ROBERTS G-E-M

RESOURCES AREA

(GRA NO. NV-08)

TECHNICAL REPORT

(WSA NV 060-541)

Contract YA-553-RFP2-1054

Prepared By

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Final Report

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TABLE OF CONTENTS

Table of Contents cont.

Table of Contents cont.

Page

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

The Roberts Geology-Energy-Minerals (GEM) Resource Area (GRA) is about 30 miles northwest of Eureka, in central Eureka County, Nevada. There is one Wilderness Study Area (WSA), NV 060-541.

The rocks in the GRA are sedimentary formations 200 million to 600 million years old, in part covered by volcanic units less than 40 million years old. Within the WSA only the oldest sediments, from 350 million years old, are exposed with a small area covered by the volcanic units. The dominant geological structure is the essentially flat-lying Roberts Mountain thrust fault, on which rock units slid many miles about 300 million years ago. Here the upper plate sedimentary unit of about 500 million years old slid from a position at least 50 miles to the west into the present site of the Roberts Creek Mountains where it overlies the 350 million to 600 million years old sedimentary rocks. Because of the long distance of movement, the rocks along the fault are intensely broken and crushed, which makes them highly permeable and therefore favorable sites for mineralization. Most of the rocks below the thrust fault in the WSA area are of a type generally favorable for mineralization, and one unit, the Roberts Mountain Formation, is highly favorable for large low-grade gold deposits of the Carlin type. The sedimentary unit above the thrust fault has some favorability for metal mineralization and is highly favorable for barite mineralization. In and near the WSA millions of years of erosion have eroded a number of "windows" through the thrust fault to expose the rocks below it and also to leave only a relatively thin cover of the rocks above the fault in most places. There are a great many places where the rocks are altered ro contain minor mineral occurrences or have geochemical anomalies, all of which may be indicative of the presence of gold deposits. As a result, the WSA and the area around it is one of the most active areas in Nevada for mineral exploration.

The principal mining district in the GRA is the Mount Hope district in the southeast corner of the GRA, which has produced more than one million dollars in zinc and cadmium, both of which are strategic and critical metals. In the same district the discovery of a major molybdenum deposit has been announced recently. West of and extending into the WSA is the Antelope district which has produced some lead and zinc from widely scattered small deposits. A large, low-grade Carlin-type gold deposit was recently discovered about four miles west of the WSA. Barite has been produced from mines not far northeast and southwest of the WSA.

The only patented claims are in the Mount Hope district, several miles from the WSA. There are a great many unpatented claims, most of them in the Mount Hope district, but also substantial numbers in and along the east and south sides of the WSA; and perhaps fifty or more claims are within the WSA. There are oil and gas leases covering the northern half of the WSA. There are no

geothermal leases or sodium and potassium leases in the GRA and there are no material sites in the WSA.

The southern one-third of WSA NV 060-541 is classified as highly favorable for gold resources with a low level of confidence, and the remainder is classified as moderately favorable with a low level of confidence. The entire WSA is classified as having low favorability for uranium resources with a low level of confidence; thorium is not expected to occur in it. Most of the WSA is classified as moderately favorable for limestone and dolomite resources with a moderate level of confidence; and small parts of the eastern and southern edges have low favorability for nonmetallic mineral resources, with a low level of confidence. The entire WSA is classified as having moderate favorability for barite resources, with a low level of confidence. There is very low favorability for oil and gas, but there is low favorability for geothermal resources. The WSA has no known favorability for sodium and potassium resources or for any other geological resources.

If good color aerial photography is available, study of this for color variations that might suggest alteration is recommended, to be followed up by field work if possible alteration is recognized. Examination of one prospect is recommended, if it has not already been done. A stream sediment sampling geochemical program is recommended for part of the WSA.

I. INTRODUCTION

The Roberts G-E-M Resources Area (GRA No. NV-08) contains approximately 260,000 acres (1,000 sq km) and includes the following Wilderness Study Area (WSA):

WSA Name	WSA Number
Roberts	NV 060-541

The GRA is located in Nevada in the Bureau of Land Management's (BLM) Shoshone/Eureka Resource Area, Battle Mountain district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 39°50' north latitude, 116°50' west longitude and includes the following townships:

T 24 N, R 50-52 E	T 22 N, R 49-52 E
T 23 N, R 49-52 E	T 21 1/2 N, R 52 E

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

15 minute:

Roberts Creek Mountain

The nearest town is Eureka which is located about 30 miles southeast of the WSA. Access to the area is via State Route 51 to the east and State Route 21 to the west. Access within the area is via unimproved light duty and dirt roads scattered throughout 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.

The WSA in this GRA was not field checked.

One original copy of background data specifically applicable to this GEM Resource Area Report has been provided to the BLM as the GRA File. In the GRA File are items such as letters from or notes ontelephone conversations with claim owners in the GRA or the WSA, plots of areas of Land Classification for Mineral Resources on maps at larger scale than those that accompany this report if such were made, original compilations of mining claim distribution, any copies of journal articles or other documents that were acquired during the research, and other notes as are deemed applicable by the authors.

As a part of the contract that resulted in this report, a background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included 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.

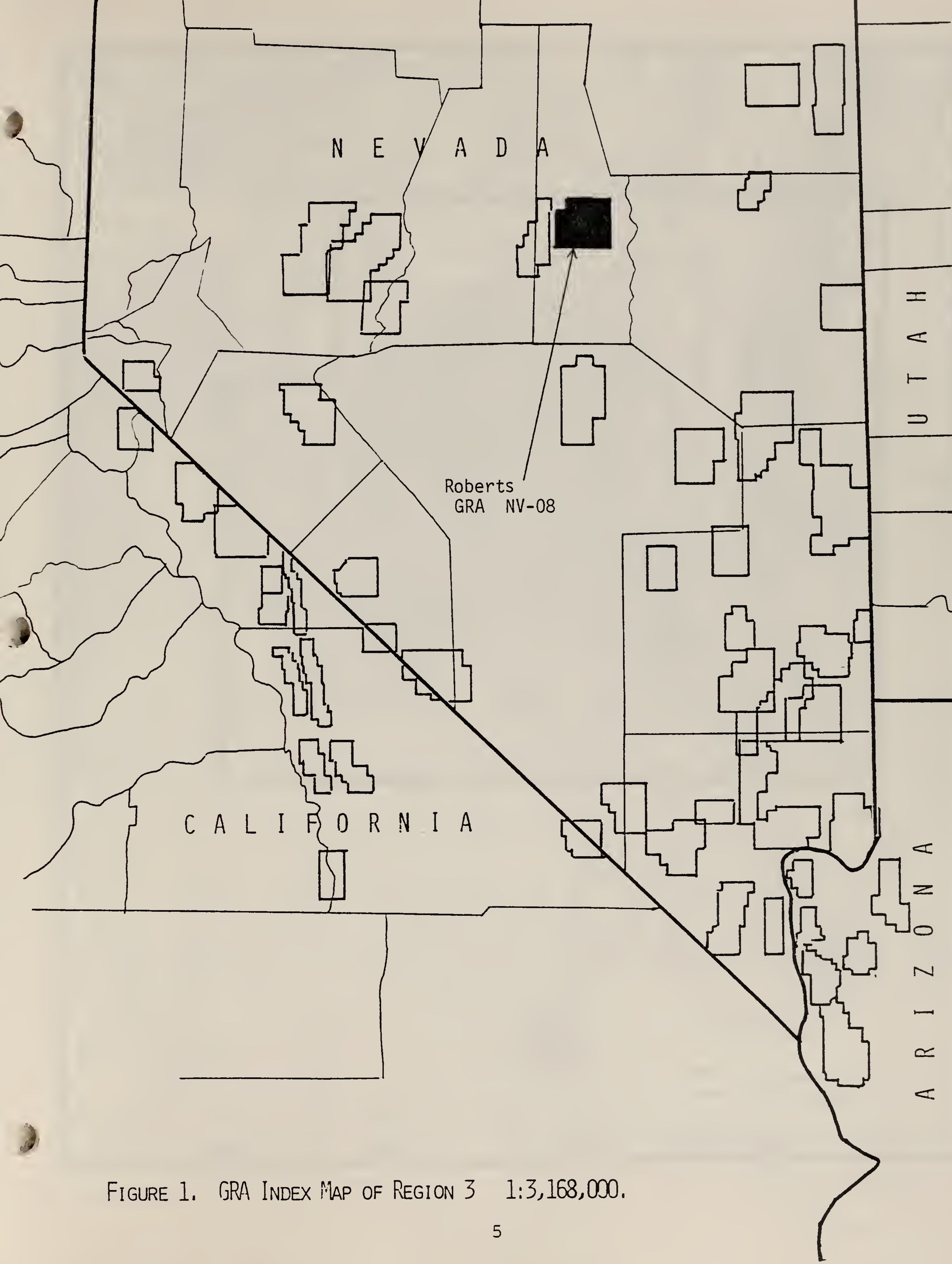
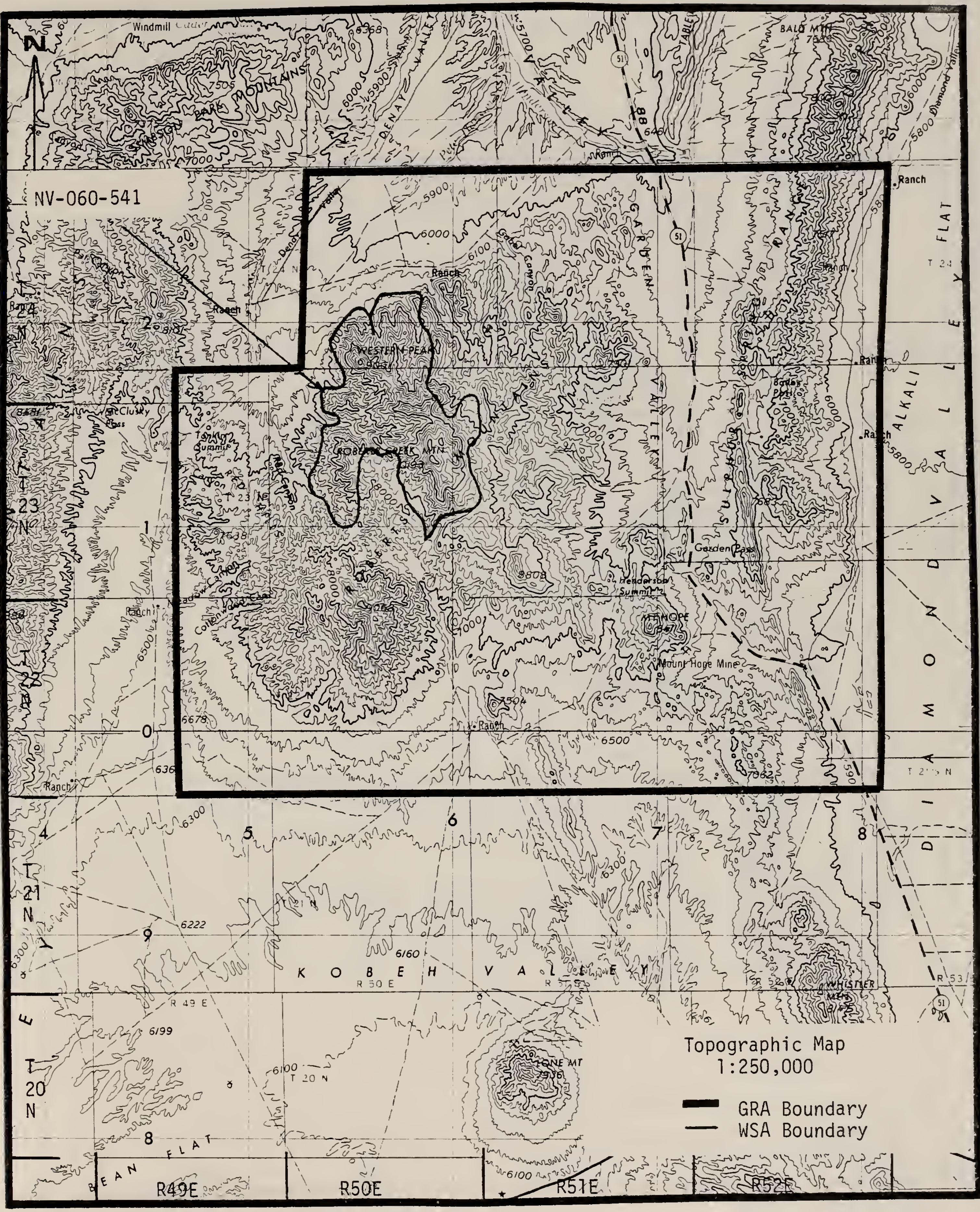


