University of Nevada, Reno

Nevada Bureau of Mines and Geology

Nevada Bureau of Mines and Geology Open-File Report 14-3

An Updated Mineral and Energy Resource Assessment of the Desert National Wildlife Range Clark and Lincoln Counties, Nevada

John Muntean, Nick Hinz, Tim Cramer, David Davis, Greg Dering, Chris Sladek

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Cover photo: View of tilted late Paleozoic carbonate rocks with Joshua trees in the foreground at the south end of the Las Vegas Range within the Desert National Wildlife Range, Clark County, Nevada. *Photo by John Muntean.*

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Executive Summary

In March 2013, the U.S. Fish and Wildlife Service (USFWS) contracted the Nevada Bureau of Mines and Geology (NBMG) to update the mineral and energy resource assessment of the Desert National Wildlife Range (DNWR). The first such assessment of the DNWR was completed by NBMG in January of 1993, and was published as NBMG Open-File Report 93-2, *Energy and Mineral Resource Assessment of the Desert National Wildlife Range, Eastern Section, Clark and Lincoln Counties, Nevada*. That assessment covered approximately 740,000 acres managed by USFWS east of the Nellis South Range military complex and was required to evaluate lands within the DNWR for withdrawal from mineral entry. In order to extend the period of withdrawal from entry for another 20 years, an updated assessment and report is required. This report provides the needed assessment.

The original 1993 assessment was very comprehensive. That assessment did not find any mineral resources that were commercially exploitable. It did identify areas with potential for discovery of locatable metallic, industrial and energy mineral commodities and leasable and saleable mineral and energy commodities. The original assessment included a review of available data on geologic setting, metallic and industrial minerals, uranium, geothermal resources, and oil and gas resources of the DNWR. It included remote sensing studies of Landsat imagery and extensive helicopter-supported field work of the remote DNWR, which entailed detailed examination, mapping, and sampling of known prospects. It also included refuge-wide geochemical characterization of unaltered rocks to determine background concentrations of elements of economic interest, as well as stream sediment sampling.

The updated assessment reported here did not attempt to duplicate the efforts of the original assessment. It focused on applying advances in the understanding of metallic mineral deposits and geothermal systems over the last 20 years to ensure that the original survey did not miss subtle aspects indicative of large covered resources in the DNWR. These included updated exploration models for metallic mineral deposits and geothermal systems and more sophisticated remote sensing technologies. Field checks and sampling were undertaken, but the field work was not nearly as extensive as the 1992 program, in that there was no helicopter support. The updated assessment of industrial minerals was largely restricted to lithium potential and a preliminary economic assessment that evaluated whether DNWR's vast potential for limestone (for cement) and aggregate could be commercially viable in the next twenty years. For the first time, all the data from the 1992 program and from this current assessment were put into a GIS database that allowed a more thorough analysis of all the different data sets to assess potential.

As in the original 1992-1993 assessment and report, this updated assessment did not identify any commercially exploitable resources. The potential maps for metallic mineral deposits are different than the 1992-1993 assessment, but the potential for such deposits is still low. Except for very low potential for lithium in the Desert Lake playa, no new areas of mineral and energy potential were identified in this study. There is low potential for structurally controlled geothermal systems in the DNWR. If they exist, there is a high probability that the temperature would be <60° C and too low for electricity generation. However, this temperature would be suitable for low-temperature direct-use applications such as heating buildings or greenhouses. Based on our evaluation, the potential for large high-value resources, such as precious metals or large base metal deposits, is very low. In the next few pages, the potential is summarized in series of tables and maps.

Table ES-1. Definitions of Mineral Resource Potential and Certainty of Assessment (taken from NBMG OF93-2)

Table 1-1. Definition of mineral resource potential and certainty of assessment.*

Definitions of Mineral Resource Potential

LOW (L) mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

MODERATE (M) mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH (H) mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN (U) mineral resource potential is assigned to areas where information is inadequate to assign low. moderate, or high levels of resource potential.

NO (N) mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

Definitions of Level of Certainty

A Available information is not adequate for determination of the level of mineral resource potential.
B Available information suggests the level of mineral resource potential.
C Available information gives a good indication of the level of mineral resource potential.
D Available information clearly defines the level of mineral resource potential.

*Modified from Goudarzi 1984.

Relationships between levels of resource potential and certainty.

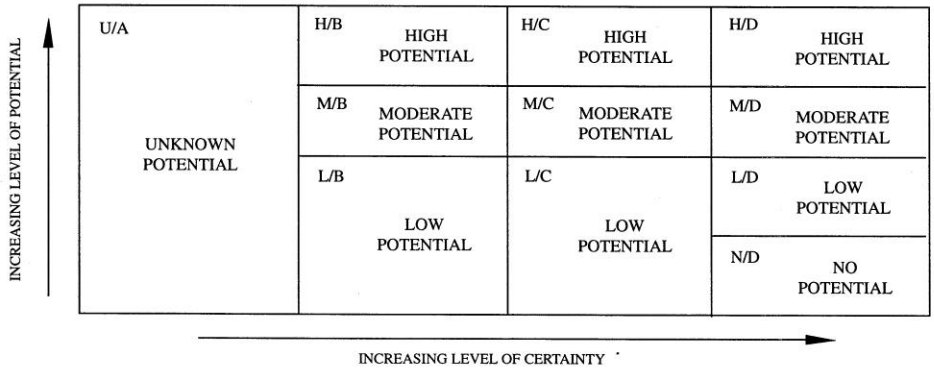

Table ES-2. Potential Areas of Locatable Metallic Mineral Commodities Identified by NBMG in 2014.

Mineral Deposit Type	Area	Resource Potential	Certainty Level	Comments
Zinc-Lead-Copper-Silver Deposits	June Bug mine and Sampson-Juniper prospects	High	D	Defined by well-mapped mines, prospects, stream sediment anomalies and dolomitization mapped by ASTER imagery.
Zinc-Lead-Copper-Silver Deposits	North June Bug	High	C	Down-dip extension of June Bug Mine mineralization underneath the Bird Spring Fm. Defined by stream sediment anomalies and dolomitization mapped by ASTER imagery.
Zinc-Lead-Copper-Silver Deposits	South Las Vegas Range	Low	C	Offset of Valley thrust that is spatially associated with mineralization in the June Bug mine and Sampson-Juniper area
Zinc-Lead-Copper-Silver Deposits	Gass Peak thrust (Castle Rock, Quartzite Hill, Wamp Spring)	Low	C	Apparent control of base metal-silver occurrences along the Gass Peak thrust
Zinc-Lead-Copper-Silver Deposits	Joe May Canyon	Low	C	Defined by stream sediment anomalies, old prospects, and structure
Zinc-Lead-Copper-Silver Deposits	Lake Mine area	Low	C	Defined by occurrence along Gass Peak thrust and sporadic base metal anomalies in rocks and stream sediments
Zinc-Lead-Copper-Silver Deposits	Southeast Indian Springs	Low	C	Defined by stream sediment anomaly
Carlin-type Gold deposit	Lake Mine area	Low	C	Defined by large alteration zone of limonite staining, silicification and As-Hg-Sb-Tl geochemistry
Carlin-type Gold deposit	Central Sheep Range	Low	C	Defined by high As in stream sediments, favorable host rocks, and limonite-clay alteration interpreted from ASTER imagery
Carlin-type Gold deposit	Indian Springs	Low	C	Defined by high As in streams and rocks

Table ES-3. Potential Areas of Locatable Industrial Mineral Commodities Identified by NBMG in 2014.

Mineral Resource	Area	Resource Potential	Certainty Level	Comments
Lithium	Desert Lake playa	Low	C	Anomalous lithium in playa sediments. Brine at depth,, if present, should be sampled
High-calcium Limestone	Areas underlain by Guilmette Fm.	High	C	No change from NBMG 1993 report. Defined by chemical content, lithology, and stratigraphy.
Cement Limestone	Areas underlain by Guilmette Fm., Mississippian limestone, and Bird Spring Fm.	High	C	No change from NBMG 1993 report. Defined by chemical content, lithology, and stratigraphy.
Dolomite	Areas underlain by Nopah Fm., Smokey member	High	C	No change from NBMG 1993 report. Defined by chemical content, lithology, and stratigraphy.
Silica	DNWR	Low	D	No change from NBMG 1993 report.
Building Stone	DNWR	Moderate	B	No change from NBMG 1993 report. No specific deposits of unique stone found.
Lightweight Aggregate	DNWR	Low	D	No change from NBMG 1993 report. No known occurrences of suitable material.
Perlite	DNWR	Low	D	No change from NBMG 1993 report. No known occurrences of suitable material.
Gypsum	DNWR	Low	D	No change from NBMG 1993 report. Unfavorable stratigraphy.
Clay	DNWR	Low	D	No change from NBMG 1993 report. No known occurrences of sufficient purity.
Borate Minerals	DNWR	Low	D	No change from NBMG 1993 report. No known occurrences.
Zeolites	DNWR	Low	D	No change from NBMG 1993 report. No ore grade occurrences

Table ES-4. Potential Areas of Leasable and Saleable Energy and Mineral Commodities Identified by NBMG in 2014.

Mineral Resource	Area	Resource Potential	Certainty Level	Comments
Geothermal	DNWR	Low	C	Several areas with favorable structural settings that could host blind geothermal systems. Temperature likely not high enough for power generation, but could be used for heating.
Oil and Gas	DNWR	Low	C	Hydrocarbon shows near DNWR, but rocks sampled in DNWR have low source rock and preservation favorability.
Lithium	Desert Lake playa	Low	C	Anomalous lithium in playa sediments. Brine at depth, if present, should be sampled.
Sand and Gravel	Areas underlain by Quaternary alluvium	High	C	No change from NBMG 1993 report. Coarse alluvium with Horse Spring Fm. Or Tertiary volcanic rocks in source area.
Sand and Gravel	Areas underlain by Quaternary alluvium	Moderate	B	No change from NBMG 1993 report. Coarse alluvium with Tertiary volcanic rocks in source area.
Sand and Gravel	Areas underlain by Quaternary alluvium	Low	B	No change from NBMG 1993 report. Coarse alluvium with Horse Spring Fm. in source area.
Sand and Gravel	Areas underlain by Quaternary alluvium and playa sediments	Low	C	Fine-grained sediment.

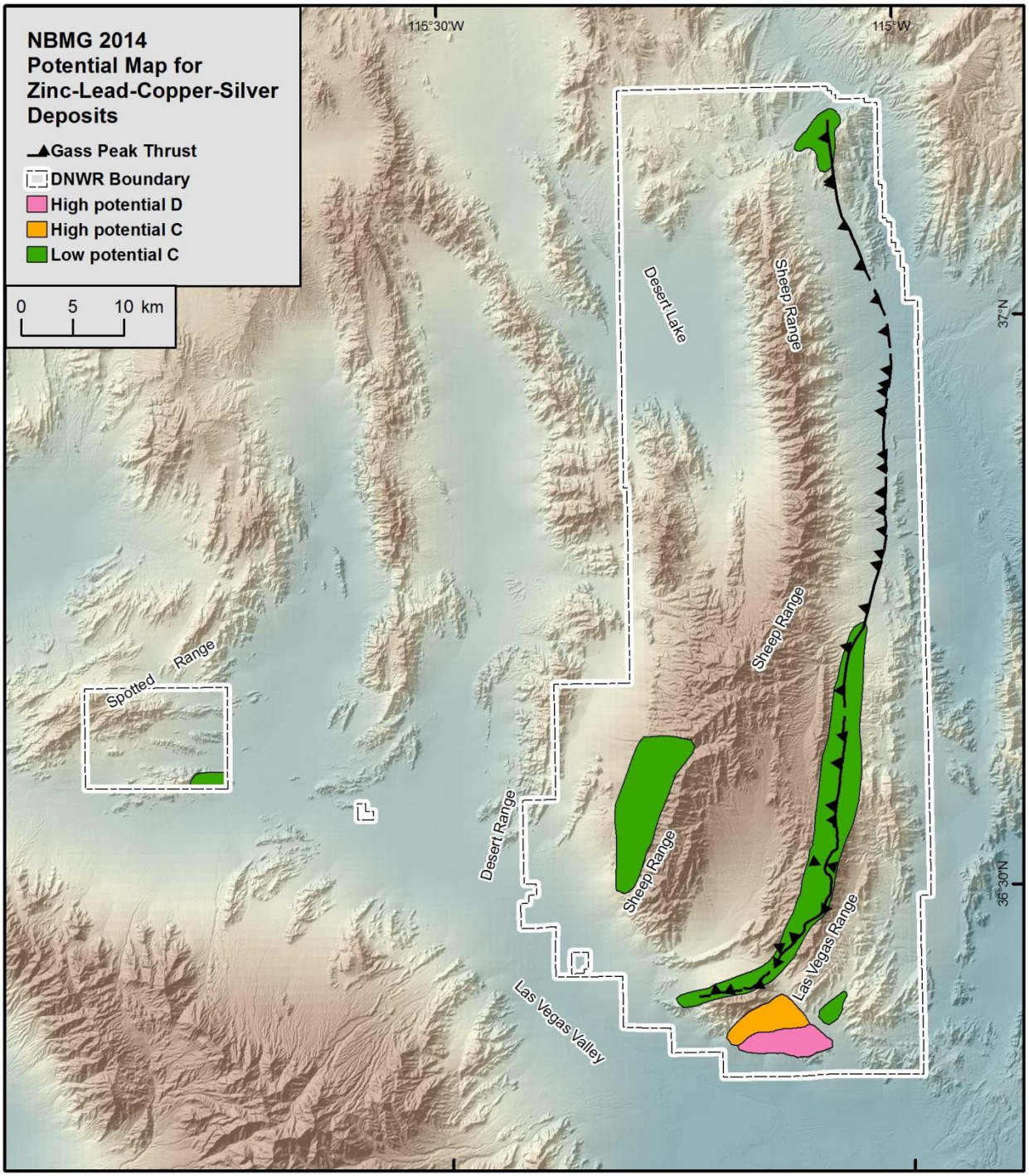

Figure ES-1. Map showing potential for zinc-lead-copper-silver deposits in the DNWR.

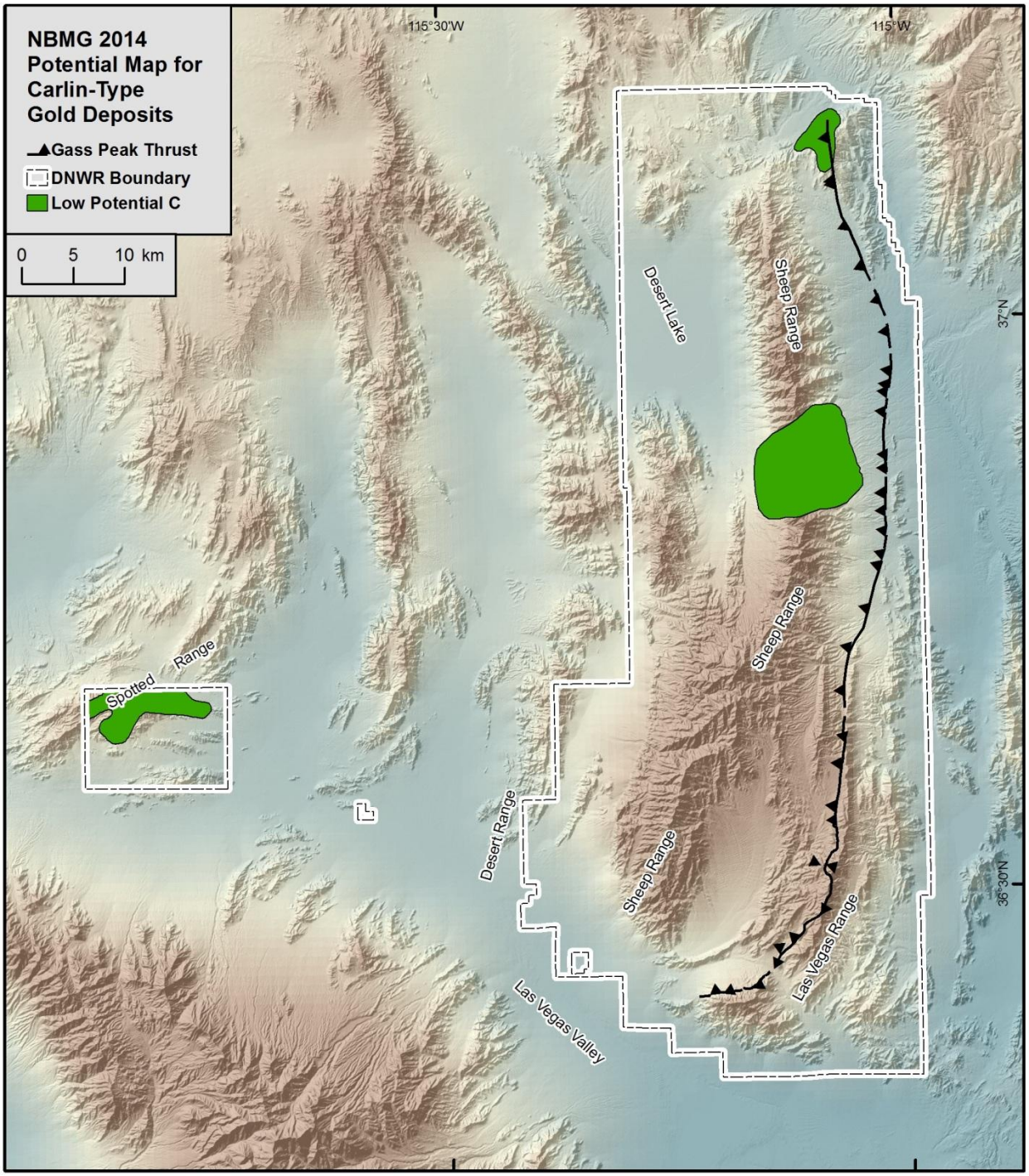

Figure ES-2. Map showing potential for Carlin-type gold deposits in the DNWR.

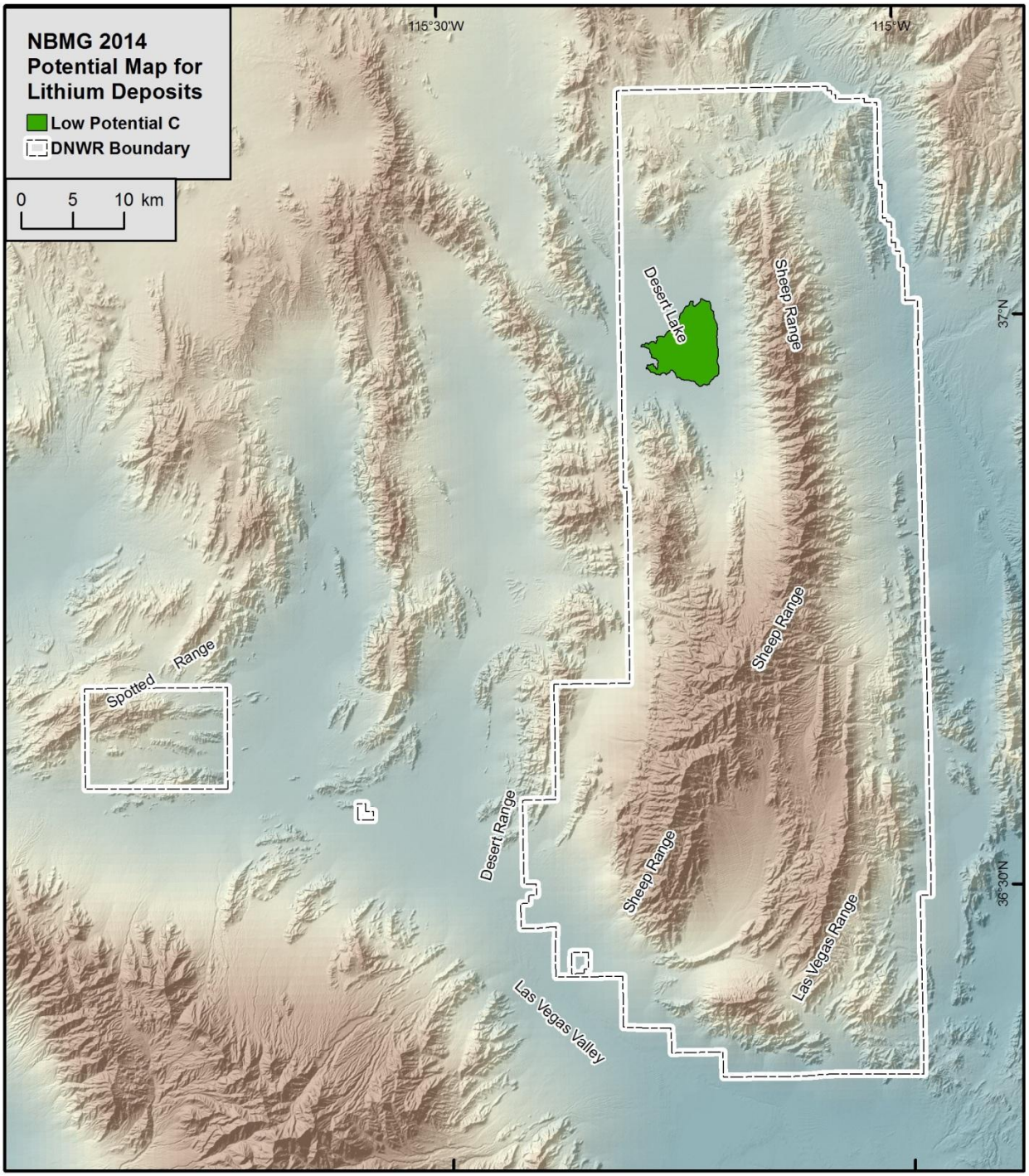

Figure ES-3. Map showing potential for lithium in the DNWR.

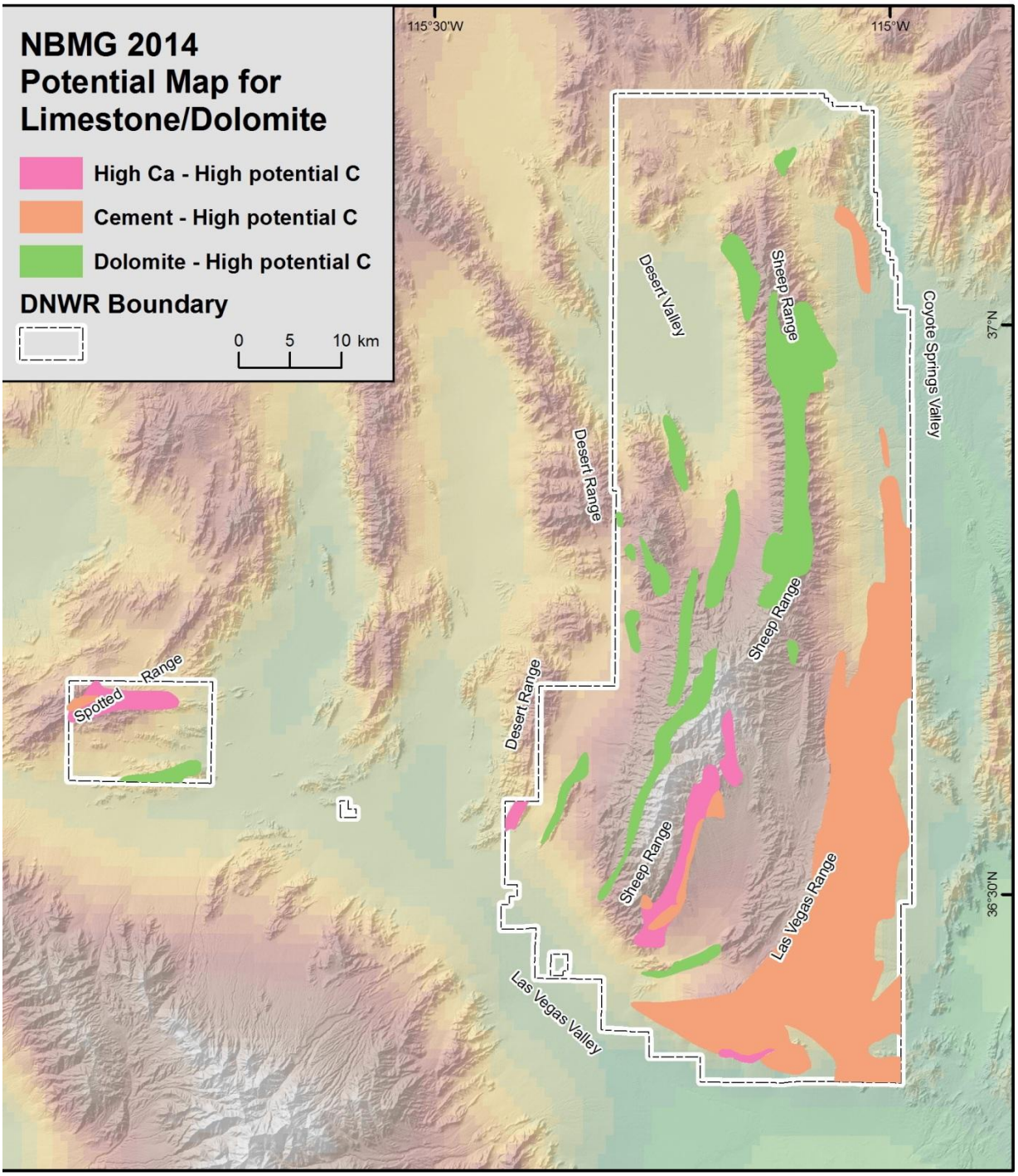

Figure ES-4. Map showing potential for limestone and dolomite in the DNWR. No change from NBMG 1993 report.

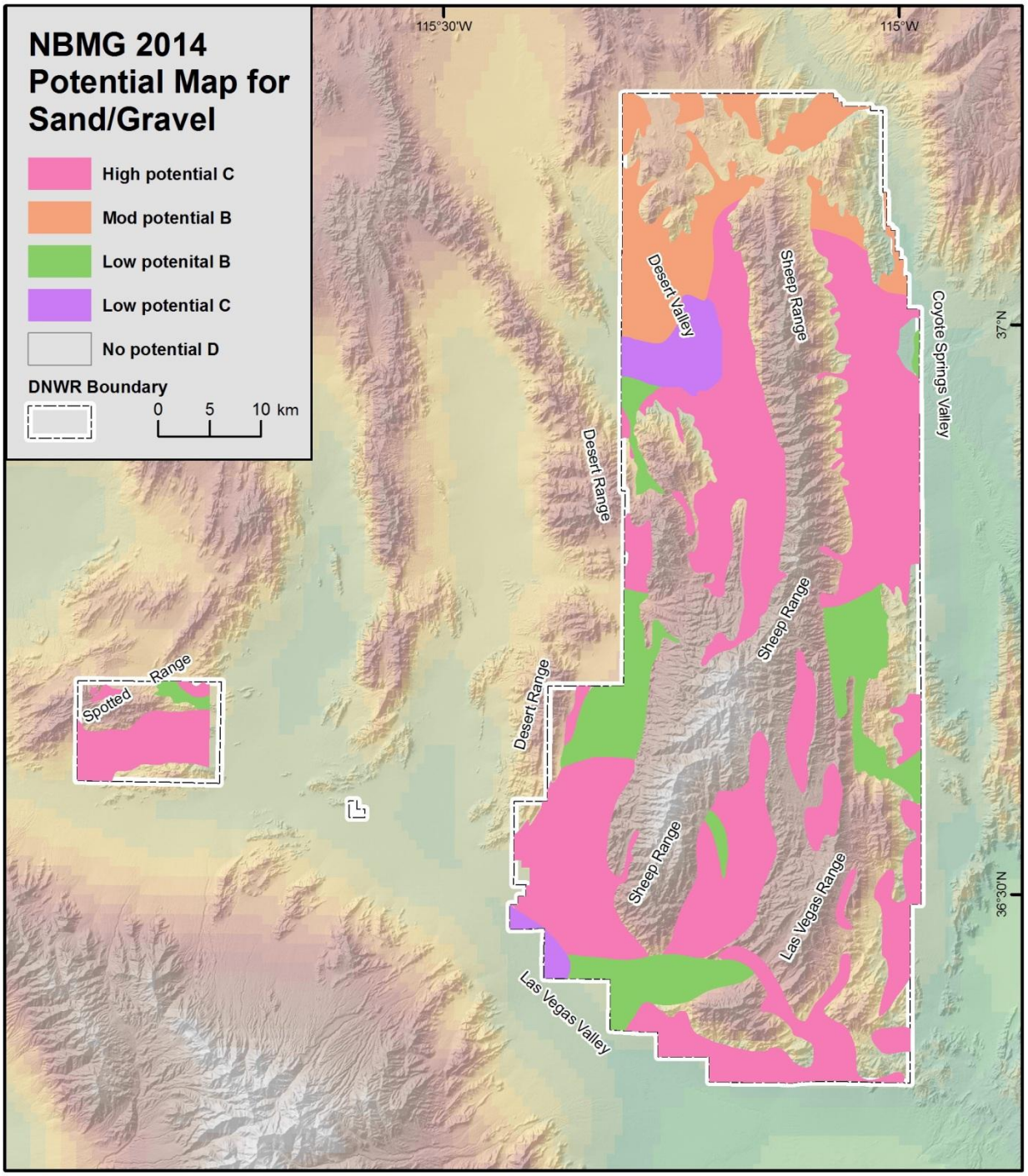

Figure ES-5. Map showing potential for sand and gravel in the DNWR. No change from NBMG 1993 report.

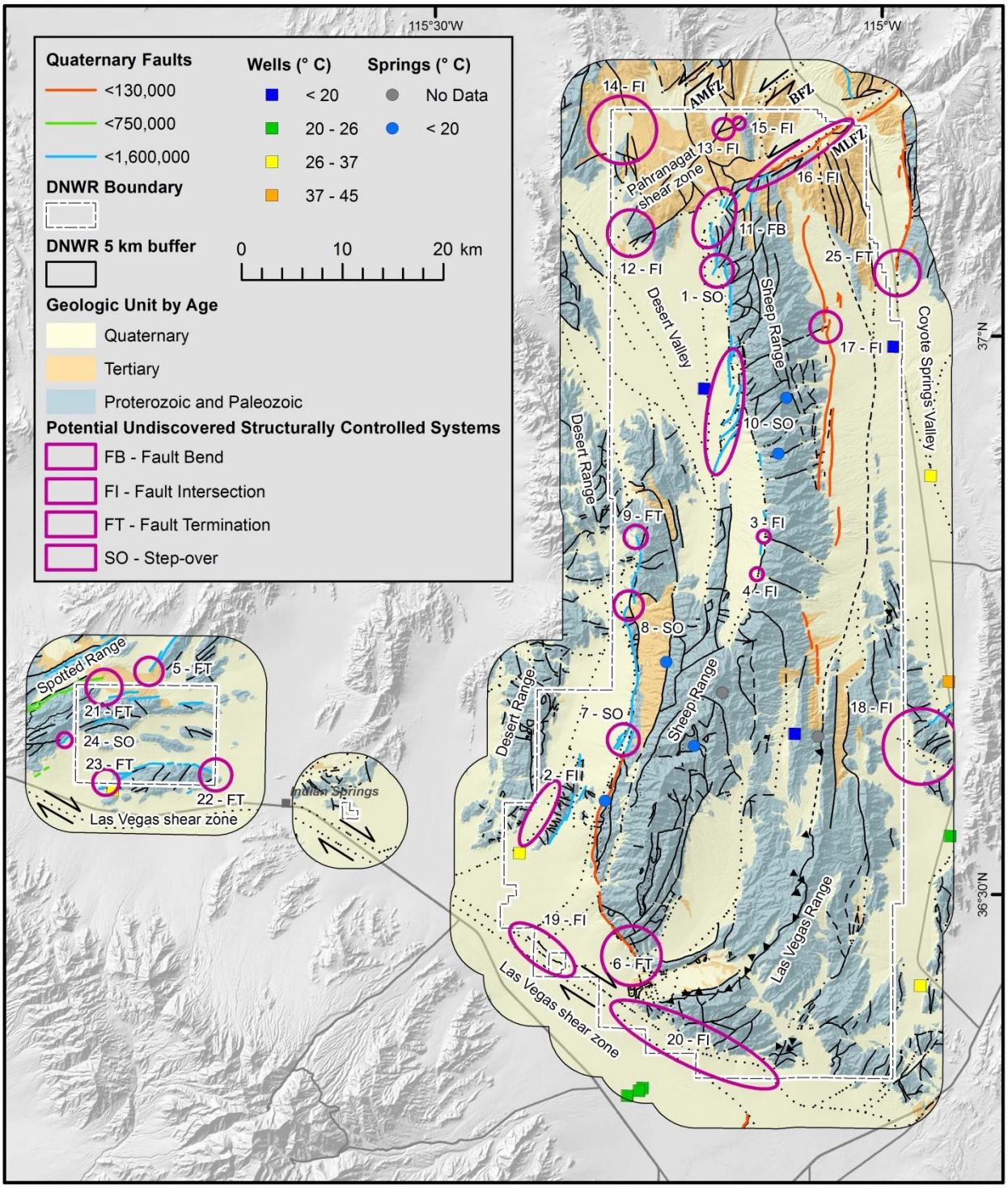

Figure ES-6. Map showing potential for blind geothermal systems in the DNWR (magenta circles and ovals). See caption in Figure 54 for more detailed explanation.

Introduction

Purpose of Investigation

The U.S. Fish and Wildlife Service (USFWS) proposes to extend for another 20 years the period of withdrawal from mineral entry on approximately 740,000 acres of the Desert National Wildlife Range (DNWR), in order to protect these lands from impacts of mining and energy development. A primary requirement to obtain the extension is completion of an updated mineral and energy assessment report that follows the U.S. Bureau of Land Management guidelines for an intermediate level of detail assessment. The purpose and objective of this project is to provide an update of the original mineral and energy assessment, which was completed and released by the Nevada Bureau of Mines and Geology (NBMG) in 1993. The lands studied during this investigation consist of two parts and are illustrated in Figure 1. The largest portion lies east of the Nevada Test and Training Range (NTTR), which is a part of the Nellis Air Force Base. The other much smaller portion is located in the southwest corner of the NTTR, which will be referred to in this report as Indian Springs. As Figure 1 shows, the study does not cover the entire DNWR, much of which is administered by the Air Force. Throughout this report, when reference is made to the DNWR, we are describing only the large eastern portion and the Indian Springs fraction, the yellow-shaded, cross-hatched regions on Figure 1.

Location

The DNWR is located in northwestern Clark County and southeastern Lincoln County, Nevada and lies within a broad, U-shaped mountainous area bounded by U.S. Highway 95 on the southwest, U.S. Highway 93 on the east, and Interstate 15 on the southeast (Fig. 1). The southern boundary of DNWR is located about 10 miles north of the city of Las Vegas, and the major entry point to DNWR, Corn Creek Field Station, is about 27 miles by highway and improved gravel road from the city. The range is partitioned into three parts. A western section of about 760,000 acres, including the Spotted, Pintwater, and Desert Ranges, lies within the Nevada Test and Training Range, which is a part of the Nellis Air Force Base. That portion is closed to public entry. The eastern section covers about 674,000 acres, including the East Desert, Sheep, and Las Vegas Ranges, is administered by USFWS. Although the eastern portion is open to public access, it is currently being administered as a wilderness area, and there are access restrictions. A third section, a 66,000-acre parcel of land in the southern Spotted Range north of Indian Springs is also administered by the USFWS, but it is surrounded by Nellis Air Force Base and public access to this area is limited.

Land Status

The Desert Game Range was established by Executive Order on May 30, 1936. The purpose was to protect a herd of about 18,000 desert bighorn sheep and their habitat. The DNWR was established by Public Land Order 4079 on August 26, 1966. An application from withdrawal from mineral entry was filed for the DNWR in 1974. The application expired in October 1991. As part of the renewal process to continue the withdrawal, the NBMG carried out the first mineral and energy assessment of the DNWR in 1992. The legal land descriptions for lands subject for the current application for continuation of withdrawal from mineral entry are listed in Appendix A.

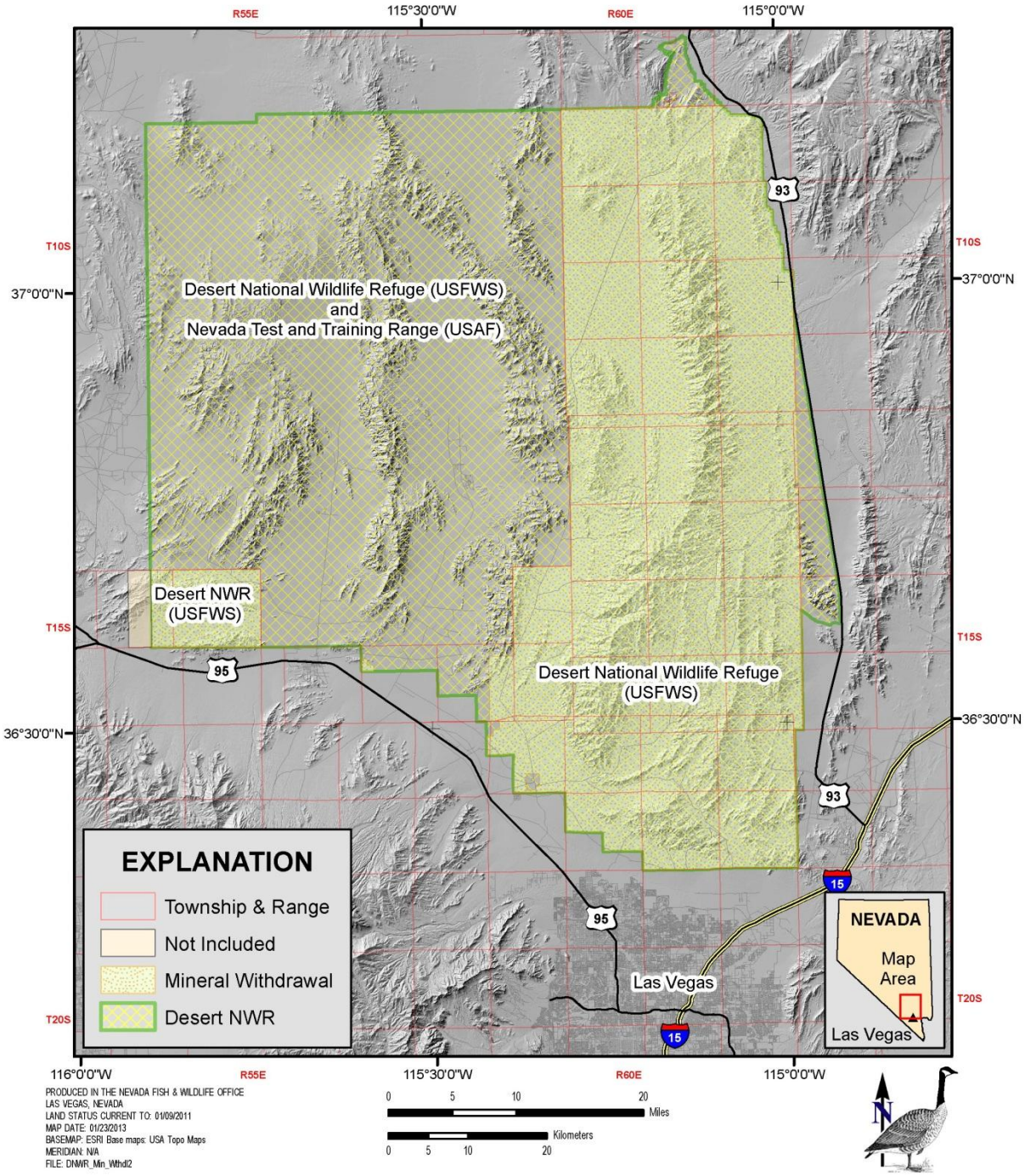

Figure 1. Map showing location of the Desert National Wildlife Range (cross-hatched area) and the portion that is evaluated in this report for its mineral and energy potential (stippled yellow shade). Figure was generated by the U.S. Fish and Wildlife Service.

Physiographic Setting and Access

The DNWR is situated in the southern part of the Great Basin region of the Basin and Range physiographic province, a region characterized by a series of generally north-trending mountain ranges separated by wide, alluvial valleys. The physiography of the DNWR and its limited road access are illustrated in Figure 2. It shows geographic features and locations discussed in the text.

Most of the Great Basin is an area of internal drainage. With the exception of the northern Sheep Range, however, much of the DNWR is cut by stream networks that lead into either Las Vegas Wash or Pahranagat Wash and, eventually, drain to the Colorado River. Drainages on the western slope of the northern Sheep Range lead to Desert Lake, a usually dry playa lake occupying Desert Valley (Fig. 2).

The DNWR contains portions of seven mountain ranges north of Las Vegas Valley. From west to east across the southern portion of the Wildlife Range, these are the Spotted Range, Pintwater Range, Desert Range, East Desert Range, Sheep Range, and Las Vegas Range. Low portions of the Pahranagat and East Pahranagat Ranges extend southward into the northern portion of the DNWR. The Black Hills, a group of low hills rising from the valley between the Desert Range and the southern Sheep Range, are also within the area.

Elevations range from about 2,450 feet at the margin of Las Vegas Valley on the southern boundary of the DNWR to 9,921 feet atop Hayford Peak, a difference of some 4,912 feet. Elevations in the Las Vegas Range reach 7,132 at Quartzite Peak and 6,942 feet at Gass Peak. The southern face of the Las Vegas Range, south of Gass Peak, is quite rugged, where there is about 4,000 feet of relief. Saddle Mountain, in the East Desert Range, reaches an elevation of 7,034 feet and rises about 2,100 feet above the valley floor.

There is only limited road access within the large eastern portion of the DNWR. The smaller Indian Springs fraction had no road access in the fall of 2013. On the eastern portion of the DNWR, roads are two-track dirt roads that are only periodically maintained. Commonly stretches of road are closed, as was the case in the fall of 2013. Other roads are have not been maintained for years and are essentially impassable. It can take three to four hours to drive along the Alamo road on the west side of DNWR from the Corn Creek Field Station to the north end of DNWR.

Summary of 1992 Mineral and Energy Assessment

The original energy and mineral assessment was accomplished over a 12-month period. Eight geologists and geochemists worked on the project. It involved compilation of available information on geology, geophysics, geochemistry and mineral resources of the study area. Landsat TM satellite imagery was used to highlight geology and structural patterns and attempted to identify zones of hydrothermal alteration, which then focused subsequent field checks. A geochemical characterization study, which involved sampling of major lithologic units present in the study area, provided baselines values for evaluation of geochemical sampling programs. Field examinations of identified mines, prospects, and mineral occurrences within the project area were carried out. Select samples of what appeared to be ore-grade material were sampled to provide information on metals and other elements of interest. Accessible mine workings were examined, sampled, and mapped. Using data generated from literature review, imagery interpretation, and mineral-site examinations, NBMG designed a stream

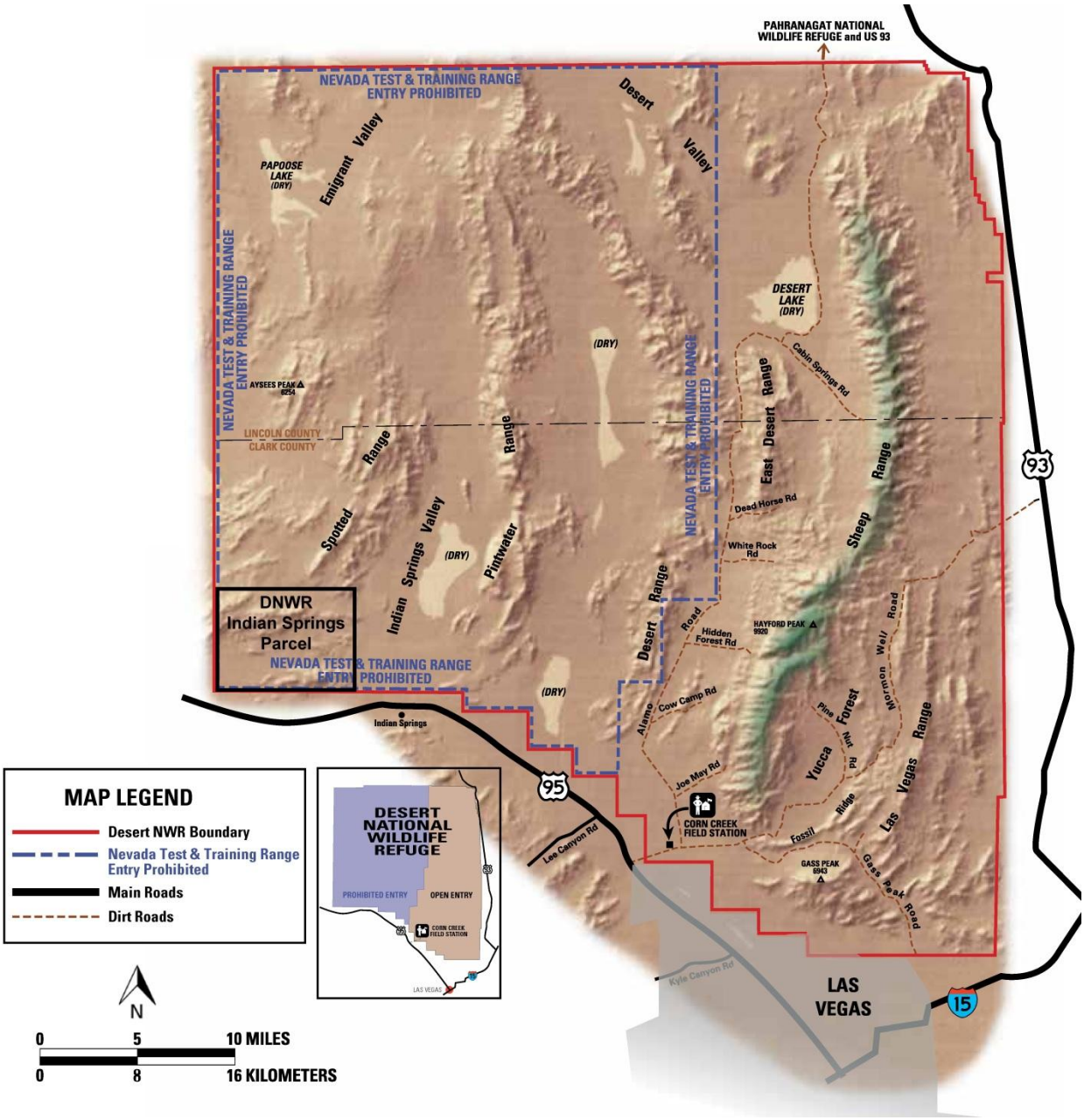

Figure 2. Map showing locations and physiographic features of the Desert National Wildlife Range referred to in the text. Also shows road access for the larger, eastern portion of the refuge. Slightly modified from a figure generated by the U.S. Fish and Wildlife Service.

sediment program to investigate areas of interest and to provide background data for regional evaluation purposes. Much of the field examinations and sampling were supported by helicopter use.

From these data, areas of mineral potential were defined and assessments were made of the types of known and undiscovered mineral occurrences that may be present at the DNWR, as well as the favorability for their occurrence. The levels of mineral resource potential and certainty of assessment were assigned using a system described in Goudarzi (1984) and summarized in Table 1.

Table 1. Definitions of Mineral Resource Potential and Certainty of Assessment (taken from NBMG OF93-2)

Table 1-1. Definition of mineral resource potential and certainty of assessment.*

Definitions of Mineral Resource Potential

LOW (L) mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

MODERATE (M) mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

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B Available information suggests the level of mineral resource potential.
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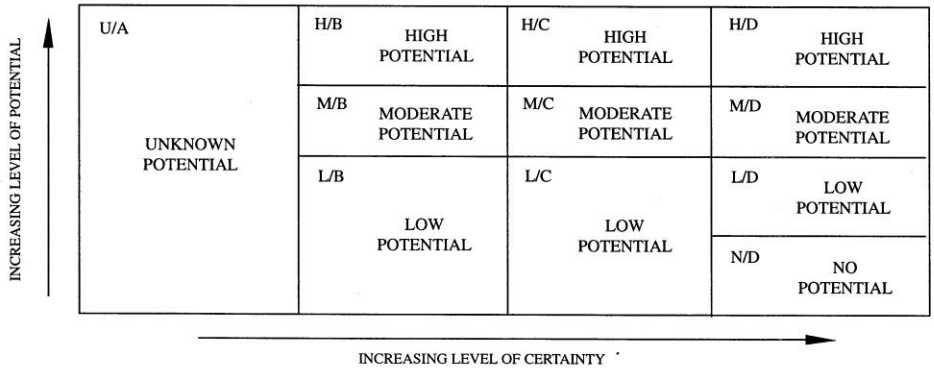
*Modified from Goudarzi 1984.

Relationships between levels of resource potential and certainty.



Based on the assessment NBMG identified 17 potential areas for locatable metallic mineral commodities, nine for base metals, and eight for precious metals (Table 2; Figs. 3-4). Only three of the 17 areas had potential that was considered high or moderate, all of which were for base metals. In addition, it identified four large areas that were considered to have high or moderate potential for high-calcium limestone or cement limestone. All other locatable industrial minerals commodities were determined to have low potential, except for building stone, though no specific deposits of unique stone were identified (Table 3; Fig. 5). Regarding leasable energy, potential for geothermal, and oil and gas were considered low at the DNWR. Moreover, potential for saline minerals was considered low. However, two areas were considered to have high or moderate potential for saleable sand and gravel (Table 4; Fig. 6). Despite the comprehensive assessment by NBMG, no areas of commercially exploitable resources were found to be present.

Table 2. Potential Areas of Locatable Metallic Mineral Commodities Identified by NBMG in 1993. (taken from NBMG OF93-2)

Table 1-1. Potential areas for locatable metallic mineral commodities.

Mineral Resource	Area	Resource Potential	Certainty Level	Map	Comments
Base Metals	June Bug-Sampson-Anomaly Wash	High	D	Fig. 9-1	Defined by mines and prospects, alteration, and stream sediment anaomalies. Past production.
	North June Bug	High	C	Fig. 9-1	Defined by stream sediment anomalies.
	South Las Vegas Range	Low	C	Fig 9-1	Defined by favorable stratigraphy only.
	Joe May-Deadman	Low	C	Fig. 9-1	Defined by stream sediment anomalies and structure.
	Lower Pahranagat Lake	Moderate	C	Fig. 9-1	Defined by stream sediment and rock anomalies and alteration.
	Long Canyon	Low	C	Fig. 9-1	Defined by rock and stream sediment anomalies.
	Castle Rock-Quartzite Hill	Low	C	Fig. 9-1	Defined by rock anomalies.
	North of Desert Lake	Low	C	Fig. 9-1	Defined by stream sediment anomalies.
	South Indian Springs	Low	C	Fig. 9-1	Defined by stream sediment anomalies.
Precious metals	JuneBug-North June Bug-Sampson-Anomaly Wash	Low	C	Fig. 9-2	Defined by stream sediment anomalies. Very minor production recorded.
	Joe May-Deadman	Low	C	Fig. 9-2	Defined by stream sediment anomalies.
	Cabin Spring	Low	C	Fig. 9-2	Defined by stream sediment anomalies.
	Lower Pahranagat Lake	Low	C	Fig. 9-2	Defined by stream sediment anomalies.
	South of Medsger Pass	Low	C	Fig. 9-2	Defined by stream sediment anomalies.
	North of Desert Lake	Low	C	Fig. 9-2	Defined by stream sediment anomalies.
	South Indian Springs	Low	C	Fig. 9-2	Defined by stream sediment anomalies.
	North Indian Springs	Low	C	Fig. 9-2	Defined by stream sediment anomalies.

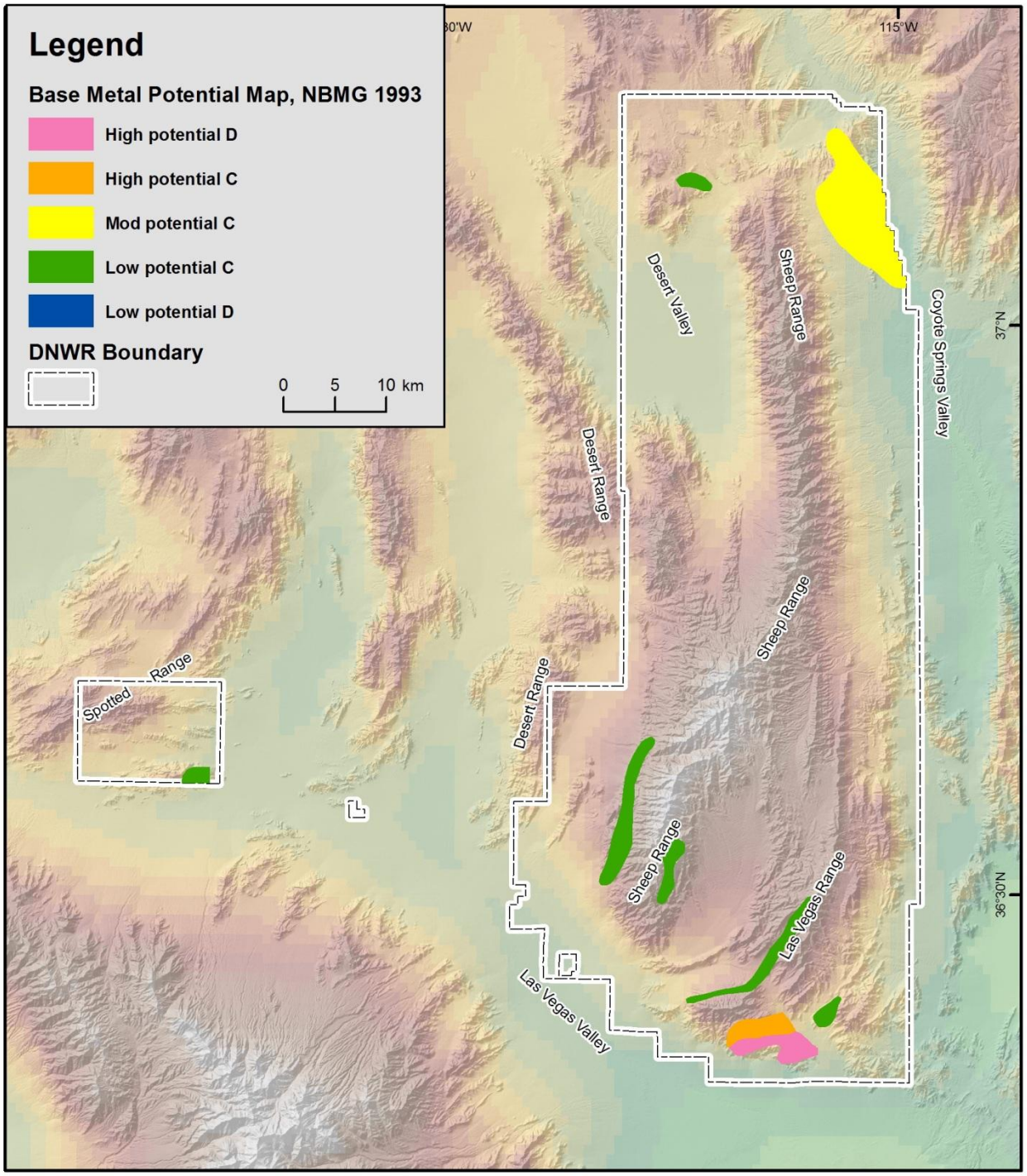


Figure 3. Map showing base metal potential as reported in original 1993 NBMG assessment report.

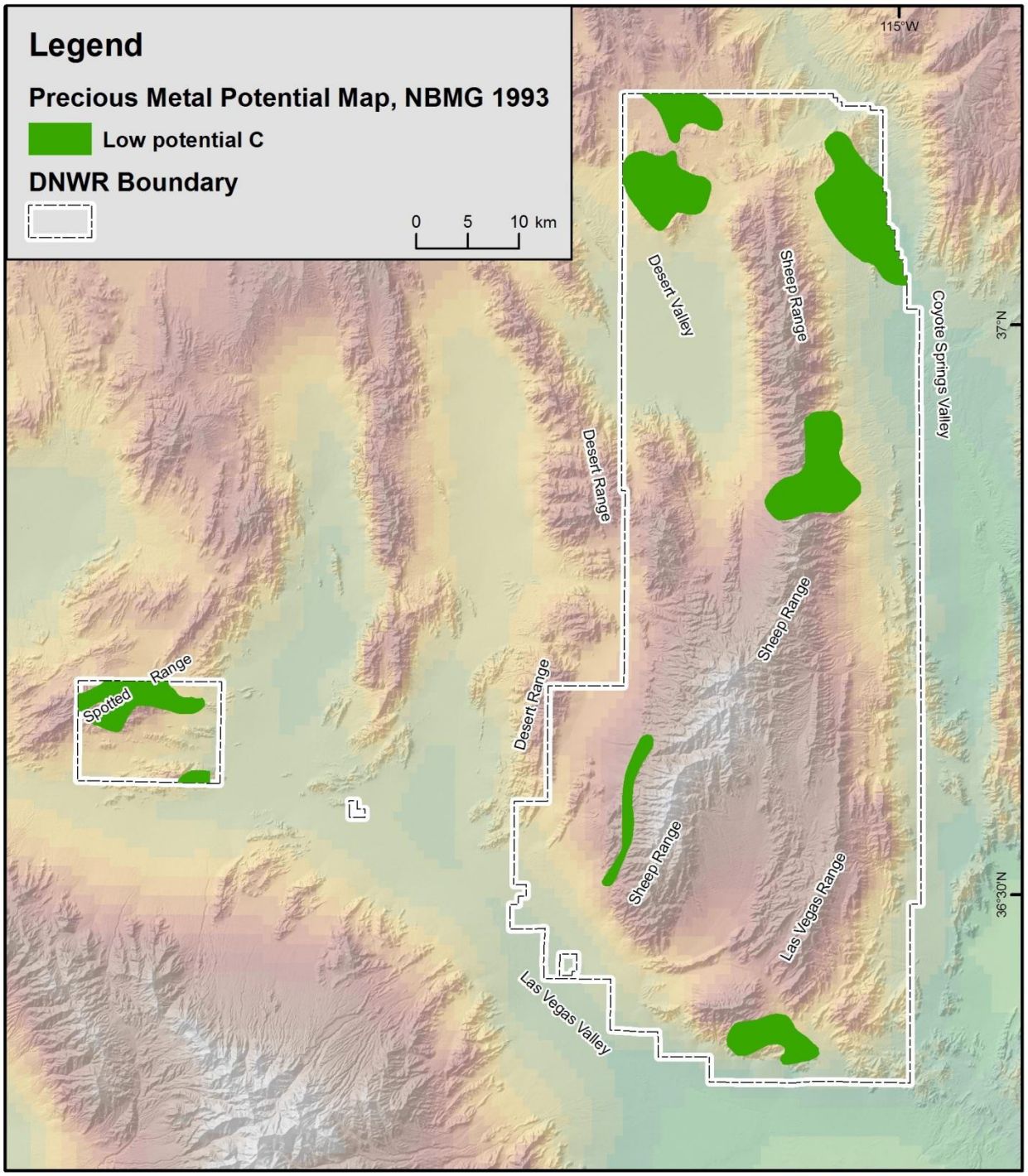


Figure 4. Map showing precious metal potential as reported in original 1993 NBMG assessment report.

Table 3. Potential Areas of Locatable Industrial Mineral Commodities Identified by NBMG in 1993. (taken from NBMG OF93-2)

Table 1-2. Potential areas for locatable industrial and energy mineral commodities.

Mineral Resource	Area	Resource Potential	Certainty Level	Map	Comments
High-calcium Limestone	Areas underlain by Guilmette Formation	High	C	Fig. 9-3	Defined by chemical content, lithology, and stratigraphy.
Cement Limestone	Areas underlain by Guilmette Formation	High	C	Fig. 9-3	Defined by chemical content, lithology, and stratigraphy. Same areas as those that have high potential for high-calcium limestone.
	Areas underlain by Mississippian limestone	High	C	Fig. 9-3	Defined by chemical content, lithology, stratigraphy, and absence of alteration.
	Areas underlain by Bird Spring Formation	Moderate	C	Fig. 9-3	Defined by chemical content, lithology, and stratigraphy.
Dolomite	Areas underlain by Nopah Formation, Smokey Member	High	C	Fig. 9-3	Defined by chemical content, lithology, and stratigraphy.
Silica	DNWR	Low	D		Silica resources are too expensive to mine and process.
Building Stone	DNWR	Moderate	B		No specific deposits of unique stone found.
Lightweight Aggregate	DNWR	Low	D		No known occurrences of suitable material.
Perlite	DNWR	Low	D		No known occurrences.
Gypsum	DNWR	Low	D		Stratigraphy unfavorable.
Clay	DNWR	Low	D		No known occurrences of sufficient purity.
Borate Minerals	DNWR	Low	D		No known occurrences.
Zeolites	DNWR	Low	D		No known occurrences of sufficient purity.
Uranium	DNWR	Low	D		No ore grade occurrences.

Table 4. Potential Areas of Leasable and Saleable Energy and Mineral Commodities Identified by NBMG in 1993. (taken from NBMG OF93-2)

Table 1-3. Potential areas for leasable and saleable mineral commodities.

Mineral Resource	Area	Resource Potential	Certainty Level	Map	Comments
Oil and Gas	DNWR	Low	D		Hydrocarbon shows near DNWR, but rocks sampled in DNWR have low source rock and preservation favorability.
Geothermal	DNWR	Low	C		Low temperature resources may be present at great depths.
Saline Minerals	DNWR	Low	D		No known occurrences.
Sand and Gravel	Areas underlain by Qal	High	C	Fig. 9-4	Coarse alluvium without Horse Spring Fm. or Tertiary volcanics in source area.
	Areas underlain by Qal	Moderate	B	Fig. 9-4	Coarse alluvium with Tertiary volcanics in source area.
	Areas underlain by Qal	Low	B	Fig. 9-4	Coarse alluvium with Horse Spring Fm. in source area.
	Areas underlain by Qal and Qp	Low	C	Fig. 9-4	Fine-grained sediment.

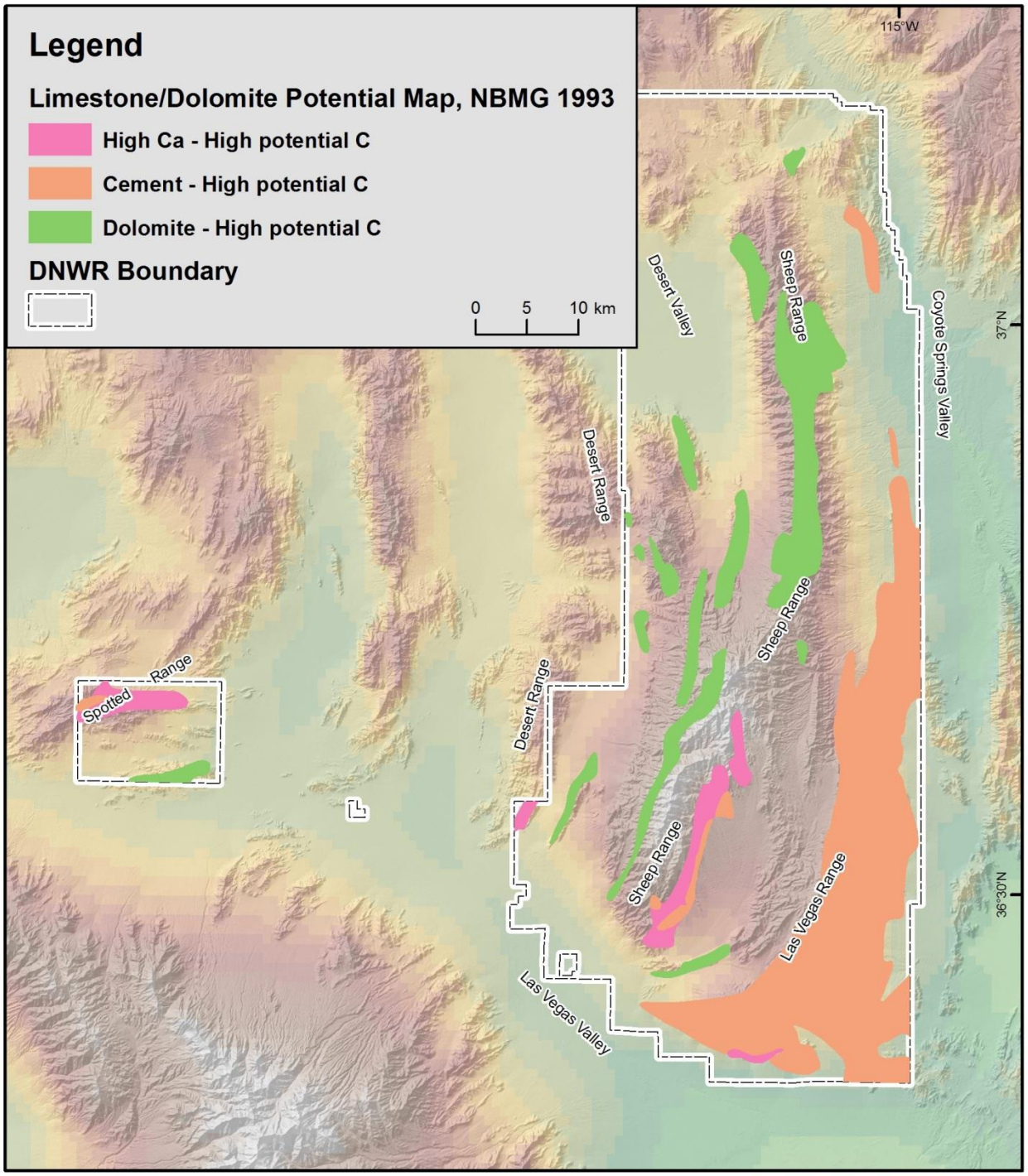


Figure 5. Map showing high-calcium limestone, cement limestone, and dolomite potential as reported in original 1993 NBMG assessment report.

