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WESTERN ARIZONA PROJECT

A regional geologic-metallogenic-target delineation study for precious metals in the Ajo, Phoenix and parts of Lukeville, Salton Sea, El Centro, Prescott, Needles, Kingman and Williams 1° X 2° Sheets

Prepared by

William A. Rehrig and Robert T. Wilson

APPLIED GEOLOGIC STUDIES INC.

with

Section on Tectono-Stratigraphic Units

by

James J. Hardy, Jr.

February, 1985

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SUMMARY AND CONCLUSIONS

1. The arduous construction of the 1:250,000 Tectono-Stratigraphic base map for the western Arizona study region has proved useful in various ways:

   a. It has provided a means for regional correlation of like tectono-stratigraphic units resulting in a coherent familiarity with the region.

   b. Map construction has forced the systematic review and collation of all available literature (maps, journals, reports, books, etc.) on the geology of the study region. This work process facilitated the writing of a comprehensive review on the tectonic evolution of western Arizona into which to integrate precious metals mineralization.

   c. In a general way, the map has led to the recognition of regional stratigraphic and structural controls on metallization. This resolution was made possible largely because of the extra pains that were taken to capture stratigraphic and structural detail from all scales of geologic reference material (including theses and low-altitude air photos).

   d. The maps (plus overlays) provide clients with a unique data base which can incorporate in-house field data and be applied as a useful reference guide while conducting prospect reconnaissance.

2. CRIB, MILS and regional geochemical data (listings and map overlays) have facilitated the merging of metallogeny in general and gold-silver in particular with the regional geologic framework. Within time-cost constraints of this project, these metals data have been adequate to meet objectives of the project. They are, however, less than complete in some areas (i.e. CRIB-MILS not updated; certain elements from NURE not available). Future efforts to improve these data bases might improve the regional correlation between specific geologic structures and metals occurrences.

3. An overview of metals distribution in the study region reveals some unusually large areas barren of occurrences. The region south of the Gila River lineament, including the Ajo volcanic field is the most obvious, with several smaller gaps existing between known mineral districts scattered through the map area. The major causes for these deplete areas are probably cultural (bombing ranges, indian reservations) and geologic (post-mineral cover). In contrast, areas anomalously abundant with metals localities show large-scale, pre-mineral, geologic controls. Examples include:

   a. Northeast-trending intrusive-metals belts distributed through the southern Bradshaw Mountains.

   b. Mineralization concentrated around the margins of the large Harcuvar metamorphic core complex.

c. Metals associated with broad zones of prominent WNW-trending faults which break across the study region just to the south and to the north of the Harcuvar MCC.

d. Metal district clustering along the southern Colorado River region which have in common outcrops of well mineralized Mesozoic sedimentary-metamorphic rocks and substantial Tertiary, volcanic-related mineralization.

d. A long, NNW-elongate zone of metallization distributed the length of the Black Range in Mohave County attributable to volcanic-subvolcanic, epithermal, Tertiary mineralization in an upper-plate detachment structural setting.

f. The Cerbat-Wallapai trend of NNW-direction, which appears largely controlled by Laramide intrusive events (porphyry systems) forming a more mesothermal, polymetallic vein character to the belt.

4. A comprehensive District Focus section makes up the bulk of this report and should prove to be its most valuable asset. In a virtual encyclopedia of data for some 78 precious metals districts or areas, considerable geologic detail, past and recent historical information, competitor activity news, assay and production figures and bibliographic data are summarized. The Mines of Interest sections lay out innumerable exploration-acquisition targets that warrant immediate follow-up activity. They may occur within or outside of broader areas of favorability described at the end of the report.

5. The following deposit types have been recognized and are thought most favorable as precious metals exploration targets: (a) detachment fault, (b) lower-plate, microdiorite dike, (c) thrust fault, (d) Mesozoic stratiform, (e) hotspring-volcanic, (f) Vincent-Chocolate Mountain allochthon, (g) Precambrian lode (stratiform-metamorphic). Less favorable, porphyry-related veins and simple vein deposit types are also recognized.

A particular mineral assemblage (earthy and specular hematite, copper silicates and carbonates, calcite, quartz and gold) appears diagnostic for the detached environs of metamorphic core complexes with mylonitic upper plates. Carbonate breccias are commonly represented in the deposit areas. Such provinces as the Harcuvar and neighboring Whipple MCC terranes are characterized by a proliferation of these kinds of mineral occurrences which are not usually found in other detachment localities. We acknowledge the presence of upper plate type detachment terranes (i.e. Black Range) elsewhere, but these appear to be shallow, rather "dry" zones of extensional disruption rather far removed from zones of ductile deformation. They have served as "well prepared," receptacle sites for happenstance hydrothermal events linked to epithermal, subvolcanic processes. At these localities, variable mineral assemblages (even lead, zinc-silver dominant) are commonly present. Mineralization circumscribing or lying above mylonitic zones, on the other hand, is believed more pervasive and with consistent mineralogical character largely because of immense, circulating, metals-bearing fluid fronts derived from sources in the mylonitic lower plate. Mineral deposition/replacement has occurred within middle- and upper-plate positions influenced by rapid, compressed temperature and chemical gradients.

The close spatial association between gold-quartz veins and fairly primitive, basic, microdiorite dikes is noted regionally. This relationship is best exemplified in the Harcuvar metamorphic core complex (lower plate) where the dikes are calc-alkaline, of mid-Tertiary age, and are most abundant.

A totally new emphasis is placed on a complex, poorly understood Mesozoic setting for gold-silver mineralization - one characterized by syngenetic, stratiform controls and thrust faulting. The model is founded on the thesis of acid hotspring activity and exhalite deposition during Jura-Cretaceous sedimentation and volcanism but embodies superimposed processes of metamorphism, plutonism and regional thrusting to redistribute and upgrade initially anomalous gold concentrations. Unusual, stratiform sequences of alumino-silicate alteration and exotic mineral associations (scheelite, kyanite, andalucite, dumortierite, tourmaline) typify some of these Mesozoic occurrences. Precambrian terranes are also found permissive for hosting primary, exhalative concentrations of base and precious metals. This Proterozoic basement has, like the Mesozoic basinal deposit, seen precious metals remobilized and reconcentrated by subsequent magmatic, metamorphic or deformational events.

The Vincent-Chocolate Mountain allochthon model is the "grand" example of the thrust fault-gold association. Its favorability stems from the intrinsically high gold character of the lower plate (Orocopia Schist) coupled with structural preparation along and above the fault zone (perhaps augmented by Tertiary extensional reactivation). Of course, plutonic incursion through this stacked sequence is imperative.

6. Although regional NURE geochemical stream sediment data are not completely available for all desired elements or in all areas, many anomalies of interest exist throughout the study region. Those for gold are most extensive. In addition to affirming the presence of major districts or areas of production, the anomalies illuminate some grass roots localities rather deplete in known mines/prospects which may have been under-prospected.

7. From the regional populations of precious metals, a number of districts and areas have been highlighted as the most favorable "ball parks" in which to focus exploration. Clients will find numerous mines or prospects as specific targets which are described within these broader areas. Target areas are listed below under appropriate deposit models.

1. <u>Detachment fault</u>
   a. Cienega district
   b. Northern Plomosa district
   c. Eastern Harquahala district
   d. Big Eye area-Castle Dome district
   e. Black Range terrane
   f. Gold Basin district
   g. Miscellaneous areas

2. <u>Lower-plate, microdiorite</u>
   a. Cunningham Pass district

3. Thrust fault
   a. Little Harquahala district
   b. Harquahala district
   c. Southern Plomosa district

4. Mesozoic stratiform
   a. Ellsworth district
   b. Dome Rock district
   c. Southern Plomosa district
   d. Gila City district
   e. Silver and Northern Trigo areas
   f. Miscellaneous area

5. Hotsprings-volcanic-related
   a. Resolution (Sheep tanks) mine
   b. Eastern Vulture district - Western White Picacho district
   c. Papago mine (Cimarron Hills)
   d. Castle Creek district
   e. New Water-Alamo Springs-Sheet Tanks region
   f. Big Horn-Osborne districts
   g. Kofa district
   h. Boulder Creek property (McConnico)
   i. Miscellaneous areas

6. Vincent-Chocolate Mtns. allochthon
   a. Eureka (southern Trigo Mtns)
   b. Other areas

7. Precambrian lode-exhalative
   a. White Picacho district
   b. Castle Creek district
   c. Orizaba mine
   d. Black Canyon district
   e. French Gulch district
   f. Eureka-Bagdad area
   g. Webb district
   h. Gold Basin-Lost Basin districts
   i. Pine Grove-Tiger area
   j. Miscellaneous areas

In conclusion, we have left the explorationist with a bountiful assortment of favorable deposit models, target areas and specific locations upon which to focus gold-silver exploration. They have filtered out of a laborious and comprehensive geologic-metallogenic analysis. Some of the site-specific targets are obvious and immediately ready for follow-up. Concepts put forward here and larger areas of favorability will required a systematic, longer-term, grass roots approach before bearing fruit as discrete discoveries.

RECOMMENDATIONS

1. Data from this project should be reviewed and filtered as soon as possible to arrive at a prioritized list of specific targets fitting the objective criteria of each client.

2. Longer term, broader areas of favorability may be suited for second-pass enlargement of geologic-metals map bases (to 1:125,000 or 1: 62,500 scales) to allow for incorporation of greater detail and field-acquired data (geologic and geochemical).

3. Selectivity of the "ball park"-sized areas for further focus should be guided by, among other things, host rocks displaying originally high precious metals character (i.e. Orocopia or Mesozoic meta-sedimentary/volcanic rocks, portions of Yavapai schist terrane), coincident with subsequent, polycyclic intrusion, metamorphism and deformation.

4. For mid to late Tertiary mineralization, gold-silver seem closely aligned with both felsic and mafic (microdiorite) dike-sill bodies in upper- and lower-plate positions. Specific geologic and geochemical research is advised to sort out and add perspective to these magmatic associations.

5. Specific interactions and sequencing between quasi-associated(?) syngenetic, metamorphic, magmatic and thrust aspects of Mesozoic gold are as yet far from resolved. For example, are the gold-related areas of stratiform alumino-silicate rocks products of original, syndepositional, leaching and alteration, or are they related to dynamo-thermal processes of deep-seated thrusting and attendant metamorphism? If truly syngenetic, where in the stratigraphic section do they occur? Is there a direct relationship with Mesozoic volcanism? Volcanic rocks are more common westward into the Mojave province of California. Concerted field and laboratory research should focus on these and related questions. Answers are paramount to effective exploration in this environment.

6. We recommend aerial surveillance of areas targeted for containing hot-springs, epithermal types of deposits. Advanced argillic, pyritic alteration characteristic of these kinds of deposits would be readily identified from the air or from color photos.

7. Because of the smaller size and close-spaced nature to some areas of MCC-related detachment fault gold-copper occurrences (i.e. Cienega, Northern Plomosa districts), we recommend a multi-property acquisition strategy whereby reserves can be cumulated and unitized to one mill-leach processing facility. Even some concentrated vein localities like the Dutch Flat (Mohave Mtn. district) may be amenable to this approach.

8. We recommend watching for outcrops of Orocopia Schist which may exist in poorly mapped terranes adjacent to newly recognized exposures of the schist. The margins of the schist terranes would be especially prone to containing gold-dominant deposits, especially of a grass roots nature.

DESCRIPTION OF TECTONO-STRATIGRAPHIC UNITS

The following section is a full description of the tectono-stratigraphic units which were used in the preparation of the geologic base map (plate 1). This map forms the fundamental base sheet for the series of metals and exploration overlays which accompany the Western Arizona Project report. The Tectono-stratigraphic map is the most comprehensive compilation ever assembled at this scale for Arizona and it probably will remain so for some time to come. A thorough understanding of it will be facilitated by the following unit descriptions and bibliographic references.

PGsy - Yavapai Series

The Yavapai Series in central and northwestern Arizona consists of two groups of volcanic and volcaniclastic rocks totaling more than 40,000 ft (12 Km) in thickness. These two groups, the Ash Creek and Big Bug Groups, constitute a time-stratigraphic sequence in a provincal sense (Anderson and Silver, 1976). Istopic dating of zircons places the depositional period of the Yavapai Series from at least 1,775 + 10 m.y. to 1,820 + m.y. but a more realistic general interval is 1700 to 1850 m.y. (Silver, in Anderson and others, 1971). Rocks of both groups are generally metamorphosed to greenschist facies with preservation of relict depositional textures. Locally, near younger intrusive bodies, or regionally, such as in northwest Arizona, the rocks are metamorphosed to amphibolite grade.

Exposures of Yavapai Series rocks are concentrated in a northwest-trending zone from near Wickenburg on the south, to Bagdad on the north. Rocks of the Yavapai Series make up a large part of the Hieroglyphic, Bradshaw, New River, and Wickenburg Mountains (Plate 1).

The Ash Creek Group is approximately 20,000 ft (6 Km) thick though neither the top, nor the bottom, of the sequence is exposed. Anderson and Creasy (1958) divided the Ash Creek Group into seven formations based upon lithology and stratigraphic position. The lowest exposed section of the Group consists mainly of basaltic and amygdaloidal pillow lavas of che Gaddes Basalt overlain by rhyolitic tuffs and flows of the Buzzard Rhyolite. Three intertounging formations overlie the Buzzard Rhyolite; they are the Burnt Canyon Dacite, Bridal Pup Andesite, and the Shea Basalt. These units are overlain by approximtely 3800 ft (1200 meters) of rhyolite flows, tuffs, and breccias of the Deception Rhyolite. Capping the entire sequence are volcaniclastic cherty-sediments and intercalated dacite flows, domes and breccias that comprise the Grapevine Gulch Formation (Donnelly and Hahn, 1981; Anderson and Silver, 1976) (Figure 1).

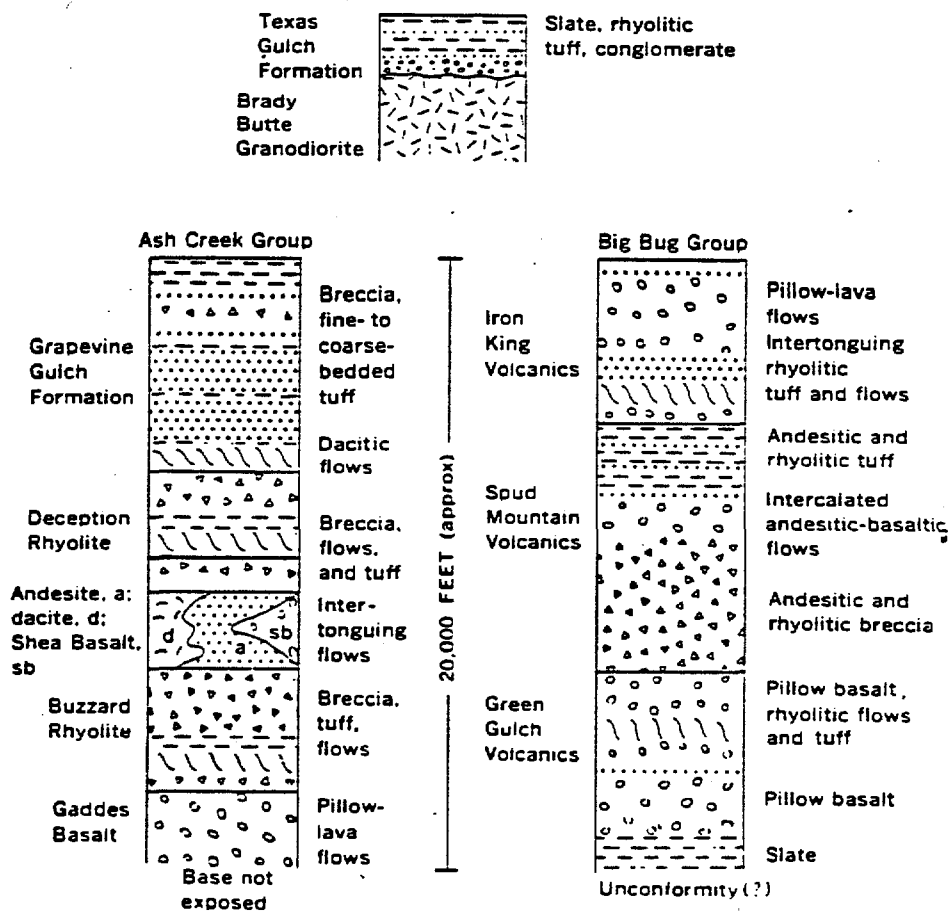


Figure 1. Generalized sections of the Ash Creek and Big Bug Groups and of the Texas Gulch Formation.

(From Anderson and Silver, 1976)

An isotopic age determination on a zircon taken from the Deception Rhyolite near the United Verde massive sulfide deposit yields an age of 1,820 ± 15 m.y. Therefore, the lower part of the Ash Creek Group is at least somewhat older (Anderson and Silver, 1976).

The rocks of the Big Bug Group are generally more deformed than those of the Ash Creek Group, particularly in the area between Prescott and the Shylock fault(?) zone. In that region the rocks are overturned, isoclinally folded and generally well foliated. East of the Shylock zone, rocks of the Big Bug Group are much less foliated and isoclinal folding is not well developed (Anderson and Silver, 1976).

The Big Bug Group, like the Ash Creek Group, is approximately 20,000 ft (6 Km) thick, but is broken into only three formations. The Spud Mountain Volcanics separate the older Green Gulch Volcanics from the younger Iron King Volcanics (Figure 1). The Iron King and Green Gulch Volcanics consist essentially of pillow and amygdaloidal basalts. The Spud Mountain Volcanics consist of a complex, intercalated sequence of andesitic and rhyolitic volcaniclastic horizons, flows, tuffs, and tuffaceous sandstone and siltstone (Donnelly and Hahn, 1981; Anderson and Silver, 1976).

Zircons from rhyolites in the upper part of the Spud Mountain Volcanics and plutons intruding the Big Bug Group yield similar isotopic age dates. A rhyolite flow in the Big Bug Group gave an age of 1,775 ± 10 m.y. (Silver, in Anderson and others, 1971). Two localities in the Brady Butte Granodiorite yielded an isotopic age of 1,770 ± 10 m.y. (Silver, in Anderson and others, 1971). The overlap of ages between the volcanics and intrusive rocks indicates the close temporal association of volcanism and plutonism during that time (Anderson and Silver, 1976; Donnelly and Hahn, 1981).

Donnelly and Hahn (1981) have reconstructed the volcanic stratigraphy of both the Ash Creek and Big Bug Groups. They believe that the Ash Creek Group represents a single mafic to felsic volcanic cycle, while the Big Bug Group comprises at least two such cycles. Both cycles clearly show a calk-alkaline differentiation trend and reflect a bimodal or basalt/andesite to rhyolite assemblage. The exact nature of the tectonic environment under which the Yavapai Series was deposited and subsequently metamorphosed is uncertain as is the case with most Precambrian "greenstone" belts. Despite uncertainties many workers believe that volcano-stratigraphic successions that comprise the Yavapai Series are an ancient analog to modern island arc terranes (Anderson, 1978; Anderson and Guilbert, 1979; Stensund and More, 1980). What does seem to be certain, is that the entire cycle of deposition, plutonism and metamorphism of the Yavapai Series lasted from pre-1,820 ± 15 m.y. to about 1,720 ± 15 m.y. (Anderson and Silver, 1976).

Where possible, Donnally and Hahn (1981) separated various lithologic phases of the Yavapai from one another; we have followed this convention. PGsy designated with the subscript "e" is a group of undifferentiated coarse-to-fine-grained epiclastic sediments and exhalite deposits. Those Yavapai outcrops denoted with a "v" are undifferentiated subaqueous and subaerial felsic lavas and tuffs including associated hypabyssal intrusive rocks. Units designated with an "m" include mafic to intermediate tuffs and lavas (cf. Donnelly and Hahn, 1981).

PGsp - Precambrian Pinal Schist

The Precambrian Pinal Schist is made up of fine- to medium-grained, brownish-gray-green, highly contorted, biotite and muscovite quartzofeldspathic schist, quartz-mica schist, and amphibolite that crops out in the extreme eastern parts of the study area generally east of a line south from Wickenburg. The best exposures of the Pinal Schist are located in the Vulture, Big Horn, and Vekol Mountains of southwestern and west-central Arizona (Plate 1). In these areas, outcrops are often strongly foliated with foliation coincident with primary layering. A penetrative, streaky mineral lineation is found in the plane of foliation in southwestern Arizona, but generally, it is weakly developed in other areas. Locally, well-developed fracture cleavage cuts layering at a high-angle (Briskey and others, 1978).

The Pinal Schist is thought to have some volcanic and volcaniclastic protoliths. Sediments appear to dominate the section, but andesite, dacite, rhyodacite porphyries and rhyolites do make up parts of the sequence in some areas (Silver, 1978). Silver (1978; 1963) believes that his studies of pre-deformational volcaniclastic sediments and intrusive rhyodacite sheets place Pinal deposition at between 1680 and 1700 m.y. ago with deformation/metamorphism ending at about 1625 m.y. B.P.

Thickness of the Pinal Schist varies, but it can be as thick as 20,000 ft (6 km) (Silver, 1978). The nature of the depositional environment in which the Pinal accumulated is not well known. Silver (1978) believes that a large part of the sequence is the product of turbidite deposition; Condie (1982), believes that at least part of the section reflects shallow marine and fluvial deposition. The metavolcanic rocks in the sequence indicate volcanic sources nearby.

PGm - Precambrian Metamorphic Rocks, Undifferentiated

Several varieties of Precambrian metamorphic rocks, excluding most schistose rocks, are found in western Arizona. The majority of these rocks crop out in the eastern and northern parts of the study area particularly in the Hualapai, Harcuvar, Harquahala, Cerbat, Black Mountains, and along the southwestern margin of the Colorado Plateau. Few Precambrian rocks are found in the southern and western parts of the study area where they presumably exist but are undated or are covered by younger rocks. (Plate 1).

The high-grade metamorphic rocks consist mainly of quartzofeldspathic gneiss, amphibolite, mica schist and minor quartzite. Foliation in these rocks is generally steeply dipping and strikes mainly north-northeast. These rocks are often intruded by sills, dikes, and lenses of Precambrian granitic to dioritic rocks (Reynolds, 1980).

In the metamorphic core complex terranes of western Arizona (Harquahala, Harcuvar, and Buckskin Mountains) rocks of a presumed Precambrian age have been overprinted by late Mesozoic deformation and a mid-Tertiary mylonitic fabric whose foliation defines east-northeast-trending arches (Rehrig and Reynolds, 1980). Rocks which we have mapped as Precambrian in the Harcuvar and east part of the southern Buckskin ranges are generally composed of biotite rich, quartzofeldspathic gneiss and schist, migmatite, and amphibolite that display a low-dipping mylonitic foliation and a smeared, cataclastic mineral lineation that trends dominately northeast. Within the Harcuvar core complex, it is extremely difficult to sort out Precambrian protoliths from amphibolite-grade, Mesozoic(?) paragneisses which are

thought to exist through much of the eastern Buckskin ranges (See Mesozoic Metamorphic Rocks section).

Rocks, therefore, labeled PЄm on Plate 1 may consist of any number of metamorphic rock types, but are dominated by quartzofeldspathic gneisses. In and around metamorphic core complexes, the rocks are overprinted by Tertiary or late Mesozoic deformation that imparts to the rocks a low-dipping foliation and a low-plunging mineral lineation.

In summary, our PЄm unit may in fact represent Yavapai-like rocks; but they have suffered greater structural and metamorphic overprints than normal Yavapai Series rocks.

PЄs - Precambrian Schistose Rocks, Undifferentiated

This generic term is used to designate those schistose rocks, of probable Precambrian age, that are not known to be correlative to either the Yavapai Series or the Pinal Schist, or those sequences with too little information available to assign them to specific stratigraphic sequences. This unit may contain a variety of schistose rocks derived from many protoliths, and can be found throughout the study area. The majority of these rocks are concentrated in the northern and southern parts of the study region.

PЄd - Precambrian Gabbro and Diorite

Gabbro and related rocks, anorthosite, diorite and diabase are found near Bagdad as small irregular masses that intrude a variety of rocks. The gabbro is dark, fine- to coarse-grained, and composed of hornblende, augite, plagioclase and quartz. The diorites are granular, hypidiomorphic rocks composed of quartz, plagioclase, biotite, and hornblende. Locally some of the rocks have a gneissic texture (Anderson, Scholgi, and Strobell, 1955). These rocks are probably of a similar age to those quartz diorite plutons that form the roots of the Yavapai Series volcanic terrains.

PЄg, PЄgo - Precambrian Granite and Oracle Granite

A large part of the study area is underlain by Precambrian granitic to granodioritic plutons (PЄg). These rocks crop out mainly in the northern and northeastern parts of the region while a younger porphyritic quartz monzonite suite, Oracle Granite (PЄgo), crops out over a large portion of southern and southeastern Arizona (Plate 1), (Peterson, 1938; Silver and others, 1977).

The granitic to granodioritic plutons (PЄg) of the northern half of the study area are thought to be the older of the two Precambrian granitic suites. These rocks constitute large parts of the Aquarius, Date Creek, Arrastra, and Hualapai Mountains (Plate 1); the plutons also make up a large part of the Precambrian terraine of the "Transition Zone" northeast of Wickenburg. These rocks often intrude the Yavapai Series and have been dated at 1760 $\pm$ 10 m.y.B.P. (Anderson and Silver, 1976). This age places them nearly contemperaneous with Yavapai Series volcanism, probably making them roots of this Proterozoic volcanic belt.

These precambrian granitic plutons (PGg) contain a variety of facies but are dominated by granular, hypidiomorphic, locally gneissic diorites and quartz diorites. The rocks are composed essentially of quartz, plagioclase, biotite, and hornblende. The more gneissic facies generally have a medium-grained texture and foliated structure composed of quartz, lagioclase, orthoclase, biotite, and sphene (Anderson and others, 1955).

Peterson (1938) coined the term Oracle Granite (PGgo) for pinkish, coarse-grained, porphyritic quartz monzonite found near Mammoth, Arizona. Silver and others (1977) later included the Oracle Granite as part of a large suite of quartz monzonitic plutons that perforated the North American continent about 1.4-1.5 b.y. ago. Because of the distinct age differences and compositions, the two Precambrian granitic suites have been mapped separately on Plate 1. In the study area, Oracle Granite outcrops over large parts of the White Tank, Sierra Estrella, Maricopa, Spring, and Vekol Mountains, and Buckeye Hills (Plate 1). It is also found as a deformed phase in the Harquahala and Little Harquahala Mountains.

Typical Oracle Granite of the study area is a coarse-grained porphyritic quartz monzonite. It is characterized by tabular potassium feldspar phenocrysts (up to 3 cm) in a coarse groundmass of orthoclase, plagioclase, quartz, biotite, and muscovite. The Oracle Granite is generally only locally or weakly foliated except in areas overprinted by Mesozoic or Tertiary deformation.

PGag - Precambrian (Upper Proterozoic) Apache Group

Strata of the Upper Proterozoic Apache Group consist of three diverse rock types, which reflect varying tectonic conditions. The basal unit of the Apache Group is the Scanlon Conglomerate, a coarse debris-flow deposit that is composed of a red-brown, clast supported boulder and pebble conglomerate that grades laterally into coarse-grained, braided stream deposits. Upward, the Scanlon Conglomerate grades into reddish-pink, fine-grained, alternating sequences of volcaniclastic mudstone and sandstone of the Pioneer Formation. The Pioneer Formation reflects a decrease in stream competence and increased basin stability. The Pioneer is succeeded upward by the Dripping Spring Quartzite, a nearshore marine and coastal plain deposit reflecting stable basin conditions. The Dripping Spring Quartzite consists of well sorted, cross-stratified, quartz arenite with interbedded mudstone and siltstone. Overlying the Dripping Spring Quartzite and capping the Apache Group is the Mescal Limestone; the Mescal is a mixed siliciclastic-carbonate representing nearshore to open-marine deposits that consist of interbedded light blue-gray, micritic to coarsely crystalline, algal limestone and fine-grained, sandy limestone and limey sandstone.

Middleton and Blakey (1984) believe that the Apache Group reflects the evolution of a tectonic depositional basin from inception to stability. The Apache Group, though prevalent throughout most of central and southeastern Arizona, is only found in the extreme southeastern part of the study area, in the Vekol Mountains (Plate 1).

Paleozoic Sedimentary Rocks - General Statement

Exposures of Paleozoic sedimentary rocks are not extensive but occur scattered throughout western Arizona becoming more numerous in southern Nevada and

northwestern Arizona. Paleozoic strata of the study area represent shallow shelf to continental depositonal systems. These rocks consist of interbedded limestone, sandstone/quartzite, dolomite, shale and siltstone that locally may be metamorphosed to various degrees (Hardy, 1984).

In west-central Arizona the best exposures of Paleozoic rocks are found in the Little Harquahala, Harquahala, and Plomosa Mountains (Plate 1). Depending upon the mountain range and geologist, these rocks have been correlated to either the Grand Canyon-Colorado Plateau section, or to the southeast Arizona Paleozoic section (Reynolds, 1980). Perhaps a more realistic interpretation of the Paleozoic strata in west-central Arizona is that the lower Paleozoic (Psl) section is correlative to the southeastern Arizona section, while the upper Paleozoic (Psu - Mississippian and younger) more closely resembles the Grand Canyon-Colorado Plateau sections (Miller, 1970; Shackelford, 1976; Varga, 1977; Richard, 1983; Hardy, 1984). For west-central Arizona, this convention will be followed.

Paleozoic strata along the southern edge of the Colorado Plateau, northeast of Kingman, and in the Las Vegas-Lake Mead region have no such discrepencies between their lower and upper sections. The entire Paleozoic section correlates closely with the classic Colorado Plateau section. However, in order to keep lithotectonic unit nomenclature consistent, the lower Paleozoic is separated from the upper Paleozoic here as elsewhere. Note that the Psl designation does not necessarily imply rigid rock stratigraphic equivalence between the central and northern parts of Plate 1, only rough time-stratigraphic equivalence (i.e., Cambrian to Devonian in age).

Lower Paleozoic strata of northwestern Arizona and southern Nevada consists of a sequence similar to that in west-central Arizona. The basal unit consists of pale yellow to reddish quartz sandstone and interbedded sandy siltstone of the Cambrian Tapeats Sandstone. The Tapeats may be as much as 50 meters thick, but is typically 20-40 meters in thickness. The Tapeats is overlain by the Bright Angel Shale, an interbedded sequence of sandy shale, sandstone and dolomite. It typically has thicknesses of 100-150 meters. The Muav Limestone overlies the Bright Angel Shale; near Las Vegas, the Muav is correlatable to the lower part of the Bonanza King Formation. The Muav Limestone and Bonanza King Formation are comprised of limestones and dolomites; the sequence may be up to 200 meters thick. The Muav Limestone is in turn overlain by up to 330 meters of undifferentiated strata thought to be Cambrian in age. This unit is a thick sequence of interbedded limestone, dolomite, shale and calcareous sandstone. Capping the lower Paleozoic section in northwestern Arizona is the Devonian Temple Butte Limestone which is roughly equivalent to the Martin Formation to the east and south (?) and to the Sultan Limestone to the west in Nevada. The Temple Butte Limestone attains thicknesses 140-150 meters in places.

Maximum thickness of the Cambrian through Devonian strata in the northwestern part of the study area is close to 900 meters. These thicknesses increse to the west near Las Vegas as the depositional environment changes from the shelf to the Cordilleran miogeocline.

Psl - Lower Paleozoic Sedimentary Rocks (Cambrian-Devonian)

In west-central Arizona the basal Paleozoic sedimentary unit consists of the white, brown, or maroon quartzite of the Cambrian Bolsa Quartzite. The Bolsa has a maximum thickness of 100 meters but is generally much less. The Bolsa is overlain by a sequence of interbedded calcareous sandy shale and fine-grained quartzite. This unit has been correlated with the Abrigo Formation. It may be up to 50 meters thick but commonly may be tectonically thinned to several meters or less. The Devonian Martin Formation, a sequence of dolomitic limestone and dolomite, overlies the Abrigo. This unit is always less than 100 meters thick, but averages 20-30 meters thick (Richard, 1983; Hardy, 1984). Maximum thickness of the lower Paleozoic strata in west-central Arizona is about 250 meters. It is commonly much less due to structural and tectonic thinning.

Lower Paleozoic strata of northwestern Arizona and southern Nevada consist of a sequence similar to that in west-central Arizona. The basal unit is a pale yellow to reddish, quartz sandstone and interbedded, sandy siltstone of the Cambrian Tapeats Sandstone. The Tapeats may be as much as 50 meters thick, but is typically 20-40 meters in thickness. The Tapeats is overlain by the Bright Angel Shale, an interbedded sequence of sandy shale, sandstone and dolomite. It typically has thicknesses of 100-150 meters. The Muav Limestone overlies the Bright Angel Shale. Near Las Vegas, the Muav is correlatable to the lower part of the Bonanza King Formation. The Muav limestone and Bonanza King Formation are made up of limestones and dolomites; the sequence may be up to 200 meters thick. The Muav Limestone is in turn overlain by up to 330 meters of undifferentiated strata thought to be Cambrian in age. This sequence is made up of interbedded limestone, dolomite, shale and calcareous sandstone. Capping the lower Paleozoic section in northwestern Arizona is the Devonian Temple Butte Limestone which is roughly equivalent to the Martin Formation to the east and south (?) and to the Sultan Limestone to the west in Nevada. The Temple Butte Limestone attains thicknesses of 140-150 meters in places.

Cumulative thickness of the Cambrian through Devonian strata in the northwestern part of the study area is close to 900 meters. These thicknesses increase to the west near Las Vegas as the depositional environment changes from shelf to the Cordilleran miogeocline.

Psu - Upper Paleozoic Sedimentary Rocks (Mississippian-Permian)

Stratigraphic units representing the Upper Paleozoic sedimentary rock designation (Psu) are essentially the same in both northwestern and west-central Arizona. The Mississippian Redwall Limestone is the lowermost rock unit in this sequence. In western Arizona the Redwall is composed of 115-125 meters of homogeneous, medium to massive bedded limestone and dolomite which is light-gray to reddish-pink in color (Hardy, 1984). The Redwall Limestone in northwestern Arizona generally consists of 165-185 meters of olive-gray to red-brown and yellow-brown, massive, fine- to coarse-grained, medium to finely bedded, limestone and dolomite (McKee and Gutschick, 1969).

The Redwall Limestone in west-central Arizona is overlain by the Pennsylvanian-Permian Supai Formation, while in the northwest it is overlain by the Supai and

its equivalents - the Callville and Pakoon Limestones and the Esplanade Sandstone. The latter three are to be found near Las Vegas. Rocks correlated with the Supai in west-central Arizona consist of white, pink and maroon sandstones with intercalated limestones and mudstones. Thicknesses range from 165 to approximately 200 meters (Richard, 1983; Hardy, 1984). The Supai and its equivalents in northwestern Arizona consist of interbedded calcareous sandstone, mudstone, limestone, and conglomerate. Thicknesses vary but are generally between 300 and 400 meters.

The Permian Coconino Sandstone, famous for its large tubular-planer cross-stratification, overlies the Supai Formation in west-central Arizona. The Coconino is a homogeneous, thin-bedded, fine-grained, vitreous quartz arenite. Coconino thickness is nearly a constant 200 meters throughout the region (Miller, 1970; Richard, 1983). The Supai is overlain by the Pennsylvania-Permian Hermit Shale in the northern part of the study area. The Hermit is a thick (300 + m) sequence of red siltstone and calcareous sandstone that is in turn overlain by a relatively thin sequence of Coconino Sandstone. The Coconino can be up to 120 meters thick, as in the Grand Canyon, or as thin as 12 meters on Wheeler Ridge near the eastern edge of Lake Mead (Plate 1). The Coconino is everywhere composed of white to pink, well sorted, cross-stratified, massive quartz arenite.

Between 200 and 335 meters of varicolored limestones of the Permian Kaibab and Toroweap Limestones overlie the quartzites of the Coconino in west-central Arizona (Miller, 1970; Richard, 1983). Typically, the units are light tan to blue gray in color with numerous chert masses and fossils enclosed in a fine-grained, massive, medium bedded, dolomite and limestone (Hardy, 1984). To the north, the Kaibab and Toroweap consist of between 150 and 200 meters of massive white, yellow, medium bedded, banded, fossiliferous sandy, cherty limestone.

Ps - Paleozoic Sedimentary Rocks, Undivided

This designation is used for those expsoures where structural and/or stratigraphic complexities do not allow break out of lower or upper units at the scale of Plate 1. The unit is also used for those exposures that cannot be placed in the more specific units due to limited information. The majority of rocks mapped as Ps on Plate 1 contain both upper Paleozoic (Psu) and lower Paleozoic (Psl) sedimentary rocks juxtaposed in complex fashion by faulting.

PMs - Paleozoic/Mesozoic Sedimentary Rocks, Undifferentiated

This unit designation is used solely in those locations where structural and/or stratigraphic complexities do not allow Paleozoic and Mesozoic rocks to be separated from one another at the scale of Plate 1. This unit is used only rarely and is not meant to imply that the rocks so designated are of an unknown character; rather, this unit may contain Mesozoic sedimentary rocks (Ms) and either lower Paleozoic (Psl) or upper Paleozoic (Psu) sedimentary rocks.

Mesozoic Sedimentary Rocks - General Statement

Exposures of Mesozoic sedimentary rocks are found throughout the study area. The Mesozoic strata can be conveniently grouped into northern and southern assemblages

based upon their dissimilar stratigraphy and presumed depositional environments. The boundary between the two assemblages is approximately the southern edge of Lake Mead (Plate 1).

The northern assemblage consists of those Mesozoic rocks of the Las Vegas-Lake Mead region. These strata are essentially of Colorado Plateau and Great Basin affinities with well-defined North American correlations and cratonal-miogeoclinal facies. The southern asemblage, west-central and southwestern Arizona, consists of strata that are lithologically dissimilar from the northern assemblage and represent distinct, but yet poorly understood, depositional environments. Deposition may have been into tectonically active, laterally discontinuous basins (Richard, 1983), possibly as a result of rifting.

Recent work (Harding and others, 1983) has suggested that there is perhaps some time-stratigraphic correlability between the two assemblages, but this by no means implies rock-stratigraphic correlation; much work needs to be done before any stratigraphic correlations between the northern and southern asemblages can be made. In all probability, no realistic correlations are feasible.

Southern Assemblage

Ms - Mesozoic Sedimentary Rocks

A thick sequence of interbedded arkosic sandstone, graywacke, conglomerate, siltstone, quartzite, shale, and minor limestone define the Meoszoic sedimentary sequence in west-central and southwestern Arizona. The sequence is best exposed in the Granite Wash, Little Harquahala, Plomosa, Dome Rock and Harquahala Mountains and has been studied by Miller (1970), Crowl (1979), Marshak (1979), Robison (1978), Harding (1978), Richard (1983), and Hardy (1984). On Plate 1, the rocks along the western flank of the southern Plomosa Mountains are designated as Ms, but in this area are mainly volcanic (Miller, 1970). In other areas, Ms also includes variable proportions of volcanic constituents.

Recent work by Harding (1982) and Harding and others (1983) has correlated the majority of the Mesozoic section in the Plomosa, New Water Mountains and Livingston Hills to the 7.3 km thick McCoy Mountains Formation in the Mojave desert. The McCoy Mountains Formation consists of an interally coherent stratigraphy of sandstone, conglomerate, siltstone, and mudstone. Paleocurrent indicators show southward directed transport in a fluvial environment suggested by cross-strata, ripple marks, channels, fining upward sequences, and fossil wood (Harding, 1982; Harding and others, 1983). Paleomagnetic data suggest that the sequence was mildly metamorphosed during the Jurassic; thus, deposition was somewhat earlier than that time, but later than underlying Jurassic felsic volcanics.

The McCoy Mountains Formation appears to have occupied a unique tectonic environment during the Jurassic in that its apparent depositional basin is now bounded by large scale thrust faults or suture zones (Figure 2). Harding and others (1983) take this present structural configuration to indicate that the McCoy Mountains Formation and underlying Jurassic volcanics were deposited next to, and then deformed between, the North American craton and an outlying allocthonous terrane during the Jurassic.

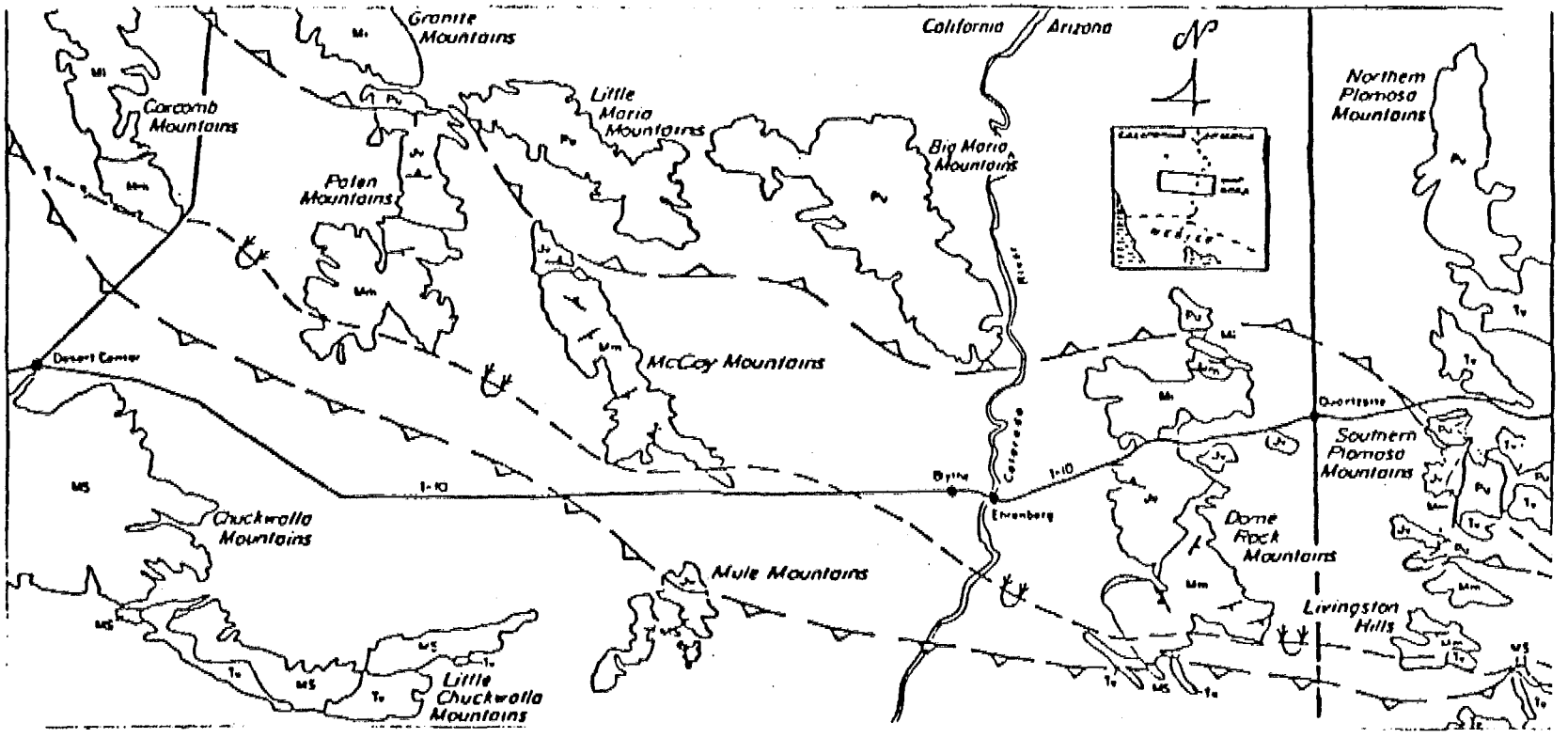


Fig. 2. Tectonic setting of the McCoy Mountains Formation in southwestern California and southwestern Arizona. Map legend: *Tv* = Tertiary volcanic rocks; *Mi* = Mesozoic intrusive rocks, *Mm* = McCoy Mountains Formation, *Jv* = Jurassic volcanic rocks, *Pu* = Precambrian, Paleozoic, and Mesozoic rocks of North America, *MS* = Mojave-Sonora composite terrane.

(From Harding and others, 1983)

The coarsely detrital and conglomeritic Mesozoic rocks of southwest Arizona are perhaps best characterized by their heterogeneity (interstratial and clast content), poor sorting, "dirty" character, association with volcanism and inferred sedimentational environment of active tectonism. As discussed by Harding (1978) and Marshak (1979), correlatable sections are not known and the rocks are devoid of fossils. As exemplified by the Livingston Hills and Apache Wash sections (Harding, 1982), gross sequences of conglomerate, graywacke or siltstone are recognized yet extreme interstratal variations occur within the units. Abrupt lithology changes from red-brown, matrix-supported boulder conglomerate with clasts from several centimeters to several meters in diameter, to dark gray, thin-bedded, graywacke and siltstone occur numerous times through short intervals (i.e., <30 m). In the Granite Wash Mountains, cyclic, alternations from dirty, arkosic sandstone to siltstone-shale forms a section of at least 1000 m thick. These rocks are interstratified with Jurassic volcanic rocks at the northwest end of this range.

Thick sections of coarse-grained sandstone and quartzite occur in the Dome Rock Mountains and the hills to the south of the Little Harquahala Mountains (just north of Interstate 10). Commonly these clastic rocks carry orange-brown calcite rhoms or iron oxide pseudomorphs after pyrite crystals up to a centimeter or two in size.

Of special interest as hosting mineralization, are unusual stratigraphic intervals of highly aluminous or carbonate-rich character which appear interbedded with thick graywacke sections. As these intervals have been observed in metamorphosed sections, the exact nature of the protoliths, whether sedimentary or volcanic, is somewhat conjectural. Their outcrop distribution is included under Mm, Mesozoic metamorphic rocks.

The correlation of Arizona Mesozoic(?) sedimentary rocks with stratigraphically similar McCoy Mountains Formation is problematical; but overall, is probably valid. For the most part, formal nomenclature is lacking for Mesozoic(?) sequences outside of the McCoy Mountains Formation. In addition, age is mainly assumed from stratigraphic position and relationships to late Cretaceous deformation (Richard, 1983; Hardy, 1984). This is especially true in the Little Harquahala, Harquahala, and Granite Wash Mountains where a sequence of arkosic sandstones, conglomerates and shale overlies Paleozoic sedimentary rocks and are deformed by late Cretaceous deformation (Richard, 1983; Hardy, 1984). It is not known specifically how these strata correlate to other Mesozoic(?) sections in the region, or to the McCoy Mountain section. Permissible age brackets for any of these sediment packages extend from the Triassic to middle Cretaceous. Thicknesses of these isolated sections vary but generally where well exposed and not severely faulted, many hundred meters thick (Richard, 1983).

A very similar sequence of Mesozoic(?) arkosic sandstone, conglomerate and graywacke is found in southern Arizona (Briskey and others, 1978). These rocks are best exposed in the Sheridan Mountains of the Papago Indian Reservation. The majority of these rocks display a moderate degree of metamorphism and are, therefore, discussed in the section on Mesozoic metamorphic rocks.

Northern Assemblage

Js, Trs - Jurassic Aztec Sandstone; Triassic Moenave, Chinle, and Moenkopi Formations.

The four units that make up the northern Mesozoic sedimentary section represent a complex sequence of continental, fluviatile and shallow, nearshore marine to subaerial deposition. The Jurassic Aztec Sandstone (Js) is a red to buff colored, well-sorted, moderately well-indurated, quartz arenite with distinctive, large scale, tabular-planar, cross-stratification (Marzolf, 1982). The upper Triassic Moenave and Chinle Formations along with the middle to lower Triassic Moenkopi Formation are grouped into the Trs designation. The Moenave and Chinle Formations are a sequence of red, fluviatile, gypsiferous sandstone, siltstone, and conglomerate. The Moenkopi Formation represents a nearshore marine to subaerial-marine sequence of limestone, sandstone, siltstone and gypsum.

Ks - Cretaceous Conglomerate

Red-brown, matrix supported, boulder conglomerate and fanglomerate, red arkosic sandstone, volcanic breccia, quartzite, and volcanic andesite and rhyolite flows are found in the Vekol Mountains of the Papago reservation in southwestern Arizona. As mapped on Plate 1, the unit includes the Vekol Formation, Chiapuk Rhyolite, and the Phonodoree Formation (Heindl, 1965; Dockter and Keith, 1978). Datable Cretaceous sedimentary rocks are not known elsewhere in the study region. It may be that the McCoy Mountains and Livingston Hills-like rocks in western Arizona become as young as mid-Cretaceous age, but this has not been firmly ascertained.

Jv, Mi, Ji - Mesozoic Volcanic and Granitic Rocks

Exposed in the western half of the study area is a heterogeneous assemblage of intermediate to silicic, volcanic and plutonic rocks of probable Mesozoic age (Miller, 1970; Shackelford, 1975; Crowl, 1979; Marshak, 1979; Reynolds, 1980; Rehrig and Reynolds, 1980; Richard, 1983). On Plate 1 this assemblage is broken into three units dependant upon age: Jurassic volcanic rocks (Jv), Mesozoic intrusive rocks (Mi), and the more precisely dated Jurassic intrusive rocks (Ji).

The volcanics (Jv) are best exposed in the Dome Rock, Plomosa, and Little Harquahala Mountains (Plate 1). Locally, Jurassic volcanic rocks comprise a fair amount of Mesozoic sedimentary sections (Ms), such as in the Granite Wash and southern Plomosa Mountains. The Jv designation is only broken out where volcanics make up practically all of the sequence. Jurassic volcanic rocks range from dacitic and quartz latitic to rhyolitic compositions and include ash-flow tuffs, flows, and coarse breccias. The volcanics are often interbedded with volcaniclastic rocks and mudstone. The volcanic sequences may be as much as 5 km thick, but unmapped thrusting may have thickened the section (Crowl, 1979). The volcanic sequence in the Dome Rock Mountains has yielded a late Triassic-early Jurassic U-Pb age date and a 176 m.y. K-Ar age (Silver, as reported by Crowl, 1979). It should be noted that variable degrees of metamorphism and cleavage foliation have affected the volcanic rocks in some areas.

Granitic plutons (Mi, Ji) are exposed in several locations in southern Arizona, such as the Dome Rock Kofa, Plomosa, Little Harquahala and Comobabi Mountains and the Kupk Hills (Plate 1). These plutons may represent magmas that are roughly synchronous with the volcanic rocks that they locally intrude (Reynolds, 1980). Haxel and others (1980) have dated much of the Mesozoic plutonic activity on the Papago Indian Reservation as Jurassic. It is assumed, but not strictly known, that the Mesozoic plutonic rocks in west-central Arizona are of a similar age. Recent U.S. Geological Survey mapping in the Kofa Mountains region shows many Jurassic plutons. In the northern Kofa and Eagle Tail Mountains, reconnaissance mapping by Rehrig indicates K-spar rich, megacrystic, quartz monzonite to granitic bodies intrude Mesozoic-like clastic rocks. Contacts are characteristically diffuse through a broad zone of metasomatism in the sedimentary hostrocks where detrital textures appear granitized. Where plutonic rocks are known to be Jurassic in age, they are designated as Ji on Plate 1; otherwise, where age dates are inconclusive or are not known, the rocks are designated Mi.

For the most part Mesozoic plutonic rocks consist of relatively quartz-rich, alkali-feldspar granite to granodiorite. Locally, synenitic and dioritic phases occur, particularly in the southern parts of the study area (Haxel and others, 1980). A particular common porphyritic granite, megacrystic in Kspar, occurs in many regions. This rock closely resembles the 1.4 b.y. Oracle or Ruin granite, but age dates in the 160 $\pm$ 10 m.y. range have been found (unpublished data, Silver; Rehrig). Examples occur in the Buckskin, Granite Wash, Little Harquahala, Eagle Tail and Kofa Mountain areas.

Mm - Mesozoic Metamorphic Rocks

A large part of the Mesozoic sedimentary and volcanic rocks in west-central and southwestern Arizona have been at least partially metamorphosed. Those rocks that have been more strongly metamorphosed we have elected to place in a separate category, herein designated Mm (Mesozoic metamorphic rocks). The majority of these rocks are located in the Buckskin, Harcuvar, Granite Wash, Castle Dome, Dome Rock and Trigo Mountains in west-central Arizona and the Agua Dulce and Cabeza Prieta Mountains in southwestern Arizona (Plate 1).

The unit may be composed of a variety of rock types but is dominated by lithologies of quartzofeldspathic schist and gneiss, metavolcanic rocks, staurolite-cordierite schist, epidote-quartz schist, calc-silicate paraschist, granofels, metaconglomerate, and quartzite (Crowl, 1979; Haxel and others, 1984; Hardy, 1984). Metamorphic grade varies widely from place to place and locally even within the same sequence (Hardy, 1984). An example of this variation occurs along the western margin of the Harcuvar metamorphic core complex in La Paz County (Plate 1). In the Granite Wash and Buckskin Mountains, Mesozoic sedimentary rocks become progessively metamorphosed eastward through an interval of 2-3 miles approaching the Hercules thrust (Rehrig and Reynolds, 1980). These transitions toward the core of the Harcuvar metamorphic core complex suggest that the protolith or "lower-plate" original lithology for parts of the complex in the Buckskin Mountains may be metasedimentary in origin and of possible Mesozoic age (Rehrig and Reynolds, 1980). This might also apply to lower-plate mylonitic gneiss in the Rawhide Mountains, and perhaps at the west end of the Harcuvar Mountains

(Plate 1). The fairly common occurrences of tectonized marble interlayered with quartzofeldspathic mylonitic gneisses in the lower plate of the Rawhide Mountains (Shakelford, 1976) and the Buckskins (Rehrig, unpubl. field notes) reinforces this possibility. Local variation in metamorphic grade may be due to differing protolith reactivity. Larger scale variance may be a function of tectonically juxtaposed slices of variably metamorphosed Mesozoic terranes along Cretaceous-early Tertiary thrust faults (Hardy, 1984), or to the position of Mesozoic plutons.

Certain lithologic intervals within the Mesozoic metasedimentary sections appear to host syngenetic or metamorphic mineralization. Commonly the host strata are quartz muscovite schists which bear disseminated sulfides (pyrite and chalcopyrite). Exotic minerals such as kyanite, dumortierite, andalucite and tourmaline are found associated with these potash and alumina enriched horizons. They are the focus of considerable discussion in the later parts of this report and should be of interest to precious metals exploration.

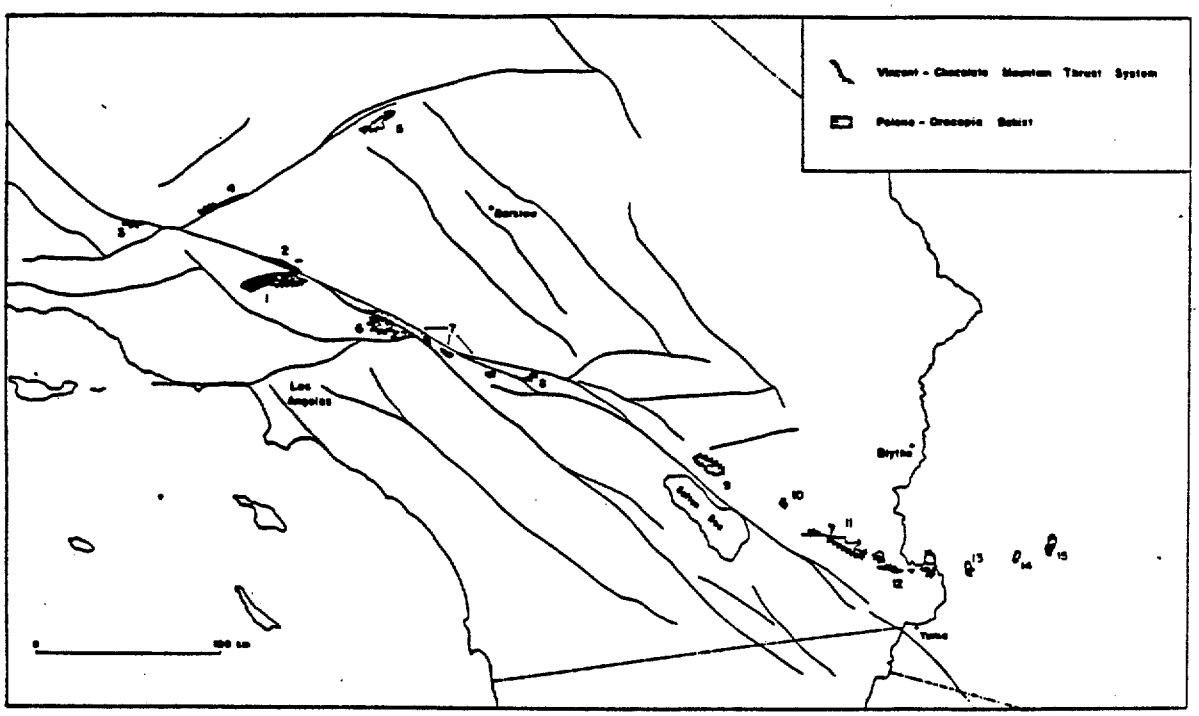
The age of metamorphism appears to be constrained to middle and late Mesozoic time. In the Granite Wash Mountains, the 85 m.y. Tank Pass pluton cuts across metamorphic isograds (Rehrig and Reynolds, 1980). Harding and others (1983) report a Jurassic age for deformation and mild metamorphism of the Jurassic McCoy Mountains Formation. Haxel and others (1984), Haxel and Dillon (1978), and Haxel and others (preprint) propose that metamorphism occurred during the Late Cretaceous in southern Arizona. These models propose that overthrusts of crystalline rocks resulted in an overthickened crust; this overthickened crust along with crustal heat flux from the mantle together created a thermal regime that resulted in regional metamorphism of rocks beneath a regional allochthon (Haxel and others, 1984). U-Pb and K-Ar age dating indicates that this deformation and metamorphism took place about 60 to 80 m.y. ago (Haxel and others, 1984; Hardy, 1984).

JKs - Orocopia Schist

The Orocopia Schist is part of a regionally extensive package of metamorphic rocks (Pelona-Rand-Orocopia Schists) of lower-greenschist to lower-amphibolite facies with a probable Cretaceous/Paleocene metamorphic age. The Orocopia Schist forms a discontinuous belt, exposed through structural windows, east of the San Andreas Fault in California, that extends southwestward into Arizona through the southern Trigo, Castle Dome and Middle Mountains and as far east as Neversweat Ridge in central Yuma County (Plate 1, Figure 3) (Haxel and Dillon, 1978).

Haxel and Dillon (1978) describe the Orocopia Schist as a 3500 meters thick body of schistose rocks whose chief characteristics are a uniform textural and outcrop character; a medium to dark gray colored, flaggy, quartzofeldspathic schist and interlayered biotite schist with little, if any, compositional banding. Fuchsitic carbonate horizons have been noted in the Mojave terrain, some of which contain sulfides (Dillon, 1975; Hulin, 1925; Haxel, 1977). The base of the Orocopia Schist is nowhere exposed thus, 3500 meters must be considered a minimum thickness.

Protoliths of the Orocopia are thought to be predominately arkosic sandstone (graywacke), siltstone and claystone with lesser amounts of basanite(?),



Number	Location	Name of schist
1	Sierra Pelona(*)	Pelona
2	Portal and Ritter Ridges, Quartz Hill	Pelona
3	Mount Pinos, Mount Abel	Pelona
4	Tehachapi Mountains	Pelona
5	Rand Mountains(*)	Rand
6	Eastern San Gabriel Mountains (southeast of San Jacinto fault)	Pelona
7	Blue Ridge to Crafton Hills (between San Jacinto and San Andreas faults)	Pelona
8	North side of San Gorgonio Pass	Pelona
9	Orocopia Mountains(*), Mecca Hills	Orocopia
10	Central Chocolate Mountains	Orocopia
11	Southern Chocolate Mountains	Orocopia
12	Picacho-Peter Kane Mountain area, California; Trigo Mountains, Arizona	Orocopia
13	Middle Mountains, Arizona	Orocopia
14	Castle Dome Mountains, Arizona	Orocopia
15	Beaverwest Ridge, Arizona	Orocopia

Figure 3. Distribution of the Pelona-Orocopia schist and Vincent-Chocolate Mountain thrust system (after Jennings, 1973; Ehlig, 1968; Dillon, 1976; Haxel, 1977) and Cenozoic strike-slip faults (after Jennings, 1973; Crowell, 1975a) in southern California and southwesternmost Arizona. Schist bodies are numbered as in Table 1; schist bodies 1 to 9 are the same as shown by Ehlig (1968, fig. 1). Some of the smaller schist bodies are shown slightly exaggerated in size and the geometry of most of the thrust faults is simplified.

(From Haxel and others, 1978)

fenomanganiferous chert, limestone and interstratified mafic to ultramafic rocks. The lower part of the sequence contains well preserved sedimentary structures, including graded bedding, which suggest distal turbidite fan or basin plain deposition (Haxel and Dillon, 1978; Walker, 1967). Haxel and Dillon (1978) explain the presence of limestone and chert in a basically clastic depositional environment as related to submarine volcanism represented by the basanites. The spatial association of basanite, marble, and chert suggest that the chert and limestone accumulated above the reach of clastic sedimentation, presumably on topographic highs (Ganison, 1974; Haxel and Dillon, 1978).

Rocks of the Orocopia Schist are structurally overlain along the Vincent-Chocolate Mountains Thrust by allochthonous Precambrian to Mesozoic crystalline rocks. Locally, metamorphic grain size within the schist increases toward the thrust indicating an inverted metamorphic zonation. Lineations along the Vincent-Chocolate Mountains thrust, in both upper-plate crystalline rocks and lower-plate schist, are generally coparallel in a north-northeast/south- southwest direction. These relationships indicate that metamorphism occurred beneath the thrust plate of the Vincent-Chocolate Mountains fault system and was generally coeval with movement along the thrust. Haxel and Dillion infer a northeast direction for overthrusting based upon fold vergence data.

The upper plate of the Vincent-Chocolate Mountains Thrust fault contains Mesozoic plutonic rocks as young as 80 ± 10 m.y. which are cut by the thrust. The plutons have not been dated in the schist (Ehlig, 1981). Based upon K-Ar and Rb-Sr isotopic ages obtained from thrust zone mylonites and lower-plate metamorphic rocks, movement on the thrust may have taken place between 50 and 60 m.y. ago (Ehlig, 1981).

Recent work by Haxel and others (in press) casts doubt upon the currently accepted metamorphic ages of the Orocopia Schist and the Vincent-Chocolate Mountains thrust zone. Detailed mapping in conjunction with structural and stratigraphic relations with the Jurassic (?) Winterhaven Formation suggest that several major events intervened between the metamorphism of the Orocopia Schist and the setting of K-Ar dates at 60 m.y. B.P. Haxel and others (in press) believe that the 60 m.y. dates represent post-metamorphic cooling ages and that the primary metamorphic age of the Orocopia Schist is older than 60 m.y, perhaps as old as early Late Cretaceous.

Ki - Late Cretaceous Plutons

Mid- to late Cretaceous or "Peninsular-age" plutonic rock crops out over a large part of the Granite Wash-Harcuvar Mountain region (Plate 1). The best exposures are near Granite Wash Pass and Tank Pass in the Granite Wash Mountains. The Tank Pass pluton is equigranular to slightly porphyritic and varies from quartz monzonite (adamellite) to granite and is locally 2-mica bearing (Reynolds, 1980; Rehrig, 1984 personal commun.). The pluton varies from completely undeformed to penetratively foliated and lineated as it is traced eastward into the Harcuvar metamorphic core complex (Rehrig and Reynolds, 1980).

Although K-Ar age dates for this batholith range from 55 to 44 m.y.B.P. (Rehrig and Reynolds, 1980), Rb/Sr dating establishes an 87 m.y. age for the pluton (Rehrig, 1984 personal commun.). Unpublished K-Ar data (Rehrig, 1984 personal

commun.), shows Cretaceous dates (80-90 m.y.) for granodioritic bodies in the Bullard Peak and areas of Maricopa County (Plate 1). Although specific age data for pre-Laramide (>75 m.y.), Cretaceous plutonism is rare in Arizona, the few recently retrieved dates suggest that "Peninsular" plutonism may be more common than thought. The meager evidence to date indicates that the composition of Cretaceous and Laramide plutons are similar: granodiorite or quartz monzonite.

TKv - Laramide Volcanic Rocks

Laramide volcanic rocks are found only in small isolated outcrops in southwestern Arizona. In particular, they are found near Ajo and in the Vekol Mountains (Plate 1). These volcanic rocks are comagmatic with Laramide plutonism that is widespread throughout southern and southwestern Arizona.

The majority of Laramide volcanic rocks consist of rhyolite, rhyodacite, and dacite or basalt flows. Gray to pink felsite flows with K-feldspar and biotite phenocrysts generally make up the major portion of the Laramide volcanic rocks in southwestern Arizona. Dacites are normally porphyritic with phenocrysts of hornblende, feldspar and biotite in a dense gray groundmass (Dockter and Keith, 1978). Basalts, which are rare, usually occur as dikes but occasionally are found as dark-gray to black, locally porphyritic flows (Rytuba and others, 1978).

TKi - Laramide Intrusions 75-50 m.y. B.P.

Intrusive rocks of Laramide age are a suite of generally calc-alkalic to locally alkalic rocks that occupy a unique position in the tectonic history of the southwestern United States. Rocks of this age can be found throughout western Arizona, locally as small isolated plutons, or as in the case in extreme southwestern Arizona, a large pluton known as the Gunnery Range batholith. Smaller batholiths and stocks such as those in the Wickenburg region, at Ajo, and in the Granite Wash Mountains, also occur (Plate 1).

Most Laramide age rocks in western Arizona are generally medium to coarsely crystalline, locally porphyritic, biotite quartz monzonite to granodiorite. Groundmass mineralogy consists of an holocrystalline mixture of potassium feldspar, plagioclase and quartz; phenocrysts are generally of subbedral to euhedral crystals of quartz, plagioclase, potassium feldspar, and biotite. Pegmatitic and aplitic phases are common in many areas and may intrude all other Laramide age rocks (Briskey and others, 1978).

For this report, we have chosen Damon and others' (1964) definition of the Laramide. This model defines the Laramide as an epoch of intense calc-alkalic magmatism that flared up about 75 m.y. ago and continued until about 50 m.y. ago when magmatism abruptly ended. Damon and others' (1964) model easily allows placement of dated rocks within specific time constraints; this is as opposed to Coney and Reynolds (1977) model for the Laramide which is built upon tectonic considerations that cannot always be identified in western Arizona.

Ts - Tertiary Sediments Undivided

Map units labeled Ts on Plate 1 are nearly all products of non-marine sedimentation in fluviatile and lacustrine environments. The Tertiary sedimentary sequence is dominated by reddish-brown, coarse boulder and cobble conglomerate and fanglomerate with a sand and silt matrix; the sequence also includes silty sandstone, sandy siltstone, fine-grained bedded tuff, evaporites, and intercalated volcanic and pyroclastic rocks. In the Yuma area, Ts includes marine limestone/claystone of the Pliocene Bouse Formation.

Eberly and Stanley (1978) have divided the Tertiary section in southwestern Arizona into two units based upon their stratigraphic relationship to a major unconformity. This boundary delineates a fundamental change in the style of extension and accompanying magmatism during the Tertiary. These workers date the unconformity at about 12-13 m.y.B.P. after which typical Basin-and-Range block faulting predominated. Although not designated on Plate 1, it should be noted that those Tertiary sedimentary rocks deposited prior to the onset of Basin and Range style extension are of a fundamentally different character than those deposited afterward. Extreme southwestern Arizona was the locus of marine sedimentation associated with the proto Gulf of California during the Pliocene.

Pre-late Miocene, continental sedimentary rocks vary from coarse, poorly sorted, arkosic sandstones to conglomerates and slope breccias. They tend to be red-brown in color, and the sequences are characterized by numerous angular unconformities.

In the Las Vegas-Lake Mead region, the Ts designation is applied mainly to the Muddy Creek Formation and its equivalents. The southern two-thirds of Plate 1 have several formations representing the Ts designation; these include, but are not limited to, the Bouse Formation (marine), Daniels Conglomerte, Chapin Wash Formation, and the Locomotive Fanglomerate (Figure 4).

Tsl - Tertiary Lacustrine Sediments

This unit, a subdivision of Ts, is used exclusively for those Tertiary sedimentary sequences that are predominately of lacustrine facies. In western Arizona, they occur in only two areas: (1) adjacent to Lake Mead; and, (2) in the Date Creek Basin and adjoining areas (Plate 1).

Tertiary lacustrine sediments in the region are composed essentially of siltstone, claystone, tuffaceous sediments, silty sandstone and interbedded evaporites. Those lacustrine sediments found near Lake Mead are part of the highly variable, and regionally extensive, Muddy Creek Formation. The lacustrine facies are presumably found in the more basinward parts of the depositional basins while the coarse clastic facies of the Muddy Creek Formation occupy positions near the basin margins.

Facies relationships are much the same for the lacustrine sediments of the Date Creek Basin area (Plate 1), though these rocks have not been correlated to any regionally extensive formation. This unit, in the Date Creek Basin area consists of a heterogeneous assemblage of algal, tuffaceous, and micritic freshwater limestone, siltstone, silty sandstone and local conglomeritic horizons; much more

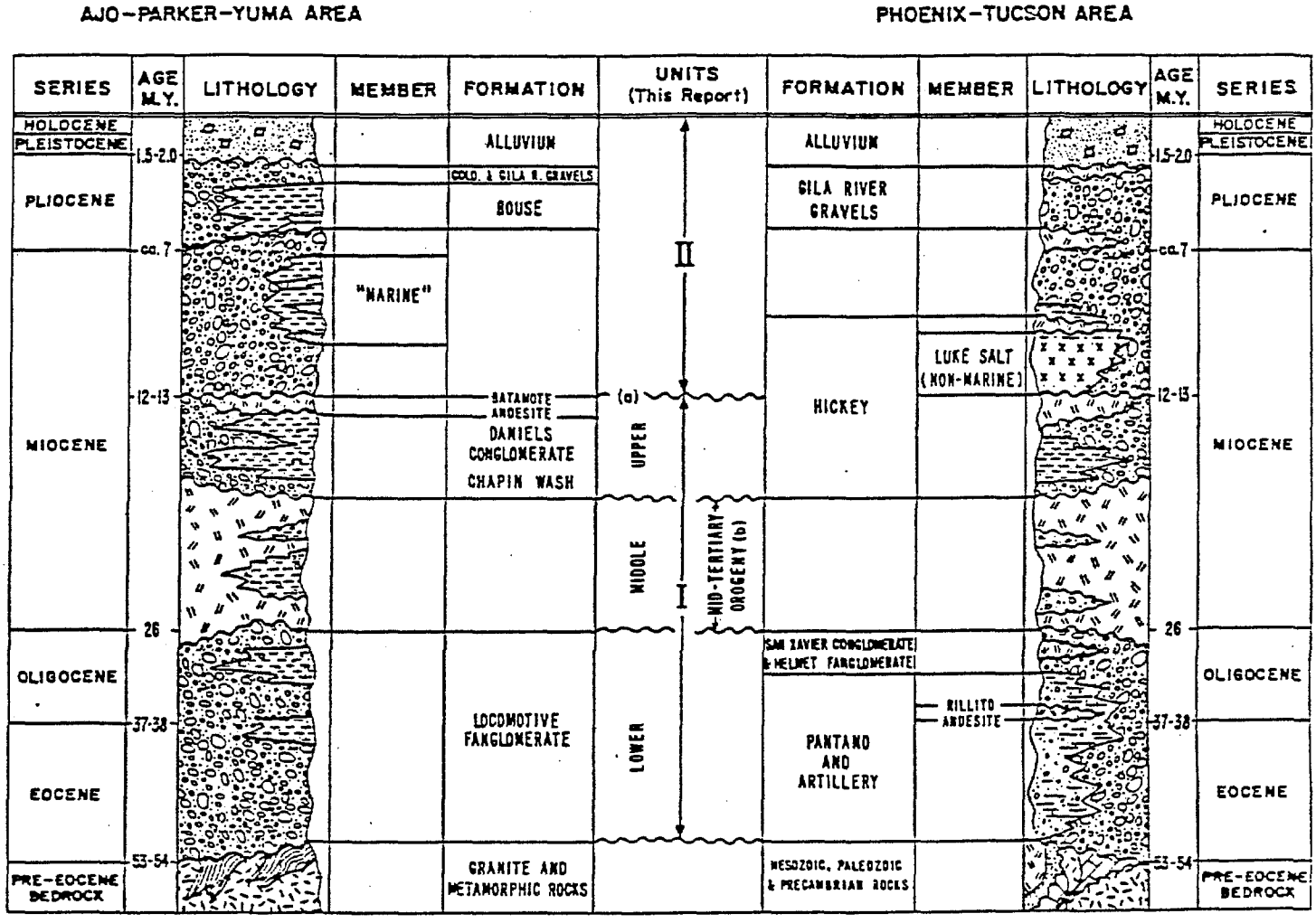


Figure 4 Composite stratigraphic column of southwestern Arizona (ages of series boundaries from Geological Society of London, 1964, p. 260–262). Unconformity (a) represents erosional surface that was disrupted by beginning of late Miocene block faulting. Mid-Tertiary orogeny (b) modified from Damon (1964, p. 13–15). Terminology references: Wilson (1933), Gilluly (1946), Lasky and Webber (1949), Heindl (1959), Cooper (1960), Metzger (1968), Finnell (1970), McKee and Anderson (1971), Eaton and others (1972), and Mattick and others (1973).

(From Eberly and Stanley, 1978)

limestone is present in the Date Creek Basin lacustrine section than in the lacustrine facies of the Muddy Creek Formation.

Tv - Tertiary Volcanic Rocks, Undivided

Although Tertiary volcanic rocks cover large parts of western Arizona, their ages, composition and source areas are not completely known. Consequently, some of the volcanic rocks within the study area have had to remain undivided on our map. The majority of these rocks are located in the Kofa, Tank, Mojave and Aguila Mountains of southwestern Arizona (Plate 1). Units mapped as Tv on Plate 1 may occur as mafic to felsic volcanic flows, tuffs, domes, or pyroclastic deposits. Except for those rocks in the southern Trigo-northern Tank Mountains region, areas of undivided Tertiary volcanic rocks (Tv) are scattered and small.

Tof and Tom - Older Tertiary Felsic and Intermediate Volcanic Rocks

Cenozoic volcanism began in western Arizona about 32 m. y. ago accompanying the beginning of early crustal extension in the region. A major pulse of calc-alkaline volcanism occurred in the region between about 30 and 24 m.y. B.P., but lasted somewhat longer in the western and northwestern parts of the study area (Otton, 1982) (Figure 5). The onset of volcanism was initially accompanied by widespread alkalic rhyolitic ash flow tuffs subsequently superceded by basaltic andesites, dacites and high silica rhyolites. Otton (1982) suggests that these rocks were extruded through a warm, plastically extending crust with a brittly extending thin skin in a manner similar to that proposed by Eaton (1979) for the Basin and Range in general.

Older volcanism (i.e. 20-30 m.y. B.P.) is concentrated in the southwestern parts of the study area, particularly in the Kofa and Castle Dome Mountains. Although detailed mapping has only recently taken place in most of the volcanic terranes of western Arizona, several possible calderas have been postulated (Plate 1). They are located in the Date Creek Mountains and parts of the Castle Dome, Chocolate, Middle and Kofa Mountains. The Kofa caldera is defined by a steep, negative residual Bouger gravity anomaly (Gutman, 1981; 1982).

On Plate 1, unit designation Tom represents rocks of intermediate and minor mafic compositions (i.e., andesites, dacites, and basalts). Although the term "m" (mafic) is used for this calc-alkaline association, it should be noted that these rocks are mainly andesites and dacites and, therefore, distinct from the Tym unit. Normally, these rocks consist of dense, pink to gray, locally porphyritic flows of andesite/trachyandesite and dacite that are intercalated with breccia and reddish-brown, volcaniclastic sediments. Some flow rocks have tabular phenocrysts of pyroxene, and plagioiclase encased in a finely-crystalline groundmass of plagioclase, pyroxene and opaque minerals (Briskey and others, 1978).

Tof lithologies are essentially of felsic volcanic rocks of rhyodacite to rhyolite composition. Large exposures of Tof are limited mainly to the Kofa, Castle Dome, Sand Tank, and Sauceda Mountains regions of southwestern Arizona (Plate 1); the aerial extent of this unit may be controlled by the position of inferred calderas, particularly in the Kofa Mountains (Gutman, 1981; 1982).

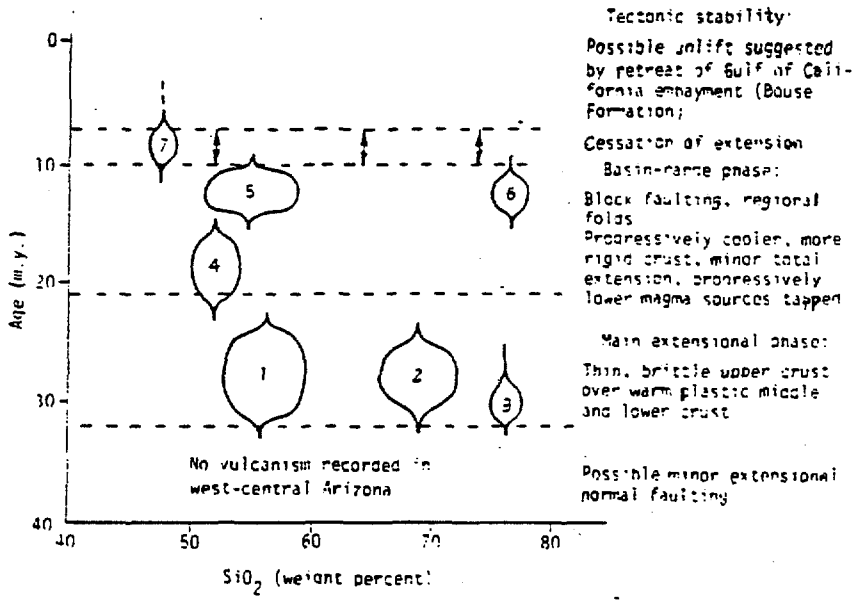


Figure 5 - Relation between silica composition, time of eruption, and structural events associated with volcanism in west-central Arizona. Approach here suggested by Elston and Bornhorst (1979). Time of inception of eruption is approximate. Older volcanic rocks: 1- basaltic andesite; 2- dacites and low-silica rhyolites; 3- potassic rhyolites. Younger volcanic rocks: 4- silicic basalts; 5- basalts and basaltic andesites; 6- potassic rhyolites; 7- low-silica basalts.

(From Otten, 1982)

Compositionally, rocks of the Tof unit are most commonly porphyritic quartz latite, rhyodacite, and rhyolite flows with intercalated breccia and tuffaceous rocks. Representative samples consist of plagioclase, potassium feldspar, quartz and hornblende phenocrysts in an aphanitic to cryptocrystalline groundmass of potassium feldspar and quartz (Briskey and others, 1978; Rytuba and others, 1978).

Tyf-Tym - Younger Tertiary Felsic and Mafic to Intermediate Volcanic Rocks

Volcanic and tectonic styles throughout nearly the entire western United States, including western Arizona, underwent a profound change during the mid-Miocene. Subduction along the western edge of California ceased and by about 19-20 m.y. ago all collision related compressional tectonism had been replaced by a crustal extension regime and associated strongly bi-modal basalt-rhyolite assemblages related to Basin and Range tectonism.

Volcanic rocks younger than about 19 m.y.B.P. have been subdivided into two catagories on Plate 1: Younger Tertiary Felsic rocks (Tyf), and Younger Tertiary Mafic rocks (Tym). Unit Tym consists of rocks of basalt to andesitic basalt composition. The majority of these rocks are made up of numerous flows of dark-purplish-gray to dark gray basaltic andesite lava and breccia with lesser amounts of true basalt. Interbedded with these mafic rocks may be thin beds of white to red tuffaceous sediments and coarse clastic rocks (Anderson, 1978; Suneson and Lucchita, 1983). Locally, these rocks are porphyritic with phenocrysts of plagioclase or quartz in a finely-crystalline groundmass of plagioclase, pyroxine, quartz, biotite, hornblende, and olivene (Suneson and Lucchita, 1983).

Rocks of the Tym designation are located predominately in the Black, Little Horn, and Growler Mountains and the Castaneda Hills (Plate 1). Younger mafic volcanic rocks in western Arizona are generally between 5.4 and 19 m.y. in age, with major pulses of mafic volcanism at about 16-18 m.y. and 5-10 m.y. ago (Anderson, 1971; Otten, 1981; Suneson and Lucchita, 1983).

In general, younger felsic volcanic activity (Tyf) took place between about 10 and 17 m.y. ago in most of western Arizona. This places the majority of the volcanism between the two major pulses of mafic activity. Younger Tertiary felsic volcanic rocks were mainly errupted from isolated volcanic centers scattered throughout western Arizona. The most notable of these centers is that near Oatman in the Black Mountains. Other centers of rhyolitic activity occur in the Date Creek-Arrastra Mountain region, the Castaneda Hills, and the Ajo Range in extreme southwestern Arizona (Plate 1).

The felsic volcanic rocks that make up the largest part of the Tyf unit are generally rhyodacitic to rhyolitic in composition. They occur as interstratified, lobate to lenticular shaped bodies consisting of domes, flows, breccias, tuffs, and pyroclastic deposits. Normally, flows form short, stubby masses that are intercalated with tuffs near rhyolite domes. Lavas are generally light colored, massive flows composed of quartz, sanidine, oligioclase, biotite and hornblende; locally, some lavas may be topaz-bearing (Anderson, 1978; Burt and others, 1981; Suneson and Lucchita, 1983).

Ti, Tui, Tmi, Tli - Tertiary Plutonic and Hypabyssal Rocks

Several designations of Tertiary intrusive rocks are used on Plate 1. These designations are based either upon composition, texture, or upon age in the case of holocrystalline rocks. An attempt was made to label Tertiary hypabyssal rocks with a subscript to denote composition. Thus, Tertiary intrusions with a subscript "r" (Tir) signify rocks of rhyodacite to rhyolite composition; those with an "a" (Tia) subscript are dacitic to andesitic in composition. Units designated Ti are of unknown character and may be of plutonic or subvcolcanic character.

Tertiary hypabyssal rocks can be found throughout most of western Arizona; large areas of intrusive rhyolite are located in the Sand Tank-Sauceda Mountains region south of Gila Bend. Scattered, smaller exposures are located virtually throughout the study area with perhaps the best exposures being in the Arrastra Mountain-Date Creek Basin area northwest of Wickenburg; in the Castaneda Hills-Buckskin Mountains region northeast of Parker; and near Oatman in the Black Mountains (Plate 1). Intrusive rocks of a mafic composition are relatively insignificant and are located mainly in the northern half of the study area.

Compositionally, Tertiary felsic intrusive rocks are generally composed of finely crystalline, hypidiomorphic to porphyritic rhyolite and rhyodacite. Phenocrysts are of mainly euhedral to anhedral quartz, potassium feldspar, plagioclase, hornblende, biotite, and magnetite. Groundmass mineralogy is composed predominately of microcrystalline quartz, potassium feldspar, plagioclase, biotite, apatite, and magnetite.

Plutonic rocks are designated strictly by age, not composition. These rocks are generally granodiorite to quartz monzonite in composition. Unpublished chemical data by Rehrig comparing mid-Tertiary and Laramide plutonic rocks in the southwest has shown essentially no major differences between the two suites of magmatic rocks. Generally, both are calc-alkaline rocks of intermediate composition. Age brackets for Tertiary plutonic rocks are as follows: (1) Upper Teritary (Tui), less than 20 m.y.B.P.; (2) Middle Tertiary (Tmi), 20-40 m.y.B.P.; and, (3) Lower Tertiary (Tli), 2-mica-bearing plutonic rocks, 40-50 m.y. in age.

Tertiary plutonic rocks crop out throughout western Arizona. More specifically, they are generally comagmatic with the volcanic rocks with which they are spatially and temporally(?) associated. The best example of this may be near Oatman where the Times Porphyry (Tui) intrudes its coeval volcanic rocks (Clifton, 1980). Spatial, but not necessarily temporal, association is found between volcanic and plutonic rocks in the El Dorado-Black Mountains south of Lake Mead, the Newberry Mountains of southernmost Nevada, and several areas in southwestern Arizona particularly in the Chocolate, Kofa, Big Horn, and Vekol Mountains (Plate 1).

Lower Tertiary 2-mica plutonic rocks display a distinctive mineralogy that makes them unique in the framework of Arizona Phanerozoic magmatic history (Keith and others, 1980). These rocks are normally granite to quartz monzonite in composition, but are distinctive in that they are biotite, muscovite, and garnet-bearing. Often the 2-mica granites are medium to coarsely crystalline (commonly rich in pegmatite phases), locally porphyritic and consist of quartz, plagioclase, and potassium feldspar in addition to biotite, muscovite, and garnet.

These 2-mica granites are thought to be part of a regionally extensive plutonic event. These rocks underlie approximately 65% of the area of the Santa Catalina-Rincon-Tortolita complex near Tucson and large parts of the Harquahala and White Tank Mountains in west-central Arizona (Plate 1) (Keith and others, 1980). Age dates by Keith and others (1980) from 2-mica granites in the Santa Catalina Mountains are remarkably concordant at 44-50 m.y.; Rehrig (unpublished data) has constrined the age of the 2-mica pluton in the Harquahala Mountains as between 40-55 m.y.B.P. A similar age may be inferred for other 2-mica granites in western Arizona as well.

QTb - QTi - Quaternary and/or Tertiary Basalt and Vents

This unit is reserved exclusively for those basaltic rocks 5 m.y. in age or less. These are found exclusively in the Sentinel and Pinacate volcanic fields near Gila Bend and the Mexican border (Plate 1). Basalts of these fields are typically black, locally vesicular or amygdaloidal and generally megacryst- bearing flows and vents. The rocks are characterized by large megacrysts of plagioclase, pyroxene, and olivine in a dense, fine-grained groundmass.

Vents for many flows are small, eroded spatter or scoria cones, steeply dipping dikes, or small domes. The rocks often are seen as large, desert varnish-coated boulders.

TECTONIC OVERVIEW

(WITH NOTES ON REGIONAL METALLOGENESIS)

Introduction

The preceding section of the report has described tectono-stratigraphic units for Plate 1 and should provide an adequate familiarity with the kinds of rocks which occur in western Arizona. It now becomes the task of the present chapter to weave these descriptions into a coherent tectonic history. Such a summary containing brief comments on known, major mineralization events, will set the stage for the rigorous treatment of metallization and target areas, resulting from interpretation of the map series and mine-district analysis.

Precambrian

The oldest known rocks in western Arizona are the 1700 to 1850 m.y. volcanic and volcaniclastic rocks of the Yavapai series which occur in the central- northeast portion of the study region. Equivalent rocks to the northwest are the Vishnu Series; and to the southeast, the Pinal Schist. Basement rocks exposed elsewhere in the region are more strongly metamorphosed (amphibolite-grade) than the dominantly greenschist facies of the Yavapai series. It is suspected that many of these higher grade rocks are derived from Yavapai-like protoliths, especially in the northwest part of the state (personal commun., Phil Anderson, 1982).

The apparent general absence of Precambrian rocks south of Interstate 10 should be noted. This gap may be an artifact of insufficient dating and the difficulty in sorting out variably metamorphosed Mesozoic rocks from true basement. The isolated 1.7 b.y. date reported by L. Silver (in Dillon, 1975) on the gneissic granite of Pilot Knob just west of Yuma and a recent 1.7 b.y. date on gneisses in the Mohawk Mountains south of I-8, Ajo sheet (personal commun., G. Haxel, 1984), suggests a poorly recognized presence of Precambrian rocks in the southwest corner of Arizona.

Precambrian plutonism can be roughly subdivided into periods from about 1650 to 1760 m.y., 1400 to 1500 m.y. (becoming as young as about 1350 m.y. in the northwest part of the state), and the less extensive 1000 $\pm$ 100 m.y. diabase event associated with Apache Group sediments. Unpublished work by Rehrig in southcentral Arizona suggests a 2-mica plutonic event pre-dating the Apache diabases and post-dating the Oracle granite, but its presence in western Arizona has not been validated.

The oldest plutonism tends to be basic in its composition (gabbro and diorite) and is related either to the Mazatzal Orogeny (Wilson, 1939) or to Yavapai magmatism. Many of these plutons are variably foliated with trends parallel to those in the hosting metamorphic rocks (Reynolds, 1980). The most widespread magmatic event is post orogenic and includes the 1.4 to 1.5 b.y. equivalents of the Oracle or Ruin granites in southcentral Arizona. Rocks of this epoch are characteristically megacrystic in Kspar and are porphyritic quartz monzonite to quartz monzonite porphyry. These plutons have invaded vast expanses of the Hudsonian basement in middle North America and the petrogenetic mechanisms for such volumes of uniform,

atectonic magma generation, especially in terms of plate tectonic schemes, remains unresolved.

Late Proterozoic, Apache Group sediments are not common in western Arizona. In most of Arizona, thicknesses of these rocks are less than about 1500 ft. Equivalent rocks of the Grand Canyon Series in extreme northwest Arizona are 10,000 to 12,000 ft thick. In nearly all localities, the Apache sediments are intruded by 1150 m.y. diabase sills and dikes.

Tectonism in the Precambrian was concentrated in the 1600 to 1700 m.y. Mazatzal Orogeny or "Revolution" (Wilson, 1939) during which Yavapai sediments and volcanics were variably metamorphosed, intruded and folded about NNE- to NE-trending axes. Actually, two and perhaps more distinct phases of folding affected these rocks and deformation may have been polycyclic at different times and in different places. Any plate tectonic ideas regarding primary rock generation or subsequent orogeny are purely speculative. Since the nearest pre-Proterozoic crust to the Yavapai of central Arizona occurs in central Utah, a subduction history is difficult to piece together. What remains fairly certain is that the setting consisted of an oceanic island arc or immature arc marginal to some Archean continent. The tectonic setting for late Proterozoic sedimentation throughout North America is rift-related, which also appears to be the case in Arizona. The Grand Canyon disturbance subsequent to sedimentation resulted in diabase intrusion and normal fault development (Moore and Wilson, 1965).

Major metals mineralization in the Prcambrian occurred during deposition of Yavapai rocks resulting in polymetallic, stratabound deposits of volcanogenic and

exhalative origin. These deposits, some with carbonate facies gold, appear associated with terminal felsic phases of mafic to felsic volcanic cycles; evidence suggests that at least four of these mafic to felsic cycles occurred in the Proterozoic of Arizona (Donnelly and Hahn, 1981). Minor synsedimentary mineralization (U $\pm$ base-metals) is known from dark, fine-grained, arenaceous rocks of the Dripping Springs Quartzite along the Mogollon Rim area north of Globe-Miami.

Paleozoic

Strata which have been correlated with Paleozoic rocks of southeastern Arizona or the Colorado Plateau sequence exist in small scattered exposures through western Arizona. The sequence is best exposed in the Plomosa, Harquahala, and Little Harquahala Mountains (Plate 1). The section is thin, less than a few thousand feet thick, with carbonates, shales and sandstones displaying a cratonic or shelf environment. Sediment transport is assumed to have come from the transcontinental basement arch to the northeast. Dramatic thickening into the miogeocline occurred just to the northwest of Arizona into what is now southern Nevada.

Arizonan Paleozoic rocks display essentially no effects of the mid-Paleozoic Antler Orogeny as is evidenced in Nevada, nor any other structural deformation of consequence attributable to Paleozoic or terminal Paleozoic disturbances elsewhere in North America. It is not uncommon in the western part of the state to find severely deformed and metamorphosed outcrops of Paleozoic rocks; however, their condition is believed a consequence of Mesozoic or Laramide tectonism. Although Paleozoic rocks, particularly carbonate sections, have served as good hosts for younger metallization, no metal deposits of Paleozoic derivation are known.

Mesozoic

Mesozoic supracrustal rocks through the middle part of western Arizona are significantly distinct from the cratonic sections described on the Colorado Plateau and from the thick, mainly marine accumulations of southeast Arizona. These distinctive lithologies have also been described through large portions of the Papago Indian Reservation (Haxel and others, 1980). Equivalent rocks in the southwest corner of the state are suggested by the early work of Wilson (1933, 1962), but definitive study has been inhibited by the presence of restricted bombing and gunnery ranges.

Unequivocal Triassic age rocks are not known in western Arizona. Some red bed sequences in the Alamo and Quartzite areas may be of this age (Reynolds, personal commun., 1985). The Mesozoic sedimentary sequence where mainly studied (the Dome Rock, Plomosa, Harquahala, Little Harquahala, Granite Wash Mountains, and adjacent areas of the Mojave Desert) (Figure 6), appears to start with continental rocks overlying volcanics of Jurassic age or similar strata deposited directly onto Paleozoic carbonate rocks (Reynolds, 1980; Marshak, 1980; Harding, 1980). The Mesozoic rocks are red beds, arkosic sandstones to conglomerates and graywackes of extraordinary thicknesses (2-6 km). They are essentially devoid of fossils, with a clast character suggestive of initial Paleozoic source areas followed by sources made up of volcanic and granitic rocks (Harding, 1980). Both provinces are probably representative of North American continent (Robison, 1980).

The beginnings of this sedimentary sequence in many areas appears coeval with Jurassic volcanism consisting commonly of felsic flows and shallow intrusive equivalents. Granitic plutons, typically megacrystic in Kspar, somewhat alkalic in

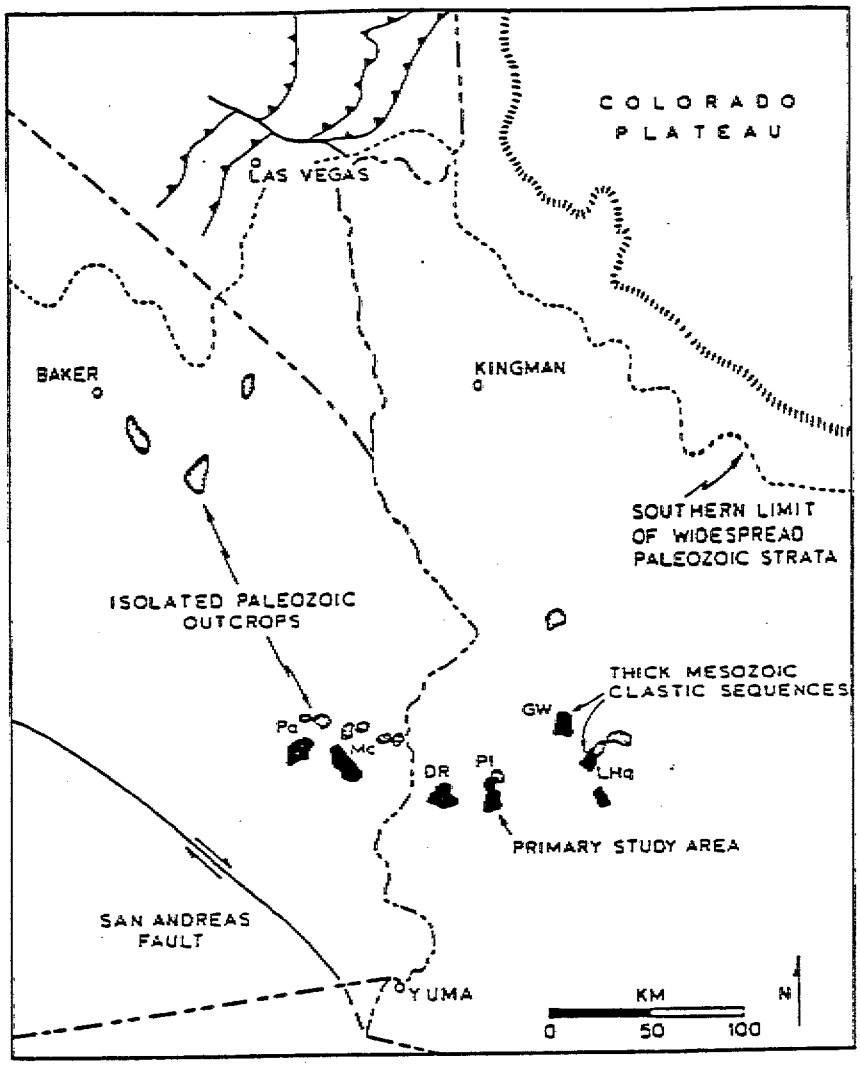


Fig. 6.. Geologic setting of thick, Mesozoic clastic sequences (black) in western Arizona and southeastern California: DR - Dome Rock Mountains; GW - Granite Wash Mountains; LHq - Little Harquahala Mountains; Mc - McCoy Mountains; Pa - Palen Mountains; Pl - Plomosa Mountains. (Modified from Robison, 1979.)

(From Robison, 1980)

chemistry, and closely resembling 1.4 b.y. Oracle-like rocks, are found intruding Paleozoic and Mesozoic sedimentary and volcanic sections. These intrusive bodies are important because in some areas, dark, clastic sedimentary sequences appear to overlie the plutons unconformably (Reynolds, 1980; Rehrig, unpubl. observations in the Granite Wash Mountains). The few dates available for the plutons fall in the early- to mid-Jurassic interval and suggest contemporaneity with volcanism. This volcanism is part of a major Jurassic magmatic arc which existed both off- and onshore, marginal to the North American craton. This arc marked the emergence of the modern circum-Pacific subduction system (Dickinson, 1981).

As indicated above, some of the "dirty", immature (poorly sorted, feldspathic, lithic-rich), Mesozoic sedimentary rocks appear to post date Jurassic magmatic activity. There are, however, indications in some ranges, both in SE California (i.e., Dillon, 1975) and SW Arizona (i.e., Crowl, 1979; Richard, 1983; Rehrig, unpubl. data), that considerable thicknesses of metagraywackes are intruded by Jurassic plutons (i.e., Cargo Muchacho Mountains, Dome Rocks, Little Harquahala Mountains, and possibly the Eagle Tails). These graywackes may be of early Mesozoic age or are related to Jurassic tectonism. In an overall sense, it appears logical to loosely associate much of this sedimentation in the region of interest to Jurassic arc tectonism and interior, probably fault controlled continental basins that were closely associated with calc-alkaline to alkaline volcanism and plutonism. A back arc setting with extension along WNW to EW trends has been suggested (Bilodeau, 1978, Robison, 1980). Paleocurrent data indicate a north to south sediment transport (Harding, 1980; Robison, 1980).

As cited by Robison (1980), the fault-bounded basin through middlewestern Arizona may have been bounded by a continental terrane on the north and a volcanic provenance on the south.

Cretaceous sedimentation cannot be specifically confirmed; however, it seems likely that deposital environments inherited from the Jurassic continued into the Cretaceous (Robison, 1980). Placing a tectonic cap on this orogenically active sediment deposition are mid- to late-Cretaceous 90 m.y. plutons (i.e., Tank Pass batholith in Harcuvar-Granite Wash Mountain area) which intrude the Mesozoic sections. Curiously, major sedimentary accumulations resulting directly from Laramide tectonism and uplift at the end of the Mesozoic have not been delineated.

Mesozoic along with Paleozoic supracrustal rocks have been intensely deformed through western Arizona. In some areas, this condition is accompanied by varying degrees of metamorphism. The recognition of this tectonism, and the close ties between deformational foliation, folding, metamorphism and profound thrust faulting has only emerged during the last few years by means of reconnaissance and detailed mapping by a number of workers (Miller, 1966; Varga, 1977; Crowl, 1979; Rehrig and Reynolds, 1980; Reynolds, 1980; Reynolds and others, 1980; Hardy, 1984). Miller's mapping of the Quartzite 15' quadrangle in the early 1960's gave a preview of the structural complexities. Subsequent work has established large areas cut by pervasive cleavage or foliation at wide angular discordance to bedding; isoclinal, small-scale to nappe-like folds; and stacked thrusts involving allochthonous slices of crystalline and gneissic basement. Mylonitic fabrics commonly occupy considerable thicknesses (up to 100 m) along the fault structures and into the upper plates. The overall deformation is penetrative and ductile with

considerable attenuation of stratigraphic units. The deformational style is similar to that documented in the Big Maria Mountains of SE California by Hamilton (1982). Reynolds (1980) cites evidence for southward-directed tectonic transport. Dillon (1975) and Haxel and Dillon (1978) suggest a close temporal and spatial association between thrusting and metamorphism. Unpublished work by Rehrig and Wilson in the southeast Mojave region and by Rehrig and Reynolds (1980) in the Harcuvar metamorphic core complex suggests that areas of higher grade (amphibolite-facies) metamorphism may be related to centers of deep-seated Mesozoic plutonism and thrusting.

The most profound and least understood thrust structure in western Arizona is the Vincent-Orocopia overthrust which appears to extend from the Chocolate Mountains of southeast California across the Colorado River to as far east as the Neversweat Ridge area on the military reservation (Figure 3) (Haxel and Dillon, 1978, and Plate 1). In isolated exposures, this structure generally separates Orocopia Schist in the footwall from North American crystalline rocks (Mesozoic plutons or basement gneisses) of the upper plate. The Orocopia rocks represent a relatively uniform oceanic or trench assemblage of metagraywackes with subordinate, interbedded intervals of metachert, metabasite, metaultramafic rocks and a few carbonate (exhalite?) horizons. The Orocopia has been likened to the Franciscan subduction complex of western California (W. Hamilton and G. Haxel, personal commun., 1984). New age data, however, refutes this connection. Concordant U-Pb zircon ages of 163.2 and 160.9 m.y. (Mukasa and others, 1984) from a pre-metamorphic pyroxene-hornblende diorite dike that intrudes the graywacke and basalt protolith prio to thrust-related metamorphism in late Mesozoic time, provides a <u>minimum</u> age for the protolith of the Orocopia schist. This minimum age

indicates that the Orocopia could not be related to the compositionally similar, but younger, Franciscan complex. The discovery of Orocopia rocks and their inferred thrust relationships within Arizona establishes a tectonic connection with the Mojave province of California. This connection may have extremely important tectonic and metallogenic significance.

In general, age constraints for the intense compressional tectonism and metamorphism are well established between the age of youngest rocks affected, the Jura-Cretaceous supracrustal rocks, and dates on the oldest cross-cutting intrusive rocks, which are of Laramide age. In detail and from place to place, these constraints differ. For example, Harding (1980) cites paleomagnetic and structural evidence suggesting that metamorphism and deformation in the McCoy Mountains Formation, a SE California equivalent to the "dirty," orogenic sediments of Arizona, is no younger than late Jurassic and that the protolith is, therefore, older (mid-Jurassic to Triassic ?). In the Granite Wash Mountains along the western margin of the Harcuvar metamorphic core complex, the 87 m.y. Tank Pass batholith appears to cross cut metamorphic isograds in the Mesozoic rocks, yet there is circumstantial evidence that metamorphism may be roughly associated with this plutonism (Rehrig and Reynolds, 1980). Either way, this would place this phase of tectonism as mid-Cretaceous in age or older. As much of the Tank Pass pluton is deformed (foliate with subtle lineation), tectonism continued after its emplacement. In the Harquahala Mountains, Reynolds and others (1980) have documented an amazing thrust geometry with at least two major plates of allochthonous Precambrian rocks and subjacent plates of strongly deformed Paleozoic and Mesozoic metasedimentary rocks. The thrusting discordantly cuts recumbent, southeast-vergent folds; and kinematic indicators suggest southward

fault transport (Hardy, 1984). The time of thrusting is bracketed by the Mesozoic rocks affected and undeformed cross cutting dikes of 2-mica granite with Rb/Sr ages of 40-55 m.y. (Rehrig, unpubl. geochron. data). One of these thrusts, the Hercules fault, is intruded by the Tank Pass (80-90 m.y.) pluton in the Granite Wash Mountains (Reynolds, 1985, pers. comm.) which dates the structural event as pre-mid-Cretaceous. Haxel and others (1980) describe relationshps in the Papago Reservation indicating that thrusting and metamorphism are closely related and that anatactic 2-mica granites (dated at 58 m.y.) were intruded during the waning stages of this tectonism. Haxel and Dillon (1978) argue that the major displacement on the Vincent-Orocopia thrust culminated in late Cretaceous time.

In summary, the Mesozoic is marked by a dramatic change from the relatively placid conditions of the Paleozoic. Although Sonoman (Triassic) orogenic events are not recognized, certainly by early Jurassic time, the southwest cratonal margin of North America was experiencing major fault-controlled basinal development with actively eroded margins. Much of this sedimentation was coeval with volcanism and establishment of a continental magmatic arc (possibly of WNW-trend) in this region. Closely following sedimentation, Jurassic continental sediments and volcanic rocks were overprinted by severe folding, thrusting and metamorphism. Some of this tectonism may be associated with the Mule Mountain suture zone as described by Tosdal (1982). Orogenic-style sedimentation may have continued into the Cretaceous, as did the orogeny itself in the form of supracrustal and basement deformation, metamorphism and plutonism. Mylonitic and low-angle tectonic or metamorphic fabrics commonly transposed on basement and Mesozoic rocks were the results. The tectonic fabrics exhibit highly ductile and penetrative structures, lit-par-lit injection, amphibolite-grade metamorphism (?), and the involvement of

basement cored thrusts are suggestive of fairly deep-seated, high temperature conditions. The termination of this orogenic setting did not occur until latest Cretaceous time, as evidenced by the fact that most of the Laramide plutons are unfoliated epizonal bodies which discordiantly cross cut the deformed and metamorphosed fabrics.

Late Cretaceous to earliest Tertiary Laramide plutonism was responsible for porphyry copper deposits, base metal replacement deposits and copper skarns through much of Arizona. The Ajo, Bagdad and Ithaca Peak copper mines are the only examples of major porphyry deposits in the western part of the state, although other, uneconomic systems exist (see overlay 4). For a number of years, exploration efforts attempted to determine why porphyry deposits were not as numerous in the west as in the southeastern part of Arizona. Precious metals occurrences are known spatially related to the copper deposits but some of these may be the results of superimposed, later events. Curiously, more gold has been produced from porphyry copper deposits in Arizona (i.e., Ajo - 1.6 million oz., Bisbee - 2.8 million oz.) than from most other types of metals occurrences (Keith and others, 1983a).

Although largely unsubstantiated in the literature, we feel that there are highly significant precious metals associations to be found within the Mesozoic sedimentational-metamorphic setting of western Arizona. These associations, which will be fully described later in this report, are controlled by primary, gold-bearing, lithologic factors; metamorphism; intrusive activity and thrust faulting. Many gold-bearing, tungsten associated deposits in these rocks are found controlled by major and minor thrust faults.

Tertiary

The catastrophic, compressional and plutonic events of the Laramide Orogeny continued into the Tertiary until about 40 m.y.B.P. We know of scattered occurrences of Laramide-age volcanic rocks through the Sonoran province, but major accumulations of sedimentary rocks, have not been delineated. Perhaps the 32 m.y. old Whitetail Conglomerate described in the Superior-Ray area (Cornwall and others, 1971) comes as close as is currently possible to being called a product of Laramide tectonism and erosion. There is, nevertheless, a conspicuous gap in the sedimentary record in western Arizona from about mid-Cretaceous time until the mid-Tertiary at about 30 m.y.B.P.

Originally, the Laramide Orogeny in Arizona was defined by a widespread burst of plutonism ranging from 75 to 50 m.y.B.P. (Damon and others, 1964). The widely recognized plutons of this magmatic event are typically high-level, commonly zoned, calc-alkaline bodies of quartz diorite to quartz monzonite composition. Granodiorite is a good average characterization. A similarly spectacular magmatic epoch occurred from about 30 to 20 m.y during mid-Tertiary time. Spaning the Tertiary, therefore, are two major magmatic peaks separated by what has been called a magmatic gap from about 50 to 30 m.y. (Figure 7).

Recently, a distinct, Eocene plutonic event has become recognized which appears to fill the magma gap at least from 50 to about 40 m.y. (Keith and Reynolds, 1980; Keith and others, 1980). The Eocene intrusions are peraluminous, alkali-rich, 2-mica, garnet-bearing granites or monzogranites with common pegmatite affiliations. They would be characteristic of S-type magmas and, as clearly

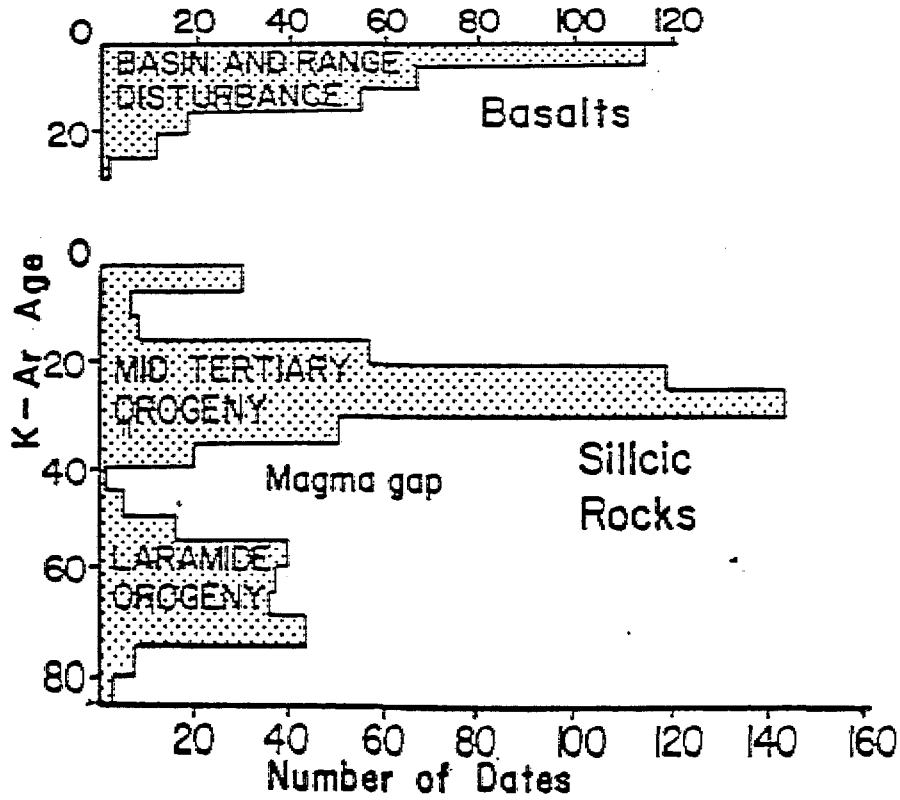


Figure 7: Histogram of late Cretaceous-Cenozoic isotopic data for plutonic and volcanic rocks of Arizona and New Mexico, updated from Damon and Mauger (1966) and Damon (1971). Note that the Eocene magma gap separates magmatism due to the Laramide and mid-Tertiary orogenies. Magmatism during Basin and Range Disturbance is dominantly basaltic.

(From Damon and others, 1981)

demonstratable in the field, are not associated with biotite-hornblende-bearing plutons. They are not, therefore, part of any normal differentiation sequence, as has been evidenced by Haxel and others (1980) for equivalent rocks in the Papago Reservation ("Presumido-type"). As indicated above, these Eocene magmatic bodies are of special interest because they bear a close temporal relationship with the end of Laramide Orogeny. In addition, their peculiar chemistry, high initial strontium ratio(>0.71) and disassociation with any I-type, subduction associated magmas suggest a crustal source for their generation. The absence of other types of Eocene plutonism is taken to mean that tectonic or plate tectonic conditions were significantly different from those of the preceding "classical" Laramide Orogeny. In fact, as suggested by Keith (1984, personal commun.), this Eocene plutonism may have accompanied the most severe phase of Laramide compression and crustal shortening.

Traditionally, the presence of muscovite in plutonic assemblages has indicated crystallization at substantial crustal depths (i.e., >10 km). A high proportion of the muscovite-biotite plutons occur in the highly deformed, metamorphosed, and mylonitic hostrocks of the metamorphic core complexes (i.e., Harcuvar, Harquahala White Tank, Picacho, Catalina-Rincon), which also is suggestive of deep seated tectonism. The complete story is not yet in on this unique period of magmatism with its differences from the earlier (75-50 m.y.), shallower, hornblende-biotite plutonic suite.

Through much of the region of study, Oligocene-Miocene (mid-Tertiary) rocks are characterized by continental volcanic and associated sedimentary deposits of the so called "ignimbrite flareup" (Coney, 1980) or mid-Tertiary orogeny. Volcanics

include abundant welded and non-welded tuffs, lava flows, pyroclastic deposits, and numerous hypabyssal dikes, plugs and stocks with both volcanic and holocrystalline textures. Compositionally, these magmatic products are of intermediate to felsic, calc-alkaline character and, curiously, vary little from the average composition of Laramide magmatic rocks (Rehrig, unpubl. data). The time span of this volcanic and plutonic activity extended from as early as about 30 m.y. to perhaps 18 m.y. (Figure 7). Toward the end of the epoch, more mafic and quartz alkalic rocks were erupted or intruded.

Mid-Tertiary, clastic sedimentary rocks include locally thick deposits of red-brown colored, arkosic, fanglomerate; sandstone to mudstone; slope breccias and fine-grained sequences of light- or vari-colored shale, siltstone, limestone and tuffaceous rocks (Reynolds, 1980). In the Buckskin-Rawhide Mountain region (Plate 1), the iron stained, terriginous rocks are commonly carbonate rich with interbedded lacustrine horizons. There, a relatively thick composite section is represented by the Artillery and Chapin Wash Formations (Laskey and Webber, 1948, Shackelford, 1976; Otton, 1980) which spans the mid-Tertiary period from perhaps as early as 40 m.y. to 16 m.y.B.P. As reviewed by Reynolds, stratigraphic study (i.e., Laskey and Webber, 1949; Eberly and Stanley, 1978, and others - refer to Reynolds, 1980, p. 11) indicates variable thicknesses of ferruginous, arkosic conglomerate at the base of mid-Tertiary sections with basalt or basaltic andesites at the top. Between these boundary lithologies, the relative stratigraphic positions and abundances of andesite dacite to rhyolite and intercalated, epiclastic rocks vary widely from place to place. Commonly, this variance is dependant upon the location of major volcanic centers. In the study region, volcanic centers may occur in the Kofa-Castle Dome area, Ajo volcanic

field, Palo Verde-Gila Bend Mountain area, Eagle Tail-Bighorn Mountains, McClenden Peak Area (east of Alamo Dam), Castle Hot Springs area east of Wickenburg, and within the Black Mountains of northwest Arizona.

Diametrically opposed to Laramide tectonism of compression and crustal contraction, the mid-Tertiary is typified by extension and crustal expansion. This deformation involved the dynamic stretching, normal shear, and pull apart processes obviously more extreme than can be attributed to mere relaxational rebound from the previous orogeny. Structural features resulting from the extensional orogeny include NNW ($\pm$ 20°)-trending dike and vein swarms (Rehrig and Heidrick, 1976); upper crustal blocks (generally including the mid-Tertiary volcanic and sedimentary cover) variably rotated and tilted on listric normal faults; and shallow-dipping detachment faults in places occurring on subjacent zones of mylonite. The mylonitic rocks exhibit profound ductile flattening, extension and shear (Crittenden and others, 1980; Reynolds, 1980; Rehrig, 1981).

In most areas, the extensional deformation was shallow and brittle. It was accommodated by intrusive dilation, and low-angle normal faulting. At certain localities, chiefly represented by the metamorphic core complexes, the orogenic strain was ductile, resulting in the mylonitic zones. In these areas, older, pre-existent low-angle metamorphic, mylonitic or thrust fabrics inherited from Mesozoic tectonism are observed as is the occurrence of mid-Tertiary plutonic bodies, occasionally of near batholithic proportions.

Genetic models have been proposed for the metamorphic core complexes. They vary from crustal boudins to ductile shear zones (Davis and Coney, 1979; Rehrig and

Reynolds, 1980; Wernicki, 1981; Hamilton, 1982; Davis, 1983). Whatever the explanation, their origin must be made compatible with the Cordilleran-wide burst of calc-alkaline. magmatism, crustal heating and attenuation, and the dramatic reduction or cessation of subduction processes along the continental margin from about 30 + to 18 2 m.y.B.P.

As is now well substantiated, both tectonic and magmatic regimes changed significantly during the interval 19 to 15 m.y.B.P. The change varied from place to place, so the interval is fairly broad. Structually the transition involved low-angle, listric faulting with relatively large horizontal displacements changing to steeper, planar(?), normal faulting with predominant vertical throw. Petrologically, intermediate, calc-alkaline magmatism changed to bi-modal, largely basaltic volcanism (Anderson, 1971; Rehrig and others, 1980; Reynolds, 1980). Tectonics later than 15 m.y.B.P. should be thought of as basin- and range-style and responsible for the elongate physiography which presently typifies much of the study region.

Metal deposits of Tertiary age are largely associated with processes of volcanism and extension. Curiously, the deposits appear to be more precious metals dominant than the base metal-ores of Laramide time. Tertiary mineralization occurs mainly as discrete, epigenetic veins cutting volcanic or older rocks. From cross cutting relationships, age dates on host volcanic rocks and a few mineralization dates (see Metallization section of report), the general impression is that most mineralization corresponded to the interval 30 to about 16 m.y.B.P. and is probably related to late stage, felsic(?), intrusve phases of volcanic cycles. An exception to this time scheme may exist in the Black Mountains area of Mojave

County and in the Searchlight-El Dorado area of Nevada where mineral-related intrusive rocks are younger than 15 m.y.

As will be dealt with in substantial detail further in the report, some Tertiary gold metallization is closely associated with copper in the setting of the metamorphic core complexes and their detachment faults. Although we will argue that some of the metallization and alteration in the detachment zone setting may be derived from processes of ductile deformation at depth (mylonites), the presence of gold appears enhanced in those occurrences where felsic intrusive bodies have invaded the faulted and brecciated horizons. Some of these intrusions may be relatively young (18 to 15 m.y.) and of rhyolitic composition. Elsewhere, mineralization is commonly structurally controlled by shallowly dipping listric faults, formed on the fragmented upper plates to possible detachment-like faults at depth. In lower-plate positions, copper-gold deposits in veins and fracture zones appear commonly associated with microdiorite dike swarms of 21 to 27 m.y. age.

