GEOLOGY AND PRODUCTION OF
MIDDLE TERTIARY
MINERAL DISTRICTS IN ARIZONA

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GEOLOGY AND PRODUCTION OF MIDDLE TERTIARY MINERAL DISTRICTS IN ARIZONA

INTRODUCTION

Areas of known metallic mineralization in Arizona, with recorded production, have been divided into 453 mineral districts, nearly 180 of which are known or suspected to be mid-Tertiary in age (Keith and others, 1983a,b). This report briefly describes the geology of mid-Tertiary mineral districts in Arizona that were considered by Keith and others (1983a,b) to be mid-Tertiary, and examines the basis of age determinations for each of them. This report is preliminary in nature, and Bureau-directed mapping and research continues in order to clarify the nature of mid-Tertiary metallogenesis.

Table 1 consists of summaries, based largely upon a review of the published literature, of the geology of mid-Tertiary mineral districts of Arizona. Only mineral districts with greater than 100 tons recorded production are included in the compilation. Following each mineral district name is a list of the metals produced, in order of decreasing value at the time of production. A brief description of the geology of each mineral district is provided and succeeded by a discussion of the data constraining the age of each district. Many of the districts designated as mid-Tertiary by Keith and others (1983a,b) are thought by us to be older, but are included for completeness. The essential references for each mineral district are also provided. The references are cited by number and listed alphabetically and numerically at the end of this report. Keith and others (1983b) provide a comprehensive list of references for all metallic mineral districts in the Basin and Range Province of Arizona. Many of these references are of limited value; therefore, we list only those most useful in compiling the basic geologic and geochronologic information. Figure 1 is a map showing all the mineral districts in Arizona of presumed middle Tertiary age. We have included districts of problematic age on the figure for completeness.

Table 2 is a list of mineral districts divided into lithotectonic associations. Our review suggests that most of the mid-Tertiary mineral districts may be separated into four groups; these include mineralization related to 1) volcano-plutonic complexes, 2) microdiorite dikes, 3) regional detachment faults, and 4) stratabound occurrences (see also Spencer and others, in press). The mineral districts in table 2 are listed in two categories, those mineral districts that are known to be or are probably associated with the listed lithotectonic element, and those thought to be possibly related to that lithotectonic element. The differences between known and possible associations are based on confidence in the data and on the amount of data available. The geologic setting of many of these mineral districts is still poorly known and the available published literature is often sparse. Figures 2, 3, and 4 show the mineral districts thought to be related to volcano-plutonic complexes, microdiorite dikes, and detachment faults, respectively.

Table 3 lists the present value of production from Arizona's middle Tertiary mineral districts. The Engineering and Mining Journal average 1983 price is used to calculate the present value figures. Copper, gold, silver, molybdenum, and uranium prices have experienced a steady and sometimes sharp decline since the time of this compilation, while the other metal prices have experienced modest gains in value. The decline in precious metal prices (nearly 30% and
50% for gold and silver respectively) result in inflated total value figures when compared to the current market place (as of January, 1985). The most striking result of this compilation is that the recorded gold and silver production accounts for 84% of the total present value of metals produced from middle Tertiary mineral districts, hence the current interest by exploration companies in this metallogenic epoch.

Table 4 lists the grade of Cu, Pb, Zn, Mo, Ag, and Au ore produced from mid-Tertiary mineral districts. The table does not include grades for Mn, U, V, and W production because such information is not consistently available. Only those mineral districts with total recorded production in excess of 100 tons are listed. The data are complied from U.S. Bureau of Mines mine statistics and are current to 1981.

The lithotectonic associations of table 2 and the grades listed in table 4 are merged to create table 5, which shows the average and weighted grade for each lithotectonic association. The average grades are arithmetic means of the individual district grades, and hence subject to bias by an anomalously high or low value. Weighted grades are calculated by summing the total production for each metal in ounces or pounds and dividing by the total ore produced for each lithotectonic association. The grades are calculated using only the known or probable lithotectonic associations.

Each lithotectonic group of districts is weakly characterized by a distinct set of grades, the statistical significance of which is currently under investigation. The volcano-plutonic complexes are characterized by the highest lead and silver values with correspondingly lower copper values. The microdiorite-related mineralization is highest in copper and gold, but low in lead and zinc. Detachment-fault-related mineralization is high in copper and lead values. The most impressive result of this analysis is that all three lithotectonic associations have average gold grades that could be profitably exploited under current market conditions.
Figure 1

Mid-Tertiary Mineral Districts in Arizona
## TABLE 1. GEOLOGIC DESCRIPTIONS OF MID-TERTIARY MINERAL DISTRICTS

### COCHISE COUNTY

**DISTRICT: APACHE PASS**

**PRODUCTION:** Au, Pb, Ag

**GEOLOGIC SETTING:** The Apache Pass District is located within a thick sequence of west-northwest-striking, southwest-dipping Paleozoic and Cretaceous sediments with a thick rhyolite and andesite sequence overlapping on the north. The orebodies are veins and replacement deposits. Minor barite and molybdenite occur in the district.

**AGE:** The date of Apache Pass mineralization is uncertain. Karl Tsuji (pers. comm., 1984) states the ore precedes the 34 m.y.B.P. old "Turkey Track" andesite. A possible period of mineralization, therefore, is an extensive 55.9 m.y.B.P. (Laramide) plutonic event.

**REFERENCES:** #18, #60, #64, #65, #100, #161, #185, #194

**DISTRICT: CALIFORNIA**

**PRODUCTION:** Pb, Zn, Ag

**GEOLOGIC SETTING:** The California District is underlain by a structurally complex sequence of Paleozoic and Cretaceous sediments that are capped in the center of the district by late Cretaceous andesites. West-northwest-striking thrust faults and north-northeast-striking normal faults are the dominant structures. Pipes, shoots, lenses, pockets, and chimneys are characteristic orebody morphologies. Galena, sphalerite, chalcopyrite, arsenopyrite, pyrite, cerussite, anglesite, wulfenite, scheelite, chrysocolla, azurite, malachite, native Cu, native Au, and native Ag are ore minerals. Gangue minerals include psilomelane, pyrolusite, garnet, epidote, chlorite, calcite, clinozoisite, quartz, wollastonite, gypsum, tremolite, and limonite. Silicification is extensive.

**AGE:** ABGMT file data associates mineralization in the California district with the Jhus Canyon pluton which yielded a 30 m.y.B.P. K-Ar biotite age (Shafiquallah and others, 1978). ABGMT file data states that the 28 m.y.-old Chiricahua volcanics overlie the mineralization.

**REFERENCES:** #18, #100, #185

**DISTRICT: MIDDLE PASS**

**PRODUCTION:** Zn, Cu, Ag, Pb, Au, Mo

**GEOLOGIC SETTING:** The Middle Pass district lies in the complexly faulted Paleozoic
and Cretaceous sediments of the Dragoon Mountains. Many of the north- and northwest-trending contacts are reverse or thrust faults. Extensive poorly mineralized outcrop of the 24 m.y.-old Stronghold Granite separates the well-mineralized northern and southern portions of the district. Northwest-trending rhyolite dikes are locally abundant. Another intrusive, possibly related to the 185 m.y. Gleeson quartz monzonite, crops out at a few widely spaced localities in the southern end of the district. The orebodies are skarns, mantos, and chimneys.

AGE: The general association of ore deposits with the extensively-outcropping Stronghold quartz monzonite is suggestive of a genetic relationship. The 24 m.y.-old age of the quartz monzonite is therefore suspected to be the age of mineralization.

REFERENCES: #18, #58, #59, #61, #76, #100, #126, #185

DISTRICT: PEARCE

PRODUCTION: Ag, Au, Cu, Pb

GEOLOGIC SETTING: The mineralization at Pearce is almost exclusively in the Pearce Volcanics which include andesite flows, quartz latite, rhyolite ash flows, tuffs, and epiclastic volcanics. The veins are along major normal faults and in subvertical sheeted zones. Native silver, acanthite, cerargyrite, embolite, and native gold are ore minerals. Quartz, calcite, and adularia are gangue. Potassic alteration is pervasive.

AGE: ABGMT file data gives a 28-30 m.y. K-Ar biotite age as the time of mineralization. These volcanics are almost certainly mid-Tertiary the same age as nearby volcanism in the Chiricahua Mountains. The reported radiometric determination, however, must be viewed with caution as the district has undergone extensive potassic alteration.

REFERENCES: #93, #100

DISTRICT: RUCKER CANYON

PRODUCTION: Ag, Au

GEOLOGIC SETTING: The Rucker Canyon properties consist of vein mineralization in the Mural Limestone of the Cretaceous Bisbee Group. The outcrops in Rucker Canyon are controlled by an east-west-trending fault that exposes the Bisbee Group beneath an uppermost Cretaceous andesite and a thick Oligocene silicic-tuff sequence.

AGE: Intrusive activity associated with either the latest Cretaceous andesite or the thick Oligocene volcanics is the probable agent of mineralization. The geochemical signature is similar to that of the California mineral district of known mid-Tertiary age, therefore a mid-Tertiary age seems likely.

REFERENCES: #18, #100
DISTRICT: SWISHELM

PRODUCTION: Pb, Ag, Au, Zn, Cu, Mo

GEOLOGIC SETTING: The Swisshelm district is on the flank of a major NNW-trending fold of Paleozoic limestones. The anticline is cored by the Swisshelm diorite porphyry. North-northwest-trending thrust faults are a pervasive structural element in the district. The orebodies are dominantly lead replacements with recoverable copper, silver, and gold. Skarns are present in the Pennsylvanian Naco Group and are localized at the intersection of thrust faults and a variably trending fracture system.

AGE: Shafiquallah and others (1978) reports K-Ar biotite ages of 31 and 34 m.y.B.P. for the Swisshelm stock which intrudes the NNW-trending anticline. This stock is presumed to be responsible for mineralization.

REFERENCES: #18, #58, #72, #100

DISTRICT: TEVISTON

PRODUCTION: Au, Ag, Pb, Cu

GEOLOGIC SETTING: The mines of the Teviston district are small and consist primarily of base-metal oxides, carbonates, and minor sulfides in irregular quartz veins cutting Precambrian Pinal Schist. Precious metal values are erratic but present. Richter and Lawrence (1983) map Tertiary felsic flows and pyroclastic deposits, and granitic plugs and dikes close to the Teviston district.

AGE: Keith and others (1983a,b) ascribe a mid-Tertiary age for this district by virtue of the district's genetic relationship to a 35-40 m.y.-old dike swarm. The age of the dike swarm cannot be verified, although it is mapped as Tertiary by Richter and Lawrence (1983). This district is very similar to the Apache Pass mineral district, where we have proposed a Laramide(?) age. The age of the Teviston district is therefore problematic.

REFERENCES: #100, #156

DISTRICT: YELLOWSTONE

PRODUCTION: Au, Ag, Pb, Cu

GEOLOGIC SETTING: The Yellowstone district is underlain by Precambrian granitoids with minor klippen of Paleozoic limestones and shales. The Johnny Lyon Hills display extensive low-angle faulting of mid-Tertiary age (Dickinson, 1984). Two types of mineralization are evident. In brown carbonate host rocks, veins of variable width contain malachite, chrysocolla, and chalcocite, with opaline quartz, boxwork limonite, and calcite as gangue. In the Precambrian Johnny Lyon granodiorite, mineralization is sparse and in short veins. Chalcopyrite, malachite, chalcocite, pyrite, trace galena, and limonite occur in massive milky opaline-quartz veins, in vuggy veins, and open fractures. The Yellowstone district mineralization may be related to mid-Tertiary detachment faulting.
AGE: Cooper and Silver (1964) describe low-angle faults that cut the Precambrian granites and state that mineralization in these granites cuts low-angle faults; therefore, the bulk of the mineralization is middle Tertiary. Cooper and Silver (1964) also acknowledge some Precambrian mineralization in the granite.

REFERENCES: #18, #38, #50, #100

GILA COUNTY

DISTRICT: Ramsdell

PRODUCTION: Mn

GEOLOGIC SETTING: Psilomelane and pyrolusite occur in a quartzose gangue forming stringers and small lenticular pods along a fissure in coarse-grained quartz diorite. These high-grade lenses and podiform masses are surrounded by a network of manganiferous seams and veinlets filling minor fractures of the host quartz diorite.

AGE: Undated. Proximity to Superior ash-flow tuff and by analogy with other districts weakly suggestive of mid-Tertiary age.

REFERENCES: #70, #121, #199

DISTRICT: SUNSET

PRODUCTION: Mn

GEOLOGIC SETTING: Manganese minerals occur in shattered Precambian Dripping Spring(?) quartzite along a shear zone striking N70W and dipping 65 NE. Seams, veinlets, and various sized irregular masses of psilomelane, pyrolusite and wad. Silica and iron oxides are the dominant gangue minerals.

AGE: Undated; NW strike suggests a mid-Tertiary age.

REFERENCES: #70

GRAHAM COUNTY

DISTRICT: ARAVAIPA

PRODUCTION: Zn, Pb, Cu, Ag, Au, Mo

GEOLOGIC SETTING: The Aravaipa District is lithologically varied with moderately complex structure. Pinal schist, Precambrian granite, Paleozoic sedimentary rocks, Cretaceous sedimentary and volcanic rocks, and extensive middle-Tertiary intrusives and volcanics are the most prevalent rocks. Ore bodies are located along a north-northeast, high-angle, normal-fault set and a second set of east-trending, sinuous, low-angle faults. Ore bodies are veins and less important replacements.
Middle Tertiary rhyolite dikes are commonly associated with ore. Galena and sphalerite dominate with lesser chalcopyrite. Quartz, chalcedony, amethyst, specularite, and fluorite are gangue. Silicification is pervasive.

AGE: The association of ore with rhyolite dikes presumably related to the 25 m.y.-old Santa Teresa granite indicates a middle tertiary age.

REFERENCES: #40, #49, #150, #159, #170, #171, #172

DISTRICT: BLACK HAWK
PRODUCTION: Mn

GEOLOGIC SETTING: Manganese minerals occur in narrow veins and along a broad fracture zone cutting 1.4 b.y.-old Precambrian biotite quartz monzonite. The veins are largely filled with quartz and contain small local bunches of manganese oxides, which include psilomelane and pyrolusite. Quartz and calcite comprise an abundant gangue.

AGE: Veins are in lower-plate rocks of the Eagle Pass detachment fault. The fault cuts middle Tertiary rocks; therefore mineralization is middle Tertiary or younger. A middle Tertiary age is favored.

REFERENCES: #28, #48

DISTRICT: RATTLESNAKE
PRODUCTION: Ag, Au

GEOLOGIC SETTING: The Rattlesnake District is in the southern Galiuro Mountains, an area underlain by middle to late Tertiary volcanics. The deposits are mostly hosted in andesitic to rhyolitic volcanic fragmentals and breccia. The district is centered on a NNW-trending syncline. Native gold, hematite, pyrite, chrysocolla, and quartz are the ore minerals. The orebodies are associated with andesite porphyry dikes.

AGE: A 25-20 m.y.B.P. old date is given by analogy to dated andesite dikes elsewhere in the Galiuro Mountains.

