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MOUNT DAVIS RESOURCES AREA

(GRA NO. AZ-03)

TECHNICAL REPORT

(WSAs AZ 020-007, 020-008, and 020-021)

Contract YA-553-RFP2-1054

Prepared By

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Final Report

April 22, 1983

TABLE OF CONTENTS

Table of Contents cont.

Table of Contents cont.

Page

LIST OF ILLUSTRATIONS

ATTACHMENTS
(At End of Report)

EXECUTIVE SUMMARY

The Mount Davis Geology-Energy-Minerals (GEM) Resource Area (GRA) includes the following Wilderness Study Areas WSAs: AZ 020-007, AZ 020-008 and AZ 020-021.

The Mount Davis GRA is in western Mohave County in the Black Mountains just east of the Colorado River. The GRA is located approximately 30 miles southeast of Las Vegas, Nevada, and is adjacent to the eastern boundary of the Lake Mead National Recreation Area. The geology of the GRA consists of Precambrian (greater than 600 million years old) overlain by much younger sedimentary and volcanic rocks less than 60 million years old.

There are three mining districts within the GRA, and from north to south they are the Eldorado Pass, Gold Bug and Mockingbird, which together have produced over $100,000 in bullion prior to 1910 from quartz veins.

Strategic and critical minerals within the GRA include silver and copper. Silver is associated with the gold in the quartz veins, but production of silver was much less than that of gold. Copper is found in minor amounts in some veins, but there is a major copper-molybdenum (Cu-Mo) induced-polarization geochemical anomaly in the northern part of the GRA which could possibly represent a major Cu-Mo porphry system at depth.

There are very few patented claims in the GRA, and what few there are, are within one of the mining districts but not within any of the WSAs.

Unpatented lode claims within the GRA number over 800 and are concentrated in the eastern portion of the GRA outside the Lake Mead National Recreation Area. Two WSAs partially lie within this claim group. WSA AZ 020-007 contains approximately 15 unpatented lode claims and WSA AZ 020-008 contains approximately 53 unpatented lode claims.

Oil and gas leases cover the available Federal lands in the GRA and included WSAs, as this area is part of the Overthrust Belt, an area of high current oil interest. No geothermal leases are found in the GRA.

The two northern WSAs within the GRA (AZ 02-007 and AZ 02-008) are classified as having high to moderate favorability for metallic mineral resources with a high confidence level. This is because of their partial inclusion in or proximity to mining districts which have shown past production; proximity to known IP and geochemical anomalies, the existence of claims within the WSAs; and similar geology as the adjacent mining districts with the possibility of mineralized structures extending into the WSA.

The southern WSA, AZ 02-021, has been classified as low favorability with a low confidence level for metallic mineral resources because no known occurrences or mining claims are found in it (except one in Sec. 30), however, the geology is similar to the nearby mining districts.

Uranium and thorium have a low potential with a low confidence level in all the WSAs. Nonmetallics have a low potential with a low confidence level except for sand and gravel (saleable resources), which have a high to moderate potential with a high to moderate confidence level in parts of the WSAs. Oil and gas have a low favorability with a low confidence level, while geothermal resources have a moderate to low favorability and a low to very low level of confidence in the WSAs.

There is a lack of adequate geological mapping in this area and additional mapping and contact with those mining companies which have worked or are working in the area may prove beneficial. Sampling would also be of further assistance.

I. INTRODUCTION

The Mt. Davis G-E-M Resources Area (GRA No. AZ-03) contains approximately 90,000 acres (365 sq km) and includes the following Wilderness Study Areas (WSAs):

WSA Name	WSA Number
Van Deeman	AZ 020-007
Mockingbird	AZ 020-008
Mount Davis (4 Parcels)	AZ 020-021

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°45' north latitude, 114°30' west longitude and includes the following townships:

T 28 N, R 21,22 W	T 27 N, R 21,22 W
T 26 N, R 20-22 W	T 25 N, R 21,22 W

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

15-minute:

Mt. Perkins	Black Canyon

7.5-minute:

Mt. Davis	Chloride
Mt. Tipton	Grasshopper Junction

The nearest town is Willow Beach which is located about 10 miles northwest of the GRA and about 5 miles west of U.S. Highway 93. Access to the area is via U.S. Highway 93 in the northeast and via Cottonwood Road in the southeast. Access within the area is by light 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 column 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 two of the three WSAs were field checked on the ground October 23, 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 XXX page 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.

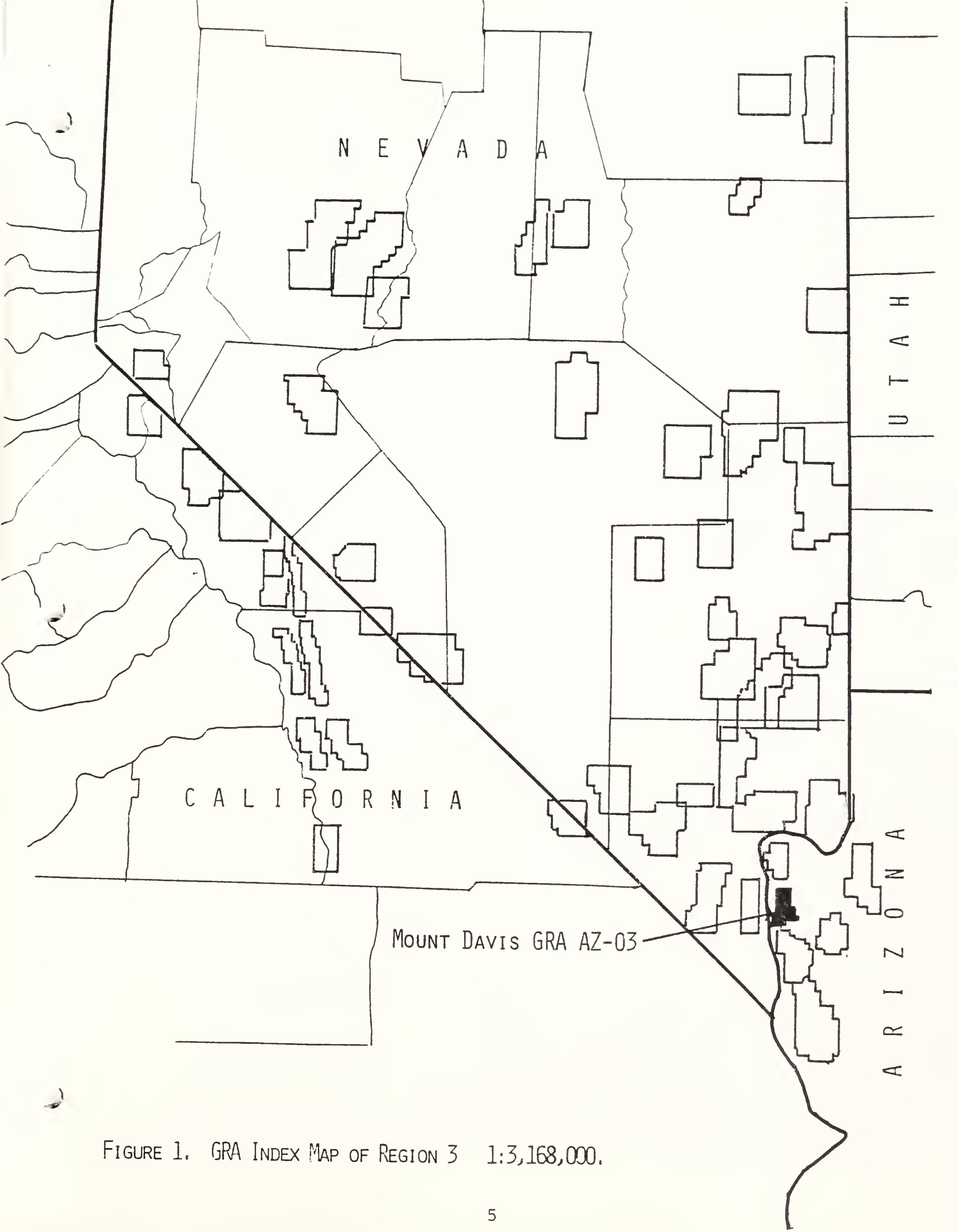
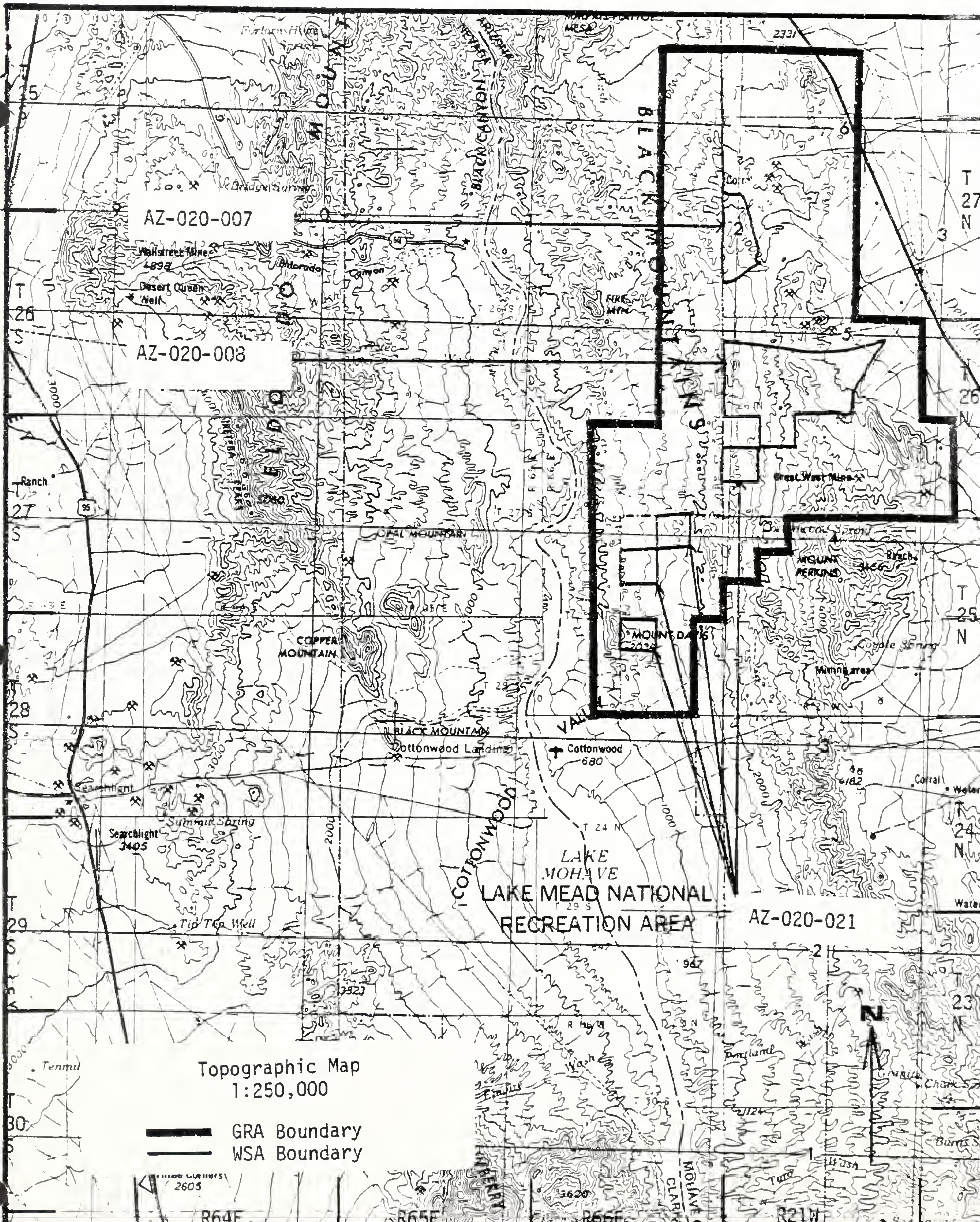


