WEEPAH SPRING G-E-M RESOURCES AREA

(GRA NO. NV-17)

TECHNICAL REPORT

(WSA NV 040-246)

Contract YA-553-RFP2-1054

Prepared By

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Final Report

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EXECUTIVE SUMMARY

The Weepah Spring Geology-Energy-Minerals (GEM) Resource Area (GRA) is in Lincoln and Nye Counties, Nevada, 20 miles north of Hiko which is in Lincoln County. There is one Wilderness Area (WSA), NV 040-246, which is mostly in Lincoln County but the northern end extends into Nye County.

The rocks in the northern two-thirds of the WSA are sediments 300 million to 400 million years old. Similar rocks are present at depth in the southern part of the WSA but the surficial rocks are volcanic flows and ash falls probably 20 million to 60 million years old. The volcanic rocks are the remains of an old volcano, and the intrusive rock in the throat of the volcano is recognized in the south end of the WSA.

There are no mining districts in the GRA; the nearest major one is Pioche, about 35 miles to the east, which has produced large quantities of lead, zinc and silver. Several lesser districts are similar distances from the GRA.

There are no patented claims in the GRA but there are a great many -- several hundred at least -- unpatented claims and many of these are within the WSA. The northwestern part of the WSA is essentially completely covered with claims, and a smaller area on the east side is completely covered. There has been rather extensive drilling and bulldozing in some parts of the claimed areas. About thirty square miles of oil and gas leases cover the WSA and most of the GRA is leased as well. There are no Federal geothermal leases.

The northwestern part of the WSA has moderate favorability with moderate confidence for metallic minerals on the basis of mineralization reported by claim holders and also by independent sources, a small part of the east edge has moderate favorability with low confidence for the same reason. The remainder of the WSA has low favorability with very low confidence for metallic minerals on the basis of the geology. Much of the WSA has moderate favorability with moderate confidence for nonmetallic minerals because of extensive limestone and dolomite deposits and sand and gravel. The southern half has low favorability with low confidence for nonmetallic minerals. The entire WSA has low favorability with low confidence for uranium and has no known potential for thorium. The WSA has low favorability with very low confidence for both oil and gas and geothermal, the latter for low-temperature resources. The entire WSA has very low favorability with high confidence for sodium and potassium. Although Coal Valley lies immediately west of the WSA, there is no known potential for coal in the WSA.

An effort to obtain more information on alteration and mineral occurrences from claim holders in and near the WSA is recommended. Geological reconnaissance for alteration and mineral occurrences,

and for geothermal sample collection, is recommended for the unclaimed part of the WSA.

I. INTRODUCTION

The Weepah Spring G-E-M Resources Area (GRA No. NV-17) contains approximately 190,000 acres (790 sq km) and includes the following Wilderness Study Area (WSA):

WSA Name	WSA Number
Weepah Spring	NV 040-246

The GRA is located in Nevada within the Bureau of Land Management's (BLM) Schell Resource Area, Ely district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 38°00' north latitude, 115°00' west longitude and includes the following townships:

T 3 N, R 60-62 E	T 1 N, R 60-62 E
T 2 N, R 60-62 E	T 1 S, R 60-62 E

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

7.5-minute:

Timber Mtn. Pass West	Timber Mtn. Pass East
Oreana Springs	Weepah Spring
Deadman Spring	Seaman Wash
White River Narrow	

The nearest town is Hiko which is located approximately 18 miles south of the southern GRA border on State Route 38. Access to the area is via State Route 38 to the east. 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 WSA on a topographic base at a scale of 1:250,000.

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

This GRA Report is one of fifty-five reports on the Geology-Energy-Minerals potential of Wilderness Study Areas in the Basin

and Range province, prepared for the Bureau of Land Management by the Great Basin GEM Joint Venture.

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

The WSA in this GRA was 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 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.

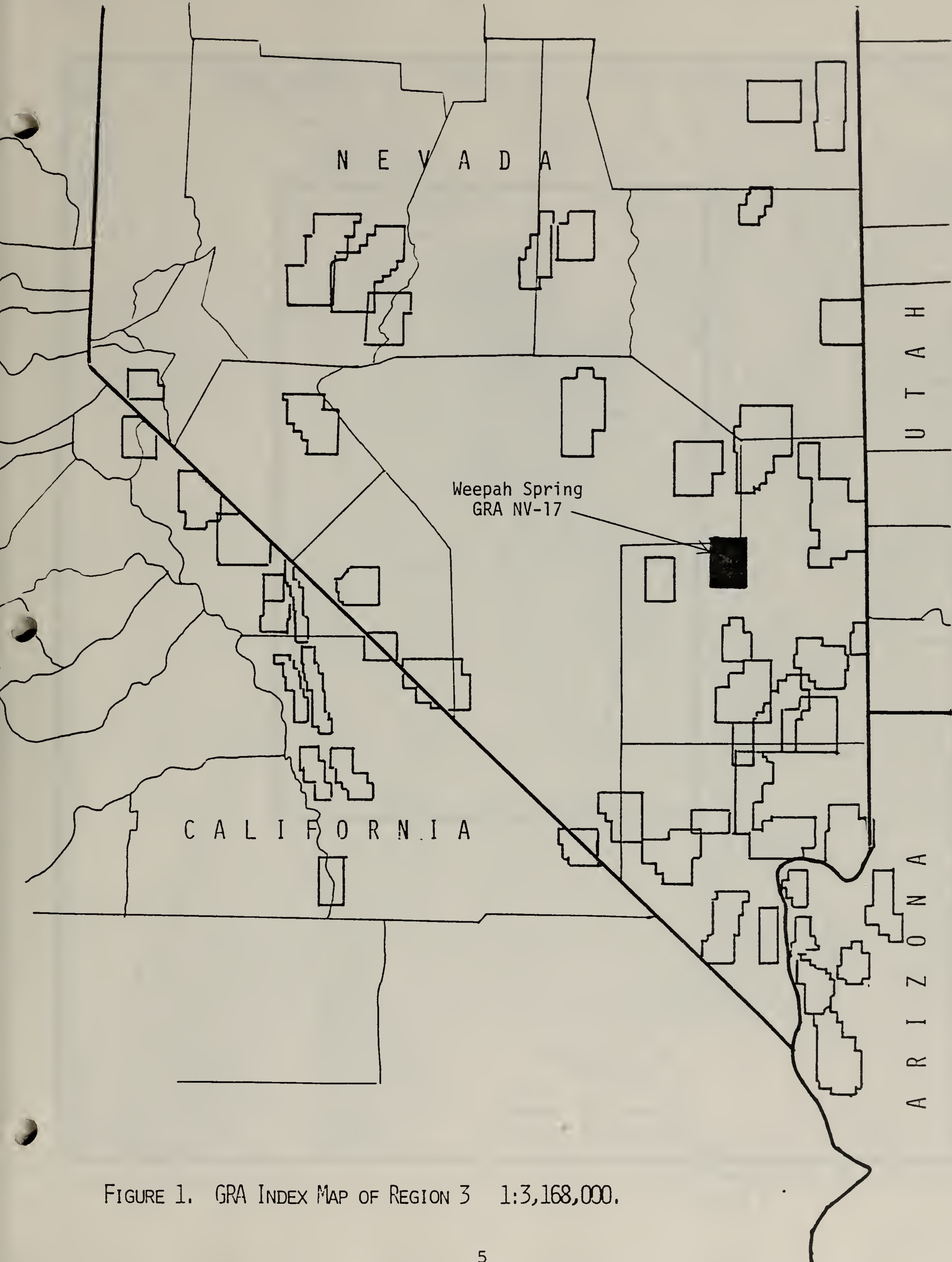
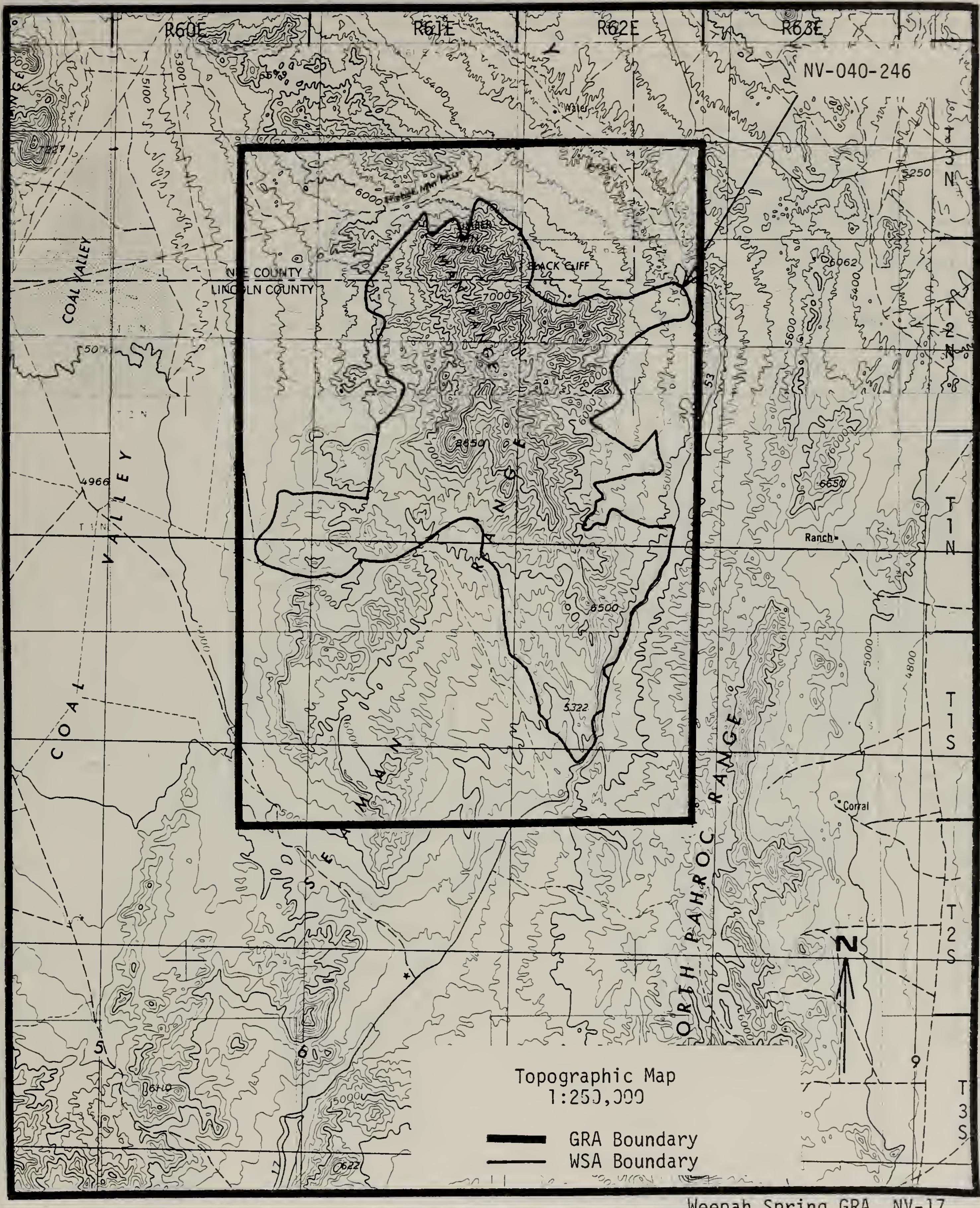


