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GEOLOGY, ENERGY AND MINERAL RESOURCES ASSESSMENT OF THE MARICOPA AREA, ARIZONA

BY

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Prepared for:

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

December 31, 1982

Geo-Scientific, Professional and Engineering Services

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GEOLOGY, ENERGY AND MINERAL RESOURCES ASSESSMENT
OF THE MARICOPA AREA, ARIZONA

by

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SUMMARY

The Maricopa "Geological, Energy and Mineral (GEM) Resources Area" (GRA) is located in Maricopa and Pinal Counties, southwestern Arizona, and contains five "Wilderness Study Areas" (WSAs). The GRA lies within the Sonoran Desert section of the Basin and Range Province.

Basement consists of Precambrian (1.8-1.7 b.y.B.P.) gneisses intruded by granitic rocks (1.5-1.3 b.y.B.P.). In the southeastern part of the GRA, the basement is unconformably overlain by Late Proterozoic and Paleozoic shallow-marine sandstones, mudstones, limestones and dolomites. A Mesozoic magmatic arc extended over the southern part of the GRA and rhyolite ash flow and terrestrial sediments were deposited in local basins. Laramide (70-50 m.y.B.P.) quartz monzonite plutons intrude Precambrian and Paleozoic rocks in the southeastern part of the GRA. The mid-Tertiary orogeny (35-14 m.y. B.P.) involved deposition of a thick sequence of fluvial and lacustrine sediments in local basins; outpouring of calc-alkaline volcanics; and emplacement of metamorphic core complexes and listric normal faulting, largely outside the GRA. Basin and Range faulting became dominant 14-4 m.y.B.P. and was accompanied by basin-fill sedimentation and basaltic volcanism. Since 4 m.y.B.P., the main geological processes have been erosion and deposition of alluvium.

Geologic environments potentially favorable for occurrence of mineral or energy resources in the GRA include: Precambrian metamorphic and igneous rocks; Laramide intrusives; and mid- and Late Tertiary basin-fill sediments. The Precambrian rocks host four pegmatitic mica occurrences that are probably related to Precambrian granite intrusion and metamorphism. The southern half of the GRA lies within the ENE-trending zone of porphyry copper deposits. The Vekol deposit lies just to the south of the GRA, and one gold/silver occurrence in the southern part of the Table Top sub-area may be related to a Laramide intrusives. Mid- and Late Tertiary valley-fill sediments and volcanics contain uranium source rocks, permeable horizons, and locally may contain reductants. No uranium occurrences are known but Tertiary sediments may locally be favorable for uranium accumulation. Warm (greater than 25°C) geothermal waters are present within Tertiary basins in the northern Estrella sub-area and in the northeastern and west-central Table Top sub-area.

The North Maricopa Mountains, Butterfield Stage Memorial, and South Maricopa Mountains WSAs are underlain by Precambrian gneiss and granite and by Tertiary valley-fill sediments and volcanics. The Precambrian metamorphic rocks underlying the South Maricopa Mountains WSA are moderately favorable for copper because several occurrences are present in the area. The southwestern parts of the North and South Maricopa Mountains WSAs are moderately favorable for uranium because underlying Tertiary strata probably contain suitable source rocks, aquifers and reductants. The northeastern part of the North Maricopa Mountains WSA and the southwestern part of the South Maricopa

Mountains WSA are moderately favorable for geothermal resources because these areas are underlain by known low temperature geothermal water.

The Sierra Estrella WSA is underlain by Precambrian gneiss and granite. It is moderately favorable for the occurrence of mica because a mica mine is present within the area.

The Table Top Mountain WSA is underlain by Precambrian schist and granite, Tertiary basalt and by Tertiary sediments. The part underlain by schist is considered moderately favorable for metallic minerals because of the presence of several copper occurrences and the proximity of the Vekol porphyry copper deposit. The northwestern part of the WSA is moderately favorable for geothermal energy because it is underlain by an area of known low temperature geothermal water.

Important recommendations for further work in the WSAs include:

1. Hydrothermal minerals associated with the copper occurrences should be radiometrically dated to determine whether the mineralization is Precambrian, Mid-Mesozoic, Laramide or mid-Tertiary.
2. Uranium solubility index should be calculated for well waters in areas potentially favorable for uranium.
3. Areas of uranium potential should be field checked for the presence of source rocks, aquifers and reductants.
4. Pegmatites should be field checked for the presence of industrial minerals.

INTRODUCTION

Purpose and Methodology

The need for "Geological, Energy and Minerals (GEM) Resources Assessment" of "Wilderness Study Areas" (WSA) has been recognized for some time by the Bureau of Land Management (BLM). The assessment is now being performed by various contractors for the BLM.

Wilderness Study Areas, widely scattered within the Sonoran Desert and Mexican Highlands and grouped into Region 5 by the BLM, are being studied and assessed by Geoexplorers International, Inc. The present report pertains to five WSAs in southwestern Arizona which have been grouped together into the Maricopa Geological Energy and Minerals Resources Area (GRA).

The purpose of the present study is to assess the potential for locateable, leaseable and saleable resources within the GRA, and specifically within each of the WSAs. This assessment has been carried out through literature study of the geology, structure and economic geology of the GRA, and a consideration of the regional paleogeographic, plate tectonic and metallogenic setting of the GRA within the southern Cordillera. Thus, the assessment is not only based on data from the GRA itself, but also on metallogenic concepts within the regional paleogeographic and plate tectonic framework.

Location and Access

The Maricopa Geological Resources Area is located in Maricopa and Pinal Counties in southwestern Arizona. It lies within the Lower Gila and Phoenix Resource Areas of the BLM-administered Phoenix District. It occupies the southeastern part of the Phoenix 1:250,000 quadrangle, approximately between latitude $32^{\circ} 30'$ and $33^{\circ} 15'$ and longitude $111^{\circ} 55'$ and $112^{\circ} 40'$. The Maricopa GRA has been subdivided into the Estrella and Table Top sub-areas,

as shown in figure 1. The five WSAs within the Maricopa GRA are listed in Table 1 and their locations are shown in figure 1. *Not on Fig 1*

Important access into the GRA is provided by the following: the Southern Pacific Railroad, which runs east-west across the central part of the Estrella sub-area; U.S. Highway 80, which runs along the western edge of the Estrella sub-area; and Arizona Highway 82, which runs across both sub-areas from west to east. Access to most of the valleys in the GRA is along numerous light-duty and unimproved dirt roads, but access for vehicular traffic to the mountainous areas is very limited. No major towns are present within the GRA, but Phoenix lies 10 - 15 miles to the north of the Table Top sub-area.

PHYSIOGRAPHY

The Maricopa GRA lies within the Sonoran Desert section of the southern Basin and Range Province (Fenneman, 1931; Heindl, 1960), which lies to the southwest of the Colorado Plateau. The area has a pronounced north-south to northwest-trending topographic grain which reflects Miocene Basin and Range normal faulting. The fault scarps have been eroded back considerable distances to form extensive pediments, and the range fronts are considerably embayed (Tucker, 1980). This is because much of southwestern Arizona has been almost free of tectonic activity for the past several million years.

The GRA can be divided into three distinct physiographic terrains (figure 1): mountainous-to-hilly; lowland; and floodplain terrains.

The mountainous-to-hilly terrain constitutes tectonic uplifts which are cored mainly by Precambrian granites and gneisses. The Maricopa and Sand Tank Mountains and the Sierra Estrella trend northwest and the Table Top and Vekol Mountains trend north-south, probably reflecting Basin and Range faulting (Davis, 1981). The Buckeye Hills have an anomalous east-northeast trend typically associated with metamorphic core complexes (Davis, 1981).

Figure 1. LOCATION OF THE ESTRELLA AND TABLE TOP SUB-AREAS OF THE MARICOPA GRA.
Surface physiography and depth to basement contours in feet, after Oppenheimer and Sumner (1981).

TABLE 1

WILDERNESS STUDY AREAS IN THE MARICOPA GRA

Sub-Area	WSA No.	WSA Name	Acres	km ²
Estrella	020-157	North Maricopa Mtns.	75,483	305.5
	020-164	Butterfield Stage Memorial	9,566	38.7
	020-163	S. Maricopa Mtns.	72,002	291.4
	020-160	Sierra Estrella	14,190	57.0
Table Top	020-172	Table Top Mtns.	39,823	161.2
Total			211,064	853.8

The lowland terrain constitutes tectonic, generally fault-bounded, depressions in which valley-fill sediments have been deposited and which have been widened through formation of pediment surfaces. In the north, the Rainbow Valley parallels the Sierra Estrella and Maricopa Mountains, whereas in the east, the Vekol Valley runs roughly parallel to the Vekol Mountains. Both valley systems probably reflect Basin and Range deformation.

The flood plain is present along the Gila River in the southeast and northeast corners of the Estrella sub-area. These are the richest agricultural areas in the GRA.

GEOLOGY

Southwestern Arizona is an area of highly complex geology. Rocks range in age from Precambrian to Recent, and the region has been affected by Precambrian, mid-Mesozoic, Laramide and mid-Tertiary orogenies and by Basin and Range faulting. Important advances in the understanding of this complex terrain have been made since the publication of the Geologic Map of Arizona (Wilson et al., 1969) and have been summarized by Reynolds (1980). These advances have largely been the result of a greatly increased number of radiometric data (Shafiqullah et al., 1980); regional analysis of deformation (Rehrig and Heidrick, 1967; Davis, 1981); recognition of metamorphic core complexes (Davis and Coney, 1979; Coney, 1980; Davis et al., 1980; Rehrig and Reynolds, 1980); recognition of the relationship between subduction magmatism and metallogenesis in the southern Cordillera (Coney and Reynolds, 1977; Damon et al., 1981); and an increased level of mapping of Cenozoic basins as a result of intense uranium exploration during the late 1970s (Eberly and Stanley, 1978; Scarborough and Wilt, 1979).

The lithology and stratigraphy, structural geology and tectonics, paleontology and geologic history of the Maricopa GRA are discussed in

this section in order to facilitate the assessment of mineral potential within the GRA and, specifically, within the enclosed WSAs. The regional geologic setting is shown in figure 2 and detailed geology of the Maricopa GRA is presented in figures 3 and 4.

Lithostratigraphy - Rock Units

In southwestern Arizona, older Precambrian crystalline basement is overlain by younger Precambrian and Paleozoic shallow marine sediments; Mesozoic volcanics and continental clastic sediments; mid-Tertiary volcanics and clastic continental sediments; and late-Tertiary volcanics and valley-fill sediments. Intensive activity and metamorphism took place during the Precambrian, mid-Mesozoic, Laramide and mid-Tertiary. Metamorphic core complexes were probably emplaced during the latter event.

Older Precambrian Rocks

Older Precambrian rocks in Arizona crop out most extensively in the northwest-trending Central Mountain region, to the northeast of the Maricopa GRA. Here they have been divided into three distinct northeast-trending belts (Titley, 1982; see figure 2A) which, according to Anderson (1976), accreted onto the North American craton from the southeast.

The northwesterly of these belts consists of gneisses which are in part metavolcanic facies (Stensrud and More, 1980) and were deposited about 1.8 b.y.B.P. (Titley, 1982). The central belt consists of the Yavapai Series which was deposited 1.82 - 1.775 b.y.B.P. (Anderson and Silver, 1976). It is a greenstone belt which is approximately 40,000 feet thick and is dominated by volcanic and volcanoclastic rocks of basaltic to rhyolitic composition (Anderson and Silver, 1976; Titley, 1982) and has been metamorphosed to the greenschist facies. Massive sulfide copper-zinc deposits are associated

Figure 2: Paleotectonic and paleogeographic maps of Arizona showing location of the Maricopa GRA.

- A. Location of Precambrian terrains and the Holbrook, Bright Angle-Mesa Butte and Colorado lineaments, after Warner (1978) and Titley (1982).
- B. Location of mid-Mesozoic magmatic arc, the Mojave-Sonora megashear and mid- to late Mesozoic red beds, after Dickinson (1981). The red beds postdate the magmatic arc and probably extend farther to the southwest than shown.
- C. Location and age trends of major porphyry copper deposits. Note that these are aligned parallel to northwest-trending Paleozoic-Mesozoic discontinuities (Lowell, 1974; numbers 1-6 correspond to discontinuities named in Heidrick and Titley, 1982), along northwest-trending Laramide magmatic arcs (v pattern), and along northeasterly Precambrian trends (Heidrick and Titley, 1982). Curved black lines show location of arc at different times, as given.
- D. Location of Precambrian alkali and alkali-calcic intrusions and mid-Tertiary metamorphic core complexes, mid-Tertiary alkali-calcic volcanics and sedimentary domains (Scarborough and Wilt, 1979).

Figure 2A.

Figure 2B.

Figure 2C.

FIG.4. GEOLOGIC, ENERGY AND MINERAL RESOURCES MAP OF THE TABLE TOP MTS SUB-AREA, ARIZONA

Scale
1 : 250,000
LEGEND: See enclosed

Figure 5. **LEGEND**
FOR

GEOLOGIC, ENERGY AND MINERAL RESOURCES MAPS

Scale of all maps is 1:250,000 or as otherwise indicated.

GEOLOGY AND LITHOSTRATIGRAPHY

After Wilson et al.(1969) and modified after Oppenheimer and Sumner (1981),
Scarborough (1979), Scarborough and Wilt (1979),
Shafiqullah et al.(1980), Titley (1981,1982).

