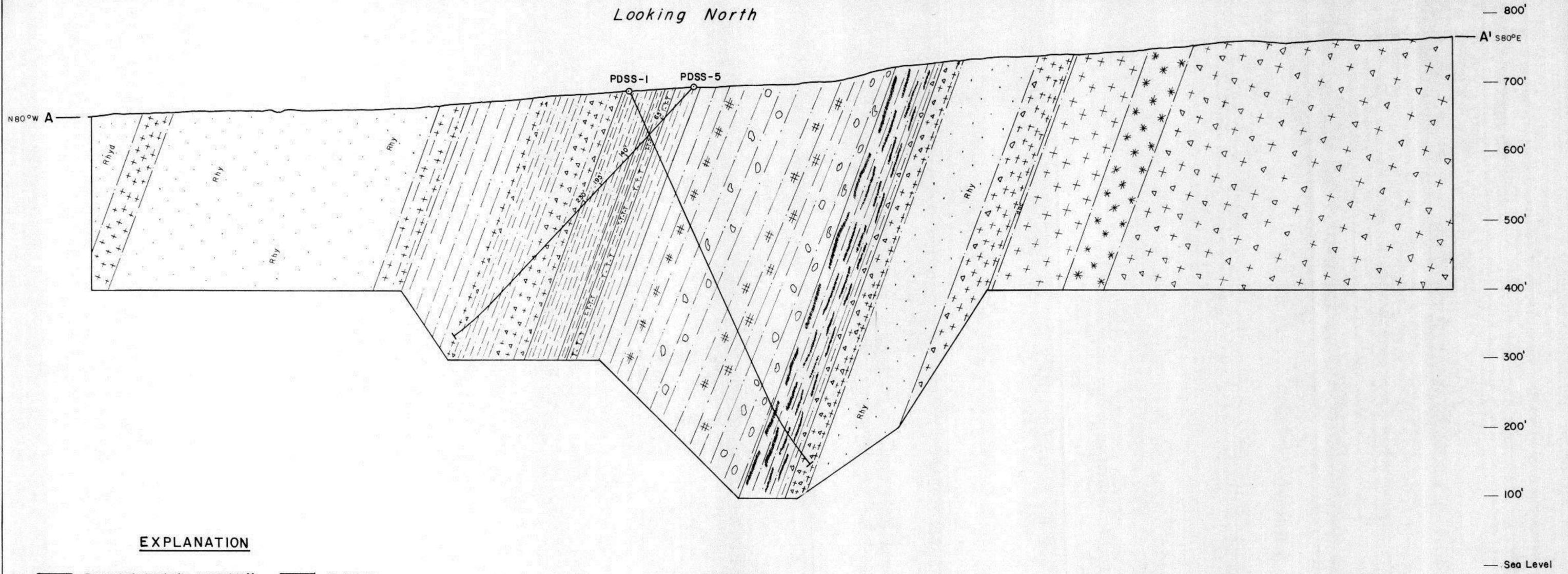
Cobarrus County, North Carolina

SCALE: H: 1" = 100'	CONTOUR INTERVAL:	REVISIONS
V:	DATE: JULY, 1981	BY: R.J.M., D.F.L., R.B.L.
SHEET OF	DRAWING NO:	FILE:

**2.10. Geologic cross section A-A', Silver Shaft Mine area, Cabarrus County, North Carolina. Phelps Dodge Exploration East, Raleigh, N.C., Scale 1 inch = 100 feet**

By Robert J. Moye

Looking North

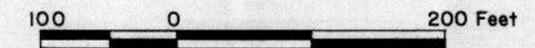


**EXPLANATION**

- |  |                                   |  |                              |
|--|-----------------------------------|--|------------------------------|
|  | Re-worked rhyodacite crystal tuff |  | Mudstone                     |
|  | Ryodacite crystal tuff            |  | Fragmented                   |
|  | Rhyolite ash                      |  | Siliceous                    |
|  | Rhyodacite ash                    |  | Talc                         |
|  | Dacite crystal tuff               |  | Pyrrhotite laminae           |
|  | Dacite tuff                       |  | Lithologic contact           |
|  | Rhyodacitic crystal-lithic        |  | Projected lithologic contact |
|  | Volcanic epiclastic               |  | Drill hole                   |
|  | Siltstone                         |  | Limit of drill hole data     |
|  | Silty mudstone                    |  | Mineralized zone             |

**PDSS - 5**  
 65' - 140' - Anomalous silver values  
 195' - 230' - Anomalous silver values

**SCALE**

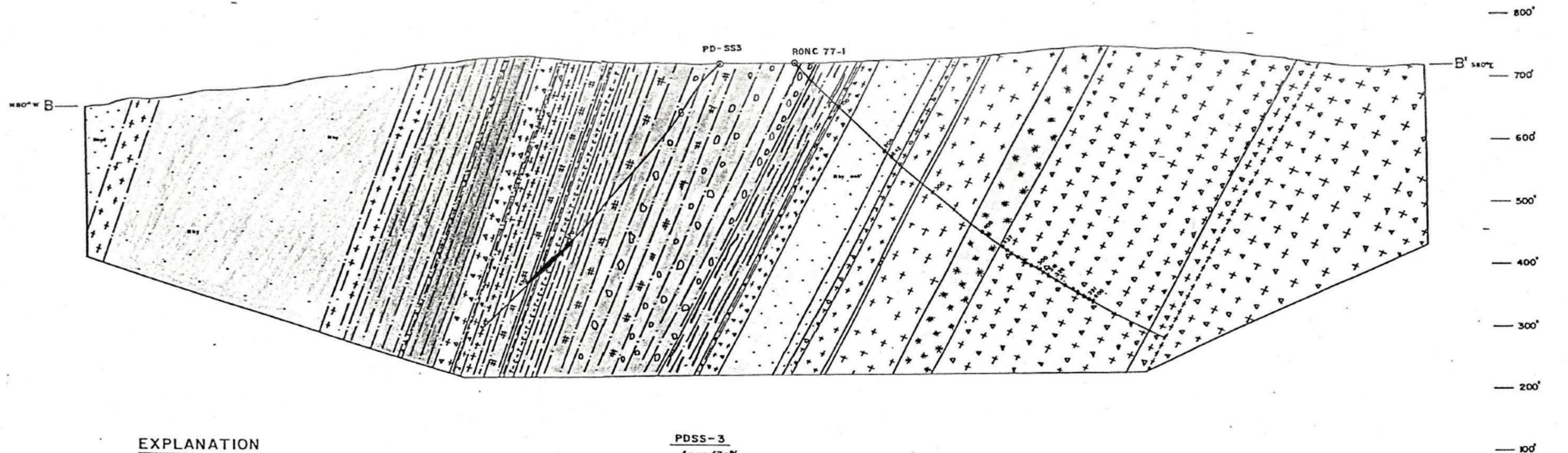


<b>phelps dodge</b> Exploration East, Inc.			
<b>CROSS SECTION SS-A-A'</b>			
<b>SILVER SHAFT MINE AREA</b>			
Cabarrus County, North Carolina			
<b>SCALE</b>	H: 1" = 100'	<b>CONTOUR INTERVAL:</b>	
	V:	DATE: JUNE, 1981	BY: R. J. M.
<b>SHEET</b>	<b>OF</b>	<b>DRAWING NO:</b>	<b>FILE:</b>

**2.11. Geologic cross section B-B', Silver Shaft Mine area, Cabarrus County, North Carolina. Phelps Dodge Exploration East, Raleigh, N.C., Scale 1 inch = 100 feet**

By Robert J. Moye

Looking North



EXPLANATION

- |  |  |  |                              |
|--|--|--|------------------------------|
|  | Re-worked rhyodacite crystal tuff          |  | Mudstone                     |
|  | Rhyodacite crystal tuff                    |  | Fragmented                   |
|  | Rhyolite ash                               |  | Siliceous                    |
|  | Rhyodacite ash                             |  | Talc-carbonate exhalite      |
|  | Dacite crystal tuff                        |  | Pyrrhotite laminae           |
|  | Dacite tuff                                |  | Lithologic contact           |
|  | Rhyodacite crystal and crystal-lithic tuff |  | Projected lithologic contact |
|  | Volcanic epiclastic                        |  | Drill hole                   |
|  | Siltstone                                  |  | Limit of drill hole data     |
|  | Silty mudstone                             |  | Mineralized zone             |

PDSS-3	
Ag oz / Zn %	
3rd	.38/120
	.31/009
	.35/01
	3.50/050
	.40/014
4th	.26/026
	.61/031
	.76/076
	1.40/280
	1.40/222
	6.13/148
	.35/164
	4.85/150
	13.89/248
	13.56/440
4th	3.44/540
	1.48/140
	.33/025
	.72/068
4th	.11/008

8.89ozAg / 1.26%Zn

SCALE



Figure 5

phelps dodge Exploration East, Inc.

CROSS SECTION SS-B-B'  
SILVER SHAFT MINE AREA

Cabarrus County, North Carolina

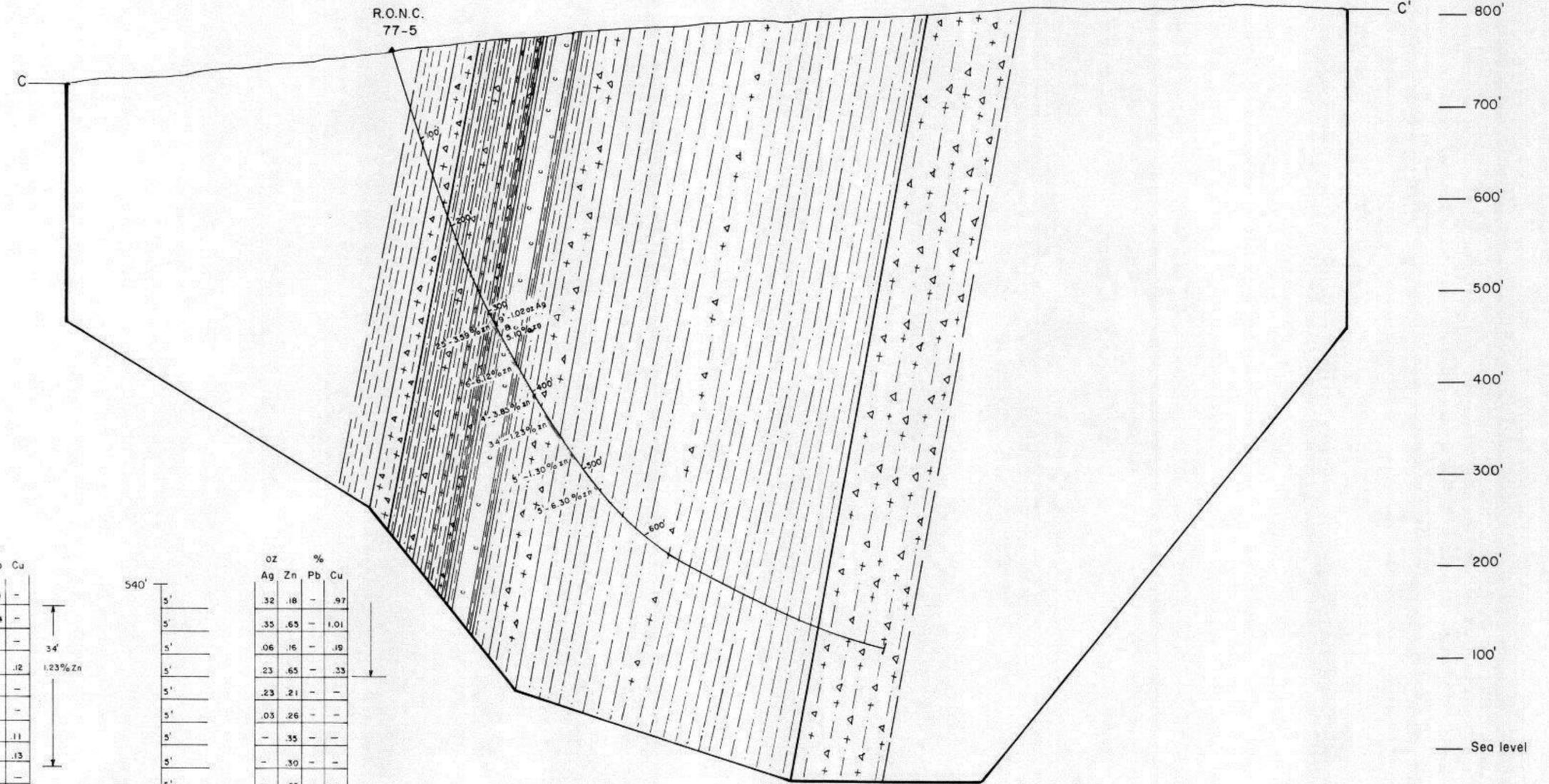
SCALE	H: 1" = 100'	CONTOUR INTERVAL:		REVISIONS	
	V:	DATE: JUNE, 1981	BY: R.J.M.		
SHEET	OF	DRAWING NO.:		FILE:	

**2.12. Geologic cross section C-C', Silver Shaft Mine area, Cabarrus County, North Carolina. Phelps Dodge Exploration East, Raleigh, N.C., Scale 1 inch = 100 feet**

By Robert J. Moyer

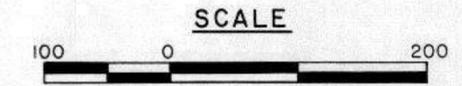
Looking North

-  Undifferentiated lower volcanic sequence
-  Undifferentiated upper volcanic sequence
-  Rhyodacite crystal tuff
-  Epiclastic/reworked tuff
-  Siltstone
-  Mudstone
-  Talc-carbonate exhalite
-  Chert exhalite
-  Formation contact
-  Lithologic contact (approximate where dashed)



DDH RONC - 77-5

Elevation (ft)	Interval (ft)	oz		%			
		Ag	Zn	Pb	Cu		
303	5'	.02	.05	.013	.015		
308	5'						
313	5'	.12	.056	.015	.007		
316	3'	1.49	3.15	.25	.07		
319	3'	.88	5.10	.24	.05		
322	3'	102/3.10	7.05	.23	.03		
328	6'	.38	2.15	.12	.11		3.59% Zn
338	5'		1.85	.17	.15		
455	5'		4.35	.24	.12		
459	4'		.65				
464	5'		.44				
468	5'		.77				
473	5'		.48				
363	5'		.49	.13			
365	2'		.06	.41	.14		
368	3'		.23	7.00	.25	.33	
371	3'		.15	3.25	.18	.25	
500	5'		.06	.79		.20	
503	5'		.12	1.35	.20	.10	
509	5'		.06	.72	.30		
514	5'			.53	.21		
520	6'			.31	.22		
585	5'		.06	.71	.28		
589	4'		.15	3.85	.37	.12	4' 3.85% Zn
604	5'		.03	.71	.10		
610	5'			.72	.19		
420	4'			.63			
420	4'			.57			
420	5'			.45	.10		
459	5'		1.45	.34			34'
468	5'		1.30		.12		1.23% Zn
473	5'		1.28				
485	5'		.59				
499	5'		1.39		.11		
503	5'		1.72		.13		
509	5'		.80				
514	5'		.60				
520	5'		.60				
526	5'		.85				
532	5'		1.30		.29		5' 1.30% Zn
538	5'		.50		.21		
544	5'		.21		.34		
550	5'				.32		
556	5'				.35		
562	5'				.30		
568	5'				.25		
574	4'				.22		
580	5'				.27		
586	5'						
592	5'				.17		
598	6'				.19		
604	5'						
610	6'						
420	5'		.06	6.80		.46	6' 6.80% Zn
426	5'		.26		.40		
432	5'		.16		.60		
438	5'		.06		.27		
444	5'						40'
450	5'						0.65% Cu



**phelps dodge** Exploration East, Inc.

**CROSS SECTION C-C'**  
**UNION COPPER MINE AREA**  
Cabarrus County, North Carolina

SCALE	H: 1" = 100'	CONTOUR INTERVAL:		REVISIONS	
	V:	DATE: JULY, 1981	BY: R. J. M.		
SHEET	OF	DRAWING NO:		FILE:	

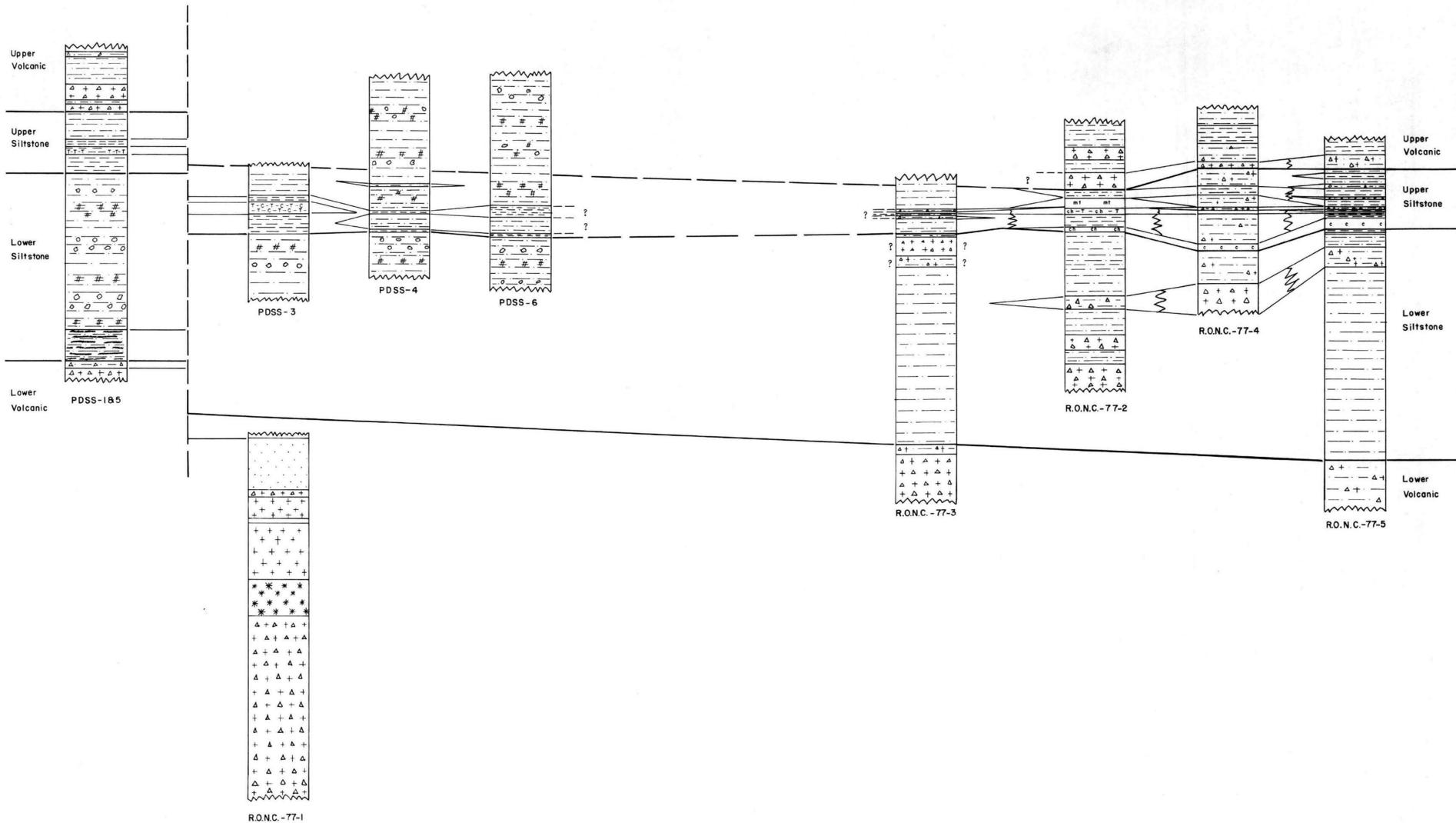
**2.13. Longitudinal cross section and drill hole correlation diagram with idealized stratigraphic column, Silver Shaft Mine area, Cabarrus County, North Carolina. Phelps Dodge Exploration East, Raleigh, N.C., Scale 1 inch = 100 feet**

By Robert J. Moyer

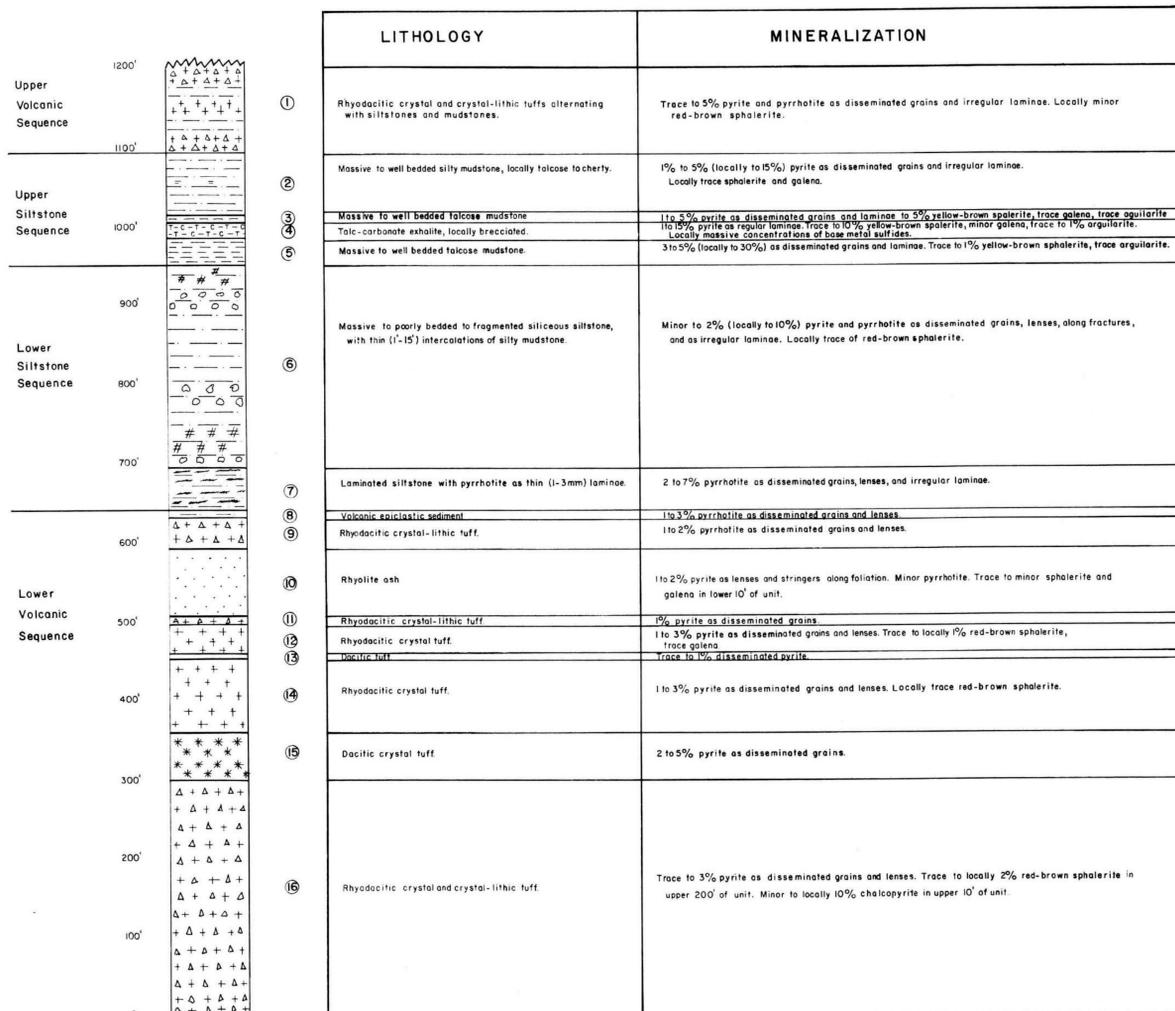
# CORRELATION DIAGRAM of PHELPS DODGE and CONOCO DRILL HOLES

## SILVER SHAFT AREA

## UNION COPPER AREA



## IDEALIZED STRATIGRAPHIC COLUMN SILVER SHAFT MINE — JOE'S BLUFF AREA



*phelps dodge* Exploration East, Inc.

### SILVER SHAFT MINE PROJECT

Cabarrus County, North Carolina

SCALE	H: 1" = 100'	CONTOUR INTERVAL:	REVISIONS
	V:	DATE: MAY, 1981	BY: R.J.M.
SHEET	OF	DRAWING NO:	FILE:

### **3.0. Geology and mineral deposits of the Cid District, Davidson County, North Carolina**

**3.1. Reconnaissance report for Silver Hill area mines and Silver Valley Mine,  
Davidson County, North Carolina, for Cyprus Mines Corporation and Louisiana Land  
and Exploration Company**

By Earl M. Jones

*Silver Hill  
Outside Prospects*

Reconnaissance Report for Silver Hill Area Mines

Silver Valley Mine

Surface features consist of a large dump area with foundation remains of an old mill. Attached to the dump is a shaft which appears to be inclined underneath the dump. There may be a filled in shaft inside the old foundations. To the northeast of this dump is another smaller dump with a shaft to the west of it and a prospect pit north of it.

The main dump rock is a cherty looking light gray rhyolite (the shaft is sunk into it). There is little mineralization in it. Massive red or white quartz is the next most abundant rock. A mafic rock (andesite basalt ?), black, fine grained, sugary textured, and sparkly, contains the most mineralization with disseminated pyrite, galena, and chalcopyrite. Lastly, a highly weathered rock occurs in outcrop below the northern dump which appears to be a fine grained bedded tuff. It is extremely hard, red and tan colored, and clearly bedded with no mineralization except for possible sulfides along bedding planes.

Andesite basalt and rhyolite (with pyrite mineralization) are found in the stream between the two dumps.

Three sample lines were taken between the two dump areas at N30W to crosscut the trend.

Much flagging plus some aluminum foil and wire were found in the area indicating recent geochemical and geophysical surveys.

### Conrad Hill Mine

Surface features include one main dump area, the main shaft just to the east, and two clusters of shallow shafts north and northeast of the dump area.

The country rock in the area is a serpycite schist, but the mine rock is a combination of white quartz and siderite. Euhedral crystals of both can be found on the rock piles. The next most abundant mineral is botryoidal and specular hematite. Also, small amounts of chalcopyrite and chalcocite can be found.

General geologic evidence seems to indicate that the quartz mass is an intrusive into the country rock.

Four samples lines were run in a N65W direction above and below the mine area to crosscut the main part of the intrusive body.

### Emmons Mine

There are no surface features except for some bricks underneath an old oak tree. The shaft is apparently in the middle of a corn field and filled in.

The only outcrops are along the roadside. They are a very silty mudstone, similar to argillite, with generally blocky cleavage (sometimes fissile). They usually have a dark red color and are fine grained, but occasionally have a red and white color and are coarse grained. All outcrops are highly weathered and some are faintly laminated.

Some float in a nearby field is a mafic schist with disseminated pyrite mineralization.

Samples were taken along two roads to crosscut the trend which is determined by an imaginary line between the Cid and Emmons Mine.

#### Cid Mine

There are no surface features except a small pit ( 1' deep)near the intersection of Cid Road and Old Highway 109.

There are no outcrops in the area except some argillite looking mudstone which is similar to that found near the Emmons Mine. One thousand feet below the intersection is a dike looking feature which may be quartz monzonite. In the same area, coarse grained tuff float was noticed.

Soil sample lines were taken along both roads to cover the imaginary trend between the Cid Mine and Emmons.Mine.

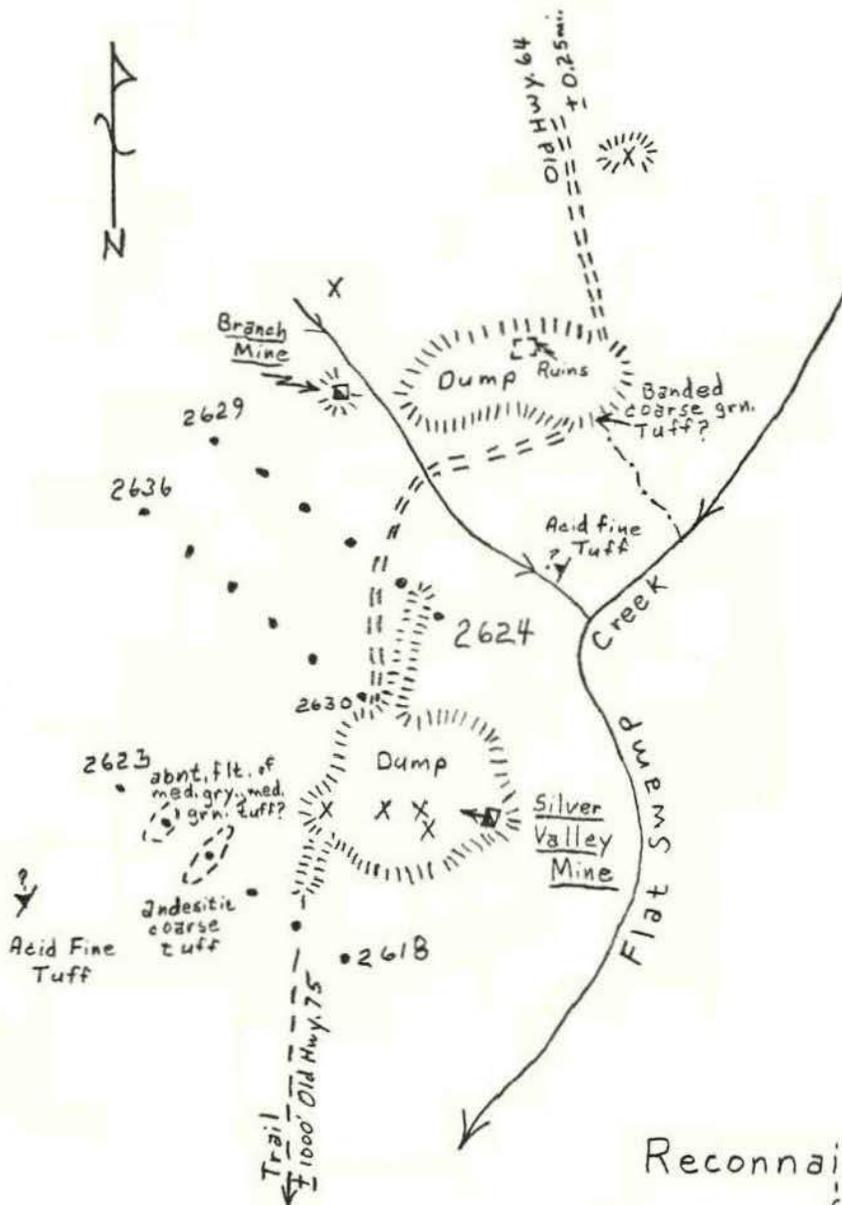
#### Sechrist Mine

There are no surface features except a filled in shaft seventy five feet north of Route 47.

The roadcut reveals a sandy argillite, sometimes silicified and outcropping massively. A few laminations can be seen.. Some argillite shows little pieces of breccia when broken open. To the east of the argillite is an andesite basalt, light green and medium to coarse grained. Andesite basalt float is found south of the road also.

The Silver Hill Fault is projected between the two units and seems to be substantiated by the breccia and silicification found in the area.

Three soil sample lines were taken in an EW direction, one on the road, the next five hundred feet south of the road, and the last, nine hundred feet south of the road, with an equal number of samples taken in each unit. The purpose was to cover the trend area between th Silver Hill Mine and the Sechrist Mine.

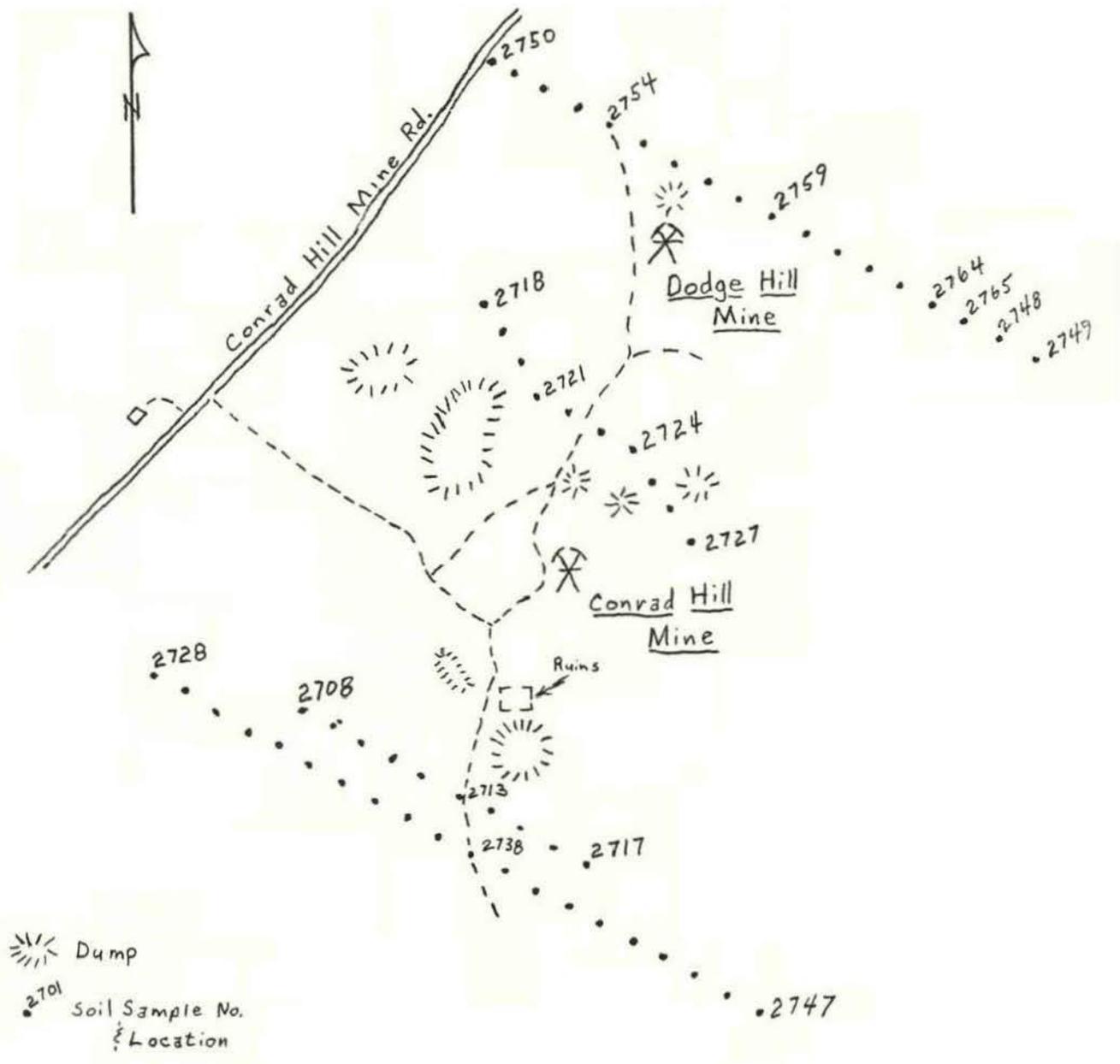


Reconnaissance Map  
 &  
 Soil Sample Locations  
 of the  
 SILVER VALLEY MINE  
 Davidson Co., N.C.

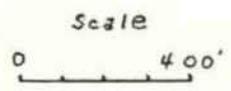
- ▣ Shaft
- X Pit
- ☼ Dump
- 2620 Soil Sample
- No. & Location

Scale  
 0 ————— 300'  
 (APPROX.)

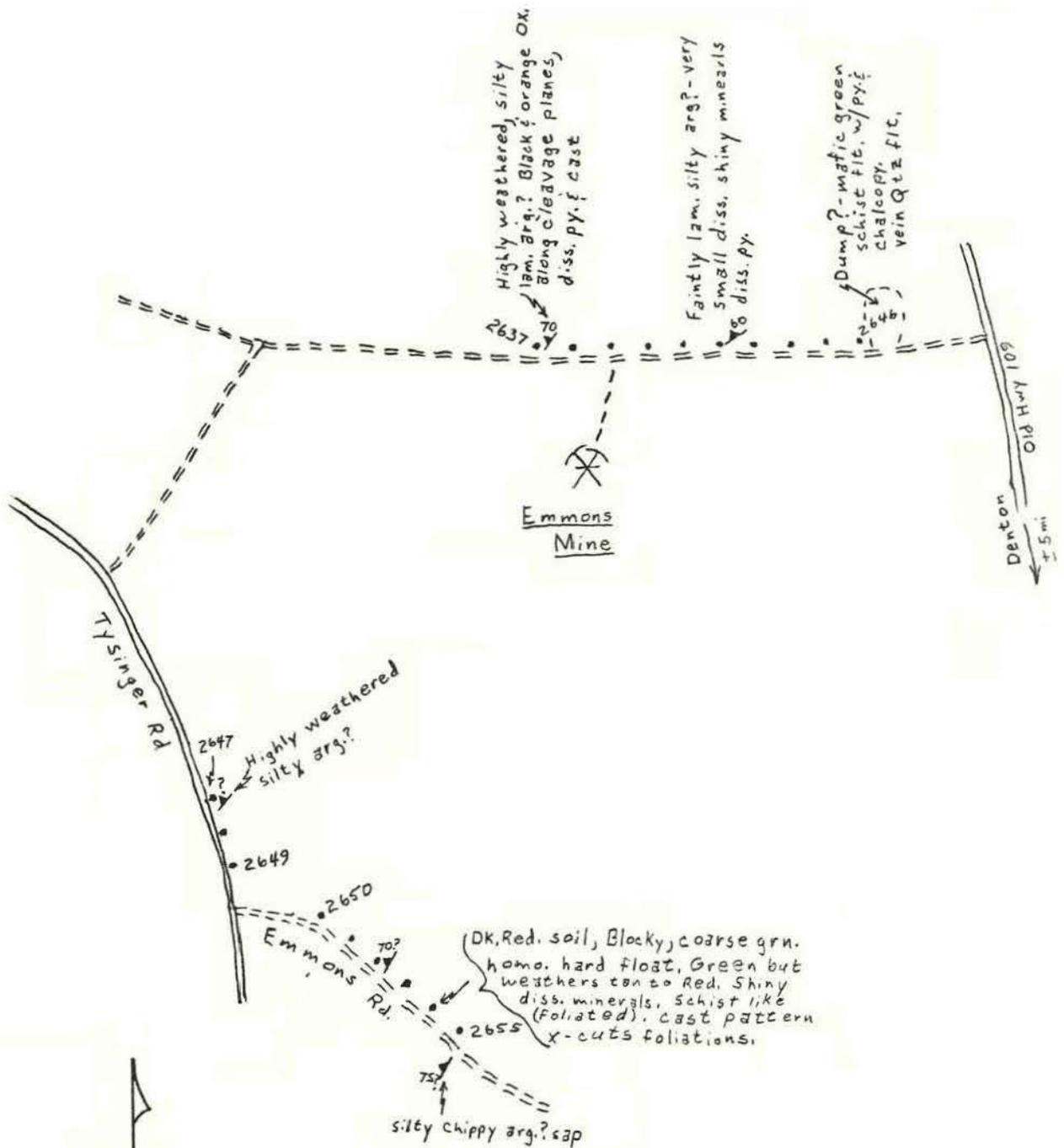
Note: Soil Sample Nos. Preceded  
 by 74-01A-?



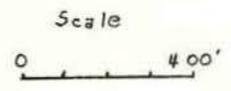
Soil Sample Locations  
of the  
CONRAD HILL MINE AREA  
Davidson Co., N.C.



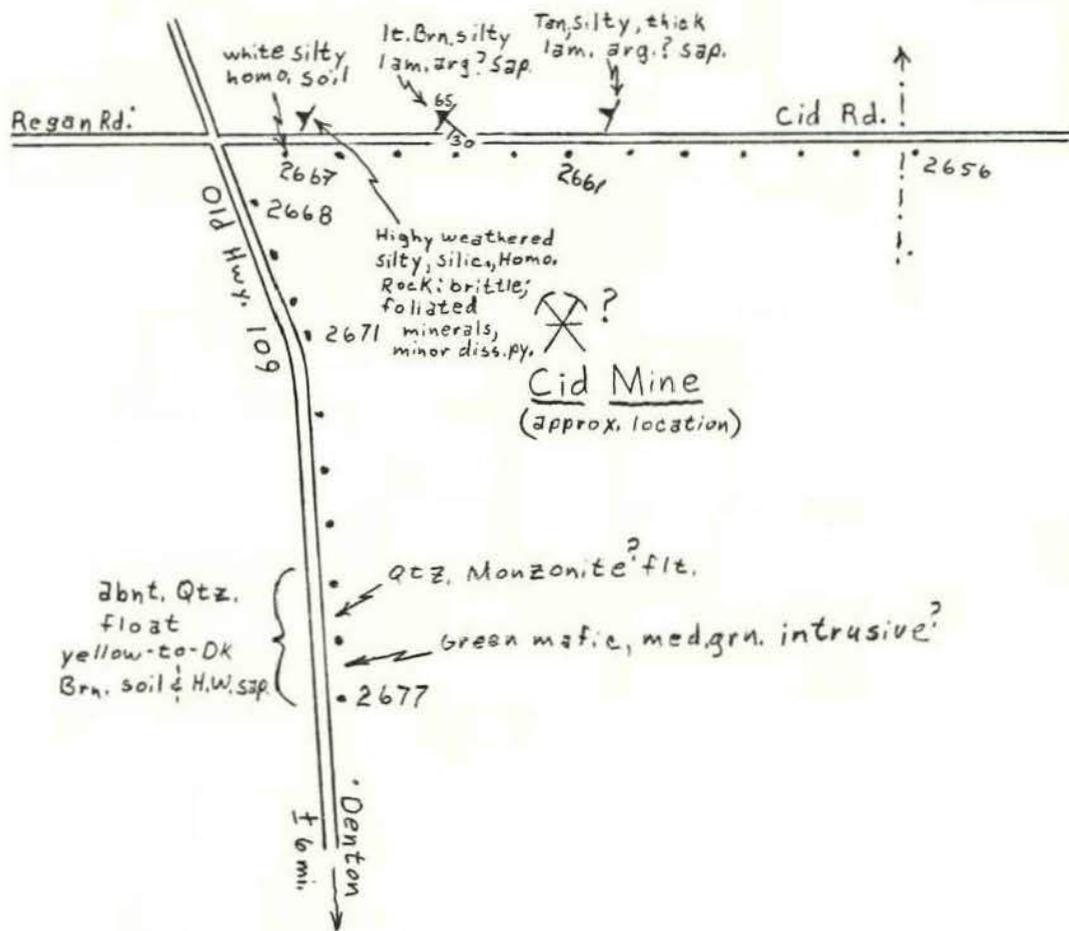
Note: Soil Sample Nos. Preceded  
by 74-01A-?



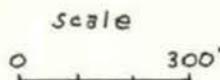
Soil Sample Locations  
of the  
**EMMONS MINE AREA**  
Davidson Co., N. C.



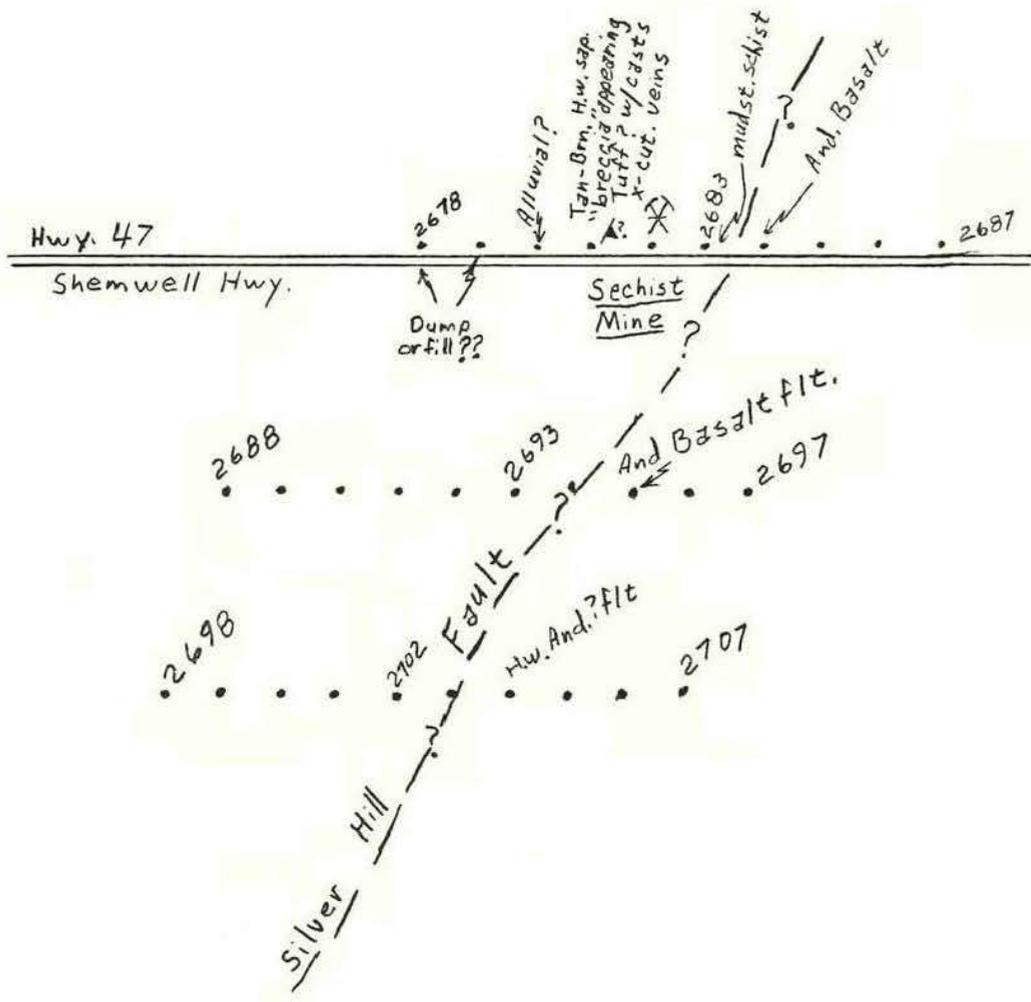
Note: Soil Sample Nos. Preceded  
by 74-01A-?



