MOUNT TIPTON G-E-M RESOURCES AREA (GRA NO. AZ-04) TECHNICAL REPORT (WSA AZ 020-012/042)

Contract YA-553-RFP2-1054

Prepared By

Great Basin GEM Joint Venture
251 Ralston Street
Reno, Nevada 89503

For

Bureau of Land Management
Denver Service Center
Building 50, Mailroom
Denver Federal Center
Denver, Colorado 80225

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 Tipton Geology-Energy-Minerals (GEM) Resource Area (GRA) includes the following Wilderness Study Area (WSA): AZ 020-012/042.

The Mount Tipton GRA is in western Mohave County in the Cerbat Mountains north of Kingman, Arizona. The GRA consists predominantly of Precambrian rocks which are greater than 600 million years old.

A major mining district, the Wallapai or Chloride district, is found in the southern portion of the GRA and just outside the southern boundary of the WSA. The district was a major past producer of gold, silver, lead, zinc and copper from vein deposits. Production exceeded a million dollars worth of the metals.

Strategic and critical minerals include lead, copper and silver produced from the Chloride district but not from within the WSA.

There are no patented claims within the WSA. Two large blocks of unpatented claims extend into the WSA. One block is in the Indian Springs-Pine Canyon area in the northwest portion of the WSA and the commodity they were staked for is unknown. The other block of claims is along the southern border of the WSA and was presumably staked for uranium or metallic minerals.

Oil and gas leases cover all the checkerboard Federal mineral estate ownership in the WSA as this part of Arizona is part of the Overthrust Belt, an area of high current oil interest and potential. There are no geothermal leases.

The WSA is considered to have a low favorability for metallic and nonmetallic mineral resources with a low confidence level because of its proximity to a past major producing mining district, similar geology to that district, and claims found within the WSA. The eastern part of the WSA has a moderate favorability for uranium with a moderate confidence level, the western part has low uranium favorability at low confidence level, the entire WSA has low thorium favorability at a low confidence level, and a low favorability with a very low confidence level for oil and gas. Geothermal resources have a moderate to low favorability with a low confidence level.

There is a lack of available detailed geologic mapping in the WSA. More detailed information would considerably help in further delineating mineral potential in the area.

I. INTRODUCTION

The Mt. Tipton G-E-M Resources Area (GRA No. AZ-04) covers approximately 109,000 acres (443 sq km) and includes the following Wilderness Study Area (WSA):

WSA Name	WSA Number
Mt. Tipton	020-012/042

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 is near 35°30' north latitude, 114°15' west longitude and includes the following townships:

T 26 N, R 17-19 W	T 24 N, R 17-19 W
T 25 N, R 17-19 W	T 23 N, R 18 W

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

7.5 minute:

Chloride	Mt. Tipton
Grasshopper Junction	

The nearest town is Chloride which is located in the south part of the GRA, at the end of Highway 62. Access to the area is via Stock Hill Road to the north and U. S. Highway 93 to the south and west. Access within the area is via Highway 62 to Chloride and various light duty and unimproved roads.

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

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

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

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

The WSA in this GRA was checked by air on October 22 and field checked on the ground on 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 background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included with the GRA File to this GRA report. There are some geological environments that are known to be favorable for certain kinds of mineral deposits, while other environments are known to be much less favorable. In many instances conclusions as to the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most important aspects of geological environments that were in the minds of the authors when they wrote these reports.

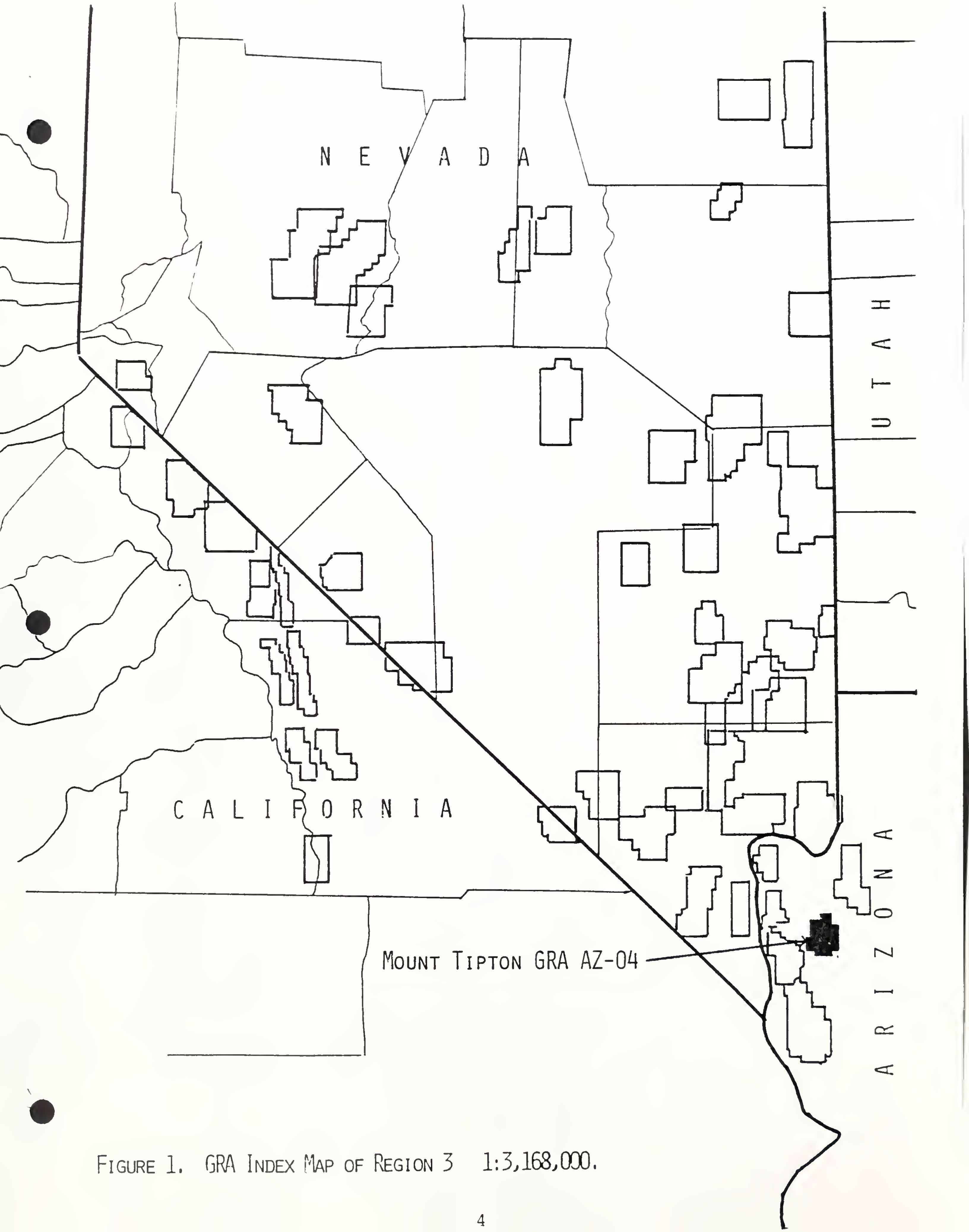
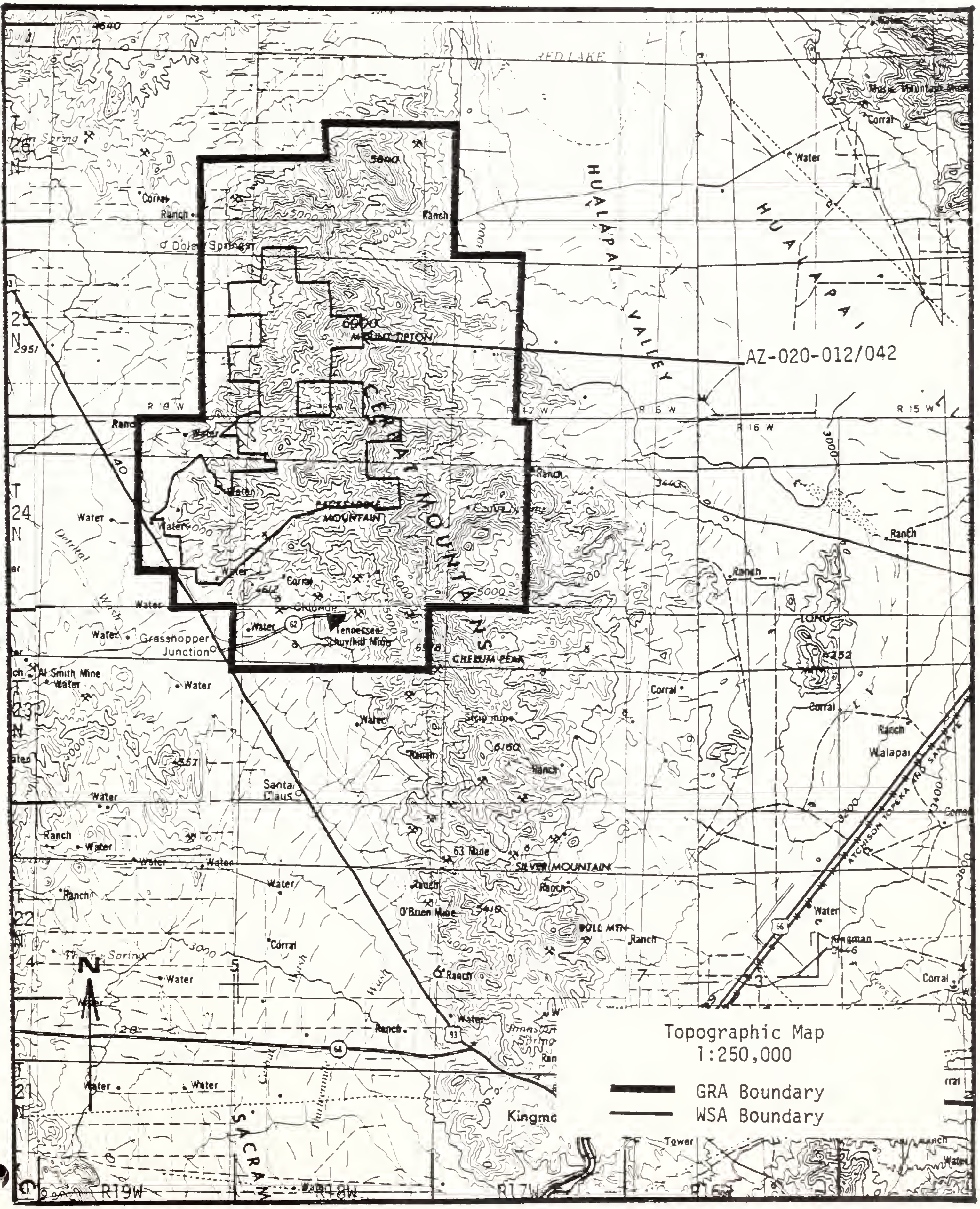