QUATERNARY		Qs	Unconsolidated alluvial fan and floodplain deposits.
		Ts	Conglomerates, sandstones, mudstones and minor limestones. Locally tuffaceous.
MID TERTIARY		Tvi	Intermediate volcanics, flows and tuffs.
		Tb	Basaltic flows and breccias.
		Ti	Small stocks of basaltic to intermediate composition.
		Tki	Quartz monzonite intrusives.
LOWER TERTIARY - UPPER CRETACEOUS			
PALEOZOIC	CAMBRIAN- ORDOVICIAN	OEs	Undifferentiated quartzite , sandstone and shale.
		Pzs	Undifferentiated quartzite, sandstone, shale, dolomite, limestone.
PRECAMBRIAN	YOUNGER	pEa	Apache Group: quartzite, sandstone, shale, siltstone,dolomite and limestone.
		pEdb	Diabase dikes, sills and flows.

PRECAMBRIAN

OLDER

pEgr

Granitic intrusives.

pEsc

Schist.

pEgn

Gneiss.

Contours in feet show depth to basement ,
after Oppenheimer and Sumner (1981).

Radiometric dates:

40-14 million years, before present

SPECIAL SYMBOLS OF STRUCTURAL FEATURES

After U.S. Geological Survey

	Contact - Dashed where approximately located; short dashed where inferred; dotted where concealed
	Contact - Showing dip; well exposed at triangle
	Fault - Dashed where approximately located; short dashed where inferred; dotted where concealed
	Fault, showing dip - Ball and bar on downthrown side
	Normal fault - Hachured on downthrown side
	Fault - Showing relative horizontal movement
	Thrust fault - Sawteeth on upper plate
	Anticline - Showing direction of plunge; dashed where approximately located; dotted where concealed
	Asymmetric anticline - Short arrow indicates steeper limb
	Overturned anticline - Showing direction of dip of limbs
	Syncline - Showing direction of plunge; dashed where approximately located; dotted where concealed
	Asymmetric syncline - Short arrow indicates steeper limb
	Overturned syncline - Showing direction of dip of limbs
	Monocline - Showing direction of plunge of axis
	Minor anticline - Showing plunge of axis
	Minor syncline - Showing plunge of axis

Strike and dip of beds - Ball indicates top of beds known from sedimentary structures

	Inclined		Horizontal
	Vertical		Overturned

Strike and dip of foliation

	Inclined		Vertical		Horizontal
--	----------	--	----------	--	------------

Strike and dip of cleavage

	Inclined		Vertical		Horizontal
--	----------	--	----------	--	------------

Bearing and plunge of lineation

	Inclined		Vertical		Horizontal
--	----------	--	----------	--	------------

Strike and dip of joints

	Inclined		Vertical		Horizontal
--	----------	--	----------	--	------------

Note: planar symbols (strike and dip of beds, foliation or schistosity, and cleavage) may be combined with linear symbols to record data observed at same locality by superimposed symbols at point of observation. Coexisting planar symbols are shown intersecting at point of observation.

SPECIAL SYMBOLS

FOR ENERGY AND MINERAL RESOURCES

KNOWN DEPOSITS AND OCCURRENCES

-O Oil field	-C Coal deposit	-Mineral orebody - as specified with symbol
-G Gas field	-C Coal occurrence	-Mineral deposit - as specified with symbol
-Os Oil shale		-Mineral occurrence - as specified with symbol
		-Mineral district (Fig.=inserted map)

EXPLORATION AND/OR MINING ACTIVITY

MINERALS AND COAL

Mineral deposit, mine or prospect with recorded prod.	Vertical shaft	Active gravel or clay (cl) pit
Prospect or mine with no recorded production	Inclined shaft	Inactive gravel or clay (cl) pit
Accessible adit, or tunnel	Active open pit, or quarry	Exploration hole with data available
Inaccessible adit, or tunnel	Inactive open pit, or quarry	Exploration hole without data
		Mining district (Fig.=inserted map)

PETROLEUM

Oil well	Show of gas	CO ₂ - or He-hellum- rich well
Oil and gas well	Show of oil	Dry well - abandoned
Gas well	Show of oil and gas	
	Shut-in well	

GROUND WATER

Water well of special importance	Brine	Thermal water
Water well of high yield	Mineral water	Radioactive water
Flowing water well		Thermal point

ENERGY RESOURCES

O Oil	C Coal	U Uranium
G Gas	Cb Lignite (brown coal)	Th Thorium
Os Oil shale	Cp Peat	Gt Geothermal
Ot Tar sands		

MINERAL RESOURCES

METALS

Al Aluminum	Cu Copper	Mo Molybdenum	Tl Thallium
Sb Antimony	Ga Gallium	Ni Nickel	Sn Tin
As Arsenic	Ge Germanium	Nb Niobium or Columblum	Ti Titanium
Be Beryllium	Au Gold	Pt Platinum group	W Tungsten
Bi Blismuth	Fe Iron	RE Rare earth	V Vanadium
Cd Cadmlum	Pb Lead	Re Rhenium	Zn Zinc
Cr Chromium	Li Lithium	Sc Scandium	Zr Zirconium and Hf Hafnium
Cs Cesium	Mn Manganese	Ag Silver	
Co Cobalt	Hg Mercury	Te Tellurium	

NONMETALS - INDUSTRIAL MINERALS

ab Abrasives	di Diatomite	fs Feldspar	mg Magnesian refractories
al Alum	Nonmarine and marine evaporites and brines	F Fluorite (fluorspar)	mi Mica
as Asbestos	pt Potash	gs Gem stones	ph Phosphate
Ba Barite	na Salt - mainly halite	ge Graphite	pl Pigment and fillers
be Bentonite	gy Gypsum and anhydrite	He Helium	qz Quartz crystals
ca Calcite	nc Sodium carbonate or sulfate	kl Kaolin	sl Silica sand
cl Clay	bn Boron minerals	ky Kyanite and related minerals	S Sulfur
Construction materials:	nl Nitrates	ls Limestone	tc Talc
cs Crushed stone	Sr Strontium	lm Lithium minerals	ze Zeolites
la Lightweight aggregates, includ.:	Br Bromine		hm Humate
pm Pumice and volcanic cinders	cc Calcium chloride		
pe Perlite	mg Magnesium compounds		
ec Expanded clay, shale, slate			
vm Vermiculite			
sg Sand and gravel			
cr Cement raw materials			
bs Building stones			
ll Lime			

SPECIAL GEOLOGICAL FEATURES

POINT OF SPECIAL GEOLOGIC INTEREST

m Mineral occurrence	s Structural, bedding, foliation, etc.,	u Radioactive spring
f Fossil locality	b Brecciation, shear zone, etc.,	g Thermal spring
v Volcanic phenomenon	y High yield spring	a Extensive rock alteration
t Stratigraphic sequence	p Spring with mineral water	r Lithologic type locality

FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE FOR MINERAL RESOURCES

FAVORABILITY:

1A - Undefined

1 - Not favorable - combine with either B, C, or D

2 - Low

3 - Moderate

4 - High

} combine with either A, B, C, or D

LEVEL OF CONFIDENCE:

A - Insufficient data

B - Indirect evidence

C - Direct evidence

D - Abundant direct and indirect evidence

with submarine rhyolitic volcanism, especially in the Prescott-Jerome area (Donnelly and Hahn, 1981). The southeastern belt consists of the Pinal Schists which were deposited 1.7 - 1.68 b.y.B.P. (Silver, 1978) and consist of quartz-muscovite schist, arkose and quartzite (Titley, 1982).

The older Precambrian rocks were metamorphosed and intruded by granites during the Arizonan revolution 1.76 - 1.63 b.y.B.P. (Damon, 1968) and were intruded by granites during the Mazatzal revolution 1.5 - 1.4 b.y.B.P. (Damon, 1968; Silver et al., 1977).

In the Maricopa GRA, older Precambrian rocks are found in both the Estrella and Table Top sub-areas. They underlie most of the Sierra Estrella, the Maricopa and Table Top Mountains and part of the Sand Tank Mountains. They consist of gneiss in the Sierra Estrella and schist in the Maricopa, Sand Tank and Vekol Mountains and granitic intrusions which are present in all of the above ranges.

According to Shafiqullah et al. (1980), the metamorphic rocks in the Sonoran Desert section of the Basin and Range Province are generally dark amphibolite gneisses and augen gneisses, in contrast to the lower grade greenschists to the northeast. The southwestern extension of the boundary between the Yavapai Series and the Pinal Schists and the approximately coincident Holbrook Line (see figure 2A) of magnetic anomalies projects to the west of the GRA. It is not known whether this geologic boundary can be extended this far to the southwest, but if so, then the Precambrian metamorphic rocks in this GRA could be the higher grade equivalent of the Pinal Schist.

The granitic rocks, according to Wilson et al. (1969), may range in composition between granite and quartz diorite. According to P. Anderson (pers. comm. to Scarborough and Wilt, 1979), they are alkali and alkali-calcic and range in age from 1.5 - 1.3 b.y.B.P.

Younger Precambrian

Younger Precambrian rocks crop out extensively in southeastern Arizona, but further west they extend into the Table Top-Vekol Mountains area in the Table Top sub-area. Here they have been described by Heindl and McClymonds (1964), who noted the presence of the Pioneer Formation, Dripping Springs Quartzite and Mescal Limestone, all of the Apache group, that are intruded by diabase sills and overlain by basalt.

The Pioneer Formation consists of greenish, reddish, and purplish gray siltstone interbedded with gray quartzite. It is 350 feet thick and rests unconformably on older Precambrian granite.

The Dripping Springs Quartzite includes the basal Barnes Conglomerate Member, which consists of light to gray conglomerate quartzite and is 24 feet thick; the middle member, which consists of crossbedded, ripple-marked, light gray, brownish gray, and red quartzite, which is 206 feet thick; and the upper member, which consists of light-to-dark gray, brownish gray, and greenish gray, crossbedded quartzite interbedded with light, greenish gray and brownish gray siltstone and mudstone, which is 595 feet thick. The Dripping Springs quartzite rests conformably on the Pioneer Formation.

The Mescal Limestone is a dark gray, brownish, and red dolomite interbedded with lesser greenish gray limestone and dark green siltstone and mudstone. It rests conformably on the Dripping Springs Quartzite.

Paleozoic

Paleozoic sedimentary rocks crop out only in the southernmost part of the Table Top sub-area in the Vekol-Table Top Mountains. Formations present in this area include the Bolsa Quartzite and Abrigo Formation, described by Heindl and McClymonds (1964); the Martin Formation, described by Teichert

(1965); and the Escabrosa Limestone, described by Bryant (1968). These are shelf sediments deposited on a stable platform east of the Wasatch Line (figure 2B) separating them from the Cordilleran geosyncline.

The Bolsa Quartzite consists of a basal conglomerate which grades upward into a light gray to brownish gray, fine-grained, crossbedded sandstone which is cemented with quartz and locally dolomite and has a porosity of less than two percent. The Cambrian Bolsa is 200 feet thick and rests unconformably on older Precambrian and on the Apache Group.

The Abrigo Formation consists of light gray to pale red shales, siltstones and fine-grained sandstones that are locally dolomitic and interbedded with minor, thinly-bedded limestones. The formation contains trilobites and is middle Cambrian. It rests conformably on the Bolsa Quartzite. In the Vekol Mountains it is 44 feet thick, but it thickens to 600 feet further to the east.

The Martin Formation is divided into the Becker's Butte Member and the Jerome Member. The Becker's Butte Member consists of yellowish red to gray fluviatile sandstones which, near the base, contain conglomerate layers and become progressively more shaly towards the top. Coalified plant fossils are present near the top and the member is Early Devonian. The thickness varies from 8 - 145 feet and the member rests disconformably on the Abrigo Formation. The Jerome Member consists of a basal, gray, laminated, fetid dolomite which in turn is overlain by interbedded sandstone, siltstone, shale and limestone. The Jerome Member is fossiliferous with brachiopods, gastropods, fishes and ostracods. It varies in thickness between a few feet and 100 feet. It is mid-Devonian and rests conformably on the Becker's Butte Member.

The Escabrosa Limestone is a sequenced gray to white calcilutite and crinoid coquina between 600 and 700 feet thick. As well as abundant crinoids,

it contains some corals, bryozoans and brachiopods, is late Devonian to Mississippian, and rests conformably on the Martin Formation.

Mesozoic

Mesozoic sediments crop out locally in the southernmost part of the Table Top sub-area, at the northern end of the Vekol Mountains. They consist of the Phonodoree Formation, Vekol Formation and the Chiapuk Rhyolite (Heindl, 1965). The ages of these formations are not well known except that they are post-Paleozoic and pre-Tertiary.

The Phonodoree Formation consists of orange-brown pebble conglomerate, red arkose, white quartzite and red to brown mudstone. It is 150 - 300 feet thick and rests with an angular unconformity on the Martin Formation and the Escabrosa Limestone.

The Vekol Formation consists of conglomerates with andesite pebbles, arkosic sandstone, greywacke, quartzite, and mudstone, probably deposited in local basins. It is 1,000 - 2,000 feet thick and rests conformably and partially disconformably on the Phonodoree Formation.

The Chiapuk Rhyolite is a welded ash flow tuff which is up to 200 feet thick and rests disconformably on the Vekol Formation.

