BLACK MOUNTAINS SOUTH G-E-M

RESOURCES AREA

(GRA NO. AZ-06)

TECHNICAL REPORT

(WSAs AZ 020-024 and 020-028/029)

Contract YA-553-RFP2-1054

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Final Report

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EXECUTIVE SUMMARY

The Black Mountains South Geology-Energy-Minerals (GEM) Resource Area GRA includes the following Wilderness Study Areas (WSAs): AZ 020-024 and AZ 020-028/029.

The Black Mountains South GRA is located approximately 15 miles west of Kingman in Mohave County, Arizona. The area is underlain by Precambrian rocks (greater than 600 million years old) which have been overlain and intruded by Tertiary (less than 60 million years old) volcanics ranging from rhyolite to basalt in composition. The Quaternary (less than three million years old) basalt was the last volcanic unit deposited and currently forms the caps of the high flat-topped mesas in the southern portion of the GRA.

There are three major mining districts within the GRA. They are from north to south: the Union Pass; the Oatman, by far the largest and most important; and the Boundary Cone. The mineral deposits occur mainly in quartz veins, and gold was the principal metallic mineral commodity produced. Silver was the only strategic and critical mineral produced from within the GRA and this came as a by-product of the gold extraction. Nonmetallic production from within the GRA included brucite, clay and perlite.

There are abundant mining claims, especially in the vicinity of the old mining districts. Much of the west half of WSA AZ 020-024 contains claims, along with the northwest portion of WSA AZ 020-028/029.

Oil and gas leases cover much of the Federally owned mineral rights within the GRA, as this area is considered to be a part of the Overthrust Belt. There are no geothermal leases in the GRA.

WSA AZ 020-024 is generally thought to have a high to moderate favorability for metallics with a moderate to high confidence level, a low favorability for uranium with a low confidence level, no favorability for thorium deposits with a very low confidence level, and a moderate favorability for nonmetallics with a moderate confidence level. There is a low favorability with a very low confidence level for oil and gas, and a low favorability for geothermal resources with a moderate confidence level.

WSA AZ 020-028/029 has predominantly a low favorability for metallic mineral resources with a low confidence level except in the Oatman and Boundary Cone areas where favorability is high with a high confidence level, and in three isolated areas where alteration is evident and where the favorability is moderate. Uranium has low favorability and the nonmetallics show high to moderate favorability with a high to moderate confidence level in much of the WSA. Oil and gas have a low favorability with a very low level of confidence, and geothermal resources have a moderate to high favorability with a moderate to high confidence level.

In general there is a moderate favorability for additional gold and silver mineralization in most of the northern WSA and in limited portions of the southern WSA. There is a perlite, clay and zeolite deposit within the southern WSA and the possibility of additional zeolites in the northern WSA.

More detailed mapping, geochemical sampling, and further discussions with those who have worked in the area would be helpful in further assessing the areas mineral potential.

I. INTRODUCTION

The Black Mountain South G-E-M Resources Area (GRA No. AZ-06) contains approximately 340,000 acres (1,379 sq km) and includes the following Wilderness Study Areas (WSAs):

WSA Name	WSA Number
Warm Springs	AZ 020-028/029
Mount Nutt	AZ 020-024

The GRA is located in Arizona within the Bureau of Land Management's (BLM) Kingman Resource Area, Phoenix district. Figure 1 is an index map showing the location of the GRA. The area encompassed by the GRA is near 35°00' north latitude, 114°30' west longitude and includes the following townships:

T 21 N, R 19-20 W	T 17 N, R 18-20 W
T 20 N, R 19-20 W	T 16-1/2 N, R 18-20-1/2 W
T 19 N, R 18-20 W	T 16 N, R 19,20 W
T 18 N, R 18-20 W	

The areas of the WSAs are on the following U. S. Geological Survey topographic maps:

15-minute:

Topock

7.5-minute:

Union Pass	Secret Pass
Oatman	Mount Nutt
Boundary Cone	Warm Springs
Warm Springs, SW	Warm Springs, SE
Yucca, NW	Yucca
Franconia	Buck Mountains

The nearest town is Kingman which is located about 15 miles northeast of the GRA. Access to the area is via State Highway 68 to the north, Interstate 40 to the south and east, and via the paved road between going through Oatman. Access within the area is by numerous light duty and unimproved roads.

Figure 2 outlines the boundaries of the GRA and the WSAs on a topographic base at a scale of 1:250,000.

Figure 3 is a geologic map of the GRA and vicinity, also at 1:250,000. At the end of the report, following the Land Classification Maps, is a geologic time scale showing the various geologic eras, periods and epochs by name as they are used in the text, with the corresponding age in years. This is so that the reader who is not familiar with geologic time subdivisions will have a comprehensive reference for the geochronology of events.

This GRA Report is one of fifty-five reports on the Geology-Energy-Minerals potential of Wilderness Study Areas in the Basin and Range Province, prepared for the Bureau of Land Management by the Great Basin GEM Joint Venture.

The principals of the Venture are Arthur Baker III, G. Martin Booth III, and Dennis P. Bryan. The study is principally a literature search supplemented by information provided by claim owners, other individuals with knowledge of some areas, and both specific and general experience of the authors. Brief field verification work was conducted on approximately 25 percent of the WSAs covered by the study.

The GRA was checked by aerial reconnaissance on October 22 and the WSAs were field checked on the ground on October 21, 1982.

One original copy of background data specifically applicable to this GEM Resource Area Report has been provided to the BLM as the GRA File. In the GRA File are items such as letters from or notes on telephone conversations with claim owners in the GRA or the WSA, plots of areas of Land Classification for Mineral Resources on maps at larger scale than those that accompany this report if such were made, original compilations of mining claim distribution, any copies of journal articles or other documents that were acquired during the research, and other notes as are deemed applicable by the authors.

As a part of the contract that resulted in this report, a background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included with the GRA File to this GRA report. There are some geological environments that are known to be favorable for certain kinds of mineral deposits, while other environments are known to be much less favorable. In many instances conclusions as to the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most important aspects of geological environments that were in the minds of the authors when they wrote these reports.

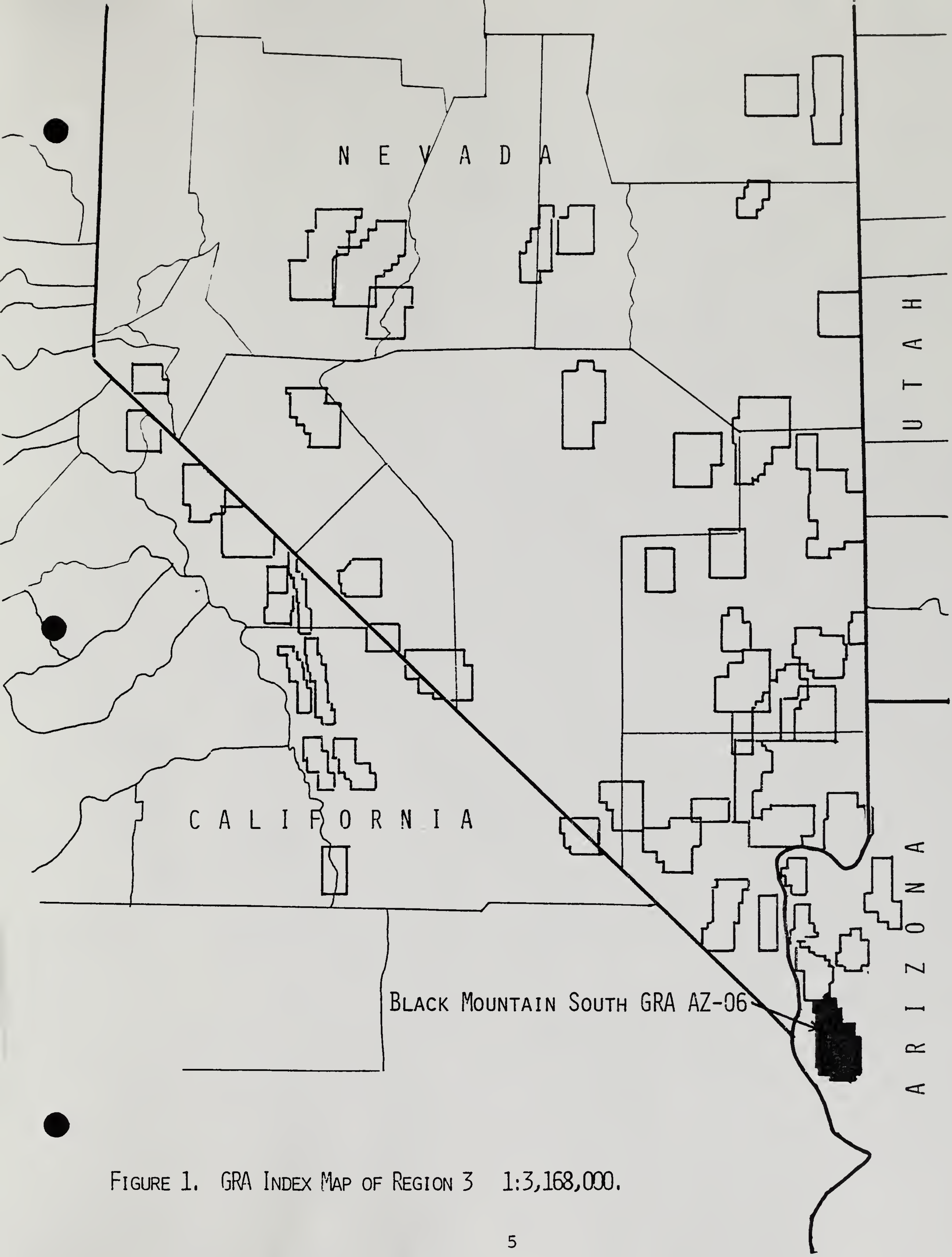
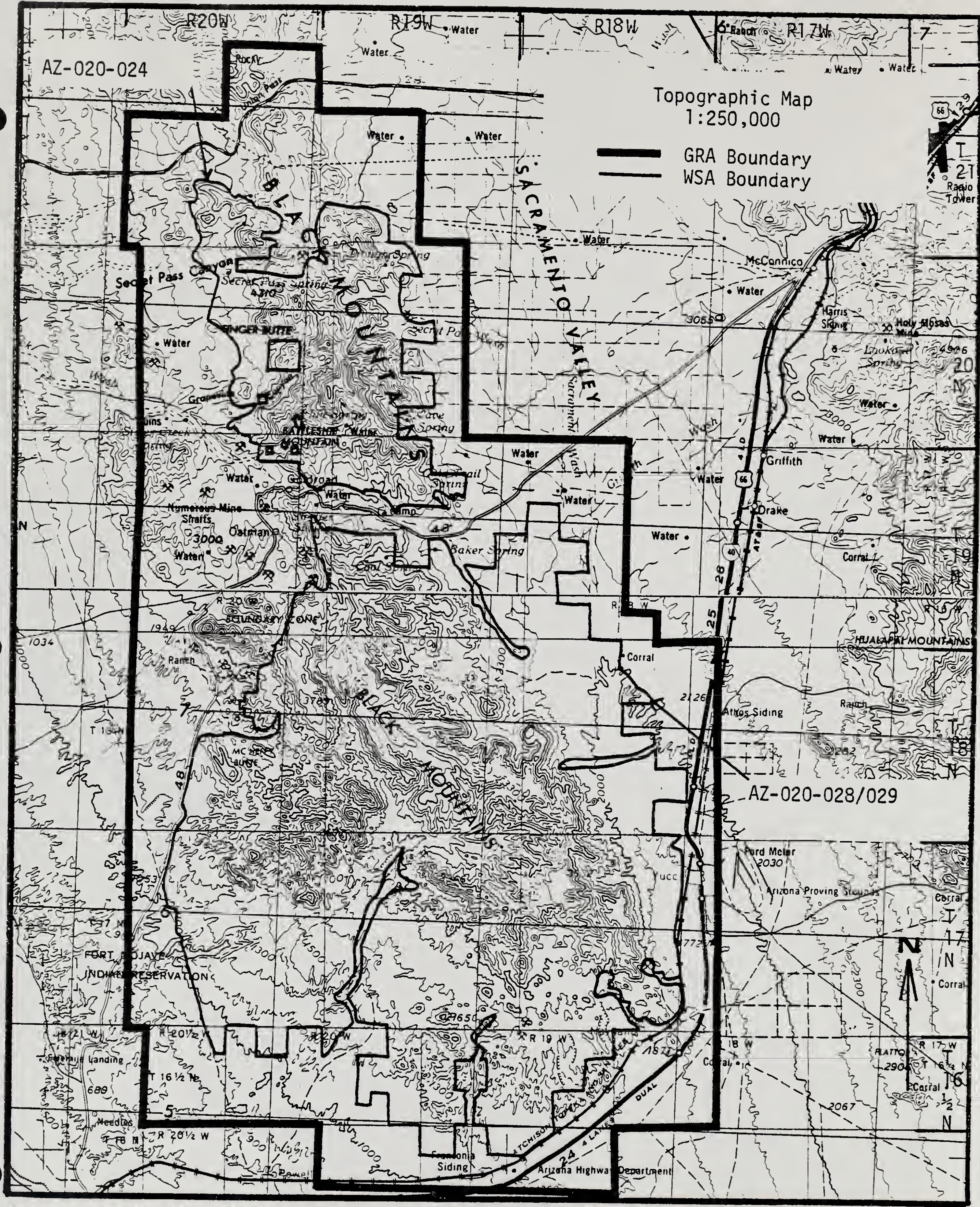