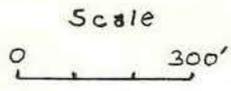
Reconnaissance Map  
 &  
 Soil Sample Locations  
 of the  
 CID MINE AREA  
 Davidson Co., N.C.



Note: Soil Sample Nos. Preceded by 74-01A-?



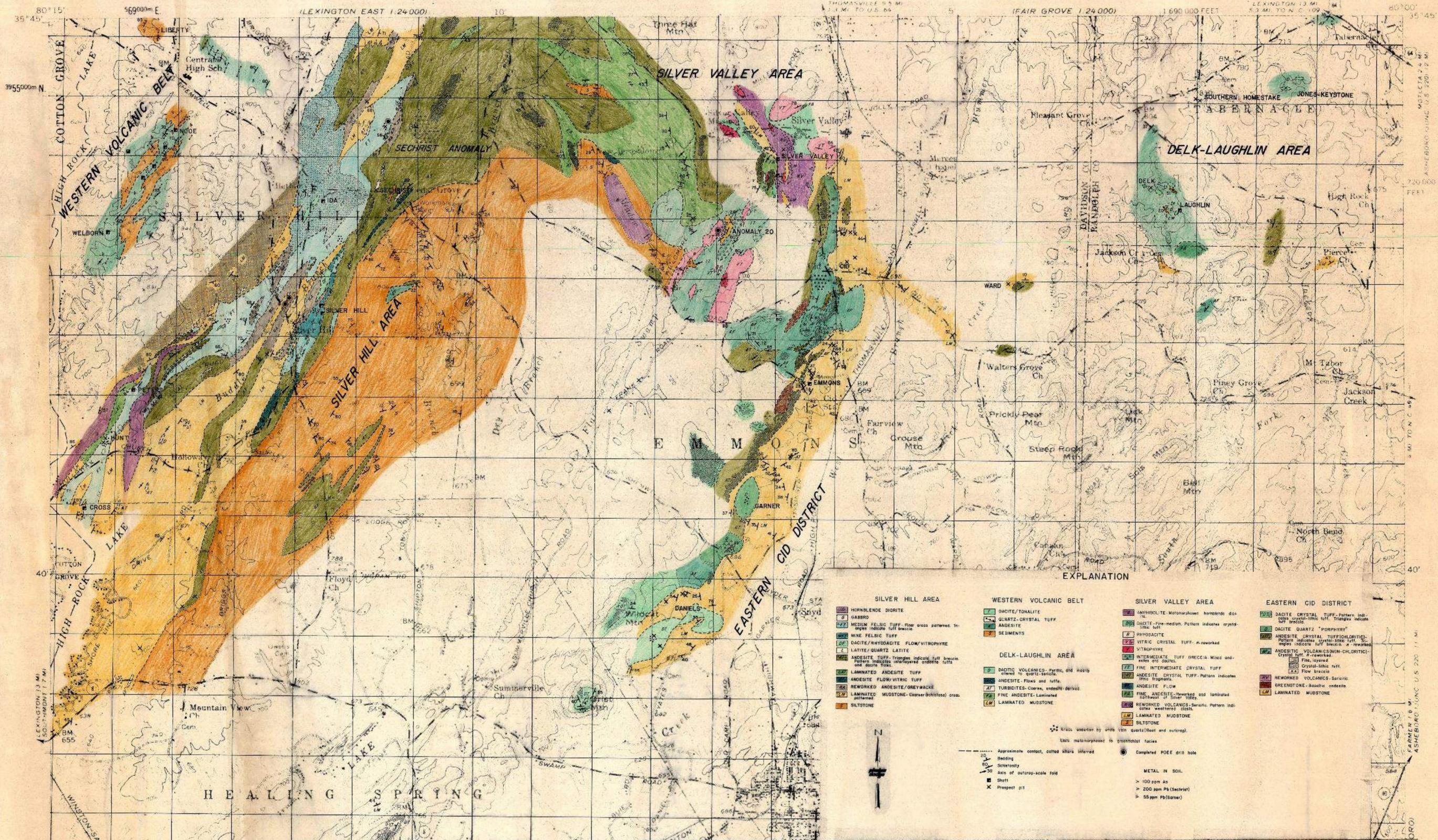
Soil Sample Locations  
of the  
**SECHRIST MINE AREA**  
Davidson Co., N.C.



Note: Soil Sample Nos. Preceded  
by 74-01A-?

**3.2. Geologic map, Cid Mining District, Davidson County, North Carolina, Phelps Dodge Exploration East, Raleigh, N.C., scale 1 inch = 2,000 feet**

By Phelps Dodge Exploration East, 1978



**EXPLANATION**

SILVER HILL AREA	WESTERN VOLCANIC BELT	SILVER VALLEY AREA	EASTERN CID DISTRICT
100 HORNBLende DIORITE	10 DACTITE/TONALITE	100 ANHIDRite Metasandstone hornblende dolo	100 DACTITE CRYSTAL TUFF-Pattern indi-
101 GABBRO	11 QUARTZ-CRYSTAL TUFF	101 DACTITE-Fine-medium. Pattern indicates crystal-	101 DACTITE QUARTZ "PORPHYRY"
102 MEDIUM FELSIC TUFF. Flow areas patterned. In-	12 ANDESITE	102 RHYODACITE	102 ANDESITE CRYSTAL TUFF/CLORITIC-
103 MINE FELSIC TUFF	13 SEDIMENTS	103 VITRIC CRYSTAL TUFF. Reworked	103 ANDESITE CRYSTAL TUFF. Pattern indicates
104 DACTITE/RHYODACITE FLOW/VITROPHYRE		104 VITROPHYRE	104 ANDESITIC VOLCANICISM-CHLORITIC-
105 LATITE/QUARTZ LATITE		105 INTERMEDIATE TUFF (BRECCIA. Mixed and-	105 FINE, layered
106 ANDESITE TUFF. Fringes indicate tuff breccia and		106 FINE INTERMEDIATE CRYSTAL TUFF	106 CRYSTAL-LIQUID TUFF
107 LAMINATED ANDESITE TUFF		107 ANDESITE CRYSTAL TUFF. Pattern indicates	107 FINE BRACIOLE
108 REWORKED ANDESITE/GREYWACKE		108 ANDESITE FLOW	108 REWORKED VOLCANICIS. Sericite. Pattern indi-
109 LAMINATED MUDSTONE-Claystone (Siltstone) areas		109 FINE ANDESITE. Reworked and laminated	109 GREENSTONE-Basaltic andesite
110 SILTSTONE		110 LAMINATED MUDSTONE	110 LAMINATED MUDSTONE
		111 SILTSTONE	

**DELK-LAUGHLIN AREA**

10 DACTITE VOLCANICIS. Pattern, dolo and	100 DACTITE METAMORPHOSIS TO GREENSTONE FACIES
11 ANDESITE-Flows and tuffs	101 DACTITE METAMORPHOSIS TO GREENSTONE FACIES
12 TURBIDITES-Clayey, andesitic debris	102 DACTITE METAMORPHOSIS TO GREENSTONE FACIES
13 FINE ANDESITE-Laminated	103 DACTITE METAMORPHOSIS TO GREENSTONE FACIES
14 LAMINATED MUDSTONE	104 DACTITE METAMORPHOSIS TO GREENSTONE FACIES

**Other Symbols:**

- Approximate contact, dotted where inferred
- Basins
- Schistosity
- Axis of outcrop-scale fold
- Shalt
- Prospect pit
- Completed POEE drill hole
- METAL IN SOIL:
  - > 100 ppm As
  - > 200 ppm Pb (Sechrist)
  - > 55 ppm Pb (Garner)

**PHELPS DODGE EXPLORATION EAST, INC.**  
**GEOLOGIC MAP**  
 CID MINING DISTRICT  
 DAVIDSON COUNTY, NORTH CAROLINA

SCALE: H: 1" = 2000'	CONTOUR INTERVAL:	REVISIONS:
V: 1" = 2000'	DATE: OCT, 1978	BY:
SHEET OF	DRAWING NO:	FILE:

#### **4.0. The Silver Hill Mine VMS deposit, Cid District, Davidson County, North Carolina**

#### **4.1. Core drilling location map, cross-sections, and core logs for the Silver Hill Prospect, Davidson County, North Carolina**

By Tennessee Copper Company, 1961



*File Copy - serial in 1.1*  
*Silver Hill Property*

# TENNESSEE COPPER COMPANY

DIVISION  
TENNESSEE CORPORATION  
NEW YORK OFFICE -- 61 BROADWAY  
COPPERHILL, TENN.

*Carr*  
*MWS*  
*CANT*

*Please Return*

Mine Office  
Ducktown, Tennessee  
May 10, 1961

Mr. T. A. M. Stevenson  
Box 427,  
Winston Salem, N. C.

Dear Mr. Stevenson:

Attached hereto is a report of the development and drilling at your Silver Hill Mine.

Surface drill holes were AX size, underground drill holes were EX size except for the down drilling from the 14 level crosscut which was AX.

We believe that the enclosed data provides the basis for an accurate evaluation of the mineralization in the area tested.

We regret the findings did not provide sufficient encouragement for us to continue and express our appreciation for your cooperation during this venture.

With best regards to yourself and family,

Yours very truly,

*H. F. Kendall*

H. F. Kendall,  
Superintendent of Mines

HFK:rlb

Enclosure.



# TENNESSEE COPPER COMPANY

DIVISION  
TENNESSEE CORPORATION  
NEW YORK OFFICE -- 61 BROADWAY

COPPERHILL, TENN.

Mine Office  
Ducktown, Tennessee  
April 11, 1961

Mr. T. A. M. Stevenson  
P. O. Box 427  
Winston Salem, N. C.

Dear Mr. Stevenson:

Enclosed find maps of surface diamond drilling at Silver Hill. I hope this will suffice until we get the logs of the holes complete.

You will note that surface holes run No. 1 through No. 16 and there are duplicating underground holes from 1 to 16. The copper, zinc and lead are assayed on percent and gold and silver are assayed as ounces per ton.

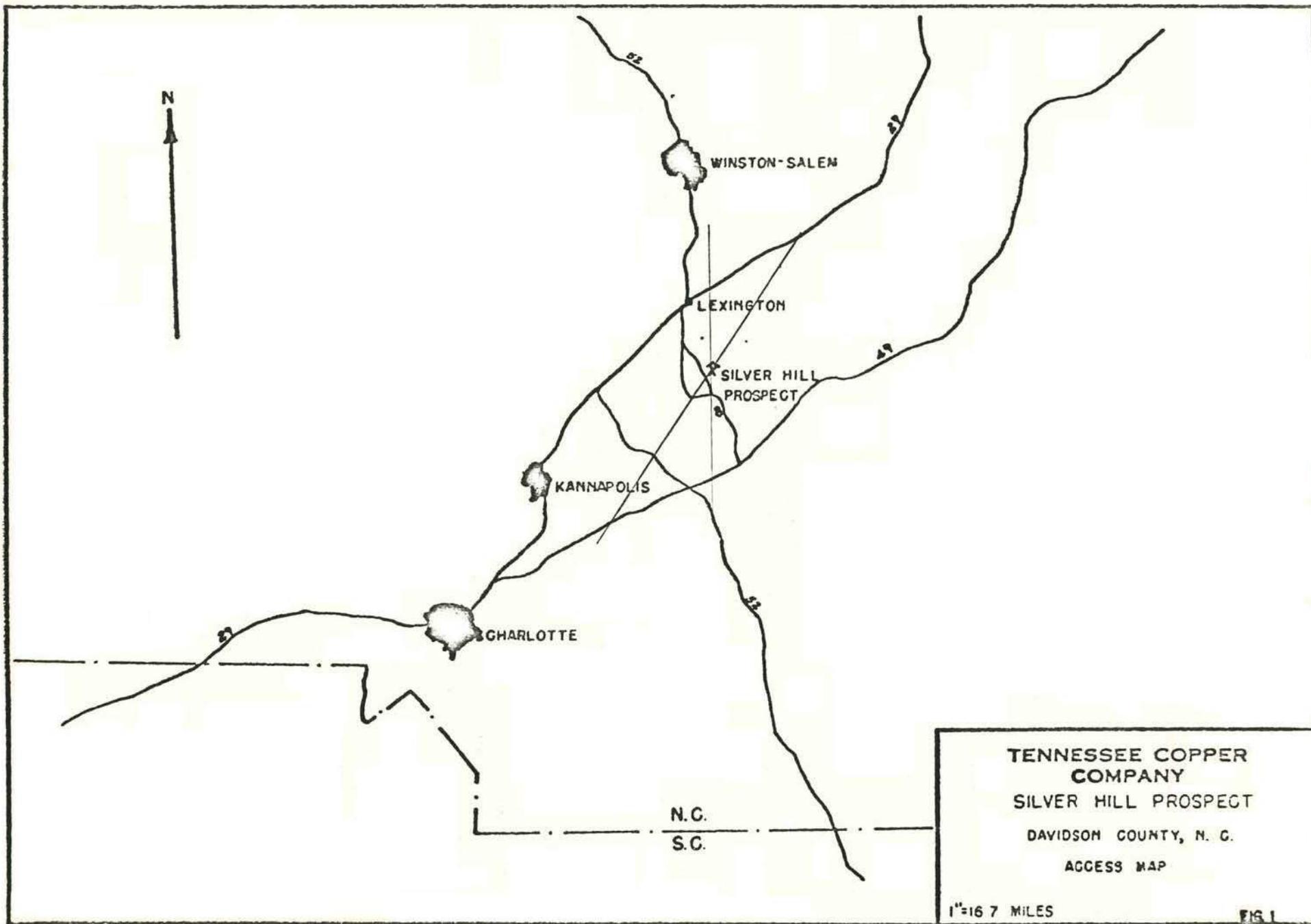
With kindest regards,

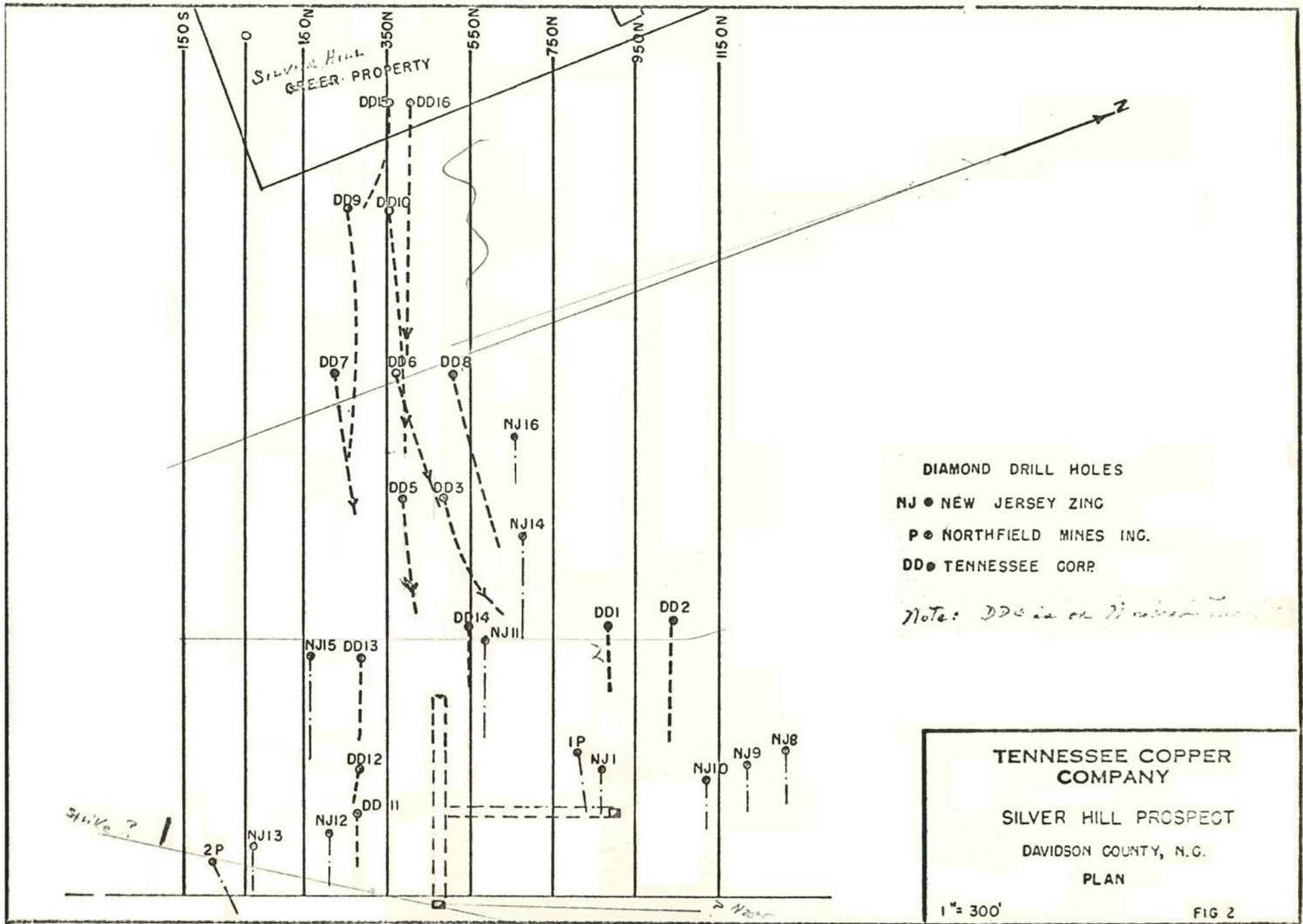
Very truly yours,

  
Otis Gibson,  
Geologist

OG:rab

Please Return  
TAMG





DIAMOND DRILL HOLES  
 NJ ● NEW JERSEY ZINC  
 P ● NORTHFIELD MINES INC.  
 DD ● TENNESSEE CORP.

*Note: DDs in on 21' rebar lines*

**TENNESSEE COPPER COMPANY**  
**SILVER HILL PROSPECT**  
 DAVIDSON COUNTY, N.C.  
 PLAN  
 1" = 300'  
 FIG 2

*1135-E 7/11-2008*

*Fig 2*

Silver Hill Surface Hole No. 1 Depth 650 Feet  
Latitude 16,854.3 Departure 4,019.0  
Elevation of Collar 879.4 Bearing S70E Dip 85°

<u>Interval</u>	<u>Material</u>
0-40	No Core
40-45	Weathered sericite slate; pyrite in seams.
45-108	Fine grained tuff; occasional pyrite in seams.
108-125	Green Stone coarse tuff; chlorite, epidote and hornblende.
125-230	Fine grained tuff, vugs @ 140-155; Fault @ 125-135
230-246	Green Stone coarse tuff; chlorite, epidote and hornblende; calcite seams
246-410	Fine grained tuff; Scattered pyrite
410-419	Shear zone; some quartz and chlorite; Slate
419-468	Fine grained tuff; epidote @ 421, 442-452; little pyrite
468-488	Quartz with epidote; Bleb of sphalerite @ 468 & 487
488-571	Fine grained tuff; occasional pyrite grain
571-650	Tuff; fault @ 594; numerous fractures; occasional calcite seams; occasional pyrite grain

Survey

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
200	79-30	S59E
440	69-30	S67E

No Value

N70W



D NORTH SHAFT

D

T.C. 1

NO VALUES

TENNESSEE COPPER  
COMPANY  
SILVER HILL PROSPECT  
DAVIDSON COUNTY, N. C.  
CS-9N

SCALE 1"=100'

FIG. 4

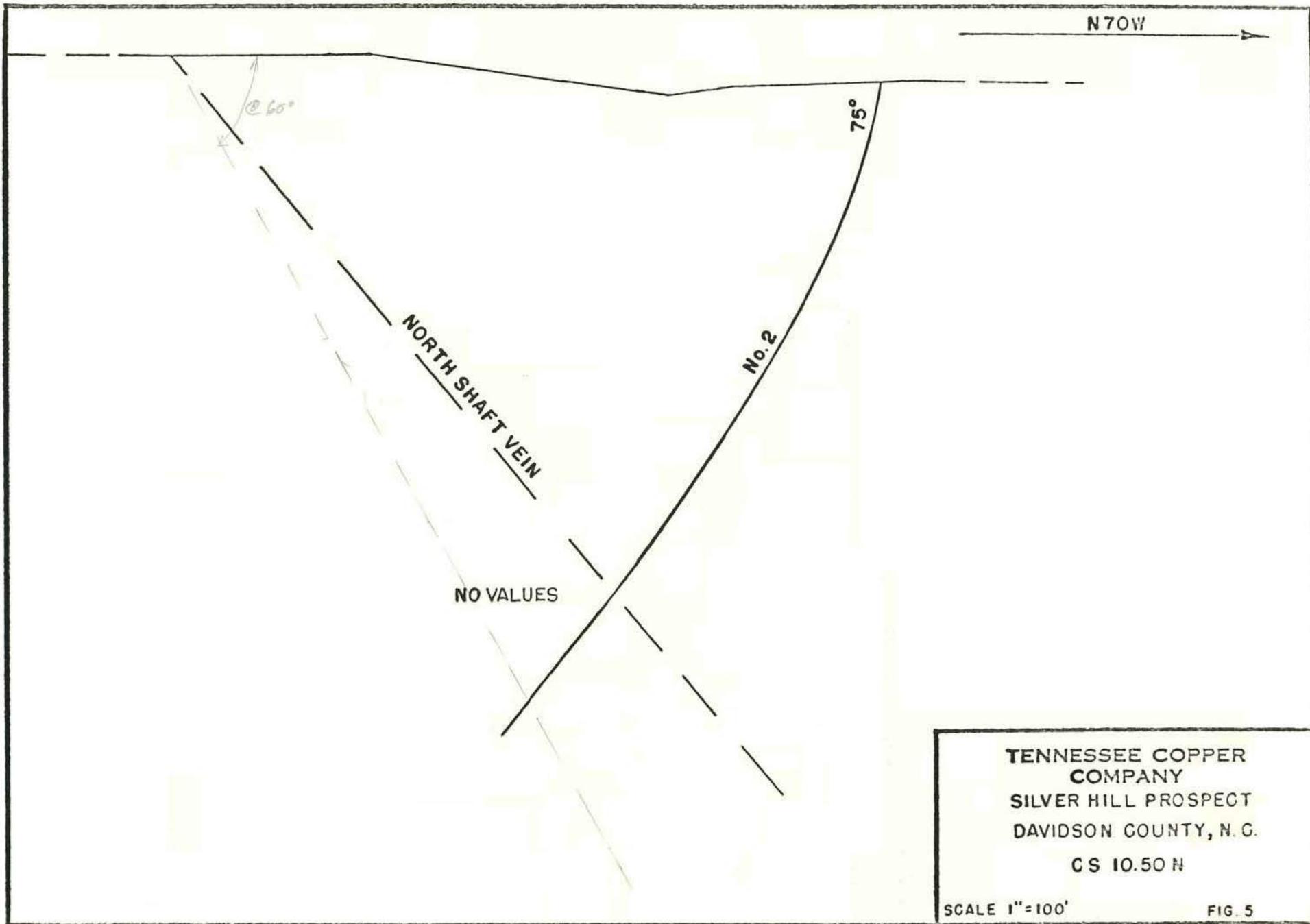
Silver Hill Surface Hole No. 2      Depth 600 Feet  
 Latitude 17,001.10      Departure 4,064.20  
 Elevation of Collar 882.10      Bearing S70E      Dip 75°

<u>Interval</u>	<u>Material</u>
0-39	No Core
39-69	Partially weathered siliceous sericite slate
69-74	Basic dike? Hornblende predominate
74-112	Fine grained tuff; water course @ 90-110; vugs
112-125	Siliceous sericites slate; Bedding about angle 45° to core.
125-175	Acid tuff
175-184	Basic dike? Hornblende predominate
184-478	Tuff; occasional pyrite grains; fault zone @ 247-269
478-545	Tuff; fine grained; occasional pyrite grained
545-600	Tuff with some conglomerate; occasional pyrite grains

Survey

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
395		S69E

No Value



(4A)

Silver Hill Surface Hole No. 3      Depth 819 Feet  
 Latitude 16,552.5      Departure 3651.6  
 Elevation of Collar 863      Bearing S70E      Dip 85°

Interval	Material
0-30	No Core
30-60	Slightly weathered slate, quartz congl. bedding about angle 20° to core
60-116	Tuff; few calcite seams. Bedding about angle 25° to core vugs @ 103-116; water course.
116-124	Greenstone coarse tuff; chlorite, epidote and hornblende
124-303	Tuff; vugs @ 186-222; occasional pyrite grains; Sheared @ 222-290
303-308	Greenstone coarse tuff; chlorite, epidote and hornblende with calcite
308-697	Tuff; quartz @ 416-420; occasional pyrite, fine grained; shear zone 663-689
697-730	Tuff; Some pyrite; little zn. & pb.
730-732	Heavily mineralized slate; zn, & pb. predominate
732-736	Shear zone little zn. & pb. mineralization
736-737	Heavy mineralized slate; cu., zn., & pb. predominate
737-818	Tuff; fine grained; occasional pyrite grains
818-819	Fault zone; sheared tuff

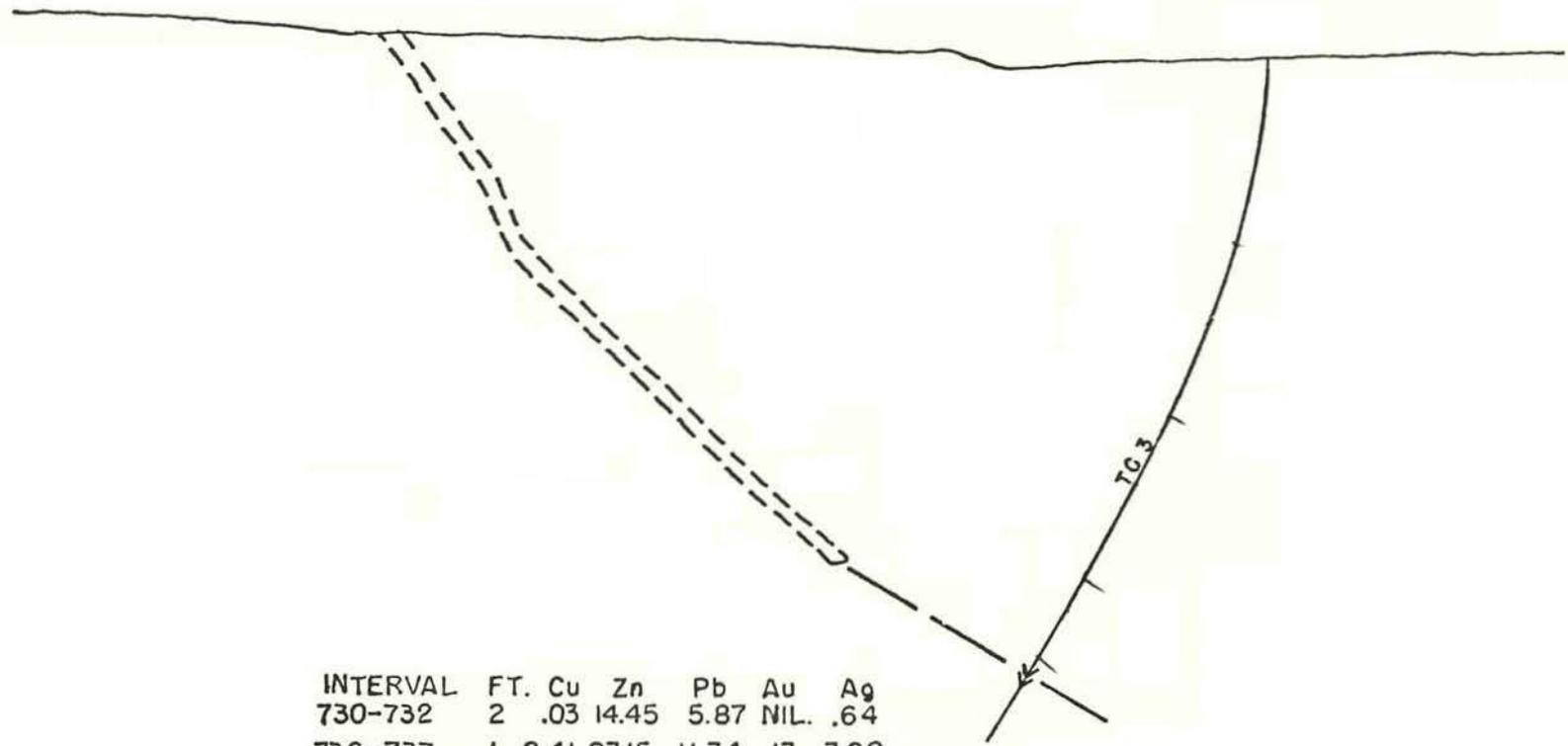
Survey

Depth	Dip	Bearing
295	70-30	S77E
650	57-30	N65-30E

*Handwritten notes:*  
 } (Bearing  $\frac{455^{\circ}30'}{2}$ ), 77°45' S 73°30'E  
 } (Bearing  $\frac{128}{2}$ ), 64° N 79°15'E

Interval	Feet	% Cu.	% Zn.	% Pb.	Oz. Per Ton	
					Au.	Ag.
730-732	2	0.03	14.45	5.87	Nil	0.64
736-737	1	2.41	23.15	11.34	0.13	3.20
	7		7.4			

S 70E



INTERVAL	FT.	Cu	Zn	Pb	Au	Ag
730-732	2	.03	14.45	5.87	NIL.	.64
736-737	1	2.41	23.15	11.34	.13	3.20

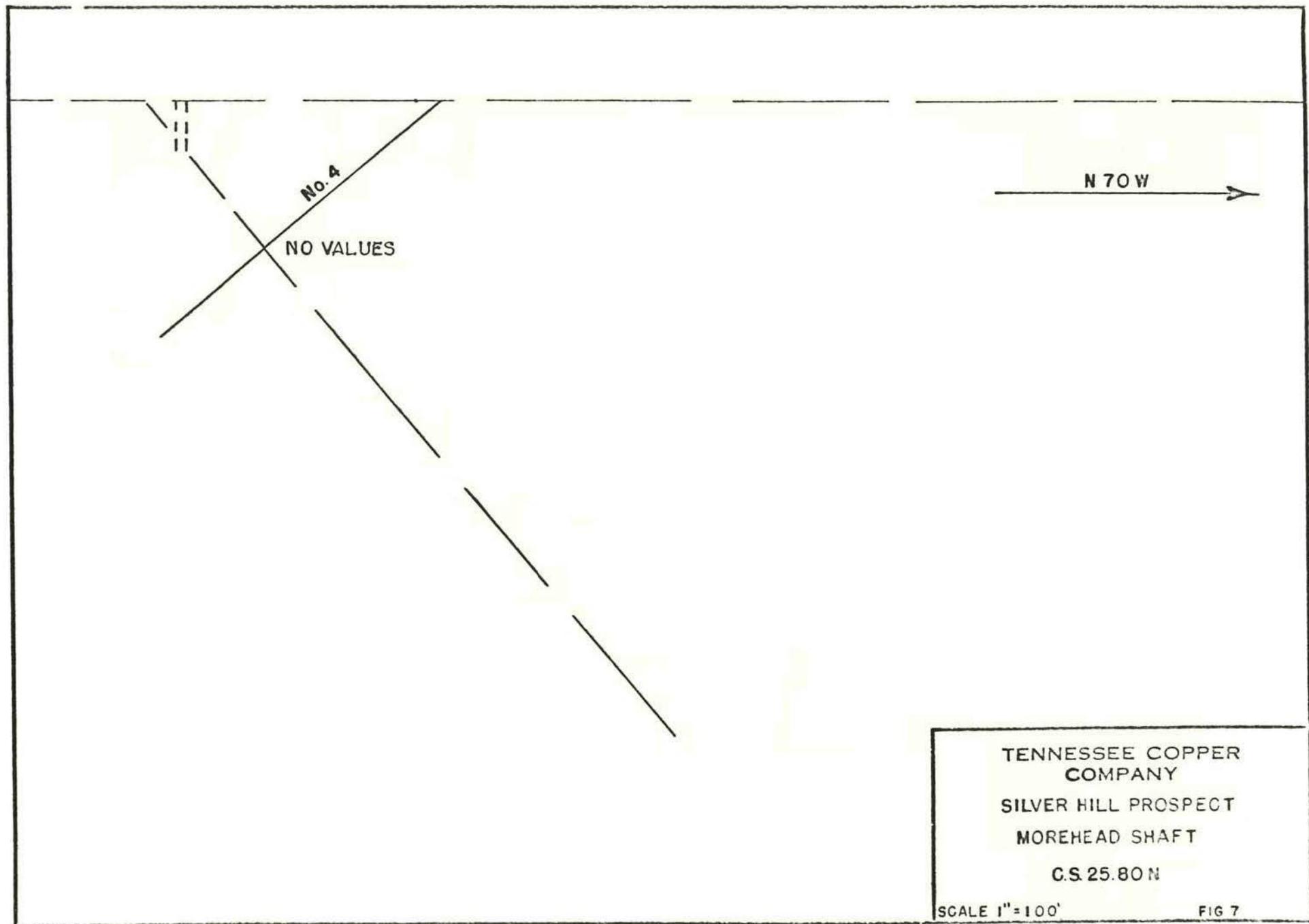
TENNESSEE COPPER  
COMPANY  
SILVER HILL PROSPECT  
DAVIDSON COUNTY, N.C.  
GS 500 N  
1"=200'  
FIG 6

Silver Hill Surface Hole No. 4      Depth 300 Feet  
Hole Not Shot In;  $\frac{1}{2}$  mile northeast of Silver Hill Shaft  
Bearing S70E      Dip 40°

<u>Interval</u>	<u>Material</u>
0-25	No Core
25-139	Greenstone coarse tuff; chlorite & epidote; weathered 28-31
139-290	Fine grained tuff; barren quartz @ 169-171; occasional pyrite & calcite
290-297	Coarse tuff with some chlorite
297-300	Tuff; fine grained

Survey None

No Value



Silver Hill Surface Hole No. 5      Depth 950 Feet      *Map after Hole 16*  
 Latitude 16,457.0      Departure 3,622.6  
 Elevation of Collar 862      Bearing-Vertical

Interval      Material

---

0-28      No Core  
 28-436      Tuff; conglomerate 74-118; some chlorite  
 436-455      Shear zone; slate; some cgl.; shear zone 436  
 455-682      Tuff; scattered pyrite; shear 556-558; some calcite seams  
 682-684      Shear zone; slate  
 684-685      Mineralized chloritic slate; some zn., pb. & pyrite  
 685-735      Tuff; fine grained  
 735-749      Sulfide ore with some lime silicates; zn., pb.  
 749-755      Slightly mineralized slate  
 755-940      Tuff; fine grained, calcite seams, epidote & chl.  
 940-950      Tuff; coarse grained than above

Surveys

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
300	76	S73-30E
705	61-30	S83E

Assays

<u>Interval</u>	<u>Feet</u>	<u>% Cu.</u>	<u>% Zn.</u>	<u>% Pb.</u>	<u>Oz. Per Ton</u>	
					<u>Au.</u>	<u>Ag.</u>
735-749	14	0.17	29.06	8.43	1.47	2.48

Silver Hill Surface Hole No. 6      Depth 1076 Feet      *Map after Hole 16*  
 Latitude 16,547.0      Departure 3,336.0  
 Elevation of Collar 844      Bearing Vertical

<u>Interval</u>	<u>Material</u>
0-25	No Core
25-192	Tuff; fine grained; calcite @ 129; pyrite @ 138
192-304	Tuff; chlorite, bedding about angle 45° to core @ 304
304-375	Alternate layers of fine and coarse grained tuff
375-626	Tuff; fine grained; vugs @ 490-495
626-630	Barren quartz
630-898	Fine grained tuff; few pyrite grains; some chlorite
898-920	Shear zone; flt.; vugs; 3" opening @ 909
920-928	Heavily mineralized tuff; zn. & pb. predominate
928-951	Tuff; some quartz & calcite; blebs of pyrite
951-957	Mixed sulfide and tuff; zn. & pb. predominate
957-989	Tuff slightly mineralized; opening 979-989
989-999	Soft chlorite schist, sheared
999-1076	Tuff; some pyrite seams; epidote chlorite and quartz

Surveys

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
345	75°	S78E
800	60°	N89E

Assays

<u>Interval</u>	<u>Feet</u>	<u>% Cu.</u>	<u>% Zn.</u>	<u>% Pb.</u>	<u>Oz. Per Ton</u>	
					<u>Au.</u>	<u>Ag.</u>
920-928	8	0.36	18.28	6.95	.05	1.36
951-957	6	0.14	9.32	7.44	.05	1.88

9

(9)

Silver Hill Surface Hole No. 7      Depth 991 Feet      *Map after Hole 9*  
 Latitude 16,405.7      Departure 3,293.7  
 Elevation of Collar 845      Bearing-Vertical hole

<u>Interval</u>	<u>Material</u>
0-22	No Core
22-306	Tuff; fine grained; some chlorite, calcite & Pyrite; Conglomerate @ 60-97 & 127-161
306-344	Greenstone; epidote and chlorite predominate
344-805	Tuff; some calcite & pyrite; water course @ 791-798
805-914	Tuff; fine grained; water course @ 909; Dark slate @ 913-914
914-916	Sulfide ore with some slate; zn. & pb. predominate
916-991	Tuff; siliceous @ 952-970; some pyrite & calcite

Surveys-

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
400	70-30	S77-30E
900	60-00	S83-30E

Assays

<u>Intervals</u>	<u>Feet</u>	<u>% Cu.</u>	<u>% Zn.</u>	<u>% Pb.</u>	<u>Oz. Per Ton</u>	
					<u>Au.</u>	<u>Ag.</u>
914-916	2	0.57	16.10	6.74	0.04	1.15

10

(10)

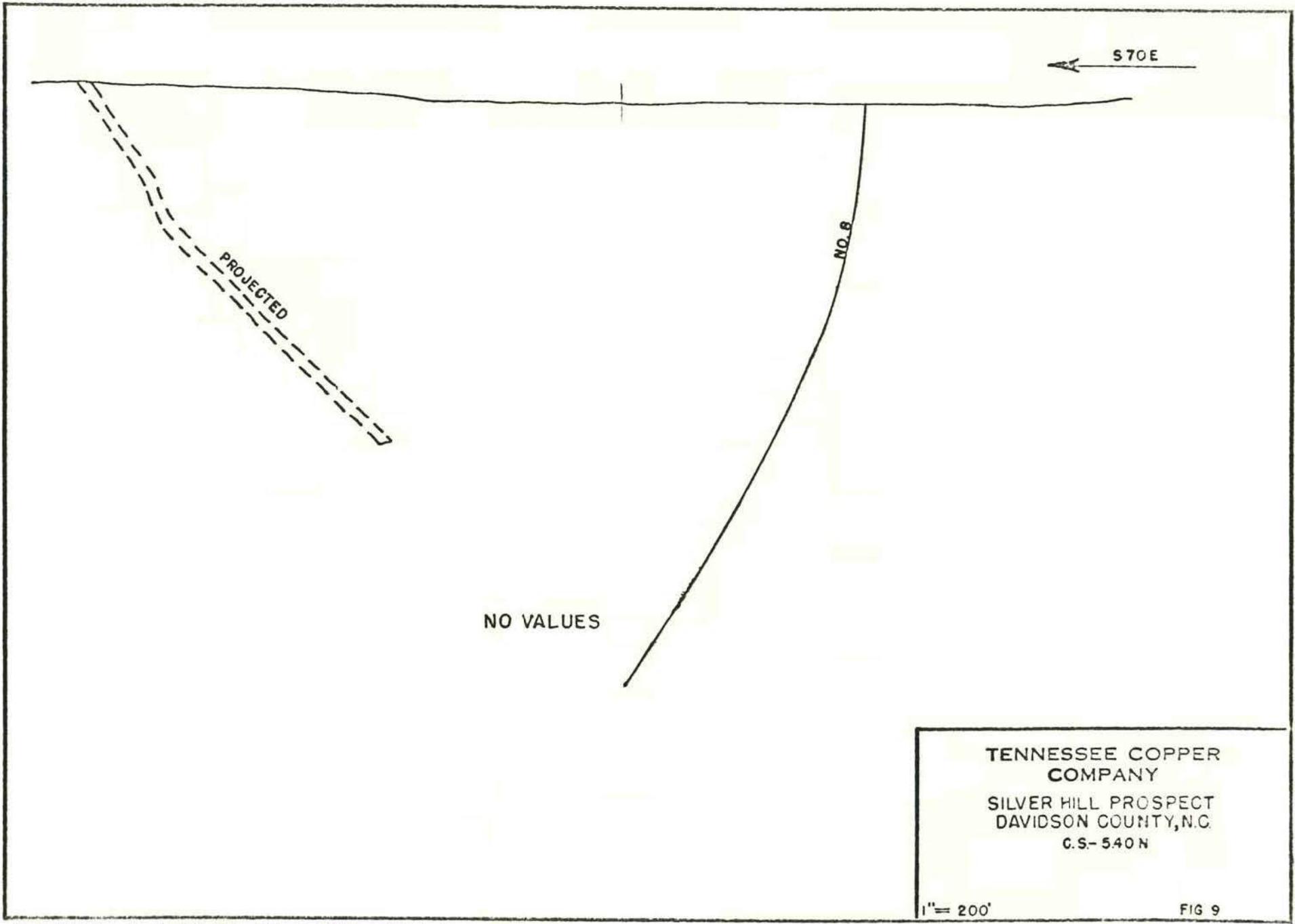
Silver Hill Surface Hole No. 8      Depth 1025 Feet  
Latitude 16,680.6      Departure 3,399.3  
Elevation of Collar 847      Bearing-Vertical

<u>Interval</u>	<u>Material</u>
0-22	No Core
22-285	Greenstone; chlorite, epidote predominate; fault @ 189; water course @ 189; numerous calcite seams & blebs;
285-586	Tuff; alternate layers fine and coarse material; quartz & calcite @ 369; water course @ 450-470, 527 & 542
586-750	Tuff; fine grained
750-788	Greenstone; chlorite, epidote & calcite; 8" barren quartz @ 774 & 780
788-897	Tuff; fine grained; 1/8" zn. seam @ 858 & 859; some calcite
897-1025	Tuff; fine grained; chlorite increases with depth; slight pb. & zn. mineralization @ 959; some calcite

Surveys

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
400	67	S85E
800	50-30	S87-15E

No Value



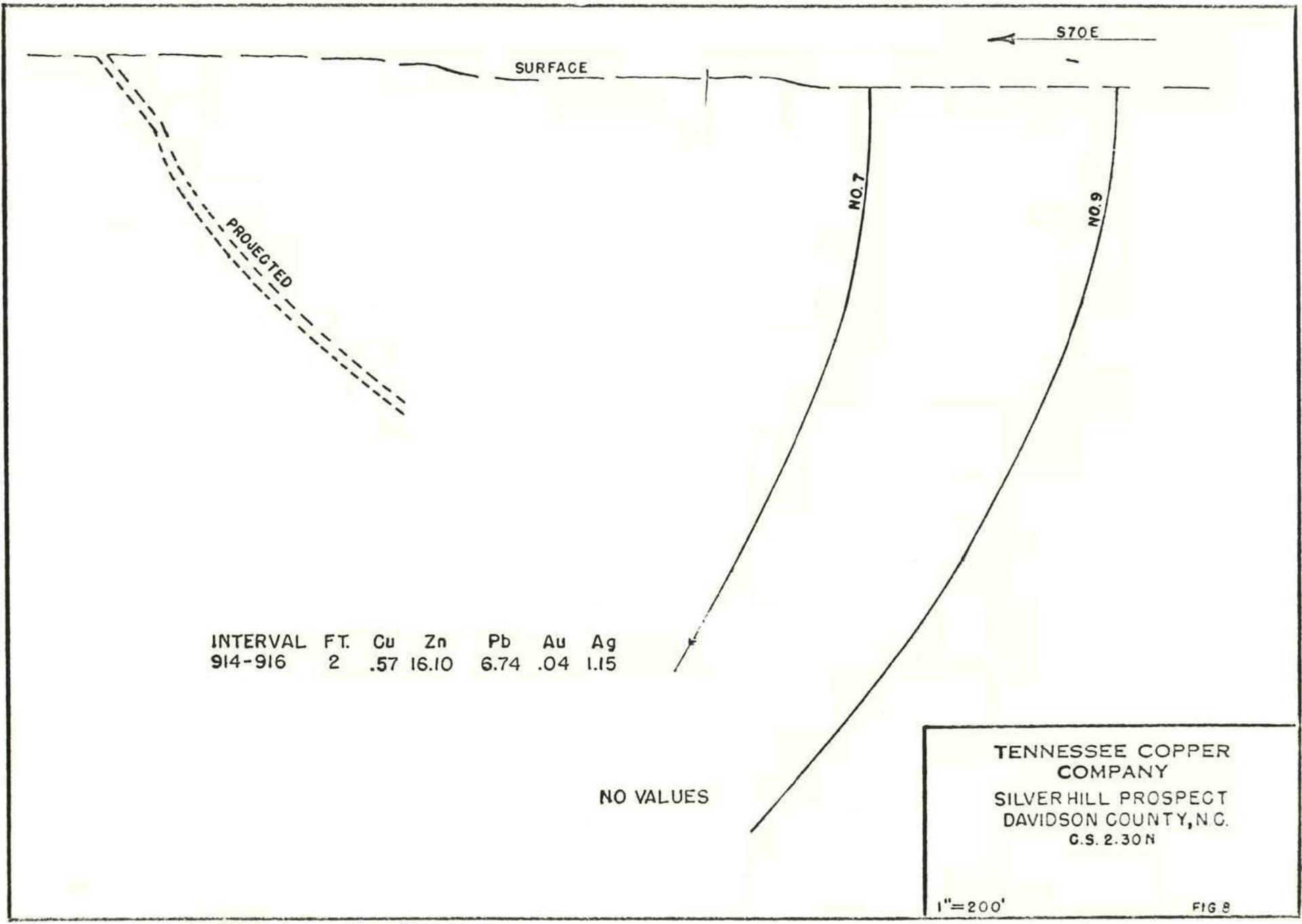
Silver Hill Surface Hole No. 9      Depth 1368 Feet  
 Latitude 16,575.4      Departure 2,921.7  
 Elevation of Collar 865      Bearing-Vertical

<u>Interval</u>	<u>Material</u>
0-27	No Core
27-30	Weathered sericitic slate
30-494	Tuff; fine grained; some calcite; occasional pyrite grains
494-549	Chlorite, epidote, carbonate tuff
549-1127	Alternate layers of fine & coarse tuff; some calcite; occasional pyrite with chlorite & epidote
1127-1188	Alternate coarse & fine tuff
1188-1220	Sheared zone; breccia, some talc; slickensides, bleb of zn. @ 1204 & 1207; some calcite
1220-1368	Alternate coarse & fine tuff; occasional pyrite & pyrrhotite grains some epidote, chlorite and calcite

Surveys

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
345	71-30	S71-30E
800	58-15	S76-15E
1340	47	S63E

No Value



Silver Hill Surface Hole No. 10      Depth 1289 Feet      *Map after Hole 14*  
 Latitude 16,660.1      Departure 2,965.2  
 Elevation of Collar 866      Bearing-Vertical

<u>Interval</u>	<u>Material</u>
0-38	No Core
38-48	Weathered sericite schist; bedding about angle 30
48-302	Greenish slate or tuff: chlorite epidote, quartz, sericite. Fault 234-235; bedding about angle 45 @ 150'
302-500	Tuff; fine grained; occasional pyrite grain; chalcopyrite bleb @ 343 Sheared @ 430; cleavage about angle 50 to core @ 385
500-1112	Alternate layers of coarse & fine grained tuff. bedding about angle 65 to core @ 920'; Sheared @ 1016-1034; vugs
1112-1195	Coarse grained tuff; with chlorite, some calcite sheared 1155-1160 Little zn. & pyrite
1195-1198	Zinc & pyrite mineralization in slate
1198-1223	Slightly mineralized tuff; little pyrite & zn. calcite seams & blebs common
1223-1289	Sheared tuff: chlorite & sericite

Surveys

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
358	69-30	S77E
805	55	S74-30E
1100	50	S73-30E

Assays

<u>Interval</u>	<u>Feet</u>	<u>% Cu.</u>	<u>% Zn.</u>	<u>% Pb.</u>	<u>Oz. Per Ton</u>	
					<u>Au.</u>	<u>Ag.</u>
1195-1198	3	0.14.	19.80	1.18	Trace	0.72

Silver Hill Surface Hole No. 11      Depth 252 Feet      *Map after Hole 13*  
 Hole Not Shot In      Bearing S70E      Dip 60°

<u>Interval</u>	<u>Material</u>
0-61	No Core
61-103	Fined grained tuff; vugs & water course @ 91-93
103-122	Coarse green tuff; fractured; many vugs and calcite
122-157	Alternate bands of fine & coarse tuff; bedding about angle 80; vugs and sheared 150-157
157-222	Alternate bands of fine & coarse tuff; coarse tuff contains chlorite & calcite
222-252	Fine grained tuff; brecciated 227-238 & 240-251 occasional pyrite & blebs of calcite

Surveys--None

No Value

Silver Hill Surface Hole No. 12      Depth 400 Feet  
Hole Not Shot In      Bearing-Vertical

Map after Hole 13

Interval	Material
0-27	No Core
27-105	Alternate layers of fine and coarse grained tuff; many vugs 48-56; many fractures
105-171	Fine grained tuff
171-282	Coarse grained tuff; chlorite & calcite. Zn @ 234½; slightly mineralized 274-282
282-287	Zinc & pyrite mineralization in green tuff
287-300	Green tuff; coarse grained
300-400	Alternate fine & coarse grained tuff. Sphalerite seam @ 312, 362, 377; Sheared 377-400

### Survey

Depth	Dip	Bearing
370	70	S56-40E

### Assays

Intervals	Feet	% Cu.	% Zn.	% Pb.	Oz. Per Ton	
					Au.	Ag.
282-287	5	0.60	7.45	4.81	0.04	1.30
274-287	Av 13'	.30	4.52	2.13	.02	.60
234-235	1'	.13	17.30	1.30	nil	tr.

see pp 73

Silver Hill Surface Hole No. 13      Depth 625 Feet  
Hole Not Shot In      Bearing-Vertical

<u>Interval</u>	<u>Material</u>
0-18	No Core
18-203	Alternate layers of fine & coarse grained tuff; numerous fractures; Pyrite in fractures; coarse tuff has green color; chlorite, epidote common
203-396	Alternate layers of coarse and fine grained tuff. Chlorite & epidote common in coarse tuff.
396-438	Alternate layers fine and coarse tuff with some calcite sheared 386-424; pyrite in fractures.
438-442	Green tuff sheared and mineralized with zn. and pyrite
442-470	Fine grained tuff; fractured; little mineralization
470-531	Fine grained tuff; occasional pyrite as fracture filling
531-542	Coarse green tuff; some pyrite and calcite
542-625	Fine grained tuff; occasional zn.; occasional pyrite grains.

