ORIENTATION AND RECONNAISSANCE GEOCHEMICAL EXPLORATION SURVEYS OF THE MONTE CRISTO RANGE AND PILOT MOUNTAINS, ESMERALDA AND MINERAL COUNTIES, NEVADA

by

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ABSTRACT

Exploration geochemical surveys were conducted in the Monte Cristo Range and Pilot Mountains, Nevada to characterize secondary geochemical dispersion, determine trace element patterns related to mineralization, determine optimum stream sediment size-fractions for reconnaissance exploration and, identify areas of potential mineralization. A total of 399 stream sediment, non-magnetic heavy mineral concentrate, and rock samples were collected at 177 sites. Samples were analyzed for 31 elements by semiquantitative spectrographic (DC-ES) and atomic absorption (AA) methods.

Orientation surveys were designed and implemented at the Ag-Pb and Au-Ag vein deposits of the Gilbert District and the W-skarn deposits of the eastern Pilot Mountains District. Twenty-nine stream sediment sites were selected, active alluvium sampled, and seven-size fractions and a non-magnetic heavy mineral concentrate were isolated for chemical analysis. In the Gilbert District eleven pathfinder elements (Ag, As, Bi, Cd, Cu, Mo, Pb, Sb, Sn, W, and Zn) are anomalous and dispersed downstream from Ag-Pb mineralization and seven pathfinder elements (Ag, As, Bi, Cu, Mo, Pb, and W) are anomalous and dispersed downstream from Au-Ag mineralization. In the Pilot Mountains District eight pathfinders (Ag, Bi, Cu, Mg, Mo, Pb, W, and Zn) are anomalous and dispersed downstream from W-skarn mineralization.

Pathfinder elements were used in the reconnaissance surveys to delineate areas of known mineralization and to evaluate the surrounding areas for potential mineralization of similar types. In the Monte Cristo Range five anomalous areas are delineated by -60 mesh stream sediment and non-magnetic heavy mineral concentrates that have potential for Au-Ag, Ag-Pb, and Mo mineralization. In the Pilot Mountains two follow-up areas are delineated by 49 anomalous sample sites. One area, located in the northern Pilot Mountains, is defined by multi-element (Ag, As, Bi, Mg, Mo, Pb, Sb, W, and Zn) anomalies in samples of non-magnetic heavy mineral concentrates. Six samples within this area exhibit an anomalous three element suite of W ± Ag, Bi, Mg, or Mo. These six sites are potential follow-up areas for the occurrence of W-skarn mineralization. Another follow-up area, located in the southern Pilot Mountains, is defined by twelve -60 mesh stream sediment samples consisting of anomalous Cu ± Sb, Pb, Zn, As, and has potential for a porphyry type base metal system.

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INTRODUCTION

Objectives and Scope of Research

This thesis has two objectives. The first is to determine and characterize the nature of secondary geochemical dispersion and element associations around the Gilbert and Pilot Mountains mining districts using two orientation surveys. The second is to evaluate the potential for occurrence of similar deposits in the surrounding mountain ranges by applying the results from the first objective to a reconnaissance stream sediment survey.

There were four phases in this research. Phase I included literature research and design of two orientation and reconnaissance surveys during the spring, 1982. Phase II involved the implementation of the orientation and reconnaissance surveys and preliminary evaluation of the orientation survey data during the summer, 1982. Phase III utilized results of the second phase to design a follow-up survey to delineate areas of anomalous metals concentration during 1983. Phase IV of the project involved data interpretation and presentation of results.

Location and Physiography

The study areas consist of the Monte Cristo Range and

Pilot Mountains located in west-central Nevada, 30 to 70 miles west and northwest of Tonopah in the Basin and Range physiographic province (pl. 1; fig. 1). Access to the area from Tonopah, Nevada is by U.S. Routes 6 and 95, then by numerous county dirt roads and unmaintained jeep trails.

The Basin and Range physiographic province covers approximately 250,000 square miles including most of Nevada, and parts of Arizona, California, Idaho, New Mexico, Oregon, Texas, Utah and northern Mexico. The province is characterized by north-south trending, long narrow mountain ranges separated by broad valleys filled with alluvium. Topography of the ranges is rugged with abundant outcrop. Most streams are ephemeral, though rivers are perennial in the southern part of the province.

Climate and Vegetation

The area is characterized by an arid to semiarid climate with an extreme annual temperature range between -22 F and 110 F (Ross, 1961). Total precipitation is 3 to 8 inches annually with snowfall common during the winter (Ross, 1961; Albers and Stewart, 1972).

Vegetation is dominantly sagebrush and prickly pear cactus in the Monte Cristo Range and at lower elevations in the Pilot Mountains. Pinyon and juniper pines form moderate

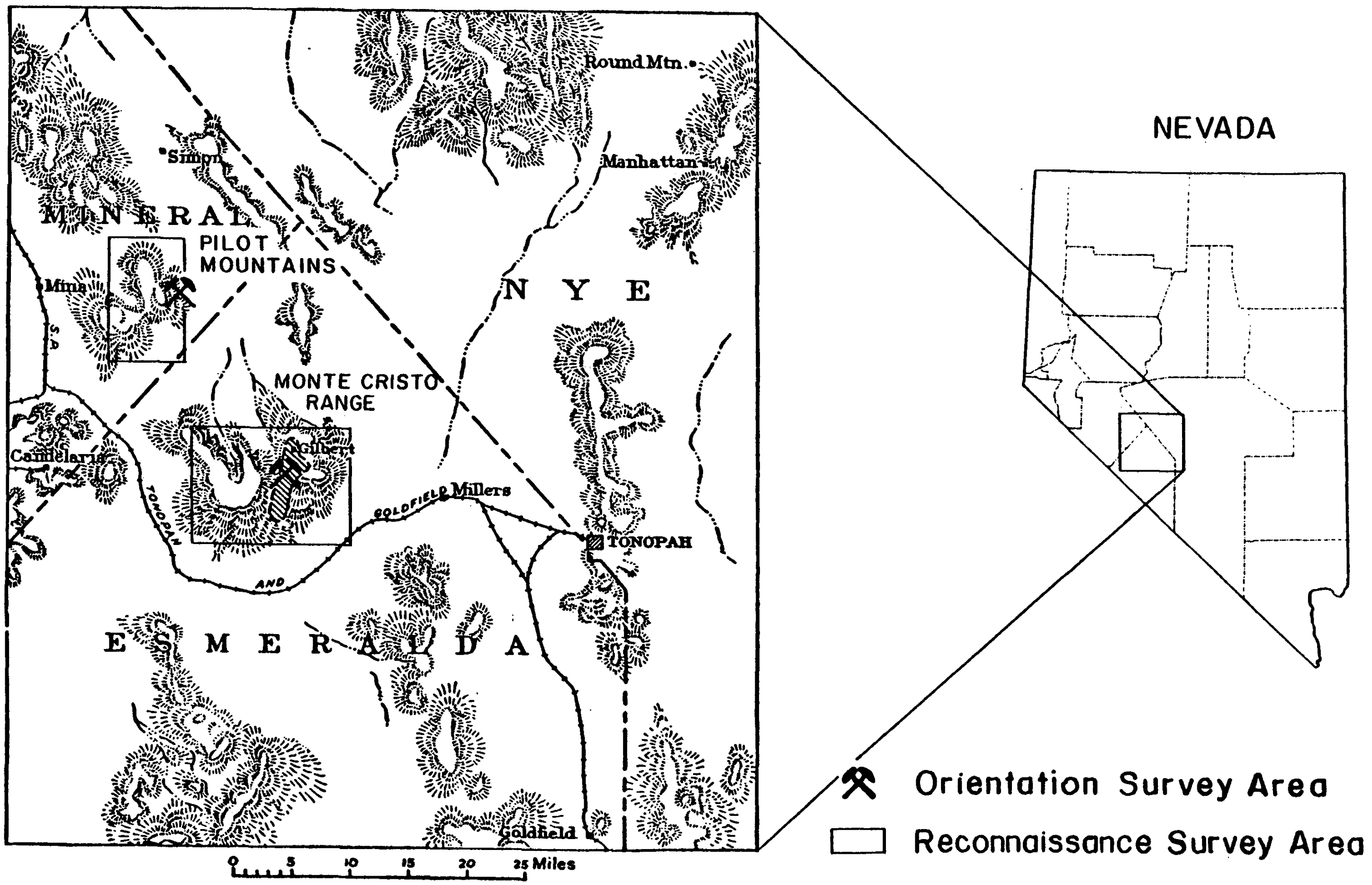


FIGURE I

LOCATION MAP, AFTER FERGUSON (1928).

forest cover above 7000 feet in the Pilot Mountains and sparse cover in the Monte Cristo Range.

Previous Work

Several stream sediment surveys have been carried out in the Basin and Range province utilizing various sediment fractions. The most recent compilation of exploration geochemical studies in the Basin and Range province was published as a special issue by the Association of Exploration Geochemists (Lovering and McCarthy, 1978). The stream sediment studies were applied to exploration for silver, copper, lead, zinc, molybdenum, and beryllium. There have been few published articles applied to stream sediment sampling in areas draining known gold or tungsten mineralization in the Basin and Range province. Griffitts and Alminas (1968) sampled stream sediments draining a precious metal district in southwestern New Mexico. They evaluated the -80 mesh and non-magnetic heavy mineral fractions of stream sediment. Their results showed that tellurium effectively outlined mineralized terranes and that the non-magnetic heavy mineral fraction showed a marked enhancement in contrast between anomalous and background metal contents.

Pincus (1982) studied the secondary dispersion around auriferous jasperoids in east-central Nevada. He evaluated spring water and three fractions of stream sediment (-14 to +80 mesh; -80 to +156 mesh; -156 mesh). His results showed that the coarse fraction (-14 to +80 mesh) exhibited the greatest geochemical contrast downstream of mineralization. Pincus also concluded that physical weathering predominates over chemical weathering.

Mehrtens (1986) studied the secondary dispersion of gold and "other pathfinders" downstream from disseminated gold deposits in north-central Nevada. He compared three fractions of stream sediment and found that gold and mercury in the -200 mesh fraction were useful in discriminating between significant and non-significant geochemical anomalies that were spatially related to disseminated gold deposits.

Fredericksen (1974) studied the secondary dispersion of tungsten downstream from a scheelite skarn occurrence, a wolframite-bearing vein deposit, and a scheelite-bearing vein prospect, all located in southern Arizona. He evaluated five fractions of stream sediment (-12 to +35 mesh; -35 to +80; -80 to +120; -120 mesh; and panned concentrates) and concluded the following: (1) the -80 to +120 mesh fraction provided the greatest contrast at the wolframite-vein deposit, (2) the -120 mesh fraction showed the greatest contrast at the scheelite prospects, and (3) the panned concentrates provide the greatest contrast in defining tungsten anomalies.

Several workers have contributed to understanding the regional geology of the study area. Muller and Ferguson (1939) and Ferguson and Muller (1949) of the U. S. Geological Survey investigated the regional geology. Geologic reports of Esmeralda County (Albers and Stewart, 1972) and Mineral County (Ross, 1961) revised regional and local geologic information as well providing mineral resource data for these areas. Moore (1981), Stewart (written commun., 1982), and Stewart (1985) have revised the geologic maps of the Monte Cristo Range. Large-scale geologic mapping and revisions of previous work in the Pilot Mountains were carried out by Nielsen (1964), Wetterauer (1977), and Oldow (1978).

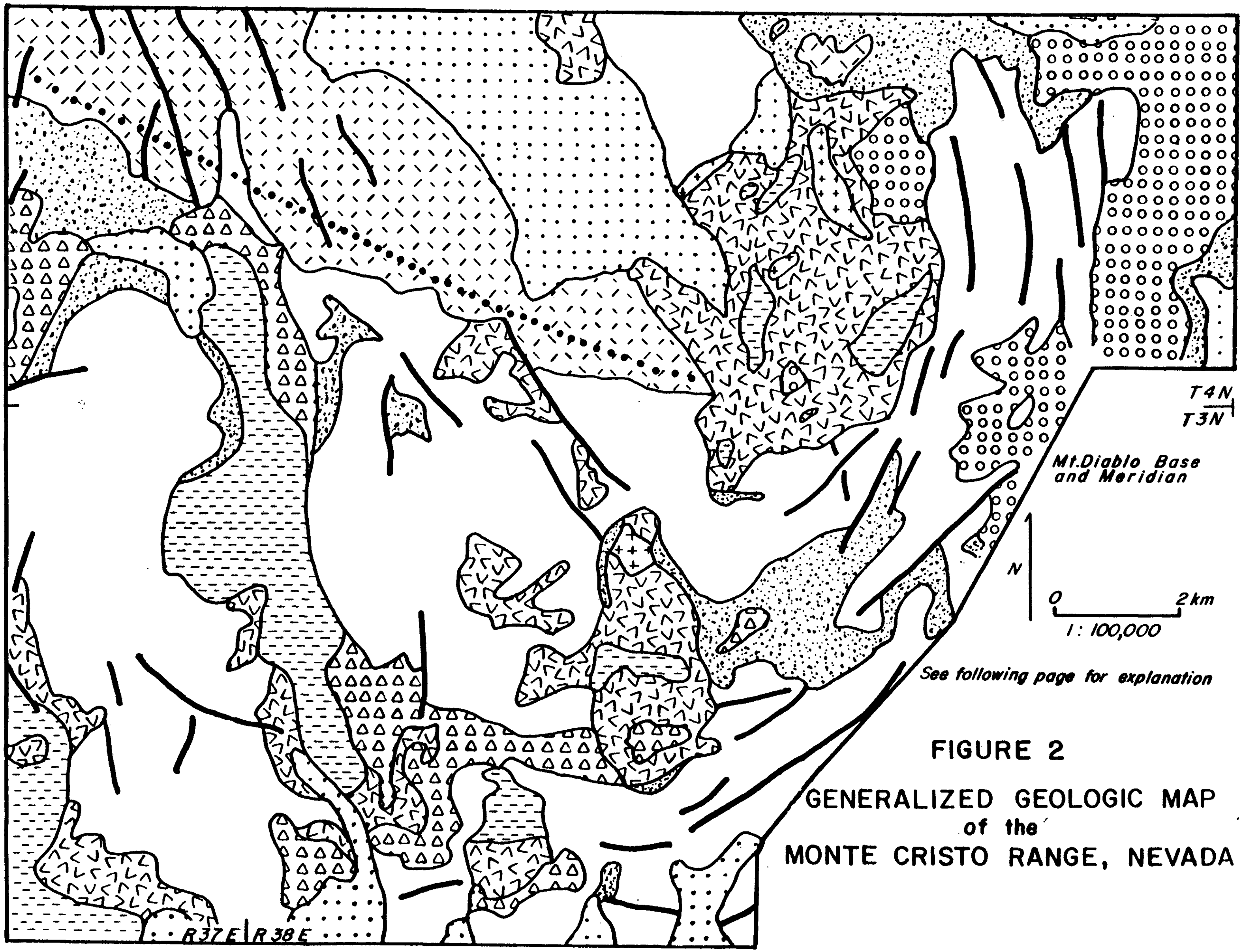
GEOLOGY

Regional Setting

The Monte Cristo Range and Pilot Mountains are geologically distinct from one another. The study areas are located 100 miles east of the Sierra Nevada Batholith. The lithologies of the Monte Cristo Range (fig. 2) are dominated by Tertiary volcanic rocks while the Pilot Mountains (fig. 3) consist of late Paleozoic to Mesozoic sedimentary rocks and Cretaceous intrusive rocks.

Several orogenic events have deformed the rocks of Nevada since mid-Paleozoic time. The events are characterized by folds, thrusts, high-angle and strike-slip faults. The events are termed the Antler, Sonoman and Nevadan orogenies, which began during the Late Devonian and ended during Cretaceous time. The youngest event to affect the region was crustal extension which has evolved the present topography of the Basin and Range province (Stewart, 1978). Basin and Range structure is characterized by high-angle normal faulting along N-S to NE-SW trending breaks that began during early to middle Miocene time (21-16 Ma).

Regionally, the Monte Cristo Range and Pilot Mountains lie within the Walker Lane belt (Locke and others, 1940). The Walker Lane is a NW-SE trending shear zone with right-



See following page for explanation

FIGURE 2

GENERALIZED GEOLOGIC MAP
of the
MONTE CRISTO RANGE, NEVADA

EXPLANATION
of
MONTE CRISTO RANGE, NEVADA
GEOLOGIC MAP

(geologic map on previous page)

—	Contact
━	Fault
••••	Excelsior lineament

CENOZOIC ROCKS

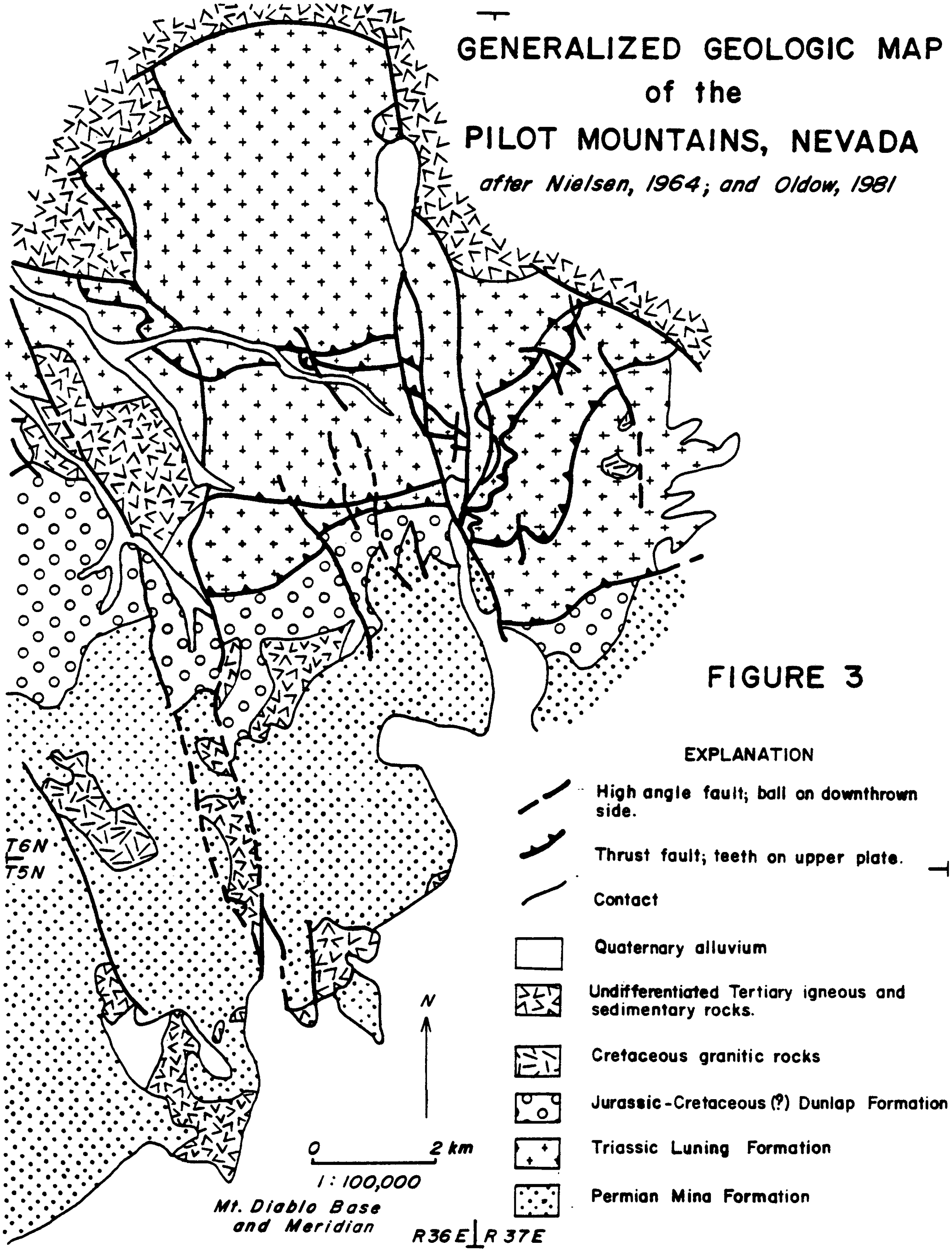
⁘	Alluvial deposits
⋋	Olivine basalt
☐	Gilbert andesite
○	Rhyolite flows and shallow intrusives
▒	Sedimentary rocks
△	Lava flows and intrusive (?) rocks of Blair Junction
⌐	Tuff of Castle Peak
+	Older andesite

PRE-CENOZOIC ROCKS

┅	Undivided sedimentary and igneous rocks of Cretaceous, Triassic, Mississippian, and Ordovician age.

