DRILLING REPORT OF
THE COPPER SPRINGS PROSPECT AREA,
GILA COUNTY, ARIZONA

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Abstract

An evaluation drilling program consisting of 12 shallow (300 ft.) rotary hammer-NC core holes located on an 800 feet side square grid pattern was carried out to test the commerical possibilities of a supergene orebody. This orebody had been previously tested with 7 diamond drill holes by Kerr-McGee Oil Industries. They had estimated a low grade (0.37% copper), 17.5 million tons orebody.

The hopes of further extension of this orebody to the south and southwest have not been affirmed by Humble's drilling program, and the grade of the ore proved to be lower than the Kerr-McGee values.

The very low grade of this supergene orebody located in the Copper Springs area is mostly due to low grade protore and incomplete replacement of the sulfides. Hydrothermal alteration (argillic) is associated with the orebody and controlling factors for the mineralization have been the increased porosity and permeability of the Pinal Schist near the northeastern end of a SW-NE trending anticline axis as well as proximity to the Santa Ana fault and the faulted Pinal Schist-Schultze granite contact.

Twenty shallow validation holes have complemented the knowledge of the area and two of them, namely CS-7 and CS-8, showed indications of possible interesting mineralization.

From the data of the shallow hole drilling program possible ore reserves of 37 million tons of 0.26% Cu have been estimated for the zone of supergene enrichment. The ore consists almost entirely of chalcocite. Adequate conditions occur for an acid leach "in situ" operation: good

permeability of the overburden and ore zone, fairly tight rock unit underlying the ore zone and good topographic location of the chalcocite zone.

Results from the testing of the zone of hypogene mineralization by two deep holes (CS-A and CS-B) show that the protore is too low grade to be of commercial interest (0.15% Cu), and that conditions did not improve at depth near the anticline axis or a breccia pipe. It also showed that the Schultze granite-Pinal schist contact dips at a very steep angle and is not shallow as expected.

INTRODUCTION

The main purpose of this report is to examine and analyze the characteristics of the zone of supergene mineralization from the data provided by the evaluation drilling program at the Copper Springs area. Discussion of data from other areas provided by the validation drilling program will be briefly undertaken.

Previous Work

Small exploratory workings in the claimed area date back to the late 1800's and early 1900's. They consist mostly of small pits and adits, mostly along the lower slopes of the major east-west trending ridge, where outcroppings of the secondary enriched zone occur and in the Santa Ana fault zone. There is no published data on any of these workings, and it is not known if they were part of a large program. They are most likely the individual effort of small claim holders to develop their properties.

In 1947 the Miami Copper Company took an option of claims held by Mr. J. M. Santa Ana. They drilled a 600 feet deep churn drill hole in the north slope of the main ridge, on Mr. Santa Ana's Lonesome Pine No. 3 claim. A road to this site was built, which is still the main access to this part of the property. Results of this drill hole are not available. In 1963, Bear Creek Mining Company did surface reconnaissance work on this area. They were shortly followed by Kerr-McGee Oil Industries, Inc., which did surface reconnaissance and geochemical sampling, followed by 12 diamond drill holes of which 9 were drilled in the area discussed in this report and three in an area of possible supergene mineralization to the east. A report discussing the drilling results and tonnage calculations was made available to Humble Oil by Kerr-McGee. Their reported tonnage was 17×10^6 tons of 0.37% copper. The core from the 9 drill holes in the area of main interest,

plus one from the eastern area, is presently held by Humble and was relogged by Mr. W. D. Burton. Check assays were also run on the Kerr-McGee BX holes which were within a 0.1% of the values reported. In 1966 Kerr-McGee leased the property to Phoenix Ventures which drilled 25 BX shallow holes, mostly on the northern slope of the main ridge. No results are available from this program. In 1967 Phelps-Dodge Corp. drilled a 1,500 feet deep vertical hole in agreement with Kerr-McGee. This hole was located in Schultze granite about 700 feet from the contact with Pinal Schist and east of the Santa Ana fault. There is no available data from this drill hole, which was possibly testing hypogene mineralization based upon surface evaluation data. This area is coincident with one of Humble's high copper geochemical areas, although molybdenum is not anomalous here.

Present Investigation

An area covered by 156 unpatented claims was staked by Humble Oil in April, 1969, after Kerr-McGee had dropped their claims. A program of surface rock geochemical sampling was carried out accompanied by detailed geologic mapping (1:6000 scale). The claims were validated by 20 rotary hammer and core drill holes which started in early June, 1969. An evaluation of the area of best possibilities for secondary enriched mineralization, in the western part of the claimed area, hereby termed the Copper Springs area, was planned. A square grid pattern, with 800 feet spacing, was adopted, using as origin the location of drill hole KM-1 on top of the main ridge (Plate I).

The regional geologic, detailed surface geologic and geochemical data, as well as the results of the 20 validation drill holes (CS-1 through CS-17, plus CS-1A, CS-10A and CS-15A) and of evaluation drill holes CS-18, CS-21, CS-22, CS-26, and CS-27, are fully described and discussed by Burton

(November, 1969). Therefore, the present report will be concerned with the data obtained by the drill hole program with emphasis upon the evaluation drilling of the Copper Springs area. This will be done mainly by examination of the data plotted on the attached cross-sections (Plates II and III), and the examination of drill and assay logs of the 20 validation holes and the 12 evaluation drill holes: CS-18, CS-20, CS-21, CS-26, CS-27, CS-28, CS-30, CS-32, CS-36, CS-37, and CS-39.

Size and Location of the Copper Springs Area

The size of the investigated Copper Springs area is approximately 4,800 feet (E-W) by 3,200 (N-S) feet, or approximately 0.564 square mile. It is located within Sections 13, 14, 23 and 24 of T1S and R14E. It is situated in the NE part of the Pinal Ranch Quadrangle, Arizona Topographic sheet, scale 1:24.000 (U.S.G.S., 1948). Based upon our coordinate system, using drill hole KM-1 as the origin, the four corners of this area have the following coordinates (N2400, W2400); (N2400, E2400); (S800, E2400); and (S800, W2400).

ROCK UNITS DRILLED

Pinal Schist

The regional characteristics of this unit have been well described by Peterson(1962). The local characteristics encountered in the surface geologic mapping were fully described by Burton (1969).

The Pinal Schist term has been used to comprise a large variety of rock subtypes. These rocks form a complex of low grade metamorphic rocks of sedimentary origin, mostly shale and feldspathic sandstone, which were submitted to dynamic and thermal metamorphism (Peterson, 1962).

In the Copper Springs area, the drill hole data gathered show that a few types of schist occur. No petrographic data are available, and the characteristics and types described below are the result of megascopical observation of the core with the help of a 10X hand lens and low power binocular microscope.

Eye examination of the core renders the Pinal Schist of this area as a massive monotonous section of rocks which appear to have the same mineral composition. More detailed examination shows that a few subtypes can be distinguished based upon different mineral content and texture as provided by the original sedimentary rock.

The schist shows a light brown to tan color in the weathered zone. This color, mostly caused by the Fe oxides present in the zone, turns gradually into gray which becomes darker with depth. The intensity of the gray to black color of the schist in the non-oxidized zone is mostly controlled by the amount of biotite and other ferromagnesian minerals present. In some drill holes the limit of the weathered zone is very sharp.

The grain size of the schist is varible and depends upon the texture of the original sedimentary rock. In general, it can be crudely defined as

varying from very fine submicroscopic to medium. The medium texture has grains up to 3 mm. in intercept. The degree of uniformity of the grain sizes is also very variable, especially in the medium size grain variety. Burton (1969) describes a coarse granite texture facies of the Pinal Schist near its contact with the Madera diorite in the southern part of the staked area. He explains this coarse facies as a consequence of alteration produced by the intrusion of the diorite. However, the drill data from holes CS-1A, CS-2, CS-3, CS-4, and CS-9, which are located near this contact, intersected mostly fine grained schist. Since the grain size variations of the schist in this area are horizontally and vertically distributed in the section, it is most likely that they are caused by lithologic and facies changes of the original sedimentary rock section and now reflected in the schist.

The mineral composition of the schist in the Copper Springs area is variable and gives rise to a few subtypes of which the most common ones are quartz-sericite schist, quartz-muscovite schist, quartz-biotite-muscovite schist, quartz-biotite schist, quartz-chlorite schist, and chlorite schist. The principal constituent minerals are quartz, sericite, muscovite, biotite, and chlorite, which produce the different subtypes. Next in importance are the feldspars, mostly plagioclase. Other minor constituents are amphiboles, pyroxenes and magnetite. Amorphous silica has been observed in some of the core but it is mostly secondary, filling pore spaces. The proportions of the different components are very variable even within one subtype. Quartz is the most persistent one and is present in all the subtypes, although it is not always the major component. A careful examination of the attached drill logs gives a good idea of this compositional variability. The most common schist subtypes are: quartz-sericite, quartz-biotite-muscovite (or sericite) and quartz-biotite schists. The least common are the chlorite and quartz-chlorite subtypes. Good examples of these chlorite schists can be seen on

the core of holes CS-27, CS-30, and CS-32. All these compositional subtypes have their textural varieties, except the chlorite schist which has always been observed as very massive and fine grained.

Segregation of quartz and feldspar present, from the micas and ferromagnesians, is usually well developed giving the rock a layered appearance. Segregation, however, is not so well developed in the quartz-chlorite subtype. Some of the very fine grained varieties of schist approach the characteristics of a slate when the slaty cleavage is developed. This is not surprising since the Pinal Schist is partly derived from shales. Slate facies of the Pinal Schist formation outcrop to the SW of the claimed area. Frequently, the quartz-feldspars occur in small lenses. Biotite frequently occur in more or less thick aggregates usually flattened along the foliation which gives the rock a mottled appearance.

Foliation is well developed in the Pinal Schist of the Copper Springs area. Its dip is variable and as can be seen from the attached cross-sections (Plates II and III), its intensity follows the major anticline structure mapped by Burton (1969) and which strikes SW-NE. Bedding features are imperceptible to weak and where present they were observed to be parallel to the foliation. Joints are usually well developed especially in the more quartzose facies. Various sets are usually present. Most of the joints are filled by quartz and quartz-sulfide veins. Most of the limonites and oxidized products are present along the joint planes in the oxide zone.

Fault zones cutting the Pinal Schist in the Copper Springs area have been observed in the drill holes to develop a coarse to medium grained breccia. This breccia is generally composed of angular to subrounded, poorly sorted, fragments of the schist cemented or held together by a clayey

matrix. Fragments having up to a 5 cm. intercept have been encountered. Much decomposition of the schist and development of a yellow clay around the fragments of the breccia is possibly the result of the action of acidic waters flowing through these more permeable zones. Talc develops frequently in shear surfaces of the schist especially in the chloritic subtypes possibly from the alteration of pyroxenes and amphiboles present in the rock.

It appears that the degree of metamorphism to which the sedimentary rocks, which now form the Pinal Schist, were subjected was regional low grade dynamic metamorphism of the chloritic zone.

Peterson (1962) dates the Pinal Schist as of early Precambrian age and this metamorphic complex constitutes the oldest unit which crops out in this area. It also covers most of the Copper Springs area and is the host rock for the supergene mineralization target under investigation by Humble Oil.

Diabase

A diabase has been found in the core of various drill holes at the Copper Springs and adjacent areas.

It was found cutting Pinal Schist in drill holes: CS-4 in the intervals 110'-120' and 180'-200-; CS-10 in the intervals 1'-15' and 80'-85'; CS-21 in the interval 105'-110'; CS-26 in the interval 130'-160'; CS-27 at 65' and from 110'-113'; and CS-32 in the interval 85'-90'.

It was observed cutting Schultze granite in drill holes: CS-8 between 80'-85' and in hole CS-37 in the interval 15'-25'.

It is important to note that the diabase was cut by holes which are located near or at the contact of the Pinal Schist with both the Schultze granite and the Madera diorite. This fact might indicate that the diabase was intruded in weakness zones expressed in part by those intrusive contacts.

This becomes even more possible from the fact that drill holes CS-8, CS-10, CS-26, CS-27, CS-32, and CS-37 are located at or near the contact of the Pinal Schist and the Schultze granite which is mostly a faulted contact.

In drill hole CS-26 the diabase is cut by Schultze granite (porphyritic quartz monzonite) and the diabase itself cuts the Pinal Schist.