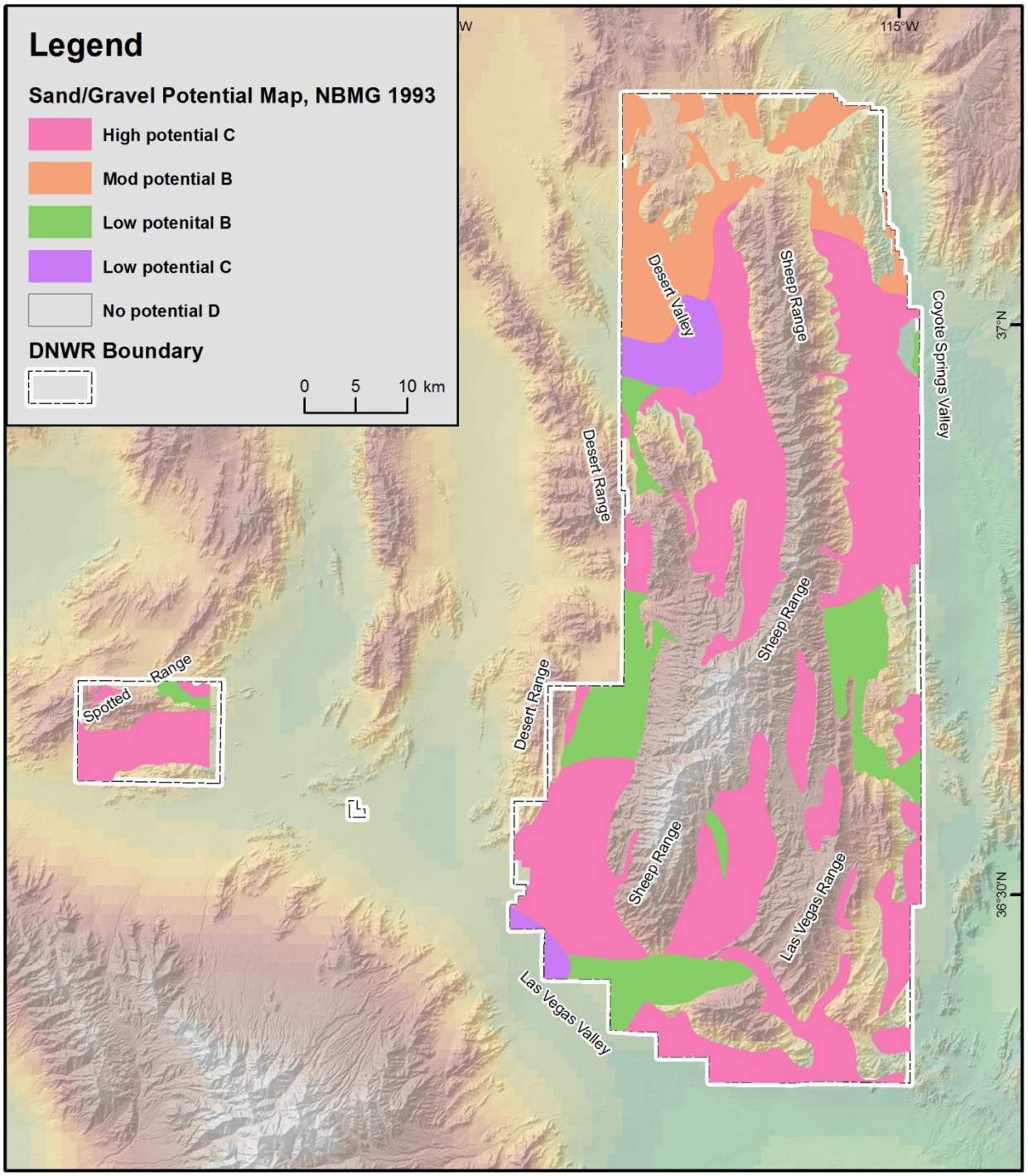


Figure 6. Map showing sand and gravel potential as reported in original 1993 NBMG assessment report.

Approach and Methods Employed in Updated Assessment

Objectives

The objective of the current assessment reported here was not to reproduce the original NBMG survey completed 20 years ago. That survey was a thorough, comprehensive evaluation of the mineral and energy resources of the DNWR. The objective of this updated assessment was to apply new advances in understanding of the genesis and exploration for mineral and energy resources, especially for geothermal energy and metallic mineral deposits. In addition, it aimed to look for features that might have been missed or under-appreciated in the original assessment. Moreover, many of the areas of low potential for precious metals were based on the geochemical anomalies determined from the stream sediment sampling program. Not all these stream sediment anomalies were followed up in the original assessment. Also, geothermal energy was not being targeted for development twenty years ago. Since then, the amount of geothermal power plants and net production in megawatt-hours has almost doubled. Much of that increase in production has been triggered by an increased understanding of Nevada's geothermal systems, largely driven by research by NBMG, which has led to the discovery of many blind systems. In addition, the DNWR contains large areas of carbonate rocks that have moderate to high potential for high-calcium limestone, cement limestone, and dolomite. Additionally the DNWR has large areas of alluvium that could be a source of sand and gravel. Though generally considered to be low-margin commodities, limestone and aggregate are critical for construction. Thus, the health of the construction industry and the demand and sources for cement and aggregate in the Las Vegas area need to be considered, both in their current state and into the foreseeable future. Next we outline the methods and approaches employed in the updated assessment.

Metals

The current assessment for potential of metallic mineral deposits investigated whether any of the mines, prospects, and mineral occurrences in the DNWR described by NBMG in 1993 fit any of the occurrence models for metallic mineral deposits, especially models for gold deposits in Nevada. Why gold? Gold production in Nevada in 2012 totaled 5.6 million ounces, which had a value of $9.37 billion. It accounted for 76% of the U.S. total gold production and helped make the U.S. the fourth leading gold producer in the world in 2012 (Muntean, 2014). Moreover, several hundred million dollars were spent on exploring for gold in Nevada, mostly on drilling. Of the 126 projects drilled for metals in 2012, 106 were drilled for gold (Davis and Muntean, 2014). Gold production and exploration has been at these levels in Nevada for over 30 years. Models for how these deposits form and how to explore for them have been greatly refined over the last 20 years. The most important type of gold deposit in Nevada, Carlin-type deposits, accounted for 75% of the production in 2012. These deposits are characterized by sub-micron gold disseminated in Paleozoic carbonate rocks. Many of the discoveries of these deposits in the last 20 years have been under alluvial cover, where there was only subtle expression of them along the range front (Muntean and Taufen, 2011). The abundance of Paleozoic carbonates in the DNWR and indications of trace element chemistry consistent with Carlin-type gold deposits reported in the 1993 NBMG report warranted reexamination of the potential for such deposits. Some of the areas for precious metal potential outlined in the 1993 report were followed up in this assessment with field checks and additional sampling, specifically aimed at evaluating the potential for Carlin-type deposits.

Most of the known mines and prospects described in the NBMG 1993 report were base metal deposits, mainly zinc and lead with silver, local copper, but with little to no gold. Most of these deposits are hosted in Paleozoic carbonates. There are several occurrences of similar deposits in southern Nevada, the largest concentration of which are in the Goodsprings District located about 40 km southwest of Las Vegas. These occurrences in southern Nevada, long considered enigmatic, were recently the subject of modern research conducted by the U.S. Geological Survey and published by Vikre et al. (2011). Some of the base metal occurrences in the DNWR were followed up in this assessment with field checks and additional sampling, aimed mainly at testing how they fit with the models put forward by Vikre et al (2011). Attention was paid to better determining the extent of hydrothermal dolomitization that is associated with the deposits in the DNWR, as described in the 1993 NBMG report, and with the deposits in the Goodsprings district, as described by Vikre et al. (2011).

As mentioned above, field examinations were carried out to re-assess the potential for metallic mineral deposits. A total of 10 days were spent in the DNWR by NBMG geologists John Muntean and Tim Cramer, who were supported by Bret Pecoraro, a NBMG field technician. Access was by driving 4WD trucks until roads were impassable, and then hiking into the areas of interest, which were up to three miles from where the truck was parked. About one to two areas were examined per day. Prior to working at DNWR, Muntean and Cramer spent a day becoming familiar with the deposits in the Goodsprings district. A total of 77 rock samples were collected from the DNWR. Of these samples, 40 were submitted for 58 assays and multi-element analyses. Some samples had more than one assay/analysis to determine the metal content for specific features. The samples were analyzed by ALS Minerals in Reno, Nevada. Fire assays were done for gold (AA finish), platinum (ICP finish), and palladium (ICP finish) on a split of the sample. The other split was digested with four acids and analyzed for 48 elements by a combination of ICPMS and ICPAES. Mercury was analyzed by cold vapor/AA. In addition, 68 pulps remaining from rock samples collected from mines, prospects, and mineral occurrences by NBMG in 1992 were analyzed the same exact way. This was done so to better compare the data. Moreover, the analytical techniques have improved significantly in 20 years, both the accuracy and precision. Detection limits for some elements are lower as well. These new analyses along with their samples locations and descriptions are in Appendix B. In addition, polished thin sections were prepared from 32 samples for detailed petrographic analysis.

Remote Sensing

As mentioned above, the original NBMG assessment of the DNWR employed Landsat TM imagery to highlight geology and structural patterns and attempted to identify zones of hydrothermal alteration that could be associated with mineral deposits, mainly metallic mineral deposits. As described in more detail below, the current assessment utilized ASTER and Landsat ETM imagery. ASTER has much higher spectral resolution than Landsat that allows for mapping of individual alteration minerals or groups of alteration minerals. In this study, we targeted calcite, dolomite, iron oxides and clay minerals. ASTER also has a thermal band that can be used to evaluate the presence of silica. The processing and interpretation of the remote sensing data were completed by Tim Cramer and constituted his Master's thesis at the University of Nevada, Reno.

Remote sensing studies are valuable in assessing large remote areas like the DNWR. Extensive zones of intense hydrothermal alteration associated with large precious and base metal deposits should

be recognizable with standard aerial photography (zones of light colored clay alteration brown to red iron oxides). However, if such deposits are mostly covered by alluvium or bedrock, only a portion of the edge of a deposit's alteration halo may be exposed. Also, as mentioned above, the alteration features of carbonate-hosted base metal deposits and Carlin-type gold deposits are much more subtle than metallic mineral deposits hosted in igneous rocks, and thus not as easily recognized. Also, as previously mentioned, widespread hydrothermal dolomitization is characteristic of types of base metals deposits recognized in the DNWR. Jasperoid (silicification of carbonate) and clay alteration are common in Carlin-type deposits. Anomalous amounts of limonites (e.g., goethite, hematite, jarosite) should also be present in both types of deposits.

Industrial Minerals

NBMG and USFWS agreed during initial planning of the updated assessment, that there was no reason to re-evaluate the potential of all the industrial mineral commodities listed in NBMG's 1993 report. However, they agreed that lithium should be looked at again, given its increased use in batteries over the last 20 years, and the fact that several companies are currently exploring for lithium in Nevada. In this assessment, we collected 6 samples of the Desert Lake Playa, and analyzed them for lithium, boron, and all the other elements in the same way done for the rock samples described above. In addition, the samples were analyzed by X-ray diffraction in order to determine the mineralogy of the playa samples, mainly to see if lithium-bearing minerals were present.

NBMG and USFWS also agreed to update the assessment of cement limestone and aggregate, but by doing a preliminary evaluation of the demand in southern Nevada for those commodities and of the current sources of those commodities in southern Nevada outside the DNWR, and whether those sources could supply the Las Vegas area for the foreseeable future.

Geothermal

In the original assessment, NBMG relied mainly on available data from springs and exploratory oil wells near the DNWR and concluded that geothermal potential was low and would be limited to commercial heating rather than power production. Since the original assessment 20 years ago, many of the new geothermal systems found in the Nevada have been blind. In the last ten years, research by NBMG and the Great Basin Geothermal Center at UNR has shown that most of the known geothermal systems in the Great Basin region are associated with specific fault patterns or structural settings. NBMG geologists, Nick Hinz and Greg Dering, examined geologic maps and fault databases to look for these favorable settings and followed this up with five days of field reconnaissance to evaluate their potential to host blind systems.

Compilation of Previous Assessment Data and New Data into GIS Database

The data used in the current assessment was placed into an ArcGIS database, which allowed for better analysis and evaluation of potential. These data included available geologic maps (raster and vector data) for the area, geochemical analyses (old and new), geophysical data, areas of potential, and base map data. The list of data is in Appendix C.

Geologic Setting

The summary of geologic setting for the DNWR presented here is based mainly on previous compilation work and published geologic maps. Not much new work has been done since the original 1992-1993 NBMG assessment. The maps by Longwell et al. (1965), who produced the first geologic map of Clark County; Guth (1980), who did detailed mapping of the central swath of the large eastern portion of DNWR; and Jayko (2007), who mapped the north end as part of a much larger project that extended north of the DNWR, still remain the main sources of mapping of the DNWR. The large eastern portion of the DNWR was part of a large compiled geologic map of the Colorado, White River and Death Valley groundwater flow systems that was published by Page et al. (2005). Figure 7 is a geologic map of the DNWR that incorporates the Page et al. (2005) compilation, as well as Stewart and Carlson's (1979) state geology map of Nevada. A detailed 1:24,000 scale map of the Gass Peak SW quadrangle was also published by Ramelli et al. (2011). Besides these studies additional information for the summary came from Guth (1981), Wernicke et al. (1982), Wernicke et al. (1984), and Best et al. (2013a,b).

The DNWR occurs in the Neoproterozoic to Paleozoic miogeoclinal passive margin sequence that formed during rifting of the supercontinent Rodinia to form what is now the western margin of North America. The Neoproterozoic part of the sequence is dominated by clastic rocks formed during active rifting, whereas the Paleozoic portion is dominated by carbonate rocks. The carbonate rocks of Cambrian through Devonian age within the DNWR formed on a carbonate platform in a middle to inner shelfal environment. During the late Devonian-Early Mississippian, the DNWR lied along the western margin of a foreland basin caused by the Antler Orogeny. This foreland basin persisted until Upper Mississippian and Pennsylvanian carbonates were able to prograde seaward over the basinal deposits. Within the DNWR, Neoproterozoic to Cambrian clastic rocks and Cambrian to Devonian carbonate rocks were thrust over Mississippian age carbonates along the Gass Peak thrust fault, which formed during the Cretaceous Sevier Orogeny.

The oldest rocks at the DNWR are the Neoproterozoic to Cambrian clastic rocks, which are exposed along the trace of Gass Peak thrust. Formations include the Neoproterozoic Stirling Quartzite and the Cambrian-Neoproterozoic Wood Canyon Formation, which is primarily siltstone and quartzite. These rocks are overlain by Cambrian platform carbonates consisting of the Carrara, Bonanza King, and Nopah Formations. The Carrara Formation is a transitional sequence that is predominantly shale near its base and limestone near its top. The Bonanza King Formation consists of limestone and dolomite, whereas the Nopah Formation consists of basal shale with limestone interbeds (Dunderberg Shale member) and an upper massive dolomite. Overlying the Nopah are carbonates of the Ordovician Pogonip Group. Within the DNWR, the silty carbonates of the Pogonip Group are strongly dolomitized. Overlying the Pogonip Group is the distinctive white Eureka Quartzite, which is overlain by equally distinctive dark gray, massive Ely Springs Dolomite. Overlying the Ordovician rocks is the Silurian to Lower Devonian Laketown Dolomite. Devonian carbonates overlying the Laketown are mainly dolomites that are equivalent to the Sevy, Simonson, and Guilmette Formations. The Devonian-Mississippian Pilot Shale and Mississippian Joana Limestone locally overlie the Devonian rocks. In the footwall of Gass Peak thrust in the southeast corner of the DNWR in the Las Vegas Range, is a thick section (~2,500 m) of Lower Permian to Upper Mississippian light gray limestone with chert, silt, and sandy interbeds which comprise the Bird Spring Formation. The Bird Spring Formation overlies chert-bearing limestones of the

Upper to Lower Mississippian Monte Cristo Group. Massive limestones and dolostones of Upper Devonian to Late Mississippian age are locally exposed beneath the Monte Cristo Group. They likely correlate with the Guilmette Formation. As described later in the report, the limestones of the Bird Spring and Monte Cristo are commonly hydrothermally dolomitized.

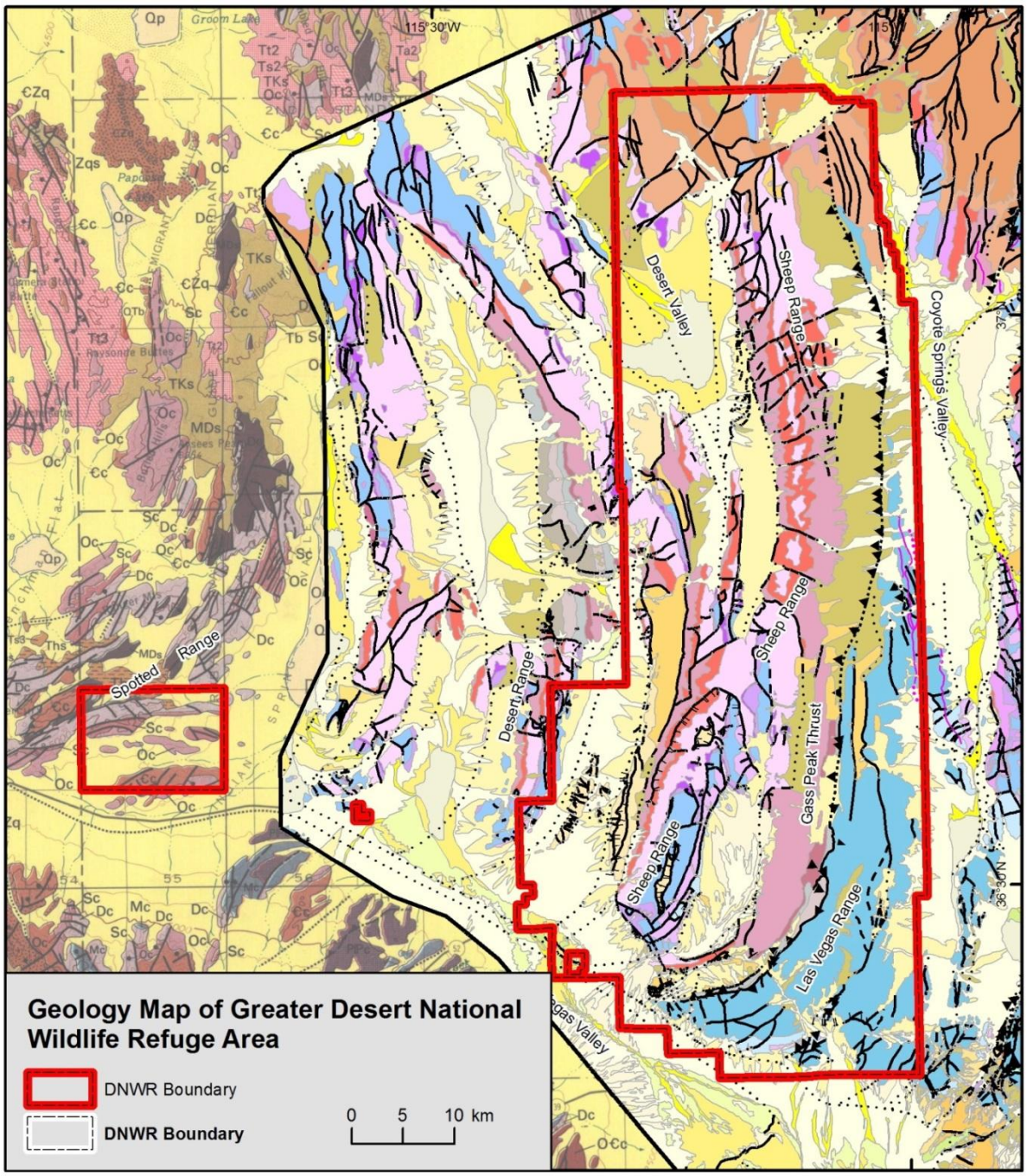


Figure 7A. Geologic map of the greater Desert National Wildlife Range area. The eastern part of the map bounded by the black thick line is geology compiled Page et al. (2005). Legend for this map in Figure 7B. Backdrop is Stewart and Carlson's (1978), state geologic map of Nevada.

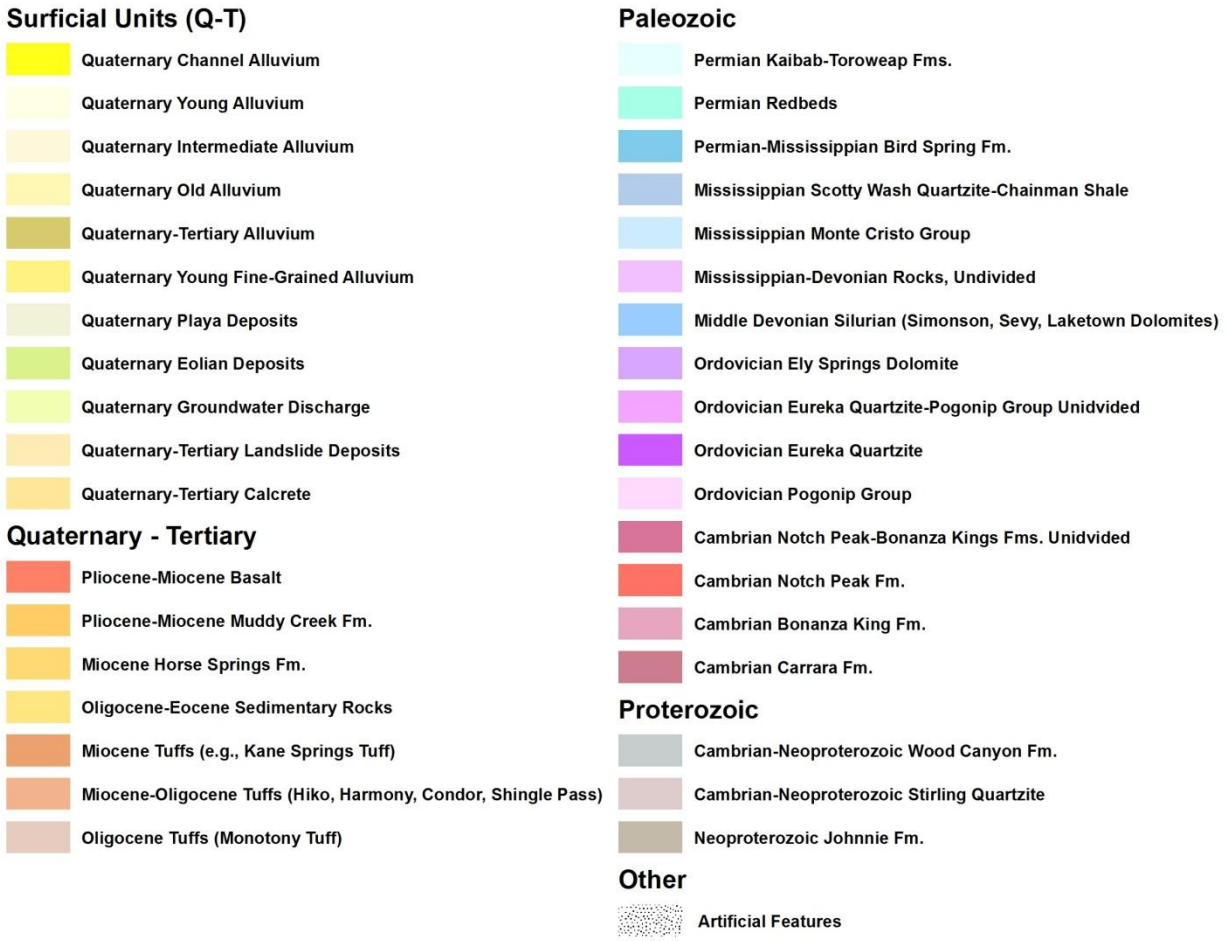


Figure 7B. Legend for the Page et al (2005) portion of the geology map of the greater Desert National Wildlife Range area shown in Figure 7A.

There is no evidence for Paleozoic contractional deformation at the DNWR. The eastern extent of the Roberts Mountain thrust, which was emplaced during the Antler Orogeny, is located about 220 km northwest of the DNWR. The Cretaceous Sevier Orogeny resulted in emplacement of the Gass Peak thrust and contractional deformation of Paleozoic rocks in the DNWR. It correlates with the Wheeler Pass thrust south of Las Vegas Valley (Fig. 8). The upper plate of the Gass Peak thrust has a stratigraphic displacement of 6 km and has moved nearly 40 km eastward. Exposures of the Gass Peak thrust follow the northern and western crest of the Las Vegas Range from Gass Peak to vicinity of Wamp Spring. Exposures along this trace place the Neoproterozoic Stirling Quartzite, Cambrian Wood Canyon Formation, or the Cambrian Bonzana King Formation over the Lower Permian to Upper Mississippian Bird Spring Formation. The base of the thrust is a complex zone of imbricate faulting. This complexity is well exposed in the Lake Mine area described below. Minor thrusting in the lower plate occurs locally. It is related to the Gass Peak thrust and places Mississippian Monte Cristo Group and Upper Devonian to Lower Mississippian carbonates (Guilmette Formation and Joanna Limestone) over the Bird Spring

Formation. Within several kilometers of the Gass Peak thrust, folds occur in both the upper and lower plates.

The northwest-trending Las Vegas Valley shear zone forms the southern boundary of a large area of Miocene (~20-10 Ma) extensional faults that overprint the Sevier thrust belt (Figs. 8, 9). It is a complex right-lateral shear zone with up to 65 km of displacement. The right-lateral shear is evident in the distinct westward bending of the Gass Peak thrust to an almost east-west strike as it nears the shear zone. The Wheeler Pass thrust south of the Las Vegas shear zone is likely the right lateral offset of the Gass Peak thrust. At the north end, the zone of extensional faults is bounded by the northeast-trending, left-lateral Pahranagat shear zone. Within the DNWR, a normal fault system on the west flank of the Sheep Range is interpreted to be a breakaway zone that forms the eastern boundary of a highly extended terrain, commonly referred to as the Sheep Range detachment system. It stretches 65 km westward to the area of the Spotted Range-Ranger Mountains-Specter Range, where the Las Vegas Valley shear zone appears to terminate in an oroflexural bend (Figs 8, 9).

Within this highly extended terrain, Tertiary sedimentary deposits filled syn-tectonic basins that are related to the major west-dipping extensional faults of the Sheep Range detachment system (Fig 10). The Tertiary age basin fill throughout the DNWR consists of beds of limestone, claystone, dolomite, sandstone, and volcanic tuff (ash fall and epiclastic deposits). These rocks overlie a basal conglomerate composed of Paleozoic clasts. This Tertiary sequence has been correlated with the Horse Spring Formation.

Volcanic rocks within the DNWR are confined to the north end of the DNWR, in the northeast corner of the Sheep Range, in the northeast corner of Coyote Spring Valley, and at the south end of the of the Pahranagat and East Pahranagat Ranges within the Pahranagat shear zone. They are Tertiary ash flow tuffs sourced from calderas located to the north and northeast of the DNWR. The oldest tuff is the 27.57 Ma rhyolitic Monotony Tuff derived from the Monotony Valley caldera in the Central Nevada caldera complex to the north of DNWR. The next younger tuffs exposed in DNWR are the rhyolitic tuffs of the Shingle Pass Formation (26.38-26.98 Ma), which was sourced from the Quinn Canyon Range Caldera in the Central Nevada caldera complex. Next are the rhyolitic tuffs of the Condor Canyon Formation (23.04 Ma, 24.15 Ma) and the Harmony Hills Tuff (22.56 Ma), an andesitic ash flow tuff. Both tuffs were derived from the Caliente caldera complex, located northeast of the DNWR. The next youngest tuff is the rhyolitic Hiko Tuff (18.51 Ma) sourced from the Delamar caldera of the Caliente caldera complex. The youngest tuffs exposed in the DNWR are the Kane Wash Tuff (14.39-14.67 Ma), which is of peralkaline, rhyolitic composition. It was sourced from the Kane Springs Wash Caldera in the Delamar Mountains northeast of the DNWR. It is important to note that there are no known exposed igneous intrusions or locally sourced volcanic rocks of any age in the DNWR.

The Pahranagat shear zone cuts the Tertiary ash flow tuffs. The fault zone strikes about N50°E, is about 13 km wide, and extends for about 40 km. Within the DNWR, the southern boundary of the shear zone is defined by the Maynard Lake fault that generally follows the southern edge of the topographic break separating the northern Sheep Range from the southern reaches of the Pahranagat and East Pahranagat Ranges. The parallel Buckhorn fault is located about 6.5 km to the north. The northern boundary of the shear zone is defined by the Arrowhead Mine fault, which is located north of the DNWR. The three faults that define the shear zone dip steeply to the northwest, and they all show oblique slip that contains a major component of normal dip-slip in addition to left-lateral motion. The

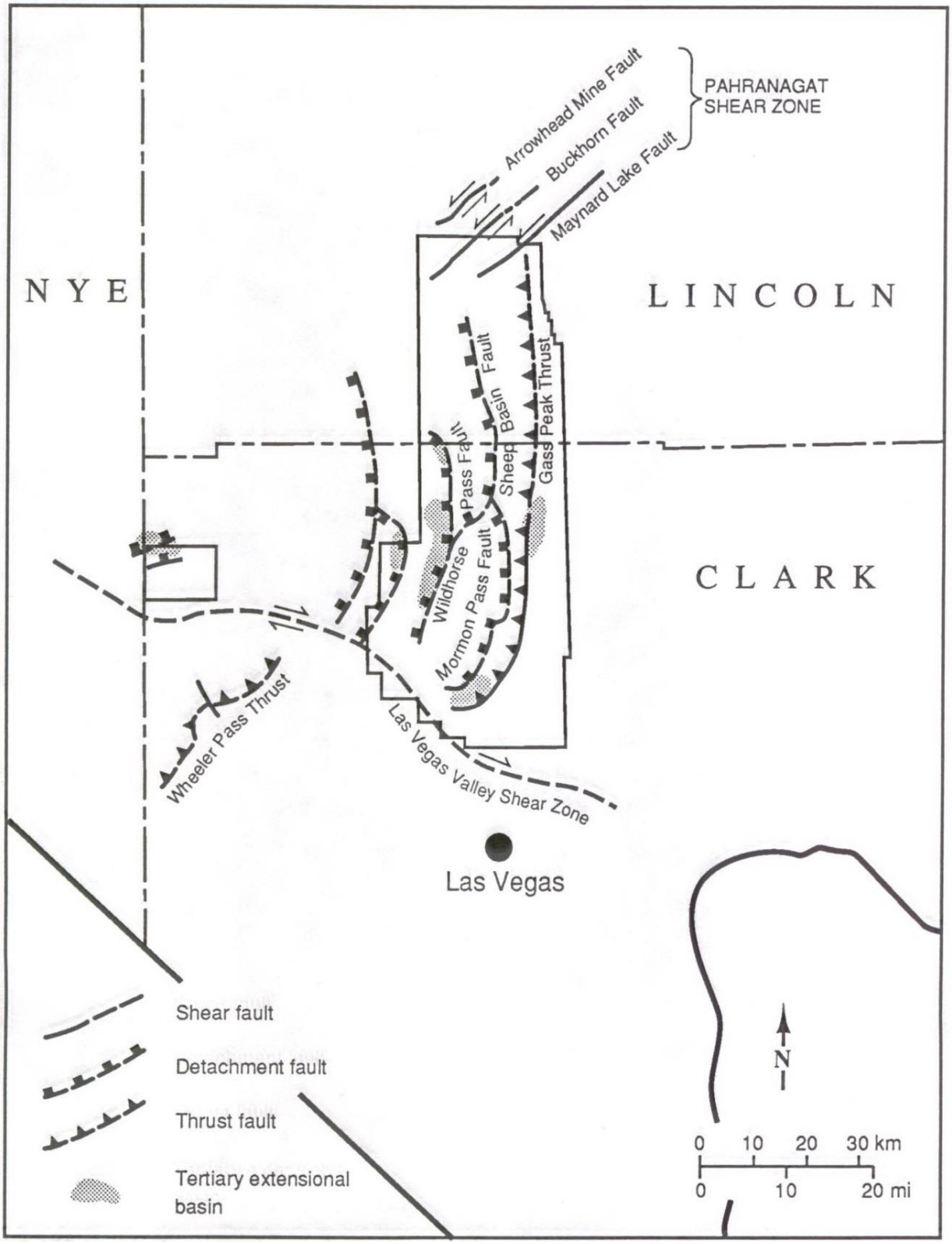


Figure 8. Regional structures in the vicinity of the Desert National Wildlife Range. Taken from original NBMG 1993 report (Tingley et al., 1993).

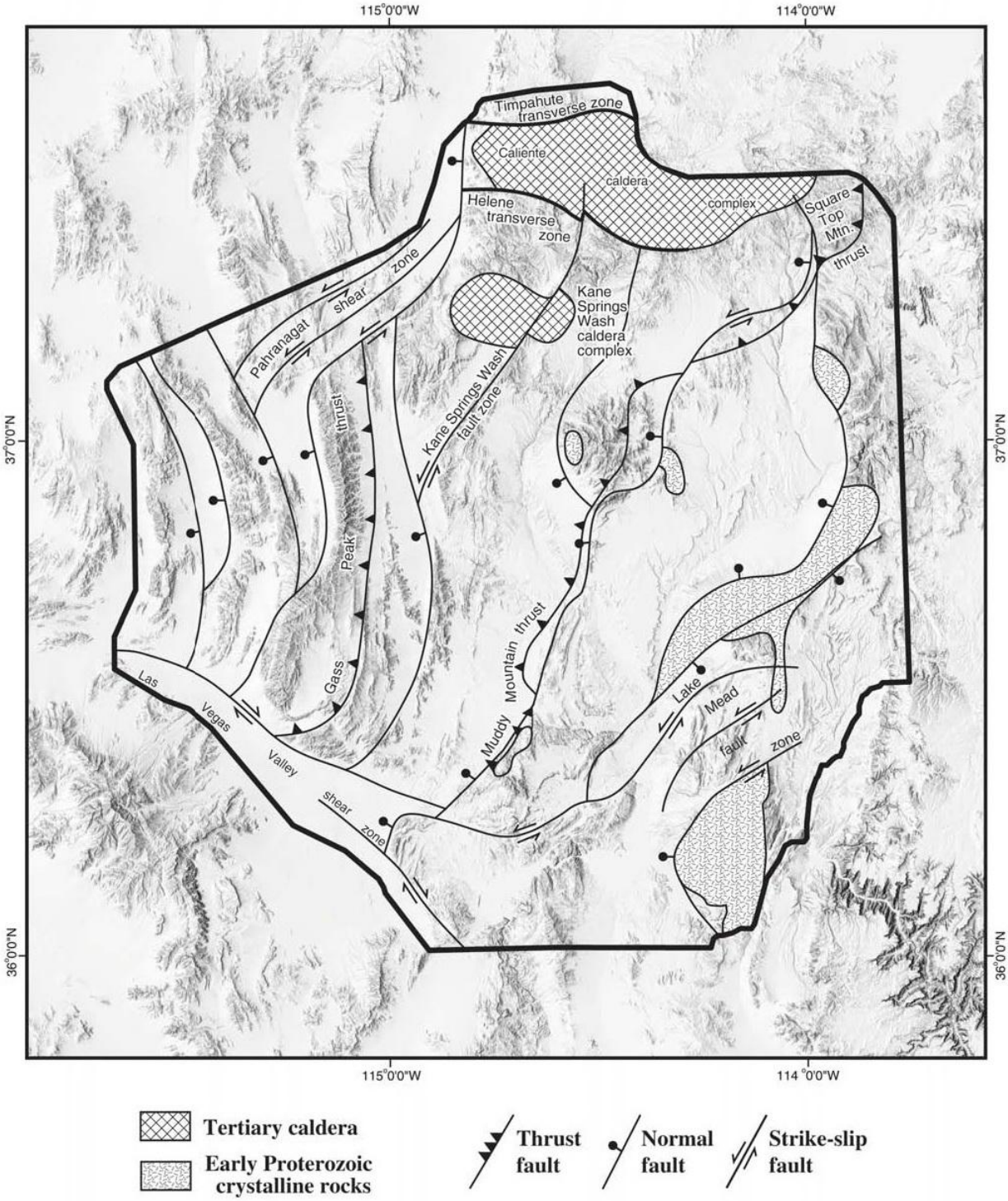


Figure 9. Generalized map of the principal structures features in NBMG Map 150 by Page et al.(2005) – "Geologic Map of Parts of the Colorado, White River, and Death Valley Groundwater Flow Systems. " DNWR occurs on the west side of the map.

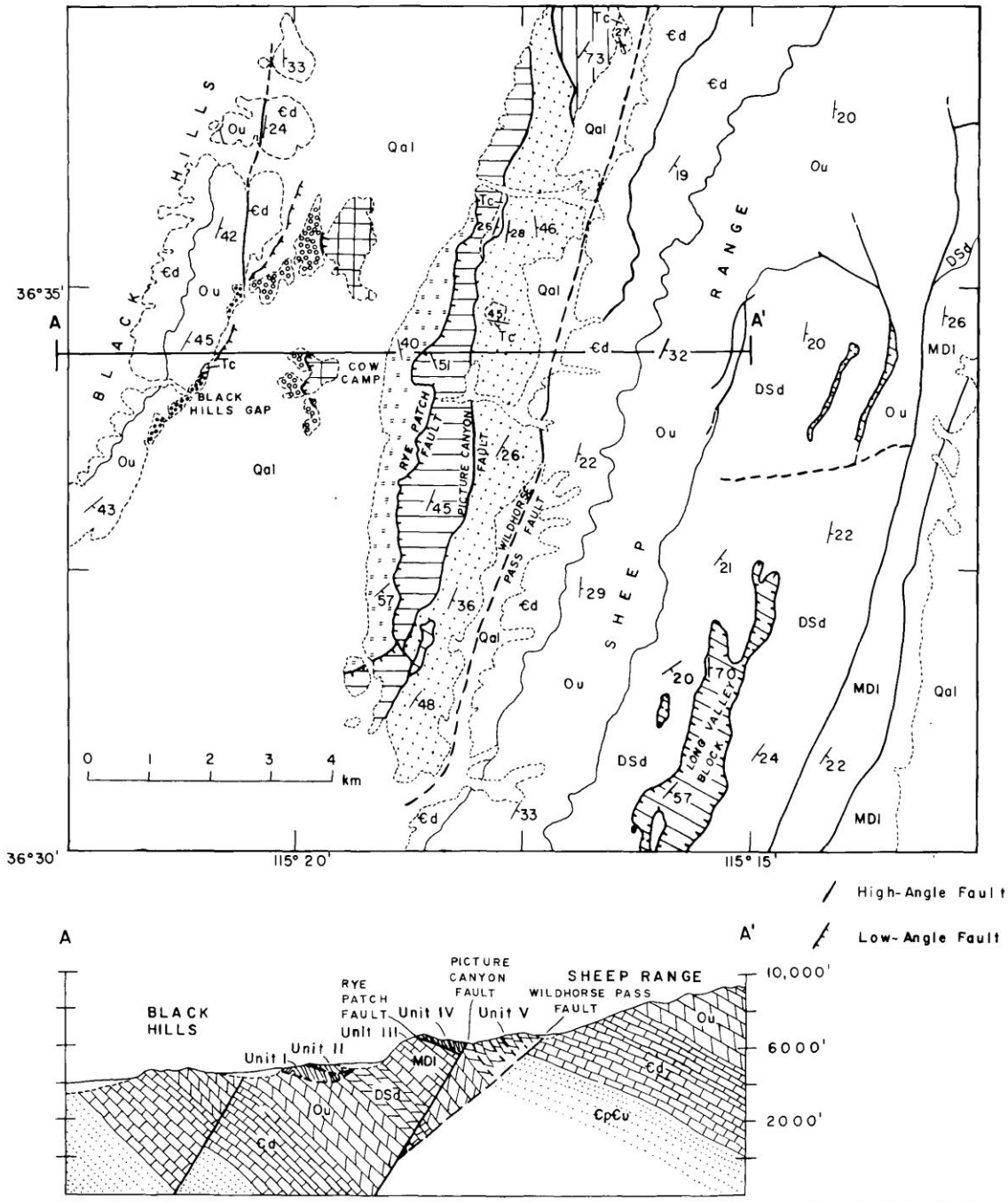


Figure 3. Geologic sketch map, southwestern Sheep Range and Black Hills, Clark County, Nevada. The map covers all of the Black Hills 7.5′ quadrangle and the southwestern portion of the Hayford Peak 15′ quadrangle. Section A–A′ goes through the Hoodoo Hills Havoc in the vicinity of Cow Camp and is drawn without vertical exaggeration. Formation symbols used are: Ꞓbk, Bonanza King Formation; Ꞓn, Nopah Formation; Op, Pogonip Group undifferentiated; Oa, Antelope Valley Formation; Oe, Eureka Quartzite; Oes, Ely Springs Dolomite; Dn, Nevada Formation; Ddg, Devil's Gate Limestone; Mp, Pilot Shale; Mj, Joana Limestone; Mis, Indian Springs Formation; and PPbs, Bird Spring Formation. The unit ꞒpꞒu in the subsurface corresponds to the Eocambrian clastic wedge which crops out in the Desert and Las Vegas Ranges. (Explanation on facing page.)

Figure 10. Map and cross-section of the southern Sheep Range, showing the eastern margin of the Sheep Range detachment system discussed in the text. Taken from Guth (1981).

Pahranagat shear zone is interpreted to have formed sometime after 7.7 Ma. Fault scarps and active seismicity at the north end of the Sheep Range indicate Quaternary activity for at least the Maynard Lake Fault. All three faults appear to terminate in the Desert Hills just west of the western boundary of the DNWR.

The geology summarized above pertains to the regional geologic setting and to the geologic setting of the large eastern parcel that makes up greater than 95% of the DNWR's area. The Indian Springs portion of the DNWR (~ 140 square km) is located about 30 km west of the large eastern parcel. The previously described Cambrian to Devonian carbonate strata in the upper plate of the Gass Peak thrust comprises the vast majority of bedrock exposure in the Indian Springs parcel. They occur near the western terminus of the Sheep Range detachment system described above, in east-west oriented hills just south of the Spotted Range. The strata strike mainly east-west as a result of their proximity to the Las Vegas Valley shear zone, which is just south of the Indian Springs parcel. The Miocene Horse Springs Formation is locally exposed at the north end of the parcel. There are no exposed igneous rocks on the Indian Springs parcel.

Geophysics

The majority of the gold deposits in Nevada discovered in the last 25 years were covered by post-ore alluvial sediments (Muntean and Taufen, 2011). Regional aeromagnetic and gravity data and interpretations of that data by the U.S.G.S. (Singer et al., 1996) were used to assess the presence of intrusions in the subsurface and to evaluate the thickness of Cenozoic basin fill that could be covering bedrock-hosted mineral deposits. Figure 11 shows the aeromagnetic data with evidence for an intrusion in the southeast corner of the DNWR. Based on Blakely et al. (1996) and Grauch (1996), the magnetic source for this interpreted intrusion is deeper than 1 km and likely deeper than 4 km. The interpretation of the subsurface intrusion and others in Figure 11 is speculative, given there is no evidence in the surface geology of any intrusions. An alternate interpretation is that the large anomaly is an upwarp of magnetic Proterozoic basement rocks in the subsurface. Other than that anomaly, the rest of the DNWR is characterized by a flat pattern of magnetic lows, consistent with the lack of igneous rocks in the region. The northeast-trending Las Vegas Valley shear zone is very apparent as a distinct linear magnetic low feature.

Figure 12 shows the estimated depth to bedrock in the alluvial valleys of the DNWR and surrounding areas. Dohrenwend et al. (1996) combined a statewide compilation of gravity data (isostatic residual values interpolated to a 2-km by 2-km grid) with available oil and gas-, geothermal-, and water-well data to approximate depths to dense, generally pre-Tertiary and/or crystalline basement. Figure 12 shows the depth to bedrock is likely less than a kilometer in the alluvial basins of the DNWR, and likely less than a half a kilometer in most parts of the basins. If present, bedrock-hosted metal deposits, which have high tonnages and/or have high average grades, could potentially be economic underneath the alluvial basins of the DNWR. An exception is the southern boundary of the DNWR where the depth to bedrock in Las Vegas Valley increases to greater than a half a kilometer within 0.5-2 km of the range front.

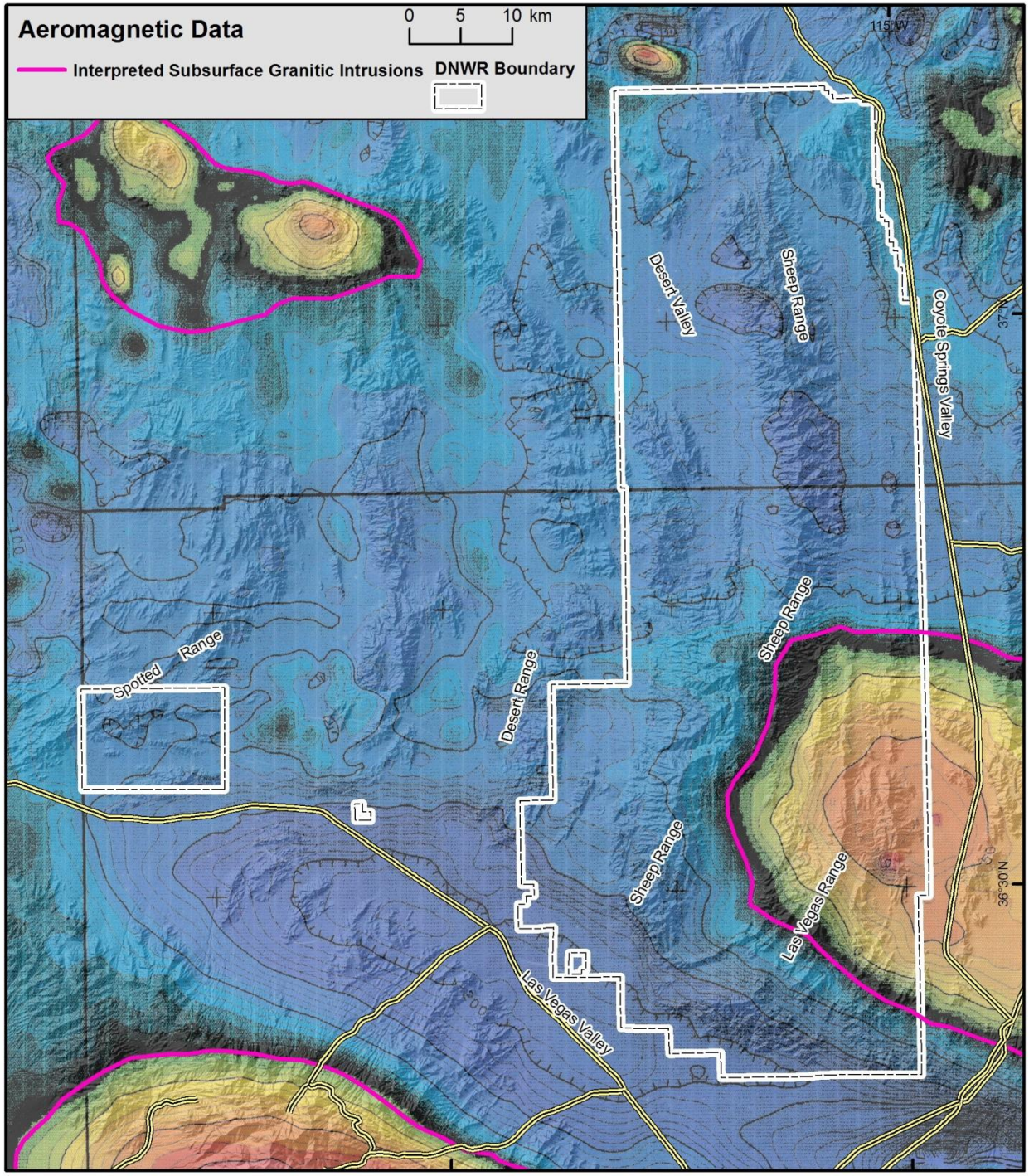


Figure 11. Aeromagnetic map of the vicinity of the DNWR. Magenta lines outline interpreted subsurface granitic intrusions. See discussion in text.

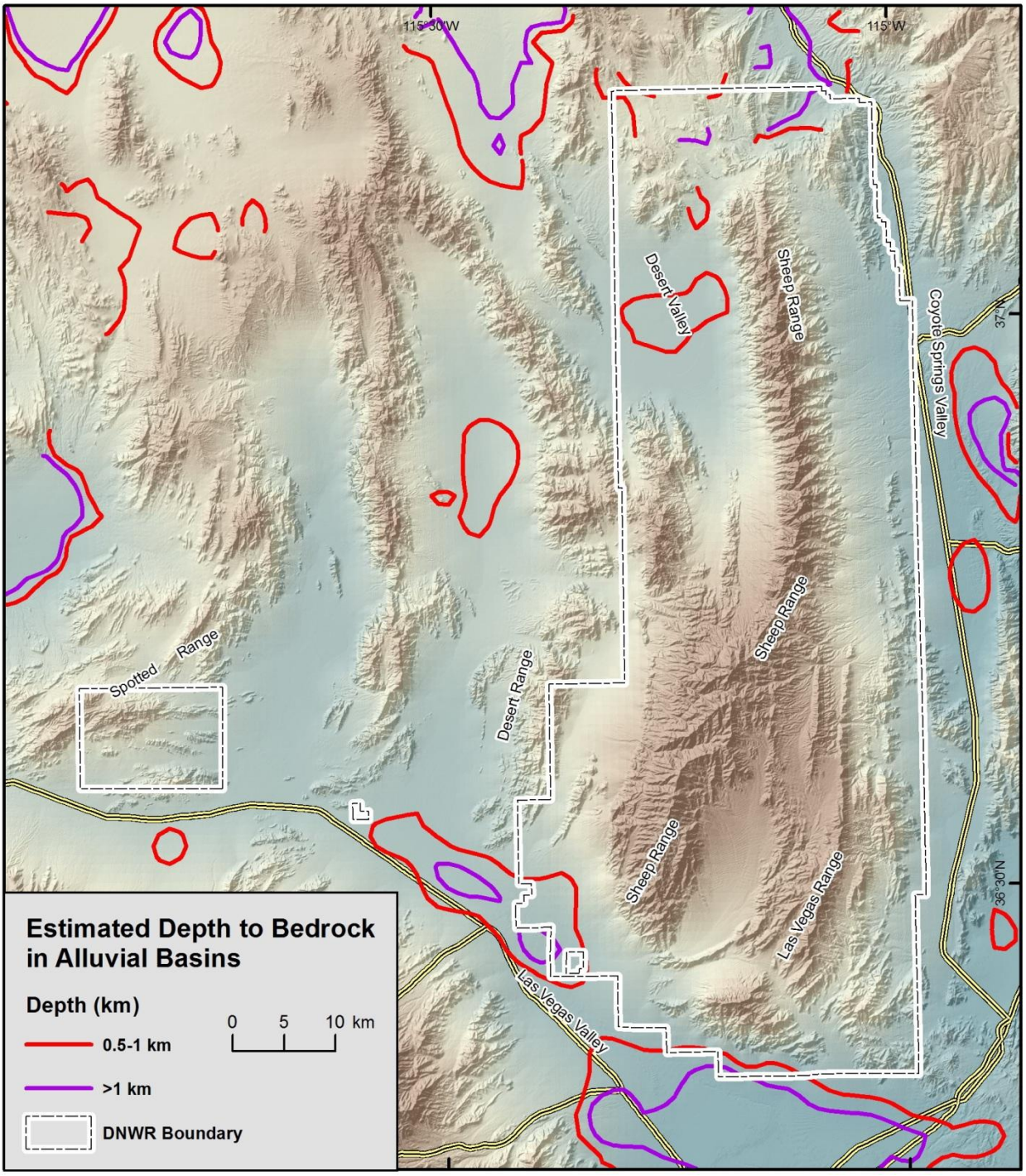


Figure 12. Map showing estimated depths of alluvial basins in the vicinity of the DNWR. See text.

Remote Sensing Study

Introduction

The vastness and limited vehicular access of the DNWR presents challenges for cost-effective mineral assessments. The large area necessitates an approach that allows an initially broad evaluation of the DNWR to refine targets for subsequent time-intensive and costly field exploration and validation. Remote sensing is a tool that can assist in the initial broad evaluation, by helping map lithologies, structures, and hydrothermal alteration zones. Remote sensing is now widely used by the mining and mineral exploration industry to explore in mainly remote, sparsely vegetated areas, like the Andes of South America. During the 1992-1993 assessment of the Desert National Wildlife Range (DNWR) Landsat Thematic Mapper (Landsat TM), a medium resolution, multispectral imaging spectrometer, was used to locate areas of potential alteration and mineralization, and to map the extent of various geologic units and structures (Tingley et al., 1993). During this revisited assessment two newer multispectral imaging spectrometers were used to evaluate the DNWR. Intermediate products guided field studies and sampling programs, and spectra collected from field samples have been incorporated with the remote sensing data to create mineral potential maps. Limestone, dolomite, silica, iron oxides and clay minerals serve as proxies for regional lithologies and several minerals commonly associated with a variety of hydrothermal ore deposits (Vaughan et al., 2005; Rowan et al., 2003a,b; Thompson et al., 1999; Harris et al., 1998; Baldridge et al., 2013). The remote sensing study summarized here is the subject of Tim Cramer's Master of Science thesis at UNR.

In this assessment the remote sensing instruments used were Landsat Enhanced Thematic Mapper Plus (ETM+), which has nearly the same spectral and spatial resolution as the Landsat TM sensor used in the original NBMG assessment (Table 5, Fig. 13), and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). Landsat ETM+ was launched April, 1999, and ASTER launched December, 1999. The Landsat ETM+ sensor collects images comprised of 7 spectral bands covering an approximate area of 170 km X 183 km. ASTER collects images comprised of 14 spectral bands over a 60 km X 60 km area. Both instruments have been configured to collect data in wavelengths most useful for Earth observations avoiding regions of the electromagnetic spectrum where atmospheric water and CO¬2 degrade the signal beyond use. The additional bands on the ASTER sensor were engineered specifically to aid in mineral discrimination (Table 5, Fig. 13). Both instruments collect data in the visual-near infrared (VNIR), short-wave infrared (SWIR), and thermal infrared (TIR) regions of the electromagnetic spectrum, from 0.35-12.0 microns, at the spatial and spectral resolutions shown in Table 5. Landsat ETM+ and ASTER data have been acquired data over most of the Earth's land surface.

ASTER imagery allows potential mineral mapping, either individual minerals or groups of minerals. The objective was to identify zones of hydrothermal alteration that cut across lithologies, which could be in the form of clays, limonite (mainly iron oxides), carbonates (especially dolomite), or silicification. Clays and carbonates are recognized in the SWIR region and limonites in the VNIR. Silicification can be detected in the TIR region.

Hydrothermal metallic mineral deposits that become mines, especially those that occur in Nevada, commonly have alteration zones that are larger than the ore deposit. If exposed, these large zones are commonly, but not always, recognizable in standard aerial photography, especially if they are rich in clay and iron oxides. If the mineral deposit is covered by alluvial basin fill or post-ore rocks, only an edge of the hydrothermal alteration zone might be exposed. Our expectation was that the more

modern Landsat ETM+ and ASTER imagery might help us detect such alteration zones that were overlooked in the original assessment. This is discussed in more detail in the section of the report that covers the potential for metallic mineral deposits.

Table 5: Summary of Landsat ETM+ and ASTER spectral and spatial characteristics.

Landsat ETM+ and Landsat TM*				
Band	**Band Pass**		**Band Center**	**Spatial Resolution**
1	0.45	0.52	0.485	30m
2	0.52	0.60	0.560	30m
3	0.63	0.69	0.660	30m
4	0.76	0.90	0.830	30m
5	1.55	1.75	1.650	30m
6	10.40	12.5	11.450	60m*
7	2.08	2.35	2.215	30m
ASTER				
Band	**Band Pass**		**Band Center**	**Spatial Resolution**
1	0.52	0.6	0.560	15m
2	0.63	0.69	0.660	15m
3	0.78	0.86	0.820	15m
4	1.6	1.7	1.652	30m
5	2.145	2.185	2.164	30m
6	2.185	2.225	2.204	30m
7	2.235	2.285	2.259	30m
8	2.2695	2.365	2.329	30m
9	2.36	2.43	2.394	30m
10	8.125	8.475	8.3	90m
11	8.475	8.825	8.65	90m
12	8.925	9.275	9.1	90m
13	10.25	10.95	10.6	90m
14	10.95	11.65	11.3	90m

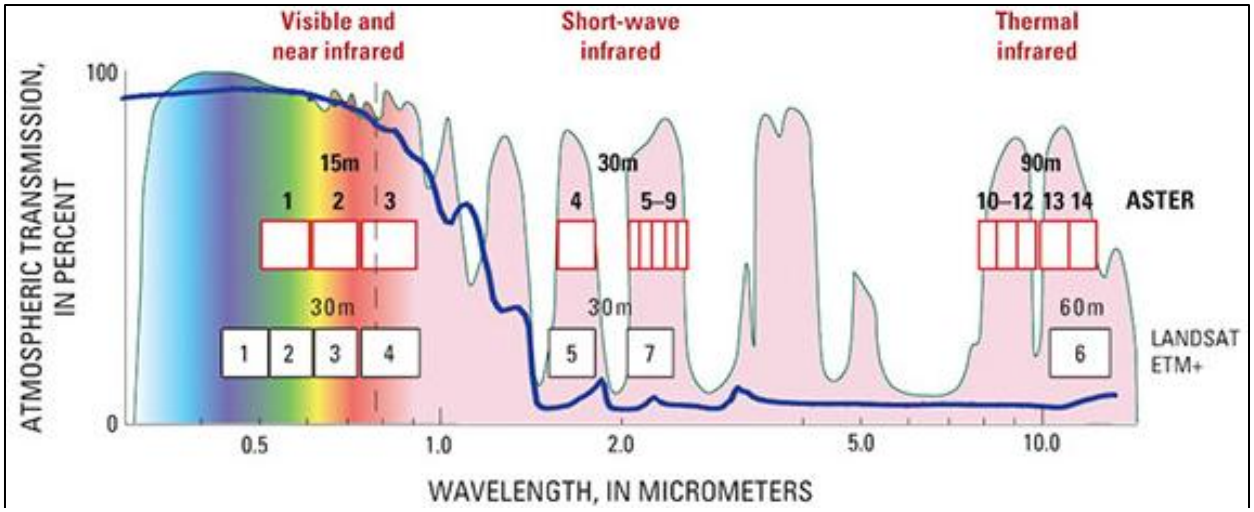


Figure 13. Spatial and spectral characteristics of bands from ASTER and Landsat ETM+. Background displays relative electromagnetic spectrum transmittance through the atmosphere. The section from 4.5-9.0 µm displays the visible spectrum chromatically; beyond 9.0 µm atmospheric CO_2 and H_2O create absorbance features which limit reflectance in the SWIR and TIR to narrow "windows". Several of these "windows" are monitored by ASTER and less so by Landsat ETM+. (Modified from Kabb et al., 2003).

Image Processing

Landsat ETM+ images are available for free through the USGS at www.earthexploer.usgs.gov. Four scenes were needed to cover DNWR, and they were selected based on similar times of year and lack of clouds and snow.

(1) LE70390341999185EDC00 collected July 4th, 1999
(2) LE70390351999185EDC00 collected July 4th, 1999
(3) LE70400341999224EDC00 collected August 8th, 1999
(4) LE70400351999224EDC00 collected August 8th, 1999.

The downloaded radiance data were converted to reflectance data and atmospherically corrected using ENVI preprocessing routines. A variety of different true and false color composite images were studied during processing and prior to field work, utilizing several band ratio combinations to highlight a variety of potential mineralization schemes. A variety of processing techniques were applied to the images including both supervised and unsupervised classification methods, principle component stretches, and decorrelation stretches. Preliminary evaluation of these methods found that simple band ratio combinations, sometimes combined with a principle component stretch (PC), were most successful at displaying meaningful information from the Landsat ETM+ imagery (Fig. 14). Here band ratios were selected based on their success in previous studies and their ability to highlight known mineralization and alteration at DNWR; images with "(PC)" following the Red-Green Blue (R-G-B) combination are principle component images, which highlight differences between bands (Inzana et al., 2003; Patel and Rampal, 1992; Ramadan and Kontny, 2004; Harris et al., 1998; Sabins, 1999; Ramadan et al., 2001 and

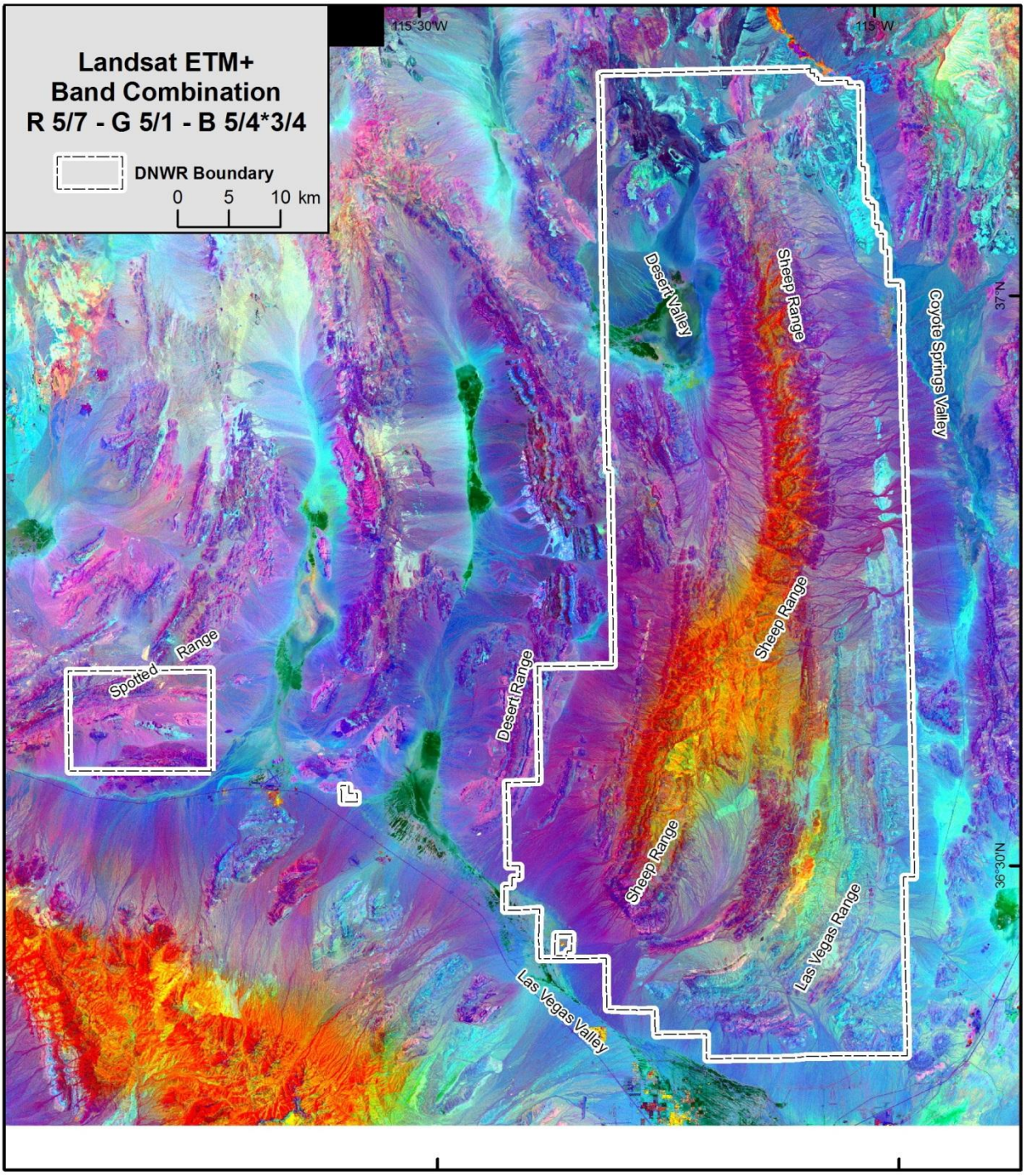


Figure 14. The Landsat ETM+ band ratio image shown here is a false color, band ratio, composite image with R-G-B bands 5/7-5/1-5/4*3/4. The 5/7 band ratio, assigned to the red channel, highlights limonite (Fe-oxides) and clay minerals, but also can pick up vegetation. Band ratio 5/1, assigned to the blue channel, and is meant to highlight gossanous regions. Band ratio 5/4*3/4 was assigned to the green channel to highlight differences in lithologies.

others). Seven new Landsat ETM+ false-color band and band ratio combinations are included with the remote sensing data products and three images, (8), (9), (10), used during the previous mineral assessment of the DNWR are also included. The red-green-blue (RGB) combinations used and the geologic and mineralogic features that they highlight are summarized in the Table 6.