Hole Not Surveyed

Assays

<u>Intervals</u>	<u>Feet</u>	<u>% Cu.</u>	<u>% Zn.</u>	<u>% Pb.</u>	<u>Oz Per Ton</u>	
					<u>Au.</u>	<u>Ag.</u>
438-442	4	0.14	4.60	1.39	Nil	0.26

Silver Hill Surface Hole No. 14      Depth 500 Feet  
Latitude 16,545.72      Departure 3,918.98

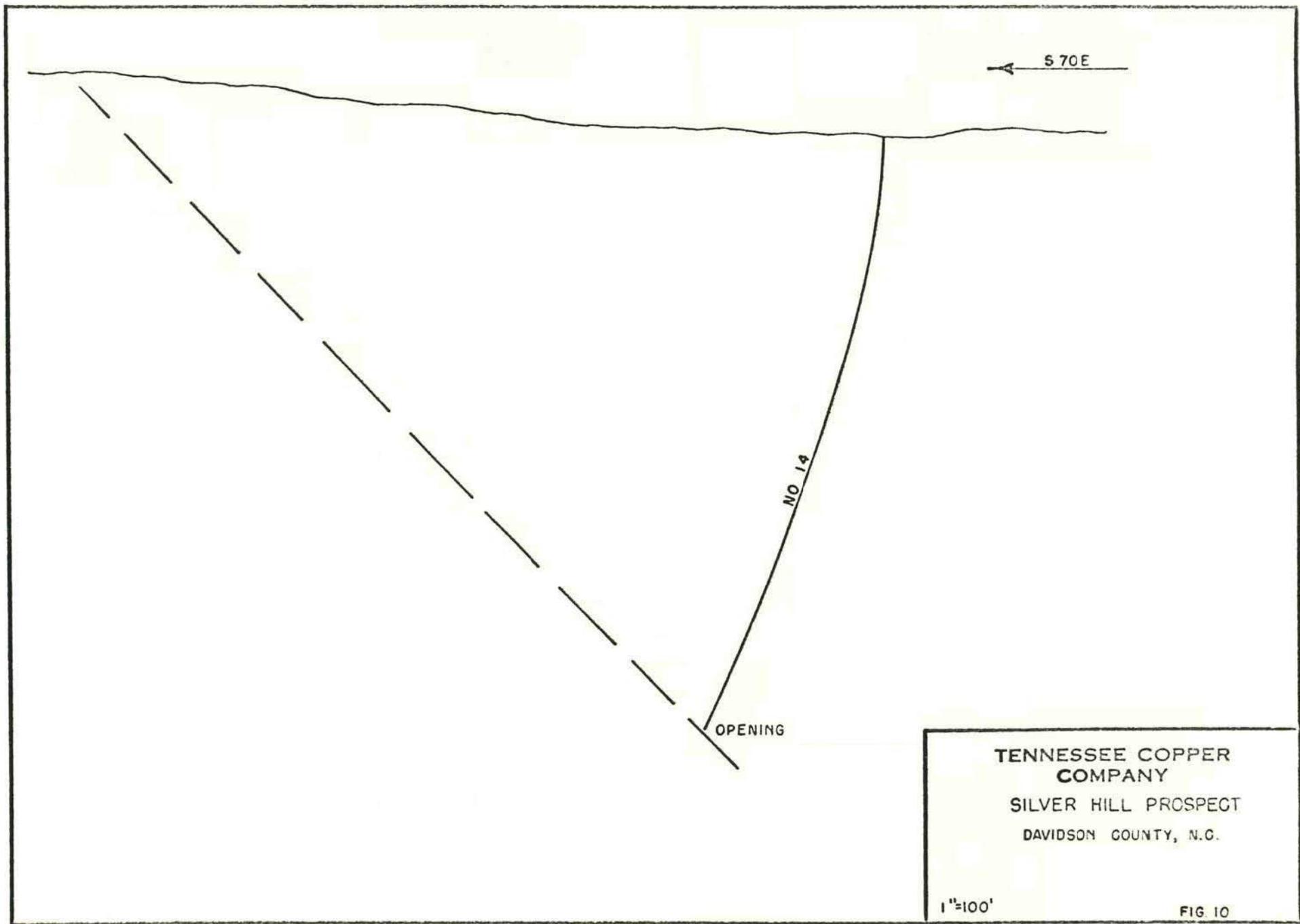
Elevation of Collar 858      Bearing S65E      Dip 85°

<u>Interval</u>	<u>Material</u>
0-12	No Core
12-73	Fine grained tuff; occasional pyrite grains
73-87	Coarse green tuff; fractures filled with calcite
87-255	Fine grained tuff; sheared 245-248; fractures common
255-256	Quartz and calcite
256-445	Alternate bands of fine and coarse tuff; sheared with vug at 320; some calcite and pyrite sheared 410-425
445-498	Fined grained tuff; little zn. mineralization @ 479-480; occasional pyrite grains
498-500	Opening. Drilled into mine timber.

Surveys

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
405	66	S68E

No Value



177

Silver Hill Surface Hole No. 15      Depth 742  
 Latitude 16,745.1      Departure 2,728.1  
 Elevation of Collar 873      Bearing S70E      Dip 88

<u>Interval</u>	<u>Material</u>
0-22	No Core
22-89	Fine grained tuff; cleavage about 25° to core
89-249	Coarse grained tuff; much chlorite, sheared 155, 161-179, calcite in fractures and seams; occasional pyrite grains.
249-390	Alternate layers of fine and coarse tuff. Calcite in fractures; Fractures common.
390-601	Fine grained tuff; sheared with calcite in fractures; occasional pyrite grains.
601-742	Fine grained tuff; sheared @ 605 & 734-742; some epidote @ 690-734 Hole abandoned at 742 due to hole deflecting to far south.

Surveys

<u>Depth</u>	<u>Dip</u>	<u>Bearing</u>
405	67-30	S59E
722	54-30	S45E

No Value

**4.2. Status report on the Silver Hill examination, Davidson County, North Carolina,  
for Cyprus Mines Corporation and Louisiana Land and Exploration Company**

By E. M. Jones and I.T. Kiff, 1973

STATUS REPORT  
ON  
THE SILVER HILL EXAMINATION  
DAVIDSON COUNTY, NORTH CAROLINA  
1973

For  
Cyprus Mines Corporation  
and  
Louisiana Land and Exploration Company

By  
Earl M. Jones and Irving T. Kiff

Earl M. Jones  
Exploration Geologist  
5612 Kingston Pike  
Knoxville, Tennessee 37919

January 1974

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## INTRODUCTION AND SUMMARY

Examination of the Silver Hill Mine, Davidson County, North Carolina, was included as part of the 1973 program of the Cyprus Mines Corporation - Louisiana Land and Exploration Company joint venture in the southeast United States. Consequently, a land position at Silver Hill was established quickly and in-the-field exploration was initiated in January 1973. The Silver Hill project therefore received most of the attention, time, and resources of the joint venture program during the year. As a result, considerable data was obtained, and it is the purpose of this report to summarize and interpret the information.

Exploration at Silver Hill included geologic mapping, geochemical sampling, geophysical surveying and diamond drilling. Each of these operations are summarized separately in this report. In addition, a summary of the current land position at Silver Hill is included.

Geologic mapping in the Silver Hill area resulted in recognition of volcanic stratigraphy environmentally favorable for the occurrence of volcanigenic massive sulfide deposits. It was then possible to extend the geologically favorable area approximately 1 mile to the northeast of the mine and 5 miles to the southwest.

As a result of geochemical sampling, we are able to confirm an anomaly along the surface trend of ore bodies mined during an early period of operation. Several additional geochemical anomalies were located which remain to be tested. There is some indication that the mercury content of soils may prove to be a useful and effective geochemical tool in the Silver Hill area.

Although magnetic surveys at Silver Hill proved inconclusive, VLF electromagnetic surveying did indicate several anomalous areas. The causes of the VLF anomalies are not known conclusively. An induced polarization survey produced very satisfactory results. Three favorable zones were delineated which remain to be tested by drilling during 1974.

Six holes were drilled at Silver Hill in 1973. Three were in the mine area and three south of the mine. Hole 1 passed through 27 feet of mineralization, and holes 2 and 3 showed weak, but positive, traces. Holes 4 and 5 drilled south of the mine were negative, and hole 6 drilled near an I. P. anomaly contained weak, but encouraging mineralization.

We conclude, on the basis of geology and available subsurface, geochemical, and geophysical data, that the Silver Hill area remains a viable exploration target of high priority.

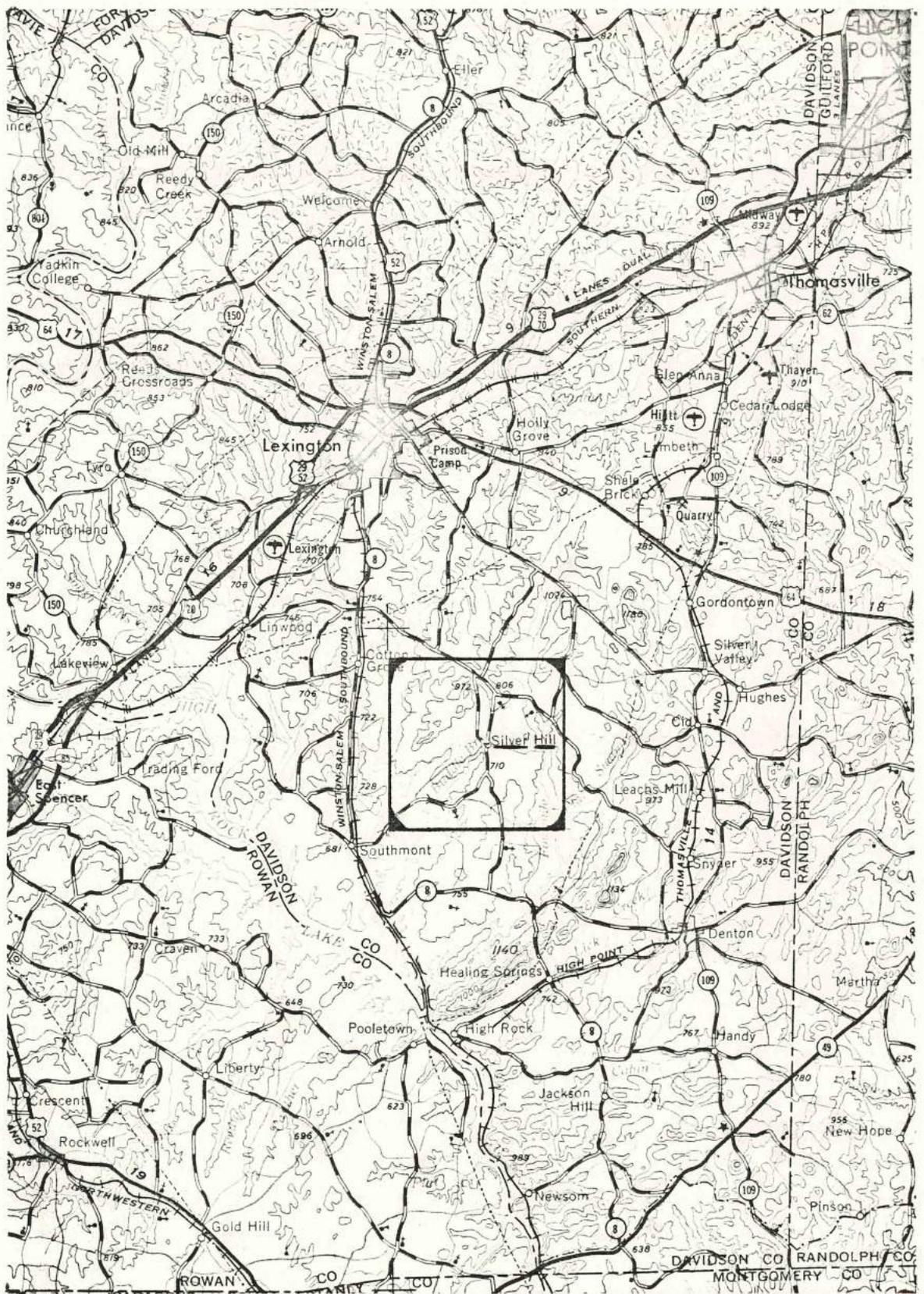
## HISTORY

The Silver Hill Mine, located approximately 10 miles south of Lexington (Figure 1), has the distinction of being one of the oldest and deepest mines in North Carolina and certainly one of the very few in the Southern Piedmont region that was valuable chiefly for its output of silver, lead, and zinc. Like many of the Piedmont mines, its period of active production was confined largely to the 19th century. Later intermittent operations were essentially efforts to solve metallurgical problems inherent in the complex sulfide ore. The mine has continued to attract attention over the years and a brief recapitulation of its mining and exploration history follows.

### Mining

Mineralization was first discovered at Silver Hill in the spring of 1838. Early accounts describe the discovery by Jonathan Byerly, the owner, as occurring after he had observed a lack of plant growth on a small seven square yard patch of ground in one of his cultivated fields. Upon examining the spot, Byerly found a lead carbonate mineral and soon thereafter sold the land to Mr. Roswell King of nearby Lexington, North Carolina. King sunk a shaft, developed the mine, and later formed the Washington Mining Company which operated the mine until 1852.

Early production from one 60-foot shaft consisted chiefly of lead carbonate and disseminated plates of native silver. Soon the relatively shallow oxidized ores gave way to sulfides which presented great problems



A M S 1:250,000

FIG. 1. Silver Hill Examination Location Map

in extraction of the metals. Operations continued, however, and many methods and modifications were used in separating and recovering the metals. A second shaft was sunk which eventually reached a depth of 200 feet. Two parallel veins, each up to 10 feet in thickness, were developed and mined during this period. They were separated by about 30 feet of country rock and extended laterally for about 300 feet near surface. The veins were supposedly cut off at both ends by faults.

In January 1855, the Silver Hill Mining Company assumed control of the property and operated until 1861.

During the period 1861-1864, the Silver Hill mine was worked at intervals by the Confederate Government for lead.

Following the Civil War the mine was operated continuously by a succession of companies until 1882. During this period, in 1872, an inclined shaft was driven to 650 feet. In 1878 a large body of carbonate ore was discovered above the 250-foot level and worked out over the next two years. In 1882, difficulties in treatment of the sulfide ore and litigation over the title caused cessation of mining and the workings were allowed to fill with water.

In 1898, the West Prussian Mining Company unwatered the mine and made other improvements. In widening the shaft above the 200-foot level considerable native silver was found. In 1900, difficulty in treating the sulfide ore again seems to have put an end to the working.

In 1906, the property was purchased by Mr. T. A. M. Stevenson, Winston-Salem, North Carolina, the present owner.

The total production from the Silver Hill Mine is popularly estimated at \$1,000,000 or more.

### Exploration

During Mr. Stevenson's ownership and prior to 1973, the Silver Hill property had been investigated several times. Three separate companies: the New Jersey Zinc Company, Northfields Mines, and the Tennessee Copper Company explored the properties during the years 1941-42, 1951, and 1959-1961, respectively. A summary of their work and results follows.

#### New Jersey Zinc Company

During 1941, the New Jersey Zinc Company conducted an exploration program at Silver Hill which consisted primarily of (1) dewatering the workings to the 250 level and (2) the diamond drilling of 5,971 feet from 19 shallow angle holes. The program, in part directed by Bob Stevenson (son of T. A. M. Stevenson), was apparently directed at expanding the ore zone both north and south of the mine. The drill core has since been lost and no evidence of ore intersections in the holes, with the possible exception of holes 10 and 13, are known.

#### Northfield Mines, Incorporated

In 1951, Northfield Mines, Incorporated, a Canadian company, carried out an electromagnetic survey at Silver Hill and drilled a total

of 757 feet of ore from two angle holes. Although thirteen conductors were encountered by the McPhar survey and recommendations for drill locations were made accordingly; neither of the holes were located in the McPhar recommended locations. Some mineralization was encountered in the two holes, but apparently none was ore grade.

#### Tennessee Copper Company

The Tennessee Copper Company, in 1959, began a program aimed at determining if sufficient ore could be found at Silver Hill to make it once again a producing mine. The Tennessee Copper Company program consisted of (1) the drilling of 12,064 feet of core from 16 vertical surface holes, (2) the dewatering and deepening of the old incline shaft to the 14 level, (3) the development and detailed sampling of three drifts and a cross cut, and (4) the underground drilling of 104 core holes (Plate 1).

At first the Tennessee Copper Company program appeared very puzzling to us, especially in regard to the limited amount of surface work conducted with relation to the underground work. However, as our program developed and our studies and evaluations evolved, it became more evident that their decision to go underground was certainly not as hasty as it first appeared. Out of 16 surface holes drilled, seven contained either "ore" or "potential ore" grade intersections.

Otis Gibson, retired Tennessee Copper Company geologist, stated recently that in his estimation, the work at the mine proved the existence

of a narrow, discontinuous, cigar-like lens that would conservatively contain at least 250,000-300,000 tons of ore at today's prices.

The total costs of the Tennessee Copper Company work, completed in 1961, is estimated at 1.5 million dollars.

#### Ore Reserves

According to information supplied to us from the Stevenson files, the Tennessee Copper Company calculated a possible 20,000 tons of ore averaging 15.8% zinc, 6.9% lead, 0.23 oz. gold, and 1.79 oz. silver from the 10, 11, and 12 levels. These estimates were calculated at a time when metal prices were considerably lower than today and are considered quite conservative.

During 1973, a more up-dated estimate was calculated by Russell Chadwick, Spokane, Washington. Chadwick's estimate, compiled from Tennessee Copper Company data and data prepared in the Knoxville office, estimates that 191,100 short tons of ore averaging 0.275% copper, 10.84% zinc, 4.16% lead, 0.077 oz. gold, and 1.25 oz. silver, remains underground and on the dumps at Silver Hill. In addition, Chadwick stated in his report that the reserves could be somewhat larger than reported because of erratic sampling and often times overlooked mineralization.

## GEOLOGY

### Regional Geology

The southeastern region of the United States is subdivided into four provinces on the basis of both their physiographic and coincident geologic differences. North Carolina encompasses varying portions of these provinces which range from the Precambrian Blue Ridge, lying in the western part of the state, across the Paleozoic Piedmont to Mesozoic and younger sediments of the Atlantic Coastal Plain in the eastern half of the state (Figure 2).

The Blue Ridge is underlain by Precambrian rocks which constitute the cores of a chain of anticlinoria extending 700 miles from Southern Pennsylvania to Eastern Alabama, and serves as the structural backbone of the southern part of the Appalachian System. The axis of the Blue Ridge also corresponds in a general way to the change from miogeosynclinal rocks on the west to eugeosynclinal rocks on the east within the Paleozoic geosyncline. On the west, folded and faulted Paleozoic strata constitute the Valley and Ridge Province which underlies a very limited area in Western North Carolina. East of the Blue Ridge, but separated by the narrow Brevard zone, lie metamorphosed volcanic and sedimentary rocks of the Piedmont Province. The Piedmont in turn is succeeded further east by onlapping sediments of the Atlantic Coastal Plain.

### Blue Ridge

The Blue Ridge in Western North Carolina consists of a basement complex of granitic gneisses which are assigned an age of about a

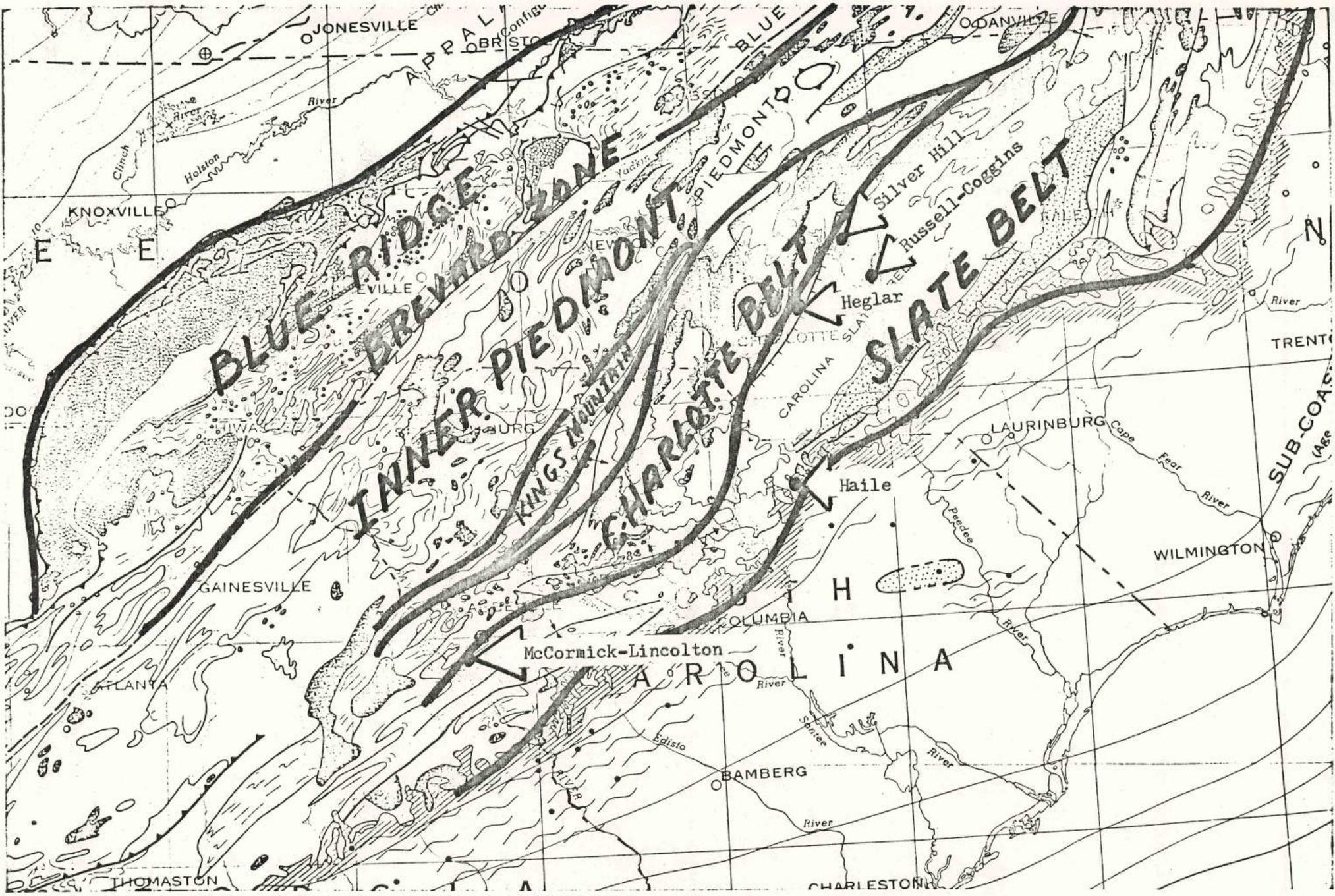


FIG. 2. Map showing geologic belts of North Carolina and South Carolina

billion years and is nonconformably overlain by Late Precambrian mica schist, mica gneiss, and amphibolite derived from metamorphism of sedimentary and volcanic rocks. Sharply bounded granitic plutons mark intrusive episodes during the Late Precambrian and Late Paleozoic. Numerous, small ultramafic bodies were also emplaced during the Paleozoic. Several periods of deformation and accompanying metamorphism are evidenced by present metamorphic textures, mineral assemblages, and the most obvious structural elements. Thrusting is most characteristic of Blue Ridge tectonics and occurred during several episodes in the Paleozoic. Tectonic transport was to the northwest and the entire Blue Ridge in North Carolina is probably allochthonous.

#### Piedmont

The Piedmont is underlain by metamorphic and igneous rocks generally distributed in northeast-trending belts (Figure 2). Extending eastward from the Blue Ridge are the Inner Piedmont, Kings Mountain, Charlotte, and Carolina Slate belts. The belts are zones of different grades of regional metamorphism imposed on a great thickness of volcanic and sedimentary rocks much modified by folding and the intrusion of igneous rocks. Separating the belts in the Piedmont from the Blue Ridge is the Brevard belt. The Brevard is a narrow zone of cataclastic rocks derived from gneisses and schists in the adjacent Blue Ridge and Inner Piedmont and are not, in themselves, a stratigraphic sequence. To the east the Piedmont crystalline rocks are onlapped by unmetamorphosed rocks

of the Atlantic Coastal Plain. Other sedimentary rocks in the Piedmont were deposited in a series of narrow, northeast trending graben-like depressions of Triassic age.

The Inner Piedmont belt is characterized by high-grade metamorphic schists and gneisses and represents the zone of regional metamorphic climax in the Carolinas. On the west side the Inner Piedmont belt is marked by a zone of retrogressive cataclastic metamorphism as the Brevard belt is approached. Its termination on the eastern side with the Kings Mountain belt probably represents a change in metamorphic grade rather than the juxtaposition of rocks of different ages.

Low grade metamorphic rocks of the Kings Mountain belt are distributed within a relatively narrow zone in Southern North Carolina. Rocks in the belt are believed to extend further north than shown in Figure 2. They are thought to be obscured by folding, faulting, and other geologic features. Major rock types in the Kings Mountain belt are phyllite, schist, quartzite and marble.

The Charlotte belt includes medium- to high-rank metamorphic rocks, and a complicated sequence of intrusive igneous rocks. The metamorphic rocks are mainly schist, gneiss, amphibolite, and meta-gabbro. The igneous rocks range in composition from granite to gabbro. The older intrusive rocks are commonly foliated and conformable to regional structures; the younger ones massive and cross-cutting. Intrusions of quartz monzonite, granite, syenite, and gabbro are among the most conspicuous younger series. Radiometric age determinations generally

indicate emplacement during the Paleozoic, and the younger intrusions are probably Late Paleozoic.

The Carolina Slate belt lies in the central and eastern Piedmont of North Carolina. To the west, the Slate belt is in contact with the Charlotte belt and to the east it extends beneath the Coastal Plain. Rocks of the Slate belt are low rank, generally greenschist facies, metamorphic rocks of sedimentary and volcanic origin. Common types include phyllite, argillite, tuff, breccia, and volcanic flows. Intrusive rocks range from rhyolite and granite to gabbro. The major structural elements in the Slate belt conform to the northeast regional fabric.

#### Geology of the Silver Hill Area

The Silver Hill area lies within the Carolina Slate belt near its contact with the Charlotte belt in Davidson County, North Carolina (Figure 2). Silver Hill is located in the northwest quarter of the 15' Denton Quadrangle sheet which was mapped geologically by the USGS in the 1960's. The map was subsequently published in 1971, but did not, in our opinion, adequately detail the geology of the Silver Hill area. The problem was not only one of scale, but interpretation as well. We believed that it was necessary to resolve to our satisfaction certain conflicts in previously published work in the general area. Initial field work in January and February 1973, at Silver Hill was therefore directed toward mapping an area 4-1/2 miles by 4-1/2 miles on aerial photos at a scale of 400 feet to the inch and centered on the Silver



Hill Mine (Figure 3). Reference is made to the 400 foot scale geologic map of the Silver Hill area on file in the Cyprus Mines Corporation and Louisiana Land and Exploration Company offices.

Slate belt rocks in the subject area trend northeastward and consist of a sequence of argillites, tuffs, and rhyolite flows of unknown thickness. To the east the rocks are in the greenschist facies or regional metamorphism, but westward from the Silver Hill Mine itself the metamorphic grade slightly increases as the Charlotte belt boundary, located just west of our map area, is approached. Mapping to the east was extended across the Silver Hill fault which is a major structural feature. Intrusive bodies of quartz monzonite and diorite-gabbro were mapped in the western portion of the area.

#### Stratigraphy

Four distinct units of volcanic and sedimentary strata were mapped in the Silver Hill area. These sequences have been dated Ordovician by the USGS. Middle Cambrian type trilobites have been found in argillite, similar to that observed in our mapping, about 30 miles south of Silver Hill. Other investigators have found that rubidium-strontium radiometric ages place the rock sequences in the Cambrian.

The oldest sequence mapped is a volcanic unit of predominantly sub-aerially deposited felsic pyroclastic rocks and designated as the felsic tuff unit. These rocks occur along the west side of the Silver Hill fault and are the host rocks of the Silver Hill orebody. The felsic

tuff unit is cut out less than a mile northeast of the Silver Hill Mine by the Silver Hill fault which trends obliquely across the regional stroke. Through the mine area the felsic tuffs attain a thickness in excess of 2,000 feet, but then southwestward to about 1,200 feet and continue on to High Rock Lake beyond our 400 scale mapping.

Rock types in the felsic tuff unit are felsic-lithic tuffs, welded tuffs, and rhyolite flows. More mafic tuffs of andesite or perhaps dacite composition occur as interbeds within the felsic tuffs. Wherever they are prominent, these more mafic rocks were mapped separately. Generally fine-grained, moderately to well-bedded tuffs become more common near the top of the unit.

Overlying the volcanic felsic tuff sequence is a volcanic-sedimentary sequence consisting of three mappable units. The basal unit is a distinctive argillite conformably overlying the volcanic tuffs. The argillite is characterized by alternating light and dark laminae ranging from about 1 mm to 3 mm in thickness. Occasional silty beds up to 1 cm are present. Northeast of the Silver Hill Mine the argillite is also cut out by the Silver Hill fault but it thickens southwestward.

The second volcanic-sedimentary unit recognized in the Silver Hill area conformably overlies the argillite and occurs to the west as a sequence of felsic tuffaceous argillite and bedded felsic tuffs. The felsic tuffaceous argillites predominate. They consist of argillaceous rocks with varying amounts of tuffaceous material included. They are usually well-bedded and bedding is on a thicker scale than that of the

laminated argillites. When the volcanic component becomes the dominant material in the rocks, they are designated as bedded felsic tuffs. These rocks are fine-grained, siliceous or silty, showing distinct bedding on a scale of about one-half inch. They might be more properly described as volcanic siltstones. The rocks in this unit become progressively more metamorphosed to the west until they assume a phyllitic character.

The youngest unit lies east of the Silver Hill fault. The rocks are very little metamorphosed argillite, siltite, and graywacke. Bedding is moderately distinctive.

The most important result of our mapping of the stratigraphy in the Silver Hill area was recognition of the felsic tuff unit below the laminated argillite. USGS mapping did not indicate such a unit. Their map shows argillite continuous to the Silver Hill fault. Although we avoided using published stratigraphic nomenclature in our mapping, we believe that the sub-aerially deposited felsic tuff unit represents a sequence which is correlative with the Uwharrie formation. The three younger, bedded units are believed to be equivalents of similar rocks in a second sequence which overlies the Uwharrie formation, both of which outcrop a few miles to the southeast in the vicinity of Albemarle, North Carolina. The Uwharrie-argillite boundary is regarded as a favorable geologic environment for the occurrence of massive sulfide deposits. Base and precious metal occurrences are known in the Uwharrie outcrop area.

## Intrusive Rocks

Intrusive rocks were mapped only in the western part of the Silver Hill area. One body of quartz monzonite occurs in the northwest portion of the map area and two elongated diorite-gabbro bodies outcrop toward the southwest. The quartz monzonite is coarse- to medium-grained, somewhat schistose and weathers to a grayish sandy soil containing distinctive quartz "eyes." The diorite-gabbro weathers to a reddish brown soil. The rock appears to be schistose. Fresh exposures are not present and mapping was based largely on its distinctive soil.

## Structure

Rock units in the Silver Hill area trend from N 10° E to N 40° E and dip steeply to the northwest. East of the Silver Hill fault southeast dips were noted which become more gentle beyond our map area. These attitudes serve to define the northwest limb of a broad synclinal structure, as mapped by the USGS in the Denton Quadrangle, which terminates against the fault in the eastern part of our map area.

The dominant structural element in the subject area is the Silver Hill fault. It trends northeast-southwest and has been mapped by the USGS for several miles in both directions beyond the confines of our map. Because of our prior experience in the North Carolina Slate belt, we felt, initially, that the existence of the fault might be questionable. It was thought, for instance, that an alternative stratigraphic correlation

could be established which would negate the existence of the fault. After mapping in the Silver Hill area, however, we accept the existence of the Silver Hill fault. This acceptance is based on the truncation of a regional fold and our map units, the obvious increase in metamorphism across the fault, the noticeable change in lithology across the fault, and our tentative stratigraphic correlations.

It is probable that minor faulting occurs in the area, but definite field evidence is lacking.

Completion of our mapping in the Silver Hill area provided a basic understanding of the geologic setting of the Silver Hill Mine itself and identified the areal extent and distribution of the favorable volcanic sequence away from the mine.

#### Geology of Silver Hill Mine

A second phase of geologic mapping was conducted in the immediate vicinity of the Silver Hill Mine itself and a geologic map prepared (Plate 2). Aerial photos at a scale of 100 feet to the inch served as the base. In addition to normal traverses, the geologic section exposed along the mine road was measured and mapped in detail by E. Jones and I. Kiff. Also, six back-hoe trenches were cut in key areas across the trend of the mineralized zone.

## Rock Types

Rocks in the mine area are of two general types, felsic and andesitic tuffs. The two types are interbedded and quite variable lithologically. Felsic tuffs predominate in the overall section but andesitic tuffs are prominent locally. Felsic rock types in the mine area are:

- 1) Felsic tuff; a variable lithology. The tuffs may be compact and fine grained with a chalky or ashy texture and few, if any, coarser clasts (lapilli). Grain size may increase and the size and quantity of included fragments may also increase. Color of the rock in surface exposures ranges from a light gray, to gray, to a very pale green. The felsic tuffs occur mainly through the central portion of the mine area and many beds carry iron oxide spots or casts after sulfides. At depth, drill cores show these tuffs to be pyritic and contain horizons with scattered lead and zinc mineralization. These rocks are intimately associated with the Silver Hill ore lens.
- 2) Lapilli tuff; a variety of felsic tuff containing abundant clastic fragments greater than 5 mm in diameter. The lapilli are usually inset into a somewhat finer matrix and when lapilli constitute half or more of the rock it was designated lapilli tuff. The clasts are lithic fragments, generally of a felsite. In Trench 3 near the surface projection of the mineralized zone, 1 to 2 inch fragments of felsic tuff and rhyolite occur in a breccia. Other lapilli tuff and breccia was noted in Trench 5. Overall, lapilli tuffs constitute a very minor portion of the volcanic sequence and are generally restricted to a zone through the mine area.
- 3) Rhyolite; a term applied to extremely fine-grained, compact, microcrystalline siliceous rocks which occur in beds from 1 to 10 feet thick. The rock is tough, but repeated hammer blows will shatter the rock into splintery fragments with conchoidal surfaces. Color ranges from gray to pink, weathering to a chalky white. Flow-banding was noted in a few places such as in the eastern part of Trench 3. It is probable that most of the rocks are not

flows but welded tuffs and perhaps flow tuffs. Much of the rock contains disseminated pyrite in cubic form.

- 4) Bedded felsic tuff; consists of fine-grained tuffs showing distinct bedding. Light-colored bands from 1-4 mm alternate with darker 1-2 mm bands. Relatively coarser, more siliceous types have less distinct bedding ranging up to 1 inch or more in thickness. Some of the thinner bands or laminae are very pyritic or consist entirely of pyrite as shown in cores. The bedded tuffs occur east of the mine in a zone adjacent to the Silver Hill fault, in very thin interbeds in the mine area itself, and west of the mine near the top of the volcanic sequence.

The andesitic tuffs also exhibit a quite variable character.

Andesitic rocks in the mine area are:

- 1) Andesitic tuff; consists of a foliated, fine-grained chlorite (and epidote?) matrix enclosing tuffaceous lithic clasts of an obscure nature. The rock weathers to a tan-buff to greenish color. Grains of quartz? are sparingly present which have a milky or opalescent-like appearance and coated by a thin film of iron oxide. The grains are in the form of rods and spindles ranging from about 1 mm to over 10 mm in length. Some of the andesitic tuffs contain iron oxide spots or casts and fresh float and drill core shows abundant cubic pyrite in the rock. In some beds manganese oxides are very abundant in fractures and along folia which imparts a brown color to saprolite exposures. Limited beds of andesitic tuff characterized by flakes or scales of a white-mica or sericite-like mineral were also noted. These scales give the rock a noticeable "spangled" effect.
- 2) Green-gray tuff; usually fine-grained with a minor coarser clastic component. The rock is variable as some limited beds of coarser fragmentals were noted. The rock actually may be dacitic rather than andesitic. It is intimately associated with felsic tuffs along the mineralized surface trend where it displays variegated oxidation colors.
- 3) Andesite; a medium-grained resistant rock, gray-green in color. It is blocky and lacks a distinctive foliation. It is observed in Trenches 1 and 2 and along the mine road to the east. On excavation by back-hoe, the rock tended to separate into  $\pm$ 1 foot polygonal blocks.

## Mineralization

Primary mineralization at the Silver Hill Mine is a complex of sphalerite, galena, and pyrite, with minor chalcopyrite, probable argentite, and traces of other sulfide species. Gold, present in the ore, likely occurs within the sulfides. The ore minerals occur in the adjacent lenses which are generally parallel and conformable to the enclosing silicified tuffs. Sulfide bodies of this type are classified as volcanigenic massive sulfide deposits. Observations of ore on surface dumps indicate that the orebody is fine-grained, banded, and the sulfide minerals are intimately admixed. The appearance of the Silver Hill ore is very similar to that of massive sulfide deposits of worldwide occurrence and in particular with those of the Bathurst District in New Brunswick in the northern portion of the Appalachian System. The gross similarities in ore type, presence of ore lenses, and similar volcanic environment were prime factors in recommending that Silver Hill be the subject of an exploration program.

Based on old reports and Tennessee Copper Company exploration, the lower lens or "east vein" is known to extend down dip at least 1,400 feet. This dimension may be thought of as extending along the keel of a trough. The width of the mineral filled trough is about 300 feet at the surface, narrowing to about 50 feet at its extreme depth. The lens (see Plate 1) ranges in thickness from 5 to 15 feet. A second, somewhat narrower but thicker lens or "west vein" lies a short distance stratigraphically above the lower lens. In fact, the upper lens approaches the lower lens and makes limited contact with it at least once along its downward course.

In repeating the findings of Chadwick given earlier, 191,000 short tons of ore are present in the existing ore lenses.

Early mining was directed toward exploiting the oxidized portion of the ore lenses. It is believed that little of this material remains in place and the condition of the surface is now such that no meaningful observation or examination can be made readily.

Outside of the main ore lenses several small discrete and noteworthy occurrences of sulphides have been observed. Pyrite, galena, and sphalerite occur as blebs or concretions both above and below the ore zone in core from the mine area. Fracture filling yellow and ruby sphalerite has been observed in the core, both near and at a considerable distance away from the ore zone. Disseminated pyrite and pyrrhotite occurs throughout various lithologies, while cubic pyrite occurs primarily in the green andesitic units and some rhyolites.