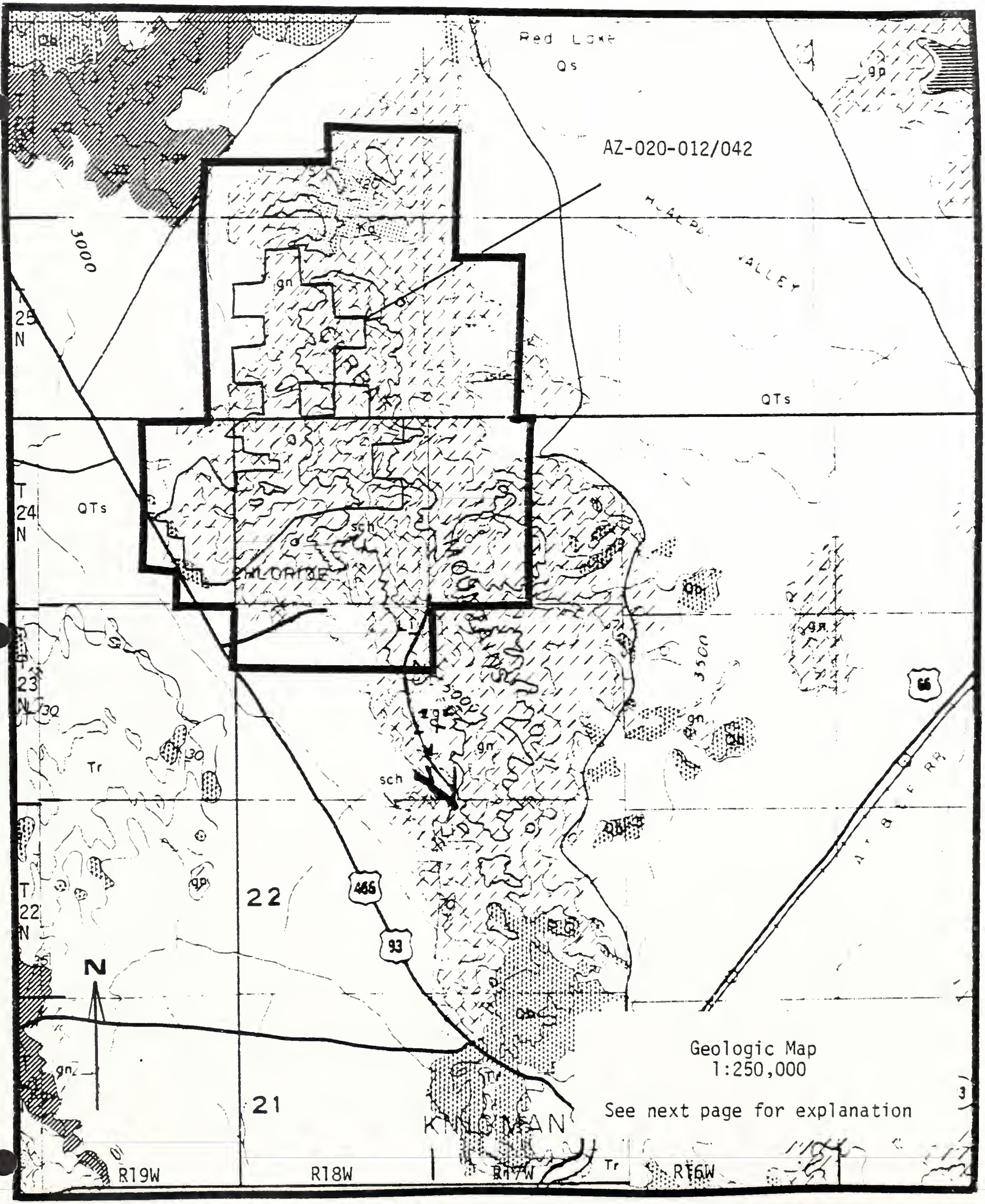
FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Kingman and Williams Sheets

Mount Tipton GRA AZ-04

Figure 2



Mohave County Geologic Map, Wilson and Moore (1959)

Mount Tipton GRA AZ-04

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

LARAMIDE

TRIASSIC AND JURASSIC

TRIASSIC

EXPLANATION CONT.

TRIASSIC

Rc
Chinle formation

Rs
Shinarump conglomerate

Rm
Moenkopi formation

PERMIAN

Pk
Kaibab limestone
Includes Toroweap formation

Pc
Coconino sandstone

Ph
Hermit shale

PENNSYLVANIAN AND PERMIAN

PPs
Supai formation

PPc
Callville limestone

MISSISSIPPIAN AND DEVONIAN

CDl
Redwall and Martin limestones

CAMBRIAN

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 Tipton GRA is an assemblage of Precambrian granite, gneiss and schist intruded by Laramide age granite plutons and locally unconformably overlain by mid-Tertiary andesite flows, tuffs and agglomerate. In the very southwest corner of the study area unnamed Quaternary basalt caps the older rocks.

Structure in the area is dominated by northwest trending fissures which host the lead-zinc-copper-silver mineralization in the Chloride District. Precambrian basement rocks have been folded to form a northeast striking anticline near the town of Chloride.