Processed Level 2B ASTER images were acquired through the Japanese Global Distribution System (GDS), at a cost of ~$300 USD per scene. The four atmospherically corrected and reflectance/emissivity calibrated ASTER scenes used in this study were:

(1) AST1_0010171853010106260661 collected October 17, 2000
(2) AST1_0010171852430106260659 collected October 17, 2000
(3) AST1_0005101854350204120789 collected May 5, 2000.
(4) AST1_0507271838130508020119 collected July 27, 2005

The ASTER scenes were then loaded into ENVI where processing methods similar to those used on the Landsat ETM+ data were used; however, due to slight differences between scenes, each image needed to be processed individually to avoid compounding problems relating to image artifacts. True and false color images were analyzed; band ratios were created based on prior authors' successful work, and regions of interest (ROIs) were selected as training sites for ENVI mapping tools. During processing it became apparent that the alluvium in the scenes was negatively affecting the end products. Using the 15 m true color ASTER imagery and elevation profiles, a mask was created so that only in situ outcrops were mapped. Following the methods used in Nimoyima 2003 and Gabr 2010 mineral indices were created for hydroxyl, kaolinite, alunite, and calcite minerals (Table 7). Additional mineral indices following Agar, 2010 were used for dolomite, silica and iron oxide (Table 7). Band thresholds of index band images were adjusted to select pixels that best fit the spectral profile of the desired index mineral, highlighting continuous units, which indicates that the pixels are part of homogeneous outcrops. Individual index maps were then exported to ArcGIS to cross reference with known areas of mineralization and geochemical anomalies (Figure 15). Figure 16 summarizes the work flow the image processing utilized in this study.

Field Checking, Spectroscopy, and Construction of Mineral Maps

Using the compiled data in GIS, field targets were selected based on accessibility, proximity to geologic structures and lithology, alteration and geochemical anomalies, and density of index pixels. Field targets were initially used to verify the success of remote image processing. GPS located samples were collected at each field site and later spectrally analyzed in the lab using an ASD TerraSpec. Spectra were then interpreted using Specwin software and a spectral library (Fig. 17).

After comparing field observations and index maps, five minerals/mineral groups were selected for continued processing. Clay minerals, limonite (goethite, hematite, jarosite), dolomite, limestone (calcite), and silica (with TIR) were selected and mapping using ENVI's Spectral Angle Mapper (SAM) algorithm. The SAM uses spectra derived from either a user provided spectral library or from selected regions of interest to classify each pixel from satellite derived spectra, either as one of the mineral groups or as unclassified. Here, ASD TerraSpec data were used to create a spectral library of the most pure samples, this library was resampled to ASTER band positions and used to guide the SAM mapping algorithm. Results are shown in Figure 18.

Table 6. Landsat ETM+ Band and Band Ratio Combinations used during Image Processing.

Landsat ETM+ Band Combination Images and Descriptions		
Ratio Image #	**R-G-B Bands**	**Descriptions**
0	**3-2-1**	**True color Visual Near Infrared (VNIR) image**
1	**5/7-3/2-4/3**	**Red-Clay/Al-OH - Green-Iron Oxide -Blue- Veg.**
2	**5/7-4/7-4/2**	**Red/purple-FeOx/AlOH Green/Yellow-Carbonate Rocks Blueish-Veg.**
3	**5/7-5/1-(5/4)(3/4)**	**Red-FeOx+AlOH Blue-Gossan Green-Mafic vs Felsic rx.**
4	**3/4-4/5-5/7**	**Red-Outcrop Blue-Gossan Green-FeOx+AlOH**
5	**7-4-2 (PC)**	**False color principle component stretch. principle component (PC) stretch disallows matching mineral groups to colors.**
6	**5/7-5/1-4 (PC)**	**Colors should distinguish FeOx+AlOH, from mafic+FeIII rock use of PC stretch disallows matching mineral groups to colors but highlights differences between selected bands.**
7	**5/7-4/5-3/1 (PC)**	**Initial combination Red-FeOx+AlOH Blue-Gossan+Fe rich Green-FeOx. PC stretch disallows matching mineral groups to colors but highlights differences between selected bands.**
8 **9** **10**	**5-4-1** **5/7-3/1-1** **5/7-3/1-5/4**	**Images used during 1993 assessment of DNWR. Primarily as a lithological discrimination image and to identify alteration as zones of higher albedo, not areas around Gass Peak in the in the north. Additionally other areas of red and magenta colors may indicate FeOx and clay minerals commonly associated with alteration.**

Table 7. ASTER Band Ratio and Mineral Indexing Method used during Image Processing.

ASTER Band Rato and Mineral Index Methods				
	Red	Blue	Green	Source
1	4/8 FeOx	4/2 Alteration	8/9 Contrast	Gabr et al., 2010
2	5/6 Sericite	7/6 Muscovite	7/5 Kaolinite	Hewson (CSIO)
3	4/2 Gossan	4/5 Alteration	5/6 Host	Volesky
4	5/6*7/6 Phengitic	6/8 Amphibole	4/5 Laterite	Bierwith
5	5/3 + 1/2 FeIII	(6+8)/7 Dolomite	(7+9)/8 Carbonate	Rowan Combination Image
6	3	2	1	True Color Image
7	(11*11)/ (10*12)	13/14	12/13	Nimoyima
8	Red - FeOx	Green/yellow - Clay		Index Threshold Map
	Magenta - Silica	Purple - Dolomite	Cyan/blue-limestone	
Mineral Index Methods				
Dolomite Mask of ratios 4/5>1; 5/6>1; 7/6<1; 7/5<1; 7/8<1; 9/8>1, 6/9>1 on SFF result for Dolomite 1				
Calcite Mask of ratios 4/5>1, 5/6>1, 7/6<1, 7/5<1,7/8>1,9/8>1, 5/8>1, 6/9>1 on SFF result for SFF result for Calcite 3				
FeOx Mask of ratios 2/1, 3/2, & 3/1 within known ranges for goethite, hematite & jarosite on PC3 of PC123				
AlOH Mask of ratios 4/5>1; 7/6>1, 7/8>1; on ratio 7/6				
SiO2 Mask of band ratios 12/13<1; 12/11<1; 13/11>1; 11/10>1 on TIR MF result for silica				

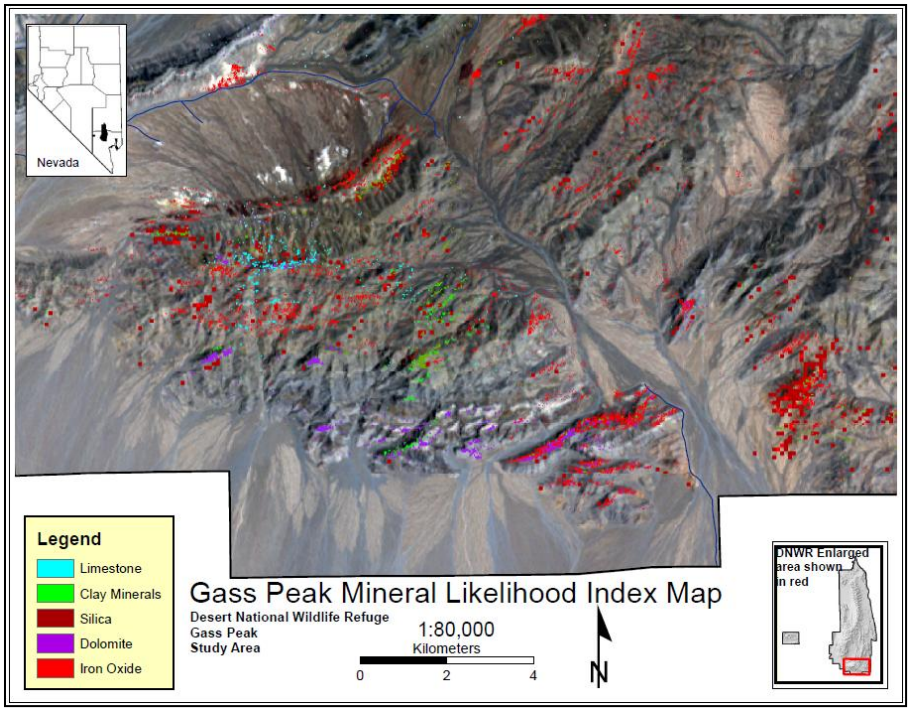


Figure 15. Mineral Likelihood Index Map from processed ASTER data in the Gass Peak area. The mineral index methods of r limestone (calcite), clay minerals, silica, dolomite, and limonite (iron oxides) are listed in Table 7. Field checks focused on investigating individual pixels for verification. Note how many of mapped minerals mimic stratigraphy, indicating its lithology is being mapped rather than hydrothermal alteration zones, which should cut across stratigraphy in at least some areas.

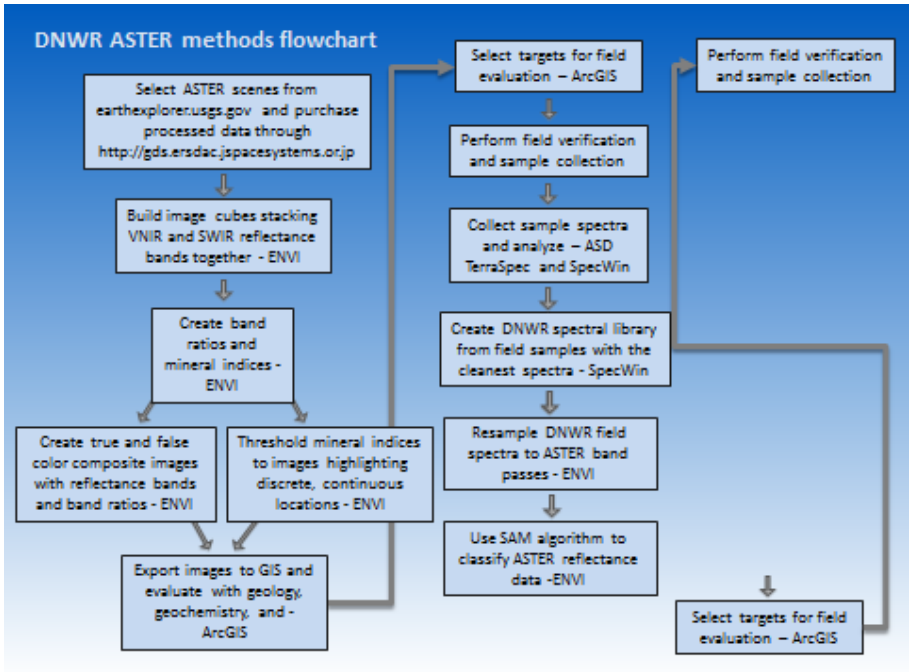


Figure 16. Flow chart that summarizes the work flow for the image processing utilized in this study.

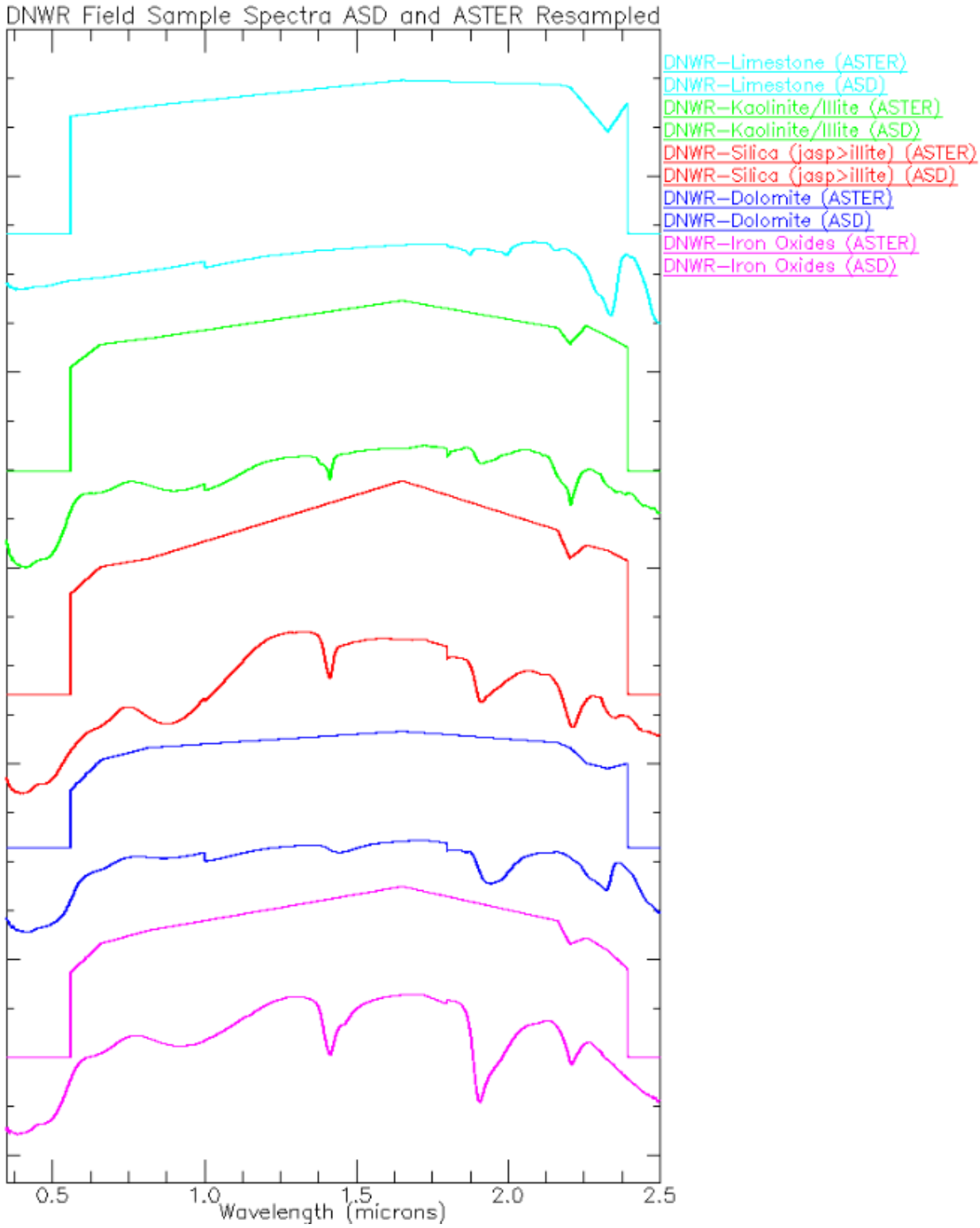


Figure 17. High resolution spectra from samples collected in the field compared to the same data re-sampled to ASTER spectral wavelengths. The ASTER re-sampled data are used as a reference library during SAM processing as described in the text.

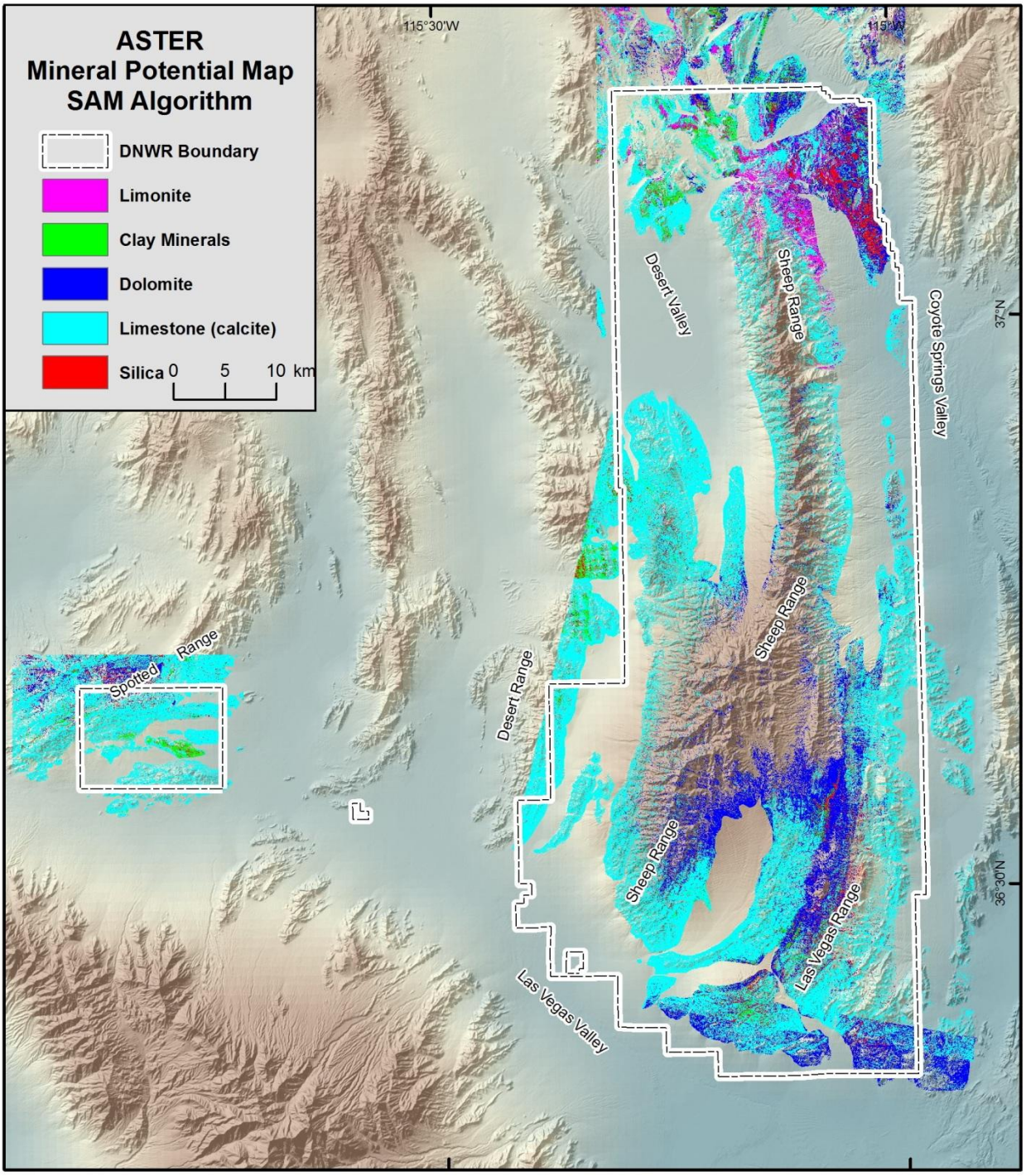


Figure 18A. Mineral map produced using the SAM algorithm as described in the text, showing the distribution of limonite (Fe-oxides), clay minerals, dolomite, limestone (calcite), and silica (by NIR). Colored-coded pixel shows the dominant mineral in the area of pixel (15 m on a side). The analysis excluded the alluvial basins. The area without signal along the crest of the Sheep Range is likely the result of increased vegetation and trees at higher elevations. The abrupt linear boundary in the southeast corner of the DNWR is likely caused by albedo differences between two images.

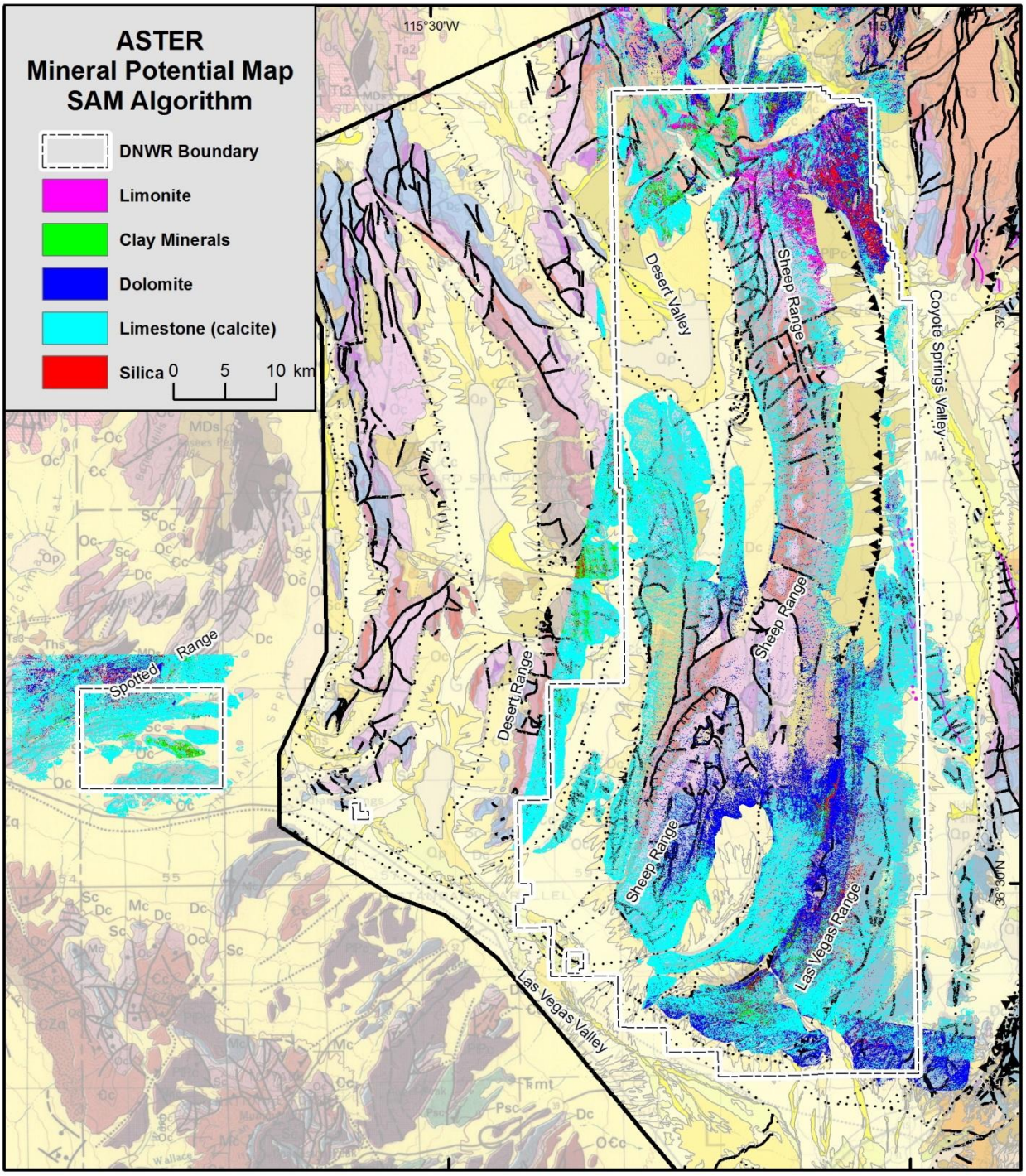


Figure 18B. Same as Figure 18A, except shows Figure 7A geologic map as a backdrop. See Figure 7B for explanation of units.

Discussion of Results

The images indicate the spectral response is largely caused by mineralogy of the rock units and formations, rather than by hydrothermal alteration. Zones of limonite in the images, which could be related to the weathering of sulfides in a metallic mineral deposits, are almost entirely restricted to Tertiary volcanic rocks, which, based on field checks, are unaffected by hydrothermal alteration. Clay minerals, which should be expected in alteration zones, were outlined in only few areas in the processed imagery. Where present, though, areas of clay appear to be related to lithology rather than hydrothermal alteration. Field checks indicated clays were related to local shales, siltstones, and clay-rich partings on thin-bedded limestone. Field checks of areas of silica as indicated by images using the TIR bands indicated the presence of silica-rich lithologies such as chert and quartzite, and in some cases documented false anomalies, such as dark gray dolomite.

Two areas of known alteration and mineralization, the Gass Peak District at the south end of the DNWR and the Lake Mine area at the northeast end of the DNWR, show only subtle expressions in the ASTER imagery using the SAM algorithm. Hydrothermal dolomite, which is associated with mineralization in the Gass Peak District, only shows as sporadic dolomite-dominant pixels in the image. This is consistent with field checks. The imagery confirms the absence of a large zone of pervasive dolomitization, which would be expected to be associated with large carbonate-hosted base metal deposits. Field checks of the Lake Mine area indicated that limonite, silica, and some clay were the main alteration features; however, the imagery indicates the alteration is limited to what was observed in the field. More detailed maps showing Landsat ETM+ and ASTER imagery in conjunction with geology and geochemistry will be presented in the section evaluating the potential for metallic mineral deposits, including both the Gass Peak District and the Lake Mine area. In summary, the remote sensing imagery, by itself, did not detect any new zone of hydrothermal alteration and mineralization in the DNWR that was not evaluated in the original 1992-1993 NBMG assessment.

Assessment of Potential for Metallic Mineral Deposits

Introduction

Nevada is a well-endowed state with respect to metallic mineral deposits. The value of Nevada's non-fuel mineral production was valued at $9.04 billion in 2013, the third straight year that it led the United States (USGS Minerals Commodities Summary 2013). About 95% of that value was from metals and 90% from gold. Nevada, if it were a country, was the fourth largest gold producer in 2012, behind China, Australia, and Russia. Besides gold, Nevada is a significant producer of copper, silver, and molybdenum, with likely increasing production of those metals in upcoming years (Muntean, 2014, Davis and Muntean, 2014).

Almost all of Nevada's metals are mined from hydrothermal ore deposits, almost entirely from the northern half of the state. Most of the gold occurs in Carlin-type gold deposits, where sub-micron gold occurs in variably oxidized pyrite in replacement bodies that occur mainly in lower Paleozoic carbonate rocks. Gold also occurs, commonly with silver, in epithermal deposits that are mainly hosted in Cenozoic volcanic rocks. Gold, copper, molybdenum, tungsten, silver, lead, and zinc occur in intrusion-related deposits including porphyry, skarn, and polymetallic vein and replacement deposits. These three broad classes of hydrothermal ore deposits account for almost all of Nevada's past production in metals.

In the original 1992-1993 assessment, NBMG visited the known abandoned mines and prospects in the DNWR. They sampled them and mapped them at levels ranging from reconnaissance to very detailed. Thus, the known occurrences are well-documented in NMBG's 1993 report. They are summarized in Table 8, and their locations are shown in Figure 19. In addition, they did a stream sediment sampling program designed to detect new mineral occurrences. They did not follow up on many of the anomalies that resulted from that program. They outlined them as areas of low potential. They categorized the areas of potential as either being for base metals or for precious metals.

The original assessment did not apply models for different types of ore deposits. A mineral deposit model can be viewed as "systematically arranged information describing the essential attributes (properties) of a class of mineral deposits" and may be empirical (descriptive) or theoretical (genetic) (Cox et al., 1986). It includes such things as: geological features, economic commodities, grade and tonnage characteristics, geological setting, genesis, ore controls, geophysical and geochemical characteristics, and other aspects that are useful in exploration. Mining and mineral exploration companies routinely apply deposit models in their exploration programs. In this updated assessment we evaluated the available data and any newly collected data in the framework of mineral deposits. Specifically, we applied models for the three main families of deposit types in Nevada mentioned above: (1) intrusion-related base and precious metal deposits, (2) epithermal precious metal deposits, and (3) Carlin-type gold deposits.

Our field work in November of 2013 mainly focused on visiting the known areas of mineralization described in the original 1992-1993 assessment and checking new areas that had aspects consistent with Carlin-type gold deposits. During these field checks, rock samples were collected for petrographic study and geochemical analyses. Fifty-eight new analyses were done for 52 elements on 50 samples. In addition, the pulps from 66 rock samples of mineralization collected in 1992 were re-analyzed with the same package as the new samples. The locations of these and new samples are shown in Figure 20.

Table 8. Summary of Mineral Deposits and Occurrences.

Deposit Group	Metals	Production History	Geology	Remarks
June Bug Mine (Gass Peak District)	zinc, lead, silver, (gold)	1,000 tons of ore yielding 620,000 lbs Zn, 16,607 lbs Pb, 2,418 oz Ag, 9.25 oz Au; 1916-1917	Oxidized zinc ore consisting mainly of hydrozincite and hemimorphite along with cerrusite and galena. Occurs as replacement bodies in the Bullion Limestone of the Mississippian Monte Cristo Group. Near the ore bodies the limestone are dolomitized, commonly with zebra textures. The limestone of the Monte Cristo are folded into a series of anticlines and synclines in immediate hanging wall of the Valley thrust, which places to Monte Cristo Group over the Upper Mississippian-Lower Permian Bird Spring Formation. The Valley thrust is a sympathetic footwall thrust of the Gass Peak thrust.	Maze of ~2,500 feet of interconnected underground workings on the east side of canyon. Ore remains in some pillars, but no ore remains in exposed stope faces. Complex post-ore faulting appears to have made mining difficult. Potential offset ore at depth to north and east in hanging-wall segments of faults. Nine ore samples collected from pillar walls in the mine averaged 12.6% Zn, 0.23% Pb, 1.5 oz/ton Ag, <5 ppb Au. Workings on west side consist of 90 feet of adit and prospect cuts.
Sampson-Juniper (Gass Peak District)	zinc, lead, copper, silver (gold, uranium)	None	Series of workings and prospect pits, mainly associated with dolomitization (commonly zebra-textured) along northeast fractures zones. Local jasperoid. Main workings at the "Sampson Claim" contained lenses of mainly hematitic gossan, hemimorphite, and copper oxides. Uranium occurs with copper. Other prospects commonly have clots of hematitic gossan. Geologic setting is same as June Bug mine area, which occurs along strike. Most of working and prospects are in the Bullion Limestone of the Monte Cristo Group.	Main workings at "Sampson Claim" consist of open cut and adjacent inclined shaft that is 75 feet deep and about 90 feet of underground workings.
Castle Rock (Gass Peak District)	copper, silver	None	Pits along a N85°E-striking, steeply NW-dipping, 10 ft-wide fault zone in sheared white quartzite that is either the Stirling Quartzite or Wood Canyon Formation. Occurs in the hanging-wall, less than 200 m from Gass Peak thrust, which dips about 60° underneath the pit. Copper oxides and clots of specular hematite occurs as fracture coatings.	Three prospect pits. Minor silver, but very low lead and zinc.
Quartzite Hill (White Caps District)	lead (silver, copper, zinc)	No recorded production	Workings explore fault zone separating dolomite of the Wood Canyon Fm. From Stirling Quartzite. Gossan up to 2 feet thick occupies the fault zone and contains thin veinlets and pods of galena. Fault zone strikes N10°E and dips 60°-75°NW. Occurs in the hanging-wall, less than 600 m from Gass Peak thrust, which dips underneath the workings.	Workings consist of a 120-foot-long adit and numerous surface cuts. Adit at south end was not driven far enough to intersect the fault zone. Elevated Mo and As.
Wamp Spring	zinc, lead(?)	No recorded production	Prospect shaft exposed shear zone along bedding in Stirling Quartzite, which has shaly partings. Shear zone is 6-8 feet thick with limonite-rich lenses and stains. Shear strikes N15°E, and dips 70°NW. Hematite casts after pyrite in the sheared quartzite.	Prospect shaft and adit appear to date from the 1930s. Two NBMG samples of quartzite with limonite after pyrite showed no anomalous metals.

Table 8 (continued). Summary of Mineral Deposits and Occurrences.

Deposit Group	Metals	Production History	Geology	Remarks
Joe May (Joe May Canyon District)	lead, silver	No recorded production	Small 15-foot-deep shaft sunk on dolomite of the Bonanza King Fm. on a N30°E, steeply dipping shear zone that is parallel to Wildhorse Pass fault. Very minor limonite along outcrop of the shear zone. Spots of black oxidized galena on the west wall of the shaft, in the shear zone. Dump contains recrystallized dolomite with thin calcite-galena veinlets. Thin breccia veins cutting the wall rock have galena-calcite matrix.	NBMG dump sample contained 1.16% Pb, 2.53 ppm Ag, but nothing else notable. A NBMG sample of siliceous, gossanous float in Ordovician Pogonip Group dolomite collected ~1 km east of the shaft had 961 ppm As, 886 ppm Cu, 1.24 ppm Hg, 40.1 ppm Mo, 770 ppm Pb, 88.3 ppm Sb, 133.3 ppm Sn, and 453 ppm Zn.
Wildhorse (Joe May Canyon District)	lead, silver(?)	No recorded production	Shaft sunk in the Bonanza King Formation dolomite. Dump material from shaft is mostly cellular gossan composed of hematite and goethite and massive reddish brown jasperoid. Local breccias with jasperoid fragments in gossanous matrix. A cut also exists 20 feet downslope west of the shaft. Gossan pods occur along dolomite bedding in the cut, and a N30°E-striking, steeply NW-dipping shear zone is exposed at the north end of the cut. A N-striking, 60°W-dipping fault zone with gossan pods is exposed about 30 feet downslope to the west of the shaft.	Last work probably was in the 1940s-50s. Two NBMG samples of the dump material had up to 1385 ppm As, 157 ppm Cu, 1310 ppm Pb, 35 ppm Sb, and 102 ppm Zn.
Lake Mine	Unknown, see remarks	None, staked in 1899	Outcrop of hematite-goethite gossan and jasperoid in limestone of unknown age. Gossan is cellular mass of limonite, probably after massive pyrite. Zone of breccia, gossan, jasperoid trends NNW and dips steeply W. Zone of coloration and jasperoid-hematite replacement trends NS, likely along a thrust fault. Replacement zone is conformable with bedding.	Only one prospect pit with small decline sunk on structure. Appears to have seen no activity since it was staked in 1899. Unsure if any metals of interest at encouraging grades were ever encountered. Gass Peak thrust likely trace nearby. Mineralization post-dates thrusting but pre-dates volcanic rocks, the oldest of which are Late Oligocene. A NBMG sample of the dump material contained 262 ppm As and 44 ppb Au, the highest Au assay of any NBMG analysis of DNWR samples. However, did not contain elevated Zn, Pb, Cu, or Ag.

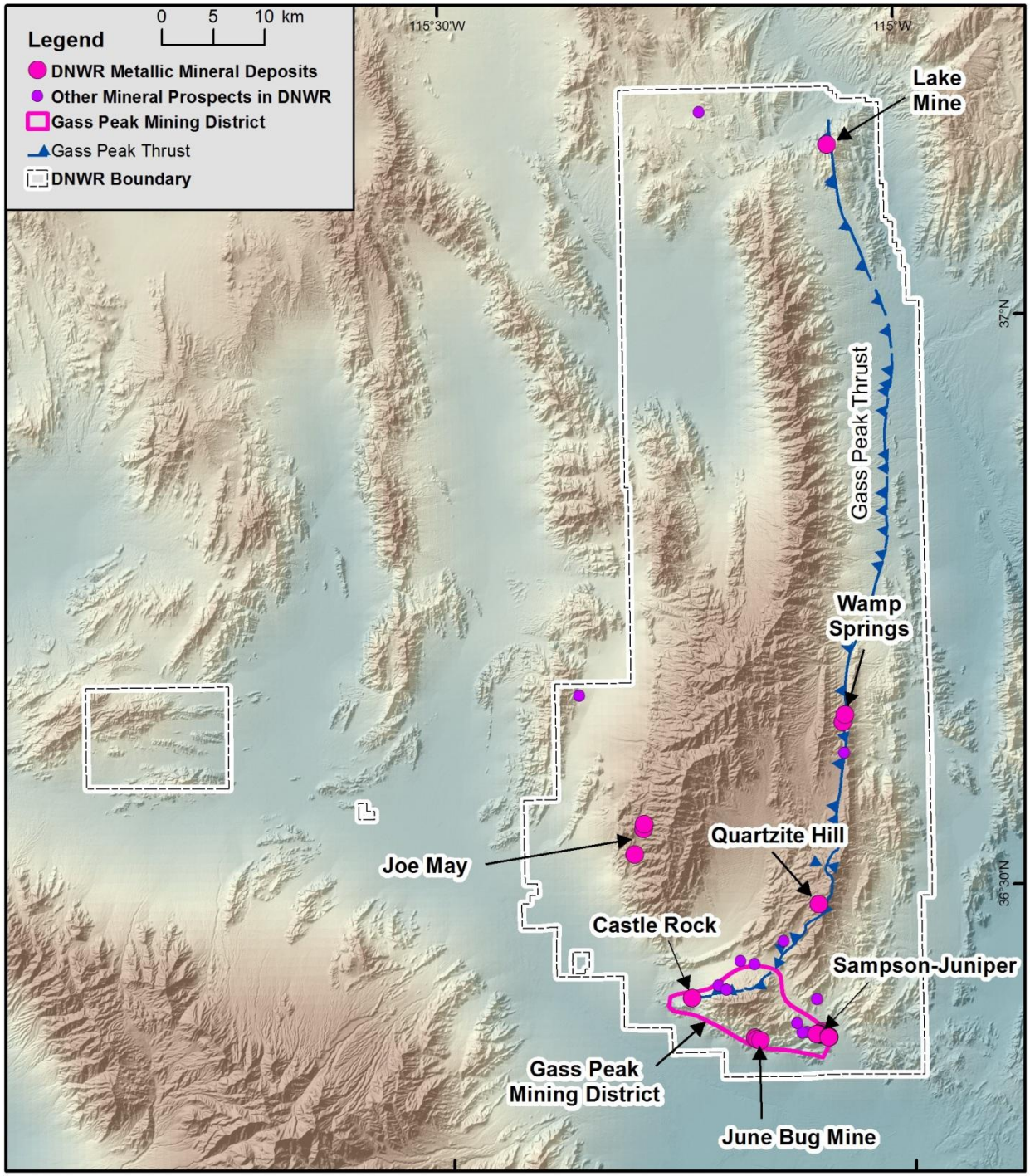


Figure 19. Locations of known metallic deposits in the DNWR summarized in Table 8. Also shows other mineral occurrences described in NBMG's original 1993 assessment report. Gass Peak thrust shown for reference. As described in Table 8 and in text, almost all the mineral deposits are spatially associated with the Gass Peak thrust or sympathetic thrusts in its footwall.

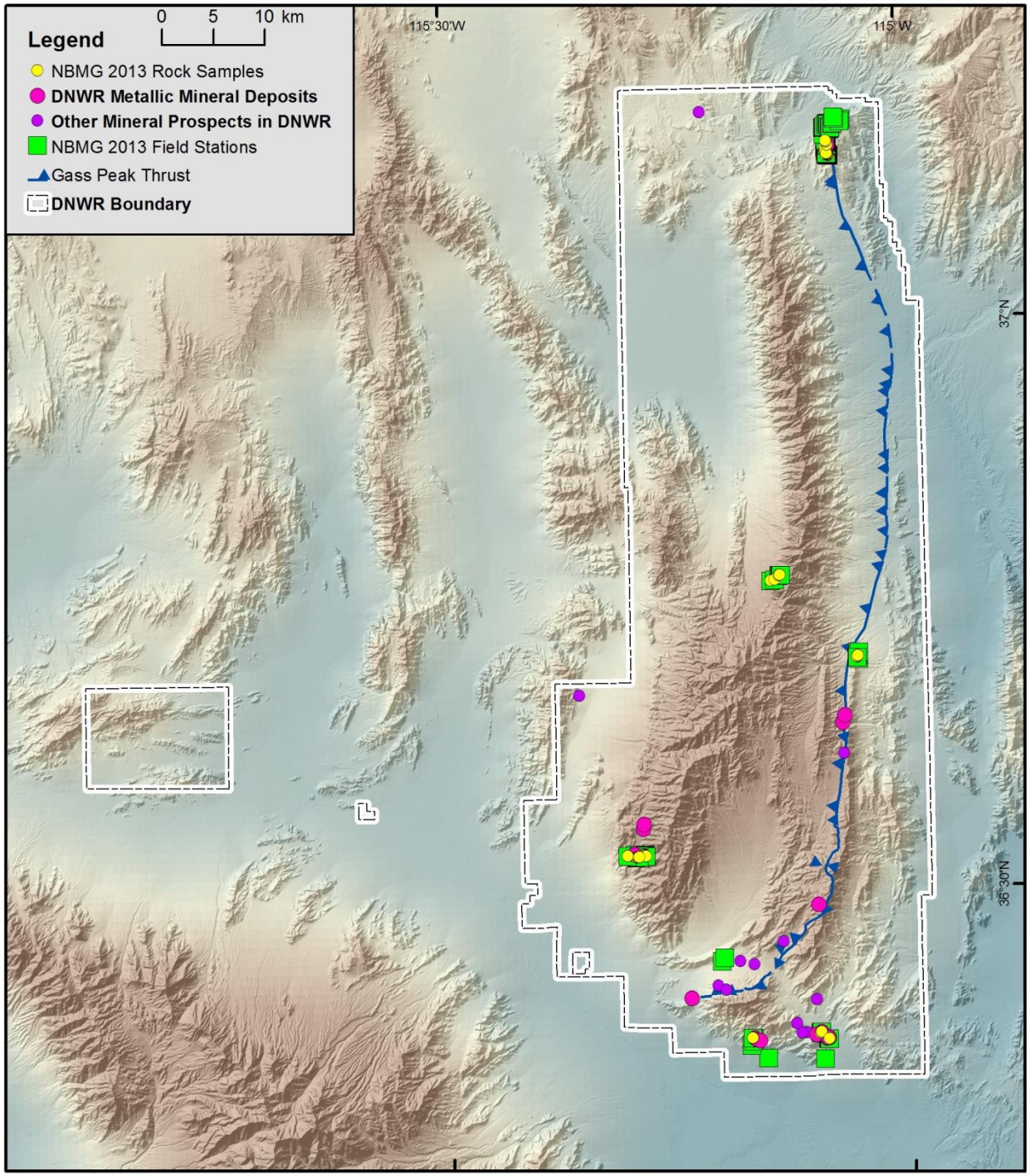


Figure 20. Locations of NBMG 2013 field checks and rock samples collected for current updated assessment.

Geochemistry

Geochemistry plays an important role in assessing potential for metallic ore deposits, and determining the type of deposit, if one exists. Maps of precious and base metals and select elements that are indicators of precious and base metal deposits are shown and briefly described in this section. The maps show the analyses of the 2013 rock samples, the re-analyses of the 1992 rocks samples, and the limonite float chip fraction of the 1992 stream sediment samples collected by NBMG. The float chip samples were collected by scavenging an area of the drainage channel for iron- or manganese-stained rocks, jasperoid, vein quartz, or calcite. In 1992 NBMG also collected standard silt samples, which represent a composite sample of the drainage basin. Those are not shown in the maps.

Except for locally silver, the concentrations of precious metals in the DNWR are only very weakly anomalous. The results would be considered poor for most exploration geologists. For gold, of the 124 rock chip samples of mineralized rock, only 19 samples had greater than 5 ppb (Fig. 21). The highest gold assay was 44 ppb, which was from the Lake Mine area. Of the 199 limonite float chip samples of stream sediments, only three analyses were above 5 ppb gold. Platinum and palladium were two of the 52 elements that were analyzed in the rock samples. They occur at locally high concentrations in the Goodsprings district and a few other localities in southern Nevada, as discussed below. Only two of the 124 rock chip samples had platinum assays above the 5 ppb detection limit. The highest assay was from a sample from the June Bug mine area, but it was only 15 ppb. Thirty-six samples assayed above the 1 ppb detection limit for palladium. The highest assay was only 12 ppb, in a sample from the Lake Mine area. Figure 22 shows no areas of anomalous silver in the stream sediments, except for the June Bug mine area and a few isolated sites. The five samples with the highest silver concentrations in mineralized rock samples, ranging from 79.7 to 312 ppm, occur in the Sampson-Juniper group of prospects at the east end of the Gass Peak mining district. The June Bug mine and prospects along the Gass Peak thrust have locally strongly anomalous silver concentrations above 3.6 ppm.

Arsenic, mercury, and antimony are commonly pathfinder elements for gold and silver. Anomalous arsenic is widespread in the DNWR, both in the main large east parcel and in the much smaller Indian Springs parcel (Fig. 23). The Lake Mine has the highest five arsenic concentrations in rock samples (4650 ppm to ≥10,000 ppm). High values also occur in the June Bug mine area, the Joe May Canyon area and in the Sandy Wash area at the north end of the Indian Springs parcel. The arsenic values of the limonite float in stream sediment analyses are conspicuously high in a narrow region of the central part the Sheep Range on both the east and west sides of the range. These anomalies are discussed in more detail below in the assessment of Carlin-type gold deposits. Mercury is highest in analyses from the Sampson-Juniper, June Bug mine, Lake mine, and Joe May Canyon area, as well as sporadically in samples from other prospects along the Gass Peak Thrust (Fig. 24). NBMG did not analyze for mercury in the stream sediment samples that were collected in 1992. Anomalous antimony and the concentrations of antimony, both in rocks and limonite float in stream sediments, are not nearly as widespread or as high as those for arsenic (Fig. 25). Again, the most anomalous zones are the Sampson-Juniper, June Bug mine, Lake mine, and Joe May Canyon areas. Antimony values are relatively low along the Gass Peak thrust, except for in the Lake Mine area. Tellurium is also anomalous (high of 3.99 ppm) in rock samples from the Sampson-Juniper, June Bug mine, Lake mine, and Joe May Canyon areas, whereas thallium (high of 127 ppm) and selenium (high of 71 ppm) are anomalous in the Sampson-Juniper and Lake Mine areas.

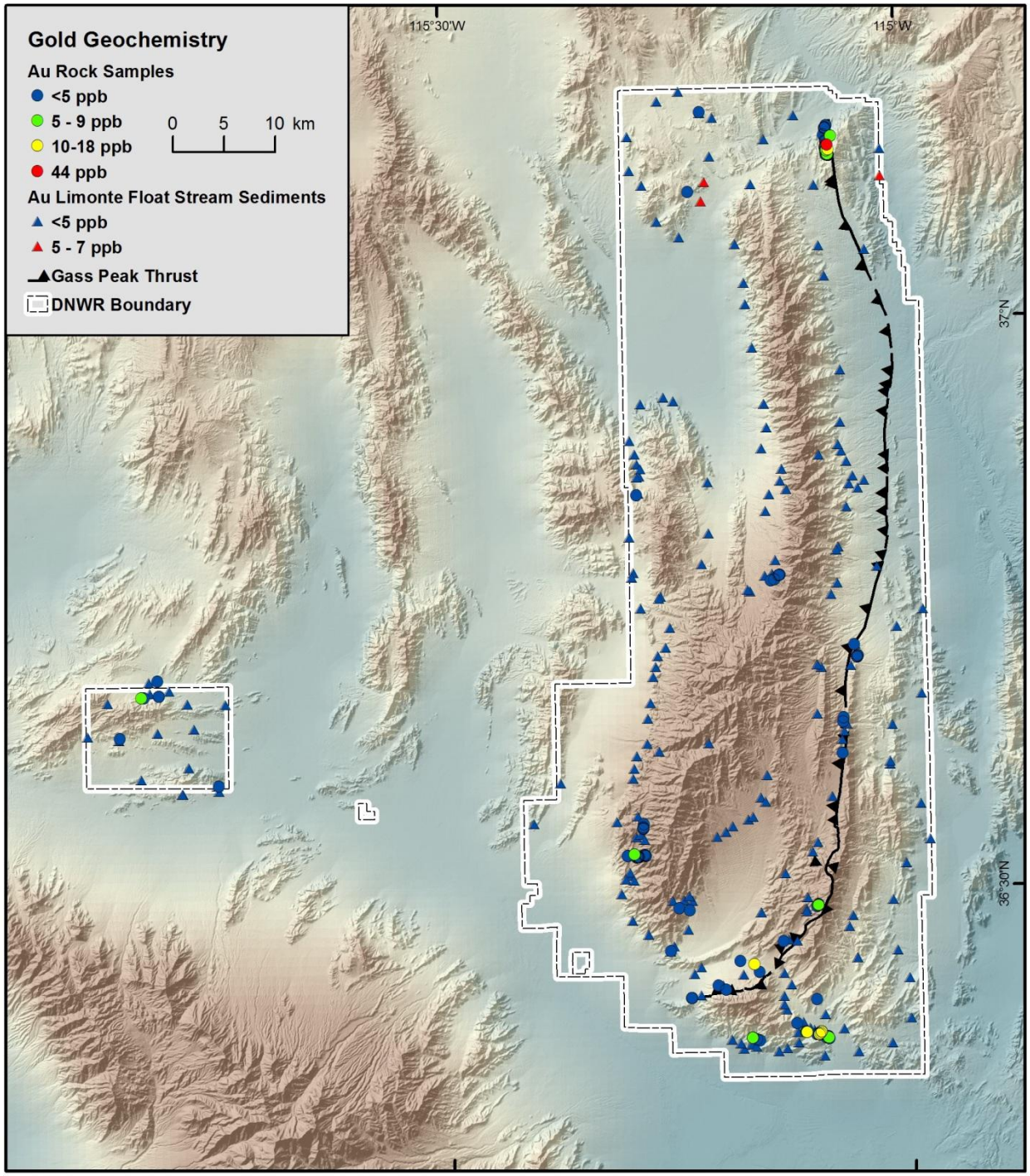


Figure 21. Distribution of gold concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

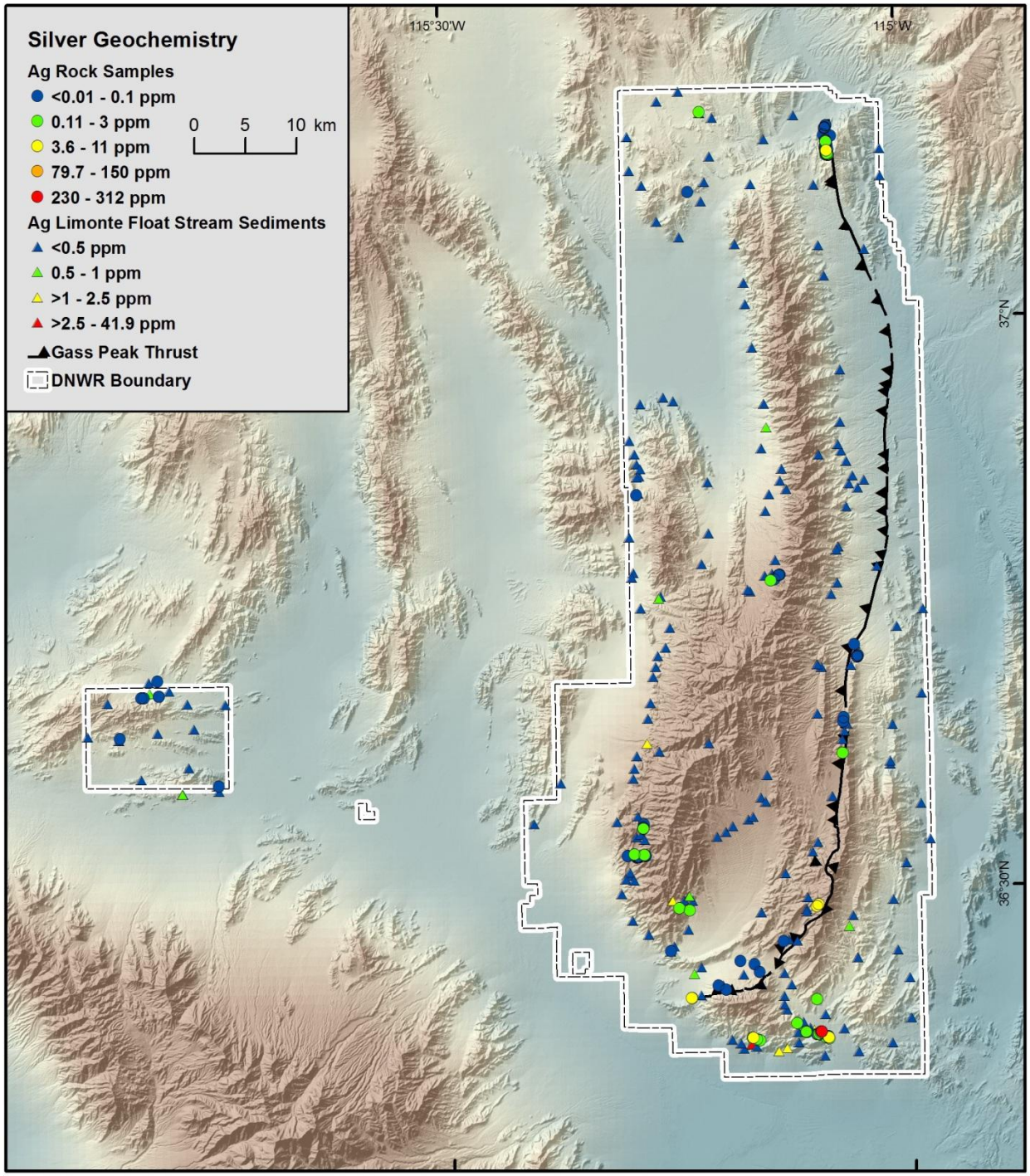


Figure 22. Distribution of silver concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

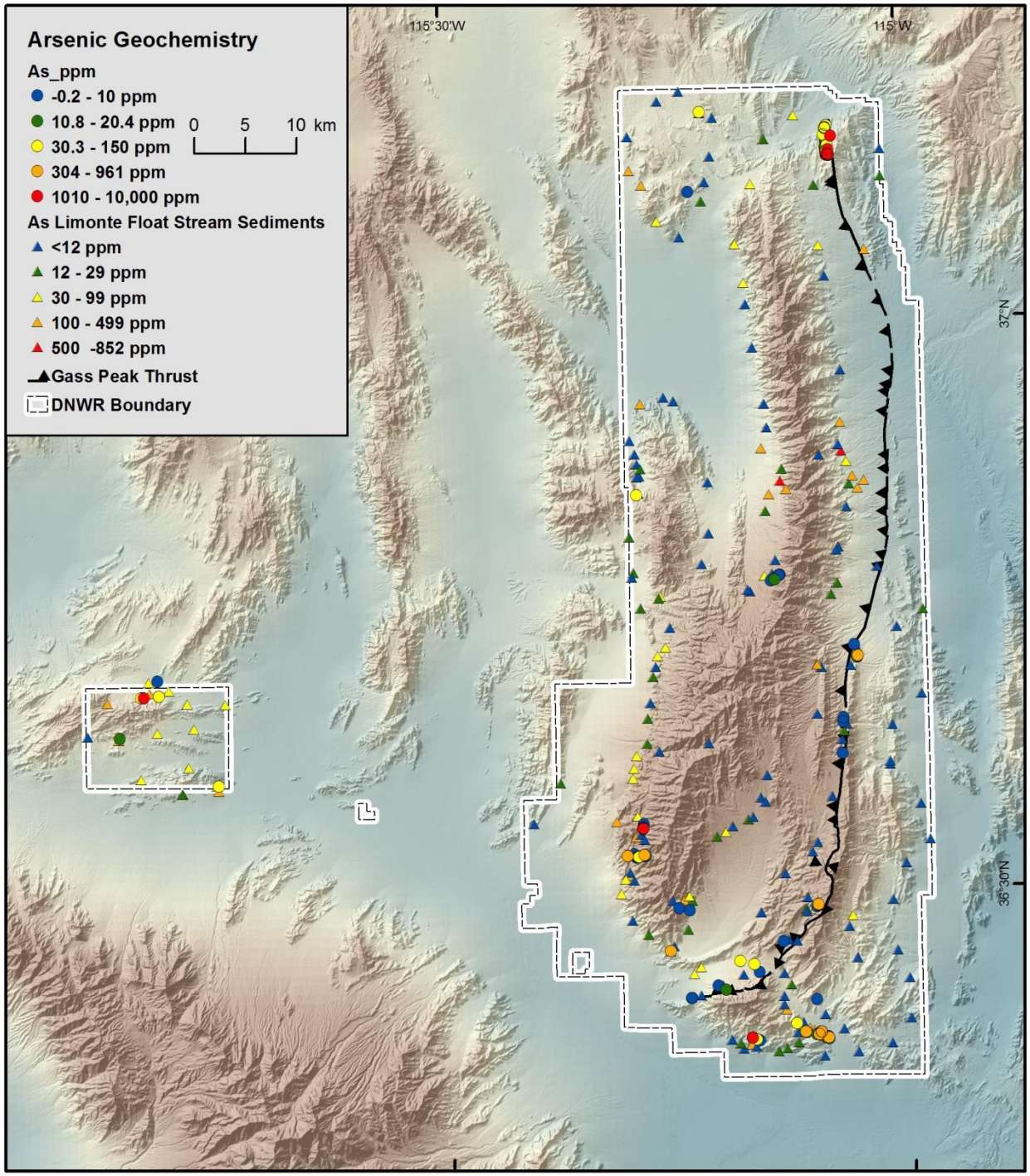


Figure 23. Distribution of arsenic concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

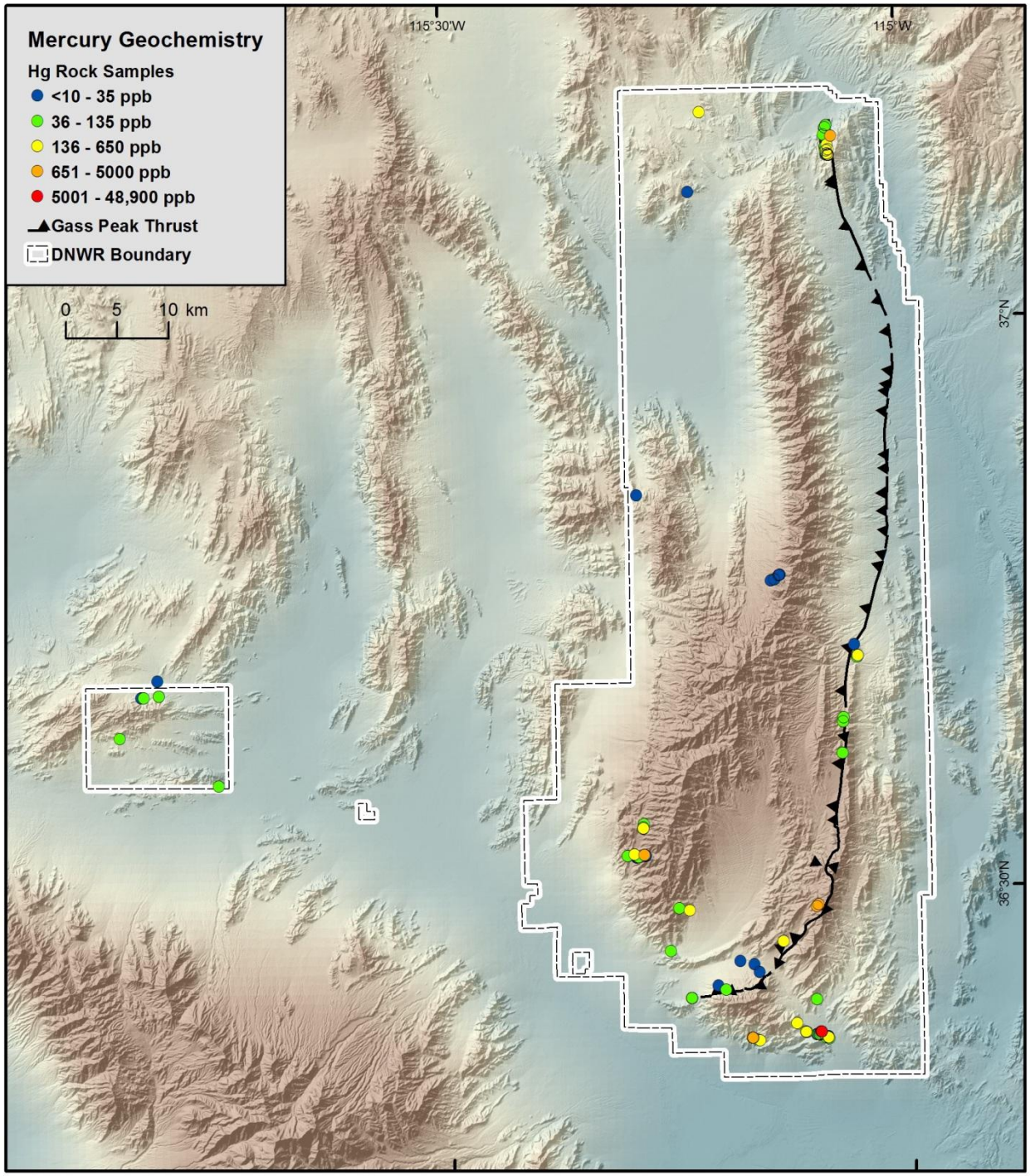


Figure 24. Distribution of mercury concentrations in mineralized rock samples collected by the NBMG from the DNWR.

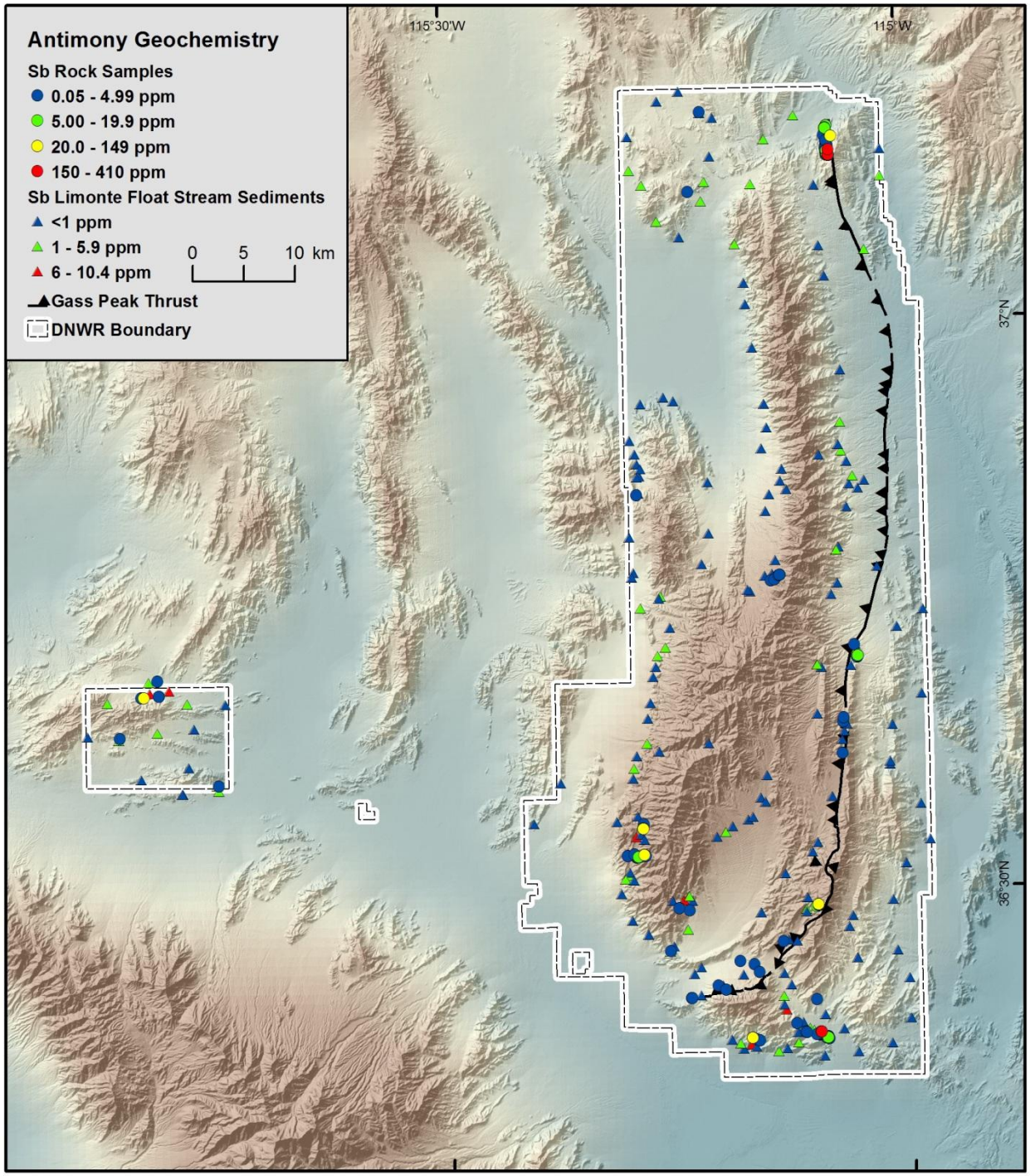


Figure 25. Distribution of antimony concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

The only known mineral deposits on the DNWR are base metal deposits, with the only recorded production from the June Bug mine, which most of its produced value was from zinc. Elevated levels of zinc are widespread in the DNWR, especially in the Gass Peak mining district and the southeast corner of the DNWR in the Mississippian to Permian carbonates that constitute the lower plate of the Gass Peak thrust (Fig. 26). Joe May Canyon, the Lake Mine, and areas along the Gass Peak thrust are elevated but values are not as consistently high as to the southeast in the footwall of the thrust. Lead shows a similar pattern to zinc, but the anomaly at the southeast end of the DNWR is not as strong as for zinc (Fig. 27). Anomalous lead values are not as pervasive and widespread in the stream sediments as for zinc. Copper shows a very similar pattern as lead (Fig. 28). At the south end of East Desert Range along Dead Horse Road, there was one limonite float stream sediment sample with 449 ppm copper, but no other elements with concentrations of interest. The drainage occurs in Miocene sedimentary rocks of the Horse Springs Formation. Only the June Bug mine and Sampson-Juniper areas have consistently elevated molybdenum (Fig. 29) and uranium (Fig. 30) in the rock and stream sediment samples. The stream sediment samples at the north end of the DNWR have elevated zinc, lead, copper, molybdenum, and uranium, which reflect the abundant Tertiary volcanic rocks in that area.