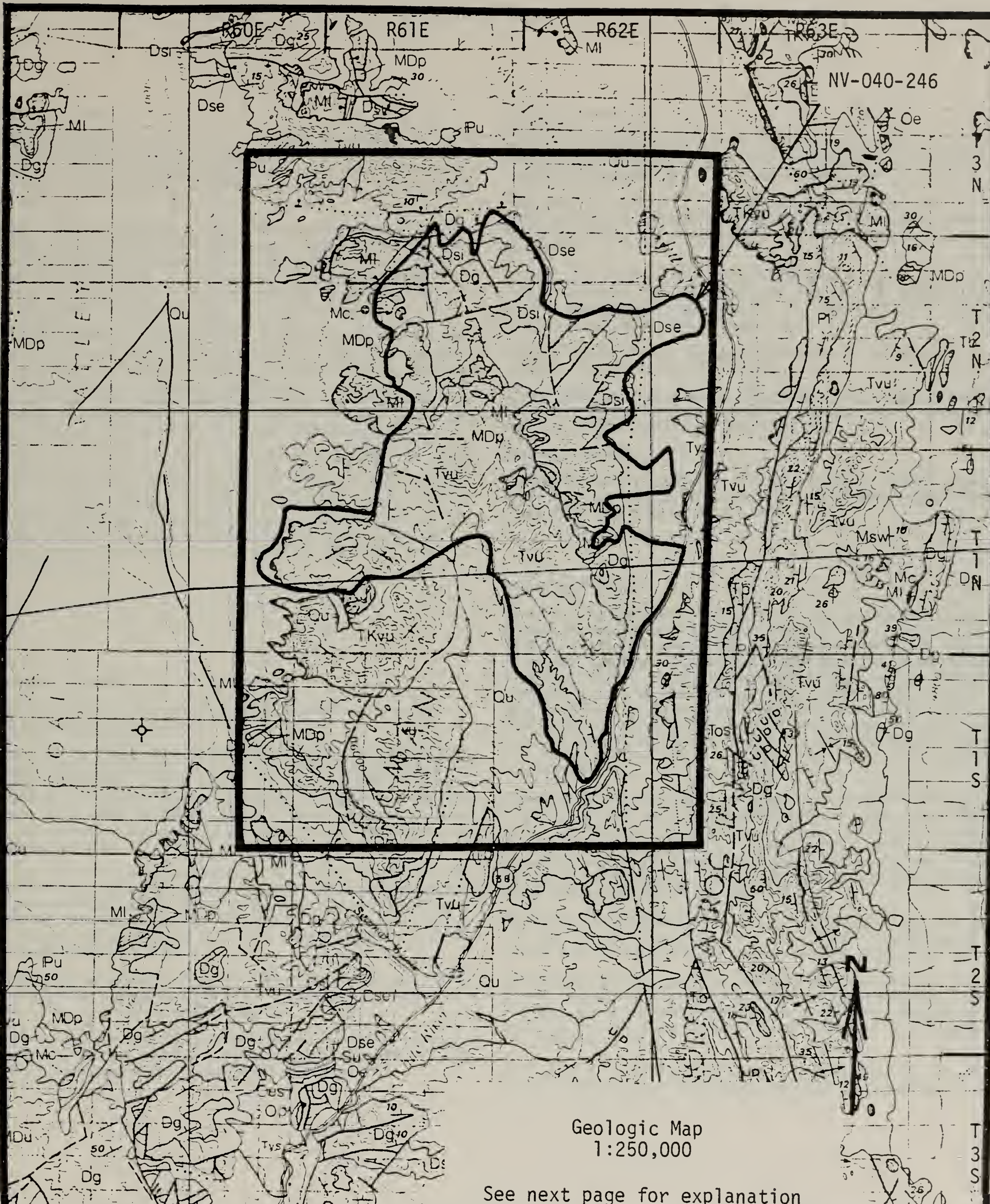
FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Lund and Caliente Sheets

Weepah Spring GRA NV-17

Figure 2



Geologic Map
1:250,000

See next page for explanation

Howard (1978)

Weepah Spring GRA NV-17
Figure 3

EXPLANATION

Cenozoic Sediments

Quaternary, Undifferentiated (Qu): *Includes all sedimentary rocks and surface exposures of recent playa deposits, dune sands, lake beds, shoreline deposits and younger as well as certain older exposures of gravels and other alluvium associated with pediments and mountain streams.*

Tertiary Younger Sediments (Tys): *Sedimenetary rocks of Miocene and Pliocene age including older lake beds of the Muddy Creek Formation and Panaca Formation in Lincoln and Clark Counties: the Muddy Creek Formation in Southwestern Utah; pre-Quaternary sediments in the White River Valley; and sediments associated with ash-flow tuffs near Antelope Summit in White Pine County.*

Tertiary Sediments, Undifferentiated (Tsu): *Primarily Miocene and upper Oligocene deposits including tuffaceous sediments interbedded with ash flow tuffs, the Horse Camp Formation and various unidentified tuffs, tuffaceous shales and diatomites in Nye County; intravolcanic tuffaceous and clastic sedimentary rocks in Lincoln and Nye Counties; and conglomerates and limestones of uncertain age in the Conger-Confusion Ranges and the Cricket Mountains of Utah.*

Tertiary Older Sediments (Tos): *Includes the Sheep Pass Formation in Lincoln and Nye Counties; the Gilmore Gulch Formation in Nye County; unnamed lacustrine limestones in southern Lincoln County; older gravels, conglomerates, tuffaceous and clastic sedimentary rocks, limestones, cherts, claystones, silts, carbonaceous shales and oil shales in Elko County; and older limestones of the Illipah area and the Kinsey Canyon Formation of the Schell Creek and Grant Ranges in White Pine County.*

Cenozoic Volcanics

Quaternary Basalt (Qb): *Basalt, andesite and latite of Quaternary or late Tertiary age in Nye County.*

Tertiary Basalt (Tb): *Intermediate and basaltic lavas including the Fortification Basalt Member of the Muddy Creek Formation in Clark County; basalt flows, basaltic cinder, tuff and lava cones which are included in parts of the Banbury Formation and latite flows in Elko County; basalt flows and dikes in Lincoln County; andesite and basalt flows of various ages in North Central Nevada; and basalt and basaltic andesite flows in Southwestern Utah.*

