UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Geochemical and Geostatistical Evaluation of American Flats-Silverton Planning Units, San Juan Volcanic Province, Colorado

by

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With an introduction by William D. Heran

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GEOCHEMICAL AND GEOSTATISTICAL EVALUATION

AMERICAN FLATS-SILVERTON PLANNING UNITS

SAN JUAN VOLCANIC PROVINCE, COLORADO

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United States Bureau of Land Management
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BARRINGER RESEARCH

INTRODUCTION

This report was prepared as part of the Bureau of Land Management (BLM) minerals resource inventory of the American Flats-Silverton Planning Units in southwest Colorado (fig. 1). Barringer Research Incorporated conducted a geochemical and geostatistical study of the area in which 1200 stream-sediment samples were analyzed and the results statistically processed. Geophysical data from an airborne electromagnetic and an airborne radiometric survey were also incorporated in the results of the study.

The area is located in the western San Juan Mountains, between Silverton and Lake City, Colorado (fig. 1). The study was done to further assess the mineral potential of this area. Analysis of the results indicate that there are areas of potential mineralization, and that continued exploration activity is warranted. The basic information pertaining to this study has been released in the following U.S. Geological Survey (USGS) Open-file reports:

USGS Open-File Report 80-541, 1980, "Stream-sediment geochemical survey of the Bureau of Land Management's American Flats-Silverton Planning Unit in southwest (Lake City area) Colorado."

USGS Open-File Report 80-917, 1980, "Helicopter airborne electromagnetic survey (using the Dighem^{II} system) of parts of the Lake City caldera, Hinsdale County, Colorado."

USGS Open-File Report 81-568, 1981, "Contour maps of uranium, uranium-thorium ratio, and total field magnetics, Lake City area, San Juan Mountains, Colorado."

USGS Open-file report 81-567, 1981, "Stacked profiles of data from a helicopter airborne radiometric and magnetic survey of the Lake City area, San Juan Mountains, Colorado." (note: in microfiche form)

The conclusions reached in the present report are the sole responsibility of Barringer Research Inc.

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ABSTRACT

A mineral assessment of the American Flats-Silverton Planning Units was undertaken by Barringer Research Incorporated under the terms of contract YA-512-CT9-229 with the Bureau of Land Management. The study took the form of a geochemical-geostatistical survey in which 1200 stream sediment samples were collected and analyzed for a broad range of elements. Geochemical results were submitted to statistical processing which included factor, discriminant, multiple regression and characteristic analysis. Particular attention was given to the integration of conceptual geological models of vein, porphyry and volcanic uranium mineralization in the geostatistical interpretation. Geophysical data provided by the United States Geological Survey was incorporated in the final stages of assessment of the results of the study.

The area has a long and varied mining history and the survey results confirmed the vein mineral potential for base and precious metals, and directed attention toward areas that might warrant continued exploration activity. Areas that might have potential for porphyry and volcanic uranium mineralization were also defined. The multivariate geochemical/geological approach proved to be an effective method for rapid mineral assessment of the survey area.

CONCLUSIONS

1) Geology, geochemistry, and geostatistical analyses indicate that continued exploration activity is warranted over most of the study area.

2) Thirty-six areas of specific interest for further work and interpretation are listed in Table 1 and the locations are referenced in Figure 1.

3) Models and training areas used in the multivariate geostatistics were unique, generally well defined, and useful aids in the interpretation of the geochemistry applied to mineral assessment of the area.

