CONTRACT YA-553-CT1-1096

GEOCHEMICAL AND GEOSTATISTICAL EVALUATION
WILDERNESS STUDY AREAS,
WINNEMUCCA DISTRICT, NORTHWEST NEVADA

VOLUME I

Prepared for:

United States Bureau of Land Management

Prepared by:

R.A. Connors
M.L. Robinson
J.F. Bukofski
W.T. Meyer
R.J. Howarth

Barringer Resources Inc.
1626 Cole Blvd., Suite 120
Golden, Colorado 80401

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ABSTRACT

Barringer Resources Inc., has undertaken a geochemical-geostatistical study of the Wilderness Study Areas in the Winnemucca District, Northwestern Nevada, for the Bureau of Land Management. As an aid in assessing the mineral potential of the area, 1900 stream sediment samples were collected and analyzed for 33 elements.

The data set was interpreted using factor analysis, characteristic analysis, and descriptive statistics. Multiple regression techniques were applied to regional geologic data. Eight elements not clearly accounted for in geostatistical processing were presented as single-element maps. Twenty areas within the district were shown to have some degree of potential for mineral exploitation.

Should a similar project be considered in the future, two recommendations are: 1) sample numbers and density should be closely matched to the geologic complexity of the areas being sampled; 2) rock chip geochemistry should be included in order to aid and expand the interpretation of the stream sediment geochemical data.

CONCLUSIONS

In order to evaluate the mineral potential of the Wilderness Study Areas in the Winnemucca District, an integrated geological, geophysical and geochemical approach was taken. Geological and geophysical background was obtained through extensive literature research, while geochemical information was largely assembled by means of a multi-element stream sediment survey of the area. Computer techniques were then used to integrate the quantified data in order to classify the areas according to mineral potential. This study does not provide data which will allow the assignment of economic significance to the individual anomalous areas, nor will it indicate whether or not a mine is present. However, the results do provide information on where mineralization may logically be expected to occur.

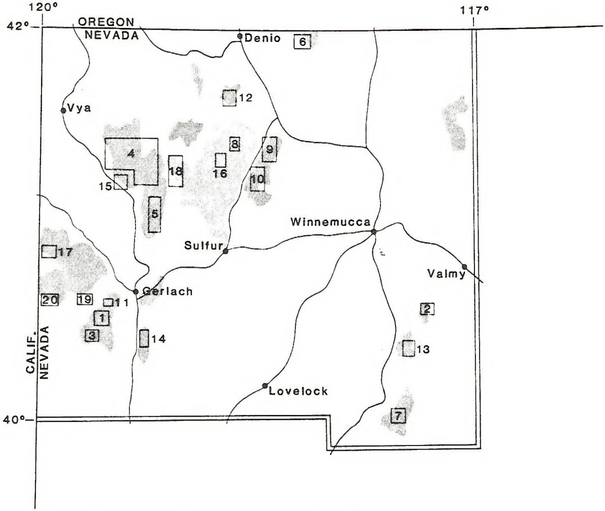
Twenty anomalous areas within Wilderness Study Areas of the Winnemucca District proved to be of significant mineral interest when classified by one or more analytical techniques. Anomalous areas are listed in Table 1 by location and method of interpretation. Figure 1 shows the locations of these regions within the study area. These twenty areas represent a significant mineral potential. While it may be useful for purposes of discussion to rank the areas, it should be kept in mind that all twenty areas are significantly above background in some geochemical parameter.

Some interpretational ambiguity was noted in two of the rated areas, namely Leonard Creek Slough (Black Rock Desert) and Smoke Creek Reservoir. In the Leonard Creek Slough area additional field work would be required to determine the possible influence of geothermal activity or drainage from a known mining district on the observed geochemical anomaly. At Smoke Creek, the geochemical anomaly in tungsten and zinc does not fit known models of mineralization, and detailed field investigations should be carried out to verify the geochemical data.

TABLE 1. ANOMALOUS AREAS WITHIN THE WILDERNESS STUDY AREAS, WINNEMUCCA DISTRICT, NEVADA

Area	Forecast Mineral Exploitation Index (page 43)	Factors (pages 35–40)			Characteristic Models (pages 47–48)					Single Element Plots (pages 32–33)							
		4	7	8	Hg	Mafic Cu–Ni	Base & Precious Metals	Vol-canic U	Epi-thermal Au & Ag	W	Ba	Zn	Mo	U	Hg	Ag	Au
Central Fox Range	3	1	3	1	3	—	2	—	1–2	—	2	1	1	—	2	2	—
China Mountain	2	1	1	1	Not Covered					—	1	2	—	—	3	2	—
Southern Fox Range	2	1	3	2	—	—	3	—	2	—	3	2	2	—	2	3	—
Northern Calico Mountains	—	1	3	3	—	1	—	3	—	3	1+	—	2	—	2	3	2
Southern Calico Mountains	—	2	2		—	3	—	2	—	2	3	—	—	—	—	2	—
Disaster Peak	3	—	—	—	—	—	—	2	3	2	—	—	—	3	2	—	2
Augusta Mountains	2	2	—	—	—	3	—	2	3	3	—	1	—	—	—	—	—
Leonard Creek Slough (Black Rock Desert)	—	2	—	—	3	3	3	—	3	3	3	—	3	—	3	—	—
Northern Jackson Mountains	—	2	—	3	—	—	3	3	3	—	—	—	—	—	3	3	—
Southern Jackson Mountains	—	—	3	3	—	1	3	—	3	3	—	—	3	—	3	—	2
Northern Fox Range	—	—	—	—	—	—	3	—	—	—	—	—	—	2	3	—	—
Duffer Peak	2	—	3	3	—	—	—	3	—	—	—	—	3	1	1	—	—
Mount Tobin	2	—	1	—	—	—	—	—	—	1	—	—	—	—	1	—	—
Southern Selenite Range	—	3	—	—	—	—	—	—	—	—	—	3	—	1	—	—	—
Butte Spring	—	—	3	3	—	—	—	—	—	3	—	—	2	—	—	—	—
Pinto Mountain	—	—	—	—	—	—	—	—	—	1	—	3	—	—	—	—	—
Hole in the Ground	—	—	—	—	—	2	—	—	—	—	—	3	—	—	—	—	—
Central Black Rock Range	—	—	—	—	—	3	3	—	3	—	3	3	3	—	—	—	—
Hog Spring	—	—	—	—	—	2	—	3	—	—	—	—	—	—	2	—	—
Smoke Creek	—	—	—	—	—	—	—	—	—	3	—	—	—	—	3	—	—

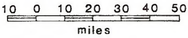
1 Strong response   2 Intermediate response   3 Isolated anomalous value



1. Central Fox Range
2. China Mountain
3. Southern Fox Range
4. Northern Calico Mountains
5. Southern Calico Mountains
6. Disaster Peak
7. Augusta Mountains
8. Leonard Creek Slough
9. Northern Jackson Mountains
10. Southern Jackson Mountains
11. Northern Fox Range
12. Duffer Peak
13. Mt. Tobin
14. Southern Selenite Range
15. Butte Spring
16. Pinto Mountain
17. Hole in the Ground
18. Central Black Rock Range
19. Hog Spring
20. Smoke Creek

▨ Wilderness Study Areas

Approximate Scale



LOCATION OF ANOMALOUS AREAS
WITHIN THE WILDERNESS STUDY AREAS
WINNEMUCCA DISTRICT, NEVADA

Figure 1

BARRINGER RESOURCES

INTRODUCTION

Barringer Resources Inc., on behalf of the Nevada State office of the Bureau of Land Management, has undertaken a geochemical-geostatistical study of the Wilderness Study Areas within or adjacent to the Winnemucca District of Nevada (Contract #YA-553-CT1-1096). The purpose of this study was to assess their present mineral potential. The work plan consisted of the following seven phases:

Phase I	Collection of 1900 stream sediment and heavy mineral samples and compilation of published geologic data.
Phase II	Geochemical analysis of stream sediment samples for 33 elements selected by Bureau of Land Management personnel.
Phase III	Data processing including: 1) Digitizing sample locations, geology, mine workings and prospects. 2) Determination of means, standard deviations, correlation coefficients, standard normalized values, and grid cell geochemical averages.
Phase IV	Geological modeling to determine possible mineralization within the study area.
Phase V	Evaluation of geostatistical analyses including factor, multiple regression, characteristic, and discriminant techniques. Selection of two or more geostatistical techniques which best describe the data from the study area.
Phase VI	Integration and interpretation of geochemical data, geostatistical results and geological modeling.
Phase VII	Final report preparation.

The report consists of eight sections: Abstract, Conclusions, Introduction, General Geology, Geochemistry, Data Base Development, Geostatistics and Discussion and Recommendations. Maps, geochemical data and geostatistical output have been placed into appendices to allow easy access to the data. Maps showing geochemical data or geostatistical output (Appendices A, B, and C) include approximate boundaries of the Wilderness Study Areas. The areas are labeled with the numerical code set out in U.S. Bureau of Land Management Wilderness Status Map, June 1981.

APPROACH

The approach used by Barringer Resources, Inc., was to use as much available information and data as possible to guide the interpretation of the data generated during the field work. Thus, online and manual literature searches were initiated before, during, and after the field work. Data processing and statistical methods are applied to the data in order to extract as much information as possible. The following portions of this report demonstrate the combination of geological modelling based on the literature and statistical identification and interpretation of empirical relationships within the data set.

Acknowledgement is made to the individuals and mining companies with active exploration programs within the area for proprietary information to which we were allowed access. This information contributed to the meaningful interpretation of data within the area. Personnel of the Bureau of Land Management aided in this survey by their support, assistance with land access, and general background knowledge of the area.

GENERAL GEOLOGY

INTRODUCTION

The study area is located in northwestern Nevada between 117^{o} and 120^{o} west longitude and $39^{o}45'$ and 42^{o} north latitude. This area is in the Basin and Range structural province of the Great Basin. The Basin and Range is bounded on the west by the Sierra Nevada Batholith, on the north by the Snake River Basalts, and on the east by the Colorado Plateau (Figure 2). This area has been at or near a plate boundary for most of Phanerozoic time and consequently displays considerable complexity in tectonic and petrologic detail.

STRUCTURE AND TECTONICS

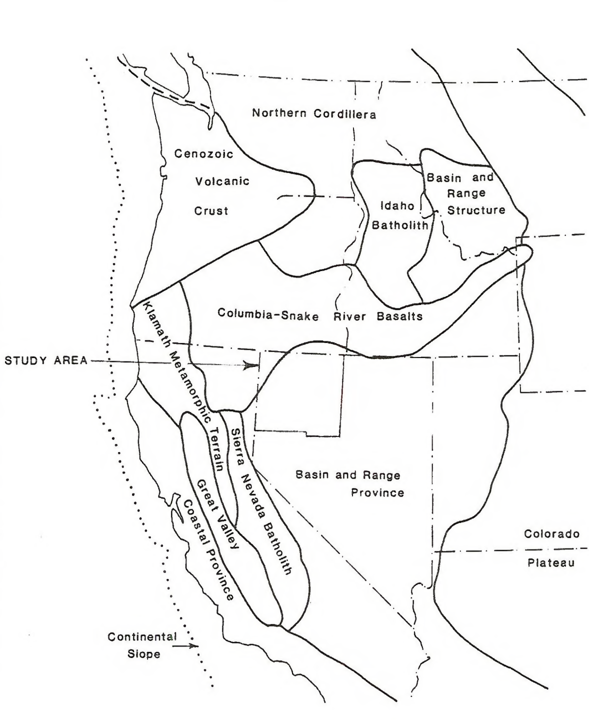
The following section is summarized from Stewart (1980), except where otherwise noted.

Pre-Antler Orogeny Structures

Assymetrically folded and overturned Cambrian rock units at Edna Mountain in Humboldt County have been ascribed to a late Cambrian tectonic event. This event is not recorded in other areas of Nevada, so must be considered local in extent.