Tertiary Volcanics, Undifferentiated (Tvu): *Early to late Tertiary volcanic rocks ranging in composition from silicic to intermediate; primarily rhyolites, dacites, quartz latite flows, ignimbrites and pyroclastics of widespread occurrence. These rocks are listed under various subdivisions in Elko, Lincoln, and Nye Counties; North Central Nevada and Southwestern Utah.*

Tertiary Older Volcanics (Tov): *Pre-Miocene volcanic rocks lithologically similar to Tertiary Volcanics, Undifferentiated (Tvu). Listed under various subdivisions in Nye County.*

Intrusives (TKJi): *Occurred from mid-Jurassic through late Tertiary. Widespread intrusions ranging in composition from granitic through gabbroic and in texture from holocrystalline to porphyritic.*

Mesozoic Sediments

Tertiary-Cretaceous Sediments (TKsu): *Continental sediments consisting of fanglomerates, clastics, tuffs and limestones. Includes the Gale Hills Formation and the Overton Fanglomerate.*

Cretaceous Sediments (Ks): *Chiefly non-marine siltstone, shale, conglomerate and limestone. Includes lower Gale Hills Formation, Thumb Formation, Baseline Sandstone, Willow Tank and Newark Canyon Formations.*

Jurassic (Ju): *Eolian cross-bedded sandstone in Utah, volcanically derived sediments, ash flows and basic lava flows in northern Elko County. Includes Navajo Sandstone, Aztec Sandstone, Frenchie Creek Formation and Bayer Ranch Formation.*

Jurassic-Triassic (JTRu): *Includes Nugget and Aztec Sandstones and Chinle Formation of southern Nevada.*

Triassic (TRu): *Shallow marine sedimentary rocks including Chinle, Shinarump, Thaynes and Moenkopi Formations in the west and continental to shallow marine sediments in the east.*

Mesozoic Volcanics

Tertiary-Cretaceous Volcanics (TKvu): *Occur in Lincoln County where it covers wide areas of the Clover, Del Mar, Wilson Creek, White Rock and Mahogany Mountains.*

Paleozoic Sediments

Permian, Undifferentiated (Pu): *Shallow marine intertidal and continental sediments. Includes Gerster Formation, Plympton Formation, Kaibab Limestone, Pequop Formation, Coconino Sandstone, Arcturus Formation, Rieptown Formation, Rib Hill Sandstone, Riepe Springs Formation, Carbon Ridge Formation and Loray Limestone. With the exception of parts of White Pine County, local symbols are used to identify all Permian outcrops. In White Pine County, local symbols are used except for the Park City Group which is grouped with the Arcturus and Rib Hill Sandstones (Par). To avoid confusion, non-standard symbol used for Permian in Utah has been replaced with the standard "P".*

Pennsylvanian-Permian (PPu): *Marine sandstone and limestone (dolomatized in places). Includes Rib Hill Sandstone, Riepe Spring Limestone and Ferguson Mountain Formation in southern Elko County; Strathearn Formation, Buckskin Mountain Formation, Beacon Flat Formation and Carlin Canyon Formation in Eureka County; Pablo Formation in Nye County; and Oquirrh Formation or group in Utah. Local symbols are used where possible.*

Pennsylvanian, Undifferentiated (Pu): *Includes Ely Limestone, Moleen and Tomera Formations. To avoid confusion, the non-standard symbol used for Pennsylvanian in Utah has been replaced by "P".*

Mississippian Upper (Mu): *Includes Diamond Peak and Bird Spring Formations, Callville Limestone, Scotty Wash Formation, Ochre Mountain Limestone and Manning Canyon Shale in parts of Clark County. Chainman Shale is combined with Diamond Peak Formation in some parts of Utah.*

Mississippian, Chainman Shale (Mc): *Includes Mountain City Formation in Elko County and Eleana Formation in Nye County.*

Mississippian, Lower (Ml): *Includes Monte Cristo and Rogers Spring Limestones in Clark County; Joana, Mercury and Bristol Pass Limestones in Lincoln County; and Joana Limestone elsewhere.*

Mississippian-Devonian, Undfiferentiated (MDu): *Includes Rogers Spring Limestone and Muddy Peak Limestone in parts of Clark County; Joana Limestone and Pilot Shale in Elko County; Pilot Shale, Joana Limestone, Chainman Shale and Diamond Peak Formation in Eureka and White Pine Counties.*

Mississippian-Devonian, Pilot Shale (MDp): *Shown in combination with other Mississippian Formations in Clark, Elko, parts of Lincoln, Eureka and White Pine Counties.*

Devonian-Cambrian, Undifferentiated (DSOCu): *Undivided limestone and dolomite occurring in Lincoln County.*

Devonian-Ordovician, Undifferentiated (DSOu): *Dolomites in Elko and Nye Counties.*

Devonian, Upper (Du): *Primarily Devils Gate and Guilmette Formations. Also includes Sevy and Simonson dolomites in parts of White Pine County. Contains Guilmette, Devils Gate, Simonson and Sevy in Elko County under the heading of* Dgd. *Local symbols used where possible.*

Simonson Dolomite (Dsi): *Alternating light to dark gray fine to coarse grained dolomite. Included with other Silurian and Devonian sediments in North Central Nevada and parts of Utah. Grouped with Sevy Dolomite in parts of Clark, Elko, Eureka, Nye, and White Pine Counties.*

Sevy Dolomite (Dse): *Very light colored, dense, distinctly bedded unfossiliferous dolomite. Combined with other Devonian and Silurian sediments in parts of North Central Nevada and Utah and with the Simonson Dolomite in parts of Clark, Elko, Eureka, Nye and White Pine Counties.*

Sevy and Simonson Dolomites, combined (Dun): *Also includes the Sultan and Muddy Peak Limestones in Clark County; Nevada Formation in Elko County; Devils Gate Formation in Eureka County; Nevada Formation, Woodpecker Limestone, Oxyolk Canyon Sandstone and Rabbit Hill Formation in Nye County; Nevada Formation and Devils Gate Formation in Eureka County and the Nevada Formation in White Pine County. Local symbols are used where possible.*

Devonian, Western Facies (Dw): *A portion of the western allochthonous assemblage. Includes Woodruff Formation and Slaven Chert in Eureka County and silicious siltstone in the Cockalorum Wash area of Nye County.*

Silurian, Undifferentiated (Su): *Includes Lone Mountain and Laketown Dolomites throughout the mapping area, the Elder Sandstone and Fourmile Canyon formation in Eureka County, and the Roberts Mountain formation in Nye County. In White Pine County, the Silurian deposits are grouped with the upper Ordovician sediments under the heading of Silurian-Ordovician, Undifferentiated* (SOu).

Upper Ordovician, Undifferentiated (Oupu): *Includes Ely Springs and Fish Haven Dolomites and the Hanson Creek Formation. Local symbols are used where possible. Listed as Ordovician, Undifferentiated* (Ou) *in parts of North Central Nevada. In Clark County, Ely Springs Dolomite has been divided from the rest of* Oep *by the author. The Eureka Quartzite and Pogonip Group are grouped with Silurian sediments under the heading Silurian-Ordovician, Undifferentiated* (SOu) *in Elko County.*

Ordovician, Eureka Quartzite (Oe): *Light colored vitreous quartzite and hard sandstone. Also includes the Swan Peak Quartzite in parts of Utah. In Clark County, the Eureka Quartzite has been separated from* Oep *by the author. In parts of North Central Nevada, the Eureka Quartzite has been grouped with other Ordovician sediments under the heading of* Ou. *In White Pine County, the Eureka Quartzite has been grouped with the Pogonip Group under the heading of*

Ordovician, Pogonip Group (Op): *Limestone, silty limestone, shale and interformational conglomerates. In Clark County, the Pogonip Group has been separated from* Oep *by the author. Includes the Garden City Limesione in parts of Utah. In White Pine County, the Pogonip Group is grouped the Eureka Quartzite under the heading of* Ol.

Ordovician, Undifferentiated (Ou): *Includes the Pogonip Group, Ely Springs Dolomite, Eureka Quartzite and Comus Formation in North Central Nevada.*

Ordovician, Vinini Formation (Ovi): *Part of the western allochthonous assemblage. Includes Valmi Formation in parts of North Central Nevada. Local symbols are used where possible.*

Cambrian-Ordovician, Undifferentiated (OCu): *Occurs in Elko, Eureka, Nye and White Pine Counties as shale and limestone and is usually so identified when metamorphosed to phyllite. Includes the Tennessee Mountain Formation in Elko County, Board Canyon, Sequence in North Central Nevada, Windfall Formation in Nye County and the lower Ordovician and post-Dunderberg Shale in the Schell Creek Range of White Pine County. In some parts of Nye County,* OCu *is metamorphosed to slate and marble instead of phyllite.*

Cambrian, Upper and Middle (Cu): *Primarily limestones, dolomites, shales and quartzites. Includes Edgemont and Peak Limestones in Elko County; Highland Peak formation, Patterson Pass Shale, Pole Canyon Limestone, Chisholm Shale and Lyndon Limestone member of the Chisholm Shale in Lincoln County; Harmony Formation, Preble Formation, Pioche Shale, Eldorado Dolomitee, Geddes Limestone, Secret Canyon, Hamberg, Dole and Dunderberg Shales, Windfall Formation, and Scott Canyon Formation in North Central Nevada; Windfall Formation, Dunderberg Shale, Tybo Shale and Lincoln Park Formation in Nye County; Notch Peak Formation, Dunderberg Shale, Orr Formation, Weeks Formation, Marjum Formation, Wheeler Shale, Swasey Formation, Whirlwind Formation, Dome Limestone, Howell Formation and Tatow Formation in Utah; and Corset Spring Shale, Notch Peak Limestone, Dunderberg Shale and Windfall Limestone in White Pine County. Metamorphosed to schist in Elko County.*

Cambrian, Lower (Cpmp): *Primarily Prospect Mountain Dolomite and Pioche Shale. Also includes Tapeats Sandstone, Wood Canyon Formation, Lyndon Limestone, Chisholm Shale and Carrera Formation in Clark County; Sterling Quartzite and Wood Canyon Formation in parts of Lincoln County; Busby Quartzite in the Gold Hill area of Utah and the Stella Lake Quartzite in White Pine County.*

Precambrian

Precambrian Sediments (pCs): *Includes the Johnnie Formation, Sterling Quartzite and some metamorphics in Clark County; Johnnie Formation and lower units of Prospect Mountain Quartzite in Lincoln County; McCoy Creek Group in Elko County; and the McCoy Creek Group excluding the Stella Lake Quartzite in White Pine County.*

Precambrian Intrusives (pCi): *Includes the Gold Butte Granite in Clark County and other undifferentiated igneous and metamorphic rocks, primarily granites and pegmatites.*

II. GEOLOGY

The Weepah Spring GRA lies in the Basin and Range geomorphic province in northern Lincoln and northeastern Nye Counties. WSA 040-246 includes most of the Seaman Range which is composed of Paleozoic marine sediments that are overlain by Tertiary volcanics in the south-central part of the study area. The broad dissected cone of the extinct volcano, which produced most of the volcanic units in the study area, is a prominent topographical feature.

The range is bounded on the east, south and north by Pliocene age normal faults. A thrust sheet of Mississippian clastic rocks over Devonian rocks has tentatively been identified by Tschanz and Pampeyan (1970) in the northern part of the range.

1. PHYSIOGRAPHY

The Weepah Spring GRA lies in the Basin and Range province in northern Lincoln and northeastern Nye Counties. WSA 040-246 includes most of the Seaman Range which is composed of Paleozoic marine sediments that are overlain by Tertiary volcanics in the south-central part of the study area. A principal feature of the volcanic terrane is the broad dissected cone of an extinct volcano -- the source of volcanics in the area. The range is fault bounded on the east by the Pahroc fault and on the south by the Seaman Pass fault.

The topography of the range is rugged where Paleozoic sediments are exposed and more moderate in the volcanic covered area in the southern part of the GRA. Elevations along the crest of the range increase towards the north with the highest peak reaching 8,650 feet.

The eastern side of the Seaman Range drains into the White River, which discharges into the Muddy River, a tributary of the Colorado. The western flank drains internally into Coal Valley. Both valleys are at an elevation of about 5,000 feet.

2. ROCK UNITS

The oldest rock unit in the Weepah Spring GRA is the Devonian Simonson Dolomite, a sequence of alternating dark and light dolomites. The Guilmette Formation, composed of a series of limestone and dolomite, was conformably deposited over the Simonson in Middle-Upper Devonian time.

An atypical facies of the Upper Devonian-Lower Mississippian Pilot Shale, which consists of yellow-orange calcareous siltstone, occurs near the crest of the range north of the volcanic rocks. Unconformably overlying the Pilot Shale is an unnamed sequence of Lower Mississippian limestone.

The Upper-Mississippian Chainman Shale, Scotty Wash Quartzite and undivided Pennsylvanian limestone in the north end of the Seaman Range are found in a thrust plate tentatively correlated with the Silver King thrust.

Undifferentiated Cretaceous through mid-Tertiary volcanics have been mapped by Tschanz and Pampeyan (1970) in the area of the broad dissected volcanic cone in the southwest corner of the study area. In the center of this cone is a circular plug of Miocene age andesite. Tuffs, spheroidal weathered ignimbrites, and perlitic rocks of Miocene age have been differentiated by Tschanz in the southern part of the GRA.

Pliocene lacustrine deposits, informally referred to as the White River lake beds (Tschanz and Pampeyan, 1970), are probably equivalent to the Panaca and Muddy Creek Formations. These rocks are largely siltstone and clay shale that rest unconformably on all underlying rocks.

Older gravels composed of rocks eroded from nearby mountains were deposited during the Pliocene(?)-Pleistocene in the valley east of the range and in Pahrock Valley in the southern part of the GRA.

3. STRUCTURAL GEOLOGY AND TECTONICS

The dominant structural feature in the Weepah Spring GRA is the Pahroc fault which bounds the eastern flank of the range. The Pahroc fault trends north-south for over 45 miles. The Seaman Pass fault trends northwest and forms the southern boundary of the range.

Two pre-volcanic(?) north-south-trending faults in the northern part of the range are transected by a younger east-west-trending normal fault. In Pahroc Valley two slightly north-northeast-trending normal faults have formed a narrow graben.

The Upper Mississippian Chainman Shale, Scotty Wash Quartzite and the Pennsylvanian limestone in the Seaman Range in Nye County appear to be thrust over Devonian rocks (Tschanz, 1970). This inferred Sevier orogeny thrust plate is tentatively correlated with the Silver King thrust in the Egan Range to the northeast.

4. PALEONTOLOGY

The only rocks with potential for paleontological resources within the Weepah Spring GRA are Mississippian and Devonian rocks of the Chainman Shale, Pilot Shale, Joana Limestone, Nevada Formation and the Diamond Peak Formation. Of these, the Joana Limestone is fossiliferous on the west side of the Seaman Range, and in outcrops along the road through Timber

Mountain Pass. Fossils are marine invertebrates, dominated by corals, and exposed discontinuously along strike.

The majority of the area is characterized by igneous volcanic flows and shallow intrusives.

5. HISTORICAL GEOLOGY

Throughout the Paleozoic miogeosynclinal sediments were deposited throughout the area. Sediments deposited during the early Mesozoic were largely eroded over most of Lincoln County during the Sevier orogenic period that began with uplift in Late Triassic time, and culminated in thrust faulting in Late Jurassic or Cretaceous time.

The Sevier orogeny was followed by volcanism which occurred predominantly in mid-Tertiary time. Basin and Range faulting began sometime during the mid-Tertiary with the most intense activity occurring subsequent to the outpouring of early Pliocene volcanics. Middle Pliocene lake beds and tuffs were unconformably deposited over older rocks, and in turn, were overlain by Pliocene(?)-Pleistocene(?) gravels derived from nearby mountains.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There are no metallic mineral deposits known in the WSA or the GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

There are some old workings on the east side of the range in Sec. 6, T 2 N, R 62 E within the WSA. These were visited in 1979 by Dennis Bryan who described them as a 30-foot deep shaft and a 50-foot long adit in limestone. The workings follow narrow one- to two-foot wide veins striking N 30 E and dipping near vertically. The veins consist predominantly of iron oxides with lesser amounts of calcite with some azurite and malachite.

On the west side of the range there are several prospect pits in alluvium in and near Sec. 7 of T 2 N, R 61 E just outside the west boundary of the WSA. The purpose of these pits is unknown.

Farther south in Sec. 27 and 28 of T 2 N, R 61 E Dennis Bryan in 1979 identified three drill holes in limestone. The surrounding area has abundant jasperoid in the limestone indicating the presence of mineralization. This is within and on the western boundary of the WSA.

Lewis Sandberg of Ely, Nevada, informs us that the Louie and Leone claims in Sections 22, 27, 28, 29, and 30, T 2 N, R 62 E, were drilled in part for uranium and in part for gold. Results were disappointing. The claims are partly within the WSA.

3. Mining Claims

There are many mining claims in the GRA, many of which are in the WSA.

Bear Creek staked lode claims in parts of 29 sections between 1979 and 1981 in the northwest portion of the GRA, many of which are within the WSA. On the east side of the range, and again partially within the WSA, there is a block of lode claims covering parts of six square miles. Amax has a group of claims in Sec. 32 and 33 of T 2 N, R 61 E. The previously described old workings in Sec. 6, T 2 N, R 62 E have lode claims over them. There are numerous other lode claims on the west side of the range, some of which are in the WSA.

4. Mineral Deposit Types

The only descriptions of mineralization in the region are those by Dennis Bryan presented above. The jasperoid he describes is believed by many geologists to be indicative of the presence of Carlin-type gold deposits -- large, low-grade, disseminated open-pittable deposits. The intensive staking in this general area, including the western part of the GRA and the WSA by major companies as well as others, indicates that this potential has been recognized. The veins he describes inside the east boundary of the WSA are not very indicative of any particular kind of mineralization but are clear evidence that there has been mineralization.

5. Mineral Economics

The small vein deposits described are not economically attractive because of their limited tonnage and the necessity of mining underground; however, if they are high grade in gold or silver they might be mineable. Carlin-type deposits, if present, are much more promising economically, since they promise large tonnages that can be mined and processed at relatively low cost.

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

The major uses of silver are in photographic film, sterlingware, and increasingly in electrical contacts and conductors. It is also widely used for storage of wealth in the form of jewelry, "coins" or bullion. Like gold it is commonly measured in troy ounces, which weigh 31.1

grams, twelve of which make one troy pound. World production is about 350 million ounces per year, of which the United States produces about one-tenth, while it uses more than one-third of world production. About two-thirds of all silver is produced as a by-product in the mining of other metals, so the supply cannot readily adjust to demand. It is a strategic metal. Demand is expected to increase in the next decades because of growing industrial use. At the end of 1982 the price of silver was $11.70 per ounce.

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There are no nonmetallic mineral deposits known in the GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

There are no nonmetallic mineral occurrences or prospects known to exist in the GRA. Some of the rock units in the GRA such as the limestone has potential for use in lime or cement, or other materials could have local construction applications.

3. Mining Claims, Leases and Material Sites

There are many mining claims in the GRA but none are known or believed to be for nonmetallic mineral commodities. There are no nonmetallic mineral leases or material sites.

4. Mineral Deposit Types

Since there are no reported nonmetallic mineral resources in the GRA a description of deposit types is not applicable.

5. Mineral Economics

The Weepah Spring GRA is a substantial distance from major metropolitan centers and from rail transportation, so it is unlikely that the limestone and dolomite deposits will be mined in the forseeable future. Other materials could be used locally for construction purposes.

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.

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 -- within a few miles as a rule. However, for some applications such as high-quality concrete there are quite high specifications for sand and gravel, and acceptable material must be hauled twenty miles and more. Demand for sand and gravel fluctuates with activity in the construction industry, and is relatively low during the recession of the early 1980s. Demand is expected to increase by about one third by the year 2000. In the early 1980s the price of sand and gravel 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 WSA or GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

   There is one radioactive occurrence in the WSA (see Uranium Land Classification and Mineral Occurrence Map) at the Lucky Strike claims (nos. 1-9), T 2 N, R 61 E where radioactivity is associated with an iron stained, silicified breccia (Garside, 1973). No uranium or thorium minerals were recognized. The wall rock type is unknown, but it is probably Paleozoic carbonates.

3. Mining Claims

   The only known uranium or thorium claims or leases in the WSA or GRA are the Lucky Strike claims (nos. 1-9) which are described above. These claims have probably lapsed.

4. Mineral Deposit Types

   The radioactive occurrence at the Lucky Strike claims is probably a fracture filling in Paleozoic carbonates associated with silicification and iron oxides.

5. Mineral Economics

   Uranium and thorium appear to be of little economic value in the WSA or GRA. Only one small occurrence has been located, 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, 1982). 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 oil and gas deposits in the area of the GRA and vicinity.

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

There are no oil seeps, but five miles west of the WSA American Quazar Petroleum Company drilled the Adobe Fed. 19-1 Wildcat to 7,706 feet in 1979 (Nevada Bureau of Mines and Geology, 1982).

3. Oil and Gas Leases

Approximately 30 square miles of Federal leases cover the western, or Coal Valley, side of the WSA, and virtually surround the WSA to the north and east in the White River Valley.

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 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.

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 GRA or immediate vicinity.

3. Geothermal Leases

There are no recorded Federal geothermal 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 utilized in the form of hot water or steam normally captured by means of drilling wells to a depth of a few feet to over 10,000 feet in depth. The fluid temperature, sustained flow rate and water chemistry characteristics of a geothermal reservoir determine the depth to which it will be economically feasible to drill and develop each site.

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

All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year around mining in cold climates (86°F), residential space heating (122°F), greenhouses by space heating (176°F), drying of vegetables (212°F), extraction of salts by evaporation and crystallization (266°F), and drying of diatomaceous earth (338°F).

Unlike most mineral commodities remoteness of resource location is not a drawback. Domestic and commercial use of natural thermal springs and shallow wells in the Basin and Range province is a historical fact for over 100 years.

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

D. OTHER GEOLOGICAL RESOURCES

There are no other geological resources known to exist in the GRA or the WSA.

E. STRATEGIC AND CRITICAL MINERALS AND METALS

A list of strategic and critical minerals and metals provided by the BLM was used as a guideline for the discussion of strategic and critical materials in this report.

The Stockpile Report to the Congress, October 1981-March 1982, states that the term "strategic and critical materials" refers to materials that would be needed to supply the industrial, military and essential civilian needs of the United States during a national emergency and are not found or produced in the United States in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals.

There are no strategic and critical minerals or metals known to exist in the GRA or the WSA.

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

Kleinhampl and Ziony (1976) and Tschanz and Pampeyan (1970) provide good geological mapping at a scale of 1:200,000 and 1:250,000 respectively; this scale is too small to show more than major stratigraphic units and major faults. We found no published information about mineral occurrences or alteration in the GRA; all information available comes either from Dennis Bryan, one of the authors of this report, or from private parties. The quantity of geological information available is low, though its quality is high for the scale of the mapping. The quantity of information pertaining to mineralization is moderate but its quality is low -- because except for that from Bryan, it is generalized and locations are not very specific. Overall our confidence in the geologic and mineralization data available is low.

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 040-246

M1-3C. This classification area covers the northwestern part of the WSA, which is mostly Paleozoic sediments. It includes the almost completely staked area and the jasperoid described by Bryan above. In the northern part of the area Glen Davies of 5352 Eugene Avenue, Las Vegas, says there is the Red Head group of 16 claims in Section 32, T 3 N, R 61 E, which have been in his family since 1939. He says there is cinnabar present on the claims, which are just inside the WSA. The presence of jasperoid and of mercury (cinnabar) mineralization are indicative of possible Carlin-type gold deposits, and the intense staking by major companies and others indicates that this potential has been recognized. These are the reasons for the moderately favorable classification and the moderate confidence level.

M2-3B. This classification area covers a small part on the east side of the WSA, in Paleozoic sediments, including the part staked and drilled for uranium and gold as described by Mr. Sandberg, above. Drilling is the modern equivalent of digging prospect holes, and the fact that it was done indicates that there is some evidence of mineralization. This is the reason for the moderately favorable classification, and the low confidence level.

M3-2A. This classification area covers the remainder of the north part of the WSA that is underlain by Paleozoic sediments. It is classified as having low favorability because the rocks are the same as those in the low to moderately favorable areas east and west of it, and the veins in the northeastern part described by Bryan. Since all the evidence for the classification is projected in from surrounding areas, the confidence level is very low.

M4-2A. This classification area covers the southern part of the WSA in which the exposed rocks are Tertiary volcanics. This area is close to a known Tertiary andesite plug and the center of the volcanic pile surrounding it -- and perhaps also to the center of the Tertiary magma that presumably was the source of the mineralization farther north and east. There may be Carlin-type gold deposits in the Paleozoic rocks beneath the volcanics, and also in Tertiary tuff layers that are mapped in the volcanic pile. This is the reason for the low favorability classification. The confidence level is very low, since the classification is based entirely on geologic reasoning with no known evidence of mineralization either in the form of direct information or claim locations.

b. Uranium and Thorium

WSA NV 040-246

U1-2B. This land classification covers almost all of the WSA except for small portions on the eastern, southern and western margins, and the southwest, southeast and north central parts of the GRA. The area is covered by Paleozoic carbonates and Cretaceous and younger volcanic rocks. The area has low favorability with a low level of confidence for uranium fracture filling type deposits in the carbonates and volcanics which may have formed during Tertiary volcanic activity. The radioactive anomaly at the Lucky Strike claims may be this type of occurrence.

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

WSA NV 040-246

U2-2B. This land classification covers small portions of the southern, western and eastern portions of the WSA and the northwest, northeast and south central portions of the GRA. The area is covered by Quaternary gravels and alluvium and Tertiary lake deposits, and has low favorability for epigenetic sandstone type uranium deposits. Volcanic rocks which occur in the hills adjacent to the alluvial deposits may be a source of uranium which can be leached by ground water and deposited in chemically reducing areas in the alluvium or lake sediments.

