LA MADRE MOUNTAINS/PINE CREEK G-E-M RESOURCES AREA

(GRA NO. NV-32)

TECHNICAL REPORT

(WSAs NV 050-0412 and 050-0414)

Contract YA-554-RFP2-1054

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Final Report

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EXECUTIVE SUMMARY

The La Madre Mountains/Pine Creek Geology-Energy-Minerals (GEM) Resource Area (GRA) includes the following Wilderness Study Areas (WSAs): NV 050-0412 and NV 050-0414. The La Madre Mountains/Pine Creek GRA is located in west-central Clark County, Nevada just west of Las Vegas.

Geologically the GRA and included WSAs consist of 200 to 500 million year old sediments consisting primarily of carbonate rocks. The massive Aztec sandstone forms high spectacular cliffs on the east side of the GRA in Red Rock Canyon. The Keystone thrust fault is a major structural element in both WSAs, thrusting older rocks over the younger Aztec sandstone.

Metallic mineral resources are not reported to occur in either WSA, but minor lead-zinc replacement deposits are found to the immediate north and east of WSA NV 050-0412 within the GRA. Also, the productive Goodsprings mining district is just south of the GRA in similar rock units and produced gold, silver, lead, zinc and copper. Nonmetallics which have been produced in WSA NV 050-0412 include a minor amount of gypsum in the north and sandstone for building stone in the south. Extensive deposits of gypsum sandstone, silica and carbonates are found in the GRA.

There are no patented claims in either WSA. Unpatented claims in the WSAs were staked for gypsum in the north and metallics in the south. There are numerous claims outside the WSAs in the Charleston Park area, the Iron Age claims area, near Blue Diamond and in the Lovell Canyon area. A large group of placer claims in the Lovell Wash area is controlled by Magmum Mining which claims to have extensive tonnages of low-grade gold.

For metallics the majority of both WSAs is considered to have a low favorability with a low confidence level including that area covered by Magmum Mining's gold claims. The younger sediments are considered to have a very low favorability with a low confidence level for metallics. The rock underlying the alluvium in the WSAs is considered to have a low favorability with a very low confidence level. Uranium has a low favorability with a low confidence level, and thorium has a very low favorability with a very low confidence throughout both WSAs.

For nonmetallic mineral resources a gypsum deposit inside the boundary of the northern WSA is considered to have a high favorability with a high confidence level, but other potential gypsum areas have a moderate favorability with a moderate confidence level. The Aztec sandstone has a moderate favorability for silica and building stone with a moderate confidence level. The carbonate units which form the bulk of both WSAs have a moderate favorability for cement or lime with a moderate confidence level, and the alluvium in the WSA has a moderate favorability with a moderate confidence level.

Oil and gas has a low favorability with a very low confidence level and geothermal has a moderate favorability with a very low confidence level.

Additional work to further delineate mineral resources in the WSAs should include more detailed mapping, a thorough investigation of Magmum's claims, and more detailed investigation of those areas of the WSAs near claims or known or possible mineral occurrences.

I. INTRODUCTION

The La Madre Mountains/Pine Creek G-E-M Resources Area (GRA No. NV-32) contains approximately 300,000 acres (1,200 sq km) and includes the following Wilderness Study Areas (WSAs):

WSA Name	WSA Number
La Madre Mountains	NV 050-0412
Pine Creek	NV 050-0414

The GRA is located in Nevada within the Bureau of Land Management's (BLM) Esmeralda Resource Area, Las Vegas district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 36°10' north latitude, 115°30' west longitude and includes the following townships:

T 19 S, R 56-59 E	T 21 S, R 56-59 E
T 20 S, R 56-59 E	T 22 S, R 57-59 E

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

15-minute:

Corn Creek Springs	Mountain Springs
Blue Diamond	

7.5-minute:

Grapevine Spring	Tule Spring Park
La Madre Mountain	Blue Diamond, NE
Blue Diamond	Blue Diamond, SE

The nearest town is Blue Diamond which is located in the southeastern part of the GRA. Access to the area is via the Blue Diamond Road to the south, State Route 39 to the north, and State Route 85 across the central part of the GRA.

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.

Both WSAs in this GRA were field checked on December 6, 7 and 10 of 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 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 in 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 teh 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.

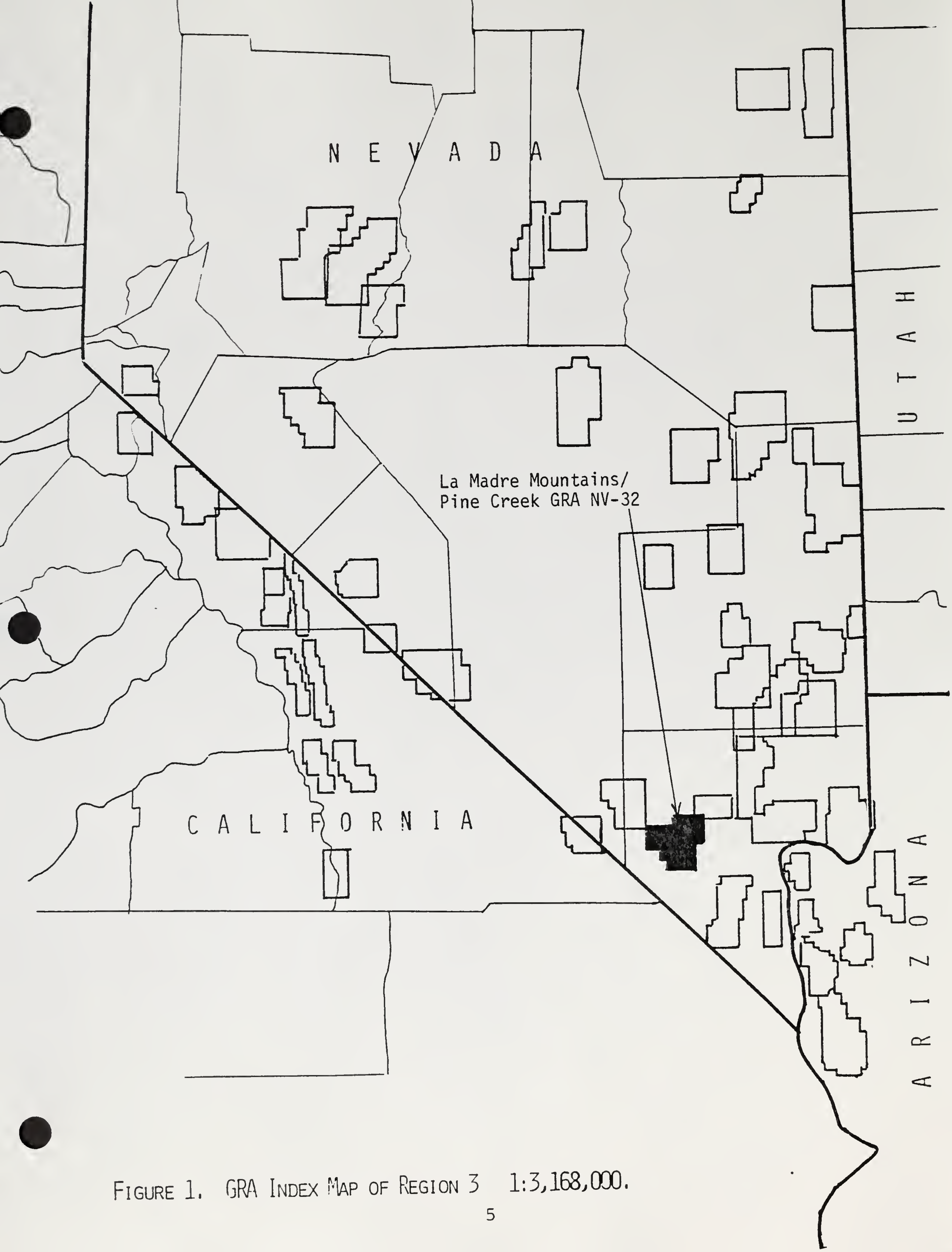
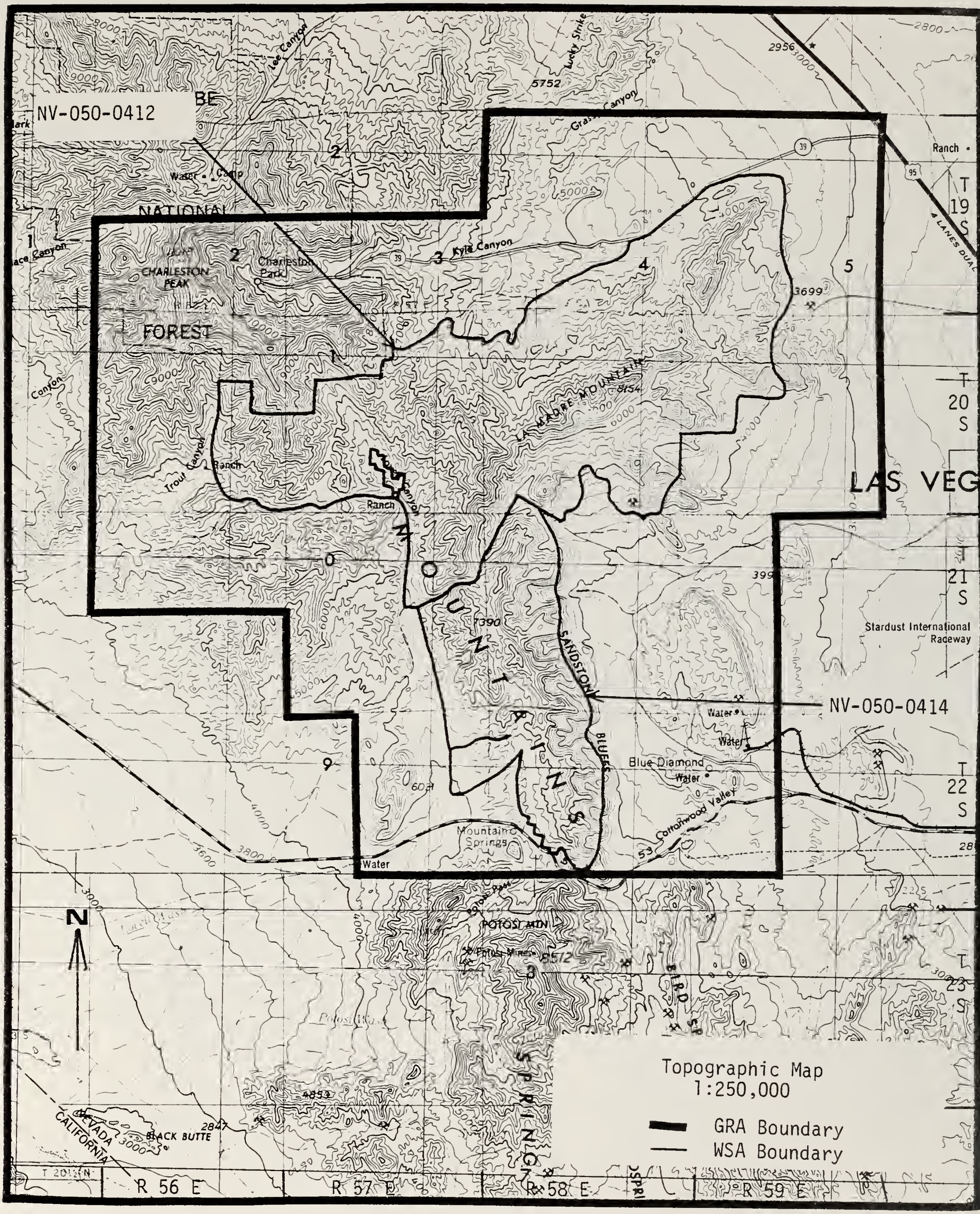