#### Alteration

Essentially five types of alteration have been observed at Silver Hill. Based on examination of drill core they are:

- 1) Chlorite; occurs primarily along certain silicified fracture zones. It is a primary constituent in the andesitic rocks.
- 2) Epidote; occurs as veinlets or threads in or near silicified fracture zones such as shears.
- 3) Calcite; occurs primarily in andesite units as spots or vugs which are sometimes stretched into boudinage-like stringers. Calcite may also occur along thin, erratic hairline fractures.

- 4) Silica; occurs both as veins and massive replacement. In Hole 1 intense silicification was noted near the ore zone.
- 5) Bleaching; certain units appear bleached. This type of alteration is most often associated with silicification.

### Structure

Rocks at the Silver Hill Mine are foliated, strike northeast and dip steeply to the northwest. At a depth of 200 feet the dip flattens to about 45° (Plate 9). Strike ranges from N 10° E to N 14° E both east of the mine and about 500 feet in the hanging wall. Rocks enclosing the ore lens strike about N 30° E. In the western parts of Trenches 3 and 5, strikes of N 55° E to N 60° E were recorded. Although no folds or faults were identified at the mine, it is likely that the variations in attitude are the result of flexure or displacement.

Older reports of underground geology at Silver Hill describe faults which trend both northeast and northwest and cut out the ore bodies (Plate 2). No direct evidence of these faults was observed. In drilling, possible fault zones were encountered but their attitude and extent are not known at this time. Faulting in the mine area was also postulated by Geoterrex on the basis of their geophysics. Reference is made to their report.

Shearing is noted at the mine, particularly in felsic tuffs, and perhaps a bit more strongly in the area of strike change noted above. Examination of the drill cores reveal also the presence of minor shearing in places. It is possible that shearing in the fine-grained rocks is

a function of ductility contrast between rock types as often the interbedded rhyolites and coarser pyroclastics show only simple fracturing.

## GEOCHEMISTRY

During 1973 a total of 1,309 soil samples were collected in the Silver Hill area (Figure 4). The samples, taken at depths of 4 to 8 inches and at intervals ranging from 5 to 100 feet were collected along roads, back-hoe trenches, VLF and I. P. lines, and analyzed for lead, zinc, mercury, and copper by Skyline Labs, Incorporated, Denver, Colorado. The total area sampled covers an area 2,000 feet wide and 9,300 feet long (the "favorable zone") and is shown in detail on Plates 3, 4, 5, and 6.

Initial sampling at Silver Hill concentrated on the immediate mine area where attention was being directed at determining conditions of the ore body and related geologic conditions by the utilization of back-hoe trenching and saprolite mapping. This trench and road sampling was successful in determining:

- 1) The presence of a 50 to 100 foot wide lead-zinc anomaly (based primarily on  $\pm 1,000$  ppm lead values) that coincide with the apparent trend of the mine ore zone and existed from the mine road northeast to Trench 2, a distance of 1,100 feet.
- 2) The presence of a 400 foot wide "Halo like" zinc anomaly which was later confirmed in drill core as being caused by weak, scattered sphalerite through a wide section either side of the main "ore lens."

Later in the year, following the completion of three holes in the mine area and our advanced knowledge of the mine mineralization, it was decided to take advantage of the surveyed I. P. lines and more ideal fall field conditions and extend the sampling southeast toward High



Rock Lake. This phase, completed in November, now gives us thorough, uniform, sample coverage over a large segment of the area including the mine dump, tailings, and contaminated alluvial areas. An explanation and discussion of the sampling and results follows.

### Lead

Background lead values (Plate 3) for the area are in the order of 25-30 ppm, but appear to increase toward the mine. Five apparent (low magnitude) anomalies occur outside the main mine anomaly and are currently being followed-up in detail. No explanation for the cause of these anomalies or the size of the mine anomaly are, as yet, known. It is felt that the broad mine anomaly is caused by the actual mineralized lens and its associated halo and contamination which naturally occurs in a mining environment.

### Zinc

Background zinc values (Plate 4) are in the order of 35-40 ppm with anomalies expressing a similar pattern to lead. Anomalies 2, 3, 4, and 6 are definitely coincident with lead and are considered to be of significant interest. Other scattered one station anomalies are not considered to be as important as the coincident anomalies but will be checked further after checking of the more critical anomalies is completed.

### Copper

Copper values (Plate 5) for the area are low and apparently reflect the relatively low copper content of the Silver Hill ore. Therefore, no

samples other than the initial tests from road and trenches, were run for copper.

### Mercury

Anomalous mercury values (Plate 6) from the mine road "ore zone" show a considerable coincidence of the Silver Hill mineralization with mercury. This fact, coupled with our knowledge that other unknown sulfide lenses are most likely non-outcropping, enhanced our chances of finding these bodies associated with mercury vapors that had migrated up dip and concentrated in the soil.

Several scattered anomalies are shown; but only five are considered of interest at present and will be checked further during 1974.

## GEOPHYSICS

Several geophysical surveys were conducted in the Silver Hill area during 1973. The work was carried out by both Cyprus personnel and contractors and is described:

### Surveys

#### Fluxgate Magnetics

A reconnaissance magnetic survey using a small flux-gate magnetometer over the known ore zones at the Silver Hill property was conducted by Peter Chapman and Bill Sharp during March 1973. The work was inconclusive because of (1) the low-magnetic susceptibility of the mineralization, (2) excessive instrument drift, and (3) interference from large amounts of metal debris in the mine area.

#### VLF Electromagnetics

During March 1973, Chapman and Sharp also conducted a VLF electromagnetic survey to determine the utility of EM geophysics in locating favorable ore horizons for future evaluation. The survey utilized a Scintrex Scoopus VLF unit which measures the directional field strength of low frequency radio waves continuously transmitted from several military radio stations in the United States. The conductive horizons within the volcanic pile act as antennas and distort the radio signal. Plate 7 shows both the area covered in general and the data obtained in the mine vicinity in detail. The horizontal signal strength is

plotted as contour intervals and the areas with the highest readings (+80) represent areas of maximum distortion from conductive horizons.

To date no conclusive correlation (through drilling, etc.) of the anomalies with mineralization has been found. However, causes of the VLF anomalies do appear somewhat coincident with the large and fairly continuous andesite units mapped in the area.

#### Anzman I. P. and Magnetism

On September 5-7, 1973, J. R. Anzman conducted a one-line (4,800 foot long, 300 foot electrode spacing) induced polarization survey and a 3,400 foot long (measurements at 30 foot intervals) magnetic survey. Results of Anzman's I. P. work was inconclusive in showing a correlation between responses and massive sulphide ore and the magnetic survey did not yield diagnostic information that could be used as an exploration guide.

#### Geotrex I. P. and Electromagnetics

In the period from October 14 to October 30, 1973, Geotrex Limited, Ottawa, Ontario, completed an induced polarization and electromagnetic survey in the Silver Hill mine area (Plate 7). The purpose of the two surveys was to check the manner in which these two methods could detect the mineralization present in the known ore zone and then apply these techniques in an attempt to map other zones of mineralization along the geologically favorable trend.

Although the electromagnetic (horizontal loop) technique failed to be of any use as a tool (probably because of the high sphalerite content of the mineralized zone), the induced polarization method proved to be an excellent tool for mapping metallic sulphides in the test area. Three zones or trends have been outlined and will be the subject target of several drill holes during 1974.

## DRILLING

During the last half of 1973, a total of 3,870 feet of core was drilled in the Silver Hill area. This footage is the result of drilling six holes, three in the mine area and three south of the mine (Figure 5). Three of the holes, 1, 2, 3, drilled in the mine area contained recognizable and assayable mineralization, but unfortunately none were of ore grade. All holes were drilled vertically and all deflected to the southeast at angles ranging from 16° to 55°. Only one hole, number 6, was not surveyed. A brief summary of each hole follows (for detail and geologic description, the reader is referred to Plates 1, 8, and 9 and drill logs of the holes).

### Hole 1

Sexton Brothers Drilling Company started drilling hole 1 on June 10 and abandoned at a depth of 412.6 feet on June 23 because of excessive bit costs. The hole was re-entered by Joy Drilling Company in early July and drilled to a bottom depth of 919.0 feet on August 9. The hole, located approximately 460 feet N 83° W of the inclined shaft was located with the major objective to penetrate a thick portion of the known ore lens and the footwall stratigraphy.

Eleven surveys, taken at 50 and 100 foot intervals, showed that the inclination away from the vertical increased from 0° at the collar to 55° at 900 feet. Vertical depth of the 919-foot hole was 795.57 feet with a lateral drift of approximately 387 feet in a S 68° E direction.



Scattered zinc mineralization was noted in the hole from bedrock (10.5 feet) to a depth of 550 feet. The most encouraging zone, a section of fine-grained, dark gray banded tuff with very fine grained laminae-like bands of pyrite, sphalerite and galena, occurred between 358 and 377 feet (Plate 8). Although more than one type of sphalerite was noted in the core, which is indicative of two or more episodes of mineralization, it is our opinion that the mineralization is of sedimentary-volcanic origin.

### Hole 2

Hole 2 was collared on August 13 on a bearing N 77° W and 1,090 feet from the shaft collar. The hole was located with the intention of intersecting both the East and the West veins at a point between the 12 and 14 levels at a depth of approximately 950 feet. The hole, however, deviated too far to the south, missing the primary target and at a bottom depth of 1,039 feet was in the footwall below the secondary target without having penetrated either the East or the West veins. Surveys for the hole show a final deviation of 47° from the vertical and a total lateral drift of 460 feet in a S 73° E direction.

Visible metallic mineralization within the hole is confined to pyrite and a few scattered sections, up to 4 inches in thickness, containing bands of sphalerite and minor galena. Twenty-five assays from the interval 801-887 feet are anomalous and interesting--but not ore grade.

### Hole 3

Hole 3, located approximately 250 feet south of hole 1 was started on September 24 and bottomed at a depth of 419 feet on October 10. The site for the hole was chosen primarily because (1) there were no known drill holes in the immediate vicinity; (2) it would further test the southern extension of the geochemical anomaly, and (3) any ore grade intercepts would extend the dimensions of the Silver Hill ore body.

Unfortunately, the hole which deviated  $16^{\circ}$  from vertical in a S  $56^{\circ}$  E direction contained only one interesting mineralized zone, a 1 inch and a 3 inch band of sphalerite at 353 and 357 feet. Eight samples from the 336-364 foot interval contained only one significant assay, one foot of 2.5% zinc at 353 feet.

### Hole 4

Hole 4 located approximately 75 feet east of the paved road and 1,750 feet south of the mine road intersection was collared on October 25 and bottomed at a depth of 637 feet on November 12. The site for this hole was chosen because of (1) a large VLF anomaly, (2) a high mercury-in-soil anomaly, and (3) an I. P. anomaly (which was better defined in later lines) was roughly coincident with the VLF anomaly.

The hole deflected S  $40^{\circ}$  E at a  $44^{\circ}$  angle, consisted primarily of dark green, medium-grained andesite, and was essentially barren of sulphide mineralization.

### Hole 5

Hole 5, located 400 feet south of hole 4 on I. P. line 24 S was collared on November 15 and bottomed on December 11 at a depth of 706 feet. The hole, spotted with the intention of intersecting an I. P. anomaly on line 24 S (see Geoterrex report), is more interesting than hole 4. A larger percentage of felsic, mine type, volcanics and mineralization (pyrite and pyrrhotite) was noted from 400-450 feet. No mineralization worthy of assay was noted.

### Hole 6

Hole 6 was collared on December 14 and bottomed on December 24 at a depth of 150 feet. The hole, thoroughly oxidized to 78 feet, consisted essentially of fine to medium-grained gray tuff. Pyrite was scattered throughout and zinc "shines" and "smears" occur from 94 to 135 feet. The core has been sawed and prepared for assay.

LAND

During 1973, an additional 318.59 acres of land was acquired in the Silver Hill area. This added acreage brings our total holdings from five owners to 1,356.63 acres. A list of the owners keyed to designations on Figure 6 are:

<u>Owner</u>	<u>Acreage</u>
Stevenson (A)	1,038.04
Tysinger (B)	39.00
Foster (C)	42.85
H. Palmer (D)	151.00
M. Palmer (E)	<u>85.74</u>
Total	1,356.63

Payments to these owners in 1973 and payments and due dates for 1974 are:

<u>Owner</u>	<u>1973 Payment</u>	<u>Date Due</u>	<u>1974 Payment</u>
Stevenson	\$6,000.00	2/1/74	\$7,500.00
Tysinger	195.00	8/22/74	195.00
Foster	228.20	8/22/74	228.20
H. Palmer	755.00	8/22/74	755.00
M. Palmer	428.70	9/6/74	428.70

Land acquisition in the Silver Hill area during the past year proved to be a tedious task. Initial contacts with several owners seemed to assume that rapid agreements could be negotiated. However,

DENTON QUADRANGLE  
 NORTH CAROLINA  
 15 MINUTE SERIES (TOPOGRAPHIC)

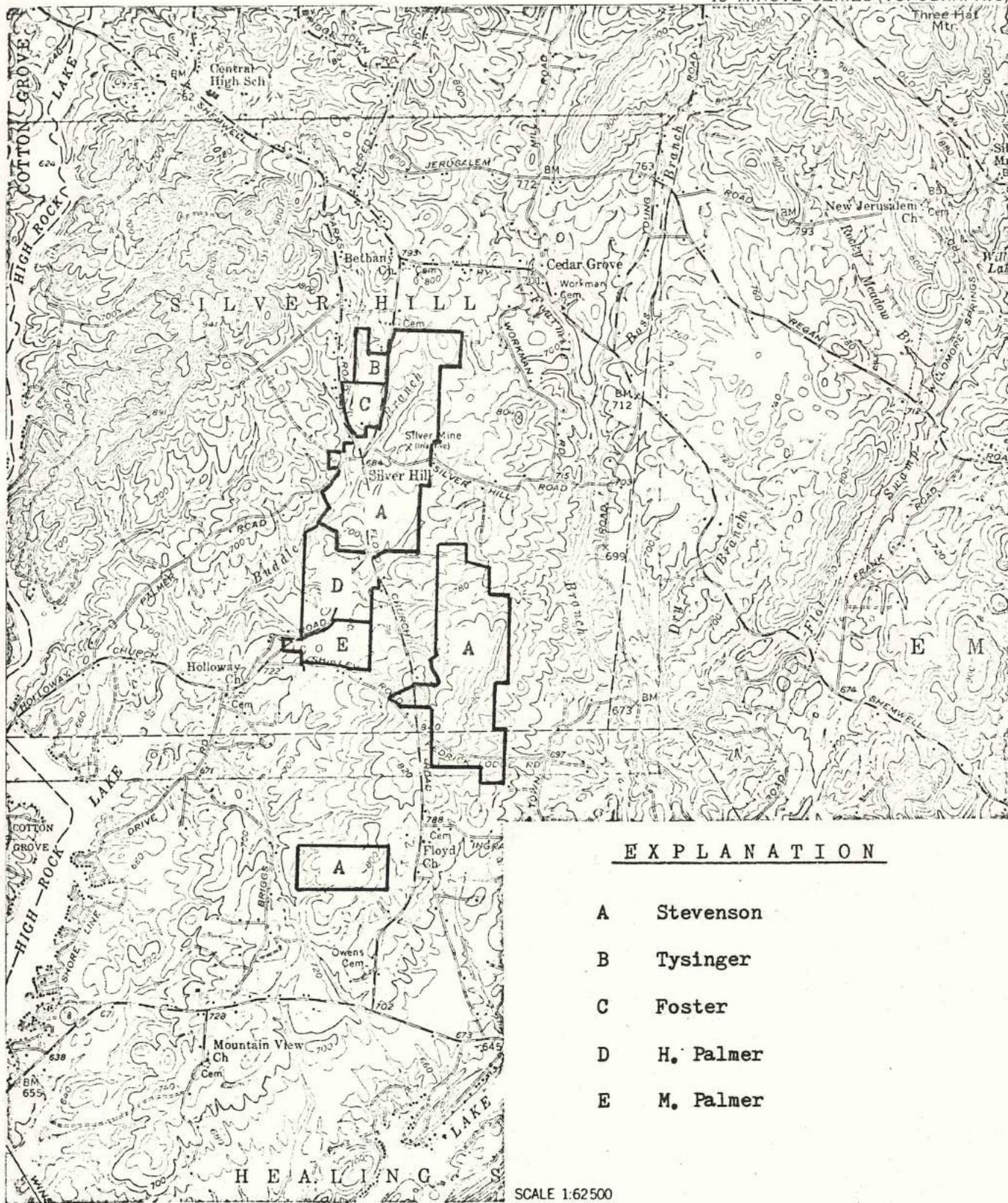


FIG. 6. Silver Hill Land Map

as in other areas of the rural Southeastern United States, time and patience seemed to be necessary in dealing with the owners.

Although we did not acquire as much land as originally planned, we did, nevertheless, obtain adequate coverage for the 1973 program and likely enough for our proposed 1974 work.

## COSTS

During 1973, approximately \$139,100 was spent on the Silver Hill Examination. A breakdown of these charges is:

Acquisition	\$ 9,700
Salaries and Wages	4,000
Surveying and Mapping	100
Geophysics	14,000
Geochemistry	7,000
Outside Contract Services	62,100
Drilling	35,500
Excavation	500
Assaying	500
Travel	1,500
Equipment	200
Miscellaneous	<u>4,000</u>
Total	\$139,100

## CONCLUSIONS

On the basis of extensive geological, geochemical and geophysical examination during 1973, it is concluded that the Silver Hill area remains favorable for continued exploration for a massive sulfide deposit. Although limited drilling during the latter half of 1973 did not discover any important new mineralization, many anomalous zones detected by geochemical and geophysical methods remain to be tested. It is also to be noted that geochemical work across the favorable volcanic stratigraphy to the southwest of the Silver Hill mine is not complete, and it is anticipated that more anomalous zones may still be located.

Authorization to continue the Silver Hill Examination was received from Cyprus Mines Corporation and Louisiana Land and Exploration Company in December 1973. The proposed program for 1974 consists primarily of shallow angle hole drilling and follow-up geochemical soil sampling.

**4.3. Report on induced polarization and electromagnetic survey for Cyprus Mines Corporation in Davidson County, North Carolina by Geoterrex Limited, Ottawa, Ontario, Canada**

By P. Norgaard and M. Carson, 1973

REPORT  
on an  
INDUCED POLARIZATION  
and  
ELECTROMAGNETIC SURVEY  
for  
CYPRUS MINES CORPORATION

in  
DAVIDSON COUNTY  
NORTH CAROLINA

by  
GEOTERREX LIMITED

85-293

OCTOBER 14 - OCTOBER 30, 1973

OTTAWA  
NOVEMBER, 1973

P. NORGAARD, P. ENG.,  
SENIOR GEOPHYSICIST.  
M. CARSON, B. SC.,  
GEOPHYSICIST.

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## I. INTRODUCTION

In the period from October 14 to October 30, 1973, Geoterrex Limited of 2060 Walkley Road, OTTAWA, Ontario completed an Induced Polarization and Electromagnetic survey on behalf of Cyprus Mines Corporation of SPOKANE, Washington. The survey was carried out in the Silver Hill area, Davidson County, North Carolina.

The purpose of the induced polarization and electromagnetic surveys was initially to check the manner in which these two methods could detect the mineralization present in the known ore zone and then apply these techniques in an attempt to map other zones of mineralization along the geologically favourable trend.

The field work was carried out under the direction of D. Brown, B. Sc., and M. Carson, B. Sc., both Geoterrex staff geophysicists. The entire project was completed under the direction of P. Norgaard, Senior Geophysicist.

## II. PERSONNEL

The following is a list of Geoterrex personnel necessary to the completion of the survey, as well as the time spent by each person on the project during the field operation and in the office for the completion of the compilation and interpretation of the final report.

<u>FIELD SURVEY OPERATION</u>	<u>NUMBER OF MAN DAYS</u>
Dan Brown, Geophysicist, 2060 Walkley Road, OTTAWA, Ontario.	10
Michael Carson, Geophysicist, 2060 Walkley Road, OTTAWA, Ontario.	4
Ken Keith, Operator, P.O. Box 1688, TUCSON, Arizona.	14
Mark Borschardt, Operator, Box 355, BAUDETTE, Minnesota.	14
Arbie Billings, Helper, c/o Manpower, LEXINGTON, N. Carolina.	7
Brian Anderson, Helper, c/o Box 355, BAUDETTE, Minnesota.	5

OFFICE COMPILATION AND REPORTNUMBER OF MAN DAYS

Peer Norgaard, Senior Geophysicist,  
2 Rebecca Crescent,  
OTTAWA, Ontario.

1

Michael Carson, Geophysicist,  
2060 Walkley Road,  
OTTAWA, Ontario.

2

### III. GEOPHYSICAL SURVEY INSTRUMENTS

For the Induced Polarization survey Time Domain instruments were employed.

The Induced Polarization receiver used is of Newmont design and manufactured by Scintrex Limited, CONCORD, Ontario. The receiver has the integration time constant adjusted to give readings of apparent chargeabilities equivalent of the fact that it actually operates on a timing cycle of 2 seconds on; 2 seconds off; and an integration time of 0.65 seconds. The transmitter employed is an Elliot 1.5 kilowatt unit manufactured by the Elliot Geophysical Company, TUCSON, Arizona.

The electromagnetic survey was carried out with a McPhar V.H.E.M. unit operating at a frequency of 2400 hz. This unit is manufactured by McPhar Geophysics Limited, DON MILLS, Ontario.

Detailed specifications of the various instruments used are included in the appendix to this report.

#### IV. GEOPHYSICAL SURVEY PROCEDURES

##### IV.1 INDUCED POLARIZATION

###### IV.1.1 GENERAL DESCRIPTION

The induced polarization method is based on the electro-chemical phenomenon of overvoltage, that is, on the establishment and detection of double layers of electrical charge at the interface between ionic and electronic conducting materials when an electrical current is caused to pass across the interface. In practice, two different field techniques, namely, Time Domain and Frequency Domain have been employed to execute surveys with this method. These techniques can yield essentially equivalent information.

All naturally occurring sulphides of metallic lustre, some oxides and graphite, give marked induced polarization responses when present in sufficient volume, even when such materials occur in low concentrations and in the form of discrete non-interconnected particles.

Each rock and soil type exhibits appreciable induced polarization response, usually confined to a relatively low amplitude range, which is characteristic of the specific rock or soil. Certain clays and platy minerals including serpentine, sericite and chlorite, sometimes give rise to abnormally high responses. These effects are attributed largely to so called "membrane" polarization.

In order to measure I.P. effects in a volume of rock one passes current through the volume by means of two contact points or electrodes and measures existing voltages across two other contact points. In the "Time Domain" method, which was employed on the present project, a steady current is passed for a period of from one second to several tens of seconds and then abruptly interrupted. The polarization voltages built up during the passage of the current will decay slowly after the interruption of the current and will be visible for at least several seconds after the interruption.

#### IV.1.2. DATA ACQUIRED

The field measurements taken were as follows:

- i) The applied current,  $I_a$ , flowing through the two current electrodes during measurement.
- ii) The primary voltage,  $V_p$ , which exists between the potential electrodes while the current is flowing.
- iii) The apparent chargeability,  $M_a$ , which is the I.P. effect noted for one complete cycle; i.e. for two current pulses applied in opposite directions.

#### IV.1.3. DATA REDUCTION

The apparent chargeability,  $M_a$ , in milliseconds per volt is read directly on the Newmont type I.P. receiver.

As mentioned above, the chargeability is measured for one complete cycle rather than per single pulse.

From the observations of primary voltage  $V_p$ , and the applied current,  $I_a$ , the apparent resistivity is calculated at each station as follows:

$$\rho_a = \frac{V_p}{I_a} \cdot K$$

where:

- $\rho_a$  = apparent resistivity in ohm metres
- $V_p$  = primary voltage in volts
- $I_a$  = applied current in amps
- $K$  = constant dependent on the array geometry.

#### IV.1.4 I.P. SURVEY PROCEDURES

For the present survey only the dipole-dipole configuration was used, generally with a dipole size,  $a$ , of 200 feet and dipole separations,  $na$ , for  $n$  values of 1 to 6. A shorter dipole length of  $a = 100$  feet was used on one line in an attempt to pinpoint more accurately an anomaly noted with the 200 foot dipole length.

#### IV.1.5 I.P. INTERPRETATION METHODS

Based on a mathematical representation of I.P. effects developed by Seigel (1959) it is possible to predict the anomalous response to be expected from a specific body with a given chargeability and resistivity contrast. Using

simple models such as spheres and dikes theoretical curves can be constructed on the basis of which anomalies due to localized bodies can be interpreted.

When the dimensions of a polarizable medium are large in comparison with its depth below surface, as is often the case in investigations of porphyry type deposits, a two layer approximation is adequate.

For more complex geometries mathematical solutions are often lacking but for such cases one may resort to model studies or to computer calculated solutions.

## IV.2 THE HORIZONTAL LOOP ELECTROMAGNETIC METHOD

### IV.2.1 GENERAL DESCRIPTION

In the horizontal loop prospecting system two light-weight coils, one receiving and one transmitting, are kept horizontal and a fixed distance apart. The receiver measures both in-phase and quadrature components of the secondary or anomalous field as a percentage of the primary field intensity. Measurements of this type can only be made if there is a mechanical link between the receiver and the transmitter which is used for the dual purpose of maintaining an accurate separation between the coils and of obtaining a reference signal from the transmitter for the phase measurement. The results are presented as profiles showing the variation of real (in-phase) and imaginary

(out-of-phase or quadrature) components of the secondary field plotted at the mid point between the coils. The system is symmetrical and the positions of transmitter and receiver are interchangeable.

In the surveying technique used with the horizontal loop system, the transmitter and receiver travel progressively along a traverse perpendicular to the anticipated strike of the conductive zone. A constant separation is maintained by keeping the connecting cable taut.

#### IV.2.2 INTERPRETATION OF HORIZONTAL LOOP E.M. DATA

The horizontal loop profile over a single vertical conductor shows a negative trough of which the shoulders exhibit small positive values. One distinct advantage of the horizontal loop data is that it gives a direct indication of the width of a body. Thus, quantitative determinations of the conductivity, expressed in mhos per meter, and the width are possible.

## V. DATA PRESENTATION

The results obtained from the survey are presented on 10 plates accompanying this report. Plates 1 through 9 are plots of the chargeability and apparent resistivity in pseudo section. The former is contoured at 0, 20, 30, 40, 50, 80 and 100 milliseconds, while the latter is contoured at 200, 400, 600, 800, 1000, and 2500 ohm-metres. The electro magnetic data is presented in profile form, with a vertical scale of 1 inch = 20 percent total field. Plate 10 is a chargeability contour plan for dipole separations of  $n_a = 200$  feet and  $n_a = 600$  feet. The axes of the anomalies are presented as shaded areas on plate 10. A horizontal scale of 1 inch = 400 feet has been used throughout.

## VI. DISCUSSION OF RESULTS

At the beginning of the survey programme the horizontal loop electromagnetic technique was tried over the ore zone on lines 4S, 0 and 4N. The best response was obtained on line 4S but even here the results were far from definitive which is not surprising considering that the majority of the sulphides supposedly are sphalerite. Based on the results obtained in completing these test traverses it was decided to abandon the idea of employing the electromagnetic method as an exploration tool in this particular case.

The induced polarization work completed over the test area was far more successful in detecting the ore zone in that quite distinct apparent chargeability responses were noted over the zone. Since sphalerite does not yield a polarization response the anomaly noted is probably caused by the associated disseminated galena and pyrite.

In addition to the chargeability anomaly associated with the ore, other induced polarization anomalies were detected but as these anomalies appeared quite distinct and well separated from the ore zone it was decided to carry on with the I.P. technique in an attempt to map the possible strike extensions of the mineralized zone in the test area. The survey coverage was thus extended to line 32S and as far north as line 16N. In the process of the routine coverage

of the area located between line 16N and line 32S three zones of anomalous polarization characteristics were noted which for ease of reference have been designated zones I, II and III.

The induced polarization anomaly designated as zone I contains the ore zone as defined for the test traverses. The present survey has mapped this particular mineralized zone along the full extent of the grid; in fact the I.P. anomaly suggests that the zone is still open both towards the north and the south off the present grid. A very distinct offset in the axis of the chargeability anomaly which occurs between lines 4N and 4S is possibly related to cross-faulting which is inferred in the geological map of this area.

The anomaly pattern related to this mineralized zone is very similar along the entire strike length in terms of the amplitude and width as indicated by the data obtained for dipole separations (na) of 200 feet. This would suggest that the depth to the top of the polarizable material remains about the same as for the initial test area where the various parameters are well established. However, where a rather distinct westerly dip is apparent in the test area on lines 0 and 4S, the anomaly patterns suggest a much more steeply dipping tabular source on all other traverses. In fact, it is quite impossible to determine from the combined induced polarization - resistivity

results alone which way the causative body is dipping. Limited detailed work employing a dipole size of 100 feet and a dipole separation of 100 feet on line 20S suggest a depth of cover of less than 50 feet on the zone at this point.

Although the amplitude of the chargeability response is quite uniform along the entire length of the zone a slightly greater concentration of polarizable material as well as a greater than average width is indicated on line 24S where the source material appears to be located between station 1W and 2W. An increase in the apparent chargeability response probably indicates an increase in the concentration of metallic sulphides such as pyrite and galena which is not necessarily reflecting an increase in the sphalerite content.

Because the polarizable material comes to within a short distance of the surface in terms of the 200 foot dipole length used for the survey the chargeability contour plan prepared from the results obtained from  $n = 1$ ,  $a = 200$  yields the best description of the position of the anomalous body. On this contour plan the interpreted position of the axis of the mineralized zone is clearly indicated as a shaded area the width of which is related to the actual width of the zone.

Zone II is located in the north east quarter of the survey area namely east of station 9E and north of line 4S. It appears to be terminated at the same interpreted fault which is responsible for the offset in zone I on line 0. However, where zone I is without doubt related to a relatively steeply dipping tabular body zone II is the expression of a much wider body of polarizable material. In fact the zone is open towards the east and north off the present grid. Because of the very uniform apparent chargeabilities noted within this wide zone it is suspected that this anomalous area is reflecting a geological unit which contains rather uniformly disseminated material such as pyrite, graphite or possibly magnetite. A concentration of the order of 1% - 2% average by volume of chargeable material is suggested.

Although zone II appears to be very broad and related to a uniform distribution of anomalous material a trend of slightly higher apparent chargeabilities was noted within the zone as indicated on the contour plan prepared from the chargeability values obtained for  $n = 1$ . This axis should be used as the target if the anomaly is to be checked by drilling.

Apparent chargeability values of the order of 25.0 milliseconds were observed at the extreme west end of lines 16S and 20S suggesting the possibility of the location of a third zone of polarizable material just west of the present

grid. The station values in question were obtained with the electrode array positioned very near a road which creates the possibility of noise or cultural effects. The existence of zone III is thus rather questionable on the basis of the present data but it should be noted that if cultural effects are responsible then for some reason no such effect appear further south along the same road where it is traversed by lines 24S, 28S and 32S.

## VII. CONCLUSIONS AND RECOMMENDATIONS

The electromagnetic technique failed to be of any use as a tool for mapping the extent of the mineralized zone as it did not define the zone of interest in the test area. Although massive or near massive sulphide mineralization apparently is present here the reason for the failure of the E.M. technique is most likely the high sphalerite content in the mineralized zone.

The induced polarization method proved to be an excellent tool for mapping the metallic sulphides within the grid area and the mineralization present in the test area has been clearly outlined by the present survey. The zone, zone I, appears to be open both towards the north and the south.

The mineralization in zone I appears to be rather uniform in concentration but there is the possibility of a slightly higher than average concentration of metallic sulphides on line 24S.

The axis of zone I is clearly indicated on the accompanying contour plan. For testing the zone by drilling the drill collars should be located to intersect the position of the axis as indicated on the plan at a distance of 75 feet - 100 feet below the surface. Drilling is not recommended on line zero at least in the initial stages as this line is interpreted to coincide with an east - west fault zone which creates a distinct offset in the anomaly axis here.

Anomaly II which is located in the north east corner of this grid is related to a rather wide zone of polarizable material which appears to be open off the grid both towards the north and east. Because of the apparent width and the very uniform polarization responses noted it is suspected that this anomaly is related to a geologic unit which contains a rather uniform distribution of disseminated polarizable material. An axis of sorts exists within the broad zone as indicated on the accompanying contour plan. If drilling is contemplated on this anomaly this axis should serve as the target as described for zone I.

The possibility of a third zone exists just west of the present grid off the end of lines 16S and 20S, however these lines would need to be extended towards the west in order to obtain proper definition.

Respectfully Submitted,



P. Norgaard, P. Eng.,  
Senior Geophysicist.

M. Carson,  
Geophysicist.

APPENDIX

## INSTRUMENT SPECIFICATIONS

### Newmont Receiver:

#### Electrical -

Primary Voltage Range	300 microvolts to 30V Accuracy $\pm 3\%$
Input Impedance	300 K ohms
Chargeability (M) Reading Range	0-100 and 0-300 milliseconds Accuracy $\pm 5\%$
Curve Factor (L) Reading Range	0-100 and 0-300 milliseconds Accuracy $\pm 5\%$
Delay Time Before Integration	0.45 seconds
SP and VLF Noise Compensation	Manual: $\pm 1.5$ volts Automatic: 1mV range $\pm 10$ mV total 30 volt range $\pm 10$ volt total
Power Supply	Internal rechargeable nickel cadmium batteries. Rated life 45 hours/charge.
Temperature Range	$-20^{\circ}$ to $130^{\circ}$ F ( $-29^{\circ}$ C to $+55^{\circ}$ C)
Humidity Range	to 100% non-condensing

NOTE: A time reference signal is remotely obtained from the received primary signal to give coherent detection.

Automatic SP corrections are applied during each reading period using a memory circuit.

#### Mechanical:

Weight	$13\frac{1}{2}$ lbs. (6.1 kg) including batteries.
Dimensions	14" x 11" x $6\frac{1}{2}$ " (32.5 cm x 28 cm x 16.5 cm).

ELLIOTT GEOPHYSICAL COMPANY  
1.5 KW I.P. TRANSMITTER

SPECIFICATIONS:

INPUT POWER:	120 volt 400 Hz single phase at 1800 VA, relatively insensitive to input voltage/frequency regulation
OUTPUT POWER:	1500 watts
OUTPUT VOLTAGE:	200 to 3000 volts in 12 switch selected steps
OUTPUT CURRENT:	5 Amps maximum.
OUTPUT IMPEDANCE DRIVE:	40 ohms to over 10,000 ohms.
TIME CYCLE:	On/off periods (symmetrical) adjustable at factory from 0.5 to 10 seconds.
TEMPERATURE RANGE (AMBIENT):	-15°C to +60°C (+5°F to 140°F)
WEIGHT, COMPLETE WITH CASE:	45 pounds.
DIMENSIONS, IN CASE:	10.5 inches high by 16 inches wide by 11.5 inches deep

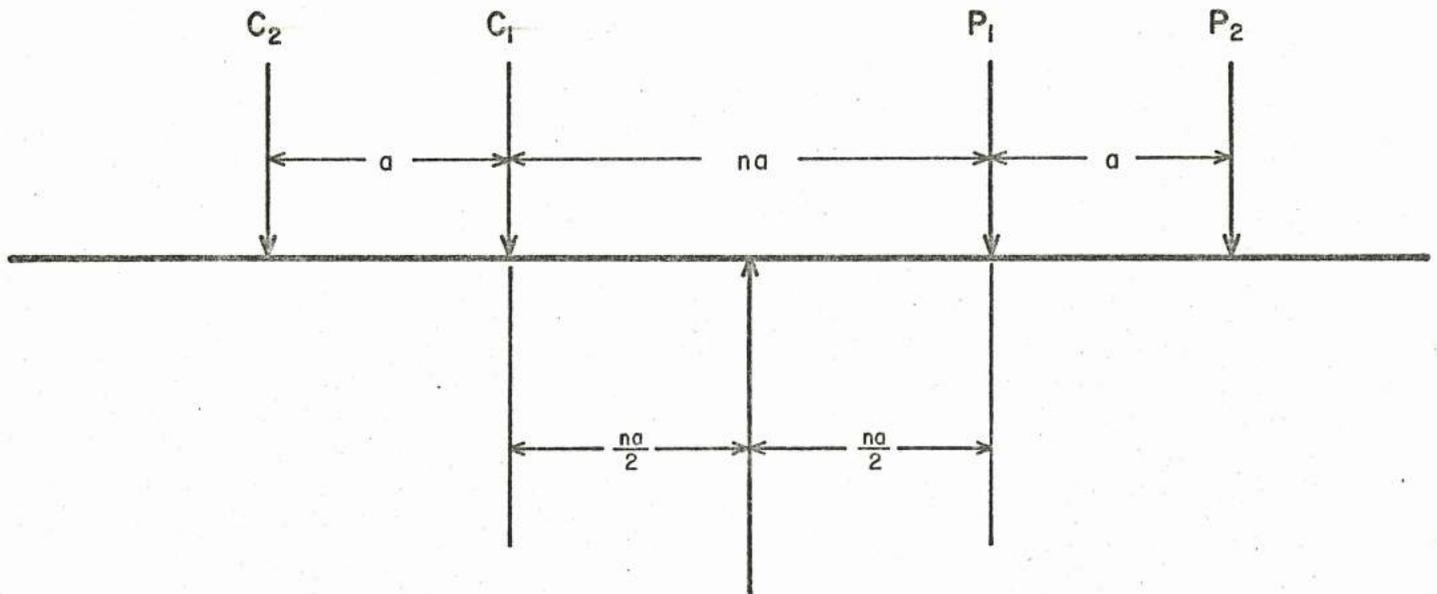
ELLIOTT GEOPHYSICAL COMPANY  
1.5 KW I.P. GENERATOR

SPECIFICATIONS:

Model P-15A

Output - volts	120
Phase	single
Frequency - hertz	400
Power - KVA	2
Engine	Briggs & Stratton Type 100232
Fuel	gasoline
Power Rating - HP	4
Starter	Recoil
Alternator	Alleco Brushless
Cooling	None
Overall dimensions - height - in.	17
length - in.	25
width - in.	18
Nominal weight - pounds	72

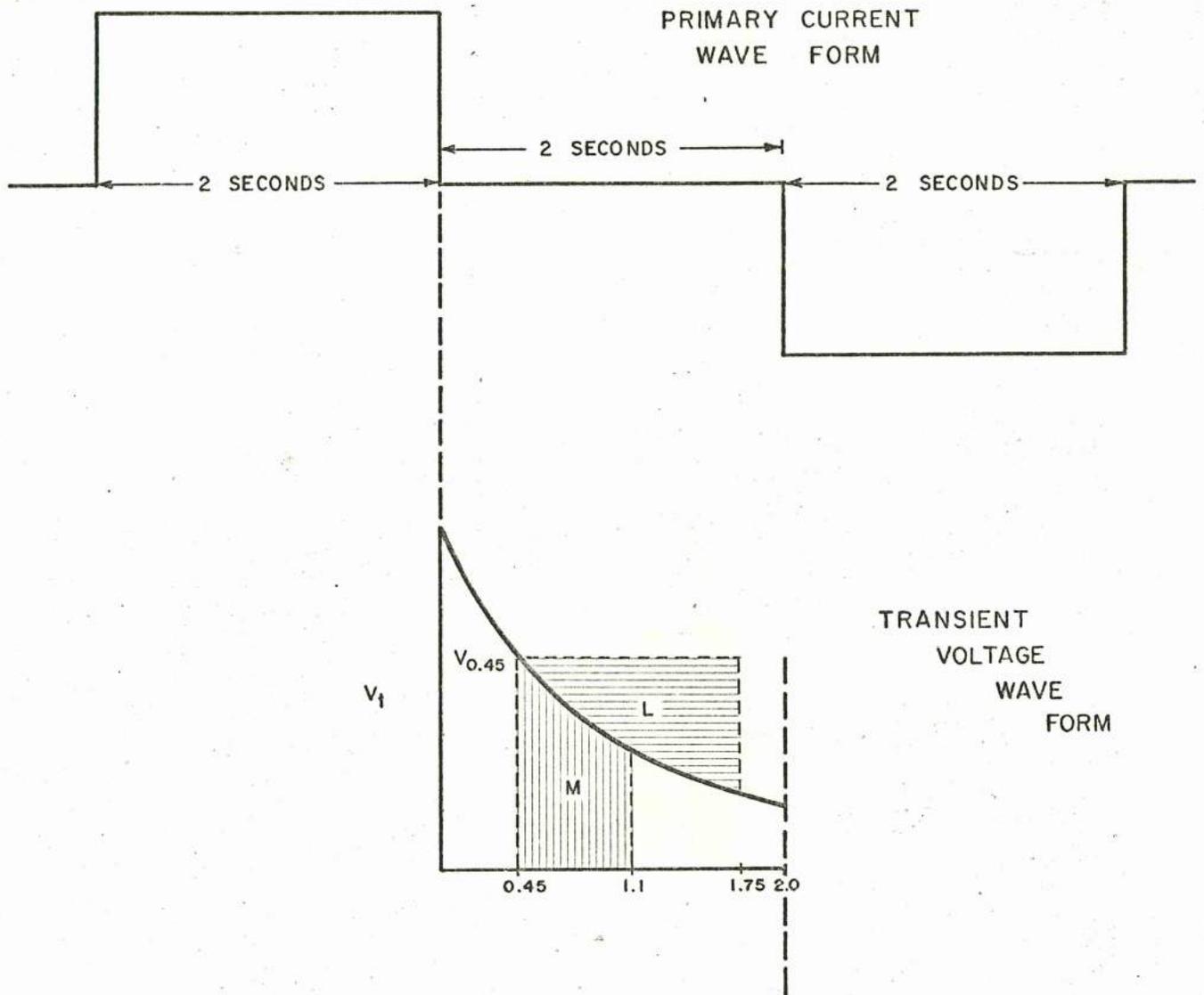
# DIPOLE-DIPOLE ELECTRODE CONFIGURATION



PLOTTING  
POSITION

$a$  = DIPOLE LENGTH

$n = 1, 2, 3$  etc.



NEWMONT - TYPE TIME DOMAIN WAVE FORMS  
AND QUANTITIES MEASURED

FIGURE B

## V.H.E.M. UNIT SPECIFICATIONS

Operating Frequencies: 600 and 2400 cycles per second

Operating Range:

Vertical Loop - Null width of approximately  $\pm 10^\circ$  at a transmitter-receiver separation of 500 feet.

Horizontal Loop - Transmitter - receiver separations of 100, 200 or 300 feet.

Transmitter Power Supply: Special High Energy, Lightweight battery pack - Supply Voltage: 48 volts - Supply Current 250 milliamperes.

Approximate Battery Life: 15 hours of transmission time.

Note: The above battery supply may be replaced by any d.c. power source of 48 volts and  $\frac{1}{4}$  ampere rating.

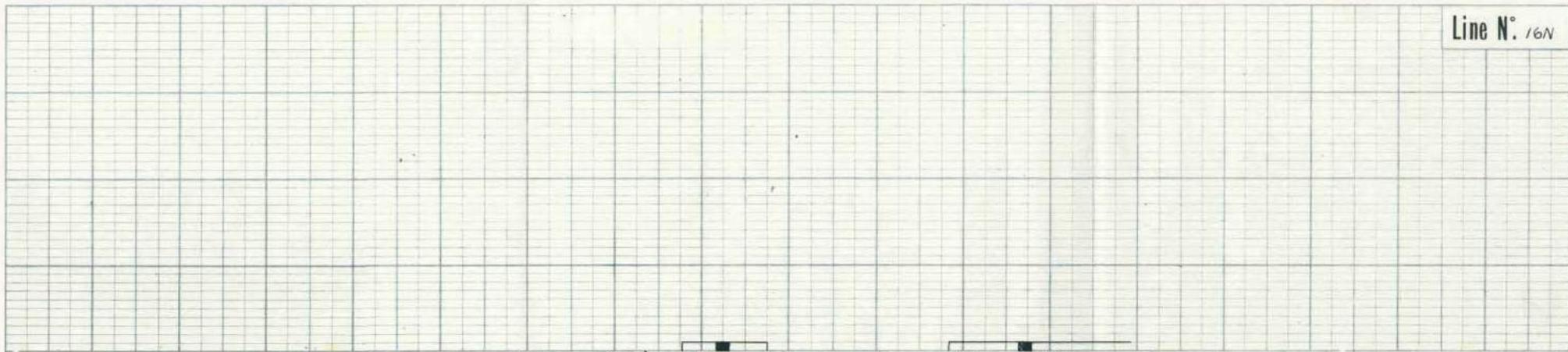
Receiver Supply: 2 type E146 Eveready battery. Approximate battery life: 250 operating hours.

Operating Temperature Range: 35°F to 120°F.

Weights:

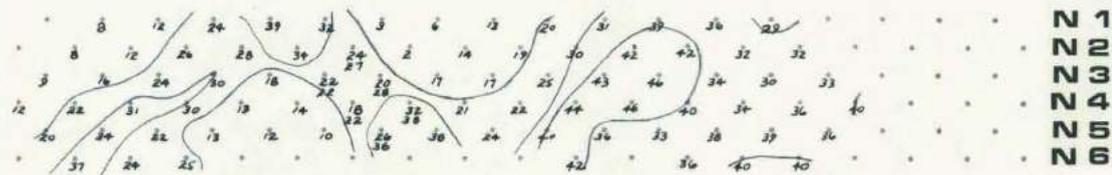
Transmitter - 9 lbs.

