CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the

James Doyle Sell Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

GEOLOGICAL INTERPRETATION OF THE PALO VERDE MINE
BASED UPON DIAMOND DRILL CORE

INTRODUCTION

The Palo Verde Mine ~~is~~ owned and operated by the Banner Mining Company, Tucson, Arizona. This mine is relatively new with only a meager amount of underground workings to use for geological study. This paper was written almost entirely on the strength of the geologic interpretation based upon diamond drill holes spaced 250 feet apart in an equilateral triangular grid system. *1

~~The Palo Verde Mine~~ is located in the Pima Mining District, Pima County, Arizona, approximately 20 miles south of Tucson along the Twin Buttes road immediately south of the San Xavier Indian Reservation. ~~The mine is bounded north, south and east by American Smelting and Refining Company's Mission project and~~ on the west by Banner's Mineral Hill-Daisy area. The general locale of this mining area is on the gentle sloping alluvium covered pediments on the northeast flank of the Sierrita Mountains. The alluvial covering averages 200 feet in the vicinity of the shaft with the closest bedrock outcropping approximately 4200 feet to the southwest. The elevation above sea level at the Palo Verde Shaft collar is 3242 feet. *2

During September, 1969, a five compartment steel and concrete shaft was started. Shaft sinking progressed fairly rapidly in relatively dry ground until a large flow of water was tapped at the 960 foot level. Prior to the shaft sinking a churn drill hole was drilled 35 feet to the south of the shaft location and no water was hit until the hole reached below the 1100 foot level. Stations have been cut at the 700, 800 and 900 foot levels with plans for future expansion below these.

Plans for a thousand ton-per-day production have been made and work is now in progress underground on all levels according to schedule. Diamond drilling is still in progress as the outer limits of the Palo Verde ore body have not yet been delineated in all directions. Approximately 40,000 feet of diamond drilling plus several thousand feet of churn drilling have constituted

the exploration and development program in this area.

ROCKS

The basement complex in this area is presumably the Precambrian? "Sierrita" granite which is an unmineralized and slightly chloritized light greenish gray, medium to coarse grained granite. It is exposed on the surface 1½ miles to the west of the Palo Verde shaft and in the bottom of several diamond drill holes in the vicinity of the shaft. The surface of the granite dips uniformly at a low angle to the north and east in the area.

In addition to the Sierrita granite we have other intrusives such as quartz monzonite porphyry and andesite dikes. The intruded host rocks are limestones and quartzites of Paleozoic age and arkose, graywacke and argillite of Cretaceous age.

The quartz monzonite porphyry consists of quartz, feldspar and biotite mica, mineralized with ranging amounts of pyrite, chalcopyrite and molybdenite. The size of the feldspar phenocrysts range from microscopic to ¼ inch, with an occasional pink phenocryst up to 3/4 inch in length. The feldspar phenocrysts comprise approximately 60% of the porphyry. The biotite mica flakes are small and sparsely disseminated through the porphyry. Gypsum is prevalent throughout as small veinlets and coatings on the exposed surfaces in the fractures. The porphyry has been extensively crisscrossed with small 1/16 to ½" veinlets of late quartz containing pyrite and molybdenite as a rule. The porphyry forms a massive sill-like body somewhat anticlinal in nature with the axis dipping to the west at a low angle. This sill is not confined to the Palo Verde area alone but extends to the south, the west and northwest. A major portion of the top of the porphyry sill and related ore bodies have been removed by erosion. Numerous small

fingerlike apophyses protrude from the mass into the sedimentary host rocks.

The addesite is in the form of relatively thin dikes intruding the limestone and arkose east of the shaft but have not as yet been found in= truding into the quartz monzonite porphyry. The dikes are no doubt post mineralization in age

STRUCTURE

The true structural conditions prevailing at the Palo Verde Mine area are not entirely decipherable from the limited amount of information revealed by drill holes. Certain indisputable structural relationships, however, do exist a d from these a reasonable geologic picture can be pieced together.

A low angle thrust fault separates the Precambrian(?) Sierrita granite from the overlying porphyry and sedimentary formations. Typical of most thrusts a gouge and brecciated zone up to 16 feet in thickness has been found whenever drilling penetrated the fault. The gouge is usually gray to green gray, constining small sub-angular to rounded fragments with no discernible mineralization. The competent overlying rocks are intensely fractured up to 50 feet above the fault surface.