Geology adapted from: Moore (1981), Stewart (written communication, 1982), and Stewart (1985).

FIGURE 2a



GENERALIZED GEOLOGIC MAP of the PILOT MOUNTAINS, NEVADA

after Nielsen, 1964; and Oldow, 1981

FIGURE 3

lateral movement, possibly initiated during the Mesozoic, with recent movement during the Late Cenozoic (Stewart, 1985).

On a local scale the study area is in a disrupted zone of sigmoidal bends and dextral faults. Events of the Nevadan orogeny and Basin and Range extension have significantly influenced the structure of the Monte Cristo Range and Pilot Mountains.

Stratigraphy

Paleozoic Rocks

The oldest rocks that crop out in the Monte Cristo Range are the Ordovician Palmetto Formation which consists of black chert, greenish-gray to light-gray argillite, light -gray fine- to coarse-grained quartzite, and pillow lavas (Stewart, 1985). Juxtaposed with the Palmetto Formation are Mississippian age strata consisting of limestone, dolomite, and silicified dolomite (Poole and Sandberg, 1977; Stewart, written commun., 1982; Stewart, 1985). The contact relationship between these strata is unclear.

Permian rocks of the Mina Formation, exposed in the southern Pilot Mountains, are composed of volcanogenic turbidites, pelites, and chert (Speed, 1977). Turbidites consisting of fine- to coarse-grained sand and volcanic debris dominate the section. The pelites consist of red and green mudstones and are intercalated with quartzose sandstones and feldspathic turbidites.

Mesozoic Rocks

Mesozoic sedimentary rocks consist of the Candelaria Formation, Luning Formation, and Dunlap Formation. The Candelaria Formation crops out in the Monte Cristo Range where it is juxtaposed with Mississippian and Ordovician strata. The Candelaria Formation, Early Triassic in age, is composed of green-gray siltstone, chert, and quartz arenite to fine conglomerate (Muller and Ferguson, 1939). The Luning and Dunlap Formations, exposed in the Pilot Mountains, have been extensively studied by Oldow (1978) and Wetterauer (1977), respectively. The Luning Formation is in fault contact with the Mina Formation and is of Late Triassic age. It is up to 8350 feet thick and consists of a varied sequence of carbonates, chert, conglomerate, tuff, and argillaceous sediment. The Dunlap Formation is Cretaceous-Jurassic in age and is composed of red and maroon sandstone, sedimentary breccia, siltstone, shale, and conglomerate (Speed, 1981). The clastic sediments of the Dunlap Formation are intercalated with minor amounts of limestone and volcanic debris.

Small stocks, sills, and dikes of intermediate to felsic composition are exposed throughout the study area. In the Monte Cristo Range, age determinations on sericite from an altered quartz monzonite stock give results of 194 ± 4 Ma by K-Ar methods (Silberman and others, 1975). On the eastern slope of the Pilot Mountains, age determinations on biotites from two quartz monzonite stocks give results of 83.4 ± 3.1 Ma and 80.4 ± 2.1 Ma by K-Ar methods (Grabher, 1984).

Cenozoic Rocks

The Tertiary rocks of the Monte Cristo Range are dominated by volcanic units which unconformably overlie Paleozoic and Mesozoic strata. The lowest Tertiary rocks are Late Oligocene or Early Miocene and consist of a sequence of flows and breccias of andesitic to rhyodacitic composition, as well as welded and non-welded rhyolite tuffs that are locally siliceous (Moore, 1981). These volcanics are overlain by 650 feet of lacustrine strata consisting of claystone, siltstone, fine- to very fine-grained sandstone, diatomite, conglomerate, and monolithologic breccia. The lacustrine sediments are intruded and overlain by rhyolite domes, porphyritic andesite, and olivine basalt.

In the Pilot Mountains voluminous flows of andesite accumulated before and during deposition of Upper Miocene and Lower Pliocene sediments of the Esmeralda Formation (Ferguson and others, 1953, 1954; Ross, 1961). The Esmeralda Formation consists of shale, mudstone, fresh-water limestone, tuffaceous sandstone, conglomerate and fanglomerate, and is up to 500 feet thick (Nielsen, 1964). Interfingering with, overlying, and intruding the Esmeralda Formation is a porphyritic rhyodacite, which occurs as dikes, flows, and domes.

Structural Geology

Monte Cristo Range

The Monte Cristo Range is structurally complex and anomalous to west-central Nevada because of its arcuate shape and diversity of rocks. Several blocks of Paleozoic, Mesozoic, and Cenozoic rocks are juxtaposed with each other. Contacts between pre-Tertiary rocks are poorly defined. The Monte Cristo thrust, located on the southwest flank of the range, is one of the largest thrusts in the area, juxtaposing Ordovician, Mississippian, and Triassic rocks (Ferguson and others, 1953).

Locally, several faults and unconformities have been mapped by Moore (1981) in the southern part of the range. Mapping by Stewart (written commun., 1982) and Stewart

(1985), and gravity surveys by Snyder and Healy (1983) have added to the data base of previous workers. Stewart (1985) has proposed two major east-west trending dextral faults, the Excelsior and Coaldale fault zones, on the north and south sides of the Monte Cristo Range, respectively, to explain the anomalous structure of this area. Snyder and Healy (1983) postulated that nested calderas may explain the arcuate shape of the range.

Pilot Mountains

The structural geology of the Pilot Mountains has been investigated by Ferguson and Muller (1949), Nielsen (1964), Wetterauer (1977), and Oldow (1978, 1981). Mapping by Oldow (1978) has shown that pre-Tertiary strata of the Pilot Mountains consist of a succession of stacked thrust sheets and overturned folds formed during Mesozoic compressional deformation. Oldow (1981) has proposed three episodes of deformation during emplacement of the allocthonous terrain of the northern Pilot Mountains.

During the Tertiary, normal and strike-slip faults were active in the Pilot Mountains. The Soda Springs Valley fault on the western margin of the range and the Bettles Well Fault zone on the eastern margin are the most prominent right-lateral strike-slip faults in the area, and may be related to Walker Lane movement (Nielsen, 1964).

Mineral Deposits

Gilbert District

The Gilbert District, also known as the Desert District, is located in the northeast part of the Monte Cristo Range (pl. 1; fig. 1). Two periods of ore deposition were recognized by Ferguson (1928) and have been characterized geochemically by Nash and others (1985a).

An early period of mineralization, associated with granitic intrusives, is best exhibited at the Carrie Mine. Ore mineralogy consists of argentiferous base metal sulfides in quartz veins located near the contact of Mississippian limestone and quartz monzonite. Limestones have been locally silicified, forming jasperoid ledges throughout the district. A specimen of ore collected by Ferguson (1928) from the 100 foot level consists of pyrite, galena, tetrahedrite, minor chalcopyrite and covellite, oxides of iron and manganese, carbonate of copper, and bindheimite [Pb Sb O (O,OH)].

The later period of mineralization produced precious-metal veins hosted in the Palmetto Formation, Mississippian limestone, and Tertiary volcanic rocks, usually near masses of intrusive rhyolite (Ferguson, 1928). Free gold, the principal ore mineral of the deposits, was found with silica veins. Silver was the principal metal of one of the mines in the district, occurring as pyrargyrite, cerargyrite, and argentite in a quartz vein hosted by rhyolite breccia (Ferguson, 1928). The several small mines, short tunnels, prospects, and irregular pits representing this later period of mineralization will be collectively referred to as the Gilbert Au-Ag prospects.

Pilot Mountains District

The Pilot Mountains District, also known as the Sodaville District, was discovered in 1913 by T. Pepper and C. Keough while they were searching for stray steers and found an outcrop of limestone laced with cinnabar (Knopf, 1916). The district has produced mercury, turquoise, tungsten, gold, lead, silver, and bentonite (Knopf, 1916; Lincoln, 1923; Foshag, 1928; Vanderburg, 1937; Bailey and Phoenix, 1944; Phoenix and Cathcart, 1952). The tungsten deposits have been described by Hess and Larsen (1922), Vanderburg (1937), Kerr (1946), and Grabher (1984) and characterized geochemically by Nash and others (1985b).

Tungsten mineralization was discovered in 1916 on the east slope of the Pilot Mountains and located in the Gunmetal, Garnet, and Desert Scheelite groups of claims (pl. 1;

fig. 1). Three types of tungsten ore were recognized by Hess and Larsen (1922). They described the ores as:

> "... tactite ore, quartz-calcite-scheelite vein, and bunches of quartz, calcite, galena, and scheelite, rich in silver."

Kerr (1946) reported on the occurrence of garnet, calcite, diopside, chlorite, amphibolite tactite zones, and wulfenite and argentiferous galena in quartz veins. Scheelite is the dominant ore mineral, occurring in garnet and or pyroxene tactites.

The tactite-ore horizons of the Desert Scheelite, Gunmetal and Garnet areas are variable in grade and extent (Grabher, 1984). The Desert Scheelite deposit is base-metal enriched and contains a tactite zone that extends 2000 feet along the contact of a stock, and 1000 feet downdip within the Luning Formation. This tactite has greater than 20% sulfides, mostly pyrite, chalcopyrite, and sphalerite. Selective metasomatic replacement of carbonate rocks within the Luning Formation has produced multiple stratiform tactites. The occurrence of high-grade scheelite in pyroxene-garnet tactites is relatively limited throughout the area. Some of the deeper, pyroxene-tactite horizons are very low grade but contains considerable molybdenite. The variability of scheelite grade appears to be related to many factors, not limited to permeability and composition of the

Luning Formation and the effects of multiple intrusive events within the local area (Grabher, 1984).

GEOCHEMICAL METHODS

The purpose of this chapter is to discuss the methods used to meet the objectives of the study. This involves the design of sampling surveys, sample collection methods, sample preparation, and the analytical techniques utilized in this study.

Sampling Surveys Design

Orientation Survey

The orientation survey is a preliminary investigation to determine geochemical characteristics of anomalies associated with mineralization. The geochemical characteristics of drainage dispersion in the Gilbert and Pilot Mountains Districts to be determined are:

1. threshold values of chemical elements associated with mineralization;
2. factors that influence metal dispersion in stream sediment downstream from mineralized areas;
3. anomalous metals dispersed downstream from mineralized areas; and
4. optimum stream sediment size-fraction for reconnaissance exploration in similar environments.

Previous geochemical orientation studies performed in the Basin and Range province have tested a range of stream sediment size-fractions and have reached differing conclusions (Griffitts and Alminas, 1968; Fredericksen, 1974; Pincus, 1982; Mehrtens, 1986). In this investigation individual orientation surveys were designed to characterize mineralization in each of the two mining districts. Eight fractions of stream sediment material (table 1) were isolated for study to determine the optimum sieve-size for metals exploration in the Basin and Range province.

The orientation survey of each district involved the sampling of three drainages upstream and downstream from known mineralization. Background response was examined in an adjacent drainage lacking known mining activity. Seventeen sites were selected and sampled in the Gilbert District and twelve sites were selected and sampled in the Pilot Mountains District.

Reconnaissance Survey

A reconnaissance sampling program was designed to meet the goals of the U. S. Geological Survey (USGS) mineral resource appraisal project. Site accessability, time and funding were the major constraints of the project. Sample density was established by the USGS and chosen to be approx-

Table 1

Cross reference chart showing sample number* prefixes and sieve size for medium evaluated.

Prefix	U.S. Standard ASTM Mesh #	Opening (mm)	
1) TZSA	-35 to +45	0.50	0.35
2) TZSB	-45 to +60	0.35	0.25
3) TZSC	-60 to +80	0.25	0.177
4) TZSD	-80 to +120	0.177	0.125
5) TZSE	-120 to +200	0.125	0.074
6) TZSF	-200	0.074	
7) TZSS	-60	0.25	
8) TZC	-25	0.71	

Explanation:

* data presented in Siems, Zuker, and Goldsmith (1984);

\- minus indicates material passed through sieve;

\+ plus indicates material that did not pass through sieve;

TZS sieved to -60 mesh, unless with 4th letter, then represents size fraction as noted above;

TZC non-magnetic heavy mineral concentrate sieved to -25 mesh.

imately 1 sample per 3 square miles. Two stream sediment samples were collected at each site, the first was sieved in the laboratory, and the second bulk sample was panned in the field. Rock samples were collected whenever a major lithologic unit, mineralization type or alteration type was recognized.

Sample Collection

Three hundred and ninety-nine samples were collected at 177 sites. Fifty-eight samples of stream sediment material were from the orientation survey areas and 341 samples were from the reconnaissance survey area (pl. 1). Material collected were stream sediment, heavy mineral concentrate, and rock chip samples.

Stream Sediment

A composite stream sediment sample, weighing 20 lbs., was collected at most of the 177 sites. It was taken from the active part of the stream channel (dry), perpendicular and parallel to the flow direction, approximately 30 feet upstream and downstream from the initial site. Material was collected from the surface to a depth of five inches and care was taken to avoid collection of any bank material.

At the site, stream sediment was sieved through a 10 mesh stainless steel screen into a steel gold pan. The -10 mesh material was then split by hand into two subsamples. One 5 lb. subsample was sieved in the laboratory prior to submission for chemical analysis. The second subsample was panned in the field at a later date and a heavy mineral concentrate was isolated and saved for subsequent processing.

Rocks

Rock samples were collected throughout the study area to determine background and anomalous geochemical concentration values in major lithologies exposed in the region. The rock samples were identified in the field and any signs of alteration or visible mineralization were noted. Rock samples consisted of 5 lbs. of chips with a diameter of 1 to 2 inches.

Sample Preparation

Stream Sediment

Stream sediment from the orientation survey areas was screened through a nest of stainless-steel sieves into seven fractions (table 1). Reconnaissance stream sediment was screened using a 60 mesh sieve. The fractions with particle size greater than 100 mesh were hand ground in a mortar and pestle to -100 mesh.

Heavy Mineral Concentrates

Preparation of heavy mineral concentrates (TZC) involved five steps prior to chemical analysis. In general, these procedures included: panning, sieving, heavy liquid separation, magnetic separation, and hand grinding of the sample. The procedures used are standard at the USGS laboratories and have been described by Meyer and others (1979).

The bulk stream sediment samples were transported to the closest running stream and panned using techniques discussed by Theobald (1957). The sample was panned until most of the feldspar, quartz, and organic matter was removed and light colored minerals formed a thin layer on top of the darker heavy minerals concentrated at the bottom of the pan.

The next four steps were completed at the USGS laboratories in Golden, Colorado. The heavy mineral concentrate was screened through a 25 mesh stainless steel sieve. The -25 mesh fraction was then separated into light and heavy mineral fractions using bromoform [density (d) = 2.85 g/ml]. The light fraction ($d \leq 2.85$ g/ml) consisting mostly of quartz and feldspar, was discarded and the heavy fraction ($d \geq 2.85$ g/ml) was dried and separated according to its magnetic susceptibility using a Frantz Isodynamic Separator.

The magnetic fractions were discarded and the non-magnetic fraction was split, then hand ground to -100 mesh and submitted for analysis.

Rocks

Rock samples were crushed to a size of 1/4 inch using a "Chipmunk" jaw crusher. A 1/2 lb. split was then pulverized with ceramic plates, and the -100 mesh material was submitted for chemical analysis.

Analytical Methods

Chemical Analyses

Stream sediment, non-magnetic heavy mineral concentrate, and rock samples were analyzed by the USGS, Golden, for 31 elements using a semiquantitative direct-current arc emission spectrographic (DC-ES) method (Grimes and Marranzino, 1968). The DC-ES method provides a rapid determination of total major and trace element concentrations from stream sediment, heavy mineral concentrates, and rock samples. Elements determined by this method and their detection limits are presented in table 2. Chemical analysis of the heavy mineral concentrate fraction (TZC) yields a high concentration of some elements, thus a smaller sample size (5 mg instead of 10 mg) was used to reduce

Table 2

Detection limits (DL) for semiquantitative spectrograhic (DC-ES) and atomic absorption (AA) analyses.

Semiquantitative Emission Spectrograph (DC-ES)*					
Element	Lower DL	Upper DL	Element	Lower DL	Upper DL
Ca (%)	0.05	20	La	20	1000
Fe (%)	0.05	20	Mn	10	5000
Mg (%)	0.02	10	Mo	5	2000
Ti (%)	0.002	1	Nb	20	2000
Ag	0.5	5000	Ni	5	5000
As	200	10000	Pb	10	20000
Au	10	500	Sb	100	10000
B	10	2000	Sc	5	100
Ba	20	5000	Sn	10	1000
Be	1	1000	Sr	100	5000
Bi	10	1000	Th	100	2000
Cd	20	500	V	10	10000
Co	5	2000	W	50	10000
Cr	10	5000	Y	10	2000
Cu	5	20000	Zn	200	10000
			Zr	10	1000

Atomic Absorption (AA)**		
Element	Lower DL	Upper DL
As	5	-
Bi	1	-
Cd	0.1	-
Sb	1	100
Zn	5	2000

Explanation: values reported as ppm, except where noted;
- no data available;
* based on a 10 mg sample, Grimes and Marranzino, 1968;
** based on a 2 g sample, Viets and others, 1984.

interferences. The detection limits of these samples (TZC) were increased by two reporting intervals.