Burton (1969) did not observe any outcrops of diabase during his field mapping campaign. The scarcity of outcrops of diabase in the area is probably due to its weak nature to resits the weathering agents and because it is mostly covered by debris of other rocks. This view is expressed by Peterson (1962). The writer observed a dike of diabase striking NNE-SSW cutting Madera diorite in the southern part of the claimed area. The diorite is very weak to weathering and the relatively more resistant diabase stands a few feet above the flat diorite terrain.

From observation of the core and the outcrop in the southern part of the area the diabase can be described megascopically as a very fine grained (aphanitic), massive, black to dark gray rock. Since no petrographic data are available the mineral composition of the diabase due to its fine grain, cannot be accurately described. Observation with a binocular microscope of the cuttings show very minor amounts of quartz, plagioclase and dark minerals, possibly ferromagnesians. Some biotite flakes were observed. Magnetite appears to be a major component in the diabase estimated up to 20% as in CS-32. The diabase cut in CS-32 reacted with HCl indicating alteration of the calcic plagioclase. Peterson (1962) reports that the most common types of diabase rocks in the Globe-Miami area range from augite diabase which contains no hornblende to hornblende diabase which contains none to little augite. He has observed some olivine or pseudomorphs of serpentine, as much as 10%, in the diabase. He also noticed ophitic texture in this rock. This rock can be more generally termed a dolerite.

Joints are very well developed in the diabase dike observed cropping out in the southern part of the area, as well as in the core. Possibly due to its aphanitic nature no lineations or foliations are visible in this rock. Brecciation and faulting occurs at some of the contacts of the diabase with the schist and granite (CS-21 and CS-37) with no noticeable contact metamorphism. The true nature of these contacts may be in part obscured by the younger hydrothermal alteration of the rocks of the area.

The diabase in the Copper Springs area has been observed cutting the Early Precambrian Pinal Schist (CS-4, CS-10, CS-21 and CS-26), cutting Madera diorite and at two places cutting the Upper Cretaceous to Lower Tertiary Schultze granite (CS-8 and CS-37) and in one instance, in drill hole CS-26, being cut by the Schultze granite (porphyritic quartz monzonite). This poses an age problem possibly indicating the diabase younger than some facies of the Schultze granite described by Burton (1969) and older than others, but placing the age of the diabase from late Cretaceous to early TErtiary. Peterson (1962) places the diabase as a pre-Schultze granite intrusion.

Schultze Granite

The rock unit second in extension in the Copper Springs area is the Schultze granite. In the whole area investigated by Humble Oil the following holes were located in granite: CS-8, CS-13, CS-14, CS-15, CS-15A CS-16, CS-17, CS-37, and KM-8, KM-9, KM-11 and KM-A12. The last five holes correspond to the Kerr-McGee drilling program. Of these holes only CS-37, KM-9 and KM-12 are within the Copper Springs area proper.

Burton (1969) described four facies of the granite and a related breccia pipe. Of the four facies only three have been drilled: the quartz-monzonite porphyry on the NE (drill holes CS-13, CS-14, CS-17, KM-9 and KM-A12);

the porphyritic quartz monzonite in the NW (drill holes CS-15, CS-15A and CS-16) and the granite porphyry in the north-central part of the claimed area (drill hole CS-37). Phelps-Dodge drilled a 1500 feet deep vertical hole in what appears in the surface as a favorable area of the quartz-monzonite porphyry where secondary K-feldspar and quartz-sericite, as well as minor secondary copper minerals abound. Drill hole CS-30 located almost at the contact of the Pinal Schist with the breccia pipe, did not cut the latter. Hole CS-26, as has been previously mentioned in this report, intersected fingers of granite cutting both the schist and the diorite.

The quartz monzonite porphyry and the porphyritic quartz monzonite facies described by Burton (1969) are difficult to distinguish from one another by megascopic characteristics observed in the core. They both contain coarse grain (up to 5 cm. in diameter) quartz phenocrysts, usually euhedral, which are contained in a medium grained groundmass of quartz, orthoclase, sodic plagioclase, muscovite and biotite. Overall quartz content varies from 20% to 50%, plagioclase from 40% to 20%, orthoclase from 30% to 10% and muscovite and biotite from 5% to 10% each. Minor constituents as magnetite, pyrite, apatite, hubnerite, scheelite, possibly cassiterite and various secondary Fe oxides make up the remainder of the granite mass. In both facies there are orthoclase phenocrysts. Quartz phenocrysts usually form up to 20% of the mineral composition while the orthoclase phenocrysts are less abundant with a maximum of only 10%.

The granite intersected by drill hole CS-37 is porphyritic. In this facie most of the phenocrysts are pink subhedral orthoclase up to 5 cm. in intercept with very well developed cleavage. Up to 20% of the rock is formed by the orthoclase phenocrysts with few quartz phenocrysts. The groundmass is composed of medium grained quartz (30%-60%) orthoclase and other feldspars (20%-30%), and muscovite and biotite (5%-20%). Biotite

has been observed to be more abundant and predominate over muscovite. Biotite is usually in smaller plates than muscovite.

All three facies have a light color in the core of the drill holes. The granite porphyry has a more intense pink color possibly due to its higher content of pink orthoclase. They all vary from light to medium tan, to light gray. The unweathered portion of all facies is, as expected, very hard due to its high siliceous and uniform composition; and this condition made the rate of drilling slower in the granite than in the schist with a higher consumption of diamond bits. Core recovery was excellent, almost 100%, as can be seen in attached drill logs for holes CS-13, CS-14, CS-17, and CS-37.

Lineations or preferential alignment directions have not been noticed on a megascopic scale in the granite cut by the drill holes of this area. Foliation is not developed in the granite. However, jointing is prominent in all facies of the Schultze granite and can be clearly recognized in the core, although it is more striking on the surface outcrops. Many of the joints are filled with quartz and quartz-sulfide veins.

Only two drill holes, CS-3 and CS-26, intersected the Pinal Schist-Schultzegranite contact. In both holes the contact consisted of "fingers" of the granite cutting the schist in the vicinity of the contact. In the case of CS-3, where only cuttings were recovered, the nature of the contact could not be observed well. In drill hole CS-26 the contact seems gradational with some degree of metasomatism. However, in none of these two holes any typical contact metamorphic or pneumatolitic minerals were observed. In the surface the Schultze granite-Pinal Schist contact in the Copper Springs area and to the west show indication of being faulted. There is development of tectonic breccia and it appears that at least in certain areas (in the road to CS-10 and CS-10A) it has been thrusted over the Pinal Schist.

Peterson (1962) assigned a late Cretaceous to early Tertiary age to the Schultze granite. Creasey, et al. (1962) give a 58 m.y. by K-Ar methods to this granite. Burton (1969) describes an order of emplacement for the different facies of the granite. But if the diabase cuts some of the facies of the granite, as described previously in this report, this may mean that these intersected facies could be pre-diabase possibly of the same age and related to the Lost Gulch quartz monzonite. The Lost Gulch quartz monzonite and quartz monzonite porphyry facies crop out to the north of the area investigated by Humble Oil and is the host rock for the mineralization at Castle Dome mine. Peterson (1962) describes the emplacement of the Lost Gulch quartz monzonite as one of the earliest intrusions accompanying the Late Cretaceous early Tertiary orogeny.

Talus Deposits

These deposits consist of unconsolidated scree material deposited in the bottom of slopes or where a change in the grade of the slopes occur. They are usually coarse grained poorly sorted accumulation of angular to subrounded fragments of granite or schist. A reddish clay material, the product of the weathering of the schist fragments by the meteoric waters running down slope, is often present in these deposits.

Talus deposits are not important as far as mining is concerned in the Copper Springs area. The same can be said of the alluvial deposits of this area. These recent age deposits are both very thin and easily removable.

The only relatively thick scree material accumulation cut by the drilling was in hole CS-32 where 30 feet were intersected. Drill hole CS-32 is at the bottom of the slope of the major east-west trending ridge. No other major talus deposit was cut by the drill holes, since if present, they were most likely removed at the time the site was built.

Organic rich clayey soil develops over the schist varying with the schist facies which crop out. It can be as much as a foot thick as in the vicinity of drill hole CS-37. The soil developed over the granite is very thin and poor.

STRUCTURE

The Pinal Schist in the Copper Springs and adjacent areas investigated by the drill hole program shows good development of foliation. The major anticline structure mapped by Burton (1969) shows well in the core of the drill holes near the axis. The foliation in CS-5, CS-12, and CS-26 is close to horizontal. These two holes are located at or very near the axis of the anticline. The assymetry of this structure shows well. In holes CS-21, CS-22, CS-30 and CS-39 located in the northwestern limb of the anticline, the foliation is steep. The core from dill holes CS-36, CS-18, KM-1 and KM-3 located on the southeastern limb of the anticline shows moderate dip of the foliation. It is assumed that the foliation is generally parallel to the bedding as found by Burton (1969) on his surface mapping survey and as described by Peterson (1962).

The other major structures in the Copper Springs area, the Santa Ana Fault, was tested by drill hole CS-27. This vertical drill hole cut through 220 feet of the fault zone and showed that the angle of dip of the fault is larger than 70°. In KM-9, one hundred feet of this fault dipping 60° cuts the granite.

No other major fault was found as a result of the drilling program. Minor fault zones were intersected in drill holes: CS-20 (15 feet); CS-22 (26 feet); CS-28 (2 zones, 10 feet) and smaller zones in these same holes and others. The faults are both found cutting the Schultze granite and the Pinal Schist.

Tectonic breccia develops in many of these fault zones. Its characteristics, when they are formed in the Pinal Schist, have been described above. In both the schist and the granite there is development of slickensides and alteration of ferromagnesians present to chlorite and talc.

There is usually strong development of clays as alteration product of feldspars. Pyrite and chalcopyrite in these zones are crushed and frequently oxidized.

Major regional structural features in the Globe-Miami district which have influence on the Copper Springs and adjacent areas have been described by Peterson (1962); Masson (1967) and Burton (1969) and will not be discussed in this report.

HYDROTHERMAL ALTERATION

Various types of alteration can be recognized in the examination of the core from the drill holes of the area claimed and investigated by Humble Oil. Since no petrographic data are available, a thorough description of the alteration is difficult and will be limited to gross low power magnification examination.

Alteration is expressed differently in different rocks due to their different physical and chemical characteristics. This can be clearly observed from the observation of the alteration in the Schultze granite and the Pinal Schist of the Copper Springs area.

The different types of alteration which are recognized from visual examination of the core are:

1. Potassic
2. Quartz-sericite-muscovite
3. Argillic
4. Propylitic

These types of alteration approach the definitions or descriptions given by Schwartz (1947) and Creasey (1966) but, have also noticeable differences.

The potassic alteration is best developed in the Schultze granite. It has been recognized in the porphyritic quartz monzonite facies (CS-16), in the granite porphyry (CS-37), and in the quartz monzonite porphyry (CS-13, CS-14, CS-17, and KM-A12). It has only been observed once in the Pinal Schist in the core of drill hole CS-20. It is expressed as very thin veinlets of pink K-feldspar, very often associated with quartz. The density of these veinlets is usually low and in general the intensity of this alteration can be considered as weak. Biotite has not been observed associated in this mineral assemblage. Chalcopyrite was observed associated with the K-feldspar

veins in the surface near the location of the Phelps-Dodge drill site.

The quartz-sericite-muscovite alteration is best developed in the quartz monzonite porphyry facies of the Schultze granite. It was found in drill holes CS-8, CS-13, CS-14, CS-17, KM-9 and KM-A12. It is expressed mostly in veinlets of quartz with sericite and less commonly muscovite. Pyrite is commonly associated and there is zoning of these minerals. This alteration facies is also somewhat developed in the Pinal Schist.

The more widespread alteration type in the Copper Springs area is the argillic, especially in the Pinal Schist. This type of alteration is best developed in the schist and is expressed by the presence of clay minerals accompanied by sericite and fine grained muscovite. Chlorite has been observed in this alteration facies like at CS-6, but is not common. This latter facies could correspond to one of the assemblages which contain chlorite described by Creasey (1966) in his argillic type alteration. The quartz-sericite-muscovite and the argillic facies are commonly together. The sericite of the argillic alteration has a satin sheen and can be distinguished from the "primary" sericite-muscovite of the Pinal Schist (Burton, 1969).