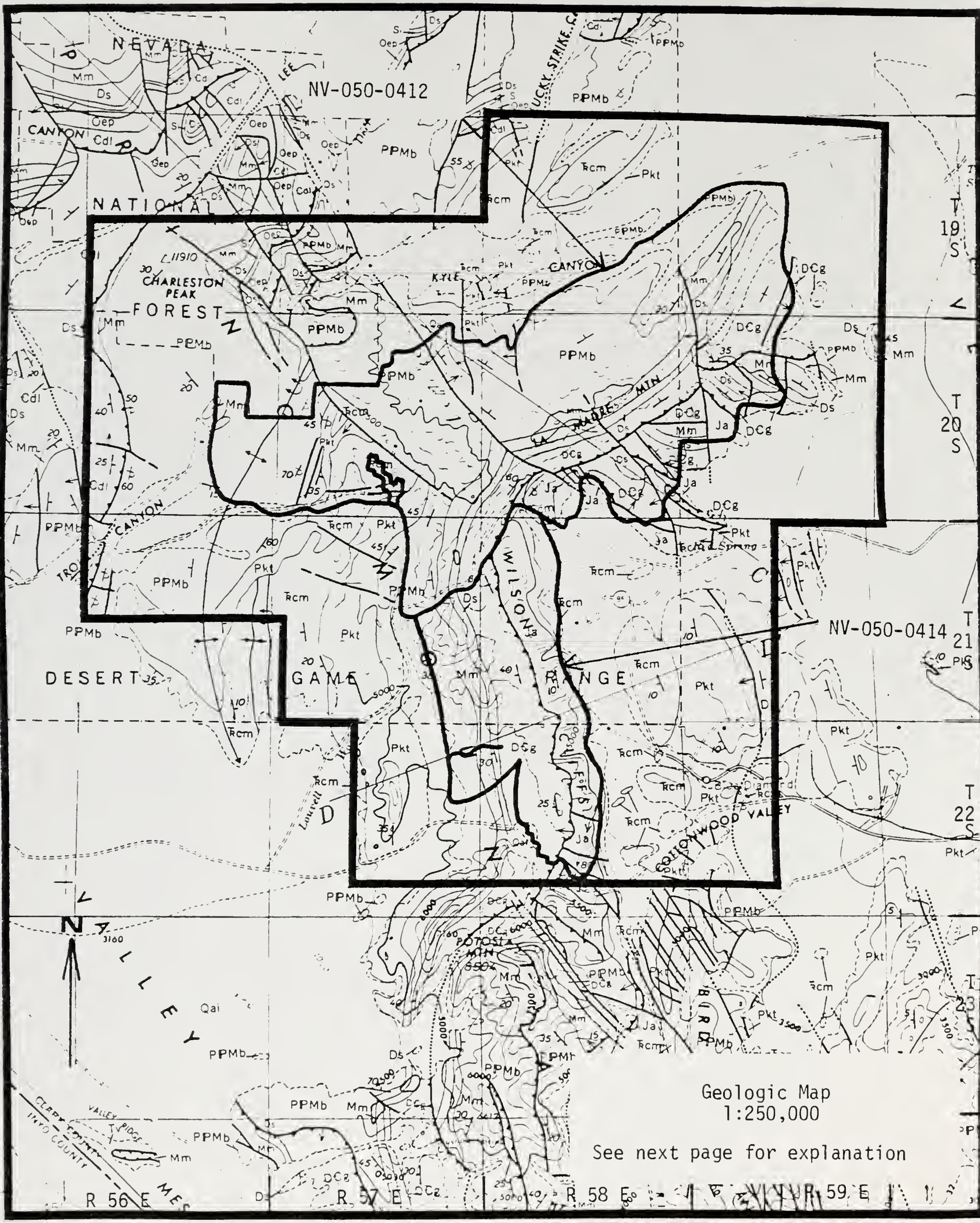
Figure 1. GRA Index Map of Region 3 1:3,168,000.



Las Vegas Sheet

La Madre Mountains/Pine Creek GRA NV-32

Figure 2



Longwell, Pampeyan, Bowyer and Roberts (1965)

La Madre Mountains/Pine Creek GRA NV-32

Figure 3

EXPLANATION

CLARK COUNTY

Qa

Alluvium

Q

Las Vegas Formation

UNCONFORMITY

Tv | Tb

Volcanic rocks

Tv, undifferentiated volcanic rocks
Tb, Fortification Basalt Member of Muddy Creek Formation

TKgr | TKi | TKc

Intrusive rocks

TKgr, holocrystalline rock; mainly granite, quartz monzonite, granodiorite, and diorite
TKi, undivided porphyritic rocks. Includes granite porphyry, rhyolite, trachydolerite, and other intrusives ranging from basaltic to rhyolitic
TKc, undifferentiated intrusive rocks, mainly quartz monzonite and diorite containing roof pendants of volcanic rock, Paleozoic limestone and dolomite, and Precambrian rocks

CRETACEOUS(?) AND TERTIARY

Ja

Aztec sandstone

Ṙcm

Chinle and Moenkopi Formations, undivided

EROSIONAL UNCONFORMITY

Pkt

Kaibab, Toroweap, and Coconino Formations, and red beds, undivided

Pzc

Paleozoic carbonate rocks, undifferentiated
Found only in Muddy Mountains

Pzr

Remnants of thrust plate
Paleozoic rocks of Pennsylvanian to Cambrian age. Found only in North Muddy Mountains

EASTERN CLARK COUNTY

TKg

Gale Hills Formation
Mapped only south of the Muddy Mountains

Kt

Thumb Formation
Mapped only northwest of Boulder Basin. May be correlative with lower part of Gale Hills Formation

Pliocene(?)

Tmc

Muddy Creek Formation

ANGULAR UNCONFORMITY

Th

Horse Spring Formation

TKo

Overton Fanglomerate

ANGULAR UNCONFORMITY

Kbu / Kbl

Baseline Sandstone
Kbu, upper member
Kbl, lower member

Kwt

Willow Tank Formation

ANGULAR UNCONFORMITY

PPMc

Callville Limestone

Mr

Rogers Spring Limestone

MD

Rogers Spring Limestone and Muddy Peak Limestone, undivided
Grouped only in Frenchman Mountain

Dmp

Muddy Peak Limestone
Mapped only in Virgin and South Virgin Mountains

QUATERNARY

TERTIARY

CRETACEOUS(?) OR TERTIARY(?)

CRETACEOUS(?)

CRETACEOUS

TRIASSIC JURASSIC(?)

PERMIAN

MISSISSIPPIAN, PENNSYLVANIAN AND PERMIAN

MISSISSIPPIAN

DEVONIAN AND MISSISSIPPIAN

CARBONIFEROUS

DEVONIAN

SILURIAN

ORDOVICIAN

WESTERN CLARK COUNTY

PPMb

Bird Spring Formation

Monte Cristo Limestone

Lower and Upper Mississippian

MISSISSIPPIAN

Ds

Sultan Limestone

Middle and Upper Devonian

DEVONIAN

Sl

Lone Mountain Dolomite

Found only in northern Spring Mountains and west of Dry Lake Valley

SILURIAN

Oep

Ely Springs Dolomite, Eureka Quartzite, and Pogonip Group, undifferentiated

Eureka Quartzite, where present, shown as marker bed. Found only in northern Spring Mountains and west of Dry Lake Valley

Lower, Middle, and Upper Ordovician

ORDOVICIAN

DCg

Goodsprings Dolomite

(Found only in the area west and southwest of Las Vegas)

CAMBRIAN TO DEVONIAN (?)