Receiver - 8½ lbs.



12W 8W 4W 0 4E 8E 12E 16E

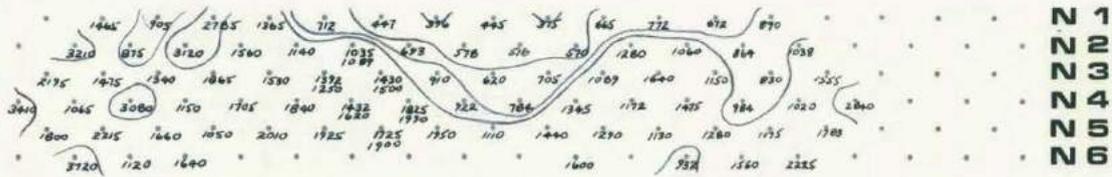
Ma (Milli seconds)



2 1  
2 2  
2 3  
2 4  
2 5  
2 6

LINE 16N

Pa (Ohm Meters)



2 1  
2 2  
2 3  
2 4  
2 5  
2 6

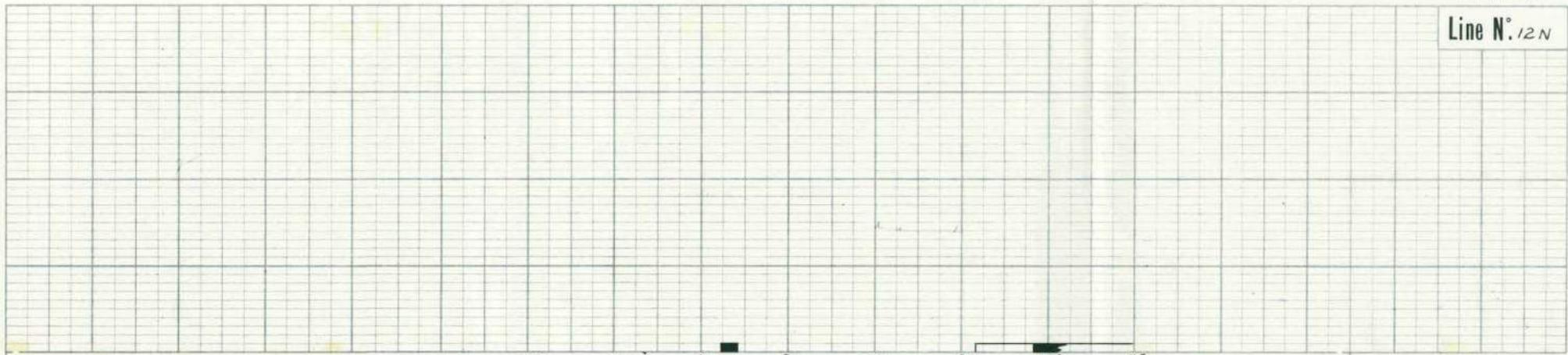
DIPOLE LENGTH

**D.C. PULSE I.P.;** CHARGING TIME 2 SECS.  
 (CHARGEABILITIES FOR COMPLETE CYCLE) OFF-TIME 2 SECS.  
 DELAY TIME 0.45 SECS.  
 INTEGRATION TIME 0.65 SECS.



Client .. CYPRUS MINES ..  
 Area .. SILVER HILL ..  
 Survey .. DIPOLE-DIPOLE ..

Job N°: 65-290 ..  
 Date 28-10-73 ..  
 Dipole (a) 200' ..



Ma (MilliSeconds)

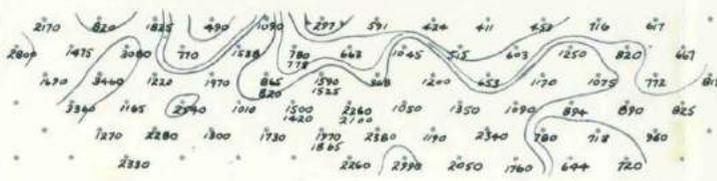
Pa (Ohm Meters)

12W 8W 4W 0 4E 8E 12E 16E



N 1  
N 2  
N 3  
N 4  
N 5  
N 6

LINE 12N



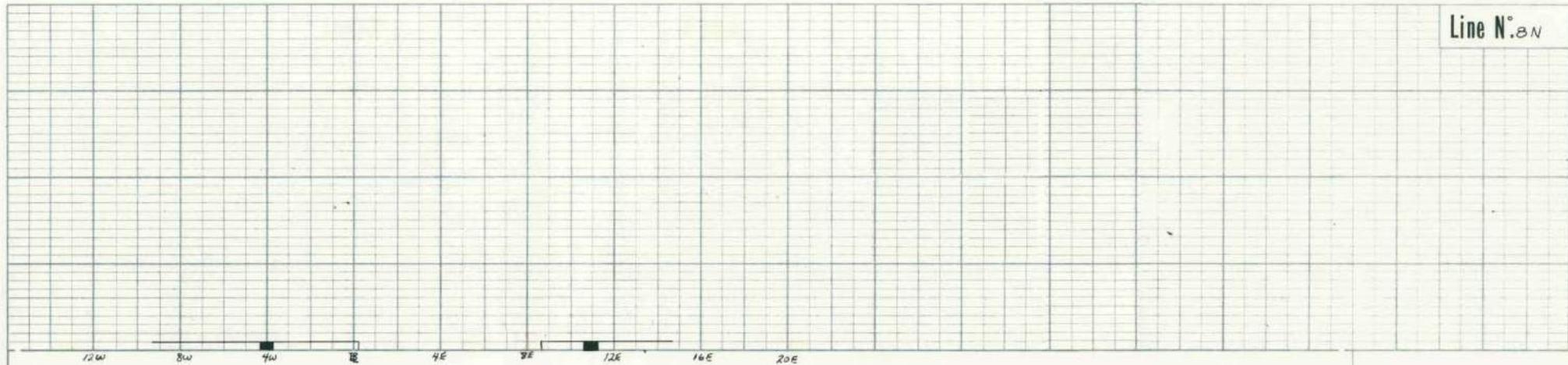
N 1  
N 2  
N 3  
N 4  
N 5  
N 6

DIPOLE LENGTH

**D.C. PULSE I.P.;** CHARGING TIME 2 SECS.  
 (CHARGEABILITIES FOR COMPLETE CYCLE) OFF-TIME 2 SECS.  
 DELAY TIME 0.45 SECS.  
 INTEGRATION TIME 0.65 SECS.



Client ... CYPRUS MINES ..... Job N°: 85-290  
 Area ... SILVER HILL ..... Date 27-10-73  
 Survey ... DIPOLE - DIPOLE ..... Dipole (a) 200'



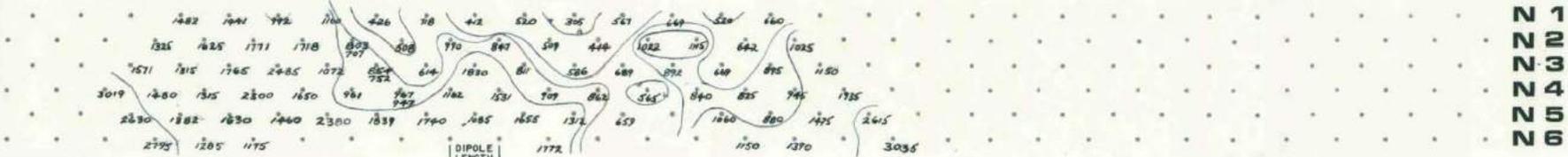
Ma (Milliseconds)



N 1  
N 2  
N 3  
N 4  
N 5  
N 6

LINE 8N

Pa (Ohm Meters)



N 1  
N 2  
N 3  
N 4  
N 5  
N 6

DIPOLE LENGTH

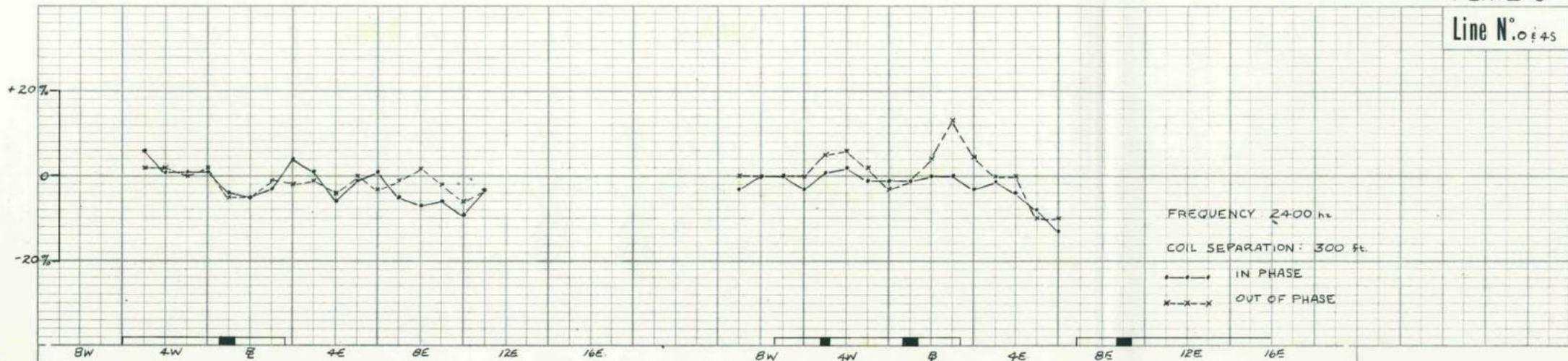
**D.C. PULSE I.P.;** CHARGING TIME 2 SECS.  
 (CHARGE ABILITIES FOR COMPLETE CYCLE) OFF-TIME 2 SECS.  
 DELAY TIME 0.45 SECS.  
 INTEGRATION TIME 0.65 SECS.



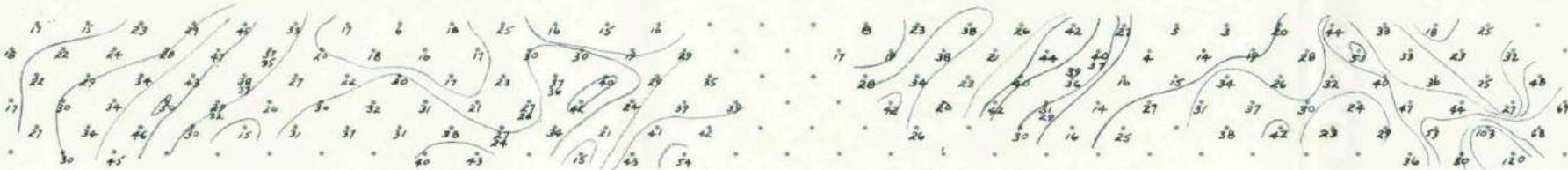
Client ... CYPRUS MINES ...  
 Area ... SILVER HILL ...  
 Survey ... DIPOLE-DIPOLE ...

Job N<sup>o</sup> 85-290.  
 Date 24.125-10-73.  
 Dipole (a) 200'





Ma (Millitesla)



N 1  
N 2  
N 3  
N 4  
N 5  
N 6

Pa (Ohm Meters)



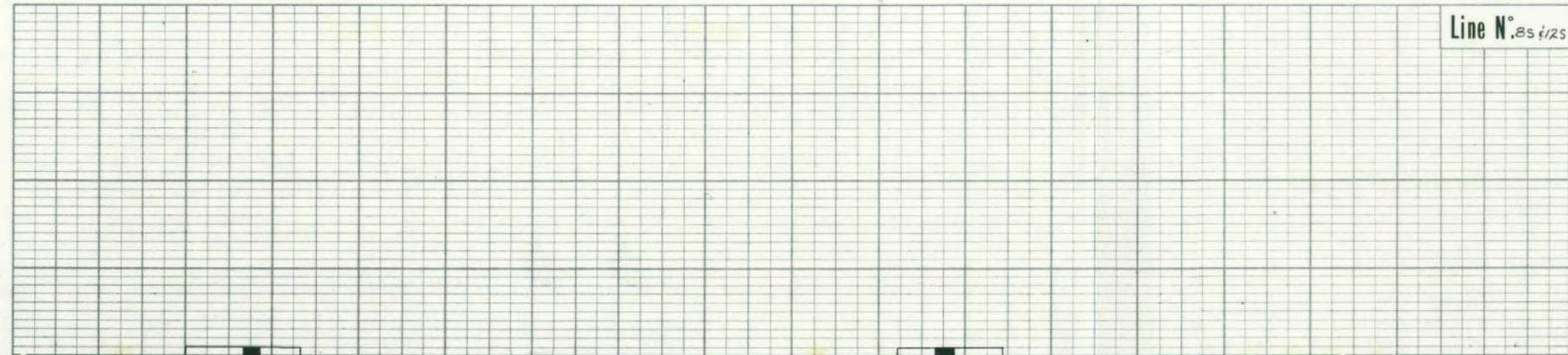
N 1  
N 2  
N 3  
N 4  
N 5  
N 6

**D.C. PULSE I.P.;** CHARGING TIME 2 SECS.  
 (CHARGEABILITIES FOR COMPLETE CYCLE) OFF-TIME 2 SECS.  
 DELAY TIME 0.45 SECS.  
 INTEGRATION TIME 0.65 SECS.

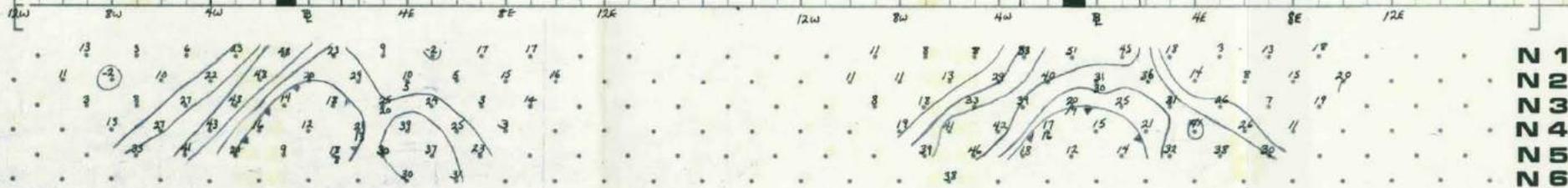


Client .. CYPRUS MINES ..  
 Area .. SILVER HILL ..  
 Survey DIPPLE - DIPPLE ..

Job N°: 85-290.  
 Date 15th. 10-73.  
 Dipole (a) 200'.

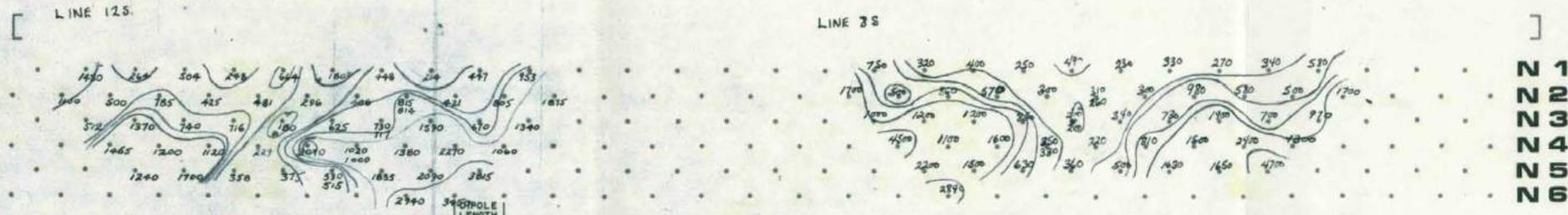


Ma (Milliseconds)



N 1  
N 2  
N 3  
N 4  
N 5  
N 6

Pa (Ohm Meters)



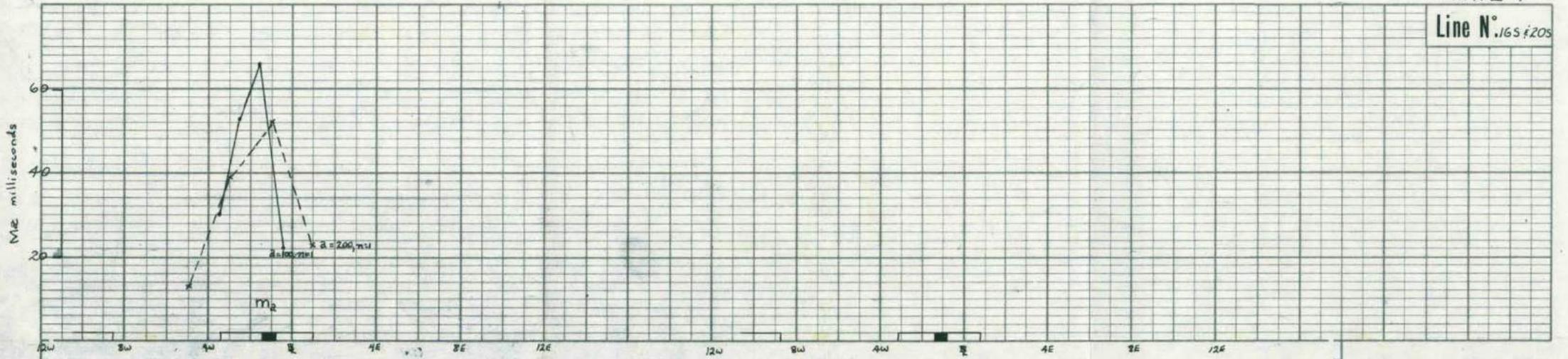
N 1  
N 2  
N 3  
N 4  
N 5  
N 6

**D.C. PULSE I.P.;** CHARGING TIME 2 SECS.  
 (CHARGE ABILITIES FOR COMPLETE CYCLE) OFF-TIME 2 SECS.  
 DELAY TIME 0.45 SECS.  
 INTEGRATION TIME 0.65 SECS.



Client: CYPRUS MINES  
 Area: SILVER HILL  
 Survey: DIPOLE-DIPOLE

Job N°: 85-290  
 Date: 19.8.21-10-78  
 Dipole (a): 200'

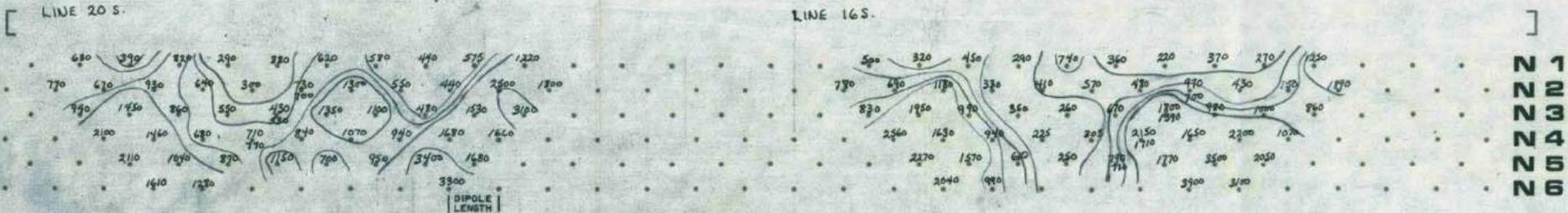


Ma (Mili seconds)



N 1  
N 2  
N 3  
N 4  
N 5  
N 6

Pa (Ohm Meters)



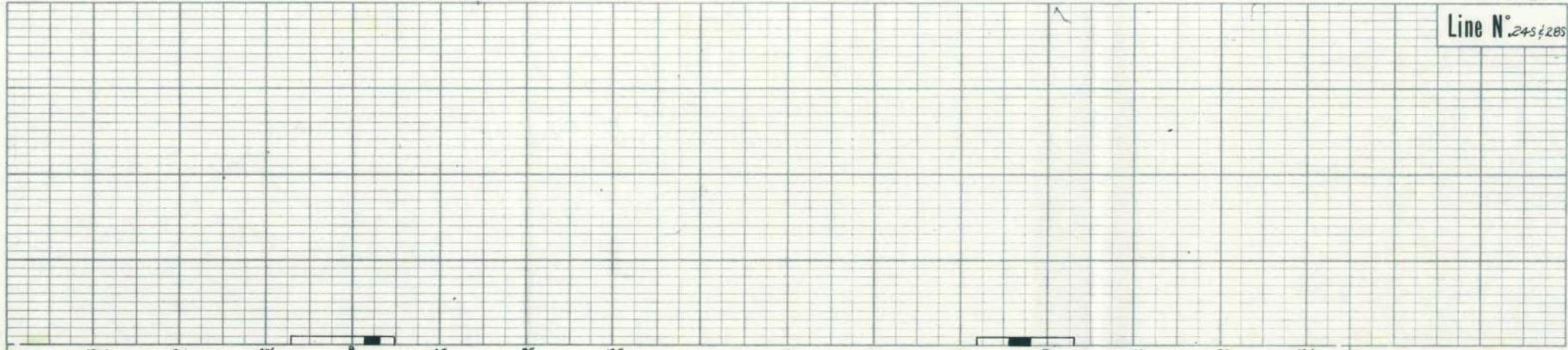
N 1  
N 2  
N 3  
N 4  
N 5  
N 6

**D.C. PULSE I.P.;** CHARGING TIME 2 SECS.  
(CHARGEABILITIES FOR COMPLETE CYCLE) OFF-TIME 2 SECS.  
DELAY TIME 0.45 SECS.  
INTEGRATION TIME 0.65 SECS.



Client .. CYPRUS. MINES .....  
Area .. SILVER. HILL .....  
Survey .. DIPOLE: DIPOLE .....

Job N°: 85-290.  
Date 22-10-73  
Dipole (a) 200'



12W 8W 4W E 4E 8E 12E 12W 8W 4W E 4E 8E 12E

Ma (Milliseconds)



N 1  
N 2  
N 3  
N 4  
N 5  
N 6

Pa (Ohm Meters)



N 1  
N 2  
N 3  
N 4  
N 5  
N 6

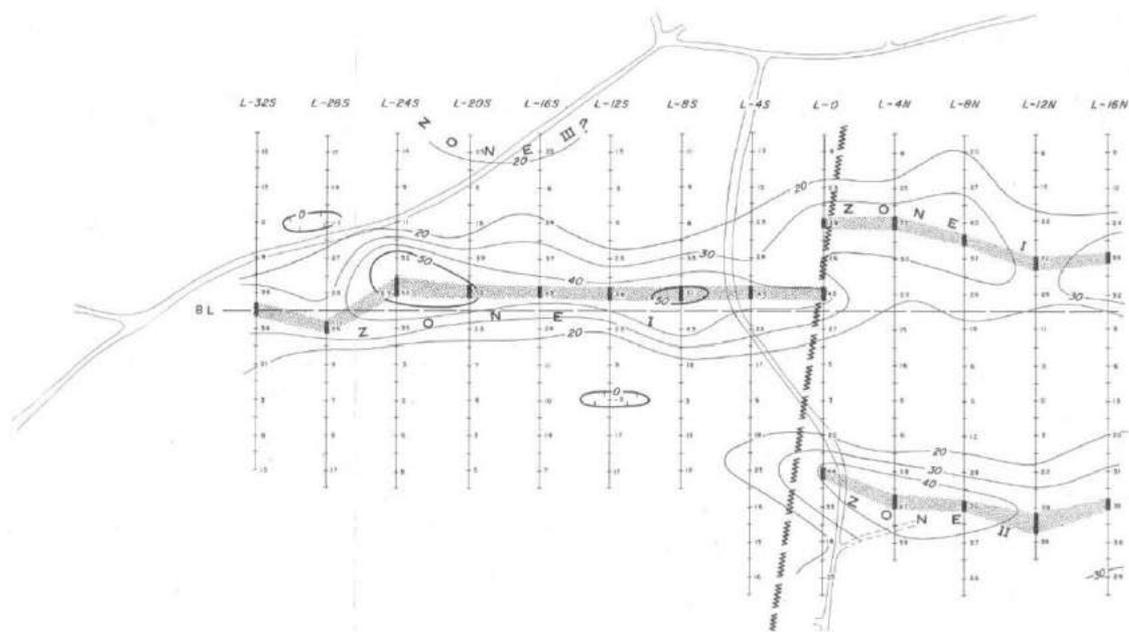
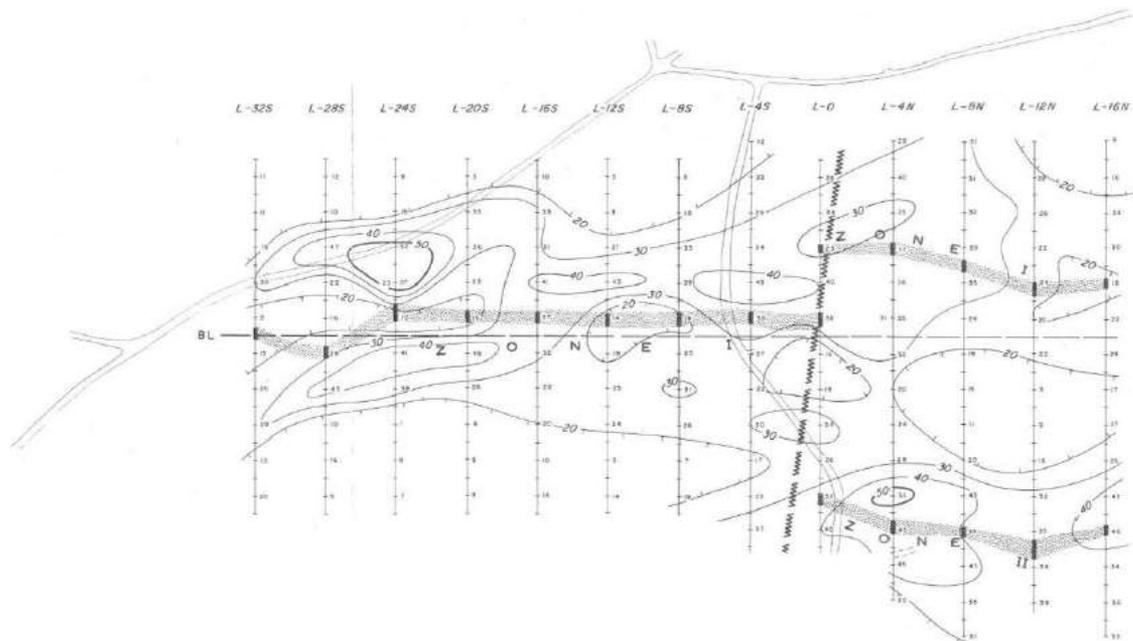
**D.C. PULSE I.P.;** CHARGING TIME 2 SECS.  
 (CHARGEABILITIES FOR COMPLETE CYCLE) OFF-TIME 2 SECS.  
 DELAY TIME 0.45 SECS.  
 INTEGRATION TIME 0.65 SECS.



Client ... CYPRUS MINES ...  
 Area ... SILVER HILL ...  
 Survey ... DIPOLE-DIPOLE ...

Job N°: 85-290  
 Date 23/25-10-78  
 Dipole (a) 200'





**4.4. Induced polarization and magnetic surveys, Silver Hill Project, Davidson County, North Carolina, for Cyprus Mineral Corporation, Cyprus Mines Corporation, Spokane, Washington**

By J.R. Anzman, 1973

INDUCED POLARIZATION AND MAGNETIC SURVEYS

SILVER HILL PROJECT

DAVIDSON COUNTY, NORTH CAROLINA

by

Joseph R. Anzman  
Consulting Geophysicist

for

Cyprus Mines Corporation  
Spokane, Washington  
October 17, 1973

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INTRODUCTION. . . . . 1  
INDUCED POLARIZATION. . . . . 2  
MAGNETICS . . . . . 5  
CONCLUSIONS . . . . . 6  
RECOMMENDATIONS . . . . . 7

ILLUSTRATIONS

Map Pocket

LOCATION OF INDUCED POLARIZATION AND MAGNETIC TRAVERSES

MAGNETIC PROFILE

INDUCED POLARIZATION PROFILE - LINE 1

INDUCED POLARIZATION AND MAGNETIC SURVEYS

SILVER HILL PROJECT

DAVIDSON COUNTY, NORTH CAROLINA

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INTRODUCTION

This report presents the results of induced polarization and magnetic surveys carried out for Cyprus Mines Corporation at the Silver Hill Project, Davidson County, North Carolina.

The geologic target was massive lead-zinc sulfide mineralization. Mining of this material had taken place in prior days. Drilling by other companies has outlined some tonnage of this mineralization still in the ground. Use of the induced polarization and magnetic methods was predicated on trying to detect the mineralization or any unique geologic conditions to which the mineralization was related. By correlating the results of these surveys with known geology and drill results, guidelines for further exploration in the area would hopefully be acquired.

## INDUCED POLARIZATION

Induced polarization measurements were made using frequency domain equipment at 0.1 and 1.0 Hz. A dipole-dipole electrode configuration was used at an electrode spacing of 300 feet. One line was surveyed and had a total length of 4,800 feet. The work was done on September 5-6, 1973.

A 300-foot electrode spacing was chosen so as to yield an expected depth of penetration in the order of plus/minus 500 feet. This depth would be reasonably close to the vertical depth of drilling that was being done by Cyprus Mines Corporation contemporaneously with the I.P. survey.

Anomalous frequency effects were realized from 15E-15W. The anomalous body is nearest the surface at 0-3E.

On the west end of the line, the frequency effects are not anomalous on the nearby electrode separations. But on the wider separations, anomalous values are obtained. This pattern would seem to be indicative of a sulfide body that is sloping away from the survey line to the west. From prior geological knowledge, it is known that this slope would be to depth rather than to the side. The sending diagonal at 6W-9W is not anomalous, so it would seem at first glance that this location is the cutoff of the anomalous ground. However, with a sulfide body that is sloping to the west, it may just be that

the body is too deep to be "seen" when using a 300-foot electrode spacing.

The pattern on the east end of the line is somewhat similar to that on the west end. Frequency effects are not anomalous on the nearby electrode separations, but are anomalous on the wider separations. But here the similarity ends. On the wider separations on the east end, a defineable pattern is present consisting of the strongest frequency effects realized in the survey. On the east end, then, it would appear that a discrete geologic body is present causing this response, and is centered at about 9E. With only the one line being surveyed, it is not possible to tell if the causitive body is at depth or to one side of the survey line.

Based on the above evaluation of anomalous conditions, the anomaly is considered as still being open beyond 15E and 15W.

A low resistivity zone is present in the interval 0-3E and is present on the first electrode separation. The pattern of this anomaly indicates that it is likely caused by a body that has a finite depth extent; a near-surface hemisphere would be a good visualization.

In the search for massive sulfides, low resistivity would be a sought-after parameter. In the case of the zone at 0-3E, one possibility is that it is due to the broken ground at the area of the old mine workings. However, a second possibility is that it is due to structural

conditions which had a part to play in the emplacement of the massive mineralization that has been mined out. No other low-resistivity zones considered significant are present.

## MAGNETICS

Magnetic measurements were taken at 30-foot intervals along one traverse 3,420 feet long on the road about 400 feet south of the mine shaft. A total of 115 measurements were taken using a proton magnetometer. The work was done on September 7, 1973.

From east to west, the magnetic values show a gradual increase, probably due to a deep-seated source. Superimposed on this are a number of local features that are due to materials closer to the surface. These features are of low magnetude, generally having a relief in the order of 50 gammas. In some cases, they can be correlated with known surface geology. However, and most important, this one traverse does not yield any features which would seem to relate to the known mineralized area in a way that provides any useful exploration guidelines.

## CONCLUSIONS

The induced polarization survey has shown an anomalous area from 15E to 15W, with the anomaly not yet closed off at these locations. The anomaly is nearest the surface at 0-3E. To the west, the anomaly appears to slope to depth. On the east, a separate anomalous body is centered at 9E either at depth or to one side of the survey line.

The presence of massive sulfide mineralization has not been indicated by the I.P. work. There are a number of possibilities that may explain this situation:

1. massive sulfide mineralization may not exist,
2. massive sulfide mineralization may exist, but may be of a non-conductive type and not detectable by electrical methods of geophysical surveying---that is, sphalerite,
3. any massive sulfide mineralization that may be present may be of too small a size to be detectable by the induced polarization method at an electrode spacing of 300 feet.

The magnetic results did not yield any diagnostic information that could be used as a guide to further exploration.

## RECOMMENDATIONS

The presence of an anomalous response, although without any indication of massive sulfide mineralization, may be a positive aspect of the survey results. Perhaps the presence of more widespread and disseminated sulfide mineralization is the only geologic condition that is uniquely detectable by surface geophysical techniques. If massive sulfides are associated with this widespread mineralization, then induced polarization work could be done to outline the limits of the sulfide area. As with the present survey results, this new work may show the location at which sulfides are closest to the surface. This type of information when correlated with geologic data may provide locations for test holes.

The possibility also exists that elsewhere within the disseminated sulfide area, massive sulfides are present that are conductive. If so, their presence may be detected by additional I.P. work. If indicated, they would certainly constitute drill targets. Along with this, low resistivity zones, such as the one at O-3E, that may possibly be due to structural conditions of exploration interest, may also be outlined. These types of targets may be defined, perhaps, by electromagnetic methods also.

Admittedly, these comments do not point to specific actions to be taken that usually fall under the heading of "recommendations."

Rather, they seek to point out some reasonable and plausible possibilities for future exploration. Certainly these comments should be tempered by geologic considerations.

*Joseph R. Anzman*

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Joseph R. Anzman  
October 17, 1973

**4.5. Status report II on the Silver Hill examination, Davidson County, North Carolina, for Cyprus Mines Corporation and Louisiana Land and Exploration Company, Knoxville, Tennessee**

By E.R. Jones, 1974

THE SILVER HILL EXAMINATION  
DAVIDSON COUNTY, NORTH CAROLINA

1974

STATUS REPORT II  
ON  
THE SILVER HILL EXAMINATION  
DAVIDSON COUNTY, NORTH CAROLINA  
1974

For  
Cyprus Exploration Company  
and  
Louisiana Land and Exploration Company

By  
Earl M. Jones

Earl M. Jones  
Exploration Geologist  
5612 Kingston Pike  
Knoxville, Tennessee 37919

August 1974

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## Summary

Exploration of the Silver Hill Mine, Davidson County, North Carolina, was continued during the first six months of 1974 by Cyprus Exploration Company and Louisiana Land and Exploration Company. The 1974 exploration program was a continuation of the joint venture geochemical, geophysical and geological program started during 1973 by the two companies. During early 1974, considerable additional data was obtained, and it is the purpose of this report to summarize and interpret the information.

Initial 1974 work at Silver Hill involved the extension of geochemical coverage both north and south of the mine. A total of 1,306 soil samples were collected from the extension areas and in follow-up of 1973 anomalies. Evaluation of the sampling was successful in outlining ten separate geochemical anomalies, of which, several were later drilled.

Eight shallow holes were drilled at Silver Hill in 1974. Four were in the mine area and four south of the mine. All holes were drilled to test either geochemical or geophysical anomalies. Unfortunately, none of the holes contained ore grade, or even encouraging, mineralization.

A geological/geochemical reconnaissance of several Silver Hill area sulphide mines and prospects were also conducted during 1974. Five major prospects were sampled and mapped. Results of

the work does not readily justify follow-up or continued studies in these areas.

We conclude, on the basis of the 1973-74 exploration program, that if an unknown economic massive sulphide lens exists at Silver Hill, it is (1) either too small to be detected by our coverage of the area or (2) lies buried at depths too deep to be detected by tools used in our program.

### Introduction

On the basis of extensive geological, geochemical and geophysical work conducted during 1973 (summarized in a report by Jones and Kiff, February, 1974), it was concluded that the Silver Hill area remained a favorable target for an economic massive sulphide deposit. Authorization to continue exploration of the area during 1974 was received and plans formulated during the latter part of 1973.

Basically, the 1974 program was aimed at (1) determining the extent of geochemical soil anomalies along the "favorable geologic trend" and (2) determining the cause of the 1973 geophysical and geochemical anomalies within the trend. Soil sampling and diamond drilling, with limited geophysical work constituted most of our time and resources in the immediate Silver Hill area while some geologic scouting and sampling of nearby prospects consumed several man hours. The following report will deal primarily with the work conducted during the period January 1-August 1, 1974.

## Geochemistry

During 1974 a total of 1,306 soil samples were collected in the Silver Hill area. The samples, taken at depths of 4 to 8 inches and at intervals ranging from 5 to 100 feet, were collected south of the mine near High Rock Lake, in the mine area north of the 1973 sampling, and in selected anomalous areas detected in 1973 (see Figure 1 and attached maps). The 1973-74 survey, entails the collection of 2,615 samples and gives reasonably adequate coverage of most of the recognized potentially mineralized zone. The area covered by the survey extends from a point 3,200 feet northeast of the mine to a point 21,700 feet southwest of the mine, a zone approximately 1,000-2,000 feet wide and 4-1/2 miles long.

Initial 1974 sampling concentrated on detailed follow-up of several anomalous areas detected in the 1973 sampling. Boxlike grids were prepared and sampled near ten scattered 1973 anomalies. Areas expressing positive results after follow-up were later drilled and essentially proven to be barren of Silver Hill type mineralization.

After completion of the follow-up sampling, twenty-eight lines averaging 1,000 feet in length were run south of the mine and an additional four lines averaging 3,200 feet in length were sampled north of the mine. Unfortunately, no significant mercury, lead or zinc anomalies were detected in these areas. For detail the reader is referred to maps in the appendix of this report.

DENTON QUADRANGLE  
 NORTH CAROLINA  
 15 MINUTE SERIES (TOPOGRAPHIC)

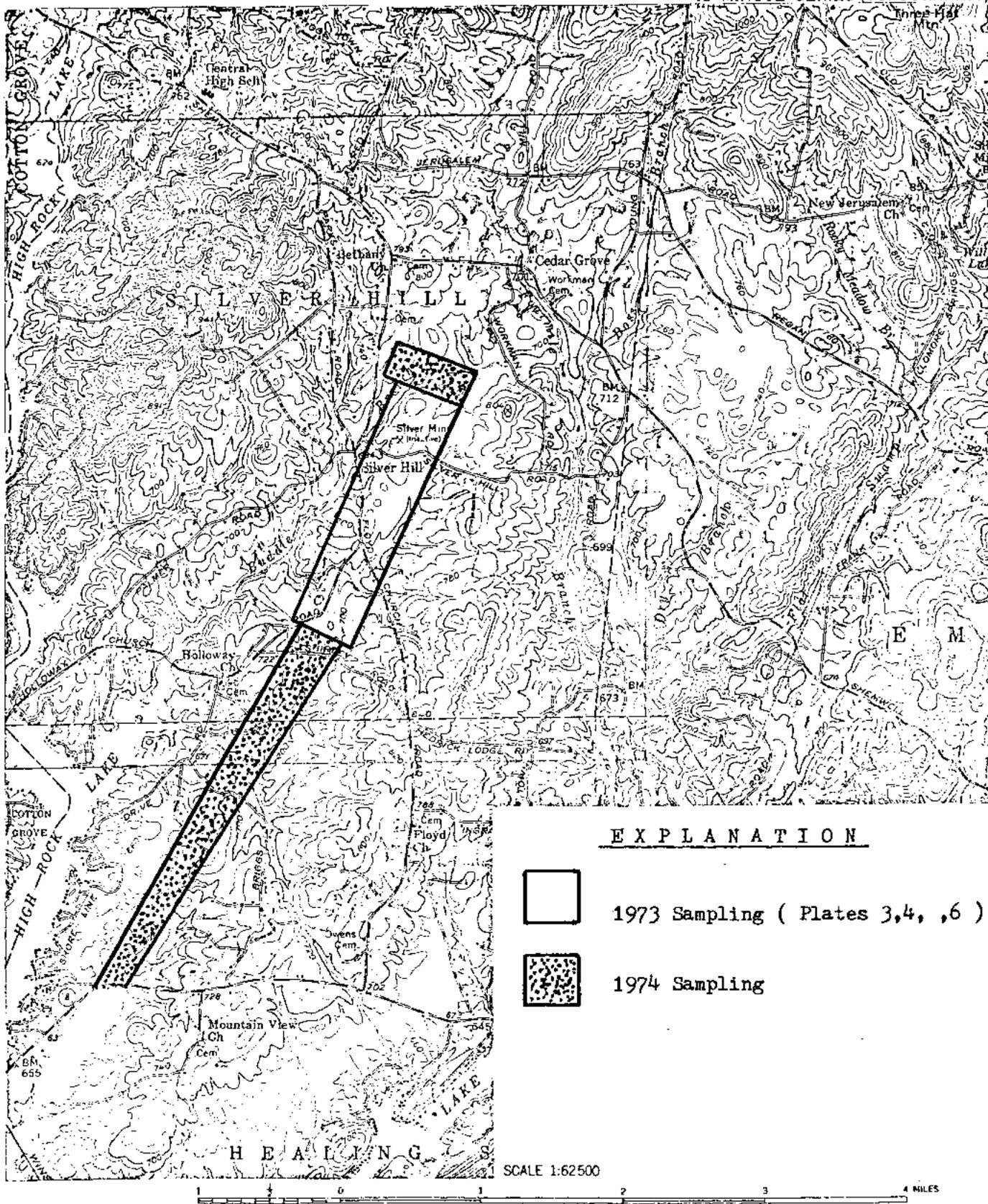


FIGURE 1 Silver Hill Geochemical Sampling

### Geophysics

During 1974 only a small, rather insignificant, amount of geophysical work was conducted in the Silver Hill area. An area approximately 2,000 feet north of Highway 8 (in the favorable trend) was suspected to be a magnetic high by Wood and Leinart. Several magnetic readings were taken in the area with inconclusive results.

### Drill Core Studies

Marcus Wood spent a considerable amount of time re-logging 1973 drill core and working on correlation of lithologies between holes. The work conducted during periods of inclement weather was conclusive in establishing a continuity of lithologies of a general nature only. Detailed correlations were totally absent, even in closely spaced holes.

### Drilling

During the period March 16-June 7, 1973, a total of 1,701.5 feet of core was drilled in the Silver Hill area by the Joy Drilling Company. The footage is the result of drilling eight shallow angle holes, four in the mine area and four south of the mine (Figure 2). All holes were drilled at 60° angles into geochemical or geophysical anomalies, but unfortunately none contained encouraging mineralization. Most likely all the holes deflected slightly, but none were surveyed because of their shallow and barren nature. A brief summary of each hole follows (for geologic description and detail

the reader is referred to the attached summary logs or the detailed logs on file in company offices).

#### Holes 7-14

Hole 7, located 400 feet southeast of the paved road on I. P. line 24 S., was collared on March 16 and drilled to a final depth of 390 feet on April 1. The hole, drilled at 60° angle to the southeast into the I. P. anomaly on line 24 S., consisted primarily of fine to coarse tuff with occasional disseminated pyrite.

Hole 8, located 200 feet east of hole 7, was collared on April 4 and bottomed on April 12 at a depth of 150 feet. This hole drilled with the intention of completing "the fence" across the well defined I. P. anomaly on line 24 S., was quite similar (lithologically) to hole 7. Only one anomalous sulphide (cubic pyrite) zone was noted in the hole at a depth of 70 to 80 feet.

Hole 9, located 200 feet west of the I. P. baseline on line 9 S., was drilled during April. The hole, spotted with the intention of testing the I. P. anomaly on line 8 S., was bottomed at a depth of 209 feet. One narrow (2-3 inch) mineralized stringer of pyrite, was noted in the hole.

Hole 10, located 200 feet west of the I. P. baseline and 200 feet north of hole 9 was collared on April 24 and bottomed on April 30 at a depth of 161.5 feet. The hole was drilled with the intention of testing an I. P.--geochemical anomaly. Unfortunately, the hole, which consisted primarily of fine to medium grained tuff, contained only occasional disseminated pyrite.

Hole 11, located in a geochemical anomaly in a "swampy" area 750 feet S. 65° E. of the I. P. baseline on line 7.5 S., was collared on May 1 and bottomed on May 11 at a depth of 200 feet. The entire hole was composed of fine grained banded tuff with sparse disseminated pyrite.

Hole 12, located 950 feet N. 65° W. of the I. P. baseline on line 32.25 S., was collared and drilled to a bottom depth of 204 feet during May. The hole, drilled in a geochemical-geophysical anomaly, was composed of dark and green andesitic tuff with occasional zones of cubic pyrite.