With the possible exception of the Black Range-El Dorado area, there is little mineralization associated with post-15 m.y. volcanism. In other areas of the southwest Cordillera (i.e., the Mojave Province), gold mineralization is frequently found in hot spring of subvolcanic settings associated with <15 m.y. felsic intrusive centers. In the study region, however, volcanism of this age is generally basaltic and lacks much mineral occurrence or potential.

METALLIZATION

The discussion in this, the major sections of the report, deals with the regional distribution of precious metals in western Arizona, the detail of the various districts and mines, and the formulation of ore deposits models. Our regional conclusions come from an analysis of the geologic base map (Plate 1) with metals overlay sheets and the derivative "Metals-Related Structures and Lithologies" overlay.

Metals overlays were derived from a combined plotting of available CRIB-MILS data. Unfortunately, only Yavapai County has received an update for CRIB entries, thus leaving other counties with less than complete occurrence inventories. Combining available MILS precious metals localities with CRIB has, however, produced a sufficiently rigorous data base for the study. Combining precious metals with the "Other Metals" overlay, gives a comprehensive picture of mineral distribution through the study region and allows general associations to be made between mineral districts and tectonic elements or lithologies.

The District-Mine Focus section represents the results of an exhaustive literature analysis of precious metals, mines, prospects and districts. Because of the lack of regional assessment reports such as exist for Yuma County (Keith, 1978), considerable work was expended seeking out unpublished reports and records on occurrences in other counties (Arizona Dept. of Mineral Resources, file data). The authors' own field notes and personal experience were relied on in a number of areas. We feel confident that the district description

section is the most updated and comprehensive inventory available under one cover which treats precious metals, their geologic setting, historical production, competitor activity, etc. It should prove a highly useful reference for explorationists.

The formulation of deposit models was largely objective, falling out of our district and mine analysis. Some new insights regarding detachment fault mineralization are offered and a fascinating new Mesozoic deposit type characterized by syngenesis, metamorphism and thrust faulting is described.

Overview and Regional Distribution

This section briefly describes the most widespread distribution of metals populations through the study region. These distribution patterns are best seen using the tectono-stratigraphic base map in conjunction with the Metals-related Structures and Lithologies map (Overlay 4), the metals overlay sheets and the district map (Overlay 5). It can be noted in introduction, that few specific structures, such as individual faults or dike zones, can be correlated directly with metals deposits on the basis of the regional maps alone. The same can be said of specific lithologies. Such resolution does exist, however; its recognition has come largely as a result of the in-depth and comprehensive mine-prospect-district focus part of the overall project. The difficulties in seeing specific mineral controls from regional map data alone can probably be attributed to two main causes: (1) the lack of decent mapping (i.e. 15', 7½' quadrangle) throughout most of the study area, and (2) the relatively incomplete

status of CRIB-MILS computerized metal occurrence file data. Only one county in Arizona (Yavapai) has been recently updated by CRIB and one can obviously see from the metals overlays the results as a significantly increased population of occurrences.

Despite these encumbrances, study of the regional map series does permit some interesting general observations regarding the overall distribution of metals.

Areas of Metal Depletion

1. Southeastern part of study region (Lukeville, most of Ajo and southeast portion of the Phoenix 1° x 2° sheets): Generally the lack of metallization may be due to several factors: (1) the relatively extensive tracts of ground effectively closed to mineral entry (bombing ranges and indian reservation), (2) large areas covered by mafic volcanic flows of relatively young age, (3) a batholithic sized body or bodies centered in the Maricopa Mountains, of barren Oracle, 1.4 to 1.5 b.y. "granite." There are a few isolated base and precious metals occurrences scattered through the Ajo sheet. It is difficult to say whether or not uninhibited prospecting during the last 40 years would have led to a larger population of known prospects and mines. The total absence of mineral localities in the Ajo volcanic field north and northeast of the Gunsight Hills and Ajo, is not easily explained. Most of these rocks are not post-mineral (as is Tum and Qtb) and there are numerous small intrusive centers scattered through the field.

Of undetermined significance is the observation that the general northern boundary of the barren region corresponds rather closely with the Gila River lineament, a subtle, undefined, ENE-trending linear element which has been recognized for a number of years.

2. Gap between the Dome Rock and Castle Dome districts: Part of the mineral occurrence sparseness may be owed to the presence of military withdrawals. Mafic and felsic Tertiary (Oligocene-Miocene) volcanics make up most of the area. They are intruded by numerous dikes probably similar to those in the major Castle Dome district. It is thus curious why the northern Castle Dome Mountains and adjacent areas are so barren.

3. Gap between the Mohave and Cienega-Santa Maria-Rawhide districts: The southern part of this gap may be due to post-mineral volcanic and sedimentary cover. The Precambrian granitic and gneissic rocks to the north in the Bill Williams Mountains are anomalously barren of prospects as if the Crossman Peak detachment fault just to the north.

4. Southernmost Black Range (south of Oatman district): A fairly extensive post-mineral, basalt cover hides much of the mid-Tertiary volcanic rocks in this area. Also, whereas the Oatman and Union Pass districts represent volcanic centers with numerous vents, subvolcanic stocks and dikes, there appears to be much less of these features within the barren area to the south. This apparent barrenness should be qualified due to a few mine symbols (on topo maps) not recorded on CRIB-MILS maps plus the presence of a few NURE geochem anomalies flanking the very south end of the range.

5. Gap between Gold Basin and Wallapai districts, Cerbat Mountains: The Precambrian rocks of this relatively barren area occur with outcrops of Mt. Davis and Patsey mine volcanics. Contacts are depositional and low-angle faults or detachment structures. Although known metal occurrences are few, there are numerous NURE anomalies scattered through the area.

6. Barren areas along the northeast margin of the study region in elevated Precambrian basement terrain: Much of the wide gap between the Cottonwood and Eureka-Bagdad may be partly owed to the extensive cover of post-mineral Tertiary volcanic rocks. The Precambrian exposures west of this cover, however, are also usually deplete in mineralization. When compared to basement terrain to the south which is well mineralized, the cause of the gap may be the lack of Phanerozoic intrusion. These possible causes appear to also apply to the narrower gap in mineralization between the Crosby and Martinez-Weaver-French Gulch districts.

Areas of Metal Concentration

1. Southern Bradshaw Mountains (east half of Prescott 1 x 2° sheet): This regional has a greater concentration of base/precious metals than any comparable-sized area in the study region. Some of this enhancement may be due to the updated CRIB status in Yavapai County; however, much of the populous nature is felt to be geologic. Within the well mineralized area, there appear to be several diffuse belts of northeast trend where metal occurrences are most concentrated. The southern of these belts includes the Pine Grove-Tiger,

Minnehaha and Black Rock districts. A parallel belt may be present from Tip Top to White Picacho. Although Precambrian age, stratibound occurrences are present, it is of interest to note that the majority of the metals occurrence population is probably of Mesozoic-Tertiary derivation. Inspection of Plate 1 reveals that Phanerozoic plutons and dikes are also concentrated along these metalliferous belts, and are probably the cause for the belts definition. It is also evident that these belts roughly correspond with similar trending belt of Yavapai schist, suggesting that the metals are possibly being leached from this older source. Note that the Pine Grove-Black Rock belt can be extended to the southwest through the numerous occurrences in the Vulture and northwest Big Horn districts. This same southwest extension hosts the Laramide Wickenburg batholith belt with associated, northeast trending dike swarms.

Perhaps a similar, en echelon belt is present from the Martinez district on the southwest to the French Gulch district and beyond to the northeast. Certainly the NE-trending, Laramide belt through the Eureka-Bagdad district has had its effect on the populous distribution of metals localities in that area. From a very regional perspective, there may be some fundamental tie-in between these NE-trending intrusive metal belts through the basement and the anomalously NE-elongate foliation arches of the Harcuvar MCC. Note particularly the alignment of the Bagdad zone with the mineralized belt through the Rawhide and western Buckskin ranges.

2. Harcuvar metamorphic core complex (MCC): Nearly circumscribing the complex are populations of metals localities and districts. As is usual for MCC, the interior core portions, in this case represented by the Harcuvar and

southeasternmost part of the Buckskin ranges, are relatively barren whereas the detached margins are rich with occurrences (i.e. Cienega, Santa Maria, Alamo, Rawhide, Bullard and eastern part of Harquahala districts) The detachment fault or fragmented upper plate copper-gold mineralization extends into the Mojave region just west of the Cienega district where it is part of a broad zone of over 200 occurrences around the Whipple MCC (Ridenour and others, 1982). The scattered mineralization which is present in the core (Cunningham Pass) is related to swarms of Tertiary microdiorite dikes trending northwest through the metamorphic-mylonitic crystalline rocks. These dikes have exerted mineral (Cu-Au) influence in conjunction with Mesozoic thrust structures elsewhere in the lower plate; for example, in the Harquahala, Ellsworth and possibly Little Harquahala districts.

Note should be made of other probable MCC in the study region, principally the South Mountains and White Tank Mountains. Why are these so deplete in metals occurrences? Actually the South Mountain MCC has produced significant gold (Salt River Mountains district) but from lower plate rocks intruded by abundant Tertiary dikes. These dike swarms are prolific in the White Tank Mountains, but few metals occurrences have been noted. A major reason for the overall mineral scarcity in the South Mountain and White Tank MCC may be attributed to the lack of outcropping exposures of the detachment zones for these complexes.

3. <u>Southwest quarter of Phoenix 1 x 2° sheet</u>: A concentration of districts including the Gila Bend, Eagle Tail, Sheep Tank, Alamo Springs, Kofa and Tank Mountain areas are singled out mainly because of their general location along a broad, diffuse zone of WNW faulting. The faults definitely

have latest expression in the Tertiary, controlling dike emplacement and having lateral motion in the southern Plomosa Mountains (Miller, 1970). They appear to most closely relate to mineralization in the Sheep Tank and Alamo Springs areas. Although as late as Tertiary, a fundamental WNW structural direction is present through southern Arizonan basement which has been called the Texas Lineament. The fault zone appears to cross through the south end of the Plomosa and Dome Rock Mountains, but any ties in these areas with mineralization is undocumented.

4. Districts along the Colorado River from Plomosa Mtns. to Yuma: There appears to be no linear features of noteworthy regional extent that characterizes mineralization in the Plomosa, Dome Rock, Trigo, Silver-Eureka, Castle Dome, Laguna, Muggins, Laguna-Gila City, Fortuna or La Posa districts. In all these areas, Mesozoic metasedimentary/metavolcanic and plutonic rocks are present and Jura-Cretaceous mineralization related to syngenetic, metamorphic, plutonic and thrust-fault aspects of the rocks has occurred, as documented in the Plomosa and Dome Rock districts. There is, in addition, substantial Tertiary mineralization which commonly is lead-zinc-silver rich and related to subvolcanic (dike) or volcanic processes (i.e. Castle Dome, Eureka-Silver districts).

5. Black Range of Mohave County: The long, NNW-trending string of districts and deposits stretching from Oatman on the south to the Minnesota district in the north are generally part of a Tertiary mineralizing event attributable to volcanic and subvolcanic processes. The Black Range block

represents a highly fragmented and listrically tilted upper plate to detachment fault-metamorphic core complex terrain west of the Colorado River in southernmost Nevada. Numerous, low-angle listric structures commonly contain the mineralization. Curiously, the mineralization suites in the Black Range are significantly different from those surrounding the Whipple-Harcuvar MCC to the south. They are not hematite or copper rich. They have quartz-carbonate gangues with gold-silver ratios in the 1:1 to 2:1 range. Crossing the belt of districts, through the southern Oatman area is a strand of WNW-trending fault zones possibly continuous from the Bagdad-Diamond Joe trends to the east. Vein trends at Oatman reflect this WNW structural trend (Rehrig and Heidrick, 1976) along with the regional NNW-vein trend for the mid-Tertiary.

6. The Cerbat trend, Mohave County: From the Greenwood district on the south, through the Pine Peak, Diamond Joe, Maynard, McConnico and Wallapai district on the north, there is a distinct NNW-alignment. This overall trend parallels many of the veins found in the various districts. In the southern districts, the veins may be of mid-Tertiary age; however, to the north, Laramide aged mineralization appears to dominate. The heavy concentration of metals occurrences in the Wallapai district are thought to be a result of metal zoning around the Mineral Park porphyry copper-moly system of Laramide age (Thomas, 1949; Wilkinson, 1981). The Maynard and Diamond Joe districts constitute further examples of metals associated with Laramide porphyry-related hydrothermal systems. There is therefore a mesothermal, polymetallic vein character to this NNW mineral belt.

7. Districts along the eastern boundary of the Ajo 1 x 2° sheet: A population of metals occurrences is distributed through the Vekol, Cimarron Hills and Quijotoa districts on the Papago Indian Reservation. Although some of the mineralization in these districts is of mid to late Tertiary age, the striking, nearly total absence of metals localities to the west through the Ajo volcanic field is particularly difficult to explain. Mineralization in the various districts is variable as to type and age. Jurassic, Cretaceous and Tertiary plutonism and metal deposits are probably in the Quijotoa district and the Vekol district is chiefly a result of Laramide porphyry copper and polymetallic carbonate replacement deposition. Tertiary hydrothermal sites may be superimposed in certain areas.

District Focus

In this section of the report we have dealt with specific mining districts and areas where gold has been produced or where interesting clusters of prospects and occurrences exist. All of these districts are identified on Overlay 5.

We have attempted to provide brief descriptive summaries of these areas in terms of their location, geology (including aspects of mineralization) and history (including production figures), mines of interest, and pertinent references. Mention is made of exploration concepts thought to be deserving of attention in many of the individual districts.

The mines of interest part of this section has been considerably expanded from previous formats used in our NE Washington, Challis and Mojave projects. While not every district has properties described, we have made an earnest effort to include such data in the lesser known districts. Districts where we have excluded these data were usually ones which had abundant mine descriptions published in previous works. In such cases we felt that it would be as easy for the reader to refer to those references as to duplicate it herein. The exception would be where we may have come across a particularly intriguing property which we felt displayed unusual potential or fit a particular model.

Mines described under the mines of interest section may not all be "interesting" in an exploration sense. So little information is known about many of the gold producing districts in western Arizona that we adopted the policy of simply including descriptions of most, or all, of the mines where any information

was available in order to present the client with as much data as possible in these areas. While many of the described mines or prospects will not be of prime exploration interest, we feel that these data will be useful in toward understanding the nature of mineralization in these areas. This format should also prove useful during reconnaissance field studies by providing descriptions of properties that might otherwise be merely unknown prospect or mine symbols on topographic quad maps.

Because of factors which include past production, structure, mineralization and alteration, or stratigraphic criteria, many of the mines described in this section, do indeed possess characteristics warranting exploration interest. Since this project has been subscribed to by both small and large companies, small targets, or mines with small to moderate size potential, are described as well as areas which might be favorable for larger sized targets. The reader is encouraged to review all the mine listings to ascertain which might best fit individual company's target criteria. Many of these mines deserve reconnaissance examination and sampling during any systematic future regional exploration program. We feel we have provided enough target data to fuel a follow-up program for at least several seasons.

Certain districts or areas displaying the most geologically favorable or permissive terranes for precious metals are discussed under the Exploration-Target Delineation section of this report. These areas are also identified on Overlay 5. It is in these areas where exploration efforts should be maximized.

ALAMO DISTRICT

Location:

The district is rather ill defined geographically, but includes mineral occurrences in the easternmost Buckskin Mountains of La Paz County just south of the Bill Williams river near Alamo Dam. Most of the occurrences fall in R12 and 13W, T10 and 11N, within the Ives Peak 15' quadrangle.

Geology and History:

The Buckskin Mountains constitute part of the Harcuvar metamorphic core complex (Rehrig and Reynolds, 1980) with individual ranges being low-amplitude foliation arches of northeast-trend. The arches expose cores of mylonitic and migmatitic metamorphic rocks (quartzofeldspathic gneisses) and foliated plutonic rocks with gently dipping foliation and northeast striking lineation. Alaskitic, pegmatoid, 2-mica intrusive bodies are common to the gneisses. These rocks have been mapped previously as being Precambrian in age, however, reconnaissance mapping by Rehrig has shown that Mesozoic sedimentary rocks (arkose, greywacke) along the western boundary of the metamorphic core complex appear to become progressively metamorphosed possibly converting to granodioritic migmatized gneisses eastward into the core of the complex. In the area north of Ives Peak, the gneisses contain lenses and beds of tectonized marble, the less metamorphosed counterparts of which are found in "dirty" terrigenous sedimentary rocks occurring in the Mesozoic sections exposed in the Granite Wash Mountains and extreme southwest portion of the Buckskin ranges.

Bordering the mylonitic foliation arches in the eastern Buckskin Mountains is the classic mid- to late-Tertiary, low-angle detachment fault zone upon which tilted and disrupted redbed, conglomeritic and volcanic rocks of the Miocene Chapin Wash and Oligocene-Miocene Artillery Formations are found (Lasky and Webber, 1944, 1949). Chloritic breccias derived from the mylonitic rocks of the lower plate occur beneath the detachment zone. The Buckskin detachment fault flanks the Buckskin ranges on both margins of the Lincoln Ranch basin as well as outcrops very sparingly around the eastern nose of the arch (Figure). Northwest-trending, reverse-oblique slip faults such as the Lincoln Ranch fault post-date detachment faulting (Shackelford, 1976).

Mineralization in the Alamo district consists mainly of low-grade manganese deposits within the Chapin Wash Formation and small precious metal-copper deposits closely associated with the Buckskin detachment fault system. The gold-silver occurrences were worked as early as the late 1800's where shipments of ore running as high as 50 opt Ag and 0.26 opt Au reportedly were processed in a small mill in Reid Valley (Lincoln Ranch basin). Total estimated production from the district is about 824 tons containing 27 tons Pb, 22 tons Cu, 984 oz Ag, and 66 oz Au. In the area southwest of Alamo Dam, precious metal copper occurrences are found in brecciated or fault zones within mylonitic metasedimentary rocks of Mesozoic-Paleozoic (?) age.

Although production has been quite small from the district, the presence of the regional detachment fault in the Alamo area which has been occasionally prospected along its trace, upgrade the area as a grass roots exploration target. Mineralization associated with the metamorphosed Mesozoic-Paleozoic (?) sedimentary-volcanic section may also be present.

Mines of Interest:

Montana-Arizona mine: (T10N, R13W, Sec. 18) Oxidized copper-silver-gold mineralization in several fissure veins cut Mesozoic-Paleozoic (?) schists, gneisses and carbonate beds. Local high-grade gold pockets are reported, with ores generally averaging about 6% Cu, 0.8 oz Ag, and 0.1 oz Au.

Mystery Hill mine group: (T10N, R13W, Secs. 17 & 18) A cluster of workings in Mesozoic-Paleozoic (?) schist and thin carbonate beds cut by fissure veins along a silicified fault zone. One report cites the occurrence as a 5 ft wide blanket vein traceable for 400 ft. Copper carbonates and silicates are dominant with gangue of quartz, calcite and fluorite. Group produced over 500 tons averaging 3% Cu, 2 opt Ag and 0.1 oz Au.

Bernarde mine: (T10N, R13W, Sec. 19) Oxidized copper with precious metals values is concentrated along the Lincoln Ranch reverse fault which places mylonitic/gneisses above Chapin Wash redbeds. Mine produced some 138 tons of ore running about 1% Cu, 0.1 oz Ag, and 0.1 oz Au.

References:

Keith, 1978; Arizona Dept. Mineral Resources, file data.

ALAMO SPRINGS DISTRICT

Location:

The Alamo Springs district covers the northern part of the Kofa Mountains where they straddle the La Paz and Yuma County lines. Past references often refer to the district as the Alamo district which lends confusion with the Alamo district in northern La Paz County near the Bill Williams River. Most of the district is located in T1N and N 1/2 T1S, R16W. It lies within the boundaries of the Kofa Game Range and, thus, prospecting is restricted to patented claims and claims valid in 1974.

Geology and History:

The district is poorly known and has received little study. Jones (1916) visited part of the district and Wilson (1933, 1934) briefly studied the area. The oldest rocks exposed in this portion of the range consist of Mesozoic sediments that have been intruded by large bodies of granite which are currently thought to be of Jurassic age. The Mesozoic sediments are partially metamorphosed and consist of shale, sandstone, conglomerate and minor limestone (Keith, 1978). A thick section of mid-Tertiary volcanic rocks of andesitic to rhyolitic composition unconformably overly the Mesozoic rocks. These volcanics are part of the Kofa volcanic field. A large, northwest-southeast-elongate, subvolcanic plug of intermediate to rhyodacitic composition intrudes the volcanic rocks in T1N, R16W. Gently tilted to flat lying basaltic flows of late Miocene age cap the section.

The district lies along a pronounced structural zone that trends west-northwest through this region. This zone appears to consist of several separate strands that merge to form a zone from 10 to 20 miles wide. This feature must certainly represent a zone of fundamental weakness in the underlying basement; we would suggest it represents part of the Texas Lineament. This feature appears to control mid-Tertiary diking and intrusion, as well as the localization of mineral districts. The Alamo Springs district lies to the northwest and along the same strand of this zone as does the Sheep Tank mining district.

Mineralization discoverd to date in the district has been relatively insignificant; mostly associatd with fault or shear zones or with the Jurassic and Tertiary intrusions. Oxidized copper mineralization has been prospected in numerous placs in the plutonic rocks. Keith (1978) lists the Alamo and Alonak mine groups as examples of this type of mineralization. In 1957 and 1964 some 65 tons of ore averaging 1.4% Cu and minor Ag was shipped from these prospects (Keith, 1978). The mineralizaion reportedly consisted of small seams and veins of chrysocolla, malachite and copper oxides accompanied by sericite, epidote, chlorite alteration and magnetite. Numerous shallow prospects containing fine-grained free gold occur in major shear zones cutting the volcanic rocks and warrant investigation. While little actual gold production has occurred in the district, some small amounts of ore were very high grade (7 opt Au) and placer gold occurs in spots attesting to the disintegration of auriferous lodes. The northwest-trending shear zones that cut this region could offer an ideal setting in which disseminated gold deposits might form. Areas of silicification,

argillization, dike swarms and shallow intrusion should all be examined for any associated gold mineralization in this setting. A geochemical reconnaissance covering the entire transverse shear system displayed in this part of Arizona would be worthwhile. Ascertaining exactly what areas are open to mineral entry, however, must be the first order of priority in this district and contiguous areas.

Mines of Interest:

Geyser Prospect (Silent King): (NW 1/4 Sec 25, T1N, R17W; protracted). A N80° W trending brecciated zone in andesite porphyry that dips 45°S, can be traced on the surface for about 1.5 miles. On the Geyser claims the lode ranges in width from a few feet up to 60 ft wide, and forms a prominant ledge as much as 30 ft high for a distance of some 2000 ft. The ledge consists mainly of brecciated country rock replaced by silica. Calcite is abundant in the lode particularly on the footwall where many stringer and veinlets occur. Pseudomorphic quartz after calcite occurs in the hanging wall. Gold occurs free and is more abundant along the hanging wall where it is associated with FeO_x stained Kaolinized material. An iron-stained breccia streak reportedly carried high grade values. Developed by an inclined shaft 300 ft deep with workings on the 140 ft and 200 ft levels. This vein system should be explored using modern vein exploration techniques.

Rand Prospect: (NE 1/4 Sec 26, T1N, R17W; protracted). Located on the west end of same vein-fault system as the Geyser Prospect. At this locality, the lode is about 5 ft wide and consists of brecciated biotite andesite cemented by calcite with some iron-stained material from which gold reportedly can be panned. Breccia fragments are typically silicified and contain small nodules and veinlets of chalcedonic quartz. Some FeO_x after pyrite. Prospected by shallow shaft and drift.

I.X.L. Prospect: (W. Cen. Sec 36, T1N, R17W; protracted). Located near eastern end of the same system that contains the Geyser lode. Prospect developed by shallow inclined shaft driven on FeO_x-stained breccia zone in volcanic rocks cemented by fine-grained quartz. At this location the breccia zone is cut by latter calcite veinlets. Exploration of this prospect should be part of larger program to evaluate the entire "Geyser" vein system.

Regal Claims: (NE 1/4 Sec 36, T1N, R17W; protracted). Claims located on the south side of Red Raven Wash. Country rock of andesite porphyry and tuff is here cut by numerous gold-bearing veins and stringers of quartz and calcite that display steep dips. In places, quartz displays pseudomorphic replacement of calcite. Manganese oxides abundant in places. On Regal No. 1 claim an inclined shaft about 35 ft deep is driven on a 6 ft wide iron-stained and brecciated zone in andesite that trends N80°W and dips 45°S. This zone said to assay $8 per ton Au (1933 prices).

Cemitosa Prospect: (W. Cen. Sec 12, T1N, R16W; protracted). Located in Cemitosa Wash, a short distance from Cemitosa Tanks. Ten ft wide brecciated fault(?) zone trending N50°W, with a vertical dip, cuts andesite porphyry and can be traced for 1500 ft along strike. Brecciated zone displays FeO_x-staining and is cut by numerous veins and stringers of calcite. Fine gold reportedly could be panned from parts of the lode. Low-grade gold assays.

Ramshorn Claims: (N. Cen. Sec 31, T1N, R17W; protracted). Light colored tuffs and brown andesites intruded by an elongate body of andesite porphyry. The area is strongly cut by two sets of joints trending N35W and one that trends a little north of east. Breccia zones cut bedrock and are apparently gold-bearing in places. FeO_x-stained calcite occurs in some of the breccias. Showings are developed by shallow cuts, several shafts and tunnels.

C.O.D. Group: (SW 1/4 Sec 32, T1N, R16W; protracted). Gold-bearing(?) breccia zone in andesite porphyry trending N70°W exposed in several places along Red Raven Wash. Zone ranges between 10 and 40 ft wide and is partly silifified. Dump material on shallow workings display silicified andesite fragments, calcite and gouge.

Kofa Queen: (NW 1/4 Sec 8, T1S, R17W; protracted). Keith (1978) reports that in 1921 this property produced some 100 tons of ore averaging 0.8 opt Au and 1 opt Au.

References:

Jones, 1915; Keith, 1978; Wilson, 1933

BIG HORN DISTRICT

Location:

The Big Horn Mining District as used in this report essentially covers the Big Horn Mountains and the northern portion of the Belmont Mountains. It is contiguous with the Osborne district to the southeast and at times has been referred to as the Aguila district.

Geology and History:

Like the Osborne district to the south, the Big Horn district has received little detailed geologic study. Much of the region is composed of low, rolling, pediment covered hills that separate local patches of rugged topography. Much of the western portion of the district is underlain by Precambrian gneisses that resemble similar rocks from the nearby Vulture Mountains. This western portion of the district is separated from the Harquahala Mountains by a valley that roughly coincides with the projected trace of the Harquahala detachment surface. Most of the range is covered by mid-Tertiary volcanic rocks that range from andesite to rhyolite in composition. In places, the volcanics display considerable hydrothermal alteration. The volcanic pile is generally believed to be of a more felsic character towards the northeastern part of the district and of a more intermediate character in the central and southern portions of the district. A northward-trending septum, 1½-2 miles wide, of Precambrian schist generally separates the two areas. The exact nature of the volcanic field, however, is so poorly known that detailed study might considerably change the current geologic picture. The district is cut by pronounced, northwest-trending faults and Tertiary dike swarms. In places the dikes appear to be related to mineralization and probably mark exhumed source regions that fed the volcanic deposits. Low-angle Tertiary faults are also common in parts of the district and in places are mineralized with either Mn or Au. Portions of the Laramide Wickenburg batholith (see Vulture district, this study) poke out through windows in the younger volcanic rocks. These outcrops form a general northeast trend similar to, and on strike with, the batholith in the Wickenburg Mountains.

Mines in the district have been exploited for both gold and manganese. While both types of mineralization must in part be of Tertiary age, they seem to be mutually exclusive in any given mine. The manganese ores are the typical low temperature replacement and vein deposits that are so common to this part of Arizona. Several gold properties have had production in the district and some sampling was being conducted by a small Canadian firm in February, 1984, on the U.S. (Big Horn) mine. Keith and others (1983a) credit the district with 12,000 tons of gold-bearing ore that contained 2,800 oz Au; 1,000 oz Ag; 20,000 lbs Cu; 6,000 lbs Pb; and 65,300 tons of manganese ores that contained 42,457,000 lbs of Mn.

Access to many parts of the district is very poor and thus it would seem that the area could hold some potential for undiscovered ore deposits. The volcanic rocks in particular, appear to be of prospecting interest for low-grade disseminated deposits. Reconnaissance geochemistry and aerial surveillance for alteration zones is recommended.

Mines of Interest:

U.S. (Big Horn, Furlough, Hauxhurst) Mine: (Sec. 1, T4N, R8W) This is a very interesting mine that has had some early production. Mineralization consists of gold-bearing, quartz-specular hematite-copper oxide veins and veinlets that form a ribbon stockwork across parts of a major north-northwest-trending dike-like intrusive body of rhyolitic composition. Most of the early exploration and mining activity appear to have concentrated along the margin of the dike with the Precambrian basement. Much of this dike (which is over 1 mile long and 100 ft wide) is highly fractured, silicified and mineralized, and a large tonnage, low-grade target can be easily envisioned. The deposit was located in 1900, and ten claims (Furlough 1-10) were patented in 1916.

During this time a substantial tonnage of gold ore is reported to have been shipped to the Humboldt smelter. This early ore apparently occurred as enriched streaks and bands that varied between 2 and 10 ft in width, that were separated by less intensely mineralized material. The old workings exploited two main brecciated zones that were about 300 ft apart. Each zone ranged in width between 10 and 50 ft. The zones are highly silicifed and thus provide excellent outcrops that can be traced for about 1 mile.

Development consists of two vertical shafts, 480 and 500 ft deep, respectively, that are about 300 ft apart. From these shafts numerous crosscuts and drift were run, mainly on the 100 and 200 ft levels. Both shafts reportedly remained in oxidized material to their bottoms. Additional short shafts and tunnels also dot the area. Just before the Vulture mill closed down at the beginning of WW II, a Wickenburg resident trucked and milled about 4,500 tons of dump material from which $4.50/ton Au and 0.50-0.75% Cu were recovered. At this same general time, 16 carloads of ore were shipped to a smelter and reportedly returned a net of $5.50-$12.00/ton. A small bench where a 8 ft wide band of ore was mined in the 1950's, reportedly averaged 0.68 opt Au. Although the shafts have been inaccessible for a long time, a U.S. Bureau of Mines engineer report dated in 1943, indicated that sampling along a 100 ft drift on the 150 ft level produced averaged results of 0.16 opt Au and 1.3% Cu. Unsubstantiated reports from old miners indicated that the gold content increased slightly with depth. This writer has briefly examined the property on the ground and there is obviously potential for several million tons of low-grade material present. According to a Mining Record article (2-8-84) the patented claims are presently held by a joint venture between a Canadian firm, Roddy Resources Inc., of Vernon, B.C., and Black Consulting Inc. of Parker, Colorado. Roddy conducted preliminary sampling and mapping early in 1984. A limited drilling project was supposedly planned for May, 1984. The mineralization is interesting as it is very similar in character (i.e. quartz-specular hematite-FeOx-oxide copper) to that which is associated with nearby metamorphic core complexes. Sampling by Roddy (G. Belik, personal commun., 1984) indicated that the mineralization was strongly anomalous in tungsten (up to several hundred ppm).

Watson (1968) reported that SW of the mine, Precambrian schist is criss-crossed by a large number of tuffaceous dikes which were believed to be feeders for the ignimbrites that cap the geologic section in the area. This would be an interesting area to geochem for low grade gold values.

El Tigre Mine: (Secs. 27 & 34, T5N, R9W) At the Tigre mine, a flat, lensoidal quartz vein occurs which pinches and swells, and is surrounded by highly sheared material from Precambrian host rocks. The Precambrian gneisses are granitic and amphibolitic much like those that occur in the Vulture Mountains. The quartz vein appears nearly conformable to the foliation in the gneisses. This foliation strikes northeast, and dips variable up to 40° to the northwest. The quartz vein and adjacent sheared gneisses contain considerable iron staining, occasional Cu oxide stain, and apparently carry considerable gold. The geometry of the vein is shallow dipping (nearly flat), apparently in arch form, and outcrops near the top of a ridge. It has been eroded off on two sides. Prospecting in deeper shafts at N and S ends of the vein beneath the shallower mineralized zone reportedly cut two separate veins, but little or no production was made from them.

The deposit was discovered in 1914 and was reportedly most active between 1918 and 1924. During 1921, Wilson and others (1967) report that some bullion was produced in a 10-stamp mill located about 3.5 miles west of the mine. Ore was also run in 1922. The production for 1923 was reported as $14,454 in gold (±725 oz). Total production figures are not available.

Ore consists of massive to coarse-grained quartz with abundant specularite and limonite. Wallrock alteration consists mainly of sericitization. Wilson reports that most of the production came from drifts and stopes which extend for a few tens of feet into the vein. The orebody was thought to have had a maximum width of 5 ft. A 1925 mining engineer report housed in the ADMR, estimated blocks of probable ore in the mine as follows: 1 block of 26,300 tons average $20/ton, 1 block of 12,000 tons averaging $49.00/ton and another block of 3,500 tons averaging $30.00/ton. If these figures are anywhere close to being correct, then it seems that a small tonnage of fairly high grade ore could remain in the ground. A few hundred yards to the east, the gneisses are marked by occasional sulfide quartz stringers, some cutting foliation at low angles and some conformable to foliation. A composite sample taken through this iron-stained side of the hill indicated anomalous gold.

Pump Mine: (Sec. 21, T5N, R9W) Country rock consists of schist and granite that form relatively level to rolling pediment surface. The vein strikes approximately east and west and dips to the north at about 46°. The granite host rock is said to contain bands of schist running about parallel with the vein. Upper workings display oxidized ores while ore in the lower levels is not oxidized and the gold is associated with sulfides of iron, copper, lead and zinc. The main development is a 320 ft incline shaft with levels at 18, 75, 100 and 175 ft. A total of 390 ft of drifting has been done from the shaft. Shafts to the east and west of the main shaft show a strong, well mineralized vein. Ore reportedly breaks well with strong walls. The vein has been prospecting for 4,000 ft on the surface by a number of shafts and numerous open cuts. Up to 1936, very little systematic mining had been done. The mill was run for a short time in 1936-37 and then closed because of poor recovery when sulfide ores were run. During the five months the mill operated, it was estimated that the heads ran about $12/ton. The mine was examined during the war years by the U.S. Bureau of Mines engineers, who granted a DME loan on the basis of indicated or proven reserves. The loan was spent establishing a 4.5 mile

long pipe line, storage tanks, pumps, etc. The RFC took over the property in 1942 to protect its loan. Only a small part of the ore reserves were reportedly mined.

Big Horn Copper: (Sec. 36, T4N, R9W) A group of 43 was claims staked around 1968 and prospected in the early 1970's. Claims cover an area of sheared, coarse- to medium-grained, gray to reddish granite. Sparse copper oxide mineralization occurs in N45°E flat dipping shears and fractures. Veins range from several inches to 2.5 ft in widths. South of an east-west ridge, some thin, fissile, carbonaceous schist and reddish quartzite reportedly crop out. Schist reportedly is cut by copper bearing pegmatite and jasper veins. Area is prospected by dozing. Assays reportedly range from 10% to 30% Cu and from trace to 38 opt Ag (must be high grade sample).

References:

Arizona Dept. Mineral Resources, file data; Keith and others, 19831; Metzger, 1938; Watson, 1968; Wilson and others, 1967; Wilson and Rehrig, unpubl. data and field notes.

BLACK CANYON (KAY) DISTRICT

Location:

The Black Canyon district covers a N-S elongate area that is about 18 miles long and 8 miles wide in E-W direction. The area occurs between the eastern foot of the Bradshaw Mountains and the Agua Fria River; and stretches from the Maricopa County line northward to the vicinity of Cordes.

Geology and History:

Much of the district lies to the north of the project area. Only part of it will be discussed here. The district follows a narrow N-S trending belt of Yavapai schist that is intruded on both its west and east sides by Precambrian granite. The eastern edge of the schist is separated from the granite by a 2000-5000 ft strip of diorite thought to be a border phase of the granite. Tertiary volcanic flows cover much of the eastern and southwestern margins of the district. Lindgren (1926) discussed 5 types of mineral deposits occurring within the district; these include: (1) Precambrian base-metal massive sulfide deposits, (2) Precambrian iron formation, (3) Precambrian gold-quartz veins, (4) younger low-angle precious metal veins believed to be related to rhyolite porphyry dikes, and (5) gold placer deposits.

The Yavapai schist in the Black Canyon district straddles the Shylock fault zone; a highly controversial feature that juxtaposes contrasting protolith lithologies within the schist along its length. Some people suggest that this zone resembles a "growth" fault or major "break" like those that occur in the greenstone terranes of the Canadian Shield. The fact that stratiform massive sulfide deposits (i.e. Exxon's Kay deposit) occur in the district along with Precambrian gold-quartz veins, add interest this concept. This would seem like a logical place to search for stratiform, pyritic gold deposits.

The Precambrian quartz veins are described as occurring in both the schist and the granite. These veins consist of glassy quartz containing some sulfides, free gold and tourmaline.

The "flat" gold veins are interesting in that they are described by Lindgren (1926) as being very flat veins that cut "squarely across" the schistosity of the hosting Yavapai Series. Yet Anderson and Guilbert (1979) indicate that one of these deposits, the Golden Belt, is a distal sulfide-facies iron formation deposit. These "flat" veins carried from $5-$40/ton in Au (1926 prices) and from 1-10 opt Ag. The ores are oxidized near the surface; carrying abundant FeOx, some lead and free gold. At about 50 ft depths, galena and pyrite become abundant and gold occurs mainly in the galena.

The cross-cutting nature does not rule out their possible stratiform deposits. DeWitt (1979) showed that stratigraphy in similar Yavapai schist in the Mayer area cut across metamorphic schistosity. It is thereby possible that these glassy, cross-cutting quartz veins could be remobilized stratiform deposits.

The character of these deposits is a problem that needs to be resolved. If these deposits are distal stratiform exhalites, this region may indeed hold potential for economic stratiform lode gold mineralization.

Within the study area, however, the main lode gold mineralization consists of Precambrian veins that occur about 4 or 5 miles south of Bumblebee. Lindgren briefly mentions the Bianchiana, Nigger Brown and Gillespie properties as examples. High grade ores were treated in arrastres at the Bianchiana property; while the Nigger Brown mine was said to be developed by a shaft with ore shipped. The Gillespie mine produced about $80,000 in gold during the early days (Lindgren, 1926).

While the "flat" gold veins occur mainly 8-12 miles north of the project boundary we will briefly describe several of them because of their controversial nature and potential exploration significance.

Mines of Interest:

Golden Belt mine: (Sec. 1, T10N, R1E) The Golden Belt was originally located in 1873 and produced a few hundred tons of shipping and milling ore prior to 1916. The property was largely idle between 1916-1930. In 1931 to 1934, the property was reopened and the mill refurbished. In 1931, 134 tons of concentrates from 1,345 tons of ore were produced and 107 tons of smelting ore were shipped. Operations were continued through 1932 and 1933. The Golden Belt vein strikes approximately N60°E and dips from 10° to 23° SE. Host rocks consist of Yavapai schists that have been intruded by dikes of both felsic and mafic compositions. Lindgren (1926) suggested the vein probably fills a thrust fault. The vein ranges in thickness from a few inches to about 3 ft in width and carried from $5 to $40 in Au (1934 prices) and 1-10 opt Ag per ton. Oxidized portions of the vein contained FeOx, lead and some free gold. Below about 50 ft depth, galena and pyrite predominate, and the gold occurs mainly in the galena. Silver is said to decrease with depth. In 1934, the property had been developed by an 800 ft inclined shaft and several hundred feet of horizontal workings.

Silver Cord mine: (Sec. 12, T10N, R1E) The Silver Cord vein dips south or southeast at a dip of less than 20°, and is traceable through six claims. The vein contains gold, silver and some pyrite, galena and chalcopyrite. Wilson and others (1967) state that the deposit was operated for several years, and twenty or thirty carloads of shipping ore was produced. In 1912, 224 tons of ore containing $40.67 a ton in Au, Ag, Cu and Pb was reportedly shipped. The Old Brooks (American Flag) mine, one of the property on the Silver Cord vein, shipped 12 carloads of ore that ran $75-$18 per ton. A small production from the Silver Cord was also obtained between 1925-1930.

Golden Turkey mine: (Sec 1. T10N, R1E) The Golden Turkey mine is located a few hundred feet south of the Golden Belt property and may be a continuation of the same. Bedrock consists of Yavapai schist whose schistosity strikes northward and dips nearly vertically. The Golden Turkey vein strikes northeastward and ranges in dip from 30° to less than 10°SE. The vein is described by Lindgren (1926) as occupying a fissure zone that probably resulted from thrusting. On

the surface the vein ranges from a few inches to more than a foot in width and in places forms a branching lode several feet wide. Vein filling consists of coarsely crystalline, glassy quartz together with abundant irregular masses and disseminations of pyrite, galena and sphalerite. Chalcopyrite occurs locally. Gold accompanies the sulfides, particularly the pyrite. Alteration in the vein's wallrocks consist of intense sericitization, silicification and in places contain disseminated metacrysts of pyrite.

By 1934, the mine was developed by a 500 ft inclined shaft and about 2000 ft of horizontal workings. Most of the ore was said to have been taken from below the 350-level, particularly where the vein flattened in dip. Oxidation extends to about 250 ft on the incline. No production came from the mine until 1933, when more than 4,000 tons of ore were run through the Golden Belt mill. The mine was more or less in continuous production from 1933-1942. An unpublished report by old-time mining engineer J. S. Coupal in 1942, states that net smelter returns for the Golden Turkey up to 1941 were $1,148,053, and that production from the Golden Turkey extension (Ex. Golden Belt) had been about $300,000; for a total of $1,448,000 for the combined properties. Metal values from the Golden Turkey were the following percentages: Au 60%, Ag 35%, and Pb 5%. In 1939 and 1940 when much of the ore was coming from lower levels of the mine, the Pb and Zn content in the mill concentrates ran as high as 24% and 25%, respectively. Coupal described the vein as a "blanket" type with a normal dip of about 14°SE. The vein was reportedly continuous throughout the property's 60 acres. The very flat nature of this deposit makes one wonder if modest tonnages could be bulk mined from surface pits following the trace of the vein.

In the late 1970's and early 1980's a small Canadian (?) company (Alanco, Ltd.) was evaluating the potential for processing the Golden Turkey tailings. Their work indicated that some 171,144 tons of material averaging 0.027 opt Au and 0.44 opt Ag were contained in the tailing pile. The property is presently held by Minerals Trust Corp. of Phoenix, Arizona (100 W. Clarendon, Suite 1260, 85013).

References:

Arizona Dept. Mineral Resources, file data; DeWitt, 1979; Lindgren, 1926; Wilson and others, 1967.

BLACK ROCK DISTRICT

Location:

The Black Rock mining district covers an area of approximately 30 square miles centered on the ghost town of Constellation (Monte Cristo mine) in extreme southern Yavapai County. The major portion of the district covers the northern part of T8N, R3W and the southern part of T9N, R3W. The area is accessible by 13 miles of dirt and gravel roads from Wickenburg.

Geology and History:

The geology of the Black Rock district is relatively complex and poorly studied. The only geologic study of any consequence in the district is a master's thesis by Nichols (1983) who mapped several square miles surrounding the Monte Cristo mine. This district discussion is drawn largely from her work.

Deeply weathered Precambrian granitic gneiss and mafic schist make up basement in the district. The granitic gneiss produced a whole rock rubidium-strontium age of 1734 Ma (Nichols, 1983). Nichols believed the gneiss had an igneous protolith. The black schist is an enigmatic rock type and occurs as lenses and pods up to several hundred meters in length in the mafic schist. This schist locally grades into amphibolite and is also thought by Nichols to have an igneous protolith. Nichols interprets these rocks as a granitic pluton that prior to metamorphism had been intruded by mafic dikes from surrounding volcanic centers active during mid Proterozoic time.

The basement gneisses and schist are cut by a regional-scale pegmatite diking that occurred in late Proterozoic time (Jahns, 1952). These pegmatites have been mined for rare-earth metals in the nearby White Picacho district several miles to the south.

Northwest-trending dikes of Tertiary (?) microdiorite and rhyolite cut the Precambrian basement and are believed to be feeders to mostly eroded volcanic rocks similar in age and petrology to those found in the nearby Hieroglyphic and Vulture Mountains. The dikes were intruded along a zone of parallel, northwest-trending faults that mimics the trend evident in many other mid-Tertiary vein and dike systems found across western Arizona. Nichols (1983) believes a rhyolite vent occurs in Slim Jim wash, north of the Monte Cristo mine.

Epithermal quartz veins containing copper, gold and some silver have been emplaced along the same fault zones as the microdiorite dikes. Veins commonly contain brecciated dike material and the richest veins are usually those that evidence the greatest dike involvement (Nichols, 1983). In addition to the epithermal quartz veins, an unusual silver-nickel-cobalt-arsenide deposit occurs at the Monte Cristo mine (Bastin, 1922; Nichols, 1983). This deposit saw much promotion in the early 1900's because of discovery of a small, but very high-grade, lens of native silver in 1911. Bastin (1922) compared it to

the native silver ores of Cobalt, Ontario. Nichols (1983) study indicated that the Monte Cristo deposit is unrelated to the other ore deposits of the district. Its ore petrology, mineralogy and trend are completely different from the other veins in the district and are suggestive of a Precambrian origin.

Intense sericitically altered quartz monzonite porphyry of unknown age was encountered at 268 meters in a drill hole on the Monte Cristo property (Nichols, 1983). What relationship, if any, this rock has to the mineralization in the district is unknown.

Mining activity was carried on in the Black Rock district as early as the 1870's, but most production apparently occurred in the early 1900's. Keith and others (1983a) list recorded production between 1902 and 1976 as amounting to 40,000 tons containing 9,700 oz Au; 110,000 oz Ag; 400,000 lbs Cu; and 444,000 lbs Pb. Hewett and others (1936) noted the district was worked as early as the 1870's and had produced about $400,000 prior to 1904. Based on figures cited by Wilson and others (1967) this writer would estimate total gold production from the district as about 11,125 oz; the Gold Bar (O'Brien) and Oro Grande mines being the largest producers.

Mines of Interest:

Oro Grande Mine: (Sec. 24, T8N, R5W) Located about 1 mile east of the Hassayampa River and 4½ miles by road north of Wickenburg, the area was prospected for copper and silver in the 1870's. In 1900, a 10-stamp mill was installed, 340 ft shaft sunk and several thousand feet of development work completed. The workings produced 8,600 tons of ore averaging $5.32 in gold (± 27 opt) in 1904. Mineralization occurs in fractured and brecciated nearly vertical fault zone that strikes N37°E. In places this zone is greater than 100 ft in width and is cut by transverse, narrow and irregular veins and stringers of white quartz along which occur pseudomorphs of limonite after pyrite. The principal orebody mined was apparently irregular in shape and several tens of feet in maximum widths. This zone was discontinuously stoped between the 200 ft level and the surface. Ore consists of brecciated country rock cemented by brown to black limonite, calcite and coarse glassy quartz. Free gold occurred as ragged particles mainly in the limonite associated with the quartz. Wilson and others (1967) report that considerable amounts of low-grade, gold-bearing material was exposed by the drifts that explored the breccia zone E and NE of the stoped area. This property appears to hold good potential for considerable low-grade (±.10 opt Au) tonnage remaining across the wide breccia zone. It should be thoroughly examined and sampled.

O'Brien (Gold Bar) Mine: (NE¼ Sec. 33, T9N, R3W) About 15 miles northeast of Wickenburg the deposit was located in 1888; a 10-stamp mill was erected in 1091 and reportedly treated some 4,000 tons of material that yielded $60,000. In 1907-08, Interior Mining and Trust Co. reported to have erected a 100-ton mill and mined the orebody from the surface to 385 ft level on the incline. The 1907 production was listed as $33,402 in bullion and concentrates; 1908 production from the district is reported to have been $91,749 in gold; the

largest producer being the O'Brien mine. Shaft was eventually sunk to the 700 ft level. The O'Brien vein occurs within a fissure zone that strikes N70°E and dips shallowly (30°) NW. Vein fillings consist of coarsely crystalline quartz that in the upper oxidized zone is rather cellular, containing cavities filled with hematite and limonite after pyrite. Pyrite is present in the deeper levels. Gold occurs as fine to medium coarse particles both in the quartz and in the iron minerals. Wallrocks supposedly display intense sericitization. The main orebody was chimney shaped, about 40 x 50 ft in cross section at the surface and plunged 30° SW. During war years, U.S. Bureau of Mines engineers noted 10 shafts, 37 cuts, 19 tunnels, and one winze on a 100 ft wide vein about 3,000 ft long containing good surface showings of copper. The good gold ore apparently occurs as shoots in the larger vein structure. This wide structure should be looked at in terms of low-grade ore or additional smaller high-grade reserves.

Groom (Milevore Copper Co.) Mine: (Sec. 12, T8N, R3W) The property was prospected for copper in the early 1930's by means of a 500 ft shaft and considerable diamond drilling. Mineralization occurs in two parallel trending veins, some 250 ft apart that strike N20°W and dip near vertical. Veins are traceable on the surface for more than a mile. Vein fillings consists mainly of hematite, limonite, quartz, locally abundant chrysocolla, malachite and copper pitch. The easternmost vein displays the strongest mineralization and is generally 3 to 6 ft or greater in width. It pinches out in places and is accompanied by an altered dike of intermediate composition. Some siliceous gold ore was produced from the property in the 1930's. Fine grinding was required for adequate recovery. The ratio of gold to silver in bullion produced was about 7 to 3.

George Washington (Loncar): (Sec. 33, T9N, R3W, about 13 miles northeast of Wickenburg) Property consists of seven unpatented claims. A vein up to 5 ft wide, dipping about 62° is traceable over several claims by its bold quartz outcrop. Workings consists of a 150 ft crosscut tunnel to the vein, a 55 ft incline shaft, a 65 ft raise and a lateral on the tunnel level. This work is on the George Washington #3. Faulting with some displacement has taken place. As of 1936, there was nothing that could be called ore reserves. Only gold values are considered in this occurrence, although there is some Ag and Pb present. At the time the property was examined by USBM engineers in 1936, it was believed that 7500 tons of $14.70 ore (@ 1936 prices) could be developed over a width of 4 ft. Considerable work was done on the vein. Where worked, the vein narrowed and was as a whole uncommercial. There are occasional concentrations of Pb ore.

Unida: (Sec. 8, T8N, R3W) In granite cut by andesite, a vein up to 4 ft wide follows a small andesite dike. This vein dips about 60° and has spotty gold values with small amounts of copper near the surface. Development consists of three adits connected by raises, totalling about 1,575 ft. Lowest tunnel is inaccessible. Some stoping has been done on the two upper adits. Five samples taken by USBM engineers (1943) over an average width of 28 inches gave weighted averages of 0.11 Au, 2.25% Cu, 62.5% silica. When examined by USBM engineers, it was estimated that no more than 500 tons of ore existed in the

mine. Owner later claimed he had developed 15,600 tons of ore. Small production is recorded. Ore consists of malachite, chrysocolla, some dark gray copper sulfide, probably chalcocite, and traces of chalcopyrite, together with minor values in gold.

Black Rock Mine: (SW¼ Sec. 33, T9N, R3W) This property discovered about 1900 was developed by a Canadian concern as a gold property. Some years later when Canadian currency was frozen for operations outside the Dominion, work stopped. Principal workings are an inclined shaft with side drifts. Ore is oxidized material in a porphyry dike which shows some sulfide at the bottom level 435 ft down. It is reported that 20 samples taken prior to 1943 from the mineralized porphyry dike averaged $18.00 in Au and 5% to 15% Cu. Width was given as 46 inches. A 1,000 ton test mill run in 1907 gave $3.36 per ton (gold at $20.67). Little information is available on the character of the ore. The group consists of three patented and several unpatented lode claims.

MGM No. 1: (Sec. 25, T8N, R4W) Barite occurs in a low-angle fault zone with volcanic breccia on the hanging wall and altered granite on the footwall. USBM engineers visited the property in the 1940's (?). The following information is based on their report. The zone strikes north-south and dips 20°W. The known length is 50 ft, the width 4 ft, and the depth 25 ft. It has been explored by a 60-foot bulldozer cut, 8 ft deep, along the outcrop, and a 50 by 100 ft bulldozer stripped area above the outcrop. No production has taken place and no ore reserves could be estimated. No work was being done when visited. Barite may form 20% of the material within the fault zone (no mention made of any assays run for Au or Ag).

Selle: (Sec. 26(?), T8N, R4W) From Wickenburg, the property is reached 4.5 miles up the Constellation Road, then right one mile, then first road to left for 15 miles. A vein reportedly is traceable on the surface for 1,800 ft and is 10 inches or so wide. It parallels a hornblende dike 40 to 50 ft wide, carrying copper minerals. An assay from the bottom of a shaft on the vein showed 6.1% Cu and $14.60 in Au (@ $35/oz). Three lode claims make up the group with chalcocite, chalcopyrite and malachite carrying gold.

Keystone: (Secs. 9 and 10, T8N, R3W) A vein 1 to 2 ft wide reported to be developed by a 400 ft shaft with levels at each 100 ft. Examined by USBM engineers in 1943. Ore is said to be about 2% Cu carrying some gold and silver. Workings are inaccessible but there is nothing to indicate that a worthwhile tonnage of copper can be produced. It should be noted, however, that USBM engineers were looking for war scare metals and little attention was paid to Au and Ag.

Garcia (Pearl): (Sec. 12, T8N, R3W) Ore occurs in a vein about 1 ft wide. Prospect was worked for its gold content but owners claim ore shipped went 3% Cu. A 30 ft shaft near the edge of the wash has been filled with wash material. There is also a 40 ft tunnel on the vein. In 1943 there was apparently nothing that could be classed as shipping ore in sight. Two claims make up the group.

Arizona Copper Belt Mining Company Mine: (Location inexact; a short distance northwest of Monte Cristo mine) Workings include three shafts, 200 to 300 ft deep with some several hundred feet of workings on a narrow vein that strikes S65°W and dips 45°N. Small production of gold-bearing copper ore in 1912 and attempts were made to develop gold ore on the property in the 1930's.

Monte Cristo Mine: (NW¼ Sec. 4, T8N, R3W) Rather extensive workings explore 3 to 6 ft wide vein that trends N2°W and dips 52°W. Nichols (1983) reports that coarse-grained barite, quartz and calcite (in decreasing order of abundance) constitute the majority of the vein material. Bastin (1922) notes three ore types in the mine: chalcopyrite ores (containing chalcopyrite and some tennantite, siderite, calcite and pyrite); chalcopyrite ore with magnetite and hematite (and some siderite, calcite, quartz and pyrite); and rich silver ores which contain cobalt, nickel and arsenic. The deposit (vein?) trends considerably different from other veins in the district and is considered for this reason and its unusual mineralogy to be possibly as old as Precambrian. If this is true, then one must wonder about the possibility of it being syngenetic with its Precambrian host rocks. In 1974, the mine was dewatered and retimbered by Southcan Mining Ltd. of Vancouver, B.C. This company conducted a program of underground mapping, sampling and diamond core drilling through 1979. Nichols (1983) reports this data to be very incomplete, ambiguous and not of much use. Callahan Mining Corp. of Phoenix reportedly relogged some of Southcan's core. The present status of the property is unknown.

References:

Arizona Dept. Mineral Resources, mine file data; Bastin, 1922; Nichols, 1983; Wilson and others, 1967.

BLACK ROCK HILL DISTRICT

Location:

The area consists of low hills forming a near connection between the Little Harquahala and Eagle Tail Mountains in La Paz County (T3N, R13W). The I-10 freeway passes through the area. The Black Rock Hills are found in the central part of the Hope 15' quadrangle.

Geology and History:

Predominant rock types include Mesozoic sedimentary and variably metamorphosed rocks, Jurassic (?) or Precambrian porphyritic quartz monzonite, and Tertiary lamprophyric dikes. The porphyritic quartz monzonite is highly sheared, chloritic and resembles the probable Jurassic pluton in the Sore Fingers area of the southeastern Little Harquahala Mountains (Rehrig, unpubl. field notes). On Hill 1597, approximately 1½ miles west of the Salome Emergency Airfield (see Hope 15' quad), the quartz monzonite forms the footwall of a low-angle fault (thrust ?) which places a Mesozoic (?) sedimentary sequence of poorly sorted arkoses and slope breccias on the hanging wall. The sedimentary beds dip northeastward toward the west dipping thrust. The granitic rocks of the lower plate are cataclastically deformed for 5 to 20 ft below the fault (Rehrig, unpubl. mapping).

The long, northwesterly-trending ridge of the Black Rock Hills is a hogback of clastic Mesozoic rocks dipping southwest. They may be faulted eastward onto the arkosic-slope breccia mentioned above.

In Section 18, T3N, R13W, the porphyritic quartz monzonite is cut by numerous, high-angle, quartz veins ranging in width from a few inches to 2 ft. The veins carry copper as chalcopyrite. Their gold content is not known. The veins trend NNE to NE, similar to the prevailing strike of copper-gold veins in quartz monzonite porphyry at the Rio del Monte mine in the Little Harquahala district. In the northeast quarter of Section 18, the Hilltop mine produced a small tonnage of lead-silver ore.

References:

Arizona Dept. Mineral Resources, file data; Rehrig, unpubl. field notes.

BOUSE DISTRICT

Location:

The metal occurrences east and northeast of the small community of Bouse on State Route 78 in La Paz County have been traditionally included within the larger Plomosa mining district to the west. In this report we split off those mineral occurrences in the Bouse Hills for separate discussion. Actually, there are no precious metals occurrences on our map overlay falling in the Bouse Hills. The district is described here merely because of what we feel may be favorable geologic factors. The Bouse district is covered by R16 and 17W, T7N, and is mapped as part of the Utting 15' quadrangle.

Geology and History:

The geology of the Bouse Hills is very poorly known. The Arizona county maps show the northeast portion of the hills to be made up of Mesozoic granitic rocks. These are dioritic to granodioritic in composition. A biotite K-Ar age of 16 m.y. was obtained for the granodiorite (Shafiqullah and others, 1980), but is possibly a reset or cooling age. A large area of mid-Tertiary andesitic volcanic rocks occur west and southwest of the plutonic rocks. Recently the contact between volcanics and the granitic rocks has been found to be depositional (Spencer, 1985, personal commun.). A single traverse through the range by Rehrig a few years ago indicated that there are small exposures of Mesozoic (?) sedimentary rocks poking out from beneath the Tertiary volcanic cover.

A number of prospects and small mines occur within the volcanic rocks of the Bouse Hills. Most appear to be manganese occurrences such as the Black Bird or Black Hills mine groups, where manganite, psilomelene and pyrolucite occur in fractures and breccia zones with calcite. A few of the prospects, such as the Barber Gene mine (Sec. 13, T7N, R17W) produced barite and fluorite from northwest-trending, high-angle fault and fractures zones. Copper oxide mineralization is reported, but no data is available as to any precious metals values. Despite this lack of precious metals in the Bouse volcanic rocks, the possibility of detachment or low-angle structures and possible exposure windows into Mesozoic rocks make the environment favorable as a grass roots exploration area.

References:

Arizona Dept. Mineral Resources, file data; Keith, 1978.

BULLARD PEAK DISTRICT

Location:

Bullard Peak-Bullard Pass area is located in southwest Yavapai County at the east end of the Harcuvar Mountains. The Bullard mine, the most noted property in the area, is found in Section 11, T8N, R10W (Smith Peak 7½' quadrangle). Access to the area is via dirt roads from U.S. Highway 60 in the Aguila area.

Geology and History:

The Bullard mineralization occurs within a fairly thick sequence of mid-Tertiary volcanic and epiclastic rocks which have been highly tilted on listric faults and a basal detachment fault wrapping around the southern and eastern flank of the Harcuvar Mountain foliation arch (a portion of the Harcuvar metamorphic core complex, Rehrig and Reynolds, 1980). These supra-crustal rocks strike WNW obliquely into the ENE-striking, shallowly south dipping detachment surface. The Bullard volcanic sequence dips steeply southward and vertical attitudes can be measured in places.

The Tertiary volcanic-sedimentary section has been radiometrically dated at various places along the prominent northwest-trending range running from the Harcuvar range to the Aguila Valley. Dates range from 24 to 17 m.y. (Brooks, W.E., 1984, unpubl. data). Dates less than 20 m.y.B.P. are felt to represent thermal and metasomatic resetting with eruption ages probably falling into the range 20-25 m.y. The rocks consist of interlayered, ferruginous arkosic sandstones, boulder conglomerates, basaltic andesite to latite lava flows, and an occasional rhyolite or rhyodacitic welded tuff. Metamorphic rock beneath the detachment surface consists of strongly mylonitic quartzo-feldspathic gneiss, intruded by pre-deformational leucocratic-pegmatoid sills and dikes and post-mylonite microdiorite bodies (Rehrig, 1982). In the immediate area of Bullard Pass, the thick, tilted, red-brown conglomeratic rocks of the upper plate rest in unconformable contact against non-mylonitic Precambrian basement which is separated from the mylonitic lower plate by the silicified and brecciated detachment fault dipping 35° south (Rehrig, unpubl. mapping).

Mineralization in the area is typical of that found regionally controlled by detachment and listric faulting in upper plate Tertiary rocks adjacent to the metamorphic core complexes. The mineral assemblage is quartz, carbonate, hematite, manganese oxides, and production has been for copper and gold. This assemblage occurs in relatively simple fissure fillings or horse tail structures emplaced either in listric faults dipping north or nearly bedding conformable, antithetic structures dipping south. The host rocks consist of iron- and manganese-stained clastic or volcanic rocks of mid-Tertiary age.

The Bullard deposits were worked prior to 1912 as is evident from early consultant reports (see references below). Bancroft (1911) referred to the Bullard mine as having been mined earlier by the Yuma Copper Company, but the

property was idle when he examined it. A 1944 notation from Arizona Dept. of Mineral Resources refers to 60 years of sporadic production and USBM drilling in which three of four drill holes intersected the ore zone. Two thousand feet of mine development are cited at the time.

At the Bullard mine, the copper-gold deposit is a simple fault-fissure vein cutting a basaltic andesite or basalt flow. The width of the structure varies from 1½ to 9 ft and it is traceable on the surface for several hundred feet along strike. Early reports indicate ore averaged 3-4% Cu and $7-$8/ton gold (@ $20/oz). Reserve estimates ranged from 5,000 (USBM, 1944 as "indicated') to 34,000 tons. From 1935 to 1944, the mine is reported to have produced 17,792 tons. Vein mineralogy consists of quartz and calcite with minor hematite and epidote. Past production was mainly from oxidation products of copper (chrysocolla, tenorite, cuprite) which carried gold. Vein material shows brecciation and cementation by silica.

From a modern perspective, it appears that occurrences in the Bullard area are of a detachment-listric fault setting and are strictly of rather small scale vein dimensions with limited tonnage potential. At the Bullard mine, grades in gold were in the range of 1/3 oz so, it might pay to investigate structural or lithologic factors which might contribute to the delineation of larger tonnages than would be represented by single veins say of 1-5 ft ore widths. In the Bullard Peak area, brief inspection of the main detachment fault showed silicification, brecciation, superimposed quartz veining and evidence of sparse, disseminated sulfides in a few exposures (Rehrig, unpubl. mapping). Possible exploration target strategy therefore in this area consists of mapping out the mineralized upper plate structures and pursuing favorable intersections, either in upper plate position or at the detachment zone itself.

Mines of Interest: Bullard mine (see description above).

References:

Bancroft, 1912; Spurr files, Univ. of Wyoming archives; Arizona Dept. Mineral Resources files.

CASTLE CREEK DISTRICT

Location:

The Castle Creek district is located in southern Yavapai County and historically covers the drainage area of Upper Castle Creek (mainly T8N, R2W). For purposes of this report it will be extended to the southeast to encompass the area surrounding the Castle Hot Springs down to the Maricopa County border.

Geology and History:

Like much of the southern border of the Bradshaw Mountains, the Castle Creek district has limited published geologic information available. Lindgren (1926) described the major mines in the district and Ward (1977) reported on the geology in the Castle Hot Springs region. Wilson and others (1967) briefly mention the district and the Golden Aster mine in particular. Satkin (1981) evaluated the geothermal potential of the Castle Hot Springs. Jahns (1952) has described the geology in the nearby White Picacho pegmatite district.

The Castle Creek district straddles the transition zone between the Basin and Range and Colorado Plateau physiographic provinces. The general stratigraphic sequence in the district consists of a basement of Yavapai Series schists derived from a protolith of volcanic and sedimentary rocks. Proterozoic granites and pegmatites intrude the schists and in places make up most of the exposure. Ward (1977) notes that highly altered dikes of andesitic composition, probable Cretaceous or early Tertiary age, in places cut Precambrian basement. The Castle Hot Spring volcanic field of Miocene age (Ward, 1977) unconformably overlie the Precambrian rocks. The volcanics are thickest in the Castle Hot Spring area south to the Maricopa county border. These rocks lie within a NNW- to NW-trending graben that is believed to be volcano-tectonic in origin (Ward, 1977; Satkin, 1981). The graben consists generally of a faulted and tilted series of volcanic rocks that separate Yavapai Series schists to the southwest from Precambrian Bradshaw granite to the northeast (Ward, 1977; Sheridan and others, 1979). The graben structure in the Castle Hot Spring area is controlled by regional NW-SE-, NE-SW-, and NS trending normal fault sets (Ward, 1977). Steeply dipping, en echelon normal faults trending NW-SE are contemporaneous with graben formation and suggest NE-SW Tertiary extension. Minor NE-SW trending faults are believed to reflect inherited fabric in the underlying Precambrian basement. The NS-trending faults are youngest and cut both older fault sets and may be related to Basin and Range tectonism (Ward, 1977).

The lowermost part of the Castle Hot Spring volcanic field consist of a sequence of basalts and rhyolitic tuffs, 300-450 m thick, that unconformably overlie the basement rocks. Alkali olivine basalts form the lowest member of this volcanic sequence. As basaltic volcanism waned, rhyolitic volcanism took its place producing lava piles and widespread ashflow tuffs. The rhyolitic lavas are generally confined to the southern portion of the field (Ward, 1977) where dome complexes are recognized. A thin basalt flow caps rhyolitic section and marks the end of the basalt-rhyolite volcanism in this area. A sequence of

interbedded lahars and latite flows overlie the basalts and tuffs and are the youngest igneous rocks in the district. Thick accumulations of these latites occur near vents such as Hells Gate, Crater Canyon, and probable vents at Four Tanks Canyon, Buckhorn Mountain and Garfias Mountain.

Structurally, the region is characterized by normal faulting and tilting with a consistent rotation of blocks toward the northeast (Satkin, 1981). This rotational faulting with blocks repeatedly downdropped to the southwest is consistent with the regional NW to NNW structural graben in this part of the transition zone. Faulting and tilting extend with progressively less effect toward the northeast from the Vulture Mountains through the Castle Hot Spring area nearly to the Bradshaw Mountains (Satkin, 1981; Rehrig and others, 1980).

Argillic and sulfataric alteration is widespread in these volcanic rocks and Ward (1977) describes several such areas in his study. In the southern portion of the district, the most severe alteration occurs immediately west of Big Hells Gate and Cedar Basin and is locally referred to as Bitter Creek alteration (Ward, 1977). At this locality, the rocks are complexly faulted and have been severely altered by hydrothermal fluids. Ward notes the Bitter Creek area is pock-marked by prospect pits and littered with old claim posts. In Garfias Wash near Cedar Basin the latites display much argillic alteration and contain disseminated pyrite. Low topography developed along AD wash has resulted from differential erosion of altered volcanic rocks in this area. Fountain-like deposits of opaline silica and chalcedony occur at several localities on Hells Gate Mountain. A large dike of silica sinter is reported by Ward to extend from Ramon Tank for about 0.4 km northwest along Bitter Creek. In places this "dike" stands 12 m above the topography and is in excess of 30 m wide. It apparently fills a fault zone. These areas should be looked at and sampled with the idea of possible disseminated gold mineralization in mind.

Shafigullah and others (1980) noted that biotite latite porphyry dated by K-Ar methods at 17.98± 0.43 in the Buckhorn Mountains is hydrothermally altered and sulfide bearing in several areas.

Economic mineralization in the district is largely restricted to veins cutting the Precambrian rocks. Lindgren (1926) notes that several types of veins occur in the district, including: 1) gold-copper veins, deeply oxidized, with chrysocolla and specularite and in places carrying gold and silver (i.e. Swallow, Whipsaw, Jones and Copperopolis mining properties); 2) gold-quartz veins such as the Lehman (Golden Aster) mine; and 3) lead veins exemplified by the long vein that trends westward from Copperopolis. Lindgren also notes that a few placers were also worked in the district, the best occurring in American Gulch north of Brigg's ranch. The gold-copper veins are notable in that they characteristically contain bright blue chrysocolla intergrown with radiating plates of specularite. Dale (1961) describes several tungsten properties hosted by Yavapai schist in the Castle district. While there is no mention of gold with the tungsten occurrences, Dale's description of the schist host rock is interesting. In at least two of the prospects this schist is described as magnetite-rich and at the Joyce K Group the host rocks are banded, magnetic,

dark-colored schist which in the mineralized zone consists of "altered" bands of schist composed of epidote, quartz and calcite which carried some scheelite. This particular locality would seem to warrant some attention to determine whether the schist represents some form of metamorphosed chemical sediment (i.e. iron formation) which may also carry gold.

Lindgren (1926) suggests that gross production up to that time amounted to less than $500,000. Keith and others (1983) credit the district with some 2,500 tons of ore that contained 1,400 oz Au; 1,500 oz Ag; 115,000 lbs Cu and 12,000 lbs Pb.

Mines of Interest:

Lehman (Golden Aster) Mine: (Sec. 27, T9N, R2W) Property is located on a granite ridge about 1-1/8 miles north of Copperopolis (Wilson and others, 1967). A low-angle vein system strikes N10°W, dips 25°W, cutting Precambrian granite. The deposit is made up of at least three closely spaced parallel and branching veins containing glassy quartz with limonite, tourmaline and in places coarse gold. Early ore was packed by burro to a 5-stamp mill on Spring Creek. Small production was achieved in the early 1930's. The deposit was developed by shallow shafts and at least 1,000 ft of tunnels and raises. This occurrence should be investigated. The branching parallel vein network could possibly have resulted in development of a low grade situation outward into the wallrocks. If this has happened, then the shallow dip of the vein might lend itself to surface mining.

Swallow (Buzzards Roost) Mine: (SW¼ Sec. 6, T8N, R2W) Geology near the mine consists of Precambrian granite cut by dikes of andesite and granite porphyry. Several gold-bearing veins on property contain chrysocolla and hematite. Main vein strikes N10°W, dips 70°E and has been developed by a 225 ft shaft. Best ore consisted of copper stained rusty mass with chrysocolla and copper pitch and was reported to have contained 1 to 3 opt Au. This material was milled on the property with a 10-stamp amalgamation mill. The first 1,000 tons mined, plated $60/ton Au (±3,000 oz Au). Gold values got lower with depth. Water was hit at 225 ft depth and hampered development below this level. Assays at this depth were claimed to have run $21/ton Au (± 1 oz). Ore ran 3-15 ft in width but averaged closer to 6-8 ft. Typical vein material was said to average 2% Cu and $5/ton Au (@ $20/oz Au). In some places, ore shoots contained 5-8% Cu associated with bands of specular hematite and calcite. Gold is mostly associated with red hematitic material. Footwall of the vein is granite with a hanging wall of porphyry. The ore is reportedly contained in the hanging wall. Work in the late 1930's and early 1940's indicated erratic gold values ranging from $2-$300/ton. A northern vein was said to be developed by a 300 ft shaft with much ore stoped over a 200 ft length. This vein strikes N33°W, and dips 60°E. Another vein located 100 ft north of this vein carried oxidized and platty specularite with chrysocolla, quartz, calcite and fluorite over a several feet width. This particular vein has been mined for its gold ore with free gold occurring in the well oxidized material. Lindgren reported that a specimen of bismuthinite was taken from this vein. ADMR files indicate that considerable gold ore was mined and shipped from the Moonlight mine lying south of Buzzard Roost Gulch. This was considered a southern extension of the Swallow vein and carried high copper with $22/ton gold values.

Whipsaw Mine: (Sec. 8, T8N, R2W) A narrow vein system 1-3 ft. wide strikes NS and dips 45°-60°W. Vein has a porphyry footwall and schist hanging wall. Vein carried chrysocolla, copper pitch (brown oxide), specular hematite and limonite. Gold occurs with copper in the oxidized material. Good ore ran about 12% Cu and 0.48 opt Au. Gold is reportedly visible in some ore. Highest gold values are thought to be confined to tiny stringers or pockets with average grades probably run much lower in gold. The country rock is mainly a mica schist with local intrusions of porphyry and patches of volcanic cover consisting of rhyolite and andesite flows, breccias and tuffs. Old reports in ADMR also mentions a coarse feldspar rock which may be a latite which occurs in this region. The vein is developed by a shaft a few hundred feet deep. A smelter was built in 1890 on Whipsaw Creek to treat ore from this property.

Joyce K Claims: (Sec. 14, T9N, R2W) The property is located on upper drainage of Ryland Gulch, a tributary to Castle Creek. This is an old scheelite property in banded, magnetic schist described in places as consisting of altered bands of schist composed of epidote, quartz and calcite containing sparse schist. This may represent a metamorphic skarn of an exhalative protolith. We would suggest some exploration in the narrow belt of schist exposed in the Castle Creek district.

Unnamed Prospect: (Location inexact, 1,000 ft north of Copperopolis on Copperopolis Creek) Lindgren's (1926) brief description seems to describe a stockwork deposit filling a zone (shear?) striking N60°W and dipping SW that is 100 ft wide. The ore reportedly consists of limonite and bright-blue chrysocolla. Some ore was shipped. Shaft and workings were developed in 1880, but were largely caved when Lindgren visited the property. There is no mention of any gold values in this deposit. Similar chrysocolla veins in the area, however, often contain good gold values. If this zone also contains low-grade gold, it could represent a bulk tonnage target.

Bitter Creek area: (Numerous prospect pits in area covering Secs. 1, 2, 11, 12, T7N, R2W) Ward (1977) describes the area as displaying hydrothermal alteration in the volcanic rocks covering this area. The gold and copper mineralization, he states, may or may not be related to this alteration. Area should be examined for possible hot spring type gold deposits. Also, the long "sinter" dike described by Ward near Ramon Tank on Bitter Creek should be examined with respect to it possibly representing an upper barren zone of a productive epithermal vein system.

Dahlia Group: (Sec. 2, T8N, R2W; west side of Walker Gulch) Group consists of tungsten claims staked in the 1950's. Bedrock consists of brown, thinly fissile, micaceous schist. A series of lenses or a single vein, composed of quartz, tourmaline, and sparse scheelite cuts the schist. The vein appears to be discontinuous. Masses of quartz and tourmaline crop out at two other spots not on strike of the vein.

C and W Claims: (Sec. 25, T9N, R2W; on saddle between Walker and Banty Creeks) Highly magnetic Precambrian schist (sedimentary protolith?) comprises basement. Schist is a few hundred feet wide and strikes NE. Some crosscutting faults have been prospected for tungsten.

Jonell Group: (Secs. 30 & 31, T9N, R1W) Sparse, sporadic scheelite occurs in short, narrow, discontinuous quartz stringers in a NE-trending belt of Precambrian Yavapai schist that is approximately 2 miles wide. These stringers are typically conformable with the strike of the schist. Only a few such stringers have been prospected.

References:

Arizona Dept. Mineral Resources, file data; Lindgren, 1926; Wilson and others, 1967; Ward, 1977; Jahns, 1952; Satkin, 1981; Rehrig and others, 1980; Shafigullah and others, 1980; Dale, 1961.

CASTLE DOME DISTRICT

Location:

The district is located in the southern portion of the Castle Dome Mountains in Yuma County. Most of the mineral occurrences, mines and prospects are clustered tightly in an area southwest of Castle Dome Peak along the western margin of the range (T4S, R18 and 19W). This area lies just outside the U.S. Army Artillery Range, but within the Kofa National Game Refuge. Generally, metals exploration in this district is severely hampered because of these land restrictions.

Geology and History:

The Castle Dome Mountains are similar in gross character to the Kofa Mountains. Both ranges contain extensive outcrops of thick (2000-3000 ft), mid-Tertiary, volcanic rocks dating in the 20-25 m.y. range (Logan and Hirsch, 1982; Dahm and Hankins, 1982). The silicic to intermediate tuffs and lavas of the Castle Dome range may represent outflow units from vents or caldera sources within the Kofa Mountains. The Tertiary volcanics cover a "basement" of probable Mesozoic metasedimentary and metavolcanic rocks. The contact of Tertiary rocks with metamorphics may be depositional in places but has been recently mapped as a low-angle detachment fault (see Plate 1) (Logan and Hirsch, 1982; Haxel, 1984, pers. commun.). In T5S, R17W, a small area of Orocopia schist has been recognized (Haxel, pers. commun.) which is also in detachment contact with Tertiary volcanics.

Specifically, the geology of the Castle Dome silver district is dominated by an intense NNW-trending dike swarm mapped in detail by Wilson, 1933 (Figure 6). The dikes are of dacitic (dioritic) and rhyolite compositions, the latter being somewhat younger. Age of dikes are 19 to 20 m.y. Note from Figure , that the volcanics of the main range are tilted moderately westward, presumably into the detachment contact with older rocks.

The mineral deposits of the district are chiefly argentiferous galena, fluorite, barite fissure veins cutting Mesozoic rocks and the abundance of Tertiary dikes. The veins are richest where hosted by the dacitic dike rocks in close association with quartz porphyry intrusive bodies. The veins trend parallel with the many dikes and are steeply dipping. They lense from a few feet to over 10 ft in width. At the surface, veins are marked by oxidized cappings of lead minerals along with weathered fluorspar, calcite and barite. The vein deposits are rich in galena with depth and contain little or no copper. Silver ores were extracted from individual ore chutes along the veins and workings were seldom taken below about 300 ft. Other minerals found in the deposits include hydrozincite, smithsonite, wulfenite, vanadinite, mimetite, quartz, calcite and aragonite.

Southwest of Thumb Butte a small district (Thumb Butte or Old Montezuma) yielded copper, zinc and lead mineralization with quartz-calcite veins. The Copper Glance mine was the principal producer.

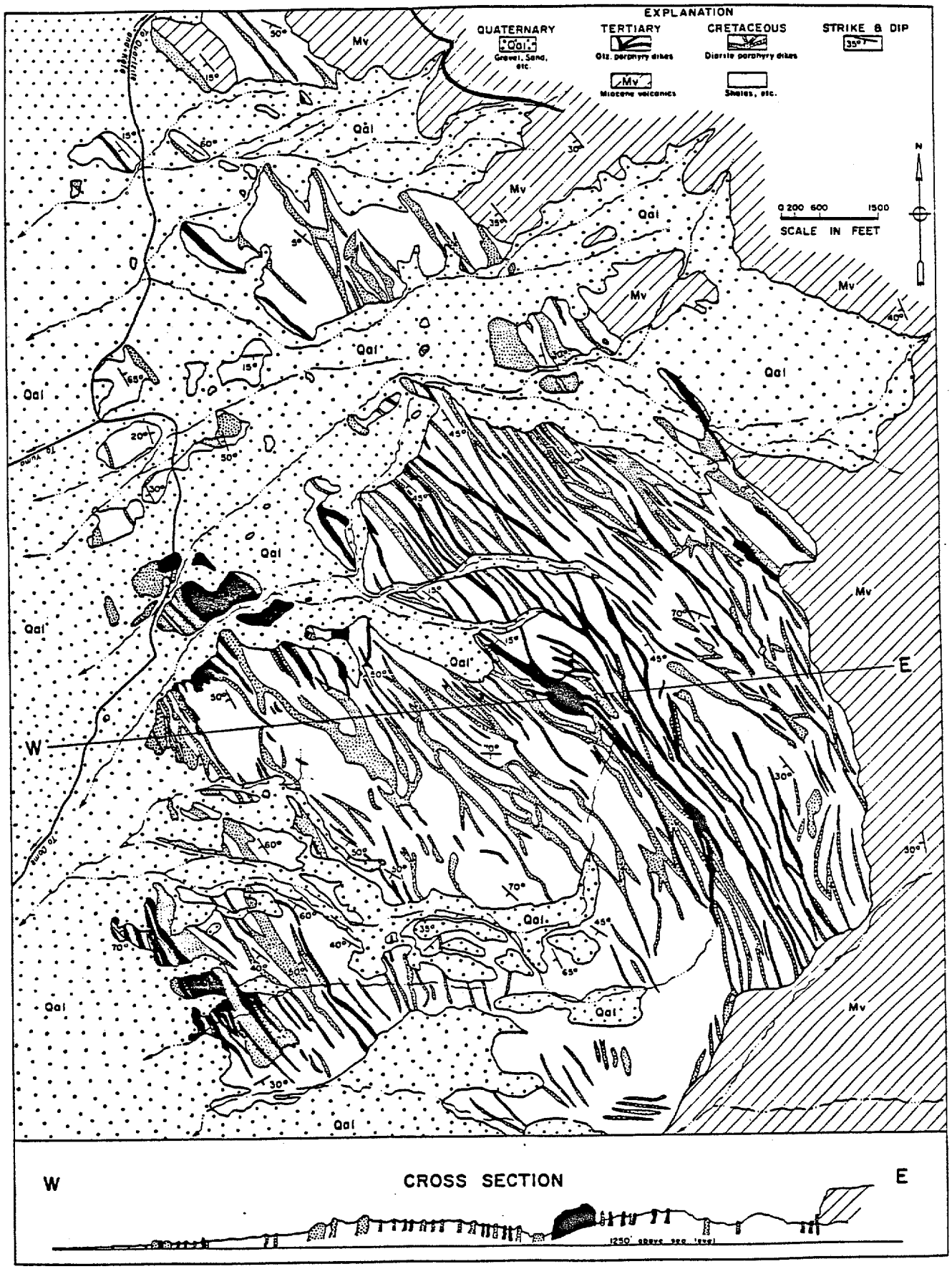


Fig. 8. Geologic map of the Castle Dome District, Arizona. (Redrawn from Eldred D. Wilson, 1930)

(From Logan and Hirsch, 1982)

Three miles east of the main cluster of Castle Dome workings, a deep canyon at the head of Big Eye Wash is the site of numerous, but small, gold-copper veins and veinlets with quartz. These deposits are the source for small gold placer deposits in adjacent washes. This mineralization occupies a probable detachment fault zone between Tertiary andesites and rhyolite dikes and shattered Mesozoic quartzites. A small stock has intruded the fault zone.

Total metal production for the district through 1974 would be estimated at 121,000 tons of ore yielding at least 10,697 tons Pb; 498,000 oz Ag; 2,000 oz Au; 38 tons Zn and 36 tons of Cu.

Mines of Interest:

Big Eye, Outlook and Lookout mines (T4S, R18W, Sec. 34) Gold, silver and oxidized base metal mineralization occurs in shattered Mesozoic quartzite along a detachment (?) shear zone with hanging wall of steeply tilted and argillized mid-Tertiary andesites intruded by rhyolite. Note is made of a pre-mid-Tertiary syenite body occurring along strike of the mineralized zone. Properties produced about 2,370 tons averaging 0.9 opt Au, 8 opt Ag, and minor Cu and Pb. Mineralized zone produced small gold placer deposits yielding a minimum of 7,000 oz gold.

Copper Glance mine (T5S, R18W, Sec. 19) Chalcocite, copper carbonates, minor lead-zinc and silver-gold in irregular calcite-quartz veins and veinlets cutting Mesozoic schist, shale, limestone and arkoses. Zone of mineralization is NS-trending and 20 ft wide. Silver enriched capping is found at the surface. Property produced only about 135 tons of ore averaging about 7% Cu, 11 opt Ag, and 0.1 opt Au.

Mable mine group (T4S, R18W, Sec. 31) Base and precious metals in pockets, and irregular masses in gangue of crystalline calcite, fluorite and minor barite occur in multiple fissure veins cutting Mesozoic shales intruded by dioritic and rhyolite dikes. Property only produced 200 tons from the 1880's, but ore averaged 0.2 opt Au and 8 opt Ag with 20% Pb.

Sheep claim (T6S, R17W, Sec. 15) An area in the southeastern end of the Castle Dome Mountains formally known as the Mofitt district exhibits numerous quartz veins yielding gold and, reportedly, lead. Only a few carloads of ore (unknown grade) have been shipped. The veins cut an altered biotite granite and there is extensive yellow brown iron oxides noted over the mineralized area.

The property lies rather isolated, several miles to the southeast of the Castle Dome district boundary on Overlay 5. It is #071 on the Precious Metals overlay. It is included as of interest because of the notable color-alteration anomaly seen by Rehrig on a recent plane trip between Yuma and Phoenix. Unfortunately, the property is currently on the Yuma Proving Ground.

The reader should note that the major Castle Dome mine group of workings of lead, zinc, silver have not been singled out for description. This is mainly due to the negligible gold content of the ores. Unfortunately, the location of the

overall district within the Kofa game range and its status as a Wilderness Study Area, severely downgrade the favorability of the region as a current exploration target region. Although the Big Eye mine area looks quite attractive and the nearby Orocopia schist and bounding thrust (?) detachment settings equally prospective, the overall land status of the Castle Dome region may prohibit any further metals exploration activity.

References:

Dahm and Hankins, 1982; Logan and Hirsch, 1982; Wilson, 1933.

CIENEGA DISTRICT

Location:

The numerous mines and prospects of the Cienega region occur in a relatively small area along the Arizona side of the Colorado River between the town of Parker and Parker Dam in northernmost La Paz County . The area could be considered in the westernmost part of the Buckskin Mountains. The area falls in T10N, R18 and 19 W, within the Black Peak 15' topo quadrangle.

Geology and History:

The geologic setting of the Cienega district is extremely complex structurally as well as lithologically. The complexities are due largely to the jumbled or chaotic conditions resulting from the superposition of Laramide thrusting and metamorphic effects with Tertiary listric and detachment faulting. Rock types include pre-Tertiary higher-grade metamorphic rocks and lower-grade metasedimentary assemblages, and small patches of plutonic or metaplutonic rocks. The gneisses and schists have previously been assigned a Precambrian age. They may, however, be a package of more intensely metamorphosed Mesozoic supracrustal rocks. The less metamorphosed carbonates and quartzites with recognizable Carboniferous fossils (Darton, 1925) are of Paleozoic age. Small exposures of a coarsely porphyritic, partially deformed (augened), quartz monzonite is complexly juxaposed against the metamorphic rocks. It is either of Precambrian or Jurassic age. Tertiary rocks include an older sedimentary (volcanic) sequence of Chapin Wash (mainly redbeds; named Copper Basin Fm. in California) which are complexly tilted on listric structures or angularly unconformable on older rocks, and a younger flat-lying sequence of <15 million year old fanglomerates and basalt flows (Osborne Wash Formation). Tertiary subvolcanic dikes, plugs, and irregular intrusions of pre- and post-Osborne Wash ages cut all lithologies in the area.

Structurally the area constitutes an upper plate assemblage above the Whipple-Buckskin detachment surface. Consequently, the rocks are shattered and brecciated everywhere and are cut by a myriad of normal and listric normal faults. Pre-Tertiary structure consists of a more ductile style of deformation, imparting foliated, metamorphic and thrust or fold-induced fabrics to the rocks. Low-angle contacts between Paleozoic and Mesozoic lithologies are in part thought to be thrust or fold controlled.

Mineral deposits, chiefly of copper silicates, carbonates or oxides that usually contain gold and minor silvers were discovered and worked prior to 1900. Production records for mines such as Billy Mack, Sue and Quartz King date from 1870 to 1884. The district has produced intermittently through recent times, but no recorded production has been recorded since 1969. The Cienega district is noted for the rather consistent gold content to its copper ores, averaging about 0.6 opt (Keith, 1978). Total estimated and recorded district production is some 19,000 tons containing 917 tons of copper, 11,707 ounces of gold, and 3,364 ounces silver.

There has been little reliable data with which to fully assess the mineralization in the district. The several theses from the University of Missouri at Rolla which were done in the Cienega district do not supply the necessary perspective (Zambrano, 1965; Osborne, 1965; Al Hashima, 1965). Certain generalizations, however, do appear valid. Copper-gold-hematite mineralization occurs in a variety of lithologies ranging from the metamorphic gneisses and schists to Paleozoic (?) carbonate, to the Miocene Chapin Wash fanglomerates and intermixed volcanic rocks. The mineralization appears to favor the carbonate units, where replacement type deposits occur, commonly accompanied by considerable silicification. Mineralization in nearly all cases exhibits rigid structural control exerted by faults and fracture zones or their intersections.

Descriptions by Keith (1978) indicate that many deposits in the district are localized along one or more thrust faults. These structures appear to separate predominantly carbonate facies along the easternmost margin of the district from Precambrian (?) schists and metamorphic rocks farther west. Specifically the controlling structure places metamorphics, commonly referred to as schistose, micaceous quartzite on the upper plate from Paleozoic - Mesozoic rocks of the lower plate. The thrust fault(s) commonly strike northeast and dip northwest.

In summary and as noted from mine descriptions (below), we have a close-spaced cluster of deposits displaying remarkable similarities in mineralogy and structural character. The copper-hematite association is consistent and gold along with the commonly abundant presence of quartz is always present. Most all properties produced ore with gold running > 0.2 opt. The frequent reference in Keith (1978) to occurrences occupying thrust zones is of great interest because these structures are important ore localizers in many other districts of the study area (i.e. Harquahala, Ellsworth, Little Harquahala). Although the mineralization suite is typical of the detachment fault setting, it is curious that the low-angle structures have been called thrusts. Field checking is recommended to determine the specific nature of these structures, as well as to determine the size or size potential of the numerous showings. Descriptions of mines do not give sufficient details as to the size of overall mineralized zones, although it is assumed that higher grade bodies previously mined were rather small and discontinuous. There may be, however, considerable merit to the district if clusters of occurrences are considered collectively (see exploration section of report).

Mines of Interest:

Arizona McGinnis mine (T10N, R18W, Secs. 9, 16, 17) Oxidized copper mineralization that is gold-bearing occurs in stringers and replacement zones in metamorphosed Paleozoic (?) carbonates. The deposit occurs along and in the footwall below a flat shear zone (thrust ?) with hanging wall of quartz schist. Limited production of about 170 tons averaged 9% Cu, 0.6 opt Au, and 0.1 opt Ag.

Eagle Nest mine (T10N, R18W, Sec. 16) Copper-gold mineralization occurs in calc-silicated Paleozoic (?) and Mesozoic metasedimentary rocks along a thrust (?) structure with hanging wall of schist (Precambrian ?). Silicification and quartz veining is said to be prominent. Property produced some 4,000 tons of ore averaging 3.5% Cu, and 0.2 opt Au, with only minor silver.

Carnation mine: (T10N, R18W, Sec. 21) Mine occurs just below unconformity with Osborne Wash basalts. Mineralized zone projects beneath the post-mineral volcanic cover. Chrysocolla, malachite, azurite and hematite, with gold occur in irregular vuggy, siliceous replacement bodies in Paleozoic (?) carbonate lenses and along a well developed silicified thrust (?) zone of considerable width separating a
footwall of Paleozoic-Mesozoic metasediments from a hanging wall of quartz mica schist (referred to as Precambrian by Keith, 1978). Thrust structure appears to be the same as that controlling mineralization at Eagle Nest and possibly Arizona McGinnis mines. Both properties show strong quartz. Carnation produced some 8,000 tons of 4% Cu, 0.2 opt Au, and 0.05 opt Ag ore.

Golden Ray mine group (T10N, R19W, Sec. 24) Another thrust (?) controlled copper (oxides-carbonates)-gold occurrence along shear structure separating Precambrian (?) metamorphic rocks from footwall Paleozoic (?) rocks. Mineralization occurs mainly as stringers and replacement pods in the deformed footwall carbonates. Mine produced about 175 tons running 1.5% Cu, 0.56 opt Au and 0.2 opt Ag. This production came from only about 2 years work.

Billy Mack mine group (T10N, R19W, Sec. 14) Irregular pockets, seams and disseminations of oxidized copper minerals, specular and earthy hematite and free gold in cellular quartzose zones along a NE-striking, 45° northwest dipping contact between Paleozoic (?) carbonate and chloritic, micaceous schist. Contact reported to be a thrust fault by Keith (1978). Abundant siderite veinlets cut the carbonate footwall. Ore mineralization is said to be spotty and discontinuous (Bancroft, 1911), however, the mine produced 3,000 tons of material averaging about 4.5% Cu, 0.6 opt Au, and 0.2 opt Ag.

Lion Hill mine group (T10N, R19W, Sec. 25) Hematite, copper oxides and silicates and gold occur in highly fractured and folded carbonate and calc-silicated carbonate of Paleozoic (?) age. Mineralization is developed as bedding replacements and along normal faults which follow the axis of an anticlinal structure. Production noted as 700 tons averaging about 0.4% Cu, 0.2 opt Ag, and 2.4 opt Au.

Sue mine (T10N, R19W, Sec. 23). Copper-iron and gold mineralization in brecciated, quartzose zone cutting Paleozoic - Mesozoic limestones and schists. Chalcopyrite is reportedly replaced by supergene bornite, covellite and chalcocite. Hematite veining cuts the sulfides with the latest minerals being malachite, azurite and chrysocolla. Mineralized zones possibly localized by low-angle faulting (thrusts ?). Manganese also reported. Production reported as 400 tons averaging 3.5% Cu, 0.2 opt Au, and 0.1 opt Ag.

Capilano and Rio Vista Northside and Southside mines (T10N, R19W, Sec. 26) Gold, copper, hematite, mineralization with quartz along the fractures, faults and in brecciated silicified zones along faulted (thrust ?) contact between Paleozoic carbonate and overlying schistose quartzite. At the Rio Vista Southside property, parallel vein-like bodies of mineralization occupy a wide, near vertical shear zone in Paleozoic - Mesozoic metasediments, along an anticline. Rio Vista properties produced several hundred tons of material averaging about 5.8% Cu, 0.4 to 0.5 opt Au, and 0.1 to 0.3 opt Ag.

Mammon mine group (T10N, R18W, Sec. 34) Hematite, oxidized copper and minor gold occurs in a siliceous, quartz flooded zone along a high-angle shear zone between micaceous schists (Mesozoic ?) and a late Tertiary intrusive body. Some mineralization occurs as veinlets and replacements within the schist. The mine is surrounded by post-mineral sediments and basalts of the Osborne Wash Formation. Production from the property amounted to about 800 tons averaging 4.5% Cu, 0.07 opt Au and 0.16 opt Ag. U.S. Bureau of Mines report states that 6,000 tons of 3-4% Cu were shipped and that 1,200 to 1,500 tons of 5% Cu and $2 gold (@ $35/oz) are on the dump.

Arizona Pride mine (T9N, R17W, Sec. 4). Oxidized copper, hematite and gold in irregular veinlets, clots, breccia fillings, tabular bodies in lensoidal marble layers. Mineralization is controlled by fractures and faults along a low-angle thrust (?) placing Paleozoic carbonate over Precambrian (?) metamorphic rocks. Mine produced intermittently from the early 1900's, but with only a few tens of tons production averaging about 0.2 opt in gold.

References:

Bancroft, 1911; Darton, 1925; Keith, 1978; Osborne, 1965; Al Hashima, 1965; Zambrano, 1965.

CIMARRON HILLS (SALT WELL, GREENBACK) DISTRICT

Location:

The Cimarron Hills district encompasses an area lying south of the Vekol Hills that covers the Copperosity Hills, Cimarron Mountains and the Sheridan Mountains. The northwestern portion of the district lies in the extreme southwest corner of Pinal County. The majority of the district extends southward into northern Pima County. All of the district lies within the Papago Indian Reservation.

Geology and History:

The oldest rocks in the district consist of Precambrian Pinal Schist exposed in the northern and southern portions of the Cimarron Mountains. Rocks once mapped as Precambrian schists in the southern Sheridan Hills are now believed to be Mesozoic in age (see Plate 1). Paleozoic sediments occur in the Sheridan Hills, faulted against the Mesozoic metamorphic rocks. During the Late Cretaceous-Early Tertiary Laramide orogeny, the area was partially covered by volcanic flows and tuffs and intruded by a large composite (?) plutonic complex that ranges from quartz diorite and granodiorite to quartzmonzonite and granite. Rocks of this igneous complex are widespread in the northern and eastern Cimarron Mountains.

Large portions of the district are covered by lavas and tuffs that are part of the widespread Ajo volcanic field of mid-Tertiary age (Floyd and Miller, 1984). These rocks are mainly andesitic to rhyodacitic in composition in this portion of the field, except for the northeast trending belt of volcanics in the Copperosity Hills which are basaltic to felsic in character (see plate 1). Numerous dacitic to latitic plugs, dikes and sills intruded the older rocks penecontemporaneous with the Tertiary volcanic activity. This intrusive activity is related to mineralization in the Greenback mine area.

The character of mineralization in the district is fairly diverse. A large amount of the mineralization, particularly in the Cimarron Hills and Sheridan Mountains, consists of scattered, generally weak, base and precious metal showings along faults and fracture zones in both the older rocks and the Tertiary volcanics. These showings have only been productive for gold and silver in near-surface, secondarily enriched zones. Some of this mineralization may in part be of Laramide age.

Deposits in the northern end of the Cimarron range are more interesting and appear to be epithermal in nature. At the Greenback mine, gold-silver plus minor amounts of copper, tungsten, fluorine and molybdenum (?) mineralization is believed to be related to dacitic plugs and dikes of mid-Tertiary age (26 m.y., Theodore, personal commun., 1981). At both the Greenback and the Papago mines, low-grade gold mineralization is associated with shear or fault zones that display much silicification and abundant FeOx. Mineralization at both properties is dispersed across zones ranging between 40 to 200 ft wide.

In addition to the precious metals, the district has produced a considerable amount of manganese from replacement deposits of manganese oxides in brecciated Paleozoic limestone along fault zones and in fault breccia cutting Laramide intrusive rocks. Keith (1978) estimates manganese production of some 9,500 tons worth about $250,000.

Recorded precious and base metal production for the Cimarron Mountains part of the district amounted to some 120 tons of ore which yielded about 80 oz Au, 400 oz Ag, and about 11 tons of Cu (Keith, 1978). The Greenback mine area is credited with a production of 800 tons of ore which yielded 100 oz Au, 3200 oz Ag, and 2000 lbs Cu (Keith and others, 1983a).

For the company willing to attempt work on the Papago Indian Reservation, both the Greenback and Papago mines appear to be worthy of further examination and sampling.

Mines of Interest:

Papago Mine: (T10S, R2E, Sec. 8) The Papago mine was located in 1902. In 1926, the Papago Gold Mining Co. of Casa Grande was organized to test the property. This company did considerable surface trenching and shaft work which was still in progress in 1934 (Tenney, 1934). Basement in the mine vicinity consists of coarse-grained granitic rocks. Mineralization occurs in a large, prominent vein that is exposed on the surface for over a mile. This vein cuts the granite and consists of highly brecciated and silicified granite with numerous later veinlets (stockwork ?) of manganese and iron-stained calcite. The vein or shear zone strikes E-W, dips 40°-60°S, and is 40 to 150 ft wide. The quartz is reportedly much stained by FeOx and all samples indicated the general dissemination of finely divided gold and some silver mineral (Tenney, 1934). At the time of Tenney's writing, over 657 ft of exposure, surface trenching and sampling had been completed and trenching demonstrated continuity of values extending 1242 ft west and at least 1000 ft east of the proven ground. In the 657 ft of proven ground, a geometrical average value over an average width of about 48 ft of the footwall portion of the vein averaged $1.73 in gold and $1.05 in silver (Tenney, 1934). For the 1242 ft to the west, the average of scattered samples yielded about $1.81 in gold and silver, and the eastern portion of the vein yielded values from $1.28 to $3.86 in gold and silver from scattered samples. Several areas contained higher grades. In one spot, sampling across 40 ft averaged $5.42; in another area trenching over 50 ft in width averaged $4.08. (Note all samples were calculated using $35 per oz Au and 64½ cents per oz Ag).

The strength and width of this vein offers a very good bulk tonnage target. It seems likely that because of the relatively low gold-silver values that this mine probably never produced any material. Current prices could make this prospect highly attractive.

Greenback Mine: (T10S, R2E, Sec. 33) The Greenback mine is a highly interesting occurrence. Basement consists of Pinal Schist that has been intruded by a series of porphyry plugs, sills and dikes. Tenney (1934) states that the

porphyries vary widely in composition from diorite to quartz monzonite. More recent mapping of the area by the USGS (cf. Dockter and Keith, 1978) describe this rock as dacite porphyry ranging to diorite. Theodore (unpubl. data) has obtained a 26 m.y. age date on this rock. The mineralization is closely related to the porphyritic intrusions. Tenney describes two types of mineralization. The first type occurred after intrusion of the porphyries and involved partial shattering of this rock type. Hydrothermal solutions invaded the brecciated rock depositing veinlets of sericite and sulfides. Sulfides were also disseminated in the rock. Oxidation has produced a limonite-stained, kaolinizied, slightly copper-stained mass containing veinlets of chrysocolla. The first locations were made on outcrops of this mineralization.

The second type of mineralization succeeded the first and consists of silica flooding of a major fault zone that cuts the porphyry and strikes N70°W. The silification contains some pyrite and copper sulfides and low-grade gold mineralization. This mineralization is characterized by a network of quartz veins which strikes NW in a zone of intensely brecciated porphyry. The quartz is somewhat FeOx and CuOx stained and contains sporadic pockets rich in free gold (Tenney, 1934). Fractures cutting the quartz are filled by calcite with some MnOx and FeOx. This zone is about 3000 ft long and varies between 50 to 200 ft in width. The general dip is about 60°S. Individual veins within this zone range from 1 to 50 ft in width.

It is on this second type of mineralization that the Greenback and Pinal shafts (the two major workings in the area) were sunk on gold rich outcrops. The rich ore, however, was quite shallow, bottoming at 35 and 50 ft in the respective workings. The principal working is the Pinal shaft which was sunk to a depth of 688 ft on a 50° incline with levels driven east and west on the 50, 150, 300 and 500 ft levels. The Greenback shaft was sunk to a depth of 100 ft on a 40° incline. A small amount of drifting was done on the 100 ft level. In the Pinal shaft the gold seems to have been associated with pyrite and FeOx. The vein was probably faulted off in the Greenback shaft. The 100 ft level was driven entirely in country rock cut by numerous calcite veins dipping at various angles.

We would suggest that both the first type of mineralization and the wide fault zone should be tested for low-grade, bulk mineable Au-Ag values.

Unnamed Site: (Sec. 8, T11S, R13E; protracted) Briskey and others (1978) describe an ovoid breccia that crops out about 1 mile northeast of the town of Ventana. The breccia consists of angular to subangular, small to large fragments of Precambrian Oracle granite and Precambrian Y Apache Group rocks locally enclosed or surrounded by dense mats of anastomizing, milky-white quartz veins; some fragments are Tertiary intrusive trachite. Clasts and quartz veins are intruded by small dikes of Tertiary trachyandesite porphyry. The area display sporadic bleaching, clay alteration, and FeOx staining. No mention is made of any associated metals. The area should be checked for low-grade gold mineralization.

References:

Briskey and others, 1978; Dockter and Keith, 1978; Floyd and Miller, 1984; Keith, 1974; Keith and others, 1983a; Tenney, 1934.

COTTONWOOD (WALKOVER) DISTRICT

Location:

The Cottonwood mining district is located in Mohave County about 9 miles southeast of Hackberry along the edge of the Cottonwood Cliffs (T23N, R12W).

Geology and History:

The district lies along the northern portion of the Cottonwood Cliffs which are a continuation of the Grand Wash Cliffs and mark the western margin of the Colorado Plateau. In this region, the plateau is floored by Precambrian dark colored schists and gneisses that are intruded on the northwest part of the district by granites of Precambrian and Laramide age. The Precambrian rocks are overlain by lower Paleozoic sediments to the southeast of the district and by nearly horizontal volcanic rocks within the district. A northeast-trending dike swarm cuts the volcanic rocks and some of the Precambrian metamorphic rocks. Two strong fault trends are exhibited in the Precambrian basement rocks; one strikes northwest and the other strikes north-northeast generally parallel to the large normal faults (i.e. Grand Wash fault) that cut the Colorado Plateau.

The mineral deposits of the district consist of gold-bearing quartz veins in the granitic gneiss and schist. The district was not discovered until around 1907 and little detailed information about the deposits is known. The Walkover mine which has been the major producer of the district has been described by Wilson and others (1967). Their description of the mine indicates a mineralized vein occurring in medium foliated, dark-colored schist. No mention is made whether the vein cuts, or is enclosed by, the schist. This consideration is important as the mineralization is described as consisting of abundant banded sulphides (mainly pyrite, arsenopyrite and chalcopyrite) below the water table. This description makes one suspicious that the Walkover Mine might possibly be a massive sulfide occurrence. The ore ran quite high in gold (several carloads in 1934 ran between 1.00 to 1.29 opt Au) and makes the mine and surrounding area worthy of some additional investigation.

Hewett and others (1936) described the district production to that date as amounting to some $70,000 in combined metals. Keith and others (1983a) credited the district with some 13,500 tons of ore containing 3000 oz Au, 6,000 oz Ag, 457,000 lbs Cu and 500 lbs Pb.

Mines of Interest:

Walkover Mine: (Sec 30, T23N, R12W.) Vein strikes S25°E and dips 75°W in dark-colored Precambrian schist. Ore is oxidized to the 100-ft level and is accompanied by much iron oxide and some copper stain. Below the water level, ores consist of abundant banded sulfides consisting mainly of pyrite, arsenopyrite and chalcopyrite. Gangue of the vein is brecciated, glassy, gray quartz and altered fragments of schist. The vein is cut by several southwest striking faults and is

developed to a depth of 365 ft and for a maximum length of 200 ft south of main shaft. The vein has been largely stoped from the surface to the 100 foot level. Wilson and others (1967) indicated the width of the ore shoot ranged from 8 inches to 5 ft and averaged about 2 ft. The "vein" displays some characteristics of being a massive sulfide body syngenetic with the Precambrian schist. The high gold content of its ores indicate that this property should be looked at.

Big Ledge (Helen Claims): (Sec 33, T28N, R20W.) The Big Ledge claims cover a zone of red, brecciated and recemented, jasper. Mineralization is said to be chiefly Pb, Zn and Fe sulfides and carbonates that carry some gold and silver.

References:

Keith and others, 1983a; Schrader, 1909; U.S.A.E.C. Report RME-158.

CROSBY DISTRICT

Location:

The Crosby district covers a northeast-trending belt of scattered gold occurrences that lie immediately south of the Eureka-Bagdad district and west of Grayback Mountain in western Yavapai County.

Geology and History:

Like many districts in this part of Arizona, we have little information about the geology, mineralization or early production of the Crosby district. It appears that at one time it was considered part of the Eureka-Bagdad district which we have discussed separately. Metzger (1938) described the geology and mining activity at the Oro Bueno and Arizona-Homestake mines, and Wilson and others (1967) have discussed the Crosby mine.

From the meager descriptions it appears that the district is floored by a complex of granite, gneisses and schist of Proterozoic age (see Plate 1). Much of the granite is probably equivalent to the 1,400 m.y. old Lawler Peak granite which is widely exposed in the Eureka-Bagdad district to the north. Foliation in the Precambrian rocks mainly trends northeast and usually displays steep to vertical dips.

Descriptions of several of the mines in the district indicate that mineralization is mainly confined to narrow (?), northeast-trending, quartz veins that, in two of the three cases we have information for, dip at shallow angles to the east. Keith and others (1983b) suggest that the mineralization may be in or near a detachment fault. This suggestion undoubtedly comes from the descriptions of the low-angle veins. We are not aware of any detachment fault that has been recognized in this area. Core complex related detachment faults, however, do occur in the nearby Rawhide Mountains to the west and in the Harcuvar Mountains to the south, and so the possibility of a detachment in this area cannot be completely ruled out.

The veins were mainly gold producers although some silver, copper and lead was also produced. Wilson and others (1967) report that a small shipment of ore mined from the Crosby in 1931 averaged more than 1.7 opt Au. Metzger (1938) noted that assays at the Arizona-Homestake property ran up to $47/ton and that a considerable tonnage of $8-$10 ore appeared to exist at the property. Recorded district production between 1901-1957, from USBM files (Keith and others, 1983a) amounted to 9,800 tons of ore which yielded 5,000 oz Au; 4,700 oz Ag; 21,000 lbs Cu; and 8,500 lbs Pb.

Mines of Interest:

Crosby (Nieman) Mine: (T13N, R8W, Secs. 4 & 9) Narrow quartz vein (1-18 inches wide) strikes N10°E and dips 20°-30°E in banded gray schist that is intruded by pegmatite, rhyolite-porphyry and mafic dikes. Vein filling consists of coarse-textured, grayish-white quartz with bunches and disseminations of pyrite. Upper ores are oxidized and rich in gold. Wallrocks contain considerable

sericite. Workings include a 350 ft incline and associated drifts. Vein is reportedly largely stoped out for a distance of 325 ft from the surface to the 165 ft level. Vein is cut off on the south by a fault. The property recorded production in 1906-1907, 1911-1916, 1927-1931. Lessees obtained $1,870 from 22 tons of ore in 1927, and 100 tons of ore mined in 1931 averaged more than 1.7 opt Au.

Arizona-Homestake Mine: The property consists of claims on both sides of Santa Maria River. Country rock consists of granite and schist. The "Homestake" claims on the south side of the river cover two well-defined, subparallel veins that strike about S30°W and are about 300 ft apart. The vein nearest the river dips 30°E while the other vein dips about 55°-60°E. The claims north of the river (Weepah) cover a vein that strikes about NS and dips about 80°E. Metzger (1938) noted that development on the vein nearest the river on the Homestake claims included a 200 ft shaft on the dip of the vein with 300 ft of drifting at the bottom. The other vein on the Homestake claims is developed by a 140 ft shaft with some 200 ft of drifting on two levels. A stope on the 100 ft level of this vein was 4 to 8 ft in width. The vein north of the river was developed by an adit drift, connected to a winze on the dip of the vein and by a shallow shaft with a small amount of drifting. Metzger (1938) notes that an assay map of the properties show a large range of gold and silver values from $1.50 to $47.00 a ton. He indicated that the assay map indicated a "considerable" tonnage of $8-$10 ore. A 35-ton/day flotation mill was completed early in 1936 processed about 1500 tons of material (mostly low-grade dump material) between March and April worth about $4000. The mill burned in July and the mine has been apparently idle since.

Oro Bueno Mine: The Oro Bueno vein strikes about NS and dips about 45°W. Country rock is mainly granite although Metzger (1938) notes that a schist belt roughly parallels the vein. The mine was said to have been idle for many years prior to 1938. Development by the early miners consisted of two 500 ft adit drifts that are connected by a raise. Considerable stoping was done above the upper level. A cyanide mill was built in 1936, but had not yet been put into operation at the time of Metzger's (1938) visit.

References:

Keith and others, 1983a, 1983b; Metzger, 1983; Wilson and others, 1967.

CUNNINGHAM PASS DISTRICT

Location:

The district is located in the western part of the Harcuvar Mountains, La Paz County in T7N, R12 and 13W. Workings are mainly concentrated in Cunningham Pass along and just west of the paved road connecting the town of Wenden to the south, with Alamo Dam to the north. The district is plotted in the northwest quarter of the Salome 15' quadrangle.

Geology and History:

The district occurs in the middle of the Harcuvar foliation arch, one element of the Harcuvar metamorphic core complex (Rehrig and Reynolds, 1980). For the most part, rocks west of Cunningham Pass consist of the Tank Pass plutonic complex, a mid-Cretaceous batholith with pendants of migmatite gneiss of either Precambrian or Mesozoic age. East of the pass the rocks are mainly migmatitic and mylonitic gneisses strongly intruded by leucocratic, muscovite-bearing granite and pegmatite bodies. The topographic pass through the Harcuvar foliation arch appears to roughly form an eastern contact to the Tank Pass, plutonic terrane and may be an expression of a prominent NW-trending zone of faults and Tertiary basic dikes which transects the foliated rocks.

The district was active around the turn of the century with the Critic mine (Cunningham Pass Copper Company) being the principal producer. The Cunningham district has also been described as part of the Ellsworth or Harcuvar districts. Bancroft (1911) cites production of the Cunningham Pass Copper Co. through 1909 as 600-700 tons averaging 12% Cu and from 1/2 to 1 opt Au. Consultant reports refer to 6 carloads (1912-13) averaging 12% Cu and $29/ton Au (@ $20/oz) with numerous assay results $>$ 0.2 oz in Au. The Critic mine, northwest of the Centroid mine, shipped at one time 1,772 tons of ore averaging 11.5% Cu and 0.75 opt Au (Arizona Dept of Mineral Resources files). Keith and others (1983a) cite total production from the district as 4000 oz Au and 2600 oz Ag.

Ore deposits in the immediate Cunningham Pass area consist of variably dipping (35° to 80°), northwest-striking fissure or fault veins which cross cut the flat-lying foliation in host gneisses and interlayered aplite-pegmatite lenses. At least 7 individual veins are mentioned. Veins vary considerably in width from a few inches to 50 ft. Thickness changes occur in both dip and strike directions. One consulting report (mid-1950's) cites a 100 ft wide vein at the 300 ft level in the main shaft of the Critic mine.

A prominent swarm of basic dikes trend roughly parallel to the veins. These are probably the regionally occurring mid-Tertiary microdiorite bodies dated elsewhere (Rehrig and Reynolds, 1980; Rehrig, 1982) at from about 21 to 28 m.y. B.P. At Cunningham Pass, the basic dikes are noted as carrying very little mineralization (post-ore?), whereas felsitic or "quartz porphyry" dikes appear associated more closely with mineralization.

The mineral suite typical of the district consists of specularite, quartz, magnetite, chrysocolla, chalcopyrite and some supergene chalcocite. Bancroft (1911) notes calcite and barite veinlets filling post-mineral fractures. Other sources report siderite in the ores. Secondary enrichment appears to be an important aspect to upgrading ore zones in both copper and gold.

Southwest of the Cunningham Pass area, isolated quartz, copper, gold veins occur at the Bonanza and Doland mines. At the Doland property (Sec. 5, T6N, R13W), a James Yovell (Rainbow Mining Co.) in 1982 was reported (ADMR files) to have a leach operation treating material running 0.18 to 0.05 opt Au with considerable copper oxide content. The Bonanza mine (Sec. 26, T7N, R13W) worked spotty Cu, Au and Ag from irregular, lensing veins associated with a wide zone of diorite-diabase dikes along a probable NW striking shear zone (713 tons averaging ± 2% Cu, 0.22 opt Au, 0.2 opt Ag).

Mines of Interest:

The Cunningham Pass area appears to offer the most favorable exploration environment in the overall district. Values of gold in previously mined ore are good (> 0.1 opt). Size potential and consistency to ore in veins is, however, limited because of lensoidal nature of pay zones. Consulting reports from the mid-1950's note that open-pit, low-grade ore potential is focused in the area of the Horse Whim shaft (ADMR files). A major, gossaned, Cunningham Pass fault zone is also mentioned in the report which has not produced in the past but which may not have been adequately explored.

The mineralization appears to be rigidly controlled by faults, veins and perhaps by the distribution of dike zones. We would think that careful mapping and consideration of structural factors might delineate zones where mineralization may increase. A favorable target projection may be where the NW-trending feeder structures intersect a NE-striking, detachment zone flanking the Harcuvar foliation arch on either its northwest or southeast sides.

References:

Bancroft, 1911; Tovote, 1918; Arizona Dept. Mineral Resources (ADMR) files; Keith, 1978.

DIAMOND JOE (CEDAR VALLEY) DISTRICT

Location:

The Diamond Joe district is located in the east-central portion of the Hualapai Mountains about 12 miles northwest of Wikieup. For purposes of this discussion we have also included the contiguous area that Keith and others (1983a) refer to as the Cedar Valley district. In actuality, the Cedar Valley district was historically referred to as a poorly defined area that embraces the western flank of the Hualapai Mountains.

Geology and History:

There is precious little published information on the Diamond Joe mining district. This part of the Hualapai Mountains is underlain mainly by Proterozoic metamorphic rocks. In the Diamond Joe district, these rocks have been intruded by the Late Cretaceous (72 m.y.; reported in Keith and others, 1983b) Diamond Joe quartz monzonite pluton and related (?) dikes. Much of the mineralization in the district appears to be related to this intrusion. Keith and others (1983b) state that mineralization in and around the stock consists of genetically related veins and disseminations. During the late 1970's the area was prospected as a porphyry copper play because if its surface exposures of copper-molybdenum mineralization. Hess (1924) describes some of the molybdenum mineralization and makes reference to the operations at the Leviathan mine. Hansen (1977) conducted a surface mapping and soil sampling program that suggested that the district overlies a porphyry system. One drill hole was put into a molybdenum soil sample anomaly in the Precambrian rocks near the contact with the Laramide intrusion. Lost circulation resulted in the hole being abandoned short of its proposed depth and before it cut the proposed intrusive target. No ore grade mineralization was found. Mineralization in the southern part of the district (Cedar Valley) may be of a different character than that found spatially near the Diamond Joe intrusion. Keith and others (1983b) identify this mineralization as being NW-striking middle Tertiary veins.

Hewett (1936) states that pre-1904 production from the Cedar Valley district was about $100,000. Keith and others (1983a) indicate that production from the Diamond Joe portion of the district between 1916-1981 amounted to 6,000 tons of ore that yielded 100 oz Au; 30,000 oz Ag; 60,000 lbs Cu; 40,000 lbs Pb; and 300 lbs Zn; production from the Cedar Valley portion of the district from 1903 to 1936, amounted to 1,300 tons of ore which yielded 700 oz Au; 6,600 oz Ag; and 600 lbs Cu.