Table 9 shows descriptive statistics for gold, silver, arsenic, copper, molybdenum, lead, antimony, uranium, and zinc. For samples that had concentration, a value of half the detection limit was used. The results in Table 9 are affected by differences in the detection limits between the mineralized rock samples analyzed in 2014 versus all of the other analyses that were analyzed in 1992.

Potential for Intrusion-related Deposits

Deposits associated with upper crustal felsic intrusions are the main source of the world's copper, molybdenum, tungsten, and tin, and are important sources for gold, silver, zinc, and lead. Several different deposit types can be associated with intrusion-related hydrothermal systems. Porphyry copper systems are the ones most coveted by mining companies. Figure 31 is a schematic cross-section of porphyry copper system, showing all of the different types of deposits that could potentially be present. Such systems are large and, even if only in the subsurface, should have some surface expression or some geophysical signature, typically a magnetic high due to magmatic or hydrothermal magnetite or a chargeability high due to sulfides. As discussed above, there is a large magnetic anomaly at the southeast end of the DNWR that could be caused by a felsic intrusion, but, if present, is likely at depth of greater than 4 km. Even at that depth there should be some dikes or high-temperature alteration present above such an intrusion, if it was a porphyry system. However, as noted above, no intrusions have been recognized in the DNWR. Given the abundance of carbonate rocks, one would expect some high-temperature skarn formation if a porphyry system was present, but no skarn has been recognized. Also, as shown in Figure 31, metals are strongly zoned around the intrusive porphyry system. Molybdenum and copper are more proximal to the higher temperature center, whereas lead and zinc typically occur along the edges of the porphyry system. Figure 32 shows Zn/Cu ratios for mineralized rock samples. No zonation is apparent. Pb/Cu ratios also show no patterns. No evidence of a large porphyry system is present on the surface or in the subsurface in the DNWR. Whether or not the zinc-lead-silver-copper mineralization at June, Sampson-Juniper, Joe May and the Lake Mine is related to a deep intrusion or to basinal fluid flow is discussed below.

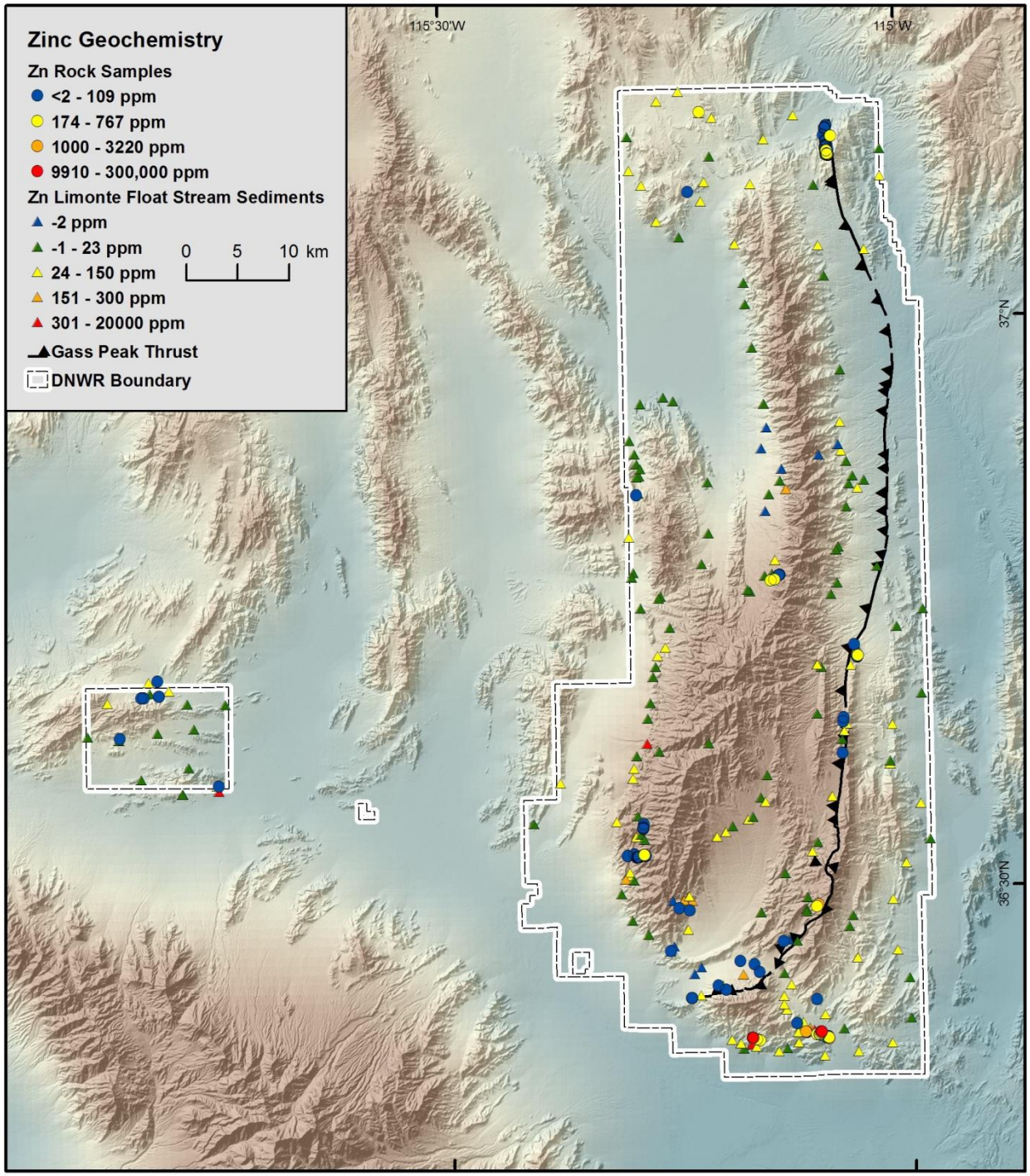


Figure 26. Distribution of zinc concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

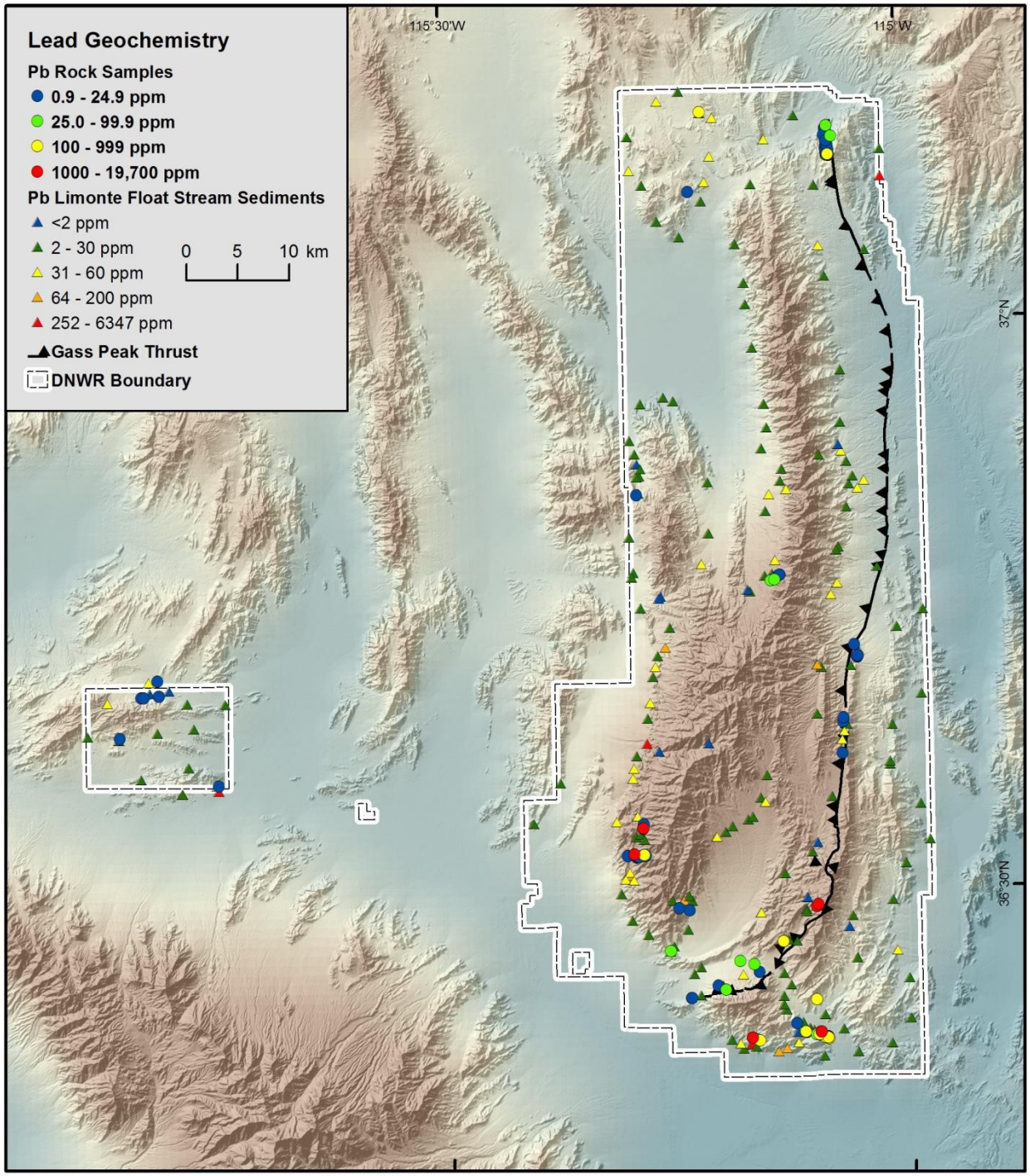


Figure 27. Distribution of lead concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

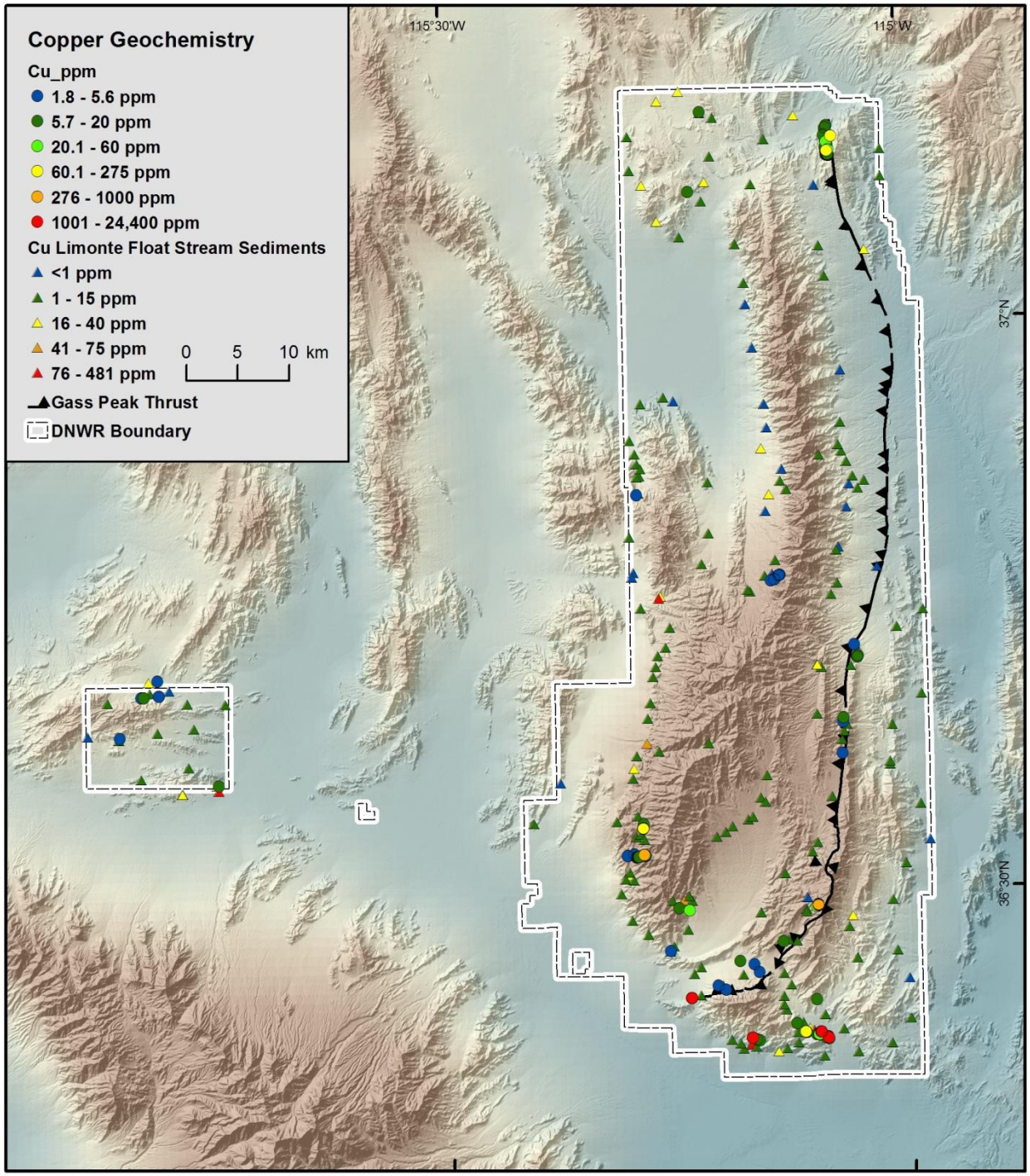


Figure 28. Distribution of copper concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

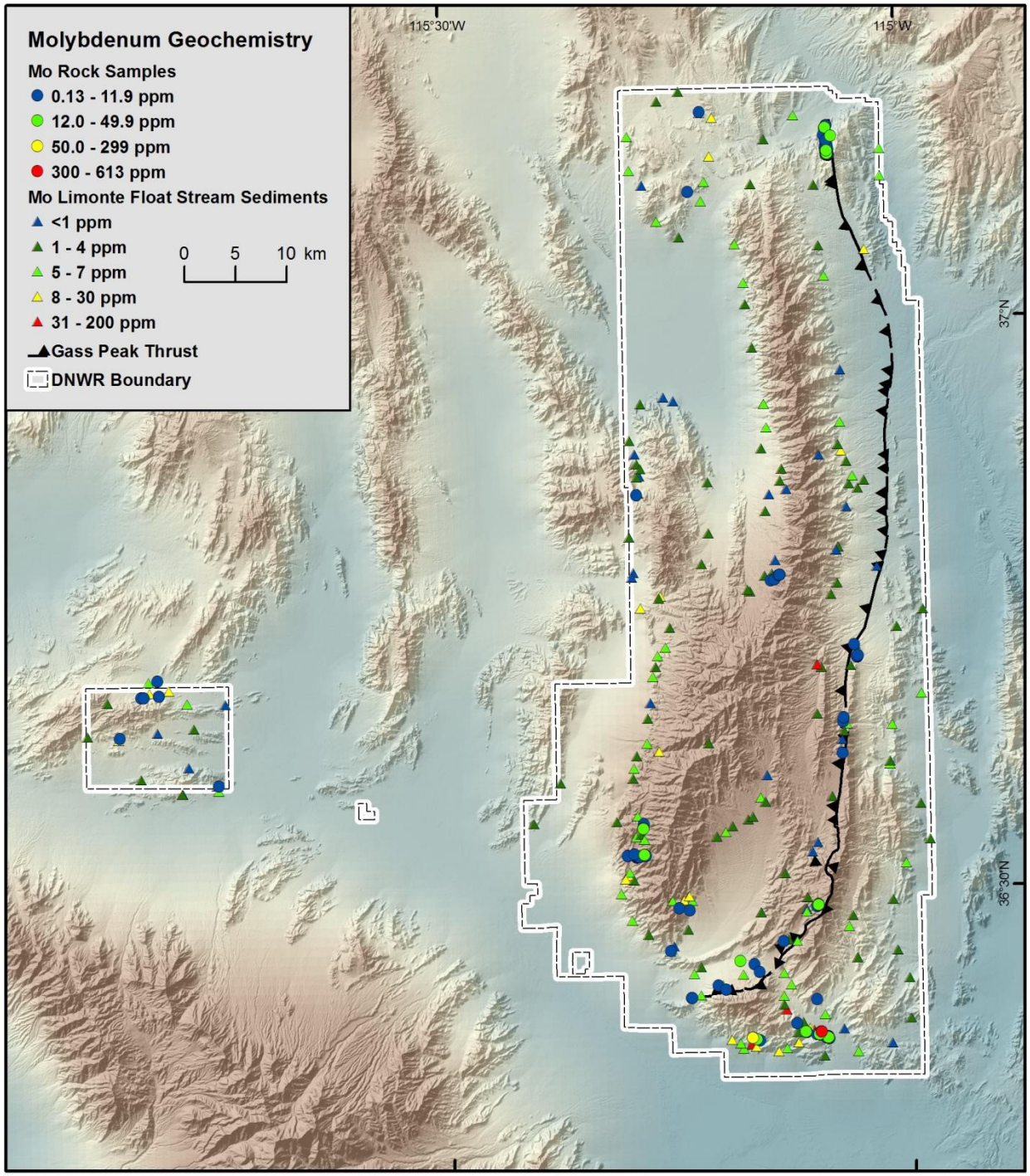


Figure 29. Distribution of molybdenum concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

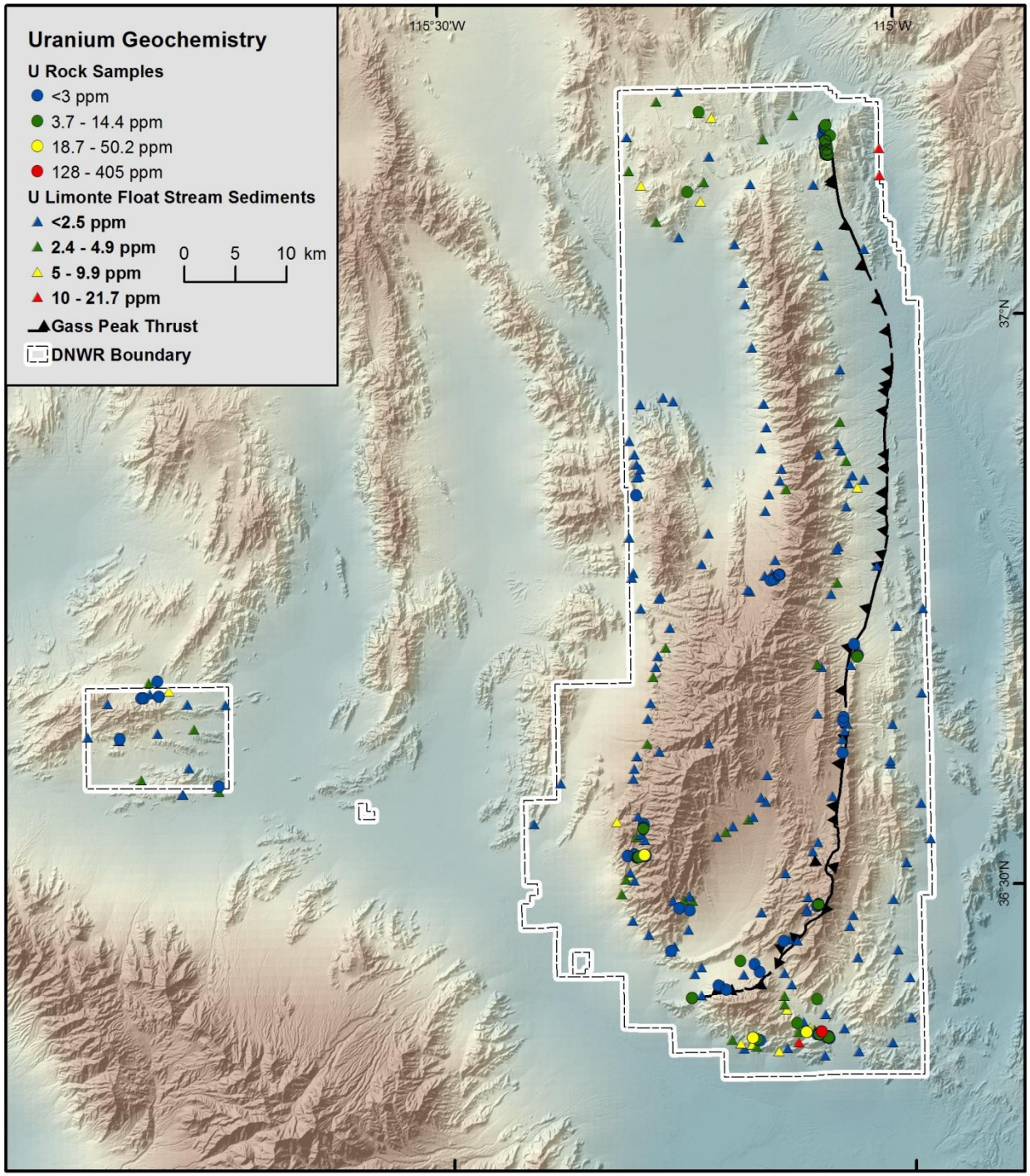


Figure 30. Distribution of uranium concentrations in mineralized rock samples and limonite float in stream sediment samples collected by the NBMG from the DNWR.

Table 9. Descriptive Statistics for Selected Element of Interest for the Various Sample Types Analyzed by NBMG in the Original and Current Mineral Assessments of the DNWR.

Gold ppb	Mineralized Rock	Limonite Float Stream Sediment	Silt Stream Sediment	Background Paleozoics	Background Tertiary Horse Springs Fm.	Background Tertiary Tuffs
Mean	3.86	1.3	1.4	1.01	1	1
Median	2.5	1	1	1	1	1
Standard Deviation	4.62	1	1.5	0.12	0	0
Minimum	2.5	1	1	1	1	1
Maximum	44	7	14	1	1	1
Number Analyses	124	200	177	75	13	11
Detection Limit	5	2	2	2	2	2
Silver ppm	**Mineralized Rock**	**Limonite Float Stream Sediment**	**Silt Stream Sediment**	**Background Paleozoics**	**Background Tertiary Horse Springs Fm.**	**Background Tertiary Tuffs**
Mean	7.89	0.5	0.32	0.41	0.48	0.34
Median	0.05	0.3	0.25	0.25	0.25	0.25
Standard Deviation	39.44	3	0.31	0.25	0.33	0.2
Minimum	0.005	0.25	0.25	0.25	0.25	0.25
Maximum	312	42	2.9	1.1	1.1	0.8
Number Analyses	124	200	177	75	13	11
Detection Limit	0.01	0.5	0.5	0.5	0.5	0.5
Arsenic ppm	**Mineralized Rock**	**Limonite Float Stream Sediment**	**Silt Stream Sediment**	**Background Paleozoics**	**Background Tertiary Horse Springs Fm.**	**Background Tertiary Tuffs**
Mean	416.86	52.2	5.2	4.33	7.24	3.91
Median	18.85	11.5	4.9	2.3	3	3.1
Standard Deviation	1514.26	109	1.67	8.08	12.86	2.03
Minimum	0.1	1	2.4	0.25	1.2	1.3
Maximum	10000	852	18	59	49	7.5
Number Analyses	124	200	177	75	13	11
Detection Limit	0.2	0.5	0.5	0.5	0.5	0.5
Copper ppm	**Mineralized Rock**	**Limonite Float Stream Sediment**	**Silt Stream Sediment**	**Background Paleozoics**	**Background Tertiary Horse Springs Fm.**	**Background Tertiary Tuffs**
Mean	654	12.4	12.24	7.93	7	13.73
Median	6.1	5	12	6	4	13
Standard Deviation	3318	47	3.7	6.36	9.64	10.85
Minimum	1.8	0.5	5	1	2	5
Maximum	24,400	481	27	32	38	43
Number Analyses	124	200	177	75	13	11
Detection Limit	0.2	1	1	1	1	1

Table 9 (continued). Descriptive Statistics for Selected Element of Interest for the Various Sample Types Analyzed by NBMG in the Original and Current Mineral Assessments of the DNWR.

Molybdenum ppm	Mineralized Rock	Limonite Float Stream Sediment	Silt Stream Sediment	Background Paleozoics	Background Tertiary Horse Springs Fm.	Background Tertiary Tuffs
Mean	21.73	5.4	0.76	1.85	1.73	2.73
Median	2.01	3	0.5	0.5	0.5	2
Standard Deviation	82.87	15	0.56	3.47	3.75	2.32
Minimum	0.13	0.5	0.5	0.5	0.5	0.5
Maximum	613	200	3	19	14	8
Number Analyses	124	200	177	75	13	11
Detection Limit	0.05	1	1	1	1	1
Lead ppm	**Mineralized Rock**	**Limonite Float Stream Sediment**	**Silt Stream Sediment**	**Background Paleozoics**	**Background Tertiary Horse Springs Fm.**	**Background Tertiary Tuffs**
Mean	675	69.2	12.66	8.57	8.69	1
Median	11.3	21	3	1	9	1
Standard Deviation	2569.11	462	16.83	9.45	6.82	0
Minimum	0.9	1	1	1	1	1
Maximum	19,700	6347	129	35	22	1
Number Analyses	124	200	177	75	13	11
Detection Limit	0.5	2	2	2	2	2
Antimony ppm	**Mineralized Rock**	**Limonite Float Stream Sediment**	**Silt Stream Sediment**	**Background Paleozoics**	**Background Tertiary Horse Springs Fm.**	**Background Tertiary Tuffs**
Mean	14.84	1.1	0.54	0.35	0.37	0.44
Median	0.975	0.4	0.5	0.1	0.3	0.4
Standard Deviation	50.08	2	0.17	0.66	0.5	0.24
Minimum	0.05	0.1	0.1	0.05	0.05	0.2
Maximum	410	10	1	4	1.9	0.9
Number Analyses	124	200	177	75	13	11
Detection Limit	0.05	0.1	0.1	0.1	0.1	0.1
Uranium ppm	**Mineralized Rock**	**Limonite Float Stream Sediment**	**Silt Stream Sediment**	**Background Paleozoics**	**Background Tertiary Horse Springs Fm.**	**Background Tertiary Tuffs**
Mean	7.55	2.2	1.98	1.29	3.61	5.43
Median	1.15	1.6	1.8	1	3.1	5.4
Standard Deviation	38.18	2	0.75	1.3	1.55	2.01
Minimum	0.2	0.4	0.9	0.1	1.4	2.9
Maximum	405	22	5.1	5.9	7.1	9
Number Analyses	124	200	177	75	13	11
Detection Limit	0.1	0.2	0.2	0.2	0.2	0.2
Zinc ppm	**Mineralized Rock**	**Limonite Float Stream Sediment**	**Silt Stream Sediment**	**Background Paleozoics**	**Background Tertiary Horse Springs Fm.**	**Background Tertiary Tuffs**
Mean	3769.73	164.8	33.02	11	28.15	63.36
Median	44.5	19	20	1	6	59
Standard Deviation	27,401	1433	71.07	19.79	36.75	26.61
Minimum	1	1	1	1	1	28
Maximum	300,000	20,000	921	93	111	108
Number Analyses	124	200	177	75	13	11
Detection Limit	2	2	2	2	2	2

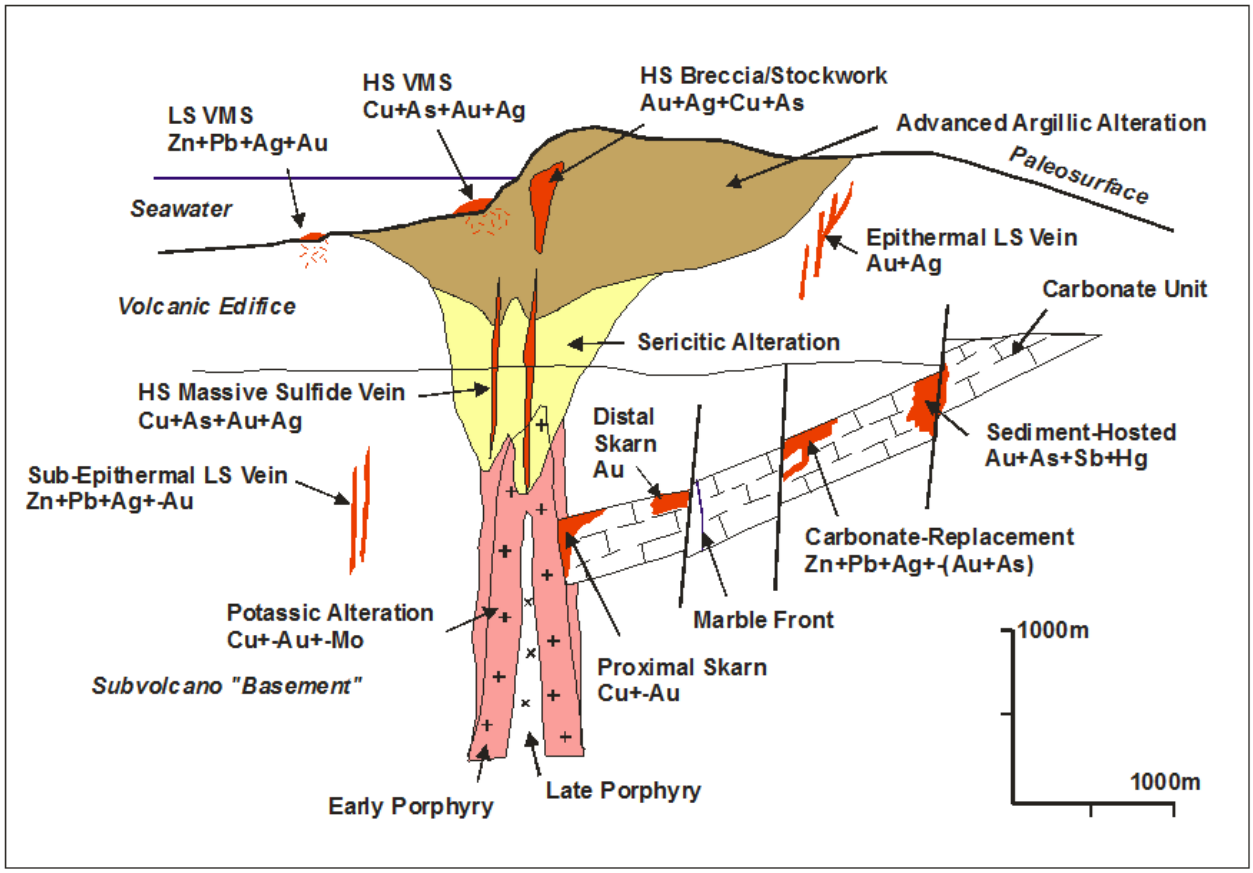


Figure 31. Schematic diagram of a porphyry copper system showing the different types of mineral deposits, metals, and hydrothermal alteration types in relationship to an upper crustal porphyry intrusive center. Modified from Sillitoe (1995). HS=high-sulfidation, LS=low-sulfidation, VMS=volcanogenic massive sulfide.

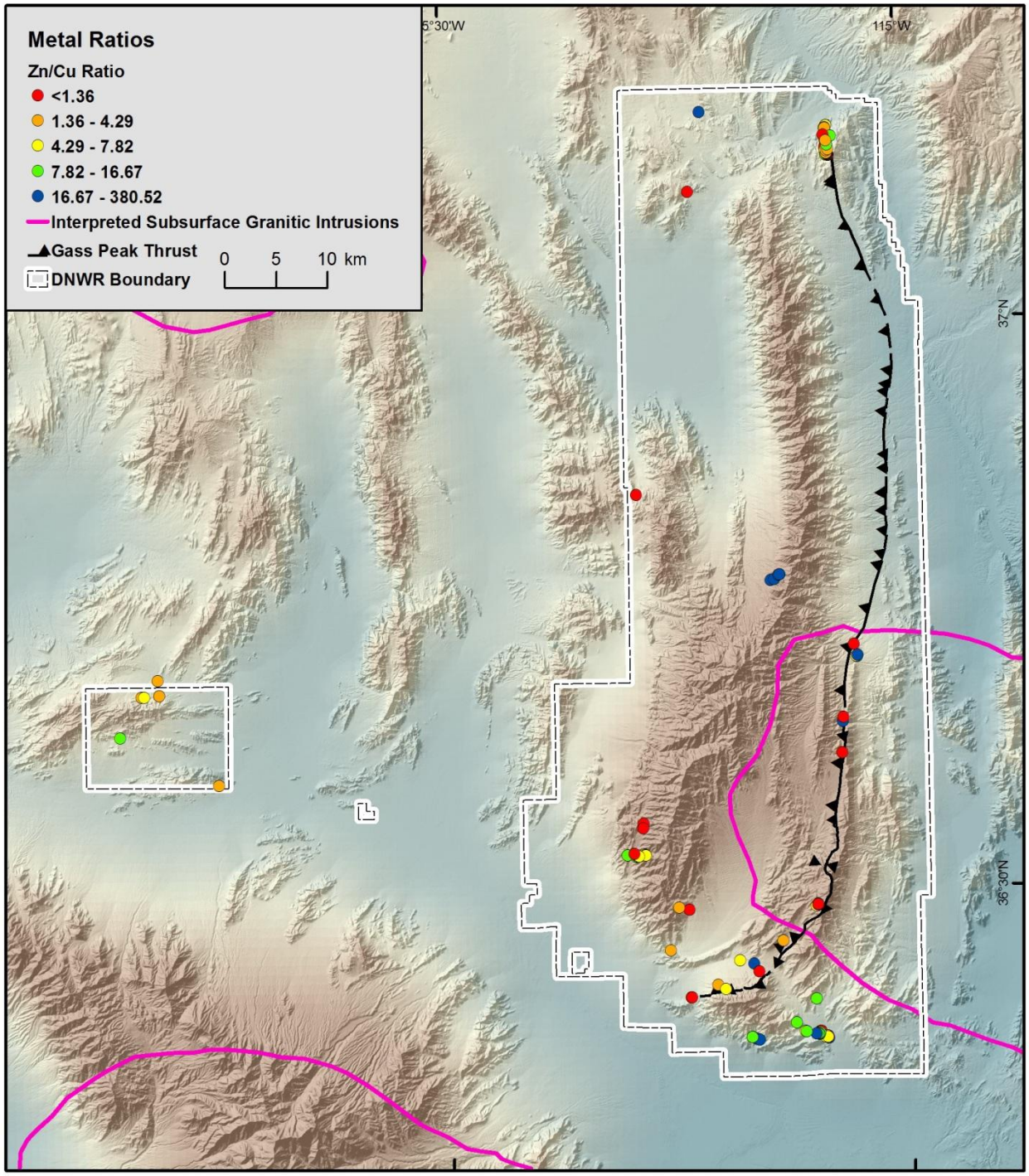


Figure 32. Distribution of zinc/copper ratios in mineralized rock samples collected by the NBMG from the DNWR in order to test whether there is any zoning patterns related to possible subsurface granitic intrusions interpreted from aero-magnetic data. As discussed in the text the zinc/copper ratio should increase away from the intrusion. No zonation is apparent.

Potential for Volcanic-Hosted Epithermal Gold-Silver Deposits

Several small to medium-sized low-sulfidation gold-silver deposits occur within the Pahranagat shear zone northeast of the DNWR. The closest are the deposits of the Delamar district located 40 km northeast of the DNWR. The Delamar district has produced approximately 650,000 ounces of gold. The Delamar Mine was the main producer of the district and reportedly produced 217,000 ounces of gold and 420,000 ounces of silver. The district is located along the southwest margin of the Delamar caldera, which erupted the Hiko Tuff at 18.56 Ma. Ash flows of the Hiko Tuff occur in the northern end of DNWR as mentioned above. Ore occurs in quartz veins that are hosted mainly in Cambrian quartzite, just outside the caldera. The strike length of the veins extends to 2,700 feet. Ore also occurred in Cambrian carbonates as bedding replacement ores. Rhyolitic to basaltic dikes are also present. A schematic model for low-sulfidation epithermal gold-silver deposits is shown in Figure 33.

Although the same rocks occur in the DNWR, no epithermal quartz veins have been recognized. Alteration could include illite- or montmorillonite-bearing clay alteration with or without calcite, shallow steam-heated alteration containing alunite and kaolinite, deeper propylitic alteration containing chlorite, epidote and other mineral or abundant limonite resulting from weathering of sulfides. No significant alteration zones have been detected in the Tertiary volcanic rocks in DNWR, either from field checks, aerial photography, or remote sensing. Alteration in the Lake Mine area is consistent with epithermal alteration in carbonate terrains, but it is older than the Tertiary volcanic rocks. The biggest difference between the DNWR and areas of epithermal deposits in the Delamar district and elsewhere in Nevada is that there is no magma source underneath the volcanic rocks in the DNWR. All the volcanic rocks in the DNWR were sourced from outside the DNWR, as discussed above, including the Hiko Tuff from the Delamar caldera. Ash flow tuffs that traveled several kilometers from their source calderas are simply not very prospective for epithermal deposits. The potential for volcanic-hosted epithermal gold-silver deposits is considered here to be very low.

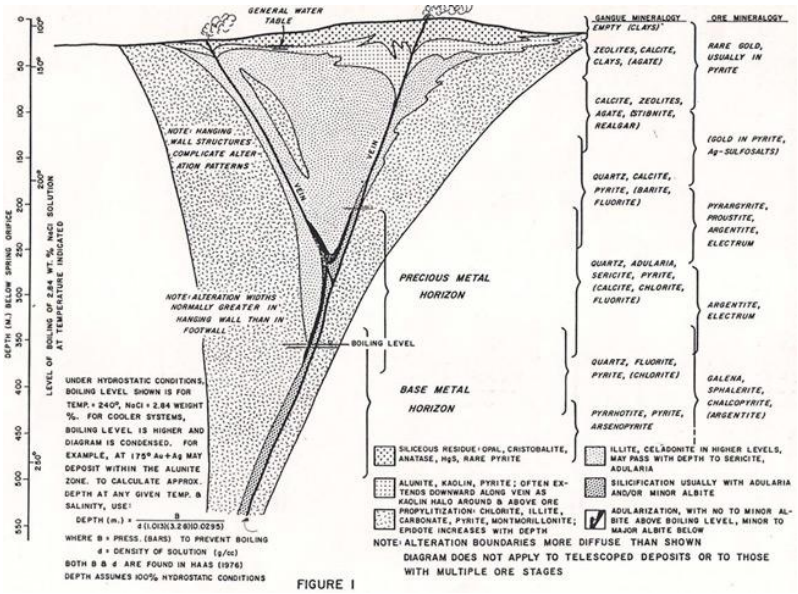


Figure 33. Schematic cross-section showing key features of low-sulfidation epithermal vein deposits in the southwestern United States. From Buchanan (1981).

Zinc-Lead-Copper-Silver Deposits in the DNWR

Most of the known mineral occurrences in the DNWR are very similar (Table 8, Fig. 19). They are zinc-lead-copper-silver deposits hosted in Paleozoic rocks, either as massive sulfide in dolomitized limestone or as sulfide coating fractures and filling breccia matrices in quartzite and other siliciclastic rocks. Most are spatially associated with Gass Peak thrust that places Cambrian rocks over Permian-Mississippian rocks. The largest one with higher grades are spatially associated with sympathetic thrust in the footwall of the Gass Peak thrust, such as the Valley thrust that places Mississippian rocks over Permian-Mississippian rocks. The mineralization appears to post-date thrusting, which is Cretaceous in age (Albian-Ceomanian, ~93-112 Ma), but definitely pre-dates emplacement of the Oligocene and Miocene ash flow tuffs. Besides zinc, lead, copper, and silver, the occurrences contain high concentrations of arsenic, mercury, and antimony, locally high concentrations of molybdenum and uranium, and locally very weakly anomalous gold, platinum and palladium.

The June Bug mine, which is the only deposit in the DNWR with recorded production, and Samson-Juniper prospects in the footwall of the Gass Peak thrust have much higher zinc concentrations than the occurrences in the hanging wall, and have higher molybdenum and uranium values. NBMG did detailed underground mapping in its original assessment. The workings in the June Bug mine consist of four small interconnected levels (Fig. 34). The ore bodies at June Bug were small, lenticular pods of zinc and lead minerals contained within envelopes of banded light-dark dolomite (zebra rock) that formed near the base of the Bullion Member of the Monte Cristo group (Figs. 35, 36). Lenses were discontinuous, were up to a meter or so thick, and extended up to five to ten meters along strike and dip. Both the zebra banding and the replacement mineralization appear to conform to bedding in the host carbonate rock. Much of the mineralization must have been sphalerite and galena, which was later oxidized to hemimorphite, hydrozincite, cerrusite and other oxide zinc and lead minerals during weathering. Extensive post-ore faulting cut and offset the ore lenses, making the ore difficult to follow and mine. The mineralization at the Sampson-Juniper prospects along stratigraphic strike to the east of June Bug is very similar, just smaller and more discontinuous (Figs. 37-38).

The commonalities between the zinc-lead-silver deposits suggest a common origin. Their widespread extent suggests regional hydrothermal processes. Except for the Gass Peak district, which is credited for only about $38,000 production in zinc, lead, silver, and gold, none of the mines and prospects within the DNWR have recorded production. However, there are deposits with recorded production in the areas around the DNWR in southern Nevada that bear on the metallic mineral potential of DNWR. Figure 39 shows the distribution of past-producing metallic mineral deposits in southern Nevada.

The most productive of those shown in Figure 37 were the deposits mined in the Goodsprings district southwest of Las Vegas. Recorded production from Goodsprings is ~109,000 tons of zinc, 47,000 tons of lead, 2,500 tons of copper, 2.1 million ounces of silver, 90,000 ounces of gold, 1,300 ounces of platinum and palladium, and minor amounts of Co, V, Ni, Hg, Sb, Mo, Mn, Ir, and U. These metals were recovered from ~760,000 tons of ore mined from nearly 90 deposits during the period of 1856 to 1957 (Longwell et al., 1965). These same elements are enriched in the zinc-lead-copper-silver deposits and occurrences of the DNWR, except for possibly iridium, which was not analyzed by NBMG.

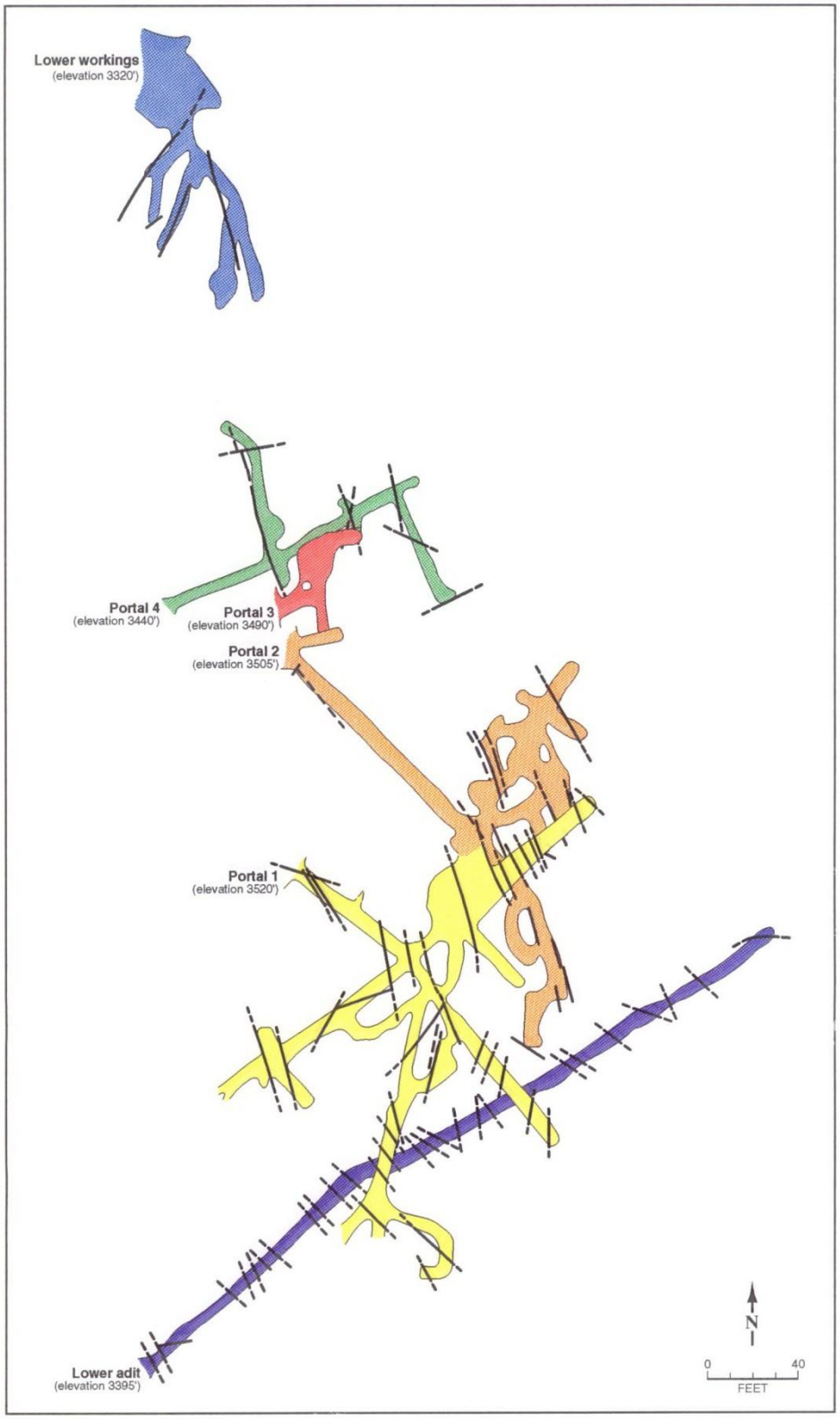


FIGURE A-4. June Bug Mine composite of underground workings

Figure 34. Map of the underground workings at the June Bug mine, as mapped my NBMG. Taken from NBMG's 1993 DNWR assessment report.

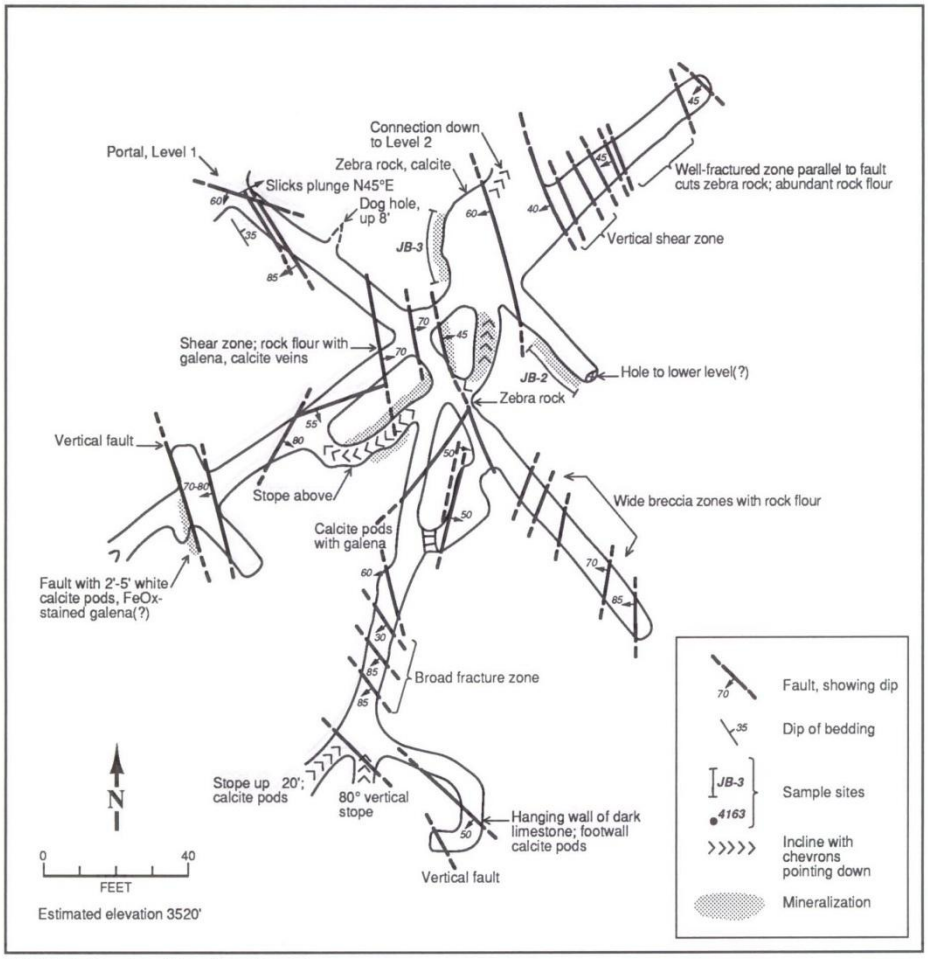


FIGURE A-5. June Bug Mine Level 1

Figure 35. Map completed by NBMG in 1992 of Level 1 of the June Bug mine. Note the dimensions and discontinuous nature of the stopes and remaining mineralization.

Figure 36. Sample of zebra dolomite from the June Bug mine. Formed by hydrothermal replacement of limestone.

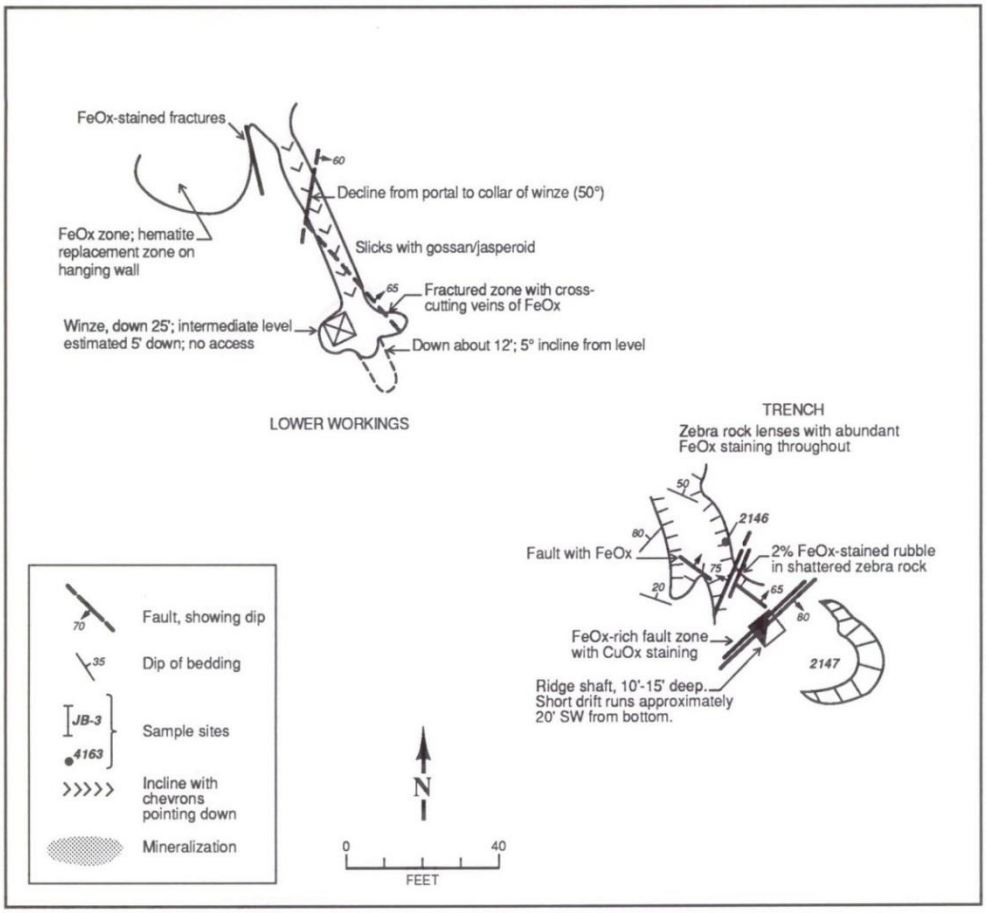


Figure 37. Map of the Sampson Claim prospect, drawn at same scale as Figure 33. Similar features as those at June Bug as shown in Figure 33, just much weaker.

Figure 38. Highest grade sample collected by NBMG at DNWR. From the Sampson claim prospect. Contains 11 ppb Au, 143 ppm Ag, 304 ppm As, 5.85 ppm Bi, 107 ppm Cd, 159 ppm Co, 23,300 ppm Cu, 7.3 ppm Hg, 549 ppm Mo, 1850 ppm Ni, 4340 ppm Pb, 44 ppm Sb, 15 ppm Se, 3.8 ppm Sn, 3.07 ppm Te, 128 ppm U, and 37,600 ppm Zn.

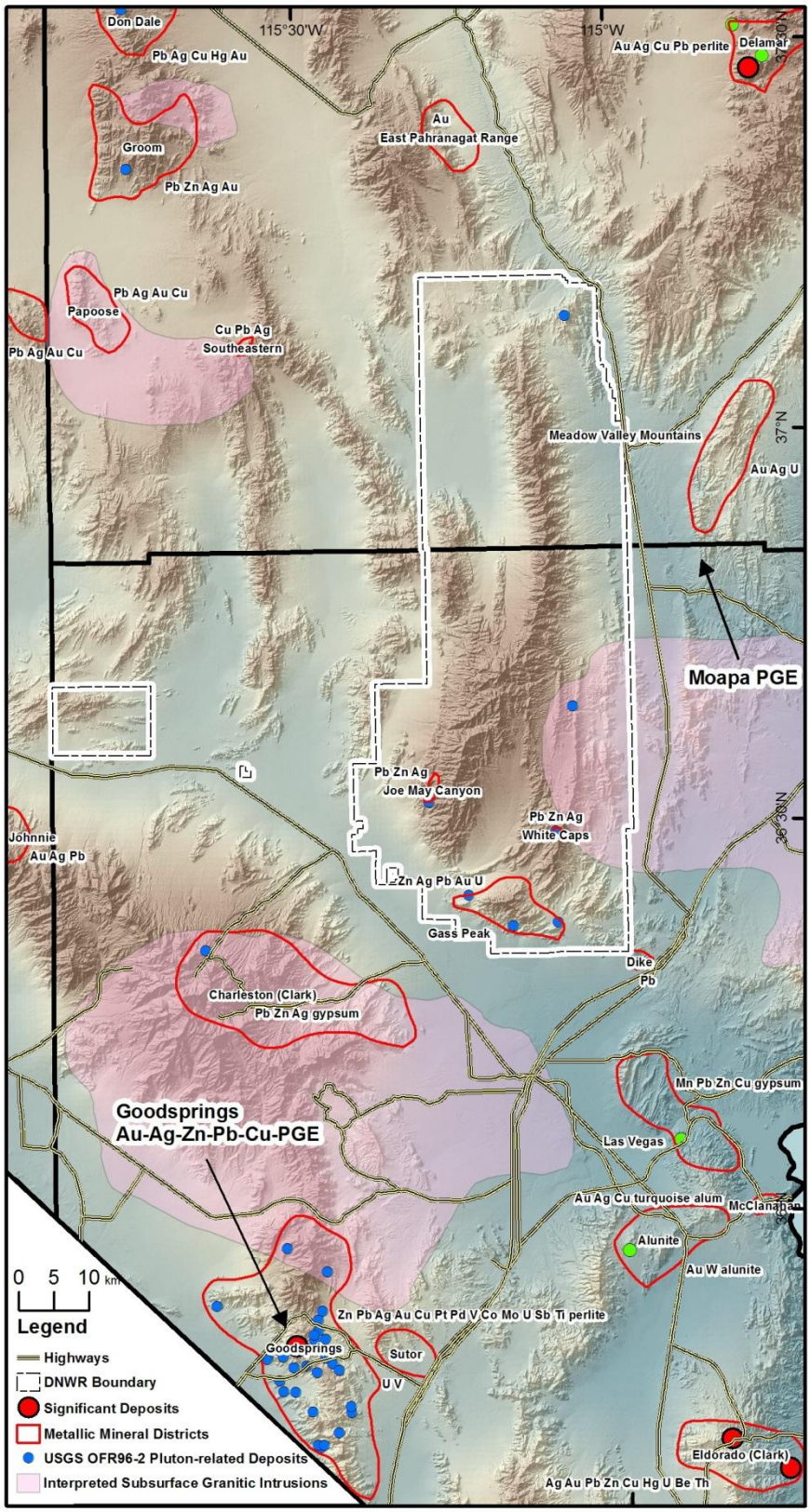


Figure 39. Location of metal mining districts and significant metallic mineral deposits in the vicinity of DNWR in southern Nevada.

The dimensions of the Goodsprings district are ~17 km by 30 km (Fig. 40). This is comparable of the dimensions of the area of Zn-Pb-Cu-Ag deposits encompassed by the June Bug mine, Sampson-Juniper prospects, Wamp Spring, Quartzite Hill, and Joe May Canyon. Most of the deposits in the Goodsprings district occur 3 to 8 km west and south of town (Fig. 40). The deposits are spatially associated with the Keystone thrust. Similar to the Gass Peak thrust in the DNWR, deposits occur both in the hanging wall Neoproterozoic-Early Cambrian carbonates and the Mississippian Monte Cristo Group and Mississippian-Permian Bird Spring Formation carbonates in the footwall. The main alteration type is dolomitization, including the zebra banding as seen in the DNWR. However, there are also Late Triassic felsic porphyry intrusions at Goodsprings.

Until recently, the deposits at Goodsprings were thought to be intrusion-related based on the spatial relationship of several deposits with the porphyry intrusions (Hewett, 1931). This led the U.S.G.S. to classify many of the Zn-Pb-Cu-Ag-(Au) deposits in southern Nevada, including those in the DNWR, as pluton-related polymetallic replacement deposits, based on the relationships observed in the Goodsprings district and the large plutons in subsurface as interpreted from the aero-magnetic data (Fig. 39). However, in a recent study by Vikre et al. (2011), two periods of mineralization at Goodsprings were proposed, based mainly on isotopic studies. The first stage was a zinc-dominant Mississippi Valley Type (MVT) mineralization event that was superposed by lead-dominant mineralization with copper, gold, silver and platinum-group elements. The second stage is interpreted to be temporally related to the emplacement of the Triassic intrusions. Therefore, both events are interpreted to pre-date thrusting. However, in the DNWR the mineralization appears to post-date thrusting. Vikre et al. (2011) analyzed galena from the Sampson and Quartz Hill prospects in the DNWR, from which isotopes suggest Pb and S were sourced from underlying Neoproterozoic siliciclastic rocks rather than from intrusions. The preferred interpretation for the Zn-Pb-Cu-Ag deposits in the DNWR is that they are related to regional scale, amagmatic, basinal fluid flow during Sevier age thrusting in late Early to early Late Cretaceous or some later time prior to emplacement of Oligocene ash flow tuffs.

The known occurrences of the Zn-Pb-Cu-Ag deposits in the DNWR are not considered economic and will likely never be mined in the future no matter if the land is closed to mineral entry or not. However, one should consider the potential for additional deposits that have not yet been discovered. As mentioned many times, the main hydrothermal alteration associated with these deposits is dolomitization of the preferred limestone host rocks. Dolomitization of limestone results in volume loss resulting in the brecciation and increased porosity and fracture permeability (Fig. 41). The ore forming fluids in basinal fluids, such as those responsible for MVT deposits, are typically oxidized, saline brines between 75° and 200°C (Leach, 2010). These fluids are low in reduced sulfur and transport metals as chloride complexes. Metals are then deposited when the ore fluid mixes with fluid rich in reduced sulfur or interacts with a hydrogen gas sulfide reservoir. The dolomitizaton records the transport of the metalliferous saline brines. During dolomitization, iron, zinc and other metals are deposited in trace amounts in the dolomite. During this assessment, we analyzed several zones of hydrothermal dolomite with a Niton portable XRF analyzer. Analyses showed several 100 ppm Zn and several 1000 ppm Fe in the dolomite.

Given dolomite is the primary alteration product, we took a closer look at the ASTER imagery in the June Bug –Sampson-Juniper area to map out dolomitic alteration of the carbonates in the Monte Cristo Group and Bird Spring Formation. Figure 42 shows the distribution of dolomite as mapped with

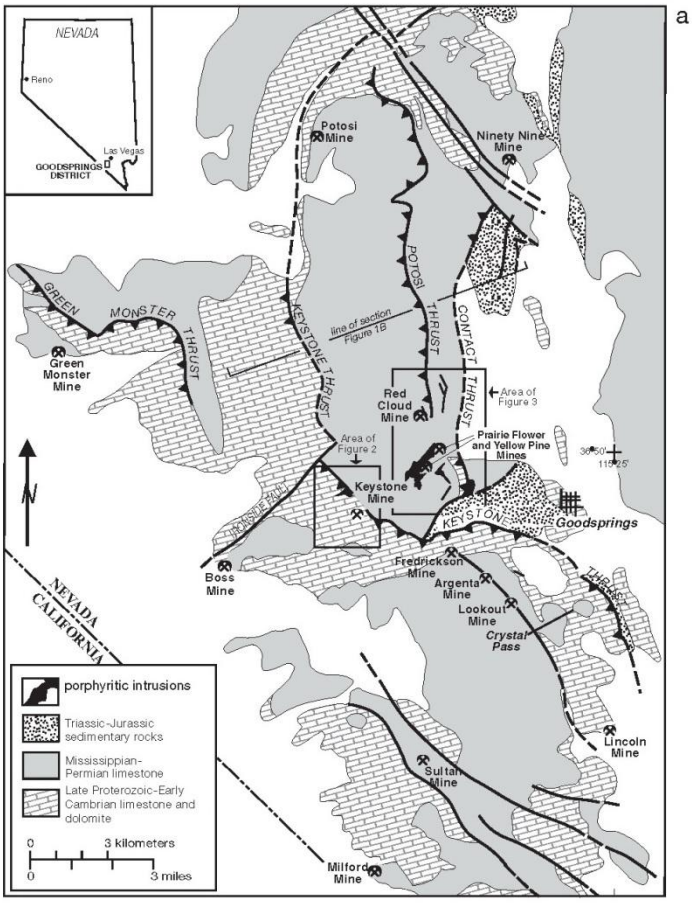


FIG. 1. a. Generalized geologic map of the Goodsprings district (modified from Hewett, 1931), showing regional stratigraphy and structure, porphyritic intrusions, locations of many mines referred to in the text, the town of Goodsprings, and coverage of Figures 2 and 3. Unpatterned areas are colluvium. Most small-volume dikes are not shown. b. Generalized southwest-northeast section of the Goodsprings district (after Hewett, 1931). c. Distribution of larger deposits based on dominant metal (Zn, Pb) and metal associations (Cu-PM-PGE; Zn and Pb and/or significant Cu). See Figures 2, 3, Hewett (1931, 1956), and Longwell et al. (1965) for unlabeled deposit names and deposit production. PGE = platinum group elements (Pd, Pt), PM = precious metals (Au, Ag).

Figure 40. Map from Vikre et al. (2011) showing the main part of the Goodsprings district.

Figure 41. Hydrothermal dolomitization (buff color) of limestone (gray) in Monte Cristo, Sampson Hill in the DNWR. Note the increased brecciation in the dolomitized parts. No zebra dolomite in this locality.