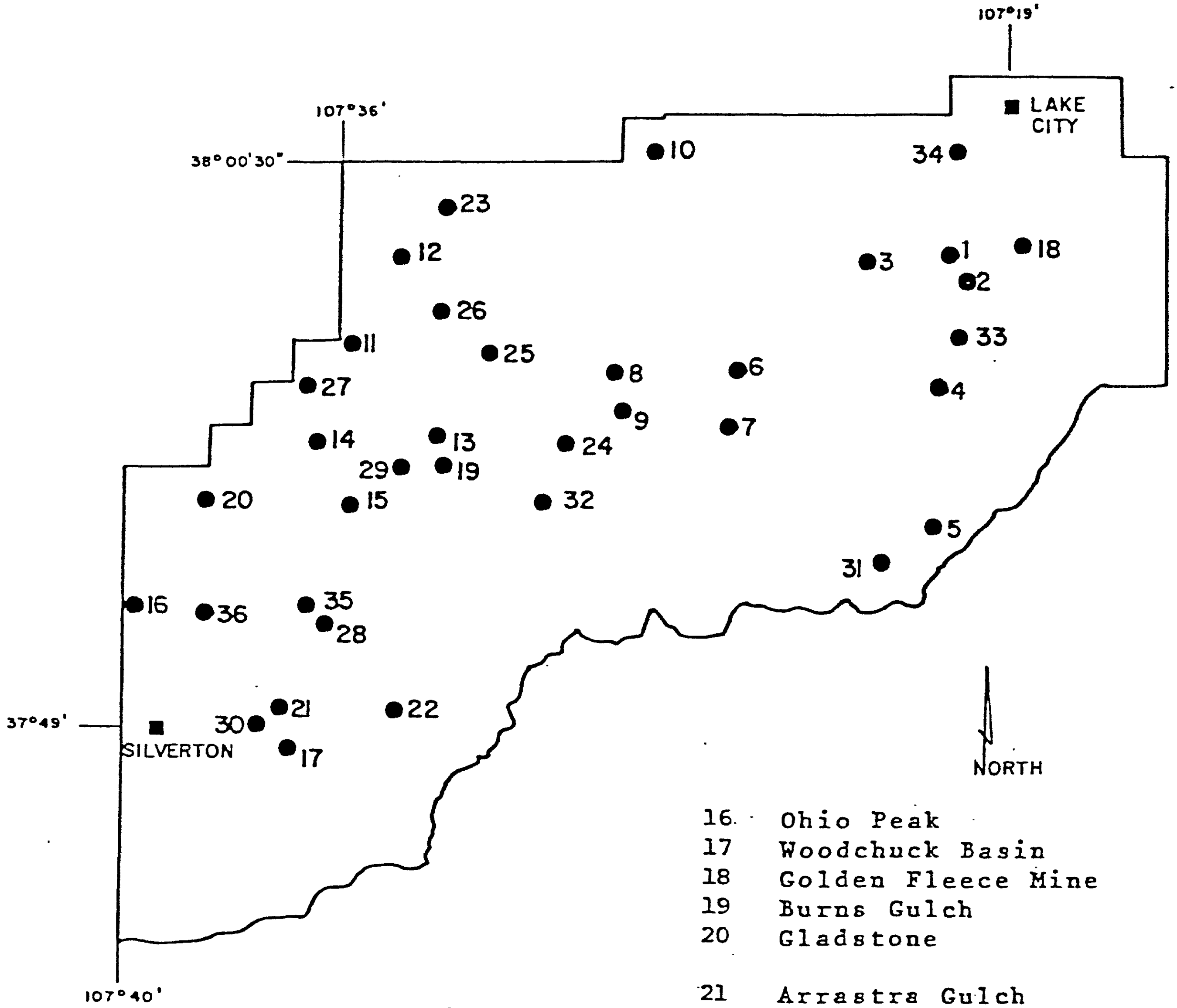
4) The geophysics flown over the area was incorporated in the interpretation at the final stage of the study, and tended to complement the geological and geochemical data.

5) The methods employed in this study provided a rapid and comprehensive means of assessing the mineral potential of the American Flats-Silverton Planning Units and can be used as a model for future area-wide mineral evaluation programs.