There are reasons to believe that this major thrust fault is the same one that Cooper (1) has named the "San Xavier" thrust, and which he predicts has lateral movement up to 6½ miles. If Cooper's hypothesis is correct, then the roots of the Palo Verde and adjoining ore bodies are in the Twin Buttes Area. There are corresponding similarities which leads the writer of this paper to agree with Cooper. Thrusting and normal faulting definitely occurred at two and possibly more intervals of time. The pre-mineral faulting was probably relatively steep dipping and it was here in these zones of weakness that the mineralization took place.

Post mineral faulting is evidenced underground by ore bodies being cut off and displaced by both thrusts and northeasterly shears. The faulting above the San Xavier thrust was complimentary to it and of small magnitude. In the east Palo Verde area these steep dipping shears served also as channel-ways for the late andesite dikes to follow. Minor bedding plane slips, small thrust faults and local rolls along the bedding are indicative of previous compressional stresses in the area. The abundant steep dipping quartz and

and sulfide veinlets in the quartz monzonite porphyry also indicate pre-mineral fracturing. Drill core information prohibits the interpretation of any definite fracture pattern in the area, but future underground developments will no doubt disclose one or more patterns.

ALTERATION

Alteration of the rock types in the Palo Verde Area has been very intense with very little remaining that did not undergo the hydrothermal processes of recrystallization and metasomatism. Alteration is more pronounced in the vicinity of the intrusive porphyry sill but extends well beyond the boundaries of the Palo Verde area. The zones of alteration in respect to their spatial relationship to the porphyry are (1) Kalinization, (2) Silicification, pyritization, and (3) Recrystallization of the limestones.

In the quartz monzonite porphyry hydrothermal alteration has kaolinized over 75% of the feldspars and biotite mica. Quartz and small quantities of sericite also resulted from this alteration. The crystal structure of the quartz phenocrysts has been mostly obliterated by resorbtion of the silica. The twining planes and crystal faces of the feldspars are also obscured by the alteration processes. Sericite and chlorite are present in the porphyry in small scattered amounts of minor importance. In the sedimentary rpcks particularly the graywacke and arkose adjacent to the porphyry secondary feldspar have been formed. Epidotization of the arkoses an graywacke has taken place over a wide spread area and whenever encountered in quantities the pyrite ratio increases also.

In the tactite-garnet zone at the Palo Verde the alteration products are garnet, clay garnet, hematite, chlorite, and pyroxenes such as diopside and wollastonite. The clay-garnet is undoubtedly the product of some brecciation and hydrothermal alteration of the garnet and epidote rocks. It consists of small rounded and sub angular fragments of garnet and epidote in an argillaceous matrix with chalcopyrite and bornite appearing as small blebs throughout. The unaltered garnet rock is reddish brown to dark green in color, dense and extremely hard. The chalcopyrite and bornite favor this rock particularly in the lower limits where it approaches the calcium silicate zone where the predominant silicate minerals are diopside, wollastonite and

and tremolite.

In the calc-silicate zone dark brown to black sphalerite predominates with bornite and chalcopyrite intermixed to some extent. Whereever chalcopyrite is found ~~in~~ with the sphalerite it is usually as small blebs speckled throughout. The sphalerite usually serves as a line of demarcation between ore and waste. Small amounts of it ~~is~~ are found in the marbleized limestone isolated from the ore bodies by waste. The limestone grades from the calc-silicate zone into barren marble and bleached limestone then into grey white unaltered limestone where few unrecognizable fossils are present. Graphite is rare but does occur in the limestone in association with a fault zone.

Minor bleaching and alteration of the host rocks is found where the late andesite dikes have intruded . These andesite dikes are unmineralized being definitely post mineralization, but whether they are pre or post thrusting is problematical and do not serve in any useful geologic manner.

ORE DEPOSITS

The known ore deposits in the Palo Verde Mine area are classified as pyrometasomatic in type, occurring in the limestones and contact silicate zones as replacements and in the porphyry, arkose and related clastic rocks as disseminations. The mineralizing solutions appear to have entered the rocks from the south and west in proximity to the porphyry. This assumption is based primarily on the zonal arrangement of the mineral assemblage. The higher grade ore bodies formed in the tactite, below the quartzite, in gentle rolls plunging downward to the north and northwest on dips ranging from 24 degrees to 42 degrees.