Laramide Orogenic Period

The Laramide was a period of volcanism, intrusion and intense tectonic activity in southern Arizona. It is of particular importance because a large number of porphyry copper deposits were formed at this time, especially in southeastern Arizona (Damon and Mauger, 1966; Shafiqullah et al., 1980; Titley, 1981; Heidrick and Titley, 1982; see figure 2C). The magmatic and tectonic activity was related to a southeastward sweep of the magmatic arc

as the dip of the Benioff zone decreased (Coney and Reynolds, 1977; Clark et al., 1982).

In the Maricopa GRA, Laramide intrusives occur in the Vekol Mountains at the southern end of the Table Top sub-area. A short distance to the south, Laramide intrusives are associated with Vekol porphyry copper deposits (Chaffee, 1977; Steele, 1978). Here Laramide stocks, dikes and sills of hornblende quartz monzonite porphyry intrude Precambrian diabase and Paleozoic sedimentary rocks. In the Table Top sub-area small Laramide stocks intrude Precambrian diabase and Apache Group sediments, and lower Paleozoic sediments.

Metamorphic Core Complexes

More than a dozen metamorphic core complexes have been identified and described recently in southwestern Arizona. They occur along a northwest trending zone that extends from southeastern to west-central Arizona and are part of a more extensive zone that runs from Sonora to Arizona, through eastern Nevada, Idaho, eastern Washington and southeastern British Columbia (Coney, 1980). Their general features have been summarized recently by Davis and Coney (1979) and Reynolds (1980), as follows. Metamorphic core complexes are characterized by metamorphic and mylonitic rocks whose gently-dipping foliation defines broad domes which generally are elongated in a ENE to NE direction. The core of the domes consist of amphibolite facies gneisses and granites that have undergone ductile deformation. Up section a mylonitic fabric with an ENE-to-NE lineation is overprinted on both igneous and metamorphic rocks. This grades upward into a greenschist facies breccia over a short distance and records a sharp thermal and strain gradient. The breccia is overlain by a normal decollement zone, or dislocation surface, above which allochthonous, deformed, but unmetamorphosed upper plate rocks are present.

These range in age from Precambrian to Miocene and have undergone listric normal faulting as recently as mid-Miocene. The core complexes typically record 30 - 20 m.y.B.P. K-Ar cooling ages. It is generally agreed that the complexes formed in an extensional environment (back-arc spreading?) during and after the fast regression of the magmatic arc 40 - 20 m.y.B.P. (Coney and Reynolds, 1977) at a time of high heat flow. Davis and Coney (1979) regard the complexes as megaboudins formed from the crystalline basement. Rehrig and Reynolds (1980) agree that the complexes formed by an extensional process but consider that the metamorphic core complex itself developed between, rather than within, separating blocks.

Metamorphic core complexes occur in the White Tank Mountains and in the South Mountains to the north and northeast of the Maricopa GRA respectively. A brief reconnaissance by Rehrig and Reynolds (1980) shows that in the Buckeye Hills in the northwest corner of the Estrella sub-area abundant metamorphic and granitic rocks show a mylonitic foliation and an E-to-NE-trending lineation. The anomalous ENE trend of this range also suggests that the uplift is related to metamorphic core complex deformation.

Mid-Tertiary

Mid-Tertiary rocks are here defined to include all sedimentary and igneous rocks deposited after the Laramide orogeny and the post-Laramide period of peneplanation, and before Basin and Range type faulting became dominant. These pre-Basin and Range rocks have been divided into three units by Eberly and Stanley (1978) and Scarborough and Wilt (1979).

The lowest unit consists of indurated, red to brown arkosic fluvial sandstone, fanglomerates of gneissic and granitic provenance up to 300 feet thick, and minor lacustrine sediments with some algal limestone. Andesitic to rhyolitic volcanics increase in abundance towards the upper part of this unit.

The middle unit is characterized by voluminous intermediate to felsic volcanism that is associated with the mid-Tertiary orogeny. The volcanics consist of flows, ash flow tuffs, tuff breccias and ash of latitic, quartz latitic, rhyolitic, and trachytic composition and flows and flow breccias of basaltic, basaltic andesite, and andesitic composition (Reynolds, 1980). Small intrusions of the above compositions are also present. The volcanic rocks are interbedded with red sand and gravel fluvial deposits, massive fanglomerates, and lacustrine deposits with local organic-rich facies, algal limestones, and water-laid tuffs. It is within such beds that the uranium deposit of the well-known Anderson Mine is located (Sherborne et al., 1979).

The upper unit consists of grayish brown, poorly consolidated sandstones, fanglomerates, mudstones, and water-laid tuffs. The rocks contain abundant volcanic debris. They are overlain and intercalated with basaltic volcanic mudstones in lacustrine deposits and contain fresh water ostracods.

The mid-Tertiary rocks rest unconformably on Precambrian, Paleozoic, Mesozoic, and Laramide rocks. They were deposited in northwest-striking basins which were tilted northeastward and southwestward as shown in figure 2D (Scarborough and Wilt, 1979).

The mid-Tertiary volcanic rocks lie mainly in the middle unit, but they do extend into the lower and upper units. The volcanism was extremely voluminous, and in southwestern Arizona about a million cubic kilometers were emptied (Shafiqullah et al., 1980). These may have been largely emptied from cauldrons such as have been identified in the Datil volcanics in southwestern New Mexico by Elston (1978) and Elston and Bornhorst (1979). However, no such cauldrons have been identified in southwestern Arizona to date. The volcanism lasted from 35 m.y.B.P. to about 12 m.y.B.P., with the interval between 24 and 12 m.y.B.P. being the transition from the mid-Tertiary orogeny to Basin and

Range faulting, which did not take place simultaneously throughout southwestern Arizona (Shafiqullah et al., 1980). In western Arizona the intensity of volcanism peaked about 21 m.y.B.P. as the volcanic arc swept westward during the steepening of the Benioff zone in the late Oligocene and early Miocene (Coney and Reynolds, 1977). At first the volcanism was calc-alkaline, but as the main magmatic arc passed westward the volcanism became highly potassic with eruption of potassic trachyandesites and ultra-potassic trachytes (Shafiqullah et al., 1980). Towards the close of the mid-Tertiary orogeny, volcanism became almost entirely basaltic.

In the Maricopa GRA, mid-Tertiary rocks crop out in the Sand Tank Mountains in southern Estrella sub-area, and in the southern half of the Table Top sub-area. In the Sand Tank Mountains, sediments, intermediate volcanics and basalts unconformably overlie Precambrian granite. In the Table Top sub-area, basalt unconformably overlies Precambrian and Paleozoic rocks. The volcanics are the northernmost extent of the Ajo volcanic field (Scarborough, 1979).

Mid-Tertiary rocks underlie much of the valley-fill sediments that were deposited during and after Basin and Range faulting (Eberly and Stanley, 1978). Based on seismic profiling and available well data, they have shown that to the west of Estrella near the Gila Bend Mountains about 1,500 feet of middle unit volcanics and 600 feet of upper unit clastics are present. Along the Hassayampa River to the northwest of Estrella about 1,000 feet of middle unit volcanics and 600 feet of upper unit clastics are present. The thickness of these units in the GRA is not known.

Late Tertiary

Late Tertiary deposits are found in all the tectonic basins formed during the Basin and Range disturbance. The depth of these basins have been estimated

by Oppenheimer and Sumner (1980) through gravity modeling and drillhole data and is shown in figure 3 and summarized in figure 1 of this report. The depths of these basins are highly variable, but those that are deeper than 1,000 feet include parts of western and northeastern Estrella and northeastern Table Top sub-areas.

The deposits consist mainly of poorly consolidated, tan colored fan-glomerate, sandstone, and siltstone of fluvial and lacustrine origin, and minor basalt (Scarborough and Wilt, 1979; Reynolds, 1980). These deposits rest unconformably on mid-Tertiary or older rocks.

The initiation of Basin and Range faulting and deposition of basin-fill sediments took place 13 - 12 m.y.B.P. according to Eberly and Stanley (1978). Shafiqullah et al. (1980), however, present evidence to show that the transition from the mid-Tertiary orogeny to the Basin and Range disturbance took place over the time interval between 19 and 12 m.y.B.P., and that the basaltic volcanism decreased in intensity from 9 to 4 m.y.B.P. The interval during which Basin and Range tectonism, volcanic activity and sedimentation was dominant in southwestern Arizona was probably 14 - 4 m.y.B.P. (Shafiqullah et al., 1980), though some basaltic volcanism is as young as 1 m.y.B.P.

Latest Tertiary and Quaternary

During the last four million years, volcanic and tectonic activity has slowed down in southwestern Arizona. The dominant geological processes have been erosion of ranges and formation of extensive pediments, deposition of fanglomerates and deposition of alluvium, mainly near the Gila River.

Structural Geology

The GRA lies within the North American craton and east of the Wasatch Line and has been affected by tectonism during Proterozoic, mid-Mesozoic,

Laramide and mid-Tertiary orogenies and most recently by the Basin and Range disturbance. The area is, therefore, structurally complex. It is only recently, and largely as a result of detailed structural studies and extensive radiometric dating, that the structure and tectonics of the area has begun to be understood. Particularly important recent studies include strain analysis of various deformations by Davis (1981) and a summary of recent radiometric dates by Shafiqullah et al. (1980).

During the Arizonan revolution, 1.76 to 1.63 b.y.B.P. (Damon, 1968), the Precambrian rocks were folded about ENE-striking axes and underwent N-S to NNW faulting (Davis, 1981). The Colorado lineament (see figure 2A), a major strike-slip system according to Warner (1978), was initiated about this time and its southwestern extension passes to the northwest of the GRA.

No pronounced tectonic or igneous activity took place during the Paleozoic, but southwestern Arizona was strongly affected by a mid-Mesozoic magmatic arc and a later period of metamorphism and folding. The magmatic arc extended across southwestern Arizona (see figure 2B; over the southern part of the GRA) during mid-Jurassic and produced voluminous volcanism and granitic plutonism. The area underwent folding and metamorphism after deposition of molasse-like sediments and prior to the Laramide orogeny, but these rocks are not preserved in the Maricopa GRA. Northwest-trending strike slip faulting was initiated (Davis, 1981) and movement along the Mojave-Sonora left-lateral megashear (see figure 2B) probably took place at this time (Silver and Anderson, 1974). Northwest-trending discontinuities in depositional patterns (see figure 2C) were produced in southeastern Arizona (Titley, 1976).

The Laramide was a period of intense tectonism and localized magmatic activity which were associated with the southeastward migration of the magmatic arc (Coney and Reynolds, 1977; Lowell, 1974). The Laramide

basement-cored uplifts and thrust faults which strike NNW to NW (Nielsen, 1979; Davis, 1981); the WNW left-lateral strike-slip faulting of the Texas zone of Schmitt (1966); and the ENE-striking tensional features (Rehrig and Heidrick, 1976) are all probably related to ENE plate motion and compression. Laramide plutons associated with porphyry copper mineralization have a pronounced NNW to NW trend and a secondary ENE trend (Heidrick and Titley, 1982; see figure 2C). The former is parallel to the Laramide magmatic arc and basement-cored uplifts, and the latter is parallel to Precambrian fold axes and Laramide tensional features. One of the ENE trends passes through the southern part of the Maricopa GRA (see figure 2C).

The mid-Tertiary orogeny lasted approximately from 34 to 14 m.y.B.P. (Shafiqullah et al., 1980) and involved eruption of large volumes of volcanic rocks, emplacement of metamorphic core complexes (figure 2D) and listric normal faulting. These geologic events accompanied the steepening of the Benioff zone and the resultant westward migration of magmatic arc at this time (Coney and Reynolds, 1977).

The volcanism produced enormous volumes of ignimbrite eruptions and was dominantly calc-alkaline but became potassic in the later stages. In southwestern New Mexico similar volcanics originated from numerous cauldrons (Elston and Bornhorst, 1979). Cauldrons may be present in southwestern Arizona, although none have been located to date. The absence of thick felsic volcanics observed in the Maricopa GRA, however, makes it unlikely that such structures are present there.

Metamorphic core complexes are characterized by mylonitic augen gneiss and an overlying brittle fracture zone separated by a dislocation surface from an allochthonous upper plate which is unmetamorphosed (Davis and Coney, 1979; Coney, 1980; Rehrig and Reynolds, 1980). The mylonitic foliation defines

gently dipping, NE-to-ENE-striking dunes which have physiographic expression. The mylonitic rocks have a pronounced NE-to-ENE lineation which is developed parallel to the direction of extension in the lower plate. Most workers agree that the metamorphic core complexes indeed formed as a response to extension in a NE-SW to ENE-WSW direction. Davis (1980) considers the complexes as mega-boudins, whereas Rehrig and Reynolds (1980) consider that the complexes developed in areas of high heat flow between separating blocks. The relationship of the core complexes to the coeval volcanism is not known. The Buckeye Hills in the northwest corner of the Estrella sub-area has local mylonitic foliation which is possibly associated with a metamorphic core complex.

Listric normal faulting is common in the upper plates of metamorphic core complexes. The faults merge downward into the dislocation surface. The spoon-shaped, gravity-like faults generally strike northwest and typically involve Oligocene and mid-Miocene rocks (Davis, 1981).