Antler Orogeny Structures

The Devonian and early Mississippian Antler Orogeny created only minor folding. The principal structure created during this event is the Roberts Mountain Thrust. The thrust moved siliceous, deep-water sediments and volcanics up to 90 miles east and emplaced them on shelf clastic and carbonate units. The thickened section created the north and northeast trending Antler Highlands. Erosion of these highlands provided the coarse clastic sediment



after Hamilton and Myers, 1966.

STRUCTURAL PROVINCES OF THE WESTERN UNITED STATES

Figure 2

BARRINGER RESOURCES

found in basins on either side. The location of the leading edge of the thrust and the Antler Highlands relative to the study area is indicated in Figure 3. In the study area, lower plate rocks crop out in the Osgood Mountains, Edna Mountain, Battle Mountain, and Sonoma Range. Upper plate rocks are divided into broad, thin, interleaved thrust plates.

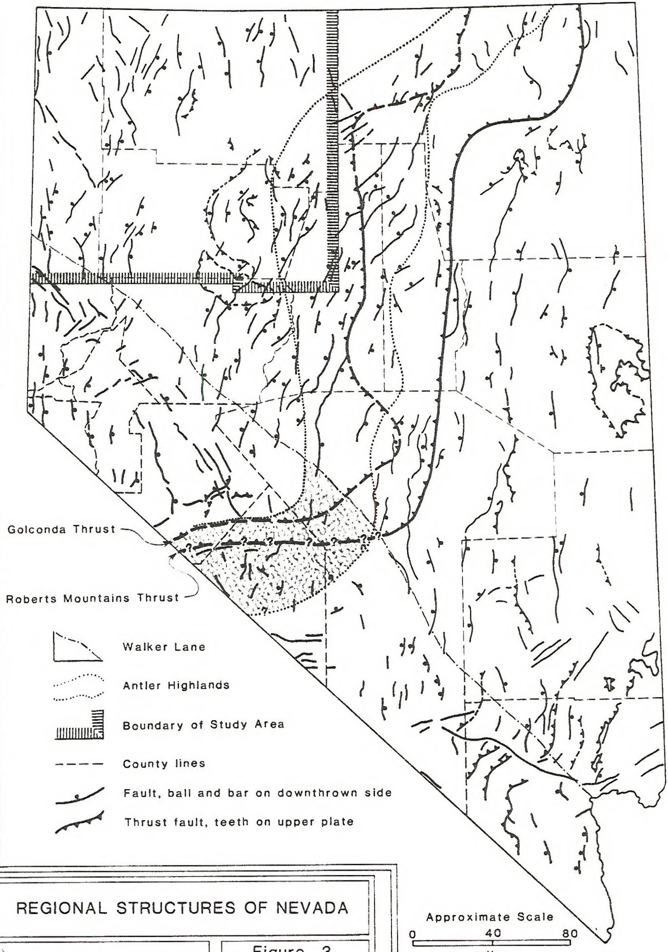
Following the Antler Orogeny, the Antler Highlands continued to be uplifted through late Paleozoic time as evidenced by accumulations of coarse clastic sediments along its flanks. Broad uplift of much of central and northeastern Nevada during Pennsylvanian time is seen in a widespread unconformity. Thrusting and folding of Pennsylvanian and lower Permian rocks at Edna Mountain in Humboldt County suggest local tectonic activity during Permian time, although this opinion is not wholly accepted (Stewart, 1980, p. 59).

Sonoma Orogeny Structures

The late Permian-early Triassic Sonoma Orogeny caused folding and faulting in Pennsylvanian and Permian rocks in northern and north central Nevada. The Golconda thrust which has recently been assigned to the Sonoma event consists of siliceous deep water sediments and volcanics tectonically emplaced on terrigenous detrital and carbonate rocks. The upper plate of this thrust consists of subtle complicated homoclinal folds and interleaved bedding plane thrusts. Figure 3 shows the leading edge of this feature relative to the study area.

Post Sonoma Orogeny Structures

Smaller scale post-Sonoma thrusting, folding and tectono-clastic sedimentation started in Central and Northern Nevada during late Triassic or early Jurassic time. In the study area, these features are seen as elements of the Fencemaker, Clear Creek, and Deer Creek Thrusts. Open and overturned folds with north and northeast trending axes accompany these faults.



REGIONAL STRUCTURES OF NEVADA

Figure 3

BARRINGER RESOURCES

A broad belt of irregular topography termed the Walker Belt or Walker Lane roughly parallels the southwestern border of Nevada. This belt includes the southwest corner of the study area (see Figure 3). The nature of boundaries, timing, and amount of movement along this feature are the subject of considerable debate among geologists. The sense of movement is right lateral, and deformation as early as late Jurassic is possible. Mid-Tertiary volcanic units have apparently been offset, while late Tertiary volcanic rocks in the same area have not. Cumulative right lateral movement may be as much as 20 miles (Stewart, 1980, p. 86-87).

Basin and Range Structures

Extensional tectonics apparently started about 17 m.y. ago and continue into recent times. This event is seen as a series of northwesterly, northerly, and northeasterly trending normal and reverse faults (see Figure 3). These range front faults create the characteristic Basin and Range topography evident in Nevada today. Evidence from various parts of the province suggest three theories of deformation. The first is a horst and graben system in which the range front faults extend in planes downward to a shallow depth where they intersect. The second theory is that the faults flatten with depth to listric normal faults. The ranges represent tilted slices of the sedimentary section. The third theory is that the Basin and Range is a series of tilted, fault bounded, elongate, rhombohedral blocks. The edge tilted up forms a range, and the part tilted down forms a basin. There is no commonly held theory at present. Estimates of crustal extension range from 10% to 100% depending on the deformation model of the estimator.

Tectonics

Many explanations of the tectonic features seen in the Basin and Range have been advanced. Vertical tectonics, erosion and sedimentation, and mineral phase changes in the mantle have been advanced by Roberts (1968, 1972). Other workers, including Hamilton and Myers (1966), Atwater (1970), and Burchfiel and Davis (1972), have proposed various schemes of interaction between lithospheric plates to explain the structural and igneous features. No uniformity of opinion has been reached in the literature, and the reader is referred to Stewart (1980), for a review of these theories and their supporting evidence.

STRATIGRAPHY

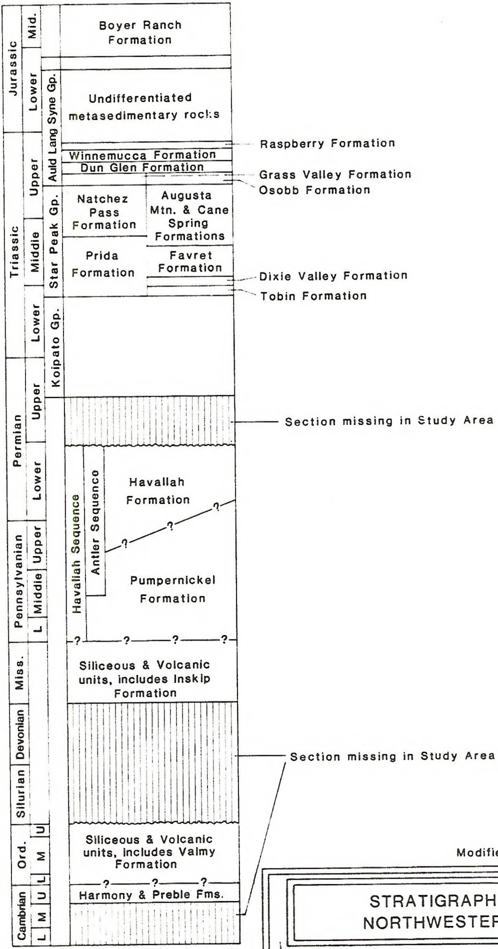
The oldest units in the study area occur in windows through the Roberts Mountain Thrust in the Osgood Mountains, Sonoma Range, East Range, Hot Springs Range, and Battle Mountain. These rocks are shale, thinly bedded limestone, quartzite, conglomerate, siltstone, and dolomite of Cambrian age (Figure 4). They are overlain by the upper Cambrian Harmony formation which is largely composed of feldspathic arkose.

Ordovician siliceous and volcanic rocks, the Valmy formation throughout much of the study area, are tectonically emplaced above the Cambrian units. They are overlain by Mississippian siliceous and volcanic rocks. The Mississippian is represented by the Inskip formation through most of the area.

Pennsylvanian and Permian rocks are composed of clastic, thin carbonate, and greenstone units of the Havallah and Antler sequences.

Mesozoic clastic and carbonate units are widely distributed through the study area. These complex units are adjacent to and interfinger with Permo-Triassic andesitic flows, rhyolite tuffs and flow breccias, and related volcanoclastic rocks.

Plutonic rocks from Jurassic to mid-Tertiary in age are widely distributed within the study area. Most of the bodies are granodiorite to quartz monzonite in composition and of Cretaceous age. Several Jurassic plutons crop out near the southeast corner of Humboldt County, and several Cretaceous diorite bodies occur in the central part of the area (Plate I). Smith, et al., (1971), noted that the granitic rocks are petrographically and chemically similar to intrusive rocks of the same age in the Sierra Nevada and Idaho



Modified from Johnson, 1977

STRATIGRAPHIC UNITS,
NORTHWESTERN NEVADA

BARRINGER RESOURCES

Figure 4

Batholiths. If so, the study area may lie astride a zone of intrusions connecting the north end of the Sierra Nevada Batholith with the south end of the Idaho Batholith.

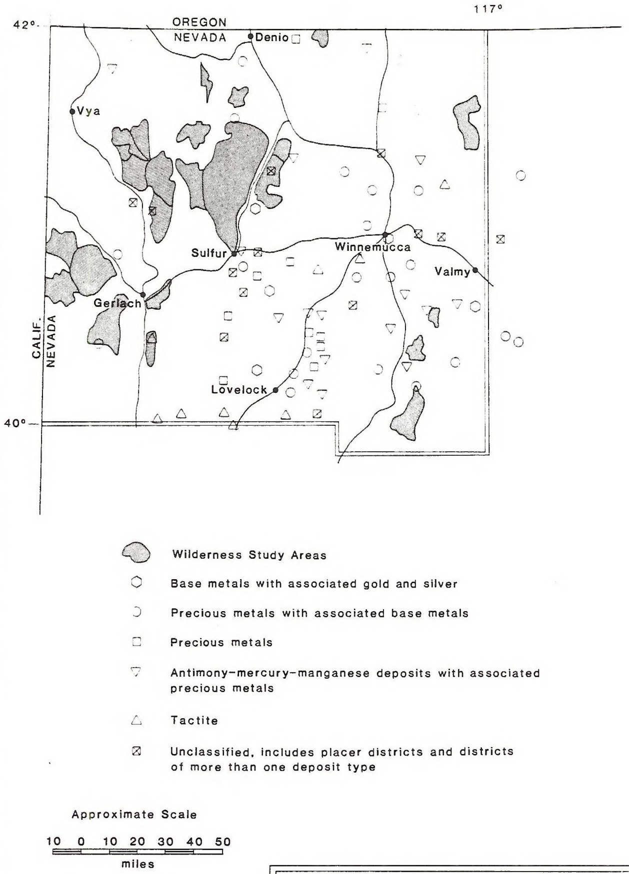
Cenozoic volcanism started in northeast Nevada about 40 m.y. ago and continued, migrating outward, until about 6 m.y. ago (Anderson, et al., 1969). The volcanic activity was episodic with andesite to quartz latite lavas and hypabyssal intrusives followed by rhyolitic tuffs and ash flow sheets and ending with bimodal basalt-rhyolite flows and domes (McKee and Silberman, 1970). Statewide geologic mapping (Stewart and Carlson, 1974), shows that the study area does not include most early event rocks. Silicic flows and ash flow sheets dated at 34 m.y. to 17 m.y. are present in the central and western parts of the study area. The youngest episode, dated from 17 to 6 m.y. includes the Snake River Basalts to the north. These andesite, basalt, and rhyolite flows, domes, ashflows, and hypabyssal intrusives are distributed throughout the area.