Cdl

Dolomite and limestone, undivided

Middle and Upper Cambrian

Cq

Quartzite, shale, and limestone, undivided

Includes Tapeats Sandstone, Wood Canyon Formation, Pioche Shale, Lyndon Limestone, Chisholm Shale, and Carrara Formation

Lower and Middle Cambrian

CAMBRIAN

---

pCsj

Sterling Quartzite and Johnnie Formation, undivided

PRECAMBRIAN

UNCONFORMITY

pCu **pCm**

Precambrian rocks

pCu, *Precambrian rocks, undivided (mapped separately in the Virgin and South Virgin Mountains)*

Gold Butte Granite of Longwell, 1936

pCm, *gneiss and schist*

PRECAMBRIAN

II. GEOLOGY

The La Madre Mountains/Pine Creek GRA lies within the Basin and Range Province in west-central Clark County, Nevada. The study area includes a large portion of the Spring Mountain Range which contains northwest trending La Madre Mountain.

All exposed formations in the study area are of sedimentary origin (see Figure 3). Paleozoic carbonate and clastic sequences have been overlain by Jurassic and Triassic limestone, shales and sandstones. These sediments have been completly folded and thrusted by tectonic forces related to the Late Cretaceous Laramide Orogeny. Basin and Range normal faulting during the Late Tertiary further offset the thrusted and folded sediments.

Most of the following geological description is taken from Longwell and others, 1965.

1. PHYSIOGRAPHY

The La Madre Mountains/Pine Creek GRA lies within the Basin and Range Province in west-central Clark County, Nevada. The study area includes a large portion of the Spring Mountain Range which is highly irregular in plan and contrasts sharply with the linear ranges to the north across Indian Springs Valley.

The Spring Mountains are the highest range in Clark County with several areas attaining altitudes above 11,000 feet. Charleston Peak is at an elevation of 11,918 feet. The northern crest of the range trends generally northwest, rotates to nearly north-south near lattitude 36°10', and continues southward to the state line. Northeast-trending ridges at right angles to the axis of the range in the eastern part of the GRA reflect important structural trends. The topography is rugged with resistant Paleozoic limestone, dolomite, and sandstone formations forming high vertical cliffs. Scenic Red Rock Canyon borders WSA NV 050-0414 to the east. The lowest elevations in the GRA are approximately 3,000 feet in elevation to the east in Las Vegas Valley.

Late Cenozoic cemented gravels along the washes are important as aquifers which conduct water from the high range to beneath Las Vegas and Pahrump Valley. No permanent streams exist in the study area, and seasonal flow is mostly of the interior type with only the Las Vegas Valley draining into the Colorado River.

2. ROCK UNITS

In the Spring Mountain GRA all exposed formations are of sedimentary origin. All of the Paleozoic systems are represented with a maximum thickness of about 23,000 feet, which in turn is overlain by about 4,000 feet of Triassic and Jurassic sediments.

The oldest rocks in the study area are unnamed undivided dolomite and limestone of Middle to Upper Cambrian age. These rocks crop out above the Keystone Thrust along the western margin of the study area. The Goodsprings Formation, a thin-bedded fine-grained dolomite about 2,000 feet thick, was deposited next during the Late Cambrian.

The Ordovician Ely Springs Dolomite, Eureka Quartzite, and Pogonip Group, found only in the northern Spring Mountains, were then deposited. The Lone Mountain Dolomite was laid down during the Silurian followed by the deposition of the Sultan Limestone during the Devonian.

Conformably overlying the Sultan Limestone is the Mississippian Monte Cristo Formation. It is divided into the following four members: 1. thin-bedded basal limestone, 2. heavy-bedded limestone and dolomite, 3. shaly limestone, 4. massive limestone. The Bird Spring Formation was next deposited throughout the Carboniferous. The thickness of this formation is estimated to be 3,500 feet of limestone and arenaceous sediments with an increase in sandstone up-section.

The Kaibab limestone which includes some clay, sandstone and gypsum beds was deposited during the Permian. An erosional unconformity separates the Kaibab from the overlying limestone, sandstone and shale of the Triassic Moenkopi Formation. The Moenkopi is overlain by thin-bedded shales and sandstones of the Chinle Formation which in turn, is conformably overlain by the Jurassic age massive aeolian Aztec sandstone which forms the spectacular cliffs in Red Rock Canyon.

Late Cenozoic age cemented gravels locally form cliffs along active washes. These gravels are important as aquifers and conduct water from the high range to beneath the Pahrump and Las Vegas Valleys.

3. STRUCTURAL GEOLOGY AND TECTONICS

The geologic structure of the Spring Mountains is extremely complex. The dominant structural features are large thrust faults with associated large folds formed during the Late Cretaceous Laramide Orogeny. The northwest-trending crest of La Madre Mountain is near the axis of a broad anticlinal arch which has been modified by faulting. Basin and Range type normal faults are abundant with northwesterly strikes predominant, though directions vary widely. The northwest-trending Griffith Fault in the center of the GRA has a major strike slip component to its displacement.

The sinuous Keystone thrust fault with Cambrian dolomite at the base overrode the Jurassic Aztec sandstone. This thrust is offset by several normal faults along its outcrop. Repeated movement of this thrust is evidenced by the plate north of the bend in the thrust, resting upon detached blocks exhibiting thrust structure identical with that south of the bend.

A thrust fault exposed in Kyle Canyon is terminated on the west against the normal northwest-trending Griffith fault. The overridden beds are high in the Bird Springs Formation and the plate consists mainly of lower beds of the same formation. Thrusts and folds near Lucky Strike Canyon appear to be offset continuations of the Kyle Canyon thrust.

The Deer Creek thrust which ends against the strike slip Griffith fault is traceable northeastward for four miles to the La Madre fault near Deer Creek. Cambrian dolomite and limestone at the base of the thrust plate lie on beds of the Bird Spring or the Monte Cristo and Sultan Formations.

The Lee Canyon Thrust, which at the crest of the range turns in strike from north to northeast, has in the foot wall strata ranging from the Ordovician Pogonip to the Carboniferous Bird Spring Formation, and Cambrian sediments in the hanging wall.

Numerous north- to northwest-trending Basin and Range normal faults have offset the thrust plates in the study area. Between Kyle and Lee Canyons several large normal faults have their downthrown side toward the crest of the range.

4. PALEONTOLOGY

The major unit favorable for paleontological resources are rocks of the Bird Spring Formation exposed in the northwestern part of the La Madre Mountains/Pine Creek GRA, where brachiopod bryozoan and coral faunas occur along the north slope of La Madre Mountain and Kyle Canyon, and the hills north of Cottonwood Valley in the southern part of the area (Nolan, 1924, 1929; Hazzard and Mason, 1936). The Pennsylvanian Hermit Shale, where exposed in Lovell Wash, is locally fossiliferous.

The Triassic Chinlee Formation, which is exposed in outcrops along the Sandstone Bluffs on the southeastern margin of the Spring Mountains is not known to contain fossils at any sites within the GRA, as is the overlying Aztec sandstone.

Devonian and Ordovician undivided rocks, probably equivalent to or a continuation of the Goodsprings Dolomite, are elsewhere sparsely fossiliferous (Hewett, 1931), but no localities are known from within the GRA. Small areas of Laketown Dolomite (Silurian) and rocks assignable to the Monte Cristo Group (Mississippian) crop out within the area, but are not known to be fossiliferous within the study area.

5. HISTORICAL GEOLOGY

Throughout the Paleozoic marine sedimentation proceeded under uniform conditions unless interrupted from time to time by the close approach of the shoreline. The shoreline approach caused the arenaceous content of the sediments to dominate over the calcareous, in other words, carbonate rocks were being deposited offshore while sandstones were being deposited close to shore.

At the close of the Permian the area was uplifted and eroded. Following the deposition of the Triassic Moenkopi Formation, the region received continental deposits from highlands to the south and southeast through the early Jurassic.

During the Jurassic, early thrusting, normal faulting and erosion occurred. The Aeolian Aztec Sandstone was deposited during this time. Subsequent to Jurassic time thrusting related to the Cretateous(?) Laramide Orogeny and Tertiary Basin and Range faulting further deformed the Paleozoic and Mesozoic sediments. The present topography has been formed by erosional modification of the Basin and Range block-faulted Paleozoic sediments and thrust sheets.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There are two properties in the GRA which have reported minimal production prior to 1929. Both are in the northern part of the GRA and according to Longwell and others (1965) are included in the Charleston district. The Griffith mine just north of Charleston Park (see Metallics Land Classification and Occurrence Map) produced some lead, while the Iron Age claims near the eastern border of the GRA, produced iron gossan with perhaps a little lead and zinc. These deposits reportedly are small oxidized lead-zinc replacement ores in dolomitized limestones. The Griffith mine is well outside the WSAs while the Iron Age claims border the eastern edge of WSA NV 050-0412.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

No other reported metallic mineral occurrences are known in the GRA except those described in the previous section. Several prospects and three shafts are located at the Iron Age claims described above in the SE 1/4 of Sec. 4, T 20 S, R 59 E. Iron oxides are abundant in veinlets and discontinuous replacement deposits in the limestone over a large area. No primary sulfides were recognized.

The mineral resource potential of the Red Rocks Escarpment Instant Study Area, located in the southeastern portion of the GRA was assessed in 1980 by R. G. Bohannon of the U. S. Geological Survey and R. W. Morris, U. S. Bureau of Mines.

They concluded that the geologic and geochemical evidence did not indicate the existence of any mineral deposits in the Red Rocks Escarpment Instant Study area that are of economic importance. Apparently, the abundant and concentrated ore-forming solutions responsible for metallic mineral deposits in the Goodsprings district, south of the area, did not migrate along the Keystone thrust into the Instant Study area (Bohannon and Morris, 1980).

