CHARLES R. RANNEY
MINING ENGINEER

PHONE 625-3088
BOX 99, SANTO TOMAS RTE
SAHUARITA, ARIZONA

No Number listed -

PHONE 703
AVE JUAREZ 231
CANANEA, SONORA, MEXICO

PRELIMINARY REPORT

CHICO MINES PROPERTY
Kingman, Arizona

by

Charles R. Ranney

C. K. MARTIN & ASSOCIATES
Mining Administration and Development
4178 North 21st Avenue
Phoenix, Arizona 85015
(602) 246-9573

July 1973

CHICO MINES PROPERTY
Kingman, Arizona

INDEX

MAP INDEX

P. O. Box 99
Wikieup, Arizona 85360

July 18, 1973

Mr. Charles E. Goetz
Mining-Exploration
P. O. Box 2228
Phoenix, Arizona 85002

Dear Mr. Goetz:

Please find my accompanying report on your Chico Mines Property.

I spent more time than anticipated because the property has more economic potential than I expected.

Please note my specific Conclusions and Recommendations.

Respectfully submitted,

Charles R. Ranney
Mining Engineer

CRR:lc

CHICO MINES PROPERTY
Kingman, Arizona

CONCLUSIONS

1. Because of recent increases in the price of metals, particularly silver and gold, the possibilities of developing a producing mine, or mines, at the Chico Mines property are excellent.

   Immediate exploration and development are recommended for the 4 major vein deposit systems.

2. The Chico Mines Claims along the northern boundary, possible favorable areas for a large porphyry copper type deposit, might better be farmed out to a large, well-financed organization.

CHICO MINES PROPERTY
Kingman, Arizona

INTRODUCTION

A. Location

The Chico Mines Property is situated in Mohave County, in the Hualapai Mining District of the Cerbat Mountain Range, in northwestern Arizona. The nearest railroad station is at Kingman on the Santa Fe railroad. It is reached from the property by about 5 miles of improved dirt road and 14 miles of pavement, U. S. Highway 93.

To the north, the Chico Property adjoins the claims of the open pit Ithaca Peak copper-molybdenum operation of Pennzoil-Duval Corporation, currently mining 18-20,000 tons of ore per day.

This preliminary report was prepared for the owner of the Chico Mines Property, Mr. Charles E. Goetz of Phoenix, Arizona.

B. Purpose of Investigation

Preliminary investigation of the Chico claims was undertaken to evaluate the economic possibilities of the property, both from the standpoint of a possible large disseminated copper-molybdenum producer, and as a medium sized base metal and gold silver producer.

Approximately 10 days were spent on the property. Considerable difficulties were encountered in correlating the claim posts in the field to the 'surveyed' claim maps. These maps are not correct for the patented claims as shown. Furthermore, most of the unpatented claims are not marked in the field. This omission should be corrected and a correct survey established.

I wish to thank Mr. Francis J. Denten for his very able assistance in the sampling and appraisal of the property.

Mr. Jack Owens and Mr. Denys Poyner also made valuable contributions.

CHICO MINES PROPERTY
Kingman, Arizona

SUMMARY

1. The Chico Mines Property comprises 48 claims, 2 patented, located in Sections 31, 32, T. 23 N., R. 17 W., and Sections 5, 6, T. 22 N., R. 17 W., Gila and Salt River Meridian.

2. The claims, for the most part, are situated around the old Stockton Hill mining camp, and they border the Mineral Park Region. The Chico north claims' boundaries adjoin the Ithaca Peak Claims of the Pennzoil-Duval Corporation; to the south, the Chico Claims adjoin the Golconda Mines group, the second largest base metal producer in the Hualapai mining district.

3. Rocks exposed at the surface include granites, gneisses, schists, and amphibolites of pre-Cambrian age, intruded by the Ithaca Peak granite or quartz monzonite porphyry, the center of which lies north of the Chico claims. This intrusive, with related dykes and sills, is thought to be the source of most of the mineralization in the district. It has tentatively been assigned to the Mesozoic Era.

4. The ore mineralization on the Chico claims can be separated into two types. The first is represented by the vein deposits, occurring along fissures in all of the rock types. Most of the veins strike from N. 30 W. to N. 60 W., dipping steeply to the northeast. The northwest veins vary in width, averaging 3-4 feet, but they increase to up to 30 feet wide at vein junctures. Along the 'Broncho' dyke area, extending from the Golconda Mines workings past the most northerly Chico Claims' boundaries, ore mineralization strikes N. 10° E., and it dips approximately 60 degrees to the northwest. Junctures where the northwesterly trending vein systems intersect the Broncho dyke appear to be very favorable loci for ore.

5. Potentially favorable areas for a large commercial copper porphyry, quartz-sulphide stockwork, deposit lie along the northern boundary of the claims where monzonite porphyry outcrops occur as possible small cupolas. Drainage to the south of these outcrops shows abundant copper sulphate precipitation. The possibility of locating turquoise in connection with copper mineralization, as at Turquoise Mountain nearby, should not be overlooked. A limited geochemical sampling program should be considered as a guide to possible drilling.

Summary (Cont'd.)

6. At least four major vein systems are exposed on the Chico Claims. They trend northwest from Stockton Hill to intersections with the manganese stained 'black dyke' (Broncho Dyke) which extends N. 10° E. from the Golconda Mines workings.

   Looking from northeast to southeast they are: (see map)

   1. The Alpha Vein.
   2. The Black Knight-Cashier Vein.
   3. The Little Boy-Mint Vein, with the '98' Vein possibly joining the Mint vein from the northeast.
   4. The Blackfoot Vein which appears to be joined by the Gold Reserve Vein below Stockton Hill.

   In addition, the Ithaca Peak porphyry tongue extending as a dyke southeastward to the Oro Plata Mine (Golconda Extension) continues along the Pasadena No. 1., the Mammoth No. 7., and the Mammoth No. 5. claims. (see map)

   The True Blue Vein (patented claim) extends northwesterly between the Broncho Dyke fissure system and the monzonite porphyry tongue fissure system. Intersections along both of these dyke fissure systems with the north west trending vein systems have been shown to be extremely favorable ore loci by present sampling and previous workings.

7. Results of recent spot check sampling are tabulated and shown on Map No. .

8. Because of recent increases in metal prices, and most particularly silver and gold, the probabilities of developing a producing mine, or mines, at the Chico property are greatly increased. Development work at the property during the past few years does not appear to have been conducted in a miner-like fashion.

   No mining operation in the United States today can be made to pay without mechanization. Mechanization is the answer to high labor costs. The development of trackless mining equipment for small and intermediate, as well as large scale, underground mining can be successfully applied at the Chico Mines property.

CHICO MINES PROPERTY
Kingman, Arizona

RECOMMENDATIONS

1. The Chico property can be considered as two separate and distinct units. Each unit should be handled in a different manner.

   A. Unit A comprises areas along the northern boundary, the possible favorable areas where a large commercial porphyry copper type deposit might be found and developed. Preliminary geochem work could aid in delineating favorable areas for drilling. These areas might better be farmed out to a large well-financed organization for exploration and development.

   B. Unit B encompasses the vein deposits, comprising four major vein systems. Because of increases in metal prices, particularly silver and gold, the time is propitious for immediate exploration and development.

2. The proposed work on the vein system deposits should be undertaken in two phases, phase No. 2. being contingent upon the results of phase No. 1.

Phase No. 1.

This phase consists primarily of checking vein junctures, pumping and cleaning out old workings, bulk sampling, and development for the proving up of sufficient tonnages to justify and serve as a guide for a milling installation.

The use of an adequate bulldozer, preferably a D 8 H Caterpillar, or its equivalent, is a necessity.

The access tunnel on the Little Boy claim should be cleaned out and thoroughly checked. There is a very good possibility of mining high grade silver ore from this area. (see map)

The incline shaft near the northeast corner of the True Blue Claim, intersecting the "Broncho Dyke at shallow depth, should be pumped out and thoroughly sampled. Spot sample checks of dumps and dyke outcroppings showed around an ounce per ton of gold and 15 oz. /ton of silver. This incline was driven by Mr. Jack Owens who reports that very good gold values were discovered along the dyke.

Recommendations (Cont'd.)

Other northwest vein junctures with the Broncho Dyke and the monzonite porphyry tongue to the west should be opened up with a bulldozer.

Phase No. 2.

Pursuant to the exploration and ore development accomplished in Phase No. 1., a new development incline should be driven to allow access to the most favorable areas of the major vein systems at depth.

This work must be undertaken with trackless mining equipment in order for a profitable mining operation to be carried on in the present high labor market.

2. Phase No. 2.

Selection and installation of milling equipment, pursuant to development and testing of stockpiled ore, might better be carried out in two phases also. A 100 ton initial milling unit should be adequate to handle the initial phase. Any addition should be dependent upon subsequent development.

CHICO MINES PROPERTY
Kingman, Arizona

History and Production

From 1863-1900, oxidized portions of the fissure veins were prospected and mined. Very high grade concentrations of silver ore were reportedly discovered. No exact production figures are on record.

The value of metals produced during the years 1904-48, U. S. Bureau of Mines Report, was about $22,500,000. Values were principally in lead and zinc with subsidiary silver and gold. In 1943, the Tennessee Mine was reported as producing about 150 tons crude ore per day, averaging 7 per cent zinc, 3.5 per cent lead and 17 to 25 ounces of silver per ton.

Pennzoil-Duval Corporation is reportedly producing 18-20,000 tons of ore per day averaging around 0.50 percent copper and 0.045% molydenum, averaging around 12 dollars per ton.

The yearly Pennzoil-Duval production now amounts to more than the entire production of the Hualapai mining district previous to their operation.

Accessibility

The Cerbat Mountains rise sharply from the detritus filled valleys bordering them on the East and the West. Total relief is about 3500 feet.

The Chico Claims are easily accessible by a number of recently bulldozed roads, cutting and exposing the major vein systems.

Climate and Vegetation

The climate is arid, with mild winters and relatively hot summers.

Vegetation is sparse chiefly of the desert types. Scrub pinon and juniper is found at the higher elevations.

Water

Ample water for mining is found in the old workings.

Sufficient water for a moderate-sized milling operation can be developed in the fissure systems.

CHICO MINES PROPERTY
Kingman, Arizona

General Geology

The Chico Area is underlain by pre-Cambrian schist, amphibolite and altered granite, cut by later intrusions of Mesozoic granite and monzonite phorphyries, known locally as the Ithaca Peak Granite. This intrusive, with related dykes and sills, is believed to have been the source of most of the mineralization of the Hualapai Mining District.

Outlying bodies of the Ithaca Peak granite are particularly abundant on the Chico Mines Area, extending from Mineral Park south into the former Stockton Hill and Cerbat Mining Camps.

Many veins occur in nearly vertical fault fissures that strike northwestward and outcrop for considerable distances. The fault fissures are largely occupied by breccia with abundant shearing and some gouge. Ore lenses, though not continuous, are numerous and tend to be of greater vertical than horizontal extent. The best ore shoots are discovered close to intersections and vein junctures. Most of the ore lenses now exposed contain quartz, sphalerite, galena and pyrite with a fair amount of gold and silver. High grade gold and silver is found not only at the higher elevations of the major vein systems but also along their intersections with the 'Broncho Dyke'.

Ore Reserves

There are no blocked out ore reserves on the property. However, there is ore exposed in the Mint tunnel and in many places on the surface, cuts, trenches, old dumps, Etc.

As previously mentioned, abundant copper Sulphate precipitation may be noted in drainage areas to the south of the northern Chico Claims which border the Pennzoil-Duval properties.

Charles R. Ranney
Mining Engineer

DEPARTMENT OF MINERAL RESOURCES
STATE OF ARIZONA
FIELD ENGINEERS REPORT

MC-42
SPECIAL

Mine Cashier Date July 29, 1940

District Wallapai, Mohave County, Ariz. Engineer Elgin B. Holt
P.O. Box 288
Kingman, Ariz.

Subject:

SYNOPSIS REPORT

OWNERS: Bert Abelman, J. A. Bell and A. A. Rose.
Bert Abelman, Agent, Chloride, Arizona.

LOCATION: Property is located on the west side of the Cerbat range at an approximate elevation of 4,500 feet.

METALS: Gold, Silver, Lead, Zinc and Copper; Silver and Gold predominating.

GEOLOGY: The rocks of this area are essentially of the pre-Cambrian complex, consisting of granite, gneiss and dark schists. These older rocks are intruded by younger masses of granite-porphyry.

AREA: The Cashier group consists of 5 mining claims, covering three or four prominent veins, including the Alpha vein, which traverses the Cashier claim for 1,500 feet; this claim being the northwest extension of the Alpha mine.

DEVELOPMENT WORK consists of a crosscut tunnel 1,000 feet in length, the object of which was to cut the Cashier, Alpha, Summit, and many other veins. The tunnel was driven many years ago; but was never completed. About 75 feet from face of tunnel a vein was intersected, which may or may not be the Cashier vein. This vein is 5 feet wide and an 18-inch pay streak from which less than a carload of ore was shipped, assaying $23 per ton in gold and silver.

By driving the Cashier tunnel an additional 250 feet it should intersect the Alpha vein 800 feet below the surface and at a point 50 feet northwest of the northwest end of the Alpha claim. Also, should this tunnel be continued about 2,200 feet beyond the Alpha vein, the Summit vein should be cut at a depth of approximately 2,000 feet from the surface, Also there are a number of undeveloped ore-bearing veins between the Alpha and Summit veins. Hence if this tunnel could be driven an additional distance of 2,500 or 3,000 feet a vast amount of commercial ore should be exposed in the various veins it would open up.

Work on surface outcrop of the Cashier vein consists of open cuts, showing vein to be 3 feet wide, from which 3 lots of ore were shipped, assaying as follows: One car of 30 tons, $48 per ton; 1/2 car of 20 tons, $64 per ton; 1/2 car of 20 tons, $51 per ton; two other cars were shipped; but the assay results of these are not available. This data was furnished by Mr. Abelman.

WATER now flowing from the Cashier tunnel fills a 1.5-inch pipe. It is believed that after the Alpha and other veins are cut by this tunnel a great deal more water will be encountered sufficient to supply a large milling plant which could be located directly below the portal of said tunnel.

NOTE: As the Alpha vein traverses Cashier ground for 1,500 feet, as above set forth, a brief description of the Alpha property is submitted, as follows:

The ALPHA MINE is located on the west side of the Cerbat range, at an elevation of 5,300 feet, more or less, at a point about 2,200 feet south-southwest of the Summit property. It was worked up to 1939 by the Alpha-Keystone Mines, Inc., and ore produced, averaging around $12 per ton in gold and silver alone, was hauled to the Keystone mill for treatment.

The Alpha property is opened by tunnels on vein, striking south 30 deg. east. The croppings are a prominent reef of black iron and manganese stained quartz. The vein ranges from 4 to 20 feet wide and ore contains silver sulphide, assaying up to 1,000 ounces silver to the ton. Iron pyrite, galena, zinc blende and chalcopyrite are also present in the ore. Hence all values can readily be recovered by selective flotation.

The mine has been an excellent producer of shipping and milling ores through the years and a great deal of money has been made out of it by various owners.

According to F. C. Schrader (1909): "A consignment of 400 tons of ore, shipped from Alpha mine, is reported to have netted $125 per ton.

In Conclusion, the Cashier property is recommended to anyone looking for an attractive development setup on which to spend some money, with the end in view of opening up a large amount of mill tonnage out of which considerable money should be made. However, any company taking over the Cashier group should also secure, if possible, both the Alpha and Summit properties.

(SIGNED) Elgin B. Holt.

Geo-Processing, Inc.
Gibson Mine Division
P.O. DRAWER X • MIAMI, ARIZONA 85539 • August 26, 1977

CHICO MINE GROUP

INTRODUCTION

A Very Low Frequency electromagnetic survey was conducted on the CHICO mine group, in sections 31 and 32, T28N, R17W, and sections 5 and 6, T27N, R17W, G&SRBM, in the Cerbat Mountains north of Kingman, Arizona, on August 5 and 6, 1977, and this survey indicated that the most interesting anomalous zones existed in the northerly portion of the CHICO mine area. It was therefore, recommended that additional VLF survey lines be run in the northern area, to further explore this interesting area and to define drill targets, if they exist.

It was requested by, Messrs. Alex Prohoroff and Scott Hazen, agents for Mr. Charles E. Goetz, that two data line miles of additional VLF survey lines be run and this was accomplished on August 20, 1977. This survey consisted of extending Lines 1 B and 1; initiating new lines, Lines 1 C, 1 E, 1 D and 7 A, along with (5) interconnecting lines.

It was requested that three (3) drill sites be determined, if possible. Three drill sites have been suggested that could test the interesting anomalous zones.

DISCUSSION OF RESULTS

As was done in the previous report, to organize the interpretive results, each survey line will be discussed starting with Line 1. Line 1, was extended to the west an additional 1500 feet to 25W, and also to the east to 9E, and this line indicates an anomalous zone from about 5W to 5E, and this could be tested by a drill hole collared at 0+00, and inclined approximately 55°, from the horizontal, to the east for a depth of about 500 feet. Line 1, also indicates a northeasterly anomalous zone from 22W and to the west, and also on the interconnecting line between Lines 1 and 1 C, along stations 25W. Line 1 B, was extended to the east to 10E, to develop the anomalous zone found during the previous survey, and now suggests another drill site collared at about 5W, and inclined

to the east at approximately 55°, to a depth of about 500 feet. Lines 1 C and 1 E, Line 1 E was offset 100 feet north because of the inaccessible nature of the steep ridge to the east, these two lines are considered as one, indicate interesting anomalous zones, and could be tested by collaring a drill hole at station 0+00 on Line 1 C, and inclining the hole approximately 55° to the west to a depth of about 500 feet. Line 1 D, indicates possible a fairly narrow near surface structure, this structure could possible be tested by the Line 1 C drill hole. Line 7 A, called 7 A because of the inadvertent use of 7 used in the previous survey, indicates that the northeasterly anomalous zone has a possible break, however, the northwesterly zone is in evidence.

CONCLUSIONS AND RECOMMENDATIONS

This survey substantiates the conclusions of the previous survey, that the northern area of the CHICO mine area is the most interesting. Three drill holes have been suggested to test the anomalous zones. These drill holes should all be angle holes, with an inclination of approximately 55° from the horizontal. The three suggested drill sites are as follow:

Drill site on Line 1 B, collared at station 5W, inclined 55° to the east for a depth of approximately 500 feet,

Drill site on Line 1, collared at station 0+00, inclined approximately 55° to the east for a depth of approximately 500 feet,

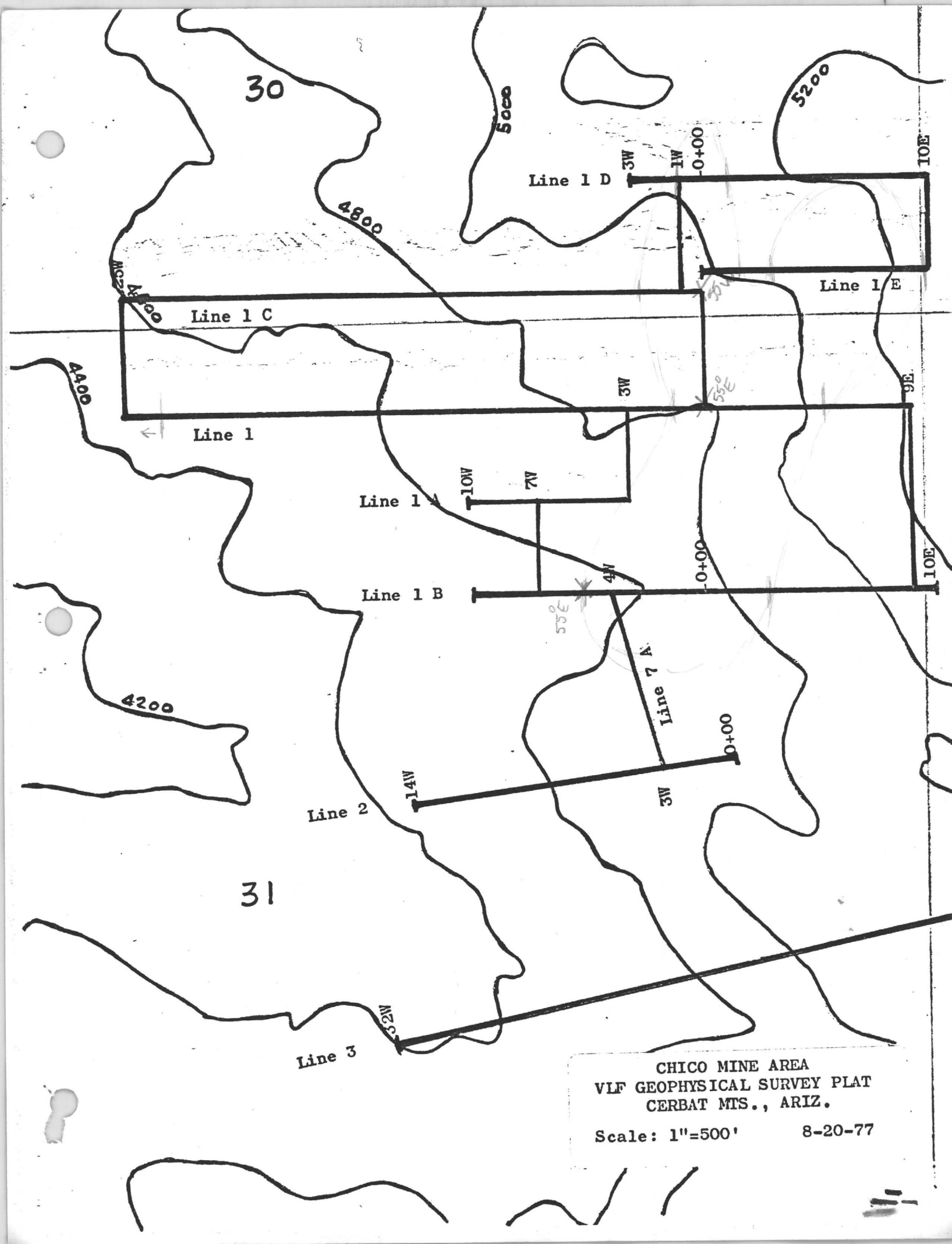
Drill site on Line 1 C, collared at station 0+00, inclined approximately 55° to the west for a depth of 500 feet.

It should be stated that the depth of drilling is arbitrary, and could be of less depth, if warranted by the material intersected in the drill holes, However, these depths seem realistic to test the anomalous zones.

This report was prepared by:

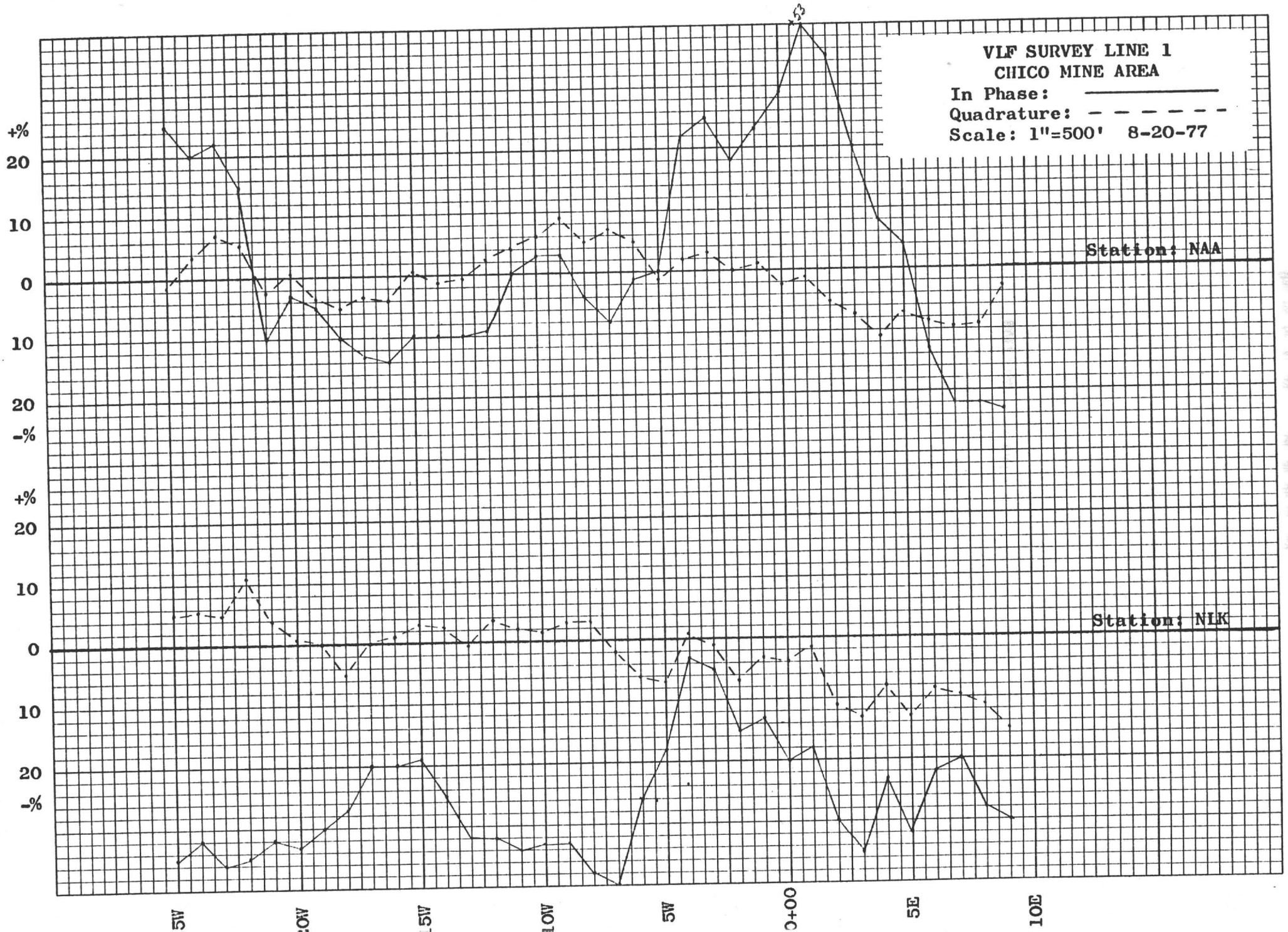
Nicholas H. Carouso

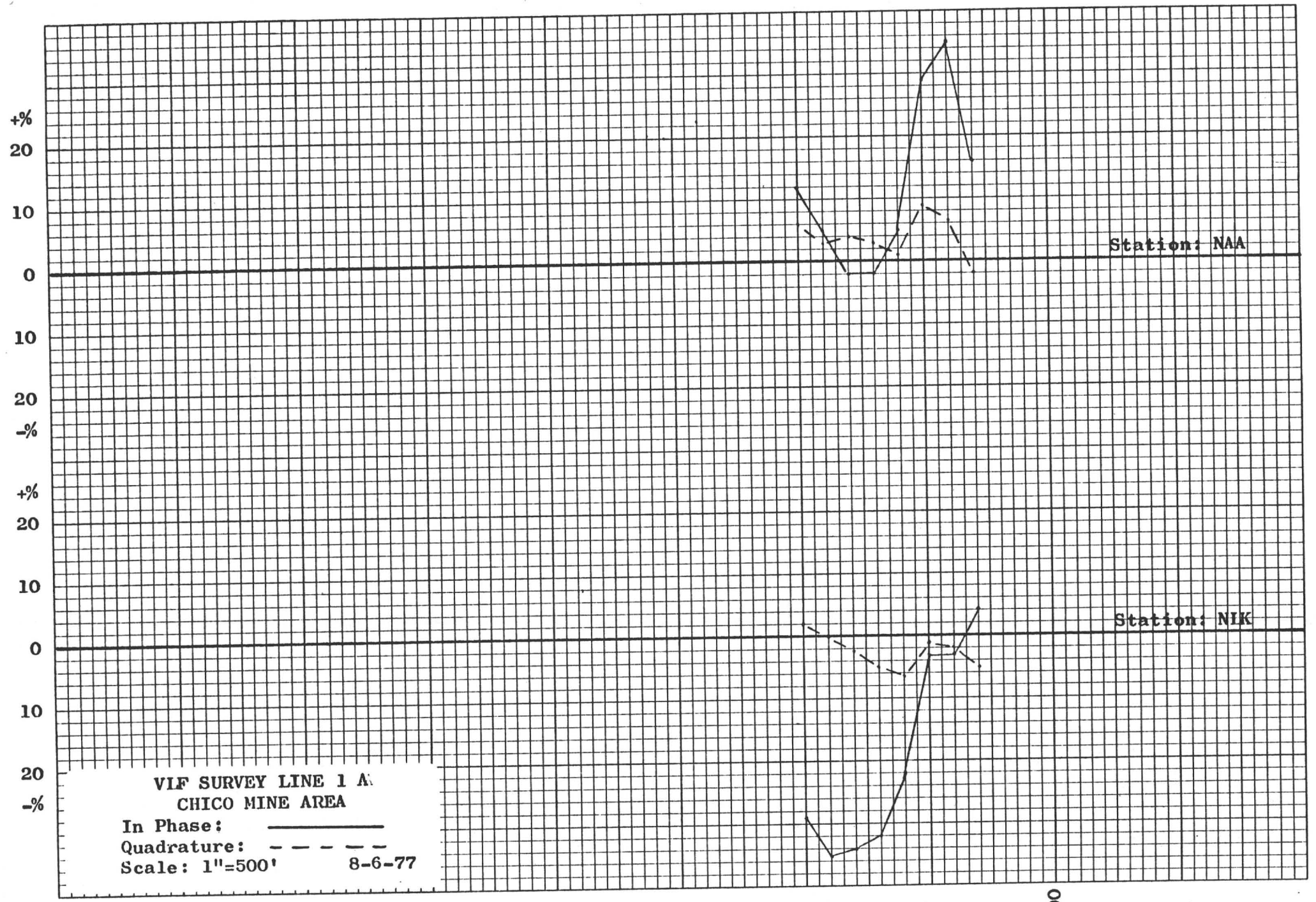
Nicholas H. Carouso
President
GEO-PROCESSING, INC.

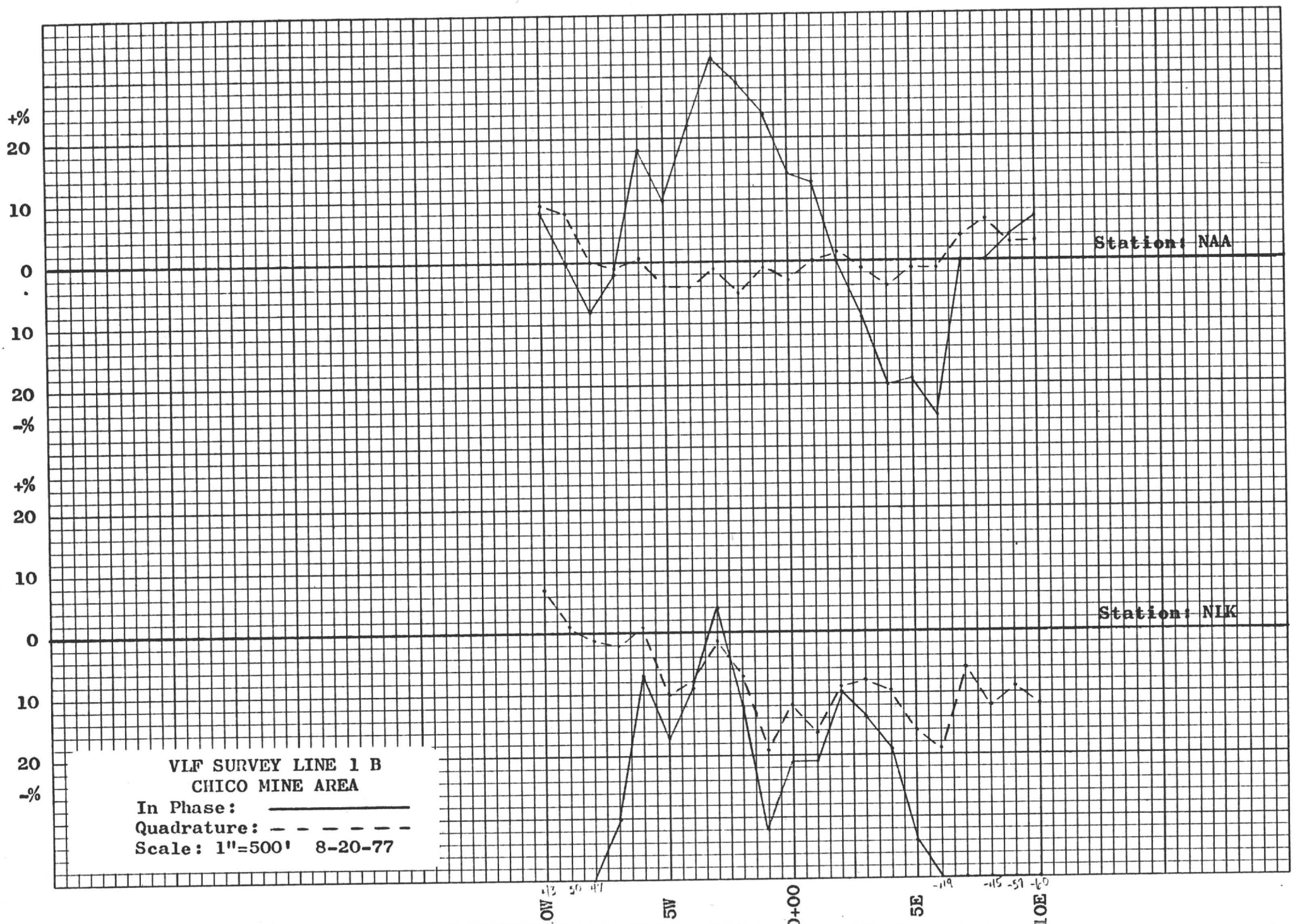


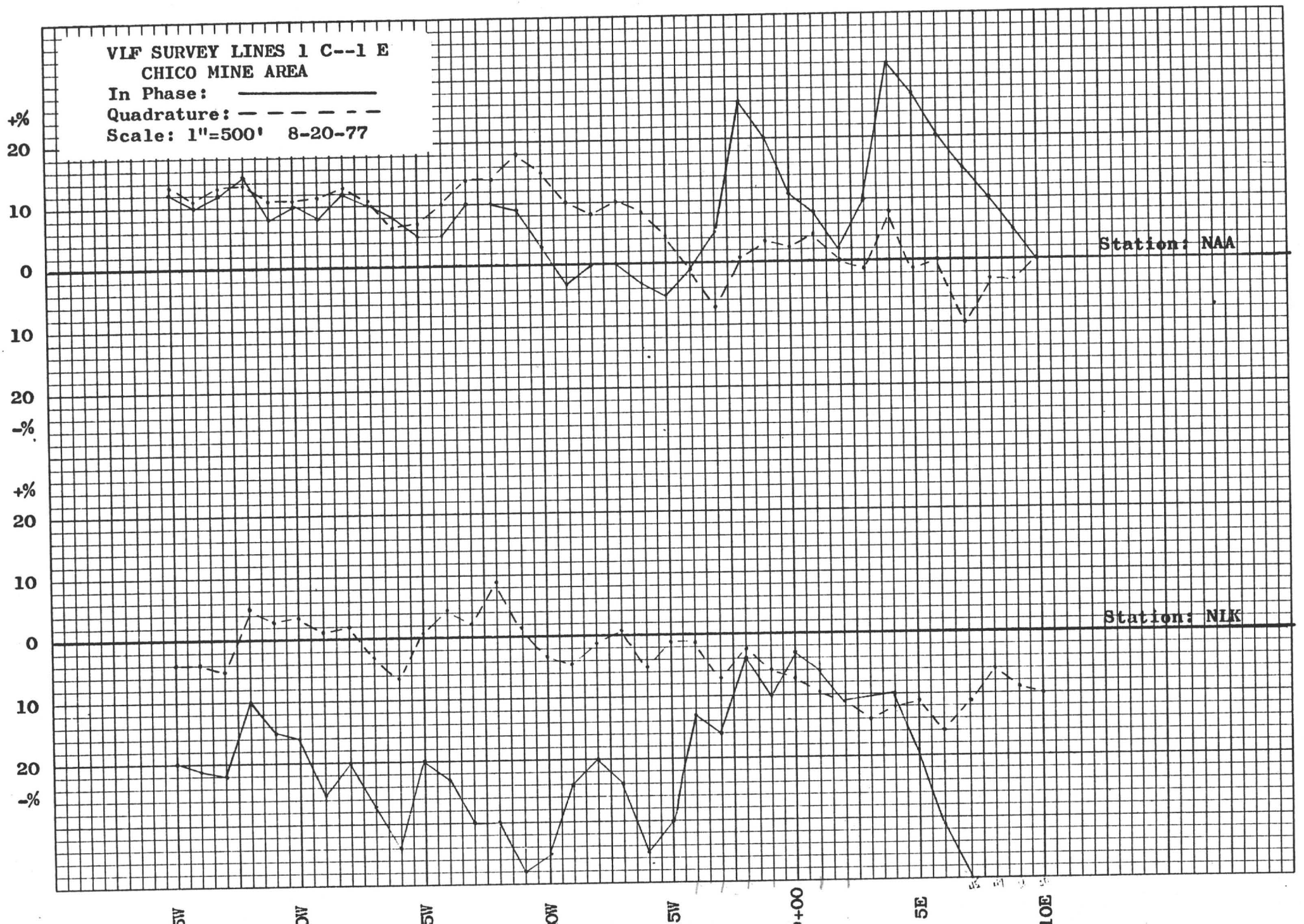
CHICO MINE AREA
VLF GEOPHYSICAL SURVEY PLAT
CERBAT MTS., ARIZ.