REFERENCES: #40, #41, #42, #90, #194

DISTRICT: SAN CARLOS
PRODUCTION: Mn

GEOLOGIC SETTING: Manganese minerals occur in seams, stringers, and small irregular bunches distributed sporadically along northwest-trending fractures and brecciated zones in volcanic rocks. The ore minerals are chiefly psilomelane, pyrolusite, and wad. Calcite and iron oxides are the principal gangue minerals. The larger mineralized bunches, seldom exceeding one foot in greatest dimension, are composed largely of small nodules and stringers of ore mixed with calcite and brecciated
wallrock fragments.

AGE: Bromfield and Schride (1956) map the volcanic rocks hosting the San Carlos district as older Tertiary volcanic rocks. This volcanic package is a succession of rhyolitic, andesitic, and basaltic flows, breccias, and tuffs. The volcanics of the San Carlos district are almost certainly of mid-Tertiary age; it seems probable the manganese deposits are of mid-Tertiary age also.

REFERENCES: #31, #42, #70

DISTRICT: STANLEY

PRODUCTION: Pb, Cu, Ag, Au, Zn

GEOLOGIC SETTING: The Stanley District encompasses a diverse series of rocks. The southwest portion of the district has N10W- to N40W-striking Paleozoic sedimentary rocks with moderate SW dips. A block of Precambrian granite crops out to the northeast. A large Tertiary quartz monzonite pluton and Oligocene volcanics are present in the periphery of the district. The northwest-trending Deer Creek syncline dominates the southwestern part of the district. Although Cretaceous sediments and volcanics are infrequent hosts, Paleozoic limestone is the prevailing host to veins and replacements. A variety of volcanics and dikes are associated with ore and include quartz porphyry, andesite, and rhyolite volcanics, and diabase dikes. Chalcopyrite, sphalerite, bornite, azurite, pyrolusite, and stibnite are reported ore minerals. Quartz, calcite and pyrite are reported gangue with lesser fluorite, barite, specularite, johannsenite, garnet, and magnetite.

AGE: The ore is presumed to be contemporaneous with the extensive 25 m.y.-old Santa Teresa Granite.

REFERENCES: #159, #185

GREENLEE COUNTY

DISTRICT: ASH PEAK

PRODUCTION: Ag, Au, Cu, Pb, Zn

GEOLOGIC SETTING: The enormous amount of silver produced from the Ash Peak district came from veins and replacements hosted by a thick middle-Tertiary volcanic and volcaniclastic sequence. The section attains a thickness of up to 1000 m and is intruded by northwest-trending dikes that may have been controlled by N45W-trending normal faults. Plugs of diabase locally intrude the section as well. Precious metal mineralization is restricted to the Miocene rhyolite domes, flows, and pyroclastics of the Ash Peak-Rhyolite Peak flow dome-cone complex (Richter and others, 1983) and characteristically has argentite, rhodochrosite, and pyrite, with banded chalcedonic quartz. Psilomelane and lesser pyrolusite with calcite hosted by basalt constitutes a second, separate ore type. The common northerly strike to these manganese orebodies in contrast to the exclusive N45W trend of the precious metal mineralization supports
two distinct phases of mineralization.

AGE: Richter and others (1983) assign a 22 to 23 m.y. age for the Ash Peak-Rhyolite Peak eruptive center which contains the N45W-trending vein of the Ash Peak Mine.

REFERENCES: #70, #114, #144, #154, #155

DISTRICT: GILA HOT SPRINGS

PRODUCTION: Mn

GEOLOGIC SETTING: Manganese occurs at the Gila Hot Springs district in pods and lenses in the Bonita Creek Conglomerate. The ore cuts bedding in the conglomerate at a high angle. Wad, pyrolusite, and barite are ore minerals. Black and white calcite are prevalent gangue minerals.

AGE: The host Bonita Creek Conglomerate is locally interbedded with pyroclastic air-fall and ash-flow deposits of the Tolgate Wash eruptive center and the upper andesite flows of the Guthrie Peak-Turtle Mountain Formation. Richter and others (1983) state that these volcanics were erupted from 19 to 24 m.y. ago, hence the manganese mineralization is no older than about 20 m.y.

REFERENCES: #62, #70

DISTRICT: TWIN PEAKS

PRODUCTION: Ag, Au, Cu, Pb

GEOLOGIC SETTING: The Twin Peaks district lies exclusively within a thick pile of silicic and intermediate volcanics ranging in age from Oligocene to mid-Miocene. A white, massive, flow-banded rhyolite of middle oligocene age is the dominant rock type. A set of mid-Oligocene rhyolite dikes trends N45E and another set of Miocene mafic dikes trends N50W to N70W. The Twin Peaks Mine proper is a north-trending manganese vein in New Mexico. The only documented Arizona production from the Twin Peaks District is at a minor fluorite-manganese property. Ratte and Hedlund (1981) show areas of extensive alteration and veining in adjacent New Mexico, suggesting that the majority of base and precious metal production may have come from New Mexico.

AGE: A Oligocene to middle Miocene age of mineralization is reasonable, in view of the predominance of a middle Oligocene rhyolite host. By analogy to the nearby and similar Ash Peak District, a 22 m.y.B.P. is possible.

REFERENCES: #70, #86, #114, #144

LA PAZ COUNTY

DISTRICT: ABC
PRODUCTION: Mn

GEOLOGIC SETTING: Psilomelane occurs in brecciated wallrocks and north-south-striking, steeply west-dipping, parallel, shear veins cutting Tertiary andesitic volcanics.

AGE: The veins cut a volcanic package informally known as the Trigo Mountain Volcanics. These volcanic rocks are considered to be mid-Tertiary in age based on correlation with similar dated rocks in the Castle Dome Mountains, and similar rocks throughout southwestern Arizona.

REFERENCES: #44, #63, #73

DISTRICT: ALAMO

PRODUCTION: Cu, Au, Pb, Ag

GEOLOGIC SETTING: Copper carbonates, silicates, and minor sulfides at depth, with local lead carbonate in fissure veins. Strong silicification with minor epidote, fluorite and selenite in association with the veins in and near a low-angle normal fault zone. The veins are found in altered mylonitic schist and gneiss, and are located near dikes and intrusive plugs of quartz monzonite.

AGE: These deposits are inferred to be related to mid-Tertiary movement on the Whipple-Buckskin-Rawhide Mountains detachment fault. However, the presence of sulfides and the possible association of mineralization with dikes and intrusive plugs suggests that at least some of the mineralization might not be related to detachment faulting.

REFERENCES: #47, #103, #137

DISTRICT: ARTILLERY

PRODUCTION: Mn

GEOLOGIC SETTING: Stratabound manganese oxides in the Artillery district occur in the early to middle Miocene Chapin Wash Formation in western Arizona. Manganese oxides are locally present in the clay cement of every type of sedimentary rock in the Chapin Wash Formation, including siltstone, sandstone, conglomerate and tuff. Supergene enrichment of some of the ore has raised the grade of the ore from 3-4 percent to 6-7 percent Mn.

AGE: Volcanic rocks in the Chapin Wash Formation have yielded early to middle Miocene K-Ar ages.

REFERENCES: #63, #117, #125, #130, #136, #168, #174

DISTRICT: BOUSE

PRODUCTION: Au, Cu, Ag, Mn
GEOLOGIC SETTING: Veins of barite and of pyrolusite, psilomelane, and manganite with calcite occur in brecciated middle Tertiary volcanic wallrocks (Keith, 1978).

AGE: Most of the deposits are hosted by middle Tertiary volcanic rocks, and therefore are middle Tertiary or younger. A middle Tertiary age is favored since this was a time of widespread magmatism and faulting.

REFERENCES: #103, #106, #107, #174

DISTRICT: CIENEGA

PRODUCTION: Cu, Au, Ag

GEOLOGIC SETTING: Small, discontinuous, replacement bodies containing copper silicates, carbonates, and oxides, occur with iron oxides and spotty gold values. The deposits are associated with faults, fractures, and shear zones along and above the Whipple-Buckskin-Rawhide detachment fault system. Blocks of partially metamorphosed Paleozoic and Mesozoic limestones, shale, quartzites, and underlying Precambrian metamorphic rocks host the orebodies.

AGE: These deposits are located along structures thought to be related to the Whipple-Buckskin-Rawhide detachment fault system of mid-Tertiary age. A middle Tertiary or younger age is indicated, and a middle Tertiary age is probable.

REFERENCES: #21, #47, #103

DISTRICT: CINNABAR

PRODUCTION: Hg, Cu, Au, Ag

GEOLOGIC SETTING: Spotty disseminations of cinnabar occur with minor metacinnabar, malachite, chrysocolla, gold, and silver. Gouge, brecciated quartz, calcite, and siderite comprise the gangue. Ore and gangue minerals occur in strongly iron-stained faults and fissures cutting Mesozoic schists.

AGE: Age is Mesozoic or Cenozoic. Keith and others (1983a,b) assign a middle Tertiary(?) age for reasons that are not given in their paper.

REFERENCES: #21, #103, #106, #107

DISTRICT: CLARA

PRODUCTION: Cu, Ag, Au

GEOLOGIC SETTING: Copper silicates and carbonates occur with minor chalcocite and sparse leaf gold. Gangue consists of abundant calcite, quartz, gypsum and hematite. Mineralization consists of fracture fillings along and near the Buckskin-Rawhide detachment fault. This fault places middle Tertiary conglomerates over mylonitic gneiss.
AGE: Mineralization is related to the middle Tertiary Buckskin-Rawhide Mountains detachment fault, and therefore is mid-Tertiary in age.

REFERENCES: #21, #103, #174

DISTRICT: CUNNINGHAM PASS

PRODUCTION: Cu, Au, Ag, Pb

GEOLOGIC SETTING: Spotty, but typically high-grade pockets of copper-gold-silver mineralization occur with quartz, iron oxides, siderite, calcite, and barite in lenses. The lenses of mineralization are found within or along contacts with northwest-trending microdiorite dikes that have intruded Mesozoic and Cenozoic metamorphic and granitic rocks.

AGE: Microdiorite dikes in the Harquahala Mountains yielded a hornblende K-Ar age of 28.6 m.y.B.P., and a biotite K-Ar age of 22.1 m.y.B.P., indicating mid-Tertiary age for the ore deposits.

REFERENCES: #21, #103, #148

DISTRICT: ELLSWORTH

PRODUCTION: Cu, Au, Ag, Pb

GEOLOGIC SETTING: Numerous, irregular, splitting and lensing veins of quartz, siderite, calcite, and brecciated wallrock containing spotty, oxidized and sulfide copper mineralization, occur with gold and silver metallization. Some veins are associated with microdiorite or rhyolite(?) dikes that intrude Mesozoic metasedimentary and metavolcanic rocks and, locally, Paleozoic metasedimentary and Precambrian crystalline rocks.

AGE: Mid-Tertiary age is probable if mineralization is associated with microdiorite dikes, since similar dikes of mid-Tertiary age are known in the nearby Harquahala Mountains.

REFERENCES: #21, #103, #174

DISTRICT: FOOLS FOLLY

PRODUCTION: Mn

GEOLOGIC SETTING: Pyrolusite is found along steeply-dipping, east-trending fracture zones in volcanic rocks. The fractures extend almost continuously for 200 meters along strike. Gangue consists mostly of unreplaced fragments of the host volcanic rocks.

AGE: Host volcanic rocks are probably mid-Tertiary in age. If so, mineralization is mid-Tertiary or younger.
REFERENCES: #69

DISTRICT: HARCUVAR

PRODUCTION: Cu, Au, Ag

GEOLOGIC SETTING: Spotty copper sulfides and secondary copper mineralization in irregular quartz-siderite veins or associated with microdiorite or diorite dikes. Some of the veins and middle Tertiary microdiorite dikes are in northwest-striking fissure zones. Host rocks are Mesozoic granite and metamorphic rocks.

AGE: The microdiorite dikes are almost certainly middle Tertiary in age based on correlation with dated dikes in the Harquahala Mountains. Associated mineralization is probably middle Tertiary in age.

REFERENCES: #21, #103

DISTRICT: HARQUAHALA

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: The Harquahala district is composed of pockety, irregular, and lensing deposits along veins and as replacements. The ores are characteristically gold and silver rich with minor contributions from oxides of base metals. Ore shoots are associated with quartz, calcite and abundant iron oxides. The wallrocks include Precambrian granitic and gneissic rocks, Paleozoic sediments, and undated microdiorite dikes. The wallrocks are locally silicified, sericitized, and brecciated. Veins and replacements are near northwest to north-northwest-striking faults and microdiorite dikes. Although the dikes are thought to be genetically related to the ore occurrences, mineralization is, at least in part, spatially associated with Mesozoic thrust faults.

AGE: The spatial association of mineralization with middle Tertiary microdiorite dikes indicates that many of the deposits are middle Tertiary in age. Further detailed study, including geochronologic studies, are needed to accurately determine the age and nature of all of the deposits.

REFERENCES: #15, #21, #103, #105

DISTRICT: LA CHOLLA

PRODUCTION: Au, Cu, Ag

GEOLOGIC SETTING: Spotty and irregular copper, gold, and silver mineralization as disseminations and veins in or near northwest- to west-northwest-striking microdiorite dikes. The veins are quartz-rich and occur along faults in Mesozoic metasedimentary and metavolcanic rocks. Crowl (1979) describes malachite in noses of folds in Mesozoic McCoy Mountains Formation at the Copper Bottom mine.
AGE: The northwest-striking microdiorite dikes are almost certainly mid-Tertiary based on dike orientation and on lithologic similarity to dated dikes in other ranges.

REFERENCES: #21, #43, #103

DISTRICT: LA PAZ

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: Spotty gold, silver, and gold-bearing pyrite with minor copper and lead mineralization in lensing massive quartz and iron-oxide-rich veins. The veins are in shear zones cutting Mesozoic metavolcanic rocks. A nearby rhyolitic plug of unknown age may be related to the mineralization. Crowl (1979) describes chrysocolla in fractures in metavolcanic rocks with associated quartz-sericite-pyrite hydrothermal alteration of host metavolcanics.

AGE: There is insufficient data to reliably constrain the age of this district, although it is almost certainly Laramide or mid-Tertiary. A probable mid-Tertiary age for the rhyolite plug, and a possible relationship between mineralization and the rhyolite plug, suggest a mid-Tertiary age of mineralization.

REFERENCES: #43, #103

DISTRICT: LINCOLN RANCH

PRODUCTION: Mn

GEOLOGIC SETTING: Manganese oxides coating grains, clasts, and fracture surfaces in sheared and faulted Tertiary sandstone and conglomerate. Some mineralization predates latest movement on the Buckskin detachment fault.

AGE: Middle Tertiary age is indicated by the association with middle Tertiary rocks.

REFERENCES: #74, #174

DISTRICT: LITTLE HARQUAHALA

PRODUCTION: Au, Ag, Pb, Cu

GEOLOGIC SETTING: Rich, pockety shoots of gold with minor silver in a gangue of iron oxides, shattered quartz, and gypsum. The ore shoots are found in shear zones cutting Precambrian granites, shattered Cambrian quartzites, and strongly folded and faulted Paleozoic sedimentary rocks, and are locally near microdiorite dikes. The richer deposits occur in the shattered quartzites.

AGE: Apparent association with mid-Tertiary microdiorite dikes in some parts of the district (Keith and others, 1983a,b) is suggestive of a middle Tertiary age of mineralization.
REFERENCES:  #21, #103

DISTRICT:  MAMMON

PRODUCTION:  Cu, Au, Ag

GEOLOGIC SETTING:  Hematite replacement bodies and breccia fillings with spotty, narrow, and lensing oxidized copper mineralization with minor gold and silver, along shear zones between metamorphics and granitic intrusives, and along schistosity in the schists.