3. Mining Claims

There are no patented claims in either of the WSAs. Patented claims are found in the GRA, however, at Mountain Springs and north of Blue Diamond presumably for gypsum.

There are a great many unpatented claims within the GRA, most of which are placer. There are approximately 37 lode claims and 184 placers. Many are for unknown commodities.

Lode claims suspected of being located for metallics include the Leona Silver group and the Pain in the Ass group in Secs. 34 and 36 of T 19 S, R 57 E in the northern part of the GRA just north of WSA NV 050-0412. Also the Copper Hill group is believed to be for metallics in the southern part of the GRA adjacent to Mountain Springs in Secs. 18, 19 and 20 of T 22 S, R 58 E.

A large group of at least 60 placer claims in T 22 S, R 57 E in the Lovell Canyon area northwest of Mountain Springs have been staked for gold by Magnum Mining Company. A local newspaper article (Kruger, 1982) claims there is 86 million tons averaging 0.15 ounces of gold per ton. A field check of the area indicates that Quaternary alluvium, Bird Springs Formation (carbonate rocks), and members of the Kaibab and Toroweap Formations underlie the placer claims. This area, based on the available geological evidence, would not appear to have a potential for massive low-grade gold occurrences such as that reported. Additional investigation is necessary to verify the reported gold occurrences.

4. Mineral Deposit Types

The limited lead-zinc mineralization in the Charleston district is reported to be oxidized replacement deposits in dolomitized limestones. Reported gold(?) in Lovell Canyon may be placer.

5. Mineral Economics

Small, narrow, sporadic underground replacement lead-zinc deposits are for the most part uneconomical at present for the major mining companies. Perhaps a small operator could make a profit on these types of deposits if he could block out additional ore which presently is unknown.

Eighty-four million tons of 0.15 ounces gold per ton on the claims in Lovell Wash is economic to mine and should make it the largest gold mine in the country if the reports are accurate.

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 electrical instrumentation. In the United States and some other countries gold is measured in troy ounces that weigh 31.1 grams -- twleve 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 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 DEPOSITS

1. Known Mineral Deposits

The major nonmetallic mineral deposit in the GRA is the gypsum mine at Blue Diamond which is found in the Permian red beds and the overlying Toroweap and Kaibab Formations. The gypsum beds are commonly massive gypsum five to 15 feet thick. The deposits near Blue Diamond have been mined since 1925 and are presently operated by the Flintkote Company. These gypsum deposits are outside the WSAs in the southeastern portion of the GRA.

Another gypsum deposit inside the northern boundary of WSA NV 050-0412 is located in Secs. 27 and 34 of T 19 S, R 58 E in what is mapped as the Bird Springs Formation. A field check of this site, however, revealed thick northeastward-dipping gypsum beds associated with shales and thin limestones, possibly making these units the Kaibab or Toroweap Formations. Some of the gypsum had been mined in the past.

Sandstone has been quarried in the past from Sec. 35, T 29 S, R 58 E, in the Jurassic Aztec sandstone.

There are at least three operating sand and gravel pits in the alluvium near the northeastern border of the WSA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Blue Diamond Hill in the southeastern part of the GRA near the Blue Diamond mine can be considered a large area of gypsum mineralization as there are numerous prospects and gypsum outcrops in this area.

Many of the Aztec sandstone outcrops throughout the GRA are potential building stone or silica sources and the carbonate units could be utilized perhaps for cement or lime manufacture.

3. Mining Claims, Leases and Material Sites

There are abundant mining claims throughout the GRA, the majority of which are placer claims, and probably were located for nonmetallic mineral commodities.

There are approximately 184 placer claims in the GRA. In the southeastern corner of the GRA Flintkote has claims near Blue Diamond that presumably are for gypsum. In Secs. 27 and 34 of T 19 S, R 58 E there are approximately 10 associated placer claims called White Beauty which are for the gypsum deposit described above. Some of these claims are within the north boundary of WSA NV 050-0412.

Along the east boundary of WSA NV 050-0412 are several placer claims of Great Western Aggregates or Charleston Stone Products, presumably for building stone or aggregates. These are in the vicinity of a past and present sand and gravel pit and the Iron Age lead-zinc workings.

In Secs. 8, 9, 16 & 17 of T 21 S, R 57 E, there are nine lode claims named Barite which were staked in 1981. It is not known what these were staked for. A field check of the area did not identify the claims.

There are no known material sites in the WSA, but there are many outside the WSA within the GRA, most of which are on the eastern side of the GRA closer to the population center of Las Vegas.

4. Mineral Deposit Types

The gypsum and sandstone are sedimentary deposits. The gypsum in an evaporite sedimentary deposit. The sandstone is a aeolian sedimentary detrital deposit of sand deposited during the Jurassic.

Sand and gravel is found in recent alluvium eroded from the existing mountain ranges.

5. Mineral Economics

The gypsum in the southeastern portion of the GRA is obviously of such extent and grade to be economically mineable. Large reserves are in this same area. Since Flintkote is one of this countries principal miners and users of gypsum, they have a substantial advantage when mining the product versus an independent miner, as they use the gypsum to manufacture finished products as well. In other words, they control their own market to a certain extent.

By far the greatest use of gypsum is in prefabricated products, mostly wallboard, which account for nearly three-fourths of all usage. Most of the remainder is used in cement, as an agricultural soil conditioner, and in plaster. The United States consumes about 20 million tons of gypsum annually, about two-thirds of it produced domestically. Gypsum is a relatively common mineral and occurs in large deposits, and the United States has practically unlimited reserves. However, although its commonness makes it a low-priced material, some plants on the eastern seaboard use imported raw material that can be transported by ship at low cost; these account for the imports of gypsum. United States consumption is forecast to nearly double by the year 2000, with domestic production keeping up with demand except in those special situations where imported material can compete. The price of gypsum is about $7 per short ton.

Sand and gravel is in high demand in the Las Vegas area and depending on the quantity and quality of sand and gravel, the alluvium on the eastern side of this GRA is and could be further utilized because transportation costs would be minimal. Factors influencing the sand and gravel market in Las Vegas are basically the relative healthiness of the construction industry and the availability of nearby sand and gravel. Restrictive land uses are having a considerable impact on this industry. Even though there are abundant sand and gravel sources available, alternate demands and uses for the surface resources precludes the development of most sand and gravel sources close to Las Vegas.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

There are no known uranium or thorium deposits in the WSA's or GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

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

There are no known uranium or thorium occurrences within the WSAs or GRA. However numerous low grade uranium and radioactive occurrences are present in the Goodsprings Mining district (Garside, 1973) which is located just south of WSA NV 050-0414. These occurrences are associated with limonite, hydrozincite, ferruginous chert, carbonaceous shale and secondary copper minerals in the oxide zones of sulfide vein deposits in the Mississippian Monte Cristo Limestone. The Goodsprings deposits were mined for gold, copper, lead and zinc. Associated uranium occurrences are low grade and very little, if any, uranium production has occurred.

3. Mining Claims

There are no known uranium or thorium claims or leases in the WSAs or GRA.

4. Mineral Deposits

Deposit types cannot be discussed due to the lack of uranium or thorium occurrences in the area.

5. Mineral Economics

Uranium and thorium are probably of little economic value in the GRA due to the lack of known occurrences of these elements.

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

Oil and Gas Resources

1. Known Oil and Gas Deposits

There are no known oil and gas deposits in the GRA.

2. Known Prospects, Oil and Gas Occurrences and Petroliferous Areas

No oil seeps are reported to be in the GRA or vicinity, although the C. J. Lichtenwalter and C. M. Turpin, Turpin No. 1 (Locality #1 on the Oil and Gas Occurrence and Land Classification Map) was drilled in WSA 050-0412. This 1961 well reached a total depth of 777 feet after encountering oil shows in the 307-to 777-foot interval. The well made one-third barrel of high gravity oil after acidizing (Nevada Bureau of Mines and Geology Oil and Gas Files, 1982).

Tri-State Oil Exploration Co. Miskell-Government No. 1 (#2) was drilled to 2602 feet in 1959 (Schilling and Garside, 1968). Nine additional drilling locations to the east and southeast of the GRA represent 19 oil exploration wells and drill holes. At least two, the Red Star Oil Co., Nelson No. 1 (#3) and the U. S. Oil Co., Wilson No. 1, had oil shows in the Paleozoic section (Lintz, 1957).

3. Oil and Gas Leases

Federal oil and gas leases cover all the WSAs completely. The area may also have deeper drilling objectives since it may be in the Overthrust Belt.

4. Oil and Gas Deposit Types

Oil deposits that have been found and developed, and those that are being explored for in the Basin and Range to date, have been limited to the Upper Paleozoic section of the miogeosyncline and the Tertiary section of the intermontane basins. The source rocks are assumed to be in Paleozoic horizons, such as the Mississippian Chainman Shale, and perhaps also the Tertiary section.

The reservoirs at the Trap Spring and Eagle Springs oil fields in Railroad Valley are the Oligocene Garrett Ranch volcanics or equivalent, which produce from fracture porosity; or the Eocene Sheep Pass Formation, a freshwater limestone. Minor production has been recorded from the Ely(?) Formation of Pennsylvanian age at Eagle Springs. It may be that production also comes from other units in the Tertiary or Paleozoic sections in the Blackburn oil field in Pine Valley or the Currant and Bacon Flat oil fields in Railroad Valley.

