ARROW CANYON/LAS VEGAS RANGE G-E-M RESOURCES AREA

(GRA NO. NV-29)

TECHNICAL REPORT

(WSAs NV 050-0215, 050-0216, and 050-0217)

Contract YA-553-RFP2-1054

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Final Report

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EXECUTIVE SUMMARY

The Arrow Canyon/Las Vegas Range Geology-Energy-Minerals (GEM) Resource Area (GRA) includes the following Wilderness Study Areas (WSAs): NV 050-0215, NV 050-0216 and NV 050-0217. The GRA is located in north-central Clark County, Nevada approximately six miles west of the town of Moapa and adjacent to the Desert National Wildlife Range.

Geologically the GRA is composed predominantly of 300 to 500 million year old carbonate rocks exposed in the Arrow Canyon and Las Vegas Ranges and flanked by younger alluvium in the valleys. The Muddy Creek Formation, ranging in age from 3-12 million years old, is found in the northern portion of the GRA, and is an older alluvial deposit. Structurally, the older bedrock units are faulted and folded and have been uplifted to their present position by Basin and Range faulting.

The only known metallic mineral deposit in the GRA is the Lead King mine along the extreme southern border of the GRA just south of WSA NV 050-0217. A minor amount of lead was produced from a shear zone in carbonate rocks. There are no other known metallic mineral occurrences in the GRA or the WSAs. Lead is considered a critical and strategic mineral.

Nonmetallic mineral production has included silica from the Eureka Quartzite in the Arrow Canyon Range, limestone presently being mined and manufactured into lime by Flintkote near Apex in the southern portion of the GRA, and bentonite(?) from the Muddy Creek Formation in the northern portion of the GRA.

Patented claims in the GRA are found on the limestone deposit being mined near Apex, outside the WSA, and one is found just outside the border of WSA NV 050-0215 at the Tiffany Silica Quarry. Unpatented claims are mainly for the nonmetallic mineral commodities limestone, silica and clays. The only unpatented claims within any of the WSAs are a couple believed to be staked for clays in the very northern part of WSA NV 050-0215.

All of the land within the WSAs have been leased for oil and gas. There are no geothermal leases in the WSA.

The bedrock exposures in WSAs NV 050-0215, NV 050-0216, and the northern two-thirds of NV 050-0217 show no evidence indicating metallic mineral favorability with a low confidence level. The southern portion of NV 050-0217 has a low favorability with a low confidence level based on the nearby Lead King mine. The bedrock underlying the alluvium in all the WSAs has a low favorability for metallics with a low confidence level. Uranium has a low favorability with a low to very low confidence level throughout all the WSAs. Thorium has a very low favorability with a very low confidence level in all the WSAs. WSA NV 050-0215 has a high to moderate favorability with a high to moderate confidence level for

nonmetallics including silica, carbonates, sand and gravel, and clays. WSAs NV 050-0216 and NV 050-0217 have a moderate favorability for carbonates and sand and gravel with a moderate confidence level. The favorability for oil and gas and geothermal resources is low with a very low confidence level.

Recommendations for further work in the WSAs include more detailed mapping of the bedrock and the Muddy Creek Formation, more information on the reported metallic and nonmetallic deposits and occurrences, and further contact with claim owners in the GRA.

I. INTRODUCTION

The Arrow Canyon/Las Vegas Range G-E-M Resources Area (GRA No. NV-29) includes approximately 240,000 acres (980 sq km) and includes the following Wilderness Study Areas (WSAs):

WSA Name	WSA Number
Arrow Canyon Range	NV 050-0215
Fish & Wildlife #2	NV 050-0216
Fish & Wildlife #3	NV 050-0217

The GRA is located in Nevada within the Bureau of Land Management's (BLM) Caliente Resource Area, Las Vegas district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 37°30' north latitude, 114°5' west longitude and includes the following townships:

T 13 S, R 62-64 E	T 17 S, R 62,63 E
T 14 S, R 62-65 E	T 18 S, R 62,63 E
T 15 S, R 62-65 E	T 19 S, R 62,63 E
T 16 S, R 62-64 E	

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

15-minute:

Arrow Canyon　　　　Dry Lake

7.5-minute:

Wildcat Wash, SW　　　　Wildcat Wash, SE

The nearest town is Moapa which is located approximately six miles east of the northeastern GRA boundary near Interstate 15. Access to the area is via U.S. Highway 93 which runs north and south down the middle of the GRA. Access within the area is via unimproved dirt roads scattered throughout the GRA, mostly peripheral to the WSA.

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.

WSA NV 050-0215 was field checked on December 4 and 6, 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 the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most important aspects of geological environments that were in the minds of the authors when they wrote these reports.

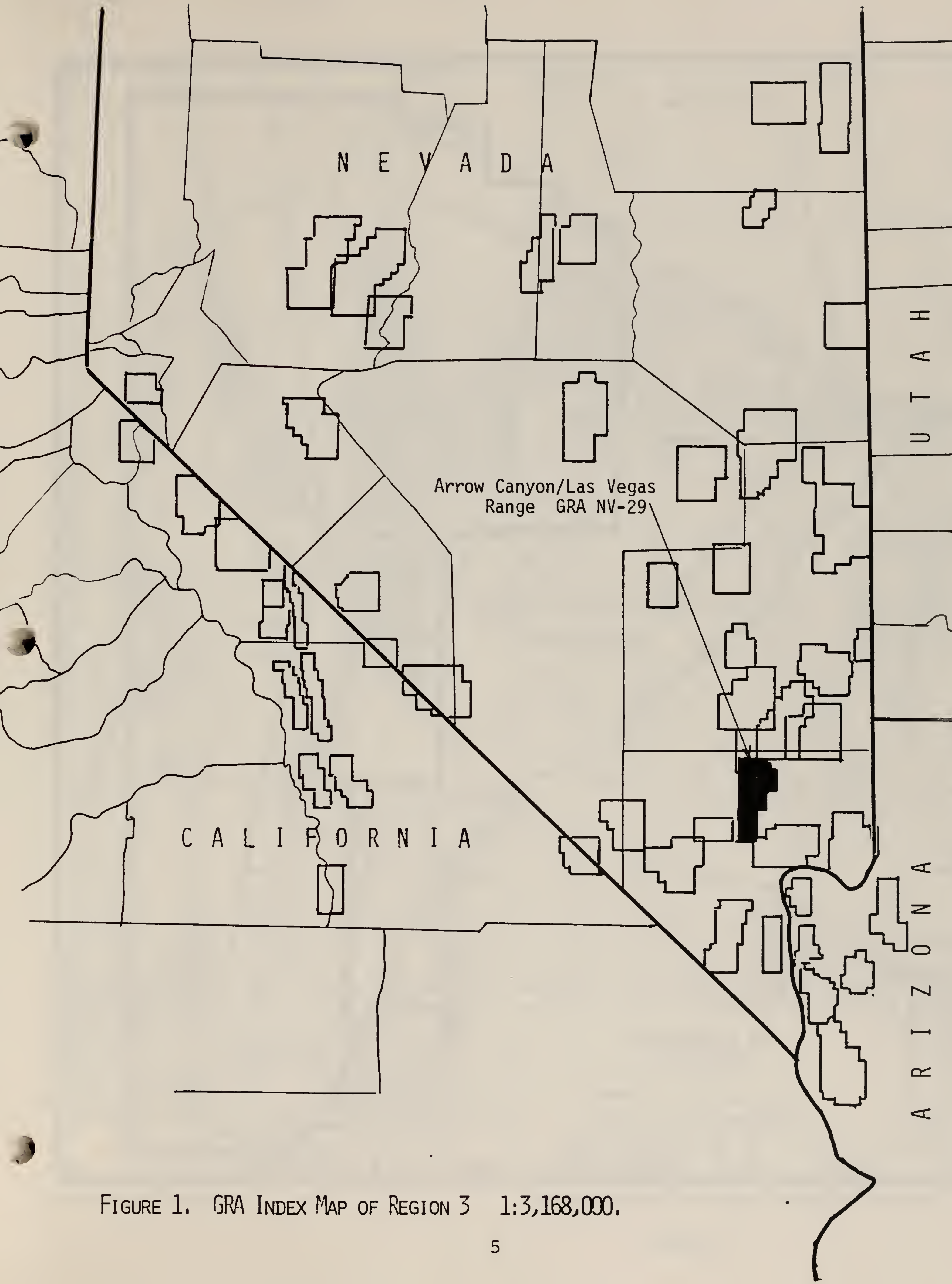
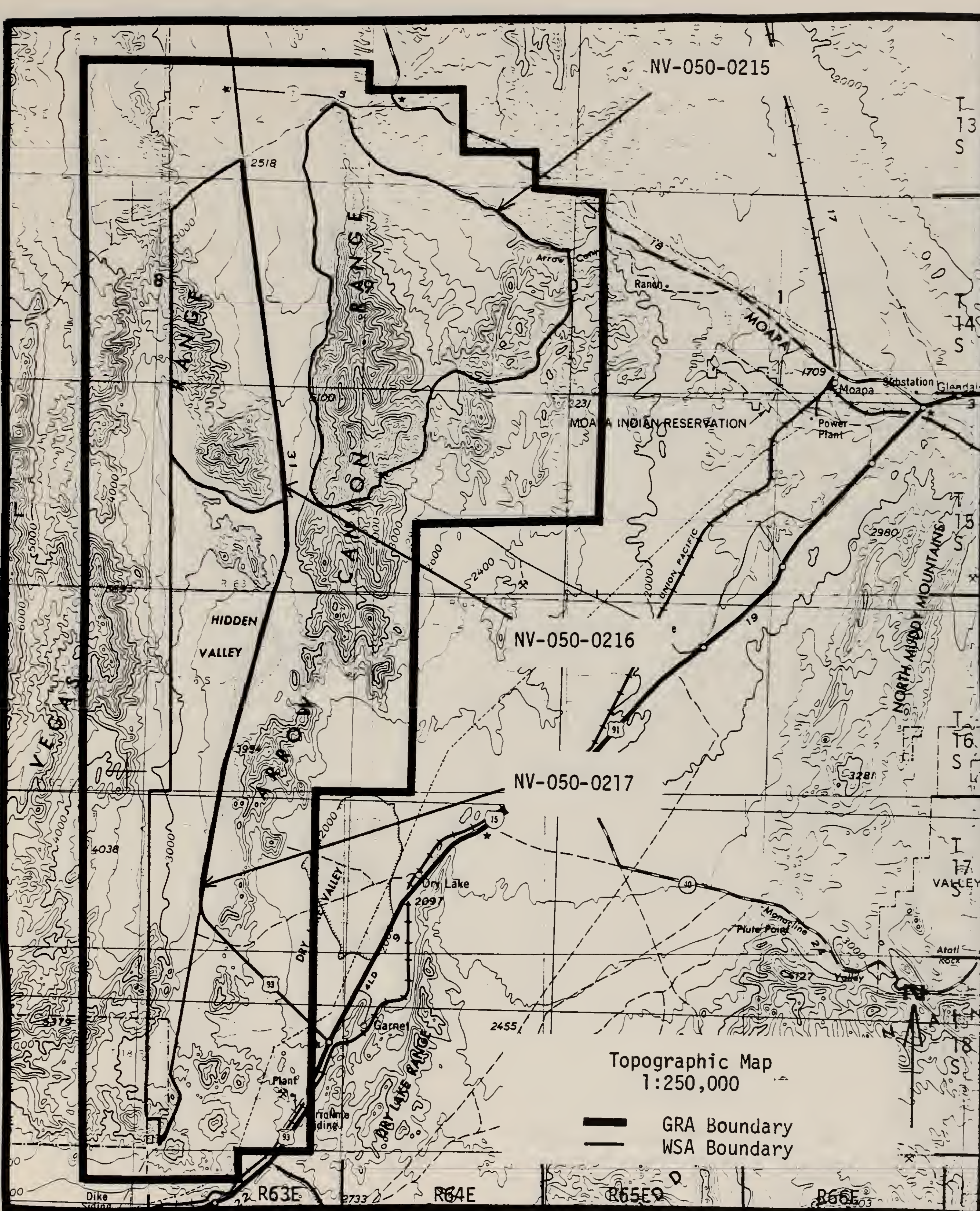