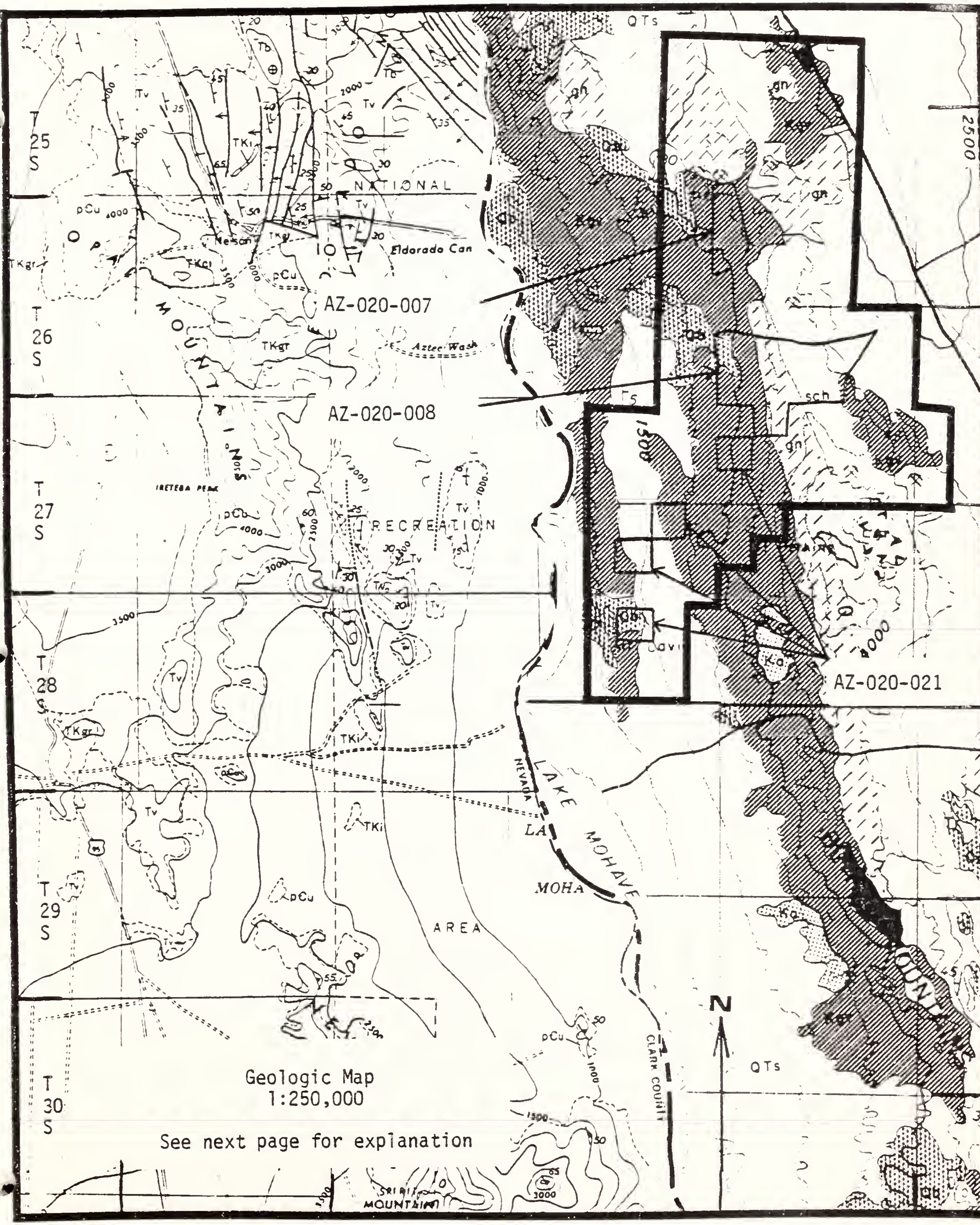
FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Kingman Sheet

Mount Davis GRA AZ-03

Figure 2



Mohave County Geologic Map, Wilson and Moore (1959)

Mount Davis GRA AZ-03

Figure 3

EXPLANATION

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.

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.

Lgr
Granite and related crystalline rocks

Dikes and plugs
Rhyolitic to andesitic in composition.

Ks
Limestone conglomerate

Ka
Andesite
Flows, tuff, and agglomerate

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

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

Rc
Chinle formation

Rs
Shinarump conglomerate

Rm
Moenkopi formation

QUATERNARY

TERTIARY

CRETACEOUS

TRIASSIC AND JURASSIC

TRIASSIC

LARAMIDE

EXPLANATION CONT.

TRIASSIC

℞c	**Chinle formation**
℞s	**Shinarump conglomerate**
℞m	**Moenkopi formation**

PERMIAN

Pk	**Kaibab limestone** *Includes Toroweap formation*
Pc	**Coconino sandstone**
Ph	**Hermit shale**

CAMBRIAN MISSISSIPPIAN PENNSYLVANIAN AND DEVONIAN AND PERMIAN

PPs	**Supai formation**
PPc	**Callville limestone**
CDl	**Redwall and Martin limestones**
Ct	**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 Mount Davis GRA is an assemblage of Precambrian basement rocks overlain by Tertiary volcanics and younger sediments. The Precambrian consists of metamorphosed gneiss and schist with intercolated granitic assemblages. The volcanics can be divided into two distinct assemblages, both Miocene in age, consisting of rhyolitic to intermediate flows and tuffs. Detrital valley fill makes up most of the remaining section in the area.

The structure of the area is dominated by Basin and Range influences but modified by the Colorado River. Drainage flows to the river and on the west deep canyons have stripped off much of the older detrital alluvium exposing bedrock consisting of both the Precambrian and Tertiary volcanics.

Recent geological mapping in the northwest part of Arizona is lacking and the only geologic map available which covers all the 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 what was originally mapped, both in age and origin. The principal source of information for the general geologic description for this GRA is from Anderson, 1978, Geologic Quadrangle Map of the Black Canyon Quadrangle, which bounds the north portion of the GRA. Information on the geology to the south of this GRA is therefore sketchy, and has had to be interpolated to a large extent.

1. PHYSIOGRAPHY

The Mt. Davis GRA is located in the Basin and Range Province in western Mohave County, Arizona, near the Colorado River. The study area includes the portion of the north-south trending Black Mountains from Mt. Davis in the south to several miles southeast of Flattop Mesa in the north. The Black Mountains lie between the Detrital Valley on the east and the Colorado River on the west. This area is not typical Basin and Range topography, as runoff does not flow to enclosed basins, but rather the Colorado River has modified the drainage. Much of the runoff flows west to the Colorado River carving deep canyons in previous valley fill and underlying bedrock. To the east the drainage is into Detrital Wash, which flows north until it reaches the Colorado River near Bonnelli Landing.

Elevations along the crest of the range average about 3,000 feet with the highest point being the northern slope of Mt. Perkins which reaches 4,400 feet. The lowest elevation in the GRA is just adjacent to Lake Mohave, which has a constant water level of approximately 647 feet above sea level.

2. ROCK UNITS

The oldest rocks in the study area are metamorphosed Precambrian rocks consisting of biotite-almandine gneiss and schist, and garnetiferous granite pegmatite. The unit is often segregated into bands of granite gneiss and schist a few feet to many tens of feet wide. There are locally both mafic and silicious segregations. These metamorphosed Precambrian rocks are found near the northern border of the GSA and along its eastern edge.

A Laramide(?) age granitic intrusive is found in the Gold Bug district in the west central portion of the GRA.

Deposited unconformably over the Precambrian metamorphics is a series of Tertiary volcanics. These volcanic rocks include the Patsy Mine Volcanics, and the Mount Davis Volcanics both of Miocene age. The Patsy Mine Volcanics consist of rhyolite lavas and tuffaceous sedimentary rocks in its upper part to andesite lava and breccia in its lower part. Sedimentary rocks consisting of volcaniclastic and tuffaceous rocks are also present locally (Anderson, 1978). These volcanics are found throughout the GRA, but predominate in the west. On the Mohave County Geologic Map (Wilson and Moore, 1959) these volcanics were dated as Cretaceous and were not subdivided.

Overlying the above metamorphic and volcanic assemblage, again unconformably, is the Muddy Creek Formation of Pliocene-Miocene age. It has previously been mostly mapped as alluvium on the county map in the north portion of the GRA. It consists of mostly detrital alluvial deposits derived from the Black Mountains subsequent to their uplift by basin and range faulting. One member of the unit is the Fortification Basalt Member, described by Anderson as lavas which are intercalated with and overlying the sedimentary rocks of the Muddy Creek Formation. Malpais Flattop Mesa consists of several separate basalt flows and other areas within the GRA which are mapped as Quaternary basalts are also probably this same unit.

Quaternary alluvium is found in all the washes flowing west to the Colorado River and throughout Detrital Valley to the east.

3. STRUCTURAL GEOLOGY AND TECTONICS

The oldest structures preserved within the GRA are found in the Precambrian metamorphic rocks, where they appear as schistosity, folding and minor thrusting. The trend of the schistocity is about N 30°E, with the dip vertical or steeply to the east. Jointing and faulting in the Precambrian rocks predominantly trends north-northwest, with vertical or steeply east-northeast dips. Fissures in the Tertiary volcanics approximately follow the joint pattern trend of the underlying Precambrian basement rocks (Schrader, 1909).

Tertiary Basin and Range faulting has obviously had an influence on the present day topography of downdropped valleys and uplifted ranges.

The Black Mountains is a compound horst block. Much tectonic movement was taking place during mid-Tertiary with basin and range faulting starting in the Miocene. Along the western boundary of the Black Mountains there are steeply dipping, northerly trending faults with large displacements.

4. PALEONTOLOGY

The majority of the Mount Davis GRA is not favorable for preservation of fossils. Fluviatile and lacustrine sediments within Lake Mohave are a potential site for the occurrence of Quaternary nonmarine mollusca (Hannibal, 1912) and vertebrates from strata mapped as Quaternary. No fossiliferous localities have been recorded from within this GRA. Other lithologies within this GRA are not suitable for preservation of paleontological resources.

5. HISTORICAL GEOLOGY

During the Precambrian granitic igneous rocks were metamorphosed to gneiss and schist. A long period of erosion followed, presumably base-leveling these rocks. Paleozoic marine sediments similar to those found in the Grand Canyon area, but thinner, were probably deposited over the Precambrian metamorphics, but were removed by erosional processes during early Tertiary and pre-Tertiary time (Lee, 1908).

Volcanism began during the middle Tertiary with the extensive extrusion of andesitic to rhyolitic flows and tuffs. Contemporaneously with or shortly after the deposition of these flows, basin and range uplift renewed the erosional processes which stripped away these volcanics in the eastern half of the study area, once again exposing the Precambrian rocks.

The erosion of highlands and the deposition of stream gravels formed thick layers of alluvial deposits during late Tertiary, and were intercolated with locally numerous basalt flows.

The Colorado River cut into the nearby landscape to the west and erosion proceeded rapidly carving steep canyons along the west slope of the range. The alluvial gravels were eroded away to a great extent exposing the underlying Precambrian metamorphics and Tertiary volcanics. This is the same geological regime which dominates the area at present. Recent alluvium is found in the western drainages and in the wide valley to the east.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

Several mining districts which produced mainly precious metals are located within the Mount Davis GRA. Listed from north to south, the Eldorado Pass, Gold Bug and Mockingbird districts produced over $100,000 in bullion prior to 1910 from quartz-filled fissure veins.

The Eldorado Pass district located in T 27 N, R 21 W, contains several mines located on gold- and silver-bearing quartz veins cutting Precambrian granite which is intruded and locally overlain by Tertiary volcanics. Mines included within the district are the Pope, Burrows, Pauly, and Flynn group. The Burrows mine (Sec. 12, T 27 N, R 22 W,) was the largest gold producer with an estimated past production of +$10,000 (Schrader, 1909). In the southern part of the district, the Pauly mine produced an unknown quantity of copper from a vein along a granite-volcanic contact.

The Gold Bug district is located near the summit of the range midway between the Eldorado and Mockingbird districts, three miles to the north and south respectively. Mines within the district have developed on several narrow, parallel, epithermal, northeast-trending, quartz veins or shear zones in Miocene volcanics. The ore contains rich free gold-bearing quartz with minor silver and favors the hanging wall where it is locally associated with a diorite dike. Rich ore has been extracted from the oxidized zone which extends down about 300 feet. The principal mine in the district was the Gold Bug which produced $65,000 from rich oxidized ore that has reportedly been mined out (Schrader, 1909). Other past producing mines in the distruct are the Mohave, Porter and Golden Age, and Liberty properties. The Van Deeman mine located in Sec. 29 of T 27 N, R 21 W, produced an unknown quantity of gold and silver from quartz veins cutting Precambrian metavolcanics overlain by Tertiary andesite (MILS data).

The north-south-trending Mockingbird district is about five miles long and two and one-half miles wide. The principal mines in the district were the Mockingbird, Hall, Great West, and Poccahontas, which together produced about $40,000 from flat-lying and steeply dipping north-south-trending epithermal veins. A recent report on the Mockingbird district by Gulf Mineral Resources (Wilkins, 1982) estimates 500,000 tons of ore-grade material averaging 0.10 oz. of gold per ton.

The Mockingbird mine, located in the northern portion of the district, was developed on a flat lying vein in an altered lamprophyre dike. The 6-foot thick vein consists of red and green stained quartz and breccia with the finely divided gold usually associated with abundant hematite. Past production is more than $20,000 with blocked out ore of several times this amount remaining in the mine. This property was visited in the field on October 23, 1982, which confirmed the flat-lying vein and abundant mining claims in the area.

The Hall, Great West, and Pocahontas mines are situated in low foothills of Precambrian granite in the southern part of the district. The mines developed steeply north dipping, east-west-trending, narrow, quartz veins which contain free gold and auriferous pyrite. Development at these mines reached a depth of about 200 feet. Past production figures for these mines is not available.

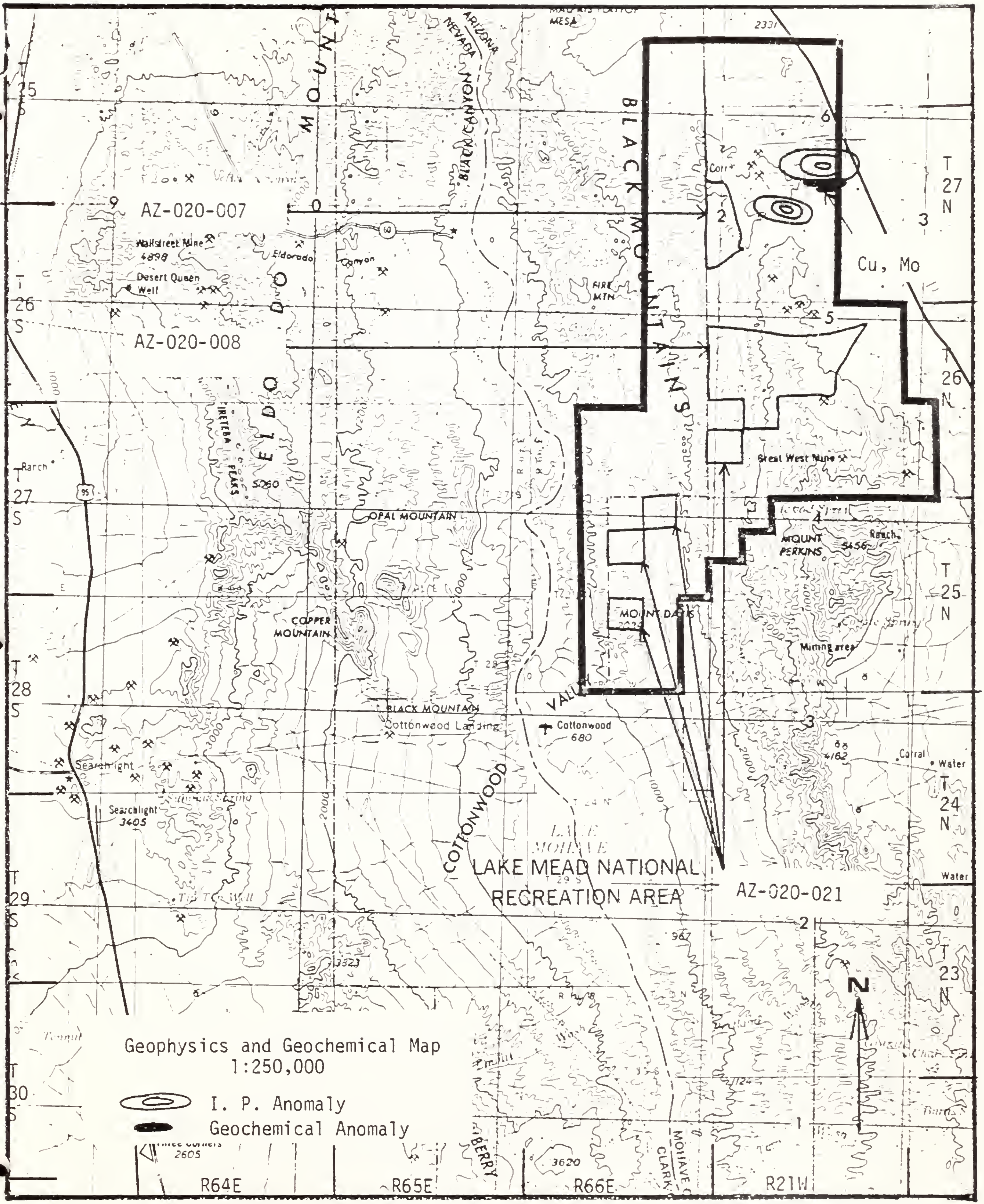
The Fayro #1 Mine, located southeast of the Mockingbird district, produced an unknown quantity of gold, silver, and sand. The source rock for the placers is probably the exposed eroding auriferous quartz veins of the Mockingbird District (MILS Data).

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Scattered prospects and pits occur within the vicinity of the three known gold producing districts in the study area. Shallow shafts, pits, and short adits are probably located along the extensions of known producing quartz veins and minor parallel structures.

A large IP anomaly related to disseminated sulfides in Precambrian schists has been detected one mile due east of the Pope Mine in the Eldorado Pass District by Kennecott (Figure 4). A copper-molybdenum geochemical anomaly corresponding with outcroppings of quartz monzonite is located on the southern edge of the IP anomaly and is probably related to it (Anonymous source, 1982). Gulf Mineral Resources has claimed a large portion of land on the eastern edge of this anomaly.

An IP anomaly about two square miles in area has also been identified to the south in Secs. 20 and 21, T 27 N, R 21 W, by Utah International. A zone of secondary quartz-sericite alteration occurs on the southeastern edge of the IP anomaly; and one mile southeast of this area occurs a zone of quartz veinlets in schist which was drilled by Utah International in 1977. The sericitized quartz veinlets contain pyrite, chalcopyrite and about .002% molybdenum.



Mount Davis GRA AZ-03

Figure 4

A copper prospect in Sec. 7, T 26 N, R 21 W, has explored mineralization near a north-south-trending contact between Precambrian schist and Tertiary lavender andesite. Spotty copper mineralization occurs along joints and in quartz veinlets within a half mile stretch parallel to the schist-andesite contact.

The Van Deeman mine area has several prospects which explored veinlets bearing copper, barite, and gold. Mineralization is erratic and restricted to shear zones (Major Mining Company Source, 1982).

3. Mining Claims

Very few sections within the study area contain patented claims. Several patents have been located in the Gold Bug and Eldorado districts, but the majority of claims are large blocks of unpatented claims covering the mining districts and I.P. anomalies. Within the GRA nearly 46 square miles has been at least partially claimed (see Claim Map).

A large blanket of unpatented claims covers most of the three major mining districts and I.P. anomalies described above. Gulf Mineral Resources has staked 332 lode claims over the eastern edge of an I.P. anomaly in the northeast quarter of T 27 N, R 21 W. D & G Mining Company staked at least 90 lode claims along the western portion of this anomaly in 1964 and has kept the assessment work current through 1981. Large blocks of claims staked by Charlie Klunkes were located in the Gold Bug district and the Van Deeman mine area. These claims are located in the general area of interest of Utah International. Numerous smaller blocks of claims have been located in the Mockingbird district to the south by various claimants.

The Van Deeman mine area is apparently the site of an upcoming cyanide heap-leach operation for gold recovery from old waste dumps and surface ore according to a mining plan filed with the Kingman BLM office.

4. Mineral Deposit Types

Historically, production from mining districts and isolated mines within the Mt. Davis GRA have produced mainly gold and silver and some base metals from mineralized zones within quartz filled structures and shear zones. Total production from the GRA is probably below $100,000 (Elsing and Heineman, 1936).

From north to south the Eldorado, Gold Bug, and Mockingbird districts produced mainly gold and silver from pods and ore shoots in the oxidized portions of narrow epithermal quartz veins. The average depth of development of the oxidized portion of the veins is about 300 feet, with an increase of base metals with depth. Veins are often associated with dikes of varying composition which were also emplaced along the structures.

The large IP anomalies identified by Kennecott and Utah International in the northeastern portion of the GRA have a considerable exploration potential. Large blocks of ground surrounding these anomalies were staked in the early 1970s and have had assessment work filed annually through 1981. It is not known to what extent these properties have been explored for copper-molybdenum porphyry potential.

5. Mineral Economics

The narrow quartz veins from which gold, silver and base metals have historically been produced, are not currently of exploration interest to most major large mining companies because of target type and small tonnage potential. Because the veins range from only several inches to a maximum of five feet thick, costly underground extraction methods would be needed.

An exceptionally high grade ore would be required to finance underground mining of these small to moderate size deposits. Reportedly, most of the high grade oxidized ore has been depleted from these mines. As reported by Gulf Minerals (Wilkins, 1982), however, it appears that these vein-type deposits in the Mockingbird district have potential for further production by open pit mining methods of significant amounts of precious metals.

The economic potential for smaller companies mining small precious metal deposits may be good in this area as is evidenced by the gold heap leach operation apparently starting at the Van Deeman Mine.

The IP anomalies and large areas surrounding them were staked by large mining companies in the early 1960s and 1970s, with assessment work kept current through 1981, indicating continued interest in the properties. It is not known to what extent these properties have been explored for copper-molybdenum porphyry potential.

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 -- and 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 byproduct 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

There are no known nonmetallic mineral occurrences within the GRA other than sand and gravel.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

The only reported nonmetallic mineral occurrences within the GRA includes barite in the gold-copper veins at the Van Deeman Mine and reported sand extraction at the Fayro #1 placer mine southeast of the Mockingbord district. No additional information is known about these occurrences.

Several potential material sale sites (sand and gravel) for construction purposes and for maintenance of public highways has been identified by the Arizona Department of Transportation. These sites are in alluvium on the east flank of the Black Mountains and in and around WSA AZ 020-008. In fact a material sale permit was mistakenly issued to the department from on a site within the eastern boundary of this WSA, but no extraction has as yet taken place and the material sale is to be cancelled. The apparent favorability of this area for sand and gravel may be because the alluvium here is derived from the Precambrian rocks to the immediate west. In general this material is more competent than alluvium which is derived from volcanic bedrock, which predominates in much of the Black Mountains.

There is a possibility of mineral producing pegmatites existing within the Precambrian, such as in the northern Mt. Wilson GRA, but none have been reported. Field checking of the Precambrian unit indicated there were some coarse-grained granitic dikes or phases which probably have previously been referred to as pegmatites.

Perlite may occur in the rhyolitic phases of the Mt. Davis and Patsy Mine volcanics, similar to the Black Mountains GRA to the south, but none has been reported.

3. Mining Claims, Leases and Material Sites

There are no known nonmetallic mining claims or leases within the GRA.

4. Mineral Deposit Types

The reported barite occurrence is found in epithermal veins associated with gold and copper mineralization. The sand and gravel occurrences are part of detrital alluvium derived from erosion of the adjacent mountains.

5. Mineral Economics

Since very little is known about nonmetallic occurrences within the GRA, the mineral economics cannot be addressed except that the lack of known nonmetallics would indicate a low economic potential.

The barite probably occurs in minor amounts in the vein deposits as an accessory mineral. Sand and gravel resources are known to exist, and the Arizona Department of Transportation is interested in the area for construction needs for nearby roads.

In general not enough is known concerning potential nonmetallic mineral resources of the GRA. Other commodities could possibly exist which as yet have not been recognized.

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 per cent of all sand 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.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

   There are no known uranium or thorium deposits within or near the GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

   No uranium or thorium occurrences have been noted within or near the GRA.

3. Mining Claims, Leases, and Material Sites

   Claims and leases for uranium and thorium have not been noted for the GRA or surrounding area.

4. Mineral Deposit Types
   No uranium or thorium deposits are known within or near the study area.

5. Mineral Economics

The GRA apparently does not contain economic concentrations of uranium or thorium.

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 & Gas Resources

There are no known oil and gas deposits, hydrocarbon shows in wells or as surface seeps in the region, but essentially all the Federally-administered lands within and in the vicinity of the WSA are leased for oil and gas resources (see Oil and Gas Lease Map). This area is considered to be within the Overthrust Belt, and consequently is considered to have potential for oil and gas. There is no oil and gas occurrence and land classification map for this report.

Geothermal Resources

There are no known geothermal deposits, prospects, or occurrences within the Mt. Davis GRA or in the immediate region; nor are there any Federal geothermal leases in the region. There is no geothermal lease map, but there is a geothermal occurrence and land classification map at the back of the report.

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

The western portion of the GRA is within the Lake Mead National Recreation Area which is sometimes known for its scenic geologic resources.

E. STRATEGIC & 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.

Strategic and critical mineral commodities reported within the GRA include copper and silver. The silver was produced and is found in veins often associated with gold, while the copper has been found to a small extent in vein deposits. IP and geochemical anomalies suggest there may be a large Cu-Mo porphry system in the northern part of the GRA.

IV. LAND CLASSIFICATION FOR G-E-M 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 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 reasons 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.

The very northern portion of the GRA is covered by Andersons (1978) geologic map at a scale of 1:62,500 but coverage does not include any of the WSAs. Geologic mapping of the WSAs is found on Wilson and Moore's (1959) Mohave County map at a scale of 1:375,000 or Longwell's (1963) reconnaissance geologic map. Neither of these maps are detailed in geology or structure and neither address mineralization.

With respect to the WSAs, the detail of the published geologic mapping is inadequate for the purpose of assessing the mineral potential. The other available information concerning the mining districts and present interest in the area, however, is good. Overall, our confidence level in the information available for WSAs AZ 002-007 and AZ 002-008 is high. Our confidence level in the information available for WSA AZ 002-021 is moderate.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA AZ 020-007 and WSA AZ 020-008

M2-3D. This classification indicates a moderate favorability with a high confidence level, and includes much of the bedrock area of the Black Mountains within this GRA, consisting of either the Tertiary volcanics or Precambrian rocks. The gold-silver-bearing quartz veins are found in both. The potential in this classification area is for gold-silver. We believe the potential for mineral deposits is high based on the evidence discussed below.

M1-4D. This classification indicates a high favorability with a high confidence level and includes the three mining districts in the GRA. The three have shown past production and include the Eldorado, Gold Bug and Mockingbird districts. A more detailed discussion of the districts are included in the discussion below for classification area M2-3D.

A field check of the Mockingbird WSA, WSA AZ 020-008, indicated there were mining claims within the WSA, several prospect pits following varied attitudes of mineralized structures within the WSA, and adjacent mines and prospects showing north-south trends extending into the WSA. An aerial reconnaissance of the WSA indicated that the major structural trends within the WSA are generally north-south and therefore extend into the adjacent areas which have been mined in the past.

Wyman (1974) in his dissertation on the relationship of exploration targets to structure in the region, listed the Mockingbird district as a potential exploration target based on favorable geologic structures, igneous activity and mineralization.

A Gulf Mineral Resources report (Wilkins, 1982) indicates the Mockingbird district, extending into the southern portion of WSA AZ 020-008, has a potential of 500,000 tons of 0.10 oz of gold/ton. They believe the deposit may be amenable to open-pit mining and leaching.

At least one exploration company (anonymous source) believes the area has high potential based on the structural similarity to the Eldorado mining district to the west across the river in Nevada. There, Anderson (1971) has described low angle structures related to detachment faulting. Similar structure is found in this region of the Black Mountains in Arizona.

The Mockingbird WSA lies between the Gold Bug mining district on the north and the Mockingbird mining district on the south, both of which show past production. Both districts are reported to have followed northerly-trending gold veins, meaning these structures could be extrapolated into the WSA. Approximately 53 lode claims have been staked within this WSA.

The northernmost WSA, the Van Deeman WSA, AZ 02-007, is in close proximity to mineralized areas, and lies between the Pope mine on the north and the Van Deeman mine on the south. The Van Deeman mine is presently the site of a soon-to-be started small gold heap leach. The WSA borders on the east with an IP anomaly that was reportedly found by Utah International in the early seventies and which is now staked. Approximately 15 lode claims are found within the WSA, and are part of a large group of over 400 lode claims located in the early 70s in this area and to the east by "Klunkes" in the early 70s.

This classification area also includes another IP (Induced Polarization) anomaly and at least one associated Cu-Mo geochemical anomaly. These anomalies were only recognized during the last decade, and subsequently practically every inch of ground has been located. The anomaly extends out into the alluvial cover of the valley to the east and this area has also been staked. We do not know the extent of exploration of this area or whether the anomalies have been drilled.

The boundary of this classification area extend outside the two referenced WSAs and are subject to varied interpretation and drawn principally using similar geology, locations of past producers and prospects, and claim locations. The available geologic mapping (Mohave County Geologic Map) has many discrepancies, but was used for this delineation. The classification area was also extended into Lake Mead National Recreation Area based on similar geology and the fact the claim blocks terminate when they intercepte the boundary of the recreation area. It is not legal to locate claims within the Recreation Area however locatable minerals are leasable. For various reasons leases for minerals within Lake Mead National Recreation Area are either not often pursued or not generally issued by the Park Service.

M2-3B. This classification area is one of moderate favorability with a low confidence level, and includes the deeper alluvial cover on the extreme eastern edge of WSA AZ 020-008. The depth of the alluvial cover and the nature of the underlying bedrock is unknown. However, the area is classified as moderate potential because of the adjoining high to moderate favorability areas, inferring that these classifications may continue beneath the alluvial cover.

WSA AZ 020-021

M4-2B. This classification area of low favorability and low confidence level covers three square miles of the WSA and includes the bedrock area underlain by Tertiary volcanics and alluvium which includes Mt. Davis along the western boundary of the GRA. The area contains no known prospects or occurrences and no claims, indicating a lack of interest in the area. The reason for the rating of low favorability, 2, is that according to the available geologic mapping (Wilson and Moore, 1959) the geology is similar to that to the east where mineralized quartz veins cut the Tertiary volcanics. The three mining districts previously described in the area to the northeast show mineralization in both Tertiary volcanics and the underlying Precambrian rock. The nature of the underlying bedrock or Precambrian at this location is unknown, but it could be mineralized.

b. Uranium and Thorium

WSA AZ 020-007

U1-2B. This classification area includes Precambrian pegmatites, granitic gneiss and schist plus Miocene volcanics of rhyolitic to andesitic composition. The area includes all of the WSA, and it is considered to be of low favorability at a low confidence level for uranium and thorium deposits. There are no known uranium or thorium occurrences or anomalies in or near the WSA or the GRA. There is some potential for uranium and thorium in the Precambrian pegmatites, and for uranium as vein deposits in the Precambrian rocks and Miocene rhyolitic volcanics. Both of these units could be environments for uranium. These Miocene volcanics were eroded from the eastern half of the WSA and the GRA soon after deposition due to Basin and Range uplift. The western part of the WSA and the GRA is, therefore, more prospective for uranium mineralization though uranium's high mobility still makes the eastern area moderately prospective.

WSA 020-008

U1-2B. This classification area has a low favorability at low confidence level for uranium and thorium deposits as discussed under WSA 020-007.

U2-2B. This classification area has a low favorability for uranium and thorium deposits at a low confidence level. It includes Quaternary-Tertiary alluvium and Miocene-Pliocene Muddy Creek Formation alluvial deposits. There is a low potential for resistate mineral concentrations of uranium and thorium in the alluvium, though the sedimentary processes along the mountain range probably would not provide sufficient reworking of the sediments in an aqueous environment to allow concentration of the resistate minerals as heavy mineral sands. The source of the uranium and thorium would be the Precambrian pegmatites in the Black Mountains.

The area has some potential for small epigenetic sandstone-type uranium deposits in the alluvial sediments of the Muddy Creek Formation and the Quaternary-Tertiary alluvium. Sources of the uranium could be the Precambrian granitic metamorphic rocks or the Miocene rhyolitic volcanics. However, fluvial sand channels are most likely not well developed in the alluvial deposits, and there is probably a lack of reductants (e.g. organic material) to precipitate the uranium from ground water in these particular sedimentary deposits. There are no known sandstone uranium deposits in or near the WSA and the GRA, though there are a number of small uranium occurrences in the Muddy Creek Formation in northwestern Mohave County (Luning and others, 1981).

WSA 020-021

U1-2B. This classification area has a low favorability for uranium and thorium deposits at a low confidence level as discussed under WSA 020-007.

U3-2B. This classification area through the center of the WSA includes Quaternary-Tertiary alluvium and Miocene-Pliocene Muddy Creek Formation alluvial deposits. It has a low favorability for uranium and thorium deposits at a low confidence level as discussed under WSA 020-008, area U2-2B.

U4-2B. This classification area on the western part of the WSA includes Miocene rhyolitic and andesitic volcanics. It has a low favorability for uranium deposits at a low confidence level and is not prospective for thorium deposits. There are no known uranium or thorium occurrences within or near the WSA or the GRA. The Miocene rhyolitic volcanics are a potential uranium source and uranium could be concentrated in fractures within the volcanics. There is no apparent source for thorium in or near the WSA.

c. Nonmetallic Minerals

WSA AZ 020-008

N1-2B. This classification indicates low favorability with a low confidence level. This area includes all the bedrock outcrops within the WSA, from the Precambrian on the east to the Tertiary volcanics to the west. No nonmetallic occurrences have been reported except for barite as minor gangue mineralization in some gold-copper veins to the north. The low favorability is based on the fact that pegmatites have been mined to the north of this GRA in the same Precambrian rocks which are found in this GRA, and that there are perlite occurrences to the south of this GRA in apparently similar volcanic units. The lack of detailed geologic information and mapping precludes a more definitive classification of this GRA. The rock units could, however, be used for various construction applications.

N2-4D. This classification indicates a high favorability with a high confidence level. This area includes the eastern part of the WSA, which has been designated by the Arizona Department of Transportation as a suitable materials site for use in constructing and maintaining nearby public roads.

WSA AZ 020-007

N1-2B. This classification indicates a low favorability with a low confidence level. This area covers the entire WSA which has been mapped as volcanic rocks. The rationale for its low favorability for nonmetallic minerals is similar to that described above under WSA AZ 020-008. Reconnaissance from the air indicated this WSA did not look favorable for perlite occurrences, however.

WSA AZ 020-021

N1-2B. This is a low favorability classification with a low confidence level. One section of this WSA, lying to the immediate south of WSA AZ 020-008, is included in this classification for the same previously mentioned reasons. The square mile is composed entirely of volcanics. The same rationale applies as described above for this same classification area in WSA AZ 020-008.

N3-2B. This is a low favorability classification with a low confidence level. This area includes the volcanic rocks in the Mount Davis area. No nonmetallics have been reported here. There is a possibility of perlite occurrences, since similar geology to the south is reported to have perlite. Also, any of the included rock units could be used for some type of construction material application.

N4-3C. This classification area includes the sand and gravel in the alluvium along the western portion of the GRA and affects only WSA AZ 020-021. The 3 classification indicates a moderate favorability for the accumulation of sand and gravel resources as the area is mapped as alluvium. The C confidence level indicates a moderate level of confidence in this classification because most alluvium is composed of sand and gravel. It has not been classified higher however because the physical and chemical properties of the material in this area is unknown. Additional testing would need to be completed before it was known if the material could be effectively utilized as sand and gravel.

2. LEASABLE RESOURCES

a. Oil and Gas

WSAs AZ 020-007, AZ 020-008, AZ 020-021

OG1-2A. 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.

b. Geothermal

WSA AZ-020-007

G1-3B. The WSA is within one mile of a southeast-trending, linear outcrop of Quaternary basalt. These youthful volcanics indicate a probable shallow heat source at depth. The linear configuration of the outcrop indicates it is controlled by a major fault which appears to extend into the WSA.

WSA AZ-020-008

G2-3B. This classification incorporates an area of Quaternary basalts which indicate, because of their youth, the presence of a heat source and probable favorable structure.

G3-2A. The very general nature of the geologic map makes a positive determination difficult, except to note that Quaternary basalts have been mapped throughout the immediate region.

WSA AZ-020-021

G4-2A. The very general nature of the geologic map makes a positive determination difficult, except to note that Quaternary basalts have been mapped throughout the immediate region. The linear configuration of the mountain front indicates the probable presence of deep-seated normal faults in both sections.

G5-3B. This classification incorporates an area which includes Quaternary basalts, which indicate the presence of a heat source and probable favorable structure.

c. Sodium and Potassium

S1-1B. The included WSAs are not considered to have potential for sodium or potassium.

d. Other

There are no other leasable mineral commodities known within the WSAs in this GRA.

3. SALEABLE RESOURCES

The sand and gravel discussion for all three WSAs has been included above under the nonmetallic classification and includes areas N4-3C and N2-4D.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

1. Time would be well spent further contacting mining companies or individuals who have worked or are working in this GRA to get as much additional detailed information as possible on the geology and potential mineralization in the area.

2. More detailed geologic mapping of the WSAs and the surrounding mining districts would help greatly in assessing the mineral potential of the individual WSAs.

3. Detailed geochemical sampling would further assist in delineating potential favorable areas of mineralization.

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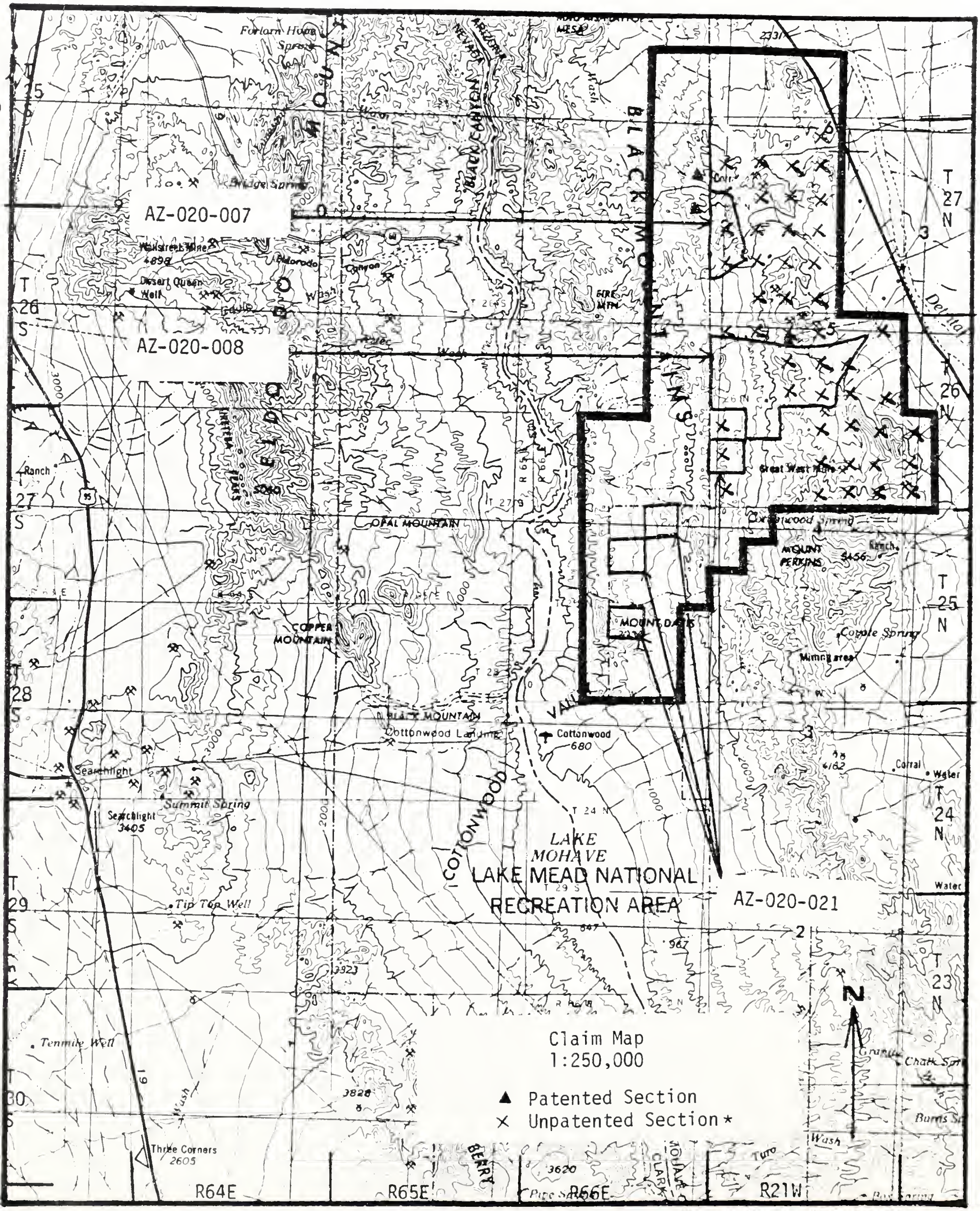
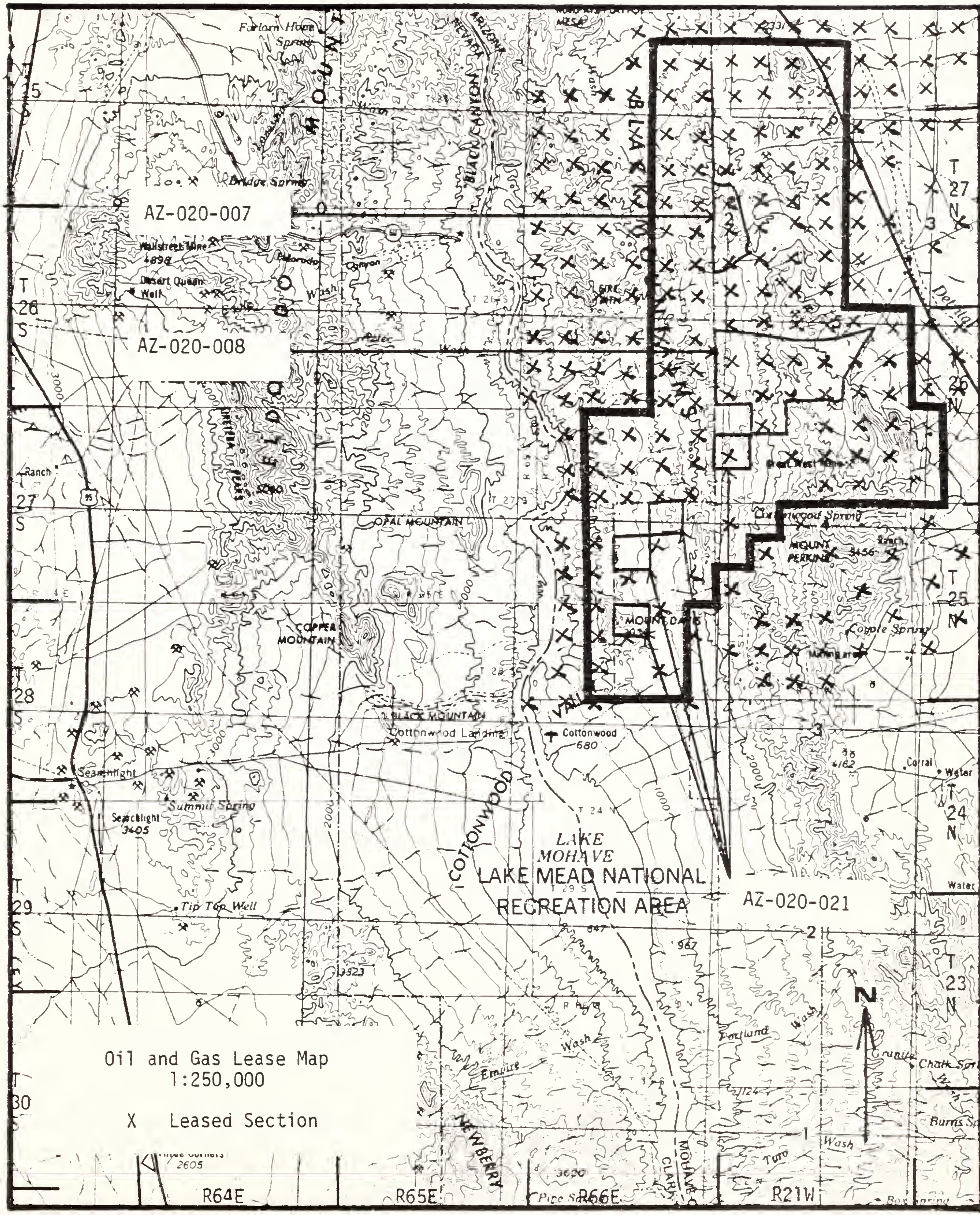


Mount Davis GRA AZ-03

*X denotes one or more claims per section


AZ-020-007
AZ-020-008
AZ-020-021
LAKE MEAD NATIONAL
RECREATION AREA
Oil and Gas Lease Map
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X Leased Section
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R66E
R21W
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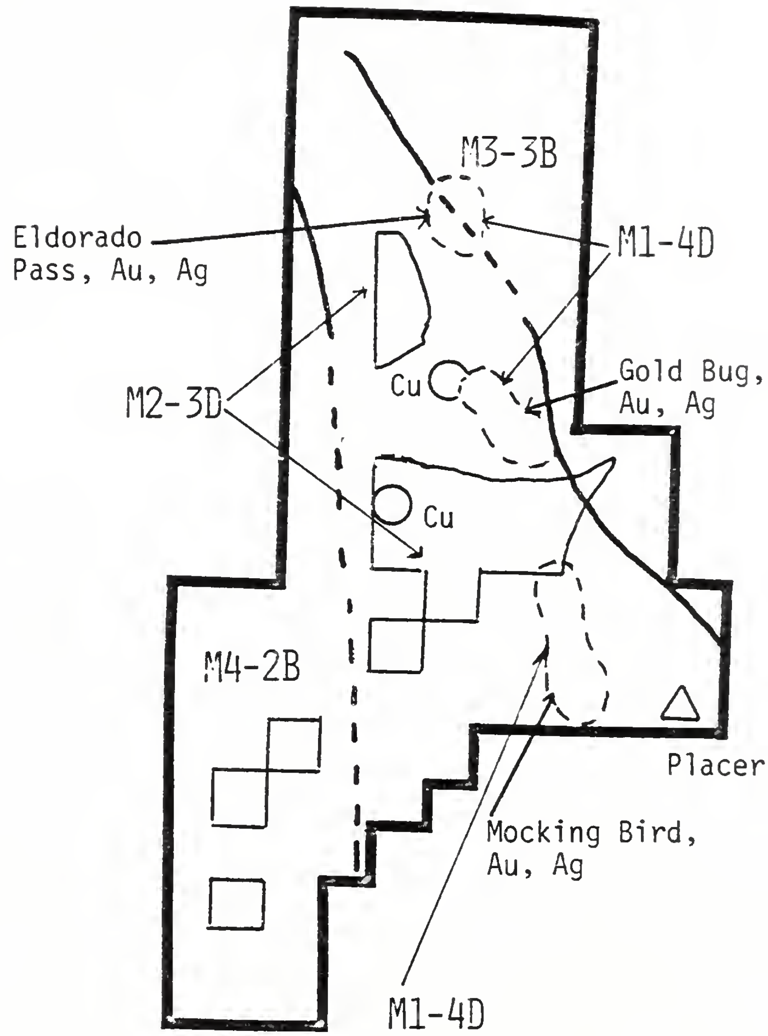


EXPLANATION

Mining District, commodity

Mine, commodity

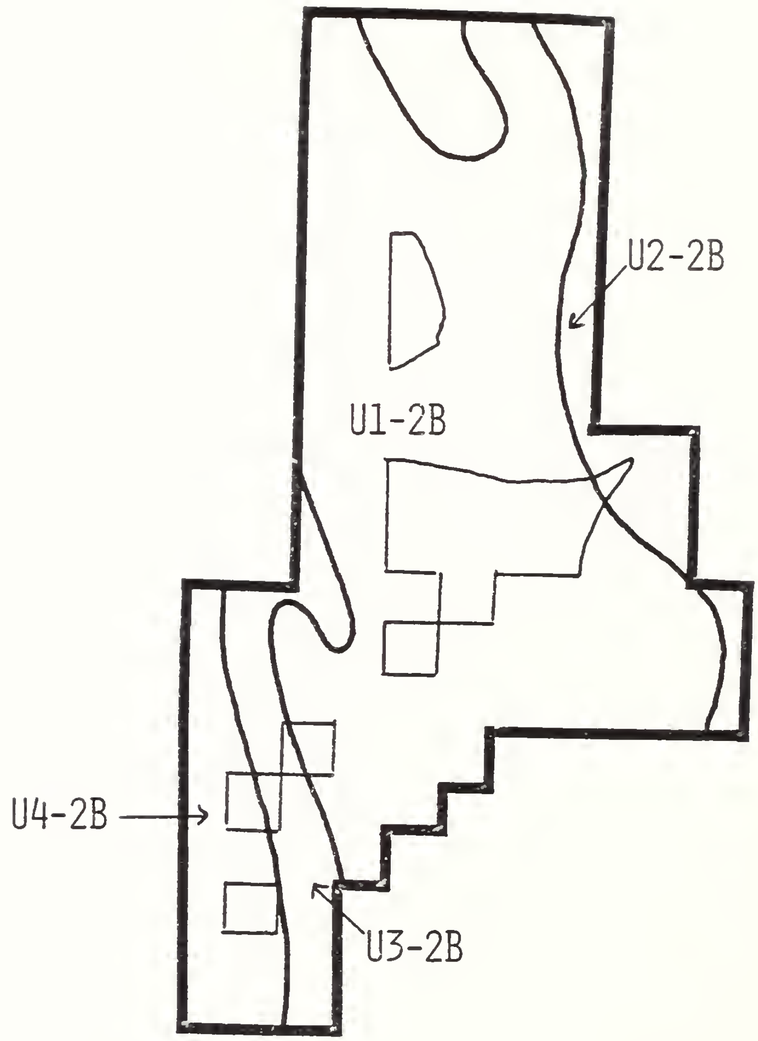
Occurrence, commodity

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Metallics

Mount Davis GRA AZ-03
Scale 1:250,000



EXPLANATION

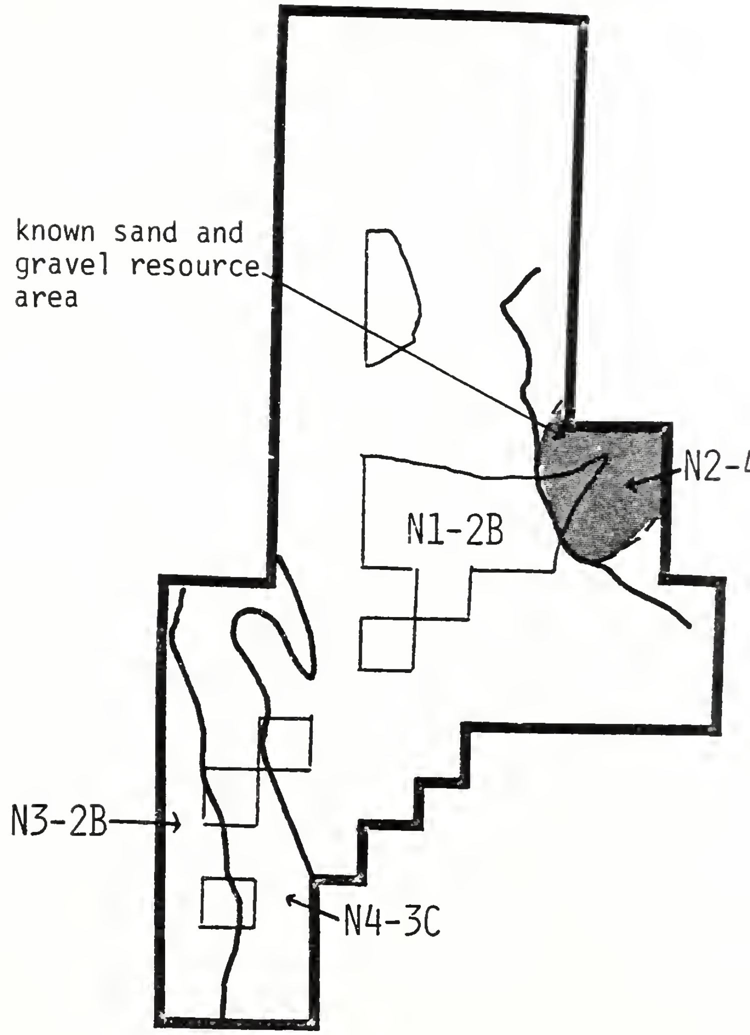
Uranium Occurence

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Uranium

Mount Davis GRA AZ-03
Scale 1:250,000



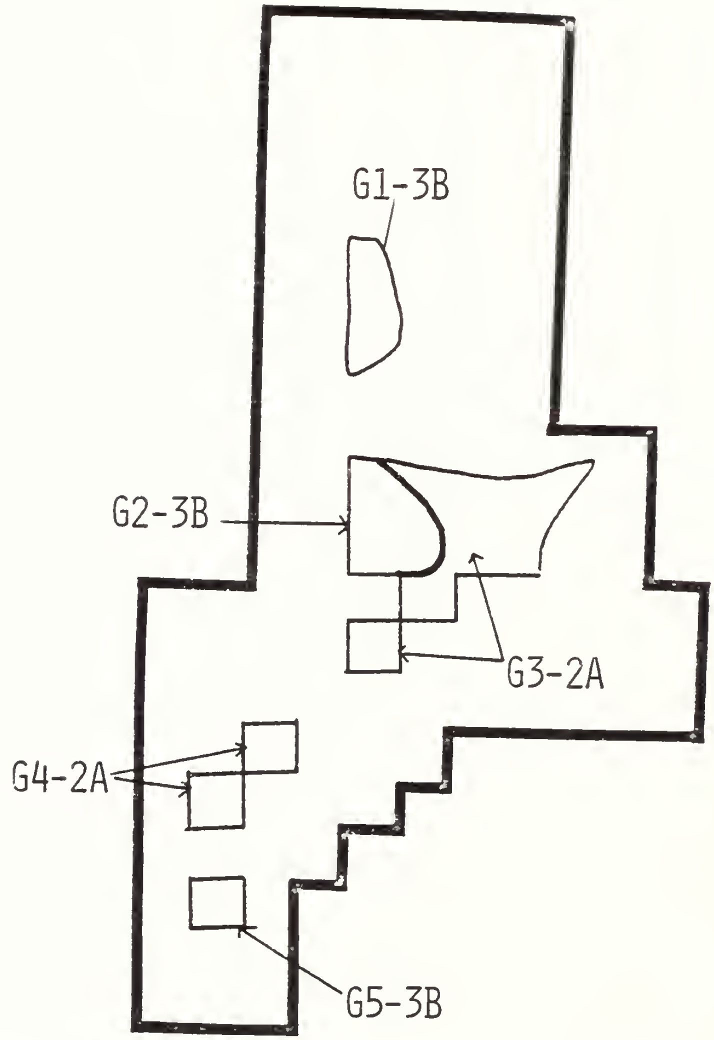
EXPLANATION

Land Classification Boundary

— WSA Boundary

Land Classification - Mineral Occurrence Map/Nonmetallics

Mount Davis GRA AZ-03
Scale 1:250,000



EXPLANATION

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Geothermal

Mount Davis GRA AZ-03
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 Ohradovich, 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