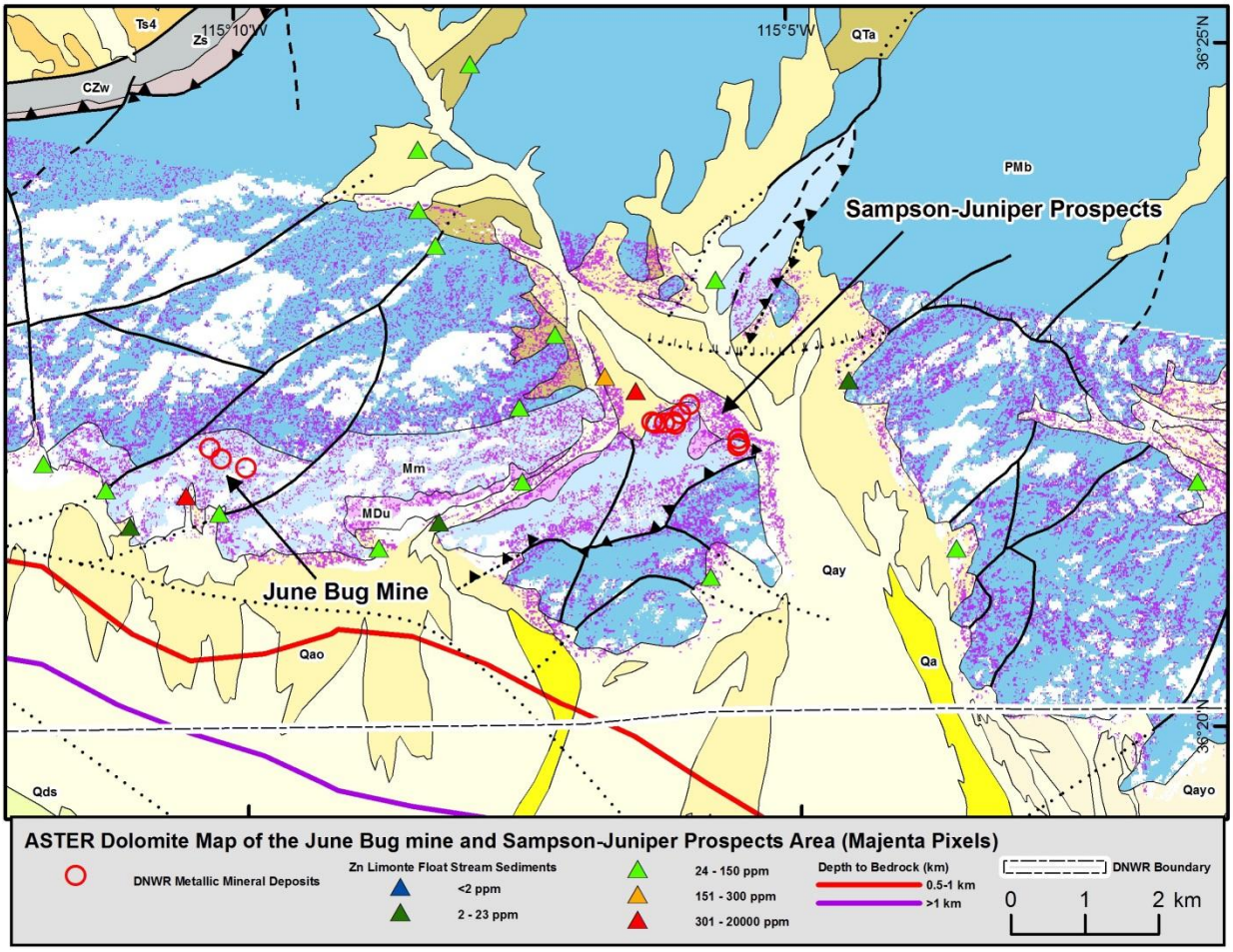


Figure 42. Map of the June Bug mine and Sampson-Juniper prospect area, showing the distribution of dolomite as interpreted from ASTER data. The magenta pixels represent areas likely having dolomite using the SAM algorithm, whereas the white areas represent area where there is likely no dolomite, using the mixture tuned matched filtering (MTMF) infeasibility algorithm. Geology is from map of Page et al. (2005). Mm = Mississippian Monte Cristo Group carbonates. PMb-Permian-Mississippian Bird Spring Formation carbonates. Also shown are stream sediments samples color-coded by zinc concentration in limonite float. The depth to bedrock in the alluvial basin is interpretation by USGS of regional gravity data.

ASTER Imagery. The imagery suggests more dolomite near the contacts between the Monte Cristo Group and Bird Spring Formation, both in the June Bug area, where the Bird Spring depositionally overlies the Monte Cristo, and in the Sampson-Juniper area where Monte Cristo overlies the Bird Spring along the Valley thrust. This fairway of dolomitization between those two contacts is also where the mineral occurrences and highest grade stream and rock chip samples occur. Dolomitization appears to decrease away from this fairway. As seen in the field, the imagery indicates dolomitization is spotty and is nowhere complete over large areas, as was observed in the field (e.g., Figure 41).

There is no evidence in the data that there will be any better zinc-lead-copper-silver deposits in the DNWR than what was mined in the June Bug mine area. There is some potential for more June Bug

type ore down dip below the apparently strongly dolomitized Bird Spring Formation. The stream sediment data suggest no other targets east or west of the June Bug – Sampson/Juniper area. Also, the gravity data in the Las Vegas Valley to the south shows bedrock drops off to greater than 500 m within 1-1.5 km of the range front; thus, there is not a lot of room to hide a large deposit underneath the pediment gravels at reasonable mineable depths. For comparison, Figure 43 shows the Southeast Missouri mining district, a world-class lead-rich MVT district. Potential for economic zinc-lead-copper-silver deposits is interpreted to be very low on the DNWR.

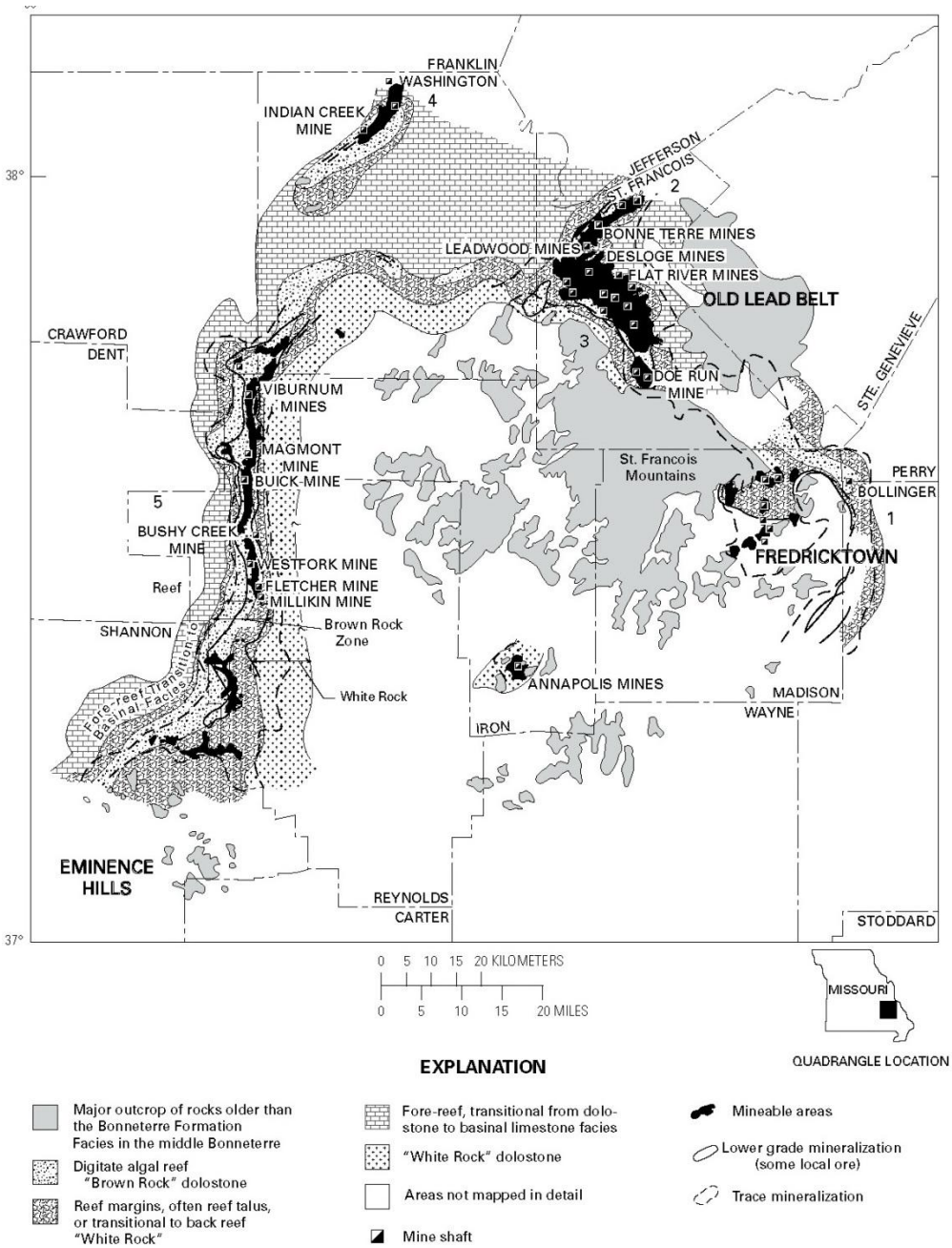


Figure 43. Map of the Southeast Missouri mining district, one of the world's large MVT districts. Note the scale and compare it to Figures 39 and 42.

Potential for Carlin-type Gold Deposits

As mentioned near the beginning of this report, Carlin-type gold deposits are the most important type of ore deposit in Nevada. Carlin-type gold deposits in Nevada are hydrothermal replacement bodies hosted mainly by early Paleozoic miogeoclinal carbonate rocks, in which gold occurs in solid solution or as submicron particles in pyrite (prior to weathering). They are of mid-Tertiary age, an age that corresponds to a change from compression to extension and renewed magmatism in Nevada. They tend to occur in clusters along old, reactivated basement rift structures and are preferentially hosted by carbonate-bearing rocks within or adjacent to structures in the lower plate of regional thrust faults that have siliciclastic upper plate rocks. They share a similar hydrothermal alteration and ore paragenesis that is characterized, first, by dissolution and silicification of carbonate, sulfidation of iron in the wall rock, and formation of gold-bearing arsenian pyrite. This is the main ore assemblage and is a direct result of reaction between the ore fluid and wall rock. It is followed by late open-space deposition of orpiment, realgar, and stibnite. The geochemical ore signature is Au-Tl-Hg-As-Sb-(Te) with low Ag and base metals. They lack mineral or elemental zoning at the scale of <5-10 km laterally and <2 km vertically. Figure 44 shows a cross-section through the original Carlin mine, which illustrates typical aspects of ore body morphology and alteration features of Carlin-type deposits. Table 10 summarizes key exploration criteria for Carlin-type deposits at various scales in Nevada.

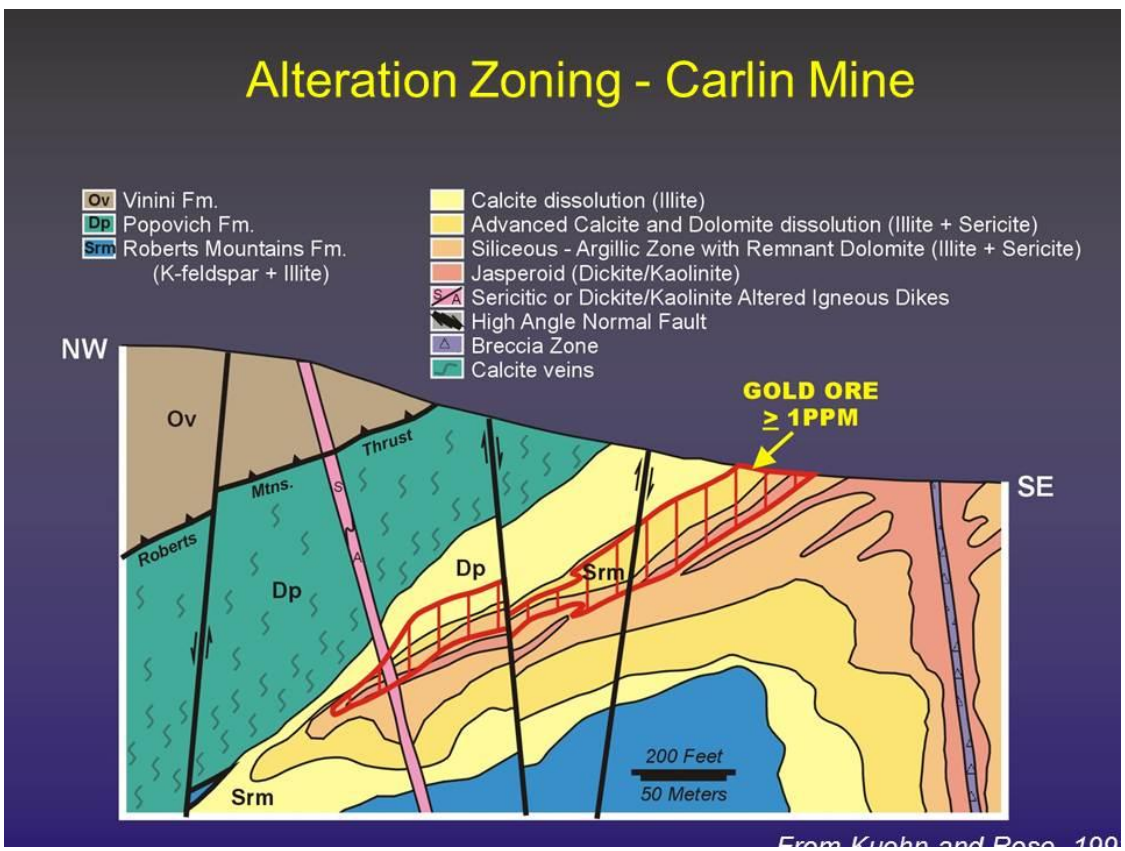


Figure 44. Cross-section modified from Kuehn and Rose (1992) through the original Carlin deposit showing alteration zonation.

Table 10. Exploration Criteria for Carlin-type Gold Deposits in Nevada

Old reactivated fault zones

- Mainly NNW- and WNW-trending
- Fault tips and step-over/accommodation zones
- Intersections with NE-trending faults
- Intersections with Mesozoic granites
- Second-order high faults with minimal displacements tend to host ore

Carbonate-bearing host rocks

- Gentle dips
- Ferroan carbonates
- Thin-bedded silty carbonates (slope facies)
- Carbonate debris flow breccias
- Karsts on the shelf (sequence boundaries)

Major thrust faults with siliciclastic upper plates and carbonate-bearing lower plates

- Creates a permeability/reactivity contrast which forces fluids to move out of high-angle faults and into reactive carbonate rocks

Structural culminations

- Intersecting antiformal features that result in domes
- Duplexes in thrust systems

Low-angle features

- Hinge zones of anticlines
- Sills and low-angle dikes
- Low-angle faults
- Interbedded greenstones
- Areas of rheologic contrast (bedding plane slip)

"Gold-only" geochemistry

- Gold (few <5 ppb samples)
- As, Hg, Tl, Sb, (Te)
- Low Ag (Ag:Au less than 1:1)
- Low Cu, Pb, Zn, Mn (except in area of older base metal mineralization)

Favorable alteration/mineralization

- Decalcification/silicification of carbonates (recessive, rarely crops out)
- Jasperoid bodies, both along faults and stratiform
- Argillized igneous and siliciclastic rocks
- Illite and/or kaolinite/dickite
- Reports of orpiment, realgar, stibnite, barite, cinnabar
- Aresenian pyrite (though not necessarily limited to Carlin-type deposits)

Tertiary felsic dikes

- Indicates underlying magma chamber that is heat engine for hydrothermal system and potentially source of metals
- Deep batholitic magma body, therefore hypabyssal stocks, rather than dikes, would be a negative

Note: None of these criteria by themselves are diagnostic of a Carlin-type deposit.

Abundant early Paleozoic shelfal facies carbonate rocks occur in the DNWR. Carbonate rocks of the same age host Carlin-type deposits in northern Nevada, but most are slope facies. However, the multi-million ounce Long Canyon gold deposit, which was discovered in the early 2000s and is currently being developed by Newmont Mining Corp., occurs in shelf-facies carbonates near the town of Wells, well east of the Carlin Trend. It occurs in carbonate rocks that straddle the Cambrian-Ordovician boundary. This boundary is important in that it represents a sequence boundary, in which there was a low-stand in global sea level. This is important in that carbonates on the shelf of this age were exposed to the surface and formed karst. The ore horizon at Long Canyon is a paleo-karst, and paleo-karst occurs at the Cambrian-Ordovician boundary in many localities in eastern Nevada. On the slope to the west, carbonate debris flow breccias occur along the same boundary. Karst and debris flow breccias are important host rocks in many Carlin-type deposits.

The Cambrian-Ordovician boundary is well-exposed in the DNWR, where carbonates of the Ordovician Pogonip Group overlie the Cambrian Notch Peak Formation, the same two formations that host ore at the Long Canyon deposit. Until the discovery of Long Canyon, exploration companies largely ignored these shelfal facies rocks. In addition significant arsenic anomalies (up to 852 ppm) with mainly low silver base metal concentrations (up to 296 ppm Zn, but otherwise <100 ppm for base metals) occur in the limonite float chip fraction of drainage basins below exposures of this contact in the central part of the Sheep Range (Fig. 45). Interestingly the ASTER maps show the distribution of clay minerals and goethite (a limonite mineral) to be most abundant along the Ordovician-Cambrian contact. However, all the gold assays of the stream sediment samples were <5 ppb.

Some of best arsenic anomalies were from the stream that goes to the old Cabin Springs campground. During our field checks in November, the road to Cabin Springs was in such bad shape we could only get within 10 km of the campground. From Cabin Springs, it is a rugged climb to the Cambrian-Ordovician contact (~300-400 m elevation difference). To check that would have involved backpacking for a few nights. We were not equipped for that because we expected the Cabin Spring Road to be accessible. The approach from the east of the Sheep Range is not much better. Figure 46 is a Google Earth image of the west side of the sheep range showing the location of the sample with 852 ppm As, the terrain, and possible sources of the anomaly. Limonite staining is recognizable in the image, but nothing that looks like a major hydrothermal alteration zone. The regional gravity data indicate the depth to bedrock on the pediments on both sides of the central Sheep Range is less than 500 m; thus one cannot rule out a covered deposit (Fig. 12).

A site to the south, where the Cambrian-Ordovician contract was accessible (6 km hike from truck), was checked in the field. The arsenic concentrations in the stream sediment samples were much lower. Nothing suggesting Carlin-type mineralization was recognized. Karsting was present in the upper Notch Peak Formation as well as local zebra-textured hydrothermal dolomite, but metal concentrations were weakly anomalous at best.

In summary, potential for Carlin-type gold deposits is low in the DNWR. Favorable host rocks are present, but the DNWR lacks most of the exploration criteria listed in Table 10. A possible exception is the Lake Mine area, which is described separately next.

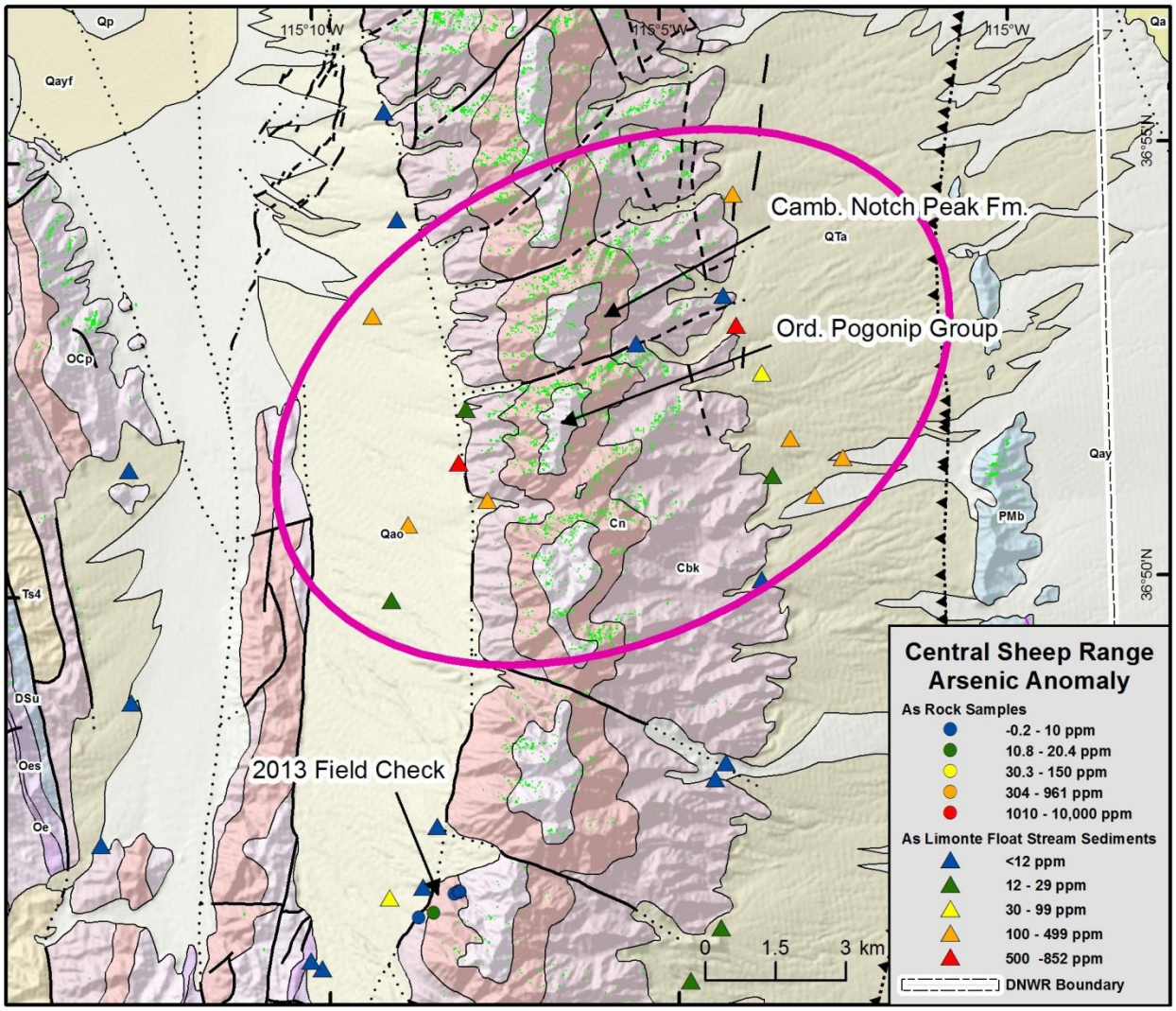


Figure 45. Map showing arsenic in limonite float chip anomaly in stream sediments on the west and east sides of the central part of the Sheep Range. Magenta oval encircles the anomalous stream sediment samples that had up to 852 ppm arsenic and the potential sources in the range. Also shows ASTER mineral maps for clays (green pixels) and the limonite goethite (red pixels). Geology is from map of Page et al. (2005). The Cambrian Notch Peak Fm and Ordovician Pogonip group are pointed out, as well as the site of the November 2013 field check.

Figure 46. Oblique Google Earth view of west side of Sheep range showing location of 852 ppm As anomaly (red triangle) and a 224 ppm As anomaly (orange triangle) in the Cabin Springs drainage. White lines are from geology map of Page et al. (2005) which shows lower and upper contact of Cambrian Notch Peak Formation, the major cliff-former. The Ordovician Pogonip Group caps the tops of the range. Change from brown to green represents difference in type of imagery utilized by Google Earth.

Potential of the Lake Mine Area

The most conspicuous alteration zone exposed at the surface in the DNWR is the Lake Mine area. The alteration is best outlined with ASTER imagery (Fig. 47). The alteration consists of extensive limonite staining, weak to moderate clay alteration, and common silicification, including formation of jasperoid bodies, the only such bodies observed in the DNWR.

The zone occurs in Paleozoic limestones, dolomites, and quartzite. Geologists have assigned these rocks to different formations ranging in age from Cambrian to Mississippian. Based on our field checks, we believe the rocks are Cambrian or Ordovician. The Early Paleozoic rocks appear as a window through Tertiary ash flow tuffs that border the Paleozoic rocks to the east, south, and west, the oldest of which is the 27.57 Ma Monotony Tuff. The Tertiary ash flow tuffs are not affected by hydrothermal alteration; thus, the alteration is older than 27.57 Ma. The window of altered Paleozoic rocks is elongated north-south and is about 4 km long and about a 1.5 km wide. Maps show the trace of the Gass Peak thrust through the Lake Mine or to the east underneath Tertiary ash flow tuffs. If the Paleozoic rocks in the Lake Mine are Cambrian-Ordovician, then the alteration zone is in the hanging

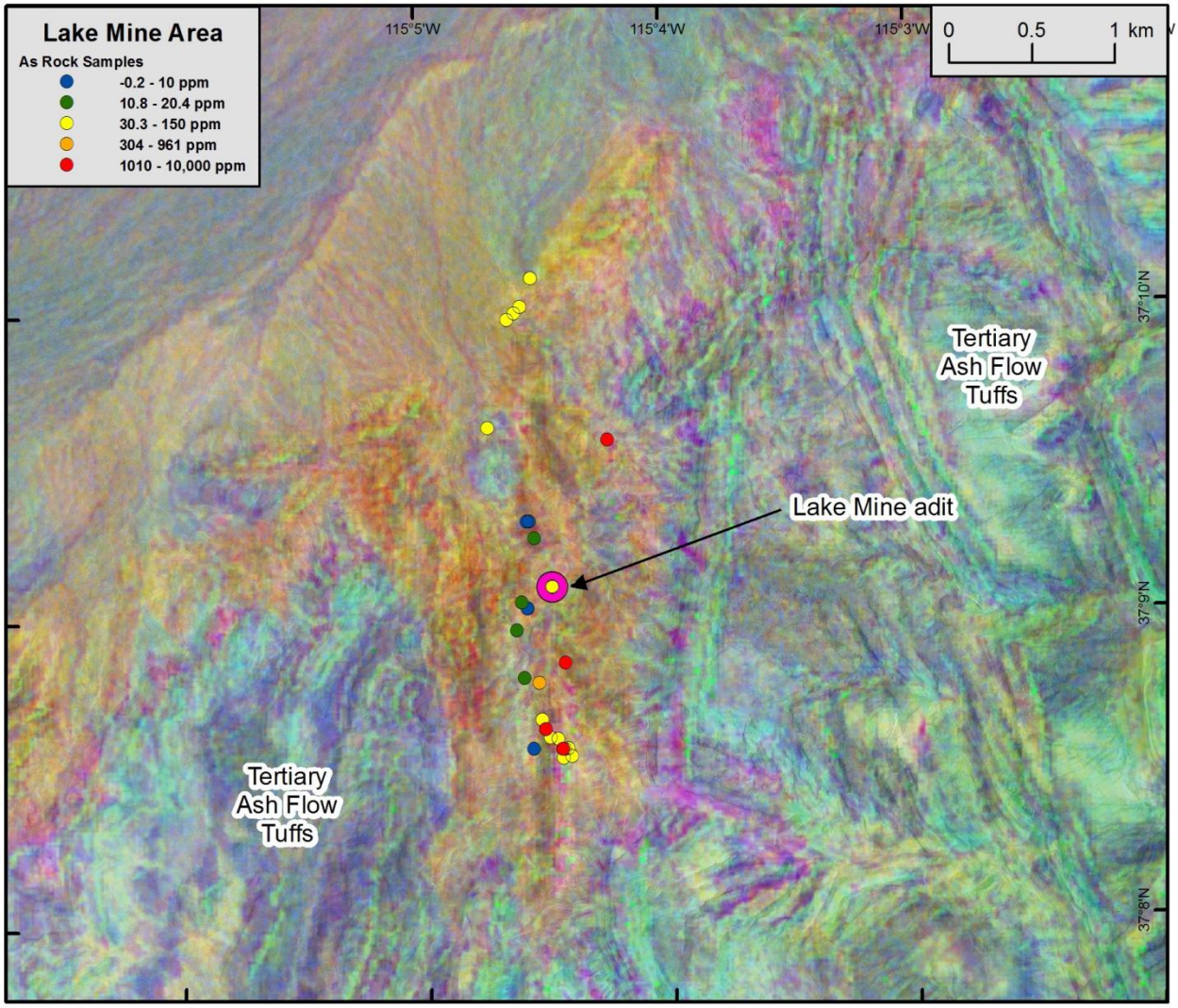


Figure 47. ASTER image of the Lake Mine area using a band ratio by Gabr et al. (2010) to accentuate limonite (red). The altered Paleozoic rocks are the orange-red-purple rocks. The apple green colors are less altered carbonates within the alteration zone. The surrounding layered blue to green zones are the unaltered Tertiary flow tuffs. The small dots are rock samples color coded for arsenic. The magenta dot is the Lake Mine adit, from which rock samples have elevated metals concentrations, but not as high as other samples from the alteration zone.

wall of the Gass Peak thrust. The Paleozoic rocks are commonly brecciated, both unaltered and hydrothermally altered rocks, suggesting the alteration post-dates the brecciation. If the brecciation is related to the emplacement of the Gass Peak thrust, then age of the alteration is bracketed between late Early Cretaceous/Early Late Cretaceous and 27.57 Ma.

The alteration style is significantly different than the dolomitization associated with the Zn-Pb-Cu-Ag occurrences described above. Progressive alteration of limestone is exhibited by bleaching, to decalcification with minor silicification, to jasperoid bodies (Figure 48). No quartz veining was observed.

The alteration style is more consistent with Carlin-type gold deposits, as is the geochemistry. Table 11 shows descriptive statistics. The concentrations of copper, lead, zinc, and silver are relatively low compared to the zinc-lead-copper-silver deposits discussed above. In contract the concentrations of arsenic, mercury, antimony, and especially thallium are as high if not higher. The geochemistry is consistent with a Carlin-type deposit. However, only 5 of the 34 samples had gold assays above the 5 ppb detection limit. Only one was higher than 10 ppb, at 44 ppb, the highest gold assay of any of the NBMG assays of samples from the DNWR. Because of these low gold assays, potential is considered low for an economic Carlin-type deposit in the Lake Mine area.

Table 11. Descriptive Statistics for Selected Element for Rock Samples Analyzed from the Lake Mine Area

	Au (ppb)	Ag (ppm)	As (ppm)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	Tl (ppm)	Zn (ppm)
Mean	4	0.32	1112	74	0.214	5.21	12	27.46	5.18	69
Median	2.5	0.045	43.5	25	0.065	2.18	6.6	2.10	0.09	26
Standard Deviation	7.22	1.57	2751	104	0.348	7.10	19.3	83.51	22.09	133
Minimum	2.5	0.005	0.8	2	0.005	0.26	0.9	0.27	0.01	3
Maximum	44	9.18	>10,000	378	1.85	30.3	111	410	127	732
Number Analyses	34	34	34	34	34	34	34	34	34	34
Detection Limit	5	0.01	0.2	0.2	0.01	0.05	0.5	0.05	0.02	2

For analyses that were less than detection, half the detection limit was used for the statistics.

Potential for Metallic Mineral Deposits in the Indian Springs Portion of the DNWR

The Indian Springs portion of the DNWR has no known historic mines or mineral prospects. The geology consists of an east-trending anticline cored by Cambrian Notch Peak Formation and Dunderberg Shale. Ordovician through the Mississippian Monte Cristo Group strata is exposed on the north flank of the anticline (Fig. 49). In the very northwest corner of the parcel, a thrust fault places Cambrian rocks over tightly folded Devonian and Mississippian strata. Tertiary Horse Springs formation on-laps the Paleozoic rocks at the north end in an area referred to as Sandy Wash.

In 1992 NBMG collected 16 stream sediment samples and 7 rocks samples from the Indian Springs parcel. Except for arsenic, metals are only locally elevated (Fig. 49). The highest arsenic concentration was 1010 ppm (rock sample); however, the highest gold assay was from a rock sample that assayed only 5 ppb. The high arsenic samples come from the north end where there are limonitic jasperoid breccias and gossans developed along east to northeast-trending faults in presumably Mississippian carbonates. Base metals were low except for a few samples in the southeast corner, where a limonite float chip in stream sediment sample had 2732 ppm Zn, 872 ppm Pb, and 76 ppm Cu. Limonite-stained, fractured dolomite occurs up stream. One rock sample had much lower values for those metals.

ASTER imagery mainly shows lithologic patterns suggesting limestone rather than dolostone is the dominant lithology. The clay and silica response trending west-northwest is related to the Ordovician Eureka Quartzite, and is not considered to be hydrothermal alteration. The silica, dolomite, limonite response is characteristic of the Horse Springs formation rather than an alteration feature.

No field checks were done of the Indian Spring parcel. After speaking with U.S. Fish and Wildlife Rangers, we found out we would have to access the property by first entering the Nellis Test and

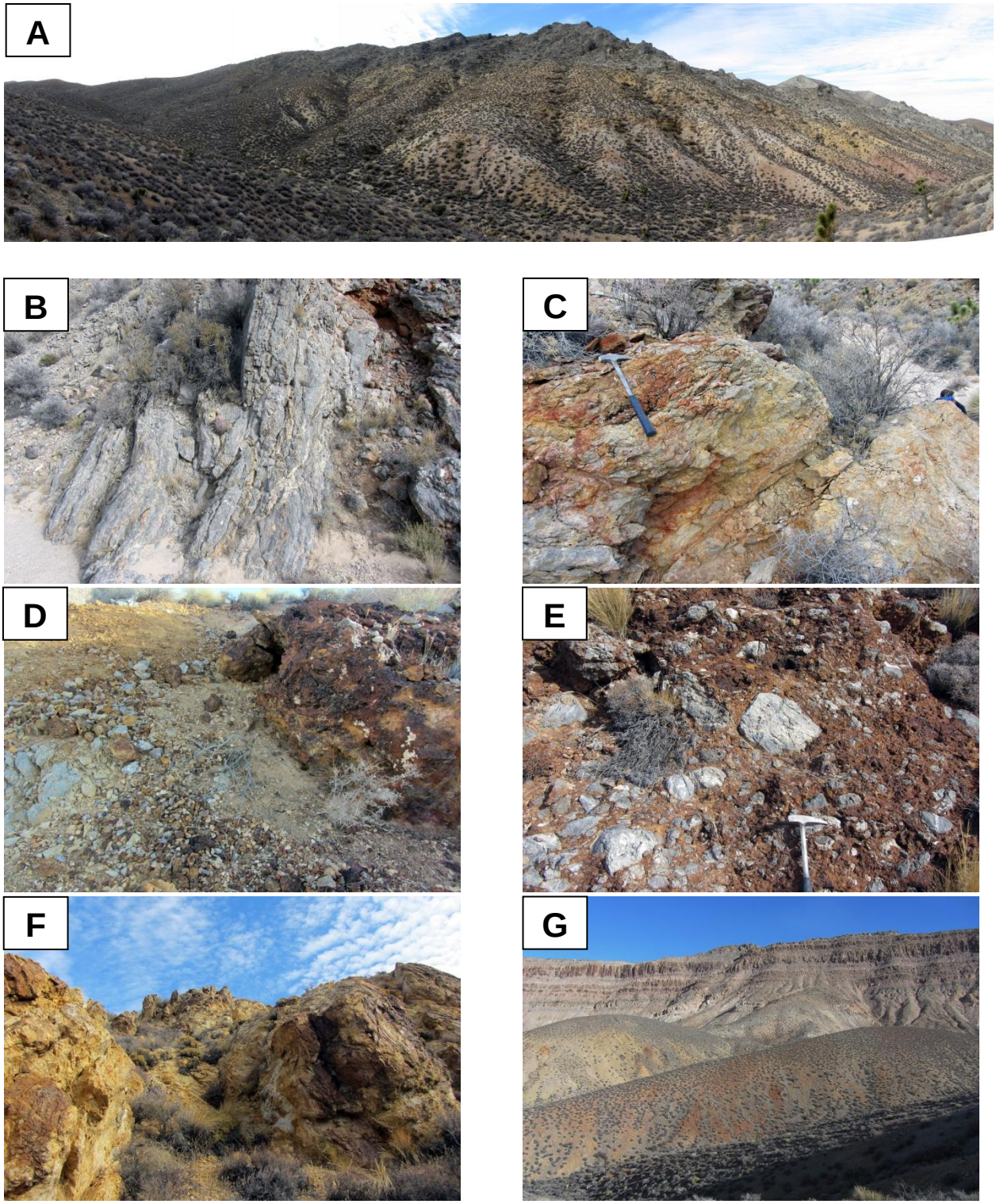


Figure 48. Photographs from November 2013 field check of the alteration zone in the Lake Mine area. **A.** Looking west at the western boundary of the alteration zone. **B.** Unaltered Paleozoic limestone. This lithology is the protolith to much of the alteration. **C.** Weakly altered limonite-stained, brecciated limestone. **D.** Jasperoid breccia (left side). **E.** Breccia with limestone fragments and ferruginous matrix. Possibly related to emplacement of Gass Peak thrust . **F.** Limonite rich fractured quartzite. **G.** Looking at unaltered Tertiary ash flow tuffs that form east boundary of alteration zone.

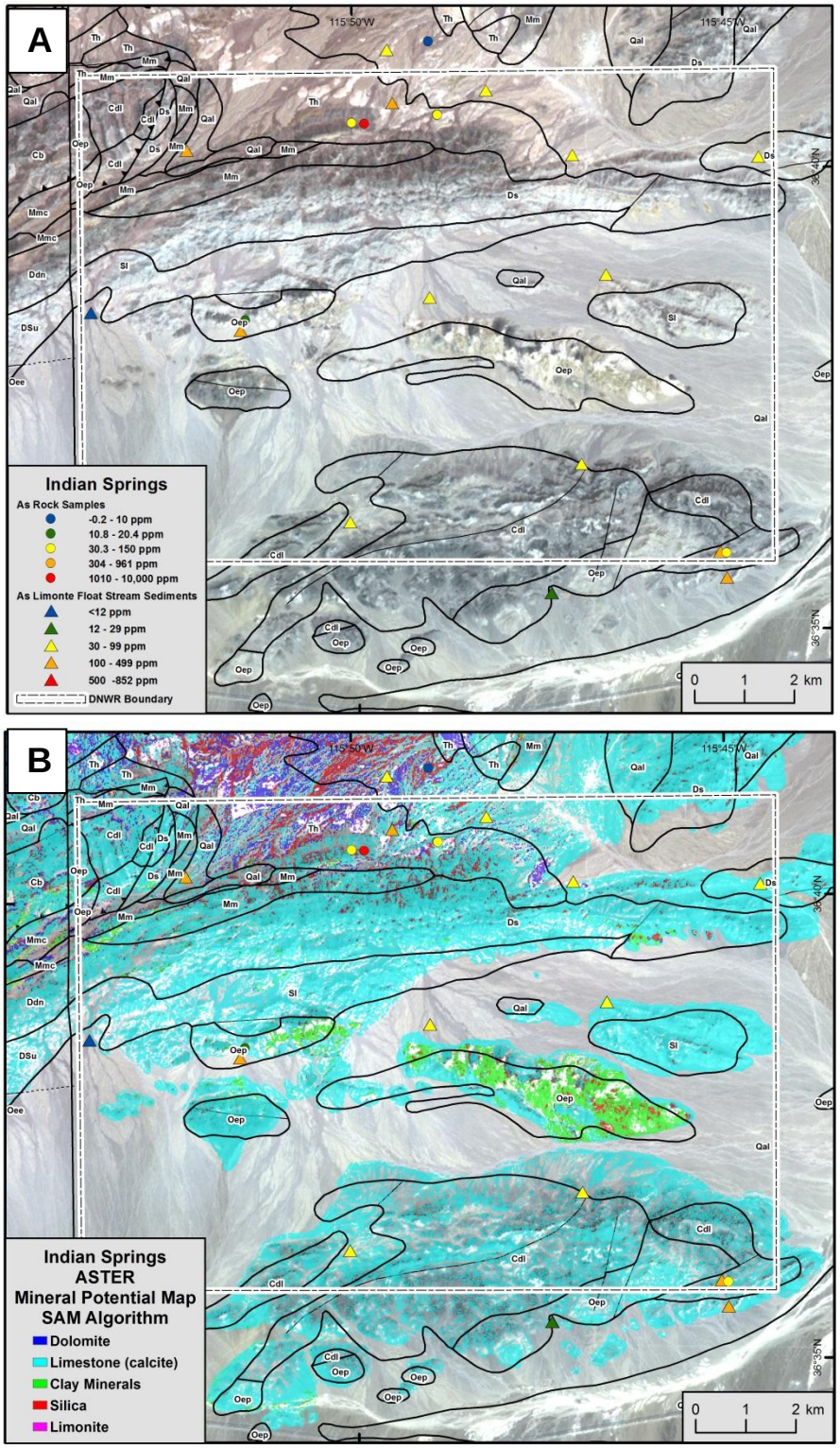


Figure 49. Indian Springs parcel of the DNWR. **A.** Shows geology from state map of Stewart and Carlson, 1978. Also shows arsenic in rock samples and in limonite float in stream sediment samples. Backdrop is an ASTER image shown in "true color." **B.** Same map with ASTER overlay using the SAM algorithm as described in the text, showing the distribution of limonite (Fe-oxides), clay minerals, dolomite, limestone (calcite), and silica (by NIR).

Training Range. The closest accessible road to the Indian Springs Parcel within Nellis required hiking about 10 km to get to the nearest outcrop of bedrock in the Indian Springs parcel.

There are arsenic anomalies at Indian Springs, but nothing else of interest except for one stream sediment sample at the southeast corner with high zinc and lead. We consider the potential to be low in the Indian Springs parcel for both Carlin-type gold deposits and zinc-lead-copper-silver deposits.

Summary of Potential for Metallic Mineral Deposits in the DNWR

The potential for metallic mineral deposits in the DNWR has not changed in any significant way in the last 20 years. The potential is lower than stated in the 1993 NBMG report. The potential for intrusion-related deposits, such as porphyry and skarn deposits, is very low, as is the potential for volcanic-hosted epithermal deposits. The potential to find economic mineralization similar to the zinc-lead-copper-silver deposits on the DNWR, such as the June Bug mine, is low, and the potential to find deposits bigger that the June Bug mine is very low. We consider there is low potential at best for similar mineralization in the Lake Mine area.

The potential to find Carlin-type mineralization is low as well. The Lake Mine has higher potential for precious metals but the lack of any significant gold assays is discouraging. Though the arsenic stream sediment anomalies on the west and east flanks of the central part of the Sheep Range have not been followed up on the ground, nothing else supports the presence of a Carlin-type deposit.

Assessment of Potential for Industrial Mineral Deposits

Introduction

As stated above, only lithium potential was re-evaluated in this updated assessment. The potential for all other industrial mineral commodities is considered to be the same as reported in the original 1993 NBMG assessment. However, as pointed out above, a preliminary evaluation of the demand in southern Nevada for cement limestone and aggregate and of the current sources of those commodities in southern Nevada outside the DNWR was done to assess whether those sources could supply the Las Vegas area for the foreseeable future.

Potential for Lithium Deposits

As reported by Hofstra et al. (2013), lithium is an energy-critical element (American Physical Society, 2011) that is used in lightweight rechargeable lithium-ion batteries to power a wide array of portable electronic devices such as cell phones, laptop computers, and power tools (Goonan, 2012). The growing use of lithium in rechargeable batteries for electric and hybrid vehicles is expected to dominate the market in the 21st century (Gruber et al., 2011; Goonan, 2012). Lithium is produced primarily from brine in arid lacustrine basins on the Altiplano in South America and the Tibetan Plateau of China. Such an environment exists in the Great Basin region of the western United States.

The only lithium produced in the United States is from the Great Basin, from the Clayton Valley brine deposit located in southwestern Nevada about 240 km northwest of the DNWR. The Clayton Valley operation has been producing lithium carbonate and lithium hydroxide from brine pumped from the Clayton Valley playa since 1966. It is currently being operated by Rockwood Lithium, Inc. The concentration of lithium in the discovery well was 678 ppm, but has since declined to be about 200 ppm. Resources at Clayton Valley are estimated to be only about 0.3 Mt of lithium.

Lithium-enriched ash-flow tuffs and overlying rhyolite flows of late Miocene age in a range to the southeast of the Clayton Valley playa have been proposed to be the source of the lithium in the brine (Price et al., 2000). Lithium ranges up to 228 ppm in obsidian and 192 ppm in unaltered rhyolite tuff. Perlite is 53% depleted in lithium relative to relict obsidian in rhyolite lava flows. Likewise, weathered and/or altered tuff is 83% depleted relative to fresh tuff. Prior to development, a salt flat and brine pool existed in the north part of the playa. Tuffaceous lacustrine sediment deposits during the Late Miocene or Pliocene contain up to 1300 ppm lithium and average 100 ppm (Kunasz, 1974). Hectorite clay ($Na_{0.3}(Mg,Li)_3Si_4O_{10}(OH)_2$) in modern and ancient playa sediments contain from 350 to 1171 ppm lithium (Kunasz, 1974). The formation of alternating lacustrine deposits, salt beds, and lithium-rich brines has been attributed to multiple wetting and drying periods during the Pleistocene (Munk and Chamberlain, 2011). Munk and Chamberlain (2011) proposed a model for the Clayton Valley that involves: (1) leaching of lithium from lithium-enriched rhyolite tuff by meteoric water, (2) collection and evaporative concentration in the playa, and (3) compositional evolution of brine in the subsurface due to mixing and water-rock reactions with aquifers and possibly Pleistocene hectorite-bearing playa sediments. Figure 50 from Bradley et al. (2013) illustrates a schematic deposit model for lithium brines in arid lacustrine basins, such as the one in Clayton Valley.

The Desert Lake playa near the northwest corner of the DNWR was sampled by NBMG in its original assessment. From one site, a saline crust sample (upper 1 cm) and a silt sample (from 1-30 cm

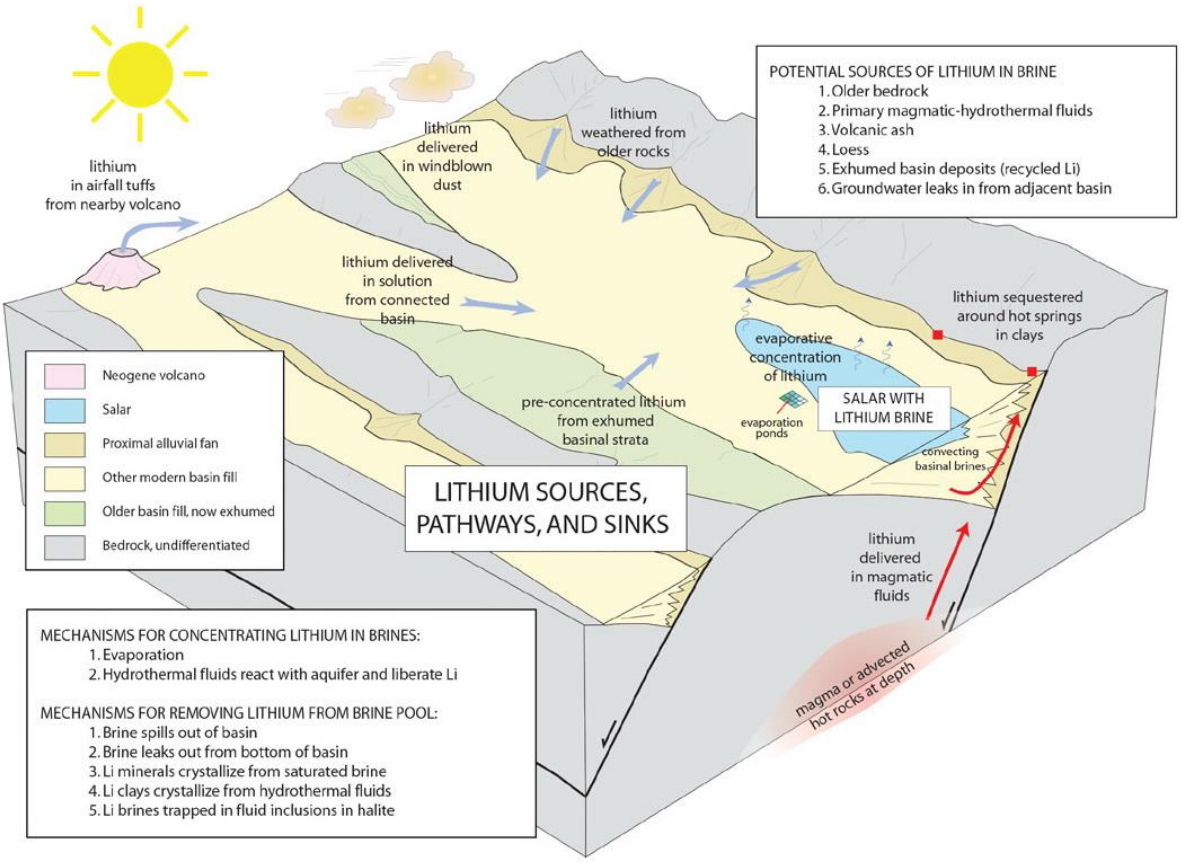


Figure 50. Schematic deposit model for lithium brines showing part of a closed-basin system consisting of interconnected sub-basins. The sub-basin containing the salar is the lowest. Taken from Bradley et al. (2013).

depth) was taken and lithium was analyzed by ICP-AES (inductively coupled plasma atomic emission spectroscopy) following multi-acid digestion. The saline crust had a lithium concentration of 43 ppm, and the silt had a concentration of 80 ppm lithium.

In this study six samples were taken from 6 sites (Fig. 51). At each site, four holes spaced about 10-15 meters apart were dug to depths of approximately 0.5 meters. The samples were taken from the bottom 0.25 meters of the four holes and composited into a single sample for east site. The sites were spaced between 315 and 365 meters over a distance of about 1700 meters within 600 meters of the eastern edge of the Dry Lake Playa. The samples were screened to minus 180 microns and then analyzed by ICP-MS after a four acid digestion. The lithium concentrations ranged between 55.0 and 65.8 ppm, similar to the concentrations at the site sampled in the original NBMG assessment. X-ray diffraction (XRD) analyses of the samples showed quartz, calcite, dolomite in all six samples, as well as sanidine, plagioclase, analcime and hectorite. An attempt was made to separate clay in one of the samples. XRD analysis of this clay concentrate confirmed the presence of the hectorite, the lithium bearing clay mineral mentioned above (Fig. 52).

Two samples of fresh Miocene rhyolitic volcanic tuffs in the East Pahranagat Range at the north end of the DNWR have lithium concentrations of 33 and 9 ppm. These analyses were part of the

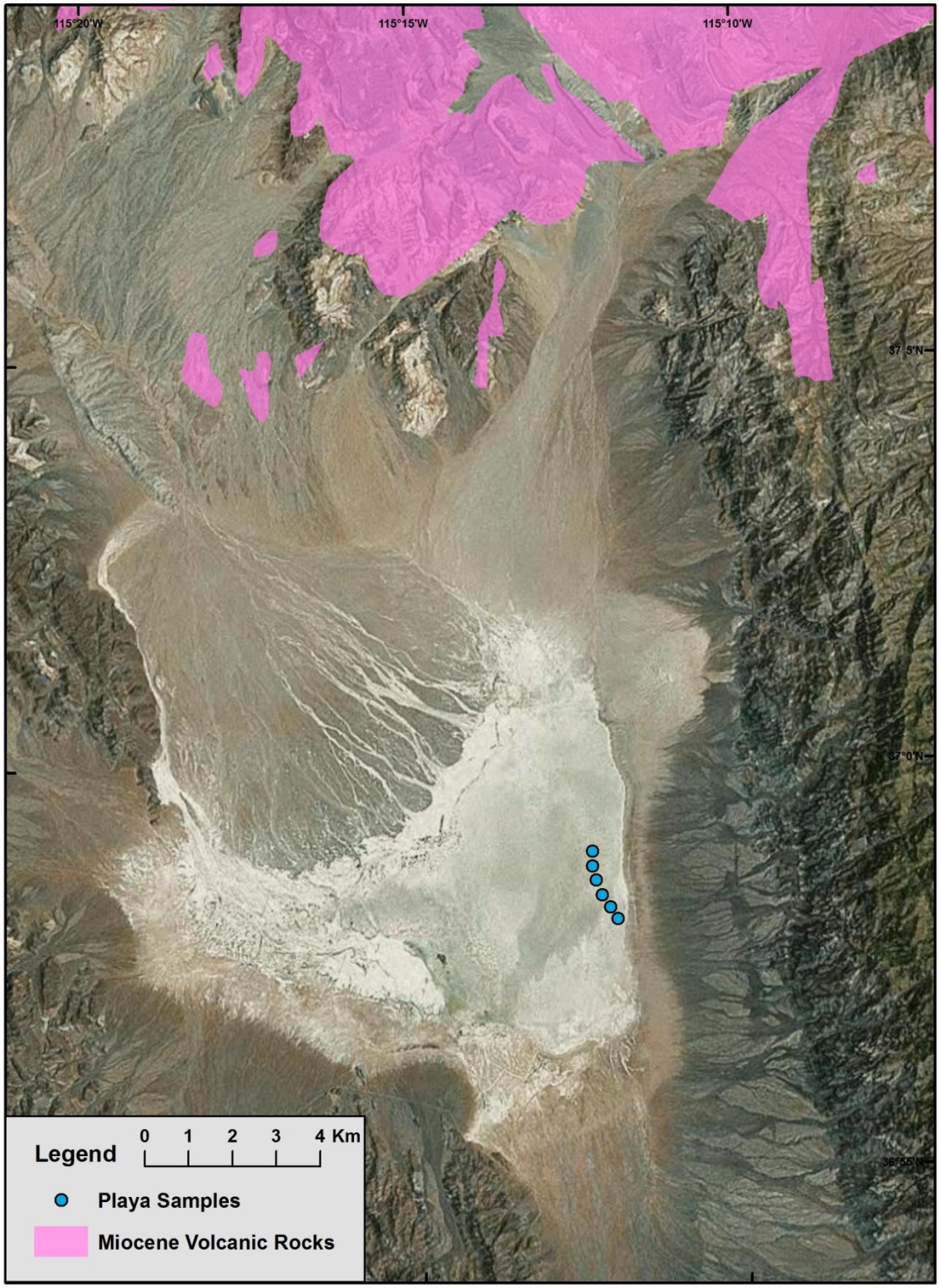


Figure 51. Map showing locations of the 6 playa samples taken from the Desert Lake playa. Playa occurs in an enclosed basin in the hanging-wall of a normal fault that bounds the western side of the northern Sheep Range. Also shown are exposed volcanic rocks, which are Oligocene and Miocene rhyolitic ash flow tuffs sourced from calderas several tens of kilometers to the north and northeast of the DNWR.

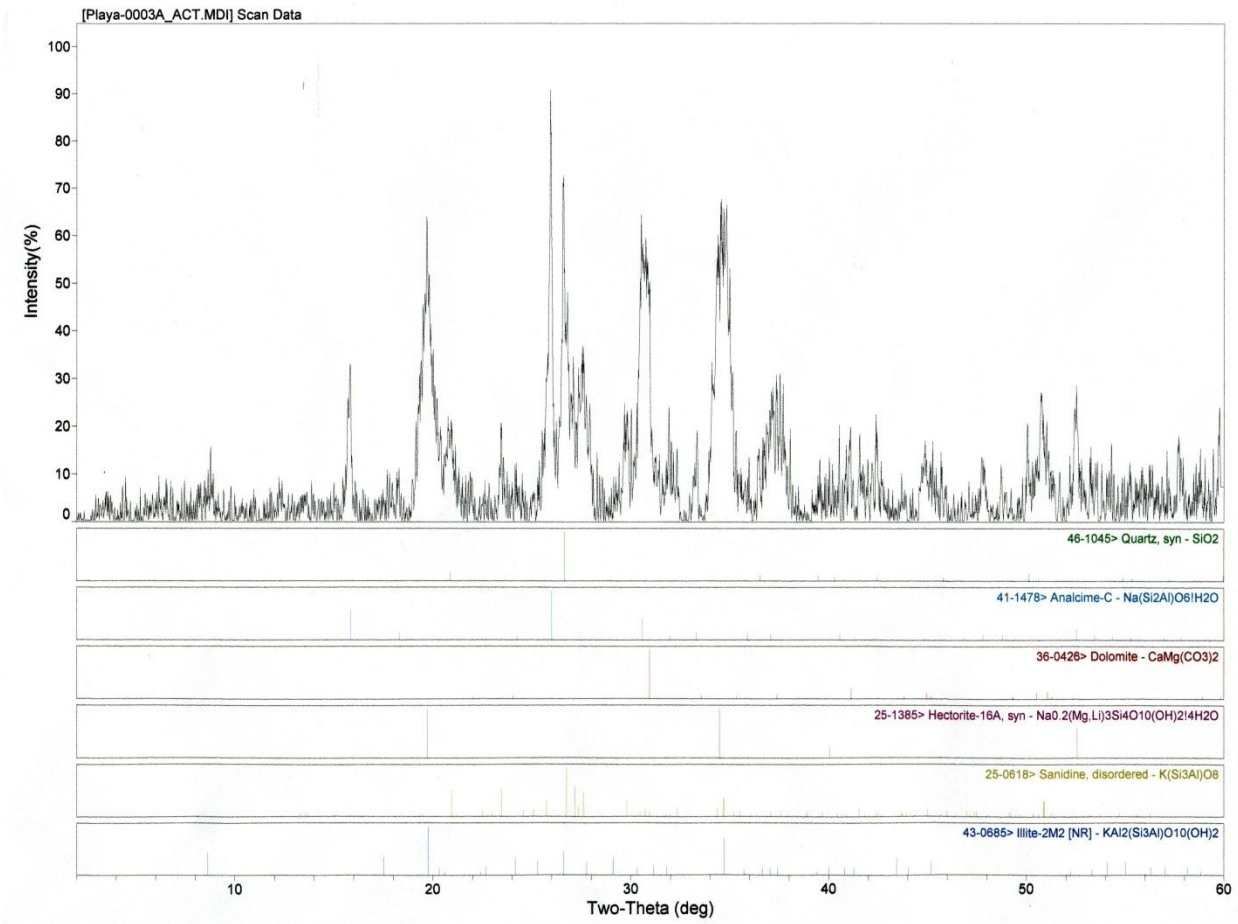


Figure 52. X-ray diffractogram of Desert Lake playa sample #3. Shows minerals present and their peaks

geochemical characterization sampling that NBMG did in its original 1992-1993 assessment. Water from these two samples drains south into the Desert Lake Basin. Other rhyolite tuffs at the north end of DNWR at site that drain northeastward into Pahranagat Lakes have up to 57 ppm lithium. The concentrations of lithium in the rhyolitic rocks of the DNWR are low compared to the lithium concentrations of fresh rhyolitic volcanic rocks near Clayton Valley, which range from 119 to 228 ppm lithium. Lithium-enriched rhyolitic volcanic rocks that act as sources for lithium are an important feature of lithium brine deposits (Price et al., 2000; Munk and Chamberlain, 2011; Hofstra et al., 2013).

The U.S. Geological Survey sampled sediments from 58 playas in Nevada in the 1970s (Bohannon and Meier, 1976). Average concentrations from these playas ranged from 10 to 640 ppm lithium. The Desert Lake Playa in the DNWR was not sampled as part of that program. Playas near the DNWR that were sampled in the U.S.G.S program included: (1) Las Vegas Valley – just south of the DNWR, 8-29 ppm lithium, 7 samples; (2) Dry Lake – 10 km east of the DNWR, 9-550 ppm lithium, average of 175 ppm, 129 samples; and (3) Tickaboo Valley – 8-40 km northwest of the DNWR, 25-68 ppm lithium, average of 40 ppm, 23 samples.

Companies have been recently exploring for lithium in Nevada since 2007 (NBMG Nevada Mineral Industry Reports 2007-2012). Most of the exploration has been in Esmeralda County near Clayton Valley and other nearby playas looking for brine deposits. Several other playas in western Nevada outside Esmeralda County have been explored as well. The exploration companies sample the playa sediment and/or brine in the playa. Lithium concentrations of playa sediments reported in these exploration projects range up to several thousand ppm. As pointed out above, the Clayton Valley playa sediments range up to 1,300 ppm lithium and average 100 ppm.

In addition to brine deposits in Nevada, Western Lithium USA Corp. is looking to develop its Kings River Valley Lithium Project in northern Humboldt County. Chevron Resources originally discovered and evaluated the resource in the 1970s and 1980s. The lithium occurs in clays, including illite and a smectite clay that is probably hectorite. Western Lithium has a patent for a proprietary process for separating lithium compounds from the lithium-rich clays. It has estimated a proven and probable reserve of 27,135,000 metric tonnes grading 0.395% lithium, which is two orders of magnitude higher than the lithium concentrations found in the hectorite in the Desert Lake playa sediments at the DNWR.

We conclude in this assessment, as was concluded in the original assessment, that the potential for lithium resources at the DNWR is low. We also conclude the available information gives a good indication that the potential is low; thus, using the Goudarzi system, we would classify the potential as L/C. Thus far, no brine samples have been collected from the Desert Lake Playa. If a greater certainty is required, we recommend the collection of brine samples, which could require drilling.

Potential for Borate Deposits

The boron concentrations in the six playa samples ranged from 190 to 350 ppm. A salt leach was used on the clay concentrate to see if any soluble borate minerals would show up on an XRD pattern; however, none of the peaks matched any of the common borates. For comparison borate mines typically contain sections of sediments up to nearly 100 meters thick that are rich in borate minerals or that contain boron-rich brine, such as the Boron/Kramer and Searles Lake deposits in the Mohave Desert in California (Kistler and Helvaci, 1994). The closest borate occurrences to the DNWR are at Calleville Wash and White Basin, located about 32 km southeast of the DNWR. At Calleville Wash, a two to six meter-thick bed in the Miocene Horse Springs rich in colemanite was mined. Total production was about 200,000 tons averaging near 20 percent B_2O_3. The Horse Springs Formation does occur at the DNWR. We conclude that available information gives a good indication that the potential is low for borate deposits at the DNWR, which like for lithium is a potential classification of L/C.

Assessment of DNWR as a Future Source of Cement Limestone and Aggregate

The mainstays of the Nevada's and especially the Las Vegas metropolitan area's economy has historically been gaming and tourism. During most of this period since NBMG's original 1992-1993 assessment, at least through 2007, the Las Vegas metropolitan area experienced phenomenal growth which fueled a construction boom and created a real estate bubble. The construction boom expanded the need for industrial minerals, particularly sand, gravel, crushed stone, cement, and gypsum. However, gaming, tourism, and construction are all particularly susceptible to economic downturns.

The national gross domestic product (GDP) during the period from 1993 to 2000 started on an upswing, as the economy recovered from a recession in 1990-1991. Between 1993 and 2000 the annual growth rate of Nevada's GDP averaged 9.4% before slowing to 4.8% during the national recession in 2001. Between 2002 and 2006 Nevada's GDP grew at an average rate of 8.1%, before slowing to 0.6% in 2007 just before the start of the "great recession", which started in December of 2007 and lasted until June of 2009. Data for Clark County, available starting from 2001, show that the local GDP grew 2.7% in 2002 and had an average growth rate of 7.3% during the period from 2003 through 2007. The "great recession", hit Clark County particularly hard, with GDP shrinking for 3 straight years at an average rate of 4.3%. In 2011 and 2012, Clark County's GDP rebounded at an average rate of 1.3%.

Population and job growth are obviously dependent upon economic health. The 2002 recession appeared to have little impact on Clark County's economy; however, the impact of the "great recession" was severe. Between 1993 and 2013, the population of the Las Vegas Metropolitan Area grew 122% from 902,338 to an estimated 2,002,000. Between 1993 and 2007, the annual growth rate averaged 5.2%. During much of this time, Las Vegas was one of the nation's fastest growing metropolitan areas. Since the start of the "great recession", the growth rate has slowed and has averaged 1.5%. A population forecast developed at the University of Nevada Las Vegas estimates the population in the Las Vegas metropolitan area to grow to 3,291,000 by 2050 at a modest annual rate that will vary between 0.8% and 2.7% (Tra, 2012). Between 1993 and 2011, the labor force of the Las Vegas metropolitan area grew from 487,782 to 998,907. However, since 2011, the labor force has declined 0.7% to 991,851. Between 1993 and 2007, the unemployment rate averaged 5%. With the onset of the "great recession", unemployment rose to 14.2% in 2010 and had since receded to 9.8% near the end of 2013.

During the period of growth leading up to the "great recession" the construction industry was a significant driver to the huge increases in Nevada's GDP. A rising population needs places to live and work, and construction is an indication of the need for industrial minerals especially aggregate, cement, and gypsum. Between 1995 and 2002, the overall annual number of building permits issued varied between 28,162 and 31,951. The number jumped to 39,237 in 2005 but declined precipitously 87% to a low of 5,147 in 2011. 2012 saw a modest increase to 7,375. About 75% of these permits were for single units.

The number of permits issued specifically for single units provide a rough estimate of residential construction. Between 1995 and 2002, the number increased at an annual average rate of 3% from 20,062 to 24,702 during the ramp up of the construction boom. The number jumped 28.5% from 2002 to 2004 to 31,741 as construction really took off. The number declined slightly in 2005, but declined precipitously 88% to 3,777 between 2005 and 2009 with the bursting of the real estate bubble. The number of permits stood at 6,108 (Bureau of Economic Analysis; Bureau of Labor Statistics; Census Bureau; Tra, 2012).

