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GEOLOGY, ENERGY AND MINERAL RESOURCES ASSESSMENT OF THE KITT PEAK AREA, ARIZONA

BY

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GEOLOGY, ENERGY AND MINERAL RESOURCES ASSESSMENT OF THE KITT PEAK AREA, ARIZONA

by

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SUMMARY

The Kitt Peak "Geological, Energy and Minerals (GEM) Resources Area" (GRA) lies within Pima County, Arizona and contains the following Wilderness Study Areas (WSAs):

Coyote Mountains (020-202), and
Baboquivari Peak South (020-203B).

Precambrian rocks do not occur in this part of Arizona. The oldest rocks which crop out in the area are Paleozoic shallow-water clastics and carbonates, which were thermally and regionally metamorphosed in the Laramide and mid-Tertiary. Mesozoic continental clastics and volcanics were deposited both before and after emplacement of voluminous Jurassic intrusives during the mid-Mesozoic orogeny, S-type granites were intruded during the Laramide and are associated with regional metamorphism of Paleozoic and Mesozoic sediments, and they may be associated with early stages of metamorphic core complex emplacement. The mid-Tertiary orogeny lasted from 35 to 14 m.y.B.P. and involved the following: Deposition of a thick sequence of fluvial and lacustrine sediments in northwest-striking downwarps; outpouring of calc-alkaline volcanics including ash-flow deposits possibly related to cauldrons; emplacement of metamorphic core complexes; and listric normal faulting which offset Mesozoic to mid-Tertiary volcanic and sedimentary rocks. Basin and Range faulting became dominant 14-4 m.y.B.P. and was accompanied by bimodal volcanism. Since 4 m.y.B.P. the main geological processes have been erosion and deposition of alluvium.

Geologic environments potentially favorable for the occurrence of mineral or energy resources in the WSA include: Paleozoic and Mesozoic sediments and metamorphosed equivalents; Mesozoic plutonic rocks; Mesozoic volcanic rocks; Laramide intrusive rocks; mid-Tertiary metamorphic rocks; mid-Tertiary volcanic rocks; mid- and late Tertiary sediments; and recent alluvium.

Numerous tungsten and polymetallic deposits are hosted by Paleozoic and Mesozoic sediments and are related to Laramide plutonism and metamorphism. Hydrothermal gold, silver and copper deposits are apparently associated with Jurassic plutonism. Mesozoic volcanic rocks host polymetallic deposits related to Cretaceous volcanism, Laramide plutonism, or mid-Tertiary metamorphic core complex emplacement. Laramide intrusives are related to hydrothermal gold-silver and base-metal deposits, tungsten and uranium mineralization, and beryl occurrences in pegmatites. Hydrothermal gold, silver, copper, lead and manganese mineralization is related to mid-Tertiary volcanics. Several tungsten, gold and silver placer deposits occur in Recent

alluvium.

The Coyote Mountains WSA (020-202) is underlain by metamorphosed Paleozoic sediments, Jurassic and Laramide intrusives, Mesozoic sediments and volcanics, and Recent alluvium. The Coyote Mountains may represent a mid-Tertiary metamorphic core complex. One copper-bearing pyrometasomatic replacement deposit in the WSA is hosted by metamorphosed Paleozoic limestones. Molybdenum and uranium mineralization located near the WSA is probably related to Laramide plutonism. The WSA is of low to moderate favorability for the occurrence of metallic minerals and uranium.

The Baboquivari Peak South WSA (020-203B) is underlain by early and late Mesozoic volcanics and sediments, Jurassic granite and Laramide pegmatite. A silver and gold occurrence is located in the WSA and may be related to Laramide dikeing. Beryl occurs in Laramide pegmatites near the northern edge of the WSA. The WSA is considered moderately favorable for the occurrence of metallic minerals, of low favorability for the occurrence of uranium, and parts of the WSA and adjacent areas that are underlain by Laramide pegmatites are moderately favorable for the occurrence of nonmetallic minerals.

Important recommendations for further work in the WSAs include:

1. Large areas of the WSAs should be field checked for the occurrence of hydrothermal alteration that may be related to mineralization.
2. Geochemical sampling and analysis of rocks of the possible metamorphic core complex should be done to check for enrichment of several elements.
3. The uranium occurrence (U 14) located near the Coyote Mountains WSA should be field checked for mineralization and/or radioactivity.
4. Laramide pegmatites in the WSAs should be field checked for the occurrence of uranium and beryl.

 

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 two WSAs in southern Arizona which have been grouped together into the Kitt Peak 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, with 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 Kitt Peak GRA is located in Pima County, southeastern Arizona. The GRA lies in the southwestern part of the Tucson 1:250,000 quadrangle and in the northwestern part of the Nogales 1:250,000 quadrangle. Arizona Highway 86 traverses the northern half of the area and Arizona Highway 286 traverses the eastern half of the Kitt Peak GRA (fig. 1). Numerous dry-weather and

FIG. 1. PHYSIOGRAPHIC MAP OF SOUTH-CENTRAL ARIZONA SHOWING LOCATION OF SONORA, WYMOLA AND KITT PEAK AREAS. Depth to bedrock contours, interval = 1600 ft., from Oppenheimer and Sumner (1980).

light duty roads provide access to ranches and small towns in the valleys; some of these roads extend into the lower reaches of the Baboquivari Mountains. The Kitt Peak National Observatory is located in the north-central part of the GRA and the Papago Indian reservation occupies the western half of the area. No major towns are present in the GRA, but Tucson lies about 25 miles east-northeast of the Kitt Peak GRA. The two WSAs within the Kitt Peak GRA are described in Table 1.

**Table 1. Wilderness Study Areas in the
Kitt Peak GRA**

WSA No.	WSA Name	Acres
020-202	Coyote Mountains	5080
020-203B	Baboquivari Peak South	2065
	Total	7145

PHYSIOGRAPHY

The GRA lies within the Sonoran Desert section of the Basin and Range Province of Fenneman (1931). The area has north-south and northeast-trending topographic grains reflecting Basin and Range faulting and, perhaps, lineation of a mid-Tertiary metamorphic core complex. Basin and Range fault scarps have eroded back to form extensive pediments and range fronts are embayed (Tucker, 1980). This is because much of southern Arizona has been almost free of tectonic activity for the past several million years.

The Kitt Peak GRA can be divided into two distinct physiographic terrains: mountainous - to - hilly and lowland terrains.

The mountainous - to - hilly terrain is comprised of the Baboquivari Mountains, Quinlan Mountains, Coyote Mountains, Bell Mountain, Dobbs Buttes and Martina Mountain, which trend north-south to northeast through the GRA, the southern Comobabi Mountains in the northwest corner of the GRA, Los

Animas Mountain in the southwest part of the GRA, and Las Guijas Mountains in the southeast corner of the GRA.

Baboquivari Valley, in the western part of the area, and Altar Valley, in the eastern part of the GRA, comprise the lowland terrain. Both are probably fault-bound basins which have widened due to the formation of pediments. Both valleys are filled with more than 4800 feet of sediments.

GEOLOGY

Southern Arizona is an area of highly complex geology. Rocks range in age from Cambrian to Recent, and the area has been affected by mid-Mesozoic, Laramide and mid-Tertiary orogenies, and Basin and Range faulting. Important advances in the understanding of the complex geology of southern Arizona 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 dates (Haxel et al., 1980; Shafiqullah, et al., 1980); regional and local analyses of deformation (Davis, 1981; Gardulski, 1980; Davis et al., 1981; Rehrig and Heidrick, 1967); recognition of metamorphic core complexes (Coney, 1980; Davis et al., 1981 and 1980; Rehrig and Reynolds, 1980; Davis and Coney, 1979); recognition of the relationship between subduction magmatism and metallogenesis in the southern Cordillera (Damon et al., 1981; Coney and Reynolds, 1977); and an increased level of mapping of Cenozoic basins as a result of intense uranium exploration during the late 1970's (Scarborough and Wilt, 1979; Eberly and Stanley, 1978).

The lithology and stratigraphy, structural geology and tectonics, paleontology and geologic history of the Kitt Peak 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 Kitt Peak GRA is illustrated in figure 3.

Lithostratigraphy-Rock Units

In the Kitt Peak GRA and adjoining areas of the Papago Indian Reservation, Precambrian rocks do not crop out. The oldest rocks in the GRA are Paleozoic shallow marine sediments, which have been engulfed by Laramide intrusives and penetratively metamorphosed; Mesozoic sediments, intrusives and volcanics; Laramide intrusives, sediments and metamorphic rocks; mid-Tertiary intrusives, volcanics and clastic continental sediments; late Tertiary valley-fill and pediment-capping sediments and recent alluvium. Intense activity and metamorphism took place during the mid-Mesozoic, Laramide and mid-Tertiary. Metamorphic core complexes were probably emplaced during the latter event.

Precambrian

The Baboquivari Mountains, the central range of the Kitt Peak GRA, occupy an area of southern Arizona which contains no outcroppings of Precambrian rocks and few outcroppings of Paleozoic sediments (Wright and Haxel, 1982; Haxel et al., 1980). Radiometric data indicate that the aluminous Laramide Pan Tak pluton of the Coyote Mountains is probably derived from a Precambrian source (Wright and Haxel, 1982; Haxel et al., 1980).

Paleozoic

Three Paleozoic formations have been tentatively identified in the Coyote Mountains of the Kitt Peak GRA. Sediments of the Cambrian Bolsa Quartzite and Abrigo Formation and the Devonian Martin Formation are present within the Laramide Pan Tak Granite (Gardulski, 1980). The Paleozoic sediments have been dilated and contact metamorphosed by the intrusion, then

Introduction

The purpose of this study is to investigate the effects of the proposed system on the performance of the system. The study is divided into two main parts: a theoretical analysis and an experimental evaluation. The theoretical analysis is based on the principles of the system and the results of previous studies. The experimental evaluation is based on the results of a series of experiments conducted on a real system. The results of the study are presented in the following sections.

The first part of the study is a theoretical analysis of the system. This part is based on the principles of the system and the results of previous studies. The second part of the study is an experimental evaluation of the system. This part is based on the results of a series of experiments conducted on a real system. The results of the study are presented in the following sections.

The results of the study show that the proposed system has a significant positive effect on the performance of the system. The results are presented in the following sections.

Figure 2: Paleotectonic and paleogeographic maps of Arizona showing location of the Kitt Peak 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.

Figure 4. **LEGEND**
FOR
GEOLOGIC, ENERGY AND MINERAL RESOURCES MAPS
Scale of all maps is 1:250,000 or as otherwise indicated.

LITHOSTRATIGRAPHY

After Wright and Haxel (1982), Haxel and others (1980), Gardulski (1980), Davis and others (1981), Wilson and others (1969), Heindl and Fair (1965), Heindl (1965), and Fair (1965).

QUATERNARY	Qs	SEDIMENTS - Alluvium; mostly sand and silt.
LATE TERTIARY TO QUATERNARY	QTs	SEDIMENTS - Dominantly gravels; includes alluvial fan and pediment deposits.
MID-TERTIARY	Tvs	SILICIC VOLCANICS - Rhyolitic tuffs, agglomerates and possibly fluvial clastic rocks. Includes Kohi Kug Volcanics.
	Ts	SEDIMENTS and VOLCANICS, undifferentiated.
	Tvi	INTERMEDIATE VOLCANICS - Andesite flows, breccias, and conglomerates of the Yellowstone Wash Formation in the Baboquivari Mountains and other units elsewhere in the area.
	Ti	INTRUSIVES - Dikes, sills and possibly plugs and small epizonal plutons. Intermediate to silicic composition.
CRETACEOUS TO TERTIARY	TKs	CONGLOMERATE - Possibly the Fresno Conglomerate; thick-bedded, red conglomerate.
	TKgn	METASEDIMENTARY ROCKS - Thermally and regionally metamorphosed equivalents of the Cambrian Bolsa Quartzite and Abrigo Formation and the Devonian Martin Formation. Calc-silicate rocks and quartzite tectonite.
	TKsc	METASEDIMENTARY AND METAVOLCANIC ROCKS - Greenschist facies metamorphic equivalents of the All Molina and Pitoikam Formations of Jurassic (?) age. Phyllite, schist, semischist, metaconglomerate, quartzite, metarhyolite, greenschist, minor gneisses.
	TKg	GRANITIC ROCKS OF PRESUMIDO TYPE - Aluminous granitic rocks, including garnet-two-mica granites. Pan Tak Granite, Gu Chuapo Granite, Presumido Peak Granite and other unnamed plutons.
CRETACEOUS	Kr	ROSKRUGE RHYOLITE - Rhyolite flows, tuffs, and agglomerates with interbedded sediments and andesitic to dacitic flows. Dominantly pyroclastic in the Dobbs Buttes area.
	Ka	ANDESITE - Undifferentiated andesite flows, tuffs and breccias; may include some sediments.
	Ks	SEDIMENTS - Undifferentiated continental clastic sediments; may contain lesser volcanics. Includes Sand Wells Formation in northern Coyote Mountains.

MESOZOIC

Mzv

UPPER MESOZOIC VOLCANICS AND SEDIMENTS - Andesite to rhyolite flows, tuffs, breccias and subvolcanic intrusives, and continental clastic rocks of the Chiull Shaik and Sand Wells Formations.

Mzgr

JURASSIC GRANITIC ROCKS - 165 to 145 m.y.B.P. granites to granodiorites with alkalic intrusives, diabases, and quartz diorites.

Mzs

LOWER MESOZOIC SEDIMENTS AND VOLCANICS - Andesitic to rhyodacitic flows, tuffs and breccias, and continental clastics of the Ali Molina, Pitoikam, Mulberry Wash Volcanic, and Roadside Formations.

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.

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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-helium- 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		

Introduction

1.1 Background

1.2 Objectives

1.3 Scope

The purpose of this study is to investigate the effects of the proposed system on the performance of the system. The study will focus on the following objectives:

- 1. To determine the impact of the proposed system on the system's performance.
- 2. To identify the factors that influence the system's performance.
- 3. To evaluate the system's performance under different conditions.

1.4 Methodology

2. Literature Review

2.1 Introduction

The literature review is a critical component of any research project. It provides a comprehensive overview of the existing knowledge on the topic and identifies the gaps in the current research.

The literature review is organized into three main sections: a general overview of the topic, a detailed review of the existing research, and a synthesis of the findings.