AGE:  Mineralization is almost certainly the result of intermittent hydrothermal activity associated with low-angle normal faulting in the Whipple-Buckskin-Rawhide Mountains. The faulting, and probably also the mineralization, are mid-Tertiary age.

REFERENCES:  #21, #47, #103, #189

DISTRICT:  METATE

PRODUCTION:  Mn

GEOLOGIC SETTING:  High-grade (~40% Mn) zones of soft pyrolusite, psilomelane, and manganite, with very little gangue, occur as irregular replacements along a minor fold in limestone. Ore bodies are discontinuous along strike and typically less than a meter thick and no longer than 4 meters. The manganese-rich replacements appear to be localized in a westerly-dipping fissure zone cutting the northern limb of a fold in the limestone. Reconnaissance mapping indicates that most of the district is underlain by Mesozoic metavolcanic rocks.

AGE:  Host limestone is of unknown age but possibly Mesozoic age, suggesting a Mesozoic or Tertiary age for mineralization. A mid-Tertiary age is suggested by similarity to dated Mn deposits in adjacent areas.

REFERENCES:  #69, #103, #174

DISTRICT:  MIDDLE CAMP

PRODUCTION:  Pb, Au, Ag, Cu

GEOLOGIC SETTING:  Spotty gold, silver, lead, copper, and zinc mineralization in quartz veins, stringers, and in replacement deposits along fractures in Mesozoic metamorphic and granitic rocks. The veins are locally northwest-striking and thought to be associated with the Diablo quartz monzonite. Chalcopyrite is associated with gold-bearing veins at the Marquitta and Goodman mines (Crowl, 1979).

AGE:  The veins have the characteristic mid-Tertiary strike, but may be related to the Diablo quartz monzonite of probable Mesozoic age.

REFERENCES:  #43, #103

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DISTRICT: MIDWAY

PRODUCTION: Cu, Au, Ag

GEOLOGIC SETTING: Spotty, oxidized copper mineralization with minor sulfides and gold. Hematite, quartz, barite, and fluorite are present as gangue. The ore is along fractures cutting Mesozoic sediments and Precambrian gneisses, or as replacements in limestones.

AGE: The mineralogy and style of mineralization suggest metallization related to movement on the Buckskin-Rawhide detachment fault of mid-Tertiary age.

REFERENCES: #103, #174

DISTRICT: MOON MOUNTAINS

PRODUCTION: Au, Ag

GEOLOGIC SETTING: Spotty gold and silver mineralization with minor, partly oxidized copper sulfides in lensing quartz veins and disseminations cutting Mesozoic (?) metamorphic rocks.

AGE: The Moon Mountains detachment fault of mid-Tertiary age is exposed at the north end of the east ridge of the Moon Mountains. Mineralization at this locality is clearly related to the fault and hence is mid-Tertiary. Little geologic information is available from other parts of the Moon Mountains although a mid-Tertiary age has been suggested (Keith and others, 1983a,b) for other areas of mineralization in the district.

REFERENCES: #103

DISTRICT: NEW WATER

PRODUCTION: Ag, Pb, Cu, Au

GEOLOGIC SETTING: Spotty silver, lead, and copper oxide mineralization with limonite along joints, fractures, and small high-grade chimneys in epidotized porphyritic andesite and volcanic agglomerate.

AGE: The host volcanic rocks are mid-Tertiary, hence mineralization is mid-Tertiary or younger. Mineralization is probably a consequence of widespread mid-Tertiary magmatism, and therefore is probably mid-Tertiary in age.

REFERENCES: #63, #103

DISTRICT: NORTHERN PLOMOSA

PRODUCTION: Au, Cu, Ag, Pb
GEOLOGIC SETTING: Spotty, fine-grained gold with oxidized copper, silver and lead mineralization in narrow, lensing and irregular veins. Ore is found along faults, and at intersections between cross-fractures and the contact of shale, limestone and welded tuff with Precambrian gneiss and schist. Veins also cut Miocene volcanic rocks. Brecciation of the wallrocks is intense, with local replacement of the wallrock by manganese and iron oxides.

AGE: The veins are hosted in part by middle Tertiary volcanic rocks, so are mid-Tertiary or younger in age. Most of the district is in the upper plate of the Plomosa detachment fault, and mineralization could be related to faulting. If so, the deposits are mid-Tertiary in age.

REFERENCES: #21, #63, #106, #107

DISTRICT: PLANET

PRODUCTION: Cu, Au, Ag

GEOLOGIC SETTING: Copper carbonates and silicates, with minor copper sulfides and pyrite at depth, occur in disseminations, veinlets, and irregular, lensing, replacement bodies of specular hematite. Wallrocks are brecciated carbonates and shales. Some carbonate masses may have been formed by replacement of preexisting rocks. The orebodies are found along a flat fault zone with gouge, quartz, calcite and feldspar.

AGE: Mineralization is within the Buckskin-Rawhide low-angle detachment fault system of mid-Tertiary age, and is probably related to faulting. A mid-Tertiary age is strongly suggested.

REFERENCES: #103, #189

DISTRICT: SILVER

PRODUCTION: Ag, Pb, Cu, Zn, Au

GEOLOGIC SETTING: Deeply oxidized argentiferous lead, zinc, and copper mineralization in a gangue of quartz, calcite, limonite, barite, and fluorite. Ore-bodies are spotty, irregular and lensoidal. Middle Tertiary volcanic and sedimentary rocks host the ore shoots along high-angle normal faults.

AGE: Recent work (Pietenpol, 1983) in this district suggests the vein deposits are associated with high-angle normal faulting and volcanism of the Basin and Range disturbance. The age of volcanism, faulting, and mineralization is middle to late Tertiary.

REFERENCES: #21, #136A, #142

DISTRICT: SOUTHERN PLOMOSA
PRODUCTION: Cu, Au, Ag, Pb

GEOLOGIC SETTING: Largely oxidized, spotty copper, gold, and silver mineralization with minor lead, in small, irregular, lensing pods. The ore shoots are found in highly deformed, schistose, silicified, epidotized Paleozoic limestones and Mesozoic continental sediments. The quartz-rich mineralized zones are associated with microdiorite dikes.

AGE: Microdiorite dikes associated with mineralized zones are almost certainly mid-Tertiary in age based on lithologic similarity to dated dikes in nearby ranges.

REFERENCES: #21, #103

DISTRICT: SWANSEA

PRODUCTION: Cu, Ag, Au

GEOLOGIC SETTING: Disseminated and veinlet copper oxide mineralization in several large, irregular lensing hematite replacement bodies. Chalcopyrite, bornite, and pyrite are found at depth in a gangue of quartz, chlorite, and epidote. Ore bodies are in a basal section of a folded block of replacement (?) carbonate and schist that is in low-angle, normal-fault contact with mylonitic gneiss.

AGE: These deposits are the result of hydrothermal activity along the mid-Tertiary Buckskin-Rawhide detachment fault system, and formed during faulting.

REFERENCES: #103, #189

DISTRICT: TRIGO MOUNTAINS

PRODUCTION: Pb, Ag, Au, Cu

GEOLOGIC SETTING: Spotty, high-grade, gold-silver mineralization in a gangue of vuggy and banded quartz, iron oxides, ferruginous calcite, and pyrite. Ore bodies are cavity and fracture fillings along shear zones in Tertiary volcanic rocks and in Mesozoic (?) and Precambrian basement rocks.

AGE: This district is possibly related to the Trigo Mountain detachment fault system of mid-Tertiary age. At least some of the mineralization is hosted by mid-Tertiary volcanic rocks, and is therefore mid-Tertiary or younger. A mid-Tertiary age is favored.

REFERENCES: #73, #103

MARICOPA COUNTY

DISTRICT: AGUILA
PRODUCTION: Mn

GEOLOGIC SETTING: Manganese mineralization occurs in Precambrian metamorphic and granitic rocks and overlying Tertiary andesites and light-colored tuffs. The manganese deposits are as prevalent in the basement rocks as in the younger volcanic rocks. Faulting is common in the area, and locally has disrupted the continuity of orebodies. The chief manganese minerals are a mixture of pyrolusite, psilomelane, and manganite. The gangue is composed largely of calcite, quartz, and unreplaced fragments of the wallrocks. The manganese minerals occur as fissure fillings, as irregular masses, and in networks of smaller seams surrounding brecciated fragments of country rock. Individual deposits range from narrow veins, with small but enriched ore shoots, to wide shears and brecciated zones of lower grade material. The majority of the veins and mineralized fracture zones strike north and dip steeply to the west.

AGE: Since the ore occurs in mid-Tertiary volcanic rocks, it is mid-Tertiary or younger. A mid-Tertiary age is favored since this was a time of widespread magmatism and tectonism.

REFERENCES: #69

DISTRICT: BIGHORN

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: Precambrian crystalline rocks and Laramide granitic rocks constitute the bedrock in the Bighorn District. A westward prong of Tertiary volcanics extends into the district from the extensive andesites of the central Bighorn Mountains. Precious metal mineralization is restricted to massive, coarse-grained, quartz pods and veins with hematite and limonite in low- to high-angle shears in Precambrian schists and foliated granite. The veins are locally commingled with felsic dikes. The wall rocks are notably sericitized. The Aguila manganese-barite district lies in the same general area as the native gold mineralization of the Bighorn District.

AGE: The age of mineralization is uncertain but a mid-Tertiary age is suggested because mineralization is associated with "basic dike rocks" of the El Tigre mine (Wilson and others, 1967), and these dikes may be mid-Tertiary microdiorite dikes as in the nearby Harquahala Mountains where they have yielded mid-Tertiary K-Ar dates. Other mineralized areas are associated with northeast-trending rhyolitic dikes, and may be Laramide.

REFERENCES: #148, #149, #185, #191, #194

DISTRICT: CAVE CREEK

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: The Cave Creek District is extensive and encompasses many orebodies. The district is located at the southern edge of the Yavapai Series massive-sulfide belt. Bedrock consists of a basal tholeiitic to calc-alkaline
metavolcanic sequence with an upper calc-alkaline sequence with a distinct set of banded iron formations and tuffaceous sediments. Mineralization at the Grey's Gulch and Phoenix-Maricopa Mines of the district is probably of Precambrian age. In contrast, the majority of the mines are intimately associated with porphyritic rhyolite and porphyritic diorite-andesite dikes which are probably of Cretaceous or Tertiary age. Native gold in quartz is the most commonly cited mineralogy. Vanadinite, molybdenite, galena, malachite, azurite, anglesite and hematite also occur.

AGE: The association of mineralization with unfoliated dikes and intrusives indicates a probable Laramide or mid-Tertiary age.

REFERENCES: #11, #54, #185, #194

DISTRICT: GOLDFIELD

PRODUCTION: Au, Ag

GEOLOGIC SETTING: The Goldfield District is astride a horst block of Precambrian Ruin Granite which lies between the late Oligocene-Miocene Goldfield and Superstition volcanic fields. The volcanic piles range from basanites to high silica rhyolites in composition. The ore is dominantly free gold in north and north-northeast-trending, fault-controlled quartz veins. Some orebodies have andesitic volcanics along the fracture zones. Pyrite and limonite are also reported but, notably, no copper minerals are known.

AGE: Sporadic Miocene(?) dikes associated with some orebodies suggest mineralization is related to the mid-Tertiary volcanics.

REFERENCES: #138, #185, #194

DISTRICT: OSBORNE

PRODUCTION: Pb, Au, Cu, Ag, Zn

GEOLOGIC SETTING: Northeast- to northwest-trending, steeply dipping veins cutting Precambrian crystalline and middle Tertiary volcanic rocks characterize the Osborne district. The veins are commonly associated with silicified and brecciated zones in the volcanic rocks. Galena, chalcopyrite, chalcocite, sphalerite, and pyrite are found in a gangue of quartz and calcite. The upper levels of the mine workings are oxidized and marked by the presence of base metal carbonate and oxide minerals.

AGE: Veins cut middle Tertiary volcanic rocks, and therefore are middle Tertiary or younger. A middle Tertiary age is favored since this was a time of widespread magmatic and tectonic activity.

REFERENCES: #15

DISTRICT: PAINTED ROCK
PRODUCTION: Cu, Pb, Ag, Au

GEOLOGIC SETTING: The Painted Rock district lies in the low hills off the northwest flanks of the Painted Rock Mountains. Bedrock in the Painted Rock district consists of middle Tertiary andesite flows and agglomerates which are intruded by a variety of dike rocks. South of the district quartz latite porphyry abundantly intrudes the andesite. These rocks are overlain by an approximately 475-meter-thick ash flow tuff with vitrophyre that forms prominent massive to columnar outcrops. The youngest units in the Rowley Mine area are calcite-cemented volcanic gravels which form benches. Mineralization is restricted to a N30W- to N40W-trending fault zone in the andesite that dips 40 to 50 northeast. The fault lies between two ore types: a quartz vein on the footwall and a barite vein on the hangingwall. The quartz vein is of fairly uniform, 2 meter thickness and contains no gouge or breccia. The quartz vein is a massive replacement of the andesite. The barite vein ranges 5 to 10 meters thick and is generally brecciated and deformed (Wilson and Miller, 1974). The inferred hypogene mineralization is barite, quartz, fluorite, galena, pyrite, chalcopyrite, and sphalerite (Wilson and Miller, 1974).

AGE: The mineralization occurs within volcanic rocks of possible mid-Tertiary age, and is therefore mid-Tertiary or younger. A mid-Tertiary age is favored since this was a time of widespread magmatism.

REFERENCES: #112, #176, #200

DISTRICT: PIKES PEAK

PRODUCTION: Au, Cu, Pb, Ag

GEOLOGIC SETTING: The Pikes Peak district is in Precambrian schist and banded iron formation. Andesitic dikes intrude the sequence and are associated with much of the mineralization. The mineralization is in veins and pods and contains notable lead and zinc oxides and sulfides along with native gold, cerargyrite, vanadinite, wulfenite, descloizite, and gangue of hematite, magnetite, pyrolusite, and hausmannite.

AGE: Many ore deposits are associated with andesitic dikes that are almost certainly of mid-Tertiary or Laramide age.

REFERENCES: #15, #185, #198

DISTRICT: RELIEF

PRODUCTION: Au, Ag

GEOLOGIC SETTING: No published description of the general geology of the Relief district is available. The Wilson and others (1957, 1969) maps show the mines in granite of Precambrian age and near a Laramide(?)-granitoid. Ore is in quartz veins cutting granite and syenite. Free gold, copper carbonates, and free silver are the ore minerals.

AGE: Uncertain, but probably Laramide or mid-Tertiary.
REFERENCES: #15, #149, #198

DISTRICT: SALT RIVER MOUNTAINS

PRODUCTION: Au, Cu, Ag

GEOLOGIC SETTING: The South Mountains (previously referred to as the Salt River Mountains) contain two terranes; the eastern half of the range is mylonitized granodiorite, granite, and alaskite of mid-Tertiary age, and the western half consists of Precambrian metamorphic and granitic rocks that are mylonitized in the east but gradually less so to the west. The Salt River Mountains mineral district is in quartz veins in the Precambrian terrane and is associated with a north-northwest trending dike swarm. Mineralization closely followed cessation of mid-Tertiary mylonitization. Native gold is the ore mineral with limonite and hematite gangue. Sericitization is widespread.