The rapid growth of the Las Vegas metropolitan area was severely impacting the surrounding public lands, and Nevada's congressional delegation worked to relieve some of these issues at the Federal level. Below are three of the acts passed in that regards. The impact of these acts at the DNWR is both direct, by the addition of some land, and indirect, by accommodating to needs of an expanding population and increased tourism.

The first of these acts was the "Southern Nevada Public Land Management Act of 1998." Rapid growth of the Las Vegas metropolitan area was causing significant impacts upon the Lake Mead National

Recreation Area, the Red Rock Canyon National Conservation Area, and the Spring Mountains National Recreation Area, which surround Las Vegas Valley. The BLM managed large numbers of small and large parcels interspersed with or adjacent to private land in the Las Vegas Valley, which made many of these parcels difficult to manage. It was recognized that in order to promote responsible and orderly development in the Las Vegas Valley, some those public lands should be sold by the Federal Government based on recommendations made by local government and the public. Congress passed the "Southern Nevada Public Land Management Act of 1998" to provide for the orderly disposal of these lands in Clark County, and to use the proceeds for the acquisition of environmentally sensitive lands in the State of Nevada with priority given to lands in Clark County. The effect of this act on the Las Vegas metropolitan area was to make it easier to convey public lands to the private sector and allow for the expansion and development of the urban area. This expansion spurred more construction and the need for local industrial minerals particularly sand, gravel, crushed stone, aggregate, gypsum, and cement (BLM; PUBLIC LAW 105 – 263-OCT. 19, 1998).

The second act was the "Ivanpah Valley Airport Public Lands Transfer Act." With the rapid urban growth of Las Vegas came a projected increase in air passenger counts to near capacity at the McCarran International Airport. This resulted in plans to build a second airport south of Las Vegas. The preferable site was a dry lake bed between Jean and Primm in Ivanpah Valley. In 2000, Congress passed the "Ivanpah Valley Public Lands Transfer Act" to allow for the conveyance of 5,750 acres of public lands to Clark County to build a new airport and related infrastructure. Construction was expected to begin in 2010 and be completed in 2017. However, the passenger count dropped off during the "great recession", and plans for the new airport were shelved, but environmental studies continued. McCarran airport's capacity is 53,500,000 passengers per year, and 40,000,000 passengers were accommodated in 2010. The capacity is expected to increase with the expansion of the McCarran International Airport and adoption of a satellite-based air traffic control system. Should the passenger count exceed 60,000,000 passengers per year, a new airport will be needed. The building of a new airport is anticipated to require a large amount of sand, gravel, crushed stone, aggregate, and cement, though exact figures have not been published (BLM; PUBLIC LAW 106–362—OCT. 27, 2000; LVRJ article 10/2/2013; https://www.mccarran.com/DoingBusiness/Vision2020.aspx).

The third act was the "Clark County Conservation of Public Lands and Natural Resources Act of 2002." With the growth and its impingement on surrounding federally managed lands, Clark County has faced many competing land issues. Some groups such as the Nevada Wilderness Coalition wanted all public land in Clark County designated as wilderness, while others wanted all public land in Clark County privatized. Urban expansion and the development and improvements in infrastructure were hampered by the need for the private sector to acquire public land. Other major issues included access to public lands, recreational use, illegal dumping, conservation of natural resources, and preservation of cultural sites. Congress passed the "Clark County Conservation of Public Lands and Natural Resources Act of 2002" in an effort to address most of these concerns. The Act designated 232,033 acres in 17 new wilderness areas and the expansion of an existing one. The Sloan Canyon National Conservation Area was created and the Red Rock National Conservation Area was expanded. The DNWR was enlarged with the addition of 26,433 acres between it and US 93. Mineral entry was withdrawn within these areas with the wilderness areas overlapping parts or most of the Muddy Mountain and Arrow Canyon non-metal mining districts and the Charleston, Crescent, and Newberry metal mining districts. On the other hand, a

number of acres adjacent to nine of the wilderness areas and the DNWR were dropped from the withdrawals. The Act also provided for conveying public lands for infrastructure and other purposes and made some changes to the Southern Nevada Public Land Management Act of 1998. The main effect of this Act on the Las Vegas Metropolitan area was the setting aside of public lands in an effort to preserve the environment. However, a long term consequence might be restricted access to natural resources. It is not clear how future resources, especially new areas for industrial minerals, might be affected if the pace of urban expansion accelerates (BLM including map; PUBLIC LAW 107–282—NOV. 6, 2002; Senate Hearing 107-846).

With this economic and land status backdrop for the Las Vegas metropolitan area, we discuss the potential need to access industrial mineral resources at the DNWR that were determined in the original 1992-1993 NBMG assessment to have high potential. These included high-calcium limestone, cement limestone, dolomite, and construction aggregate.

Between 1993 and 2013, Chemical Lime Co. mined high-calcium limestone from its Apex mine and processed it at their plant in Henderson. The operation makes high-calcium quicklime used in metallurgical processing, paper manufacturing, and environmental markets. The company also shipped crushed limestone. Production is confidential, but the Department of Taxation shows that between 2000 and 2008 the annual gross proceeds varied between $5,405,033 and $8,780,383 and averaged $6,439,658. The proceeds dropped to $8,259,082 in 2009, rose annually afterwards, and were up 37% to $11,284,272 in 2012, mainly due to price and production increases. Most of the company's products are used outside of the Las Vegas Metropolitan area. No known studies of the total resources in the Las Vegas metropolitan area have been released, but the company also has operations in 14 other states and Canada and would not need to look for reserves at the DNWR.

Between 1993 and 2013, the only cement plant in Nevada in continuous production was the Nevada Cement Co. operation near Fernley, which produced various types of cement for Nevada and California markets. The building boom in the Las Vegas metropolitan area required large amounts of cement, but local concrete suppliers and construction firms were plagued by temporary cement shortages from the 1990s through 2005. Later shortages were due in part to the curtailment of Chinese imports and increased environmental regulations on plant emissions.

Despite abundant local limestone suitable for cement production, only one cement plant had sporadic production, and several companies at different times only considered plans for building cement plants. The Royal Cement Co. (American Cement and Aggregate after 2001) operated the Logandale plant about 10 miles southeast of Moapa for two stints, and the cement was used in the Las Vegas metropolitan area. The plant produced about 50,000 tons annually between 1995 and 1997 and up to 120,000 tons annually between 1999 and 2003. Limestone was mined near the plant site, silica was brought in from Utah, and iron ore was brought in from California. The plant was closed in 2003 and was dismantled in 2011.

In 1998, at least two companies were researching the feasibility for new cement plants near Las Vegas. Of these, U.S. Cement worked on a scheme to process clinker produced outside Nevada, and another company studied the possibility of utilizing local raw materials. In 2004 Cementos Pacasmayo, a large Argentinian cement company, dropped plans to build a cement plant in the Las Vegas area.

In 2004, Ash Grove Cement Co. announced an agreement with the Moapa Band of Paiute Indians to build a 1.5 million-tons/year capacity cement plant on the Moapa reservation northeast of Las

Vegas. Limestone for the cement would be quarried from a site on the east flank of the Arrow Canyon Range near the western border of the reservation, six to seven miles east of the DNWR. The limestone was thought to be relatively pure. Other materials needed for cement production would be delivered by truck or rail. In 2007, a new tribal government was elected that were against construction of the plant, and the agreement was cancelled.

In 2008, Holcim (US) Inc. acquired a long-term lease option to the mining rights on a 1,760-acre site about 40 miles east of Las Vegas and announced that they would be testing the limestone reserves there for potential raw materials for cement production. Holcim (US) is looking at potential future growth in the Nevada and Utah markets. The company's Devil's Slide cement plant in Utah provided cement to their sister company, Aggregate Industries, in Las Vegas.

In 2009, Infrastructure Materials Corporation of Reno, Nevada, owned 12 projects for cement grade limestone in Nevada. Two of the projects were in Clark County, the MM Claim Group located about 15 miles south of Las Vegas, Nevada and the Royale Claim Group located about 10 miles south of Las Vegas. Both project areas were largely underlain by carbonates of the Mississippian to Permian Bird Spring Formation. Four of the projects were in Lincoln County. The Burnt Springs Claim Group was located in the Burnt Springs Range 6 to 10 miles northwest of Caliente. It covered limestone in the lower part of the Cambrian Highland Peak Formation. The Blue Nose Claim Group was located along the south edge of the Clover Mountains about 25 miles southeast of Caliente, Nevada, and covered limestone of the Mississippian Monte Cristo Formation. The Jumbled Mountain Claim Group was located about 40 miles southeast of Caliente and covered three isolated outcroppings of Paleozoic limestone. The Lime Mountain Claim Group was located 35 miles southeast of Caliente and covered limestone of the Mississippian Monte Cristo Formation. The last three were about 50 to 60 miles east of the northeast corner of the DNWR. As of 2012, only the Blue Nose Group was being studied for development of a cement plant.

No recent studies of the total resources of cement grade limestone in the Las Vegas metropolitan area have been published. However, cement grade limestone outside of the DNWR is common and is already being mined. An economic need to mine what is at the DNWR is unlikely. Any potential local shortages will be from increased restrictions on access to resources on public lands outside of the DNWR (MI1993-MI2012; USGS Commodities).

Between 1993 and 1997, Chemical Lime Co. (Lhoist North America) mined dolomite from the Sloan quarry and dolomitic and high-calcium limestone from the Apex quarry. The dolomite was converted to dolomitic limestone at their plant in Henderson for use in the manufacture of stucco and glass. Chemical Lime Co. closed their Sloan operation in 1997, but continued dolomitic limestone production at Apex. The Henderson plant processes Type S hydrated dolomitic lime for building and home construction. Because of the decline in demand from the drop in the housing market, the company suspended operations in 2009 at its Grantsville, Utah plant, but the production capacity at Apex and Henderson was adequate to make up the difference.

Between 1993 and 2013, Bardon Materials Inc. (now a subsidiary of Aggregate Industries) also produced dolomite at the Sloan quarry. The dolomite was crushed and used as construction material.

In 2006, Service Rock Products Corporation of California applied to the BLM to build and operate an aggregate pit called the Sloan Aggregate Mine in section 32, T23S, R61E, and in 2007, CEMEX applied to build and operate an aggregate pit called the Mohave Minerals Project in section 29. The site is about

30 miles south of the DNWR. The mining from the two pits, expected to eventually grow into one large 2,500-foot deep pit covering about 640 acres, was proposed to produce 126,000,000 tons of mostly limestone and dolomite over a 20- to 30-year period. The sale request for the material, referred to as the Sloan Hills Competitive Minerals Sale, exceeded the volume limitations for noncompetitive sales and had to be done on a competitive basis. Public scoping meetings ended in January 2008, and a plan of operation was filed with the BLM in 2009. A draft Environmental Impact Statement was completed in the summer of 2011, and the final Environmental Impact Statement and Record of Decision were released in February 2013. The project was strongly opposed by local residents. In the Record of Decision, the BLM did not authorize the project.

No recent studies of the total resources of dolomite in the Las Vegas metropolitan area have been released. However, dolomite and dolomitic limestone outside of the DNWR is common and, like cement grade limestone is already being mined. An economic necessity to mine dolomite from the DNWR is unlikely. Any potential local shortages will be from increased restrictions on access to resources on public lands. The Sloan project was proposed during the height of the construction boom, and production of dolomite and dolomitic limestone from existing mines appears to have been adequate to supply the depressed construction needs during the "great recession". (MI1993-MI2012; BLM news release, 4/26/2013; Proposed Sloan Hills Competitive Minerals Sales Final Environmental Impact State and Record of Decision)

Between 1993 and 2000, production of construction aggregate varied between 16,000,000 and 21,000,000 tons and averaging 19,000,000 tons. Sand and gravel accounted for between 85% and 92%, averaging 86%, of the production with crushed stone making up the difference. Following the increase in construction, production jumped 37% to 26,000,000 tons in 2001 and almost doubled again to 50,320,000 tons in 2005. Production fell to 38,300,000 tons in 2006 and rose again to 43,000,000 tons in 2007. With the onset of the "great recession", production declined 53% to 20,400,000 tons in 2009 and declined another 17% to 17,000,000 tons in 2012. Preliminary data for the State for the first six months of 2013 suggest the decline has continued. After 2002, sand and gravel accounted for between 65% and 80% of the production, averaging 74%, with crushed stone making up the difference.

Between 1993 and 2012, over 440,000,000 tons of sand and gravel and almost 118,400,000 tons of crushed stone were mined. Through 2004, the averaged combined price was $4.50 per ton with little variation. Data for 2005 onward showed the price of sand and gravel varied between $4 and $5.78 per ton, averaging $4.85 per ton, and the price of crushed stone varied between $6.51 and $10.78 per ton, averaging $8.96 per ton.

At the height of the construction boom, seven companies were producing more than 1,000,000 tons of aggregate annually, and three more were producing between 500,000 and 1,000,000 tons. The major production areas included Blue Diamond, Jean, Lone Mountain, Mesquite, Primm, Racetrack/Salt Lake Highway/Speedway for sand and gravel, and Apex Landfill (limestone), El Dorado (granite), and Sloan (dolomite) for crushed stone. Most production came from private property, but much of it still came from mostly community pits on public lands, which included East, Jean, Mesquite, North and South Jean Lake, Salt Lake Highway, Speedway, and parts of Lone Mountain, with at least 7,000,000 tons reported for 2005. For several years, the Lone Mountain area produced over 10,000,000 tons annually. The east side came under pressure because of residential development to the edge of some of the pits.

Production on the east side ended by 2012 but expanded westward. The Apex Landfill Pit started up in 1998.

Since the onset of the "great recession", production for all companies has fallen. Only two companies produced more than 1,000,000 tons in 2012. Several of the companies producing more than 500,000 tons in 2006, sold out or stopped production in the area, and at least two went out of business. Production from pits on public lands fell to 1,500,000 tons by 2010 but rebounded to 2,500,000 tons in 2011. The Eldorado Pit ended production in 2008 and was sold (MI1993-MI2012; USGS Commodities).

No sand and gravel production was recorded within the DNWR for the period 1993 to 2013. However, sand and gravel pits on BLM land within a few miles of the boundary mined material similar to that at the DNWR, and contributed greatly to the aggregate production, though most of the production occurred prior to the onset of the "great recession." A number of pits in T19S, R61E, section 14; T19S, R62E, sections 21, 22, and 24; and T19S, R63E, sections 10, 18, and 19 produced at least 15,000,000 tons between 1993 and 2013 of which about 11,000,000 tons were from public lands. These included the Salt Lake Highway and Speedway Pits, which were encroached upon by the northward expansion of Las Vegas. A pit operated mainly by Ready Mix, Inc. in T17S, R58E, section 9, about three miles west of the DNWR boundary produced almost 626,000 tons. Several pits near Indian Springs also produced over 155,000 tons. In addition, pits located just northeast of the DNWR boundary near Lower Pahranagat Lake produced over 118,000 tons.

For the original 1992-1993 assessment, NBMG compiled an inventory of sand and gravel pits in the Las Vegas and Pahrump areas, but no reserves were calculated. The area of Las Vegas that was compiled was mostly in T19-25S, R59-63E. Most of that area is now built over and unavailable for construction aggregate production. Also, no known recent studies of the total resources construction aggregate in the Las Vegas Metropolitan Area have been published. While production can be expected to rebound as the economy improves, for the immediate future, production from existing pits will probably be sufficient for the area needs. Again, any potential local shortages will be from increased restrictions on access to resources on public lands outside the DNWR.

Assessment of Potential for Geothermal Resources

Introduction

The Desert National Wildlife Range (DNWR) is located in the southern part of the Great Basin region (Fig. 53), an area that hosts more than 400 known geothermal systems with temperatures ranging from 37 to 270° C (Faulds et al., 2011). Most of these geothermal systems are not related to upper crustal magmatic heat sources but are instead structurally (fault) controlled. Temperatures are generally >200° C at 5-6 km depth across much of the Great Basin, whereas average temperature gradients range from 15 to 80° C/km in the upper one kilometer of crust (SMU, 2011). The conventional structurally controlled geothermal systems in the Great Basin are associated with permeable fault zones that facilitate convective heat flow. In addition to the conventional structurally controlled systems, a new type of potential geothermal resource termed "deep stratigraphic reservoirs" or "hot sedimentary aquifers" has recently been recognized in the western United States (e.g., Allis et al., 2011). This study assesses the potential for both conventional structurally controlled systems and deep stratigraphic reservoirs in the DNWR.

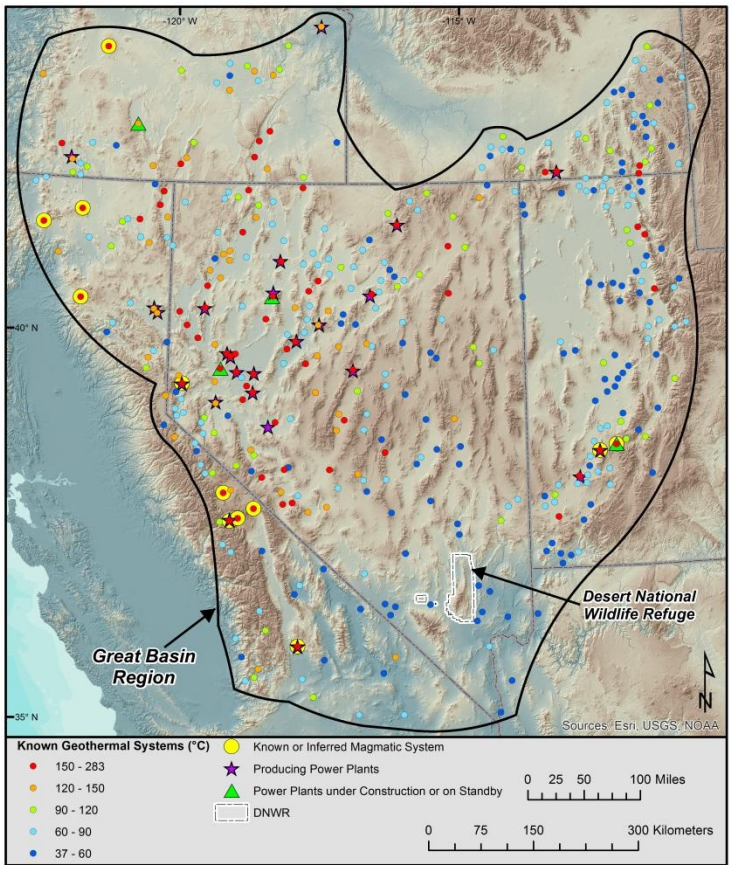


Figure 53. Geothermal systems and geothermal power plants in the Great Basin region. Figure modified from Faulds et al. (2012).

Previous assessments of geothermal resources in the Great Basin region have not identified any geothermal resources, active or inactive, structurally controlled or deep stratigraphic reservoirs within the DNWR (Garside and Schilling, 1979; Garside, 1994; Tingley et al., 1993; Allis et al., 2011, 2012). Many

of the structurally controlled geothermal resources in the Great Basin region are blind, meaning that they are not associated with active surface manifestations such as hot springs or fumaroles (e.g., Desert Peak geothermal area, Benoit et al., 1982). Absolute confirmation that a blind geothermal systems exists in a given area typically necessitates a combination of exploration methodologies such as 2m temperature probes, temperature gradient hole drilling, and geochemical analyses of fluids. However, circumstantial evidence including structural settings, recency of faulting, structural analyses of fault zones, and regional tectonic strain rate can be used to evaluate the relative potential for blind, structurally controlled systems in a given area (Faulds et al., 2006; 2011; 2012; 2013; Bell and Ramelli, 2007). Deep stratigraphic reservoirs do not have surface expressions and exploration is accomplished through spatial comparison of regional temperature gradient data, deep drill-hole data, depth of Cenozoic basins and underlying bedrock lithology (e.g. Allis et al., 2013; Deo et al., 2013).

This study incorporated a review of regional data including published geologic maps, reports, journal articles, public geothermal databases and field reconnaissance of select areas within the DNWR. Thermal anomalies of some geothermal systems in Great Basin extend up to 10 to 12 km across (e.g., Salt Wells geothermal area, Coolbaugh et al., 2006; Skord et al., 2011), and thus initial clues to the location of an active geothermal system in the DNWR, such as hot springs or wells, anomalous geochemistry from springs or wells, bedrock alteration, or spring deposits may be located several kilometers outside the boundary. Therefore, data were analyzed both across the DNWR and within a 5 km buffer around the DNWR. Air photo imagery was examined and field reconnaissance was accomplished for key parts of fault zones to assess recency of faulting relative to Quaternary time and search for active or inactive geothermal features such as thermal springs, spring deposits, epithermal mineral veins, and alteration of bedrock and sediments.

Geologic Setting

Within the DNWR, Late Proterozoic to Late Paleozoic sedimentary strata compose most of the mountain ranges, while Tertiary volcanic and sedimentary rocks locally dominate the low unnamed ridges in the far north end of the DNWR (Fig. 54). The Proterozoic and Paleozoic strata exposed in the DNWR were folded and faulted during the Sevier Orogeny in the Cretaceous, and both the Paleozoic and Tertiary strata have been cut by normal and transverse faults that initiated during a period of rapid extension in the middle to late Miocene and locally continues today (e.g., Guth, 1981; USGS, 2010; Kreemer et al., 2010). Most of the mountain ranges are east-tilted, bound by major west-dipping, north-striking range-front normal faults (Stewart and Carlson, 1978; Stewart, 1998; Page et al., 2005). The regional north-south Basin and Range structural grain is locally disrupted by transverse shear zones, the dextral Las Vegas shear zone to the south, the sinistral Pahranagat shear zone to the north, and the sinistral Spotted Range shear zone to the west. The Las Vegas Valley shear zone accommodated >60 km of dextral shear between middle to late Miocene along strike-slip faults in northern Las Vegas Valley and through oroclinal flexure extending ~20 km north and south of the strike slip faults (Burchfiel, 1965; Longwell, 1974; Nelson and Jones, 1987; Sonder et al., 1994). Oroclinal flexure has resulted in clockwise vertical axis rotation of fault blocks bound by sinistral-oblique faults, easily recognized by the north-south structural grain curving to approximately east-northeast strike at the southern end of the Las Vegas, Sheep, Desert, and Pintwater Ranges (e.g., Frenchman Mountain; Castor et al., 2000). The western part of the DNWR is cut by numerous east- to northeast-striking sinistral oblique faults that accommodated both oroclinal flexure associated with the dextral Las Vegas Valley shear zone and the sinistral displacement along Spotted Range shear zone centered immediately northwest of this part of the DNWR (Carr, 1984). At the north end of the DNWR, the north-striking Basin and Range normal faults and Mesozoic-age thrusts have been displaced left-laterally across three major northeast- to east-northeast-striking fault zones in the Pahranagat shear zone (Jayko, 1990, 2007; Taylor et al., 2000; Long, 2012).

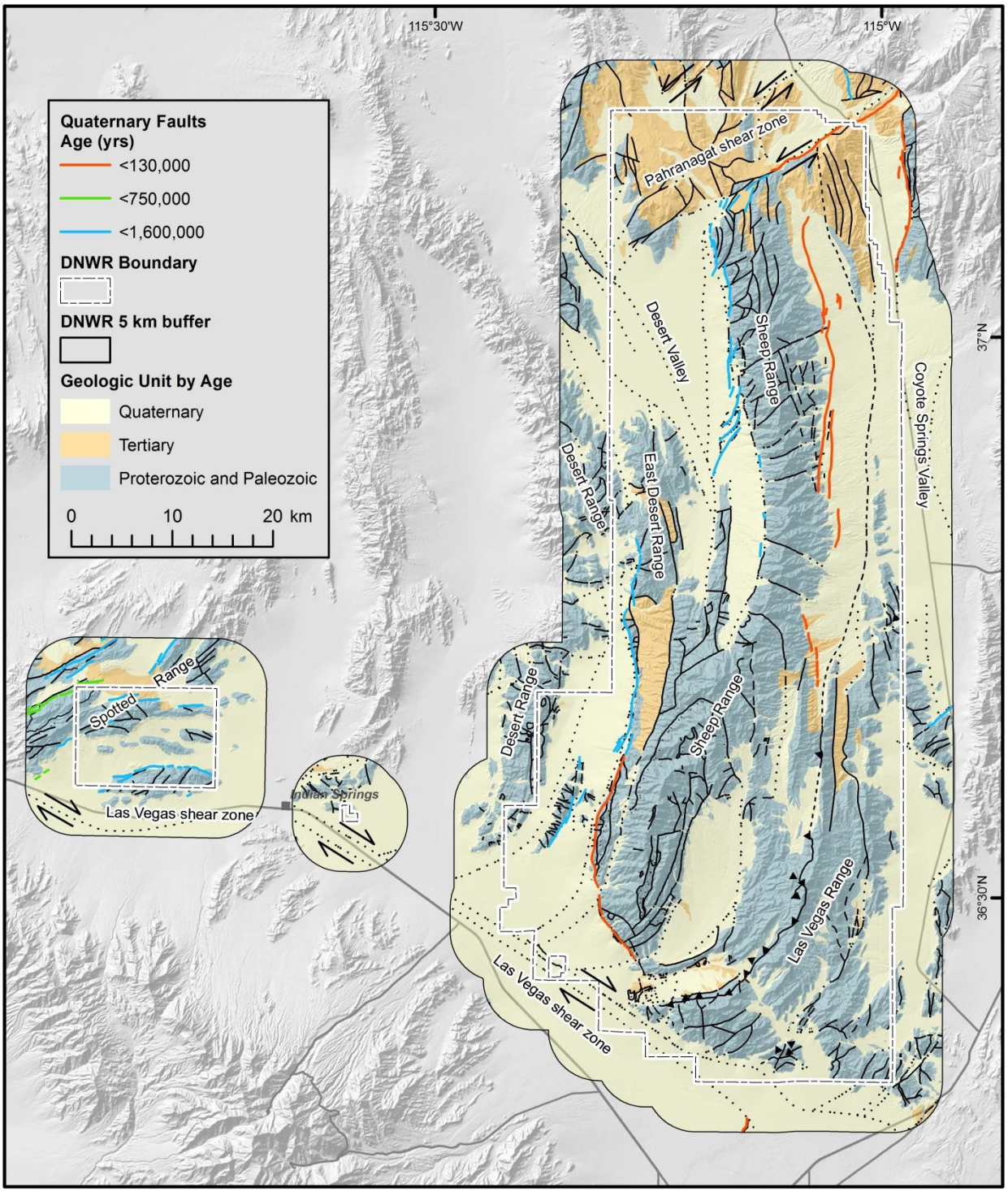


Figure 54. Shaded relief map with overlay of simplified geologic units, major fault zones (Stewart and Carlson, 1978; Page et al., 2005; Jayko, 2007), and highlighted Quaternary fault segments (USGS, 2010).

While most of the cumulative strain accommodated along normal and strike-slip faults within the DNWR took place during the middle to late Miocene, locally distributed Quaternary fault scarps, GPS

geodesy, and seismic activity indicates that many of these faults remain active today. Range-front faults along both the East Desert and Sheep Ranges are locally associated with Pleistocene fault scarps (Fig. 54; USGS, 2010; this study). Many of the faults in the Spotted Range with documented long-term sinistral-oblique displacement are also associated with Pleistocene scarps, although Quaternary displacement is mostly normal offset (USGS, 2010). One of the three major northeast-striking sinistral-oblique fault zones in the Pahranagat shear zone is associated with Pleistocene scarps, while Quaternary scarps are absent from the other two fault zones. Quaternary scarps are not associated with the west-northwest-striking strike-slip faults associated with the Las Vegas Valley shear zone or with range-front faults along the Las Vegas Range. According to recent GPS geodetic data, the DNWR as a whole sits in a region with relatively low strain rate relative to much of the rest of the Great Basin region (Kreemer et al., 2012). While strain rates are relatively low for much of southern Nevada, there is a concentrated belt of historic seismicity and localized strain known as the southern Nevada shear zone that extends east-northeast-west-southwest from the Colorado Plateau to the eastern California shear zone and accommodates ~1.1-1.8 mm/yr of dextral shear (Kreemer et al., 2010). The Pahranagat shear zone is part of the greater southern Nevada shear zone and is the structural domain within the DNWR that is the most seismically active and has the greatest strain rate as determined by GPS geodesy. Overall, the absence of recognized Holocene fault activity within the DNWR is fitting with the low regional strain rate as determined by GPS geodesy relative to the Great Basin region as a whole (Kreemer et al., 2012).

Conventional Fault-Controlled Geothermal Systems: ***Temperature and Geochemistry Data***

Examination of publically available geothermal databases (NBMG and GBCGE, 2012; SMU, 2008) yield data for 20 sites including springs and wells within the DNWR study area (Table 12, Fig. 55). Spring temperatures are all cold, ranging from 9.5 to 15° C. Well temperatures include cold and warm wells ranging from 11.5 to 41° C. Depth data is available for only four of the wells and one of these, CSV-3 clearly has an anomalous temperature gradient of 88° C/km, relative to the corresponding regionally calculated temperature gradient of 45° C/km (Coolbaugh et al., 2005). Well depth data are not available for the remaining wells and therefore the elevated temperatures recorded in warm wells (e.g. VF2-2 and USFWS Well SBH-1) may simply correspond to well depths reflecting the regional geothermal gradient of 33 to 62° C/km across the DNWR area (Coolbaugh et al., 2005). Well CS4-3 has the only measured thermal anomaly for the entire DNWR study area. However well CSV-3 is 4.5 km east of the DNWR boundary in Coyote Springs Valley and probably relates to a low temperature structurally controlled system localized to this valley rather than to a geothermal system in the DNWR.

Geothermometry is available for many of the springs and wells, and many of these calculations reflect elevated temperatures (Table 12, Fig. 55). However, the charge balances are suspect for all of these calculations and reflect poor quality data. Typically acceptable charge balances are good for values of 0-5%, fair at 5-15%, and poor for values >15% (e.g., Shevenell et al., 2012). Two sites, CSV-1 and Desert Valley Well have charge balances that fall just outside of the fair range (5-15%) at 15.2% and 17.9%, respectively. However, all the charge balances do indicate poor data quality across-the-board, and these calculated geothermometers should not be trusted. Geothermometry is one area where further work could be accomplished through analyzing water samples from the DNWR.

Table 12. Measured and calculated (geothermometry) spring and well temperatures

Spring or Well Name	Type	Well Depth (m)	Measured Temperature (°C)	Temperature Gradient (°C/km)	Ca-Na-K (°C)	Quartz, no steam (°C)	Chalcedony (°C)	Charge Balance (%)
Sawmill Spring	S	n/a	--	n/a	-1.9	24	-8.9	76.2
Wiregrass Spring	S	n/a	9.5	n/a	-9.9	45.3	12.7	87.7
Cow Camp Spring	S	n/a	14.5	n/a	-1	55.3	22.9	42.4
Wamp Spring	S	n/a	--	n/a	11	70.4	38.7	75.7
White Rock Spring	S	n/a	15	n/a	54	99	68.8	70.4
Sheep Spring	S	n/a	15	n/a	7.4	48	15.4	66
Lamb Spring	S	n/a	13.5	n/a	-6.2	45.3	12.7	52.6
CSV-1	W	--	15.4	--	40.2	65.3	33.3	15.2
Desert Valley Well	W	--	19	--	67.1	100.9	70.9	17.9
USFWS Well DR-1	W	--	--	--	58.4	73.6	41.7	24
Mormon Well	W	--	11.5	--	-23.3	55.3	22.9	63.4
USFWS Well SBH-1	W	--	29	--	36.6	67.1	35.1	28.5
VF-2	W	--	34	--	48.7	53.6	--	--
CSV-3	W	237.8	41	88 [45]	68	38.7	--	--
SHV-1	W	280.5	25	18 [52]	25	43.5	--	--
Test Well 10	W	--	27.2	--	1.4	20.5	--	--
NWIS Well 216 S18 E63 05AADB1	W	--	27.2	--	50.7	29	--	--
NV Division of Forestry Well - Floyd R Lamb State Park	W	237.8	23	13 [58]	30.5	33.3	--	--
NWIS Well 212 S19 E60 04DCBB1	W	103	21.4	14 [58]	--	--	--	--
NWIS Well 212 S19 E60 08 1	W	--	21	--	1.9	15.4	--	--

Data in table are from NBMG and GBCGE (2012) and correspond to point data in Figure 53. Data in gray-filled boxes are located within the 5 km buffer outside the DNWR. Type: S, Spring; W, Well. Temperature gradient calculated in this study using a surface temperature of 20° C. Regional temperature gradient from Coolbaugh et al., (2005) in brackets after calculated temperature gradient (e.g., 88 [45]).

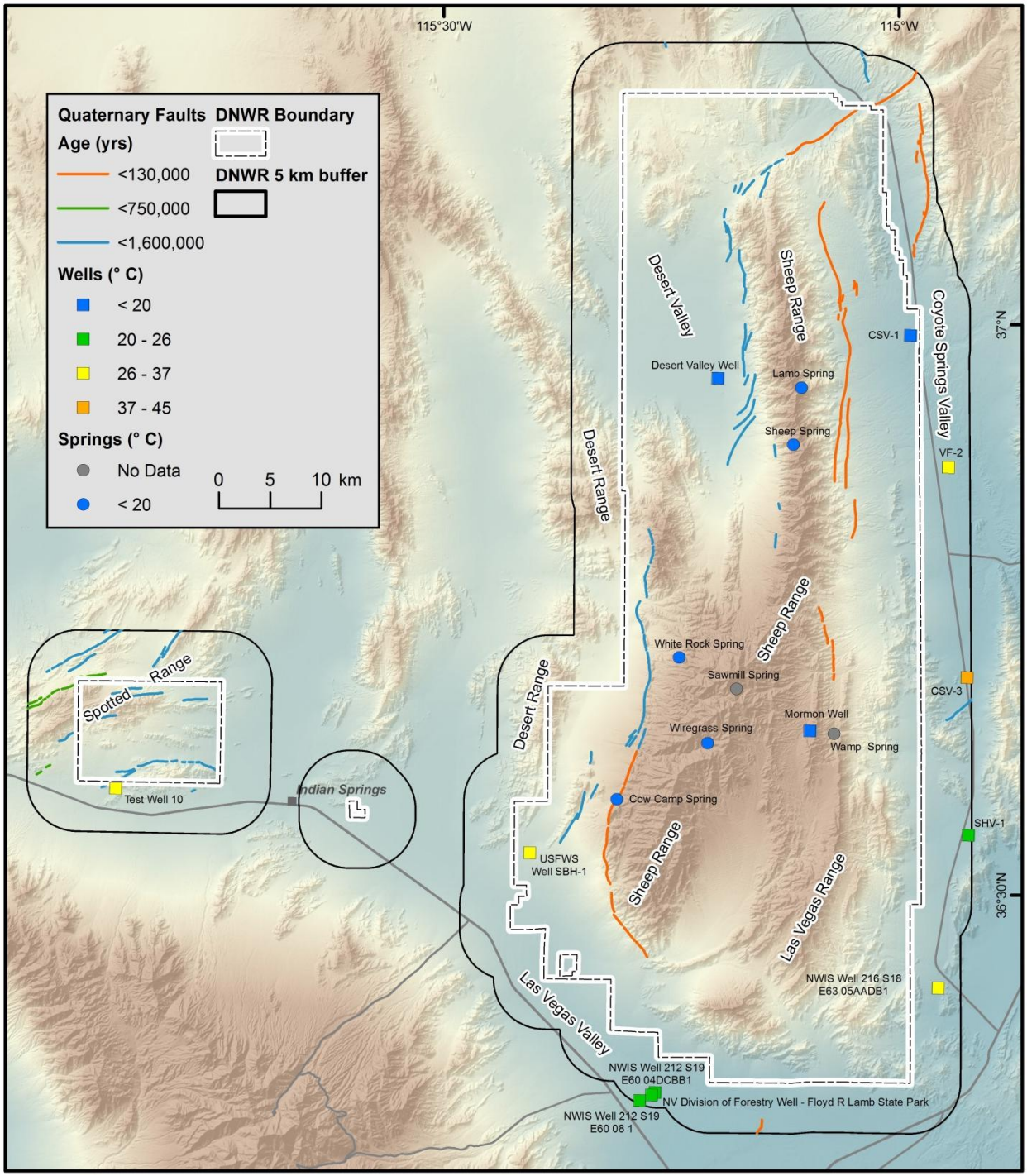


Figure 55. Shaded relief map of the DNWR showing spring and well temperature data (Table 12) and Quaternary faults (USGS, 2010).

Conventional Fault-Controlled Geothermal Systems: Potential Blind Structurally Controlled Geothermal Areas

Research has shown that most of the known geothermal systems in the Great Basin region are associated with specific fault patterns or structural settings. The most common settings include terminations of major normal faults, accommodation zones (belts of intermeshing, oppositely dipping

faults), step-overs in range-front faults, and fault intersections (Faulds et al., 2011, 2013). In contrast, the central segments of major normal faults with maximum displacement contain relatively few geothermal systems. Not every one of these settings across the Great Basin region host geothermal systems, but they are the most likely place to prospect for blind, undiscovered geothermal systems (e.g., Kratt et al., 2010; Anderson and Faulds, 2013).

Through evaluation of geologic maps, fault databases, and field reconnaissance we have identified 25 potential structures that may host blind, undiscovered geothermal systems in the DNWR (Table 13, Fig. 56). These structures include 12 fault intersections of major faults (e.g., Figs 57 and 58), seven terminations of major faults, five range-front fault stepovers (e.g., Fig. 59), and one fault bend in a range-front fault. All of these structures are related to normal and/or transverse faults associated with Basin and Range extension. Most of these structures have been evolving over the past several millions of years, and, if any one of these structures ever hosted geothermal activity, it is possible that geothermal activity has waxed and waned relative to changes in fault activity along the respective fault zones.

Currently, there is minimal existing temperature and geochemical data in these areas to definitively confirm or deny whether these structures host geothermal systems (Table 12, Figs. 55 and 56). Active surface manifestations in the form of fumaroles, hot springs, or spring deposits were not observed during field reconnaissance conducted in this study or in previous studies (Tingley et al., 1993). Evidence of geothermal fluid flow was observed at two fault intersection locations (ID 12 and 16, Table 13, Figs. 56 and 57) in the form of silica-cemented fault breccia. The silica was amorphous crystal form and was probably related to hydrothermal fluids. Hydrothermal silica deposits such as these indicate that fluids had to have reached at least 180° C. In each location the silica cemented fault breccia was limited to segments of the fault zones cutting only Miocene and/or Paleozoic rocks. Furthermore, the major faults in these locations have probably not ruptured since the early Pleistocene and thus associated geothermal activity may have waned or ceased entirely by present day.

If any geothermal systems are present in the DNWR, they are most likely blind (no active surface manifestations such as hot springs or fumaroles). To help evaluate the relative resource potential of the 25 structural settings identified in this study, we have listed the most recent inferred age of faulting and slip and dilation tendency of the primary faults defining each of these areas (Table 13). The reason for these fault analyses is that the majority of the high temperature systems (≥150° C) in the Great Basin region are associated with faults active in the Holocene (Bell and Ramelli, 2007). Furthermore, critically stressed fault strands are the most likely fault segments to act as fluid flow conduits (Barton et al., 1995; Sibson, 1994; Townend and Zoback, 2000). The tendency of a fault segment to slip or to dilate provides an indication of which sections of a fault zone within a geothermal system are most likely to transmit geothermal fluids (Morris et al., 1996; Ferrill et al., 1999). Seven of the 25 structures have a high slip and dilation tendency rating. Sixteen of the 25 structures are associated with faults active in the Quaternary. None of the structures are associated with faults inferred to be active in the past 15,000 years, however four of the structures are associated with faults estimated at being active in the late Pleistocene (15,000 to 130,000 years ago) and one of these is associated with the major faults oriented for high slip and dilation tendency. Based on these criteria, this stepover (GIS Id 10, Fig. 56) in the range-front along the west side of the Sheep Range has the highest potential for hosting a blind geothermal system within the DNWR. Table 13 summarizes structures that may host undiscovered blind geothermal systems in the DNWR (GIS Id #, Fig. 56). Sources for defining structural settings, age of faulting, and slip and dilation tendency listed in footnotes. Structures: SO, Step-over, FI, Fault Intersection, FT, Fault Termination, FB, Fault Bend. SDTR, Slip and Dilation Tendency Rating: H, High; M, Moderate; L, Low. Structure(s) highlighted by gray boxes indicate most favorable structures based on age of faulting and slip and dilation tendency rating.

Table 13. Structures that may host undiscovered blind geothermal systems in the DNWR (Fig. 56)

GIS Id	Structure	Age of faulting (yrs)	SDTR[7]	Description
1	S[1,2,3,5,6]	<1,600,000[1,2,6]	L	Left step in a west-dipping range-front fault zone that bounds the west side of the northern Sheep Range
2	FI[1,3,6]	>1,600,000[1,2,6]	H	Series of intersections between older WNW-striking faults in basement rocks with a younger NNE-striking west-dipping normal fault separating the Black Hills from the Desert Range
3	FI[1,2,3]	<1,600,000[1,2]	M	Intersections between older WNW-striking faults in basement rocks with range-front fault along the west side of the Sheep Range
4	FI[1,2,3]	>1,600,000[1,2]	M	Intersections between older WNW-striking faults in basement rocks with range-front fault along the west side of the Sheep Range
5	FT[1,2,4]	<1,600,000[1,2]	H	Southward termination of the west-dipping range-front fault along the west side of the Spotted Range. Fault zone ends within 5 km buffer around the westernmost island of the DNWR.
6	FT[1,2,3]	<130,000[1,2]	L	Southward termination of the range-front along the southwest side of the Sheep Range. This fault also intersects several prominent NE-striking normal faults exposed in the bedrock in the Sheep Range.
7	SO[1,2,3]	<1,600,000[1,2]	H	Stepover and/or fault splay-intersection along the range-front along the west side of the Sheep Range
8	SO[1,2,3]	<1,600,000[1,2]	L	Right step along west-dipping range-front fault from Banded Ridge north across Yellowjacket Canyon to Dead Horse Ridge
9	FT[1,2,3]	<1,600,000[1,2]	L	Northward termination of the west-dipping range-front fault along the east side of Saddle Mountain in the East Desert Range
10	SO[1,2,3,6]	<130,000[1,6]	H	Stepover in west-dipping active range-front fault system from Mule Deer Ridge to the Sheep Range
11	FB[1,2,3,4,6]	<1,600,000[1,2,6]	M	Fault bend in north end of W-dipping range-front fault along NW side of the Sheep Range and fault intersections between the Sheep Range-front fault and the Maynard Lake fault zone in the Pahranagat shear zone
12	FI[1,3,5,6]	<1,600,000[1,6]	H	Intersection of unmapped NNW-striking W-dipping range-front fault along the SW end of the Pahranagat Range with the sinistral-oblique NE-striking Maynard Lake fault zone in the Pahranagat shear zone
13	FI[1,3,5,6]	>1,600,000[1,2,6]	H	Intersection of NNW-striking west-dipping normal fault with NE-striking sinistral oblique Buckhorn fault in the Pahranagat shear zone
14	FI[1,3,5]	>1,600,000[1,2]	H	Intersection of NNW-striking west-dipping normal fault with probable SW extension of the NE-striking sinistral oblique Arrowhead Mine fault in the Pahranagat shear zone
15	FI[1,3,5,6]	<1,600,000[1,6]	H	Intersection of NNW-striking west-dipping normal fault with NE-striking sinistral oblique Buckhorn fault in the Pahranagat shear zone
16	FI[1,3,5,6]	<1,600,000[1,6]	H	Intersection of numerous NNW-striking west-dipping normal faults cutting Tertiary volcanic strata with the ENE-striking sinistral Maynard Lake fault zone in the Pahranagat shear zone
17	FI[1,2,3,5]	<130,000[1,2]	M	Intersection with NE-striking fault cutting the Paleozoic rocks in the Sheep Range with a west-dipping normal fault along the northeast side of the Sheep Range
18	FI[1,3,4]	<1,600,000[1,2]	H	Multiple intersections between NW to NNW-striking down-to west normal faults along the northeast side of Hidden Valley and NE-striking faults in the northeast part of the Las Vegas Range
19	FI[1,3]	>1,600,000[1,2]	H	Multiple intersections between concealed NE-striking normal faults and the concealed NW-striking Las Vegas shear zone
20	FI[1,3]	>1,600,000[1,2]	H	Multiple intersections between concealed NE-striking normal faults and the concealed NW-striking Las Vegas shear zone
21	FT[1,2,4]	<750,000[1,2]	M	Eastward termination of ENE-striking normal-oblique(?) fault on the north side of North Ridge and a right step across East Sandy Wash to the ENE-striking fault on the north side of South Ridge
22	FT[1,2,4]	<1,600,000[1,2]	L	Eastward termination of the Cactus Springs fault
23	FT[1,2,4]	<1,600,000[1,2]	H	Westward termination of the Cactus Springs fault
24	SO[1,2,4]	<1,600,000[1,2]	H	Small left-step in sinistral(?) normal fault along south side of South Ridge
25	FT[1,2,3]	<130,000[1,2]	L	Southward termination of west-dipping range-front along the southwest end of the Delamar Mountains along Pahranagat Wash

[1]GoogleEarth Imagery, [2]USGS (2010), [3]Page et al. (2005) [4]Stewart and Carlson (1978) [5]Jayko (2007) [6]Field reconnaissance in January 2014 [7]Slip and dilation tendency values were obtained for each fault in the USGS Quaternary fault database (USGS, 2010) within the DNWR from Siler (*in prep, 2014)* and are based on unit-less ratios of the resolved stresses applied to the fault plane by the measured ambient stress field. Values range from a maximum of 1, a fault plane ideally oriented to slip or dilate under ambient stress conditions, to zero, a fault plane with no potential to slip or dilate. Some individual structural settings include multiple faults of differing orientations relative to the regional stress field, each with specific slip and dilation tendency values. A qualitative assessment was made of the overall slip and dilation tendency of each structure as a whole (High = most faults >0.84, Moderate = most faults <0.84 and >0.55, and Low = most faults <0.55 and > 0.24). With respect to structures not associated with Quaternary faults, key fault orientations were compared with the results (*Siler, in prep 2014*) of Quaternary faults of similar orientation located nearby.

Regional Trends of Structurally Controlled Geothermal Systems

Without additional exploration work, there is no way to definitively predict how many of these structures may contain blind undiscovered geothermal systems. And if blind geothermal systems are present at any of these locations, there is no way to precisely constrain the temperature or size of a system based on the current available data. However, there are some key regional relationships that can help characterize the nature of blind structurally controlled geothermal systems within the DWNR should a system exist. The spatial density of known geothermal systems in southern Nevada is overall lower than the density in northwest Nevada or north-central Utah (Figs. 53 and 60, Faulds et al., 2011, 2012). The relatively low regional strain rate as reflected by GPS geodesy (Fig. 60; Kreemer et al., 2012) and recency of faulting (USGS, 2010; this study) both indicate low regional potential for active geothermal systems within the DNWR. Based on temperatures of known geothermal systems in southern Nevada, a potential blind structurally controlled geothermal system (should one exist) would most likely be <60° C. This temperature is insufficient for power generation but is conducive for direct use (heating buildings, green houses, etc.).

Deep Stratigraphic Reservoirs

Many deep sedimentary basins throughout the world have hot water aquifers that cover very large extents. Development of such aquifers for electricity generation has generally not been feasible due to the moderate temperatures (<150°C) and/or cost-prohibitive depths at which these reservoirs/aquifers commonly occur. However, recent documentation shows that in western Utah and eastern Nevada, these aquifers could have higher than typical temperatures of 175 to 200°C at potentially economically extractible depths of 3 to 4 km (Allis et al., 2011, 2012; Anderson, 2013; Deo et al., 2013). The occurrence of such aquifers at such depths is made possible by the relatively high heat flow and high temperature gradients in the western United States. Thick accumulations of sediments with low thermal conductivities in intermontane basins allow for high temperature gradients to develop where conductive heat flow is high (Allis et al., 2011, 2012, 2013). In eastern Nevada and western Utah, where heat flow reaches 80 to 100 mW/m^2, temperatures can reach 175 to 200°C at depths of 3 to 4 km. Data compiled from oil and gas drilling indicate that lower Paleozoic carbonate rocks underlie basin fill in these areas and that these carbonates commonly have permeabilities necessary to sustain the flow rates needed for power production (Allis et al., 2012; Kirby, 2012).

Paleozoic carbonate rocks probably underlie much of the Cenozoic basins in the DNWR. Temperature gradients are relatively cool across most of the bedrock-cored ranges (<45° C/km), but reach upwards of 60° C/km in some of the basins along the margins of the DNWR. However, estimated depths of basin fill deposits do not reach more than one km within the DNWR (Fig. 61; Jachens et al., 1996). Thus, the theoretically optimal ingredients for deep stratigraphic reservoirs: basins with minimum three to four kilometers depth, basins underlain by carbonate rocks, and regionally high heat flow rates are not met within the DNWR (e.g., Deo et al., 2013).

Although available data indicated that the DNWR has low potential for deep stratigraphic aquifer resources, insufficient data such as deep drill-holes preclude adequate evaluation of the potential across the DNWR. More detailed gravity data, temperature gradient data, deep drill-holes and seismic reflection surveys would be needed to more fully assess this resource potential. While the DNWR probably lacks deep stratigraphic reservoirs capable of electricity production, basins reaching upwards of 1 km with sufficient permeability may have fluid temperatures suitable for low-temperature direct-use applications such as heating buildings or greenhouses.

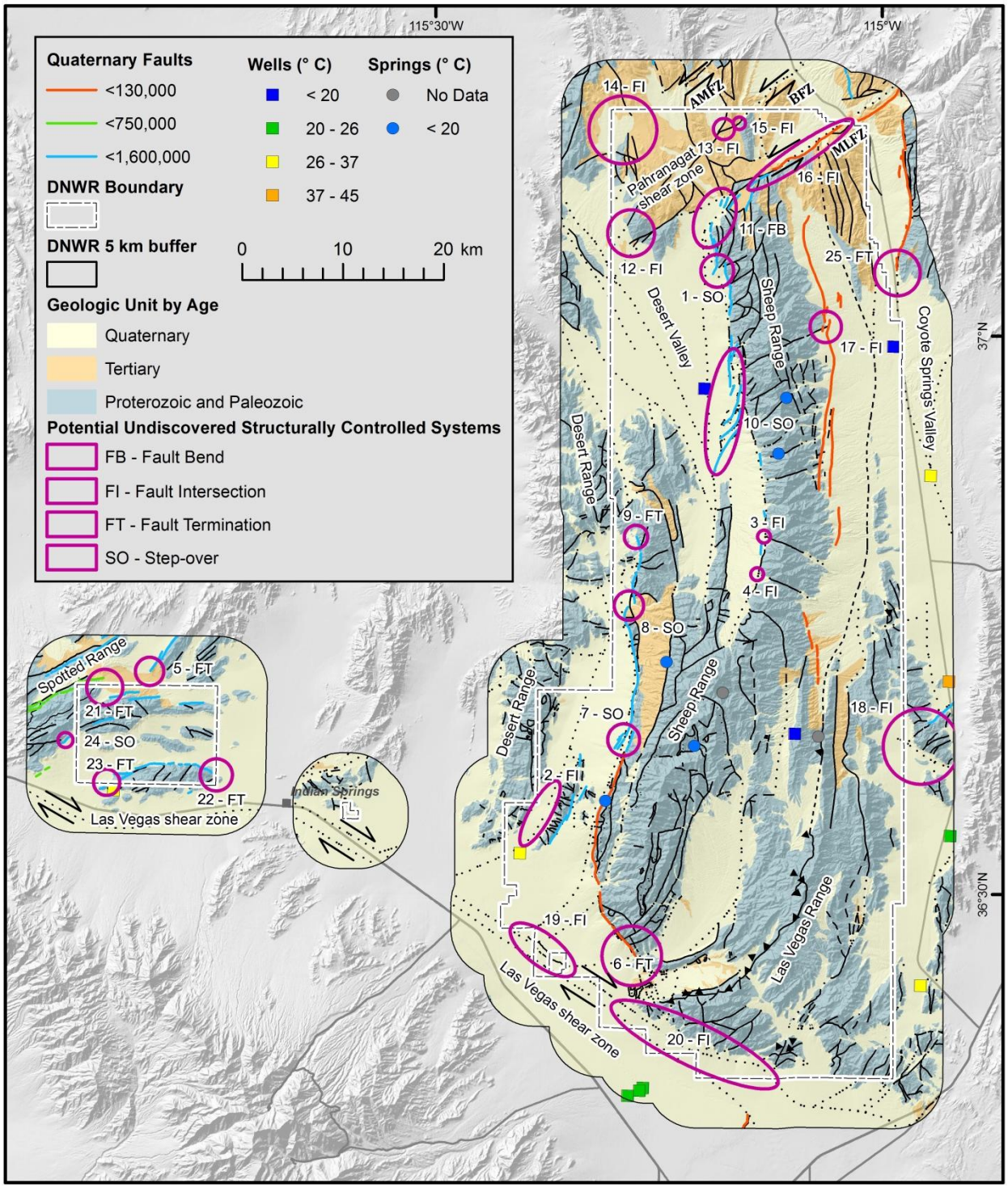


Figure 56. Shaded relief map of the DNWR showing well and spring temperature data points (Table 1), Quaternary faults (USGS, 2010), and potential structural settings that could host undiscovered blind geothermal systems (Table 13). Potential structural settings are depicted with a circle or oval that is larger than most well fields of producing systems (1-3 square km). The size of the polygon depicts the general target area within which a blind resource may reside. Fault names in the Pahranagat shear zone from Jayco (2007): MLFZ, Maynard Lake fault zone; BFZ, Buckhorn fault zone; AMFZ, Arrowhead Mine fault zone.

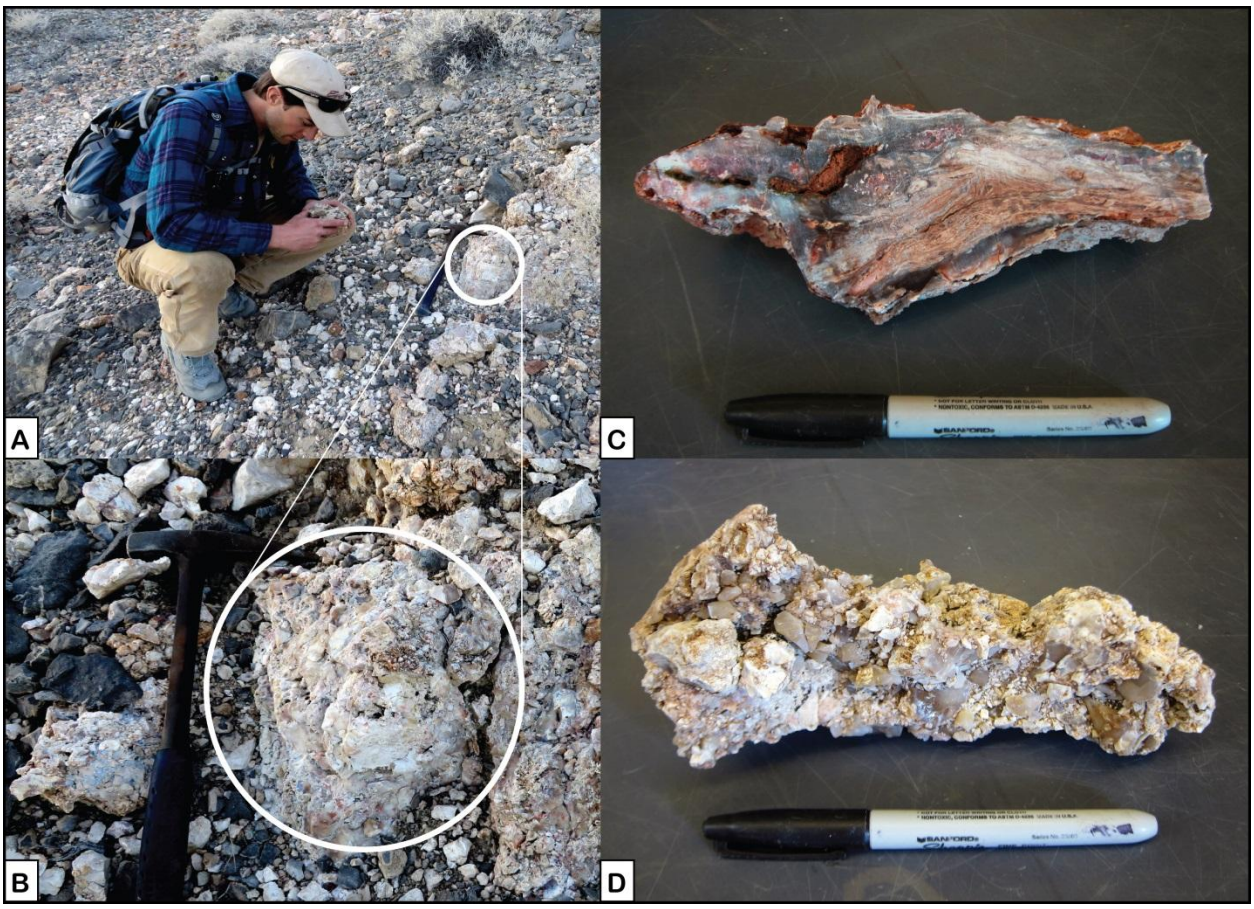


Figure 57. Silicification associated with fault intersection between northeast-striking sinistral Maynard Lake fault zone and a north-south west-dipping normal fault zone (GIS Id 12, Table 2, Figure 3). (A) Low-relief outcrop of silicified fault breccia encountered along a strand of the northeast-striking Maynard Lake fault zone. (B) Close-up photo of the same outcrop in (A) with rock hammer in same position. (C) Wet slab sample from outcrop shown in (A) and (B). (D) Uncut sample of silica-cemented (fault?) breccia from separate outcrop 100m west-southwest of outcrop shown in (A) and (B). Fault strands only observed cutting the Miocene and Paleozoic bedrock and not the Quaternary surficial deposits.

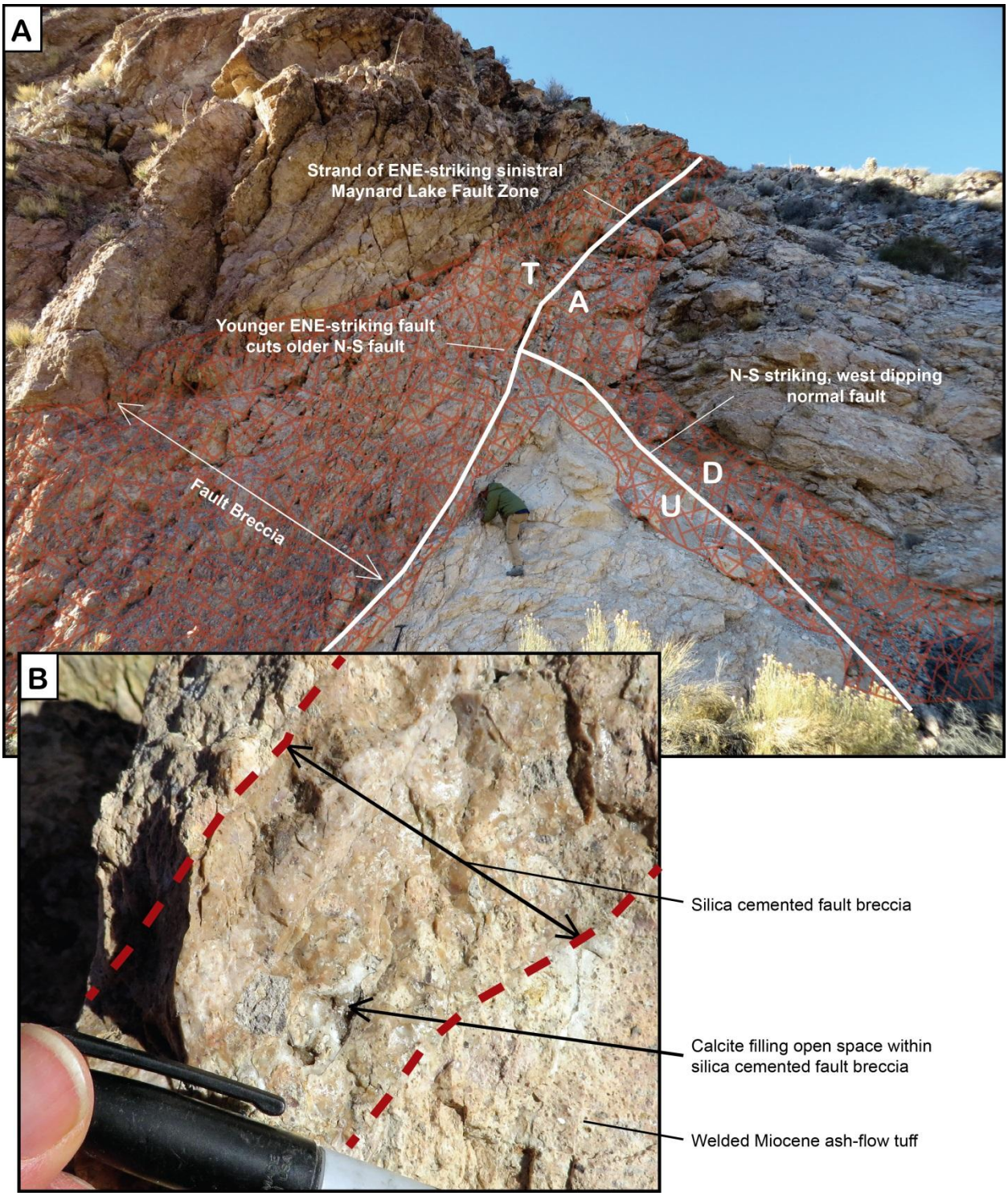


Figure 58. (A) Fault intersection between northeast-striking sinistral Maynard Lake fault zone and a north-south west-dipping normal fault zone (GIS Id 16, Table 2, Figure 54). North-striking normal fault offset by the sinistral Maynard Lake fault zone. Silica and calcite veining and cementation of fault breccia noted in outcrop. (B) Close up of hand-sample with silicified fault breccia. Silica and calcite veins only present in Miocene volcanic rocks and not in the overlying Quaternary sediments. Fault strands only observed cutting the Miocene bedrock and not the Quaternary surficial deposits.

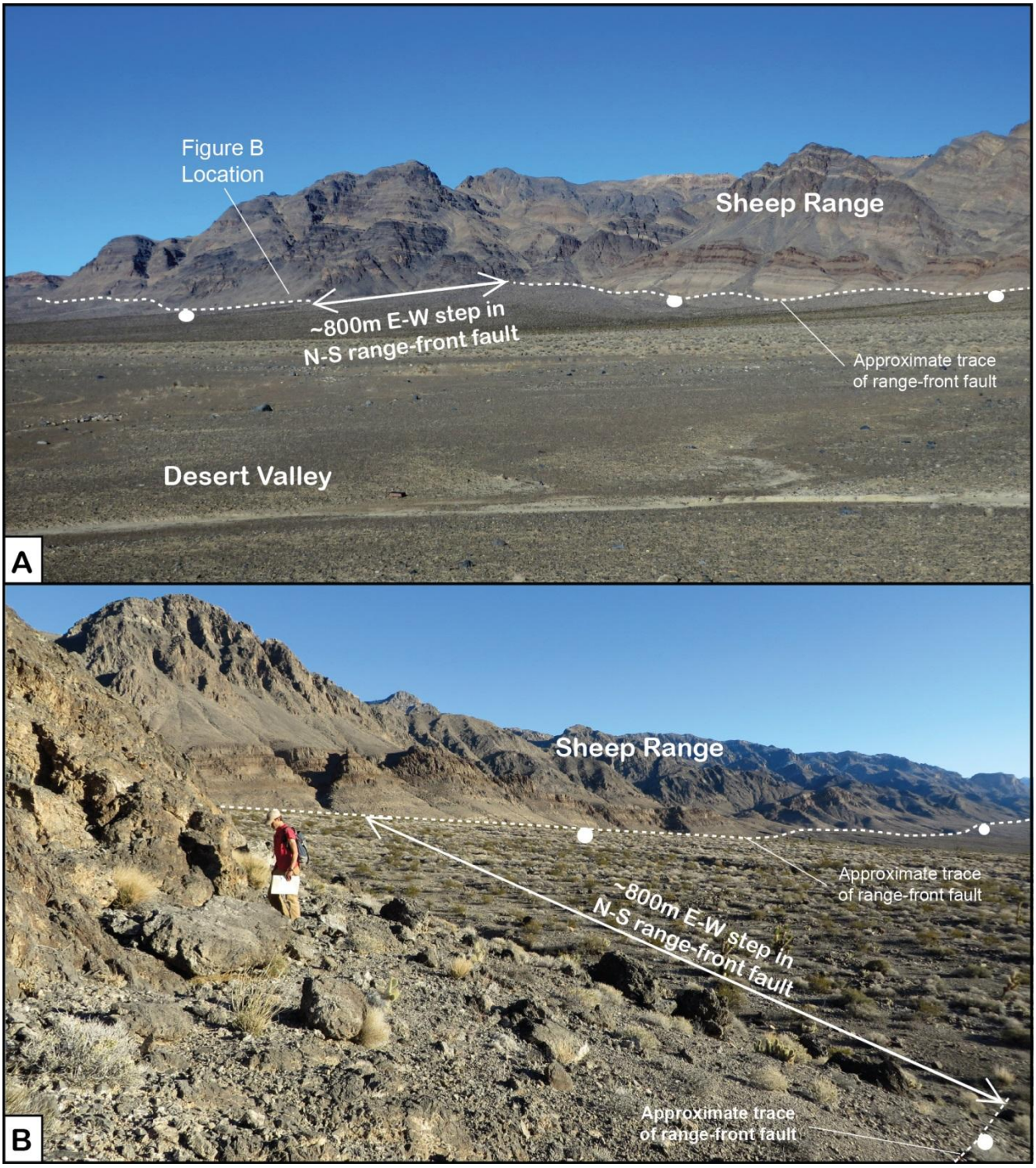


Figure 59. Stepover in west-dipping range-front fault along northwest side of the Sheep Range (GIS ID 1, Table 13, Fig. 56). This structure was identified as one of 25 potential structures that may host a blind geothermal system in the DNWR. Quaternary scarps not locally observed on either side of this stepover, but sharp relief along the bedrock-alluvial fan contact may indicate early Quaternary fault slip.