So little is known about this region that no statement can be made concerning its exploration potential. Even though much of the mineralization may be porphyry copper related, there is enough uncertainty about the district wide metallogenesis that a brief geologic reconnaissance of the district is probably warranted.

Mines of Interest:

Cedar Mine: (Location inexact; some 28 miles from Yucca by trail, in the Cedar mining camp) A 1912 report in J. E. Spurr's records in the mining archives at the University of Wyoming make mention of this property. Geologically, the setting consists of granite (Precambrian ?) and eruptives (Tertiary ?) containing quartz veins. The property was reported on as early as 1894. The two largest mineralized structures were called the "east" and "west" veins. East vein averages 2 ft wide and consists of quartz carrying silver and gold with some zinc and pyrite. The West vein averages 4 ft wide and also carries gold and silver. The property consists of 16 claims, 7 of which are patented. The Arnold claim, on the East vein (?), was developed by a 200 ft shaft and workings on two levels. In 1903 the mine was flooded below the 100 ft level. Ore was reported stoped out above the 100 ft level. On this level the vein averaged 2-5 ft wide with the ore shoot running 400 ft along strike. Average of 14 samples taken at various places ran $49 in Ag and $13 Au. An average of 12 other samples averaged 56.7 opt Ag, 0.63 opt Au, 2.4% Zn, 3.2% Fe and 5.7% S. In 1912, the property had a 15-stamp mill, compressor, assay office and equipment. All ore mined was said to average $20, only 10% of which was recovered on the plates. Spurr's group rejected the property because the veins were too small and the ore was believed refractory because of zinc. Their report stated that previous workers had expended $400,000 on the property.

References:

Hansen, 1977; Hess, 1924; Hewett, 1936; Keith and others, 1983a, 1983b; unpubl. reports.

DOME ROCK DISTRICT

Location:

This district is located in La Paz County west of the community of Quartzite. We have arbitrarily designated the area to be that between the Colorado Indian Reservation on the north and the Yuma Proving Grounds on the south. Our boundaries take in the La Paz, Middle Camp, Oro Fino and La Cholla districts of Keith (1978). Most of these mineralized areas fall within the Dome Rock Mountains located in T3, 4 and 5N and R20, 21W. U.S. Interstate 10 from Quartzite to Blythe passes east-west through the central part of the district.

Geology and History:

The geologic setting of the district can be summarized briefly as consisting of Mesozoic sedimentary and metamorphic rocks that are intruded by one large Jurassic pluton and a number of smaller Laramide or mid-Tertiary intrusive bodies. Although not shown on the Yuma County geologic map (Wilson, 1960), there are small outcrops of probable Paleozoic rocks such as in the Boyer Gap area northwest of Quartzite (Rehrig, unpubl. field notes). Generally, these rocks have been so tectonized, attenuated and metamorphosed that their age designations are most difficult to determine.

The Mesozoic rocks are mainly metamorphosed, poorly sorted, lithic-rich sandstones, siltstones and conglomerates correlated tentatively to the McCoy Mountains Formation of eastern California and the Livington Hills Formation of the southern Plomosa Mountains, Arizona (Tosdel, 1982). This terrigenous section rests depositionally (?) and is partially interstratified with siliceous to intermediate metavolcanic rocks common to the northern part of the Dome Rock Mountains (Crowl, 1979). These volcanics have been dated as early to middle Jurassic age (L. Silver <u>in</u> Crowl, 1979).

The largest pluton in the district is the Middle Camp quartz monzonite, a 160 m.y. old, coarse-grained, porphyritic body with leucogranite phases. This body makes highly irregular, complex and metasomatic contacts with metamorphic host rocks.

All rocks older than the undeformed Diablo quartz monzonite plutons are deformed tectonically (Crowl, 1979). There is a rumored 85 m.y. date on this pluton. A pervasive cleavage or structural foliation is discordantly developed to varying degrees through the Jurassic sediments, volcanics and plutons. It trends WNW and dips shallowly northward. Although details are lacking because of insufficient mapping, it is suspected that major internal thrusts and isoclinal folds exist in the range and that a picture as complex as that mapped by Miller (1970) in the neighboring Plomosa range will emerge in the Dome Rocks as well.

A variety of mineral occurrences have been prospected in the Dome Rock district. These include numerous, small gold-quartz showings; extensive shallow placer gold deposits, a large advanced argillic alteration area containing shows of molybdenum, tin and tungsten, a porphyry copper prospect, small scattered copper prospects, and occurrences of mercury, lead, magnetite and specular hematite. The overall distribution of gold mineralization and placer gold

deposits to be crudely marginal to the large Middle Camp quartz monzonite suggests a possible genetic tie to Jurassic plutonism. Additionally, early reports by Jones (1916) mention a predominance of gold-quartz veining in the La Paz subdistrict restricted to the lower, metavolcanic rocks (i.e. the quartz-albite schist of Crowl, 1979). Veining is concordant with metamorphic foliation (EW to WNW strikes) and is also cross cutting ($\sim$N-S strike). The concordant veins are the largest and most persistent. Even exotic, non-metallic occurrences such as kyanite, dumortierite, andalucite and sillimanite are reported from Mesozoic sediments at several localities. These characteristics suggest to us a strong influence of lithologic control or stratibound effects on metallization. All in all the geologic setting characterized by Jurassic plutonism, stratibound-like gold and alumino-silicate alteration appears much like that in the Cargo Muchacho Mtns. of southeastern California where three large gold discoveries have been developed.

The two major placer gold operations, the Farrar Gulch (T4N, R21W, Sec. 36) and La Paz Wash workings (T4N, R20W, Sec. 26), together produced over 100,000 oz gold; largely prior to 1900. This large placer production plus the numerous smaller workings throughout the district emphasize the overall favorability of the area. The interesting mercury-bearing prospects around a locality called Cinnabar at the southern end of the Dome Rock range is also described with this district.

Mines of Interest:

Apache mine (T6N, R21W, Sec. 35, Colorado River Indian Reservation) Gold-silver in lensing quartz vein cutting Mesozoic metasediments intruded by rhyolite plug. Produced very high grade gold (330 tons of 2.4 opt), but probably low tonnage potential. Added negative factor is location on reservation ground.

Darling mine (T5N, R20W, Sec. 33) Weak copper and pockets of scheelite associated with contact metamorphism (?)(epidote, calcite, biotite, quartz) along a sheared contact between carbonate and dark, micaceous schist. Mineralization may also be of the stratiform type. Gold is mentioned as occurring with the mineralization but no assays or production are mentioned. The Tungsten Hill mine nearby (T5N, R20W, Sec. 27) also produced scheelite (4000+ tons of 0.4% WO_3) from a garnetized, epidote-bearing tactite zone along a schist-limestone contact. Numerous quartz veins cut the mineralized zone.

The Goodman mine group (T4N, R21W, Secs. 23-25) Reported as the richest gold deposit in the Dome Rock region, the Goodman workings span 2 to 3 miles along a WNW strike. Production was from a long, lensing, massive (1 to 40 ft thick) quartz vein in a north-dipping shear zone cutting mylonitized Middle Camp quartz monzonite. Mineralization is spotty free gold, auriferous pyrite and minor copper-lead. Strong epidote is mentioned as well as rare earths. The occurrence is said to be the source for the large placer deposits in La Paz Wash (T4N, R20W, Sec. 26) and Farrar Gulch (T4N, R21W, Sec. 36). The Goodman workings produced some 11,000 tons of ore that averaged 0.33 opt Au and 0.02 opt Ag. Copper was not recovered.

Maraquitta mine (T4N, R20W, Sec. 22) Gold and silver with minor base metals occurs in a lensing quartz vein (N20°W, 20° NE dip) cutting considerably altered Middle Camp and Diablo quartz monzonite plutons. Host of mineralization at the mine is quartz mica schist.

Strong chlorite, epidote and sericitization are mentioned in the mineralized area. Where the productive quartz zone is hosted by metasediments, it fills a possible thrust that is fault nearly conformable to bedding foliation. The mine produced some 180 tons of one averaging about 0.6 opt Au and 0.3 opt Ag. Scheelite was reported.

Note that the Oro Fino placers just south of the mine (T4N, R20W, Sec. 27) produced about 6,000 oz Au. The adjacent Middle Camp placers (T4N, R20W, Secs. 21 & 28) also produced about 6,000 oz Au. The source of the placer gold is said to be numerous small gold-bearing veins and stringers on Middle Camp Mountain.

Julian mine group (T4N, R19W, Sec. 30) Gold-silver and minor base metals in multiple veins and stringers along fracture zones in Jurassic granite with pegmatite dikes. Produced about 350 tons of 0.55 opt Au material.

Sugarloaf Peak area (T3N, R20W, Sec. 3) Centered over several square miles surrounding Sugarloaf Peak is an area of intense hydrothermal alteration (sericite, argillization, alunite). The altered zone appears to be suddenly faulted off to the south and southwest of the peak; and to the north and northwest, it extends nearly to the interstate highway. The property has attracted much modern exploration interest starting as a moly porphyry play by Congdon and Carey in the 1960's. Most recently the property is under option from Westworld Resources of Houston to Amselco. Although numerous high-level geochemical anomalies (Pb, Mo, Bi, W, Tl) are reported over the altered area, drilling and trenching have thus far failed to delineate any economic mineralization. Anomalous geochemistry at the surface typically disappears within 50 ft of depth suggesting mechanical or chemical enrichment in oxidized rocks. On Sugarloaf Peak and adjacent hills where the alteration is most intense, a silicified felsic rock occurs which looks like either erosional remnants of a rhyolite flow or shallow intrusive plugs. Although the felsite occurs within an overall area of bleached, argillized and pyritic Mesozoic metasediments and could be interstratified with them, it is possible that the felsite represents a shallow Tertiary subvolcanic hot springs system having little to do with the gold-dominated Mesozoic mineralization elsewhere in the district (Rehrig, unpubl. field notes).

In Section 4, T3N, R20W, a property called the Leadville (Hartsif) is described as an 80 by 150 ft elliptical gossan containing disseminated galena and rhyolite. Ore running 6% to 17% Pb, about 5% Bi and .18% tin. Deposits believed hosted in felsic breccia or tuffaceous pipe.

Copper Bottom, Yellow Dog, and Yum Yum mine area (T3N, R20W, Secs. 23, 28, 14 & 15) The mines and prospects occur in the La Cholla mining district of Keith, 1978, in which he describes numerous quartz veins and stringers carrying gold,

copper and silver. Crowl (1979) notes a syngenetic character at least for the copper, which is apparently restricted to the noses of folds within certain stratigraphic horizons of the Mesozoic metasedimentary sequence. Bedding plane quartz-copper-gold veinlets are mentioned at the Yum Yum deposit. The Copper Bottom produced about 100 tons of 19% Cu, 1.6 opt Au and 27 opt Ag ore. The Yum Yum property yielded 176 tons of 1 opt Au and 0.2 opt Ag.

Note that in this area the La Cholla placer deposits produced some 9,500 oz Au and 900 oz Ag.

Cinnabar mine area (T2N, R20W, Sec. 3) Although this area, located in the southern Dome Rock Mountains about 8 miles southwest of Quartzite, is within the Yuma Proving Grounds, it is of sufficient interest to describe as part of the Dome Rock district. The old Cinnabar mine worked a N47°-55°W near vertical fault zone in highly brecciated Mesozoic metavolcanic rocks. Parallel fault strands widen the main vein from about a foot to several feet. In addition to disseminated cinnabar, copper carbonates are conspicuous within the gangue of silica, calcite and siderite. The mineralization is reported to contain gold and silver. The appearance of magnetite near the vein was noted by Bancroft (1911). A Hg production of 540 flasks is reported for 1916.

Approximately 1½ miles west of the Cinnabar mine, old prospects in T2N, R20W, Secs. 4 or 5 (up a steep narrow gulch at about 1,600 ft elevation) explore quartz, sericite, tourmaline, copper and free gold which as described by Bancroft (1911) occurs in a zone striking N55°W with a flat dip (15°) to the southeast. Siderite and cinnabar is reported to also be in the shallow-dipping structure. The fine-grained, quartz-sericite schist and impure carbonate beds which host the mineralized zone are described as being extensively tourmalinized and silicified.

In this general area (S.Cen. Sec. 9, T2N, R20W), an antimony occurrence of stibnite has been noted in Arizona Dept Mineral file data. A reference source for this prospect is Arizona Bur. Mines Bull. 122.

References:

Bancroft, 1911; Jones, 1916; Keith, 1978; Crowl; 1979; Arizona Dept Mineral Resources, file data; Rehrig, unpubl. field notes; Tosdel, 1982; Wilson, 1960.

EAGLE TAIL DISTRICT

Location:

The Eagle Tail district or area as described by Keith (1978) essentially covers the Eagle Tail Mountains and Cemetery Ridge in the extreme southeast corner of La Paz County. The southeastern portion of the Eagle Tail Mountains extend into Maricopa County.

Geology and History:

The Eagle Tail Mountains are a NW-trending range composed mainly of Oligocene(?)-Miocene volcanic rocks. The range appears to be a fault block that has been rotated to the southwest as the Miocene volcanic rocks dip in that direction.

Pre-Tertiary granitic and metamorphic rocks occur at lower elevations along the NE flank of the range. These rocks include Precambrian or possibly Jurassic porphyritic granitic rocks that display variable amounts of weak foliation, and Mesozoic metasedimentary rocks. The metasediments vary from well-bedded, mica schists, quartzites and arkosic quartzites to massive meta-arkose which takes on an igneous appearance in Sections 17 and 18, T2N, R11W. A thin bed of marble occurs in the metasediment package in Section 17. The weakly foliated small bodies, dikes and sills of equigranular, non-foliate granodiorite to diorite are of Laramide age (51.6 m.y. K-Ar minimum age on partly chloritized biotite; Rehrig, unpubl. data). They may represent a southwest extension or end to the Wickenburg batholith (see Vulture district write-up).

Mid-Tertiary volcanic rocks overlie the pre-Tertiary basement and make up the main rock type of the range. The older volcanic rocks generally strike northwest and display variable dips to the southwest. These rocks consist of vitrophyric flows, thick ash-flow tuffs, tuffaceous breccias and pyroclastic deposits that resemble the volcanic section in the nearby Big Horn Mountains. A basal yellowish buff-colored tuffaceous sandstone or pyroclastic deposit lies nonconformably on the older rocks in part of the range. This volcaniclastic unit contains biotite phenocrysts that yields a 23 m.y. K-Ar date (Shafiqullah and others, 1980). This unit is similar to basal volcaniclastic deposits occurring in parts of the Big Horn, Vulture and Kofa ranges (Rehrig, unpubl. data).

A few isolated buttes on the NE side of the range and more extensive outcrops on the SW side of the Eagle Tail range consist of late Miocene flat-lying basalts which overlie the tilted older volcanic strata with angular unconformity. In Sections 20, 17 and 18, T2N, R11W, there occurs beneath the tuffaceous sandstone (described in the preceeding paragraph) a 500-1000 ft section of conglomerate with interbedded thin tuff beds and dacitic flows. This section is deposited on the older crystalline rocks. Clasts from one section of the conglomerate are of medium-grained quartz diorite to granodiorite that resembles certain phases of the Laramide Wickenburg batholith. Clasts within this wedge of conglomerate reach sizes of 2-3 meters. Other lenses contain clasts of a locally occurring meta-arkose and coarse-grained quartz monzonite porphyry. This conglomerate section pinches out within 1-2 miles along strike toward the SE and the yellowish volcanoclastic unit again rests directly on the older crystalline rocks (Rehrig, unpubl. data).

An intense swarm of porphyry dikes intrudes the pre-Tertiary rocks and the Tertiary volcanic section. These dikes and shallow plugs generally strike NW and commonly dip shallowly to moderately NE (about perpendicular to bedding). Others appear to be sills injected along volcanic bedding planes and dip SW. These dikes vary considerably in composition and texture: some are felsic and aphanitic, others are darker colored and porphyritic. Purplish rhyolite porphyry dikes yield a biotite age of about 20 m.y (Shafiqullah and others, 1980). These dikes look very similar to dikes in the Vulture Mountains that give a 16 m.y. whole rock K-Ar date.

Cemetery Ridge, reportedly named for the graves of prospectors killed in the 1870's (Keith, 1978), consists of a low, northwest-trending range of mostly interrupted and broken hills with gentle pediment slopes. The topography becomes more rugged in the northern and southern portion of the range. Mesozoic metamorphic rocks (mainly gneisses and schists) underlie most of the range. These rocks are overlain by Tertiary rhyolitic to basaltic volcanic rocks on the northern, southern and western portions of the range. Northwest-trending Tertiary rhyolite dikes and small plugs intrude the schist. Wilson (1933) made a reconnaissance of the area and noted schist along the western margin, granite intruding the schist, and numerous dikes of rhyolite and granite porphyry and some hornblendite.

Prospecting in the Eagle Tail district dates back to the mid-1860's and spotty mineralization has attracted sporadic prospecting since. Except for some hand picked 22% manganese ore, there is no reported production from the district (Keith, 1978). According to Wilson, the mineralization found along the northwest side of the Eagle Tail Mountains occurs as spotty base and precious metals shows. These are mostly oxidized and enriched near the surface, displaying a gangue of quartz, calcite and barite in fissure and fracture zones cutting the Tertiary volcanic rocks. Keith (1978) lists the Eagle Tail (Golden State) group in NW¼ Sec. 28, T2N, R11W, and the Gentry Lead-Silver mine in north-central Sec. 2, T1N, R11W as examples of this kind of mineralization. Keith (1978) notes that along Cemetery Ridge, weak copper mineralization with minor gold and silver has been prospected at several locations. This mineralization typically occurs with a gangue of iron and manganese oxides, quartz, gouge and brecciated wallrock along fractures and faults cutting Mesozoic schist, granite and Tertiary dikes. Wilson noted brittle, asbestiform actinolite in lensing veins in Mesozoic schist near irregular altered dikes associated with veinlets and masses of magnetite along Cemetery Ridge east of Deadman Tank. A color anomaly in Sec. 34, T2N, R11W attracted exploration attention during the porphyry copper days. It was explored by IP and a few shallow drill holes on the pediment just to the north. The anomaly is caused by dispersed, largely pyritic mineralization occurring within a thin band of metasediments caught between porphyritic granite (Jurassic?) and Laramide quartz diorite. Some of the Tertiary rhyolitic dikes have locally caused alteration and minor sulfides in adjacent country rocks (Rehrig, unpubl. data).

Another occurrence that may deserve looking at, if the area is examined, is the White Mountain property (located at intersection of Secs. 4, 5, 8, 9, T1N, R10W). ADMR files indicate that country rock in this area consists of gneiss that has been intruded by a semicircular stocklike mass of fine-grained intrusive rock that is roughly 900 x 1400 ft, elongated in a NE-SW direction.

Gneiss in this area is also fine grained, but can be distinguished by distorted quartz grains. Introduced quartz is reportedly present in both rocks as blebs and veinlets. The rock is said to carry 0.1-0.5% Cu and some gold and silver.

Finally, information from J. E. Spurr's records at the University of Wyoming's mining archives mentions a property in the Eagle Tail district. The abstract, dated June 13, 1912, lists no mine name or exact location, but simply describes the property as a vertical shaft 90 ft deep on a vein that dips 45°. The vein reportedly contained an ore shoot 600 ft long and 30 ft wide that was reported to run $8-$12/ton in free milling quartz. There was a possibility that the mineralized zone extended farther.

In reality, there is very little geologic information, other than of a reconnaissance nature, known about Eagle Tail mineralization. The amount of intrusive activity in the district would seem to warrant some grass roots exploration efforts. Interestingly, the CRIB data show a Hg, Au, Ag property (the Nations Mercury location) as occurring in the older volcanic section in the southeastern part of the range. On Plate 1, it would appear that it occurs at the northern end of a major dike swarm cutting the volcanic rocks. Unfortunately, the CRIB files give no information about this property. This would be a very interesting property to check out to see whether or not it exists and what the character of its mineralization might be.

References:

Keith, 1978; Rehrig, unpubl. report and field notes; Wilson, 1933.

EL DORADO PASS-GOLD BUG DISTRICT

Location:

The El Dorado Pass-Gold Bug mining districts have historically been considered as separate but contiguous mining districts in northwestern Mohave County. The districts essentially cover the western half of T27N, R21W. They are considered as one district in this report.

Geology and History:

This portion of the Black Range displays complex faulting that has resulted in Miocene volcanic rocks being in low-angle and listric fault contact with the Precambrian basement. The structure of the area adjoining the district to the north is dominated by northerly striking normal faults many of which dip at angles of 10° to 20° (Anderson, 1978). Anderson (1971) attributes the low-angle faulting in this part of Arizona and adjoining Nevada to extreme east-west distension of the upper crust. The potential of these low-angle faults for hosting bulk-tonnage gold targets has fueled much recent exploration activity in the region.

The northern part of the district is usually referred to as the El Dorado Pass mining area. Schrader (1909) described the country rock as consisting of Precambrian granite that is intruded by and locally overlain by Tertiary volcanic rocks. Wilkins (1984) who mapped the area in some detail provides a much more informative picture of the geology. The basement consists of a Precambrian complex of gneiss, diorite and schist that is cut by a number of listric normal faults. Within the district these listric faults cut and rotate a Laramide(?) porphyry copper system to the west. The faults dip to the west and juxtapose contrasting alteration assemblages and intrusions associated with the porphyry copper deposit. Miocene (?) volcanic rocks of the Patsy Mine volcanics occur in the northern and western part of the district. The contact of these volcanic rocks with the underlying basement gneisses is described as a low angle "detachment" type fault that consists of a low-dipping undulatory surface with brecciation in both the footwall and the hanging wall. The volcanic rocks in the upper plate are steeply tilted and dip into the low angle fault contact. These volcanics generally dip 50° to 88°E and are cut by a NNW- to NW-trending set of listric normal faults. Near the Pope mine the volcanic and porphyry copper terranes are separated by a high-angle, tear fault which trends EW to ENE. The porphyry copper system was apparently drilled a few years ago by Gulf.

Precious metals exploration in this portion of the district has most recently been focused on the low-angle detachment terrane, particularly in the Pope and Van Deeman mine areas. The Van Deeman property has been recently acquired by Amselco who were in the process of exploring the property in 1984. They are apparently exploring the property in light of a detachment model.

The Pope mine lies in the footwall of the low-angle detachment fault. Mineralization occurs in a discontinuous series of high-angle, brecciated quartz veins that trend WNW and cut Precambrian schist and gneiss with a weak phyllic

alteration overprint (Wilkins, 1984). It is not clear whether the veins are related to the porphyry copper system or whether they occupy the low-angle fault system; relationships are not clear cut. In 1977 an attempt was made to develop the property into a small heap leach operation. Existing evidence at the mine indicates that the attempt failed.

The southern part of the district has been historically referred to as the Gold Bug camp. This property consists of several patented claims. Schrader (1909) and Wilson and others (1967) give the only descriptions available of the camp. The property was discovered in 1892 and has produced some very rich ore. One 50-ton shipment of selected ore mined prior to 1895, netted $43,000 after all transportation and smelter charges were deducted. Little is known about the character and relationships of the mineralization. The mine is not far from the Van Deeman property and should be examined to determine what its relationship, if any might be to the detachment fault in this area.

Keith and others (1983a) credits the entire district (including Pope and Gold Bug estimates) with 18,000 tons of ore produced from which were recovered 7,500 oz Au, 6,000 oz Ag, 2,000 lbs Cu, and 7,000 lbs Pb.

This district would appear to be quite interesting. The Gold Bug property should certainly be examined. In addition the volcanic terrane to the west and north of the district would also appear to be candidates for detachment type faults. We would recommend that this area be examined for potential low-grade bulk tonnage mineralization with a detachment model in mind.

Mines of Interest:

Gold Bug: (T26N, R21W, Sec. 4) Discovered in 1892 by Morman prospectors, the deposit is described as consisting of two steeply NE-dipping veins about 22 ft apart which occur in volcanic rock. The gold occurs mainly near the hanging wall associated with FeOx in the oxidized zone and with pyrite and galena below the 200 ft level. Vein gangue is mainly shattered quartz. Some ore has been spectacularly rich. Prior to 1895, 50 tons of shipped ore netted $43,000. Property owners erected a 20-ton Huntington mill on the Colorado River some 10½ miles from the mine and ran some 800 tons of low-grade ore. Their operation saved only 58% of the assay value which amounted to $12,000 or $15/ton (old prices). Prior to 1908 the mine had been developed by 15 shafts and open cuts, and about 2,300 ft of underground workings. Work on the 290 ft level in 1908 disclosed the vein had an average width of about 5 ft with ore streaks on both walls which were 18 inches in maximum width. The material in the ore streak was reportedly often very rich in gold and silver. Much ore was said to remain in the mine at the time of Schrader's report.

Mohave Gold Property: (T26N, R21W, Sec. 4) Located near the Gold Bug mine. Wilson and others (1967) note that several small shipments of ore containing about 0.75 opt Au were made from this property. Nothing is reported about the geology.

References:

Anderson, 1971, 1978; Keith and others, 1983a; Schrader, 1909; Wilkins, 1984.

ELLSWORTH DISTRICT

Location:

In La Paz County, this district arbitrarily takes in the broad zone of metal occurrences in the Granite Wash Mountains bordering the McMullen Valley on the west (Plate 1). This northwest-trending range joins the predominant NE-elongate Harcuvar Mountains at their extreme western end. U.S. Highway 60 passes through the Granite Wash Mountains at Granite Wash Pass between the small town of Salome and the Vicksburg road junction at Hope. The Ellsworth district area is mapped along the west margin of the Salome 15' quadrangle, the east margin of the Utting 15' sheet and a small, northwest portion of the Hope quadrangle.

Geology and History:

The regional geologic setting of the district is its position along the western margin of the Harcuvar metamorphic core complex. This margin is generally one of a rapidly prograded metamorphic front which increases eastward toward the Hercules thrust fault and affects Mesozoic and Paleozoic supracrustal rocks (Rehrig and Reynolds, 1980; Reynolds, 1980; Reynolds, 1985, personal commun.). Metamorphism varies from lower greenschist facies on the southwest to amphibolite facies at the northeast. Large scale thrusting has been recently proposed for complex, tectonically interleaved sequences of Paleozoic metasediments, Mesozoic clastic and volcanic sequences, and Precambrian gneisses and foliated granitoid rocks (Reynolds and others, 1983). The major thrust structure appears to be equivalent to the Hercules fault in the Little Harquahala-western Harquahala Mountain areas which places Precambrian basement on top of Mesozoic and Paleozoic metasedimentary rocks. The Hercules fault has recently been mapped through the southern Granite Wash Mountains where it places Precambrian rocks along the easternmost fringe of the range on top of an internally deformed and partially metamorphosed Mesozoic sedimentary section (Reynolds, 1985, personal commun.). Large plutons of mid-Cretaceous and early Laramide ages (Tank Pass granite, 87 m.y. and Granite Wash granodiorite, 65-70 m.y.) discordantly intrude the thrusts and deformed layered sequences. Tertiary rocks in the Granite Wash area consist of abundant NW-trending dikes and gently dipping basaltic rocks exposed along the west flank of the range.

Mineral occurrences in the Ellsworth district were discovered in the 1860's, but little production was recorded until the earliest 1900's when the Parker cut-off of the Arizona & California Railroad was built. Earliest production and expanded exploration resulted in some "spectacular" free gold occurrences (i.e. Glory Hole mine near Salome, 1909) and copper discoveries around Harcuvar Peak in the Harcuvar range. Total tonnages produced from the district are small and estimated at 14,000 tons from which were recovered 386 tons Cu; 14,700 oz Ag; 2,400 oz Au; 12 tons Pb; and 4.5 tons Zn (Keith, 1978). Tungsten occurs in the district but was not mined until the 1950's when some 1,000 short ton units of WO_3 was produced through 1974. A few carloads of hand picked barite are also reported for the district.

With the exception of a few quartz-siderite-hematite-copper-gold (± flucrite) veins associated with Tertiary diking that cuts gneiss and foliated granitic rocks in the westernmost Harcuvar Mountains (Cottonwood and Tank Pass areas), mineralization in the Granite Wash Mountains is somewhat variable as to type. From an assessment of literature descriptions and our own field observations, we recognize the following deposit types:

1. Veins, fracture fillings and lenses cutting silicified Paleozoic (?) carbonate, Mesozoic (?) schists, and Mesozoic granite carrying an assemblage of quartz-scheelite-siderite-barite and minor zinc and copper. Thrust faulting may have exerted some control on the mineralization.

2. Contact metasomatic or replacement mineralization of Cu-Fe (with or without Au-Ag) in favorable Paleozoic or Mesozoic metasedimentary horizons. Possible structural control by thrust faults or low-angle shear zones.

3. Quartz-carbonate-copper-gold fissure and fault veins similar to those in the Cunningham Pass district which appear associated with mafic or acidic (?) Tertiary diking that cuts all pre-Tertiary rocks.

4. Pyritic (± minor Cu or Au) mineralization suggestive of a stratiform nature, and thought to be controlled by volcanic or sedimentary lithologies in the Mesozoic section. Mineralization is believed to be augmented by thrusting and metamorphic processes. Alumino-silicate alteration (hydrothermal and/or metamorphic) which accompanies or hosts mineralization includes minerals such as sericite (muscovite), actinolite, kyanite, andalucite, dumortierite, garnet, tourmaline, epidote, amphibole, magnetite and scheelite.

The common association of tungsten with many of the occurrences through the district is distinct. The metal is thought to be of various origins including contact metasomatism by nearby Mesozoic intrusive bodies, metamorphic processes within carbonate-rich Paleozoic or Mesozoic sequences or perhaps even of exhalative derivation. In places the tungsten occurs with subordinate copper, iron, zinc and gold. A number of small gold placers should be noted which occur in terranes of Mesozoic metasediments which form a line from Vicksburg, north to Salome Peak. Some 300 ounces of production from gravels in many small washes is mentioned by Keith (1978).

Mines of Interest:

Desert mine: (T5N, R14W, Sec. 21) An area within arenaceous shales, argillites, etc. of the Granite Wash Mesozoic section are cut by a "wide" zone of small, discontinuous quartz and carbonate veins, stringers and masses of amorphous silica carrying gold and copper with varying iron and manganese oxides. Veining is roughly conformable to bedding or schistosity in the metasediments. A prominent felsic dike (Laramide K-Ar date, Rehrig, unpubl. data) intrudes the metasediments near the workings. The zone of quartz influx is thought to be the source of fairly rich but localized gold placers in adjacent washes. Depending on the extent, frequency and grade of the secondary quartz and carbonate flooding, the Desert mine area might be an attractive exploration target. About 700 tons of ore previously mined averaged 0.3 opt gold, 2% copper and 5 opt silver.

Three Musketeer - PeeWee - Jewel Anne mine group: (T6N, R15W, Secs. 24, 25) This group of workings are known mainly for their tungsten production which occurs as disseminations, pockets, discontinuous veins and stringers of scheelite cutting silicifed Paleozoic (?) carbonate, granitic dikes and Mesozoic schists. Quartz, siderite and barite accompany the tungsten. Minor copper, zinc and iron oxides are also mentioned. Quartz veins up to 16 ft thick trend northeast and dip only 30-45°E at the Three Musketeer property. The mineralization appears concentrated along a wide shear zone or thrust which separates Precambrian (?) metamorphic rocks from overlying Paleozoic sediments (Reynolds, 1985, pers. commun.). As late as the 1970's, tonnages were mined which ran from 0.5 to 0.7% WO_3. Reserves at the Three Musketeer mine were reported in 1977 to be about 3½ million tons of 0.5 to 1% WO_3. At the Jewel Anne, veins range from 1" to 2.5' with scheelite reported in the rocks through widths of from 1 to 15 ft for strike lengths up to 200 ft. There have been unsubstantiated reports that the mineralization in places carried low-grade gold. This possibility should be checked by further sampling.

Yuma mine: (T6N, R14W, Sec. 30) An early, fairly prominent producer (8,600 tons averaging 2.3% Cu, 0.3 opt Ag, 0.03 opt Au) of mainly copper derived from contact metasomatic mineralization in strongly tectonized carbonate beds that are sandwiched between metamorphosed siltstone, shales and graywackes and cut by numerous felsic and "post-mineral" mafic dikes. Over 7000 tons were produced from 1941 to 145. The main mass of the Cretaceous Tank Pass granite occurs just northeast of the mine area.

Mineralization appears to be roughly stratibound and is restricted to an unusual, thinly banded carbonate sequence with metamorphic mineral assemblages which include garnet, magnetite, scheelite, epidote, actinolite, and sericite (see Figure). The favorable stratigraphic sequence is thought to be Paleozoic rocks emplaced tectonically along major thrust faults (Reynolds, 1985; personal commun.). These rocks extend out of the local Yuma mine area and can be traced into adjacent canyons. Grades in gold at the mine are reported as high as 0.05 opt and 31 channel samples across 200 ft averaged 1%+ Cu, .04 opt Au (ADMR file data). Chalcopyrite and bornite stockworks and low-angle veins up to 10 ft thick are reported. A 1943 engineering report cites reserves of 10,000 tons measured and 216,000 tons indicated; with assays running 1.8% Cu, 0.03 opt Au and 0.30 opt Ag.

Although Yuma ores run lean in gold, the large extent to the productive stratigraphic interval (~400,000 tons of potential reserves), unusual metasomatic mineral assemblages (including extensive magnetite, quartz, actinolite at the nearby Iron Dyke workings), geochemically anomalous gold (i.e. > 0.05 ppm) over a wide area constitute reasons for considering the mine and surrounding area a prime exploration target.

Dandy mine group: (T5N, R14W, Sec. 6) Irregular, discontinuous fissure-quartz veins cut Mesozoic metasediments. Veins are gold-bearing with copper, silver, lead and zinc. The small reported production (190 tons) averaged quite high in gold (0.6 opt) with 4 opt Ag and 3% Cu.

Glory Hole mine: (T5N, R14W, Sec. 33) Multiple, discontinuous veins of quartz containing gold and other metals occur in Mesozoic metasediments with gangue of siderite, hematite and manganese oxides. A "wide" shear zone is mentioned. Amphibolite horizons (metavolcanic ?) conformable to foliation in the meta-graywacke section are described as is a dolomitic horizon which bears "beautiful free gold" (Bancroft, 1911). Bancroft also alludes to bulk mining possibilities for the mine area, based on the "frequent occurrence" of the small mineralized gash veins.

True Blue mine group: (T5N, R14W) Quartz seams and lenses carrying gold, silver and copper occur in a NW-striking breccia zone cutting Mesozoic sedimentary rocks. No size is given for the zone but 200 tons of production averaged about 0.7 opt Au.

Big Dyke Copper prospect: (T5N, R14W--2 mi N of Vicksburg) In foliated schist cut by thin dikes, lenses of quartz, generally quite thin and short in length, occur with small amounts of Cu, Au and Ag. Work has been done in two principal areas. The largest area has been explored by over 500 ft of lateral workings and a 25 ft shaft. Here a large open cut above the tunnel showed mineralization. Of five samples taken, the highest was 0.8 opt Ag, 0.10 opt Au and 1.37% Cu across 12½ ft. Lowest was 0.5 Ag, 0.02 Au and 0.91% Cu from 9 ft. At the other mineralized area, assays were of about the same grade except for a cut from which 15 tons of $131 ore had been taken. A sample at this locality, across 17 inches, assayed 5.1 opt Ag, 0.88 opt Au and 0.15% Cu. Property is old. A small mill operated here about 20 years ago and from indications of the tailings dump, milled about 1,000 tons of ore. Mine has been worked intermittently since 1891.

Calcite mine: (T5N, R14W, Sec. 14) Numerous prospect pits, cuts and several shallow shafts have explored a stratiform, quartz-sericite schist interval within Mesozoic metamorphic rocks just beneath the Hercules thrust. The altered stratigraphic sequence is moderately to strongly pyritic, iron-stained and bears secondary quartz, alumino-silicate minerals (i.e. kyanite, pyrophyllite, dumortierite) and anomalous gold. Tourmaline and andalucite horizons overlie the pyrite-muscovite schist interval. Tungsten mineralization is also reported. The mineralized stratigraphy is cross-cut by the later 65 to 70 m.y. granodiorite of Granite Wash Pass.

References:

Bancroft, 1911; Dale, 1959; Ciancanelli, 1965; Keith, 1978, Arizona Dept. Mineral Resources, file data.

EUREKA (BAGDAD) DISTRICT

Location:

The Eureka mining district is located in western Yavapai County, about 40 miles west of Prescott in west-central Arizona.

Geology and History:

The oldest rocks in the Bagdad area are schists of Precambrian age that have been correlated with the Yavapai Series (Anderson and others, 1955). Using the nomenclature shown on our map (Plate 1), these rocks are subdivided into three subgroups based on protolith lithologies (cf. Donnelly and Hahn, 1981). These are protoliths predominantly of mafic volcanic rocks, epiclastic sediments and felsic volcanic and volcaniclastic rocks. The Yavapai schist is intruded by Precambrian granitic rocks that exhibit a wide range of compositions. Granodiorite gneiss crops out in the northern and eastern portion of the area. Bodies of gabbro and related quartz diorite and diabase are widespread, but only one such intrusion west of Bagdad is of sufficient size to show on our map. The youngest Precambrian intrusive rocks consist of large amounts of granite, of which two facies have been distinguished; the Lawler Peak granite and the Cheney Gulch granite. The Lawler Peak granite is a megacrystic (large orthoclase phenocrysts), biotite-muscovite granite that intrude the Yavapai Series, gabbro, alaskite porphyry and granodiorite gneiss (Anderson and others, 1955). The Lawler Peak granite is in turn intruded by Cheney Gulch granite which is a fine- to medium-grained granite.

The Cheney Gulch granite is mainly exposed in the southern part of the district. Both granites are intruded by dikes and bodies of aplite-pegmatite. Rhyolite welded tuff of late Cretaceous-early Tertiary age unconformably overlies the Precambrian rocks on Grayback Mountain. Scattered small stocks, plugs and abundant dikes of quartz monzonite, quartz monzonite porphyry and diorite porphyry (74 m.y. age reported in Keith and others, 1984), also of Laramide age but slightly younger than the welded tuff, intrude the altered terrain forming a seven-mile long belt that trend N60°-70°E (Medhi, 1978). The Bagdad stock is the largest and only known productive stock in this belt. Tertiary to Quaternary clastic sedimentary rocks intercalated with basalt and rhyolite flows and tuffs overlie the older rocks and cap many of the mesas in the region (Anderson and others, 1955).

Several different styles and ages of mineralization exist in the district. The best known deposits consist of the Laramide age porphyry copper-related deposits which are accompanied by some peripheral lead-zinc-silver (±gold) veins. The famous Old Dick, Bruce and Copper King deposits are Precambrian, volcanogenic massive sulfide deposits that occur within the northeast-trending Bridle Formation of the older Precambrian Yavapai schist series (Clayton and Baker, 1973; Anderson and others, 1955). The primary sulfide ores are mainly chalcopyrite associated with pyrrhotite, arsenopyrite and small amounts of lead (Clayton and Baker, 1973). Nearly two million tons of massive sulfide ore were produced from the district (Donnelly and Hahn, 1981). Dates by Silver (1968)

suggest the massive sulfide ores were syngenetic with submarine volcanism and sedimentation that occurred between 1740-1760 m.y.B.P. Along Boulder Creek, northeast of Bagdad, wolframite-bearing veins in griesen are associated with the muscovite-biotite phase facies of the 1400 m.y.B.P. (Silver, 1968) Lawler Peak granite.

Gold output from the district has come largely from a number of gold-silver-zinc-lead fissure deposits; the most important of which have been the Hillside and Crosby mines. Anderson and others (1955) suggest that while some evidence is equivocal, cross-cutting relationships indicate that this type of mineralization post-dates intrusive bodies associated with the Laramide quartz monzonite. Other mines or prospects mentioned by these workers that are believed to be of similar kindred are the Mountain Spring, Comstock-Dexter, Stukey, Goodenough, Cowboy and Vidano claims. These veins range in width from less than 1 foot to 4 feet and are traceable for distances varying from several feet to one mile. The longer veins actually consist of several discontinuous veins that crop out intermittently along strike.

While these veins apparently fill actual fault fissures, it is interesting to note that almost all of them are restricted to the Hillside mica schist member of the Yavapai schist. This schist consists of a sequence of alternating layers of muscovite schist, quartz-muscovite schist, muscovite quartzite and some tourmaline schist. Sillimanite needles are present in some layers (Anderson and others, 1955). Anderson and others (1955) suggest that the protolith of the Hillside mica schist was a series of shale, sandy shale and impure sandstone that accumulated in a basin after a period of considerable volcanic activity. It seems possible that this unit might provide a source of gold to the later vein deposits. Anderson and others (1955) mention that near the Hillside vein, small veinlets of sulfide, with or without quartz, fill minor fractures in the Hillside mica schist; locally some of these veinlets were mineable and some were higher grade than the main vein. Some of the faults that strike eastward were locally mineralized with high-grade, gold-silver ore with the adjacent few feet of schist showing "replacement" ores of commercial value. This writer suggests the possibility that this mineralization might have been actually syngenetic in the schist and later was remobilized into economic deposits. The distribution of the gold veins mainly restricted to the Hillside schist is thought provoking and suggests a protolith heritage. Anderson and others (1955) also believed the Copper King and Old Dick massive sulfide ores were later replacement deposits within the Precambrian rocks.

The Hillside mine was discovered about 1880 with actual mining commencing in 1887. The most active periods of activity were from 1887-1902, 1909-1914, 1934-1942 and from 1948-1951. Cumulative production between 1887-1951 is given by Anderson and others (1955) as amounting to 58,748 oz Au; 1,315,264 oz Ag; 398,813 lbs Cu; 6,396,122 lbs Pb; and 3,300,524 lbs Zn. In 1941, mill-head assays averaged 0.18 opt Au, 4.1 opt Ag, 2.0% Pb, 3.7% Zn, and 0.3% Cu. No limit at depth by decreasing values was found in the mine; in fact, a small increase in gold, sphalerite and pyrite occurs in the lower levels (Anderson and others, 1955). In 1951, better than average ore was mined from the 800-ft, 900-ft, and 1000-ft levels.

While the Hillside, Comstock-Dexter and other gold-bearing mines in the district follow high-angle fault zones, low-angle faults also occur in the district; and some are mineralized (Anderson and others, 1955; Wilson and others, 1967). The age of these low-angle faults are not known, nor is it known if they are reverse (thrust) or normal. Elsewhere in the southwestern U.S. low angle structures host commercial gold mineralization where brecciation along them has been sufficient to allow room for fluid soaking and deposition of low-grade, large tonnage deposits.

A final point of interest involves what may be hotspring deposits in the Gila conglomerate. Anderson and others (1955) describe beds of rhyolite tuff intercalated with the conglomerate. These tuffs are typically poorly stratified but thinly bedded. Most of the volcanic material is white pumice lapilli and ash. These workers note that in some places (i.e. near Copper Creek Mesa) it is largely altered to clay. In other places, the tuff is locally altered to a grayish-white cavernous opal rock. Locally along the eastern margin of Bozarth Mesa the tuff is completely replaced by black opal that resembles obsidian. The clay and opal replacement could easily be caused by diagenetic processes in an alkaline lake setting, however, it is also possible that the alteration resulted from late Tertiary hotspring activity. This should be given some reconnaissance geologic and geochemical attention to further evaluate the occurrence.

Mines of Interest

Hillside Mine: (Located in Secs 16 & 21, T15N, R9W on Boulder Creek a little more than 3 miles north of Bagdad) The Hillside vein strikes N10°W at the south end of the mine and changes to a N25°E strike at the north end. Its dip averages between 75°-80° to the west, but overall is not very uniform. The main vein and several branches are said to occupy a zone of faults that had both pre- and post-mineral activity. A 3-ft gouge zone reportedly occurs with the vein. Branching veins appear on both sides of the main vein and in places were of commercial grade and width. Anderson and others (1955) note that at both the north and south ends of the workings, the tendency for the vein to branch, hindered attempts to find profitable extensions. High-grade stringers of silver ore were found beyond both ends of the mine workings. Exploration reportedly indicated that the vein may be dying out to the north, but that no limit at depth was found. Cross sections revealed that changes in the dip of the vein had some control on its width and grade. Where the vein is convex to the west, it is wider and often contains better gold and silver values. The vein has been worked some 2,700 ft along strike. More than 16,000 ft of underground workings have been driven along the vein at various levels. The mine was worked to the 1,000-ft level. The vein averaged 2.5 ft wide in the upper levels and 4 ft wide on the 800-1000 ft levels. Wallrock alteration along the vein is usually several inches to 1 ft in width and consists of sericite with some quartz introduction. Several stages of quartz-sulfide deposition is believed to have occurred in the vein. Hypogene mineralization includes arsenopyrite, gold, pyrite, galena, sphalerite, chalcopyrite, tetrahedrite, argentite and manganosiderite all in a quartz gangue. Secondary uranium minerals are noted in the upper oxidized ores and an assay recorded 2.3% U_3O_8 on a company assay plan on the 700 ft level. This writer would

suggest that primary uraninite probably occurs in some of the sulfide ores. The southern extension of the Hillside vein would seem worthy of some exploration considerations.

Comstock-Dexter Mine: (Sec. 28, T15N, R9W) Property is located along Butte Creek about 1.5 miles south of the Hillside mine. The Comstock-Dexter vein is considered to be a part of the south extension of the Hillside vein. Bedrock consists of Hillside mica schist that strikes northward and dips almost vertically. The vein reportedly strikes and dips essentially with the lamination of the schist. The mine is opened by over 4,000 ft of workings along the vein. The mine worked in late 1890's and by 1901 had shipped some high-grade ore and had processed oxidized material worth $18,000 in gold and silver in a 5-stamp amalgamation mill. Sulfide ore was reached at depth and become uneconomic. The vein consists of stringers and irregular masses of coarse-grained quartz which contains bunches and disseminations of sulfides (mainly pyrite, galena and sphalerite). It varies in width from several inches to at least 3 ft. The property was reportedly last worked in the 1930 to 1938 period. Hoagland (1937) states that some 47,745 tons of probable ore were present in the mine in 1937, averaging $13.48 per ton in gold and silver. While no tonnage figures are known for 1938, records indicate that production amounted to 410 oz Au; 6,500 oz Ag; 1,363 lbs Cu; and 8,080 lbs Pb. From this figure, it seems likely that only several thousands tons maximum were mined in 1938. Either the potential ore figures were grossly wrong or modest reserves must remain in the ground.

Cowboy Mine: (Sec. 14, T14N, R9W) Small irregular quartz vein strikes N10-30°W and dipping 50-80°W in Hillside mica schist. Discovered in 1889, the first recorded production occurred in 1911. Recorded production amounts to 350 tons of ore values at $9,173 ($4,779 in gold). The mine is developed by a shaft about 200 ft deep with about 700 ft of drifts. Workings were flooded in 1945. Reports suggest gold-silver values were greater in oxidized zone which varies from 25 to 150 ft in depth. Vein fillings reportedly consist of narrow lenticular masses of brecciated jasper together with coarsely crystalline, gray quartz. Schist makes up most of the country rock. Gold occurs mainly with lead minerals and usually in the jaspery bodies.

Kyeke Mine: (Sec. 29, T15N, R9W) Crushed zone 3 to 5 ft wide strike NW and dipping 35° to the east. Structure appears to be complex and high-angle structures may exist as well. In the shallow workings the ore is oxidized but contains kernels of fresh sulfides consisting mainly of arsenopyrite with a little pyrite. Shallow workings consist mainly of 50 ft adit and small underhand stope. Reportedly property produced some 60 tons of oxidized ore in 1936 and 1937 which yielded 15 oz Au and 29 oz Ag. A similar crushed zone reportedly crops out on the ridge to the south of the portal of the lower adit. This zone is about 1 ft wide, strikes N25°E and dips 40°E. Mineralization consists of partly oxidized arsenopyrite and quartz. Hand-sorted ore from this zone is reported to average $27/ton in gold and silver. Exposures are too poor to determine if this zone is an extension of the Kyeke zone.

Goodenough Mine: (Sec. 20, T15N, R9W) Copper-lead-zinc-quartz vein carries arsenic, gold and silver, in a rhyolite breccia plug. Ore reportedly contained too much arsenic for shipping ore. Metals recovered by smelter were gold, silver and copper.

Mountain Spring Mine: (Sec. 17, T14N, R9W) Parallel, interlacing, and branching quartz veins occur along the Mountain Spring fault zone which separates Precambrian Hillside mica schist and Lawler Peak granite on the east and Precambrian Bridle formation on the west. The veins average about 1 ft or less, but range up to 3 ft in places. The veins contain sulfides and gold, dip steeply and can be traced for about 1,500 ft. Primary sulfides in the veins are galena, sphalerite, chalcopyrite and pyrite. The sulfides are oxidized in the upper parts of the veins. In the shaft at Mountain Spring the vein reportedly consists of a series of parallel quartz and sulfide stringers separated by sericite schist. Reportedly the mine produced small shipments of hand-sorted ore for some time after 1942.

King Peak Property: Property consists of 13 patented claims in the area on the east side of King Peak about two miles SW of Bagdad. Little information available. Anderson and others (1955) note that in 1907, the Old Camp Mining and Milling Co. started an extensive exploration for gold in an area where small quartz veins crop out east of King Peak. The company reportedly drove 3 adits and patented the claims, but never shipped any ore.

Southern Cross Mine: (Sec. 32, T14N, R10W) Lenticular vein strikes northward and dips almost flat to 15°E in vertically foliated mica schist. Gangue consists of coarse-massive, grayish-white quartz that carried limonite and secondary copper minerals in fractures and small cavities. Wallrocks display sericitization and limonite staining. Vein ranges in thickness from a narrow seam up to 4 ft. In 1934, 55 tons of ore were shipped that ran from 0.75 to 1.0 opt Au. Workings include 70 ft incline shaft and 2 near-surface drifts with small stopes on the vein.

Mammoth (Hubbard) Mine: (Sec. 12, T14N, R10W) Old property that produced several cars of ore between 1931-34. Mine was developed on narrow southward-dipping fault zone that displays some FeOx and CuOx. Small ore shoot was discovered between 80- and 100-ft levels that strikes S70°W, dips 40°NW. This shoot was about 20 ft long by 2-2.5 ft thick. Vein material consists of milky quartz, calcite and purple fluorite. Pyrite occurs as small masses and disseminations in the quartz. The ore mined from this shoot reportedly averaged 0.4% Cu, 0.51 opt Au, and 2-3 opt Ag.

Zannarapolis Group: (Secs. 1, 2, 11, 12, & 14, T13N, R10W; on south slope of Grayback Mtn.) Zannarapolis group consists of 8 patented and 42 unpatented claims. Scheelite was discovered on the claims in 1941, but long prior to this the arroyos on the property were placered for gold using dry washers. The scheelite workings consist of a 200 ft shaft, an open pit, and many shallow shafts, trenches, and prospect pits (Dale, 1961). Bedrock consists of Precambrian mica schist with some gneiss and granite. In places the schist contains silicated limestone stringers; some being as much as 2 ft wide. Foliation strikes N20° to 60°E with steep to vertical dips. Mention is made of one small tourmaline-bearing pegmatite. The zone of scheelite deposition is reported to be approximately 3 miles long and ½ mile wide.

The main shaft is situated at the north end of scheelite-bearing outcrops that extend southward for about 1000 ft. Here the scheelite occurs in lenses associated with discontinuous veins of epidote and quartz. Scheelite also occurs disseminated in epidote-diopside rock and along random fractures in silicified schist.

Dale (1961) describes the scheelite as commonly occurring in a fine-grained greenish rock that usually contains quartz and probably feldspar in addition to epidote and diopside. Patches of calcite and brown garnet occur locally. Another mode of occurrence found near the north end of the property consisted of scheelite occurring in quartz-biotite schist intimately associated with small amounts of epidote said to reflect weak hydrothermal alteration of the schist; and with veins and pods of quartz that are generally less than 3 inches wide and from several inches to a few feet long. Dale also mentions that other minerals observed include pyrite, magnetite, garnet, calcite, fluorite and rhodinite. The relation of these to the scheelite was not known. We would suggest that this ore be examined for Precambrian stratiform mineralization and to determine the source of the gold recovered from the placers draining the schist.

References:

Anderson and others, 1955; Clayton and Baker, 1973; Donnelly and Hahn, 1981; Medhi, 1978; Silver, 1968; Wilson and others, 1967.

EUREKA DISTRICT

Location:

The Eureka district is contiguous with the Silver district to the north and covers the extreme southern end of the Trigo range along an eastward bend in the Colorado River (southern 1/2 of T4S, R22W). Like the Silver district, access to the Eureka district must pass through the U.S. Army's Yuma Proving Grounds. The southern part of the district lies within the Imperial National Wildlife Refuge.

Geology and History:

The southern end of the Trigo Mountains, where the Eureka district is located, consists of a very rugged, steep terrane with alternating canyons and ridges displaying several hundred feet of relief. Nearly all the district is underlain by Orocopia schist that generally strikes northeast to north and dips at various angles to the northwest and southeast. Faults of various trends cut the schists; as do a few aplitic dikes.

Information on the mineralization in the Eureka district is very sketchy. The district is usually included in the Silver district so production totals are difficult to determine. Wilson (1933) mentions the district and several of the claim blocks. Keith (1978) describes several of the old properties and notes some placer production from the district.

Veins in the district occupy fault zones that strike about N70°E and dip moderately to steeply NW. These veins are typically narrow, averaging about three ft in width, but in places swell to widths of 20 ft or more (Wilson, 1933). While the veins are often persistent over long lengths, ore shoots are described as being pockety and rather localized (usually in the vicinity of intersections of the main vein with cross fractures).

Vein fillings consist of manganiferous, ferruginous and white calcite intermixed with breccia masses and gouge. Cellular and crystalline quartz occurs in places. The deposits have been valued for their silver and gold values. Ore shoots are described by Wilson (1933) as consisting of limonite, hematite, cerussite and smithsonite with pods and veins of galena and ferruginous, black sphalerite. Wilson also mentions that the wallrocks display pronouned sericitization with varying amounts of silicification and chloritization along with abundant small metacrysts of pyrite.

Keith (1978) narrates the early mining history of the Eureka district. Mineralization was found by prospectors in the early 1860's and the district was formally organized in 1862. Keith (1978) reports that much argentiferous lead ore was shipped from veins near the river prior to 1860. George Silby, owner of a smelting works in San Francisco, worked the Riverview (Eureka) mine in the 1860's and shipped the high-grade lead-silver ore to his smelter by boat. An unknown but small amount of placer gold has also been won from the district.

Mines of Interest:

Riverview Mine (Eureka): (NE 1/4 Sec 31, T4S, R22W.) Shafts, tunnels and open cuts have been developed on pockety ore shoots of argentiferous and gold bearing lead and zinc carbonates in a gangue of FeO_x, manganiferous to ferruginous calcite and brecciated wall rock of schist. Alteration consists of silicification and chloritization. Walls contain pyrite metacrysts. Property worked intermittently since 1875. Production is estimated by Keith (1978) to have been some 150 tons of ore averaging about 14% Pb, 6 opt Ag, 8% Zn and 0.2 opt Au.

Mendevil Claims: (NE 1/4 Sec 1, T4S, R23W.) Irregular veins containing Pb and Ag in gangue of barite, celestite, calcite, and quartz fill fault zone separating schist and Tertiary volcanics. Some spots reportedly average 5% Pb and 15 opt Ag. Vein walls display chloritization. Deposit was developed by shallow trenches and pits.

Picacho Copper: (Approx. Sec 35 and 36, T4S, R23W.) In an area underlain by schist, porphyry and granite, numerous quartz veins carrying shallow secondary copper mineralization are common. Mineralization is weak with little found extending more than 10 ft below the surface. Samples taken by USBM engineers in 1942 from 2 cuts gave the following results: 0.015 opt Au, 0.12 opt Ag and 3.80% Cu across 2 ft width; 0.005 opt Au, Tr Ag and 0.22% Cu across 5 ft width. Grab sample of sorted ore gave 0.455 opt Au, 3.67 opt Ag and 11.01% Cu. This mineralized area has been known for 40 or 50 years and has numerous pits and cuts. Previous attempts to work it have resulted in failure.

References:

Ariz. Dept. Mineral Resources, file data; Keith, 1978; Wilson, 1933.

FORTUNA DISTRICT

Location:

The Fortuna Mining district is located about 16 miles southeast of Yuma in southwestern Yuma County. The district covers the central part of the Gila Mountains which now lies within the Luke Air Force Bombing Range and is restricted to mineral entry.

Geology and History:

The central part of The Gila Mountains is underlain by an extensive section of Mesozoic gneisses, schists and amphibolite which are intruded by a large granite pluton of Mesozoic age about 4 miles southeast of the Fortuna Mine. Stocks of a more leucocratic granite and aplite intrude the metamorphic rocks in the vicinity of the mine. These have been mapped as Laramide bodies on the Yuma County Geologic map, but could be as young as middle Tertiary. Felsic dike swarms of pegmatitic to aplitic composition also cut the metamorphic rocks. At least some of these dikes seem to be related to the Laramide (?) stocks.

The Mesozoic schists and part of the gneisses were believed by Wilson (1933) to have been derived from a sedimentary protolith. This interpretation is consistent with what these writers have observed in other nearby Mesozoic gneisses that contain significant gold mineralization. We believe these sediments may have played an important role as a source for metals in the younger deposits hosted by these rocks. This subject is treated in more detail in other sections of this report. The metamorphic fabric strikes predominantly west or southwest parallel to original bedding (transverse to the range) and dip steeply southward (Wilson, 1933). These rocks have been cut by a number of faults in the vicinity of the Fortuna mine.

Gold mineralization was discovered in the district in 1892 by four prospectors who sold their claims to interests that later became the La Fortuna Gold Mining and Milling Company (Keith, 1978). Although numerous, small, gold-bearing veins were discovered and prospected, only the Fortuna lode became a major producer. Blake (1897) and Wilson (1933) provide the most detailed descriptions of the mineralization and geology of the Fortuna lode. The Fortuna vein or veins apparently occur in a complex network of faults that in part both precede and postdate the mineralization. Gold occurs as fine-grained, native metal associated with pyrite and minor copper minerals in a gangue of brecciated quartz with calcite and iron and manganese oxides. In the high-grade quartz, microscopic examination (Wilson and others, 1967) reveals tiny bodies and irregular to interlacing veinlets of hematite, locally altering to limonite. Gold occurs as rounded grains within hair-like cracks and as irregular veinlets within the limonite.

Mineralization occurs along an irregular faulted zone and in lensing intersecting veins that filled fault and fracture zones in the schists. The main orebody consisted of a branching chimney like mass that outcropped at the surface as two

separate branches. These branches joined at about 500 ft depth, where they formed a single ore body with dimensions of 100 ft long by 1.5 to 12 ft wide. The orebody was lost at a fault in 1904 at about the 800 ft level. Later exploration managed to locate only a small segment of the faulted off vein between the 900- and 1,100-ft levels.

Wilson and others (1967) note that wallrock alteration accompanying the Fortuna vein consists mainly of carbonatization and silicification and suggest that the mineralization/alteration package resembles mesothermal deposition.

Keith (1978) lists estimated and recorded production from the Fortuna district as being 134,489 oz Au, 10,655 oz of silver and 98 lbs Cu from some 213,500 tons of ore; of which almost all was won from the Fortuna deposit.

While the district was a bonanza gold district and would be interesting to explore in light of new ideas concerning the Mesozoic metasedimentary rocks in this part of Arizona, the district lies within the military withdrawal area and thus it is not open to mineral entry.

References:

Blake, 1897; Bryan, 1925; Darton, 1925; Keith, 1978; Wilson, 1933; Wilson and others, 1967.

FRENCH GULCH (ZONIA, WALNUT GROVE) DISTRICT

Location:

The French Gulch district in this report refers to an area which encompasses the 3 small contiguous mining districts of French Gulch, Zonia and Walnut Grove. The area covers the northeastern portion of the Weaver Mountains, about 6 miles southeast of Kirkland Junction.

Geology and History:

The geology of the northeastern portion of the Weaver Mountains is very poorly known. Wilson (1961) and Johnson (1972) describe the gold placers of the Walnut Grove district but give only the briefest discussion to the bedrock geology of the area. Donnelly and Hahn's (1981) geologic map showing the distribution of Proterozoic rocks in central Arizona, subdivide the Precambrian schist exposed in the district into packages composed predominantly of mafic volcanics, felsic volcanics and volcaniclastics, with some epiclastic sediments. Kumke (1947) described the geology of the Zonia mine area.

The oldest rocks exposed in the district consist of a complex assemblage of Yavapai Schist. These schists form a northeast elongate zone which is about 8 miles long in its maximum direction and up to several miles wide. The schist is sandwiched between Precambrian granitic and dioritic rocks along its northwestern and southeastern flanks. Tertiary volcanic rocks cap the Precambrian rocks on the northern and western portions of the district.

The Walnut Grove placer district includes portions of the Placerita, French, Cherry, Blind Indian and Mill drainage areas which feed into the Hassayampa River system. Wilson (1961) states that in much of this vicinity, the Weaver Mountains consist of a northeast sloping pediment into which the gulches have dissected. The system of placers along the Hassayampa River was most actively worked between 1885 and 1890 (Johnson, 1972). Blake (1899) stated that "The placers. . . . at Placerita have long been known and worked, and are regarded as good wages mines." In the late 1880's, a dam was built at Walnut Grove (near the junction of Cherry Creek with the Hassayampa) to permit hydraulic operations at Rich Hill and large scale placering on downstream portions of the Hassayampa. The 1890 failure of this dam and the subsequent loss of some 150 lives in the insuing flood is a dark spot in early Arizona mining lore. Gold-bearing gravels in the district have been mined along the upper parts and side gulches of Placerita Gulch, near the confluence of French and Placerita Gulches and on French Gulch about 1 mile south of Zonia. Gold found was fairly coarse and many nuggets in the 1/4- to 1/2-oz size range were reportedly recovered (Johnson, 1972). Other placer gravels were located in the district; some were on the east side of the Hassayampa, but none were as productive as those on French and Placerita Gulches. Johnson (1972) lists all the main placer areas along the Hassayampa drainage system.

The source of the gold in the placer gravels was believed by Wilson (1961) to have been derived from many small gold-bearing quartz veins that occur in the

Precambrian rocks. Unfortunately, we have little knowledge about these lode deposits. Several of the deposits (i.e. Zonia, Zonia McMahon, Victory Copper and possibly the Silver Crown and Copper Crown) are probably syngenetic massive sulfide deposits in the Yavapai schist. Some by-product gold and silver is associated with these ores and thus they could be a source for at least some of the gold in the placer gravels. The CRIB and MILS data also list several gold-predominant deposits including the Vesuvius, Malpai, Bonanza, Portland and Pocket and Sunset mines. These deposits may also be a source for the placer gold. While most of these gold dominant deposits appear to cut granitic rocks on our map, several are in the schist and should be examined for possible syngenetic relationships. In addition, some of the base-metal massive sulfide ores in the Bradshaw Mountains contained considerable by-product precious metals, particularly in their oxidized gossans. While deposits of this type in the French Gulch district are thought to be small, there may be potential for leachable gold ores to exist in the oxidized cappings of some of the massive sulfide ores. In his report on Arizona molybdenum occurrences, Hicks (1979) states that the Fiesta group (3.5 miles SW of Kirkland Junction) contained cerussite, molybdenite, silver and gold. This deposit consists of quartz veins 1 to 30 ft thick cutting a quartz porphyry.

Mines of Interest:

Moyer: (T11N,R4W) Located approximately 16 miles southwest of Kirkland (Location inexact, no other references). The vein parallels schistosity which is almost vertical. It is marked on the surface by a black siliceous outcrop. No ore crops out on the property, but the orebearing lenses of quartz which form a series of small, connected shoots, apparently lies near the surface. The deposit was mined by stripping the surface and moiling out the ore. In 1937, when the property was visited by USBM engineers, an area bout 100 ft had been stripped. A carload shipment averaged 1.02 opt Au. Seven samples taken by the USBM engineers averaged 0.39 opt Au. The differences between the shipped ore and the engineer's samples were believed to have resulted from ores closet to the surface being somewhat higher grade.

References:

Blake, 1899; Donnelly and Hahn, 1981; Hicks, 1979; Johnson, 1972; Kumke, 1947; Wilson, 1961.

GILA BEND MOUNTAINS DISTRICT

Location:

The Gila Bend Mountains mining district covers the western end of the Gila Bend Mountains in the extreme northeast corner of Yuma County. This part of the range is sometimes referred to as the Nottbusch Mountains.

Geology and History:

This area of Arizona is very poorly mapped. Wilson's (1933) reconnaissance of the mining district is the most detailed published account available. The oldest rocks exposed in the district are strongly laminated Precambrian (?) schists that are Pinal-like in appearance. These rocks consist mainly of fine-grained quartz, sericite and chlorite, but chert-banded, gray limestone predominates in places. Dikes of andesitic to granite composition cut the schists in places. The schists are intruded by Laramide granite on the east which serves to separate the schists from a large body of Precambrian gneissic rocks. On the western end of the district, the schists are overlain by dark, cherty limestone and sandstone that shows minor faulting and tilting. These sediments are mapped as Tertiary on our lithotectonic map (Plate 1), but they could be as old as Mesozoic. The southern half of the district is covered by a thick sequence of mid-Tertiary volcanic rocks that include andesites, basalts and tuffs. In places, northwest-trending dikes intrude the volcanic rocks.

The district lies along a pronounced, regional, west-northwest-trending structural zone that continues westward to the Colorado River. This zone appears to represent a deep-seated basement fault system, probably a strand of the Texas Lineament. The central and eastern portions of the Gila Bend Mountains contain pronounced northwest-trending dike swarms and intrusive bodies of mid-Tertiary age that cut similar aged volcanic rocks. While these areas are not known to display any associated mineralization, they may represent "sleeper" areas in which to explore for disseminated type gold targets along major structures in proximity to the Tertiary intrusions.

Gold mineralization in the district occurs in quartz fissure veins or silicified zones in the schist or granite. Wilson (1933) believed oxidation of the veins had concentrated gold near the surface and developed considerable iron oxides in the veins. Minor copper oxides, carbonates and silicates also occur with the iron oxides. Partly oxidized lead-fluorite-quartz veins are also known to occur in a fault zone in calcareous and cherty schist (Yellow Breast prospect; See Wilson, 1933).

The mention of cherty and calcareous horizons in the Precambrian schist is interesting. These units may represent cherty or calcareous iron formation protoliths that may have potential for hosting Precambrian gold mineralization. This possibility we consider worthy of follow up.

Mines of Interest:

Bill Taft (Little Jane) group: (SW-1/4 Sec 11, T25, R11W.) Country rock is of steeply dipping Precambrian schist that is in places cut by andesitic dikes that strike S80°E. Gold-bearing quartz veins and fracture zones occur ist. Workings are all shallow, probably with only small, unrecorded production. The Little Jane claim, about 3/8 mile east of the Bill Taft workings, displays an east-striking quartz vein. This narrow vein dips shallowly (20°) to the south and is associated with heavy sericitic, brown hematite. It reportedly contained coarse, visible gold near the surface.

Belle Mackeever Group: (Location inexact; less that 1/2 mile northwest of the Bill Taft shaft.) Talus covered, Precambrian foliated schist hosts a silicified, gold-bearing zone that is exposed in a few shallow cuts. This 2-1/2 foot zone is made up of bunches or lenses of quartz alternating with streaks of brown and black FeOx. Portions of this zone reportedly assayed from $40 to $139 per ton (1933). What strike continuity this zone might have beneath the Talus cover was not known at the time. Wilson (1933) examined the prospect.

Yellow Breast Prospect: (Location inexact; about 3/4 mile northeast of the Bill Taft workings.) Calcareous schists containing 1/4 inch wide chert bands is locally exposed under gravel-mantled pediment surface. These schists strike N30°W with near vertical dips. Schist is cut by galena bearing fluorite vein that is developed by 2 shallow vertical shafts. What is of interest in this prospect is the calcareous schists with the thin chert horizons. Area should be examined to determine if it has any potential for hosting gold-bearing metaexhalitive horizons.

Camp Creek Prospect: (W. Cen. Sec 1, T25, R11W.) Gray silicified schist is intruded by many irregular dikes of granite porphyry. Schist is cut by numerous eastward-trending fractures. One fracture zone is some 15 ft wide at surface and is marked by abundant siliceous hematite and limonite with small veinlets and veins of chrysocolla and malachite. It reportedly also contains some free gold. Some workings developed from two 100-foot shafts about 50 ft apart. On the 30 foot level, this zone has reportedly splayed into 2 narrow fracture zones containing limonite and some copper-stain. The gold content of this zone is unknown.

Maricopa Chief: (W1/2 Sec 7, T35, R9W.) The Homestake vein has been developed by an 80 ft incline shaft and several open cuts. The Gold Hill vein has been developed by open cuts and by a 120 ft incine shaft with short drifts going off at the 60- and 120-ft levels. This vein has been prospected for about 500 ft. Eight samples taken by USBM engineers in 1935 at favorable places in the vein averaged $37.64 across a 28-in width.

References:

Arizona Dept. Mineral Resources, Mine file data; Wilson, 1933.

GILA CITY (DOME) DISTRICT

Location:

The Gila City or Dome mining district covers the extreme northern end of the Gila Mountains (T8S, R21W) about 13 miles east of Yuma.

Geology and History:

The Gila City district is known mostly as a placer producing locality. The site became well known in 1858 when as many as a thousand men rushed to the area to work its gulches and canyons. The gravels were very rich and much gold (>26,000 oz; Johnson, 1972) was retrieved from an area that had an east-west length of about 2 miles and a width of 1/4 to 3/4 mile.

The geology of the northern Gila Mountains has been described by Wilson (1933). The area is floored by a sequence of Mesozoic metamorphic rocks that are intruded on the south by an outlier of the Gunnery Range batholith. A low-angle fault zone or possible unconformity is overlain on the north by a sequence of tilted, well stratified, weakly consolidated Tertiary sediments. The Tertiary rocks consist of mud-cracked clays, marls, arkoses and sandstones that constitute the bedrock of the placer locality.

The Mesozoic metamorphic rocks are predominantly schists and gneisses that strike eastward, dip 20° to 80° southward and form an east-west-trending belt that is about 3.5 miles long by 1 mile wide (Wilson, 1933). The total exposed thickness of these rocks is on the order of about 2000 ft. Wilson believed the schists were derived from a sedimentary protolith, while the protolith of the gneisses could not be determined. Within these rocks occur an unusual sequence of black schists that are conformably overlain by a marble-bearing schist. In places the marble unit obtains a maximum thickness of about 150 ft, but it typically is of irregular thickness and is in part interbedded with schist and quartzitic material. Some contact metamorphic minerals are reported in the marble, but Wilson believed regional metamorphism was responsible for the recrystalization of these rocks. This marble formation is reported to contain spotty tungsten mineralization along its length (Dale, 1959). The entire metamorphic package is cut by dikes of pegmatite and granite in numerous places.

The source of the gold in the placer deposits is somewhat problematic as no high-grade gold-veins have been found in the northern Gila Mountains. Wilson believed the gold was derived from the weathering of numerous low-grade and pockety gold-bearing quartz veins in the Mesozoic metamorphic rocks. This would be a setting much like that in the Dome Rock district west of Quartzite. A few irregular and lensing quartz veins containing weak and spotty oxidized copper mineralization and gold have been explored in the black schist (Keith, 1978) and marble part of the Mesozoic section.

The association of gold deposits (placers) hosted by or derived from Mesozoic metamorphic rocks along the Colorado River in southwestern Arizona seems to be

more than coincidental. The gold deposits in the central part of the Gila Mountains (Fortuna) are also associated with these rocks. It seems likely to us that there is something intrinsic in these rocks that allow them to be equated with many of the gold districts in the region between Yuma to Quartzite. We have seen evidence that makes us suspect that possible weak syngenetic mineralization within the sediment/volcanic protoliths in these areas may provide an abnormally high background of gold and associated metals to be scavanged into economic concentration by later igneous/metamorphic events. This could be the ultimate source for the gold in the Gila City placers.

Also of interest, is the fault Wilson (1933) notes that separates the tilted Tertiary sediments from the Mesozoic strata. The geomorphology of the contact suggests that this fault could be a low-angle normal fault or detachment zone, which in other parts of Arizona are known to be mineralized. While, Wilson gave no indication of this possibility, it could be something else to check out.

Mines of Interest:

McKay Prospect: (NE 1/4 Sec 13, T8S, R21W) (protracted). Black schist encloses quartz veins of dense, vitreous white quartz containing numerous limonites after pyrite. Quartz is extensively brecciated and cemented with ferruginous calcite and hematite that weather black. Deposit is developed by shallow shaft and old tunnels.

McPhaul Prospect: (N. Cen. Sec 14, T8S, R21W) (protracted). Mineralized vein following fault separating schist footwall from marble hanging wall. The deposit contains chrysocolla, malachite, limonite, hematite and some gold. Wulfenite occurs near the walls in upper workings. Coarse sericite is abundant along the vein walls.

Reference:

Dale, 1959; Johnson, 1972; Keith, 1978; Wilson, 1933.

GOLD BASIN (GOLD HILL) DISTRICT

Location:

The Gold Basin mining district is located in northern Mohave County, south of Lake Mead and about 95 km north of Kingman. The Gold Basin district is adjacent to, and often described with, the nearby Lost Basin district (cf. Theodore and others, 1982). The two districts are separated by Hualapai Valley.

Geology and History:

The Gold Basin district exhibits a complex geologic history, aspects of which have been recently studied by a number of workers (i.e. Blacet, 1968, 1975; Theodore and others, 1982; and Myers and Smith, 1984). Theodore and others (1982) describe field relationships of the geology and mineralization as well as laboratory results of metallogenic studies in great detail. This brief synopsis is largely abstracted from their study.

The Gold Basin district is located in the Basin and Range physiographic province just west of its boundary with the Colorado Plateaus. The district (as well as the Lost Basin district to the east) occurs in an uplifted platform and includes a north-south trending range (White Hills) that consists mostly of Proterozoic basement rocks from which the Paleozoic section has been removed by erosion.

Basement in the district consists of Proterozoic X metamorphic and igneous rocks. The gneiss is the most widespread unit in the range and is the major host to the known gold-quartz vein deposits. The unit includes both paragneiss and orthogneiss which are believed to be in the 1,750 m.y. age range. These rocks consist of an assemblage of metasedimentary rocks, composed mainly of quartzofeldspathic gneiss, but interlayered with biotite-garnet-sillimanite schist, cordierite gneiss and amphibolite. Locally the amphibolite sequence is predominant and consists of metagabbro, metadiabase, metaclinopyroxenite and metawehrlite. The amphibolite normally crops out as variably sized lensoid masses. In addition, metamorphic rocks in the district also include meta-quartzite, thin lenses of marble, calc-silicate gneiss, banded iron formation and metachert. Theodore and others (1982) note that pelitic metamorphic rocks are widespread throughout the gneiss terrane in the Gold Basin - Lost Basin districts. This assemblage includes; biotite-muscovite schist, tourmaline schist, almandine-biotite ± staurolite schist and gneiss, kyanite gneiss and schist and sillimanite - and cordierite-bearing gneiss and schist.

The gneiss complex is intruded by Proterozoic X igneous and metaigneous rocks, the most widespread of which include gneissic granodiorite, and a complex of porphyritic monzogranite and leucocratic monzogranite referred to as the Garnet Mountain complex. The porphyritic monzogranite of Garnet Mountain was most likely emplaced about 1,600 m.y. ago (Theodore and others, 1982). Proterozoic Y(?) diabase occurs locally as NW-trending dikes. An elongate, N25°E trending body of gneissic granodiorite crops out over about 10 km² area in the Gold Basin district. Theodore and others (1982) note that the eastern contact of

this body with the surrounding gneiss appears to have acted as an important conduit for the circulation of fluids associated with the gold mineralization. Prospects and productive mines are especially concentrated along an approximately 2 km strike length of this contact.

A late Cretaceous, (72.0 ± 2.1 m.y.; McKee in Theodore and others, 1982) peraluminous, two-mica, monzogranite crops out in a 4-5 km² area in the southern part of the Gold Basin district. This pluton is undeformed and includes some facies of episyenite, minor aplite and pegmatite.

The oldest Tertiary rocks in the general area are Miocene volcanic rocks believed to be Mount Davis or Patsey Mine equivalents (cf. Anderson, 1971), consisting of rhyolitic tuffaceous sedimentary rocks and fanglomerates. The volcanic rocks consist mainly of andesite. The base of the volcanic pile is poorly exposed in the Gold Basin - Lost Basin area, but rather is marked by a low-angle detachment surface. The overall tectonic history of the detachment fault is still poorly understood. Theodore and others (1982) suggest that it is not similar to dislocation surfaces spatially associated with Cordilleran metamorphic core complexes, but rather may be associated with near-surface distension associated with the emplacement of plutons pene-contemporaneous with the Mount Davis volcanics (cf. Anderson, 1971; Anderson and others, 1972). This detachment fault borders the White Hills along its entire western margin.

Miocene-Pliocene sediments of the Muddy Creek Formation are younger than the volcanic rocks. The early depositional history appears to have been largely an environment of small basins and topographic lows associated with interior drainage. The Hualapai limestone member, however, was probably deposited in a marine environment at the northern end of an extended embayment of the Gulf of California beginning more than 8.9 m.y. ago (Blair and others, 1977).

Blacet (1969, 1975) and Theodore and others (1982) describe four types of lode gold deposits known in the Gold Basin - Lost Basin districts:

1. The most common lode gold deposits occur associated with widespread quartz-cored pegmatite-vein system, presumably emplaced in late Cretaceous time and genetically associated with the two-mica magmatism. These veins were deposited along both high- and low-angle, pre-existent structures in the Proterozoic X terrane.

2. Some gold-bearing quartz veins are believed to be Proterozoic in age and probably related to emplacement by the nearby 1,400 m.y. granite of Gold Butte, which crops out to the north of Lake Mead.

3. Disseminated gold occurs in small alteration pipes of fluorite-bearing episyenite, whose emplacement is presumably genetically related to the intrusion of the two-mica granite.

4. Gold-quartz mineralization occurs in the low-angle Miocene detachment fault. Theodore and others (1982) attribute this mineralization as Cretaceous vein deposits that were tectonically caught up and drug along the Miocene low-angle fault. The Cyclopic mine is the type example of this mineralization.

These workers suggest that most of the gold in vein and pipe deposits probably reflect either remobilization of gold from gold-bearing, near-surface Proterozoic source areas, or anatectic incorporation of gold into Late Cretaceous, peraluminous, two-mica magmas from very deep gold-bearing Proterozoic sources. Gold deposition occurred in a mesothermal environment during the galena-, chalcopyrite-, ferroan-carbonate-bearing stages of the veins. Laboratory studies indicate fluids were moderately saline (4-16 wt % NaCl equiv.), nonboiling, and also contained considerable CO_2 and locally fluorine. These workers suggest these salinities bridge the composition interval between epithermal precious metal and porphyry copper deposits.

Myers and Smith (1984a, 1984b) also recognize a Tertiary mineralizing event at the Cyclopic mine. This episode of gold mineralization was directly controlled by the detachment fault and is localized in the hanging wall of the detachment fault and in the footwalls of high-angle structures antithetic to the detachment surface. This mineralization is apparently low grade, relatively minor in importance, and is characterized by pervasive argillic and localized ferric alteration.

Most of the lode mines in the Gold Basin district occur in the southern portion of the district. Gold ore was discovered in the district in the early 1870's with most of the production prior to 1932 coming from the El Dorado, Excelsior, Golden Rule, Jim Blaine, Never-Get-Left, O.K. and Cyclopic properties (Theodore and others, 1982; Schrader, 1909). By 1881 ores were being worked in two stamp mills. By 1882 the El Dorado mine included 26,000 tons of developed ore (Burchard, 1883). The Cyclopic mine which was discovered in the 1880's became the main population center of the district during the early 1900's. This mine was intermittently in production between 1904 and 1934, and overall has been one of the largest producers in the district. In 1936 the property was acquired by new owners and produced nearly steadily through 1940. In addition to the Cyclopic, the O.K. and Excelsior mines were relatively steady producers over the years. Theodore and others (1982) state that the following mines also had intermittent production during the depression era mining revival between 1930 and 1942: Harmonica, El Dorado, Fry, Gold Hill, Golden Link, Golden Rule, M.O., Morning Star, and San Juan group. In 1980, Santa Fe Mining Company staked some 246 mining claims covering most of the southern part of the district. Whether or not they still hold this position is not known. Keith and others (1983a) credit the district with some 20,000 tons of production from which were produced 9,400 oz Au; 2,900 oz Ag; 34,000 lbs Pb; and 400 lbs Cu. This estimate would appear to be somewhat low.

Theodore and others (1982) suggest several avenues in which to channel addition exploration in the Gold Basin (and Lost Basin) districts. These include:

1. Prospecting for sequences of rock that might form favorable replacement zones adjacent to, or nearby any of the gold bearing veins. Suggested units include Proterozoic X carbonate, amphibolite, etc. Tectonically shattered zones would also fit into this category.

2. If the episyenite alteration pipes containing the disseminated gold formed as hypothesized, then such an environment must reflect a mineralized level geologically deeper than the bulk of the veins cropping out in the district. Thus, all quartz-fluorite-bearing veins should be evaluated as to whether or not they reflect the upper quartz depositing portions of a system which at depth includes early quartz-dissolving and late gold-depositing paragenesis. In addition, the two-mica monzogranite may contain disseminated gold-bearing episyenitic facies at depth.

3. The entire trace of the low-angle detachment surface should be evaluated for the occurrence of Cyclopic-type, "mechanically entrained" gold-quartz deposits. These writers indicate that this fault is poorly exposed in many areas, but that in places increased abundances of tectonically polished or striated vein quartz in float may indicate areas of similar tectonically caught up mineralization.

   We would also add to this consideration the Tertiary mineralization aspects controlled by this structure as identified by Myers and Smith (1984a, b). This might make this feature a much more attractive target similar to environments that are being heavily prospected at present in the nearby Black Range and other parts of the southwest. We would hasten to point out the number of Hg and As NURE anomalies that occur near the trace of this structure (see NURE overlay), particularly in the northern part (sometimes referred to as Gold Hill) of the district. We recommend that these anomalies be given additional field checking and sampling.

4. The Proterozoic X metamorphic rocks may be potential hosts for syngenetic, stratiform deposits. Theodore and others (1982) indicate that there are suggestions that boron-enriched fluids were important in the paragenesis of tourmaline-bearing schists. Such conditions may reflect exhalative horizons emanating from centers in the protolith of the metamorphic rocks.

   We would add that these workers also describe thin beds of carbonate-rich units (now marble, calc-silicate marble and skarn) that are spatially, closely associated with amphibolite (mafic to ultramafic protoliths). These could well be carbonate-rich exhalites. Some of the calc-silicate marbles contain such minerals as garnet, zoisite and clinozoisite, and possibly chloritoid. Minerals such as chloritoid and garnet are often found in the footwall or lateral facies of Archean syngenetic metal deposits. Metarhyolite and metachert horizons are also described within the gneissic terrane. Nearly all of the recognized gold-bearing iron formations in the Proterozoic of Arizona consist of small cherty horizons associated with rhyolite domes (Ed DeWitt, personal commun., 1985; also compare Swan and others, 1981).

5. Minor-element signatures in the native gold from several localities in the Gold Basin and Lost Basin districts indicate a possible relationship to a buried porphyry-type system. This relationship needs further evaluation.

The Gold Basin district contains numerous prospects and mines. The major early mines are described by Schrader (1909), and Wilson and others (1967). Theodore and others (1982) published Blacet's field descriptions of nearly every prospect in the Gold Basin - Lost Basin districts. We have reproduced a few of the most interesting ones below in the Mines of Interest Section. Any reader interested in the district should seek the complete list found in Theodore and others (1982).

Mines of Interest:

El Dorado Mine: (T28N, R18W, Sec. 21 SW¼) The mineralized vein seems to average 3 ft thick and dips ESE 25°-30° at west side of workings shallowing to nearly horizontal at the tunnel portals on the east side of the ridge. The workings generally dip 20°ESE parallel to the vein. The country rock is intensely sheared, cataclastic, medium-grained Proterozoic X gneissic granodiorite. The mineralized vein(s) are occupying an intensely sheared zone that is of probable late Cretaceous-early Tertiary age. Although the vein quartz is fractured (locally intensely), it is not brecciated.

Some veins crosscut highly foliated gneissic granodiorite, but generally they approximately parallel the schistosity. No red or clay gouge nor indication of notable Tertiary movement is present. The main vein also parallels a pegmatite, and in part, the 2 m thickness of quartz probably reflects the quartz-core stage of the pegmatite. The quartz vein lies between a crumpled and kink-banded, schistose granodiorite and an overlying sill of leucogranite pegmatite. There is abundant chrysocolla, moderate galena, but no chalcopyrite seen. Some wulfenite and cerrusite are also present.

In the irregular surface cut 30 ft northwest of the opening at the northwest end of the underground stopes, altered biotite lamprophyre has consistent chilled margins against the mineralized vein quartz. This indicates the mafic dikes and sills are post-mineralization. Intensely sericitized leucogranitic sills occur below the vein here, indicating a somewhat crosscutting relationship. Numerous veins 1 in to 3 ft thick are concentrated in an intensely sheared, gently dipping but undulating zone.

Unnamed Site: (T30N, R18W, Sec. 28 SE¼) Group of approximately N10°W striking veins which dip 30°-35° NE crop out here. Irregular stringers and elongate masses of coarsely crystalline barite are somewhat abundant in this general area as late fillings of en echelon gashes. Ankerite is associated with the barite, and an albite-pyrite-ankerite assemblage is common along the walls of individual veins.

Excelsior Mine: (T28N, R18W, Sec. 22 NW¼) Thin quartz-carbonate veinlets parallel the foliation in a highly foliated zone that strike N35°-40°E. The

highly foliated shear zone shows silicification, sericitization, and flooding by carbonate, and the zone occurs between gneiss and porphyritic monzogranite. The bulk of the alteration and quartz veinlets are concentrated in a zone approximately 22 ft wide. The veins include quartz-carbonate-chlorite-pyrite-galena (trace)-gold(?) assemblages.

Senator Mine Area: (T28N, R19W, Sec. 14, NW¼) A horizontal adit penetrates a low-angle fault, which is in turn offset about 3 ft a high-angle normal fault. An upper prospect nearby is an open cut 50 ft long, entirely in deformed gneiss, containing commonly isolated, blocks, and lenses of crushed quartz. A trace of pyrite was found on one vein fragment.

Cyclopic Mine: (T28N, R18W, Sec. 30, SW¼) Series of northwest open cuts and pits along a Miocene detachment fault breccia which is exposed in place at several localities. Free gold occurs in at least one hand sample picked up in southern half of series of cuts. Abundant angular fragments are found containing milky-white quartz with dark-reddish-gray matrix. Considerable cellular gossan, with wulfenite is common. Old underground workings were intersected in some of the open cuts, but none were accessible. Numerous prospects, pits and trenches occur in the lower (?) gouge zone. Vein quartz is brecciated and widely scattered in the gouge as blocks 2 ft long and approximately 1 ft thick. Veins contain galena, pyrite, ferrocalcite, malachite (alteration of chalcopyrite(?)), wulfenite, gold and cerrusite. Brilliant crimson mineral may be cuprite. Red, brown, and black Fe and Mn(?) oxides are present. Tertiary mineralization is characterized by pervasive argillic and ferric alteration. Samples of this mineralization reportedly run 0.002-0.065 opt Au.

Cyclopic No. 6 Prospects: (T28N, R19W, Sec. 25, NE¼) A major splay of the detachment fault zone containing red-brown gouge and comminuted monzogranite cuts through the prospects. A minor fault strikes N10°-15°E, dips approximately 40°W, and is possibly parallel to the main fault system. Quartz-carbonate-pyrite veins and recemented quartz breccia of the Cyclopic type occur in the gouge zone.

Approximately 500 to 1000 ft southeast of this locality, there are numerous prospects, pits and trenches in the lower gouge zone. Vein quartz is brecciated and widely scattered in the gouge as blocks 2 ft long and approximately 1 ft thick. Veins contain galena, pyrite, iron carbonate, malachite (alteration of chalcopyrite(?)), wulfenite, gold and cerrusite. Brilliant crimson mineral may be cuprite. Red, brown and black iron and manganese (?) oxides are relatively abundant.

Unnamed Prospect: (T28N, R20W, Sec. 26, NE¼) Gold-bearing quartz + pyrite + carbonate vein material occurs in a coarse, angular landslide breccia. Trace of gold is visible, and may indicate covered mineralized area of Cyclopic type.

Owens Mine: (T28N, R19W, Sec. 1, NW¼) Underground workings at the mine probably measured at least 300 ft. Head frames and ladders have been removed. Considerable chrysocolla and malachite occur as staining along a narrow fault zone which parallels the gneissic layering in the hanging wall. There is a slight discordance of the fault plane with the attitude of the layering in the

footwall gneisses. Amphibolite and biotite gneiss are the main rock types in the mine area, but at least one 2 ft thick bed of laminated iron formation crops out at several points southwest and west of the main shaft. Calc-silicate rock is cut locally by quartzose veins or pegmatitic alaskite. The veins include fine-grained granular quartz, iron carbonate, specularite, pyrite and secondary copper minerals. Sericitization is intense and widespread.

Unnamed Site: (T28N, R19W, Sec. 11, SE¼) Altered amphibolite here shows silicification and flooding by carbonate. In addition, a quartz-carbonate-hematite-pyrite vein crops out and contains some secondary copper minerals.

Unnamed Site: (T28N, R18W, Sec. 35, SW¼) Leucosyenitic pipe, elongated in a northeasterly direction crops out at this locality. Its overall dimensions at the surface are about 60 by 200 ft. The pipe contains a quartz-free central zone which also shows fairly abundant concentrations of fluffy orange iron oxide(s) replacing iron carbonate. The outer portion of the pipe shows increasing concentrations of quartz in irregularly distributed stringers and veinlets. Although this locality shows no fluorite or obvious pyrite, the pipe here is nonetheless similar to that exposed in Sec. 27 (see below) which contains visible disseminated gold.

Unnamed Prospect: (T28N, R18W, Sec. 27, SE¼) Fluorite-gold-pyrite-bearing episyenitic rocks cut fine- to medium-grained biotite monzogranite. Gold occurs in leached cavities in these episyenitic rocks. In outcrop, the episyenitic rock occurs in four small pipe-like masses, the largest of which measures about 25 ft across. Two shallow prospect pits have been dug on the pipes, most likely because of the color anomaly resulting from the oxidation of pyrite.

Unnamed Prospects: (T30N, R18W, Sec. 19, NE¼-protracted) Gold was observed at five different prospects in this general area. A vertical shaft approximately 100 ft deep had the largest amount of secondary (?) gold. The veins generally pinch and swell irregularly, and are composed essentially of quartz, carbonate, pyrite and gold. They may be Proterozoic in age.

Unnamed Prospects: (T29N, R18W, Sec. 17, NW¼NE¼-protracted) A series of pods and stringers of quartz veins are emplaced along what appears to be a N80°W striking and 35°-50° N dipping shear zone. An early quartz-carbonate-pyrite-galena-chalcopyrite-gold assemblage in the veins has been brecciated and cut by subsequent seams of white calcite, limonite and barite. Bladed groups of thin barite crystals fill vugs from which the early carbonate has been leached. Considerable free gold is found along pyritic seams in large quartz blocks on the easternmost dump along these workings. Galena and chalcopyrite are also abundant. Country rock consists of an altered granitic gneiss sequence within the gneiss unit.

References:

Anderson, 1971; Anderson and others, 1972; Blacet, 1968, 1969, 1975; Blair and others, 1977; Burchard, 1883; Keith and others, 1983a; Myers and Smith, 1984a, 1984b; Schrader, 1909; Swan and others, 1981; Theodore and others, 1981; Wilson and others, 1967.

GREENWOOD (SIGNAL) DISTRICT

Location:

The Greenwood district is a northwest elongated district that is located at the extreme southern end of the Hualapai Mountains and just north of Arrastra Mountain in southern Mohave County.

Geology and History:

We could gather little definitive information on the Greenwood district. Tungsten mineralization in the district has been described by Wilson (1941) and Dale (1961). Radioactive occurrences have been investigated in the district and reported on by the AEC (in RME 158). Hewett and others (1936) indicate that gold quartz veins occur in Precambrian gneiss and schist, and that the district has yielded a small amount of gold for many years. Production between 1902-1962 is recorded as some 2,000 tons of ore which yielded 1,000 oz Au, 600 oz Ag, 400 lbs Cu, 1,000 Pb. Production prior to 1902 was not recorded and is unknown.

The district is underlain by a Proterozoic metamorphic complex consisting of gneisses and schist that are presumably about 1,800 m.y. old. This complex has been intruded by somewhat younger Proterozoic granitic bodies, particularly near the southern end of the district. These rocks are cut by numerous dikes of aplite, pegmatite and other igneous rocks of uncertain but probably numerous ages. Patches of Tertiary volcanic flows locally overlie these older rocks.

The district is noted for its tungsten occurrences which appear to be mainly glassy quartz veins of Precambrian age. These veins often strike and dip conformably with the fabric in the gneissic rocks (generally NE-trends), and contain irregular disseminations and bunches of wolframite and scheelite with sparse chalcopyrite.

Little information can be gleaned about the gold deposits. Wilson (1941) in describing the tungsten occurrences mentions that the old "Greenwood" mine "in the eastern part of the area" was reported to have been worked for gold and silver many years ago. The gold veins are said to strike northwest and appear to be related to a dike swarm of similar trend that may be mid-Tertiary in age (Keith and others, 1983b). The single description that we found of one of the gold veins in this district indicates that it had a relatively shallow dip of 35°; indicating that it might be a listric fault and thus very possibly of mid-Tertiary age. Definitive information on the district, however, is essentially non-existent.

This is another area that will require a reconnaissance investigation in order to determine the actual characteristics of its gold mineralization, and what, if any, potential it may hold for future exploration.

Mines of Interest:

State Mine: (T13N, R12W, Sec. 4 SE¼) This is an old property that was checked by AEC geologists in the early 1950's for radioactivity. The property consists of 8 surface trenches, a 150 ft cross-cut tunnel, a 35 ft inclined shaft and 65 ft of drift. Mineralization occurs in a 6 ft wide vein striking N60°W, dipping 35°S which cuts a coarse, pink granite porphyry. The vein consists of quartz with hematite bands that contains gold and silver. Eleven samples taken by AEC personnel showed minor amounts of uranium.

References:

AEC Report RME 158; Dale, 1961; Hewett and others, 1936; Keith and others, 1983a, 1983b; Wilson, 1941.

GUNSIGHT (MEYERS) DISTRICT

Location:

The Gunsight district is located in the extreme western portion of the Papago Indian Reservation approximately 15 miles southeast of Ajo, Arizona. Access is via 2½ miles of good gravel road from the town of Schuchuli (Many Chickens).

Geology and History:

The Gunsight Hills region consists of low, deeply weathered, erosional hills that form an extensive area of subdued topography on granitic pediment. This pediment represents the exposed portion of a large granitic pluton of presumed Laramide age that crops out over an area of roughly 30 square miles. In places the pediment is thinly veneered by alluvium. The total extent of the pluton is unknown as younger volcanics overlie it to the north and south. Phases within the pluton have been described as ranging between quartz monzonite, granite and quartz diorite in composition (Nelson, 1963; Jones, 1974).

Intruding this pluton and making up Gunsight Hill is a highly differentiated, mid-Tertiary subvolcanic complex of quartz monzonite, granite (rhyolite) and alaskite porphyry bodies (Figure 9) (Wilson, 1978). The relationship of the monzonite plug to the granite and alaskite bodies is somewhat uncertain. The outcrop of the exposed portion of this plug and co-magmatic (?) dike swarm is transverse to the northwest striking alaskite body and for this reason it may possibly represent a different period of igneous activity. A K-Ar date of a biotite separate from the quartz monzonite produced a 26.7 m.y. age (unpubl. data Gunsight Mining Co.).

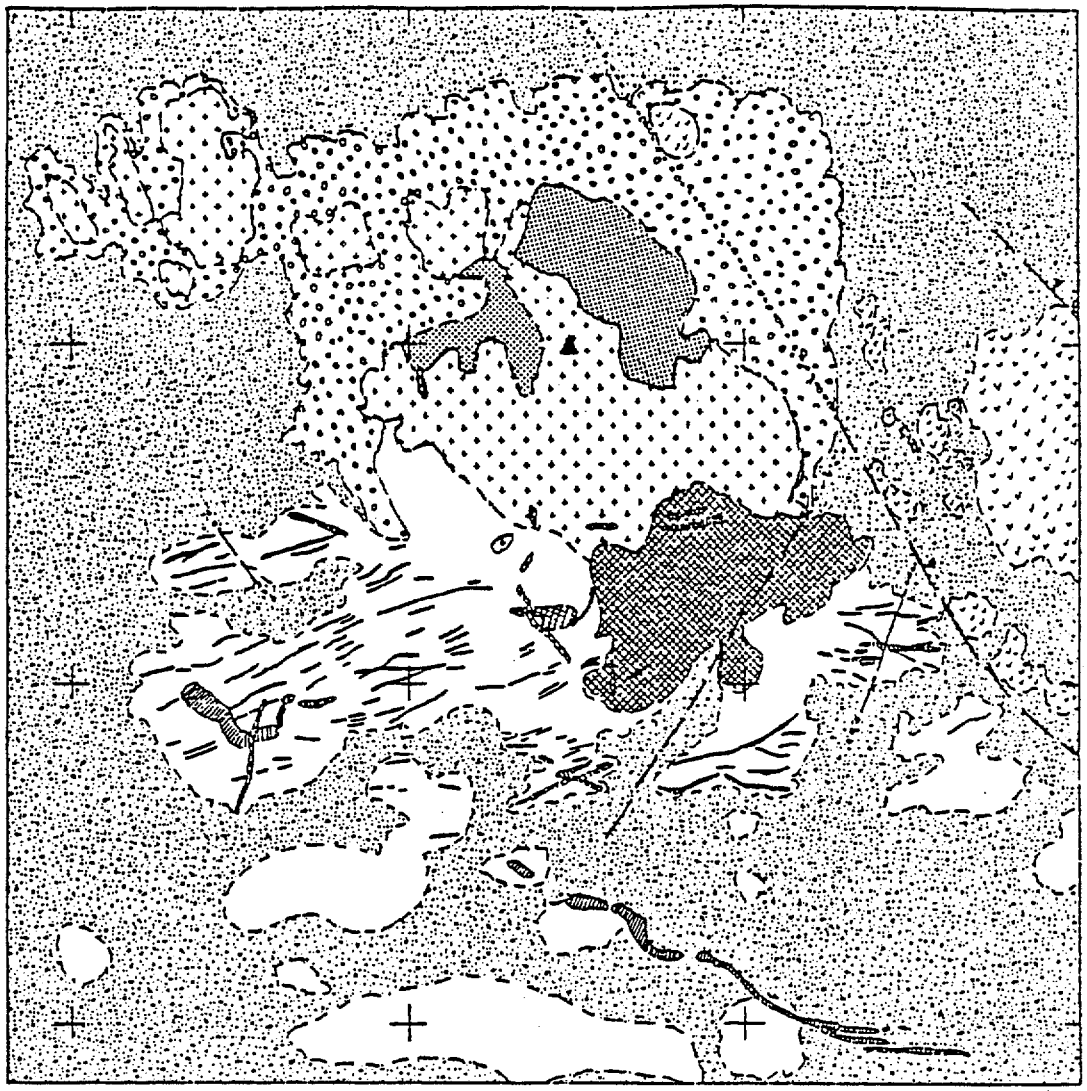
The older granite basement complex is extensively altered and recrystallized surrounding the Gunsight Hill intrusive center. A gneissic fabric is evident surrounding the intrusion and extends several hundred meters outward from it.

The mid-Tertiary composite stock is host for numerous epithermal veins from which most of the ore in the district has been produced. The veins are mainly fissure type veins, but locally some stockwork veining has localized along the massively fractured and brecciated margins of the stock. Veins that have been explored outward in the older granite terrane are probably also related to the mid-Tertiary complex. Some, however, may have been generated during regional low-angle deformation at the close of Cretaceous time (cf. Haxel and others, 1984).

Within the productive veins associated with the Tertiary intrusions, argentiferous galena appears to have been the main ore mineral of importance; however, gold, various tungsten and molybdenum minerals, as well as sphalerite, chalcopyrite and chalcocite also occur in various amounts. Gangue minerals include amethystine quartz, barite and fluorite.

The Gunsight Hills were first prospected in the late 1860's (Keith, 1974). McKelvey (1927) mentions interviewing a Mrs. Levy, who as a teenager, passed by the property in 1873 in a wagon train traveling on the old Tucson Trail.

Figure 9. General Geology Gunsight Hills Intrusive Complex.



(R. Wilson, 1977)

EXPLANATION

Quaternary	Recent Alluvium & Pediment Surfaces
Quaternary-Tertiary	Fanglomerate
	Volcanics
	Trachyandesite Dikes
	Rhyolite Porphyry Dikes
Mid-Tertiary	Alaskite Granophyre
	Gunsight Granite
	Mafic Dikes (andesite, latite? & monzonite)
	Quartz Monzonite Porphyry
laramide (?)	Granite Basement Complex

Faults (ball on downthrown side)

"At that date the property was worked in a small way. The ore was sorted, sacked and hauled by wagon train to Yuma on the Colorado River, a distance of about two hundred miles. It was then loaded on the steamer operated by Capt. Polhemus and carried down the river to the Gulf of California. The ore was then transferred and loaded aboard sailing vessels and taken to a smelter at Swansea, Wales, where it was treated."

In 1878 the Gunsight mine was located, and by 1882 had developed sizeable workings. The report of the United States Mint for 1882 and 1883 contains lengthy and exuberant reports on the activity taking place at the Gunsight mine.

The demonitization of silver in 1893 resulted in the closing of the mine and shortly thereafter the property was raided by the Apache Indians who completely destroyed the old mining equipment, boilers and five miles of water pipe line (McKelvey, 1927). Subsequent attempts to reopen the mine by Mr. Sheehan in the early 1920's and by Eastern finance in the early 1930's were unsuccessful.

Full (1970) gives an excellent account of the early history of the mining district and the major prospects contained therein. The reader interested in a more complete history of each of the major prospects of the district are directed to his report.

Little recorded production from the Gunsight district exists. That most of the production came before the demonitization of silver in 1893 is obvious. Unfortunately, records for this era were poorly kept or are non-existent.

Keith (1974) in describing the production of the Gunsight mine, states: "Shaft and turnel workings: Prospected as early as 1870's and reportedly produced some 15,000 tons of $40/T Pb-Ag ore in 1881-1884. Sporadic production of some 120 tons of ore averaging 22% Pb, 5 oz Ag/T and oz Au/T since 1918."

Mines of Interest:

Gunsight Mine: (Sec. 16, T14S, R4W) The Gunsight has been responsible for nearly all of the districts production. Mineralization consisted mainly or argentiferous lead ore that in places carried some gold values. Keith (1974) reports that the mine produced some 15,000 tons of $40/T Pb-Ag ore between 1881-1884. Although attempts were made to reopen the mine in the 1920's and 1930's, efforts were unsuccessful. The vein has been mapped on the surface for over 4,000 ft. Old workings consist of the Gunsight shaft with tunnels on four levels. The majority of the past production occurred above the 200 ft level where the vein averages nearly 12 ft in width. Patented and unpatented claims were taken over in the 1960's by the Gunsight Mining Corporation (100 W. Clarendon, Suite 1260, Phoenix, AZ 85013) who continue to hold the property. Work done by this company has reportedly proven roughly 23,000 tons of reserves remaining above the 200 ft level with much larger reserves being possible at depth.

References:

Full, 1970; Haxel and others, 1985; Jones, 1974; Keith, 1974; McKelvey, 1927; Nelson, 1963; Wilson, 1978.

HACKBERRY DISTRICT

Location:

The Hackberry district is located in the central portion of the Peacock Range and several miles west of the settlement of Hackberry in northern Mohave County.

Geology and History:

There is very little information available on the mines and geology of the Hackberry district. The Peacock Mountains are a northward-trending spur coming off the northern end of the Hualapai Mountains. The range is made up almost entirely of Proterozoic gneisses and schists that have been intruded in the northern and central portion of the range by a somewhat younger Proterozoic granite. In the southern-central part of the range, these rocks display WNW-trending foliation that dips to the south. A northeast-trending dike swarm of unknown age cuts the Precambrian rocks to the east of the district. These dikes are likely of late Cretaceous age and genetically related to the Laramide intrusive complex exposed north and east of Hackberry. Isolated patches of Tertiary volcanic rocks occur mainly on the southern and eastern flanks of the range.

Hewett and others (1936) describe the district as being developed on quartz veins in Precambrian gneiss and schist. Keith and others (1983b) suggest that veins might be of late Cretaceous age indicating that the mineralization may be related to the nearby Laramide intrusions. With so little information available, however, one should not rule out the possibility of Precambrian mineralization being present. Production records (Hewett and others, 1936) indicate that the ores contained considerable base-metals in addition to commercial quantities of gold and silver. Descriptions of the mineralization in the nearby Cottonwood district are suggestive of Precambrian massive sulfide type. Schrader (1909) described this area under the Maynard district and stated that the "Old Hackberry mine" was for many years a heavy producer and "is credited with a production of $1,000,000." The ores were treated by the chlorination process.

The majority of the production from the district was won before 1904. Elsing and Heineman (1936) credit the district with producing some 5,000 oz Au and 560,000 oz Ag between 1875 and 1906. A substantial amount of silver-lead ore was mined from the district in 1915 and 1919 (Hewett and others, 1936). Production between 1919 and 1942 was apparently small. Hewett and others (1936) state that recorded production between 1907 and 1932 amounted to 8,146 tons yielding 2,153 oz Au; 79,381 oz Ag; 5,983 lbs Cu; 156,498 lbs Pb; and 21,604 lbs Zn.

The paucity of data on this district coupled with substantial past production, indicate that it is probably an area deserving examination.

References:

Elsing and Heineman, 1936; Hewett and others, 1936; Keith and others, 1983b; Schrader, 1909.

HARQUAHALA DISTRICT

Location:

The district consists of mines and prospects scattered through the Harquahala Mountains, the highest, most prominent and southernmost of the anomalously NE-oriented ranges of west-central Arizona. The range lies in both La Paz and Maricopa Counties and extends from the Little Harquahala Mountains on the southwest nearly to the Vulture Mountains on the northeast. The district is included on the Aguila, Gladden, Lone Mountain and Salome 15' quadrangles.

Geology and History:

An overview to the geology of the Harquahala region features a stack of major thrust faults bounding markedly distinct lithologies. These remarkable structures maintain continuity from the Little Harquahala Mountains, to the northeast end of the range (Reynolds and others, 1980; Harding, 1983). In ascending order, the various thrusts consist of the Hercules fault with upper plate of Precambrian crystalline rocks over Mesozoic sedimentary-metamorphic rocks; the Golden Eagle thrust with Paleozoic rocks thrust over Precambrian basement; an overlying, thin plate of Precambrian (?) quartz monzonite porphyry; and the Harquahala thrust with its uppermost plate of Precambrian metamorphic and granitic rocks. Many of the allochthonous rocks, including the granites, are deformed and mylonitic zones commonly occur along the thrust faults. This overall deformation is Mesozoic in age with thrusting culminating in Laramide time.

Closely following thrusting, a major pulse of two-mica granite was intruded. Sills, dikes and small plutons of this alkali-rich, muscovite-bearing granite discordantly cut the deformed sequences and make up most of the Laramide plutons shown on the county geologic map by Wilson. The age of this magmatism is approximately 40-55 m.y. (Rehrig, unpubl. Rb-Sr dating).

Developed throughout the northeast end of the range is a pervasive mylonitic deformational fabric with low-angle, arch-like foliation plunging gently eastward and a northeast-trending lineation. This fabric is superimposed on all previous rock types including the two-mica granites, and increases in intensity upsection and eastward to a low-angle detachment fault which wraps around the east end of the range (Rehrig and Reynolds, 1980). The mylonitic foliation and detachment are characteristic of mid-Tertiary extensional deformation within metamorphic core complex terranes in the southwestern U.S. (Davis, 1980; Rehrig and Reynolds, 1980). Discordantly intruding all previous lithologies and structures are swarms of NW- to WNW-trending microdiorite dikes dated between about 20 and 27 m.y. (Rehrig and Reynolds, 1980; Rehrig, 1982). Latest expressions of faulting are NW-striking, NE-dipping reverse and right lateral slip structures such as those that pass through the linear Sunset and Dushey Canyons (Scarborough and others, 1983).

Mineralization through the Harquahala range is dispersed through a variety of lithologies. Metal occurrences, worked mainly for precious metals, date back to the 1800's. Most gold-silver deposits contain minor base metals, particularly copper. Tungsten associations like those described in the neighboring Granite Wash Mountains are also noted. Precious metal production from the district totals about 2,450 oz Au and 7,043 oz Ag (Keith and others, 1983a) with the main producers being the Socorro, Hercules, and San Marcos mines (± 600 oz Au each).

A number of occurrences in the Harquahala district appear spatially associated with certain thrust faults. Examples in the western part of the range include the Socorro, Hidden Treasure, Silver Queen, Why Not-Clipper, and Mars-Mescal mine groups (T5N, R11 and 12W) which plot near the trace of the Golden Eagle. Most of these occurrences were mined principally for Au, Ag and Cu from quartzose zones and veins in the vicinity of the main thrust or in structures cutting hanging wall Paleozoic rocks. Microdiorite dikes are commonly found in close proximity to the mineralized outcrops. The Hercules mine and nearby workings at the west end of the Harquahala range plot in the vicinity of the trace of the Hercules thrust. At Sunset Mountain immediately southwest and west of these gold occurrences, an erosional window exposes lower-plate Mesozoic metasediments beneath the structure. Upper-plate rocks consist of Precambrian (?) foliated quartz diorite and mafic gneisses which apparently host the mineralization which is associated with quartz lenses and veins. Along the southeast flank of the Harquahala range (T5N, R10W, Secs. 11 & 14) near Arrastre and Sunset Canyons, numerous prospects occur along the trace of a low-angle fault separating lower-plate Paleozoic carbonates from upper-plate Precambrian (?) quartz monzonite porphyry. Mineralization in this locality appears best developed where higher-angle shear zones and microdiorite dikes cut the thrust zone.

There are also a number of Au, Ag and Cu occurrences within granites and metamorphic rocks which may be associated with Tertiary microdiorite dikes intruded along high-angle shear zones. The metals occur with quartz, carbonate and iron or manganese oxides; and veins are commonly sheared or brecciated. These deposits resemble those found in the Harcuvar Mountains (i.e. Cunningham Pass district). Although descriptions indicate that most of these occurrences are single vein structures or otherwise small deposits, some (like the San Marcos mine group) reported tonnages of exceptionally high grade (i.e. 2 opt Au). It may therefore be warranted to check them for structural factors which could have either dispersed or concentrated veining (i.e. intersections, multiple veining); or which may have lead to dissemination outward into wallrocks from narrower feeder structures. Examples of these occurrences include the Gold Leaf, Rattlesnake, and Rosebud mine groups (T5N, R12W, Sec. 13); the San Marcos workings (T5N, R12W, Sec. 14); small workings or prospects in Sections 23, 25 and 31 of T5N, R11W; the Snowball mine (T5N, R10W, Sec. 29); perhaps such properties as the Sunshine or Linda mines in Dushey Canyon; the prospect on a N70°W vein in Section 17, T5N, R10W; and workings in a NW-trending vein between Arrastre and Sunset Canyons (Sec. 14, T5N, R10W).

Flanking the range at its eastern end are a few scattered occurrences of hematitic, copper carbonate-oxide mineralization commonly with gold, which are located in the mid-Tertiary detachment fault zone separating mylonitic crystalline rocks of the core complex from the mid-Tertiary volcanic and clastic rocks of the Big Horn Mountains and Eagle Eye Mountain. These occurrences are not too obvious mainly because exposure of the detachment is quite poor along the southeast margin of the Harquahala range.

In Sections 32 and 33 of T5N, R10W and Section 6, T4N, R10W, mineralization at the Alaska and Rainbow mines may have some relationship with an unexposed detachment zone nearby but the association is difficult to document because of extensive overburden (see Mines of Interest below).

Mines of Interest:

As described above, there are many precious metals mines and prospects located in the Harquahala district, any one of which might hold interest or offer potential for further production or ore extensions. We have singled out only the few described below because of special factors of interest such as higher grade, particularly favorable structural settings, or the like.

Socorro mine area: (T5N, R12W, Sec. 25). Presently held by the Campbell family of Salome, Arizona and promoted geologically by consultant Stan Keith of MagmaChem Inc., the Socorro property was worked from the early 1900's intermittently to about 1960; during which time it produced more than most mines in the district (4,800 tons averaging about 0.2 opt Au; 638 oz Ag). The mineralization (gold, pyrite, minor Pb, Cu, W, quartz) is localized within the Golden Eagle thrust as flat-lying quartz lenses and locally steeply dipping veins. Additional factors controlling ore deposition along the thrust surface appears to be the intersection of a steeper dipping, NW-striking Socorro fault zone and intrusion of microdiorite dikes into or along this zone (Figure 31).

The cross-structures have produced considerable brecciation along the thrust zone into which gold-bearing quartz has been injected. Sericitic alteration is commonly observed in the Precambrian granite porphyry on both sides of the Golden Eagle thrust zone. The old Socorro mine was extensively sampled in the fall of 1982 by St. Joe and a number of shallow drill holes were placed in the immediate mine area. Although interesting values were reported from this work, the St. Joe option was dropped.

Considerable geochemical work associated with current prospecting over the mine area has delineated a broad and fairly well zoned gold anomaly paralleling the trace of the major thrust fault (Figure 10). The anomaly occurs in highly fractured and veined Bolsa quartzite overlying the thrust. The quartzite is steeply dipping but is in unconformable (with minor shearing) contact upon 1-4 b.y. Oracle-like granite. The granite for 100-200 ft away from the contact is altered to clay and sericite and carries sparse quartz veining and sulfides, with anomalous (.00X to .02 opt) gold. The quartzite adjacent commonly assays about twice as much in gold. Geochemical gold reaches values of 0.025 opt in places at the surface accompanied by from 5 to 50 ppm tungsten. High arsenic

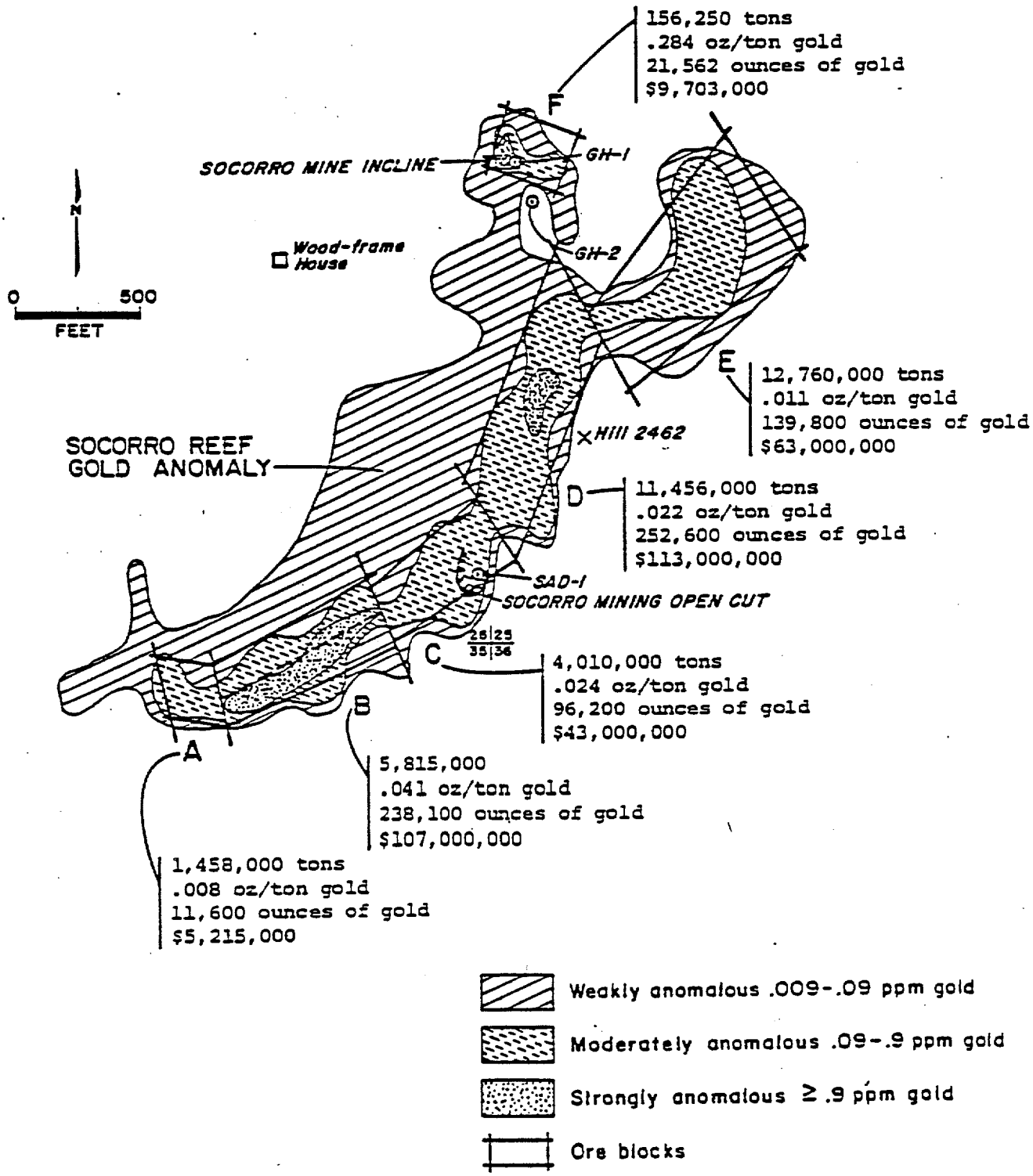


Figure 10. Map of Socorro Reef gold anomaly showing drill hole locations and grade-tonnage blocks discussed in text.
(From Keith, in Scarborough and others, 1983)

and mercury geochemistry is noted in thin jasper zones cutting Paleozoic rocks south of the gold anomaly. The anomaly was drilled in 1983 by Noranda. Seventeen holes (deepest = 500 ft) produced a range in gold values from about .00X to .08 opt. The principal ore target, conceptualized to lie within the thrust zone below the surface anomaly (Figure 10), was not intersected during the drilling.