MINERAL DEPOSITS

The following section discusses mineral deposits of many types. Some deposits such as oil and gas, coal, geothermal, and various industrial minerals are not assessible by multielement reconnaissance geochemical techniques.

Mining Districts

There are 74 mining districts in the region (Plate II and Figure 5). The mineral deposits developed in these districts include tactites, base and precious metal vein deposits, and antimony-mercury-precious metal deposits. Table 2 lists the deposits in these groups. The production of most districts is small with only Battle Mountain having more than 100 million dollars worth of accumulated production up to 1976 (Schilling, 1976). Major features of the districts are tabulated on Plate II.



LOCATION OF
METAL MINING DISTRICTS,
NORTHWESTERN NEVADA

Figure 5

BARRINGER RESOURCES

Table 2
Mining Districts, Northwestern Nevada

DEPOSIT TYPE	NUMBER OF DISTRICTS*
Tactite	13
Base Metals with associated gold and silver	5
Gold and silver with associated base metals	24
Gold and silver	13
Mercury, antimony, manganese with associated gold and silver	15
Placer	5

Data from Schilling, 1976
* Districts with more than one type of deposit are listed with each type.

Tactites

Tactite deposits are the major source of tungsten in the study area. Byproduct amounts of copper, zinc, and gold are recovered from some deposits as well. The principal tactite districts are: Potosi, Mill City Rosecreek, Ragged Top, and Hooker. The tactites are usually formed where Jurassic or Cretaceous granodiorite bodies intrude Paleozoic or Mesozoic carbonate or calcareous shale units. Scheelite, pyrite, chalcopyrite, powellite, molybdenite and pyrrhotite occur in a gangue of quartz, actinolite, tremolite, pyroxene, garnet, epidote, and calcite. Realgar and orpiment are prominent gangue minerals at the Getchell Mine.

Base Metals with Associated Gold and Silver

The districts producing principally base metals with associated precious metals are: Battle Mountain, Arabia, Antelope, Red Butte, and Harmony. These deposits are principally fault and fracture controlled veins in sedimentary, metasedimentary, and volcanic rocks. Granodiorite stocks, rhyolite plugs, and diabase to aplite dikes are present within many districts. The veins contain various combinations of cinnabar, pyrite, arsenopyrite, chalcopyrite, sphalerite, stibnite, and galena in a gangue of quartz, sericite, fluorite, mangano-calcite and calcite. The upper levels of some veins contain various combinations of azurite, malachite, tetrahedrite, jamesonite, and antimony oxides.

The open pit mines at Copper Basin and Copper Canyon produce oxide and sulfide copper ores in sediments of the Battle and Harmony formations.

Precious Metal Veins with Associated Base Metals

Districts in this category include: Deephole, Warm Springs, Varyville, National, Paradise Valley, Awakening, Dutch Flat, Winnemucca, Gold Run, McCoy, Rosebud, Sierra, Washiki, Kennedy, Jersey, and Muttlebury. The deposits in these districts also tend to be fault and fracture controlled quartz veins. The host rocks are sedimentary, metasedimentary, and volcanic rocks. Most districts are spatially if not genetically associated with Jurassic-Cretaceous granodiorite stocks and plutons, and rhyolitic plugs and hypabyssal intrusives of the Rochester formation. The veins contain various combinations of pyrite, tennanite, galena, tetrahedrite, stibnite, electrum, native gold, cinnabar, anglesite, limonite, chalcopyrite, sphalerite, scheelite, covellite, cerargyrite, cerussite, and argentite in a gangue of quartz, calcite, chalcedony, fluorite, clay, apatite and iron oxides.

Precious Metals

Districts producing principally gold and silver include: Disaster, Rebel Creek, Donnelly, Scossa, Haystack, Farrell, Indian, Velvet, Rochester, Rye Patch, and Unionville. The lodes produced in these districts include fault and fracture controlled quartz veins, small stockworks, and silicified zones in tuffaceous volcanic rocks. Ore minerals are various combinations of native gold, electrum, arsenopyrite, galena, tetrahedrite, stibnite, chalcopyrite, sphalerite, native silver, cerargyrite, argentite, cerussite, covellite and bornite in a gangue of alunite, quartz, sericite, barite, malachite, manganese oxides, tourmaline, calcite, fluorite, and limonite. Host rocks consist of sedimentary, metasedimentary, and volcanic rocks. Intrusive and hypabyssal rocks are spatially, at least, associated with most districts. The volcanic rocks and hypabyssal intrusives of the Koipato group and the overlying sediments of the Prida and Natchez Pass formations are particularly prominent host rocks in this group, though they contain mineral deposits of other types as well.

Antimony - Mercury - Manganese - Deposits with Associated Precious Metals

Districts of this type include: Lone Pine, Opalite, Poverty Peak, Bottle Creek, Sulphur, Poker Brown, Imlay, Star, Mount Tobin, Black Knob, Spring Valley, Antelope Springs, Black Diablo, Gold Banks, and Iron Hat. Deposits within these districts occur as fault and fracture controlled quartz veins, small disseminations, replacement of matrix material in breccia, coatings on conglomerate pebbles and coatings on carbonate fracture surfaces. The deposits are enclosed in sedimentary, metasedimentary, and volcanic rocks. Ore minerals include various combinations of cinnabar, calomel, native mercury, native sulfur, cerargyrite, gold, stibnite, tetrahedrite, galena, jamesonite, pyrargyrite, argentite, covellite, and braunite in a gangue of quartz, chalcedony, fluorite, alunite, beryl, calcite, epidote, jasper and rhodonite.

Uranium Occurrences

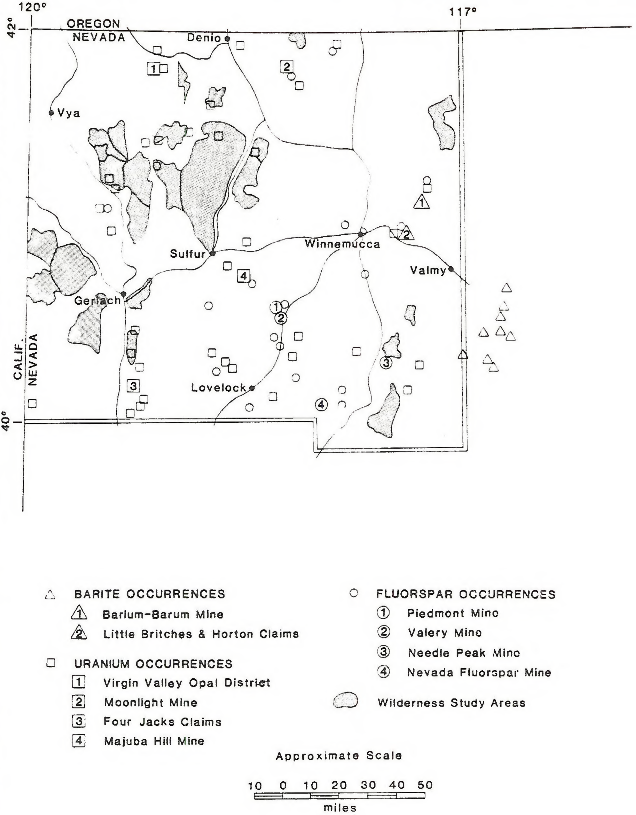
Garside (1973), indicates 40 radioactive occurrences in the study area. Table 3 summarizes these occurrences. The most productive from this area is 500 tons of ore shipped from the Moonlight Mine between 1953 and 1955 (Figure 6). Uranium is either not present or present in very minor amounts in the hydrothermal vein deposits. A possible exception may be the metazeunerite occurrence at the Majuba Hill Mine, though the mineralogy and petrology of Majuba Hill suggests that the deposit may be the result of volcanic rather than hydrothermal processes. The volcanic environment appears to be enriched in uranium with most radioactive occurrences in volcanic rocks. Uranium remobilized from the igneous/volcanic environment is deposited in a variety of Tertiary and Quaternary sedimentary environments.

Table 3 Uranium Occurrences, Northwestern Nevada

	HOST ROCK TYPE					
TYPE OF OCCURRENCE	Lavaflows and plugs	Ash-flow tuffs	Tertiary and Quaternary sediments	Pre-Tertiary sedimentary volcanic and low rank metamorphic rocks	Plutonic and high grade metamorphic rocks	Springs and ground water
Associated with base and precious metals	1*			3	2	
Pegmatite and accessory minerals					3	
Uranium mineralization only		2*	3*	5*	3	
Anomalous radioactivity, no visible mineralization	7	2	4	2	2	1

Numerals indicate number of occurrences.
Numerals with asterisk indicate minor production.

Modified from Garside, 1973



LOCATION OF BARITE, FLUORITE, & URANIUM OCCURRENCES, NORTHWESTERN NEVADA

BARRINGER RESOURCES

Figure 6

Uranium in the volcanic environment is well documented in the McDermitt caldera complex. Located on the Nevada-Oregon border, the McDermitt caldera complex consists of a nested sequence of at least five collapse structures. Volcanic rocks are primarily peralkaline ash-flow tuffs with associated volcaniclastic units. Age dates given for the caldera related rocks range from 17.9 to 15.8 m.y. (Rytuba and Glanzman, 1979).

Anomalous concentrations of uranium at McDermitt are localized in the tuffaceous sedimentary rocks and in late stage rhyolitic domes and intrusives emplaced along the ring fracture zones. The rhyolitic deposits are of greater importance. Most uranium production to date has come from the Moonlight Mine which straddles the southwest boundary of the caldera complex. In general the volcanic rocks at McDermitt are enriched in uranium together with mercury and lithium. It seems probable that uranium was remobilized from the volcanic environmnent and reconcentrated in the late stage rhyolitic phases, precipitating along faults and fractures in the host silicic rocks.

Fluorspar Occurrences

Papke (1979), reports 23 fluorspar occurrences within the study area (Figure 6). Four areas, Needle Peak Mine, Valery Mine, Nevada Fluorspar Mine, and Piedmont Mine, have recorded production of 900 tons, 1932 tons, 1 car load, and 250 tons respectively. The first three of these mines involves fluorite replacement of carbonate along fault breccia zones. The fluorite occurs in irregular masses with greater or lesser amounts of quartz, calcite, barite, halloysite, sericite, and host rock fragments. The Piedmont Mine consists of a quartz-fluorite vein in rhyolite porphyry.

The small shows and occurrences of fluorite in the study area are along the northern end of the arcuate zone of fluorite occurrences outlined by Papke (1979).

Table 4

Fluorspar occurrences, Northwestern Nevada

Occurrences	15	
Deposit, no ore produced	4	
Deposit, 1000 tons of ore produced	3	Piedmont, Needle Park, Nevada fluorspar Mines
Deposit, 1000 to 2000 tons of ore produced	1	Valery Mine
Total	23	

Modified from Papke (1979).

Barite Occurrences

Barite occurs as a relatively minor gangue in some base and precious metal vein deposits in the study area. It also occurs up to several percent in some of the fluorspar deposits. According to Papke, 1973, there are two occurrences in the Osgood Mountains (Figure 6). One of these, the Little Britches and Horton claims, has had past production. A string of occurrences in the Shoshone Range south of Battle Mountain flank the study area on the southeast side. These deposits are bedded and apparently the result of replacement of limestone and chert by barite (Steward, McKee, and Stager, 1977).