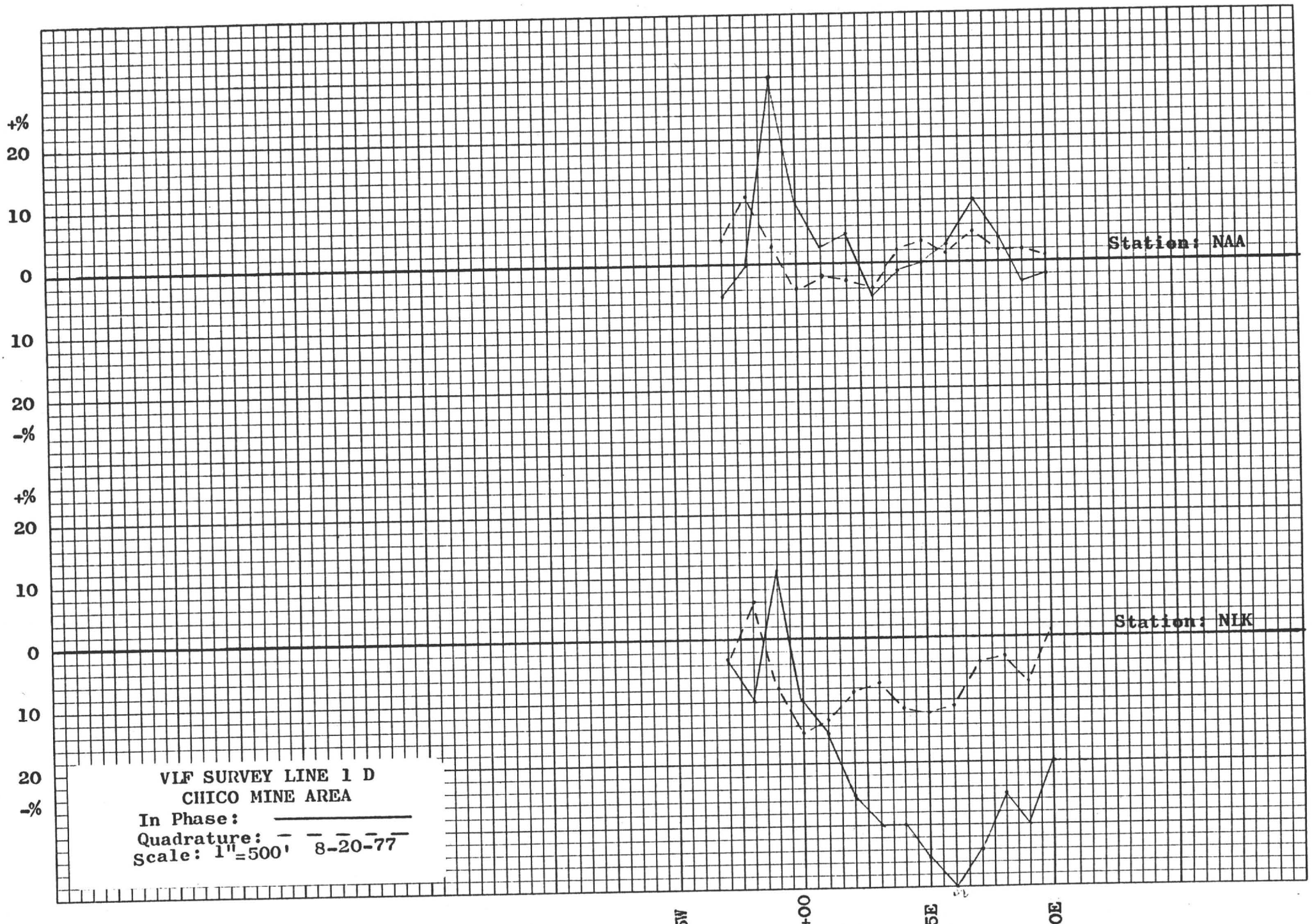
Scale: 1"=500' 8-20-77

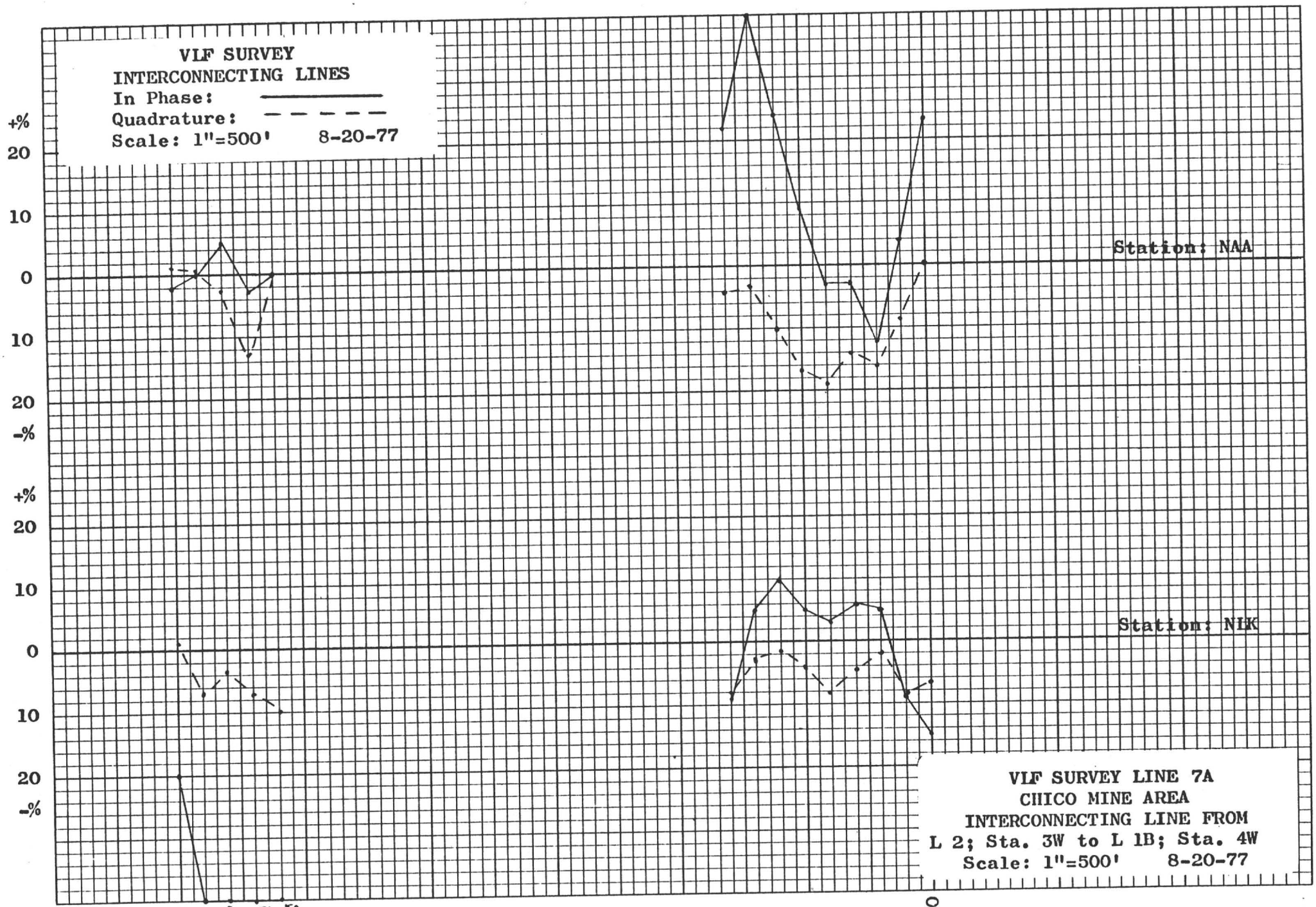




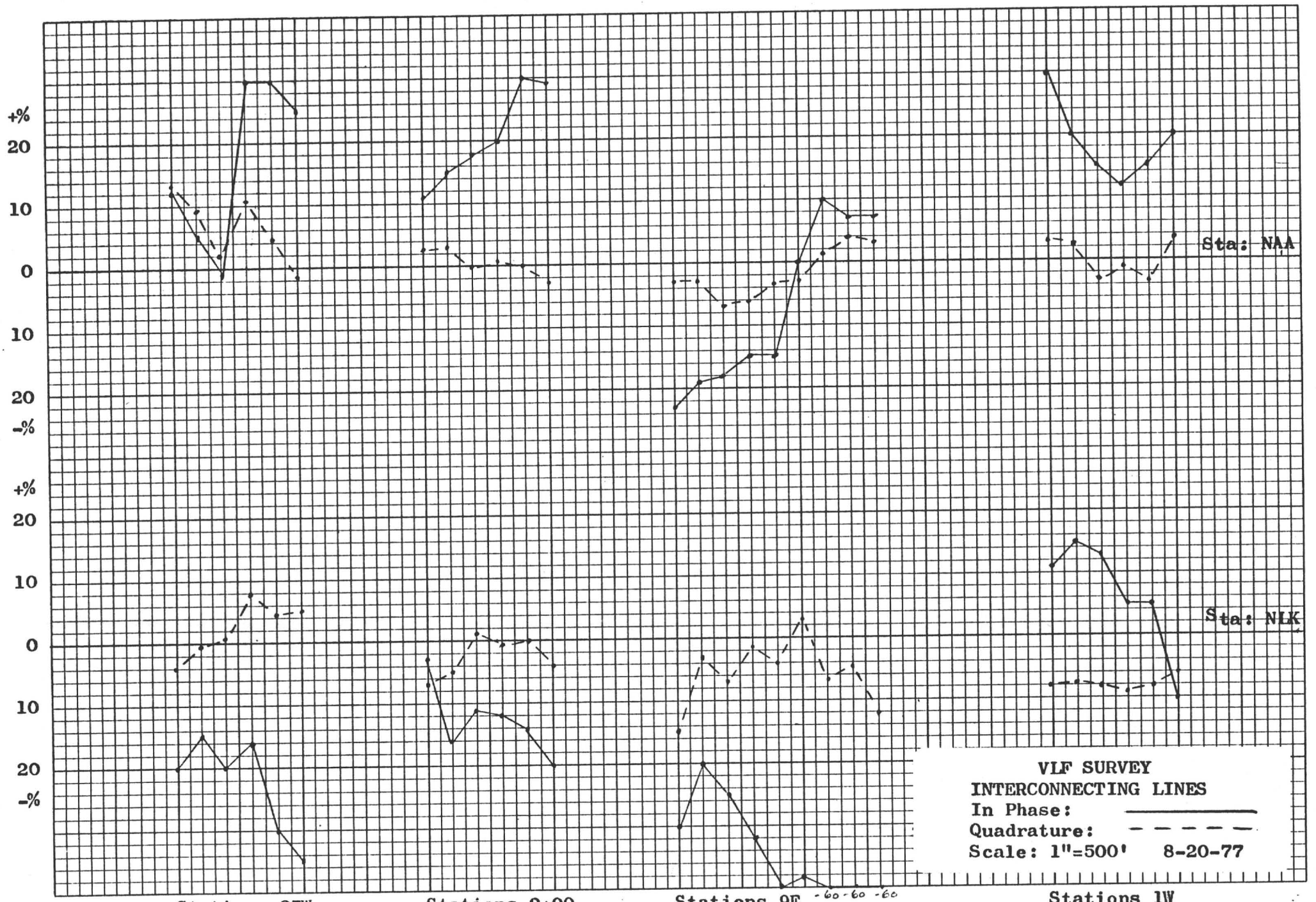


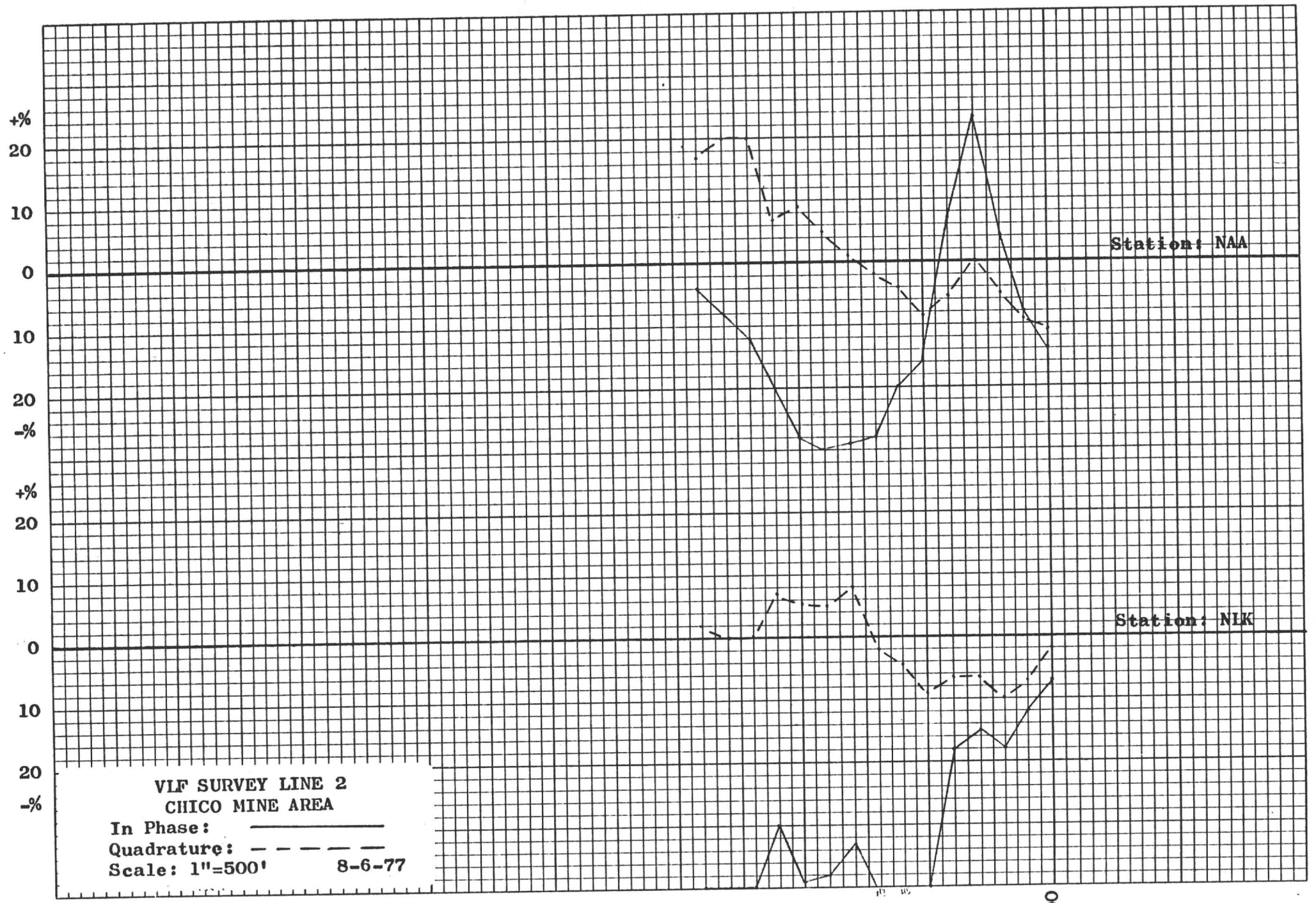


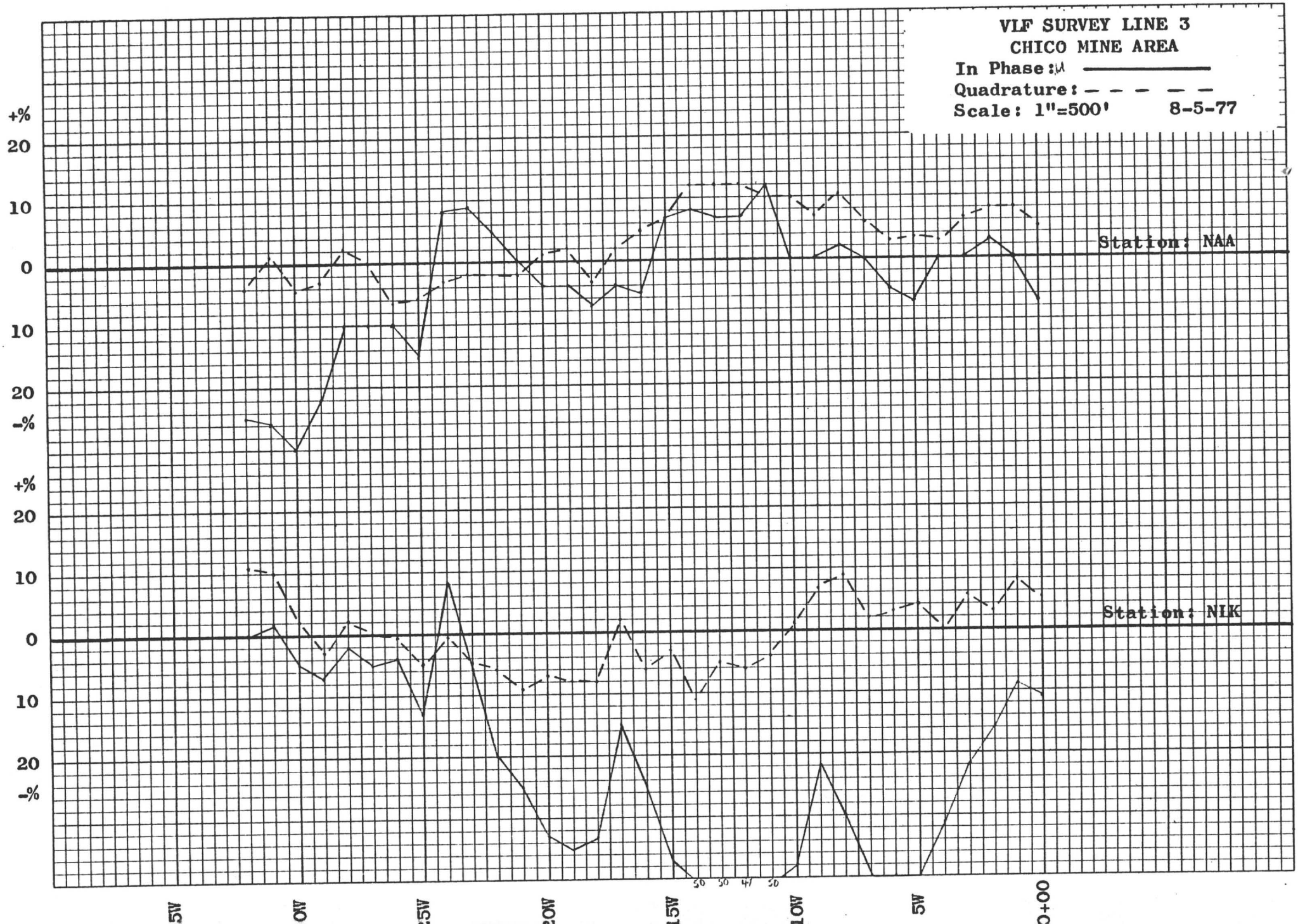




VLF SURVEY LINE 7A
CHICO MINE AREA
INTERCONNECTING LINE FROM
L 2; Sta. 3W to L 1B; Sta. 4W
Scale: 1"=500' 8-20-77







WILLARD D. PYE
Consulting Geologist
3418 NORTH FORGEUS AVENUE
TUCSON, ARIZONA 85716

TELEPHONE 327-2956

#2

August 11, 1976

CHICO MINE AND RMC PROPERTIES

WALLAPAI MINING DISTRICT

MOHAVE COUNTY, ARIZONA

REGISTERED GEOLOGIST
CERTIFICATE NO.
4033
WILLARD D.
PYE
Date Signed 8/11/76
Arizona U. S. A.

Willard Pye

WILLARD D. PYE
Consulting Geologist
3418 North Forgeus Avenue
Tucson, Arizona 85716

Telephone 327-2956

August 11, 1976

CHICO MINE AND RMC PROPERTIES

WALLAPAI MINING DISTRICT

MOHAVE COUNTY, ARIZONA

INTRODUCTION

Location

The RMC holdings are located primarily in Sec. 31, T. 23 N., R. 18 W., but extend short distances into the adjacent sections to the east and south. The general area of the occurrence of the claims is in the Wallapai Mining District, also known in whole or in part as the Chloride, Mineral Park and Cerbat Mining Districts.

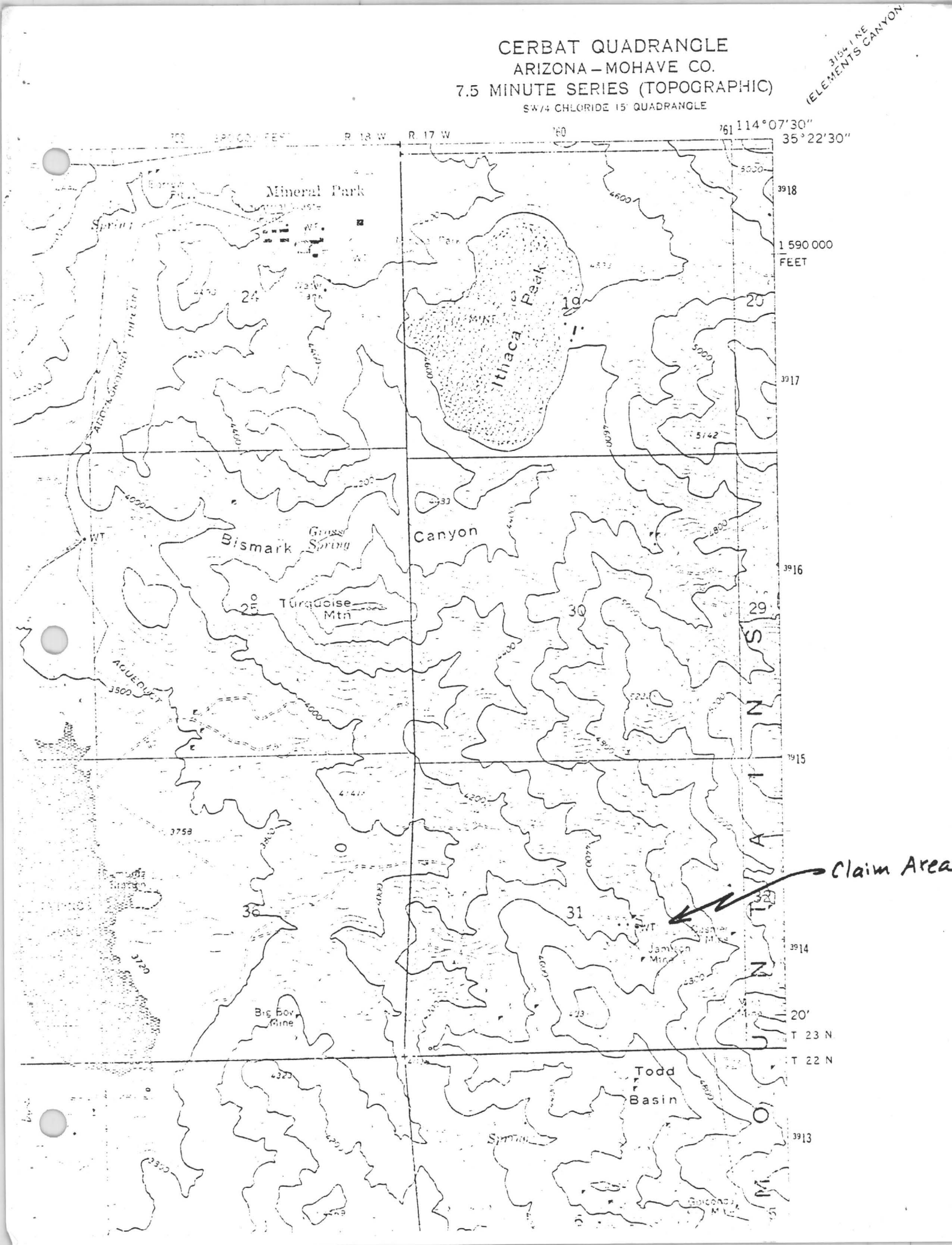
The property is located about 7 miles southeast of Chloride or 10 miles northwest of Kingman, Mohave County, Arizona.

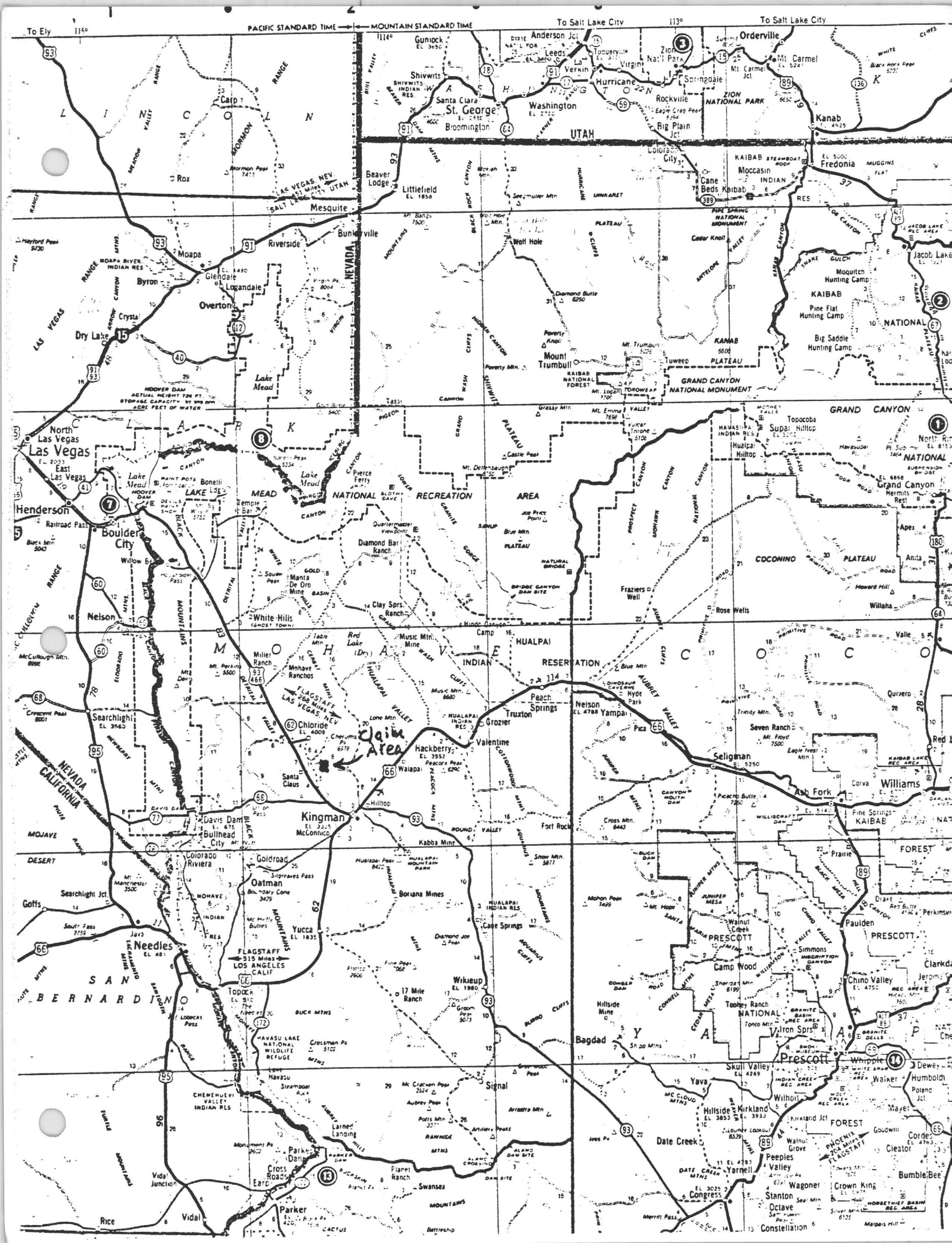
Property

The property held by RMC is reported to consist of 49 non-patented lode mining claims and two patented claims. Examination of ownership and title is beyond the scope of this report, but attached to this report is an Affidavit of Labor performed upon them for the Assessment Year 1974-75.

Topography and Relief

The claims lie in Lane Springs Basin and the upper portion of Todd Basin in the central portion of the Cerbat Mountains. They extend from near the western summit of the range to its lower portion. The topography is rugged and mountainous with a relief of over 1000 feet. An average elevation is about 4500 feet. The Cerbat 7½ minute Quadrangle Map of the U. S.


CERBAT QUADRANGLE
ARIZONA – MOHAVE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
SW/4 CHLORIDE 15' QUADRANGLE
3154 I NE
(ELEMENTS CANYON)
114°07'30"
35°22'30"
R. 18 W.
R. 17 W.
Mineral Park
Ithaca Peak
Bismark
Gross Spring
Canyon
Turquoise Mtn
Aqueduct
Big Boy Mine
Jamison Mine
Todd Basin
Claim Area
1 590 000 FEET
T 23 N
T 22 N
SANTA MARIA MTS.



To Ely
PACIFIC STANDARD TIME
MOUNTAIN STANDARD TIME
To Salt Lake City
To Salt Lake City
Gunlock
Anderson Jct
Leeds
Toquerville
Zion Nat'l Park
Orderville
Mt Carmel
Mt Carmel Jct
Shivwits
Virgin
Verkin
Hurricane
Springdale
Rockville
Santa Clara
St. George
Bloomington
Washington
Big Plain Jct
ZION NATIONAL PARK
Kanab
UTAH
Colorado City
Fredonia
Moccasin
Cane Beds
Kaibab
Beaver Lodge
Littlefield
Mesquite
LAS VEGAS, NEV. SALT LAKE CITY, UTAH
Carp
Rox
Mormon Peak
LINCOLN
Moapa
Riverside
Bunkerville
Glendale
Logandale
Overton
Byron
Crystal
Dry Lake
NEVADA
Wolf Hole
Diamond Butte
Mount Trumbull
Tuweep
KAIBAB PLATEAU
GRAND CANYON NATIONAL MONUMENT
Jacob Lake
Moquitch Hunting Camp
KAIBAB
Pine Flat Hunting Camp
Big Saddle Hunting Camp
NATIONAL
HOOVER DAM ACTUAL HEIGHT 726 FT. STORAGE CAPACITY 32,359,000 ACRE FEET OF WATER
Lake Mead
North Las Vegas
Las Vegas
East Las Vegas
Henderson
Boulder City
Railroad Pass
Hoover Dam
LAKE MEAD NATIONAL RECREATION AREA
Pierce Ferry
Temple Bar
Quartermaster Viewpoint
Diamond Bar Ranch
Manta De Oro Mine
White Hills
Clay Sprs. Ranch
Nelson
GRAND CANYON
Supai
Hualpai Hilltop
Grand Canyon
COCONINO PLATEAU
Fraziers Well
Rose Wells
Willaha
Hindu Canyon Camp
HUALPAI INDIAN RESERVATION
MOHAVE
Miller Ranch
Mohave Ranchos
Music Mtn. Mine
Chloride
FLAGSTAFF 268 Miles LAS VEGAS, NEV.
Claim Area
Hackberry
Valentine
Crozier
Truxton
Peach Springs
Nelson
Yampai
Pica
Seligman
Ash Fork
Williams
Searchlight
Santa Claus
Walapai
Hilltop
Kingman
McConnico
Davis Dam
Bullhead City
Kabba Mine
Fort Rock
Colorado Riviera
Goldroad
Oatman
Searchlight Jct.
Goffs
Bonanza Mines
Yucca
Cane Springs
Needles
FLAGSTAFF 315 Miles LOS ANGELES CALIF
Topock
SAN BERNARDINO
17 Mile Ranch
Wikieup
Bagdad
Hillside Mine
HAVASU LAKE NATIONAL WILDLIFE REFUGE
Lake Havasu
CHEMEHUEVI VALLEY INDIAN RES
Signal
Larned Landing
Parker Dam
Cross Roads
Earp
Parker
Planet Ranch
Swansea
Vidal Junction
Vidal
Rice
Prairie
Paulden
PRESCOTT
Walnut Creek
Camp Wood
Simmons
Chino Valley
Toohey Ranch
Iron Sprs
Prescott
Whipple
Skull Valley
Yava
Hillside
Kirkland
Kirkland Jct
Date Creek
Peeples Valley
Yarnell
Wagoner
Congress
Stanton
Octave
Constellation
Crown King
FOREST
PHOENIX 204 Miles FLAGSTAFF
Humboldt
Mayer
Cordes
Cleator
Bumble Bee

Geological Survey depicts the topography of the area.