At the Palo Verde mine we have two types of ore bodies, the first and most extensive being the lower grade disseminated type, and the second type B ore body of considerable higher grade being located in the tactite zone. Although directly related to the mineralization, the quartz monzonite porphyry contains no appreciable amounts of copper sulfides. The bulk of the sulfide mineralization in the porphyry is iron pyrite, with chalcopyrite averaging less than ~~0.96% copper~~ ore grade. molybdenite mineralization is confined almost entirely to the porphyry and quartzite suggesting favorability for the more acid rocks.

A definite relationship exists between the intrusives and the ore bodies in the intruded host rocks. Varying with distance from the quartz monzonite contact the degree of metamorphism and intensity of mineralization decreases. Paragenetically the minerals appear to be related in the following manner:

Silicate minerals developed early in the alteration process with sulfide minerals being deposited last and replacing silicate minerals in part. Apparently some recrystallization of the silicate minerals has taken place during the time of sulfide deposition.

Two ~~or~~ or more stages of mineralization are associated with the porphyry intrusion and being pre "San Xavier" thrusting in age. The first stage introduced the bulk of the ore minerals whereas the second or later stages

formed the small veinlets of quartz, pyrite and molybdenite.

Mineralization has been intense in the more favorable tactite zone where the higher grade of ore is associated with the iron rich reddish-brown garnet rock. The paragenetic sequence and spatial relationship outward from the intrusive quartz monzonite porphyry consists of pyrite, molybdenite, chalcpyrite, bornite and sphalerite. Magnetite is conspicuous by its absence in this immediate area, but is abundant however on the south flank of the quartz monzonite porphyry sill in the Daisy Mine. A small (6 inch) vein of Argentiferous tetrahedrite and quartz cutting the porphyry was discovered in the shaft at the 350 foot level.

OXIDATION AND ENRICHMENT

The zone of oxidation and secondary enrichment in the Palo Verde area averages 30 feet in thickness with a maximum thickness of 70 feet. The deepest supergene sulfides bottomed at 283 feet below the ground surface. The lack of an appreciable blanket of enriched chalcocite indicates that leaching and migration of copper from the oxide zone was absent. Small amounts of copper oxides were encountered in the caliche capping immediately above the orebody indicating a slight upward migration of the copper.

The principal minerals resulting from the oxidation and enrichment are chrysocolla, chalcocite and various iron oxides. Malachite and azurite have been noted only on rare occasions in this zone. In the lower portion of the oxidized zone black copper oxides are not too infrequently found immediately above the chalcocite coated pyrites of iron and copper. A relatively sharp line of demarcation is formed by the chalcocite with the underlying hypogene sulfides.

Oxidation has obliterated the original texture and characteristics of the rock types found in the upper portions of the oxide zone. The lack of oxides at depth in any of the intensely fractured rocks indicates that the

supply of oxygen was cut off at a very definite and uniform limit. This is suggestive of the permanent ground water level at the time prior to the formation of the caliche conglomerate capping.

CONCLUSION

Pending underground development and confirmation of the geologic picture as represented here by drill cores, it appears that the following conclusions and predictions can be made.

1. Chemical favorability rather than structure was the controlling factor in the locallization of the ore bodies.
2. The higher grade ore bodies can be located by the use of wall rock alteration and the zonal arrangement of the ore minerals
3. The bottom of the ore bodies will be found once the sphalerite zone is reached.
4. Additional Ore bodies of higher grade but at greater depths will be found to the west of the Palo Verde Shaft.

ACKNOWLEDGEMENT

Acknowledgement is due the management of the Banner Mining Company for permission to make this report possible.