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

c. Nonmetallic Minerals

N1-3C. This classification area covers the western lower slopes of the Seaman Range and small parts of the western edge of WSA NV 040-246. Quaternary alluvium exposed here includes by definition sand and gravel, which is the reason for the moderately favorable classification. The confidence level is only moderate because, while the sand and gravel must be present, the quality at any given point is unknown.

N2-3C. This classification area covers the eastern slope of the Seaman Range and parts of the east side of the WSA where Quaternary alluvium is mapped. The rationale for the classification and level of confidence is the same as

for N1-3C.

N3-3C. This classification area covers the valley reentrant into the Seaman Range south of the WSA and includes parts of the south-central area of the WSA. The rationale for its classification and confidence level is the same as for N1-3C.

N4-3C. This classification area covers most of the northern part of the WSA in which Paleozoic rocks crop out. Large areas of these rocks are limestone or dolomite, of which large quantities are used elsewhere in industry, particularly as lime or cement rock. The moderately favorable classification is based on the presence of these rocks, while the moderate confidence level stems from the fact that the quality of the limestones and dolomites is unknown.

N5-2B. This classification area covers most of the southern part of the WSA which is underlain by Tertiary volcanic rocks. No economic use is known for these rocks, but any mineral material may become an economically feasible nonmetallic mineral if someone is sharp enough to figure out a market for it. This is the reason for the low favorability and low confidence level.

2. LEASABLE RESOURCES

a. Oil and Gas