Recent geologic mapping in the northwest part of Arizona is lacking, and the only geologic map available which covers the GRA is Wilson and Moore's county map published in 1959 at a scale of 1:375,000. Some of the units on this map have subsequently been found to be of a different age based on K-Ar age dating techniques. Geology in the area has been interpolated from various district reports by mining companies, the private sector, and other research material.

1. PHYSIOGRAPHY

The Mount Tipton GRA lies within the Basin and Range Province and is located in west central Mohave County, northwest of Kingman. The study area includes the north half of the north-northwest trending Cerbat Mountains.

The rugged topography of the Cerbat Mountains is typical of deeply incised Precambrian gneiss and granite masses. Elevations along the crest of the mountains range from about 4000 to 6900 feet at Mt. Tipton. Drainage is predominantly perpendicular to the northwest trend of the Black Mountains with runoff flowing into the Hualapai Valley on the east and Detrital-Sacramento Valley to the west.

2. ROCK UNITS

The oldest rock units are Precambrian granite, gneiss and schist. The 1.2 billion year old Precambrian Chloride granite, exposed north and northwest of Chloride has intruded the older 1.3 billion year old Precambrian gneiss, forming a central band at the northeast end of a large fold. The gneiss forms the majority of the north half of the study area and is locally garnetiferous. The Precambrian schist crops out north and south of Chloride in the southern portion of the GRA (Eaton, 1980).

Laramide granite plutons associated with copper mineralization were intruded in the central Cerbat Mountains near Chloride and south of the GRA at Ithica Peak during the late Cretaceous-early Tertiary (Stone and Witcher, 1982).

The oldest reliably dated volcanic rocks in the study area are less than 25 million years old and rest nonconformably upon Precambrian basement rocks in the northern portion of the GRA, or on Laramide intrusive rocks in the southern part (Anderson and others, 1972). This sequence consists of a series of andesite flows, tuffs, and agglomerates.

The most recent effusive rock is an unnamed Quaternary basalt which locally includes tuff and agglomerate. Outcrops of this formation are found in the southwest corner of the WSA.

3. STRUCTURAL GEOLOGY AND TECTONICS

The oldest structures preserved are gneissic and schistose structure of the Precambrian rocks. Large and small folds in the schistocity generally have axes that strike northeast. The most prominent fold is a large anticline, plunging northeast near the town of Chloride. In contrast, sheeting, faults and joints most commonly have a northwesterly strike.

The most outstanding structural feature in the study area is the subparallel northwest-trending fault fissures in the Chloride area along which veins have formed. The age of this faulting is unknown, but it is postulated by Dings (1950) that it occurred after the gneissic and schistose foliation was developed in the Precambrian complex and prior to the late Mesozoic intrusions. Brecciation of the veins and dikes indicates that some minor movement occurred throughout and following ore deposition.

Jointing is pronounced throughout the study area and in places grades into sheeted and sheared zones. The joints generally strike from N 30° W to N 60° W, approximately parallel to the mineralized fissures and dip steeply to the northeast or to the southwest.

4. PALEONTOLOGY

The dominant lithologies (metamorphic and igneous) preclude the occurrence of fossils within the GRA. Late Tertiary and early Quaternary sediments adjacent to the area on the east and west may contain terrestrial fossils, although no record of any localities from those areas are known.

5. HISTORICAL GEOLOGY

During the Precambrian, existing granitic rocks were intruded by the Chloride granite which formed a central band at the northeast end of a large fold.

Paleozoic marine sediments similar to those of the Grand Canyon once blanketed the area but were stripped away by a long period of erosion.

Laramide granitic intrusions and rhyolitic to andesitic dikes were emplaced in the southern portion of the study area during the late Cretaceous-early Tertiary. The dikes formed along existing northwest-trending fault and joint planes in the crystalline Precambrian basement rocks. The mineralization of fissures in the study area is related to the late stage cooling of the granitic intrusions.

Volcanism activated during the mid-Tertiary with the deposition of a series of andesitic flows, tuffs and agglomerate. A period of erosion followed and thick deposits of detrital material accumulated in the valleys bounding the Cerbat Mountains. Volcanism reactivated during the early Quaternary with the deposition of basalt, most of which has been removed in the study area by erosional processes.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

The only known mining district within the Mt. Tipton GRA is the Wallapai district. The northern portion of the Wallapai district, historically known as the Chloride district, occurs in the southern portion of the study area adjacent to the WSA.

Early production came from the near surface bonanza silver chloride deposits in steeply dipping north-northwest-trending siliceous fissure veins cutting Precambrian igneous and crystalline metamorphic rocks. Later production came from the development of the zinc-lead primary ore below the oxidized silver-chloride zone and the zone of secondary enrichment. Zinc-lead production reached its peak from 1915 to 1917 when metal prices were high and there was large-scale production from the Tennessee mines.

About 15 mines within the southern portion of the GRA, but outside the WSA, produced the following approximate quantities of gold, silver, copper, lead and zinc: (Au) $.715 million, (Ag) $2.223 million, (Cu) 1.9 million lbs, (pb) 41.850 million lbs, (Zn) 20 million lbs.

The greatest concentration of veins occurs in the eastern part of the Chloride district where more than 100 veins are present in an area of about six square miles. Despite the abundance of veins, large quantities of ore from mines within the GRA have been found only in the Tennessee-Schuylkill mine. The width of ore shoots in most of the veins is from one to five feet, and the length and depth vary from as little as 10 feet up to 350 feet. In the Tennessee-Schuylkill, the ore shoots range from 1-15 feet in width, from 100-500 feet in strike length, and from several hundred to over 1,000 feet in depth (Thomas, 1949). The Tennessee-Schuylkill properties produced 53% of the copper and 76% of the lead of the total district production.

Other mines in the district located within the GRA, but outside the WSA, are: Juno, Elkhart, Distaff, Samoa, Rainbow, Lucky Boy, Payroll, Silver Hill, and Arizona Magma mines.

2. Known Prospects, Mineral Occurrences and Mineralized Areas.

Prospects located within the Mt. Tipton GRA are concentrated in the Wallapai district area in the southern portion of the study area. Information covering the mines in the northern portion of the study area indicated on the Kingman AMS sheet, were not found on 7.5-minute maps of the area or mentioned in readily available research material.

The outer zones of mineralization surrounding the Mineral Park intrusive center to the south of the GRA extend into the study area. The Cu-Mo porphyry zone in the central stock at Mineral Peak has been mined by Duval. The Zn-Pb-Ag zone which surrounds the stock is in turn surrounded by a Ag-Au zone. Beyond the Ag-Au zone is an outer zone that corresponds to the Au-Ag-U zone of similar mineralized systems in the Front Range Mineral Belt. Although the uranium potential has not been thoroughly evaluated, anomalous water samples in the Big Wash area along the southern boundary of the WSA have reported values that average 20 times background.

3. Mining Claims

Patented claims in the Mt. Tipton area are concentrated in the Chloride district. Portions of 13 sections contain patented claims in this area, none of which are located within the boundary of WSA 020-012/042.

Over six square miles of unpatented lode claims were staked in 1980 by Vicky Barton and Shirley Kazlaskia in the Indian Springs-Pine Canyon area southeast of Dolan Springs. An aerial reconnaissance of this area revealed some recent workings which could possibly be inside the WSA but no field confirmation of this was made. It is not known for what reason these claims were staked.

In 1981 American Selco staked over 100 unpatented lode claims in the area due north of the town of Chloride and extending into the southern portion of the WSA.

Exploration efforts reportedly focused on potential base metal porphyry targets at depth. The claims have been subsequently dropped indicating their exploration efforts were not fruitful.

On the southern border of the GRA Duval has numerous unpatented lode and placer claims. Other small blocks of unpatented claims in the Chloride district are held by the private sector.

4. Mineral Deposit Types

Precious-base metal mineral deposits within the Mt. Tipton GRA are believed to be related to the Laramide age Ithica Peak granite. The Chloride district contains the northern portion of Cu-Pb-Ag, Ag-Au, and Au-U zones surrounding the copper-moly porphyry zone mined by Duval at Ithaca Peak.