Propylitic alteration is very poorly developed and weak in the area investigated by Humble Oil. It has been recognized in drill holes CS-6, CS-36, CS-30, and KM-7. Talc and chlorite are developed but are not observed to be associated with epidote or calcite as is common.

If the alteration types from the data of the drill holes are plotted in a map of the area, two major areas of alteration are defined. The largest one consists of moderate argillic-quartz-sericite alteration and comprise drill holes CS-5, CS-39, CS-21, KM-3, CS-11, CS-22, CS-12, CS-26, CS-36, KM-9, CS-28, and CS-8. This L-shaped area follows very closely the axis of the anticline up to the Santa Ana fault zone. From this fault

eastward it parallels the schist-granite contact. The southwestern end of this L-shaped area is at CS-5, the inflection point at CS-22 and the eastern end at CS-8. As will be recognized later, this alteration zone coincides fairly well with the shape of the supergene orebody. The other interesting area of alteration is along and near the Pinal Schist-Schultze granite contact. It is potassic alteration and extends from drill hole CS-16 on the west to drill hole CS-14 on the east.

Many of the fault zones cut by the drill holes are moderate to strongly altered (argillic facies). This is evident in CS-27 which cut through the Santa Ana fault.

A weak marginal propylitic zone may occur to the southeast of the major L-shaped argillic-quartz-sericite zone. This possibility is only based upon data from drill holes CS-6 and KM-2.

METALLIC MINERALIZATION

Two types of mineralization have to be distinguished in the investigated are: hypogene and supergene.

Hypogene Mineralization

Since the drilling program was designed to investigate the supergene mineralization, less data is available for the evaluation of the hypogene mineralization. However, in all the evaluation drilling holes at least a few feet were drilled in the protore.

The principal minerals in the protore are pyrite, chalcopyrite, and molybdenite. Pyrite is the most abundant and molybdenite the least. They occur in thin veinlets, usually along joint planes and fractures. The veinlets are from hairline (1 mm.) to a maximum of 5 mm. thick. The pyrite, chalcopyrite and molybdenite are usually associated with quartz in these veinlets and sericite and muscovite are frequently present. Some zoning has been observed in the mineralization with pyrite and chalcopyrite occupying the center of the veinlets, molybdenite borders the pyrite and the quartz and sericite occurs in the walls of the veinlets. Pyrite is frequently observed disseminated in the host rock a few millimeters away from the veinlets. The majority of the veinlets only carry pyrite and in some drill holes (i.e. CS-36) chalcopyrite veinlets containing no pyrite or molybdenite have been observed. Molybdenite has also been observed to occur alone, but not frequently.

The mineralized veinlets are often concordant with the foliation, since apparently this was one of the weakness planes for circulation of hydrothermal fluids as well as along the joint system.

It is also possible that much of the pyrite in the concordant veinlets and the one disseminated in the rock is syngenetic and much older.

Other metallic minerals observed in this zone are bornite and covellite. Although no sphalerite or zinc minerals have been observed in the hypogene assemblage, there are usually much higher than background values of zinc in the mineralized intervals. Pb, Co and Ni are usually equal to background in the mineralized intervals and only amount to a few tens ppm. Au and Ag are nil in the hypogene assemblage.

By averaging the available intervals of protore drilled for their copper content it can be observed that it varies from 0.10% to 0.20%, which is below the commercial ore grade. The ratio pyrite/chalcopyrite varies from 10/1 to 3/1.

The age of the mineralization is post Late Cretaceous - early Tertiary intrusives. That is, it followed the intrusion of the Schultze granite (Peterson, 1962).

There is undoubtedly close relationship between the hydrothermal alteration and the mineralization. Mineralization, although weak and discontinuous, occurs along the contact of the Pinal Schist and the Schultze granite as evidenced by the numerous surface localities along this contact where copper and Fe oxides occur as for example a few feet east of drill hole CS-37. This zone of mineralization along the contact could associate with the weak potassic alteration described previously in this report. Mineralizttion occurs along the Santa Ana fault where argillic alteration is strong to moderate. The L-shaped argillic-quartz-sericite alteration zone described above coincides well with the low grade supergene orebody in its north and northeastern portion.

Increased permeability near the axis of the anticline in the Pinal Schist, produced by the more strained rock in this area and more permeability along the reactivated Santa Ana fault appear to be controlling factors for the mineralization (Burton, 1969). The data obtained from

the drill holes in the Copper Springs area do point out to these facts. The frequently faulted and brecciated Pinal Schist-Schultze granite contact appear to be another controlling factor, although the mineralization along this contact is discontinuous and weak.

Supergene Mineralization

The most important mineralization in the Copper Springs area is the zone of secondary enrichment of copper.

The ore mineral is chalcocite which replaces chalcopyrite and pyrite as in all of the large orebodies of the Globe-Miami area (Castle Dome, Copper Cities, and Miami-Inspiration). Other secondary minerals which occur in this zone are cuprite, covellite, bornite and native copper. They occur in very minor amounts. Very minor amounts of cinnabar have been observed in drill holes CS-26, CS-28, and CS-36 along fracture planes. A few checks on the Hg content show 100 ppb in some of the copper mineralized intervals.

The oxides from the leached zone are limonite, jarosite, goethite, and minor hematite. In the supergene oxide zone these oxides have been observed along with tenorite, malachite, chrysocolla, azurite (rare) and ferrimolybdate. Boxwork after chalcopyrite and pyrite in the oxide zone is common and shows that the pyrite/chalcopyrite ratio is large.

As shown in Table I, the supergene oxide mineralization is of very low grade (0.13%-0.22% copper) and varies in thickness from 5 feet to 70 feet and its depth varies from a few feet from the surface to 195 feet in drill holes CS-7 and CS-18, and 220 feet in CS-39. The copper oxide zone is of noticeable appearance in drill holes where the secondary enriched zone is also of some interest (CS-8, CS-11, CS-18 and CS-22). The only interest of this low grade copper oxide zone is that the copper can be easily removed by acidified waters in a leach in place operation and will increase the total copper content of the solution.

From the observation of the core of the drill holes of the Copper Springs area which have cut the chalcocite zone, it can be concluded that the process of replacement has not been complete in this area. Although most of the chalcopyrite is replaced, the pyrite is usually only coated or has shallow replacement in its crystals. Good example of this incomplete replacement is seen in the chalcocite zone of drill hole CS-28. Reasons for this incomplete replacement could be: (i) The low copper concentration of the leaching solutions; (ii) the low pH of the ground waters which carries most of the copper away in solution; and (iii) short time of contact between copper rich groundwaters and primary minerals due to rapid circulation caused by considerable porosity and permeability. Of these factors the availability of copper is the most important since the protore is low grade in this area.

As can be seen from the attached cross-sections the boundary between the chalcocite zone and the oxide zone is usually sharp. The chalcocite zone is generally within the mixed oxide-sulfide zone reaching frequently into the sulfide zone.

The supergene mineralization in the Copper Springs area is emplaced in the Pinal Schist. Only weak development is observed in the granite (KM-12).

PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE SUPERGENE OREBODY

Tables I and II summarize the assay data from the drilling carried out in the Copper Springs area and show the mineralized intervals.

A rapid inspection of Table I shows that only drill holes CS-11, CS-12, and CS-22 have intersected a zone of supergene enrichment with possible commercial interest for a leach in place operation. Only these three drill holes show zones of a grade above 0.30% copper. Drill holes CS-8, CS-18, CS-20, CS-26, and CS-36 show intervals with grade above 0.20% copper in the chalcocite zone. CS-27 shows a long interval with 0.20% copper, mostly due to chalcopyrite since no chalcocite was observed in this hole.

In order to examine more closely the data of the drill holes which show interesting mineralization they will be repeated below in the same manner as Table II.

Drill Hole	Thickness (ft.)	% Copper	Elevation of bottom of enriched zone considered (ft.)
CS-8	40.0	0.23	5531.0
CS-11	115.5	0.30	4884.0
CS-12	38.0	0.29	4934.0
CS-18	13.0	0.23	5042.3
CS-20	9.2	0.28	5173.0
CS-22	80.5	0.31	4782.3
CS-26	63.5	0.21	4950.3
CS-36	50.0	0.20	5050.0

Of these eight holes, CS-8 is the only one located outside the Copper Springs area proper.

From the assay of these intervals one can conclude that the intensity of replacement has only been from 1.5 to 2.0 times the protore grade and not 3.5 to 4.0 times as reported by Kerr-McGee (Fitzgerald, 1964).

When indicated in the location map the surface expression of this low grade orebody is an L-shaped figure with the open legs looking SE. Its SW end is KM-3, its angle corner is at CS-22, and it widens to the east with a NE end at KM-9 and a SE end at CS-8. KM-1 and CS-20 have been left out of this area since the chalcocite zone thins out sharply towards the south and is only 9 feet thick in these two holes and 13 feet in CS-18.

Actually the mineralization appears very discontinuous and the main zone of interest is that in the northern part of the area, which strikes WNW-ESE and encloses drill holes CS-22, CS-11, CS-12, KM-4 and KM-A6. Drill hole KM-3 could be a separate mineralized zone or could join with the main area. No drill hole data are available to determine this since CS-19 was not drilled.

Inspection of cross-sections N000, N800, N-1000, N-1200, N-1600, E-000, E-800, E-1200, and W-800 shows that the supergene orebody attains its maximum thickness of about 100 feet between CS-11 and CS-12 where the orebody is horizontal (Section N-1200). The orebody slopes and thins somewhat toward the north (Section W-800 and E-800). Towards the east, there is a very slight slope upwards from CS-22 to CS-26 (Section N-1600), with no change in the thickness which averages 80 feet. Towards the south the orebody first slopes upward at about 20^{0} and south of KM-1 it slopes downward at a few degrees. South of CS-12 towards CS-18 it thins out very rapidly from 100 feet to 13 feet at CS-18 and 9 feet at KM-1 and CS-20. (Section E-000). Sections N-000 and N-1600 show a rapid thinning out of the orebody towards the west accompanied by a downward slope of a few degrees. Section S-800 shows that

CS-7 was only in the oxide zone and was not deep enough to intersect the chalcocite zone. It also shows that no chalcocite zone is present in the southwestern part of the area as shown by the results of CS-6.

From the examination of all these cross sections it is observed that the orebody follows the present topography to a certain extent sloping northward, westward and southward from the thicker part around CS-11 and CS-12.

The chalcocite zone has been found above and below the present water table but, is generally below it.

If we use the mineralized intervals shown at the beginning of this section, an ore grade of 0.27% copper is obtained. This grade can increase up to 0.36% copper if the smaller higher grade intervals (Table I) are used for CS-11, CS-12, and CS-22. However, by doing this the tonnage is considerably reduced since the thickness of the interval is reduced 2.3 times in CS-11, 1.9 times in CS-12, and 3.2 times in CS-22.

CONCLUSIONS AND RECOMMENDATIONS

The most important conclusions obtained from this investigation are:

1. There is a low grade supergene orebody mostly restricted to the area previously investigated by Kerr-McGee and emplaced almost entirely in the Pinal Schist. The ore mineral is chalcocite. It does not extend towards the west and southwest as expected; and though it extends southward, its thickness is very small and its grade very low in this direction. Its boundaries and shape are described in this report.

2. The very low grade of the supergene orebody is mostly due to the low copper content of the protore from which it formed (0.1%-0.2% copper) and the fact that the replacement has not been complete. Only the chalcopyrite has been replaced while pyrite has only chalcocite coatings. Pyrite/chalcopyrite ratios are high in the protore of the Copper Springs area so the amount of copper available is low and the quantitites of chalcopyrite to be replaced are small.

3. The mineralization agrees well with an argillic-quartz-sericitic alteration pattern. Controlling factors appear to be increased permeability in the northeastern end of the major anticline, and proximity to both the Santa Ana fault and the somewhat faulted Pinal Schist-Schultze granite contact, where potassic alteration occurs in the granite.

4. Extreme care in the sampling procedure and the use of a bigger hole diameter to increase the size of the sample did not influence in the estimation of the ore grade, as compared to the assay results obtained by Kerr-McGee.

5. The grade of the ore is lower than that calculated by Kerr-McGee (0.26% copper versus 0.37% copper) and the commercial value of

this orebody will depend upon the availability of an economic and efficient leach in place method. The topography of the Copper Springs area, as well as the elevation of the chalcocite zone are favorable for such a mining operation.