Considerably deeper drilling (to 1,500 ft) is required to test the concept. Any deposit found might be in the 0.05 to perhaps 0.2 opt range and would require underground mining. One especially favorable factor to the blind target is the size, strength and complex multi-element development of the geochemical dispersion pattern. Such a pattern may indicate an unusually large or strong hydrothermal system at depth and thus justify the deeper exploration required. In the immediate area of the old Socorro mine estimates of 100,000 to 200,000 tons of .05 to .1 opt may exist as reserves (S. Keith, 1985, personal commun.).

Hercules mine: (T5N, R12W, Sec. 18) This property and surrounding occurrences produced modest but higher grade (0.2 opt and above) tonnages of quartz-copper-gold ore from veins, lenses and pods of quartz associated with higher-angle shears and diorite dike zones cutting foliated quartz diorite. The structural setting is the upper plate of the Hercules thrust fault, a major tectonic feature exposed in the immediate vicinity of the mines. Depending upon depth to this structure, and development of intersecting structures, subsurface ore targets may exist in this area.

Hidden Treasure mine: (T5N, R11W, Sec. 29) Originally located in 1932, it produced some 1,775 tons of exceptionally high grade ore (nearly 1 opt Au and 3.9 opt Ag) from a mineralized, high-angle shear zone cutting Paleozoic rocks. Gold occurs in pockets, some of very high grade. A stope 20 ft wide is mentioned from mine descriptions. Considerable copper and manganese oxides accompany mineralization. Wallrocks show intense silicification and sericitization and may not have been tested for low-grade metallization. Additional favorability to the area may be the major thrust (Golden Eagle) underlying the Paleozoic rocks at some depth.

San Marcos mine: (T5N, R12W, Sec. 14) A typical quartz-filled shear zone cutting granitic Precambrian rocks, this property is mentioned chiefly because of the high grades produced (averaging 2 opt Au) and reference to a "strongly sheared zone." According to verbal reports from recent prospect evaluations of the property, the main ore zone is in a flat, mylonitic shear zone invaded by quartz. It has been interpreted as a detachment zone, but probably is a Mesozoic or Laramide thrust zone. Similar but narrower zones occur in stacked fashion in the main hanging wall. These subsidiary structures give highly anomalous gold values, but only over thickness <3 ft. The owner of the San Marcos is Mr. Harry Hildebrand of Phoenix.

In neighboring properties such as the Gold Leaf, Rattlesnake and Rosebud mine groups, spotty but persistent gold values with minor copper occur with quartz in brecciated and shear zones cutting gneissic granite. Ore values in the ½ oz Au range are common.

Tungsten Giant mine group (T5N, R12W, Sec. 30). Scheelite in discontinuous quartz veins cuts granitic rocks. Although no gold is mentioned, tungsten-gold associations are common in the region and inspection or sampling of this area for gold might be warranted.

Why Not, Clipper and Gold mine group: (T5N, R11W, Sec. 30). Precious metals with copper and hematite occur in irregular fissure veins of quartz and calcite cutting Paleozoic-Mesozoic metasediments intruded by basic dikes. Mines may occur near the Golden Eagle thrust. The mine group produced exceptionally high grade gold (3.3 opt) from 370 tons.

Alaska and Rainbow mines: (T5 & 4N, R10W, Secs. 32, 33 and 6) The Alaska property was discovered in 1920 and produced 1,200 tons averaging about 0.25 to 0.75 opt in gold. The ore occurs within a 3-15 ft thick breccia zone containing coarsely crystalline quartz, hematitic oxides, calcite, chrysocolla and traces of fluorite. Apparently, gold values are best where the chrysocolla and hematite are most abundant. Several grab samples at the mine yielded geochemical gold in excess of several ppm (Rehrig and Wilson, unpubl. data). The breccia cuts probable Mesozoic mylonitic metasedimentary rocks at a very low dip angle southward, which is reportedly cut off and displaced(?) by a north-dipping, high-angle fault. Textures and alteration in the breccia are similar to those observed in mid-Tertiary detachment zones and indeed, the Alaska structure may be such a zone, but one developed within lower plate rocks. An upper detachment fault zone should be present at some distance structurally above and just to the southwest of the Alaska and Rainbow workings. Mr. Del Schultz of Phoenix currently has a large claim block covering the Alaska mine. Dozer cuts and sparing outcrops in the vicinity of the nearby Rainbow mine expose numerous quartz and calcite veinlets and small veins, containing gold, iron oxides, traces of chrysocolla and fluorite. Most commonly these veins intrude shallow dipping foliation planes of the mylonitic, metamorphic host rocks, or crosscut them at very acute angles(NS, 30-40°E dip).

Because of the proximity of these mines to the covered projection of the main Harquahala detachment fault, the shallow dip of mineralized structures, the dispersion of mineral showings, the relatively high geochemical values in gold and the widespread extent of thin alluvial cover, we feel this area warrants further exploration.

References:

Arizona Dept. Mineral Resources, file data; Bancroft, 1911; Keith, 1978; Rehrig and Wilson, unpubl. mapping and recon. exploration data; Scarborough and others, 1983; Wilson, 1967.

HUMBUG DISTRICT

Location:

The Humbug district lies within the drainage area of Humbug Creek and its tributaries Rockwell, Swilling and Carpenter Creeks in southern Yavapai County. The district covers much of the SW 1/4 T9N and NW 1/4 T8W, R1E and adjoins the Tip Top district, which lies to the east. It includes the old mining communities of Humbug and Columbia.

Geology and History:

Bedrock in the district consists of large bodies of Precambrian Yavapai Series schists that are surrounded and intruded by Precambrian Bradshaw granite. In places, numerous dikes of rhyolite and granite porphyry composition and northeast-trend cut the Precambrian rocks. Wilson and others (1967) mention that considerable pre- and post-mineral faulting is evident in the district and, like the dikes, is principally of northeastward strike. Some of the post- mineral faults are large and influenced development of some of the major drainages in the district.

Ore deposits mined in the district include both veins and placers (Lindgren, 1926; Wilson and others, 1967; Wilson, 1961; Johnson, 1972). The placer deposits were apparently worked the earliest and were the most productive. The main placers occurred in Swilling, Carpenter and Rockwell gulches, but gold-bearing gravels are said to extend for more than 20 miles along Humbug, French and Cow Creeks (Wilson, 1961). Productive gravel bodies along these creeks are generally less than a few hundred ft wide and are a maximum of 20 ft deep.

All the veins strike east-northeast, fill fault fissures and dip steeply to the northwest. Johnson (1972) states that the placer gold in the upper reaches of Humbug Creek was probably derived from gold veins that intersect and offset the rhyolite porphyry dikes in that area.

The vein fillings consist of massive to coarsely crystalline grayish-white quartz containing irregular masses, veinlets and disseminations of fine to coarse-grained pyrite and galena (Wilson and others, 1967). Arsenopyrite is locally abundant and sphalerite is reportedly abundant in one vein. Gold is mostly contained within the iron minerals, but galena apparently carries a little gold and is locally argentiferous (up to 40 opt Ag). Some free gold occurs as irregular veinlets and particles within the quartz, filling fractures and cavities. In the shallow oxidized zones, the gold is entirely free. This writer has observed beautiful specimens of leaf gold from vein material in the Columbia area.

Veins are typically narrow (± 3 ft) and persist for long distances. Wilson and others (1967) note that one vein is traceable on the surface for more than 9000 ft. Ore shoots vary in size from a few ft to a few hundred ft in length and typically are very narrow, often less than a foot wide. Values, however, can be very high grade, ranging between .25 to over 9 opt Au (Wilson and others, 1967).

Wallrock alteration consists of intense sericitization which has softened the rock enough to allow for low-cost mining.

Wilson and others (1967) believed the mineralogy, alteration and nature of the vein structure indicated deposition in the mesothermal zone. Lindgren (1926) suggested that the veins were of similar trend and character to those in the adjoining Tip Top district except that they carried more gold than silver. He believed that the veins in both districts were genetically related to the dikes of rhyolite porphyry. While the dikes and related mineralization in the Tip Top district are believed to be mid-Tertiary in age (Curt Kortemier, personal commun., 1984), the Columbia veins may not. Utah International discovered and put 8 drill holes into a buried Laramide porphyry copper system in Sec 15, T8N, R1W. The outline of this buried pluton has been drawn on our lithotectonic map for reference purposes. This stock lies only 1-1/2 miles west of Columbia and Humbug, fueling speculation that these veins may represent outlying manifestations of this porphyry system. If this is the case, then the rhyolite dikes might be Laramide in age.

Total prodution from the district is unknown. Keith and others (1983a) give recorded production between 1901 and 1942 as some 4,200 tons containing 1,700 oz Au, 8,300 oz Ag, 105,000 lbs Cu and 48,000 lbs Pb. Wilson (1961) lists recorded placer production from the district between 1934-49 as being $17,545.00. While pre-1900 placer production is unknown, it is believed to have been substantial.

Mines of Interest:

Acquisition Mine: Located 1-1/2 miles north of Columbia (Sec 6, T8N, R1E). Early English mining venture. A 10-stamp mill was built on the property, but apparently there was no production. Mine saw renewed activity and some promotion (?) in the early 1980's. Present status of property is unknown.

References:

Johnson, 1972; Keith and others, 1983; Lindgren, 1926; Wilson, 1961; Wilson and others, 1967.

KOFA (S.H.) DISTRICT

Location:

The Kofa mining district is located in the southern part of the Kofa Mountains of northern Yuma County. The district is accessible via graded county road that connects with U.S. Highway 95 at the small settlement of Stone Cabin about 50 miles north of Yuma. The district lies within the boundary of the Kofa Wildlife Refuge and mining, unfortunately, is restricted to existing mining claims.

Geology and History:

The oldest rocks in the district consist of a northwest-trending belt of Mesozoic schist and metasediments that are exposed along the southern part of the Kofa range. The schist forms hills of low relief in stark contrast to the large cliffs of volcanic rocks that make up most of the range. Wilson (1933) describes these metasediments as consisting of sandstones, shales, conglomerate and limestone. Slate was noted as cropping out near the North Star Mine, and quartzite conglomerate clasts are reported to occur in the schist 3 km east of the slate occurrence (Hankins, 1984). Hankins (1984) separated the schist into two basic lithologic units: biotite schist and biotite-hornblende schist. Harding (1978) suggested that these rocks might belong to the Mesozoic Livingston Hills Formation. Hankins (1984) noted a semi-pelitic sedimentary origin for the metamorphic rocks and agreed that they indeed might be part of the Livingston Hills Formation.

These rocks display a northwest-trending foliation that typically dips to the southwest. The foliation results from compositional banding of minerals and parallelism of biotite and muscovite in these rocks. Small, northeast-trending pegmatite dikes and plugs of Cretaceous(?) age intrude the schists. A northwest-trending dike swarm of mid-Tertiary age pervades the schist and appears in part to be related to a large plug of rhyodacite porphyry that intrudes the schist southeast of the district.

A 900-meter thick, somewhat tilted sequence of mid-Tertiary andesite flows and thick rhyolite flows and ignimbrites uncomformably overlies the Mesozoic basement and constitutes the bulk of the Kofa range. These rocks appear to form a large silicic volcanic field that extends south into the Castle Dome Mountains (Gutmann, 1981). Volcanic rocks in both ranges produce Miocene (about 25-19 m.y.B.P.) K-Ar age dates (Shafiquallah and others, 1980; Hankins, 1984; Gutmann, 1981). The eruption of such large thicknesses of silicic volcanic rocks in these ranges must have been accompanied by cauldron collapse. While the area is too imprecisely mapped to be able to recognize discrete calderas, a huge gravity low is centered west of the Kofa Mountains and is speculated to repressent a cauldron subsidence feature (Gutmann, 1981). The volcanic rocks are separated from the schists to the south by a complex, anastomizing fault system that probably represents some type of volcanotectonic bounding fault (Gordon Haxel, mapping in progress). Further to the south, near the King of Arizona Mine, a northwest-trending fault seprates the schist from an exotic volcanic breccia that is thought to possibly overly a major vent zone (Hankins, 1984). The matrix of this breccia is pyroclastic(?) in character and rhyolitic in composition.

The mineralization in the Kofa district was discovered in the 1890's. Blake (1898) was the first to describe the early workings and make note of the bonanza ores that sometimes ran 40 opt Au in the upper workings. Nearly all of the production from the district has been won from two mines: the King of Arizona and the North Star. The King of Arizona was discovered in 1896 and worked until 1910 when the deeper ores became uneconomical (Keith, 1978; Wilson, 1933; Jones, 1916). During this period, the mine was credited with producing some $3.5 million in gold-silver bullion. The North Star mine was discovered in 1906 on a vein located a short distance to the north of the King of Arizona, and was worked until 1911 when the ores became unprofitable. Its production is valued at $1.1 million. Numerous other deposits containing gold-silver with minor base metals were explored in the district, but production from them has been very small (Keith, 1978). Attempts to reopen the King of Arizona have been unsuccessful to date. Small tonnages of manganese and tungsten have also been produced from the district (Keith, 1978; Dale, 1959). Keith (1978) credits production from various mines in the district as follows:

Mine	Tonnage (tons)	Au (oz)	Ag (oz)
King of Arizona	739,300	170,039	73,930
North Star	38,735	54,229	23,241
Quartette	550	715	1,100
Rob Roy	435	44	22
Iron Wood	534	267	214
TOTALS	779,554	224,268	98,507

Some 2500 oz of placer gold have also been produced from the district (Keith, 1978), as well as some 7000 lbs Cu, 2500 lbs Pb, 148,00 lbs Mn and 544 short ton units of WO_3 (Keith and others, 1983a).

The gold-silver deposits consist of typical bonanza type, epithermal veins that follow west-northwest-trending faults. Mineralization commonly is enhanced where north-striking faults intersect the northwest-trending veins (Hankins, 1984). The veins contain fine gold and silver minerals along with local and minor copper and lead mineralization, abundant manganese oxides, pyrite, minor fluorite and scheelite. Gangue consists mainly of quartz, silicified and brecciated rhyolite dike material, adularia and manganiferous calcite. Aphanitic dikes of felsic composition that produce K-Ar ages of 19.8$\pm$ 0.9 m.y.B.P. are spatially associated with mineralization (Hankins, 1984). Adularia separated from the North Star vein which is hosted by one of these rhyolite dikes produced a K-Ar date of 22.1$\pm$ 2.4 m.y.B.P. (unpublished data, AGS) which is concordant within its error with the age of the dikes. A similar felsic dike swarm is associated with lead-silver mineralization in the Castle Dome Mountains to the south (Wilson, 1951; Gutmann, 1981). Veins containing only manganese oxides have also been prospected within the district (Keith, 1978). Hankins (1984) studied the mineralogy of the district veins and concluded that there is no spatial relationship between specific manganese minerals and gold mineralization. Hankins concluded that the Kofa district ores and veins were typical of other epithermal manganese-gold systems in the western U.S. and around the world.

Alteration mapping conducted by Hankins disclosed that wallrock along the North Star vein varies from silicification and adularia nearest the vein outward to

propylitic alteration. Ore shoots along the vein displayed phyllic alteration. At the King of Arizona vein, alteration was more complex as a result of volcanic venting and diking. Metasedimentary rocks within and surrounding the exotic volcanic breccia are propylitized. The matrix to the breccia itself was noted as being strongly carbonated. The King of Arizona vein is adularized, pyritized and enveloped by zones of pyrite and silica alteration (Hankins, 1984).

Hankins concluded that probably the most efficient exploration strategy for the district was one that assumed undiscovered ore deposits would most likely occur in geologic environments similar to those that host the North Star and King of Arizona mines. The setting at these mines is one in which veins are hosted by rhyolite porphyry dikes that fill west-northwest-trending structures. Alteration mapping could be useful for modeling ore shoot targets. Productive ore shoots along the North Star vein are surrounded by phyllic alteration. At the King of Arizona vein, silicification and pyritization are useful exploration guides.

As we have mentioned in several of the other district summaries, there seems to be a persistent formula associated with Tertiary metallization in certain districts in southwestern Arizona. The major ingredients appear to consist of mesozoic metasediments, extensive Tertiary faulting and a Tertiary heat source to form a hydrothermal system. Again, there seems to be some quality in the Mesozoic rocks that lend themselves to being hosts to later ore deposits that typically contain precious metals, some base metals, manganese oxides and anomalous tungsten and boron (typically in the form of tourmaline). We would suggest the Mesozoic protoliths were enriched in these elements to begin with and have passed this heritage along to the Tertiary hydrothermal systems. Evidence for this in the Kofa district includes Wilson's (1933) mention of shales in the Mesozoic section containing finely disseminated pyrite. Hankins (1984) mentions that pyrite altered to hematite is typically present in the schists and in places makes up 5% of the rock. Haxel (personal commun., 1984) has also noted cherty layers within the Mesozoic section that contain abundant magnetite. These might possibly be exhalative banded iron formations.

In 1981, Western Minerals Exploration Company had a lease on the major claim block in the district and were shopping major companies for a joint venture partner. Their main targets consisted of ore shoots and extensions along proven veins in the district. Their concept was probaby not bad as there has been little or no drilling exploration in the district to search for new ores. Whether this program was actually carried out is unknown to these writers.

Two targets that would seem to be of some interest for potential disseminated mineralization include the large, porous, exotic volcanic breccia that lies in the southern part of the district near the King of Arizona mine and the complex, anastomizing fault zone that separates the Mesozoic schist from the Tertiary volcanics to the north. This fault zone, if pre-mineral, would be an ideal site for major focusing of hydrothermal fluids. We assume, however, that most of this zone is probably not available to mineral entry.

References:

Blake, 1898; Dale, 1959; Gutmann, 1981; Hankins, 1984; Jones, 1915; Keith, 1978; Shafiquallah and others, 1980; Wilson, 1933.

LAGUNA (LAS FLORES) DISTRICT

Location:

The Laguna district is located in the Laguna Mountains north of the Gila River and about 16 miles northeast of Yuma. A large part of the district is covered by the Yuma Proving Grounds and is not open to mining activity.

Geology and History:

The Laguna hills consists of a group of low hills and rugged ridges surrounded by elevated pediments. Schists and gneisses of probable Mesozoic age underlie most of the district, particularly the eastern half. These rocks are intruded by Mesozoic (probably late Cretaceous) granitic rocks in the northern part of the range. The metamorphic rocks are also cut by numerous pegmatite dikes and quartz veins that generally trend parallel to the major metamorphic foliations. Tertiary sediments consisting of well-stratified sandstones, siltstones and gypsiferous clays cover most of the western portion of the range. These rocks are tilted and faulted. Their contact with the older rocks is often a fault contact (Wilson, 1933). Isolated patches of volcanic rocks occur along the western flank of the range. In places, volcanic rocks are interbedded with the thick Tertiary sedimentary pile.

The Laguna district is noted mostly as a placer gold district, although some gold-quartz veins have had limited production. Lode mineralization is characterized by lenticular and brecciated quartz veins that occur along fault or fracture zones in the Mesozoic metamorphics (Keith, 1978). These veins contain abundant iron oxides with some siderite, gypsum, manganese oxide and gouge. Gold occurs free, often ragged, as grains. Some silver and minor copper also occur in the ores. The Las Flores group (SW¼ Sec. 26 and NW¼ Sec. 35, T7S, R21W) which consists of the Traeger, Golden Queen and Pandino (India) mines have been sporadically worked and prospected from the 1860's to about 1940; producing some 500 tons of ore averaging about 0.4 opt Au and 0.1 opt Ag (Keith, 1978). Host rocks for the Flores mines consist of dark anbd light gray quartz-feldspar schist, possibly a meta-arkose, with low to moderate dipping foliation. Mineralization is associated with quartz veining within and cross-cutting the foliation.

Placer gold has been recovered from three separate localities in the district: the Laguna Dam placers; Las Flores placers; and the McPhaul placer area. The source of the gold in the placers is believed to be derived from the small, irregular, gold-bearing quartz veins in the Mesozoic schists (Wilson, 1933; Keith, 1978). Total production from the district is estimated by Keith (1978) to be about 7,500 oz Au and 1,100 oz Ag.

Johnson (1972) and Wilson (1961) describe the placers and give locations for the three areas. References to the early placer activity can also be found in these accounts.

Interestingly, once again we observe a correlation between gold-bearing deposits of uncertain age and Mesozoic metamorphic rocks which have produced considerable placer gold concentrations. As mentioned in other parts of this report, this association is repeated many times in southwestern Arizona. Related to this association may be the current exploration play in the western Laguna Mountains, where some high-priced "real estate" is being bargained for by several major companies. Reportedly, the geology of the prospect is similar to the Mesquite area in the Chocolate Mountains west of the river.

References:

Johnson, 1972; Keith, 1978; Wilson, 1933, 1961.

LA POSA (FISCO, WELTON HILLS) DISTRICT

Location:

The La Posa district covers the southern part of the Welton Hills and the Copper Mountains about 30 miles southeast of Yuma. The area is within the Luke Air Force Bombing Range and withdrawn from public entry.

Geology and History:

The Welton Hills consist of Mesozoic gneiss and schist that form an isolated group of irregular, scattered and rugged hills and buttes that are separated and encircled by alluvium covered pediments (Keith, 1978). The Copper Mountains, located to the east and southeast of the Welton Hills, are a more rugged range consisting of a central belt of Mesozoic metamorphic rocks intruded on the south by Cretaceous granite. These are separated from tilted beds of Mid-Tertiary arkosic sandstone and conglomerate by a shallow dipping normal fault described as a detachment by Pridemore and Craig (1982). These sediments strike north-northwest and display moderate dips to the southwest. The geology of the district is poorly known, and its location on the bombing range virtually precludes any major new studies at present. Although briefly mentioned by Bryan (1925) and Darton (1925), Wilson (1933) has provided the only description of any consequence concerning the district and its mineralization.

Wilson (1933) noted that the Welton Hills contained many low-grade, gold-bearing quartz veins of predominantly west to N35°W strike. These veins display highly variable dips, some being very low angle (10°); which suggests a possible relationship to the detachment fault in the Copper Mountains. The veins consist of coarsely crystalline quartz that is weakly banded, locally vuggy and characteristically shows abundant iron oxide with minor chrysocolla and malachite. Brown, ferruginous calcite occurs as fracture-linings and vug fillings. No sulfides were observed by Wilson. Wilson (1933) reported that certain veins in the Welton Hills were spectacularly stained by copper that extended a distance into the wallrocks. In places, these copper-stained gneisses carried visible specks of free gold. Sericitization with lesser amounts of silicification also occur in the wallrocks. Similar mineralization, along with gypsum and jarosite, reportedly occurs in the Copper Mountains (Keith, 1978). A small amount of placer gold has been recovered from the alluvium close to the gold-bearing veins in the Welton Hills (Johnson, 1972). Keith and others (1983a) credit district production as some 500 tons of ore which contained 500 oz Au, 200 oz Ag and 5000 lbs Cu. The main prospects in the Welton Hills include the Double Eagle, Poorman, Draghi, Donaldson, Wanamaker, McMahan, Weltonia, Northern and Shirley Mae mines (Wilson, 1933).

Mines of Interest:

<u>Welton Hills (Draghi, Frazier)</u>: (NE-1/4, Sec 20, T10S, R18W.) A fault zone marked by 8 ft of breccia and gouge strikes N35°W, dips 10° to 40° NE and contains a

quartz vein. Bedrock consists of fine-grained, banded, biotite gneiss that strikes NW and dips 40°SW. Vein contains intermixed chrysocolla and brown cherty hematite. Deposit is developed by 2 tunnels and was sporatically worked for many years. Production in mid-1930's amounted to some 365 tons of ore averaging about 0.54 opt Au and .2 opt Ag.

Poorman (Desert Dwarf): (NW-1/4, Sec 2, T10S, R18W.) Vertical fault zone cuts gneiss, strikes N56°W and contains banded quartz vein with FeOx. Ore reportedly carried about $4 to $5/ton (old prices) in gold. The deposit was developed by several shafts and some tunnels. Small amount (100 tons) of ore produced averaged about 0.25 opt Au and 0.1 opt Ag.

Double Eagle (Gold Leaf): (Cen. Sec 22, T10S, R18W.) Westward striking fault zone, dips 57°N and cuts Mesozoic gneiss. The fault is marked by shattered and brecciated zone 6 ft across that locally displays sericitization, iron and copper staining. Narrow quartz vein fills fault zone. Some 50 tons of production averaged 1.6 opt Au, 0.8 opt Ag and .3% Cu. Prospect was developed by shaft and tunnel.

References:

Bryan, 1925; Darton, 1925; Keith, 1978; Keith and others, 1983a; Pridemore and Craig, 1982; Wilson, 1933.

LITTLE HARQUAHALA DISTRICT

Location:

The Little Harquahala Mountains are a southwest extension of the higher and more prominent Harquahala Mountains in La Paz County. The two ranges are separated by the Harrisburg Valley. The Little Harquahala range is included entirely within the Hope 15' quadrangle. It is accessed by the Hovatter dirt road southward a few miles from the town of Salome on U.S. Highway 60, or from the south where the dirt road intersects Interstate 10.

Geology and History:

Mines and mineral showings in the Little Harquahala Mountains occur in a geologic setting highlighted by Mesozoic high-angle faulting, two phases of folding, and late Cretaceous thrusting (Richards, 1983). The affected rocks include the Precambrian basement of gneisses and a megacrystic, quartz monzonite porphyry (1.4 b.y.?), Paleozoic cratonal sedimentary rocks, and complex Mesozoic sedimentary sections of continentally derived terrigenous rocks (arkosic-greywacke sandstones to conglomerate), volcaniclastic deposits and felsic to intermediate volcanic rocks. In the Sore Fingers area at the southeast end of the mountains, a coarsely crystalline, possibly Jurassic, quartz monzonite porphyry intrusive complex occurs. This body makes a poorly defined, transitional intrusive contact with "granitized" (?) Mesozoic or Precambrian metamorphic rocks at its north end and is in strongly mylonitized thrust (?) contact with Paleozoic or Mesozoic sedimentary rocks along part of its southwest margin (Richards, 1982; Rehrig, unpubl. mapping).

Paleozoic rocks rest in depositional contact against Precambrian basement in the Martin Peak area but are in thrust contact elsewhere in the range. The Hercules thrust places Precambrian granitic rocks upon Mesozoic supracrustal rocks at numerous localities. To the south, Mesozoic clastic rocks appear to be depositional onto Paleozoic units.

In the northwest part of the range, deformed and thrust faulted Mesozoic rocks of the Harquar Peak area are discordantly intruded by the 65 to 70 m.y. Granite Wash pluton. Mid-Tertiary lamprophyric (microdiorite) dikes of NW- to WNW-strike cut all rock types.

Gold mineralization is widespread in the Little Harquahala Mountains. The district as a whole has produced 143,406 oz Au; 90,093 oz Ag; and 50,378 lbs Cu (Keith and others, 1983a). Several deposit types appear to be present. Marginal to the Laramide Granite Wash pluton on the northwest flanks of Harquar Peak, several areas of pervasive, sericitic-argillic alteration, and bleaching and disseminated sulfides (py > cp) occur. These areas are marked by numerous silica-flooded dikes following a prominent NNE-trending shear zone (Rehrig, unpubl. mapping). Due to the proximity of this mineralization to the Laramide pluton, a genetic associated is suspected.

The host of prospects, workings and mines, occurring from just north of the Golden Eagle mine southward to Martin Peak, appear generally localized along the contact between Precambrian quartz monzonite porphyry and overlying Paleozoic rocks. There has been much confusion concerning this contact and interpretations vary from unconformity (Bancroft, 1911) to intrusive (Keith, 1978) to major thrust (Richards, 1982). Production from this contact zone has been concentrated primarily at the Golden Eagle and Bonanza or Harquahala mines where gold and silver with minor base metals occurred in a myriad of shear zones, faults and common low-angle structures in both Precambrian granitic rock in a footwall position and deformed Paleozoic sediments in the hanging wall. Footwall rocks are host to mineralized shears and disseminated sulfides, in places up to 200 ft structurally below the Paleozoic contact. In proximity to the mineralized thrust (?) faults which occur in the contact zone, there have been rare occurrences noted of a fine to medium grained, equigranular quartz monzonite (Rehrig, unpubl. field notes). This intrusive phase if injected into the structurally prepared contact zone, may be related to the mineralization.

The precious and base metals coming from the Rio del Monte mine area at the north end of the district are specifically related to veins, lenses and shoots of white quartz cutting deformed (foliate) Precambrian quartz monzonite porphyry. The veining appears concentrated in a flat-lying contact zone (thrust ?) between the granitic rocks and an overlying (?) chloritic schist. The granitic host rocks are themselves allocthonous on the Hercules thrust fault which is exposed a short distance west of the property.

Finally, some of the mineral occurrences in the district may be associated with the regional swarm of dark, fine-grained, microdiorite dikes of mid-Tertiary age which trend NW to WNW and are seen spatially related to copper-gold occurrences in the Cunningham Pass district, through the Granite Wash Mountains, and at numerous localities in the main Harquahala range.

The Little Harquahala district has been worked intermittently since the late 1800's and has produced a substantial amount of precious metals. Various modern attempts have been made to explore the area. In the early 1970's, CF&I drilled at the Harquahala mine, possibly attempting to find porphyry copper mineralization. In 1984, Tenneco and Noranda laid claim blocks on some areas around the Bonanza and Golden Eagle mine, but reportedly they have not yet encountered anything of significance. Although past production has been relatively small and exploration intense, we feel the area has a combination of geologic factors including; major thrust faults, intrusive events, and favorable Mesozoic stratigraphy which in the right combination, could contribute toward forming a major precious metal deposit. Some attention appears warranted toward checking and sampling areas of more pervasive alteration which may not have had previous mining activities. Such areas exist north and northwest of Harquar Peak, some patches in the Rio del Monte mine area (see Mines of Interest) and through portions of the Sore Fingers crystalline complex (Richards, 1982).

As a sideline, attention is called to the group of shafts and prospects located in Sec. 1, T4N, R12W. We have no indication from our metal overlays of what commodity was mined.

Mines of Interest:

Harquahala mine (Bonanza): (T4N, R13W, Secs. 22, 27) Discovered in 1888, and worked extensively until 1918 and intermittently to 1964. Keith (1978) cites 150,000 tons of production averaging about 0.85 opt Au and 0.53 opt Ag (127,500 oz gold). Consulting reports dated 1912 cite incomplete mill runs for the Bonanza from 1893 to 1898 as 58,163 tons with bullion returning $561,862 (a $20/oz Au). A U.S. Bureau of Mines engineer assessment report from the 1940's cites consulting engineering estimates of bulk-low grade reserves totaling 5 million tons of just over 0.1 opt material perhaps amenable to open pit mining methods.

Geologic descriptions of the deposit are sketchy. Mineralization, primarily of gold with very minor silver and traces of base metals, occurs in broken and sheared Paleozoic rocks and into the equally fractured and brecciated underlying Precambrian quartz monzonite porphyry. Many low-angle veins are mentioned. Apparently the richest gold came from highly hematized, quartz, calcite, brecciated material above the water table concentrated at fault intersections (Bancroft, 1911). At depth, within the granitic footwall, considerable disseminated, fracture stockwork and breccia zone auriferous pyrite is described. Although descriptions at the mine do not specify the exact nature of the Paleozoic granite contact, recent mapping (Richards, 1982; Rehrig, unpubl.) suggests that the Golden Eagle thrust projects into the Bonanza area from the north a short distance (Golden Eagle mine area). The Bonanza workings (those accessible) were recently thoroughly sampled by Gulf Minerals Corp. and the data may be available. Tenneco has copies of these results.

Golden Eagle mine: (Approx. 1 mi NNE of Harquahala mine) Regionally the deposit is located within the trace of the Golden Eagle thrust zone as has been stated. Specific geologic data are lacking except to indicate that the ore is relatively high grade in gold within pyrite-chalcopyrite-bearing rock. Assays reported by Bancroft (1911) run 0.48 to 1.12 opt Au, 1.32 to 2.88 oz Ag, and 0.25 to 4.84% Cu. A consulting report (1916) cites ore values of around $21 (about 1 opt with vein widths of 10 to 37 ft wide. This report cites 1893-1898 production of 1,722 tons returning $31,429 at $20/oz gold price. Mentioned are the results of 27 samples (average width cut = 4½ ft) averaging $18.97. Grab samples from dumps ran around $21.

Reports from recent exploration ventures at the mine state that gold mineralization is best developed in quartzite above the thrust fault. In granite of the footwall, gold is present but largely in subeconomic grades. The trenches which cut mineralized granite at the surface yield highly anomalous gold values.

About 1/2 mile north of the main Golden Eagle shaft, a small open pit is developed in footwall quartz monzonite at some slight distance structurally below the Golden Eagle thrust. The granitic rocks are intensely fractured and sparsely sulfide-bearing. A grab sample ran 0.2 ppm Au and 36 ppm Ag (Rehrig, unpubl. data).

Rio del Monte mine: (T4N, R13W, Sec. 4) Worked in the early 1900's, the property produced only meager amounts of ore (350 tons) averaging about 0.2 opt Au, 0.7 opt Ag, and minor copper and zinc. Mineralization is associated with a basal zone of NNE- to NE-trending, high-angle quartz fissure veins cutting deformed (flatly foliated) Precambrian quartz monzonite porphyry which is in possible thrust contact with altered and foliated Mesozoic detrital sediments and volcanic rocks. Precious metals appear closely confined to individual quartz lenses and veins (~1 to 10 ft thick) without much indication of values within intervening granitic host rock. Just west of the mine workings, within Mesozoic schistose rocks, are several small areas of intense, pervasive bleaching (sericitic, argillic alteration) seemingly disconnected from the individual quartz veins.

References:

Bancroft, 1911; Keith, 1978; Keith and others, 1983a; Arizona Dept Mineral Resources, file data; Rehrig, unpubl. mapping and notes; Richards, 1982.

LOST BASIN DISTRICT

Location:

The Lost Basin district is located to the east of the Gold Basin district and south of Lake Mead in northern Mohave County. The two districts are separated by Hualapai Valley.

Geology and History:

The Lost Basin district is located just to the west of the Colorado Plateau in the Basin and Range physiographic province. The district is geologically contiguous with the Gold Basin mining district to the west and the two are often discussed together (cf. Theodore and others, 1982; Blacet, 1968, 1975). A more thorough discussion of Proterozoic rock types found in the Loast Basin area can be found under the Gold Basin district discussion. Basement in the district consists of Proterozoic (X) metamorphic and granitic rocks that are nonconformably overlain on the eastern part of the district by alluvial fanglomeratic deposits of the Muddy Creek Formation which locally includes lenses and beds of rhyolitic tuff (Theodore and others, 1982). Amphibolite comprises a significant proportion of exposed Proterozoic gneissic units in the southern parts of the Lost Basin range. Theodore and others (1982) suggest this sequence consists of metagabbro, metadiabase, metaclinopyroxenite and metawehrlite.

The Lost Basin range is bounded on the east by the Grand Wash fault zone. Regional eastward to northeastward tilting of the Lost Basin block along this fault has resulted in the present relationship of widespread Precambrian exposures on the western flank being covered by fanglomeratic deposits as one approaches the eastern flank. East of the Lost Basin district, extensive Paleozoic rocks are exposed in the Grand Wash Cliffs.

Theodore and others (1982) discuss the geologic, structural and geomorphic history of the Lost Basin - Gold Basin in great detail. Our synopsis greatly oversimplifies the complex geologic history of the region. Interested readers are referred to these workers' lengthy discussion of the area.

Lode gold mineralization in the district consists of narrow (4-6 ft average width), iron- and copper-stained quartz veins that occur in the Proterozoic granite and gneissic rocks. These veins usually display north-trending strikes and steep dips. Similar to the Gold Basin area, Theodore and others (1982) believed the gold in the Lost Basin veins probably reflect either remobilization of gold from gold-bearing, near-surface Proterozoic source areas or anatectic incorporation of gold into Laramide, peraluminous two-mica magmas from very deep gold-bearing sources. The gold was then deposits by hydrothermal systems associated with emplacement of the 72.0 m.y. old two-mica monzogranite in the southern White Hills. These workers believed that deposition of gold occurred in a mesothermal environment during galena-, chalcopyrite-, ferroan-carbonate-bearing stages of vein development. Fluid inclusion studies indicate that salinities associated with gold deposition in the Lost Basin - Gold Basin districts largely bridge the fluid composition interval between epithermal and porphyry copper mineralization.

The principal gold veins in the district were discovered about 1886 and considerable ore was reported to have been periodically mined and milled or treated in arrastres (Schrader, 1909). Schrader (1909) noted that production prior to 1909 was reported to be many thousand dollars, chiefly in gold. Hewett and others (1936) noted recorded production between 1904-1932 was valued at less than $45,000 (in Au, Ag, Cu). The King Tut placers were discovered in 1931 and between 1934-1942, a gold production valued at $23,510 was credited to the placer area (Wilson, 1961). Most activity in the district since the 1930's relates to the placer deposits.

While finding new ore shoots within the known veins of the district would seem to offer little hope of finding targets suitable for most mining companies, Theodore and others have offered a number of suggestions for directing future exploration efforts in the Lost Basin - Gold Basin region. These are described under the Gold Basin district description and all will not be repeated here. The two which seem most appropriate for the Lost Basin district are as follows:

(1) Prospecting for sequences of rock that might form favorable replacement zones adjacent to, or nearby any of the gold-bearing veins that crop out. Suggested units include Proterozoic carbonate, amphibolite, etc. Tectonically shattered zones would also fit into this category.

(2) Possible syngenetic or stratiform gold mineralization in the Proterozoic metamorphic rocks. Theodore and others (1982) suggest that boron-enriched fluids were probably important in the paragenesis of the tourmaline-bearing schists locally exposed in the Precambrian terrane. These workers felt such conditions may have been reflective of exhalative horizons emanating from centers in the protoliths of the metamorphic rocks. Possibly even more appropriate for the Lost Basin area is that these workers also noted thin beds of carbonate-rich units (now marble, calc-silicate marble and skarn) that are spatially associated with amphibolite (which in the southern Lost Basin area is believed to have been derived from mafic to ultramafic protoliths). We would wonder if the carbonates could be carbonate-rich exhalites. Some of the calc-silicate marbles contain minerals such as garnet, zoisite, clinozoisite and possibly chloritoid. Some of these minerals are used as footwall indicators of mineralization associated with stratiform mineralization in the Archean. Also mentioned are horizons of metachert and metarhyolite within the gneissic terrane. Gold-bearing exhalative chert horizons associated with Proterozoic rhyolite domes occur in the Bradshaw Mountain (cf. Swan and others, 1981).

Schrader (1909) and Wilson and others (1967) describe the early lode mines of the district. Theodore and others (1982) have reported Blacet's field notes of the various prospects that he looked at in the Lost Basin and Gold Basin area. We have reproduced several of Blacet's more interesting descriptions below in the Mines of Interest section.

Mines of Interest:

Miss Texas no. 2 (T29N, R17W, Sec. 17, NE¼) A 30 to 50 ft wide pyritized zone striking N60°W parallel to foliation in the surrounding gneiss is cut by several

quartz veins which can be followed toward the southeast for at least 0.3 km. Location of the zone is about 300 ft S25°E from the stone monument of the Miss Texas no. 2 claim.

Ideas Lode no. 30: (T29N, R17W, Sec. 17, NE¼) Workings occur along a nearly flat-lying shear zone which contains irregularly distributed, quartz-yellow-brown carbonate veins more or less parallel to the shallow-dipping foliation. Some evidence exists to indicate the rock was flooded by yellow-brown carbonate.

Unnamed prospect: (T30N, R17W, Sec. 29, SW¼) A small prospect pit occurs along a major 30 ft wide range-front fault between iron-oxide stained quartzo-feldspathic gneiss and interlayered amphibolite and caliche-cemented fanglomerate or talus. Clearly, quartz-carbonate vein material is broken up in the zone suggesting the fault zone may have followed locally an already emplaced vein. The fault zone also shows evidence of having originally contained much highly sericitized, chloritized and carbonate-altered gneissic fragments. No sulfides or gold were observed; a little weathered pyrite was noted.

Unnamed prospect: (T30N, R17W, Sec. 32, NW¼) Prospect adit is located about 500 ft southwest of lower dump of the Golden Gate mine. The adit essentially follows a well-developed, vertical, N50°E striking fault. Prominent cross faults include an east-west fault dipping 5°S. A little copper staining occurs on brecciated blocks of quartz-carbonate-minor chalcopyrite. Considerable sericitization and carbonatization of the country rock was noted, but no vein material observed. A short adit directly up the ridge to the south exposes a prominent fault striking north-south to N10°E. This fault occurs between the brecciated footwall of an east-dipping quartz-carbonate vein which is up to 2 ft thick. The faulting postdates the quartz-carbonate vein whose footwall it follows. There is abundant sericitization and carbonate flooding of the quartzofeldspathic gneiss within several feet of the vein. The brecciated vein material locally looks like that at the Cyclopic mine. A shaft at the top of the ridge is vertical and includes abundant broken-up vein quartz. Some free gold was noted.

References:

Blacet, 1968, 1975; Hewett and others, 1936; Schrader, 1909; Swan and others, 1981; Theodore and others, 1982; Wilson, 1961; Wilson and others, 1967.

MARTINEZ DISTRICT

Location:

The Martinez mining district is located in southern Yavapai County, at the southeast margin of the Date Creek Mountains about 3 miles north of the small settlement of Congress Junction. The district covers the east-central portion of T10N, R6W.

Geology and History:

The Martinez district is sometimes considered part of the larger Weaver district to the east. For the purposes of this report, each district will be discussed separately. Wilson and others (1967) cite early reports as indicating that gold was discovered in the Martinez district as early as 1870. Due to the complex nature of the ores, little production resulted until about 1889. Major production did not really begin until 1894, and lasted only until about 1910. Between 1889 and 1910, production from the three major mines in the district (the Congress, Niagara and Queen of the Hills) was as follows (Wilson and others, 1967):

Mine	Tons of Ore	Recovered Au (oz)	Recovered Ag (oz)
Congress	379,022		
Niagara	293,215		
Queen of the Hills	20,125		
TOTALS	692,332	388,477	345,598

Average tailings assays were $1.20 (@ $20.67 per oz Au).

Production between 1910 and 1934 amounted to small lessees and attempts to rework dumps and old tailings. The Congress mine was reopened in 1937 and produced about 24,000 oz Au before being shut down during World War II. Keith and others (1983a) credit district production through 1950 as amounting to 990,000 tons of ore from which were produced 432,500 oz Au, 466,000 oz Ag, 201,000 lbs Cu and 1600 lbs Pb. In 1965, D. W. Jaquays acquired part of the old Congress property and established the Congress Consolidated Gold Mining Co. (Pay Dirt, Sept. 1984). This company continued to enlarge its district holdings and built a heap leach plant that produced about 4000 oz Au in the late 1970's. In 1981, Congress Consolidated optioned the property to Magic Circle Energy Corporation, a small oil company based in Oklahoma City (Pay Dirt, Sept. 1984). Magic Circle drilled some 100 core holes and discovered extensions of the old Congress veins. Magic Circle's find is reported to contain some 350,000 tons of reserves with an average grade of 0.28 opt Au. In 1984, Magic Circle entered into a joint venture agreement with Echo Bay Mines Ltd. of Edmonton, Alberta, to develop the property. Echo Bay has agreed to spend $7.25 million in development to earn 51% interest in the property. As of September, 1984, Echo Bay reportedly had 2 geologists along with 2 drill rigs on the property.

Basement in the eastern part of the Date Creek Mountains consists mainly of coarse-grained biotite granite of Prcambrian age. Intruding the granite are numerous dikes of aplite, pegmatite and "greenstone" (diabase?). Wilson and others (1967) noted that the greenstone dikes are fine-grained, dense, greenish-black rocks that consist of a finely divided aggregate of hornblende, calcite and quartz containing scattered grains of magnetite and pyrite.

Gold-bearing veins, of which the Congress, Niagara and Queen of the Hills have been the most important, generally fill fault fissures which strike westward and dip at shallow angles northward. The Congress fissure occurs within a 15 ft wide greenstone dike and dips 20° to 30°N. Vein fillings consist of massive, coarse-textured, grayish-white quartz containing irregular masses, bands and disseminations of fine-grained pyrite. Sparse galena is also present and free gold is uncommon. While the course of the vein within the greenstone dike is quite irregular, ore-bearing zones are generally flat lenses near the footwall (Wilson and others, 1967). These lenses commonly terminate as stringer zones. Staunton (1926) reported that, "Although the Congress vein is continuous and well defined for a mile or more to the west of the mine workings and shows both the characteristic quartz and sulfides, the pay ore was practically confined to a shoot in the vein pitching to the northwest and coinciding closely with the intersection of one of the fissure veins in the granite. The granite vein is faulted by the Congress vein so that the intersection is obscure in the mine workings. The portion of the granite vein in the hanging wall of the Congress carried bodies of pay ore." The Congress ore shoot varied greatly in length on different levels, the longest being 1800 ft on the 650 level. The ore shoot pinches down in certain levels to the point where no stoping could be done, the averge thickness of the ore shoot was reportedly less than 3 ft (Wilson and others, 1967).

Other veins exist entirely within the granite unassociated with any greenstone dikes. These veins typically strike east-west (parallel to the Congress structure), but display steeper dips (i.e., 40° to 50°). These veins also generally have more extensive development of quartz than displayed by the Congress vein and are generally of lower grade. They characteristically carry some galena and display higher silver contents. The Niagara vein which hosted a commerical orebody to a depth of 2000 ft is an exmaple of this type of vein.

Both the Congress and Niagara veins were cut off on the east by the same fault. Neither vein was apparently definitely located beyond this point. Wilson and others (1967) and Metzger (1938) give more detailed accounts of the mining operations in the Congress and Niagara mines.

Mines of Interest:

Congress Extension Mine: (Sec 15, T10N, R6W.) The property is located about .5 mile west of the Congress Mine. It was first operated in 1890's by means of a 950 ft shaft that opened onto 9 levels, each extending approximately 100 ft east and west of shaft. Small but steady production was achieved in the 1920's and early 1930's from ore that averaged $8.50 to $17.50 worth of gold per ton. Vein strikes east-west in granite and dips 35° to 40°N. Orebody apparently occurred as a flat lens about 3 ft thick.

Vein consists of massive, locally shattered, white quartz that contains bunches and disseminations of pyrite with some chalcopyrite. Oxidized vein material contains abundant limonite and some copper oxides. This mine is separated from the Congress and Niagara veins by an area of alluvium in which the outcrops are lost. What relationship the Congress extension mine has to the more productive Congress or Niagara veins is not known. The mode and character of the ore in these deposits, however, is very similar.

Reese Mine: (Location inexact, about 6 miles due north of Congress Junction at the summit of the Date Creek Mountains.) In 1936, the property consisted of 2 patented and 11 unpatented claims. A quartz vein 2 to 4 ft thick occurs along a diorite dike intruded in Precambrian granite. Vein strikes northwest and dips about 30° northeast. It reportedly is more oxidized and altered at its northern part. At the southern end of the property, the vein consists mainly of quartz containing auriferous sulfides of iron, lead and copper with some zinc. The best ore reportedly occurs with yellow and brown FeO_x. The property is extensively developed by 2 inclined shafts, the southern one being 1180 ft deep and the northern one being 300 ft deep. There are a number of levels from each of the shafts, but the extent of the workings could not be determined in 1936 because of caving. Mining activity was renewed in March, 1936. Shipments from the upper part of the southern portion of the vein averaged $9 to $15 per ton in gold. Later activity centered on the northern shaft where shipments averaged $40 to $60 per ton gold (1936 prices). Appreciable amounts of gold apparently occur in the fractured parts of the rock adjacent to the vein, as samples of fines from the waste dump ran up to $8 per ton gold. Ore ranged in thickness from 6 to 18 inches. Between March 1935 and August 1936, the mine produced some 770.7 tons of ore that was valued at $14,877 (about 425 oz Au).

References:

Keith and others, 1983a; Metzger, 1938; Staunton, 1926; Wilson and others, 1967.

MAYNARD (WHEELER WASH) DISTRICT

Location:

The Maynard mining district is located on the northeastern end of the Hualapai Mountains, Mohave County, about 15 miles southeast of Kingman.

Geology and History:

The Hualapai Mountains are a Precambrian plutonic-metamorphic complex that has been uplifted in Basin-Range time (Stensrud and More, 1980). This complex is intruded by a number of late Cretaceous or Tertiary stocks and numerous dikes, swarms, particularly along its eastern flank (see Plate 1). The oldest Precambrian rocks in the Hualapai Mountains are believed to be middle Proterozoic in age (± 1,800 m.y.) and consist of intermediate to felsic schists, gneisses and amphibolites. In the west-central part of the range relict textures in these rocks show that they were derived from volcanic, volcaniclastic and sedimentary protoliths that have undergone amphibolite facies regional metamorphism (Stensrud and More, 1980). These rocks host syngenetic massive sulfide deposits in the Hualapai mining district. The older metamorphic rocks have been cut by numerous semi-conformable Precambrian granitic plutons and later Precambrian pegmatites and diabase dikes. In the northern Hualapai Mountains, Kessler (1976) identified and dated three such plutons: the Hualapai Granite (1397 ± 69 m.y.); the Holy Moses Granite (1364 ± 24 m.y.); and a medium-grained granite (1337 ± 38 m.y.). Wilkinson (1981) noted that the Precambrian rocks in the Cerbat Mountains were regionally correlative with similar rocks in the Hualapai's. The Diana Granite west of Chloride appears to correlate in composition and age (1350 m.y. Shafiquallah and others, 1980) with the younger Precambrian granites in the northern Hualapai Mountains.. These 1300-1400 m.y. old intrusions in the Hualapai and Cerbat Mountains are believed to be part of the anorogenic granitic suite recognized by Silver and others (1977) in western North America (Wilkinson, 1981). The pegmatites that intrude these granites and the older Precambrian rocks have been dated by Kessler as 1100 ± 161 m.y. old.

In the Maynard mining district the Proterozoic rocks have been cut by several north to northeast-elongate plutons of late Cretaceous (?) age. Keith and others (1983b) cite an unpublished (?) date of 65 m.y. on a quartz monzonite pluton in the district. Much of the precious and base metal mineralization in the district is believed to be associated with these Laramide intrusions (Vuich, 1974).

Mineralization was first discovered in the district in 1865 by a party of prospectors headed by John Moss (Schrader, 1909). They located several mines, named the district "Wauba Yuma," and then were soon chased away by Hualapai Indians. Lieutenant Wheeler of the U.S. War Department camped in the district in 1871 while making a reconnaissance of the area. A group of San Francisco prospectors camped nearby, named their first location Wheeler lode, and renamed the district, "the Maynard district," after one of its members. Schrader notes

that for a decade or more, beginning in the early 1870's, the district furnished a livelihood to a considerable number of people who confined their operations to the rich oxidized surface ores. The production during this time was reported to be fairly large. Hewett and others (1936) estimate production prior to 1904 to be several hundred thousand dollars, mainly in silver. The recorded district production between 1904 and 1932 is given by Hewett and others (1936) as 3,982 tons of ore yielding 643 oz Au; 90,093 oz Ag; 3,149 lbs Cu; and 104,248 lbs of Pb. Vuich (1974) took individual mine data and made a district estimate of total production of between several hundred thousand dollars to a million dollars. Total tonnage mined was estimated at 40,000 tons. Vuich (1974) stated that in tonnage mined and in dollar value, the metal commodities produced (in order of decreasing importance) were: silver-gold, lead-zinc (a close second), copper, and molybdenum-tungsten (tungsten a distant fourth).

Nearly all of the mines were abandoned since the 1950's and many of the mills and headframes were removed. The district was heavily prospected during the 1960's and 1970's by a number of companies interested in porphyry copper mineralization. At least 6 diamond drill holes were drilled to depths of between 800-1600 ft prior to 1974 (Vuich, 1974).

The mineralization sought by the early miners was contained in strong and persistent fissure veins described by Schrader (1909) as being similar to those in the Cerbat Mountains (Wallapai mining district). These veins mainly strike northwest, are from 1 to 6 ft wide and were mined principally for horn silver. The veins also carried bromyrite (?) and copper sulfides.

Vuich (1974) noted a regional (district-wide) metallogenic zoning of the vein deposits. The innermost zone contained molybdenum-tungsten veins, giving way outward to zones of copper-molybdenum, lead-zinc-silver, and finally to silver-gold bearing veins. He believed that the mineralization patterns, metal zoning and wallrock alteration were suggestive of being related to a porphyry copper system. His mapping indicated that mineralized exposures represented either two separate porphyry systems or a single deposit that had been displaced some 4,500 ft in a right lateral sense of motion along an east-northeast fault zone. Vuich further notes the possibility that the inner tungsten zone may represent a Precambrian tungsten belt that has had Laramide mineralization superimposed upon it. Vuich felt that the potential for the occurrence of massive sulfide and large, lode vein deposits within the Maynard district is minimal.

There is little published information about the mines in the Maynard district. Schrader (1909) mentions that the American Flag, Enterprise, Great Eastern group and Siamese were among the most important. Of his descriptions, the American Flag appears the most interesting. Wilson (1941) and Dale (1961) describe the tungsten-bearing (some also produced precious metals) deposits of the district.

Mines of Interest:

American Flag Mine: (T20N, R15W, Sec. 26) The mine was discovered in 1874 and was worked principally by adit drifts. Schrader reports that the main vein is from 1-4 ft in width and that the ore shoot is relatively large. Ore consisted mainly of antimonial silver, some gold and a little zinc. Much of the ore was very rich; most sold from the mine averaged more than $100/ton. Net returns from a 21 ton shipment sent to Swansea, Wales was said to have been $11,500. Reported production was said to be about $400,000.

Telluride Chief (Standard Minerals): (T20N, R15W, Secs. 18 & 24) Basement consists of granite cut by numerous dikes of aplite and pegmatite. The granite is cut by extensive N30°W striking fissures marked by iron-stained outcrops and sericitic alteration. The property was located in 1874 for gold and silver; most exploratory work was done between 1916 and 1918, at which time a shaft was sunk 450 ft and lateral work was done off the 200-, 300-, and 400-ft levels. A 100-ton gravity-flotation mill was built to treat gold-silver-molybdenite ores. In 1935, seven cars of gold-silver-copper ores were shipped. In the 1943 to 1950 era some prospecting was performed for tungsten. The vein fillings consists of coarsely crystalline quartz that in places contains pyrite and molybdenite; in other places, pyrite and small particles of wolframite and scheelite. Samples taken by the USBM engineers in 1943 in the accessible workings averaged 0.09 opt Au, 5.45 opt Ag, and 0.75% WO_3 across a 16-inch width.

Gold King: (T19N, R15W, Sec. 14) In 1943, the Gold King had a well established camp and a 50-ton mill. The main shaft is partly caved and in need of retimbering. Several hundred tons of milling ore were claimed to lie on the dump. Several fissure veins exist on the property: the Comet #1 has been the most developed. This vein is 3.5 ft wide and has been developed by a shaft 336 ft deep, having about 170 ft of drifting. In 1943, USBM engineers took 4 samples from various places underground. The highest grade assay was 1.2 opt Ag, 0.09 opt Au, 0.42% Pb, and 6.78% Zn, across 42 inches; the lowest assay was 1.4 opt Ag, 0.02 opt Au, 0.92% Pb, and 1.15% Zn.

References:

Arizona Dept. Mineral Resources, file data; Dale, 1961; Hewett and others, 1936; Kessler, 1976; Shafiquallah and others, 1980; Stensrud and More, 1980; Schrader, 1909; Vuich, 1974; Wilkinson, 1981; Wilson, 1941.

McCONNICO DISTRICT

Location:

The district is located several miles southwest of Kingman and southeast of McConnico station on the Santa Fe Railway, along the border of the Sacramento Valley with adjacent low foothills of Kingman Mesa.

Geology and History:

The district is underlain by Precambrian granite and gneisses which are covered by Tertiary volcanic rocks to the north and east. Little information is known about the district and its ores. Schrader (1909) states that the country rock is mainly Precambrian granite, which in the valley portion of the district is covered by wash debris. Schrader further states that the ore deposits are contained principally in gold-bearing pegmatite dikes and shear zones that cut the granite in a northerly direction. In places the veins are associated with later basic intrusions. At the Bi-Metal mine, the mineralization is reportedly in an altered Precambrian microcline granite associated with a plagioclase and hornblende bearing intrusive rock.

The principal deposits of the district are noted by Schrader (1909) as being the Bi-Metal, the McKesson group and the Boulder Creek group. ADMR files indicate that the Bi-Metal has had some $70,000 in gold production. Keith and others (1983a) list recorded district production between 1908 and 1950 as being 23,000 tons which contained 3,600 oz Au; 1,800 oz Ag; and 200 lbs Cu. The deposits may be Tertiary in age and possibly are related to intrusive phases of the nearby volcanic rocks which nearly surround the district on all but the west side.

Mines of Interest:

Bi-Metal (McGuire) Mine: (Sec. 4, T20N, R17W, and Sec. 34, T21N, R17W) An altered and mineralized area of Precambrian granite roughly 300 ft in diameter is apparently cut by a system of northerly and easterly shears (sheeting). The mineralized zone dipping about 45°N is localized by these shears. On the south boundary of the mineralized area, the granite is intruded by a dark gray intrusive dike which also dips about 45°N beneath the deposit. Schrader reports that both the dike and the granite contain considerable pyrite. Gold occurs mainly as fine-grained free metal which occurs mainly in the oxidized and fractured zones of the granite. In this zone the pyrite is oxidized to FeOx which "brilliantly" stains the rocks. The gold apparently occurs in limonite boxworks after sulfides. Schrader thought the deposit was enriched by mechanical weathering of eroded overlying mineralized granite. To the east, the deposit was thought to terminate above the mine at a point where the slope steepens with talus, but it was also believed that the deposit could extend beneath the talus upward toward the top of the mesa and may possibly connect with a similar deposit about 0.5 miles to the northeast. The deposit was worked mainly by an open pit and 60 ft shaft with short drifts on the 40 ft level. The mineralization sounds interesting and may have some potential for bulk tonnage low-grade ore. It should be checked.

Boulder Creek Group: (Sec. 22, T20N, R16W) Located in the southern part of the district and discovered in 1906, the property developed at first by shallow shafts and pits. Country rock is of pegmatitic granite, somewhat schistose, that weathers into boulders up to 60-80 ft in diameter. The deposit consists of two ledges that lie at nearly right angles to each other and form a "T-square", of which the top trends NW-SE and the stem extends SW. These ledges may be dikes or merely mineralized zones in the granite. The SW-trending portion of the system is reportedly 100 to 1,000 ft wide with a known length of about 1/4 mile. Where opened by a 30 ft shaft, the zone consists nearly entirely of red oxidized pegmatite which in places is "honeycombed" with boxworks of what is believed to have been pyrite. Much of the rock taken from this shaft was said by Schrader to have run $3-$100/ton in gold (@ $20/oz Au). The NW-SE ledge also has a maximum width of about 1,000 ft and is reported to have a known strike extent of about one mile. It is composed of coarse granite similar to that exposed in the previously mentioned 30 ft shaft, and a considerable portion was said to be ore. Schrader reported that ore taken from openings on the Baby mine claim No. 2 was reported to average about $12 in gold and 20 opt Ag. It was also stated to contain some galena and chalcopyrite. While these must obviously have been "high-grade" samples, this property might have a bulk tonnage potential if low-grade mineralization could be shown to occur over wide widths along these ledges. The area should be checked.

References:

Arizona Dept. Mineral Resources, file data; Keith and others, 1983; Schrader, 1909.

McCRACKEN DISTRICT

Location:

This district designation is applied to the immediate area of the McCracken mine north of the Rawhide Mountains in southern Mohave County. The district would encompass T13N, R14 and 15W.

Geology and History:

The district occurs in Precambrian gneisses and granitic rocks intruded by minor dikes and granitic bodies of Mesozoic or Tertiary age. These basement rocks are nonmylonitic and retain their Precambrian structural character.

The McCracken mine is the principal producer in the area, yielding ores carrying 2 to 11 opt silver as argentiferous galena and with only traces of gold. The deposit occurs as a wide, complex, high-angle vein zone cutting coarse-grained, quartz-mica schists and diorites intruded by granites which are in turn cut by later dioritic dikes. The veins trend north-south and dip 65°E, but shallow somewhat with depth. The mineralized zone has a 1/2 to 2 mile strike length and attains widths from 12 to 50 ft. The sulfide minerals occur in a typical epithermal banded gangue of calcite-siderite-barite and amythystine quartz.

During recent years, Fischer-Watt Mining Co. produced 50,000 tons of ore yielding 250,000 oz Ag and 1 million pounds of lead (P. Durning, personal commun., 1985). Currently the Arizona Silver Company is mining the high-grade reserves (75,000 tons of 9.5 opt Ag) outlined by Fischer-Watt. Reportedly there are two open-pitable deposits outlined. One has 300,000 tons of 4 opt material; the other contains 130,000 tons of 2-3 opt reserves.

References:

Arizona Dept. Mineral Resources, file data.

MIDWAY-CORONA DISTRICTS

Location:

The Corona district consists of a small group of prospects and workings found along the mutual boundary between R14-15W, T8N, flanking the southwesternmost slope of the Buckskin Mountains in La Paz County. The mines are located in the southeast quarter of the Swansea 15' quadrangle about 7 miles east of the old Midway site.

The Midway district encompasses those few scattered mines and prospects distributed along the southwest margin of the Buckskin Mountains within the Midway-Battleship Peak area (Swansea 15' quadrangle).

Geology and History:

Original claims in the Corona district were located about 1895 and worked sparingly in the early 1900's. The three principal workings consist of the Mammoth, Chicago and Copper Glance mines. A carload of ore from the Copper Glance was reported to carry 22% Cu and from $4-$5 per ton Au (@ $20/oz). Production from this district is assumed to be quite small as no figures have been reported.

Host rocks for the mineralization generally consist of metaigneous or metasedimentary gneiss or foliate granodiorite cut by sills and dikes of aplite and pegmatite. Along the western front of the Buckskin ranges, a prograde metamorphic transition from sediments to metasedimentary facies has been reported (Rehrig and Reynolds, 1980). This same metamorphic front exists in the nearby Granite Wash Mountains. This metamorphic gradient is complicated by the presence of the Hercules thrust which juxaposes Precambrian quartzofeldspathic gneisses over the Mesozoic metasedimentary rocks. Rocks of the Corona district may therefore represent either strongly metamorphosed graywackes derived from Mesozoic protoliths, deformed pre-Laramide, Mesozoic plutonic bodies or Precambrian gneissic rocks. Foliation in these rocks strikes NE to ENE and dips shallowly ($< 25°$) southerly. There is a mineral lineation which bears N50°-65°E (Rehrig, unpubl. mapping). Flanking outcrops of the gneisses are low-lying hills and scattered exposures of Tertiary redbeds and conglomerates. The Mammoth mine occurs at the contact between basement gneiss and the Tertiary rocks. The Chicago and Copper Glance mineralization occurs within the metamorphic rocks.

The Chicago and Copper Glance deposits are relatively small-scale veins striking NNW to NW and with steep dips. Both veins are only a few inches wide with fluorite, barite, quartz, hematite, minor magnetite accompanying copper silicate, chalcopyrite and chalcocite mineralization. At the Copper Glance property, a post-mineral, basic dike (probably mid-Tertiary microdiorite) is mentioned (Bancroft, 1911) as shattering the vein.

The Mammoth deposit is localized along the contact between basement gneisses and manganese-iron stained, Tertiary fanglomerate. Although Bancroft interprets

this contact as depositional, the surface is a 25° south-dipping fault which possibly may be a detachment structure (Rehrig, unpubl. data). Slickensides and grooves on this fault trend NE and NNW. Mineralization consists of hematite, quartz, barite, minor fluorite, and chrysocolla.

Mineral occurrences are only sparcely distributed within the Midway district (Plate 1, metals overlays). Mineralization generally consists of spotty, oxidized, copper occurrences with subordinate Au and Ag occurring in veins, shear zones or as replacement bodies within Mesozoic metasedimentary rocks. Gangue minerals include hematite, quartz, and local barite, fluorite. Production from the few mines has been small with only hand picked material (± 250 tons) reported to have been mined. Keith (1978) indicates total production amounted to approximately 4 tons Cu, 45 oz Au, and 34 oz Ag.

Mines of Interest:

Although the copper-gold veins in the gneisses of the Corona district appear of minor consequence, the Mammoth mine is of interest because of its localization by a possible detachment structure. Much of this structural zone is covered by alluvium so its ultimate extent is not known. Sampling and a careful surface examination is recommended.

Descriptions of copper-silver mineralization with minor sulfides conformably banded within Mesozoic phyllitic schists, quartzite, black shales and carbonate lenses at the Battleship mine (Sec. 3, T8N, R15W) and the Arizona Midway mine (Sec. 1, T8N, R16) suggest possible stratiform or syngenetic type mineralization with possible metamorphic overprints. Although only minor gold has been reported from these occurrences, their similarities with gold-bearing deposits of this unusual type elsewhere, create interest. For this reason, the broad northwest trending zone of transitional metamorphism within Mesozoic sedimentary-volcanic rocks along the southwest margin of the Buckskin ranges may be a favorable environment in which to explore for stratibound gold deposits.

References:

Bancroft, 1911; Keith, 1978; Rehrig, unpubl. field notes.

MINNEHAHA-SILVER MOUNTAIN DISTRICT

Location:

The Minnehaha-Silver Mountain district is located in the southern Bradshaw Mountains southwest of the settlement of Crown King. The district is contiguous on its east and north boundaries with the Pine Grove-Tiger district.

Geology and History:

The district lies in a fairly remote and rugged portion of the Bradshaw range that at times provides for difficult access. The geology of the area is known only in gross detail and Lindgren's (1926) brief account is the only published information on the district. The oldest rocks in the district are Yavapai Series schists that occur as a 2-3 mile wide belt that trends northeasterly through the area from near Copperopolis on the south to Tiger on the north. The schist is truncated near Tiger by a large Laramide pluton. This narrow "septum" of schist is intruded on its western margin by Precambrian Brady Butte granodiorite and by the somewhat younger Precambrian Crazy Basin quartz monzonite on its eastern flank. Pliocene basalt (?) overlies the Precambrian rocks in several patches along the western margin of the district. Lindgren (1926) notes that "scattered and scant" mineralization occurs across the region. Some of this mineralization was believed to be connected with an extension of the Crown King belt of rhyolite porphyry dikes, now known to be Laramide in age. A Laramide porphyry copper deposit occurs near Copper Basin (not to be confused with Copper Basin near Prescott) associated with the stock shown on Plate 1. Exxon drilled a number of deep core holes into this system in the early 1970's. Although a fair sized system, not enough supergene enrichment was present to make it ore grade. Other veins in the district were believed to be Precambrian in age. At least one mine, the Pacific, would appear to be a stratibound massive sulfide deposit. Placer mining was conducted along Minnehaha Creek during the 1880's, producing an estimated $100,000 (±5,880 oz Au). This gold was thought to have been mainly derived from the Fortuna lode. Wilson and others (1967) mention several properties that were being worked in a small way during the 1930's. Keith and others (1983a) list production from the area between 1901-50 as 1,050 tons of ore that contained some 420 oz Au, 2,000 oz Ag; 10,600 lbs of Cu; and 8,600 lbs Pb.

The mention of Precambrian mineralization by Lindgren is interesting and should be investigated further. Some potential for gold-rich massive sulfide mineralization may also exist in this district. The Pacific mine (Lindgren, 1926) may be an example. Although mainly a pyritic body with a little Cu, Au and Ag, the deposit displays a leached gossan cap over some 3,000 ft of length that could possibly contain low-grade, heap leachable gold ore of little interest to the early miners.

Mines of Interest:

Button Mine: (Sec. 31, T10N, R1W) The deposit consists of a Precambrian (?) vein in wallrock of amphibolite. Country rock in the vicinity is Bradshaw

granite (Brady Butte granodiorite) with some amphibolite and diorite. Vein is composed of glassy quartz that contains some pyrite, chalcopyrite, galena and sphalerite. The deposit is developed by a 400 ft shaft with drifts extending about 650 ft northward and 100 ft southward. A 5-stamp mill was erected on the property to treat the ores. Most of the work occurred around 1900.

Boaz Mine: (Sec. 1, T9N, R2W) Precambrian (?) quartz vein trends east-west. Lindgren reported it to be a "spotty" vein, "frozen to the walls". Some of the ore from the upper workings reportedly ran $20/ton (@ $20/oz Au). Workings are fairly substantial; one shaft is reported to be 650 ft deep with drifts amounting to over 2,500 ft. Mine was opened around 1902 and equipped with a 20-stamp mill and a cyanide plant.

French Creek Barite Deposit: (NW¼ Sec. 29, T9N, R1W) Located on west side of Silver Mountain, barite occurs with manganiferous siderite within a 3 to 5 ft fault zone in schist. The zone strikes N45°W, about normal to the schistosity, and dips 70°NE. As shown by occasional outcrops, the deposit is at least 300 ft long, 2 to 5 ft wide, and 50 ft deep. It has been explored by a 50 ft adit and two old caved pits, all probably made in a search for gold ore. No work was being done when the property was visited by USBM engineers in 1958. No barite ore has been produced from the deposit. Since this is in Precambrian schist and massive sulfide deposits occur in the area, one wonders if the barite and siderite are being remobilized from a nearby Precambrian source.

Pacific Mine: (Sec. 9, T9N, R1W) Lindgren describes the property as a big iron dike with very little copper, gold and silver. He states that the deposit is evidently "a pyritic impregnation" of the hosting schist. The CRIB data indicate the deposit consists of quartz lenses parallel to the foliation in the schist. The schist in the vicinity of the mine is described as a "hornblendic" phase of the Yavapai schist with a porphyry dike 50 to 150 ft in width. The deposit displays a leached gossan for 3,000 ft. The ores were copper carbonate near the surface, succeeded at a depth of 50 ft by secondary chalcocite, with bornite and chalcopyrite. The ore was estimated to contain 3% Cu with some silver and gold. Lindgren lists the width of several orebodies as being 9, 14, and 25 ft. Development consisted of 1,500 ft of drifts and a 500 ft shaft (at least two other shafts are also on the property). Lindgren's description suggests the deposit to be a massive sulfide deposit, while the CRIB data indicates it as a quartz vein occurrence. This certainly warrants additional checking. If an actual massive sulfide deposit, the gossan cap may be enriched enough in gold to be a small, but viable low-grade target.

Lane Mine: (Sec. 11, T9N, R1W) A silver-bearing quartz-calcite vein is rich near the surface. United States Mint report for 1884 stated that a 4-stamp mill was built on the property and that $50,000 in silver and gold was recovered from 300 tons of ore.

References:

Keith and others, 1983a; Lindgren, 1926; Wilson and others, 1967.

MINNESOTA DISTRICT

Location:

The Minnesota district is located south of Lake Mead and just east of Hoover Dam, in extreme northwestern Mohave County.

Geology and History:

We could find no description of any mines in this area. USBM records (Keith and others, 1983a) show production credited to this area between 1939-56, amounting to 2,600 tons that yielded 400 oz Au; 6,000 oz Ag; 14,000 lbs Cu; and 400 lbs Pb.

Geologic maps of the region have been compiled by Longwell (1936, 1963) and Anderson (1978). Mapping by these individuals indicate that the rocks within the district consist of highly faulted Miocene volcanics. These rocks are mainly andesitic to rhyolitic in composition and are overlain (on the eastern side of the district) by a wedge of Pliocene Muddy Creek Formation. Wilson Ridge in the Black Range to the east was the source area for much of the detritus in the clastic wedge which includes large landslide masses of megabreccia (up to several miles in length) that broke from the rising mountain front and slid into the subsiding basin (Longwell, 1951).

Just to the east end of the district, Proterozoic gneisses and schists are intruded by the large composite Wilson Ridge pluton (13.6-15.1 m.y.; Anderson and others, 1972).

We have little information concerning the nature of the mineralization in the district. Keith and others (1983b) suggest that it consists of middle Tertiary veins along faults cutting the Miocene volcanic rocks. We are not sure, however, where these veins are supposed to occur. Plutonic rocks similar to that on Wilson Peak occur in the canyon of the Colorado River to the west (Anderson, 1969) and associated fine-grained border facies intrusive rock and altered volcanic country rock are also reportedly abundant in the canyon (Anderson and others, 1972).

Longwell (1936) mapped a belt of intense alteration extending east-west in an area directly north of Black Canyon (north of the district in Nevada ?). He also noted that directly west of Fortification Hill, silicified limestone and sheared quartzite beds of unknown age occurred in the midst of an intensely altered zone, characterized by an abundance of epidote and some specular hematite. Longwell thought that the Fortification Hill area had been a "principal center" of hydrothermal activity as pre-Pliocene rocks exposed on the west and south flanks of the hill had been altered to a highly colored, nearly incoherent mass, that had since been eroded into a "badlands" topography.

Longwell (1936) also described widespread alteration of Precambrian granitic rocks, east and northeast of Fortification Hill, and believed that it represented the same general center of hydrothermal activity. He states that almost complete sericitization and kaolinitization of the feldspars give the rock a bleached appearance.

While we can make no definitive statements concerning the potential of the area, the alteration certainly sounds interesting. A brief geologic reconnaissance through the area seems warranted and should provide some answers about the character of the mineralization in the district.

References:

Anderson, 1969, 1978; Anderson and others, 1972; Keith and others, 1983a, 1983b; Longwell, 1936, 1951, 1963.

MOHAVE MOUNTAIN DISTRICT

Location:

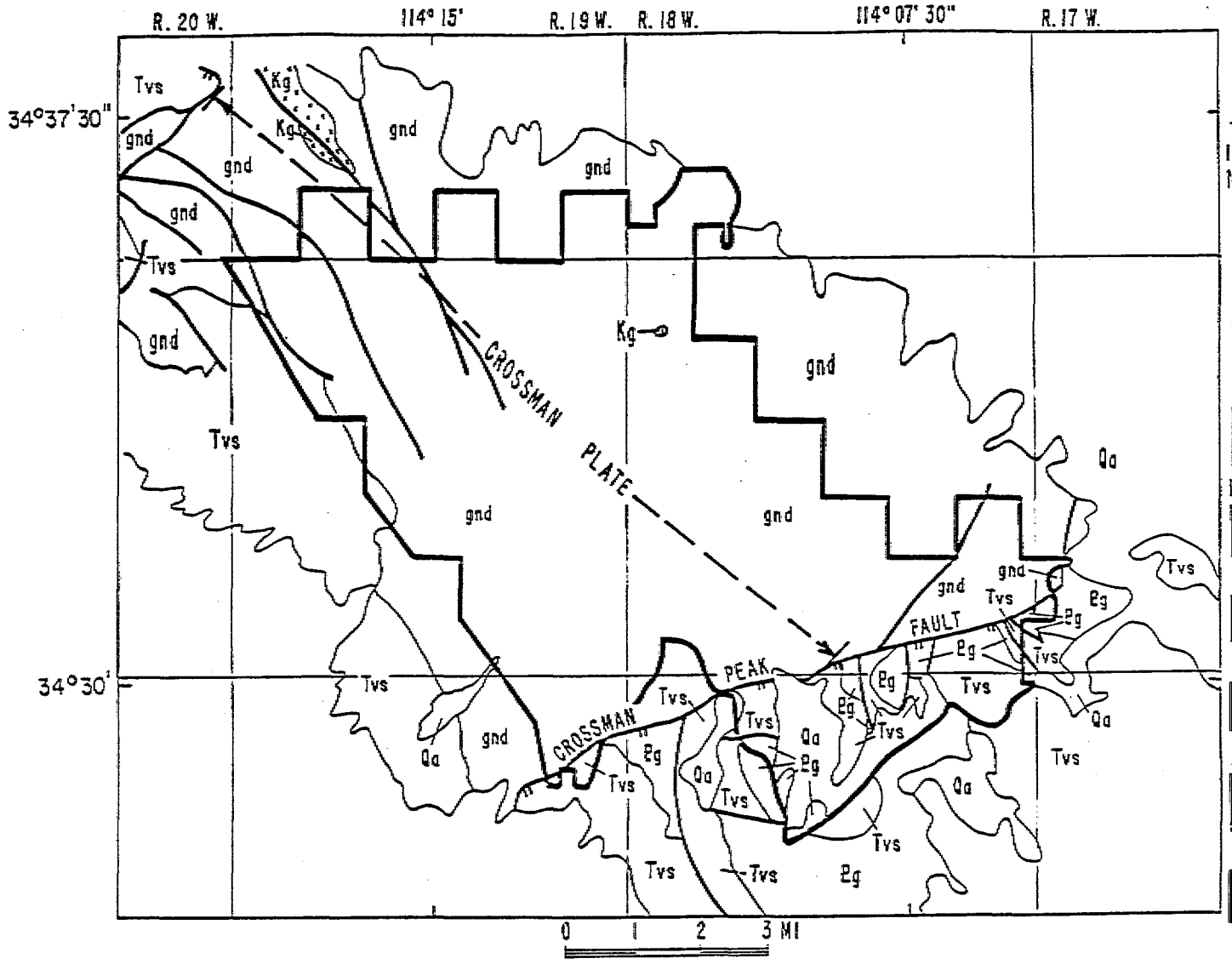
The Mohave Mountain block trends northwest extending from the Colorado River at Topock to the Bill Williams River in southwesternmost Mohave County. The southeast half of the range separated from the northwestern Crossman Peak area by the lower-lying Standard Wash area is referred to as the Bill Williams Mountains. These ranges occur south of the Black Mountains and northwest of the Rawhide Mountains. The distribution of metals occurrences through the Mohave and Bill Williams ranges does not define well clustered, district-size distributions. Therefore, mines, prospects, etc. are collectively lumped within one large area. Much of the Mohave range is enclosed within the Crossman Peak Wilderness Study Area (WSA).

Geology and History:

Generally, the Mohave Mountain block consists of a main, elevated ridge of Precambrian basement flanked along the southwestern margin by southwest dipping Tertiary volcanic and clastic rocks. Basement rocks of the Crossman Peak portion of the range are intruded by an enormous, NW-trending Tertiary dike swarm. Recent geologic work by the U.S. Geological Survey (Howard and others, 1982; Nakata, 1982; Pike and Hansen, 1982; Light and others, 1983) has determined that the entire Mohave range basement block has been rotated up to 80° on a major detachment fault dipping off the Chemehuevi metamorphic core complex to the west. Within the low-lying Standard Wash area, highly tilted Tertiary layered rocks and underlying Precambrian plutonic rocks rest upon an ENE-trending, shallow south dipping, detachment fault called the Crossman Peak fault. Detachment faults are also mapped at the northwest end of the range around the Needles, Tumarion and Powell Peak areas.

In the Mohave Mountains (Crossman Peak WSA) the recent mineral resource potential studies performed jointly by the U.S. Bureau of Mines and the U.S. Geological Survey have greatly added to the knowledge of metals occurrences in this area. Results of comprehensive sampling, mine/prospect evaluation and mapping are summarized in publications by Light and others (1983) and Light and McDonnell (1983). This work has led to overall estimates of mineral resource potential or favorability summarized for precious metals as follows: high potential for small deposits of lode gold, silver and tungsten and placer gold, particularly in the central Crossman Peak area and in areas surrounding the Wing mine, the J and J mine, and Pittsburg mines (Figure 11). Placer potential appears highest in washes draining the precious metals-favorable central area (Figure 11).

Generally precious metals mineralization in the Mohave Mountains is related to polymetallic, bull quartz veins trending N10°-20°E with steep dip, that cut the Precambrian crystalline rocks. The SE veins, in addition to yielding gold-silver, contain sphalerite, galena and chalcopyrite. Rarely, muscovite occurs adjacent to veins. The Crossman Peak Tertiary dike swarm cuts the veins. A Cretaceous age-date on vein-related (?) muscovite may indicate the age of mineralization.



EXPLANATION

- Qa — ALLUVIUM (QUATERNARY)
- Tvs — VOLCANIC AND SEDIMENTARY ROCKS (TERTIARY)
- Kg — GRANITE AND DIORITE (CRETACEOUS ?)
- Pg — GRANITOID ROCKS (PROTEROZOIC)
- gnd — GNEISS AND DIKES (TERTIARY AND PROTEROZOIC)

- CONTACT
- FAULT — Hachures on upper plate of detachment fault
- APPROXIMATE BOUNDARY OF WILDERNESS STUDY AREA

- 5 — MINERAL DEPOSIT
- 9 — DEPOSIT CONTAINING INDICATED OR INFERRED RESOURCES -- See table 2

AREA OF MINERAL RESOURCE POTENTIAL for placer gold

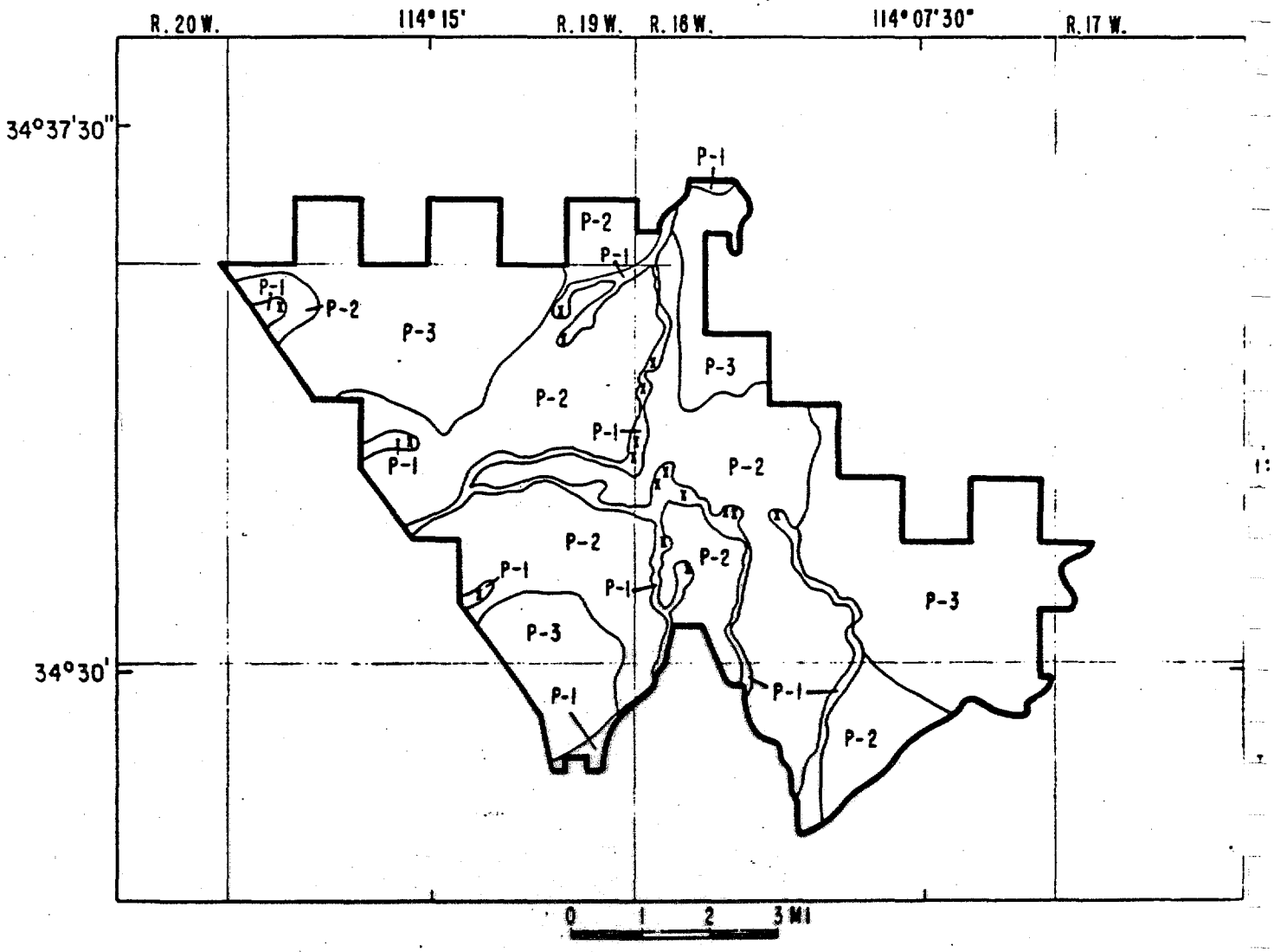
- P-1 High
- P-2 Moderate
- P-3 Moderate

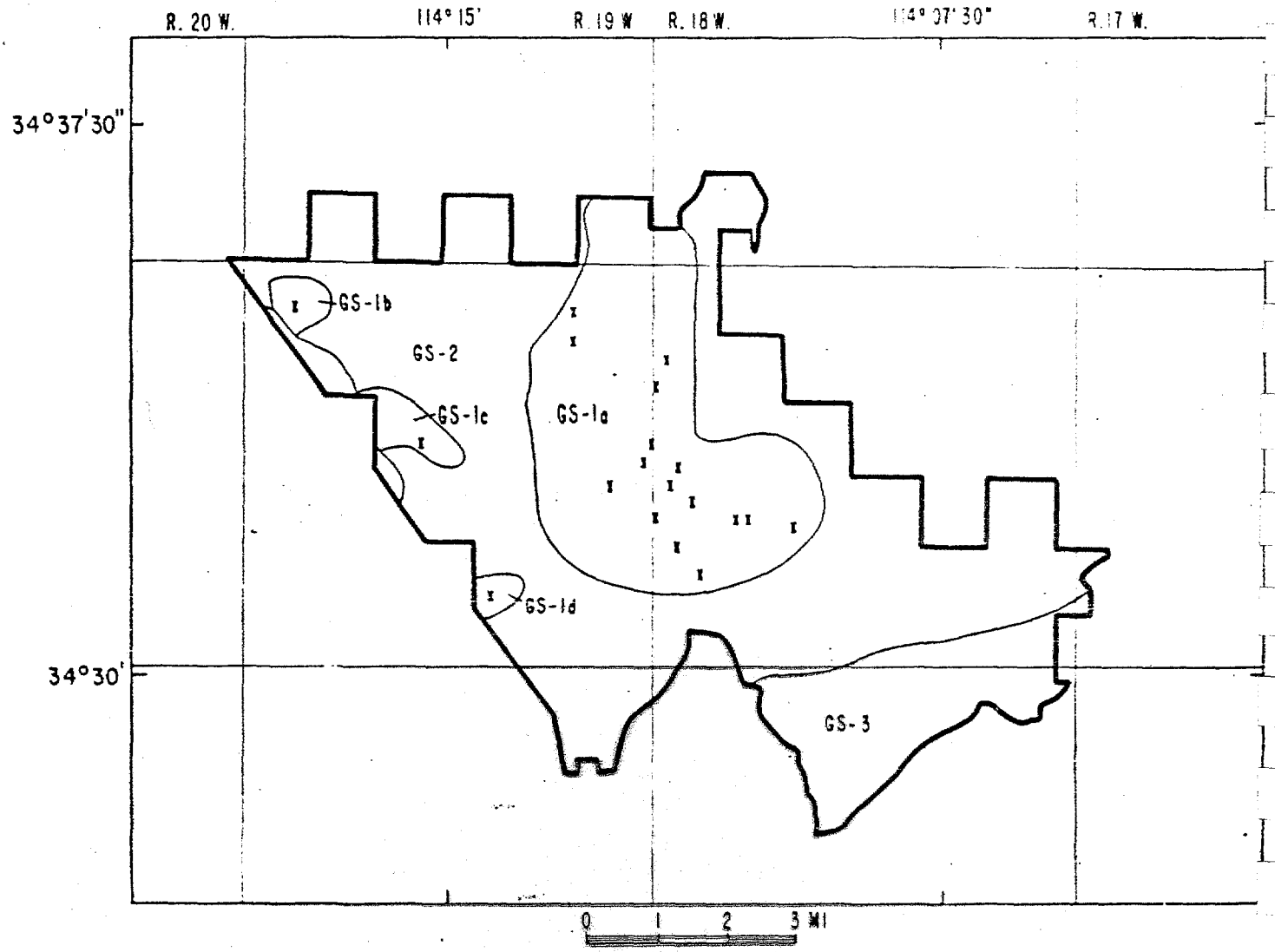
- MINE

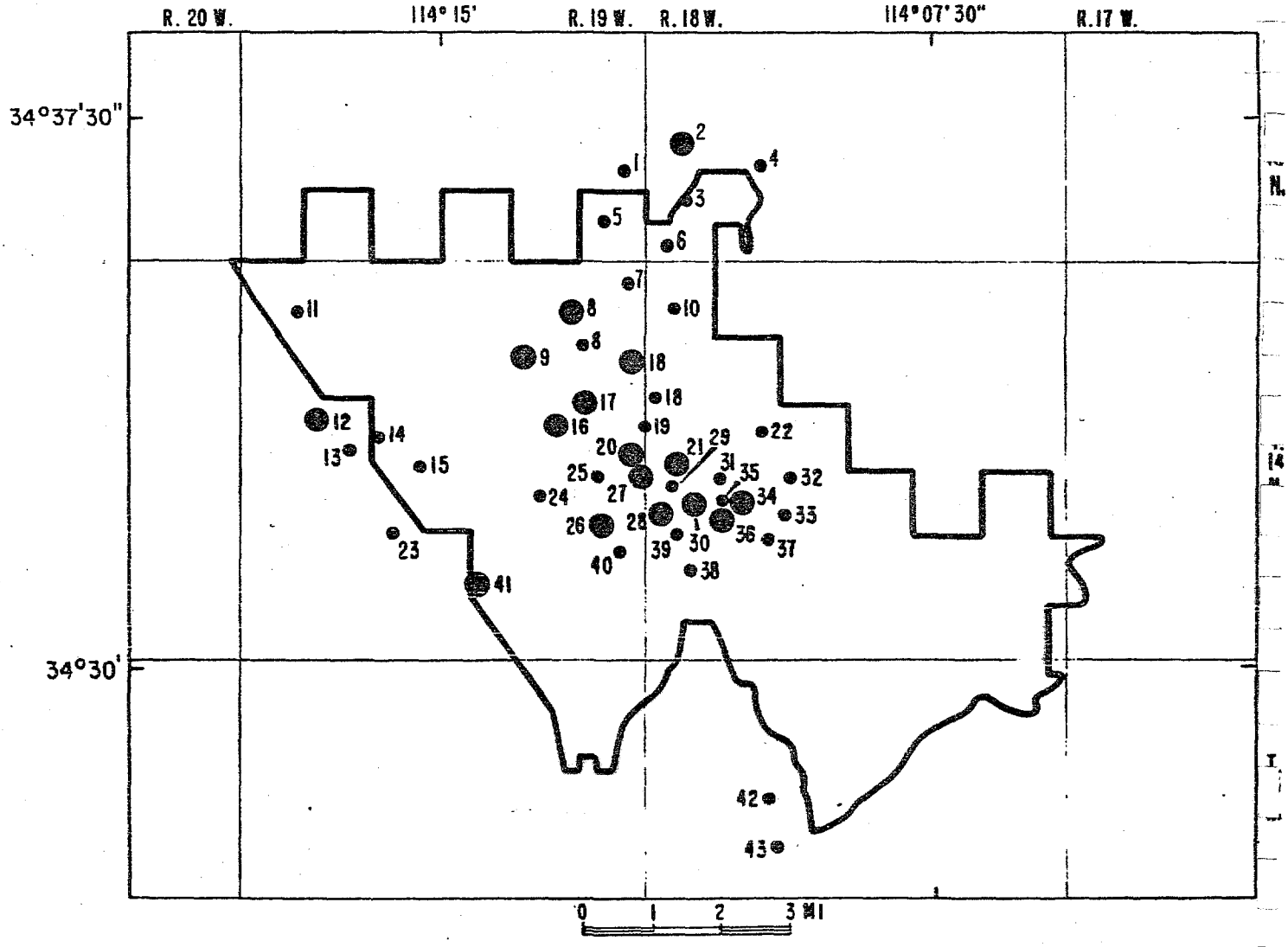
AREA OF MINERAL RESOURCE POTENTIAL for lode gold and silver (see table 3).

- GS-1 High. 1a, numerous deposits known to have produced some gold or silver; 1b, area around Wing mine; 1c, area around J & J mine; 1d, area around Pittsburg mine
- GS-2 Moderate
- GS-3 Moderate

Figure 11—Generalized geologic map of the Crossman Peak Wilderness Study Area.


R. 20 W.
114° 15'
R. 19 W.
R. 18 W.
114° 07' 30"
R. 17 W.
34°37'30"
34°30'
P-1
P-2
P-3
0 1 2 3 MI


R. 20 W.
114° 15'
R. 19 W
R. 18 W.
114° 07' 30"
R. 17 W.
34° 37' 30"
34° 30'
GS-1b
GS-2
GS-1c
GS-1a
GS-1d
GS-3
0
1
2
3 MI


R. 20 W.
114° 15'
R. 19 W.
R. 18 W.
114° 07' 30"
R. 17 W.
34° 37' 30"
34° 30'
0 1 2 3 MI

Veins are usually relatively thin (< 1-2 ft) and consist of simple fissure fillings with negligible wallrock alteration and low iron staining indicative of low sulfide content.

To aid in assessing the favorability areas of the Crossman Peak WSA (Figure 11), a page of descriptive data from the report accompanying Map MF-1602-A (Light and others, 1983) is reproduced below:

Lode gold and silver

All of the pre-Tertiary terrane in the Crossman Peak Wilderness Study Area has high to moderate potential for lode deposits of gold and silver in quartz veins and pods. Areas GS-1a to d (fig. 5) are considered to have high potential; areas GS-2 and GS-3 are considered to have moderate potential (fig. 5). The criteria used to define the resource potential of areas GS-1, GS-2, and GS-3 are listed in table 3.

Area GS-1—High potential for lode deposits of gold and silver.—Areas containing numerous deposits that are known to have produced gold and silver or for which indicated or inferred resources have been calculated (Light and McDonnell, 1983) are designated as GS-1a to GS-1d on figure 5. These areas have the highest potential in the wilderness study area for gold and silver deposits related to a Cretaceous(?) hydrothermal system. Additional deposits will most likely be in high-grade pockets in the veins previously mined and prospected, or along the same structural trends which controlled these veins. Such deposits are expected to range in grade from 0.005 to 1.0 oz gold per ton and in size from 100 tons to 8,000 tons or possibly greater. Four areas meet the criteria for GS-1. The largest area, GS-1a, is 6 mi long and as much as 4 mi wide, covering the central and north-central quarter of the wilderness study area. Smaller areas labeled GS-1b, GS-1c, and GS-1d encompass the vicinity of the Wing, J & J, and Pittsburg mines.

Area GS-1a—Area GS-1a encompasses numerous deposits that are known to have produced some gold or silver and includes the Arrastra Well area, Green Feather mine, Scotts Well area, Sunrise mine, Ra claims, Dutch Flat group, and numerous unnamed workings. Lode production from the Arrastra Well area (no. 8, fig. 4) probably came from an adit and a decline in the ridge approximately one-quarter mile northwest of Arrastra Well. Six samples with an average width of 9 in. from the mineralized quartz vein in these workings contained as much as 0.6 oz silver per ton and 0.328 oz gold per ton. Inferred resources are 350 tons at an average grade of 0.32 oz silver per ton and 0.21 oz gold per ton (Light and McDonnell, 1983).

The Green Feather mine (no. 9, fig. 4) is in an area of propylitic alteration and consists of an adit with 150 ft of drifts and a 35-ft inclined shaft cut along a gently dipping northwest-striking quartz vein. Seven samples having an average width of 8 in. from the mineralized vein contained values as high as 0.407 oz gold per ton. Inferred resources are 210 tons averaging 0.05 oz gold per ton.

Two unnamed adits, 110 and 90 ft long, cut along a quartz vein in sec. 14, T. 14 N., R. 19 W. (no. 16, fig. 4) contained values as much as 1.54 oz gold per ton and 2.4 oz silver per ton as detected in seven samples that average 2 ft wide. This deposit contains 610 tons of inferred resources averaging 0.41 oz gold per ton and 1.3 oz silver per ton.

An unnamed adit (no. 17, fig. 4) cut along a quartz vein in the SW 1/4 sec. 12, T. 14 N., R. 19 W., contains as much as 0.872 oz gold per ton and 0.7 oz silver per ton as detected in four samples that average 1.3 ft wide. Approximately 120 tons of inferred resources averaging 0.24 oz gold per ton and 0.45 oz silver per ton have been calculated for this deposit.

The Scotts Well area (no. 18, fig. 4) consists of 13 adits, ranging in size from 10 to 130 ft long, and numerous prospect pits and trenches. A total of 73 samples were collected from the various workings cut along quartz veins and faults; these contained as much as 4.0 oz silver per ton, 1.702 oz gold per ton, and 11.0 percent lead. Calculations based on 14 samples with an average width of 1 ft from one group of workings define inferred resources of 770 tons at average values of 0.19 oz gold per ton and 0.62 oz silver per ton. Resource estimates could not be made for the remainder of the Scotts Well area because of limited access or extent of the workings.

The Sunrise mine (no. 20, fig. 4) is on a patented claim which produced gold from a 2-ft-wide quartz vein that trends about N. 20° E. Galena, blackjack sphalerite, pyrite, and an unidentified silver-bearing mineral also occur in the vein. The amount and grade of ore produced is not known. However, more than 2000 ft of drift on three levels with extensive stoping between the levels and a winze of unknown depth indicate that at least several thousands of tons of material were removed.

Sericitic alteration adjacent to the vein and propylitic alteration in the country rock were observed at the Sunrise mine; resource estimates are confidential to the private ownership. However, analyses were obtained from ten samples taken from a deposit 1/4 mi west of the main mine workings, and beyond the boundary of the patented claim. In these samples gold concentrations in the quartz vein ranged from a trace to 2.04 oz per ton. This deposit has an estimated 480 tons of inferred resources averaging 0.20 oz gold per ton and 0.18 oz silver per ton.

A group of 3 adits, 2 trenches, and several prospect pits were cut on a northeast-trending quartz vein in sec. 18, T. 14 N., R. 18 W. (no. 21, fig. 4). Seven samples with an average width of 2.5 ft contained gold concentrations from trace amounts to 0.294 oz per ton. This deposit has an estimated 750 tons of inferred resources at an average of 0.08 oz gold per ton.

Two adits in south-central sec. 24, T. 14 N., R. 19 W. (no. 21, fig. 4) were driven along a quartz vein. Analyses of eight samples, with an average width of 2 ft, detected gold concentrations from trace amounts to 0.475 oz per ton. This deposit contains 920 tons of inferred resources that average 0.14 oz gold per ton.

A 15-ft adit and 2 trenches expose a mineralized quartz vein in the NE 1/4 sec. 24, T. 14 N., R. 19 W. (no. 27, fig. 4). Four vein samples with an average width of 1.6 ft contained as much as 0.55 oz gold per ton; inferred resources are 1,330 tons averaging 0.05 oz gold per ton.

At the Ra mine (at no. 28, fig. 3), seven samples with an average width of 1.3 ft were taken from a 90-ft adit and from a winze that was flooded at 45 ft. Sample analyses detected metal concentrations to 3.2 oz silver per ton, 0.058 oz gold per ton, 1.30 percent copper, 5.6 percent lead, and 0.65 percent zinc. There are 490 tons of indicated and 330 tons of inferred resources averaging 0.01 oz gold per ton and 0.57 oz silver per ton.

The Little Maud mine in the Dutch Flat group (no. 30, fig. 4; see also area T, below) comprises three adits driven along a northeast-trending quartz vein. Eight samples with an average width of 2.6 ft from the largest adit (220 ft in length) contained gold values from trace amounts to 0.618 oz per ton. This adit has 5,600 tons of inferred resources averaging 0.05 oz gold per ton.

The irregular distribution of gold in mineralized veins and the tendency for gold to be concentrated in high-grade pockets is well demonstrated in two adits at the Lost Dutchman mine in the Dutch Flat group (no. 36, fig. 4). Eight samples with an average width of 1.6 ft contained 0.006 to 8.82 oz gold per ton and trace amounts to 2.0 oz silver per ton. Adit No. 1 has 140 tons of inferred resources containing an average of 0.02 oz gold per ton and 0.20 oz silver per ton, and adit No. 2 has 470 tons of inferred resources containing a weighted average of 1.74 oz gold per ton and 0.47 oz silver per ton. The high average gold value in adit No. 2 is due to one sample that contained 8.82 oz gold per ton.

Area GS-1b—Area GS-1b surrounds the Wing mine (no. 11, fig. 4). This area is known to have had some minor high-grade gold production (Light and McDonnell, 1983). Resource estimates could not be calculated for the mine because the main workings were inaccessible for sampling. However, the quartz vein and fault at the Wing mine both contain gold, silver, lead, zinc, and molybdenum mineralization and meet the remaining criteria used to define GS-1 (table 3).

Area GS-1c—Area GS-1c surrounds the J & J mine (no. 15, fig. 4) in sec. 16, T. 14 N., R. 19 W. The J & J mine was originally called the Golden Gate mine and produced some gold-bearing ore in 1934 (Malach, 1977). Maximum values of 0.382 oz gold per ton, 9.3 oz silver per ton, 1.64 percent copper, 4.3 percent lead, and 0.57 percent zinc were detected in the 21 samples of 1.9 ft average width collected from the J & J mine. A few tens of tons of base and precious metal-bearing resources are present at this site, but the irregular distribution of samples with anomalously high metal values precludes calculation of a resource estimate.

Area GS-1d—Area GS-1d surrounds the Pittsburg mine (no. 41, fig. 4) which is located about 3 mi northeast of Lake Havasu City, on the west side of the wilderness study area in sec. 27, T. 14 N., R. 19 W. The Pittsburg mine was developed during the interval from 1933 to 1939, when a shaft was sunk more than 200 ft and drifts were cut at several levels. The workings are in a quartz-bearing fault zone that trends northeast and contains silver, galena, sphalerite, barite, and gold. High-grade ore shipments from the mine contained as much as 126 oz silver per ton, 6.5 oz gold per ton, and 7.0 percent lead (Arizona Department of Mineral Resources, file data).

Analytical data from 27 samples averaging 2.7 ft wide from the Pittsburg mine were used to calculate inferred resources of 8,000 tons averaging 3.1 oz silver per ton, 0.06 oz gold per ton, 0.8 percent lead, and 0.6 percent zinc. A nearby area has inferred resources of 1,125 tons averaging 0.64 oz silver per ton (Light and McDonnell, 1983).

Area GS-2—Moderate potential for lode deposits of gold and silver.—Area GS-2 comprises the remainder of the pre-Tertiary terrane north of the Crossman Peak fault. This area has neither known past production nor deposits for which resources could be calculated. However, the geologic and tectonic setting is the same as area GS-1, and, although area GS-2 may have lower potential for gold and silver deposits than area GS-1, area GS-2 has a moderate potential for the occurrence of additional deposits of the same type and size as in area GS-1. The criteria used to define area GS-2 are listed in table 3.

Area GS-3—Moderate potential for lode deposits of gold and silver.—This area lies south of and structurally above the Crossman Peak fault. It contains numerous fault-bounded blocks that expose Proterozoic granitoid rocks like those at the Manitowoc mine (no. 43, fig. 4) one-half mile outside the wilderness study area. Gold mineralization similar to that at the Manitowoc mine may be found inside the wilderness study area in this area. In addition, low dips measured on the Crossman Peak fault project Proterozoic gneiss of the Crossman plate southward to shallow depths beneath the rocks exposed in the overlying plate; therefore, deposits of gold and silver, similar to those described for areas GS-1 and GS-2, may exist at depths of a few hundred to a few thousand feet in area GS-3. The criteria used to define area GS-3 are listed in table 3.

Special attention should be called to the observation that precious metals occurrences in the Mohave region do not appear to be spatially associated with known detachment faults such as the Crossman Peak fault. In the Topock area, several small manganese deposits are known as well as a few gold prospects (Boulder Gold Dome and Jackpot mines-MILS data), at the northwestern end of the Mohave range. No geologic or production data are available except an overall figures of 100 oz Au for the Topock district (Keith and others, 1983a). This overall disassociation between metals and detachment faults is curiously distinct from areas like the Cienega, Santa Maria and Rawhide districts, where the association is well documented by numerous prospects and mines.

A notation in Hewett and others (1936) describes some gold-silver veining in Precambrian rocks in the Buck Mountains just northeast of the Mohave range, but only $1000 production is recorded. Two mines, the Ideal and Palo Verde properties, are listed in the MILS file (#47 on precious metals overlay).

Mines of Interest:

The following mines and prospects occur in the Crossman Peak WSA. We consider that they offer the best potential for hosting economic Au-Ag mineralization even though resource estimates of the USBM are still relatively small. Further details are found in references by Light and others (1983) and Light and McConnell (1983).

Arrastra Well mine: (T14N, R19W, Secs. 1, 2, 11 & 12) Numerous prospect pits and inclined shafts have accessed locally high concentrations of gold and secondary placer deposits in adjacent washes. USBM estimates resource potential of about 350 tons averaging 0.21 opt Au and 0.32 opt Ag.

Unnamed prospects (T14N, R19W, Sec. 17) Prospect pits and 12 ft shaft dug in tilted late Tertiary volcanic or intrusive rhyolite. Anomalous gold and silver concentrations are disseminated through a wide area of the rhyolite. USBM cite inferred resources of about 5,500 tons averaging 0.03 opt Au and 0.19 opt Ag. Careful follow-up exploration might delineate better mineralization.

Scotts Well mine: (T14N, R18W, Sec. 7; and T14N, R19W, Sec. 12) Numerous adits, prospect pits and shaft worked, multiple NS-trending quartz sulfide veins up to 3 ft thick cutting Precambrian gneisses. USBM estimates inferred resources of 770 tons averaging 0.19 opt Au and 0.62 opt Ag. Veins cut unaltered rocks and probably represent only small exploration potential.

Unnamed prospects: (T14N, R19W, Sec. 24) Three adits and several prospect pits yield high concentrations of gold and minor copper in multiple quartz veins and fault zones. USBM estimates inferred resources of ±920 tons of 0.14 opt Au. Another prospect about 1 mile to the northeast has explored quartz veins with resource estimate of 1,330 tons of 0.05 opt gold material.

Dutch Flat subdistrict (T14N, R18W, Secs. 20, 21, 29 & 30) Inactive mines include the Little Maud, Kempf (Evelyn), Jupiter, Pioneer, Lost Dutchman and Gold Band or Crown. A 2½ sq. mi. area contains eight mines and attractive

prospects which have worked numerous NE-striking quartz veins and mineralized fault zones containing precious metals, zinc, copper and minor lead with substantial tungsten values. Area represents highest tungsten potential in the study area. The Kempf mine produced several hundred tons of ore running $15 in gold ($36/oz) from at least five veins. The Little Maud vein is 9 to 42 inches wide and outcrops for 2,000 ft. The Pioneer vein is 2 ft wide and 1000 ft long. The Gold Crown vein was described as the largest producer from the group with one ore shoot bearing 238 tons of reserve.

According to USBM estimates a minimum of about 12,000 tons of 0.05 to 0.1+ opt Au resources could be available from just three of the eight properties in the district.

Pittsburg mine: (T14N, R19W, Secs. 27 & 34) One adit, five shafts and numerous prospect pits yield very high concentrations of Ag, Pb, Au with barite, copper and zinc in significant quartz vein. Resource estimates by USBM give 8,000 tons averaging 0.06 opt Au, 3.1 opt Ag, 0.8% Pb and 0.6% Zn.

References:

Arizona Dept Mineral Resources, file data; Light and others, 1983; Rehrig, unpubl. field notes; Wilson, 1967.

MOON MOUNTAINS DISTRICT

Location:

The district takes in those few metals occurrences located in the low-lying hills of the Moon Mountain area just north of the Dome Rock Mountains in La Paz County. Two separate ridges of outcrops occur in the area. The westerly of these trends NNW through T 5 and 6 N, R 21 W, and includes Moon Mountain at its north end. The easterly of the ridges trends NNE through Range 20 West, Townships 5 and 6 North.

Geology and History:

Lithologies predominating in the Moon Mountains are typical of those occurring in the adjacent northern Dome Rock Mountains. Mesozoic (?) metamorphic rocks of various facies are the principal supracrustal rock types. They range from quartzofeldspathic gneisses to lower grade, metavolcanic and metasedimentary sequences. They are intruded by numerous pegmatites, several small plutons of Mesozoic age as well as by dikes presumably of Tertiary age. As elsewhere in this western Arizona Mesozoic terrain, thrust faults internal to the Mesozoic rocks are probably present.

Mineralization in this area is highlighted by Amoco's relatively recent discovery of what is called the Copperstone copper-gold deposit which occurs in poorly outcropping, sand covered hills in Section 12 of T6N, R20W. The deposit was initially pursued by Cyprus mines several years ago and has been evaluated thereafter by Amoco. The deposit is reported to have somewhere in the neighborhood of 10 million tons of about 0.07 opt Au with associated copper. The ore setting is a long (1-2 miles), listric (?) fault zone cutting metavolcanic rocks of Mesozoic age which outcrops (?) just above a flat-lying Tertiary detachment fault. The fault vein zone is said to actually displace the detachment fault. Mylonitic rocks are described below the detachment structure and both detachment and lower plate (?) rocks are not economically mineralized. The uppermost part of the mineralized zone is unconformably covered by post-ore Chapin Wash Formation and overlying dacite volcanics of Miocene age.

Gold occurs with pervasive earthy and specular hematite, oxidized copper, amythystine quartz, barite, magnetite and calcite. Copper is said to be zoned more heavily above and below the gold zone. Gold is not as closely related to late barite, carbonate veining. Minor sulfides are found at depth but the orebody is chiefly developed above the oxide-sulfide interface.

The Copperstone mineralized fault zone has structural and mineralogical (hematite, copper, quartz) characteristics typical of detachment fault or upper plate mineralization described in the neighboring Plomosa and Cienega districts. Several other Au, Ag, Cu occurrences are known from the Moon Mountains district (Keith, 1978). Thrust or Mesozoic related mineralization may also be a possible target in the area.

Mines of Interest:

Copperstone deposit: (See discussion above)

Apache mine: (T6N, R21W, Sec. 35--Colorado River Indian Reservation) Gold-silver occurs in lensing quartz vein cutting Mesozoic metasediments intruded by a rhyolite plug. The mine produced high-grade gold (330 tons of 2.4 opt), but its location on the Indian Reservation is a notable negative factor.

Valenzuella mine: (T5 or 6 N, R20W, Sec. 32 or 5) Copper mineralization (up to 3% Cu) with possible precious metals occurs along a sinuous, EW-striking, north dipping shear zone in Mesozoic (?) schists. The vein is variable in width from a few inches to several feet. Ore mineralization in irregular pockets and stringers consists of copper and gold in a gangue of quartz and calcite. Chrysocolla, malachite, pyrite, gold and considerable hematite are the ore minerals. Ore grades reportedly ran several percent copper and 0.05 to 0.1 opt gold. Developed in the past by a 900 ft decline and about 1600 ft of drifts, this property also occurs on Colorado River Indian ground.

References:

Arizona Dept Mineral Resources, file data; Bancroft, 1911; Keith, 1978.

MUGGINS (VINEGARROON) DISTRICT

Location:

The Muggins mining district covers the Muggins Mountains in southern Yuma County, about 20 miles east of Yuma. The gold producing part of the district lies within T7S, R19 and 20W. The district lies within the Defense Department's Yuma Test Station.

Geology and History:

The Muggins district is mainly known as a gold placer district. The Muggins Mountains are floored by gneissic rocks that crop out as a northeast-trending block across the northern portion of the range. Previously, these rocks were thought to be of Precambrian age (Ross, 1923), but more recent work has assigned them to a Mesozoic age. Tertiary volcanic rocks consisting of andesitic lavas, breccias, agglomerates and rhyolitic flows overlie the gneisses on the south. The central and southern portion of the range is apparently underlain by a thick sequence of Tertiary clays and silts (Wilson, 1933) which are probably of lacustrine origin (Keith, 1978). These sediments are capped by thick gravels of Tertiary to Quaternary age.

Wilson's (1933) reconnaissance noted that the Mesozoic metamorphic rocks have been cut by numerous pegmatite dikes and quartz veins and stringers. He further described interbedded conglomerates and tuffs within the Tertiary rhyolite lava flows; and that the lacustrine section also contains interbedded volcanic tuffs and ash layers, opalized mudstone and chalcedonic layers. It would be interesting to know if the chalcedony and opalization resulted from diagenetic processes or from hot springs active at the time the lacustrine lake was developing. Uranium is known to occur in the lacustrine sediments (Keith, 1978).

Gold placer deposits have been exploited in the past from two main areas in the district (Keith, 1978): (1) Along the southwestern margin of the range in canyons and washes draining southward from Muggins Peak, Klothos Temple (Coronating Peak), and Long Mountain; and, (2) in the upper reaches of Vinegaroon Wash. Mining and prospecting date back to the 1860's and probably produced a considerable amount of placer gold. Keith (1978) credits placer production in the district through 1942 as 2748 oz of gold.

In the southwestern part of the range, gold-bearing gravels occur as ancient bars on terraces above and in the stream channels where the bedrock consists of conglomerates intercalated with the Tertiary lavas (Keith, 1978). The conglomerate is composed of gneiss and granite pebbles in a sandy to clayey matrix. Wilson (1961) believed the source of the gold in the placers to be gold-bearing quartz veins in the Mesozoic gneiss, schist, and granite. Erosion of the veins produced low-grade placers in the conglomerate where subsequent erosion and concentration produced economically recoverable deposits in the bars (Keith, 1978). Placers in the Vinegaroon Wash were felt to have been directly derived from the disintegration of veins in the Mesozoic metamorphics. These quartz veins are known

to contain sparse free gold and minor copper in places. Locally, copper staining also occurs in the pegmatite dikes. Many of these veins and mineralized shows have been sporatically prospected with little success. Keith (1978) reports that lode production from scattered prospects and mines have a cumulative total of some 410 tons of ore which contained 251 oz Au, 116 oz Ag, and 567 lbs of Cu.

As elsewhere in southwestern Arizona, we find an association of placer gold and/or gold-bearing quartz veins associated with metamorphosed Mesozoic rocks in the Muggins district. What potential that might exist for discovery of bulk-tonnage type gold deposits is unknown and will stay that way for some time as the district lies within the Department of Defense's Yuma Test Station and is withdrawn from mining activity.

References:

Keith, 1978; 1961 Ross, 1923; Wilson, 1933.

MUSIC MOUNTAINS DISTRICT

Location:

The Music Mountains mining district lies in the foothills of the Grand Wash Cliffs in Mohave County, about 25 miles north of Hackberry.

Geology and History:

The Music Mountains district as described by Schrader (1909) is underlain by Precambrian gneissic granite (probably including some schist) that is intruded by the 65.5± 3.5 m.y. (young, 1979) Music Mountain quartz monzonite pluton. The Precambrian rocks display a well-marked foliation that trends N30°E and dips about 65°SE. Both the Precambrian and younger intrusive rocks are cut by a well-developed sheeting that strikes N60°W and dips vertically (Schrader, 1909).

Mineralization in the district consists of narrow, gold-quartz veins that cut the basement rocks. The veins generally strike NW and dip steeply to the NE. Shrader (1909) indicates that some of the veins follow (or are associated with) diabase-basalt dikes. The veins contain considerable iron oxides to depths of about 200 ft, below which pyrite and galena become abundant locally (Wilson and others, 1976). Keith and others (1983b) suggest the veins are genetically related to the Laramide Music Mountain pluton. The Ellen Jane, Lucky Cuss and Southwick were the principal veins in the district.

The district was discovered in about 1880 with lessees producing considerable rich surface ores from nearly all of the principal veins. Some of this ore was extremely rich. Schrader (1909) states that considerable ore was produced from the Golden Serpent property that ran $300-$400/ton in gold. Even at the time of his visit some of the ore from this property ran 7-8 opt gold. The Ellen Jane mine was the most important in the district, however, and the camp's history was largely synonymous with the development of this property. Keith and others (1983a) credit the district with some 9,500 tons of production between 1886-1948, that yielded 4,500 oz Au; 12,000 oz Ag; 3,000 lbs Cu; and 38,000 lbs Pb.

Mines of Interest:

Ellen Jane Mine: (Located near the head of Camp Wash) The vein strikes NW and dips 80°NE. It is 4-7 ft in width and is associated with a diabase dike in granite. The vein is typically separated from its walls by prominent gouge zones. The vein consists of quartz and much brecciated wallrock. The ore streak is up to 3 ft in width but averages only 5 inches. Shipping ore was said to run as high as $500/ton in gold; mill run ore, however, averaged from $10-$20/ton in gold. The vein is oxidized to the 200 ft level where sulfides become present (pyrite and galena). The property was discovered in 1880 and had most of its production before 1904. In 1907, underground developments included a 200 ft shaft and about 1,500 ft of workings.

Rosebud (Portland-Mizpah) Mine: (T26N, R15W, Sec. 17) The mine was located shortly after the Ellen Jane. From 1926 to 1932 the property was worked by the Portland and Mizpah Mining Co, which produced some bullion from a 100-ton mill in 1929, with poor recovery rates. In 1931, the company produced about $4000 worth of bullion from 500 tons of ore which was run through a new amalgamation and cyanide mill. In 1932, the mine was developed by a 400 ft shaft and some 2,500 ft of workings.