The GRA is within or close to the North American Overthrust Belt which has good oil and gas production in Wyoming/Utah, Mexico and Canada (Oil and Gas Jour., May 12, 1980). The Federal leases in Nevada are for rank wildcat acreage, and surficial stratigraphic units do not necessarily have a direct bearing on possible drilling objectives at depth, considering overthrust structural implications.

Recent seismic surveys (e.g., Seisdata Services, 1981; Geophysical Service Inc., 1981; GeoData, 1981: Index maps in GRA File) indicate, in part, the general area of industry interest. This and certain other data may be purchased, but deep exploratory test data are not readily available. Published maps of the Overthrust Belt in Nevada are very generalized, and are not necessarily in agreement because exploration is at an early stage (Oil and Gas Jour., May 12, 1980; Western Oil Reporter, June, 1980; Keith, 1979: Index maps in GRA File).

5. Oil and Gas Economics

The low level of production from Nevada Basin and Range oil fields, which are remote from existing pipelines, existing refineries and consuming areas, necessitates the trucking of the crude oil to existing refineries in Utah, California and Nevada. Since the discovery of oil in Nevada in 1953, the level of production has fluctuated. Factors which have affected the production from individual wells are: reservoir and oil characteristics; Federal regulations; productivity; environmental constraints; willingness or ability of a refiner to take certain types of oil; and of course, the price to the producer, which is tied to regional, national and international prices.

Geothermal Resources

1. Known Geothermal Deposits

There are no known higher temperature geothermal deposits in the GRA, but White Rock spring in WSA 050-0412 flows 78°F at 1,450 gpm according to Garside and Schilling (1979).

2. Known Prospects, Geothermal Occurences, and Geothermal Areas

There are no known geothermal occurrences or thermal areas in the GRA.

3. Geothermal Leases

There are no Federal leases on record.

4. Geothermal Deposit Types

Geothermal resources are hot water and/or steam which occurs in subsurface reservoirs or at the surface as springs. The temperature of a resource may be about 70°F (or just above average ambient air temperature) to well above 400°F in the Basin and Range province.

The reservoirs may be individual faults, intricate fault-fracture systems, or rock units having intergranular permeability -- or a combination of these. Deep-seated normal faults are believed to be the main conduits for the thermal waters rising from thousands of feet below in the earth's crust.

The higher temperature and larger capacity resources in the Basin and Range are generally hydrothermal convective systems. The lower temperature reservoirs may be individual faults bearing thermal water or lower pressured, permeable rock units fed by faults or fault systems. Reservoirs are present from the surface to over 10,000 feet in depth.

5. Geothermal Economics

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

Higher temperature resources (above 350°F) are currently being used to generate electrical power in Utah and California, and in a number of foreign countries. As fuel costs rise and technology improves, the lower temperature limit for power will decrease appreciably -- especially for remote sites.

All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year-round 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 an historical fact for over 100 years.

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

D. OTHER GEOLOGICAL RESOURCES

The Red Rock Canyon Recreation Lands are known for their stark beauty formed by the massive and high sandstone outcrops of the eroded and weathered Aztec sandstone.

There are also several caves in the Charleston Peak area in the northwestern part of the GRA.

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 during a national emergency and are not found or produced in the United States in sufficient quantities to meet such a demand. The report does not define a distinction between strategic and critical minerals.

Lead and minor zinc has been produced from the two above described deposits of the Charleston district. Production was very minor, however, and future potential looks limited.

IV. LAND CLASSIFICATION FOR G-E-M RESOURCES POTENTIAL

The geological map which includes both WSAs is Longwell and other's (1965) at a scale of 1:250,000. The scale of this map is too small to show a great deal of geological detail other than gross lithologies. Structural details, veining, or alteration, if present, are not shown. Even though the map detail is not satisfactory for adequately evaluating mineral resources, the quality of the data and the confidence level in that data is good. The information on mineral resources comes principally from Longwell and others (1965) and it contains very little detail on any of the mineral occurrences in the two included WSAs. Overall, the quantity of data concerning mineral resources is low, but the confidence level in that data ranges from moderate to high.

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.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA NV 050-0412 and WSA NV 050-0414

M1-2B. This classification area of low favorability with a low confidence level covers all the Paleozoic sediments in both WSAs which are principally composed of carbonates. There are no known metallic occurrences within the WSAs in these units but outside the boundaries of the WSAs there is the Iron Age claims on the northeast boundary and the Griffith mine near Charleston Park to the north of the WSA boundary. In addition, outside the GRA boundary to the south is the well known Goodsprings district with these same units. Goodsprings is a major past producer of gold, silver, copper, lead and zinc. The ore in the district is found principally in the Monte Cristo Limestone. The area is structurally much more complex than the geology in the WSAs to the north. The 2B classification indicates low favorability for metallic mineral resources based on the above discussion.

M2-1B. This classification area of no evidence of favorability with a low confidence level includes all the Mesozoic sediments in the WSAs including the Aztec sandstone, the Chinle and Moenkopi Formations, and the Kaibab and Toroweap Formations. These units do not indicate favorability for metallic mineral resources anywhere in the area -- hence the classification 1B.

M3-2B. This classification area of low favorability with a low confidence level includes the Magmum Mining Company placer claims covering mostly alluvium in the Lovell Wash area in WSA NV 050-0414. Reports of the property maintain there is millions of tons of low grade gold. These claims need further verification. The 2B classification is based solely on the presence of the claims and the reported results of testing on these properties.

M4-2A. This classification area of low favorability with a very low confidence level includes the alluvium within both WSAs. The nature of the bedrock beneath the alluvium is unknown and placer deposits are not expected. The low favorability is because there is mostly a low favorability classification in the adjoining mountains, therefore similar rocks with a similar potential may underlie the alluvium. The very low confidence level is because there is no evidence to suggest buried mineralization.

b. Uranium and Thorium

WSAs NV 050-0412 and NV 050-0414

U1-2B. This land classification covers most of WSA NV 050-0412, WSA NV 050-0414 and the GRA. The area is covered by Paleozoic to Mesozoic carbonates, shales and sandstones. The area has low favorability with a low confidence level for fracture-filling, vein or sandstone type uranium deposits. Vein or fracture filling uranium deposits, if present, would probably be related to vein sulfide deposits in the Mississippian carbonates similar to those which occur in the Goodsprings district. Uranium in this type of deposit is typically low grade, however. Aerial radiometric anomalies have been detected over outcrops of the Bird Spring Formation in WSA NV 050-0412 and in the Charleston Peak area (Western Geophysical Company, 1979), indicating that there may be some uranium potential in the area. There is a remote possibility of sandstone type deposits in the Chinle Formation which is exposed in the southwestern and southeastern parts of the GRA, but there does not appear to be a uranium source in the area.

The area has very low favorability with a very low confidence for thorium, due to the apparent lack of thorium source rocks such as pegmatites.

U2-1A. This land classification covers small areas along the margins of both WSAs and parts of the GRA which are covered by Quaternary alluvium. These areas have very low favorability with very low confidence for epigenetic sandstone-type uranium deposits because there are apparently no suitable source rocks exposed in the area.

The area has very low favorability with a very low confidence level for thorium due to the lack of source rocks.

c. Nonmetallic Minerals

WSA NV 050-0412 and NV 050-0414

N1-3C. This classification area of moderate favorability with a moderate confidence level covers the sand and gravel, alluvial deposits along the east side of the WSAs. There are currently active development of sand and gravel deposits in the alluvium just east of the WSA boundary in the northeast part of the WSA. The proximity to Las Vegas presently makes aggregates in this area especially attractive for their potential utilization.

N2-4D. This classification area of high favorability with a high confidence level includes the gypsum deposits which have been mined to a very limited extent in Secs. 27 and 34 of T 19 S, R 58 E, within the WSA. The gypsum here is believed to be part of the Kaibab or Toroweap Formation.

N3-3C. This classification area of moderate favorability with a moderate confidence level includes the remaining areas within the WSAs which have been mapped as Kaibab or Toroweap as both have gypsum members. These areas have a potential for gypsum.

N4-3C. This classification area of moderate favorability with a moderate confidence level includes all outcrops of Aztec sandstone in the WSAs. This unit has potential for silica and has been used in the past for building stone.

N5-3C. This classification area of moderate favorability with a moderate confidence level includes all the remaining bedrock in the WSAs which are predominantly carbonate units. These rocks have potential for lime or cement manufacture.

2. LEASABLE RESOURCES

a. Oil and Gas

WSA NV 050-0412 and NV 050-0414

OG1-2A. The geology of both WSAs are very similar. Oil shows were encountered in a shallow well in WSA 050-0412. Additional wells in the immediate area have also found oil shows in the Paleozoic section which is known to underlie the two WSAs.

Companies have leased all the WSA lands as part of a program by many companies to evaluate the Overthrust Belt-type objectives in this region.

b. Geothermal

WSAs NV 050-0412 and NV 050-0414

G1-3A. The White Rock Spring flows at a very low thermal temperature (78°F) at a rate of 1450 gpm. There is a reasonably good possibility that this thermal occurrence extends southward into WSA 050-0414, following the structural trend. Although the temperature is quite low, the flow is appreciable. This thermal site could possibly be developed as a spa -- close to and readily accessible from Las Vegas.

c. Sodium and Potassium

S1-1D. There are no sodium or potassium occurrences known to exist in the GRA or the WSAs. There is no classification map for this commodity.

3. SALEABLE RESOURCES

Saleable resources, sand and gravel, have been included above under nonmetallic mineral resources and include classification area N1-3C.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

1. The geologic mapping in both WSAs, especially the Paleozoic and Mesozoic carbonate units and their structure, should be more detailed, especially to the northeast in the vicinity of the Iron Age claims; along the northern boundary south of Charleston Park and the old workings there; and to the south near Mountain Springs to see if the Goodsprings district or Potosi mine area structures and mineralization extend north into the WSA.