AGE: The gold deposits of the Salt River Mountains district are of middle Tertiary age.

REFERENCES: #149, #152, #185, #194

DISTRICT: SAN DOMINGO

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: Middle Tertiary(?) veins along faults, possibly within the upper plate of a regional detachment fault system (Keith and others, 1983a,b). A thorough literature review did not reveal any substantive geologic descriptions for this district.

AGE: Keith and others (1983a,b) locate the district partly within mid-Tertiary volcanic rocks, indicating a mid-Tertiary or younger age.

REFERENCES: #106, #107

DISTRICT: SUNRISE

PRODUCTION: Cu, Ag

GEOLOGIC SETTING: Mineralization at the Sunrise Mine occurs along a fault that strikes N20E and dips 45NW. Schistose Precambrian metamorphic rocks form the footwall and biotite granite of unknown age forms the hangingwall. A stockwork of lenticular quartz veins occupy a zone 3-6 meters wide along the fault. Fine to coarse grains and flakes of gold occur within brecciated white quartz with abundant limonite and hematite. Native gold, native silver, and copper carbonates are the ore minerals. The wallrocks exhibit sericitization, silicification and carbonatization.

AGE: Probably Laramide or mid-Tertiary.
REFERENCES: #15, #149, #151, #198

DISTRICT: VULTURE

PRODUCTION: Au, Ag, Pb, Cu

GEOLOGIC SETTING: The Vulture vein occurs along a north-northwest striking, northeast dipping fault zone in Precambrian schist. Granite of unknown age hosts some of the deposits at depth in the Vulture Mine. A granite is associated with the gold-bearing quartz veins. In the oxide zone native gold occurs in milk quartz with occasional wulfenite. Below the oxidized zone pyrite, galena, sphalerite, and chalcopyrite are found.

AGE: The nearby presence of a large Laramide plutonic body (the Wickenberg batholith) is suggestive of a Laramide age, but the association of the quartz veins with north-northwest-trending a granite porphyry dike is suggestive a mid-Tertiary age.

REFERENCES: #149, #151, #185, #194

DISTRICT: WEBB

PRODUCTION: Cu, Au, Ag, Pb

GEOLOGIC SETTING: Precambrian schist intruded by granitic plutons of uncertain age forms the country rock in the Webb district. Mineralization is in veins striking variably from N10E to N35W. Mineralization is also in quartz monzonite dikes. Ore minerals are chrysocolla, malachite, cuprite, bornite, chalcopyrite, and chalcocite. The B & H #6 barite prospect is also within the district and is presumably a consequence of a separate, later mineralizing event.

AGE: Cheeseman (1974) suggests that copper mineralization in this district is either of volcanogenic origin or related to the weak development of a porphyry copper system. The relationship between ore and host rocks is equivocable.

REFERENCES: #36A, #176

DISTRICT: WINIFRED

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: Country rocks in the Winifred district include Precambrian metamorphic rocks (Yavapai Series) and a granitoid of unknown age. The major vein strikes southeast and consists of coarse, vuggy greyish-white quartz with occasional calcite and hematite. Pyrite is also locally present.

AGE: Northwest strike could be indicative of a middle Tertiary age.

REFERENCES: #185, #194, #198
MOHAVE COUNTY

DISTRICT: ARTILLERY PEAK

PRODUCTION: Ag, Cu, Au, Pb

GEOLOGIC SETTING: Very little geologic information exists for this district. Available information indicates that ore-minerals including chrysocolla, malachite, chalcocite, and gold and silver are present in veins hosted by Paleozoic limestone and Precambrian schists. The veins are associated with rhyolite dikes that intrude the lower Artillery Formation.

AGE: K-Ar dates from the Artillery formation give a 21-16 m.y.-old age for this unit. The rhyolite dikes are no older and possibly are considerably younger; a mid-Tertiary age of mineralization probable, although a late-Tertiary age is possible.

REFERENCES: #117, #136, #167, #168

DISTRICT: BLACK BURRO

PRODUCTION: Mn

GEOLOGIC SETTING: Soft, finely-divided, manganese oxides disseminated through a reddish sandstone similar to the Chapin Wash Formation. Parts of the outcrop have undergone supergene enrichment and are characterized by numerous fractures filled with psilomelane and pyrolusite.

AGE: The host sediments and ore are probably correlative with the lower Miocene Chapin Wash Formation.

REFERENCES: #68, #136, #167, #168

DISTRICT: BLACK DIAMOND

PRODUCTION: Mn

GEOLOGIC SETTING: The Black Diamond deposit occurs in a steeply dipping fault zone cutting Paleozoic carbonate rocks. The zone is up to 20 meters wide, strikes NE, and is exposed for several hundred feet along strike. The fault zone is composed of brecciated fragments of silicified limestone. The manganese minerals, consisting of wad, pyrolusite, and psilomelane, occur in a complex pattern of fractures surrounding the brecciated fragments of limestone. Where the fractures are numerous and closely spaced they may coalesce and form irregular masses of high-grade ore.

AGE: Mesozoic or Cenozoic.

REFERENCES: #69, #128
DISTRICT: BUCK MOUNTAINS

PRODUCTION: Au, Pb, Ag, Cu

GEOLOGIC SETTING: Available literature on this district is sketchy and inconclusive. ABGMY file data indicates the Yucca Mine of the Buck Mountains mineral district is a major manganese producer. The Palo Verde and Ideal mines in the northern part of the district are located within an area of Precambrian crystalline rocks, and the Arizona Yucca mine appears to be within either Precambrian crystalline or mid-Tertiary volcanic rocks.

AGE: Unknown.

REFERENCES: #15, #92

DISTRICT: CEDAR VALLEY

PRODUCTION: Au, Ag, Cu

GEOLOGIC SETTING: Small pods and lenses of marmatite, chalcopyrite, and galena replacing altered black hornblende schists and grey siliceous schists. Gangue minerals include quartz, pyrrhotite, magnetite, anthophyllite, tremolite, and pyrite. Ores fill open fissures in schists and pegmatite dikes. In 1947 the ores assayed 10% combined base-metal sulfides with minor precious metal credits.

AGE: There is no direct evidence for the age of this district. Many of the mines in this district are minor W producers. The description of this district is unlike any other mid-Tertiary mineral district. There is no compelling evidence for a mid-Tertiary age, and the metallogeny of the district would more likely indicate a Precambrian or Mesozoic age for the deposits.

REFERENCES: #157

DISTRICT: CHEMHEUEVIS

PRODUCTION: Au, Pb, Ag, Cu

GEOLOGIC SETTING: Precambrian schist locally cut by high-grade gold veins that tend to be irregular and narrow. The veins are filled with coarse-textured brecciated white quartz, pyrite and galena, and are associated with diorite and granite porphyry dikes. Most mines in the district are tungsten prospects with erratic values of scheelite in thin streaks. Both tungsten-rich and base- and precious-metal-rich veins strike northeast.

AGE: Keith and others (1983a,b) have assigned a mid-Tertiary age to this district. The presence of important tungsten prospects and northeast-trending veins and dikes brings this age into question, and a Laramide age is considered possible.

REFERENCES: #45, #92, #95, #132, #194
DISTRICT: CLEOPATRA

PRODUCTION: Cu, Au, Ag, Pb

GEOLOGIC SETTING: Copper carbonates, silicates, and oxides, and gold and silver, are present in replacement bodies of hematite and within veins of quartz, calcite, and limonite. The veins strike northwest and dip to northeast. Paleozoic metasediments host most of the ore, in particular marbles and quartzites. The veins are part of a low-angle normal fault system.

AGE: This district is part of the Buckskin-Rawhide low-angle detachment system of mid-Tertiary age.

REFERENCES: #19, #167, #168

DISTRICT: CYCLOPIC

PRODUCTION: Au, Ag, Pb, Cu

GEOLOGIC SETTING: The Cyclopic district contains ores formed during two periods of mineralization. The first stage of mineralization is characterized by high-angle, NE-striking, gold-bearing quartz veins that are the result of hydrothermal activity related to a nearby Cretaceous granite. Hosts rocks for this mineralization are Precambrian rapakivi-type granite and gneiss. The Cretaceous gold-quartz veins were then incorporated in a mid-Tertiary detachment fault zone. The second period of gold mineralization is characterized by pervasive argillic and localized ferric alteration. Ferric alteration, accompanied by gold mineralization, is confined to the hangingwall of the detachment fault zone and to the footwall of high angle structures antithetic to the detachment surface.

AGE: Theodore and others (1982) state unequivocally that the deposits of the Cyclopic Mine are related to and localized by a west-dipping, mid-Tertiary, low-angle, detachment fault zone. Other deposits in the district are of inferred Cretaceous age.

REFERENCES: #127, #165, #179A, #194

DISTRICT: EL DORADO PASS

PRODUCTION: Au, Ag, Cu

GEOLOGIC SETTING: Gold is associated with iron oxides in the oxidized portion, and with pyrite and galena in the unoxidized zones. Quartz and shattered quartz crystals are the predominant gangue mineral in these steeply dipping veins. The veins cut Patsy Mine volcanics and Precambrian granite, gneiss and schist.

AGE: The veins are time equivalent or younger than the Patsy Mine volcanics of Miocene age; therefore this district is of middle Miocene age.

REFERENCES: #12, #165, #194
DISTRICT: EMERALD ISLE

PRODUCTION: Cu, Au, Ag

GEOLOGIC SETTING: Chrysocolla, tenorite, and cuprite filling fissure veins and cementing alluvium. This exotic copper accumulation is derived from the Mineral Park porphyry copper deposit and related veins.

AGE: Although the district is designated mid-Tertiary by Keith and others (1983a,b), the alluvium is no older than Pliocene and is probably Quaternary (R. Scarborough, pers. comm., 1984).

REFERENCES: #51, #180, #181

DISTRICT: GREENWOOD

PRODUCTION: Au, Ag, Cu, Pb, (W)

GEOLOGIC SETTING: Precambrian granite, gneiss, aplite, and pegmatite locally overlain by Tertiary volcanic rocks. Half to five meter-wide veins of glassy quartz containing irregular disseminations and bunches of wolframite and scheelite with minor chalcopyrite. Iron and copper staining near the surface is abundant. Sericitic alteration of the wallrocks is noticeable.

AGE: Keith and others (1983a,b) consider this district to be a mid-Tertiary gold district. Reported gold production from this district is minor, and the district is probably more correctly designated tungsten district. A Precambrian or Mesozoic age is possible.

REFERENCES: #45, #119, #192

DISTRICT: LEAD PILL

PRODUCTION: Pb, Au, Cu, Ag

GEOLOGIC SETTING: Quartz veins with galena, fluorite, barite and gold cutting Precambrian gneiss. The veins are related to the intrusives at Potts Mountain. The rhyolites and andesites have a northwest-striking foliation.

AGE: No radiometric ages are available in the Potts Mountain area, but the geologic map of Mohave County (Wilson and Moore, 1959) shows these rocks to be Tertiary.

REFERENCES: #19, #195

DISTRICT: McCONNICO

PRODUCTION: Au, Ag, Cu

GEOLOGIC SETTING: Gold and pyrite in pegmatitic dikes and shears cutting Precambrian
microcline granite. Gold is concentrated in an elluvial placer derived from once overlying mineralized rock. Hypogene ore is probably very low grade.

AGE: A mid-Tertiary age is suggested by Keith and others (1983a,b), but this is speculative since there are insufficient data to make an age determination.

REFERENCES: #96, #165

DISTRICT: McCracken

PRODUCTION: Ag, Pb, Au, Cu

GEOLOGIC SETTING: Argentiferous galena with quartz-calcite-barite-gangue filling fissure veins in Precambrian gneiss and schist. Evidence for brecciation is abundant in both veins and country rock. Keith and others (1983a,b) suggest that this district is related to a mid-Tertiary low-angle breccia zone, perhaps suggesting detachment related mineralization. However, some veins dip steeply (65) and the Buckskin-Rawhide detachment fault is probably several hundred meters below the surface in this area.

AGE: Age is unknown, although if mineralization is related to detachment faulting, it is mid-Tertiary.

REFERENCES: #165, #177

DISTRICT: Mesa

PRODUCTION: Mn

GEOLOGIC SETTING: Psilomelane and pyrolusite in fractures and podiform masses cutting calcite marble, with less important bedded manganese deposits in reddish, sandy sediments resembling the Chapin Wash Formation of Laskey and Webber (1949).

AGE: These sediments are probably correlative with the Miocene Chapin Wash formation.

REFERENCES: #63, #69, #137, #177

DISTRICT: Minnesota

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: Horn silver in gangue of iron-stained, crushed and brecciated quartz forming veins that flatten with depth. The veins cut Precambrian granite gneiss, schists, and Patsy Mine volcanics.

AGE: Several K-Ar dates indicate that the Patsy Mine volcanics are middle Miocene in age. The veins are clearly younger than earliest Patsy Mine volcanism, but are probably related to the same pulse of mid-Tertiary magmatism. A mid-Tertiary age seems almost certain.
REFERENCES: #12, #165

DISTRICT: OATMAN

PRODUCTION: Au, Ag, Cu

GEOLOGIC SETTING: Quartz-calcite-adularia veins bearing electrum cut the Gold Road and Oatman latites. The veins strike NW and in many cases are associated with late-stage rhyolite porphyry dikes. Sulfides are rare except for pyrite in wallrocks adjacent to the veins. Propylitic alteration is district wide, while an alunite-illite-montmorillonite alteration assemblage lies above all productive veins in the district.

AGE: K-Ar dates from the Oatman district volcanics give late Oligocene to early Miocene ages. The mineralization is almost certainly related to volcanism, and hence is of mid-Tertiary age.

REFERENCES: #37, #118, #143, #165, #183

DISTRICT: OWENS

PRODUCTION: Ag, Au, Pb, Cu, Zn

GEOLOGIC SETTING: Veins and replacements above a mid-Tertiary detachment fault. This district is in close geographic proximity to the Buckskin-Rawhide detachment fault system, and Keith and others (1983a,b) infer that mineralization is related to faulting. A thorough literature review did not reveal any substantive geologic descriptions of this mineral district, and the relationship of mineralization to detachment faulting should be considered speculative at present.

AGE: If mineralization is related to the Buckskin-Rawhide detachment fault, then this is a mid-Tertiary mineral district; should this relationship not be demonstrable then the age should be considered unknown.

REFERENCES: #106, #107, #167, #168

DISTRICT: PILGRIM

PRODUCTION: Au, Ag

GEOLOGIC SETTING: Free gold in veins cutting across the fault contact between hangingwall rhyolites and footwall andesites. The volcanic rocks are probably equivalent to the Patsy Mine volcanics. Rhyolite porphyry dikes are commonly found in the fault zones. Veins are filled by quartz, calcite, pyrolusite and minor sulfides. Wallrocks are extensively silicified and brecciated. Red fault gouge and waxy green-yellow quartz mark high-grade ore zones.

AGE: If these volcanic rocks are time equivalent with the Miocene Patsy Mine volcanics, then a mid-Tertiary age is appropriate. There is little doubt about the
correlation.