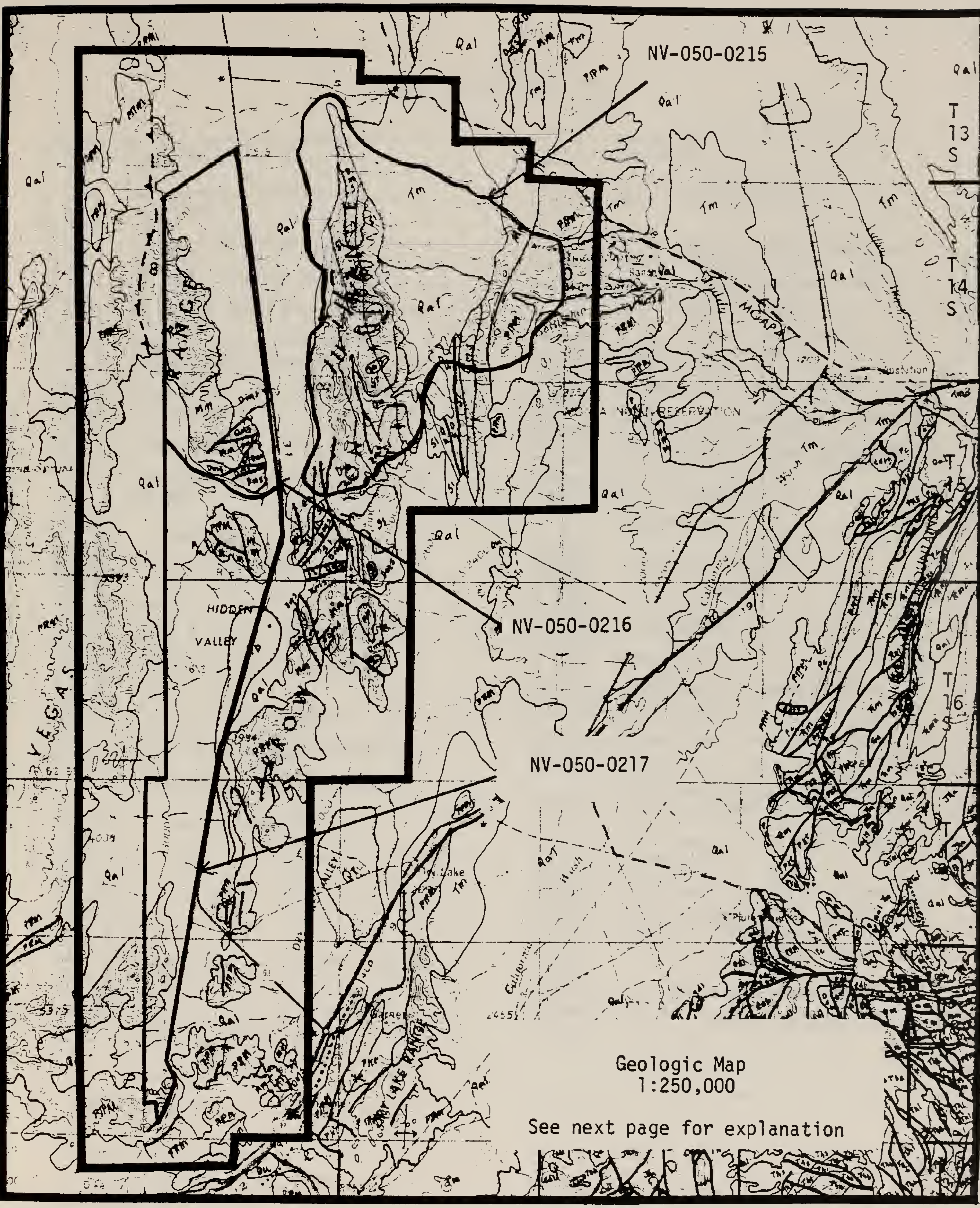
FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Las Vegas Sheet

Arrow Canyon/Las Vegas Range GRA NV-29

Figure 2



Bohannon (1978)

Arrow Canyon/Las Vegas Range GRA NV-29

Figure 3

DESCRIPTION OF MAP UNITS

Qal	ALLUVIAL DEPOSITS (HOLOCENE AND PLEISTOCENE?)
Qp	PLAYA DEPOSITS (HOLOCENE AND PLEISTOCENE?)
Qc	CHEMEHUEVI FORMATION (PLEISTOCENE)
Ql	LAS VEGAS FORMATION (PLEISTOCENE)
Qm	CALICHE OF MORMON MESA (PLEISTOCENE)
Qrd	GRAVEL OF THE COLORADO AND VIRGIN RIVERS (LOWER PLEISTOCENE)
QTal	ALLUVIAL FAN DEPOSITS (QUATERNARY AND TERTIARY)
Tb	BASALT (PLIOCENE AND MIOCENE)
	MUDDY CREEK FORMATION (PLIOCENE? AND MIOCENE)
Tm	Claystone unit
Tmf	Fortification Basalt Member
Tpav	ASH-FLOW TUFF (MIOCENE)
Tp	ROCKS OF PAVITS SPRINGS (MIOCENE)
Thv	ROCKS OF THE HAMBLIN-CLEOPATRA VOLCANO (MIOCENE)
Thvi	INTRUSIVE ROCKS (MIOCENE)
Tmdv	MOUNT DAVIS VOLCANICS (MIOCENE)
	HORSE SPRING FORMATION (MIOCENE)
Ths	Sandstone and silver tuff
Thl	Rocks of Lovell Wash
Thb	Limestone of Bitter Ridge
Thf	Lower member
Tsu	UNDIFFERENTIATED SEDIMENTARY ROCKS (TERTIARY)
Kb	BASELINE SANDSTONE (UPPER AND LOWER CRETACEOUS)
Kwt	WILLOW TANK FORMATION (LOWER CRETACEOUS)
Ja	AZTEC SANDSTONE (JURASSIC)
₮mc	MOENAVE (UPPER TRIASSIC?) AND CHINLE (UPPER TRIASSIC) FORMATIONS
₮m	MOENKOPI FORMATION (MIDDLE? AND LOWER TRIASSIC)
Pkt	KAIBAB LIMESTONE AND TOROWEAP FORMATION (LOWER PERMIAN)
Pc	CLASTIC ROCKS (LOWER PERMIAN)
PPM	CALLVILLE LIMESTONE AND BIRD SPRING FORMATION (LOWER PERMIAN, PENNSYLVANIAN AND UPPER MISSISSIPPIAN)
Mm	MISSISSIPPIAN ROCKS
	DEVONIAN ROCKS
Dmp	Muddy Peak Limestone
Dms	Sultan Limestone
Sl	SILURIAN ROCKS
Ou	ORDOVICIAN ROCKS
OCu	UNDIFFERENTIATED ORDOVICIAN AND CAMBRIAN ROCKS
Cdl	CARBONATE ROCKS (UPPER AND MIDDLE CAMBRIAN)
Cu	UNDIFFERENTIATED CLASTIC ROCKS (MIDDLE AND LOWER CAMBRIAN)
C-Du	UNDIFFERENTIATED DEVONIAN THROUGH CAMBRIAN ROCKS
Pzu	UNDIFFERENTIATED PALEOZOIC ROCKS
pCsj	STIRLING QUARTZITE AND JOHNNIE FORMATION (PRECAMBRIAN)
pCum	ULTRAMAFIC ROCKS (PRECAMBRIAN)
pCgn	GNEISS AND SCHIST (PRECAMBRIAN)
pCrg	RAPAKIVI GRANITE (PRECAMBRIAN)

CONTACT

FAULT

THRUST FAULT

LOW-ANGLE FAULT

ANTICLINE

SYNCLINE

II. GEOLOGY

The Arrow Canyon GRA lies within the Basin and Range Province and is located in north-central Clark County about six miles due west of the town of Moapa (see Figure 2). Included within the GRA are the north-south-trending Arrow Canyon Range and an eastern portion of the Las Vegas Range.

The study area is comprised of an assemblage of pricipally carbonate Paleozoic rocks which range in age from Ordovician to Permian (see Figure 3). The Pliocene(?) Muddy Creek Formation occurs locally in adjoining basins.

Structures in the study area consist of thrust faults and broad folding related to the Cretaceous Laramide Orogeny and Tertiary Basin and Range normal faulting. As evidenced by the disturbance of clays of the Muddy Creek Formation along normal fault traces, Basin and Range tectonism was still active during the Pliocene.

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

1. PHYSIOGRAPHY

The Arrow Canyon GRA lies within the Basin and Range Province in north-central Clark County about six miles due west of the town of Moapa.

The study area includes the Arrow Canyon Range, the southern extension of the eastern foothills of the Meadow Valley Range, and a eastern portion of the Las Vegas Range. The ranges trend north-south and are composed of broadly folded Paleozoic sediments which have been further modified by normal faulting.

Topography along the range crests is rugged with elevations averaging about 4,000 feet, while the adjacent Dry Lake Valley to the east is near 2,000 feet. A distinctive feature of the north end of the Arrow Range is the steep rugged ridge sloping evenly downward like the tip of an arrow that disappears to the north under valley alluvium.