No further drilling is recommended at present and the property should be retained pending the results of the geophysics and possible drilling evaluation of the area of hypogene mineralization located east of the Copper Springs area.

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APPENDICES

APPENDIX I

SUMMARY OF THE RESULTS OBTAINED FROM THE TESTING OF THE ZONE OF HYPOGENE MINERALIZATION

The data obtained from the drilling of the two vertical holes CS-A (T.D. = 2057') and CS-B (T.D. = 1488') to test the protore zone in favorable areas have provided the following information:

1. The average grade of the protore in the Copper Springs area appears to be lower than 0.15% Cu and, therefore, non-commercial.

2. The angle of dip of the Schultze granite-Pinal schist contact is larger than 60° or it is most irregular and becomes progressively steeper towards the south.

3. The increase in the degree of fracturing near the axis of the anticline did not improve the grade of the protore as was expected. Proximity to the breccia pipe in the western part of the area did not increase the metallic mineralization at depth. This breccia pipe cannot be considered a feature of importance in controlling the mineralization.

4. The intensity of mineralization is associated with certain facies of the Pinal schist. This is possibly due to the differences in the fracture density of each facies because of its different rock mechanics characteristics.

5. The copper and molybdenum anomalies in the areas of these two holes are both affirmed by the anomalous content of the rock in these two elements down to 100 feet. The shallow anomalous copper content is due to supergene enrichment, but the anomalous molybdenum content is primary.

Drill holes CS-A and CS-B were drilled in the time period of 13 February to 29 May, 1970. Total depth of CS-B was proposed for 2,000 feet, but due to the extremely poor copper showings and to the lack of supporting evidence for any improvement with depth, it was terminated at 1,488 feet.

No down hole resistivity and induced polarization surveys were run in either drill hole as had been proposed, due to the low grade of the protore.

Conclusions and Recommendations

The results of the drilling of CS-A and CS-B show that the grade of the protore is too low for a present commercial operation. Also, the mineralization is very irregularly distributed even in favorable locations, as at the sites of these two holes.

No further investigation is recommended for the zone of hypogene mineralization in this property at present.

The possibilities of a leach in place operation should be investigated for the chalcocite zone from the technical and economic point of view. Even if this operation proves to be of no economic interest to Humble Oil, it will make the Copper Springs property of more value for sale to a smaller operator and at the same time will give our company experience in the evaluation of similar conditions for future use.

APPENDIX II

GENERAL OBSERVATIONS FROM THE RESULTS OF CS-A

I. Rock Units

1. Two rock units were intersected by drill hole CS-A:

a) A facies of the Schultze granite. This facies is a medium to fine grain size quartz monzonite with the following approximate mineral composition: 20% quartz, 60% feldspers and 20% muscovite and biotite. It has a porphyritic texture with quartz and plagioclase phenochrysts up to 6 millimeters in diameter. Quartz phenochrysts are subrounded and plagioclase phenocrysts are euhedral. This quartz monzonite was intersected from 0 to 67 feet of depth. The nature of the contact with the schist could be both tectonic and igneous. There is brecciation at this contact and a 20 foot fault zone in the schist. A possible igneous thermal contact is indicated by the noticeable decrease in grain size of the quartz monzonite towards the contact with the schist.

b) Pinal Schist Various facies of this schist were cut by the drilling of CS-A. Six facies have been distinguished by megascopic characteristics in the schist. These facies have been defined by their different mineral composition and grain sizes. They are: 1. A light grey fine grained quartzose schist; 2. A medium grain size biotite - quartz schist frequently silicified; 3. A coarse grain biotite - chlorite, soft, usually massive schist; 4. A quartz-chlorite medium grain size schist; 5. A fine grain size, black, massive, hard schist with a diabase composition and 6. A light grey, fine to medium grain size schist with a tuffaceous composition. The boundaries of these facies are frequently gradational and poorly defined due to syngenetic conditions and by homogenization imposed by the metamorphic process. More facies could be defined by a petrographic study of the rock section.

From observations of the Pinal Schist in the drill holes of the Copper Springs area it can be concluded that this schist is a low grade metamorphic complex possibly formed from a clastic sedimentary section which contained thin volcanic members. The metamorphism which formed the schist was most likely regional acting during one or more tectonic periods.

The principal mineral components of the schist are quartz, biotite and muscovite. Magnetite occurs in some of the facies, usually confied to layers paralleling the foliation. This fact indicates a possible sedimentary origin of the magnetite and shows that the original bedding of the sedimentary rocks is frequently, if not always coincident with the layering of the schist. Biotite is frequently altered to chlorite.

II. Structure

The results of CS-A show that the contact of the Pinal schist with the Schultze granite is not shallow. If the dip of the contact is to the south as shown by previous drill holes and surface evidence, the dip is steep (60° or more).

Foliation is well developed in almost all of the schist facies. Its dip varies from 0° to 30° down to 1750 feet, where it becomes steeper (larger than 60°). However, this increase in the angle of dip is influenced by an 18° deviation from the vertical, of the hole, below 1,700 feet.

There are various joint sets developed in the schist. Their dip angle and degree of development varies with the schist facies as can be expected from the different behavior of each of these facies materials to the applied and residual stresses. The most prominent joint sets in all the hole dip at 45° and at 70° or more. They are coated with calcite. The coating is usually very thin (< 2 mm.). A possible older system of joints dip at 30° and 60° and was the one impregnated by the sulphide rich hydrothermal fluids. The dips of this latter system varies with the facies as previously explained and frequently they dip at 45° and 80° to 90°.

There are a few small fault zones (5 to 10 feet wide)throughout CS-A, but the major faulted intervals are two; one between 1,717 feet and 1,761 feet of depth and the other from 1,862 feet to 1,906 feet. There is development of gouge. Slickensides and talc occur in shear planes.

III. Hydrothermal Process

The mineralization intersected by this drill hole is undoubtedly hydrothermal. It follows along fractures or fissures (secondary structurally controlling features) which have a definite pattern. There is alteration evident in the host rock near the veinlets although very often it is not well developed. Without a microscopic study it is difficult to determine the possible depth of mineralization. Crudely, based on the alteration products, it is possibly upper mesothermal to lower epithermal.

a) Metallic Mineralization The metallic elements present are in their decreasing order of abundance: Fe, Cu and Mo. The most common

hypogene minerals are pyrite, chalcopyrite and molybdenite. Very minor and irregularly distributed is bornite. All of these sulphides occur in very thin veinlets, usually less than 5 millimeters thick. Pyrite occurs most frequently alone. Molybdenite occurs usually associated with pyrite and shows zoning. The molybdenite is fine grain and occurs near the walls showing it was precipitated before the pyrite which lies near the center of the vein and is coarser grain. Chalcopyrite occurs in the veinlets alone or associated with pyrite. For the pyrite-chalcopyrite veinlets it is more frequent that the chalcopyrite is more abundant than the pyrite. In just a few veinlets observed in this drill hole chalcopyrite occurs associated with minor amounts of molybdenite.

Bornite is always associated with chalcopyrite and occurs in the richer Cu veinlets. In many of the pyrite or chalcopyrite veinlets there is a red earthy mineral, possibly an arsenide or sulfide which is present in very minor amounts and is of little importance. It is common to observe that the 100% pyrite veinlets and those containing only chalcopyrite dip at different angles in the same interval. This possibly indicates deposition during two different periods along different fracture directions. The pyrite is usually in steeply dipping veinlets 70° or more while the chalcopyrite is in veinlets dipping at a lower angle (30° to 45°). Specular hematite in very minor quantities was observed in some of the pyrite veinlets at 1,157 and 1,165 feet. This primary hematite occurs in very small isolated grains in the gangue of these veinlets.

The grain size of the metallic minerals is always very fine except for the pyrite which develops crystals up to 2 millimeters as its longest dimension. Chalcopyrite, molybdenite and bornite are always massive but, pyrite frequently shows well developed cubic crystals.

The depositional texture of the ore minerals is difficult to establish without a microscopic study but it appears to be more of open space filling than replacement or colloidal.

Supergene mineralization was intersected by drill hole CS-A between 85 feet and 105 feet. It consists of chalcocite replacing chalcopyrite of the hypogene mineralization. Minor amounts of covellite and cuprite were observed in this interval. The zone of oxides extends from the surface to 85 feet, both in the granite and in the schist. Both indigeneous and exotic limonites were observed. Malachite is present between 72 and 84 feet and tenorite above 50 feet.

b) Alteration In general, the Pinal schist is not a very reactive rock and the alteration zones or halos are not strongly developed in it. However, products of alteration are observed near the sulphide veinlets.

The most widespread alteration is weak argillization of the feldspars more clearly observed near the veinlets. However, the more strongly developed alteration is silicification best developed between 850 and 1200 feet and especially at the mineralized interval between 980 and 1017 feet. There is sericitization near some of the veinlet walls and secondary biotite is developed in some of the veinlets and in the host rock near the walls of these veinlets. Pyrite is a common alteration product usually associated with sericite and can be observed in the host rock near some of the sulphide veinlet walls.

c) Gangue All sulphides in the veinlets are associated with quartz. In some of the veinlets there are geodes and well developed quartz crystals. However, most of the quartz is massive and very fine grained. Purple quartz (amethyst) was observed in one veinlet. Minor gangue minerals which only occur in some of the veinlets are sodic feldspar, biotite, chlorite, epidote and calcite.

Quartz veins parallel to the foliation are very frequent. They are barren and correspond to a previous period of hydrothermal deposition. Calcite deposited along joint and fracture planes appear to be unrelated to the metallic mineralization.

IV. Geochemistry

The results of the geochemical analyses of the core samples for copper and molybdenum show the following results:

1. The background for copper is very variable (from 300 to 750 ppm.). The threshold for this element is about 1,000 ppm. The lower background for copper decreases below 1,600 feet.

2. There are seven anomalous copper zones. The shallowest with values up to 3,400 ppm. correspond to the chalcocite zone. All others are due to hypogene mineralization. Of the latter only two have values above 2,000 ppm. (at 750 and around 1500 feet). All these anomalous zones are narrow and widely separated. The thickest one is 20 feet at 1500 feet.

3. There are no anomalous copper zones below 1520 feet.

4. The molybdenum background is between 5 and 30 ppm. The threshold is 60 to 80 ppm.

5. There are five Mo anomalous zones, only one with values above 1,000 ppm. (at 940 and around 1,010 feet). They are also narrow, the widest one 20 feet thick.

6. Only the interval from 993 to 1013 feet is anomalous both in Mo and Cu. This supports what has been said previously of the rare association of molybdenite and chalcopyrite.

7. The results of the geochemical analyses indicate that there is no commercial zone of hypogene mineralization intersected by this drill hole. Copper mineralization is present but is very low grade and the anomalous intervals are too thin.

General Observations

It appears that the metallic mineralization is frequently related to a definite facies of the schist. A possible explanation is that the fractures were best developed in some of these facies allowing a better deposition of the products in the hydrothermal fluids in them.

APPENDIX III

GENERAL OBSERVATIONS FROM THE RESULTS OF CS-B

I. Rock Units

Two rock units were cut by drill hole CS-A:

a) Pinal Schist: Most of this hole was drilled in this unit. The more frequent facies drilled was a fine to medium size grain, dark gray quartz-biotite-sericite schist. The schist is compact except in some fractured zones.

b) Diabase: This unit cuts the Pinal schist in the following intervals: 264' to 266'; 435' to 437'; 598' to 616' and 752.5' to 759'. The diabase is dark green to black, aphanitic, with high magnetite content. It is cut by numerous shallow angle calcite veinlets. The contact with the schist appears to be always at a low angle (30^{o}), and much fracturing occurs in the schist near the contact.

II. Structure

The foliation is very steep along the whole length of this hole. This was expected since it is located in the steep northwest limb of the assymetric anticline. Dip of foliation was continuously larger than 70^{o}. Minor fault zones with increased fracture density were intersected by this hole, the largest one from 1102' to 1141'.

III. Hydrothermal Process

a) Metallic mineralization: The mineralization is undoubtedly epigenetic as observed in drill hole CS-A. It follows fractures and secondary features of the rock. The introduced metallization was produced by a hydrothermal process of post-Schultze granite intrusion age.