About 14 m.y.B.P. a transition occurred between listric faulting and Basin and Range normal faulting. Basin and Range faults strike NW to N-S (see figure 1) and are high angle faults (Davis, 1981). The present-day ranges and basins resulted from this tectonic episode which was terminated in much of southwestern Arizona about 4 m.y.B.P.

Paleontology

Paleontological documentation is important for three major reasons, as follows:

- a. guide fossils which in the sedimentary sequence are most useful for stratigraphic correlation,
- b. outstanding fossil specimens or fossils which are extraordinarily well preserved can be beneficial to science and/or tourism, and

- c. fossils can be excellent indicators of the paleogeographic and paleoecological environments; as a result, even moderately to poorly preserved "uninteresting" fossils can be geologically important.

Plant fossils must also be considered important as organic material can trigger the precipitation of uranium and/or other metals.

The following is a brief summary of the sedimentary formations of the Maricopa GRA and WSAs listing types of fossils present. To the authors' knowledge, there are no fossil localities of outstanding importance, either scientifically or as curiosities.

Older metamorphic rocks of the Maricopa GRA include the metasedimentary Pinal (?) Schist which was deposited 1.7 to 1.68 b.y.B.P. The Apache Group, of late Precambrian age, includes siltstone and quartzite of the Pioneer Formation; the Dripping Springs Quartzite, which contains siltstone and mudstone beds as well as quartzite; and the Mescal Limestone, a dolomite with siltstone and mudstone beds. To the knowledge of the authors, none of the Precambrian rocks of the Maricopa GRA contain any fossils.

Paleozoic fossil-bearing formations crop out in the Table Top sub-area. Trilobites occur in the mid-Cambrian Abrigo Formation (Heindl and McClymonds, 1964). The early Devonian Becker's Butte Member of the Martin Formation contains coalified plant remains, and the mid-Devonian Jerome Member of the same formation has a fossil assemblage including brachiopods, gastropods, fish and ostracods (Teichert, 1965). Crinoids, coral, bryozoans and brachiopods occur in the late Devonian to Mississippian Escabrosa Limestone (Bryant, 1968).

No fossils are reported to occur in the Mesozoic Phonodoree and Vekol Formations (Heindl, 1965).

The lowest mid-Tertiary unit of Scarborough and Wilt (1979) and Eberly and Stanley (1978) contains algal limestone in other areas. The middle mid-Tertiary units of the same groups of authors consist of volcanic rock interbedded with fluvial deposits, fanglomerates and algal fluvial sands and gravels, fanglomerates and lacustrine deposits including organic-rich beds and algal limestones. No reports of plant or animal fossil occurrences in the late Tertiary and Quaternary basin-fill sediments are known to the authors.

The North Maricopa Mountains, Butterfield Stage Memorial and Sierra Estrella WSAs are underlain by Precambrian crystalline rocks and Quaternary basin-fill sediments. As stated above, fossils are not reported to occur in these rocks.

The South Maricopa Mountains WSA includes outcroppings of Precambrian metasedimentary Pinal (?) Schist, mid-Tertiary basalts, and Quaternary basin-fill sediments. Although unreported, interbeds of potentially fossil-bearing sedimentary rocks could occur within the basalt unit.

Precambrian metasedimentary rocks; undifferentiated Paleozoic sediments, possibly including the fossil-bearing Abrigo, Martin and Escabrosa Formations; Tertiary volcanic rocks; and Quaternary sediments all crop out in the Table Top WSA. Apache Group sediments may be present in the sub-surface. As is the case with the mid-Tertiary volcanics in the South Maricopa Mountains, it is not known if any sedimentary interbeds occur within the volcanic units of the Table Top sub-area.

Geologic History and Paleogeographic Development

The geologic history of the area is long and complex, and only a brief synopsis is presented here. Excellent summaries of the main geological events that affected the southern Cordillera of North America are given by

Burchfiel (1979) and Dickinson (1981). More detailed accounts pertaining particularly to southwestern Arizona are given by Shafiqullah et al. (1980) and Reynolds (1980). The geologic history can be summarized as follows:

1. 1.8 to 1.6 b.y.B.P. volcanic and clastic rocks were accreted onto the North American craton from the southeast (Anderson, 1976; Anderson and Silver, 1976; Silver, 1978; Titley, 1982). The boundary between the dominantly volcanic and volcanoclastic Yavapai Series and the clastic nonvolcanic Pinal Schists coincides with the Holbrook Linear which passes to the northwest of the GRA (see figure 2A). The rocks were folded about northeasterly axes, metamorphosed and intruded by anorogenic granites 1.5 to 1.4 b.y.B.P. (Damon, 1968, Silver et al., 1977).
2. Some time after this, but before 1.2 - 1.1 b.y.B.P., the area was uplifted and eroded. The eastern part of the GRA was then submerged beneath epicontinental seas and shallow marine clastic sediments and minor carbonates of the Apache Group were deposited (Heindl and McClymonds, 1964).
3. The Apache Group was intruded by diabase sills and dikes 1.2 to 1.1 b.y.B.P. (Damon, 1968). Locally, the Apache Group is overlain by basaltic rocks of similar age to the intrusives.
4. The area was uplifted and bevelled, and during the Cambrian, the eastern part of the GRA was again submerged beneath epicontinental seas. At this time, shallow marine clastic sandstone, mudstone and minor limestone were deposited (Heindl and McClymonds, 1964).
5. No deposition took place during the Ordovician and Silurian, and the Cambrian is disconformably overlain by a thick Devonian

to Early Mississippian transgressive sequence of fluvial sandstone, shallow marine clastic rock and dolomitic carbonate rock (Teichert, 1965; Bryant, 1968).

6. No record of Late Paleozoic sediments is found, and possibly they were removed by erosion during the mid-Mesozoic orogeny. Molasse-like Mesozoic sediments were deposited in local basins in the eastern part of the GRA (Heindl, 1965). The upper part of this sequence contains volcanic material, possibly derived from the magmatic arc that extended over the southern part of the GRA during the mid-Jurassic (see figure 2B).
7. The Laramide was a period of intense tectonic activity characterized by NNW-to-NW striking basement-cored uplifts and thrust faults (Nielsen, 1979; Davis, 1981); WNW-striking, left-lateral faults of the Texas zone (Schmitt, 1966); ENE-striking tensional features (Rehrig and Heidrick, 1976); and intrusion of small epizonal plutons along NW and ENE trends (Heidrick and Titley, 1982). The magmatic activity proceeded from northwest to southeast as the dip of the Benioff zone flattened in the time interval from 70 to 50 m.y.B.P. (Coney and Reynolds, 1977).
8. The Laramide was followed by a period of tectonic quiet and erosion.
9. The mid-Tertiary orogeny lasted from about 35 to 14 m.y.B.P. During this time, a great thickness of fluvial and lacustrine sediments interbedded with voluminous felsic to intermediate volcanics were deposited in northwest-striking basins (Eberly and Stanley, 1978; Scarborough and Wilt, 1979). The volcanism was mainly calc-alkaline (Shafiqullah et al., 1980) and was

dominated by ignimbrite eruptions, possibly related to cauldrons. Coeval with the volcanism was the emplacement of metamorphic core complexes which occur along a northwest-trending zone (Coney, 1980) to the north of the GRA. Associated with the core complexes, and also present elsewhere in southwestern Arizona, are listric normal faults (Davis, 1981) which offset mid-Tertiary volcanic and sedimentary rocks. Volcanism and tectonism migrated westward during the mid-Tertiary as the dip of the Benioff zone steepened (Coney and Reynolds, 1977).

10. After the westward passage of the magmatic arc, listric normal faulting gave way to steep, normal, Basin and Range faulting which became dominant after 14 m.y.B.P. (Shafiqullah et al., 1980). At this time basalt became the predominant volcanic rock, the present ranges were uplifted, and the basins were filled with fluvial, lacustrine and marine sediments.
11. Since 4 m.y.B.P. volcanism and tectonism have been minor (Shafiqullah et al., 1980), and the dominant geologic processes have been erosion of ranges resulting in the formation of extensive pediments and deposition of fans in the basins and alluvium along major rivers.

ENERGY AND MINERAL RESOURCES

The following are descriptions of known mineral deposits, prospects, occurrences, mineralized areas and thermal wells and other energy resources (figures 3 and 4) in the Maricopa GRA. Information was derived from the following resources: U.S. Geological Survey (1972, 1982), U.S. Bureau of Mines (1982), Arizona Bureau of Mines (1969), Stipp et al. (1967) and McCrory

and O'Haire (1965). These descriptions represent a summary of the information regarding individual mines and occurrences that is available to the writers. Figures 3 and 4 show locations of the listed mines, mineral occurrences, and thermal wells.

Known Mineral Deposits, Mines or Prospects with Recorded Production

1. Hightower Mica Mine
Location: 33°11'49"N, 112°13'45"W
Secs. 2, 12, 27, T3S, R1E and Sec. 34, T2S, R1E
Latitude and longitude given are for center of main deposit.
Commodity: Mica
Ore Materials: Muscovite.
Description of Deposit: None
Geology: Muscovite books in pegmatite and coarse flakes in schistose wall rock.
Production: Some processed and shipped as ground mica.
References: U.S.G.S. CRIB Mineral Resources File 12, Record 765, p. 2083-2084.
11. Altuda
Location: Maricopa County; 32°48'38"N, 112°23'56"W
Precision 500 m; T7S, R1W, Sec. 19
Elevation: 634m: 100 M
Status: Past Producer.
Operation Type: Surface and underground.
Map Name: Estrella, 15 min.; Ajo 2 degree quad.
Commodities: Gold, silicon, iron, silver, hematite-magnetite.
References: U.S.B.M., 1982, MILS.
17. Dads Creek Placers
Location: 33°15'22"N, 112°34'26"W
Secs. 8, 9, 10, 15, 16, 17, T2S, R3W, Gila and Salt River Meridian
Commodity: Au
Ore Materials: Unknown.
Description of Deposit: Placer.
Geology: Unknown.
Production: Small production reported.
Reference: M.G. Johnson, 1972, U.S.G.S. Bulletin 1355.
Note: Exact location was not available to the author of U.S.G.S. Bulletin 1355. The location given above is an estimate.
26. Gravel Pit
Location: Pinal County; 32°49'4"N, 112°07'48"W; Precision 100 m; T7S; R2E, W2, Sec. 14
Elevation: 579 m: 100 m
Status: Past Producer.

- Operation Type: Surface.
Map Name: Antelope Peak, 15 min.; Ajo 2 degree quad.
Commodities: Sand, gravel.
Reference: U.S.B.M., 1982, MILS.
27. Gravel Pit
Location: Pinal County; 32°50'26"N, 112°04'8"W; Precision 100 m; T7S, R3E; SWSESE Sec. 5
Elevation: 468 m; 100 m.
Status: Past Producer.
Operation Type: Surface.
Map Name: Antelope Peak, 15 min.; Ajo 2 degree quad.
Commodities: Sand, gravel.
Reference: U.S.B.M., 1982 MILS.
28. Gravel Pit
Location: Pinal County; 32°50'50"N, 112°02'45"W; Precision 100 m; T7S, R3E; NWSW Sec. 3
Elevation: 442 m; 100 m.
Status: Past Producer.
Operation Type: Surface.
Map Name: Antelope Peak, 15 min.; Ajo 2 degree quad.
Commodities: Sand, gravel.
Reference: U.S.B.M., 1982 MILS.
32. Good Earth
Location: Maricopa County; 32°15'9"N, 112°39'19"W; Precision 500 m; T2S, R4W; SESENE Sec. 15
Elevation: 293 m; 100 m.
Status: Exp. prospect.
Operation Type: Placer.
Map Name: Buckeye, 15 min.; Phoenix 2 degree quad.
Commodities: Columbium, niobium.
Reference: U.S.B.M., 1982 MILS.
33. Striped Mountain Claims
Location: Maricopa County; 33°15'37"N, 112°39'54"W; Precision unknown; T2S, R4W; NWNWNW Sec. 15
Elevation: 354 m; 100 m.
Status: Raw prospect.
Operation Type: Surface.
Map Name: Buckeye, 15 min.; Phoenix 2 degree quad.
Commodities: Uranium, gemstone, feldspar, mica, semiprecious silicates.
Reference: U.S.B.M., 1982 MILS.

Known Prospects, Mineralized Areas, and Geothermal Resources
with No Recorded Production

2. Bosque Group
Location: 32°59'32"N, 112°30'00"W
Sec. 18, T5S, R2W
Commodity: Mn

Ore Materials: Manganite, pyrolusite, psilomelane.
Description of Deposit: Mineralization in fissure zone. Surface workings.
Geology: Ore replaces granite in fissure zone.
Production: Unknown.
References: U.S.G.S. CRIB Mineral Resources File 12, Record 814, p. 2195-2196.

3. Unnamed Granite Location

Location: 33°08'12"N, 112°36'24"W
Sec. 30, T3S, R3W, Gila and Salt River Meridian
Commodity: Building stone.
Ore Material: Granite.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
Reference: McCrory.

4-6. Unnamed Mica Occurrences

Location: 4: 33°13'23"N, 112°35'11"W
Sec. 29, T2S, R3W, Gila and Salt River Meridian
5: 33°14'18"N, 112°35'26"W
Sec. 20, T2S, R3W, Gila and Salt River Meridian
6: 33°14'20"N, 112°34'18"W
Sec. 21, T2S, R3W, Gila and Salt River Meridian
Commodity: Mica.
Ore Material: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
Reference: F.J. McCrory and R.T. O'Haire, 1965.