Drainage from the mountains is predominantly perpendicular to the north-south trend of the ranges. Most of the drainage is considered internal as it flows to enclosed basins. The Muddy River, which runs along the north edge of the GRA however, has external drainage and flows into Lake Mead.

2. ROCK UNITS

The oldest rock units in the study area are an undivided sequence of Ordovician marine sediments which includes the Pogonip Group (limestone, dolomite, and shale), Eureka

Quartzite, and the Ely Springs Dolomite. The Silurian Lone Mountain Dolomite is the next youngest formation and crops out in the trough of the Arrow Canyon syncline. Overlying the Silurian sediments is the Devonian Sultan Limestone which is more than 1,800 feet thick in the Arrow Canyon Range. All these units crop out in the northern half of the Arrow Canyon Range in WSA NV 050-0215.

The Lower Mississippian Monte Cristo Limestone was deposited next, and the five members of this formation crop out along the east and west limbs of the Arrow Canyon syncline (Langenheim and others, 1962). The Bird Spring Formation of limestone and dolomite with subordinate shale and sandstone horizons was deposited throughout the Carboniferous-Permian. Both the Monte Cristo Limestone and the Bird Spring Formation crop out in the southern extension of the eastern foothills of WSA NV 050-0215.

The Muddy Creek Formation was deposited over an angular unconformity during the Pliocene(?), and crops out in Dry Lake Valley and in the gap between the Arrow Canyon Range and the Meadow Valley Mountains. These widespread alluvial deposits are coarse-grained near the mountain borders, and grade basinward into regular beds of fine-grained sandstone, siltstone and clay.

3. STRUCTURAL GEOLOGY AND TECTONICS

Structures in the study area consist of thrust faults and broad folding related to the Cretaceous Laramide Orogeny and Tertiary Basin and Range normal faulting.

A principal structural feature is the north-trending Arrow Canyon syncline which plunges to the north at the north end of the range. The axis of the syncline lies along the eastern flank of the main Arrow Canyon Range with the west limb forming the main ridge of the Arrow Canyon Range. Tight folds related to compressional forces of the Gass Peak Thrust occur in the northern Las Vegas Range (Longwell and others, 1965).

East of the Arrow Canyon syncline is a north-trending, shallow dipping thrust fault which may be an extension of the Dry Lake Thrust to the south (Longwell and others, 1965). East of this fault the Silurian Lone Mountain Dolomite and the Devonian Sultan Limestone have been folded and overturned to the east.

Thrusting within the Bird Spring Formation has occurred along the north trending crest of the Las Vegas Range (Longwell and others, 1945). Tight folds, probably related to the thrust's compressional forces, are found to the east and north of the thrust fault trace.

Normal faults in the study area strike nearly north, and several with smaller displacement strike northwest. The northwest flank of the Arrow Canyon Range has probably been uplifted along a north-striking fault.

Several large near vertical subparallel faults repeat formations in the middle portion of the Arrow Canyon Range.

As evidenced by the disturbance of clays of the Muddy Creek Formation along normal fault traces, Basin and Range tectonism was still active during the Pliocene. More recent displacements have not been documented in the area.

4. PALEONTOLOGY

The occurrence of paleontological resources within the Arrow Canyon/Las Vegas Range is so ubiquitous that any enumeration of specific localities would be beyond the goals of the present report. The entire Arrow Canyon Range and a part of the Las Vegas Range are essentially a continuous series of fossil localities, in many instances numerous localities being separated only by slight differences in stratigraphic position and not at all by geographic differences separable on a map. An estimate of those localities recorded in the literature (for example Langenheim, 1956; Langenheim and others 1960, 1962; Lane, 1963, 1964; Lane and Webster 1965, 1966; and several others) in addition to the experience of the present author and collegues, would indicate something well in excess of one hundred separate sites. Therefore, a somewhat generalized discussion of the more notable occurrences is presented herein, and more detailed information may be obtained by consulting those references indicated for this GRA.

Paleozoic marine rocks of several formations are exposed in the Arrow Canyon and Las Vegas Ranges, and are almost continuously fossiliferous along strike in Arrow Canyon proper. In the northeastern corner of the resource area is the type locality of several new species of brachiopods and corals, while Battleship Wash (the first canyon south of Arrow Canyon) is a locality of a significant Permian crinoid fauna from the Bird Spring Formation (Lane, 1964). Some twenty-five genera of Permian crinoids are recorded from these areas. Inside the eastern boundary of the resource area is the type locality of Parulocrinus vetulus Lane (Lower Pennsylvanian-Morrovian) from the W 1/2 Sec. 12, T 14 S, R 64 E (Lane, 1964). Thus, a relatively complete sequence of Late Paleozoic crinoids (from Morrovian to Wolfcampian) is recorded from within the GRA. The base of the Permian, not recognized in most parts of the Cordillera, may be detected in Arrow Canyon by the first occurrence of crinoid genera of the families Taxacrinidae and Sagenocrinitidae as well as by lower Wolfcamp species of the fusulinid Pseudoschivagerina. Longwell and Dunbar (1936) in their treatment of the Pennsylvanian/Permian

boundary, note that the Arrow Canyon Range is one of the few places in western North America where biostratigraphic control of boundary is evident. Late Pennsylvanian and Early Permian fusulinid faunas are abundant throughout the area of study, and are probably the same general fauna as that described from Mountain Springs, Clark County.

Conodonts from the lower and upper Mississippian Monte Cristo Group have been recorded from the Arrow Canyon Range by Pierce (1969), and although no precise locality data was obtained several different localities are involved. Permian coriodonts from the Bird Spring Formation have been studied, and included in the larger studies of conodont biostratigraphy.

Ordovician rocks of the Pogonip Group are exposed throughout the Arrow Canyon Range, and there are recorded several localities which yielded fossil mollusca. Many of these localities are apparently the same as some recorded by other authors as coral and brachiopod localities. It would require a great deal of precise review to determine exact relationships.

5. GEOLOGIC HISTORY

Throughout the Paleozoic a thick sequence of marine sediments was deposited. The predominantly carbonate facies include clastic sequences indicating an oscillation of the Paleozoic shoreline.

At the end of the Paleozoic the area was uplifted and eroded. Cretaceous tectonic forces caused thrusting and folding of the Paleozoic sediments. The landform was further modified by Basin and Range type normal faulting which probably initiated during the Middle Tertiary and continued intermittently throughout the Pliocene.

Thick clastic and chemical precipitate sequences accumulated in structural basins during the Late Tertiary. The Muddy Creek Formation was deposited at this time, and except for recent alluvium is the youngest formation in the Arrow Canyon Range GRA.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There is one known metallic mineral deposit in the GRA known as the Lead King mine (called the Dike district by Longwell and others, 1965). It is located along the extreme southern boundary of the GRA in the southeastern quarter of Sec. 6, T 19, S, R 63 E (see Metallic Land Classification and Mineral Occurrence Map). It is located in gently dipping Carboniferous limestones. The workings consist of one 242-foot inclined shaft exploring a shear zone striking northwest and dipping north. Two carloads of ore were reportedly shipped from the mine averaging 59% lead sometime in the early 1900s. The ore minerals were galena and lesser amounts of cerussite. The mine is approximately one mile south of the southern tip of WSA NV 050-0217.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Based on the available evidence there are no other known metallic mineral occurrences or prospects in the GRA.

3. Mining Claims

In the vicinity of the Lead King mine there are at least sixteen lode claims which may have been located in connection with the mineralization at the Lead King mine (see Claim Map). The claims were located in 1980 and their assessment work has been kept current. None of these claims extend into the nearby WSA.

4. Mineral Deposit Types

The mineralization at the Lead King mine occurs along shear zones in the carbonate units, apparently as high temperature replacement type deposits.

5. Mineral Economics

Narrow, sporadic replacement-type lead deposits are not presently economically attractive to the major mining companies because of their limited tonnage potential and high underground mining costs. The small miner, however, could possibly find these types of deposits economically feasible to develop.

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.

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There are four nonmetallic mineral commodities which have reported production in the GRA: limestone, bentonite, silica, and sand and gravel. The largest nonmetallic producer by far is Flintkote's limestone mine and lime plant at Apex in the extreme southeast corner of the GRA (see Nonmetallic Land Classification and Mineral Occurrence Map). Production is from the Crystal Pass Member of the Sultan Limestone, which is a very high calcium, low magnesium limestone. Limestone has been mined from this locality for at least thirty years.

Small quantities of bentonite have reportedly been mined from a deposit in the Muddy Creek Formation fourteen miles northwest of Moapa near the northeast boundary of WSA NV 050-0215. It is reported to be a white bentonite bed almost three feet thick adjacent to diatomaceous beds (Longwell and others, 1965). Some diatomaceous material from this location has been cut for building stone. A field check of this locality in December of 1982, however, showed a few prospect pits only and if there was production, it was very small. No diatomite was recognized.

Silica has been quarried from the Eureka Quartzite in a deposit called the Tiffany Quarry in the Arrow Canyon Range on the southeastern boundary of WSA NV 050-0215. The middle part of the Eureka Quartzite is the source of the silica which was apparently suitable for low-alumina silica refractories and metallurgical stone. This quarry has not been active for many years.

A quarry is presently in operation on the west side of the Arrow Canyon Range in the Eureka Quartzite in Sec. 27, T 15 S, R 63 E along Highway 93. They are mining the quartzite and apparently crushing and screening the white rock to about minus one inch. The use for the material is unknown but it may be being used in Las Vegas as decorative stone.

A gravel deposit has been utilized in the northwest corner of the GRA in the alluvium next to U. S. Highway 93. Other material sites have been designated by the BLM along Highway 93, including some within the two WSAs on the west, but they have not been mined.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

In the vicinity of the Apex limestone deposit there is an area which has been prospected while delineating the extent of the high calcium limestone. No other reported occurrences of high calcium limestone are known of within the GRA, but the possibility exists that additional high calcium members of the Sultan Limestone are present in the northern portion of the Arrow Canyon Range in WSA NV 050-0215 where the Sultan Limestone has extensive outcrops.

Two other silica occurrences are reported in the Eureka Quartzite within a few miles of the Tiffany Quarry, but these are also outside the WSA. The Eureka Quartzite crops out extensively in the northern Arrow Canyon Range and within the WSA.

3. Mining Claims, Leases and Material Sites

There are many mining claims in the GRA, the majority of which are believed to have been staked for nonmetallic mineral commodities (see Claim Map). Both patented and unpatented claims may be found in the vicinity of the Apex limestone quarry. There are several claims in the northern part of the GRA in the vicinity of the reported bentonite deposit, at least two of which are at least partially within WSA NV 050-0215. One patented claim and two unpatented claims are present in the vicinity of the Tiffany silica quarry. There are a group of six association placer claims in T 15 S, R 64 E in a north-south orientation following the outcrop of the Eureka Quartzite. Most of the other unpatented claims in the GRA are placer claims and cover carbonate outcrops, presumably for limestone for use in either lime or cement manufacture. One large block of at least 87 placer claims in the southern part of the Arrow Canyon Range in T 17 S, R 63 E, is known to have been staked for its potential as a cement raw material (Bryan, 1983).