Accessibility

Approximately 12 miles northwest of Kingman a well graded road branches from Interstate I-10 and leads to the Duval Mining operations at Mineral Park. From this, a County road leads into the claim area and eventually over the Cerbat Mountain crest and ultimately back into Kingman. This road is steep and mountainous but readily passable except after flash floods when portions of it may be washed out. Local mine trails lead off from this road and may not be passable if recent work has not been done on them.

The main line of the Santa Fe Railroad passes through Kingman.

Power and Water

Although electric power at one time extended through the area and power poles are still present, wires have now been removed. The nearest power would be the Mineral Park areaabout 2 miles to the northwest.

Water is foundin some of the mine shafts and could be used for limited purposes. Run-off after rains would be rapid and only limited storage would be possible. Wells would also probably have only a limited capacity. If large quantities of water are necessary, as for a mill, it may be necessary to import the water from the Sacramento Valley at the base of the Cerbat Mountains or locate the mill in the valley.

Climate

The climate is typically semi-arid with warm to hot and dry summers and moderate to cool winters. Snow would not be a problem. Rainfall occurs in the winter and as thunderstorms in the summer. The latter may produce flash floods because of the rapid run-off and may cause temporary local problems with roads and structures in the bottoms of the valleys and washes. Otherwise climate should offer no problems as to mining.

Labor, Housing and Supplies

The property is located in a mining area and, therefore, numerous people are present who know mining from the days when the mines were active. However, operations on these claims will essentially be all underground and

underground miners are advancing in years. The current mining operations at Mineral Park are open pit rather than underground. However, adequate man-power is available in the general area.

Housing is absent on the property but is available at Kingman with some additional units at Chloride and elsewhere.

Local supplies are available at Kingman, but most mining supplies and equipment will have to come from Las Vegas, Phoenix or other distant centers.

Milling and Smelting

There is presently no mill in the area. One is available at Wikieup some 75 miles to the southeast. Reportedly Mohave County is considering building a mill in the general Kingman area, but as yet there are no definite plans. This is not a direct shipping ore, therefore, milling facilities will have to be provided.

There is no smelter in the area. Concentrates from the mill can be shipped to El Paso, to Pacific Coast or even foreign smelters.

Scope of Report

The present report is based upon two days in the field examining the property and on the writer's general and specific knowledge of the area from previous work in the region. The purpose of the visit to the property was to familiarize the writer with the specific claims and the work done by Mr. Kevin M. Kenney who has spent considerable time on them. Since Mr. Kenney has examined and taken samples from most of the accessible mines, the writer did no underground examination. Time was spent on the surface geology, exposed mineralization, and vein relationships. The writer determined the accuracy of Mr. Kenney's observations and fully approves of his work and findings and has included his summary report as a portion of this report. From notes and recorded observations Mr. Kenney can substantially expand his reported findings should that become necessary in the future.

Drilling was done on the property during the 1974-75 assessment year, but the results of that drilling have not been included as part of this evaluation because of lack of knowledge of the location of the holes and their correlation with the available records. Several of the holes were observed while in the field, but

TABLE 1.—*Production of gold, silver, copper, lead, and zinc in the Wallapai district, Mohave County, Ariz., 1904–48, in terms of recovered metals*

[Compiled by Metal Economics Branch, U. S. Bureau of Mines, Salt Lake City, Utah]

Year	Crude ore produced (dry tons)	Gold (oz.)	Silver (oz.)	Copper (lbs.)	Lead (lbs.)	Zinc (lbs.)	Value (dollars)
1904	1,531	1,592.42	64,335	1,459	6,036	----------	----------
1905	5,868	1,137.09	58,751	173	112,266	----------	[illegible]
1906	9,946	2,772.00	125,331	114,502	904,590	----------	----------
1907	13,013	5,358.62	58,895	12,917	1,229,654	30,666	229,[illegible]
1908	2,179	1,193.13	29,931	11,929	249,328	505,133	76,[illegible]
1909	11,675	2,350.77	69,966	1,774	113,112	5,264,121	374,[illegible]
1910	1,109	421.33	48,509	29,341	235,368	----------	47,[illegible]
1911	12,092	2,735.75	71,233	27,428	2,394,629	960,097	[illegible]
1912	4,472	1,401.87	43,761	7,828	1,350,920	799,219	174,[illegible]
1913	32,933	2,588.27	177,853	30,782	5,171,988	4,233,642	[illegible]
1914	22,492	1,265.41	85,951	18,247	3,768,192	4,932,108	472,[illegible]
1915	85,635	5,262.75	243,819	46,171	6,472,406	17,382,849	2,[illegible]
1916	104,658	6,16[illegible]	226,237	190,807	5,825,791	17,024,026	3,[illegible]
1917	104,362	7,012.38	234,187	84,394	6,087,742	17,127,596	2,[illegible]
1918	4,739	987.82	42,068	91,79[illegible]	[illegible]3,492	82,853	[illegible]
1919	3,372	872.91	41,531	90,900	504,065	----------	111,[illegible]
1920	2,369	682.81	37,500	11,10[illegible]	338,623	----------	84,[illegible]
1921	10,266	1,008.88	82,947	15,875	278,321	----------	118,3[illegible]
1922	3,455	553.94	42,099	22,058	84,142	----------	61,2[illegible]
1923	1,150	235.81	25,843	21,500	11,620	----------	30,[illegible]
1924	388	165.30	5,027	6,460	172,088	----------	21,[illegible]
1925	3,109	758.29	38,744	26,646	341,646	174,703	89,[illegible]
1926	10,056	2,034.39	75,470	80,728	637,805	1,609,206	281,[illegible]
1927	19,289	837.17	48,4[illegible]	37,226	695,080	1,184,454	[illegible]
1928	995	198.45	10,770	10,450	43,791	150,319	[illegible]
1929	1,849	298.54	10,224	19,393	64,296	133,414	27,[illegible]
1930	342	103.06	4,181	2,411	37,040	35,104	7,[illegible]
1931	103	15.88	253	581	----------	----------	[illegible]
1932	236	193.55	3,555	2,393	17,500	----------	5,[illegible]
1933	333	236.11	3,517	1,422	56,946	11,024	[illegible]
1934	1,057	223.69	4,718	2,737	11,514	10,698	11,[illegible]
1935	14,775	1,665.20	76,519	26,566	140,725	133,205	125,[illegible]
1936	39,185	5,782.00	193,763	167,850	1,681,478	1,647,960	[illegible]
1937	119,246	15,348.00	528,640	400,182	4,978,220	3,428,554	1,[illegible]
1938	109,810	15,027.[illegible]	509,518	311,163	4,607,249	3,319,812	1,2[illegible]
1939	[illegible]8,716	9,301.00	451,32[illegible]	140,077	1,40[illegible]	1,339,092	[illegible]
1940	76,317	8,135.00	284,700	224,221	4,067,480	8,589,000	1,[illegible]
1941	70,398	7,500.00	213,577	[illegible]	4,816,[illegible]	4,092,666	[illegible]
1942	70,533	5,406.00	157,112	[illegible]	3,312,000	4,487,700	[illegible]
1943	43,724	1,922.00	88,695	[illegible]	2,781,800	3,081,000	[illegible]
1944	33,579	805.00	57,856	1,0[illegible]	1,[illegible]	2,091,000	[illegible]
1945	24,462	1,063.00	49,708	[illegible]	1,[illegible]	1,367,000	[illegible]
1946	34,869	739.00	38,229	[illegible]	737,000	971,000	[illegible]
1947	46,224	474.00	45,253	456,100	1,365,500	1,713,200	[illegible]
1948	51,734	691.00	32,059	621,400	891,100	1,344,700	[illegible]
Total	1,276,266	124,491.40	4,863,757	5,712,992	71,473,292	109,520,515	22,472,9[illegible]

About $ 98,790,000 at today's prices

TABLE 2.—*Production of gold, silver, copper, lead, and zinc of selected mines in the Wallapai district, Mohave County, Ariz., cumulative from 1901 through 1948, in terms of recovered metals*

[Compiled by Metal Economics Branch, U. S. Bureau of Mines, Salt Lake City, Utah]

Mine	Gold (oz.)	Silver (oz.)	Copper (lbs.)	Lead (lbs.)	Zinc (lbs.)
→ Alpha (*m*)	292	35,499	22,265	16,476	
Altata and Altata Extension (*c*)	382	56,024	136,616	7,691	
Badger, Hercules, and Hercules group (*c*)	561	12,257	1,418	331,365	52,524
Bonner group (*s*)	1,697	79,382	21,603	2,195,988	39,948
Blackfoot (*cer*)	158	11,886	19,617	101,565	144,369
Blue Bell (*s*)	469	50,954	44,274	182,631	
Cerbat (*cer*)	42	2,055	1,153	4,120	
Champion (*cer*)	982	22,689	14,931	825,998	335,391
C. O. D. (*s*)	1,550	151,263	23,924	348,872	28,188
Columbus-Monroe Doctrine (*cer*)	646	5,053	4,370	17,322	154,533
Copper Age (*c*)	3	1,062	266	24,575	
Distaff (*c*)	93	55,883	1,392	149,680	
Elkhart (*c*)	662	10,385	7,482	245,199	
Empire and Silver Union (*c*)	1	2,475	122		
Eureka (*c*)	7	2,311	3,371	23,861	42,714
Flores (*cer*)	422	396	172	512	
→ George Washington (*m*)	114	11,059	15,777	31	
→ Golconda (*m*)	20,752	510,180	354,703	2,031,719	56,226,020
→ Golden Eagle and Bobtail (*m*)	1,777	25,845	890	40,076	
Golden Gem (*cer*)	2,478	8,213	3,303	14,980	
Hidden Treasure (*c*)	251	9,074	7,897	159,861	231,345
Idaho (*cer*)	280	5,285	4,742	9,348	51,960
Juno (*c*)	1,239	43,128	4,517	235,408	154,138
→ Keystone (*m*)	2,703	452,049	340,778	348,845	114,903
Little Chief (*s*)	391	68,351	2,070	111,823	
Lucky Boy (*c*)	1,923	40,438	280	8,140	
Mary Bell (*c*)	26	955	557	19,155	28,733
Midnight (*c*)	44	8,533	10,746	4,122	
Minnesota-Connor (*c*)	2,890	228,129	50,702	169,722	71,053
→ Mint (*m*)	222	15,265			
New London (*cer*)	13	3,268	1,558	136,699	31,243
→ Nighthawk group (*m*)	324	16,297	5,410	1,589	
Old Colony (*s*)	21	2,909	654	4,370	
Paymaster (*cer*)	99	25,090			
Payroll (*c*)	128	4,104	11,694	39,928	192,137
Pinkham (*c*)	56	14,695	55,136	3,133	
Rainbow (*c*)	2,400	34,582	4,748	313,271	22,426
Redemption (*c*)	21	4,042	11,449		
Rico (*s*)	1,149	15,309	1,449	2,620	
Samoa and Samoan (*c*)	4,480	57,891	4,454	656,377	67,856
St. Louis (*cer*)	24	11,142	1,070	855,841	1,496
Silver Age (*c*)	24	3,550			
Silver Hill (*c*)	708	8,842	10,722	229,949	143,594
Tennessee and Schuylkill (*c*)	42,383	1,514,187	839,857	59,897,096	66,805,807
Towne (*c*)	144	6,286	2,108	5,516	
Vanderbilt (*cer*)	1,012	2,119	327	2,568	
→ Washington and Washington Extension (*m*)	58	2,205	1,610	1,700	

c, Chloride camp; *m*, Mineral Park camp; *cer*, Cerbat camp; *s*, Stockton camp.

→ Mines in or near the Chico and RMC claims.

the numbers on the holes and other data have been lost. Most of these holes were shallow being about 50 feet in depth; few are over 150 feet in depth. The drill logs and assays are inconclusive as to the location of specific veins. Many apparently sought for mineralization along the Bronco dike.

Substantial information on the Wallapai Mining District, Chloride District, Mineral Park District and so forth is available in the published literature and in other available reports from various sources. However, time restrictions for the present preliminary study of the RMC properties precluded no more than a brief review of some of the more important data.

GEOLOGY

Rock Formations

Precambrian Rocks

The Precambrian rocks consist of an old sequence of strongly metamorphosed (altered by heat and pressure) sedimentary (fragmental rocks derived from older rock types and usually deposited in water environments) and igneous (molten material at high temperature which has been injected into other rocks or flowed out on the surface of the ground) rocks. These metamorphosed older rocks are now represented by a variety of schists, amphibolites and gneisses. Intruded into these older rocks are one or more granitic masses together with associated basic (dark colored) and acidic (light colored) dikes and veins. The dikes and veins consist of fine grained aplites, coarse grained pegmatites and quartz veins.

The granitic masses range from coarse grained to fine grained and from very light color, possibly an alaskite, to a dark gray, possibly dioritic. Most of them are a light gray granitic type of rock. Most of them have been highly sheared and metamorphosed and now have a gneissic or somewhat banded structure, although shearing and gneissic structure are not always present.

The granitic rocks, whether gneissic or not, and to some extent the other Precambrian rocks have been intruded by irregular, in places highly contorted quartz veins ranging from an inch to several inches in thickness. These are in contrast to the more regular pegmatitic and aplitic dikes.

Mesozoic(?) Rocks

A large mass or stock of coarsely to finely crystalline granitic to dioritic rock occupies the west-central portion of the Cerbat Mountains with its center at Mineral Park but with off-shoots extending into the claim area. This stock is known as the Ithica Peak granite. Its age has been considered to be Jurassic, Cretaceous or early Tertiary.

Associated with this stock are pegmatitic and aplitic dikes, granitic tongues, as well as basic dikes. None of these intrusives show metamorphism although some have been highly altered by later mineralizing solutions. Some of the dikes are very persistent, such as the Bronco dike which can be traced for a number of miles across the country and which passes through the RMC group of claims. These dikes can range from a few inches in thickness to over 50 feet and in places may be several hundred feet wide.

The dikes tend to be intruded parallel to the structural pattern of the area, namely trending northwest to north-northwest with some northeast trends. Dip is usually steep but may be as flat as 45°. The granitic masses, which often are somewhat porphyritic tend to be more irregular in pattern and shape.

Most of the above dikes are believed to be associated with the Ithaca Peak granite, although some of the diabasic and mare basic dikes may be older.

In addition to the above dikes, just south of the claim area and extending into it are numerous thick, well developed, persistent dark to light colored rhyolitic dikes. These may be related to the Ithaca Peak granite or may be considerably younger and related to the Tertiary volcanics.

Tertiary(?) and Quaternary Rocks

Outside of the claim area are extensive volcanic accumulations of lava, tuffs and related rocks. Some of the rhyolite dikes in the area may have been feeders to these volcanics. They are presumed to be of late Tertiary age.

Quaternary alluvium is locally present in some of the stream areas and thick accumulations are found in the valley fill at the foot of the mountains.

Structure

Folds

Time did not permit a close study of the details of the

folded structures which may exist in the area. Their evidence is fragmental in the Precambrian rocks, but indications are that probably during Precambrian time one or more periods of folding occurred which probably resulted in the beds standing almost vertically in possibly isoclinal folds.

Faults, Fractures and Shear Zones

Exclusive of the late Mesozoic(?) and Tertiary(?) igneous activity consisting primarily of the intrusion of granitic and related rocks and the associated acidic and basic dikes, the most important structural features in the area consist of a series of northwest-southeast trending faults. Although at present largely concealed by valley fill and alluvium, the most prominent and important faults are those which raised the Cerbat Mountains to their present elevation above the surrounding plains.

Within the range are a series of fracture systems. The magnitude of the movement on these is not known but probably ranges from a few feet in some of the shear zones to possibly several hundreds of feet in the more important fractures of the system. These fractures trend northwest to north-northwest and are relatively steep dipping. Reportedly most of the dips in the region are to the northeast, but some are to the southwest. However, the writer has observed some with dips as low as approximately 45°.

Although the fractures tend to be relatively parallel in strike, there are variations and some of the fractures have branches and may "horse-tail" and fade out. There are also some well defined transverse fractures but these do not appear to have off-set the northwest trending faults to any appreciable amount. Some of these transverse fractures may be simply gash breaks associated with the main faulting.

The age of the northwest fractures is later than the Precambrian rocks since they cut across them with little variation in character. The age is probably Paleozoic or Mesozoic, but pre-Ithaca Peak granite and related rock intrusions, since these intrusions have in places been guided by the northwest fault system. Later movement has occurred on some of the fractures as is indicated by brecciation ond off-sets of the fracture-filling material. At least some of the transverse faults and gash fractures are of the same approximate age as the northwest trending faults, namely, pre-Ithaca Peak and related intrusion time, since some of them are filled by intrusive materials. Others are definitely later since they off-set the filled faults and may contain no igneous rock filling.

Veins

Most of the veins are associated with the various dikes. It seems to make little difference whether they are basic or acidic in character, being found along both diabasic and rhyolitic dikes. However, not all of these dikes are mineralized. Likewise, the aplitic and pegmatitic dikes do not appear to carry mineralization.

The veins at the surface may be marked by yellow to brown or reddish zones which are quartz bearing or silicified. Elsewhere, they may be marked by resistant diabasic and rhyolitic dikes. Where the ore bearing solutions were especially active these dikes may be highly altered and bleached to a a light yellow or tan color.

The veins may range in length from a mile or more to only a few hundred feet. Their width ranges from a fraction of an inch to several tens of feet wide, but it is estimated that the average width is not more than 3 - 4 feet. However, the veins typically pinch and swell horizontally and reportedly follow the same pattern with depth.

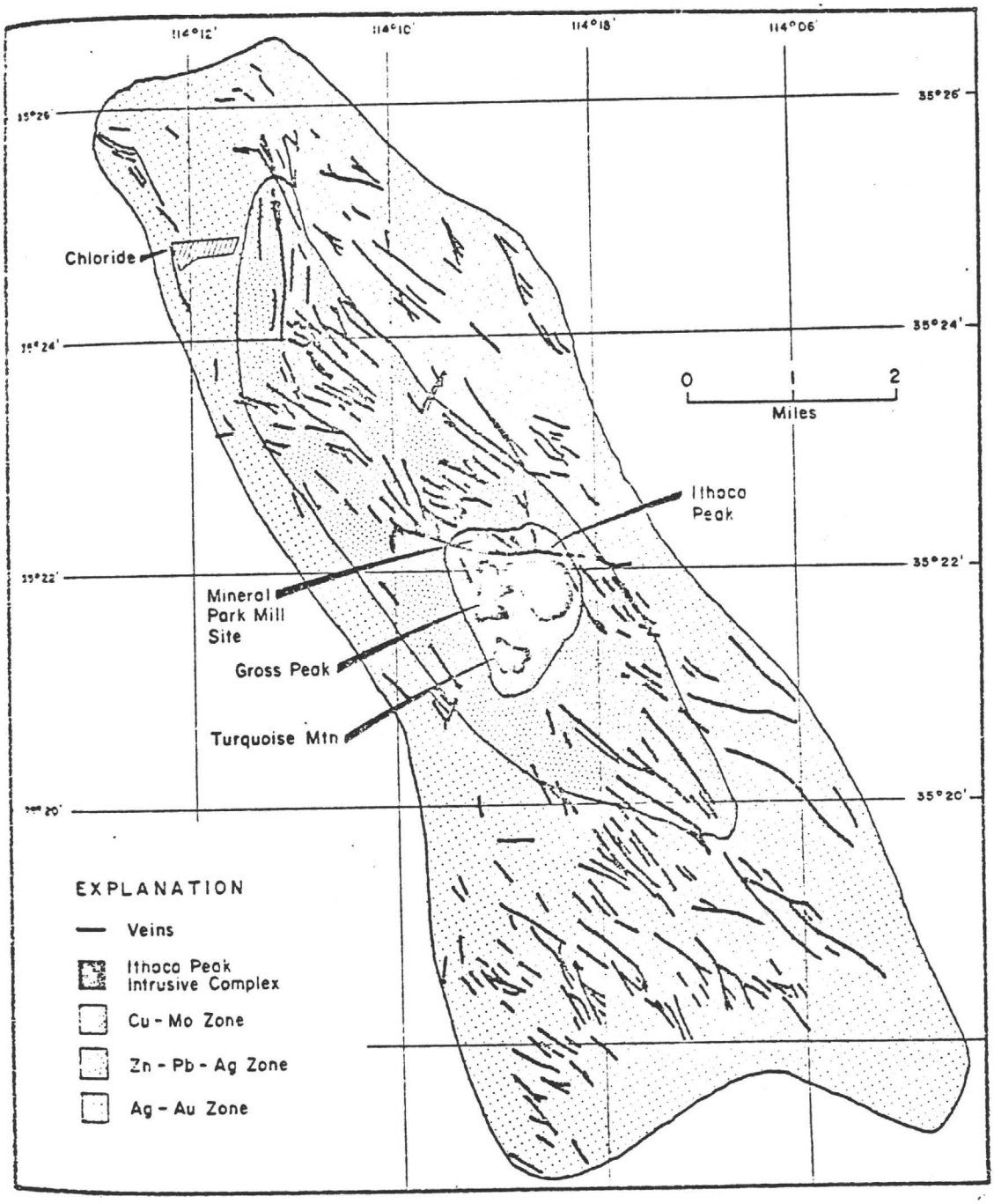
The veins usually are separated from the wall-rock by a thin to thick clay or gouge zone. The gouge zone and vein may be along the hanging-wall, foot-wall, or intermediate in the dike. In places, the gouge only is present and there is no mineralization. Where clay or gouge is present, the vein material may be readily pealed off the wall-rock; where they are absent, the vein may be frozen to the wall. The type of wall-rock or country rock appears to make little difference in the mineralization in the vein. Dissemination of ore minerals into the country rock to any great extent was not noted.

Mineralization

The age of the mineralization is not definite but it is largely post- basic dike and granitic intrusion since the mineral veins cut these dikes and the mineral bearing solutions have altered them. Mineralization along the rhyolite dikes is short and spotty in most cases; it is probably post- rhyolite dike in age.

The mineralization centers around the Ithaca Peak intrusive in the Mineral Park area. At this locality mineralization is typically copper sulfides and associated minerals. Veins may occur, but the deposit is more typically a "porphyry copper" which is now being mined as an open pit disseminated copper deposit. Although veins of higher grade of mineralization occur in the deposit, it is typically a low grade, weakly disseminated copper sulfide occurrence with an oxidized copper capping.

Mineral Zones
Silverbell



Vein Distribution and Zoning in the Wallapai Mining District (adapted from Dings, 2, Plate 1).

Surrounding the Mineral Park center is a zone several miles wide of lead-zinc-silver bearing veins and outside of that is a zone of silver mineralization. These zones do not have sharp boundaries and are gradational.

The subject claims are in the lead-zinc zone but do carry a small amount of copper and substantial amounts of silver. The mineralization occurs in veins of mesothermal type or veins which formed at moderate temperatures and pressures within the crust of the earth.

The primary mineralization is one of lead (galena), zinc (sphalerite) and silver (argentite) sulfides together with some arsenic and antimony bearing compounds (sulfo-salts). In addition small amounts of copper sulfides are present and reportedly there is minor native gold in the veins. In the area molybdenum, vanadium and tungsten bearing minerals have been found. Molybdenum usually is found with copper and very easily could be present throughout the area.

The primary silver minerals are the silver sulfides and silver sulfo-salts. However, much of the silver probably occurs with the lead as argentiferous galena.

The secondary ore consists of the near-surface oxidized minerals of lead, zinc, silver and copper together with residual concentrations of gold. In these secondary minerals are found the native metals of silver, gold and some copper.

The rich silver deposits of the area were basically the silver chlorides, bromides and native silver developed on the oxidized portions of the veins.

Depth of oxidation ranges from a few feet to several hundreds of feet. The average depth is reported to be about 100 feet. The primary sulfides become the main ore minerals below the oxidized zone and at the base of the zone is the "zone of secondary enrichment" especially important in connection with oxidized copper bearing deposits.

Porphyry Copper Potential vs. Vein Potential

The RMC holdings around the Chico Mine are typically vein deposits. They are essentially lead-zinc types which at increasing depths probably will increase in copper content. Likewise, northward towards Mineral Park the copper content of the veins will probably increase. There is no question that the property lies in an area of excellent vein development and vein-ore potential.

The open pit operation at Mineral Park, about 2 miles to the northwest, is on a porphyry copper deposit developed in the Ithaca Peak stock. Equivalents of the Ithaca Peak stock granite are present in the RMC claim area. No evidence of disseminated copper deposition was observed in the brief time spent on the claims. However, exposures of this granite are extremely limited being covered by other rock types. It is quite possible that a branch of the Ithaca Peak stock could extend into the area and underlie the property and that it might carry disseminated copper deposits. To determine this possibility would take deep IP geophysical work followed by deep drilling where indicated by the geophysical results.

PAST EXPLORATION AND DEVELOPMENT

In 1974-75 some 65 drill holes were sunk on the property. Many of these were to test the mineralization associated with the Bronco Dike. Most of the holes were about 50 feet (inclined) in total length; rarely was a hole 150 feet or more in length. These have been discussed earlier.

Pits, cuts and shafts abound in the area. These range from a few feet deep to shafts over 400 feet deep (reportedly). Adits, tunnels and cross-cuts amounting to thousands of feet of underground workings, usually along a vein, are present. Many of these have been explored by Mr. Kenney and have been sampled and assyed to varying degrees. Many of the workings are no longer accessible. The results of his findings are included as part of this report.

EVALUATION

No tonnage evaluation nor dollar evaluation can be made for the RMC holdings in the Chico Mine area. There are two main reasons for this (1) time was insufficient to do this and (2) data from past developments were insufficient or unavailable to enable any type of calculation as to value to be made.

However, there are several positive factors which suggest a good value to the property:

1. The property lies in a mining district from which extensive tonnages and values for gold, silver, copper, lead and zinc have been obtained;

2. There is abundant evidence of well mineralized veins crossing the claims;

3. A number of good mines have been opened on

various claims in the RMC holdings;

4. Assays by Mr. Kenney show areas where good values for various metals occur; detailed sampling might delimit good ore bodies based upon the location of the good assays obtained.

CONCLUSIONS

1. The property is well located in a well mineralized area.

2. There is good mineralization underlying the property in the form of silver, lead and zinc bearing veins with some associated gold.

3. The values in the veins were sufficiently good to support in the past, when metal prices were low to very low, a strong mining activity.

4. A mill will be necessary to concentrate the metal values and to eliminate waste material.

5. The extent and value of the mineralization remaining in the property area can only be determined and evaluated by additional exploration and assaying.

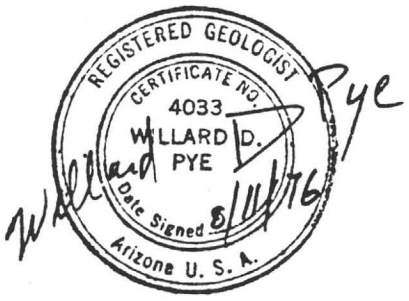
6. Future exploration and evaluation would take the form of:

   a. Geological mapping and sampling
   b. Geophysical exploration
   c. Drilling
   d. Mining exploration, blocking out and production of discovered ore.

Only those steps will be used on various portions of the property as will be most effective to determine the ore potenial and delimit its boundaries.

Willard D. Pye

Willard D. Pye
Consulting Geologist
Arizona State Board of
Technical Registration #4033
California Board of
Registration for Geologists
2654



(#4)

RESUME

WILLARD D. PYE

PERSONAL DATA

Willard Dickison Pye

Office Address: 3418 N. Forgeus Ave., Tucson, Arizona 85716
Home Address: 3418 N. Forgeus Ave., Tucson, Arizona 85716

Born: February 20, 1915

TRAINING (College and University)

Oberlin College, Oberlin, Ohio
A.B., 1935

California Institute of Technology, Pasadena
M.S., 1937

University of Chicago, Ph.D., 1942

FIELDS OF SPECIALIZATION

Undergraduate: Geology and Mathematics majors; Physics and Chemistry minors.

Graduate (M.S.): Geophysics and Economic Geology (ore deposits)

Graduate (Ph.D.): Petroleum, Ore Deposits, and Sedimentation

SCHOLASTIC HONORS

President, Geology Club, 1934-35
Phi Beta Kappa, 1935
Sigma Xi, 1937
Virgil Kirkham Fellowship in Geology (University of Chicago) 1940-42

PROFESSIONAL LICENSES

Arizona State Board of Technical Registration (Consulting Geologist) No. 4033

California State Board of Registration for Geologists No. 2654

REFERENCES

Who's Who in America

American Men of Science

Who's Who in American Education

Various oil, geological, and other directories

POSITIONS

Consulting Geologist: Full time 1970 – present; also, for short periods at various times from 1935 – 1970.

Professor of Geology, Department of Geology, University of Arizona, Tucson, Arizona, 1957 – 1970.

Chairman and Professor, Department of Geology and Geography, North Dakota State University, Fargo, North Dakota, 1947-57.

Executive Secretary, Yellowstone-Bighorn Research Association, 1954-55.

National Science Foundation Research Associate – Research Northern Great Plains, 1953-54.

Research Geologist, Princeton University, 1953-54.

Director, Elk Basin Geological Summer Field Camp, 1953-54.

The Texas Company, Rocky Mountain Division Research Geologist – special geological problems, 1946-47.

The Texas Company, in charge Idaho-Utah District, 1943-46.

National Defense Research Corporation (N.D.R.C.) - In charge classified research, for Chemical Warfare Service, 1942-43.

Illinois Geological Survey, Research Assistant, 1940-42.

University of Chicago, Instructor, 1940-42.

Carter Oil Company, Geologist, 1937-40 (Now part of EXXON corporation)

U.S. Soil Conservation Service, Sedimentation Research, 1936-37.

California Institute of Technology, Graduate Instructor, 1935-37.

Shell Oil Company, Geophysicist, 1936.

Oberlin College, Laboratory Assistant, 1933-35.

OTHER NON-COMMERCIAL ACTIVITIES (selected)

Arizona Oil and Gas Commission, Advisor, 1964-1970.

National Petroleum Council, Committee on Future Petroleum Resources of the United States, Southern Arizona and New Mexico district; also, reviewer of papers on Arizona, Utah, Western Colorado, Western New Mexico and Nevada – 1969-1970.

Director, Arizona Oil and Gas Association, 1961 – present; President 1965-66.

Director, International Geophysical Year (I.G.Y.) Aurora and Airglow studies, Northern Great Plains, 1956-57.

Director, North Dakota Institute of Regional Studies, 1956-57.

Secretary and Director, Red River Valley Investment Fund, 1957-58.

President, Northwest Investors Research, 1956-57.

Delegate and consultant to National Science Foundation conference on geology in colleges with small geology departments, 1953.

SOCIETY MEMBERSHIPS (Scientific and Professional – both current and former)

National and Regional

American Association of Petroleum Geologists

American Institute of Mining and Metallurgical Engineers

Geological Society of America

Seismological Society of America

Sigma Xi

Society of Economic Paleontologists and Mineralogists

Society of Exploration Geophysicists

SOCIETY OFFICES AND COMMITTEES

American Association of Petroleum Geologists

Committee on Stratigraphic Correlations, 1959-63

Carbonate Rock Sub-Committee, of Research Committee, 1959-61

Committee for Preservation of Samples and Cores, 1959-60

Research Committee on Subsurface Reservoir Conditions, 1948-51

American Geological Institute

Chairman, Glossary Committee on Sedimentation, 1951-56

Chairman, Glossary Committee on Paleogeography, 1951-56

Chairman, Educational Committee for North and South Dakota and Montana, 1950-54

Arizona Geological Society – Geological Society of America, Cordilleran Section

Chairman, Registration and Arrangements Committee, 1958 Joint Meeting

Editor, Stratigraphic Papers, 1959 Joint Meeting Guidebook

Field Trip Leader (Stratigraphic Trip), 1959 Joint Meeting

Arizona Oil and Gas Association

Director, 1961 – present

President, 1965-66

Chairman various committees (Speaking, Membership, Public Relations, etc.) 1961 – present

Chairman, Arizona Mineral Information Planning Committee, 1962-64

Society of Economic Paleontologists and Mineralogists

Research Committee, 1957-61

Co-chairman, Research Fund Committee, 1959-60

Steering Committee representing Society of Economic Paleontologists and Mineralogists to American Geological Institute Glossary Committee, 1953-56

Miscellaneous

Chairman, Research Committee, American Association of University Professors, 1951-52

Field Trip Leader, New Mexico Geological Society, Black Mesa Trip, 1958

Research Committee, North Dakota Geological Society, 1951-53

Chairman, Research Committee, Wyoming Geological Society, 1946-68

PUBLICATIONS

Author of approximately 50 publications on various topics including, oil and gas, coal, helium, oil shales, metallic and non-metallic mining, sedimentation, stratigraphy, paleogeological and tectonic studies, drilling and reservoir engineering, geophysics and related topics.

TRAVEL

Geological work and/or travel throughout the United States and most of the provinces of Canada. Geological work in Mexico, northwestern South America, and travel and geological work throughout Europe, Near and Middle East and North Africa.