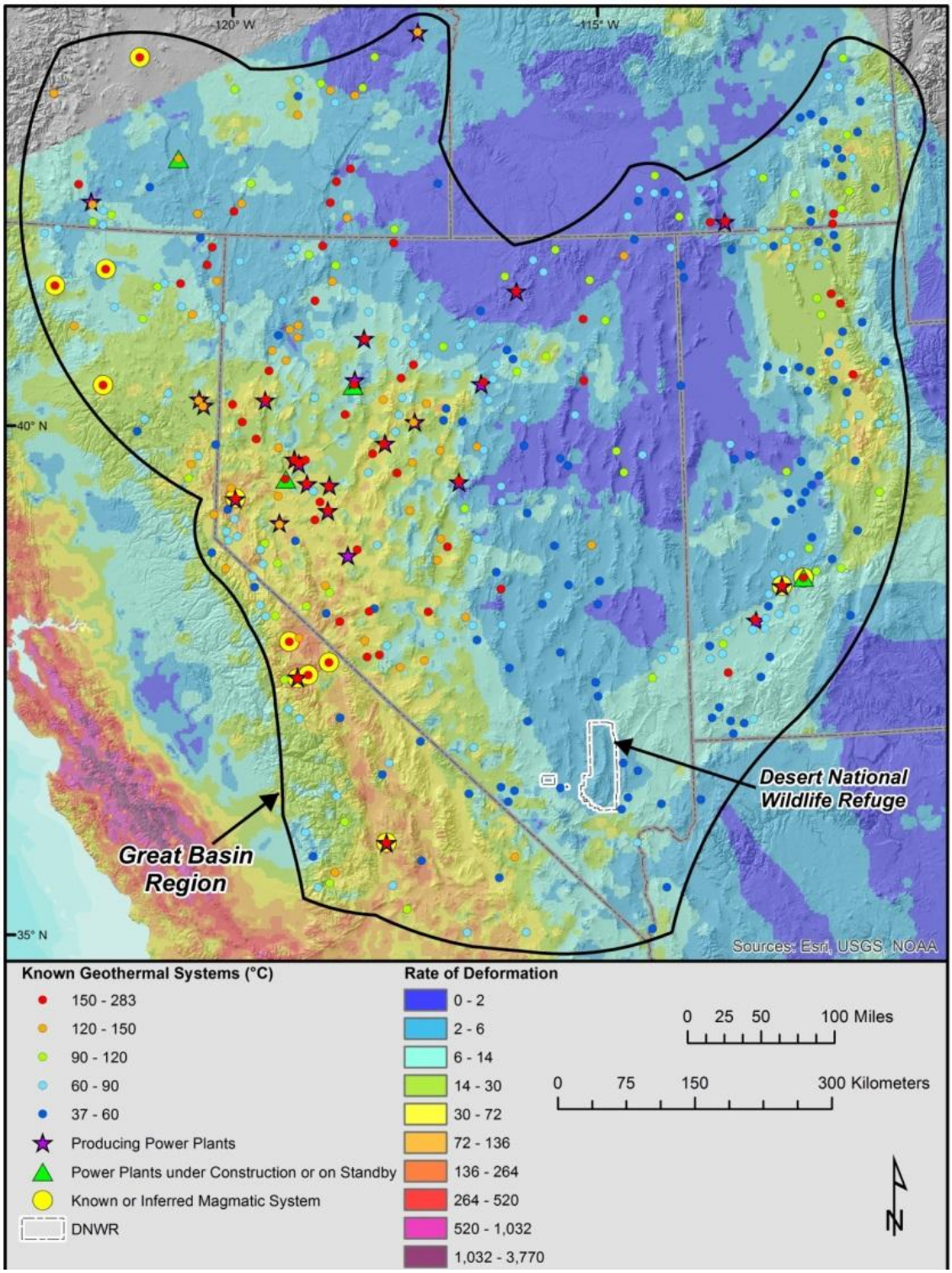


Figure 60. Map showing strain rates and geothermal systems in the Great Basin and adjacent regions. Strain rates reflect the second invariant strain rate tensor (10-9/yr; from Kreemer et al., 2012). Figure modified from Faulds et al. (2012).

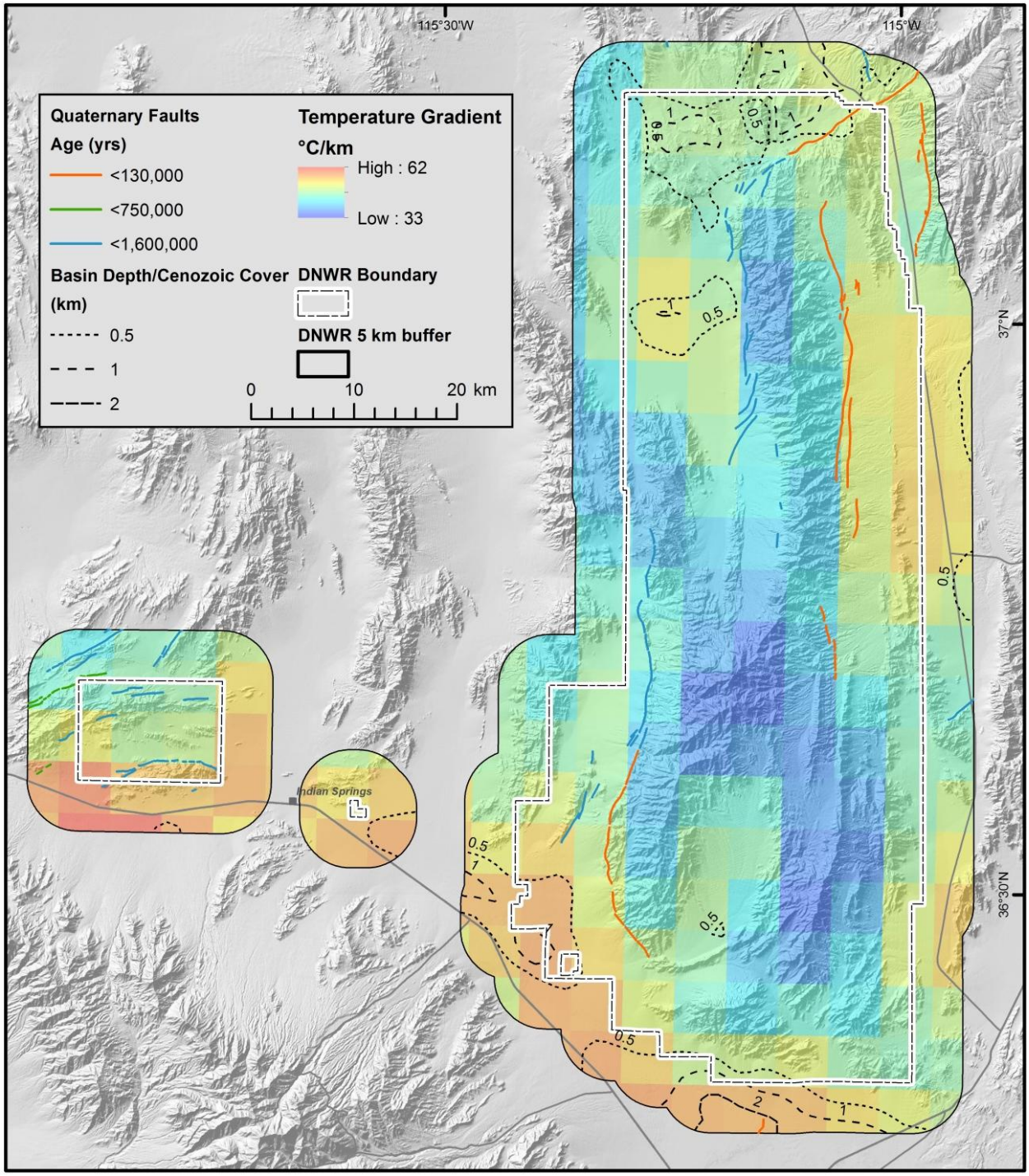


Figure 61. Shaded relief map of the DNWR with Quaternary faults (USGS, 2010). Upper crustal temperature gradient provided by Southern Methodist University (Coolbaugh et al., 2005). Estimated basin depth of Neogene basin-fill sediments and volcanic strata (black line contours) from Jachens (1996).

Summary

Evaluating measured temperatures, geochemistry, and exploration for active surface manifestations did not identify any structurally controlled geothermal resources in the DNWR and available data also indicates low potential for deep stratigraphic aquifer resources. Twenty-five areas were identified that may host blind undiscovered structurally controlled systems. These areas were ranked according to recency of fault activity and slip and dilation tendency analyses. Ultimately, blind geothermal activity cannot be determined solely from association with Quaternary fault activity or slip and dilation tendency analyses. A thorough exploration effort would need to be undertaken using proven methodologies with tools like detailed mapping, 2m temperature probes, temperature gradient drilling, geophysical surveys, and geochemical analyses to definitively determine if blind resources exist in each of these locations (e.g., Coolbaugh et al., 2006; Hinz et al., 2013). Regional relationships indicate relatively low potential for structurally controlled geothermal systems in the DNWR relative to other areas in the Great Basin region. Regional trends also indicate that if one or more systems do exist in the DNWR there is a high probability that the temperature would be <60° C and too low for electricity generation. However this temperature is suitable for low-temperature direct-use applications such as heating buildings or greenhouses.

Assessment of Potential for Oil and Natural Gas

No new assessment for oil and natural gas was completed for this report. No new information made available since 1992 changes the conclusion in the 1993 NBMG report that DNWR has a low oil and natural gas resource potential. No oil wells have been drilled within 80 km of the DNWR since the NBMG's 1993 report. The U.S. Geological Survey's 2009 report, "Geologic Assessment of Undiscovered Oil and Gas Resources of the Eastern Great Basin Province, Nevada, Utah, Idaho, and Arizona" gave no indication of any potential in vicinity of DNWR.

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Appendix A

Legal Land Descriptions for Lands Subject for Continuation of Withdrawal from Mineral Entry

58554 Federal Register / Vol. 78, No. 185 / Tuesday, September 24, 2013 / Notices

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[FXRS126108DEST0 134F1611MD FF08RDSC00; N–54955]

Notice of Application for Withdrawal Extension, and Notification of a Public Meeting, Desert National Wildlife Range; Nevada

AGENCY: Bureau of Land Management, Interior.

ACTION: Notice.

SUMMARY: The Assistant Secretary of the Interior for Policy, Management and Budget proposes to extend the duration of Public Land Order (PLO) No. 7070 for an additional 20-year term. PLO No. 7070 withdrew approximately 769,543 acres of public mineral estate from location and entry under the United States mining laws, to protect the wildlife habitat and unique values within the Desert National Wildlife Range in Clark and Lincoln Counties, Nevada. The proposed extension would apply to 768,997 acres as determined from an updated land description review. This notice gives an opportunity for the public to comment on the proposed withdrawal extension and announces the date, time, and location of a public meeting.

DATES: For a period until December 23, 2013, all persons who wish to submit comments, suggestions, or objections in connection with the proposed withdrawal extension may do so in writing. A public meeting will be held on October 29, 2013, from 12 noon to 2 p.m. at the Bureau of Land Management, Southern Nevada District Office, 4701 Torrey Pines Drive, Las Vegas, Nevada. A notice of the time and place will also be published in at least one local newspaper of general circulation no less than 30 days before the scheduled meeting date.

ADDRESSES: Written comments should be sent to the Bureau of Land Management, Attn: District Manager, Southern Nevada District Office, 4701 N. Torrey Pines Drive, Las Vegas, Nevada 89130.

FOR FURTHER INFORMATION CONTACT: Cheryl G. Cote, Bureau of Land Management at 702–515–5104, email: *ccote@blm.gov.* Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 1–800–877–8339 to contact the above individual. The FIRS is available 24 hours a day, 7 days a week, to leave a message or question with the above individual. You will receive a reply during normal business hours.

SUPPLEMENTARY INFORMATION: The withdrawal created by PLO 7070 (59 FR 39701), will expire on August 4, 2014, unless extended. The United States Fish and Wildlife Service (FWS) has filed a petition/application to extend the withdrawal created by PLO No. 7070 for an additional 20-year term with respect to the following described Federal lands:

Mount Diablo Meridian

T. 15 S., R. 54 E., unsurveyed,
Sec. 1;
Sec. 2, E½ and E½W½;
Sec. 11, E½ and E½W½;
Secs. 12 and 13;
Sec. 14, E½ and E½W½;
Sec. 23, E½ and E½W½;
Secs. 24 and 25;
Sec. 26, E½ and E½W½;
Sec. 35, E½ and E½W½;
Sec. 36.
T. 15 S., R. 55 E., unsurveyed.
T. 16 S., R. 57 E., partially surveyed,
Sec. 7, NW¼ and S½.
T. 16 S., R. 58 E., unsurveyed,
Secs. 11 thru 14, inclusive;
Secs. 23 thru 26, inclusive;
Secs. 35 and 36.
T. 15 S., R. 59 E., unsurveyed,
Secs. 2 thru 11, inclusive;
Secs. 14 thru 23, inclusive;
Secs. 26 thru 35, inclusive.
T. 16 S., R. 59 E., unsurveyed,
Secs. 2 thru 11, inclusive;
Secs. 14 thru 23, inclusive;
Secs. 26 thru 35, inclusive.
T. 17 S., R. 59 E.,
Secs. 1thru 5, inclusive;
Sec. 7, lots 3 and 4, NE¼, and S½;
Secs. 8 thru 18, inclusive;
Secs. 21 thru 26, inclusive;
Sec. 27, N½;
Secs. 28 and 33;
Sec. 34, S½S½ and NE¼SE¼;
Secs. 35 and 36.
Tps. 9, 10, 11, 12, 12½, 13, 14, 15, and 16 S., R. 60 E., unsurveyed.
T. 17 S., R. 60 E.
T. 18 S., R. 60 E.,
Secs. 1 thru 18, inclusive;
Secs. 22 thru 24, inclusive;
Sec. 25, N½;
Sec. 26, N½;
Sec. 27, N½.
Tps. 9, 10, 11, 12, 12½, 13, 14, 15, and 16 S., R. 61 E., unsurveyed.
Tps. 17 and 18 S., R. 61 E.
T. 9 S., R. 62 E.,
Sec. 4, S½S½;
Sec. 5, NW¼SW¼ and S½S½;
Sec. 6, lots 2 to 7, inclusive, and S½NE¼, SE¼NW¼, E½SW¼, and SE¼;
Secs. 7, 8, and 9;
Sec. 10, W½E½ and W½;
Sec. 15, W½E½ and W½;
Secs. 16 thru 21, inclusive;
Sec. 22, W½E½ and W½;
Sec. 27, W½E½ and W½;
Secs. 28 thru 33, inclusive;
Sec. 34, lots 1, 2, and 3, W½NE¼, NW¼, N½SW¼, and NW¼SE¼.
T. 10 S., R. 62 E.,
Secs. 3 thru 10, inclusive;
Sec. 14, SE¼NW¼, W½W½, and E½SW¼;
Secs. 15 thru 22, inclusive;
Sec. 23, W½ and W½SE¼;
Secs. 26 thru 35, inclusive;
Sec. 36, W½W½.
T. 11 S., R. 62 E., partially surveyed,
Sec. 1, W½W½;
Secs. 2 thru 12, inclusive;
Sec. 13, E½, NE¼NW¼, W½W½, and E½SW¼;
Secs. 14 thru 36, inclusive.
T. 12 S., R. 62 E., partially surveyed.
Tps. 12½, 13, 14, 15, and 16 S., R. 62 E., unsurveyed.
Tps. 17 and 18 S., R. 62 E.

The areas described above aggregate approximately 768,997 acres in Clark and Lincoln Counties. The legal descriptions of the unsurveyed lands are based on what normal survey subdivision units would be when surveyed.

The lands withdrawn by PLO No. 7070 are located about 20 miles northwest of Las Vegas, Nevada. The purpose of the withdrawal extension is to protect, enhance, and maintain wildlife resources, including bighorn sheep on one of the largest and last reasonably intact examples of Mojave Desert landscape habitats.

The use of a right-of-way, interagency agreement, or cooperative agreement would not provide adequate protection for the wildlife habitat and unique resource values within the Desert National Wildlife Range.

No additional water rights would be needed to fulfill the purpose of the requested withdrawal extension.

There are no suitable alternative sites since the lands described herein contain the natural and biological resources of interest for protection.

All persons who wish to submit comments, suggestions, or objections in connection with the proposed withdrawal extension may present their views in writing to the BLM Southern Nevada District Office, at the address indicated above. Comments, including names and street addresses of respondents, will be available for public review at the address stated above, during regular business hours, 7:30 a.m. to 4:30 p.m., Monday through Friday, except Federal holidays.

Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

Notice is hereby given that a public meeting will be held in connection with

the proposed withdrawal extension. Information on the meeting is listed under the "DATES" heading of this notice. Interested parties may file written statements at the meeting. All statements received will be considered before any recommendation concerning the proposed extension is submitted to the Assistant Secretary of the Interior for final action.

This application will be processed in accordance with the regulations set forth in 43 CFR 2310.4.

Marci L. Todd,

Associate State Director, Nevada.

[FR Doc. 2013–23155 Filed 9–23–13; 8:45 am]

BILLING CODE 4310–55–P

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[SDM 99842]

Public Land Order No. 7821; Withdrawal of National Forest System Land for Steamboat Rock Picnic Grounds; South Dakota

AGENCY: Bureau of Land Management, Interior.

ACTION: Public Land Order.

SUMMARY: This order withdraws on behalf of the United States Forest Service, 50 acres of National Forest System land from location and entry under the United States mining laws for a period of 20 years to protect the recreational uses and improvements at the Steamboat Rock Picnic Grounds within the Black Hills National Forest in South Dakota.

DATES: *Effective Date:* September 24, 2013.

FOR FURTHER INFORMATION CONTACT: Valerie Hunt, United States Forest Service, Region 2, 740 Simms Street, Golden, Colorado, 303–275–5071, *vbhunt@fs.fed.us*, or Tami Lorenz, Bureau of Land Management, Montana State Office, 5001 Southgate Drive, Billings, Montana 59101–4669, 406–896–5053, *tlorenz@mt.blm.gov.* Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 1–800–877–8339 to contact either of the above individuals. The FIRS is available 24 hours a day, 7 days a week, to leave a message or question with either of the above individuals. You will receive a reply during normal business hours.

SUPPLEMENTARY INFORMATION: This order replaces expired Public Land Order No. 6689 (53 FR 47955) which withdrew the same land to the United States Forest Service to protect the recreational uses and improvements within the Steamboat Rock Picnic Grounds.

Order

By virtue of the authority vested in the Secretary of the Interior by Section 204 of the Federal Land Policy and Management Act of 1976, 43 U.S.C. 1714, it is ordered as follows:

1. Subject to valid existing rights, the following described National Forest System land is hereby withdrawn from location and entry under the United States mining laws, but not from leasing under the mineral leasing laws, to protect the recreational uses and improvements within the Steamboat Rock Picnic Grounds:

Black Hills National Forest

Black Hills Meridian

T. 2 N., R. 5 E.,
sec. 1, S½NW¼SW¼, N½SW¼SW¼, and NW¼SE¼SW¼.

The area described contains 50 acres in Lawrence County.

2. The withdrawal made by this order does not alter the applicability of those public land laws governing the use of National Forest System land under lease, license, or permit, or governing the disposal of the mineral or vegetative resources other than under the mining laws.

3. This withdrawal will expire 20 years from the effective date of this order, unless, as a result of a review conducted before the expiration date pursuant to Section 204(f) of the Federal Land Policy and Management Act of 1976, 43 U.S.C. 1714(f), the Secretary determines that the withdrawal shall be extended.

Dated: September 9, 2013.

Rhea S. Suh,

Assistant Secretary—Policy, Management and Budget.

[FR Doc. 2013–23152 Filed 9–23–13; 8:45 am]

BILLING CODE 3410–11–P

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[LLCAD0900, L51010000.LVRWB09B2380.FX0000; CACA–048669]

Notice of Segregation of Public Lands for the Proposed Stateline Solar Farm, CA

AGENCY: Bureau of Land Management, Interior.

ACTION: Notice.

SUMMARY: This notice serves to segregate the identified public lands located in the State of California for 2 years from appropriation pursuant to public land laws, including location pursuant to the General Mining Act, but not the Mineral Leasing Act or the Materials Act of 1947. The segregation is needed to continue processing the proposed Stateline Solar Energy right-of-way (ROW) application and provide for the orderly administration of public lands and avoid conflicts between renewable energy generation and mining claims. The public land contained in this segregation totals 6,223.25 acres.

DATES: This segregation is effective on September 24, 2013.

FOR FURTHER INFORMATION CONTACT: Greg Miller, Project Manager; Telephone: 951–697–5216; Address: BLM California Desert District Office, 22835 Calle San Juan de Los Lagos, Moreno Valley, CA 92553–9046, or email: *gmiller@blm.gov.* Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 1–800–877–8339 to contact the above individual during normal business hours. The FIRS is available 24 hours a day, 7 days a week, to leave a message or question with the above individual. You will receive a reply during normal business hours.

SUPPLEMENTARY INFORMATION: Desert Stateline, LLC, submitted a ROW application to construct, operate, maintain and decommission a solar energy project on a portion of its ROW-application area. The BLM is segregating the following described public lands (6,223.25 acres in San Bernardino County, California) subject to valid existing rights:

San Bernardino Meridian,

T. 16 N., R. 14 E.,
Sec. 1, W½ lot 1 in NW¼, W½ lot 2 in NW¼, and W½SW¼;
Sec. 2, Lot 1 in NE¼, excluding that portion of the parcel shown on the Exhibit "A" map accompanying the legal description of the Ivanpah-3 BLM right-of-way lease/grant CACA–49504, dated October 7, 2010, on file at the BLM field office in Needles, CA., Lot 2 in NE¼, excluding that portion of the parcel shown on the Exhibit "A" map accompanying the legal description of the Ivanpah-3 BLM right- of-way lease/grant CACA–49504, dated October 7, 2010, on file at the BLM field office in Needles, CA., Lot 2 in NW¼, excluding that portion of the parcel shown on the Exhibit "A" map accompanying the legal description of the Ivanpah-3 BLM right-of-way lease/grant CACA–49504, dated October 7, 2010, on

Appendix B

New Geochemical Analyses and Re-analyses of New and Old NBMG Samples

Table 1. Descriptions and Locations of Re-analyzed Samples Collected by NBMG in 1992.

Sample ID	Sample Description	Easting UTM NAD83 (m)	Northing UTM NAD83 (m)
2146	Breccia zone in dolomite, 15 feet wide, some jasperoid, dolomite slightly bleached; N20-25E fractures, 75N dip; lenses of FeOx, some hemimorphite crystal limestone; very minor Cuox mineral, as botryoidal coatings on some fractures; sample taken on east wall of cut, short adit	670604	4026900
2147	Jasperoid breccia with some hemimorphite, copper carbonates, in fractured dolomite; along N60E, 80S to vertical shear structure; sample taken 20 ft south of 2146; considerable more copper-oxide-staining in this area; 15 ft-20 ft-deep shaft with short drift	670609	4026890
2152	Recrystallized limestone and dolomite with streaks and clots of red, hematite gossan, minor MnOx as dendritic fracture coatings	671027	4026361
2153	Soft, white tuff; volcaniclastic unit, some greenish and dull red coloration along steep fault zone, next to limestone contact; fine flakes of biotite, some slightly bronzish, some sericite	670149	4030051
2154	Clots of galena, dull red-grown coatings on fractures in greenish-buff massive carbonate unit; galena is steely, web-like replacement texture, calcite gangue	670150	4039080
2155	Earthy gossan, cinnamon-brown to red-brown, some botryoidal, pale-green coatings (scorodite?); some cerussite and anglesite coatings	670260	4039320
2156	MnOx and FeOx gossan, clots of specular hematite, calcite veining	666880	4035688
2157	Limestone outcrop on north side of wash; laced with orange-brown, gossany veinlets of FeOx, some white calcite; stockwork veining; limestone is not visibly altered, is dark gray-black	655910	4034740
2158	Bedded tuff, volcaniclastic, lenses of medium to coarse sandstone, some FeOx staining	664050	4033450
2159	Bedded luff, volcaniclastic rock, some medium 10 coarse-grained sandstone lenses; weak yellow-brown and cinnamon-brown FeOx staining	662666	4033759
2160	Bedded tuff, volcaniclastic rock, beds of sandstone, some fine-grained carbonate lenses, minor FeOx staining	660536	4031361
2161	Fracture coatings of green oxide copper minerals, possibly chrysocolla and some malachite, clots of specular hematite in sheared, white quartzite	657914	4030160
2162	Green oxide copper minerals on fracture surfaces in sheared quartzite, clots of specular hematite	657968	4030166
2163	Mottled dark gray and pink carbonate, recrystallized material along fault	671266	4026432
2164	Limonite-stained fault breccia, minor MnOx points	671266	4026432
2165	Limonite-hematite gossan pods in limestone; boxworks after sulfides, calcite crystals large crystals coated with gossan rims	671284	4026366
2166	Limonite gossan pods in cream-colored hydrothermal dolomite	671261	4026335
2167	Buff and red-brown, recrystallized, dolomitized patch in gray, mottled dolomite, some gossany patches	670420	4026624
2168	White, crystalline calcite/dolomite, "zebra" rock, stripped with grey lineations	670487	4026764

Sample ID	Sample Description	Easting UTM NAD83 (m)	Northing UTM NAD83 (m)
2169	Clots of FeOx gossan in re-cemented dolomite breccia along fault structure	670390	4026662
2170	Clots of red-brown and cinnamon-brown gossan in brecciated dolomite	670393	4026666
2171	Carbonate-cemented breccia, red-brown and dull, brick-red hematite stain, some gossany clots, also soft, white gouge with points pale green mineral (?)	670271	4026643
2172	Cemented breccia along steep structure, pale yellow-tan FeOx staining	670149	4026639
2173	Sheared, FeOx-stained quartzite rubble from dump, sulfide casts (hematite-after-pyrite), thin gossan coatings and veinlets in quartzite	672660	4057060
2174	FeOx staining and points in brecciated quartzite, minor quartz veinlets with sparse mica on walls, some limonite after pyrite , minor MnOx	672730	4057500
2175	FeOx-stained, sheared quartzite, limonite coatings on fractures and limonite points throughout rock, some hematite-after-pyrite casts, gossan clots	672640	4054030
2176	Bleached, fractured, iron-stained Wood Canyon Formation quartzite from along the Gass Spring fault; no observed mineralization	664530	4032720
2177	Grab sample of black jasperoid with sparse white quartz veinlets; jasperoid replaces Mississippian Anchor Limestone Member of the Monte Cristo Limestone	657760	4038712
2178	Grab sample of black jasperoid from fault breccia zone in Mississippian Anchor Limestone member; fault is First Canyon fault	656730	4038920
2179	Dump sample of recrystallized, bleached dolomite with veinlets and clots of calcite and galena; galena is medium- to fine-grained with black, sooty, oxide coating on weathered surfaces, some veinlets of galena up to 1-2mm thick; some FeOx-staining on fractures	652370	4044140
2180	Dump sample of cellular and massive hematite-limonite-pyrolusite gossan; some massive jasperoid lenses, brecciated and cemented by gossan; vugs coated with clear, botryoidal silica ; minor chrysocolla	653234	4046646
2181	Dump sample, maroon and reddish shale, some FeOx-flooded limestone and calcite veining, no obvious mineralization	664266	4026158
2182	Dump sample, prospect dump , FeOx-stained shale	664602	4026038
2183	Chip sample from hematite-goethite gossan pod exposed in face of cut, some calcite veining	663901	4026300
2191	Buff to pinkish, poorly-welded tuff; lithic- and crystal-rich; fresh biotite and quartz phenocrysts; lots of caliche; no signs of metallic mineralization	658580	4116370
2192	FeOx-stained quartz along N10W-striking, vertical fault cutting pale gray carbonate; quartz pods are irregular, up to 10ft long along strike, 1-2ft thick laced w cross-structures	606030	4059490
2193	Sheared, quartz-cemented quartzite breccia; quartzite bed 20-30 ft thick in mainly carbonate section, FeOx and MnOx varnish on weathered surfaces; NS vertical shearing; carbonate is not noticeably sheared along strike of shear zone	606020	4059495
2194	Cemented quartzite rubble along bedding-plane faulting, brecciated limestone, but quartzite is stained with points of red-orange hematite and some MnOx, shearing N50E to EW; limestone above quartzite is brecciated, cemented with jasperoid-rich material	604308	4059330
2195	Irregular breccia, matrix of limonite jasperoid and gossan; area about 15 ft in diameter, laced with gossan webbing	604560	4059310
2196	Chalcedony; stockwork of clear chalcedonic quartz veinlets in buff, soft limestone of Horse Spring Formation; veins up to 1 cm in zone exposed over about 1 m in width, zone strikes N60E, dips 10-15W, rocks in vicinity of veining is bleached in appearance	605840	4060965

Sample ID	Sample Description	Easting UTM NAD83 (m)	Northing UTM NAD83 (m)
2197	Thin veins and bunches of chalcedonic quartz, fracture and vug fillings in crystal-rich, quartz-sanidine-biotite welded ash flow tuff, no signs of metallic mineralization	657475	4108590
2198	FeOx-stained silicified limestone from sheared, replacement horizon along N15E-striking, 85SE dipping shear structure; prospect pit 4ftx4ftx3ft-deep about 300ft north of shaft; bedding in host limestone strikes N25E dips 40SE	653209	4046765
2199	Sheared, shaly limestone; thin coatings of FeOx on fracture surfaces	653244	4047078
2200	silicified limestone, gossan from oxidized pods of replacement material in limestone	653238	4046637
49005	Limonitic quartzite	661270	4030966
49064	siliceous breccia, possibly limonitized and brecciated quartzite (?)	670930	4115084
49065	Red-brown, porous (decalcified?) rocks, possibly limonitized quartzite	670930	4115084
49080	White bedded tuff, fine-grained glassy unit at least 5' thick, overlies Paleozoic limestone; bedding dips about 12 deg ESE	668206	4027694
49083	Grab sample gossan and mineralized (?) carbonate from short trench	669098	4026875
49084	Limonitic quartzite and limestone from zone ~ 30 ft thick, parallel to bedding in surrounding carbonate rock	669087	4026895
49086	Gossan from dump at vertical shaft; gossan body of unknown shape, appears to be isolated	669154	4026840
49277	Fractured carbonate rock with FeOx staining on fracture surfaces	673727	4064618
49303	Strongly brecciated and FeOx-stained Eureka Quartzite?	652486	4079074
49309	FeOx-stained Eureka Quartzite?, basal section	602178	4055378
49338	Outcrop sample, variably FeOx-stained Pilot Shale beneath Joanna Limestone and in thrust contact with Eureka Quartzite?	670785	4114832
49339	Fluidized quartzite with hematite matrix injected into limestone thrust slices	670865	4114912
49340	Eureka Quartzite?, sanded, FeOx-stained, stockwork with silica veinlets	670828	4114874
49341	Fluidized quartzite injected into carbonate matrix, thrust slices quartzite matrix abundant FeOx, dominantly hematite	671395	4114113
49342	FeOx veins and coatings with calcite, in limestone	670672	4114179
49343	FeOx stained breccia, Eureka Quartzite? in fault slivers in limestone and shale	670988	4112643
49344	Brecciated, FeOx on jasperoid intercalated with limestone	671146	4112766
49345	Massive and cellular gossan from prospect dump in limestone; zone of jasperoid, gossan and brecciation in limestone trend is NNW with a steep W dip	671062	4113224
49346	FeOx-stained, silicified limestone adjacent to fault contact with brecciated, FeOx-stained Eureka Quartzite?	670922	4113617
49350	Dark gray dolomite with FeOx fracture coatings and patches	611836	4050722
49367	Massive hematitic jasperoid-gossan from small prospect cut on ridge above (SE) of northern adit; at quartzite-carbonate contact	670262	4039190
49368	Green CuOx mineralized limestone with calcite coating fractures in breccia; sample taken about 20 ft downslope from quartzite outcrop; host rock mottled gray limestone laced with carbonate veining; bedding N30E, 60SE dip	670269	4039275

Table 2. Descriptions and Locations of Analyzed New Samples Collected by NBMG in 2013.

Sample ID	Sample Description	Easting UTM NAD83 (m)	Northing UTM NAD83 (m)
JB Bret A	June Bug Mine area, west side adits	663931	4026280
JB Bret B	June Bug Mine area, west side adits	663908	4026298
JB Bret Gos	gossanous dump sample, June Mine area, west side adits	663895	4026307
RDWJM001Slab	grab sample or ore-looking material on dump, occurs in a dolomite breccia, dolomitization continues ~10-15 m NE from workings, local Cu-oxides dump material	670601	4026897
RDWJM002Slab	dolomitization, local zebra textures, ~10 m from workings	670607	4026903
RDWJM003	contact between limestone and dolomitization	670495	4026823
RDWJM004Bxa	limonitic breccia (mostly surface coating) cutting dolomite breccia	670524	4026882
RDWJM005Slab	grab sample of dump material	670574	4026924
RDWJM005	grab sample of dump material	670574	4026924
RDWJM006FeOx	Fe-stained interbeds in Mississippian Monte Cristo limestone	671348	4026244
RDWJM007Slab	local limonite in breccia matrix in Miss Monte Cristo limestone	665628	4070812
RDWJM008	grab sample of float in area of ~50 m radius, Mapped as Cambrian Bonanza King Fm, common gray dolomite subcrop, but hillside is covered with buff-colored small pieces of limestone and dolomite float, common limonite along weathered and fractured surfaces	665949	4070912
RDWJM011	float (subcrop) sample of weakly sanded bleached dolomite, minor exotic limonite	666392	4071323
RDWJM012	sample of bleached Camb Nopah fm dolomite w common limonite coatings	666474	4071365
RDWJM013Slab	Very close to Ord Pogonip contact, light gray dolomite that is buff-colored on weathered surfaces, minor limonite	666497	4071354
RDWJM013	Very close to Ord Pogonip contact, light gray dolomite that is buff-colored on weathered surfaces, minor limonite	666497	4071354
RDWJM014	dark dolomite with light brown-tan limonite along fractures, sample of siliceous gossan from talus slope	653316	4044065
RDWJM016Slab	dark dolomite with light brown-tan limonite along fractures, sample of matrix-supported dolomite breccia	653316	4044065
RDWJM016	Op? dolomite, weakly sanded, limonite-stained, grab sample of variable alteration, N65E, 75NW minor fault	653436	4044019
RDWJM017Slab	karst breccia	653491	4043982
RDWJM019Slab	Dunderberg Shale, grab sample of Cd shale chips and some nodular limestone	652555	4043817
RDWJM020	Dunderberg Shale, thin bedded dark gray limestone that has common Fe staining	652675	4043882
RDWJM022Slab	Great outcrop of Dunderberg Shale – interbedded hale and limestone, sample is of the limestone	652675	4043882
RDWJM024Slab	gray dolomite, locally Fe-stained, near iron oxide-clay ASTER anomalies, local dropstone	652693	4043890
RDWJM027	in heart of ASTER AlOH anomaly, platy Birdspring Fm limestone, Clay-limonite bedding partings, grab sample of outcrop and scree	652693	4043890
RDWJM031	grab sample of brecciated Fe-stained limestone, fizzes, no silicification, abundant calcite veinlets	652734	4043879
RDWJM032Slab	grab sample of variably altered tan bleached limestone; amount of fizz appears to decrease with amount of bleaching; narrow ~N40W zones of light gray alteration zones (scratch, no limonite) which cut and replace limestone	652809	4043898
RDWJM033Slab	more limonite-rich mineralized looking material	651688	4043993
RDWJM033	more limonite-rich mineralized looking material	651688	4043993
RDWJM034	grab sample of bleached Fe-stained limestone w thin-bedded zones that are commonly sheared	674068	4063389
RDWJM035Slab	grab sample of white quartz rich rock -- Eureka Quartzite?, silicification?, common goethite-hematite staining	674055	4063387
RDWJM035	grab sample of white quartz rich rock -- Eureka Quartzite?, silicification?, common goethite-hematite staining	674055	4063387

Sample ID	Sample Description	Easting UTM NAD83 (m)	Northing UTM NAD83 (m)
RDWJM036	grab sample of white quartz rich rock -- Eureka Quartzite?, silicification?, common goethite-hematite staining	674015	4063446
RDWJM037Slab	grab sample of light gray quartz rich rock -- Eureka Quartzite?, silicification?; very strong limonite common dark brown locally iridescent limonite staining, in the middle of Tim Cramer's NS AlOH Aster anomaly	674084	4063545
RDWJM037	grab sample of light gray quartz rich rock -- Eureka Quartzite?, silicification?; very strong limonite common dark brown locally iridescent limonite staining, in the middle of Tim Cramer's NS AlOH Aster anomaly	674084	4063545
RDWJM038	grab sample of limonite-stained platy limestone in Tim Cramer's AlOH Aster anomaly	670878	4113127
RDWJM039Slab	Fresh-looking gray limestone proximal to alteration zone	670916	4113094
RDWJM040	Grab sample of altered limestone and overlying white quartzite/silicification	670916	4113094
RDWJM041	Grab sample of limonite-stained bleached platy limestone, clay and limonite along bedding planes; local quartz-calcite veinlets w no preferred orientation; within Tim Cramer's NS AlOH Aster anomaly	670852	4112958
RDWJM042	Thin-bedded silty argillaceous limestone that is preferentially deformed relative to thicker beds, bleached and limonite	670896	4112673
RDWJM043	Grab sample of reddish brown-gray jasperoid cutting bleached limonite-stained limestone	670955	4112244
RDWJM044	Red jasperoid cutting weakly limonite-stained white quartzite/silicification?,	671134	4112190
RDWJM045	local planar body of hematite matrix breccia cutting white quartzite/silicification? -- fault?, weathering feature?	671141	4112244
RDWJM046	jasperoid breccia, orange-red limonite, silicified fault breccia?	671163	4112248
RDWJM047	jasperoid, strong fabric	671184	4112202
RDWJM048	grab sample of dump material, Lake Mine adit, gossanous material on dump; brecciated fresh limestone with abundant calcite veins in close proximity to adit; breccia with fragments of gray limestone in ferruginous matrix in adit wall and above adit entrance	671129	4112245
RDWJM048ASlab	grab sample of dump material, Lake Mine adit, gossanous material on dump; brecciated fresh limestone with abundant calcite veins in close proximity to adit; breccia with fragments of gray limestone in ferruginous matrix in adit wall and above adit entrance	671129	4112245
RDWJM048CSlab	grab sample of dump material, Lake Mine adit, gossanous material on dump; brecciated fresh limestone with abundant calcite veins in close proximity to adit; breccia with fragments of gray limestone in ferruginous matrix in adit wall and above adit entrance	671129	4112245
RDWJM049Slab	grab sample of jasperoid breccia; light gray jasperoid/quartzite? Fragments in a ferruginous, siliceous matrix	671028	4112364
RDWJM050A	grab sample of light gray to beige jasperoid, minor to moderate goethite staining, variable silicification	671103	4112307
RDWJM050B	grab sample of light gray to beige jasperoid, minor to moderate goethite staining, variable silicification	671103	4112307
RDWJM051	grab sample of yellow-brown limonite-stained bleached limestone, only weak local silicification	671056	4112312
RDWJM052	grab sample of white quartzite/jasperoid (Eureka Quartzite?)	671056	4112312
RDWJM053	grab sample of incompletely silicified yellow-brown limonite stained sanded carbonate, strong goethite-jarosite	671028	4112364
RDWJM054	grab sample of red brown jasperoid outcrop surrounded by float of white quartzite/jasperoid	671004	4112422
RDWJM055	Grab sample of big structural breccia zone, fresh gray limestone frags in ferruginous matrix, crushed white quartzite/jasperoid -- grades into what looks like milky white quartz vein material	671067	4113223
RDWJM056	red soil with fresh Tertiary tuff cobbles, no limestone	670954	4113515
RDWJM057Slab	Tertiary-Paleozoic unconformity Paleozoic dark gray dolomite w local limestone (dolomitization?) outcrops, light gray dolomite float, just to SW in red soil with fresh Tertiary tuff float, (paleosol?),	670908	4113617

Table 3. Locations of Desert Lake Playa Samples Collected by NBMG in 2013.

Sample ID	Latitude WGS84 (deg)	Longitude WGS84 (deg)
DNWR-Playa-1	36.96783	-115.1993
DNWR-Playa-2	36.97025	-115.20113
DNWR-Playa-3	36.97278	-115.2032
DNWR-Playa-4	36.97582	-115.20467
DNWR-Playa-5	36.97875	-115.20552
DNWR-Playa-6	36.98183	-115.20545

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: 775 356 5395 Fax: 775 355 0179 www.alsglobal.com

To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 13-JAN-2014
This copy reported on
11-FEB-2014
Account: BMGN

CERTIFICATE RE13230097

Project:
P.O. No.: 14DA194323
This report is for 68 Pulp samples submitted to our lab in Reno, NV, USA on 26-DEC-2013.
The following have access to data associated with this certificate:

JOHN MUNTEAN		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
Au-AA23	Au 30g FA-AA finish	AAS
PGM-ICP23	Pt, Pd, Au 30g FA ICP	ICP-AES
ME-MS61	48 element four acid ICP-MS	
Hg-CV41	Trace Hg - cold vapor/AAS	FIMS
Ag-OG62	Ore Grade Ag - Four Acid	VARIABLE
ME-OG62	Ore Grade Elements - Four Acid	ICP-AES
Cu-OG62	Ore Grade Cu - Four Acid	VARIABLE
Pb-OG62	Ore Grade Pb - Four Acid	VARIABLE
Zn-OG62	Ore Grade Zn - Four Acid	VARIABLE

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project. Statement required by Nevada State Law NRS 519

To: NEVADA BUREAU OF MINES & GEOLOGY
ATTN: JOHN MUNTEAN
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Comments: ***Corrected copy with PO# 14DA194323 inserted***

Signature: Gael McGibbon, Director of Operations USA

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: 775 356 5395 Fax: 775 355 0179 www.alsglobal.com

To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 13-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230097

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	Au-AA23 Au ppm 0.005	PGM-ICP23 Pt ppm 0.005	PGM-ICP23 Pd ppm 0.001	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1
2146		0.18	0.010	<0.005	0.005	>100	0.02	316	20	0.43	0.31	6.27	>1000	1.08	5.1	61
2147		0.10	<0.005	<0.005	0.002	>100	0.04	555	240	0.53	24.0	1.28	45.9	7.97	306	225
2151		0.20	0.019	<0.005	0.004	>100	0.11	249	110	0.19	0.53	4.69	13.10	2.52	1.1	17
2152		0.19	<0.005	<0.005	<0.001	0.31	1.23	14.1	30	0.37	0.33	17.05	0.73	35.8	3.2	86
2153		0.17	<0.005	<0.005	0.001	0.18	3.62	5.6	340	1.45	0.44	15.00	0.38	38.8	0.9	38
2154		0.13	<0.005	<0.005	<0.001	7.29	0.59	9.1	130	0.22	0.36	11.65	3.61	7.14	4.2	64
2155		0.16	<0.005	<0.005	0.001	3.69	0.58	629	150	0.98	0.85	8.02	2.20	4.71	25.8	13
2156		0.11	<0.005	<0.005	<0.001	0.10	0.97	8.4	1730	1.61	0.48	9.80	0.05	197.5	14.0	138
2157		0.16	<0.005	<0.005	<0.001	0.02	0.04	429	20	<0.05	0.25	21.3	0.02	0.79	0.3	5
2158		0.14	0.018	<0.005	0.001	0.05	7.61	39.5	1680	2.11	0.31	3.20	0.08	92.3	3.3	80
2159		0.14	<0.005	<0.005	<0.001	0.06	5.95	149.5	530	2.01	0.17	3.94	0.17	207	1.9	156
2160		0.14	<0.005	<0.005	<0.001	0.03	1.60	1.8	790	0.72	0.09	15.65	0.14	23.8	1.5	15
2161		0.16	<0.005	<0.005	<0.001	6.97	0.47	0.6	70	0.15	8.05	0.17	0.02	12.80	1.1	234
2162		0.13	<0.005	<0.005	0.001	2.09	0.65	0.2	2320	0.11	0.60	0.11	0.02	12.60	1.6	259
2163		0.19	<0.005	<0.005	<0.001	0.02	0.02	<0.2	10	<0.05	0.01	20.1	0.04	0.58	0.8	5
2164		0.23	<0.005	<0.005	<0.001	0.02	0.13	<0.2	10	0.11	0.03	27.5	0.24	2.41	1.2	22
2165		0.30	0.005	<0.005	0.001	4.65	0.11	360	30	0.18	0.05	5.93	0.55	2.69	1.2	138
2166		0.14	<0.005	<0.005	0.001	1.25	0.13	270	20	0.08	0.03	1.43	6.51	3.62	5.8	62
2167		0.29	<0.005	<0.005	0.001	0.04	0.25	72.7	100	0.42	0.02	31.6	7.84	7.90	2.9	16
2168		0.20	0.015	<0.005	<0.001	0.04	0.03	<0.2	10	<0.05	0.01	22.1	0.44	1.09	0.7	8
2169		0.20	0.013	<0.005	0.001	0.05	0.25	89.5	3830	0.52	0.03	30.5	105.0	5.75	1.8	24
2170		0.14	<0.005	<0.005	0.001	0.13	1.12	307	140	1.08	0.14	14.65	9.71	14.15	6.3	62
2171		0.22	<0.005	<0.005	<0.001	0.27	0.54	4.6	70	0.17	0.02	20.4	1.50	2.31	1.0	16
2172		0.17	<0.005	<0.005	<0.001	0.04	0.08	17.6	30	0.11	0.02	33.2	5.86	1.86	1.1	5
2173		0.15	<0.005	<0.005	<0.001	0.03	4.17	5.2	870	0.75	0.02	7.14	1.16	10.25	1.3	73
2174		0.22	<0.005	<0.005	0.001	0.03	0.97	2.6	80	0.29	0.31	0.08	0.03	15.50	1.6	223
2175		0.23	<0.005	<0.005	<0.001	0.56	2.09	5.5	180	0.51	0.03	0.07	0.02	25.9	2.1	201
2176		0.19	<0.005	<0.005	0.001	0.01	0.52	3.5	1070	0.19	0.02	0.16	0.05	13.20	0.8	271
2177		0.27	<0.005	<0.005	0.003	0.51	0.22	4.1	30	0.12	0.03	2.05	0.11	3.09	0.7	304
2178		0.20	<0.005	<0.005	0.002	1.04	0.24	3.7	40	0.13	0.03	1.85	0.07	3.16	1.0	299
2179		0.21	0.007	<0.005	<0.001	2.53	0.58	2.9	1220	0.24	0.04	19.55	0.07	6.49	2.4	10
2180		0.26	<0.005	<0.005	<0.001	0.58	0.18	1020	50	0.07	0.21	0.33	0.16	2.51	1.3	44
2181		0.24	<0.005	<0.005	<0.001	0.30	1.88	30.3	200	0.93	0.08	23.6	4.06	33.4	16.2	45
2182		0.25	<0.005	<0.005	<0.001	0.48	1.04	9.6	30	0.78	0.03	9.89	3.09	15.25	8.0	184
2183		0.25	0.009	<0.005	0.004	2.46	0.13	1615	40	1.15	0.03	0.66	36.3	1.62	4.0	108
2184		0.20	<0.005	<0.005	<0.001	2.40	0.36	7.5	20	0.48	0.61	17.05	35.3	12.85	1.6	10
2191		0.19	<0.005	<0.005	<0.001	0.11	5.15	35.1	130	4.37	0.03	2.65	3.73	108.5	1.3	55
2192		0.27	<0.005	<0.005	<0.001	0.01	0.21	30.9	20	0.22	0.02	8.07	0.09	4.88	0.8	111
2193		0.33	<0.005	<0.005	<0.001	0.01	0.13	2.3	20	0.12	0.03	1.00	0.13	5.37	0.9	178
2194		0.30	0.005	<0.005	<0.001	0.02	0.17	96.3	30	0.30	0.02	5.60	0.05	5.30	1.6	126

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***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
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To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 13-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230097

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05	ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	Hg-CV41 Hg ppm 0.01	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01
2146		<0.05	2330	2.93	72.4	0.14	<0.1	48.9	0.472	0.01	2.6	0.9	3.53	33	7.98	0.01
2147		0.05	>10000	4.30	230	0.10	<0.1	18.3	0.906	0.02	8.5	2.6	0.66	47	179.0	0.01
2151		0.18	191.5	0.47	5.09	1.38	0.1	2.09	0.033	0.03	5.1	1.5	0.57	34	468	0.01
2152		0.56	15.0	1.29	3.25	0.09	2.3	0.06	0.023	0.17	19.0	11.4	0.14	522	3.31	0.04
2153		5.34	6.9	0.64	8.81	0.12	2.4	0.07	0.021	2.12	19.0	40.7	2.47	204	2.34	0.75
2154		0.26	57.9	2.37	2.09	0.10	0.3	1.45	0.074	0.34	2.5	3.7	5.10	8180	2.05	0.03
2155		0.55	757	35.3	3.78	0.28	0.2	3.14	0.093	0.19	2.7	2.5	0.76	1360	49.5	0.01
2156		1.48	16.1	6.55	5.01	0.16	0.5	0.21	0.110	0.47	44.5	10.9	0.76	20300	6.85	0.16
2157		<0.05	2.2	1.42	0.14	<0.05	<0.1	0.10	<0.005	0.01	0.5	1.4	13.80	71	8.22	0.02
2158		1.86	5.0	2.82	21.5	0.16	1.9	0.01	0.040	3.45	48.7	16.6	1.12	866	6.38	2.88
2159		1.86	8.3	2.82	17.70	0.21	1.6	0.02	0.044	2.83	117.5	30.2	0.47	341	20.1	2.02
2160		1.30	4.2	0.40	4.33	0.14	0.9	0.01	0.007	0.97	14.1	18.4	9.55	171	1.29	0.30
2161		0.17	>10000	0.35	1.18	0.10	0.6	0.13	<0.005	0.33	5.7	2.6	0.05	23	2.39	0.06
2162		0.24	6020	0.25	1.35	0.09	0.6	0.08	<0.005	0.55	5.6	1.4	0.05	33	0.85	0.14
2163		<0.05	17.7	0.03	0.23	0.22	<0.1	0.03	<0.005	0.01	0.5	0.7	12.95	40	0.16	0.02
2164		0.21	5.4	0.08	0.55	0.33	0.1	0.03	<0.005	0.06	1.5	2.0	6.85	29	0.21	0.02
2165		0.07	1355	8.19	1.37	0.22	0.1	0.27	0.020	0.03	2.0	5.2	2.48	36	13.25	0.01
2166		0.08	176.5	39.0	1.40	0.86	0.1	0.17	0.007	0.04	5.0	4.8	0.70	<5	35.4	0.01
2167		0.18	19.0	1.56	1.52	0.07	0.2	0.05	0.006	0.04	10.1	3.0	1.27	433	1.98	0.01
2168		<0.05	2.5	0.05	0.28	0.14	<0.1	0.04	<0.005	0.01	3.4	0.7	12.20	50	0.13	0.02
2169		0.36	18.5	1.37	2.29	0.07	0.2	0.10	0.019	0.06	6.0	1.5	3.46	256	1.08	0.01
2170		1.49	51.5	9.16	4.56	0.35	0.7	0.13	0.012	0.44	11.5	12.2	8.63	133	15.70	0.09
2171		0.87	8.0	0.27	3.21	0.09	0.2	0.10	<0.005	0.25	4.5	5.5	11.05	94	0.62	0.02
2172		0.10	8.0	1.14	1.11	0.05	0.1	0.03	0.007	0.02	4.6	1.4	2.28	116	0.42	0.01
2173		0.83	4.0	0.56	8.08	0.10	0.3	0.05	<0.005	2.22	6.9	7.9	0.41	61	0.54	1.27
2174		0.49	6.0	0.47	2.71	0.09	1.2	0.04	0.011	0.51	7.3	5.8	0.17	41	0.71	0.02
2175		1.03	5.5	1.04	6.55	0.10	1.5	0.05	0.023	1.11	11.3	6.9	0.15	26	1.00	0.46
2176		0.44	4.5	0.34	1.46	0.06	0.7	0.02	<0.005	0.32	6.5	5.6	0.05	57	0.92	0.01
2177		0.39	25.4	0.30	0.55	0.05	0.1	0.20	<0.005	0.09	6.6	4.2	0.30	35	1.21	0.03
2178		0.52	13.5	0.33	0.64	0.05	0.1	0.08	<0.005	0.09	5.5	4.6	0.27	45	1.57	0.03
2179		0.31	5.5	0.55	1.89	0.10	0.3	0.16	0.007	0.31	3.3	5.2	12.15	377	1.57	0.02
2180		0.05	157.0	>50	1.91	0.71	0.2	0.22	0.125	0.01	1.3	1.5	0.14	55	19.05	0.01
2181		3.00	12.0	9.97	5.97	0.18	0.8	0.11	0.076	0.14	16.7	28.2	0.50	2240	12.95	0.03
2182		0.25	9.9	2.81	1.80	0.09	0.9	0.25	0.021	0.10	9.1	8.4	0.10	356	9.99	0.04
2183		<0.05	848	>50	18.80	3.78	<0.1	2.92	0.032	0.01	4.2	0.6	0.41	<5	210	0.01
2184		0.26	14.6	1.30	11.25	0.05	0.2	7.05	0.222	0.23	6.6	4.6	9.80	298	0.66	0.02
2191		1.25	7.9	1.11	22.4	0.17	6.2	0.18	0.076	3.18	52.5	49.9	2.26	196	3.10	2.31
2192		0.49	3.6	0.28	0.59	<0.05	0.4	0.05	<0.005	0.13	1.8	3.4	0.54	67	1.32	0.01
2193		0.28	3.0	0.23	0.35	<0.05	0.4	0.03	<0.005	0.05	2.0	4.9	0.03	98	1.20	0.01
2194		0.35	4.0	0.43	0.52	<0.05	0.4	0.02	<0.005	0.09	2.0	6.7	0.08	77	1.27	0.01

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CERTIFICATE OF ANALYSIS RE13230097

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1	ME-MS61 Re ppm 0.002	ME-MS61 S % 0.01	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.2
2146		0.1	198.0	230	801	0.3	0.004	0.05	174.5	<0.1	43	3.2	46.2	<0.05	0.19	<0.2
2147		0.3	2680	270	4760	0.5	0.195	0.07	107.5	0.1	19	3.1	22.9	<0.05	3.99	<0.2
2151		0.2	10.6	120	>10000	1.2	0.002	3.60	81.7	0.2	768	0.6	1685	<0.05	0.33	0.2
2152		4.5	15.8	630	270	6.2	<0.002	0.03	0.37	4.7	2	0.9	118.5	0.32	<0.05	3.6
2153		6.8	8.3	420	134.0	95.8	<0.002	0.03	0.65	2.1	1	1.3	641	0.62	<0.05	9.7
2154		0.8	6.2	100	>10000	9.8	<0.002	1.19	6.42	0.7	34	0.5	471	0.08	<0.05	0.6
2155		0.5	25.5	380	>10000	6.9	<0.002	0.09	61.3	2.2	35	1.8	116.5	<0.05	0.06	0.8
2156		4.3	8.2	>10000	302	19.0	<0.002	0.03	0.37	4.5	3	0.5	515	0.20	<0.05	7.1
2157		0.1	1.0	140	41.0	0.5	0.002	<0.01	0.48	0.1	<1	0.2	67.6	<0.05	<0.05	<0.2
2158		15.4	3.3	300	46.6	83.1	0.011	0.41	0.29	2.3	1	1.9	715	0.93	<0.05	9.0
2159		21.1	5.6	260	31.8	83.7	0.047	0.55	0.68	4.5	3	2.3	426	1.45	<0.05	16.5
2160		4.8	1.8	160	14.8	39.1	<0.002	0.04	0.15	1.3	2	0.6	1210	0.35	<0.05	5.0
2161		0.7	6.2	30	9.2	10.4	<0.002	0.01	0.12	0.5	1	0.4	22.7	0.06	<0.05	2.5
2162		0.7	6.2	30	8.6	16.7	<0.002	0.07	0.11	0.4	1	0.3	67.3	0.06	<0.05	1.8
2163		0.2	<0.2	<10	2.0	0.3	<0.002	<0.01	0.07	0.1	1	0.3	60.5	<0.05	<0.05	<0.2
2164		0.4	<0.2	20	4.3	2.4	<0.002	<0.01	0.09	0.4	1	0.2	145.0	<0.05	<0.05	0.3
2165		0.3	108.5	70	209	1.1	<0.002	0.02	4.41	0.3	34	2.9	70.0	<0.05	0.16	0.2
2166		0.7	83.9	140	308	1.4	<0.002	0.11	5.41	0.3	58	0.3	38.2	<0.05	0.06	0.2
2167		0.7	30.4	510	97.5	2.1	<0.002	0.01	1.12	1.1	2	0.3	187.0	<0.05	<0.05	0.7
2168		0.2	<0.2	60	7.9	0.5	<0.002	<0.01	0.05	0.1	2	0.2	67.3	<0.05	<0.05	<0.2
2169		0.8	26.5	180	89.0	2.4	<0.002	0.09	1.74	1.0	2	0.8	284	0.05	0.07	0.8
2170		2.4	73.0	400	204	12.1	0.003	0.04	4.11	2.7	70	0.9	647	0.16	0.45	2.1
2171		1.2	6.9	190	39.4	10.6	<0.002	<0.01	1.18	1.3	2	0.5	252	0.07	<0.05	0.8
2172		0.4	11.9	420	39.1	1.2	<0.002	<0.01	2.17	0.3	2	0.2	71.0	<0.05	<0.05	0.2
2173		1.3	9.5	190	22.3	78.3	<0.002	<0.01	0.61	1.0	1	0.3	241	0.11	<0.05	1.8
2174		0.8	5.8	60	4.1	16.2	<0.002	<0.01	0.13	0.7	1	0.3	8.5	0.08	<0.05	2.2
2175		7.9	7.7	120	4.7	39.0	<0.002	0.02	0.23	3.5	1	0.8	30.8	0.57	<0.05	3.6
2176		1.0	5.5	70	3.3	11.0	<0.002	0.04	0.13	0.5	1	0.3	35.1	0.07	<0.05	2.2
2177		0.5	14.4	470	1.7	3.8	<0.002	0.02	0.18	0.6	2	0.3	39.3	<0.05	<0.05	0.4
2178		0.6	21.2	250	1.7	4.3	<0.002	0.01	0.26	0.8	1	0.3	24.9	<0.05	<0.05	0.4
2179		1.9	2.6	60	>10000	10.0	<0.002	0.18	2.11	1.2	2	0.4	510	0.13	<0.05	1.3
2180		1.0	2.1	160	1310	0.2	<0.002	0.13	35.1	0.3	5	0.6	14.5	<0.05	0.05	0.8
2181		3.3	35.0	900	95.9	9.7	<0.002	0.05	1.83	7.1	3	0.6	272	0.22	<0.05	3.4
2182		1.5	36.5	590	333	3.1	<0.002	6.49	0.76	3.5	2	0.4	120.5	0.10	<0.05	1.3
2183		0.7	331	570	3330	0.3	0.008	0.03	85.1	0.1	32	0.8	18.5	<0.05	0.28	<0.2
2184		1.2	<0.2	800	>10000	6.6	<0.002	0.94	6.72	1.3	4	1.4	82.6	0.08	0.07	1.1
2191		39.8	3.1	140	330	183.5	<0.002	0.02	1.07	1.0	3	5.1	100.5	2.93	<0.05	17.9
2192		0.6	4.9	60	12.8	4.7	<0.002	0.01	0.68	0.3	1	0.2	27.5	<0.05	<0.05	0.8
2193		0.4	3.3	50	10.9	1.7	<0.002	0.02	0.40	0.2	1	<0.2	7.6	<0.05	<0.05	0.9
2194		0.6	8.1	60	3.7	3.1	<0.002	0.02	3.93	0.2	1	<0.2	35.1	<0.05	<0.05	0.8

Comments: ***Corrected copy with PO# 14DA194323 inserted***

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: 775 356 5395 Fax: 775 355 0179 www.alsglobal.com

To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 13-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230097

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	Ag-OG62 Ag ppm 1	Cu-OG62 Cu % 0.001	Pb-OG62 Pb % 0.001	Zn-OG62 Zn % 0.001
2146		<0.005	0.08	5.1	94	3.1	3.4	>10000	0.8	230			25.7
2147		<0.005	0.15	405	409	23.7	24.5	>10000	2.1	312	2.44		1.330
2151		0.006	0.10	5.5	62	3.4	2.1	>10000	2.0	204		>20.0	1.820
2152		0.166	0.08	2.7	27	0.5	23.5	82	81.7				
2153		0.073	1.32	4.2	18	1.2	12.7	54	75.7				
2154		0.020	0.16	0.8	5	0.1	4.4	359	10.9			12.65	
2155		0.012	1.02	10.1	26	0.4	7.4	3220	6.8			7.55	
2156		0.073	0.08	2.9	25	0.4	84.4	28	25.6				
2157		<0.005	<0.02	0.6	12	0.5	1.1	6	0.6				
2158		0.142	0.66	2.6	37	0.9	18.7	98	48.0				
2159		0.222	0.69	3.8	34	1.9	30.2	57	35.2				
2160		0.045	0.22	2.1	9	0.5	5.6	18	27.3				
2161		0.013	0.06	10.1	55	0.2	2.3	2	17.4		1.470		
2162		0.015	0.09	6.1	49	0.2	2.3	2	15.6				
2163		<0.005	<0.02	0.2	2	<0.1	1.0	7	0.5				
2164		0.008	0.02	0.4	4	0.2	1.4	20	2.8				
2165		0.005	0.15	1.6	45	0.7	2.8	216	1.8				
2166		0.008	0.05	5.3	281	5.4	9.1	1380	3.5				
2167		0.013	0.41	1.9	25	1.5	16.9	399	8.3				
2168		<0.005	<0.02	0.4	5	0.1	6.1	26	1.0				
2169		0.016	0.17	1.9	25	1.5	16.8	767	6.9				
2170		0.066	0.14	4.9	190	4.9	14.2	704	24.7				
2171		0.028	0.08	1.1	74	0.6	5.5	89	7.1				
2172		0.005	0.12	0.4	15	2.2	7.3	314	2.1				
2173		0.030	0.36	0.5	10	0.6	4.3	67	8.8				
2174		0.029	0.08	0.5	8	0.2	3.1	3	36.3				
2175		0.344	0.15	0.8	37	0.5	5.9	5	45.6				
2176		0.031	0.05	0.4	5	0.2	2.2	2	22.9				
2177		0.011	0.06	1.2	16	0.3	8.5	20	4.0				
2178		0.012	0.07	1.0	11	0.2	6.1	32	5.0				
2179		0.036	0.06	1.4	6	0.2	2.5	5	10.3			1.160	
2180		0.010	0.03	3.7	135	2.2	2.4	102	6.6				
2181		0.090	0.20	4.4	59	0.4	29.5	376	28.2				
2182		0.046	0.10	1.6	13	0.2	15.4	471	29.3				
2183		<0.005	0.03	29.3	344	7.5	5.3	9910	0.8				
2184		0.019	0.42	0.6	5	0.4	4.4	>10000	8.0			8.04	1.775
2191		0.063	0.65	3.8	6	1.5	54.7	639	142.0				
2192		0.013	0.07	0.5	7	1.1	1.5	23	12.6				
2193		0.009	0.04	0.5	4	0.3	1.4	9	9.9				
2194		0.011	0.04	0.5	8	2.6	1.3	10	11.7				