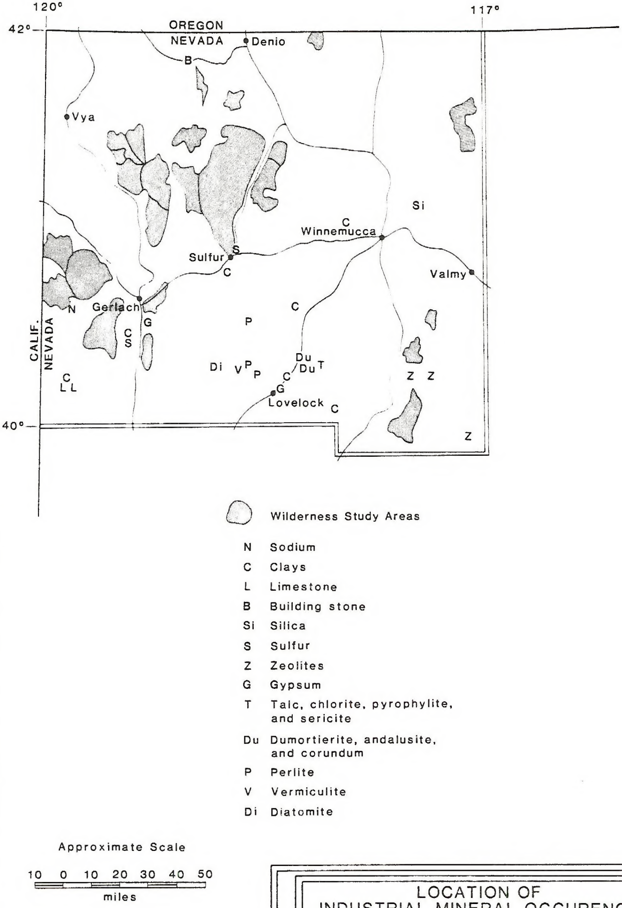
Other Industrial Mineral Occurrences

The location of industrial mineral occurrences other than barite and fluorspar is shown in Figure 7. Commodities include sodium, sulfur, clays, limestone, building stone, silica, zeolites, gypsum, talc, chlorite, pyrophylite, sericite, dumortierite, andelusite, corrundum, perlite, vermiculite, and diatomite. These commodities occur in geologic environments ranging from sedimentary to metamorphic. Characteristics which determine whether a deposit is a commercial resource include chemical purity, mineralogical association, color, consistency, and precise standards of many other physical properties in addition to considerations of grade, tonnage, and mining cost. Many of these occurrences have supported commercial extraction. For a more comprehensive discussion of individual occurrences, the reader is directed to Papke (1970, 1972, 1973), Bonham and Papke (1969), Wilden (1964), Johnson (1977), and Steward, McKee, and Stager (1977).

Oil and Gas Resources

A literature review was initiated to assess the oil and gas potential within the Winnemucca District. Sources of information included, a GEOREF computer search, reference material from the U.S. Geological Survey library in Golden, Colorado, and oil and gas data acquired from Petroleum Information Corporation. Petroleum Information has on file drilling data and logs on recent oil and gas activity in Nevada. Drilling information is current within six months.

Except for an abandoned well drilled in 1921 northeast of Sulfur, no record of drilling activity within the boundaries of the Winnemucca District is present. Based on such limited data and in an area as structurally complex as northwestern Nevada it would be speculative at best to assign areas of favorability for oil and gas resources.



Modified from Papke, 1973

LOCATION OF
INDUSTRIAL MINERAL OCCURENCES,
NORTHWESTERN NEVADA

Figure 7

BARRINGER RESOURCES

Geothermal Resources

Geologic factors considered favorable for geothermal resource potential are recent tectonism, recent volcanism, regional high heat flow and locally high geothermal gradients (Johnson, 1977). Locally high geothermal gradients are seen in the more than forty hot springs known in the study area (Waring, 1965). Sass (1971) shows that the Basin and Range Province is an area of high heatflow as well as recent tectonism. Thus, most of the criteria for geothermal potential are met in the study area.

The age of volcanic activity and plutonic emplacement within the area argue against bodies of magma acting as heat sources. Hose (1974) argues that meteoric water circulates along Basin and Range faults, is heated at depth, and returns to the surface. He cites the linear arrangement of hot springs along faults as evidence of the role played by faulting. The heat source is the combination of a thin crust over a very hot mantle.

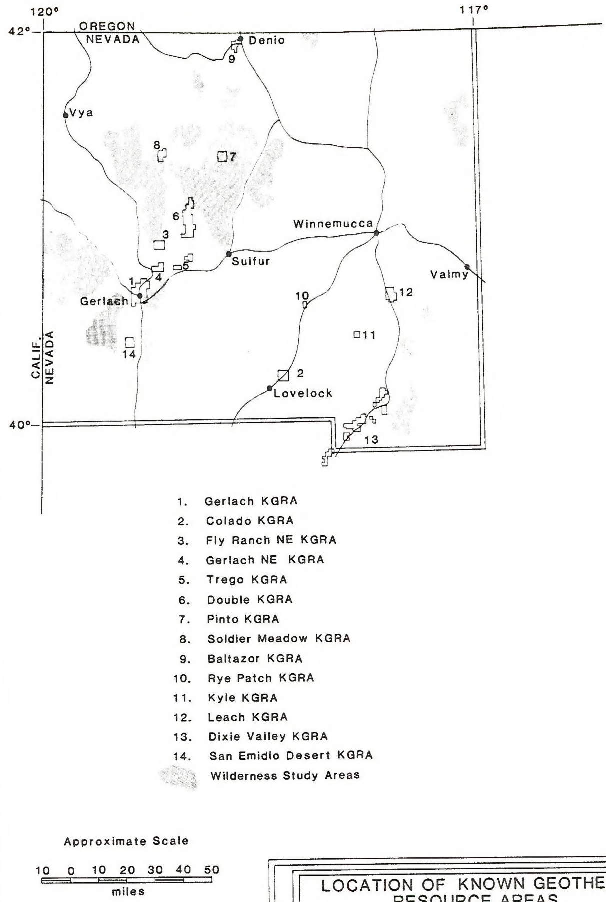
While the reconnaissance geochemical survey is unlikely to confirm or deny the possibility, it must be concluded from geologic inference that there is considerable potential for connective hot water geothermal systems. Figure 8 shows the distribution of Known Geothermal Resource Areas (KGRA's) in northwestern Nevada.

Other Possible Deposits

Massive Sulfide

The Big Mike Mine, located in the northwest end of the Tobin Range has been identified as a massive sulfide deposit (Johnson, 1977). The deposit is hosted by rocks of the Pumpernickel formation. Ore minerals include chalcopyrite, bornite, and digenite.

The rocks of the Pumpernickel and Havallah formations ought to be prospective for similar deposits within the study area. Similarly, the rocks of the Koipato group-Prida formation ought to be prospective.



LOCATION OF KNOWN GEOTHERMAL RESOURCE AREAS, NORTHWESTERN NEVADA

Figure 8

BARRINGER RESOURCES

Porphyry Deposits

The essential characteristics of porphyry deposits are present in the study area. These include: areas of hydrothermal alteration, granodiorite to quartz latite stocks, and areas of abundant, small, low temperature, epithermal veins (Lowell and Guilbert, 1970).

Mining Districts within Wilderness Study Areas

There are eleven mining districts within or adjacent to Wilderness Study Areas. These are Lone Pine District (Ca 020-1013), Jackson Creek District (020-603), Donnelly District (020-007), Hooker District (020-201), Iron Hat District (020-400P), Cottonwood District (020-014), Jersey Valley District (060-461), Mount Tobin District, Red Butte District, Leonard Creek District, and Varyville District. The characteristics of these districts are included in Plate II.

The Lone Pine District is located on the south slope of Bald Mountain in Washoe County. Cinnabar was discovered in 1929, but no significant production followed.

Rock units present are all Teritary in age. The oldest units are andesite flows, tuffs, and flow-breccias of Miocene age. This unit is overlain by the Canon Rhyolite. Both units are overlain by late Miocene-early Pliocene olivine basalts. Cinnabar with pyrite, magnetite and traces of gold occur in veinlets, stringers, and fine disseminations in the hydrothermally altered andesites (Bonham and Papke, 1969).

The Jackson Creek District is located in the Jackson Mountains in Humboldt County. The iron deposits were first mined in 1952 and had produced about 448,000 long tons of hard lump magnetite ore by 1957.

The ore occurs as veins in the Happy Creek Group or as replacement bodies adjacent to diorite intrusives. Willden (1964), believes that the diorite acted as a heat source to mobilize iron from the volcanic rocks. The Happy Creek Group is Permian in age while the diorite is Jurassic-Cretaceous in age. Thus the iron deposits in this district are considerably older than the hydrothermal deposits nearby in the Jackson Mountains (Willden, 1964).

The Hooker District is located in the central Selenite Range in Pershing County. Gypsum was first developed in the district in 1910 and production continued through 1970. Tungsten was discovered in 1941 and production of at least 19,500 tons was made between 1941 and 1957 (Johnson, 1957).

This district is underlain by metavolcanic and metasedimentary rocks of late Permian to Jurassic age. These rocks are locally overlain by Tertiary and Quaternary volcanic and sedimentary units. The Mesozoic rocks are intruded by granodiorite bodies. The gypsum occurs as large lenses under a white limestone unit adjacent to a granodiorite contact. The tungsten occurs in scheelite-bearing tactites. Locally the tactites contain scheelite, powellite, molybdenite, pyrite, pyrrhotite, and chalcopyrite. Both tungsten and gypsum deposits occur in the Mesozoic metasedimentary rocks (Johnson, 1977.)

The Iron Hat District is located in the northern Tobin Range in Pershing County. Lead-silver deposits were discovered in the district in the 1880's and were intermittently mined until about 1945. Total production has been estimated between $15,000 and $30,000. In addition, very small amounts of antimony and tungsten were mined in the early 1940's (Johnson, 1977). The discovery and development of the Big Mike deposit 9 miles west of the district focused some recent mining exploration on the district (Johnson, 1977).

A complex series of volcanic and sedimentary rocks ranging from Permian to Tertiary in age underlie the district. Units included are volcanics of the Koipato Group, the Permian Pumpernickel Formation, and Triassic Augusta Mountain and Cane Springs Formations. The lead-silver ores consist of galena, sphalerite and pyrite which replace limestone along north trending, steeply dipping fault zones. Stibnite and scheelite occur in quartz and calcite veinlets in shear zones (Johnson, 1977).

The Jersey Valley District is located near the Pershing-Lander County boundary on the west flank of the Fish Creek Mountains. The silver-lead mines were discovered in 1873 and worked intermittently until 1945. Manganese mines were located in 1934, and a very small amount of ore shipped in 1952 and 1953 (Johnson, 1977).

The rocks in the district consist of sediments of the Pumpernickel and Havallah Formations. These rocks are intruded by a small diorite stock. The silver-lead deposits are in the Havallah Formation near the diorite stock. The manganese deposits replace chert, shale, quartzite and greenstone of the Pumpernickel Formation (Johnson, 1977).

The Cottonwood District is located in the Fox Range immediately north of Pyramid Lake in Washoe County. The first mining activity took place in the district during the 1870's. Production from the district is largely unrecorded, but has been estimated to be less than $100,000 (Bonahm and Papke, 1969).

The rocks in the district are Mesozoic metasediments - chiefly slate, phyllite, marble and quartzite. The metasedimentary rocks are intruded by granodiorite stocks of Mesozoic age. This sequence is overlain by Tertiary volcanic and sedimentary rocks. The mines were developed on fault-controlled quartz veins containing jamesonite, tetrahedrite and sphalerite. Near granodiorite-limestone contacts, particularly in Rodeo Canyon, small tactites occur. Some tactites contain very minor scheelite (Bonham and Papke, 1969).

The Mount Tobin District is located in the southern Tobin Range in Pershing County. Mercury was discovered in the district before 1918, and the bulk of production occurred between 1938 and 1943. Several mines were worked briefly in the late 1950's and 1960's, though their total production was small. Fluorspar and zeolites both occur in the district, though production has been very small (Johnson, 1977).

Rocks in the district consist of metasediments of the Havallah Formation. Unconformably overlying these units is a thick section of Triassic volcanic and carbonate rocks. The section is capped with Tertiary volcanics. Hypabyssal andesite intrusives, probably of Tertiary age, are intruded along faults and fractures. The mercury deposits consist of cinnabar and locally trace amounts of pyrite and stibnite. The deposits are mineralized fractures in the China Mountain Formation of the Koipato Group. The fluorspar deposit occurs in a shear zone in an area of rhyolite and limestone. The zeolite occurrences apparently are the result of diagenesis of volcanic ash and occur in several pyroclastic or tuffaceous units (Johnson, 1977).

The Red Butte District is located on the southwest side of the Jackson Mountains in Humbolt County. The district contains iron, copper and mercury prospects, but has had very small historical production.

The iron occurrences are similar to those found in the Jackson Creek District and consist of magnetite and hematite veins in the Happy Creek volcanics. The copper occurrences consist of azurite and tetrahedrite in quartz veins in the King Lear Formation. Also, aplite dikes in diorite host small copper shows. Cinnabar fills fractures and is disseminated in a shear zone in one mercury prospect (Willden, 1964).

The Leonard Creek District and Varyville District are located at the south end of the Pine Forest Range and northern end of the Black Rock Range in Humbolt County. In the Leonard Creek District, placer gold occurs in alluvial material. Production from this area is small. In the Varyville District, gold was produced in several small mines. Total gold production did not greatly exceed $38,000 and combined production of all commodities is just over $100,000 (Willden, 1964).

The rocks in the area are Triassic and Jurassic (?) metasediments. These units are in fault contact with the metavolcanic rocks of the Happy Creek Formation. Granodiorite intrusives of Cretaceous or younger age cut the metamorphic units. Tertiary rhyolitic and dacitic volcanics intercalated with sedimentary rocks top the section. Mines in the Varyville District are developed on fault-controlled veins in the pre-Tertiary rocks.

Papke (1973) lists three industrial mineral occurrences which are within or near Wilderness Study Areas. These are Sunset fluorspar (020-621), (Figure 6), Rivermont Unconsolidated Calcium Carbonate (030-605M) and Fish Creek Clinoptilite (060-461), (Figure 7).

Review of NURE Data

Aerial radiometric and magnetic surveys were flown for each of the Lovelock, Vya, McDermitt and Winnemucca $1^{o} \times 2^{o}$ quadrangles. Flight lines are 3 miles apart in an east to west direction and north-south tie lines 12 miles apart. Data generated include radiometric profiles of K, U, Th and their ratios together with anomaly maps of K, U, Th, and their respective ratios.

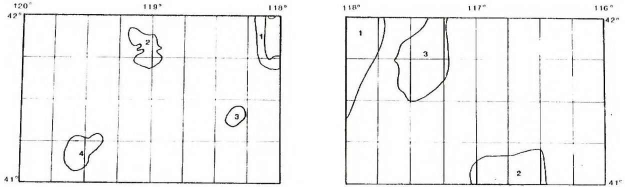
In conjunction with the geophysical study a reconnaissance hydro-geochemical and stream sediment survey was conducted over the four quadrangles. Sample density was approximately 1 sample per 5 square miles. Sample analyses included U, Th, rare earth elements and some multi-element analyses. Reference should be made to the appropriate GJBX report for a listing of the geochemical results.

To further assess and define areas of known or suspected mineralization, a uranium resource evaluation program for the Lovelock, Vya, McDermitt and Winnemucca quadrangles was initiated. Program guidelines (Castor, et al., 1981) were:

1. Field examination of previously known uranium occurrences.
2. Location and followup work of airborne radiometric and available magnetic data.
3. Location and field check of anomalous results from the reconnaissance hydro-geochemical and stream sediment survey (if available).
4. Examination of suitable geologic environments suspected of having potential for uranium mineralization. Additionally, rock, stream sediment, and water samples were collected.

The criteria used for evaluation of a favorable deposit was that it should contain 100 tons of rock grading no less than 100 ppm U_3O_8.

Figure 9 is a map of favorable areas compiled in the PGJ reports for each NTMS quadrangle.



VYA NTMS QUADRANGLE

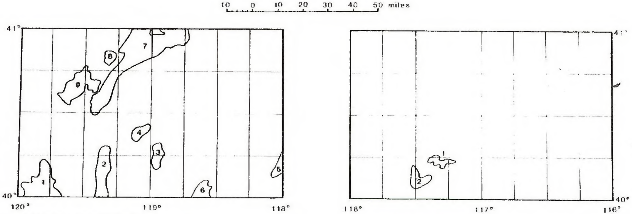
1. McDermitt Caldera Area
2. Virgin Valley
3. Boltle
4. Cottonwood Basin

Castor, (1981)

McDERMITT NTMS QUADRANGLE

1. McDermitt Caldera and Vicinity
2. Izzenhood - Ivanhoe
3. Paradise Valley - Capital Peak

Garside, (1980)



LOVELOCK NTMS QUADRANGLE

1. Hartford Hill Rhyolite
2. Winnemucca Lake Playa
3. Adobe Flat Playa
4. Bluewing Playa
5. Buena Vista Playa
6. Humboldt Sink Playa
7. Black Rock Desert Playa
8. Alkali Flat Playa
9. N.E. Smoke Creek Desert Playa

Berry, et al., (1980)

WINNEMUCCA NTMS QUADRANGLE

1. Fish Creek Basin 2. Home Station Wash

Berridge and Wolverson, (1981)

AREAS FAVORABLE FOR URANIUM OCCURRENCE

BARRINGER RESOURCES

Figure 9

GEOCHEMISTRY

Detail of sampling methods, preparation, analytical technique and quality control are included in Vol. IV, Geochemistry Section.

GENERAL PRINCIPLES

Stream sediment geochemistry is one of the principle methods of low-cost reconnaissance exploration where an integrated drainage system has developed (Meyer, et al., 1979). The composition of stream sediments is a function of the composition of the rocks, sediments and waters comprising the upstream catchment area. Mineral deposits present in the drainage basin can be detected through systematic sampling and analysis of stream sediments. Multi-element analysis enables a more meaningful interpretation of stream sediment survey results, therefore this approach was adopted for the mineral assessment of the Wilderness Study Areas within or adjacent to the Winnemucca District.

Interpretation of areas contaminated by mining activity compared to areas with no previous activity may present minor complications. For instance, metallic debris may add foreign metals to the soil and stream sediments. Old workings and mine dumps expose large areas of rock to an oxidizing environment and may considerably elevate the background levels of metals occurring in those rocks. In the geostatistical processing, emphasis is placed on ratios, and the comparison of individual values with local rather than regional backgrounds. While these problems are minimized in geostatistical processing, they should be considered carefully when evaluating isogeochemical maps (plates C-II through C-IX). It should be noted that the geostatistical analysis does not define a mineral deposit, rather, it indicates statistically meaningful mineralization. Detailed work is required to address the economic aspects of any such mineralization.

RESULTS

The preceding section on mineral deposits includes many types of commodities some of which are not assessible by reconnaissance multielement geochemistry. Thus, oil and gas, geothermal, coal, and various types of industrial mineral potential is not addressed in this part of the study. Their ommission from the following discussion does not imply the presence or absence of potential resource in these commodities, rather the unsuitability of reconnaissance geochemistry in assessing that potential.

In reviewing the geochemical results, eight elements were selected for single element maps. The elements chosen, Au, Ag, W, Zn, U, Mo, Hg, and Ba, either have special significance in the project area or are not well accounted for in the geostatistical analysis (for example, see Table 9, Page 42). These maps are presented as Plates C-II, C-III, C-IV, C-V, C-VI, C-VII, C-VIII, and C-IX. The distribution of other elements is best presented in the geostatistical analysis. Gold and silver raw values were plotted at each sample site. The other elements are plotted as standard normalized grid cell averages. Grid cell values represent the mean of all samples falling within 2500m x 2500m cells forming an overlay on the survey area. The cells are based on the UTM coordinate system. Summary statistics for these elements are presented in Table 5. Area by area results for these elements are presented in Table 1.

Table 5. Summary Statistics for Au, Ag, W, Zn, U, Mo, Hg, and Ba.

Element	Mean	Standard Deviation	Minimum	Maximum	Range
Au(ppm)	*	*	*	.169	.169
Ag(ppm)	.002	.0008	.002	.080	.078
W(ppm)	7.67	9.35	.100	200	199
Zn(ppm)	115	33.3	30	882	852
U(ppm)	.97	.82	.100	76.0	75.9
Mo(ppm)	1.63	1.17	.5	38.0	37.5
Hg(ppb)	7.86	6.79	2.0	1240	1238
Ba(ppm)	901	287	74	6400	6326

*due to the near coincidence of mean, minimum, standard deviation, and detection limit caused by the low levels of gold in stream sediments, these parameters are statistically invalid, and not used in the study.

While it is customary to interpret geochemical data by establishing threshold values for each element above which samples would be considered to be anomalous, the wide geomorphic and lithologic range of the areas does not support this approach. In this study, attention is drawn to anomalous values which stand out in relation to the local norm.

Gold (Plate C-II)

As expected, gold values are extremely sporadic. A natural separation process due to the great density of clastic particles of gold takes place in the stream sediment environment. This separation, often called the nugget effect, requires that many large bulk samples be taken for accurate gold reconnaissance. Since widely spaced stream sediment samples were taken in this survey, single sample anomalies are considered significant with respect to gold. Further, the absence of high gold values does not negate the potential of an area for significant gold deposits. The highest value is in the Southern Jackson Mountains. A significant grouping of moderately anomalous values is found at Disaster Peak.

Silver (Plate C-III)

Anomalous silver values occur at China Mountain, the Fox Range, and in the Northern and Southern Calico Mountains. The silver area in the Fox range is spatially separate from the area enriched in uranium.

Tungsten (Plate C-IV)

Anomalous tungsten values are present throughout the map area. The most significant group of high values occurs in the northern part of the Pinto Mountain Quadrangle and along the northwest margin of the Black Rock Desert. Values in these areas range from 10 to 200 ppm. Another significant cluster occurs near Division Peak.

Zinc (Plate C-V)

Notable groupings of anomalous zinc values occur in the Fox Range, Selenite Range, China Mountain, and west of the Augusta Mountains. Values in these groups range from 150 to 880 ppm. A wide group of values slightly above average is evident in the Disaster Peak area. The areal extent of these slightly elevated values is significant.

Uranium (Plate C-VI)

There are two major areas of high uranium values. The first, the Selenite Range, is associated with granitic rocks. The second, the Duffer Peak area, is associated with granodiorites. A smaller area at the north end of the Fox Range also shows elevated values.

Molybdenum (Plate C-VII)

Molybdenum values up to 5 ppm occur in the Fox Range and the Calico Mountains. These samples occur within base and precious metal enriched areas.

Mercury (Plate C-VIII)

Anomalous mercury values are distributed throughout the sample area. Values up to 30 ppb occur in the Fox Range, Duffer Peak, and Mount Tobin area. Mercury is associated with many deposits and geothermal areas, and can, therefore be expected to show up in many prospective localities.

Barium (Plate C-IX)

Barium values greater than 1500 ppm occur in the Northern Calico Mountains, the Central Fox Range, and China Mountain. Barite as a hydrothermal gangue mineral and as the primary mineral in various replacement deposits is stable in many environments. This is shown in Plate C-IX as many small isolated symbols indicating scattered areas of high values.

DATA BASE DEVELOPMENT

Sample sites were digitized from U. S. Geological Survey 7½' and 15' field maps and the locations were combined with the geochemical data. Mean, standard deviation, range of values, maximum, minimum, correlation coefficients, frequency distribution, and cumulative frequency diagrams were calculated for each element. They are included in this report as Appendix C.

For the purpose of carrying out the regional multiple regression study, the Geologic map of Nevada (Stewart and Carlson, 1974) was divided into 10 km by 10 km grid cells in the study area. Rock types were identified by numerical code and their relative area in each cell noted. Fault and fracture attitude and density were digitized for each cell. The same grid was superimposed on Army Map Service $1^{o}x2^{o}$ topographic maps and mining activity digitized.

In order to provide a uniform data base, the geochemical sample area was divided into 2500 m x 2500 m grid cells based on the UTM coordinate system and analytical results for samples falling within each cell area averaged. This resulted in a total of 850 cells and 28,050 cell averages derived from the 1900 sample locations and geochemical analyses.

The data bases resulting from this processing were used in the geostatistical analyses. They can be further manipulated to create contour maps, symbol maps, or perspective plots.

GEOSTATISTICS

The use of geostatistical analysis has gained increased recognition in the geological sciences as more applications have been developed. Geostatistics is an effective tool in the interpretation of the geological, geochemical, and geophysical data used in mineral and energy exploration. Four different applications have been evaluated in the interpretation of the Winnemucca District mineral survey. They include: 1) Factor Analysis; 2) Discriminant Analysis; 3) Multiple Regression Analysis; and 4) Characteristic Analysis.

FACTOR ANALYSIS

Methods

The interpretation of a large number of geochemical results can be a time consuming task if all the data are to be considered individually. The method of R-mode factor analysis, used here, allows a large number of geochemical results to be simplified into a smaller number of "factors", each representing a linear combination of the original suite of elements which reflects the multi-element associations present in the data. These are determined from the original interelement correlation matrix using the method of principal factoring with iteration (Nie, et al., 1975).

Each factor is extracted in such a way that the first of these new variables accounts for the greatest part of the overall data variability in terms of the original elements, and succeeding factors account for progressively lesser amounts until a suitable number of element combinations have been established. To completely account for the whole of the variation inherent in the original data set of 1900 samples and 33 elements would require as many factors as variables if there was no correlation between the original elements. The greater the interelement correlation the smaller the number of factors which will be needed to describe the data variability. Choosing of the number of factors to be extracted allows one to achieve a significant reduction in the number of variables to be mapped while still retaining an adequate description of the data variability.

On the basis of the principal factoring of the geochemical data set, the percentage variation and cumulative percentage variation accounted for by each successive factor up to the maximum possible is shown in Table 6. A solution based on 10 factors which accounts for 64.7 percent of the original data variation was chosen as a suitable model. These factors were extracted using the "oblique rotation" method (Nie et al., 1975) Table 7 shows that these interfactor correlations are all relatively low which implies that each factor is relatively unique. The extent to which one of the original suite of elements is represented in a particular factorial element association is indicated by the "factor loading" (Table 8). A perfect positive or negative correlation between an element and a particular factor would be indicated by a loading of ± 1 respectively; loading values close to zero indicate lack of any significant correlation between an element and the factor in question. The extent to which the behavior of an element is accounted for on the basis of all the factors used in the model is indicated by its "communality" value. These are listed for all the elements on the basis of a 10 factor model in Table 9. Communality values close to zero suggest that an element's variability is not well accounted for by the factor model used. This may be attributable to the fact that the element is not significantly correlated with any of the other elements in the data set as a whole. A communality value close to one will reflect an element whose behavior is highly predictable on the basis of the factor model used.

The spatial distribution of the element associations represented by the factors in the model can be mapped by recalculating the sample compositions in terms of the factors. These values are referred to as "factor scores", and will tend to be normally distributed with zero mean and unit standard deviation. Table 12, Appendix A, lists the factor scores for this analysis. Since the signs may be reversed throughout an entire set of scores for a given

TABLE 6
VARIATION ACCOUNTED FOR BY EACH FACTOR UP TO 33

FACTOR	PERCENTAGE OF OVERALL VARIANCE ACCOUNTED FOR BY FACTOR	CUMULATIVE PERCENTAGE VARIANCE
1	20.3	20.3
2	10.1	30.3
3	6.8	37.1
4	5.5	42.7
5	4.7	47.3
6	4.0	51.4
7	3.6	55.0
8	3.4	58.4
9	3.2	61.6
10	3.1	64.7
11	3.0	67.7
12	2.9	70.6
13	2.7	73.3
14	2.5	75.8
15	2.3	78.1
16	2.3	80.4
17	2.1	82.5
18	2.0	84.5
19	1.8	86.3
20	1.7	88.0
21	1.7	89.7
22	1.6	91.3
23	1.5	92.7
24	1.2	93.9
25	1.1	95.1
26	1.0	96.0
27	.9	96.9
28	.7	97.7
29	.7	98.3
30	.6	99.0
31	.4	99.4
32	.3	99.7
33	.3	100.0

TABLE 7
INTERFACTOR CORRELATIONS

FACTOR	1	2	3	4	5	6	7	8	9	10
1	1.000	.061	-.031	-.084	.278	.232	-.019	.006	-.131	-.164
2	.061	1.000	.013	-.036	-.109	-.164	-.013	.080	.152	-.200
3	-.031	.013	1.000	.150	.050	-.127	.043	.111	.079	.073
4	-.084	-.036	.150	1.000	-.033	-.029	.128	.028	.039	-.009
5	.278	-.109	.050	-.033	1.000	.221	.043	-.069	-.462	-.169
6	.232	-.164	-.127	-.029	.221	1.000	-.017	.041	-.137	-.094
7	-.019	-.013	.043	.128	.043	-.017	1.000	.097	-.001	.032
8	.006	.080	.111	.028	-.069	.041	.097	1.000	.045	-.041
9	-.131	.152	.079	.039	-.462	-.137	-.001	.045	1.000	.213
10	-.164	-.200	.073	-.009	-.169	-.094	.032	-.041	.213	1.000

TABLE 8
FACTOR LOADINGS, WINNEMUCCA DISTRICT, NEVADA

FACTOR	1	2	3	4	5	6	7	8	9	10
Al_2O_3	.20716	.34075	-.47423	-.11477	.49152	.27776	.04652	-.05200	-.61178	-.20878
CaO	.14358	-.77153	.01203	.13247	.04245	.22699	-.00672	-.12200	-.08565	.02154
K_2O	-.40642	.44210	.10926	.19817	-.58981	-.50019	.04746	.01173	.57389	.17228
Na_2O	.02719	.10428	-.72949	-.10245	-.20970	.08202	-.12446	-.05811	-.02504	-.15674
MgO	.23282	-.53795	.07744	-.09160	.47775	.44760	.00141	-.06169	-.21041	.21751
Fe_2O_3	.90388	-.00947	-.00685	-.21451	.43938	.39531	.01056	.04275	-.27387	-.27392
TiO_2	.88121	.08483	-.04502	-.13093	.37526	.27055	.00631	-.03354	-.22634	-.38744
P_2O_5	.28107	-.14879	-.21637	.06820	.25929	.88579	.02606	.01564	-.19658	-.16412
Be	-.04442	.76677	.03780	.08533	-.23192	-.07910	-.00930	.06132	.38082	-.19985
Cd	.53792	-.04552	-.03958	.04761	.51627	.43557	.00302	-.00300	-.54598	-.37921
Cr	.35101	-.17216	.04616	-.05276	.71234	.09308	.00360	-.08874	-.34184	-.14478
Cu	.36794	-.08883	.22069	-.12024	.61826	.27466	.00619	.09879	-.51202	-.04033
Ni	.11932	-.13140	.12100	.02200	.60480	.16479	-.01658	-.05697	-.35217	-.11158
Pb	-.14084	.14616	.14035	.47035	-.17325	-.19181	.10220	.13436	.18724	.12599
Sr	.02387	-.45534	-.59154	.20805	.17534	.29983	.02077	-.17945	-.12465	-.06131
Th	.07820	.42518	.01660	-.06308	-.18425	-.06317	.02213	.08282	.64681	.07994
V	.83714	-.14223	-.01682	-.18129	.56338	.39444	-.00541	.03200	-.31213	-.25019
Zn	.55031	.16612	.21957	.35310	.22917	.17932	.00661	.15585	-.16369	-.21435
Zr	-.00124	.74819	.15833	.07946	-.13503	-.21375	-.01043	-.04633	.15480	-.39377
Ag	-.00051	.01203	.13257	.36952	.00452	-.03084	.10482	.74609	.03412	.01161
As	-.14793	-.15253	.25287	.26620	-.07805	-.08133	.18727	.16030	.12222	.24479
Au	-.02241	-.01462	.04267	-.01502	.00716	.02276	.13902	.38790	-.02773	-.04205
Ba	-.05479	-.12615	-.08144	.51233	.00261	.17752	.08791	-.02946	-.06252	-.04263
Hg	-.01482	.01574	-.00306	.02799	.00405	.01754	.51096	.03519	.02512	.03387
Li	-.27504	-.09218	.32131	.16116	-.24147	-.19775	.02738	-.07517	.27684	.68774
Sb	.01743	.01511	.06040	.09099	-.01151	-.03049	.62467	.11910	.00278	-.02783

factor without changing sample relationships, inverse score values are used for convenience in interpretation in some cases (e.g. factors 3 and 9, Table 8).

TABLE 9 COMMUNALITY OF ELEMENTS, ASSUMING A 10 FACTOR MODEL

VARIABLE	COMMUNALITY	VARIABLE	COMMUNALITY
Al_2O_3	.87779	Pb	.32095
CaO	.66279	Sr	.69279
K_2O	.76867	Th	.57017
Na_2O	.59523	V	.88391
MgO	.62864	Zn*	.56394
Fe_2O_3	.91913	Zr	.69842
TiO_2	.85669	Ag*	.69272
MnO	.22921	As	.23148
P_2O_5	.82410	Au*	.16804
Be	.69631	Ba*	.33255
Cd	.66100	F	.13787
Co	.57964	Hg*	.26587
Cr	.56221	Li	.60979
Cu	.59835	Mo*	.11981
Ni	.39322	Sb	.40054
Sn	.04094	U*	.05411
		W*	.00865

* indicates elements plotted as single element symbol maps. (Appendix C, Plates C-II through C-IX).

The method is discussed in depth in Cooley and Lohnes (1962), Meyer, et al., (1979), McCammon (1975), Dawson and Sinclair (1974) and Nichol, et al., (1969), and Joreskog, et al., (1976).

Results

Table 8 is a list of the factor loadings. Based on the weighting and interrelationships of elements, factors 1,5, and 9 reflect the influence of mafic igneous rocks on the data set. While all three factors seem to reflect mafic rocks, there are distinct chemical differences between the factors. These differences are in accordance with chemical variation seen in tholeiitic, olivine, and high-alumina basalts, respectively (Carmichael, Turner, and Verhoogen, 1974, p. 32).

Factor 6 reflects the influence of intermediate composition igneous rocks. CaO, MgO, and Fe_2O_3 enrichment suggest rocks in the andesite range. This interpretation is reinforced by the weak but positive contribution of Cd, Cu, Sr, and V.

Factor 2 is the result of the influence of rhyolitic rocks. Significant positive values for Al_2O_3 and K_2O coupled with negative values for CaO, and MgO suggest the rhyolite composition. Additional contribution from Be, Zr, and Th serve to confirm this assessment.

The geologic environment leading to factor 3 is less straightforward. Based in part on the factor loading, and in part on its distribution, it is felt that this factor is the result of clay either as hydrothermal alteration or weathering products.

Factors 4, 7, and 8 represent the influence of base metal bearing vein systems, and precious metal vein systems. Factor 4 is strongly influenced by base metals and barium. Silver and arsenic are also expressed. This association is typical of the base metal with associated precious metals deposit-type discussed earlier. Factors 7 and 8 are both dominated by gold and silver, but have differing associations of other metals. When factors 7 and 8 (Plates A-VI and A-VII) are compared to each other, a spatial relationship seems to exist in several areas. This relationship, especially evident in the Fox Range, may be the result of either 1) metal zonation, 2) sediment transportation, or 3) differential geochemical migration. Additional geological reconnaissance and geochemical sampling would be required to explain and confirm the relationship.

Factor 10 is strongly dependent on lithium. The playa environment enriched in lithium may be reflected in this factor. Also, various plutonic rocks containing lithium-bearing micas may influence this factor.

Plates A-I to A-VII are symbol maps of the various factors. Factors 1, 2, 5, and 6 correspond with major rock types as seen on the geologic map (Plate I). Factors 4, 7, and 8 suggest potential mineralization at the following locations: the Fox Range, China Mountain, the Calico Mountains, the Augusta Mountains, the Jackson Mountains, Duffer Peak, and Mount Tobin.

Table 10 lists major anomalous groups of factor scores, rock types and other geologic parameters.

DISCRIMINANT ANALYSIS

Classification of geological and geochemical data for reconnaissance mapping and mineral exploration can be greatly enhanced by the use of discriminant analysis. This method allows the investigator to use his knowledge of specific areas to aid in the classification of surrounding areas with limited information.

Methods

Areas of specific interest are selected for training sets. These areas may be known rock types, mineralization types, hydrothermal alteration, or any other characteristic. The program then classifies the geochemical data within the training area and compares it to each sample in the data base. The output of this technique is a series of maps showing which samples correspond with which training set. It is possible, indeed likely, that a number of samples will be unclassified, particularly if every rock type and geochemical environment is not represented by a training set.

TABLE 10

FACTOR ANALYSIS RESULTS

Factor	Major Variables	Prominent Areal Correlation	Interpretation	Comments
1	Fe_2O_3, TiO_2, V, Zn, Cd, Cu, Zr	1) Twin Mountain 2) SE Jackson Mts. (Navajo Peak) 3) Red Mountain 4) SW Augusta Mts.	Mafic Rock Assemblage Olivine Basalt	
2	Be, Zr, K_2O, Th, Al_2O_3	1) Red Mountain 2) McConnel Canyon 3) Little High Rock Canyon 4) Idaho Canyon-Big Mountain-McGee Mtn. 5) NE Augusta Mts.	Rhyolite	Prominent areas correlate well with mapped rhyolites. Area 5 - located Area 5 - located within Fish Creek Caldera Complex.
3 (inverse)	Na_2O, Sr, Al_2O_3	1) Ouffer Peak 2) S. Calico Mts. 3) NE Selenite Range 4) Fox Range		Area 1 - contains mapped granite and phyllite. Area 2 - from field observations contained argillic alteration.
4	Ba, Pb, Ag, Zn	1) W. Fox Range 2) China Mountain 3) Yellow Hills East 4) N. Black Rock Desert 5) S. Selenite Range 6) SE Calico Mts.	Mineralization: Base and Precious Metals	Area 1 - located in Cottonwood mining district-Au,Ag,Pb. Area 2 - located in Ironhat mining district-Sb,W,Pb,Ag. Area 4 - located downstream of Varyville mining district-Au,Sb,Ag,Cu,Pb. Area 5 - located north of Hooker mining district - W.
5	Co, Cr, Cu, Ni, V, Al_2O_3, MgO, Fe_2O_3, TiO_2	1) Buffalo Hills-Hole in the Ground 2) Disaster Peak	Mafic Rock Assemblage: High Alumina Basalt	Major difference between Factor 5 and Factor 1 is addition of Al_2O_3 and MgO to major variables.
6	P_2O_5,MgO,Cd, Fe_2O_3,V,Sr	1) Selenite Range 2) Fox Range 3) Twin Mountain	Intermediate Rock Assemblage Granodiorite, Diorite, Andesite.	Prominent areas correlate well with mapped diorites.
7	Sb, Hg, As, Au, Ag	1) China Mountain 2) Cottonwood Creek 3) SE Calico Mts. 4) Mt. Tobin 5) Fox Range 6) King Lear Peak	Epithermal Mineralization: Mercury	Area 1 - located in Ironhat mining district - Sb,W,Pb,Ag. Area 4 - located in Mt. Tobin mining district - Hg,W. Area 5 - associated with Cottonwood mining district - Au,Ag,Pb. Area 6 - associated with Red Butte mining district - Cu,Au,Hg,Pb,Zn,Sb.
8	Ag, Au, Mo, As, Zn	1) Fox Range 2) China Mountain	Epithermal Mineralization: Precious Metal Veins	Area 2 - located in Ironhat mining district - Sb,W,Pb,Ag. Other small anomalies usually associated with rhyolitic rocks and/or known mineralization.
9	Th, K_2O, Be, Co	Not Plotted	Felsic Rock Assemblage: Pegmatites?	
9 (inverse)	Al_2O_3, Cd, Cu, Ni, Cr, V	Not Plotted	Mafic Rock Assemblage: Basalt?	
10	Li, MnO, As, F, MgO	1) Black Rock Desert 2) Mt. Tobin 3) Selenite Range	Inconclusive	Area 1 - Li may be attributed to detritus from various rock units.

The exponential form of the polynomial discriminant method of Specht (1967) and Howarth (1973) are used in this analysis. Investigators such as Griffiths (1966), Haynes (1972), Howarth (1971a, 1971b, 1972, 1973), Whitehead and Govett (1974), Castillo-Munoz (1973), and Rose (1972), have helped to develop the many geochemical applications of this statistical technique.

Results

Two major problems were encountered when discriminant analysis was applied to this data set. The first problem involves the definition of lithologic training areas. The lithology of the area is highly complex, requiring many small training areas. The sample distribution is quite open. The result is that no meaningful lithologic training area contained enough samples to compose a significant training set.

The second major problem also relates to sample distribution. Most of the areas of historical mineral production were not sampled, thus training sets based on known mineralization could not be constructed.

The output from discriminant analysis applied to this data set is not considered meaningful, and therefore is not included in this report.

MULTIPLE REGRESSION ANALYSIS

Methods

Various aspects of multiple regression analysis have been used in the past to forecast the mineral potential of exploration areas (Cruzat and Meyer, 1974; Allais, 1957; and DeGeoffrey and Wignall, 1970). Methods that have been developed for the design of forecasting models have been based on the distribution of known mineral wealth, or on more advanced models that include geological and geochemical multivariate data. The latter approach was applied to forecasting the distribution of mineral prospects in the Winnemucca District, thereby highlighting those areas most likely to be affected by mining/prospecting activity in the future.

The number of known prospects, workings and mines per 10km by 10km grid cell was used to categorize the past mineral exploration and mining activity in the survey area. The locations of prospects, workings and mines were digitized using U. S. Geological Survey $1^{o}x2^{o}$ topographic maps. The sum of these values within each cell was then considered to be an index of historical mineral exploitation activity in that cell. Stepwise multiple regression was used to compare the historical mining activity (dependent variable) with a series of structural and lithological parameters (independent variables). From the regression, a forecasting model was developed to predict the potential for exploration in cells not having a past history of mineral exploitation.

Results

Plate D-1 presents the results of the mineral exploitation model. The rock unit most influencing the mineral exploitation index is described as "shale, mudstone, siltstone, sandstone, and carbonate rock; sparse volcanic rock includes Auld Lang Syne Group, Nightingale Sequence of Bonham and Papke, (1969), and Gabbs and Sunrise Formations" (Stewart and Carlson, 1974). Of lesser but significant influence are Cambrian sedimentary and metasedimentary units, including the Harmony formation, Cretaceous granites, and Tertiary rhyolitic volcanic rocks. Direction and abundance of faulting had an insignificant influence on the Index.

As shown on Plate D-I, the areas of highest value fall outside the sample area. However, Duffer Peak, Disaster Peak, China Mountain, and the Fox Range which have mid-range to high predicted exploitation indices are also shown by the geochemical results to be anomalous in base and precious metals.

CHARACTERISTIC ANALYSIS

Methods

Exploration geologists often make use of conceptual models in their search for mineralization. As the data become more complex, development of accurate conceptual models becomes more and more difficult. Geochemical associations that are characteristic of certain types of mineralization are described in the literature (for example, Boyle, 1974), and may be applied to this problem.

Barringer Resources' Fortran program CONCEPT was developed on the assumption that the exploration geologist would be presented with analyses of 30 or more elements on a series of samples covering a specific map area. If the geologist has a well formed concept of the type of mineralization to be found in the area, or would like to attempt a speculative search for a particular type of mineralization, a set of elements or ratios characteristic of that deposit may be entered. The elements and ratios are weighted from 0 to 1.0 to indicate their importance in the model. The program then searches the entire data set and compares the characteristics of each cell within the map area with the characteristics of the conceptual model. The CONCEPT program, in a single pass, will examine up to ten different elements and five ratios formed from these elements. Table 11 lists the conceptual models used in this analysis. Appendix B describes the characteristics of these models in greater detail.

Further details of characteristic analysis can be found in Botbol (1971), and Botbol, et al., (1977), and Weiland et al., (1981).

Results

Table 11 lists the elements and weightings of the various characteristic models. Based on the geology and known mineral occurrences, nine models were constructed. Meaningful results were obtained for the base and precious

TABLE 11
PROBABILITIES OF CHARACTERISTIC ELEMENTS USED TO DEFINE THE CONCEPTUAL MODELS

Base and Precious Metal		Skarn		Porphyry	
Zn	1.0	W	1.0	Mo	1.0
Cu	.9	CaO	.9	Cu	.9
Pb	.8	Fe_2O_3	.8	K_2O	.8
Ag	.8	Mo	.8	Pb	.8
MnO	.7	Zn	.7	Zn	.7
Ba	.7	MgO	.7	F	.7
As	.7	Cu	.6	CaO	.5
F	.5	Fe_2O_3/Ca	.8	Na_2O	.5
P_2O_5	.4	Fe_2O_3/V	.8	K_2O/CaO	.8

Epithermal Gold and Silver		Volcanic Uranium		Massive Sulfide	
Ag	1.0	U	1.0	Cu	1.0
As	.9	Li	.8	Pb	.9
Zn	.8	K_2O	.7	Zn	.9
Ba	.8	Be	.7	Ba	.7
Au	.8	Hg	.6	Fe_2O_3	.7
Sb	.6	Th	.6	MgO	.6
Cu	.5	Mo	.6	K_2O	0.0
F	.5	As	.5	Na_2O	0.0
Be	.2	U/Th	.6	Fe_2O_3/K_2O	.8
Hg	.5			Fe_2O_3/Na_2O	.8
				MgO/K_2O	.8

Mercury		Playa Uranium		Mafic Copper Nickel	
Hg	1.0	U	1.00	Ni	.9
As	.8	Na_2O	.9	Cu	.8
Sb	.6	CaO	.8	Co	.7
U	.6	K_2O	.7	Fe_2O_3	.7
Li	.6	Sr	.7	Cr	.6
Be	.5	Ba	.4	As	.5
Mo	.5	Zn	.4	Zn	.4
K_2O	.5	As	.3	Pb	.3
K_2O/Li	.7	Mo	.3	K_2O	0.0
				Fe_2O_3/K_2O	.7

metal, volcanic uranium, epithermal gold and silver, copper/nickel, and mercury models. Plates B-I to B-V show the distribution of cells corresponding well with these models. Table 1 summarizes these results on an area by area basis.

The skarn, porphyry, massive sulfide, and playa uranium models were less successful. Sketch maps of the results of these models are included as Figures 10 to 13.

Base and Precious Metal Model: This model is weighted heavily toward copper, lead, and zinc. Silver is included as a geochemically significant constituent. Gold is not included since it is likely present in very small quantities in such deposits and is not very mobile. Plate B-I shows an area on the northwest side of the Fox Range, and Central Black Rock Range which are favorable. It is of some interest that Factor 3 (factor analysis section) which may correspond to hydrothermal alteration also highlights this area of the Fox Range. Single cells showing good correspondence with the model occur on the northwest slope of the Jackson Mountains, near Duffer Peak, southwest of Sentinal Peak, and near Smoke Creek Reservoir. In general, less significance is assigned to single cell anomalies than to groups of anomalous cells.

Volcanic Uranium Model: This model is based on the occurrences associated with the McDermitt Caldera. In addition to uranium and thorium, lithium and mercury are heavily weighted. The results (Plate B-III), show good correspondence near Disaster Peak, the Augusta Mountains, and Southern Calico Mountains.