# LOCATION OF DRILL HOLES 1 - 14

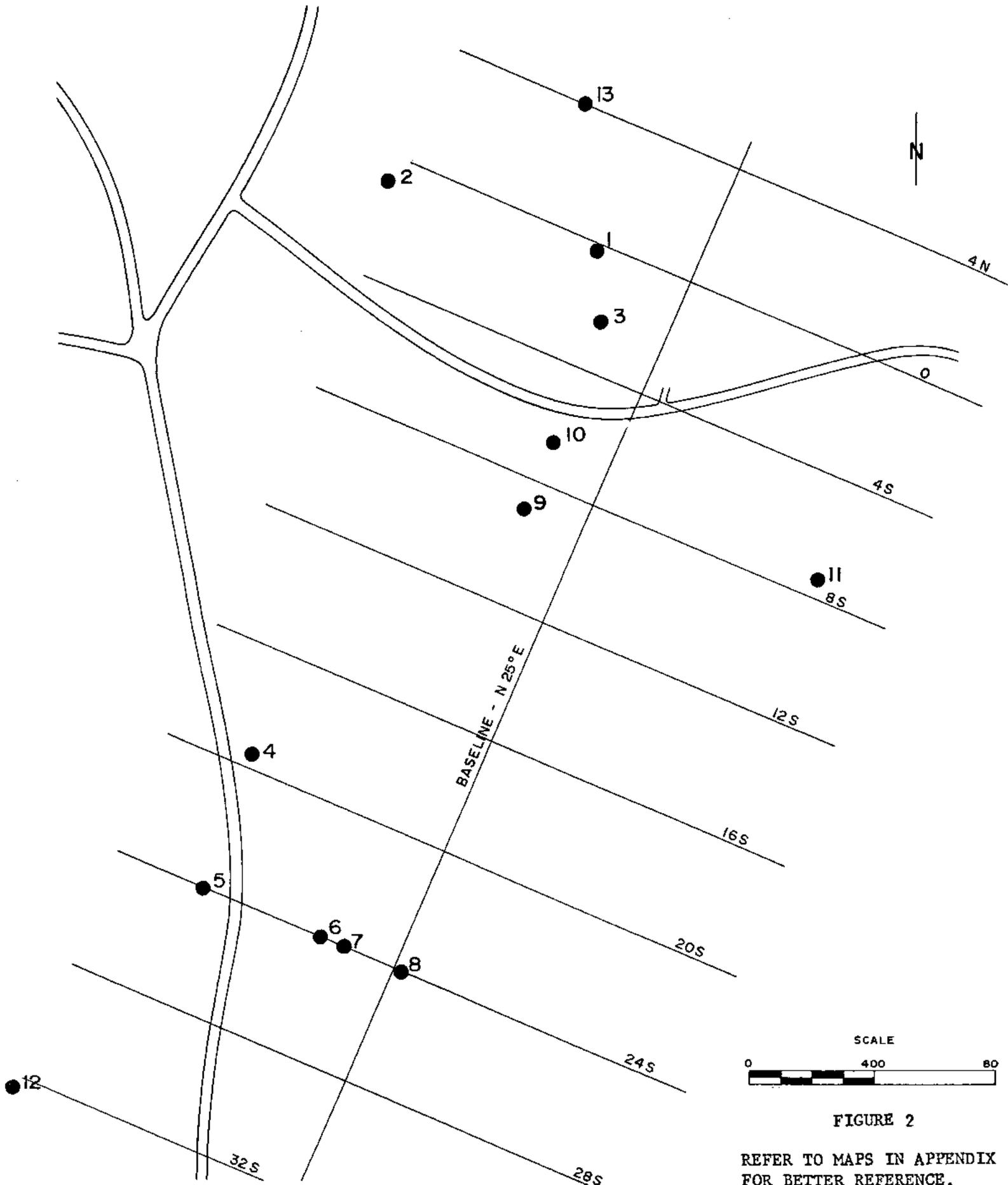
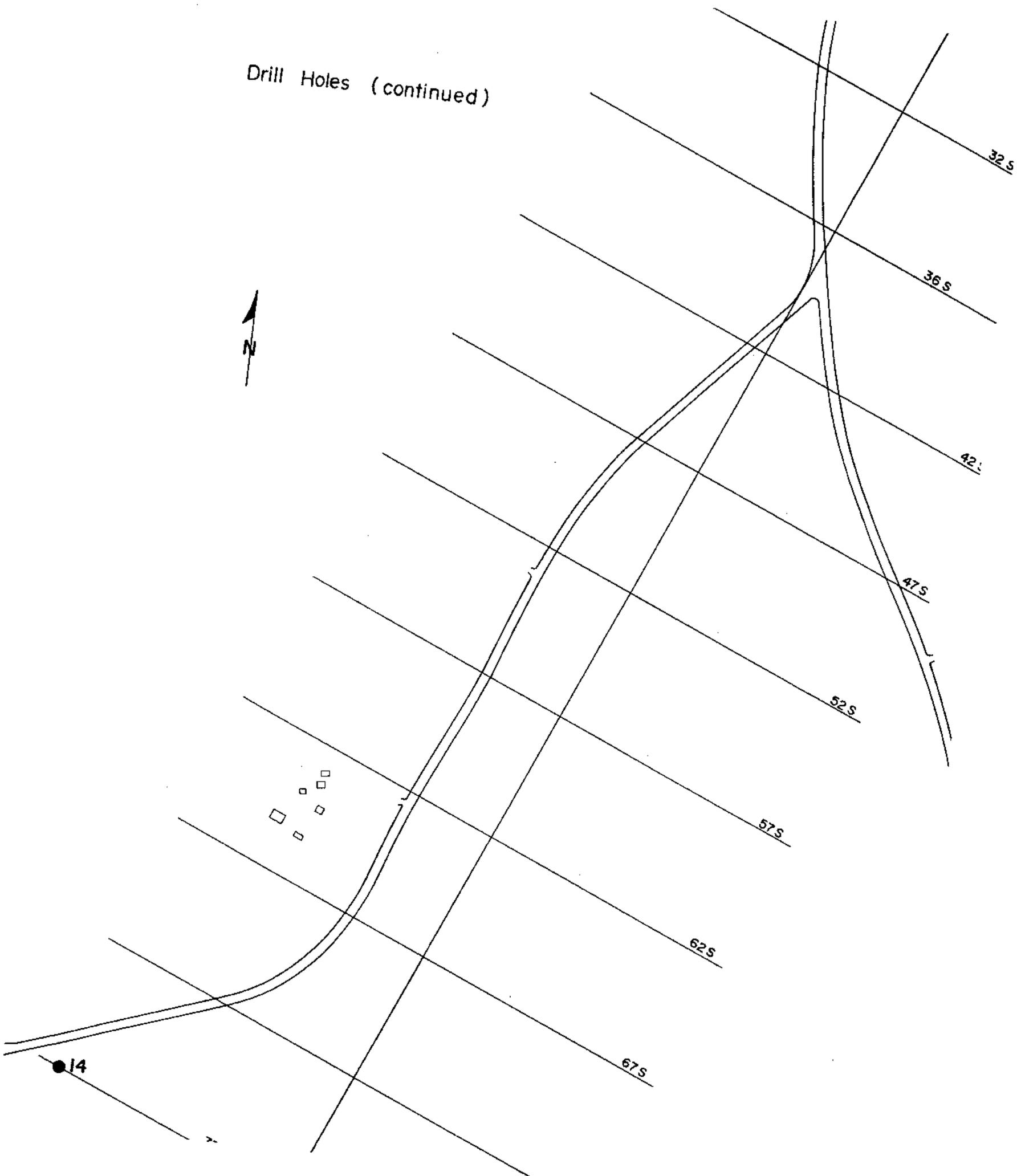


FIGURE 2

REFER TO MAPS IN APPENDIX FOR BETTER REFERENCE.

Drill Holes (continued)



Hole 13, located northwest of the Silver Hill Mine on line 4 N. 550 feet N. 65° W. of the I. P. baseline was collared in a geophysical anomaly on May 22 and bottomed on May 28 at a depth of 210 feet. The hole was composed essentially of fine to medium grained felsic (mine type) tuff and contained no visible massive sulphide mineralization.

Hole 14, located approximately 200 feet east of Holloway Church Road on line 77 S., at the site of soil sample station 9, was bottomed on June 7 at a depth of 177 feet. The hole, drilled at an angle to the southeast, was spotted on a mercury-in-soil anomaly and consisted primarily of fine grained unaltered banded tuff with sparse pyrite.

### Silver Hill Area Reconnaissance

#### General

During June, five massive sulphide prospects, Silver Valley, Conrad Hill, Emmons, Cid, and Sechrist, were examined and sampled by Wood and Leinart. These prospects, located in the general Silver Hill vicinity (Figure 3), were examined and sampled with emphasis aimed at determining if geologic conditions similar to those at Silver Hill could be detected. A total of 108 soil samples were collected and recorded on reconnaissance-type geologic maps of each prospect. Red dots were used to indicate anomalous samples on the maps and assay sheets showing all gold, silver, copper, lead, zine, and molybdenum values are attached. A discussion of each prospect follows:

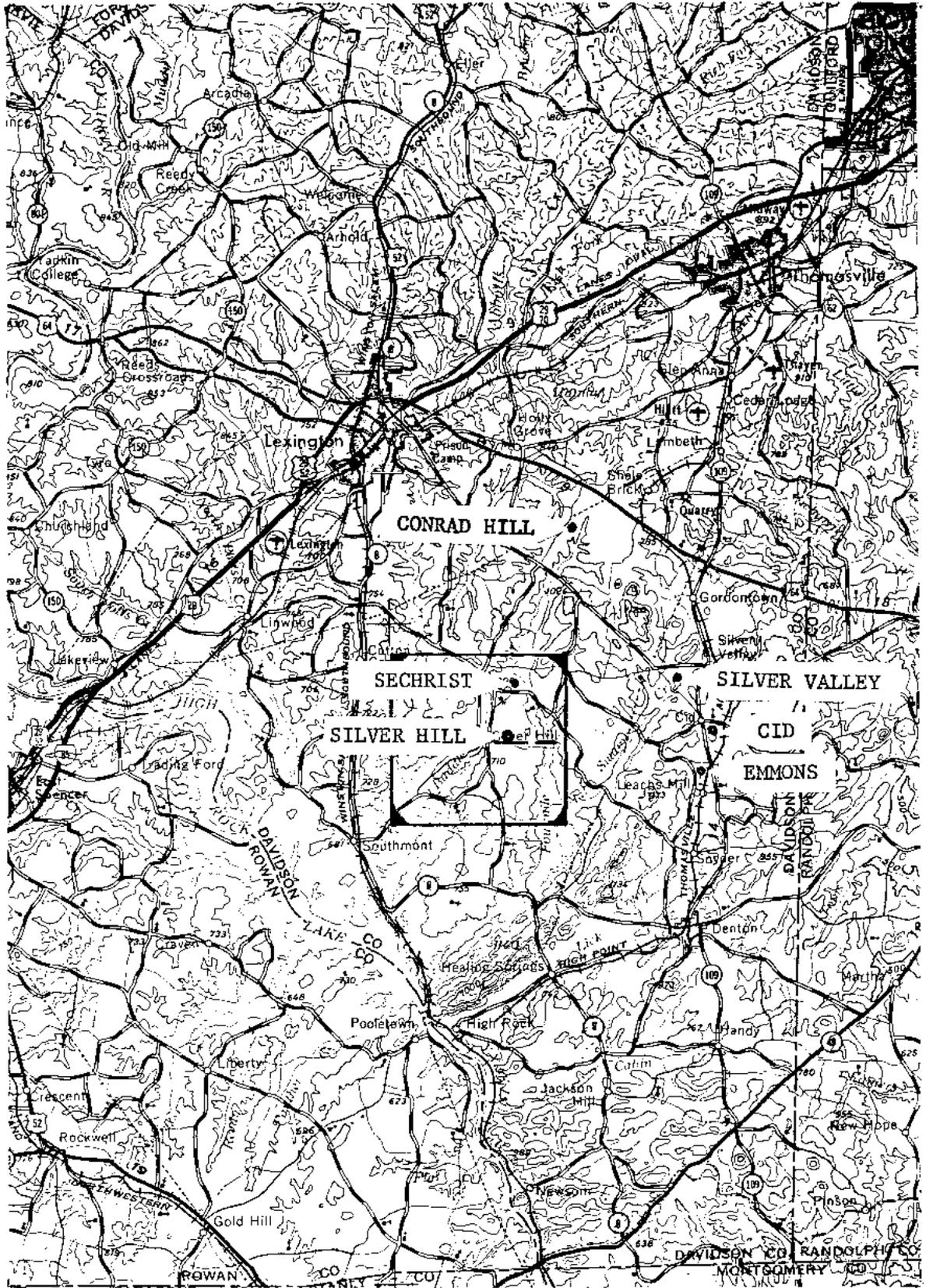


FIGURE 3 Silver Hill Examination Location Map

## Silver Valley

The Silver Valley Mine is located along the east side of a small hill approximately .25 miles south of old Highway 64. Major surface features near the mine consist of a large dump and foundation remains of an old mill. An inclined shaft is located beneath the main dump and another smaller partly filled shaft is located near the old foundation ruins. Another smaller dump and shaft, Branch Mine, are located north of the main shaft.

Observation of the dumps reveals that the majority of the dump material is composed of dense compact gray rhyolite containing very little sulphide mineralization. Most of the mineralization observed in the dumps occurs as finely disseminated pyrite, galena, chalcopyrite and pyrite in an andesitic type mafic rock.

Although outcrops are rare, a highly weathered fine grained red and tan colored tuff with recognizable bedding planes and some pyrite mineralization was observed. Andesitic basalt and rhyolite with pyrite were found in the stream between the two dumps.

Eighteen soil samples were collected from three lines. Only two samples (2618, 2619) contained significantly anomalous mineralization.

Flagging tape and aluminum foil and wire were found indicating that recent geochemical and geophysical surveys had been conducted in the area.

-  Dump
-  Shaft
-  Incline
-  Pit

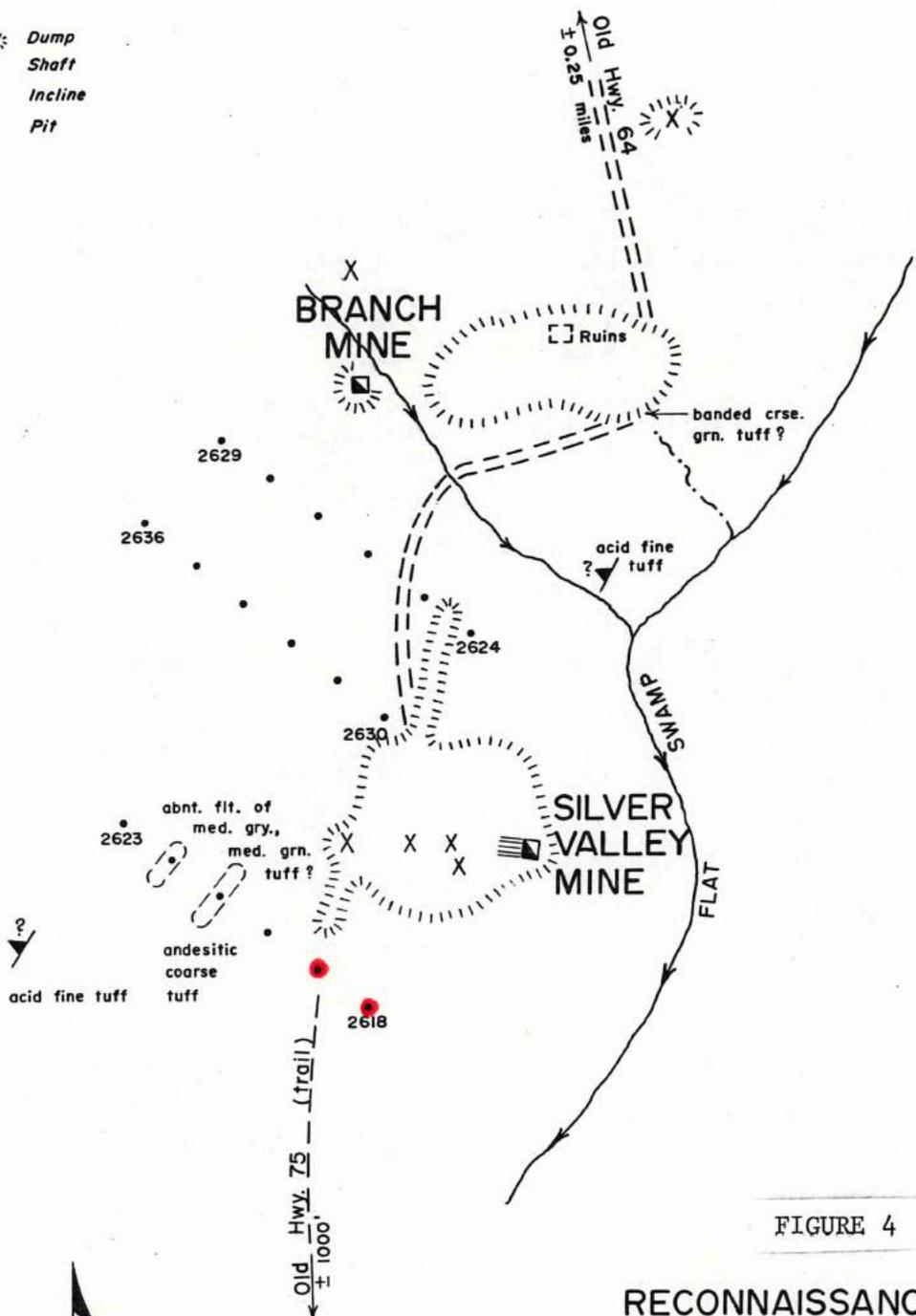
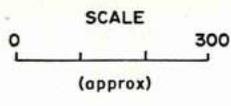


FIGURE 4

RECONNAISSANCE MAP  
AND  
SOIL SAMPLE LOCATIONS  
OF THE  
SILVER VALLEY MINE  
DAVIDSON COUNTY, N.C.



NOTE: Soil sample nos. preceded by 74-01A-



### Conrad Hill Mine

The Conrad Hill Mine, located approximately one mile south of Highway 64 consists of two main shafts and numerous dumps and smaller shafts.

The country rock of the area is essentially a white sericitic schist, but the mine mineralization is a combination of quartz, siderite, and chalcopyrite. Botryoidal and specular hematite and chalcocite were also observed in the mine area. General geologic evidence appears to indicate that the quartz mass is intrusive into the sericite schist.

Four sample lines were run in a N., 65° W., direction north and south of the mine area to crosscut the main trend of the shafts and quartz veins. Of the fifty-eight samples collected, seventeen are considered anomalous in copper and gold. These anomalies are not considered important, however, because of the contaminated nature of their locations.

### Emmons Mine

The Emmons Mine, located approximately 1200 feet west of old Highway 109 contains no apparent surface features except for some old bricks near an old oak tree. The shaft is apparently filled and located in the middle of a corn field.

The only observable geologic outcrops occur along the roadside. These outcrops are a very silty mudstone, similar to argillite, with generally blocky to fissile cleavage. These rocks usually have

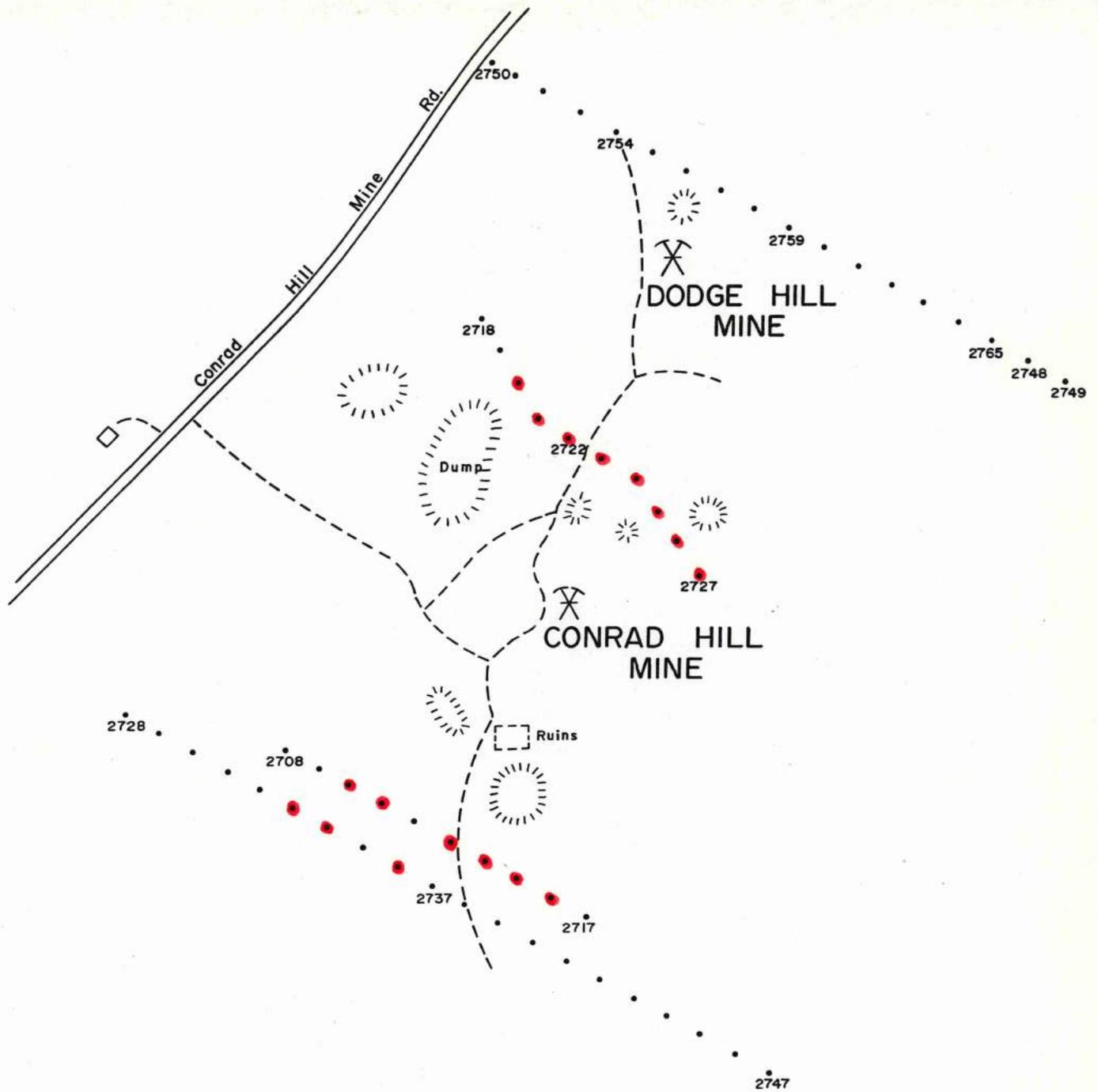
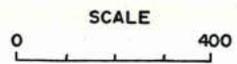


FIGURE 5

SOIL SAMPLE LOCATIONS  
OF THE  
CONRAD HILL MINE AREA  
DAVIDSON COUNTY, N. C.



NOTE: Soil sample nos. preceded  
by 74-01A-

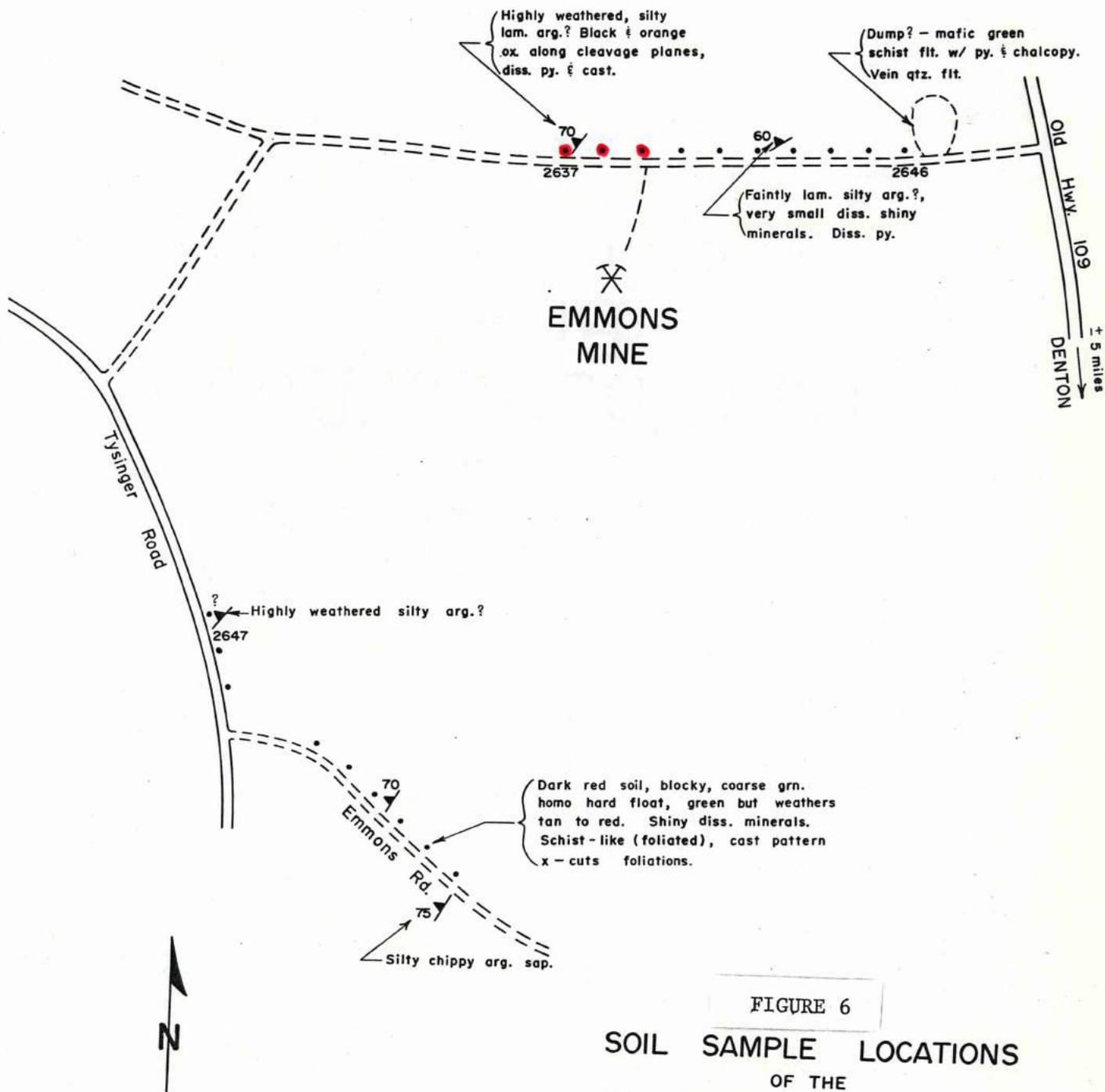
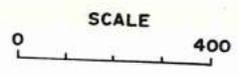


FIGURE 6  
 SOIL SAMPLE LOCATIONS  
 OF THE  
 EMMONS MINE AREA  
 DAVIDSON COUNTY, N.C.



NOTE: Soil sample nos. preceded by 74-OIA-

a dark red color and are fine grained, but occasionally they are red and white and coarse grained. All outcrops are highly weathered and somewhat faintly laminated. Some float in a nearby field resembles a mafic schist and contains disseminated pyrite.

Nineteen soil samples were collected along two roads to crosscut the projected trend between the Cid and Emmons Mines. Three samples contained weakly anomalous copper.

#### Cid Mine

No surface expression of the Cid Mine was found with the exception of a small pit near the intersection of Cid Road and old Highway 109.

There are no outcrops in the area except some argillite-mudstone similar to that at the Emmons Mine. An interesting dike-like feature, resembling quartz monzonite, was observed approximately 1,000 feet south of the intersection. In the same area, coarse grained tuff float was also observed.

Twenty-two soil samples were collected along roads to cover the Cid Emmons projected trend.

#### Sechrist Mine

The Sechrist Mine is located approximately 1-1/2 miles northeast of Silver Hill Mine and seventy-five feet north of Route 47.

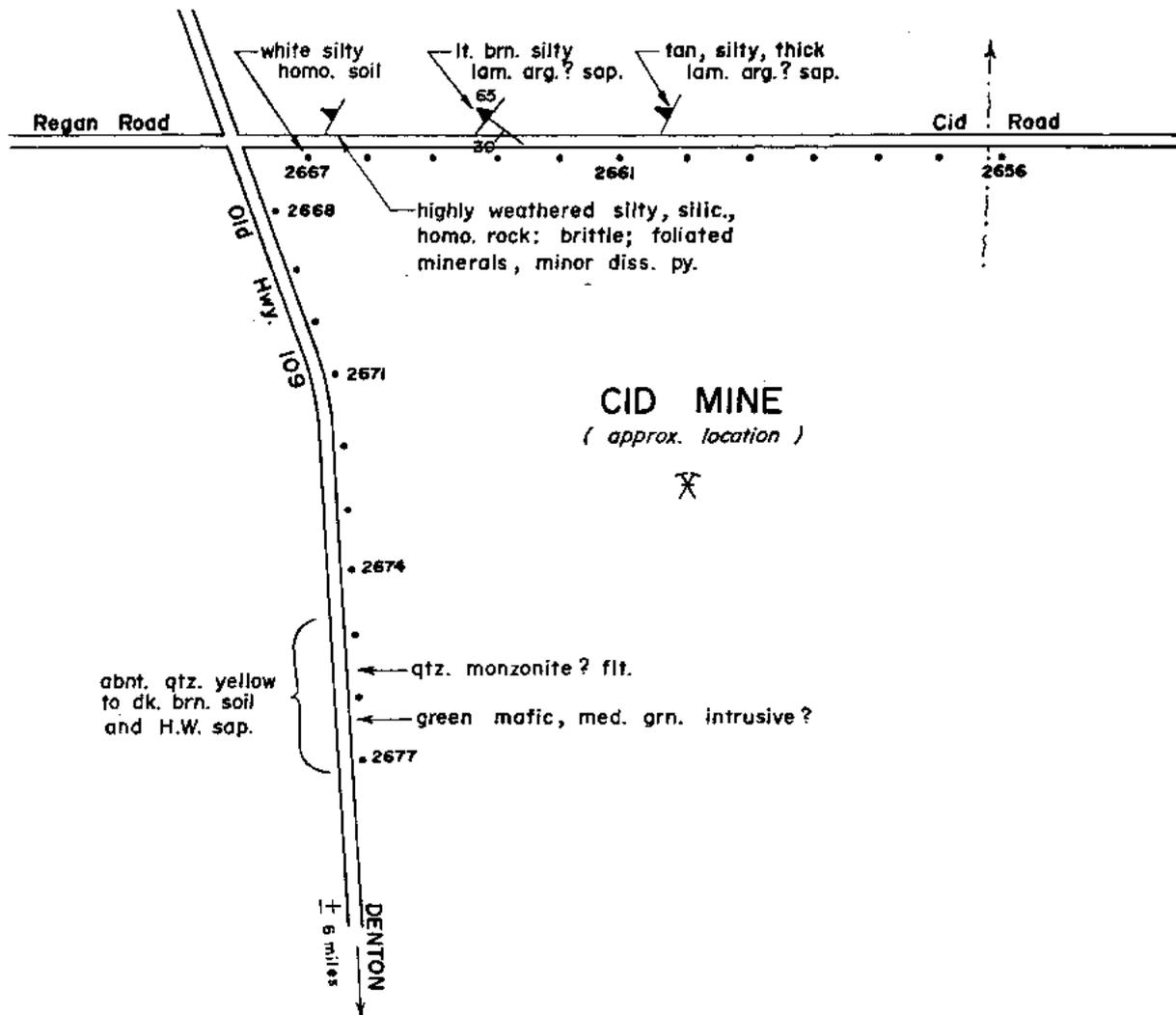


FIGURE 7

RECONNAISSANCE MAP  
AND  
SOIL SAMPLE LOCATIONS  
OF THE  
CID MINE AREA  
DAVIDSON COUNTY, N. C.



NOTE: Soil sample nos. preceded by 74-01A-

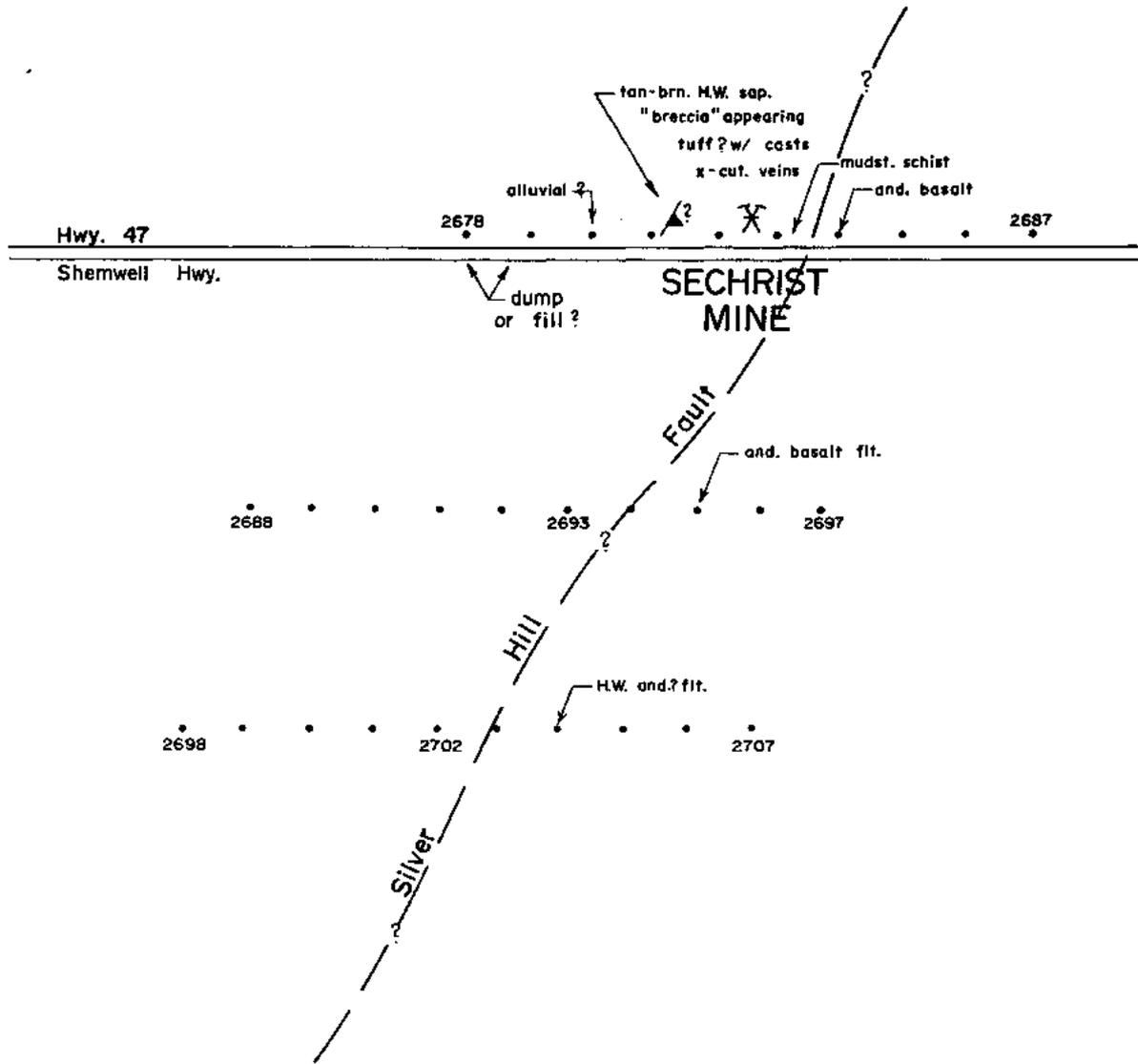
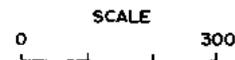


FIGURE 8

SOIL SAMPLE LOCATIONS  
OF THE  
**SECHRIST MINE AREA**

DAVIDSON COUNTY, N.C.



NOTE: Soil sample nos. preceded  
by 74-01A-

Geologic observations along the roadcuts south of the mine reveals an argillite, sometimes silicified and massive in outcrop. A few laminations are observed in the argillite. East of the argillite is a light green medium to coarse grained andesite basalt. This same unit is also found 600-700 feet south of the road. The Silver Hill Fault is projected through the area and appears substantiated to some degree by the two units and the silicification and brecciation found in the area. No significant mineralization except for some scattered disseminated pyrite in float rock was observed.

Three soil lines were run in an E-W direction across the trend of the fault and the two units. Of the twenty-nine samples collected, none appear to be of significant interest.

SKYLINE LABS, INC.

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REPORT OF ANALYSIS

Job No. 99139  
P.O. No. 001577  
August 5, 1974

Earl M. Jones  
5612 Kingston Pike  
Knoxville, Tennessee 37919

Analysis of 147 Soil Samples

Item	Sample No.	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
1.	74-01A-2618	.09	24.	290	3,200	1,150	4
2.	2619	.12	1.0	30	175	160	2
3.	2620	<.02	<.2	10	45	65	4
4.	2621	<.02	<.2	15	35	70	2
5.	2622	<.02	<.2	10	30	45	<2
6.	2623	<.02	<.2	15	20	35	2
7.	2624	<.02	.2	30	100	85	2
8.	2625	<.02	.6	25	130	170	2
9.	2626	<.02	.2	30	65	85	2
10.	2627	<.02	<.2	20	50	60	2
11.	2628	<.02	<.2	15	45	50	2
12.	2629	<.02	<.2	20	55	70	2
13.	2630	<.02	.2	10	80	115	2
14.	2631	<.02	.2	30	75	90	2
15.	2632	<.02	.2	75	55	90	4
16.	2633	<.02	.2	30	115	95	4
17.	2634	<.02	.2	30	120	140	2
18.	2635	<.02	<.2	30	80	90	4
19.	2636	<.02	.2	30	150	160	2
20.	2637	<.02	<.2	340	30	95	4
21.	2638	<.02	<.2	275	20	55	2
22.	2639	<.02	<.2	135	20	50	2
23.	2640	<.02	<.2	85	30	60	2
24.	2641	<.02	<.2	60	30	75	2
25.	74-01A-2642	<.02	<.2	45	25	60	2

↑  
Silver Valley  
↓  
Emmons  
↓

SILVER HILL AREA RECONNAISSANCE  
GEOCHEMICAL RESULTS

FIGURE 9

Item	Sample No.	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
26.	74-01A-2643	<.02	<.2	50	25	40	2
27.	2644	<.02	<.2	40	30	50	2
28.	2645	<.02	<.2	85	20	35	2
29.	2646	<.02	<.2	15	5	20	2
30.	2647	<.02	<.2	30	20	45	2
31.	2648	<.02	<.2	40	35	55	2
32.	Emmons 2649	<.02	<.2	180	30	65	2
33.	2650	<.02	<.2	30	25	60	2
34.	2651	<.02	<.2	55	30	40	<2
35.	2652	<.02	<.2	50	40	120	2
36.	2653	<.02	<.2	80	15	130	4
37.	2654	<.02	<.2	110	50	80	4
38.	↓ 2655	<.02	<.2	10	20	55	<2
39.	2656	<.02	<.2	70	35	55	2
40.	↑ 2657	<.02	<.2	40	65	70	<2
41.	2658	<.02	<.2	25	50	40	2
42.	2659	<.02	<.2	25	50	40	2
43.	2660	<.02	<.2	45	85	75	2
44.	2661	<.02	<.2	35	90	125	2
45.	2662	<.02	<.2	30	30	60	2
46.	2663	<.02	<.2	50	50	70	2
47.	2664	<.02	<.2	20	60	55	2
48.	Cid Mine 2666	<.02	<.2	5	25	20	4
49.	2667	<.02	<.2	5	35	30	2
50.	2668	<.02	<.2	5	35	35	2
51.	2669	<.02	<.2	10	70	60	2
52.	2670	<.02	<.2	10	70	45	2
53.	2671	<.02	<.2	10	60	40	2
54.	2672	<.02	<.2	5	35	20	<2
55.	2673	<.02	<.2	15	20	30	<2
56.	2674	<.02	<.2	10	20	20	2
57.	2675	<.02	<.2	40	25	60	2
58.	2676	<.02	<.2	35	30	85	<2
59.	↓ 2677	<.02	<.2	65	5	90	<2
60.	74-01A-2678	<.02	<.2	65	110	90	2

Item	Sample No.	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
61.	74-01A-2679	<.02	<.2	60	45	75	<2
62.	↑ 2680	<.02	<.2	70	55	85	4
63.	2681	.16	.4	135	90	115	6
64.	2682	<.02	<.2	100	20	85	2
65.	2683	<.02	<.2	95	<5	105	<2
66.	2684	<.02	<.2	85	50	70	2
67.	2685	<.02	<.2	95	45	65	<2
68.	2686	<.02	<.2	90	50	70	2
69.	2687	<.02	<.2	100	50	75	2
70.	2688	<.02	<.2	55	35	55	2
71.	2689	<.02	<.2	25	15	40	2
72.	2690	<.02	<.2	25	25	35	2
73.	2691	<.02	<.2	35	10	35	<2
74.	2692	<.02	<.2	95	65	65	2
75.	2693	<.02	<.2	85	15	60	4
76.	2694	<.02	<.2	105	40	100	2
77.	2695	<.02	<.2	90	45	70	2
78.	2696	<.02	<.2	90	20	70	2
79.	2697	<.02	<.2	80	40	55	4
80.	2698	<.02	<.2	25	30	55	2
81.	2699	<.02	<.2	20	20	30	2
82.	2700	<.02	<.2	15	25	30	2
83.	2701	<.02	<.2	25	30	35	2
84.	2702	<.02	<.2	65	15	50	2
85.	2703	<.02	<.2	95	15	80	2
86.	2704	<.02	<.2	100	20	95	2
87.	2705	<.02	<.2	100	45	75	2
88.	2706	<.02	<.2	90	40	55	2
89.	2707	<.02	<.2	90	45	65	2
90.	2708	<.02	<.2	40	15	45	2
91.	2709	<.02	<.2	40	40	35	2
92.	2710	.68	<.2	1,700	35	40	2
93.	2711	.90	<.2	145	45	30	2
94.	2712	<.02	<.2	45	35	95	2
95.	74-01A-2713	.06	<.2	110	20	70	<2

Sechrist Mine

Conrad Hill

Item	Sample No.	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
96.	74-01A-2714	.03	<.2	315	15	45	2
97.	2715	.06	<.2	505	35	55	2
98.	2716	.04	<.2	400	30	40	2
99.	2717	<.02	<.2	25	25	25	2
100.	2718	<.02	<.2	45	40	45	2
101.	2719	<.02	<.2	45	45	40	<2
102.	2720	.06	<.2	220	45	35	<2
103.	2721	.11	<.2	1,050	40	60	<2
104.	2722	.11	<.2	370	25	30	<2
105.	2723	.02	<.2	200	25	35	<2
106.	2724	.03	<.2	135	25	90	2
107.	2725	.47	<.2	115	25	50	2
108.	2726	.29	<.2	145	25	30	<2
109.	2727	<.02	<.2	105	35	40	<2
110.	2728	<.02	<.2	45	45	35	<2
111.	2729	<.02	<.2	35	40	35	2
112.	2730	<.02	<.2	60	20	50	<2
113.	2731	<.02	<.2	45	10	45	<2
114.	2732	<.02	<.2	30	20	30	<2
115.	2733	.03	<.2	130	15	50	<2
116.	2734	.10	<.2	395	30	30	<2
117.	2735	.04	<.2	40	15	25	<2
118.	2736	.03	<.2	160	30	40	<2
119.	2737	<.02	<.2	65	40	30	<2
120.	2738	<.02	<.2	35	15	25	<2
121.	2739	<.02	<.2	20	35	25	<2
122.	2740	<.02	<.2	20	20	25	<2
123.	2741	<.02	<.2	20	30	20	<2
124.	2742	<.02	<.2	30	35	35	2
125.	2743	<.02	<.2	15	20	80	<2
126.	2744	<.02	<.2	20	15	95	<2
127.	2745	<.02	<.2	20	20	65	<2
128.	2746	<.02	<.2	20	10	20	2
129.	2747	<.02	<.2	20	30	25	2
130.	74-01A-2748	<.02	<.2	35	20	45	2

Conrad Hill

Item	Sample No.	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
131.	74-01A-2749	<.02	<.2	25	15	40	<2
132.	2750	<.02	<.2	65	10	50	<2
133.	2751	<.02	<.2	55	15	60	2
134.	2752	<.02	<.2	40	20	60	<2
135.	2753	<.02	<.2	75	15	60	<2
136.	2754	<.02	<.2	10	15	15	<2
137.	2755	<.02	<.2	25	10	65	2
138.	2756	<.02	<.2	20	20	20	2
139.	2757	<.02	<.2	25	15	45	4
140.	2758	<.02	<.2	55	15	40	<2
141.	2759	<.02	<.2	40	20	30	<2
142.	2760	.10	<.2	35	20	35	2
143.	2761	<.02	<.2	30	15	30	2
144.	2762	<.02	<.2	25	15	30	<2
145.	2763	<.02	<.2	40	40	55	<2
146.	2764	<.02	<.2	30	55	30	<2
147.	74-01A-2765	<.02	<.2	20	30	35	<2

Conrad Hill

Charles E. Thompson  
Chief Chemist

cc: Cyprus Exploration Company

Costs

During 1974 through August, approximately \$52,830 was spent on the Silver Hill Examination. A breakdown of these charges is:

Acquisition	\$ 7,500
Salaries and Wages	4,999
Surveying and Mapping	3
Geophysics	227
Geochemistry	5,020
Outside Contract Services	10,173
Drilling	19,073
Excavation	-0-
Assaying and Sampling	1,936
Travel	3,196
Equipment	-0-
Miscellaneous	<u>703</u>
Total	\$52,830

Recommendation and Conclusion

Cyprus Exploration Company has recently terminated physical exploration of the Silver Hill property and Louisiana Land and Exploration Company has chosen to continue studies at least through the remainder of 1974. All due 1974 land payments were paid by Louisiana Land and Exploration Company during the past two weeks.