Previously formed northwest-trending faults and fissures in the Chloride district acted as conduits for mineralizing fluids derived from the cooling magma. Several periods of mineralization occurred. Fissures, some locally occupied by earlier dikes, were reopened and filled with quartz and pyrite. Subsequent reopening permitted deposition of base-metal and precious minerals. Later movement caused brecciation of the earlier deposited vein maerial and minor amounts of base metals with quartz were deposited. A final movement produced gouge and quartz breccias into which uranium was introduced in a few areas.

The mesothermal veins contain three general groups of vein minerals: oxidation products, secondary sulphide products, and primary hypogene minerals.

The oxidized zone extending 70 to 150 feet below the surface contains native gold and silver, cerargyrite and cerussite, which were the source of early production in the district. Argentite is the most common secondary sulphide and is rarely associated with cuprite, covellite, smithsonite and manganese oxide. The most abundant primary minerals are sphalerite, pyrite, galena, and chalcopyrite.

Alteration of wall rocks in the primary ore zone ordinarily extends only several feet from the veins. The most obvious alteration occurs in the mafic dikes that occupy one or both walls of the vein (Thomas, 1949). Sericitization next to the vein followed silicification, and propylitic alteration away from the vein is the common alteration pattern. The paucity of sizeable ore bodies might in part be due to the strong gouge filling of many veins. Because the majority of veins have not been explored below the oxidized zone, favorable structures at depth may yet be discovered.

5. Mineral Economics

Historically, precious metals ore had been removed by underground mining methods from near surface oxidized portions of numerous mesothermal quartz veins. District reports indicate that most of these near surface ores have been exhausted.

Major base-metal production has come from the primary ore zone of the Tennessee-Schuykill mine with less than 50% of the lead and copper district production coming from the many small mines in the Chloride district. The paucity of sizeable ore bodies might be due in part to the strong impermeable gouge filling of the veins which was formed prior to the deposition of the sulfide minerals (Thomas, 1949). Many of the mines were not developed below the oxidized zone and therefore the potential at depth for large copper-lead ore bodies has not been tested.

Although the potential exists for the discovery of new primary ore shoots below the oxidized zones of the many veins in the district, because of current low base metal prices, it is doubtful that costly underground mining of these small ore bodies would be economically feasible today. Future prices of these commodities may warrant mining however. In addition there may presently be potential for small operations which could find small high-grade, supergene enriched ore-shoots.

The recent acquisition of over 100 unpatented mining claims in the district by American Selco indicates that the area is of interest and may contain heretofore undiscovered large ore bodies attractive to large mining companies.

The potential exists for additional production of the above mentioned metals, however, but at current metal prices underground development of these ore bodies is probably questionable at this time.

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

The major uses of silver are in photographic film, sterlingware, and increasingly in electrical contacts and conductors. It is also widely used for storage of wealth in the form of jewelry, "coins" or bullion. Like gold it is commonly measured in troy ounces, which weigh 31.1 grand grams, twelve of which make one troy pound. World production is about 350 million ounces per year, of which the United States produces about one-tenth, while it uses more than one-third of world production. About two-thirds of all silver is produced as a 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.

The largest use for copper is in electrical equipment and supplies and in smaller-guage wire where its electrical conductivity is essential. It is also used in large quantities in applications where its corrosion resistance is important -- in housing, brass and bronze, sea-water corrosion resistant alloys and others. It is used also in ammunition, many chemicals, and in applications where its conductivity of heat is important. World production is about 7.5 million metric tons annually, of which the United States produces about 1.5 million tons, nearly sufficient to satisfy domestic demand. Copper is a strategic metal. There are large reserves of copper ore in the world, and the United States has greater reserves and greater resources than any other country. United States demand is expected to nearly double by the year 2000, but reserves are thought to be sufficient to meet the demand. However, environmental problems of smelting copper may hinder production, and in times of low prices foreign producers tend to maintain full production for political reasons, while domestic producers tend to restrict production for economic reasons. These pressures on the domestic copper industry weaken its competitive capability on the world market. At the end of 1982 the price of copper was 73 cents per pound.

The largest use for lead is in electrical storage batteries, the second being a gasoline antiknock additive. It has many other uses, however, including radiation shielding, solders, numerous chemical applications, and in construction. About four million metric tons of lead are produced in the world annually. The United States produces about half a million tons per year, and recovers about the same amount from scrap -- much of it through the recycling of old batteries. It imports about one-quarter of a million tons. Lead is classified as a strategic mineral. Demand is projected to increase somewhat in the next couple of decades, but environmental concerns will limit the increase. The United States has large ore reserves that are expected to last well beyond the end of this century at current production rates even without major new discoveries. At the end of 1982 the price was about 22 cents per pound.

The major uses of zinc are in galvanizing, brass and bronze products, castings, rolled zinc and in pigments or other chemicals. About six million metric tons are produced annually, with the United States producing somewhat less than a quarter of a million tons. Domestic production has decreased dramatically over the past five years, largely as the result of closing down of most zinc smelters because of environmental problems. Imports into the United States are about one million tons per year, and zinc is listed as a strategic and critical metal. Both world-wide and domestic consumption are expected to increase at a moderate rate over the next twenty years. At the end of 1982 the price of zinc was about 38 cents per pound.

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There are no known nonmetallic mineral deposits in the WSA. Outside the WSA boundaries there are deposits of sand and gravel which have been utilized in the past however.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

There are no reported occurrences of nonmetallic minerals in the WSA. A field check along the road forming the southern boundary of the WSA confirmed the presence of coarse-grained (pegmatitic) phases within the Precambrian gneisses. The alluvium in the WSA could be utilized as a sand and gravel and building stone could probably be furnished from the bedrock units.

South of the GRA in the southern Cerbat Mountains there are occurrences of turquoise, graphite, feldspar, limestone and quartz.

3. Mining Claims, Leases and Material Sites

There are no known claims staked for nonmetallics within the WSA. The claims recently staked in the Indian Springs-Pine Canyon area are for an unknown commodity.

4. Mineral Deposit Types

There are no reported nonmetallic occurrences in the WSA. Sand and gravel are present, however, and are found in the alluvial materials bordering the mountain front.

5. Mineral Economics

There are no reported nonmetallics in the WSA other than sand and gravel.

The most common use of sand and gravel is as "aggregate" -- as part of a mixture with cement to form concrete. The second largest use is as road base, or fill. About 97 percent of all 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 -- with 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 FOB 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

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

2. Known Prospects, Mineral Occurrences and Mineralized Areas

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

Uranium is associated with gold and silver and also occurs separately in veins in Precambrian granitic gneiss in the southern part of the WSA and GRA (Luning and others, 1981). Zones of alteration and brecciation, where porosities are greater, are the most favorable sites for uranium concentration. The source of the uranium is probably the intruding Mesozoic Ithaca Peak granite. Though the uranium occurrences have been too small to be of economic interest on their own, they could be recovered as a by-product from mining the precious metals. An area along Big Wash, Secs. 14-17 and 20-23, T 24 N,R 18 W, appears to be highly favorable for uranium concentration. There are numerous anomalies in water samples and radiometrics in the area (Laverty, 1982).

Uranium has also been found in lead and zinc bearing veins in the southern half of the Cerbat Mountains south of the GRA, though the uranium content has been too low to be mined on its own.

There are no known thorium occurrences in or near the GRA.

3. Mining Claims

In the Big Wash area of the GRA, along the southern border of the WSA, R. A. Laverty has recorded unpatented lode claims totalling 1,260 acres (Chlorite Nos. 1-49 and 51-66). These claims expired on September 1, 1982. A prospecting permit #7393S was issued for 240 acres in the SE/4 and E/2 SW/4 Sec. 16, T 24 N, R 18 W. It was due to expire on May 1, 1982 and it is not known whether the permit was renewed. It is not known whether uranium is included in these claims and prospecting permits, but it is probable as Mr. Laverty is a uranium geologist.

The information is not readily available on the inclusion of uranium or thorium in claims within the GRA.

4. Mineral Deposit Types

Known uranium deposit types in the WSA, GRA and the southern extent of the Cerbat Mountains are restricted to vein type deposits, commonly associated with base and precious metals. Areas of faulting, brecciation, and alteration, where porosities are increased, are the most prospective for vein type uranium concentration.