Stream sediment samples (TZS) collected during the reconnaissance survey were also analyzed by atomic absorption spectrophotometry (AA) for five elements having elevated lower detection limits by the DC-ES method (As, Bi, Cd, Sb, and Zn). The analyses and digestion were performed by the USGS using a partial-leach procedure (Viets and others, 1984). The procedure utilizes an organic separation that selectively concentrates the elements of interest into an organic phase, effectively eliminating interference elements from the aqueous solution. The detection limits for this method are presented on table 2.

Analytical and Sample Variability

The analytical precision of the DC-ES method has been published by Motooka and Grimes (1976) and is described as being within ±1 reporting interval 83 percent of the time and within ±2 reporting intervals 96 percent of the time for each element. Viets and others (1984) report a relative standard deviation of less than 10 percent for AA determination of As, Bi, and Zn, and 10-20 percent for Sb and Cd.

Duplicate samples of stream sediment (TZS) and heavy mineral concentrates (TZC) were collected at ten sites to evaluate sample variability. Duplicate sample sites were chosen randomly so that approximately five percent of the data set would be duplicates. After the duplicate samples were collected, the pairs were treated separately (i.e., panned at different times) and submitted in random order for chemical analyses.

Sample variability is a summation of the variability arising from analytical and sampling errors. Sample variability was calculated utilizing the original and duplicate sample data. The sample variability was expressed relative to the mean of the duplicate analyses in percent using the formula:

$$[|\overline{X}-x_1| / \overline{X}] * 100\%$$

where: $\overline{X} = (x_1 + x_2) / 2$

x_1 = original sample data

x_2 = duplicate sample data

Values approaching zero percent reflect low sample variability, whereas values approaching 100 percent reflect high sample variability.

DC-ES Data: The range of sample variability is from 16 to 69 percent and centers around 31 percent (table 3). The elements that have high variability generally have few unqualified data. Table 4 presents results from the DC-ES

Table 3

Total sample variability relative to the mean of site duplicates*.

Element	n	%	Element	n	%
Ca	20	22.7	Nb	13	20.7
Fe	20	29.0	Ni	12	21.7
Mg	20	23.7	Pb	20	36.2
Ti	20	21.2	Sb	3	16.7
Ag	9	46.3	Sc	20	22.8
As	1	33.3	Sn	3	69.0
Au	0	**	Sr	20	24.5
B	20	32.3	Th	0	**
Ba	18	31.9	V	20	25.3
Be	17	28.2	W	6	42.8
Bi	6	60.0	Y	20	26.5
Cd	3	43.3	Zn	5	35.2
Co	19	24.8	Zr	14	34.8
Cr	20	20.1	AA-As	10	16.8
Cu	19	20.9	AA-Bi	2	49.6
La	20	26.5	AA-Cd	10	28.7
Mn	20	33.0	AA-Sb	10	31.7
Mo	10	45.1	AA-Zn	9	18.0

Explanation: refer to table 4 for samples used in calculating these results;

* Data from Siems, Zuker, and Goldsmith (1984);

** not computed, no results within limits of determination;

n number of pairs of analyses used in calculation of sample variability;

AA- atomic absorption data, all other data are generated by DC-ES methods.

Table 4

Reproducibility of duplicate pairs of samples from DC-ES data obtained in the study area.

Duplicate Pairs		Element																														
		Ca	Fe	Mg	Ti	Ag	As	Au	B	Ba	Be	Bi	Cd	Co	Cr	Cu	La	Mn	Mo	Nb	Ni	Pb	Sb	Sc	Sn	Sr	Th	V	W	Y	Zn	Zr
TZS00019 &	020	1	3	2	2	<	<	<	3	3	3	<	<	3	2	1	2	3	1	(1)	3	5	<	2	<	1	<	3	<	2	<	2
036	037	1	2	2	1	(2)	<	<	2	1	4	<	<	2	0	1	1	1	<	<	1	1	<	0	<	1	<	1	<	0	(2)	1
043	044	2	2	2	2	0	<	<	0	0	1	1	<	2	2	1	0	0	4	<	2	2	<	1	<	1	<	3	(6)	0	(3)	3
056	057	2	1	1	0	6	<	<	1	2	2	<	<	1	1	1	1	3	<	(1)	0	4	<	1	<	1	<	1	<	1	<	2
075	076	2	2	2	1	<	<	<	3	2	2	<	<	0	1	1	2	2	<	(1)	1	1	<	0	<	2	<	2	<	1	<	1
100	102	2	0	0	0	<	<	<	1	2	0	<	<	0	0	0	2	2	1	(1)	0	0	<	1	<	1	<	0	<	2	<	2
A117	117	0	1	0	1	0	<	<	1	1	1	1	<	1	1	0	3	0	2	<	0	0	<	1	<	1	<	0	0	0	1	0
118	119	2	2	1	1	<	<	<	2	2	2	<	<	0	0	1	4	3	1	<	0	2	<	2	<	1	<	1	<	2	<	2
124	125	2	1	2	0	<	<	<	1	2	2	<	<	1	1	1	0	2	<	(1)	0	0	<	1	<	1	<	1	<	2	<	1
142	143	2	2	2	1	(1)	<	<	4	3	3	<	<	1	1	1	1	3	<	<	0	2	<	2	<	2	<	2	<	2	<	0
TZC00019 &	020	4	0	2	$\underline{3}$	<	<	<	3	$\underline{4}$	4	(4)	<	(2)	1	<	4	3	<	3	<	4	<	3	(3)	2	<	2	<	4	<	$\underline{15}$
036	037	1	1	1	3	5	<	<	3	5	(1)	$\underline{16}$	(4)	1	1	4	0	2	5	<	<	5	<	2	8	1	<	3	4	4	2	3
043	044	0	4	1	2	6	<	<	3	7	0	7	<	0	0	2	4	2	5	<	<	4	<	1	4	3	<	3	4	2	<	$\underline{8}$
056	057	0	1	0	1	<	<	<	0	2	0	<	<	(2)	1	0	0	0	<	0	(2)	2	(2)	1	<	1	<	1	<	1	<	>
075	076	2	1	0	1	<	<	<	2	0	<	(4)	<	0	3	(1)	2	3	<	(2)	<	2	<	(2)	<	0	<	2	<	4	<	>
100	102	1	2	1	1	<	<	<	0	>	<	<	<	1	1	0	0	1	<	1	<	(2)	0	1	<	0	<	1	<	2	<	>
118	119	0	0	2	1	<	<	<	1	0	1	<	<	1	0	0	0	2	<	1	<	1	<	0	<	2	<	0	<	1	<	>
124	125	2	2	2	1	<	<	<	2	0	1	<	<	2	0	0	1	1	1	1	<	0	<	1	<	0	<	0	(2)	1	<	>
142	143	0	2	1	0	(3)	<	<	0	>	<	<	1	(3)	1	2	2	2	(8)	0	<	2	1	1	<	2	<	1	(1)	0	1	>
TZR00142 &	143	2	1	2	1	3	(2)	<	4	0	1	<	<	(4)	8	4	1	2	(2)	(1)	7	3	<	2	<	4	<	2	<	1	<	1

Explanation: analytical results are reported as six steps per order of magnitude: 10, 7, 5, 3, 2, 1.5, etc., (powers of 10); 5 to 7 = 1 step, 5 to 10 = 2 steps, etc., N(5) to L(5) = 1 step, L(5) to 5 = 1 step; ( ) denotes a comparison where at least one analysis did not detect the element or exceeded the detection limit of that element; _ denotes at least one analysis exceeded the upper detection limit for that element; < denotes where both analyses did not detect the element; > denotes where both analyses exceeded the detection limit of the element.

data in differences of reported steps between the duplicate pairs of samples. This data set is small, therefore no statistically significant conclusions can be drawn from it. The elements Sn, Bi, Mo, and Ag have high variability and should be used cautiously. Tables 3 and 4 show that the variability of the DC-ES data are within acceptable ranges, and the data can be used reliably in the interpretation of geologic and geochemical processes.

AA Data: The sample variability for the five elements determined by AA methods exhibits a range of 16 to 50 percent (table 3). The sample variability for Bi is high (49.6%), but this is due to the small number of pairs (2) of unqualified data for which the sample variability was calculated. Results for Bi should be used with caution. The sample variability for these data are acceptable.

RESULTS AND DISCUSSION

The analytical results for samples collected in this study are described by Siems and others (1984). This chapter will present and discuss the geochemical data from the Monte Cristo Range and Pilot Mountains orientation and reconnaissance surveys.

Terminology

Statistics for the geochemical data are presented in tabular form (tables 5-6, 8-11, 13-14, 16-19) showing minimum value, maximum value, number of valid analyses, and number of censored analyses (qualified data) for each element. The geometric mean (GX) and deviation are calculated and presented where appropriate (tables 7, 9-11, 15, 17-19).

Histograms and GX were plotted for each element the reconnaissance data sets of each mountain range and were used to evaluate the data distribution. The GX is calculated using the formula:

$$\sum_{i=1}^{n} (\log x_i)/n = \bar{X} \qquad \text{then,} \qquad 10^{\bar{X}} = GX.$$

The geometric mean (GX) is used because the data are:

1. positively skewed;
2. DC-ES data are reported in geometric intervals, and

97% of the data in this investigation are obtained by DC-ES methods;

3. the deviation and variances of these data are proportional to the mean; and
4. spectrochemists consider errors as being on a geometric scale rather than a linear scale (Ahrens, 1955).

Background is the normal range of concentration for an element in an area excluding samples related to mineralization. For positively skewed distributions it is believed that the GX is a valid estimate of the background for a given element. Threshold is defined as the upper limit of the background range. An element is defined as anomalous when a sample contains metal concentrations higher than the threshold values for the element under consideration. For most pathfinder elements (e.g., Ag, Bi, Mo, W), the occurrence of a concentration value above lower detection limits is termed anomalous and the detection limit is threshold.

Data for certain elements analyzed in this study are highly censored (tables 5-6, 9-11, 13-14, 17-19). Geochemical data called censored or qualified data are the result of limitations imposed by the analytical techniques employed. Qualified values are assigned to the particular analytical result when the detection limits of the instrument are exceeded. The qualified value "N" is assigned when the element is not detected. If an element is detected, but is less than the lowest discernible standard value of detection, the value is designated "L", less than the amount shown. A value is designated "G" when the value is greater than the highest standard value of the instrument (Grimes and Marranzino, 1968).

Data Subsets

The total project data base has been divided into eight data subsets. For each mountain range the subsets are: orientation survey sediment fractions (TZS<u>x</u>, where x= A,B,C, D,E,F, or S; table 1), stream sediment material (TZS), heavy mineral concentrate (TZC), and rock samples (TZR). These data subsets were evaluated separately for each mountain range.

Monte Cristo Range

Gilbert District Orientation Survey

An orientation survey was carried out in the Gilbert District, located in the northeast part of the Monte Cristo Range (pl. 1; fig. 4). Seventeen sites were selected and sampled in four drainages from the district. Summaries of the data from seven size-fractions of stream sediment (TZS) and heavy mineral concentrates (TZC) are shown on tables 5 and 6.

Thirty-one elements were determined for each of the eight fractions of stream sediment material isolated for analysis. Gold and Th were not detected by DC-ES methods in the orientation survey and cannot be utilized in this investigation. Twenty-nine of the elements were above detection limits and their dispersion characteristics were evaluated. The elements are Ca, Fe, Mg, Ti, Ag, As, B, Ba, Be, Bi, Cd, Co, Cr, Cu, La, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, V, W, Y, Zn, and Zr.

To evaluate the relationship between mineralization and secondary geochemical response, four plots, one for each drainage, were generated for each of the elements analyzed. Each plot showed element concentration (vertical axis) of each sediment fraction (table 1) and their concentration at

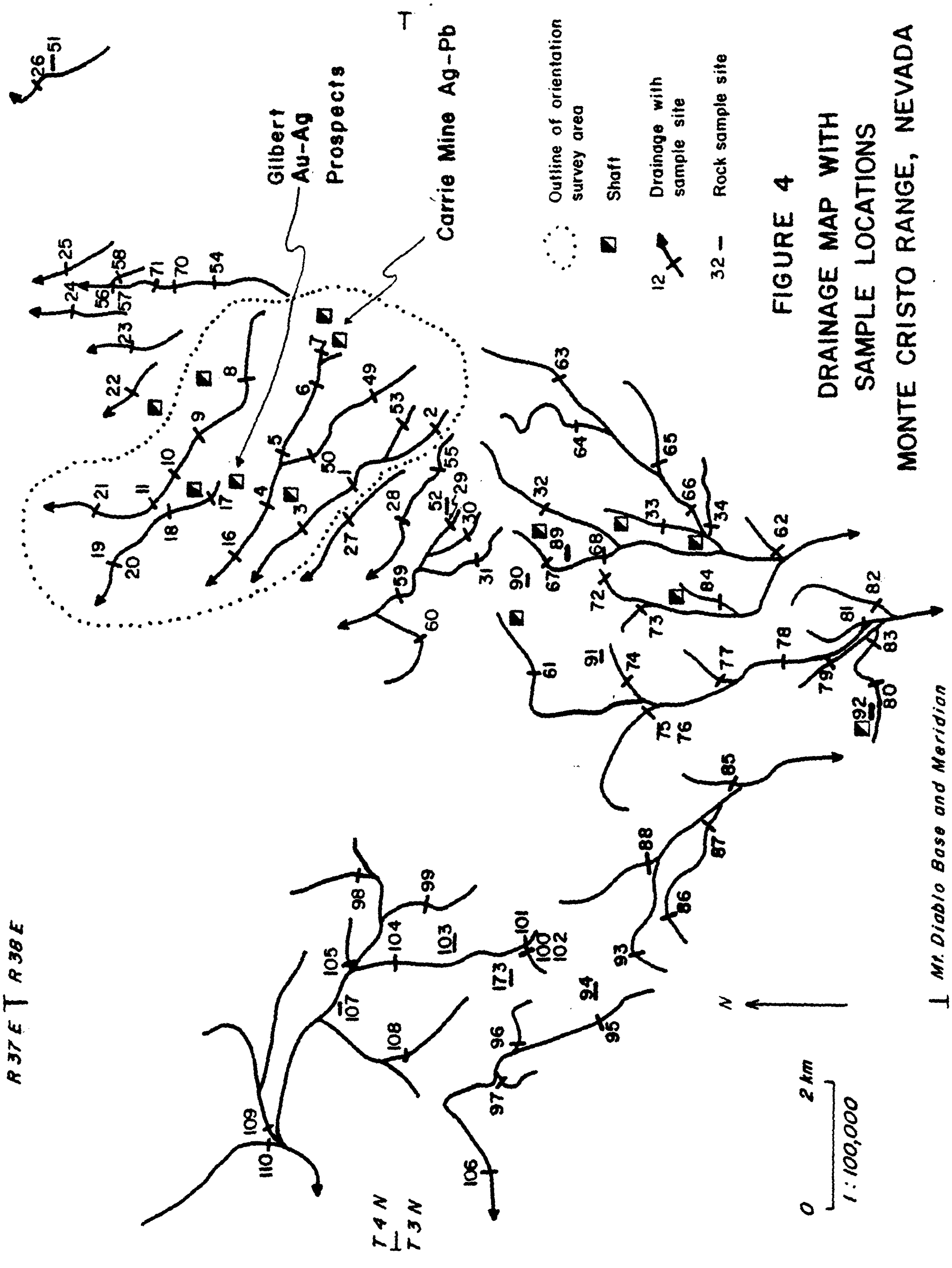


FIGURE 4

DRAINAGE MAP WITH SAMPLE LOCATIONS

MONTE CRISTO RANGE, NEVADA

Table 5

Summary of orientation survey stream sediment data (TZS) from the Gilbert District, Monte Cristo Range, Nevada, 17 sample sites, 7 fractions per site (total n=119).

Element	Minimum	Maximum	Valid	Censored
Ca%	0.5	5.	119	0
Fe%	1.5	20.	119	0
Mg%	0.5	3.	119	0
Ti%	0.15	1.0	117	2
Ag	0.5	20.	55	64
As	500.	1000.	7	112
Au	**	**	0	119
B	10.	150.	119	0
Ba	500.	5000.	119	0
Be	1.0	10.	119	0
Bi	**	**	0	119
Cd	30.	70.	6	113
Co	10.	70.	119	0
Cr	20.	500.	119	0
Cu	15.	300.	119	0
La	20.	100.	118	1
Mn	500.	3000.	119	0
Mo	5.	50.	66	53
Nb	20.	30.	6	113
Ni	10.	100.	119	0
Pb	15.	3000.	119	0
Sb	100.	100.	3	116
Sc	7.	20.	119	0
Sn	**	**	0	119
Sr	150.	700.	119	0
Th	**	**	0	119
V	70.	700.	119	0
W	**	**	0	119
Y	10.	50.	119	0
Zn	200.	1500.	18	101
Zr	70.	1000.	118	1

Explanation: values reported as ppm, except where noted;
** indicates no results within limits of determination of the analytical technique (DC-ES).

Table 6

Summary of orientation survey heavy mineral concentrate data (TZC) from the Gilbert District, Monte Cristo Range, Nevada, (n=17 sample sites).

Element	Minimum	Maximum	Valid	Censored
Ca%	0.5	10.	17	0
Fe%	0.7	3.	17	0
Mg%	0.2	1.0	17	0
Ti%	0.15	2.	15	2
Ag	5.	700.	4	13
As	500.	5000.	3	14
Au	**	**	0	17
B	20.	100.	13	4
Ba	1000.	5000.	12	5
Be	2.	3.	4	13
Bi	30.	70.	2	15
Cd	300.	300.	1	16
Co	10.	30.	11	6
Cr	20.	100.	14	3
Cu	30.	1000.	5	12
La	50.	500.	17	0
Mn	100.	700.	17	0
Mo	30.	700.	5	12
Nb	50.	300.	13	4
Ni	10.	50.	2	15
Pb	20.	30000.	15	2
Sb	700.	5000.	2	15
Sc	10.	30.	14	3
Sn	30.	30.	1	16
Sr	200.	2000.	17	0
Th	**	**	0	17
V	20.	200.	17	0
W	100.	500.	7	10
Y	20.	700.	17	0
Zn	5000.	5000.	1	16
Zr	1500.	1500.	1	16

Explanation: values reported as ppm, except where noted;
** indicates no results within limits of determination of the analytical technique (DC-ES).

sample sites located at distances downstream (horizontal axis) from mineralization (fig. 5). Utilizing these plots, histograms, geometric means and threshold values (table 7) for each element, two groups of elements could be defined based on each element's response to known mineralization. Eleven elements (Ag, As, Bi, Cd, Cu, Mo, Pb, Sb, Sn, W, and Zn) exhibit an anomalous response to mineralization. Eighteen elements show no patterns that can be related to mineralization. The results of these eleven elements are considered significant and only their dispersion will be discussed subsequently.