The general overview of the topic provides a broad context for the research. It discusses the importance of the topic and the current state of the field.

The detailed review of the existing research focuses on the specific aspects of the topic that are relevant to the study. It examines the strengths and weaknesses of the existing research and identifies the gaps in the current knowledge.

The synthesis of the findings provides a summary of the key findings from the literature review. It identifies the main trends in the research and highlights the areas that need further investigation.

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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 Columbium	Ti Titanium
Be Beryllium	Au Gold	Pt Platinum group	W Tungsten
Bi Bismuth	Fe Iron	RE Rare earth	V Vanadium
Cd Cadmium	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	pi 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			
li Lime			

MEMORANDUM FOR THE RECORD

DATE: 10/10/54

TO: SAC, NEW YORK

FROM: SAC, NEW YORK

SUBJECT: [Illegible]

RE: [Illegible]

[Illegible text block containing several lines of information, possibly a summary or list of items.]

ADMINISTRATIVE PAGE

[Illegible text block containing administrative details, possibly including dates, initials, and references.]

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

penetratively metamorphosed by a later event, and parts of the section subsequently underwent cataclastic metamorphism during the mid-Tertiary orogeny. As the Paleozoic formations retain little similarity to their unmetamorphosed counterparts which crop out elsewhere in southern Arizona, they will be discussed in a following section describing Laramide-age rocks.

Mesozoic

Mesozoic rocks of the Baboquivari Mountains and adjoining areas have been divided into three broad units by Haxel and others (1980). These units are as follows: lower Mesozoic supracrustal rocks, which are older than to coeval with Jurassic intrusives; mid- to late Jurassic plutonic rocks; and upper Mesozoic supracrustal rocks, which were formed after the mid-Mesozoic orogeny and prior to the Laramide orogeny.

Lower Mesozoic Supracrustal Rocks

Lower Mesozoic supracrustal rocks crop out in the north-center, center and northwest portions of the Kitt Peak GRA and underlie parts of both the Coyote Mountains and Baboquivari Peak South WSAs. From oldest to youngest, the lower Mesozoic rocks of the Baboquivari Mountains (central part of the GRA) are: the Ali Molina Formation, the Pitoikam Formation and the Mulberry Wash Volcanic Formation. The Roadside Formation, which is not correlative with the formations of the Baboquivari Mountains, crops out in the northern part of the GRA.

The lower Jurassic Ali Molina Formation has been divided into two parts by Haxel and others (1980). The lower part is comprised of tan to white rhyodacitic flows, tuffs and pyroclastics with lesser porphyritic andesite. Interbedded with the volcanics are quartzite and arkosic quartzite. The upper part of the Ali Molina Formation is sandstone and conglomerate (Haxel et al., 1980; Fair, 1965). The Ali Molina Formation is about 12,000 feet

thick (Haxel et al., 1980).

Overlying the Ali Molina Formation, in probable conformable contact, is the lower Jurassic Pitoikam Formation. Thickness of this formation, which Haxel and others (1980) have divided into three members, is not reported. The unnamed lower member is composed of red to maroon conglomerate, brown and white sandstone and purple and green siltstone. The middle unit is the Contreras Conglomerate Member, which is volcanoclastic conglomerate with minor interbedded sandstone and siltstone. The Chiltepines Member rounds out the section. This upper member consists of siltstone with subordinate shale, sandstone, conglomerate, and at the top, intermediate volcanic flows (Haxel et al., 1980). Fair (1965) reports a tan to white limestone in the upper part of the section.

The lower Jurassic Mulberry Wash Volcanic Formation unconformably overlies the Pitoikam Formation. The lower part of the 5000 foot thickness of Mulberry Wash rocks consists of gray, pink and red porphyritic rhyodacitic to andesitic flows intertonguing with volcanic breccia, lesser flows and small lenses of arkose and shale. The middle unit is predominantly red to brown volcanic breccia to conglomerate with lesser green-gray arkose, green mudstone, white marl and local limestone. The upper part is composed of purple to red latitic, rhyodacitic and andesitic flows with lesser breccias and tuffs (Haxel et al., 1980; Fair, 1965).

The Roadside Formation is the lower Mesozoic unit which crops out in the northern part of the GRA. The lower part of the Roadside Formation is comprised predominantly of dacitic flows with interbedded clastics ranging from mudstone to boulder conglomerate and breccia. Clasts in the coarse-grained rocks include arkose, quartzite, andesite, limestone, schist and granite. The upper part of the Roadside Formation is made up of andesite flows and breccias, with lesser brecciated limestone lenses (Heindl, 1965).

1880-1881

The first of the year was a very dry one.

The weather was very warm and the crops were very good.

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Jurassic Plutonic Rocks

Mid- to late Jurassic intrusives ranging in age from 165 to 145 m.y.B.P. underlie much of the Baboquivari Mountains and also crop out in the South Comobabi Mountains in the northwest part of the GRA. Most of the rocks are quartz-rich and range from alkali feldspar granite to granodiorite with alkalic intrusives occurring in the Comobabi Mountains.

The Kohi Kug Granite is described by Fair (1965) as a brick red to tan porphyritic granite associated with dark gray diabase and pods of gray, equigranular monzonite. The Kohi Kug Granite apparently crops out in the northern Baboquivari Mountains.

The Otero Granite of the Baboquivari Mountains is a medium-grained, gray, quartz- and biotite- bearing porphyry. The Baboquivari Granite crops out at Baboquivari Peak and in the western part of the range and is a coarse-grained, reddish, porphyritic rock with large phenocrysts of potassium feldspar and clusters of chlorite (Heindl and Fair, 1965). Granodiorite, quartz monzonite and quartz diorite intrusives occur in the Quinlan Mountains of the north-central part of the GRA (Min, 1965).

Wright and Haxel (1982) and Gardulski (1980) described the Jurassic intrusives of the Coyote Mountains. Four units crop out in the southern part of the mountains: sphene-bearing hornblende-biotite and biotite granodiorite and monzonite, both intruded by biotite monzogranite and syenogranite. Mesocratic sphene- and epidote- bearing biotite-hornblende quartz diorite, hornblende-epidote diorite and augite hornblendite crop out in the northeast Coyote Mountains. Gardulski (1980) notes that some of the northern rocks have glomeroporphyritic texture with clots of chlorite, some with pyroxene cores.

THE HISTORY OF THE

REIGN OF KING CHARLES THE FIRST

IN WHICH ARE CONTAINED THE
MOST REMARKABLE PAS-
SAGES OF HIS LIFE AND REIGN
FROM HIS MARRIAGE TO HIS DEATH
IN THE YEAR 1649
BY
JOHN BURNET
BISHOP OF SALISBURY
IN TWO VOLUMES
THE SECOND VOLUME
LONDON
Printed by J. Streater, at the Sign of the Gun, in St. Dun-
stons Church-yard, 1697

Upper Mesozoic Supracrustal Rocks

Upper Mesozoic units of the Kitt Peak GRA are dominantly sedimentary with lesser volcanics. The Chiuli Shaik Formation, of late Jurassic or Cretaceous age, crops out in the central and southern parts of the GRA. It is composed of 2000 feet of andesite flows, breccias, rhyolite tuffs and subvolcanic intrusions (Haxel et al., 1980; Heindl and Fair, 1965). The Sand Wells Formation of probable Cretaceous age, but possible late Jurassic age, crops out in the southern Comobabi Mountains and in the northernmost part of the Coyote Mountains. The Sand Wells Formation is about 1900 feet thick in the southern Comobabi Mountains and is composed of a basal conglomerate overlain by a middle unit of sandstone, siltstone, conglomerate, mudstone and subordinate volcanics. The upper part of the Sand Wells consists of volcanic breccia and flows of intermediate composition, with minor sandstone beds (Haxel et al., 1980). The Roskrige Rhyolite crops out over much of the northeast part of the area and is composed of rhyolite flows, tuffs and agglomerates with intercalated sediments and andesitic to dacitic flows. In the Dobbs Buttes area, the 1250 feet of the Roskrige Rhyolite is dominantly pyroclastic and is interbedded with water-laid tuffaceous sediments. The Cretaceous unit unconformably overlies the Roadside Formation but nowhere is in contact with rocks of the Sand Wells Formation (Heindl, 1965).

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 fig. 2C). Of the 35 major porphyry copper deposits in Arizona, 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 2C). The intrusives associated with the porphyry copper deposits were emplaced during the southeastward 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).

Intrusives, metamorphic rocks and possibly sediments of Laramide age occur in the Kitt Peak GRA. Laramide intrusive rocks crop out in the Las Guijas Mountains in the southeast corner of the GRA, through most of the length of the Baboquivari Mountains, in the Coyote Mountains in the northeast and the Quinlan Mountains and South Comobabi Mountains in the northwest. Metamorphic rocks crop out in the South Comobabi Mountains, the Coyote Mountains and the Baboquivari Mountains in the southern part of the GRA. Conglomerate which may be Laramide or younger in age crops out northwest of Baboquivari Peak (see fig. 3).

Laramide granitic rocks of the Kitt Peak GRA and adjoining parts of the Papago Indian Reservation have been termed by Haxel and others (1980) as "granites of Presumido type" after granites of Presumido Peak, an area in the

Baboquivari Mountains south of the GRA. The Presumido Peak granite crops out in a small area at the southern edge of the GRA and is a garnet-two-mica granite. These highly aluminous granites are comparable to S-type granites, thought to be of sedimentary origin by Chappell and White (1974).

Haxel and others (1980) noted characteristics of the leucocratic muscovite- and garnet-bearing granites of the Presumido type, as follows:

1. The rocks have no hornblende, but contain all combinations of biotite, white mica and garnet. In Arizona, Laramide intrusives associated with porphyry copper deposits are all hornblende-bearing.
2. Most of the Presumido type granites were emplaced as two phase intrusions; the older phase contains little or no garnet, but the younger, highly leucocratic phase has sparse to common garnet and grade into or consist largely of pegmatite.
3. Most Presumido type rocks are monzogranites in composition and are not associated with hornblende-bearing rocks - the rocks are not part of a differentiation sequence. Intrusive contacts are sharp.

Wright and Haxel (1982) also note a strong spatial relationship between these aluminous granites and regionally metamorphosed rocks of the same age.

The 58 ± 3 m.y. old Pan Tak granite of the Coyote Mountains intrude Jurassic granites and diorites in the northeast and southwest, and Paleozoic sediments of the Bolsa Quartzite, Abrigo Formation and Martin Formation form a discontinuous septum running north-south down the center of the pluton (Wright and Haxel, 1982; Davis et al., 1980b, Gardulski, 1980). It fits all characteristics of Presumido type granites. The younger phase is garnetiferous and composed almost entirely of pegmatites, with aplite dikes also occurring (Wright and Haxel, 1982).

The Gu Chuapo granite of the northwest Quinlan Mountains and southeast Comobabi Mountains is also a garnet-two-mica granite but grades into granite porphyry.

Linear-shaped Laramide intrusives which stretch from the Quinlan Mountains south through the Baboquivari Mountains contain beryl-bearing pegmatites.

No information is available on the Laramide intrusive of the Las Guijas Mountains in the southeastern corner of the GRA.

Paleozoic sediments of the Coyote Mountains have a fairly complex metamorphic history. In addition to contact metamorphism resulting from intrusion, the sediments have been affected by more than one penetrative deformational event. Garnet, epidote, K-feldspar, diopside, dolomite, muscovite and ubiquitous quartz are metamorphic phases which occur in several assemblages in metamorphosed limestone. Quartzites are visibly lineated. An early regional metamorphism foliated all rocks younger than the second phase of the Pan Tak pluton (Gardulski, 1980). As the Coyote Mountains were greatly affected by the mid-Tertiary orogeny, metamorphic history of the rocks will be discussed more completely in a following section.

Greenschist facies regional metamorphism affected the Mesozoic rocks of the Ali Molina and Pitoikam Formations. These rocks, termed the metamorphic rocks or schist of Chutum Vaya, crop out in a large zone in the southern part of the GRA. A gradational contact exists between the Mesozoic rocks (Mzs) and the Laramide schist (TKsc) at the northern end of the schist body - schists can be traced laterally into relatively unmetamorphosed Mesozoic parent rock. Metamorphic rocks of Chutum Vaya consist of quartzofeldspathic to quartzose phyllite and schist, arkosic semischist, epidotized sandstone, metaconglomerate, quartzite, metarhyolite, greenschist and some gneissic rocks. Foliation is predominantly westward-dipping and lineation plunges

gently to moderately NNW to NE. Kink folds and crenulations also occur (Haxel et al., 1980).

Laramide metamorphics of unknown nature are associated with garnet-two-mica granites of the Quinlan Mountains and South Comobabi Mountains. Laramide intrusives in the Kitt Peak GRA are both synmetamorphic and post-metamorphic (Haxel et al., 1980).

Haxel and others (1980) report that conglomerates (TKs, fig. 3) are either Laramide or younger in age. These conglomerates may be the thick, red Fresno Conglomerate of Fair (1965). Age of the unit, which rests unconformably on Mesozoic volcanics and sediments and is overlain by mid-Tertiary rocks, cannot be well-bracketed. It is quite possible that the conglomerate is part of a post-Laramide molasse-type deposit.

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 an 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.

Rocks of the Coyote Mountains, and a "sister" complex of rocks in the Pozo Verde Mountains approximately five miles south of the GRA, possess a number of characteristics common to metamorphic core complexes.

The rocks of the Pozo Verde Mountains include garnet-two-mica granites which intrude dominantly Mesozoic rocks. 100 km² of the area has been metamorphosed into a mylonitic tectonite, with foliation dipping south. Between the Pozo Verde Mountains and the Coyote Mountains is non-mylonitic country rock protolith of the Baboquivari Mountains. K-Ar cooling age of muscovite associated with the metamorphic event in the Pozo Verde Mountains is 24 m.y.B.P. (Davis et al., 1981).