REFERENCES: #12, #165, #194

DISTRICT: PINE PEAK

PRODUCTION: Au, Zn, Pb, Ag, Cu

GEOLOGIC SETTING: Gold in a steeply-dipping, east-west striking, oxidized gouge zone cutting Precambrian amphibolite schist.

AGE: Keith and others (1983a,b), propose that this district is related to a northwest trending dike swarm. Very little is known about this district, and late Cretaceous-Tertiary intrusives have been mapped in the vicinity. Although a mid-Tertiary age has been proposed by Keith and others, a late Cretaceous - early Tertiary age is a distinct possibility. Since most mid-Tertiary dikes in Arizona are northwest-trending, it would be especially important to establish a relationship between mineralization and dike emplacement in order to more confidently propose a mid-Tertiary age.

REFERENCES: #15, #106, #107

DISTRICT: RAWHIDE

PRODUCTION: Pb, Au, Cu, Zn, An

GEOLOGIC SETTING: Anglesite, cerussite, and chrysocolla with minor gold and silver in hematite replacement bodies. Host Paleozoic limestones overlie a low-angle normal fault underlain by mylonitic gneiss.

AGE: Mineralization is related to the mid-Tertiary Buckskin-Rawhide detachment fault, therefore the age of mineralization is mid-Tertiary.

REFERENCES: #15, #167, #168

DISTRICT: UNION PASS

PRODUCTION: Au, Ag

GEOLOGIC SETTING: Finely divided gold in quartz-calcite stringers, lodes, and veins cutting Precambrian Katherine granite and local rhyolite. Veins are commonly associated with rhyolite porphyry dikes are are nearly vertical and vuggy. High-grade zones are marked by the presence of adularia and/or manganese oxides. Fluorite and iron staining are also present. Wallrocks proximal to the veins are typically shattered and silicified; those distal from the veins may be kaolinized.

AGE: Mid-Tertiary age by analogy to the adjacent Oatman district.

REFERENCES: #118, #165, #194
DISTRICT: VIRGINIA

PRODUCTION: Au, Ag, Cu, Pb

GEOLOGIC SETTING: Free gold in quartz-hematite-calcite veins with minor amounts of adularia and epidote cutting Patsy Mine volcanics and Precambrian granites and metamorphic rocks. Vein dips vary from steep to flat-lying. The mines are all near the Epperson Fault, and veins are spatially associated with diabase dikes.

AGE: The veins of the district cut the mid-Tertiary Patsy Mine volcanics and are probably related to the mid-Tertiary magmatic pulse. A mid-Tertiary age seems almost certain.

REFERENCES: #12, #124, #165, #194

DISTRICT: WHITE HILLS

PRODUCTION: Ag, Au, Cu, Pb

GEOLOGIC SETTING: The source of ore in the White Hills district is NW striking, moderately to steeply dipping veins cutting Precambrian (?) gneissic granite and amphibolite schist. The locally brecciated veins consist of quartz, manganese and iron oxides, silver chlorides and horn silver. Vesicular hornblende-augite andesite and agglomerate overlie the basement. Schrader (1909) suggests the veins are related to feeder dikes of the overlying volcanic rocks.

AGE: The volcanic rocks of the White Hills district are probably correlative with the Mt. Davis volcanics dated by Anderson and others (1972) as mid-Tertiary. A mid-Tertiary age for the White Hills district seems likely.

REFERENCES: #12, #165

DISTRICT: YELLOW JACKET

PRODUCTION: Zn, Ag, Au, Cu, Pb

GEOLOGIC SETTING: Keith and others (1983a,b) report that mineralization occurs as veins and replacements. The production data is from one year of mining activity in the 1970's, and as yet there is no published geologic information concerning this mineral district.

AGE: So little is known about this district that any age call is extremely speculative.

REFERENCES: #106, #107

DISTRICT: YUCCA

PRODUCTION: Mn
GEOLOGIC SETTING: Wad-like oxides intimately mixed with sandy sediments in lenses interlayered with barren sandstone, and cut by psilomelane and pyrolusite filled fractures. Fragments of brecciated country rock, calcite, barite, and iron oxides are the primary gangue minerals in the fractures.

AGE: The host rocks are probably correlative with the Miocene Chapin Wash Formation and thus the bedded manganese is Miocene in age. The veins are possibly related to hot springs of probable Miocene age.

REFERENCES: #63, #69, #136

PIMA COUNTY

DISTRICT: ARAVACA, (OCEANIC)

PRODUCTION: Cu, Au, Ag, Pb, Zn

GEOLOGIC SETTING: The country rocks of the Arivaca-Oceanic district are Mesozoic sandstones, conglomerates, and shales that are disrupted by east-west-trending faults. A second, lengthier set of faults trend N45W and are commonly intruded by Laramide intermediate dikes. Ore minerals are argentiferous-auriferous galena, sphalerite, chalcopyrite, native gold, wolframite, scheelite, silver chlorides and pyrite. Mineralization is scattered and frequently associated with Tertiary-Cretaceous intrusives. Historically, three areas with various styles of mineralization have fallen under the Arivaca district. A Laramide tungsten district in the northwest Las Guijas Mountains, a gold-base metal district in the central and southern Las Guijas Mountains, and a mid-Tertiary gold district in the San Luis Mountains are all included in the Oceanic district as defined by Keith and others (1983).

AGE: The virtual absence of middle Tertiary rocks and the extensive outcrop of Cretaceous-Tertiary dikes make a late Cretaceous or Paleocene age most likely for the deposits in the Las Guijas Mountains.

REFERENCES: #14, #102, #108, #197

DISTRICT: BABOQUIVARI

PRODUCTION: Au, Ag, Cu, Pb

GEOLOGIC SETTING: The Baboquivari Range has a complex history of Mesozoic through Tertiary magmatism with lower Jurassic silicic volcanics, an upper Jurassic granodiorite batholith, early Tertiary granite, and a mid-Tertiary magmatic episode with lamprophyre and rhyolite dikes. The Allison Mine is the major producer in the district and has ore in pods and breccia related to dike swarms and sills. Native gold, argentite, and silver-gold chlorides are the major ore minerals. Keith (1974) proposes a discernable district-wide metal zonation pattern where precious and base metal mineralization is bound by tungsten on the north and south margins. The orebodies are commonly associated with rhyolite dike swarms that yielded a 26 m.y. K-Ar age.
AGE: The probable genetic association of the orebodies with the dated rhyolite dikes indicates a mid-Tertiary age.

REFERENCES: #53, #66, #68, #84, #88, #101, #108, #185, #194

DISTRICT: BEN NEVIS

PRODUCTION: Ag, Au, Cu, Pb

GEOLOGIC SETTING: This small district is characterized by quartz-calcite-barite veins cutting Tertiary rhyolites. The typically epithermal veins follow fault zones in an irregular and lensing fashion. Free gold and silver chlorides are the primary ores with a minor base metal component.

AGE: The mines of the Ben Nevis district are localized along the contact between Tertiary rhyolite and andesite (Rytuba and others, 1978). This volcanic package is as yet undated, although a Miocene age is probable for these units, and the district itself.

REFERENCES: #75, #101, #160

DISTRICT: BLACK DRAGON

PRODUCTION: Mn

GEOLOGIC SETTING: Hard and soft wad-type oxides with small amounts of pyrolusite have partially replaced, and occur as coatings and narrow fracture fillings in, a sheared or fractured rhyolite. Haxel and others (1980) map the area as Jurassic rhyodacite porphyry of the Mulberry Wash Volcanics Formation. The mineralized zones are discontinuous for nearly 700 meters of strike length. The mineralized fractures can be traced along the surface by their capping of desert varnish.

AGE: The mineralization is hosted by Jurassic rocks; therefore, the age of mineralization is Jurassic or younger.

REFERENCES: #70, #84, #101

DISTRICT: CADILLAC

PRODUCTION: Mn

GEOLOGIC SETTING: Seventy meters of strike length have been explored along the fault contact between Tertiary fine-grained basalt and vesicular basalt; the contact strikes N15W, and dips 60°E. Manganese minerals are present in a breccia zone 1-2 meters wide against the vesicular basalt. Psilomelane has replaced much of the cementing material of the breccia zone and appears as rims around unreplaced basalt fragments. Adjacent to the breccia zone the sheared and shattered basalt contains manganese oxides in thin fracture fillings and small nodules.
AGE: Kahle and others (1978) assign a Tertiary age to the host basalts; therefore, the age of mineralization is Tertiary or younger.

REFERENCES: #70, #99

DISTRICT: CERRO DE FRESNAL

PRODUCTION: Au, Ag, Cu

GEOLOGIC SETTING: The Cerro de Fresnal District is on the western margin of an extensive northeast-trending silicic volcanic field. The western edge of the district is in a Laramide granite. Ore minerals include silver and gold chlorides in a fissure zone, and weathered and oxidized quartz veins with free gold and silver.

AGE: Keith and others (1983a,b) infer that a 30 to 25 m.y.-old northwest-striking dike swarm is the agent of mineralization. However, a genetic relationship between mineralization to dike emplacement has not been established, and a Laramide age of mineralization is a distinct possibility.

REFERENCES: #101, #197

DISTRICT: RINCON

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: The Rincon district is in the upper plate of the mid-Tertiary Catalina detachment fault. The Colossal Cave area is dominated by the southwest dipping Catalina detachment fault and numerous north-trending normal faults. A Laramide pluton intrudes Precambrian Apache Group and Paleozoic sediments. Mineralization includes spotty pockets of lead and copper oxides as replacements in Paleozoic limestones. Epidote, pyrite, garnet, and limonite accompany extensive silicic alteration. A brecciated-barite bearing fault zone in Paleozoic limestone represents a separate style of mineralization.

AGE: Mid-Tertiary structural disruption in this area has been severe. It is likely that the brecciated barite in the fault zone is mid-Tertiary, but the age of the replacement deposits is uncertain. Mid-Tertiary replacement deposits in limestone occur above mid-Tertiary detachment faults in western Arizona, indicating that the replacements could be mid-Tertiary.

REFERENCES: #1, #57, #101, #110, #182, #188

PINAL COUNTY

DISTRICT: COPPER BUTTE

PRODUCTION: Cu, Ag, Au, Pb
GEOLOGIC SETTING: The Copper Butte deposit is in the Oligocene Whitetail conglomerate. The conglomerate is poorly sorted and consists of angular clasts of Pinal Schist. The Whitetail variously rests on Precambrian Pinal Schist intruded by Ruin Granite, or upon Paleozoic sediments. The deposit and its enclosing conglomerate are bounded by Miocene Apache Leap Tuff. Ore minerals are chrysocolla and black copper wad. The deposit is not clastic copper, but rather it is a precipitate from groundwater. The protore source is unknown and Philips (1976) suspects the nearby presence of an as yet unfound porphyry copper deposit. However, it is possible that prior to middle to late Tertiary low-angle normal faulting, the deposit was located closer to porphyry copper mineralization near Ray.

AGE: By analogy to other exotic copper bodies, the mineralization is presumed to be middle to late Cenozoic.

REFERENCES: #13, #140, #141, #185

DISTRICT: CRESCENT

PRODUCTION: Mn

GEOLOGIC SETTING: The most important manganese deposits are along fracture zones in the Precambrian Mescal Limestone and Dripping Spring Quartzite. A few small deposits have been found along narrow fractures in the fanglomerates of the San Manuel Formation which overlie the Precambrian rocks. Most of the mineralized fracture zones follow bedding planes in the older rocks. The ore minerals consist of psilomelane, pyrolusite, and manganite, which occur in irregular lenticular masses, veinlets, and interlacing seams surrounding fragments of unreplaced wallrocks. The chief gangue minerals are iron oxides, quartz, and calcite.

AGE: The presence of deposits in the mid-Tertiary San Manuel Formation indicates a mid-Tertiary or younger age. We favor a mid-Tertiary age because this was a time of widespread magmatism and tectonism, in contrast to younger, relative quiescence.

REFERENCES: #70

DISTRICT: GREENBACK

PRODUCTION: Au, Ag, Cu

GEOLOGIC SETTING: The general geology of the Greenback district is characterized by late Cretaceous through middle Tertiary volcanics and minor faulting. Laramide granite, hornblende porphyry, and dacite constitute the majority of outcrops. The Copperosity Mine is the major producer in the district. Here the ore occurs in veins, and replaces Paleozoic limestone. Ore minerals are chrysocolla, malachite, azurite, copper pitch, and native copper. Gangue are jasper, hematite, goethite, and jarosite. Other deposits occur as quartz veins in dacite and granite. The Greenback district may be distal and contemporaneous with the Pinal Grande mineral district, a porphyry copper system.

AGE: The abundance of Laramide intrusives in the area is suggestive of a Laramide
The Mammon District lies mostly in Precambrian Pinal schist. The district's northern perimeter contains Precambrian Apache Group sediments cut by a major N20-trending fault and numerous lesser E-W trending faults. The northern reaches of the district contain similarly faulted sections of Paleozoic sediments. District ore geology includes limestone replacements in Mississippian Escabrosa limestone; vein fillings in Laramide(?) andesite porphyry with oxides and sulfates of lead, zinc, silver, vanadium, and free gold with notable advanced argillic alteration; schist-hosted quartz veins with chrysocolla, malachite, cerargyrite, wulfenite, vanadinite; and free gold with epidote, chlorite, pyrite gangue at the Mammon mine.

The presence of pebble dikes, the lead-zinc-copper element suite, and the proximity of the 67 m.y.-old Lakeshore porphyry copper all suggest Mammon mineralization may be related to the Laramide Lakeshore system.

Precambrian Oracle quartz monzonite is the major country rock of the Mammoth district. Tertiary intrusive rhyolite breccia is the predominant ore host, and Oracle quartz monzonite is a lesser host. Mineralization centers on the northwest-trending Mammoth and Dream faults, and is associated with significant silicic alteration. Sphalerite, galena, and molybdenite are the major ore minerals with fluorite and barite as common gangue.

The veins intrude the late Oligocene Cloudburst volcanics and are cut by the Miocene San Manuel fault; this indicates a mid-Tertiary age.

The Martinez Canyon district is in a thin sequence of Miocene siliceous volcanics that rest on Precambrian Pinal Schist. Most of the mines fall along a north-trending fault system. The mineralogy includes galena, cerussite, anglesite, hematite, azurite, chrysocolla, pyromorphite, cerargyrite, embolite, quartz, limonite, fluorite, and barite.
AGE: Creasey (1978) reports dates on biotite of 17.4 m.y.B.P. for the quartz latite which is assumed to be contemporaneous with mineralization.

REFERENCES: #15, #164, #178, #179, #185

DISTRICT: MINERAL HILL

PRODUCTION: Ag, Cu, Au, Pb, Zn

GEOLOGIC SETTING: Pinal Schist is the prevailing country rock in the Mineral Hill district. North- to N40W-trending shear zones punctuate the terrane and control mineralization. Galena dominates with lesser sphalerite, cerargyrite, argentite, cerussite, and anglesite. ABGMT file data include the Reymert Mine as the northern extension of the district. The Reymert has black calcite, manganese-silver ore which is frequently characteristic of mid-Tertiary precious metal mineral districts.

AGE: ABGMT file data and Keith and others (1983a,b) infer that 18 to 15 m.y.-old, quartz latite dikes adjacent to the district are genetically related to mineralization. A north- to northwest-trend of the mineralized shear zones is supportive of a mid-Tertiary age.