There are no known thorium occurrences within or near the WSA or the GRA.

5. Mineral Economics

There is insufficient data on uranium and thorium in the GRA to make an economic evaluation of the area. Exploration to date indicates that the uranium deposits are too small to be mined on their own. Since they do occur with gold, silver, lead, and zinc, the uranium could be recovered as a by-product.

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 probable 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 and 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 contain non-competitive oil and gas leases (see Oil and Gas Lease Map). There is no oil and gas occurrence and land classification map with this report.

Geothermal Resources

There are no known geothermal deposits, prospects, or occurrences within the Mt. Tipton GRA. Just seven miles south of the WSA is a 880-meter well that had a bottom hole temperature of 40°C (NOAA, 1982). Wells twelve miles to the east in Hualapai Valley have temperatures of 48° to 76°C at depths of 651 to 1,228 meters; and fifteen miles to the south 36°C and 37°C surface discharge were recorded for two wells of unknown depths (Geothermal Occurrence and Land Classification Map). 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 GEOLOGICAL RESOURCES

There are no other known outstanding geologic resources within the WSA.

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.

Lead, copper and silver, currently on the U. S. stockpile list, of strategic and critical minerals have historically been produced from the Chloride district located in the southern portion of the Mt. Tipton GRA and bordering the WSA on the south. The total district production of these commodities has been estimated by the Arizona Bureau of Mines to be: (Cu) 1 million lb, (Pb) 30 million lbs, and (Ag) $650,000. Zinc, which is listed as a strategic and critical mineral has been produced mainly from the Tennessee-Schuykill mine. Approximately 20 million pounds of zinc have been extracted from this mine.

IV. LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

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

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

In connection with nonmetallic mineral 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 entire WSA 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 the mineralization. It is not sufficiently detailed for the purpose of assessing mineral potential other than from a broad viewpoint perhaps. Much more detailed geologic mapping has been done for the Chloride mining district to the south of the WSA, some of which covers the southern portion of the WSA. These references include Titley (1982), Laverty (1982) and Eidel and others (1968). Overall our confidence level in the available information ranges from moderate for Wilson and Moore's map to high for the abundant information pertaining to the Chloride district to the south.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA AZ 020-012/042

M1-2B. This classification area includes all the bedrock outcrop area of the WSA which is almost entirely composed of Precambrian rocks. The entire WSA is considered to have a low favorability for metallics with a low confidence level because of its proximity to the adjacent Chloride district to the south, similar geologic host rocks present, as in that district, and mining claims which cover parts of the WSA. The typical veining system is not present within the WSA, however, as is present to the south at Chloride. Also, there is no evidence of intrusive activity in the WSA as at Chloride or further south at Mineral Park.

M2-2A. This classification area is one of low favorability with a very low confidence level includes a small part of the extreme northwest portion of the WSA which is covered by alluvium. The depth and nature of the bedrock is unknown but since the adjoining bedrock exposures are classified as 2, then these buried units should also be 2, but we have no evidence to substantiate this, hence the A confidence level.

b. Uranium and Thorium

U1-3C. This classification area indicating moderate uranium favorability at a moderate confidence level includes Precambrian granite, gneiss and schist intruded by Mesozoic granite and capped by mid-Tertiary andesitic volcanics. Uranium is associated with gold and silver vein deposits in the Precambrian granite and granitic metamorphics in the southern part of the WSA and GRA; and uranium is also associated with lead and zinc vein deposits in these same units in the southern GRA, south of the WSA and also further south, beyond the GRA. No large uranium deposits have been found within or near the WSA or the GRA, and the uranium associated with the metals could only be economically recovered as a by-product from mining the metals.

There is a small aerial radiometric uranium anomaly just north of the town of Chloride which is associated with uranium occurrences in metallic vein deposits (Luning and others, 1981). This anomaly is within the GRA though south of the WSA.

Exploration to date indicates that the southern part of the WSA is more prospective than the northern section for uranium associated with metallic vein deposits. No other types of uranium occurrences are reported in the WSA or the GRA.

Thorium has low favorability at a low level of confidence within the area as there are no known occurrences. There is some potential for both thorium and uranium occurring in pegmatites within the WSA and GRA.

U2-2B. This classification area of low uranium and thorium favorability at low confidence levels includes Quaternary and Tertiary alluvial fan deposits along the western border of the WSA and GRA. There are no known uranium or thorium deposits in this area though there is some low potential for resistate mineral concentrations in fluvial sands (e.g. monazite sands) in the alluvium. The resistate minerals could weather out of the pegmatites and granites in the range and be carried onto the alluvial fan though it is doubtful that the sedimentary processes would allow sufficient reworking of the sediments to concentrate the resistate minerals in a heavy mineral deposit.

There is some potential for epigenetic sandstone-type uranium deposits in the alluvium. The source of the uranium would be the numerous uranium occurrences in the metallic-vein deposits of the range. The uranium would be dissolved in the groundwater and carried down into the alluvium. It is doubtful that a large uranium deposit would occur in this area since fluvial sand channels are probably not well developed in the alluvium and there is probably a lack of reductants (e.g. organic material) to cause precipitation of the uranium from the groundwater.

c. Nonmetallic Minerals

N1-2B. This classification area is one of low favorability with a low confidence level and includes all the bedrock outcrop area of the WSA which is composed almost entirely of Precambrian gneisses. The entire area is considered to have a low potential because even though the geology may be similar to that of the Cerbats farther south which have nonmetallic occurrences such as turquoise and graphite, there are no nonmetallic occurrences within the WSA nor typical veins along which the occurrences farther south are found.

The pegmatitic phases in the Precambrian gneisses hold little potential for most typical nonmetallics associated with this rock type outside of possibly quartz and feldspar, for the pegmatitic phases appear to be little more than coarse-grained granites.

In addition any rock type can be used for construction materials or other uses depending on its particular physical or chemical properties.

N2-3C. This classification is for moderate favorability for sand and gravel with a moderate confidence level and includes the small area covered by alluvium in the extreme northwest corner of the WSA. The alluvium could possibly be suitable for sand and gravel or other construction related applications.

2. LEASABLE RESOURCES

a. Oil and Gas

WSA AZ 020-012/042

OG-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 stratagraphic units do not necessarily have a bearing on possible drilling objectives at depth, considering overthurst structural implications.

b. Geothermal

WSA AZ 020-012/042

G1-3B. This classification incorporates an area where Quaternary basalts have apparently been extruded along a range front fault. The presence of these youthful volcanics indicates an existing heat source at depth.

G2-2A The entire area is underlain by the Cerbat Mountains Precambrian granite gneiss, and some Quaternary sediments of the Detrital Valley. The geologic map is very generalized in the GRA area. Low temperature waters are present in the immediate region to the northeast and the south.

c. Sodium and Potassium

S1-1D. The WSA is not considered to have potential for sodium or potassium.

d. Other

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

3. SALEABLE RESOURCES

Materials suitable for materials sales, sand and gravel, have been discussed above under nonmetallics and includes classification area N2-3C.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

1. The claim group and the new workings in the northwest portion of the WSA should be field checked. A reconnaissance of this northern part of the WSA was made using a small plane but no ground verification was made. An apparent new excavation at the foot of the range near Sec. 17, T 25 N, R 18 W (there is a possibility this is a developed spring).

2. Contacting more of those companies or individuals who have knowledge of the area or who have worked in the area may further shed light on the mineral potential of the WSA (including Arizona Small Miners Association).

3. More detailed mapping in the WSA would also help greatly in determining mineral potential.

VI. REFERENCES AND SELECTED BIBLIOGRAPHY

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

Anderson, R. E., Longwell, C. R., Armstrong, R. L., and Marvin, R. F., 1972, Significance of K-Ar ages of Tertiary rocks from the Lake Mead Region, Nevada-Arizona: Geological Soc. of America Bull., v. 83, no. 2, p. 273.

Bastin, E. S., 1924, Origin of certain rich silver ores near Chloride and Kingman, Arizona: U. S. Geol. Surv. Bull. 750, pp. 17-39.

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

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

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

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

Crib, U. S. Geological Survey.