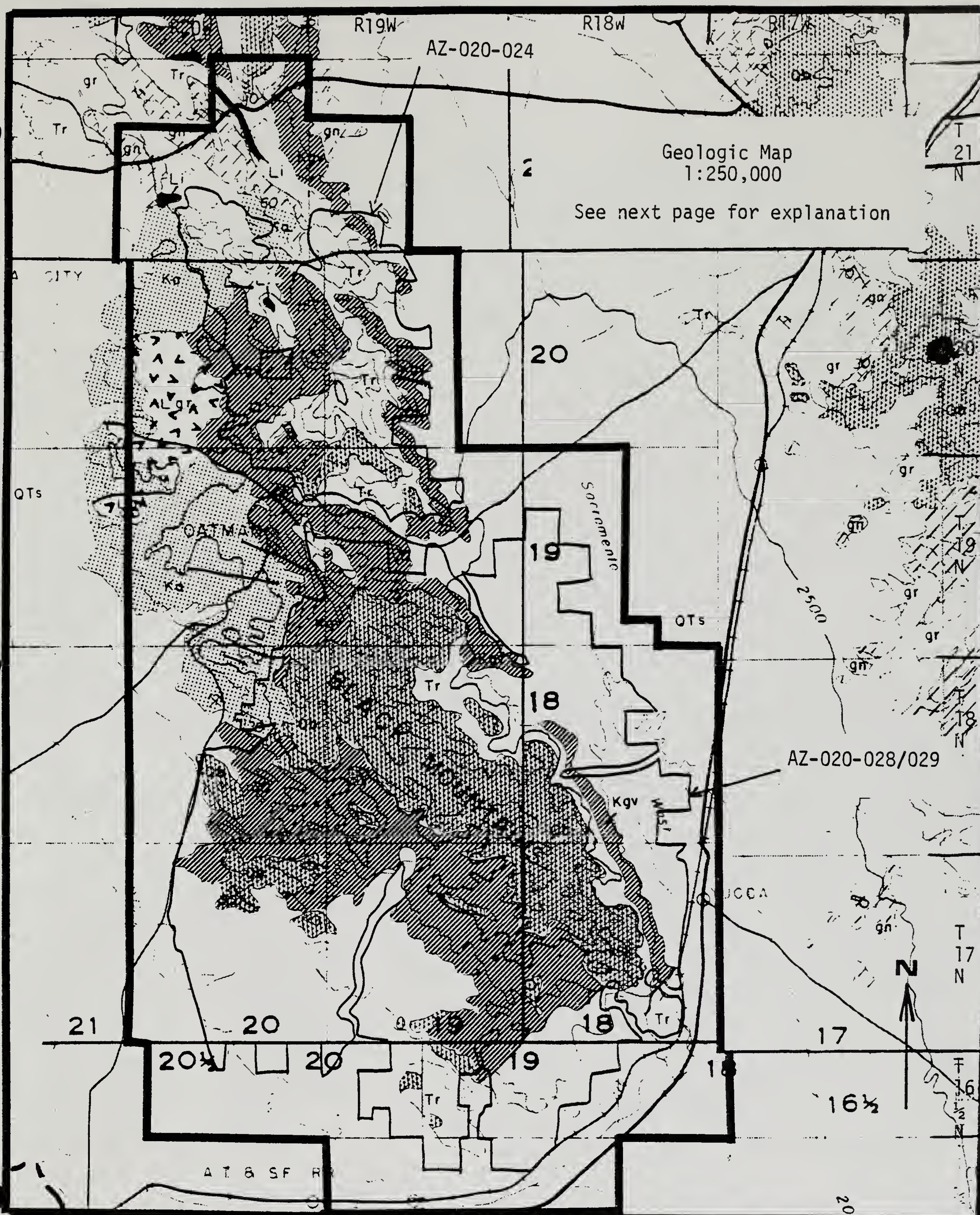
Figure 1. GRA Index Map of Region 3 1:3,168,000.



Kingman and Needles Sheets

Black Mountain South GRA AZ-06

Figure 2



Mohave County Geologic Map, Wilson and Moore (1959)

Black Mountain South GRA AZ-06

Figure 3

E X P L A N A T I O N

QUATERNARY

Qs — Silt, sand, and gravel.

Qb — **Basalt**
Locally includes tuff and agglomerate.

Dikes and plugs

QTs — Sand, gravel, and conglomerate.

QTl — **Lake Deposits**
Siltstone, sandstone, and limestone.

QTb — **Basalt**
Locally includes tuff and agglomerate.

TERTIARY

Ts — Sand, gravel, and conglomerate.

Tr — **Rhyolite**
Includes tuff and agglomerate

Ta — **Andesite**
Flows, tuff, and agglomerate

TKs — Sandstone, shale and conglomerate
Includes some basalt.

LG — Granite and related crystalline rocks

Dikes and plugs
Rhyolitic to andesitic in composition.

LARAMIDE

CRETACEOUS

Ks — Limestone conglomerate

Ka — **Andesite**
Flows, tuff, and agglomerate

Kr — **Gold Road volcanics**
Includes rhyolite, latite, and andesite. Locally contains volcanic glass.

TRIASSIC AND JURASSIC

ƦJg — **Glen Canyon group**
Includes in descending order, Navajo sandstone Kayenta formation, Moenave formation, and Wingate sandstone.

TRIASSIC

Ʀc — Chinle formation

Ʀs — Shinarump conglomerate

Ʀm — Moenkopi formation

EXPLANATION CONT.

TRIASSIC

Rc
Chinle formation

Rs
Shinarump conglomerate

Rm
Moenkopi formation

PERMIAN

Pk
Kaibab limestone
Includes Toroweap formation

Pc
Coconino sandstone

Ph
Hermit shale

PENNSYLVANIAN AND PERMIAN

PPs
Supai formation

PPc
Callville limestone

MISSISSIPPIAN AND DEVONIAN

CDl
Redwall and Martin limestones

CAMBRIAN

Tonto group

OLDER PRECAMBRIAN

gr
Granite and related crystalline intrusive rocks

di
Diorite porphyry

sch
Schist

gn
Granite gneiss

SYMBOLS

Contact, showing dip

Fault, showing dip
Dashed where approximately located

Thrust fault
(T, upper plate)

Axis of anticline

Axis of syncline

Strike and dip of beds

90
Strike of vertical beds

Mine

II. GEOLOGY

The Black Mountains South GRA is an assemblage of Precambrian granite gneisses and schists which has been locally intruded by Tertiary intrusives and extensively overlain by thick mid-Tertiary and Quaternary volcanic sequences. The mid-Tertiary volcanics are comprised mainly of trachyte rhyolite, quartz latite flows, breccias, and tuffs. Widespread Quaternary olivine basalt occurs in the southeastern portion of the study area.

The Black Mountains are an uplifted block bound by Basin and Range faults which became activated sometime during the Miocene. Much of the eastern slope is bound by steep north-northwest trending faults. The topography on the west side of the range in this area is more subdued with foothills giving way to gently dipping alluvial slopes extending to the Colorado River.

Recent geological mapping in the northwest part of Arizona is lacking and the only geologic map available which covers the entire GRA is Wilson and Moore's county map published in 1959 at a scale of 1:375,000. Many of the units on this map have subsequently been found to be radically different than when originally mapped. Information on the geology is, therefore, sketchy and has had to be interpolated from various mining district reports and research material.

1. PHYSIOGRAPHY

The Black Mountains South GRA is located in the Basin and Range Province in west central Mohave County near the Nevada State Border. The study area encompasses a portion of the range from Union Pass in the north to the southern tip of the range at Franconia Siding along Interstate 40.

Elevations along the northwest-trending crest of the Black Mountains average about 4,000 feet. Drainage is predominantly westward into the Colorado River although several small tributaries to Meadow Creek flow eastward into Sacramento Valley.

The Black Mountains have been carved from gently dipping volcanic rocks, and have the general topographic character of a dissected mesa. The degree of dissection varies considerably with some areas being mesa-like or moderately hilly and other parts extremely rugged.

The Elephant's Tooth and Boundary Cone are both plugs of Tertiary rhyolite near the town of Oatman which command attention because of their tower like form and light color.

2. ROCK UNITS

The oldest rock unit in the study area is an unnamed Precambrian gneiss approximately 1,800 million years old (Kessler, 1976), which crops out near the northern border of the GRA and forms the basement complex throughout this GRA.

Unconformably overlying the Precambrian gneiss is a thick widespread sequence of Tertiary volcanics consisting of trachyte, welded tuffs, rhyolite, quartz latite flows, sedimentary tuff breccias, landslide breccias, and minor carbonaceous shales and limestones. In the Oatman district, this volcanic series is referred to as the Alcyone Formation.

These volcanics are intruded by the lower Miocene Times Porphyry which manifests itself as a granophyre lacolith northwest of Oatman.

A series of Miocene volcanics was unconformably deposited over the older volcanics and Times Porphyry. This sequence contains trachyte flows, pyroxene latite flows, breccias and tuffs, and biotitic pyroxene latite flows. These formations in the Oatman district have been given the following local formation names respectively: the Esperanza Formation, Oatman Formation, and Golden Road Formation. The Oatman Formation contains most of the economic ore bodies in the Oatman district where it is approximately 1,000 feet thick but thins rapidly away from the district.

The next youngest formations are undivided, unnamed middle Miocene latite and rhyolite flows. These flows crop out in the eastern half of the study area.

The Moss porphyry intruded the above mentioned volcanics south of Oatman during the late Miocene.

Rhyolite plugs, dikes and flows were next deposited along northwest-trending structures.

Subsequent to the Tertiary volcanic activity, thick accumulations of alluvial and fluvial detritus were deposited in the valleys bordering the Black Mountains.

Widespread Quaternary unnamed olivine basalt overlies the above listed formations and is the youngest effusive formation found in the study area. A large flat mesa-like outcropping of this unit occurs in the southeastern portion of the study area in WSA AZ 020-028/029.

3. STRUCTURAL GEOLOGY AND TECTONICS

The oldest structures preserved are near vertical northwest-trending joints within the Precambrian rocks. Structures in the overlying Tertiary volcanics generally follow this jointing trend of the underlying Precambrian basement rocks.

Tertiary Faulting is described in the Oatman district by Ransome (1923) as pre-mineralization, contemporaneous with mineralization and post-mineralization. Veins within the district predominantly occur along northwest trending fault traces and dikes also follow the regional northwest trend.

A five-mile diameter circular caldera complex discovered by the study of landsat imagery and high altitude photography is believed to encompass an area around and to the north of Oatman (Clifton, 1980). This concentric set of fractures postdates the Middle Miocene Moss Porphyry but predates the Upper Miocene rhyolite dikes, plugs and flows. Radiating fractures originating near the center of the circular feature cut the rhyolite dikes and concentric set of fractures. This radial set of fractures hosts the mineralization in the Oatman district.