Jemison Mine,

Cerbat Mountains

Hualpai Mining District

Mohave County

Arizona.

REPORT OF L. WEBSTER WICKES.

Kingman, Arizona,

Dec. 26th, 1916.

GNAEDINGER. Report

JEMISON MINE.

Summary.

The Jemison is an exceptionally good prospect. There is less gamble than usual as to opening ore in quantity and in the metallic content of the ore. The physical condition of the metals is not as refractory as others in the district that are being successfully treated. Milling conditions are improving almost daily.

The vein is strong and like all the others of the Cerbat Mountains will undoubtedly continue to great depth. The bottom of the shoots have not yet been reached in any mine with which the writer is familiar. Two properties are developed over 1200 feet in depth. Two shoots on the Jemison are assured and adjoining ground will probably give others. It is true in the district, so far, that surface shoots have all continued in ore with deeper development and development has in several cases opened shoots of ore that were not indicated in the veins at the surface.

There is no tonnage blocked out, but 170 feet of drifting in the lower Jemison tunnel is on ore that will yield a good profit. Experiments so far made indicate that by means of gravity and flotation concentration, combined with partial roasting and magnetic separation of the iron from the zinc products will be made such that the operator of the Jemison will get paid for 80% or more of the metallic content of the ore.

This property is in Mohave County, Arizona. It is on the West slope of the Cerbat Mountains, about half way between Kingman and Chloride. It is reached by road in seventeen miles from Kingman, which is on the main line of the Santa Fe Railroad. The mine is four miles from Mineral, a station on the branch railroad running from Kingman to Chloride.

The wagon road from Kingman is passable to automobiles but the last two miles to this property are very bad and would be unsuitable for trucks at present, being up a rocky gulch. The rise is 150 ft. to 200 ft. to the mile. This poor portion of the road is the branch from the main truck road to Golconda and serves at this time no other property than the Jemison. A suitable road for Ore hauling from the Junction of the Golconda road to the mine will cost about $3500.00. The present road, though subject to repeated washing out, is sufficiently good to handle all freight, etc., by teams and wagon during preliminary and development operations.

Telephone and electric power lines pass within a mile of the property. The nearest post-office is "Golconda," at the Golconda Mine about a mile and a half by foot trail to the south.

Kingman is the main supply point. It is a town of 5,000 people and the various stores and supply houses carry everything in stock that is necessary for all except the largest operations.

There are several surveyors and assayers available doing custom work. Haff and Colwell, whose permanent address is Oatman, Arizona, are very reliable for anything in the way of surveying, and R. C. Jacobson, Kingman, is a careful and reliable assayer.

Throughout the section fuel oil or electricity from the Desert Power and Water Company is used for power. On small installations the former is usually the cheapest as the rate for current is 2-1/2 cents per Kilo-watt for small quantities, decreasing to 1-7/8¢ per kilo-watt on a consumption of 400,000 kilo-watts per month. This is roughly equivalent to $12.00 to $15.00 per H.P. per month. Timber is a serious item as "O.P." (Douglas Fir) costs $28.00 to $35.00 per M. in Kingman in carload lots. Fuel oil costs from 4-1/2¢ up, F.O.B. Kingman. Distillate for Hoists etc., ranges around 11¢ per gallon. For this particular case electricity would be the best for any preliminary operations due to the road conditions unless the mine is sufficiently developed when the time comes to put in machinery to warrant a permanent road. Depending on hauled fuel with the present road would be too uncertain.

There is available water on the ground for all domestic purposes for some time to come. All the mines in the district make water with depth, ranging up to 150 gallons per minute. The mines are the source of all water for milling purposes.

At present the principal producing properties of the district are the Golconda (Union Basin Mining Company) and the Tennessee (U.S.Smelting, Refining and Mining Company). The Golconda is about a mile, in an air line, south of the Jemison. It is developed to some 1200 feet in depth and is at present producing about 1800 tons monthly of zinc ore and concentrate running 40% zinc and carrying a little gold and silver.

The Banner mine of the Arizona Butte Mining Company

is producing a little lead concentrate. Various other properties are making intermittent shipments.

The production of the district was originally almost entirely silver. The surface ores in numerous places were rich in native silver, horn silver and ruby silver. As depth was gained the precious metals decreased but large bodies of base metals were opened, principally zinc and lead with occasional copper bodies. It is these base metals that make the mines of today.

The Keystone mine has a mill under construction and there are two custom mills being talked about. One of the custom mills is being considered by the Zinc Concentrating Company, who will begin erection as soon as they are reasonably assured of tonnage. Their mill as outlined, will include roasting and magnetic separation as well as the usual wet methods. They are in the field for zinc product high in iron.

The Jemison group consists of four locations relatively situated as shown on the accompaning map. There are some seventy-five acres or so covered. The map shows the ground as it is monumented. The claims are all irregular and in the case of the "White and Blue" claim the location may be illegal. I would earnestly recommend that as soon as the mine work will warrant, amended locations be made and the claims brought within the legal limits as to size and that the exterior lines be made parallel and corner posts put up.

There are no permanent improvements on the ground. There are tents and camp equipment sufficient for five or six men. All work now is by hand, no machinery.

There have been numerous articles published about the mines in the Cerbat Mountains, but the summary and the most reliable information given the general public is in U. S. Geological Survey Bulletin No.397 where Mr. F. C. Schrader gives the results of his study of the section made during the winter of 1906 and 1907. Mr. Schrader published a later article at page 1935 in the November 1916 Bulletin of the American Institute of Mining Engineers.

At the Jemison the country rock is the usual "Pre-Cambrian Complex" of the Cerbat Mountains. It exists here as a medium grained granite, with a little of the jointing and gneiss forming action. There have been two sets of intrusions; Mr. Schrader speaks of them as "Tertiary" and "Pre-Tertiary."

The "Pre-Tertiary" is represented on this ground by the "Broncho Dyke", which runs the lengths of the Mammoth and Mendocino claims. The dyke was the reason for locating and is the "vein" of these claims. It strikes nearly north and south and continues to the south well into the Golconda Extension holdings and to the north about 1000' beyond the end line of the Mammoth claim. It has a total length of some 4500 feet.

The Tertiary intrusives are not positively identified on this ground, though a latite (?) that appears near the common end line of the Mendocino and Mammoth claims and which strikes a little west of south from the Broncho Dyke probably belongs to this group. Just to the west of these claims is the Pasadena Dyke. It is one of the Tertiary rhyolites which strikes N. 10° to 30° W. and a similar one is seen at the top of the ridge of the range near the south east end of the Night Hawk.

While no appreciable tonnage has been found on any of the dykes, values in gold and silver can be obtained almost any where along their strike and in places several tons have been taken out that are very rich. The indications, however, are that these pockets are purely surface enrichment.

The mines of the district are all on well defined veins that make out at sharp angles to the dykes. Mineralization has followed both sets of intrusions. Though it is by no means a proven fact, and further development and observation may prove otherwise, the present indications are that the veins making out from the Pre-Tertiary dykes are richer in copper, iron and gold, while those out from the Tertiary are richer in silver and lead. This does not apply, however, to a large area near Mineral Park where there is a disseminated pyrite carrying copper in a rhyolite porphyry that has produced a number of secondarily enriched copper deposits. The Galena usually gives way to iron and the iron to zinc. Due to heavy and rapid erosion the oxidized zone is shallow and primary sulphides are often found close to the surface. In many places the surface zone is that of secondard enrichment. Much ruby silver was found in the early days in the oxidized ore. Both in the oxidized and in the sulphide zones the various base metals showing are refractory mixtures of pyrite, chalcopyrite, blend and galena. In the past some of these ores have proven too refractory to handle. At present, however, unless the conditions are exceptional, almost any of the sulphides can be separated and marketed with a saving of better than 80%. By this is meant that various combinations of flotation with a partial roast and magnetic separation have given, both in practice and in experimental work, clean marketable products.

It is well to remember that the so-called blend of the Cerbats is really not a straight sinc-sulphide, but is in fact a marmatite; that is an iron-zinc sulphide, the iron being chemically combined. The result is that a forty-five to forty-six per cent Zn concentrate is as rich as can ordinarily be made. The pure mineral runs but 51% Zn.

The promising showing of this ground is on the Jemison vein. This strikes S. 47° degrees E. and makes out from the Broncho Dyke at about the middle of the Mendocino claim. It is traceable definitely nearly to the S.E. end of the Jemison claim. At a point about 200 feet from the Broncho Dyke a branch vein takes off which strikes about S. 68 Degrees E.

A tunnel has been driven to the intersection of the dyke and vein and from the intersection is continued as a drift on the vein. On December 25th, 1916, it opened the vein for 170 feet. Values and sampling are indicated on theaccompanying assay map. The face is still in very good looking ore. There are three upper tunnels that develop the vein to a certain extent. The two upper tunnels are in oxidized material entirely, though occasionally a speck or two of sulphide remains. An old stope near the face of the upper tunnels is reported to have produced several hundred tons of ore going $200.00, the values being mainly in gold. This stope, though caved, shows a shoot apparently about 40 ft. long. The tunnel is on the vein for nearly 300 feet before getting into the stope.

The lowest of these three upper tunnels is really a crosscut and evidently only reaches the branch vein mentioned above. The vein's width wherever mineralized is from two to five feet and so far averages 3.25 feet. The ore will evidently

occur in shoots. The one in the lower tunnel now being driven, so far is shown to be over 200 feet in length.

The shoot indicated in the upper tunnel by the old stope can be expected by comparison, as a little greater depth is attained, to be longer than the 40 feet now shown. It would be reasonable to expect, out of a length of vein of 1500 feet, that at least one third of it would be mineralized, and entirely possible that there would be even more. Barren zones will undoubtedly be encountered in drifting along the vein, but the croppings and the experience thruout the district would indicate that values would be found along one third of the vein's length. The Jemison vein is lost on the surface near the upper (S.E.) end of the claim, but the indications are that the vein showing on the Little Johnnie is the same.

At the present time there is nothing in any of the upper tunnels to be considered, except that a shoot of ore is quite positively indicated by the old caved stope. The middle or cross cut tunnel, so far only cuts the branch vein.

The showing that gives the property its principal value is in the Main or lower tunnel. As this leaves the dyke and penetrates the hill it gets more and more into the unaltered, primary, sulphides. The present face (12-24-16) shows very little oxidation. The ore is a mixture of Sulphide of Iron, Copper, Zinc, and Lead "i.e." Pyrite, Chalcopyrite, Blend and Galena. There are bunches of Arsenopyrite intermittently along the foot wall. The relative proportions of the minerals are best seen in the analyses on the assay map and particularly in the analyses of the dump samples. In places there are signs of secondary enrichment, but the zone is apparently thin. Some of the higher assays of copper are undoubtedly due to secondary glance. It is to be expected that the copper will

decrease as one gets farther from the dyke and also that it will decrease with depth. This has been the case at the Alpha and other properties in the vicinity, but it is true that none of them had as much chalcopyrite showing in their upper works as the Jemison.

There is nothing in the way of "Blocked out Ore" at present. One might stope a little but the backs are shallow and too near the oxidized and leached zone. In driving the present main tunnel, the mineral could be sorted carefully and approximately 15% of the ground broken would be available for shipping. The Jemison vein now averages 3.25 feet wide, which means 65 tons for each foot of depth on a shoot 200 feet long.

Driving three feet a day, would mean some 90 cu.ft. or about 8 tons, 15% of which or 1.2 tons is available for direct shipment, after hand sorting, as long as present conditions remain unchanged. This 1.2 tons would be about, as indicated by the sampling; Au. 0.15 oz., Ag 30.0 oz., Cu 7.0%, Pb 1.5%, Zn 6.5%, Fe 12.0 %. This would yield:

Au.		$3.00
Ag.	95% at 60¢	15.10
Cu.	7% gets paid for 120# at say 25¢ quoted less 2.5¢ for marketing charge	27.00

This is about a $45.00 ore:

Hauling to the railroad now would be at least $3.00, which with $7.00 frieght and $7.00 treatment or $45.00 less $17.00, would leave a balance of $28.00 as the value of the product on the dump. This indicates that for a while at least $30.00 to $35.00 could be realized a day. This would materially help, but would not pay all expenses, assuming

assuming hand mining and hand sorting on three shifts. It would take especially good work to make three feet with hand steel. Bunches of arsenopyrite occur in a streak on the footwall and this product can be segregated in drifting and made to yield some return as it carries high gold values, averaging one and one half ounces. Its tonnage is, however, decidedly limited. A selected piece of the arsenopyrite gave 30 oz. gold per ton.

Depending on the policy of the operators, it might not be worth while at this time, to try to make any of the above segregations, but to put all the material on the dump to be handled later by mill or otherwise. It will be hard to save the material in dumps as there is no place that will be free from possible loss by freshets. The metal prices are more apt to decrease than to hold their present values.

The ore markets at present are Humbolt, Sasco and Hayden for Copper products, while the nearest lead smelters are Selby and El Paso. Zinc products of this section usually go to Bartletsville, Okla. Some products can be marketed at the Needles Concentrator of the U. S. Smelting, Refining and Mining Company. The latter plant takes some complex ores of the Cerbat Mountains when they are righer in lead, for a treatment charge of from $2.50 to $3.00. They buy the lead concentrate they make and hold the zinc concentrate or other product on "shippers order."

Milling costs, including developing and milling, can be reasonably estimated at $5.00 a ton on the Jemison. The Golconda is working at this figure and their conditions are exceptionally difficult. The Golconda mines their vein in places at a width of only 12 inches and yet keeps their average figure down to the above $5.00. They allow $1.25 of that for development. $1.25 is a fair allowance for putting the ore or concentrate on the cars, assuming a fair truck road. The usual figure for this section for freight and treatment on material of average grade is $14.00 for lead, iron and copper products. When Spelter is quoted at seven cents, 40% zinc products are worth $20.00 to $21.50 a ton loaded on the cars at Mohave County common points.

The Jemison will mine cheaply by comparison, as the width is good and the walls stand well. The vein being practically vertical also helps.

Of the surrounding ground, there is nothing of interest at present to the immediate west and north. To the south is the Ora Plata Mine of the Golconda Extension Company. It has a shaft 360 feet deep. The property has a number of cross breaks or veins out from the Broncho Dyke. They produced much high grade ore in the early days, its past production having been supposed to be $500,000.00. Some copper showed near the surface, but apparently not as much as at the Jemison. From the 100 to the 285 levels, the ore became very refractory, being a mixture of Pyrite, Galena and Blend, high in iron. It was high in total metal values, but hard to segregate. On the 360 foot level a marked decrease in the pyrite and increase in zinc occurred. The lead seemed to hold about the same. No ore was shipped or treated from the lower (360) foot level, but it was

seen by the writer just before it was allowed to fill with water and the showing was very attractive. At that time, January 1916, the property was under option to O. A. Tumner, who owing to financial difficulties was unable to hold the property and it eventually reverted to the owners, Mr. O. D. M. Gaddis, et al, of Kingman. It has been recently (Dec.1916) re-optioned and work of unwatering is being started. The old shaft is small and in bad condition so it is proposed to drive a long tunnel from hear the Golconda Road which will cut the old shaft between 300 and 325 feet. This tunnel c cross cuts a number of veins showing on the surface. The mine makes about 150 gallons of water a minute. It is described on page 100 of U.S.Geological Survey Bulletin No. 397.

The surrounding ground which is most interesting to the operators of the Jemison, is that which lies to the south east and east. I refer to the Clamp claims and the Night Hawk. Their relative position is shown on the accompanying maps. There is very little work that amounts to anything on the Clamp ground, but as has been said before, the Jemison vein is probably continued as the vein on the Little Johnnie Claim. The amended claims would have a common end line. There is every indication of a shoot near the middle of the Little Johnnie and beyond the Little Johnnie is the ground of the Nelson Bros. who have some high grade surface enrichment ore and every indication of two shoots, however, it is too far away to be of particular interest at this time.

The Night Hawk Mine consists of two claims, the Night Hawk and Rip Van Winkle. It is briefly described on Page 103 of U. S. Geol. Survey Bul. No.397. Some very high grade gold and silver ore has been taken out in the past and there is every indication of strength in the bottom of the present lowest

workings. It is now being worked by leasers, who shipped this fall (1916) a car of hand sorted material that netted them over $300.00 per ton. The Night Hawk has a long strong shoot and though it is narrow, being only about 18 inches to two feet wide, its higher values make it attractive. No systematic sampling has been done on the property as it is not so situated as to be readily handled as an individual property. There are two ways it could be worked; by a long tunnel from the north west end of the Scotty claim, owned by Paul White, which would be a drift, or by a cross cut from the Jemison, assuming that the Jemison tunnel is driven to or under Clamps Little Johnnie claim. This latter is the more attractive. In the natural course of events, the Jemison tunnel will reach the Clamp ground and from there the cross cut to the Night Hawk, will be over 1000 feet shorter than the drift from the Scotty. This would also cross cut the veins on Clamps Mint claim as well as several minor veins that show on the surface. It is true that only minor ore shoots are seen at the surface on this intervening ground, but it is much more promising than a drift with the country. The cross cut would also have a little greater depth. The whole question of the Night Hawk in connection with the Jemison, is one of the future, but it would be considered to a certain extent when figuring on possibilities. The control is in the hands of Mr. I. M. George, of Kingman, who will be found a very reasonable man with whom to do business.

Experiments have been made demonstrating the success of flotation and of partial roast and magnetic separation, as a means of treating the ores of the Cerbat Mountains.

Jig and table concentrates are made which take care of the lead. The middle product is given a partial roast

and then sent to a magnetic separator giving zinc and iron products. The copper will be with the iron and is shipped by itself. If the copper content is low, the iron is combined with the lead concentrate and sent to the lead smelters. The slimes and tailings from the above treatment are put thru flotation machines.

RECOMMENDATIONS.

The Fractions between the Jemison, Little Johnnie and Valley View No.1 claims, should be located at once. Clamp should locate the fraction between the Rip Van Winkle and the Mint.

An option should be obtained on the Clamp holdings.

Amended location notices and corner posts should be put up at once.

Additional and more substantial camp facilities should be provided and telephone communication established with Kingman, which latter can be done with three quarters of a mile of line to the Ora Plata.

Some ground on the slope a half mile to a mile west of the present camp should be located for a possible future Mill site.

The present lower tunnel should be pushed with all possible speed to prove the length of the present ore shoot and to open the ore at the other end of the claim. Whereas the present shoot near the Broncho dyke should be developed to a greater depth, it is the feeling that the horizontal extent and the existence and length of other shoots is the most important thing for the immediate future.

The installation of machinery is dependent on the policy and finances of the operators with regard to the terms of their option.

In submitting this report on the Jemison Mine for your consideration, I must reming you that my examination was necessarily hurried, and I was able in my two days at the property, to cover only the country in the immediate vicinity of the mine. Among the various properties, however, that I have examined for yourself, as well as others, I find the Jemison the first one, for some time, that I can sincerely recommend; believing that a personal inspection yourself, as well as reports of other engineers you may employ, will but bear out the impression this prospect left with me. I can heartily recommend it to your further investigation and exploitation.

The LOCATION of the property is about fifteen miles northerly from Kingman, in the Hualpai Mining District, Mohave County, Arizona; in a range of comparatively low hills known as the Cerbat Range. It is reached by auto road (about 17 miles) from Kingman, and is about three and one-half miles from the nearest shipping point, Mineral, on the Kingman-Chloride Branch of the Santa Fe Railroad. Kingman is the supply center, a substantial town on the main line of the Santa Fe. The general topography is typical of the Arizona desert land, sparse vegetation and no continuous running streams. Timber must be shipped in, and water for mining purposes secured from springs or the mines themselves. In this regard I will state that I saw one mine operating a 250 ton mill with ease, by the aid of the mine water alone. For domestic purposes numerous springs of good water are available and the Jemison itself has several such on its own property. As regards timber, the rock in the various openings visited, stood well and, with a back-filling system of mining, a comparatively small amount of timber should be necessary.

TRANSPORTATION from the mine must be by auto truck, and the cost should not exceed Two Dollars a ton, which might and probably would decrease to about One Dollar in handling any

quantity.

The PROPERTY of the Jemison Mines Company consists of four practically full claims:- the White and Blue, Mammoth, Mendocino and Jemison Lodes, with some small fractions in addition. These claims lie well up the slope of the main range and can be developed to great extent by tunnels, though shaft-work will be immediately necessary in the event of opening a mine. The claims are so located as to include over three thousand feet along a dyke later described herein, and a full fifteen hundred feet along the main vein exposed.

The GEOLOGY of the country has been described by F. C. Shrader in Bulletin No. 397 of the U.S. Geological Survey. The main range rock in the make-up of the Cerbat Range is granite, somewhat gneissic in character. This granite or gneiss is cut by innumerable masses and dykes of the volcanics consisting principally of granite porphyry, rhyolites and andesites. Numerous true fissure veins occur throughout the Range, striking off from these dykes and closely correlated to them. On the Jemison property I found such a dyke, from 40 to 70 feet in width, traversing the Mendocino and Mammoth claims and is the "vein" of these claims, and extends beyond them in both directions along a general course of N.10°W. with a dip of about 55° to the West. Several veins have been developed on the property, all closely related to the dyke. The principal one of these is the Jemison Vein, through there is also a very promising galena vein exposed in a small way on the Mammoth claim. The Jemison Vein is well defined along its outcrop for a thousand feet. This vein was worked years ago through two tunnels about 600 feet East of the present workings, and a cave stope shows that ore was shipped that is reported to have run very high in copper and gold.

The WORKINGS at present open and being used consist of a tunnel and a winze from a short cross-cut tunnel. This winze

was sunk on the vein about half way between the upper gold-silver ore shoot and the mount of the main working tunnel. The winze in its fifty feet of depth shows a marked improvement in appearance of the vein and ore-content, and at the bottom shows three feet of good sulphide ore. The main working tunnel entered the vein along the course of the dyke, as this tunnel first crosscuts then follows the dyke. At 190 feet from the mouth the vein leaves the dyke and takes its permanent course of S.55°E. From this point to the face, about 155 feet, there is a well banded shoot of ore containing, continuously, the sulphides of iron and copper, though the face shows two feet of sphalerite that would assay f to 7% zinc. This shoot of ore at this time (Nov.17, 1916) is 150 feet long, with an average width of 3½ feet; but from the appearance of the ore itself and also the presence of the first sulphide ore in the winze, 60 feet ahead, which is only about 10 feet above this level, I would say there is no stopeable ore yet developed. The last sixty feet of this drift however, shows an average width of four feet and at the face it measured 5 feet and 8 inches, the last 30 feet of which included a well banded seam of arsenopurite, about 7 inches thick, that my sampling showed to average 1.74 oz. Gold, with a sample from the face running as high as 5.40 oz. My sampling from the face outward, show a length of 60 feet, 4 feet wide assaying (average) 3.5% Copper, 0.4 oz. Gold and 16 oz. Silver, The balance of the drift shows a smaller width of ore till it dies out in the dyke but for 100 feet would average 2½ ft. wide with the same copper content, though a probable lower ratio of gold and silver.

The SURROUNDING MINES include the Golconda now profitably operating, and which lies about one-half mile from the Jemison claim and its vein must be either the same as the Jemison, or one closely paralleling it. The Golconda Central, also within one-half mile, but more to the South, is also working and shipping. The LaPlatte or Golconda Extension to the South, with a

rich production to its credit; The Night Hawk lying about East of the Jemison reported to have some very high grade ore; besides a great many more smaller properties.

The immediate future DEVELOPMENT will be comparatively simple, as well as cheap. This should consist of following the ore and the vein to at least get under the old worked stope. As the rock has all the appearance of breaking well, this drifting should not be very expensive. I neglected to state earlier in this report that electric power is available for more extensive work, and the power line may be tapped in about one mile of pole line. After it is determined how long an ore shoot or how many are present, it will be necessary to sink both to develop as well as to aid the surface poant and disposition of buildings, waste, etc.

The Jemison is not yet a mine, in spite of its past shipping history and the development lately of this new shoot; for there is no real ore in sight or blocked out, nor a long enough ore shoot developed to be able to figure on anything certain. But with the ore that has been developed, showing, in its comparatively shallow depth such a marked improvement in the tenure of ore and size, together with the presence of another or the same shoot 500 ti 600 feet ahead, the top of which has already produced some rich ore, the Jemison may certainly be termed a very fine prospect.

(Signed) ERNEST G. GNAEDINGER,

Mining Engineer.

THE PORPHYRY COPPER-MOLYBDENUM ORE DEPOSITS AT MINERAL PARK, ARIZONA

By
Harrison A. Schmitt

GEOGRAPHY

The Mineral Park area of the Wallapai mining district is approximately 16 miles north 22 degrees west from Kingman, Arizona. The highway distance to the area from Kingman and from the Santa Fe railroad which serves Kingman is about 18 miles. Las Vegas, Nevada is about 105 miles to the northwest. The climate is semi-arid with rainfall of approximately 10 inches per year. The elevation averages around 4,250 feet.

The district is in the northwest trending Cerbat mountain range. The town of Kingman has a population of about 7,000 and for income depends on the tourist trade, ranching, and the railroad and mining business. The presently developed ore body lies in Ithaca Peak which is near the west center area of the Cerbat range. The Mineral Park townsite is in a mountain valley adjacent to the peak. It is on an early wagon trail which crossed a divide to the east.

HISTORY

The townsite was completely abandoned a few years ago. The old cemetery testifies to the hardships of the early days.

Various geologists have described the district. Important publications include those of Schrader (7), Dings (1) and Thomas (8).

The Wallapai district is well known for its lead-zinc veins with minor silver, gold and copper which have produced about $27 million in gross value of metals. In the past decade, however, production has been negligible.

The resemblance of the outcrops to those of the "porphyry coppers" attracted early attention. The Utah Copper Company (around 1910 ?) may have been the first company to drill an exploration hole in the district. Their drilling consisted of a churn drill hole on the southeast side of Ithaca Peak within the area of the present ore body. In 1915 the Calumet and Arizona Company drilled three churn drill holes on Gross Peak, about 3,000 feet southwest of Ithaca Peak. In the 1950's a Mr. Chapman drilled two holes 2,500 feet north of Gross Peak and in 1952 Bear Creek Mining Company drilled six holes in the area of Ithaca Peak.

In 1949 Thomas in his paper (8) remarked that "the mineralization is of the well-known disseminated or porphyry copper type." Dings (1) called it a stockwork. Actually, it is a porphyry copper deposit with much of the ore mineralization in small gash veins.

About September 1958, Mr. Keith Martin said that he liked the area and urged me to visit it. This I did at the request of Duval Sulphur & Potash Company. At that time, Page Morris was president of Duval Sulphur & Potash Company and George Atwood was resident manager of its Copper Division. Further reconnaissance work was started in November. Late in December, it was decided that Duval would endeavor to option and/or purchase the mining claims needed for a mine and plant and locate all the intervening ground. This encompassed an area totaling about four sections. Later, several more

sections were added. Churn and diamond drilling was started May 1, 1959. The decision to build a plant was made in October 1962. William Roper was in charge in the field and George Atwood and Ben Messer carried out the often difficult land acquisition negotiations. Messer had the overall responsibility for the last stage of the drilling and underground work. Dr. H. J. Thiele was hydrological consultant. Two water fields were developed.

Dorman O'Leary, an engineering consultant, did much of the early claim location work. Robert Lenon, a mineral land surveyor, surveyed a large number of claims for patent. Boyles Brothers Drilling Company drilled some of the first diamond drill holes, particularly the ones which were located on the top of Ithaca Peak and required helicopters for transportation of drilling equipment and supplies. Metler Brothers Drilling Company of Tucson did most of the later diamond drilling and the churn drilling was done by the Mike Wininger Drilling Company of Phoenix. Aerial Mapping Company of Boise, Idaho carried out the aerial photography and made the photogrammetric contour maps.

GEOLOGY

Except for the mineralization, that is, the hypogene and supergene phases including the capping, and the broad structural features, I did not have much to do with the detailed geologic studies. Don Clippinger, John Frost, Irving Gray and Keith Martin did most of the work on the lithology and local structure. Because of the time limitation, their data were largely unavilable for this paper. Much remains to be done.

The Cerbat range (Schrader (7)) appears to be a tilted fault block with critical boundary faults on the southwest and with a tilt to the northeast. The range is only about 24 miles west of the Colorado plateau. It is marked by numerous northwest dikes, faults and fault veins, although a few of the dikes, faults and veins bear north-south and east-west and there are a few other deviations. An early (?) pre-Cambrian terrane of schists and gneisses and gneissoid granite is cut by younger granite and porphyry which in turn is cut by largely rhyolite dikes (Dings (1)).

The ore mineralization is later than the dikes. Thomas (8) believes that it occurred at the close of the Tertiary volcanic acticity and that the Ithaca Peak porphyry may be Tertiary in age. Dings thinks it is Mesozoic, Nevadan in age. The mineral suites include chalcedonic quartz and complex silver minerals. Vugs are present. Thus shallow (epithermal) hypogene deposition is suggested. Dings, however, thinks it is mesothermal.

The Mineral Park ore and gangue mineralization chiefly affects the pre-Cambrian rocks and the Ithaca Peak intrusives. The chief hypogene gangue minerals are sericite, quartz, pyrite, clay (?) and secondary biotite. The hypogene ore minerals known to date are chalcopyrite and minor bornite and molybdenite. Secondary minerals include chalcocite and the various secondary iron, copper and molybdenum minerals. Turquoise was mined for many years and is still mined under lease.

The Ithaca Peak ore body is a typical enriched chalcocite blanket. The capping thickness is approximately 150 feet; the ore thickness, 140 feet. The tonnage estimates vary from 40 to 60 million depending upon basic assumptions used as to costs, cut-off, recoveries and copper price. The per

ton value of the ore is about the same as at the Esperanza property although the ratio of the molybdenum to copper is greater. The waste overburden to be removed prior to commencement of ore production is 23 million tons. It is estimated that the pre-mining stripping will be completed by June 1964.

The aerial photographs reveal a circular form centering around Ithaca Peak. This is perhaps a resolution due in part to the topography and in part to the "circular" "granite" and porphyry intrusions. However, it has been noted previously that in aerial photographs ore mineralization centers in places show such circular or knotty forms. The regional northwest lineation, i.e., the dike, fault and fault-vein swarm stands out as well as does the northeast pre-Cambrian lineation. Less prominent are the north-south and east-west faults and fault veins. In the area of the ore body the northwest and northeast lineations can be distinguished. Clippinger's mapping of the surface area of the ore body reveals intricate shattering with joints, sheeting and faults predominating in the north 40 degrees west, east-west, north-south and north 60 degrees east directions.

Two plans and two sections of the ore body are shown in Figures 1, 2, 3 and 4. The axial trend is northwest. The south end bends southwest. East-west cross-section 2 on the north side reveals a normal blanket-like form, but 400 feet south in about the center, east-west cross-section 6 suggests the presence of a root. A diamond drill hole put down in the center of this thick section bottomed at 876 feet in fair grade, largely primary, ore. This part of the ore body has the highest molybdenum content. The highest molybdenum intercepts contained abnormally abundant sericite and/or

muscovite. The central waste area has a high quartz content. The three dimensional form of the ore body is that of a mushroom.

The outcome of the preliminary reconnaissance capping-alteration observations compared with the known ore body is shown by Figure 2. The lack of good correspondence on the northwest is explained by the normally unfavorable high-pyrite type gossan in that area. The open end to the south contains marginal ore that possibly will be mined at some future date. The exact south limit has not been defined.

GENERAL DISCUSSION

The classic requirement for the genesis of the chalcocite blanket or horizontally tabular type of ore body is a ground surface that is not being eroded too rapidly and a fairly stable ground water surface. Most of the ore bodies in the Southwest are only roughly tabular and some depart greatly from tabularity.

Although the top of the Ithaca Peak ore body appears to conform generally with the present ground surface, it appears unstable. Thus, there are several large oxidation holes (or cones or fissures) cutting through the blanket from which the copper has been largely leached out. The pyrite in the capping is "lagging behind," i.e., some occurs above the chalcocite. The ground water in the adjacent valley stands at about 4,250 feet, but the top of the blanket only 4,000 feet away is at 4,800 feet. In the valley, the sulphides are only a few feet from the surface. Thus, the conditions for enrichment do not seem to follow the classical concept. The ore body, furthermore, seems out of adjustment with the present ground surface and ground water surface. Erosion appears well ahead of oxidation and enrichment.

Nevertheless, the conformation, i.e., parallelism, of the mountain surface and the top of much of the ore body needs to be rationalized. At several places on the lower slopes, the top of the blanket is less than 50 feet below the surface. The capping in places is very dense and impervious.

The Tertiary history of the Southwest is gradually being unraveled. Gregory, Lance, McKee and others offer converging evidence of a Tertiary history somewhat as follows: The last convulsive type of orogeny that included thrusting appears to have occurred in the Miocene, possibly late Miocene. This was closely followed by erosion with some areas approaching a base level possibly near sea level. This relative quiescence may have lasted until the end of the Miocene or early Pliocene. During this period, the Colorado river system was established on a poorly drained broad valley with neighboring mature uplands. This was terminated by the epeirogenic uplift that gave rise to the Colorado plateau and that may have started slowly in early Pliocene and climaxed in upper Pliocene and Pliestocene. The basin and range faulting accentuated with time. We see much evidence of the youthfulness of the present erosion cycle. Thus, in the Southwest, stream gradients are high and sulphides are found in stream bottoms or even at high elevations.

The Ithaca Peak ore body, therefore, may have been largely concentrated in pre-Pliocene time. Since then, the Colorado basin, of which this is a part, has been uplifted some thousands of feet. It seems apparent that the ore body is trying to adjust itself to the mountain profile. This appears possible in some places because of the tightness of the rock, with retained water in the pores in fairly recent times when there was more rainfall. In

some places the ore body appears to be in a process of destruction rather than in one of reconstitution. It may be that the large accumulation of copper at the Emerald Isle mine was derived from the copper released to the ground water through accelerated erosion and oxidation.

The localization of the copper in the Mineral Park area by position and by genesis is of probable interest. It lies only slightly off center from the larger and surrounding area of lead-zinc veins containing some copper, gold and silver. Some of the lead-zinc veins "cut" the porphyry copper ore. The district along with Bagdad and Jerome is part of a north-west prong or extension from the "copper oval" in the Tucson area. Mineral Park is only 24 miles west of the fault that bounds the Cottonwood-Aguarius cliffs on the west.