7. Unnamed Sand and Gravel Occurrence

Location: 33°14'22"N, 112°36'27"W
Sec. 19, T2S, R3W, Gila and Salt River Meridian
Commodities: Sand and gravel.
Ore Materials: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: F.J. McCrory and R.T. O'Haire, 1965.

8,10. Unnamed Mineral Occurrences

Location: 8: 32°49'30"N, 112°27'59"W
Sec. 16, T7S, R2W, Gila and Salt River Meridian
10: 32°47'38"N, 112°25'46"W
Sec. 26, T7S, R2W, Gila and Salt River Meridian
Commodities: Unknown.
Ore Material: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: U.S.G.S. Map MR-46.

9. Noonam Group
Location: Maricopa County; 32°45'54"N, 112°26'36"W
Precision 500 m; R2W; SENENE Sec. 3
Elevation: 707 m; 100 m.
Status: Unknown.
Operation Type: Underground.
Map Name: Estrella, 15 min.; Ajo 2 degree quad.
Commodity: Copper.
Reference: U.S.B.M., 1982 MILS.
12. Papago Indian Chief Mine
Location: 32°46'14"N, 112°29'55"W
Sec. 31, T7S, R2W, Gila and Salt River Meridian
Commodity: Cu.
Ore Materials: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: U.S.G.S. Map MR-46.
13. New Maricopa Copper Company
Location: 32°45'56"N, 112°28'12"W
Sec. 4, T8S, R2W, Gila and Salt River Meridian
Commodity: Cu.
Ore Materials: Unknown.
Description of Deposit: Unknown; underground workings.
Geology: Unknown.
Production: Unknown.
References: U.S.G.S. Map MR-46; U.S.B.M., 1982, MILS.
14. Unnamed Copper and Gold Occurrence
Location: 32°47'52"N, 112°24'17"W
Sec. 19, 30, T7S, R1W, Gila and Salt River Meridian
Commodities: Cu, Au.
Ore Materials: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: U.S.G.S. Map MR-46.
- 15-16. Unnamed Copper Occurrences
Location: 15: 32°56'31"N, 112°22'52"W
Sec. 29, T5S, R1W, Gila and Salt River Meridian
16: 32°57'52"N, 112°22'29"W
Sec. 32, T5S, R1W; Gila and Salt River Meridian
Commodity: Cu.
Ore Materials: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: U.S.G.S. Map MR-46.

18. Area of Low Temperature Geothermal Waters

Location: T2S, R1W; T2S, R3W; T2S, R4W; T3S, R1E;
T3S, R1W; T4S, R1W
Geology: Deep basin.
Production: None.
References: Information from Witcher et al., 1982, who state:
"Existing knowledge does not in general permit the
inference that thermal waters may be found every-
where within the depicted areas, nor do the boun-
daries represent current knowledge of the areal
extent of the geothermal resources."
Note: Wells (shown in figure 3) have reported temperatures
of 35-38°C.

19. Unnamed Fluorite Occurrence

Location: 32°40'35"N, 112°02'39"W
Sec. 4, T9S, R3E, Gila and Salt River Meridian
Commodity: F
Ore Material: Fluorite.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: F.J. McCrory and R.T. O'Haire, 1965.

20-22. Unnamed Copper Occurrences

Location: 20: 32°43'58"N, 112°10'55"W
Sec. 17, T8S, R2E, Gila and Salt River Meridian
21: 32°42'29"N, 112°09'12"W
Sec. 28, T8S, R2E; Gila and Salt River Meridian
22: 32°43'25"N, 112°09'16"W
Secs. 16, 21, T8S, R2E, Gila and Salt River Meridian
Commodity: Cu.
Ore Materials: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: U.S.G.S. Map MR-46.

23. Unnamed Silver and Gold Occurrence

Location: 32°38'44"N, 112°07'34"W
Sec. 14, T9S, R2E, Gila and Salt River Meridian
Commodities: Ag, Au.
Ore Materials: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: U.S.G.S. Map MR-46.

24. Unnamed Manganese Occurrence

Location: 32°41'27"N, 111°57'44"W
Sec. 33, T8S, R4E, Gila and Salt River Meridian
Commodity: Mn.
Ore Materials: Unknown.
Description of Deposit: Unknown.
Geology: Unknown.
Production: Unknown.
References: U.S.G.S. Map MR-46.

25. Area of Low Temperature Geothermal Waters
Location: T5S, R2E, T5S, R3E; T5S, R4E; T6S, R2E;
T6S, R3E; T6S, R4E
Geology: Deep basin.
Production: None.
Note: This area is considered favorable for the
discovery and development of low-temperature
(lower than 100°C) geothermal resources,
but extent of the resources may not be fully
understood at this time.
Thermal well located SW-1/4 Sec. 25, T5S, R2E.
29. Chloride Mountain
Location: Maricopa County; 32°44'26"N, 112°28'45"W;
Precision unknown, T8S, R2W; SW Sec. 8
Elevation: 761 m: 100 m
Status: Exp. prospect.
Operation Type: Underground.
Map Name: Kaka, 15 min.; Ajo 2 degree quad.
Commodities: Gold, silver.
Reference: U.S.B.M. 1982 MILS.
30. Bosley Gold
Location: Maricopa County; 33°10'55"N, 112°18'50"W;
Precision unknown; T3S, R1W, Sec. 12
Elevation: 377 m: 100 m
Status: Raw prospect.
Operation Type: Mineral loc.
Map Name: Mobile, 15 min.; Phoenix 2 degree quad.
Commodities: Gold, copper, silver.
Reference: U.S.B.M. 1982 MILS.
31. Sylvania Mica
Location: Maricopa County; 33°12'42"N, 112°12'35"W;
Precision unknown; T2S, R1E, Sec. 36
Elevation: 1158 m: 100 m
Status: Unknown.
Operation Type: Unknown.
Map Name: Montezuma Peak, 7.5 min.; Phoenix 2 degree quad.
Commodities: Mica, gemstone, gold, semiprecious silicates,
feldspar, copper.
Reference: U.S.B.M. 1982 MILS.
34. Area with Known Geothermal Potential
Location: T5S, R2W; T6S, R3W; T6S, R2W; T6S, R1E, T6S, R2W;
T7S, R1W; T7S, R1E; T7S, R2E; and T8S, R1E
Commodities: Geothermal energy.
Geology: Basin filled with Tertiary and Quaternary sediments.
Production: Unknown.
Reference: Jones, 1979.
Note: Location was approximated from a small-scale map
in Jones (1979) by paralleling the 400 foot depth-
to-basement contour lines (see figure 3). Known
occurrences of water with low to moderate temper-
ature (30°C - 150°C) are contained within the
area.

Mining Claims, Leases, and Material Sites

There are many mining claims in the Maricopa GRA. However, according to the BLM records (as of June 1982), all valid claims are located in three main areas, namely: the northeastern part of North Maricopa Mountains WSA, the eastern part of South Maricopa Mountains WSA, and Sierra Estrella WSA. All these claims are unpatented. The claim density, i.e. number of claims per square mile (section), is shown in figures 6 and 7 and more detailed records are included in Table 2.

According to the BLM records, there are no mining claims in the Table Top sub-area.

In spite of our efforts, we were unable to determine the specific types of deposits or mineral commodities for which these claims were filed.

During this study we have also thoroughly investigated the status of oil and gas leases. As a result, an outline of all land currently either fully or partially leased is shown in figures 6 and 7. It can be noted, too, that much of the federal and fee land is leased for five- or ten-year terms.

Within the Maricopa GRA there are few material sites, all located within a few miles of the northeast boundary of the Table Top WSA.

Mineral Deposit Types

Geological environments to be considered as potentially favorable for the occurrence of mineral or energy resources include the following:

- Older Precambrian igneous and metamorphic rocks,
- Younger Precambrian sedimentary rocks,
- Paleozoic and Mesozoic sediments,
- Jurassic arc intrusive rocks,
- Laramide intrusive rocks,
- Mid-Tertiary metamorphic core complexes

Fig 6. CLAIM DENSITY MAP, WITH OIL AND GAS LEASING STATUS, OF THE ESTRELLA SUB-AREA.

Note: hachured lines enclose oil and gas leases; numbers are claims per section.

Fig 7. OIL AND GAS LEASING STATUS MAP OF THE TABLE TOP SUB-AREA, ARIZONA.

Note: hachured lines enclose oil and gas leases.

TABLE 2:

CLAIM DENSITY RECORDS IN THE WILDERNESS STUDY AREAS (WSA),
ESTRELLA SUB-AREA, ACCORDING TO BLM (JUNE 1982),
ARIZONA STATE OFFICE

Township	Range	Section	Claims For Each Section	Claimants	Latest Assmt. Date	Remarks
WSA 020-157 North Maricopa Mountains						
2S	2W	31	NW 1	Johnson, Alvin/ Beebe, Bradley	none	placer
			NE 1	"	"	"
			SW 1	"	"	"
			SE 1	"	"	"
3S	2W	5	SE 1	"	"	"
			NW 1	"	"	"
			NE 1	"	"	"
		6	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		8	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		13	NW 1	Rainbow Mining Co.	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		14	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		17	NW 1	Johnson, Alvin/ Beebe, Bradley	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		20	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"

TABLE (Cont'd.)

Township	Range	Section	Claims For Each Section	Claimants	Latest Assmt. Date	Remarks
WSA 020-157 North Maricopa Mountains (Cont'd.)						
3S	2W	21	NW 1	Johnson, Alvin/ Beebe, Bradley	none	placer
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		22	NW 1	"	"	"
			SW 1	"	"	"
		26	NW 1	Texas Iron, Inc.	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		27	NW 1	Johnson, Alvin/ Beebe, Bradley	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		28	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		29	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		30	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		31	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		33	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"

TABLE (Cont'd.)

Township	Range	Section	Claims For Each Section	Claimants	Latest Assmt. Date	Remarks		
WSA 020-157 North Maricopa Mountains (Cont'd.)								
3S	2W	34	NW 1	Johnson, Alvin/ Beebe, Bradley	none	placer		
			SW 1	"	"	"		
			NE 1	"	"	"		
			SE 1	"	"	"		
		35	NW 1	Texas Iron, Inc.	"	"		
			SW 1	"	"	"		
			NE 1	"	"	"		
			SE 1	"	"	"		
	3W	35	NE 1	Johnson, Alvin/ Beebe, Bradley	"	"		
			SE 1	"	"	"		
		3W	1	NW 1	"	"	"	
				NE 1	"	"	"	
SE 1	"			"	"			
25	NW 1		"	"	"			
	SW 1		"	"	"			
	NE 1		"	"	"			
26	NE 1	"	"	"	"			
	SE 1	"	"	"	"			
WSA 020-160 Sierra Estrella								
2S	1E	33	S2 1	Texana, Inc.	"	lode		
			SW 4	"	"	"		
SE 2			"	"	"			
3S	1E	2	SW 1	Minexa Arizona, Inc.	"	placer		
		3	NW 1	Seven-Mile Mng. Assn.	"	"		
			NE 1	"	"	"		
			SW 2	Minexa Arizona, Inc./ Seven-Mile Mng. Assn.	"	"		
			SE 2	"	"	"		
		4	A11 1	Texana, Inc.	"	lode		
			W2 4	"	"	"		
			E2 2	"	"	"		

TABLE (Cont'd.)

Township	Range	Section	Claims For Each Section	Claimants	Latest Assmt. Date	Remarks
WSA 020-160 Sierra Estrella (Cont'd.)						
3S	1E	4	N2 1	Texana, Inc.	none	1ode
			S2 2	"	"	"
			NW 10	Minexa Arizona, Inc./ Seven-Mile Mng. Assn./ Texana, Inc.	"	"
			SW 11	"	"	"
			NE 6	"	"	"
			SE 5	"	"	"
		5	SW 5	Seven-Mile Mng. Assn./ Texana, Inc.	"	4-1ode 1-placer
			SE 6	Minexa Arizona, Inc./ Texana, Inc.	"	4-1ode 2-placer
			NW 1	Seven-Mile Mng. Assn.	"	placer
			S2 1	Texana, Inc.	"	1ode
			W2 4	"	"	"
			E2 4	"	"	"
		8	S2 1	"	"	"
			N2 2	"	"	"
			A11 1	"	"	"
			NW 10	Minexa Arizona, Inc./ Seven-Mile Mng. Assn./ Texana, Inc.	"	8-1ode 2-placer
			SW 6	"	"	4-1ode 2-placer
			NE 10	"	"	8-1ode 2-placer
			SE 6	"	"	4-1ode 2-placer
		9	A11 1	Texana, Inc.	"	1ode
			N2 2	"	"	"
			S2 1	"	"	"
			W2 5	"	"	"
			E2 1	"	"	"
			SW 6	Seven-Mile Mng. Assn./ Texana, Inc.	"	5-1ode 1-placer
			SE 4	Minexa Arizona, Inc./ Seven-Mile Mng. Assn./ Texana, Inc.	"	1-1ode 3-placer
			NW 12	"	"	10-1dde 2-placer
			NE 4	"	"	2-1ode 2-placer

TABLE (Cont'd.)