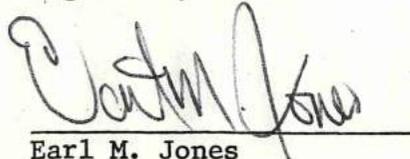
A favorable recommendation for further exploration of the property could easily be justified on the basis of:

- 1) The probable existence of a small high grade 200,000 ton ore body at the mine (general mining studies during the year by Cyprus indicates a probable net income of \$1,000,000 at today's metal prices).
- 2) The need for detailed geologic information near the ore lens, which likely is attainable from underground studies only.
- 3) The lack of close spaced drilling in the immediate mine area.
- 4) The elusive uncontrolled nature of this type of deposit throughout the world.
- 5) Availability and control of a good land position.
- 6) Favorable long range price structure for base metals.

*Note*  
✓ Error in study in not using cost for new shaft

Disregarding the justification for continuing exploration, it must be stated that results of our 1973-74 program has concluded that if an unknown economic massive sulphide lens exists in the Silver Hill area, it is (1) either too small to be detected by our coverage or (2) lies buried down dip beneath the detectable limits of tools employed by our program. It is further concluded, however, that the area still remains a valid volcanigenic massive sulphide target which could someday, with any degree of fortune, become a producer.

August 22, 1974

  
Earl M. Jones

SILVER HILL EXAMINATION  
 DRILL HOLE SUMMARY LOGS  
 HOLES 1-14

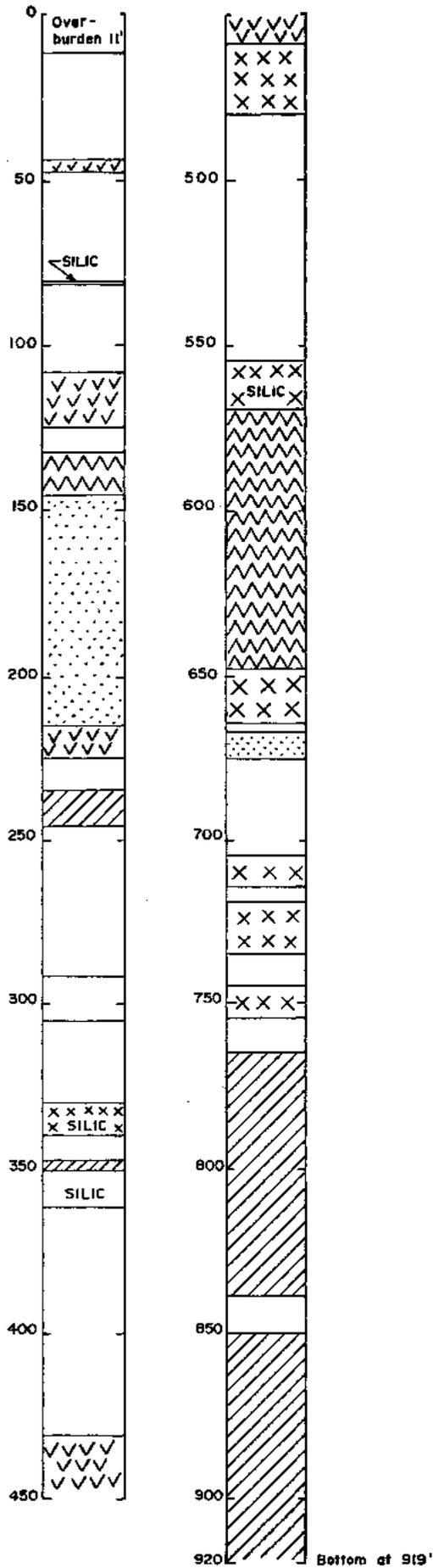
EXPLANATION

	FINE GRAINED TUFF		MEDIUM GRAINED TUFF
	ANDESITE		COARSE GRAINED TUFF
	RHYOLITE		BANDED TUFF
	LAPILLI TUFF		SILICEOUS TUFF

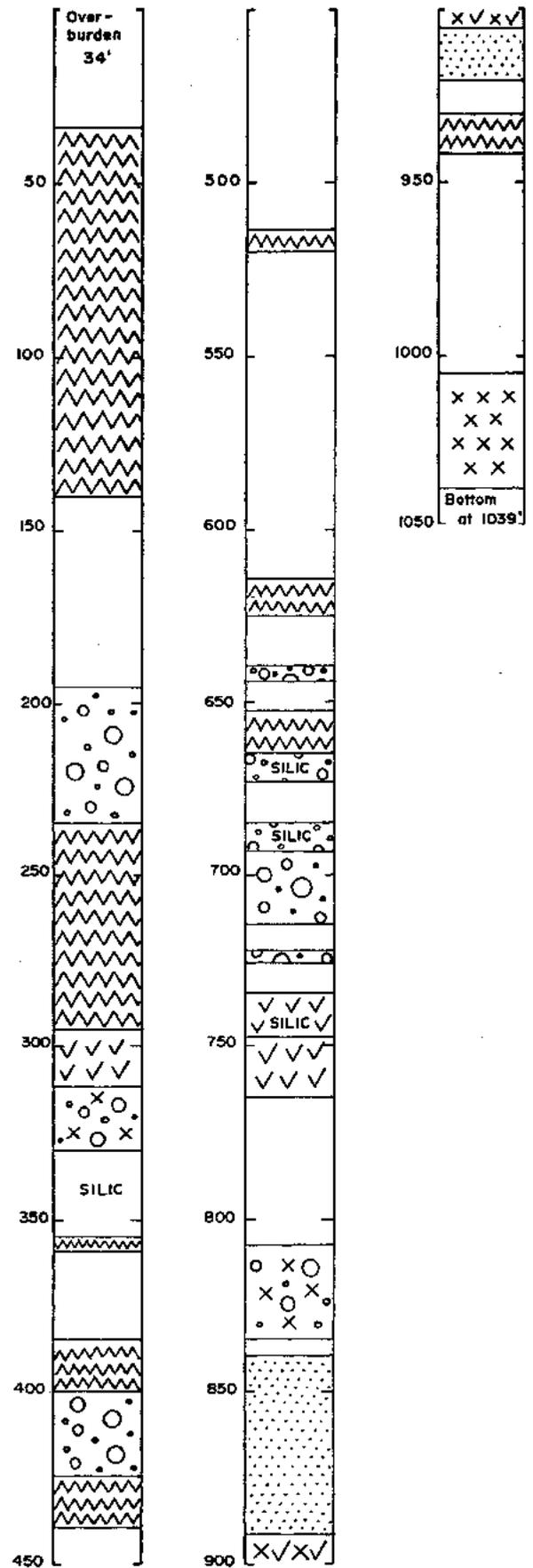
VERTICAL SCALE  
 1 INCH = 50 FEET

FIGURE 10

# HOLE NO. 1



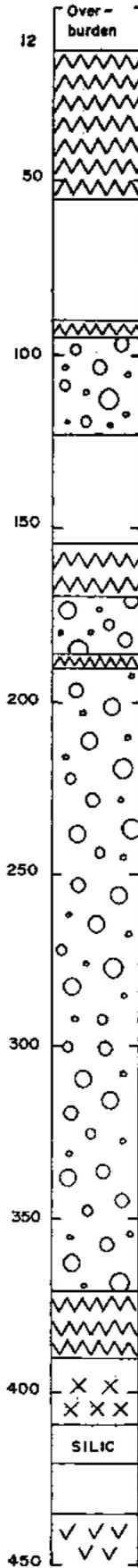
# HOLE NO. 2



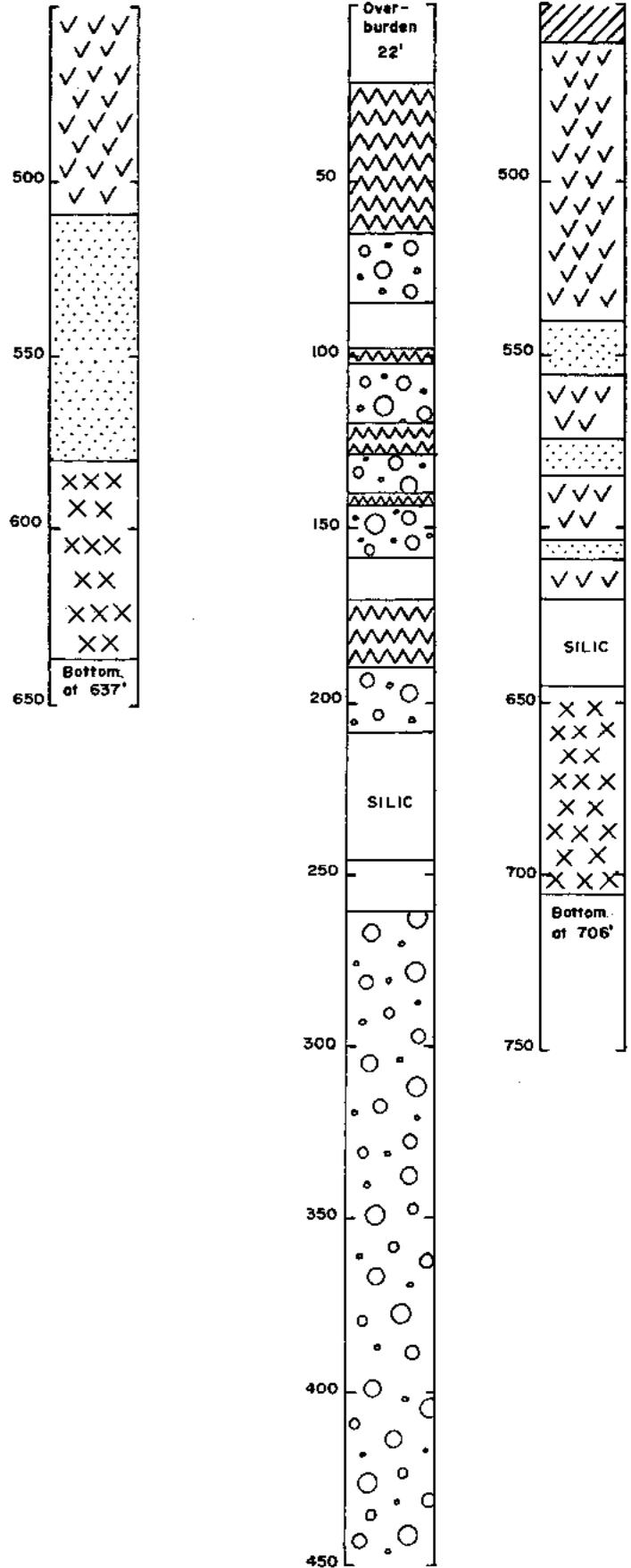
HOLE NO. 3



HOLE NO. 4



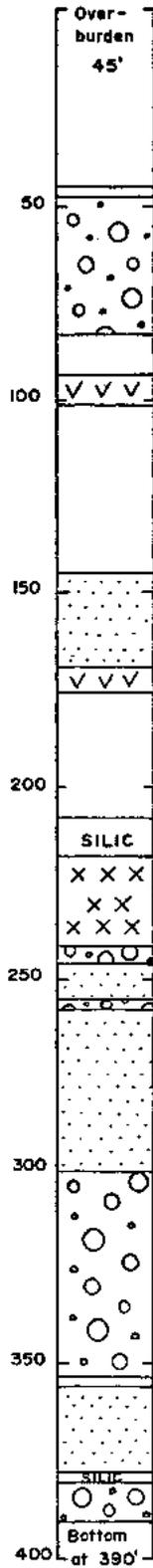
HOLE NO. 5



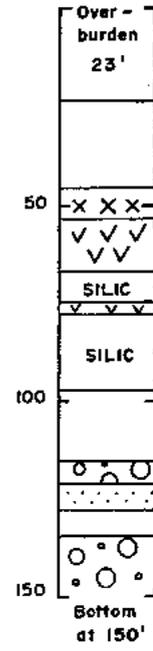
HOLE NO. 6



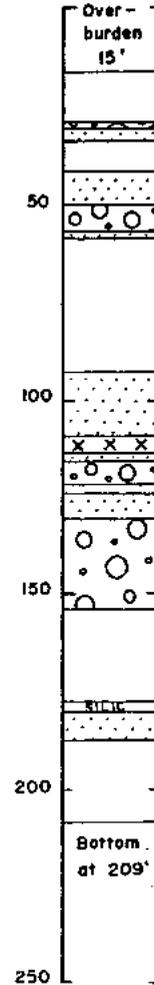
HOLE NO. 7



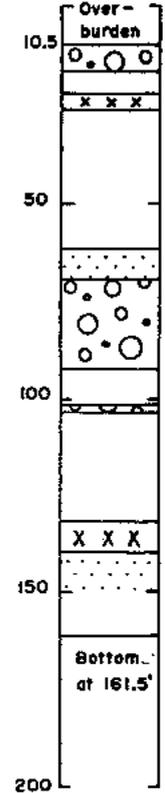
HOLE NO. 8



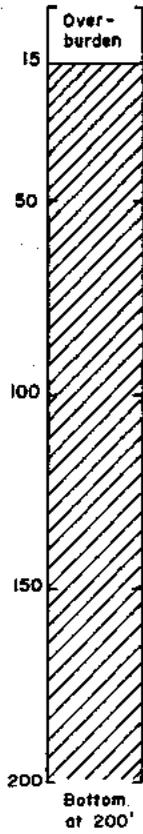
HOLE NO. 9



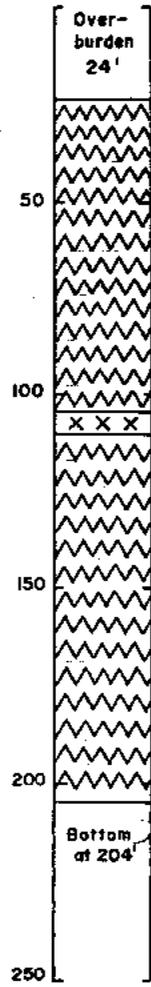
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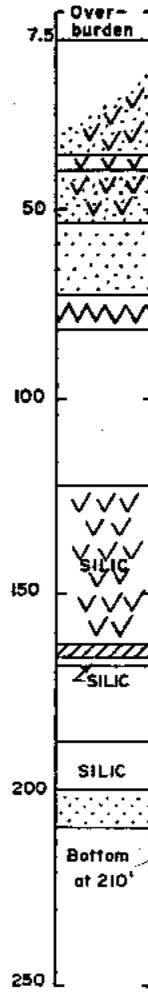
HOLE NO. 11



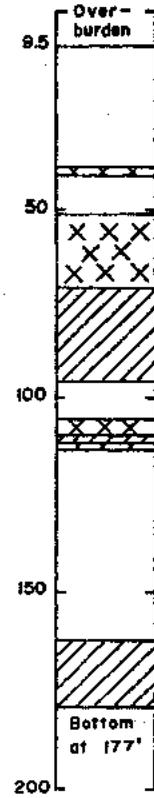
HOLE NO. 12



HOLE NO. 13

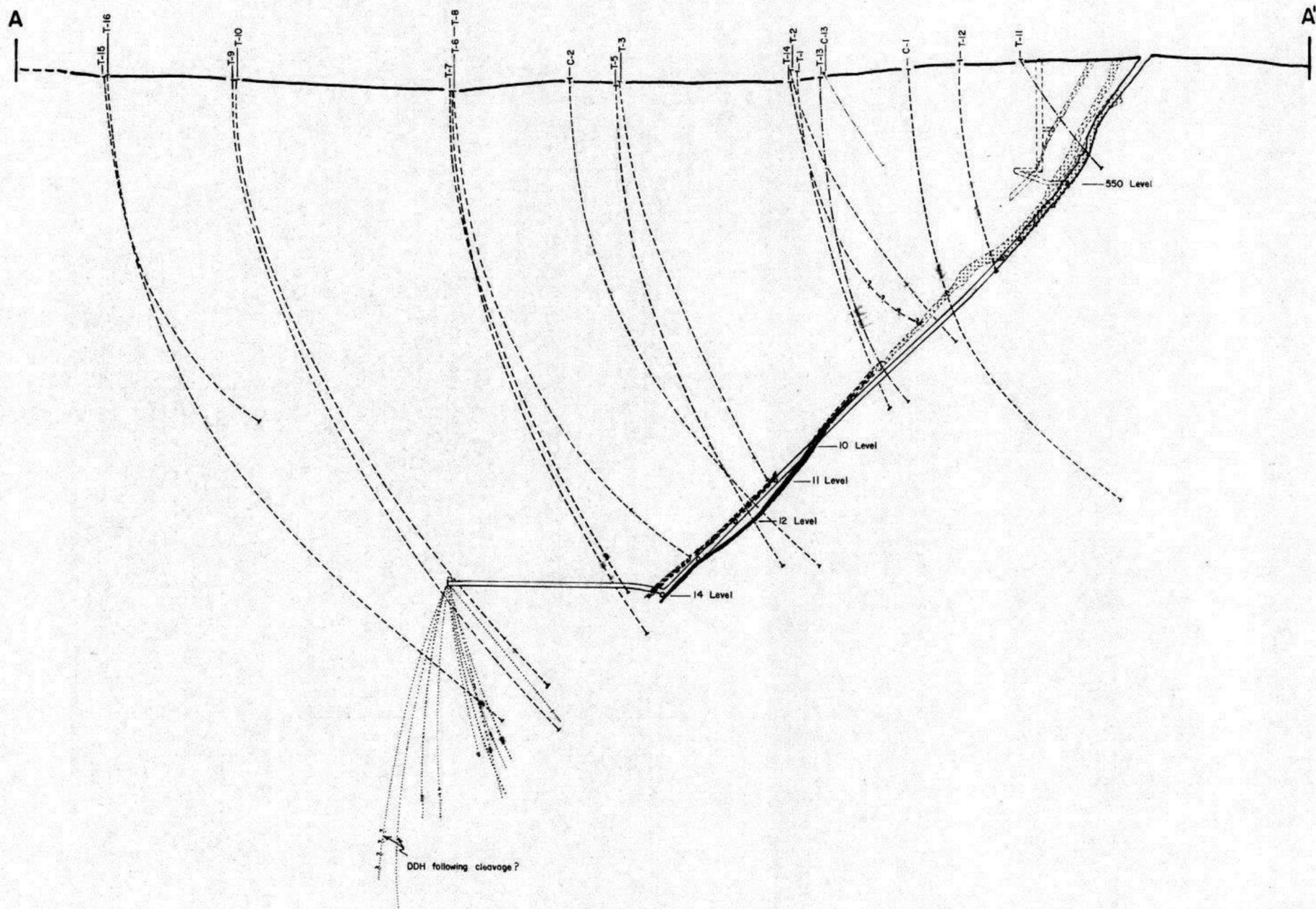


HOLE NO. 14



**4.6. Vertical Projection, Silver Hill Mine area, Davidson County, North Carolina  
(Cross section with project of ore body and drill holes), Phelps Dodge Exploration  
East, Raleigh, N.C., scale 1 inch = 200 feet**

By Phelps Dodge Exploration East, 1976

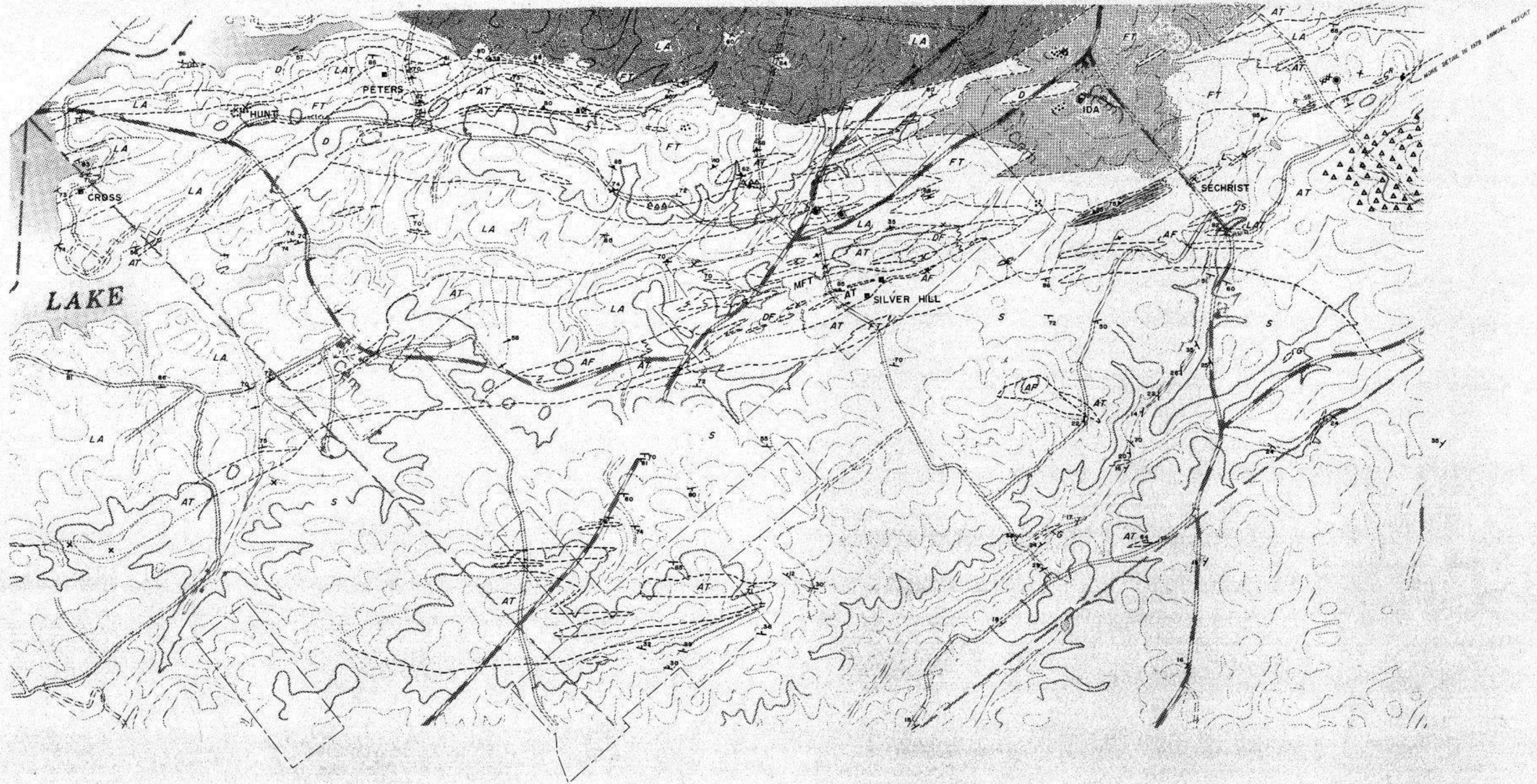
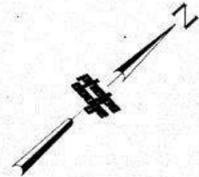


- drill hole - surveyed
- unsurveyed, deflection inferred
- unsurveyed, no data
- ..... underground drill hole
- T Tennessee Copper Co. (1959-61)
- C Cyprus Mines (1973)

<b>PHELPS DODGE EXPLORATION EAST</b>				
<b>SILVER HILL MINE AREA</b>				
DAVIDSON COUNTY, NORTH CAROLINA				
VERTICAL PROJECTION				
SCALE	H 1" = 200'	CONTOUR INTERVAL:		REVISIONS
	V:	DATE 2-18-76	BY:	
SHEET	OF	DRAWING NO:		

**4.7. Geology map, Silver Hill Project, Davidson County, North Carolina, Phelps Dodge Exploration East, Raleigh, N.C., scale 1 inch = 1,000 feet**

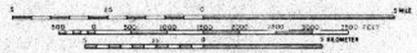
By R.D. Thomas, 1977



- D** HORNBLENDE DIORITE - Medium to coarse grained, locally quartz-hornblende diorite. Occasionally porphyritic. Hornblende is in various stages of chloritization. Accessory minerals include epidote, apatite and magnetite.
- G** GABBRO - Dark gray medium grained olivine-pyroxene gabbro. Minor apatite and trace of pyrite. Aeromagnetic map indicates the unit is probably disposed as shallow, dike-like bodies with limited surface exposure but substantial subsurface extent.
- LA** LAMINATED ARGILLITE - Aphanitic, light brown to greenish brown finely laminated sericite-chlorite-quartz phyllite with traces of pyrite. Coarsest areas are patterned.
- S** SILTSTONE - Gray, arkosic graywacke. Massive to well-bedded. Weathers light brown.
- ΔFT** MEDIUM FELSIC TUFF - Light gray quartz-sericite schist. Feldspar crystals are commonly altered to clay. Occasionally up to 3% pyrite. Triangles denote areas underlain by tuff breccia with lithic fragments to 2'. Finer (phyllitic) areas are patterned.
- DF** DACITE/RHYODACITE FLOW/VITROPHYRE - Medium gray aphanitic rock consisting mainly of quartz, sericite and plagioclase in varying proportions. Trace of pyrite found.
- MFT** "MINE" FELSIC TUFF - Light gray, fine grained metasediment/reworked felsic tuff consisting mainly of quartz and sericite in varying proportions.

- L** LATITE/QUARTZ LATITE - Light gray, medium grained intrusive(?) rock which has been silicified by quartz veining. 5-10% disseminated pyrite.
- ΔAT** ANDESITE TUFF - Green, fine-to-medium grained chlorite, epidote, plagioclase bearing rock. East of Silver Hill Mine, this unit commonly contains flattened andesitic(?) lithic fragments up to 3/8". West of Silver Hill, the unit is probably reworked. Fresh rock contains up to 35% calcite. Southwest of Silver Hill Mine, the unit is commonly coarse grained with subhedral plagioclase and hornblende crystals up to 1/4", local magnetite, and specular hematite. Triangles denote areas underlain by andesite tuff breccia, with lithic fragments to 2". Area of interlayered andesite tuffs and dacite flows is patterned.
- LAT** LAMINATED ANDESITE TUFF - Greenish gray chlorite schist with coarse chloritic laminae. 0.02" oval plagioclase crystals are common. A finer grained (phyllitic) variety probably represents reworked andesitic tuff.
- AF** ANDESITE FLOW/VITRIC TUFF - Aphanitic green rock with occasional euhedral plagioclase crystals in an epidote, chlorite, plagioclase bearing groundmass. Gray varieties lack chlorite and epidote in the groundmass. Trace of pyrite found.
- △ Areas underlain by white vein quartz (float and outcrop).

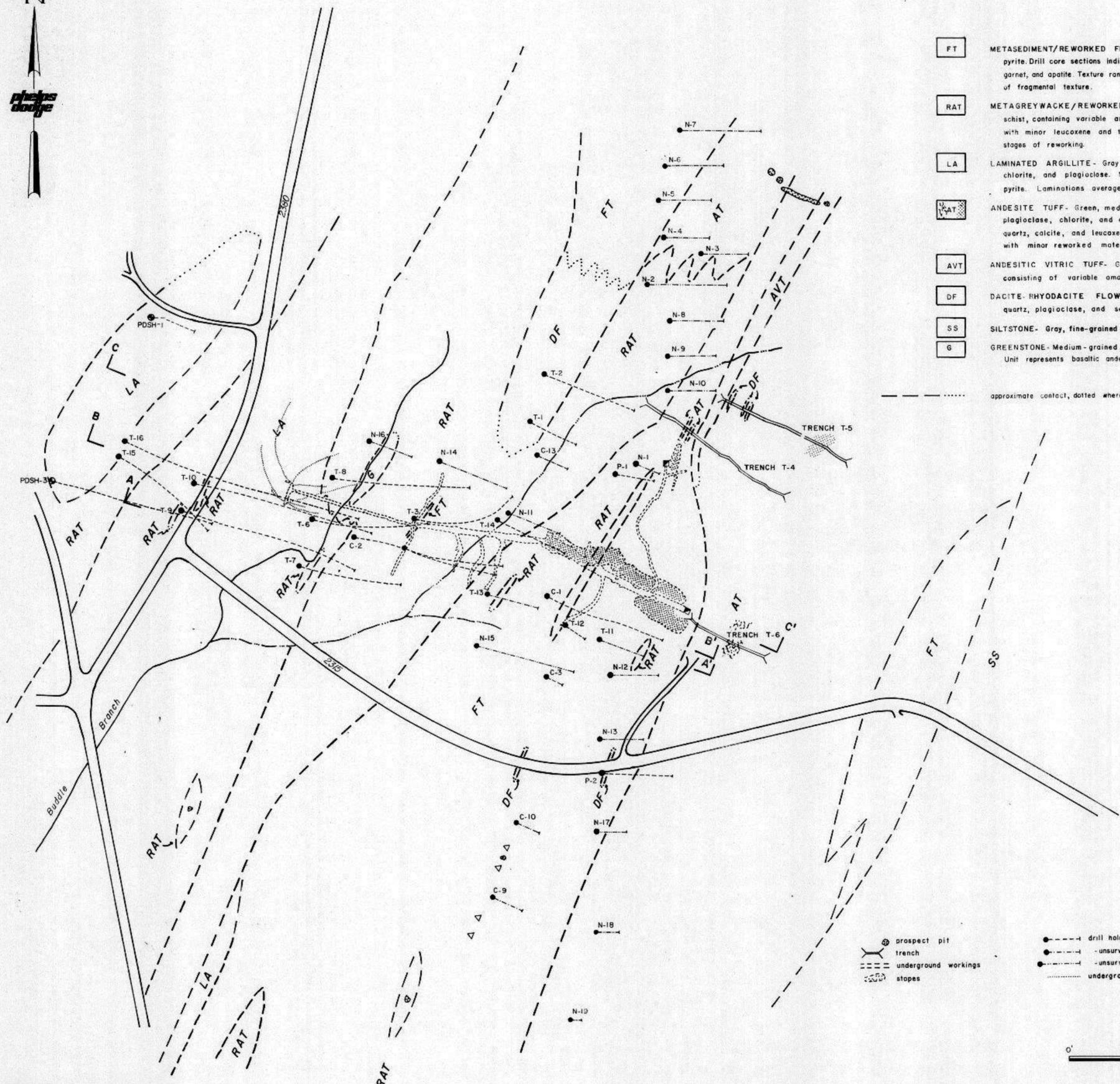
- Approximate contact
- ..... Inferred contact
- 82° Strike and dip of bedding
- 70° Strike and dip of schistosity
- ↗ Axis of outcrop-scale fold
- Shaft
- × Small prospect pit
- Completed drill hole
- Foster Property
- Stevenson Property



<b>PHELPS DODGE EXPLORATION EAST, INC.</b>			
GEOLOGY MAP			
SILVER HILL PROJECT			
DAVIDSON COUNTY, NORTH CAROLINA			
SCALE	H: 1" = 1000'	CONTOUR INTERVAL:	REVISIONS
SHEET	DATE: OCT., 1977	BY: RDT	
OF	DRAWING NO.:	FILE: NCO-95	

**4.8. Silver Hill Mine area, geology and drill holes, Silver Hill Project, Davidson County, North Carolina, Phelps Dodge Exploration East, Raleigh, N.C., scale 1 inch = 200 feet**

By R.D. Thomas, 1977



- FT** METASEDIMENT/REWORKED FELSIC TUFF - Fine light gray quartz-sericite schist, with tr. pyrite. Drill core sections indicate local occurrence of microcline, chlorite, biotite, dolomite, garnet, and apatite. Texture ranges from Tuffaceous to reworked. Triangles indicate zones of fragmental texture.
- RAT** METAGREYWACKE/REWORKED VOLCANICS - Gray to greenish-gray, fine to medium-grained schist, containing variable amounts of chlorite, sericite, plagioclase, calcite, and quartz, with minor leucoxene and tr. pyrite. Unit represents intermediate volcanics in various stages of reworking.
- LA** LAMINATED ARGILLITE - Gray phyllite containing variable amounts of sericite, quartz, chlorite, and plagioclase. Minor to trace amounts of leucoxene, apatite, calcite, and pyrite. Laminations average .1" in thickness.
- AVT** ANDESITIC VITRIC TUFF - Gray to greenish-gray, aphanitic, massive, plagioclase-rich rock consisting of variable amounts chlorite, epidote, quartz, and sericite. Tr. pyrite.
- DF** DACITE-RHYODACITE FLOW/VITROPHYRE - Grey, aphanitic, massive rock containing quartz, plagioclase, and sericite. Tr. pyrite.
- SS** SILTSTONE - Gray, fine-grained arkosic metagreywacke. Massive to well-bedded. Tr. pyrite.
- G** GREENSTONE - Medium-grained, massive rock consisting mostly of chlorite and epidote. Unit represents basaltic andesite volcanics.

--- approximate contact, dotted where inferred

- prospect pit
- trench
- underground workings
- △ stope
- drill hole-surveyed
- -unsurveyed, deflection inferred
- -unsurveyed, no data
- underground drill hole

- N New Jersey Zinc Co. (1941)
- P Northfield Mines (1951)
- T Tennessee Copper Co. (1959-61)
- C Cyprus Mines (1973)
- Phelps Dodge Exploration East (1977)

Core No.	Depth (ft)	Interval (ft)	Sample No.	Grain Size	Color	Texture	Mineralogy	Notes
7-1	420	1945-20	no data					
7-2	550	2705-75	288-289	0.23	tr.	tr.	all	all
			319-320	0.12	tr.	tr.	all	all
			321-360	0.06	tr.	tr.	all	all
			370-380	0.06	tr.	tr.	all	all
			400-405	0.06	all	tr.	all	all
			405-410	0.06	all	tr.	all	all
			410-415	0.06	all	tr.	all	all
			415-420	0.06	all	tr.	all	all
			420-425	0.06	all	tr.	all	all
			425-430	0.06	all	tr.	all	all
			430-435	0.06	all	tr.	all	all
			435-440	0.06	all	tr.	all	all
			440-445	0.06	all	tr.	all	all
			445-450	0.06	all	tr.	all	all
			450-455	0.06	all	tr.	all	all
			455-460	0.06	all	tr.	all	all
			460-465	0.06	all	tr.	all	all
			465-470	0.06	all	tr.	all	all
7-3	900	2705-75	no assays					
7-3	919	2705-85	699-700	0.52	1.50	tr.	all	all
			700-705	0.26	0.25	tr.	all	all
			705-710	0.05	0.05	tr.	all	all
			710-715	0.02	0.05	tr.	all	all
			715-720	0.06	0.25	1.87	all	all
			720-725	0.06	0.40	tr.	all	all
			725-730	0.07	1.70	tr.	all	all
			730-735	0.03	14.45	1.87	all	0.62
			735-740	0.03	1.35	tr.	all	tr.
			740-745	1.41	23.15	11.26	0.13	7.20
			745-750	0.06	0.75	tr.	all	tr.
			750-755	0.06	2.45	1.46	tr.	2.25
			755-760	0.06	0.45	tr.	all	tr.
			760-765	0.05	0.10	tr.	all	tr.
			765-770	0.05	0.45	0.70	all	tr.
			770-775	0.04	0.35	tr.	all	tr.
7-4	300	2705-40	115-117	0.23	0.10	tr.	all	all
			200-205	0.03	0.10	tr.	all	all
7-4	350	vertical	688-691	0.15	16.70	4.14	0.03	2.60
			775-776	0.17	26.26	3.38	all	tr.
			775-780	0.06	0.06	1.09	tr.	7.48
			780-781	0.21	4.46	6.50	0.02	1.28
			785-787	0.02	3.00	2.37	0.03	0.35
			845-850	-	-	-	-	-
7-6	1076	vertical	908-920	0.06	0.22	0.41	tr.	tr.
			920-928	0.36	19.25	4.23	0.05	1.30
			928-943	0.06	0.66	0.50	0.02	0.10
			945-951	-	-	-	-	-
			951-957	0.14	9.32	7.04	0.03	1.04
7-7	991	vertical	1013-1016	0.06	-	-	-	-
			1020-1021	0.08	-	-	-	-
			1025-1027	0.05	1.79	tr.	tr.	tr.
			1027-1028	0.05	3.50	tr.	tr.	tr.
			1030-1031	0.07	12.10	6.26	0.06	1.15
			1035-1037	0.06	0.76	tr.	tr.	tr.
			1038-1042	0.03	0.46	tr.	tr.	tr.
7-8	1203	vertical	1161-1168	0.16	0.25	all	-	-
			1168-1170	0.11	1.10	tr.	tr.	all
			1170-1175	0.18	0.32	all	-	-
			1175-1180	0.26	0.79	all	-	-
			1180-1185	0.31	0.44	all	-	-
7-9	1265	vertical	no assays					
7-10	1225	vertical	1171-1175	0.23	5.76	1.43	all	0.10
			1176-1180	0.49	1.59	2.35	all	0.10
			1181-1185	0.26	0.65	0.18	all	0.10
			1186-1190	0.34	19.80	1.25	tr.	0.72
			1191-1203	0.05	2.86	0.96	all	0.10
			1204-1208	0.26	4.66	0.53	all	0.10
			1209-1213	0.05	4.66	1.41	tr.	0.10
			1214-1218	0.09	18.08	2.26	tr.	0.70
			1219-1221	0.05	9.69	2.07	tr.	0.36
			1221-1223	0.07	3.58	1.79	tr.	0.24
7-11	252	2705-60	no assays					
7-12	400	vertical	230-235	0.13	17.30	1.25	all	tr.
			236-238	0.10	0.40	tr.	tr.	tr.
			239-240	0.06	2.73	0.72	tr.	0.26
			240-242	0.16	1.11	all	tr.	tr.
			242-247	0.05	7.43	4.21	0.26	1.20
7-13	423	vertical	430-440	0.14	4.50	1.20	all	0.26
			441-442	0.17	1.23	0.24	0.22	0.44
			443-444	0.03	2.07	tr.	tr.	tr.
			445-447	0.03	0.20	tr.	tr.	tr.
			448-449	0.03	2.57	0.57	all	tr.
			450-457	0.10	4.38	1.24	0.08	0.28
			457-471	0.13	1.24	1.08	all	tr.
7-14	500	305B-25	475-480	0.22	1.25	1.37	all	0.36
7-15	742	2705-80	no assays					
7-16	1430	2705-88	1395-1396	0.07	0.60	4.80	0.21	1.20
			1396-1407	7.50	30.70	10.23	0.28	2.66
C-1	915	vertical	370-375	0.06	1.30	0.45	tr.	0.22
			375-377	0.06	1.1	0.48	tr.	0.22
			377-386	0.06	1.5	1.25	0.08	0.73
			386-388	0.06	1.24	0.21	tr.	0.05
7-17	1970	vertical	no assays					
7-18	515	vertical	no assays					

**phelps dodge** Exploration East, Inc.

## SILVER HILL MINE AREA, GEOLOGY AND DRILL HOLES

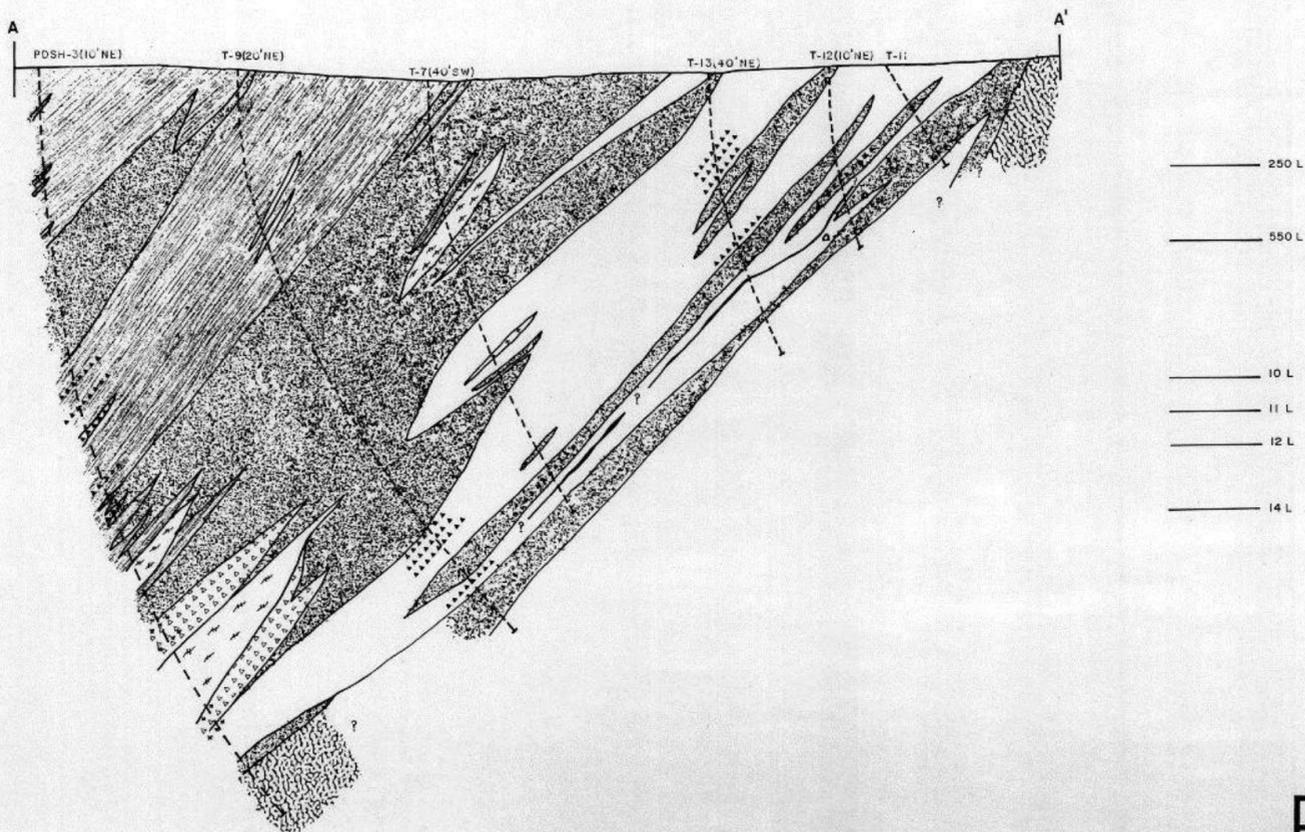
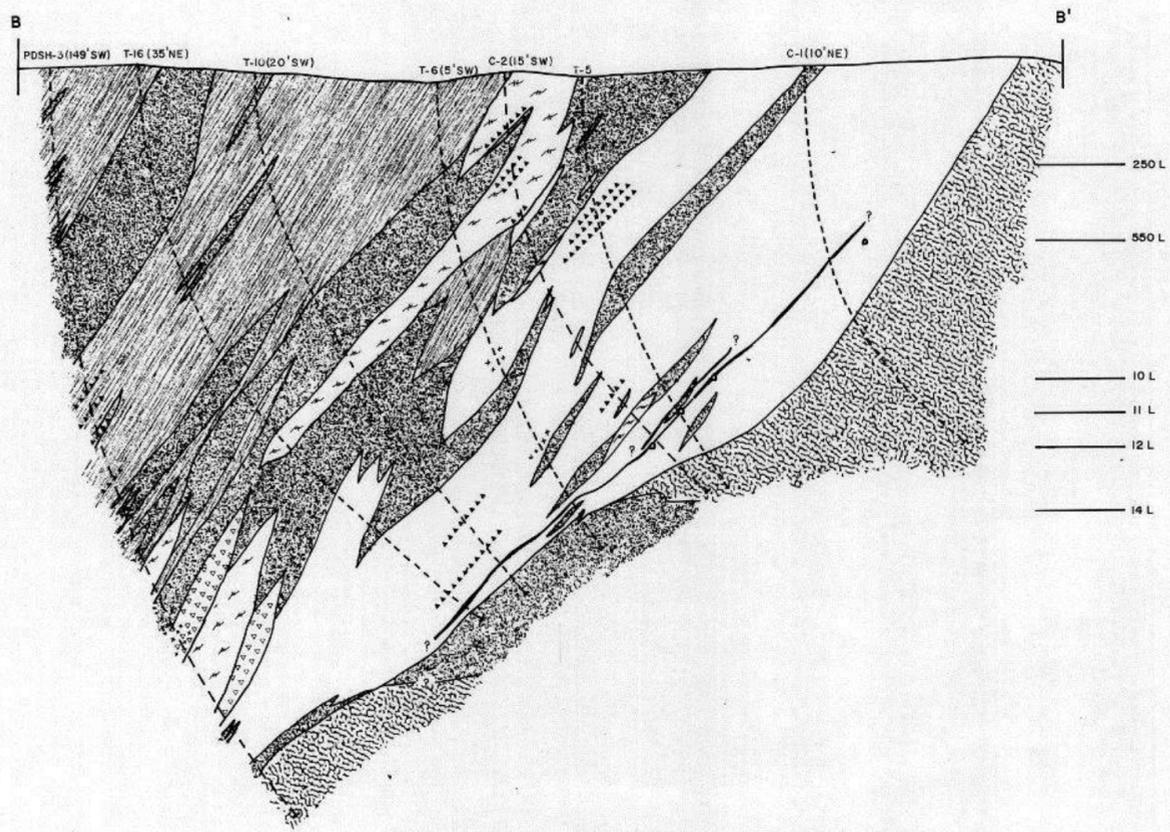
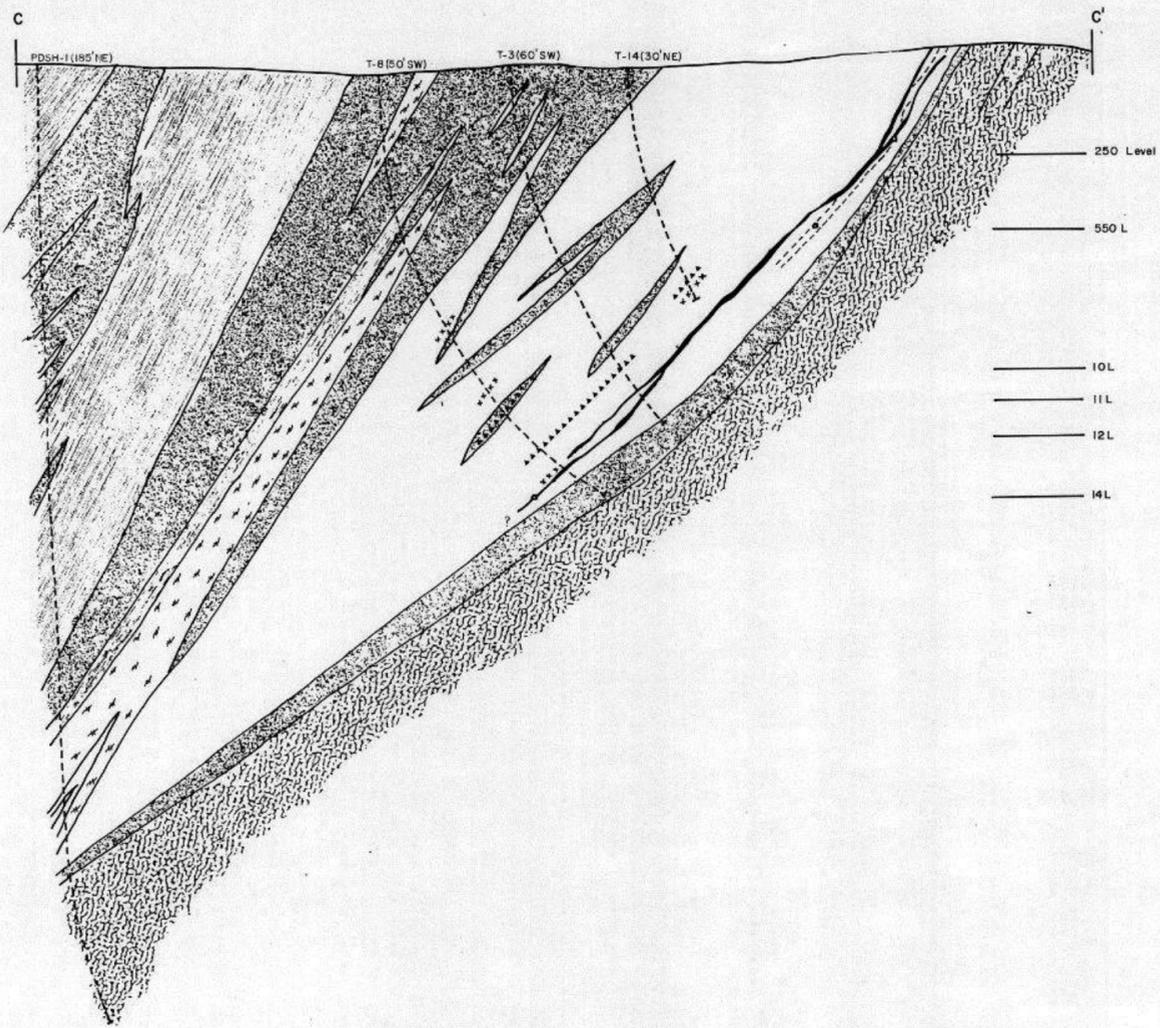
### SILVER HILL PROJECT

DAVIDSON COUNTY, NORTH CAROLINA

<b>SCALE</b>	H: 1" = 200'	CONTOUR INTERVAL:	<b>REVISIONS</b>
	V:	DATE: OCT., 1977	BY: RDT
<b>SHEET</b>	OF	<b>DRAWING NO:</b>	<b>FILE: NCQ-95</b>

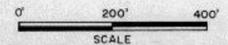
**4.9. Cross sections, Silver Hill Mine area, Silver Hill Project, Davidson County, North Carolina, Phelps Dodge Exploration East, Raleigh, N.C., scale 1 inch = 200 feet**

By R.D. Thomas, 1977



**EXPLANATION**

- LAMINATED ARGILLITE
  - METAGREYWACKE / REWORKED VOLCANICS—Triangles indicate fragmental texture
  - METASEDIMENT / REWORKED FELSIC TUFF—Triangles indicate fragmental texture
  - ANDESITE TUFF—F where flow
  - DACITE-RHYODACITE FLOW/VITROPHYRE
  - DACITE TUFF
  - GREENSTONE—Basaltic andesite flow
  - ORE LENS
- workings indicated where they intersect section
- drift
  - shaft



<b>phelps dodge</b> ENGINEERS & GEOLoGISTS			
<b>GEOLOGIC SECTIONS-SILVER HILL MINE AREA</b>			
SILVER HILL PROJECT			
DAVIDSON COUNTY, NORTH CAROLINA			
SCALE	H: 1" = 200'	CONTOUR INTERVAL:	REVISIONS
	V: 1" = 200'	DATE: OCT. 1977	BY: R.D. THOMAS
SHEET	OF	DRAWING NO:	FILE:
			5 / 78

**5.0. The Silver Valley Mine VMS deposit, Cid District, Davidson County, North Carolina**

**5.1. Silver Valley Project Termination Report, Phelps Dodge Exploration East, Raleigh, N.C.**

By David F. Lee, 1981

**SILVER VALLEY PROJECT  
TERMINATION REPORT  
NCQ-95**

**D. F. Lee  
November 30, 1981**

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## PLATE

Plate 1 Geologic Location Map of the Silver Valley Mine Area
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## SUMMARY

The Silver Valley project, located approximately twelve miles southeast of Lexington in Davidson County, North Carolina, is comprised of 950.53 acres leased from Virginia Rock and Minerals Corporation through an Agreement of Assignment between PDEE, Inc. and Conoco, Inc. who previously held the lease (see Figure 1).