Without going into detail at this time with respect to the evidence and interpretation of the regional structural conditions, we should note that the Mineral Park and Bagdad copper deposits are very close to the west "boundary" of the Wasatch-Jerome zone of deformation or orogen. Actually, with the exception of Santa Rita, Tyrone and Ajo, all of the major south-western copper deposits are in this zone or adjacent to it.

In detail the Ithaca localization appears to be a three or four way lineation intersection intimately associated with one or more plug-like (?) intrusives (Figure 1). The localization of the peak with nearly exact conformation to the ore body appears to be related to (1) the reinforcing of the rock, especially by alteration, (2) the resistant high quartz center (Figure 2), and (3) the soft pre-Cambrian schist on the north and southeast sides.

SAMPLING

Much of the drilling was done by churn drills. For dependable sampling of bulk type ore bodies, I prefer the churn drill using the now more or less conventional procedures. The chief argument for the churn drill is that in ore bodies as erratic as the "porphyry" coppers often are, as large an amount of spoil as possible is usually desirable depending upon the distribution of ore values. With this type of drill, this spoil may be from 10 to 40 times as much as with the diamond drill. The diamond drill may be more advantageous where geological information is needed. It can be used for inclined holes and is cheaper. I like to use a few diamond drill holes interspersed with churn drill holes, usually in the earlier stages of drilling until the best and cheapest method is apparent. At Mineral Park, many inclined diamond drill holes were needed because of the inaccessibility of many of the drill locations.

As is well known in sampling, we contemplate possibilities from the rarely encountered good homogeneity to extreme inhomogeneity. In the latter case, especially encountered in some gold ores, the entire ore body must be mined before the grade of the ore is known. The bulk copper deposits may fall between these extremes.

In addition to the above aspect of ore bodies is the problem of isolated bunches and masses of ore, i.e., plums in a pudding versus a continuity of streaks, veins, beds, etc. Where the ore body is hidden, we may not be able to be sure, even after extensive drilling, that we do not have "plums in a pudding." Drilling of this latter type of distribution may give deceptively low or high average values. For this reason, most

engineers and geologists feel that some testing by workings of greater or lesser extent is needed to reveal the character of the distribution of the valuable minerals. At the same time, the adequacy of the sampling procedures may be checked by raises and winzes on some of the diamond and churn drill holes. A further dividend is bulk samples for mill tests.

At Kingman, a program of underground testing was carried out that eventually totaled 3,500 feet of drifts and raises. In the beginning, the fact that the assays in raises for, say, ten foot intercepts were appreciably lower than certain relatively high runs in the churn drill holes that were being checked caused some dismay until it was realized that the large bulk of a raise sample smooths out the erratic distribution of the copper in the much smaller samples from drill holes.

This theory seems to have been supported at Mineral Park for when the 3,500 feet of underground work had been finished the average assay when compared with that of the drill holes deviated by only 0.01% Cu.

ACKNOWLEDGMENTS

I am indebted to Duval Sulphur & Potash Company for suggesting that I be the first to announce the details of the development of this new porphyry copper-molybdenum deposit and to John Frost, Don Clippinger, William Roper, Irving Gray and Keith Martin for many field data and ideas. Bill Bessinger took, and kindly supplied, the excellent helicopter project slides.

Presented at the Tucson
meeting of the AIME
December 3, 1962

SELECTED REFERENCES

1. Dings, M. G., "The Wallapai Mining District, Cerbat Mountains, Mohave County, Arizona"; U. S. Geological Survey, Bulletin 978E, 1951.

2. Gregory, H. E., "Colorado Drainage Basin," Am. Jour. Sci., Vol. 245, pp 694-705, 1947.

3. Lance, J. F., "Stratigraphic and Structural Position of Cerozoic Fossil Localities in Arizona," Arizona Geological Society, Vol. 11, pp 155-159, 1960.

4. McKee, E. D., "Sedimentary Basins of Arizona and Adjoining Areas," Bulletin G.S.A., Vol. 62, pp 481-506, 1961.

5. Nolan, T. B., "The Basin and Range Province in Utah, Nevada and California," U. S. Geological Survey, PP 197D, 1943.

6. Schmitt, H. A., "The Origin of the Southwest Metallogenic Province," presented at New York City AIME convention, February, 1958. (Unpublished)

7. Schrader, F. C., "Mineral Deposits of the Cerbat Range.....," U. S. Geological Survey, Bulletin 397, 1909.

8. Thomas, B. E., "Ore Deposits of the Wallapai District, Arizona," Ec. Geol., Vol. 44, pp 663-705, December 1949.

9. Wilson, E. D., Moore, R. T., "Structure of Basin and Range Province in Arizona," Southern Arizona Guidebook II, A.G.S., p. 89, 1959.

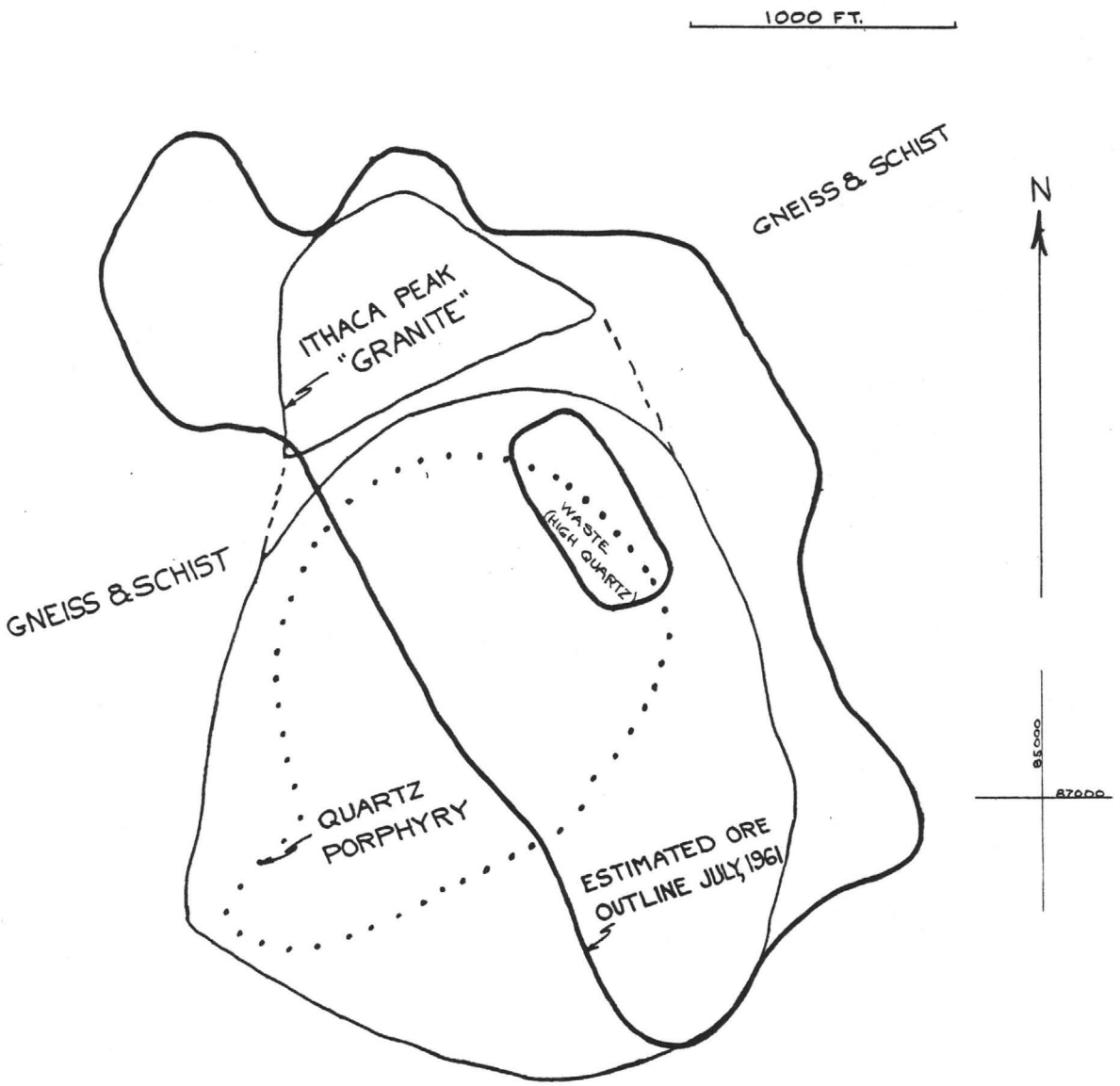


Fig. 1

ITHACA PEAK ORE BODY
AND IGNEOUS ROCK OUTLINES

D. CLIPPINGER, I. GRAY

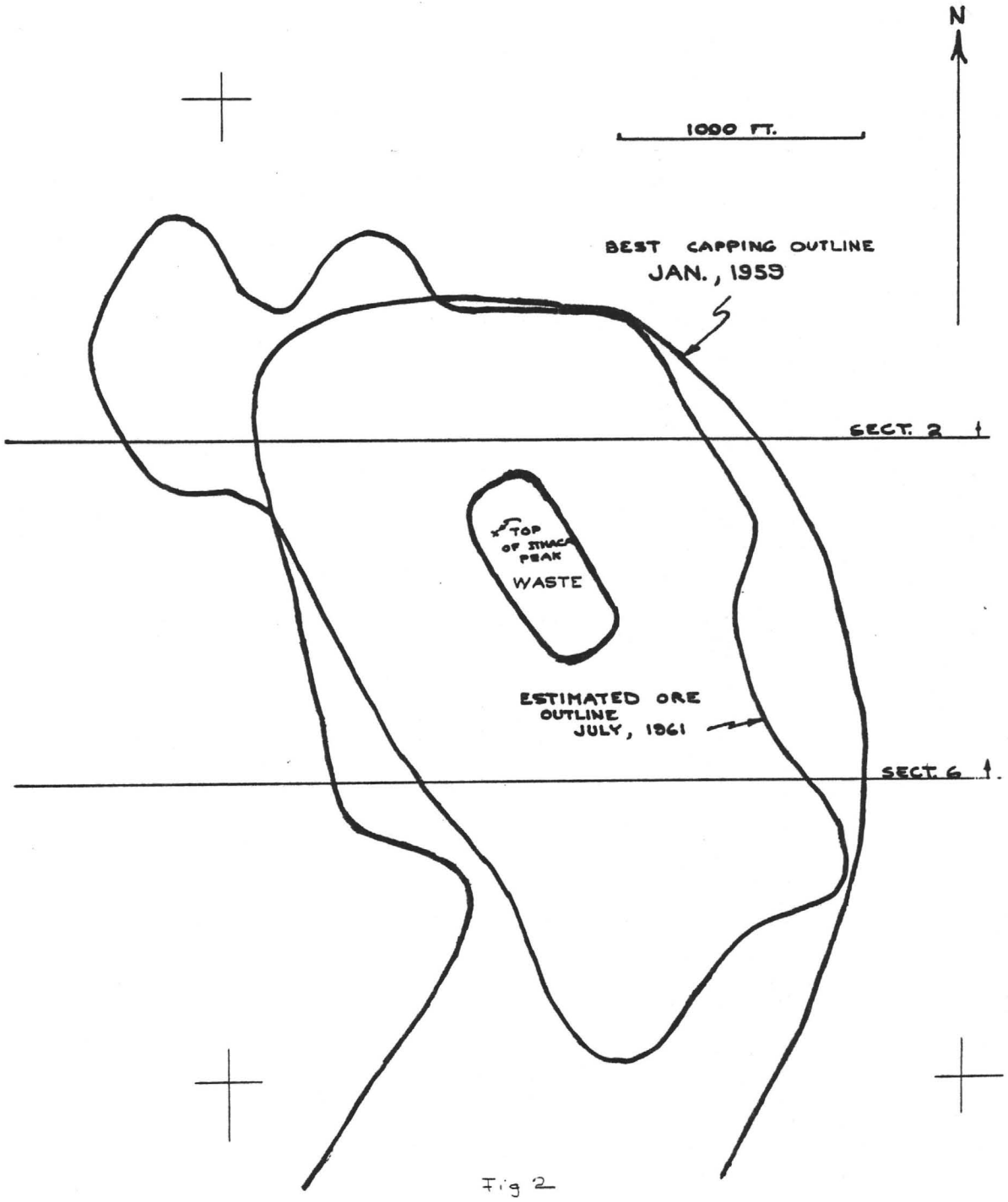


Fig 2

ITHACA PEAK ORE BODY

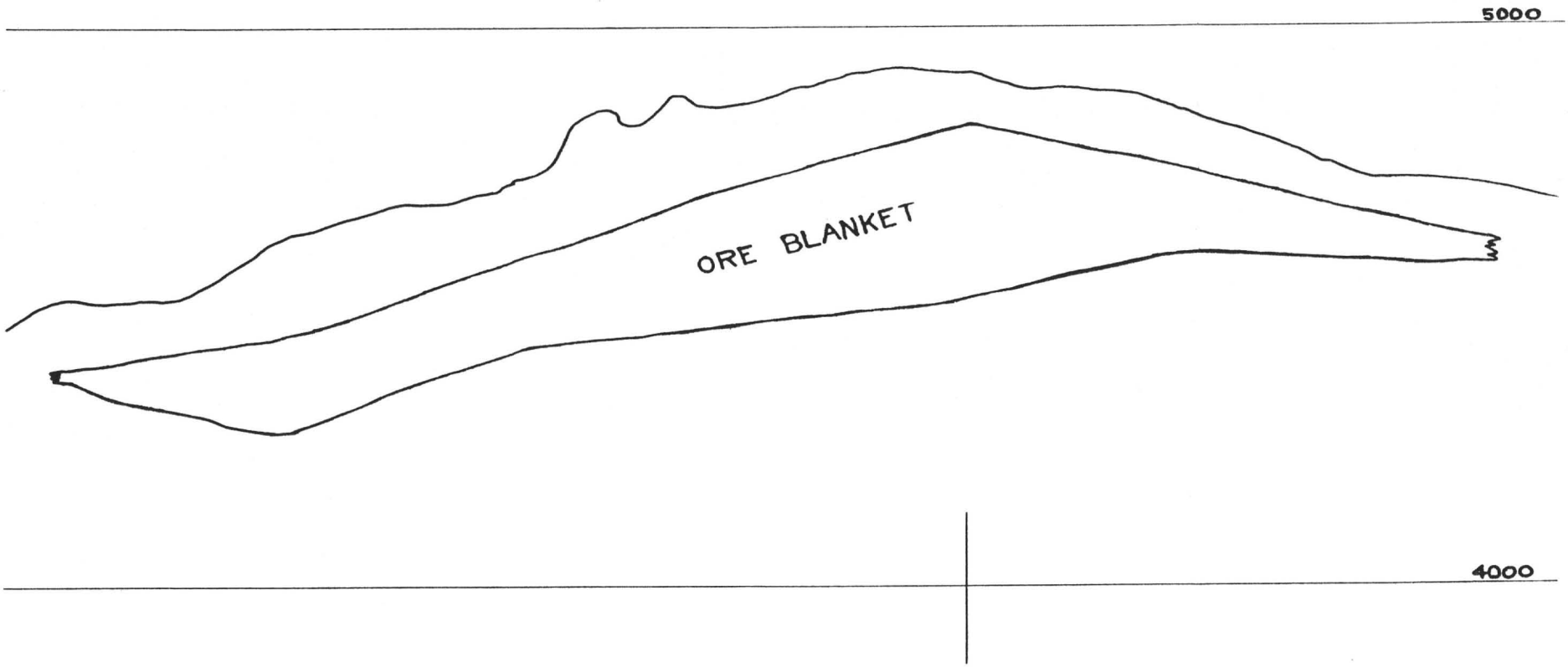


Fig. 3

SECT. 2

LOOKING NORTH

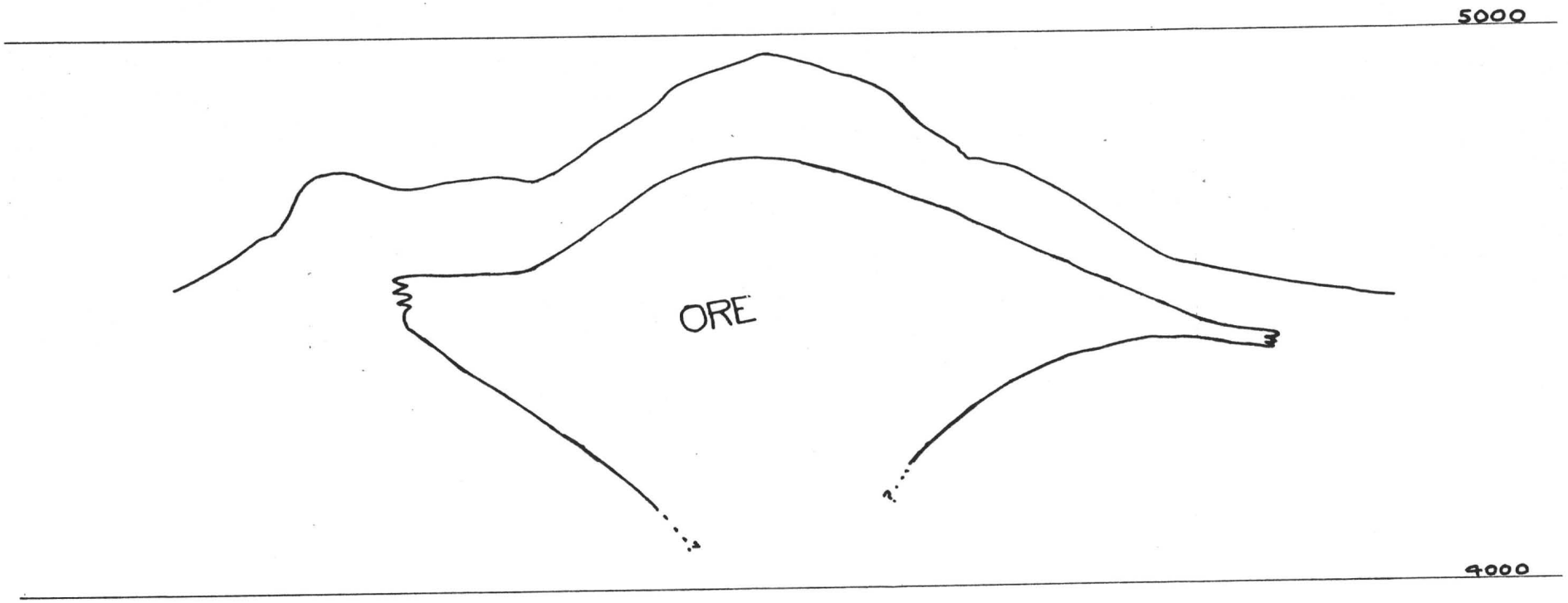


Fig. 4

500 FT.

SECT. 6

LOOKING NORTH

DUVAL CORPORATION

MINERAL PARK PROPERTY

KINGMAN, ARIZONA

DESCRIPTION OF DUVAL'S MINERAL PARK CONCENTRATOR

PRESENTED BEFORE THE

MINERAL DRESSING DIVISION, ARIZONA SECTION, A.I.M.E.

MAY 6, 1966

PREPARED BY

ANTHONY GOMEZ JR. - METALLURGIST

MINERAL PARK CONCENTRATOR - DUVAL CORPORATION

HISTORY

Mineral Park is located in Mohave County, Arizona, about 16 miles northwest of Kingman. It is situated on the western slope of the Cerbat Mountain Range in the Wallapai Mining District, which is about 10 miles long and 5 miles wide.

The earliest mining in the area was for turquoise by Aztec Indians 500 or more years ago. Crude stone hammers and other stone artifacts are still found in ancient trenches, adits, and other workings in turquoise Mountain.

In 1863, gold was discovered in the Cerbat Mountains; however, the camp of Mineral Park is not mentioned until 1870, when rich silver ore was found in the Keystone Mine. The richest ore in the district was produced from the Keystone Mine. It's production is reported to have totaled 3,000 ounces of gold, 450,000 ounces of silver, and small amounts of copper, lead and zinc.

News of the Keystone discovery brought prospectors and miners into Mineral Park from the mining camps of Utah, Nevada and Northern California. In 1876, Mineral Park had a population of 500 and had become the county seat. Soon a number of small mines were discovered and placed in operation. The principal metal values were gold and silver and most of the ore was shipped to the Selby smelter in San Francisco at a cost of $125.00 a ton. Some of the richer ores were shipped by mule drawn wagons to Hardyville on the Colorado River, then by steamer to Yuma, Arizona.

From there it was sent to San Francisco over the newly built Southern Pacific Railroad, and finally, by sailing vessel to Wales in Great Britian.

Declining silver prices in 1882 curtailed much of the mining activity around Mineral Park, although several small lead-zinc and copper properties continued to operate, almost continuously, as late as World War II. As metal prices declined, and high grade reserves were depleted, practically all of the operations in the district were forced to shut down. Only a few gem quality turquoise mining operations were able to continue.

The first drilling in the area was done in 1906-1907 by Calumet and Arizona on what is now known as Gross Peak. In 1948, another copper company drilled six holes in and around Ithaca Peak.

In October 1958, Duval Corporation began acquiring claims in the Mineral Park area and during the period from June 1959 to July 1962, 89 churn drill holes and 34 diamond drill holes were completed. This program outlined a crescent shaped porphyry-type copper-molybdenum ore body embracing Ithaca Peak.

An underground sampling program confirmed the continuity of the ore body and the samples taken from the raises checked the drill hole results. After the final feasibility and engineering studies were completed in late 1962, the decision was made to develop the property as an open pit mine with milling facilities to treat 12,000 tons per day.

Stripping operations commenced in January 1963. Construction of the concentrator and auxiliary facilities started in March 1963. The concentrator start-up and testing began in October, 1964, and the first concentrates were produced in early November 1964. By February, 1965, the designed 12,000 tons per day milling capacity was reached and the plant has been in production ever since and is currently milling 14,000 to 15,000 tons per day.

February 1966

MINERALOGY AND GEOLOGY

The Ithaca Peak ore body is a disseminated porphyry-type copper deposit. It consists of a stockwork or fractured mass of quartz monzonite and quartz porphyry. This stock intrudes precambrian schist, which is also fractured and mineralized. The ore mineralization consists predominantly of chalcocite and molybdenite. The chalcocite extensively replaced pre-existing chalcopyrite and coats nearly all pyrite. Minor amounts of sphalerite, argentiferous galena, covellite, as well as chalcopyrite are also contained in certain areas of the pit. Turquoise and minor copper sulfates are the only copper minerals in the shallow oxidized capping. Ferrimolybdite is also abundant in the capping. The gangue consists of quartz, sericite, and clay.

CRUSHING

Crushing of the ore utilizes conventional three stage crushing by a 48 x 77 primary gyratory crusher, followed by one 13 x 84 secondary cone crusher, and two 7 x 84 tertiary cone crushers, operating in closed circuit with vibrating screens. The crushers are equipped with hydraulically supported mantles to facilitate the the adjustment of the crusher settings while operating under load. These hydraulic installations are equipped with Duval designed instrumentation and automatic controls. Thus, the secondary-tertiary crusher circuit is subject to fully automatic control by setting the tertiary crusher at a desired product size and operating each crusher in the circuit at optimum capacity.

Ore is delivered from the mine to primary crusher by 65 ton end dump trucks. The ore is dumped directly on the crusher and the crushed ore, usually minus 8 inches, discharges onto a 72 x 16 inch apron feeder. The coarse crushed product is conveyed to a 35,000 ton live capacity open storage pile.

The coarse ore is drawn from the stock pile by 28 Jeffrey vibratory feeders each capable of feeding 0 to 200 tons per hour. It is then conveyed on 48" belts to the secondary crusher plant and the ore is weighed by a nuclear belt scale. The ore is fed to a 6 x 12 vibrating grizzley with 1-3/8" slots. The oversize from the grizzley is crushed by the secondary crusher and the undersize discharges on a 6' x 14' vibrating screen with 5/8" slots. The secondary crusher product discharges to another vibrating screen. The oversize from this screen joins the oversize from the first screen and is conveyed to the tertiary crushers, which are in closed circuit with vibrating screens. The circulating oversize material is returned to the tertiary crushers and the undersize joins the undersize from the first two screens on a 48" conveyor which takes it to a 10,500 ton live capacity fine ore bin in the mill where a Link Belt traveling tripper distributes it over the length of the bin.

The primary crusher has a design capacity of 1,500 tons per hour and operates 2 shifts a day six days a week. Design capacity of the secondary-tertiary circuit is 1,000 tons per hour. This provides for a 7 day week, 2 shift per day operation. Crusher and auxiliary equipment maintenance is performed on the off-shifts.

Each crushing plant has its own dust collecting system. The dust is recovered with centrifugal type rotoclone collectors with pick-up points also located in the fine ore bin and the wet grind feed belts.

WET GRINDING

Wet grinding operations, along with flotation, are performed in two mill sections that are metallurgically independent. Each section produces its own

final concentrate and tailings. This allows for competitive plant scale metallurgical testing.

Each grinding section consists of two grate discharge mills each in closed circuit with 20" cyclone classifiers. The mills are 20' diameter by 11' long and are powered by 1500 HP synchronous motors. These mills were designed as autogenous mills, using ore media instead of steel grinding media. Although the mills are capable of production in excess of their designed capacity as autogenous mills, additional tonnage capability was realized by using conventional steel media and the mills are presently operating as ball mills.

The mills reduce 80% minus 1/2" feed to a 80% minus 100 mesh product at 35-38% solids for flotation feed. Each mill is fed from four feeder chutes located under the mill fine ore bin. The belts for these chutes are driven by a variable speed motor that is controlled by the operator for making manual tonnage changes. These belts discharge into two gathering belts and then into the mill feed belt which passes through a nuclear belt scale and discharges into the mill feed spout. The mill feed rate is subject to automatic control by utilizing the power draught of the mill, which is measured continuously. The mill speeds are 65% of critical.

Total water addition to the grinding circuits is controlled by instruments. The water is divided between the mill feed spout and the mill discharge pump sump to maintain the desired mill discharge pump density.

The ball mill discharge is delivered to the cyclones by a 12 x 10 Denver SRL pump or a 10" Wilfley. These pumps are used interchangeably. The cyclone and pump arrangement was engineered for minimum head. The cyclones are mounted with their axis 15 degrees from horizontal, and the underflow discharges are oriented toward the mill feed spout. The cyclone overflows are gathered together

and discharged into a pipe that feeds the rougher flotation pulp distributor. The cyclones are equipped with 3" refrax apex inserts and 6-3/4" nihard vortex finders. The cyclone connections are victaulic couplings to allow for easy removal of individual cyclones for repairs.

Three of the mills are charged with 2" and $2\frac{1}{2}$" forged steel balls. The fourth mill is charged with $1\frac{1}{2}$" and $2\frac{1}{2}$" cast steel balls. The ball size feed ratio is 1 to 1 on all mills. Double wave chrome-moly shell liners are used. The feed head liners and discharge grates are also made of chrome-moly steel. Other wear parts are made of nihard or chrome-moly steel. Three mills have 3/8" discharge grate slots and one mill has $\frac{1}{2}$" slots.

FLOTATION

The two flotation sections are equipped with No. 24 Denver free flow cells with double froth overflows and froth paddles. The roughers are arranged in 14 parallel rows (banks) of 10 cells each in each flotation section. Each rougher bank is provided with Duval automatic pump level controls at each of three levels.

The tailings from the roughers are the final plant tailings and are flowed by gravity to the tailings thickener. The rougher flotation concentrate is advanced for up-grading and is first re-ground in two ball mills, one per section. The re-grind mills are 10' x 10' grate discharge mills charged with $1\frac{1}{2}$" cast steel balls, to grind to essentially all minus 200 mesh. Initially, the rougher concentrate is pumped to three 10" cyclone classifiers per mill. The underflow is fed to the re-grind mills and the overflow is pumped to a pump distributor for feeding to parallel rows of cleaning flotation cells.

The cleaner cells are arranged in 8 banks per section, and 4 cells per bank. Duval automatic pulp level controls are provided on each bank. Finished concen-

trate is produced in the first two cells. Concentrate from the last two is fed to re-cleaner cells for further cleaning. The cleaner rejects are returned to the primary grinding circuit as part of the automatically controlled dilution water.

Re-cleaning is accomplished in each section by two rows of 4 cells each. The re-cleaner rejects are returned to the cleaner feed and final copper-molybdenum concentrates are flowed to a 50' diameter thickener on each section.

Flotation reagents currently in use are: Potassium Amyl Xanthates and Reagent S-3302 as copper-molybdenum flotation collectors along with stove oil as the molybdenite promoter. MIBC is the frother. The reagents are fed by flowrators located on instrument and flotation control panels. Recorders provide a continuous and permanent record of reagent consumption. Flotation feed alkalinity, normally in the PH range of 11.5, is automatically controlled by instrument controlled addition of milk of lime to the grinding mill feed.

All the flotation products are sampled by automatic samplers. The mill feed is sampled manually by the operator.

TAILINGS DISPOSAL

The final plant tailings are thickened in 225' thickeners, one per section. Make-up water is added to the tailings thickener. The thickener overflow is used in the mill as process water. Thickener underflows are controlled manually by darts in spigot lines. The pulp density is maintained at 55% solid and the slurry flows by gravity through 15" transite pipe to the tailings dam. Where they are required, drop boxes are provided to maintain a line gradient of 0.8% to control pulp velocity.

The tailings line on the dam is maintained horizontal with 149 outlets spaced 39' apart provided for cyclone connections. The tailings dam is developed by raising an 8 foot berm with a 3/4 yard dragline using the coarse sands

deposited in front of the berm by cyclone classifiers. The cyclone overflow material is released 40 feet in front of the berm. After the sanding phase is completed, the tailings are released without classification at a high volume flow rate to permit transport of tailings as far beyond the dam as possible.

Water from the tailings collects at the end of the tailings disposal area and is diverted by channels following the natural contours to a pond or ditch. The reclaimed water is returned to the mill by a skid mounted pump with a suction hose.

CONCENTRATE HANDLING

The final copper-molybdenum concentrates are advanced to 50' diameter thickeners in each section. Thickener overflows join the mill water circuit and the combined underflows are pumped to the molybdenum recovery plant. The pulp density of the underflow is controlled by instrumentation.

Finished copper concentrate is the reject of the molybdenite rougher flotation. The concentrate is piped to one 60' diameter thickener. The underflow is pumped to one of two 8' x 10' four disc filters. One filter is used most of the time; however, the second one is maintained ready for use as required. The filtered concentrate cake is conveyed to a storage area, then loaded by front end loader into 25 ton trucks and hauled to the railroad siding in Kingman for shipment.

MOLYBDENUM RECOVERY

The thickened copper-molybdenum concentrates are pumped to the molybdenum recovery plant. After conditioning, the pulp is steamed and heated in a 6' 6" pressure vessel. The hot pulp leaving the steamer passes through heat exchang-

ers to transfer the heat to the cold pulp feeding the steamer. Instrumented controls are provided for the steaming operation.

The steamed pulp is cooled by dilution and conditioned with the flotation reagents and then pumped to flotation. Rougher flotation is conducted in two parallel banks of 10 Number 24 Denver flotation machines having double froth overflows and equipped with froth paddles. The pulp level in the cells is controlled automatically. Rougher tailing is the final copper concentrate. The rougher concentrate is piped to a 40' diameter thickener. Thickener underflow is fed to a 6" cyclone operating in closed circuit with a 5' x 6' ball mill. The cyclone overflow is pumped to the head cell of a 10 cell bank of cleaner flotation machines.

Single froth overflow flotation machines are used for cleaner flotation. The cleaner rejects are returned to the copper-molybdenum concentrate thickeners. All of the cleaner concentrate is pumped to the number five cell of a 10 cell bank of recleaning flotation machines. Cell-to-cell re-cleaning is provided with concentrates advancing to the number 1 cell in the bank, which produces the final molybdenite concentrate. Re-cleaner rejects are returned to the cyclone feed in the re-grind circuit.

Molybdenite concentrate is stored in a surge tank and pumped to a 4' x 4' drum filter. The filter cake discharges to a conveyor belt equipped with a load cell belt scale and fed into a 20 foot I.D. ten hearth roaster. The roasting operation is fully instrumented with hearth temperature recorder controllers, burner flame-out protection, draft controllers, and automatic lighting of pilot lights and burners. The roaster calcine discharge is passed through a hammer-mill to reduce lumps. The calcine is further purified by leaching. It is filtered, washed and finally dried in a 10 foot I.D. four hearth dryer. Purified molybdenum trioxide calcine is weighed and packaged in 55 gallon drums for shipment.

Reagents used in molybdenite flotation are: Sodium ferro cyanide as depressing agent, stove oil as collector, MIBC as frother, and sulfuric acid for PH adjustment.

REAGENTS

The reagents used in both plants and their amounts are shown in the table below.

TABLE I

COPPER-MOLY FLOTATION

REAGENT	LBS. PER TON ORE MILLED
Potassium Amyl Xanthate	0.006
S-3302	0.020
Stove Oil	0.050
M. I. B. C.	0.080
Lime	3.20
MOLY FLOTATION	
Sodium Ferro Cyanide	4.75
Stove Oil	0.75
M. I. B. C.	0.80
Sulfuric Acid	1.60

Mixing and storage of all reagents is performed in one building. Stove oil, MIBC, and concentrated sulfuric acid are stored outside the reagent building in steel tanks. Stove oil and MIBC are piped and gravity fed directly to points of use. Concentrated sulfuric acid is diluted before piping it to the feed points.

The xanthate and sodium ferro cyanide are mixed with water in tanks and gravity fed to the mill and points of use. Reagent S-3302 is fed from stock tanks in the reagent building.

Lime is purchased as pebble quick lime. It is slaked on day shift only in a 5 x 6 ball mill operating in closed circuit with a 24" spiral classifier. The slurry produced, 18% solides, is piped to two lime storage tanks and then circulated through the lime loop.

WATER AND POWER

Fresh water is pumped from five wells located about 14 miles southwest of Mineral Park. The water system is capable of delivering 3,000 gallons per minute into a 16" pipeline to two booster stations and then to a 46,000 gallon raw water terminal tank located on the mill site. It is then pumped to a 281,000 gallon head tank for distribution throughout the plant. A radio microwave system automatically operates the pumping system.