Township	Range	Section	Claims For Each Section	Claimants	Latest Assmt. Date	Remarks
WSA 020-160 Sierra Estrella (Cont'd.)						
3S	1E	10	SW 3	Seven-Mile Mng. Assn./ Minexa Arizona, Inc.	none	placer
			NW 2	"	"	"
			NE 2	"	"	"
			SE 1	Seven-Mile Mng. Assn.	"	"
		11	SW 2	Seven-Mile Mng. Assn./ Minexa Arizona, Inc.	"	"
			NW 2	"	"	"
			NE 2	"	"	"
			SE 2	"	"	"
		12	N2 1	Danenhauer, E.	1980	lode
			NE 1	"	"	"
			NW 2	Coker, Randy/ Pogue, Roy Jr.	1981	"
			SW 3	Beck, James W./ Coker, Randy/ Pogue, Roy Jr.	"	"
			A11 1	Beck, James W./ Pogue, Roy Jr.	none	"
			S2 1	"	1981	"
			W2 4	"	"	"
			E2 4	"	none	"
			SE 4	"	1981	"
		13	A11 1	"	none	"
			N2 1	"	"	"
			W2 4	"	"	"
			E2 4	"	"	"
			SE 1	Seven-Mile Mng. Assn.	"	placer
			NE 5	Pogue, Roy Jr./ Beck, James W./ Seven-Mile Mng. Assn.	"	4-lode 1-placer
			NW 6	Coker, Randy/ Pogue, Roy Jr./ Beck, James W./ Minexa Arizona, Inc./ Seven-Mile Mng. Assn.	1981	4-lode 2-placer
			SW 2	Minexa Arizona, Inc./ Seven-Mile Mng. Assn.	none	placer

TABLE (Cont'd.)

Township	Range	Section	Claims For Each Section	Claimants	Latest Assmt. Date	Remarks
WSA 020-160 Sierra Estrella (Cont'd.)						
3S	1E	14	NW 2	Minexa Arizona, Inc./ Seven-Mile Mng. Assn.	none	placer
			NE 2	"	"	"
			SW 2	"	"	"
			SE 2	"	"	"
		15	NW 2	"	"	"
			NE 2	"	"	"
			SW 2	"	"	"
			SE 2	"	"	"
		16	NW 1	Texas Iron, Inc.	"	"
			NE 1	"	"	"
			SW 1	"	"	"
			SE 1	"	"	"
		23	NW 2	Seven-Mile Mng. Assn.	"	"
			SW 1	"	"	"
			SE 1	"	"	"
		24	SE 1	"	"	"
			NE 2	Minexa Arizona, Inc./ Seven-Mile Mng. Assn.	"	"
			NW 3	"	"	"
			SW 2	"	"	"
		WSA 020-163 South Maricopa Mountains				
5S	1E	7	NE 1	Seven-Mile Mng. Assn.	"	"
			SE 1	"	"	"
		8	NW 1	"	"	"
			SW 1	"	"	"
		19	NW 1	"	"	"
			SW 2	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		29	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"

TABLE (Cont'd.)

Township	Range	Section	Claims For Each Section	Claimants	Latest Assmt. Date	Remarks
WSA 020-163 South Maricopa Mountains (Cont'd.)						
5S	1E	30	NW 1	Seven-Mile Mng. Assn.	none	placer
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
		31	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 2	"	"	"
		32	NW 1	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
6S	1E	5	NE 1	"	"	"
			SE 1	"	"	"
			SW 1	"	"	"
		6	NW 2	"	"	"
			SW 1	"	"	"
			NE 1	"	"	"
			SE 1	"	"	"
5S	1W	32	NE 1	Russel, C.	1981	lode
		33	NW 1	"	"	"

Mid-Tertiary volcanic rocks,
Mid-Tertiary basin-fill sediments,
Late-Tertiary basin-fill sediments,
Recent alluvium, and
Active geothermal systems.

Older Precambrian Rocks

Numerous massive sulfide deposits are found in the Precambrian rocks in Arizona. Invariably, the deposits are associated with submarine rhyolitic volcanism (Donnelly and Hahn, 1981) and are either of the proximal or distal type (Anderson and Guilbert, 1979). The proximal deposits are copper- and, locally, zinc-rich rock and were formed atop or on the flanks of rhyolitic centers; the distal types are zinc- and lead-rich, contain silver and gold, and were formed at the same time but in an adjacent basin. The massive sulfide deposits are associated with banded iron formations which are zoned with sulfide facies near the rhyolitic center and carbonate and hematite facies more distant (Anderson and Guilbert, 1979). Metavolcanic rocks occur in the Yavapai Series and in the gneissic terrains to the northwest; both lie to the northwest of the Holbrook Line (see figure 2A) which separates them from the non-volcanogenic Pinal Schists. The southwesterly extension of the Holbrook Line passes to the north and west of the GRA which suggests that massive sulfide deposits are not likely to be present in the Precambrian metamorphic rocks of the GRA. This is supported by the fact that there are no identified massive sulfide deposits of the proximal or distal types nor any banded iron formations in the GRA.

The Precambrian rocks within the GRA host four mica occurrences, two manganese occurrences, and eight copper occurrences. The mica occurs in

pegmatites within Precambrian granites and schists and is probably related to Precambrian granite intrusion and metamorphism. Very little is known about the manganese and copper occurrences, but they are probably related to Laramide or mid-Tertiary metallogenesis, which is described in a later section. Gold-bearing quartz veins occur in Precambrian metamorphic rocks in other parts of Arizona, but are not reported to occur in this area.

Younger Precambrian Rocks

The Proterozoic Dripping Springs Quartzite contains uranium deposits near diabase intrusions (Granger and Raup, 1969). The deposits lie in a gray carbonaceous siltstone either below or above a barren quartzite and contains uraninite, pyrite, pyrrhotite, base metal sulfides, fluorite, ankerite, calcite, phlogopite and chlorite. The above mentioned authors consider the deposits to be genetically related to the diabase because:

1. Late stage differentiates of the diabase are enriched in uranium.
2. Uranium occurs close to diabase.
3. Diabase and uranium mineralization have same radiometric age.
4. Uranium was deposited at temperatures of several hundred degrees Celsius.

Dripping Springs Quartzite and diabase intrusions occur in the southern and southwestern part of the Table Top sub-area. No uranium occurrences are known to be present, but the geologic environment, according to criteria of Granger and Raup (1969), is favorable.

Paleozoic and Mesozoic Sediments

Paleozoic and Mesozoic sedimentary rocks in southwestern Arizona have been considered potentially favorable for accumulation of hydrocarbons,

especially those sediments located in the Overthrust Belt (Peirce, 1982; Keith, 1980). All exploration holes drilled in the area to date, however, have been dry (Peirce, 1979; Keith, 1981; Peirce, 1982; see figure 4). In the Maricopa GRA three dry holes have been drilled in the northern part of Estrella sub-area (see figure 4). The only area where Paleozoic and Mesozoic sedimentary rocks crop out in the GRA is the southern part of the Table Top sub-area. Here, potential source rocks for hydrocarbons are shales and fetid carbonates in the Abrigo and Martin Formations and potential reservoir rocks are the above mentioned formations and possibly the overlying Mesozoic clastic sediments. In the southern Table Top sub-area, however, the Paleozoic and Mesozoic sediments are structurally complex and are intruded by several Laramide intrusives and are not considered favorable for accumulation of hydrocarbons (Jaime Rizo, written comm.).

Jurassic Arc Intrusives

During the mid-Jurassic a magmatic arc extended across the southern part of the Maricopa GRA (Dickinson, 1981; see Figure 2). Porphyry copper mineralization is associated with Jurassic igneous rocks at Bisbee to the southeast of the GRA and, according to Titley (1982), the Jurassic represents a metallogenic epoch in the southwest warranting exploration. However, no Jurassic intrusive rocks are known to crop out in the GRA, thus, potential for Jurassic porphyry copper deposits is not great.

Laramide Intrusives

The Laramide was a time of emplacement of all but one (Bisbee) of the porphyry copper deposits in Arizona and adjacent New Mexico and Mexico. Of the 35 major porphyry copper deposits in this region, 32 lie to the southeast of the Holbrook Line where basement is Pinal Schist, and 3 lie to the

northwest where basement consists of Yavapai Series and gneissic-metavolcanic terrain (see figure 2). The intrusives associated with the porphyry copper deposits were emplaced during the eastward sweep of the magmatic arc (Damon et al., 1981; Clark et al., 1982) and possibly are related to the decrease in the dip of the Benioff zone at this time (Coney and Reynolds, 1977). The porphyry copper deposits appear to be aligned along northwest and east-northeast trends (see figure 2C; Heidrick and Titley, 1982). The northwesterly trend is sub-parallel to Mesozoic linear discontinuities in depositional patterns (Titley, 1976); the trend of Laramide basement-cored uplifts and faults (Nielsen, 1979; Davis, 1981); the Texas zone of Schmitt (1966); and the trend of the Laramide magmatic arcs. The ENE-trend is sub-parallel to Precambrian fold axes and to Laramide tensional fractures (Rehrig and Heidrick, 1976). The intrusions related to the porphyry copper deposits are small in area (seldom over 3 km²) and may have been emplaced along the NW and ENE structural intersections (Titley, 1982).

One of the major ENE porphyry copper trends passes through the Table Top sub-area (see figure 2C). Vekol porphyry copper deposit lies just to the south of Table Top. Here, pyrite, chalcopyrite and molybdenite mineralization is associated with stocks, dikes and sills of Laramide quartz, feldspar, hornblende porphyries, and the mineralization occurs in Proterozoic diabase and Proterozoic to Devonian quartzites, sandstones, shales and limestones (Steele, 1978).

Small Laramide intrusives are present in south-central Table Top sub-area just north of the Vekol deposit and in the northwest corner of the Estrella sub-area. In the former area, the Laramide plutons intrude Proterozoic diabase and Apache Group sediments, and Paleozoic sediments, just as at Vekol. One silver/gold occurrence (23) lies close to a Laramide intrusive.

The proximity of this area to the Vekol deposit suggests that it is moderately favorable for occurrence of hydrothermal deposits associated with Laramide plutons. No mineral occurrences are known to be associated with the Laramide pluton in the northwest corner of the Estrella sub-area.

Mid-Tertiary Metamorphic Core Complexes

The potential for mineral deposits associated with metamorphic core complexes is not well known as it is only during the last decade or so have the complexes themselves have been widely recognized. In an important work Coney and Reynolds (1980) and several co-workers have attempted to assess uranium favorability of these complexes, and in so doing, they have also provided useful information on some other elements. Some important findings of this study, which also includes the report by Keith and Reynolds (1980) and Reynolds (1980), are as follows:

1. Uranium related to plutonic processes tends to be associated with potassium-rich rocks ($K_2O > 4\%$).
2. Uranium related to metamorphic processes may be transported by fluids released through dehydration reactions. Geochemical studies by Keith and Reynolds (1980) show that mylonitization is not associated with any changes in U or Th concentration. However, the rich Graeber Lease uranium deposit located in the Kettle metamorphic core complex, Washington, occurs in mylonitic gneisses and may be of metamorphic origin (Reynolds, 1980).
3. The dislocation surface and the underlying chloritic breccia represent a permeable horizon along which fluids migrated (Reynolds, 1980). Geochemical studies in the Rawhide Mountains by Keith and Reynolds (1980) show that these rocks are enriched

in U, Th, Cu, Zn, Fe, V, Li, and Cr compared to the protolith, contain uranium occurrences, and more widespread hematite, limonite, Cu, and Au mineralization. Coney and Reynolds (1980) consider that investigation of these zones' downdip into the nearby basins may be worthwhile.

In the Maricopa GRA the Buckeye Hills in the northwest corner of the Estrella sub-area contain metamorphic and granitic rocks which show low-dipping, mylonitic foliation and, according to Rehrig and Reynolds (1980), could be part of a metamorphic core complex. No mineral occurrences are known in this part of the Buckeye Hills, but a dislocation surface, possibly enriched in U, Cu, or Au, could underlie the basin-fill sediments in the Rainbow Valley.

Mid-Tertiary Volcanic Rocks

Mid-Tertiary volcanics in southern Arizona, southwestern New Mexico and Mexico are associated with gold/silver and base metal lode deposits (Damon et al., 1981; Clark et al., 1982). The volcanics were erupted when the magmatic arc swept rather rapidly westward, possibly as a result of the steepening of the Benioff zone (Coney and Reynolds, 1977). In southwestern New Mexico the deposits are associated with cauldrons from which voluminous ignimbrites and other volcanics were erupted (Elston, 1978). As yet, no such cauldrons have been identified in Arizona, but the voluminous ignimbrites and numerous deposits suggests that such cauldrons could be present.

The volcanics occur mainly in the southern part of the GRA. They are mainly basaltic, but minor intermediate volcanics are also present. The GRA is on the northern margin of the Ajo volcanic field, and it is unlikely that major cauldrons are present in the area.

In the Maricopa GRA there are four manganese occurrences that are within or near mid-Tertiary volcanics or intrusives. Hewett and Fleischer (1960), in a regional study of manganese oxide vein deposits, concluded that most were formed from hydrothermal fluids associated with late stages of volcanic activity; it is likely that these deposits are of a similar nature. No production is recorded from any of the occurrences.