The oxide zone extends down to 43 feet. The mixed oxide-sulfide zone continued to 99 feet. The minerals of these two zones are: goethite, jarosite, malachite, and tenorite. Chalcocite appeared in the core at 60 feet and a thin chalcocite zone extends down to 96 feet. The supergene enrichment is very weak in this zone.

The hypogene mineralization from below 100 feet down to the total depth of 1488 feet consisted of very thin veinlets of pyrite, minor chalcopyrite and very minor molybdenite. The mineralization in this hole is much weaker than in CS-A, with the protore having less than 0.1% Cu content. Cu background was very low (under 200 ppm.). Molybdenum was well below 0.02% with a background under 20 ppm. Pyrite is the dominant sulphide and all metallic minerals are associated with quartz.

b) Alteration: The predominant hydrothermal alteration appears to be the introduction of silica. Argillization is common in the fractured zones and sericitization is weak.

Barren quartz veins parallel to the foliation were introduced during a much older hydrothermal process than the one which introduced the Cu metallization.

Table

Mineralized Intervals Intersected by the Drill Holes

Collar Elev.	T.D.	Intervals	Foot-age	Content (%Cu)	Mineral	Classification	Rock	Obs.
5220'	187'	155-185	30	0.114	Chalcocite coating pyrite	N.C.	Schist	Oxide & sulphide zone.
5262'	146'	-	-	-	-	N.C.	Schist all oxide zone	No Cu values above 0.1%
5448'	205	-	-	-	-	N.C.	Schist oxide & sulph. zones	No values above 0.1%
5334'	205'	-	-	-	-	N.C.	Schist	One isolated value >0.1% Cu. Ox. & Sulph. zo
5153'	105'	-	-	-	-.	N.C.	Schist all oxide zone	No values >0.1% Cu
5101'	159'	-	-	-	-	N.C.	Schist oxide & sulph. zones	No values >0.1% Cu
5504'	210'	180-190 175-195	10 20	0.34 0.22	Malachite	N.C. G.I.	Schist	All oxide zone
5741'	210'	105-135 145-210 170-210	30 65 40	0.19 0.19) 0.23)	Malachite, tenorite (Chalcocite, (coating pyrite) (Chalcopyrite	N.C. G.I.	Granite	Oxide & Sulph. zo
5720'	103'	-	-	-	-	N.C.	Schist	No Cu value >0.1% oxide zone
4483'	110'	-	-	-	-	N.C.	Schist & diabase	Oxide & sulph. zo
4193'	35'	-	-	-	-	N.C.	Schist	Oxide & sulph. zo
5132'	268'	15-85 152.5-263.0 166.2-187.4 211.2-240.0	70 5.5 21.2 28.8	0.13 0.30 0.40 0.42	Malachite, tenorite (Chalcocite (Chalcopyrite	G.	Schist	Oxide & sulph. zo

Table I (Cont'd.)

Collar Elev.	T.O.	Intervals	Footage	Content (%Cu)	Mineral	Classification	Rock	Obs.
5130'	248.7'	135.0-234.5 178.0-216.0 196.0-216.0	99.5 38 20	0.22 0.29 0.31	Chalcocite (Chalcocite, minor (Chalcopyrite, bornite	G.	Schist	Oxide & Mix ox-sul
5144.4	120'	56.5-73.0	16.5	0.21	Chalcopyrite	N.C. G.I.	Granite	Sulphide zone only
5733'	132'	95-128	33	0.09	Tenorite, Chalcocite (weak)	N.C.	Granite	Mineralization at oxide-sulphide z
4218+ 4247'	70 140	-	-	avg. 20 ppm		N.C.	Granite	Oxide & sulphide z
4525'	146	-	-	avg. 100 ppm		N.C.	Granite	Oxide & sulphide z
4670'	148'	-	-	avg. 200 ppm		N.C.	Granite	Oxide & mixed oxid sulphide zone
5330'	311	115-155 175-195 205-292.6 224.7-237.7	40 20 87.6 13.0	0.13 0.15 0.13) 0.23)	tenorite (ox.zone) ten.&malachite (ox.zone) chalcocite zone	N.C. G.I.	Schist	oxide &mix. ox-sul sulph. & chalcoci zones.
5428'	333.8	246.8-255.0	9.2	0.28	chalcocite zone	N.C.	Schist	ox., & mix. ox.sulp sulph. &chalcocit (weak) (zones)
4965'	142.0'	100.3-108.9	8.6	0.13	chalcocite zone (weak)	N.C.	Schist	ox., & sulphide zo
5040'	286.1'	45 - 75 177.2-257.7 177.3-202.2	30 80.5 25	0.17 0.31) 0.44)	Cu oxide zone chalcocite; cuprite in chalcocite zone	G.	Schist	ox., &mix. ox-sulph zones
5150'	223'	136.2-199.7	63.5	0.21	Chalcocite, chalcopyrite	N.C. G.I.	Schist	ox., mix. ox-sulph. zones. Chalcocit zone.
5147	225.6	25 - 42.7 69.6-193.0	17.7 123.4	0.17 approx. 0.20	Malachite Chalcopyrite	N.C.	Schist	ox., mixed ox-sulph sulph. zones. No chalcocite zon

Table I (cont'd.)

Collar Elev.	T.D.	Intervals	Footage	Content (%Cu)	Mineral	Classification	Rock	Obs.
5521'	297.0'	150-283	123'	0.14	Chalcocite	G.I.	Schist	oxide; mix. ox-sul and sulph. zones Chalcocite zo...
4750.3'	155.0	55- 65	10	0.10	Chalcocite	N.C.	Schist	ox.; mix. ox-sulph and sulph. zones Weak chalcocite
4995.1'	136.8'	70- 75	5	0.13	Malachite	N.C.	Schist	ox., mix. ox-sulph and sulph. zones N chalcocite.
5160'	296.7'	60-110	50	0.20	Chalcocite	N.C.	Schist	ox.; mix ox-sulph. and sulph. Chalc cite zone.
4726'	102.3'	-	-	avg. <150 ppm	-	N.C.	Granite	ox.; mix ox-sulph. sulph. zones.
5013'	219.5'	40- 50	10	0.13	Cu oxides	N.C.	Schist	Three zones and v.. chalcocite zone.

The classification is an arbitrary qualitative estimation of the mineralization in the drill hole.

N.C. - non-commercial (very poor)
G. - good mineralization
G.I. - good indication of mineralization

Table II*

Mineralized Intervals Intersected by the Kerr-McGee Drilling Program

Drill Hole	Thickness (ft.)	% Copper	Elevation of bottom of Enriched Blanket (ft)
KM-1	9	0.33	5,209
KM-2	19.6	0.34	5,403
KM-3	65	0.35	5,050
KM-4	80	0.40	4,980
KM-5	41	0.45	4,929
KM-A6	78 (vertical)	0.35	4,982
KM-A7	63 (vertical)	0.22	5,090

*From Fitzgerald (1964)

COPPER SPRINGS BLOCK
PROJECT 507
Gila County, Arizona

The Copper Springs Block is located in Township 1 South, Range 14 East, Sections 10, 11, 13, 14, 15, 22, 23, 24: A portion thereof, Gila County, Arizona, and contains the following stated property:

(1) Unpatented claims owned by Humble Oil & Refining Company, 155 claims.
(2) Unpatented claims owned by Joseph M. Santa Anna et al and under Lease and Purchase Option to Humble, 20 claims.
(3) Unpatented claims owned by Esther S. Nieto and under Lease and Purchase Option to Humble, 2 claims.

177 total unpatented lode claims controlled by Humble Oil & Refining Company.

Humble located 155 claims on April 5, 1969, to August 11, 1969, inclusive and comprising approximately 3,202.46 acres. The Humble "Crow" claims are numbered 1-149 inclusive and 154-159 inclusive. There is no royalty outstanding on these claims and the total staking costs are $9,284.18.

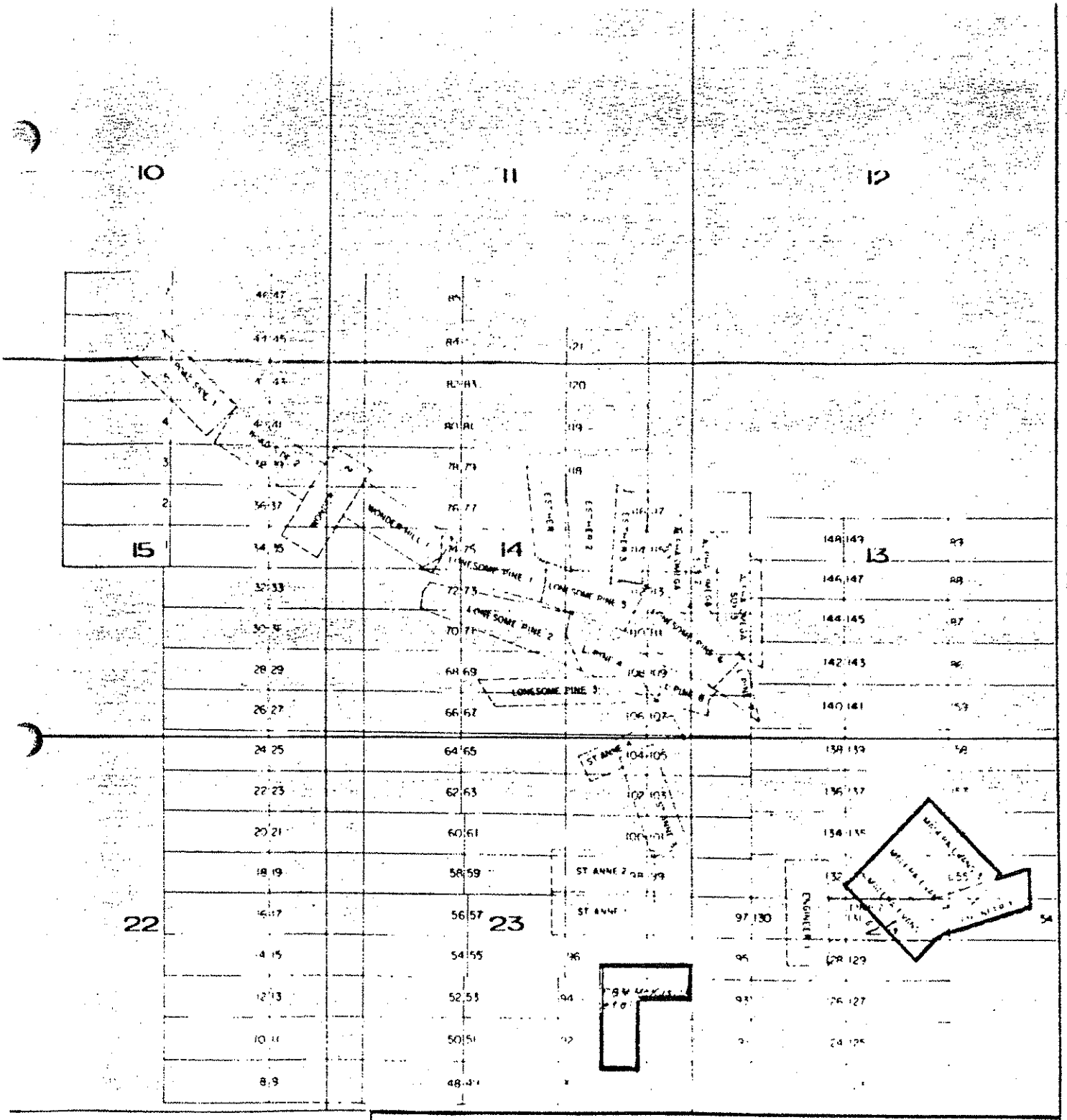
The 20 claims owned by Joseph M. Santa Anna et al are under "Mining Property Lease and Purchase Option" dated April 15, 1969, to Humble as Optionee. This agreement contains an end price of $120,000.00. There are advance royalty payments due December 31, 1971, in the amount of $10,000.00 and December 31, 1972, and each successive December 31 in the amount of $25,000.00 until the total end price is paid. Humble has paid advance royalty payments in the amount of $18,000.00 as of May 20, 1971, which is applicable to the end price. The royalty is 5% N.S.R. and thirty day cancellation notice to owners.

The two claims owned by Esther S. Nieto are under "Mining Property Lease and Purchase Option" dated April 23, 1969, to Humble as Optionee. The agreement contains an end price of $12,000.00. There are advance royalty payments due December 31, 1971, in the amount of $1,000.00 and December 31, 1972, and each successive December 31 in the amount of $2,500.00 until the total end price is paid. Humble has paid advance royalty payments in the amount of $1,800.00 which is applicable to the end price. The royalty is 5% N.S.R. and thirty day cancellation notice to owner.