Reclaimed water from the thickeners is reconverted into pump sumps and then pumped to the points of use in the mill loop. Reclaim water from the tailings disposal dam is pumped to a 3,000,000 gallon concreted reservoir. Storage tank overflows are collected in this reservoir. The reservoir provides make-up water to the tailings thickener overflow for the mill loop.

Mine water and fire protection water is taken off the line from the terminal tank and the head tank.

Power to the plant is supplied by Citizena Utilities Company by a generating plant located at Mineral Park. Three phase alternating current is supplied at 4,160 volts and 60 cycles. The voltage is stepped down by transformers as required for distribution to the various circuits throughout the plant. The water field is supplied current directly from Davis Dam. The average power consumption for 1965 was 16.74 KWH per ton of ore milled.

LABOR

Mill operations are under the supervision of the Mill Superintendent, assisted by a Mill Foreman. All of the mill operations are supervised each shift by a shift foreman.

Crusher and mill maintenance is performed by day crews from the Maintenance Department, except for routine repairs which are made by a shift mechanic. Also, an electrician and instrument technician are assigned to every shift.

Mill operating hourly rated personnel averaged 73 in 1965. This includes operators, sub-operators, and laborers.

METALLURGY

The principal recoverable minerals in the ore are chalcocite and molybdenite. Ore milled in 1965 averaged 0.460% total copper with .050% as acid soluble copper and .030% molybdenum. The ore is metallurgically classified as two types - monzonite and schist. Blending of the two types of ore is practiced whenever possible.

Daily laboratory analysis of all flotation and end products serve as means for quality control and metallurgical production statistics.

Typical metallurgical performance data are shown on Table II.

TABLE II

Tons milled per day = 14,000 to 15,000

Operating time, % of possible = 95.0

COPPER-MOLY FLOTATION

FEED	
% Total Copper	0.480
% Acid Soluble Copper	0.065
% Sulfide Copper	0.415
% Molybdenum	0.030
% Acid Soluble Molybdenum	0.002
TAILS	
% Total Copper	0.075
% Acid Soluble Copper	0.040
% Sulfide Copper	0.035
% Molybdenum	0.006
CONCENTRATE	
% Copper	22.0 to 25.0
% Molybdenum	1.25
RECOVERIES	
Total Copper	85.0
Sulfide Copper	92.0
Molybdenum	80.0

MOLYBDENUM FLOTATION

Feed, % Mo	1.25
Tails, % Mo	0.040
MoS_2 Concentrate, % Mo	55.50
MoO_3 Calcine, % Mo	62.0
Section Recovery	96.0
Overall Recovery	76.0

1965

Tons ore mined - Pit Run 4,914,494

 lbs of Concent. 36,618,689

PPTs 1,483,888

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 397

MINERAL DEPOSITS

OF THE

CERBAT RANGE, BLACK MOUNTAINS, AND GRAND WASH CLIFFS

MOHAVE COUNTY, ARIZONA

BY

F. C. SCHRADER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

The Estella prospect has six veins, which are mostly small, some of the larger being about 2 feet thick. They strike mostly about N. 60° to 70° W. and dip steeply southwest. They consist principally of quartz and other oxidized material and are said to have produced good silver chloride ore, and some that contained values of $25 in gold to the ton.

The Estella-Bronco vein, to judge from the croppings, is about 4 feet thick and has an extent of at least 200 feet. It dips northeast at angles of about 80°. Its ore contains iron pyrites and green silver chloride. The vein of the Flora prospect is 20 to 30 inches wide. It dips about 30° NE., and contains two 3 to 5 inch streaks of oxidized galena ore, which is reported to average about $30 in lead to the ton. The deposit is associated with the contact of the aplitic intrusive with the older granitic rocks.

The Congress prospect, also known as the "Great Bronco," is situated in Mineral Park Wash, about three-eighths of a mile west of Mineral Park, mainly on the south side of the wash. It is owned by James Uncapher. It is a mineralized shear zone, or a fault zone, with an observed width of 300 feet and a reported width elsewhere of 600 feet. It trends N. 50° W., is in alignment with Ithaca Peak and Niggerhead, and is reported to be the same "ledge" on which the Queen Bee mine is located. It is probable that the Queen Bee and Pinkham veins and the Congress ledge are all associated in this locality, but their direct connection was not traced. The deposit occurs mainly in the granite porphyry at or near its contact with the pre-Cambrian complex. It consists of more or less silicified and in part altered and iron-stained gray porphyritic granite, with pyrite and chalcopyrite forming the principal part of the ore, disseminated more or less throughout. The deposit, where best exposed and opened in the wash by shallow workings extending more or less across it, is reported to average about $5 a ton in copper, silver, and gold. Here conspicuous patches and areas of malachite and azurite resulting from recent oxidation occur on the surface and basal slopes of the workings, and much of the surface diggings is stained yellowish and greenish. The deposit has received the consideration of some of the largest companies in the Southwest. Whether values will be found in depth seems doubtful.

The McDonald prospect, situated within a few hundred feet of the top of Cherum Peak on the south side, is on a ledge that dips steeply north and is reported to contain tungsten ore.

The Argo prospect, said to be located at an elevation of about 6,000 feet, is reported to have shipped some high-grade ore running from 200 ounces up in silver and containing good lead values.

The Swift claim is said to have produced and shipped some ore containing good values in gold, silver, and lead.

The ore shoot of the Sabbath [illegible] vein, opened by [illegible]90-foot shaft, is reported to contain about 2 ounces of gold and 40 to 50 ounces of silver to the ton.

CERBAT DISTRICT.

GENERAL OUTLINE.

LOCATION AND HISTORY.

The Cerbat district extends southward from the Mineral Park district for about 4½ miles and from the border of Sacramento Valley on the west to the crest of the range on the east, with a maximum width of about 3 miles in the southern part.

Cerbat, the principal camp and post-office, is situated on Cerbat Wash in the foothills at an elevation of about 4,000 feet, 3 miles from the nearest station of the Arizona and Utah Railroad on the west and 14 miles north of Kingman. Its origin dates from the early sixties, when the Golden Gem, Cerbat, Idaho, Twins, Champion, Vanderbilt, Eureka, Flores, Esmeralda, and Columbus mines were discovered or opened. It has always been a producer of high-grade ore and is reported to have produced more than $2,000,000.

A small smelter was operated here in the so-called Indian days, in the middle of the sixties, but for want of proper fluxes, for which tin cans and scrap iron were substituted, the process was not very successful, the lead being turned out in an extremely crude state.

TOPOGRAPHY.

The district ranges in elevation from 3,000 feet in the foothills on the west to 5,000 feet on the east. Stockton Hill, on the opposite slope of the range, is reached by trail only. (See fig. 16.)

The southern part of the district is drained mainly by Cerbat Wash, which leads westward across the district into Sacramento Valley. Its principal tributary from the south is Charcoal Canyon, which is several miles long and joins it just below Cerbat.

The northern part of the district is drained principally by Long Wash, which leads northward and westward into Sacramento Valley. The nearest railroad station to this part of the district is Mineral, about 3 miles to the west. Several small depressions which open into Long Wash from the east are known as Union Basin, Todd Basin, and Lane Springs Basin.

GEOLOGY.

The country rock is the pre-Cambrian granite, gneiss, and schist complex. It is intruded by dikes of minette, granite porphyry, diabase, rhyolite, basalt, and other rocks, some of which are associated with workable veins and are too greatly sericitized for determination. The complex is also flanked on the west by masses of the Tertiary volcanic rocks, principally rhyolite.

Probably the best exposure in the Cerbat Range is in Charcoal Canyon southeast of Cerbat. The canyon cuts across the beds diagonally and exposes most of the pre-Cambrian rocks, including granite, gneiss, pegmatite, schists, and syenite, together with veins and dikes occurring in the complex. The series is cut by faults, some of which now contain ore bodies.

The schistosity strikes north-northeast, with dip mainly west-northwest, varying from 70° to vertical, and the jointing trends west-northwest, with steep dip to the northeast.

Prominent among the dikes is the well-known "great white dike," so called from the fact that it weathers light buff. It extends throughout the greater part of the canyon and is associated with workable ore deposits. It is 40 feet or more thick. It crosses Cerbat Wash near the mouth of Charcoal Canyon, underlies the Gross ranch to the northwest, and is reported to extend much farther. It is a dark greenish basic rock, which is now altered and sericitized beyond adequate determination. Though profusely jointed and sheared, it seems to be younger than the granite porphyry intrusives with which it comes into contact.

THE DEPOSITS.

The ore deposits of this district contain principally gold, silver, and lead. They occur in fissure veins, which in general have a northwesterly trend and a steep northeasterly or southwesterly dip. Those situated north of Cerbat Wash are chiefly gold-bearing; those to the south contain principally silver and lead. The gangue is mainly quartz and the values usually favor the hanging wall. The principal minerals are pyrite, chalcopyrite, galena, zinc blende, stibnite, and native gold. Near the surface native silver, horn silver, argentite, and ruby silver appear, but the water level is only about 80 feet deep, and consequently primary sulphide ore comes in at relatively slight depth.

The deposits are opened by about thirty mines, a sketch of some of which follows. The most important mines, nearly all of which are now producing, are the Golden Gem, Vanderbilt, Champion, Oro Plata, Paymaster, New London, Idaho, Cerbat, St. Louis, Flores, Twins, Columbus, Alpha, Night Hawk, and Rip Van Winkle.

MINES NEAR CERBAT WASH DRAINAGE ON THE NORTH.

GOLDEN GEM MINE.

Location, history, and production.—The Golden Gem mine is located at Cerbat, on the hillside which slopes to the west. The mine was discovered and began to ship ore in 1871. Subsequently it lay idle for some time until it was acquired by T. L. Ayers, who shipped a very large amount ($200,000 reported) of rich (5-ounce) gold ore. He also hauled some of the ore to the C. O. D. mill, and left over

2,000 tons of second-grade ($24) ore on the dump, much of which still remains. Later the property was bonded to the Golden Gem Mining Company, of New York, of which Senator Warner Miller was president. This company sunk the shaft deeper and drifted, but as the ore on the 300-foot level fell off in grade, the mine was closed in 1904. It remained idle until 1906, when it was sold for $75,000, and is now owned by the Golden Star Mining and Milling Company.

A 40-ton mill with four Nissen stamps, recently installed, is now daily turning out about $350 worth of concentrates from the ore formerly left on the dump. Twenty per cent of the gold is collected on the plates. Preparations are being made to unwater and retimber

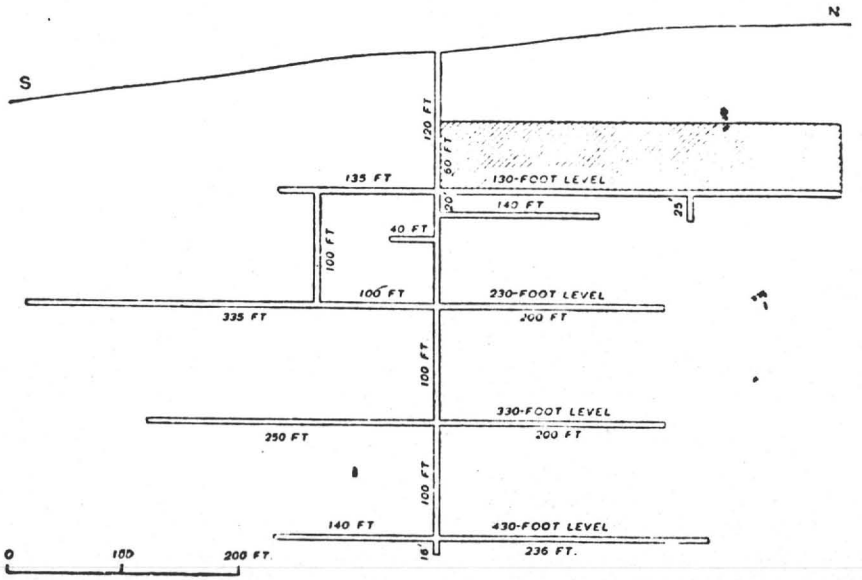


FIGURE 13.—Longitudinal section showing development of Golden Gem mine.

the old shaft of the mine, which at the time of visit was filled with water to the 200-foot level. This mine has produced good ore from the surface down, and the total production is said to have amounted to $190,000.

Development.—The mine is developed principally by a two-compartment shaft, 435 feet deep, and four levels containing about 1,200 feet of drift, winzes, and stopes. The levels are located at 130, 230, 330, and 400 feet below the surface. The first level contains 350 feet of drift north and 135 south from the shaft; the second level 200 north and 355 south, the third level 200 north and 200 south, and the fourth level 246 north and 140 south. (See fig. 13.) The only stopes are on the 130-foot level. They extend 66 feet horizontally and from 62 to 81 feet vertically.

The principal surface equipments are the 40-ton mill above mentioned, a 34-horsepower hoist, and distillate engines, aggregating 79 horsepower, for operating the plant.

Geology and ore deposits.—The country rock is the pre-Cambrian granite, gneiss, and schist complex. Fine-grained iron-gray gneissoid schist usually forms the hanging wall of the vein. The structure trends north-northeast and the rocks are intruded near by by diabase and granite porphyry or monzonite porphyry dikes. The much-altered diabase occurs in association with the vein.

The vein strikes about N. 40° W. and dips about 78° NE. It ranges from 6 to 14 feet in width and usually carries from 2 to 6½ feet of pay ore running from $10 to the ton upward. The ore shoots are reported to be more regular in the deeper part of the mine than near the surface.

The gangue is chiefly quartz and altered rock and is imperfectly banded. Some of the quartz is similar to the Gold Road type described on page 158. The ore contains chiefly gold, but carries also silver in places as high as 60 ounces a ton. The ore minerals are galena (5 or 6 per cent), zinc blende, pyrite, and stibnite. The vein is banded and shows evidence of intradepositional faulting. The values usually favor the foot wall, but vary in position, and locally rich ore streaks 2 feet wide occur on both sides of the vein.

Southeast of the mine the vein is about 6 feet in width and, as shown by croppings, extends about one-fifth of a mile to Cerbat Wash, where there are some indications that it may be split. So far as opened in the mine and two surface prospects beyond, the ore is reported to run about $20 to the ton.

On the 130-foot level, 270 feet northwest of the shaft, the vein is faulted off diagonally along the schistosity on the south or foot-wall side of a 4-foot band of dark schist. The ore shoot from the shaft to this point looks well and is reported to average high in gold.

The face of the drift extending south of the shaft on this level is reported by the foreman who had charge when the mine was suspended to contain a 24-inch streak of $48 ore.

VANDERBILT GROUP.

General description.—The Vanderbilt group comprises the Vanderbilt, Idaho, and Columbus mines, situated near together in the foothills at Cerbat, just north of the Golden Gem mine. The group is owned by the Cerbat Mining Company, with headquarters at St. Louis. At the time of visit the company was installing a 25-ton mill to treat the low-grade ore from the upper part of the mines by calcination and amalgamation of the concentrates, there being a large amount of low-grade ore, especially in the Vanderbilt. The ore from the lower levels, owing to its richness, is shipped direct to the smelter.

Vanderbilt mine.—The principal mine of the group is the Vanderbilt mine, located about half a mile northwest of the Golden Gem and a little above it, near the head of Flores Gulch, which drains westward into Sacramento Valley. The Vanderbilt is one of the oldest mines in the camp. It was located early in the sixties and is now producing. It is developed principally by a 300-foot shaft and 800 feet of drift and crosscuts.

The country rock (locally called syenite) is pre-Cambrian fine-grained gneissoid chloritic schist, and is probably derived from a diorite which has been greatly sericitized and otherwise altered. Associated with the vein on the foot-wall side is a "porphyry dike," which may represent the intrusive granite porphyry.

The deposits occur in a fissure vein, which, like the Golden Gem vein, dips about 80° NE. and is supposed to represent the northwestward continuation of the Golden Gem and Idaho veins beyond their point of junction.

The ore, as in the Golden Gem mine, contains chiefly gold values, but carries silver also. The ore minerals are pyrite, zinc blende, and stibnite. The ore occurs mainly on the hanging-wall side. The best grade is reported to average about $500 or more to the ton. Galena occurs from the surface down to the 200-foot level, below which no lead ore has yet been found.

From the upper levels the mine is reported to have produced $150,000, and it has also yielded considerable ore to the present company.

Idaho mine.—The Idaho mine is located at Cerbat, near the Golden Gem mine, on slightly lower ground in a gulch on the west. It is one of the early discoveries of the camp, its ore being worked by Mexicans in arrastres during pioneer days, and it has been worked in a small way since 1871. It is developed principally by a 110-foot shaft sunk on the vein and 275 feet of drift. The shaft is reported to be wholly in ore and to show in the bottom a width of 5 feet of solid ore, which averages about $20 to the ton.

The geology and the ore are similar to those of the Golden Gem mine. The vein strikes N. 20° E. and dips 80° E. It averages about 4 feet in width and its ore shoot about 2 feet. The ore contains principally gold, with some sulphide of silver, galena, pyrite, and a little chalcopyrite. The production is reported to be $250,000.

Columbus mine.—The Columbus mine is about one-fourth mile northwest of the Vanderbilt mine, near the upper side of Flores Wash. The deposits are contained in a fissure vein, which has been opened principally by two shafts reported to be 175 and 200 feet deep and by 500 feet of drift. The production is said to be several hundred tons of rich ore.

ROBERT EMMET MINE.

The Robert Emmet mine, situated north of the Vanderbilt mine, is reported to be on a large vein, which is said to contain good values in gold and to have been a producer of rich gold ore.

FLORES MINE.

The Flores mine is located in the foothills on the upper part of Flores Wash, a short distance below the Vanderbilt and Columbus mines, northwest of Cerbat, and about 700 feet above Sacramento Valley. The property comprises a group of four mining claims.

The mine was first located in 1871 by a party of prospectors from Nevada, but owing to the hostility of the Indians actual mining did not begin until 1875 or 1876. At one time the mine was known as the Five Forks mine, from the ramification of the north end of the vein into five parts.

One of the early operators was Charles M. Gross, sr., a resident of Mineral Park, who afterwards became owner of the mine. In 1888 it was acquired by the Flores Mining Company, of Philadelphia. This company at once installed a 14-ton double-rocker mill, hoist, and other machinery and worked the mine until 1893, when, owing to financial difficulties, the mine was closed and sold for taxes. It was bought by W. N. Gurley, whose widow still owns it. The mine has not been operated since 1893, and is now filled with water to the 100-foot level.

The mine is reported to be developed to a depth of about 300 feet, with but little stoping. The principal surface equipments are a 5-stamp mill and a steam hoist. The mill is equipped for fine crushing and amalgamating, as the ore contains free gold.

The production is reported to have been considerably more than $200,000.

The country rock is the pre-Cambrian granitoid schist, and the intrusive granite porphyry seems to be present near by. The deposit is in a fissure vein about 4 feet thick, which dips 80° to 85° NE., but at the surface, where the vein is crosscut by Flores Gulch, it locally dips in an opposite direction. The croppings are chiefly reddish and brown iron-stained quartz and crushed or brecciated rock.

Though some ore averaging as high as $1,000 to the ton has been produced, the ore is mostly of too low grade to ship. It is contained in an oxidized gangue, composed chiefly of quartz and altered rock.

The ore contains gold, with silver sulphide, some zinc blende, and galena. It favors the hanging-wall side of the vein. Mr. Gross is reported to have handled ore averaging $60 or more only, but the Flores Company, with the mill now on the ground, profitably handled ore ranging as low as $6 a ton.

ESMERALDA MINE.

The Esmeralda mine is located in low, gently rolling foothills about a mile west-northwest of Cerbat, at an elevation of about 3,750 feet. It is owned by the Ark and San Antonio Mining and Milling Company, of St. Louis. It is developed principally by a 200-foot shaft and two levels containing about 250 feet of drift, with some stoping near the surface. The 110-foot level extends 90 feet south and 30 feet north of the shaft. At the time of visit the shaft contained water. The principal equipment is a 10-horsepower steam hoist.

The production is reported to be $90,000.

The country rock is the pre-Cambrian complex, with schistose structure trending about N. 35° W. The rock is intruded near the mine on the northeast by a fine-grained granite porphyry dike, several hundred feet in width.

The deposit is a fissure vein, which strikes N. 35° W., parallel with the schistosity in the country rock, and dips about 75° SW. The vein is from 4 to 5 feet in width. Its gangue consists mainly of quartz and crushed and more or less altered country rock. Oxidation extends to the depth of 90 feet below the surface, below which the ore consists of sulphides and contains chiefly pyrite and chalcopyrite, with gold and silver. A carload of the concentrates that was shipped is reported to have averaged 13.42 ounces of gold and 40 ounces of silver to the ton. The ore usually shows a crude banding about parallel with the vein.

CERBAT MINE.

The Cerbat mine is about a mile northeast of Cerbat, and the Golden Gem mine, in the foothills, on a side gulch of Cerbat Wash and near the top of the ridge separating it from Long Gulch on the north, at an elevation of about 4,600 feet. This mine is one of the early discoveries. Two operators were killed in it by the Indians in pioneer days. It was opened in 1869 and was worked by a whim in 1875. About 1880 a large mill was installed in the gulch below the mine, but operations have now been suspended for some time. The mine is owned by the Cerbat Mining and Milling Company, of Minneapolis. It is credited with a production of about $300,000.

The mine is developed principally by a 180-foot shaft, drifts, and stopes. The principal surface equipment is the large mill above mentioned.

The deposit forms a fissure vein 4 to 10 feet wide, contained in the pre-Cambrian complex. The vein strikes north-northwest, with bold croppings locally rising 8 or 10 feet above the surface. The gangue is mostly quartz, with some crushed and recemented rock. The ore

contains chiefly gold, with silver and copper also. The copper occurs mainly in the form of chalcopyrite and carbonates. A conspicuous coating of malachite is now forming on the ore walls and surface of the workings in the mine. Most of the rich ore seems to have been taken out, but the mine is reported to contain a large amount of good milling ore.

BUNKER HILL MINE.

The Bunker Hill mine is located in the mountains, a short distance east of the Cerbat mine. It is owned by John Mulligan. It is said to contain two veins situated close together. The ore, some of which has been shipped to the Needles smelter, is said to contain high values in gold and copper.

MINES IN UNION BASIN.

Union Basin, comprising an area about 1 mile in diameter, is located northeast of the Cerbat mine, in the upper part of Long Wash, which heads to the north of the upper part of Cerbat Wash. The nearest railroad station is Mineral, 5 miles distant, reached by wagon road descending Long Wash. The basin contains about a dozen small mines and prospects, not all of which were visited. The most important are described in the following paragraphs.

PAYMASTER MINE.

The Paymaster mine is located in the southern part of Union Basin, at the head of Long Wash, about half a mile north of the Cerbat mine, at an elevation of about 4,500 feet. It is an old mine and was profitably worked in the seventies, when the cost of mining supplies and of the reduction of ore was many times what it is now. It is owned by the Victor-Paymaster Mining Company, of Los Angeles, and is now producing. The total production is reported to be about $200,000.

The mine is developed principally by a 230-foot 60° inclined shaft and about 1,200 feet of drift, with upraises and stopes. It produces considerable water. The principal surface equipments are a steam hoist and a pump. At the time of visit a gasoline hoist and new machinery were being installed for more expeditious work.

The vein is contained in the pre-Cambrian complex, strikes N. 70° W., and dips 75° NNE. Locally it attains a width of about 15 feet. The gangue is chiefly mineralized quartz, in which the ore occurs principally in shoots, ranging from 16 to 24 inches in width.

The quartz contains principally silver values, with some gold. Much of the silver is in the form of ruby silver. The ore is said to range from $50 a ton upward. Some of it contains about 500 ounces of silver to the ton.

ALEXANDER GROUP.

The Alexander group of mines is located just northeast of the Paymaster mine, on northwestward slopes between 4,400 and 5,000 feet in elevation. It comprises four claims, the Alexander Nos. 1 and 2, Lazy Man, and Granfield. The two former are situated on the same vein and the two latter on separate veins. The veins were discovered in 1880 by Captain Lane, of Lane Springs Basin, and located in 1890 by James Dundon, of Cerbat, who is the present owner. The production of the property is reputed to exceed $5,000, the main part being derived from Alexander No. 1 claim.

The Alexander No. 1 is developed by three shafts and drifts. The shafts are 60, 80, and 230 feet deep. The shaft of the Alexander No. 2 is 100 feet deep. The Lazy Man contains a tunnel 125 feet in length, and two small shafts. On the Granfield claim the vein is opened by two inclined shafts, 35 and 100 feet deep and 500 feet apart.

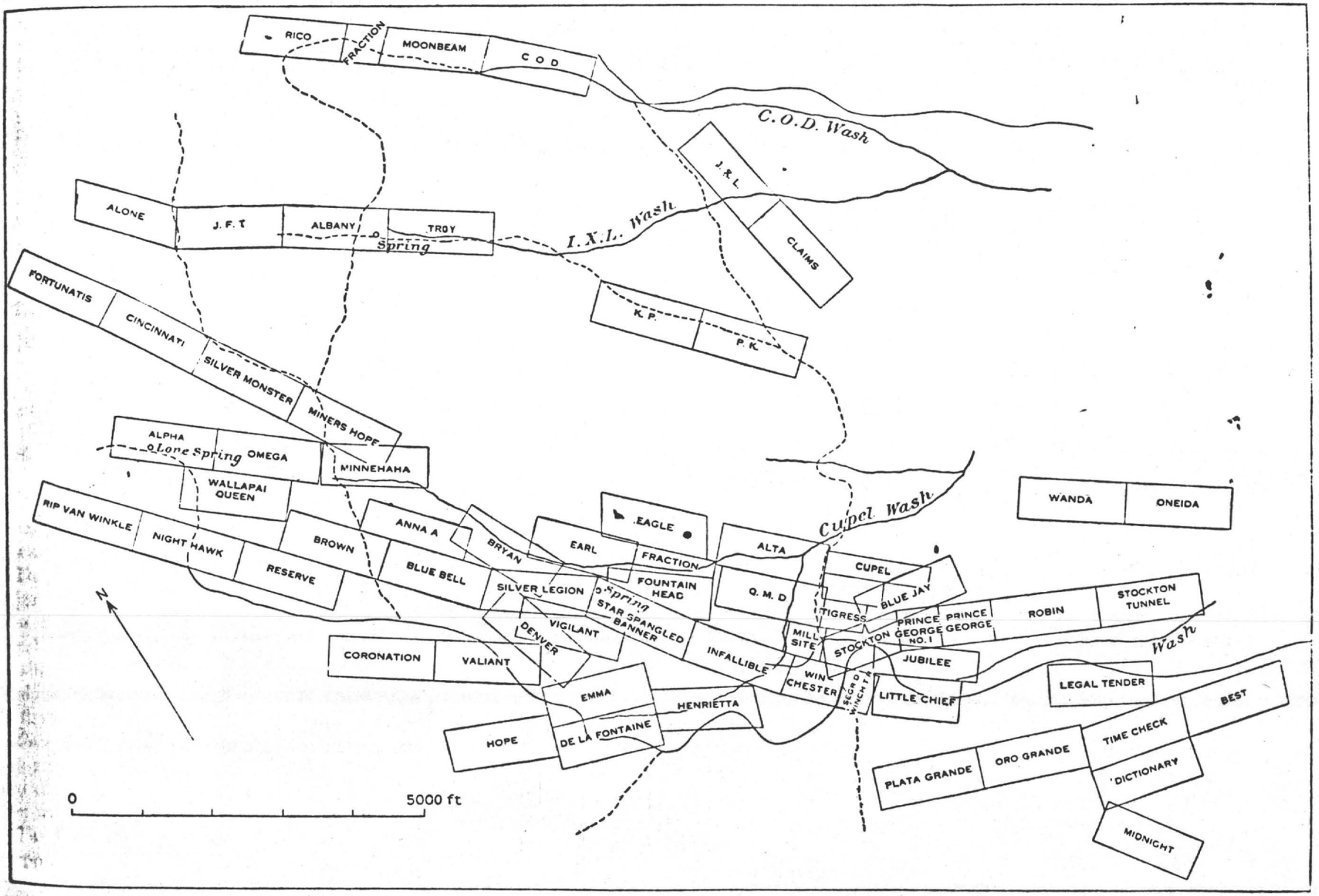
The country rock is the pre-Cambrian gneiss complex. The veins strike northwesterly and dip northeasterly at angles of 60° to 80°. They range from 2 to 4 feet in thickness and are oxidized down to water level, which lies at about 80 feet below the surface.

The gangue is mainly kaolin, with some quartz. It is hard in the oxidized zone, but soft below water-level. The ore usually favors the hanging wall and is said to occur in a nearly continuous shoot, about 18 inches in width. It contains silver, gold, iron, and lead. In the oxidized zone it contains principally soft horn silver and gold, with a little oxide of iron and carbonate of lead, the silver in places averaging about 500 ounces to the ton. Below water level the ore is chiefly sulphide, the lead occurring in the form of galena and the iron as pyrite, and there is reported to be an increase in the amount of silver, with little or no decrease in the amount of gold.

OTHER MINES.

The Climax mine is located on rough ground in the eastern part or head of Union Basin. It formerly belonged to James Dundon, of Cerbat, who recently sold it to a stock company of Denver. It is developed by several shallow shafts and drifts. The vein dips steeply southwest or is nearly vertical. The sulphide ore contains gold, silver, pyrite, chalcopyrite, and galena. The values are chiefly in gold and silver.

The Silver, Eddy, and Tub mines are said to be located on the same vein or lode, which in the Silver mine attains a width of about 100 feet. The Silver mine, owned by James Mulligan, is said to be developed mainly by shallow shafts and several hundred feet of drift. The ore is of low grade, containing principally gold and silver values, and is said to concentrate well.



CLAIMS IN STOCKTON HILL DISTRICT.

According to reports the Tub mine is developed principally by shafts and crosscuts. Here the vein varies from 30 to 80 feet in width and widens downward. It is reported to show at a depth of 40 feet a 4-foot streak of galena, containing values in gold and silver, and at 60 feet below the surface an ore body about 20 feet in width, which averages about $10 in gold and 20 ounces in silver to the ton, and contains zinc, copper, and lead. The mine is known to have produced several hundred tons of lead carbonate ore, most of which averaged about 40 per cent of lead.

The Big Bethel mine is reported to be situated on a large vein containing a shoot of high-grade ore and is credited with a production of $10,000.

The Golconda mine, owned by E. F. Thompson and E. B. Smith, is opened by shaft, tunnel, and adit drift. It is reported to have produced from essentially surface workings several hundred tons of rich ore containing chiefly gold, silver, and lead values, with some copper and zinc. Some of the ore was treated at the old Empire mill in Todd Basin with good results. Recently the 300-foot level is reported to have been driven 200 feet on a 4-foot ore shoot that assays 50 per cent of zinc.

The Green Linnet mine is said to be opened principally by a 100-foot shaft and about 500 feet of drift and to have a good showing of ore.

Some of the mines of Union Basin are now said to be shipping ore to Iola, Kans., and Oklahoma for treatment. The ore is reported to average about 50 per cent of zinc, and to contain good values in gold and silver.

MINES IN TODD BASIN.

Todd Basin, a valley about 2 miles long, is situated immediately north of Union Basin and, like it, drains westward into Long Wash. The topography is generally rugged. The mines described in the following notes are the most important in this locality.

ORO PLATA MINE.

The Oro Plata mine, one of the heaviest and most continuous producers, is located in the eastern part of the district near the axis of the range and the head of the main gulch, at an elevation of about 4,300 feet. It is reached by wagon road. The mine was first located and owned by Mexicans, under whom it began to be worked early in the seventies. It was next owned by J. P. Lane, whom the tailings are said to have netted $70,000, but, who, in 1882, sold it to a party of ranchers under the lead of H. Wilson. These men worked it and shipped ore to the smelters in Colorado, and finally sold the mine to J. W. Garret in 1895. In 1897 and 1898 the mine produced $150,000. Recently it has been purchased by the Oro Plata Mining Company, of St. Louis.

The mine is developed to a depth of 280 feet, principally by shafts, drifts, adit drifts, tunnels, and stopes, aggregating, it is said, about 7,000 feet of underground work distributed on three levels. The mine produces considerable water, ample for all milling purposes. The principal surface equipments are a 20-horsepower steam hoist and an air compressor. At the time of visit ground was being broken for a new mill.

The country rock is the pre-Cambrian gneiss, extensively intruded by coarse granite porphyry, a large dike of which crosses the gulch just below the mine. In the mine the granite porphyry seems to be associated with the vein, as does also a large 40-foot dike of finer-grained granite porphyry.

The vein, about 4 feet in width, normally dips about 80° NE. It is locally enriched by intersection with another vein. (See fig. 14.)

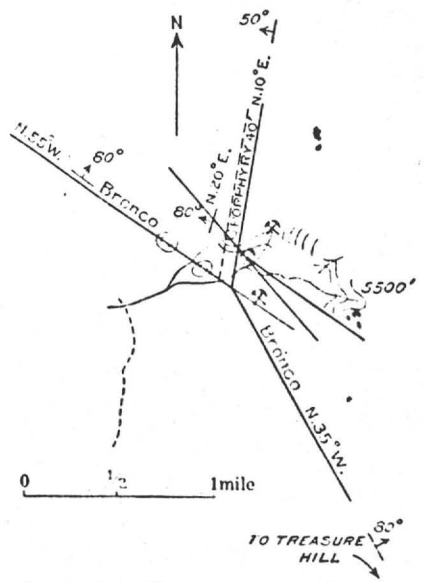


FIGURE 14.—Sketch showing relation of veins at Oro Plata mine.

The ore, which occurs chiefly in a banded quartz gangue, contains principally gold and silver. There are small amounts of chalcopyrite, zinc blende, pyrite, and galena. The ore shoots are said to be richer and more regular in the deeper part of the mine than near the surface. The ore averages in gold 3 ounces and in silver 25 ounces to the ton, and in lead about 6 per cent. There is said to be good ore in the bottom of the mine, which carries about 7 per cent of lead. The value of the output of the mine from July 14, 1896, to February 18, 1901, as shown by the sheets of the Arizona Sampler Company, which bought the ore at Kingman, was approximately $206,000 (2,527 tons of ore, averaging $80 to the ton), of which about 75 per cent was in gold and the balance in silver and lead. The price paid in the recent purchase of the mine was based on the assumption that the ore on the whole averages $37 to the ton, including the large bodies of moderate-grade ore left in the mine above the 280-foot level during earlier work.