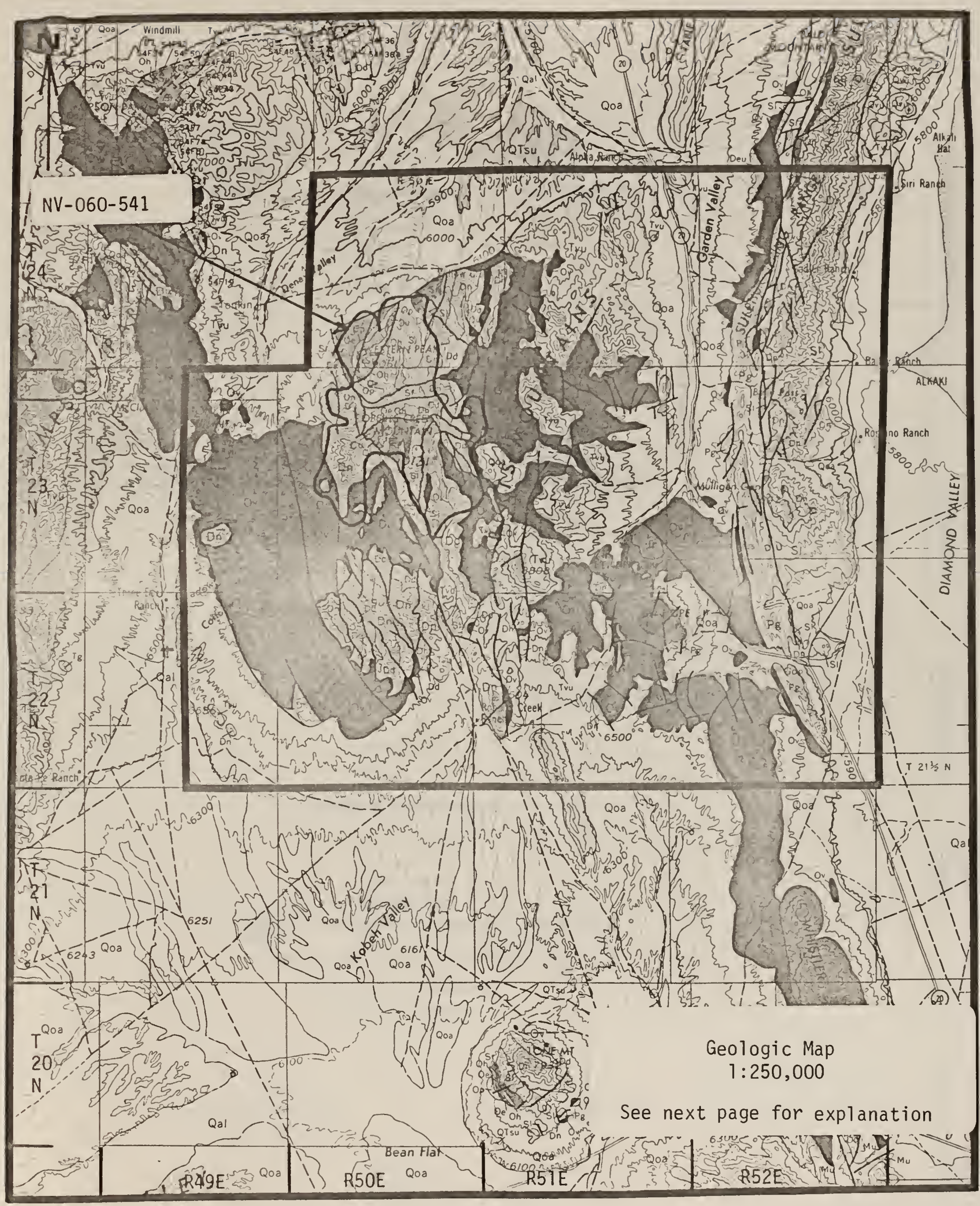
FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Millett Sheet

Roberts GRA NV-08

Figure 2



Roberts, Montgomery, and Lehner (1967)

Roberts GRA NV-08

Figure 3

EXPLANATION

Qal — Alluvium

Qp — Playa deposits

Qs — Sinter deposits

Qoa — Older alluvium

Qvu — Volcanic rocks, undivided

QUATERNARY

QTsu — Sedimentary deposits, undivided

QTvu — Volcanic rocks, undivided

Tg — Gravels

Tvu — Volcanic rocks, undivided

TERTIARY

ir — Intrusive rocks
Includes Jurassic, Cretaceous, and Tertiary rocks

Kn — Newark Canyon Formation

CRETACEOUS

KJv — Volcanic rocks
Includes porphyritic rocks of Permian(?) age in Dry Hills.

JURASSIC(?) AND CRETACEOUS(?)

MAJOR ANGULAR UNCONFORMITY

OVERLAP ASSEMBLAGE
(CLASTIC ROCKS)

Pg — Garden Valley Formation
Queried where doubtful

Pc — Carbon Ridge Formation

PERMIAN

PPb — Brock Canyon Formation

PENNSYLVANIAN OR PERMIAN

Pe — Ely Limestone

PENNSYLVANIAN

Mc

Diamond Peak Formation

Mc

Chainman Shale

Mu

Sedimentary rocks, undivided

In the Eureka area includes Chainman and Diamond Peak Formations and may include at the base the Mississippian Joana Limestone. In the northern part of the county, includes unnamed conglomerate and the Mississippian and Pennsylvanian Tonka Formation of Dott (1955). Queried where doubtful.