4. PALENTOLOGY

No fossil localities are known from within the Black Mountains South GRA. The only (low) potential exists in units mapped as Quaternary and Tertiary sediments; no sedimentary interbeds are recorded from this area.

5. HISTORICAL GEOLOGY

During the Precambrian existing granitic rocks were metamorphosed into gneiss which contains structures which record deformational stresses.

Paleozoic marine sediments similar to those which are found in the Grand Canyon area, were deposited but stripped away by long periods of erosion prior to mid-Tertiary volcanism and plutonism.

Igneous activity initiated during the Eocene and continued through the Miocene with intermittent periods of erosion.

Faulting following the general northwest trend of the underlying Precambrian jointing, occurred throughout the Tertiary. In the Oatman district, studies by Clifton, (1980) and Thorson (1971) indicate that faulting patterns are related to a large circular caldera system. The middle Miocene set of fractures around the caldera rim were intersected by late Miocene faults radiating from near the center of the caldera. The radiating set of faults were mineralized sometime during the late Miocene and contain the major producing bonanza ore bodies of the Oatman district.

A period of erosion marks the end of the Tertiary and thick accumulations of detrital material were deposited in valleys adjacent to the Black Mountains.

Volcanism reactivated during the early Quaternary with the extrusion of extensive flows of olivine basalt. These flows have been dissected by erosional processes forming the present day topography.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC RESOURCES

1. Known Mineral Deposits

The mining districts within the Black Mountains south GRA, listed from north to south are: Union Pass, Oatman, which now includes the Vivian and Gold Road districts, and Boundary Cone. All are located in the northwest portion of the GRA. The major mineral deposits within the districts occur mainly in northwest-trending, steeply dipping epithermal quartz veins in Tertiary volcanic rocks and contain values predominantly in gold. The Oatman district was by far the largest producer with an estimated 2.2 million ounces of gold and 0.8 million ounces of silver extracted from 3.8 million tons of ore. Specific production figures for the Union Pass and Boundary Cone districts are not available but production probably did not exceed several hundred thousand dollars worth of bullion. Mining activity in the smaller districts died down in the early 1900s, however the Oatman district remained in production until the onset of World War II.

The eastern portion of the Union Pass district is located within the northern border of the GRA. Deposits in the district consist of gold bearing blanket veins, lodes, and irregular silicified rhyolite bodies found on or near a Tertiary rhyolite, intrusive-Precambrian granite contact with values occurring on both sides of the contact. The principal properties in the eastern and southwestern parts of the Union Pass district are the O.K. Group, San Diego, Expansion, and Tragedy groups, Union Pass mine, and the Monarch, Sunlight, Coleman, Colorado, Miller, and Golden Eagle properties.

The Oatman district located in the central portion of the GRA was a major producer of gold and silver. An estimated total production of 2.2 million ounces of gold and 0.8 million ounces of silver was produced between 1897 and 1942. A total of 3.8 million tons of ore averaging 0.58 oz/ton gold and 0.17 oz/ton was extracted from eight major ore bodies and numerous lesser deposits (Clifton, 1980).

About 90% of the total district production was extracted from epithermal quartz-calcite plus adularia lode deposits hosted by the Tom Reed and Gold Road Structures in the central part of the district. The structures occur within a radial set of fractures originating near the center of a five mile wide Circular Caldera complex (Clifton, 1980). The format of the orebodies varies from tabular fissure fillings to complex stockworks of quartz-calcite veins ranging from fractions of an inch to 15 feet wide. The wider ore shoots are often found in dilatant zones formed largely by dip-slip movement along non-linear structures. The majority of gold was found associated with silver in electrum which assays about 800 fine. No base metals or sulphide minerals other than pyrite have been found in the central district.

From the air and in aerial photos many of the vein structures can be easily seen and traced, as they are more resistent than their host rock and stick out of the ground as long linear structures.

The Boundary Cone district is located one mile south of the Oatman district caldera boundary. The deposits are gold bearing and occur in two distinct types: as deposits along the rhyolite-andesite, andesite tuff and granite contacts; and fissure veins in the Tertiary andesite.

The major gold-bearing veins occur in the northeastern part of the district. The veins strike northwest, dip steeply and average about 10 feet in width. The average reported grade of ore from these veins ranged from $13-15/ton in the early 1900's. These veins have been developed by the Iowa mine, Crazy Boy group, Highland Chief, Mountain Beauty, Krauss, and Golden Era properties.

Deposits at the rhyolite-andesite contacts occur mainly in the western part of the Boundary Cone district. The deposits are hosted in a 6-10 foot wide zone of greenish quartz located predominantly on the rhyolite side of the contact. The greenish quartz is identical to that found in the Oatman district suggesting a common genetic relationship. Minor production of ore averaging $17/Ton from this green quartz zone at the Kyle property has been recorded (Schrader, 1909).

2. Known Prospects, Mineral Occurrences and Mineralized Areas

A vast number of prospects exploring for precious metals are located within the major mining districts in the GRA. The entire west flank of the Black Mountains in the study area to several miles south of Boundary Cone can be considered a zone of mineralization.

Because most of the orebodies in the Oatman district did not crop out, numerous shallow shafts, pits and adits were excavated on a hit and miss type exploration approach along veins and structures. The west slope of the Black Mountains in a six mile wide strip is dotted with prospects from Silver Creek in the north to several miles south of Boundary Cone.

Prospects are also clustered around the Moss mine (Secs. 19 & 30, T 20 N, R 20 W) which developed northwest trending veins along structures radiating from the northwest perimeter of the Oatman Caldera. A one and one-half mile east-west trending strip between the Moss mine and the Central Oatman district to the south has very few prospects located within it.

In the Union Pass district area numerous prospects occur in a northwest trending belt from Secret Pass Wash in the southeast to several miles beyond Sugarloaf Mountain in the north. These prospects are mainly located along the trend of gold producing veins.

An unknown shaft and several drill holes in Tertiary volcanics are found in Secs. 9, 10, 14, 15, 16, 17 and 23 of T 17 N, R 19 W. This is reportedly the "Tom Kew" prospect which is in volcanics showing silicification and other alteration assemblages. There is a long arcuate area here of alteration of apparently andesitic volcanics adjacent to and beneath the capping basalt flows to the immediate east. This area was field checked.

Another area of alteration spotted from the air and field verified occurs in Sections 35 and 36 of T 17 N, R 19 W and Sections 19 and 20 of T 16-1/2 N, R 19 W. This alteration area is the site of a previous clay producer and includes considerable silicification.

The Gold Trail mine in Sec. 10, T 19 N, R 19 W was field checked and consists of a northwest-trending vein along a major near vertical normal fault which juxtaposes andesites on the east against rhyolitic tuff units on the west. The vein attains a width of three to five feet near the mine shaft and consists of fractured and brecciated andesites with quartz and iron oxides. The host rock is partially silicified near the vein. Two recent drill holes attempted to explore the vein at depth.

3. Mining Claims

Unpatented mining claims are located in almost every section of the Black Mountains from Union Pass in the north to several miles south of Boundary Cone. This area includes the three gold mining districts located with the GRA.

The Union Pass district in the north has been covered with unpatented lode claims by major mining companies such as Freeport and Crown Resources. Many claims are also held in this area by M. Brock & M. Pemberton.

Most of the Oatman district has been claimed by Fischer-Watt Mining Company and Crown Resources.

Houston Oil and Minerals Corporation has located numerous unpatented claims in the south portion of the Boundary Cone district.

Patented claims are also found within the GRA but are mainly restricted to the three major gold mining districts. Several patented claims are located in the Secret Pass mine area east of Secret Pass Canyon and in the Gold Trail Spring area about five miles east of Goldroad.

4. Mineral Deposit Types

By far the most important mineral deposits within the study area are the epithermal gold bearing quartz-calcite-adularia veins in the Union Pass, Boundary Cone and especially the Oatman district. Based on similarities in content and mode of occurrence veins in the three districts appear to be genetically related to a large thermal source which gave rise to at least several local thermal centers. Because the most recent and detailed research material pertains to the Oatman district, which is also most important economically, further discussion will be limited to that area.

The ore deposits of the Central Oatman district are located within a wedge of fractures which radiate from a point near the center of the five mile radius caldera. The large gold deposits were formed in bends of flexures on the radial structures which produced openings subsequent to dip-slip movement. Phyllic zones of alteration are found above every known ore body in the district. Phyllic alteration mapping may prove to be a useful exploration tool for the discovery of additional ore bodies.

Fluid inclusion studies indicate that the most productive deposits coincide with a zone of boiling. Episodic fractures caused by tectonic adjustments were resealed by gold-bearing solutions. The chlorite-bearing green quartz found in all three districts was one of the later mineralizing stages and also the richest in gold (Lausen, 1931).

Five stages of quartz-clacite plus adularia deposition has been recognized in the Oatman district. All stages were gold-bearing, however only the last three are associated with commercial grade ore. The gold/silver ratio in the quartz increased from 1:6 in the first stage to 4:1 in the late stage.

5. Mineral Economics

The potential is high for significant additional gold and silver production from epithermal vein type deposits within the GRA. However, as pointed out by Clifton (1980), American exploration groups are more interested in longer term, larger tonnage open-pit operations that are less labor intensive. Fischer-Watt Mining Company and Hecla have formed a joint venture to form an exploration program geared toward finding new high-grade ore shoots along known structures in the Oatman district. The target drilling would be based on vein contouring, alteration mapping, fluid inclusion studies, and geochemical sampling.

Other major mining companies, including Freeport, Houston Oil and Minerals, and Crown Resources, have large blocks of claims in and surrounding the known districts. It is possible that these companies are prospecting for large tonnage, open-pittable, hot springs-type deposits which would be found higher in the hydrothermal system which produced the vein deposits. Specific data concerning the potential hot springs-type deposits in the study has not been publically documented; however, the geologic environment appears suitable for their occurrence. The "Tom Kew" property and the area where clay was previously mined several miles to the southeast of Oatman, shows alteration characteristics which may fit this scenario.

The major use of gold is for storing wealth. It is no longer used for coinage because of monetary problems, but many gold "coins" are struck each year for sale simply as known quantities of gold that the buyer can keep or dispose of relatively easily. The greatest other use of gold is in jewelry, another form of stored wealth. In recent years industrial applications have become increasingly important, especially as a conductor in electronic instrumentation. In the United States and some other countries gold is measured in troy ounces that weigh 31.1 grams -- twelve of which make one troy pound. Annual world production is about 40 million ounces per year, of which the United States produces somewhat more than one million ounces, less than one-fourth of its consumption, while the Republic of South Africa is by far the largest producer at more than 20 million ounces per year. World production is expected to increase through the 1980s. For many years the price was fixed by the United States at $35 per ounce, but after deregulation the price rose to a high of more than $800 per ounce and then dropped to the neighborhood of $400 per ounce. At the end of 1982 the price was $460.50 per ounce.

The major uses of silver are in photographic film, sterlingware, and increasingly in electrical contacts and conductors. It is also widely used for storage of wealth in the form of jewelry, "coins" or bullion. Like gold it is commonly measured in troy ounces, which weigh 31.1 grand grams, twelve of which make one troy pound. World production is about 350 million ounces per year, of which the United States produces about one-tenth, while it uses more than one-third of world production. About two-thirds of all silver is produced as a by-product in the mining of other metals, so the supply cannot readily adjust to demand. It is a strategic metal. Demand is expected to increase in the next decades because of growing industrial use. At the end of 1982 the price of silver was $11.70 per ounce.

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

Three nonmetallic mineral commodities have showed a limited amount of past production in the GRA. Refractory clay was mined in the 1960's from a deposit in the southeast quarter of Sec. 35, T 17 N, R 19 W. A limited amount of perlite was produced in the 1940's from a deposit near Yucca. Both these deposits are in WSA 020-028/029. Brucite from just west of Oakman was produced in the early 1950's.