The Madera-Evans #1-3, Engineer #1-3 lode claims and the fee land owned by McKusick et al are not in control of the Humble block.

A total amount of $242,000.00 including capital and exploration expense has been spent on the acreage controlled by Humble within the Copper Springs Block.

All of the claims owned or optioned by Humble have been assessed for the assessment year ending 9/1/70 and the affidavit is recorded in Docket 289 - Pages 957-960 inclusive.



Not controlled by HORCo.

HUMBLE OIL & REFINING COMPANY

MINERALS DEPARTMENT

COPPER SPRINGS AREA

Project # W-507

Gila County, Arizona

HUMBLE OIL & REFINING COMPANY

Minerals Department
112 California Avenue
Reno, Nevada 89502

November 3, 1969

RECEIVED
NOV 5 1969
HUMBLE OIL & REFINING CO.
WESTERN METALS - DENVER

TO: Mr. Richard R. Weaver
FROM: William D. Burton
SUBJECT: Geologic Report for Copper Springs
Project No. 507, Arizona

Here is my report on the geology of the Copper Springs Prospect, Gila County, Arizona.

The geologic map, cross-sections, alteration map, quartz vein density map and limonite map have already been submitted.

Since development drilling is still in progress, I reported on drill hole information only in general terms.

William D Burton

William D. Burton

WDB:b

Enclosure

ABSTRACT

The Copper Springs prospect No. 507 is located at the southern edge of the Globe-Superior copper belt, about four miles south of the porphyry copper deposit at Miami, Arizona. Kerr-McGee previously held the property, and partially drilled out a low-grade chalcocite blanket. Humble staked 156 claims, drilled 20 validation holes, and is currently grid drilling the chalcocite zone to determine its in-place leach potential.

Precambrian Pinal schist is buttressed between later Precambrian Madera diorite to the south and Late Cretaceous-Early Tertiary Schultze granite to the north. The reactivated, north-trending Santa Anna fault zone cuts Pinal schist and Schultze granite. West of the fault the schist is sharply folded into a northeast-trending anticline. Hydrothermal sericite is common along the fold axis. Significant alteration in the Schultze granite is restricted to a quartz monzonite porphyry facies characterized by secondary K-feldspar flooding and strongly oriented quartz-muscovite veining.

Pyrite, chalcopyrite and minor molybdenite occur in quartz-veinlet stuckworks. Primary sulfide mineralization in the schist is controlled by (1) multi-directional fracturing along the anticlinal fold axis and (2) proximity to the Santa Anna fault zone. Within the Schultze granite, quartz-sulfide veining is found only in the quartz monzonite porphyry facies, and is strongest near the Santa Anna fault zone.

A weak and erratic zone of chalcocite enrichment is developed in schist at the northern end of the anticlinal fold axis where primary mineralization is strongest. Chalcocite replacing sulfide veinlets, cuprite, covellite, bornite, and native copper are the secondary minerals present. Chalcopyrite protore averages about 0.1% copper and is usually enriched three to four times in the chalcocite blanket. Humble's drilling thus far indicates that significant enrichment is restricted to the area previously developed by Kerr-McGee, and that thickness and grade are highly variable -- typically 20 to 80 feet thick and 0.25% to 0.40% copper.

Structural setting, alteration and mineralization of the quartz monzonite porphyry facies is somewhat analogous to the Castle Dome mine area located six miles to the northwest. Deep IP surveys should be run to test for a deep primary target.

PROGRESS REPORT

GEOLOGY OF THE COPPER SPRINGS PROSPECT NO. 507

GILA COUNTY, ARIZONA

William D. Burton
October 31, 1969

INTRODUCTION

Location

The Copper Springs prospect is located in the Pinal Mountains of Gila County, about four miles south of the Miami-Inspiration porphyry copper deposit at Miami, Arizona. The property is in sections 10, 11, 13, 14, 15, 22, 23, and 24 of Township 1 S., Range 14 E., and has a total area of about five square miles. The area is referred to variously as the Summit, Bellevue, or Pinal Mountains mining district.

Accessibility

From Miami take State Highway 60-70 west 3.2 miles to the Schultze Ranch left turnoff. Follow a rough dirt road south up Copper Springs Canyon about one-and-one-half miles to the prospect. The southern part of the property can be reached by turning south off State Highway 60-70 4.8 miles west of Miami and following the county-maintained dirt road south and east about four miles up Pinto Creek. A four-wheel-drive vehicle is necessary to get about the property.

Claims

Humble staked the prospect area with 156 unpatented claims (Crow No. 1-156) in April, 1969. The staked area also covers the Santa Anna and Ponder claim groups optioned by Humble (see claim map). Humble's claims were validated by drilling 20 rotary and diamond drill holes on groups of ten or less claims. Each validation hole is capped and marked by a red 4" x 4" discovery post with discovery notice in accordance with Arizona mining claim laws.

Geographic Setting

The prospect area is made up of rugged hills and steep canyons typical of the Mountain Province of central Arizona. Elevations range between 4,200 feet and 6,500 feet. Pinon pine trees grow along the higher hills, while low shrubs and bushes dot the lower slopes. Many ridges are covered with dense thickets of manzanita.

History and Development

Numerous shallow prospect pits and small adits were dug in the early 1900s. Most of the old workings follow copper oxide showings along the outcropping edge of the chalcocite blanket and in the Santa Anna fault zone. In 1947 Inspiration Copper Company claimed the property and drilled several churn holes in Pinal schist. Later Bear Creek Mining Company staked the same area, but apparently did not drill. Phelps-Dodge subsequently drilled at least one deep core hole in Schultze granite.

Kerr-McGee claimed the Copper Springs area in 1964, optioned the Santa Anna claims, and drilled at least 12 core holes in an attempt to develop leach grade ore in a low-grade chalcocite blanket formed in Pinal schist. Kerr-McGee offered the property to Humble in 1967 (submittal No. D-289-67), and reported indicated reserves of 17 million tons of .37% copper in a chalcocite zone averaging 65 feet thick based on five holes which penetrated the zone. The submittal was rejected.

In April of 1969, when it was learned that Kerr-McGee had dropped the property, Humble decided to stake the area on the following basis:

1. Humble was interested in low-grade leach targets.
2. The chalcocite blanket developed by Kerr-McGee's drilling was open to the southwest and could extend another mile in that direction. (Humble obtained the drill core from 10 of the 12 holes drilled by Kerr - McGee - See drill logs and assays in Appendix.)
3. A large area of Pinal schist east of the chalcocite blanket was found to be anomalous in copper by Holman kit soil-sampling.

4. Quartz-sericite alteration in the adjacent quartz monzonite intrusive indicated potential for a deep primary copper target.

The closest active mining operation is about one mile west of the Copper Springs property at the old mining camp of Bellevue. A small pilot leach operation has started in-place leaching along a five- to ten-foot-wide chalcopyrite vein in Pinal schist. The property, known as the Gibson Mine, was recently submitted to Humble and was rejected as being too small. The Miami-Inspiration porphyry copper deposit is four miles north of Copper Springs, and the Castle Dome porphyry copper deposit is located about six miles to the northwest.

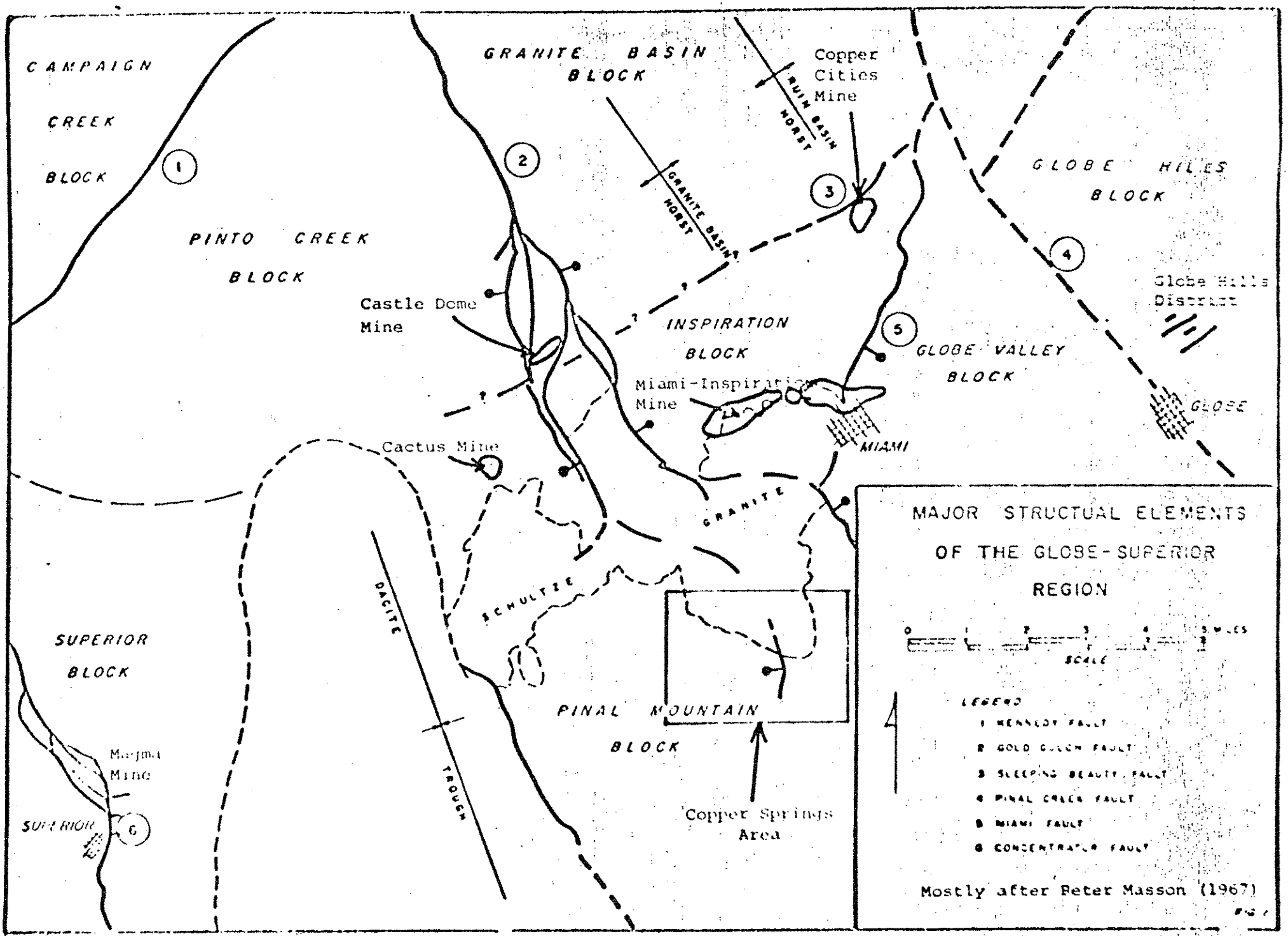
REGIONAL GEOLOGY

Lithology

The prospect is located at the southern edge of the Globe-Superior copper belt -- a major east-northeast trending structural zone along which the copper deposits at Superior, Castle Dome, Miami - Inspiration, Copper Cities and Globe are situated (see Figure 1). The oldest rocks are Lower Precambrian Pinal schist which forms the basement complex for the surrounding region and has a strong northeast direction of foliation. Pinal schist is intruded by several Precambrian igneous stocks including Madera diorite and Ruin (Oracle) granite. Younger Precambrian sedimentary rocks of the Apache series rest unconformably on Pinal schist and the intruded igneous rocks. Paleozoic limestones and quartzites occur in scattered outcrops. The central part of the Globe-Superior structural belt is mainly occupied by Late Cretaceous-Early Tertiary granitic rocks and associated diorites and diabases. The largest stock is the Schultze granite (60-62 million years). Tertiary dacitic ignimbrites cover a large area at the western end of the belt. Gila conglomerate fills many of the down-faulted blocks.

Structure

Northwest-trending tilted fault blocks typical of the Basin-and-Range Province are the dominant structural elements along the Globe-Superior copper belt. Mid-Tertiary faulting was superimposed upon a Late Cretaceous-Early Tertiary complex of dominately northeast and northwest-trending faults and partly fault-controlled intrusives.