MISSISSIPPIAN

ANTLER OROGENY

PRE-OROGENIC ROCKS

WESTERN ASSEMBLAGE (SILICEOUS AND VOLCANIC ROCKS)

Dwu

Sedimentary rocks, undivided

DSwu

Sedimentary rocks, undivided

May include beds partly equivalent to the Vinini Formation in Tuscarora Mountains, Pine Valley, and Fish Creek Range.

Swu

Sedimentary rocks, undivided

Mapped only in the southern Cortez Mountains (Fourmile Canyon Formation).

SOwu

Sedimentary rocks, undivided

In part equivalent to Valmy and Vinini Formations. Mapped only in Simpson Park and Tuscarora Mountains.

Ova

Valmy Formation

Ov

Vinini Formation

EASTERN ASSEMBLAGE (CARBONATE ROCKS)

Dd

Devils Gate Limestone

May include the Devonian and Mississippian Pilot Shale at the top

Dn

Nevada Formation

In Monitor Range includes Rabbit Hill Limestone.

Deu

Sedimentary rocks, undivided

Includes the Wenban Limestone and Pilot Shale in the Cortez area.

DEVONIAN

Sl

Lone Mountain Dolomite

Sr

Roberts Mountains Formation

SILURIAN

SOeu

Sedimentary rocks, undivided

Mapped only in the Mahogany Hills. Includes Hanson Creek and Roberts Mountains Formations, and Lone Mountain Dolomite.

Middle (?) and Upper Ordovician

Oh

Hanson Creek Formation

Middle Ordovician

Oe

Eureka Quartzite

Ou

Sedimentary rocks, undivided

Mapped only in the Eureka district. Includes the Pogonip Group, Eureka Quartzite, and Hanson Creek Formation.

Lower and Middle Ordovician

Op

Pogonip Group

Includes Goodwin Limestone, Ninemile Formation, and Antelope Valley Limestone.

ORDOVICIAN

Middle and Upper Cambrian

Ch

Hamburg Dolomite

Cu

Sedimentary rocks, undivided

DSwu

Sedimentary rocks, undivided
May include beds partly equivalent to the Vinini Formation in Tuscarora Mountains, Pine Valley, and Fish Creek Range.

Swu

Sedimentary rocks, undivided
Mapped only in the southern Cortez Mountains (Fourmile Canyon Formation).

SOwu

Sedimentary rocks, undivided
In part equivalent to Valmy and Vinini Formations. Mapped only in Simpson Park and Tuscarora Mountains.

Ova — Valmy Formation

Ov — Vinini Formation

Nevada Formation
In Monitor Range includes Rabbit Hill Limestone.

SILURIAN

Sl — Lone Mountain Dolomite

Sr — Roberts Mountains Formation

ORDOVICIAN

SOeu — Sedimentary rocks, undivided
Mapped only in the Mahogany Hills. Includes Hanson Creek and Roberts Mountains Formations, and Lone Mountain Dolomite.

Middle(?) and Upper Ordovician

Oh — Hanson Creek Formation

Middle Ordovician

Oe — Eureka Quartzite

Ou — Sedimentary rocks, undivided
Mapped only in the Eureka district. Includes the Pogonip Group, Eureka Quartzite, and Hanson Creek Formation.

Lower and Middle Ordovician

Op — Pogonip Group
Includes Goodwin Limestone, Ninemile Formation, and Antelope Valley Limestone.

CAMBRIAN

Middle and Upper Cambrian

Ꞓh — Hamburg Dolomite

Ꞓu — Sedimentary rocks, undivided
Includes in descending order: Windfall Formation, Dunderberg Shale, Hamburg Dolomite, Secret Canyon Shale, Geddes Limestone, Eldorado Dolomite, Pioche Shale, and Prospect Mountain Quartzite

Contact
Dashed where approximately located or where gradational

D
U
Fault
Dashed where approximately located; dotted where concealed. U, upthrown side, D, downthrown side; queried where doubtful

Thrust fault
Dashed where approximately located; sawteeth on upper plate

x 54F42
Fossil locality
Descriptions of fossils are given in text under Fossil Data. Fossils are listed within their appropriate assemblages and time periods in order of decreasing age.

II. GEOLOGY

The Roberts GRA lies in the Basin and Range geomorphic province in central Eureka County, Nevada. The study area includes most of the Roberts Mountains and a portion of the north-south-trending Sulphur Spring Range.

The Roberts Mountains are an eastward-tilted block composed of western assemblage rocks with a belt of windows of eastern assemblage rocks through the central part, overlapped on the east by volcanic rocks.

The narrow Sulphur Spring Range which adjoins the Roberts Mountains in the southwest, is composed mainly of eastern assemblage rocks which at one time were probably covered by the Roberts Mountains thrust plate.

The Mississippian Roberts Mountain thrust is the major structural feature in the GRA. Numerous late Tertiary Basin and Range normal faults transect both the eastern and western assemblage of rocks and bound the eastern range front of the Sulphur Creek Range and the western and northern margins of the Roberts Mountains.

1. PHYSIOGRAPHY

The Roberts GRA lies in the Basin and Range geomorphic province in central Eureka County, Nevada. The study area includes the somewhat triangular in outline Roberts Mountains and the northerly-trending southern portion of the Sulphur Spring Range to the east. The southeastern portion of the Roberts Mountains merges directly into the Sulphur Spring Mountains, interrupted by Mount Hope, an oval-shaped mountain with a summit elevation of 8,167 feet. WSA NV 060-541 covers Western Peak and Roberts Creek Mountain to the south in the Roberts Mountains.

Roberts Creek Mountain is the highest topographic point with an elevation of 10,125 feet. The alluviated margins of the Roberts and Sulphur Spring Mountains range in elevation from 6,000 to 6,500 feet so that a maximum relief of 4,000 feet is represented by Roberts Mountains.

Intermittent streams drain the area in a roughly radial pattern. Roberts Creek, a permanent relatively large stream for this region, flows southward from Roberts Creek Mountain.

2. ROCK UNITS

Two very different groups of rocks are represented in the Paleozoic section in the Roberts GRA. Lower Paleozoic rocks were deposited in a geosyncline, with miogeosynclinal limestones and shales deposited toward the east side -- the

"eastern facies" rocks -- and eugeosynclinal siliceous and volcanic rocks deposited toward the west side -- the "western facies" rocks. Movement of as much as 90 miles on the Roberts Mountain thrust fault during the Antler Orogeny in Late Devonian and Early Mississippian resulted in western facies rocks being thrust over eastern facies rocks. Subsequent erosion stripped off much of the western facies rocks in the Roberts Mountains, leaving numerous and extensive "windows" of eastern facies rocks exposed. The eastern facies rocks consist of a thick series of numerous formations. The western facies rocks here consist of only the Ordovician Vinini Formation.

The oldest rock unit in the Roberts GRA is an undivided sequence of Cambrian sediments which includes from youngest to oldest, the Windfall Formation, Dunderberg Shale, Hamburg Dolomite, Secret Canyon Shale, Geddes Limestone, Eldorado Dolomite, Pioche Shale and Prospect Mountain Quartzite (Roberts and others, 1967).

The next youngest formation is the Lower and Middle Ordovician Pogonip Group which in the Roberts Mountains area consists of thinly bedded dark-gray limestone and dolomites. The Eureka Quartzite was deposited next, and is about 500 feet thick on the northwest side of Roberts Creek Mountain. The upper 300 feet are mostly white vitreous quartzite and the lower 200 feet are predominantly dark- and light-gray quartzite. The Hanson Creek Formation, which lies with probable disconformity upon the Eureka quartzite, consists of thin calcareous sandstones, dark-gray dolomitic limestones, and gray fine-grained limestone (Merriam and Anderson, 1942).

The next formation deposited was the Lower Silurian Roberts Mountains Formation, the type section of which lies on the west side of Roberts Creek Mountain where it is 1,900 feet thick. The Roberts Mountain Formation is perhaps the most favorable formations in northern Nevada for major gold deposits of the Carlin type. At the type section the formation consists mostly of dark slate-gray limestones and grades into the overlying Lone Mountain Dolomite which is light gray and generally has massive bedding.

The next youngest rock unit, the Nevada Formation, is well exposed in the Sulphur Spring Mountains. The formation is calcareous and predominantly limestone, but in the upper 600 feet numerous dolomitic members occur.

In redefining and subdividing the "Nevada Limestone" of Hague (1892), the Devonian beds of central Nevada that lie above the Stringocephalus zone were designated by Merriam (1940) as the Devils Gate Formation. The lower Devils Gate consists of dolomites and dolomitic limestones and the uppermost 800 feet of the formation is predominantly fossiliferous limestone.

The Garden Valley Formation, deposited during the Permian, is the next youngest rock unit and consists of four members: a basal limestone unit 450-500 feet thick; 800-1,000 feet of conglomerate and sandy carbonaceous shale; 900-1,000 feet of quartzite and chert cobbles cemented by silica; and the 550 feet thick upper member of purple end red shales and conglomerate (Roberts and others, 1967).

The Vinini Formation, which here is the only rock seen in the upper plate of the Roberts Mountains thrust, was deposited in the western siliceous facies during the Ordovician. The lower Vinini consists of dark-gray quartzites, arenaceous limestones and finely laminated sandy and silty sediments. Near the top of the lower Vinini lava flows and tuffs occur at several localities. A succession of bedded cherts and black organic shales constitutes the upper Vinini.

Post-thrusting Late Cretaceous-Early Tertiary rhyolite porphyry plugs were emplaced next in the Henderson Summit and Mount Hope area. The Mount Hope porphyry plug has been mineralized with sphalerite and galena. Abandoned workings are located on the southeastern margin of the plug (Merriam and Anderson, 1942).

An unnamed sequence of Tertiary volcanics are the next youngest rock unit. Merriam and Anderson (1942) recognized the following sequence in ascending order: 1) rhyolitic tuff and breccia up to 700 feet thick; 2) 200 feet of andesitic lava; and 3) thick flows of quartz latite.

Older alluvial fans along the flanks of the mountain ranges consist largely of poorly sorted debris which probably accumulated during Late Tertiary and Pleistocene time following major uplift (Roberts and others, 1967).

3. STRUCTURAL GEOLOGY AND TECTONICS

The most striking structural feature of the Roberts Mountains is the very extensive low-angle Roberts Mountain thrust fault that resulted in the discordant position of Vinini Ordovician strata over Paleozoic rocks of varying age. The base of the thrust plate is usually marked by a very pronounced breccia zone at least 30 to 40 feet thick. The Roberts Mountain thrust, a product of the Antler orogeny, is dated as Late Devonian and Early Mississippian (Stewart, 1980). The geometry of folding indicates an east to southeast direction of tectonic movement in modern coordinates (Evans and Theodore, 1978). The Roberts Mountain thrust fault is regionally a highly favorable structure for the localization of large Carlin-type gold deposits.

The earliest distrubance recognized in the Paleozoic rocks of the Roberts Mountains is marked by an unconformity at the base of the Eureka Quartzite which was caused by uplift in Early

Ordovician time (Merriam and Anderson, 1942).

The Sonoma orogeny in northwestern Nevada in Late Permian time (Silberling and Roberts, 1962) probably contributed clastic rocks to the upper part of the Garden Valley Formation.

Pliocene-Pleistocene Basin and Range normal faulting in this area occurred after the andesite flows were deposited. Normal faults in the area generally trend in a northerly direction with east-west-trending faults being subordinate. Range front faults occur along the eastern margin of the Sulphur Spring Mountains, and the northern and western margins of the Roberts Mountains. An extensive normal fault separating the Silurian Lone Mountain Dolomite and the Permian Garden Valley Formation trends northerly for over 13 miles in the Sulphur Spring Range. It is suggested by Merriam and Anderson (1942) that the numerous internal faults in the Roberts Mountains formed at the same time as the boundary faults outlining the Roberts Mountains and Sulphur Spring Mountains.

4. PALEONTOLOGY

The Roberts Mountains are mostly Paleozoic marine sediments in complex structural relationships, distinguished by their paleobiological content. Several formations contain characteristic marine shelf facies fossils, dominated by brachiopods, corals, mollusks and trilobites. Skeletal reef forming corals within the Roberts Mountain Formation and equivalent units are common throughout the carbonate facies, as are abundant rugose corals (Merriam and McKee, 1976). Except where recrystallized, the limestones and sandy limestones within the GRA are discontinuously fossiliferous. Major formational units containing paleontological resources are the Roberts Mountain, Lone Mountain and Nevada Formations.

5. HISTORICAL GEOLOGY

Eastern facies sediments were deposited in the area throughout the Early Paleozoic. An unconformity at the base of the Ordovician Eureka Quartzite was caused by local uplift. A second orogenic episode, the Antler orogeny, disrupted the previous sedimentary cycle and culminated in the Early Mississippian Roberts Mountains thrust which brought siliceous and volcanic rocks of the western assemblage over the eastern carbonate assemblage. The Antler orogenic belt emerged during deformation and uplift and large quantities of clastic debris was deposited eastward in the adjacent sea.

Orogenic pulses continued intermittently into Permian time. The Sonoma orogeny in northwestern Nevada in Late Permian time probably contributed clastics to the Garden Valley Formation.

Intrusive activity began sometime during the Late Cretaceous-Early Tertiary, followed by volcanism during the mid-Tertiary. Metallic mineralization in the area resulted from this period of magmatism. Basin and Range faulting was predominantly during the Pliocene-Pleistocene and is responsible for most of the present-day topography.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

The principal mining district is the Mount Hope district in the southeastern part of the GRA, which produced more than one million dollars worth of zinc and lead during the 1940s (Roberts and others, 1967). The zinc mineral was exceptionally high in cadmium, a strategic and critical metal commonly associated with zinc, and the mine operators received bonuses from the U. S. Government for this production according to the former manager of the mine (Arthur Baker III, personal communication). During 1982 Exxon Corporation announced the discovery of a major molybdenum deposit in the district.

The Antelope district covers part of the western side of the GRA and extends farther west. This is an areally large district with widely scattered prospects and very little production. Most of the prospects are on lead and zinc occurrences in limestone but antimony also has been prospected. Localities #1 and #2, as well as #3 which is within the WSA (numbers are on the Metallic Minerals Occurrence and Land Classification Map) are considered to be in the Antelope district.

At the west edge of the GRA, in the Antelope district, the Tonkin Spring gold discovery (#4) was announced in 1982. On the basis of early drilling this Carlin-type deposit is thought to have about 1.7 million tons of ore at about 0.1 ounce gold per ton. According to Murphy and others (1978) the rocks in this vicinity are mostly Vinini Formation in the upper plate of the Thrust fault, but there are numerous small windows through the Roberts Mountain thrust in which Eastern Assemblage rocks are exposed. The deposit is probably in or close to the thrust fault.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Within the WSA, Roberts and others (1967) show the July claims (#3) as a zinc prospect, about two miles east of Western Peak in the Antelope district. Other zinc and antimony prospects of the district lie to the west of the WSA.

All Minerals Corporation has claims in and near the southwest corner of the WSA, and reports drilling just outside of the WSA apparently in Sec. 28, T 23 N, R 50 E (unsurveyed)(#5). This portion of the WSA has narrow barite veins and iron-stained breccia zones demonstrating mineralization at numerous places in rocks both above and

below the Roberts Mountain thrust fault (See notes on conversation with Fred Hilton in GRA file).

Newmont Mining Corporation has claims in and near the southeast corner of the WSA, and reports drilling just outside the WSA in Secs. 26, 27 and 35, T 22 N, R 50 E (unsurveyed)(#6). The claims have anomalous geochemical values as well as occurrences of jasperoid and barite that are indicative of Carlin-type gold mineralization (See correspondence from Odin Christensen in GRA file).

Newmont Mining Corporation also has claims in and near the eastern border of the WSA and reports drilling just outside the WSA on these in Sec. 1, T 23 1/2 N, R 50 E (unsurveyed) and Sec. 1, T 23 N, R 50 E (unsurveyed) (#7). Again, anomalous geochemical values and occurrences of jasperoid and barite indicative of gold potential are mentioned (See correspondence from Odin Christensen in GRA file).

From numerous comments it appears that there are a number of other active prospects in the GRA. It is difficult to distinguish here between prospects seeking Carlin-type gold deposits and prospects seeking barite, because barite can be an indicator of gold mineralization. Probably at least some presumably-barite prospects are also considered gold prospects by their owners.

3. Mining Claims

There are a great many unpatented claims in the GRA, most of them in the southeastern part of the Mount Hope district. There are 50 to 100 claims within the WSA: those of All Minerals Corporation in the southwest corner, those of Newmont in the southeast corner and along the eastern edge, and a few of unknown ownership in the middle of the north end of the WSA.

4. Mineral Deposit Types

The July claims in the middle of the north end of the WSA are described as a zinc prospect (Roberts and others, 1967); but nothing else is known of them. Other old prospects are also on base metal occurrences. Most mineralization and alteration occurrences are clearly being prospected as indications of potential Carlin-type gold deposits -- large, low-grade disseminated ore bodies in calcareous rocks in structurally disturbed areas, particularly the Roberts Mountain thrust but perhaps also near other structures.

5. Mineral Economics

Carlin-type gold deposits are avidly sought after by mining companies because they are amenable to low-cost open pit mining and relatively low-cost cyanide extraction of the gold from the ore. Large deposits of remarkably low grade -- as low as 0.03 ounce of gold per ton of rock -- can be mined profitably.