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To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 13-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230097

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	Au-AA23 Au ppm 0.005	PGM-ICP23 Pt ppm 0.005	PGM-ICP23 Pd ppm 0.001	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1
2195		0.26	<0.005	<0.005	<0.001	0.02	0.30	1010	30	1.23	0.02	34.7	0.23	9.41	8.5	12
2196		0.32	<0.005	<0.005	<0.001	0.02	0.22	1.5	140	0.19	0.02	11.70	0.06	3.30	1.2	67
2197		0.09	<0.005	<0.005	<0.001	0.02	1.00	2.3	230	0.89	0.02	2.87	0.05	14.05	1.9	436
2198		0.30	<0.005	<0.005	<0.001	0.01	0.31	1.0	10	0.24	0.02	19.85	<0.02	5.73	1.0	7
2199		0.33	<0.005	<0.005	<0.001	0.01	0.44	5.8	10	0.30	0.07	19.50	<0.02	8.45	2.2	8
2200		0.34	<0.005	<0.005	<0.001	0.48	0.27	1385	40	0.13	0.10	1.36	0.06	4.11	1.2	8
49064		0.22	<0.005	<0.005	0.001	0.04	0.14	19.0	10	0.16	0.02	1.75	0.21	6.18	0.7	263
49065		0.22	<0.005	<0.005	<0.001	0.04	0.24	39.4	10	0.25	0.02	8.37	0.14	5.24	1.2	166
49080		0.17	<0.005	<0.005	<0.001	0.07	5.87	8.1	20	4.12	0.27	0.41	0.05	43.0	0.4	39
49083		0.32	<0.005	<0.005	0.001	0.36	1.00	64.3	50	0.36	0.04	27.5	0.40	10.95	6.0	36
49084		0.32	<0.005	<0.005	<0.001	0.13	1.10	17.1	70	0.55	0.04	18.20	0.60	33.3	12.6	121
49086		0.33	<0.005	<0.005	<0.001	0.60	1.18	347	50	1.03	0.16	12.45	1.83	9.76	11.4	60
49277		0.13	0.014	<0.005	<0.001	0.10	0.56	3.0	30	0.17	0.02	24.5	1.07	6.59	1.0	50
49303		0.14	<0.005	<0.005	<0.001	0.01	0.16	5.3	20	0.06	0.03	0.52	0.06	13.45	1.4	299
49309		0.15	<0.005	<0.005	<0.001	0.05	1.68	34.4	40	0.24	0.07	0.30	<0.02	27.5	1.2	265
49338		0.33	<0.005	<0.005	<0.001	0.05	1.49	18.4	40	0.77	0.05	13.30	0.27	31.1	2.9	57
49339		0.27	<0.005	<0.005	<0.001	0.03	0.40	40.9	10	0.35	0.02	13.35	0.30	9.90	0.7	136
49340		0.23	<0.005	<0.005	<0.001	0.04	0.23	38.8	20	0.17	0.04	0.43	<0.02	6.41	1.0	241
49341		0.27	<0.005	<0.005	<0.001	0.03	0.67	97.3	30	0.50	0.04	5.04	0.16	12.95	1.4	165
49342		0.20	0.006	0.008	<0.001	0.05	0.41	4650	70	4.41	0.04	14.35	1.37	5.15	361	104
49343		0.13	<0.005	<0.005	<0.001	0.01	2.05	261	30	0.22	0.07	0.28	0.05	32.0	2.0	370
49344		0.14	0.007	<0.005	0.012	9.18	1.19	778	80	2.49	0.06	0.71	0.49	15.55	1.9	378
49345		0.28	0.010	<0.005	0.001	0.09	1.68	>10000	140	0.27	0.07	0.55	0.60	17.85	1.6	123
49346		0.18	0.044	<0.005	<0.001	0.05	0.76	262	300	1.34	0.03	27.1	0.36	14.55	28.1	32
49347		0.25	<0.005	<0.005	0.001	0.01	0.12	8.0	20	0.18	0.01	4.39	0.05	1.24	0.8	293
49350		0.28	<0.005	<0.005	<0.001	0.02	0.38	53.7	590	0.42	0.04	20.9	0.14	27.6	5.0	23
49367		0.29	0.006	<0.005	<0.001	0.78	0.57	132.5	80	1.53	0.06	0.25	0.18	5.19	28.8	22
49368		0.06	0.008	<0.005	<0.001	0.75	0.87	133.5	110	1.72	0.07	0.33	0.17	7.13	28.2	37

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To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 13-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230097

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05	ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	Hg-CV41 Hg ppm 0.01	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01
2195		0.95	7.4	2.73	1.22	0.07	0.3	0.04	<0.005	0.09	5.3	1.8	0.17	947	2.51	0.01
2196		0.33	4.3	0.45	0.73	<0.05	0.1	0.02	<0.005	0.09	1.8	9.0	5.76	696	1.02	0.04
2197		0.52	8.9	0.70	2.89	0.06	0.3	0.03	<0.005	0.46	8.1	5.2	0.43	108	3.82	0.34
2198		0.17	2.1	0.35	1.10	0.11	0.3	0.04	0.006	0.03	2.8	5.8	12.60	166	0.41	0.01
2199		0.11	7.6	1.38	1.18	0.08	0.3	0.06	0.012	0.04	4.3	5.7	12.20	268	1.51	0.01
2200		0.10	138.5	>50	1.96	0.89	0.2	0.05	0.044	0.04	1.8	1.6	0.39	222	13.55	0.01
49064		0.26	4.9	0.43	0.60	<0.05	0.3	0.06	<0.005	0.05	2.5	3.2	0.03	44	1.22	0.01
49065		0.75	6.9	0.64	1.00	<0.05	0.3	0.05	0.006	0.06	2.3	3.5	0.04	104	1.48	0.01
49080		5.29	3.5	0.58	16.50	0.13	3.3	0.01	0.032	3.66	20.0	23.8	0.32	250	6.45	2.49
49083		0.28	7.9	4.93	1.48	0.06	0.5	0.25	0.013	0.14	8.6	9.6	2.12	2600	9.04	0.13
49084		0.98	8.9	5.92	3.39	0.14	1.1	0.22	0.035	0.12	30.3	12.7	1.75	1120	9.20	0.06
49086		2.34	147.5	24.3	11.35	0.09	0.9	0.14	0.041	0.41	7.9	11.2	0.25	486	14.30	0.01
49277		0.39	3.2	0.29	1.47	0.06	0.4	0.13	0.006	0.20	7.2	6.8	0.51	35	0.90	0.01
49303		0.13	4.4	0.30	0.52	<0.05	0.2	0.02	<0.005	0.06	7.0	2.1	0.06	109	1.32	0.01
49309		0.53	4.9	1.76	4.48	0.06	1.2	0.02	0.015	0.73	14.3	3.3	0.21	24	2.48	0.01
49338		2.44	4.3	1.21	3.62	0.07	0.8	0.05	0.018	0.46	18.5	14.2	0.28	325	5.39	0.01
49339		1.02	5.0	0.85	1.32	<0.05	0.4	0.03	0.007	0.12	4.2	3.1	0.07	159	5.02	<0.01
49340		0.38	5.8	0.49	0.73	<0.05	0.4	0.05	<0.005	0.43	2.4	7.0	0.08	36	16.80	0.05
49341		2.16	5.5	1.07	1.90	<0.05	0.6	0.03	0.007	0.21	5.9	6.1	0.07	107	5.22	0.01
49342		2.27	90.5	29.0	3.82	0.14	0.3	1.85	0.007	0.09	5.0	1.9	0.18	240	26.7	0.01
49343		0.75	6.0	2.81	4.93	0.05	1.8	0.06	0.031	0.47	14.8	8.7	0.07	30	6.46	0.01
49344		2.14	80.2	3.21	3.29	0.08	0.5	0.54	0.017	0.27	16.7	8.9	0.10	45	30.3	0.02
49345		5.54	26.8	35.0	9.82	0.16	0.6	0.62	0.044	0.58	15.8	7.7	0.20	8	10.45	0.15
49346		0.63	7.5	8.65	3.22	0.06	0.5	0.15	0.031	0.25	9.0	3.6	0.60	3400	9.46	0.01
49347		0.17	3.7	0.33	0.51	<0.05	0.1	0.01	<0.005	0.06	0.6	5.2	0.09	31	2.48	0.03
49350		0.25	13.0	1.76	1.21	0.05	0.2	0.10	0.010	0.19	11.9	9.2	4.77	4620	7.09	0.02
49367		0.70	464	>50	1.72	0.29	0.2	0.29	0.028	0.17	4.6	3.9	0.29	617	23.8	0.01
49368		1.10	480	>50	2.51	0.53	0.3	0.36	0.032	0.26	5.6	5.4	0.30	723	24.8	0.01

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1664 NORTH VIRGINIA ST.
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Finalized Date: 13-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230097

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1	ME-MS61 Re ppm 0.002	ME-MS61 S % 0.01	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.2
2195		0.9	14.3	190	11.8	4.5	<0.002	0.02	33.8	1.3	2	<0.2	71.7	<0.05	<0.05	0.5
2196		0.7	2.1	70	2.3	5.7	<0.002	0.01	0.26	0.4	1	<0.2	671	<0.05	<0.05	0.5
2197		2.1	11.0	160	5.6	16.1	<0.002	0.02	0.47	0.8	1	0.5	135.5	0.14	<0.05	2.4
2198		1.3	<0.2	70	12.2	1.0	<0.002	<0.01	0.37	0.7	1	<0.2	115.0	0.08	<0.05	0.7
2199		1.7	4.7	60	13.0	1.2	<0.002	<0.01	0.35	1.1	2	0.3	108.5	0.11	<0.05	1.0
2200		0.9	1.7	170	382	1.3	<0.002	0.11	28.6	0.6	14	0.2	49.1	<0.05	<0.05	0.6
49064		0.4	6.6	50	80.8	1.6	<0.002	0.01	3.29	0.2	<1	0.2	3.8	<0.05	<0.05	0.8
49065		0.5	6.0	70	30.8	2.3	<0.002	<0.01	6.15	0.5	<1	0.2	11.3	<0.05	<0.05	0.8
49080		22.4	1.4	30	28.1	168.5	<0.002	0.01	1.09	3.0	1	3.0	30.4	2.11	<0.05	20.4
49083		1.8	16.8	360	15.1	4.6	<0.002	0.05	0.86	2.0	4	0.6	486	0.11	0.26	1.6
49084		2.8	39.0	>10000	19.4	5.6	<0.002	0.07	1.20	3.8	3	0.6	240	0.15	<0.05	4.0
49086		3.0	47.3	460	233	8.8	<0.002	0.08	2.06	2.0	2	0.5	46.7	0.20	0.06	2.5
49277		1.2	13.3	800	2.0	7.7	<0.002	<0.01	0.27	1.1	1	0.4	1250	0.07	<0.05	0.9
49303		0.4	5.1	350	2.0	1.2	<0.002	0.02	0.26	0.4	<1	0.3	14.1	<0.05	<0.05	0.6
49309		3.2	7.4	70	4.5	13.4	<0.002	0.02	0.56	2.2	<1	0.6	26.7	0.20	<0.05	3.7
49338		2.8	9.6	150	8.7	22.9	<0.002	<0.01	1.47	4.3	1	0.6	131.0	0.17	<0.05	2.8
49339		0.7	4.1	90	6.6	4.1	<0.002	<0.01	12.45	1.5	1	0.3	17.5	0.05	<0.05	1.1
49340		0.4	7.1	70	2.3	2.3	0.002	0.09	6.59	0.1	1	0.2	24.2	<0.05	<0.05	0.9
49341		1.2	8.6	130	7.9	7.3	<0.002	<0.01	17.70	1.1	<1	0.3	16.0	0.07	<0.05	1.7
49342		0.6	316	250	32.7	4.6	<0.002	<0.01	47.8	1.0	20	0.3	171.0	<0.05	0.13	0.6
49343		2.6	7.1	180	6.7	12.1	<0.002	0.16	1.53	1.4	1	0.5	69.4	0.18	<0.05	5.8
49344		1.8	85.5	2560	4.8	13.6	0.006	0.02	10.80	1.7	7	0.5	235	0.11	0.09	1.7
49345		1.5	21.1	840	5.7	27.9	0.002	0.71	281	2.3	7	0.6	209	0.10	0.11	3.7
49346		1.6	114.0	1300	7.7	6.1	<0.002	0.10	2.28	7.0	2	0.3	295	0.11	<0.05	1.3
49347		0.4	5.1	20	0.9	2.1	<0.002	<0.01	0.71	0.2	<1	0.2	14.0	<0.05	<0.05	0.2
49350		0.9	21.1	4150	7.4	5.2	<0.002	0.01	0.38	2.0	1	0.2	312	0.06	<0.05	1.3
49367		0.5	34.9	280	465	7.0	<0.002	0.11	6.61	1.2	2	0.2	16.3	<0.05	<0.05	0.9
49368		0.8	34.6	280	484	10.9	<0.002	0.11	6.88	1.6	2	0.3	18.4	0.05	<0.05	1.4

Comments: ***Corrected copy with PO# 14DA194323 inserted***

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: 775 356 5395 Fax: 775 355 0179 www.alsglobal.com

To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 13-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230097

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	Ag-OG62 Ag ppm 1	Cu-OG62 Cu % 0.001	Pb-OG62 Pb % 0.001	Zn-OG62 Zn % 0.001
2195		0.015	0.07	0.6	43	20.7	5.7	54	14.7				
2196		0.011	0.06	1.9	7	0.5	1.7	10	5.0				
2197		0.037	0.13	8.8	16	0.4	3.7	10	9.1				
2198		0.021	0.02	0.8	5	0.3	2.8	<2	9.3				
2199		0.029	0.03	1.2	8	0.3	3.1	3	10.6				
2200		0.005	0.02	3.8	25	1.2	2.2	15	5.0				
49064		0.011	0.04	0.3	4	0.6	1.3	25	10.9				
49065		0.012	0.08	0.5	8	1.0	2.6	33	12.8				
49080		0.045	0.85	6.8	2	2.6	21.1	26	76.9				
49083		0.056	0.12	5.2	48	0.4	16.4	109	21.2				
49084		0.097	0.23	18.7	57	0.8	77.5	77	43.8				
49086		0.099	4.42	4.0	128	2.6	7.7	1000	37.3				
49277		0.035	0.12	1.7	17	0.4	7.6	45	13.6				
49303		0.009	0.06	0.3	4	0.3	0.8	4	7.5				
49309		0.100	0.06	0.8	31	3.0	4.0	2	46.3				
49338		0.078	0.10	0.9	40	0.9	22.9	35	32.3				
49339		0.018	0.04	0.7	10	3.3	6.2	27	16.2				
49340		0.010	0.04	0.4	7	0.9	1.2	12	12.8				
49341		0.037	0.09	0.7	19	1.6	4.5	20	21.7				
49342		0.018	0.83	4.3	358	9.6	16.4	732	37.2				
49343		0.093	0.08	1.1	28	0.5	4.9	6	68.5				
49344		0.051	0.12	4.5	142	2.1	34.0	293	24.7				
49345		0.059	27.5	14.4	102	0.7	5.4	84	22.2				
49346		0.053	9.66	5.8	57	0.4	17.4	69	18.4				
49347		0.006	0.10	12.8	6	0.3	0.5	9	3.7				
49350		0.017	0.78	1.5	22	1.0	10.8	35	8.7				
49367		0.012	0.34	7.7	32	0.4	9.7	53	8.7				
49368		0.018	0.43	8.1	36	0.4	10.8	55	12.6				

Comments: ***Corrected copy with PO# 14DA194323 inserted***

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Finalized Date: 13-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230097

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REE's may not be totally soluble in this method.
Applies to Method: ME-MS61

Detection limits on samples requiring dilutions due to interferences or high concentration levels have been increased according to the dilution factor.
Applies to Method: Hg-CV41

LABORATORY ADDRESSES

Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.

Applies to Method:			
	Au-AA23	LOG-24	WEI-21

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:				
	Ag-OG62	Cu-OG62	Hg-CV41	ME-MS61
	ME-OG62	Pb-OG62	PGM-ICP23	Zn-OG62

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To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 16-JAN-2014
This copy reported on
11-FEB-2014
Account: BMGN

CERTIFICATE RE13230096

P.O. No.: 14DA194322
This report is for 58 Rock samples submitted to our lab in Reno, NV, USA on 26-DEC-2013.
The following have access to data associated with this certificate:

JOHN MUNTEAN		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um
CRU-21	Crush entire sample >70% -6 mm
CRU-QC	Crushing QC Test
PUL-QC	Pulverizing QC Test

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
PGM-ICP23	Pt, Pd, Au 30g FA ICP	ICP-AES
ME-MS61	48 element four acid ICP-MS	
Hg-CV41	Trace Hg - cold vapor/AAS	FIMS
Ag-OG62	Ore Grade Ag - Four Acid	VARIABLE
ME-OG62	Ore Grade Elements - Four Acid	ICP-AES
Cu-OG62	Ore Grade Cu - Four Acid	VARIABLE
Pb-OG62	Ore Grade Pb - Four Acid	VARIABLE
Zn-OG62	Ore Grade Zn - Four Acid	VARIABLE
Au-AA23	Au 30g FA-AA finish	AAS

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project. Statement required by Nevada State Law NRS 519

To: NEVADA BUREAU OF MINES & GEOLOGY
ATTN: JOHN MUNTEAN
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****
Comments: ***Corrected copy with PO# 14DA194322 inserted***

Signature: Joyce Quiroz, Laboratory Manager, Reno

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Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	Au-AA23 Au ppm 0.005	PGM-ICP23 Pt ppm 0.005	PGM-ICP23 Pd ppm 0.001	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1
JB Bret A		0.62	<0.005	<0.005	0.001	10.10	0.04	5.1	<10	<0.05	0.02	19.55	490	1.72	1.6	6
JB Bret B		0.20	<0.005	<0.005	<0.001	0.10	0.04	<0.2	<10	<0.05	0.01	20.5	2.93	1.77	1.2	15
JB Bret Gos		0.90	0.008	0.015	0.005	1.55	0.15	1480	20	1.18	0.11	0.27	20.1	5.10	83.8	89
RDWJM 001Slab		0.32	0.011	<0.005	0.001	>100	0.03	304	90	0.58	5.85	2.92	107.0	2.17	159.0	21
RDWJM 002Slab		0.80	<0.005	<0.005	<0.001	0.42	0.02	0.4	20	<0.05	0.01	21.9	1.90	1.35	1.6	4
RDWJM 003		0.09	<0.005	<0.005	<0.001	0.13	0.07	<0.2	10	<0.05	0.01	22.2	4.07	3.84	1.2	7
RDWJM 004Bxa		0.37	<0.005	<0.005	<0.001	2.77	0.10	20.4	40	0.12	0.03	2.18	1.02	5.93	1.7	71
RDWJM 005Slab		0.46	0.013	<0.005	0.006	>100	0.01	455	10	0.57	0.04	2.71	490	2.00	14.4	30
RDWJM 005		0.73	<0.005	<0.005	0.002	79.7	0.03	125.0	10	0.26	0.03	13.05	>1000	2.14	2.8	14
RDWJM 006FeOx		0.19	<0.005	<0.005	<0.001	1.02	0.07	4.0	10	<0.05	0.02	8.47	8.94	2.16	0.5	13
RDWJM 007Slab		0.13	<0.005	<0.005	<0.001	0.30	0.09	0.4	10	0.08	0.01	33.3	5.54	2.29	0.8	4
RDWJM 008		0.82	<0.005	<0.005	<0.001	0.09	1.00	11.7	60	0.23	0.02	13.55	1.46	14.40	2.3	8
RDWJM 011		1.53	<0.005	<0.005	<0.001	0.06	1.18	4.3	180	0.20	0.05	11.45	1.01	9.05	1.8	11
RDWJM 012		0.55	<0.005	<0.005	<0.001	0.02	0.48	1.4	50	0.24	0.02	12.70	0.25	10.95	1.1	5
RDWJM 013Slab		0.59	<0.005	<0.005	<0.001	0.02	0.21	<0.2	20	0.14	0.01	18.15	0.34	9.98	1.3	3
RDWJM 013		0.23	<0.005	<0.005	<0.001	0.03	0.95	<0.2	110	0.37	0.04	17.70	0.29	14.90	1.8	4
RDWJM 014		0.16	<0.005	<0.005	<0.001	0.19	0.20	961	50	0.16	0.82	0.92	1.18	3.96	47.8	7
RDWJM 016Slab		0.35	<0.005	<0.005	<0.001	0.03	0.62	6.2	40	0.33	0.04	13.55	0.16	16.70	2.1	8
RDWJM 016		0.61	<0.005	<0.005	<0.001	0.01	0.93	12.4	30	0.48	0.04	17.75	0.08	13.20	2.7	6
RDWJM 017Slab		0.37	<0.005	<0.005	<0.001	0.02	0.45	2.8	30	0.23	0.01	17.65	0.13	9.52	1.5	6
RDWJM 019Slab		0.09	<0.005	<0.005	<0.001	0.01	2.50	<0.2	90	0.29	0.04	25.2	0.09	49.3	6.0	15
RDWJM 020		0.19	<0.005	<0.005	<0.001	0.01	0.22	<0.2	10	0.15	0.04	34.7	0.17	17.55	1.4	1
RDWJM 022Slab		0.20	<0.005	<0.005	<0.001	0.01	1.28	<0.2	80	0.33	0.05	29.2	0.15	40.7	3.1	8
RDWJM 024Slab		0.17	<0.005	<0.005	<0.001	0.03	0.10	1.7	<10	0.09	0.03	20.1	0.07	1.63	1.6	1
RDWJM 027		0.61	<0.005	<0.005	<0.001	0.10	0.45	2.2	30	0.16	0.02	18.60	0.67	5.31	0.8	36
RDWJM 031		0.74	<0.005	<0.005	<0.001	0.05	0.71	67.6	10	0.31	0.02	27.9	0.56	9.62	1.3	16
RDWJM 032Slab		0.08	<0.005	<0.005	<0.001	0.01	3.10	141.5	70	0.72	0.10	7.95	0.40	22.1	1.1	39
RDWJM 033Slab		0.49	<0.005	<0.005	<0.001	0.04	0.36	67.1	20	0.13	0.01	5.35	0.18	6.95	1.0	13
RDWJM 033		0.61	<0.005	<0.005	<0.001	0.03	0.74	325	20	0.34	0.02	13.20	0.24	18.65	3.4	13
RDWJM 034		0.28	<0.005	<0.005	<0.001	0.02	1.19	9.2	40	0.41	0.05	24.9	0.15	23.0	4.0	14
RDWJM 035Slab		0.19	<0.005	<0.005	<0.001	0.02	0.70	8.1	30	0.09	0.03	0.38	0.23	10.80	0.5	10
RDWJM 035		0.48	<0.005	<0.005	<0.001	0.03	0.75	20.0	30	0.15	0.04	0.11	0.13	17.35	1.1	9
RDWJM 036		0.23	<0.005	<0.005	<0.001	0.03	0.96	15.5	20	0.08	0.07	0.15	0.09	11.65	0.4	16
RDWJM 037Slab		0.30	<0.005	<0.005	<0.001	0.04	0.48	108.0	10	0.18	0.08	0.21	0.16	9.24	7.7	20
RDWJM 037		0.12	<0.005	<0.005	<0.001	0.02	0.48	350	20	0.56	0.07	0.19	0.26	8.38	19.2	20
RDWJM 038		0.27	<0.005	<0.005	<0.001	0.08	1.77	18.7	60	0.51	0.08	24.3	0.61	27.6	4.5	21
RDWJM 039Slab		0.12	<0.005	<0.005	<0.001	0.05	0.40	6.5	20	0.14	0.02	35.0	0.21	9.70	1.0	8
RDWJM 040		0.23	<0.005	<0.005	<0.001	0.01	0.18	5.3	10	<0.05	0.05	0.61	0.09	6.94	1.2	14
RDWJM 041		0.72	<0.005	<0.005	<0.001	0.03	1.92	10.8	50	0.39	0.08	22.2	0.19	34.7	4.9	22
RDWJM 042		0.63	<0.005	<0.005	<0.001	0.02	1.33	12.2	20	0.35	0.05	16.85	0.12	25.2	2.3	16

Comments: ***Corrected copy with PO# 14DA194322 inserted***

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1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05	ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	Hg-CV41 Hg ppm 0.01	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01
JB Bret A		<0.05	99.6	0.07	1.13	0.17	<0.1	4.09	0.099	0.01	3.3	0.4	12.40	132	4.83	0.02
JB Bret B		<0.05	3.0	0.03	0.52	0.28	<0.1	0.07	0.011	0.02	7.1	0.5	12.80	30	0.37	0.03
JB Bret Gos		0.05	2170	>50	28.9	5.64	0.1	1.66	0.019	0.03	12.3	1.1	0.22	<5	202	0.01
RDWJM 001Slab		<0.05	>10000	3.80	480	0.13	<0.1	7.3	2.76	0.01	3.9	5.5	1.46	73	549	<0.01
RDWJM 002Slab		<0.05	42.9	0.08	0.93	<0.05	<0.1	0.15	0.007	0.01	6.8	0.8	12.20	54	1.81	0.02
RDWJM 003		0.08	14.4	0.10	0.68	<0.05	0.1	0.03	<0.005	0.03	9.6	0.8	11.35	141	0.56	0.02
RDWJM 004Bxa		0.12	51.7	0.92	1.23	<0.05	0.1	0.05	0.005	0.02	2.1	2.5	0.97	247	5.25	0.01
RDWJM 005Slab		0.05	1380	4.17	42.2	<0.05	<0.1	10.05	0.673	0.01	3.8	1.0	1.48	250	613	<0.01
RDWJM 005		<0.05	268	0.98	11.85	<0.05	<0.1	2.61	0.077	0.01	5.1	1.0	8.08	153	312	0.01
RDWJM 006FeOx		0.12	13.5	0.22	0.57	0.09	<0.1	0.10	<0.005	0.02	2.3	2.7	0.15	66	6.09	0.01
RDWJM 007Slab		0.14	4.9	0.08	0.41	<0.05	0.1	0.02	<0.005	0.03	5.8	1.0	0.19	27	2.06	0.01
RDWJM 008		0.32	5.4	0.95	4.01	<0.05	0.9	0.02	0.007	0.33	6.3	3.7	7.24	653	1.43	0.01
RDWJM 011		0.42	4.4	0.57	2.42	<0.05	1.0	0.01	0.008	1.46	3.7	1.5	6.87	120	1.54	0.03
RDWJM 012		0.23	2.2	0.46	1.30	<0.05	0.4	0.01	0.010	0.52	4.3	3.5	7.31	150	0.61	0.02
RDWJM 013Slab		0.05	2.7	0.41	0.73	0.12	0.1	<0.01	0.006	0.26	4.0	0.6	11.65	191	0.44	0.03
RDWJM 013		0.35	2.7	0.43	2.74	0.07	0.9	<0.01	0.010	1.15	6.1	2.5	10.30	175	0.45	0.04
RDWJM 014		0.18	886	>50	1.64	1.90	0.3	1.24	0.356	0.05	2.0	2.0	0.41	<5	40.1	0.01
RDWJM 016Slab		0.62	3.8	0.59	1.96	<0.05	0.6	0.02	0.012	0.54	6.4	4.3	8.44	105	1.03	0.02
RDWJM 016		1.94	6.7	0.68	2.47	<0.05	0.5	0.02	0.012	0.62	6.3	7.2	11.30	169	0.69	0.02
RDWJM 017Slab		0.19	2.7	0.30	1.30	0.05	0.3	0.01	0.006	0.42	4.5	2.2	11.20	131	0.76	0.02
RDWJM 019Slab		0.36	4.0	2.48	6.83	<0.05	0.8	0.02	0.031	0.79	25.1	16.0	1.29	1020	0.20	0.37
RDWJM 020		0.05	2.8	0.23	1.10	<0.05	0.1	0.01	<0.005	0.09	7.4	1.3	0.37	4790	0.14	0.04
RDWJM 022Slab		0.43	5.5	1.00	3.45	<0.05	0.6	0.01	0.020	0.55	19.4	8.0	1.24	851	0.17	0.17
RDWJM 024Slab		0.05	3.6	0.25	0.56	0.15	0.1	0.01	<0.005	0.05	0.8	0.6	12.90	147	0.93	0.02
RDWJM 027		0.33	3.0	0.25	1.22	<0.05	0.3	0.02	0.005	0.15	5.2	6.5	1.08	44	0.52	0.01
RDWJM 031		3.72	3.0	0.61	1.83	<0.05	0.4	0.12	0.007	0.19	6.7	7.3	0.24	206	0.68	<0.01
RDWJM 032Slab		6.64	10.4	0.53	7.81	<0.05	1.8	0.03	0.037	1.23	15.6	31.5	0.48	104	0.98	0.04
RDWJM 033Slab		0.84	2.4	0.50	0.96	<0.05	0.2	0.03	<0.005	0.11	4.2	3.7	0.26	130	1.50	0.01
RDWJM 033		1.88	3.6	1.17	1.84	<0.05	0.4	0.06	0.009	0.27	12.7	7.2	0.53	265	5.51	0.01
RDWJM 034		3.98	5.7	0.63	2.98	0.10	0.6	0.03	0.007	0.47	16.4	16.7	1.31	601	0.56	0.01
RDWJM 035Slab		0.23	3.4	0.54	2.12	0.08	0.4	0.01	<0.005	0.31	4.8	1.4	0.07	47	0.61	<0.01
RDWJM 035		0.27	2.9	1.24	2.11	0.08	0.8	0.04	<0.005	0.25	6.5	2.2	0.06	30	0.95	<0.01
RDWJM 036		0.20	2.5	1.95	2.48	0.06	0.7	0.01	0.006	0.37	4.8	1.2	0.06	41	0.82	0.02
RDWJM 037Slab		0.23	5.4	1.24	1.32	0.07	0.4	0.06	0.006	0.14	4.5	1.8	0.03	51	3.39	0.01
RDWJM 037		0.43	9.3	3.34	1.49	0.08	0.4	0.16	0.005	0.17	3.9	2.4	0.05	89	8.39	0.01
RDWJM 038		1.49	10.2	1.11	4.34	0.09	1.1	0.07	0.017	0.87	15.1	3.8	1.75	494	2.44	0.02
RDWJM 039Slab		0.22	3.1	0.21	0.96	0.08	0.2	0.13	0.005	0.21	6.3	2.7	0.26	234	0.50	<0.01
RDWJM 040		0.42	3.3	0.48	0.48	0.07	0.2	0.02	<0.005	0.07	3.2	4.9	0.02	65	1.26	0.01
RDWJM 041		1.41	6.6	1.08	4.35	0.11	1.3	0.06	0.026	0.95	17.4	3.9	1.75	372	0.46	0.01
RDWJM 042		0.71	5.0	0.79	2.80	0.09	1.0	0.04	0.014	0.58	13.6	5.2	1.53	387	1.01	0.01

Comments: ***Corrected copy with PO# 14DA194322 inserted***

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
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Phone: 775 356 5395 Fax: 775 355 0179 www.alsglobal.com

To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1	ME-MS61 Re ppm 0.002	ME-MS61 S % 0.01	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.2
JB Bret A		0.2	4.9	250	651	0.5	0.018	0.01	2.57	0.2	19	0.6	63.3	<0.05	0.06	<0.2
JB Bret B		0.3	1.9	160	5.6	0.6	0.003	<0.01	0.10	0.4	1	2.0	21.5	<0.05	<0.05	0.2
JB Bret Gos		1.1	945	830	2890	0.8	0.033	0.02	114.5	0.4	71	1.2	20.8	<0.05	1.34	<0.2
RDWJM 001Slab		0.2	1850	270	4340	0.3	1.130	0.05	44.1	0.1	15	3.8	40.3	<0.05	3.07	<0.2
RDWJM 002Slab		0.2	8.4	150	17.5	0.2	0.002	<0.01	0.20	0.1	1	<0.2	93.6	<0.05	<0.05	<0.2
RDWJM 003		0.4	3.6	210	22.5	1.2	<0.002	<0.01	0.20	0.4	1	<0.2	80.3	<0.05	<0.05	0.2
RDWJM 004Bxa		0.3	9.2	250	64.0	1.1	<0.002	0.04	0.85	0.2	2	0.2	24.5	<0.05	<0.05	0.4
RDWJM 005Slab		0.1	76.5	330	7940	0.2	0.022	0.01	11.70	0.1	48	8.2	11.5	<0.05	1.05	<0.2
RDWJM 005		0.2	22.9	510	>10000	0.2	0.066	0.01	6.22	0.1	32	0.8	55.3	<0.05	0.25	<0.2
RDWJM 006FeOx		0.1	3.2	130	169.0	1.0	<0.002	0.01	0.57	0.2	<1	<0.2	57.5	<0.05	<0.05	0.2
RDWJM 007Slab		0.6	3.2	170	87.0	1.1	<0.002	0.01	0.20	0.5	1	<0.2	133.5	<0.05	<0.05	0.3
RDWJM 008		3.7	4.0	540	27.9	11.5	<0.002	<0.01	0.16	2.0	1	0.3	66.9	0.25	<0.05	1.8
RDWJM 011		2.2	2.6	250	20.6	28.5	<0.002	0.01	0.14	1.3	1	0.2	50.3	0.16	<0.05	1.6
RDWJM 012		1.3	1.6	260	6.7	9.4	<0.002	0.02	0.09	0.8	1	<0.2	72.4	0.08	<0.05	0.9
RDWJM 013Slab		0.7	1.8	180	7.4	3.3	<0.002	<0.01	0.05	0.7	1	<0.2	63.1	<0.05	<0.05	0.4
RDWJM 013		2.8	1.8	330	8.5	19.7	<0.002	0.02	0.09	1.7	1	0.3	101.0	0.20	<0.05	2.2
RDWJM 014		0.6	173.5	390	770	2.1	<0.002	0.05	88.3	0.7	10	133.5	16.6	<0.05	0.13	0.8
RDWJM 016Slab		2.3	3.0	320	7.2	11.7	<0.002	0.01	0.18	1.8	1	0.3	68.6	0.15	<0.05	2.1
RDWJM 016		2.8	3.8	280	8.9	13.9	<0.002	<0.01	0.60	2.0	1	1.2	76.3	0.19	<0.05	1.6
RDWJM 017Slab		1.3	1.8	560	4.9	6.9	<0.002	0.01	0.15	1.2	1	0.3	87.8	0.08	<0.05	1.0
RDWJM 019Slab		4.7	13.3	240	3.7	25.7	<0.002	<0.01	0.10	4.7	1	0.4	708	0.31	<0.05	4.0
RDWJM 020		0.8	<0.2	4760	11.7	3.0	<0.002	<0.01	0.07	0.5	1	<0.2	718	<0.05	<0.05	0.9
RDWJM 022Slab		3.0	5.1	1430	10.1	18.1	<0.002	<0.01	0.08	2.4	2	0.3	866	0.20	<0.05	2.9
RDWJM 024Slab		0.6	3.0	60	5.4	1.3	<0.002	<0.01	0.20	0.4	1	<0.2	38.4	<0.05	<0.05	0.4
RDWJM 027		1.0	6.0	780	3.0	6.1	<0.002	0.01	0.26	0.9	1	0.2	1320	0.06	<0.05	0.7
RDWJM 031		1.5	4.9	20	4.4	8.0	<0.002	<0.01	5.96	2.1	1	0.2	279	0.09	<0.05	1.2
RDWJM 032Slab		6.9	9.5	170	9.8	54.8	<0.002	0.01	2.33	3.2	2	1.0	160.0	0.47	<0.05	5.1
RDWJM 033Slab		0.5	5.6	20	2.9	4.5	<0.002	<0.01	1.36	0.8	1	<0.2	35.6	<0.05	<0.05	0.7
RDWJM 033		1.4	20.3	80	4.6	11.4	<0.002	0.01	4.49	3.0	2	0.2	121.5	0.09	<0.05	1.6
RDWJM 034		2.6	7.6	110	4.9	23.2	<0.002	<0.01	0.25	3.0	1	0.5	319	0.17	<0.05	2.0
RDWJM 035Slab		0.4	2.2	60	20.4	8.0	<0.002	<0.01	0.15	0.5	<1	0.3	29.6	<0.05	<0.05	1.1
RDWJM 035		0.7	3.6	140	13.7	6.4	<0.002	0.01	0.29	1.0	<1	0.3	47.3	0.06	<0.05	1.8
RDWJM 036		0.7	1.7	60	7.8	7.1	<0.002	0.19	0.58	0.6	<1	0.3	24.0	0.06	<0.05	1.5
RDWJM 037Slab		0.5	20.4	830	10.0	3.6	<0.002	0.01	7.01	0.3	<1	0.2	16.5	<0.05	<0.05	1.1
RDWJM 037		0.5	49.7	1130	20.4	4.8	<0.002	0.01	18.55	0.6	1	0.2	19.3	<0.05	<0.05	0.9
RDWJM 038		3.6	17.9	320	6.5	28.1	0.003	0.01	0.95	3.8	2	0.6	189.5	0.25	<0.05	3.0
RDWJM 039Slab		0.5	5.6	40	2.8	6.3	<0.002	0.01	0.27	1.8	1	<0.2	301	<0.05	<0.05	0.6
RDWJM 040		0.3	3.6	350	3.0	1.9	<0.002	0.01	0.46	0.2	<1	<0.2	13.6	<0.05	<0.05	0.8
RDWJM 041		3.9	11.3	220	7.4	28.9	0.002	<0.01	0.53	3.8	2	0.6	219	0.27	<0.05	3.5
RDWJM 042		2.2	9.4	360	4.1	15.2	<0.002	0.01	0.27	3.5	1	0.4	163.0	0.14	<0.05	2.6

Comments: ***Corrected copy with PO# 14DA194322 inserted***

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To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	Ag-OG62 Ag ppm 1	Cu-OG62 Cu % 0.001	Pb-OG62 Pb % 0.001	Zn-OG62 Zn % 0.001
JB Bret A		<0.005	<0.02	0.4	6	0.3	6.4	>10000	1.1				3.79
JB Bret B		<0.005	<0.02	0.5	3	<0.1	17.5	318	1.0				
JB Bret Gos		<0.005	0.07	21.0	360	9.1	12.1	>10000	3.2				1.175
RDWJM 001Slab		<0.005	0.12	128.0	150	16.8	8.1	>10000	1.0	143	2.33		3.76
RDWJM 002Slab		<0.005	<0.02	0.8	2	0.1	5.7	224	0.6				
RDWJM 003		0.005	0.04	0.8	22	0.3	9.4	199	2.2				
RDWJM 004Bxa		0.005	0.07	0.9	17	0.7	1.9	185	3.7				
RDWJM 005Slab		<0.005	3.39	12.5	26	5.5	6.0	>10000	0.8	147			>30.0
RDWJM 005		<0.005	0.66	1.6	9	4.1	8.6	>10000	0.5			1.970	13.20
RDWJM 006FeOx		<0.005	0.05	0.5	4	0.1	3.5	1530	1.5				
RDWJM 007Slab		<0.005	0.02	0.5	3	0.1	8.4	435	2.2				
RDWJM 008		0.157	0.06	0.8	17	0.4	5.8	230	30.5				
RDWJM 011		0.054	0.13	1.0	5	0.3	4.9	105	35.6				
RDWJM 012		0.024	0.05	0.5	4	0.2	5.5	56	13.2				
RDWJM 013Slab		0.011	0.03	0.5	3	0.1	3.7	41	4.6				
RDWJM 013		0.059	0.10	1.0	6	0.3	6.0	58	29.1				
RDWJM 014		0.013	0.39	50.2	41	3.2	2.2	453	10.5				
RDWJM 016Slab		0.046	0.07	1.3	6	0.2	6.1	26	21.1				
RDWJM 016		0.056	0.18	1.5	7	0.3	5.6	13	20.0				
RDWJM 017Slab		0.028	0.04	1.0	4	0.2	4.3	19	11.8				
RDWJM 019Slab		0.090	0.08	0.7	18	0.5	16.1	44	27.8				
RDWJM 020		0.009	<0.02	0.3	1	0.1	5.9	29	3.3				
RDWJM 022Slab		0.058	0.06	0.5	10	0.2	11.5	46	20.2				
RDWJM 024Slab		0.006	<0.02	0.6	2	0.1	0.8	11	2.6				
RDWJM 027		0.026	0.04	1.0	16	0.3	6.6	49	10.8				
RDWJM 031		0.032	0.35	4.4	36	3.8	11.8	39	13.1				
RDWJM 032Slab		0.177	0.64	2.2	81	2.2	9.5	63	63.5				
RDWJM 033Slab		0.013	0.21	1.1	10	0.4	3.9	28	6.5				
RDWJM 033		0.036	0.36	1.9	26	1.5	11.1	60	15.9				
RDWJM 034		0.070	0.07	3.7	46	0.5	14.5	21	23.2				
RDWJM 035Slab		0.010	<0.02	0.3	2	0.1	1.8	21	12.5				
RDWJM 035		0.015	<0.02	0.7	7	0.2	2.4	24	21.3				
RDWJM 036		0.019	<0.02	0.4	6	0.1	2.4	11	26.5				
RDWJM 037Slab		0.015	0.02	0.5	10	0.5	3.4	82	15.9				
RDWJM 037		0.013	0.13	0.7	25	1.4	3.4	174	17.7				
RDWJM 038		0.116	0.11	1.8	35	0.5	22.4	57	39.3				
RDWJM 039Slab		0.015	<0.02	1.4	19	0.1	12.4	21	7.2				
RDWJM 040		0.006	<0.02	0.2	2	0.1	1.6	17	8.6				
RDWJM 041		0.132	0.06	1.6	32	0.5	19.4	9	47.2				
RDWJM 042		0.065	0.05	1.1	48	0.4	15.1	26	39.1				

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1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	Au-AA23 Au ppm 0.005	PGM-ICP23 Pt ppm 0.005	PGM-ICP23 Pd ppm 0.001	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1
RDWJM 043		1.37	<0.005	<0.005	<0.001	0.04	0.68	9.2	10	0.09	0.04	4.43	0.24	12.05	1.9	13
RDWJM 044		0.41	<0.005	<0.005	<0.001	0.03	0.73	56.9	10	0.08	0.09	0.43	0.37	17.70	6.5	19
RDWJM 045		0.48	<0.005	<0.005	<0.001	0.07	1.80	220	30	0.24	0.13	0.34	0.57	24.6	7.3	28
RDWJM 046		0.75	<0.005	<0.005	<0.001	0.08	1.64	41.6	20	0.19	0.06	0.12	0.25	19.80	2.3	34
RDWJM 047		0.42	<0.005	<0.005	<0.001	0.05	1.53	34.1	20	0.11	0.06	0.07	0.13	16.60	3.2	31
RDWJM 048		0.84	<0.005	<0.005	0.001	0.14	0.99	>10000	160	0.18	0.07	5.36	0.50	22.0	1.2	69
RDWJM 048ASlab		0.28	<0.005	<0.005	<0.001	0.05	0.08	340	10	0.06	0.02	35.9	0.05	3.87	0.5	3
RDWJM 048CSlab		0.17	<0.005	<0.005	0.001	0.05	0.48	2120	30	0.06	0.06	0.42	0.03	9.43	0.2	19
RDWJM 049Slab		0.30	<0.005	<0.005	<0.001	0.13	0.63	8040	40	0.41	0.05	1.76	1.84	12.80	5.2	15
RDWJM 050A		0.40	<0.005	<0.005	<0.001	0.16	0.29	213	20	0.23	0.03	0.75	0.22	35.7	2.1	13
RDWJM 050B		0.36	0.007	<0.005	0.001	0.03	0.16	41.2	30	0.07	0.01	1.83	0.26	4.99	0.5	13
RDWJM 051		0.65	<0.005	<0.005	0.001	0.02	0.15	62.7	20	0.14	0.01	8.41	0.50	3.13	0.7	6
RDWJM 052		0.52	<0.005	<0.005	0.001	0.07	0.15	9.1	30	0.05	0.01	2.64	0.16	4.53	0.5	11
RDWJM 053		0.84	<0.005	<0.005	0.001	0.04	0.34	89.5	20	0.13	0.02	0.39	0.19	6.46	0.8	7
RDWJM 054		0.90	<0.005	<0.005	0.001	0.04	2.08	227	40	0.25	0.02	0.21	0.05	23.7	0.8	29
RDWJM 055		0.43	<0.005	<0.005	0.001	<0.01	0.36	45.4	30	0.16	0.01	33.5	0.24	9.81	1.1	6
RDWJM 056		0.34	<0.005	<0.005	0.001	0.21	6.11	12.6	420	1.90	0.21	7.11	0.39	72.0	12.3	56
RDWJM 057Slab		0.30	<0.005	<0.005	0.001	<0.01	0.14	0.8	20	0.12	0.03	22.5	0.07	3.45	1.7	2

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RENO NV 89557-0178

Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05	ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	Hg-CV41 Hg ppm 0.01	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01
RDWJM 043		0.40	3.1	0.59	1.53	0.07	0.4	0.03	<0.005	0.19	6.5	2.6	1.27	105	1.47	0.01
RDWJM 044		0.25	8.3	1.42	1.61	0.08	0.5	0.34	0.005	0.16	10.6	3.4	0.05	45	2.20	0.01
RDWJM 045		0.72	9.7	3.90	3.80	0.09	0.9	0.37	0.025	0.48	13.2	6.2	0.10	118	5.35	0.01
RDWJM 046		1.07	5.5	2.30	5.38	0.07	1.0	0.32	0.032	0.41	12.1	6.3	0.11	32	2.06	0.01
RDWJM 047		0.44	6.2	1.14	3.66	0.07	0.9	0.28	0.014	0.28	10.3	5.6	0.07	47	1.66	0.01
RDWJM 048		3.42	14.2	26.7	6.41	0.10	0.6	0.63	0.032	0.78	21.5	5.9	0.14	64	9.32	0.39
RDWJM 048ASlab		0.43	2.3	0.64	0.25	0.06	0.1	0.13	<0.005	0.02	3.5	0.7	0.07	267	0.76	<0.01
RDWJM 048CSlab		1.44	17.0	6.53	1.92	0.06	0.4	0.56	<0.005	0.18	10.6	4.6	0.06	25	2.04	0.01
RDWJM 049Slab		0.54	4.8	9.55	1.34	0.10	0.4	0.45	<0.005	0.14	8.2	5.6	0.25	61	12.80	0.01
RDWJM 050A		0.35	6.3	1.00	1.11	0.08	0.3	0.11	0.005	0.05	17.5	7.1	0.04	71	2.16	<0.01
RDWJM 050B		0.22	1.8	0.40	0.46	<0.05	0.4	0.04	<0.005	0.05	1.9	4.6	0.79	41	1.00	<0.01
RDWJM 051		0.23	1.8	0.41	0.49	<0.05	0.3	0.07	<0.005	0.04	1.3	4.1	1.19	159	0.71	0.01
RDWJM 052		0.27	2.2	0.48	0.45	<0.05	0.4	0.03	<0.005	0.04	1.7	8.6	0.47	77	0.72	0.01
RDWJM 053		0.33	1.8	0.68	0.95	<0.05	0.5	0.14	<0.005	0.13	3.0	4.0	0.06	27	2.43	0.01
RDWJM 054		1.60	2.1	7.03	6.87	0.05	1.7	0.02	0.027	0.92	10.5	3.7	0.12	36	1.66	0.01
RDWJM 055		1.85	1.9	0.43	0.99	<0.05	0.3	0.04	0.005	0.13	4.5	2.7	0.15	189	1.17	0.01
RDWJM 056		9.71	25.7	3.14	16.60	0.10	3.3	0.01	0.061	1.55	35.9	59.7	1.49	227	2.77	0.12
RDWJM 057Slab		0.29	2.6	0.10	0.61	0.33	0.1	<0.01	0.006	0.07	1.3	1.1	12.80	145	0.26	0.02

Comments: ***Corrected copy with PO# 14DA194322 inserted***

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: 775 356 5395 Fax: 775 355 0179 www.alsglobal.com

To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1	ME-MS61 Re ppm 0.002	ME-MS61 S % 0.01	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.2
RDWJM 043		0.8	8.3	1180	3.5	4.8	<0.002	0.01	0.42	1.3	1	0.2	32.6	0.05	<0.05	1.4
RDWJM 044		1.0	12.3	660	5.6	4.0	0.002	0.03	1.73	0.6	1	0.3	40.6	0.06	<0.05	1.5
RDWJM 045		2.3	24.4	850	8.6	12.0	<0.002	0.17	4.06	0.9	<1	0.5	210	0.17	<0.05	2.9
RDWJM 046		3.1	15.7	420	14.3	12.1	<0.002	0.03	1.84	1.1	1	0.8	60.8	0.21	<0.05	3.5
RDWJM 047		2.8	10.8	220	7.0	8.9	<0.002	0.02	1.08	1.1	1	0.5	47.5	0.18	<0.05	2.9
RDWJM 048		1.5	12.5	800	18.0	30.1	0.002	2.11	410	2.4	3	0.4	421	0.09	0.10	2.8
RDWJM 048ASlab		0.1	2.1	50	1.2	0.9	<0.002	0.03	7.23	0.7	<1	<0.2	67.2	<0.05	<0.05	0.2
RDWJM 048CSlab		1.0	1.6	170	1.4	7.4	<0.002	0.04	72.7	0.4	4	2.7	152.5	<0.05	0.06	0.7
RDWJM 049Slab		0.6	29.2	710	8.1	3.9	<0.002	0.03	13.25	3.2	12	0.3	87.1	<0.05	<0.05	1.4
RDWJM 050A		0.5	5.6	330	111.0	1.9	<0.002	0.01	5.54	0.4	1	0.2	47.2	<0.05	<0.05	1.6
RDWJM 050B		0.3	1.8	70	13.0	1.3	<0.002	0.01	1.16	0.2	1	<0.2	14.5	<0.05	<0.05	0.8
RDWJM 051		0.3	2.4	40	19.8	1.3	<0.002	<0.01	1.91	0.2	1	<0.2	16.2	<0.05	<0.05	0.6
RDWJM 052		0.4	1.8	80	7.0	1.3	<0.002	0.02	0.85	0.3	1	<0.2	15.7	<0.05	<0.05	0.9
RDWJM 053		0.6	5.5	70	2.2	3.4	<0.002	0.01	13.10	0.3	1	<0.2	14.4	0.05	<0.05	1.2
RDWJM 054		1.8	3.3	280	6.0	19.8	<0.002	0.47	3.48	1.7	1	0.4	54.3	0.15	<0.05	3.7
RDWJM 055		1.0	1.4	40	3.3	5.8	<0.002	0.01	3.10	1.0	2	0.2	122.0	0.05	<0.05	0.9
RDWJM 056		12.9	34.1	960	16.5	87.9	<0.002	0.01	1.00	11.4	2	2.2	191.5	0.94	0.05	11.4
RDWJM 057Slab		0.6	0.6	50	3.5	2.3	<0.002	<0.01	0.44	0.4	1	<0.2	45.6	<0.05	<0.05	0.3

Comments: ***Corrected copy with PO# 14DA194322 inserted***

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: 775 356 5395 Fax: 775 355 0179 www.alsglobal.com

To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	Ag-OG62 Ag ppm 1	Cu-OG62 Cu % 0.001	Pb-OG62 Pb % 0.001	Zn-OG62 Zn % 0.001
RDWJM 043		0.027	0.08	0.9	12	0.2	7.4	26	12.4				
RDWJM 044		0.029	0.09	1.1	17	0.3	3.6	57	15.6				
RDWJM 045		0.076	0.10	2.1	48	0.5	5.3	81	31.6				
RDWJM 046		0.091	0.04	2.0	53	0.5	3.7	12	37.2				
RDWJM 047		0.080	0.09	1.3	33	0.6	3.1	7	33.5				
RDWJM 048		0.058	127.0	11.8	79	0.6	5.0	39	20.9				
RDWJM 048ASlab		0.005	5.91	2.7	8	0.1	8.6	5	3.6				
RDWJM 048CSlab		0.050	1.43	1.7	16	0.5	1.4	3	13.4				
RDWJM 049Slab		0.018	0.38	11.7	53	0.6	18.5	181	14.0				
RDWJM 050A		0.016	0.19	0.9	11	1.0	2.3	200	16.3				
RDWJM 050B		0.008	0.05	0.3	2	0.2	1.0	33	11.4				
RDWJM 051		0.007	0.06	0.4	4	0.2	1.5	58	10.0				
RDWJM 052		0.009	0.06	0.4	1	0.2	1.5	12	11.4				
RDWJM 053		0.018	0.04	0.6	3	0.6	1.2	80	15.5				
RDWJM 054		0.061	0.15	1.0	28	0.4	5.6	4	54.9				
RDWJM 055		0.018	0.06	0.6	7	1.3	6.4	14	10.7				
RDWJM 056		0.359	0.61	3.8	86	1.5	26.5	92	115.5				
RDWJM 057Slab		0.009	0.05	0.5	5	0.3	2.4	3	5.0				

Comments: ***Corrected copy with PO# 14DA194322 inserted***

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1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 16-JAN-2014
Account: BMGN

CERTIFICATE OF ANALYSIS RE13230096

CERTIFICATE COMMENTS

Method	
ME-MS61	REE's may not be totally soluble in this method.
Hg-CV41	Detection limits on samples requiring dilutions due to interferences or high concentration levels have been increased according to the dilution factor.
Au-AA23	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
CRU-21	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
CRU-31	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
CRU-QC	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
LOG-22	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
PUL-31	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
PUL-QC	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
SPL-21	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
WEI-21	Processed at ALS Reno located at 4977 Energy Way, Reno, NV, USA.
Ag-OG62	Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
Cu-OG62	Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
Hg-CV41	Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
ME-MS61	Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
ME-OG62	Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
PGM-ICP23	Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
Pb-OG62	Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
Zn-OG62	Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

ALS USA Inc.
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To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 8-JAN-2014
Account: BMGN

CERTIFICATE WN13230663

Project: 2013 DNWR Playa Samples
P.O. No.:
This report is for 6 Soil samples submitted to our lab in Winnemucca, NV, USA on 30-DEC-2013.
The following have access to data associated with this certificate:

JOHN MUNTEAN		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SCR-41	Screen to -180um and save both

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
Hg-CV41	Trace Hg - cold vapor/AAS	FIMS
PGM-ICP23	Pt, Pd, Au 30g FA ICP	ICP-AES
Au-AA23	Au 30g FA-AA finish	AAS
ME-MS61	48 element four acid ICP-MS	

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project. Statement required by Nevada State Law NRS 519

To: NEVADA BUREAU OF MINES & GEOLOGY
ATTN: JOHN MUNTEAN
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS USA Inc.
4977 Energy Way
Reno NV 89502
Phone: 775 356 5395 Fax: 775 355 0179 www.alsglobal.com

To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 8-JAN-2014
Account: BMGN

Project: 2013 DNWR Playa Samples

CERTIFICATE OF ANALYSIS WN13230663

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	Au-AA23 Au ppm 0.005	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2
DNWR-Playa-1		1.39	<0.005	0.07	3.37	36.2	410	1.08	0.14	10.55	0.15	37.4	4.5	17	3.76	12.5
DNWR-Playa-2		1.44	<0.005	0.07	3.52	20.2	410	1.16	0.13	10.10	0.12	37.0	4.3	16	3.57	10.4
DNWR-Playa-3		1.28	<0.005	0.06	3.95	18.5	360	1.37	0.16	9.50	0.17	43.1	5.4	20	4.50	12.6
DNWR-Playa-4		1.29	<0.005	0.08	4.08	17.7	360	1.43	0.16	8.71	0.17	40.8	5.5	20	4.74	13.0
DNWR-Playa-5		1.29	<0.005	0.07	4.17	15.5	380	1.54	0.16	8.14	0.17	43.1	5.5	20	4.83	13.2
DNWR-Playa-6		1.22	<0.005	0.07	4.65	16.7	390	1.54	0.16	8.03	0.17	43.5	5.8	22	5.44	14.1

***** See Appendix Page for comments regarding this certificate *****

ALS USA Inc.
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To: NEVADA BUREAU OF MINES & GEOLOGY
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 8-JAN-2014
Account: BMGN

Project: 2013 DNWR Playa Samples

CERTIFICATE OF ANALYSIS WN13230663

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05	ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	Hg-CV41 Hg ppm 0.01	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2
DNWR-Playa-1		1.25	8.68	0.06	1.3	0.01	0.026	1.57	18.5	65.8	6.04	376	1.44	1.27	6.9	10.8
DNWR-Playa-2		1.22	9.13	0.10	1.3	0.02	0.028	1.69	18.8	55.0	5.20	365	0.75	1.62	6.9	9.9
DNWR-Playa-3		1.53	10.65	0.15	1.6	0.02	0.036	1.99	21.7	59.0	4.94	458	2.19	2.11	7.9	12.7
DNWR-Playa-4		1.58	10.90	0.12	1.7	0.01	0.031	2.05	20.0	59.0	4.63	467	1.95	2.66	8.1	12.8
DNWR-Playa-5		1.61	11.05	0.13	1.7	0.01	0.032	2.09	21.3	59.8	4.59	465	1.06	2.58	8.4	13.5
DNWR-Playa-6		1.79	11.80	0.15	1.9	0.02	0.031	2.37	21.3	64.3	4.80	517	1.17	2.52	9.0	14.1

***** See Appendix Page for comments regarding this certificate *****

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1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 8-JAN-2014
Account: BMGN

Project: 2013 DNWR Playa Samples

CERTIFICATE OF ANALYSIS WN13230663

Sample Description	Method / Analyte / Units / LOR	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1	ME-MS61 Re ppm 0.002	ME-MS61 S % 0.01	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.2	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02
DNWR-Playa-1		520	10.7	68.1	0.002	0.57	0.94	4.4	1	0.9	1350	0.47	<0.05	6.3	0.125	0.37
DNWR-Playa-2		540	9.9	67.3	<0.002	0.39	0.85	4.3	1	1.0	893	0.49	<0.05	6.2	0.119	0.33
DNWR-Playa-3		680	11.6	76.6	<0.002	0.44	0.93	5.2	1	1.2	727	0.57	<0.05	7.4	0.142	0.37
DNWR-Playa-4		660	11.5	79.2	0.002	0.73	1.03	5.3	1	1.2	668	0.61	<0.05	7.4	0.141	0.39
DNWR-Playa-5		610	12.6	80.1	<0.002	0.77	1.01	5.4	1	1.2	648	0.62	<0.05	7.6	0.143	0.40
DNWR-Playa-6		640	12.2	87.4	<0.002	0.58	1.12	5.9	1	1.4	717	0.64	<0.05	8.0	0.159	0.45

***** See Appendix Page for comments regarding this certificate *****

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UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 8-JAN-2014
Account: BMGN

Project: 2013 DNWR Playa Samples

CERTIFICATE OF ANALYSIS WN13230663

Sample Description	Method / Analyte / Units / LOR	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5	PGM-ICP23 Au ppm 0.001	PGM-ICP23 Pt ppm 0.005	PGM-ICP23 Pd ppm 0.001
DNWR-Playa-1		3.8	40	1.7	9.9	45	48.0	<0.001	<0.005	<0.001
DNWR-Playa-2		2.2	41	1.5	10.1	42	47.0	<0.001	<0.005	<0.001
DNWR-Playa-3		3.2	44	1.6	11.6	55	56.5	<0.001	<0.005	<0.001
DNWR-Playa-4		2.6	47	2.1	11.3	57	59.6	<0.001	<0.005	<0.001
DNWR-Playa-5		1.8	51	1.8	12.1	60	59.2	0.001	<0.005	<0.001
DNWR-Playa-6		2.0	60	1.9	13.1	67	65.6	0.001	<0.005	<0.001

***** See Appendix Page for comments regarding this certificate *****

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1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 8-JAN-2014
Account: BMGN

Project: 2013 DNWR Playa Samples

CERTIFICATE OF ANALYSIS WN13230663

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REE's may not be totally soluble in this method.
Applies to Method: ME-MS61

LABORATORY ADDRESSES

Processed at ALS Winnemucca located at 3275 Fountain Way, Winnemucca, NV, USA.
Applies to Method: LOG-22 SCR-41 WEI-21

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.
Applies to Method: Au-AA23 Hg-CV41 ME-MS61 PGM-ICP23

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To: NEVADA BUREAU OF MINES & GEOLOGY
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1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 25-JAN-2014
Account: BMGN

CERTIFICATE RE14011521

Project: 2013 DNWR Playa Samples
P.O. No.:
This report is for 6 Soil samples submitted to our lab in Winnemucca, NV, USA on 22-JAN-2014.
The following have access to data associated with this certificate:

JOHN MUNTEAN		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
FND-02a	Find Sample at Branch Lab

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-ICP41	35 Element Aqua Regia ICP-AES	ICP-AES

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project. Statement required by Nevada State Law NRS 519

To: NEVADA BUREAU OF MINES & GEOLOGY
ATTN: JOHN MUNTEAN
UNR, MS - 178
1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS USA Inc.
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1664 NORTH VIRGINIA ST.
RENO NV 89557-0178

Finalized Date: 25-JAN-2014
Account: BMGN

Project: 2013 DNWR Playa Samples

CERTIFICATE OF ANALYSIS RE14011521

Sample Description	Method Analyte Units LOR	ME-ICP41 B ppm 10
DNWR-Playa-1		350
DNWR-Playa-2		200
DNWR-Playa-3		220
DNWR-Playa-4		210
DNWR-Playa-5		190
DNWR-Playa-6		220

***** See Appendix Page for comments regarding this certificate *****

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Finalized Date: 25-JAN-2014
Account: BMGN

Project: 2013 DNWR Playa Samples

CERTIFICATE OF ANALYSIS RE14011521

CERTIFICATE COMMENTS

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:	FND-02a	ME-ICP41

Appendix C

List of GIS Data Compiled by NBMG for the DNWR

1. Mineral Deposit Data
   - Locations and descriptions of known mineral deposits and prospects in the DNW
   - Active Nevada mines (2012-2013)
   - Mining districts
   - Mining features from USGS 1:24,000 topographic quadrangle maps
   - USGS Mineral Resource Data System points (locations of mineral deposits)
   - Industrial mineral deposit locations in Nevada
   - Gold and silver deposits of Nevada
   - Significant gold, silver, copper, and/or molybdenum deposits of Nevada
2. Geothermal Data
   - Geothermal well data
   - Well temperature data
   - Spring temperature data
   - Known regional geothermal system
3. Petroleum Data
   - Oil wells
   - Seep shows
   - Source rocks
4. Geologic Data
   - Quaternary faults
   - Conodont data (age and color alteration index)
   - Geotectonic terrain boundaries
   - 2013 NBMG field stations/notes
5. Geologic Maps that cover the DNWR or areas near the DNWR
   a. Vector Data
      - State map of Nevada by E. Crafford (slightly modified from Stewart and Carlson, 1978)
      - Geologic Map of Parts of the Colorado, White River, and Death Valley Groundwater Flow Systems, by Page et al., (2005), NBMG Map 150.
      - 4 other published maps
   b. Raster Data
      - Geologic Map of Nevada by Stewart and Carlson (1978)
      - Geologic Map of the Pahranagat Range 30’ x 60’ Quadrangle, Lincoln and Nye Counties, Nevada by Jayko (2007), USGS Scientific Investigations Map 2904
      - 17 other published maps
6. Geochronology
   - Various databases of age dates from the USGS and NBMG
7. DNWR Geochemical Data

a. NBMG 1993
    - Rock-chip samples of mineralized material
    - Limonitic chips in stream sediment samples
    - Stream sediment silt samples
    - Geochemical characterization (background) rock samples
b. NBMG 2014
    - Rock-chip samples
    - Playa samples

8. Remote Sensing Data generated by NBMG in 2013-2014
    - ASTER – various band ratio combination and mineral map images
    - Landsat TM – various band ration combination and mineral map images
9. USGS 1996 Assessment of Nevada's Mineral Potential (NBMG OFR96-2)
    - Gravity data and thickness of Cenozoic rocks
    - Magnetic data
    - Geology
    - Tertiary magmatism
    - Cenozoic mineral deposits and igneous rocks
    - Granitic plutons interpreted from magnetic data
    - Subsurface basin geometry
    - Photogeologic interpreted young faults
    - Pluton-related mineral deposits
    - Epithermal and other mineral deposits
    - Permissive tracts for mineral deposits
10. Base Map Data
    - Rivers and streams
    - Towns and cities
    - Boundary data
    - Roads
    - Topographic data: 1:24,000 and 1:100,000 digital raster graphs of USGS topo maps
    - NAIP Imagery
    - DEM data
11. Mineral Deposits and Geothermal Energy Potential Maps
    a. NBMG 1993
    b. NBMG 2014