PDEE, Inc.'s interest in the property was to confirm and test the existence of a previously untested coincident lead and zinc soil geochemistry anomaly and moderate IP anomaly as reported by Conoco, Inc.

Exploration consisted of soil and rock geochemistry, ground geophysical surveys, mapping, and drilling. Data from the 1976 airborne INPUT survey by Questor Surveys, Ltd. were also re-evaluated for the Silver Valley Mine area. The airborne survey failed to locate a conductor indicative of massive sulfide mineralization. Ground geophysics indicated the existence of two sub-parallel moderately conductive zones with roughly coincident weak soil geochemistry anomalies as outlined by the soil geochemistry survey.

A single diamond drill hole was collared north of the mine workings to test the coincident HLEM, IP-resistivity, and soil geochemistry anomalies. The metallized horizon responsible for the geophysical responses was intersected but contained only minor base metal sulfides.

Due to the fact that no significant mineralization was encountered and no new targets were located, mineral leases will be terminated at the end of 1981 and the project terminated.

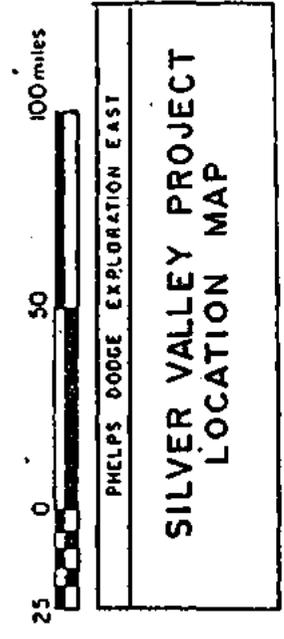
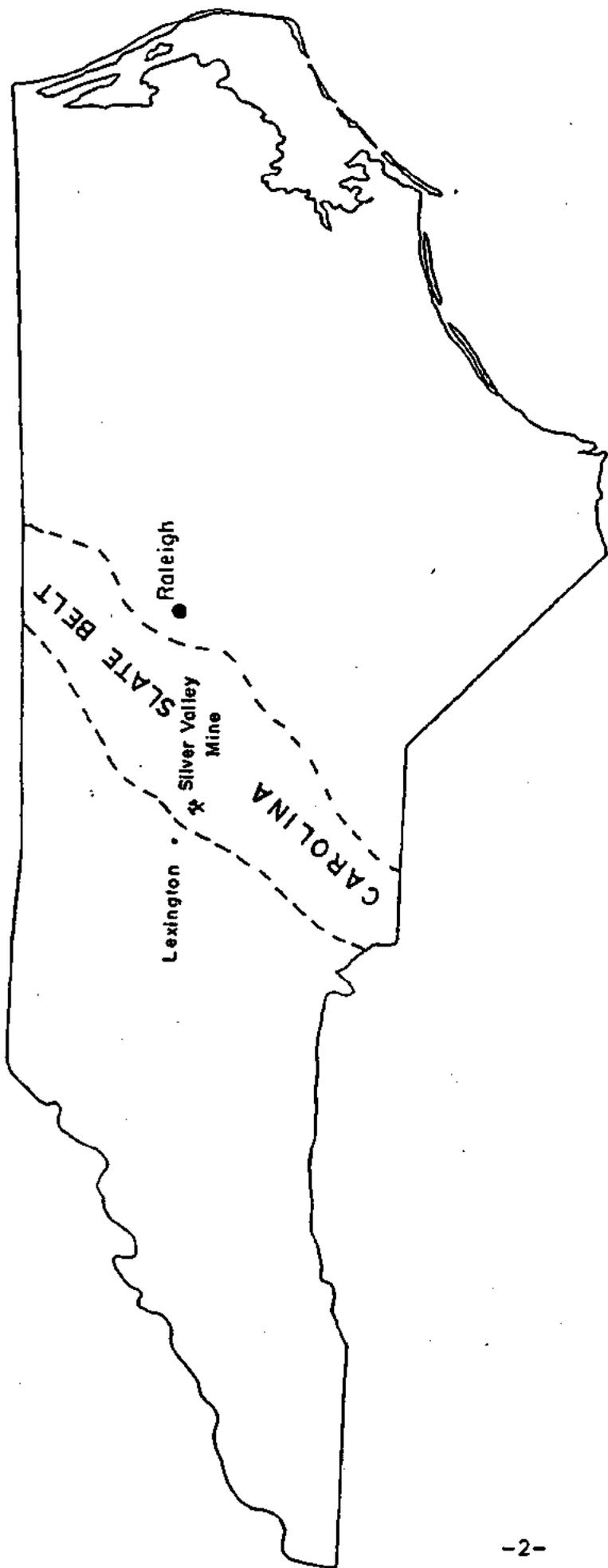


Figure 1

## HISTORY

The Silver Valley deposit was discovered in June of 1880. As of January of 1883 two shafts had been sunk, a vertical shaft to 100 feet and a decline to 170 feet, inclined -45' and in the vein. By 1910 the vertical shaft had been extended to 210 feet and had been worked on two levels, -150 foot level and -210 foot level. The inclined shaft had been worked on three levels, - 50 foot level, - 100 foot level, and - 170 foot level. The mine was worked intermittently and was closed after a period of approximately ten years.

Since 1910, but prior to PDEE's occupation of the property since 1979, three companies have done exploration on the property. Southern Aggregates Corporation and Virginia Rock and Minerals Corporation both did exploratory diamond core drilling in the vicinity of the mine workings but failed to outline any new ore reserves. Conoco, Inc. occupied the property between March, 1974 and September 1979 and carried out an exploration program consisting of geochemistry, surface and airborne geophysics, and diamond core drilling. Conoco, Inc. also failed to locate any new ore reserves but left the northern extent of the property untested by core drilling.

In September of 1980, a program was designed to confirm the existence of coincident soil geochemistry and surface geophysical anomalies in the northern portion of the property as reported and left untested by Conoco, Inc.

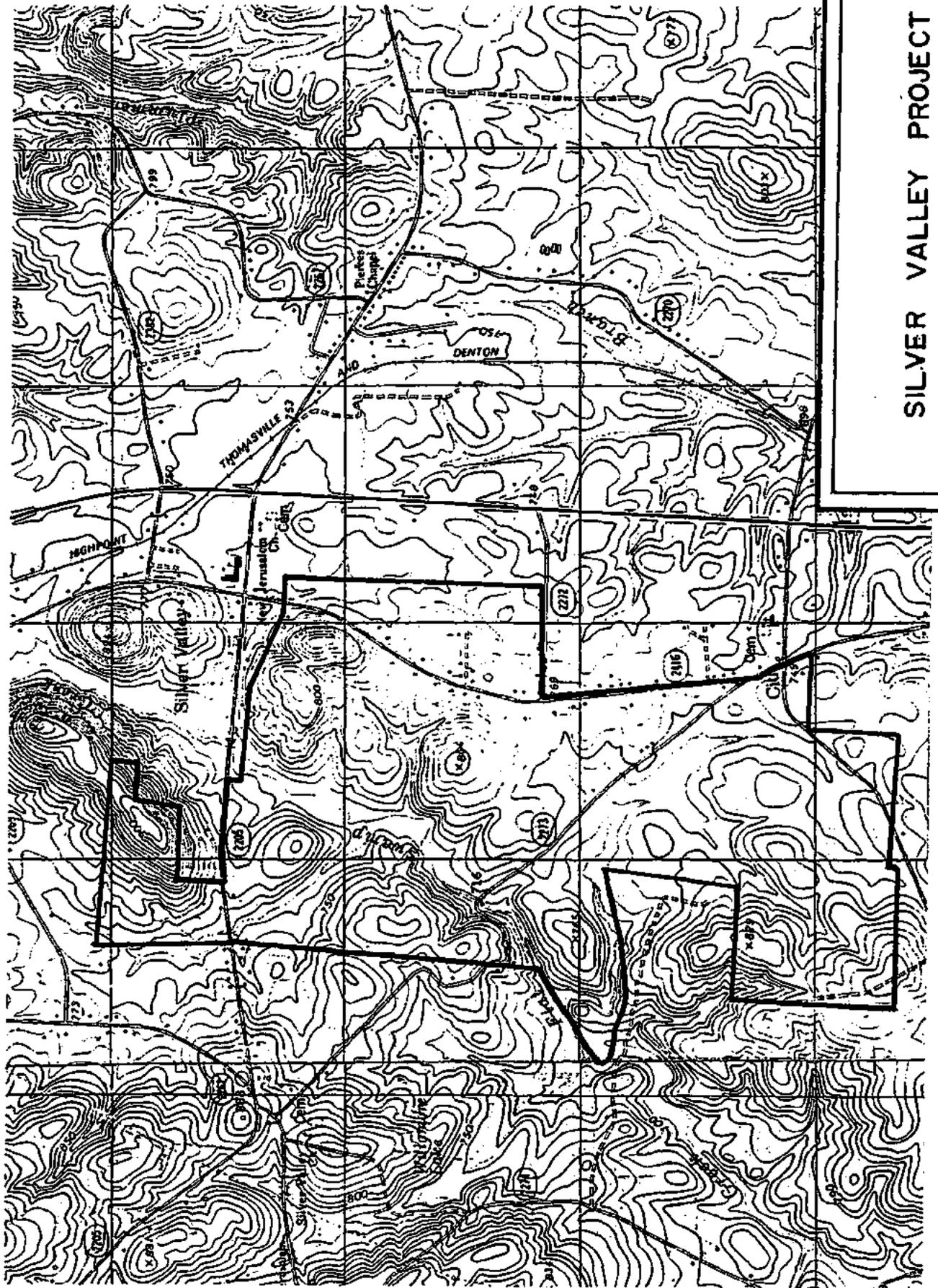
## LAND STATUS

The Silver Valley project area consists of 950.53 acres of

mineral rights leased by Conoco, Inc. and assigned to PDEE, Inc. through an Agreement of Assignment dated September 4, 1979 (see Figure 2). The owner of the mineral rights, which have been severed from the surface rights, is Virginia Rock and Minerals Corporation of Oxford, North Carolina. The surface rights are controlled by six large landowners and two subdivisions.

The original lease agreement between Conoco, Inc. and Virginia Rock and Minerals Corporation was dated March 1, 1974 with Conoco subject to the following terms:

1. Annual property payments of \$1,901.06 for years one through eight; \$2,851.59 for years nine through fifteen; and \$4,752.65 for year sixteen, and each anniversary date thereafter while the lease is in effect. The annual payments on the first through fifteenth anniversary dates shall be rental, and not advance royalty.
2. Annual payments for year sixteen and each anniversary date thereafter shall be advance royalty payments.
3. Production royalty payments are based on 5% net smelter returns.



SILVER VALLEY PROJECT  
PROPERTY MAP

Figure 2

## SUMMARY OF WORK DONE

### GEOCHEMISTRY

A total of 113 soil samples were collected at one hundred foot intervals along a grid constructed north of the mine workings (refer to Plate 1 for grid location). The samples were analysed for copper, lead, zinc, cobalt, and arsenic and found to contain anomalous values of copper, lead, and zinc. Anomalous soil concentrations were recorded for "the hill" north of the mine, I.E. the untested Conoco anomaly, and an extensive area surrounding the mill site. It is thought that contamination may be partially responsible for the anomalous concentrations in the area surrounding the mill site and numerous prospect pits and trenches, but that there is an overall anomalous zone north of the mine workings (see Table 1 and Plate 1).

Geochemistry, rock assay, was also run on several samples of massive sulfide material from the main dumps and on channel samples collected across the vein exposure in the decline. Massive sulfide material was found to contain up to 33.78 oz/ton silver and gossanous material from the decline was found to contain up to 8.76 oz/ton silver, the silver being contained within galena (see Table 2).

### GEOPHYSICS

Three types of geophysics were run in the Silver Valley area at various times.

The 1976 airborne INPUT survey by Questor, Ltd. encompassing

the Silver Hill-Sechrist project areas, also covered the Silver Valley area. The INPUT did not detect any conductors indicative of massive sulfide mineralization in the Silver Valley area.

In the fall of 1980 a Horizontal Loop EM - Max Min survey was run over the soil geochemistry grid. The EM survey indicated a weak but definite conductive zone trending in a north-north-westerly direction, with the most conductive zone occurring near station 4 West on Line 8S (see Plate 1).

During March of 1981, a new grid, Grid #2, was constructed to cover the most interesting EM target and a coincident lead-zinc geochemical high. IP-resistivity was run over the 3 line grid. The survey suggested two zones of anomalous response, a weakly anomalous zone from 4 - 5 West to 5 East on Grid #2, and a stronger zone from about 0 to 2 East on Lines 0 and 2 South and from 0 to 3.5 East on Line 2 North. Although a discrete narrow zone was not suggested, considerable sulfide mineralization over a good width was suggested (see Plate 1).

#### DRILLING

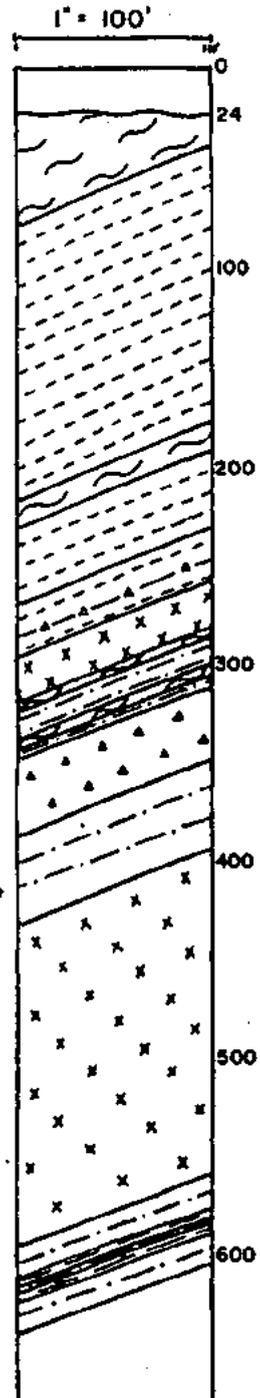
A diamond drill hole, designed to test the coincident IP and soil geochemistry anomalies was collared at 1.5 W on the 0 Line of Grid #2 and angled  $-45^{\circ}$  in a  $S80^{\circ}E$  direction (see Plate 1). The hole intersected the favorable horizon but failed to encounter economically significant mineralization, though disseminated mineralization thought responsible for the geophysical and geochemical responses was encountered (see Figure 3, and Table 3).

**GEOLOGIC LOG**

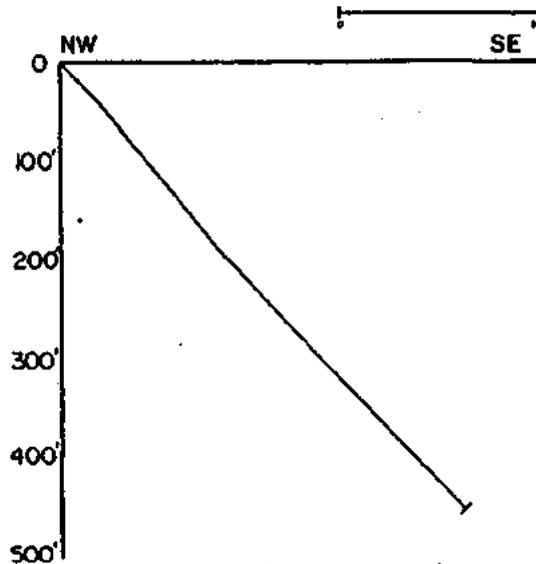
**ASSAY RESULTS**

**SECTIONAL VIEW (1" = 200')**

**SUMMARY OF GEOLOGY**



Interval	ppm Ag	% Pb	% Zn
24.0-25.0'	1.5	<0.01	0.214
25.0-30.0'	2.0	<0.01	0.124
30.0-35.0'	1.5	<0.01	0.152
35.0-40.0'	2.0	<0.01	0.048
40.0-45.0'	5.0	0.01	0.009
45.0-50.0'	3.0	0.01	0.046
50.0-55.0'	5.0	<0.01	0.010
55.0-60.0'	5.0	0.01	0.030
60.0-65.0'	5.0	0.01	0.006
65.0-70.0'	4.5	0.01	0.017
70.0-75.0'	3.0	0.01	0.028
75.0-80.0'	1.5	<0.01	0.013
80.0-85.0'	1.0	<0.01	0.009
85.0-90.0'	1.5	<0.01	0.036
90.0-95.0'	3.5	0.01	0.011
95.0-100.0'	5.0	0.01	0.040
100.0-105.0'	4.5	0.01	0.134
105.0-110.0'	4.0	0.01	0.050
110.0-115.0'	4.5	0.01	0.032
115.0-120.0'	5.5	0.02	0.034
120.0-125.0'	5.5	0.02	0.102
125.0-130.0'	7.0	0.12	0.170
130.0-135.0'	11.5	0.27	0.540
135.0-140.0'	1.5	0.06	0.116
140.0-145.0'	3.0	0.13	0.340
145.0-150.0'	2.0	0.10	0.286
150.0-155.0'	2.0	0.10	0.610
155.0-160.0'	1.5	0.08	0.212
160.0-165.0'	1.0	0.09	0.220
165.0-170.0'	1.5	0.16	0.384
170.0-175.0'	3.5	0.41	0.440
175.0-180.0'	3.0	0.14	0.184



Collar Elevation = 715'  
 Bearing S 80° E  
 Drilled 5/19/81 - 5/29/81

- Bio-Qtz.-Feldspar meta sed./ meta volc.
- Rhyolite ash
- Reworked rhy. to rhyodac x-tal-tuff
- Qtz.- Carb. vein
- Sil. rhyolite (ash?)
- Epiclastic siltstone/ ash
- Sil. rhyolite (ash x-tal tuff)
- Andesitic to mafic ash/mudstone

- 0 - 24 Overburden
- 24 - 37 Biotite - quartz - feldspar meta sed./ meta volc. Intermixed with felsic ash in lower portion of interval.
- 37 - 178 Felsic ash, locally well laminated with graded bedding, locally siliceous and color variant. Pyrite to 15% locally, trace disseminated sphalerite, galena, and chalcocopyrite locally.
- 178 - 181 Biotite - quartz - feldspar meta sed./ meta volc.
- 181 - 186.5 Quartz - carbonate vein containing pyrrhotite, galena, sphalerite, and pyrite as irregular masses to 3 cm.
- 186.5 - 190 Biotite - quartz - chlorite - feldspar meta sed./ meta volc. locally calcareous. Trace chalcocopyrite and pyrrhotite along fractures. Trace pyrite as disseminated grains and blebs and sprays along fractures.
- 190 - 230 Light to medium grey siliceous rhyolite ash. Trace pyrite, chalcocopyrite, galena, and sphalerite locally.
- 230 - 255 Rhyolite to rhyodacite reworked x-tal-tuff. Locally slightly calcareous. Trace pyrite and sphalerite as fine discontinuous veinlets.
- 255 - 282 Dark grey siliceous rhyolite(ash?). Trace disseminated pyrite.
- 282 - 285 Biotite - quartz - feldspar meta sed./ meta volc. 1% py as fine disseminations.
- 285 - 298 Siliceous epiclastic siltstone/ash. Trace pyrite locally as discontinuous veinlets.
- 298 - 303 Biotite - quartz - feldspar meta sed./ meta volc. 1% pyrite as disseminated grains and fracture fillings.
- 303 - 305 Siliceous epiclastic siltstone/ash.
- 305 - 348 Dark grey siliceous rhyolite (ash-tal tuff). Dense and massive. Trace to 1% pyrite as scattered grains and sprays along fractures.
- 348 - 392 Siliceous (epiclastic?) siltstone/ash.
- 392 - 544 Light to dark grey massive siliceous rhyolite. Trace to 2% pyrite locally as fine disseminations, trace disseminated sphalerite and pyrrhotite.
- 544 - 570 Bottled dark grey siliceous (epiclastic?) siltstone/ash. Trace sphalerite and pyrite as disseminated grains.
- 570 - 572 Dark green andesitic to mafic ash/mudstone. Trace to 1% pyrite.
- 572 - 577 Bottled dark grey siliceous (epiclastic?) siltstone/ash. Trace sphalerite and pyrite.
- 577 - 581.5 Dark green andesitic to mafic ash/mudstone.
- 581.5 - 602 Bottled dark grey siliceous (epiclastic) siltstone/ash.

- 8 -

Figure 3

SILVER VALLEY PROJECT  
 DAVIDSON COUNTY, NORTH CAROLINA  
 PDSV - 1

## GEOLOGY

The geologic setting of the Silver Valley deposit was defined by examination of regional mapping by the USGS, interpretation of relogged Conoco drill holes on the property, and detailed and reconnaissance mapping by PDEE personnel.

The Silver Valley Mine is located near the western margin of the Carolina Slate belt. Rock units consist of lower Paleozoic, probably late Cambrian to early Ordovician, volcanics, volcanoclastic and volcanically derived sediments that have been metamorphosed to lower green schist facies. Major structure in the area is the proposed Floyd Church Syncline, a broad synclinal structure that plunges at a shallow angle to the southwest. The structure is due to warping of the sequence during regional metamorphism.

The Silver Valley Mine is located on the eastern limb and near the hinge of the Floyd Church Syncline. The mineralization occurs in rhyolite vitrophyres with associated chert exhalite horizons and a sequence of felsic (rhyolite) ash. It has been inferred, through examination of dump material, that a small silver bearing massive sulfide lens has been mined out. Other than truly massive sulfide ore, there is disseminated mineralization in the rhyolite ash, pods and masses of massive sulfide in a quartz vein that has intruded the ore bearing horizon, stringer type ore in fractures in cherty exhalite that has been fractured or brecciated, and interstitial sulfides in a biotite + quartz + carbonate host that has been interpreted as a chemical precipitate horizon.

The mineralized horizon lies between rhyo-dacitic, dacitic, and andesitic crystal and crystal-lithic tuffs to the west

and dacitic to andesitic volcanics to the east (see Plate 1). Primary sedimentary structure, coarse to fine sequences, within the rhyolite ash unit intersected by drill hole PDSV-1 indicates that the sequence is upright. Detailed surface mapping indicates that the mineralizing event come near the end of the felsic (rhyolitic) volcanic episode before deposition of the stratigraphically higher dacitic volcanics and sediments now west of the mine area.

#### DISCUSSION AND CONCLUSIONS

The exploration program at Silver Valley was designed to confirm the existence of Conoco's untested soil geochemistry and geophysical anomalies. The anomalies were confirmed and better outlined by soil geochemistry and surface geophysics and were consequently tested by diamond core drilling. The remainder of the property was also examined through reconnaissance mapping and no additional targets were located through this means. Because the targeted mineralization proved to be sub-economic and no additional targets were located, i.e. during the 1976 INPUT survey and reconnaissance mapping to the south, the lease and the project are being terminated at the end of 1981.

APPENDIX A

TABLES 1,2,and 3

Soil Geochemistry, Channel Sample Assay, and  
Drill Core Assay Results

TABLE 1 SILVER VALLEY SOIL GEOCHEMISTRY RESULTS

<u>SAMPLE NUMBER</u>	<u>ppm Zn</u>	<u>ppm Cu</u>	<u>ppm Pb</u>	<u>ppm Co</u>	<u>ppm As</u>
SV-8S+12E	27	5	13	5	<10
SV-8S+11E	40	9	20	5	<10
SV-8S+10E	19	3	13	5	<10
SV-8S+9E	21	6	13	5	<10
SV-8S+8E	7	7	13	5	<10
SV-8S+7E	5	5	15	3	<10
SV-8S+6E	9	3	28	3	<10
SV-8S+5E	33	4	38	5	<10
SV-8S+4E	19	3	23	5	<10
SV-8S+3E	31	8	18	10	<10
SV-8S+2E	68	8	48	10	<10
SV-8S+1E	73	9	63	10	<10
SV-8S+0	81	8	18	10	<10
SV-8S+1W	118	9	53	10	<10
SV-8S+2W	333	10	93	8	<10
SV-8S+3W	68	8	110	8	20
SV-8S+4W	330	15	135	10	<10
SV-8S+5W	338	21	425	10	<10
SV-8S+6W	123	15	55	5	15
SV-8S+7W	11	3	13	3	40
SV-8S+8W	68	16	50	5	30
SV-8S+9W	12	6	38	18	10
SV-8S+10W	18	7	20	8	10
SV-8S+11W	16	5	13	5	<10
SV-8S+12W	16	8	13	5	15
SV-4S+12E	15	5	10	5	<10
SV-4S+11E	23	5	15	8	<10
SV-4S+10E	14	5	13	5	<10
SV-4S+9E	18	7	10	5	<10
SV-4S+8E	25	7	10	5	<10
SV-4S+7E	20	8	13	10	<10
SV-4S+6E	69	8	78	10	<10

Table 1 (continued)

<u>SAMPLE NUMBER</u>	<u>ppm Zn</u>	<u>ppm Cu</u>	<u>ppm Pb</u>	<u>ppm Co</u>	<u>ppm As</u>
SV-4S+5E	26	6	13	5	<10
SV-4S+4E	66	6	38	5	<10
SV-4S+3E	100	16	350	10	30
SV-4S+2E	60	18	400	18	50
SV-4S+1E	35	17	475	13	40
SV-4S+0	65	14	375	8	30
SV-4S+1W	85	28	375	18	50
SV-4S+2W	34	10	245	13	40
SV-4S+3W	82	24	500	15	25
SV-4S+4W	162	25	375	10	25
SV-4S+5W	39	10	45	13	<10
SV-4S+6W	16	5	15	3	25
SV-4S+7W	27	8	30	5	15
SV-4S+8W	15	9	15	10	<10
SV-4S+9W	15	10	20	33	<10
SV-4S+10W	28	6	20	5	<10
SV-4S+11W	25	8	30	5	<10
SV-4S+12W	21	15	27	10	25
SV-0+12E	15	6	10	8	<10
SV-0+11E	16	5	10	15	<10
SV-0+10E	9	3	13	3	<10
SV-0+9E	8	3	10	3	<10
SV-0+8E	10	4	13	3	<10
SV-0+7E	38	9	13	5	<10
SV-0+6E	30	3	37	5	<10
SV-0+5E	26	15	100	8	<10
SV-0+4E	41	17	152	8	15
SV-0+3E	23	18	275	10	20
SV-0+2E	19	8	192	5	25
SV-0+1E	15	12	105	3	75
SV-0+0	54	43	425	10	50
SV-0+1W	46	36	274	5	50
SV-0+2W	96	80	900	18	75
SV-0+3W	43	56	157	5	60
SV-0+4W	28	20	275	8	25

Table 1 (continued)

<u>SAMPLE NUMBER</u>	<u>ppm Zn</u>	<u>ppm Cu</u>	<u>ppm Pb</u>	<u>ppm Co</u>	<u>ppm As</u>
SV-0+5W	33	16	220	10	25
SV-0+6W	18	8	18	13	<10
SV-0+7W	14	15	13	5	15
SV-0+8W	16	12	15	5	<10
SV-0+9W	25	11	18	8	<10
SV-0+10W	16	8	15	8	<10
SV-0+11W	14	8	13	5	<10
SV-0+12W	15	14	13	5	15
SV-4N+9E	11	5	13	5	<10
SV-4N+8E	10	5	13	5	<10
SV-4N+7E	10	5	13	5	<10
SV-4N+6E	125	8	400	3	<10
SV-4N+5E	12	12	15	5	<10
SV-4N+4E	30	6	40	5	<10
SV-4N+3E	16	7	38	5	<10
SV-4N+2E	17	12	43	5	<10
SV-4N+1E	41	13	78	8	<10
SV-4N+0	19	20	73	13	<10
SV-4N+1W	15	10	38	8	<10
SV-4N+2W	17	43	43	10	<10
SV-4N+3W	15	13	23	5	<10
SV-4N+4W	13	8	13	3	<10
SV-4N+5W	15	8	28	3	<10
SV-4N+6W	15	8	10	5	<10
SV-4N+7W	18	8	15	13	15
SV-4N+8W	27	13	30	65	<10
SV-4N+9W	18	9	35	40	<10
SV-4N+10W	12	5	10	5	<10
SV-4N+11W	10	6	13	8	<10
SV-4N+12W	13	9	13	15	<10
SV-8N+5E	19	3	13	3	<10
SV-8N+4E	19	3	15	3	<10
SV-8N+3E	10	2	10	3	<10
SV-8N+2E	28	5	20	3	<10

Table 1 (conclusion)

<u>SAMPLE NUMBER</u>	<u>ppm Zn</u>	<u>ppm Cu</u>	<u>ppm Pb</u>	<u>ppm Co</u>	<u>ppm As</u>
SV-8N+1E	10	6	8	3	<10
SV-8N+0	14	7	13	3	15
SV-8N+1W	10	5	10	5	<10
SV-8N+2W	8	5	10	3	250
SV-8N+3W	10	5	10	3	<10
SV-8N+4W	14	6	13	5	<10
SV-8N+5W	11	3	13	5	<10
SV-8N+6W	18	10	13	10	<10
SV-8N+7W	1	2	10	5	<10
SV-8N+8W	45	5	13	5	<10
SV-8N+9W	14	4	5	5	<10
SV-8N+10W	14	3	13	20	<10

TABLE 2 SILVER VALLEY DUMP AND VEIN CHANNEL SAMPLES - ASSAY RESULTS

<u>SAMPLE NUMBER</u>	<u>%Pb</u>	<u>%Zn</u>	<u>ppm Ag</u>	<u>oz/ton Ag</u>	<u>ppm Au</u>	<u>oz/ton</u>
*SVMD - C1	35.2	20.4	1157.0	33.78	2.10	
**SVIG - C1	1.35	0.12	16.0	0.47	0.36	
**SVIG - C2	2.25	0.156	49.0	1.43	0.55	
**SVIG - C3	3.10	0.295	260.0	7.59	19.20	0.56
**SVIG - C4	6.70	0.330	300.0	8.76	5.00	
**SVIG - C5	0.95	0.113	51.5	1.50	0.37	
**SVIG - C6	4.85	0.215	22.0	0.64	2.80	

\* SVMD denotes grab samples of typical massive sulfide dump material combined and assayed as a single sample.

\*\* SVIG denotes channel samples across the vein exposure in the decline.

TABLE 3

PD SV - 1 ASSAY RESULTS

<u>Sample Number</u>	<u>Sample Interval</u>	<u>ppm Ag</u>	<u>% Pb</u>	<u>% Zn</u>
PDSV-1.1	24.0-25.0'	1.5	<0.01	0.214
PDSV-1.2	25.0-30.0'	2.0	<0.01	0.124
PDSV-1.3	30.0-35.0''	1.5	<0.01	0.152
PDSV-1.4	35.0-40.0'	2.0	<0.01	0.048
PDSV-1.5	40.0-45.0'	5.0	0.01	0.009
PDSV-1.6	45.0-50.0'	3.0	0.01	0.046
PDSV-1.7	50.0-55.0'	5.0	<0.01	0.010
PDSV-1.8	55.0-60.0'	5.0	0.01	0.030
PDSV-1.9	60.0-65.0'	5.0	0.01	0.006
PDSV-1.10	65.0-70.0'	4.5	0.01	0.017
PDSV-1.11	70.0-75.0'	3.0	0.01	0.028
PDSV-1.12	75.0-80.0'	1.5	<0.01	0.013
PDSV-1.13	80.0-85.0'	1.0	<0.01	0.009
PDSV-1.14	85.0-90.0'	1.5	<0.01	0.036
PDSV-1.15	90.0-95.0'	3.5	0.01	0.011
PDSV-1.16	95.0-100.0'	5.0	0.01	0.040
PDSV-1.17	100.0-105.0'	4.5	0.01	0.134
PDSV-1.18	105.0-110.0'	4.0	0.01	0.050
PDSV-1.19	110.0-115.0'	4.5	0.01	0.032
PDSV-1.20	115.0-120.0'	5.5	0.02	0.034
PDSV-1.21	120.0-125.0'	5.5	0.02	0.102
PDSV-1.22	125.0-130.0'	7.0	0.12	0.170
PDSV-1.23	130.0-135.0'	11.5	0.27	0.540
PDSV-1.24	135.0-140.0'	1.5	0.06	0.116
PDSV-1.25	140.0-145.0'	3.0	0.13	0.340
PDSV-1.26	145.0-150.0'	2.0	0.18	0.286
PDSV-1.27	150.0-155.0'	2.0	0.18	0.610
PDSV-1.28	155.0-160.0'	1.5	0.08	0.212
PDSV-1.29	160.0-165.0'	1.0	0.09	0.220
PDSV-1.30	165.0-170.0'	1.5	0.16	0.384
PDSV-1.31	170.0-175.0'	3.5	0.41	0.440
PDSV-1.32	175.0-180.0'	3.0	0.14	0.104

Table 3 (continued)

<u>Sample Number</u>	<u>Sample Interval</u>	<u>ppm Ag</u>	<u>% Pb</u>	<u>% Zn</u>
PDSV-1.33	190.0-191.0'	3.0	.09	.440
PDSV-1.34	210.0-211.0'	1.5	.03	.080
PDSV-1.35	230.0-231.0'	3.0	.22	.340
PDSV-1.36	283.0-284.0'	2.0	.01	.015
PDSV-1.37	299.0-300.0'	2.0	.01	.022
PDSV-1.38	360.0-361.0'	.5	.01	.011
PDSV-1.39	392.0-393.0'	.5	.01	.011
PDSV-1.40	438.0-439.0'	7.0	.06	.080
PDSV-1.41	500.0-501.0'	1.0	.01	.011
PDSV-1.42	579.0-580.0'	.5	.01	.011

**5.2. Geologic/location map of the Silver Valley Project area, Davidson County, North Carolina, Phelps Dodge Exploration East, Raleigh, N.C., scale 1 inch = 200 feet**

By David F. Lee, 1981

**EXPLANATION**

**SYMBOLS**

- Shaft
- Declined shaft with direction and angle of declination
- Caved shaft
- Trench
- Mine dump surrounding caved shaft
- Diamond drill hole, direction and extent of surface projection indicated, approximate extent of drill pad indicated.
- Inferred lithologic contact
- Approximate lithologic contact
- Strike and dip of bedding
- Strike and dip of foliation
- Strike and dip of vertical foliation
- US route
- State secondary road (unsurfaced)
- Mine road and access roads to prospects and drill sites
- Bridge
- Barbed wire fence
- Creek
- Limit of outcrop as mapped

**GEOCHEMICAL SOIL SAMPLE RESULTS**

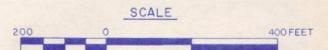
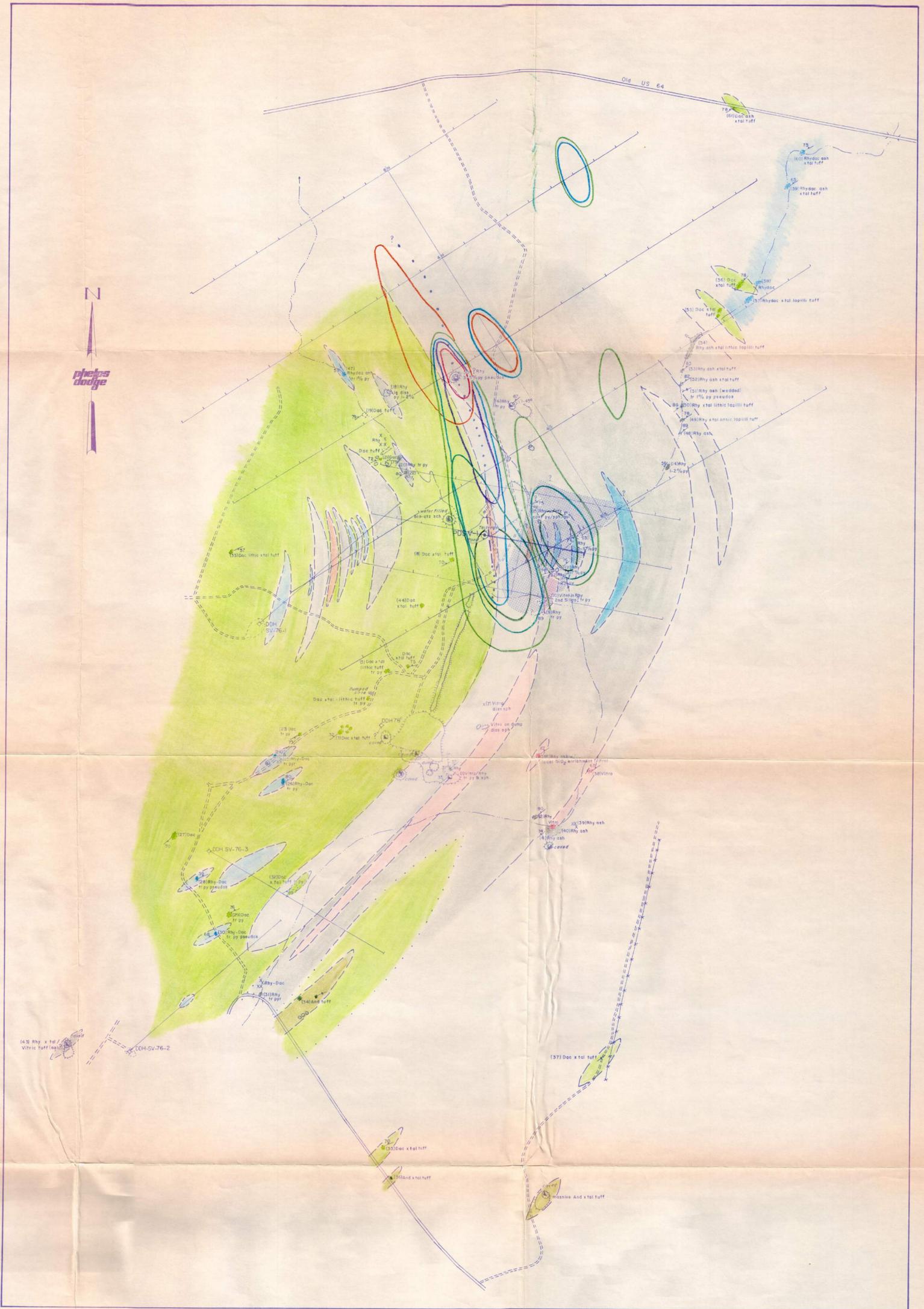
- Zinc ≥ 300 ppm
- Zinc ≥ 100 ppm
- Zinc ≥ 85 ppm
- Lead ≥ 500 ppm
- Lead ≥ 400 ppm
- Copper ≥ 80 ppm
- Copper ≥ 40 ppm

**GEOLOGY**

- Biotite-quartz-feldspar schist (meta sedimentary/meta volcanic)
- Rhyolite ash tuff (undifferentiated)
- Dark grey siliceous rhyolite
- Siliceous epiclastic siltstone/felsic ash
- Rhyolite vitrophyre
- Rhyodacite (undifferentiated)
- Dacitic volcanics (undifferentiated)
- Andesitic volcanics x-tal tuffs

**GEOPHYSICS**

- EM Conductor Axis
- Strong
- Moderate
- Weak
- Moderately anomalous IP response



LOCATION MAP

<b>phelps dodge</b> Exploration East, Inc.			
GEOLOGIC LOCATION MAP of the <b>SILVER VALLEY MINE AREA</b> Davidson County, North Carolina			
SCALE	H: 1" = 200'	CONTOUR INTERVAL:	REVISIONS
	V:	DATE: AUG., 1981	BY: D.F.L.
SHEET	OF	DRAWING NO:	FILE: