# GRAND WASH CLIFFS G-E-M RESOURCES AREA

(GRA NO. AZ-02)

TECHNICAL REPORT

(WSAs AZ 020-014 and 020-015)

Contract YA-553-RFP2-1054

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Final Report

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EXECUTIVE SUMMARY

The Grand Wash Cliffs Geology-Energy-Minerals (GEM) Resource Area (GRA) includes the following Wilderness Study Areas (WSAs): AZ 020-014 and AZ 020-015.

The GRA is in central Mohave County, Arizona just south of the Colorado River. The geology of the GRA consists of Precambrian (greater than 600 million years old) basement rocks overlain by thick accumulations of sediments 300 to 600 million years old which form the western escarpment of the Colorado plateau.

Past mineral production within the GRA has come predominantly from the Music Mountain gold district south of the WSAs in the southernmost part of the GRA and is reported to have produced over $20,000 prior to 1909. At Garnet Mountain in the west central part of the GRA also outside the WSAs an unknown quantity of sheet mica, a strategic and critical mineral, has been produced. None of the production and none of the known mineral occurrences have been reported from within the two WSAs in this GRA.

The only patented claims within the GRA are in the Music Mountain gold district along the south edge of the GRA. Here there are seven unpatented claims as well. There are no patented claims in either WSA.

At least 25 lode claims and 28 association placer claims are found in the Garnet Mountain area. The placer claims are a continuation of hundreds of placer claims covering the alluvial valley fill to the immediate west of the GRA covering potential gold placer deposits from the Gold Basin Placer District. The lode claims are probably associated with the pegmatites of Garnet Mountain and may be associated with some reported tungsten mineralization also. There are no unpatented claims in either WSA.

Oil and gas leases cover all the BLM ground within the GRA and the two included WSAs as this area is part of the Overthrust Belt, an area of high current oil interest. There are no geothermal leases within the GRA or the WSAs.

The northernmost WSA is classified as having no indication of favorability for metallic mineral resources with a very low confidence level, a low favorability for uranium and thorium resources with a low confidence level, a moderate favorability for nonmetallic mineral resources with a moderate confidence level; and a low potential for geothermal and oil and gas resources with a low confidence level.

The southern WSA is classified as having a low to no indication of favorability for metallic mineral resources, with a very low confidence level, a low favorability for uranium and thorium with a low confidence level, a moderate to low favorability for nonmetallic mineral resources with a moderate to low favorability, a moderate to low favorability for geothermal energy resources

with a very low confidence level, and a low favorability for oil and gas resources with a very low confidence level.

The classifications are based on very limited information and the fact there appears to be little interest in the area, and no past production or even reported prospects or occurrences. More detailed information would be needed to adequately assess the true mineral potential of the area.

# I. INTRODUCTION

The Grand Wash Cliffs G-E-M Resources Area (GRA No. AZ-02) covers approximately 200,000 acres (811 sq km) and includes the following Wilderness Study Areas (WSA):

| WSA Name | WSA Number |
|---|---|
| Grapevine Wash | AZ 020-014 |
| Grand Wash Cliffs | AZ 020-015 |

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°50' north latitude, 114°00' west longitude and includes the following townships:

| | |
|---|---|
| T 31 N, R 15,16 W | T 28 N, R 16,17 W |
| T 30 N, R 15,16 W | T 27 N, R 15,16 W |
| T 29 N, R 15,16 W | T 26 N, R 15 W |

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

15-minute:

| | |
|---|---|
| Iceburg Canyon | Garnet Mountain |

7.5-minute:

| | |
|---|---|
| Columbine Falls | Grapevine Canyon |
| Quartermaster Canyon, SW | Music Mtns., NW |

The nearest town is Truxton, northeast of Kingman, which is about 20 miles south of the GRA on U.S. Highway 66. Access to the area is via the paved road to Pierce Ferry Boat Anchorage on the west and U.S. Highway 66 about 20 miles south of the GRA. Access within the area is via 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.

None of the WSAs in this GRA were field checked.

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.

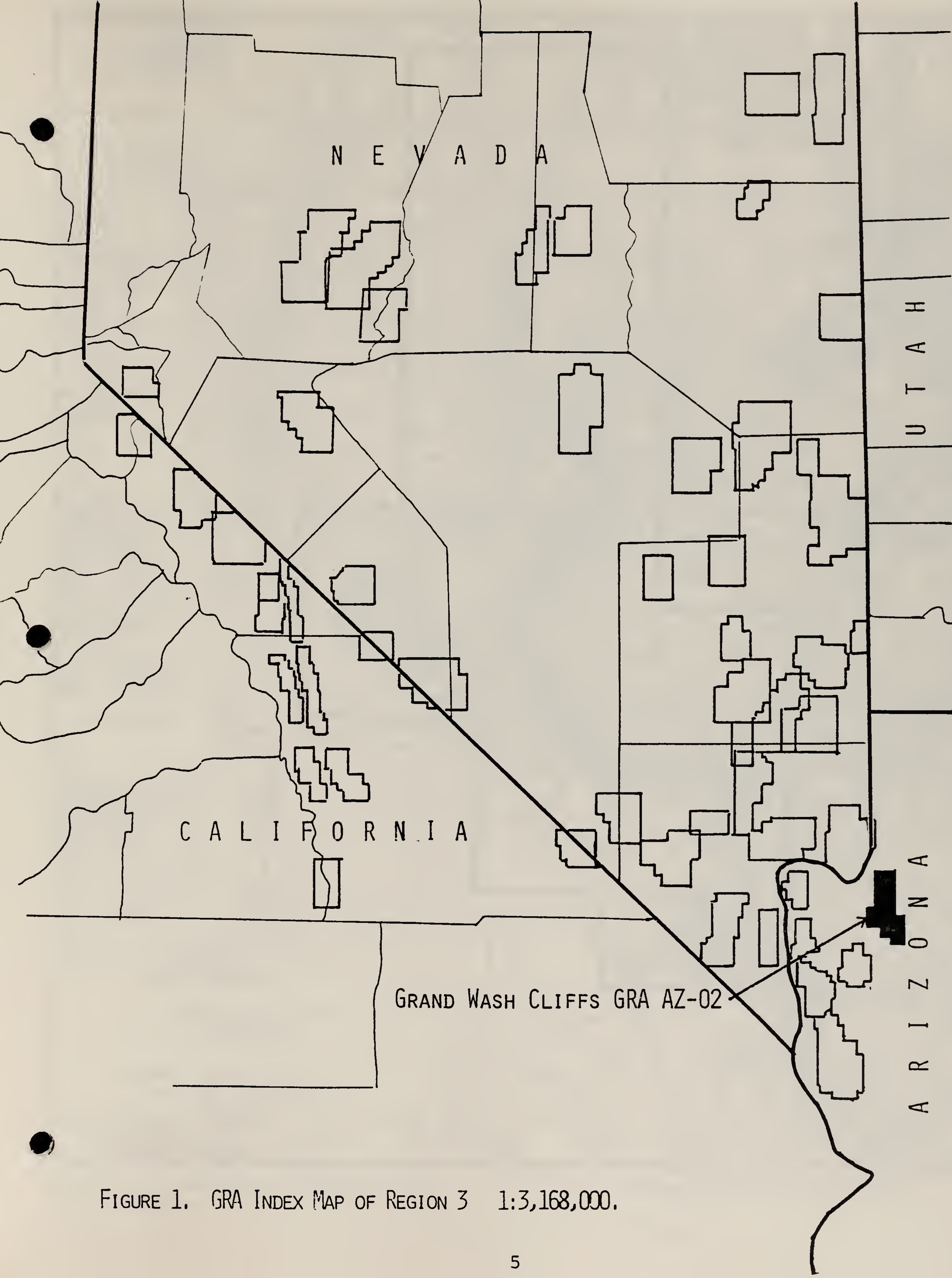
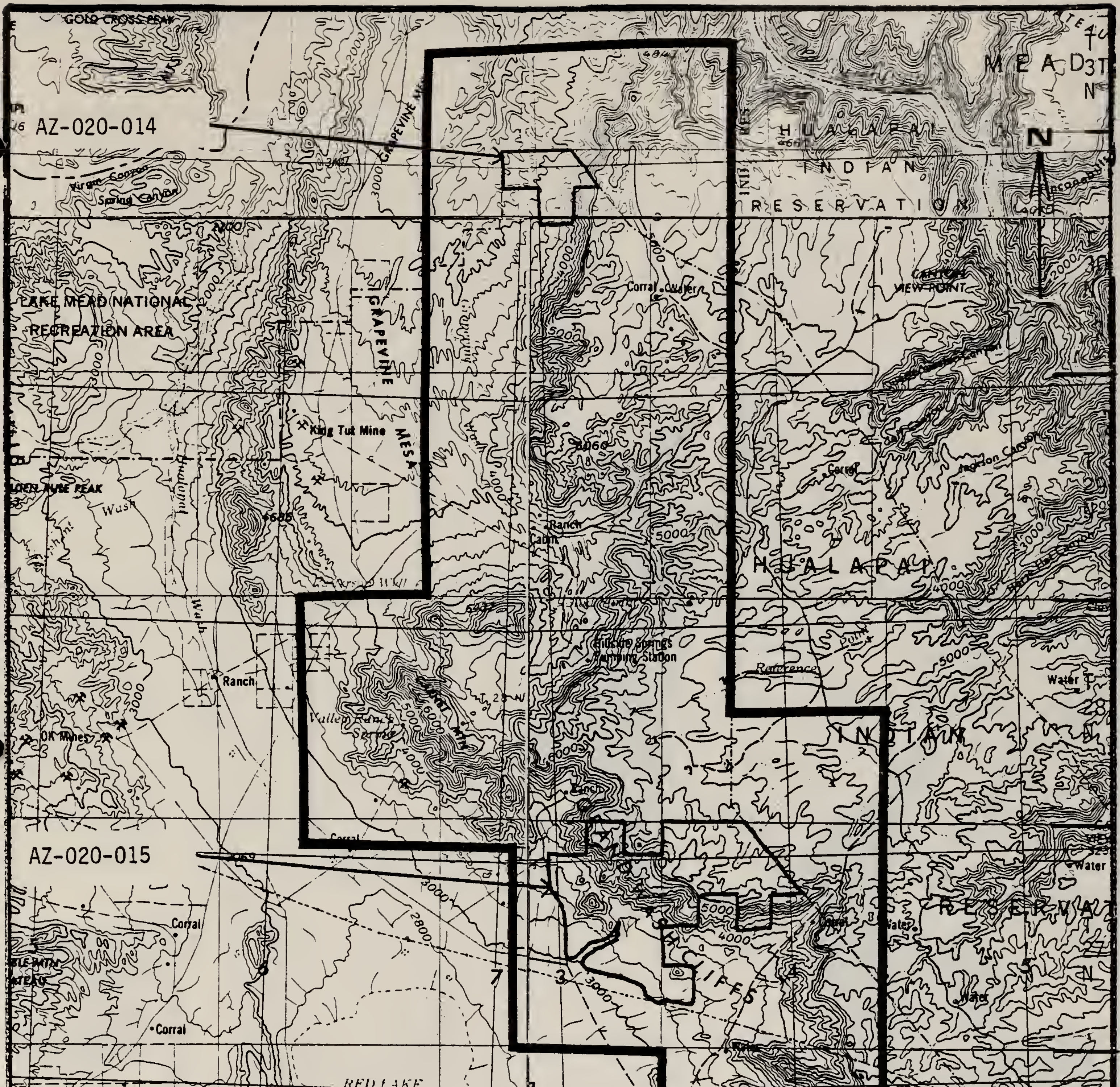


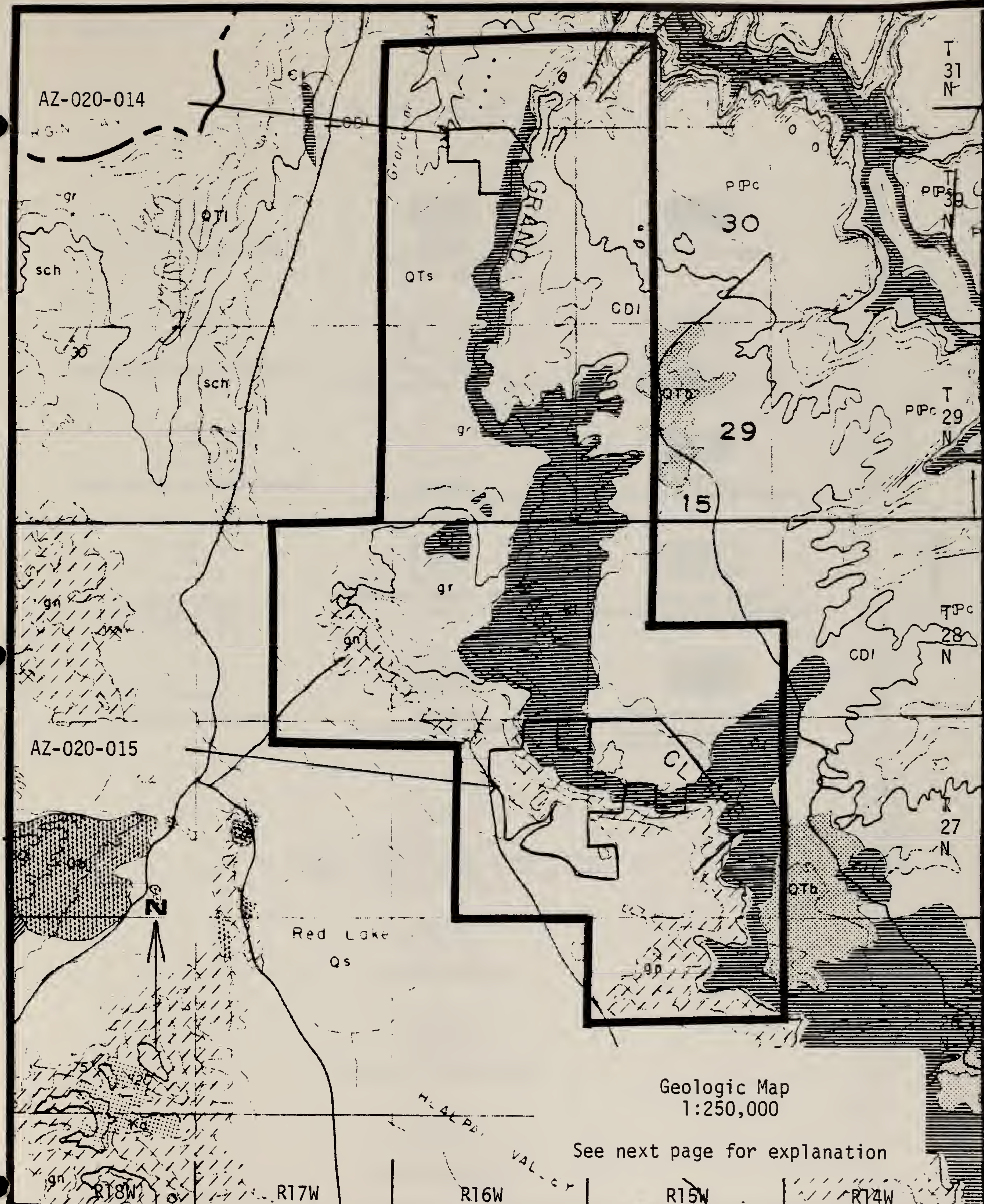

FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.




Las Vegas, Grand Canyon, Kingman and Williams Sheets

Grand Wash Cliffs GRA AZ-02

Figure 2




Mohave County Geologic Map, Wilson and Moore, (1959)

Grand Wash Cliffs GRA AZ-02

Figure 3

# EXPLANATION

**QUATERNARY**

Qs — Silt, sand, and gravel.

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

**Dikes and plugs**

**QUATERNARY – TERTIARY**

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*

**TERTIARY – CRETACEOUS (LARAMIDE)**

TKs — Sandstone, shale and conglomerate *Includes some basalt.*

Lgr — Granite and related crystalline rocks

Lf — **Dikes and plugs** *Rhyolitic to andesitic in composition.*

**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**

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

**TRIASSIC**

TRc — Chinle formation

TRs — Shinarump conglomerate

TRm — Moenkopi formation

## TRIASSIC

TRc
**Chinle formation**

TRs
**Shinarump conglomerate**

TRm
**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**

**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 Grand Wash Cliffs GRA is located along the western edge of the Colorado Plateau in what has been described as the transition zone. The Colorado Plateau is composed of Paleozoic marine sediments unconformably overlying Precambrian basement rocks. Quaternary basalt flows locally cap the Paleozoic sediments.

Structure and physiography of the area is dominated by the Grand Wash Cliffs escarpment formed by near vertical displacement along the Grand Wash fault in the middle Tertiary. To the east and parallel to the Grand Wash escarpment in the northern section of the GRA are at least two normal faults of unknown age traceable for 20 miles.

Recent geological mapping in the northwest part of Arizona is lacking and the only geologic map available which covers the WSAs in the GRA is Wilson and Moore's county map published in 1959 at a scale of 1:375,000. Information on the geology is therefore sketchy and has had to be interpolated from various district reports and other research material.

### 1. PHYSIOGRAPHY

The Grand Wash Cliffs GRA is located on the western boundary of the Colorado Plateau Province. The study area includes the western escarpment of the Grand Wash Cliffs from the Grand Canyon south to the Music Mountains.

Elevations along the escarpment range from 4,500 feet in the north to 6,761 feet at Music Mountain in the southern portion of the study area. Streams in this GRA predominantly flow northeast and drain into the Colorado River.

The Colorado Plateau in this area is comprised of Carboniferous Redwall limestone. It terminates on the west in the great escarpment, Grand Wash Cliffs, which expose marine sediments of the Cambrian Tonto Group and Precambrian gneiss and granite.

The dominant topographic feature in the area is the northwest trending escarpment of the Grand Wash Cliffs formed by displacement along the near vertical Grand Wash fault. The normal displacement along this fault is estimated to be at least 6,000 feet (Darton, 1910).

### 2. ROCK UNITS

The oldest rocks in the study area are the Precambrian metamorphosed granites found along the escarpment. This unnamed sequence contains gneiss, schist and granite including pegmatite. In the Garnet Mountain area these rocks were

intruded by a later Precambrian granitic stock. Detailed geologic mapping has been done by Blacet (1975) in the Garnet Mountain area.

Unconformably overlying the Precambrian metamorphics are Cambrian marine sediments of the Tonto group which includes limestone, shale, and sandstone; and overlying that are the Carboniferous Redwall and Martin limestones.

A post-Cambrian(?) quartz monzonite stock was intruded in the Music Mountain district area. Dikes and masses of diabase of unknown age associated with quartz veins also occur in this area (Schrader, 1909).

The Mississippian Redwall and Martin limestones were deposited unconformably over the Tonto Group. This massive limestone is distinguished by its reddish color and caps the Colorado Plateau in the study area.

The next rocks deposited in the GRA are Quaternary basalt flows, tuffs, agglomerates and cinders. These volcanics cap the plateau in the central and southern portions of the study area.

Pleistocene stream, lake, and intermontane sediments are the most recent rocks deposited in the area. They accumulated in the structural lows of Hualapai Valley and Grapevine Wash west of the Grand Wash Cliffs.

## 3. STRUCTURAL GEOLOGY AND TECTONICS

The oldest structures preserved in the study area occur in the Precambrian metamorphic rocks which exhibit a schistose structure formed by deformational processes. The trend of the schistocity is generally N 30°E with vertical or steep dips. Joints within these rocks strike north-northwest and dip steeply to the east-northeast. Fissures in the study area roughly parallel the jointing trend.

The Grand Wash fault which forms the break between the Colorado Plateau and the Great Basin is the dominant structure in the study area. Uplift of the Colorado Plateau occurred along this fault sometime during the middle Tertiary with movement traceable into the early Pleistocene. The history of displacement along the Grand Wash fault has not been a simple continuous movement (Hamblin, 1978). The west side of the fault is estimated to be downdropped 6,000 to 7,000 feet. The average relief along the Grand Wash Cliffs is approximately 3,000 feet. The remaining 3,000 to 4,000 feet of movement along the fault is covered by later alluvium in the valley to the west.

To the east and parallel to the Grand Wash escarpment in the northern section of the GRA are at least two normal faults of unknown age which can be traced for nearly 20 miles. They may possibly be related to the uplift of the Colorado Plateau.

## 4. PALEONTOLOGY

The northern one third of the Grand Wash Cliffs GRA has the highest potential for paleontological resources, from strata mapped as Quaternary (Chemeuvi, Bouse, Gilla equivalents) and PPC (Pakoon and Callville limestones and equivalents). The Quaternary lacustrine and fluviatile sediments elsewhere contain fossil mammals, mollusks, and leaf floras of latest Tertiary and early Quaternary age.

Late Paleozoic marine strata of the Pakoon and Callville include bryozoans, brachiopods, cephalopods, and corals, although no localities from within the GRA were identified from the literatire. Lateral equivalents of these strata exposed several miles east of the GRA include the fossiliferous Earp and Horquilla Formations and other related miogeosynclinal carbonate and clastic units of late Pennsylvanian and Permian age.

Other lithologies within and adjacent to the GRA are considered to have no potential for (or low potential for) paleontologic resources, the only potential residing in the late Tertiary-Quaternary fluviatile and lacustrine sediments.

## 5. HISTORICAL GEOLOGY

During the Precambrian, deformational forces formed folds and faults and metamorphosed the existing granites into gneiss and schist. Subsequently a later Precambrian granitic stock intruded these metamorphic rocks.

Previous to the deposition of Paleozoic marine sediments a long period of erosion base-levelled the preCambrian rocks. The Tonto group was deposited during the Cambrian over this surface. Sedimentation recurred during the Carboniferous with the deposition of the Redwall and Martin limestones.

An extensive erosional period stripped off much of the Paleozoic sedimentary sequence and formed the Mohave Peneplain. Gilbert (1875) suggests that much of this erosion took place during the Cretaceous.

Sometime during the middle Tertiary and before the completion of the Mohave Peneplain, the Grand Wash fault was formed with a displacement of several thousand feet. During the early Pleistocene this fault was reactivated with the uplift of the Colorado Plateau (Darton, 1910).

Extrusive basalts were deposited during the middle Pleistocene after the uplift of the Colorado Plateau.

During late Pleistocene intermittent streams and other erosional processes led to the deposition of the alluvial valley fill.

## III. ENERGY AND MINERAL RESOURCES

### A. METALLIC MINERAL RESOURCES

#### 1. Known Mineral Deposits

The Music Mountain district located on the southern border of the Grand Wash Cliffs GRA and several miles south of WSA 020-015 produced a considerable amount of predominantly gold ore from five northwest-striking, steeply-dipping, quartz-filled fissure veins. Several mines developing the veins occur within a two square mile area. Although no specific district production data is available, Schrader (1909) estimates that over $20,000 has been produced.

There are no mining districts in either WSA.

#### 2. Known Prospects, Mineral Occurrences and Mineralized Areas

In the Music Mountain District, numerous pits, shafts and adits follow the extensions of productive portions of northwest-trending quartz veins. These prospects occur within a two square mile area in Secs. 17 and 18 of T 26 N, R 15 W.

Approximately six miles northeast of the Music Mountain district, near the eastern edge of the WSA, a hematite prospect has been explored. No specific data concerning this property is available.

The Music Mountain tungsten prospect is located on the northeast flank of Garnet Mountain. Two tungsten prospects have been reported in the Mineral Location Information supplied by the Arizona Department of Mineral Resources, north of Garnet Mountain, in alluvium well below the outcrop area of the Grand Wash Cliffs. It is suspected that these locations are inacurate as it is very unusual that two tungsten prospects would be in alluvium, furthermore the detailed topographic quadrangle maps showed no evidence of workings or even bedrock exposures at these locations. The two purported prospects are located in Secs. 7 and 19 of T 29 N, R 16 W and are several miles southwest of WSA 020-014.

The U. S. Geological Survey has reportedly done some geochemical sampling in the Garnet Mountain area northwest of WSA AZ 020-015 in connection with Blacet's (1975) preliminary geologic map of the same area but those results were not available.

Numerous unpatented placer claims in the alluvial valley northwest and west of Garnet Mountain are the western extension of a large blanket of placer claims which cover gold-bearing gravels of the Gold Basin placer district. Erosion of gold and silver bearing quartz veins in the White Hills gave rise to the formation of the placers to the east. Because of their location on the opposite slope of the valley from the main district to the west, it is doubtful that these claims have produced any gold.

3. Mining Claims

There are no mining claims known to be in either of the two WSAs.

In the Grand Wash Cliffs GRA only Sec. 12 of T 26 N, T 15 W in the Music Mountain district contains patented claims.

Unpatented claims are predominantly in the Music Mountain district and the Garnet Mountain area. In the Music Mountain district, seven unpatented claims are in a two square mile area on the western edge of the district.

About 25 unpatented lode claims in the Garnet Mountain area, west of WSA 020-015, cover tungsten and mica-feldspar prospects and mines. The claims are in an eight square mile area on the north and west flanks of Garnet Mountain.

Numerous unpatented placer claims located in the valley to the north of Garnet Mountain are the eastern extension of a large blanket of claims covering gold-bearing gravels of the Gold Basin placer district. A few claims are located northeast, due east and southeast of Garnet Mountain.

There is one lode claim just north of WSA 020-015 in Sec. 17, T 28 N, R16 W, in the Cambrian sediments, that was located in 1981 for an unknown commodity. This could possibly be a wrong location.

4. Mineral Deposit Types

The major mineral deposits in the Grand Wash Cliffs GRA consist of narrow gold- and silver-bearing quartz veins of the Music Mountain District and gold placers on the eastern fringe of the Gold Basin district.

The narrow northwest trending quartz-filled fissure veins of the Music Mountain district occur within a post-Cambrian(?) quartz monzonite body which prevails throughout the district. The veins are mesothermal with an increase in base metals with depth. The age of diabase dikes associated with the mineralization is unknown.

Total district production is estimated to be over $20,000 (Schrader, 1909).

The Music Mountain tungsten mine occurs in Precambrian granites at Garnet Mountain but no specific geologic or production information is available.

The eastern fringe of the Gold Basin placer district extends to the western slope of Garnet Mountain. Because of their distance from the White Hills, the source of the gold, and the low total production from the main placer district, it is doubtful that the placers within the study area produced any appreciable quantity of placer gold.

## 5. Mineral Economics

Gold-bearing veins in the Music Mountain district several miles south of WSA AZ 020-015 are narrow, averaging from several inches to four feet in width. Ore in the veins averages about 0.1 oz Au/ton across a four-foot mining width which is sub-economic in light of today's underground mining costs. Because of the lack of large tonnage potential and inadequate grade, these mines are probably presently of minimal interest to mining companies.

Gold placer claims near Garnet Mountain located on the opposite slope of the valley from the main production site of the Gold Basin placer district probably did not produce significant quantities of placer gold and, therefore, their economic potential is very low.

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.

## B. NONMETALLIC MINERAL RESOURCES

### 1. Known Mineral Deposits

There are no known nonmetallic mineral deposits in either WSA.

At Garnet Mountain, four miles to the northwest of WSA 020-015, the M & P claims have produced an unknown quantity of sheet mica, flawed muscovite books, potassium feldspar and quartz from pegmatites in Precambrian granite.

### 2. Known Prospects, Mineral Occurrences and Mineralized Areas

There are no known nonmetallic mineral occurrences in the WSAs.

Several prospects at Garnet Mountain, however, explore mica and feldspar bearing pegmatites in the Precambrian granite. Rare earth mineralization has also been reported.

### 3. Mining Claims, Leases and Material Sites

There are no nonmetallic claims, leases, or material sites in either WSA.

About 25 unpatented lode claims in the Garnet Mountain area, however, west of WSA 020-015, cover tungsten and mica-feldspar prospects and mines.

A reported sand and gravel borrow pit is located immediately south of WSA 020-015 in Sec. 32, T 27 N, R 15 W but past or current activity is unknown.

### 4. Mineral Deposit Types

The nonmetallic mineral deposits in the Grand Wash Cliffs GRA outside the WSAs consist of quartz-mica-feldspar pegmatites at Garnet Mountain and sand and gravel in the alluvial sediments.

### 5. Mineral Economics

Lack of data pertaining to the pegmatite deposits at Garnet Mountain precludes an estimation of production potential, but they probably do not contain sufficient tonnage to be economically feasible.

## C. ENERGY RESOURCES

### Uranium and Thorium Resources

1. Known Mineral Resources

   There has been no uranium production and there are no known significant uranium deposits within or near the GRA or the included WSAs.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

   Radioactive occurrences are indicated on the Uranium Land Classification and Mineral Occurrence Map included at the back of the report.

   There is only one known uranium occurrence, just within the western boundary of the GRA outside the WSAs near Garnet Mountain, Sec. 2(?), T 27 N, R 17 W (Minobras, 1978). Not much is written in the literature regarding this occurrence. It appears to be in Quaternary/Tertiary alluvial sediments.

3. Known Mining Claims

   There is only one uranium claim within the GRA but outside the WSAs, as noted in the literature, and it has probably lapsed. There are no known thorium claims or leases within the WSAs or the GRA.

4. Mineral Deposit Types

   Information is not available on the type of uranium occurrence on the southwestern boundary of the GRA. There are no other known uranium occurrences within the GRA or the WSAs.

5. Mineral Economics

   The lack of available data prevents an accurate determination of uranium economics within the GRA, though they would appear to have no economic value for the area.

   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.

Thorium is used in the manufacture of incandescent gas mantles, welding rods, refractories, as fuel for nuclear power reactors and as an alloying agent. The principal source of thorium is monazite which is recovered as a byproduct of titanium, zirconium and rare earth recovery from beach sands. Although monazite is produced from Florida beach sands, thorium products are not produced from monazite in the United States. Consequently, thorium products used in the United States come from imports, primarily from France and Canada, and industry and government stocks. Estimated United States consumption of thorium in 1980 was 33 tons, most of which was used in incandescent lamp mantles and refractories (Kirk, 1980b). Use of thorium as nuclear fuel is relatively small at present, because only two commercial thorium-fueled reactors are in operation. Annual United States demand for thorium is projected at 155 tons by 2000 (Kirk, 1980a). Most of this growth is forecast to occur in nuclear power reactor usage, assuming that six to ten thorium-fueled reactors are on line by that time. The United States and the rest of the world are in a favorable position with regard to adequacy of thorium reserves. The United States has reserves estimated at 218,000 tons of $ThO_2$ in stream and beach placers, veins and carbonatite deposits (Kirk, 1982); and probably cumulative demand in the United States as of 2000 is estimated at only 1,800 tons (Kirk, 1980b). The price of thorium oxide at the end of 1981 was $16.45 per pound.

## 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). 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 Grand Wash Cliffs GRA. Four miles south-southwest of WSA AZ-020-015 and outside the GRA are three thermal wells with temperatures of 48° to 76°C, at depths of 651 to 1228 meters (see Geothermal Occurrence and Land Classification Map) (NOAA, 1982). These wells are near the center of the Quaternary sediment-covered valley. There are no Federal geothermal leases in the region, and no geothermal lease map is included with 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 GEOLOGIC RESOURCES

The Grand Wash Cliffs area is known for its scenic beauty with the Lower Cambrian sediments forming spectacular cliffs. In addition, the Grand Canyon National Park borders the GRA to the north and east.

## 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.

There are no reported strategic and critical metallic or nonmetallic mineral resources within the WSAs. Tungsten, sheet mica and possibly quartz crystals occur in the GRA occurrences, but additional information such as tonnages and grade is lacking.

## 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 classification, 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 rock, 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 covering the two included WSAs is limited to Wilson and Moore's (1959) Mohave County map at a scale of 1:375,000. This map is neither detailed in geology nor structure and does not address mineralization. It is not sufficiently detailed for the purpose of assessing mineral potential other than from a broad viewpoint. More detailed mapping is available of the Garnet Mountain area to the west (Blacet, 1975) and the Music Mountain area to the south (Schrader, 1909) of WSA AZ 020-015

Overall our confidence level in Wilson and Moore's map is moderate and the other information utilized for this report moderate to high.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA AZ-020-014

M1-1A. This classification area includes the lower Paleozoic sediments of the Colorado Plateau along the eastern edge of the WSA. Due to the lack of available detailed geological information and the lack of known mineral occurrences we are ranking this as having no indication of favorability (classification 1) with a confidence level of A, or very low level of confidence.

M2-1A. This classification area covers the alluvium comprising most of the western two-thirds of the WSA. The area is classified like that above, as having no indication of favorability for metallic mineral resources with a very low confidence level. The nature and potential of the bedrock beneath the alluvium is unknown but is assumed to be similar in nature to the exposed bedrock to the east.

WSA AZ-020-015

M3-1A. This classification area is the same as M1-1A, in that it is the lower Paleozoic sediments of the Colorado Plateau area. The classification area covers most of the northern and eastern portions of the WSA. There are no known mineral deposits in this classification area within the WSA. One hematite occurrence has been reported to the immediate east of the WSA boundary but no other details of this occurrence are known. There is also a mining claim covering unknown commodities four miles north of the WSA.

M4-2A. This classification area is one of low favorability with a very low confidence level, and includes the outcrop area of Precambrian rocks including gneisses and granites(?) which are outlined on the county geologic map. These rock types are therefore the same as those which host the gold veins in the Music Mountains, approximately six miles to the south, and similar to the pegmatite and tungsten(?) occurrences at Garnet Mountain six miles to the northwest. Since this area contains no known deposits or occurrences or claims, and more detailed geologic information is lacking, but it does have broadly similar geology to mineralized areas, this area is classified 2A.

M5-2A. This classification of low favorability with a very low confidence level covers the alluvium along the southern portion of the WSA. The nature of the bedrock beneath the alluvium is unknown but is assumed to be similar to the exposed Precambrian bedrock to the

immediate north.

b. Uranium and Thorium

WSA AZ-020-014

U1-2B. This classification area includes the lower Paleozoic sediments along the eastern edge of the WSA. This area is considered one of low favorability at low confidence levels because there are no known uranium or thorium resources in the area. Source rocks for uranium or thorium are not known to be present in the area.

Breccia pipe uranium deposits, similar to the Orphan mine in the Grand Canyon, may be prospective in the WSA where sedimentary rocks are underlain by the Carboniferous Redwall Limestone which is found in the WSA. The WSA is not considered highly favorable for breccia pipe uranium deposits as there are no overlying acidic volcanics or granitic rocks which could be a uranium source. In addition, breccia pipe uranium deposits are associated with stable platforms and the WSA is in a transition zone on the eastern edge of the Basin and Range Province.

U2-2B. This classification area includes the Quaternary and Tertiary alluvial sediments in the eastern two-thirds of the WSA. Since there are no known uranium or thorium occurrences or radiometric or geochemical anomalies in the area, we have given this area a low favorability at a low confidence level. The uranium mineralization and associated aerial radiometric uranium anomaly at the Kissee-Mitchell claims, Sec. 18, T 30 N, R 18 W, occur in limestone of the Tertiary Muddy Creek Formation (Luning and others, 1981), which is also probably present within the WSA in this area.

WSA AZ-020-015

U3-2B. This classification area indicating low favorability at a low confidence level takes in the lower Paleozoic sediments in the north and eastern portion of the WSA. The rationale for this classification are the same as those under area U1-2B.

U4-2B. This classification area indicating low favorability includes the Precambrian granitic gneisses as outlined on the county geologic map. There is no indication of uranium or thorium being present in the area or within this particular unit, but since this apparently is a granitic source rock, uranium and thorium could possibly be present.

U5-2B. This classification area includes the alluvium in the southern portion of the WSA. There is a low favorability for uranium and thorium at a low confidence level since no uranium or thorium occurrences or anomalies have been identified in the area. The possibility does exist, however, that if uranium and thorium concentrations were found to occur within the adjacent granitic gneisses (classification area U4-2B) then this environment may also have potential as uranium can be carried by groundwater and redeposited in a favorable alluvial environment, and thorium may occur as concentrations of resistate minerals (monazite) in the alluvium.

c. Nonmetallic Minerals

WSA AZ-020-014

N1-3C. This classification area includes all the lower Paleozoic sediments. No nonmetallics have been reported here except for hematite which could possibly be used as an industrial mineral pigment. The possibility exists that these sediments such as the limestones, shales and sandstones could be bulk-mineable for certain industrial uses, i.e., cement, construction materials, etc. The market and transportation costs would probably govern their future potential.

N2-3C. This classification area is one of moderate potential with a moderate confidence level and includes the sand and gravel in the alluvial cover which comprises most of the WSA.

WSA AZ-020-015

N3-3C. This classification area is identical to that of N1-3C above, under the discussion of the lower Paleozoic sediments.

N4-2B. This classification area consists of the Precambrian gneisses which are outlined on the county geologic map. These are the same host rocks as those to the west which are associated with the pegmatites containing the mica, feldspar and quartz. The pegmatites have not been reported as occurring within the WSA, however. There is a possibility that these rocks could be used for some industrial mineral purpose, but what is presently unknown. Future market conditions would govern future potential for industrial minerals.

N5-3C. This classification area is the same as N2-3C and is alluvium which could be used for sand and gravel. There is a reported borrow pit just outside the very southern edge of the WSA.

## 2. LEASABLE RESOURCES

### a. Oil and gas

WSAs AZ-020-014 and AZ-020-015

OG1-2A and OG2-2A. 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-020-014

G1-2B. This WSA is within an area cut by numerous, deep-seated, normal faults which extend in a northeasterly direction to the Pakoon Springs (off map). These springs have a recorded temperature of 28°C (NOAA, 1982).

G2-3A. This classification incorporates that part of the WSA which is underlain by valley alluvium, and which is an extension of the geologic environment of the three thermal wells to the south.

G3-2A. This area is underlain by Precambrian granite gneiss and lower to middle Paleozoic sedimentary rocks. The area is within a region of thermal springs and wells.

Both WSAs are within a few miles of outpourings of Quaternary basalts, which indicates a heat source at depth.

### c. Sodium and Potassium

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

### d. Other

There are no other leasable mineral commodities known within the WSAs or even within the GRA.

3. SALEABLE RESOURCES

The sand and gravel discussion for both WSAs has been included above under the nonmetallic classification and includes areas N2-3C and N5-3C.

## V. RECOMMENDATIONS FOR ADDITIONAL WORK

1. It should be emphasized that this entire GRA has very limited information on geology and mineral resources. The potential for economic mineral resources within the included WSAs appears low, but this is based on the sketchiest of information. More detailed geologic information, if it were to become available from unknown sources, would be of further value in helping to assess the mineral potential of the WSAs.

2. Because of the limited number of mineral resource occurrences in the GRA, and the overall low potential for additional mineral resources within the WSAs and the higher priority of other GRAs in Arizona, we did not recommend a field check of this area.

3. There are a couple of items which should be addressed in this GRA, however. The locations of the two reported tungsten occurrences north of Garnet Mountain are believed to be wrong. These locations should be resolved by again reviewing the Arizona Department of Mineral Resources files and, if necessary, a field check. The reported hematite occurrence just east of WSA 020-015 should be looked at to determine its significance and its possible implications for mineral potential in the adjacent WSA.

4. The U.S. Geological Survey has reportedly done some geochemical sampling in the Garnet Mountain area but these results were not reviewed for this report. These results should be traced down and analyzed to see if it could possibly influence the WSA to the east.

# [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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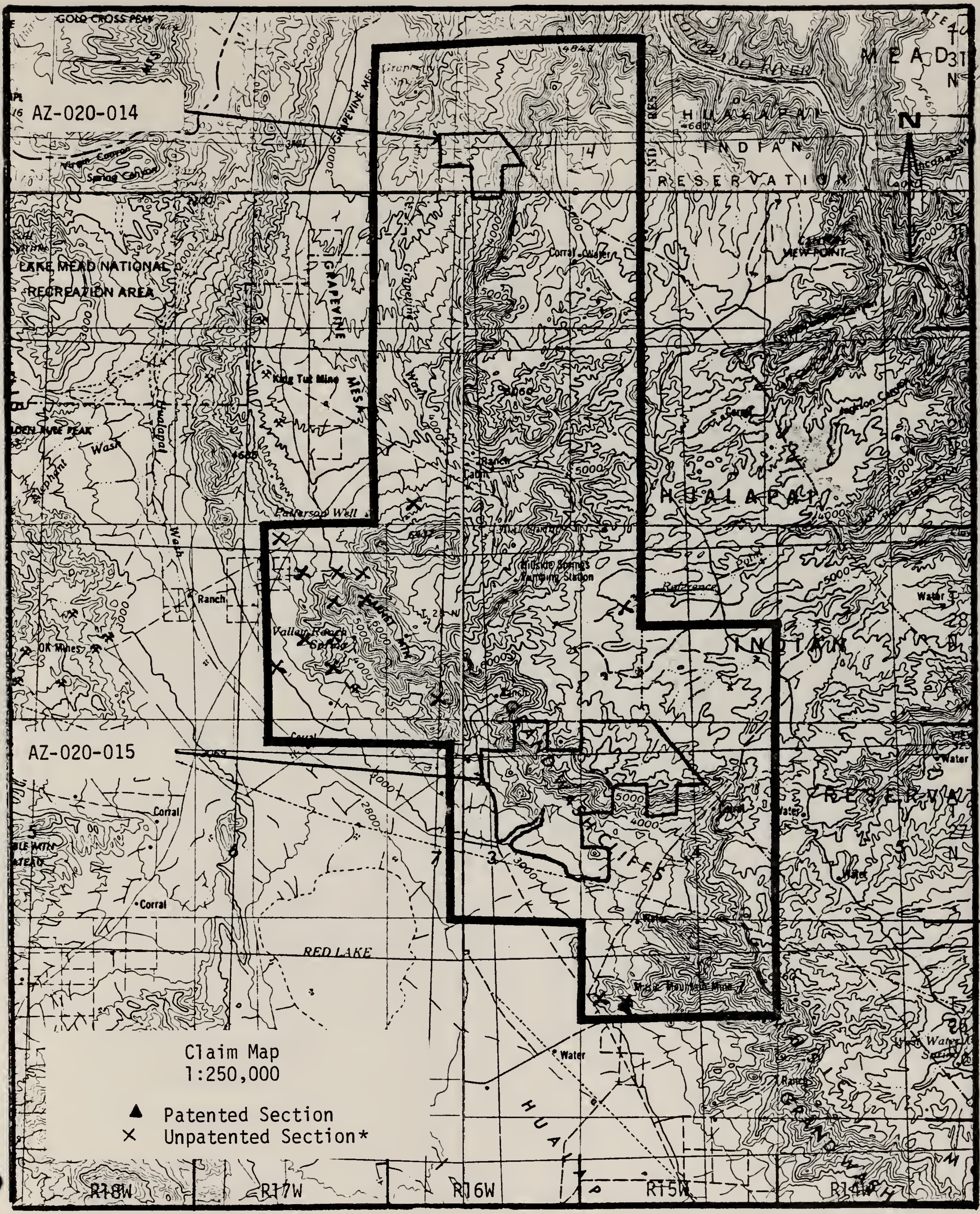
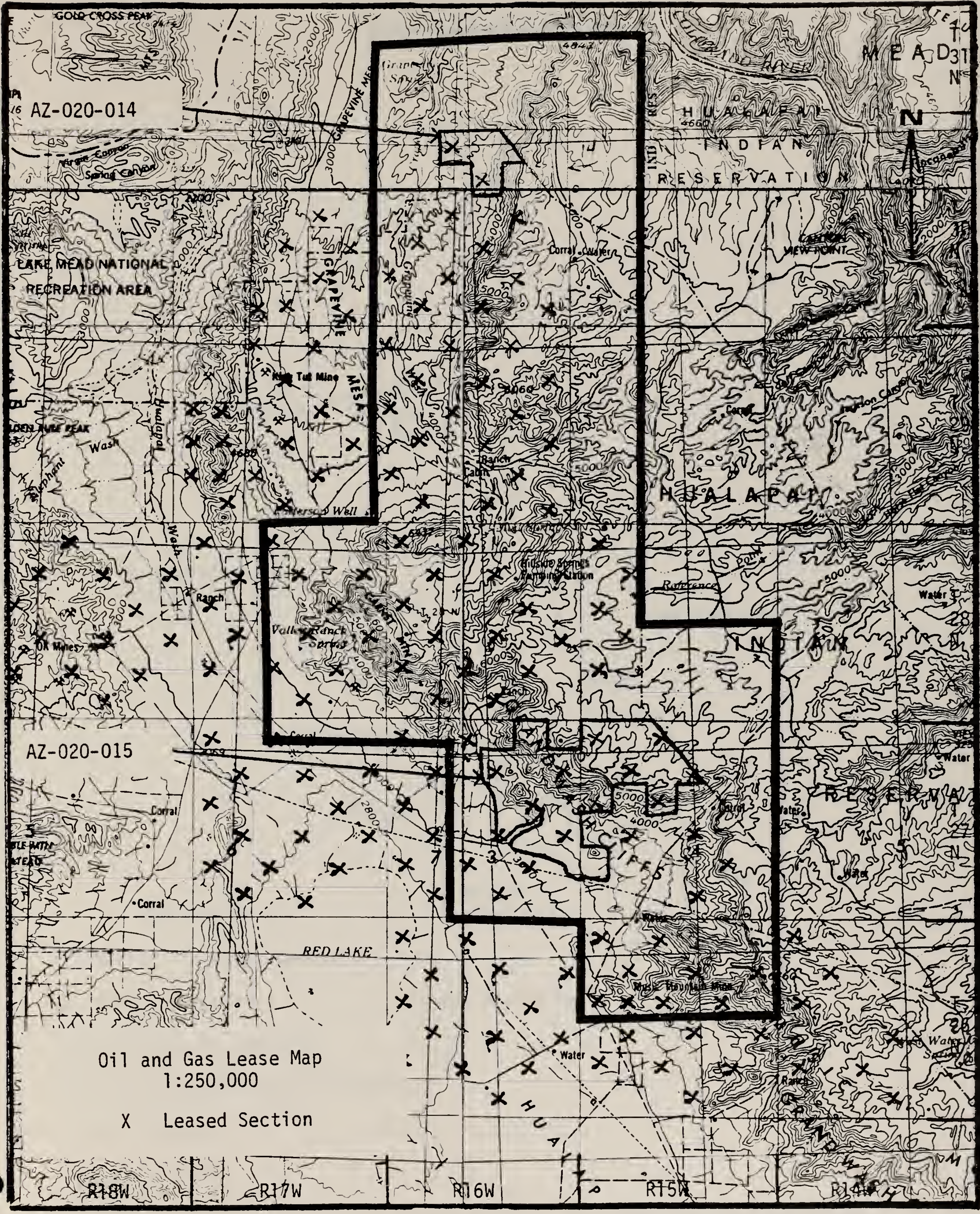
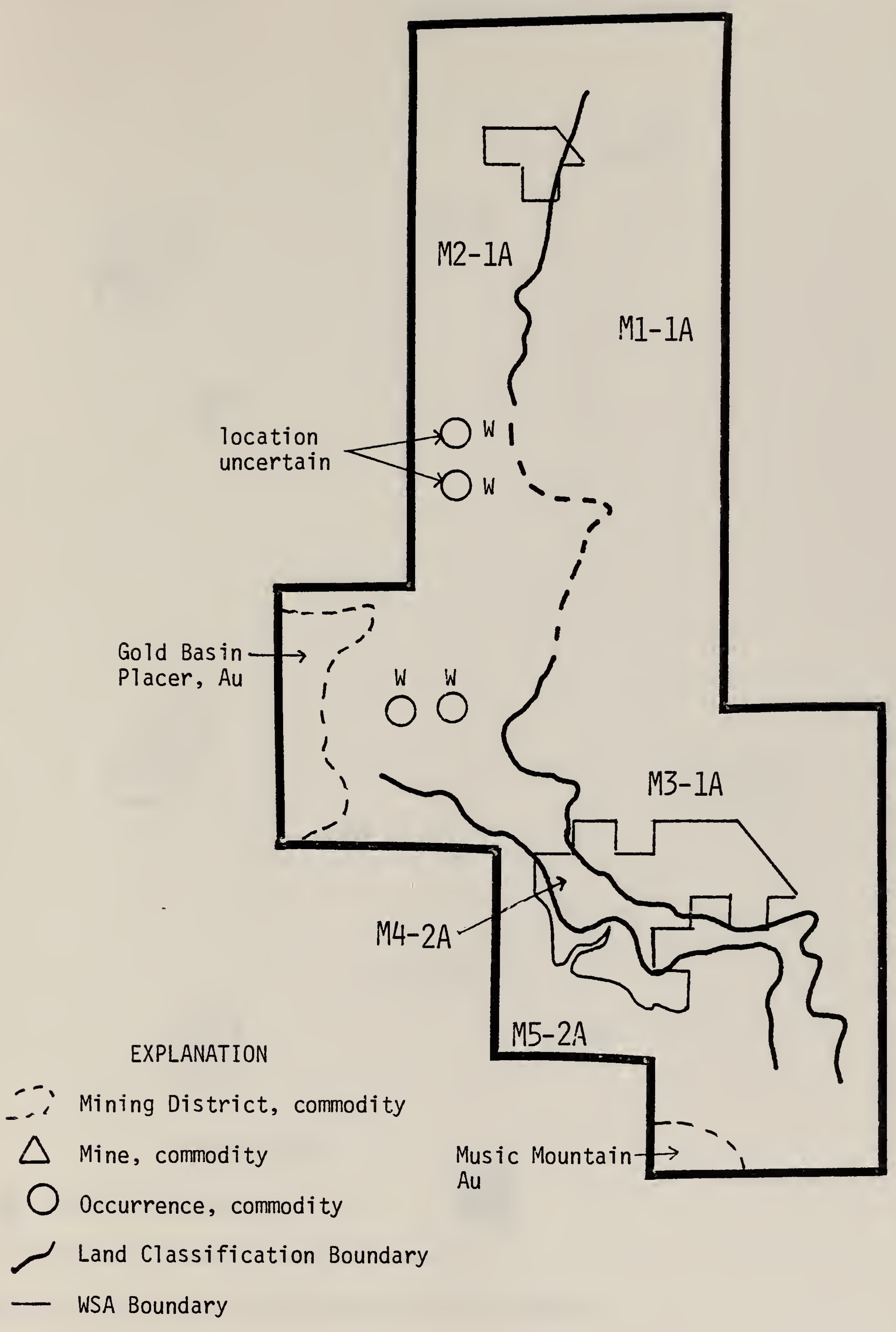



*X denotes one or more claims per section

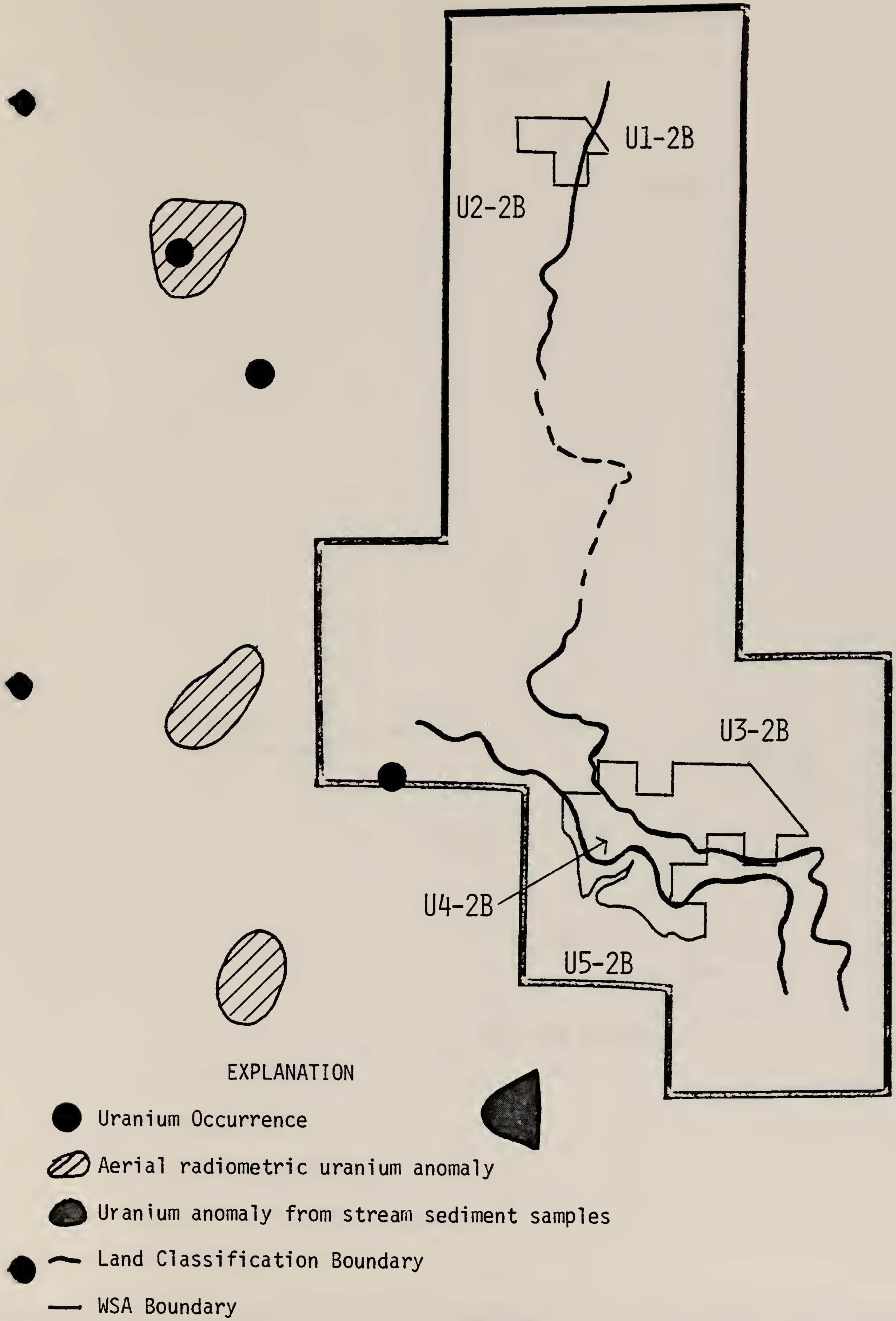
Grand Wash Cliffs GRA AZ-02



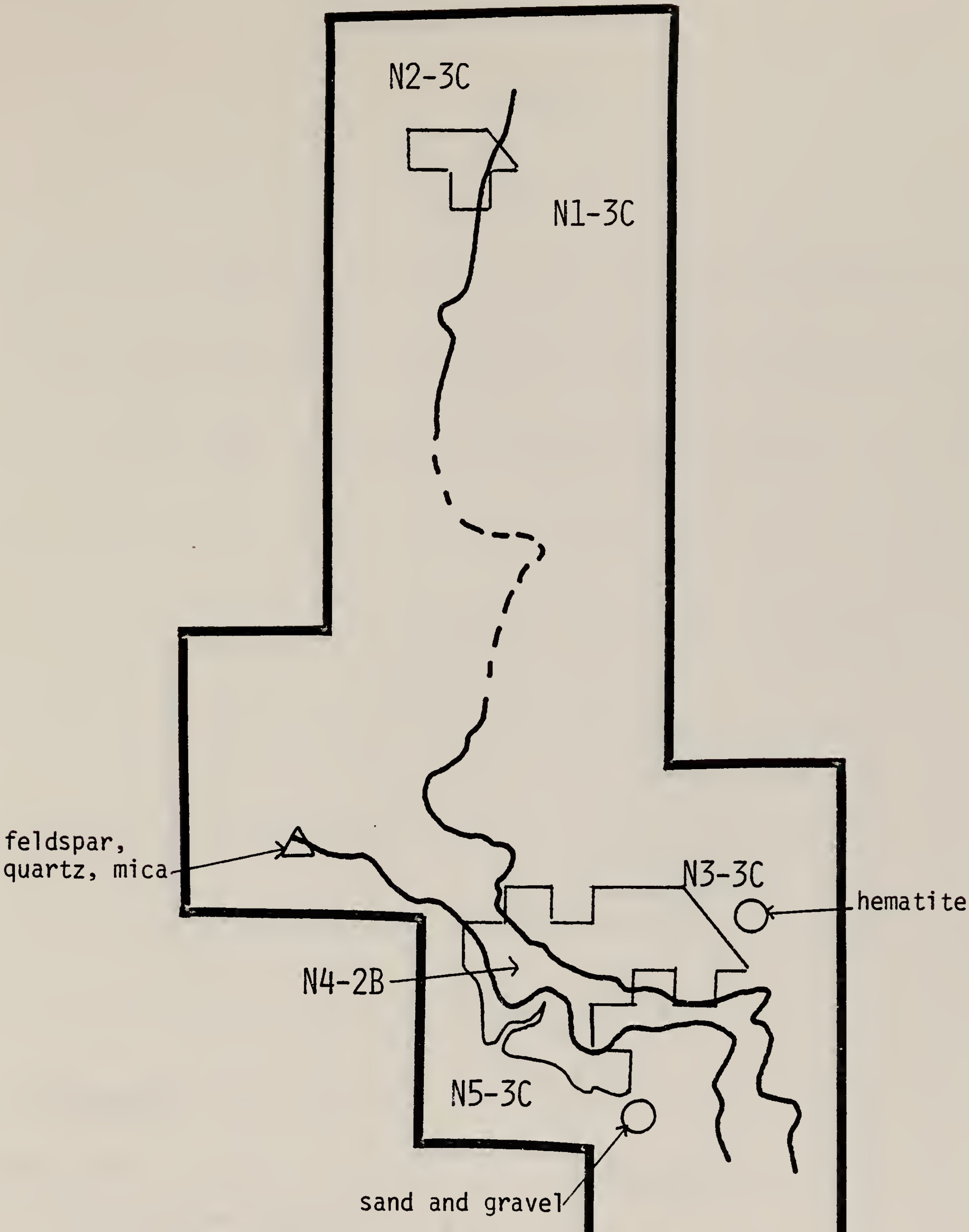

Grand Wash Cliffs GRA AZ-02




Land Classification - Mineral Occurrence Map/Metallics Grand Wash Cliffs GRA AZ-02
Scale 1:250,000




Land Classification - Mineral Occurrence Map/Uranium Grand Wash Cliffs GRA AZ-02
Scale 1:250,000




EXPLANATION

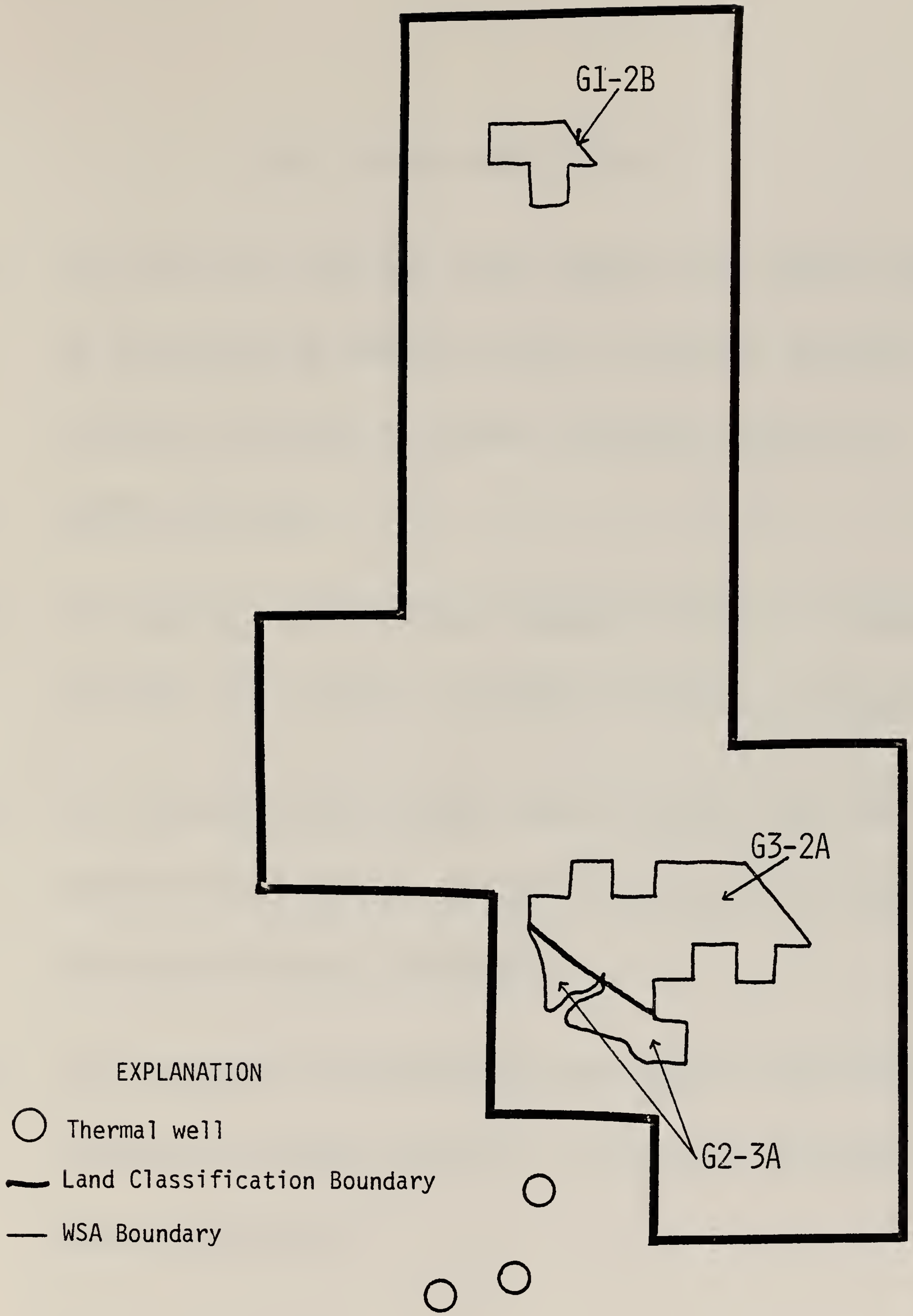
△ Mine, commodity

○ Occurrence, commodity

~ Land Classification Boundary

— WSA Boundary

Land Classification - Mineral Occurrence Map/Nonmetallics Grand Wash Cliffs GRA AZ-02
Scale 1:250,000




Land Classification - Mineral Occurrence Map/Geothermal Grand Wash Cliffs GRA AZ-02
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)<br>Lower (Early) | 136 |
| | Jurassic | Upper (Late)<br>Middle (Middle)<br>Lower (Early) | 190-195 |
| | Triassic | Upper (Late)<br>Middle (Middle)<br>Lower (Early) | 225 |
| Paleozoic | Permian [4] | Upper (Late)<br>Lower (Early) | 280 |
| | Carboniferous Systems: Pennsylvanian [4] | Upper (Late)<br>Middle (Middle)<br>Lower (Early) | |
| | Carboniferous Systems: Mississippian [4] | Upper (Late)<br>Lower (Early) | 345 |
| | Devonian | Upper (Late)<br>Middle (Middle)<br>Lower (Early) | 395 |
| | Silurian [4] | Upper (Late)<br>Middle (Middle)<br>Lower (Early) | 430-440 |
| | Ordovician [4] | Upper (Late)<br>Middle (Middle)<br>Lower (Early) | 500 |
| | Cambrian [4] | Upper (Late)<br>Middle (Middle)<br>Lower (Early) | 570 |
| Precambrian [3] | | 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