At least one material site has been utilized in the GRA, but this is outside the WSAs. Much of the alluvium in the GRA has potential for sand and gravel. Other material sites ahve been delineated in the GRA by the BLM, some of which are within the western two WSAs.

4. Mineral Deposit Types

The high calcium limestone is a sedimentary rock which is crystalline white to light grey, thin-bedded and free of siliceous or ferruginous material (Longwell and others, 1965). The silica also comes from a sedimentary rock, sandstone, which is very pure silica in the form of quartz grains and cement, and which has been at least partially metamorphosed to quartzite. The clays (bentonite?) come from the Muddy Creek Formation and are lake sediments.

The other limestones in the area which may be suitable for cement manufacture are sedimentary rocks and may or may not have been metamorphosed.

5. Mineral Economics

Flintkote's lime operation has been in production for many years and their end product is marketed in Nevada and several nearby states. Not enough is known of the bentonite at the north end of WSA NV 050-0215 to adequately determine its economics.

The Eureka Quartzite is widespread and in one area is presently being mined on a small scale. Other silica is presently being mined in Clark County from soft, easily mineable Cretaceous sandstone near Overton. The Eureka quartzite is a harder material and more costly to mine than the Overton sandstones.

There has been interest in limestone for cement manufacture in the Las Vegas area for many years. Raw materials for cement can have a wide range of chemical composition, so except for unacceptable magnesium (dolomite) contents some of the limestone units within the GRA could possibly be used in cement. Detailed chemistry of the units would be needed. At least one company (?) or group has gone to the trouble of staking at least 87 claims covering carbonate units in the southern Arrow Canyon Range for cement raw materials.

A large but unknown proportion of silica or industrial sand (quartzite) is used in making glass, which is almost entirely silica. The second largest use is as foundry sand which is used to make molds for metal castings, and some is used as a flux in certain smelting operations. Sand is used as an abrasive in applications such as

sandblasting, as a filter in various kinds of water treatment, and in a multitude of minor uses. The United States uses about 30 million tons of silica sand annually, essentially all produced domestically. Except for highly specialized sands, silica sand is a relatively low-riced material and must be produced within a few hundred miles of the point of use. Silica sand consumption in the United States is forecast to increase by about 50 percent by the year 2000. The average price for silica sand is about $10 per ton, but the price for specific sands varies widely depending on the end use and the specifications required.

Pure limestone and dolomite are used principally to produce lime, but some is used as rock for building stone, crushed rock and similar applications. The principal uses of lime are in steel smelting, water purification, as an alkali, in paper and pulp manufacture and sewage treatment. Other uses for lime are in sugar purification, mortar, and as an agricultural soil conditioner. Limestone with certain clay impurities (called cement rock) or purer limestone with clay added, is used to make cement that is mostly consumed in construction. The United States uses about 20 million tons of lime and 85 million tons of cement annually. For both lime and cement the raw material must be mined within a very few miles of the processing plant, because it has a very low value in the form of run-of-mine rock -- two or three dollars per ton. There are numerous lime and cement plants in the United States, and most of them sell most of their product within a 200 mile radius of the plant. Some cement is imported in the form of clinker, which is the kiln-fired rock that is then ground in the United States. In the early 1980s the price F.O.B. plant of both lime and cement is about $40 per ton.

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

at about $5 per ton, while the highest-priced clay, kaolin, averages about $65 per ton.

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 flucturates with activity in the construction industry, and is relatively low during the recession of the early 1980s. Demand is expected to increase by about one third by the year 2000. In the early 1980s the price of sand and gravel F.O.B. plant averaged about $2.50 per ton but varied widely depending upon quality and to some extent upon location.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

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

2. Known prospects, Mineral Occurrences and Mineralized Areas

   There are no known uranium or thorium occurrences within the GRA or the WSAs. However, anamolous radioactivity has been noted just north of WSA NV 050-0215 and west of the southern tip of WSA NV 050-0217 (see Uranium Land Classification and Mineral Occurrence Map). In the first case radioactivity is associated with black Paleozoic limestone in Secs. 6 or 7, T 13 S, R 64 E at the Fry and Jeffers claim, and in the latter case radioactivity is associated with malachite, chrysocolla and iron oxides in a breccia zone in the Monte Cristo limestone, in Sec. 24,

T 18 S, R 61 E at the Sampson and Sampson No. 1 claims (Garside, 1973).

3. Mining Claims

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

4. Mineral Deposit Types

A description of deposit types in the GRA is not possible due to the lack of known uranium or thorium occurrences in the area.

5. Mineral Economics

Uranium and thorium do not appear to occur in economic quantities within or near the GRA. Only two minor radioactive occurrences have been noted in the area surrounding the GRA, as noted above.

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 known to be in the GRA or vicinity, although United Petroleum Apex No. 1 (Locality #1 on Oil and Gas Occurrence and Land Classification Map) was drilled to 1,455 feet in 1948, and Southern Oil Investments Apex No. 1 (also #1) was drilled to 1,455 feet in 1950 (Lintz, 1957) in WSA 050-0217. During early 1983 Grace Petroleum Corporation Arrow Canyon No. 1 (#2) drilled to 17,110 feet (Nevada Bureau of Mines and Geology, 1982) inside the GRA. In addition, just a few miles east of the GRA the following exploratory wells were drilled (Lintz, 1957; Garside and others, 1977):

   Last Chance Oil Co., Crystal No. 1 (#3)
   1,102' TD, 1950

   Southern Great Basin Oil & Gas, Government No. 1 (#4)
   5,085' TD, 1954 (oil and gas show)

   G. G. Exploration No. 1 (#5)
   1,130' TD, 1949

   Sandia, Duff No. 1 (#6)
   438' TD, 1971

   Chevron U.S.A., Inc. Colorock Quarry No. 1 (#7)

   Chevron U.S.A., Inc. Buffington Pocket No. 1 (#8)

3. Oil and Gas Leases

   Federal oil and gas leases cover all three of the WSAs.

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 miogeosynlcine 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 Pennyslvanian 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 geothermal deposits in the GRA.

2. Known Prospects, Geothermal Occurrences and Geothermal Areas

No prospects, occurrences or thermal areas are known to be present in the GRA, but just two miles east of the GRA are a number of thermal wells and springs known as the Moapa area. Here the thermal waters coming up through the Paleozoic rocks issue from the alluvium at up to 90°F. Iverson's Warm Spring has been used for irrigation and bathing (Garside and Schilling, 1979).

3. Geothermal Leases

There are no Federal leases in the GRA or vicinity.

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 uitlized 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

There are no unusual or unique geological resources known to exist in the GRA or the WSAs. There are no coal or oil shale resources known to exist in 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 in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals.

Lead the only strategic and critical mineral in the GRA was produced on a very limited scale from the Lead King mine on the southern boundary of the GRA but none was produced from within any of the WSAs.

IV. LAND CLASSIFICATION FOR G-E-M RESOURCES

The geologic maps which cover the WSA include Longwell and others, 1965, and Howard, 1978, both at a scale of 1:250,000 and both essentially the same for this GRA. Longwell's map, however, shows the outcrop area of the Eureka Quartzite which is classified separately below and on the Land Classification Map as N2-4D. The scale of these maps is too small to show a great deal of geological detail other than gross lithologic differences. 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 is good and the confidence level in the information is good. The data on mineral resources comes principally from Longwell and other, 1965, and is not detailed. Overall the quantity of data concerning mineral resources is low, but the quality and level of confidence in that data we do have is good.

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 050-0215 and NV 050-0216

M1-1B. This classification area includes all of the Paleozoic bedrock units in the two WSAs and indicate there is no evidence of favorability for metallic mineral resources with a low level of confidence (see Metallic Land Classification and Mineral Occurrence Map). There are no known metallic occurrences in these WSAs, nor does the available geology imply that mineralization extends into the WSAs. Similar rocks do show evidence of mineralization elsewhere in southern Nevada, but there is no such evidence here.

M2-2A. This classification area is one of low favorability for metallic mineral resources with a very low confidence level and includes the alluvium and the Tertiary Muddy Creek Formation. The nature of the bedrock beneath the alluvium is unknown. These bedrock units are mineralized in other areas of southern Nevada, but their nature is unknown at these locations; therefore, it is considered that these unseen units have a low favorability for metallic minerals. In areas where the Muddy Creek Formation is present there is also a low favorability for manganese as manganese is present in the Muddy Creek Formation at many other areas in western Clark County.

WSA NV 050-0217

M1-1B. This classification area includes the northernmost bedrock outcrop area in the WSA, with the rationale for this classification as described above for the previous WSAs.

M2-2A. This classification area includes the alluvium in the WSA and is the same as described above for the previous WSAs.

M3-2B. This classification is one of low favorability with a low confidence level and includes the southern bedrock exposures in the WSA. The 2B classification is because of the presence of the nearby Lead King mine which produced a minimal amount of lead in the early 1900s. The vein at the Lead King mine is less than two miles from the southern boundary of the GRA and strikes northwest toward the WSA. There may be a possibility of additional as yet unknown veins or extensions of this structure within the WSA.

b. Uranium and Thorium

WSAs NV 050-0215, 050-0216, and 050-0217

U1-2B. This land classification, indicating low uranium favorability with a low confidence level, covers the western and eastern portions of WSA NV 050-0215, a northwest to southeast trending area in WSA NV 050-0216 and the northeastern corner and southern tip of WSA 050-0217. This classification also covers parts of the GRA which are covered by Paleozoic carbonates. This area has low favorability for uranium concentration as fracture fillings in the carbonates. Two minor radioactive occurrences of this type are present in areas surrounding the GRA in similar rock types, but source rocks for uranium or thorium deposits do not appear to be present in the area.

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

U2-2A. This land classification covers the central portion of WSA NV 050-0215, the northeast and southwest corners of WSA NV 050-0216, the majority of WSA 050-0217, and parts of the GRA which are covered by Quaternary alluvium. This area has very low favorability with a very low level of confidence for epigenetic sandstone-type uranium deposits. The source rocks for the alluvial deposits are Paleozoic carbonates which are typically poor sources of uranium. However, uranium may occur in fracture fillings in the carbonate bedrock beneath the alluvium as is possible in area U1-2B so the area is classified as having low favorability with a very low confidence level.

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

c. Nonmetallic Minerals

WSA NV 050-0215

N1-3C. This classification area of moderate favorability with a moderate confidence level includes all the exposures of the Muddy Creek Formation in the WSA. The potential exists for clays as there are clay occurrences and claims here. Elsewhere in the Muddy Creek Formation in Clark County to the south and east, abundant gypsum deposits are present. Diatomite has also been reported here but has not been confirmed.