Darton, N. H., 1925, A resume of Arizona geology: Ariz. Bureau Mines Bull. 119, p. 180.

Dings, M. G., 1950, Wallapai mining district, Mohave County, Arizona: Arizona Bur. Mines Bull. 156, pt. 1, pp. 138-142.

Eaton, Larry G., 1980, Geology of the Chloride mining district, Mohave County, Arizona: MS thesis, New Mexico Institute of Mining and Technology.

Eidel, J. J., Frost, J. E., and Clippinger, D. M., 1968, Copper-molybdenum mineralization at Mineral Park, Mohave County, Arizona, in Ridge, J. D., ed., Ore deposits of the United States 1933-1968: New York, AIME p. 1259-1281.

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

Elsing, M. J., and Heineman, E. S., 1936, Arizona metal production: Ariz. Bur. Mines Bull. 140, pp. 73-95.

Exxon Minerals, 1982, Personal communication.

Fischer Watt Mining Company, 1982, Personal communication.

Garrett, S. K., 1938, Tennessee-Schuylkill mine: Ariz. Bur. Mines Bull. 145, pp. 117-119.

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

Hart, Olin M., Hetland, D. L., 1953, Preliminary report on uranium bearing deposits in Mohave County, Arizona: United States Atomic Energy Commission. R.M.E. 4026.

Haury, P. S., 1947, Examination of zinc-lead mines in the Wallapai mining district, Mohave County, Arizona: U.S. Bur. Mines Rep. Inv. 4101.

Hernon, R. M., 1938, Cerbat Mountains: Ariz. Bur. Mines Bull. 145, pp. 110-117.

Kirk, William S., 1980a, Thorium in Mineral Facts and Problems, 1980 ed., U. S. Bureau of Mines, Bull. 671, p. 937-945.

Kirk, William S., 1980b, Thorium in Mineral Yearbook, vol. I, Metals and Minerals, U. S. Bureau of Mines, p. 821-826.

Kirk, William S., 1982, Thorium in Mineral Commodity Summaries - 1982, U. S. Bureau of Mines, p. 160-161.

Laverty, R. A., 1982, A mining prospect in the Cerbat Mountains, Mohave County, Arizona: private report.

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

Mason R. T., 1917, Mining in northwestern Arizona: Min. and Sci. Press, pp. 627-628.

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

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

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

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

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

Pierce, H. W., Principal Geologist, 1982, Personal Communication: State of Arizona Bureau of Geology and Mineral Technology, Tucson.

Sante Fe Mining Co., 1982, Personal communication.

Schrader, F. C., 1909, Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona: U.S. Geol. Surv. Bull. 397.

Schrader, F. C., 1917, Geology and ore deposits of Mohave County, Arizona: Am. Inst. Min. Eng. Trans., vol. 56, pp. 195-236.

Silver, L. T., 1967, Apparent age relationships in the older Precambrian stratigraphy of Arizona (abs.) I.U.G.S. Comm. Geochron. Conf. on PE stratified rocks, Edmonton, Canada.

Sterrett, D. B., 1908, Precious stones: Mineral Resources U. S., 1908, pt. 2, pp. 847-852.

Stone and Witcher, 1982,(in preparation) Geothermal Resources in Arizona. ABGMT Open File Report.

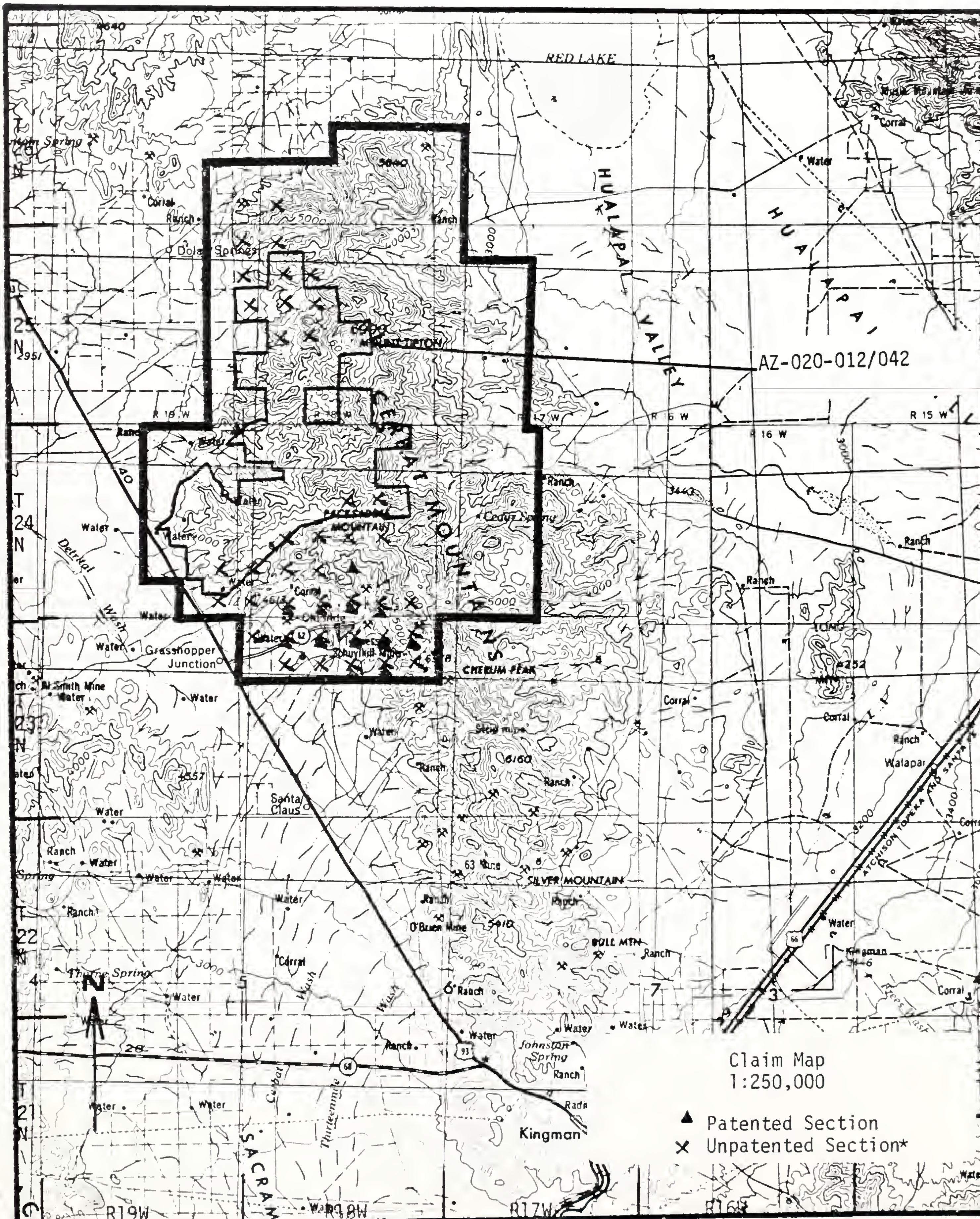
Tainter, S. L., 1947, Johnny Bull-Silver Knight lead-zinc property, Cerbat Mountains, Mohave County, Arizona: U.S. Bur. Mines Rept. Inv. 3998.

Thomas, B. E., 1949, Ore deposits of the Wallapai district, Arizona: Econ. Geology, vol. 44, pp. 663-705.

Titley, S. R., 1982, Advances in Geology of the Porphyry Copper Deposits: Univ. of Arizona Press, Tucson, Az.