Widespread in Jurassic intrusive rocks and Paleozoic sediments and common in the older phase of the Pan Tak granite is west- to SW-dipping foliation with subordinate west- to WSW-dipping lineation. This metamorphism was contemporary with intrusion of the older phase of the Pan Tak Granite (Wright and Haxel, 1982). A later metamorphic event in the Coyote Mountains

produced penetrative NE-dipping foliation and NNW-plunging lineation in metaquartzites and discrete, NE-dipping, curvilinear slip surfaces in the pegmatite, part of the younger phase of the Pan Tak Granite, that encloses the metasedimentary rocks (Gardulski, 1980). Gardulski (1980) suggests that this ductile shear resulted from plastic flow accompanying flattening and NNW extension. The penetratively metamorphosed rocks are truncated by the Ajo Road Fault or Decollement (see fig. 3), a north-dipping normal fault. At least a one hundred meter thickness of Coyote Mountain rocks has a brittle, mylonitic foliation, associated with movement along the fault, which overprints the ductile deformation. A zone of chloritic breccia directly underlies the fault. A Tertiary dike emplaced after the ductile deformational event is truncated by the Ajo Road Decollement, suggesting a deformational hiatus between the penetrative event and activation of the decollement (Gardulski, 1980). Hanging wall rocks north of the fault are volcanics and sediments of the Mesozoic Roadside and Sand Wells Formations. The Mesozoic rocks are brittly deformed, with fracturing, faulting and shearing common. Adjacent to the fault, brittle deformation is intense and the rocks are shattered and have a pasty, gouged appearance (Gardulski, 1980; Davis et al., 1981).

Rocks of the Coyote Mountains, with north-dipping mylonitic foliation, and Pozo Verde Mountains, with south-dipping foliation, are unusual for core complexes as a very large mass of rocks (around 25 miles in length) that were unaffected by mid-Tertiary metamorphism separate the two areas. The Coyote and Pozo Verde Mountains certainly were greatly affected by the mid-Tertiary orogeny, but may not be metamorphic core complexes, at least as currently defined.

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), and stratigraphy of the units is summarized in figure 5.

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 well-known uranium deposit of the 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

PHOENIX-TUCSON AREA

FIG.5 COMPOSITE STRATIGRAPHIC COLUMN OF SOUTHWESTERN ARIZONA. Unconformity (a) represents erosional surface that was disrupted by beginning of late Miocene block faulting. From Eberly and Stanley (1978).

ostracods.

The mid-Tertiary rocks of Arizona rest unconformably on Precambrian, Paleozoic, Mesozoic, and Laramide rocks. In the Kitt Peak GRA, mid-Tertiary rocks rest unconformably on Mesozoic sediments and volcanics. 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 southern 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 southern Arizona (Shafiqullah et al., 1980). In southeastern Arizona the intensity of volcanism peaked about 26 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 the 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 Kitt Peak GRA, mid-Tertiary volcanics and sediments crop out in the western Baboquivari Mountains at the center of the GRA, Comobabi Mountains in the northwest, the foothills of the Roskrige Mountains in the

northeast and the Black Hills at the eastern edge of the area (see fig. 3, units Ts, Tvs, Tvi, Ti). Additional information is available only for the Coyote Mountains - Baboquivari Mountains area.

Mid-Tertiary rocks of the Coyote Mountains consist of generally N-S trending, near vertical dikes. The dikes are about one meter wide by six to 60 meters long and are composed of augite phenocrysts in a felty groundmass of plagioclase, quartz, chlorite and opaques. Although termed lamprophyres by early workers, these rocks lack the high potassium and/or sodium content characteristic of lamprophyres. One Tertiary dike in the western Coyote Mountains consists of phenocrysts of magnetite in a fibrous chloritic(?) matrix (Gardulski, 1980). Wright and Haxel (1982) report the occurrence of similar dikes in the east-central Baboquivari Mountains; there the "lamprophyre" dikes are cut by 24 m.y.B.P. rhyolite dikes.

Heindl and Fair (1965) report the occurrence of Tertiary volcanic conglomerate, andesite flows, rhyolite tuffs, welded tuffs and agglomerates in west-central Baboquivari Mountains. Fair (1965) describes the Yellowstone Wash Formation of that same area. The Yellowstone Wash Formation consists mainly of deep red, bedded conglomerate with lesser interbedded andesite flows, some possibly correlative with the 25-30 m.y.B.P. Turkey Track Porphyry of the Tucson area, and sedimentary breccias. This formation probably unconformably overlies late Mesozoic rocks and Laramide(?) conglomerate (Fair, 1965; Haxel and others, 1980). Overlying the Yellowstone Wash Formation are 1250 feet of rhyolite, tuff, welded tuff, tuff breccia, andesite, and clastics of fluvial origin, which Fair (1965) terms the Kohi Kug volcanics.

Late Tertiary

Late Tertiary deposits occur 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 1. The Baboquivari valley, in the western part of the Kitt Peak GRA, and the Altar Valley, in the east, both are greater than 4800 feet deep.

The deposits consist mainly of poorly consolidated, tan colored fanglomerate, sandstone, and siltstone of fluvial and lacustrine origin, and minor basalt (Scarborough and Wilt, 1979; Eberly and Stanley, 1978). 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 and others (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.

Structural Geology

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

mid-Tertiary orogenies and most recently by the Basin and Range disturbance. The area is, therefore, structurally very 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 and others (1980).

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 fig. 2C) 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. Northwest-trending strike slip faulting was initiated (Davis, 1981) and movement along the Mojave-Sonora left-lateral mega-shear (see fig. 2B) probably took place at this time (Silver and Anderson, 1974). Northwest-trending linear discontinuities in depositional patterns (see fig. 2) were produced in southeastern Arizona (Titley, 1976).

The Laramide was a period of intense tectonism and localized magmatic and metamorphic 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 fig. 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.

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 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 southern Arizona, although none have been located to date.

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 often have physiographic expression. The mylonitic rocks have 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 Coyote Mountains in the northwest corner of the Kitt Peak GRA has 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). An example is the northwest part of the GRA; the Mesozoic volcanics and sediments are believed to be listric-faulted upper plate rocks of the Coyote Mountains metamorphic core complex (Wright and Haxel, 1982).

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 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

Fossils are 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.

No fossils are reported from the sedimentary rocks of the Kitt Peak GRA. Gardulski (1980) reports that any fossils originally occurring in the

Paleozoic metasediments of the Coyote Mountains have been destroyed. Other workers in the Baboquivari Mountains have not reported about fossils. Upper Mesozoic sediments of the Sierrita Mountains, just east of the GRA, contain pelecypods, gastropods and fresh water ostracods. Fossils may also occur in unmetamorphosed sediments of the Kitt Peak GRA.

Geologic History

The geologic history of the area is 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 southern Arizona are given by Titley (1982) and Shafiqullah and others (1980). The geologic history can be summarized as follows:

1. No Precambrian rocks now occur in the GRA and surrounding areas,
2. During the Cambrian the GRA was submerged beneath epicontinental seas. At this time, shallow marine clastic sandstone, mudstone and minor limestone were deposited (Heindl and McClymonds, 1964).
3. No deposition took place during the Ordovician and Silurian, and the Cambrian is disconformably overlain by a Devonian to Early Mississippian transgressive sequence of clastics and carbonates (Teichert, 1965; Bryant, 1968).
4. Late Paleozoic sediments do not occur in the area; possibly they were removed by erosion during the mid-Mesozoic orogeny. Molasse-like sediments were deposited in local basins in the GRA (Heindl, 1965). The upper part of this sequence contains volcanic material, possibly derived from the magmatic arc that

extended over the GRA during the mid-Jurassic (see fig. 2B). Much of the Baboquyivari Mountains consists of Jurassic intrusives and later Mesozoic sediments and volcanics.

5. 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). Several Laramide intrusives crop out in the GRA and Laramide metamorphic rocks crop out in the northwest, northeast and southern parts of the Kitt Peak GRA.
6. The Laramide was followed by a period of tectonic quiet and erosion.
7. 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) possibly including the Coyote

Mountains in the northern part of the GRA. Associated with the core complexes and also present elsewhere in southern Arizona are listric normal faults (Davis, 1981) which offset upper plate rocks. Volcanism and tectonism migrated westward during the mid-Tertiary as the dip of the Benioff zone steepened (Coney and Reynolds, 1977).

8. 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.
9. 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, thermal wells and other energy resources (fig. 3) in the Kitt Peak GRA. Information was derived from the following sources: U.S. Geological Survey (1972, updated 1979 and 1981), Keith (1974), Johnson (1972), Peirce and others (1970), Arizona Bureau of Mines (1969), Stipp and others (1967), Fair (1965) and McCrory and O'Haire (1965). Scarborough and Wilt (1979) and Luning and Brouillard (1982) were consulted for uranium occurrences within the GRA; the Arizona Department of Mineral Resources (1981) list of active mines was also consulted; Witcher and others

The following table shows the results of the
analysis of variance for the different
factors considered in the study.

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(1982) was consulted for geothermal resources.

Known Mineral Deposits, Mines or Prospects with Recorded Production

1. Good Enough Claims (nos. 1 and 2)

Synonym Names: Zappia Claims; Soto Group; Esperanza Group; Whitcomb.
Location: 31°38'54"N, 111°21'51"W
Sec. 31, T20S, R10E.
Commodities: W (major product); Ag, Au, Cu (minor product); Pb (potential).
Ore Materials: Wolframite series (huebnerite) with minor scheelite.
Deposit Description: Small, N75°W-N60°W trending, 60-50°NE dipping, ore in quartz lenses in irregular fracture zone through granitic formation; exposed for 800 ft. along strike, underground workings.
Geology: Mineralization in Cretaceous volcanic breccia associated with Laramide granite, cross-faulting and post-mineral lamprophyre dikes.
Production: Yes, 50 tons of Au, Ag, Cu, 40,000 pounds of WO₃ concentrate.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1623, p. 4234-4237; Keith, 1974.

2. St. Jude Mine

Location: 32°07'14"N, 111°27'11"W
Sec. 17, T15S, R9E.
Commodities: Ag, Cu (major products); Pb, Au, Ba, Mn (minor products); Ba, Mn (occurrence).
Ore Materials: Argentite, native silver (main); manganese, barite (minor).
Deposit Description: Small deposit located in a shear zone, shaft workings.
Geology: Mineralization in Cretaceous sediments and volcanics associated with Cretaceous-Tertiary granitic intrusions. Mineralization in fault zone cutting Cretaceous sediments.
Production: Yes, 300 tons of ore.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1138, p. 2957-2959; Keith, 1974.

3. Columbia Mine Group

Location: 32°03'30"N, 111°47'15"W
Sec. 1, T16S, R5E.
Commodities: Cu, Ag (major products); Au (minor product).
Ore Materials: Copper carbonates, chalcocite.
Deposit Description: Small, irregular shaped deposit in a vein/shear zone, tunnel workings.
Geology: Mineralization in Cretaceous-Tertiary granitics.
Production: Yes, small amount, .1 oz Au/T, 29 oz. Ag/T, 19% Cu, produced in 1907.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12,

ARTICLE IN FULL
THE TREATMENT OF THE ACUTE INFLUENZA

BY
DR. J. H. HAY, JR., CHICAGO, ILL.

THE influenza epidemic of 1918-1919 has been the most severe in the history of the world. It has been characterized by its rapid spread, its severity, and its high mortality rate. The disease has been a source of great concern to the medical profession and the public alike.

The influenza virus is a small, spherical particle, about 0.1 microns in diameter. It is composed of a protein coat and a core of nucleic acid. The virus is highly contagious and can be transmitted by direct contact with an infected person or by inhalation of droplets from the nose or mouth of an infected person. The incubation period is usually 1 to 4 days.

The symptoms of influenza are usually sudden in onset and include fever, chills, headache, muscle aches, and fatigue. The respiratory system is also affected, with sore throat, cough, and nasal discharge. The disease is usually self-limiting and resolves within a week or two.

The treatment of influenza is primarily symptomatic. Rest, fluids, and antipyretics are the mainstays of therapy. Antibiotics are not indicated unless there is evidence of a secondary bacterial infection. The use of antiviral drugs is still experimental.

The prevention of influenza is based on the isolation of infected persons and the use of masks and handkerchiefs. Vaccination is also available, but its effectiveness is still under investigation.

The influenza epidemic of 1918-1919 has been a major public health problem. It has resulted in the death of millions of people and has caused great suffering. The study of this epidemic has provided valuable information about the nature of the influenza virus and the mechanisms of its transmission.

The treatment of influenza is still a subject of active research. The development of effective antiviral drugs and the use of vaccines are the most promising approaches to the control of this disease.

The influenza epidemic of 1918-1919 has been a major public health problem. It has resulted in the death of millions of people and has caused great suffering. The study of this epidemic has provided valuable information about the nature of the influenza virus and the mechanisms of its transmission.

Record 1155, p. 3006-3008; Keith, 1974.

4. **Buster Lode Prospect**

Location: 31°39'54"N, 111°23'W
Sec. 25, T20S, R9E.
Commodities: W, Au, Ag.
Ore Materials: Wolframite.
Deposit Description: Small, located in barren quartz plugs.
Geology: Mineralization in Cretaceous-Tertiary granite and sediments, a number of shallow and deep workings on hanging wall of contact show only sparse mineralization; no evidence for good mineralization.
Production: Yes, small amount.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1622, p. 4232-4233.

5. **Corona Group**

Location: 32°00'31"N, 111°49'23"W
Sec. 27, T16S, R5E.
Commodity: Au.
Ore Materials: Pyrite, gold.
Deposit Description: Small, NW-trending, 60°SW dipping, vein shaped, underground workings, inclined shaft.
Geology: Mineralization in Mesozoic diorite porphyry and slate.
Production: Yes, small amount.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1157, p. 3012-3014; Stipp et al., 1967.

6. **General Electric Mine**

Synonym Names: Grande Lode; Immense Lode; General Electric Mine I, II, III, IV, V, Las Guijas Group.
Location: 31°39'51"N, 111°22'51"W
Sec. 25, T20S, R9E.
Commodities: W (major product); Ag, Au, Cu (minor); Fe, Pb, Zn, Mn, F (occurrence).
Ore Materials: Wolframite with pyrite, chalcopyrite, galena and bornite.
Deposit Description: Medium, N65-80°W trending, 78°N dipping, ore occurs sporadically in quartz veins, underground workings.
Geology: Mineralization in volcanic breccia associated with Cretaceous-Tertiary granite, mineralization occurred at contact of granite with breccia, N65°W fault zone.
Production: Yes, small amount, 2000 tons of AuAgCu ore, 155,000 pounds WO₃ concentrate.
References: U.S.G.S., 1981, CRIB Mineral Resources file 12, Record 1621, p. 4229-4231; Keith, 1974.