N2-4D. This classification area of high favorability with a high confidence level includes the Eureka Quartzite outcrops in the WSA. As it was mapped by Longwell and others (1965) the quartzite appears as a separate unit on the Clark County geologic map. The quartzite has been and is presently being mined near the border of the WSA. In addition there are many claims covering some of the quartzite outcrops outside the WSA. From the available information and from our own field visit in December of 1982 it is believed that the physical properties of the entire Eureka Quartzite is consistent, hence the 4D classification for the entire unit (this 4D classification is shown as a dotted line on the Land Classification Map and represents the outcrop of the Eureka quartizite in the WSA).

N3-3C. This classification area of moderate favorability with a moderate confidence level includes the remaining bedrock outcrop areas in the WSA which are primarily carbonate rocks but may include minor amounts of shale. The carbonates have potential for use in lime and cement manufacture. To the south in the GRA Flintkote operates a lime plant which utilizes nearby pure limestone from the Sultan Limestone which is also found in the WSA. In addition, dolomitic lime is mined and processed elsewhere in Clark County.

Cement can be manufactured from limestone of varying chemical compositions. There are abundant mining claims in the GRA and to the east covering these same carbonate formations which have been staked for cement raw materials. Detailed examination would be necessary to adequately evaluate a site specific area however.

N4-3C. This classification area of moderate favorability with a moderate confidence level includes all the alluvium in the WSA and it could probably be utilized for sand and gravel for nearby construction needs. Detailed examinations of individual sites would be needed to adequately appraise quality.

WSA NV 050-0216 and WSA 050-0217

N3-3C. This classification area is one of moderate favorability with a moderate confidence level. These are carbonate units and the rationale for this classification is as explained above in the previous WSA classification.

N4-3C. This classification area is one of moderate favorability with a moderate confidence level. This is the alluvium and potential material sites are widespread in this area. The BLM has delineated some potential material sites within these two WSAs, but these locations have not been shown on the Land Classification Map. This

entire area would appear to make a good aggregate source as the same carbonate host rocks elsewhere in the Las Vegas valley yield good aggregate deposits. A more detailed site-specific evaluation is necessary, however, to more adequately assess potential.

2. LEASABLE RESOURCES

a. Oil and Gas

WSAs NV 050-0215, NV 050-0216 and NV 050-1027

OG1-2A. Two wells have been drilled in WSA 050-0217, one of which, United Petroleum Apex No. 1 (#1), had hydrocarbon shows. The Grace Petroleum well (#2) located five miles to the southeast and inside the GRA, was recently bottomed at 17,110 feet. Data on this well is being withheld. Other wells outside the GRA have recorded oil shows as well.

The WSAs are covered in their entirety by Federal oil and gas leases. They are not only prospective for the normal Paleozoic sections, but also are prospective as being part of the Overthrust Belt.

b. Geothermal

WSAs NV 050-0215, NV 050-0216 and NV 050-0217

G1-2A. The WSAs are situated in the known low-temperature geothermal area of southern Nevada. The Maopa geothermal area just east of WSA 050-0215 is a commercially viable area for non-electric use of this resource. Although the WSAs are apparently not on direct structural trend with Moapa, the requisite Late Cenozoic faulting, which acts as conduits for rising thermal waters, probably is present.

c. Sodium and Potassium

S1-1B. There are no sodium or potassium resources known or suspected to exist in the GRa or the WSAs. There is no map for this commodity.

3. SALEABLE RESOURCES

The saleable resources, sand and gravel, have been discussed above under nonmetallic resources and include all areas covered by classification N4-3C.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

Little is known of the Muddy Peak Formation in WSA NV 050-0215. This unit and the clay deposits in the northern portion of the WSA should be mapped in greater detail to adequately assess the nonmetallic mineral potential. The entire bedrock outcrop area of the included WSAs should be mapped in greater detail also. The southern carbonate outcrops in WSA NV 050-0217 should be investigated for metallic minerals similar to those at the small Lead King mine directly to the south, and this mine should be more thoroughly evaluated. The operating quartzite mine on the west side of the range should be investigated to determine what its end use is. Claim holders in the GRA should be contacted again for any additional geological input they may have.

VI. REFERENCES AND SELECTED BIBLIOGRAPHY

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

Armstrong, R. L., 1963, Geochronology and geology of the eastern Great Basin in Nevada and Utah: Ph.D. thesis, Yale University, New Haven, Conn.

Bissel, H. J., 1964, Ely, Arcturus, and Park City groups (Pennsylvanian-Permian) in eastern Nevada and western Utah: American Assoc. Petrol. Geol. Bull., v. 48, p. 565-636.

Bohannon, R. G., 1978, Preliminary geologic map of Las Vegas 1° x 2° Quadrangle, Nevada, Arizona, and California: U. S. Geol. Survey Open File Report 78-670.

Bryan, D. P., 1983, Personal communcation.

Christy, R. B., 1958, Some Permian fusulinid faunas near Lee Canyon, Clark County, Nevada: M. S. Thesis, Univ. Illinois, Urbana.

Chamberlain, T. L., 1971, The Ordovician-Silurian boundary in the Arrow Canyon Range, Clark County, Nevada: M. S. Thesis, Univ. Illinois.

Garside, L. J., 1973, Radioactive mineral occurrences in Nevada: Nevada Bur. Mines Bull. 81, 121 p.

Garside, L. J., and Schilling, J. H., 1979, Thermal waters of Nevada: Nevada Bur. of Mines and Geol. Bull. 91.

Garside, L. J., Weimer, B. S. and Lutsey, I. A., 1977, Oil and gas developments in Nevada, 1968-1976: Nevada Bur. Mines and Geol. Rept. 29.

Geodata, 1981, Eastern Nevada multifold seismic data available: Geodata Corp., Denver, Colorado.

Geophysical Service Inc, 1981, Southeastern Nevada Hingeline: Non-exclusive seismic surveys available.

Hazzard, J. C., 1937, Paleozoic section in the Nopah and Resting Springs Mountains, Inyo County, California: California Jour. Mines and Geology, v. 33.

Howard, E. L., e.d, 1978, Geologic map of the eastern Great Basin, Nevada and Utah: Terra Scan Group Ltd.

Johnson, J. G., and Reso, A., 1966, brachiopods from the Pilot Shale (Devonian) in southeastern Nevada: Jour. Paleontology, v. 40, no. 1, p. 125-129.

Keith, S. B., 1979, The great southwestern Arizona overthrust oil and gas play: Arizona Bur. of Geol. and Min. Tech., March.

Lane, N. G., 1963, A silicified Morrowan brachiopod faunule from the Bird Spring Formation, southern Nevada: Jour. Paleontology, v. 37, no. 2, p. 379-392.

Lane, N. G., 1964, New Pennsylvanian crinoids from Clark County, Nevada: Jour. Paleontology, v. 38, no. 4, p. 677-684.

Lane, N. G. and Webster, G. D., 1965, New Permian crinoid fauna from southern Nevada (abs.): Geol. Soc. America Spec. Paper 82, p. 119.

_____, 1966, New Permian crinoid from southern Nevada: Univ. California Publ. Geol. Sci., v. 63, p. 1-60.

Langenheim, R. L., 1956, Lower Mississippi stratigraphic units in southern Nevada (abs.): Geol. Soc. America Bull., v. 67, no. 12, p. 1773.

Langenheim, R. L., Jr., Carso, B. W., Kemerly, J. B., Mccutcheon, V. A., and Waines, R. H., 1960, Paleozoic section in the Arrow Canyon Range, Clark County, Nevada (abs.): Geol. Soc. America Bull., v. 71, no. 12, pt. 2, p. 2064.

Langenheim, R. L., Jr., Carss, B. W., Kennerly, J.B., McCutcheon, V. A., and Waines, R. H., 1962, Paleozoic section in Arrow Canyon Range, Clark County, Nevada: Am. Assoc. Petroleum Geologists Bull., v. 46, p. 592-609.

Langenheim, R. L., Jr., Nelson, W. J., Grove, K. A., and McGouney, J. E., 1974, Fussulinid occurrences in relation to carbonate microfacies of Bird Spring Group, Arrow Canyon Range, Clark County, Nevada: American Assoc. Petrol. Geol. and SEPM Ann. Meeting, v. 1, p. 56.

_____, 1977, Fusulinids in carbonate microfacies of Bird Springs Group, Arrow Canyon quadrangle, Clark County, Nevada: Jour. Paleontology, v. 51, no. 5, p. 1016-1022.

Langenheim, R. L., Jr., and Larson, E. R., 1973, Correlation of Great Basin stratigraphic units: Nevada Bur. Mines and Geol., Bull. 72, p. 1-36.

Lintz, J. L., Jr., 1957, Nevada oil and gas drilling data, 1906-1953: Nevada Bur. Mines Bull. 52.

Lochman-Balk, C., 1956, The Cambrian of the Rocky Mountains and southern deserts of the United States and adjoining Sonoma province, Mexico, in the Cambrian system, it's paleogeography and the problem of it's base: 20th Internat. Geol. Cong., v. 2, pt. 2, p. 529-560.

Longwell, C. R., 1945, Low-angle normal faults in the Basin and Range province: Am. Geophys. Union Trans., v. 26, pt. I, p. 107-118.

_____, 1960, Possible explanation of diverse structural patterns in southern Nevada: Am. Jour. Sci., v. 258-A, p. 192-203.

Longwell, C. R., and Dunbar, C. O., 1936, Problems of Pennsylvanian Permian boundary in southern Nevada: American Assoc. petroleum Geologists Bull., v. 20, no. 9, p. 1198-1207.

Longwell, C. R.,Pampeyan, E. H., Bowyer, Ben, and Roberts, R. J., 1965, Geology and mineral deposits of Clark County, Nevada: Nevada Bur. of Mines Bull. 62.

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

Nevada Bureau of Mines and Geology, 1982, List of wells drilled for oil and gas, January 1977 through the present (November 8, 1982): Nevada Bur. of Mines and Geol. List L-4.

Nevada Bureau of Mines and Geology Oil and Gas Files, 1982.

Nolan, T. B., 1943, The Basin and Range Province in Utah, Nevada and California: U. S. Geol. Survey Prof. Paper 197D, p. 141-146.

Nowak, F. J., 1972, Microfacies of the Upper Bird Spring Group (Pennsylvanian-Permian), Arrow Canyon Range, Clark County, Nevada: Ph.D. Dissertation Univ. Illinois, Urbana. 73 p.