Mid-Tertiary Basin-Fill Sediments

Mid-Tertiary valley-fill sediments are widespread in southwestern Arizona and, since the discovery of the Anderson Mine (Sherborne et al., 1979), have become a prime target for uranium exploration. The Anderson Mine itself, located some 75 miles northwest of the GRA, has reserves of nearly three million pounds of U_3O_8 , a figure in excess of previously quoted estimates for the entire Basin and Range Province (Sherborne et al., 1979).

In order to form a uranium deposit by the agency of circulating groundwater or connate water, it is necessary to have adequate uranium source rocks, permeable sediments for the water to flow through, and a reductant to precipitate the uranium. Suitable source rocks are plentiful in southwestern Arizona and in the GRA. Their distribution is shown in figure 2D (after Scarborough and Wilt, 1979); and they include Precambrian alkali and alkali-calcic granites, alkali-calcic Tertiary volcanics and metamorphic core complexes which locally contain two-mica granites, and uranium enriched detachment zones and chloritic breccias (see previous section). Particularly good sources of uranium are potassium-rich igneous rocks (Keith and Reynolds, 1980), such as the potassic trachyandesites and ultra-potassic trachytes associated with later stages of the mid-Tertiary orogeny (Shafiqullah et al., 1980). In the Anderson Mine, the source of the uranium is postulated

to be tuffaceous-like sediments from which connate water and uranium were squeezed out during compaction (Sherborne et al., 1979). Such tuffaceous lacustrine sediments are common in the mid-Tertiary sequence, especially in the middle and upper part of Unit I of Eberly and Stanley (1978). Permeable horizons suitable for transport of uranium, especially fluvial reddish sandstones and gravels, are plentiful within the Tertiary sequence. Reductants are also locally present. At the Anderson Mine, reductants are organic-rich mudstones (Sherborne et al., 1979). In the Plomosa and Gila Bend Mountains they are fetid (organic?) limestones (Scarborough and Wilt, 1979). Another possible reductant is past and present-day geothermal water which, even today, are widely distributed in southwestern Arizona and within the Maricopa GRA (see mineral deposits, figures 3 and 4). If such geothermal waters are reducing, and they often are, then precipitation of uranium could occur at the interface between oxidizing groundwater and reducing geothermal water.

Tertiary sediments crop out in the southern part of the Estrella sub-area and probably also underlie the Late Tertiary sediments in the deeper basins (shown in figure 3). This has been shown to be the case in areas to the north and west based on drillhole and seismic profiling data by Eberly and Stanley (1978). No uranium occurrences are known in the GRA; however, geological conditions, as discussed above, appear favorable for the accumulation of uranium.

Late Tertiary Basin-Fill Sediments

Late Tertiary sediments are present in all basins formed as a result of Basin and Range faulting. The depths of these basins are indicated by contours shown in figures 3 and 4, which are interpreted by Oppenheimer and Sumner (1981) from gravity data. As in the case of the mid-Tertiary sediments,

adequate uranium source rocks and permeable horizons are widespread. Extensive organic reductants are not known to be present in these sediments, but the widely occurring warm geothermal waters (see figures 3 and 4, mineral occurrences map) may be sufficiently reducing to cause precipitation of uranium.

No uranium occurrences are known in the GRA, but conditions in the Late Tertiary sediments may be locally favorable for its accumulation.

Recent Alluvium

Alluvium formed in present day river valleys is a possible site for concentrations of placer gold. One placer gold occurrence is reported in the northwest corner of the Estrella sub-area. This occurrence is along the Rainbow Valley close to the Buckeye Hills where Laramide intrusives and/or a possible metamorphic core complex may have been the source.

Active Geothermal Systems

Extensive, but low temperature, geothermal resources are known to be present in southwestern Arizona (Jones, 1979). Factors that are favorable for the existence of substantial geothermal systems include: presence of a high temperature heat source; the presence of aquifers, which allow large volumes of water to circulate through the hot rocks; and the presence of cap rocks, which prevent the escape to the surface of at least some of the hot fluid.

In southwestern Arizona, the intensity of volcanic activity has been waning during the past 4 million years; however, basalt flows as young as 1.3 m.y.B.P. are present (Shafiqullah et al., 1980). Aquifers and cap rocks in the form of gravels and sands, and lake beds, respectively, are present in the Late-Tertiary basin-fill sediments. These sediments occupy tectonic

depressions resulting from Basin and Range faulting and many are over 5,000 feet deep. It is within these basins that warm geothermal fluids ($> 25^{\circ}\text{C}$) are present.

In the Maricopa GRA, warm water is present in northeastern and northwestern Table Top sub-area and in northeastern and southern Estrella sub-area (see figures 3 and 4, mineral resources).

Mineral Economics

The assessment of the geological, energy and mineral resources favorability potential should rely upon not only geology, but must also be concerned with economic factors and priorities. This includes economic discovery, recovery, cost of production of the resource from sources of different quality or concentration in various locations, and transportation. Then special consideration must be made on the strategic and critical minerals and metals. However, due to the limited scope of this project, economic analyses of various mineral commodities can only be discussed briefly.

Non-strategic commodities present in the North Maricopa Mountains (020-157) WSA are granite (building stone, deposit number 3) and low-temperature geothermal resources (18). The Sierra Estrella (020-160) WSA encompasses no occurrences of non-strategic commodities but located a few miles west is a low-temperature geothermal area (18). An area of known geothermal potential (34) is located in part in the South Maricopa Mountains (020-163) WSA. Butterfield Stage Memorial (020-164) and Table Top Mountains (020-172) WSAs contain no occurrences of non-strategic commodities.

The low-temperature geothermal areas (18 and 25) have been defined by geologic evaluation of the areas and investigation of irrigation and other water wells in the areas. Well water temperatures are around 35°C , quite

TABLE 4

LIST OF COMMODITIES PRESENT IN THE MARICOPA GRA

Commodity	Location and number of occurrence as listed in previous section and production status: * - former producer							Strategic /Critical Commodity
	Wilderness Study Area					Outside WSA but in GRA sub-area		
	020-157	020-164	020-163	020-160	020-172	Estrella	Table Top	
columbium/nobium						*32		X
copper			15,16		2,6	14,15 16,12 13	3	X
gold						*11,30 *17,29		
silver							4	X
manganese						2	5	X
iron						*11		
uranium						*33		
geothermal	18		34	18	34		25	
fluorite							1	X
feldspar				31		33		
gemstones						31		
mica				*1,31 4,10 8		5,4 6		X
granite (bldg. stone)	3					18 34		
sand and gravel						6,7 *27,*28 26		

low, which limits their usefulness. Distance from major population areas is also a limiting factor, but it is possible these waters could be used to heat greenhouses and for other agricultural purposes.

Information about the feldspar, gemstone, granite, iron, sand and gravel, and uranium occurrences was derived from the U.S. Bureau of Mines MILS File (1982), the U.S. Geological Survey CRIB File (1972, 1979), and McCrory and O'Haire (1965 - map of occurrences of non-metallic minerals and materials in Arizona). Unfortunately, these sources provide limited information and, thus, the economic evaluation of these commodities can only be very general.

Strategic and Critical Minerals and Metals

Within the Maricopa GRA occur the strategic and critical minerals and metals columbium/niobium, copper, fluorite, manganese, mica, and silver.

Niobium (a strategic metal, deposit number 32) is known to exist near, and northwest of, the North Maricopa Mountains (020-157) WSA. This explored prospect (U.S. Bureau of Mines, 1982) reportedly has produced some ore. Three mica occurrences are located a few miles north of the WSA. A manganese prospect is located near both the North Maricopa Mountains and the Butterfield Stage Memorial (020-164) in the area between these WSAs and the South Maricopa Mountains (020-163) WSA. Two copper occurrences, each are located within the South Maricopa Mountains and the Table Top Mountain (020-172) WSAs, with another copper occurrence located less than one mile south of the Table Top Mountain WSA. The Sierra Estrella (020-160) WSA contains two mica deposits, one of which is a past producer of ground mica. The potential for occurrence of sheet mica, a strategic commodity, in the Precambrian rocks of all the WSAs is unknown, but cannot be ignored.

Niobium has become a very important metal as our technology advances, with metallurgical, electronic, chemical and nuclear uses. Although

abundant elsewhere in the world, manganese, critical to the steel industry and also used in the chemical industry, is nearly absent in the United States. Copper, although considered a strategic and critical metal, occurs in abundance in Arizona and, therefore, it will take further depletion of current resources or great discoveries to bolster the copper occurrences in the South Maricopa Mountains and Table Top Mountains WSAs and make them economic. Sheet mica still is used in electronics and other industries (Brobst and Pratt, 1973). Discoveries of sheet mica within the WSAs would be of importance.

In summary, one can notice that although the Maricopa GRA contains no active mines and few prospects that produced in the past, there are occurrences of strategic and critical metals and minerals. Even these few unseemingly meager deposits should not be ignored, because if properly examined and explored, they may generate economically valuable discoveries.

THE GEOLOGY, ENERGY AND MINERAL RESOURCES OF THE WILDERNESS STUDY AREAS

In this section each individual WSA is discussed with respect to its physiography, geology, mineral occurrences, resource potential, and recommendations for further work. For most of the WSAs, detailed and specific information is lacking and, in this case, information pertinent to the particular WSA will be summarized from preceding sections. The classification of resource potential and level of confidence is according to the scheme provided by the Bureau of Land Management (attachment 9, dated March 24, 1982). The classification is summarized on the maps in figures 8 through 15 and detailed below:

Classification Scheme

1. The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.

2. The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.
3. The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.
4. The geologic environment, the inferred geologic processes, the reported mineral occurrences, and the known mines or deposits indicate high favorability for accumulation of mineral resources.

Level of Confidence Scheme

- A. The available data are either insufficient and/or cannot be considered as direct evidence to support or refute the possible existence of mineral resources within the respective area.
- B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.
- C. The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.
- D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

North Maricopa Mountains WSA (020-157)

The WSA lies within the Maricopa Mountains and in the southwest extends into the Gila River basin. The mountains are steep and have a relief of about 1,000 feet. They have been deeply dissected and are embayed by pediments.

Most of the WSA is underlain by granitic rocks which are part of an anorogenic alkali to alkali-calcic, granitic to quartz dioritic intrusive series emplaced 1.5 to 1.3 b.y.B.P. The southwestern corner of the WSA is underlain by sediments and possibly mid-Tertiary sediments and volcanics.

No mineral occurrences are known within the WSA. One building stone quarry of unknown production is located in the northwest corner.

Land Classification for GEM Resources Potential

Metallic Minerals - The entire WSA (Area 2) is considered to be of low favorability at a confidence level of B (figure 8) for the following reasons:

- a. Absence of occurrences in the WSA.
- b. Absence of sizeable mines in nearby areas of similar geology.
- c. Absence of geological conditions that would favor occurrence of such deposits. For instance, there are no Precambrian volcanic rocks, no mid-Jurassic or Laramide intrusives, and no mid-Tertiary volcanic rocks.

Uranium - The southwestern part of the WSA (Area 1) is considered to have moderate favorability at a confidence level of B (figure 9) for the following reasons:

- a. There is an absence of uranium occurrences.
- b. On the other hand, the area is underlain by a thick sequence of Tertiary sediments where suitable source rocks, aquifers, and reductants may be present.

The rest of the WSA (Area 3) is considered to have low favorability at a confidence level of B for the following reasons:

- a. There is an absence of known uranium occurrences in the area.

Fig 8. FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE MAP FOR METALLIC MINERALS (COPPER) RESOURCES OF THE ESTRELLA SUB-AREA, ARIZONA.

Fig 9. FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE MAP FOR URANIUM RESOURCES OF THE ESTRELLA SUB-AREA, ARIZONA.

- b. Conversely, Precambrian granitic rocks, possible sources of uranium, underlie the WSA.

Geothermal - The northeastern corner of the WSA (Area 4) and an area southeast of the WSA have moderate favorability at a confidence level of C (figure 10) for the following reasons:

- a. The areas extend into a known geothermal potential area.
- b. However, Area 4 is underlain largely by granite which probably has a low permeability.

The rest of the WSA is considered to be unfavorable at a confidence level of B because it is underlain by Precambrian granitic rocks which are likely to be of low permeability.

Non-Metallic Minerals (mica) - The entire WSA (Area 5) is considered to be of low favorability for the occurrence of mica at a confidence level of B (figure 11) for the following reasons:

- a. No mica occurrences are reported for the area.
- b. Precambrian granitic rocks which may contain mica-rich pegmatitic zones underlie much of the WSA.

An area just adjacent to, and northwest of, the WSA (Area 6; see figure 11) has been assigned moderate favorability at a confidence level of B as mica occurrences are reported in that area.

Building Stone - The northwest part of the WSA (Area 7) has a moderate favorability at a confidence level of C (figure 12) for the following reasons:

- a. A granite quarry is located in this area.
- b. It is not known what the production has been and whether it is now in operation.

Fig 10. FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE MAP FOR GEOTHERMAL RESOURCES OF THE ESTRELLA SUB-AREA, ARIZONA.

Fig 11. FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE MAP FOR NON-METALLIC MINERALS (MICA) RESOURCES OF THE ESTRELLA SUB-AREA, ARIZONA.

Fig 12. FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE MAP FOR BUILDING STONE (GRANITE) RESOURCES OF THE ESTRELLA SUB-AREA, ARIZONA.