REFERENCES: #16, #164, #179, #185

DISTRICT: MINERAL MOUNTAIN

PRODUCTION: Au, Cu, Ag

GEOLOGIC SETTING: The Mineral Mountain occurrence is similar to Martinez Canyon. The geology of the district is characterized by an intensely faulted section of Precambrian crystalline rocks that are overlain by Miocene silicic volcanics and intruded by dominantly N25W- to north-trending quartz latite dikes. The vast majority of the mineralization is localized along these dikes. The south end of the district has a east-west- to N80W-trending fault zone that marks the southern end of mineralization. Galena, anglesite, cerussite, native gold, and native silver are ore minerals.

AGE: Theodore and others (1978) propose a late Cretaceous-early Tertiary age for the deposit by inference that mineralization is related to the 71 m.y. Mineral Mountain pluton. In contrast, ABGMT file data and Keith and others (1983a,b) infer a mid-Tertiary age based on the close association of mineralization with 15.8 to 17.4 m.y.-old quartz latite dikes. The Miocene age of mineralization is preferred.

REFERENCES: #178, #179, #185

DISTRICT: OWL HEAD

PRODUCTION: Cu, Ag, Au

GEOLOGIC SETTING: The Owl Head mineralization is restricted to middle Tertiary
volcanic rocks that rest on the Guild Wash low-angle, normal fault. Beneath this detachment surface are the mylonitized Precambrian rocks of the Tortolita and Suizo Mountains. Chalcocite, chrysocolla, and chalcopyrite are common. Malachite, azurite, native gold, argentiferous galena, argentite, and tenorite are also reported. Specularite is extensive as is sericitic and propylitic alteration. Local placer magnetite deposits have recorded production.

AGE: A mid-Tertiary age for mineralization is almost certain based on the association of mineralization with a mid-Tertiary fault and with mid-Tertiary volcanic rocks.

REFERENCES: #22, #23, #24, #25, #32, #104

DISTRICT: PICACHO

PRODUCTION: Au, Cu, Ag

GEOLOGIC SETTING: Two areas, one in the vicinity of Picacho Peak and a second to the NE, both fall within the Picacho district as defined by Keith and others (1983a,b). The southern part of the district, near Picacho Peak at the SSW end of the Picacho Range, consists of a basalt and basaltic agglomerate of Miocene age, and is in the upper plate of a detachment fault. Northwest-trending structures control the mineralization which consists of chrysocolla, copper oxides, and specularite. The northern part of the district is in the main portion of the Picacho Range and consists of mylonitic Precambrian and Cenozoic rocks. This area is the lower plate of the detachment terrane and the mylonitic gneisses appear to represent a northwest continuation of mylonitic gneiss in the Rincon, Santa Catalina, and Tortolita mountains. Mineralization here consists of chrysocolla, malachite, azurite, and extensive specularite in quartz veins. The deposits are in Precambrian granite gneiss and diabase dikes with occasionally associated andesite dikes.

AGE: The association of mineralization with a mid-Tertiary low-angle normal fault and with mylonitic gneiss of probable mid-Tertiary age is suggestive of a mid-Tertiary age. Mineralization within mid-Tertiary volcanic rocks at the southwest end of the range must be mid-Tertiary or younger.

REFERENCES: #22, #29, #52

DISTRICT: RANDOLPH

PRODUCTION: Ag, Pb, Au, Cu

GEOLOGIC SETTING: Keith and others (1983a,b) infer northwest-striking, middle Tertiary veins to be associated with a probable 18-15 m.y.-old northwest-striking rhyolitic dike swarm. ABGMT file data indicates that the veins trend northeast and cut Precambrian diabase and granite.

AGE: The northeast trend of the veins, if true, is suggestive of a Laramide age.

REFERENCES: #106, #107, #147
DISTRICT: SAWTOOTH

PRODUCTION: Mn

GEOLOGIC SETTING: The Sawtooth district in the northern end of the Sawtooth Mountains, contains deposits that are hosted by Tertiary basalt, latite, and trachyandesite flows and are confined to northeast- or northwest-striking, steeply-dipping fractures and faults. Ore occurs as lenses, pods, replacements, and veinlets in and surrounding brecciated fragments of the country rock. Manganese oxides, psilomelane and pyrolusite are found in a gangue of calcite, which is locally manganiferous.

AGE: The manganese ores are hosted by undated Tertiary volcanics, which are lithologically similar to known mid-Tertiary volcanics in neighboring mountain ranges. The age of mineralization is likely mid-Tertiary.

REFERENCES: #26, #27, #70

DISTRICT: SILVER REEF

PRODUCTION: Ag, Cu, Au, Pb

GEOLOGIC SETTING: Mineralization in the Silver Reef district is intimately associated with Tertiary vesicular andesite that overlies Oracle Granite and with dikes that intrude Pinal Schist. The deposits are localized along east-west trending faults and fissures. Native silver, galena, argentite, cerargyrite, wulfenite, vanadinite, and chrysocolla are reported ore minerals.

AGE: The volcanics have been dated at 25.3 m.y.-old and presumed to be contemporaneous with ore formation. A younger age is possible for the mineralization.

REFERENCES: #20, #27, #36, #81, #158

DISTRICT: SLATE

PRODUCTION: Ag, Au, Pb, Cu

GEOLOGIC SETTING: deposits consist of veins and limestone replacement occurrences related to andesite porphyry dikes and sills. Silver-rich galena and free gold are found associated with quartz, pyrite, and sphalerite. The veins are extensively brecciated, and the wallrocks are silicified, pyritized, sericitized, and argillized. Replacement deposits are confined to Paleozoic limestones that are recrystallized and pyritized. Both vein and replacement deposits are oxidized as indicated by abundant iron and manganese oxides and base metal oxides and carbonates.

AGE: These deposits are intimately related to andesite dikes and sills. Heindl(1960) correlates the dikes and sills of the Slate Mountains with those of the Ajo area and/or the Tucson Mountains, both of Laramide age. These correlations are highly speculative, so the age of mineralization could be either Laramide or mid-Tertiary.
REFERENCES: #27, #81, #87

DISTRICT: SUPERSTITION MOUNTAINS

PRODUCTION: Au, Cu, Ag

GEOLOGIC SETTING: The Superstition Mountains prospects are along an east-west trend that flanks the southern end of the Superstition volcanic complex. The volcanic complex is a thick, diverse sequence of Miocene age. Mineralization occurs in both Precambrian Ruin Granite and Tertiary volcanics. Peterson and Jinks (1983) describe a predominantly base metal character in contrast to the gold-pyrite ore of the nearby Goldfield district, and report that there has been no production from the Superstition Mountains district.

AGE: A middle Tertiary or younger age is certain since deposits are in part hosted by middle Tertiary volcanic rocks.

REFERENCES: #129, #137, #138

DISTRICT: TABLE MOUNTAIN

PRODUCTION: Cu, Au, Ag

GEOLOGIC SETTING: Rocks of the Table Mountain area are cherty and dolomitic Mississippian Escabrosa Limestone overlain unconformably by the lower andesite unit of the middle Tertiary Galiuro Volcanics. The north end of the eastern contact between the limestone and volcanics is a northwest-striking fault, but the remaining contacts are depositional (Simons, 1964). The principal ore-bearing rock is a layer of gray or mottled red, brown, and white massive jasperoid or jasperoid breccia. The jasperoid zone contains chrysocolla, malachite, azurite, dioptase, and other base metal oxides and carbonates. The ore minerals are found in irregular concentrations and pods along fault and joint surfaces. Other than jasperoid, only quartz and barite are common gangue minerals.

AGE: The Table Mountain deposits may have been derived from the nearby Laramide Copper Creek porphyry copper system to the southwest as Keith and others (1983b) suggest. Simons (1964) suggests that ore deposition occurred prior to the deposition of the Galiuro volcanics, but the age of mineralization is not well constrained, except that it predates the Galiuro Volcanics.

REFERENCES: #40, #116, #170, #172, #185

DISTRICT: WOOD CAMP CANYON

PRODUCTION: Cu, Ag, Au

GEOLOGIC SETTING: Keith and others (1983a,b) suggest that the Wood Camp Canyon district is a middle Tertiary porphyry copper system associated with the Wood Camp Canyon pluton. Lowell (1974, and pers. comm., 1985) describes disseminated copper
mineralization of subeconomc grade and tonnage in this area. Peterson (1960) states that the intrusive relationships between the Wood Camp pluton and the overlying Apache Leap Tuff are uncertain. Map relationships suggest that this pluton is in fault contact with the Apache Leap Tuff and may not be intrusive.

AGE: The age of this district depends critically upon the nature of the Wood Camp Canyon pluton - Apache Leap Tuff contact. If this contact is intrusive, then the district is of middle Tertiary age, but if this is a fault contact, as map relations suggest, then the Wood Camp Canyon mineralization is more likely Laramide.

REFERENCES: #124A, #136B

DISTRICT: ZIG ZAG

PRODUCTION: Mn

GEOLOGIC SETTING: Hard psilomelane occurs in a gangue of manganiferous calcite and quartz in high-grade streaks and veinlets along three parallel veins in coarse-grained granitic rocks. The veins strike N10W to N25W, dip steeply to the southwest, and are up to 30 meters apart. Where the granite is shattered, a network of thin seams of manganese minerals may extend outward for several meters beyond the veins.

AGE: The age of this district is unknown, but may be middle Tertiary based on the north-northwest strike of the veins.

REFERENCES: #70

SANTA CRUZ COUNTY

DISTRICT: AUSTERLITZ - YELLOW JACKET

PRODUCTION: Au, Ag, Cu, Pb

GEOLOGIC SETTING: Mineralization in the Austerlitz district is found in tabular lenses associated with northwest-trending rhyolite dikes. The Jurassic Cobre Ridge tuff is the major country rock. Quartz veins containing native gold, native silver, chrysocolla, and pyrite are the ore assemblage. The Little Doe Mine hosts minor uranium mineralization.

AGE: The northwest trend of rhyolite dikes intimately associated with the ore is suggestive of a middle Tertiary age.

REFERENCES: #71, #108, #113, #185

DISTRICT: CAVE CREEK

PRODUCTION: Cu, Ag, Pb
GEOLOGIC SETTING: The Cave Creek district as defined by Keith and others (1983a,b) is poorly known. The deposits consist of spotty, oxidized, silver-rich, copper mineralization filling fault contacts and along intrusive contacts. The deposits are hosted by Cretaceous Fort Crittenden Formation and Triassic Mount Wrightson Formation (Drewes, 1971).

AGE: Keith and others (1983a,b) propose a mid-Tertiary age for this district based upon a spatial relationship with rhyolitic dikes of Oligocene(?) age (Drewes, 1972). The dikes are undated; yet they post-date regional Laramide mineralization and unconformably underlie Oligocene age Pantano Formation (Drewes, 1972). Drewes (1972) proposes a Paleocene to Oligocene age for these rocks. The genetic relationship between these dikes and the Cave Creek occurrences is not at all clear, and further geologic evaluation is necessary to document the importance of these dikes to the weakly mineralized Cave Creek deposits. A Laramide age for this district is permissible. The Cave Creek district is ringed by Laramide age mineral districts (Keith and others, 1983a,b).

REFERENCES: #55, #56, #102

DISTRICT: ORO BLANCO

PRODUCTION: Pb, Zn, Ag, Au, Cu

GEOLOGIC SETTING: Mesozoic rhyolites, quartz latite ash flows, tuffs, and arkose overlain by late Cretaceous terrestrial sediments are the major stratigraphic units in the Oro Blanco district. Laramide plutons are abundant and include the late Cretaceous Ruby Diorite and the Paleocene-Eocene Sidewinder Quartz Monzonite. Three types of ore are noted: quartz veins filling fractures with lenses containing galena, chalcopyrite, sphalerite, tetrahedrite, and pyrite; native silver and gold in flat, shallow faults with strongly pyritized and silicified quartz monzonite dikes; and steeply dipping, tabular zones of argillitized, brecciated tuff with trace uranium mineralization.

AGE: The near absence of middle Tertiary igneous rocks, the overwhelming abundance of Cretaceous through Paleocene intrusives, and the varied base metal character of the ore all suggest a Laramide, not middle Tertiary, age. The presence of precious metal mineralization in low-angle faults and occasional uranium values suggest that some mineralization is middle Tertiary, although the production statistics point to preeminence of the Laramide age deposits.

REFERENCES: #102, #111, #113, #185, #187

YAVAPAI COUNTY

DISTRICT: BATTLE FLAT

PRODUCTION: Ag, Cu, Au, Pb, Zn

GEOLOGIC SETTING: Bedrock within the Battle Flat district consists of the Precambrian
Brady Butte granodiorite and surrounding metasediments of the Texas Gulch Formation and metavolcanics of the Spud Mountain volcanics. Ore is associated with northeast-trending feldspar porphyry dikes of possible Laramide age that parallel the trend of foliation and faulting in the Precambrian rocks. The orebodies consist of quartz-pyrite veins with native silver, silver chlorides and oxides, and argentiferous galena. Spatz (1974) describes a similar geologic setting for parts of the Pine Flat district, 5 km to the north; this district is a porphyry copper prospect of Laramide age.

AGE: Keith and others (1983a,b) suggest a mid-Tertiary age for the veins of the Battle Flat district. The northeast trend of the veins and proximity to the Pine Flat district suggest that this district is of Laramide age.

REFERENCES: #7, #120, #173, #185

DISTRICT: BLACK CANYON

PRODUCTION: Au, Ag, Pb, Cu, Zn

GEOLOGIC SETTING: The bedrock of the Black Canyon district consists of Precambrian metasedimentary and metavolcanic rocks near and within the north-trending Shylock fault zone. The southern portion of the district is adjacent to the Precambrian Crazy Basin batholith. Dikes ranging in composition from basalt to rhyolite are, in many areas, spatially if not genetically related to the ore deposits. Native silver, ruby silver, silver chlorides and minor free gold are common ore minerals. Precious metal mineralization is associated with galena, pyrite, sphalerite, and minor chalcopyrite in low-angle quartz-calcite-siderite veins. The veins are discordant to the dominant northeast-trending foliation of the Precambrian metamorphic rocks, and commonly dip to the southeast. Wallrocks are locally affected by intense sericitization and silicification.

AGE: The dikes associated with mineralized material in the Black Canyon district are undated, but thought to be Miocene (E. DeWitt, written comm.). The high silver content and low-angle nature of the veins also points to a mid-Tertiary age of mineralization according to DeWitt (written comm.).

REFERENCES: #4, #5, #6, #114, #120, #185, #194

DISTRICT: BLACK DOME

PRODUCTION: Mn

GEOLOGIC SETTING: Pyrolusite and psilomelane occurring in fractures, seams, and small irregular masses surrounding brecciated fragments of Miocene volcanic rocks and Precambrian granitic rocks. The deposit also contains large amounts of calcite (travertine?), much of it manganiferous.

AGE: The deposits are hosted, in part, by mid-Tertiary volcanic rocks, indicating that they are mid-Tertiary or younger in age. A middle to late Tertiary age is
favored as this was a time of widespread magmatism.

REFERENCES: #69

DISTRICT: BLACK HILLS

PRODUCTION: Cu, Ag, Au, Pb, Zn

GEOLOGIC SETTING: There is scant information available for this district. Lindgren (1926) describes the deposits as consisting of quartz-calcite veins with variable amounts of sphalerite, galena, pyrite, bornite, tetrahedrite, and tennantite. Oxidized portions of the veins are characterized by ankerite, azurite, and malachite. The east-west-trending, low-angle veins cut the volcanics of the upper unit of the Precambrian Grapevine Gulch Formation near the north-trending Shylock Fault.