A potential zeolite deposit occurs just south of the McHeffy Butte, south of Oatman.

The clay, zeolite and perlite deposits were field checked and also overflown.

Sand and gravel is present in the alluvium within the WSAs.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Zeolite in the form of mordenite occurs in at least four areas in the GRA; one east of Goldroad between the two WSAs; one in Union Pass; one in the northeast corner of WSA AZ 020-009; and the other just south of the McHeffy Butte in the southern WSA. The latter deposit is one currently under evaluation by a major mining company.

Other clay deposits have been reported in the vicinity of Sec. 35, T 17 N, R 19 W where clay has previously been mined.

Numerous perlite occurrences are located in Secs. 21, 23, 26, 27, 28, 29, 33, 34, and 35 of T 17 N, R 18 W and Secs. 20 and 29 of T 16 1/2 N, R 18 W. These occurrences were confirmed in the field. An additional perlite occurrence was found during the field check in the southeastern quarter of Sec. 20, T 16 1/2 N, R 19 W. Undoubtedly more exist in the area. All the above perlite occurrences are adjacent to or within WSA AZ 020-028/029.

Pumice or cinder is also reported to occur in the southeast part of WSA AZ 010-029/029 but these occurrences could not be verified in the field or from the air.

Rhyolite suitable for use as building stone is found in the Secret Pass Canyon area on the northwest edge of the GRA.

Silica and fluorspar occurrences are found in Grapevine Canyon five miles northwest of Oatman and also to the east of the Midnight mine. Fluorite occurs as pale green and purple crystalline material in quartz veins in the Oatman district, sometimes associated with the gold mineralization.

Brucite and magnesite reportedly occur in other areas of the Oatman district but are mainly concentrated in Sections 7, 8, 17 and 18, T 19 N, R 20 W, just west of Oakman. There is reportedly near 50,000 tons of reserve. The brucite is reported to occur in Tertiary sedimentary beds overlain by andesite.

3. Mining Claims, Leases and Material Sites

Just south of McHeffy Butte a major mining company has located claims in four sections covering the above mentioned zeolite occurrences.

A few claims are located in the southeastern portion of WSA 020-028/029, in the Tertiary volcanics near Haviland and presumably are for perlite.

Some of the claims west of Oakman may have been located for brucite/magnesite.

4. Mineral Deposite Types

The zeolites are the product of presumably hydrothermal alteration of ash flow volcanic tuff units.

The clay deposit is the result of hydrothermal alteration of siliceous to intermediate volcanic rocks as observed in the field. Abundant silica was introduced during this alteration.

The perlite occurs predominantly in the form of glassy silicic tuff breccias but also as portions of rhyolite flows.

The brucite and magnesite occurrences to the west of Oatman and the WSAs are in Tertiary sediments overlain by andesites.

The fluorite occurs in the mineralized veins and is a product of hydrothermal activity.

The silica, in the form of chalcedony, is found throughout the Oatman district both in the volcanics and as erosion products in the alluvium. The chalcedony was formed by either alteration or groundwater remobilization of silica.

5. Mineral Economics

Because so little data is available concerning the size and quality of the nonmetallics it is not known whether presently economically feasible production of these commodities is possible. The market and transportation costs would play a decisive role for these commodities.

The perlite occurrences in or near the WSA seem abundant and mineable but the present perlite market is not favorable for their development because of the abundance of closer deposits to the market area.

The clay deposits may be developable but their high silica content may preclude some uses.

Brucite has been mined in the past and reserves have been delineated. It is unknown whether the market would justify reopening these deposits.

The most common use of sand and gravel is as "aggregate" -- as part of a mixture with cement to form concrete. The second largest use is as road base, or fill. About 97 percent of all snad and gravel used in the United States is in these applications in the construction industry. The remaining three percent is used for glassmaking, foundry sands, abrasives, filters and similar applications. The United States uses nearly one billion tons of sand and gravel annually, all of it produced domestically except for a very small tonnage of sand that is imported for highly specialized uses. Since construction is by far the greatest user of sand and gravel, the largest production is near sites of intensive construction, usually metropolitan areas. Since sand and gravel are extremely common nearly everywhere, the price is generally very low and mines are very close to the point of consumption -- within a few miles as a rule. However, for some applications such as high-quality concrete there are quite high specifications for sand and gravel, and acceptable material must be hauled twenty miles and more. Demand for sand and gravel fluctuates with activity in the construction industry, and is relatively low during the recession of the early 1980s. Demand is expected to increase by about one third by the year 2000. In the early 1980s the price of sand and gravel F.O.B. plant averaged about $2.50 per ton but varied widely depending upon quality and to some extent upon location.

Perlite is a glassy volcanic rock that has the unusual property of expanding to about 20 times its original volume when heated to the proper temperature and almost all of it is used in the expanded form. The largest use of perlite, accounting for more than half of United States consumption, is in construction where it is used as lightweight and insulating aggregate in concrete, alone as an insulator, as an aggregate in fireproof plastic mixes for structural steel, and in other applications. About 15 percent of usage is as a filter aid in many food and beverage applications. Less than 10 percent is used in agriculture as a soil conditioner, and a great variety of other applications consumes the remainder. The United States uses about 600,000 short tons annually and produces this much plus a little more that is exported. Consumption is forecast to about double by the year 2000, with production keeping up with demand. The price of crude perlite is about $25 per short ton.

There are several major varieties of clay, differing both in their mineralogy and their uses, and some materials that mineralogically are clay are called by other names, while some that technically are not clay are called clay. Large amounts of white clay (kaolin) are used as filler in paper to produce the glossy sheen of magazine pages. Even larger quantities of common clay are used in making bricks, drain tile, and other construction products. Certain clays are used extensively in ceramics and in refractory materials. Minor uses include drilling muds, foundry sands, purifying materials for oils, and a great many more. The United States uses about 50 million tons of clays annually, nearly all of it produced domestically. Consumption is forecast to about double by the year 2000, with production increasing in amount the same proportion. The price of clay varies widely depending on the kind of material: the average price is a little lower than $20 per ton, but common clay is valued at about $5 per ton while the highest-priced clay, kaolin, averages about $65 per ton.

Most zeolites presently being used are synthetic minerals but deposits of zeolites are known to exist and some of these are being developed and markets are being sought for them. Few details are known about the economics of zeolites so this description of their mineral economics is necessarily generalized. The United States probably uses much less than 100,000 tons of zeolites annually. Japan, where natural zeolites are used as agricultural soil conditioners and in paper, probably uses appreciably more. United States use, mostly of synthetic zeolites, is largely as catalysts in the cracking of petroleum, as molecular sieves (in which application molecules of some compounds essentially become lost in the intricate crystal structure of the zeolite, while those of other compounds pass through), and as ion exchangers. The United States has large deposits of natural zeolites, sufficient to sustain large consumption. Some advocates of zeolites foresee that the present miniscule domestic production will increase to many thousands or tens of thousands of tons in coming years, as large-scale applications are found for their unusual characteristics. There is no established price for zeolites.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

No uranium or thorium has been produced from the GRA and there are no known significant uranium or thorium deposits within or near the GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

There are no known uranium or thorium prospects, mineral occurrences, or mineralized areas within or adjacent to the GRA.

3. Mining Claims

There are no known uranium or thorium mining claims within the WSAs or the GRA.

4. Mineral Deposit Types

Deposit types cannot be discussed for the WSAs and the GRA as there are no known uranium or thorium occurrences in the area. The large study area provides a variety of geologic environments for uranium deposition.

5. Mineral Economics

The lack of known uranium and thorium occurrences in the GRA indicates unfavorable uranium and thorium economics for the GRA.

Uranium in its enriched form is used primarily as fuel for nuclear reactors, with lesser amounts being used in the manufacture of atomic weapons and materials which are used for medical radiation treatments. Annual western world production of uranium concentrates totaled approximately 57,000 tons in 1981, and the United States was responsible for about 30 percent of this total, making the United States the largest single producer of uranium (American Bureau of Metal Statistics, 1982). The United States ranks second behind Australia in uranium resources based on a production cost of $25/pound or less. United States uranium demand is growing at a much slower rate than was forecast in the late 1970s, because the number of new reactors scheduled for construction has declined sharply since the accident at the Three Mile Island Nuclear Plant in March, 1979. Current and future supplies were seen to exceed future demand by a significant margin and spot prices of uranium fell from $40/pound to $25/pound from January, 1980 to January, 1981 (Mining Journal, July 24, 1981). At present the outlook for the United States uranium industry is bleak. Low prices and overproduction in the industry have resulted in the closures of numerous uranium mines and mills and reduced production at properties which have remained in operation. The price of uranium at the end of 1982 was $19.75/pound of concentrate.

Oil and Gas Resources

There are no known oil or gas fields, hydrocarbon shows in wells or as surface seeps in the region. There are numerous Federal oil and gas leases of record throughout the area, including much of the two WSAs (see Oil and Gas Lease Map). There is no oil and gas occurrence and land classification map for this report.

Geothermal Resources

Oatman Warm Springs with a surface flow of 29°C is located in the heart of the Black Mountains within the AZ 020-028/029 WSA (see Geothermal Occurrence and Land Classification Map). The mountain mass is dominantly Cretaceous volcanics, overlain by some Tertiary rhyolite and capped by a large section of Quaternary basalts. There is no record of existing Federal geothermal leases, and no geothermal lease map is included with the report. The Oatman resource site is described only as a seep with total dissolved solids of 372 mg/l (NOAA, 1982).

Just off the eastern edge of the AZ 020-028/029 WSA, and still within the GRA is a 306-meter well with a surface discharge temperature of 34°C (NOAA, 1982).

Resource data is too sparce to enable either a description of the deposit or the mineral economics.

Geothermal resources are utilized in the form of hot water or steam normally captured by means of drilling wells to a depth of a few feet to over 10,000 feet in depth. The fluid temperature, sustained flow rate and water chemistry characteristics of a geothermal reservoir determine the depth to which it will be economically feasible to drill and develop each site.

Higher temperature resources (above 350°F) are currently being used to generate electrical power in Utah and California, and in a number of foreign countries. As fuel costs rise and technology improves, the lower temperature limit for power will decrease appreciably -- especially for remote sites. All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year around mining in cold climates (86°F), residential space heating (122°F), greenhouses by space heating (176°F), drying of vegetables (212°F), extraction of salts by evaporation and crystallization (266°F), and drying of diatomaceous earth (338°F).

Unlike most mineral commodities remoteness of resource location is not a drawback. Domestic and commercial use of natural thermal springs and shallow wells in the Basin and Range province is a historical fact for over 100 years.

Development and maintenance of a resource for beneficial use may mean no dollars or hundreds of millions of dollars, depending on the resource characteristics, the end use and the intensity or level of use.

D. OTHER GEOLOGICAL RESOURCES

Agate and other forms of chalcedony occur in the gravels between Topock and Oatman and much of the Oatman mining district has been designated a rockhound area by the BLM. A fire opal deposit has been reported northeast of Oatman in AZ 020-024.

E. STRATEGIC AND CRITICAL MINERALS AND METALS

A list of strategic and critical minerals and metals provided by the BLM was used as a guideline for the discussion of strategic and critical materials in this report.

The Stockpile Report to the Congress, October 1981-March 1982, states that the term "strategic and critical materials" refers to materials that would be needed to supply the industrial, military and essential civilian needs of the United States during a national emergency and are not found or produced in the United States in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals. Appreciable amounts of silver, the only strategic and critical mineral in the GRA, have been produced as a secondary commodity from gold mines within the study area. From gold mines in the Oatman district 0.8 million ounces of silver were extracted from 3.8 million tons of ore indicating that the average silver grade of 0.21 oz Ag/ton is very low and by itself would not be an economically feasible target. As a by-product of gold production, however, significant additional silver potential exists in the area.

Fluorspar is a strategic and critical mineral and occurs as a gangue in the gold-bearing quartz veins of the district. The quality and quantity of fluorspar is unknown but due to the narrow vein type deposits, it would probably be uneconomical for extraction unless it was a by-product of gold production.