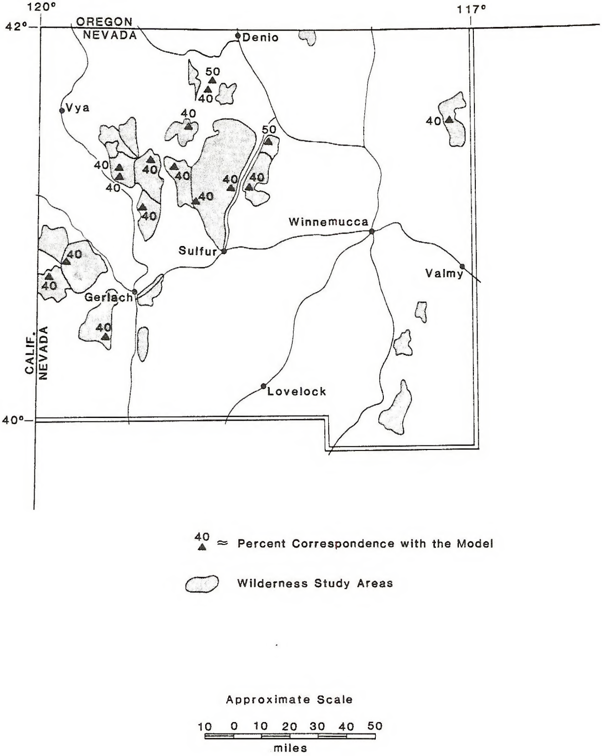
Single cells showing good corresondence with the model are the Northern Calico Mountains, the Hog Spring, the Northern Jackson Mountains, and Duffer Peak.

Gold and Silver Vein Model: The Epithermal Gold and Silver model (Plate B-II) shows anomalous results in the area of the Central Fox Range. Significant correspondence with the model is seen on the west flank of the Jackson Mountains, the west flank of the Black Rock Range, and the northern end of the Augusta Mountains.

Mercury Model: This model was based on the Cordero deposits. Arsenic, antimony, and uranium are heavily weighted in addition to mercury. Plate B-IV, shows areas corresponding to the model at the Fox Range and in the Black Rock Desert.

Mafic Copper-Nickel Model: This model heavily weights copper and nickel. Areas of significant correspondence within the Northern Calico and Jackson Mountains are outlined.

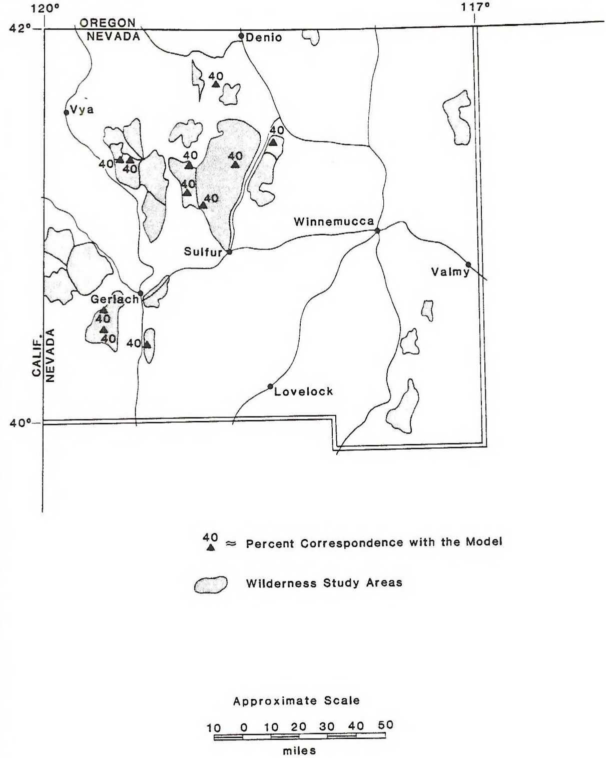
Other Models: Figures 10, 11, 12, and 13 show the results of other models. These models are apparently too general. In the cases of the massive sulfide and porphyry models, no data from a local analogous deposit is available to further constrain the model. The inherent geochemical variation in the playa uranium and tactite deposits require that the model be similarly general. Thus the information contained in Figures 10, 11, 12, and 13 is assigned a low level of significance.



MASSIVE SULFIDE CONCEPTUAL MODEL

BARRINGER RESOURCES

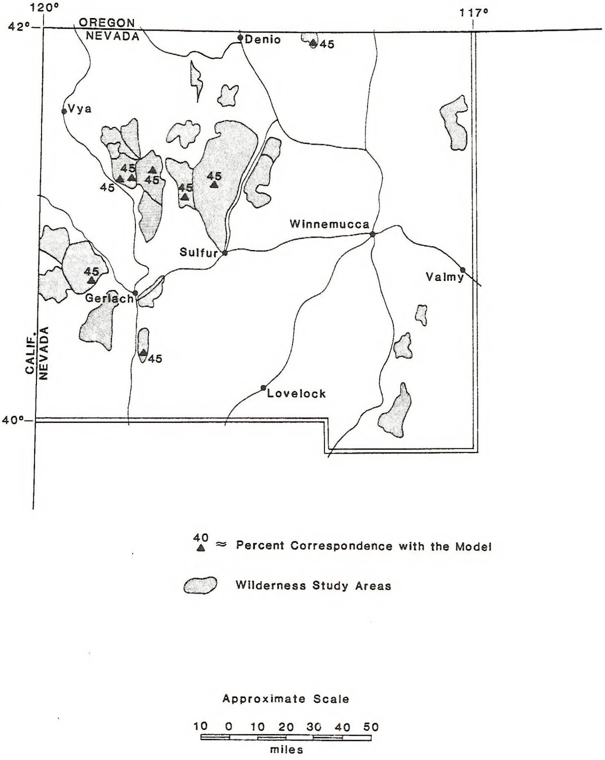
Figure 10



PORPHYRY CONCEPTUAL MODEL

Figure 11

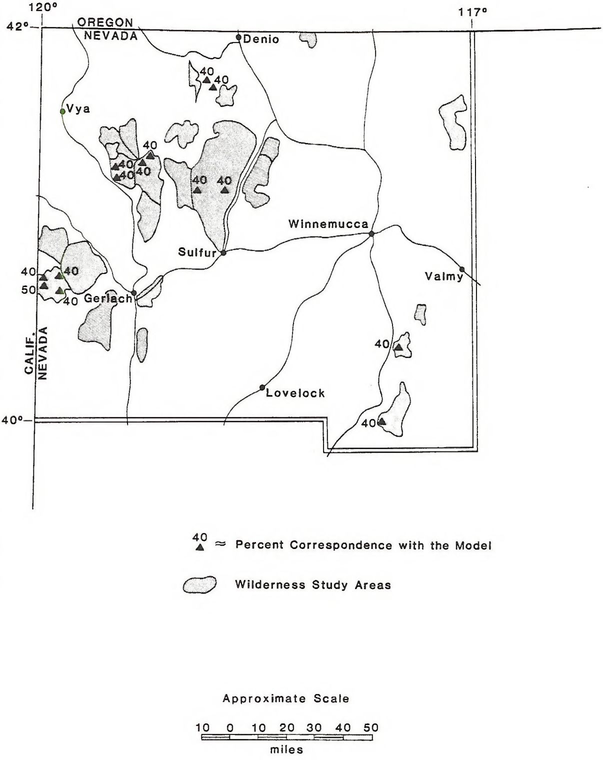
BARRINGER RESOURCES



PLAYA URANIUM CONCEPTUAL MODEL

BARRINGER RESOURCES

Figure 12



TACTITE CONCEPTUAL MODEL

BARRINGER RESOURCES

Figure 13

DISCUSSION AND RECOMMENDATIONS

DISCUSSION

Within the Wilderness Study Areas sampled, some 20 anomalous areas were outlined. These are listed in Table 1. While it is possible to rank the areas, and perhaps valuable to do so for some purposes, it should be pointed out that all 20 areas indicate some demonstrable mineral potential. Of these areas, the Fox Range, China Mountain, Calico Mountains, Augusta Mountains, and Disaster Peak areas are shown favorable by several interpretive techniques. Factors 4, 7, and 8 (Plates A-III, A-VI, and A-VII) which relate various proportions of precious and base metals highlight the metallic indicator elements. Characteristic analysis shows likely deposit types to include Cordero-type mercury, base and precious metal vein, epithermal gold and silver, and volcanic uranium types. All of these areas except the Calico Mountains are highlighted by the Forecast Mineral Exploitation Index (Plate D-I). This is of particular interest since the Forecast Mineral Exploitation Index does not include geochemical data, thereby serving to reinforce geochemical interpretation with regional geologic data.

The Jackson Mountains, Duffer Peak, and Mount Tobin areas show a good response to the metal dominated factors. These areas show a general correspondence with one or more deposit types in the characteristic analysis. Duffer Peak and Mount Tobin areas are identified in the Forecast Mineral Exploitation Index (Plate D-I).

The Selenite Range, Butte Spring, Pinto Mountain, Hole in the Ground, Black Rock Range, and Hog Spring areas are anomalous in one or more elements. Additionally, the Selenite Range and Butte Spring have a low but significant response to the metal dominated factors. The economic significance of these areas should be assessed after the other areas have been evaluated.

Stream sediments consist of detrital rock material, weathering products, organic debris, and other surficial material transported downslope by stream action and a variety of other processes. Soil and sediment are a chemical environment separate from unweathered rock in place, thus the elements in a stream sediment sample reflect a combination of their distribution in the host rock, transportation in detrital sediment, and chemical dispersion. These considerations make stream sediment sampling a powerful reconnaissance tool since the expression of even small targets may be wider and easier to locate than the body of metal in rock. When interpreting individual samples, however, allowance for migration of anomalies must be made. The geostatistical techniques involve grid cell averages which generalize individual sample locations and partially offset migration problems. However, even with cell averaged data, the processes of migration must be considered.

Certain ambiguities in interpretation of the geochemical data have been noted. For example, the geochemical expression in the Leonard Creek Slough area may be the result of three processes. Outwash from the Varyville Mining district to the north may have provided the metal in the sediment. Modern geothermal activity, seen as nearby hot springs, may have mobilized elements at depth and deposited them near the surface. A third possibility is the presence of buried mineralized rock. Additional field work and sampling would be required to explain the geochemical results seen in this area. In addition, the Smoke Creek Reservoir area is anomalous in tungsten and zinc. The reasons for this anomaly are not clear. The basalts vary from 100 to 1000 feet thick within the region and effectively mask the underlying rock units.

It is of academic interest that the processed data allows chemical distinction of rock types not seen in the geologic mapping. Factors 1, 5, and 9 (Plates A-I, and A-IV) divide mafic rock types. This interesting classification does not, however, serve to enhance or diminish the potential for ore deposits in basaltic terraine. Factors 7 and 8 (Plataes A-VI and A-VII) seem to suggest primary geochemical zoning of metals in the Fox Range rather than the result of secondary differential migration or transportation.

RECOMMENDATIONS

In a future survey of this type with similar objectives, a different array of sample locations would be beneficial in several ways. First, sample density should be closely matched to the diversity and complexity of the geologic environment. Large areas of relatively homogeneous rock type require fewer samples than complex areas. Secondly, the size of the sub-areas sampled should be considered in relation to the analytical techniques planned for the program. This would insure that the distribution of sample locations would not prevent proper interpretation of the data. Thirdly, all geologic environments should be sampled representatively. Areas of known mineralization and areas known to be at or below background provide detailed indices within the data set as well as the characteristic elemental signature of that environment. This can be of considerable aid in interpreting the data set.

It is also recommended that future studies consider including a supplemental rock chip geochemical survey. The combination of surveys has several major benefits associated. First, rock chip sampling of known deposit types provides very good data on trace element signatures. Secondly, whole rock geochemical data provides the potential for dividing suites of rock units into favorable or unfavorable categories based on petrogenetic criteria. Thirdly, rock chip data from the major lithologic units can provide an excellent basis for predicting and assessing the characteristic stream sediment geochemical response in those environments.

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