CAMPAIGN CREEK BLOCK
PINTO CREEK BLOCK
GRANITE BASIN BLOCK
INSPIRATION BLOCK
GLOBE HILLS BLOCK
GLOBE VALLEY BLOCK
SUPERIOR BLOCK
PINAL MOUNTAIN BLOCK
RUIN BASIN HORST
GRANITE BASIN HORST
Copper Cities Mine
Castle Dome Mine
Miami-Inspiration Mine
Cactus Mine
Globe Hills District
GLOBE
MIAMI
Magma Mine
SUPERIOR
Copper Springs Area
DACITE TROUGH
SCHULTZE GRANITE
1
2
3
4
5
6
MAJOR STRUCTUAL ELEMENTS OF THE GLOBE-SUPERIOR REGION
SCALE
LEGEND
1 KENNEDY FAULT
2 GOLD GULCH FAULT
3 SLEEPING BEAUTY FAULT
4 PINAL CREEK FAULT
5 MIAMI FAULT
6 CONCENTRATOR FAULT
Mostly after Peter Masson (1967)

Both periods of faulting were controlled by a strong Precambrian rectilinear pattern of northeast and northwest structures. The younger faulting consisted mostly of reactivation along pre-existing Precambrian fault zones. The northeasterly trend of the Globe-Superior structural belt may be controlled by a Precambrian shear zone. For a detailed structural analysis of the regional geology, refer to Peter H. Masson's report "Structural Study of the Globe-Superior Area," file No. 35-4-4.

Mineralization

Metallization occurs throughout a broad zone between Globe and Superior, although the important ore bodies are aligned along a narrow northeast-trending belt. Mineral and structural zoning occurs along the belt: lead, zinc, precious metals and copper vein deposits characterize the two ends of the belt at Globe (Old Dominion Mine) and Superior (Magma Mine), while porphyry copper deposits without notable precious or other base metals are found in the central part of the belt (Miami-Inspiration, Copper Cities, and Castle Dome open pit mines). Hydrothermal alteration and mineralization took place at the close of the Late Cretaceous-Early Tertiary period of granitic intrusions. The porphyry copper deposits are situated along the northern boundary of these granitic intrusions at or near the Pinal schist contact. Primary ore controls appear to be: (1) reactivated northwest-trending faults along which mineralizing fluids ascended and (2) intensely shattered contact zones between late phase granitic porphyries and Pinal schist. Subsequent supergene enrichment is responsible for the important economic copper deposits.

GEOLOGY OF THE PROSPECT

The claimed area was mapped at a scale of 1"=500' on enlarged topographic sheets. Black and white aerial photographs at the same scale were available for field use. The area is shown on U. S. G. S. Map MF-81 "Preliminary Geologic Map of the Pinal Ranch Quadrangle, Arizona" by N. P. Peterson (1961) at 1:24,000.

Lithology

Pinal Schist

Lower Precambrian Pinal schist crops out between Schultze granite to the north and Madera diorite to the south. It weathers to

rounded hills and ridges with slopes that are mostly covered with soil or talus. Because of downhill creep only the larger outcrops are reliable for foliation and fracture orientation.

Typically, the Pinal schist is a fine to medium-grained quartz - sericite-biotite schist of sedimentary origin. Quartz and sericite generally make up most of the rock with biotite, sometimes altered to chlorite, in varying amounts. Some thinner units contain a high percentage of feldspar grains. Magnetite is present in variable minor amounts as fine disseminated grains. Along its contact with the Schultze granite the schist contains abundant disseminated magnetite and is noticeably magnetic. The Pinal schist varies in color from light to dark gray, depending on the amount of biotite and magnetite present.

The rock is distinctly foliated. Foliation results from thin, parallel lamminae comprised almost entirely of quartz grains and sericite alternating with thin, parallel lamminae of biotite. Often the biotite is in discontinuous lamminae or in crudely aligned blebs .2-.4 inch in diameter. Relic bedding is common and parallels foliation. Glassy quartz segregations in stringers and irregular lenses one to four inches wide are common throughout the area. Quartz segregations always parallel foliation and are often localized along crests of small folds. Ptygmatic folding is commonly observed.

Along a narrow zone adjacent to the Madera diorite, Pinal schist described above grades into a medium to coarse-grained quartz-muscovite-biotite schist and is mapped as a separate schist facies. Foliation is faint and indistinct except in fine-grained units. This coarse-grained zone is an alteration facies related to intrusion of the adjacent madera diorite. Near the Madera diorite contact the foliation becomes highly contorted, and within a few feet of the contact the rock grades into dark-gray, dense hornfels.

Madera Diorite

Lower Precambrian Madera diorite intrudes Pinal schist in the southern part of the mapped area. The rock is a coarse, evenly-grained biotite-quartz diorite. It has subhedral, nonporphyritic granular texture as seen with the hand lens. Plagioclase, quartz, and biotite in grains .1 to .2 inch in diameter, are the most abundant minerals. Minor epidote,

chlorite, and calcite occur as alteration products. The rock is prominently jointed, with the major set of fractures striking northeasterly and dipping steeply to the west. Typically it weathers to soil-covered hills with only scattered bedrock exposures. Partly assimilated schist inclusions are common along the intrusive contact.

Diabase

No outcrops of diabase were observed in the prospect area, but diamond drill hole CS-26, located in Pinal schist about 350 feet west of the Schultze granite contact encountered a thirty-foot interval of diabase which cuts the schist at a steep angle and is intruded by several small stringers of Schultze granite. The diabase is dark gray in color, fine to medium grained and strongly magnetic.

Schultze Granite

Late Cretaceous-Early Tertiary Schultze granite intrudes Pinal schist across the northern border of the prospect area. The schist is brecciated and silicified along parts of the contact. Generally the contact is steeply dipping or vertical, but locally it may be highly irregular. Two major sets of regional fractures characterize the joint system. The most prominent set strikes northeast to east-west and is steeply dipping. The other set strikes north-northwest. No flow structures were recognized in the mapped area.

Four facies of Schultze granite and a related breccia pipe in the Pinal schist are recognized. Age relationships are not certain, but based on mineralization and alteration, the approximate order from oldest to youngest appears to be: Granite porphyry, porphyritic quartz monzonite, breccia pipe, quartz monzonite porphyry, and aplite.

(1) Granite porphyry facies: Typical Schultze granite crops out in the north-central part of the mapped area. It forms bold, smooth outcrops which generally are grayish or greenish-yellow in color. The rocks are characterized by abundant pink orthoclase phenocrysts (30-60%) up to four inches in length set in a medium to coarse-grained groundmass of white plagioclase (30-50%), orthoclase (20-30%), porphyritic quartz (25%), and olive-brown biotite (2-10%) with minor amounts of muscovite and magnetite. A hand lens

shows that the groundmass is subhedral and most of the plagioclase is zoned. The rock is closer to quartz monzonite, but here is called granite porphyry to emphasize its identity with typical Schultze granite. Prominent wide-spaced joints are set one to three feet apart. Contacts with adjacent porphyritic quartz monzonite and quartz monzonite porphyry facies are sharp in some places and gradational in others. Near the schist intrusive contact the granite porphyry is finer grained and silicified.

(2) Porphyritic quartz monzonite facies: At the northwestern corner of the area are bold, smooth-weathering, light buff-colored outcrops of porphyritic quartz monzonite. The rock is composed of numerous euhedral quartz phenocrysts.1 to .3 inch diameter (20-25%) set in a medium-grained groundmass of buff orthoclase (35-45%),white plagioclase (20-40%) and minor biotite (2-5%). Scattered orthoclase phenocrysts (5-10%) up to one inch in length are fairly common. Jointing is prominent and typically spaced one-half to two feet apart. Near the Pinal schist contact the rock is finer grained and silicified.

(3) Breccia pipe facies: About 1,000 feet south of the porphyritic quartz monzonite-Pinal schist contact is a small breccia pipe (700 feet by 350 feet) in shattered and brecciated schist. Interstices of the breccia are filled with a light buff-colored, granitic rock-flour matrix related to Schultze granite. The breccia is mostly composed of irregular and rounded fragments of Pinal schist usually less than one foot across and includes a few small fragments of Schultze granite. The central core of the pipe is mainly rock flour. It has prominent joints spaced one to two feet apart which strike northwest and dip forty to fifty degrees northeast. Contacts with surrounding Pinal schist are shattered and brecciated. Time relationship with other Schultze granite facies is unknown.

(4) Quartz monzonite porphyry facies: The northeastern part of the mapped area is occupied by light buff outcrops of an intrusive facies characterized by abundant stubby, bipyramidal quartz phenocrysts .2 to .4 inch in diameter scattered through a medium to coarse-grained groundmass. The rock varies from porphyritic quartz monzonite to quartz monzonite porphyry with quartz (25-50%), pinkish-gray orthoclase (35-45%), and white plagioclase)30-40%) the principal minerals. Lesser amounts of muscovite (3-5%), biotite (2-4%) and magnetite (less than 1%) are also present. Euhedral orthoclase phenocrysts .5 to 1 inch

in length are fairly common. Grayish-pink secondary orthoclase commonly occurs in irregular veinlets and as thin borders along quartz veins. Typically the prominent northeast to east-west striking joints contain veinlets .1 to .4 inch wide of quartz and cross-oriented muscovite. Not connected with the Schultze granite stock, but also mapped as quartz monzonite porphyry because of similar lithology are three dikes within the Pinal schist and two small intrusive bodies in the Madera diorite.

(5) Aplite facies: An irregularly-shaped aplitic body and occasional aplite dikes occur within the quartz monzonite porphyry facies. The aplite is very light tan in color and weathers nearly white. The rock is very fine grained, with small subhedral quartz phenocrysts .05 to .1 inch in diameter scattered throughout. Within the irregularly shaped aplite body the most prominent joints strike east-west to west-northwest and dip steeply south. Contacts with the quartz monzonite porphyry facies vary from sharp to gradational. Aplite dikes parallel jointing within the quartz monzonite porphyry facies and generally strike east-west to northwest.

Structure

The Pinal schist is squeezed and buttressed between two intrusive bodies -- Madera diorite to the south and Schultze granite to the north. The schist is divided into two separate structural units by a major fault in this report called the Santa Anna fault zone. Where exposed the fault zone is 40 to 60 feet wide, strikes about N. 5° W. and dips 60-70° west. Rock fragments and gouge within the zone are strongly argillized and commonly stained with copper oxides. The fault branches a short distance into the Schultze granite and could not be traced farther north. To the south the fault cannot be followed into the Madera diorite.

Pinal schist west of the Santa Anna fault zone is sharply folded into a northeast-trending anticline which parallels regional foliation and the adjacent Madera diorite contact. The anticline is asymmetric having steeper foliation attitudes along its northwestern flank (see cross-section A-A'). The fold plunges 10-20° to the southwest except near the Schultze granite contact where the plunge increases to 30-40°. Minor foliation-plane faults are common along

both flanks of the fold axis. Numerous northwest-trending faults were mapped in isolated outcrops, but their continuity along strike was never established -- perhaps because of the extensive talus and soil cover.

Pinal schist east of the Santa Anna fault zone is not strongly folded. Foliation generally follows the regional trend of northeasterly strike and southeasterly dips except where deformed near the Schultze granite and Madera diorite intrusives (see cross-section B-B'). Several minor faults strike northwest and dip to the southeast. Three northeast-trending dikes of quartz monzonite porphyry cut the schist without brecciation of the surrounding rock.

Map pattern of the Pinal schist-Madera diorite intrusive contact and the contrast in schist deformation on either side of the Santa Anna fault zone suggest that the fault was an old Precambrian zone of weakness along which Madera diorite intruded and folded Pinal schist west of the fault. Reactivation of the fault occurred subsequent to, and perhaps also contemporaneously with, intrusion of the Schultze granite stock.

Mechanism of Schultze granite emplacement into Pinal schist varies markedly on either side of the Santa Anna fault zone. From the western edge of the mapped area to about 600 feet east of the fault zone, the intrusive contact cuts across Pinal schist foliation trends and the schist is brecciated everywhere along the contact. Similarly, Pinal schist is strongly brecciated near the breccia pipe. East of the Santa Anna fault zone, however, Pinal schist foliation dips away from, and generally parallels, the Schultze granite intrusive contact without significant brecciation. Also, Schultze granite dikes and intrusive bodies not connected with the main stock are emplaced passively without brecciation of the surrounding rock. This difference in emplacement mechanism -- i.e., forceable west of the fault and passive east of the fault -- suggests differences in depth or time of emplacement. Possible explanations are that the western fault block has been down-dropped from a higher, near-surface position (1); the whole area has been rotated through a large angle to the west(2); and (3) the two intrusive areas were emplaced at different times under different confining pressures.