IV. LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

Land classification areas are numbered starting with the number 1 in each category of resources. Metallic mineral land classification areas have the prefix M, e.g., M1-4D. Uranium and thorium areas have the prefix U. Nonmetallic mineral areas have the prefix N. Oil and gas areas have the prefix OG. Geothermal areas have the prefix G. Sodium and potassium areas have the prefix S. The saleable resources are classified under the nonmetallic mineral resource section. Both the Classification Scheme, numbers 1 through 4, and the Level of Confidence Scheme, letters A, B, C, and D, as supplied by the BLM are included as attachments to this report. These schemes were used as strict guidelines in developing the mineral classification areas used in this report.

Land classifications have been made here only for the areas that encompass segments of the WSA. Where data outside a WSA has been used in establishing a classification area within a WSA, then at least a part of the surrounding area may also be included for clarification. The classified areas are shown on the 1:250,000 mylars or the prints of those that accompany each copy of this report.

In connection with nonmetallic mineral classifications, it should be noted that in all instances areas mapped as alluvium are classified as having moderate favorability for sand and gravel, with moderate confidence, since alluvium is by definition sand and gravel. All areas mapped as principally limestone or dolomite have a similar classification since these rocks are usable for cement or lime production. All areas mapped as other rocks, if they do not have specific reason for a different classification, are classified as having low favorability, with low confidence, for nonmetallic mineral potential, since any mineral material can at least be used in construction applications.

Geologic mapping of the WSAs is covered by Wilson and Moore's (1959) Mohave County map at a scale of 1:375,000. This map gives little geological or structural detail and does not address mineralization. The map is not sufficiently detailed for the purpose of accurately assessing mineral potential and our confidence in the map is only moderate. Descriptions of the Oatman district in the available literature are good, however, and our confidence in this information is high.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA AZ 020-024

M1-4D. This classification area is one of high favorability with a high confidence level and is the Union Pass district which has past production of gold from veins, lodes, and irregular silicified rhyolite bodies. The boundaries for this area were drawn principally in the locations of past mining activity and similar geology and would be subject to modification with more detailed information. The classification is 4D because of old mines, prospects and claims, the reported production, and similar geologic environment. The classification area includes portions of the northern part of the WSA.

M2-4D. This classification area is one of high favorability with a high confidence level includes the Oatman district which was by far the largest past producer within the GRA, and the smaller Boundary Cone mining district to the south. The Oatman district was a past gold and silver producer along veins and other structures associated with the radial structures of a caldera which is centered near Oatman. The Boundary Cone district was a gold producer along lithologic contacts and fissure veins in the andesites. The boundary for this classification area is based on the locations of old workings and geology and may be subject to change with more detailed information. The classification is 4 because of the numerous old mines and prospects and claims in the area and D because of the availability of information documenting past production. The classification area includes part of the western edge of the WSA.

M3-3B. This classification area is one of moderate favorability with a moderate confidence level and includes the area outside the mining districts, but in close proximity, which contain unaltered Tertiary volcanics identified on the map as the Golden Door Volcanics. There are abundant mining claims in this unit in parts of the WSA and some prospects and other workings. The geology is similar to that which has shown mineralization on the fringes of the Oatman district. There are a few structures in this area which show minor mineralization; and at least part of these units are spatially related to the proposed caldera centered in the Oatman district.

M4-3A. This area is moderately favorable but with a low confidence level and includes the Tertiary rhyolite and Quaternary basalt crops out as shown on the geologic map. The rhyolites consist predominantly of cliff-forming tuffaceous units which have no reported metallic mineralization reported in them. The basalts are the latest geologic unit deposited and are post mineralization. The nature of the units below the basalts are unknown but since they have a moderate potential and appear to everywhere underly these younger units then this area should also have a moderate potential. Since we do not have any evidence of mineralization however, the level of confidence is very low.

M5-2A. This is the alluvial cover along the east edge of the WSA. The nature of the bedrock beneath the alluvial cover is unknown but since the adjacent volcanic units are classified 3A, there must be potential for mineralization in the buried bedrock also, hence the 2A classification which is one of low favorability with a very low confidence level.

WSA AZ 020-028/029

M2-4D. This is the area of the Oatman and Boundary Cone mining districts which had past gold production. This classification area has been previously discussed above and is one of high favorability with a high confidence level.

M6-2B. This classification area of low favorability with a low confidence level contains broadly similar geology to that which is mineralized on the fringes of the Oatman and Boundary Cone districts to the north. There are no known mining claims in this area which have been staked for metallics however.

M7-2A. This area of low favorability with a very low confidence level includes the Tertiary rhyolites and Quaternary basalts in the WSA, and the rationale for the classification is the same as that for classification M4-2A above. This area covers approximately one-third of the WSA and includes all the bedrock exposures in the central and eastern portions of the mountain range. In addition, there are three smaller areas of basalt outcrop on the southwestern edge of the bedrock exposures of the WSA. These younger volcanic units cap the underlying older volcanics which elsewhere show mineralization. The underlying older units could be mineralized and surrounding the area are classified 2B to 3B. A 2A classification is for the underlying rocks.

M8-3B. This classification area of moderate favorability with a low confidence level includes three areas within M6-2B, the eastern two of which were field checked. The southernmost one was included because of the abundant alteration, including silicification, present in a large area, a portion of which was mined for clay at one time. The middle "Tom Kew mine", area contains at least two old workings and a small mill and several drill hole locations. This area is also highly altered and shows minor mineralization along fractures. The third area to the west contains a few mining claims and some old workings but was not field checked. All three areas showed noticeable alteration when overflown.

M9-2B. This classification area of low favorability with a low confidence level includes the western portion of the large Quaternary basalt cap on the crest of the range. The reason for the 2B classification is that mining claims cover this area indicating there may be interest in the underlying volcanics beneath the basalts.

M10-2B. This area of low favorability with a low confidence level is outlined solely because of one reported gold prospect and several gold placer claims in the alluvium to the east. Nothing additional is known about this area and it was not field checked. This area is located in the northeastern portion of the WSA.

M5-2A. The classification of low favorability with a very low confidence level contains all the remaining alluvial cover in the WSA. The nature of the bedrock beneath the alluvium is unknown but since where exposed the bedrock has at least a 2 favorability classification then it may also have potential where it is hidden beneath the alluvium.

b. Uranium and Thorium

WSAs AZ 020-024, AZ 020-028/029

U1-2B. This land classification area covers essentially all of WSA AZ 020-024 and the central part of WSA AZ 020-028/029. Uranium has low favorability with a low level of confidence and thorium has no favorability with a very low level of confidence for concentration within the area. The abundant Tertiary rhyolitic and tuffaceous deposits, Tertiary granitic rocks, and Precambrian granitic gneiss of the range are all potential source and host rocks for uranium. The uranium could occur as vein-type, fracture fill, or contact metamorphic deposits in the area.

The southwest portion of WSA AZ 020-024 is of particular interest for uranium concentration as it is covered by a Miocene caldera. Radial fractures associated with the caldera host many of the gold and silver deposits of the Oatman district. Epithermal gold bearing quartz-calcite-adularia vein deposits are also important in the Oatman district. The same processes responsible for the gold and silver mineralization could also have concentrated uranium with or near the precious metal deposits. The Miocene granites and rhyolites of the range and caldera are likely source rocks for gold, silver, and uranium.

Thorium is not prospective in the area at a very low confidence level as pegmatites do not appear to comprise much of the section.

U2-2B. This land classification includes those parts of the WSAs covered by Quaternary/Tertiary sedimentary deposits. This includes the eastern, southern and southwestern sections of WSA AZ 020-028/029. The area has low favorability for uranium with a low level of confidence as epigenetic sandstone type deposits, the source of the uranium being the acidic volcanics and granitic rocks of the range.

Thorium is not favorable in the area at a very low confidence level as there are no apparent source rocks for thorium within or near the area.

WSA AZ 020-028/029

U3-2A. This land classification covers the central part of the WSA which is overlain by Quaternary basalts. Both uranium and thorium are traditionally lacking in basaltic volcanics indicating that the area is not favorable at the surface for uranium or thorium concentration, however granitic and rhyolitic rocks as occur in area U1-2B are probably present beneath the basalts, so the area has been designated as having low favorability for uranium at a very low confidence level.

c. Nonmetallics

WSA AZ 020-024

N1-3C. This classification area which is one of moderate favorability with a moderate confidence level includes most of the bedrock outcrops in the WSA and includes predominantly the Tertiary silicic rocks. Numeraous zeolite occurrences have been reported in these units, and perlite has been reported in similar units to the south and north. The classification is predominantly for the zeolite potential in the silicic tuff units within the area. A great deal of detailed mapping would be required to adequately assess the potential of this area however.

N2-2B. This area of low favorability with a low confidence level lies along the western edge of the WSA and includes the Tertiary andesite outcrops. Further south in the Oatman district brucite was previously mined from apparently Tertiary sediments within this unit. Little is known about this area and it was not field checked, and therefore it is unknown whether a similar geologic environment favorable to brucite formation exists.

N3-2B. This area of low favorability with a low confidence level includes the Quaternary basalt outcrops. No nonmetallic is known to be reported within this unit except that this material could be used for nearby construction needs perhaps, but is unlikely because of market conditions and transportation.

N4-3C. This is the alluvium along the east side of the WSA. The material could be used for nearby construction applications and this area is one of moderate favorability with a moderate confidence level.

WSA AZ 020-028/029

N5-4D. This is the potential zeolite deposit south of McHeffy Butte. This area is high favorability with a high confidence level The zeolites occur in altered silicic tuffs, reportedly in high enough concentrations to be economically mined. The area is covered by mining claims and has been systematically explored and sampled.

N1-3C. This classification area of moderate favorability with a moderate confidence level is in the same unit as the reported zeolite occurrences and therefore has potential. Overflying the area indicated there may be several more areas with similar silicic tuff units that could contain zeolites. A detailed mapping program would be necessary to adequately outline areas of further zeolite potential.

There is reported small-scale prospecting and mining of opalized quartz from within this unit also.

N6-4D. This area of high favorability with a high confidence level has shown past perlite production and a field check indicated sufficient reserves for a mining operation. The quality of the material is unknown and would have to be further evaluated.

N7-4D. This area of high favorability with a high confidence level produced refractory clay in the past and has sufficient reserves for further production. The quality of the material would have to be further assessed and the market would dictate its viability.

N8-3C. This area of moderate favorability with a moderate confidence level includes mapped outcrops of the Tertiary rhyolite and has potential for perlite. Other perlite occurrences were noted in this area during the field check.

N3-2B. This is the Quaternary basalt and has been previously described above.

N2-2B. This area has also been addressed above. In the Oatman area quartz in the form of chalcedony is found here, consequently that area is designated a rockhound area by the BLM.

N4-3C. This area of moderate favorability with a moderate confidence level is the alluvium within the WSA and could be used for local construction applications.

2. LEASABLE RESOURCES

a. Oil and Gas

WSAs AZ-020-024 and AZ-020-028/029

OG1-2A and OG-2-2A. There has been little or no serious oil and gas exploration within the region, and no indications of oil or gas occurrences in Mohave County. The GRA is within the Overthrust Belt which has prolific production in Wyoming/Utah, Mexico and Canada. The Federal leases are for rank wildcat acreage, and surficial stratigraphic units do not necessarily have a bearing on possible drilling objectives at depth, considering overthrust structural implications. The main mass of the Black Mountains does not have any leasing activity, probably due to areas of somewhat higher relief, but the unleased areas are essentially the same geologically.

b. Geothermal

WSA AZ-020-024

G1-2C. The presence of Quaternary basalts within the WSA and two wells having 36° and 37°C water only three miles to the east are indications of a heat source at depth. In addition the WSA includes a region of high chemical geothermometers (Swanberg and others, 1977).

WSA AZ-020-028/029

G2-4D. This classification encompasses Oakman Warm Spring (29°C) and the immediate vicinity.