Nowak, F. J., and Carozzi, A. V., 1973, Microfacies of the Upper Bird Spring Group (Pennsylvanian-Permian), Arrow Canyon Range, Clark County, Nevada: Archives Des Sciences 25, Fasc. 3, p. 343-382 (Arch. Sci. Soc. Phys. Hist. Nat. Geneve).

Oil and Gas Jour., May 12, 1980, What's been found in the North American Overthrust Belt.

Papke, K. G., 1982, Personal communcation. Industrial Minerals Geologist, Nevada Bur. of Mines and Geology.

Papke, K. G., 1973, Industrial mineral deposits of Nevada: Nevada Bur. of Mines and Geology, Map 46.

Papke, K. G., 1970, Montmorillonite, bentonite, and fullers earth deposits in Nevada: Nevada Bur. of Mines and Geology Bull. 76.

Poole, F. G. and Sandberg, C. A., 1977, Mississippian paleogeography and tectonics of the western United States, in Stewart, et al Paleozoic paleogeography of the western United States: Soc. Econ. Paleontology and Mineralogy, Pacific Coast Paleogeog. Symp.

Rafuse, B. E., 1973, Bathymetry of conodonts from the Bird Spring Formation of Arrow Canyon, Nevada: Unpub. M.S. thesis, Univ. Washington, Seattle.

Reinhold, M. L., and Langenheim, R. L., Jr., 1977, Late Devonian conodont biostratigrpahy, Las Vegas Range, Clark County, Nevada: Geol. Soc. America [abs.] v. 9, p. 646-647.

_____, 1977, Late Devonian Frasnian-Fammenian conodont biostratigraphy, Las Vegas Range, Clark County, Nevada: U.S.A. Newsletter Stratig., v. 6, no. 3, p. 183-193.

Rich, M., 1959, Stratigraphic section and fusulinids of the Bird Spring Formation near Lee Canyon, Clark County, Nevada: Unpub. Ph.D. Dissertation, Univ. Illinois, Urbana, 188 p.

_____, 1960, Chaetetes in the Bird Spring Formation Lee Canyon, Clark County, Nevada: Jour. Paleontology, v. 34, no. 4, p. 761-762.

_____, 1961, Stratigraphic section and fusulinids of the Bird Spring Formation near Lee Canyon, Clark County, Nevada: Jour. paleontology, v. 35, p. 1159-1180.

_____, 1962, Mississippian stigmarian plant fossil from southern Nevada: Jour. Paleontology, v. 36, no. 2, p. 347-349.

Roberts, W. B., 1956, Stratigraphy of the Lower to Middle Paleozoic carbonate sequence in the eastern Great Basin (abs.): Geol. Sec. America Bull., v. 67, no. 12, pt. 2, p. 1781.

Ross, J. R., 1972, Fossils from the Ordovician bioherm at Meiklejohn Peak, Nevada: U. S. Geol. Survey Prof. Paper 685, p. 1-47.

Sando, W. J., 1980, The paleoecology of Mississippian corals in the western coterminous United States: Acta Paleontologica Polonica, v. 25, nos. 3 & 4, p. 619-631.

Seisdata Services, 1981, Seismic data available in southern Nevada.

Stewart, J. H., 1970, Upper Precambrian and Lower Cambrian strata in the southern Great Basin, California and Nevada: U. S. Geol. Survey Prof. Paper 620, p. 1-206.

_____, 1980, Geology of Nevada - a discussion to accompany the geologic map of Nevada: Nevada Bureau of Mines and Geol. spec. Publ., no. 4, p. 1-136.

Stewart, J. H., and Carlson, J. E., 1978, Geologic map of Nevada: U. S. Geol. Survey in cooperation with Nevada Bur. of Mines and Geology.

U. S. Geological Survey, 1882-1923: Mineral resources of the United States.

Vanderburg, W. O., 1937, Reconnaissance of mining districts in Clark County, Nevada: U.S. Bur. Mines Inf. Circ. 6964.

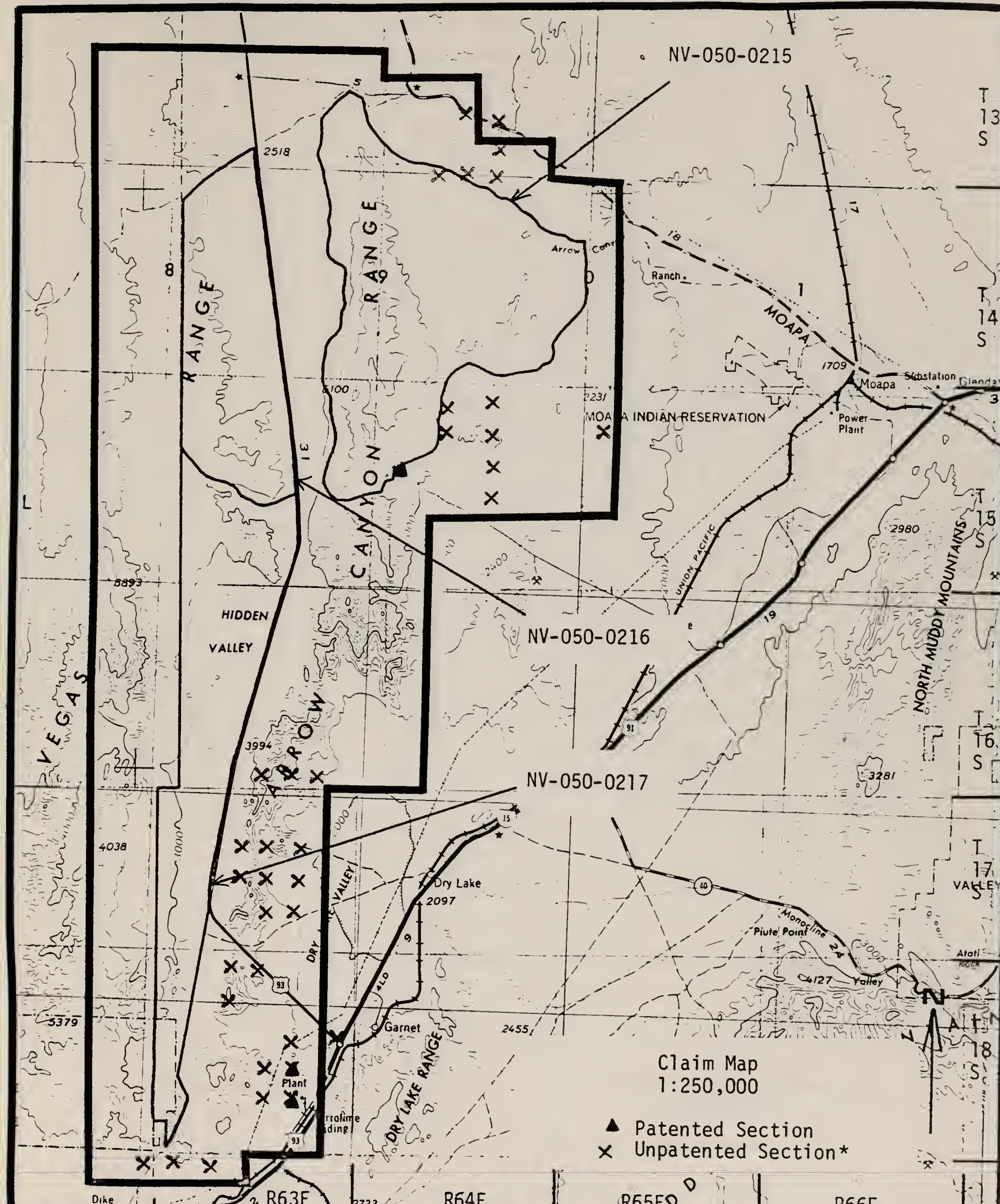
Webb, G. W., 1958, Middle Ordovician stratigraphy in eastern Nevada and western Utah: American Assoc. Petroleum Geologists Bull., v. 42, p. 503-522.

Webster, G. D., 1966, Biostratigraphy of the pre-Desmoines part of the Bird Spring Formation, northern Clark and southern Lincoln Counties, Nevada: Unpub. Ph.D. Dissertation, Univ. California, 268 p.

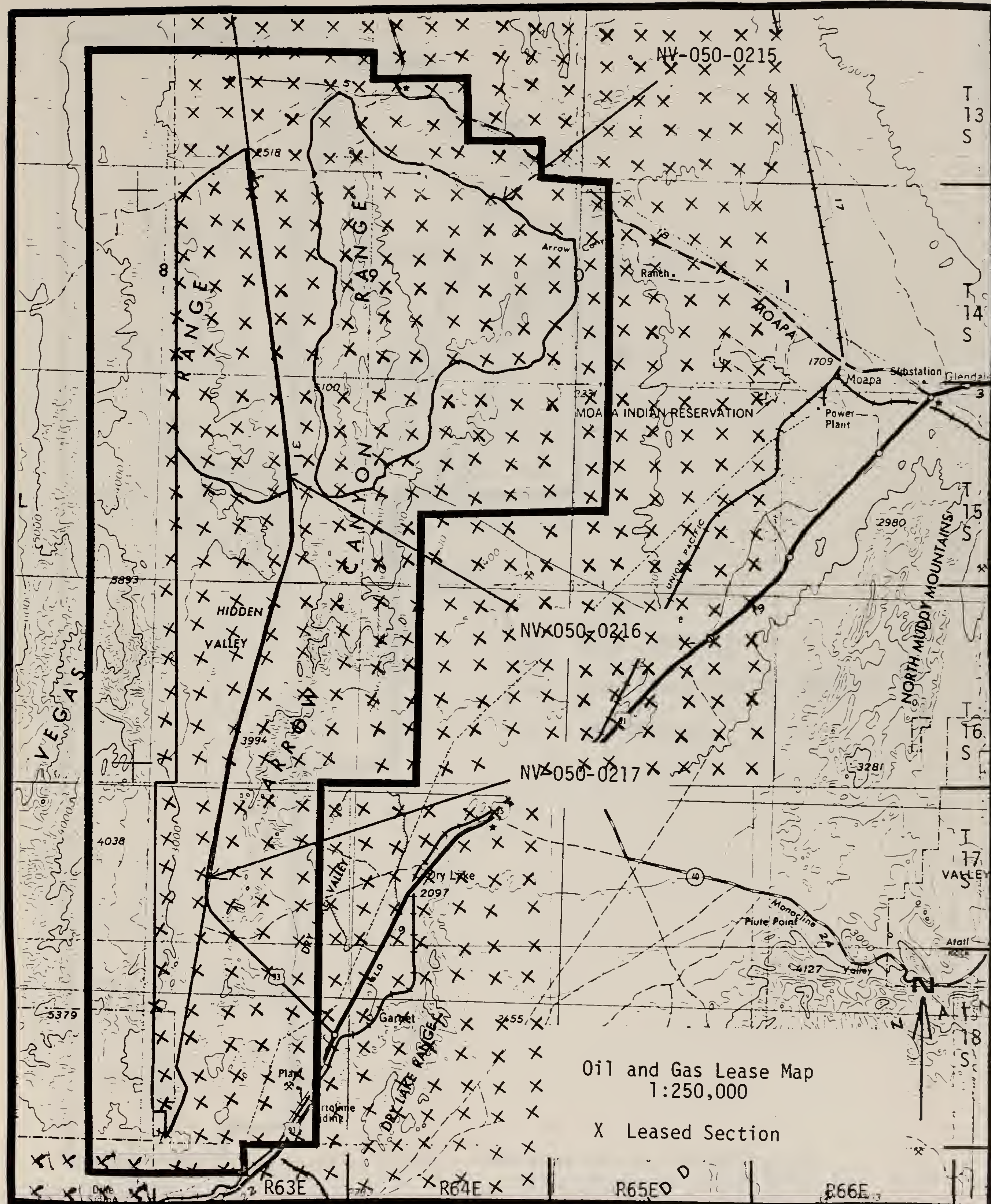
Webster, G. D., and Lane, N. G., 1967, Additional Permian crinoids from southern Nevada: Kansas Univ. Paleont. Contrib. Paper 27, p. 1-32.