OG-2A. The WSA is in a heavily leased area, and has about 30 square miles of leases within its boundaries. The presence of the Adobe Fed. 19-1 deep test just five miles away is indicative of the serious interest industry has for the potential. The well intersected Tertiary volcanics and the Joanna Limestone at depth -- both potential drilling objectives in Nevada. However, because the Lower to Middle Paleozoic section is at the surface in much of the WSA, a higher rating does not seem warranted.

b. Geothermal

WSA NV 040-246

G1-2A. The WSA is centrally located regionally within an area of low- to moderate-temperature geothermal resources which are genetically related to the deep-seated Basin and Range faulting. Similar faulting underlies the eastern part of the WSA, and is geographically close to major faulting to the north and west. These faults commonly are conduits for rising thermal waters which come to the surface as springs or may be intersected at relatively shallow depths by wells.

c. Sodium and Potassium

S1-1D. There is no geological reason to expect potential for sodium and potassium in the WSA, so it is classified throughout as having very low favorability for these commodities with high confidence. No map is presented for sodium and potassium..

d. Other Resources

Despite the name of Coal Valley, which lies immediately to the west of the WSA, there is no known potential for coal in the WSA.

3. SALEABLE RESOURCES

Saleable resources have been covered in the section on Nonmetallic Minerals.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

1. All of WSA 040-246, except perhaps those parts known to have claims, should be geochemically surveyed.

2. An effort should be made to obtain from claim holders more specific information concerning mineral or alteration occurrences on their properties, and geochemical data if available.

3. Literally nothing is known about possible alteration or mineral occurrences in most of the WSA. All but the northwest corner of the GRA, which is covered by claims, should be field checked for alteration and mineral occurrences, and have at least a coarse geochemical sampling program.

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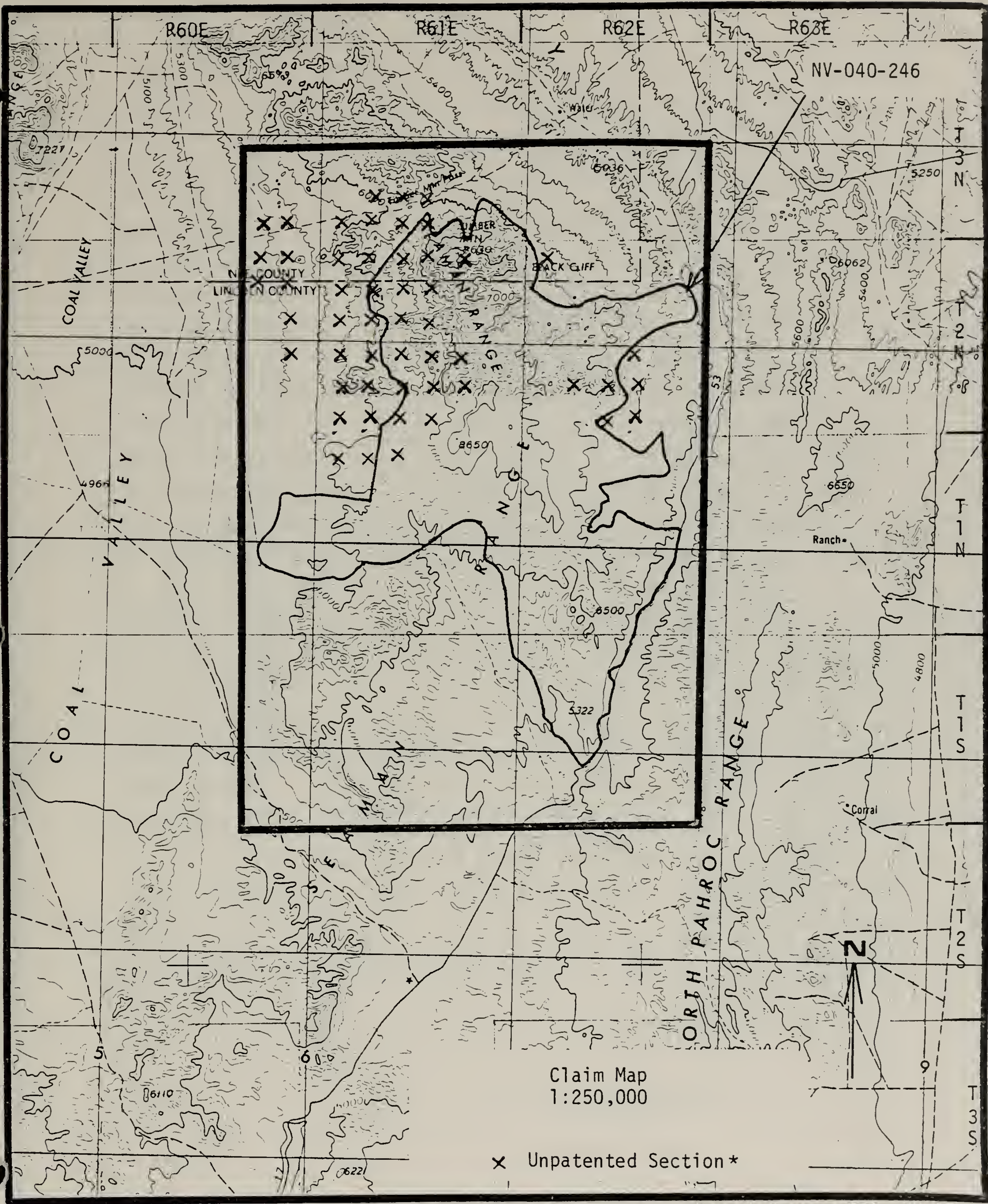
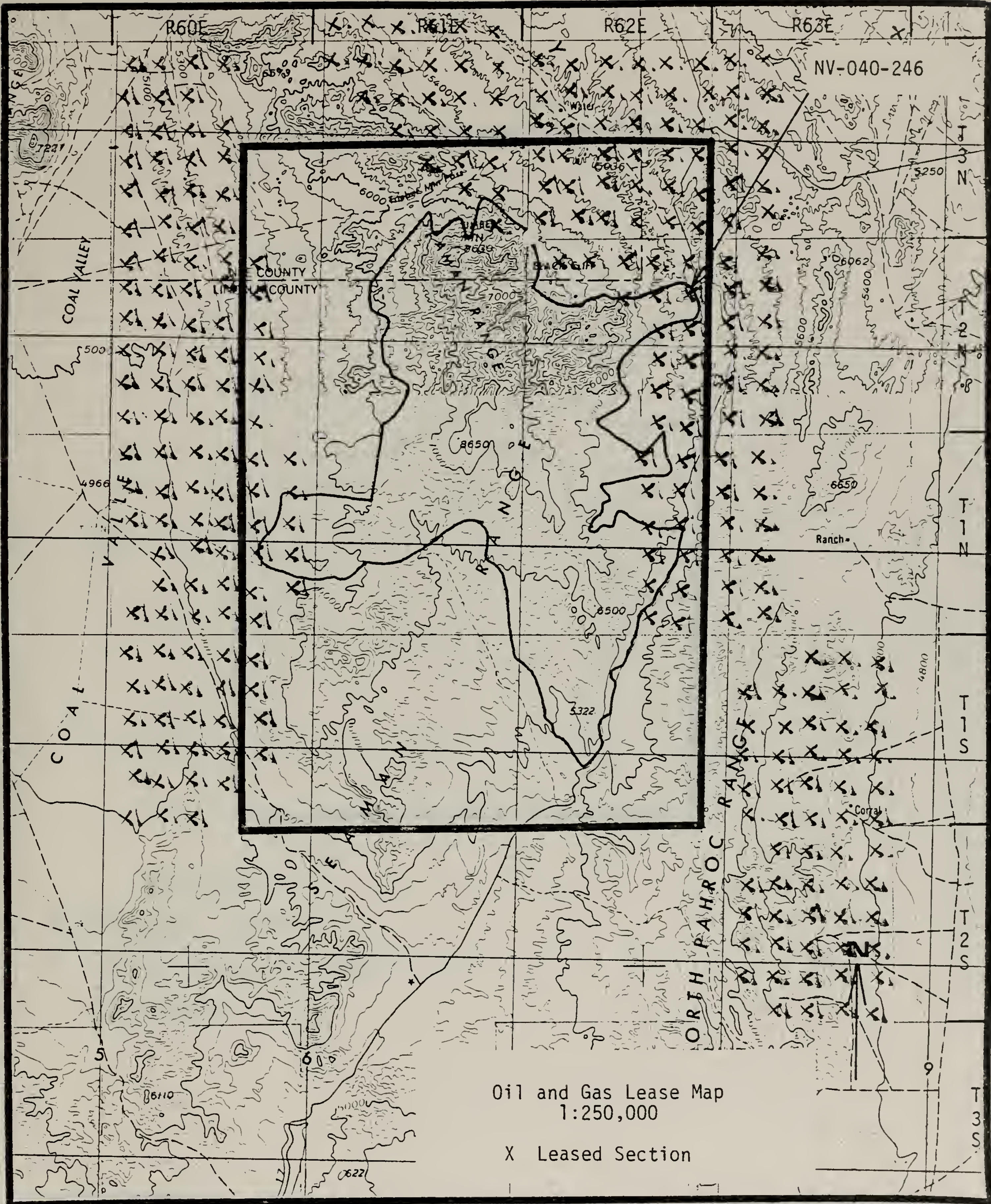
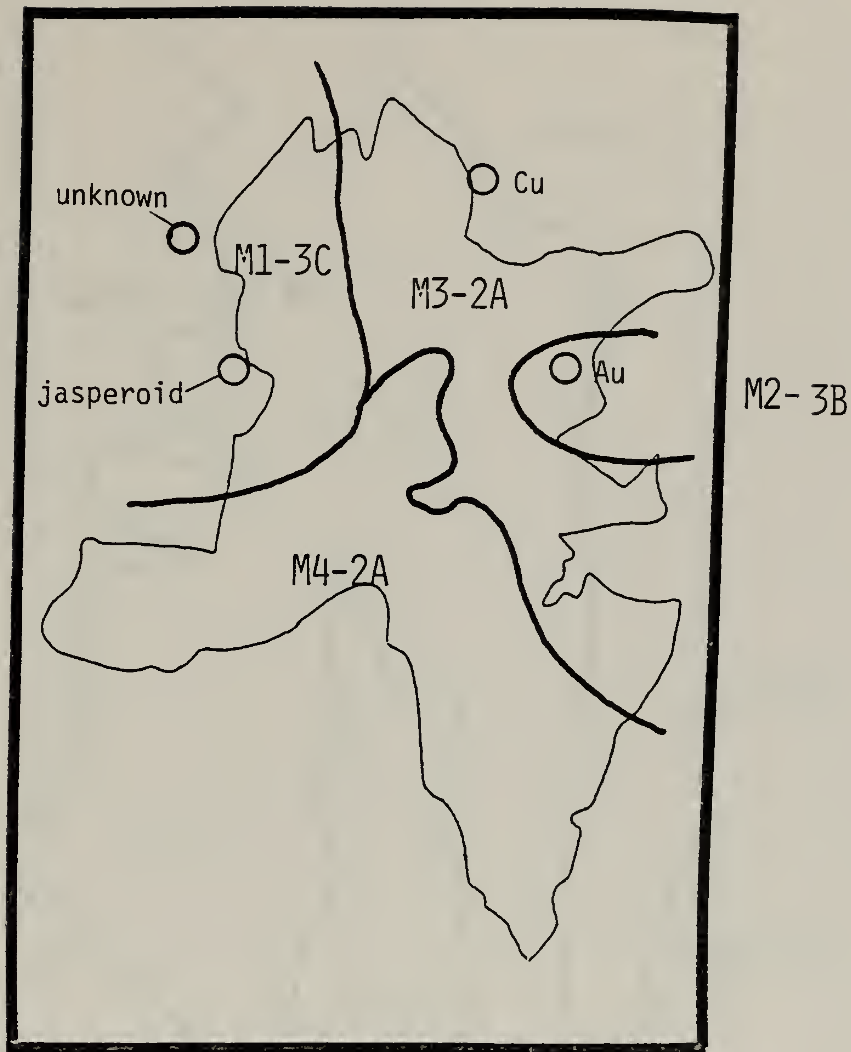