Single Element Dispersion: Seventeen sites were selected and sampled in four drainages from the district (pl. 1; fig. 4). Five sites (7, 6, 5, 4, 16) were selected in a drainage below the Carrie Ag-Pb mine. Eight sites (8, 9, 10, 11, 21, 17, 18, 19) were selected in two drainages, upstream and downstream from the Gilbert Au-Ag prospects. Four sites (2, 53, 1, 2) were selected in an adjacent drainage south of the Carrie Ag-Pb mine drainage where no known mining activity was present.

All dispersion distances discussed below are considered minimum distances. The actual dispersion distance lies between the anomalous site and the next site of background metal concentration downstream. The different fractions of

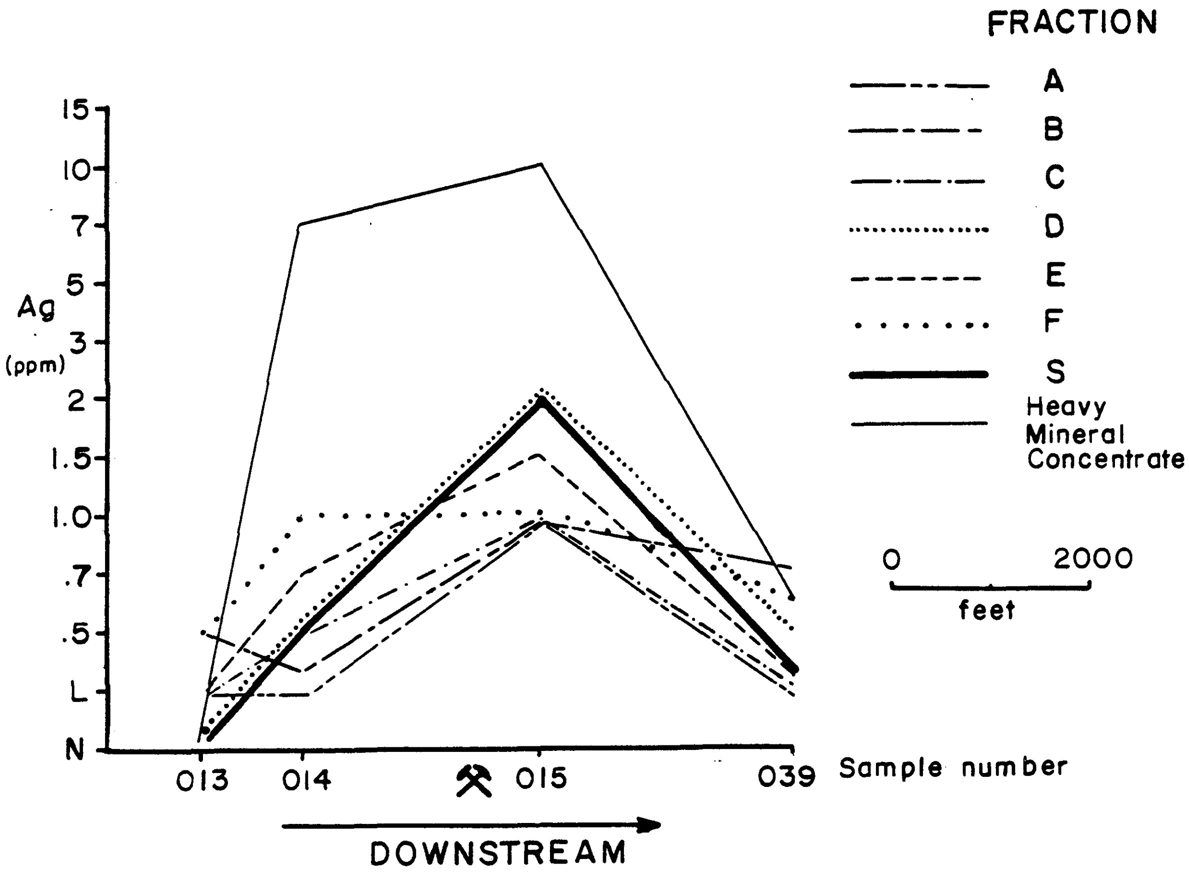


Figure 5

Downstream dispersion of Ag in eight fractions of stream sediment. See Table 1 for mesh fraction designation.

Table 7
Mean and threshold values from reconnaissance data, Monte Cristo Range, Nevada (n=80 samples).

Stream Sediment Data (TZS)

Element	Geometric Mean (ppm)	Threshold ppm	%
Ag*	0.33	0.5(L)	78
As*	102.	200(L)	99
Bi	-	-	-
Cd	-	-	-
Cu	27.9	50.0	72
Mo*	3.3	5.0(L)	78
Pb	39.8	70.0	69
Sb*	50.4	100(L)	99
Sn	-	-	-
W	-	-	-
Zn*	104.	200(L)	95
AA-As*	16.7	30.0	68
AA-Bi*	0.50	1.0(L)	99
AA-Cd*	0.12	0.2	58
AA-Sb*	2.8	4.0	66
AA-Zn*	76.7	80.0	64

Heavy Mineral Concentrate Data (TZC)

Element	Geometric Mean (ppm)	Threshold ppm	%
Ag*	0.75	1.0(L)	89
As*	271.	500(L)	91
Bi*	10.9	20(L)	92
Cd*	25.8	50(L)	99
Cu*	7.3	15.0	85
Mo*	7.4	10(L)	86
Pb*	36.1	70.0	76
Sb*	126.	200(L)	79
Sn*	11.1	20(L)	92
W *	61.3	100(L)	80
Zn*	266.	500(L)	94

Explanation: * geometric mean calculated by setting censored values (N or L) to 1/2 the detection limit; - indicates not computed, no results within limits of determination of the analytical technique (DC-ES); % indicates percent of samples classified as background.

stream sediment (TZS<u>x</u>, where x = A,B,C,D,E,F, or S) used in the orientation survey will be referred to using the fourth letter of the prefix for each sieve fraction size (table 1). Anomalous metal concentration is a concentration that is equal to or greater than the threshold values determined (table 7).

<u>Silver.</u> Silver is anomalous in the drainage below the Carrie Ag-Pb mine for 6500 feet in the fine fractions (C,D,E,F,S). Silver in the heavy mineral concentrates is anomalous for 2400 feet downstream from the Ag-Pb mine.

Silver is anomalous in the drainages from the Gilbert Au-Ag prospects in the coarser fractions (A,B,C,D,S) for 3000 feet downstream. Silver was not detected in the heavy mineral concentrates from the drainages below the Au-Ag prospects.

<u>Arsenic.</u> Arsenic is anomalous in the drainage below the Ag-Pb mine for 600 feet in all stream sediment media (TZS<u>x</u>). Arsenic in the heavy mineral concentrates is anomalous for 6500 feet downstream from the Ag-Pb mine.

Arsenic was not detected in the stream sediment media (TZS<u>x</u>) of the drainages from the Au-Ag prospects. Arsenic in the heavy mineral concentrates is anomalous for 3000 feet downstream from the Au-Ag prospects.

Bismuth. Bismuth was not detected in the TZSx media below the Ag-Pb mine. Bismuth in the heavy mineral concentrates was not detected at 600 feet downstream, but is anomalous at the next site, 2400 feet downstream from the Ag-Pb mine.

Bismuth was not detected in the TZSx media in the drainages from the Au-Ag prospects. Bismuth in the heavy mineral concentrates is anomalous for 800 feet downstream from the Au-Ag prospects, but was not detected at 3000 feet downstream, and is again anomalous at 6800 feet downstream.

Cadmium. Cadmium is anomalous in the drainage from the Ag-Pb mine for 600 feet downstream in all TZSx media. Cadmium in the heavy mineral concentrates is anomalous for 600 feet downstream from the Ag-Pb mine.

Cadmium was not detected in TZSx media from the drainages below the Au-Ag prospects. Cadmium in the heavy mineral concentrates was not detected downstream from the Au-Ag prospects.

Copper. Copper is anomalous in the drainage below the Ag-Pb mine for 6500 feet downstream in the B,C,F, and S fractions. At 9600 feet only the B and F fractions are anomalous. Copper in the heavy mineral concentrates is anomalous for 2400 feet downstream from the Ag-Pb mine.

Copper is anomalous in the drainages from the Au-Ag prospects for 3000 feet downstream in the A,B,C,D,F, and S fractions. Copper in the heavy mineral concentrates showed no anomalous response in the drainages below the Au-Ag prospects.

Molybdenum. Molybdenum is anomalous in the drainage below the Ag-Pb mine for 6500 feet downstream in the B,C,D,E, and S fractions. Molybdenum in the heavy mineral concentrates is anomalous for at least 12,800 feet downstream from the Ag-Pb mine.

Molybdenum is anomalous in the drainages from the Au-Ag prospects for 6800 feet downstream in the A,B,C,D,E, and S fractions. The F fraction is anomalous in Mo at 800 feet and at 6800 feet downstream, but not at 3000 feet downstream from the Au-Ag prospects. Molybdenum was not detected in the heavy mineral concentrates downstream from the Au-Ag prospects.

Lead. Lead is anomalous in the drainage from the Ag-Pb mine for 9600 feet downstream from mineralization in the finer fractions (C,F,S). Lead in the heavy mineral concentrates is highly anomalous for a minimum distance of 12,800 feet downstream from the Ag-Pb mine.

Lead is anomalous in the drainages from the Au-Ag prospects in the A,C, and S fractions for 3000 feet downstream, and the S fraction is still anomalous at 6800 feet downstream. Lead in the heavy mineral concentrates is not anomalous at 800 or 3000 feet downstream, but is anomalous at 6800 feet downstream from the Au-Ag prospects.

Antimony. Antimony is anomalous in the drainage from the Ag-Pb mine for 600 feet downstream in all TZSx media. Antimony in the heavy mineral concentrates is anomalous for a distance of 9600 feet downstream from the Ag-Pb mine.

Antimony was not detected in the TZSx media downstream from the Au-Ag prospects. Antimony was not detected in the heavy mineral concentrates downstream from the Au-Ag prospects.

Tin. Tin was not detected in the TZSx media downstream from the Ag-Pb mine. Tin in the heavy mineral concentrates is anomalous at a distance of 2400 feet downstream, but was not detected at the previous site, 600 feet downstream from the Ag-Pb mine.

Tin was not detected in the TZSx media in the drainages from the Au-Ag prospects. Tin was not detected in the heavy mineral concentrates at 800 or 2400 feet downstream, but is anomalous at 6800 feet downstream from the Au-Ag prospects.

Tungsten. Tungsten was not detected in the TZSx media downstream from the Ag-Pb mine. Tungsten in the heavy mineral concentrates is anomalous for 12,800 feet downstream from the Ag-Pb mine.

Tungsten was not detected in the TZS<u>x</u> media downstream from the Au-Ag prospects. Tungsten in the heavy mineral concentrates is anomalous for 3000 feet downstream from the Au-Ag prospect.

Zinc. Zinc is anomalous in the drainage from the Ag-Pb mine for 9600 feet downstream in the coarse fractions (B,C,D). Zinc in the heavy mineral concentrates is anomalous for 600 feet downstream from the Ag-Pb mine.

Zinc was not detected in the TZSx media downstream from the Au-Ag prospects. Zinc was not detected in the heavy mineral concentrates downstream from the Au-Ag prospects.

Discussion: Several aspects of the orientation survey at the Carrie Ag-Pb mine and the Gilbert Au-Ag prospects warrant additional comment. A summary of the fractions and the dispersion distances for each element are presented on table 8.

In the drainage below the Carrie Ag-Pb mine eight elements (Ag, As, Cu, Mo, Pb, Sb, W, and Zn) are anomalous and dispersed a minimum distance of 6500 feet downstream of Ag-Pb mineralization (table 8). In the stream sediment fractions (TZSx) Pb, Cu, Zn, Ag, and Mo are anomalous and

Table 8

Summary table of element dispersion distances and fractions, Gilbert District, Monte Cristo Range, Nevada.

Carrie Ag-Pb Mine

Element	TZSx Fraction x=ĀBCDEFS	Dispersion Distance (ft)*	TZC	Dispersion Distance (ft)*
Ag	--XXXXX	6500	X	2400
As	XXXXXXX	600	X	6500
Bi	-------	0	X	2400
Cd	XXXXXXX	600	X	600
Cu	-X---X-	9600	X	2400
Mo	-XXXXXX	6500	X	12800
Pb	--X--XX	9600	X	12800
Sb	XXXXXXX	600	X	9600
Sn	-------	0	X	2400
W	-------	0	X	12800
Zn	----XX-	9600	X	600

Gilbert Au-Ag Prospects

Element	TZSx Fraction x=AB̄CDEFS	Dispersion Distance (ft)*	TZC	Dispersion Distance (ft)*
Ag	XXXX--X	3000	-	0
As	-------	0	X	3000
Bi	-------	0	X	6800
Cd	-------	0	-	0
Cu	XXXX-XX	3000	-	0
Mo	XXXXX-X	6800	-	0
Pb	------X	6800	X	6800
Sb	-------	0	-	0
Sn	-------	0	-	0
W	-------	0	X	3000
Zn	-------	0	-	0

Explanation: sieve fraction designation (mesh size): A -35+45, B -45+60, C -60+80, D -80+120, E -120+200, F -200, S -60; TZC is heavy mineral concentrate; X in a column indicates anomalous sieve fraction; - in a column indicates fraction that is not anomalous; * minimum dispersion distance.

dispersed consistently in the finer (F,S) fractions relative to the coarser (A,B) fractions. Anomalous dispersion patterns for all five elements are recorded in the F fraction (-200 mesh), whereas the C and S fractions contain anomalous Ag, Cu, Mo,and Pb at a minimum distance of 6500 feet. The concentration of Mo and Ag diminishes downstream at a faster rate in the coarse fractions relative to the fine fractions (E,F,S) downstream. This can be caused by physical breakdown of sediment during transportation, the occurrence of similar mineralization downstream that has previously gone undiscovered which is causing an increase in Mo-Ag concentration in the fine fractions downstream, and/or coprecipitation of these metals downstream. Anomalous concentrations of Pb, Mo, W, Sb, and As (listed in decreasing order of dispersion distance) are dispersed in the heavy mineral concentrates a minimum distance of 6500 feet downstream from the Carrie Ag-Pb mine (table 8) and as far as 12,800 feet downstream.

Seven elements (As, Ag, Bi, Cu, Mo, Pb, and W) are anomalous in the drainages for 3000 feet below the several mines, short tunnels, prospects, and irregular pits representitve of the Gilbert-type Au-Ag mineralization (table 8). Anomalous concentrations of Pb, Mo, Ag, and Cu (listed in decreasing order of dispersion distance) are dispersed in the S fraction (-60 mesh). The coarser fractions (A,B,C,D) consistantly show anomalous levels of Mo, Cu, and Ag downstream of mineralization. Anomalous Pb, Bi, W, and As, (listed in order of decreasing dispersion distance) are dispersed in the heavy mineral concentrate a minimum distance of 3000 feet downstream. Bismuth dispersion is erratic. This is most probably due to the high sample variability (table 4). Copper, Mo, and Ag in the drainages from the Au-Ag prospects are anomalous in the TZSx media, but are not anomalous in the heavy mineral concentrates. This pattern may be due to chemical weathering. Sulfide minerals in a arid-semiarid environment are subject to chemical breakdown to form secondary minerals. The secondary minerals would then be lost during panning, due to their earthy and friable habit.

The drainage from the Carrie Ag-Pb mine is characterized by anomalous Cd, Sn and Zn, whereas these metals are not detected in the drainages from the Gilbert Au-Ag prospects. The occurrence of anomalous Cd and Zn in the stream sediment fraction (TZS) is useful in distinguishing these two types of mineralization. The occurrence of these three metals in the heavy mineral concentrate are also characteristic of Carrie-type Ag-Pb mineralization.

The -60 mesh (S) and -200 mesh (F) fractions are media that can be used to delineate mineralized areas (table 8). In the drainages from the Gilbert Au-Ag prospects the -60 mesh fraction works slightly better than the -200 mesh fraction, whereby the -60 mesh exhibits four anomalous elements and only Cu is anomalous in the -200 mesh fraction at the same distance downstream. In the drainages of the Carrie Ag-Pb mine the -200 mesh fraction exhibits eight anomalous elements downstream and the -60 mesh fraction exhibits six anomalous elements at the same distance downstream (table 8). The -60 mesh fraction delineates both types of deposits.

The heavy mineral concentrates indicate mineralization in both areas. This study shows that the heavy mineral concentrates can be collected at greater distances downstream from known mineralization than the TZS$\underline{x}$ media and still indicate mineralization (table 8).

Conclusions: Eleven pathfinder elements were identified in the drainage from the Carrie Ag-Pb mine and were dispersed downstream in the media evaluated (table 8). Seven pathfinder elements were identified in drainages from the Gilbert Au-Ag prospects and were dispersed downstream in the media evaluated (table 8). Lead, Mo, Cu, and Ag are pathfinders for Carrie-type Ag-Pb or Gilbert-type Au-Ag mineralization in the -60 mesh fraction for a minimum distance of 3000 feet downstream from the source. The -60 mesh fraction is a practical fraction useful in delineating mineralized areas at a reconnaissance level of metals exploration.

The non-magnetic heavy mineral concentrates have different pathfinders and dispersion distances for each mineralization type (table 8). Near the Carrie Ag-Pb mine Mo, Pb, W, Sb, and As were dispersed a minimum of 6500 feet downstream from mineralization. At the Gilbert Au-Ag prospects Pb, Bi, As, and W were dispersed a minimum of 3000 feet downstream from mineralization. The heavy mineral concentrates indicate mineralization at a greater distance downstream from the Carrie Ag-Pb mine than the -60 mesh fraction (table 8).