Mary E. Vein: (Located about 200 yards northeast of Ellen Jane vein) A small vein or stringer that runs nearly parallel to the Ellen Jane vein is largely hosted in diabase. It consists of a thin sheet of reddish, dense crushed material that contains a 5-6 inch quartz vein filling a fault fissure and containing $300 (1907 prices) in gold per ton. Associated minerals are iron oxide and a small amount of calcite. Prior to 1907, the property had been worked to a depth of 150 ft by cuts and drifts.

References:

Keith and others, 1983a, 1983b; Schrader, 1909; Wilson and others, 1967; Young, 1979.

NEW WATER AND BEAR HILLS AREA

Location:

The New Water Mountains form a northwest trending range connected at its northwest end with the southern Plomosa Mountains. The range lies just south of Interstate Highway 10 in R16W, T3N. Between I-10 and U.S. Highway 60, the Bear Hills make up another northwest oriented range of low hills extending to the southeast from the main Plomosa Mountains.

Geology and History:

Both the New Water Mountains and the Bear Hills are made up of mid- to late-Tertiary volcanic rocks. In the New Waters, the volcanics which are gently tilted to the southwest, rest in depositional contact with Mesozoic (?) quartzites and detrital rocks along the northeast flank of the range. Basal sections of the volcanics are mainly andesitic with upper portions becoming basaltic. Subordinate welded tuffs of rhyodacitic to rhyolite composition occur within the lower andesitic flow sequence. Eagle Eye Peak, which forms a prominent landmark within the range may be a rhyolitic intrusive plug. Other felsic intrusive rocks are also known to cut the volcanic pile (Rehrig, unpubl. field notes). Northwest trending, normal faults are prominent through the range.

The Bear Hills consist of a slightly southwest tilted sequence of mid- to late-Tertiary andesitic to basaltic volcanic rocks similar to those occurring in the New Water range.

The principal metals occurrence in the New Water range is an interesting copper-oxide deposit spread over a sizeable 2½ X ½ mile area in Sections 15, 16, 17 and 22, T3N, R16W. In the late 1960's, the property known as the Moore mine group, was owned by the Hovatter family who were promoting it as a porphyry copper deposit. The copper, mainly as chrysocolla, occurs extensively along fractures, joints, faults and in local brecciated chimneys within the mid-Tertiary volcanic rocks near their basal unconformity with Mesozoic metasedimentary rocks. Copper staining is also present in the older metasediments. The overall distribution of mineralization appears localized by major, northwest-striking, high-angle normal faults. Curiously little if any source for the oxidized copper can be found. It may come from small bodies of intrusive rhyolite in the vicinity of the mineralization. The area reportedly produced some 480 tons of ore during the 1940's which averaged about 3.7% Cu and 1 opt Ag. No gold is reported.

In the vicinity of Eagle Eye Peak, which may be rhyolitic plug, there are a number of altered areas in the volcanic rocks which have been prospected. We have no data on these areas, but the volcanic setting would appear favorable for precious metals.

In the Bear Hills, several mines or prospects occur as veins cutting the Tertiary volcanics. The National Debt mine (T4N, R16W, Sec. 35) was a small manganese producer (traces of beryllium). Two other mines, described below produced copper, silver, gold ores.

Mines of Interest:

Shamrock mine: (T4N, R16W, Sec. 22) Oxidized copper, manganese, lead and precious metals occur with jasperized quartz in a fault vein in Tertiary andesite. The mine produced some 200 tons averaging about 6% Cu, 39 opt Ag and .01 Au.

Safford mine: (T4N, R16W, Sec. 27) A simple fissure quartz vein in Tertiary andesite produced about 150 tons averaging 0.34 opt Au and 0.5% Cu.

References:

Keith, 1978; Arizona Dept Mineral Resources, file data; Rehrig, unpubl. prospect exam. data.

NORTHERN PLOMOSA DISTRICT

Location:

The district or region of metal occurrences is found in the northern part of the Plomosa Mountains, a north and northwest trending range located in T4, 5, 6 and 7N, and R17, 18W of La Paz County, north of U.S. Highway I-10. The range is included on the Bouse and Quartzite 15' topographic quadrangles.

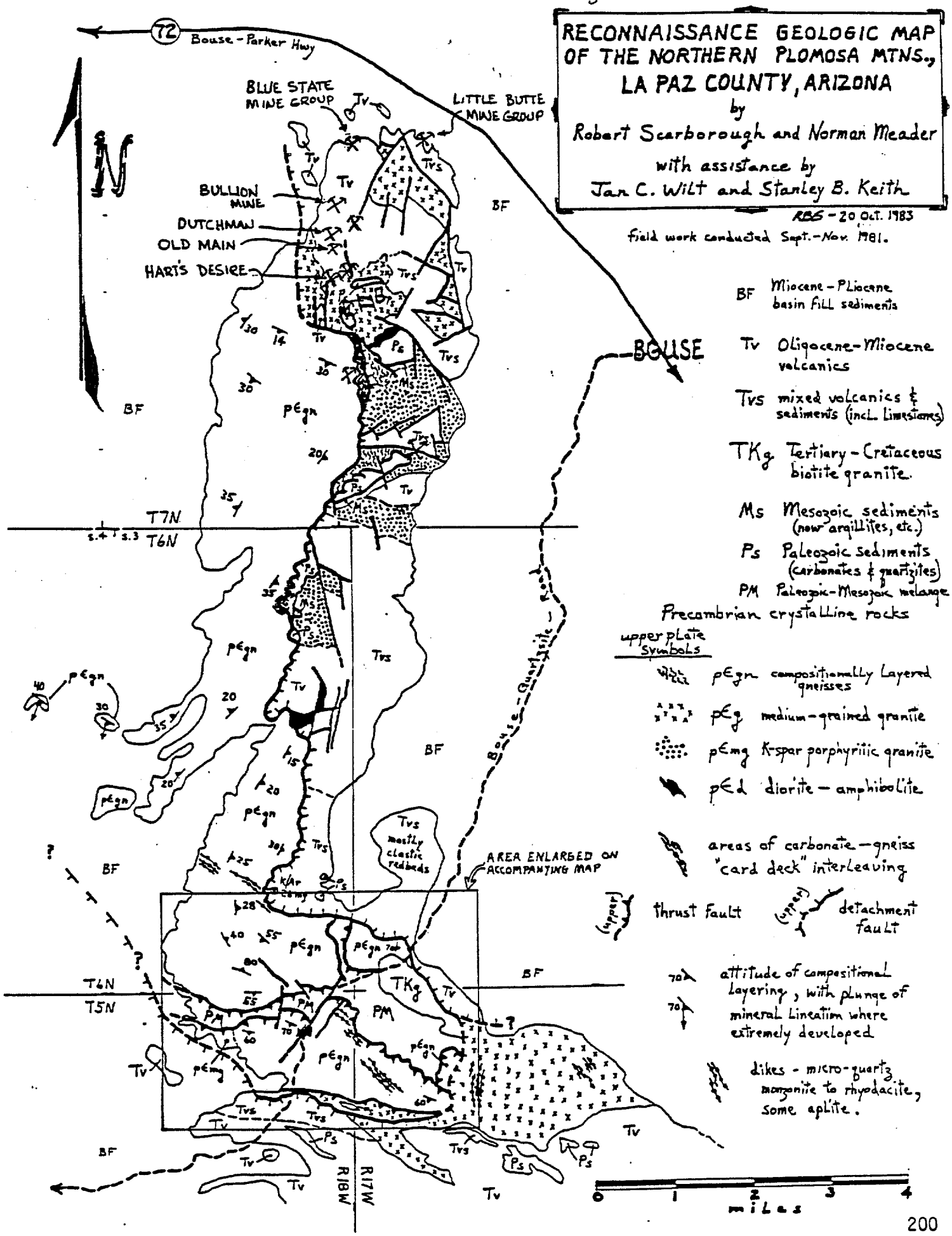
Geology and History:

The southern part of the district is made up of a substantial thickness of southwesterly tilted mid-Tertiary volcanic rocks primarily of andesite, but with some interstratified flows and welded tuffs of rhyolitic or rhyodacitic composition. The volcanics are strongly affected by normal and listric normal faults of NW-strike and NE dip which have rotated volcanic strata up to 60°.

The northern Plomosa Mountains are extremely complex geologically and poorly understood. Only the recent reconnaissance work of Scarborough and others (1983) have begun to unravel the tectonic development of the various Precambrian, Mesozoic and Tertiary structures and lithologies (Figure 12). Much of the range exposes amphibolite facies metamorphic rocks exhibiting low to moderate dipping foliation. These rocks were mapped as Mesozoic metasediments by Wilson (1960) and as Precambrian gneisses by Scarborough and others (1983) (Figure 12). On Plate 1, we have adopted the more recent interpretation, realizing nonetheless the strong possibility of a Mesozoic protolith. Similar Mesozoic rocks outcrop in the Harcuvar metamorphic core complex farther east. As particularly well displayed in the area traversed by the Bouse-Quartzite road (Figure 12), these metamorphics are tectonically interleaved with Paleozoic-Mesozoic supracrustal rocks on a series of south-dipping thrust faults. Farther north along the north-south length of the range the gneisses are in profound fault contact (the Plomosa fault) with a detached, upper-plate, chaotic assemblage of Precambrian (or Mesozoic) granitic rocks, Paleozoic and Mesozoic metasedimentary units, and Oligocene-Miocene volcanic or mixed volcanic-sedimentary sequences. The Plomosa fault, dipping shallowly eastward, is interpreted (Scarborough and others, 1983) as a major late Mesozoic thrust which has been reactivated in mid-late-Tertiary time as a detachment fault. On the upper plate, Precambrian (?), Paleozoic and Mesozoic units are juxaposed on Mesozoic thrusts. Tertiary strata depositionally rest on the older thrusted lithologies but have been tilted consistently to the south-southwest on a series of WNW-striking listric faults which may merge with one or more detachment structures such as the Plomosa fault. The NNE-oriented extension direction deduced from the listrically tilted Tertiary rocks is substantiated by many northwest to west-northwest striking Tertiary dikes of micro-quartz monzonite and microgranite, rhyodacite, and aplite.

Most of the mineralization in the Northern Plomosa district is in fact in the north part of the range with a lesser number of more disperse occurrences to the south. These southern occurrences produced more Pb-Zn-Ag and less Au than mines to the north. Metallization is quite variable as to metal species with

Figure 12.



(From Scarborough and others, 1983)

different associations present, such as: copper-gold, lead-zinc-silver, gold-silver alone, manganese-iron oxides, barite-fluorite. Most of the manganese and barite-fluorite deposits are as replacement zones (Mn) or in fault fissure veins cutting Oligocene Miocene volcanic-sedimentary sequences.

The dominant setting for gold (silver is greatly subordinate) appears to be as fault breccia or fracture zone mineralization, either within the mid-Tertiary volcanic-sedimentary sequences or in structures separating the Tertiary rocks from underlying Precambrian (?) basement. Most of these deposits occur near the main Plomosa detachment fault within the badly fragmented upper plate. Only one small copper-hematite deposit (Sidehill mine, T7N, R17W, Sec. 30) occurs in the lower-plate rocks. Dioritic dikes are commonly mentioned in the mineralized areas described. The mineral associations for the gold are typically hematite (earthy and specularite) with oxidation products of copper (chrysocolla, malachite) and quartz. Oxidation of veins is deep ($\simeq$ 200 ft) but original sulfides (pyrite-chalcopyrite) were occasionally reached by mining. Several areas of pervasive alteration and disseminated sulfide are mentioned. Grades of gold mineralization from a number of the occurrences is exceptionally high (i.e. > 0.2 opt). With sufficient host rock preparation, larger tonnages of 0.05 to 0.1 opt might be expected. Thus we feel exploration potential exists in the district; especially in the northern part of the district where occurrences are concentrated, and where undelineated structural considerations remain to be worked out (see target delineation section of report).

The Excelsior mine may represent an attractive setting for gold in the district which may occur elsewhere in the northern Plomosa Mountains. The host rocks of metamorphosed (metasomatic) carbonates (Paleozoic ?) tectonically emplaced within Mesozoic metasediments resembles the environment described at the Yuma mine (Ellsworth district, Granite Wash Mountains). Mineralization in these disturbed metasedimentary horizons is often tungsten rich and may be of Laramide, rather than mid-Tertiary, age. Similar occurrences appear to exist in the southern Plomosa district (i.e. Night Hawk, White Dike and Colorado mine groups).

Mines of Interest:

Blue Slate mine group: (T7N, R17W, Sec. 7) Secondary copper mineralization (chrysocolla, malachite, etc.) with abundant specularite and some precious metals in coarse, vuggy quartz occur in a near vertical, N60°W fissure vein. A flat-lying body of replacement specularite, copper, etc. along a contact between shale and limestone occurs nearby. Host rocks appear to be Mesozoic metasediments intruded by dioritic porphyry dikes. Property produced some 130 tons of 3% Cu, and 1 oz Au. Relatively high-grade in gold, but probably represents minor tonnage potential.

Little Butte mine: (T7N, R17W, Secs. 7 and8) The mine dating from the early 1900's, is developed along a wide normal fault zone trending N14°E with 45°SE dip dividing Tertiary sedimentary rocks from Precambrian gneissic granite. About 700 ft strike length of the vein is cut off on the southwest by a NW-striking structure and to the north by an EW-trending fault. Mineralization

is enhanced by the intersecting cross-structures. The main vein is from 4 to 6 ft wide with ore of brecciated quartz, specularite, chrysocolla and malachite. Parallel veins vary from 2 inches to 2 ft. Visible gold reportedly occurs as thin flakes along microfractures. Mineralization in small fracture zones extends some 20 to 30 ft into both footwall and hanging walls. One report (1943) cites a quartz-iron gossan at the property which can be traced for 3000 ft along strike and which is 50 to 200 ft wide. Sampling of the 125 and 200 ft levels of the mine averaged 1.5% Cu and from $2 to $7/ton gold (@ $35/oz).

Immediately adjacent to the mine at the acute angle fault intersection between the Little Butte vein and the NW-striking fault, considerable disseminated sulfides and argillic alteration is found. Sampling and two drill holes established the sulfides as mainly pyrite with traces of copper. The area is, however, anomalous in gold with a few high geochemical values reported.

The main Little Butte vein made heavy water flow at 210 ft which eventually caused abandonment of the workings. At least one meager attempt to dewater the mine in the early 1960's met with failure. Total production from the property amounted to 5,800 tons averaging about 0.45 opt Au, 0.16 opt Ag, and 2% Cu. Mine produced nearly 2/3 of the district's total gold.

Bullion or Scotchman mine group: (T7N, R18W, Sec. 12) The main mine produced copper-gold ore from a 2-3 ft wide, N50°E striking, 62°SE dipping fault vein in Tertiary volcanic-sedimentary rocks cut by diorite dikes. The ore is oxidized copper with local chalcocite. About 700 ft to the southwest, another 3-4 ft wide brecciated shear zone contains oxide copper and specularite and strikes N62°W with a 55°SW dip. The Bullion workings produced less than 100 tons running about 11% Cu and 0.1 opt Au.

Dutchman mine: (T7N, R17W, Sec. 18) Steeply dipping fault zone with highly fractured and altered rock within Tertiary volcanic rocks produced oxidized copper and visible gold in area of strong iron stain and specularite. Chalcocite is reported in main fault zone. Property produced about 1,000 tons running about 0.8 opt Au, 0.1 opt Ag, and 1% Cu. Mine was worked in the 1960's for gold specimens for mineral collectors.

Old Maid mine: (T7N, R18W, Sec. 13) Gold with hematite, vuggy quartz and minor copper in lensing veins and major fault striking N45°W (dip 47°NE). Brecciation along fault measured 4 to 6 ft in width and structure can be traced for about 800 ft on the surface. Some 150 tons of production averaged very high grade gold (2.6 opt), 0.6 opt silver, but only 0.1% Cu.

Heart's Desire mine: (T7N, R18W, Sec. 13) Spotty, lensoidal bodies of oxidized copper, lead and precious metals with sulfides at depth along fault zones and at fault intersections. Host rocks are Tertiary volcanics intruded by dioritic dikes. Property produced about 200 tons running 7% Cu, 2% Pb, 3 opt Ag, and 1.6 opt Au.

Excelsior mine: (T5N, R17W, Sec. 5) The deposit is described as a copper skarn occurrence with minor precious metals in an epidote-garnet-bearing zone in Paleozoic (?) limestone that is interstratified with schist and intruded by probable Laramide biotite granite. Host rock relationships suggest Paleozoic rocks are tectonically (thrust) interleaved with Mesozoic metasediments much like the setting for mineralization at the Yuma mine in the Granite Wash Mountains. At the Excelsior, ore consists of pockets of chalcopyrite, bornite, copper oxides, pyrite and strong hematite. Mine produced some 700 tons of ore averaging 4.4% Cu, 0.67 opt Ag, and 0.03 opt Au.

References:

Bancroft, 1911; Jemmett, 1966; Keith, 1978; Arizona Dept Mineral Resources, file data; Scarborough and others, 1983.

NORTHERN TRIGO DISTRICT (CIBOLA)

Location:

This name is designated to the metals occurrences distributed through the northwestern portion of the Trigo Mountains in Yuma County, Arizona. Most of the mines and prospects are found a few miles southeast of the small farm settlement of Cibola near the Colorado River in T2S, R23W, where they occur between the river and the Yuma Proving Grounds to the east.

Geology and History:

The northern Trigo Mountains consists mainly of variably tilted blocks of mid- to late Tertiary volcanic rocks resting in fault and depositional contact with crystalline rocks described mostly as rapakivi granite of probable Precambrian age (Garner and others, 1982). Metamorphic gneiss and schist occur in the basement to a lesser extent. Although mapped as Mesozoic by Wilson, 1933, they are interpreted as probable 1.7 to 1.8 b.y. Precambrian rocks by Garner and others (1982). Sills probably belonging to the regionally extensive Proterozoic ($\sim$1 b.y.) magmatic epoch intrude the basement rocks.

There has been much speculation as to the existence of a detachment fault surface in the Trigo Mountains. Garner and others (1982) make a case for one; our limited field data, howver, does not support this interpretation. Our field observations in the southern Trigo Mountains indicate that the major structural setting is one of numerous normal or listric normal faults without evidence for the existence of any laterally extensive detachment surface (see descriptions of Silver District). At the far northern end of the Trigo range along the dirt road from U.S. 95 to Cibola, the Tertiary volcanics are in depositional contact with underlying crystalline rocks (Rehrig, unpubl. field notes). Recent mapping by Tosdell and Haxel (1984, pers. commun.) east and southeast of Cibola indicates that the lower Tertiary volcanic contacts are in part depositional and in part formed by low-angle normal faults (see Plate 1). Tilting on these multiple faults have imparted easterly and northeast dips to the Tertiary flow, tuffs and interbedded volcaniclastic strata. While some low angle faults are evident, they are not believed to represent a detachment surface (D. Tosda, 1985, pers. commun.). They are probably listric in nature.

Ore deposits in the Cibola region are somewhat distinct from those in southern parts of the Trigo Mountains in having higher gold to silver ratios. The gold mineralization is spotty and occurs in gangues of banded quartz, iron oxides and ferruginous calcite. A number of the occurrences are clustered in metamorphic rocks adjacent to one of the NNW-striking normal fault contacts with Tertiary volcanics. Distributed through the volcanics are numerous manganese deposits. Total gold production was small (±52 tons high grade), but assayed as much as 6 opt Au. Placers accounted for 323 oz Au with minor Ag. Manganese deposits, common to the district, yielded as much as 31,000 long tons running 20-30% Mn.

Mines of Interest:

Grand Central mine (T1S, R23W, Sec. 36) Spotty, but high-grade gold with minor silver and trances of copper occurs with banded quartz, limonite and ferruginous calcite in fractures and multiple veinlets along a fault zone (N5E, 65°E) in schist intruded by granite porphyry dikes. The vein is up to 3 inches wide and is traceable across two claims. Similar vein occurrences are noted 1 to 2 miles south of the mine (the Jupiter and Broadway properties). Weighted averages of mineable ore equal 0.48 opt Au across 20.4 inches. Note the presence of numerous small gold placer workings in this general area (T2S, R23W, Secs. 1 & 2). Sources of the gold are said to be small quartz veins in the Mesozoic or Precambrian schists. The placers have yielded about 300 oz Au.

The only significant gold reported from the northern Trigo Mountains occurs in the Grand Central mine area and area just to the south along the fault contact with Tertiary volcanic rocks. Although the isolated veins are described as small, the co-existent placer deposits (also small) may signal interest in more disperse gold-bearing quartz-vein or veinlet occurrences within schistose rocks. The environment sounds similar to areas within the Dome Rock Mountains to the north.

References:

Arizona Dept Mineral Resources, file data; Garner and others, 1982; Keith, 1978; Wilson, 1933.

OATMAN (SAN FRANCISCO) DISTRICT

Location:

The Oatman mining district is located on the western slope of the southern end of the Black Mountains about 29 miles southwest of Kingman, Arizona.

Geology and History:

The Oatman district includes the mining camps of Gold Road, Vivian, and Boundary Cone. Most of the production from the district has come from epithermal vein systems within a complex and thick sequence of late Tertiary sub-alkaline, intermediate and silicic volcanic rocks. These volcanics unconformably overlie a crystalline basement of Precambrian granite and gneiss. Locally, dikes and small epizonal plutons intrude both the basement and volcanics. Veins in the Katherine district, located approximately 15 miles north-northwest of Oatman, are similar in mineralogy, and believed to have had a genesis similar to those of Oatman. The two districts are usually described as one. Unlike the Oatman district, however, epithermal veins in the Katherine district occur primarily within the Precambrian crystalline rocks which have been intruded by dikes and plug-like bodies of rhyolite (Lausen, 1931). Many of these veins are hosted by low-angle normal faults that are believed to be listric into a shallow, regional detachment feature (cf. Durning, 1984).

Gold was discovered at the Moss vein in 1863, but major development in the area did not occur until 20-30 years later. Total gold production for the Oatman district was about 3,800,000 tons from which was extracted 2,200,000 oz Au and 800,000 oz Ag (Durning, 1984).

The ore deposits mined at Oatman were veins and lodes formed within transverse fault zones, most of which range in strike from west to northwest and dip steeply to the north. Many of the faults have undergone right-lateral strike-slip movement. The veins range in width from a fraction of an inch to 30 ft; with individual veins often varying considerably in width over very short distances. They commonly consist of brecciated fragments of country rock cemented by crustified chalcedonic quartz, calcite, fluorite, andularia, minor base-metal sulfides, acanthite, silver sulfosalts, and finely disseminated gold (Boyle, 1979). Lausen (1931) recognized five distinct stages of quartz deposition in the veins with the later stages generally accompanied by fine-grained adularia and economic concentrations of gold.

The volcanic sequence found at Oatman is part of the considerably larger Black Mountains volcanic province, which extends along both sides of the Arizona-Nevada border from Parker to Lake Mead. The volcanic province as a whole exhibits an unusual assemblage of mafic to silicic rocks that range in composition from basalts, trachytes and calcic latites to quartz-latites and rhyolites. The volcanism was accompanied by widespread epizonal plutonism and epithermal mineralization (Liggett and Childs, 1975; Anderson, 1978). Plutonism and volcanism in the Black Mountains province were accompanied by

intense faulting and stratal rotation that Anderson (1971) interpreted as thin-skin effects of extreme crustal stretching and attenuation. This was followed by high-angle, normal faulting that produced the present basin and range topography.

The affects of the shallow attenuation are well exposed along much of the Black Range. Much of the range, particularly in the northern and central portions, is cut by listric normal faults that merge into a regional (?) low-angle "detachment" surface. A detachment type fault, however, has not been recognized in the Oatman district. If one exists in this portion of the Black Range, then it must be at a considerably lower structural level than what is presently exposed in the district.

The rocks of the Oatman district have been studied by a number of workers. Thorson (1971) and Wells (1937) provide chemical analyses of the volcanic rocks. Thorson (1971) has shown that there are no true andesites in the Oatman district; and recognized basalt at the base of the volcanic sequence. He designated all other rocks, exclusive of the younger capping basalts, as rhyolite, trachyte, latite and quartz-latite. Christiansen and Lipman (1972) included the Oatman district in their fundamentally basaltic suite (bimodal). Anderson (1978) suggests that the chemical data of the volcanic rocks from the Oatman district display neither bimodality nor typical calc-alkaline chemical characteristics. DeWitt and Thorson (in press) suggest that the volcanic rocks compose a lower Miocene shoshonitic volcanic sequence (alkaline to sub-alkaline), and were formed during minor extensional tectonism. Thus, many questions remain unanswered concerning the nature of the volcanism in the Oatman district and the Black Range in general.

The mineralized veins in both the Oatman and Katherine areas appear to be spatially related to dikes and plugs of quartz-bearing rhyolite porphyry. These rhyolite porphyries are typified by a fine-grained equigranular ground mass of quartz and K-feldspar, and phenocrysts of quartz, which sometimes are partially resorbed (Thorson, 1971). Opaque-looking phenocrysts of sanidine or albite (?), plus or minus biotite, are also present.

In the Oatman district most of these rhyolite plugs and dikes occur in the middle or eastern parts of the district (Figure 13). As some of the rhyolite porphyries were intruded up into the younger volcanics, Thorson (1971) believed that they were feeders for parts of the younger volcanics which have been removed by erosion. Two prominent examples of these exposed "feeders" are Elephant Tooth (19.6 m.y.; DeWitt and Thorson, in press), just east of the town of Oatman, and Boundary Cone, near the southern end of the district. A chemical analysis of the rhyolite at Boundary Cone (Wells, 1937) shows it to be a highly differentiated, high-silica alkali-feldspar rhyolite. Disseminated sulfides occur in dikes radiating from the main mass at Boundary Cone.

Locally, mineralized veins occur along the margins of these rhyolites dikes and, in places, the veins appear to be within the dikes themselves; in other cases, the veins offset the dikes. Personnel of Fisher-Watt Mining, who control a major part of the district and who have had an ongoing exploration

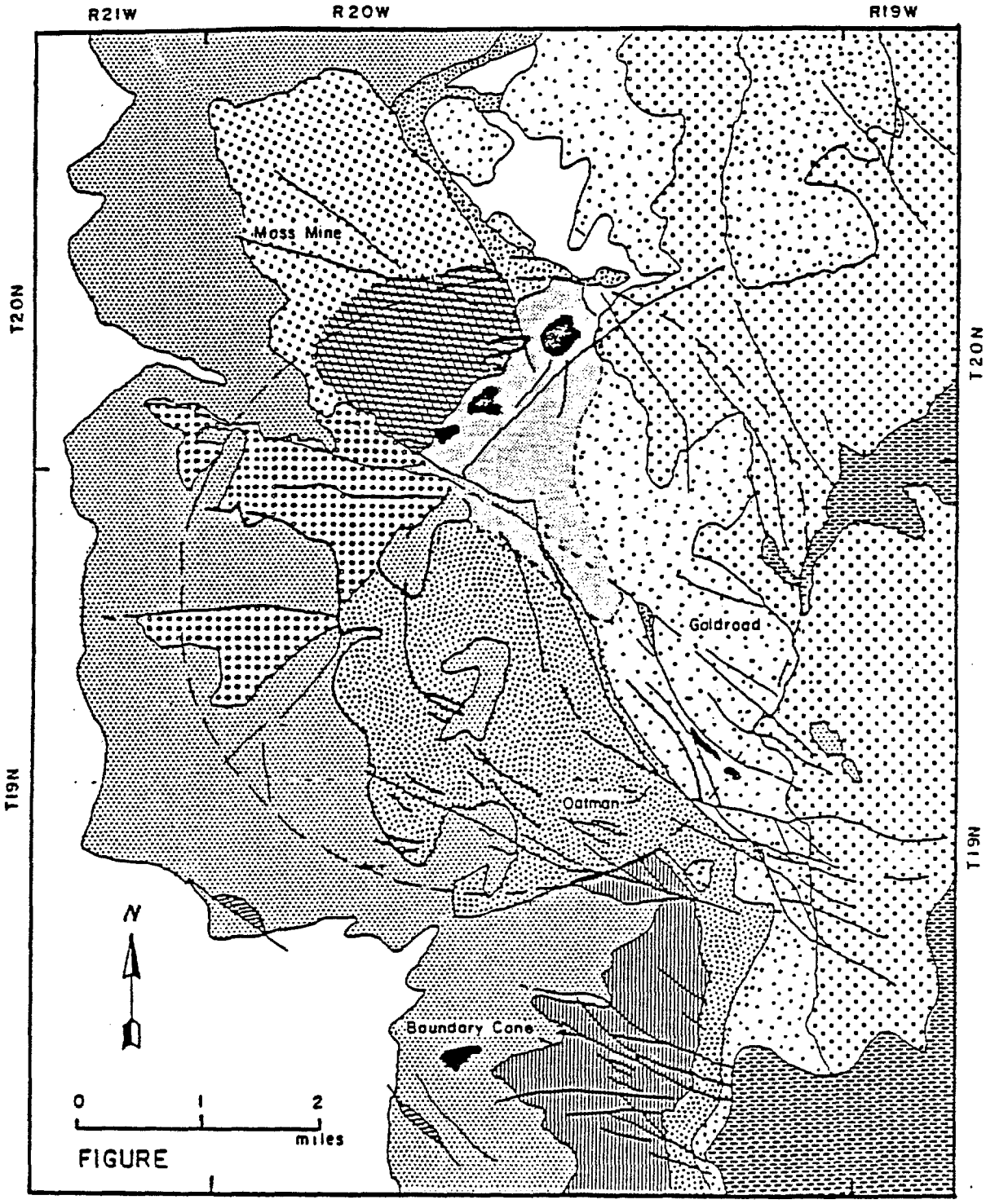


Figure 13. GEOLOGY AND STRUCTURE OF THE OATMAN DISTRICT

(From Clifton and others, 1980)

QUATERNARY	ALLUVIUM	
MIDDLE AND UPPER MIOCENE	OLIVINE BASALT	
	RHYOLITE DIKES, PLUGS	
	MOSS PORPHYRY 10.4 ± .5 my	
	LATITE, RHYOLITE (undifferentiated) 18.7 ± .9my	UPPER VOLCANICS
	GOLD ROAD LATITE 18.2 ± .9 my	MIDDLE VOLCANICS
	OATMAN LATITE	
	ESPERANZA TRACHYTE	
LOWER MIOCENE	TIMES PORPHYRY 22.6 ± 1.8 my	LOWER VOLCANICS
	ALCYONE FORMATION	
PRECAMBRIAN	GRANITE, GNEISS, SCHIST	

VEINS — — — — PHOTO LINEARS

AREA OF ILLITIC ALTERATION

Compiled from: Ransome (1923), Lausen (1931), Thorson (1971), Clifton et al (1980)

LEGEND TO FIGURE 13

program in the district for some years, feel that the mineralization in the district closely followed the rhyolites in time (P. Durning, personal commun., 1980). There is some postulation that the mineralization is genetically related to a buried rhyolitic magma chamber that produced the dikes and small intrusive bodies. The ultimate source of the metals may be from somewhere else, possibly the Precambrian basement.

A "mixed feldspar" separate from ore stage mineralization in the Kokomo vein collected by this writer has been dated at 20.3 m.y. old. Since the Kokomo mineralization in places cuts a rhyolite porphyry dike, the ages of the rhyolite (19.7 m.y. on Elephant Tooth) and mineralization must be considered to be nearly concordant. Biotite from the top of the Gold Road latite which is both pre-rhyolite and pre-mineralization has been dated by K-Ar methods at 18.2 ± 0.9 m.y. (Thorson, 1971).

The Times Porphyry, a domal laccolith-like mass of granophyre that intrudes the lower volcanics, has been dated at 22.6 ± 1.8 m.y. old (Thorson, 1971) on hornblende from the core of the intrusion. Chemical analyses of the Times Porphyry show it to be an epizonal pluton containing a border facies with the composition of high-silica alkali-feldspar rhyolite. Thorson believed that the Times Porphyry predated the whole upper volcanic series. Lausen (1931), however, thought that the intrusive rhyolite bodies and the Times Porphyry were all derived from the same magma chamber. DeWitt and Thorson (in press) concur that the Times Porphyry and rhyolite stocks and dikes are genetically related.

Much has been written about the individual mines in the Oatman district. Lausen (1931), Wilson and others (1967), Clifton and others (1980, and Durning (1984) give much data on the individual mines and major ore shoots. We will not repeat these lengthy data here, but rather refer the interested reader to these references.

Some ore remains in the district and recent exploration by Fisher-Watt Mining Co. has outlined additional tonnage. Durning (1984) notes that when the Gold Road mine was closed in 1942 by War Board Order #L-208; reported reserves remained of about 250,000 tons of 0.25 opt Au. He further states that drilling by Fisher-Watt at the United Western mine shows an open-ended reserve of greater than 200,000 tons grading 0.20 opt Au.

Mining of these relatively low-grade ores would probably resume if enough high-grade material could be found to justify the capitalization costs of a new mill. This is largely what Fisher-Watt and their various joint venture partners have been attempting to find since the late 1970's.

References:

Anderson, 1971; 1978; Boyle, 1979; Christiansen and Lipman, 1971; Clifton and others, 1980; DeWitt and Thorson, in press; Durning, 1984; Lausen, 1931; Liggett and Childs, 1975; Ransome, 1923; Thorson, 1971; Wells, 1937; Wilson and others, 1967.

OSBORNE DISTRICT

Location:

The Osborne mining district covers the southern and central portions of the Belmont Mountains south of the Vulture mine on the southern margin of the Hassayampa Plain.

Geology and History:

Precambrian schists, gneisses and granites make up most of the little studied Osborne district. The schists are believed to be part of the Pinal series and thus are probably composed of mainly sedimentary and volcaniclastic protoliths. Mid-Tertiary volcanic rocks cover older rocks on the northern and western portions of the district. Numerous subvolcanic plugs and northwest-trending dike swarms cut the older rocks and probably served as feeders to now eroded portions of a once more extensive volcanic field. The subvolcanic plugs form a crude east-west belt across the southern portion of the Belmont Mountains. At least some of these intrusions are andesite and latite porphyries in composition and host significant mineralization.

The largest and most productive mine in the district, the Tonopah-Belmont, was discovered in 1904. The ores of the district are generally base-metal dominant (Pb-Cu) but contain considerable precious metals. Between 1927 and 1928 the Tonopah-Belmont produced some 23,420 tons of ore (ADMR files). The 1927 production amounted to 2,326 tons which averaged 0.39 opt Au, 3.2 opt Ag, 5.3% Pb, and 0.7% Cu. Between 1927 and 1930, production from the mine amounted to $610,000; of this total, gold and silver production amounted to $210,000 and $120,000, respectively. Keith and others (1983a) list recorded district production between 1916-57 as amounting to 86,000 tons from which were recovered 13,000 oz Au; 195,000 oz Ag; 1,369,000 lbs Cu; 7,701,000 lbs Pb; and 500 lbs Zn.

Although remote, the district has received some recent renewed exploration interest. B.T. Gold Explorations of Havelock, Ontario has been conducting exploration near the Tonopah-Belmont mine since 1982 (Northern Miner, July 5, 1984). This company is proposing to seek financing for exploration in four areas of anomalous surface geochemistry that are at least 35 ft across with values in excess of 0.45 opt Ag. A B.T. Gold Exporations assessment work report indicates that the anomalies are associated with a contact area between andesite and shales (schist ?). Gold and copper values reportedly increase near the contact and are associated with areas of silicification, sericitization, alunitization, and porpylitization. The Northern Miner story indicated that sampled zones of alteration assayed 0.075 opt Au over 45 ft. A large tonnage, low grade target is being sought. Likewise, the nearby Morningstar property was also reportedly being sampled by a small company in 1983.

With such little geologic information known about the district, a thorough surface reconnaissance with geochemical sampling seems in order. The Tertiary subvolcanic plugs appear to warrant special interest, especially near their contacts with the Precambrian rocks.

Mines of Interest:

Tonopah-Belmont (Belmont McNeil) Mine: (W½ Sec. 36, T4N, R7W) Pb-Cu-Au-Ag mineralization occurs in fractured zones and brecciated margin of an andesite plug that displays considerable relief above the low hills in the immediate vicinity. The plug intrudes Precambrian schist and is but one of many similar bodies that occur in the southern part of the Belmont Mountains. The plug is roughly prismatic and approximately 1,000 ft on a side. Its walls are fluted and nearly vertical and indicate that it was probably some sort of volcanic neck. The hosting Precambrian rocks are highly fractured and dikes in a semi-radial pattern surround the plug. ADMR file data indicate that brecciated fracture zones extend away from the plug toward the west for at least one mile and similar fractures also extend toward the southeast. The outer fringes of the fractures are filled by latite porphyry. It is believed that the mineralizing fluids came up the fractures and breccia zones of the plug to form the open fillings and replacement type ores that have been exploited to date. Veins that fill the fractures in the plug itself are typically about 300 ft long and average about 4 ft thick. There has apparently been an intersection of three such veins with the margin of the plug, where the ores reportedly become 30 ft wide over varying length and are described as becoming "ore pipes."

The property was most extensively worked in the periods 1926-30, 1940-41, and 1944-46. During the latter period the mine was said to have had much damage to its workings due to pillar robbing, etc. The mine reportedly has a 450 ft shaft with over 12,000 ft of lateral workings. The ore shoots were reportedly mined from the surface to the 400 ft level below the adit (about 600 vertical feet).

The property was examined in 1961-62 by the Milca (Onego Corp.) Mining Co. of Pittsburg, Pennsylvania, who repaired the shaft and drilled a 1,043 ft diamond drill hole, which apparently yielded rather unencouraging results. A report in the ADMR by a J. E. Wilson, E.M., who apparently worked about 4 months on the property for Milca, states the following:

> "The veins filling the fractures are 400' plus long and 4' wide until the intersection of veins #2, #3 and #4 are reached at which place they attain a width of up to 40'. The dip of the NE vein is 78 degrees S and the rake is eastward. The SE vein has almost a vertical dip and rakes N. These ore shoots were mined thru to the surface from the 400' level below the adit level. The adit level is 200' plus and minus (allowing for contour) below the surface.
>
> The rake of the vein after intersection plunges sharply to the East and because of this deviation the shaft penetrated the end of the ore shoot. An X-cut was driven South from the bottom of the shaft to allow for the dip of the vein and then a drift tunnel was driven E to pick up the vein at the point where the vein raked into it. The vein at this point is

eight feet wide and was drifted on for a distance of about 400'. The ore was stoped upward for about 15' and the vein is strong and consistent the full length of the drift from the point where the vein raked into the drift.

Two winzes were sunk to a depth of 20' on the level and both are damp from about 10' down and water about two feet deep is standing in the bottoms of each. They both contain sulphides and indicate that water level has been attained. There is no diminuation of the vein at the bottom of the winzes and it is my conviction that the vein will continue downward to a great depth. I cut chip samples from the faces at the bottom of the winzes and the assays revealed 12.2% copper, .43 oz gold, 3.6 oz silver and .82% lead."

The B. T. Gold Explorations of Ontario reported in 1984 that surface trenching revealed a zone 50 ft wide that averaged 0.07 opt Au. They were apparently going to promote a stock issue in an effort to raise drilling money.

The property sounds interesting and should be examined as a joint venture or buy out exploration possibility.

Morningstar (Belmont Eastern) Mine: (Sec. 6, T3N, R6W) The property was first worked in 1928, but was then left idle until 1937 when three cars of ore were shipped. In 1940 the property was leased and small production accompanied exploration and development work until 1946 when the mine was again idle. Mineralization is described as 3 veins averaging about 2.5 ft thick; two strike northerly and one trends EW. The veins are hosted by andesite near a contact with rhyolite. They seem to dip toward the rhyolite contact and enclose the rhyolite on 3 sides; west, south and east. The rhyolite is reportedly considerably altered as is the andesite adjoining it. The ore consists mainly of chalcocite and copper carbonates, thought to have formed by oxidation of primary chalcopyrite. Development consists of a 24° inclined shaft 425 ft in length; a 30 ft vertical shaft with a 35 ft drift from the bottom reportedly all in ore; one 102 ft tunnel probably all in ore and several surface cuts and trenches. In 1937, the ore reportedly averaged 9.15% Cu, 2.30 opt Ag, 0.01 opt Au. While the gold values are very low, one wonders if this ore was mined from oxidized surface ores for its copper content and that the gold values might be somewhat leached. The nearby Tonopah-Belmont mine which might have similar character ores, displayed comparable copper and silver values, but had much higher gold.

Moon Anchor Mine: (Sec. 31, T4N, R7W) No description is available. CRIB files indicate that it was a vein deposit in andesite that has had some production. Major commodities were Pb, Ag, Au (apparently in order of importance). Mine production amounted to 25 tons/day in December, 1942.

Scott Lead Mine: (Sec. 21, T4N, R7W) Two intersecting veins; one strikes N15°E, the other N15°W. Veins carry argentiferous galena in quartz gangue. Some 22 tons of ore shipped around 1945 than ran 12% Pb and 26 opt Ag. Ore carries about 0.03 opt Au. The deposit is probably small.

Divide Iron Cap: (Sec. 10, T4N, R7W) The host rocks are volcanics underlain by rhyolite and andesite. Two veins about 400 ft apart reportedly are traceable on the surface for 3,000 ft. The Divide vein occurs at a lithologic contact and is reportedly 6 to 8 ft wide. The Iron Cap vein is from 3 to 6 ft wide. The two veins trend northwest. Development consists of shallow workings. Values in the Divide vein occur in hematite and average about 0.12 opt Au and 1.5 opt Ag. Iron Camp vein has values of about 0.10 opt Au, 1 opt Ag, and 2.5% Pb according to a 1939 report.

References:

Arizona Dept. Mineral Resources, file data; Keith and others, 1983a.

PIKES PEAK (MORGAN CITY) DISTRICT

Location:

The Pikes Peak district covers the central and southern portions of the Hieroglyphic Mountains which are located about 12 miles north of Sun City in northern Maricopa County.

Geology and History:

The Hieroglyphic Mountains consist of low pediment flanked hills floored by Precambrian schists and granitic rocks that in places are cut by mid-Tertiary volcanics dikes. Small patches of felsic volcanic rocks overlie the Precambrian basement as scattered erosional remnants. Volcanic rocks increase in thickness and volume northeastward toward the Castle Hot Springs area and northwestward in the White and Red Picacho areas where major volcanic vents occur. Ward (1977) indicated a possible volcano-tectonic depression exists in the Castle Hot Springs area. Miocene or Pliocene(?) basalt flows (Hickey Basalt equivalent) unconformably cap the geologic section in the Hieroglyphic Mountains.

The Precambrian schists exposed in the district have a predominantly sedimentary protolith. These rocks have been the source of considerable interest as they contain a large Proterozoic banded iron deposit (i.e. Slatt and others, 1978; USBM RI-5319). They are also of interest in that they seem to contain carbonate-rich zones that may be of exhalative origin which could provide a potential source of metals.

Known gold mineralization occurs in steep to shallow dipping epithermal veins that are largely composed of dark calcite where they crop out at the surface. Several separate areas of mineralization occur in the district. The Copper Lakes (Clementine) and the Mystic deposits have been recently drilled and contain moderate to small reserves respectively. The Black Prince mine has been the major historic producer in the district. Tungsten mineralization also occurs in the district and one prospect occurs very near the Clementine gold deposits.

Keith and others (1983a) list known production from the district between 1917 and 1960 as amounting to some 2,400 tons of ore containing 1,000 oz Au, 2,000 oz Ag, 11,000 lbs Cu, and 55,000 lbs Pb. Almost all of this production probably came from the Black Prince and Morgan City properties. Copper Lakes Mining Co., a small Canadian exploration company, conducted a shallow drilling program in 1980-81 that outlined a low-grade reserve on the Clementine property. According to N. American Gold Mining Industry News (Oct. 26, 1984), Copper Lakes claims the property contains "proven and probable reserves" of 5.52 million tons averaging 0.055 opt Au and another 7.7 million tons of "possible" reserves of similar grade. An earlier report (1983) in this same journal indicated that "proven" reserves amount to 1.1 million tons grading 0.054 opt Au. This firm has spent considerable money on erecting buildings, an optimistically large heap-leach pad, water storage facilities and leach

circuitry. Typical of many small Canadian stock companies, Copper Lakes apparently got into financial difficulties and the operation was forced to close in 1982 without ever really producing any gold. The company apparently corrected the situation in 1984 and is again in control of the property. Although the proven reserves are small and of low-grade, they are apparently semi-reliable and based on about 200 shallow drill holes (D. Wahl, personal commun., 1982). Mr. Wahl studied the geology of the deposit area and indicated that some areas of potential were not drilled. This writer would consider that the "possible" and "probable" reserves are probably highly speculative.

In 1980, Ranchers Exploration Co. began drilling the nearby Mystic property. Ranchers drilled 88 core and rotary holes on the Mystic vein system and succeeded in outlining a small but high-grade ore body that contains 26,130 tons of ore grading 0.72 opt Au and 0.37 opt Ag (Pay Dirt, Sept. 1984). Ranchers joint ventured the property to Goldsil Mining and Milling, Inc. in 1984, who started construction on a decline in August. Production is expected to begin in late 1984 or early 1985. Goldsil expects the mine to have a two-year life with a planned mining rate of 75 tons per day. About 12,000 oz Au are anticipated to be produced in the first year of operation.

The district obviously contains considerable gold mineralization. Tertiary epithermal mineralization is one obvious target; Precambrian syngenetic mineralization is a more remote possibility that should be investigated in this region. There appears to be a distinct possibility of a Precambrian source of gold in some of the Tertiary deposits in this and adjoining districts (i.e. Castle Creek, White Picacho). Actual Precambrian gold mineralization of commercial grades, however, still lacks documentation in this region.

Mines of Interest:

Clementine (Charlotte, White Peak) Property: (Secs. 10 & 15, T5N, R1W) Epithermal calcite-quartz veins fill brecciated and shattered zones cutting Precambrian schists. Most veins appear to run approximately N65°-70°W with shallow dips to the SW. These veins contain quartz, siderite, ankerite, calcite and some manganese and iron oxides. The veins contain some vugs lined with clear to amethystine quartz and some fluorite. The Charlotte mineralized zone consists of several flat veins which steepen to 40° dips at about 30 ft below the surface. This property has a rather celebrated history. It was explored by Peter Hurkos, the famous psychic, and backers in the 1960's who claimed by psychic revelation to have been led to the mine which was beyond a doubt, the Lost Dutchman mine. We are not sure what Hurkos was smoking at the time of his revelation, but it undoubtedly must have been imported. At some later time the property passed to a Phoenix plumber who involved the Copper Lakes people in the late 1970's. Copper Lakes announced in October, 1984 (N. American Gold Mining Industry News) that they had agreed to buy out the remaining 80% ownership for $6 million and were planning to go into production to produce 7,000 oz Au/year by crushing and agglomeration leaching at a mining rate of 1,700 tons per day. Copper Lakes state they have proven drilled reserves of 1.1 million tons grading 0.054 opt Au, "probable" reserves of

5.5 million tons of similar grade, and 17.7 million tons of "possible" reserves. These figures are reportedly based on 25,800 ft of 5-inch percussion drilling. This writer believes that the "probable" and "possible" reserves are highly speculative at best; however, it is believed that untested favorable areas could still exist at the property. While probably not a large deposit, it could be of interest to a small company. The heaviest mineralized area reported (ADMR) has surface dimensions of about 150 by 200 ft and is said to be bordered by 2 transverse siderite veins which are said to be older than the rest of the mineralization. These siderite veins are 1-2 ft wide, consist of siderite and ankerite, and contain Pb-Zn values. D. Wahl (personal commun., 1982) indicated that Precambrian schists in the vicinity of the main mineralization contain carbonate-rich sediments (possible exhalites) that may provide a source for gold and carbonate in the Tertiary veins. He further suggests that a Tertiary rhyolite vent is exposed near the mine which may have acted as a heat source for some of the hydrothermal system. Some reports indicate that the schist in the mine vicinity has been rotated along an extensive flat fault.

Mystic Mine: (Secs. 11 & 12, T5N, R1W) Little detailed geologic information is known about this property. Gold mineralization reportedly occurs in an east-west shear and is of high-grade (often greater than 1.5 opt Au) but spotty character. The orebody extends to within 75 ft of the present surface and downward to a depth of 300 ft. Drilling by Ranchers Exploration suggested a lithologic control to the mineralization. At one time Ranchers apparently controlled or proposed to control some 22,600 acres of land surrounding the Mystic because of its similarity in geology. It was widely rumored at the time that the mineralization was syngenetic to the Precambrian with remobilization by Tertiary trachyte dikes. The presence of banded iron formation in the vicinity undoubtedly helped promote the idea. The American Copper and Nickel Co. entered into a joint venture with Ranchers in 1982 and after some 2,000 ft of core drilling advised the partnership that its limited drilling had not produced evidence of the type of deposit it was seeking, They withdrew in 1983. Drilling by ACNC and Ranchers encountered considerable ore grade material, but much of this had little or no continuity. Surface sampling by Ranchers indicated the presence of significant gold mineralization on some 20 acres having similar geologic environment to that where the original Mystic drilling had been conducted. They felt a major drilling program would be necessary to explore the property adequately, but decided not to proceed without outside funding. Exploration by Ranchers since 1980 has apparently outlined 26,130 tons of mineable material that averages 0.72 opt Au and 0.37 opt Ag. Goldsil Mining Co. optioned the property from Ranchers and started a decline to the ore zone in August, 1984.

At the surface the mineralization is marked by epithermal calcite veins that fill fault or fracture zones in the Precambrian basement. Foliation of the schist strikes nearly NS and dips vertically. It resembles the Pinal schist in some respects. The area is crosscut by some EW andesite to trachyte appearing dikes that dip steeply to the south. Mineralization is apparently restricted to the Precambrian footwalls of the dikes. Occasionally the dikes themselves are mineralized. The mineralized dikes are reportedly altered and

heavily stained with red-brown limonite. Veins are said to occur en echelon or as parallel structures and consist mainly of calcite and manganese filling. The mineralized zone seems to extend some 3000 ft along strike. While the surface expression of the dikes are unmineralized, a reddish color anomaly is reported to occur over the mineralized area. The property was discovered in about 1972 by two retired Sun City residents who were attracted to the property by Pb-Zn values. They performed some assessment work drilling over the years to develop the Pb-Zn mineralization. Eight holes in one cross-sectional line averaged 2.2% Pb and 2.75% Zn with minor Cu. The gold mineralization occurs about 500 ft west of the Pb-Zn mineralization and was discovered in one or two drill holes exploring the extent of the base metal mineralization. It is not known if the Pb-Zn and the Au mineralization are part of the same or different systems.

Pikes Peak Iron Deposits: (Secs. 8, 17-19, T6N, R1W and Secs. 13, 24, 25, T6N, R2W) Owned by Kaiser Steel Co., banded iron formation ores occur in 10 large lenses and many smaller ones in Precambrian schist. Iron occurs mainly in limonite and hematite. Iron ores lie in a zone 500-2,000 ft wide by about 16,000 ft in length. Ore lenses are parallel and trend NE. U.S. Bureau of Mines tested parts of the deposit and estimated 100,000,000 tons of material averaging about 30% Fe with variable but high SiO_2 and 2.5 to 3% Mg (see USBM RI-5317).

Pikes Peak (Morgan City) Claims: (Sec. 31, T7N, R1W) A 1-2 ft vein (mainly calcite) at the surface strikes N to NE and dips steeply east in Yavapai (?) schist. It has been followed for about 2,000 ft along strike. Information is sketchy, but the vein may occur at a fault contact between schist and Tertiary volcanics. The upper 50 ft of the vein was free milling with pyrite becoming abundant below this level. Vein is thought to disappear in the volcanics several hundred feet north of the main shaft. The vein is said to weaken toward the south and is offset by faulting towards its NE end. Additional veins (mainly narrow and discontinuous) are said to occur east and west of the main vein. Some of these subsidiary veins have had production. Numerous prospect pits and shallow drifts are reported to occur along NE-trending quartz veins (usually less than 18 inches wide) in the SW corner of Section 31.

The principal workings consist of a 265 ft shaft with drifts at 100 and 200 ft levels. Several hundred tons of free milling ore is said to have been mined from the shaft in the early days. An additional 200-300 tons of free milling ore reportedly came from the same vein about 200 ft south of the shaft. Many shallow pits occur along strike between these two areas, from which ore was claimed to have been mined and shipped. Other veins in the area reportedly occur in both the schist and volcanics and at the contact between the two. Many of these structures have never been prospected. In 1941, 223 tons of ore were mined and shipped from the 100 ft level of the 265 ft shaft. This material averaged 0.32 opt Au, 0.47 opt Ag, and about 0.5% Cu. At the bottom of the shaft the vein reportedly ran 0.265 opt Au, but because of the sulfides apparently wouldn't mill as well. In 1935, about 1200 tons of tailings that had been treated in a crude cyanide plant near the mine produced about $8,000 (±400 oz Au).

ADMR files indicate that 5 patented claims and 2 patented mill sites were for sale in 1982 and that Fred Johnson (who at times acts as an agent for Ranchers Exploration Co.) was looking at the property for a client who was reportedly interested in the claims. Johnson claimed to be optimistic about possible reserves on the northeast end of the vein structure where it is fault displaced in segments and eventually goes under volcanic cover. He apparently felt that the area merited some drilling.

Spanish Diggins: (SW Sec. 32, T7N, R1W) No information concerning geology. Property includes a drift located near the wash east of Pikes Peak mine. Property reportedly has had some production.

White Peak Silica Mine: (Sec. 15, T5N, R1W) Large quartz body mined and shipped as flux to the Ajo smelter. Averaged 95-96% silica and 0.75 opt Ag. The deposit is said to contain about 100,000 tons of material available for shipping.

Prince of Arizona: (SW¼NE¼ Sec. 16, T5N, R1W) Mineralization occurs on a fracture zone dipping about 30°. The vein filling is principally sheared country rock with considerable amounts of manganiferous calcite containing some Au, Ag, Pb and V. There are several inclined shafts with lateral workings. Some stoping was done near surface for Au and Pb on these 10 patented claims.

References:

Arizona Dept. Mineral Resources, file data; Johnson, 1972; Keith and others, 1983a; Wilson, 1961; R. T. Wilson, unpubl. field notes.

PILGRIM DISTRICT

Location:

The Pilgrim mining district lies on the eastern edge of the central portion of the Black Range about 9 miles west of Chloride. The district trends northwest and is about 2 miles in length. It lies in the NW portion of T23N, R19W.

Geology and History:

The district lies in the eastern foothills of the Black Range. Bedrock consists mainly of rhyolitic volcanic rocks of probable "Patsey Mine" age (c.f. Anderson and others, 1972). The history of the district essentially parallels the history of the Pilgrim mine which has had a fairly substantial production. Schrader (1909) describes the Pilgrim mine as being situated at the contact between the volcanic rocks and a granite porphyry basement. Schrader defines the contact as a low-angle fault that has massive to brecciated rhyolite as the hanging wall and granite porphyry as the footwall. Hastings (1937), on the other hand, states that the footwall is ill-defined, but that it mainly consists of andesite that is complicated by a number of rhyolite intrusions. He further states that the fault separating the rhyolite from the andesite is a well defined shear zone that strikes N30°W and dips 30° to the west. The hanging wall of this zone is marked by a persistent streak of red gouge that ranges up to 4 ft in thickness.

The footwall of the main shear zone is cut by a series of minor, high-angle, shear zones that strike roughly NS. In places, these high-angle faults continue on through the hanging wall. The acute angle intersections between the high-angle faults with the major low-angle fault are said to have produced noticeable enrichment along the footwall. Where these high-angle faults continued on through to the hanging wall, a large, low-grade orebody developed from wall to wall (Hastings, 1937). A typical cross-section showing the relations of the orebodies to the structure is shown in Figure .

Hastings believed the NS-striking, high-angle faults served as "feeders" of the mineralization into the main shear zone. As of 1937, five of these feeders had been traced on the surface, and two had been developed by underground drifting. Mineralization along the feeders consisted of stringer zones of narrow quartz veins separated by barren andesite or rhyolite. The stringers ranged from less than 1 inch to 24 inches in width and formed zones from 4 to 22 ft in width. Individual stringers contained up to 1,000 opt Au. Hastings (1937) notes that ore broken from stoping these stringers across an 8 ft face averaged 1.75 opt Au.

The vein material between walls consisted mainly of brecciated fragments of underlying tuffs. The distance between walls varied with depth, but was said to average about 60 ft. Commercial bodies of 3 to 18 ft in width were found along each wall (Figure 14). In 1937, orebodies were most often found in the rhyolite rather than the andesite; in apparent response to the rhyolite's ability to shatter more readily in the fault zones.

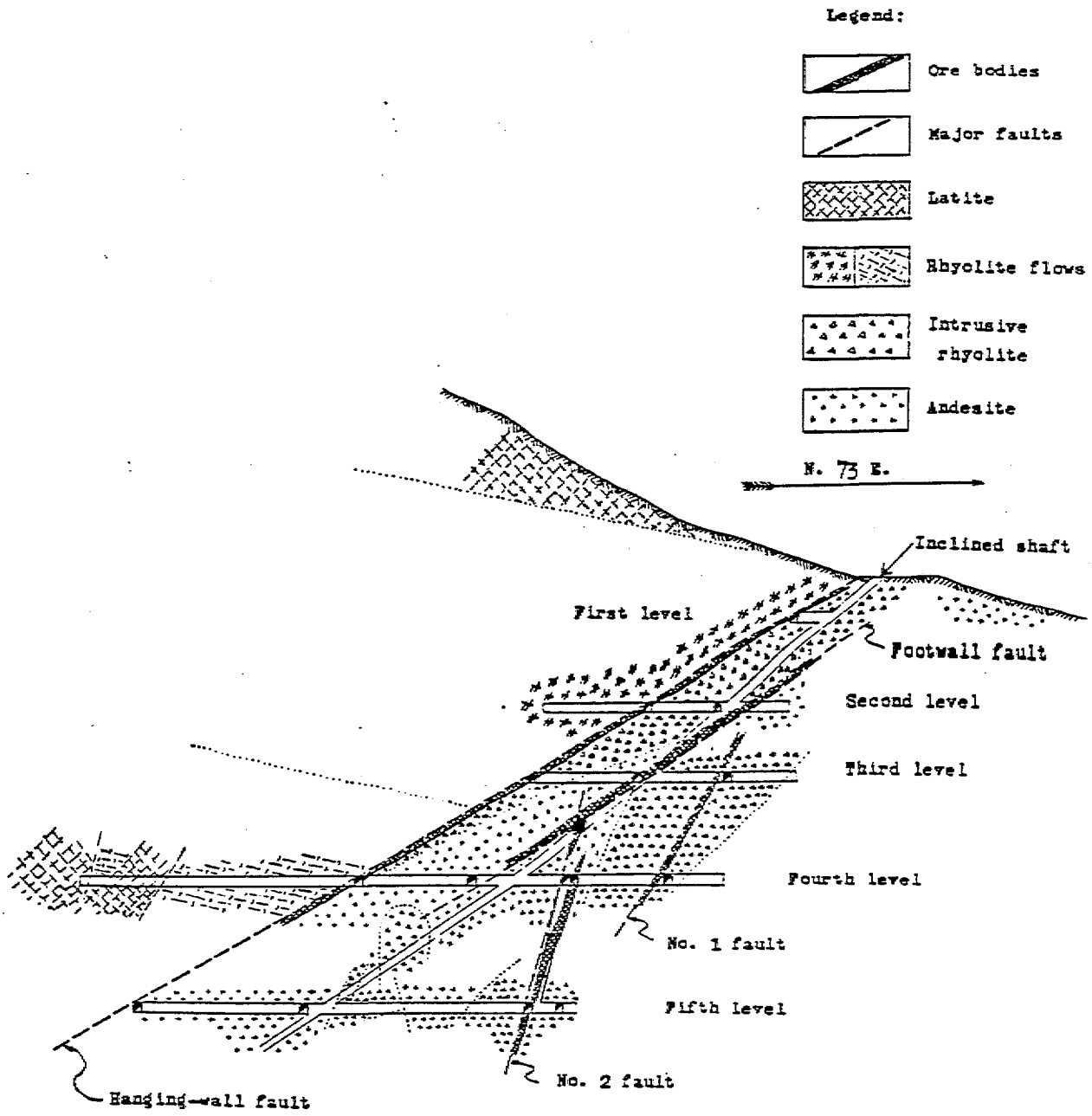


Figure 14 – Typical vertical cross-section at main shaft, Pilgrim mine, showing relation of ore bodies to structure. Scale, 1 inch equals 100 feet.

(From Hastings, 1937)

Hastings (1937) described three major types of ore that were encountered in the mine:

1. Quartz-rhyolite breccia where the quartz resembled the 4th and 5th stage quartz in the Oatman district (c.f. Ransome, 1923). This quartz is either waxy yellow or waxy green in color, with primary values predominating but with secondary values in the cleavages of both quartz and rhyolite.

2. Quartz-rhyolite breccia, in which the quartz is of the 5th stage (waxy green color) only and has primary values of very fine gold disseminated throughout the quartz.

3. Calcite-quartz breccia, with variations of calcite replaced by quartz and spar.

Hastings (1937) indicated that detailed geologic studies of the mine area showed that ore deposition and structural conditions of faulting were very complex and nonsystematic. Reliance could not be placed upon projection of ore or faults from one level to the next because of structural complexities. He states that successive vertical cross-sections at 50 or 100 ft intervals do not appear to be sections of the same mine. These conditions presented a serious problem for prospecting and mine development. The mine practice was to generally "follow the ore."

The Pilgrim mine was located about 1903 and the main shaft had been sunk to a depth of 360 ft with some drifting and high-grade ore shipped by 1907. The mine was mainly idle between 1907 and 1928. In 1928 the mine was leased with some development and high-grade ore being milled. Between 1933-34 the mine was leased to the Pioneer Gold Mining Co. and considerable development work was performed and a flotation mill was built. In 1937 the vein was developed by numerous pits and shafts along the 4,500 ft of surface exposure. The main shaft on the Pilgrim claim was sunk to a depth of 575 ft on a 37° incline. Stations were cut on the 50, 150, 263, 354 and 500 ft levels. Hastings states that horizontal workings amounted to nearly 7,000 ft. Major production at the mine began in 1935 when 26,000 tons of ore were produced. In 1936 production amounted to 29,304 tons of ore which averaged (heads) 0.265 opt Au and 0.137 opt Ag (Hastings, 1937).

Keith and others (1983a) have combined the production from the Portland and Pilgrim districts. Recorded production from the Pilgrim mine amounts to 23,100 oz Au and 17,250 oz Ag from 157,500 tons of ore (Keith, personal commun., 1985). Production figures also show that the Scott mine produced some 1,050 oz Au and 747 oz Ag from 4,650 tons of ore. We could not find the location of this property. It may be the property that the South Pilgrim Mining Co. was prospecting in 1934 about 0.5 mile south of the Pilgrim mine (Wilson and others, 1967).

The nature and dip of the Pilgrim fault indicates that it might be a listric fault or possibly even a detachment-like low-angle fault. It would seem that

the wide brecciated zone of the low-angle system might hold some potential for low-grade open-pitable reserves. This possibility should be examined. We have no knowledge of who currently controls the property. In 1976 someone was augering the tailings from the Pilgrim mill.

References:

Arizona Dept. Mineral Resources, file data; Hastings, 1973; Schrader, 1909; Wilson and others, 1967.

PINE GROVE-TIGER (CROWN KING) DISTRICT

Location:

The Pine Grove-Tiger mining district consists of two contiguous mining camps, Pine Grove being the more northerly, located in the central Bradshaw Mountains 40 miles by road southeast of Prescott. The district essentially covers the eastern half of T10N, R1W (protracted).

Geology and History:

A northeastward-trending belt of Precambrian Yavapai Series schist, intruded on its western and eastern flanks by Precambrian granites and diorite (gabbro) constitutes basement in the district. The Precambrian Brady Butte granodiorite intrudes the western flank of the Proterozoic schists and has been dated at 1770 ± 10 m.y. (U-Pb/Zr, Anderson and others, 1971). Its intrusion predates regional folding and metamorphism. The somewhat younger Precambrian Crazy Basin quartz monzonite intrudes the schist belt on its eastern side. Intrusion of this batholith post dates most of the regional deformation (DeWitt, 1979).

The belt of Proterozoic schist extends for miles both to the southwest and to the northeast and is divisible on our map into packages dominated by mafic volcanics and those that consist mainly of epiclastic sediments (cf. Donnelly and Hahn, 1981). DeWitt (1976, 1979) mapped the area in detail and describes the Proterozoic schists as consisting essentially of two units consisting of (oldest to youngest): (1) some 3500 m of basaltic-rhyolitic flows and pyroclastics that are interbedded with chert, limestone, and oxide facies iron-formations; which are unconformably overlain by, (2) pelitic sedimentary rocks. Subsequent regional deformation resulted in isoclinal folding of all stratified rocks about steeply dipping, northeast-striking axial planes (DeWitt, 1976). DeWitt's mapping, contrary to previous investigators in the area (i.e., Anderson and others, 1971), indicates that stratigraphy trends across the regional foliation (N30°E), although it is elongated in that direction. Thus, within the stratified volcanic sequence, rocks are oldest on the north and youngest on the south.

A granodiorite pluton of Laramide age (65 m.y. date reported by Keith and others, 1983b), covering a several square mile area intrudes the older rocks near the central portion of the district and is host to many of the productive veins. Northeast-trending rhyolite porphyry dikes cut the Precambrian rocks and the Laramide pluton and are themselves believed to be of Laramide age. An alternative possibility is that the dikes are of mid-Tertiary age as they exhibit a trend similar to mid-Tertiary rhyolite dikes that are related to epithermal silver-gold-tungsten veins in the Tip Top district 10 miles further south.

Lindgren (1926) and Wilson and others (1967) describe the vein deposits in the district. DeWitt (1976) describes several volcanogenic massive sulfide deposits hosted in the Proterozoic schists. The gold-bearing deposits of the district are generally contained in three separate groups of veins. These veins strike north-northeast, dip about 60°NW, and are usually less than 5 ft wide (Wilson and

others, 1967). The most productive of the vein deposits occur in the Laramide granodiorite, although productive deposits have also been mined from the Precambrian rocks.

Vein gangue consists mainly of quartz with some ankerite and calcite. Much of the quartz is drusy and contains pyrite, chalcopyrite, sphalerite, galena and some tetrahedrite (Lindgren, 1926). Free gold occurs with the sulfides in places; however, most of the mined ore was at least partly oxidized. Near the surface, ores were very rich in gold and silver, often containing $100/ton (pre-1926 prices) in these metals. Some mines were gold dominant while others were richer in silver. The rich silver ores tended to be accompanied by abundant ankerite (Wilson and others, 1967). Most workers believe the veins to be genetically related to either the Laramide granodiorite or the related rhyolite dikes. Porphyry copper mineralization associated with the Laramide pluton supports this idea. (Exxon drilled a porphyry system near Crown King in the late 1960's.) The fact that the unoxidized veins are sulfide rich indicate that the gold-silver mineralization may represent an outward Pb-Zn-Au-Ag zoning fringe of a porphyry copper system (cf. Keith and others, 1983b).

Mining activity was reported at a few mines in the district as early as 1874, but significant production probably did not occur until after 1890 (Koschmann and Bergendahl, 1968). The Crown King mine was the largest gold producer in the district. It was most active between the periods of 1893-1900, 1903-1923, and 1934-1951. Between 1890-1901, the ore shoot was followed to a depth of 650 ft and produced an estimated $1.5 million (Wilson and others, 1967). The total district production is stated by Keith and others (1983a) to be some 270,000 tons of ore that contained 122,000 oz Au, 1,115,000 oz Ag, 1,518,000 lbs Cu, 806,000 lbs Pb, and 3,312,000 lbs Zn. This estimate did not include the early estimates of production from the Cougar, Del Pasco, Oro Belle and Lincoln Mines. Wilson and others (1967) states that the production of the Oro Belle-Gray Eagle property was estimated to be $700,000 through 1912, Production between 1907 to 1909 yielded 5,662 oz Au, 16,301 oz Ag and 23,830 lbs Cu. Using this ratio of metal production and metal values current at the time, this writer arrives at a production estimate for the Oro Belle mine amounting to 29,500 oz Au, 84,700 oz Ag, and 126,000 lbs Cu. This would increase the district wide production to about 150,000 oz Au.

Besides the porphyry related (?) vein deposits, massive sulfide orebodies in the Proterozoic schist also exist in the region between Crown King and Mayer. While those found to date are mainly small to moderate size, copper dominant systems (i.e. DeSoto and Blue Bell mines), they also carried some gold (Blue Bell ores averaged 0.06 opt Au and about 2.7% Cu; Lindgren, 1926). Zinc-rich massive sulfide ores in the Bradshaw Mountains tend to carry more gold than the copper dominated systems (cf. Dewitt, 1983). The famous Iron King mine located about 28 miles to the north, contained a 5 million ton zinc-dominant massive sulfide ore body that averaged 0.123 opt Au, 3.69 opt Ag, 7.34% Zn, 2.5% Pb and 0.19% Cu (Gilmour and Still, 1968). Gold-dominant, exhalative deposits are also known to exist in the Yavapai Series schist in the Bradshaw Mountains (i.e. Swan and others, 1981) and should be considered as an exploration target in the Crown King area. DeWitt (1976, 1979) makes mention of calcareous mafic tuff (minimum thickness of 500-700m) exposed from east of the Oro Belle mine to the Gladiator mine. He felt that it was probably a tuffaceous volcaniclastic sediment associated with pillowed basalt flows. Chemically the unit resembles a marl. One wonders if this unit could

contain exhalative gold mineralization. The Gladiator mine is located in the calcareous unit near its contact with a thick pile of subaqueous andesite. Wilson and others (1967) note that "alteration" near veins in schist at the Lincoln mine consists of sericite and ankeritic carbonates. Lingren (1926) gives the most detailed descriptions of some of the old mines in the district.

Mines of Interest:

Crown King Mine: (Located southeast of Towers Mountain in Sec 10, T10N, R1W.) The mine was the most productive gold producing deposit in the district. The vein strikes north- northeast, dips 70°W and averages 2 ft in width. It cuts both the granodiorite and the Yavapai schist. Ore consists of quartz with abundant sphalerite and pyrite and some chalcopyrite and native gold. Ore reportedly averaged 0.5 opt Au and 4 opt Ag. The vein contained two ore shoots that pitched northward at low angles. The vein reportedly split at the northern end. Oxidized surface ores were very rich. Tailings from an old amalgamation mill were said to have contained 0.3 opt Au, 4.5 opt Ag and 11% Zn. Wilson and others (1967) stated that the mine was developed by, "480-ft shaft with a 913-ft tunnel 150 ft below the collar, and a 500-ft winze with 5 levels that each extend about 1,200 ft north and from 200 to 500 ft south". While all ore was said to be extracted between the surface and the 3rd level, some ore was reported to remain between the 3rd and 5th.

Gladiator (Nelson, Philadelphia, War Eagle Gladiator) Mine: (Located northeast of the Crown King in Sec 2, T10N, R1W.) Persistent vein is reportedly traceable for 5,000 ft on surface and cuts Proterozoic calcareous schist. The nearby Nelson vein is subparallel to the Gladiator vein which strikes N20°E. The Nelson vein is also traceable for a long distance, strikes N10°E, and is located a short distance to the east of the Gladiator. The Nelson vein is reportedly exposed at the 250 ft deep shaft near top of the ridge at an altitude of 7000 ft and has been opened by the Philadelphia tunnel 800 ft from the portal. Lindgren (1926) reported the tunnel follows this vein for 3000 ft, but without reaching ore. The same vein is reportedly opened by an upper tunnel 280 ft above the Philadelphia adit. Lindgren reports that in these workings, however, the Nelson vein consists of a 2-5 ft thick ankerite filling containing scant sulfides; dipping generally 60°-80°W, but in places steeply east. If the Nelson vein is identical with the vein at the shaft 1000 ft higher up on the ridge, a change has taken place in the vein filling, for in the upper shaft it shows a quartz gangue that carried $20 per ton (pre-1926 prices) gold and silver. The Gladiator vein was apparently faulted off. It reportedly yielded a considerable production of gold from oxidized quartzose ores near the surface. CRIB records indicate that the vein was mined to about the 700 ft level and that the mine contained some 4500 ft of level workings. The length of the overall mined area was about 1000 ft. The deposit is believed to be of Laramide age, but the abundant ankerite suggests a possible Precambrian heritage.

Fairview Mine: The Fairview property is located high on the ridge 2 miles north of Crown King. The vein is considered to be an extension of the Nelson and strikes N40°E and dips 70°W. In lower tunnel (230 ft long), the vein is 3-4 ft wide, generally massive and contains some pyrite and chalcopyrite. Country rock is a black clay slate of sedimentary origin striking N30°E and dipping steeply east. In places it contains quartzite beds and narrow dikes (?) of granite porphyry. Ore

was said to run $30 ton, mostly in gold. A short distance north of the Fairview tunnel, a shaft on the east side of the gulch exposes a lenticular deposit in slate consisting of siderite, magnetite, pyrite and chalaopyrite (Lindgren, 1926).

Lincoln Mine: (Located in Sec 1, T10N, R1W; about 2 miles north-northeast of Crown King at an elevation of about 7000 ft.) Vein in schist near granite contact, strikes N18E and dips steeply to west. Mine workings include 2 tunnels and a 115 ft shaft. Production recorded in 1902 and from 1905 to 1908, amounted to $135,000 from 10,000 tons of ore treated in a 15-stamp amalgamation- concentration mill. Schist contains tourmaline and near the vein displays alteration of sericite and ankeritic carbonates. Wilson and others (1967) report that the oreshoot consists of a northward-pitching zone that is 400 ft long by 5-6 ft wide consisting of drusy quartz and ankerite with pyrite, chalcopyrite, sphalerite, galena and tetrahedrite. Concentrates reportedly contained 15% copper, 1-4 oz Au and 10-24 oz Ag per ton.

OroBelle-Gray Eagle Mine: (Located in Sec 34, T10N, R1W on the southern slopes of Wasson Peak.) The mine was worked in the 1890's and between 1900 and 1912. Total production is estimated to be $700,000 mostly in gold (see district description). OroBelle veins were developed by eight tunnels, the longest of which extends 1000 ft. The Gray Eagle vein was opened by a shaft 600 ft deep. The veins are in pelitic schist; the Gray Eagle reportedly being near the contact with Bradshaw Granite. Pegmatite dikes are common in the area. The Gray Eagle vein is 2 to 15 ft wide with ore reportedly containing $20 in gold, 2 oz silver and 1% copper per ton. The OroBelle vein is reportedly small and was mainly worked by lessees. The Gray Eagle vein is said to continue northward toward Crown King, passing through the Savoy group, the Cougar and the Bradbury group. Some high-grade silver ore was supposedly taken from a 75 ft shaft on the Cougar property. Here, vein reportedly consisted of partly oxidized honeycombed quartz that was drusy in places. Ankeritic carbonates which were once present in the ores, but are now dissolved. Some sphalerite, galena and pyrite were present in the ores. Some of this ore was reportedly very rich in secondary silver ores. The Bradbury group (Lukes Mine) also contained high-grade ore similar to that found in the Cougar. It has reportedly produced at least $200,000.

Tiger Mine: Located in Sec 22, T10N, R1W about 2 miles south-southwest of Crown King. Property consists of 9 patented and 10 unpatented claims. The principal vein strikes from N10°E to N15°W, and dips 60-70°W. It consists of white, dense quartz that contains small druses and finely disseminated pyrite. Other sulfides include sphalerite, galena and tetrahedrite. A rich ore shoot in the upper levels reportedly broke up into several smaller "primary" shoots in the lower levels, probably indicating supergene enrichment of surface ores. The principal vein is developed by a vertical shaft 750 ft deep with drifts along the vein on several leels. The country rock is granodiorite. The property is one of the oldest producers in the district. Total production, valued mostly for silver, is estimated at $750,000. At least 13,000 tons were milled and averaged 0.07 opt Au and 22 opt Ag. Lindgren (1926) mentions several other veins in the Tiger group that were explored.

M. & M. Vein: Located to the east of the Tiger group, the vein is reportedly part of the same system. Tunnel on vein is located on the Poland Creek slope at the foot of Wasson Peak. The vein strikes N18°E, dips steeply west and consists of a

small fissure; 2-3 ft wide, with 6" pay streak. Ore is partly oxidized and carries good silver values. Thoroughly oxidized material pans free gold. "Black Ore" consists of quartz and ankerite (with calcite) containing pyrite, galena, sphalerite and tetrahedrite. Some native silver is also present. Best ore contained $18 in gold and 180 oz silver per ton.

Del Pasco Group: (Sec 3, T10N, R1W.) One of the older mines in the district, worked mainly in the early days with considerable production reported. The Del Pasco vein strikes north-northeast and dips 70°W. Ore contained much sphalerite, pyrite and galena, but was valued chiefly for its gold with some silver. The "Jackson Strata", said to be a branch of the Del Pasco, was worked in 1922. This vein is said to be 2-3 ft wide and occurs in diorite intruded by rhyolite dike. Vein material is partly oxidized and ran $40 per ton.

Springfield Group: (Sec 16, T10N, R1W.) Located near the divide between Poland Creek and Pine Creek. The deposit is related to a porphyry copper breccia pipe containing chalcopyrite, pyrite and quartz with small amount of purple fluorite. Pipe is about 30 ft in diameter and produced two carloads of 12% copper ore. Disseminations and stringers of chalcopyrite occur in the Laramide granodiorite near the breccia pipe. Area was considerably trenched in the early days. This property was probably the claim block that Exxon drilled as a porphyry copper target in the 1960's-70's era. Alteration in the vicinity of the mine consists of sericite calcite and chlorite with abundant albite and quartz. Irregular stockwork veinlets of chalcopyrite occur with the albitic alteration. No figures were given on its precious metals content.

Wildflower: 13 patented claims located in Sec 10, T10N, R1W. Group contains 7 distinct veins. Wildflower vein consists of a quartz-sulfide filling; sulfides being abundant. Country rock is apparently a complex assortment of quartz diorite, diorite, quartz porphyry and amphibolite which reportedly is sericitized and contains disseminated sulfides. The occurrence may be part of a disseminated porphyry copper system. Vein sulfides, in order of abundance, consist of sphalerite, chalcopyrite and pyrite. Ankeritic carbonates were apparently deposited after the quartz and sulfides, in the center of the vein. Stopes averaged 5 ft in width and vein is reportedly opened for a distance of 4400 ft. Developed by a 60° inclined shaft 700 ft deep with levels at 110,200, 300 and 480 ft. Production between 1917 to 1919 amounted to $104,000 from 13,000 tons of ore. Two ore shoots were developed by 1918. Lingren (1926) cites a report by Weed that indicates 22,000 tons of ore were contained in the northern shoot and 32,000 tons were contained in the southern (Sabronje) shoot. Ore in the southern shoot assayed $1.20 in gold (0.06 opt), 6 oz silver, 12% zinc and 2-1/2% copper.

French Lilly Mine: (Sec 11 & 12, T10N, R1E.) Principal mine workings consist of an inclined shaft from which about 3500 ft of drifting has been done on 5 levels. Lowest level is 456 ft below collar of shaft. Workings follow a shear zone in Yavapai schist that has an average strike of N45°W, dipping 45° NE. Ore mineralization is confined to discontinuous stringers and lenses of quartz associated with fractured schist and gouge. Sampling of ore gives 5% Zn, 0.7% Cu., 0.6% Pb, 1.1 oz Ag and 0.30 oz Au per ton of ore. Over 2,000 tons were produced from 1922-1925.

References:

Arizona Dept. of Mineral Resources, Mine file data; DeWitt, 1976, 1979; Donnelly and Hahn, 1981; Keith and others, 1983a, 1983b; Lindgren, 1926; Wilson and others, 1967

PINE PEAK DISTRICT

Location:

The Pine Peak mining district is located directly to the west of the Diamond Joe district in the central portion of the Hualapai Mountains, Mohave County.

Geology and History:

Like the Diamond Joe (Cedar Valley) district, there is essentially no published data on mines and mineralization of the Pine Peak district. In actuality it is probably part of the Cedar Valley portion of the Diamond Joe district. Keith and others (1983a) broke the production of the area into separate districts. We will follow their convention and keep the Pine Peak area as a separate district.

Keith and others (1983b) describe the mineralization in the district as mid-Tertiary veins and replacement deposits associated with a NW-trending dike swarm. The district appears to straddle a regional northwest-trending contact between a Proterozoic granitic batholith and a somewhat older metamorphic complex of granites, gneisses and schists (see Plate 1). The dike swarm and mineralization have been probably controlled by this contact. Tectonic movement along the zone may have created a favorable site for hosting mineralization. Some of the mineralization has been described as being of a replacement character which is interesting. Perhaps there is potential for localization of low-grade, disseminated mineralization along the NW-trending contact zone.

Since so little is actually known about this region, it might warrant some type of an examination. The character of the ores appear to be base-metal rich. Keith and others (1983a) list recorded production between 1901-40 as amounting to 27,000 tons of ore which yielded 900 oz Au; 13,000 oz Ag; 90,000 lbs Cu; 178,000 lbs Pb; and 231,000 lbs Zn.

References:

Keith and others, 1983a, 1983b.

PORTLAND DISTRICT

Location:

The Portland mining district is located on the western flank of the central portion of the Black Range. The district lies in the NE¼ T23N, R21W.

Geology and History:

The Portland mining district essentially consists of the Portland mine which was discovered about 1920. Thus, the history of the district is that of the Portland mine. This portion of the Black Range is underlain by Miocene volcanic rocks that Longwell (1963) has mapped as Mount Davis (12.3 m.y. median age; Anderson, 1971) volcanics equivalents. Longwell (1963) and Anderson and others (1972) describe the Mountain Davis volcanics as including a variety of clastic and volcanic rocks ranging in composition from rhyolite to basalt, together with beds of tuff and thick coarse rubble. On the basis of nine K-Ar dates from widely spaced localities, the eruption of the Mount Davis volcanics span about a 3 m.y. interval of late Miocene age (14.6-10.9 m.y.; Anderson, 1971). This period of volcanic activity also coincided with intense tectonism in this area. This tectonic activity is evidenced in the mountains bordering the Colorado River south of Lake Mead by large displacements on interrelated systems of stacked normal faults (many as low-angle normal faults) and transcurrent faults (Anderson and others, 1972). Anderson and others (1972) envision the resulting structural pattern as consisting of large-scale lateral movement of separately distended thin plates that have moved several miles past or over one another on the interrelated systems of low-angle and transcurrent faults. This several miles of surficial ("thin-skinned") east-west extension was accompanied by widespread shallow plutonism in this area. Many of these shallow, low-angle faults host epithermal precious metals deposits. The Portland mine apparently is hosted by such a fault. Although Longwell's mapping (1963) does not indicate such a fault, Wilson and Moore's (1959) Mojave County geologic map shows a major fault in the Tertiary volcanic rocks along which the Portland mine lies. Longwell (1963) notes that many small intrusions (unmapped) cut the Mount Davis Volcanics in this area, especially near the Portland mine.

Mineralization along the Portland structure consists of a chalcedony-calcite-fluorite vein system that contains gold-silver values in about a 1:2 ratio. Keith and others (1983a) combine the production of the Portland and Pilgrim districts and list the total under the Pilgrim district. Recorded production for the Portland mine as contained in unpublished USBM data (Keith, personal commun., 1985) amounts to some 118,300 tons of ore from which was recovered 23,400 oz Au and 54,350 oz Ag. These figures may be somewhat low as unpublished files at the ADMR indicate that between 1935 and 1940 the Portland mine produced 132,000 tons of ore which averaged about 0.20 opt Au. Since the late 1970's the mine has been explored by a number of companies. Western States Mining Co. presently controls the property and is in the process of placing a small ore body (600,000-750,000 tons grading ± 0.08 opt Au) into production.

The Portland fault, if not already explored along its length, would seem to be deserving of additional attention. Wilson and Moore's (1959) map shows the fault as having some 3 miles or so of strike length with the Portland mine occurring at its very southern end of the system.

Mines of Interest:

Portland Mine: Sec. 15, T23N, R21W. The Portland mine develops an extensive quartz (chalcedony)-calcite-fluorite vein system that occurs along a low-angle normal fault that strikes roughly NS and dips 26°E. An EW fault system that dips 47°N intersects the low- angle structure and may help to localize the mineralization. The deposit was discovered in about 1920. The mine's major production occurred between 1935 and 1940 when about 132,000 tons of ±0.20 opt Au ore was mined and milled. In 1973, estimated reserves amounted to 287,000 tons averaging about 0.19 opt Au. Shattuck Den Mining Co. examined the mine in the 1950's, but produced no ore. In 1978-79, ASARCO performed underground sampling and hammer hole drilling. Fischer-Watt optioned the property in the early 1980's and did considerable work on the property. JORNIEX, a small Canadian company, picked up the property after it was dropped by Fischer-Watt and brought in Western States Mining Co. as a joint venture partner. JORNIEX failed to meet its financial obligations to the joint venture and the property has since come under Western States complete control. Drilling by the previous exploration has succeeded in outlining a shallow dipping (26°) orebody that contains 600,000-750,000 tons of open pitable ore that averages about 0.08 opt Au (Steve Thomas, personal commun., 1985). Western States is presently stripping waste and completing a milling and crushing plant. This mill will have some gravity concentration circuit before the material will be placed on the heap leach pile. Mill completion is scheduled for sometime in March, 1985 and production is anticipate to commence immediately.

References:

Anderson, 1971; Anderson and others, 1972; Arizona Dept. Mineral Resources, mine file data; Keith and others, 1983a; Longwell, 1963; Wilson and Moore, 1959.

QUIJOTOA DISTRICT

Location:

The Quijotoa mining district lies directly east of the Gunsight Hills district in the central part of Pima County. The district covers a chain of mountain ranges that are named, from north to south, the Brownell Mountains, the Sierra Blanca, the Quijotoa Mountains, the Sierra Blanca, the Quijotoa Mountains, Ben Navis Mountain, and South Mountain (Keith, 1974).

Geology and History:

The geology of the district is described on recent geologic maps by Rytuba and others (1977) and Briskey and others (1978). The geology and tectonic history of the area is complex and aspects of these subjects have been addressed by Haxel and others (1980, 1984) who present a regional picture of Cretaceous and Tertiary orogenesis in southern Arizona.

In order to understand the geologic setting of the Quijotoa district one must have a brief overview of what is believed to have happened at the Cretaceous-Tertiary (Laramide) boundary in this part of Arizona. A very brief synopsis of Haxel and others story (1980, 1984) is as follows. Rocks in a number of mountain ranges in this part of Arizona are juxtaposed by thrust faults, regionally metamorphosed and intruded by garnet-two mica (anatectic) granites. Field relationships and isotopic geochronology indicate that these phenomena were closely related aspects of a latest Cretaceous and early Tertiary orogenic episode. The regionally metamorphosed rocks, mainly greenschist-facies quartzo-feldspathic schists, were derived from Jurassic and Cretaceous sedimentary, volcanic and plutonic sources. In at least 5 ranges in this part of Arizona, including the Sierra Blanca, these metamorphic rocks are overlain along syn-metamorphic thrust faults, by Precambrian gneiss or Late Jurassic or Late Cretaceous plutonic rocks (see Figure 15). All but one of the known and inferred thrusts have single lower plates. The regional structural relationships and the distribution of distinctive Jurassic igneous rocks in both upper plates and fensters suggest the presence of a regional allochthon in which the exposed rocks in many of the ranges, including those exposed in much of the Quijotoa district, are allochthonous. The regionally metamorphic rocks are intruded by synmetamorphic to post-metamorphic early Tertiary leucocratic granites of crustal anatectic derivation. Isotopic age dating suggests that the orogenic episode began in Late Cretaceous time and culminated in early Tertiary time (58-60 m.y.B.P.). The relationships of the above described features lead Haxel and others (1984) to speculate this episode of orogenesis involved crustal compression that caused overthrusting of crystalline rocks, produced crustal thickening in conjunction with conductive and magmatic heat flux from the mantle which resulted in regional metamorphism and generation of anatectic granites. Much of the region was later affected by middle Tertiary low-angle normal faulting that resembles faulting associated with core complexes in other parts of Arizona.

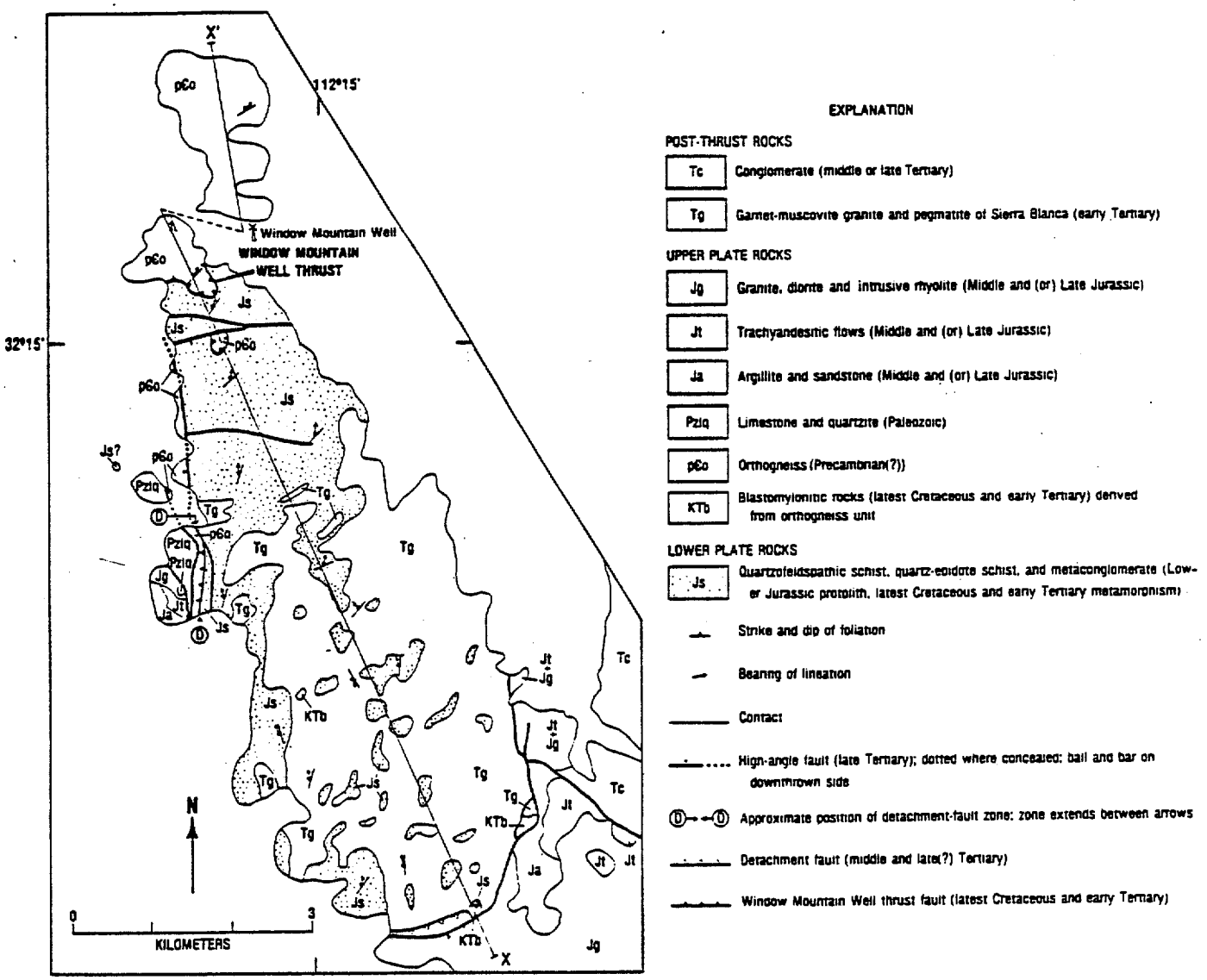


Figure 15 Simplified geologic map of the Sierra Blanca (see Fig. 2 for location). X-X' marks line of generalized cross section (Fig. 13). Thin band of blastomylonitic rocks just above Window Mountain Well thrust is not shown (but see Fig. 13). Complex geometry of inclusions of schist and metaconglomerate (unit Js) within granite of Sierra Blanca (unit Tg) and of intrusions of granite within schist and metaconglomerate unit is highly generalized. Trachyandesitic flows unit (Jt) includes minor dacitic and(or) rhyolitic flows. Foliation and lineation are sparse to absent in northeast part of granite of Sierra Blanca. Position of detachment zone on west side of range is indicated schematically.

(From Haxel and others, 1984)

Haxel and others (1984) have shown that, with the exception of a small fenster in the Sierra Blanca Range, most of the rocks that crop out in the Quijotoa district are in the upper plate of the regional allochthon described above. Parts of the ranges are covered by middle Tertiary volcanic and sedimentary rocks that are post thrusting.

The oldest rocks in the district consist of augen orthogneiss of Precambrian(?) age (Haxel and others, 1984) in the Sierra Blanca that overlie quartzofeldspathic and epidote-quartz paraschist along the "Window Mountain Well" thrust. Another segment of this fault crops out along the west side of the Sierra Blanca range. Haxel and others (1984) claim that in both areas the thrust is synmetamorphic because foliation and lineation in protomylonites at the base of the upper plate are parallel to the corresponding fabric elements in the schist of the lower plate. The Sierra Blanca is considered a fenster in the Window Mountain Well thrust. Middle Tertiary, low-angle detachment-like faulting approximately coincides with the trace of the thrust fault on the western side of the Sierra Blanca. Only the detachment fault is shown on Plate 1. A similar detachment-type fault is located on the southern margin of the range along the edge of the Sierra Blanca garnet-muscovite granite.

Upper-plate Jurassic granitic and supracrustal rocks (mainly Mesozoic sediments and Late Cretaceous [or Jurassic ?] volcanic rocks), dissimilar from rocks in the Sierra Blanca, are in fault contact with rocks on the southeast side of the Sierra Blanca and make up the bulk of the outcrops in the Brownell and Quijotoa Mountains. These rocks are similar to upper-plate rocks in the Comobabi Mountains to the east, and are inferred to belong to the upper plate of Window Mountain Well Thrust (Haxel and others, 1984). Fault-bounded bodies of Paleozoic quartzite and limestone and Jurassic granitic and supracrustal rocks on the west side of the Sierra Blanca are also believed part of the upper plate.

The Sierra Blanca garnet-muscovite granite is thought to be anatectic in origin. Haxel and others (1984) state that field relationships show the granite as being mainly post-metamorphism and post-thrusting. Some early phases of this pluton, however, may have overlapped the thrusting and metamorphic event.

Small, local concentrations of base and precious metals, barite and minor rare-earth minerals are scattered throughout the Quijotoa district (Keith, 1974). Wilson and others (1967) note that quartz veins and hematitic brecciated zones are numerous in the district, and that while some have yielded spectacular gold specimens, they have yielded only small production of gold ore. Ore mined in the past has been largely restricted to high-grade and enriched pockets of free gold and silver chlorides that occur locally in, or adjacent to, oxidized and mineralized faults or fracture zones (Keith, 1974). Quartz, calcite, hematite, manganese oxides, with some fluorite and barite, are the gangue minerals. Small amounts of uranium are also present.

Early prospecting in the district is said to date back to the days when the Jesuit and Franciscan fathers were trying to establish missions in Northern Sonora and southern Arizona. In 1883, a small rush resulted to the area by the

discovery of a rich silver pocket on Ben Nevis Mountains. The rush died with the exhaustion of the rich ore pockets. Since then, mining has been rather sporadic. Gold placers in the Horseshoe Basin and others local areas have been worked sporadically by dry methods.

Keith (1974) lists estimated and reported production of the district through 1972 as some 15,600 tons of ore containing about 11,600 oz Au; 245,000 oz Ag; 61 tons of Cu; and 29 tons of Pb. The amount of placer gold recovered is unknown. Johnson (1972) estimates total placer gold production since 1774 amounts to about 15,000 ounces.

Mines of Interest:

Heldorado (Mockingbird) Mine: (T15S, R2E, W. Cen. Sec. 13; E. Cen. Sec. 14) Spotty free gold and silver chlorides with minor copper and lead mineralization occur in quartz-calcite-hematite stringers. Mineralization is found in flat-lying fissures in Cretaceous (?) volcanic rocks. Exposures which have been worked at many places are quite small, but persistent. Workings consist of shaft, tunnel and open cut operations. Property consists of 9 claims (probably patented). Mineral occurrences are as lenses except at the Silver Queen where most of work has been done. At the Silver Queen, ore occurs in a quartz filled vein which dips about 70° and is traceable for some distance. Considerable work reportedly has been done; much of which is now inaccessible. Lower tunnel was reported to have been the main source of production. Cross faults may cut the vein in the lower tunnel. USBM engineers examined the mine in 1936 and indicated remaining ore exposures were limited. Of three samples taken by them, the highest was 1.0 opt Ag and 0.14 opt Au. Keith (1974) reports production estimate of some 450 tons averaging 0.3 opt Au and 1 opt Ag.

Weldon Mine: (T16S, R2E, E. Cen. Sec. 3) Keith (1974) reports that spotty free gold and silver chlorides occur with base metal sulfides in pockety lenses of quartz, hematite, manganese oxides, breccia and gouge along a fault zone separating Laramide (?) volcanic rocks from a granite intrusive. Property worked from 1880's to early 1900's by shaft and tunnel operations. Production is estimated to have been about 2,500 tons of ore which contained 1 opt Au and 1 opt Ag.

By Chance Mine: (T14S, R2E, NE¼ Sec 12-protracted) The deposit is described as disseminations and fracture fillings of copper carbonates with hematite and limonite in a shattered and silicified rhyolite. The property was worked by a shaft and open cut operations. In the 1950's the property produced some 1900 tons of ore which graded 5 opt Ag and 1% Cu, which were sold as siliceous smelter flux. Ores also contain some gold. Property may have some potential for low-grade disseminated Ag-Au target.

Ben Lomand (McKay) Mines: (T16S, R2E; E. Cen. Sec. 11-protracted). Irregular, narrow, lensing quartz-calcite fissure veins that contain pockety, oxidized, gold-silver-base metal mineralization. Some of the gold ore is spectacularly

rich. Worked by tunnel and shaft operations in the 1880's. Also worked in 1932. Keith (1974) reports that early production amounted to some 100 tons of ore averaging about 10 opt Au and 20 opt Ag. Production in 1932 amounted to some 200 tons of ore averaging about 10 opt Au and 3 opt Ag.

References:

Arizona Dept. Mineral Resources, file data; Briskey and others, 1978; Haxel and others, 1980, 1984; Johnson, 1972; Keith, 1974; Rytuba and others, 1977; Wilson and others, 1967.

RAWHIDE DISTRICT

Location:

We have chosen to designate this district name to the broad population of precious metals occurrences within the Rawhide Mountains of southernmost Mohave County just north of the Bill Williams River. Our Rawhide district incorporates the Rawhide, Owens, Black Burro, Mesa, Cleopatra, Lead Pill, Artillery and Artillery Peak districts of Keith and others (1983). The area of interest appears on the Artillery Peak, Castanada Hills and northernmost Swansea and Ives Peak 15' quadrangles.

Geology and History:

The Rawhide Mountains represents the far northern portion of the Harcuvar metamorphic core complex and the geology is an extension of that of the Buckskin ranges south of the Bill Williams River in La Paz County. A widespread detachment fault surface of Tertiary age separates a lower plate of mylonitic, quartzofeldspathic gneisses and subordinate metasedimentary rocks, marbles and quartzites from an upper plate consisting of a mixed assemblage of Mesozoic or Precambrian granitic rocks, Mesozoic metavolcanic rocks, Tertiary sedimentary and volcanic sequences (Shackelford, 1976).

Lower plate mylonitic gneisses show penetrative, intergranular deformation, a general flattening and mineral grain elongation defining a northeast-trending lineation. Lit-par-lit injection of granitic material into the shallow-dipping foliation planes is common. As in the Buckskin Mountains the protolith identification of lower plate rocks is difficult to make. Tentatively, we believe the lower plate represents a tectonized and smeared out melange of Precambrian crystalline rocks, Paleozoic and possibly Mesozoic supracrustal cover which has suffered profound late Mesozoic thrusting, metamorphism and mylonitization followed by mid-Tertiary mylonitic shearing and detachment faulting.

Upper-plate assemblages are chaotically faulted and tilted by listric-style faults with predominant southwest dips. Even lower plate mylonitic gneisses shows a dominant southwest dip and so an underlying lower detachment fault may lie hidden in the subsurface. Erosional exposures of the upper detachment surface reveals a broad domal morphology to the flat fault which is modified by ENE-trending flexures of low-amplitude. The overall arch and detachment is cut by several NW-striking, high-angle, oblique dip-slip and reverse faults. One of these faults, the Sandtrap Wash, is down to the northeast and forms a northeast structural boundary to the detached Rawhide province. Northeast of the Sandtrap Wash fault, the Artillery Mountains expose a fairly extensive sequence of Tertiary sedimentary rocks (Artillery and Chapin Wash Formations) exhibiting complex structural relationships with nonmylonitic (?) Precambrian rocks. Chief among these complexities is the enigmatic Artillery thrust (?), a low angle south-dipping structure which places brecciated Precambrian (?) granitic gneisses atop a southwest dipping section of Artillery Formation basalt and interbedded sediments. The Tertiary layered rocks appear to be depositional upon granitic basement in the immediate Artillery Peak area. In

the northern Artillery Mountains and Black Mesa area (north half of Artillery Peak 15' quad), exposures of nonmylonitic Precambrian granitic rocks are flanked and covered by reddish colored, terrigenous, Tertiary sedimentary sequences (Chapin Wash Fm. ?) which appear to interfinger with Miocene tuffs and ash flow deposits. The black basalts (~10 m.y.) which form the flat-lying flows of Black Mesa cover, the felsic volcanics and redbed deposits (Rehrig, unpubl. field notes).

Mineral deposits of the Rawhide region consist of three types: (1) manganese deposits primarily in Tertiary redbeds and volcanics of the Artillery Mountains and Black Burro subdistrict, (2) copper-gold occurrences associated with the Rawhide detachment surface, and (3) gold occurrences with or without associated copper in the Madril Peak and Lead Pill subdistricts. The copper-gold detachment occurrences which are concentrated in the Rawhide Mountains are by far the most extensive. They closely resemble detachment localized deposits in the Buckskin Mountains of La Paz County (see Santa Maria district descriptions) where oxidized copper minerals (chrysocolla, carbonates), hematite (earthy and specularite), gold and quartz occur in carbonate host rocks right above the flat detachment fault surface. Generally in the Rawhides, grades of gold mineralization are fairly (~0.05 opt) but the size of the deposits is typically small. At some mines such as the Cleopatra, rhyolite sills or dikes are spatially related to the mineralization. In the Madril Peak and Potts Mountain (Lead Pill) areas, poly-metallic occurrences of precious metals, barite and black calcite, with or without copper may be related to felsic intrusive bodies which cut basement granitic rocks that are outside or north of the mylonitic, low-angle foliated basement of the Rawhide province. Here the gold-silver ratio is significantly lower than for the Rawhide deposits and copper is more deficient, or absent altogether. Mineral occurrences in the Artillery Mountains are mainly manganese, calcite vein and replacement deposits occurring in Chapin Wash redbeds or interstratified volcanic rocks.

Mines of Interest:

Bonanza mine (T11N, R14W, Sec. 24) Numerous prospect pits, drift and shallow shaft pursue copper-gold-hematite showings as one 3-5 ft wide vein and in scattered fractures. Mineralization associated with Paleozoic klippen resting on the Rawhide detachment surface. Grab sample from several dump piles assayed 0.07% Cu, 0.025 opt Au, and 0.05 opt Ag.

New England mine (T11N, R14W, Sec. 10) Located on the southern slopes of Miller Mountain, the mine and numerous prospects have worked copper carbonate and gold as veins and replacements in Paleozoic limestones resting on the Rawhide detachment fault. One vein is reported as being 2 to 4 ft wide. Ore is said to run from $8 to $25 per ton (at $35/oz) in gold, 8 to 10 opt Ag, and 1-2% Cu. One 2 ft sample across the main vein assayed 0.1 opt Au, 0.05 opt Ag, and 2.4% Cu. Property is said to have produced $40,000 worth of ore. Engineering report by E. Holt (1943) quotes four samples of 2 to 3 ft quartz veins in limestone as running 0.02 to 0.36 opt Au and 2 to 9% Cu.

Little Kimble mine (T11N, R14W, Sec. 23) Several shafts and workings located at the head of Mississippi Wash have produced copper (oxide carbonate)-gold ore from a prominent, northwest-striking shear zone cutting lower-plate mylonitic gneisses. Quartz and silicification occur in the vein. Parallel veinlets occur. Property produced $76,000 from early 1900's to 1943.

Big Kimble mine (T11N, R14W, Sec. 34) A prominent and persistent vein trends northwest and dips 70°. Its width is 4 to 8 ft and it cuts lower plate mylonites. Over 600 ft of drift workings accessed by two shafts are present. Mineralization is gold and small amounts of copper carbonates and silicates. Sample results: 2 ft cut of 0.1% Cu, 0.035 opt Au and 0.2 opt Ag; 3 ft cut of 0.59% Cu, 0.03 opt Au, and 0.2 opt Ag; 3 ft cut of 0.31% Cu, 0.005 opt Au, and 0.2 opt Ag.

Deer Trail-Rawhide mines (T11N, R13W, Sec. 18) Gold, minor silver, copper and iron-manganese oxides occur traceable over 1,000 ft in severely faulted and southwest tilted Tertiary Chapin Wash Formation, redbeds at the Rawhide detachment surface. Ore grades are estimated at $8/ton (at $36/oz) and one 0.02 opt assay is reported.

Cleopatra mine group (T11N, R14W, Sec. 4) An apparent "blanket" of copper-gold mineralization replaces silicified Paleozoic (?) carbonates along and just above the Rawhide detachment surface. Quartz porphyry sills are reported to intrude the detachment in both upper plate and lower plate rocks. The mineralized zone is said to measure about 600 by 1,200 ft in areal extent with a thickness in the 10 to 20 ft range. Estimates of mineralization volume range from 1/2 to 3/4 million tons. Limited tonnages of ore previously shipped ran just over 2% Cu and from 0.02 to 0.21 opt Au. Engineering reports from the period 1913 to 1917 gave grades of 2-3% Cu and $4-$7/ton Au (at $10/oz). A 1919 consulting report quoted 7 samples averaging 1.59% Cu and 0.05 opt Au. A consulting report from the 1960's assayed the ore at 1.83% Cu, 0.12 opt Au and 0.18 opt Ag.

Silverfield mine group (T10N, R15W, Secs. 5 & 6; T11N, R15W, Secs, Secs. 31 & 32) Numerous prospects, small mines and workings occur in this area of the southern Rawhide Mountains just north of the Bill Williams River and Rankin Ranch. Mineralization is gold with oxides of copper and minor specular hematite which replace irregular masses of gray brecciated carbonate. Where copper-gold occurs, the carbonates are always flooded with varying amounts of secondary quartz. At some localities, Chapin Wash redbeds, clear quartzites, and gray-green phyllites are complexly and chaotically mixed with the brecciated carbonate lenses, layers, pods or mounds. This entire mineralized assemblage occurs resting upon the Rawhide detachment fault. All the prospects occur just above this surface. The highest grade area of gold occurs at the small Silverfield mine (W½ Sec. 32) where surface trench samples yielded values in excess of 1 opt. Numerous gold anomalies and showings occur in the varied upper plate lithologies (principally brecciated carbonate) just above the detachment surface along a NE-SW trending zone through the southeast half of

Section 31 and northeast portion of Section 6. At many of the mineral localities, geochemical results are impressive in gold but the extent of mineralized rock is quite small.

Anschutz Mining Corp. acquired and worked the area from 1981 to 1983. Their geologists interpreted the upper plate quartz and carbonates as hot spring exhalite deposits intermixed with Chapin Wash strata. Anschutz did not do any drilling.

Inspection of the area by Rehrig (1983 and 1984), led to recognition of close similarities between Silverfield and certain mineralized areas in the Buckskin Mountains (i.e. Swansea, Copper Penny, Clark, Planet), especially in regard to the carbonate breccia which is so common to all these copper and copper-gold occurrences. Although hot springs type deposits cannot be ruled out, it is our opinion that the Silverfield setting is an extremely complex upper plate mix of hydrothermal replacement carbonate, detached pieces of Paleozoic sediments, and tilted blocks of late Tertiary Chapin Wash sediments which may contain lacustrine or hot spring sinter deposits. Mineralization is superimposed into this chaotic assemblage through the introduction of quartz from some unknown source.

Although surface gold-copper occurrences are numerous, none are of sufficient size to warrant much interest. The environment could however house blind deposits that collectively may display favorable tonnage-grade parameters. Exploration for such bodies would required careful and comprehensive work.

Potts Mountain area (Mahogany, Lead Pill, Red Top mines) (T2N, R14W, Sec. 23) On the south, north and east slopes of Potts Mountain, gold, silver, black calcite, high-grade barite veins, pods and "mantos" occur in host rocks of intrusive dacite to rhyolite which intrude Precambrian biotite granitic rocks (nonmylonitic). Grades in ore run from ~1 to 7 opt Ag and from 0.16 to over 8 opt Au. At the Mahogany mine a 3 to 5 ft vein cuts altered rhyolite and dips 45°. Other veins cut diabase to the south. Combined gold-copper value to the ore runs $20 to $50/ton at 1943 prices. Copper is said to run 3 to 6%. Barite may add significantly to the economics of the orebodies.

References:

Arizona Dept. Mineral Resources, file data; Rehrig, unpubl. field notes; Shackelford, 1976; Unpubl. prospect reports.

RELIEF DISTRICT

Location:

The Relief district is located in the small group of hills west of the Hedgpeth Hills and southeast of Calderwood Butte about 5 miles north of Sun City, Arizona.

Geology and History:

The Relief district is essentially composed of the Sunrise-Relief mine (or Relief mine), which is mislocated on the topographic map of the area. The area has been historically referred to as part of the Agua Fria district which encompasses a large area adjacent to the Agua Fria River drainage basin in northern Maricopa County. Due to confusion with the Agua Fria district in Yavapai County, the Relief district is preferred in this report.

The Relief mine was discovered in 1883 and is the only mine in the district to have recorded production. Keith and others (1983a) credit the mine with 2,600 oz of Au and 200 oz Ag from 8,000 tons of ore for the period 1904-1915. Old mine reports indicate actual production could be as much as $300,000 (±15,000 oz Au). This writer estimates total production for the district (all from the Sunrise Relief mine) between 3,600 and 15,000 oz of Au.

The geology of the district consists of deeply weathered Precambrian granodiorite, that forms small hills rising to a maximum relief of 500 ft above the surrounding countryside. A pedimented surface circumscribes the hills and quickly grades into alluvium. A dioritic border facies of the granodiorite pluton is locally present. Small, poorly exposed pendents and/or xenoliths of Precambrian schist crop out in the southern part of the area and probably indicate that the plutonic margin is nearby. A small, leucocratic granite body intrudes the granodiorite about 200 meters west of the main Relief incline. This plug has been mapped as Laramide on the state map, but from its appearance we believe it is probably of Tertiary age. Fault or shear zones cut the granitic rocks and have served as channelways for both diabase dikes and later gold-bearing solutions.

Gold bearing veins occur in a nearly east-west trending crushed zone that dips approximately 45° to the north. Diabase dikes that intruded this zone have been crushed and sheared as well. The gold-bearing quartz veins and pods were later deposited along this same zone. Old reports (Arizona Department Mineral Resources files) indicate the ore was free milling with gold being the only metal of value. Gold occurred in the quartz material, in the sheared and broken diabase and as disseminations in the hanging wall. Stopes averaged about 5 ft in width, but reportedly widened to as much as 20 to 30 ft in places. The average grade of ore mined through 1916 was about 0.30 opt Au. (12,000 tons minimum of material).

Two subparallel vein systems appear to be present in the district. The northern-most one is the Relief vein from which the only known production has come. The other major vein system (Bandon vein) lies 600 to 900 ft south of the Relief vein and has a similar strike and dip. While the Bandon vein is

geologically similar to the Relief vein, it has had little exploration and no production. Underground stope maps of the Relief mine indicate that values were sub-economic until depths of at least 80-100 ft were reached. Surface assays along the Bandon vein give sporatic, generally low, gold values. This is not necessarily discouraging, considering the upgrading with depth that occurred at the Relief mine.

A moderate potential for some small tonnage of underground reserves may still remain in the two vein systems. While the district lies near the edge of the Phoenix metropolitan area, it is believed that most of the ground is patented and within an area of unincorporated Maricopa County which might not receive too much opposition about exploration. The area of mineralization is so small, however, that if the Relief and Bandon Veins cannot be both picked up, then work on either by itself is probably not warranted.

Mines of Interest:

Sunrise-Relief: (Sec 3 & 4, T4N, R1E.) Historical production between 3,600 and 15,000 oz Au prior to 1926. Lower production figure is probably most accurate. Old reports indicate that the mine was purchased in 1926 by an old Phoenix mining entrepreneur who reportedly spent some $250,000 in developing reserves that were estimated at between 35,000 to 60,000 tons. More than 5,000 ft of underground workings were supposedly developed. Before this could be mined, the man died leaving his estate in debt. Liens against the property apparently brought foreclosure and sale of the property. There is no indication that if this reserve did exist that it has ever been mined. Thus, there is some potential that 35,000 to 60,000 tons of probably 0.30 opt material may be left in this mine. Some underground examination and sampling is probably warranted.

Bandon Mine: (Sec 3 & 10, T4N, R1E.) No historical production, but vein system is subparallel with, and geologically similar to the Relief vein. The prospectus of Glendale Mining and Milling Co. (1916) notes that a crosscut driven for water storage at the 500 ft level of the Relief mine encountered a 14 ft quartz vein some 325 ft south of the Relief vein. Assays indicated the character and average grade to be similar to that in the upper levels of the Relief. The vein was not developed at that time due to difficulty in handling the flow of water that was encountered in the crosscut. The only major vein system south of the Relief is the Bandon Vein. It seems likely that the vein reportedly cut in the crosscut is the downdip extension of the Bandon vein, particularly if the Bandon vein flattens somewhat with depth. Mr. Allen Luhrs of Phoenix, owns 2 patented claims on the Bandon vein.

References:

Arizona Department Mineral Resources Files; Prospectus of Glendale Mining and Milling Co. (1916); Keith and others, 1983a; Unpublished data AGS; Wilson and others, 1967.

SALT RIVER MOUNTAINS (DELTA) DISTRICT

Location:

The Salt River Mountains district is located in the central part of the South Mountains (mainly Sec 18 & 19, T1S, R3E and Sec 13 & 24, T1S, R2E) near the southern margin of the Phoenix metropolitan area. The district lies within the Phoenix South Mountain City Park and is withdrawn from mineral entry.

Geology and History:

The South Mountains (Salt River Mountains on early maps) are composed of two fundamentally different geologic terranes (Reynolds, 1982). Precambrian metamorphic and granitic rocks comprise the western half of the range, while a composite middle Tertiary (28-25 m.y. B.P.; Reynolds, 1982) pluton underlies much of the eastern half. Numerous, north-northwest-trending Tertiary dikes intrude both terranes.

The composite middle Tertiary pluton intrudes the Precambrian terrane and consists of three phases: a granodiorite phase that makes up most of the eastern half of the range, a granite phase, and a small alaskitic phase. In places these rocks display mineralized hydrofractures. Intense mylonitization of both Precambrian and middle Tertiary rocks accompanied and post-dated Tertiary plutonism. Mylonitic rocks form a doubly plunging, northeast-trending foliation arch in the range. Mylonitic deformation was followed by brittle deformation which produced chloritic breccia. This chloritic breccia overlies mylonitic plutonic rocks in the northeast half of the arch and is probably related to a low-angle dislocation or "detachment" surface (Reynolds and Rehrig, 1980). The South Mountains rocks constitute a deformed package that is consistent with metamorphic core complex terranes elsewhere in Arizona (Reynolds and others, 1978; Reynolds and Rehrig, 1980).

Gold (± silver and copper) was discovered in the South Mountains prior to 1900, but recorded production only occurred between 1913 and 1942. The Max Delta (or Delta) mine was the major producer in the district and was in continuous operation between 1933 and 1942 when it yielded some 6,200 oz of gold and 4,300 oz of silver (unpublished records of Ace Mining Co; Reynolds, 1982). The average grade of the recovered ore was 0.45 opt Au, 0.32 opt Ag, and .09% Cu (Reynolds, 1982). A total of nine mines have historically yielded some production in the district. Keith and others (1983a) list total district production as 7,000 oz Au, 5,000 oz Ag and 28,000 lbs of Cu. The average recovered grade of ore produced from mines other than the Max Delta is given by Reynolds (1982) as 0.55 opt Au and 0.45 opt Ag.

The gold occurrences are aligned along a north-northwest trend that parallels the contact of the middle Tertiary granite and Precambrian gneiss and are spatially associated with a similar trending swarm of Tertiary felsic and dioritic dikes (Fig. 16). The veins predominantly strike north-northwest or northwest (Reynolds, 1982) and dip 60° to the east. Based on age dates, mylonitic fabrics and cross-cutting relationship of the Tertiary dikes, Reynolds (1982) believes that

Figure 16 Distribution of gold mines and prospects in the South Mountains. -- Mines and prospects are shown in black. Tertiary plutonic rocks are patterned; Precambrian rocks are left unpatterned. Selected dikes of the western dike swarm are shown with hatched lines. (From Reynolds, 1982)

the veins are the same age as dikes that are syn-to late-kinematic with respect to mylonitization and which were emplaced into north-northwest fractures that were forming in response to east-northeast extension. He believes that the gold was deposited by hydrothermal fluids whose source was probably the middle Tertiary granite or genetically related dikes.

References:

Keith and others, 1983; Reynolds, 1982; Reynolds and others, 1978; Reynolds and Rehrig, 1980; Wilson and others, 1967.