*X denote one or more claims per section

Weepah Spring GRA NV-17


R60E
R61E
R62E
R63E
NV-040-246
T3N
T2N
T1N
T1S
T2S
T3S
NYE COUNTY
LINCOLN COUNTY
COAL VALLEY
NORTH PAHROC RANGE
Ranch
Corral
Oil and Gas Lease Map
1:250,000
X Leased Section

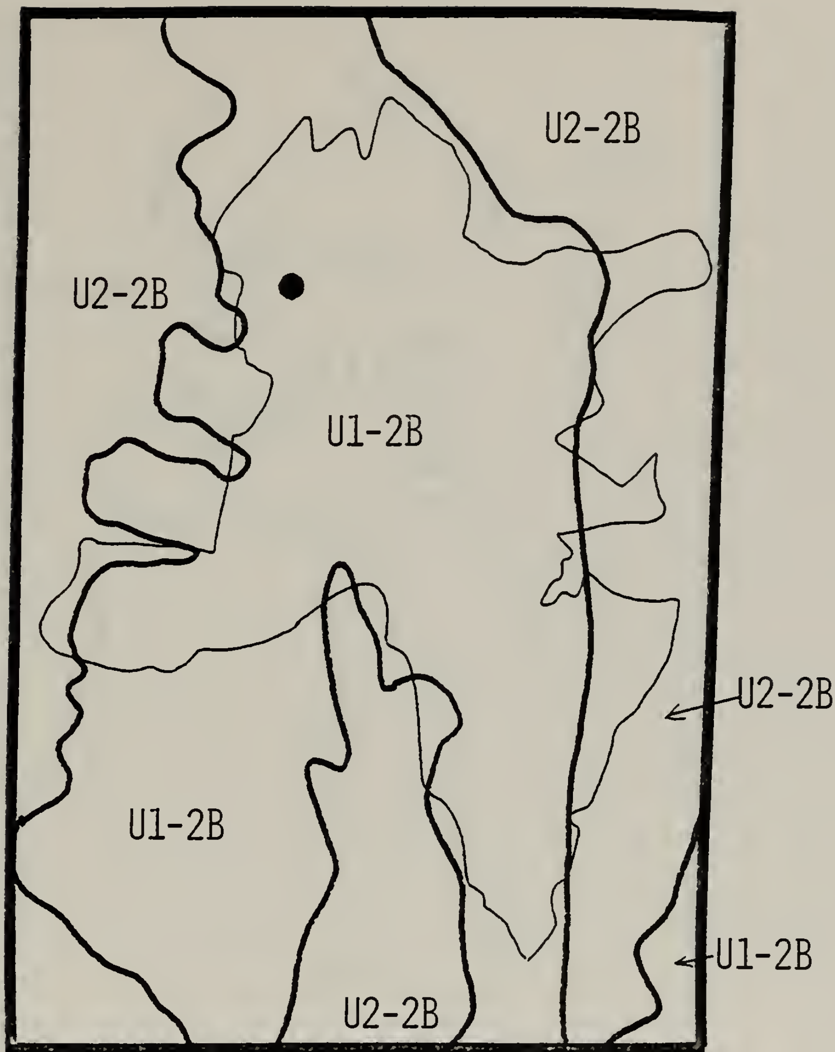


EXPLANATION

○ Occurrence, commodity

▬ Land Classification Boundary

— WSA Boundary



EXPLANATION

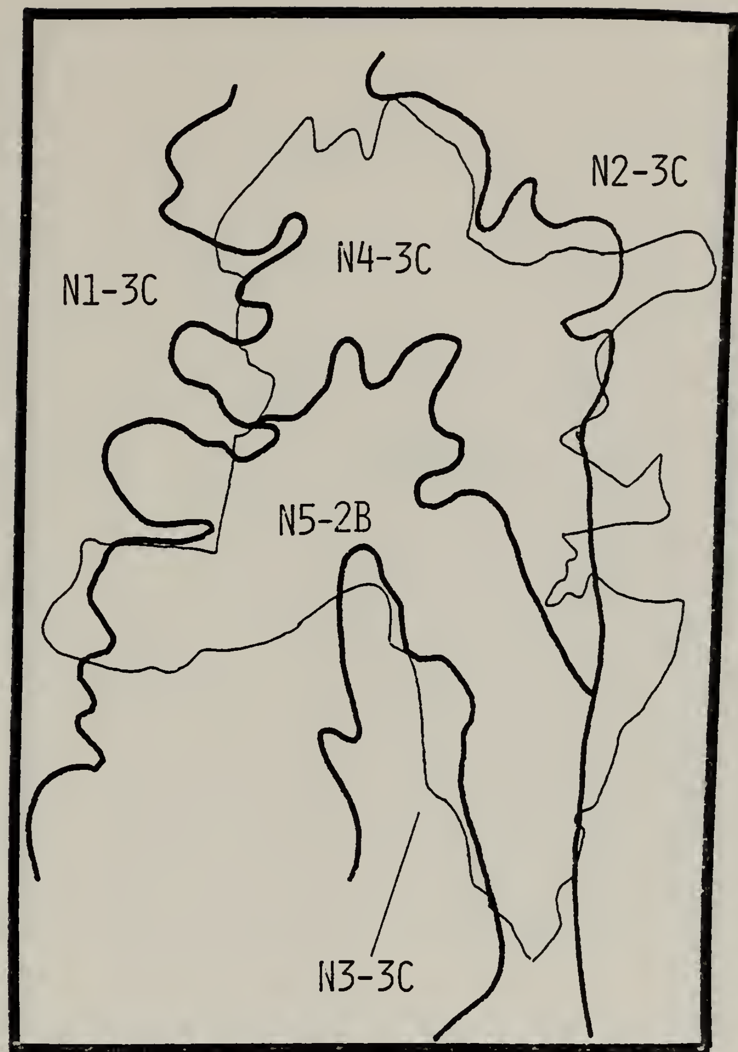
● Uranium Occurrence

━ Land Classification Boundary

— WSA Boundary

Land Classification - Mineral Occurrence Map/Uranium

Weepah Spring GRA NV-17
Scale 1:250,000



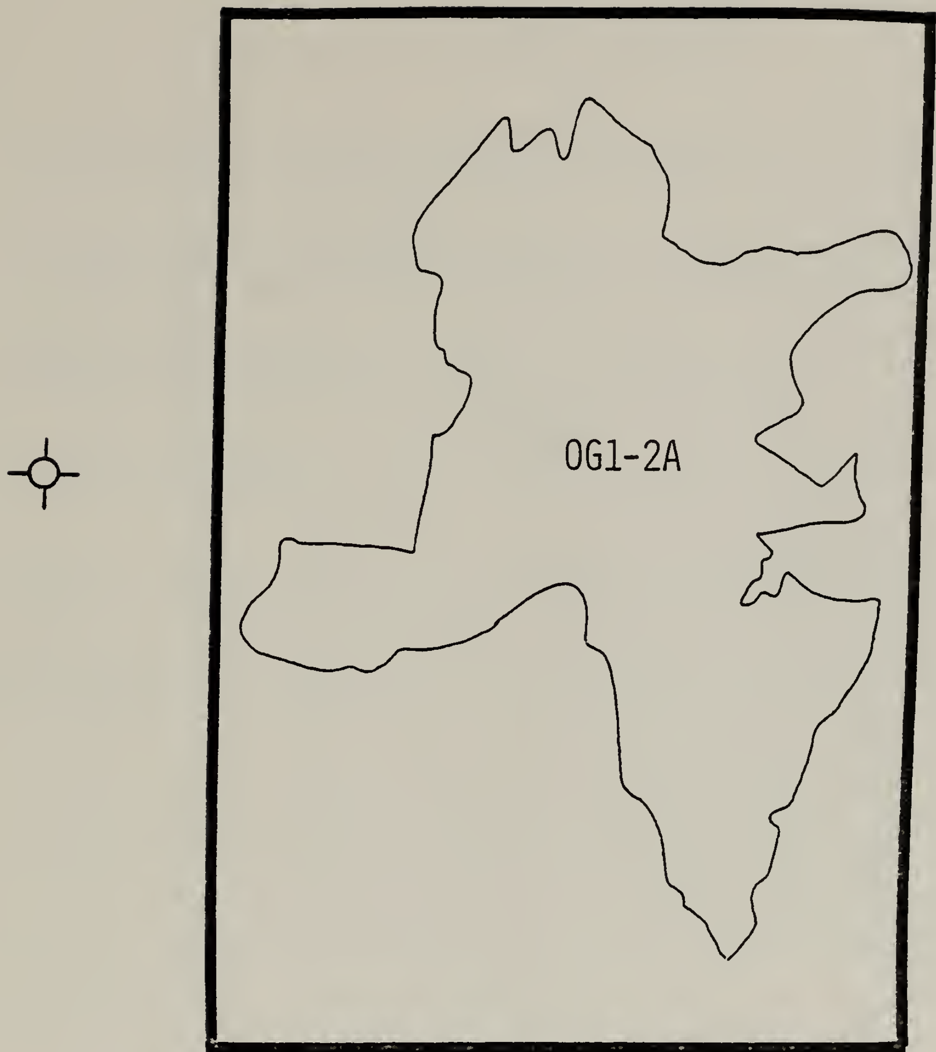
EXPLANATION

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Nonmetallics

Weepah Spring GRA NV-17
Scale 1:250,000



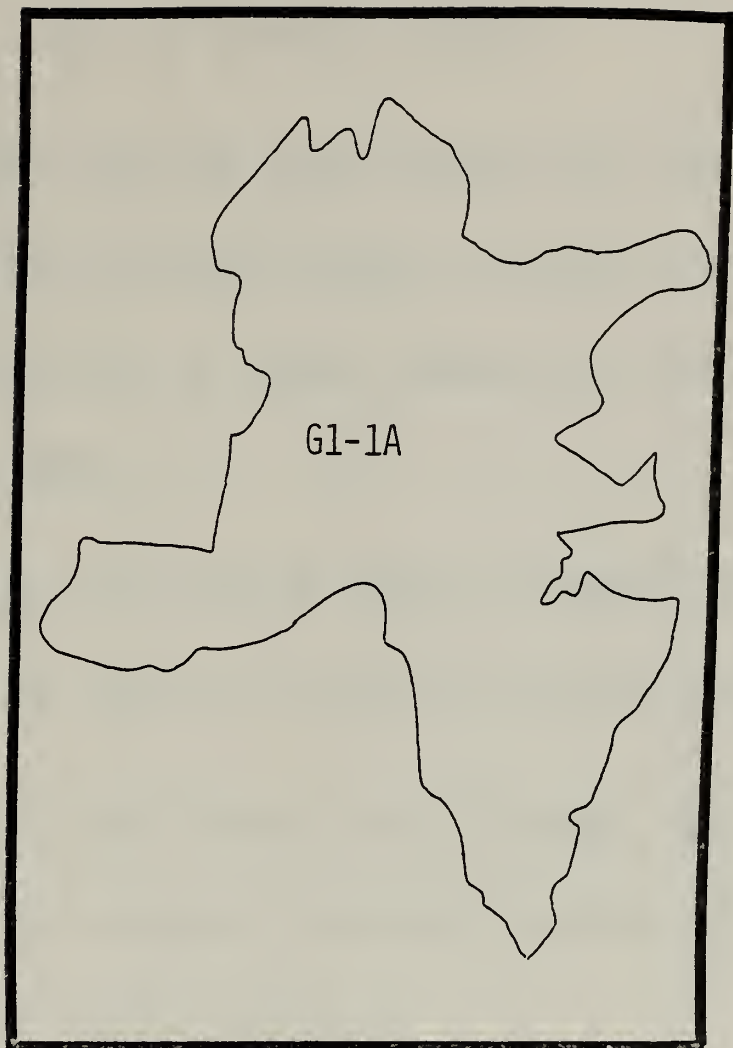
EXPLANATION

-◇- Dry hole

—— WSA and Land Classification Boundary

Land Classification - Mineral Occurrence Map/Oil & Gas

Weepah Spring GRA NV-17
Scale.1:250,000



EXPLANATION

— WSA and Land Classification Boundary

Land Classification - Mineral Occurrence Map/Geothermal

Weepah Spring GRA NV-17
Scale 1:250,000

LEVEL OF CONFIDENCE SCHEME

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

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

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

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

CLASSIFICATION SCHEME

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

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

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

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

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

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

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[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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