Cadmium, Sn, and Zn in the non-magnetic heavy mineral concentrate fraction or Cd and Zn in the -60 stream sediment material can be used to discriminate the two types of mineralization. These metals are pathfinders for Carrie-type Ag-Pb mineralization and are dispersed in the -60 mesh and heavy mineral concentrate fractions, but are not associated with Gilbert Au-Ag mineralization (table 8).

Mechanical and chemical weathering of detritus occurs in the desert environment and influences dispersion of the elements. The concentration of Mo and Ag diminishes at a faster rate in the coarse fraction relative to the fine fraction downstream from the Carrie Ag-Pb mine, indicating mechanical breakdown of minerals. The presence of anomalous Cu, Mo, and Ag in the -60 mesh fraction and lack of anomalous Cu, Mo, and Ag in the heavy mineral concentrates is attributed to chemical weathering of minerals.

Reconnaissance Survey

A total of 173 samples of rock, stream sediment, and heavy mineral concentrates were collected at 92 sites in the Monte Cristo Range (pl. 1; fig. 4). Summary statistics of the geochemical data obtained from these media are presented in tables 9, 10, and 11.

Rock samples (n = 23, where n is the number of samples) were collected of unaltered, altered, and mineralized material to determine ranges of element concentrations in the study area. Analyses obtained from the unaltered rocks (n = 14) were compared to published data compiled by Rose and others (1979), Levinson (1980), Best (1982), and Govett (1983). Chemical differences of five or more times (5x) are considered significant and will be discussed later. Basalt showed an enrichment in B(10x), Ba(6x), La(6x), Pb(6x), and depletion in Ni(6x) when compared to average basalts. The andesitic rocks are chemically similar to typical andesitic

Table 9

Summary statistics of all reconnaissance rock data (TZR)*, Monte Cristo Range, Nevada (n=23).

Element	Minimum	Maximum	Geom. Mean	Geom. Deviation	Valid	Censored
Ca%	0.05	20.	0.49	5.07	23	0
Fe%	1.0	15.	3.51	2.16	23	0
Mg%	0.03	5.	0.36	3.56	23	0
Ti%	0.02	0.5	0.14	2.08	23	0
Ag	0.5	100.	3.25	4.68	13	10
As	200.	2000.	544.	1.98	10	13
Au	**	**	**	**	0	23
B	10.	300.	55.8	2.45	23	0
Ba	150.	2000.	660.	1.97	22	1
Be	1.0	7.	2.68	1.76	18	5
Bi	**	**	**	**	0	23
Cd	**	**	**	**	0	23
Co	5.	500.	13.3	2.68	19	4
Cr	10.	700.	43.1	2.77	22	1
Cu	7.	500.	54.8	2.94	22	1
La	20.	200.	44.4	1.93	17	6
Mn	15.	2000.	249.	3.98	23	0
Mo	5.	300.	15.8	3.40	11	12
Nb	20.	20.	20.0	**	2	21
Ni	5.	1000.	20.6	3.74	22	1
Pb	10.	150.	38.4	2.16	16	7
Sb	100.	3000.	401.	3.98	6	17
Sc	5.	15.	6.95	1.39	21	2
Sn	300.	300.	300.	**	1	22
Sr	100.	1000.	238.	2.07	19	4
Th	**	**	**	**	0	23
V	30.	300.	114.	2.09	23	0
W	**	**	**	**	0	23
Y	10.	200.	20.5	1.88	22	1
Zn	700.	1000.	837.	1.29	2	21
Zr	10.	300.	78.8	2.49	23	0

Explanation: values reported as ppm, except where noted;
* includes unaltered, altered, and mineralized rock samples;
** indicates not computed, no results within limits of determination of the analytical technique (DC-ES).

Table 10
Summary statistics of reconnaissance survey stream sediment data (TZS) -60 mesh, Monte Cristo Range, Nevada (n=80).

Element	Minimum	Maximum	Geom. Mean	Geom. Deviation	Valid	Censored
Ca%	0.5	5.	1.38	1.61	80	0
Fe%	1.5	15.	4.23	1.68	80	0
Mg%	0.7	3.	1.23	1.40	80	0
Ti%	0.15	1.0	0.33	1.47	80	0
Ag	0.5	30.	1.48	4.12	13	67
As	500.	500.	**	**	1	79
Au	**	**	**	**	0	80
B	10.	150.	43.0	1.94	80	0
Ba	300.	5000.	726.	1.78	80	0
Be	1.0	10.	2.13	1.80	78	2
Bi	**	**	**	**	0	80
Cd	**	**	**	**	0	80
Co	10.	70.	20.7	1.49	80	0
Cr	30.	500.	92.8	1.67	80	0
Cu	10.	150.	28.0	1.67	80	0
La	20.	300.	40.7	1.60	78	2
Mn	300.	2000.	797.	1.66	80	0
Mo	5.	30.	8.09	1.72	18	62
Nb	20.	30.	21.2	1.17	7	73
Ni	15.	150.	35.4	1.67	80	0
Pb	10.	1500.	39.8	2.43	80	0
Sb	100.	100.	**	**	1	79
Sc	5.	20.	9.76	1.41	80	0
Sn	**	**	**	**	0	80
Sr	200.	1000.	436.	1.46	80	0
Th	**	**	**	**	0	80
V	50.	700.	137.	1.69	80	0
W	**	**	**	**	0	80
Y	10.	50.	17.4	1.54	80	0
Zn	200.	500.	271.	1.70	3	77
Zr	200.	700.	166.	1.82	79	1
AA-As	5.	400.	20.7	2.42	72	8
AA-Bi	1.	1.	**	**	1	79
AA-Cd	0.1	15.	.193	2.21	53	27
AA-Sb	1.	70.	2.99	2.36	77	3
AA-Zn	25.	210.	72.4	1.39	79	1

Explanation: values reported as ppm, except where noted;
** indicates not computed, no results within limits of determination of the analytical technique (DC-ES);
AA- indicates atomic absorption data.

Table 11

Summary statistics of reconnaissance survey heavy mineral concentrate data (TZC), Monte Cristo Range, Nevada (n=80).

Element	Minimum	Maximum	Geom. Mean	Geom. Deviation	Valid	Censored
Ca%	0.20	15.	3.95	2.32	80	0
Fe%	0.15	5.	0.98	1.78	80	0
Mg%	0.05	3.	0.44	2.05	80	0
Ti%	0.15	2.	0.88	1.97	75	5
Ag	2.	700.	17.9	17.9	9	71
As	500.	5000.	1257.	2.66	4	76
Au	**	**	**	**	0	80
B	20.	150.	35.5	1.68	66	14
Ba	500.	10000.	1771.	2.12	45	35
Be	2.	10.	3.12	1.64	33	47
Bi	20.	70.	40.2	1.64	5	75
Cd	300.	300.	**	**	1	79
Co	10.	30.	13.0	1.39	41	39
Cr	20.	200.	49.7	1.88	57	23
Cu	10.	1000.	20.7	2.89	21	69
La	50.	1000.	189.	2.07	79	1
Mn	50.	2000.	307.	2.09	80	0
Mo	10.	700.	85.9	4.22	11	69
Nb	50.	300.	84.7	1.60	60	20
Ni	10.	50.	14.7	1.94	6	74
Pb	20.	30000.	72.1	5.39	52	28
Sb	200.	5000.	547.	2.74	11	69
Sc	10.	100.	14.7	1.69	63	17
Sn	20.	200.	49.3	3.00	6	74
Sr	200.	5000.	718.	1.78	80	0
Th	200.	300.	229.	1.26	3	77
V	20.	200.	87.5	1.89	80	0
W	100.	700.	255.	2.16	10	70
Y	20.	1000.	173.	2.36	80	0
Zn	500.	5000.	889.	3.16	4	76
Zr	1500.	1500.	1500.	**	2	78

Explanation: values reported as ppm, except where noted;
** indicates not computed, no results within limits of determination of the analytical technique (DC-ES).

compositions. The rhyolites and tuffs were compared to felsic rock compilations and show relatively strong enrichments in Mg(3x-20x), B(20x), Co(10-20x), Cr(8-12x), Ni(40-60x), and V(3-10x). The fine-grained black cherty argillites were compared to compilations of data from black shales. These pre-Tertiary sediments showed a strong enrichment in As(10-20x), Sb(100x), and minor enrichment in Ba and Mo. The pre-Tertiary sediments show depletion in Mn(6x), Cr(3x), Ni(5-20x), and Zr(4x). The overall trend that is observed when comparing the Tertiary volcanic rocks and pre-Tertiary sedimentary rocks is that the sediments contain lower concentrations of Mg, Be, Co, La, Mn, Sc, Sr, Y, and Zr.

Eleven pathfinder elements determined from the orientation survey were used in the evaluation of results from the reconnaissance sampling program. Supplemental AA data obtained for As, Bi, Cd, Sb, and Zn were used to more effectively evaluate the exploration potential of the Monte Cristo Range.

Sites are considered anomalous when the concentration of two or more of the pathfinder elements exceed threshold values (table 7). As the number of anomalous elements in a sample increases, the probability that a mineralizing process may have occurred in the area also increases. Thirty sites were found to be anomalous in the Monte Cristo Range and are not related to past mining activity (table 12; fig. 6).

Discussion: The 30 anomalous sites were divided into five potential follow-up areas based on lithologies present in the drainage (fig. 7). The lithologies assigned to each drainage basin are based on field notes taken during sample collection and on published and unpublished mapping by the USGS.

Area I is located in the western part of the Monte Cristo Range and is defined by eleven anomalous sites (table 12; figs. 6 and 7). Lithologies found in the float are pre-Tertiary siliceous sediments. The anomalous element suite is diverse with the most commonly occurring elements being As, Cd, Sb, and Cu. The other anomalous elements in decreasing order of occurrence are Mo, Pb, Sn, Ag, Zn, W, and Bi. Overall, area I is anomalous geochemically and geologically presents a high potential for the occurrence of hydrothermal precious or base metal deposits.

Area II is located in the southern part of the Monte Cristo Range and is defined by five anomalous sites (table 12; figs. 6 and 7). Lithologies found in float include andesite, tuff, and minor amounts of jasperoid, quartz, and gossan. The most common anomalous elements are Sb, Zn, and

Table 12

Anomalous multi-element sample sites not related to known mining activity, Monte Cristo Range, Nevada.

Area #	Site #	Medium TZS	TZC
1	086	-	As Sn
1	087	Ag Cu Pb	Pb Sn
1	095	Ag Mo Pb	Bi Mo Sn
1	096	As Sb	As
1	098	Cd Zn	-
1	099	Cd Sb	-
1	100	As Cd Cu Mo Sb	Cu Sb
1	101	As Cd Sb	Cu Mo Sb W
1	104	As Cd Sb	Cu Sb
1	106	Cu Pb	Pb
1	109	As Cd Zn	Sb
2	075	Cd Cu Pb Zn	Bi
2	077	As Cd Sb	Cu W
2	079	Cu Pb Sb	Ag Zn
2	081	Mo Sb Zn	-
2	085	As Sb Zn	-
3	022	-	As Pb
3	023	Cd	Sb
3	026	Cd Sb	-
3	054	Cd Sb Zn	-
3	056	Ag	Sb
4	001	Cu Mo Pb Sb Zn	-
4	003	Ag As Pb	-
4	031	Bi Cu	-
4	034	As	Pb Sb
4	053	Cu Mo Pb Zn	W
4	059	Ag	Ag Sb W
4	060	Cd Cu Zn	-
4	067	Ag Cu Pb	-
5	110	Cu Mo	-

Explanation:
TZS -60 mesh stream sediment;
TZC heavy mineral concentrate;
\- no anomalous elements present.

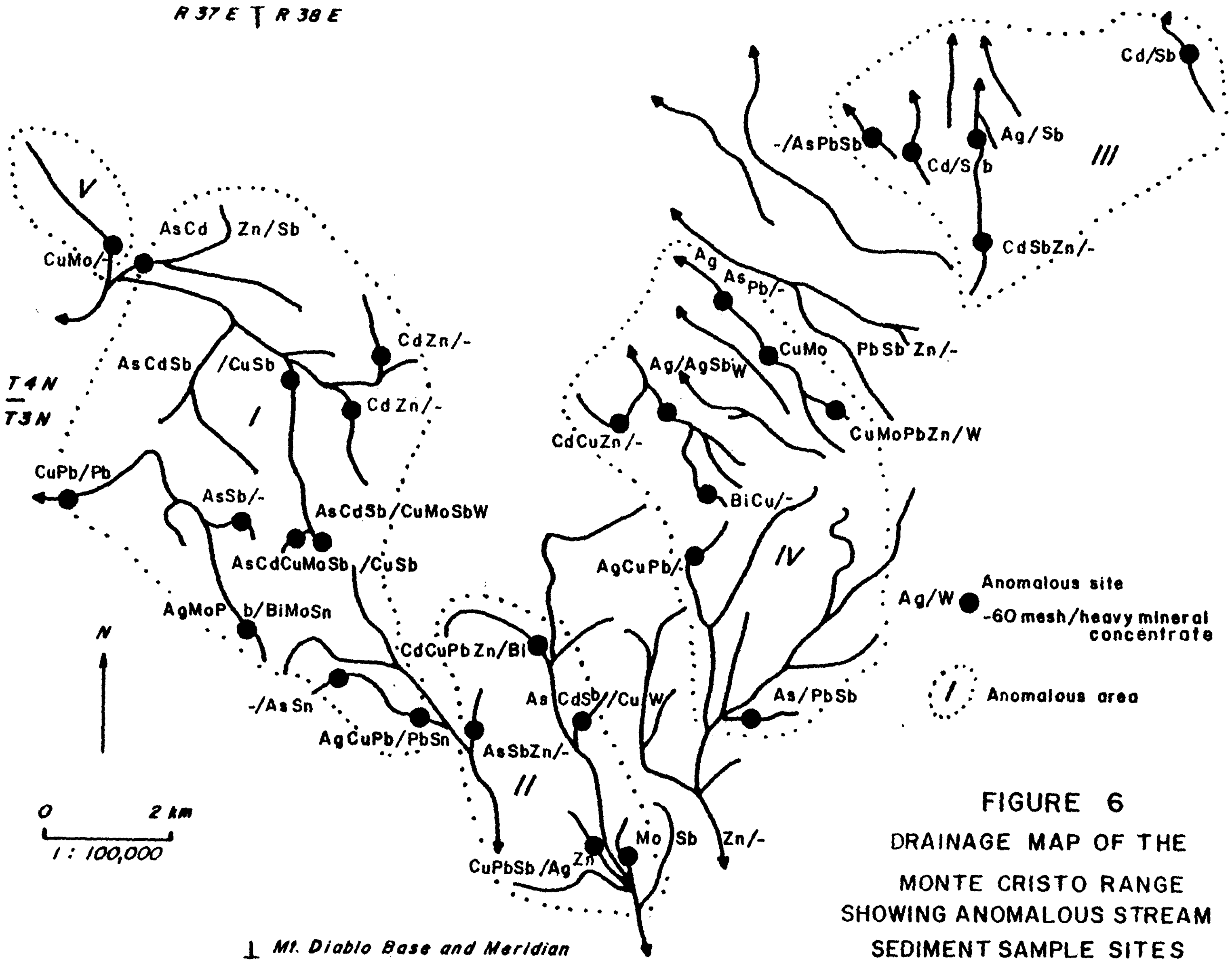


FIGURE 6

DRAINAGE MAP OF THE MONTE CRISTO RANGE SHOWING ANOMALOUS STREAM SEDIMENT SAMPLE SITES

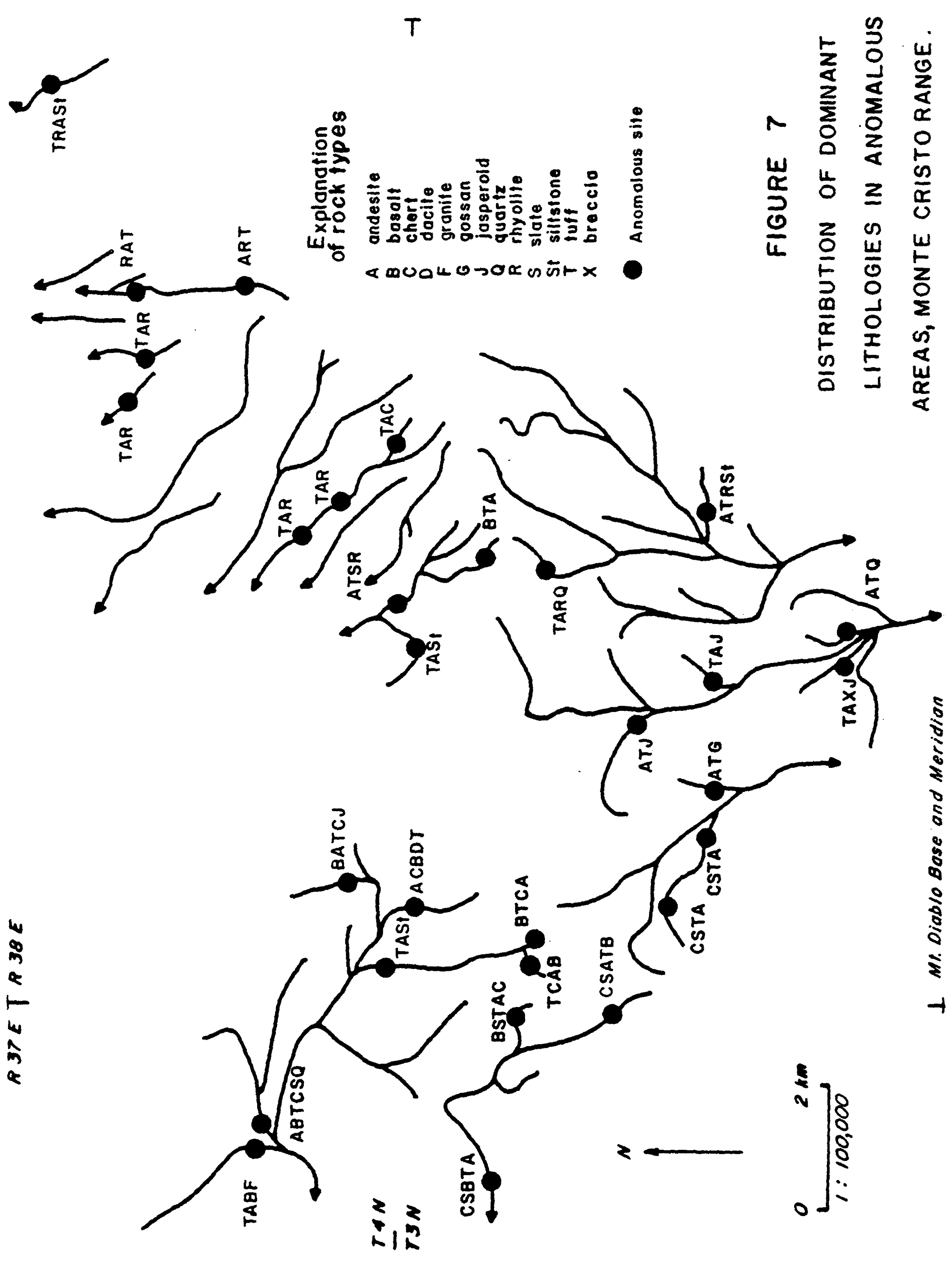


FIGURE 7

DISTRIBUTION OF DOMINANT LITHOLOGIES IN ANOMALOUS AREAS, MONTE CRISTO RANGE.

Cu, with lesser occurrence of As, Pb, Cd, Ag, Bi, W, and Mo. The presence of jasperoid and gossans in drainage sediments along with anomalous Sb, Zn, and Cu, are favorable indicators of hydothermal mineralization.

Area III is located in the northeast part of the Monte Cristo Range and is defined by five anomalous sites (table 12; figs. 6 and 7). Lithologies found in float include tuff, rhyolite, andesite and siltstone. The most common anomalous elements are Sb and Cd with lesser occurrence of As, Ag, and Zn. The area also has many faults and at least two small elongate rhyolite breccia pipes in the drainages of sample sites 54 and 56. Geologically and geochemically this area is favorable for the occurrence of mineral deposits of the Gilbert-type Au-Ag.

Area IV is located in the central part of the Monte Cristo Range, defined by eight anomalous sites, and is geologically and geochemically quite diverse (table 12; figs. 6 and 7). Lithologies found in float include tuff, andesite, rhyolite, and pre-Tertiary siliceous sediments. Lead and Cu are the most common anomalous elements of the area followed by Ag, Sb, Zn, As, Mo, W, Bi, and Cd. The potential for Carrie-type Ag-Pb or Gilbert-type Au-Ag mineralization is good for this area.

Area V is located in the northwestern part of the Monte

Cristo Range and is defined by a single sample (table 12; figs. 6 and 7). Lithologies found in float include tuff, andesite, basalt, and a single cobble of altered granite. The site is highly anomalous in Mo (7 ppm) and anomalous in Cu (50 ppm). The combination of anomalous Mo-Cu and the presence of altered granite float indicate the potential for a porphyry-type system upstream. No intrusive body has been mapped in this area of the Monte Cristo Range.

The occurrence of anomalous concentrations of Cd in the area is puzzling. Although Cd and Zn have similar crystal chemistry characteristics, they do not correlate spatially in the stream sediments. Cadmium, does however, correlate spatially with As and Sb. In the primary environment of Pb-Zn-Ag replacement vein deposits of the Coeur d'Alene district, Cd exhibits a halo around Zn, and is depleted in vein material and enriched in the wallrocks of the ore deposits (Gott and Botbol, 1973). This information suggests that the Cd anomaly may be due to: hydrothermal zoning, another mineralizing system(s), or high background concentrations of Cd in the black siliceous sediments present in Monte Cristo Range. However, the elevated lower detection limits (table 2) of the analytical procedure (DC-ES) employed for rocks in this study did not permit adequate assessment of the last explanation.

Conclusions: Rock geochemistry is useful in distinguishing major lithologic units and is of limited use in direct exploration for mineralization because of the limited number of samples (n = 23). The -60 mesh (TZS) data are the most effective in distinguishing between anomalous areas related to known mineralization and background unmineralized areas (table 12). The pathfinder elements Ag, As, Bi, Cd, Cu, Mo, Pb, Sb, W, and Zn are effective in delineating areas of potential mineralization. Cadmium is anomalous in the study area and is commonly associated with As and Sb, and not Zn, indicating another type of mineralization is present. The occurrence of the As-Cd-Sb suite of trace elements suggests another type of mineralization because it is not characteristic of the Carrie-type Ag-Pb or Gilbert-type Au-Ag mineralization.

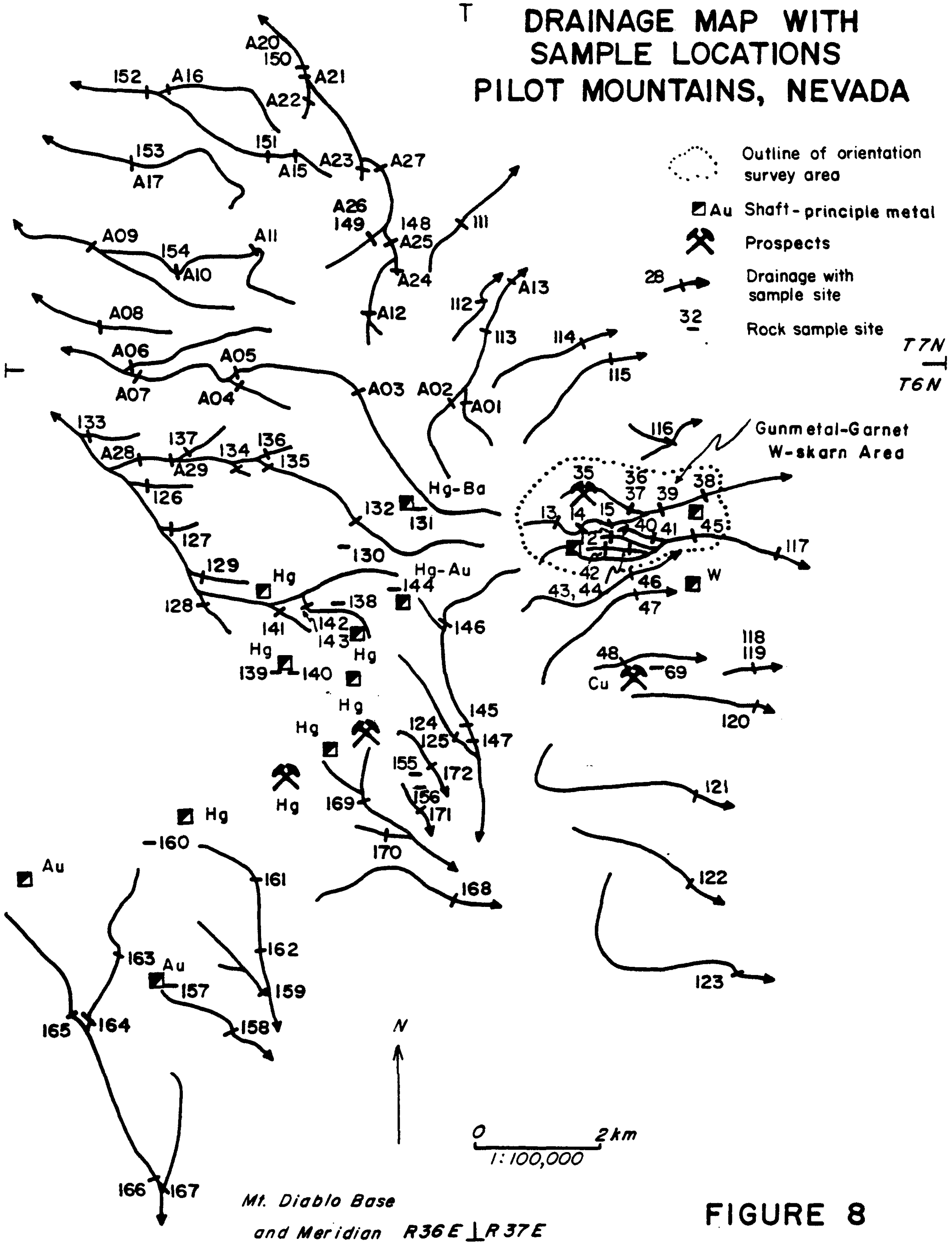
Area I is geochemically anomalous and geologically favorable for the occurrence of precious metals, unlike the types studied in the orientation survey. The area is dominated by siliceous pre-Tertiary sediments (fig. 2). This area has the greatest number of anomalous geochemical samples (n = 11), and favorable lithologies and structure which increase the potential for the localization of mineralizing processes. The anomalies in areas II and IV are not indicative of Carrie-type Ag-Pb or Gilbert-type Au-Ag mineralization, but the abundance of geochemical anomalies warrant a closer study of the rocks in these areas. Area III is very interesting, especially in the drainage of sample sites 54 and 56 (fig. 4). This drainage should be looked at closely for the occurrence of Gilbert-type Au-Ag deposits. Area V is highly anomalous in Mo (7 ppm) and Cu (50 ppm) as defined by one sample (TZS00110). A cobble of altered granite was seen in float of the drainage sediments at that site. Although no mining or prospecting activity is known to have occurred in the area, additional investigation to identify the source of Mo and Cu is recommended.

Pilot Mountains

Pilot Mountains Orientation Survey

A second orientation survey was carried out in the Pilot Mountains District, located on the eastern slope of the Pilot Mountains (pl. 1; fig. 8). Attention was confined exclusively to the W-skarn deposits situated in the eastern part of the district. Twelve sites were selected and sampled in four drainages from the Gunmetal-Garnet tungsten skarn deposits. Summaries of the data from seven size-fractions of stream sediment (TZS$\underline{x}$) and the heavy mineral concentrates (TZC) are shown on tables 13 and 14.

Twenty-seven of the 31 elements analyzed were above detection limits and their dispersion characteristics were evaluated. Gold, Cd, Sb, and Th were not detected in samples from the orientation survey. To evaluate the relationship between mineralization and secondary geochemical response, four plots, one for each drainage, were generated for each element analyzed. These plots, along with histograms, geometric means and threshold values for each element (table 15) were used to interpret the data. Two groups of elements were defined based on each element's response to known mineralization. Eight elements (Ag, Bi, Cu, Mg, Mo, Pb, W, and Zn) are associated with mineralization. Nineteen



DRAINAGE MAP WITH SAMPLE LOCATIONS PILOT MOUNTAINS, NEVADA

FIGURE 8

Table 13

Summary of orientation survey stream sediment data (TZS), Pilot Mountains District, Pilot Mountains, Nevada, 12 sample sites, 7 fractions per site (total n = 84).

Element	Minimum	Maximum	Valid	Censored
Ca%	1.5	20.	62	22
Fe%	1.0	7.	84	0
Mg%	0.5	7.	84	0
Ti%	0.1	0.5	84	0
Ag	0.5	15.	52	32
As	**	**	0	84
Au	**	**	0	84
B	20.	200.	84	0
Ba	200.	1000.	84	0
Be	1.	7.	79	5
Bi	10.	50.	27	57
Cd	**	**	0	84
Co	7.	30.	84	0
Cr	10.	200.	84	0
Cu	15.	100.	84	0
La	20.	70.	84	0
Mn	500.	2000.	84	0
Mo	5.	70.	31	53
Nb	**	**	0	84
Ni	5.	70.	84	0
Pb	20.	1000.	84	0
Sb	**	**	0	84
Sc	5.	15.	84	0
Sn	**	**	0	84
Sr	200.	2000.	84	0
Th	**	**	0	84
V	50.	200.	84	0
W	50.	700.	23	61
Y	10.	20.	84	0
Zn	200.	700.	23	61
Zr	20.	300.	84	0

Explanation: values reported as ppm, except where noted; ** indicates no results within limits of determination of the analytical technique (DC-ES).

Table 14

Summary of orientation survey heavy mineral concentrate data (TZC), Pilot Mountains District, Pilot Mountains, Nevada (n=12 sample sites).

Element	Minimum	Maximum	Valid	Censored
Ca%	7.	15.	12	0
Fe%	0.5	7.	12	0
Mg%	0.3	7.	12	0
Ti%	0.15	0.7	11	1
Ag	2.0	15.	8	4
As	100.	100.	1	11
Au	**	**	0	12
B	30.	300.	11	1
Ba	100.	10000.	9	3
Be	2.	2.	1	11
Bi	20.	200.	6	6
Cd	**	**	0	12
Co	10.	50.	9	3
Cr	50.	150.	11	1
Cu	10.	300.	8	4
La	50.	500.	12	0
Mn	300.	3000.	12	0
Mo	10.	3000.	12	0
Nb	100.	100.	1	11
Ni	100.	100.	2	10
Pb	20.	5000.	12	0
Sb	**	**	0	12
Sc	10.	15.	8	4
Sn	20.	20.	1	11
Sr	200.	2000.	12	0
Th	**	**	0	12
V	50.	150.	12	0
W	150.	20000.	12	0
Y	20.	200.	7	5
Zn	1500.	2000.	3	9
Zr	50.	2000.	11	1

Explanation: values reported as ppm, except where noted;
** indicates no results within limits of determination of the analytical technique (DC-ES).

Table 15

Mean and threshold values from reconaissance data, Pilot Mountains, Nevada.

Stream Sediment Data (n=97)

Element	Geometric* Mean (ppm)	Threshold	
		ppm	%
Ag*	0.33	0.5(L)	69
Bi*	5.34	10(L)	92
Cu	37.9	70.	77
Mg	1.28%	2.0%	73
Mo*	3.37	5.	84
Pb	47.0	70.	63
W *	30.8	50(L)	90
Zn*	108.	200.	93
AA-As*	15.6	40.	76
AA-Bi*	0.61	1.0	91
AA-Cd*	0.12	0.3	73
AA-Sb*	2.64	5.	77
AA-Zn*	76.2	75.	71

Heavy Mineral Concentrate Data (n=92)

Element	Geometric* Mean (ppm)	Threshold	
		ppm	%
Ag*	1.30	3.0	72
As*	1000.	500(L)	98
Au*	10.3	20(L)	97
Bi*	13.7	20(L)	82
Cd*	25.6	50(L)	95
Cu*	27.4	100.	77
Mg	1.11%	2.00%	65
Mo*	21.0	30.	72
Pb*	241.	1500.	80
Sb*	181.	200(L)	79
Sn*	13.1	20.	82
W *	217.	500.	70
Zn*	335.	500.	79

Explanation: all values in ppm unless noted;
* geometric mean calculated by setting censored values (N or L) to 1/2 the detection limit;
% percent of values classified as background.

elements show no patterns that can be related to mineralization. The results of these eight elements are considered significant, and only their dispersion will be discussed.

Single Element Dispersion: Twelve sites were selected and sampled in four drainages from the Pilot Mountains District. Nine sites in three drainages (14, 15, 38, 39, 40, 41, 42, 43, 45) were sampled over an 8500 foot distance downstream from the Gunmetal-Garnet W skarn deposits (pl. 1; fig. 8). Three sites (13, 14, 36) were located upstream and in an adjacent drainage where there is no known mining activity. The different fractions (TZS<u>x</u>) of stream sediment used in the orientation survey will be referred to using the fourth letter of the prefix that designates the size fraction (table 1). Anomalous metal concentration is a concentration that is equal to or greater than the threshold value determined (table 15).

<u>Silver.</u> Silver is anomalous in the drainages from the district for 8500 feet downstream in all stream sediment fractions (TZS<u>x</u>). Silver in the heavy mineral concentrates is anomalous for 8500 feet downstream from W-skarn mineralization. Silver concentration increases in all fractions downstream between the first site at 800 feet downstream and the next site at 2700 feet downstream from W mineralization.

Bismuth. Bismuth is anomalous in the drainages from the district for 8500 feet downstream in all stream sediment fractions. Bismuth in the fine fractions (F and S) was not detected at the first site below mineralization (800 feet), but is anomalous at 2700 feet and 8500 feet downstream. Bismuth in the heavy mineral concentrates is anomalous for 8500 feet downstream from mineralization.

Copper. Copper is anomalous in the drainages of the district for 8500 feet downstream from mineralization in the B,C,D,E,F, and S fractions of stream sediment. Copper in the heavy mineral concentrates is not anomalous at the site below mineralization (800 feet), but increased in concentration downstream from that site and is anomalous at 8500 feet downstream.

Magnesium. Magnesium is anomalous in the drainages of the district. Magnesium in the D,F, and S fractions is not anomalous at 800 feet below mineralization, but is anomalous at 2700 feet and 8500 feet downstream. Magnesium in the heavy mineral concentrates is not anomalous at 800 feet, but increased in concentration downstream and is anomalous at 2700 feet and 8500 feet downstream from mineralization.

Molybdenum. Molybdenum is anomalous in the drainages from the district for 8500 feet downstream in all stream sediment fractions (TZSx). Molybdenum in the heavy mineral concentrates is highly anomalous ($\geq$700 ppm) for 8500 feet in the drainages below mineralization.

Lead. Lead is anomalous in the drainages from the district for 8500 feet downstream in the A,B,C,D,E, and S fractions. Lead in the F fraction is not anomalous at 800 feet downstream from mineralization, but is anomalous at 2700 feet and 8500 feet downstream from mineralization. Lead in the heavy mineral concentrates is not anomalous at 800 feet downstream of mineralization, but is anomalous at 2700 feet and 8500 feet downstream.

Tungsten. Tungsten is anomalous in the drainages from the district for 8500 feet. Tungsten in the A,B,C,D, and S fractions is anomalous for 2700 feet downstream, whereas the C,D, and S fractions are anomalous in tungsten at 8500 feet downstream. Tungsten in the F fraction is not anomalous at 800 feet or 2700 feet downstream of mineralization, but is anomalous at 8500 feet downstream from mineralization. Tungsten in the heavy mineral concentrates is highly anomalous ($\geq$1500 ppm) for 8500 feet downstream from mineralization.

Zinc. Zinc is anomalous in the drainages of the district for 2700 feet in the A,B,C,D, and E fractions. Zinc in the

F fraction was not detected at 800 feet below mineralization, but is anomalous at 2700 feet downstream from mineralization. Zinc in the heavy mineral concentrates was not detected downstream from mineralization.

Discussion: In the drainages from the Gunmetal-Garnet W-skarn deposits, eight pathfinder elements (W, Mo, Bi, Mg, Ag, Pb, Cu, and Zn) are dispersed in the stream sediment media (TZS$\underline{x}$) and seven pathfinder elements (less Zn) are dispersed in the heavy mineral concentrates (TZC) downstream from W-skarn mineralization (table 16). Anomalous concentrations of W, Mo, Ag, Pb, Bi, and Cu are dispersed 8500 feet downstream in the C (-60 to +80 mesh) and D (-80 to +120 mesh) fractions. Five of these anomalous pathfinders (W, Mo, Ag, Pb, and Cu) are dispersed in the S fraction (-60 mesh) for 8500 feet.

Zinc exhibits a short dispersion distance downstream (2700 feet) which is due to the elevated lower detection limits (200 ppm) of the analytical method (DC-ES). Zinc in the reconnaissance survey (-60 mesh), analyzed by AA methods, is anomalous ($\geq$75 ppm) for 8500 feet downstream from W-skarn mineralization.