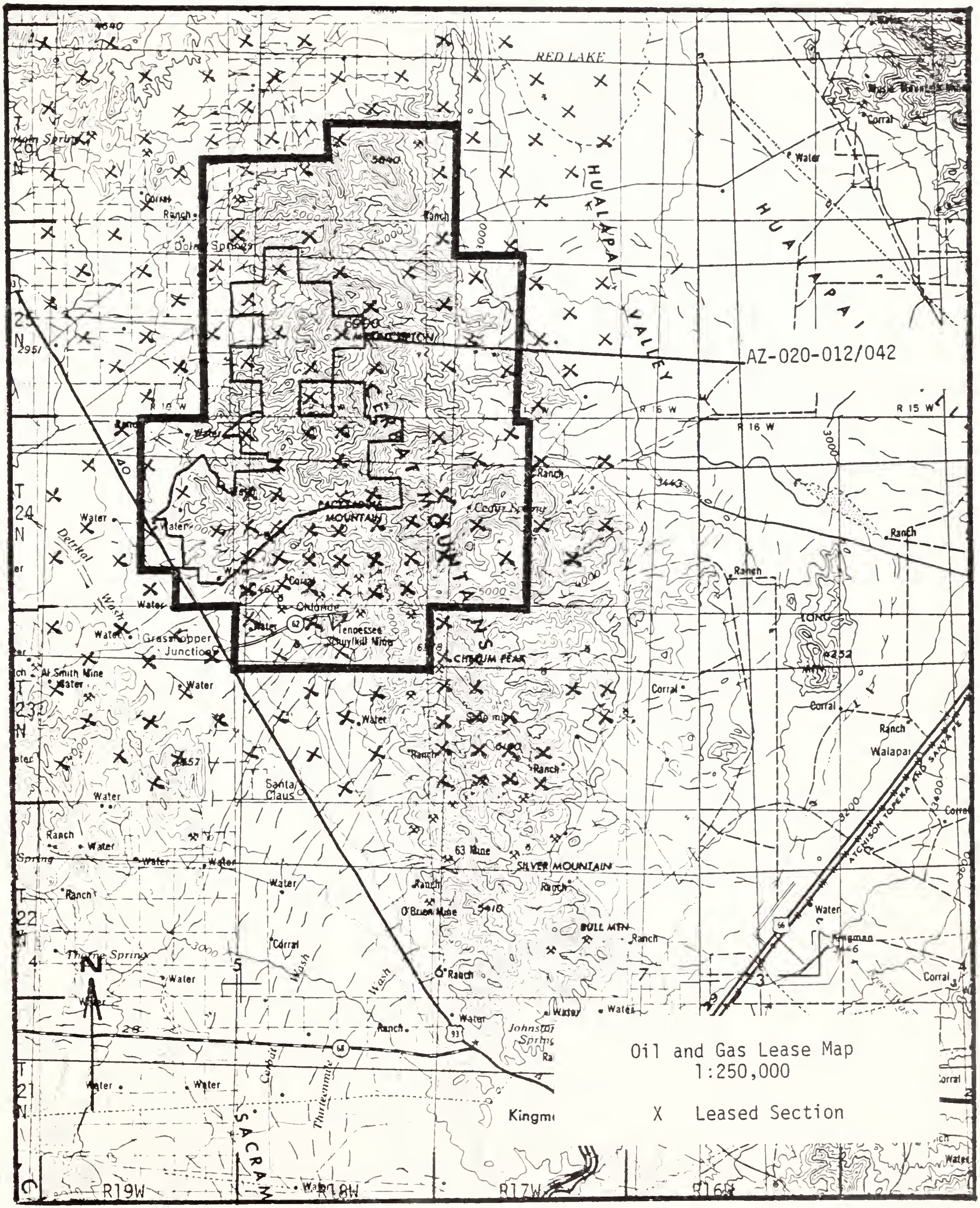
U. S. Bureau of Mines, MILS data.

Wilson, E. D., and Moore, R. T., 1959, Geologic Map of Mohave County, Arizona: Arizona Bur. of Mines, U. of A., Tucson, Az.