Reference: -
John Cooper, U.S.G.S. Bulletin No° 1112-C

Laboratory Number 75434-5 Book 38 Page 57 Date Answered 3-4-60 AC-1

THE UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION
DEPARTMENT OF AGRICULTURAL CHEMISTRY AND SOILS
TUCSON, ARIZONA

Mr. George Esquivel
U.S.P.H.S. Hosp.
Box 11067
Tucson, Arizona

WATER SAMPLE

1. Name of Owner BANNER MINING CO. Address TWIN BUTTES ROAD Town TUCSON County PIMA
REPORT TO:
2. Name of Collector RALPH MARCUS Address USPHS - P. O. BOX 11067, TUCSON Town SELLS County PIMA
3. Source: Well, spring or surface water WELL - WELL #1 mineshaft outlet - well #2 well outlet
4. IMPORTANT: Location of sampling SEC. 34 TWP. 16S R. 13E
5. Geographic location Near area of Banner Mine
6. Depth of well 550 ft. for shaft/1100' well Depth to Water Level
7. Use: Domestic, stock or irrigation No usage - pumped & run in open
8. Reason for requesting a chemical analysis water is running into Ind. Land and B.I.A. Asked Mr. Esquivel, U.S.D.H.S., Sanitarian to check in on problem to see if water contains any chemicals dangerous to Ind. land, people or livestock.

IMPORTANT

N.W.	N.E.
S.W.	S.E.

Mark Sampling Location

9. Analyses:

FIELD No.	LAB. No.	SOLUBLE SALTS ppm.	SOLUBLE SALTS EC x 10³	CALCIUM ppm.	MAGNESIUM ppm.	SODIUM ppm.	CHLORIDE ppm.	SULFATE ppm.	CARBONATE ppm.	BICARBONATE ppm.	FLUORIDE ppm.	NITRATE NO_3 ppm.	NITROGEN (N) # A.ft.	SODIUM TO CALCIUM Ratio	HARDNESS gr. gal.	% Sodium
#1 Bottle	75434	2441	2.4	591	60	42	17	1675	0	56	2.4	0	-	.07	102.	5.0
#2 Qt. jar	75435	2440	2.5	591	77	15	18	1688	0	51	2.4	0	-	.03	105.	1.8

10. Comments & Recommendations This water is fairly high in total salts, composed dominately of gypsum. The water is extremely hard and is excessively high in fluorine.

Analyst DRAPER - [illegible]

N.V.S.
N. V. SMITH

INFILCO ANALYSIS
OF WATER SAMPLES

April 19, 1960

Remarks: 17760-T - P. V. Vent Hole
17761-T - P. V. Shaft Pump Hole

ANALYSIS NUMBER:	17760-T	17761-T
Calcium	1425	1450
Magnesium	165	150
Sodium	120	75
Total Cations	1710	1675
Total Alkalinity (M)	50	54
Phenolphthalein Alkalinity (P)	0	0
Total Hardness	1590	1600
Sulfate	1650	1600
Chloride	16	20
Total Non-Carbonate Solids	1665	1620
Silica[1]	26	28
Free Carbon Dioxide[2]	12	14
Iron (Fe) Unfiltered	1.8	1.4
Iron (Fe) Filtered Thru Paper	N.D.	N.D.
Manganese (Mn)	.1	.2
Turbidity	8	7
Color	5	5
Oxygen Consumed		
pH	7.1	7.3
Specific Conductance (micromhos)		

[1] To convert to SiO_2, multiply by 1.2.
[2] To convert to CO_2, multiply by 0.88.
To convert parts per million to grains per U. S. gallon, divide by 17.1.

INFILCO ANALYSIS
OF WATER SAMPLES

April 19, 1960

Remarks: 17760-T - P. V. Vent Hole
17761-T - P. V. Shaft Pump Hole

ANALYSIS NUMBER:	17760-T	17761-T
Calcium	1425	1450
Magnesium	165	150
Sodium	120	75
Total Cations	1710	1675
Total Alkalinity (M)	50	54
Phenolphthalein Alkalinity (P)	0	0
Total Hardness	1590	1600
Sulfate	1650	1600
Chloride	16	20
Total Non-Carbonate Solids	1665	1620
Silica[1]	26	28
Free Carbon Dioxide[2]	12	14
Iron (Fe) Unfiltered	1.8	1.4
Iron (Fe) Filtered Thru Paper	N.D.	N.D.
Manganese (Mn)	.1	.2
Turbidity	8	7
Color	5	5
Oxygen Consumed		
pH	7.1	7.3
Specific Conductance (micromhos)		

[1] To convert to SiO_2, multiply by 1.2.
[2] To convert to CO_2, multiply by 0.88.
To convert parts per million to grains per U. S. gallon, divide by 17.1.