7. **Vindicator Group**

Synonym Names: Stewart-Fernstrom (Carboloy Group; Union Nos. 1-3;

Location: Guijas Nos. 1-4,
31°39'15"N, 111°22'36"W
Sec. 25, T20S, R9E.
Commodities: W (major); Cu, Au, Ag, Pb (minor).
Ore Materials: Wolframite series with some scheelite, pyrite,
chalcopryrite and galena.
Deposit Description:
Medium, N65-75°W trending, dipping steeply
northeast, irregular/pinching and swelling forms in
lenses, underground workings.
Geology: Mineralization in Cretaceous sedimentary rocks
associated with Cretaceous-Tertiary granite, vein
follows contact of granite and volcanic breccia,
quartz lenses in fracture zones through granite,
vein terminates at contact with biotite minette
dike.
Production: Yes, 31,000 pounds of WO₃ concentrate produced.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12,
Record 1620, p. 4225-4228; Stipp et al., 1967;
Keith, 1974.

8. **Obregon Claims**

Location: 31°39'N, 111°22'12"W
Sec. 25, 36, T20S, R9E.
Commodity: W.
Ore Materials: Unknown.
Deposit Description:
Small.
Geology: Unknown.
Production: Yes, small amount.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12,
Record 1619, p. 4223-4224.

9. **Badger Mine**

Location: 31°59'33"N, 111°49'13"W
SE 1/4 Sec. 34, T16S, R5E.
Commodities: Au, Ag.
Ore Materials: Auriferous iron oxides.
Deposit Description:
Small, N70°E trending. Irregular sugary
quartz-calcite vein with spotty oxidized pyrite,
showing enriched gold and silver values in iron
oxides near the surface. underground workings
consisting of relatively shallow inclined shaft.
Geology: Mineralization in Cretaceous-Tertiary granitic
intrusive. Sericitized and silicified wall rock
with oxidation near the surface.
Production: Yes, average 8 oz. Au/T, 5 oz. Ag/T in 1938.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1161, p. 3023-3025; Keith, 1974.

11. **Bonanza Mine**

Synonym Name: SRK.
Location: 32°00'22"N, 111°31'09"W
W central Sec. 26, T16S, R8E.

Commodities: Cu (major product); Ag, Au, Zn, Mo (minor products).
Ore Materials: Pyrite, chalcopyrite, bornite, covellite and chalcocite (major); molybdenite and sphalerite (minor).
Deposit Description: Small, pyrometamorphic, high grade deposit, underground shaft and adit operations.
Geology: Mineralization in Paleozoic limestone associated with Cretaceous-Tertiary aplitic to pegmatitic quartz monzonite.
Production: Yes, 700 tons of ore from 1909-1951.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1163, p. 3029-3031; Stipp et al., 1967; Keith, 1974.

12. **Calabi Placers**

Location: 31°58'54"N, 111°48'35"W
Sec. 3, T17S, R5E.
Commodity: Au.
Ore Materials: Gold.
Deposit Description: Small, placer, surface workings.
Geology: Mineralization in Quaternary gravels.
Production: Yes, small amount.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1170, p. 3051-3052.

13. **Lucido Claim Group**

Synonym Name: Golden Star.
Location: 31°59'08"N, 111°49'01"W
NE 1/4 Sec. 3, T17S, R5E.
Commodities: Au, Ag (major products); Cu (minor product).
Ore Materials: Gold and silver (major); oxidized copper (minor).
Deposit Description: Small, irregular, lensing shaped deposit in a vein/shear zone, surface and underground workings of inclined shaft and trenches.
Geology: Mineralization in Mesozoic diorite.
Production: Yes, 100 tons of ore averaging 0.4 oz. Au/T.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1171, p. 3053-3055; Stipp et al., 1967; Keith, 1974.

15. **Ventana Mine Group**

Location: 31°46'51"N, 111°39'44"W
Sec. 18, T19S, R7E.
Commodities: Cu, Ag, Au (major products); Pb, Zn, Mn (minor products).
Ore Materials: Base metal sulfides.
Deposit Description: Small deposit in a vein/shear zone, surface and underground workings.
Geology: Mineralization in Cretaceous volcanics and sediments (metamorphosed) associated with Cretaceous-Tertiary granitic intrusive.

Production: Worked sporadically to 1954, produced 185 tons of ore averaging about 1.3% Cu, 2 oz. Ag/T and 0.7 oz. Au/T.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1250, p. 3286-3288; Keith, 1974.

16. **Iowana Mine**

Location: 31°43'57"N, 111°35'03"W
Sec. 36, T19S, R7E.
Commodities: Au, Ag (major products); Pb, Cu (minor products); Zn (potential); W (occurrence).
Ore Materials: Gold and silver (major); base metal sulfides and wolframite (minor).
Deposit Description: Small, lensing in a vein/shear zone, underground workings consisting of shallow shafts and tunnels.
Geology: Mineralization in Cretaceous sediments (partly metamorphosed) associated with Cretaceous-Tertiary granite and diorite porphyry dikes.
Production: Yes, 100 tons of ore averaging 1 oz. Au/T and 16 oz. Ag/T.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1251, p. 3289-3291; Stipp et al., 1967; Keith, 1974.

17. **Jupiter Mine**

Location: 31°44'05"N, 111°35'13"W
Sec. 36, T19S, R7E.
Commodities: Au, Ag (major products); Pb, Cu (minor products); Zn (potential).
Ore Materials: Auriferous-argentiferous pyrite (major); base metal sulfides (minor).
Deposit Description: Small deposit in a vein/shear zone, shafts and tunnels, and underground workings.
Geology: Mineralization in Cretaceous metamorphosed sediments associated with Cretaceous-Tertiary granite and diorite dikes.
Production: Yes, produced about 400 tons of ore averging 0.7 oz. Au/T, 12 oz. Ag/T.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1252, p. 3292-3294; Stipp et al., 1967; Keith, 1974.

18. **Edna J. Placer**

Synonym Name: Baboquivari Placers
Location: 31°43'33"N, 111°33'34"W
Sec. 31, 32, T19S, R8E,
Sec. 5, 6, T20S, R8E.
Commodity: Au.
Ore Materials: Gold.
Deposit Description: Small, E-trending, gravel bar placer.
Geology: Mineralization in Quaternary gravel resting on granite pediment.

Production: Yes, a few tens of ounces of gold recovered.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12,
Record 1253, p. 3295-3297; Keith, 1974; Johnson,
1972.

19. **Arizona Molybdenum Mine**

Location: 31°43'11"N, 111°35'54"W
N cen. Sec 2, T20S, R7E.
Commodities: Mo (major product); Cu, Ag, Au, Pb (occurrence).
Ore Materials: Base metal sulfides and molybdenite (major); galena
(minor).
Deposit Description: Small, NW trending, lensing in pegmatitic
veins/dikes, surface and underground workings.
Geology: Mineralization in Cretaceous-Paleocene granite
associated with Cretaceous-Paleocene pegmatitic
veins, dikes.
Production: Yes, small amount.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1262, p. 3322-3324; Stipp et al., 1967;
Keith, 1974.

20. **Emmett and Elgin Mine**

Location: 31°42'47"N, 111°39'19"W
Sec. 3, T20S, R7E.
Commodities: Au (major product); Ag, Cu (minor products).
Ore Materials: Auriferous pyrite (major); base metal sulfides
(minor).
Deposit Description: Small, irregular shaped in shear zones, shallow
workings.
Geology: Mineralization in Cretaceous sediments
(metamorphosed) associated with Cretaceous-Tertiary
granitic intrusive.
Production: Yes, 150 tons of ore averaging 1 oz. Au/T, minor Ag,
Cu.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1263, p. 3325-3327; Keith, 1974.

21. **Gold King Mine**

Location: 31°42'27"N, 111°36'44"W
NE 1/4 Sec. 10, T20S, R7E.
Commodities: Au, Ag (major products); Pb, Cu (minor products); Zn
(potential); Be, Mn (occurrence).
Ore Materials: Base metal oxides and sulfides.
Deposit Description: Small, in a vein/shear zone, underground workings of
shafts, adits and pits.
Geology: Mineralization in Cretaceous metamorphosed sediments
associated with Cretaceous-Tertiary granite porphyry
dikes.
Production: Yes, 500 tons of ore averaging 1 oz. Au/T, 12 oz.
Ag/T.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1264, p. 3328-3330; Stipp et al., 1967;

Keith, 1974.

22. **Papago Chief Mine**

Synonym Name: Napoleon.
Location: 31°40'33"N, 111°37'42"W
Sec. 21, T20S, R7E.
Commodities: Cu, Ag (major products); Au, Pb (minor products); Zn (potential); U (occurrence).
Ore Materials: Base metal sulfides, metatorbenite.
Deposit Description:
Small, E-W trending, veins, underground workings.
Geology: Mineralization in Cretaceous sediments (partly metamorphosed) associated with Cretaceous-Tertiary granite and diorite dikes.
Production: Yes, 4500 tons of ore at 2% Cu, 5.6 oz. Ag/T, 0.04 oz. Au/T.
References: U.S.G.S., 1981, CRIB Mineral Resources file 12, Record 1265, p. 3331-3333; Keith, 1974.

23. **Berkley Mine**

Location: 31°40'40"N, 111°37'34"W
Sec. 21, T20S, R7E.
Commodities: Cu, Ag (major products); Au (minor products); Pb, Zn (potential).
Ore Materials: Pyrite, base metal sulfides.
Deposit Description:
Small, in a shear zone/vein, shallow workings, type unknown.
Geology: Mineralization in Cretaceous sediments (partly metamorphosed) associated with Cretaceous-Tertiary dikes.
Production: Yes, 1936-1937 200 tons of ore averaging 2.5% Cu, 0.04 oz Au/T and 6.5 oz. Ag/T shipped.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1266, p. 3334-3336; Keith, 1974.

25. **Las Guijas Tungsten Placers**

Location: 31°39'48"N, 111°22'09"W
Sec. 12, 23, 24, 25, T20N, R9E.
Commodity: W.
Ore Materials: Wolframite and scheelite.
Deposit Description:
Small, placers, surface workings. Dry and wet placer operations.
Geology: Mineralization in Quaternary stream gravels, alluvium associated with Cretaceous-Tertiary quartz veins.
Production: Yes, few tons of wolframite concentrates produced during WWI.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1268, p. 3340-3342; Keith, 1974.

26. **Liberty Mine**

Location: 31°41'38"N, 111°19'09"W
NE 1/4 Sec. 16, T20S, R10E.

Commodities: Ag (major product); Au, Pb, Cu (minor products).
Ore Materials: Argentiferous galena.
Deposit Description: Small, oxidized, irregular and spotty in a vein/shear zone, surface and underground workings.
Geology: Mineralization in Cretaceous andesite.
Production: Yes, late 1800's and early 1900's, 100 tons of ore.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1270, p. 3346-3348; Keith, 1974.

27. Silver Hill Mine

Synonym Name: Gold Coin.
Location: 31°41'15"N, 111°20'05"W
E cen. Sec. 17, T20S, R10E.
Commodities: Ag (major product); Pb, Cu, Au, Zn, Hg (minor products).
Ore Materials: Argentiferous base metal sulfides (major); tetrahedrite, cinnabar.
Deposit Description: Small, oxidized, irregular lensing in a vein/shear zone, underground workings.
Geology: Mineralization in Cretaceous-Tertiary diorite associated with Cretaceous-Tertiary diorite and andesite porphyry.
Production: Yes, sporadic operation from 1800's to 1930's, producing some 50 tons of ore.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1271, p. 3349-3351; Keith, 1974.

28. New Colorado Mine

Location: 31°41'21"N, 111°20'16"W
Sec. 17, T20S, R10E.
Commodities: Ag, Au, Pb, Cu (major products); Zn (minor product); Hg (occurrence).
Ore Materials: Argentiferous galena, freibergite, copper carbonates and oxides, sphalerite (major); cinnabar (minor).
Deposit Description: Small, partly oxidized, shaped irregularly in a vein/shear zone, surface and underground workings.
Geology: Mineralization in Cretaceous andesite porphyry.
Production: Yes, small amount.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1272, p. 3352-3354.

29. Mary G. Mine

Synonym Name: Mary E. Princess Group
Location: 31°40'27"N, 111°18'54"
Sec. 21, T20S, R10E.
Commodities: Ag (major product); Pb, Cu (minor products); Au, Zn, Hg (occurrence).
Ore Materials: Silver, galena, sphalerite, malachite, mercury, tetrahedrite, cinnabar, anglesite.
Deposit Description: Small, N10°E trending 45°W dipping, irregular, lensing form in a vein, underground

workings.
Geology: Mineralization in Cretaceous andesite porphyry.
Production: Yes, 800 tons of ore produced.
References: U.S.G.S., 1981, CRIB Mineral Resources file 12,
Record 1273, p. 3355-3357; Keith, 1974.

30. Lesjimfre Claims

Synonym Name: Greenfield State Lease
Location: 31°38'01"N, 111°37'37"W
Sec. 4, T21S, R7E.
Commodities: W (major product); F, Be (occurrence).
Ore Materials: Scheelite (main); Fluorite, vesuvianite
(beryllium)(minor).
Deposit Description:
Small, E-W trending 60°N dipping, sporadic in
shear zones. Surface and underground workings.
Geology: Mineralization in Cretaceous quartzite schistic
structure associated with Cretaceous-Tertiary
pegmatite dike, porphyritic granite and phonolite
porphyry.
Production: Yes, 2 tons of tungsten concentrate produced.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1275, p. 3361-3363; Keith, 1974.

31. More Mine

Location: 31°36'57"N, 111°25'18"W
NE 1/4 Sec. 9, T21S, R9E.
Commodities: Cu (major product); Au, Ag (minor product).
Ore Materials: Oxidized copper.
Deposit Description:
Small, located in a shear zone, surface workings
consisting of open pit and leaching operations.
Geology: Mineralization in Cretaceous sediments associated
with Cretaceous-Tertiary granitic intrusive.
Production: Yes, 1967 produced 100 tons of ore averaging 2% Cu,
4 oz. Ag/T, trace Au.
References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1276, p. 3364-3366; Keith, 1974.