2. The claims of Magmum Mining should be investigated to confirm the reports of high tonnages of ore averaging 0.15 oz gold/ton. The Barite claim group should be investigated to determine if there is mineralization and if it extends into the WSA.

3. With regard to nonmetallics, the claims covering the gypsum deposit in the north are inside the WSA and the gypsum resources there should be thoroughly delineated. Also, the other areas of the WSAs which have been mapped as Kaibab or Moenkopi should be investigated to determine if additional gypsum resources are likely.

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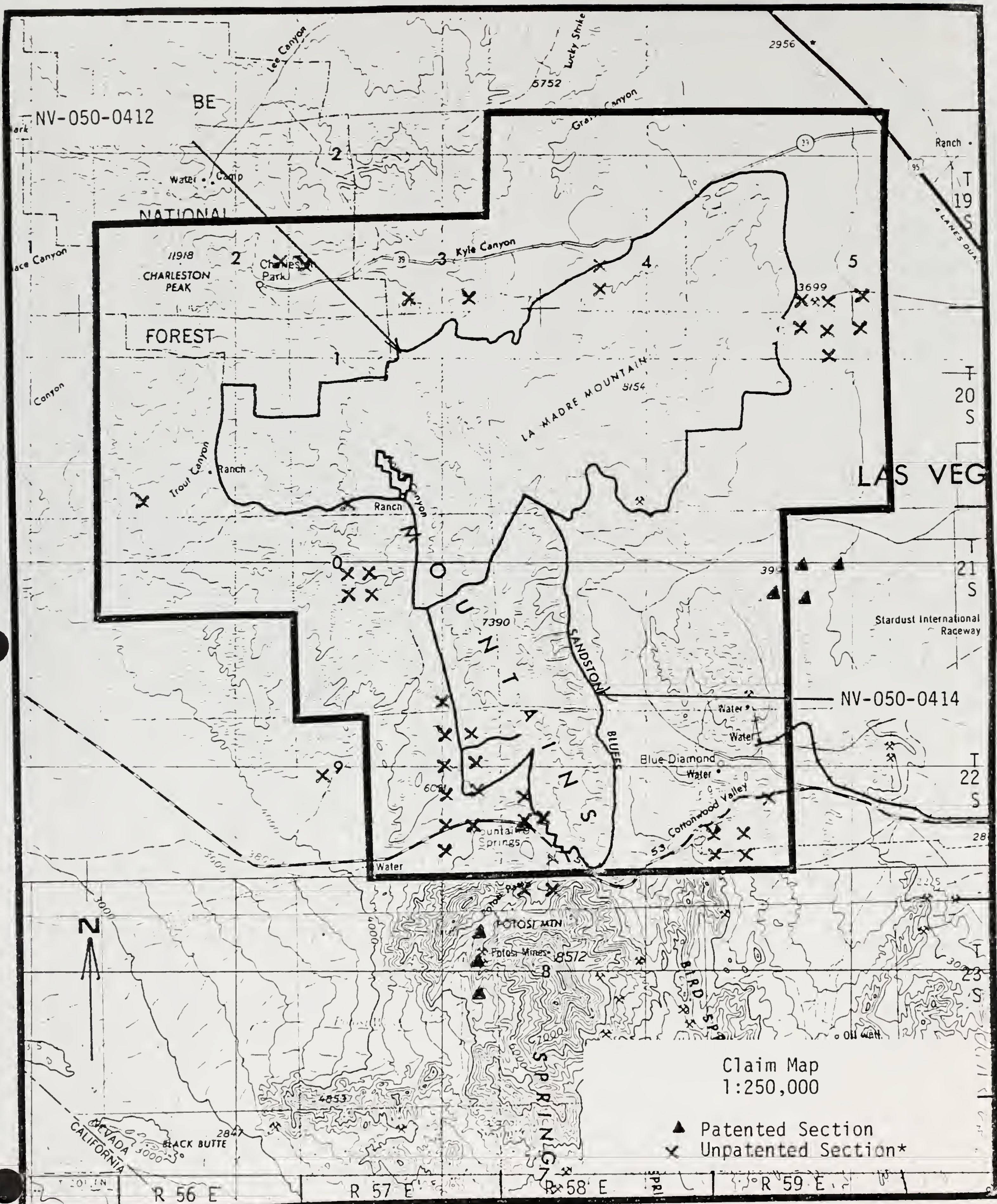
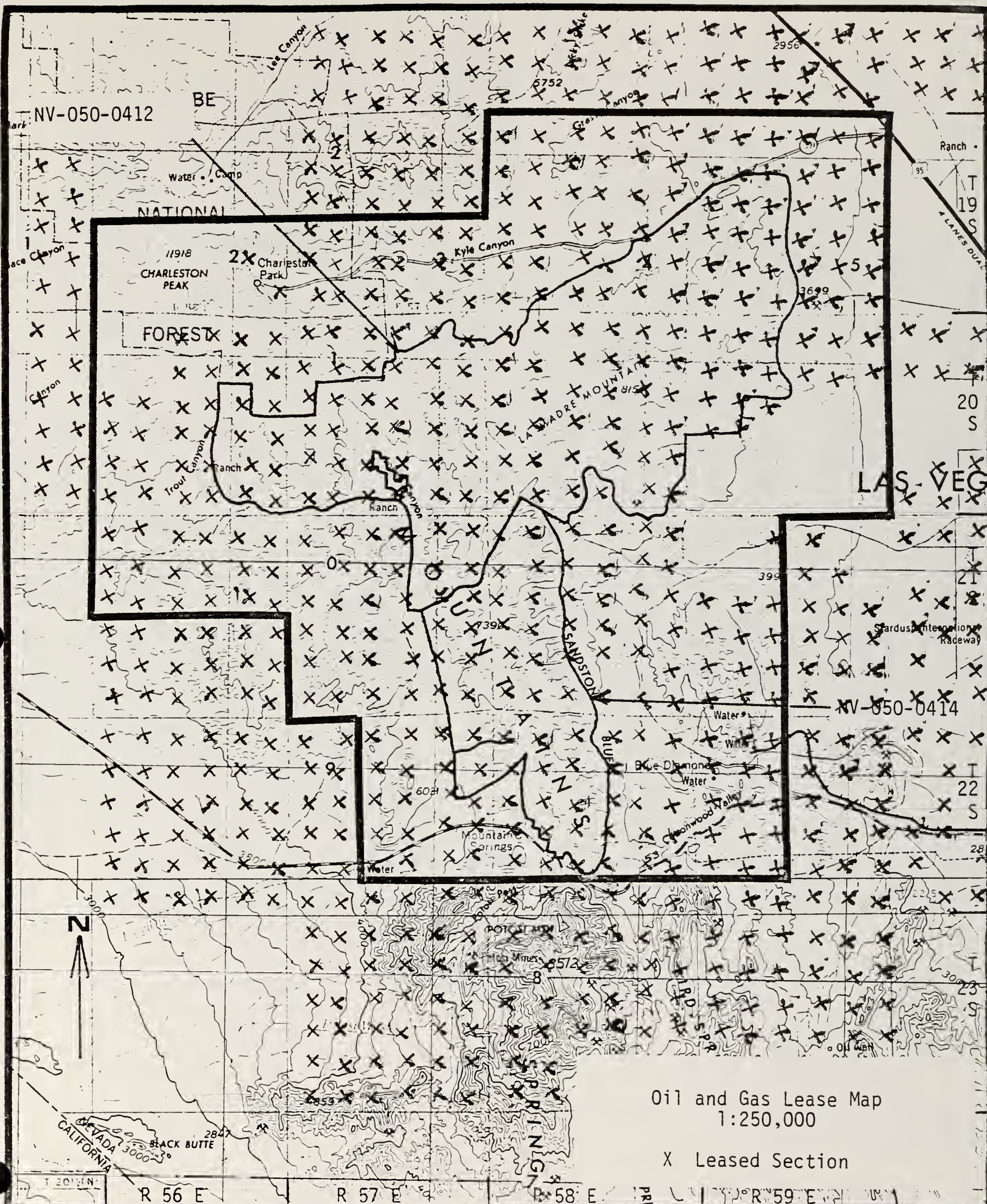
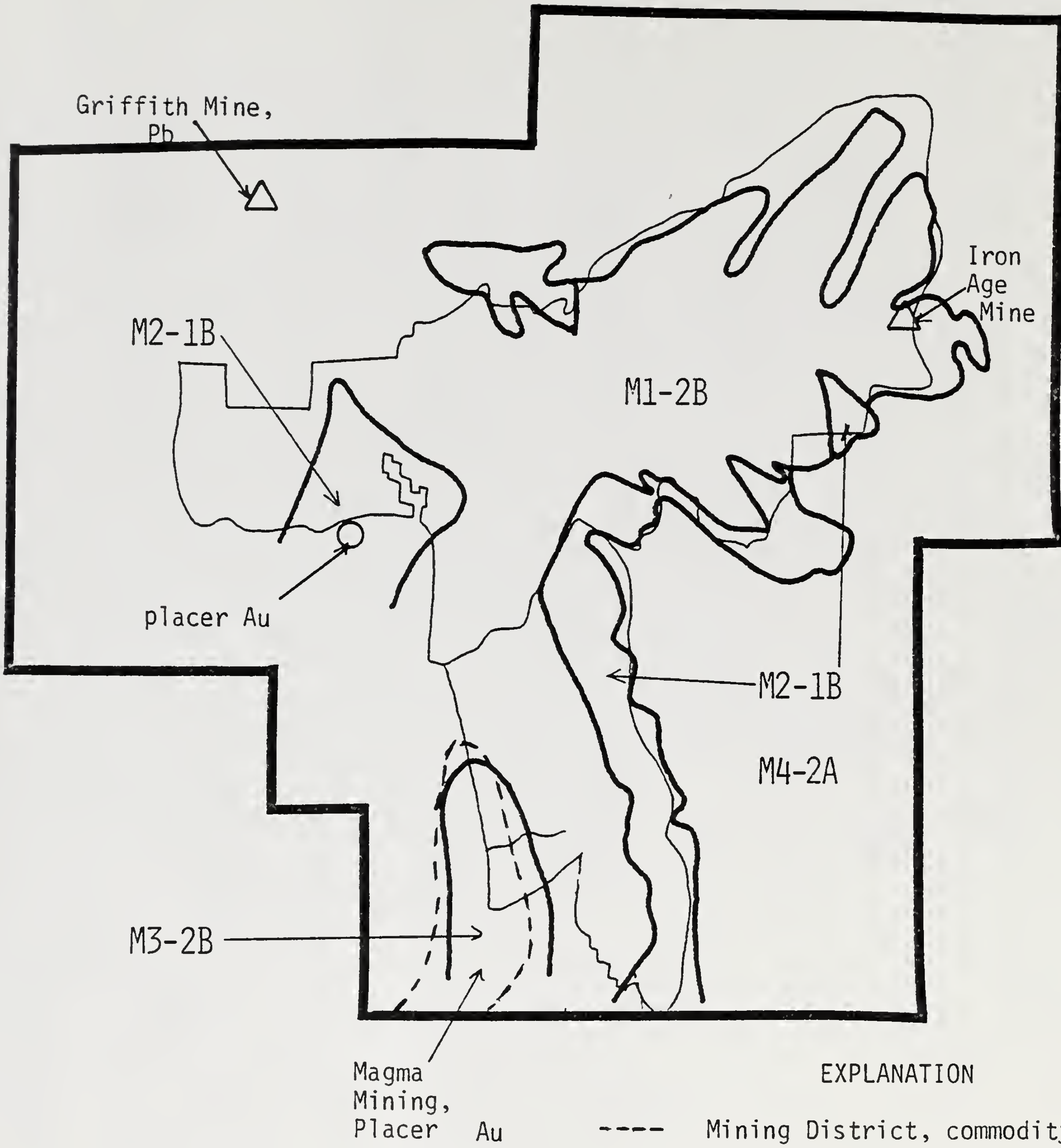