Tungsten, Mo, and Bi exhibit similar trends downstream from mineralization. The coarser fractions (A and B) decrease rapidly in metal concentration downstream relative to

Table 16

Summary table of element dispersion distances and fractions, Pilot Mountains District, Pilot Mountains, Nevada.

Element	TZSx Fraction x=ABCDEFS	Dispersion Distance (ft)*	TZC	Dispersion Distance (ft)*
Ag	XXXXXXX	8500	X	8500
Bi	XXXXX++	8500	X	8500
Cu	-XXXXXX	8500	+	8500
Mg	---+--+	8500	+	8500
Mo	XXXXXXX	8500	X	8500
Pb	XXXXX+X	8500	+	8500
W	--XX--X	8500	X	8500
Zn	XXXXX--	2700	-	0

Explanation: sieve fraction designation (mesh size):
A -35+45, B -45+60, C -60+80, D -80+120, E -120+200, F -200, S -60;
TZC is heavy mineral concentrate;
X in a column indicates anomalous sieve fraction;
\- in a column indicates fraction that is not anomalous;
\+ indicates that this fraction is not anomalous at 800 feet downstream, but is anomalous at 2700 and 8500 feet;
* minimum dispersion distance.

the F fraction, which increases in metal concentration downstream. Magnesium generally increases in concentration downstream from mineralization, the D and S fractions showing the longest dispersion train. The overall increase in concentration of W, Mo, Bi, and Mg in the finer fraction relative to the coarse fraction downstream can be explained by the comminution of minerals as they are transported downstream from mineralization. This suggests that coarser sized sediment material can be collected at the follow-up stage of drainage sampling for W-skarn mineralization.

In the heavy mineral concentrates (TZC), seven pathfinder elements (W, Mo, Ag, Bi, Mg, Pb, and Cu, in decreasing order of dispersion distance) were dispersed at least 8500 feet downstream from W-skarn mineralization (table 16). Magnesium, Pb, and Cu concentrations increase downstream between the first and second sites. Magnesium enrichment may be due to idocrase associated with W-skarn mineralization at the Gunmetal-Garnet deposits. The increase of Pb and Cu concentration downstream may be due to the close proximity of the Desert Scheelite base-metal skarn deposit and/or the Good Hope copper mine (pl. 1).

Conclusions: Seven anomalous pathfinder elements were identified (W, Mo, Ag, Bi, Mg, Pb, and Cu) and are dispersed for 8500 feet downstream from W-skarn mineralization. The

D, S, and heavy mineral concentrate fractions effectively delineate known mineralization. The sample preparation for these three media are different. The D fraction (-80 to +120 mesh) utilizes two sieves prior to analysis. The S (-60 mesh) fraction utilizes one sieve and a pulverization of the -60 mesh material to -100 mesh prior to chemical analyses. The heavy mineral concentrate fraction requires extensive sample preparation consisting of panning, sieving, heavy liquid separation, magnetic separation, and hand grinding prior to analysis (see Sample Preparation, p. 24). The fastest and most economical medium to use would be the D fraction because it requires the least sample preparation.

The breakdown of ore minerals and associated minerals is dominated by mechanical abrasion during sediment transport. The overall increase in concentration of W, Mo, Bi, and Mg in the finer fractions relative to the coarse fraction downstream is supportive of the mechanical breakdown of minerals as they are transported downstream from mineralization.

Reconnaissance Survey

A total of 216 rock, stream sediment, and heavy mineral concentrate samples were collected at 109 sites in the Pilot Mountains (pl. 1; fig. 8) during the summers of 1982 and

1983 (Siems and others, 1984). Preliminary evaluation of analytical results from reconnaissance sampling during 1982 indicated that many sites in the northern Pilot Mountains have anomalous concentrations of W ± Mo-Ag-Sb in the heavy mineral concentrate fraction. Additional sampling was performed, during 1983, at 26 sites to confirm and better define these anomalies. These samples are designated by the code "31A" (e.g., TZC31A01) and were included in the overall evaluation of the reconnaissance data. Summary statistics of the geochemical data obtained from all samples are presented on tables 17, 18, and 19.

Rock samples (n = 27) were collected of unaltered, altered, and unmineralized material to determine the range of element concentrations in the study area. Analyses obtained from unaltered rocks (n = 16) were compared to published data compiled by Rose and others (1979), Levinson (1980), Best (1982), and Govett (1983). Chemical differences of five or more times (5x) are considered significant and will be discussed later. Several of the rocks collected were altered and showed significant enrichments in Ag, As, Cd, Cu, Mo, Pb, Sb, W, and Zn (table 17). The rock types collected were andesite, quartz monzonite, quartzite, limestone, siltstone, and phyllite. The only rock type that showed any significant chemical changes was limestone, which

Table 17

Summary statistics of all reconnaissance rock data (TZR)*, Pilot Mountains, Nevada (n=27).

Element	Minimum	Maximum	Geom. Mean	Geom. Deviation	Valid	Censored
Ca%	0.07	20.0	0.89	8.13	24	3
Fe%	0.7	7.0	2.60	2.07	27	0
Mg%	0.05	7.0	0.61	4.28	27	0
Ti%	0.05	0.5	0.16	1.87	27	0
Ag	0.5	30.	1.54	4.20	11	16
As	200.	500.	271.	1.70	3	24
Au	**	**	**	**	0	27
B	10.	300.	82.9	2.61	26	1
Ba	20.	5000.	756.	3.19	27	0
Be	1.0	3.	1.58	1.53	16	11
Bi	**	**	**	**	0	27
Cd	20.	50.	31.3	1.58	5	22
Co	5.	50.	10.6	1.80	24	3
Cr	10.	500.	71.6	2.38	24	3
Cu	10.	10000.	92.7	5.44	26	1
La	20.	70.	32.4	1.52	19	8
Mn	20.	1500.	347.	3.20	26	1
Mo	5.	20.	7.98	1.70	9	18
Nb	**	**	**	**	0	27
Ni	5.	100.	16.0	2.54	25	2
Pb	10.	2000.	47.6	5.59	22	5
Sb	300.	3000.	1105.	3.26	3	24
Sc	5.	30.	8.27	1.68	26	1
Sn	**	**	**	**	0	27
Sr	100.	2000.	336.	2.52	27	0
Th	**	**	**	**	0	27
V	30.	300.	93.9	1.86	27	0
W	200.	200.	**	**	1	26
Y	10.	50.	19.2	1.45	25	2
Zn	700.	5000.	1285.	2.17	5	22
Zr	10.	300.	81.1	2.67	27	0

Explanation: values reported as ppm, except where noted;

* includes unaltered, altered, and mineralized rock samples;

** indicates not computed, no results within limits of determination of the analytical technique (DC-ES).

Table 18
Summary statistics of reconnaissance survey stream sediment data (TZS) -60 Mesh, Pilot Mountains, Nevada (n=97).

Element	Minimum	Maximum	Geom. Mean	Geom. Deviation	Valid	Censored
Ca%	0.3	20.	2.21	2.79	97	0
Fe%	1.5	10.	4.12	1.64	97	0
Mg%	0.3	5.	1.28	1.77	97	0
Ti%	0.1	0.5	0.25	1.38	97	0
Ag	0.5	2.0	0.82	1.71	16	81
As	**	**	**	**	0	97
Au	**	**	**	**	0	97
B	10.	300.	74.4	1.89	97	0
Ba	200.	1500.	580.	1.68	97	0
Be	1.	7.	2.18	1.67	91	6
Bi	10.	20.	12.4	1.33	7	90
Cd	**	**	**	**	0	97
Co	10.	50.	18.3	1.42	97	0
Cr	50.	200.	86.9	1.43	97	0
Cu	10.	150.	37.9	1.85	97	0
La	20.	150.	35.4	1.57	93	4
Mn	200.	2000.	807.	1.70	97	0
Mo	5.	200.	17.3	3.07	15	82
Nb	**	**	**	**	0	97
Ni	10.	70.	28.4	1.54	97	0
Pb	10.	200.	47.0	1.82	97	0
Sb	200.	200.	**	**	1	96
Sc	5.	30.	9.76	1.53	97	0
Sn	**	**	**	**	0	97
Sr	150.	1500.	463.	1.73	97	0
Th	**	**	**	**	0	97
V	50.	300.	111.	1.64	97	0
W	70.	700.	239.	2.72	9	88
Y	10.	70.	17.9	1.48	97	0
Zn	200.	500.	287.	1.36	7	90
Zr	50.	500.	126.	1.61	97	0
AA-As	5.	65.	25.2	1.72	77	20
AA-Bi	2.	10.	4.56	1.85	9	88
AA-Cd	0.1	7.	0.35	2.96	42	55
AA-Sb	1.0	90.	3.50	2.17	80	17
AA-Zn	35.	500.	64.3	1.58	93	4

Explanation: values reported as ppm, except where noted;
** indicates not computed, no results within limits of determination of the analytical technique (DC-ES);
AA-indicates atomic absorption data.

Table 19

Summary statistics of reconnaissance survey heavy mineral concentrate data (TZC), Pilot Mountains, Nevada (n=92).

Element	Minimum	Maximum	Geom. Mean	Geom. Deviation	Valid	Censored
Ca%	1.0	20.	5.90	1.93	92	0
Fe%	0.5	10.	2.08	1.85	92	0
Mg%	0.15	10.	1.11	2.86	92	0
Ti%	0.15	2.0	0.96	2.07	67	25
Ag	2.0	100.	7.16	2.77	33	59
As	1000.	1000.	1000.	1.00	2	90
Au	20.	100.	44.7	3.12	2	90
B	20.	500.	94.5	2.09	90	2
Ba	100.	10000.	2000.	3.62	74	18
Be	2.0	7.	3.18	1.49	34	58
Bi	20.	5000.	80.8	5.08	14	78
Cd	50.	100.	70.7	1.63	2	90
Co	10.	50.	18.7	1.57	73	19
Cr	20.	1000.	124.	2.36	90	2
Cu	10.	300.	39.2	2.56	76	16
La	50.	2000.	282.	2.65	91	1
Mn	100.	5000.	686.	2.50	92	0
Mo	10.	5000.	48.1	5.17	55	37
Nb	50.	200.	83.4	1.40	66	26
Ni	10.	100.	50.8	1.90	28	64
Pb	20.	10000.	313.	5.32	85	7
Sb	300.	15000.	1792.	3.85	19	73
Sc	10.	70.	22.0	1.95	81	11
Sn	20.	300.	44.3	2.30	17	75
Sr	200.	7000.	849.	2.29	92	0
Th	200.	500.	277.	1.49	19	73
V	50.	500.	169.	1.72	92	0
W	100.	20000.	400.	3.57	65	27
Y	20.	700.	200.	2.43	87	5
Zn	500.	5000.	1031.	1.95	19	73
Zr	50.	2000.	718.	2.98	16	76

Explanation: values reported as ppm, except where noted.

showed enrichments of Fe (5x), Ba (5-15x), La (5-10x), and V (5-10x).

Thirteen elements were used to evaluate the exploration potential of the Pilot Mountains. Eight of these elements were established in the orientation survey and an additional five elements (As, Sb, Cd, Au, and Sn) were anomalous in the rocks and stream sediments of the area.

Sites are considered anomalous when two or more anomalous elements were present at a sample site. Forty-nine anomalous sites were identified in the Pilot Mountains, utilizing the -60 mesh and heavy mineral concentrate data (table 20; figs. 9 and 10). These 49 sites are not related to known mining prospects.

Discussion: The 49 anomalous sites can be divided into two potential follow-up areas based on geology (fig. 3). Area I, defined by 12 sites, is located on the southern flank of the Pilot Mountains and is underlined by volcaniclastic and clastic rocks of the Mina Formation (table 20; fig. 9). The suite of anomalous elements in decreasing order of presence are Cu, Sb, Pb, Zn, As, Mo, Ag, Sn, and Mg. Copper has a higher background value (1-2 spectrographic steps) in the -60 mesh stream sediment of this area relative to the stream sediments of Area II, and is anomalous at 10 sites. Copper exhibits the opposite behavior in heavy mineral

Table 20

Anomalous multi-element sample sites not related to known mining activity, Pilot Mountains, Nevada.

Area #	Site #	Medium	
		TZS	TZC
1	048	Pb Sb	Pb Sb Sn
1	118	As Cu Mo	-
1	120	As Cu Mo	-
1	121	Cu Sb	-
1	122	Cu Pb	Cu Sb
1	162	Cu Pb	Sn
1	163	Cu Mg Zn	-
1	165	Ag Cu Pb Zn	Cu
1	166	Cu Sb Zn	-
1	167	Mg Zn	-
1	171	Cu Sb	Cu
1	172	As Cu Sb	Cu
2	047	As Mg Sb	Ag Bi Mg Sb W
2	111	Cd Zn	-
2	114	As Pb Sb	-
2	115	As Cd Sb Zn	-
2	116	Cu Zn	Mo W
2	127	Cd	Mo Sn
2	128	Cd Sb	Zn
2	135	Pb	Sb Sn
2	136	As Bi Cd Pb Sb Zn	Pb Sb Zn
2	146	As	Mg W
2	151	Cd	Ag Mo Sn
2	152	Mo	Sn
2	153	Mo	Ag
2	A01	As Sb	Ag Bi Cu Mo Sb W Zn
2	A02	Pb	Ag
2	A03	As Sb	Cu Pb Sb Sn
2	A04	Pb	Ag Cu Sb
2	A05	Ag Pb	Cu W Zn
2	A06	Ag Pb	Cu
2	A07	-	Cu Pb
2	A08	-	Mg Mo
2	A09	Mg Pb	Cu Mg Mo Pb Sb W Zn
2	A10	Ag Mg Pb	Cu Mo Pb Zn
2	A11	Ag Pb	Mg
2	A12	Pb	Ag Cu Sb Zn
2	A13	-	Ag Au Cu Mg Pb Sb Sn Zn
2	A15	-	Mg Zn
2	A16	Mg	Ag As Cu Pb Sb Zn
2	A17	-	Ag Mo Sb Sn W
2	A20	-	Ag Mg Mo Zn
2	A21	-	Ag Mg Sn
2	A22	-	Mg Sn W
2	A23	-	Mg Sb
2	A24	Mg	Mg Sb W
2	A25	-	Ag Bi Cd Cu Mg Mo Pb W Zn
2	A26	Mg	Ag Au Mg Sn W
2	A27	Mg	Ag Cd Cu Mg Pb Sb Zn

Explanation:
TZS -60 mesh stream sediment;
TZC heavy mineral concentrate;
- no anomalous elements present.