The total production is reported to be about $500,000, and about 5,000 tons of second-class ore, said to average about $20 a ton, lie on the dump.

PROSPERITY MINE.

The Prosperity mine adjoins the Oro Plata mine, being located on the same vein where it ascends the mountain slope on the southeast. It was formerly owned by Cal. Wright and J. P. Lane, but is now owned by Owen McNally. It is said to be developed by about 700 feet of drift, mostly adit. The ore contains principally silver. Near the surface an ore body 9 feet in width is reported to have been a large producer and to have yielded considerable ore, which averaged $220 to the ton.

PRIMROSE MINE.

The Primrose mine almost adjoins the Prosperity mine on the southeast. It is owned by G. M. Bowers and T. E. Pollock. It is developed mainly by an adit drift, the breast of which is said to be in good ore, containing gold, silver, and copper. The mine produces much water and will require the installation of machinery for deep sinking.

BLACKFOOT MINE.

The Blackfoot mine, said to have been a good producer, is southeast of the Primrose mine, near the head of the gulch. It is owned by Byron Collins and Owen McNally. It is said to be developed principally by tunnels and shafts to the depth of several hundred feet. A proposed lower tunnel would cut the ore bodies at about 100 feet below the present workings. The vein is said to pinch in places, but in general increases in width with depth, and the ore shoot varies from 6 to 24 inches in width. The ore is reported to contain gold, silver, and copper, some of it running 180 ounces of silver and 3 ounces of gold to the ton and about 15 per cent of copper.

SUCCESS MINE.

The Success mine, located near the Oro Plata, is said to be opened by tunnels, drifts, and shafts on the vein. The ore is said to be sulphide and contains gold, silver, and lead. A lot treated years ago in the old mill in Todd Basin is said to have netted $27 a ton.

MEXICAN MINE.

The Mexican mine, located in the eastern part of the basin, is reported to have produced considerable ore that averaged about 9 ounces of gold and 312 ounces of silver to the ton.

MINES IN LANE SPRINGS BASIN.

Lane Springs Basin is a short, deeply cut side valley situated northeast of Todd Basin, from which it is separated by a prominent spur-like ridge extending northwestward from the axis of the range. The basin contains six or eight mines, of which those described below are the most important.

ALPHA MINE.

The Alpha mine is located in the eastern part of the basin, at an elevation of about 5,000 feet. It is owned by Peter Cooper, Oscar F. Dennis, and Mrs. Smith. It is developed principally by two drifts, the upper one 400 feet and the lower one 200 feet in length, both of which trend about S. 30° E. along the vein, almost directly across the strike of the pre-Cambrian gneiss complex. The croppings are a prominent reef of black, iron and manganese stained quartz. The vein varies from 4 to nearly 20 feet in width, and consists principally of a gangue of imperfectly banded, fine-grained, sulphide-bearing quartz, in which the ore occurs. The ore contains silver sulphide, pyrite, galena, zinc blende, and chalcopyrite.

The mine is reported to have been a good producer. A consignment of 400 tons of ore is reported to have netted $125 a ton.

NIGHT HAWK AND RIP VAN WINKLE MINES.

The Night Hawk and Rip Van Winkle, two adjoining mines, are situated about half a mile southeast of the Alpha mine, both on the same vein in the steep northwest slope of the mountain, at an elevation of about 5,000 feet. The country rock is pre-Cambrian gneiss. The vein strikes northwesterly. In the Night Hawk it is reported to be developed principally by a drift 1,400 feet in length, whose face is located about 700 feet beneath the apex of the vein. The vein is said to be large and to contain a "pay streak" of sulphide ore ranging from 6 to 18 inches in width. The ore shoot in two localities has feathered out, and in both has been recovered with its usual values by cross-cutting into the foot wall. Much of the ore is rich; some of it is reported to have averaged $2,000 a ton in carload lots. According to record sheets of the Sampler Company, who bought most of the output from April, 1887, to January 20, 1900, the ore averages about 3 ounces of gold and 300 ounces of silver to the ton; the production during this period was 464 tons, containing values of about $244 a ton, amounting to about $113,000. The total output of the mine is reported to be $150,000, and was produced at intervals during the last seventeen years.

MINES SOUTH OF CERBAT WASH.

The principal mines situated south of Cerbat Wash are the Champion, New London, St. Louis, and Twins. As stated elsewhere, they contain chiefly silver and lead.

CHAMPION MINE.

The Champion mine is 1¼ miles southwest of Cerbat, on the west front of the range, 600 feet above and about three-fourths of a mile distant from Sacramento Valley, at an elevation of about 4,100 feet, near the head of a short wash that leads westward into the valley. It is reached by wagon road from the west. This mine is one of the early discoveries. It was fromerly worked by James Dundon, but is now owned by the Arizona-Mexican Mining and Smelting Company, of Needles, Cal. It is producing at a moderate rate. The mine is developed mainly by shafts and about 600 feet of drift to a depth of 70 feet, and it produces a little water.

The country rock is the pre-Cambrian gneiss, and it is intruded near the mine by granite porphyry and by diabase and minette dikes.

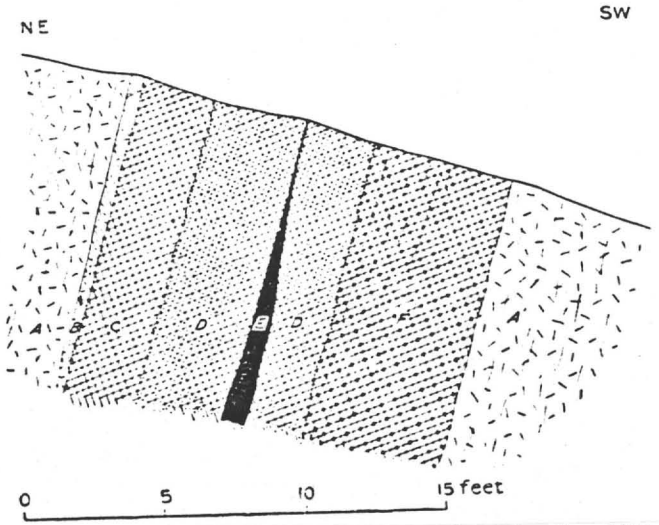


FIGURE 15.—Section of Champion vein. See text for explanation of letters.

One or more dikes are associated with the vein, which is about 12 feet in width and dips steeply to the northeast. A cross section of the vein, as sketched at the mine near the surface, is shown in figure 15. In this figure A represents country rock, consisting of alternately dark and light streaked granitic schist forming the hanging wall; B is gouge consisting principally of crushed granitic rock; C is brown, iron-stained ore; D is dark, earth-colored, fresh dike rock, which seems to be minette and contains biotite, augite, orthoclase, and andesine; E is a stringer of quartz and brown, iron-stained carbonate ore material, which widens at about 60 feet back from the face and is reported to have carried an ore shoot 1 foot in width, which, in the deeper part of the mine, becomes the main vein; F is reddish, coarse granite, or pegmatite, composed mainly of feldspar,

and toward D is sheared and cut by parallel lines produced by movement; A′ is dark granitoid schist, about the same as A, forming the foot wall. The ore is composed mainly of sulphides and contains principally lead, gold, and silver, the gold in some of it running about an ounce to the ton.

The mine has produced a large amount of ore, a considerable portion of which was high-grade surface ore. It now produces about 6 tons of ore a day, four-fifths of which is shipping ore. Only the best ore is mined. A large amount of milling ore is left in the mine and a considerable amount also lies on the dump.

NEW LONDON MINE.

The New London mine is located at the west base of the range, about one-fourth mile southwest of the Champion mine, at an elevation of about 3,800 feet, in an open wash, but little above the level of the neighboring Sacramento Valley. The mine was worked during the middle eighties, at which period it produced much good ore. It was closed about 1893 and is now dismantled of all surface equipments, but is regarded as a good property. The owners are Skee Brothers, of Santa Monica, Cal.

The mine is reported to be developed principally by two inclined shafts, drifts, and stopes. Though the deepest shaft is 150 feet in depth, the work is nearly all comprised between the 75-foot level and the surface and in a horizontal extent of 400 feet.

The vein containing the deposits is said to be similar to that of the Champion mine, but stronger, and to contain large bodies of ore. It strikes about N. 60° W. and dips 55° NE. The ore is said to average high in silver and gold, as well as in lead.

TWINS MINE.

The Twins mine is about one-fourth of a mile east of the Champion mine, in Twin Gulch, which trends northward and joins Cerbat Wash below the mouth of Charcoal Canyon. It is owned by the same company as the Champion mine, described above. It is opened by shafts and drifts to a moderate extent. It may develop into a zinc mine, for in the bottom of the mine the vein contains a shoot of zinc blende about 5 feet in width, which also contains from $7 to $8 a ton in gold. The mine is reported to have produced 300 tons of ore, aggregating a value of $[illegible].

ST. LOUIS MINE.

The St. Louis mine is about half a mile east of Cerbat and the Gem mine and the same distance southeast of Cerbat Wash and several hundred feet above it. It is accessible by wagon road. The mine was discovered about 1865. It has been a producer on a

moderate scale, and is now producing under the present own[illegible] the St. Louis Consolidated Mining and Milling Company, with headquarters at Los Angeles. This company acquired it in 1905. The property comprises 19 claims, but the developments are chiefly on the St. Louis Claim.

The mine is developed principally by adit drifts and tunnels, mostly within a vertical range of 340 feet, and contains about 1,000 feet of underground work. The shaft on the Knocker claim, however, is reported to be 110 feet deep.

Five distinct veins are reported to occur in pre-Cambrian gneiss. Several of the veins are said to converge near the southeast end of the St. Louis claim. Three of the veins trend northwest and dip 80° NE., and two trend about north and south and dip 85° E. The hanging wall of all the veins is said to be gneiss. The north-south veins are reported to have in most places a "porphyry" foot wall. These veins average about 5 feet in width and are said to be richer than the northwest-southeast veins and to contain more silver. The richest ore they contain is said to be steel galena. The ore occurs in shoots or bunches varying from 2 to 16 inches in width. It contains about $3 in gold and 12 ounces of silver to the ton and 55 to 75 per cent of lead.

The northwest-southeast veins are said to have a dark rock on the foot wall, with gneiss occurring locally on each wall. The largest of these veins is said to be 4 feet in average width, but it carries less ore than the smaller veins.

The two veins now being worked are known as Nos. 2 and 3. They are about 3 feet wide and the ore varies from 4 to 16 inches in width. In carload lots the ore is said to average about 60 per cent of lead and $2 in gold and 14 ounces in silver to the ton. Most of the ore thus far produced has been obtained within 40 feet of the surface. The management is now taking out shipping ore only and doing development work.

BLANKET VEIN PROPERTY.

The Blanket Vein property is about half a mile southwest of the Gem mine, just below the mouth of Charcoal Canyon. It is principally owned by the Golden Star Mining and Milling Company. The deposit is a gold-bearing quartz vein, resting on pre-Cambrian granite. It dips northeasterly at the low angle of about 30°, and is unique in being now bared, the granite having been completely removed from the upper surface by erosion over a nearly equidimensional area of about 500,000 square feet.

The vein is about 1 foot in average thickness and is said to contain about $8 in gold to the ton, or a total value of more than $90,000 for the area of the deposit thought to be in sight. Hornings and assays

show portions of the deposit to co[illegible]in as high as $[illegible] gold to the ton. The gold is mostly free milling. The quartz also contains some iron, principally hematite and limonite, derived from pyrite by oxidation.

STOCKTON HILL DISTRICT.

GENERAL OUTLINE.

LOCATION AND HISTORY.

The Stockton Hill district joins the Cerbat district on the east, and is about parallel and coextensive with it north and south, being situated on the opposite slope of the mountains. It is about 4 miles in width and but little more in length. It ranges in elevation from 3,500 feet at the edge of Hualpai Valley on the east to 5,500 feet at the crest of the range.

The principal and oldest camp is Stockton Hill, situated in the foothills in the eastern part of the district, 10 miles north of Kingman, at an elevation of about 4,800 feet. It dates from early in the sixties, when the principal veins were first discovered and began to produce. In former days much of the ore was shipped to Swansea, Wales, but later it was treated in the Mineral Park and Cerbat mills and shipped to the smelters in San Francisco and to New Mexico. At present the ore is hauled by wagon to Barry or Kingman, whence it is shipped, mostly to Needles. The district is reported to have produced many million dollars' worth of ore.

TOPOGRAPHY AND GEOLOGY.

The topography, shown in part in the sketch map (fig. 16), is generally rough, but the mines are nearly all accessible by wagon roads, mostly of easy grade. The drainage issues eastward into Hualpai Valley, mainly through several short side valleys or transverse washes—the Canyon Station, C. O. D., I. X. L. (known as I. X. L. Basin from the width and open character of its middle part), Cupel, Treasure Hill, and Maywell. In their upper parts most of the washes contract into V-shaped gulches.

The country rock is the pre-Cambrian gneiss and schist complex. It is reddish brown and iron stained and is intruded by dikes of granite porphyry, diabase, and other rocks, mostly of basic character. The schistosity trends about N. 30° E. and dips usually vertically or at steep angles to the northwest. The dominant jointing or sheeting strikes northwest.

ORE DEPOSITS AND MINES.

The deposits occur in pre-Cambrian gneiss or schist, intruded in places by a later aplitic granite or by basic dikes. They are fissure

veins, which in general strike northwesterly and are vertical or dip at steep angles to the northeast. The gangue is quartz and the ores contain chiefly silver, with some gold, lead, and copper. Primary sulphide minerals are galena, zinc blende, chalcopyrite, and pyrite, but the district owes its reputation to the rich silver ores, such as native silver, cerargyrite, argentite, and ruby silver, which were found in large quantities in the upper levels. The water level is about 100 feet below the surface. Galena is often found above it, while rich silver minerals descend to a considerable distance below it. The greatest depth attained is 400 feet.

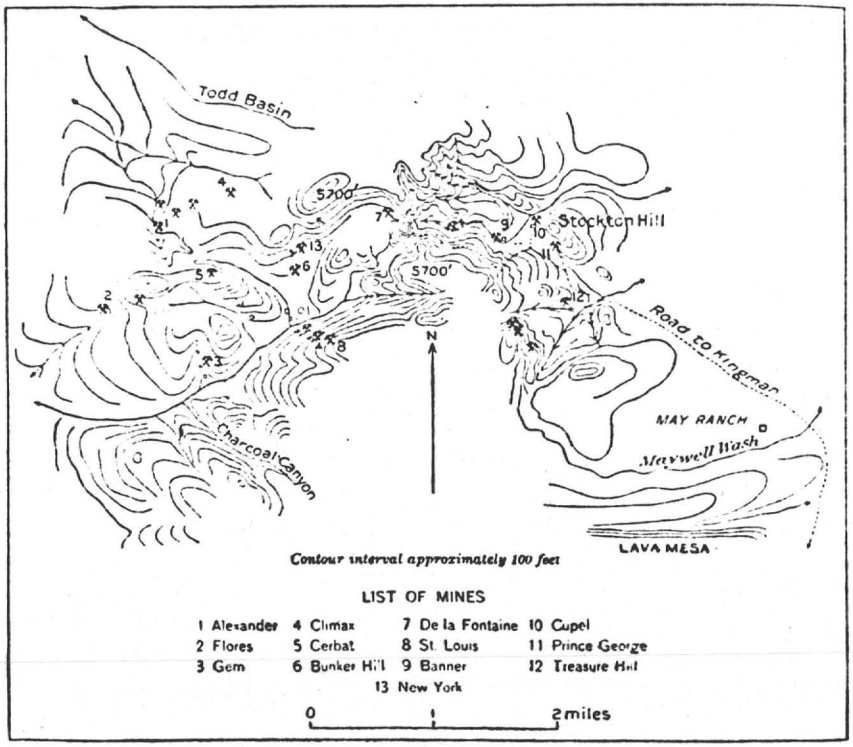
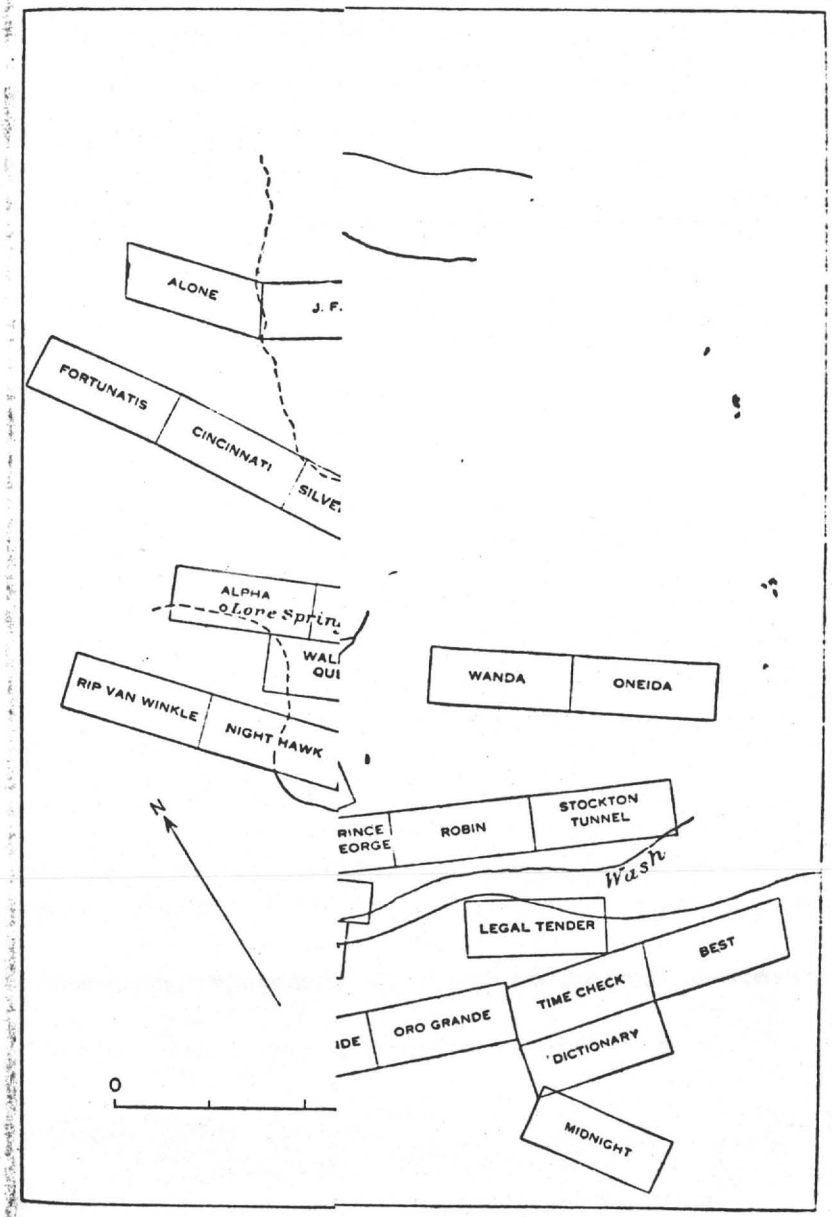


FIGURE 16.—Sketch map of Stockton Hill district and adjoining part of Cerbat district.

The district contains about 10 mines, of which the principal are the Banner Group, Treasure Hill, Little Chief, Cupel, Prince George, De La Fontaine, C. O. D., and Sixty-three. Their general distribution is shown on the accompanying sketch map (fig. 16). The principal locations made in the district are indicated on the claim map (Pl. VIII).

MINES ON STOCKTON HILL WASH.

The principal mines on or near Stockton Hill Wash are the Banner Group, Cupel, and De La Fontaine. Their situation in alignment on a nearly east-west line about 1½ miles in extent has led to the



current belief that they are all on the same vein. They are perhaps in a general way in the same mineral zone, but as the strike of the veins at the different mines does not coincide with the trend of the mines and the veins have not been traced and do not seem to connect from mine to mine the single-vein theory remains to be proved.

BANNER GROUP MINE.

Location.—The Banner Group mine (Pl. VII, *B*) is about half a mile west of Stockton Hill, near the center of the district, toward the upper or gulch part of Cupel Wash at a point where it widens into a small basin at about 4,800 feet elevation. The property is said to comprise six adjoining claims, of which the most important are the Infallible (formerly Indian Boy) and the Star Spangled Banner. The principal mine openings are on the former, whence the workings extend northwestward into the latter. The property is owned and operated by the Arizona-Mexican Mining and Smelting Company, of Needles, Cal., where the large smelter owned and operated by this company is located.

Developments.—The mine is developed principally by adit drifts, stopes, winzes, and shafts, aggregating about 2,500 feet of underground work, including the tunnel or adit drift, 1,600 feet in length, on the vein. This drift has a greatest depth of 230 feet below the surface. Several shafts, mostly shallow ones, are located up to 1,050 feet from the mouth of the drift. At 800 feet from the mouth of the drift is a gasoline hoist and a 60-foot winze, reported to be sunk all the way in good ore. The property is equipped with a nearly new 40-ton mill supplied with concentrating tables.

The production is reported to be many thousand dollars in gold, silver, and lead, the zinc thus far being culled and left on the dump. The dumps also contain much second-class ore, which is said to be suitable for concentration. The mine now works about 20 men and produces about 30 tram-car loads of ore a day, of which one-fourth is shipping ore and three-fourths milling ore. The ore is shipped to the Needles smelter.

Geology and ore deposits.—The country rock is light to iron-gray fine-grained gneiss, in which the structure trends about N. 30° E. and dips steeply to the north-northwest. Toward the veins on the foot-wall side the rock is red from oxidized pyrite.

The fissure vein strikes N. 40° W. and dips about 80° NE. The croppings consist principally of leached reddish-brown quartz. The vein averages about 7 or 8 feet in width; the ore varies from about 1 foot to 3 feet in width and usually occurs on the foot-wall side of the vein. In the face of the drift at the time of visit it was 2½ feet

wide, and associated with it on the hanging-wall side was a foot or more of soft gangue composed principally of crushed and altered granitic material, which, on being removed by blasting, leaves the intact ore bared in fine condition for loading on the cars. The shoot contains parallel seams of light-colored material, which emphasizes the roughly banded character of the ore.

The ore consists in places of pure galena, but usually it contains also zinc blende, pyrite, and chalcopyrite. The gold in some of it amounts to several ounces a ton. The silver occurs in part as sulphide and native, as masses and wire silver, which locally interlaces adjacent parts of the ore shoot. The amount of zinc increases in the deeper, northern portion of the mine. Toward the northwest end of the surface workings occurs a large amount of reddish quartz ore, which seems to contain chiefly gold values. This probably represents the body of rich gold ore reported to have been found in the surface openings of the mine. A short distance north of this locality galena and zinc-blende ore with comb quartz and chalcopyrite seem to prevail.

CUPEL MINE.

The Cupel mine is situated in the foothills at Stockton Hill camp, on the south side of Cupel Wash. This mine is regarded as probably the oldest on Stockton Hill. It was located about 1863, and was worked intermittently from that date to 1891, being constantly a heavy producer. It is said to have yielded handsome returns to lessees in the seventies, and in the eighties it was opened up by an inclined shaft to the 400-foot level by Spruance, Stanley & Co., of San Francisco. From this shaft nearly half a million dollars in silver and gold ore is reported to have been taken.

The principal equipments are a steam hoist and an excellent 200-ton mill and plant of the Joplin type, recently installed. The mine is owned by the Stockton Hill Mining Company, with headquarters at Topeka, Kans. The mine is developed principally by a shaft 400 feet deep, a three-compartment shaft 150 feet deep, drifts, and stopes to a depth of about 400 feet, the workings being nearly all situated within 300 feet of the main shaft. The mine is said to produce about 25,000 gallons of water a day.

The production of the mine is conservatively reported to exceed $500,000, and is variously estimated at one to one and a half million dollars. From September 3, 1885, to May 1, 1890, according to the smelter sheets, the output was $131,405, and averaged approximately 150 ounces of silver to the ton and 20 per cent of lead, silver at that time being worth about $1 an ounce. It is stated that the mine contains much ore in sight and that the dumps contain about 2,000 tons of ore that is estimated to mill $6 or $7 net per ton.

The country rock is the pre-Cambrian gneiss and schist complex. Three veins, which strike northwesterly but are not quite parallel, contain the ore. They are known as the Cupel, Edward Everett, and Tiger veins. Several diagonal or cross veins or stringers are also present. (See fig. 17.)

The ore contains ruby silver and horn silver, together with argentite, but in places is rich in high-grade galena and carries about $5 a ton in gold. The bulk of the ore produced contains ruby silver, and some of it is said to have averaged 3,000 ounces of silver to the ton and gave to Stockton Hill and the Cerbat Mountains their early reputation. Most of the rich ore thus far produced is said to have been taken out within a horizontal distance of about 250 feet, extending principally from the shaft northwestward and from the surface to the bottom of the mine. Beyond this portion of the mine to the northwest the ore is said to contain principally galena and some gold.

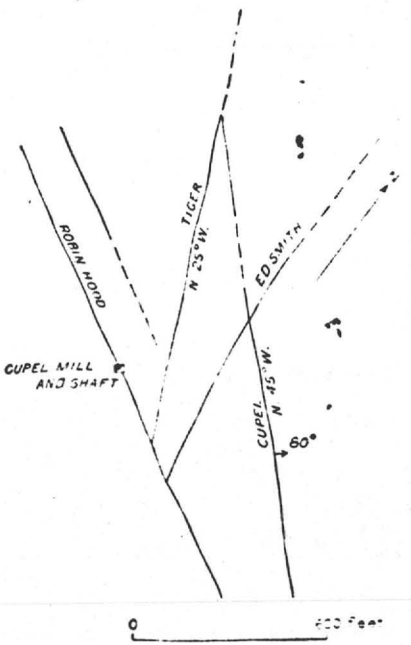


FIGURE 17.—Sketch showing relations of veins on Cupel claim.

PRINCE GEORGE MINE.

Location and history.—The Prince George Mine is located at Stockton Hill, about one-fourth mile southeast of the Cupel mine, at an elevation of about 4,600 feet. It is situated on steeply westward-sloping ground, near the head of a deep gulch that trends southward into Treasure Hill Wash.

The mine was worked principally in the eighties. After the installation of machinery the mine was operated by Mr. McKay, who soon suspended operations, since which time but little work has been done. It is now owned by the Stockton Hill Mining Company.

Production.—The production is reported to be $100,000, of which $90,000 was taken out in about ninety days, mostly from the large ore chamber.

Developments.—The principal developments are a 180-foot shaft and about 250 feet of drifts and stopes. The principal equipments are a coal or oil fuel hoist and pumps. The mine is said to produce about 20,000 gallons of water per day.

Geology.—The country rock is the pre-Cambrian complex, the prevailing phase being a medium-grained light gneiss, but next to the vein the rock is a coarse granite or pegmatite, some of which resembles graphic granite. The schistosity trends N. 30° E. and is paralleled by many small quartz stringers, none of which, however, are known to carry ore. Slickensiding in the mine indicates a nearly vertical movement.

Veins and ores.—The principal vein strikes N. 65° W. and dips about 80° NE. As shown in the mine at about 60 feet in from the mouth of the adit drift, the main vein is joined from the northwest by a second vein, which near the junction is 12 or 15 feet thick. At their junction the two veins seem to have formed an ore body 60 to 80 feet in diameter and extending to a depth of at least 50 or 60 feet below the surface. The upper portion of this ore body, particularly that in the oxidized zone, has been mined, leaving a large chamber where the ore has been removed.

The gangue is quartz and altered rock, and the ore in the unoxidized zone or lower part of the mine contains chiefly galena, argentite, and pyrite. The bulk of the ore mined from the chamber is reported to have averaged 60 per cent of lead and 300 ounces of silver to the ton, and the remainder 20 per cent of lead and 20 ounces of silver to the ton. The ore as a whole is reported to have averaged about $200 per carload, and most of the richest to have come from an ore shoot 13 feet wide.

The walls of the main vein are, as a rule, ragged, but the hanging wall of the second vein is well defined and smooth and contains a streak of ore 4 to 6 inches wide, reported to average about $600 a ton, on which the operators are now sinking. A rich 1-foot ore shoot is also reported to occur on the hanging-wall side of the main vein.

LITTLE CHIEF MINE.

The Little Chief mine is located about one-fourth mile southwest of Stockton Hill camp and about 80 feet above it, close to the main road. The mine has been worked on a small scale since the middle seventies, and has produced only high-grade shipping ore from the surface down. It is owned by the C. O. D. Mining Company. The production is reported to be more than $25,000.

The mine is developed to a depth of about 100 feet and contains about 1,000 feet of underground work, which includes a 400-foot crosscut tunnel, two 80-foot shafts, and 300 feet of drifting, the drift extending about 75 feet on either side of the two main shafts.

The country rock is the pre-Cambrian complex. To judge from talus débris on the surface at the mine, it seems to be intruded by diabase near by, and portions of a light-colored altered rock, which seems to be the intrusive granite porphyry, are associated with the vein.

The vein trends N. 40° W. and dips steeply northeast. It is about 6 feet in width and is supposed to be the Banner vein of the Treasure Hill mine, described later. The gangue is quartz and crushed and altered silicified rock. The ore shoot locally coincides in width with the vein and is stained throughout with copper carbonate. The ore contains principally green horn silver, galena, and gold, is all of shipping grade, and is said to average about as follows: Silver, 350 ounces to the ton; gold, $5 to $10 a ton; and lead, 8 to 40 per cent.

DE LA FONTAINE MINE.

The De La Fontaine mine is situated at the west side of the district on the narrow crest of the range, at about 5,100 feet elevation, where the surface falls off steeply into Cerbat Wash on the west and Stockton Hill Wash on the east, the mouth of the adit drift or tunnel and shaft being located on the Cerbat side. The mine is owned by the Stockton Hill Mining Company. It is developed principally by a shaft 400 feet in depth and two levels comprising about 1,400 feet of drifts.

The country rock is principally a reddish fine-grained gneiss. Black amphibolite schist outcrops near by and is also present in the mine, particularly in the foot wall near the shaft on the 100-foot level. Back of the superintendent's house, a few hundred feet south of the vein, are prominent croppings of dark speckled medium-grained diorite from which the amphibolite schist has probably been derived.

The vein, which strikes N. 70° W. and dips about 80° NNE., is about 7 to 10 feet in width. The gangue is principally quartz, with some partly altered coarse granitic rock, but locally the fissure is occupied by greenish or reddish slickensiding gouge. The croppings consists of a 6-foot reef of quartz, stained by iron and manganese, and rising boldly 10 or 12 feet above the surface. The ore shoot is from 1 to about 4 feet in width. Good ore bodies of this width and of considerable extent are blocked out in the lower 300 feet of the mine.

The ore contains principally galena and zinc blende and a very little pyrite; it contains locally about $2 to the ton in gold, but the ore recently blocked out in the lower part of the mine is probably of a somewhat higher grade. The ore in sight in the mine is said to contain good values.

The company plans to treat such part of the ore as may be suitable in its mill recently installed at the Cupel mine and ship the balance to smelters.

MINES ON TREASURE HILL WASH.

The principal mines on Treasure Hill Wash are the Treasure Hill, Mocking Bird, and Sixty-three.

TREASURE HILL MINE.

Locaton and history.—The Treasure Hill mine is situated in the southeastern part of the district, in southward-sloping foothills at about 4,200 feet elevation. It was discovered late in the seventies and was worked on a small scale. From 1890 to 1900 it was owned by Lehorean Moore, who sunk five or six shafts to water level, about 65 feet below the surface, and is said to have stoped out very rich ore, some of which contained 15,000 ounces of silver to the ton. In 1902 the mine was acquired by the present owner, the Treasure Hill Mining Company, which has since sunk several shafts to the depth of about 110 feet and drifted on some of the veins, notably on veins Nos. 1 and 3. The property comprises four principal contiguous claims having a common corner and two extension claims on the southeast. The production is reported to be $100,000, of which one-half was high-grade silver ore from surface workings.

Developments.—The developments consist of a 140-foot tunnel, a 120-foot double-compartment 62° 30′ inclined shaft at the distant end of the tunnel, and a double-compartment 200-foot shaft, with drifts and crosscuts to nearly all the veins, in all aggregating about 1,000 feet of underground work. The principal equipments are a gasoline hoist, a Cornish pump with a capacity of 2,000 gallons, and engines. Heavier machinery is soon to be installed.

Geology.—The country rock is principally dark-bluish granite gneiss of pre-Cambrian age. The schistosity dips about 80° NW. The rock is intruded by a small stock of the granite porphyry. It constitutes the principal mass and upper part of the rough knob situated back of the mine and locally known as the Bronco, and it is in places associated with the veins in the mine. A schistosity is superimposed and is also older than the veins.

Veins and ores.—The veins are six in number. Beginning with No. 1, they are numbered consecutively from southwest to northeast. They average about 5 feet in width at the surface. In the southeastern part of the property they lie about parallel, strike northwest, and, except No. 4, dip for the most part steeply to the northeast. Northwest of the mine vein No. 1 curves to the left and outcrops on the southwest side of the intrusive aplitic mass, while the others lie to the east and northeast of the mass, the near ones curving out "to get past it," as the miners express it. Only the veins next to the intrusive rock are now being worked.

The gangue is principally quartz, in which the ore occurs in streaks or shoots from to 200 feet long. The shoots usually favor the hanging wall and are associated with clay gouge. The ore contains galena, with some pyrite and a little chalcopyrite. No zinc has yet been found on the property. The ore, so far as the experience of the present management goes, is said to average about 100 ounces of silver and $5 to $16 in gold to the ton, and from 7 to 10 per cent of lead, in both the oxidized and unoxidized zones.

According to reports of later (1908) work, 85 feet of drift run in the lower part of the mine, contains good milling values throughout its extent and width, and an unbroken small streak of high-grade ore.

SIXTY-THREE MINE.

The Sixty-three mine is located in the southern part of the district, about half a mile southwest of the Treasure Hill mine and several hundred feet above it, in the steep south side of a gulch which drains southward into Maywell Wash. The mine, which is one of the first discoveries, was found in 1863, from which date it is named. It at once became a heavy producer of very rich silver ore. After working the mine a few years, the first owners sold it to a San Francisco company, which worked it with good results and still owns it. Later it was also profitably worked by lessees. Subsequently the decline in the market value of silver and disagreement in the owning company are said to have led to discontinuance of work. The production is reported to be $500,000.