*X denotes one or more claims per section



La Madre Mountains/Pine Creek GRA NV-32



EXPLANATION

- - - - Mining District, commodity

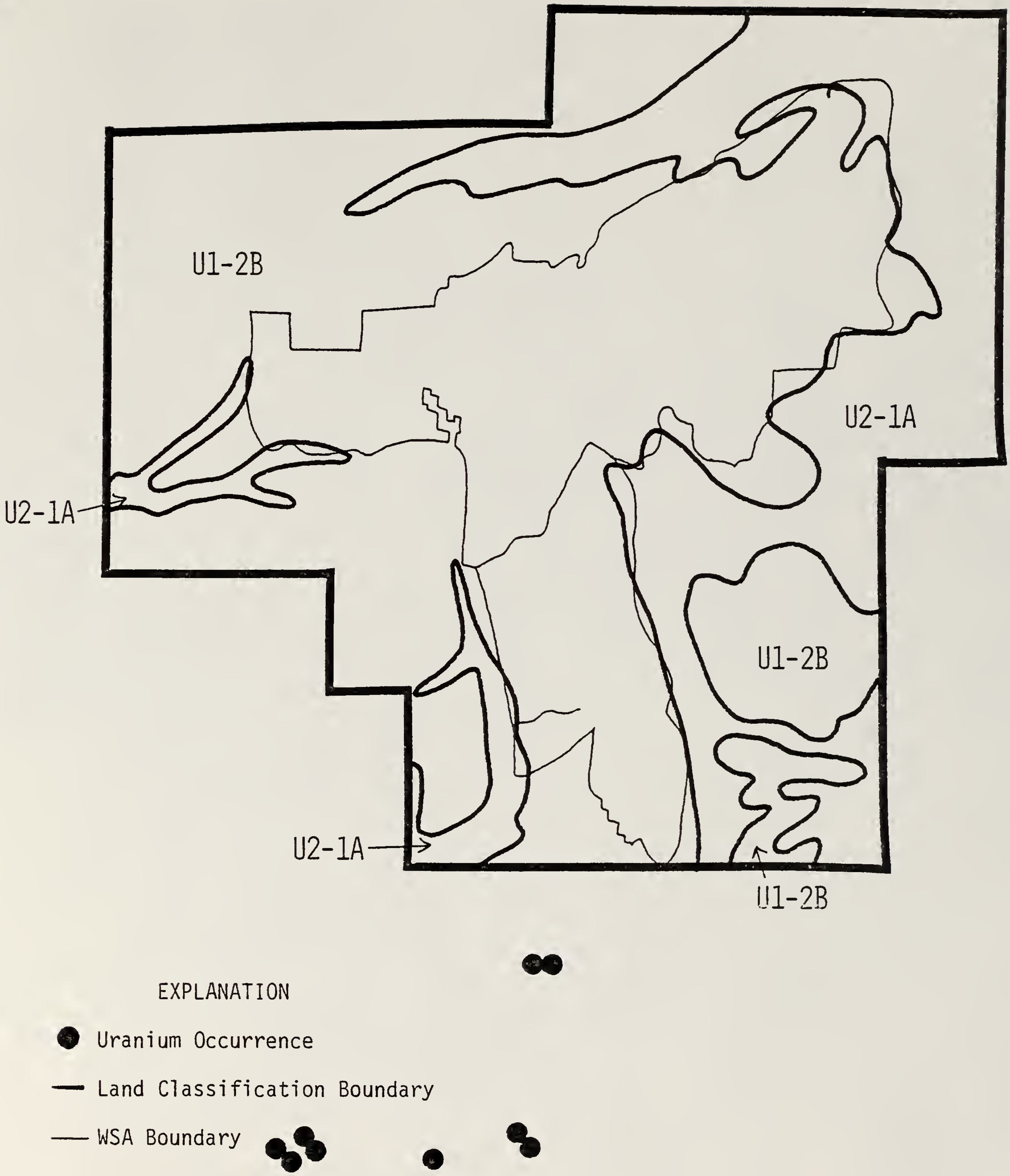
△ Mine, commodity

○ Occurrence, commodity

━━ Land Classification Boundary

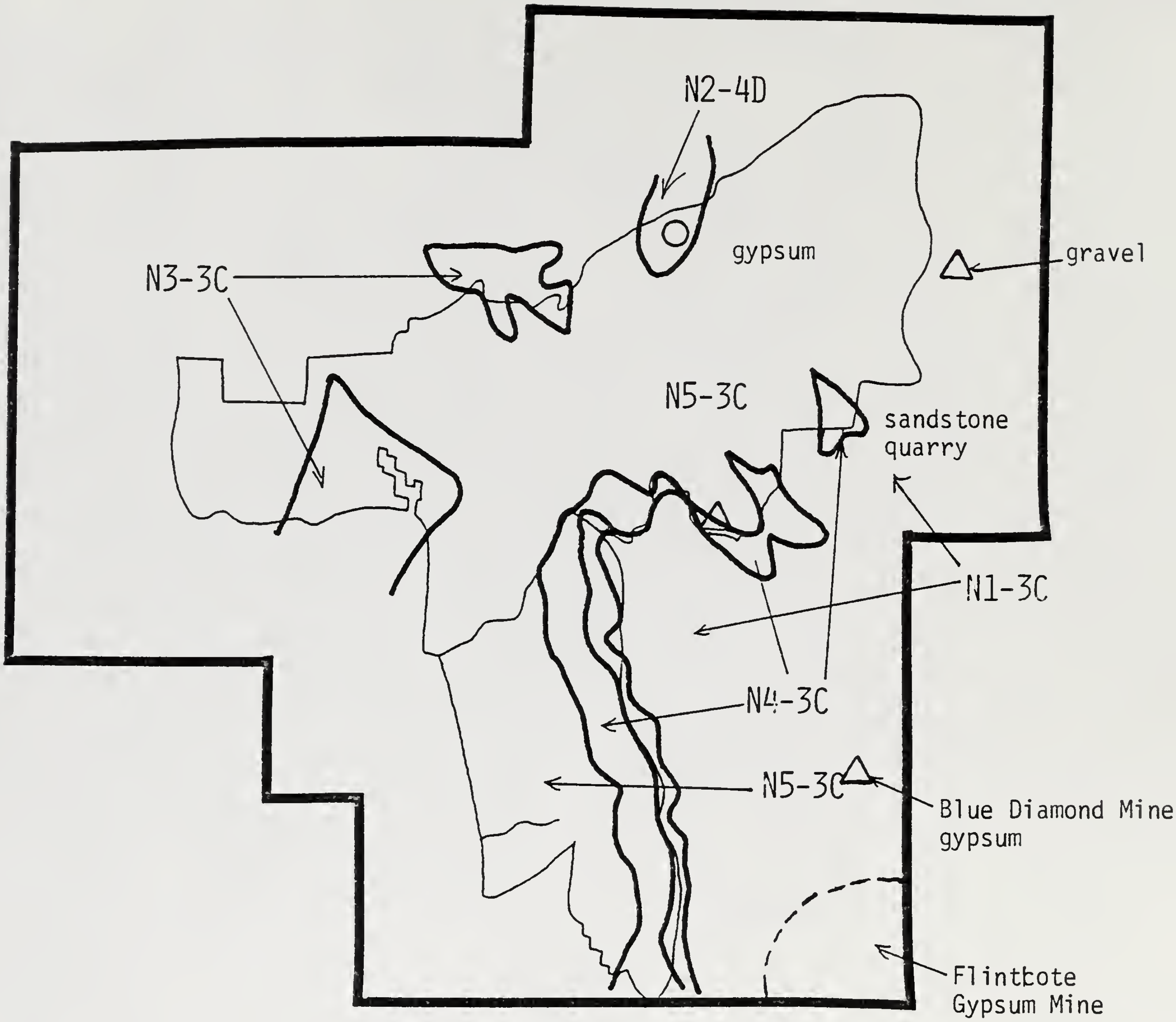
── WSA Boundary

Land Classification - Mineral Occurrence Map/Metallics
La Madre Mountains/Pine Creek GRA NV-32
Scale 1:250,000