G3-3C. The entire main mountain mass of Cretaceous and Tertiary volcanics has been subjected to Quaternary basalt outpourings from multiple fissure vents. At the center of the WSA is Oakman Warm Spring (29°C) and just outside the WSA is a 36°C well (TD 306 meters). Also, the north-south linear region of high temperature geothermometers reported by Swanberg and others (1977), covers most of the western half of the WSA. The young volcanics suggest a still present heat source at depth (NOAA, 1982).

c. Sodium and Potassium

S1-1D. There are no known sodium or potassium resources within the WSAs.

d. Other

There are no other known leasable resources within the WSAs.

3. SALEABLE RESOURCES

The saleable resources, sand and gravel, have been addressed above under nonmetallics and includes classification areas N4-3C.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

More detailed geologic mapping would greatly help in further delineating the mineral potential of the WSAs and in defining mineral potential boundaries. Further contacting individuals or companies who have worked in the area would also be of considerable help. Geochemical sampling would also be helpful in delineating potential mineralization areas of mineralization.

VI. REFERENCES AND SELECTED BIBLIOGRAPHY

Arizona Department of Mineral Resources, Arizona Industrial Mineral: Ariz. Dept. Mineral Resources Mineral Report No. 2.

Arizona Department of Mineral Resources, Arizona zeolites: Ariz. Dept. Mineral Resources, Mineral Report No. 1.

American Bureau of Metal Statistics Inc., 1982, Non-ferrous metal data -- 1981, Port City Press, New York, New York, p. 133-134.

Bureau of Land Management, District files, inventories, mining plans, Kingman Resource Area Office.

Bureau of Land Management, 1978, Needles-Boulder City-Davis Dam: Surface minerals management status map.

Calvo, S. S., 1982, Geothermal energy in Arizona, A bibliography: Arizona Bur. of Geol. and Mineral Tech. Cir. 23.

Clifton, C. G., 1980, Exploration procedure and controls of mineralization in the Oatman mining district, Oatman, Arizona: Preprint for 109th A.I.M.E. annual meeting, unpublished.

Coe and Van Loo, Consulting Engineers, Inc., 1980, Mineral location information.

Crib, U. S. Geological Survey.

Darton, N. H., 1910, Reconnaissance of parts of northwestern New Mexico and northern Arizona:. U. S. Geol. Survey Bull. 435.

Dutton, C. E., 1882, Tertiary history of the Grand Canyon district. Monograph U. S. Geol. Survey vol. 2.

Elevatorski, E. A., 1978, Arizona industrial minerals: Arizona Dept. Mineral Resources. Mineral Report No. 2.

Ericksen, G. E., 1969, Brucite and mangesite, in mineral and water resources of Arizona: Arizona Bureau of Mines Bull 180, p. 320.

Exxon Minerals, 1982, Personal communication.

Fischer Watt Mining Company, 1982, Personal communication.

Hahman, W. R., Stone, C., and Witcher, J. C., 1978, Preliminary map, geothermal energy resources of Arizona: Bur. of Geol. and Mineral Tech., Geol. Survey Branch, Univ. of Arizona, Geothermal Map No. 1.

Huntington, Ellsworth, and Goldthwaite, J. W., 1904. The Hurricane fault in the Toquerville district, Utah: Bull. Mus. Comp. Zool. Harvard Coll., vol. 42.

Johnson, M. O., 1972, Placer Gold Deposits of Arizona: U.S. Geol. SurveyBull. 1355.

Kessler, E. J., 1976, Rubidium-strontium geochronology and trace element geochemistry of Precambrian rocks in the northern Hualapai Mountains, Mohave County, Arizona: Unpublished M.S. thesis, U of A, Tucson.

Lausen, C., 1931, Geology and ore deposits of the Oatman and Katherine districts, Arizona: Arizona Bureau of Mines Bulletin No. 131.

Lee, Willis, T., 1908, Geologic Reconnaissance of a part of western Arizona, with notes on Igneous rocks by Albert Johannsen. U. S. Geol. Survey Bulletin No. 352.

Longwell, C. R. 1936, Geology of the Boulder reservoir floor Arizona-Nevada. U. S. Geol. Survey Bull. 47.

Luning, R. H., Penley, H. M., Johnson, C L., and Dotterrer, F. E., 1981, Uranium resource evaluation, Kingman quadrangle, Arizona, Nevada, and California: NURE report PGJ/F 137(81).

Minobras, 1978, Uranium deposits of Arizona, California and Nevada.

McCrory, F. J. and O'Haire, R. T., 1961, Map of known nonmetallic mineral occurrences of Arizona: Arizona Bureau of Mines, University of Arizona, Tucson.

Mining Journal, July 24, 1981, vol. 297, No. 7641.

Muffler, L. J. P., ed., 1979, Assessment of geothermal resources of the United States - 1978: U. S. Geol. Survey Circ. 790.

NOAA/National Oceanic and Atmospheric Administration, 1982, Geothermal resources of Arizona: Map prep. by Nat. Geophys. and Solar-Terrestrial Data Center from geothermal data compiled and interpreted by Witcher, J. C., Stone, C., and Hahman, Sr., W. R. of State of Arizona Bur. of Geol. and Mineral Tech.

Occidental Minerals Corp., 1982, Personal communication.

Peirce, H. W., Principal Geologist, 1982, Personal communication, State of Arizona Bureau of Geology and Mineral Technology, Tucson.

Pratt, J. H., 1902. Gold deposits of Arizona: Engineering and Mining Journal. vol. 73.

Ransome, F. L., 1923, Geology of the Oatman Gold district, Arizona: U. S. Geol. Survey Bulletin 743.

Robinson, H. H., 1907, The Tertiary peneplains of the Plateau district and adjacent country in Arizona and New Mexico: American Jour. Science, 4th Series, vol. 24.

Sante Fe Mining Co., 1982, Personal communication.

Schrader, F. C., 1909, Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave Co., Arizona.

Spurr, J. E., 1903. Descriptive geology of Nevada South of the 40th parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208,

Stone & Witcher, 1982, Mohave section - Basin and Range Province, (in preparation) Geothermal resources in Arizona: ABGMT. Open file report.

Swanberg, C. A., Morgan, Paul, Stoyer, C. H. and Witcher, J. C., 1977, Regions of high geothermal potential, an appraisal study of the geothermal resources of Arizona and adjacent areas in New Mexico and Utah and their value for desalination and other uses.

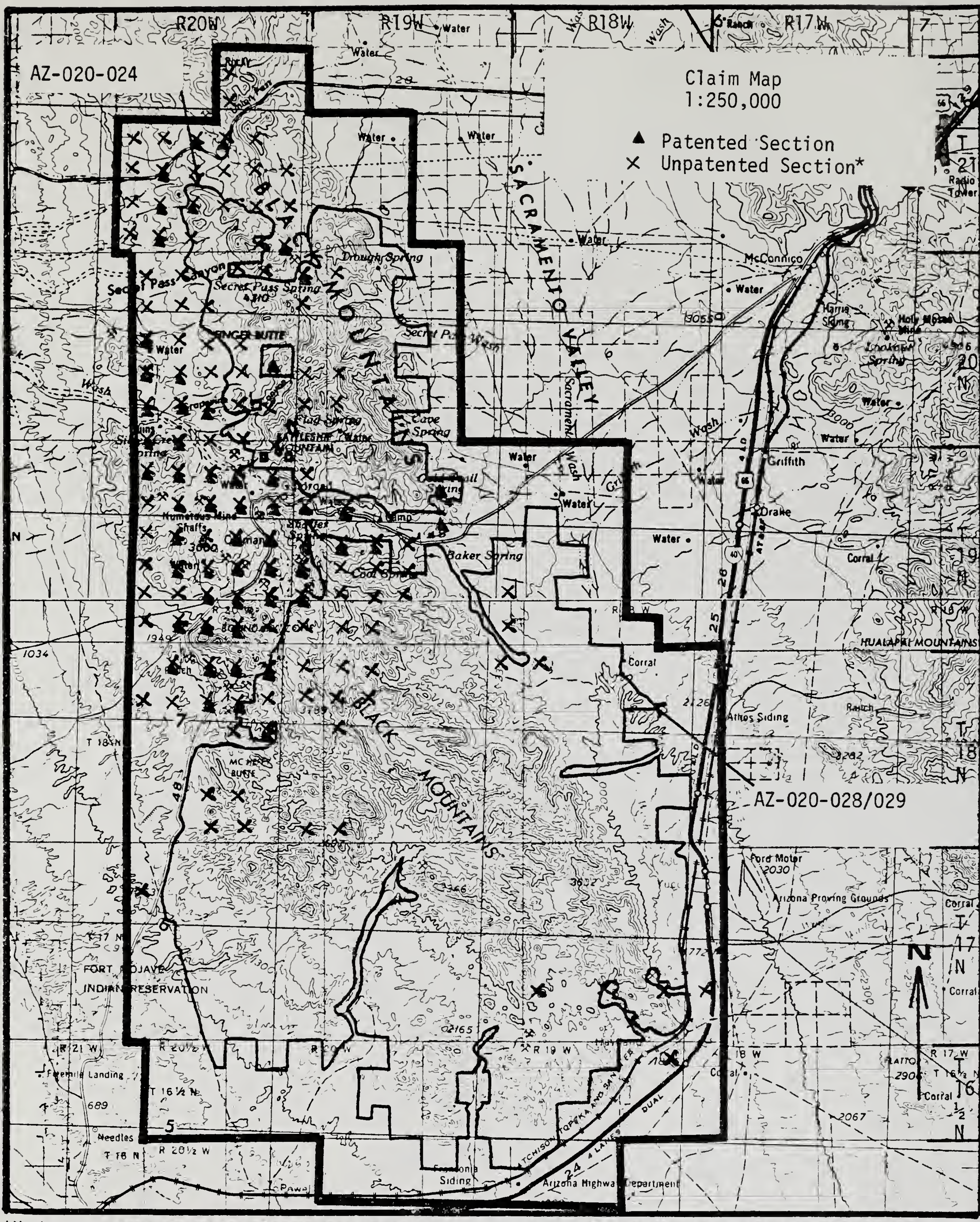
Thorson, Jon Peer, 1971, Igneous petrology of the Oatman district Mohave County, Arizona: Unpublished Ph.D. diss., U.C. Santa Barbara.

U. S. Bureau of Mines, MILS data.

Wilson, E. D., and Moore, R. T.,. 1961, Gold placers and placering in Arizona: Az. Bur. Mines Bull. 168.