SANTA MARIA DISTRICT

Location:

The district also known as the Planet, Swansea or Bill Williams district takes in metal occurrences distributed through the western Buckskin Mountains between the Alamo district on the east and the Cienega district along the Colorado River to the west. The area lies in northernmost La Paz County, adjacent to the Bill Williams River in R15 and 16W, T10N. The district is mapped on the Swansea 15' topographic quadrangle.

Geology and History:

The western Buckskin Mountains make up a portion of the Harcuvar metamorphic core complex, a widespread mylonitic metamorphosed and detachment fault terrain nearly continuous with the Whipple metamorphic core complex just west of the Colorado River in California (Rehrig and Reynolds, 1980; Davis and others, 1980; Wilkens and Heidrick, 1982). The gently arched ranges consist of mylonitic gneisses and schists, intensely intruded by plutons that vary in composition from diorite to 2-mica granite and pegmatite. Most plutonic rocks are deformed by the same ductile processes that have affected the metamorphic host rocks. The metamorphic rocks of the core ranges have experienced at least two periods of intense deformation and partial recrystallization. Both events resulted in shallow-dipping foliation and varying degrees of tectonic lineation. The earlier event was late Mesozoic age. Deep seated, relatively high temperature processes were involved. Thrusting may have accompanied the deformation. The later event was of Tertiary age and consisted of ductile mylonite development of extensional origin. Both Mesozoic and Tertiary deformations were accompanied by magmatism, the Tertiary phase being relatively high-level. Previously, the age of the Buckskin gneisses have been considered Precambrian. More recent work (Rehrig and Reynolds, 1980) suggests that some metamorphic protoliths in much of the terrain may be Mesozoic (plus Paleozoic?) sedimentary lithologies.

Flanking the Buckskin Mountain arches on most sides, and capping the mylonitic-metamorphic core sequences, is the Buckskin detachment fault above which upper-plate rocks have been profoundly faulted; tilted and altered and below which the mylonitic rocks are pervasively brecciated and propylitized. Upper-plate rocks in this region consist of Tertiary continental sedimentary and volcanic sequences (Artillery Peak and Chapin Wash Formations) and brecciated, highly faulted mixtures of Paleozoic and Mesozoic sedimentary and slightly metamorphosed rocks.

In the Santa Maria district region, peculiar carbonate lenses, layers or beds commonly occur at the detachment zone interface, always just above the mylonitic lower plate. The origin(s) of the carbonates have been difficult to assess. They have been considered as Paleozoic sediments, Tertiary lake beds, metasomatic replacement or even hot spring hydrothermal deposits. Actually all varieties may exist.

Post-mylonite rocks consist of dioritic intrusive bodies and common, NNW- to NW-trending dikes such as occur prolifically through the Harcuvar and Harquahala ranges. Post-detachment rocks include flat-lying basalt flows and intercalated conglomerates less than 15 m.y. in age. Post-detachment structures consist of high-angle northwest faults, some of which are normal, others of which display reverse or lateral slip (i.e. Lincoln Ranch fault).

Mineralization is extensive through the western Buckskin Mountains. Most prospects and mines show a close spatial association with the Buckskin detachment surface and are usually found within a few hundred feet structurally of this profound and laterally extensive discontinuity. This relationship between detachment and metal distribution is maintained through the neighboring Whipple metamorphic core complex as well (Figure 17) (Ridenour and others, 1982). Detachment mineralization of mid- to late Tertiary age typically encompasses the following suite of metallic and gangue minerals: pyrite, chalcopyrite, specularite, chrysocolla, gold, quartz, calcite and minor fluorite or barite, chlorite, and epidote. Manganese oxides and trace amounts of sphalerite or galena may also be present. Copper appears to always be present as the dominant economic metal. Gold accompanies the copper-hematite in many occurrences, but not in all.

Local structural and lithologic settings for detachment mineralization consist of the following: (1) Variably brecciated and propylitically altered plates of nonmylonitic rock ("middle plates") sandwiched between two detachment faults. Mineralization developed as disseminations, fractures fillings, veinlets, etc. in brittlely fractured, brecciated rock or as massive replacement and stringer ore bodies in carbonate rocks above the lower detachment surface; (2) Within listric fault zones of the upper plate or at their intersection with the detachment fault; (3) Within the crush zone of the detachment fault itself or (4) "Disseminated" within the chloritic-breccia zone of the lower plate. These localizing situations are diagrammatically shown in Figure .

With the exception of the Mineral Hill and Swansea mines, the occurrences in the district are small. Wilkens and Heidrick (1982) state that a total of 63 million pounds of copper; 11,900 oz gold; and 1,000 tons of manganese were produced from mines along the detachment surface. This estimate may include localities outside the Santa Maria district because Keith (1978) cites district figures of 1,405,000 tons of ore containing about 22,675 tons of copper, 24,606 oz silver, and 1,128 oz gold.

Mines of Interest

Swansea mine group: (T10N, R15W, Sec. 32) Known and prospected since the 1880's, the Swansea or Signal mine group has produced some 352,000 tons of copper ore. Average production grades ran about 3% Cu and 0.09 opt Ag. Only minor gold is reported, but no recoveries are given. Some 39 million pounds of copper were recovered. The mine lay idle between 1937 and 1959 when acquired by one of the present owners (J. Challinor). Since about 1979, various exploration groups have investigated the property. Some 50 holes have been drilled.

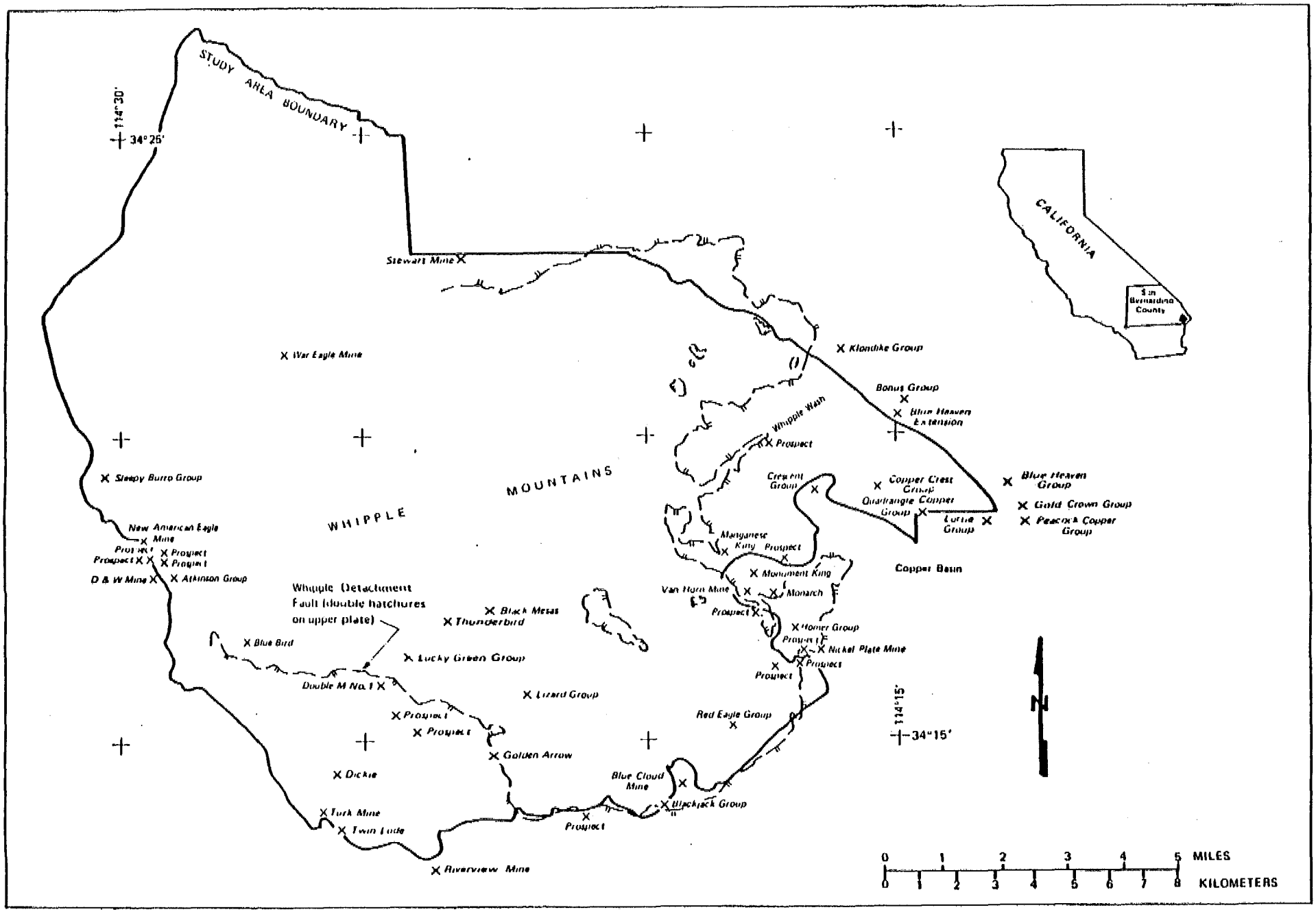


Figure 17.

Mines and prospects in the Whipple Mountains [illegible] Study Area [illegible]

Generally the high-grade Swansea ore bodies consisted of sulfide (pyrite and chalcopyrite) and specularite replacement masses of the irregular marble breccia which occurs upon the Buckskin detachment surface (Figure). The overall paragenetic sequence of mineralization consists first of the sulfide minerals closely tied to gangue minerals of quartz, epidote, chlorite. These minerals were then cut by calcite veinlets followed by specularite replacement and veining and finally by a late stage of carbonate mineralization. A lower grade, more disseminated style of mineralization has been delineated by post-1959 drilling. It consists of a disperse zone of disseminated and veinlet chalcopyrite, pyrite and bornite with specularite and native copper found in highly chloritic, "cataclastic" schists which host the carbonate breccia containing the replacement ore bodies. In addition, pyrite specularite with minor chalcopyrite have been reported from lower plate chloritic breccia beneath the detachment fault.

On the surface at the Swansea property, outcrops show a tectonic mixing of massive, light colored, carbonate breccia and gray, somewhat foliated carbonate with a chloritic nonmylonitic ("cataclastic" - Wilkens and Heidrick, 1982) schist. These rocks, which contain most of the Swansea ores, are thought to represent metamorphosed and deformed Tertiary Artillery Peak Formation in either a middle or upper plate position (Wilkens and Heidrick, 1982). It may be significant that no exposures or occurrences of intrusive rocks have been noted in the mine area.

Copper Penny prospect: (T10N, T15W, Secs. 35, 36) Thought to be a faulted extension of the mineralization at Swansea, the Copper Penny prospect was drilled by Gulf Mineral Resources in 1979 (Wilkens and Heidrick, 1982). Weak but pervasive sulfide-oxide metallization - pyrite, chalcopyrite, specularite, minor sphalerite, galena and manganese oxides were found in varying amounts throughout the lower, middle and upper plates of the Buckskin detachment system. Associated gangue minerals are calcite, gypsum, fluorite, barite, quartz and opal. The best mineralization (still uneconomic) is spatially centered upon the detachment faults, distributed between the following structural settings: (1) disseminations in chlorite breccia of the lower plate; (2) sulfide oxide replacements of reactive brecciated marble resting on the lower of two detachment faults (Figure 27a). The carbonate is exactly analogous to the carbonate hosting ore at Swansea. At Copper Penny, however, these replacements are rare; (3) open space or breccia filling at intersections of listric faults and detachment surface; (4) as gash and fault veins; and (5) as longitudinal fissure fillings along the crest or trough of large, low-amplitude folds. No significant gold values were reported as a result of Gulf's exploration.

Planet - Mineral Hill mines: (T10N, R16W, Sec. 6; T10N, R17W, Secs. 2, 10 and 11) The Planet mine, worked intermittently from 1863 to 1937, produced a minimum of 60,000 tons of ore running about 10% Cu, with minor Ag and Au (i.e. 200 oz). At the Mineral Hill deposit total production amounts to nearly a million tons averaging about 1.7% Cu with very minor gold and silver. Some 13 million pounds of copper were extracted from the large tonnages mined at Mineral Hill.

A 1978-79 exploration program was conducted by Cordex Exploration of Reno, Nevada, who drilled 15 holes between the Planet and Mineral Hill mines. The objective of the program was gold; reportedly only a few relatively minor gold-bearing listric fault zones were discovered and the venture was discontinued.

Based on drilling and surface mapping, a schematic cross section has been constructed between the two mines, some 2 or 3 miles apart (Figure 28) (Wilkens and Heidrick, 1982). The Buckskin detachment surface forms the fundamental control for mineralization. The lower plate is made up of the typical, foliated and lineated augen gneisses. In the upper plate is a homoclinally tilted sequence of Mesozoic (?) metasedimentary and metavolcanic rocks. Note from Figure that above the detachment chloritic breccia zone, occurs at several positions along the section, thin wedges and layers of marble breccia like those at Copper Penny and Swansea localities. Because of their roughly conformable attitude with respect to the detachment, and discordancy with respect to upper plate bedding, the carbonate deposits cannot be Paleozoic beds or Tertiary lacustrine strata.

Mineralization at Planet-Mineral Hill consists mainly of specularite and chrysocolla (± copper carbonates) derived from chalcopyrite. Sulfides and oxides replace marble breccia. Drill holes into the detachment chloritic breccia documented microveinlet and disseminated hematite, pyrite, chalcopyrite and rare native copper. At the Planet deposit cryptocrystalline silica pervades the marble breccia above the detachment surface in the mineralized zones.

Angelus mine: (T10N, R17W, Sec. 1) Located in the highly fractured upper plate of the Buckskin detachment between Mineral Hill and Planet mines, the Angelus property produced gold within a brecciated, silicified, and sericitized Mesozoic or Paleozoic quartzite horizon. Production amounted to some 100 tons running about 1 opt Au and 0.2 opt Ag. Note the conspicuous absence of the copper-hematite. Could this occurrence be related to Mesozoic metamorphic or syngenetic processes as at some localities in the Granite Wash Mountains?

Argus and Maryland mine group: (T10N, R16W, Sec. 6) Workings are located next to the Planet mine. Mines produced copper ore with good gold values from the detachment fault. Hematitic ore (± 250 tons) averaging about 3% Cu, 0.4 opt Au, and 0.2 opt Ag was taken as replacement lenses and bodies from brecciated marble above the flat fault.

Moro mine group: (T9N, R15W, Sec. 3) A mineralized zone containing earthy and specular hematite, chrysocolla (± copper carbonates), quartz barite, traces of fluorite and significant gold is confined as a shallowly south dipping, tabular body along the Buckskin detachment fault. Ore zone is found immediately above the dense, chloritic breccia zone of the fault. The characteristic, gray carbonate breccia in 1-3 ft thick lenses conformably overlying the fault occurs in the mine area but, unlike at Swansea, is not the host for ore (see Figure). The mineralized zone appears developed in crushed, brecciated upper plate rocks of Chapin Wash redbeds (arkoses, conglomerates) and volcanic rocks. The zone is

silicified in part and possibly intruded by a flesh-colored, rhyolite porphyry containing abundant small zenolith fragments. The porphyry is gold-bearing and cut by secondary quartz veinlets.

The mineralized detachment zone is about 5 to 15 ft thick and appears to outcrop or extend around a small, oblong hill about 1/4 mile wide and 3/4 mile long. The hill is capped by Chapin West Formation with strata tilted moderately to the southwest. Sampling yields common multi-ppm values of gold (i.e. 2-15) through the zone, but concentrations probably are quite erratic.

The mine group has been worked sporadically from early 1900's to mid-1950's, producing some 2,300 tons of 3% Cu and minor Au, Ag. Within the past two years, the property was leased to American Gold Corp. of Denver (Raymundo Chico) and close-spaced drilling was carried out over the more exposed west end of the mineralized zone. The results are not known. Currently the mine workings and surrounding area has been staked by Phelps Dodge Inc.

Clara mine group: (T10N, R15W, Sec. 35) Workings explore a Buckskin detachment zone exposed by erosion about 1 mile due east of Clara Peak, a prominent klippe of tilted upper plate Chapin Wash beds. Mineralization of chrysocolla, some chalcocite and gold-silver within brecciated fault zone material (upper plate ?) and characteristic brecciated carbonate lenses. Jasper and silica are reported in the zone. Workings produced 50,000 tons of 4.7% copper grade with values in gold and silver. Surface grab samples run high in gold (few ppm to 1 oz).

Revenue mine group: (T10N, R15W, Sec. 31) Workings are located just over a mile due west of the Swansea mine and produced only small quantities (200 tons) of hematitic, copper ore (2% Cu) carrying minor gold. The setting for mineralization is the same as at Swansea and Copper Penny areas; that is, as replacement lenses in carbonate masses resting upon the detachment surface.

References:

Bancroft, 1911; Keith, 1978; Heidrick and others, 1980; Wilkens and Heidrick, 1982; Arizona Dept. Mineral Resources, file data; Rehrig, unpubl. field notes.

SHEEP TANKS DISTRICT

Location:

The Sheep Tanks mining district covers the northwestern part of the Little Horn Mountains, in T1N and T1S, R14 & 15W, Yuma County, Arizona. It is sometimes included with The Alamo Springs district which lies to the west.

Geology and History:

The oldest rocks exposed in the Sheep Tanks district consist of a sequence of middle Tertiary volcanic tuffs, flows and breccias of predominantly rhyolitic to dacitic composition. Wilson (1933) noted that these rocks have been intruded by diorite porphyry, which forms large, irregular cross-cutting masses along with sills and dikes. Cousins (1973) who studied the district for his masters thesis failed to note these diorite porphyry masses, but mentions that these rocks have been intruded by a quartz monzonite porphyry about six miles northwest of the district. Late Tertiary olivine basalts unconformably overlie the older felsic sequence which was strongly faulted and tilted before the basalts were erupted. Cousins (1973) describes a number of different fault sets which cut the stratigraphic section; some of these faults are restricted to the older felsic part of the volcanic section. The most predominant faults exposed in the range consist of a series of parallel, northwest striking vertical faults that are felt to be continuous with similar trending, strike-slip motion faults mapped by Miller (1970) in the Quartzite quadrangle to the northwest. Of the faults restricted to the older felsic section, the most intereting is a mineralized low angle normal fault that dips about 25° to the northeast.

The first mining claims in the district were located in 1909 on a small lead vein. Little ore was actually produced until 1929, when 801 tons grading 1.63 opt Au and 15.63 opt Ag were taken from the Resolution vein. Major mining took place between 1933 and 1940 when a 100 ton/day mill was built on the property. At this same time, the Oakland (Santa Claus) mine was located in the eastern part of the district on a rich gold-silver vein. Keith (1978) estimates total production from the district through 1974 would amount to some 17,400 tons of ore containing about 20,904 oz Au, 39,731 oz Ag and 1 ton Cu. He also mentions a few ozs of placer gold were probably produced along with some 250 long tons of low-grade manganese ore.

The ore bodys of the Sheep Tanks district were predominantly precious-metal bearing manganiferous calcite deposits (i.e. Romslo and Ravitz, 1947; Mills, 1945; Cousins, 1973). The vein fillings consist of irregular masses of limonite, various manganese minerals, quartz, black and white calcite and some cross-cutting veinlets of barite. Gold and silver occur in shoots within the veins; chrysocolla and lead minerals are locally present. Visible gold is most often found as flakes associated with manganese oxides filling vugs and fractures in the quartz. Interestingly, the black calcite commonly contains about 4% manganese while the white calcite contains less than 250 ppm (Cousins, 1973).

Cousins (1973) states that all the hydrothermal deposits in the district are controlled by the older faults, and that almost all the deposits occur in broad breccia zones in rhyolite porphyry.

Quartz-hematite alteration is present adjacent to all the gold-silver orebodies (Cousins, 1973). The footwall of the Resolution vein is completely replaced by fine-grained quartz and hematite over a wide zone that grades away into a broad zone displaying unaltered feldspar phenocrysts, but whose groundmass is largely altered to quartz and sericite. Hanging wall rhyolite immediately adjacent to the ore body is completely silicified and exhibit a porous texture. Within a few feet, this texture grades into non-porous silicified rhyolite whose large K-spar phenocrysts are preserved. Hematite is abundant in this material but apparently restricted to the groundmass. Keith (1978) notes that chloritization is also present, but does not state if this is restricted to the hanging wall, footwall or both. Interestingly, Cousins (1973) reports that alteration is slight to non existant adjacent to the black calcite veins.

Cousins believed that the carbonate, manganese and other metals in the deposits were derived from cherty limestones that he believed floored the volcanic sequence at some shallow depth. Although no rocks of this type crop out in the district, he cites nearby (Clanton Hills) outcrops of mesozoic sediments as evidence in support of his theory. It is interesting that Mesozoic sediments and volcanic rocks are in close proximity to many of the other mining districts in the area.

That the Resolution vein was hosted by a low angle Tertiary normal fault is also interesting, especially in light of the recent discovery announcement by Amoco of their nearby Copper Stone deposit which is also associated with a shallow dipping Tertiary fault. In addition, Wilson and others (1967) indicated that considerable low-grade material remained in the district for want of a cheep water supply for milling needs. In fact, a 1947 report (cited by Sturdevant, 1970) indicates that the mining area contains estimated possible stripmining reserves of between 10-15 million tons of ore worth about $5/ton (gold $35/oz; Ag @ $0.77/oz). In the Resolution Hill area above the mainworkings, it was estimated that some 720,000 tons of $8/ton ore existed. The estimates were apparently based on some 4,000 assays that were taken on the property when it was in operation. Unfortunately, the western portion of the Sheep Tanks district lies within the Kofa Game Range and is withdrawn from mineral entry. What part of the potential, low-grade ores that would be affected by the withdrawl is unknown. The eastern portion of the district, however, remains open to mineral entry under the mining law.

Mines of Interest:

Sheep Tanks Mine (Resolution group): (NE1/4, Sec 1, T1S, R15W) Was the major producer in the district, accounting for nearly all of the gold-silver production district wide. The Resolution vein dips northeast at about 25°. Conservative maximum dimensions of the vein, as indicated by outcrops and mine workings, are about 800 ft north to south by 700 ft east to west. In places, the vein was 40 ft thick. A 1947 study estimated that 720,000 tons of $8/ton ore remained in Resolution Hill above the old workings. The Resolution vein and any similar flat-lying structures in the district seem worthy of further exploration. Since Keith (1978) states that the actual ore mined from the deposit averaged nearly 1.2

opt Au, one wonders how much thickness of low grade material may actually remain in the old workings itself. Tests conducted by the USBM indicated that the gold was readily leachable from the deposit while silver recovery was much more difficult.

Oakland Mine: (SE 1/4, Sec 10, T1S, R14W) Brecciated aone cut by narrow, lenticular, quartz-carbonate stringers with limonite and gouge in mid-Tertiary volcanic rocks. Wallrocks are carbonatized, chloritized and locally sericitized. Sporatic production produced small tonnage (15 tons) of extremely high grade (12.5 opt Au) ore.

Smyrna claim: (Location unexact; approximately 1/2 mile south of Sheep Tanks Camp.) Gold-bearing, low-angle brecciated zone in diorite (rhyolite) porphyry. This zone strikes northeastward, dips 30°-40° SE, and has maximum exposed thickness of 4 ft. The hanging wall is marked by a streak of coarse-grained gouge. Vein material where exposed was reported to assay a few dollars per ton ($35/oz prices).

Davis Prospect: (Sec 3, T15, R14W. 5 miles east of Sheep Tanks mine and short distance north of road to Palomas.) Here, a pediment surface with several outcrops of weathered volcanic rocks is exposed. Prospecting in 1931-32 exposed a shallow dipping brecciated zone that contains a few narrow lenticular quartz-carbonate stringers. This zone strikes N55°W and dips about 30°-50° N and is marked by a thin iron-stain gouge zone. Wallrocks are heavily chloritized and carbonated with local sericitization. The vein was explored by a shallow shaft and short workings by the United Verde Extension Mining Company in 1932, and encountered some rich, near-surface pockets. The ore averaged several dollars per ton for first 20 ft. Deeper mineralization, however, was reported to run less than $2/ton ($35/oz prices).

Unnamed Prospect: (Location inexact; 4 miles east of Sheep Tanks mine and about 1/8 mile south of road to Palomas.) Property consists of shallow workings on locally shattered diorite porphyry. Here, nearly vertical fractures strike eastward and display considerable limonitic stain. Portions of the iron-stained silicified breccia carry some gold. Prospected by old shelf and shallow cuts.

References:

Cousins, 1973; Keith, 1978; Mills, 1945; Romslo and Ravitz, 1947; Sturdevant, 1970; Wilson, 1933; Wilson and others, 1967.

SILVER DISTRICT

Location:

The Silver district is located in the southern Trigo Mountains, T3 &4S, R23W, in La Paz County, about 55 miles by road north of Yuma. The district is contiguous on the south with the Eureka district and on the north with the Trigo district. Access is through the U. S. Army's Yuma Proving Grounds and certain off road restrictions apply. Once within the district, numerous jeep trails afford ample access to most areas.

Geology and History:

The geology of the Silver district has been studied and mapped by a number of different workers, including; Wilson (1933, 1951), Parker (1966), Weaver (1982), Gardner and others (1982), Pietenpol (1983) and Tosdal (work in progress). The oldest rocks in the district consist of gneisses and schists derived from sediments that are now belived to be mid to late Mesozoic in age. Large exposures of these rocks crop out mainly in the southern and western parts of the district. Jurassic and late Cretaceous intrusions of granodiorite composition cut the metamorphic rocks in the southern part of the district. A significant zone of migmatite has been developed near the granodiorite- metasediment contact. A large body of Orocopia schist is exposed in the Eureka district south of the Jurassic granodiorite. While the orocopia is believed to be of similar age as the Mesozoic sediments to the north in the Silver district, it is of completely different provenance and separated from the sediments by a regionally extensive structure that has been called the Chocolate Mountains thrust in nearby parts of California (Haxel and Dillon, 1978). This thrust separates North American crustal rocks from oceanic Orocopia rocks. The Mesozoic metasediments and Jurassic granodiorite in the Silver district are contained in the upper plate of this regional allocthon.

Unconformably overlying the crystaline and metamorphic rocks is a thick sequence of middle Tertiary volcanic rocks, which make up most of the outcrop in the Trigo Mountains. These rocks range in composition from andesite to rhyolite and consist of flows, breccias, and pyroclastic deposits. The overall stratigraphic succession of these volcanic rocks correlates well with the volcanic stratigraphy described by Crowe and others (1970) in adjoining parts of California. Flat lying basalt flows of late Miocene or Pliocene age cover a large area of the eastern Trigos and represent the youngest igneous event in the range.

Parker (1966) spent considerable time describing the metamorphic rocks in the district. These rocks display a prevailing parallel trend of lineation, foliation and fold axes to the northeast with steep dips to the southeast or northwest. Parker describes these rocks as comprising a complex of schists, gneisses, phyllites, argillites, and gneissic granite of greenschist metamorphic facies. Within the schists he recognized several different varieties and noted that sedimentary facies changes were probably exhibited within these rocks as beds that could be continuously traced out displayed an increase in calcareous content to

the south. Unfortunately, one cannot be sureer is describing schists within the upper plate, schists within the Orchist, or both, as these rock types are not separated on his mapping. Thisrtunate as some of his schist units are unusual and may possess explorationcance. For instance, he describes a schist terrane that includes quarfeldspar schists; banded, carbonaceous calc schists (possibly metaexhalzons); and quartz-fuchsite schist. In addition, Parker (1966) states thof the schistose rocks contain chromite; indicating that some of the th may have consisted of ultramafic igneous rocks. These types of rocketimes associated with gold mineralization in greenstone belts (i.e. Abitiin Canada, Mother Lode belt in California). While it is undeniable that talization in the Silver district is mid to late Tertiary in age, the pof these distinctive older rocks make one suspect that the Tertiary ore say have "inherited" some of their metals, carbonate, barite, etc. from theing basement. This does not appear to be a unique situation. In numerous n western Arizona where we see the Mesozoic schists cropping out associatmid Tertiary to Laramide igneous activity we typically find associated ation. One wonders if the Mesozoic rocks themselves have ever been systey explored for syngenetic precious metal deposits. More about the possiificance of these rocks is discussed in other sections of this report. Aote worth mentioning is that Wilson (1933) stated that dumortierite with minte occurred in quartzose schist boulders in the Colorado River terrace downstream from the site of Clip, an old mill site where ore from the Clip; processed. These rocks would appear to be similar to kyanite bearing rthe Tumco and Vitrifax Fms in the nearby Cargo Muchacho gold district in Ca, where syngenetic aspects to mineralization may also exist.

Pietenpol (1983) recognized three stages and stfaulting within the district. These included an early stage of lowaulting, an intermediate stage of moderate to high-angle normal faultingate stage of high-angle transverse faulting. The low-angle fault is pnly in the vicinity of the Black Rock and silver Glance mines (Pietenpol, The most important faulting consists of the moderate to high-angle normal ich define a horst-graben structural setting for the district. Pietenpoland Parker (1966) relate these faults to Basin-and-Range tectonics. We2) and Garner and others (1982) have tried to relate the normal faults tion in the upper plate of a regionally extensive "detachment" surface said posed in the northern Trigo Mountains. Using this model, the faults in thelate are thought to merge into the detachment surface with depth. Data by Pietenpol's study refuted Garner's detachment picture, at least outhern Trigos. Our reconnaissance studies in the southern Trigo Mcalso indicate that regionally extensive detachment faults do not this area. For this reason, we have not included on our geologic map any o and others (1982) proposed detachment faults in the Trigo Mountains. We fident that this is true in the southern Trigo Mountains, and suspect from reconniassance and verbal communication with Tosdal (1984) that it also to the northern part of the range.

Mineralization in the district consists of lowture calcite-quartz-barite-fluorite-bearing epithermal veins that aults and fractures. Pietenpol (1983) noted that veins are present the low-angle fault and the

moderate to high-angle faults. The high-angle transverse faults commonly cut the veins and are themselves barren. Based on synmineralization brecciation, Pietenpol believed that mineralization was related to some sort of late stage volcanic activity associated with the basin-range faulting. Individual veins within the large horst-graben fault zones are persistent and have been traced along strike for as much as 2 miles. Widths are highly variable pinching and swelling along strike; in places the veins are as much as 100 ft wide. Drill hole data indicate that most veins narrow with depth. Ore shoots usually are limited to lengths of less than 100 ft and widths of less than 10 ft. Parker (1966) states that average assay values are about 6% Pb, 4% Zn, 10 oz Ag and 0.02 oz Au per ton.

The veins of the Silver district are famous for the unusual and beautiful minerals they contain. Parker (1966) identified 33 primary and secondary vein minerals. Silver, zinc and lead are the only elements of economic importance. Typical orebodies consist of limonitic, quartz-barite-calcite- fluorite fissure fillings that contain economic amounts of argentiferous galena, lead oxides, argentite, silver halides, cerussite, smithsonite and anglesite (Parker, 1966).

The district was discovered in the mid 1860's, but production did not start until 1879. While production records were not kept during the early years, Thompson (1925), estimated production from the district amounted to about $5,000,000. He based his estimate on data furnished by a local Well's Fargo agent who supposedly handled all the Bullion shipments from the district to the U.S. mint. Wilson (1951) gave a more conservative production for the district as amounting to some 1,559,201 oz Ag, 2,329,059 lbs Pb and 14,200 lbs. Zn (zinc was apparently not recovered from the ores until 1947). Since about 1976, the district has been largely tied up by New Jersey Zinc Exploration Company who has expanded about $2 million into district wide exploration.

New Jersey Zinc's exploration effort consisted of both underground and surface sampling and mapping and several hundred drill holes completed over the past 10 years. Their effort was successful in blocking out several mineralized bodies at or near the surface along three main fault systems that they refer to as the West, Central and East vein Systems.

West Vein System: Averages 10% fluorite, 3.2 oz Ag, 1% Pb and 3% Zn (non-recoverable?). There are 1.7 million tons distributed in 5 open-pitable deposits. Approximately 50 to 60 drill holes were puut into the orebodies. Apparently, there is no barite in this system.

Central Vein System: Includes the Padre Kino and Silver King veins. The Padre Kino vein dips 60° W; has massive fluorite with some barite and silver at the surface. The deposit contains about 300,000 tons of 27% fluorite and 1 oz Ag. The Silver King vein deposit dips east at moderate angle; has only fluorite and barite (no calcite or Ag) and contains about 450,000 tons of 17% fluorite and 9% barite. South of the drilled-out Silver King deposit, the vein extension has not been drilled, but is known to be a minimum width of 5 ft, probably containing 30-40% combined fluorite-barite. The northernmost mile of the productive Central vein System has never been drilled, but offers excellent potential for significant reserve additions. The known reserves of the Central veins are about 700,000 tons of 0.47 oz Ag, 22% CaF_2 and 8% barite.

East Vein System: Included are the Clip, Amelia and Revelation underground workings and structures. Total reserves approximate 3.2 million tons of nearly 4 oz Ag, and 20% barite. There is no significant fluorite.

A summary listing reserves as of 1981 is presented in Table 1. Between all three vein systems, there is approximately 6 million tons of 3-1/2 oz Ag; 600,000 tons of recoverable and marketable barite, and 230,000 tons of same for fluorite.

Feasibility studies indicate mining costs (open pit) of about $4/ton and milling of costs $8/ton. All reserves would be mined by a series of small open pits to several hundred ft maximum depths. Minable deposits are all contained within a 4 x 2 mile area favorable to a central milling facility.

References:

Crowe and others, 1979; Gardner and others, 1982; Haxel and Dillon, 1978; Parker, 1966; Pietenpol, 1983; Thompson, 1925; Weaver, 1982; Wilson, 1933, 1951.

Table 1. The following is the tonnage calculated for the three vein systems:

West Vein

	Tons	oz/T Ag	% Pb
Positive	701,200	4.07	1.04
Probable	436,000	3.1	0.93
Inferred	893,500	2.63	1.16
Total Silver-Lead	2,030,700	3.16	1.08

Central Vein (less Maxie reserves)

	Tons	oz/T Ag	% CaF_2	% $BaSO_4$
Positive	260,900	nil	17.6	8.6
Probable	106,800	nil	16.9	9.5
Inferred	367,600	0.94	25.7	6.4
Total Fluorite	735,300	0.47	21.5	7.6

East Vein (plus Maxie and M & P reserves)

	Tons	oz/T Ag	% $BaSO_4$
Positive	846,670	4.77	13.5
Probable	1,088,630	3.25	15.1
Inferred	1,325,610	3.60	27.2
Total Silver-Barite	3,260,910	3.79	19.6

(Unpubl. Report, New Jersey Zinc, 1982)

SOUTHERN PLOMOSA DISTRICT

Location:

This district is a southern extension of the northern Plomosa district and occurs in the mountains south of U.S. I-10. The district adjoins the New Water area on the east and includes mineral occurrences in the Livingston Hills to the south. Black Mesa which lies in the central part of the district is the dominant topographic feature. The district is included in Townships 3 and 4 North, Ranges 17 and 18 West of La Paz County and is found on the Quartzite 15' quadrangle.

Geology and History:

The geology of the district appears on the 15' geologic map of the Quartzite Quadrangle by Miller (1970). Generally, it consists of an extremely complex thrust terrain in pre-Tertiary rocks. The various lithologies involved in this interleaved tectonized sequence include: Precambrian plutonic rocks, Paleozoic cratonal facies sedimentary and metamorphic rocks, Mesozoic volcanic and continental sedimentary rocks and their metamorphic equivalents and Mesozoic plutonic rocks including a distinctive, chloritized, megacrystic quartz monzonite porphyry and quartz porphyry of probable Jurassic age. In places, such as just west of Guadalupe Mountain and just south of U.S. I-10, deformation in Paleozoic (?) strata that has been thrust upon Precambrian basement shows extreme plasticity and formational attenuation. Relatively short distances away, such as just north of Black Mesa, the Paleozoic section is intact and only mildly disturbed. A major lithologic unit mapped along the west margin of the southern Plomosa Mountains consists of mildly metamorphosed rhyolitic to dacitic volcanics and tuffaceous rocks resting depositionally on Precambrian quartz monzonite. Miller cites either a Precambrian or Mesozoic age for the unit. We lean toward the Mesozoic age.

Occurring in the southern Plomosas and making up the Livingston Hills to the south is a thick continental sedimentary sequence appropriately named the Livingston Hills Formation. Extensively studied by Harding (1980, 1981), this formation consists of a lowermost conglomerate member, overlain by an intermediate siltstone member and an upper graywacke member. The formation is estimated to be of Jurassic age.

Tertiary rocks consist of andesitic volcanics, minor rhyolite, hypabyssal dike rocks and the <15 m.y. old basalt of Black Mesa. With the exception of Black Mesa basalt, these rocks have been affected by rotational normal faulting (listric) and by strike-dip faulting on a broad zone of northwest-striking structures that trend through the southern part of the area.

Mineral occurrences in the district are commonly gold bearing and of interest for two special reasons: (1) a number exhibit Laramide (?) thrust control like many prospects in the Harquahala and Little Harquahala districts, and (2) at least two, the Bright Star and Night Hawk or Livingston camps, are notable because of the syngenetic or metamorphic associations of tungsten and

tungsten-gold with minor base metals. Like similar occurrences in the Granite Wash Mountains and in southeastern California (i.e. Tumco district), these deposits exhibit stratibound characteristics and display unusual mineralogical associations high in fluorine, boron and alumino-silicate alteration.

The Iron Queen, Gila Monster, and other placer deposits which fringe the western portions of the southern Plomosa Mountains produced a reported cumulative production of 18,000 oz of Au and 1,800 oz silver from 1860 to the 1950's. The extensiveness of these deposits may be an indication of favorability for the source rocks of Mesozoic (?) metavolcanic and metasedimentary lithologies and their thrust dominated contacts.

Mines of Interest:

Gold Nugget mine: (T4N, R18W, Sec. 25) Coarse gold occurs with cerrusite, anglesite, galena and oxidized copper minerals in stringer veins of white quartz and siderite along a N25W fault zone in Paleozoic quartzite cut by diorite dikes. Bancroft (1911) describes horse-tailing and minor veining outward into wallrocks adjacent to the vein. This mine produced 100 tons that averaged about 1 opt Au, 2 opt Ag and 1% Pb. Attention is also called to a gold-copper occurrence about 1 mile northwest of the Gold Nugget workings which lies along the thrust faulted contact of highly deformed Paleozoic rocks with Precambrian quartz monzonite.

Bell of Arizona mine: (T4N, R18W, Sec. 35) Gold-silver with quartz in pods and stringers cutting a fracture zone in Precambrian quartz monzonite. Property produced about 200 tons averaging 0.4 opt Au and 0.1 opt Ag.

Bright Star mine: (T4N, R18W, Sec. 34) Occurrence of tungsten as scheelite, disseminated and in discontinuous quartz veinlets, in fractured Mesozoic calcareous schist at contact with limestone. Siderite and pyrophyllite are reported. The description sounds much like suspected Mesozoic metasedimentary tungsten occurrences in the Granite Wash Mountains, some of which are auriferous. Needs sampling and inspection with gold in mind. Much of the area is covered with overburden and very little work has been done on the deposit.

Iron Queen and Copper Prince mine groups: (T3N, R18W, Sec. 3) Gold, silver and oxidized copper associated with multiple quartz veining in highly silicifed, epidotized Paleozoic (?) and/or Mesozoic metasediments and altered volcanics. Deposit occurs along a major thrust (not shown on Miller's map) between these supracrustal rocks and the quartz monzonite basement. Numerous workings produced about 1,720 tons averaging about 0.3 opt Au, 1 opt Ag and 0.6% Cu.

Apache Chief mine: (T3N, R18W, Sec. 12) Although historic production from this mine was low in gold (0.03 opt), it did recover 12 opt Ag and significant copper (11%). Tonnage mined was relatively large for the district (2,100 tons). Of further interest is the setting of mineralization within a highly thrust faulted section of Paleozoic-Mesozoic rocks intruded by diorite and quartz porphyry dikes.

Poorman and Goodman mines: (T3N, R17W, Sec. 7) Noted for its high grade gold production (3.8 opt), this occurrence is also of interest because of its probable localization along a thrust zone between Precambrian crystalline rocks and overlying deformed Livingston Hills Formation.

Night Hawk, White Dike and Colorado mine groups: (Also known as the Livingston mine group) (T3N, R18W, Secs. 34, 35 & 36) Scheelite with associated precious metals, copper, and lead occurs in disseminated pockets and small masses with bedded (?) tourmaline, quartz and calcite along a contact between calcareous, tourmalinized schist and limey quartzite beds of the Livingston Hills Formation. Gold occurs with small quartz veins and veinlets. Mineralization may be stratibound and is highlighted because of its resemblance to similar deposits occurring in the Granite Wash Mountains and in southeastern California. The Night Hawk and other occurrences are spread out along the strike of tilted bedding for over two miles. The scheelite-bearing zone is about 1.5 miles long and ranges from 100 to 600 ft wide. Stratigraphically below the mineralized section is found a quartz porphyry that is either a volcanic intrusion or extrusive flow complex.

References:

Arizona Dept. Mineral Resources, file data; Bancroft, 1911; Keith, 1978; Miller, 1970.

TANK MOUNTAINS DISTRICT

Location:

The Tank Mountains district covers the Tank Mountains, a range which extends southeastward from the Kofa Mountains in northcentral Yuma County. The two mountain ranges are separated by Engesser Pass. Except for the eastern portion of the range, the district lies within the Kofa Game Range and the Yuma Test Station.

Geology and History:

The Tank Mountains district is very remote and has been poorly studied. The geology appears to be similar to that found in the adjoining Kofa Mountains. Mesozoic schists form the oldest outcropping rocks in the district. Blocks of these rocks crop out in the western and eastern portion of the range. In the western part of the range, the schists have been intruded by Jurassic plutonic rocks and by a large mid-Tertiary subvolcanic body of felsic composition. A sequence of mid to late Tertiary volcanic rocks unconformably overlies the Mesozoic rocks and covers the central portion of the range. The oldest volcanics consist of a thick, tilted sequence of andesitic to rhyolitic tuffs, flows and breccias that cover a major portion of the western and northern parts of the range. These are, in turn, unconformably overlain by flat-lying to gently tilted basaltic lavas of late Miocene or Pliocene age in the eastern and southern portions of the range.

Mineralization discovered to date in the district has been rather unimpressive. Wilson (1933) and Keith (1978) described a few occurrences of gold-bearing, quartz-carbonate veins in the Mesozoic rocks; weak, oxidized copper mineralization in the Tertiary andesites; and low-grade manganese ores in some of the mid-Tertiary volcanic rocks. Placer deposits occur in two areas in the Tank Mountains (Wilson, 1933; Johnson, 1972), namely; the Engesser Pass area (T2S, R15 & 16W) and at Puzzles Mountain (NW-1/4 T4S, R13W). The Engesser Pass placers apparently were the most productive and formed near the Engesser prospect. The Puzzles area placers were derived from low pedimented hills that form the southeastern foothills of the Tank Mountains. Mesozoic schist is the principal rock type exposed in this area and the gold was believed to have been derived from nearby prospects (i.e. Puzzles, Golden Harp, Ramey and Regal). The Puzzles gold was coarser grained than that in the Engesser Pass placers and may indicate different ages and/or styles of mineralization for the two areas. Johnson (1972) estimates placer production from both areas as being only about 200 oz.

The gold-bearing deposits were prospected as early as the 1860's but lack of water and isolation have hampered any major development (Keith, 1978). Total precious metals production from the vein deposits are estimated not to exceed 50 tons of ore containing about 1 opt Au (Keith, 1978). A small amount of low-grade manganese ore was shipped from the district in the 1950's.

Wilson (1933) described the gold-bearing deposits as consisting of quartz-carbonate veins in the Mesozoic rocks that typically contain sulfides or oxides after sulfides. The veins are generally narrow and lenticular with wallrock alteration consisting of pronounced sericitization, silicification and carbonatization. Wilson (1933) believed the veins are mesothermal.

Mines of Interest:

Engesser (Johnnie) Prospect: (NE-1/4 Sec 25, T2S, R16W) protracted.) Property was located in 1890's (?) and some gold produced with an arrastre from surface outcrops. A long mineralizated fissure occurs that contains lenticular bodies of quartz along its length. Country rock is described as granite cut by diorite and rhyolite porphyry dikes. Adjacent to veins, wallrocks are intensely altered to sericite and carbonate. The vein strikes N20°E, dips 45°W and in outcrop consists of a few inches to 3 ft of pulverent to solid iron oxide with some angular quartz, flanked by a like thickness of yellow jarosite and limonite. The quartz will reportedly pan some gold. Several other lenticular bodies of iron oxides occur along the length of the mineralized zone. Dump material displays large aggregates of hematite and magnetite with small bunches of pyrite and minor chalcopyrite, all cut by radiating microveinlets of quartz and carbonate. Magnetite is reportedly of the lodestone variety. Deposit is developed by an irregular shaft about 300 ft deep.

Blodget Prospect: (Location inexact, about 2 miles east of the Engesser prospect.) Quartz-carbonate veins carry some gold. Quartz is locally honeycombed and contains many small bunches of brown to black iron oxide. Wallrocks are somewhat sericitized and silicified and contain numerous small bunches of hematite, chysocolla and malachite. Other quartz-carbonate veins occur in the same area.

Ramey Claim and Puzzles Area: (Sec 7, T4S, R13W.) Quartz vein occur within foliated chlorite schist and schistose diorite. Gold-bearing vein strikes N30°W and dips 45°NE and is apparently (?) conformable to the strike of enclosing schists. Vein is heavily shattered, consisting of limonitically stained quartz. Ferruginous calcite veinlets occur alongside the vein in parallel fractures. A short distance southwest, the schist contains iron-stained quartz stringers from which a few small, rich pockets of gold ore have been recovered.

Regal Prospect: (Sec 7 (?), T4S, R13W.) Northwestward trending fault breccia dips 45°SW and cuts silicified, biotite schists. In places the silicified material is rather cellular, but generally forms only thin, lenticular masses. Property developed by 2 shallow shafts and minor workings. Some gold was reportedly produced from surface outcrops. At 75 ft depth, the vein reportedly ranged in value between $2 to $10 per ton Au (1933 prices).

References:

Johnson, 1972; Keith, 1978; Wilson, 1933.

TIP TOP DISTRICT

Location:

The Tip Top mining district is located in the southern foothills of the Bradshaw Mountains; mainly in T8N, R1E. It is contiguous on the west with the Humbug district. In the past, access to the district has been via a long, arduous 4-wheel drive road. Recent exploration activity in the district, however, may have improved the access.

Geology and History:

The Tip Top district, one of the oldest in Arizona, came into being in 1875 with the discovery of the Tip Top vein. By 1883, with the ore believed exhausted in the Tip Top, the town became a virtual ghost camp. Production during this short time is reliably estimated to have amounted to between $3-4,000,000 in silver and gold; silver being by far predominant. Keith and others (1983a) list production as amounting to 28,000 ton of ore which contained 9,800 oz Au; 1,910,000 oz Ag; 2,800 lbs Cu; 28,000 lbs Pb. Mineralization consists of several narrow, epithermal silver-antimony-tungsten-gold veins that appear to be related to a shallow (?) buried pluton believed to underlie the district (Kortimeier, 1984 and personal commun.). Studies by Kortimeier (1984) indicate the district is strongly geochemically zoned with an Au, Cu, As-rich core, a Ag-rich annulus, and a peripheral zone high in Zn and Sb. He further claims the district is geochemically distinct from the adjoining Columbia-Humbug district.

The veins are hosted by Precambrian granite and pegmatite with inclusions of schist. This assemblage is cut by northeast-trending rhyolite dikes which are thought to be offshoots from the hypothesized pluton. Both the mineralization and the rhyolite dikes are believed by Kortimeier to be Tertiary in age. Attempts to date the dikes (Kortimeier, 1984) were unsuccessful due to excessive Precambrian argon in the rocks. The history of the camp mainly follows that of the Tip Top mine.

The Tip Top vein is a well defined fissure vein that strikes N50°-60°E and dips 65°-75°NW. The vein ranges in width from a tight seam up to 6 ft wide as seen in stopes. The major gangue mineral is quartz which displays druzy and coarse comb textures. Ore minerals in unoxidized ore consist of wolframite, arsenopyrite, pyrite, sphalerite, bornite and galena; paragenesis is in the order given (Lindgren, 1926). Wolframite is believed to occur mainly in the upper parts of the veins and always occur as well-crystallized crusts along the wall. The ore was partially to totally oxidized to a depth of 200 ft. The ore in these upper levels was extremely rich with secondary silver minerals and sulfasalts (mainly cerargyrite, proustite, pyrargyrite, argentite and native silver) accounting for most of the value.

Private reports based on old assay records by A. L. Flagg and J. S. Coupal, respected early mining engineers, indicated that after the original operators ceased to work the property the average ore taken out by lessees was 360 opt Ag. This record also indicated that in both the chloride and sulphide ores; the

former being near-surface, ranged from 70 to 2,100 opt Ag, while the sulphide ores varied between 121 and 1,760 opt Ag. Records from a lease in 1888, indicate that the lessees took out 150 tons of high grade ore in 90 days which had an average of 597 opt Ag. The primary source of the silver was believed to be in the galena or possibly tetrahedrite although this later mineral was not recognized in the primary ore. The ore shoots pitch to the northeast. In the lower levels the ore was said to become soft and gougy.

Mine workings include a 800 ft inclined shaft with the principal working level being the 200 ft level. Since nearly all the work was done before 1883, no records exist for the extent of the underground workings.

The major production from the mine occurred between 1875-83 when the mine was closed. It was reopened again in 1886-88 on the 5th, 6th and 8th levels. At this time the dumps were sorted and some $250,000 were recovered from them. The district has seen little mining, other than sporadic dump operations since this time. Some tungsten ore was hand sorted and shipped from parts of the dump and stope fills above the 200 level during World War I. A small amount of tungsten ore was also shipped in 1928. In 1936, La Bajada Exploration, Engineering and Equipment Co. built a flotation mill of 50 tons daily capacity and produced some silver-gold concentrates. Since that time a small amount of tungsten ore has been produced from the district. Santa Fe Minerals Co and a small independent (possibly Canadian) company have been exploring in parts of the district in the past 2 or 3 years.

References:

Arizona Dept. Mineral Resources, mine file data; Keith and others, 1983a; Kortimeier, 1984; Lindgren, 1926.

UNION PASS (KATHERINE) DISTRICT

Location:

The Union Pass district is located about 10 miles north and northeast of Bullhead City and extends from the river eastward to Union Pass. In this report the district will also include the area south of Union Pass to about Secret Pass Canyon.

Geology and History:

The Union pass district is very old, but has a rather sporadic production history. The Pyramid, Sheeptrail-Boulevard and a few other properties were discovered during the 1860's (Wilson and others, 1967). Other mines, such as the Katherine, were not discovered until about 1900. The Katherine mine was the most productive in the district and experienced its greatest production between 1925 and 1930, when it was closed. Wilson and others (1967) noted that several mines (including the Roadside and the Arabian) resumed production in 1933-1934, and their ores were treated in the Katherine mill. There has been considerable renewed interest in the district in recent years, largely brought on as the result of Fischer-Watt's exploration in the Oatman-Katherine areas.

Several major companies now hold land positions in the district and one small heap leach operation is in production at the Frisco mine. Anaconda Minerals has recently entered into a joint venture program on Fischer-Watt's Roadside property. AMOCO Minerals has also recently acquired a large land position north of the Frisco mine. Saratoga Mines reportedly has the land between the Roadside and the Frisco properties. The Arabian mine is currently held by a joint venture between Crown/Sutton Resources and Meridian Land and Minerals Co. Recent drilling by Meridian has outlined ±500,000 tons of reserves grading 0.06 opt Au at the Arabian with higher tonnages possible for 0.04 opt Au material (Durning, 1984). Keith and others (1983a) credit past production from the district between 1868-1943 as amounting to 128,000 oz Au and 313,000 oz Ag from some 704,000 tons of ore.

The geology along the west flank of the southern Black Range in the Union pass area has been described by a number of workers; including Schrader (1909), Lausen (1931), Longwell (1963) and Durning (1984). The area between Union Pass on the east to the Newberry Mountains on the west is marked by the persistence of Precambrian outcrops. Longwell (1963) suggests that the expansive belt of Precambrian outcrops marks a broad uplift along an axis trending somewhat north of west. The Newberry Mountains are now recognized as being encircled by a Tertiary detachment fault similar to detachment faults related to nearby recognized metamorphic core complexes (Mathis, 1982). While we have never viewed the detachment on the western portion of the range, the detachment fault on the eastern flank of the Newberrys is well documented. At the Bureau of Reclamation rock quarry near Davis Dam the detachment can be viewed (Longwell, 1963; Durning, 1984). These structures along the east flank of the Newberrys were first mapped as thrust faults by Volborth (1973). Mathis (1982) documented the mid-Tertiary extensional character of these detachment faults

and the related listric faulting and rotation of upper-plate units. On the eastern side of the river in the Union Pass district, rock units are mostly in an upper-plate geometry. Here we have numerous low-angle or listric faults that trend NNW that structurally repeat Miocene volcanics and older crystalline rocks above detachment faults (Durning, 1984). The dips of the volcanic rocks range from 60° to nearly horizontal. Durning (1984) noted that a small fenster of lower-plate rocks is exposed in the area around the Roadside mine east of Katherine's Landing.

Mineralization in the Union Pass district, like that in the nearby Oatman district, consists of epithermal veins and lodes consisting largely of quartz and calcite together with smaller amounts of adularia and fluorite. Lausen (1931) and Ransome (1923) have discussed the mineralogy, stages of deposition and wallrock alteration in the Oatman and Union Pass districts in considerable detail and this information need not be repeated herein. The reader can refer to these sources for more detail. While mineralization in the Oatman district is largely if not wholly confined to ore shoots in high-angle vein structures, mineralization in the Katherine-Union Pass area occurs both in high-angle veins and in low-angle structures. It is the low-angle elements that appear to possess considerable potential for low-grade, bulk mineable deposits. In light of these possibilities, the district is receiving intense exploration efforts by several major mining companies as was discussed in a preceeding paragraph. In addition to exploration, small heap leach operations are currently in progress on mineralized "detachment" or low-angle listric structures at the Frisco mine and at the Saratoga Mines property.

Since upper-plate extensional faulting is evident through much of the Black Range, this environment would warrantby reconnaissance sampling and geologic mapping. Since competition may be intense in the Union Pass district, it may be more productive to explore for this environment north of the district. Durning (1984) indicates that detachment faults are exposed on both the east and west flanks of the central Black Range, some 20-25 miles north of the Union Pass district.

The fact that much of the Union Pass district, particularly the area north of the Katherine mine, is covered by pediment gravels offers an interesting exploration problem. Some of the low-angle faults probably exist under the pediment. The question becomes one of determining how to explore for mineralized zones in this environment. Soil gas anomalies and/or water well geochemistry may be useful, but to our knowledge has not been tested in this environment for these types of deposits. It seems likely that competition in these covered areas would be minimal, and yet the potential may be high. We suggest that some thought be given to this approach in the Union Pass district. Lausen (1931) and Wilson and others (1967) list numerous mines and prospects. We have highlighted some of the more interesting ones below. Other mines mentioned by these workers, however, might also be of interest.

Mines of Interest:

Katherine Mine: (T21N, R21W, Sec. 5) The Katherine mine was discovered in 1900 and has been the largest producer in the district. The richer part of the vein

was mined out above the 300 ft level by 1904. The Katherine Gold Mining Co. sank a new shaft, built a 150-ton cyanide mill and produced over $1,000,000 in ore between 1925 and 1929. Small production continued by lessees through 1931 when the mine was closed. Total production is estimated to be about $2,000,000.

The mine occurs on a small granite knob that rises above the surrounding pediment. Mineralization consists of a "stringer lode" that strikes N62°E and dips about vertically. The lode is 60 ft wide at the surface and typically consists of a series of closely spaced stringers in the granite. At some places, however, the vein filling was solid quartz and calcite up to 10 ft or more wide. The lode narrowed underground. Near the vein the granite displayed kaolinization, iron-staining and local silicification. The lode is reportedly cut by numerous low-angle normal (?) faults that were interpreted as thrusts by the early workers. Wilson and others (1967) note that orebodies were in places offset as much as 60 ft. They also state that late movement along the vein cut the thrust planes. This raises the question of whether the low angle faulting was syn- or post-mineralization in relative age. No mention is made by these workers of mineralization along the low-angle structures so their role as a mineral controlling element cannot be evaluated without more data. The mine was developed to the 900 ft level for a length of 1,700 ft. We wonder how much low-grade material might remain across the wide stringer zone in the upper mine levels that might lend itself to open-pit stripping?

Roadside Mine: (T21N, R21W, Sec. 12). Wilson and others (1967) describe the geology in the vicinity of the Roadside property as consisting of a fan-shaped block of rhyolite which is in fault contact with granitic gneiss on the east and west. The Roadside lode strikes northward, dips 33°-38°W and occurs within a fault zone in the rhyolite. In underground workings, the ore shoot was 20 to 35 ft wide and some 75 ft long on strike. It consisted of irregular stringers and bunches of quartz and calcite in shattered, silicified rhyolite. The gold was reported to occur mainly in greenish-yellow quartz and also in streaks of iron oxide. On the 100 ft level, the ore reportedly averaged between 0.25 and 0.30 opt Au.

The Roadside lode itself was developed sporadically between 1915-1916, 1921 and in the early 1930's. Up to January 1934, the property had been developed by about 1,000 ft of workings on the 100 ft level. Production in the 1930's amounted to at least 890 oz Au and 1,734 oz Ag. Durning (1984) notes that a small fenster of lower-plate rocks occurs in the area around the Roadside mine, indicating that detachment type faulting truncates the rotated and repeated Tertiary volcanic rocks of the upper plate. Weakly to highly anomalous gold values are associated with the low-angle structures and associated, high-angle, listric(?) normal faults over a considerable area at the Roadside mine. Anaconda is presently exploring this area as a joint venture with Fischer-Watt Mining.

Frisco mine: (T21N, R20W, Sec. 16) The Frisco mine was discovered about 1893 and worked intermittently until 1933. Production was estimated to have been some 44,000 tons of $14/ton ore prior to 1916. In 1932, a considerable tonnage of ore was reportedly mined and treated at the Katherine mill. Bedrock in the

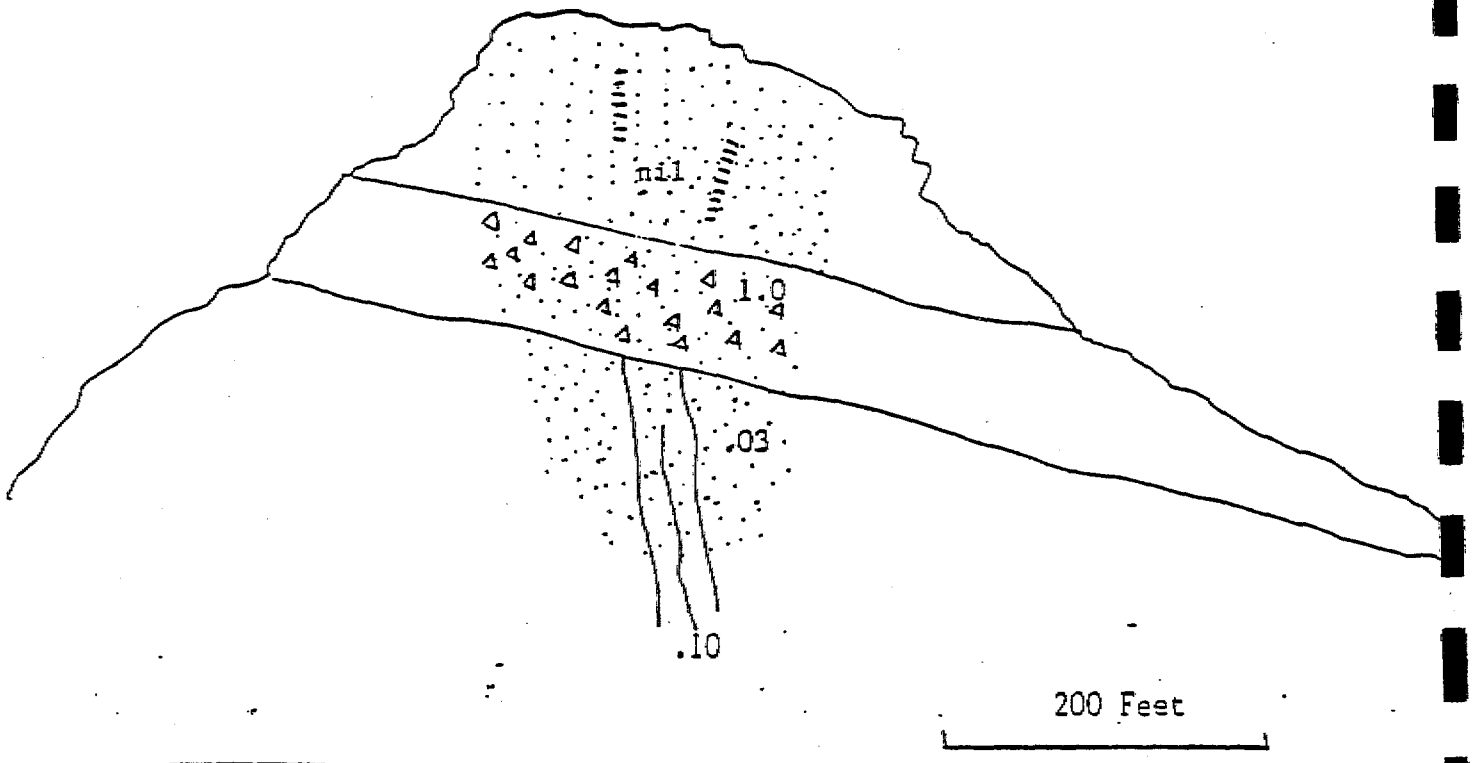
mine area consists of granite capped by rhyolite and tuff that form a low hill. The rhyolite varies from about 20 to 60 ft in thickness and may be either a flow or a sill (Bonelli, 1984). The overlying tuff is from 0 to 60 ft thick at the mine site. The mine area lies within an area that is cut by NW-trending normal faults. Bonelli (1984) suggests that warping occurred along a northeast-trending axis resulting in the formation of a synform in the center of the property. The principal vein strikes N55°E and dips 12°SE. Mineralization occurs as shallow-dipping, kidney-shaped sheets within the rhyolite that are up to 50 ft in thickness and exceed 200 ft in longest known dimension (Bonelli, 1984).

Ore consists of a quartz and chalcedony cemented breccia that locally contains abundant hematite and gypsum. The gold is very fine-grained and reportedly is contained within the chalcedony. Bonelli (1984) reports that selected drill intercepts exceed 1 opt Au. Hydrothermal alteration occurs both below and above the ore (Figure 18). Feldspars altered to clay and/or sericite accompanied by red hematite stain occurs in the underlying granite. These rocks are reported to contain up to 0.03 opt Au (Bonelli, 1984). The tuff overlying the rhyolite (ore zone) is altered to almost pure quartz and kaolinite with local opaline streaks. This material apparently contains no gold. Structural relationships and geochemical sampling suggest that hydrothermal solutions migrated up high-angle fault structures in the basement where they entered the brecciated rhyolite and precipitated the gold and gangue minerals. Brecciation in the rhyolite host may have resulted from low-angle faulting (Bonelli, 1984).

A Canadian individual leased the property in 1971 and drilled reserves adjacent to two old stopes. This individual reportedly made steps toward production in 1981, but abandoned the project because of the small size of the reserves. Frisco Land and Mining Co. started feasibility work in December of 1982 and drilled one of the two known orebodies in April 1983 (Bonelli, 1984). They initiated a small heap leach operation on the property in 1984 which is currently still in production. Reserves reported consist of some 80,000 tons grading about 0.10 opt Au that is contained in two separate zones of 60,000 and 20,000 tons, respectively. Due to the very fine nature of the gold, the ore must be crushed to -10 mesh and agglomerated in order to leach properly. Bonelli (1984) indicates that other untested targets exist on the property concealed beneath the tuff capping. These zones are defined by areas of silicification, hydrolytic alteration and the presence of sulfate minerals in the tuff.

Arabian Mine: (T21N, R20W, Sec. 20) The Arabian mine was worked on a small and intermittent manner since before 1917. This work resulted in a small, but unknown, production of gold. In 1933 and 1934, E. F. Nieman and associates worked the mine and milled several thousand tons of ore from an open cut on the property. Wilson and other (1967) credit the 1933 production as amounting to some 593 oz Au and 1,156 oz Ag. Durning (1984) described the mine as occurring along the Arabian fault zone which strikes N25-35°E, dips about 65°SE and consists of a hanging wall of rhyolite welded tuffs with a footwall of Precambrian megacrystic granite. This structure has been intruded by a

Figure 18. IDEALIZED SECTION THROUGH A FRISCO-TYPE OREBODY



Tt	Tuff
Tr	Rhyolite/Latite Porphyry
pC	Basement Granite and Gneiss
	Fracture with Opal or Chalcedony Filling
	Fracture with Quartz and Calcite Filling
	Zone of Brecciation and Silicification (ore)
	Zone of Hydrolytic Alteration
nil- 1.0	Maximum Known Gold Content within Zone

(From Bonelli , 1984)

brecciated rhyolite porphyry which hosts most of the ore. Mineralization consists of numerous gold-bearing quartz and calcite stringers veins within the brecciated rhyolite intrusive. Some fluorite occurs near the hanging wall portion of the lode. The mineralized portion was reported by Wilson and others (1967) to be 30 ft wide. The mineralized zone forms an outcrop 100 ft high by 100 ft wide by more than 500 ft long. Crown/Sutton Resources acquired the property in the early 1980's. Drilling by Meridian Land and Minerals Co. in a joint venture with Crown/Sutton indicates a reserve of 500,000 tons running 0.06 opt Au with greater tonnage potential for material of about 0.04 opt Au (Durning, 1984).

Tyro Mine: (T21N, R20W, Sec. 6) Coarse-grained gneissic granite is cut by numerous dikes of rhyolite porphyry. A stringer lode strikes NE and dips 85°SE. Lode forms a bold outcrop some 1,800 ft long by 20 to 35 ft wide. The actual width of the stringer zone is reported to vary between a few feet up to 60 ft. In 1915-1916 a shaft was sunk to the 500 ft level with some drifting on the 200 ft level. Lausen (1931) states that the vein was not found in the lower workings and that it was believed to have been displaced along one of the "thrust" faults. No production is known from the property.

Black Dyke Mine: (T21N, R21W, Sec. 2) A large vein is composed of calcite cut by numerous small quartz stringers. The vein displays a curved geometry that trends NW over a length of some 2,500 ft. About midway between the ends, the vein reported swells to a width of 150 ft. The vein was reported by Lausen (1931) to occur in a shattered rhyolite which may have been somewhat replaced by the quartz and calcite. The vein reported was sampled in the old days and was said to run about $3.00/ton (old prices). Workings in 1931 consisted of a small inclined shaft and numerous small tunnels run beneath the outcrop.

Pyramid Mine: (T21N, R21W, Sec. 6) A very old mind discovered in 1860's is the site of mineralization consisting of stringer zone cutting reddish granite. The zone strikes N65-70°E, dips near vertical and at its apex is 35 ft in width. Schrader (1909) indicates that the vein was believed to have been an extension of the Katherine zone and was prospected by a number of small pits and a shallow shaft.

Golden Cycle Mine: (Located about 2000 ft NW of the Pyramid mine) Stringer vein filling a shear zone in granite. Vein strikes more easterly than Pyramid vein and is said (Wilson and others, 1967) to join this vein somewhat less than a mile to the east. The width of the stringer zone is said to be 10-18 ft and is developed by a 115 ft shaft and some lateral workings. Near surface assays reportedly averaged $1-$3 per ton, but some underground samples ran as much as $14 per ton. The supposed intersection of the Golden Cycle and the Pyramid zones might be an interesting area to check out for increased mineralization.

References:

Bonelli, 1984; Dimmick and Ireland, 1927; Durning, 1984; Keith and others, 1983a, Lausen, 1931; Longwell, 1963; Mathis, 1982; Ransome, 1923; Schrader, 1909; Volborth, 1973; Wilson and others, 1967.

VEKOL DISTRICT

Location:

The Vekol mining district is located in the extreme southwestern corner of Pinal County about 30 miles southwest of Casa Grande. The district covers the Vekol Hills which lie within the Papago Indian Reservation.

Geology and History:

The Vekol Mountains display a complex geologic setting. Geologic studies of parts or all of the district have been performed by Hadley (1944), Carpenter (1947), Heindl (1965), Chaffee (1974, 1977) and Dockter and Keith (1978). Pinal Schist of Proterozoic X age is the oldest exposed geologic unit in the Vekol area. Just north of the district the Pinal Schist is intruded by Precambrian, coarse-grained granite that is probably of "Oracle" equivalence (see Plate 1). Apache group sediments of Precambrian Y age was deposited over the schist and are exposed in the district as minor erosional remnants. In places the Precambrian rocks are intruded by diabase sills. A sequence of Paleozoic sedimentary formations overlie the Precambrian rocks. These formations include the Cambrian Bolsa Quartzite and Abrigo Formation, the Devonian Martin Formation, and the Mississippian Escabrosa Limestone (Chaffee, 1977).

Continental sedimentary rocks and some intermediate-to-felsic volcanic rocks were deposited over the area during the Mesozoic. During Late Cretaceous time, a fine-grained, quartz monzonite stock intruded at least the Precambrian to Paleozoic portion of the stratigraphic section. The mineralization of the district is believed to be genetically related to this stock (Chaffee and Hessin, 1971). During the early Tertiary (?), diorite porphyry intruded the Abrigo Formation, forming sills in many places. Small patches of volcanic tuffs and basalt flows locally overlie the older rocks in the northern and western portions of the district. Since the mid-Tertiary, the area has been gradually buried by extensive gravel deposits derived from all of the pre-existing units. These gravel deposits are now exposed as caliche-cemented conglomerates (Chaffee, 1977). Basin and range faulting in the late Miocene has caused complex faulting and tilting of all the formations including the caliche-cemented conglomerates.

Mineralization in the district is genetically related to the Vekol porphyry copper system that is centered about 1 mile south of the Reward mine. Stockwork and disseminated mineralization occurs mainly in the Precambrian diabase and overlying Paleozoic sedimentary formations near their contact with the Laramide quartz monzonite stock. This deposit was discovered and drilled by a joint venture between Newmont Mining Corp. and Superior Oil Co. As much as 70%-80% of the deposit is buried under the late-Tertiary conglomerates and Quaternary alluvium. Most of the district production has been from irregular replacement bodies and fracture fillings in the Martin Formation and the Escabrosa Limestone. These replacements were valued for their rich secondary silver ores, but they also contained galena, sphalerite, chalcopyrite, and pyrite. These replacement deposits apparently formed where steep dipping fracture zones produced favorable structures or encountered favorable sedimentary horizons.

Major mines of the district were the Vekol, Reward, Copperosity, Great Eastern, Christmas Gift, Republic and Spondulix (Tenney, 1934). Most of the precious-metal production has come from the Vekol, Great Eastern and Christmas Gift mines.

Production from the district has amounted to over 1,000,000 oz Ag and at least 2,500 oz Au (Tenney, 1934). Considerable base metals production has come from several of the mines in the district (Keith and others, 1983a; Tenney, 1934). The Vekol mine was discovered in 1879. Most of the gold-silver production occurred before 1900.

Future possibilities of the district are uncertain. Many of the claims are probably patented and so present no major problems with the Indians. On the other hand, the majority of the district is controlled by the Papagos. Two types of targets can be envisioned for the district: (1) the possibility of low-grade silver mineralization localized across wide fracture zones in the Paleozoic rocks (i.e. Vekol and Great Eastern deposits); and (2) disseminated, low-grade silver-gold mineralization replacing favorable sedimentary horizons or localized along structural zones as a function of district metal zoning outward from the core of the porphyry copper system.

Some possibility also exists for finding more of the high-grade, replacement deposits. Tenney (1934) notes that on the Vekol property a strongly mineralized, northwest "belt" of limonite-stained limestone occurs southwest of, and parallel to, the main prospected zone. He states that no work had been done on this second structure at the water table level (where apparently much rich ore occurred in the Vekol mine).

Mines of Interest:

Vekol Mine: (T9N, R2E, Sec. 33; T10N, R2E, Sec. 4) The Vekol mine was discovered in 1879; reportedly shown to a white prospector by a Papago Indian. Ore occurs as irregular replacements of limestone within a horizon ranging from a few feet to 10 ft thick that was called the "shale" horizon by the early miners. Emplacement of these orebodies was controlled by a series of closely spaced, subparallel faults that display little throw and strike NS to N30°W. The width of this zone of faulting is about 400 ft. The mineralized horizon is capped by hard, fractured limestone and underlain by a dense dolomitized limestone. Tenney (1934) notes that the surface expression of the mineralized fault zone is a partial replacement of limestone beds (especially those with abundant chert) by limonite. The "chert" may be hydrothermal silica. Tenney further states that no lateral work was done outside of the fault zone in search of other productive areas. A second, equally strong, or stronger, belt of limonite-stained limestone is reported to occur about 400 ft to the west of the developed zone. This area was not prospected.

Two orebodies were found and mined by the early miners. The ore apparently was almost all oxidized; consisting of small nodules of horn silver, argenite and silver-bearing tetrahedrite in a gangue of iron-stained, kaolinized limestone with abundant secondary calcite veins. Slight copper-staining was

present in the gangue and silicification was only associated where the mineralization is the strongest. Drifts in the underlying dolomite cut a few beds replaced by lead, zinc and iron sulfides with a little silver.

The major workings of the mine were driven from a series of tunnels that were mostly driven at very shallow dips. These tunnels are interconnected by irregular stopes, raises and inclines which as an aggregate formed an extremely intricate network of workings that extend to the southeast a distance of 1,070 ft across a width of 320 ft. At the southeast end, the workings are connected to the Argosy shaft and other workings. The workings were very solid and little timbering was needed. Tenney (1934) reports workings aggregate about 8 miles in total length.

The majority of the production was won between 1882-1893. Some production was also recorded in the periods 1908-1909 and 1915-1916. Tenney (1934) provides the following production summary.

Year	How Treated	Price of Ag	Oz Ag Produced
1882	Sorted & shipped	$ 1.14	19,745
1883	Sorted & shipped	1.11	75,676
1884	Sorted & shipped	1.11	79,279
1885	Sorted & shipped	1.07	47,121
1885-89	Milled & bullion shipped	0.98	525,030
1889-93	Sorted & shipped	0.93	209,345
1908	Sorted & shipped	0.53	3,961
1909	Sorted & shipped	0.52	5,329
1915	Ore concentrated & shipped	0.51	30,000
1916	Ore concentrated & shipped	0.66	8,000
		Total	1,003,486

Tenney indicates that actual production was somewhat higher than the above figures indicate. At least 6 of the 22 claims of this property are patented.

Great Eastern Mine: (T9S, R2E, Sec. 35) The Great Eastern mine adjoins the Vekol property to the southeast. The principal workings are about 2,000 ft from the Argosy shaft. The property was discovered shortly after the Vekol. The outcrop was not as large and the production was reportedly much less. Tenney (1934) notes that the mine was most active between 1885 to 1894. An attempt to revive the mine was made in 1931 and 1932 when an extension of the ore zone was prospected by lessees and a small amount of low-grade Pb-Ag ore being shipped. The ore occurs as replacement deposits that are similar in character to those of the Vekol. The major structure consists of two or more faults that strike EW with steep dips. The replacement deposits occur in Pennsylvanian Limestone, and several different beds were apparently replaced by ore as was some of the gouge along the faults. The ore was all oxidized and resembled that found at the Vekol. Residual galena nodules occur surrounded by copper-stained, kaolinized limestone. The thickness of the replaced beds varied from 1 to 5 ft as indicated by the stoping. The total length of the

zone mined was about 500 ft and the upper workings were reportedly mined out. Some ore was reported to be left in the shaft. Tenney suggests that a possibility exists at depth for enriched silver ore or for deeper favorable stratigraphic horizons.

Christmas Gift Mine: (T9S, R3E, Sec. 34) The Christmas Gift mine adjoins the Reward mine (copper) to the north. The property was discovered about 1883 on an outcrop of high-grade gold ore associated with a little galena and lead carbonate. The ore was contained in a small pocket that only extended to a depth of about 15 ft below the outcrop. About $50,000 (2,500 oz) of gold was quickly produced from this high-grade pocket. Little further work was done. A vertical shaft sunk about 100 ft north of the outcrop to a depth of 200 ft with drifts run under the ore pocket produced negative results. A second small outcrop of lead ore north of the shaft was later mined, but it contained no high-grade material. Bedrock consists of cherty dark gray limestone that dips 15°-20° W. A series of three or more diorite porphyry dikes that strike N70°-80°W cut the limestone. These dikes dip steeply south and are from 3-10 ft wide. The orebodies are found at and close to the dike/limestone contacts. These contacts are typically noted by iron and copper oxides in the limestone and by abundant calcite veining extending several feet from the contacts. Locally, oxidized lead ore is associated with the limonite and calcite. Tenney (1934) states that in the "gold stope," mineralization extended a maximum distance of 30 ft away from the contact along a favorable bed for a distance of about 60 ft along the strike of the porphyry. The thickness of this bed ranged from inches up to a maximum of 6 ft.

References:

Carpenter, 19~~74~~71; Chaffee, 1974, 1977; Chaffee and Hessin, 1971; Dockter and Keith, 1978; Hadley, 1944; Heindl, 1965; Keith and others, 1983a; Tenney, 1934.

VIRGINIA-MOCKING BIRD DISTRICT

Location:

The Virginia and Mocking Bird district consists of two separate mining areas occurring in the northern Black Range of northwestern Mohave County. The areas are probably best described as separate districts, however, Keith and others (1983a, b) combine the two areas and list their production together. Since we have no way to separate the production we will also combine these two areas into one district. The Virginia mining area is the most southerly of the two.

Geology and History:

Schrader (1909) describes the country rock in the Virginia mining area as consisting of Tertiary volcanic rocks; with rhyolite and green chlorite andesite being most abundant. Mineralization occurs as southwestward dipping, epithermal veins usually with a calcite gangue. The Red Gap vein, however, was an exception and consisted mainly of brecciated quartz with adularia. Most of the ore from the Virginia area was said to have been free milling gold ore that averaged $7-$8/ton (1909 prices). The best gold is associated with specks of hematite distributed throughout the gangue.

The Mocking Bird mining area is mainly underlain by Precambrian schists and gneisses bounded on the east by a spur of volcanic rocks that extends in a northerly direction from the flank of the range (Schrader, 1909). The mining area has a general NS trend; it is about 5 miles in length with a width of about 2.5 miles. Most of the mines exploit narrow quartz veins in the Precambrian granite gneisses. These veins usually dip steeply to the north. Mines developing these veins include the Hall, Great West and Pocahontas. The Mocking Bird mine was different in that, it explored a nearly flat vein that occupied a local flow (?) or dike of altered dark volcanic rock.

The dike or flow at the Mocking Bird property appears to separate more normal lavas of trachyte, latite and rhyolite composition from Precambrian basement. It would be interesting to know whether these overlying volcanic rocks are listricly rotated. If so, then the "dike" and associated vein may actually be in a detachment type fault. This possibility should be examined. In fact, the veins in the Virginia area should also be examined to determine whether they might be hosted by listric normal faults that might merge at depth with a detachment fault. The distribution of tunnel symbols around the Klondike and Golden Door mines on the Mt. Perkins topo map, hints that the mineralized zone may have been relatively flat-lying in this area. If this is actually the case, then a bulk tonnage target might exist where the listric faults merge with the detachment.

Production from the district has been moderately substantial. Keith and others (1983a) give recorded production between 1907 and 1955 as amounting to some 76,000 tons from which were recovered 17,800 oz Au; 17,700 oz Ag; 1,000 lbs Cu; and 3,000 lbs Pb.

Mines of Interest:

Mocking Bird Mine: Located about 4.5 miles due north of Mt. Perkins in the northern part of the district, the vein lies nearly flat in a local sheet or flat-lying dike of "altered and pressed" minette. This "dike" apparently occurs at the contact between other volcanic rocks and the Precambrian basement. If the overlying volcanics are listricly rotated, then this "contact" zone must be a flat fault. The "dike" is described as containing secondary epidote, calcite and adularia. The vein is reportedly about 6 ft thick and consists of red and green quartz and breccia. Gold is the main metal of interest and occurs with some silver. The gold is finely divided and occurs with hematite, which is reportedly abundant. Ore averaged about $10/ton (1908 prices). Production prior to 1908 amounted to $20,000. Schrader reported that several times this amount of ore was said to be blocked out in the mine. Pre-1908 development consisted of 12 or 15 shafts ranging from 25 to 60 ft in depth and about 500 ft of drifts. The mineralized zone may be a flat detachment-like fault and should be examined.

Hall Mine: (T26N, R21W, Sec. 27) A vein in Precambrian granite, dips steeply to the north. It is developed by a 210 ft shaft and 2 working levels which contain about 200 ft of drifts. Vein is composed mainly of quartz and ranges in thickness from a few inches to 2 ft, and is said to be locally associated with diabase dikes. A 24-ton mill was operating at the mine in 1908. Some of the ore was extremely rich with reported assays of $10,000 or more to the ton.

Pocahontas Mine: (T26N, R21W, Sec. 26) Gold-bearing quartz vein in Precambrian granite similar to that exploited in Hall mine. Mine was developed by shaft and drifts to a depth of 200 ft prior to 1908. Schrader (1909) reported a new cyanide mill had been recently installed to replace old stamp-amalgamation mill. Gold was said to occur mainly in pyrite contained in a stained and crushed quartz gangue.

Great West Prospect: (T26N, R21W, Sec. 27) Narrow quartz vein in Precambrian granite was developed to 200 ft depth prior to 1908 by adits, drifts, shafts, cross cuts and winzes. Vein consists of gold-bearing, iron-stained oxidized quartz reported to run $10 to $80/ton (1908 prices).

Dixie Queen Mmine: Property is located about 4.25 miles SSW of Mt. Perkins in the Virginia mining area. Wilson and others (1967) mention that the mine yielded some shipping and mill ore prior to 1927. Some production was also reported in 1927-28, 1931. In 1932-33 the property was operated in a small way by lessees who treated old tailings by amalgamation and cyanidation.

Klondyke Mine: Located about 1.2 miles NW of the Dixie Queen mine in the Virginia mining area. Wilson and others (1967) mention that the mine was operated about 1900 and that about 4,500 tons of ore from the property were treated in the Klondyke amalgamation mill at the Colorado River. These tails were later treated by cyanidation.

Golden Door (Red Gap) Mine: (Located less than a mile NW of the Klondyke mine) Schrader (1909) described the mineralization in the Red Gap vein as consisting of brecciated quartz, probably with adularia, and thought that it was similar to ores at the Gold Road mine (Oatman district). The vein reportedly carried good values. The only other published information we could find on the mine is in Wilson and others (1967) who state that lessees made a small production from the property in 1933. Longwell (1963) used the volcanics in the vicinity of the mine as his type section for the "Golden Door Volcanics" which in this area are made up mostly of rhyolitic lavas, breccias and tuffs.

Anderson (1971) abandoned the term "Golden Door Volcanics" as more detailed mapping indicated that these volcanic rocks correlate with the Patsey Mine volcanics (15.2 - 22.8 m.y.; Anderson, 1971). Less than 0.5 miles east of the Virginia mining area, these volcanic rocks are in fault contact with Precambrian basement. The distribution of tunnel symbols near the Golden Door mine on the Mt. Perkins topo sheet suggest that mineralization may have been fairly flat lying. While we have no other evidence for this, it would appear to be something to check out.

References:

Anderson, 1971; Keith and others, 1983a; Longwell, 1963; Schrader, 1909; Wilson and others, 1967.

VULTURE DISTRICT

Location:

One of the most famous of the early Arizona mining areas, the Vulture district as referred to in this report, essentially covers the Vulture Mountains near Wickenburg in northern Maricopa County.

Geology and History:

The geology of the Vulture Mountains is best summarized by Rehrig and others (1980) and Fischer (1984). This range occurs within a north-northwest-trending zone of intense normal faulting that projects southward along strike to the White Tank Mountains near Phoenix where it aligns with a similar, strong north-northwest linear trend in gneissic and granitic rocks (Plate 1). The oldest rocks in the range consist of a complex sequence of schists, gneisses and granitic rocks of Precambrian age which occur mainly in the southern and western portions of the range. The schists consist of both mafic and felsic varieties. Mafic schists are common in the southern part of the range and crop out extensively around the Vulture mine and further to the east near Morristown. Fischer (1984) indicated that banded iron formations occur in the schists near Morristown. These BIFs are typically discontinuous and thin; often chert rich with laminated bands of magnetite and hematite. Dale (1959) describes several tungsten prospects that also occur in the schist.

Mapping by Rehrig disclosed a large, northeast-trending Laramide batholith (68.4 m.y.; Rehrig and others, 1980) granite intruding the Precambrian complex. This granodiorite batholith is regionally extensive and has been mapped to the northeast into the Black Rock district and portions of it can be traced beneath younger volcanic and alluvial cover southwest as far as the southern end of the Big Horn Mountains (Plate 1). Similar granitic rock also occurs in the Eagle Tail Mountains.

A sequence of silicic volcanic rocks of late Oligocene to Miocene age (26-16 m.y.; Rehrig and others, 1980) overlies the older rocks and consists of tuffs, flows and numerous hypabyssal dikes. Rhyolitic domes and associated laharic breccias occur across a large portion of the eastern Vultures, west and north of Morristown. Many of these rocks are exceptionally rich in K_2O attesting to widespread K-metasomatism.

In the Morristown area this alteration is associated with felsic domes and hot spring activity which produced alunite (Royse and Sheridan, 1970), kaolinite, silicification, and associated precious metals mineralization.

The silicic volcanic rocks are severely tilted along multiple low-angle listric normal faults that were developing at the same time as metamorphic core complex activity were developing in nearby ranges. Thin basalt flows unconformably overlie the silicic volcanic section and mark the change to basin-range type faulting. These rocks are dated at 13.5 m.y.B.P. (Rehrig and others, 1980).

Numerous gold-bearing deposits occur in the district. By far the most famous is the Vulture mine which produced an estimated $6,839,375 in ore between 1866-1917 (Wilson and others, 1967). The age of mineralization in the Vultures is a complex issue that is at present unresolved. Many, if not most of the gold-bearing deposits are hosted entirely within Precambrian rocks, which has led to the speculation that at least some of the mineralization might be Precambrian in age. Samples of schist and banded iron formation taken by Fischer (1984) establish a high regional gold background in these rocks, which suggests that the Precambrian schists in this area were at least enriched in gold probably at the time of deposition. Gold-bearing placers are present whose source appears to be largely restricted to the schist bedrock north of the Vulture mine. Wilson (1961) attributes the gold in these placers to numerous small quartz veins contained in the schist which are said to all contain visible, at times coarse, gold. The restriction of the placer source to the schists may also support a Precambrian influence on the gold mineralization. Intrusion of the Laramide Wickenburg batholith may have enhanced mineralization. The pluton itself is associated with numerous copper showings.

Gold-silver mineralization associated with hot springs activity developed with rhyolitic dome emplacement occurring at the Newsboy mine in the area west of Morristown, and attest to the fact that at least some of the mineralization is obviously mid-Tertiary in age. Thus, the mineralization story in the Wickenburg area is complex and probably involves different ages and sources. After studying some of the gold veins in the Wickenburg area, Fischer (1984) proposed a multi-stage model that involved early sub-economic concentrations of elements by Precambrian sedimentary or metamorphic processes and later reconcentration of these elements to economic levels during Laramide intrusive events. Further remobilization of elements during Tertiary volcanic processes would also seem to fit with this model.

The mining history of the district is old, colorful and largely follows the discovery and development of the Vulture Mine by Henry Wickenburg in 1863. While other mines have produced gold, the Vulture is responsible for nearly all of the recorded district totals. Keith and others (1983a) list recorded production from the district as 970,000 tons of ore from which were recovered 350,000 oz Au; 264,000 oz Ag; 298,000 lbs Cu; and 1,796,000 lbs Pb. Some estimates give the Vulture production as $15,000,000 which would probably double the above figures.

The district would certainly appear to merit further examination. Hot spring type disseminated targets should be examined in the volcanic pile on the eastern end of the Vulture range. The Newsboy mine seems to be such a deposit and the nearby Charbonneau clay deposit may be a manifestation of the same or another system. Remobilized Precambrian gold is also an intriguing concept for developing targets in the Precambrian rocks of the district.

Mines of Interest:

Besides the mines and prospects listed below, brief accounts of other property in the district are given by Fischer (1984).

Vulture Mine: (Sec. 36, T6N, R6W) The Vulture lode, discovered in 1863 in the southern portion of the Vulture range, produced a minimum of $6,839,375 in gold ore through 1917. Some estimates put this figure as high as $15,000,000. Wilson and others (1967) describe the Vulture lode as a vein that occurs within a fault zone that at the surface strikes "slight north of west and dips 45°N, nearly parallel to the formation of the schist in the footwall."

The hanging wall of the vein is in part schist and in part a granite-porphyry dike that ranges up to 80 ft in width. The gold bearing portion of the lode as discovered in outcrop covered some 85 ft in width and had well defined walls. The entire width of the lode was auriferous but there were four distinct quartz layers sandwiched between sericite "slate" that were the main ore producing horizons at the surface. The upper portion of lode was rich enough that it was actually quarried and hauled to nearby arrastras. At the 250 ft level the vein had narrowed to 47 ft in width and was richest near the walls. Wallrocks near the vein contain abundant sericite, some calcite and pseudomorphs of pyrite metacrysts. Hutchinson (1921) and Thompson (1930) describe the mining history and the mine geology of the Vulture in considerable detail. Readers are referred to these works as the most comprehensive on the subject. Hutchinson (1921) described the vein mineralogy as coarsely crystalline quartz that is locally cellular and grayish white to white in color. In the oxidized zone the quartz contained considerable iron oxide with some wulfenite crystals occurring in vugs. Below the oxidized zone the quartz contained pyrite, galena, sphalerite and chalcopyrite and coarse free gold. Back calculating from concentrate grades the original unoxidized ores probably contained .4-.5% Pb, .26-.4% Zn, .07% Cu, and $4-$7 (at $20/oz) Au per ton. Assays also indicated that the galena carried considerable gold. The length of the vein in outcrop was 1,000 ft and 2 ore shoots along it were mined to 600 ft and 1,000 ft levels, respectively. The vein has been cut by numerous faults, at least two of which had considerable throw. One of these faults, the Astor, cuts off the vein below the 905 ft level.

The Vulture claims, millsite and old historic townsite are owned and preserved by a private concern and have operated as a tourist attraction in recent years. Pegesus Mining Co. attempted to work the property in 1983-1984, but were inhibited by the owner to such an extent that they withdrew. Thus, exploration of the property with new ideas has been hampered. Fischer (1984) mentions that the mine has been the target of several reinterpretative exploration ventures in recent years.

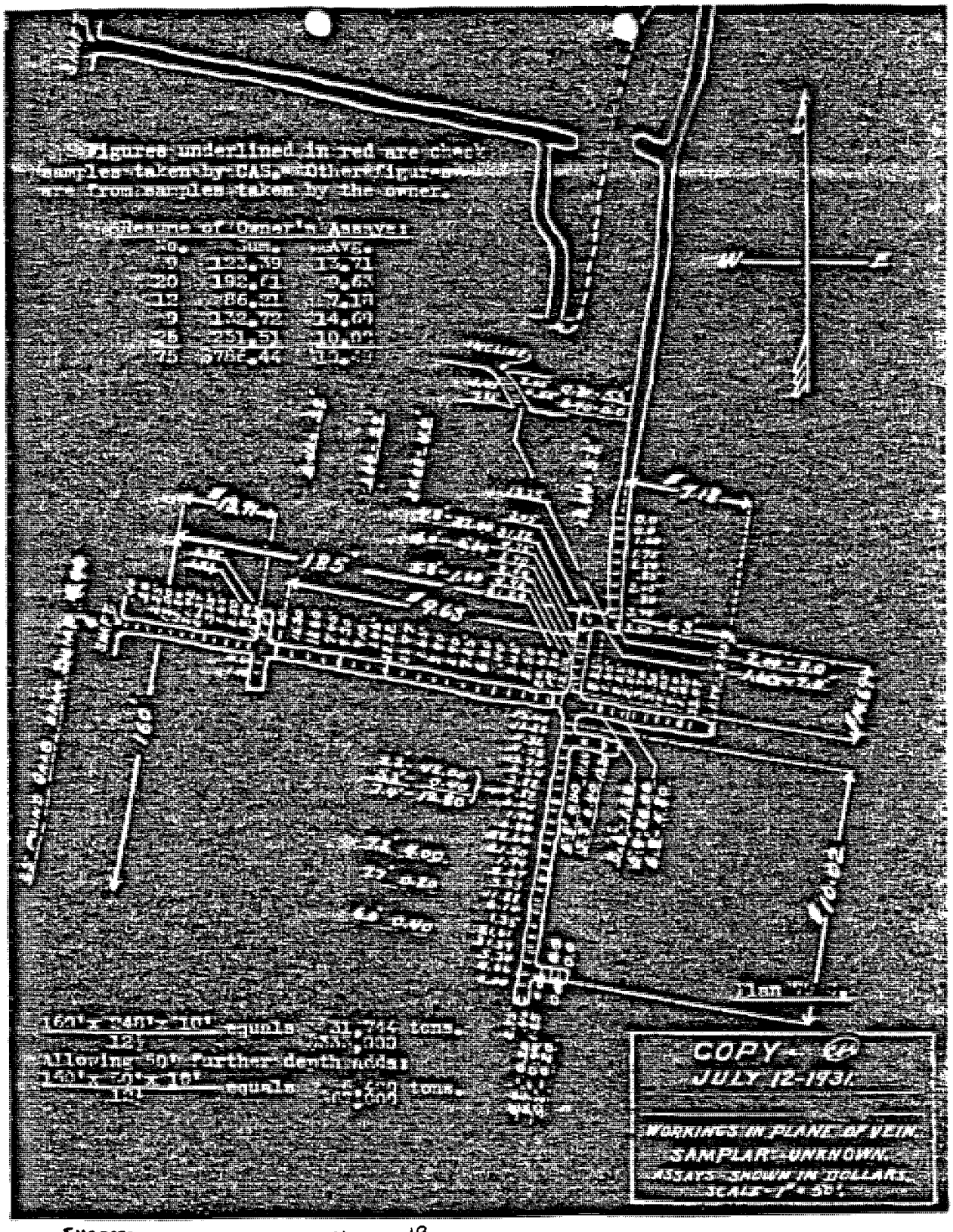
Sunrise Mine: (Sec. 33, T7N, R7W) Deposit was located in 1915. Country rock consists of Precambrian schist intruded by granite porphyry that occurs in low rolling hills largely covered by pediment. The vein strikes S20°W and dips between 35°-45° NW. Wilson and others state that vein occurs in a fault zone with granite porphyry on the hanging wall and schist on the footwall. Metzger (1938) indicates that the vein is hosted in a band of schist. The mineralized zone is reportedly a stockwork in the schist from 10 to 20 ft wide of lenticular quartz veins ranging in size from a few inches to a few feet in thickness. The outcrop of the vein is mainly covered by pediment debris. Ore shoots were

thought to have occurred where the vein flattens and is intersected by transverse fractures. Development consists of two inclined shafts (200 and 330 ft deep on the dip of the vein, respectively), a connecting drift on the 200 ft level, and 1,000 ft of drifting and cross cutting and 500 ft of raising on six levels driven at 50-60 ft intervals. Ore is said to consist of coarse, locally honeycombed to platty, brecciated quartz containing abundant limonite and hematite. Pyrite is locally present. Gold occurs mainly as medium fine to coarse grains and flakes associated with hematite and limonite in fractures and cavities. Wallrock alteration along the vein consists of sericitization, silicification, and carbonatization. Gold to silver ratios in the ore reportedly run 4:1. Metzger (1938) reported that an ore shoot on the 200 ft level ran from $8 to $12/ton in Au, was 160 ft long and ranged in width from 2 to 4 ft. The same ore shoot was opened on the 330 ft level for a distance of 135 ft with "both drift faces still in ore." During 1934, 800 tons of ore were shipped to the smelter and 400 tons were milled at a small amalgamation plant in Wickenburg. The milled ore averaged $20/ton. The shipped ore apparently ran $21.70/ton. Records at ADMR indicate that this ore shoot was believed to contain at least 31,744 tons of ore averaging about $10.49/ton in 1931 (see attached assay map, Figure 19). Metzger indicates that no systematic mining method was developed by 1938. The last production from the property came in 1942, and Keith and others (1983a) indicate total recorded production for the mine has amounted to only 1,000 tons. It seems likely that the mine was never adequately developed and explored. The width of the mineralized stockwork zone and the fact that more of the vein or similar mineralization could be hidden under the pediment debris would seem to warrant a reconnaissance of this property.

Red Cloud: (N½NW¼ Sec. 25, T6N, R6W) Volcanic and mafic schist country rock cut by a vein that bears N30°E and dips nearly vertical. The vein varies in width from 4-6 ft and is oxidized to more than 200 ft in depth. Pyrite occurs in places. Metzger (1938) reports that several samples from the 200 ft level ran $6-$8/ton in gold-silver, but "in no place in the mine is there enough of this material of this grade to constitute a commercial ore body or even make enough for a small shipment." Development consists of 300 ft shaft with levels at 85, 200, and 300 ft levels. Drifting on the two upper levels amounts to about 150 total and 185 ft with 120 ft of cross cutting at the bottom.

Banker Claims: (SE¼NE¼ Sec. 31, T6N, R5W) Granite is cut by numerous light-colored porphyry dikes that strike N45°W and a vein which strikes N75°W and dips 70°N. The vein cuts the dikes and can be traced for nearly 4,000 ft on the surface. Where prospected by surface cuts, the vein shows a width of 6 to 12 ft. Quartz is the major constituent of the vein with FeOx and MnOx occurring along fractures. The only development consists of a 35 ft shaft with a crosscut into the hanging wall, exposing 8 ft of vein without reaching the hanging wall. Four samples reported by Metzger taken from the shallow shaft returned gold values ranging from .04-.08 opt Au.

Cora Mine: (Sec. 17, T7N, R6W) This is a small mine largely developed by hand methods. Country rock is of granite and schist, with several gold-bearing veins occurring in the schist. The main structure bears about EW and dips 25°S. It



Sharpe

Figure 19.

(From ADMR Files)

is from 0.5-2.5 ft thick and consists of quartz with abundant FeOx and MnOx. The vein has been prospected at a number of places on the property with shallow shafts and open cuts. The main shaft is 100 ft deep on the dip of the vein with about 15 ft of drifting at the bottom. Metzger (1938) reports that two small shipment were made in 1935; these were 8.5 tons averaging 0.56 opt Au and 6 tons averaging 0.62 opt Au, respectively.

Gold Rainbow: (Sec. 20, T7N, R7W) A vein strikes N70°E and dips 20°S. It consists of about 1 ft of quartz in the footwall of a diorite dike that is several feet thick. Country rock in the vicinity consists of granite cut by diorite dikes. The prospect is developed by two shafts; 50 ft and 57 ft deep, respectively. One shaft is sunk on the dip of the vein, the other shaft is vertical for 26 ft where it strikes the vein, then follows the dip of vein. Prior to 1933, property made shipment of 26 tons of ore that netted 0.55 opt Au.

Charbonneau Clay Mine: (Secs. 15 and 22, T6N, R4W) Property consists of a large body of kaolinite covering an area about 1/4 x 1/2 mile, partly exposed at surface. Deposit apparently formed by hydrothermal alteration of a rhyolite dome. The shape of deposit is irregular in plan and its thickness is said to range between 40 and 300 ft. Kaolinite is capped in places by silica that is said to form a crust less than 10 ft thick. The silica cap said to grade downward into a silica-kaolinite mixture. This deposit has been mined for its clay content. The property is adjacent to the Newsboy group of claims that contain low-grade gold mineralization. This property should be examined for hot springs type disseminated gold mineralization.

Newsboy: (NW¼ Sec. 22, T6N, R4W) The property is located about 3 miles west of Morristown. Low-grade, manganiferous gold-silver ore occurs in a crushed zone in rhyolite porphyry. The zone trends about N60°W and dips 40°-60°NE. Precambrian schist forms the footwall of the zone and the rhyolite makes up the hanging wall and contains most of the ore. The schist is intruded by diabase and rhyolite dikes. Rhyolite flows and domes(?) cover the older rocks in many places. The rhyolite hanging wall carries gold over a width of 85 to 200 ft and along strike for several hundred feet. The mineralized zone has been identified over a strike length of more than 1,000 ft with only part of it being prospected. Vein gangue consists of severely shattered quartz with calcite. Although silver values run in the ounces per ton range, no silver minerals have been identified. Rare copper oxides occur and lead is present as wulfenite, vanadinite, cerussite and anglesite. Workings consist of an open pit (that obliterated some short underground adits driven prior to 1947), a 480 ft cross cut from the pit face towards the northeast, and a 200 ft incline shaft with a 500 ft drift at the bottom driven to the northeast. The open pit resulted from an operation that shipped some 11,258 tons of ore in 1940-42, which averaged 0.0683 opt Au and 8.07 opt Ag. A study of the property conducted by A. L. Flagg and D. W. Jaquays (respected local mining engineers) around 1947, indicated that 100 ft of pit depth could be attained by removing waste and ore in a 1:1 ratio. This would yield $2.00 per ton Au and Ag over a 300 ft width. The better ore was estimated to be 85 to 100 ft wide. These

workers tentatively estimated that 3,000 tons per vertical foot would give 300,000 tons for each 100 ft of pit depth. They estimated a probable grade based on samples of pit and underground workings would run 0.06 opt Au and 4 opt Ag. An 8-lb test sample sent by Flagg to the U.S. Bureau of Mines assayed 0.075 opt Au, 4.9 opt Ag, 0.5% Mn, 0.05% Cu, 0.6% Zn, 0.15% Pb, and 77% SiO_2. Nor-Quest, a small Canadian firm, picked up the property around 1984 and outlined some 60,000+ tons of Au-Ag ore amenable to a cyanide heap leach operation. Bottle tests indicated a Au recovery of about 90%, but only a 30% Ag recovery. Dydar Resources of B.C. reportedly had the property in 1983 and were trying to engineer better Ag recoveries. In 1984, the area had been reportedly drilled and shot and that at least 30,000 tons of 0.05-.06 opt Au was broken in the zone. A small pilot heap leach operation was underway in May, 1984.

This area is adjacent to a large kaolinized and silicified rhyolite dome to the east. Area should be checked for other disseminated epithermal deposits, particularly along the edge of the rhyolite domes. The size potential of the Newsboy should be fully evaluated in light of any possible joint venture opportunities that might exist with the present operators.

Queen of Sheba (La Aguila and La Firmosa): (Secs. 7, 8, 17 & 18; T6N, R4W) There is little data available for this property. Bedrock consists of Precambrian granite, gneiss and schist overlain and intruded by rhyolite-andesite flows and plugs. Basalt flows cap the older volcanic rocks. All the rocks are apparently sheared and faulted. Mineralization in the La Aguila and La Firmosa claims consists of several, irregular brecciated zones which are longest in an east-west direction. These zones vary in size from a few feet in diameter to the largest which reportedly measures 150 ft in an east-west direction and 100 ft in a north-south direction. These brecciated zones are dark reddish-brown in color and mineralized with specularite, calcite, quartz, barite and sparse fluorite. Pyrite and chalcopyrite is thought to probably exist in the unoxidized zone but are not known to occur at the surface. Copper carbonate is reportedly present in places. The property is developed by shallow shafts, tunnels and open cuts. Copper seems to be the major element of importance. The Sheba property consists of at least 57 claims that cover gold-bearing mineralization of unknown character. Old workings have been apparently cleaned out and some ore has been shipped since 1978. The Sheba vein is reportedly 1 ft thick at the surface but increases in width to about 6 ft at depth. Gold values reportedly run up to 1.25 opt Au. Property had some reported drilling in 1979. It was rumored that Freeport Minerals was actively exploring in the area in 1984.

Blue Ribbon (Flamingo 21) Mine: (Sec. 9, T6N, R4W) This is an old property dating back to at least 1882. Some reports claim it was worked by Spaniards for Au, Ag and Cu, and ore was hauled by mule train to Tucson. Vertical fissure veins cut andesite country rock. Veins are 3-30 ft wide; stopes in tunnels reportedly measured 15-18 ft in width. Stopes in brecciated andesite display quartz, pyrite, chalcopyrite and bornite. The mine is mainly noted for copper. Ores reportedly carry low amounts of gold (0.01-.11 opt). Copper values are high (0.3-12% Cu). The property may be related to the Cretaceous Wickenburg batholith.

Garcia (Hope) Mine: (SE¼NW¼ Sec. 7, T6N, R4W) There is little known information on the property. Reportedly it was discovered in the 1880's by a Wickenburg resident who sold it to a Canadian company about 1900. This company did development, built a small stamp mill, and produced some ore. Problems with water in shaft and faulted off ore stopped operations. The mine was intermittently worked in the depression years. Reportedly mine has shaft 500 ft deep and drifts on three working levels. Au and Ag in siliceous veins are said to widen to 6 ft at depth. Reportedly ore carried 0.40 opt Au and 2-3 opt Ag. Country rock is dark colored volcanics (?) and rhyolite schist. Structures are said to be somewhat contorted. Dump runs 0.05 opt Au. Fluorspar veins occur west of the property.

El Tigre (El Milagro & El Centinillo): Apparently three groups of connecting claim blocks. El Centinillo is located in SE¼SW¼SW¼ Sec. 7, T6N, R4W; El Tigre located in NW¼NW¼ Sec. 20 and SW¼ Sec. 18, T6N, R4W; and El Milagro located in the central part of Sec. 18, T6N, R4W. Little data is available. The mineralization is described as small veins that follow an irregular rhyolite intrusion in andesitic rocks or as calcite cemented breccia (6 ft wide) of clastic-volcanic material found at a contact of rhyolite and andesite lava. The strike of the calcite cemented contact is roughly east-west and its dip is reported to vary from more or less flat to about 45° to the south. Mineralization consists of iron and manganese oxides and manganiferous calcite with some secondary copper. There is reportedly some alteration and replacement of the rhyolite.

Workings on the El Tigre ground are said to be quite extensive with many hundreds of feet of workings. Dump material is reportedly much too small for the extent of the workings and indicates that ore must have been shipped. The adjoining El Milagro claim is on the opposite side of a dividing ridge. Here mineralization said to follow siliceous fractures in the andesite or is disseminated sporadically throughout the andesite itself. The El Milagro shaft is reported to be 700 ft deep. The Milagro and El Tigre claims were reportedly worked for many years intermittently by Mexicans for gold. The properties sounds interesting and should be checked out. They could have similarities to the Newsboy deposit.

References:

Arizona Dept. Mineral Resources, file data; Fischer, 1984; Hutchinson, 1921; Keith and others, 1983a; Rehrig and others, 1980; Royse and Sheridan, 1970; Wilson, 1961; Wilson and others, 1967.

WALLAPAI DISTRICT

Location:

The Wallapai mining district covers the central portion of the Cerbat Mountains in Mohave County. The center of the district lies about 15 miles to the northwest of Kingman.

Geology and History:

The Wallapai district is approximately 4 miles wide and 11 miles long, as defined by the known lateral extent of base and precious metal veining. The principal mining camps of the district were Chloride, Cerbat, Stockton Hill and Mineral Park. Mineralization in the district is related to a Laramide porphyry copper system that produced a base and precious metals zoning pattern that consists of a Cu-Mo stockwork core that gives way outward to a Cu zone, a Pb-Zn zone and finally to a Ag-Au zone (see Figure 20). The Ithaca Peak intrusions, to which the mineralization system is related, occur at the geographic center of the district.

The district is very old, discovered sometime around 1863. Mining between 1863 until 1900 sought to exploit the high-grade silver, and to a lesser extent gold, contained in the oxidized parts of the many fissure veins that occur across the district. Production for the period 1863-1904 was largely not recorded, but is estimated to have been at least $5,000,000 (Dings, 1951); which must have been valued almost entirely for its silver and gold content.

By the late 1880's the mines were operating mainly as lead-silver mines. By the early 1900's the ores were worked primarily for their lead-zinc contents, particularly during the World War I years. After 1917, exploitation was mainly confined to veins with a relatively high gold content. Gold production started to increase in 1935 and peaked in 1937-1938 (Dings, 1951). After 1942, production declined sharply. Between 1904-1948 the recorded production from the camp amounted to 1,276,266 tons of ore which contains 124,491 oz Au; 4,863,757 oz Ag; 5,712,992 lbs Cu; 71,473,202 lbs Pb; and 109,520,515 lbs Zn (Dings, 1951). In 1958 the Duval Corporation acquired the Mineral Park area and developed the Mineral Park Cu-Mo porphyry deposit. Production of Cu-Mo concentrates began in 1964. Through June 1980, total production from this deposit was 576,145,877 lbs Cu; 49,706,158 lbs Mo, and about 5,000,000 oz Ag (Vega and Wilkinson, 1984).

The geology and structural history of the Cerbat Mountain range is complex and has been discussed by a number of workers. The following brief discussion will be synopsized mainly from Dings (1951) and Vega and Wilkinson (1984). The reader wishing a more detailed account of the geology of the district is referred to these articles and to references contained therein.

The Cerbat range consists of an eastward tilted fault block of crystalline Precambrian rocks intruded by Laramide stocks and dikes, and locally covered by patches of Tertiary and younger volcanic rocks. The patches of volcanic rocks are erosional remnants of a once more extensive volcanic cover. Thomas (1949)

suggested that at one time the entire area of the Chloride quadrangle was covered by Tertiary volcanic rocks. Laramide intrusive rocks are only known along the western flank of the range.

The Cerbat Precambrian complex consists of gneisses, granites, schists and amphibolite. Thomas (1949) has divided these rocks into two groups: an older succession of stratified deposits that have been folded into open synforms and antiforms, and a granite gneiss complex. The granite gneiss complex is the major rock type of the range (Vega and Wilkinson, 1984). The complex is of batholith size and includes two distinct intrusions: the Chloride Granite (1740 m.y. by U-Pb; Silver, 1967) and the Diana Granite (1350 m.y. by K-Ar; Shafiqullah and others, 1980, K-Ar). The stratified Precambrian rocks have been subdivided into a succession of steeply dipping layers of hornblende-diopside schist, amphibolite, biotite schist, quartzite and lit-par-lit gneiss intruded by granite (Thomas, 1949). Folds have been mapped in these older metamorphic rocks. Thomas (1949) described the chloride fold as a large antiform whose axis plunged 60°, N45°E. Eaton (1980) reinterpreted this fold as a refolded fold with three fold axes. Wilkinson and others (1982) has described the contact between the granite gneiss complex and the older, folded, stratified group as not only a lithologic contact, but that it also serves as a contact between structural domains. Vega and Wilkinson (1984) summarize the major structural features of the Wallapai mining district as follows:

1. A screen of folded metasedimentary and metavolcanic rocks occurs along the western flank of the Cerbat Mountains.

2. The folded rocks are intruded by a regionally NE-foliated granitic gneiss of batholithic proportions.

3. The contact between the folded rocks and the granitic gneisses is a major and important structural element in the district.

4. Intrusion of the Ithaca Peak stocks appears to have been localized at the intersection of this contact and the Turquoise Mountain fold.

5. The contact is the locus of intrusion of rhyolite dikes and of formation of the major fault-veins of the district.

As stated previously, mineralization in the district is related to a Laramide age porphyry copper system centered on the 72 m.y. Ithaca Peak quartz monzonite prophyry intrusive complex. Vega and Wilkinson (1984) state that computer simulation modeling indicates that the porphyry Cu-Mo mineralization at Mineral Peak was not temporally related to the quartz monzonite porphyry exposed in the mine area, but rather the data indicates formation of mineralization 2 to 3 km above a source intrusion. The vein deposits from which the precious metals were won occur in all rock types and are interpreted to be the youngest mineralizing event (Vega and Wilkinson, 1984). Mineralization in these veins display the district metal zoning pattern shown in Figure 20. The veins range in length from approximately 100 ft to nearly 2 miles. They typically strike NNW (average between N20°-35°W) and dip between 60°-80°NE. Dings (1951) lists

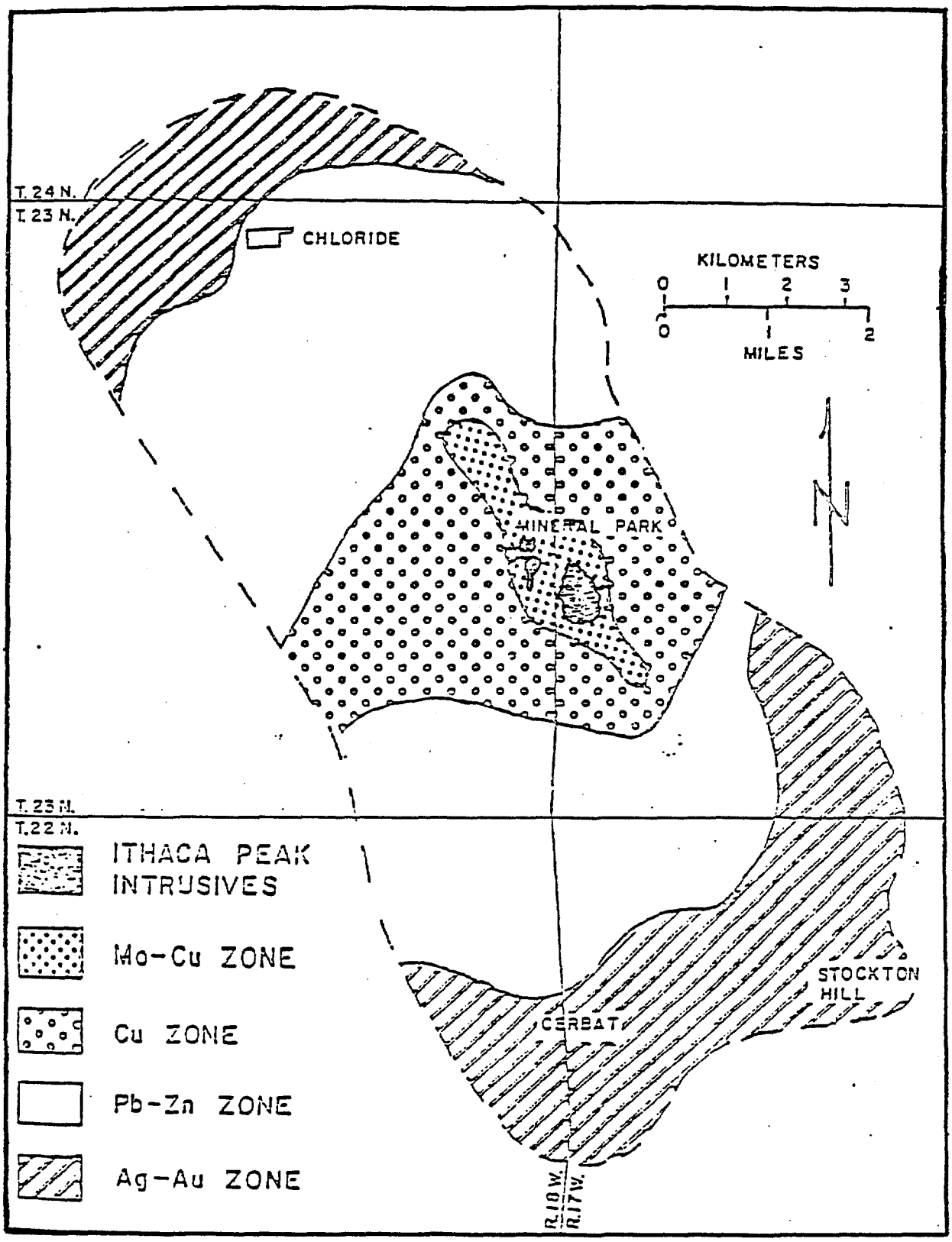


Figure 20. Metal zoning of the Wallapai Mining District based on mine production figures.

(From Vega and Wilkinson, 1984)

13 veins which exceed 1 mile in strike length. The aggregate length of the veins in the district is some 85 miles (Dings, 1951). Vein widths range between a few inches to about 33 ft, but usually average about 3-4 ft. In a few places the deposits are in lodes which usually don't exceed 50 ft. Schrader (1909) indicated that a lode 100 ft wide was encountered in the older workings of the Payroll mine. Vein widths were reportedly often exaggerated, as they frequently include considerable unmineralized wallrock between vein branches. Veins commonly pinch and swell along both dip and strike.

Ore shoots in the unoxidized zone are typically complex assemblages of galena, sphalerite and pyrite in quartz gangue. Chalcopyrite, arsenopyrite, proustite, molybdenite and argentite are locally present, but are less abundant than the other metals. Gold and silver are largely in the galena and sphalerite. Much of the vein matter is very low in grade. The sulfides have been moderately oxidized to a depth of 75-200 ft. The principal ore minerals in this zone are cerargyrite, native silver, cerussite and native gold. Ore shoots are generally small and usually range from 8-10 in to 3-4 ft in thickness. The thickest shoot found by Thomas (1949) measured 20 ft and occurred in the Tennessee mine. Larger shoots were reported to have occurred at the Golconda. One ore shoot in the Tennessee extended 400 ft horizontally and 1,400 ft vertically.

While the ores were largely mined for their lead-zinc content since the turn of the century, they were still significant precious metal producers. Dings (1951) states that in 1943 the Tennessee-Schuylkill mine was producing and milling about 150 tons of crude ore per day averaging 7% Zn, 3.5% Pb and 17-25 opt Ag. A list of recorded production for individual mines between 1901-48 is given in Table 2. Since production records were kept very poorly, these should be construed as minimum figures. The Golconda and the Tennessee are the only two mines with more than $1,000,000 in production (Dings, 1951). A fire destroyed the Golconda mill in 1917; the Golconda mine had only intermittent and small production since.