Western Oil Reporter, June 1980, Frontier wildcats aim at Thrust Belt pay zones.

Wilber, H. T., 1971, Geology of a portion of the Las Vegas Range, clark County, Nevada: B. S. Thesis, Univ. Illinois.



*X denotes one or more claims per section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VEGAS
HIDDEN VALLEY
MOAPA INDIAN RESERVATION
Moapa
Power Plant
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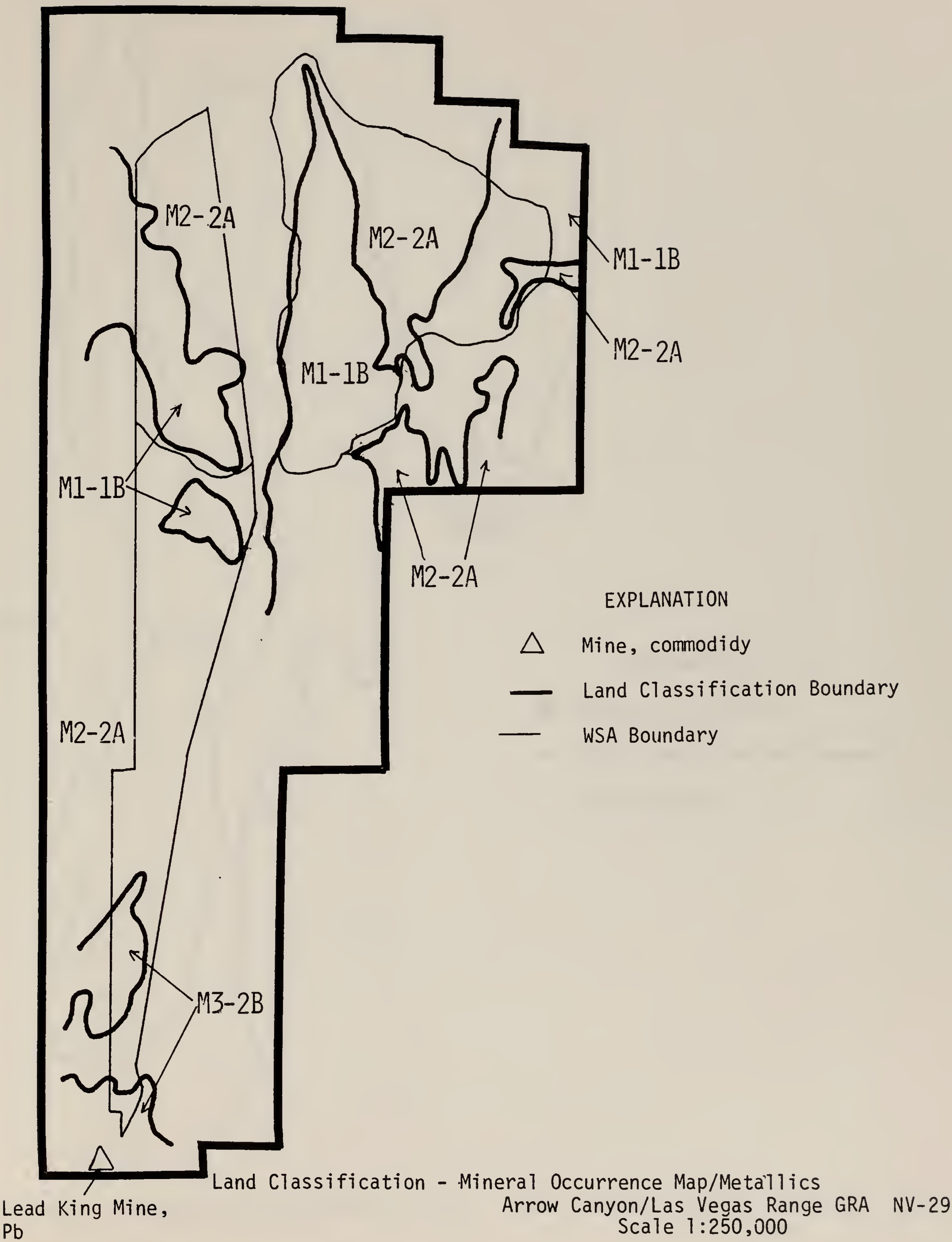
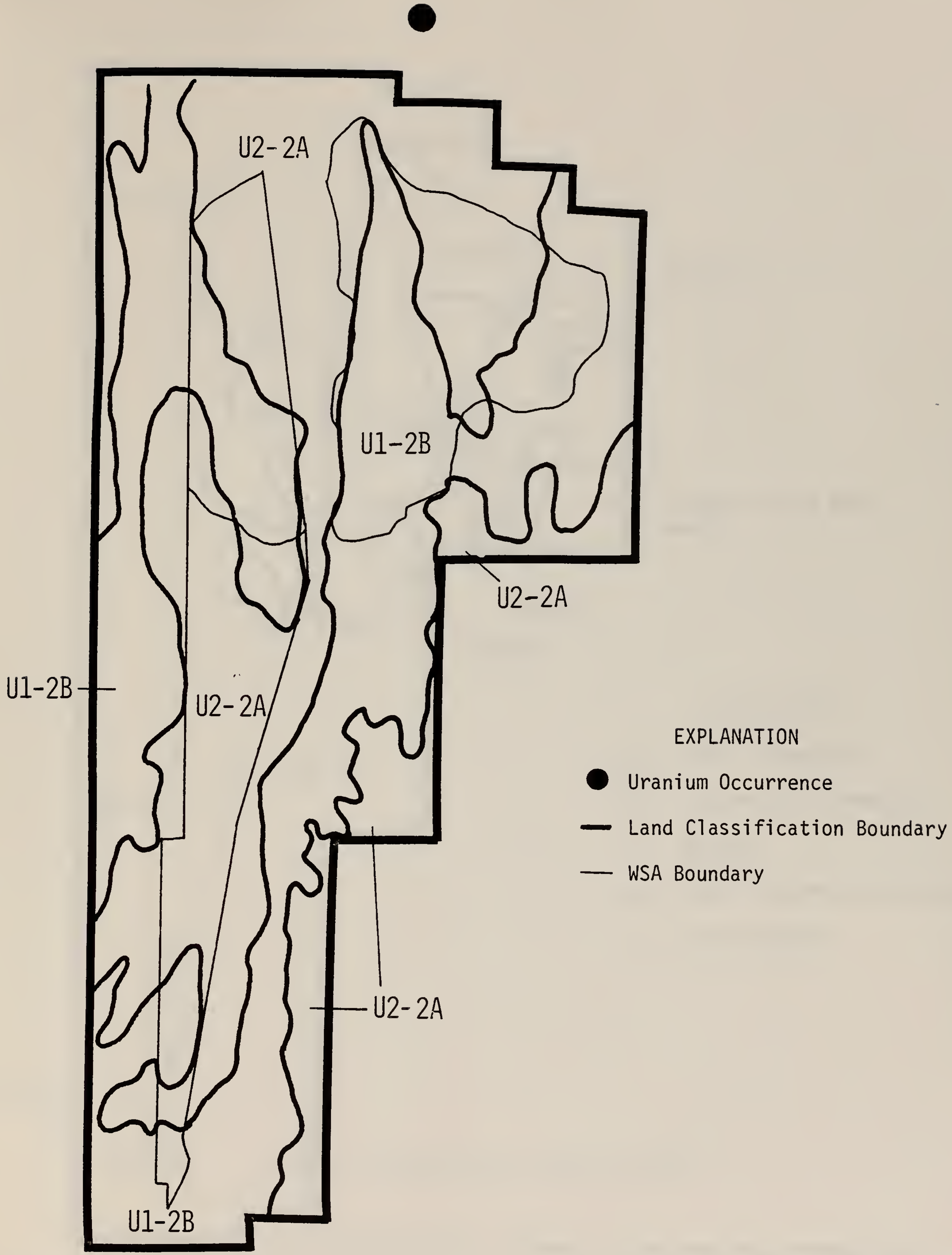


Land Classification - Mineral Occurrence Map/Metallics
Arrow Canyon/Las Vegas Range GRA NV-29
Scale 1:250,000