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

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

Two barite mines, each of which has produced some thousands of tons, are known in the GRA. One, the Visoni mine (#1), is a couple of miles northeast of the WSA in Sec. 35, T 24 N, R 50 E, and the other, the Lander Barite Co. mine (#2), is in Sec. 25, T 23 N, R 49 E (Keith Papke, personal communication, Jan. 1, 1983).

2. Known Prospects, Mineral Occurrences and Mineralized Areas

The literature makes no mention of occurrences of nonmetallic minerals in the WSA or its vicinity. However, both Hilton and Christensen (see GRA file) mention numerous occurrences of barite in the WSA and nearby.

3. Mining Claims, Leases and Material Sites

No mining claims can be identified surely as having been located for nonmetallic minerals because of the possibility that barite occurrences are indicators of gold mineralization already mentioned. There are no mineral leases in the GRA and no material sites are known in the WSA.

4. Mineral Deposit Types

The barite occurrences are described as small stringers and, apparently, replacements (Christensen, see GRA file) in the rocks both below and above the Roberts Mountain thrust fault. The mined deposits probably are replacement bodies in the Vinini Formation above the thrust fault.

The limestone and dolomite rocks are sedimentary beds with very extensive outcrop areas. The tonnage of such materials available is enormous.

5. Mineral Economics

More than 90 percent of all barite mined is used to make mud for oil and gas well drilling, where the high specific gravity, softness and chemical inertness of the mineral are essential characteristics. Other uses of abrite are in barium chemicals that have a wide variety of applications. In recent years the United States has used nearly three million tons of barite annually; usage fluctuates with oil and gas drilling activity. Domestic sources produced about two-thirds of the barite used, with Nevada being by far the largest producer. Most imported barite is used in the states near the Gulf of Mexico, where shipping costs by sea from foreign sources are lower than rail transportation costs from Nevada. Barite consumption in the United States is forecast to be about the same in the year 2000 as it presently is, although this will depend largely on oil and gas drilling activity and the forecast may be greatly in error. Domestic production is expected to continue to satisfy about two-thirds of the demand. The price for crude barite is about $25 per ton, while crushed and ground barite ready for use as drilling mud is about $50 per ton.

The barite occurrences known in the WSA are evidently too small to be potentially mineable in themselves. However, the known mines nearby and the presence of barite in the WSA, apparently in widespread occurrences, is sufficient evidence to encourage intensive prospecting for larger, mineable deposits. Undoubtedly this will take place.

The central part of the Roberts Creek Mountains, including nearly all of WSA NV 060-541, is made up of Paleozoic limestones and dolomites. These have potential for production of lime and other limestone and dolomite products. However, the Roberts Mountains are well removed from any industrial area and are a considerable distance from the nearest railroad or other low-cost transportation system. These factors make it unlikely that the limestone and dolomite here will be used in the near future.

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. of both lime and cement was about $40 per ton.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

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

2. Known Prospects, Mineral Occurrences and Mineralized Areas

   There are no known uranium or thorium occurrences in the WSA or GRA.

3. Mining Claims

   There are numerous unpatented claims in the GRA, but it is unlikely that any of these are for uranium or thorium.

4. Mineral Deposit Types

Uranium and thorium deposit types cannot be discussed due to the lack of occurrences of these elements in the WSA and GRA.

5. Mineral Economics

Uranium and thorium appear to be of little economic value in the WSA or GRA due to the lack of 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 known to exist in the GRA, but nine miles south of the GRA Depco, Inc. drilled the Silver State Federal 33-18 (#1 on the Oil and Gas Occurrence and Land Classification Map) dry deep test to 9,120 feet in 1981.

There were no reported shows (Nevada Bureau of Mines and Geology, 1982; Nevada Bureau of Mines and Geology Oil and Gas Files, 1982).

3. Oil and Gas Leases

Most of the GRA and the northern half of the WSA are leased for oil and gas.

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.

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 present in the WSA, but in the eastern part of the GRA there are numerous strong hydrothermal manifestations in the Sulphur Spring Range (Garside and Schilling, 1979):

Locality	Site Name	Water Temperature (°F)
1	Unnamed Spring	87°
2	Unnamed Spring	103-106°
3	Siri Ranch Springs	87°
4	Shipley Hot Springs	106°
5	Sulphur Springs	74°

These springs are not structurally related to the WSA region in the Roberts Mountains. To the south in Kobeh Valley the closest thermal occurrences are Bartine Hot Springs (#6) (105°-108°F) and Bartine Ranch well (#7) (116°F at 485 feet in depth).

3. Geothermal Leases

There are no Federal geothermal leases in the GRA or surrounding region.

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

No other geological resources are known in the Roberts GRA. There is no reason to expect resources of coal, oil shale, or tar sands.

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.

Antimony, a strategic and critical metal, occurs in the Antelope district at the west edge of the GRA but none is known to occur in WSA NV 060-541.

Cadmium, a strategic and critical metal, was produced from the Mount Hope mine in the southeast corner of the GRA as a byproduct of zinc mining, but none is known to occur in the WSA although there is an identified zinc prospect in the WSA.

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

Roberts and others (1967) have been quoted extensively here in connection with the overall geology of the Roberts GRA because their text discusses relationships between rock types although their map is at 1:250,000 scale. However, Murphy and others (1978) provide definitive geological mapping of the Roberts Creek Mountain 15' quadrangle at 1:24,000', with rock descriptions but no other text. Between the two, geological coverage for the WSA is of high quantity and quality. Murphy and others (1978) also show areas of alteration -- silicification (almost all associated with the Roberts Mountain thrust fault) and dolomitization. They do not show other kinds of alteration if there are such, nor do they show mineralization such as metal occurrences and the barite that is reported to be widespread. Other sources -- private, Nevada Bureau of Mines and Geology, and BLM -- have provided substantial amounts of information as to mineral occurrences and alteration. Overall, the quantity of information concerning mineralization is fair and the quality high. We consider that there is a great deal of information in private hands that we have not had access to, which is the reason we rate the quantity we have as only fair. Overall, our confidence in the geological and mineralization data we have is 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 the WSA has been used in establishing a classification area within the 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 060-541

M1-4B. This classification area includes the southern one-third of the WSA. Its irregular boundary is arbitrarily drawn about half a mile from the generalized outcrop of the Roberts Mountain thrust fault on the side toward the lower plate of the thrust. The Paleozoic sediments just below the Roberts Mountain thrust fault are known to be a favorable site for Carlin-type gold deposits at many places in northern Nevada and the rocks above it can be hosts for similar deposits. The recently-discovered Tonkin Carlin-type gold deposit is in the western part of the classification area. Geochemistry and mineralization occurrences (barite, jasperoid, antimony, zinc, gold traces) suggest the possible presence of similar deposits; and at three places there are claims within and adjacent to the WSA and there has been drilling immediately outside the WSA. The Tonkin deposit, the regional favorability of the Roberts Mountain thrust, and the mineralization and geochemical occurrences along it, are the basis for the classification as highly favorable for gold resources while the presence of only the one known deposit is the reason for the low level of confidence in the classification.

M2-3B. This classification area covers the remainder of the WSA in which rocks of only the lower plate of the Roberts Mountain thrust fault are exposed. It is the central part of the Roberts Mountain "window" through the fault, and while the thrust fault was originally present, it has now been eroded away so that the rocks exposed are those that originally lay an unknown distance below the plane of the thrust fault. While the same rocks very close to the thrust fault are apparently the most common site for Carlin-type gold deposits, other structural settings can also host such deposits. There are numerous faults in the classification area (Murphy and others, 1978) that can provide the structural setting. It is unclear whether the barite and jasperoid occurrences described by Hilton and Christensen (see GRA file) are in this classification area, but the July zinc prospect is in it (Roberts and others, 1967). These are the reasons for the classification as moderately favorable with a low level of confidence.

b. Uranium and Thorium

WSA NV 060-541

U1-2B. This land classification covers all of the WSA and most of the central portion of the GRA. The area is covered by Lower Paleozoic sedimentary rocks, Tertiary volcanics and rhyolitic intrusives. The area has low favorability with low confidence for fracture-filled uranium deposits. Uranium leached from potential source rocks (rhyolitic volcanics and intrusives) by ground water, could be deposited in fractures in the volcanics or the underlying Paleozoic sediments. Uranium also may have been introduced into fractured Paleozoic rocks during emplacement of rhyolitic stocks in the vicinity of Mount Hope southeast of the WSA.

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

U2-2B. This land classification covers areas along the margins of the GRA which are covered by Quaternary alluvium. These areas have low favorability with a low confidence level for epigenetic sandstone-type uranium deposits. Rhyolitic volcanics and intrusives are possible uranium sources in the area. Ground water can leach uranium from these rocks and deposit it in reduced zones in the alluvium adjacent to the source area.

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

c. Nonmetallic Minerals

WSA NV 060-541

N1-3C. This classification area covers nearly all the WSA. In it Paleozoic rocks, mostly limestones and dolomites, are exposed. Limestone and dolomite are used in large quantities for the production of lime, cement, and a host of other chemical, construction and industrial materials, many of which call for rather stringently-defined chemical composition or physical characteristics of the rock. The rocks are unquestionably present in the WSA, but none have been mined and their detailed chemistry and physical nature are unknown. These are the reasons for the classification of moderate favorability and the moderate confidence level.

N2-2B. This classification area covers rather small parts of the eastern and southern edges of the WSA. The rocks in this area have no known nonmetallic applications.

However, almost any mineral material can become an economically feasible nonmetallic mineral if someone is astute enough to develop a market that can use its particular chemical or physical properties. This is the reason for the low favorability and low confidence level.

N3-3B. This classification area covers the entire WSA, overlying both of the previous two nonmetallic classification areas. Barite has been mined in substantial quantities and is known to occur as small stringers and perhaps replacements in at least the southern part of the WSA (Hilton and Christensen, see GRA file), though it is not known whether it is also present elsewhere -- in areas that have not been staked. The small occurrences may well consist of barite that has been remobilized from larger deposits as a result of the hydrothermal activity that has clearly taken place. This is the reason for the classification as moderately favorable for barite resources, and the low level of confidence.

2. LEASABLE RESOURCES

a. Oil and Gas

WSA NV 060-541

OG1-1C. The WSA is underlain by Cambrian to Devonian Eastern Assemblage rocks. This entire section is older than the prospective source and reservoir horizons in Nevada. The geologic environment and inferred geologic processes do not indicate favorability for the accumulation of hydrocarbons in the WSA. The presence of leases does not necessarily change the classification to a more favorable category.

b. Geothermal

WSA NV 060-541