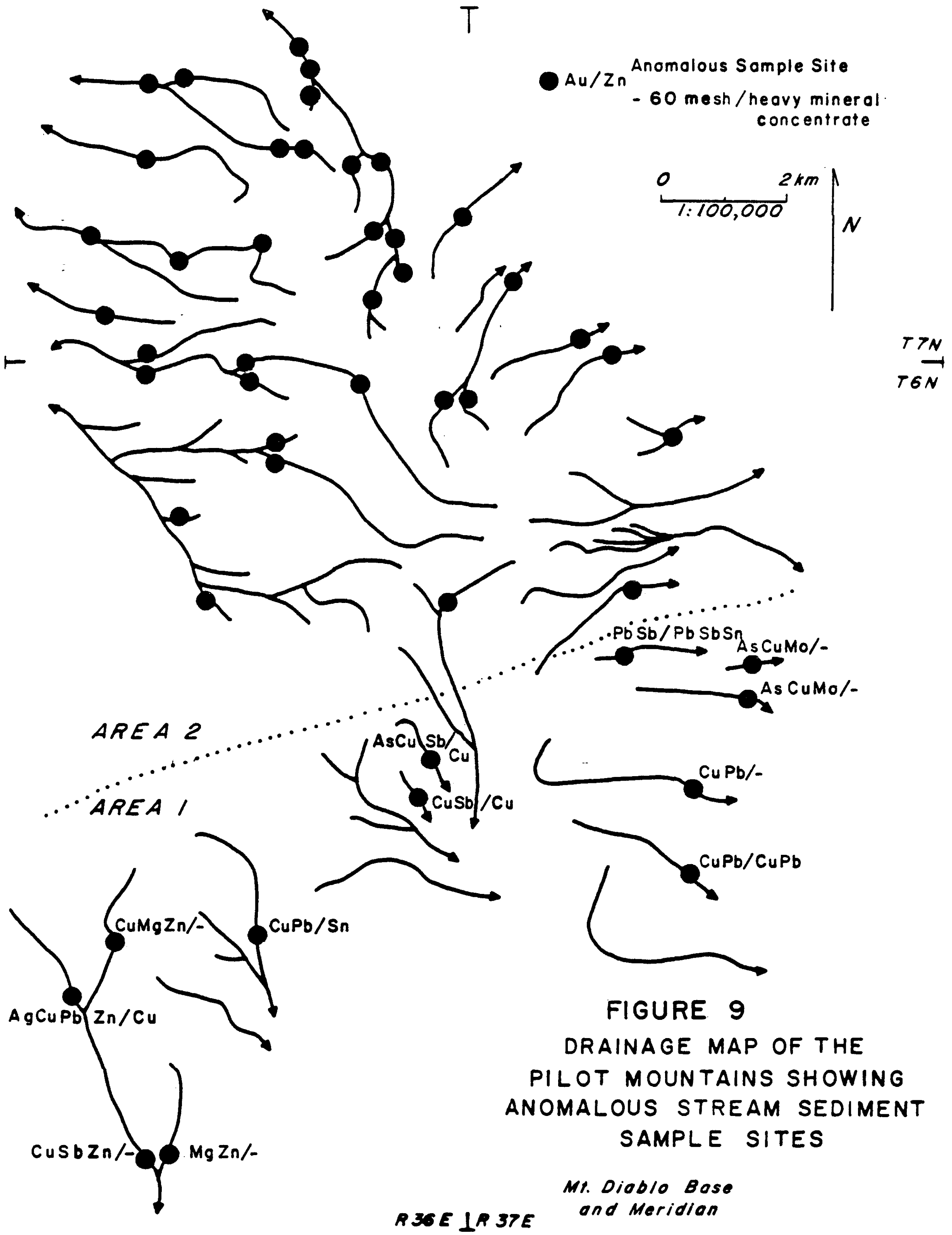


FIGURE 9
DRAINAGE MAP OF THE PILOT MOUNTAINS SHOWING ANOMALOUS STREAM SEDIMENT SAMPLE SITES

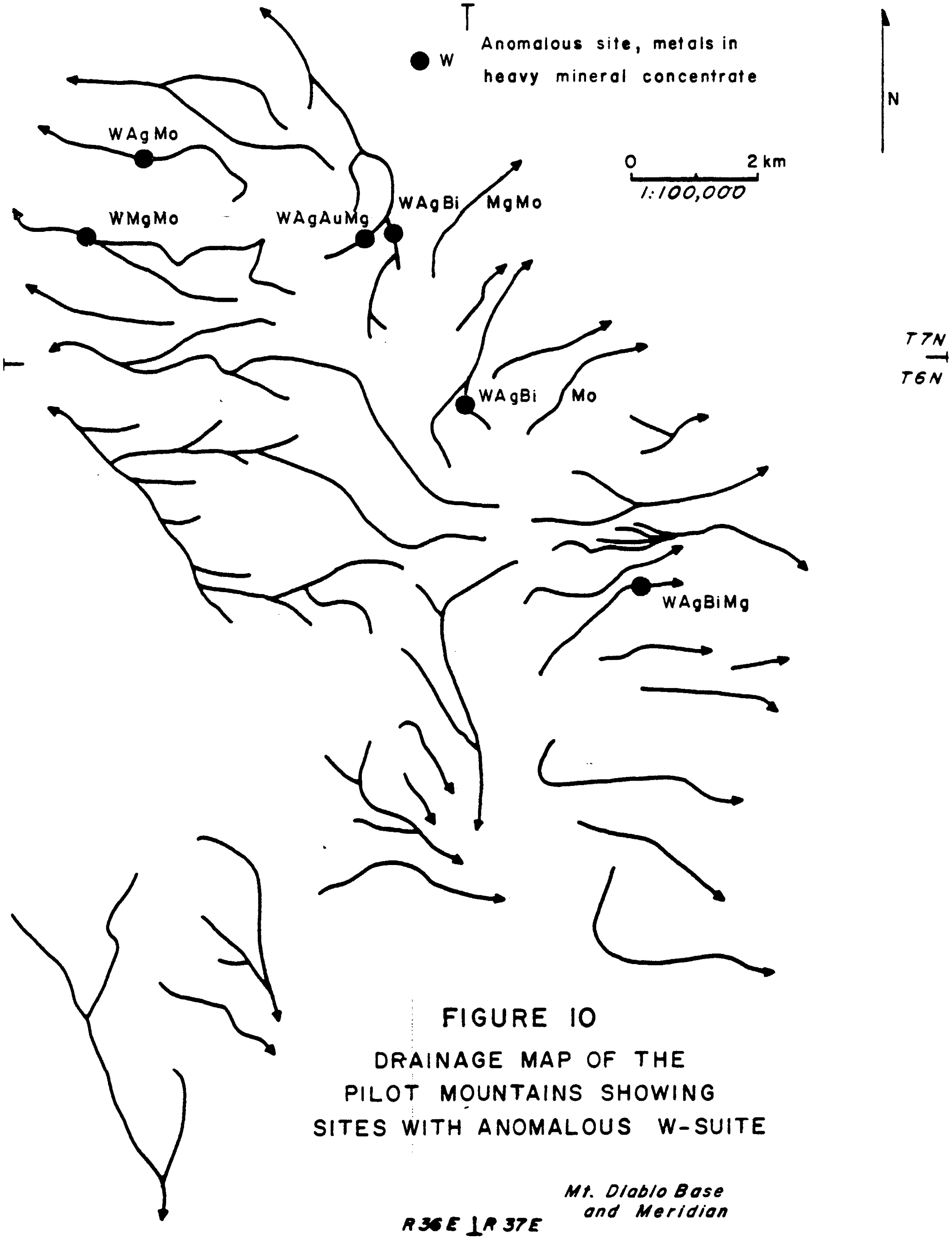


FIGURE 10

DRAINAGE MAP OF THE PILOT MOUNTAINS SHOWING SITES WITH ANOMALOUS W-SUITE concentrates, having a higher background (~1 step) in Area II relative to Area I. On the southeastern flank of the Pilot Mountains, several turquoise occurrences have been mined in the past (Vanderburg, 1937). Turquoise occurs as veinlets and nodules associated with irregular bodies of argillized quartz monzonite and quartzite of the Mina Formation (Morrisey, 1968). The presence of similar lithologies along the southern and southeastern flanks of the Pilot Mountains and anomalous Cu, Sb, As, Pb, and Mo supports the hypothesis for the occurrence of a "porphyry-type" base metal system (Nash and others (1985b). The -60 mesh stream sediment fraction is better in delineating anomalous areas relative to heavy mineral concentrates (table 20).

Area II is located on the northern flank of the Pilot Mountains and is defined by 37 sites (table 20; figs. 9 and 10). The dominant lithologies of this area are limestone and minor amounts of Tertiary andesite and tuff. The anomalous pathfinder elements in this area are diverse, the most commonly occurring are Ag, W, Zn, Cu, Sb, Sn, and Pb followed with fewer occurrences of anomalous Mo, As, Bi, Mg, Cd, and Au. No sample sites reproduced anomaly patterns similar to those established in the orientation survey of the W-skarn deposit (table 16).

The northwestern drainages of area II contain anomalously high concentrations of Sb ± Mo and W, with lesser occurrence of Cu, Pb, and Zn in the heavy mineral concentrate fraction. The -60 mesh fraction of stream sediments in this same area also exhibit anomalous concentration of Ag and Pb (table 20).

A study of anomalous sites located in area II (table 20; figs. 9 and 10) shows that the most effective sample medium for identification of W-skarn mineralization is the heavy mineral concentrate fraction. Only six of the 37 anomalous samples sites in area II are defined by the -60 mesh material (table 20).

To further evaluate the 37 anomalous sites of area II, single element plots were generated for the heavy mineral concentrate data. Four elements (Mo, Ag, Bi, Mg) were found to commonly occur with W in the drainages of the orientation survey area and elsewhere in the northern Pilot Mountains. Six sites that had anomalous W with the occurrence of two pathfinders (Mo, Ag, Bi, or Mg) were termed highly anomalous (fig. 10). The elements Ag, Bi, and Mo are well known pathfinders for W-skarn deposits (Boyle, 1974; Rose and others, 1979; Levinson, 1980) but the utility of Mg as a pathfinder is not well known. In the W-skarn environment Mg occurs in garnet, diopside, and idocrase. Idocrase is thought to be the source of Mg in the heavy mineral concentrate because it is a non-magnetic heavy Ca-Mg-Al silicate that is associated with W-skarn mineralization at the Gunmetal-Garnet deposits (Grahber, 1984).

Conclusions: Heavy mineral concentrates most effectively delineate W-skarn mineralization in the Pilot Mountains. Five pathfinder elements (W, Mo, Bi, Mg, Ag) are effective in exploration for W-skarn mineralization. The presence of anomalous W, supported by the presence of anomalous concentrations of any two of the pathfinder elements Mo, Bi, Ag, or Mg, constitute a highly favorable indicator for the occurrence of W-skarn mineralization. Six anomalous sites located in the northern Pilot Mountains suggest areas favorable for the occurrence of W-skarn mineralization (table 20; fig. 10).

The -60 mesh fraction delineates an area in the southern Pilot Mountains that is anomalous in Cu (table 20; fig. 9). The geology and geochemistry of this area suggest that there is potential for the occurrence of porphyry-type base metal system (Nash and others, 1985b).

SUMMARY OF CONCLUSIONS

Evaluation of orientation surveys implemented in the Gilbert and Pilot Mountains mining districts show that four fractions of stream sediment material and twelve pathfinder elements are effective in delineating known mineralized areas. The -60 mesh stream sediment and the non-magnetic heavy mineral concentrate fractions are effective exploration media in both areas. The non-magnetic heavy mineral concentrate fraction detects mineralization at greater distances downstream from mineralization than sieved stream sediment and is the optimum sample medium for W-skarn exploration in this environment.

In addition to the well known phenomenon of mechanical breakdown of minerals in an arid environment, chemical weathering of minerals is a contributing factor to mineral disintegration. The presence of anomalous pathfinder elements in the -60 mesh material and their absence in non-magnetic heavy mineral concentrates from the same site is attributed to chemical weathering of ore and associated minerals to secondary minerals (oxide or hydroxide form), which are lost during the panning process.

Monte Cristo Range

Gilbert District Orientation Survey

In the drainages below the Gilbert Au-Ag mines, seven pathfinder elements (Ag, As, Bi, Cu, Mo, Pb, and W) are anomalous and dispersed up to 6800 feet downstream from mineralization in the -60 mesh and non-magnetic heavy mineral fractions (table 8). In the drainage below the Carrie Ag-Pb mine, eleven pathfinder elements (Ag, As, Bi, Cd, Cu, Mo, Pb, Sb, Sn, W, and Zn) are anomalous and dispersed up to 12800 feet downstream from mineralization in the -60 mesh and -200 mesh stream sediment, and non-magnetic heavy mineral concentrate fractions (table 8).

Reconnaissance Survey

Five potential follow-up areas are delineated utilizing geolgy and multi-element (Ag, As, Bi, Cd, Cu, Mo, Pb, Sb, Sn, W, and Zn) anomalies in the -60 mesh and non-magnetic heavy mineral concentrate fractions (fig. 6; table 12). These areas are favorable for the occurrence of hydrothermal precious metal and/or base metal deposits hosted in Tertiary volcanics or pre-Tertiary sediments.

Pilot Mountains

Pilot Mountains District Orientation Survey

In the drainages of the Pilot Mountains district below the Gunmetal-Garnet W-skarn deposits, eight pathfinder elements (Ag, Bi, Cu, Mg, Mo, Pb, W, and Zn) are anomalous and dispersed up to 8500 feet downstream from mineralization in three fractions of stream sediment material (table 16). The three fractions are: 1) -60 mesh, 2) -80 +120 mesh, and 3) non-magnetic heavy mineral concentrate.

Reconnaissance Survey

Two potential follow-up areas are delineated in the Pilot Mountains based on geology and geochemical data from reconnaissance stream sediment sampling. One area, located in the northern Pilot Mountains, is defined by multi-element (Ag, As, Bi, Mg, Mo, Pb, Sb, W, and Zn) anomalies in samples of non-magnetic heavy mineral concentrates (fig. 9; table 20). Six sites within this area exhibit the anomalous suite of W plus two pathfinder elements (Ag, Bi, Mg, or Mo) and are favorable for the occurrence of W-skarn mineralization hosted in Triassic carbonates (fig. 10). Another follow-up area located on the southern flank of the Pilot Mountains, is delineated by multi-element (Cu ± Sb-Pb-Zn) anomalies in the -60 mesh fraction and is favorable for the occurrence of porphyry-type base metal system (fig. 9; table 20).

RECOMMENDATIONS FOR FUTURE WORK

Several problems recognized during this study should be addressed and considered in future studies of this type. They involve both the orientation and reconnaissance surveys in arid environments.

Orientation Surveys

1. Semiquantitative spectrographic (DC-ES) analytical methods were employed to obtain the data for this thesis. The full utility of the samples could not be realized due to two problems with the analytical method (DC-ES). These are the elevated lower detection limits of pathfinder elements and the discontinuous nature of the results reported. The elevated lower detection limits caused many elements to be censored in this data set. The discontinuous results of the readings and their resolution (±2 steps, confidence interval 96%) hampered the assessment of the pathfinder elements. Analytical instruments with lower detection limits for pathfinder elements (Ag, As, Au, Bi, Mo, Sb, Sn, W, and Zn) should be utilized. Data generated by atomic absorption spectrophotometry (AA) or inductively coupled plasma-emission spectroscopy (ICP-ES) instruments would greatly the improve quality of information obtained from the media sampled.

2. This study evaluated eight fractions of stream sediment. Similar responses were observed between similar sized fractions (i.e., -35 +45 mesh vs. -45 +60 mesh) of material. The similar geochemical response may also be due, in part, to the poor resolution of the DC-ES data. This suggests that only a limited number of fractions need be evaluated and that the fractions selected should cover the particle size range typical of stream sediment material in this environment (i.e., -10 mesh, -60 mesh, -200 mesh, nonmagnetic heavy mineral concentrates). As the -80 mesh fraction is routinely used in mineral exploration, it should be collected in any orientation survey and used as a basis of evaluating the effectiveness of the test stream sediment fractions.

3. A consistent sampling interval should be established based on deposit type and size. Sample sites should be located upstream and downstream of mineralization. A sampling interval of 500 feet for the first 2000 feet downstream of mineralization is recommended. The sample interval should be increased thereafter to a 2000 foot interval. Results from these samples would permit assessment of element dispersion characteristics that could be applied to regional and follow-up geochemical surveys.

4. A problem lies in defining the geographic limits or areal extent of the mineralizing system(s) that influenced the geology where the orientation survey is to be carried out. The significance of this problem occurs when the explorationist is trying to define threshold values. Some general guidelines to eliminate this problem are: make an estimate of the areal extent of affected ground based on geologic studies of these types of mineralizing system(s), and secondly, step out far enough away from the suspected sphere of influence from the mineralizing system(s), such that part of the orientation survey area would clearly be in an area of geochemical background. Be forewarned that, although, the background area may be outside of known mineralizing system(s), there is still the possibility of being within a sphere of influence from an unknown mineralizing system(s).

Reconnaissance Surveys

1. Future use of DC-ES data derived from similar USGS programs warrants detailed evaluation and inspection for the discovery of subtle anomalies associated with mineralization. Both the -60 mesh and non-magnetic heavy mineral concentrate fractions contain valuable information that is not readily extracted until the data are evaluated on a case by case basis. Subdividing geochemical results according to

geology is essential for a detailed evaluation and to obtain the maximum benefit from these data.

2. The recording of lithologies present in the drainage sediments and information regarding contamination are invaluable in the interpretation and evaluation of anomalous sites. The integration of field notes, geology and geochemical associations are essential in deciphering the data such that it can be applied to exploration and follow-up of anomalous areas.

3. Binocular microscopic study of heavy mineral concentrates would assist the interpretation and evaluation of geochemical anomalies. The specific minerals that carry pathfinder elements could be identified and hence linked to mineralization. This type of study would be most advantageouly applied to those sites having anomalous geochemical responses (≃ 5-10% of sites). The increased cost of this phase of the survey would likely be offset by greater confidence that could be placed in anomalies selected for follow-up evaluation.

4. Multivariate statistical methods of evaluation, such as correlation and R-mode factor analysis, were of limited use due to the elevated lower detection limits and discontinuous reporting intervals of the analytical technique utilized

(DC-ES). These methods may prove fruitful when the geochemical data collected are determined by analytical methods (i.e., AA or ICP-ES) that obtain background levels of concentration for the pathfinder elements.

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PLATE I
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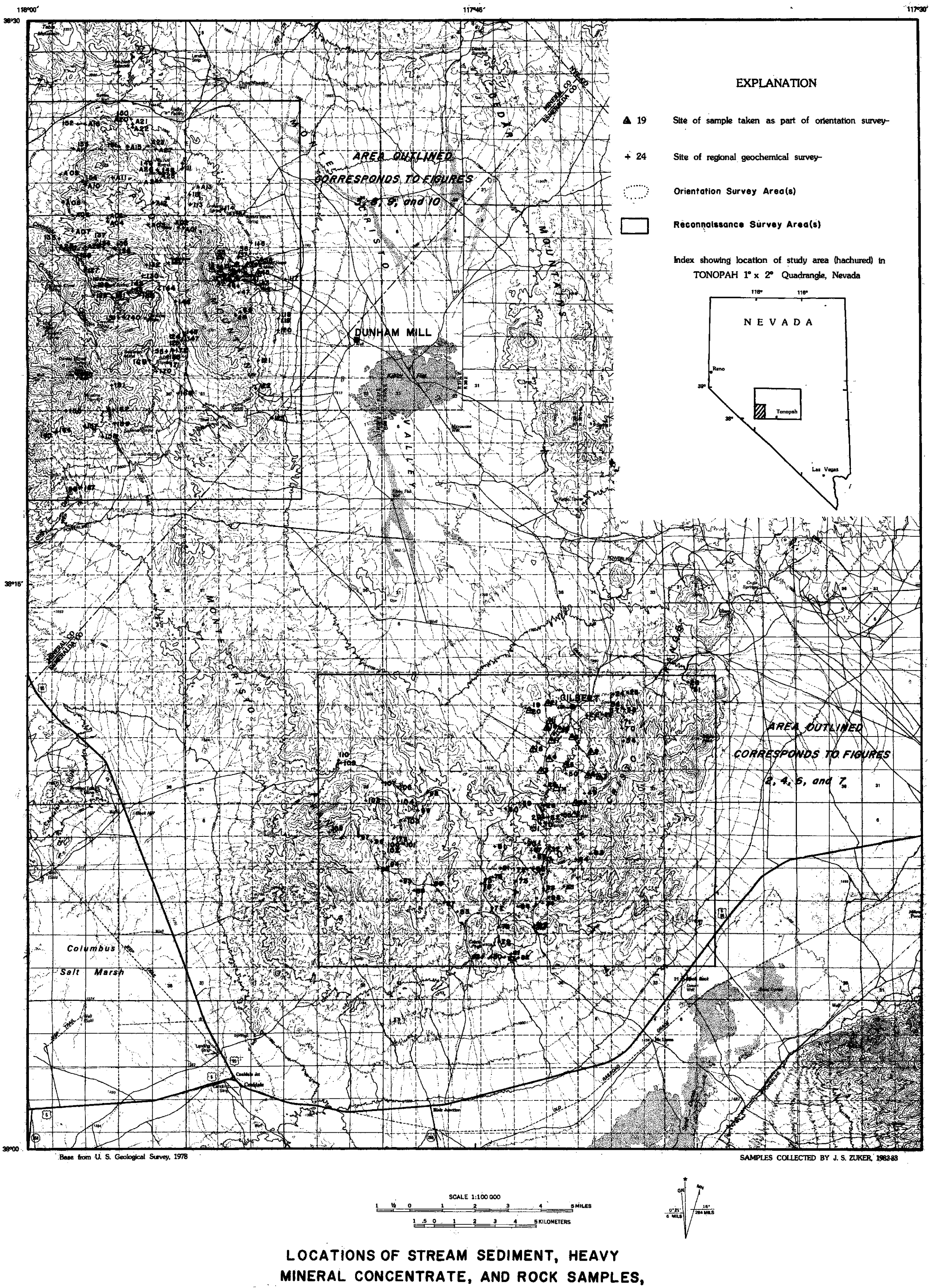

Base from U. S. Geological Survey, 1978

SAMPLES COLLECTED BY J. S. ZUKER, 1982-83

LOCATIONS OF STREAM SEDIMENT, HEAVY MINERAL CONCENTRATE, AND ROCK SAMPLES, MONTE CRISTO RANGE AND PILOT MOUNTAINS, NEVADA