Land Classification - Mineral Occurrence
Map/Uranium

La Madre Mountains/Pine Creek GRA NV-32
Scale 1:250,000



EXPLANATION

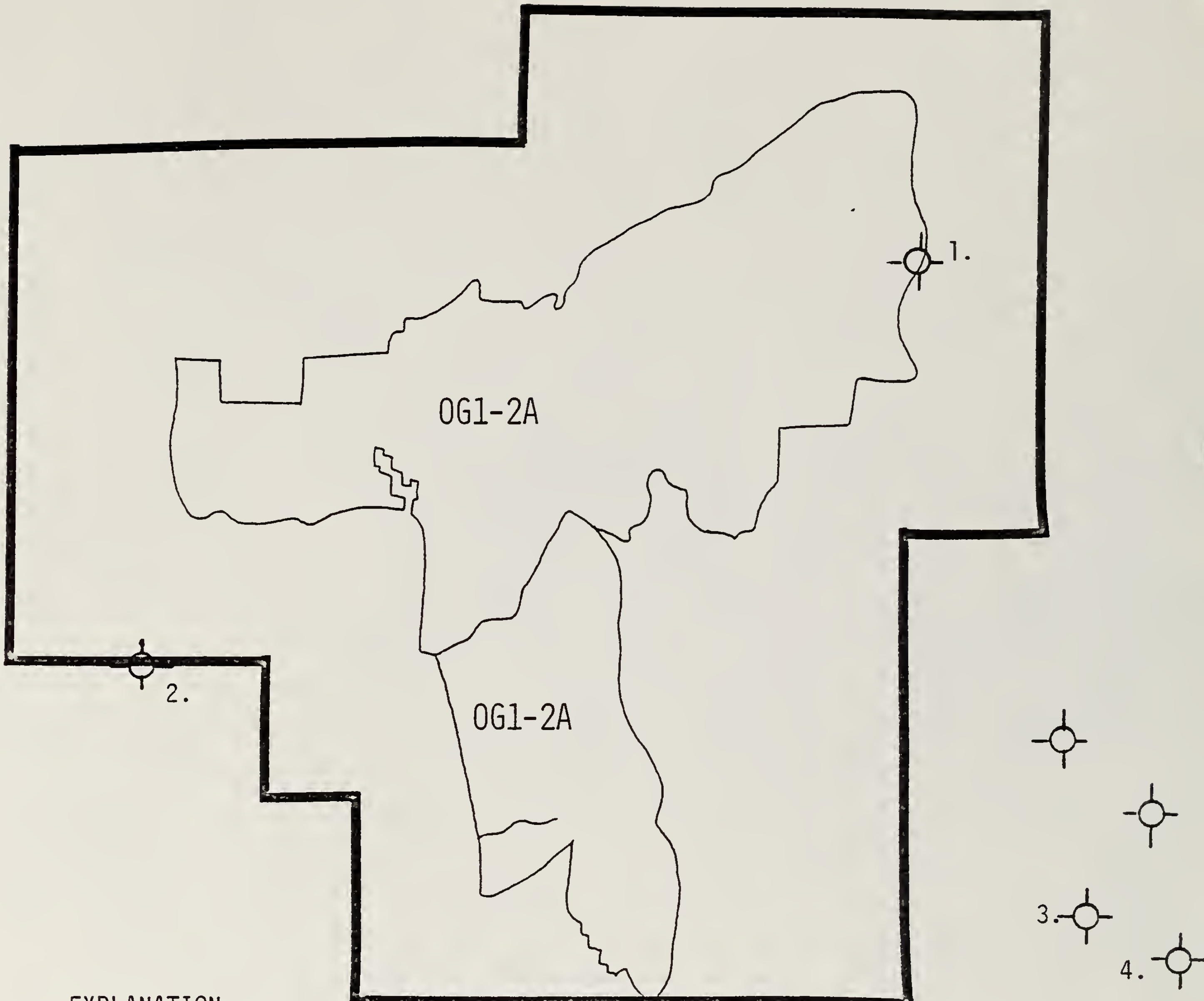
△ Mine, commodity

○ Occurrence, commodity

▬ Land Classification Boundary

— WSA Boundary

Land Classification - Mineral Occurrence Map/Nonmetallics
La Madre Mountains/Pine Creek GRA NV-32
Scale 1:250,000



EXPLANATION

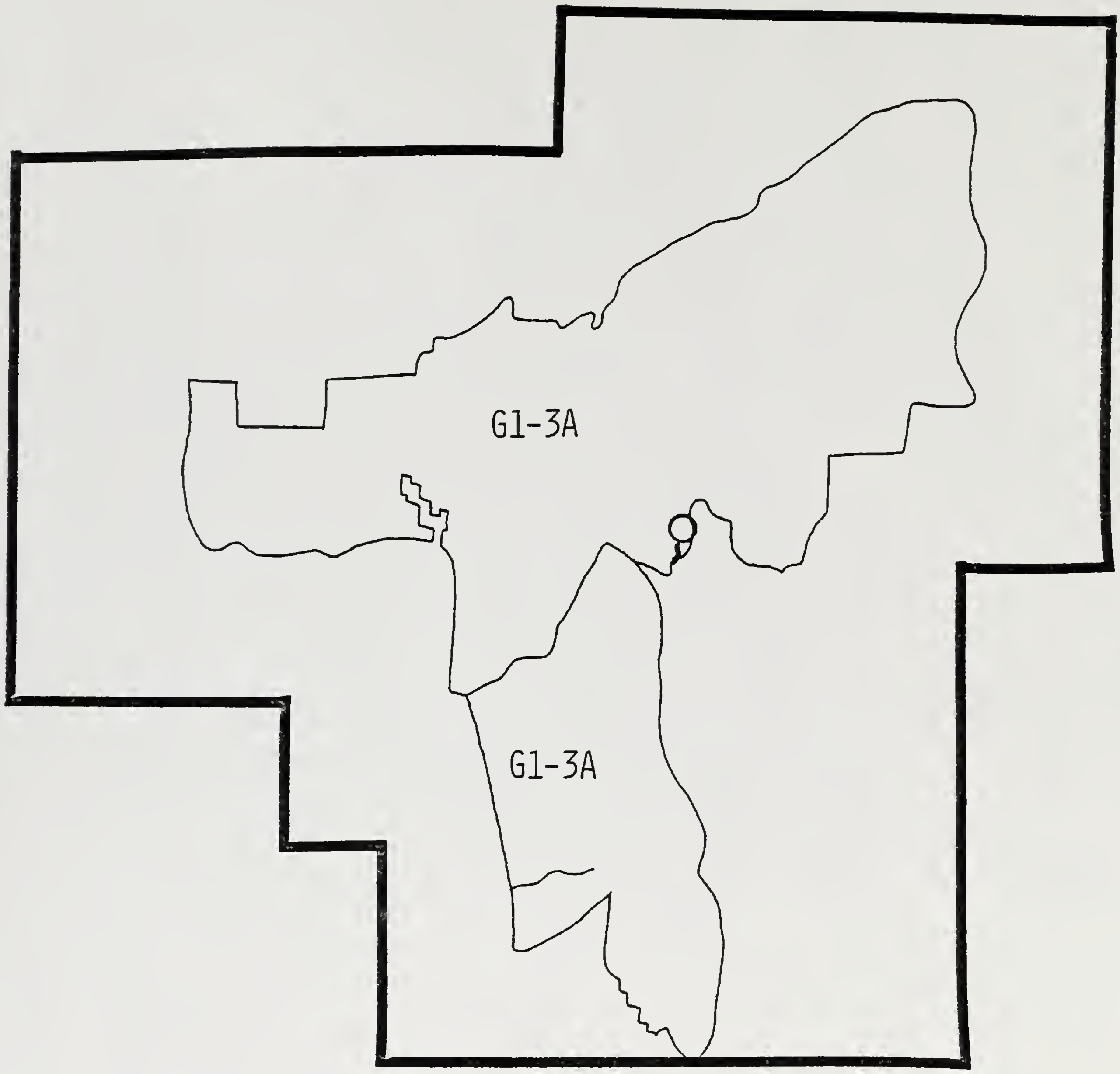
1. Reference location (see text)

Dry hole

WSA and Land Classification Boundary

Land Classification - Mineral Occurrence Map/Oil and Gas

Scale 1:250,000



EXPLANATION

Thermal Spring

WSA and Land Classification Boundary

Land Classification - Mineral Occurrence Map/Geothermal
La Madre Mountains/Pine Creek GRA NV-32
Scale 1:250,000

LEVEL OF CONFIDENCE SCHEME

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVELY MINIMAL TO SUPPORT TO REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

CLASSIFICATION SCHEME

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

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

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

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

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

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

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

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

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

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

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

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