While the district would appear to hold little potential for hosting any precious metal deposits of a size suitable for a major company, some potential probably exists for undiscovered ore shoots of a size as those mined in the past. This might be of interest to a small mining company as the base metal ores often contained substantial amounts of silver and gold.

The mines of the district are too numerous to describe here. Haury (1947), Dings (1951), Wilson and others (1967), and Schrader (1909) give details of numerous mines. We would refer the interested reader to these sources. The Golconda and the Tennessee-Schuylkill mines are the only two vein properties which have yielded more than $1,000,000 (old prices) in production; these properties will be briefly summarized below.

Mines of Interest:

Golconda Mine: (T22N, R17W, Sec. 6) The Golconda vein strikes NW and dips about 65°NE. The vein pinches and swells, ranging in thickness from 2-7 ft, although Thomas (1949) stated that unverified reports claimed ore shoots wider

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

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

Mine	Gold (oz.)	Silver (oz.)	Copper (lbs.)	Lead (lbs.)	Zinc (lbs.)
Alpha (*m*)	292	35.499	22.265	16.476	----------
Altata and Altata Extension (*c*)	382	36.024	136.616	7.691	----------
Badger, Hercules, and Hercules group (*c*)	561	12.237	1.418	331.365	52.524
Banner group (*s*)	1,697	79.382	21.603	2,195.986	39,948
Blackfoot (*cer*)	158	11.856	19.617	104.565	144.369
Blue Bell (*s*)	469	50.954	44.274	182.001	----------
Cerbat (*cer*)	42	2.055	1.153	4.120	----------
Champion (*cer*)	982	23.669	14.931	825.993	335.391
C. O. D. (*s*)	1,550	151.263	23.924	348.872	23.188
Columbus-Monroe Doctrine (*cer*)	646	5.083	4.370	17.322	154.533
Copper Age (*c*)	3	1.062	266	24.575	----------
Distaff (*c*)	93	55.883	1.392	149.600	----------
Elkhart (*c*)	662	10.385	7,482	245.199	----------
Empire and Silver Union (*c*)	1	2.475	122	----------	----------
Eureka (*c*)	7	2.311	3,371	23,861	42.714
Flores (*cer*)	422	366	172	512	----------
George Washington (*m*)	114	11.059	15.777	34	----------
Golconda (*m*)	20,752	510.180	354.703	2,031.719	56,226,020
Golden Eagle and Bobtail (*m*)	1,777	25.845	890	40.076	----------
Golden Gem (*cer*)	2,478	8.243	3.365	14.980	----------
Hidden Treasure (*c*)	251	9.074	7.897	159.861	231.345
Idaho (*cer*)	280	5.235	4.742	9.348	51.900
Juno (*c*)	1,239	43.128	4.517	235.498	154.138
Keystone (*m*)	2,703	452.049	340.778	348.845	114.063
Little Chief (*s*)	391	68.351	2,070	111.825	----------
Lucky Boy (*c*)	1,923	40.438	230	8.140	----------
Mary Bell (*c*)	26	955	557	19.155	28.733
Midnight (*c*)	44	8.533	10.746	4.122	----------
Minnesota-Connor (*c*)	2,890	228.129	50.702	169.722	71.053
Mint (*m*)	222	15.255	----------	----------	----------
New London (*cer*)	13	3.298	1.558	136.699	31.243
Nighthawk group (*m*)	324	16.297	5.410	1,589	----------
Old Colony (*s*)	21	2.969	654	4.370	----------
Paymaster (*cer*)	99	25.090	----------	----------	----------
Payroll (*c*)	128	4.104	11.694	39.928	192.137
Pinkham (*c*)	56	14.695	55.136	3.133	----------
Rainbow (*c*)	2,400	34.982	4.748	313.271	22.426
Redemption (*c*)	21	4.042	11.449	----------	----------
Rico (*s*)	1,149	15.309	1,449	2.620	----------
Samoa and Samoan (*c*)	4,480	57.891	4.454	656.377	67,986
St. Louis (*cer*)	24	11.142	1,050	855.841	1,496
Silver Age (*c*)	24	3.550	----------	----------	----------
Silver Hill (*c*)	708	8.842	10.722	229.949	143.594
Tennessee and Schuylkill (*c*)	42,383	1,514.187	839.837	59,897.096	66,805,907
Towne (*c*)	144	6.296	2.108	5.516	----------
Vanderbilt (*cer*)	1,012	2.119	327	2.568	----------
Washington and Washington Extension (*m*)	58	2.205	1,610	1,700	----------

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

(From Dings, 1951)

than 20 ft were found in the mine. The vein can be traced on the surface for some 4,000 ft, splitting into several splays at its northern end. The shaft was sunk to a depth of 1,600 ft and extensive stoping was conducted above the 1400 ft level. The mine has 12 levels and drifts were commonly 600 to 1,400 ft long. Reportedly, most of the ore has been removed from the surface to the 600 ft level. Nearly all of the production was won between 1908 to 1917 when the mill burned. Only a few intermittent and very small attempts to resume operations were made after the fire. Production (see Table) amounted to some $6,500,000. Dings (1951) notes that reports vary greatly about the grade and quantity of ore left in the workings below the 1,000 ft level. Haury (1947), however, states that good ore was reported on the 1,400 ft level. At the time of his reporting, the workings were badly caved and flooded to the 600 ft level.

Tennessee-Schuylkill: (T24N, R18W, Sec. 4) The Tennessee vein strikes N8°W and dips 85°E. The mine has been in production since the 1890's and is the largest producer of lead and zinc in the district. It has also produced considerable gold and silver (see Figure 21). Dings (1951) noted that during World War II the mine was producing about 150 tons/day that averaged 6-8% Zn, 3.5% Pb, and 17-25 opt Ag. Schroder and Allsman (1939) report that in September 1938, the mill heads on some 4,278 tons of ore run contained 0.185 opt Au, 2.26 opt Ag, 3.43% Pb, and 5.15% Zn. The average width of the stoped vein is 5 ft, although ore shoots 20 ft wide are found in the mine. Length of ore shoots ranged from 35 to 300 ft. One ore shoot north of the Tennessee shaft was mined to a depth of 1,500 ft. The Tennessee shaft was sunk to the 1,400 ft level and a winze was sunk from the 1,400 ft level to the 1600 ft level. Schroder and Allsman (1939) indicate that four ore shoots were exposed in the mine workings to depths ranging from 150 ft, "on the one farthest north of the Schuylkill shaft, to 1600 ft on the one farthest south and immediately north of the Tennessee shaft." The two intervening shoots (Figure 21) have been explored to a depth of over 1,000 ft. As of 1938, drifting was being pushed on the lower levels and north of the Schuylkill shaft as fast as mining permitted stoped to become available for waste disposal.

References:

Dings, 1951; Eaton, 1980; Haury, 1947; Schrader, 1909; Schroder and Allsman, 1939; Shafiqullah and others, 1980; Silver, 1967; Thomas, 1949; Vega and Wilkinson, 1984; Wilkinson, 1981; Wilson and others, 1967.

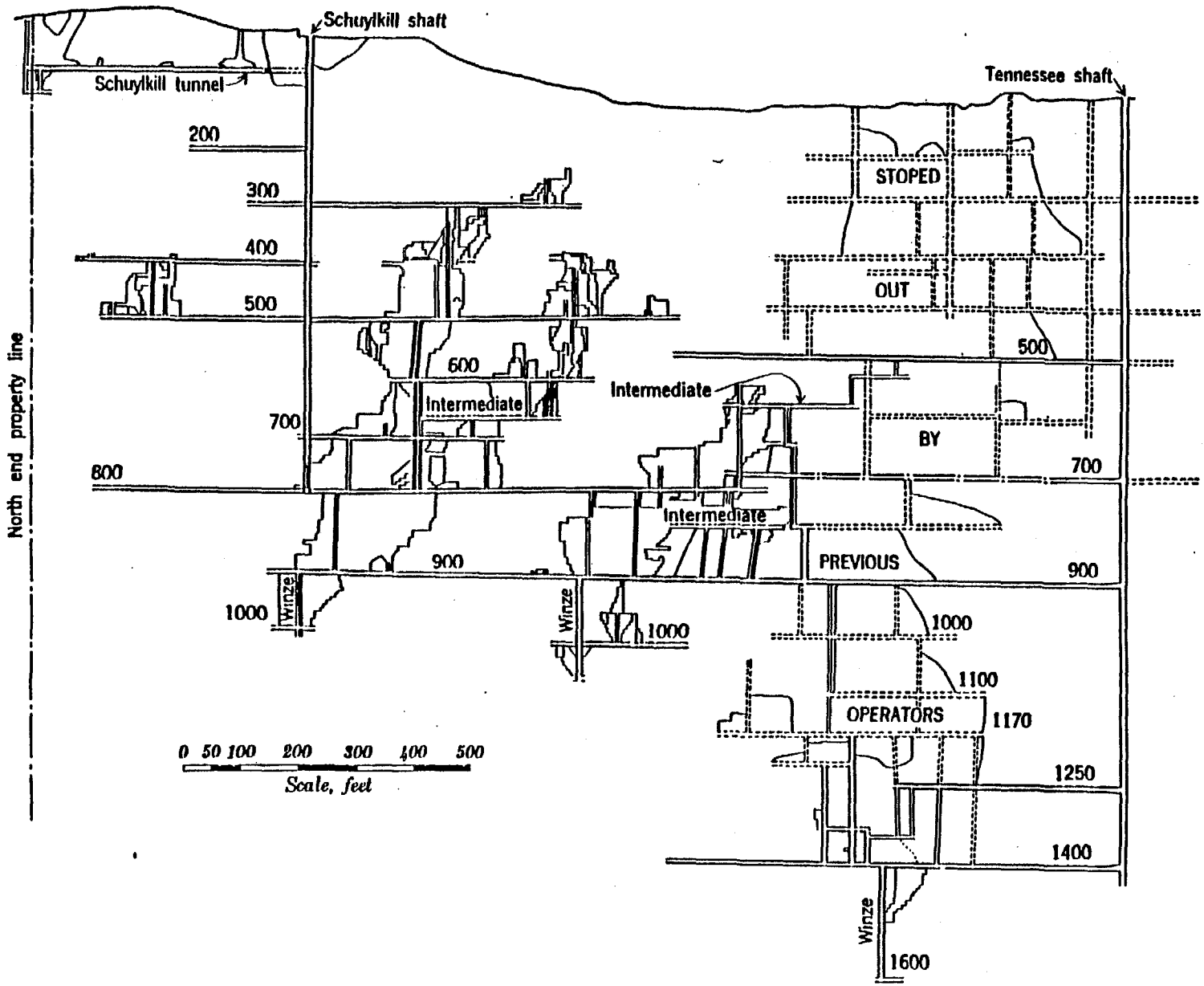


Figure 21 —Longitudinal projection, Tennessee-Schuylkill mine, Chloride, Ariz., showing stoped areas, April 1938, (after Garrett).
(from Schroder and Allsman, 1939)

WEAVER (RICH HILL, OCTAVE) DISTRICT

Location:

The Weaver mining district is located in the Weaver Mountains in southern Yavapai County. The most productive part of the district covers the southern margin of the range and is contiguous with the Martinez district on the west. In this report, the district is expanded to cover mines north of Yarnell and west of Peeples Valley. Access to the district is via Highway 89 about 20 miles north from Wickenburg.

Geology and History:

Like the nearby Date Creek Mountains which host the Martinez district, the Weaver Mountains are made up largely of Precambrian granitic rocks that consist of granite and diorite. In addition, several large, northeast-elongate bodies of Yavapai Series schists crop out in both the southern and northern portions of the range, and mid-Tertiary volcanic rocks cap parts of the higher portions of the range. Dikes and bodies of pegmatite, aplite and basic rock that trend easterly to northeasterly are abundant in some of the Precambrian basement, particularly through the main productive area. The range exhibits strong faulting of two predominant fault directions; northeast and west-northwest. The northeast-trending set appears to be offset in places by the northwesterly set and thus are the oldest. They probably reflect Precambrian or Laramide fault and shear zones. The northwest-trending structures, however, are the most abundant and prominent of the two.

While the Weaver district has been a substantial past gold producer from both placer and lode deposits, little modern geologic information on the district is available. The famous Rich Hill and Weaver "Diggins" placers were discovered in 1862 by a party of explorers which included such Arizona historic notables as Capt. Pauline Weaver, Major A. H. Peeples and Jack Swilling (Wilson, 1961; Kirkbridge, undtd). Subsequent production from the placers is unrecorded, but the operations supported a population of Americans and Mexicans numbering from 1,000 to 2,000 over a period of several years after their discovery (Kirkbridge, undtd). Johnson (1972) credits placer production from the district through 1968 as amounting to some 110,000 oz Au. The Weaver placer area covers about 40 square miles along the south flank of the range (Johnson, 1972). By far the most important area for placer production has been at the top of Rich Hill, along parts of the sides of the hill, and from gravels along Weaver and Antelope Creeks (Wilson, 1961; Johnson, 1972; and references contained therein). Other placers are found west of this area, near the Planet and Saturn mines (Sec. 21, T10N, R5W). Johnson (1972) also cited the lack of detailed geologic information of the area, but stated that the presumed source of the gold in the placers was probably from gold-bearing veins occurring in the Precambrian granite and schist.

Wilson and others (1967) and several old consulting reports supply the majority of the known geologic details of the lode gold mines that operated in the district. Basically, the geology, mineralogy and deposit characteristics

are a continuation of the Martinez district which is contiguous on the west. In fact, early reports refer to this entire region as lying along a mineral belt running through the southern slope of the Bradshaw range. The typical gold-bearing deposit in the Weaver district consists of a mesothermal quartz filled fissure vein that displays one or more periods of mineralization. The veins commonly occur in "greenstone" or porphyritic dikes intruded into the Precambrian granite. These veins generally display roughly east to northeast trends and shallow (20° to 30°) dips toward the north. Widths vary from one to several feet and reported values of mill grade ore usually ran about $13.00 per ton (@ $35/oz) up to several hundred dollars per ton. Other veins are entirely within the granite. These are typically of somewhat lower grade and carry more silver than the veins within the dikes. Wallrock alteration consists of sericitization, silicification and carbonatization.

Within the veins, gold mineralization is best developed in the most fractured zones within the quartz filling where gold values are accompanied by disseminated pyrite and some galena with very little massive sulfide enrichment (Kirkbridge, undtd). The richest ores reportedly occur with secondary hematite and limonite, although high values in gold are obtained with both the galena and pyrite. Ore shoots lie almost flat and near the footwall.

A notable feature of the ores in the district is that they remained relatively constant with depth and apparently in some of the mines the highest values were found considerably below the surface. The Congress mine in the Martinez district was productive to well below the 4,000 ft level on the incline of the vein; likewise, the depth of the Octave mine was at least 2,300 ft. The major mines of the district include the Octave, the Alvarado (Planet, Saturn) mine, Rich Hill, Consolidated and the Leviathan.

Keith and others (1983a) credit the district with 745,000 tons of lode production between 1895 and 1970 that contained 203,000 oz Au; 189,000 oz Ag; 124,000 lbs Cu; and 882,000 lbs Pb. In 1981, the Alvarado mine was being explored by Scarth Oil and Gas Co., Amarillo, Texas, who announced reserves of about 600,000 tons of ore averaging 0.27 opt Au. Add to this the estimated placer production of some 110,000 oz Au and one can see that the Weaver district was a substantial gold producer.

Mines of Interest

Octave Mine: (Located 2 miles south of Rich Hill (Sec. 5, T9N, R4W.) on a narrow pediment) The main Octave vein occurs within a fault fissure that strikes N70°E and dips from 20° to 30° NW. Wilson and others (1967) state that cleavage in vein gouge indicates that the fault was of reverse character. The vein is traceable on the surface for several thousand feet and is cut by several later faults. Vein fillings consist of coarse textured, massive to laminated, grayish-white quartz that contain masses, disseminations and bands of fine-grained pyrite, galena, and minor chalcopyrite. All of the sulfides are auriferous and little free gold exists in the deposits. Wallrock alteration consists of sericitization, silicification and carbonatization.

The vein was discovered in the 1860's but major production came between 1900 to 1905 when some $2,000,000 was produced. Some development and mining took place in the 1920's. The American Smelting and Refining Co. reopened the mine in 1934 and worked it until December of 1942. Workings developed to at least 2,000 ft depth by four shafts and several thousand feet of drifts and extensive stopes on three ore shoots. The vein is said to have opened up to 8 ft widths in places and obtained widths of milling ore up to 15 ft.

Alvarado (Plant Saturn, Liberty Gold) Mine: (Sec. 21, T10N, R5W) The Alvarado vein was discovered in 1905. The vein strikes N30°E and dips 25° to 35° NW. Rhyolite and diorite dikes parallel the quartz vein. The diorite is mineralized and in places constitutes commercial ore. Workings are developed by two shafts, 800 and 1300 ft deep, with workings on every 100 ft level. The maximum length of the vein is 4,000 ft. Mine was in operation between 1935 and 1943. Sherman and Sherman (1969) states that the Liberty Gulch Gold Mining Co. produced some $1,555,000 between 1928 and 1942 from a mine in Fools Gulch. We have no supporting evidence for this production and are rather dubious about this amount. Nevertheless, Scarth Oil and Gas Co. of Amarillo, Texas acquired the property and in a 1981 report, reportedly had blocked out approximately 600,000 tons of ore that averaged 0.27 opt Au. Their tests also indicated that previous mining operations had only recovered about 0.18 opt from past ores milled. At that time Scarth was shopping for a joint venture partner. What the status of the property is in 1984 is not known. This should be checked out.

Johnson Mine: (Location inexact, 4 miles due north of Octave) Property consists of 5 patented and 5 unpatented claims. Northeast-striking vein cuts Precambrian granite. The vein dips from 28° to 30° to the north and is adjacent to a fine-grained basic dike. The best ore apparently is associated with this dike, and is sometimes above and sometimes below it. Where both walls of vein are granite, there is very little commercial ore. The vein is from 1-2 ft thick and ore is associated with auriferous galena, pyrite, chalcopyrite, and sphalerite. Vein is cut by two northwest-trending faults. Ore has been found on both sides of the most westerly fault, but east fault seems to cut off vein entirely. Mine was being developed in 1936 and consisted of a mine adit 470 ft long, with one level above and four below, connected by an incline shaft following the dip of the vein which was 530 ft deep. Development along the vein totaled about 1,500 ft of drifting. Production amounted to about 20 tons/day.

Meyers Mine: (Located about 1 mile northwest of Octave on the west side of Weaver Gulch) Property consisted of 7 unpatented claims in 1936 which were being operated by the Consolidated Mining and Development Co. The Meyers vein strikes N60°E, dips 30° to the northwest and cuts Precambrian granite. The vein is from 1-2 ft wide and consists of coarsely crystalline quartz. Like most other mines in the district, gold is the only metal of commercial value, but is contained in auriferous galena, pyrite, and chalcopyrite. In 1936, the mine was developed by an inclined shaft 175 ft deep along the dip of the vein and by two levels at 85 and 145 ft from the collar. There is about 600 ft of combined drifting on the two levels. In May of 1936 six carloads of ore were shipped from the property.

Yarnell Mine: (Located about 1.5 miles south of the settlement of Yarnell, near the summit of Weaver Mountain) In 1936, the property consisted of 5 patented and 7 unpatented claims. Country rock is mainly granite containing northeast-trending bodies of schist. The Yarnell vein is enclosed in the granite, strikes N45°E and dips 35° to 40° northwest. Unlike most other deposits in the district, the Yarnell mineralizations are hosted in a shear zone that is 120 ft wide. Orebodies occur near both the hanging and footwalls; however, the principal ores occur in the footwall. Mineralization consists of free gold and auriferous pyrite, galena and chalcopyrite. Mineralization is reportedly quite regular in places, but in others, tongues of mineralization are said to run out into the footwall for considerable distances. Ore mined in 1936 averaged $8-$10 per ton Au. Mine workings consisted of 3 adit levels connected by raises. The lower level contained about 1000 ft of drifting on the vein. The width of the shear zone in the Yarnell mine presents an interesting situation for the possibility of low-grade mineralization. If the shear zone is mineralized across its width (±120 ft) the possibility exists for a small to moderate bulk mineable target to exist. It should be sampled and examined with this possibility in mind.

Cuba (Rooney): (Sec. 16, T11N, R5W) Vein is up to 6 ft wide, dipping about 25° and occurs in granitoid rocks. Main development consists of a 150 ft incline shaft with two levels having about 200 ft of work. Approximately half of vein area has been developed with the better parts of it stoped. Lower-grade ore left was sampled and found to average $14.35 Au (@ $35/oz) and $1.00 Ag across an average width of 2.4 ft. It is believed ore may be developed laterally as well as to greater depth. Mines in this district have been productive to 4,000 ft depths. According to USBM engineers who examined the property in 1937, estimated reserves of 1,679 tons of $13.53 ore appear left in old stopes.

Monica: (Sec. 21, T11N, R5W) The mine is old, having been worked extensively for Au in about the 1906 era. Vein is a fissure which dips about 27° and that has been opened up on incline 1,000 ft. A 1300 ft crosscut taps the vein at this depth. From 900 ft to surface the vein was extensively stoped. Stopes are all open except for a pillar on the 1,000 ft level which shows a strong, glassy white, quartz vein. Some production is reported, but the mine is thought to be worked out.

Rich Hill Mine: (Location inexact, about 4000 ft from Octave mine at the southeastern end of Rich Hill) A quartz fissure vein (2-3 ft wide) similar to nearby Octave vein strikes approximately east-west and dips 30° to 35° to the north. Shallow workings include a 150 ft incline shaft with short drifts. Vein is narrow (about 2 ft wide) but gives rather high grade assays (34 samples averaged $19.24 per ton Au; @ 1934 prices). Apparently the deposit was little explored. Wilson and others (1967) reported that 2 cars of sorted ores were shipped during the 1930's from this property.

Bee Hive (Zieger): (Location inexact, about 2 miles northeast of Octave). A northwestward-trending shear zone intersects vein that is supposed to be continuation of Octave vein. The principal workings are in Yavapai schist east of the quartz diorite. Numerous dikes of aplite and pegmatite intrude

the schist. Wilson and others (1967) report only a few thin veinlets of quartz are present, but that some flat nuggets and flaky gold were found in sheared schist. Small production was made by arrastres, but workings that included two shallow shafts and about 0.5 mile of tunnel reportedly encountered very little ore.

Bishop Mine: (About 14 miles east of Congress, AZ.; Sec 4, T9N, R4W) Small shipments are reported to carry 0.5 to 1.0 opt Au. In a schist occurs a quartz vein 1-2 ft wide carrying gold, free and combined, that by hand sorting runs from 0.5 to 1.0 Au. In 1943, the workings consisted of a 100 ft tunnel and an incline shaft on one claim and a 300 ft tunnel and 200 ft incline on another, and some open cuts. Copper showings in small amounts are present.

References:

Wilson, 1961; Wilson and others, 1967; Kirkbridge, undtd; Johnson, 1972; Unpubl. report, Scarth Oil & Gas Co., 1981; Keith and others, 1983;

WEBB DISTRICT

Location:

We have applied this name to a broad area in the northern Gila Bend Mountains which contains several prospective areas of copper-precious metals mineralization. One of these is near Webb Mountain centrally located in the area of interest, so we have arbitrarily referred to the overall areas as the Webb district or region. The region is found west-southwest of the small community of Arlington, a few miles west of Buckeye and includes T2S, R7, 8 & 9W. The area of interest is included on the SW¼ of the Arlington, N½ of the Woolsey Peak and N½ of the Dendora Valley 15' quadrangles.

Geology and History:

The district occurs in an area largely capped by rather extensive outcrops of mid to late Tertiary volcanic rocks of felsic to intermediate composition and overlying buttes and mesas of $<$ 15 m.y. old basaltic flows and conglomerates such as make up the topographic points of Black Butte, Yellow Medicine Hills (Arlington quad.), or Yellow Medicine Butte (Dendora Valley Quad) and Woolsey Peak. The earlier volcanic sequence consisting of andestic-dacite flows, felsic tuffs and volcaniclastic sediments occurs as tilted fault blocks, whereas the basalts are relatively flat-lying.

Outcropping from beneath the volcanic cover are isolated exposures of Precambrian granitic rocks, gneisses and schists. Many of the intrusive rocks are diorites and granodiorites showing various degrees of foliation. The metamorphics include quartzites, muscovite, schists, amphibolite and metarhyolites which generally strike NNE with steep dips. They have been correlated with the Proterozoic Yavapai Series (Cheeseman, 1975), but in this area are probably better referred to as Pinal schist. Younger, Mesozoic to Tertiary dike rocks or small stocks are noted intruding the basement lithologies.

Mineralization in the area is not widespread, and based on population or density of occurrences, would not be considered at all (see precious metals overlay to Plate 1). The demarked region does, however, contain several specific mines or prospects which we feel warrant special attention. Some of this base metal-gold-silver mineralization (i.e. Black Butte prospect) may be of Precambrian age, related to the Pinal (Yavapai ?)schist and be of volcanogenic or exhalative origin. Other occurrences appear to be epigenetic, related to intrusive activity and localization along structural zones.

Mines of Interest:

Black Butte prospect: (T2S, R7W, Secs. 14 & 15) Small exposures of Precambrian gneiss and schist just north of the basalt capped Black Butte exhibit considerable alteration and disperse copper-gold mineralization. Mineralization is related to numerous veins, stockworks and "blowouts" of quartz and barite which appear concentrated along contacts between basic dikes and gneisses or granitic rocks. Better mineralization is also noted at the contact between Tertiary

volcanics and basement. The area has received attention as a copper prospect with extensive sampling and drilling. Surface sampling yields numerous values >1 opt in gold, with copper ranging from 0.007 to 6.4%. Of seven holes drilled on the prospect, #4 ran from a trace to 0.59 opt Au; #7 encountered intervals assaying trace to 5.7 opt Au with Cu >1%. In hole #7, 59 ft ran from 0.03 to 0.54 opt Au with several percentages of Cu. The best mineralization was encountered along a steeply dipping structural zone which may be conformable to foliation in the metamorphic host rocks. Currently the property is held by Rhyolite Resources, 301-1285 W. Pender Street, Vancouver, B.C., VBA 422, or Box 31, Black Point Road, Powell River, B.C., Canada.

Buckeye mine: (Sec. 28, T2S, R6W) Mineralization is concentrated along a highly sheared contact between foliate granodiorite and altered Pinal Series metamorphic rocks including quartz-sericite, magnetite, pyritic, schists, quartzite, amphibolite, metarhyolite and meta-andesitic tuffaceous rocks. The magnetite-quartz-muscovite schist unit with interbeds of marble and calc-silicate rock occurs stratigraphically just below one of the metarhyolite horizons and is the principal host rock for mineralization at the Buckeye copper mine. Note that some of the schist is tourmaline bearing.

Mineralization occurs as silicates and carbonates of copper with some sulfides at depth. These minerals occur in disseminations, small lenses, streaks and pockets along foliation planes in the schist and associated with strong quartz-tourmaline veining along the sheared, N10°E to N35°W-trending contact zone. Pyrite and chalcopyrite with minor bornite-chalcocite are the chief sulfide minerals. The contact zone yields several percent copper. No gold assays are reported but precious metals are present (CRIB data). The deposit may have volcanogenic origins with superimposed mineralization due to later intrusion.

Yellow Medicine Butte (Pumpkin Glow) Prospect: (T2S, R9W, Secs. 30 & 31) Mineralization is concentrated in a granitic breccia cemented by iron oxides which is localized along a major structural zone between granite gneiss and limestone. The structure strikes N75°W, dips 80° south and is from 20 to 100 ft wide. It is exposed intermittently over a strike length of at least 1,800 ft. Argentiferous galena is reported from the zone and a number of samples run from 1 to 4 oz in Ag. Gold values vary from less than 0.02 to as high as 0.13 opt. Black calcite veinlets permeate the zone. The property is currently held by a Jim Weatherby (602) 939-3961.

References:

Arizona Dept Mineral Resources, file data; Cheeseman, 1974.

WHITE HILLS (INDIAN SECRET) DISTRICT

Location:

The White Hills mining district covers the eastern half of T27N, R20W in northwestern Mohave County. The district lies about 40 miles northwest of Kingman.

Geology and History:

The district has been described by Schrader (1908) and more recently by Huskinson (1984). The following general discussion is largely taken from Huskinson (1984). Basement in the district consists of migmatitic gneisses and granites that locally contain amphibolite pods. Foliation and schistosity trends generally N35°E with a gentle dip to the NW. Schrader (1908) mentions that the gneisses contains garnet which locally occur in 2.5 ft wide bands or zones that traverse the gneisses. Andesites to latites of the Patsey mine sequence (?) overlie the Precambrian rocks to the east, and are in turn capped by relatively flat lying olivine basalt flows. The Patsey mine volcanics are rotated and tilted (40°-50°) along a series of listric and low-angle normal faults (Wilkins, 1984) that are common this part of Arizona. The younger basalts covering the tilted sequence are relatively flat-lying. Numerous veins that strike WNW and dip to the north at 25° to 75° dips fill shear zones in the Precambrian rocks. These veins are typically 1-3 ft in average width and consist of FeOx- and MnOx-stained clay gouge. Cerargyrite is the main ore mineral and occurs as vug fillings in the quartz and as fracture filling in the shear zones. The average grade of the ore was reportedly less than 25 opt Ag, although small extremely high-grade pockets were evidently found. The dumps were reworked in the 1904 era and reportedly averaged 6-7 opt Ag.

Two mineralized vein sets occur in the area. The oldest(?) is a low-angle (20°-30°) set that appears to have been truncated by a higher angle (60°-70°) set. Both types have been productive, although the low-angle structures seem to have carried richer ore. Huskinson (1984) also mentions that low-angle bedding plane faults are numerous in the area.

Huskinson (1984) who studied the district as part of a small Canadian company's attempt to evaluate the mineral potential of the district, believed the following points were significant:

1. Oxidation and enrichment occur throughout the veins in the district. The ore is always cerargyrite (AgCl), and no sulfides (except for very minor pyrite in the Review area) have been found. The Occident and Norma mines have been developed in excess of 500 ft deep, always in oxide ore.

2. Many of the veins appear to be listric structures: (i.e., they flatten with depth). A particularly good example of this can be seen at the Africa shaft.

3. Many of the veins are shear zones with minor listric type structures displayed within the shears.

4. The White Hills do not appear to be bounded on the west by a normal basin and range fault. Depth to the basement in the center of the valley over a mile west of the camp is probably 800 ft or less.

5. There are reports that a deep hole 3 to 4 miles west of the White Hills passed through three or more parallel horizontal structures.

6. There are no intrusive rocks nearby to credit as a source of mineralization, although Gulf is said to have drilled a small porphyry copper deposit 7 or 8 miles west of the area.

Given that the above points indicate that mineralization occurs in a extensional structural setting, Huskinson (1984) believes that the mineralization at White Hills may be explained as follows:

1. Upper-plate movement over the lower plate boundary at White Hills resulted in the formation of high-angle fractures in the lower-plate sub-detachment zone.

2. These structures flattened with continued movement of the upper plate and were cut by subsequent high-angle fractures.

3. Silver, carried as a chloride complex by meteoric water circulating through the upper plate (and derived from an admittedly nebulons source), was deposited in both vein sets.

4. Because the low-angle sets are older they have been subjected to greater enrichment.

5. The upper plate is eroded and the volcanic rocks are extruded.

The district was foremost a silver district, although locally gold was present. Huskinson (1984) notes that the EMMA veins are auriferous as is the Hulda/Review area (assays of 0.68 opt Au across narrow intervals). He estimates that total production from the district is probably 6-8 million oz Ag and 5,000 oz (or less) Au.

The district was discovered in 1892 when a Hualapai Indian showed a local miner some rich silver ore from the area. As a result of some of the ore running to $1,000/ton, a rush to the camp ensued and by 1894 it boasted a population of 1,200. The camp was soon controlled by a single mining company whose principals were from Denver. They sold the property in 1895 to an English concern who brought in a new mill. The English concern failed and the mine was bought back by the original owners at a sheriff's sale. The district produced steadily for a 10-12 year period. During this time, work was mainly performed by lease miners who "chlorided" the rich ore shoots until they pinched out or were faulted off (as at the Occident/Horn Silver area).

Huskinson claims the district has never been systematically explored. Presumably the Corval Resources Ltd. who control an undetermined amount of the district, is attempting to evaluate the area.

Schrader (1908) briefly describes some of the mines in the district. Apparently by the time of his visit many of the main producers had already been closed. We only mention two such mines here, although due to our ignorance of the district, others may be of equal or greater interest.

Mines of Interest:

Grand Army of the Republic (GAR) Mine: (Sec. 11, T27N, R20W) Located about 3/4 mile north of main street (see Figure 22), the GAR vein system is one of the largest in the district. It was said to have been extensively developed to a depth of 700 ft by inclines, drifts, stopes and shafts distributed on five levels. Water level was reached at the 60 ft level. Country rock consists of highly altered and iron stained gneissic granite and schist. The deposits are contained in two nearly parallel veins about 30 ft apart. The lowermost vein is the principal producer. The veins strike N62°W and dip about 23° NE approximately conformable to foliation in the country rock. The veins increase in dip to 75° about 150 yards SE of the mine. Ore was free milling and reportedly very rich, some going as much as 6,000-7,000 opt Ag. According to Schrader (1908) the mine produced much rich ore from all of its five levels. It was the major producer during the early days and as many as 100 men would be stoping at one time. Since the early miners mainly high graded the richest parts of the veins, one must wonder what the average grade might run across the 30 ft between the two veins. Since these structures display a low dip for a considerable distance some open pit tonnage could possibly still exist.

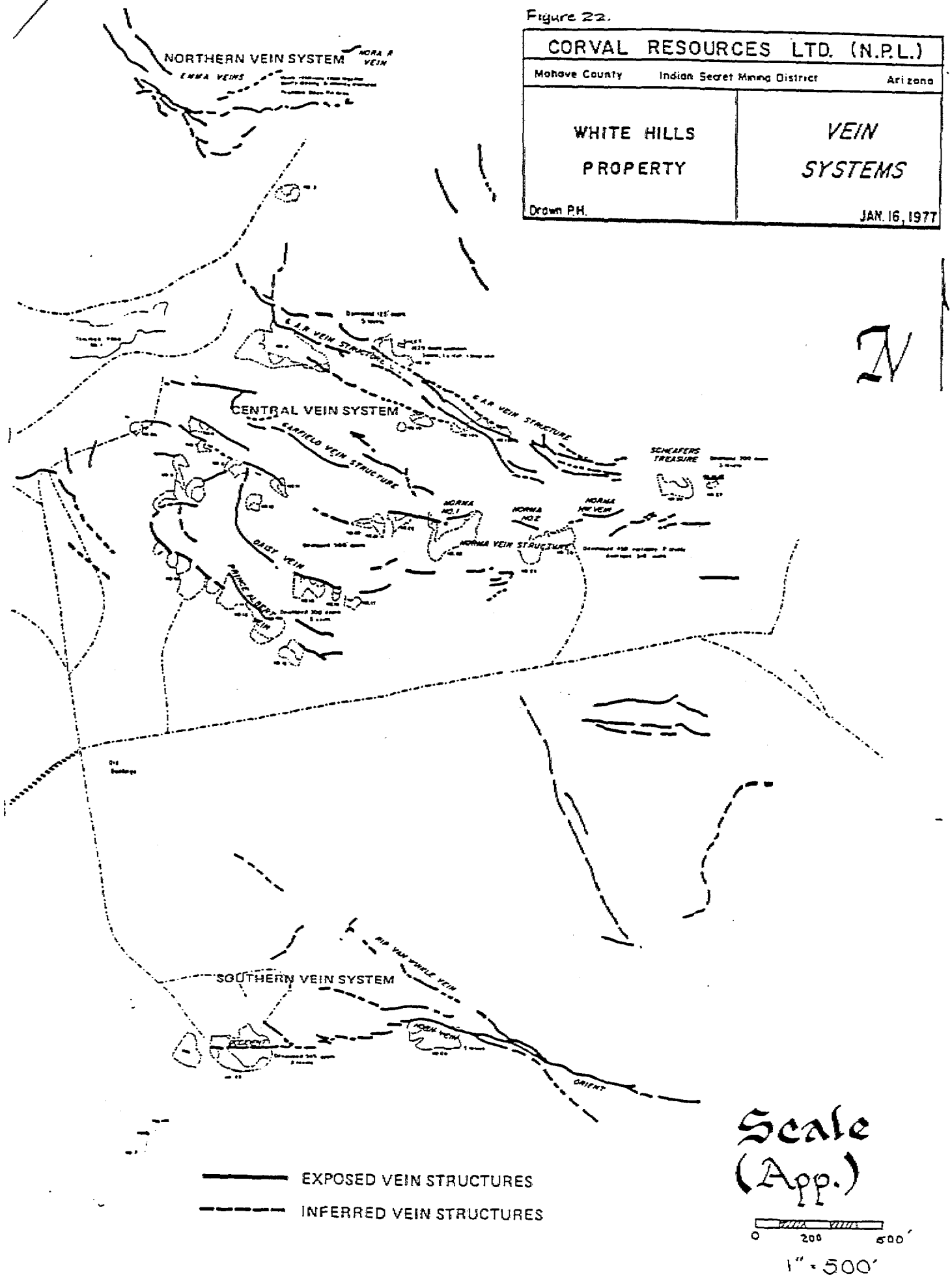
Occident and Horn Silver Mines: (Sec. 14, T27N, R20W) Located about 1/4 mile south of town, both mines are believed to be on opposite ends of same vein which has been faulted in the middle (see Figure 23). The vein is from 2-4 ft wide and consists of reddish-brown, FeOx-stained, crushed and brecciated quartz. The vein strikes about east-west and dips 60°N. Ore was said to be principally horn silver. Both mines were believed to have been quite productive. The Occident mine is thought to be 800 ft deep with considerable lateral workings. The vein flattens with depth in the Horn Silver. Huskinson (1984) indicates that the two mines are separated from one another by post-mineral faults and that the area in between has never been adequately tested for continuations of the ore shoots. This untested zone has about 600 ft of strike length and might present a nice target for a small to medium size mining company.

References:

Huskinson, 1984; Schrader, 1908; Wilkins, 1984.

Figure 22.

CORVAL RESOURCES LTD. (N.P.L.)	
Mohave County — Indian Secret Mining District — Arizona	
WHITE HILLS PROPERTY	*VEIN SYSTEMS*
Drawn P.H.	JAN. 16, 1977



(From Huskinson, 198[illegible])

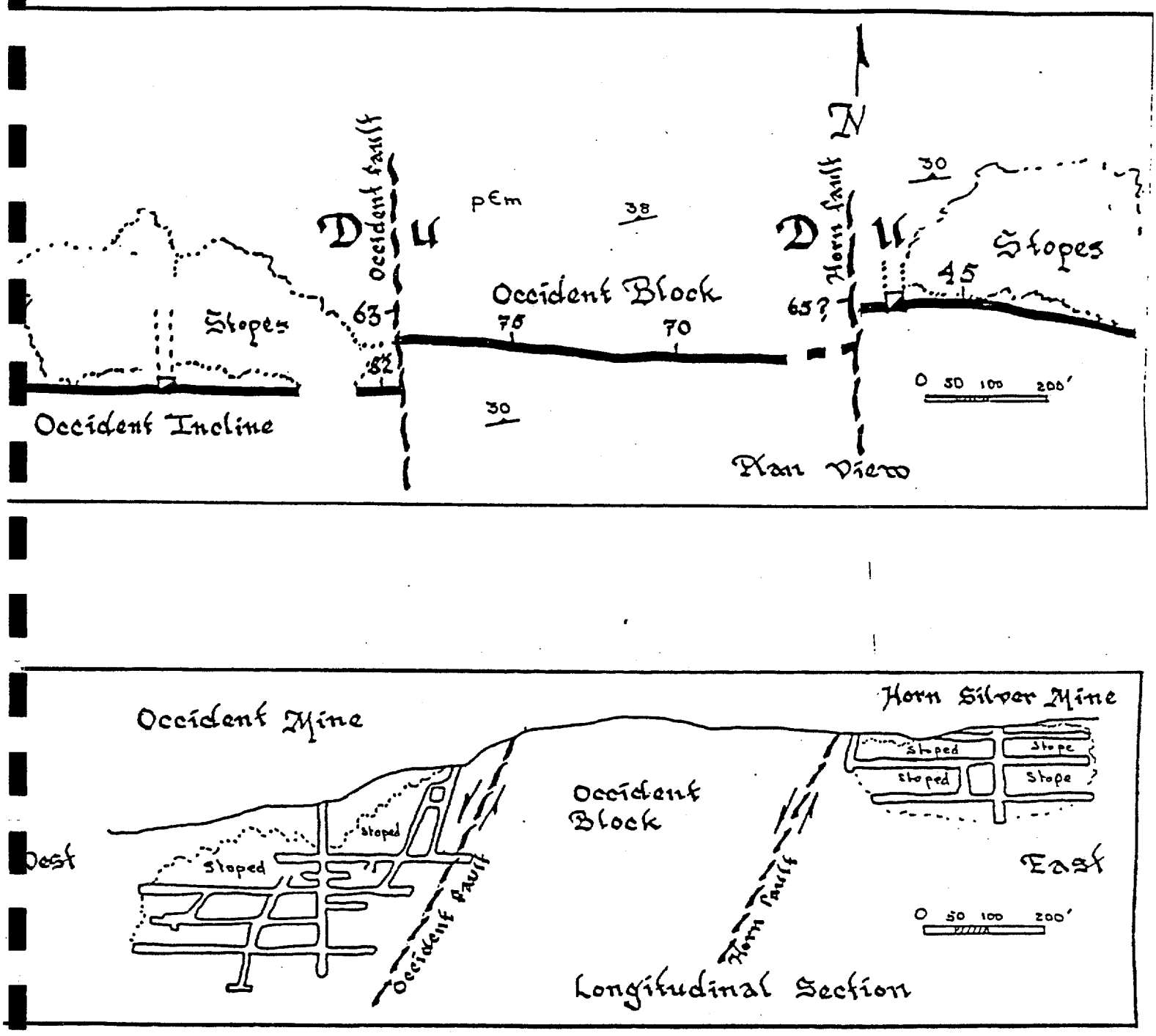


Figure 23.
Occident Mine & Horn Silver Mine area. The block of ground between these producers has not been adequately tested.
After Schrader, 1908, p.135
(From Huskinson, 1984)

WHITE PICACHO (SAN DOMINGO, WICKENBURG MTNS, RED PICACHO) DISTRICT

Location:

In this report the White Picacho district covers that area which lies north of Morristown and extends to the northeast where it becomes contiguous with the Black Rock, Castle Creek and Pikes Peak districts. It straddles the Yavapai-Maricopa county line and centers on T7N, R3W.

Geology and History:

The district covers a large area of variable relief and displays a rather diverse geologic assemblage. Yavapai Series schist floors the area and is intruded on the northern end by a Precambrian granitic complex of batholithic size. The Yavapai schists consist of thinly foliated quartz-mica schist, quartz-mica-hornblende schist and gneiss, feldspathic hornblende gneiss, quartz-feldspar-mica gneisses, amphibolite, epidote, impure quartzite and various migmatitic rock types (Jahns, 1952). Jahns (1952) states that the schist protolith includes both sedimentary and volcanic rock types. He also notes that in the northern part of the district masses of porphyritic rhyolite, diorite and gabbro occur which locally intrude the schists but which are probably older than the Precambrian granitic complex. The Precambrian rocks are cut by numerous irregular pegmatite bodies that have been extensively prospected and mined for lithium and rare-earth minerals (Jahns, 1952).

Tertiary volcanic and sedimentary rocks cover parts of the Precambrian terrane and represent remnants of a much wider accumulation. Compositions of the volcanic rocks range from basalt to rhyolite. These rocks are best preserved in the eastern portion of the district where they often form cliffs and steep ridges. They also occur as dikes, plugs and irregular bodies in the older rocks.

A system of northwest-trending faults cut through the region and are displayed on plate 1. Some of the faulting displayed in the district has had young enough movement to have affected valley fill and alluvial fan sequences (Jahns, 1952).

The district is host to a variety of mineral deposits, including; gold vein and placer deposits (i.e. Hewlett and others, 1936; Wilson and others, 1967; Wilson, 1961; Johnson, 1972), tungsten mineralization (Dale, 1959; 1961), and lithium and rare earth deposits (i.e. Jahns, 1952). Little is published about the gold mineralization in the district. The placers were known and extensively worked in the 1870's and 1880's. Wilson (1961) notes that quartz veins of probably both Precambrian and post-Cambrian ages have furnished gold to the placers. Jahns (1952) notes that quartz veins and lenses are rather common and have been worked for gold and tungsten in several parts of the district. Hewlett and others (1936) briefly mention that gold-bearing veins occur both in the surface volcanic rocks and in the Precambrian rocks, indicating that at least part of the mineralization is of mid-Tertiary age and epithermal in character.

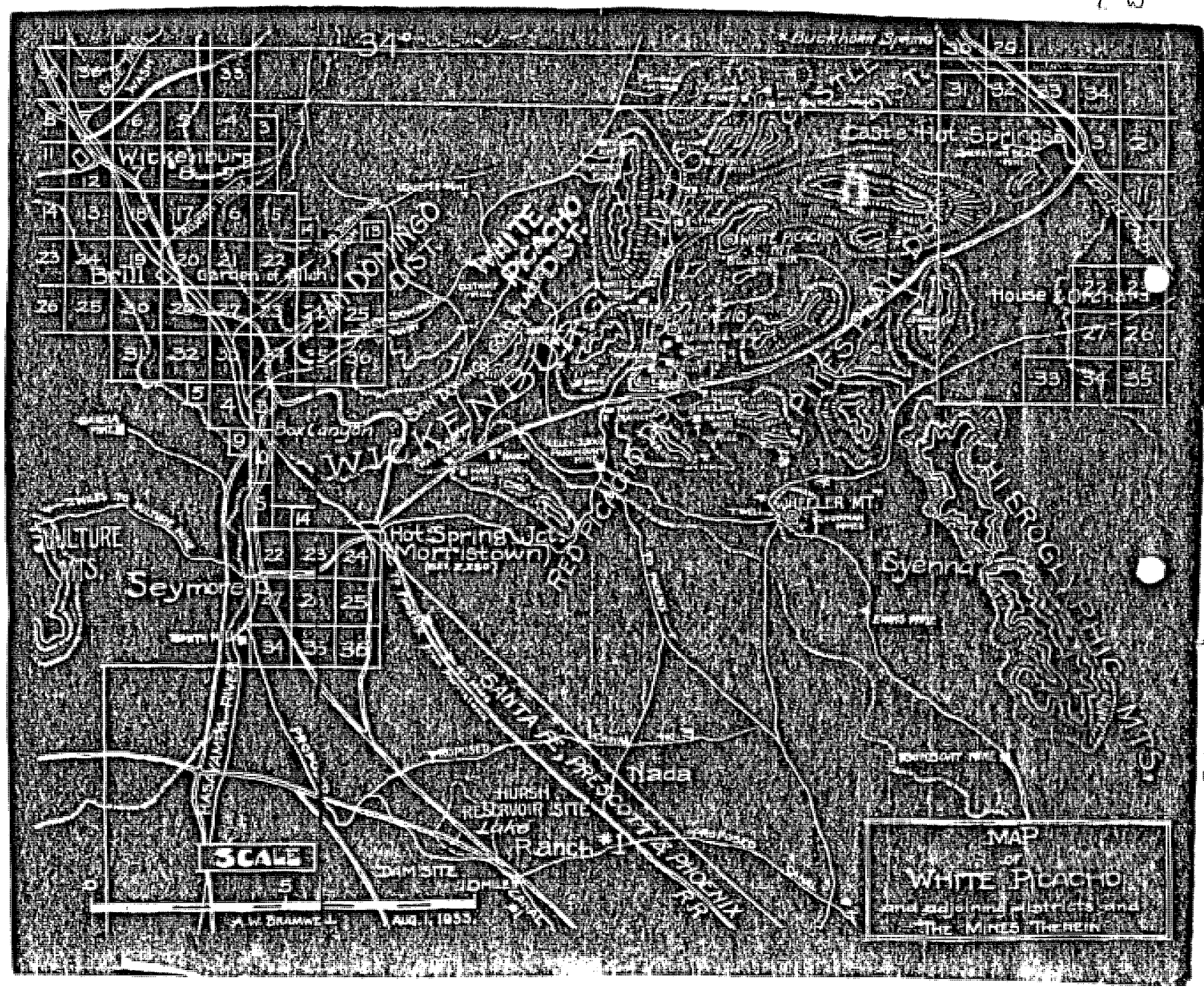


Figure 24.

(From ADMR files)

Gold production for the district is hard to ascertain. Johnson (1972) estimates that the placers have produced greater than 2,000 oz through 1968. This would seemingly be a minimum figure as pre-1900 production may have been substantial. Keith and others (1983a) indicate that records show that the combined districts under which we have called the White Picacho district, produced some 4,900 tons of ore containing 3,300 oz Au; 1,500 oz Ag; 85,000 lbs Cu, and 200 lbs Pb.

The placer area is confined mainly to San Domingo Wash, its tributaries and adjacent washes, and on mesas separating gulches (Johnson, 1972). This area is southwest of a low range of hills that include San Domingo Peak. Johnson (1972) locates many individual washes that were the scene for early placer activity. It seems likely that little modern attention has ever been given to investigating whether or not these placers have localized gold sources that might be of a character and potential size to be of present day commercial interest.

The tungsten mineralization in the district is interesting. Most of the tungsten prospects occur in Yavapai schist and many appear to be conformable to schistosity which in at least some cases can be proven to follow original bedding (i.e. Jahns, 1952). Dale (1959, 1961) makes mention of associated sparse gold mineralization with some of the showings, and a number of the prospects occur in the San Domingo Wash area which also contains the gold placers. Descriptions of the tungsten mineralization sound like they might be metamorphic skarns of thin bedded carbonate horizons originally stratibound in the schist protolith. In some cases these may represent primary carbonate-rich precipitates derived from sea-floor hydrothermal activity. We would suggest that these zones should be examined. We have included descriptions of these tungsten prospects below in the "Mines of Interest" section.

Mines of Interest:

Golden Slipper Mine: (Sec. 18, T7N, R2W) Old property that was discovered around the turn of the century was worked intermittently through about 1936. Production in the early 1930's amounted to about 358 tons which contained approximately 620 oz Au. Ore occurs in a vein in a brecciated fault zone cutting platy to schistose rhyolite. The fault zone strikes southeastward and dips about 20° NE. The vein filling consists of brecciated rhyolite with irregular stringers of quartz. Iron and copper oxides are locally present. The main ore shoot was apparently quite small. Alteration reportedly consists of sericitization and silicification near the vein and strong yellow-brown FeOx staining in the rhyolite above the vein.

Bennett (Buffalo Arizona) Mine: (Sec. 5, T6N, R2W-in Bennett Gulch) The Bennett is an old mine that sounds interesting, but that has little definitive data available. Several old reports in ADMR indicate that the country rock consists of garnet, chlorite and micaceous schists of Precambrian age which contain lithologies of quartz conglomerate, shale and greenstone. The schist has been intruded by bodies of Precambrian granite and monzonite and rhyolite that are probably of Tertiary age. These youngest intrusions tend to occur along or near the schist-granite contact. The property was discovered in the

mid-1890's and a shaft and connecting workings developed on copper-rich ore which was said to have averaged 2.5% Cu and 0.15 opt Au. These workings extended to a 318 ft depth. A gold rich zone, separate from the copper zone, reportedly occurs on the southerly slope of Ghost Peak Mountain. A 1934 report indicated that all previous work on the gold deposit occurred in the previous 15 year period in the form of assessment work and was considered of little value for evaluation purposes. The gold mineralization was reported to occur in two large quartz dikes (veins), in two large quartz porphyry dikes and as a network of numerous veins and veinlets occurring in an area between the large dikes. The porphyry dikes are highly siliceous bodies that apparently contain low grade mineralization. Some reports indicated the mineralization extended across a width of between 25-50 ft or wider. Gold occurs as very finely divided particles and is associated with abundant FeOx. The vein strikes N20°W and dips 50°SW. It is said to be traceable for at least 2000 ft along strike. Gold values of assayed material ran between 0.01 to about 0.30 opt. While the ADMR information is sketchy and at times somewhat contradictory, this sounds like an interesting property that may hold some potential for low-grade, large tonnage possibilities and should be checked out.

Fairview Property: (Sec. 16, T7N, R2W) ADMR files indicate deposit consists of a flat dipping "blanket" vein that occurs along a contact of "birds eye" porphyry and blocky fine-grained andesite. Workings consist of an inclined shaft and vertical shaft which connect with an adit tunnel. Inclined shaft is reportedly sunk to a depth of 420 ft. Horizontal mine workings amount to about 1,000 ft. The vein strikes N20°W and dips at about 40°. Ore was said to vary in width from 3-15 ft, but on the average to be about 5 ft. The vein is reported to be a breccia consisting of quartz and wallrock with considerable iron oxide and some copper silicates and carbonates. Stoping was carried out in irregular rooms along the vein, which is reportedly oxidized to a depth of about 150 ft. Gold is said to be exceedingly fine-grained. Reported values of gold averaged between $7-13.50 per ton (old prices). One report mentioned blocked ore of some 10,000 tons with another 10,000 tons of possible reserves. These figures were apparently repudiated in another engineer's report, who felt that while no proven reserves existed, the mine had good potential for developing substantial tonnages of low-grade ore averaging about $7.00/ton (1936 prices).

The property was discovered in 1883 by Mexicans who reportedly worked high-grade pockets. The mine was not developed until about 1900 by Messrs. Winston and Paine who were said to have done considerable development work and to have produced about $50,000 (± 2500 oz Au) from a small high grade stope. Some work continued on the property through 1932 when $6,800 was produced. Dump supposedly contained 3,000 tons of material than ran $8.00 per ton (old prices). The reports mention a parallel vein system in the area that contained high-grade copper (12% in places).

Young (Katherine) Mine: (Sec. 18, T7N, R2W) Mine is located 11 miles northeast of Morristown. ADMR files indicate a shaft was sunk on vein to depth of 200 ft and drifted and stoped above the 156 ft level (bottom level). Property consists of 4 patented claims (Ernest, Vincent, Winifred, and Katherine). Vein strikes nearly NS and dips 35°W. Country rock is an andesite porphyry (locally

referred to as "birds eye" porphyry) that may be flow or laccolith. Vein filling is reported to be mainly brecciated wallrock cemented by specular hematite, calcite and quartz that carried gold and copper. Free gold pans from richer ores. Copper occurs always as silicate or carbonate, small amount of Ag and some galena present. Ore mined from 1936 to 1941 amounts to $77,000. A partial list of shipments is as follows:

Tons	Average Au (opt)	Paid	Total Au (ounces)
197.31	2.51	$14,050.32	495.25
795.29	1.30	27,617.45	1033.88
446.66	0.69	7,806.02	308.20
433.22	0.32	2,702.19	138.63
1,872.48		$ 52,175.98	1975.96

Vein is said to have ranged up to 10 ft in width, but averaged about 5-6 ft. The maximum dimensions of high-grade ore shoot was 120 ft in length along strike and 120 ft in depth of the incline. Lower-grade material was reportedly left in place. About 2,000-3,000 tons of 0.30 material is believed to have remained in open workings (pillars, etc.). An equal amount of tonnage of similar grade was said to remain on the dump in a 1941 report. A shaft sunk to a depth of 45 ft, some 600 ft south of main workings on same vein ran 0.36 opt Au across 36 ft length. Respected mining engineer, G. M. Colvocoresses, believed there was a good chance that considerable potential for $20 to $25 ore (at $35/oz) could be developed by deepening the workings and that a fairly large tonnage of low-grade ore, suitable for milling, existed around the old stopes. The description of this geologic setting of this property sounds similar to that at the nearby Fairview mine. If this is the case, the entire contact between the "birds eye" porphyry (which sounds like an intrusion) and the surrounding country rock may have mineral potential.

Jumbo Copper Mine (Lower Jumbo) (Sec. 9, T7N, R3W) In a soft schist a ledge 3 to 10 ft thick stands almost vertical and can be traced for considerable distances. It carried copper minerals occurring as irregular masses in a quartzose rock which partially makes up the ledge. Extensive caved in workings on the property suggest much work in the nature of shafts, tunnels, drifts and cuts. Places that were accessible were void of mineralization. In 9 piles sorted at various places, 9 samples averaged 0.85% Cu. Au values ran up to 0.06 opt and Ag was 0.05 opt. It is possible this represents the lower grade ore sorted from earlier shipments. Five patented lode claims and one patented mill site make up the group. In 1943, 3,000 tons of siliceous low-grade Cu ore were sorted out. A grab sample assayed 0.85% Cu. In 1945, 210 tons of 1.06% Cu ore were shipped. The character of ore is carbonates, oxides and sulfides of copper in quartzose gangue.

Tamarack Group: (Secs. 15, 16, 21 & 22, T7N, R3W) Claims were located for tungsten in 1941, prior to this relocation they were worked on small gold showings with a small but unknown production. The workings on the property consist of two inclined shafts (each about 75 ft deep), and numerous shallow

prospect shafts and open cuts. Bedrock on the Tamarack claims consist of Precambrian schist containing narrow beds of "limestone," intruded by medium-grained granite and pegmatite dikes. Sparse, sporadic scheelite occurs in a garnet-epidote rock within the schist, and in one place, between the schist and limestone. Much of the area is covered by overburden. On the north part of the claims, a "tactite" lens can be traced on the surface some 700 ft. Low-grade mineralization extends into the schist. The epidote zones conform to foliation in the schist which in this location is roughly N55°W.

Homestake Group: (Secs. 13 & 24, T7N, R3W; in Trilby Wash drainage) These claims were worked as meager gold showings for a number of years and relocated for tungsten in 1949. The extent of the workings on the gold showings is unknown, but tungsten workings consist of only a few smaller dozer cuts. The scheelite occurrences are hosted by Precambrian gneiss and schist. An occurrence on the west side of Trilby Wash is hosted in hornblende schist containing thin stringers of scheelite in epidote and garnet. Bedding cleavage in the schist is said to strike EW and dips N. Another scheelite prospect is described as occurring in and along fractures in hornblende gneiss. These mineralized zones strike N60°E. Reportedly a 500 ft diamond drill hole placed vertically into the gneiss, displayed scheelite to the bottom of the hole.

Buckeye Claim: (Sec. 24, T7N, R3W) Claims located in 1953 on sporadic tungsten shows in Precambrian schist. Working consist of shallow shafts, pits and open cuts. Sparse grains of scheelite are reported to occur in narrow seams (about 12 inches wide) in a brown micaceous schist that contains local hornblende, epidote and calcite. Garnet and copper oxides also occur in the narrow seams. The mineralized zone conforms to schistosity and strikes N83°E. No mention was made of any associated gold being present.

Scheelite Reef Prospect: (Secs. 35 & 36, T8N, R3W) Claims located in 1950's. Workings consist of trenching and open cuts. Dale (1961) quotes the following description of the property from a 1950 USBM report:

> "Exposed on the property are pegmatite, lamprophyre, unaltered brown schist, and a dark-colored schist, probably hornblende. Contact metamorphism has altered the latter to a rock with a banded structure; bands of unaltered black schist up to 1 inch thick are separated by bands of 0.25 to 1 inch thick composed of epidote with a little garnet, quartz, and calcite. The banding is conformable to the schistosity which strikes N.50°E. and dips 45° to 50° NW. Scheelite is confined to highly altered portions of this schist where it is cut by fractures. It occurs principally as crystals up to one-eighth inch in size, which are on the faces of druses and fractures. Minute particles of scheelite also are sparsely disseminated in the epidote."

Climax Prospect: (Sec. 35, T8N, R3W; on San Domingo Wash) Dale (1961) describes the property as consisting of fine-grained sericitic schist that contains several scheelite-bearing zones. Schist strikes eastwards, dips northward. Scheelite apparently occurs in short crosscutting fractures. The mineralized zone is said to be cut off by Tertiary volcanic rocks.

Starlight (Buena Vista) Group: (Secs. 1 & 2, T7N, R3W; on east fork of San Domingo Wash) Claimed area, located in 1940's, covers an area underlain by Precambrian schist. The schist is cut by a number of pegmatite dikes which are both crosscutting and conformable with the schist which strikes N60°-75°E and dips moderately NW. The area is cut by numerous faults. The pegmatites are feldspathic and contain tourmaline. Scheelite is present in altered bands of hornblende schist. The bands or lenses are as much as 15 ft wide and composed of epidote with varying amounts of quartz, calcite and garnet. Cross fractures in these zones apparently cause local enrichment. Dale (1961) reports at least six mineralized bands, each about 3 ft wide, in a zone 300 ft wide. One "band" has been traced for about 600 ft, and smaller mineralized areas are said to be traceable for ½ mile eastward from the main workings (which consist of an open cut, prospects pits and considerable bulldozer cuts on the hillsides).

References:

Arizona Dept. Mineral Resources, file data; Dale, 1959, 1961; Hewyett and others 1936; Jahns, 1952; Johnson, 1972; Keith and others, 1983a; Wilson, 1961; Wilson and others, 1967.

WINIFRED (JACK WHITE) DISTRICT

Location:

The Winifred mining district is located within the boundaries of the present day Phoenix metropolitan area in the southern part of the Union Hills. The main part of the district is accessible by taking Cave Creek Road north to Beardsley Road and then west about one mile.

Geology and History:

The Winifred Mining district is a little known district that was probably discovered in the early 1870's at about the same time as the nearby and better known Cave Creek district. Most of the district consists of deeply weathered Precambrian granite that has intruded Yavapai equivalent schists. A dioritic phase has developed at the contact between the megacrystic Oracle-like granite and the schist. Minor dikes of felsic composition and probably Tertiary age cut the older rocks. Gently tilted basalts (Miocene?) cap bedrock in the northern part of the district. Gold mineralization is contained in numerous, relatively thin (±3 ft) quartz veins. The quartz is coarse- to fine-textured, locally vuggy, and grayish in color with calcite and hematite present locally. Fine-grained pyrite is locally present. While this writer has found visible free gold in vein outcrops within the district, it is quite fine in character and evidently produced no placers. Many of the mineralized veins were localized in shear or fault zones within the dioritic border phase rock.

In the northern part of the district in the area around Cave Creek dam, copper-stained, cherty to jaspery horizons in the Yavapai Schist have been prospected. Some of these zones appear to be cherty, sulfide poor iron formation. These might be interesting to look at in terms of stratiform mineralization.

Keith and others (1983a) credit the district with 2,000 oz Au, 8,000 oz Ag and 4,000 lbs Cu from some 8,000 tons of ore between 1904 and 1960. Nearly all of this production probably came during the period 1925 to 1931 when there was a flurry of activity in the district and the Jack White mine was in production. Some of the major mines such as the Jack White, Union, Contention and Fortuna were worked prior to 1900 and moderate production may have occurred before 1904. It seems likely that actual production from the district was probably 2-3 times the post 1904 production.

Due to its location bordering the Phoenix metropolitan area there would probably be little potential in trying to perform exploration in this district. Some properties like the Jack White are patented and presently are being mined for decomposed granite.

Mines of Interest:

Contention Mine: (SW¼ Sec. 35, T4N, R3E) The narrow quartz vein strikes N8°E and dips 70°W and is visible on the surface for about 500 ft where it becomes covered by alluvium. The shaft is sunk on incline to a depth of 280 ft; with

a small amount of drifting on the 60 and 120 ft levels. Ore "streak" is said to vary in width from a few inches to about 2 ft; the actual width of the structure being somewhat wider. Samples of pillars left in old stopes above the back of the 120 ft level indicated mined grades ran between 0.50 and 2.0 opt Au. In 1979, the owners of the property were planning to build a trailer park on the site.

Calumet and Cornelia Mines (Gold Reef): (Sec. 33, T5N, R3E) This is an old property with no known production. Copper oxide and gold-bearing zones were prospected in Precambrian schists that strike northeast. These schists contain interbedded ferruginous chert lenses that contain copper stain in places. An old report mentions that workings in the adjoining Slocum mine encountered sulfides at 150 ft depth. These schists are part of belt that runs from North Phoenix Mountains to Cave Creek. The area may hold some potential for small massive sulfide bodies, but most of area is of limited access due to private property and floor control withdrawn sites.

Ely Mine: (Winifred district near intersection of Secs. 16, 15, 21, 22, T4N, R3E) The property has 3 unpatented claims. There are two veins. The "Good" vein has received the most work. On this structure a 100 ft shaft has been sunk and 83 ft of drifting done. Drift shows a strong vein 4 ft wide for 62 ft. Weighted average for 8 samples from drift taken by USBM engineers in 1936 gave $13.65 Au across 18 inches. On the second vein a 100 ft shaft was also sunk but it was inaccessible at the time of the inspection.

Jack White (Erich Gold) Mine: (Secs. 21 & 22, T4N, R3E) The Jack White mine was discovered in the 1880's. Early production figures from the mine are unavailable but USBM production figures for the period 1927 to 1941 indicate that the mine had intermittent production during this period amounting to about 2030 oz Au. During this time the mine was developed to a depth of 500 ft and contained about 3000 ft of lateral workings. Several old consulting reports dated 1916, indicate that an ore shoot developed on the 200 ft level contained material that averaged about $20 per ton (@ $20/oz Au) over a width of 18 to 24 inches of quartz. Ore consisted of locally vuggy, grayish quartz that contained some calcite and irregular pods of hematite. In places, unoxidized pyrite was present. The ore shoot was said to be stronger on the 200 ft level than in higher levels.

Possibly of interest to a small company wanting to diversify into other areas is the industrial mineral potential of the mine area. Presently the mine is being considered as a potential source of decomposed granite for the Phoenix metropolitan area. Estimates indicate that the claim group contains about 4,000,000 tons of material that has a potential market price from $4.00 to $27.00 per ton in the Phoenix market, depending upon color and toughness. The property is owned by Hiram Webb, whose agent is Mineral Economics Co. (100 W. Clarendon, Suite 1260, Phoenix, AZ 85013).

References:

Arizona Dept. Mineral Resources, file data; Keith and others, 1983a; R. Wilson, unpubl. field notes; Wilson and others, 1967;

Types of Precious Metals Related Deposits

Within the study region of western Arizona we recognize a number of deposit types for gold and silver. We have allowed the resolution of these types to come largely from our in-depth analysis and categorization of the innumerable precious metals prospects, mines and districts taken from the literature and unpublished sources, many of which are described in the "Mines of Interest Section" of this report. Admittedly this background data has been integrated with many years of field experience in the region of interest and on site examination of many metals deposits, so the deposit descriptions are not entirely objective. This section of the report describes those deposit types for precious metals which we feel offer the most favorable environments for economic concentrations within the study area.

You will note that we have not developed a specific model for individual vein or lode deposits, unless those structures relate to some larger-scale model believed to be of greater economic interest. Actually most of the models we describe have associated veining at some scale, but it is only part of the broader context of like structural, stratigraphic, mineralogical and age properties which define the models. Because of the current trend toward smaller scale mining and smaller companies subscribing to this project, we have not ignored individual veins, which, because of size, might be of interest. Although the veins are not discussed in this section of the report, they are noted in the Mines of Interest sections of the preceding chapter on District Focus.

We also will not elaborate on gold-silver mineralization occurring as skarns, in veins, or zoned outward from Laramide porphyry copper-moly deposits. Actually, a possible skarn deposits of tungsten-gold are included within the discussion of thrust-fault type deposits, mainly because of their structural localization along major thrust zones. The veins of polymetallic metals (including gold and silver) which fringe the porphyry centers tend to be rather small-scale features and are not as a whole thought to constitute major targets of large tonnage and low production cost.

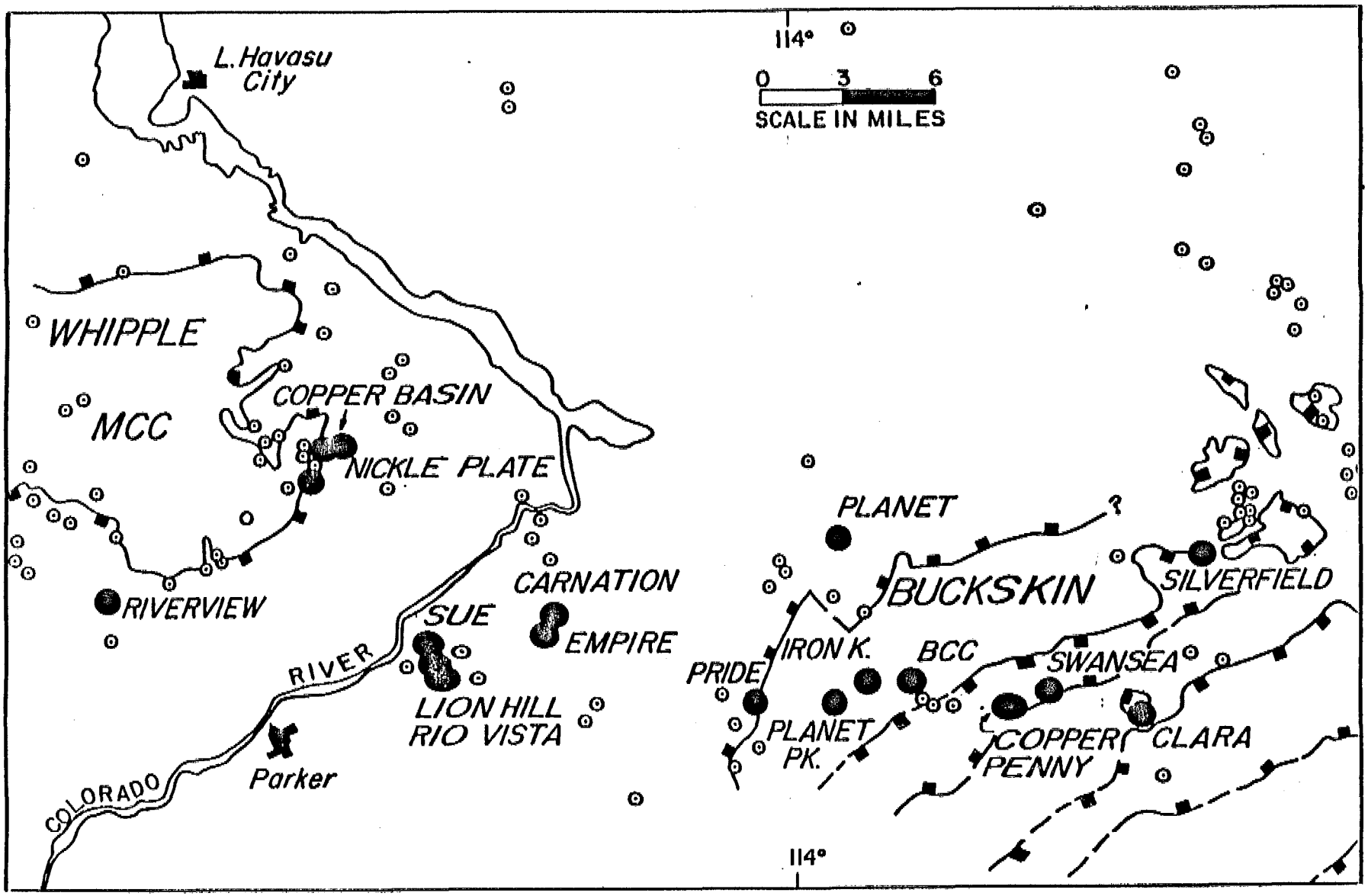
In the final chapter of this report, areas, districts and specific mines which we feel may offer the best exploration opportunities will be prioritized, targeted and discussed for each deposit type.

1. Detachment Fault Type

The initial definition of detachment fault was applied strictly to the flat or shallow dipping surface or discontinuity separating the mylonitic lower plates of metamorphic core complexes (MCC) from the tilted and fragmented upper plates commonly consisting of Tertiary volcanic or detrital rocks (Crittendon and others, 1980). Without exception, these surfaces were floored by varying thicknesses of chloritic breccia and upper microbreccia derived by brittle destruction of the underlying mylonites. With publication of the Anderson-Hamilton Volume (Frost and Martin, 1982) and with increased exploration interest in these structures, the original definition appears to have broadened considerably to include practically any low-angle structure with or without evidence of

mylonitic fabric, brecciation, or containing any indication of mineralization. In terms of the original descriptions, many of these structures are misinterpreted and include thrust faults or mere low-angle, normal faults. In places they have even been confused with normal, angular unconformities. Without attempting to belabor here the confusion that has arisen over the definition, we will include in this discussion all those metallic occurrences which are located within or adjacent to the classic detachment faults which border large parts of the metamorphic core complexes. As there are some interesting copper-gold deposits localized along normal or listric normal faults in upper plate rocks presumably above detachment faults, they will also be considered. Finally, there are a few precious metal occurrences which are located in shallow dipping, laterally extensive, shear zones of major brecciation and disruption, which generally have upper plates of tilted or rotated rocks of all ages and footwalls which are <u>not</u> mylonitic. Usually, the breccias along these fault zones are not chloritic as is the case in the metamorphic core complexes. Such zones have been called detachment faults in the Castle Dome, Mohawk, Copper, and Plomosa Mountains. Although these occurrences are few and, we believe, possibly less favorable than those in the MCC, they will be included in this deposit-type discussion.

Within and adjacent to the region of study, a multitude of gold-bearing deposits are localized within short distances of regionally extensive detachment zones associated with mylonitic rocks of MCC (Figure 25). Districts such as the Alamo, Santa Maria, Rawhide, and to a lesser extent, the Harquahala, are populated with these occurrences. Their individual structural habitats include the following



MORE IMPORTANT MINERAL OCCURRENCE (generally copper-gold)

ANY MINE OR PROSPECT

Figure 25.

Metal occurrences associated with the Whipple-Buckskin detachment fault in southeast California-western Arizona.

(refer to Figure 26). (1) Replacement and fracture-vein-breccia mineralization in shattered rocks of upper or middle plates. Commonly, an unusual, brecciated carbonate is the host for replacement deposits such as at Swansea, Copper Penny, and Planet mines in the Santa Maria district Figure 27a). Middle plates sandwiched between two detachment fault splays are especially favorable locations for containing brecciated rock suitable for receiving mineralization (Figure 27b). (2) Mineralization focused immediately along the detachment fault surface, usually in crushed upper or middle plate material (Figure 26). (3) Mineralization in tensional or extensional fault structures or breccia zones just above the detachment surface. Such structures may be listric or antithetic faults. (4) Mineralization within the chloritic breccia below detachment faults. This occurs in disseminated fashion on microfractures or veinlets within the cataclasite. We refer you to Wilkens and Heidrick (1982) for additional structural details.

The mineralogy of these detachment deposits is remarkably similar with sulfide and oxide suites represented. The sulfides are pyrite and chalcopyrite (with traces of sphalerite or galena) associated with gangue minerals of quartz, epidote, chlorite, carbonate (?) and occasional fluorite. Primary oxidized mineral phases, which are paragenetically later, include specularite, calcite, manganese oxides and in some cases, perhaps chrysocolla (Schulling, 1978). The hematite appears to be most indigenous to this deposit type, as is copper which usually occurs as silicate or carbonate minerals (Figure 27b). Gold and silver are found with most, but not all of the occurrences. A gold/silver ratio is typically from about 1 to 1 to as high as 3 to 1.

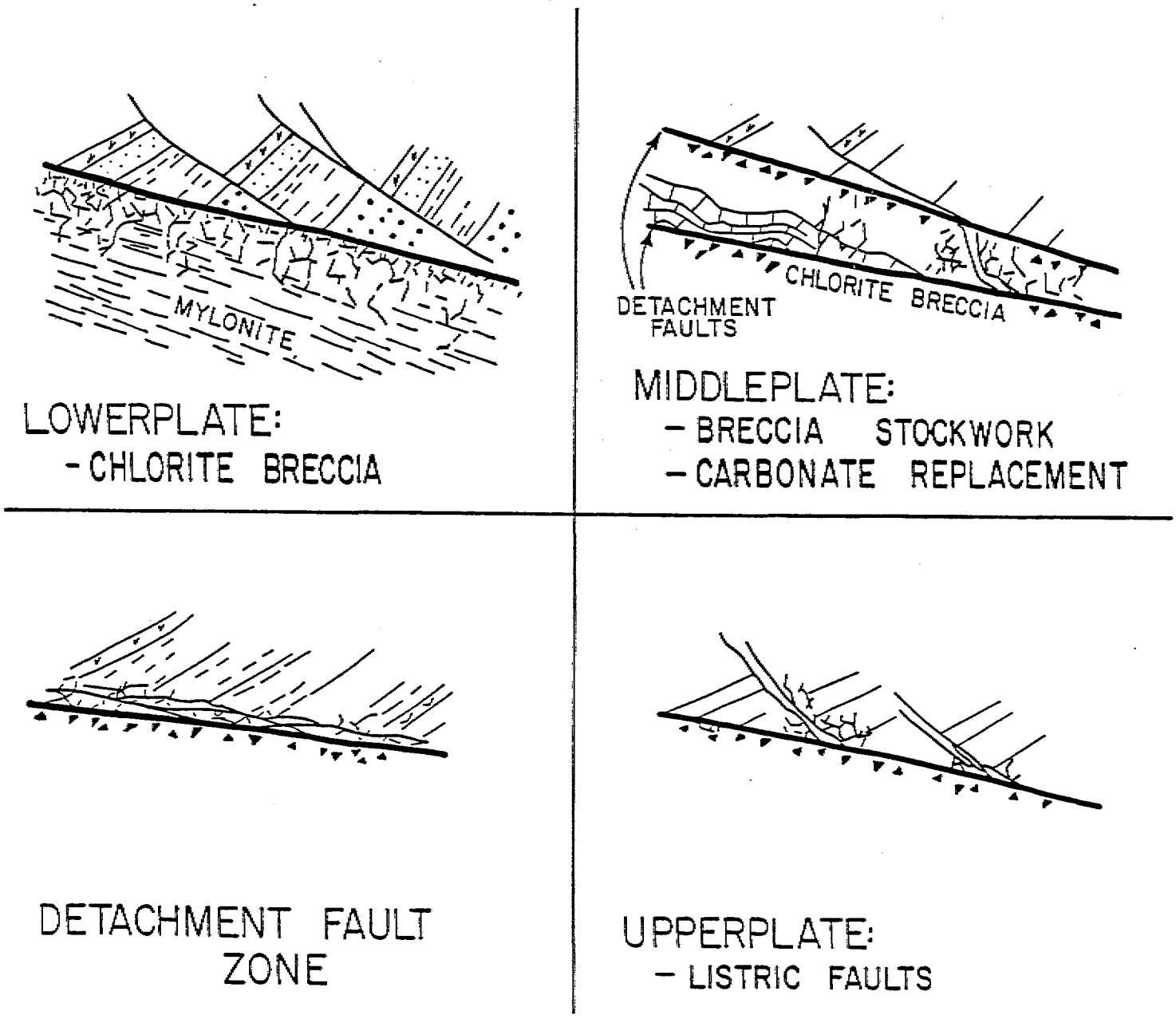


Figure 26. Schematic diagram showing structures and fractures of lower-, middle-, and upper-plate and detachment fault zones that are typical Foci for mineralization.

Figure 27 a

Sharp structural contact between chloritic breccia (hammer) and overlying brecciated marble at the Swansea mine, Buckskin Mountains. Both units are tectonically mixed in a wide detachment zone mineralized by quartz, pyrite, chalcopyrite, epidote, chlorite, calcite and abundant specular hematite. Carbonate (Marble) host unit is very common to the mineralized detachment fault setting in this part of western Arizona, where it always lies just above one or another of the detachment fault surfaces.

Figure 27 b

Open cut at the Moro property, Clark Pk. area, Buckskin Mtns, which exposes gold-copper-bearing detachment fault zone 10 to 20 ft thick. Marble breccia bodies (similar to ones at Swansea) locally overlie the detachment fault. A mineralized felsite breccia dike or sill is also interpreted to intrude the detachment zone.

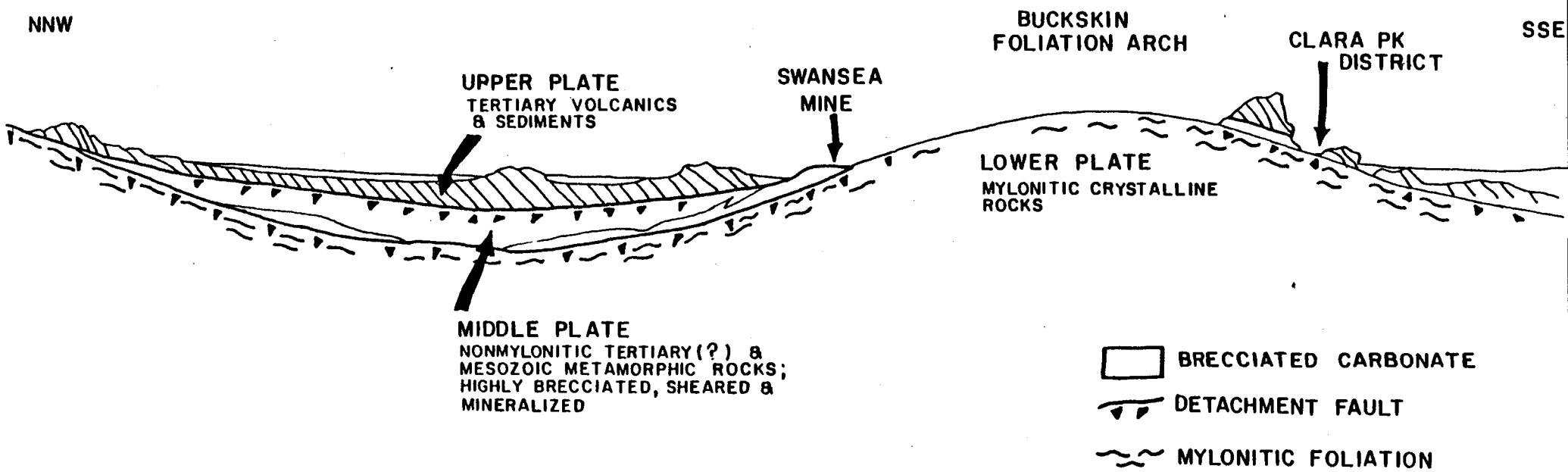


Figure 28. Schematic cross-section of Buckskin foliation arch showing location of Clara Peak district and Swansea mine area in relationship to lower-, middle-, and upper-plates.

We are unable to fully explain why gold is essentially absent from some detachment occurrences such as Swansea, Copper Penny, Mineral Hill or Planet. Our field impression of detachment deposits suggests that there is significantly more quartz found with the gold-bearing mines. We are also aware that a number of the copper-gold prospects contain high-level intrusive bodies within the mineralized zones. Where seen, these bodies are felsic. According to the Stanley Keith metals-magma scheme, the detachment-associated deposits are related to a quartz-alkalic magma series (personal commun., 1985). These magmas would be somewhat younger (i.e. 19 to 16 m.y.) than the mid-Tertiary calc-alkaline suite.

In addition to a possible magmatic source for the gold, preliminary geochemical research by Rehrig (1984) suggests that fluids charged with various metals and other elements may be derived from intense, ductile, high temperature, mylonitic processes within the lower plates of MCC. Oxygen isotope data tend to support this theory (Kerrich and others, 1984). The fluids emitted from mylonitization, appear responsible for causing the extreme fluidization, brecciation and propylitic alteration of the chloritic detachment breccia underlying the detachment surface. The highly metasomatized or altered upper plate volcanics with extremely enhanced K_2O, CaO, Fe_2O_3, and MnO contents may also represent a manifestation of this upward migrating fluid front. Not only are these detached volcanics affected geochemically by elemental gains and losses similar to those of the chloritic breccia, but it is found that apparent fission track ages of the upper plate rocks are younger than in comparable rocks away from the detachment surface (E. Brooks, 1984, personal commun). The geochemical and

isotopic data supporting a source for mineralization within the process of mylonitization certainly would apply to copper, other base metals, iron and manganese, which are generally ubiquitous to detachment-related metals occurrences in metamorphic core complexes. We do not, as yet, have the data which would indicate whether precious metals can be included in this scheme.

Our regional analysis suggests that detachment metallization is more common around MCC where mylonitic lower plate rocks are present, than it is in other detachment settings. This may be a direct consequence of the mylonite-derived fluid sources proposed above. This is not to say that detachment faults entirely within nonmylonitic, upper plate settings are barren, however, the data shows that mines and prospects are much less frequent. Where found, they appear spatially associated with intrusive sills, plugs or dikes. Examples would include the Riverside or Big Maria Mountains in California or the Mohave Mountains in Arizona. A broader case in point applies to the southern area bordering the Colorado River which would include the region north of Yuma along both sides of the Colorado. Although the area bears some of the largest gold deposits recently found in North America (Mesquite, Cargo Muchaco, Picacho), their main metals associations and trace element assemblages are decidedly distinct from known detachment occurrences elsewhere (i.e. no specular hematite, manganese, and low to nil copper). Gold-silver ratios of these large deposits are much greater than those in the detachment setting (S. Keith, 1985, personal commun.). The mines and districts which do occur in Tertiary rocks (although not necessarily in detachment faults) are distinctly Pb, Zn, Ag dominant, as exemplified by the Paymaster mine in California and the Silver-Eureka and Castle Dome districts in southwesternmost Arizona. We would

conclude, therefore that, even though upper-plate detachment faults may exist in the southern or southwest portion of the study area, they are generally barren of the typical copper-gold occurrences found to the north in the vicinity of the Tertiary MCCs.

Finally, we focus on a few areas where copper-iron-gold occurrences abound in upper-plate rocks which exhibit rotational, listric tilting but where mylonitic subplate rocks are not exposed. Some detachment-like structure is usually known from outcrop or is suspected at depth. Exemplary of these areas which exhibit detachment-like mineralization are the Cienega and northern Plomosa districts and Moon Mountains area (Plate 1). Carbonate rocks are commonly mentioned as hosts to the mineralization, at least in the first two of these districts. Replacement and fracture-fault or breccia mineralization consists generally of the mineral suites chalcopyrite > pyrite, gold, quartz, carbonate, barite and fluorite. Intense oxide mineralization featuring specularite, earthy hematite and manganese oxides and silicates and carbonates of copper has largely overprinted earlier sulfide phase minerals.

It should be noted that the regional distribution of this upper-plate copper-gold assemblage is within or adjacent to mylonitic-cored metamorphic complexes. Certainly, mylonitic lower-plate rocks must underlie the Cienega district between lower plate exposures in the Whipple and Buckskin Mountains. In the Plomosa and Moon Mountains, both surface and subsurface detachment zones are suspected, but the presence of Tertiary mylonitic rocks at depth has not been established.

For the most part, the size of detachment-related deposits has not proven to be large. The one exception is Amoco's Copperstone deposit in the Moon Mountains which reportedly is in the 7 to 10 million ton -- 0.07 opt gold range. Although mostly of copper, the 40-50 million ton deposit in Copper Basin, Whipple Mountains, California, shows that substantial amounts of rock can be mineralized in a detachment structural setting, especially within brecciated "middle-plate" rocks intruded by a metals-bearing intrusive body (Figure 29). It is the middle plate which is mineralized at Swansea-Copper Penny deposits in the Buckskins; but not until a felsic intrusive sill found its way into the detachment fault at the Clara Peak locality, did much gold appear.

Our model for detachment mineralization is depicted in Figure 30. We maintain that the frequency of mineralization has been greatly enhanced in the highly "prepared" ground marginal to or above the ductily deformed lower plates of MCC where expelled metamorphic or deformational fluids contributed to high water-rock ratio, hydrothermal flushing. Where metal-bearing, high-level magmatic bodies entered the environment, further hydrous and metals circulation resulted. The plutons may become emplaced in upper-plate detachment levels as well and mineralization may result, but this is felt to be a rarer event without the characteristic hematite-copper association.

2. Lower Plate, Microdiorite Dike Type

Mineralization of this type is found mainly in the complex metamorphosed, mylonitized, intruded and thrust faulted lower-plate rocks of the Harcuvar MCC.

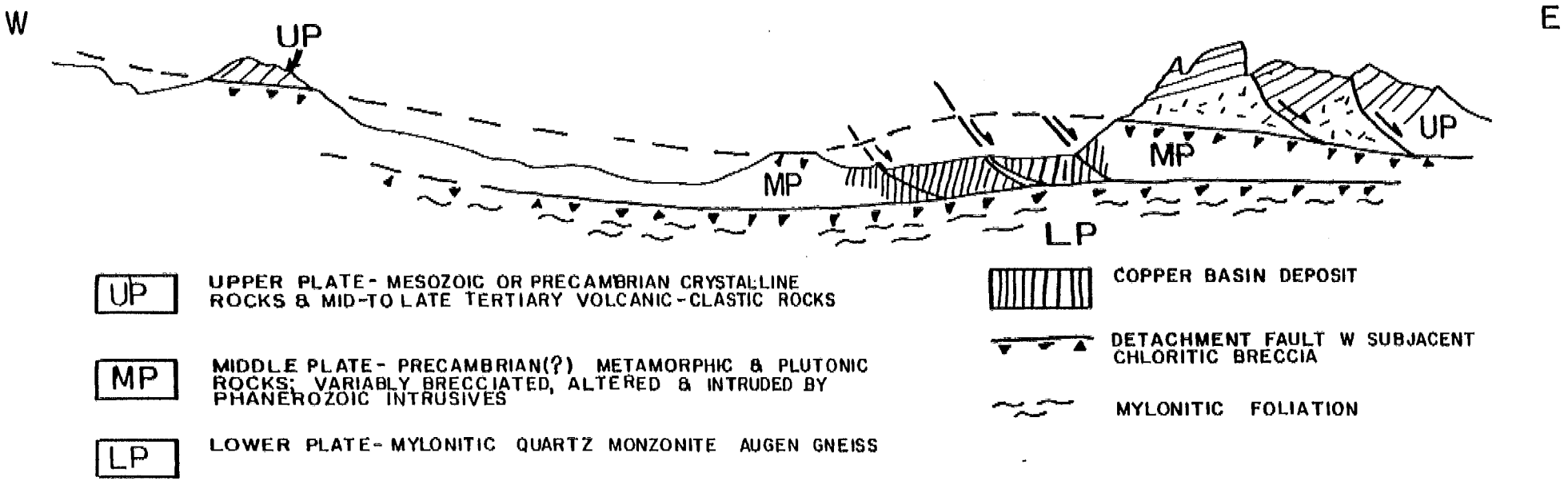
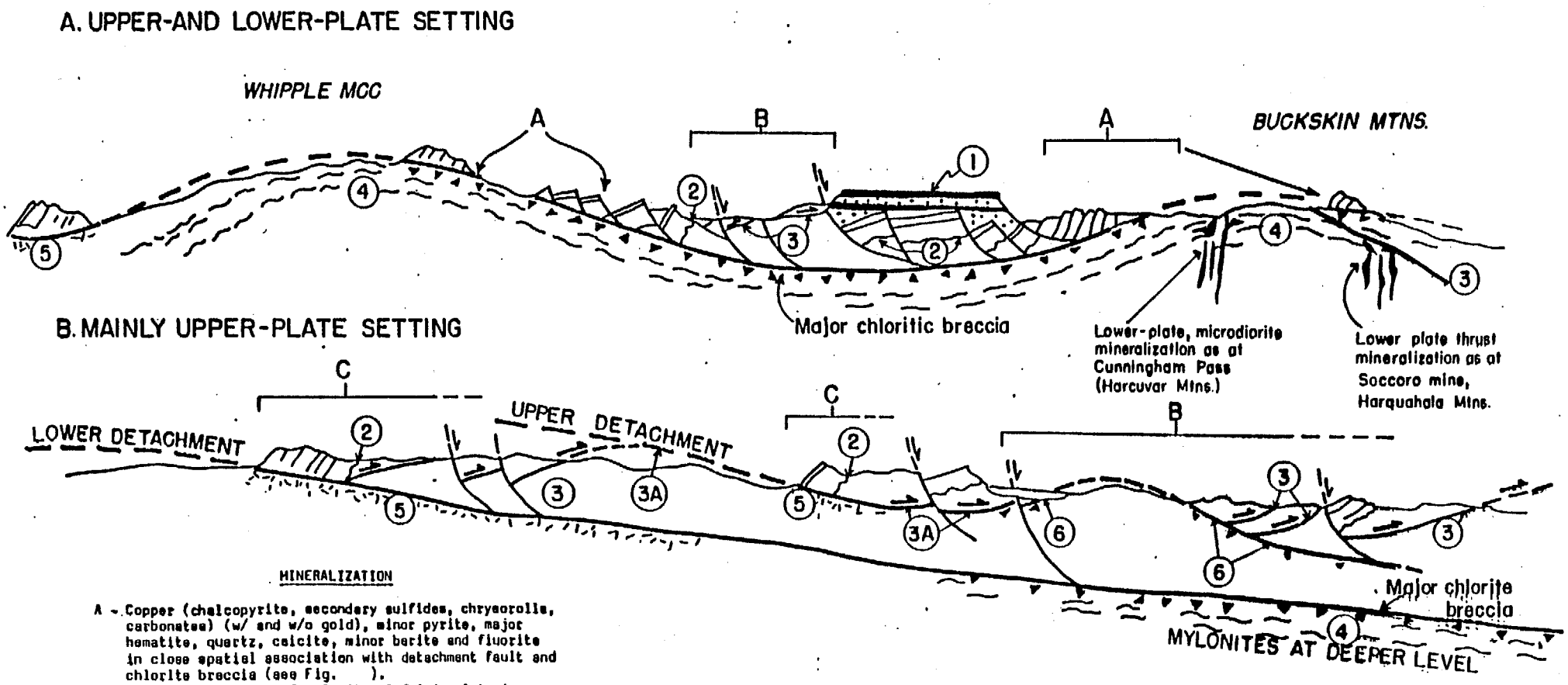


Figure 29. Cross-sectional diagram of the Whipple MMC depicting the middle-plate setting of the Copper Basin deposit.



MINERALIZATION

A - Copper (chalcopyrite, secondary sulfides, chrysocolla, carbonates) (w/ and w/o gold), minor pyrite, major hematite, quartz, calcite, minor barite and fluorite in close spatial association with detachment fault and chlorite breccia (see Fig.).
Source: Dewatering of mylonites & felsic plutonic bodies.
Example: Whipple MCC, Santa Maria, and Rawhide districts.

B - As A above with manganese oxide occurences, more gold and quartz and less chlorite-epidote in upper-plate structures, commonly replacing carbonate rocks, in faults/fractures or localized along older thrust faults.
Source: As A above.
Example: Cienega and Northern Plomosa districts.

C: Limited, polymetallic mineralization w/ or w/o gold in "dry" brecciated and fractured detachment zone.
Source: high-level intrusive (rhyolite).
Example: Riverside Mtns. (Calif.).

Tertiary volcanic sedimentary cover

Pre-Tertiary, upper-plate rocks

1. Osborne Wash. Fm. (10-13 my.)
2. Unconformity
3. Mesozoic thrust faults
3A. Detachment fault utilizing previous thrust fault
4. Mid-Tertiary mylonite
5. Shallow-level, "dry" breccia
6. Minor development of chloritic breccia

Figure 30.

Idealized cross-section of upper and lower-plates of a MMC that are favorable settings for gold mineralization. Note all are found generally associated with the detachment side of the complex.

The deposits share a common association with microdiorite dikes of NW- to WNW-trend. The deposits consist of; (1) veins occurring along fault or fracture zones housing the dikes, and (2) as deposits localized along thrust or low-angle shear zones which are intersected by the structural zones containing the dikes (see Figure 31). The dikes are consistently mafic, of calc-alkaline composition and yield low initial strontium ratios (± 0.705 to 0.706) suggesting a lower crustal, uncontaminated source (Rehrig and Reynolds, 1980). They have been dated at between about 21 and 28 m.y.B.P. and usually are found intruding and post-dating mylonitic rocks in the MCC. They pre-date detachment faulting (Rehrig, 1982).

The mineral assemblage of this deposit type consists of gold-silver (in variable ratio) accompanied by quartz and carbonate (siderite), occurring as pods, seams, veins or irregular bodies. Tungsten as scheelite appears to be a common constituent of the assemblage as is copper in sulfide and oxide form. Specular hematite and manganese oxides are occasionally mentioned. Gold values are rather high with grades commonly > 0.2 opt reported.

The above mineral assemblage exhibits some variation from occurrence to occurrence. For example, the high tungsten-quartz veining and replacement deposits in the northern Granite Wash Mountains (Ellsworth district) appear to have little precious metals and copper is sparse. Mineralization at the Socorro mine in the Harquahala Mountains is gold dominant without copper or specularite and although tungsten is geochemically present, (15-50 ppm), it is low. In the Cunningham Pass district (Harcuvar Mountains), copper was dominant averaging

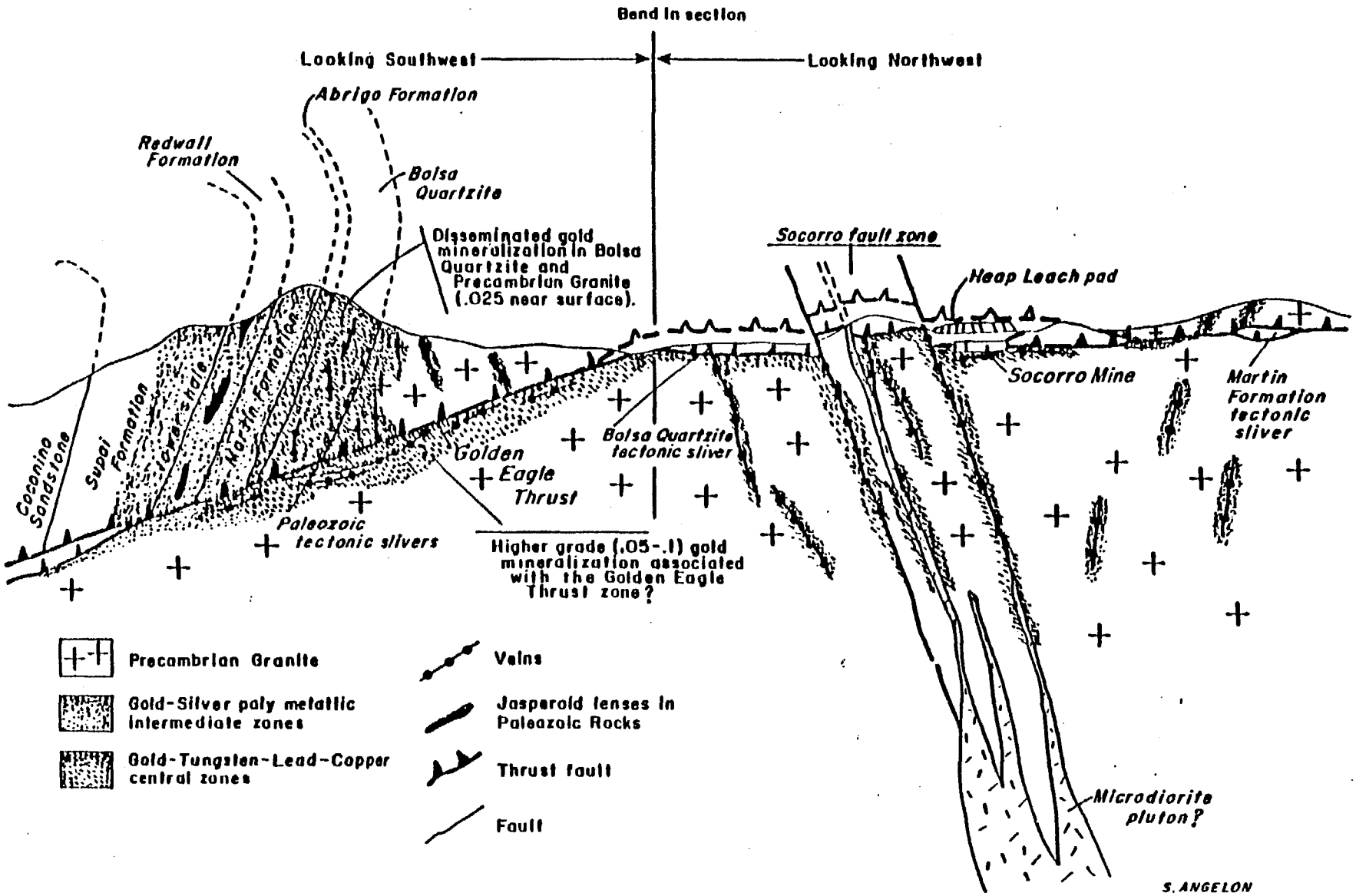


Figure 31. Cross section illustrating exploration model for inferred disseminated gold deposit beneath the Socorro Reef gold anomaly.

(From Keith, in Rehrig and others, 1985)

12%, with gold contents in the 1/2 to I opt range. In the Little Harquahala district similar mineralization localized along thrust faults may also be related to the basic dikes, but these dikes are not described as frequently as they are in the Harcuvar, Harquahala, and Granite Wash.

At the Socorro mine, Stan Keith (1985, personal commun.) demonstrates that the microdiorite dikes are syn-mineral. At Cunningham Pass, they are noted as carrying little mineralization. Whereas, a separate sequence of quartz porphyry dikes (?) are more closely associated with mineralization. At many mines and prospects, the dikes are noted, but frequently the specific temporal and geochemical relationships with the mineralization are not well established. More detailed work is thus needed to establish these relationships. The general geologic environment of the lower plate-microdiorite deposit type is illustrated on Figure .

3. Thrust Fault Type

Low-angle, thrust faults play a key role in localizing mineralization of the microdiorite dike type in the Harquahala Mountains (Figure 31). In a number of other ranges and districts, the spatial association between thrust structures and precious metals occurrences is well established, with or without the presence of the microdioritic intrusions. Occasionally, other kinds of plutonic bodies are found in the mineralized thrust localities (felsite, quartz monzonite, etc.). Examples of the thrust deposits occur in the Little Harquahala and southern Plomosa districts where the localizing structures

commonly involve granitic basement rocks in either hanging- or footwalls. In many of the metals occurrences, gold is associated with a variety of base metals with lead and silver more often noted than in other deposit types.

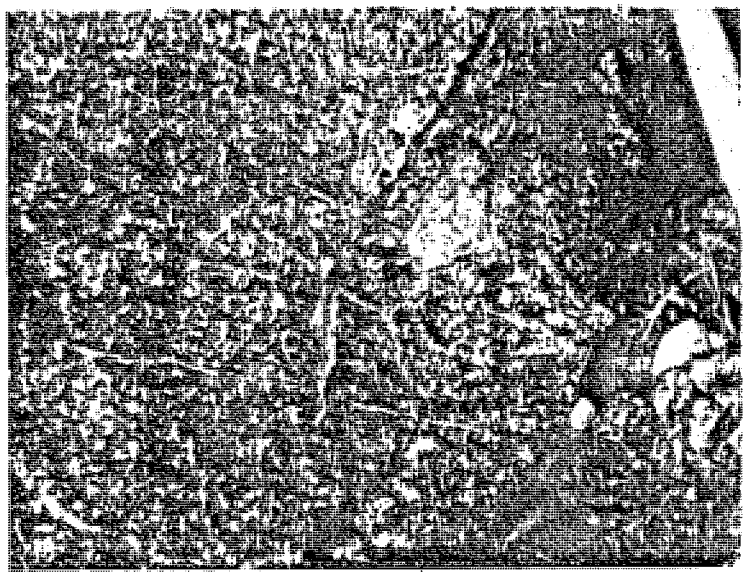
In the Cienega district, Keith (1978) repeatedly mentions that mines and prospects are located along a "thrust" structure separating Paleozoic-Mesozoic, low-grade metasedimentary rocks (footwall) from hanging wall schists and gneisses of Precambrian ? age. This configuration resembles that along the Plomosa Mountains, an equally well mineralized structure. In the Plomosas the work of Scarborough and others (1981) suggest an initial thrust origin for the Plomosa fault followed by recurrent motion as a mid to late Tertiary detachment fault. Noting that the mineral assemblages in both the Plomosa and Cienega areas are strikingly similar and of the detachment fault association, we would stress the likelihood that the controlling "thrust" in the Cienega district is a remobilized upper-plate detachment structure.

A somewhat unique thrust setting combined perhaps with metamorphism and nearby intrusion is evident at the Yuma mine in the Granite Wash Mountains (Ellsworth district), the Excelsior mine (Northern Plomosa district) and perhaps at other localities in both the southern and northern Plomosa areas (i.e. Livingston mine group). At these localities, carbonate and calc-silicate rocks believed to be pieces of the Paleozoic section are allochthonously sandwiched between thick sections of schistose Mesozoic clastic rocks along major thrust fault zones. The Paleozoic tectonic slices and Mesozoic footwall-hanging wall sequences are intensely deformed. The controlling thrust zone appears to be

intruded by 80-90 m.y. plutons which place an upper age limit on the structures. Mineralization in the form of tungsten, copper and gold is largely restricted to the carbonate or quartzitic Paleozoic slices, preferentially replacing certain stratiformal horizons. Skarn-like garnet, actinolite, epidote, chlorite, hornblende and magnetite often constitute gangue minerals to the economic mineralization (Figure 32a).

Besides the thrust fault structural control, additional factors such as contact effects and mineralization associated with nearby Mesozoic plutons and micro-diorite dikes, further complicates this model. In fact, to make matters worse, there appears in some case (i.e. Livingston mine group) to be an overlap between metamorphic-thrust characteristics and stratiform or syngenetic aspects to the metallization picture. These latter effects are seen predominantly within certain stratigraphic intervals of the thick Mesozoic volcanic-detrital sequences in the study region (see section on Mesozoic Stratiform Type, below).

Note that the thrust-type deposits described above are all found within upper plate (thrust terminology), North American rock assemblages with respect to the possible presence of the Vincent-Orocopia sole fault and Orocopia-Rand schist in a lower-plate position. Outcrops of this lower-plate lithology are found within the study region in the southern Trigo, Castle Dome, Kofa (?), and Tank Mountains (see Plate 1) and associated mineralization is discussed as a separate deposit type.



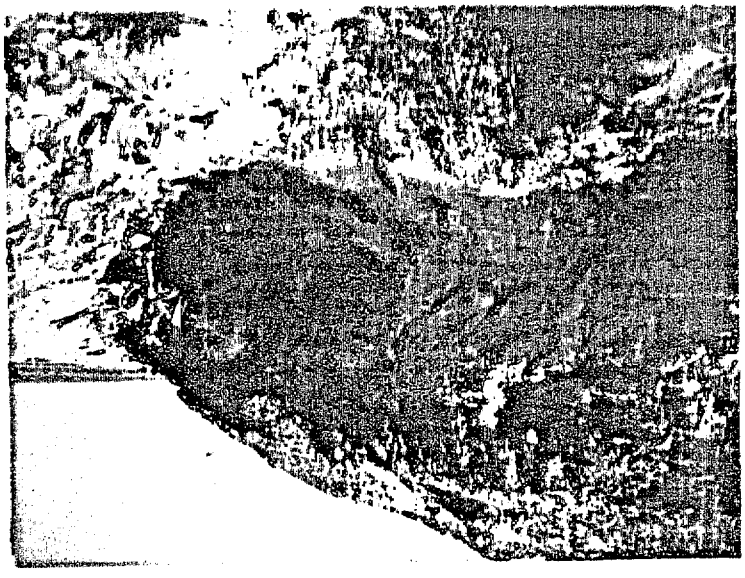


Figure 32a

Somewhat typical exposure of late Mesozoic thrust fault important to localizing gold mineralization in Southwest desert province. Photo shows the American Girl thrust in Cargo Muchacho Mountains near Yuma. Upper plate (dark rocks on upper slope) is Jurassic granite; lower plate is Mesozoic(?) quartz, sericite, kyanite, tourmaline schist. Both upper- and lower-plate rocks are strongly mylonitized and sheared.

Figure 32b

Characteristic shattering and stockwork gold-quartz mineralization in the upper plate of Mesozoic thrust fault at some localities in the Southwest desert province. Although this gold deposit is in the Mojave Desert (Morning Star mine), deposits exhibiting this structural control are anticipated in the western Arizona province.

4. Mesozoic Stratiform Type

We believe that within the study region there are syngenetic, stratiform horizons within Mesozoic terrigenous and volcanic rocks which are of exhalative or fossil-hot spring origin. We propose that when submitted to metamorphism and deep level thrust faulting, these deposits were converted into metals-bearing, stratigraphic zones of unusual alumino-silicate alteration or metamorphic mineral assemblages. Our bias regarding this mineralization type is based on interpretation of mine and prospect descriptions integrated with field observations within the study region and in southeastern California.

The best examples of this possible stratiform-metamorphic mineralization occur in the Granite Wash Mountains (Yuma (?), Calcite, Glory Hole (?) mines), southern Plomosa Mountains (Bright Star and Livingston mine group), the southwestern Buckskin Mountains (Midway-Corona district; Battleship and Arizona Midway mines), and Dome Rock Mountains (Copper Bottom, Yellow Dog, Yum Yum mines and scattered kyanite, dumortierite, sericite, andalucite occurrences). Although these localities vary in detail, their general character is summarized as follows:

(1) Unusual, metamorphic mineral assemblages restricted to stratigraphic intervals within Mesozoic metasedimentary or metavolcanic sequences.

(2) Minerals consisting of an alumino-silicate suite made up of sericite-muscovite, andalucite, pyrophyllite, kyanite and dumortierite. At some localities actinolite, magnetite, epidote and bedded (?) tourmaline are present.

(3) Disseminated pyrite, chalcopyrite, scheelite, gold and secondary quartz commonly are noted within the alumino silicate-bearing rock.

(4) Although the stratigraphic zones do not show obvious intrusive associations, Mesozoic plutons commonly occur nearby.

(5) The zones may display a rough coincidence with major thrust faults within the Mesozoic supracrustal pile.

(6) The rocks in question have been overprinted by variable grades of metamorphism from greenschist to lower amphibolite facies.

In many respects, these metasomatic-metamorphic zones and their geologic setting bear close resemblance to mineralized Mesozoic sequences that we have examined in southeastern California. In these areas quartz-monzonite schists containing kyanite, dumortierite and tourmaline are complexly interstratified with thick meta-arkose and graywacke sequences that contain gold-bearing distal iron formations (Figure 33). While some of these rocks have been considered Precambrian in the past, their similarity to Mesozoic rocks in southwestern Arizona (i.e. McCoy Mountains and Livingston Hills Formations) is undeniable. Major

thrust faults, sites of Jurassic plutonism, widespread low-angle foliation and several important gold deposits characterize these Mesozoic sequences in southeastern California. The gold deposits have definite tungsten associations. We believe that the gold is controlled by a multi-process that involves syn-genetic (exhalative), metamorphic, and structural (thrust faults) effects.

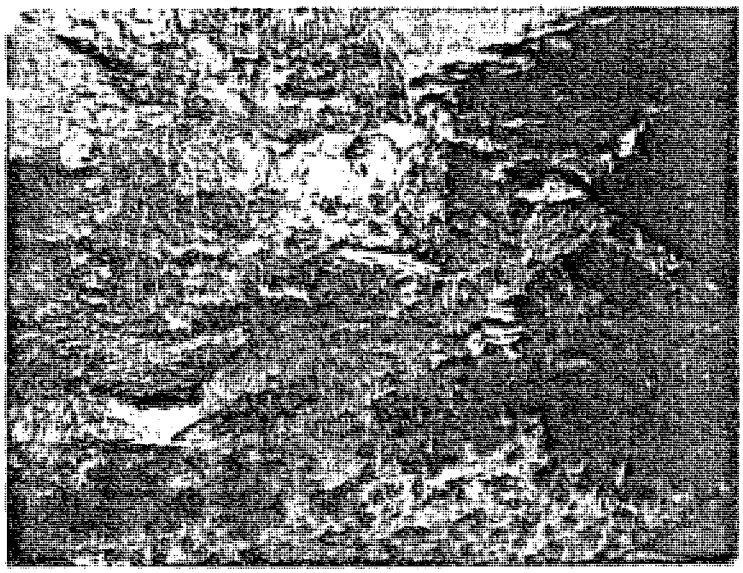


Figure 33a

Metamorphosed exhalative interval (dark, thinly layered rock) in Mesozoic(?) metasedimentary section in Southwest desert province. Exhalite unit consists of quartz, biotite, magnetite, fine-grained sulfides and gold overprinted by amphibole, epidote, actinolite. Host rocks are meta-arkoses and graywackes.

Figure 33b

Mineralized quartz-muscovite schist stratigraphy at the Calcite mine in the Granite Wash Mtns. (Ellsworth district). Foreground outcrops are shot through with secondary quartz and iron oxides. Mine dump in right background explored pyrite mineralization for gold, etc. Light-colored outcrops on distant slope are of stratibound, mineralized strata hosted by phyllitic and arenaceous graywacke schists.

Our model for the stratiform, alumino-silicate zones in western Arizona is predicated on initial hydrothermal alteration in the form of hot spring or exhalative activity associated with sedimentation within localized Mesozoic basins. These basins were fault controlled (probably rift related) and had considerable amounts of associated volcanic activity in places. This activity introduced exotic constituents such as fluorine, boron sulfides, tungsten and other metals (Au, Cu, etc.) into rocks which were also undergoing aluminous alteration. Abundances of CaO, MgO, Na_2O, TiO_2 were significantly depleted within the altered rocks, whereas SiO_2, Al_2O_3 and K_2O were relatively enriched.

The hydrothermal alteration may have directly led to the formation of the aluminous kyanite, dumortierite, pyrophyllite, muscovite, mineral suite as is evidenced from similar altered aureoles around pyritic gold deposits in Canada (R. Hodder, 1985, personal commun.; Valliant and others, 1983). Superimposed metamorphic gradients accompanied by intrusion, deformation and thrusting may also have contributed to the exotic mineral associations, as well as acted to re-distribute or upgrade economic mineralization. It may be noteworthy that several of the stratiform, alumino-silicate zones in the Granite Wash Mountains are found directly or closely beneath the Hercules thrust fault, which is perhaps the most fundamental Mesozoic structure in the Harcuvar region (Figure 33b). Hardy (1984) also noted the appearance of staurolite, kyanite, cordierite, actinolite and garnet in aluminous schistose horizons within Mesozoic rocks forming the footwall to the Harquahala (?) thrust in the south central Harquahala Mountains. Textural evidence suggests formation of these minerals by dynamo-thermal conditions related to thrusting.

As further evidence for our thesis that the Arizonan mineralized stratiform zones are largely syngenetic or syngenetic-remobilized metamorphic, we cite the work of Stanton (1982, 1983, 1984) and Fulp and Renshaw (1985). The latter reference describes volcanogenic-exhalative tungsten occurrences in the Proterozoic of New Mexico and refers to similar deposits in southern Europe, Turkey, Rhodesia, Argentina, Norway and Brazil. Some of these occur with banded quartz-tourmaline or magnetite horizons. Many, including the scheelite occurrences at Jardine, Montana and Atlantic City, Wyoming, are associated with what is described as stratibound or exhalative gold mineralization. Figure 34 is taken from Fulp and Renshaw (1985) and Valliant (1983) to illustrate possible environments for this kind of mineralization.

5. Hotspring Deposits of Volcanic-Related Origin

Low-grade, bulk tonnage, hotspring Au-Ag deposits represent an economically important source of gold production and reserves in the western United States. Examples of this deposit type are thought to include McLaughlin, California; Cinola, British Columbia; and the Hasbrouck, Borealis, Buckskin, Pyramid Peak and Round Mountain deposits in Nevada. These deposits are commonly viewed as forming a continuum with deeper, precious metals-bearing, epithermal vein and fissure deposits (i.e. Giles and Nelson, 1982; Eimon and Berger, 1982; Buchanan, 1981). This relationship is, however, quite difficult to substantiate in many, if not most cases.

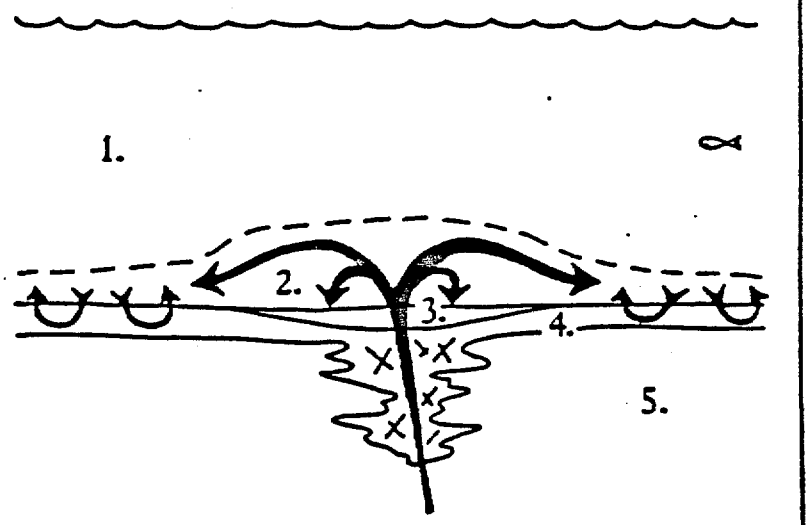
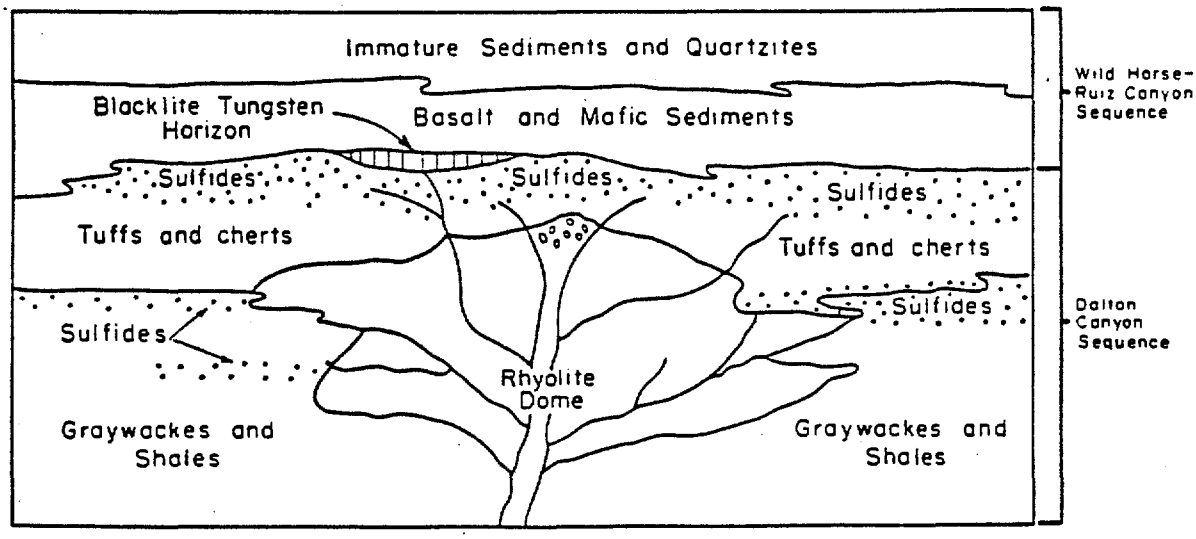


FIGURE 34a. Schematic diagram illustrating the genesis of aluminum silicate-bearing rock. Arrows indicate the direction of hydrothermal fluid flow.
1. Seawater.
2. Hydrothermal brine.
3. Orebody.
4. Altered tuff containing aluminum silicate minerals.
5. Tuff.