32. Albatros Mine

Synonym Names: Gnome King; Albatross Gold Mines.
Location: 31°37'06"N, 111°22'12"W
NE 1/4 Sec. 12, T21S, R9E.
Commodities: Au, Ag (major products); Cu, Pb (minor products); Zn
(potential).
Ore Materials: Argentiferous-auriferous galena (major); sphalerite
and chalcopyrite (minor).
Deposit Description:
Small, oxidation, enrichment near the surface,
irregular lenses in a vein/shear zone, underground
workings.
Geology: Mineralization in quartz filled fissure veins
cutting Cretaceous-Paleocene granite.
Production: Yes.
References: U.S.G.S., 1981, CRIB Mineral Resources file 12,
Record 1278, p. 3370-3372; Stipp et al., 1967;

Keith, 1974.

33. **Buena Vista Mine Group**

Synonym Names: Golden Star, Gold Rim, Rebecca.

Location: 31°36'50"N, 111°19'37"W

Sec. 4, 9, 16, T21S, R10E.

Commodities: Ag, Au (major products); Cu, Pb (minor products).

Ore Materials: Base metal sulfides.

Deposit Description:

Small, numerous, weathered veins, irregular and spotty in a vein/shear zone, shallow workings.

Geology: Mineralization in Cretaceous-Tertiary granitic intrusive, fissure zone in granitics.

Production: Yes, in 1930's produced 400 tons of ore.

References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1281, p. 3379-3381; Keith, 1974.

34. **Arivaca King Mine**

Synonym Name: Chapman.

Location: 31°37'31"N, 111°20'09"W

Sec. 5, T21S, R10E.

Commodities: Au, Ag (major product); Pb, Cu (minor product).

Ore Materials: Base metal sulfides.

Deposit Description:

Small, irregular, in a vein/shear zone, relatively shallow workings.

Geology: Mineralization in Cretaceous-Tertiary granitic intrusive.

Production: Yes, small amount.

References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1282, p. 3382-3384; Stipp et al., 1967.

35. **Backbone Mine**

Location: 31°36'52"N, 111°20'28"W.

Commodities: Au, Ag (major products); Pb, Cu (minor products); Zn (potential).

Ore Materials: Auriferous-argentiferous galena (major); sphalerite and chalcopryite (minor).

Deposit Description:

Small, near surface enrichment, irregular lenses in a vein/shear zone, shaft workings.

Geology: Mineralization in Cretaceous-Tertiary granitics.

Production: yes, 1930's and 1940's 140 tons of ore produced.

References: U.S.G.S., 1979, CRIB Mineral Resources file 12, Record 1283, p. 3385-3387; Keith, 1974.

36. **Mammoth Group**

Location: 31°36'32"N, 111°21'33"W

Sec. 7, T21S, R10E.

Commodities: Ag, Au.

Ore Materials: Unknown.

Deposit Description:

Small, vein, surface workings.

Geology: Mineralization in Jurassic granite.

Production: Yes, small amount.

References: U.S.G.S., 1981, CRIB Mineral Resources file 12, Record 1290, p. 3405-3407; Stipp et al., 1967.

37. **Elzo #4 Mine**

Location: 31°36'58"N, 111°20'30"W
Sec. 8, T21S, R10E.

Commodities: Au (major product); Ag (minor product); Pb (occurrence).

Ore Materials: Unknown.

Deposit Description:

Small, vein, surface workings.

Geology: Mineralization in Jurassic granite.

Production: Yes, small amount.

References: U.S.G.S., 1981, CRIB Mineral Resources file 12, Record 1291, p. 3408-3410.

38. **Golden Star Mine**

Location: 31°35'N, 111°20'W
Sec. 9, T21S, R10E.

Commodities: Au, Ag (major products); Cu (minor product).

Ore Materials: Unknown.

Deposit Description:

Small, vein, surface workings.

Geology: Mineralization in Jurassic (?) granite.

Production: Yes, small amount.

References: U.S.G.S., 1981, CRIB Mineral Resources file 12, Record 1292, p. 3411-3413.

39. **Jean E. Group**

Synonym Name: Black Bear Nos. 1 and 2.

Location: 32°01'44"N, 111°35'50"W
Sec. 13, T16S, R7E.

Commodities: Mn (major product); Cu, Zn, Fe (occurrences).

Ore Materials: Manganese oxides; wad manganese.

Deposit Description:

Small, N50-60°W trending, steeply northeast dipping, numerous fractures in zone contain narrow, discontinuous, high-grade veinlets of hard manganese oxides with occasional replacements of softer wad manganese in shattered areas between fractures, surface and underground workings.

Geology: Mineralization in Mesozoic rhyolite porphyry.

Production: Yes, 100 tons of ore, 1954-1955.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1515, p. 3909-3912; Keith, 1974.

40. **Black Hawk Group (nos. 1, 2 and 3)**

Synonym Names: Black Eagle nos. 1 and 2; Blue Devil nos. 1 and 2.

Location: 32°01'48"N, 111°36'11"W
Sec. 14, T16S, R7E.

Commodity: Mn.

Ore Materials: Manganese oxides; soft wad manganese.

Deposit Description:

Small, N50-60°W trending, vertical to steep NE dipping, irregular veinlets in fracture zone. There

are two parallel fracture zones 300 feet apart containing discontinuous, narrow stringers of hard manganese oxides in most fracture planes, which show gradual replacement outward from the walls and incomplete replacement of softer wad manganese in shattered areas between fractures. Surface workings.

Geology: Mineralization in Mesozoic rhyolite porphyry, fracture zone probably extends to east where it is covered by alluvium.
Production: 46 tons of sorted 20% Mn ore shipped in 1955.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 3913, p. 3913-3915; Stipp et al., 1967; Keith, 1974.

41. **Jaeger Group Mine**

Synonym Name: $31^{\circ}59'05''\text{N}$, $111^{\circ}48'47''\text{W}$
NE 1/4 Sec 1, T17S, R5E.
Commodities: Au (major product); Ag (minor product); Cu.
Ore Materials: Gold in quartz-carbonate veins, minor pyrite, chalcopyrite.
Deposit Description: Small, eastward trending, vertical dip, several narrow quartz veins form the lode, underground workings.
Geology: Mineralization in Jurassic diorite associated with Jurassic diorite to basic dikes.
Production: Yes, 2800 tons of ore from 1930-1943.
References: U.S.G.S., 1981, CRIB Mineral Resources file 12, Record 1521, p. 3926-3928; Stipp et al., 1967; Keith, 1974.

42. **Lone Eagle Mine**

Location: $31^{\circ}58'06''\text{N}$, $111^{\circ}41'45''\text{W}$
Sec. 1, T17S, R6E.
Commodity: W.
Ore Materials: Unknown.
Deposit Description: Small, $\text{N}10^{\circ}\text{E}$ trending, 60°E dipping, ore is in gouge in bedding plane fault, in a shear zone, surface workings.
Geology: Mineralization in Mesozoic quartzite. There is granular gougy material between the hanging wall of quartzite and metamorphosed limestone on footwall.
Production: Yes, small amount.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1522, p. 3929-3931.

44. **Southside Mine**

Location: $31^{\circ}56'42''\text{N}$, $111^{\circ}41'17''\text{W}$
Sec. 13, T17S, R6E.
Commodity: W.
Ore Materials: Scheelite.
Deposit Description: Small, $\text{N}65^{\circ}\text{E}$ trending, 55°SE dipping,

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located in a shear zone, surface workings.
Geology: Mineralization in Mesozoic quartzite, quartzite strikes N80°W and dips 70°N.
Production: Yes, small amount.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1524, p. 3935-3937.

45. Calvert Prospects

Synonym Name: Nelson's Pride Mine.
Location: 31°57'04"N, 111°41'25"W.
Commodity: W.
Ore Materials: Scheelite.
Deposit Description: Small, 57°E trending, 80°N dipping, located in a shear zone, surface and underground workings consisting of pits, one shaft and one diamond-drilled hole.
Geology: Mineralization in Mesozoic quartzite, epidote and manganese occur on fracture planes, rock is dense and compact leaving little room for tungsten mineralization.
Production: Yes, small amount.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1525, p. 3938-3940; Stipp et al., 1967.

48. Independence Group

Synonym Name: Independence no.1 and 2; New Dragon no. 4.
Location: 31°56'N, 111°41'11"W
Sec. 24, T17S, R6E.
Commodities: W (main product); Au, Ag, Cu (occurrences).
Ore Materials: Scheelite, chrysocolla, malachite and limonite.
Deposit Description: Small, N10°W trending, 70°E dipping, narrow deposit in shear zone, surface and underground workings.
Geology: Rock is altered and friable and contains coatings of copper oxides.
Production: Yes, small amount.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1528, p. 3946-3948.

49. Rushbeg Prospect

Synonym Name: Birthday Claim.
Location: 31°56'12"N, 111°40'49"W
Sec. 19, T17S, R7E.
Commodity: W.
Ore Materials: Scheelite.
Deposit Description: Small, N20°W trending, 30°W dipping, surface workings.
Geology: Mineralization in Mesozoic quartzite, scheelite-bearing band of hydrothermally altered material, band is overlain by massive quartzite and overlain by sheared and shattered quartzite.
Production: Yes, small amount.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12,
Record 1529, p. 3949-3951.

50. **Yellow Star Mine**

Synonym Name: Yellow Dragon no. 1 and 2; New Dragon nos. 1 and 2
Claims.

Location: $31^{\circ}55'47''\text{N}$, $111^{\circ}41'01''\text{W}$.
Sec. 19, T17S, R7E,
Sec. 24, T17S, R6E.

Commodity: W.

Ore Materials: Scheelite.

Deposit Description:

Small, SE trending, dip varies, one ore body became flat lying at the 60 foot depth; on opposite side of the ridge from this main ore body, another zone of mineralization was mined which consisted of nearly vertical southeast trending shears containing numerous narrow stringers in a mineralized fault, surface and underground workings.

Geology: Mineralization in Cretaceous quartzite.

Production: Yes, 700 tons of tungsten ore.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12,
Record 1530, p. 3952-3954; Keith, 1974.

51. **Jezebel Mine**

Location: $31^{\circ}55'35''\text{N}$, $111^{\circ}40'32''\text{W}$
Sec. 19, T17S, R7E.

Commodity: W.

Ore Materials: Unknown.

Deposit Description:

Small, 10 to 15°SE dip, lens form in a shear zone, the greatest concentration of scheelite was in the bottom 12 to 18 inches of mineralized zone, where alteration has been greatest and the siliceous material is vuggy and granular.

Geology: Mineralization in Cretaceous quartzite.

Production: Yes, about 600 tons of tungsten ore produced in mid-1950's.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12,
Record 1531, p. 3955-3957; Keith, 1974.

52. **Sparks Mine**

Synonym Name: Juanita no. 9.

Location: $31^{\circ}54'47''\text{N}$, $111^{\circ}40'14''\text{W}$
Sec. 29, 30, 31, T17S, R7E.

Commodity: W.

Ore Materials: Scheelite.

Deposit Description:

Small, $\text{S}20^{\circ}\text{W}$ trending, 70°SE dipping, lens shaped in a shear zone, there is scheelite mineralization in fracture zone, surface and underground workings.

Geology: Mineralization in Cretaceous hornfels.

Production: Yes.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12,

Record 1532, p. 3958-3960; Keith, 1974.

54. **Brown Prospect**

Synonym Name: Big Juanita Group:
Location: 31°54'52"N, 111°40'01"W
Sec. 29, 30, T17S, R7E.
Commodity: W.
Ore Materials: Scheelite.
Deposit Description: Small, NW dipping, deposit in a shear zone, surface workings.
Geology: Mineralization in Cretaceous quartzite cut by aplite dikes.
Production: Yes, 50 pounds of 62% tungsten.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1534, p. 3963-3965; Stipp et al., 1967; Keith, 1974.

55. **Last Chance Mine**

Location: 31°54'57"N, 111°40'33"W
Sec. 30, T17S, R7E.
Commodity: W.
Ore Materials: Scheelite.
Deposit Description: Small, east-west trending, vertical to east dipping, surface and underground workings.
Geology: Mineralization in Cretaceous quartzite, ore in metamorphosed band appears originally to have been limestone interbedded with sandstone layers.
Production: Yes, small amount.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1535, p. 3966-3968.

56. **San Juan Mine**

Location: 31°55'06"N, 111°40'13"W
Sec. 30, T17S, R7E.
Commodity: W.
Ore Materials: Scheelite.
Deposit Description: Small, NE trending, 45°SE dipping, lens/discontinuous band shape in a shear zone, surface and underground workings.
Geology: Mineralization in Cretaceous quartzite, mineralization mostly confined to one band.
Production: Yes, 8000 pounds of tungsten concentrate produced in 1954 and 1957.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1536, p. 3969-3971; Keith, 1974.

57. **Big Banana Mine**

Synonym Name: Big Banana nos. 1, 2, 3 Claims; Maud E. Claim.
Location: 31°54'31"N, 111°39'21"W
Sec. 32, T17S, R7E.
Commodities: W (major); Cu, Mo, F (occurrence).
Ore Materials: Molybdenum-bearing scheelite.

Deposit Description:

Small, N10-20°W trending, eastern dip, surface and underground workings.

Geology: Mineralization in Cretaceous quartzite associated with Cretaceous-Tertiary(?) metamorphosed rhyolite, tensional shears in major northwest striking fault zone.

Production: Yes, 20,000 pounds of tungsten concentrates produced.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1537, p. 3972-3974.

58. **Black Dragon Group**

Location: 31°51'23"N, 111°35'58"W
Sec. 15, 22, T18S, R7E.

Commodity: Mn.

Ore Materials: Manganese oxides, pyrolusite.

Deposit Description: Small, north-south trending, irregular fracture fillings in a vein/shear zone, discontinuous manganese minerals are present in fracture zone, surface workings.

Geology: Mineralization in Mesozoic rhyolite associated with Tertiary rhyolite.

Production: Yes, 65 long tons of sorted Mn ore and 19 tons of Mn concentrate.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1555, p. 4015-4018; Keith, 1974.

59. **Allison Mine**

Synonym Name: Chance; El Oro; Old Gold.

Location: 31°49'01"N, 111°37'58"W.

Commodities: Au (major product); Ag, quartz, Cu, Pb (minor products); Mn (occurrence).

Ore Materials: Native gold, argentite (main); silver-gold chlorides (minor).

Deposit Description: Small, eastward trending, 50°SW dipping, located in a vein/shear zone, underground workings.