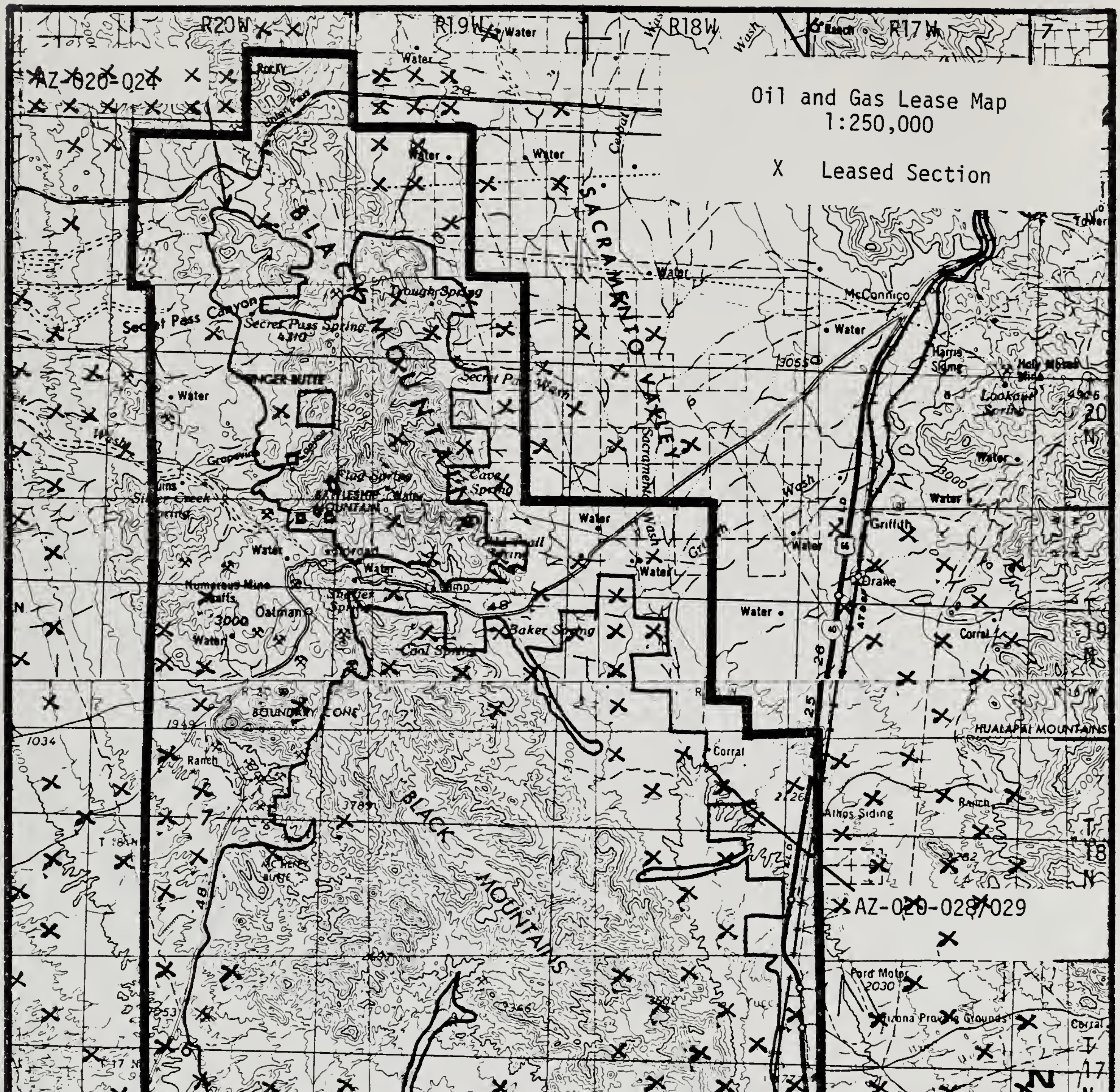
Wilson, E. D. and Moore, R. T., 1959, Geologic map of Mohave County, Arizona: Ariz. Bureau of Mines, U of A, Tucson.

Wilson, E. D., Cunningham, J.B., and Butler, G.M. 1934 (revised 1967), Arizona lode gold mines and mining: Arizona Bur. Mines. Bull. 137.