Classification - Mineral Occurrence Map/Uranium Arrow Canyon/Las Vegas Range GRA NV-29
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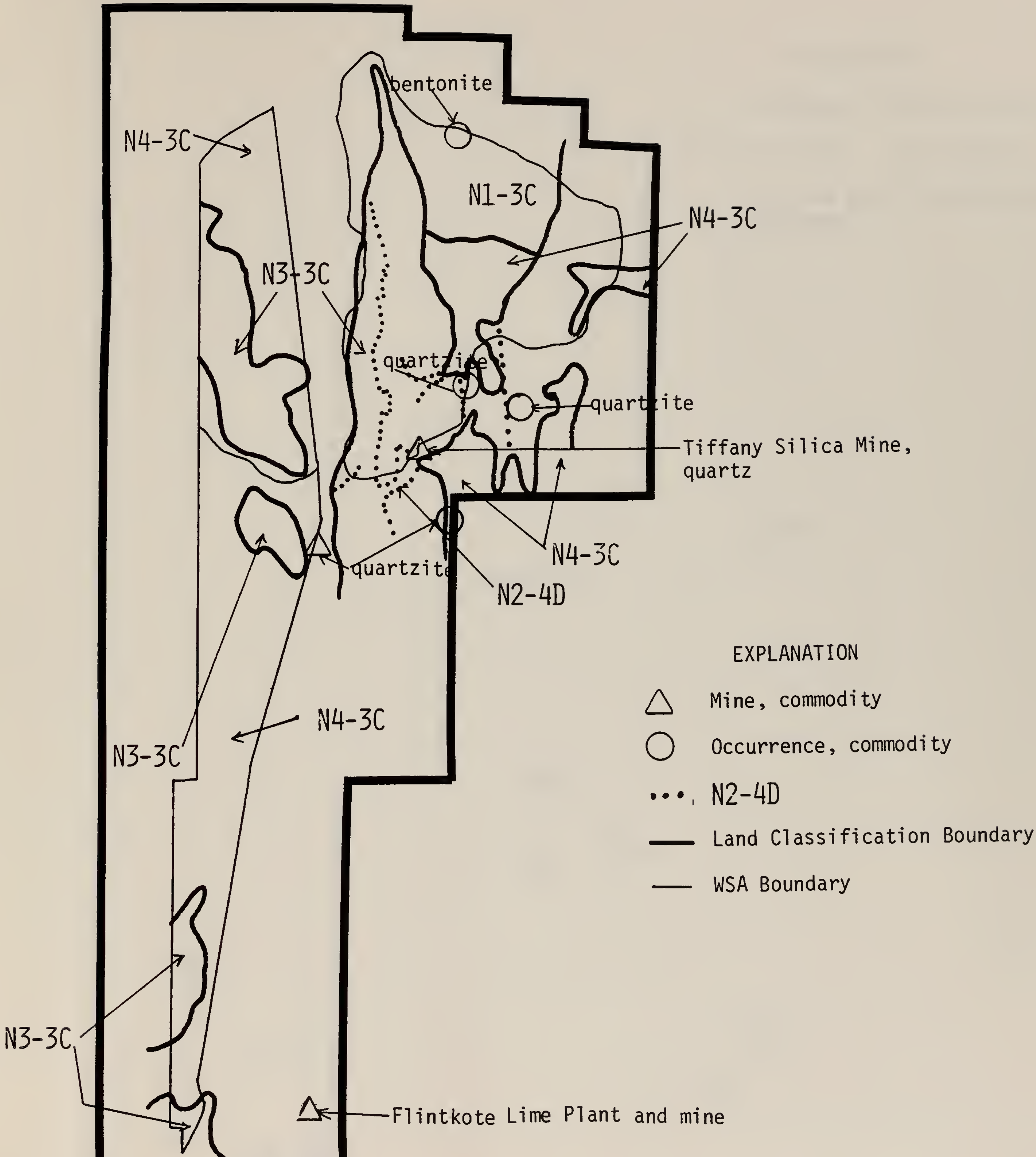

Land Classification - Mineral Occurrence Map/ Nonmetallics
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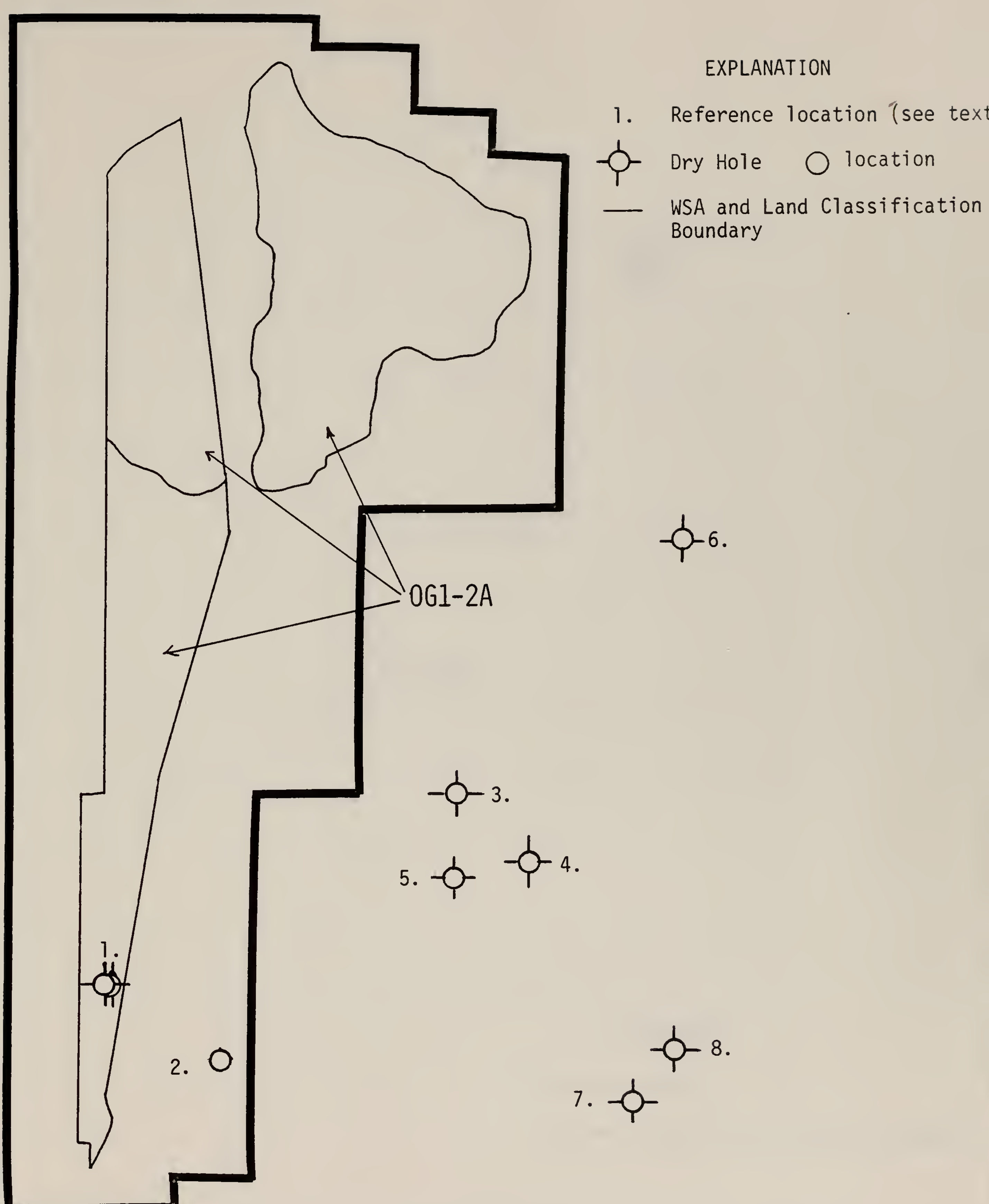
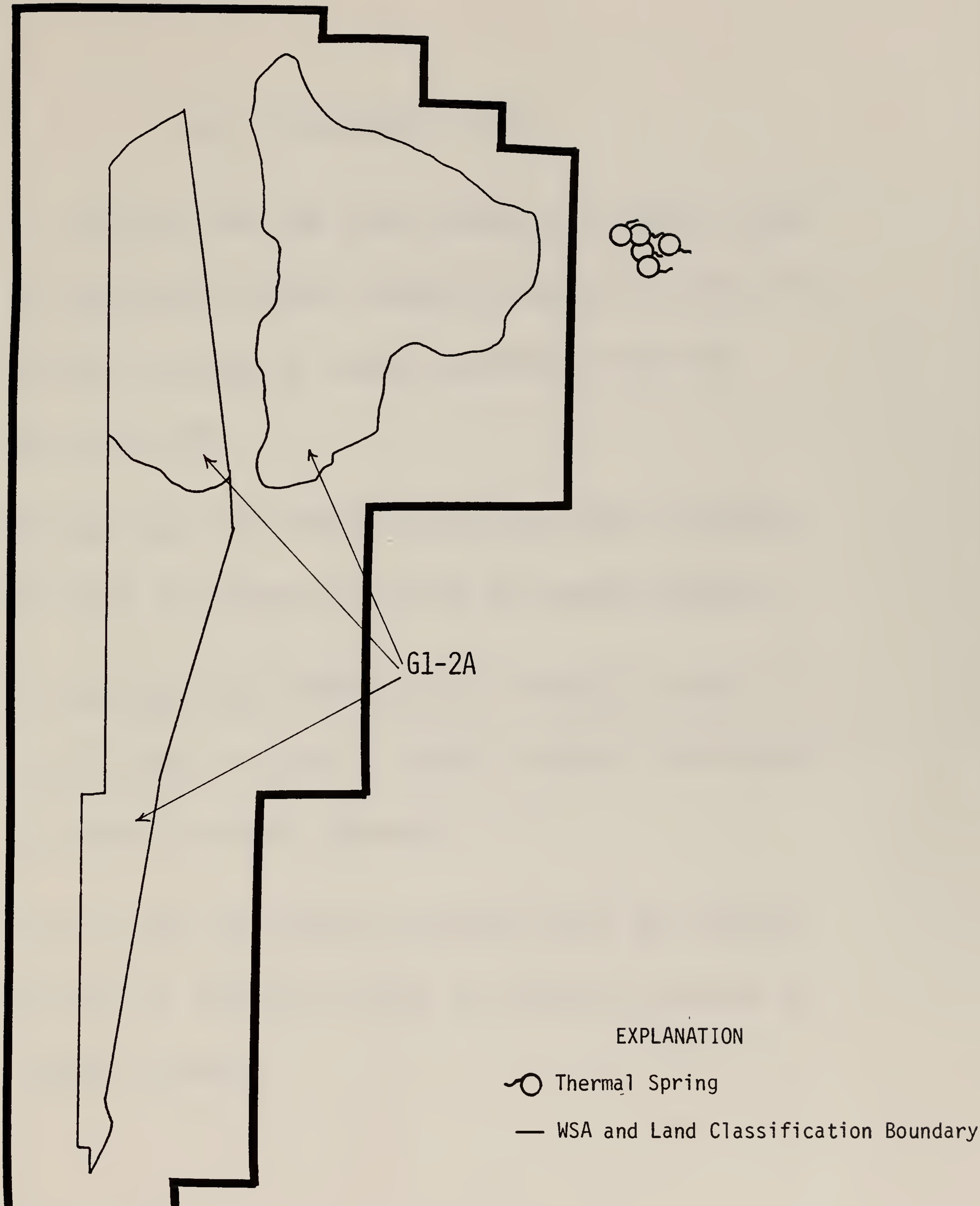


Land Classification - Mineral Occurrence Map/Oil & Gas
Arrow Canyon/Las Vegas Range GRA NV-29
Scale 1:250,000



lassification - Mineral Occurrence Map/Geothermal Arrow Canyon/Las Vegas Range GRA NV-29
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LEVEL OF CONFIDENCE SCHEME

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

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

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

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

CLASSIFICATION SCHEME

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

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

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

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

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

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

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

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

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

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

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

GEOLOGIC NAMES COMMITTEE, 1970