Geology: Mineralization in Miocene conglomerate associated with Tertiary andesites and rhyolites. Portions of vein containing abundant manganese and iron oxides have the richest ore.

Production: Yes, total recorded production 47,000 tons of ore, averaging 0.22 oz. Au/T, 2.7 oz. Ag/T, minor Cu, Pb. Worked for silica in early 1960's (flux).

References: U.S.G.S., 1981, CRIB Mineral Resources file 12, Record 1556, p. 4018-4021; Stipp et al., 1967; Keith, 1974; Fair, 1965.

60. **Giant Claims**

Synonym Names: Giant nos. 3-10; Grand Mountain Claim.

Location: 31°39'36"N, 111°40'28"W
Sec. 24, 25, T20S, R6E,
Sec. 19, 30, T20S, R7E.

 
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Commodities: Mo, W (minor products); Cu, Ag (occurrence).

Ore Materials: Molybdenum-bearing scheelite.

Deposit Description:

Small, northerly trending, east to west dipping, irregular shape in a lens, surface workings.

Geology: Mineralization in Cretaceous quartzite associated with aplite dikes, scheelite is in discontinuous lenses in quartzite beds that have probably been faulted with considerable horizontal displacement of various segments.

Production: Yes, 20 tons of low-grade copper-silver ore, 50 tons of tungsten ore produced in 1957.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1613, p. 4205-4207; Keith, 1974.

61. Gold Bullion Mine

Synonym Name: Banes 1 and Banes 2 Claims; Last Chance; Tellurium Claim Group.

Location: 31°43'24"N, 111°35'47"W
Sec. 2, T20S, R7E
Sec. 35, T19S, R7E.

Commodities: Au, Mo (major products); Ag, Cu, Pb (minor products); Zn (occurrence).

Ore Materials: Auriferous pyrite (major); chalcopyrite, galena, sphalerite, and molybdenite (minor).

Deposit Description:

Small, N70°W trending, 70-40°N dipping, deposit is quartz veins ranging in size and trend, the deposit pinches and swells in a vein/shear zone, underground workings.

Geology: Mineralization in Cretaceous sediments, cut by aplite granite.

Production: Yes, 3100 tons produced.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1614, p. 4208-4211; Stipp et al., 1967; Arizona Bureau of Mines, 1969; Keith, 1974.

63. Baboquivari Mine

Synonym Name: Black Diamond; Red and Black Chief.

Location: 31°42'27"N, 111°36'06"W
Sec. 11, T20S, R7E.

Commodities: Mn (major product); Fe, Cu, Ag, Au (occurrence).

Ore Materials: Pyrolusite, psilomelane, some rhodonite.

Deposit Description:

Small, east-west trending, north to vertical dipping, irregular and discontinuous veinlets from a fraction of an inch to a foot or more wide in sporadic areas 1,500 feet or more along strike of fracture zone.

Geology: Mineralization in shattered andesite dike cutting Cretaceous sediments.

Production: Yes, small amount.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1616, p. 4215-4217; Stipp et al., 1967; Keith, 1974.

65. Black Gold Mine

Location: 31°41'42"N, 111°23'W
NW 1/4 Sec. 13, T20S, R9E.
Commodities: W (minor product); Au, Ag, Pb, Zn, Cu (occurrence).
Ore Materials: Wolframite, scheelite, pyrite, galena, sphalerite, chalcopryrite.
Deposit Description: Small, narrow, lensing, branching in a vein, underground workings.
Geology: Mineralization in Cretaceous andesite.
Production: Yes, late 1930's 10,000 pounds of picked tungsten concentrates produced.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1618, p. 4220-4222; Stipp et al., 1967; Keith, 1974.

104. La Guijas Gold Placers

Location: Sec. 25, T20S, R9E,
Sec. 30, 31, 32, T20S, R10E.
Commodities: Au (major); Ag, Hg (minor).
Deposit Description: Placer deposit, fine gold with few nuggets.
Geology: In gravels on pediment slopes, old terraces or "mesas", and in various gulches and washes along Las Guijas Wash at or near true or false bedrock. Often admixed with clay.
Production: 1,000 oz. Au, some Ag.
References: Keith, 1974; Johnson, 1972.

105. Silver Giant Mine

Location: NE 1/4 Sec. 10, T16S, R5E.
Commodities: Ag (major); Cu (minor).
Deposit Description: Quartz vein along fracture zone.
Geology: Quartz vein cuts Cretaceous-Tertiary quartz monzonite.
Production: Few tons of ore averaging 19 oz. Ag/T.
References: Keith, 1974.

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

10. Roadside Mine

Location: 32°02'43"N, 111°30'33"W,
W cen. Sec. 11, T16S, R8E.
Commodities: Cu, Ag (main commodities); Au, Hg (minor commodities).
Ore Materials: Native copper, copper carbonates, copper oxides, sulfides, tetrahedrite, schwartzite, cinnabar and native mercury.
Deposit Description: Small, streaks in a disseminated/shear zone. Oxidation to 800 feet. Underground, shaft workings.
Geology: Mineralization in Mesozoic andesitic volcanics and

arenitic sediments associated with
aplitic-pegmatitic quartz monzonite. Along the
fault the zone is cut by cross-fracture zones.

Production: None.

References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1162, p. 3026-3028; Stipp et al., 1967;
Keith, 1974.

14. **El Conquistadors Claims**

Location: 31°58'26"N, 111°30'16"W
Sec. 2, T17S, R8E.

Commodity: U.

Ore Materials: Unknown.

Deposit Description:

Small, NE trending, 20°SE dipping, pegmatite
deposit, surface workings.

Geology: Mineralization in Cretaceous-Tertiary biotite
gneiss.

Production: None.

References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1175, p. 3065-3067.

24. **Lobos Group**

Location: 31°38'39"N, 111°40'18"W
Sec. 31, T20S, R7E.

Commodities: U (major commodity); Cu (minor commodity).

Ore Materials: Euxenite, secondary uranium minerals.

Deposit Description:

Small, vein/disseminated, surface workings.

Geology: Mineralization in Cretaceous-Tertiary quartzite
(schist) associated with Tertiary aplite-andesite
dikes (hornfels).

Production: None.

References: U.S.G.S., 1979, CRIB Mineral Resources file 12,
Record 1267, p. 3337-3339.

43. **Mego nos. 1 and 2 prospects**

Location: 31°58'50"N, 111°41'39"W
Sec. 11, T17S, R6E.

Commodity: W.

Ore Materials: Scheelite.

Deposit Description:

Small, surface workings.

Geology: Unknown.

Production: None.

References: U.S.G.S., 1972, CRIB Mineral Resources file 12,
Record 1523, p. 3932-3934.

46. **Calvert Prospects**

Synonym Name: Terry Marie nos. 1 and 2 Prospects.

Location: 31°57'N, 111°41'14"W
Sec. 13, T17S, R6E.

Commodity: W.

Ore Materials: Unknown.

Deposit Description:

Small, N70°W trending, located in a shear zone, surface workings.
Geology: Mineralization in Cretaceous quartzite associated with thin aplite dikes, formation is somewhat schistose, feldspathic quartzitic rock.
Production: None.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1526, p. 3941-3943.

47. **Cable and Gajewski Claim**

Location: 31°56'10"N, 111°41'12"W
Sec. 24, T17S, R6E.

Commodity: W.
Ore Materials: Unknown.
Deposit Description:

Small, N75°E trending, 75°SE dipping, located in a shear zone, surface workings.
Geology: Mineralization in Mesozoic metamorphic rock.
Production: None.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1527, p. 3944-3945; Stipp et al., 1967.

53. **Linda Claim**

Location: 31°54'50"N, 111°39'38"W
Sec. 29, T17S, R7E.

Commodity: W.
Ore Materials: Molybdenum bearing scheelite.
Deposit Description:

Small, deposit type unknown.
Geology: Unknown.
Production: None.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1533, p. 3961-3962.

62. **Circle Claims**

Location: 31°43'08"N, 111°35'37"W
Sec. 2, T20S, R7E.

Commodity: W.
Ore Materials: Wolframite, sparse scheelite, some pyrite.
Deposit Description:

Small, 10-20°W dipping, vein consists of a dull white quartz, surface workings.
Geology: Steep sides of Schaffer Canyon consist of a faulted complex of siliceous sedimentary beds and volcanic rocks, intruded by dikes of acidic to intermediate composition.
Production: None.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1615, p. 4212-4214.

64. **Utah Prospect**

Location: 31°39'29"N, 111°35'53"W
Sec. 26, T20S, R7E.

Commodity: Cu.
Ore Materials: Unknown.

Deposit Description:

Small, located in a tactite zone, surface and underground workings.
Geology: Mineralization in Mesozoic silicified limestone.
Production: None.
References: U.S.G.S., 1972, CRIB Mineral Resources file 12, Record 1617, p. 4218-4219.

66. **Unnamed Silica (industrial) Occurrence**

Location: Sec. 33, T18S, R7E.
Commodity: Si.
Production: Unknown.
References: McCrory and O'Haire, 1965; Stipp et al., 1967.

67. **Unnamed Mercury Occurrence**

Location: Sec. 17, T20S, R10E.
Commodity: Hg.
Production: Unknown.
References: Stipp et al., 1967.

68. **Unnamed Silver and Copper Occurrence**

Location: Sec. 13, T16S, R5E.
Commodity: Ag, Cu.
Production: Unknown.
References: Stipp et al., 1967.

69. **Unnamed Mineral Occurrence**

Location: Sec. 23, T16S, R5E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.

70. **Unnamed Silver and Gold Occurrence**

Location: Sec. 11, T21S, R9E.
Commodities: Ag, Au.
Production: Unknown.
References: Stipp et al., 1967.

71. **Unnamed Copper Occurrence**

Location: Sec. 14, T16S, R6E.
Commodity: Cu.
Production: Unknown.
References: Stipp et al., 1967.

72. **Unnamed Tungsten Occurrence**

Location: Sec. 13, T16S, R6E.
Commodity: W.
Production: Unknown.
References: Stipp et al., 1967.

73. **Unnamed Tungsten and Copper Occurrence**

Location: Sec. 36, T20S, R9E.
Commodities: W, Cu.
Production: Unknown.
References: Stipp et al., 1967.

74. **Unnamed Mineral Occurrence**
Location: Sec. 35, T20S, R9E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
75. **Unnamed Gold, Copper and Silver Occurrence**
Location: Sec. 14, T16S, R8E.
Commodities: Au, Cu, Ag.
Production: Unknown.
References: Stipp et al., 1967.
76. **Unnamed Manganese Occurrence**
Location: Sec. 13, T16S, R8E.
Commodity: Mn.
Production: Unknown.
References: Stipp et al., 1967.
77. **Unnamed Mineral Occurrence**
Location: Sec. 26, T20S, R9E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
78. **Unnamed Molybdenum Occurrence**
Location: Sec. 32, T16S, R8E.
Commodity: Mo.
Production: Unknown.
References: Stipp et al., 1967.
79. **Unnamed Lead Occurrence**
Location: Sec. 35, T16S, R5E.
Commodity: Pb.
Production: Unknown.
References: Stipp et al., 1967.
80. **Unnamed Mineral Occurrence**
Location: Sec. 12, T20S, R9E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
81. **Unnamed Tungsten Occurrence**
Location: Sec. 23, T20S, R6E.
Commodity: W.
Production: Unknown.
References: Stipp et al., 1967.
82. **Unnamed Tungsten Occurrence**
Location: Sec. 33, T20S, R7E.
Commodity: W.
Production: Unknown.
References: Stipp et al., 1967.

83. **Unnamed Uranium Occurrence**
Location: Sec. 21, T20S, R7E.
Commodity: U.
Production: Unknown.
References: Stipp et al., 1967.
84. **Unnamed Tungsten Occurrence**
Location: Sec. 26, T17S, R6E.
Commodity: W.
Production: Unknown.
References: Stipp et al., 1967.
85. **Unnamed Mineral Occurrence**
Location: Sec. 7, T20S, R8E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
86. **Unnamed Fluorite Occurrence**
Location: Sec. 5, T17S, R10E.
Commodity: F.
Production: Unknown.
References: Stipp et al., 1967.
87. **Unnamed Mineral Occurrence**
Location: Sec. 9, T18S, R7E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
88. **Unnamed Manganese Occurrence**
Location: Sec. 21, T18S, R7E.
Commodity: Mn.
Production: Unknown.
References: Stipp et al., 1967.
89. **Unnamed Mineral Occurrence**
Location: Sec. 34, T20S, R7E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
90. **Unnamed Mineral Occurrence**
Location: Sec. 29, T20S, R7E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
91. **Windy Claims**
Location: Sec. 24, T18S, R7E.
Commodity: Be.
Ore Materials: Beryl.
Deposit Description: Vein.
Geology: Beryl in 3 foot thick quartz veins cutting granite.

THE
HISTORY
OF
THE
CITY
OF
NEW
YORK
FROM
1624
TO
1898
BY
JOHN
B. HOGAN
AND
JOHN
W. HOGAN
NEW
YORK
1898

Production: Unknown.
References: Stipp et al., 1967; Arizona Bureau of Mines, 1969.

92. **Contreras Canyon**

Location: Sec. 30, T18S, R8E.
Commodity: Be.
Ore Materials: Beryl.
Deposit Description: Vein.
Geology: Beryl in quartz vein intrusive into granite.
Production: Unknown.
References: Stipp et al., 1967; Arizona Bureau of Mines, 1969.

93. **Unnamed Gold Occurrence**

Location: Sec. 31, T19S, R9E.
Commodity: Au.
Production: Unknown.
References: Stipp et al., 1967.

94. **Unnamed Tungsten Occurrence**

Location: Sec. 23, T19S, R8E.
Commodity: W.
Production: Unknown.
References: Stipp et al., 1967.

95. **Unnamed Mineral Occurrence**

Location: Sec. 31, 32, T19S, R8E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.

96. **Unnamed Mineral Occurrence**

Location: Sec. 28, T20S, R7E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.

97. **Unnamed Mineral Occurrence**

Location: Sec. 23, T20S, R7E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.

98. **Unnamed Silver and Gold Occurrence**

Location: Sec. 12, T19S, R7E.
Commodities: Ag, Au.
Production: Unknown.
References: Stipp et al., 1967.