The mine is developed principally by adit drifts and tunnels to a depth of about 200 feet below the apex of the vein. The deposit is a nearly vertical fissure vein, about 3 feet in average width, in which the ore streaks average about 15 inches in width. The ore contains principally silver chloride and is mostly of high grade. Much of it is said to have averaged 3,000 ounces of silver to the ton. A considerable portion of the ore is said to have been treated in the Cerbat and Mineral Park mills and the rest was shipped to San Francisco. As there are no base metals in the ore, the mills are said to have extracted the values to a very high degree without roasting.

MINES IN I. X. L. BASIN.

I. X. L. Basin is an open basin-like area situated in the upper part of I. X. L. Wash, about 1½ miles north of Stockton Hill. It contains several small mines and prospects, about all of which are situated on the same vein or lode. The principal mines are the K. P. and the J. F. T.

K. P. MINE.

The K. P. mine is located in the southern part of the basin on open ground at about 4,700 feet elevation. The mine is w. It

is owned by Messrs. Kimberly and Potts, of Kingman. As the water level is at about 40 feet below the surface, the developments consist principally of shallow shafts and surface openings.

The country rock is the pre-Cambrian gneiss complex. The deposit forms a vein or lode about 65 feet in width, which dips about 75° NE., and is reported to have a horizontal extent of nearly 2 miles, many locations being made on it. The gangue or filling of the fissure consists essentially of crushed or brecciated vein quartz and crushed and altered coarse granitic quartz and feldspar. The croppings consist of similar material, locally silicified and stained reddish brown and black by iron and manganese oxides. The lode carries a width of about 7 feet of concentrating ore.

The ore is of low grade. It contains principally galena and is said to average about 60 per cent of lead. It contains also some gold, silver, and copper, the copper occurring as bornite and chalcopyrite.

J. F. T. MINE.

The J. F. T. mine, located in the upper or northwestern part of the basin, is said to be developed to a depth of about 200 feet. It is reported to have been a good producer, and its ore is said to contain copper, silver, and gold.

MINES IN C. O. D. WASH.

C. O. D. Wash is located about a mile north of I. X. L. Basin. Its principal mine is the C. O. D. mine.

C. O. D. MINE.

Location and history.—The C. O. D. mine is about 2½ miles north of Stockton Hill, in the upper or gulch part of C. O. D. Wash, at about 4,900 feet elevation. It is easily reached by a good wagon road. The mine was located about 1878 and was worked in a desultory manner until 1885, when active work was begun on the property. About 4,000 tons of ore was produced in the next seven years. Activities were renewed about 1900, with an output of several hundred tons of concentrates. In 1902 machinery and a mill were installed, immediately after which the mine and mill were operated for a period of six months, when, owing to decline in the market value of silver and, it is said, mismanagement and lack of proper machinery, the plant was closed. Later the Fletcher Mining Company leased the mine under bond and worked it for a short time, shipping the ore to Needles, but is said to have soon stopped operations for want of funds. The mine was closed again November 19, 1904, and operations have not yet been resumed.

The property is reported to comprise eight claims. It is now owned by the Taggart Mercantile and Mining Company, of Kingman. The mine is filled with water up to the first level.

Developments.—The mine is developed principally by a main shaft (No. 1) about 400 feet deep and by drifts and stopes on and between two main and two subordinate levels, aggregating about 2,500 feet of underground work.

From the second or 300-foot level to the surface the ore, except some of low grade, has been mostly stoped out for a distance of about 400 feet on either side of the shaft, especially on the east side, beyond which good ore is reported. The second level extends to a point 900 feet west of the main shaft, where connection with the surface is contemplated by a new double-compartment shaft (No. 2), which is now 96 feet in depth and on completion is to be used as a main working shaft of the mine. At about 1,200 feet west of this shaft a third shaft (No. 3) is sunk to the depth of 60 feet.

The principal surface equipments are a 50-ton concentrating mill containing rolls and three Bartlett concentrating tables, a 50-horsepower engine and boiler, and two rock crushers; a steam hoist with a 40-horsepower engine; a gasoline fan with a 10-horsepower engine, and a pump. The principal source of the power used is fuel oil. The mine is reported to yield sufficient water for operating the plant.

Geology.—The country rock is mainly dark-gray coarsely porphyritic gneissoid microcline granite. It is the dominant rock from Stockton Hill to a point beyond C. O. D. Gulch. Locally it is associated with dark fine-grained chlorite schist, in which the 60-foot shaft on the west is located. The rocks are cut by dikes of a greenstone or altered basalt. Schistosity and jointing strike N. 20° W., with vertical dip. A secondary system of joints trend N. 70° W. and dips about 80° S. and seems to be parallel with the C. O. D. vein, whose fissure probably belongs to the system.

Veins and ores.—The vein is well known as the "C. O. D." vein; it strikes N. 85° W. and dips about 80° N., and is reported to be more than a mile in length and about 6 feet in average width. The gangue is mainly quartz, in which the ore occurs in shoots and lenses which vary from 1 to 7 feet in width and are mostly of considerable extent. The narrow shoots are said to be usually rich, and the wider ones contain large bodies of milling and concentrating ore. At the 250-foot level the ore shoot is reported to vary from 3 to 7 feet in width and its ore to have averaged about $250 to the ton.

The ore contains principally silver sulphide and gold, with some galena, zinc blende, and below the 250-foot level a little chalcopy-

rite.[a] It is said to be less rich in the sulphide zone in the lower part of the mine than in the oxide zone near the surface. Its run of mine, roughly computed from a record of the output from October 10, 1885, to March 6, 1901, is about as follows: Silver 160 ounces and gold 2 ounces to the ton; lead, 12 to 20 per cent.

Production.—The production is reported to be $1,300,000, that of silver alone amounting to about $1,000,000; and several thousand dollars' worth of medium-grade ore are said to now lie on the dump. The output was mostly made between the autumns of 1885 and 1892. During this period 3,687 tons of ore are reported, according to smelter return sheets, to have contained about 402,000 ounces of silver, 1,180 ounces of gold, and 515,760 pounds of lead. Later, about 1900 to 1902, about 17,550 ounces of silver, 180 ounces of gold, and 114,360 pounds of lead are said to have been obtained from 330 tons of concentrates.

MINES OF CANYON STATION WASH.

In Canyon Station Wash, about a mile north of C. O. D. Wash, there are reported to be several small mines, of which the most important seem to be the Baden-Baden, King, and Queen mines, said to be owned by Lewis Davidson, of Kingman.

MINES IN "TOP OF STOCKTON HILL" AREA.

The "top of Stockton Hill" is situated in the northwestern part of the district, at the crest of the range, between the northern part of the Cerbat district on the west and the heads of I. X. L. and C. O. D. washes on the east. The mines include the Cincinnati, Miner's Hope, Blue Bell, Fountain Head, Brown, and others, the most important of which seems to be the Cincinnati. It is situated near the crest of the range about midway between Lane Springs and I. X. L. basins. It has not been worked for many years, but is regarded as a good property.

GOLD BASIN DISTRICT.

GENERAL FEATURES.

The Gold Basin mining district, of which Basin is the post-office, is situated in the eastern part of the White Hills (fig. 18). It extends over a hilly area about 6 miles in diameter, sloping to Hualpai Wash on the east, and ranges from 2,900 to 5,000 feet in elevation. The northeastern portion, where most of the mines are situated, is rugged, being marked by longitudinal fault scarps and scored by

[a] The mine is said to contain no copper above the 200-foot level, but in an opening about half a mile west of the mine and about 500 feet above it, on what is thought to be the same C. O. D. vein, the ore, which here occurs in a milk-white quartz gangue, contains chiefly bornite and chalcopyrite, with some zinc blende, and about $20 in gold to the ton.

several deep transverse washes, of which the principal ones are Banker, O. K., and Cyclopic, situated about 2 miles apart. The nearest railway station is Hackberry, 40 miles to the south, with which connection is made by stage line. Colorado River lies 16 miles to the north. Mineral was first discovered here early in the seventies, but remoteness from the base of supplies, together with scarcity of fuel and water, renders operations expensive and has materially retarded developments. Nevertheless, considerable progress has been made and much ore has been produced and worked in arrastres and mills.

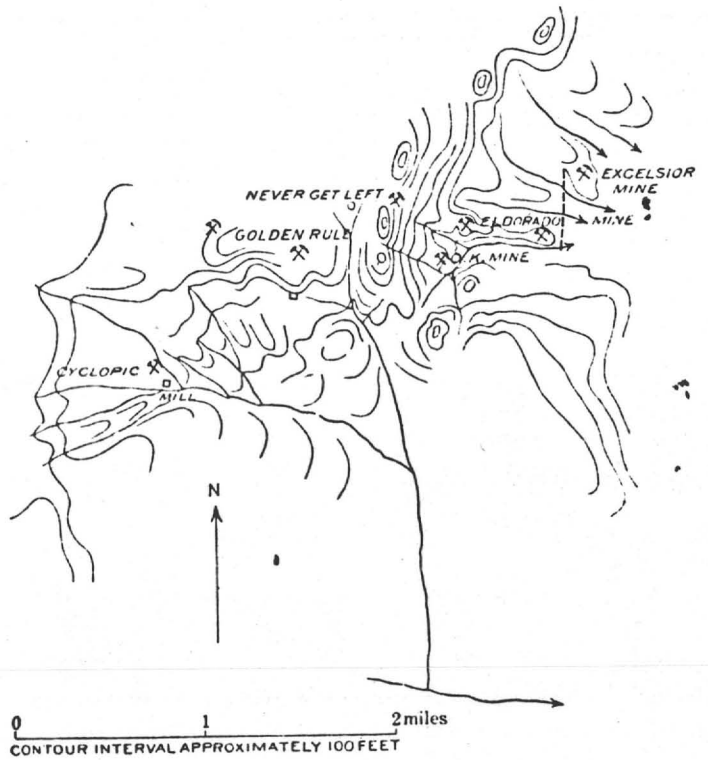


FIGURE 18.—Sketch map of Gold Basin district.

The deposits occur mainly in fissure veins in the pre-Cambrian crystalline rocks. The veins dip southeastward or northwestward, mainly at angles of 40° or 70°. The gangue is quartz, in places with siderite, and the metal is gold, mostly free milling, but it is associated with lead or copper ores, copper stain being a good indication of the gold values. Pyrite, chalcopyrite, galena, molybdenite, and wolframite are found, but the ore is largely oxidized, the water level not having been reached. Among the oxidized products are limonite, malachite, cerusite, and vanadinite.

LIBRARY COPY CENTER

NAME VANDERWALL DATE 4-25-81

TELEPHONE _____

DEPT. _____ ACCT. NO. _____

COPIES PER PAGE _____

PAGE NUMBERS:

110 THRU 119		_____ THRU _____	
_____ THRU _____		_____ THRU _____	
_____ THRU _____		_____ THRU _____	

AVOID VERBAL INSTRUCTIONS

☐ HOLD ORIGINALS

☑ TWO PAGES PER COPY IF POSS.

SPECIAL INSTRUCTIONS:

_____

_____

_____

_____

DO NOT WRITE IN BOX

OFFICE USE ONLY

TOTAL COPIES _____

BINDING _____

NOTES: _____

_____

_____

_____

_____

SUB TOT _____

TAX _____

TOTAL _____

been of great help to us and was similarly helpful to Dr. Ransome. During 1936-37 the Eagle Picher Lead Company made an examination of the area under the direction of George M. Fowler and generously contributed to the data collected. Acknowledgment is made of the contribution of Dr. C. A. Rasor, who assisted in the work.

Bibliography

Blake, W. P., The Geology and Veins of Tombstone, Arizona, Am. Inst. Min. Eng., Trans., Vol. 10, pp. 334-45, 1882.

Church, J. A., The Tombstone, Arizona, Mining District, Am. Inst. Min. Eng., Trans., Vol. 33, pp. 3-37, 1903.

Ransome, F. L., Deposits of Manganese Ore in Arizona, U.S. Geol. Survey Bull. 710, pp. 96-103, 113-19, Pl. V, 1920.

Butler, B. S., Wilson, E. D., and Rasor, C. A., Geology and Ore Deposits of the Tombstone District, Arizona, Univ. of Ariz., Ariz. Bureau of Mines Bull. 143, 1938.

Cerbat Mountains[64]

By Robert M. Hernon[65]

Introduction

Geography.—The Cerbat Mountains, in Mohave County, Arizona, extend for about 30 miles northward from Kingman, a town about 70 miles southeast of Boulder Dam. It is a desert range that attains altitudes of 5,000 to 7,000 feet and rises sharply for 1,500 to 3,500 feet above detritus-filled desert valleys. The erosion forms in this range are typical of granite and gneiss masses, except where remnants of lava flows cap mesas of the familiar southwestern type.

Water supply.—Water is not abundant in either the mountains or valleys. Some springs and wells are in volcanic rocks as at Kingman. The crystalline complex of the mountains has little primary porosity, and the small amounts of water generally found in it occur in fault fractures and joints. According to reports, wells in the detrital valley fills have yielded little water.

Literature.—The most extensive publication that deals with the Cerbat Mountains is by Schrader.[66]

Bastin[67] studied some of the rich silver ores during the secondary sulphide-enrichment investigations. Brief summaries of the geology and ore deposits have been given by others.[68]

[64] Paper prepared for, and originally presented at, the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.

[65] Assistant Professor of Geology, University of Arizona.

[66] F. C. Schrader, *Mineral Deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona* (U.S. Geol. Surv. Bull. 397, 1909).

[67] E. S. Bastin, *Origin of Certain Rich Silver Ores Near Chloride and Kingman, Arizona* (U.S. Geol. Surv. Bull. 750, 1924), pp. 17-39.

Production.—The production[69] of the Cerbat Range through 1930 is given as follows:

Copper (lbs.)	Zinc (lbs.)	Lead (lbs.)	Gold	Silver	Total
2,900,000	95,587,344	55,350,000	$2,339,000	$5,038,000	$20,270,000

To this should be added approximately $170,000 for 1931-36, inclusive, and an unknown amount for some early production which, because of marketing conditions, was not credited to the Cerbat Range. The value of the total production is estimated at $21,000,000 to $25,000,000. Nolan[70] records that the mines of the Wallapai district produced 548,035 tons of ore valued at $13,955,473 during 1902-32.

The largest past producers by far have been the Tennessee and Golconda mines. The important producers at present are the Tennessee-Schuylkill and the Arizona-Magma mines near Chloride, and Keystone, Inc., which operates in Mineral Park and in and near the "Top of Stockton Hill" area. Some custom milling ore was produced in 1937-38 by the Minnesota-Connor Mine. Numerous other mines are yielding shipping ore and custom mill ore to small operators and lessees.

The larger mills include those of the previously mentioned main active operations, besides the Oro Plata mill (now idle), and the General Ores Reduction custom mill.

History.—Most of the mines of the Cerbat Mountains were discovered between 1863 and 1900. The metals sought in the earlier days were gold, silver, and lead. Rich silver chloride, silver sulphide, and native gold ores were exploited first. With cheaper transportation, base-metal ores were mined for lead with low silver. Subsequent improvement in milling methods led to exploitation of complex lead-zinc ores. The later history of the area is essentially the history of the Golconda and Tennessee mines, as they were affected by metal prices and marketing conditions and by milling methods.

The area reached its peak production in the years 1915-17, when the annual yield averaged nearly $3,000,000. This peak coincided with high metal prices. After the World War, production was small until 1936 when the Tennessee-Schuylkill Corporation began operations.

[68] R. T. Mason, *Mining in Northwestern Arizona* (Min. and Sci. Press, 1917), pp. 627-28.
N. H. Darton, *A Résumé of Arizona Geology* (Univ. of Ariz., Ariz. Bur. of Mines Bull. 119, 1925), p. 180.
W. Lindgren, *Mineral Deposits* (4th ed., 1933), pp. 578-79.
E. T. McKnight, *Mesothermal Silver-Lead-Zinc Deposits* (Am. Inst. Min. Eng., Lindgren Volume, 1933).
T. B. Nolan and others, *Mineral Resources of the Region around Boulder Dam* (U.S. Geol. Surv. Bull. 871, 1936), pp. 18-19.

[69] Morris J. Elsing and Robert E. S. Heineman, *Arizona Metal Production* (Univ. of Ariz., Ariz. Bureau of Mines Bull. 140, 1936), pp. 73, 95.

[70] *Op. cit.*

The Tennessee Mine had a small production in the early nineties. Schrader[71] states that for some time during the period 1897-1903, it yielded thirty to fifty carloads of concentrates per month, besides high-grade ores. In 1910 a new shaft was sunk. The Needles Mining and Smelting Company operated the property until 1916 and produced a considerable tonnage of excellent grade ores. Restricted, intermittent operations characterize the years 1917-36.

The Golconda Mine, which was developed later than the Tennessee, made a small production early in this century. A good zinc ore shoot was reported developed about 1907. From 1908 to 1917 the Golconda was exploited to the 1,100-foot level and reached its maximum production in the years 1915-17, a period that coincided with the greatest production from the Tennessee Mine. Attempts have been made to reopen the Golconda since the World War, but it has produced only from shallow workings.

Geology and Ore Deposits

The facts concerning the geology were derived from published data, information supplied by geologists who have worked in the district, and the writer's observations made mainly in the east-central part of the mineralized area. No detailed geologic map of the range exists.

Rocks.—The rocks of the Cerbat Range consist of pre-Cambrian crystalline rocks, later crystalline rocks of unknown age, and volcanic rocks of probable Tertiary and Quaternary age. Some of the Paleozoic and Mesozoic sedimentary rocks of the Colorado Plateau probably extended over the Cerbat area but were removed by erosion before the Tertiary volcanic activity.

The crystalline rocks of the Cerbat Range form a complex predominantly of granite with diorite and gabbro, all generally somewhat gneissic and intruded by pegmatite, medium-grained granite, diabase, granite porphyry, and lamprophyric dikes. Small- to medium-sized blocks of very dark schist (amphibolite) are locally common. All these rocks show various degrees of schistosity and represent two or more eras.

The rocks as classified by Schrader[72] are here summarized.

Quaternary	olivine basalt flows and detritus
Tertiary	thick volcanics
(? Mineralization)	
Mesozoic (?)	granite porphyry, diabase, minette and vogesite dikes
Pre-Cambrian	coarse-grained, porphyritic, gneissoid granites, granite altered to schist, diorite, amphibolite, graphite schist, pegmatite

Granitic rocks greatly predominate in the range. The lamprophyric dike rocks are locally termed "diabase," and much of the granite porphyry of local usage is actually porphyritic granite.

[71] *Op. cit.*, p. 54.

[72] *Op. cit.*, pp. 27-42, 49-118.

The pre-Cambrian rocks are slightly to strongly schistose, and the schistosity generally strikes northeasterly but locally north or northwesterly. Pegmatite commonly occurs in tabular masses along the pre-existing schistosity. Large masses of pegmatite crop out north of Kingman; one such mass is being exploited for feldspar.

The Mesozoic (?) rocks are of undetermined age. According to Schrader[73] they cut pre-Cambrian rocks and are older than the Tertiary volcanic rocks. The ore deposits are associated with rocks of this group in space and time. The vein faults cut across the members of the pre-Cambrian group of rocks and probably across the diabase, but monzonitic dikes and highly altered dikes with quartz phenocrysts intrude along the faults and are cut by the mineralized fissures. The lamprophyric dikes also intrude the vein faults and are mineralized. The diabase has been seen to form one wall of veins and appeared to be older than the vein faults. It closely resembles the diabase sills in the Grand Canyon series and in the Apache group of southeastern Arizona. All the rocks grouped as pre-Cambrian and Mesozoic (?) may show north to northwest sheeting that appears to pass into true schistosity where most intense; this sheeting and schistosity appears to be related to the northwest system of faults.

The prominent felsitic Broncho dike of the Cerbat mining district is said to cut off and offset northwest-striking faults and their vein filling. This dike may be related to the Tertiary rhyolitic volcanic rocks. A small, similar dike crops out in lower Cerbat Wash.

The Tertiary volcanics are limited to remnants around the margins of the Cerbat Range and to the crest in the extreme north and south parts of the range. According to Darton[74] they are principally rhyolite flows, tuffs, and agglomerates. The absence of veins of the Cerbat type in the volcanics and the presence of felsitic dikes cutting across the veins are evidence that the mineralization is of pre-Tertiary age. The volcanics are absent over the main mineralized area, however, and the strike of the veins is the same as in Oatman district, where the veins are younger than volcanics probably contemporaneous with the rhyolitic series of the Cerbat Range.

A considerable thickness of detritus occupies the valleys. Some of the older detritus is covered by Quaternary olivine-basalt lava which laps over on older bedrock.

Structure.—Pre-Cambrian and later structures are not well known because of the small amount of detailed mapping in the range. The older rocks and structures are cut by faults of northwest strike. These faults are of two directions at any one place and appear to represent relief by shearing. Striations generally indicate that movement along steeply dipping faults had a larger horizontal than vertical component. Some minor faults of about

[73] *Op. cit.*, p. 30.

[74] *Op. cit.*

50 degrees dip are striated parallel with the dip. That the rocks now visible were faulted under deep-seated conditions is indicated by clay gouge and finely crushed rock along the tight fissures; no open breccia is present except postmineralization breccia in the quartz veins. Tear fractures in the wall of the faults, attitude of striations, tightness of the faults, and the development of two directions of breaks, indicate stresses were mostly compressive and that the yield was mainly by shearing.

At least four main periods of movement are discernible along the vein faults. The initial break and one period of reopening were premineral in age; one main reopening occurred during mineralization; and movement occurred after mineralization was complete.

The most prominent direction of jointing and sheeting is northwesterly. Postmineralization cross faults are known at several places in the range.

Veins.—The veins were formed by solutions rising along the system of northwest fault fissures. It is estimated that the mappable veins would aggregate a total length of 100 miles and perhaps twice that length within the main mineralized area. Much of the vein matter is barren or of very low grade but locally is ore; narrow, noncommercial stringers of the valuable minerals may persist for long distances along or in barren vein filling.

The veins consist mainly of fine-grained quartz with pyrite, galena, sphalerite, and other minerals. Lindgren[75] classes them as mesothermal, pyritic galena-quartz veins of the Freiberg type, although they contain some gold. The veins generally do not exceed 5 to 10 feet in width, although locally, some are as much as 25 or 30 feet wide. Their ore shoots as a rule are 0.5 to 4 feet in width, though lenses attain widths of 6 to 14 feet in the largest ore shoots. The veins locally show a rough banding.

Mineralogy.—The minerals ordinarily seen in hand specimens of sulphide ore are quartz of three ages, pyrite of two or more ages, galena, and sphalerite. Bastin[76] records the following minerals in the rich silver ores; those marked with an asterisk are rare under the conditions indicated.

Oxidation products: cerargyrite, native silver,* copper pitch ore,* malachite,* native copper.

Secondary sulphide enrichment products: argentite,* proustite (very rare),* covellite,* chalcocite.

Primary (hypogene) minerals: quartz (generally gray and finely crystalline), manganiferous siderite,* calcite (white), pyrite, arsenopyrite, sphalerite, galena, chalcopyrite, tennantite,* argentite, proustite, pearceite,* polybasite.

Bastin emphasizes the arsenical nature of the high-grade silver ores. He notes that proustite is abundant in such ores and tends to occur with tennantite.

[75] *Op. cit.*, p. 578.
[76] *Op. cit.*, p. 35.

Bastin[77] found native silver near fractures and vugs showing oxidation. He notes that native silver ores grade directly into rich sulphide ores below and appear to be somewhat below the silver chloride ores.

Character of ores.—The unoxidized ore shoots are generally complex assemblages of galena, sphalerite, and gangue minerals, which carry gold, silver, and a small amount of copper. Indium is reported in some ores of the range. A few unoxidized ores are essentially gold-silver ores with normally low percentages of base metal. The greatest production, however, has been of lead-zinc ores with some gold and silver. Production statistics seem to indicate that ores with high-grade zinc carry the most gold and ores with high-grade lead the most silver, but the association does not appear to be a close one. Gold occurs with a bronzy pyrite according to Garrett,[78] geologist at the Tennessee Mine. Some gold may be associated with arsenopyrite. Silver occurs as argentite and sulpho salts in unoxidized ores, as previously described.

Mineralization.—The sequence of mineralization has not been determined in detail. Main stages are as follows: Some vein faults or parts of vein faults were intruded by dikes before mineralization began. Reopening followed with introduction of quartz along most of the length of faults, whether or not intruded by dikes. This produced quartz veins or lodes in places as much as 30 feet wide. Some pyrite crystals appear to be associated with this early quartz. Mineralization had probably largely ceased when reopening of the fault fissures occurred. Solutions brought in the valuable constituents of the veins, and quartz was reworked with apparently little further addition of silica. A weak reopening followed, with introduction of a little quartz as veinlets that cut the sulphides. Later reopenings produced quartz breccias and more gouge, but mineralization seems to have completely ceased.

Vertical or concentric zoning does not appear to be striking. Zinc is said to increase with depth, but high-grade lead is found in considerable amount in depth. Copper is said to increase slightly with depth. A type of horizontal zoning is found in some ore shoots: more or less vertical or steeply raking sections of a single ore shoot are characterized by high gold, high lead, or high zinc. These horizontal variations appear to be due to changes in stability of minerals with time, as acted upon by successive intermineral reopenings. Either sphalerite or galena may occur without the other; sphalerite appears to be the earlier mineral.

Wall-rock alteration is not extensive except where strong silicification of sheeted zones occurred in the early quartz stage. The granitic rocks appear to have silicified more readily than basic dikes or schist masses. Microscopic study of the wall rocks might show more extensive alteration than is apparent to the eye.

Localization of ore shoots.—In the main mineralized sections of the Cerbat Range the 100 or more miles of vein outcrops are

[77] *Op. cit.*, p. 36.
[78] S. K. Garrett, personal communication, 1938.

composed mainly of barren or very low-grade material. According to available production records, only two mines, the Tennessee and the Golconda, exceeded a total production of $1,000,000. While a great many mines have made appreciable productions, the geological conditions favorable for ore bodies of the size of the Tennessee and Golconda are rare. These two ore shoots were explored for vertical distances of 1,600 and 1,400 feet, respectively.

Schrader[79] noted that some ore shoots coincide with intersections or forking of veins. Many vein intersections, however, do not show ore shoots.

Ore shoots appear to be localized where changes of strike or dip of the vein faults gave rise to open spaces due to the reopening movements that occurred just before and during mineralization. Open space filling seems to have been most important as far as valuable vein minerals are concerned. Areas of faults choked by either clay gouge or greatly crushed rock were too tight for big ore shoots. No striking control of ore shoots by wall rock is known. One small shoot was seen to pinch out where the vein passed from granitic rock to dense black schist.

Oxidation.—Weathering of the veins is incomplete where the filling is highly siliceous, except along open fractures or where the vein is brecciated. High-grade sphalerite ore shoots or heavy pyrite streaks were more or less completely oxidized and leached. Galena, however, is often seen on natural outcrops. Water level is ordinarily at depths of 25 to 250 feet, but oxidation does not tend to be prominent for more than 30 to 100 feet, except along open fissures. Ground water is rich in chlorine, according to Bastin,[80] who found 80 parts per million in a stream near the town of Chloride.

Secondary enrichment.—Bastin[81] does not believe that secondary sulphide enrichment of silver and copper is important in rich silver ores. His microscopic studies indicate argentite, occurring in funguslike patches, to be the main secondary silver mineral. He found pearceite and abundant proustite intimately associated with primary sulphides to be probably primary.

Several veins, however, may have undergone considerable secondary enrichment. An exploited vein in Mineral Park shows small base-metal shoots with good silver content that dropped out below the third level. The narrow Alpha vein in the Cerbat district has a strong gossan at the outcrop. Schrader[82] noted silver sulphide, pyrite, galena, zinc blende, and chalcopyrite in Alpha ore. Chalcocite can be seen in some specimens. Ores mined recently had high copper and silver content and appeared to be secondarily enriched.

Regardless of whether the veins have been enriched primarily or secondarily in silver, available evidence does not indicate that

[79] *Op. cit.*, p. 51.
[80] *Op. cit.*, p. 18.
[81] *Op. cit.*, pp. 36-37.
[82] *Op. cit.*, p. 103.

high-grade silver can be expected to extend downward more than a very few hundred feet.

Gold has been enriched residually by leaching of zinc and iron from heavy sulphide ore shoots carrying relatively low primary gold. A thin zone of very rich gold ore is reported near the bottom of the oxidized zone in several veins. This may be secondary gold. Nature of gangue, ground-water chloride ion, common presence of pyrite, and persistent though only locally abundant manganese oxides are all favorable for gold enrichment. Some gold enrichment has occurred, but how much residual and how much chemical is unknown. Such gold ore shoots have been small, but some were spectacular. Many sections of veins that are very low grade in the sulphide zone have yielded small bodies of gold ore of shipping grade from the oxidized zone.

Summary.—The Cerbat Range is an area of numerous veins with mostly small ore shoots. The excellent grade ores and fair-sized shoots of several mines indicate the area to be important and worthy of study. The great need of the present is for a good topographic map of adequate scale and for a sufficiently detailed geologic map to bring out essential features. Many problems of structure, petrology, ore occurrence, and mineralogy are unsolved. Microscopic study of ordinary sulphide ores is needed. The exact manner of occurrence of gold and silver in ores of ordinary grade should be determined.

Acknowledgments.—The writer is indebted to G. M. Fowler, of Joplin, Missouri, for direction and for the opportunity to study part of the Cerbat area. Many local people facilitated the field work and gave information.

Tennessee-Schuylkill Mine[83]

By S. K. Garrett[84]

Location

The Tennessee-Schuylkill Mine is at the western foot of the Cerbat Range, about 1 mile east of Chloride, in the Wallapai mining district, Mohave County, Arizona.

Rocks

The rocks of the Wallapai mining district can be grouped as diorite gneiss, granite, quartz monzonite porphyry, rhyolite, and diabase. The oldest rock, diorite gneiss, has been intruded by granite, and both the diorite gneiss and the granite have been intruded by quartz monzonite porphyry. The rhyolite and diabase

[83] Paper prepared for, and originally presented at, the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.
[84] Geologist, Tennessee-Schuylkill Mine.

occur as dikes, some of which are in the same fissures as veins. In one place a diabase dike has been intruded along an earlier rhyolite dike.

Veins

The fissure veins near Chloride can be grouped according to strike. One set strikes nearly north and the other about N. 25 degrees W.; the dip ranges from 35 degrees E. at the western foot of the range to 85 degrees W. near the crest. The progressive steepening toward the crest of the range may indicate overthrusting stresses as the cause of the fissuring.

The Tennessee-Schuylkill fissure vein, which can be traced for nearly 2 miles, strikes N. 5 degrees W. and dips 85 degrees NE.

Strong gouge is present on both the hanging and footwalls of the vein. There was some movement on the fissure after the formation of the vein.

At abrupt changes in strike, there is some horse tailing of the fissure, but there are no cross fissures.

Ore Deposits

The Tennessee-Schuylkill deposits occur as a vein filling a fissure in the complex of diorite gneiss, granite, and quartz monzonite porphyry. The ore is in shoots which, above the 900-foot level, rake northward and between the 900- and 1,400-foot levels are nearly vertical (Pl. XXX).

Most of the ore shoots range from 35 to 300 feet in length and average about 5 feet in width.

Ore Controls

The different wall rocks have not influenced the deposits; the ore filling is as wide in diorite gneiss as in quartz monzonite porphyry. The only recognized control is that of strike and dip of the fissure.

The four ore shoots in the Tennesee-Schuylkill Mine (Pl. XXX) occur where the vein has changed to a more than average northwesterly strike. The ore filling is wider on steep dips than on flat dips.

The combination of strike and dip control the rake of the ore shoots. A change to a northwesterly strike on a flat dip gives a pronounced northward rake, and a change in strike on a steep dip gives a rake that varies from slightly southward to vertical.

Zoning

There is marked horizontal zoning of the ore minerals in two of the ore shoots above the 900-foot level. The north limits of these two shoots contain principally galena and gold-bearing pyrite with practically no sphalerite. As the south limits of the shoots are approached, the galena and gold-bearing pyrite decrease, and sphalerite increases until, at the southern limits of the shoots, sphalerite is the only ore mineral present (Pl. XXX).

Little is known of the zoning below the 900-foot level other than a general decrease of galena and increase in sphalerite and crystalline pyrite with increased depth. On the 1,600-foot level a small amount of development along one of the ore shoots shows no galena but considerable sphalerite and crystalline pyrite.

Mineralogy

The hypogene ore minerals are galena, fine-grained gold-bearing pyrite, and sphalerite. The gangue minerals are milky quartz, fine-grained chalcedonic quartz, crystalline pyrite, and arsenopyrite.

Supergene ore minerals, found to a depth of about 80 feet are: plumbojarosite, anglesite, cerussite, bromyrite, cerargyrite, native gold, and, rarely, native silver. The supergene ores are of little importance.

The paragenesis, determined megascopically, is milky quartz, sphalerite, galena, pyrite, and fine-grained chalcedonic quartz.

The sphalerite occurs as older "black-jack," and younger "rosin-jack." Some galena shows a flow structure suggesting movement of the walls of the fissure after deposition. Argentite may account for the small amount of silver that the ore contains.

The pyrite is of two varieties. One variety occurs as well-crystallized cubes and pyritehedrons with no gold; the other is somewhat massive and fine grained and contains 0.3 to 15.0 ounces of gold per ton in the pure specimens. The gold in the pyrite is so finely divided that colors cannot be panned from a high-grade pyrite concentrate.

The fine-grained chalcedonic quartz occurs as fracture fillings in the sulphide ore.

Montana Mine, Ruby[85]

By George M. Fowler[86]

Introduction

A brief description of the geology of a limited area around the Montana Mine is presented in this paper. During the past few years a much larger area was studied in an attempt to find new ore bodies that could be worked in conjunction with this operation. At a later date it is hoped to present the results of this investigation as well as to give further details about the Montana Mine (Pl. XXXII).

The Montana Mine is in the Oro Blanco mining district, Santa Cruz County, Arizona, 5 miles north of the Mexican boundary and about 30 miles west of Nogales, Arizona.

[85] Paper prepared for, and originally presented at, the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.

[86] Consulting geologist, Joplin, Missouri.