(From Valliant and others, 1983)



(From Fulp and Renshaw, 1985)

Figure 34b. Inferred stratigraphic relations and deposition of Blacklite prospect and country rocks.

Tonnages and grades in this deposit class are highly variable. Sizes range anywhere from several hundred thousand tons up to 195 million tons (i.e. Round Mountain). Grades can run anywhere between 0.05 to 0.18 opt Au, but typically average below 0.10 opt Au. Grades as high as 0.30 opt Au have been reported (cf. Nelson and Giles, 1982).

Models explaining the formation and geologic characteristics of these deposits have been proposed by numerous workers, including: Buchanan (1981), Eimon and Berger (1982), Strachan and others (1982), Silberman (1982), Giles and Nelson (1982), and White (1982). As these papers adequately summarize the basic characteristics of this type of mineralization, it will be only briefly dealt with in this report. Those not already familiar with the subject and who wish more detailed information are encouraged to refer to the references cited.

The hotspring model (Figure 35) contains the following basic ingredients:

a. A geothermal (hydrothermal) cell with discharge localized or focused along fault structures or other permeable zones; often with attending thermal springs at the surface.

b. Permeable zones including volcaniclastics, pyroclastics and brecciated material along faults absorb ascending fluids and produce a typical mushroom-shaped cap of near-surface replacement silica and silicate minerals (cf. Giles and Nelson, 1982) that seals the system locally, restricting upward migration of the fluids.

c. Renewed fracturing associated with seismic activity, volcanism, or fluid pressure build up, breaks the silica cap and allows sudden pressure release of the contained fluids.

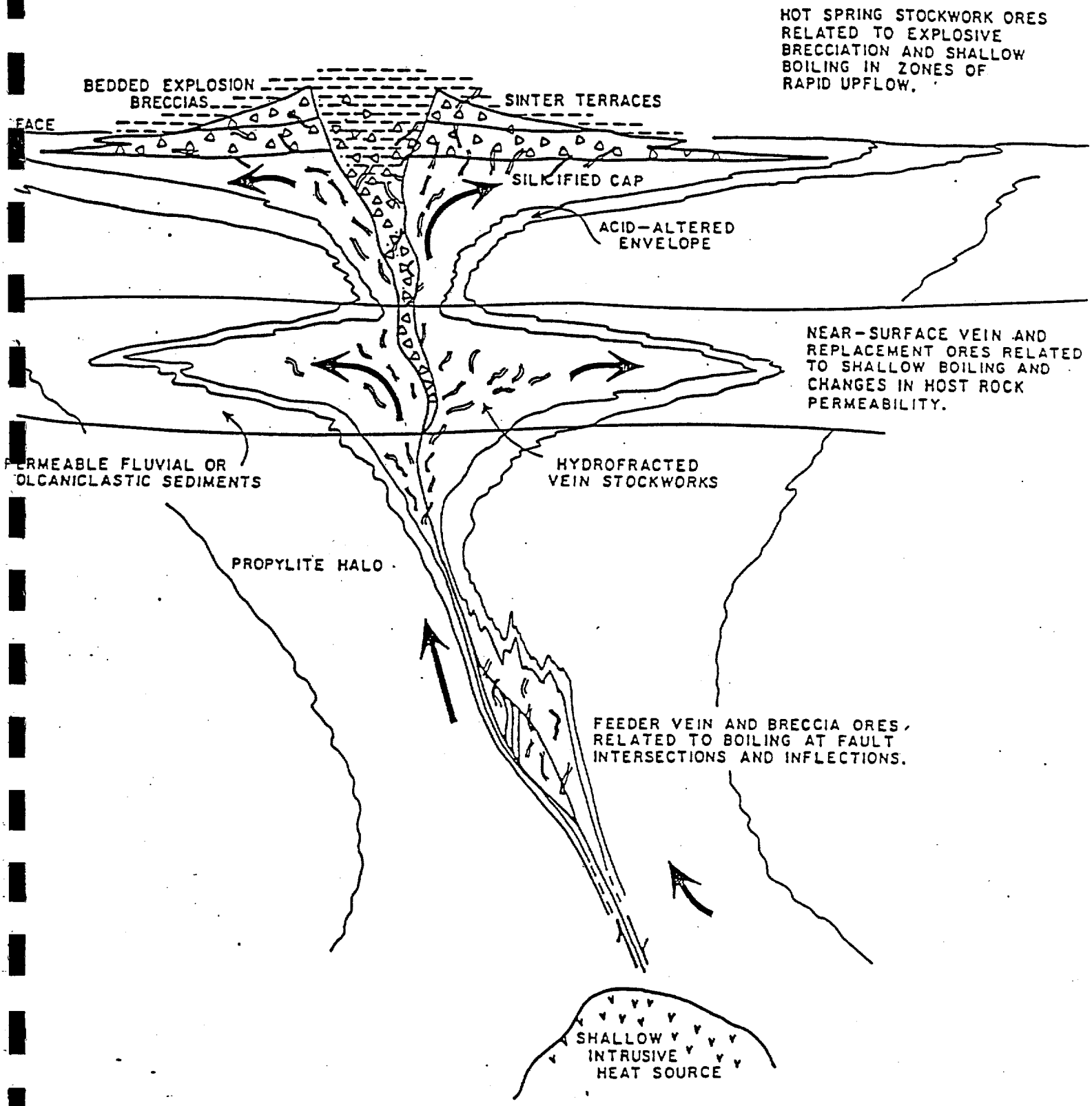


FIGURE: 35

SCHEMATIC CROSS SECTION: HOT SPRING LODE GOLD DEPOSITS

MODIFIED AFTER: BERGER AND EIMON, 1982
SAITO AND SATO, 1978

(from Giles and Nelson, 19

d. This sudden release of confining pressure typically results in boiling of the fluids. In systems with high amounts of dissolved CO_2, exsolution of the dissolved gasses can accompany the release of pressure in the form of explosive reactions such as hydrofracturing and hydrothermal brecciation (cf. Berger and Eimon, 1982; Giles and Nelson, 1982). While all hotsprings systems are not gold-bearing, all hotspring gold deposits discovered to date display evidence of this explosive hydrothermal fracturing and brecciation.

e. Focusing of fluids through the explosively fractured rocks accompanied by high-flow rates, physically raises the boiling level and causes the near surface precipitation of precious metals and sulfides (Giles and Nelson, 1982).

Gold mineralization associated with these deposits is typically of micron size, consists of native gold and electrum, and is associated with a variety of fine-grained sulfides and silver sulfosalts. Mineralization is typically contained in the silicified hydrothermal breccias and in stockworks with disseminations in the country rock.

A diagnostic suite of elements accompanies the mineralization and usually consists of anomalous concentrations of Hg, Sb, As, Tl, Ba and W (Berger and Eimon, 1982; Giles and Nelson, 1982; Silberman, 1982). Alteration often consists of a sulfidic and silicified core zoned outward into enclosing shells of alunite, kaolinite and montmorillonite (Berger and Eimon, 1982; Giles and Nelson, 1982).

Within the Arizona project, several mines display characteristics typical of hotspring deposits; and the potential for this type of deposit to exist in other areas appears to be favorable. Mines which we feel display hotspring characteristics include the Newsboy (Vulture district), the Sheep Tanks or Resolution mine (Sheep Tanks district), and possibly the Papago mine (Cimarron Hills district). The Newsboy and Resolution deposits are hosted by mid-Tertiary volcanic sequences near high level, subvolcanic intrusions or dome complexes. The Papago mine occurs in a wide shear or fault zone cutting coarse-grained granitic rocks.

Complex volcanic centers containing porous volcaniclastic (and lacustrine) sediments, tuffs and interbedded flows, that display complex faulting and which were intruded by contemporaneous plugs and shallow subvolcanic intrusions are the most favorable setting in which to look for this type of deposit within the study area. Favorable areas would also include nearby regions in which voluminous volcanic rocks did not accumulate (or were since eroded), but which display complex faulting and abundant subvolcanic intrusions and dikes of mid-Tertiary age.

6. Vincent-Chocolate Mountain Allochthon Model

In our Mojave Project summary report (Wilson and others, 1983), we described a geologic setting which we felt played a major role in the localization, and possibly the source of metals, for a number of major gold occurrences in the Mojave desert. These included the Mesquite, the Yellow Aster and Big Horn deposits.

Our basic premise was that these deposits all occur in tectonically prepared crystalline and/or metamorphosed sequences within the cataclastic upper plate of the Vincent-Rand-Chocolate Mountains thrust zone. The three deposits cited as examples are all believed to occur within the actual thrust zone itself or within a few hundred meters of this surface. Hydrothermal cells were established within the tectonically prepared thrust zone as the result of Laramide and younger intrusions. The tectonically shattered upper plate "soaked" up the mineralization which resulted in the formation of large, low-grade replacement or stockwork-type deposits. The lower-plate Orocopia schist, whose protolith was deposited in an oceanic setting, is believed to have provided a ready source of leachable metals to any circulating hydrothermal system.

Since the evidence for our model lies mainly outside the area treated in the presence report, we will reiterate the basic data from which we constructed our model.

The Pelona, Rand, Orocopia and Chocolate Mountains schists are names that have been historically applied to a grouping of 15 distinct areas of schist exposed in southwesternmost Arizona and along the San Andreas and Garlock faults in southeastern California (see Figure 3). At the time of this writing, a new occurrence of this distinctive rock type has been recognized in the eastern part of the Kofa Mountains of western Arizona by Gordon Haxel (S. Reynolds, personal commun., 1985). These schists are composed predominantly of metagraywacke containing subordinate metapelite, metabasite, metachert, marble and ultramafic rock (Haxel and Dillon, 1978), attesting to their oceanic depositional setting.

Although outcrops of the schists are presently exposed across a considerable area, they are collectively believed to represent a regional autochthon beneath the Vincent-Chocolate Mountains thrust. Tectonically transported nappes of Precambrian through Mesozoic granitic and gneissic rocks overlie the schist.

Near the thrust, upper-plate rocks are intensely broken and cataclastized (Figure 36). Below the fault the schist displays a reverse metamorphic gradient and coarsening of mineral grain size. Thrusting has been believed to have occurred in late Cretaceous or Paleocene time on the basis of reset of K-Ar age dates in the schist and by ages of the few igneous rocks known to have intruded the thrust plate (cf. Silver and others, 1984). New interpretations suggest a somewhat older age for thrusting (Haxel and others, in press).

Recent and ongoing studies (i.e. Moorehouse, 1984; Haxel and Grubensky, 1984) indicate that this thrusting has in places been reactivated in a normal sense by Tertiary detachment faulting. This localization has in places (i.e. Castle Dome Mountains) resulted in the development of hybrid faults or fault zones that range in character from (1) intact to locally reactivated thrust faults, through (2) composite fault zones consisting of a detachment fault along which slivers or lozenges of the mylonitic thrust-fault rocks are preserved, to (3) detachment faults along which the upper plate of the thrust fault still overlies the lower plate but where the actual thrust zone has been entirely excised (Haxel and Grubensky, 1984). Tertiary reactivation of the Vincent-Chocolate Mountains thrust is known or thought to occur in the Rand and Chocolate Mountains in California and in the Castle Dome Mountains in southwestern

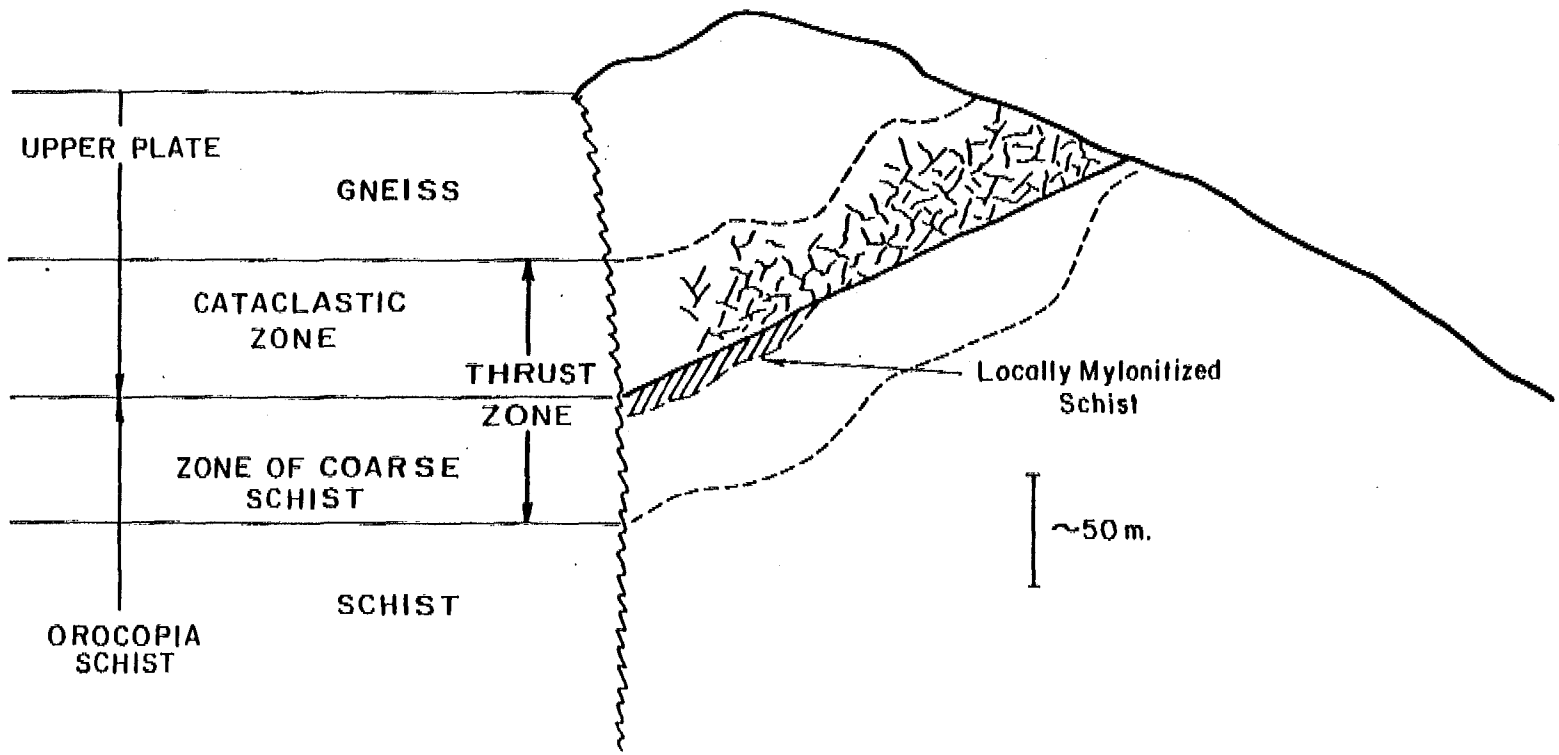


Figure 36. GENERALIZED CROSS-SECTION OF THE VINCENT-CHOCOLATE MOUNTAINS THRUST ZONE. DASHED CONTACTS ARE GRADATIONAL. (After Haxel and Dillon, 1978)

Arizona. While evidence for Tertiary movement was not established at the time we first formulated our model, we recognize that it could play an important role in the localization of mineralization along the thrust zone.

Textures and metamorphic assemblages along the thrust zone indicate that the load pressures were large and that rocks for some distance above and below the fault responded with generation of highly foliate, "tight" fabrics by intense shearing and mylonitization. Tertiary reactivation of the shear zone, on the other hand, operated under regional extension rather than compression and load pressures were much less. Deformation associated with this reactivation was more characteristically brittle in nature which is more ideally suited for open space fracturing and porosity development in which to circulate and deposit metal-bearing fluids.

While it is rumored that mineralization in Mesquite is 50-60 m.y. old, we cannot discount the possibility of overprinted Tertiary movement along the thrust may thought to be of initial ore control at Mesquite. The same multi-tectonic and multi-mineralization history may, in fact, have upgraded metallization in other areas.

As a result of our regional examination in the Mojave Desert, we feel that the setting described above has had a significant role in localizing a number of large, economically viable gold deposits. For example, Goldfield's Mesquite deposit (announced 50 to 70 million tons grading 0.05 to 0.07 opt Au; rumored to be as large as 200 million tons of similar grade) is reportedly hosted in

stockworks and fractured gneisses and granitic rocks in the upper plate of the Vincent-Chocolate Mountains thrust. Minor veins and placer deposits have been explored for years in this area. Gold mineralization reportedly occurs with sulfides in veins, stockwork veinlets, and as disseminations in the Precambrian crystalline rocks and also in metamorphosed Mesozoic (?) gneisses. Pegmatite dikes of unknown but presumably Laramide age are common in the area, and numerous bodies of middle Tertiary age granite occur in the Chocolate Mountains in the vicinity of the deposit. Sulfide-bearing stockworks and widespread chlorite alteration of the area contributed to the district being thought of as a high level manifestation of deeper porphyry copper mineralization during the 1960's and 1970's. The deposit is reported to have a "flat" bottom which some workers have suggested is a detachment fault. We suggest that this fault may actually bethe Vincent-Chocolate Mountains thrust that has possibly been reactivated during Tertiary time. There is also some suggestion that the mineralization represent remobilization of an original stratiform exhalative type deposit in the Mesozoic metamorphic rocks (Roly Ridler rumor). We regard this idea as a distinct possibility as we have repeatedly referred to the association between possible exhalative type features and Mesozoic schists and gneisses in this region.

The Big Horn mine in the Mount Baldy district near Los Angeles is another example of Vincent thrust-related mineralization. At the Big Horn, the mineralized zone lies in the Vincent thrust plane. Country rock at the mine consists of a lower plate of Pelona (Orocopia) schist that is overlain by mylonite and mylonitic gneisses in the upper plate of the thrust. The

mylonitized and cataclastic "thrust zone" near the mine ranges up to 2,000 ft thick. In the vicinity of the mine, the thrust has been intruded by a pyritized, sill-like body of quartz porphyry. Mineralization occurs mainly in the footwall portion of the thrust, commonly associated with a fractured carbonaceous schist. This fractured zone ranges in thickness between 20 to 60 ft and has been flooded and cemented by quartz and carbonate. Past mining indicates that gold occurs along the hanging wall and footwall of the mineralized zone with relatively barren rock between. The hanging wall zone has been the most productive to date. It averages 30 ft in thickness and ranges in grade from 0.12 to 0.30 opt Au. Gold values correspond well with areas of carbonate flooding which is said to consist of ankerite. Arsenopyrite and pyrite occur with the gold. Even though silicification may exist, where the carbonate disappears, the gold values are said to drop off. Exploration by the Siskon Corp. in 1974 delineated estimated reserves in the mine of 1.2 million tons grading 0.15 opt Au. The deposit is essentially open-ended and has the potential for much larger tonnage. Inspiration Copper Co. took an option on the property in 1984.

In the Rand district of California, the Rand thrust (Vincent thrust equivalent) juxtaposes upper-plate Mesozoic granitic rocks over the Rand schist. The thrust zone is exposed along the southern margin of the range, and ranges from a few feet up to 200 ft in thickness. The thrust zone is marked by mylonitization in the upper plate that consists of a distinctive interval of mylonitic carbonate plus calc-silicate and quartzofeldspathic gneiss that separates the Mesozoic granitic rocks from the Rand schist. Silver and others (1984) suggest this interval is unrelated to either the upper or lower plates and probably

represents (1) dislocated tectonic slices, or (2) an unusual hydrothermal accumulation developed at the sole during thrusting. The thrust zone has been extensively broken by later brittle normal faults and is possibly compounded by reactivation along Tertiary low-angle normal faults (Moorehouse, 1984).

Some of the mineralization in the Rand district is controlled by low-angle fault structures. The Yellow Aster orebody which produced a minimum of 550,000 ounces of gold from 3,400,000 tons of ore (80% recovery) is contained within a tectonically bounded fault wedge of quartz monzonite and Rand schist cut by rhyolite dikes. The rocks within the wedge are extremely fractured and shattered and bounded on top and bottom by low-angle faults. The upper bounding fault is pre-mineral, and served to cap the rising hydrothermal fluids and pond them within the shattered wedge.

The trace of the Rand thrust is exposed less than 1 mile south of the Yellow Aster pit. The proximity of the Yellow Aster to the thrust, its flat fault contacts and shattered nature suggests that it probably represents a tectonic sliver or imbricate feature of the main thrust. Another possibility is that it represents reactivation along the thrust by Tertiary low-angle faulting. Mineralization is believed to be related to the district wide intrusion of rhyolite porphyry during late Miocene time (± 12 m.y. ago; unpublished K-Ar date, these authors).

The last example we offer of this mineralization model is the Picacho mine located in the southern Chocolate Mountains about 20 miles north of Yuma,

Arizona. The mineralization at Picacho has long been an enigma to geologists studying the deposit. Mineralization occurs in altered, highly fractured and cataclastized Precambrian crystalline rocks that range from gneisses and schists to mylonites (Harris and VanNort, 1975). Where mineralized, these rocks contain large amounts of secondary red-brown hematite and carbonate. Ore zones are typically of tabular shape, 100-120 ft in thickness, and display shallow dips of 30-40°. Stacked orebodies probably exist in places as drilling by Chemgold has encountered zones that contain 70-100 ft of ore that give way to about 100 ft of unmineralized rocks and go back into a 100 ft thickness of ore grade material. Early drilling by Hanna (Harris and VanNort, 1974) also indicated sharp, commonly flat contacts between altered and mineralized material passing downward into fresh unaltered and unmineralized rocks. Since the Vincent thrust is exposed in nearby windows through the volcanic and sedimentary cover, we originally postulated (Wilson and others, 1983) that the mineralized zones probably represented the broken upper plate of the thrust or possibly imbricate zones above the main thrust. We also suggested that the flat, structural (?) bottom to the deposit could be a Tertiary detachment feature. Both ideas are probably correct. Recent work (E. Frost and P. Durning, personal commun.) shows that a detachment fault does exist and is exposed outside the mine areas as well as in the Dolcina ore zone itself. It seems likely that the low-angle Tertiary faulting has broken down into and along the thrust producing a compound fault zone that displays extensive brittle deformation. Chemgold's open pit reserves at Picacho amount to about 6,000,000 tons grading approximately 0.04-0.05 opt Au; with chances for expanding these reserves considered to be excellent. Early production from the mine (1904-1911) produced nearly 150,000 oz Au.

We contend that the similarities of the geologic settings of the aforementioned deposits are important and establish exploration significance to the outcrops of the Orocopia (and equivalent) schist and exposures of the Vincent-Chocolate Mountains thrust within the western Arizona study region.

Aspects of mineralization found in these deposits are incorporated into the following general model summarized below:

(1) Competent, upper-plate, Precambrian to Mesozoic gneisses and granitic rocks are mylonitized and cataclastically deformed above Orocopia schist along the regionally extensive Vincent-Rand-Chocolate Mountains thrust fault.

(2) Tertiary reactivation of the thrust zone along listric or low-angle normal faults or detachments produced compound fault structures that resulted in much brittle deformation in the upper-plate crystalline rocks.

(3) Thermally driven hydrothermal cells were localized along the thrust zone and/or the compounded Tertiary detachment-thrust zones. Any suitable igneous source for a heat driving mechanism would have to be Laramide or younger in age.

(4) Metals were scavenged by the hydrothermal cells from suitable sources such as the lower plate Orocopia schist, and deposited into the structurally prepared areas within the thrust or compound fault zones by physio-chemical changes (i.e. boiling, mixing with oxygenated meteoric waters, etc).

(Note: While suitable sources of metals could include exhalative mineralization in the upper-plate Mesozoic section or igneous sources at depth, we prefer the Orocopia schist as a source because of the oceanic

character of its protolith. Ultramafic rocks, fuchsitic schists, magnetite-rich chert beds, and carbonate and carbonaceous lenses within the Orocopia package all suggest a setting favorable for the existence of oceanic exhalative gold mineralization within the unit; providing a ready source of carbonate + metals for the circulating hydrothermal systems).

Gold mineralization in this setting has been typically coarse enough to produce placer accumulations. Thus small placer trains so common to many southwest districts may be lead-ins to targets within the Orocopia environment.

Geochemically these deposits also appear to be somewhat distinctive. While Tertiary detachment faults may help provide adequate structural preparation, these deposits do not display the typical detachment suite of elements (i.e. Cu-Fe-Au-Ba-F-Mn). Based on limited sampling, we see these deposits as containing an As-Au-Hg suite of anomalous elements. Other elements that we have limited data for, but which appear to be also anomalous include W and Cr. The chrome is an interesting and unusual component. We would suggest that its presence offers evidence of metals being scavenged from ultramafic protoliths in the Orocopia schist. Ranges of elements from some of the deposits described are given below:

	Mesquite	Picacho	Big Horn
As	100-500 ppm	4-315 ppm	10-2500 ppm
Hg	.2-1	.04-1.0	.01-.75
Cu	100	50	70
Zn	10-30	12-230	9-81
Cr	30-100	50-100	30-250
Ba	1000-2000	600-1000	25-300
W	2-5	2-7	2-5
Tl	1-2	.1-1.4	1
Sb	2-8	.1-50	2-20; avg 2-4
U	Anomalous	≤ 2	≤ 2
Bi	_	≤ 1	2

7. Precambrian Lode Gold Mineralization; Stratiform-Metamorphic Types

Gold deposits in Archean and Proterozoic greenstone terranes have been one of the world's most highly productive sources for this metal. Since these deposits are often large and relatively high-grade, they make attractive targets in today's economic conditions. Lode gold deposits in Archean greenstone terrane are generally separated into two principal members; auriferous veins and gold-bearing chemical sedimentary types (cf. Kerrich and Hodder, 1980). Likewise, base-metal massive sulfide deposits are often large gold producers in this environment and constitute another target type. While Proterozoic greenstone belt stratigraphy and tectonic history may not be completely analogous to those in the Archean, enough similarities occur to suggest that similar processes of gold mineralization may have operated in

both. The subject, however, is much too broad to attempt to treat in any form of a review fashion in this report. In addition, arguments still rage over styles of mineralization and the ultimate genesis of the deposits. The literature is filled with articles on the subject, including models for formation of the various deposits types mentioned. We would suggest readers unfamiliar with the subject review articles by Sangster (1972), Hutchinson (1976), Kerrich (1980), Franklin and others (1981), and recent books on the subject including Ontario Geological Survey Misc. Paper 110, CIM Spec. Vol. 24, and Economic Geology Monograph 5.

In a very generalized overview manner, some criteria for the association of gold in greenstone terranes follows (from Colvine, 1983; R. Hodder, personal commun., 1983):

1. Deposits occur in packages of sheared and folded rocks consisting largely of eugeoclinal-type sediments and mafic volcanics that are regionally metamorphosed to greenschist or lower amphibolite facies and intruded by major batholithic sequences (cf. Bohlke, 1982).

2. Deposits commonly display spatial associations with:
   - alteration zones (predominantly carbonatization and silicification
   - chemical sedimentary rocks (exhalites)
   - felsic intrusions or dome complexes
   - regional interfaces between dominantly volcanic and dominantly clastic sedimentary sequences (i.e. faults, facies changes, or a vertically and laterally concordant interfingering of clastic and volcanic units).
   - komatiites

3. Gold commonly occurs in quartz ± carbonate (ankerite) vein systems, and is almost ubiquitously associated with pyrite. Chrome-micas are often present.

4. The deposits are commonly associated with tellurides, arsenopyrite, tourmaline, scheelite and molybdenite.

5. There is typically a local structural control on the final localizing of gold concentrations; and concentrations of deposits commonly occur along major deformational zones or "breaks."

- Primary structures include: (a) interfaces between dominantly clastic sedimentary sections and dominantly volcanic sections (i.e. major breaks), (b) unstable second order basins flanking volcanic centers, usually fault bounded; (c) stockworks at the brecciated margins of felsic subvolcanic stocks.

- Secondary structures include: (a) ladder veins across otherwise strataform chemical sediments (i.e. Kerr Addison, Canada). These are most commonly found along major "breaks" of basin bounding, growth faults, (b) diffuse footwall veinlets, (c) remobilized veinlets in axial plane cleavages to folded chemical sediments (i.e. saddle reefs).

6. Deposits are typically tabular in form and generally are associated with thinly banded, dispersed pyrite to massive pyrite; with massive layers being generally less auriferous than finely dispersed pyrite.

Deposits sizes and grades can be spectacular. Grades commonly range from 0.17 to 0.30 opt Au; tonnages range from very small to tens of millions (M. Swan, 1982). For example, Kerr-Addison is about 40 mt grading 0.3 opt Au.

Likewise base-metal massive sulfide deposits can also be valuable gold producers. Gold-rich deposits of this type appear to bridge a spectrum between base-metal rich (i.e. Horne deposit at Noranda, Canada; 60 mt grading 0.18 opt Au) and base metal poor deposits (Dumagami deposits, Canada; 4 mt grading 0.12 opt Au). The Dumagami deposit is interesting because it may be somewhat transitional between Cu-Pb-Zn dominant massive sulfide deposits such as those at Noranda and exhalative gold deposits (R. Hodder, personal commun., 1983).

It is also interesting to note that while base metal, massive sulfide deposits in Canada are proximal to volcanic piles and associated vents, gold-bearing

chemical sediments and vein deposits are usually distal to the ediface and typically occur where the main volcanic pile interfingers with clastic rocks.

Volcanogenic massive sulfide deposits are relatively common in the Proterozoic metavolcanic stratigraphy of Arizona. It was not until the mid-1960's, however, when the volcanogenic model for Canadian Precambrian massive sulfide deposits was developed (i.e. Gilmour, 1965; Roscoe, 1965) that similar deposits hosted by Precambrian schists and gneisses in Arizona were recognized (i.e. Gilmour and Still, 1968). Since then, understanding of the characteristics of these deposits has advanced to the point where Proterozoic stratibound massive sulfide deposits in Arizona are now considered to represent a distinct metallogenic epoch and province (Anderson and Guilbert, 1979). Nearly two dozen massive sulfide deposits in Arizona have produced more than 41 million tons of ore (Donnelly and Hahn, 1981). The deposits occur in a number of localities in the Precambrian metavolcanic-sedimentary terrane exposed along the transition zone between the Colorado Plateau and the Basin and Range Province (Figure 37).

Two excellent general discussions on the geology of the deposits, their characteristics and the regional geologic framework for the Proterozoic terrane in which they are hosted have been presented by Anderson and Guilbert (1979) and Donnelly and Hahn (1981). Interested readers are referred to these articles.

The deposits are present within a thick assemblage of submarine volcanic, volcaniclastic, and epiclastic rocks that are Proterozoic in age and which occupy a time interval from about 1,700 to 1,800 m.y. age (Donnelly and Hahn, 1981).

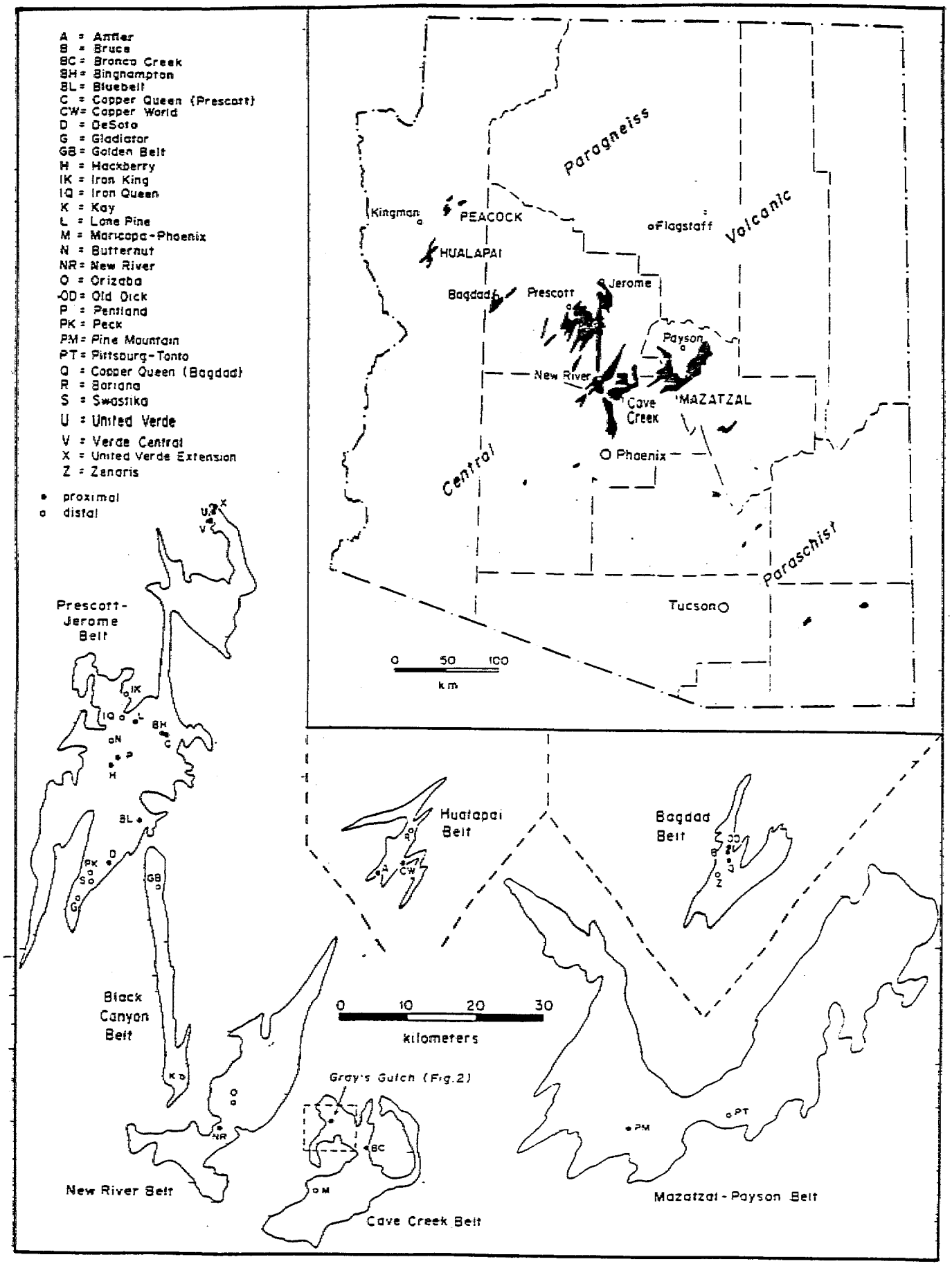


Figure 37. Distribution of middle Proterozoic volcanic and volcanosedimentary rocks in Arizona in relation to the three major Precambrian tectonic belts. Distribution of proximal and distal type massive sulfide deposits are shown within enlargements of each of the volcanic belts. All belts are enlarged to the same scale; all are in correct relative positions except the Hualapai and Bagdad belts.

(From Anderson-Guilbert, 1979)

A regional synthesis of this Proterozoic eugeosynclinal-type stratigraphy (Donnelly and Hahn, 1981) indicates that it consists of a complex volcano-sedimentary pile formed by overlapping and coalescing volcanic centers resembling a modern day volcanic arc. Lithostratigraphic correlations indicate that as many as four sequential, mafic to felsic volcanic cycles may be represented in the Province (Donnelly and Hahn, 1981).

While the deposits have been mainly Cu-Zn-Pb producers, gold and silver have been a major by-product. In fact, some deposits have been valued mainly for their precious metals production; examples include the Iron King, Hackberry, Desoto and Stoddard deposits (Donnelly and Hahn, 1981). Some tonnage and grade figures of gold-rich massive sulfide occurrences are given below:

Deposit	Iron King	Blue Bell	Hackberry
Tonnage	5 mt	.86 mt (1903-1925)	See Note*
Average Grade:			
Au (opt)	0.123	0.05	0.113
Ag (opt)	3.69	1.36	5.18
Cu (%)	0.19	3.06	2.0
Pb (%)	2.50		3.5
Zn (%)	7.34		9.0

*Note: Lindgren states the mine was a large producer, however, we have no production figures; 13,000 tons of ore was mined 1943-45, averaged above.

Data Source: Anderson and Blacet, 1972; Gilmour & Still, 1968; Lindgren, 1926.

Oxidized gold-rich gossans may occur over some of the massive sulfide deposits. These are apparently attractive heap leach targets. The oxidized gossan overlying the Gray Eagle massive sulfide deposit (1 mt grading 0.21 opt Au and 0.61 opt Ag) in northern California is an example (Lackey, 1980).

While volcanogenic massive sulfide mineralization is easy to document in the Proterozoic of Arizona, the presence of gold-bearing exhalatives and Precambrian veins are much less common.

Swan and others (1981) documented a strataform gold occurrence in the Agua Fria mining district about 20 miles southeast of Prescott (located north of the study area). The deposit is associated with a rhyolite dome and consists of a sintery silica-sericite-carbonate-rich exhalative horizon that carries green micas and arsenopyrite. Mineralization extends more than 4 km along strike and is confined to the 100 m thick exhalative section that is comprised of a series of thin auriferous sulfide lenses and intercalated schist containing disseminated sulfides. Secondary remobilization of this auriferous, sulfide facies exhalative, possibly associated with folding of the unit has resulted in highly variable, but as much as 10-fold increases in gold enrichment locally. Ladder veins typically containing quartz and auriferous arsenopyrite also cross cut the stratiform mineralized horizon.

Other "distal" massive sulfide deposits are described by Anderson and Guilbert (1979). These include the Orizaba mine in the New River district, the Maricopa-Phoenix mine near Cave Creek, and the Gold Belt mine in the Black Canyon district. These deposits are described as typically being "pyrite-sphalerite-galena rich deposits with economically significant Au and Ag and are always accompanied by iron formation to the extent that many form well-bedded, sulfide-facies iron formation deposits." The Gold Belt and Maricopa-Phoenix properties have been traditionally considered gold properties. They are also described in old reports as being hosted by veins that fill very low-angle fault structures.

The age of the McCabe-Goldstone vein near the Iron King mine has long been a puzzle to geologists in the area. Anderson and Creasy (1958) emphasized that the time of formation of the Silver Belt-McCabe vein could not be definitely established and a Precambrian age could not be ruled out. The McCabe-Gladstone mine contains complex sulfide ores that were valuable chiefly for their gold and silver content. Production prior to 1925 amounted to about $3,000,000 (Lindgren, 1926). Recent work on the property by Stan West Mining has established new "indicated" reserves of several hundred thousand tons grading about 0.30 opt Au. There is presently considerable speculation that this "vein" system may represent remobilized Precambrian stratiform mineralization.

While oxide facies iron formations are common in the Arizona Proterozoic, they are not to our knowledge gold-bearing. There is evidence, however, for other, probably hydrothermal, chemical sediments in these rocks. While they may or may not be gold-bearing, they at least indicate that chemical sedimentation may be more widespread than is generally known. For example, we have noted in certain districts the presence of disseminated scheelite occurring in sometimes banded, carbonate-epidote-magnetite-quartz lenses within the Yavapai Schist (i.e. Castle Creek, White Picacho districts). Descriptions of the tungsten mineralization suggest that some might be metamorphosed, tungsten-bearing carbonate exhalative horizons. Fulp and Renshaw (1985) discuss stratabound volcanogenic-exhalative tungsten mineralization in Proterozoic greenstone terrane near Santa Fe, New Mexico.

Tertiary (?) aged gold mineralization typically occurs in these same districts where tungsten occurs in the schist. In some cases (White Picacho district; Zanneropolis property, Eureka-Bagdad district) gold placer deposits drain the schist areas which contain the scheelite occurrences. The setting hints at possible Tertiary scavenging of gold, etc., from the Proterozoic schists. We doubt that these tungsten occurrences have ever been examined in light of exhalative models.

Tourmaline-rich horizons (tourmalinites) also occur in scattered areas of Proterozoic aged gneisses and schists within the study area (i.e. Gold Basin, Lost Basin, Eureka-Bagdad and Webb districts). These units appear to be stratiform and may indicate boron-rich chemical precipitates derived from subaqueous hotspring environments. This is significant as many tourmalinites are closely associated with a variety of stratiform mineral deposits, including gold, tungsten, tin, cobalt, and base-metal sulfides (cf. Slack, 1982; Fleischer and Routhier, 1973; and Slack and others, 1984). Slack and others (1984) have also noted that within regionally metamorphosed terranes, tourmalinites may be severely sheared and remobilized into irregular pods and lenses of coarse-grained quartz and tourmaline within a broadly stratibound setting. In amphibolite-facies terrane, discordant tourmaline-rich quartz veins and tourmaline pegmatites become common and in many cases serve as effective guides to nearby stratiform tourmalinites. Lindgren (1926) notes that tourmaline is so common a constituent of the Precambrian gold-quartz veins in the Bradshaw quadrangle that it is considered a typical, though usually scant, gangue mineral. While the Yavapai Schist in the Bradshaw Mountains is of greenschist facies rather than amphibolite

facies, we wonder if some gold quartz veins might not represent remobilization of constituents from original stratiform deposits in nearby packages of schist. Lindgren describes Precambrian veins as occurring in the Castle Creek, Minnehaha, and Black Canyon districts.

In summary, we are of the opinion that the Proterozoic greenstone terrane in Arizona is highly prospectable for stratiform and lode gold mineralization. In addition, some volcanogenic base metal deposits in this environment may be worthy gold targets as well. Possibly their main drawback is that these targets are difficult to explore for, and require intensive amounts of grass-roots geologic mapping and sampling.

NURE GEOCHEMISTRY

As part of the regional metallogenic analysis, multi-element stream sediment geochemical data (HSSR) were obtained from the National Uranium Resource Evaluation (NURE). A standard statistical analysis was applied to each element in each of the data sets. This analysis provided the following parameters for each element: mean, maximum and minimum value, range, standard deviation, skewness, kurtosis, number of valid samples, number of missing values, and a site-by-site list of sample points above the 90th, 95th, and 99th cumulative frequency percentiles. In addition, a Pearson Product Moment Correlation Coefficient Matrix was provided for the entire range of elements in each AMS sheet.

Stream sediment data were not available for all the AMS sheets in the Arizona project; only the Phoenix, Prescott, Kingman, Needles, Salton Sea, Williams and Lukeville sheets have data available. Since the area covered by the Lukeville sheet is so small and is largely within the Organ Pipe National Monument, we chose not to purchase it. Data for the Ajo and El Centro sheets are not available. Of the available sheets, all but Kingman were analyzed by SRL (Savannah River Laboratories). The Kingman data were analyzed by Lawrence Livermore Labs. Different techniques were used for analysis for each lab; Table 3 lists the analytical procedure and sensitivity limits used by each facility for the individual elements.

The quality of the data remains to be tested. Discussions with researchers in the U.S. Geological Survey working on this problem indicate that the neutron

TABLE 3. SEDIMENT ANALYSES BY HSSR LABORATORIES

ELEMENTS

LABORATORIES	Ag	Al	As	Au	B	Ba	Be	Bi	Br	Ca	Cd	Ce	Cl	Co	Cr	Cs	Cu	Dy	Eu	F	Fe	Hg	Hg*	K	La	Li	Lu	Mg	Mn	Mo	Na
LAWRENCE LIVERMORE LABORATORY	3.0 NA	50.0 NA	3.0 NA	0.015 NA		100.0 NA			1.0 NA	5000.0 NA		15.0 NA	50.0 NA	3.0 NA	5.0 NA	1.5 NA		0.2 NA	0.1 NA		2000.0 NA	1.0 NA	500.0 NA	2000.0 NA	0.3 NA		0.07 NA	50.0 NA	200.0 NA		20.0 NA
LOS ALAMOS NATIONAL LABORATORY	5.0 XRF	200.0 NA	5.0 XRF	0.01 NA		300.0 NA	1.0 AS	5.0 XRF		4000.0 NA	5.0 XRF	10.0 NA	80.0 NA	0.7 NA	5.0 NA	1.5 NA	10.0 XRF	2.0 NA	0.8 NA		2000.0 NA	1.0 NA		2000.0 NA	6.0 NA	1.0 AS	0.1 NA	1250.0 NA	10.0 NA	5.0 XRF	350.0 NA
OAK RIDGE GASSEOUS DIFFUSION PLANT	2.0 PS	500.0 PS	0.1 AA		10.0 PS	2.0 PS	1.0 PS			500.0 PS		10.0 PS	- PS	4.0 PS	1.0 PS		2.0 PS				500.0 PS	15.0 PS		500.0 PS	2.0 PS	1.0 PS		500.0 PS	4.0 PS	4.0 PS	900.0 PS
SAVANNAH RIVER LAB (1) SRL STANDARD SUITE		300.0 NA		0.01 NA								3.0 NA						1.7 NA	0.2 NA		2800.0 NA	1.0 NA			2.0 NA		0.1 NA		70.0 NA		800.0 NA
(2) SRL SUPPLEMENTAL SUITE	0.1 AA		1.0 AA			8.0 AA	0.5 AA			100.0 AA				5.0 AA	49.0 AA		6.0 AA							2000.0 PE		5.0 PE		300.0 AA		2.0 AA	
(3) ANALYZED BY OAK RIDGE AS SUPPLEMENTAL DATA	2.0 PS	50.0 PS			10.0 PS	2.0 PS	1.0 PS			50.0 PS		10.0 PS		4.0 PS	1.0 PS		2.0 PS				50.0 PS	15.0 PS		50.0 PS	2.0 PS	1.0 PS		50.0 PS	4.0 PS	4.0 PS	90.0 PS

LABORATORIES	Nb	Ni	P	Pb	Rb	Sb	Sc	Se	Si	Sm	Sn	Sr	Ta	Tb	Th	Ti	Tl	U	V	W	Y	Yb	Zn	Zr
LAWRENCE LIVERMORE LABORATORY					20.0 NA	0.5 NA	0.1 NA			0.3 NA		40.0 NA	0.5 NA	0.4 NA	2.0 NA	10.0 NA		2.0 DNC	0.5 NA	0.5 NA		1.0 NA	30.0 NA	
LOS ALAMOS NATIONAL LABORATORY	20.0 XRF	15.0 XRF		5.0 XRF	25.0 NA	1.0 NA	0.1 NA	5.0 XRF		0.5 NA	10.0 XRF	203.0 NA	1.0 NA	1.0 NA	0.8 NA	200.0 NA	- NA	0.02 DNC	5.0 NA	15.0 XRF	- NA	1.2 NA	20.0 NA	5.0 XRF
OAK RIDGE GASSEOUS DIFFUSION PLANT	4.0 PS	2.0 PS	5.0 PS	10.0 PS			1.0 PS	0.1 AA	- PS			1.0 PS			2.0 PS	10.0 PS		0.02 NA 0.25 FL - MS	2.0 PS		1.0 PS		2.0 PS	2.0 PS
SAVANNAH RIVER LAB (1) SRL STANDARD SUITE							0.4 NA	- NA		1.0 NA					2.0 NA	300.0 NA		0.4 DNC	20.0 NA			1.3 NA		
(2) SRL SUPPLEMENTAL SUITE	5.0 CM	5.0 AA	20.0 CM	10.0 AA			1.0 AA	1.0 AA			5.0 AA	50.0 AA			70.0 XRF			0.1 FL		2.0 CM	5.0 AA		11.0 AA	
(3) ANALYZED BY OAK RIDGE AS SUPPLEMENTAL DATA	4.0 PS	2.0 PS	5.0 PS	10.0 PS			1.0 PS					1.0 PS			2.0 PS	10.0 PS			2.0 PS		1.0 PS		2.0 PS	2.0 PS

* NOTE: ACTUAL ELEMENTS ANALYZED MAY VARY FOR EACH QUADRANGLE.

** * THE MINIMUM DETECTION GIVEN FOR SRL DATA MAY OR MAY NOT BE THE MINIMUM DETECTION FOR THAT ELEMENT. THE NUMBER COULD BE THE LOWEST VALUE DETECTED AND, THEREFORE BE GREATER THAN THE MINIMUM DETECTION.

CODES

- MINIMUM DETECTION VALUES ARE IN PARTS PER MILLION.
- A " - " IN THE MINIMUM DETECTION SLOT INDICATES MISSING DATA OR THAT NO MINIMUM DETECTION WAS GIVEN.
- AA = ATOMIC ABSORPTION
- AS = ARC SOURCE EMISSION SPECTROMETRY
- CM = COLORIMETRY
- DNC = DELAYED NEUTRON COUNTING
- FE = FLAME EMISSION
- FL = FLUOROMETRY
- MS = MASS SPECTROMETRY - ISOTOPE DILUTION
- NA = NEUTRON ACTIVATION ANALYSIS
- PS = PLASMA SOURCE EMISSION SPECTROMETRY
- SP = SPECTROPHOTOMETRY
- XRF = ENERGY DISPERSIVE XRF

activation technique has interference problems for a variety of elements, including gold and silver. The problem was apparently more acute at the beginning of the program and particularly with Lawrence Livermore Labs. SRL had apparently solved a portion of this same problem in their later work.

For purposes of this study, it was decided to plot anomalous values for only gold, silver and the major pathfinder elements. A more rigorous study and plotting of additional elements, element ratios or lower anomaly levels, could prove to be of significant use in the future. For this reason, the statistical data base has been reproduced for the client for any further consideration they may desire. For instance, plots of the elements Cu, Zn, Mo and W may also be of use.

The elements plotted on Overlay 3 include Au, Ag, As, Hg, Sb, and Se. Not all of these elements were analyzed for each AMS sheet. For example, of these elements, only Au was analyzed for on the Needles and Phoenix sheets; while on the Kingman, Prescott and Williams sheets, Ag, As, Sb and Hg were analyzed, but not Au.

It should also be noted that on Overlay 3 only the Au symbols represent consistent values across the entire area. For Au we have plotted three anomalous intervals: detection to 0.1 ppm; 0.10 to 0.3 ppm; and greater than 0.3 ppm. For the other elements, only the 95th and the 99th, and in some cases the 90th, cumulative frequency percentile values were used to indicate anomalous samples. The absolute value range of each percentile for each element is somewhat different on each AMS sheet. The various ranges for these values in each sheet are presented in the legend to Overlay 3.

The following elements were plotted:

Kingman Sheet	Ag, As, Hg, Sb
Needles Sheet	Au
Salton Sea Sheet	Au, Ag, As, Se
Phoenix Sheet	Au
Prescott Sheet	Ag, As, Hg, Sb
Williams Sheet	Ag, As, Hg, Sb

We found it useful to integrate the Precious Metals Overlay 1 in conjunction with the NURE geochemistry to better understand the distribution of the anomalous elements.

Results

1. Kingman Sheet

The Kingman sheet displays a number of silver, arsenic, mercury and antimony anomalies. The significance of individual point anomalies is difficult to determine. We have not given them much weight unless they happen to correspond with favorable geologic features (i.e. several single point anomalies occurring on or near a major structural feature or favorable lithologic unit). We have tended to place more emphasis on clustering of anomalies around certain areas or geologic features, and on individual sample cites that display two or three anomalous elements. While we cannot judge the quality of the NURE data, it is encouraging to note that on the California side of the Kingman sheet, disseminated epithermal gold mineralization in the Hart mining district is readily noticeable as a cluster of antimony and arsenic anomalies (with a mercury anomaly occurring nearby).

On the other hand, the Hackberry district which lies south of the Hart district and which displays abundant silicification and sporadic disseminated gold mineralization, produced only a single arsenic anomaly.

The Arizona portion of the Kingman sheet displays numerous anomalies of arsenic, mercury, antimony and silver. Those that appear most interesting to us include:

1. The arsenic and mercury anomalies which occur near the trace of the detachment fault that has been mapped along the western flank of the Gold Basin district. Low-grade mineralization and alteration occur along the detachment at the Cyclopic mine (see district description). The numerous NURE anomalies may indicate this fault has served to localized Tertiary mineralization. The area deserves follow up with more detailed geochemistry.

2. The cluster of silver and mercury anomalies occurring in the Miocene volcanic rocks in the southern portion of the White Hills (near Mountain Spring) also appears to be worthy of reconnaissance field checking. While no CRIB or MILS localities occur in this area, a couple of mine symbols are displayed on the AMS sheet in this general area.

3. Another interesting cluster of silver, arsenic and antimony anomalies occurs along the western side of the Cerbat Range just outside the northwestern edge of the Wallapai district. These anomalies seem to correspond with a small block of Miocene (?) volcanic rocks that overlie the Precambrian basement.

4. Several arsenic and one large mercury anomaly form a somewhat dispersed group or cluster overlapping the northern end of the Eldorado Pass and Gold Bug district. These anomalies are in close proximity to detachment surfaces in this part of the Black Range (see district discussion) and indicate that the area may deserve a close inspection in the field accompanied by geochemical sampling. The full extent of the low-angle faulting is not known.

5. Both the Oatman and Union Pass districts display numerous anomalies; attesting to the widespread mineralization in these areas. It is difficult to judge anomalies in the middle of districts as many of them may simply reflect old dumps or mill tailings. Some that are more distant from the major mined areas, however, might be worth examining.

6. Interesting single point anomalies in the Kingman sheet include: (a) an arsenic-mercury anomaly in Miocene volcanic rocks located near the northern end of the White Hills just south of Lake Mead; (b) a large (7 ppm) antimony anomaly that occurs near the Strong Box Group mine (SW¼ Sec. 10 and NW¼ Sec. 15, T19N, R19W) on the eastern flank of the Black Range opposite Oatman (north of Baker Spring); (c) several mercury anomalies just southeast of the Lost Basin district along the margin of the Colorado Plateau in Precambrian granitic rocks.

2. Williams Sheet

Only a small portion of the Williams sheet falls within the study area. Several interesting anomaly clusters, however, occur in this small area. A large cluster of antimony (plus one arsenic) anomalies occur in Precambrian schists in the Cottonwood district. This is a very poorly known district and the anomalies may upgrade the area as a target.

Two arsenic anomalies occurring in the southern part of the Peacock Range appear to be associated with patches of Miocene volcanic rocks which cover the Precambrian basement in this area. Not very far to the north, the Old Hackberry mine produced over $1,000,000 in gold and silver prior to 1906.

Finally, a small cluster of arsenic and antimony anomalies just to the southwest of the Maynard district may be significant. Vuich (1974) believed the district displayed a metal zoning pattern associated with a buried Laramide porphyry system. He indicates that the outermost mineralization consists of gold-silver bearing deposits (see district description).

3. Needles Sheet

Of the suite of elements that we have chosen to plot on Overlay 3, only gold was analyzed for in the Needles sheet. Most of the anomalies that exist correspond with known mining camps in which a number of gold prospects are present. Geologically, the two most interesting geochemical clusters appear to be those in the Cienega district and the three widely spaced anomalies that occur at the southern terminus of the Black Range.

The anomalies in the Cienega district correspond closely with a cluster of copper-gold occurrences (see district description herein).

The anomalies occurring at the southern end of the Black Range appear to be derived from the Miocene volcanic cover. These rocks are similar in age and composition to those which host epithermal gold mineralization in the Oatman and Union Pass districts further to the north. While this area is not known to be productive, a number of mine symbols occur on the AMS sheet. The area is cut by many large faults that display a regional WNW trend that would appear favorable for localizing mineralization. The NURE gold anomalies would seem to indicate that this area may hold more potential than previously recognized.

4. Prescott Sheet

The portion of the Prescott sheet that is covered by this project holds many anomalous points of the elements which we have chosen to plot. Unfortunately, many of these anomalies are single point-single element anomalies and thus are difficult to assess.

Interestingly, the Tertiary volcanic rocks north of the Eureka-Bagdad district display a number of scattered single point mercury anomalies. Little is known about these volcanic rocks. Much, if not most of these rocks are relatively mafic ranging in composition from andesites to basalts. Recent mapping in the general vicinity, however, has shown that large areas that were once thought to be basalts are actually rhyolite tuff, flows and intrusive domes of late (?) Miocene age (cf. Moyer, 1982; Burt and others, 1981). These rocks might well

have associated epithermal mineralization. Besides the single point anomalies, a cluster of antimony anomalies with an associated mercury and silver anomaly occurs in these volcanic rocks directly north of the Eureka-Bagdad district, just at the northern edge of Bozarth Mesa. This cluster appears to correspond with a major zone of northeast-trending faults near where it is intersected by a less obvious northwest-trending zone of faulting. The linear segment of Burro Creek which lies directly west of this major northeast-trending zone of faults shown on Plate 1 is probably part of this system or a similar, parallel feature. It should be noted that possible hot springs related opal replaces rhyolitic tuffs along the eastern margin of Bozarth Mesa in the Eureka-Bagdad area (see district description).

The only other major clusters of anomalies occur in the central part of the French Gulch district and along the southern extension of the Shylock fault zone in the Black Canyon district. Anomalies in both districts appear to be derived from deposits within the Precambrian Yavapai Series. Both districts contain stratiform, volcanogenic massive sulfide deposits which may ultimately be the source of the anomalies. On the other hand, both districts also contain gold placer and lode deposits as well. It is also known that some of the massive sulfide deposits in the Precambrian of Arizona have been substantial precious metal producers (i.e. Iron King mine) and are still worthy targets. While still an unknown entity, the possibility of stratiform gold mineralization in the Yavapai Series should also be considered a possibility. Both of these districts would be suitable areas for such mineralization to occur.

The Shylock fault zone has long been a major source of contention among workers in the Precambrian geology of Arizona. This feature has been variously described as a "fault zone," a growth fault, and simply as a zone of facies change. Of exploration significance is the fact that at least one fuchsite-bearing horizon containing gold mineralization is known to exist within, or near to, the Shylock area.

Interesting single point anomalies exist at several localities within the Prescott sheet. These include:

1. The large (12 ppm) antimony anomaly that appears to correspond with the Orizaba mine (Cu-Au-Ag) in the New River Mountains (located in the extreme southeast corner of the Prescott sheet). The Orizaba mine, which is not described under any district in this report, occurs in Yavapai Schist, near or at the contact between a metamafic volcanic sequence and a metavolcaniclastic sequence. The deposit is described as irregular mineralization in a shear zone that can be traced for at least 4,500 ft and which ranges up to 40 ft in width (cf. CRIB data). CRIB data indicates that in 1948, the property contained 90,000 tons of proven/probable ore reserves that ran 6% Cu and $2-$3/ton Au-Ag. Anderson and Guilbert (1979) suggest that the mineralization is distal sulfide facies iron formation.

2. A greater than 17 ppm silver anomaly occurs on the east side of Grayback Mountain (central part of Prescott sheet) in the general vicinity of where a ENE-trending dike swarm intersects a WNW-trending zone of faults. Bedrock is Precambrian granite and no CRIB or MILS occurrences exist in the area.

3. Two substantial mercury anomalies (2 ppm) occur near Tertiary volcanic rocks in the west-central part of the sheet. One anomaly is found just west of the Greenwood district, while the other occurs on the south flank of Arrastra Mountain. A large number of mid to late Tertiary volcanic plugs occur in the general Arrastra Mountain vicinity and the volcanic rocks near the anomaly appear to be part of a major volcanic field that has been recently studied by Brooks (1982).

5. Salton Sea Sheet

The Salton Sea sheet is the only portion of the project area where both gold and several of the pathfinder elements were analyzed for by the DOE. Many anomalies occur within and draining the Dome Rock, Northern and Southern Plomosa districts. The southern portion of the Dome Rock district in particular displays an impressive number of gold, silver and arsenic anomalies. The Jurassic volcanic rocks and Mesozoic sediments in this area appear to be the source of many of these anomalies. This area has numerous gold shows as well as at least three mercury occurrences. This area has also produced much placer gold. This should certainly be an area of high interest.

Several anomalies of gold, silver and selenium occur in an area of thrust faulted Mesozoic sediments in the Southern Plomosa district. This area may warrant consideration for mineralization in the thrust faults similar to the setting in the nearby Little Harquahala district. In this same general area a gold anomaly occurs just south of the district in Mesozoic sediments, also in the vicinity of a small thrust fault.

A single point gold-silver anomaly draining upper-plate Tertiary sediments in the central part of Northern Plomosa district is interesting in that it may indicate that parts of the detachment surface may be mineralized in the Plomosa Mountains.

Gold and arsenic anomalies occur near dike swarms cutting mid-Tertiary felsic volcanic rocks west of the Kofa district. These anomalies lie just within the Kofa Wildlife Refuge, but may indicate that contiguous volcanic rocks along the edge of the game preserve may possess settings favorable for mineralization.

6. Phoenix Sheet

As in the Needles sheet, gold was the only element of those we chose to plot, that was analyzed for the Phoenix sheet. Most of the anomalies appear to correspond with known clusters of occurrences or mining districts. Some appear far out into the alluvial valleys and may be spurious.

Interesting anomalies that cannot be readily explained by known mines include the following:

1. The gold anomaly in the western part of the Webb district occurs in Tertiary volcanic rocks near a series of NW-elongate intrusions. Although no occurrences are known in this area, it would appear to be a favorable environment for precious metal mineralization.

2. At first glance the anomaly in the Rainbow Valley in the southeast corner of the Phoenix sheet appears to be spurious. Interestingly, however, a

MILS occurrence (the Bosley Gold property) closely coincides with this anomaly. Although we don't know of any outcrop, there could easily be shallow pediment covered bedrock in this area. The area also projects on line with a major strand of the Texas Lineament that crosses the southern part of the Sierra Estrella Mountains.

3. A single point gold anomaly occurs along the southern edge of the Palo Verde Mountains. While we have "included" this range as younger Tertiary volcanic rocks (Tym) on our geologic map, they may only be a thin veneer to older mineralized rocks.

4. The anomaly in the southern part of the White Tank Mountains occurs within a strong NW-trending structural zone that has been intensely intruded by a mid-Tertiary dike swarm. The White Tanks are of interest as they are believed to be a metamorphic core complex. The small, scattered occurrences located along the southern and western margin of the range may indicate that this poorly studied range deserves a closer examination.

5. Although little gold mineralization has been found in the Eagle Tail Mountains, it possesses many similarities found in nearby productive districts and appears to be a favorable area for exploration. Thus, the gold anomaly that occurs in the extreme northwestern portion of the range in volcanic rocks cut by dikes would seem to merit examination.

6. The large single point anomaly in the Nottbusch area of the Gila Bend Mountains district occurs in a highly faulted area of mid-Tertiary volcanic rocks. This area contains a number of scattered occurrences, but represents a remote, poorly explored region overall. The anomaly is probably worthy of some ground investigation.

7. The anomalies east of the Bouse district appear to be related to dike swarms. The one in the Mesozoic metamorphic rocks may be of interest as the trace of the Hercules thrust projects somewhere through this area (Steve Reynolds, personal commun., 1985).

EXPLORATION TARGET DELINEATION

Introduction

Whereas south-central and southeastern Arizona has been known as a famous copper-bearing region noted for its large porphyry copper deposits, western Arizona is fundamentally a precious metals province noted particularly for gold (Keith and others, 1983a). The principal counties included in our project area (Mohave, La Paz, Yuma, Yavapai and Maricopa) have produced over 6,580,000 ounces of gold or nearly 50% of the state's production (Keith and others, 1983a).

Practically on the outskirts of Yuma, Arizona across the Colorado River in California, some of the most important gold resources in western North America have recently become delineated. Between Goldfield's Mesquite discovery, Newmont's orebodies in the Cargo Muchacho Mountains, and the Picacho deposit in the southern Chocolate Mountains, this resource could be as great as 13 to 14 million ounces of gold, depending largely on the cumulative size of the Mesquite orebodies.

Despite its proximity to these deposits and others in the Mojave province, western Arizona has been the site of only one important recent discovery. This is the Copperstone gold-copper deposit of Cyprus-Amoco near Parker, Arizona (Moon Mountains district). Considering the abundances of gold-silver occurrences in western counties of Arizona and the highly similar geology between the Mojave and Sonoran provinces, it seems obvious that Arizona will

yield more discoveries with continued exploration. The results of our study would certainly underscore this optimism and hopefully they may even contribute toward this discovery.

The entire object of this regional project with its maps, overlays, listings and mine-district focus has been to place precious metals mineralization in western Arizona into deposit model categories, and then to systematically delineate those deposit types, areas, districts, and specific mines offering best opportunities for future orebody discovery. Toward this end we have prepared the best regional geologic compilation possible for the mineral province, integrated in metals occurrences and stream sediment geochemistry, and painstakingly and systematically sifted through published and unpublished descriptive data to arrive at a number of prospective target areas.

In other studies of this type, we have tailored our evaluations to targets of from a half million to one million ounces. We have not abandoned these parameters in this project, however, because of the rather diverse target criteria of subscriber companies, we have tried to be broader in our standards for establishing favorability. For example, even individual veins are described in our district and mine inventory if we feel they warrant attention because of unusual high grades, anomalous widths or other extenuating factors. It should be stressed that even though some particular districts are not emphasized as targets on Overlay 5, or so described in the section which follows, they may contain specific mines of special interest which should not be ignored. Some of these isolated occurrences are listed under a

miscellaneous heading, however, the reader is encouraged to read through all of the mines described to arrive at a better feeling of the great number of interesting mines that occur in the study area.

After compiling and "digesting" the extensive amount of regional and local geologic-metallogenic data for western Arizona, we feel that the main potential for the region falls within several distinct settings which occur repeatedly and hold greatest favorability for discovery of moderate sized precious metals deposits. These settings can be equated with our ore deposit models. Some are conventional, such as the volcanogenic (hot springs) model; others are somewhat unique and may hold greatest interest because of their lack of recognition. In the section below, the most favorable districts or areas are summarized under their appropriate geologic model by number and letter. This same number-letter target designation appears on Overlay 5. Please note that a few districts possessing highly attractive geologic credentials are not prioritized because of their untenable location in military reserves or withdrawn areas.

Description

1. Detachment Faults

Although detachment fault mineralization is a relatively new concept in exploration, it has received concerted attention during the past year or two, largely due to the feeling expressed by some that the Mesquite, Cargo Muchaco and Picacho deposits are detachment controlled. We have not subscribed totally to

this idea for these particular orebodies, but nevertheless, have advertised the mid- to late-Tertiary detachment setting as regionally favorable for precious metals. In our discussion of deposit models, we have separated metamorphic core complex detachments from those not associated with mylonitic lower plates. We have also alluded to upper-plate environments for mineralization at some distance above MCC-related detachment faults. Generally our opinion is that some of the most favorable exploration potential lies with MCC-detachment terrains, because of tremendous fluid-metals systems which may have been generated as a result of ductile mylonitization in the lower plate. Precious metals may have been upgraded by intrusion of metals-source magmatic bodies into the brecciated detachment zones.

If for the sake of argument, we exclude the large deposits of Imperial County, California from this model, it becomes rapidly evident that most bonafide detachment occurrences are small; hardly considered targets in today's world. Fortunately there are two exceptions. One is the Copperstone deposit with some 10 million tons of about 0.07 opt gold and unknown grade of copper. The second is the Copper Basin deposit in the Whipple detachment zone. Although principally of copper, this deposit contains some 30 to 50 million tons of 0.4 to 0.5% copper. It was emplaced in a 300 ft thick middle plate between detachment zones. Had the hydrothermal fluid source been carrying gold instead of copper, a major sized precious metals system would have evolved. These examples lend support to the idea that the right combination of geologic factors could lead to a sufficiently large body of copper-gold ore in the detachment environment. An entirely novel exploration strategy might capitalize

on combining a number of small, closely spaced occurrences into one economic operation. This idea will be expanded upon under the appropriate target areas described below.

a. Cienega district: Factors holding the greatest attraction for this district include: (1) consistent, rather high-grade cold content to the copper ore, (2) the close-spaced density of occurrences, (3) geologic descriptions which suggest that superimposed detachment and Mesozoic thrust faulting may have controlled mineralization, and (4) the upper-plate position of the ore host block above the Whipple Mountain detachment surface and its extremely factured and brecciated condition. Although mine descriptions are of insufficient detail to assess size potential to the occurrences, the environment appears favorable for development of ore extensions in existing properties or discovery of blind ore elsewhere. Offhand the Billy Mack mine group and Carnation deposits appear to be the most impressive. Mineralization at the Carnation seems to project beneath post-ore cover (Osborn Wash Fm.) and thus blind ore may exist there.

A totally new exploration approach to this district might be to consider acquisition of several or more of the best properties with an aim toward funneling multiple orebodies to one central, close-by leaching facility. Whereas individual deposits may be sub-sized economically, the accumulated reserves from several might be substantial.

Despite our high recommendation for this district, we realize that a substantial effort is required in the way of surface mapping, mine and prospect evaluation

and shrewd structural interpretation before its ultimate potential can be assessed.

b. Northern Plomosa District: The upper-plate geologic setting here is quite similar to that in the Cienega district and favorability factors are nearly identical, particularly the impressive gold contents (i.e. Blue Slate, Dutchman, Old Maid and Heart's Desire mines), close spacing of occurrences and location of mineralization above a possible thrust-detachment combination structure. Most of our impression of favorability arises from the numerous gold-copper-hematite occurrences at the north end of the district which lie just above the Plomosa fault. Of these, the Blue Slate and Little Butte mines seem most attractive, especially the structural complications and references to multiple veining, disseminated sulfides and areas of argillic alteration described at the Little Butte property. The Old Maid and Heart's Desire mines, both located in Section 13, T7N, R18W, produced gold ores >1 opt from brecciated structural zones which may be interconnected in some way and thus constitute parts of a larger deposit.

If the numerous small occurrences actually are in the upper plate of the Plomosa structure, and if the mineralization suite is detachment related, then one should consider the intersectional areas, where mineralized upper plate structures meet the main detachment fault, as being prime exploration targets. Without careful field evaluation, it is impossible to predict at what depths these intersections might occur.

As we have proposed for exploration in the Cienega district, there may be considerable merit in considering a multiple property approach to the closely clustered occurrences in the northern Plomosa district. Several deposits cumulating their ores to a central processing plant would be well suited to the distribution of mines in the target area.

c. East end of the Harquahala district: Although significant, well established detachment occurrences are few in the district, overburden may be masking mineralization localized along the detachment bounding the east and southeast flanks of the Harquahala Mountains. We particularly are intrigued by gold-copper mineralization at the Alaska and Rainbow properties, where fairly high-grade gold values were taken from low-angle quartz veinlets, veins and breccia zones possibly in near proximity to the actual Harquahala detachment fault which is covered by thin alluvial cover. The Alaska breccia zone may represent a lower plate detachment fault itself. Because of the general environment, a few interesting occurrences, and the extensive post-ore cover, we would recommend more work here as a grass roots target area.

d. Big Eye area-Castle Dome district: An interesting gold-copper occurrence at the Big Eye, Outlook and Lookout mines located three miles east of the main Castle Dome silver workings may be a detachment deposit. As described in the Mines of Interest section for the district, mineralization occupies the rather flat shear zone between tilted Tertiary volcanics and brecciated Mesozoic (?) metamorphic rocks. The zone is intruded by dikes and a small syenite stock.

e. Black Range Detachment Terranes: The Black Range underwent many profound volcanic, intrusive and structural changes during much of the middle to late Miocene period. This complex history is still to be unraveled. Longwell (1963), Anderson (1971) and Anderson and others (1972) describe much of this complex history. Of importance to the detachment model in this particular region is the eruption of the Mount Davis volcanics (Anderson, 1971) whose eruptive history spans about a 3 m.y. interval of late Miocene age (14.6-10.9 m.y.). This period of volcanism is important in that it coincided with a tectonic setting characterized by interrelated systems of "stacked" normal faults and transcurrent faults (Anderson and others, 1972). Many of the normal faults in the Black range are low-angle and possibly of detachment relationship. Anderson and others (1972) describe this profound extension as consisting of large-scale lateral movement of separately distended thin plates that have moved several miles past or over one another on the interrelated systems of low-angle and transcurrent faults. This "thin-skinned" east-west extension was accompanied by widespread shallow plutonism and epithermal mineralization. Many of these low-angle faults are detachment-like in character and display chaotically faulted and rotated volcanic and sedimentary units in their upper plates. In actuality, the entire Black range appears to be a gigantic upper-plate block with respect to the El Dorado-Dead Mountains MCC-terrane located directly west. It is possible that many of the detachment-like faults in the Black range represent upper or middle plate detachments that possibly sole into the El Dorado-Dead Mountains MCC detachment surface at depth. While detachment type faulting is not yet recognized in the southern part of the Black range, it becomes evident on the western side of the range in the

Union Pass district. Somewhat farther to the north, detachment-type faults occur along both sides of the central portion of the range. These faults apparently continue to discontinuously crop out all the way to the northern end of the range, at least on the eastern side. In places these faults have been important localizers for epithermal mineralization. Many of the important mines in the districts that occur in the central and northern portions of the range appear to be localized along these faults. Unlike much of the detachment-related mineralization in other parts of the study area, the mineralization in the Black range is gold-dominant with little or no attending copper or hematite.

While the entire range may be prospectable, we have delineated areas on Overlay 5 which correspond with known or presumed areas where these faults are exposed. These include: (1) the Union Pass district where low-angle faults host much low-grade gold mineralization. Anaconda has recently taken over a Fischer-Watt property that may be in a window of the El Dorado detachment surface. The small heap leach operation currently in production at the Frisco mine is also hosted by a flat fault. (2) In the Portland district, epithermal mineralization occurs along the low-angle (26°) NS striking, E dipping Portland fault zone. Western States Mining is currently producing from a 750,000 ton orebody grading 0.08 opt Au hosted by this structure at the old Portland mine. (3) In the Pilgrim district gold mineralization has been mined from a low-angle fault zone that strikes N30°W, dips 30°W and separates rhyolitic volcanic rocks in the hanging wall from andesite porphyry in the footwall. The fault zone is marked by a persistent streak of red gouge and brecciation of the walls that ranges up to 60 ft in thickness. Zones mined along this fault in the past were as

much as 22 ft wide. The Pilgrim mine has been the main producer in the district, but the entire length of the fault would seem to be worthy of exploration. (4) In the Virginia-Mocking Bird district, the Mocking Bird mine explored a nearly flat vein that has been described as occupying a local flow or a "flat-lying" dike that occurs at the contact between overlying volcanic rocks and Precambrian basement. Gold mineralization that was exploited in the past along this zone was finely divided and occurred with abundant hematite. Ore mined prior to 1908 averaged about $10/ton Au (@ $20/oz prices). The Golden Door and nearby properties in the Virginia mine area may also be of interest. Although we have no description of the nature of the mineralization in the mine, Schrader (1909) indicates that the mineralization is in volcanic rocks. These volcanic rocks are mapped as being in fault contact with Precambrian basement less than 0.5 mile to the east of the mine area. The distribution of tunnel symbols near the Golden Door mine on the Mt. Perkins topographic sheet suggests that the mineralization may have been fairly flat-lying. This possibility should be examined. (5) Low-angle faults in the El Dorado Pass-Gold Bug district have been mapped by Anderson (1978) and Wilkins (1984). These faults generally strike roughly NS and display dips of 10°-20°. The outcroppings of these faults suggest that a zone of detachment may extend for 6-10 miles in a NS direction in this area separately an upper plate of listricly rotated volcanic rocks from Precambrian and Cretaceous crystalline rocks. The fault zone is described as an undulating surface with brecciation in both the hanging and footwalls. Exploration along this zone has been recently focused at the Pope and Van Deeman mine areas. The Van Deeman property has apparently been recently acquired by Amselco. The Pope mine has

attempted to exploit high-angle brecciated veins and zones in the footwall of the low-angle fault.

f. Gold Basin district: Theodore and others (1982) have mapped a low-angle fault bordering the entire western margin of the White Hills. This fault separates Tertiary volcanic rocks from underlying Proterozoic basement. The Cyclopic mine is the only productive property that occurs within this fault. Mineralization at this mine, however, is believed to consist mainly of Cretaceous age vein material that was tectonically caught up and smeared out along the detachment fault (Theodore and others, 1982). Myers and Smith (1984a), however, have recognized a Tertiary mineralizing event at the Cyclopic mine that consists of sporadic, very low-grade gold mineralization and argillic alteration that was directly controlled by the detachment fault. Although this Tertiary mineralization as presently known is very weak, it nevertheless indicates that greater concentrations could exist elsewhere along this extensive detachment-like structure. This fault has been poorly studied and is often covered by post-mineral cover, making it an area for grass-roots study. Note that several NURE geochem anomalies occur along its projected trace.

g. Miscellaneous: In addition to the detachment districts we have highlighted above, there are several others which could hold deposits but these areas are not without certain encumbrances. For example, a number of occurrences in the Rawhide district, especially the Cleopatra or New England properties, appear interesting. They also are fairly close together and might be assessed in a collective fashion as suggested in the Cienega and northern Cienega

are relatively remote and very poorly known, they have probably received relatively little recent exploration. We believe they are worth checking out. In the White Picacho area we suggest the Golden Slipper, Fairview, and Young properties may be of interest (see district discussions); while in the Black Rock district, the O'Brien and MGM No. 1 properties sound interesting.

2. Lower Plate Microdiorite Dike Setting

The gold districts fitting this geologic setting are concentrated in the lower plate of the Harcuvar MCC. In all but one instance the deposits which appear spatially, at least, related to calc-alkalic, microdiorite dikes are also localized along low-dipping thrust zones in the lower plate of the Harcuvar complex. These target areas will be described under that deposit heading.

a. Cunningham Pass district: Normally a vein district of this type would not attract our attention. However, here, numerous veins are present with some widths reported in the 50 to 100 ft range. Also there is a sketchy and brief mention of a quartz porphyry closely related to mineralization in the district. Gold values from past ores, at least in the oxidized zone were $>$ 0.1 opt. There is also a 1950's consultant opinion that the area around the Horse Whim shaft possesses open-pit potential. The largest structure passing through the district, the Cunningham Pass fault zone may have potential which was never tested. In addition, a blind target may exist where the mineralized fault-vein-dike zone of NW-trend intersects the possible ENE-trending detachment surface flanking the Harcuvar foliation arch.

Many of the silver-rich deposits exploited in the past in the White Hills district are hosted by both low-angle and high-angle fault zones. In the White Hills district and nearby area, mid-Tertiary volcanic rocks are rotated and tilted (40°-50°) along a series of listric and low-angle normal faults (Wilkins, 1984). Many of the silver-rich veins exploited in the past in the White Hills district have been truncated by high-angle faults that are also productive and may have served as feeders. Although we do not know the exact nature of low-angle faulting in the White Hills district, Huskinson (1984) indicates that the mineralization occurs within the lower plate of a detachment zone (see district discussion). Most of the district may be presently tied up by Corval Resources, Ltd. In addition, the low price of silver makes this area of less interest than similar terranes that are gold-dominant.

Haxel and others (1984) have shown that late Cretaceous thrust faults in the Quijotoa district have been reactivated along middle Tertiary low-angle detachment-like faults. While we know of no mineralization occurring along these faults, epithermal mineralization cuts middle Tertiary volcanic rocks in thesouthern part of the district. A reconnaissance of prospects in the vicinity of these faults (see Plate 1, and Rytuba and others, 1977) may be in order. The main drawback would be that the land is all on thePapago reservation.

We have found several interesting mines in the White Picacho and Black Rock districts are hosted by low-angle structures. While we know of no detachment faults in this area, we can't be sure that none exist. Since these districts

In spite of the recent "plays" in the Little Harquahala district, we feel that it constitutes prime exploration ground. The over 140,000 ounces of gold production from the district makes it a relative giant when compared to neighboring areas such as the Harquahala (2,450 oz), Cunningham Pass (4,000 oz) and Ellsworth (2,400 oz) districts. In addition to the Golden Eagle fault zone, there is the Hercules thrust exposed in the area. Perhaps a particularly observant job of mapping in the region would delineate cross structures or dike zones, which if intersecting the flat structures, would make suitable target zones. We feel the newly recognized Jurassic volcanics and plutonic rocks exposed in the district further enhances favorability as we suggest it also does in the Dome Rock Mountains (see discussion under Mesozoic Stratiform targets).

Finally there are scattered areas of alteration adjacent to Harquar Peak and through the Sore Fingers crystalline complex (Jurassic) which may be gold bearing and attributable to magmatic sources.

b. Harquahala district: The Harquahala Mountains display the most impressive array of thrust faults in Arizona. Some of the thrusts host mineral deposits which have not yielded great historical production but which are sufficient in number to attract our attention. Many of the precious metals localities appear associated with the Golden Eagle thrust, the same (?) structure which is so well mineralization in the Little Harquahala Mountains. Prominent among these occurrences is the Socorro mine where a 100,000 to 200,000 ton underground reserve (0.05 to 0.1 opt) may exist and an interesting

but speculative, larger subsurface target is predicated. The Hidden Treasure, Why Not, Clipper and Gold mine group properties also appear worth checking.

The San Marcos group of workings appears of particular interest because of the stacked zones of mineralized, shears and mylonitic thrusts carrying 1/2 to 2 opt gold values. This structural zone could be equivalent to the Golden Eagle structure as it is mapped north from the Socorro mine (S. Keith, personal commun., 1985).

The Hercules and adjacent mines are of interest because of their upper plate position close to the main Hercules thrust. Gold-quartz mineralization in complex fault-brecciated zones in the upper plate may indicate leakage from larger deposits localized along the main structure.

Many of the thrust-type deposits in this district appear related genetically with syn-mineral, microdiorite dikes which invade NW-trending fault zones cutting the thrusts. A careful mapping of the district, mindful of these igneous and structural controls, may lead to further discoveries or to a more instructive assessment of known occurrences.

c. Southern Plomosa district: Numerous mines of interest in this district appear located along or near thrust faults, commonly separating Paleozoic-Mesozoic supracrustal rocks from Precambrian crystalline rocks. Grades in gold were generally high (>0.3 opt) and some properties such as the Gold Nugget, Iron Queen-Copper Prince may contain more potential for moderately

sized tonnages. The presence of Jurassic metasedimentary and metavolcanic lithologies, possibly inherently high in gold, adds further to the favorability of the district.

4. Mesozoic Stratiform Model

The concept we offer in this report regarding a syngenetic metallization model is not found in the literature of Arizonan ore deposits. The model took seed in our minds largely through field examinations of certain precious metals deposits in the eastern Mojave province of California. The idea developed as we began to see correlatives in western Arizona. Basically, the concept recognizes certain stratigraphic horizons within a thick continentally derived, tectonic-volcanic-associated sedimentary pile, which appear to represent exalative or hydrothermally leached deposits containing anomalous metals and exotic boron-fluorine-Al_2O_3-rich mineral assemblages. Metamorphism and thrust faulting seem closely integrated with these primary or stratiform features, but the specific interrelationship between syngenesis, metamorphism, deformation and even intrusion are not as yet clearly defined.

There are in the study region extensive terrains where the appropriate Mesozoic stratigraphic sections are present either in pristine or metamorphosed conditions. These rocks appear inherently anomalous in gold occurrences and we believe this primary concentration to be largely responsible for making western Arizona a precious metals province. The superposition by subsequent tectonic events, even mid-Tertiary ductile and brittle extension, on initially high gold-bearing rocks has probably led to subsequent redistribution or concentration of precious metals.

Several districts in the project area exhibit evidence indicating they contain deposits representative of this complex Mesozoic metals model. We doubt whether our ideas regarding the model have gained much recognition within the exploration community, so if we are correct, new exploration guidelines are offered which may become of significant practical value.

a. Ellsworth district: Known occurrences of stratiform alteration and mineralization occur in the district. These localities appear in Mesozoic volcanic (?), arenaceous, sedimentary rocks which have suffered upper greenschist to lower amphibolite facies metamorphism. A number of the occurrences are found directly below the Hercules thrust fault, and this deep-level, major tectonic feature may have some fundamental relationship with both metamorphism and the stratiform zones.

Some of the areas in question are sites of mines or prospects (i.e. Calcite mine, Glory Hole mine (?)), with anomalous tungsten and gold (with and without copper) geochemistry. The Yuma mine and surrounding area has some characteristics of the stratiform model, however, the locality may also represent skarn or metamorphic mineralization preferentially along a reactive zone of Paleozoic rocks tectonically emplaced along a major thrust. Either way, we would flag the Yuma mine area as a first class prospect, worthy of immediate follow up.

There are other localities where the alumino-silicate, stratigraphic zones are noted for the occurrence of unusual minerals such as kyanite, dumortierite, tourmaline, but where they apparently have not been prospected for metals. The

foremost example has only quite recently been recognized on both east and west slopes of Peak 3432 about 1½ mi WSW of Salome Peak. The altered rocks resemble felsic volcanic rocks and they are found just beneath the Hercules thrust with upper plate Precambrian dioritic gneissic rocks atop the peak. Curiously, the horizon on Peak 3432 is not far removed stratigraphically from the interval which hosts the Yuma mine only a mile or so distant to the northwest. We heartily recommend this whole area be carefully prospected. In addition, several other mines of interest in the Granite Wash Mountains, which yielded rather high-grade gold ores should be field checked (see District-Focus section).

b. Dome Rock district: In many ways we see the stratigraphic-plutonic assemblages of the Dome Rock Mountains as perhaps most favorable for the Mesozoic mineralization model we are proposing. To promote the readers further interest, the quantity of metal occurrences, placer deposits and NURE geochemical anomalies should be noted. Any terrain which produces placers resulting in over 100,000 ounces of gold warrants careful inspection. The gold productivity which is credited to certain Mesozoic metasedimentary or especially metavolcanic rock units hints at some sort of syngenetic cause. The mention of known areas of alumino-silicate alteration with kyanite, andalucite, etc. in the Mesozoic rocks further suggests stratiform relationships as those documented in the Ellsworth district.

We view the Dome Rock district generally as a setting remarkably similar to the very productive Cargo Muchacho district in southeastern California. The equitable features consist of: (1) Mesozoic metasedimentary and metavolcanic

assemblages, (2) alumino-silicate lithologies correlatable with the Vitrifax Formation in the Cargo Muchachos, (3) a major Jurassic plutonic center, and (4) thrust faults. It seems likely that the right combination of geologic factors would have come together in the Dome Rock region to form gold deposits comparable to those presently delineated in California. We have flagged the Darling, Marquitta properties and Copper Bottom, Yellow Dog and Yum Yuma mine areas as places to begin evaluations with the Mesozoic stratiform model in mind. There is, however, a great deal of grass roots surveillance which should be expedited throughout the overall district, especially along the margins of the Middle Camp pluton, paying particular attention to thrust structures.

Although the Cinnabar area at the south end of the district sounds quite interesting, its position within the Military range precludes its from consideration as an exploration target area.

c. Southern Plomosa district: Both the Bright Star and Livingston mine areas have been suggested as possessing Mesozoic stratiform characteristics (see Mines of Interest - Southern Plomosa district). Both areas are tungsten-gold bearing and the Livingston mineralized stratigraphy appears underlain by a volcanic(?) quartz porphyry which should stir some interest. These localities should be field checked as soon as possible.

The numerous thrust structures and likely presence of Jurassic plutonism (Miller's "qmp" and "qp" units) give favorable analogies between the Plomosa and Cargo Muchacho area in California. Furthermore, the numerous but small gold

placer deposits at the west margin of the district appear to draw attention to the "pGv" unit (metavolcanic tuffs and flows) as hosting gold. We would suggest that this unit is Mesozoic in age and may contain syngenetic metalliferous intervals.

At the south end of the Northern Plomosa district the Excelsior mine appears to have some properties of the Mesozoic stratiform model. It also, however, may be a skarn zone developed in a thrust slice of Paleozoic carbonate rocks drug into the deformed Mesozoic section.

d. Midway district: There are two occurrences in this area which are suggestive of Mesozoic, syngenetic mineralization. These are the Battleship and Arizona Midway mines (see Mines of Interest section). At these localities, copper, silver and minor (?) gold occur in black, phyllitic schists, quartzite and carbonate bedded intervals in Mesozoic metasediments. The setting of the area is quite similar to that in the Ellsworth district, and it should be investigated.

e. Gila City district: The Gila City district occurs where substantial placer gold deposits have been produced from erosion of a thick section of Mesozoic-metamorphic rocks. These rocks form an EW-trending belt several miles long by about 1 mile wide at the northern end of the Gila Mountains. Within this belt occurs a sequence of black schists that are conformably overlain by an unusual marble-bearing schist that in places obtains a thickness of 150 ft. Although some contact metamorphic minerals occur in the marble, Wilson (1933) believed that regional metamorphism of a calcareous protolith was responsible

for the recrystallization of these rocks. Spotty tungsten mineralization occurs in the unit and the entire metamorphic package has been cut by numerous pegmatitic to granitic dikes. A small outlier of the Gunnery Range batholith intrudes the southern margin of the belt. The source of the gold in the placers was believed to be from erosion of numerous low-grade and pockety gold-quartz veins in the Mesozoic metamorphic rocks. The only veins that were historically prospected occur in the black schist unit and consist of irregular and lensing quartz veins that contain spotty oxidized copper shows and gold. We feel these rocks may also display stratiform characteristics but have no concrete evidence to affirm the opinion. This district appears to be one of the few areas in extreme southwestern Arizona containing these rocks which does not lie within a Military withdrawal area.

f. Silver and northern Trigo areas: Mesozoic metamorphic rocks that occur in several large, scattered blocks along the western flank of the Trigo Mountains also appear to display characteristics that imply the presence of stratiform mineralization. Wilson (1933) noted quartzose schist boulders containing dumortierite and some kyanite in Colorado River terrace gravels downstream from the site of dip. These rocks closely resemble Mesozoic rocks containing stratiform gold mineralization in southeastern California. It is therefore possible that the source for the boulders might be the large outcrops of similar Mesozoic rocks exposed along the western flanks of the Trigo Mountains.

Parker (1966) studied the Mesozoic rocks in the southern part of the range and noted that they consist mainly of schists, gneisses, phyllites, argillites and gneissic granite of greenschist metamorphic grade. Within the package of schists he recognized among others, quartz-mica-feldspar schists; banded, carbonaceous, calc-schists; and quartz-fuchsite schist. Some of the schistose rocks reportedly contained chromite and suggest that ultramafic volcanic rocks may make up part of the protolith.

While only few metal occurrences are found in these rocks, some placer gold was taken from the alluvium on the western side of the range in the Paradise Valley area. In addition the unusual mineralogy displayed by some of the schist units should be noted. In all, these subtle indications may warrant some reconnaissance investigations for stratiform-type mineralization.

g. Miscellaneous Areas: Finally we draw attention to two other occurrences of Mesozoic metamorphic rocks that may also warrant additional field checking in light of the stratiform model. These are the Cementery Ridge area in the western portion of the Eagle Tail district and the outcrop of Mesozoic rocks occurring in the extreme southeastern part of the Tank Mountains district. While we cannot identify these areas as high priority, so little is known about them that we feel reconnaissance, with this model in mind, might be considered.

The Cementery Ridge area is underlain by a large NW-SE trending block of Mesozoic schists and gneisses. In places these rocks have intruded NW-trending rhyolite dikes and plugs, and Wilson (1933) notes that granite intrudes the

schist on the western margin. This area is remote and has received little modern prospecting. Mineral occurrences, while sparse, consist of weak copper mineralization with minor gold and silver that occurs with Fe and Mn oxides, quartz and gouge in fractures and faults cutting the gneisses and schist. Wilson also noted brittle, asbestiform actinolite in lensing veins in Mesozoic schist associated with veinlets and masses of magnetite east of Deadman Tank.

Spotty gold occurrences and minor placer deposits are hosted by a package of Mesozoic schists in the eastern Tank Mountains. In the Puzzles mine (Sec. 7, T4S, R13W), gold-quartz veins are apparently conformable with the enclosing chlorite schists. Ferruginous calcite veinlets occur alongside the vein in parallel fractures. A short distance southwest, the schist is said to contain gold-bearing iron-stained quartz stringers. Nearby prospects (Regal property) are also hosted in silicified biotite schist.

5. Hot Springs Deposits of Volcanic-Related Origin

While western Arizona has not been noted for this deposit type, several mines occur within the project area which display characteristics typical of having formed in a volcanic-related hot springs environment. Several additional areas would appear to hold some potential for hosting undiscovered deposits of this type. In an area like Arizona, where outcrop exposure is good and vegetation cover is minimal, utilization of a light plane to fly over prospective terrane looking for obvious areas of argillic bleaching, iron-staining and/or silification would greatly facilitate a rapid reconnaissance of these kinds of areas.

Ground follow up could then be schedule on those areas which display favorable color anomalies.

Another technique might be the use of Landsat imagery. Since these deposits are often accompanied by introduction of large amounts of pyrite in the mineralized core and within the surrounding wallrocks, subsequent oxidation lends to the formation of secondary iron oxides. Raines and others (1985) have shown that there are infrared spectral differences between true gossans associated with massive sulfide deposits and false gossans. It seems likely that some of this technology could be useful for determining pyritic systems associated with hot spring systems as well. This technology should be investigated.

a. Resolution (Sheep Tanks) mine: (NE¼ Sec. 1, T1S, R15W) Past production amounted to about 20,000 oz Au and 39,000 oz Ag. Mineralization occurs in a low-angle fault zone cutting mid-Tertiary volcanic rocks. Wallrocks are largely altered to fine-grained quartz and hematite over a wide zone which in turn is surrounded by a broad zone of quartz sericite alteration in the volcanic rocks. The mineralized area is said to have NS and EW horizontal dimensions of 800 by 700 ft, respectively. In places mineable ore along this zone was 40 ft thick. Old reports indicate that considerable low-grade material may remain in and around the mine area. One 1947 report estimated that 720,000 tons of $8.00 per ton ore remained in Resolution Hill above the old workings. This report went on to state that within the mining area there was an estimated 10-15 million tons of possible ore that would probably run around $5 per ton gold and silver. All values were figured at $35 gold and $0.77 silver.

b. Eastern Vulture district - Western White Picacho district: (Newsboy mine and Charbonneau clay deposit) Rhyolitic domes, flows and associated laharic breccias occur in the eastern part of the Vulture district. These rocks have been considerably altered. Large areas of alunite, kaolinite and silicification are in places associated with the rhyolite domes. Precious metals sometimes occur with the silificiation. At the Newsboy mine a mineralized zone 85 to 200 ft wide displays low-grade, manganiferous, gold-silver mineralization along strike for several hundred feet. The zone may extend for as much as 1,000 ft along strike. Between 1940 and 1942, the deposit was mined by an open cut and over 11,000 tons of ore were shipped which averaged 0.0683 opt Au and 8.07 opt Ag. Lately the property has been explored by a number of small Canadian companies that have drilled out a small low-grade reserve. The area could have much greater potential. Nearby and adjacent areas display kaolinitic alteration and silification associated with a rhyolite dome.

The rhyolitic domes and associated rocks appear to extend east of Morristown into the western part of the White Picacho district. Other mines such as the El Tigre - El Milagro group should also be examined for possibly containing this type of mineralization (see Vulture district discussion). The area should be given a thorough reconnaissance, with particular attention given to mapping the volcanic stratigraphy in this region. A low altitude aerial reconnaissance would probably be useful. Stream sediment geochemistry over the volcanic field might also be worthwhile.

c. Papago mine (Cimarron Hills district): Mineralization occurs in a 40-150 ft wide shear zone that is exposed on the surface for over one mile.

Host rock is a coarse-grained granite. The mineralization is epithermal in character and consists of silicified, sheared and brecciated granite cut by numerous later veinlets of manganese and iron-stained calcite. Gold is apparently very fine-grained and disseminated across the mineralized zone. The property was actively explored between 1926-34 and much low-grade, gold-silver mineralization across an average width of 48 ft was proven, and large amounts of similarly mineralized rock was indicated. There is no mention that any of the material was ever mined; it was probably too low-grade for the period. The property lies on the Papago reservation. It is not known whether the claims were ever patented. The nearby Greenback mine should also be examined as it displays characteristics similar to the Papago mine.

d. Castle Creek district: A large part of the Castle Creek district is covered by the Castle Hot Spring volcanic field (Ward, 1977), which produced a large pile of felsic to mafic volcanic flows, tuffs and breccias. Local extrusive-intrusive dome complexes and vents are scattered across the field and sometimes are accompanied by widespread argillic and sulfataric alteration. Formation of the field is believed to be roughly contemporaneous with the rhyolitic volcanism and associated mineralization found in the nearby Morristown-Wickenburg area (eastern Vulture district). Numerous prospect pits occur in severely altered volcanic rocks in the Bitter Creek area (Secs. 1, 2, 11, 12, T7N, R2W). In Garfias Wash near Cedar Basin the volcanic rocks display much clay alteration and contain disseminated pyrite. Fountain-like deposits of opaline silica and chalcedony occur on Hells Gate Mountain, a volcanic vent area. Volcanic rocks in the Buckhorn Mountains also display hydrothermal alteration and contain disseminated sulfides in places. This area would also probably benefit from low altitude aerial reconnaissance.

e. New Water-Alamo Springs-Sheep Tanks Districts and Lineament: We have chosen to apply this name to the contiguous NW-striking zone of WNW-trending faults which pass through these mining districts. This zone has cut through mid-Tertiary volcanic rocks in this area. Similar trending dike swarms associated with this volcanism indicate that this zone both pre- and post-dates the volcanic activity. We feel that it probably represents a strand of the Precambrian Texas Lineament. Mineralization in these districts is epithermal in character and appears to be associated with centers of volcanism and subvolcanic intrusion. We feel that the magnitude of this shear zone is such that many structurally favorable areas have been produced along its trend. If some of these have localized subvolcanic intrusive activity, hydrothermal cells may have developed and produced low-grade, bulk tonnage epithermal deposits. See the district discussions for mines of interest that occur along the zone. We would suggest that ground open for mineral entry along this belt be given field reconnaissance accompanied by a regional geochemical program.

f. Big Horn-Osborne districts: The Big Horn-Osborne districts are covered by an extensive mid-Tertiary volcanic cover that is very poorly known. Numerous dikes and shallow intrusions cut these rocks and are associated with epithermal mineralization in both districts. Substantial low-grade gold mineralization is associated with an elongate, felsic vent or dike zone at the U.S. (General Grant) mine in the Big Horn district. Likewise, substantial high-grade, gold-rich polymetallic replacement mineralization occurs within a circular subvolcanic intrusion at the Tonopah-Belmont mine in the Osborne district. Recent exploration by a small Canadian company of geochemical anomalies associated with silificiation, alunitization and propylitization along a contact area

between andesite and schist (?), reportedly produced assays averaging 0.075 opt Au across a 45 ft width. These districts are so poorly known that other undiscovered areas of silification and low-grade mineralization could exist. This is certainly an area where aerial reconnaissance is recommended.

g. Kofa district: The Kofa district has been a substantial past producer of precious metals from epithermal vein deposits. Of interest is Hankin's (1984) description of an exotic volcanic breccia that lies near the King of Arizona mine. This breccia is believed to overlie a major vent zone. Alteration of this area is extensive. While it would seem likely that this area has been checked, it may be a favorable setting for a low-grade, disseminated deposit to be developed. Another favorable zone in this district is the complex anastomizing
fault system that separates the Mesozoic schists on the south from the volcanic pile to the north. This fault zone probably represents some type of major volcanotectonic bounding fault and would be an ideal zone along which to localize low-grade mineralization. Although old claims in the district are still valid, most of this area is believed to be withdrawn from new mineral entry, thus making delineation of grass roots targets nearly impossible.

h. Boulder Creek property, McConnico district: The age of mineralization is unknown, but mid-Tertiary volcanic rocks nearly encircle the district and suggest that the mineralization could be of a similar age. Boulder Creek mineralization occurs in two intersecting mineralized zones which have widths of as much as 1,000 ft. These zones contain badly sheared, pegmatitic granite that is brightly hematite-stained and which in places is "honeycombed" by

boxworks after pyrite. High, but sporadic gold values occur in both of these wide shear (?) zones. This mineralized zone would appear to have "room" for a substantial tonnage of low-grade material. The nearby Bi-Metal mine appears to be of similar character and should be examined as well. It has produced at least $70,000 worth of gold in the past.

i. Miscellaneous areas: Among the various districts certain other areas display features that might indicate disseminated mineralization of this model type. Although interesting, the potential in these areas remain an "unknown" quantity.

Longwell (1936) mapped a zone of intense alteration directly west of Fortification Hill in the Minnesota district that was characterized by intense argillic alteration containing specular hematite and epidote. He believed the area had been a principal center of hydrothermal activity. This district has produced some gold from unknown mines. Very little is known about this area.

Volcanic rocks north of the Eureka-Bagdad district display considerable NURE stream sediment geochem anomalies. These volcanic rocks appear to lie adjacent to a major NE-trending zone of faulting that continues on through the Eureka district to the south. Anderson and others (1955) state that north of Bagdad, volcanic tuffs interbedded with Gila (?) conglomerate were often altered to clay. In places the tuff has been replaced by cavernous white opal. Near Bozarth Mesa, tuff is completely replaced by black opal resembling obsidian. While this alteration and silification may be diagenetic, it could also be related to hot spring activity.

Although we have no CRIB-MILS data points located within the volcanic rocks covering the southern portion of the Black Range, mine symbols occur on the AMS sheet and several low-level, NURE gold anomalies appear in sediments draining the area. The region is cut by an extensive set of WNW faulting which we see as being mineral controlling elsewhere. These features suggest that some potential may exist for low-grade epithermal mineralization to occur in the area. This potential would be greatly enhanced if numerous dikes or subvolcanic intrusions could be documented as occurring along this zone.

Finally, mid-Tertiary volcanic rocks in the Eagle Tail, Gila Bend Mountains and Webb districts display complex faulting and intrusion by dike swarms and sub-volcanic bodies. While none of these districts have very productive in the past, they display a geologic setting that would appear to be somewhat favorable for hosting hot spring type mineralization. For example, one particularly new prospect called the Pumkin Glow (West end of Webb district) has attracted our attention because of substantial widths and strike length to a silver-gold bearing breccia zone of WNW-strike. While we can't give these overall areas the highest priority, they are so poorly known that low-grade mineralization in the past may have escaped attention within them.

6. Vincent-Chocolate Mountains Allochthon

As a result of our Mojave metallogenic study (Wilson and others, 1983) we feel a newly recognized deposit type exists in southern California and adjoining southwestern Arizona. These deposits consist of stockwork and disseminated mineralization that displays a consistent relationship to brecciated and

cataclastic upper-plate rocks of the regionally extensive Vincent-Chocolate Mountains thrust. We feel that the Mesquite (Goldfields Co.), Picacho (Chemgold), Big Horn (Inspiration Mng.Co.), and Yellow Aster (Chemgold) deposits are examples of this type of mineralization. The deposits usually occur in or near the main thrust zone, commonly localized along semi-coincident zones that may have been reactivated or compounded by Tertiary extensional faulting. Gold and other metals are believed to be scavenged from the lower-plate Orocopia schist and remobilized into the thrust zone by hydrothermal circulation cells related to late Cretaceous and younger intrusive activity.

Lower-plate Orocopia schist crops out in a east-west string of four separate occurrences in southwestern Arizona. These are found in the southern Trigo Mountains, Middle Mountains, Castle Dome Mountains and Neversweat Ridge. A newly discovered occurrence in the eastern part of the Kofa Range by Gordon Haxel of the USGS (S. Reynolds, personal commun., 1985) attest to the fact the unrecognized areas of Orocopia schist and, thus the Vincent thrust, may exist elsewhere in the southern part of the state.

Scattered gold occurrences are found in and near outcrops of the Orocopia. Unfortunately, only the outcrop in the Eureka district (southern Trigo's) appears to be open to mineral entry. The other exposures all lie within the Yuma Proving Ground or Kofa Game Refuge.

a. Eureka (southern Trigo Mountains) district: A small portion of the Chocolate Mountains thrust is known to be exposed in the district. Small disperse gold occurrences have been prospected nearby. The area is complicated

by abundant Tertiary faulting. Pietenpol (1983) noted mineralized, low-angle faulting a short distance away in the Silver district. This suggests that the thrust zone may have been reactivated or compounded by Tertiary movement - a feature often times noted in areas where deposits have been discovered (i.e. Picacho, Rand and possibly Mesquite districts).

b. Other areas: Haxel's recent discovery of Orocopia schist in the Kofa Mountains indicates that the final word is not yet in on the distribution of the Vincent-Chocolate Mountains thrust. We would suggest field checking nearby areas of Mesozoic sediments and metamorphic rocks (units Ms and Mm on Plate 1) that occur both south and north of the presently known Orocopia outcrops.

7. Precambrian Lode Gold and Gold-rich Massive Sulfide Deposits

On a regional scale, stratiform lode gold mineralization often occurs at major stratigraphic interfaces separating dominantly clastic sedimentary sections from dominantly volcanic sections. For this reason we have tried to differentiate major compositional packages within the Yavapai Series on our geologic map based on the work on Donnelly and Hahn (1981). These packages are broken down into predominant rock compositions. These include sections that are predominantly epiclastic (consisting mainly of coarse- to fine-grained sediments and exhalites with minor volcanoclastics); sections that are predominantly subaqueous to subaerial felsic lavas and tuffs (including hypabyssal intrusions, some mafic tuffs and minor epiclastics); and sections that are dominated by mafic to intermediate composition lavas and tuffs. We would suggest that gold prospects and mines occurring along these compositional boundaries be prioritized during exploration.

Additionally, there is evidence that in the Proterozoic of Arizona, stratiform gold mineralization tends to be associated with greatly restricted, cherty, carbonate-rich exhalites associated with rhyolite dome complexes (E. DeWitt, personal commun., 1985; cf. Swan and others, 1981). For this reason relatively small exhalite lenses associated with rhyolite domes within any part of the section may be worth exploring. We also recommend examining the disseminated scheelite deposits in Yavapai schist that occur within several of the districts in the southern margin of the Bradshaw range (i.e. Castle Creek, White Picacho; see district discussions).

Besides traditional lithogeochemical and geophysical exploration techniques, footwall alteration and mineralogy may serve as important guides to stratiform mineralization. Such things as localized areas of Na-depletion and K-enrichment in rocks that are otherwise Na-enriched, and increased Ba content of white micas in the footwall section, are considered to be useful exploration tools. Mineralogy is also helpful. Areas or stratigraphic horizons that contain unusual B, Mn, Fe and Al_2O_3 minerals (i.e. tourmaline, pyrophyllite, diaspore, doumortierite, Mn-garnet, chloritoid, etc) and/or alumino-silicate minerals should also be noted. Typically these minerals have been considered to be high T or P indicators, but when occurring within terranes of greenschist or lower amphibolite metamorphic grades they are now commonly thought to mark areas of ascending hydrothermal fluids, aluminous alteration and subaqueous exhalations in a sea floor setting (cf. Valliant and others, 1983; Valliant and Barret, 1982; Stanton, 1984). These mineralogic assemblages thus may represent time-stratigraphic equivalents to associated pyritic gold or base metal massive sulfide deposits.

Several districts within the southern part of the Bradshaw range overlie large exposures of Yavapai schist. Gold mines and prospects in these areas are generally felt to be Tertiary or Laramide in age, but some have been described as Precambrian veins (i.e. Lindgren, 1926). We feel that there is a good chance that the ultimate source of the metals in many of these areas may indeed be from local, low-grade concentrations in the Precambrian. We suggest therefore that some of these areas are relatively poorly explored and may offer good opportunities for finding Precambrian lode or volcanogenic gold mineralization. We describe some of these areas below:

a. White Picacho district: This is mainly a placer district, but it has had some lode gold and tungsten production. Wilson (1961) notes that quartz veins of probably both Precambrian and Phanerozoic ages have furnished gold to the placers. Tungsten mineralization occurs in several areas in the schist and descriptions of them suggest to us that they may be exhalative in nature and hosted by carbonate-rich horizons in the schist. Many of these prospects occur in the San Domingo Wash area which is also where most of the placer gold has been found. Any possible relationship between the gold and the tungsten mineralization should be checked out. It should also be ascertained whether or not the scheelite deposits are indeed of an exhalative origin. See District Focus section for mines of interest.

b. Castle Creek district: The mineralization and geologic setting in the Castle Creek district is in many respects similar to the White Picacho district. Lindgren (1926) describes several types of lode gold deposits in the districts.

Veins containing tourmaline such as the one exploited at the Lehman mine were considered to be of Precambrian age. Descriptions of tungsten occurrences in the district sound like they could be exhalative in nature. These scheelite occurrences are hosted by banded, magnetic, dark-colored schist with banding composed of epidote, quartz and calcite. While no mention is made of any gold in the scheelite occurrences, we suggest that these occurrences should be checked to determine whether or not they are exhalative in character and contain gold. If they are exhalative, then the district should be examined on a wider scale to determine further potential for stratiform gold-tungsten mineralization.

c. Orizaba mine: (Sec. 29, T8N, R3E): The Orizaba mine and an unnamed nearby placer deposit occur along the contact between a predominantly felsic volcanoclastic protolith and a predominantly mafic volcanic protolith occurring in Yavapai schist. This deposit has been variously described as a mineralized shear zone and as a distal exhalative deposit containing gold-silver. CRIB data indicate that according to a 1948 report, this property had 90,000 tons of inferred reserves grading 6% Cu and $2-$3 per ton Au-Ag. This could be a gold-rich stratiform deposit and should be examined with this possibility in mind.

d. Black Canyon district: The Black Canyon district is hosted by Yavapai schist that straddles the Shylock fault zone. While controversy still surrounds the actual nature of the Shylock zone, some workers believe that it represents a major growth fault separating major lithologic provenances within the Precambrian protoliths. In this sense, it may be similar to major "breaks" in the

Canadian Shield along which many major gold deposits occur. Base-metal massive sulfides occur in the district and Lindgren (1926) claims that some of the gold-quartz veins are Precambrian as well. The Golden Belt mine which occurs within the district, but just to the north of our study area has been described both as a low-angle vein occurring along a flat thrust in Precambrian schist (i.e. Lindgren, 1926) and to a distal Au-rich exhalite (Anderson and Guilbert, 1979). Gold deposits in this district should be given careful examination for evidence of stratiform or remobilized natures. The Golden Belt mine should be examined in particular, as well as the adjoining and geologically similar Golden Turkey group. Several NURE geochem anomalies occur in the district as well.

e. French Gulch district: Base metal massive sulfide mineralization has been mined at the Zonia mine. Numerous gold deposits occur in a felsic volcanic and volcanoclastic package within the schist. Considerable placer gold of unknown source has been won from several gulches draining the Precambrian schists. We suggest this area be given a systematic evaluation in any exploration program looking for stratiform Proterozoic gold deposits.

f. Eureka-Bagdad area: The Eureka-Bagdad district displays a complex geologic-metallogenic history. Deposits range in age from Precambrian to Laramide to probably mid-Tertiary in age. Anderson and others (1955) separated the Precambrian schists in the area into three formations or packages that consisted of distinct lithologic character. Base- metal massive sulfide deposits (i.e. Bruce, Old Dick, Copper Queen) occur in the Briddle Formation, associated with masses of Precambrian rhyolite. Interestingly, nearly all of

the gold mines that occur near the town of Bagdad are (including the two largest producers) are hosted by the Hillside Mica Schist, which consists of an alternating sequence of muscovite schist, quartz-muscovite schist, muscovite quartzite, and some tourmaline schist. Sillimanite is present in some parts of the schist and Anderson and others (1955) suggest the protolith of the schist consisted of a series of shales, sandy shales and impure sandstone that accumulated in a basin after a considerable period of volcanic activity. The Hillside and Comstock-Dexter gold mines which occur in these schists are Au-Ag rich, polymetallic deposits, which are described in as being veins by Anderson and his co-workers. Near the veins, small veinlets of sulfide, with or without quartz, fill minor fractures in the schist, and in places were mineable by themselves. We wonder if these vein deposits might not reflect a heritage from the Precambrian protoliths. We feel the gold mineralization in the Hillside Mica Schist should be examined for "greenstone gold" deposit characteristics, some of which may be remobilized.

The Zanneropolis tungsten occurrence is also hosted by a biotite mica schist and may represent syngenetic mineralization in its protolith. Gulches cutting this long and wide area of schist were originally placered for gold.

g. Webb district: The Webb district is a poorly known and studied area in west-central Arizona. Precambrian Pinal (?) schist is exposed in the district and some of the mineralization displays characteristics compatible with a stratiform, exhalative origin. Recent drilling indicates that a considerable amount of gold may exist in parts of the district. Properties that should be

evaluated for Precambrian, or remobilized Precambrian, mineralization include the Black Butte and Buckeye mine properties. The principal host rock for the Buckeye mine is a magnetite-quartz muscovite schist with interbedded marble, calc-silicate rock and metarhyolite. Some of the schist is tourmaline-bearing. The mine was mainly a copper (with some Au) producer, but the potential for precious metals has not been ascertained.

At the Black Butte property, Precambrian gneiss and schist display considerable alteration and disperse copper-gold mineralization. Recent drilling by Rhyolite Resources encountered many mineralized zones assaying from a trace to 5.7 opt Au. The best mineralization was encountered along a steeply dipping structural zone that may be conformable to foliation in the metamorphic rocks. This zone ran from 0.03 to 0.54 opt Au over a 59 ft interval.

h. Gold Basin-Lost Basin districts: Several types of gold deposits occur in the area. Theodore and others (1982) feel that boron-enriched fluids of exhalative origin were probably important in the genesis of tourmaline-bearing schists exposed locally in the Precambrian terrane that underlies most of the district. Also of interest in this area is the description of thin beds of carbonate and calc-silicate rich units that are spatially associated with amphibolite that reflects a mafic to ultramafic protolith. Some of the calc-silicate marbles contain minerals such as garnet, zoisite and chloritoid. Metachert and metarhyolite units within gneissic terrane are also recognized. Several prospects in the Mines of Interest section appear worthy of examination.

i. Pine Grove-Tiger area: Here mineralization is mostly considered to be Laramide in age. However, many of the veins lie in schist and contain abundant siderite or ankerite gangue. Mineralization is also typically polymetallic in character. DeWitt (1976) describes a calcareous, tuffaceous, volcaniclastic sediment associated with pillowed basalt flows. The Gladiator mine occurs in this unit. Lindgren (1926) also described lenticular siderite, magnetite, pyrite, chalcopyrite mineralization in slate near the Fairview mine. We wonder if some of the carbonate and precious metals in the district may not in fact be coming from a remobilization of Precambrian source, rather than all from a Laramide pluton.

j. Miscellaneous other areas: We have made mention of possible Precambrian involvement in mineralization of several other districts under the District Focus section. These include the Vulture, Minnehaha, Winifred, Cottonwood and Gila Bend Mountains districts.

8. Miscellaneous Mines and Areas

While we have already drawn attention to many individual mines under the preceding model discussion, a number of other individual mines are worthy of attention for various different reasons (i.e. past production, structural preparation, wide widths of mineralization, etc.). Since these mines have been described under Mines of Interest in the District Focus section of the report, we will only briefly repeat them here. We highlight these properties simply as a means to draw your attention to the many interesting properties that are

contained in the District Focus section of the report. We strongly recommend a thorough reading of all the mines listed in the Mines of Interest sections. Only a very few of the many interesting properties are highlighted below. (The following list is in no particular order of priority.)

a. Dutch Flat subdistrict - Mohave Mountains district: Normally, metal occurrences in the Mohave Mountain district, which consist generally of individual, relatively small scale veins, would not be highlighted in this report. The Dutch Flat area, however, is noted for a variety of precious metal-base metal-tungsten veins all located in a relatively small area (±2 sq mi). The Kempf mine alone produced from five veins. Although few of the veins exceed 3 ft in width, many exhibit strike lengths greater than 1000 ft and yield gold assays > 0.2 opt. If all these vein deposits were considered collectively, perhaps a significant small ore reserve could be cumulated at least for leachable gold and silver. The collective strategy would, of course, be most suitable for the small- to moderate-sized mining company.

b. Swallow mine (see Castle Creek district): Wide Cu-Au-hematite veins cutting Precambrian granite. Ore ran 3 to 15 ft in width; averaging about 6 to 8 ft. High, but erratic gold mineralization. The first 1000 tons mined from deposit averaged about 3 opt Au.

c. Pacific mine (see Minnehaha district): Described as pyritic impregnation of hosting Precambrian schist containing low values of Cu, Au and Ag. May

be a massive sulfide occurrence. Deposit displays a leached gossan cap over some 3000 ft of length. This leached capping could hold some potential for low-grade, heap leachable gold ore.

d. Christmas Gift mine (see Vekol district): Produced 2500 oz Au from small replacement deposit in cherty dark gray limestone near contact with diorite porphyry dike. Several other diorite dikes occur nearby. These may hold potential for other small, but high-grade replacement deposits where they intersect favorable stratigraphy.

e. Oro Grande mine (see Black Rock district): Produced about 2300 oz Au from 8600 tons of ore in 1904. Mineralization occurs in fractured and brecciated zone up to 100 ft wide that is cut by irregular veinlets and stockworks of quartz. Reported to have had considerable low-grade ore left in the mine. May be a small to moderate bulk-mineable target.

f. Bennet mine (see White Picacho district): Gold mineralization occurs across an area 20 to 50 ft wide and is said to be traceable on the surface 2000 ft along strike. Gold values are said to run between 0.01 to 0.30 opt Au. May be a small low-grade target.

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