G1-2A. The WSA is underlain by rocks that have regionally prominent faults that trend in northerly and northeasterly directions. Both fault sets pass from Paleozoic outcrop into the alluvium of the valleys. This late Cenozoic movement, in an area of known hydrothermal occurrences, indicates some favorability for their presence in the WSA.

c. Sodium and Potassium

WSA NV 060-541

S1-1D. This classification area covers the entire WSA. There is very low favorability for sodium or potassium, with a high level of confidence because of the geologic formation present. No map is presented for sodium and potassium.

3. SALEABLE RESOURCES

Saleable resources have been considered in the section on nonmetallic minerals.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

1. If large-scale (1:24,000 or less) color aerial photo coverage of WSA NV 060-541 is available, it should be studied in detail in order to determine if there are additional altered or silicified areas in the parts of the WSA that have not been staked. This will require field verification if possible alteration is recognized.

2. The zinc prospect on the July claims should be examined to determine how significant a mineral occurrence it is.

3. A moderately detailed stream sediment geochemical sampling program, combined with reconnaissance barite prospecting, should be undertaken in at least the northern two-thirds of the WSA, and preferably in all of it that is not already staked. The objective of this is partly to determine whether there is likely to be Carlin-type gold mineralization, and partly to determine whether barite occurrences are present throughout the WSA.

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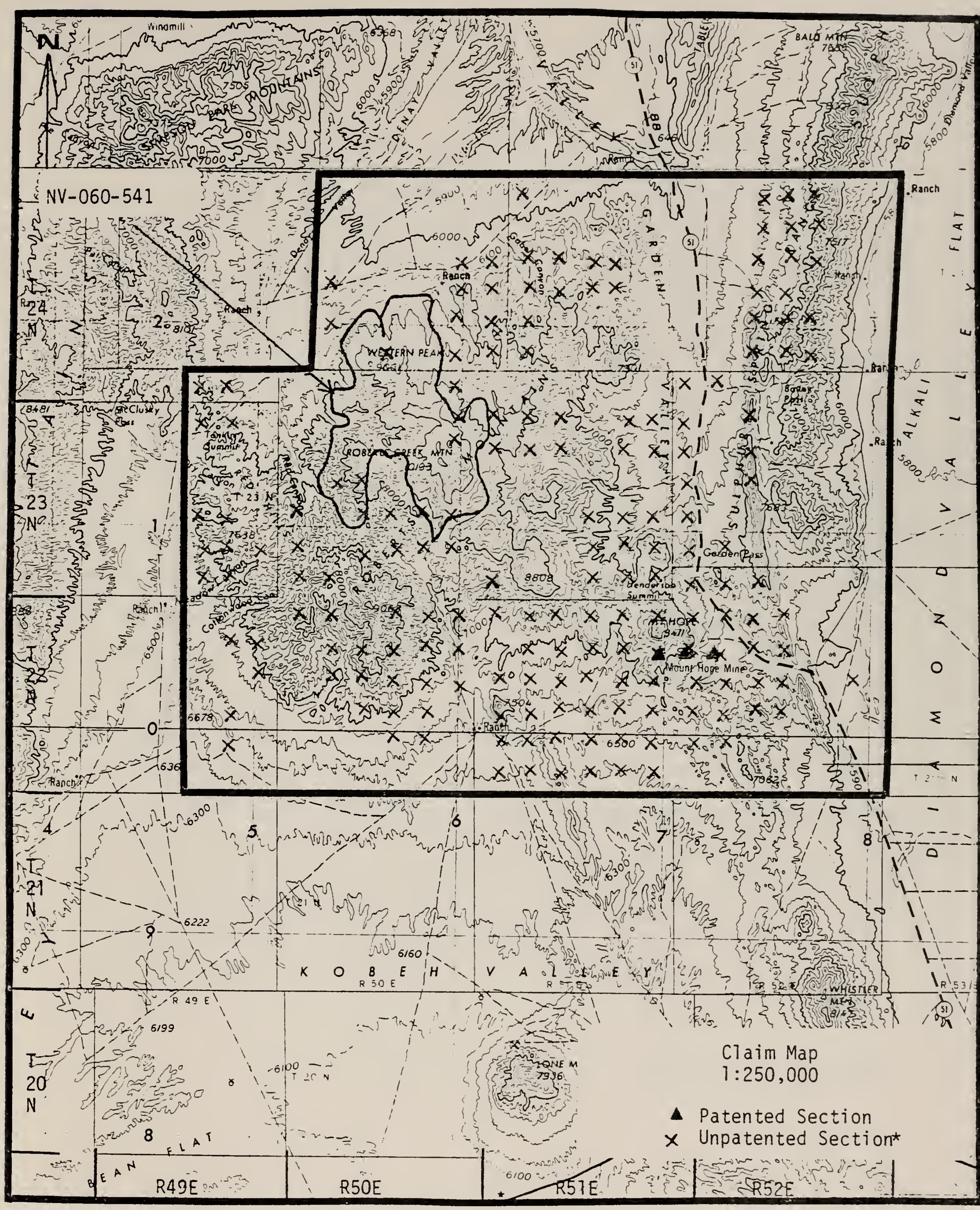
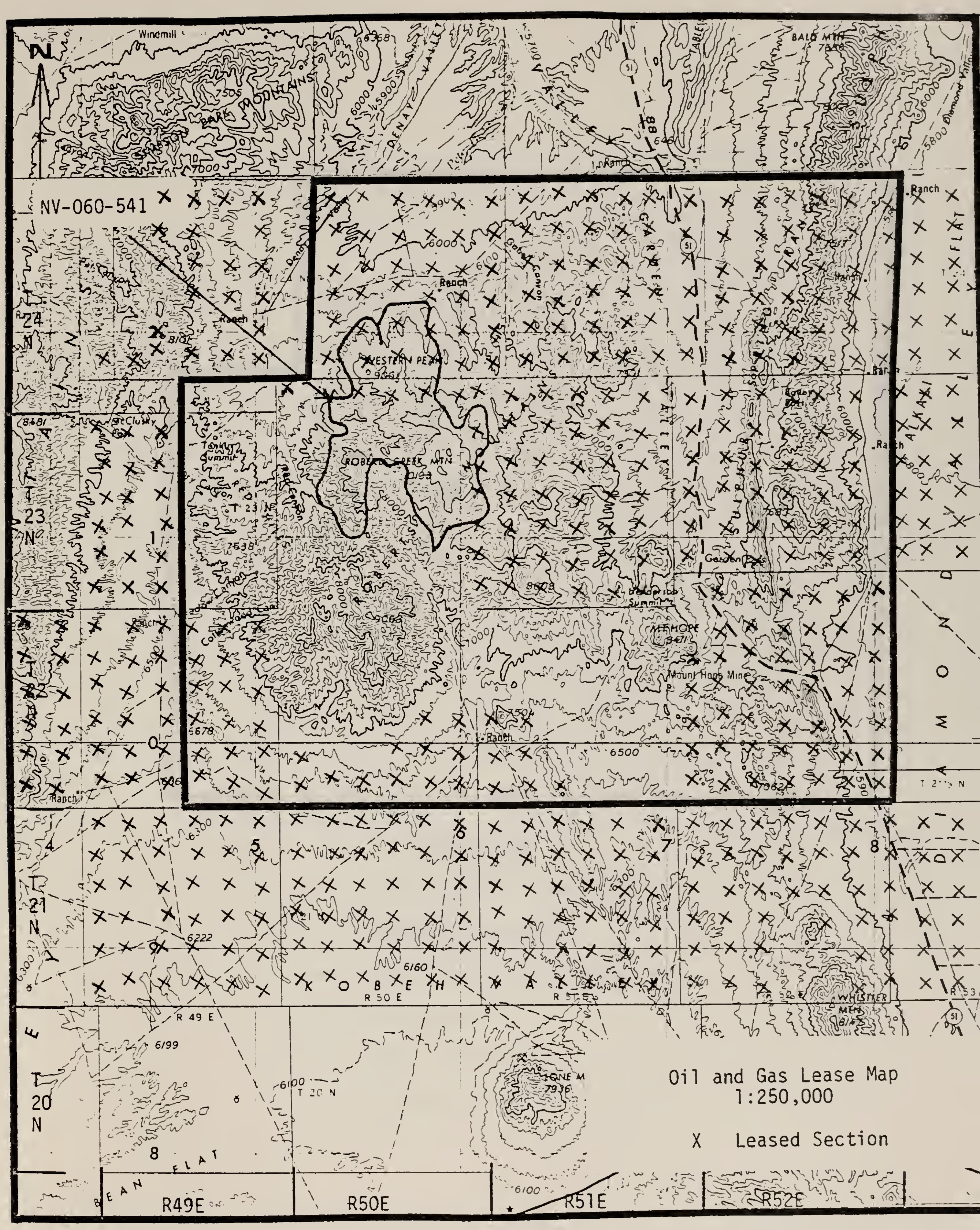
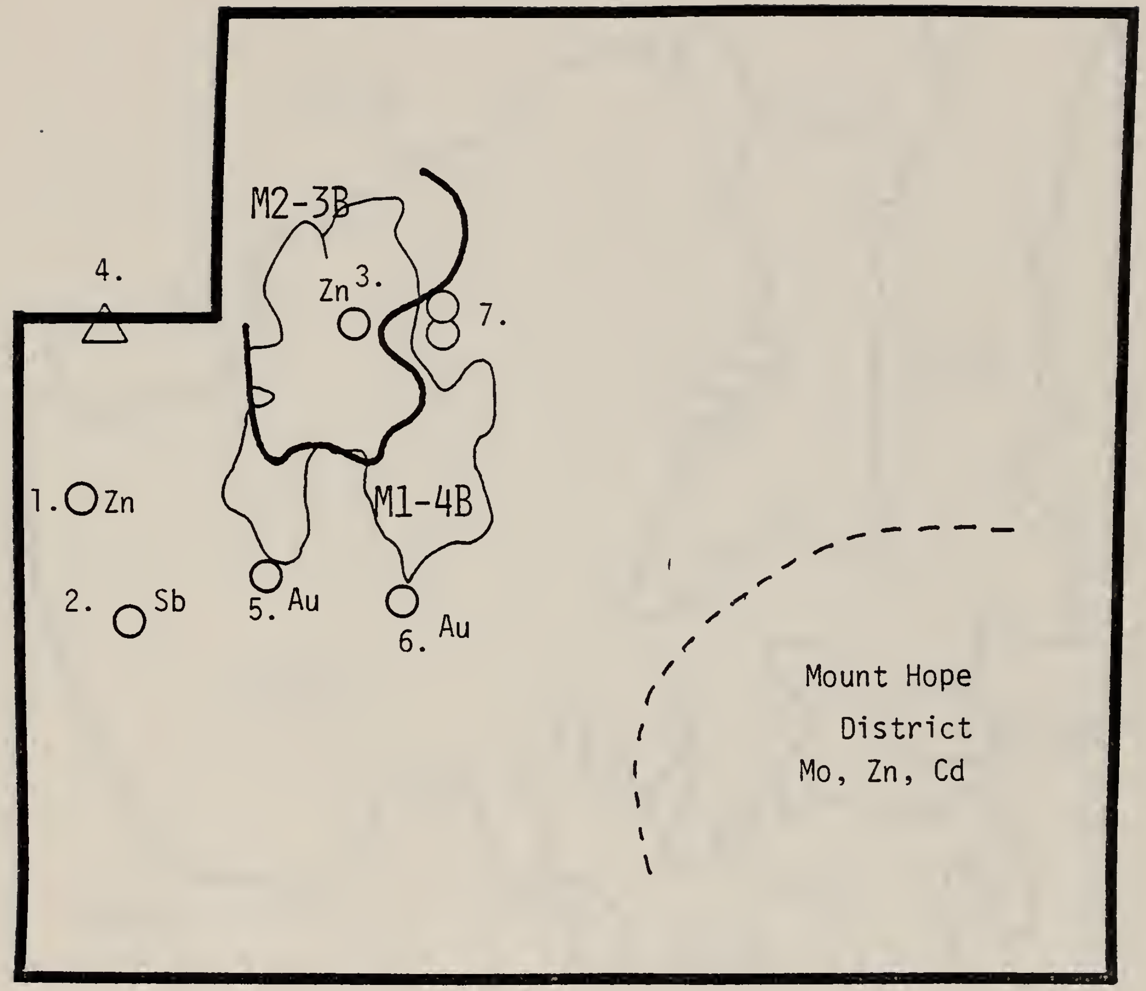