AGE: The district has been designated mid-Tertiary by Keith and others (1983a,b) because the deposits are related to a series of east-west-trending dikes. The presence of these dikes is not confirmed in the literature; they are neither mapped by Anderson and Creasey (1967), nor described by Lindgren (1926). The timing of this mineralization is unknown and the basis of Keith and others's (1983) age determination is equivocal. E. DeWitt (written comm.) proposes that the high silver and lead content and low-angle nature of the veins suggests a mid-Tertiary age.

REFERENCES: #9, #120

DISTRICT: BLACK ROCK

PRODUCTION: Au, Cu, Ag, Pb, Zn

GEOLOGIC SETTING: The bedrock in the Black Rock district consists of Precambrian amphibolite-grade metaigneous rocks, granite gneiss, and granite. Northwest-striking Miocene (?) rhyolite porphyry and mafic dikes cross-cut the east-northeast-striking fabric of the Precambrian rocks. The mafic (andesite?) dikes are locally altered and cross-cut by epithermal quartz-pyrite-siderite-fluorite veins. Chalcopyrite, galena, arsenopyrite and tetrahedrite are common ore minerals. Secondary specularite and chrysocolla occurs locally in the northwest-striking high-angle quartz-sulfide veins. The Monte Cristo mine contains nickel-cobalt arsenates and sulfides (Nichols, 1983). In contrast, the Grijalva and Oro Grande mines are characterized by pyritic copper-gold ores in thick, high-angle, northeast-striking quartz veins. The latter two vein deposits may have been rotated during middle Tertiary faulting.

AGE: The majority of the Black Rock district orebodies have northwest trends and, therefore, appear to be associated with mid-Tertiary listric normal faults that rotate Precambrian basement and the Tertiary volcanic cover in the Wickenberg area. The distinctly different trend and character of the Grijalva and Oro Grande mines suggests a Laramide age for these deposits.

REFERENCES: #4, #5, #79, #84, #134, #185, #194
DISTRICT: BOX CANYON

PRODUCTION: Mn

GEOLOGIC SETTING: Manganese mineralization occurs along steeply-dipping fractures in a volcanic breccia. The highest grade ore is found in disconnected lenticular bodies spaced discontinuously along the fracture zones. The manganese minerals, consisting of a mixture of the common oxides, occur as irregular shoots and veinlets surrounding unreplaced fragments of the volcanic breccia. Calcite, quartz, and wallrock inclusions are the principal components of the gangue.

AGE: Volcanic breccias manganese deposits are probably mid-Tertiary in age, indicating that mineralization is mid-Tertiary or younger. A mid-Tertiary (early to middle Miocene) age is favored.

REFERENCES: #69

DISTRICT: BURMISTER

PRODUCTION: Mn

GEOLOGIC SETTING: Psilomelane with opal and chalcedony in disconnected masses distributed erratically within a flat-lying bed of travertine interbedded with the Hickey Formation.

AGE: The Hickey Formation is composed dominantly of basalt of middle to late Miocene age, therefore, the manganese deposits late Miocene.

REFERENCES: #69

DISTRICT: BULLARD

PRODUCTION: Au, Cu, Ag

GEOLOGIC SETTING: The Bullard district includes two areas of mineralization: the area around Bullard Peak near the foot of the eastern Harcuvar Mountains, and the Nellie Meda Mine northeast of Aguila. The mines near Bullard Peak lie in close proximity to the Bullard detachment fault. The deposits consist of copper-stained fault gouge with quartz, calcite, barite, and minor fluorite. The brecciated and oxidized ore consists mainly of chrysocolla and malachite with minor chalcopryte. Hematite and manganese oxides are also prevalent. The wallrocks are interbedded Miocene andesites and sandstones.

AGE: Mineralization in the Bullard Peak area occurs within andesites that have been dated by Scarborough and Wilt (1979) as Miocene. The presence of a nearby detachment fault and dated volcanic rocks indicate that mineralization is mid-Tertiary in this area. Ore deposits of the Nellie Meda mine are hosted by Precambrian crystalline rocks, and are of uncertain age.

REFERENCES: #21, #153, #163
DISTRICT: CASTLE CREEK

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: The country rocks in the Castle Creek district are many and varied. Precambrian metasedimentary schists with a northeast-trending foliation predominate, Precambrian granite crops out locally, and Tertiary(?) andesite to rhyolite flows are typically associated with mineralization. A N10W to N40W trending, low-angle fault is the dominant locus of mineralization. Native gold, galena, sphalerite, chrysocolla, copper carbonates, and chalcocite are ore. Quartz, limonite, barite, pyrite, tourmaline, and abundant specularite are gangue. Lindgren (1926) outlines evidence that the copper-gold and lead veins are pre-middle Tertiary. This argument is not easily supported and the varied mineralogy suggests more than one phase of ore formation. The Independence Mine, for example, has native silver, argentiferous galena, and beryl, in contrast to the scheelite and psilomelane of the Black Butte prospect. Both of these are markedly different from the copper-gold suite of the major properties.

AGE: None of the ore deposits have been dated by radiometric techniques, and the distinct mineralogy of some of the properties suggest more than one ore forming event. The pervasiveness of specularite along the gently dipping faults, and association of probable Tertiary dikes with mineralization favor a mid-Tertiary age for these deposits.

REFERENCES: #120, #123, #185, #194

DISTRICT: CROSBY

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: Little geologic information is presently available for the deposits of the Crosby district. Wilson (1967) described northeast-striking veins composed of quartz with disseminations of pyrite in the unoxidized levels. Oxidized ore consists of brecciated quartz and limonite with free gold adsorbed onto the limonite. The country rock is Precambrian schist and granite which is locally sericitized adjacent to the veins.

AGE: Keith and others (1983a,b) describe this district as mid-Tertiary veins in and near a low-angle normal (detachment) fault. E. DeWitt (written comm.) suggests the geometry of the veins are indicative of mineralization related to a low-angle normal fault of probable mid-Tertiary age.

REFERENCES: #194

DISTRICT: DATE CREEK

PRODUCTION: U, V

GEOLOGIC SETTING: Stratabound, uraniferous mudstone, tuffaceous mudstone, marlstone, and limestone within a 260 m thick, unconformity-bounded sequence of primarily
mudstone and limestone that forms the Anderson Mine Formation of Sherborne and others (1979) and is within the mid-Tertiary Chapin Wash Formation (Otton, 1981). Uranium mineralization typically occurs in 1-3 m-thick zones that are associated with carbonaceous mudstone. Uranium-rich sediments typically contain 0.03 to 0.08 % U₃O₈ occurring in amorphous silica and associated with pyrite. Local oxidized ore in near-surface deposits contains as much as 30% U₃O₈ as carnotite and tyuyamunite.

AGE: Host sediments are early to mid-Miocene in age. Unoxidized uranium is probably of about the same age, whereas remobilization and concentration of oxidized uranium ore may have occurred in late Tertiary or Quaternary time.

REFERENCES: #131, #135, #136, #169

DISTRICT: FRENCH GULCH

PRODUCTION: Au, Ag, Cu, Pb

GEOLOGIC SETTING: The French Gulch district is in Precambrian granite. The dearth of descriptions from French Gulch preclude a detailed summary. French Gulch has a lower base-metal component and a high pyrite content, but is otherwise similar to the Walnut Grove district, suggesting a similar age and origin.

AGE: Keith and others (1983a,b) designate the French Gulch deposits as mid-Tertiary. The presence of Laramide gold-copper deposits in the area, however, favors a Laramide age for this district.

REFERENCES: #17, #89, #185

DISTRICT: GROOM CREEK

PRODUCTION: Au, Ag, Cu, Zn, Pb

GEOLOGIC SETTING: The Yavapai Series Green Gulch volcanics and Government Canyon granodiorite are the major hosts for the Groom Creek district. Cretaceous-Tertiary(?) rhyolite porphyry dikes, which are parallel or subparallel to the N10E-trending Precambrian foliation, are associated with mineralization in the area. These dikes are probably related to the 64 m.y.-old Walker stock. Orebodies are fault controlled and typically have native gold, galena, and pyrite. About two-thirds of the properties show minimal copper with the other third having notable chalcopyrite. The Silver Flake mine is uraniferous. The geologic setting of the Groom Creek is similar to that of the Mount Union and Hassayampa districts.

AGE: Keith and others (1983a,b) favor a mid-Tertiary age on the basis of the geochemical signature of the deposits. The close association of Laramide(?) rhyolite porphyry dikes with ore, and the proximity of the Laramide Walker mineral district of similar geologic setting suggests that the deposits of Groom Creek are Laramide rather than mid-Tertiary.

REFERENCES: #7, #112, #185, #194

48
DISTRICT: HARRIS

PRODUCTION: Mn

GEOLOGIC SETTING: Lenticular ore shoots of pyrolusite and psilomelane occurring in a gangue composed of brecciated sandstone, calcite, and barite, in a well-defined northwest-striking, steeply northeast-dipping vein cutting red, southwest-dipping Miocene sandstone.

AGE: The host sandstone is Miocene, therefore, the manganese deposits are Miocene or younger; a Miocene age of mineralization is preferred.

REFERENCES: #69, #153

DISTRICT: HASSAYAMPA

PRODUCTION: Au, Ag, Pb, Cu, Zn

GEOLOGIC SETTING: The bedrock geology of the Hassayampa district consists of amphibolites, slates, metarhyolites, and rhyolites of the Yavapai series Green Gulch formation. Mineralization is associated with dikes and veins that parallel a N15E-trending Precambrian foliation. Chalcopyrite, native gold, sphalerite, galena, and tetrahedrite are ore minerals. Quartz, pyrite, fluorite, and calcite are prevalent gangue. The Hassayampa district seems very similar to the nearby Groom Creek, Mt. Union, and districts.

AGE: E. DeWitt (written comm.) believes Hassayampa is of late Laramide age, in part based on the northeast-trend of the dikes and veins, and similarity to other known Laramide districts in the area. Keith and others(1983a,b) favor a middle Tertiary age based on the element suite.

REFERENCES: #7, #181, #193

DISTRICT: HUMBUG

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: Precambrian Crazy Basin quartz monzonite, and mica schists of the Yavapai Series comprise the bedrock of the Humbug district. Tertiary(? ) rhyolite porphyry dikes striking N40E to N50E and dipping 80NW are typically associated with ore. Pyrite, galena, sphalerite, arsenopyrite, native gold, ruby silvers, silver halides, and chalcopyrite in quartz veins are the ore assemblage. Wilson and others (1967) mention that sericitic alteration is pervasive in the wallrocks.

AGE: Keith and others(1983a,b) favor a middle Tertiary age. However, the northeast trend of the dikes, and the similarity of this district to the Walker, Groom Creek, and other mineral districts of this type make a Laramide age more probable.

REFERENCES: #120, #185, #194
DISTRICT: KIRKLAND

PRODUCTION: Au, Cu, Ag, Pb

GEOLOGIC SETTING: No detailed description of the Kirkland district is available. The Yavapai County geologic map (Az. Bur. Mines, 1951) shows a north-northeast-trending band of Yavapai Series schists hosting the district. The district has lithophilic accessory minerals including W, Mo, F, Hg, and Fe. Keith and others (1983a,b) state that mineralization is found in northwest- and northeast-trending rhyolite porphyry dikes.

AGE: There is insufficient geologic data for this district to make an intelligent and meaningful age determination. A Laramide or mid-Tertiary age is possible.

REFERENCES: #17

DISTRICT: MARTINEZ

PRODUCTION: Au, Ag, Cu, Pb

GEOLOGIC SETTING: The Congress Mine of the Martinez district is Yavapai County's premier middle Tertiary gold producer. Proterozoic porphyritic granite is the predominant rock type of the district. Many of the orebodies are related to east-west-trending, shallowly dipping andesite (microdiorite?) dikes of presumed Miocene age. Gold is mostly in quartz veins with auriferous pyrite, auriferous galena, and chalcopyrite.

AGE: Copper-gold mineralization related to andesite (microdiorite?) dikes in the Martinez district closely resembles microdiorite-related mineralization of known mid-Tertiary age in the nearby Harcuvar Mountains.

REFERENCES: #54, #89, #114, #185, #194

DISTRICT: MOUNT UNION

PRODUCTION: Au, Cu, Ag, Pb, Zn

GEOLOGIC SETTING: The Mount Union district bedrock geology is comprised of Green Gulch volcanics and 1760 m.y.-old granodiorites, both of which are intruded by less extensive Laramide(?) rhyolites thought to be related to the Laramide Walker stock. The foliation in the Yavapai Series trends N10E to N45E. At the Superior (Chase) property mineralization is in veins which, along with rhyolite dikes, parallel foliation. In general, however, mineralization does not follow the regional foliation, but is related to the rhyolite dikes. Ore minerals are chalcopyrite, galena, sphalerite, and argentiferous galena in quartz veins with specularite and pyrite gangue. The Mount Union mineral district is similar to Hassayampa, Groom Creek, and Walker districts.

AGE: Keith and others (1983a,b) favor a middle Tertiary age based on similarity of element suite to other mid-Tertiary districts. E. DeWitt (written comm.) favors a
Laramide age because of the local northeast trend of orebodies and by the inferred association with the Laramide Walker granodiorite.

REFERENCES: #7, #185, #194

DISTRICT: PECK

PRODUCTION: Ag, Pb, Cu, Au

GEOLOGIC SETTING: Peck has the largest historic Ag production of Yavapai County's middle Tertiary districts. The regional geology is characterized by an intensely folded sequence of Precambrian metavolcanics and granitoids. Ore deposits are associated with northeast-trending, steeply-dipping fault zones and Laramide(?) rhyolite porphyry dikes. Reported ore mineralogy is native silver, cerargyrite, tetrahedrite, argentiferous galena, and chalcopyrite.

AGE: There is no definitive data for the age of the Peck district. The northeast trend of the veins and probable association with Laramide(?) dikes provide persuasive arguments for a Laramide age. However, the extremely high silver content of the ores argues for a mid-Tertiary age of mineralization. At this time either age is considered possible.

REFERENCES: #2, #3, #8, #10, #15, #185

DISTRICT: RED PICACHO

PRODUCTION: Cu, Au, Ag

GEOLOGIC SETTING: The Red Picacho district is an inlier of Tertiary rhyolites and dacites surrounded by Yavapai Group schists that contain the extensive White Picacho pegmatite district. The Red Picacho deposits are in northwest-trending quartz veins within the middle Tertiary volcanics. Native gold is the stated ore mineral with calcite as gangue. The southern portion of the district hosts uranium and tungsten as well as gold mineralization; the host rock for these deposits is hornblende gneiss with scheelite, torbernite, schroeckingerite, and chrysocolla.

AGE: The probable mid-Tertiary age of the silicic volcanics, and the northwest trend of the veins both favor a mid-Tertiary age for this district.