Hydrothermal Alteration

Schultze Granite Alteration

Three alteration types are mapped within the Schultze granite (see Alteration Map). The weakest alteration is represented by medium -

grained, cross-oriented muscovite flakes along prominent joint planes without accompanying quartz veining (on the Alteration Map, it is labeled "coarse-grained sericite" to emphasize its hydrothermal nature). The porphyritic quartz monzonite facies, breccia pipe facies and quartz monzonite porphyry dikes are typical of this alteration type.

A stronger alteration phase is characterized by quartz veins bordered by and including irregular blebs of medium-grained, cross-oriented muscovite (also referred to on the Alteration Map as "coarse-grained sericite"). Quartz-muscovite veins mostly fill prominent joint fractures, but also occur in multi-directional stockworks. Quartz-muscovite vein alteration occurs throughout the quartz monzonite porphyry and aplite facies.

The strongest alteration phase is recognized by secondary K-feldspar which occurs as flooding in irregular veinlets and as thin borders along quartz-muscovite veins. Secondary K-feldspar constitutes approximately 5-15% of the quartz monzonite facies along an east-west zone 1,000-1,500 feet wide adjacent to the Pinal schist contact. It is common in drill core from holes CS-13 and CS-14.

Pinal Schist Alteration

Very fine-grained hydrothermal sericite occurs along the anticlinal fold axis, and also in a small area adjacent to the Schultze granite just east of the Santa Anna fault zone (see Alteration Map). Introduced hydrothermal sericite is distinguished from original schist sericite by its characteristic satin sheen. Argillization is common along faults, especially the Santa Anna fault zone. Coarse-grained quartz-muscovite-biotite schist described under Pinal schist lithology is a Precambrian alteration facies of the Pinal schist related to intrusion of the Madera diorite.

Mineralization

Primary Mineralization

Pyrite, chalcopyrite and molybdenite occur mostly in veinlets, blebs, and discreet grains associated with quartz veins and veinlets. The only significant disseminated mineralization is pyrite (3-10%) in

the breccia pipe facies. Relic pyrite and chalcopyrite are rarely observed in surface outcrops, but limonitic textures after pyrite and chalcopyrite are easily recognized. Molybdenite is common only along the Santa Anna fault zone.

Quartz-sulfide veins in the Pinal schist are typically hairline to .2 inch wide in a multi-directional stockwork. Vein density is highest along the anticlinal fold axis, near the Santa Anna fault zone and in several small areas to the east which may be related to northeast-trending fractures along which dikes and fingers of Schultze granite intruded (see Quartz Vein Density Map). The pyrite-chalcopyrite ratio generally ranges 5:1 to 8:1.

Quartz-sulfide veins within the Schultze granite are commonly .1 to .5 inch wide in a preferred northeast to east-west orientation parallel to jointing. They also occur in multi-directional stockworks in strongly veined areas. Vein density is highest near the Santa Anna fault zone and along the southern part of the quartz monzonite porphyry facies. The chalcopyrite-pyrite ratio typically is 4:1. Quartz veining is noticeably absent in the granite porphyry facies, porphyritic quartz monzonite facies and the Madera diorite.

Distribution of indigenous vein limonites after pyrite and chalcopyrite is directly related to the density of quartz veining (see Limonite Map). Mapping of goethite, jarosite, and hematite textures shows that the highest percentage of indigenous limonites occurs in Pinal schist at the northeastern end of the anticlinal axis, adjacent to the Santa Anna fault zone, and in a small area east of the Santa Anna fault. Indigenous limonites are much less common in the Schultze granite, and are mostly restricted to quartz monzonite porphyry adjacent to the Santa Anna fault.

Supergene enrichment

A weak chalcocite zone of secondary enrichment is developed in Pinal schist at the northeastern end of the anticlinal fold axis where primary sulfide mineralization is strongest. Kerr-McGee's previous core drilling and Humble's current drilling show that secondary enrichment begins at or near the oxide-sulfide zone contact and extends to a variable and gradational lower boundary. Usually the water table

is either somewhat above or below the top of the zone. The enriched blanket slopes downhill and crops out along the 4,800 to 5,000-foot elevation level. Malachite, azurite, tenorite, and limonite after chalcocite are seen in outcrops along the oxidized edge of the chalcocite blanket. The enriched zone does not follow the present steep topography, but apparently is related to an older cycle of erosion. Generally, the chalcocite zone is thickest near the anticlinal fold axis (100 feet thick in drill hole CS-11), and thins away from the fold. It also thins to the southwest and gradually dies out south of drill hole KM-3.

Chalcocite erratically coats and partially replaces pyrite and chalcopyrite veinlets. Minor cuprite, covellite and bornite are also present, with trace amounts of native copper and chalcotrichite. Unenriched protore below the chalcocite zone averages .1% copper. The better parts of the supergene blanket usually are enriched three to four times. Grade of the enriched zone does not appear to vary significantly with schist lithology,but is related to (1) density of sulfide veins available for chalcocite replacement and (2) amount of cuprite -- probably a function of varying Eh-pH conditions.

Geochemistry

640 surface rock-chip and road-cut samples were collected and geochemically analyzed for copper, molybdenum, lead and zinc (see geochemical maps for copper, molybdenum, lead, and zinc). Lead and zinc values are uniformly low and uninteresting. However, contoured molybdenum and copper values show anomalous and meaningful patterns.

(1) Molybdenum: The distribution of primary metallization is best shown by molybdenum because of its greater stability in a slightly acid environment. Highest values within the Pinal schist are (a) at the northeastern end of the anticlinal fold axis,(b) along the Santa Anna fault zone, and (c) in several small areas farther east -- generally the same areas that have the highest density of quartz veins and the highest percentage of indigenous limonites. The area of proved chalocite development is roughly outlined by the 25 ppm contour line. Significant molybdenum values do not extend southwesterly along the anticlinal fold axis. Molybdenum is uniformly low nearly everywhere within the Schultze granite except immediately adjacent to the Santa Anna fault zone. The distribution of molybdenum suggests that primary metallizing solutions did not

originate from any of the exposed Schultze granite intrusive facies, but more probably ascended along the Santa Anna fault zone.

(2) Copper: The distribution of copper is much more erratic than molybdenum because of its greater mobility in a slightly acid environment. The strongest copper values are along the Santa Anna fault zone, in adjacent schist on both sides of the fault and within the quartz monzonite porphyry facies.

Ore Controls

Chalcocite enrichment developed in areas where primary sulfide mineralization was strongest. In the area of chalcocite enrichment originally drilled by Kerr-McGee, primary mineralization is controlled by (1) multi-directional fracturing along the Precambrian anticlinal fold axis in Pinal schist into which Early Tertiary(?) quartz-sulfide solutions flowed and (2) proximity to the Santa Anna fault zone along which mineralizing solutions ascended. Primary sulfide mineralization in the Schultze granite was controlled by (1) fracturing and jointing in the quartz monzonite porphyry facies and (2) proximity to the Santa Anna fault zone along which mineralizing solutions ascended.

DRILLING

Validation Drilling

Twenty holes were drilled to validate the Humble claim group: CS-1 through CS-17, CS-1A, CS-10A, and CS-15A (see drill logs and assays in Appendix). Five-inch rotary-hammer holes were drilled to the water table, and then continued with NX or NC diamond coring to the depth required for validation. A summary of copper mineralization encountered in each hole follows (see Geologic Map for the location of holes):

Western Schist Area

Two holes penetrated the chalcocite blanket previously drilled by Kerr-McGee:

CS-11: 34 feet of chalcocite averaging 0.40% copper.
CS-12: 42 feet of chalcocite averaging 0.28% copper.

Four holes drilled southwest of the chalcocite blanket failed to intersect significant copper mineralization:

CS-1A: 30 feet of weak chalcocite averaging 0.16% copper.
CS-2: Unoxidized schist averaging 250 ppm copper.
CS-5: Oxidized schist averaging 200 ppm copper.
CS-6: Unoxidized schist averaging 225 ppm copper.

Four holes drilled at the northwest corner of the area did not penetrate significant copper mineralization:

CS-10: Unoxidized schist averaging 500 ppm copper.
CS-10A: Unoxidized schist averaging 50 ppm copper.
CS-15: Unoxidized schist averaging 10 ppm copper.
CS-15A: Unoxidized schist averaging 20 ppm copper.

Eastern Schist Area

One hole drilled near a molybdenum anomaly encountered weak copper oxide mineralization:

CS-7: Oxidized schist with malachite, includes 10 feet of 0.34% copper.

Three holes did not penetrate significant copper mineralization:

CS-3: Unoxidized schist averaging 160 ppm copper.
CS-4: Unoxidized schist averaging 250 ppm copper.
CS-9: Oxidized schist with minor copper oxides averaging 500 ppm copper.

Schultze Granite

One hole drilled in quartz monzonite porphyry at the Pinal schist contact bottomed in a weak chalcocite zone:

CS-8: 75 feet of chalcocite averaging 0.2% copper.

Three holes drilled in quartz monzonite porphyry facies penetrated very weak chalcopyrite mineralization:

CS-13: Unoxidized intrusive averaging 500-1,500 ppm copper.
CS-14: Unoxidized intrusive averaging 800 ppm copper.
CS-17: Unoxidized intrusive averaging 250 ppm copper.

One hole drilled in the porphyritic quartz monzonite facies intersected insignificant mineralization:

CS-16: Unoxidized intrusive averaging 60 ppm copper.

Grid Drilling (in progress)

Grid drilling in the chalcocite blanket area shows that the enriched zone is highly erratic and of somewhat lower grade than originally indicated by the previous Kerr-McGee drilling:

CS-18: 13 feet of 0.23% copper
CS-21: 9 feet of 0.13% copper
CS-22: 29 feet of 0.38% copper
CS-26: 64 feet of 0.23% copper
CS-27: Santa Anna fault zone - no chalcocite

SUMMARY AND CONCLUSIONS

The chalcocite blanket developed in Pinal schist at Copper Springs is formed in the area of strongest primary sulfide mineralization which is characterized by increased density of quartz veins, a high percentage of indigenous limonites after pyrite and chalcopyrite, and presence of a strong molybdenum geochemical anomaly. Primary mineralization was controlled by (1) multi-directional fracturing along a Precambrian anticlinal fold axis and (2) proximity to the Santa Anna fault zone along which Early Tertiary(?) mineralizing solutions ascended. Humble's validation and grid drilling thus far show that the chalcocite blanket is generally restricted to the same area previously drilled by Kerr-McGee, and does not extend farther to the southwest. Grade and thickness of the zone are somewhat less than was indicated by the original Kerr-McGee drill hole data.

Several smaller schist areas east of the Santa Anna fault zone are also characterized by increased quartz veining, indigenous limonites and anomalous molybdenum values, and suggest the presence of secondarily enriched zones. These areas appear to be severely limited in areal extent, however, and probably would be important only if the Kerr-McGee blanket proved mineable. Validation drill hole CS-7 is

favorably located and should be deepened below the oxidized zone to test the potential chalcocite zone..

Altered quartz monzonite porphyry east of the Santa Anna fault zone is somewhat analogous to the Castle Dome mine area six miles to the northwest. Both are quartz monzonite border facies of the Schultze granite near the Pinal schist contact, both are strongly sheeted with northeast-trending quartz-muscovite veins, and both are located on the upthrown side of major northwest-trending reactivated faults which were apparently the source for mineralizing solutions. At Copper Springs, secondary K-feldspar vein alteration and geochemical copper anomalies are common in the southern part of the quartz monzonite porphyry facies, but indigenous limonites and anomalous molybdenum values are strongest adjacent to the Santa Anna fault zone. Kerr-McGee drill hole KM-9 was drilled through the fault zone to a depth of 425 feet in altered quartz monzonite porphyry which average .1%-.3% copper. Deep IP surveys should be run across the altered quartz monzonite porphyry facies and adjacent schist to test for the possibility of increasing metallization below 425 feet.

WDB:b