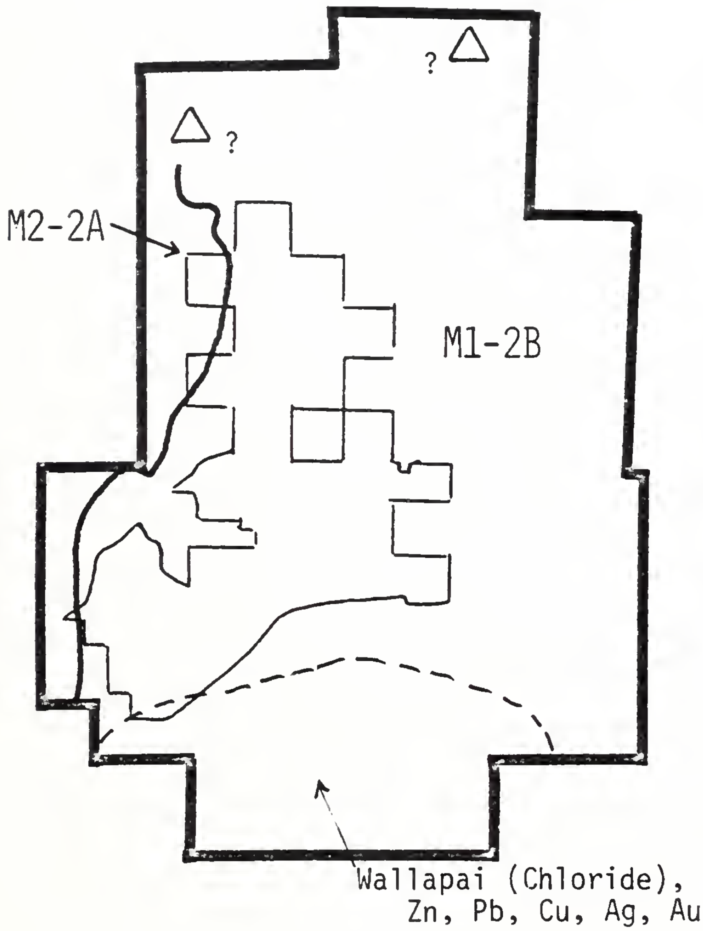


*X denotes one or more claims per section

Mount Tipton GRA AZ-04



Mount Tipton GRA AZ-04



EXPLANATION

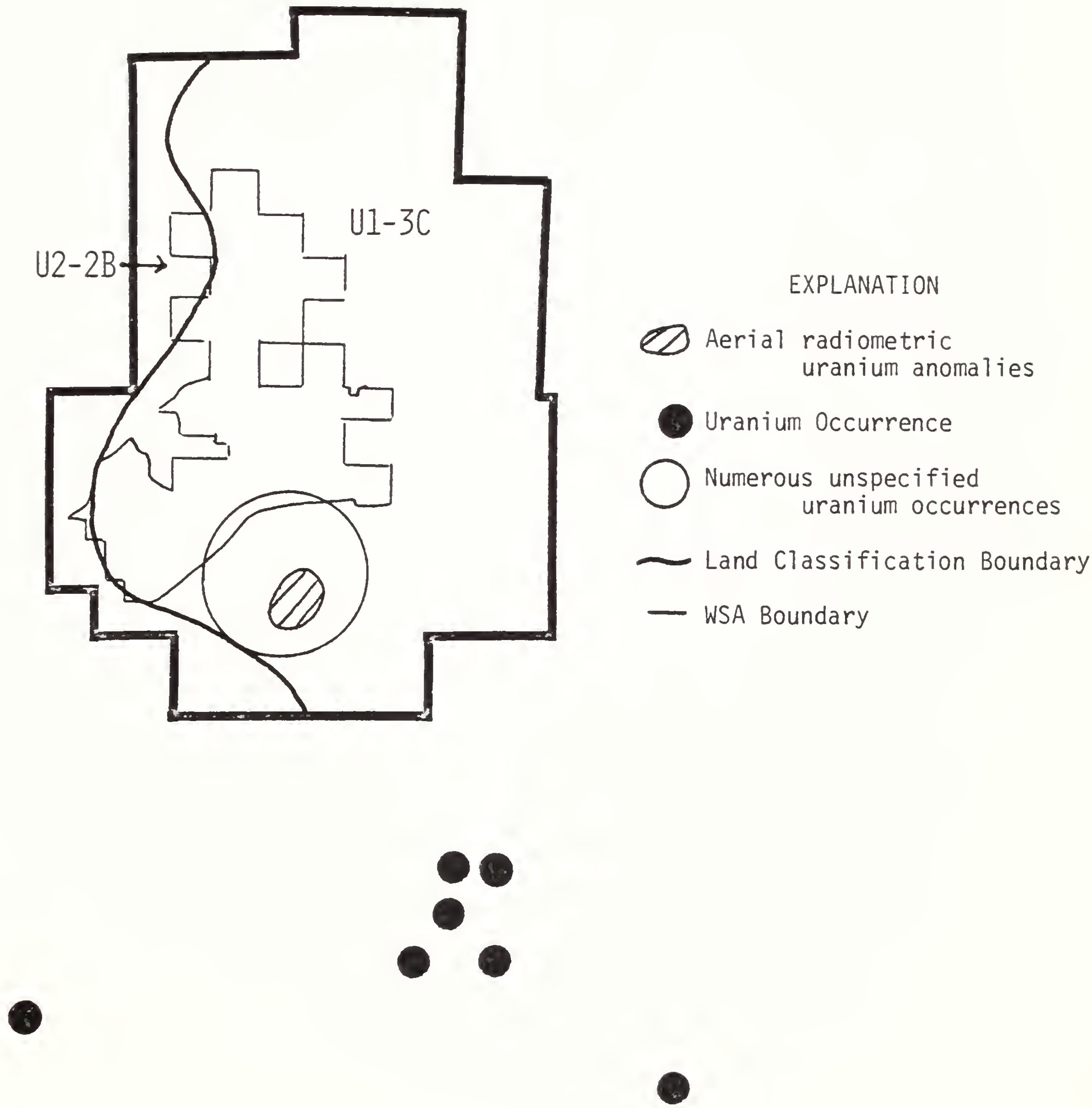
Mining District, commodity

Mine, commodity

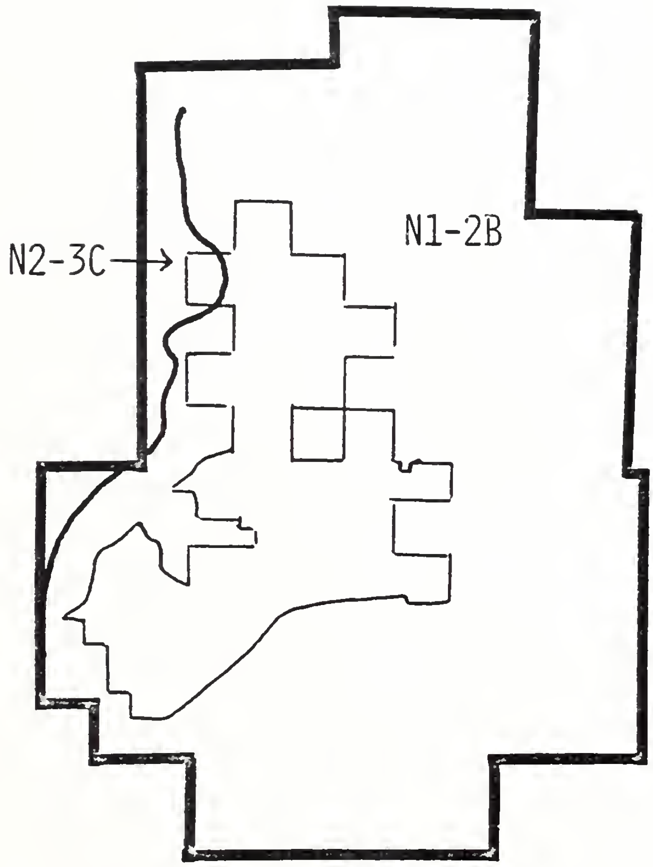
Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Metallics Mount Tipton GRA AZ-04
Scale 1:250,000



Land Classification - Mineral Occurrence Map/Uranium Mount Tipton GRA AZ-04
Scale 1:250,000

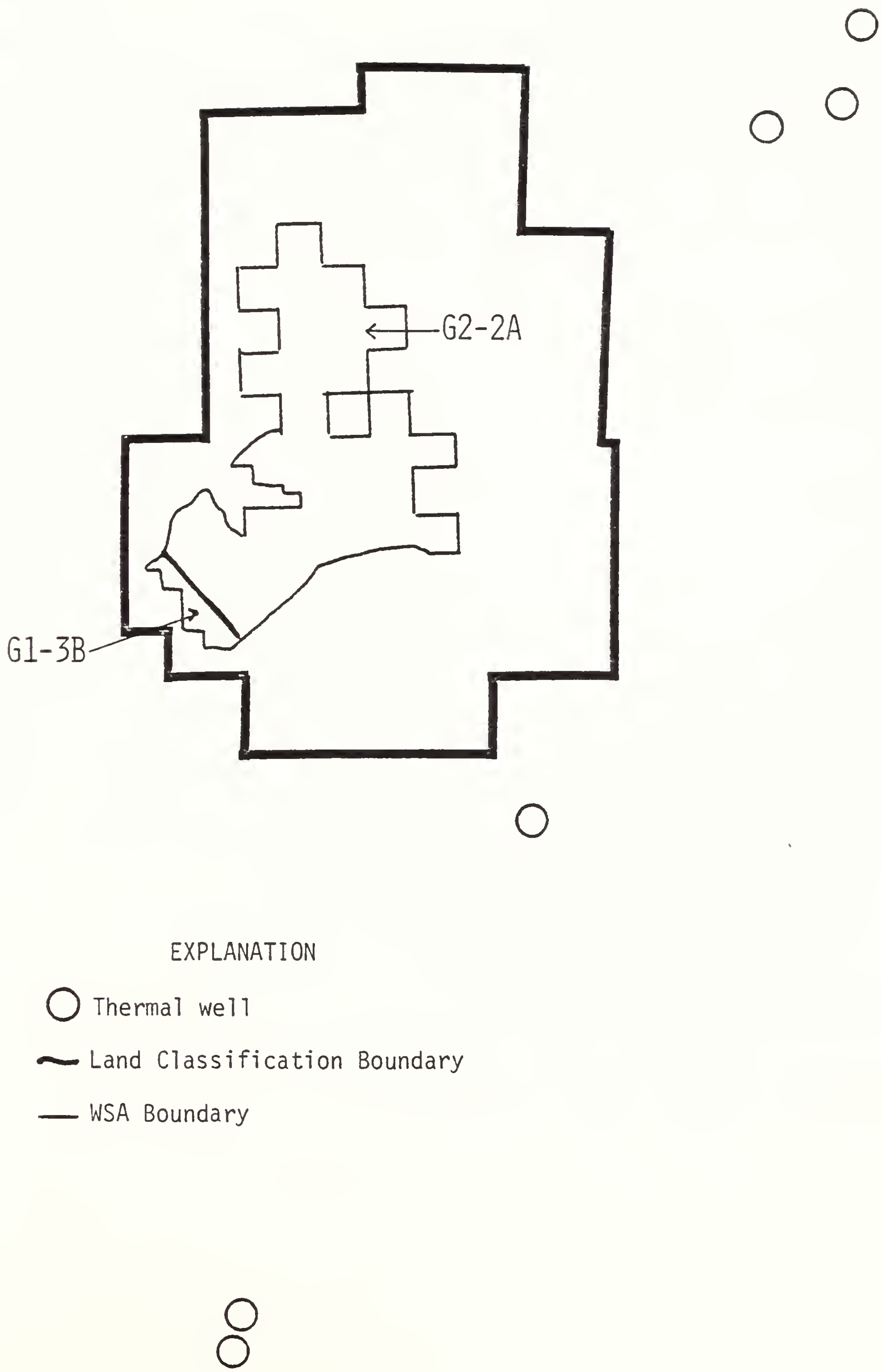


EXPLANATION

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Nonmetallics Mount Tipton GRA AZ-04
Scale 1:250,000



Land Classification - Mineral Occurrence Map/Geothermal

Mount Tipton GRA AZ-04
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)	
		Mississippian [4]	Upper (Late) Lower (Early)	345
	Devonian		Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian [4]		Upper (Late) Middle (Middle) Lower (Early)	430-440
	Ordovician [4]		Upper (Late) Middle (Middle) Lower (Early)	500
	Cambrian [4]		Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian [4]			Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600 + [3]

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

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

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

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

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

GEOLOGIC NAMES COMMITTEE, 1970