Other areas of Precambrian granitic rock outcrop within and nearby the North Maricopa Mountains WSA (Area 8) and are assigned a low favorability at a confidence level of C because there are no known granite quarries within these rocks. Areas of the WSA that are mantled by Quaternary sediments are considered unfavorable for building stone at a confidence level of B as lack of surface exposure, even though much of the area is most likely underlain by granitic rocks, increases the cost of mining.

The WSA is not favorable for the occurrence of other commodities.

Recommendations

For Area 1 it is recommended that:

- a. The area should be field checked for presence of uranium source rocks, aquifers, and suitable reductants.
- b. Available wells should be sampled and analyzed for uranium, fluoride, phosphate, carbonate, calcium, potassium, vanadium, Eh and pH, and the solubility index calculated for each sample.

Area 4 should be field checked for incidence of recent hot spring activity.

Area 7 should be field checked to assess scale of stone quarrying operations.

Sierra Estrella WSA (020-160)

The WSA lies within the Sierra Estrella Mountains with its southwest corner extending slightly into the Rainbow Valley. The mountains are steep and have relief of about 1,600 feet. They have been deeply dissected and are embayed in pediments.

The WSA is underlain by Precambrian gneiss and in the south by Precambrian granite. The granitic rocks are part of an anorogenic alkali to alkali-calcic, granitic to quartz dioritic intrusive series emplaced about 1.5 to 1.3 b.y.B.P.

No mineral occurrences are known within the WSA; but one muscovite mine, from which there has been production of unknown amount, lies surrounded by and within the WSA. The muscovite occurs in a pegmatite within the metamorphic rocks. The pegmatite could either be of metamorphic origin or it could be related to intrusion of the granite.

Land Classification for GEM Resources Potential

Metallic Minerals - The entire WSA (Area 2) is considered to be of low favorability at a confidence level of C (figure 8) for the following reasons:

- a. Absence of occurrences in the WSA.
- b. Absence of sizeable mines in nearby areas of similar geology.
- c. Absence of geological conditions that would favor occurrences of mineral deposits. For instance, there are no Precambrian volcanic rocks, no mid-Jurassic or Laramide plutons, and no mid-Tertiary volcanic rocks within the WSA.

Uranium - The entire WSA (Area 3) is considered to have low favorability at a confidence level of B (figure 9) because although the area is underlain by Precambrian gneisses and granitic rocks, potential sources of uranium, no occurrences of uranium are known.

Geothermal - The entire WSA is considered not favorable (figure 10) for potential geothermal resources because the Precambrian metamorphic and igneous rocks which underly the area are likely to be of low permeability.

Adjacent to the WSA is an area (Area 4) designated moderately favorable at a confidence level of C (figure 10) because of the presence of an area of known-low-temperature geothermal waters and thermal wells (see figure 3).

The rest of the WSA is considered to be an unfavorable environment for mica resources as it is overlain by Quaternary sediments which make mining unfeasible.

Non-Metallic Minerals - The entire WSA, excluding the pediment in the southwest and the granite in the south plus an area to the southwest, (Area 10) is considered to have moderate favorability at a confidence level of C for the following reasons:

- a. The Hightower mica mine is located within these two areas.
- b. The geology of the remaining parts of Area 10 is probably similar to that near the mica mine.

Building Stone - The entire WSA is considered unfavorable for building stone with the exception of the area of Precambrian granitic rock outcrop (Area 8) in the Southernmost portion of the WSA (figure 12). This area is considered to be of low favorability for the following reasons:

- a. No quarries are located within this area.
- b. Nonetheless, a granite quarry is located within a potentially similar outcropping Precambrian granitic rock in the North Maricopa WSA.

The WSA is not favorable for the occurrence of other commodities.

Recommendations

It is recommended that Area 10 be field checked for the presence of pegmatites that contain valuable non-metallic minerals.

Butterfield Stage Memorial WSA (020-164)

The WSA lies within the southern part of the North Maricopa Mountains. The mountains are steep and have a relief of about 1,200 feet. They have been deeply dissected.

The WSA is underlain by granitic rocks which are part of an anorogenic alkali to alkali-calcic, granitic to quartz dioritic intrusive series emplaced 1.5 to 1.3 b.y.B.P.

No mineral occurrences are known within the WSA.

Land Classification for GEM Resources Potential

Metallic Minerals - The entire WSA (Area 2) is considered to be of low favorability at a confidence level of B (figure 89 for the following reasons:

- a. Absence of occurrences.
- b. Absence of sizeable mines in nearby areas of similar geology.
- c. Absence of geological conditions that would favor occurrence of such deposits. For instance, there are no known Precambrian volcanic rocks, no mid-Jurassic or Laramide plutons, and no mid-Tertiary volcanic rocks.

Uranium - The entire WSA (Area 3) is considered to have a low favorability at a confidence level of B (figure 9) for the following reasons:

- a. There is an absence of known uranium occurrences in the area.
- b. Conversely, Precambrian granitic rocks, possible sources of uranium, underlie the WSA.

Geothermal - The entire WSA is considered to be unfavorable at a confidence level of B (figure 10) because the Precambrian granitic rock which underlies the area are probably of low permeability.

Non-Metallic Minerals (mica) - The entire WSA (Area 5) is considered to be of low favorability for the occurrence of mica at a confidence level of B (figure 11) for the following reasons:

- a. No mica occurrences are reported for the area.

- b. Precambrian granitic rocks which crop out in the area may contain mica-rich pegmatic zones.

Building Stone - Areas of Precambrian granitic rock outcroppings (Area 8) is considered to have low favorability at a confidence level of C (figure 12) for the following reasons:

- a. There are no reported building stone quarries in the WSA.
- b. A quarry is known in the North Maricopa WSA and is located with possibly similar Precambrian granitic rock.

The WSA is not favorable for the occurrence of other commodities.

South Maricopa Mountains WSA (020-163)

The WSA lies mainly within the South Maricopa Mountains, but in the west it extends into the Gila River basin and in the north into the Rainbow Valley basin. The mountains have a relief of about 1,000 feet and locally are rugged. They have been deeply dissected and are embayed by pediments.

The WSA is underlain by Precambrian schist and granite and Tertiary sediments and basalts. The area lies to the southeast of the Holbrook Line and of the known outcrops of the volcanogenic Yavapai Series. The schists are, therefore, probably the equivalents of the non-volcanogenic Pinal Schists. The granitic rocks are part of the anorogenic alkali to alkali-calcic, granitic to quartz dioritic intrusive series emplaced 1.5 to 1.3 b.y.B.P. The western part of the WSA is underlain by over 800 feet of late Tertiary sediments and possibly mid-Tertiary sediments and volcanics. The northernmost part of the WSA is underlain by more than 400 feet of similar materials, whereas mid-Tertiary basalts are present in the southeast.

Two copper occurrences with no known production are present in the Precambrian schist area which is flanked, both to the east and west, by

Precambrian granite. It is not known whether the occurrences are related to Precambrian intrusions, Laramide or Jurassic intrusions, or to mid-Tertiary volcanism.

An area of known geothermal potential is located in the western part of the WSA in late Tertiary and Quaternary basin-fill sediments.

Land Classification for GEM Resource Potential

Metallic Minerals - The Precambrian schist near the center of the WSA (Area 11) and in the east of the WSA is considered to have moderate favorability at a confidence level of C; the remainder of the WSA (Area 2) is considered to have low favorability at a confidence level of C (figure 8) for the following reasons:

- a. Metal occurrences are present, but only in the Precambrian schist.
- b. There is an absence of sizeable mines in nearby areas of similar geology.
- c. There are no metavolcanic Precambrian rocks and no mid-Jurassic or Laramide plutons near the area.
- d. Mid-Tertiary intermediate volcanic and intrusive rocks are present to the south of the WSA in the Sand Tank mountains.

The WSA is not favorable for the occurrence of other commodities.

Uranium - The western (Area 1) and northernmost (Area 12) part of this WSA are considered to have moderate favorability at a confidence level of B (figure 9) for the following reasons:

- a. There is an absence of uranium occurrences.
- b. On the other hand, the areas are underlain by thick sequences of Tertiary sediments where suitable source rocks, aquifers, and reductants may be present.

Geothermal - An area bordering the southeast, south and northwest boundaries of the WSA and covering the very westernmost part of the WSA (Area 4) is considered to be moderately favorable at a confidence level of C (figure 10) for the following reasons:

- a. The WSA extends into an area of known geothermal potential.
- b. The potential of the area is not well known at this time.

The rest of the WSA is considered unfavorable as it is underlain by schist, granite and basalt of low permeability.

Non-Metallic Minerals - Much of the WSA (those areas underlain by Precambrian schist and granitic rock (Area 5) is considered moderately favorable for the occurrence of mica deposits at a confidence level of B (figure 11). This is due to the following reasons:

- a. Mica occurrences are known in pegmatic zones in Precambrian rocks elsewhere in the Estrella sub-area, and thus may occur in similar rocks in the WSA.
- b. No occurrences are yet known in this area.

The remaining parts of the WSA are considered unfavorable for mica.

Building Stone - Areas within and nearby the WSA which are underlain by Precambrian granitic rock (Area 8) have low favorability at a confidence level of C (figure 12). Although Precambrian granite was quarried for building stone in the North Maricopa WSA, no rock is known to have been quarried in this area.

Recommendations

For Area 11 it is recommended that:

- a. The copper occurrences be field checked to determine size and nature of the mineralization.

- b. Hydrothermal minerals associated with the copper occurrences should be dated by the K-Ar Method. This may make it possible to determine whether the mineralization is associated with Precambrian, mid-Jurassic, Laramide, or mid-Tertiary hydrothermal processes.

For Areas 1 and 12 it is recommended that:

- a. The areas be field checked for presence of uranium source rocks, aquifers, and suitable reductants.
- b. Available wells should be sampled and analyzed for uranium, fluoride, phosphate, carbonate, calcium, potassium, vanadium, Eh and pH, and the solubility index calculated for each sample.

Table Top Mountain WSA (020-172)

The WSA lies in the Table Top Mountains, but in the west it extends into the Vekol Valley and in the east into a valley that drains into the Gila River. The mountains have about 800 feet of relief and are capped by basalt flows. They have been dissected and embayed by pediments.

The WSA is underlain by Precambrian schist and granite, mid-Tertiary basalt, in the west by over 400 feet of Tertiary sediments, and in the east by less than 400 feet of Tertiary sediments. The schists lie to the southeast of the Holbrook Line and of the known outcrops of the volcanogenic Yavapai Series. The granitic rocks are part of an anorogenic alkali to alkali-calcic, granitic to quartz dioritic intrusive series emplaced 1.5 to 1.3 b.y.B.P.

Two copper occurrences with no known production are present in the Precambrian schist, which nearby is intruded by Precambrian granite and overlain by Tertiary basalt. It is not known whether these copper occurrences are

related to Precambrian, mid-Jurassic or Laramide intrusions, or to mid-Tertiary volcanics.

An area of known geothermal potential underlies the northwest part of the WSA, occupying a basin formed by Tertiary Basin and Range faulting and filled with late Tertiary and Quaternary sediments.

Land Classification for GEM Resource Potential

Metallic Minerals - The Precambrian schist in the central part of the WSA (Area 13) is considered to have moderate favorability at a confidence level of B; the remainder of the WSA (Area 14) is considered to be not favorable at a confidence level of B (figure 13) for the following reasons:

- a. Metal occurrences are present but only in the Precambrian schist.
- b. There are no sizeable mines in the nearby parts of the Table Top Mountains; but the Vekol porphyry copper deposit lies some 15 miles to the south.
- c. There are no Precambrian metavolcanics and no Jurassic intrusive rocks or mid-Tertiary felsic volcanics near the WSA; but Laramide plutons do occur in the south-central part of the WSA in the northern Vekol Mountains.

Uranium - The western and eastern (Area 15) parts of the WSA are considered to have low favorability at a confidence level of B (figure 14) for the following reasons:

- a. There is an absence of uranium occurrences.
- b. On the other hand, the areas are underlain by Tertiary sediments in which suitable source rocks, aquifers, and reductants may be present.

Fig 13. FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE MAP FOR METALLIC MINERALS (COPPER) RESOURCES OF THE TABLE TOP SUB-AREA, ARIZONA.

Fig 14. FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE MAP FOR URANIUM RESOURCES OF THE TABLE TOP SUB-AREA, ARIZONA.

Fig 15. FAVORABILITY POTENTIAL AND LEVEL OF CONFIDENCE MAP FOR GEOTHERMAL RESOURCES OF THE TABLE TOP SUB-AREA, ARIZONA.

Geothermal - The northwestern part of the WSA (Area 16) is considered to have moderate favorability at a confidence level of C (figure 15). It is underlain by an area of known geothermal potential.

Recommendations

For Area 13 it is recommended that:

- a. The copper occurrences be field checked to determine size and nature of mineralization.
- b. Hydrothermal minerals associated with the copper occurrences should be dated by the K-Ar method. This may make it possible to determine whether the mineralization is associated with Precambrian, mid-Jurassic, Laramide, or mid-Tertiary hydrothermal processes.

For Area 15 it is recommended that:

- a. The areas be field checked for presence of uranium source rocks, aquifers, and suitable reductants.
- b. Available wells should be sampled and analyzed for uranium, fluoride, phosphate, carbonate, calcium, potassium, vanadium, Eh and pH, and the solubility index calculated for each sample.

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