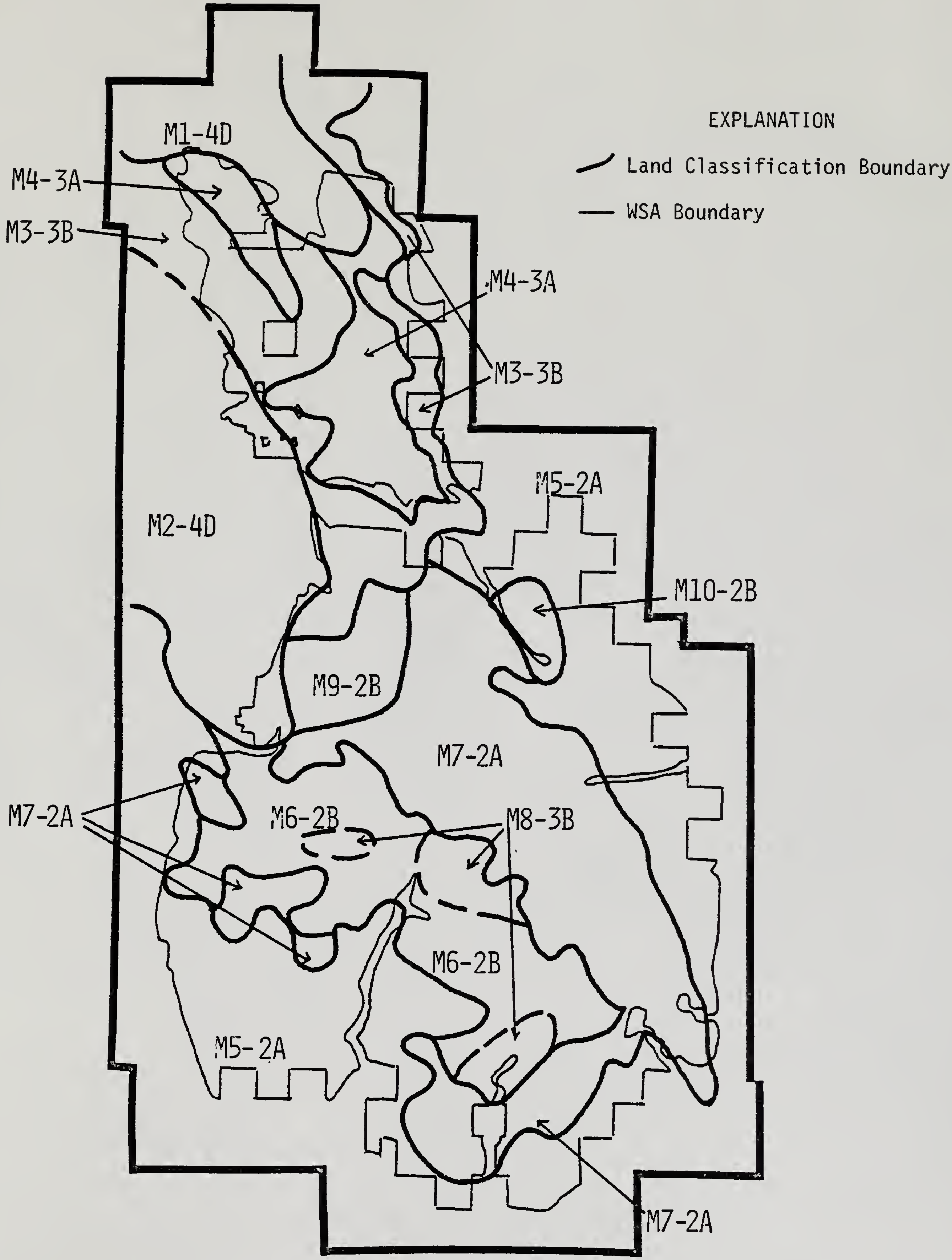


*X denotes one or more claims per section

Black Mountain South GRA AZ-06

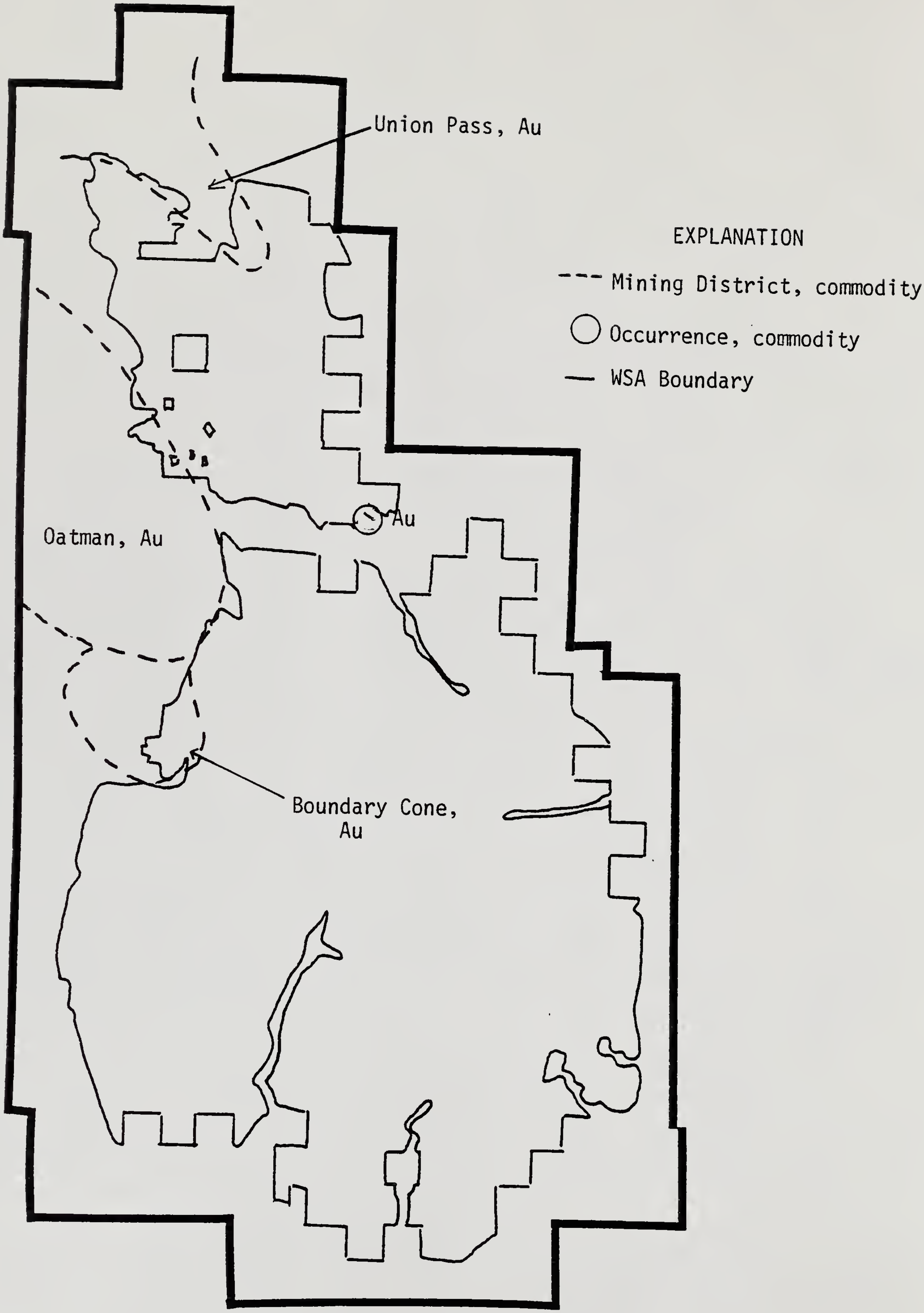


Black Mountain South GRA AZ-06



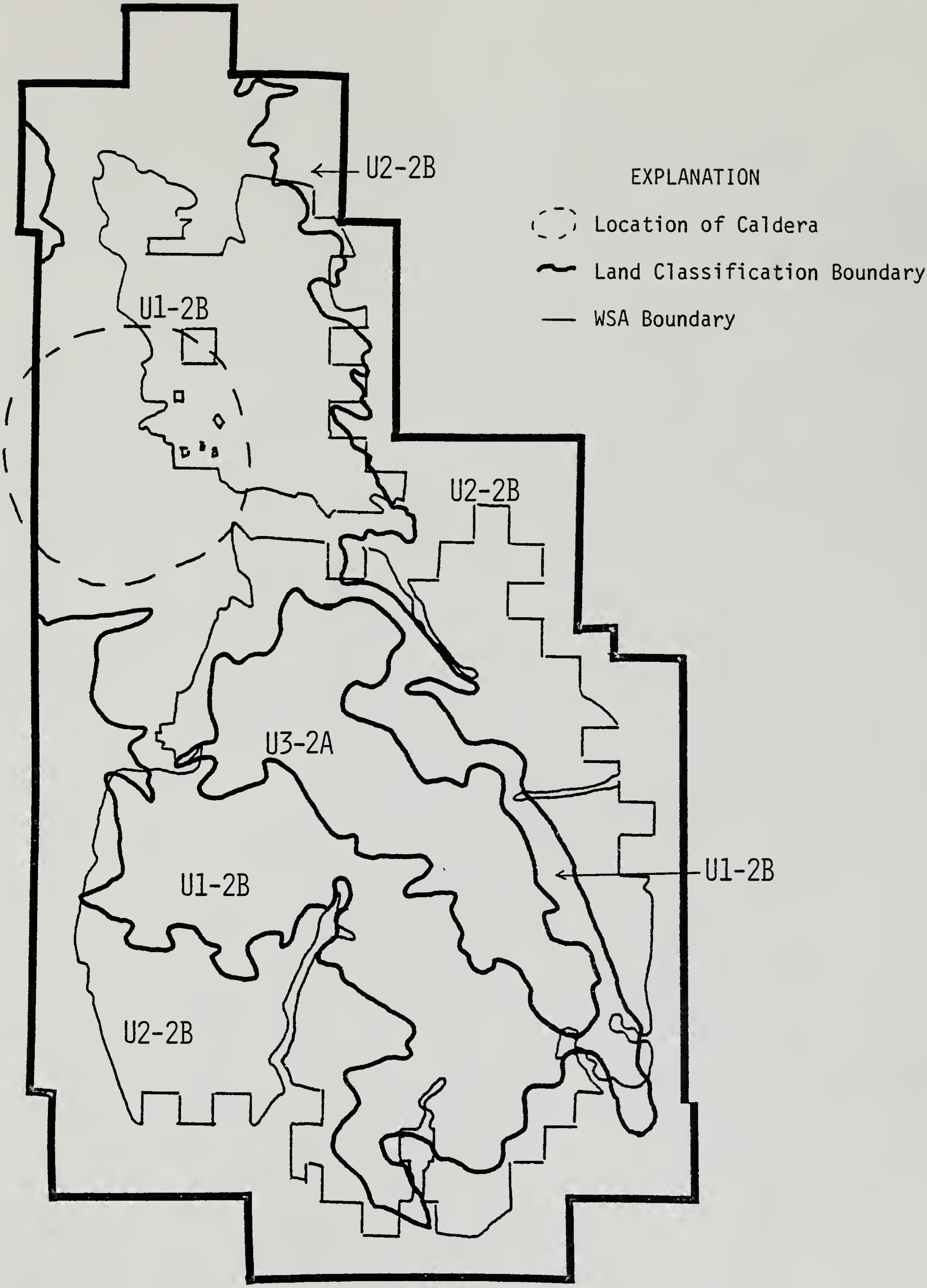
Land Classification Map/Metallics

Black Mountain South GRA AZ-06
Scale 1:250,000



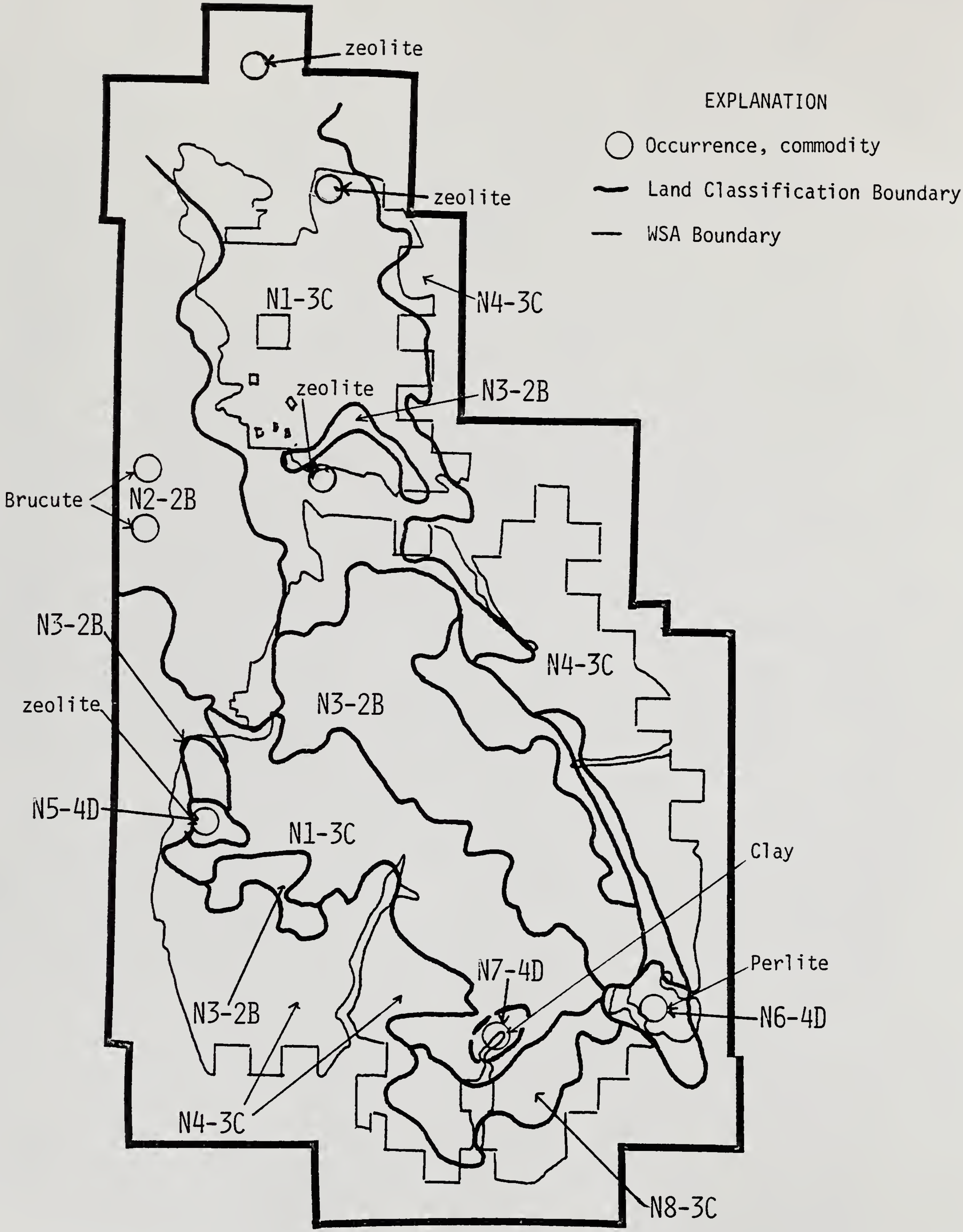
Mineral Occurrence Map/Metallics

Black Mountain South GRA AZ-06
Scale 1:250,000

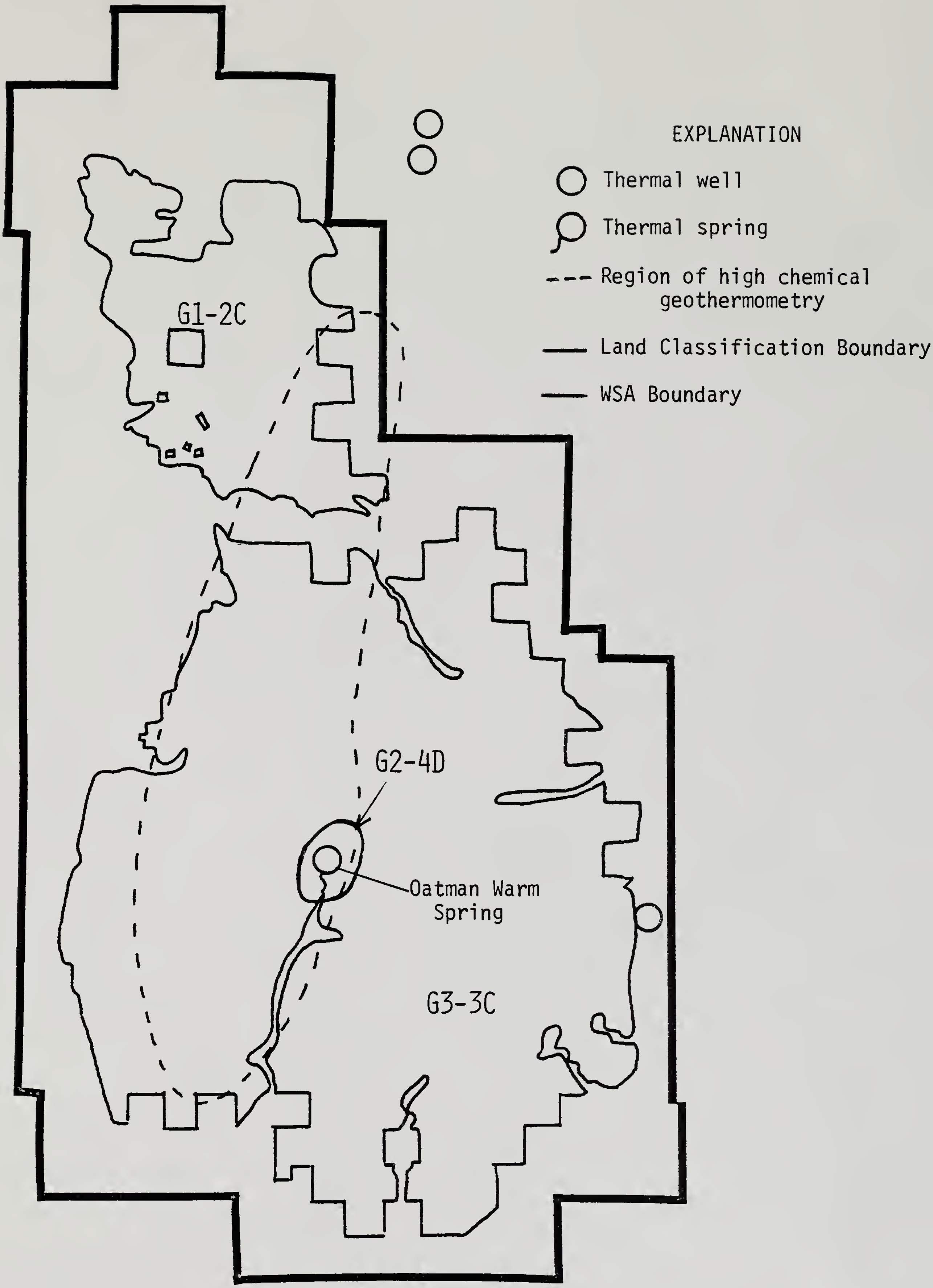


Land Classification - Mineral Occurrence Map/Uranium

Black Mountain South GRA AZ-06
Scale 1:250,000



Land Classification - Mineral Occurrence Map/Nonmetallics Black Mountain South GRA AZ-06
Scale 1:250,000



Land Classification - Mineral Occurrence Map/Geothermal

Black Mountain South GRA AZ-06
Scale 1:250,000

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 TO 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.

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

Erathem or Era	System or Period	Series or Epoch	Estimated ages of time boundaries in millions of years
Cenozoic	Quaternary	Holocene	
		Pleistocene	2-3 [1]
	Tertiary	Pliocene	12 [1]
		Miocene	26 [2]
		Oligocene	37-38
		Eocene	53-54
		Paleocene	65
Mesozoic	Cretaceous [4]	Upper (Late) Lower (Early)	136
	Jurassic	Upper (Late) Middle (Middle) Lower (Early)	190-195
	Triassic	Upper (Late) Middle (Middle) Lower (Early)	225
Paleozoic	Permian [4]	Upper (Late) Lower (Early)	280
	Carboniferous Systems: Pennsylvanian [4]	Upper (Late) Middle (Middle) Lower (Early)	
	Carboniferous Systems: Mississippian [4]	Upper (Late) Lower (Early)	345
	Devonian	Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian [4]	Upper (Late) Middle (Middle) Lower (Early)	430-440
	Ordovician [4]	Upper (Late) Middle (Middle) Lower (Early)	500
	Cambrian [4]	Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian [4]		Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600+ [3]

[1] Holmes, Arthur, 1965, Principles of physical geology: 2d ed., New York, Ronald Press, p. 360-361, for the Pleistocene and Pliocene, and Obradovich, J. D., 1965, Age of marine Pleistocene of California: Am. Assoc. Petroleum Geologists, v. 49, no. 7, p. 1087, for the Pleistocene of southern California.

[2] Geological Society of London, 1964, The Phanerozoic time-scale; a symposium: Geol. Soc. London, Quart. Jour., v. 120, supp., p. 260-262, for the Miocene through the Cambrian.

[3] Stern, T. W., written commun., 1968, for the Precambrian.

[4] Includes provincial series accepted for use in U.S. Geological Survey reports.

Terms designating time are in parentheses. Informal time terms early, middle, and late may be used for the eras, and for periods where there is no formal subdivision into Early, Middle, and Late, and for epochs. Informal rock terms lower, middle, and upper may be used where there is no formal subdivision of a system or of a series.

GEOLOGIC NAMES COMMITTEE, 1970