99. **Unnamed Mineral Occurrence**

Location: Sec. 16, T20S, R7E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.

100. **Unnamed Tungsten Occurrence**
Location: Sec. 1, T20S, R7E.
Commodity: W.
Production: Unknown.
References: Stipp et al., 1967.
101. **Unnamed Mineral Occurrence**
Location: Sec. 13, T20S, R7E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
102. **Unnamed Manganese Occurrence**
Location: Sec. 3, T20S, R7E.
Commodity: Mn.
Production: Unknown.
References: Stipp et al., 1967.
103. **Unnamed Mineral Occurrence**
Location: Sec. 17, T20S, R7E.
Commodity: Unknown.
Production: Unknown.
References: Stipp et al., 1967.
106. **Unnamed Bismuth Occurrence**
Location: Sec. 2, T20S, R8E, location approximate.
Commodity: Bi.
Deposit Description: Unknown.
Geology: Unknown.
Production: Unknown.
References: Arizona Bureau of Mines, 1969.
107. **Gismo Group**
Location: Sec. 5, T21S, R10E.
Commodities: U (major commodity); Cu, Fe (minor commodities).
Ore Materials: Uraninite, kasolite, schroekingerite.
Deposit Description: Fault-fissure vein.
Geology: In granite.
Production: Unknown.
References: Peirce et al., 1970.

Mining Claims, Leases, and Material Sites

There are numerous mining claims within the Kitt Peak GRA. According to the BLM records (as of June, 1982), in the Coyote Mountains WSA and surrounding area, the highest density of claims is in the northern part of the WSA. North of the WSA are 31 patented claims. There is one patented claim within the Baboquivari Peak South WSA (commodities unknown), and one

adjacent to the southern end of the WSA. There are two patented claims west of this WSA, also. The claim density, i.e., the number of claims per square mile (section), is shown in figure 6 and more detailed records are included in table 2.

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

Within the Kitt Peak GRA there are two silica sites which lie to the east of the Baboquivari Peak South WSA (59 and 66). To the authors' knowledge there are no other materials sites within the GRA that are near or within the two WSAs.

Mineral Deposit Types

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

- Paleozoic and Mesozoic sediments and metamorphosed equivalents,
- Mesozoic plutonic rocks,
- Mesozoic volcanic rocks,
- Laramide intrusive rocks,
- Mid-Tertiary metamorphic rocks,
- Mid-Tertiary volcanic rocks,
- Mid-Tertiary sediments,
- Late Tertiary sediments, and
- Recent alluvium.

Geologic environments and associated mineral deposit types are shown in table 3.

Paleozoic and Mesozoic Sediments

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

 

Figure 6 CLAIM DENSITY MAP, WITH OIL AND GAS LEASING STATUS, OF THE KITT PEAK AREA, ARIZONA.

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

TABLE 2

CLAIM DENSITY RECORDS IN THE WILDERNESS STUDY AREAS (WSA), KITT PEAK GRA
 ACCORDING TO BLM (JUNE 1982), ARIZONA STATE OFFICE

Township	Range	Section	Claims For Each Section	Claimants	Latest Assmt. Date	Remarks
WSA 020-202 Coyote Mountains						
16S	8E	22	SE 1	Yanez, James	1981	1ode
		23	SW 3	"	"	"
		26	W2 2	"	"	"
			NW 9	"	"	"
			SW 8	"	"	"
		27	E2 1	"	"	"
			NE 6	"	"	"
			SE 4	"	"	"
		34	NE 1	"	"	"
		35	NW 2	"	"	"

Table 3. GEOLOGICAL ENVIROMENTS OF THE KITT PEAK AREA AND ASSOCIATED MINERAL DEPOSIT TYPES

<div>MINERAL DEPOSIT TYPE</div> <div>GEOLOGICAL ENVIROMENT - HOST ROCKS</div>	S-Type Granite Tungsten Deposits	Pegmatite Deposits (Beryl)	Hydrothermal Deposits (including replacement deposits)	Uranium Deposits (all types)	"Red-Bed" Type Deposits	Hydrocarbon Deposits	Placer Deposits
Tertiary and Quaternary Alluvium							X
Late Tertiary Basin-Fill Sediments				X			
Mid-Tertiary Volcanic Deposits			X				
Mid-Tertiary Basin-Fill Sediments				X			
Metamorphic Core Complex			X	X			
Laramide Intrusives	X	X	X	X			
Mesozoic Volcanics			X				
Mesozoic Intrusives			X				
Paleozoic and Mesozoic Sediments					X	X

FIG.7 LOCATION OF OIL AND GAS EXPLORATION HOLES IN SOUTHERN ARIZONA, after Jones (1979).

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 fig. 7). In the Kitt Peak GRA one dry well has been drilled in the southeastern part of the GRA (see fig. 7). The Phillips Petroleum Project and exploration geologists for southeastern Arizona feel there is little to no oil potential in the Kitt Peak GRA (J.N. Anderson and others, pers. comm., 1982), they have found that the crystalline rocks extend to great depth.

Mesozoic red beds within the GRA are potentially favorable for the occurrence of red-bed-type copper-silver deposits such as are present in Permian and Triassic rocks in central and northern New Mexico (LaPoint, 1979, 1974a, 1974b). No occurrences of this type are known, but red-beds are present in the central region near and in the Baboquivari Peak South WSA, and metamorphosed redbeds are present south of the WSA.

The Paleozoic and Mesozoic sedimentary rocks may act as host rocks for tungsten, copper, silver, gold, lead and zinc in metamorphic or hydrothermal ore deposits in which the fluids and metals were derived during dehydration reactions accompanying prograde metamorphism as described by Hutchinson and others (1980). Numerous tungsten and polymetallic deposits are hosted in Mesozoic sediments near and related to Laramide plutonism.

Mesozoic Plutonic Rocks

During the mid-Jurassic, a magmatic arc extended across the Kitt Peak GRA (Dickinson, 1981; see fig. 2A). Porphyry copper mineralization is associated with Jurassic igneous rocks at Bisbee east of the GRA; and according to Titley (1982), the Jurassic represents a metallogenic epoch in the southwest warranting exploration. However, there is no known porphyry mineralization within the area. Jurassic granitic plutons and Mesozoic

 

diorites are responsible for at least five gold or gold-silver hydrothermal deposits within the GRA (5, 13, 36, 37 and 41). These deposits are primarily gold-silver deposits, but in two copper is also present (13 and 41), and in one (37) lead is present.

Mesozoic Volcanic Rocks

Mesozoic volcanic rocks in southern Arizona are associated with gold-silver and base metal lode deposits, these are hosted primarily in Cretaceous intermediate and silicic volcanics within the GRA (26, 288, 29, 39, 63 and 65). The polymetallic deposits may be hydrothermal deposits related to the Cretaceous volcanism, or they may be hosted in the volcanics but deposited during the Laramide plutonic activity. There are two manganese deposits (40, northwest of the Coyote Mountains WSA, and 58, northwest of the Baboquivari Peak South WSA) hosted in the volcanics. 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. A small amount of manganese ore has been produced from these two deposits.

Laramide Intrusive Rocks

The Laramide was a time of emplacement of all but one (Bisbee) of the porphyry 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 the Yavapai Series and gneissic-metavolcanic terrain (see fig. 2). The intrusives associated with the porphyry copper deposits were emplaced during the westward sweep of the magmatic arc (Clark et al., 1982; Damon et al., 1981) and possibly related to the decrease in the dip of the Benioff zone at this time (Coney and Reynolds, 1980). The

porphyry copper deposits appear to be aligned along northwest and east-northeast trends (see fig. 2; 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 thrust 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 features (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, 1981). None of the major northwest or east-northeast trends of porphyry copper deposits pass through the GRA, but porphyry copper deposits do ring the northern margin of the GRA (Wright and Haxel, 1982; Haxel et al., 1980). The Laramide rocks are host to or genetically related to numerous gold-silver, base metal and tungsten deposits of metamorphic or hydrothermal origin, but porphyry deposits within the GRA are not known.

The reason for the apparent lack of porphyry copper deposits within the GRA are not known, but could be the result of one or more of the following factors:

1. There are no Precambrian rocks within the GRA; whereas all of the porphyry copper deposits of the southwest contain Precambrian basement.
2. Most of the Laramide intrusives in this area are peraluminous and probably S-type granites. These are generally not associated with porphyry copper-molybdenum-gold deposits but rather with tin-tungsten deposits (Burnham, 1981).
3. Erosion during post-Laramide time may have progressed to deep levels removing the shallower portions of intrusives. The

presence of muscovite in several of the intrusives suggests that the level of exposure is indeed deep. The presence of tungsten mineralization also supports a relatively deep level of exposure because, as shown by Newberry and Einaudi (1981), tungsten skarns typically form at deep levels.

In light of the above discussion, it is considered that the GRA overall has a low favorability for the occurrence of porphyry copper deposits.

Silver-gold and base metal deposits are commonly hosted in Cretaceous sediments or volcanics, as are numerous tungsten deposits, and appear to be of either metamorphic or hydrothermal origin, formed during devolatilization of the pluton during cooling, or dewatering of the country rock during metamorphism. The majority of these deposits occur south of the Baboquivari Peak South WSA and southwest of the Coyote Mountains WSA.

Two beryl occurrences (91 and 92) are present north of the Baboquivari Peak South WSA, in a northwesterly trending belt of Laramide pegmatites. These beryl-bearing pegmatites may extend southward into the WSA.

The Laramide S-type granites may also be a source rock for uranium. There is one uranium occurrence (107) in a vein deposit within Laramide granite; another uranium occurrence (14) just southeast of the Coyote Mountains WSA may be related to Laramide pegmatites. Three uranium occurrences (22, 24, and 83) are hosted by Cretaceous sediments or schists; two of these are associated with Laramide granite, the third (83) is probably associated with Laramide granite.

Mid-Tertiary Metamorphic Rocks

The potential for mineral deposits associated with metamorphic core complexes is not well known as it is only during the last decade or so that the complexes themselves have been widely recognized. In an important work,

Coney and Reynolds (1980) and several co-workers 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), 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 uranium deposit of Graeber Lease 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 of metamorphic core complexes in the Rawhide Mountains in southwestern Arizona 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, and 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.

If the rocks of the Coyote Mountains do represent part of a metamorphic core complex, then there is potential for uranium, copper and gold mineralization in the area around the Ajo Road Fault.

Mid-Tertiary Volcanics

In southern Arizona, southwestern New Mexico and Mexico, mid-Tertiary volcanics are very common, and contain 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 positively identified in southern Arizona, but the voluminous ignimbrites and existing numerous deposits suggest that such cauldrons could be present.

The mid-Tertiary volcanic rocks within the GRA crop out along the western side of the Baboquivari and Quinlan Mountains and in the eastern and northeastern parts of the GRA. They range in composition from andesite to rhyolite, and include intrusives, flows and a variety of tuffs.

There is only one deposit which can be directly related to the Tertiary volcanics (59). It represents a late stage hydrothermal vein deposit containing gold, silver, copper, lead and manganese mineralization, and crops out east of the Baboquivari Peak South WSA.

Mid-Tertiary Sediments

Mid-Tertiary valley-fill sediments are widespread in southern Arizona, and since the discovery of the Anderson Mine (Sherborne et al., 1979) have become a prime target for uranium exploration.

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. Potentially suitable source rocks

within the GRA are the S-type Laramide granites and pegmatites, the Mesozoic and Tertiary volcanics and the chloritic breccias and detachment zone near the Ajo Road Fault. Suitable reductants may be present in conglomerates or fossil geothermal systems. There are no known active geothermal systems near either WSA.

Late Tertiary 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 figure 3 and interpreted from gravity data by Oppenheimer and Sumner (1981). As in the case of the mid-Tertiary sediments, adequate source rocks are widespread, and permeable horizons are present. It is not known if extensive organic reductants are present within these sediments. Reducing geothermal waters are not prevalent in the area. There are no uranium occurrences to the authors' knowledge in the late Tertiary sediments.

Recent Alluvium

Alluvium formed in present day river valleys and pediments is a possible site for concentrations of placer gold and other heavy minerals.

Within the GRA, there are four placer deposits. A tungsten placer deposit (25) and a gold, silver and mercury placer deposit (104) are present in the southeastern corner of the GRA. Two gold placer deposits are also present, one is present south of the Baboquivari Peak South WSA (18); the other (12) is present near the western border of the GRA, west of the Coyote Mountains WSA. The two placers in the southeastern corner of the GRA, in the Las Guijas Mountains, produced the most. 1,000 ounces of gold and some silver was mined at site 104 (Las Guijas Gold Placers), and a few tons of wolframite concentrate has been produced from site 25 (Las Guijas Tungsten Placers).

Active Geothermal Systems

To the authors' knowledge, there are no geothermal wells or springs within the GRA. There is a low temperature geothermal field to the east of the GRA that crosses into the GRA in the vicinity of the Black Hills.

Mineral Economics

The assessment of the geological, energy and mineral resources favorability should rely upon not only geology, but must also be concerned with economic factors and priorities. Discovery, recovery, cost of production of the resource from sources with varying qualities and/or concentrations are included in those considerations. Special consideration must be given to the strategic and critical minerals and metals. As this project is of limited scope, and because of special difficulties in southwestern Arizona, economic analyses of various commodities can only be discussed briefly.

Some factors especially important to the evaluation of the mineral and energy resources of southwestern Arizona include the following:

1. The geology of the Kitt Peak GRA is very complex and detailed information on the geology and mineral deposits of the WSAs is, in part, limited. This is multiplied by recent and ongoing reinterpretations of the geology of the Basin and Range in Arizona. In order to interpret the geology of the WSAs, and thus be able to project the types of mineral deposits that may be present in those areas, it is necessary to apply information about known areas of apparently similar geology to the interpretation of the geology of the WSAs. A wide variety of possibilities must be considered and, therefore, discussions of mineral economics must be considered

tentative.

2. Contributing to the problems listed above, and creating some other distinct difficulties, are the ruggedness and roadless nature of the WSAs. Roadlessness, a criterion for WSAs, inhibits exploration and development of mineral resources due to poor access, distance to market, and other factors which increase the expense and difficulty of geological and mineral exploration.
3. A great number of commodities, including strategic and critical minerals and metals, are known to occur in the WSAs and their surrounding areas.
4. Considering all the above mentioned problems, it is very possible that sophisticated methods currently used by professional geologic explorationists have not been fully employed in southwestern Arizona. Most of the mines and occurrences in the GRA were discovered many years ago by prospectors using simple techniques.