REFERENCES: #17, #94, #123, #185

DISTRICT: RICH HILL

PRODUCTION: Au, Ag, Pb, Cu

GEOLOGIC SETTING: The Rich Hill district is segmented and the southern portion overlaps the Congress Precambrian tungsten district. The most important mines, however, are in a cluster located 7 km south of Yarnell, AZ. The country rock consists of undifferentiated Precambrian Yavapai Series and Tertiary(?) diorite and
andesite dikes. Mineralization is in low-angle quartz veins and is frequently associated with andesite and rhyolite dikes. Native gold, galena, and pyrite predominate. Tellurides are reported at the Bee Hive Mine.

AGE: The exact age of Rich Hill is poorly constrained. The ores of the Rich Hill district are mineralogically similar to those of the Congress mine in the Martinez district. This similarity along with the presence of low-angle structures hosting the ore suggest a mid-Tertiary age. Keith and others (1983a,b) suggest that the associated dikes are microdiorite dikes, of probable mid-Tertiary age, supporting a mid-Tertiary age for mineralization.

REFERENCES: #78, #89, #162, #185, #186, #194

DISTRICT: SHEA

PRODUCTION: Ag, Au, Cu

GEOLOGIC SETTING: The Shea District is in the Yavapai Series metamorphics which include the Shea basalt, the Deception rhyolite, and unnamed granite porphyry dikes. Ore bodies trend east-west and range up to 2 m in width in low-angle structures. The ore includes pyrite, tetrahedrite, chalcopyrite, arsenopyrite, galena, and native silver. Bull quartz is the predominant gangue with lesser siderite and ankerite. The veins also produced several tons of barite. Lindgren (1926) notes extensive chlorite, epidote, sericite and quartz alteration in the wallrocks.

AGE: The high silver grades and low-angle structures are suggestive of a mid-Tertiary age.

REFERENCES: #33, #120, #185

DISTRICT: TIP TOP

PRODUCTION: Ag, Au, Cu, Pb

GEOLOGIC SETTING: The Tip Top deposits are characterized by northeast-striking veins cutting Precambrian granite and schist. The veins consist of quartz, chalcedony, comb quartz, and pyrite; ore minerals include wolframite, arsenopyrite, sphalerite, and galena. The galena is argentiferous. In the oxidized portions of the veins ruby silvers and silver chlorides are found in high grade pockets. Within 150 m of the major workings are north-northeast-striking rhyolite porphyry dikes, thought to be genetically related to the ores.

AGE: Keith and others (1983a,b) ascribe a mid-Tertiary age to these dikes and deposits. The rhyolite porphyry dikes responsible(?) for the mineralization are as yet undated, however their strike direction (NNE) is characteristic of the Laramide tectonic regime (Rehrig and Heidrick, 1976). A Laramide age is further indicated by a 67 m.y. K-Ar age on sericite (C. Kortemeir, 1985, pers. comm.).

REFERENCES: #120, #192

52
DISTRICT: TURKEY CREEK

PRODUCTION: Ag, Pb, Au, Cu, Zn

GEOLOGIC SETTING: The Turkey Creek deposits are small and poorly known. The north-south-striking, steeply-dipping veins are hosted by upper Spud Mountain volcanics and Crooks Canyon granodiorite. The high-grade zones are oxidized and consist of native silver and silver chlorides with quartz. Quartz-galena-sphalerite-tetrahedrite-chalcopyrite comprise the lower unoxidized levels of the veins.

AGE: Keith and others (1983a,b) ascribe a mid-Tertiary age for this district. Anderson and Blacet (1972) show no Tertiary magmatic rocks in the region except for the metallogenically barren Hickey Basalts. A Laramide quartz latite porphyry plug is within several miles of the Turkey Creek district (Anderson and Blacet, 1972), yet there is no demonstrable relationship between this plug and the ores. The age of this district is considered to be unknown.

REFERENCES: #7, #120

DISTRICT: WALNUT GROVE

PRODUCTION: Pb, Ag, Au, Cu, Zn

GEOLOGIC SETTING: No detailed description is available of the Walnut Grove district. The major rock types present are Precambrian Yavapai Series and granitoids. The mineralization is in quartz veins with cuprite, azurite, malachite, chalcopyrite and pyrite. The veins are related to northeast-trending silicic dikes.

AGE: The age of Walnut Grove is highly uncertain. E. DeWitt (written comm.) suggests a Laramide age, while Keith and others (1983a,b) favor a middle Tertiary age for the veins and replacements.

REFERENCES: #17, #54, #89, #185, #186

YUMA COUNTY

DISTRICT: BLACK TOP

PRODUCTION: Mn

GEOLOGIC SETTING: Pyrolusite and psilomelane in discontinuous shoots, stringers, and pods. Gangue is composed of quartz, calcite and wallrock fragments. The irregular ore horizons are along fracture veins cutting late Oligocene to early Miocene calc-alkaline andesites and rhyodacites.

AGE: Gutman (1982) has dated the volcanic rocks of the Castle Dome Mountains. The ages range from 25.0 to 20.39 m.y. B.P., hence the volcanic rocks hosting the Black Top manganese deposits are of mid-Tertiary age. We favor a mid-Tertiary age for the
mineralization.

REFERENCES: #69, #80, #103, #190

DISTRICT: CASTLE DOME

PRODUCTION: Pb, Ag, Au, Cu, Zn

GEOLOGIC SETTING: Argentiferous galena-fluorite-barite fissure veins in greenschist facies(?), Mesozoic, fine-grained, clastic metasedimentary rocks, closely associated with dacite porphyry and rhyolite porphyry dikes. The veins are in a wide, steeply dipping fault zone which cuts the metasediments and dikes. The veins may be continuous for considerable distances, but thicken from one meter to greater than three meters in width. Outcropping veins consist of fluorite, calcite, and barite with local gypsum and minor quartz. Oxide zones contain cerussite, anglesite, and lead oxide. At depth, galena occurs as sheet-like masses or irregular vein-like bodies scattered through a gangue of banded, coarsely-crystalline, varicolored fluorite, calcite, bladed to massive barite, and quartz. Wallrocks show pronounced silicification, carbonatization, and sericitization, with weak chloritization and disseminated pyrite.

AGE: Mineralization is spatially and temporally related to northwest-trending dikes. These dikes have been dated at 19.0 and 20.4 m.y.B.P. (Logan and Hirsch, 1982).

REFERENCES: #103, #122, #194

DISTRICT: HOVATTER

PRODUCTION: Mn

GEOLOGIC SETTING: Pyrolusite and psilomelane mixed with calcite and brecciated wallrocks in stringers, pods, and overlapping lenses, or irregular veins and flat tabular bodies within a large shear zone in middle Tertiary andesite flows.

AGE: The deposits are hosted by mid-Tertiary volcanic rocks, and therefore are middle Tertiary or younger. A middle Tertiary age is favored because this was a time of widespread magmatism.

REFERENCES: #69, #103

DISTRICT: KOFA

PRODUCTION: Au, Ag, Cu, Pb

GEOLOGIC SETTING: Spotty, but often high-grade, fine-grained, gold and silver mineralization in quartz-calcite gangue, forming lenses within brecciated wallrock, and in fissure veins cutting Tertiary rhyolitic to dacitic ash-flow tuffs and Mesozoic schist or slate. Northwest-striking, southwest-dipping dikes of silicic to intermediate composition are associated with zones of mineralization. Minor copper
and lead sulfide mineralization is present with locally important amounts of manganese oxides and fluorite. Wallrocks are strongly silicified.

AGE: The volcanic pile yielded K-Ar dates of 19.5 to 17.3 m.y.B.P. (Dahm and Hankins, 1982). The associated dikes are thought to be of the same age.

REFERENCES: #44, #98, #103, #190

DISTRICT: LAGUNA

PRODUCTION: Au, Ag, Cu

GEOLOGIC SETTING: The Laguna district consists of sporadic gold and silver with minor copper mineralization in lenticular and brecciated quartz veins. Gangue mineralogy consists of iron oxides, manganese oxides, siderite, gypsum, and fault gouge. The veins appear to occupy fault zones in Mesozoic schists. The wallrocks are silicified and sericitized. Locally proximal to the veins are pods of aplitic granite. The relationship between the granite pods and mineralization is unclear.

AGE: This district is insufficiently known to determine a verifiable age. Keith and others (1983a,b) suggest a mid-Tertiary or Paleocene age.

REFERENCES: #103, #190

DISTRICT: NEVER SWEAT

PRODUCTION: Ag, Cu, Pb, Au

GEOLOGIC SETTING: Irregular shoots of argentiferous galena with barite, minor fluorite, silver chlorides and sulfides, and oxidized copper mineralization. These shoots are in lensing veins and brecciated fault zones cutting Mesozoic schist. Spatially associated bodies of andesitic to rhyolitic dikes are present.

AGE: Keith and others (1983a,b) propose a mid-Tertiary age for this district because of its gross similarities with the dated Castle Dome district.

REFERENCES: #103, #190

DISTRICT: SHEEP TANKS

PRODUCTION: Au, Ag, Cu

GEOLOGIC SETTING: Strong faulting and fracturing are characteristic throughout the district. Rhyolitic flows lie unconformably beneath thick dacitic flows. Irregular masses, sills, and dikes of diorite porphyry intrude and cross-cut both the rhyolite and dacite. Intensely silicified and iron and manganese stained breccia unconformably overlie the rhyolite and diorite porphyry and lie in apparent fault contact with the dacite. The brecciated zone is locally cemented and filled by quartz-carbonate veins. The veins consist of irregular masses and streaks of limonite, pyrolusite, quartz,
and calcite, and are cut by barite veins. Shoots of gold and silver mineralization, locally with chrysocolla and secondary lead minerals, are found lensing within the veins. The wallrocks are intensely silicified, chloritized and sericitized.

AGE: Mineralization is hosted by volcanics that yield middle Tertiary ages in the nearby Kofa and Eagle Tail Mountains (Cousins, 1984).

REFERENCES: #38A, #38B, #103, #190
## TABLE 2. MID-TERTIARY MINERAL DISTRICTS BY LITHOTECTONIC ASSOCIATION

### VOLCANO-PLUTONIC COMPLEXES

<table>
<thead>
<tr>
<th>KNOWN OR PROBABLE ASSOCIATION</th>
<th>POSSIBLE ASSOCIATION</th>
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<tbody>
<tr>
<td>CALIFORNIA, COCHISE</td>
<td>RUCKER CANYON, COCHISE</td>
</tr>
<tr>
<td>MIDDLE PASS, COCHISE</td>
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MICRODIORITE DIKES

KNOWN OR PROBABLE ASSOCIATION

CUNNINGHAM PASS, LA PAZ
HARCUVAR, LA PAZ
HARQUAHALA, LA PAZ
LA CHOLLA, LA PAZ
SOUTHERN PLOMOSA, LA PAZ
SALT RIVER MTNS., MARICOPA
MARTINEZ, YAVAPAI
RICH HILL, YAVAPAI

POSSIBLE ASSOCIATION

RED PICACHO, YAVAPAI
ELLSWORTH, LA PAZ
LITTLE HARQUAHALA, LA PAZ
BIGHORN, LA PAZ

DETACHMENT RELATED

KNOWN OR PROBABLE ASSOCIATION

ALAMO, LA PAZ
CIENEGA, LA PAZ
CLARA, LA PAZ
MAMMON, LA PAZ
MIDWAY, LA PAZ
MOON MTNS., LA PAZ
PLANET, LA PAZ
SWANSEA, LA PAZ
CLEOPATRA, MOHAVE
CYCLOPIC, MOHAVE
OWENS, MOHAVE
RAWHIDE, MOHAVE
RINCON, PIMA
BULLARD, YAVAPAI

POSSIBLE ASSOCIATION

LINCOLN RANCH, LA PAZ
TRIGO MTNS., LA PAZ
AGUILA, MARICOPA
SAN DOMINGO, MARICOPA
PICACHO, PINAL

STRATABOUND

KNOWN OR PROBABLE ASSOCIATION

ARTILLERY, MOHAVE
BURMISTER, YAVAPAI
DATE CREEK, YAVAPAI

POSSIBLE ASSOCIATION

LINCOLN RANCH, LA PAZ
BLACK BURRO, MOHAVE
Probable or known relationship to volcano-plutonic complexes.

Possible relationship to volcano-plutonic complexes.

Figure 2

59
Microdiorite-Dike Associated
Mineral Districts in Arizona

Probable or known relationship to microdiorite dikes.
Possible

Figure 3
Detachment-Fault Associated Mineral Districts in Arizona

- Probable or known relationship to detachment faults.
- Possible relationship to detachment faults.

Figure 4
TABLE 3. PRESENT VALUE OF PRODUCTION FROM MID-TERTIARY MINERAL DISTRICTS

Production data for this compilation are taken from Keith and others (1983a). Metal prices, listed below, used to calculate present value of production are from Engineering & Mining Journal's (March, 1984) average annual metal prices. The prices used are the 1983 average price, except where otherwise indicated. All values are rounded-off to the nearest one hundred dollars.

COPPER: $0.78/lb; domestic refinery
GOLD: $423.83/oz; Handy and Harmon, N.Y.
LEAD: $0.22/lb; primary delivered
MANGANESE: $0.70/lb; regular 99.5%*
MOLYBDENUM: $3.64/lb; dealer oxide
SILVER: $11.44/oz; Handy and Harmon, N.Y.
TUNGSTEN: $64.48/stu WO₃; 65% min GSA 12/15/83
URANIUM: $17.50/lb U₃O₈; NUEXCO's exchange value 2/29/84
VANADIUM: $3.50/lb V₂O₅; 98% fused f.o.b. N.Y. 5/15/81
ZINC: $0.41/lb; high grade delivered

* Manganese production data based on pounds delivered to government purchasing depots at Deming, New Mexico, and Wenden, Arizona, and do not meet the grade criterion. To calculate present value we have assumed a 25% grade for this material.
MID-TERTIARY MINERAL DISTRICT PRESENT VALUE TOTALS:

Au: $1,888,769,800  
Ag: $508,786,900  
Mn: $218,313,900  
Cu: $98,261,100  
Zn: $52,019,400  
Pb: $50,519,250  
Mo: $14,357,800  
V: $8,928,300  
U: $681,400  
W: $600

GRAND TOTAL OF PRESENT VALUE FOR MID-TERTIARY MINERAL DISTRICTS:

$2,840,638,450
The following table is a compilation of grade statistics for mid-Tertiary age mineral districts in Arizona. The grades were calculated by standard means from U.S. Bureau of Mines statistics; the data is accurate to 1981, the last year USBM statistics were reported. Values of $<$0.01 and $<$0.001 indicate that the listed metal was produced but in insignificant amounts, while a value of 0.00 indicates that there is no recorded production for the listed metal.

The values for Cu, Pb, Zn, and Mo are in weight percent, those for Ag and Au are in ounces per ton.

### COCHISE COUNTY

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<tr>
<th>DISTRICT</th>
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### GRAHAM COUNTY

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## MARICOPA COUNTY

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### MOHAVE COUNTY

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### PIMA COUNTY

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### Pinal County

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### Santa Cruz County

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### YAVAPAI COUNTY

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### YUMA COUNTY

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TABLE 5. GRADES OF ORE BY LITHOTECTONIC ASSOCIATION

The average grades are arithmetic means of the individual district grades, and hence subject to bias by an anomalously high or low value. Weighted grades are calculated by summing the total production for each metal in ounces or pounds and dividing by the total ore produced for each lithotectonic association. Cu, Pb, Zn, and Mo grades are in weight percent, while those for Ag and Au are in ounces per ton.

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REFERENCES


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