*X denotes one or more claims per section


NV-060-541
Oil and Gas Lease Map
1:250,000
X Leased Section
ROBERTS CREEK MTN
WESTERN PEAK
Garden Pass
Henderson Summit
Mount Hope Mine
Ranch
Windmill
BALD MTN
WHISTLER MTN
R49E
R50E
R51E
R52E
T 24 N
T 23 N
T 21 N
T 20 N



EXPLANATION

---- Mining District, commodity

○ Occurrence, commodity

━━ Land Classification Boundary

—— WSA Boundary

△ Mine, commodity

1. Reference location (see text)

Land Classification - Mineral Occurrence Map/Metallics

Roberts GRA NV-08
Scale 1:250,000

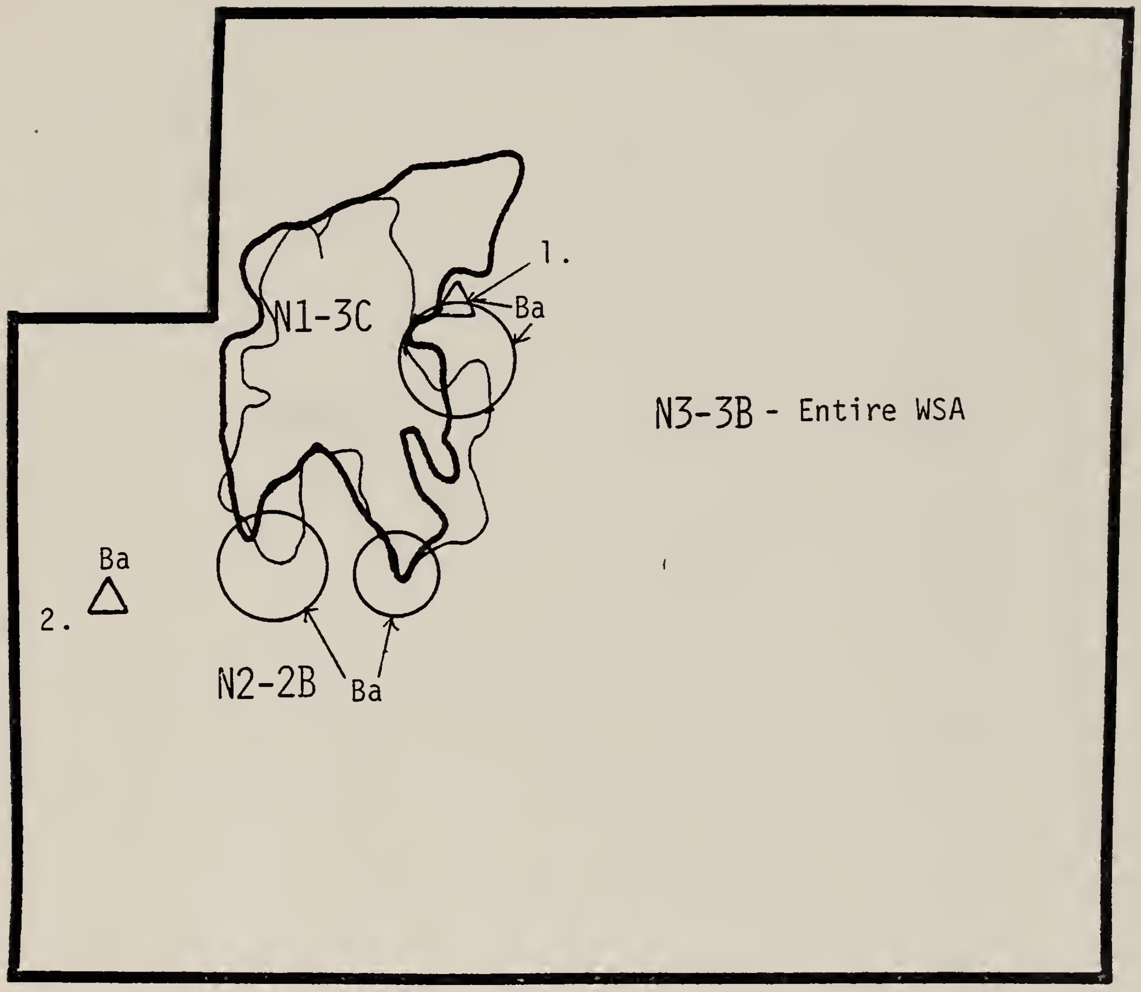
EXPLANATION

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Uranium

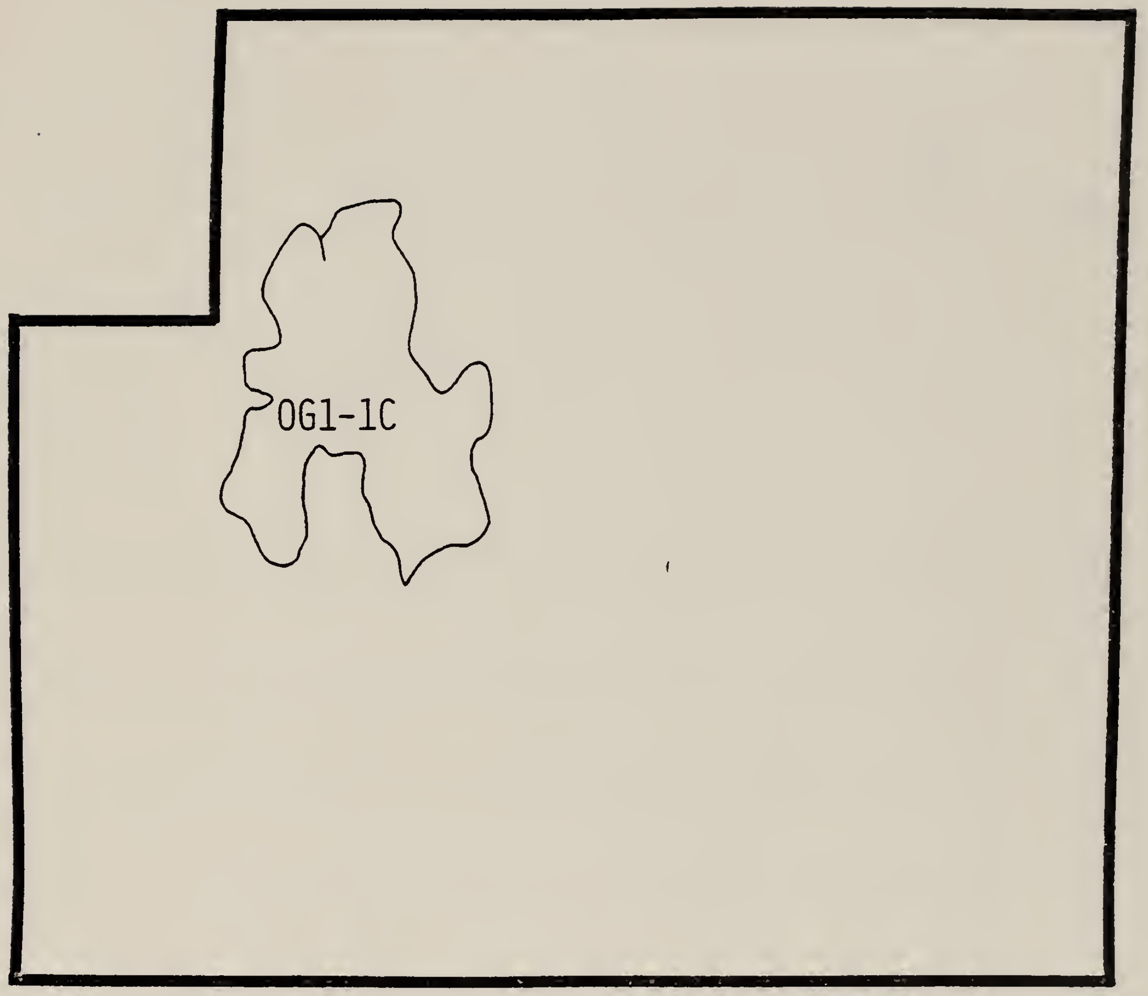
Roberts GRA NV-08
Scale 1:250,000



EXPLANATION

- △ Mine, commodity
- ○ Occurrence, commodity
- ▬ Land Classification Boundary
- — WSA Boundary
- 1. Reference location (see text)

Land Classification - Mineral Occurrence Map/Nonmetallics   Roberts GRA NV-08
Scale 1:250,000



EXPLANATION

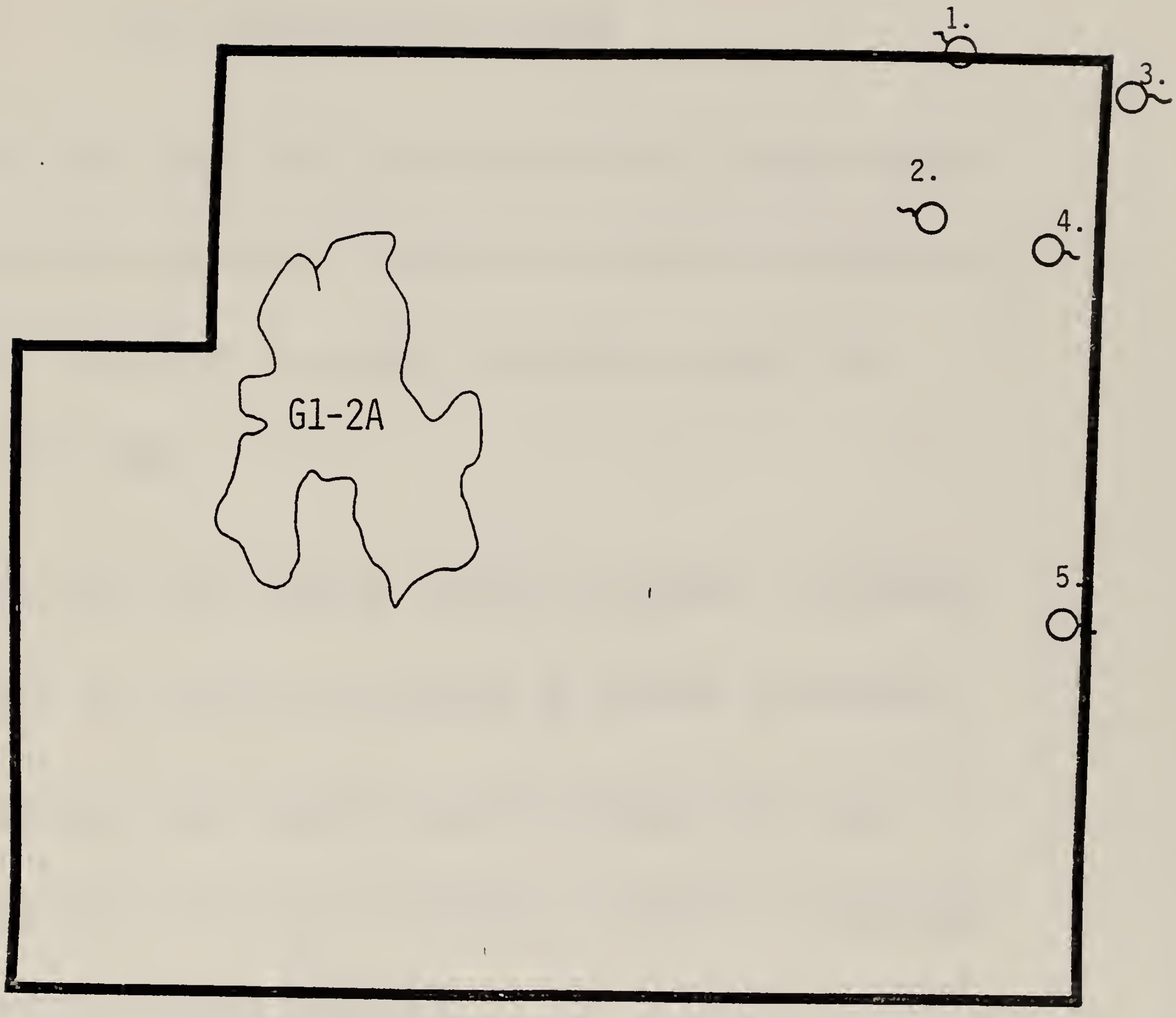
— WSA and Land Classification Boundary

⌖ Dry Hole

1. Reference location (see text)

Land Classification - Mineral Occurrence Map/Oil and Gas

Roberts GRA NV-08
Scale 1:250,000



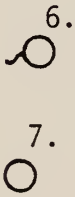
EXPLANATION

Thermal Spring

Thermal Well

1. Reference location (see text)

WSA and Land Classification Boundary



Land Classification - Mineral Occurrence Map/Geothermal

Roberts GRA NV-08
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 [3]		Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600+ [3]

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

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

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

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

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

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