Gold and molybdenum are the only non-strategic metals found in the two WSAs. The future demand for both these commodities is quite dependent on worldwide economic conditions. If the economy rebounds, molybdenum should make a comeback. Gold, however, will increase in value if economic conditions decline.

There has been much recent speculation about the potential for oil and gas occurrences in the Basin and Range of southern Arizona. It has been suggested that the Overthrust Belt, related to oil occurrences from Canada to Utah, extends into Arizona as a wide NW-SE trending belt curling around the Colorado Plateau in the Basin and Range area (Peirce, 1982; Anschutz, 1980). The theory states that around 60 m.y.B.P. older crystalline rocks thrust over

younger, possibly oil-rich, strata (Peirce, 1982). The complex structures, including Basin and Range faults, found in southern Arizona coupled with the high temperatures created by igneous activity since that time dim the possibility of preservation of oil and gas. Peirce (1982) states if the Overthrust Belt exists, or ever has existed, in Arizona, geologic complexity obscures it and drilling has not yet resolved the issue. Anschutz (1980) suggests that the Overthrust Belt could become the most important oil and gas province to be discovered in the last 20 to 30 years, but also states that it is one of the most difficult and expensive areas to explore and develop. Phillips Petroleum Co. geologists in charge of oil exploration for this part of southern Arizona now feel chances for oil and gas discoveries are minimal (J.N. Anderson and others, pers. comm.).

Strategic and Critical Minerals and Metals

The strategic metal silver occurs in both WSAs. Zinc, lead and copper also occur in the Coyote Mountain WSA. Beryllium and tungsten could also occur in the WSAs.

Zinc has a variety of industrial applications, the most important being zinc-base alloy die castings, galvanizing iron and steel products, and brass production. Much of the lead used in the United States is consumed in the manufacture of storage batteries and as a gasoline additive, although use in gasoline is not as important as it once was. Use in ammunition and solder is also important, increasingly so during wartime. More silver is consumed in photography in the United States in one year than this country produces during that time (Brobst and Pratt, 1973). Tungsten, which in addition to use in steel and chemicals, also enjoys use in non-ferrous alloys and as tungsten carbide. Copper, although considered a strategic and critical metal, occurs in abundance in Arizona.

In summary, it must be noted that the Kitt Peak GRA contains a large number of mineral occurrences and many different commodities. Deposits of strategic and critical commodities, some of which have produced, are known to occur in the WSAs and surrounding parts of the GRA. Further exploration could lead to the discovery of potentially important deposits in the GRA and WSAs.

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

In this section the individual WSAs are discussed with respect to physiography, geology, mineral occurrences, resources potential and recommendations for further work. 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) and given below. Classification of resources within and surrounding the WSAs of the Kitt Peak GRA is summarized in figures 8 through 10.

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

FIG. 8 FAVORABILITY AND LEVEL OF CONFIDENCE MAP FOR METALLIC MINERAL RESOURCES OF THE KITT PEAK AREA, ARIZONA

FIG.9 FAVORABILITY AND LEVEL OF CONFIDENCE MAP FOR URANIUM RESOURCES OF THE KITT PEAK AREA, ARIZONA

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.

The Coyote Mountains WSA (020-202)

Physiography

The WSA lies in the Coyote Mountains at the northern end of the Baboquivari range. The topography is mostly mountainous with the northeast corner having gentler slopes. Maximum relief in the WSA is about 3500 feet.

Geology

Jurassic granitic rocks are the oldest rocks in the Coyote Mountains WSA. In the southern part of the WSA, the Jurassic intrusives consist of hornblende- and/or biotite-bearing granodiorite; monzonite and monzogranite; and syenogranite. In the northeast part of the WSA are Jurassic sphene- and epidote-bearing hornblende-biotite quartz diorite, hornblende-epidote diorite

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and augite hornblendite. In fault contact with the Jurassic rocks are dacitic flows and interbedded mudstone, siltstone, sandstone, conglomerate and breccia of the Mesozoic Roadside Formation, and a small outcropping of Cretaceous (?) Sand Wells sediments, including subordinate volcanics. Garnet-two-mica granites, aplite dikes and extensive pegmatites of the 58 m.y.B.P. Pan Tak Granite crop out over much of the WSA. Much of the pluton has been regionally metamorphosed; the older phases were affected by Laramide metamorphism and pegmatites and Paleozoic sediments of the northern Coyote Mountains underwent penetrative deformation during the mid-Tertiary orogeny. There is sound evidence that rocks of the Coyote Mountains are a metamorphic core complex. In addition to the above-mentioned mid-Tertiary ductile deformation, the rocks in the vicinity of the Ajo Road Fault or Decollement, which runs through the eastern half of the WSA, are mylonitized and chloritic breccia underlies the fault near the northern border of the western part of the WSA. Upper plate rocks of the Roadside and Sand Wells Formations are shattered, sheared, faulted and gouged.

Quaternary alluvium underlies the northeast corner of the Coyote Mountains WSA.

Mineral Deposits

One mineral deposit (Cu 11) lies within the WSA and another occurrence (Mo 78) lies at the western boundary. A uranium occurrence (U 14) is located near the southeastern edge of the WSA.

The Bonanza Mine (Cu 11) is a small, high-grade pyrometamorphic deposit in metamorphosed Paleozoic limestone. Mineralization is associated with the intrusion of the Laramide Pan Tak Granite. The Bonanza Mine produced copper and silver and possibly gold, zinc and molybdenum; the mine yielded 700 tons of ore between 1909 and 1951. Mineralogy is pyrite, chalcopyrite, bornite,

covellite, chalcocite, molybdenite and sphalerite. Carrigan (1971) reports that other small replacement deposits occur in metamorphosed limestone and copper oxides are found along igneous-sedimentary contacts. Prior to 1928, ore mined averaged 10% Cu and 1.5 oz. Ag/ton (Carrigan, 1971).

Mo 78 is an unnamed molybdenum occurrence for which no information is available. It is located in the Pan Tak Granite.

The El Conquistadors Claims (U 14) are uranium claims located in pegmatites of the Pan Tak Granite. NURE fieldwork failed to find mineralization in the area (Luning and Brouillard, 1982).

Several mineral deposits and occurrences are located in Mesozoic sediments and volcanics that are possibly the upper plate of a metamorphic core complex and mineralization may be related to that event.

Land Classification for GEM Resources Potential

Metallic Minerals

The part of the WSA underlain by the Laramide Pan Tak Granite and metasediments, Mesozoic diorites, and hornblendite, Mesozoic volcanics and sediments (area 1, fig. 8), all of which may be part of a metamorphic core complex, is classified as moderately favorable for the occurrence of metallic minerals at a confidence level of B. Metallics specifically considered in this classification are Cu, Ag, Au, Zn, Mo, Hg, W and Sn.

The reasons for this classification are as follows:

1. A past producer of copper and silver (Cu 11) is located in Laramide metasediments of the WSA. Additionally, a molybdenum occurrence is located in the Pan Tak Granite at the western boundary of the WSA.
2. Numerous tungsten occurrences, many of them past producers, are associated with Laramide S-type garnet-two-mica granites,

similar to the Pan Tak Granite, of the Quinlan, Comobabi, Baboquivari and Las Guijas Mountains. Tin is also often associated with S-type granites.

3. If the Coyote Mountains are indeed a metamorphic core complex, then mineralization may occur in the mylonitic zone (northern part of the Coyote Mountains) adjacent to the Ajo Road Fault, along the fault, and in the fractured and shattered upper plate rocks. Copper, silver, manganese, gold and mercury indeed occur in heavily fractured Roadside Formation rocks of the "upper plate" in areas north of the WSA.
4. Conversely, remobilization of elements in Laramide-age deposits may have occurred during the mid-Tertiary orogeny, leaving much of the WSA barren.

The southern part of the WSA, underlain by Jurassic monzonite, granodiorite, monzogranite and syenogranite (area 2, fig. 8) is considered to be of low favorability for the occurrence of metallic minerals. Reasons for this classification are:

1. Few mineral occurrences in the GRA are related to the Jurassic intrusives and none of these occurrences are in or near the WSA.
2. The Jurassic granitic rocks are not good hosts for younger mineralization.

Uranium

The area around occurrence U 14 (area 4, fig. 9) is classified as moderately favorable for uranium at a confidence level of B. Reasons include:

1. A uranium occurrence (14) is reported in pegmatites of the Pan

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Tak Granite in this area.

2. NURE workers were unable to locate this deposit; perhaps there is no mineralization. However, many uranium occurrences reported in the Nogales quadrangle were not visited or not found during the NURE study. It is possible that attempts to locate this and other occurrences were not thorough.

The rest of the Coyote Mountains WSA north of the contact between Jurassic monzonites and associated intrusives and Laramide Pan Tak Granite (area 5, fig. 9) is of low favorability for the occurrence of uranium at a confidence level of B. The reasons for this classification are as follows:

1. Pegmatites are also located in this area.
2. Mylonites and chloritic breccias of core rocks, and upper plate rocks of other metamorphic core complexes are known to contain anomalously high levels of U and other elements, and uranium deposits.
3. However, no occurrences are reported in rocks of this part of the WSA.

Other Resources

The WSA is considered unfavorable for the occurrence of other resources.

The Baboquivari Peak South WSA (020-203B)

Physiography

The Baboquivari Peak South WSA lies in the central Baboquivari Mountains. Slopes are quite steep and the total relief of the WSA is approximately 3100 feet.

Geology

The WSA is underlain by rocks ranging in age from early Jurassic to

Laramide. The oldest rocks are rhyodacitic to andesitic volcanics and interbedded quartzite, arkose and conglomerate of the Ali Molina Formation. Conformably overlying the Ali Molina rocks are the redbeds and intermediate volcanic flows of the Pitoikam Formation. The Mulberry Wash Volcanic Formation unconformably overlies the Pitoikam Formation and consists of latitic and rhyodacitic to andesitic flows, tuffs, and volcanic breccias, conglomerate, arkose, shale, mudstone, marl and limestone. All three units are early Jurassic in age and the three units underly most of the WSA (unit Mzs, see fig. 3). The very westernmost part of the WSA is underlain by the Jurassic Baboquivari Granite, a coarse-grained, reddish, porphyritic granite, which is in fault contact with the older Jurassic rocks. The late Jurassic or Cretaceous Chiuli Shaik Formation overlies the Jurassic pluton in the western part of the WSA; the northern extension of the contact between the two units is a fault. The Chiuli Shaik Formation consists of andesite flows, breccias, rhyolitic tuffs, and sub-volcanic intrusions. The youngest rocks in the WSA, potentially beryl-bearing Laramide pegmatites, crop out in the northern tip of the WSA and are intrusive into the early Jurassic volcanics and sediments. Sections of two major faults are located in the western part of the WSA (see fig. 3).

Mineral Deposits

An unnamed silver and gold occurrence (AuAg 98) is located in the central western part of the Baboquivari Peak South WSA and apparently is in the late Mesozoic Chiuli Shaik volcanics. The Iowana Mine (Au 16) and the Jupiter Mine (Au 17) are located less than two miles south of the WSA. Both are past producers of gold and silver and averaged 16 and 12 oz. Ag per ton, respectively. Lead, copper and zinc sulfides, and wolframite also occur. The hydrothermal mineralization is related to Laramide dikes. Occurrence 98

may be similar.

Two beryl occurrences, the Windy Claims (Be 91) and Contreras Canyon (Be 92) are located close to the northern end of the WSA, and the beryl-bearing pegmatite underlies the northern corner of the WSA.

Land Classification for GEM Resources Potential

Metallic Minerals

The entire WSA (area 3, fig.8) is classified as moderately favorable for the occurrence of metallic minerals at a confidence level of B. The reasons for this classification are as follows:

1. One gold and silver occurrence is located within the WSA and several others are located a few miles to the south of the WSA occur in rocks that also underlie the WSA.
2. However, little is known about the single mineral occurrence in the WSA.
3. Potentially favorable geologic environments are found in the WSA, including Mesozoic volcanic rocks and Laramide intrusives, which could be related to hydrothermal mineralization, and Mesozoic sediments, including red beds and limestones, which could host red bed type copper + silver and pyrometasomatic replacement deposits, respectively. A Tertiary intrusive of unknown nature lies immediately west of the WSA and could also be a source of metallic minerals.

Uranium

The entire WSA (area 5, fig. 9) is of low favorability for the occurrence of uranium resources. The reasons are as follows:

1. No uranium mineralization is reported to occur in the WSA.
However,

 

2. Two uranium occurrences are located to the south in metamorphosed equivalents of Mesozoic sediments and volcanics which crop out in the WSA.
3. Laramide pegmatites, which crop out at the northern end and surround the eastern edge of the WSA, could be good sources of uranium.

Non-metallic Minerals

Areas in and around the WSA which are underlain by Laramide-age pegmatites (area 6, fig. 10) are classified as moderately favorable for the occurrence of non-metallic minerals, specifically beryl, at a confidence level of C. The reasons are:

1. Two beryl occurrences are located in Laramide pegmatites near the northern corner of the WSA. One (Be 92) is less than a mile from the WSA.
2. Beryl could occur in other areas where the same pegmatites crop out.

Other Resources

The WSA is considered unfavorable for the occurrence of other resources.

Recommendations for Further Work: Coyote Mountains WSA (020-202) and Baboquivari Peak South WSA (020-203B)

For areas 1 (Coyote Mountains WSA) and 3 (Baboquivari Peak South WSA), it is recommended that field-checking for the presence of extensive hydrothermal alteration be performed.

Additionally, for area 1 it is recommended that the dislocation surface (Ajo Road Fault), and underlying chloritic breccia and mylonite be sampled for geochemistry and analysed for Cu, Au, Ag, Zn, Fe, V, Li, Cr, U and Th to

 

check for enrichment.

Occurrence U 14 in area 4 should be visited and checked for uranium mineralization and higher than normal levels of radiation. If mineralization and/or high radiation levels are encountered, a detailed description of the geology of the area should be done.

For areas 4, 5 and 6, pegmatites should be checked for the occurrence of rare non-metallic minerals such as beryl. In addition, if significant uranium indications are encountered in area 4, area 5 should be checked for similar geologic environments.

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