TABLE 1

AREAS WARRANTING FURTHER INVESTIGATION

	Geochemical Parameters												Factor Analysis Factor #		Discriminant Analysis Training Area					Characteristic Analysis			Multiple Regression Residuals	Geophysics		
AREA	As	Ba	Be	Co	Cu	Mo	Ni	Pb	U	U/Th	V	Zn	1	3	I	II	III	IV	XII	Vein	Porphyry	Uranium		Mag High	Mag Low	eU
Red Mountain																				X		X	X			
Red Mountain Gulch		X															X			X			X			
Alpine Gulch									X											X	X	X		+		?
Williams Creek		X							X															+		
Cascade Gulch					X			X				X	X					X								
Redcloud Peak	X		X						X	X												X				+
Sunshine Peak	X								X	X												X			+	+
Burrows Park	X					X			X						X	X	X					X	X			+
Grizzley Gulch									X						X		X			X		X	X			+
Capital City					X			X				X			X		X	X		X				+		
Houghton Mtn.			X			X			X	X									X	X		X	X			+
Redcloud-Palmetto Gulch	X												X		X	X	X					X				
Grouse Gulch																	X			X		X				
Hanson Peak					X			X				X	X			X				X						
Eureka Gulch																X	X					X	X			
Ohio Peak													X	X					X	X						
Woodchuck Basin									X	X			X				X		X	X			X			
Golden Fleece Mine	X				X	X		X				X	X					X		X						
Burns Gulch	X				X			X	X	X		X	X				X		X	X	X				+	
Gladstone												X	X				X		X	X		X				
Arrastra Gulch					X	X	X					X	X						X	X		X				
Galena Mtn.	X				X	X				X		X	X				X		X	X						
Dolly Varden Mtn.										X														+		+
Handie's Peak							X								X		X									
Wood Mtn.			X			X								X		X	X		X	X		X	X			
Hurricane Basin	X															X						X				
Hurricane Peak	X															X						X				
Porcupine Gulch		X								X													X			
Picayne Gulch		X														X	X									
Blair Gulch										X													X			
Wager Gulch																				X	X					
Jones Mtn-Niagera Peak																				X						
Green Mtn.																				X						
Fanny Fern Mine													X							X	X					
Dome Mtn.																							X			
Storm Peak																									+	



1	Red Mountain	16	Ohio Peak
2	Red Mountain Gulch	17	Woodchuck Basin
3	Alpine Gulch	18	Golden Fleece Mine
4	Williams Creek	19	Burns Gulch
5	Cascade Gulch	20	Gladstone
6	Redcloud Peak	21	Arrastra Gulch
7	Sunshine Peak	22	Galena Mtn.
8	Burrows Park	23	Dolly Varden Mtn.
9	Grizzley Gulch	24	Handie's Peak
10	Capital City	25	Wood Mtn.
11	Houghton Mtn.	26	Hurricane Basin
12	Redcloud-Palmetto Gulch	27	Hurricane Peak
13	Grouse Gulch	28	Porcupine Gulch
14	Hanson Peak	29	Picayne Gulch
15	Eureka Gulch	30	Blair Gulch
		31	Wager Gulch
		32	Jones Mtn-Niagera Peak
		33	Green Mtn.
		34	Fanny Fern Mine
		35	Dome Mtn.
		36	Storm Peak

FIGURE 1: INDEX MAP SHOWING LOCATION OF PLANNING UNITS AND AREAS WARRANTING FURTHER INVESTIGATION.

INTRODUCTION

Barringer Resources Inc. on behalf of the Bureau of Land Management has undertaken a geochemical-geostatistical study of the American Flats-Silverton Planning Units (Fig. 1) in the San Juan Mountains of Colorado (Contract #YA-512-CT9-229). The purpose of this study was to assess the area's mineral potential and consisted of:

Phase I - Collection of stream sediment samples and compilation of published geologic data.

Phase II - Multielement analysis of stream sediment samples.

Phase III - Data processing, which included digitizing of all published geologic maps, stream sample site descriptions and locations, and mine workings or prospects. Means, standard deviations, correlation coefficients, standard normalized values, and grid cell averages were determined and contour maps completed for selected geochemical parameters.

Phase IV Geological modeling for possible mineralization within study areas.

Phase V Geostatistical analyses using factor, multiple-regression, characteristic, and discriminant techniques were performed to allow effective interpretation of this large data base.

Phase VI — Interpretation of geochemical, geostatistical and geological modeling data and results.

Phase VII — Preparation of the final report. Report documents work done, presents data acquired, interprets that data and puts forth conclusions based on interpretation.

The report consists of 8 sections: Conclusions, Introduction, General Geologic Setting, Geologic Models, Geochemistry, Geostatistics and Discussion. Maps and geochemical computer output have been placed into appendices to allow easier use of the data contained in this report. The raw geochemical data and sample site descriptions are not included as this data is presented as U.S. Geological Survey Open file #80-541, and on magnetic tape through the N.T.I.S. report presently in press. Geophysical data collected by the U.S. Geological Survey is included in U.S. Geol. Survey Open File #80-917 and an open file currently in press and is therefore not duplicated within this report.

Acknowledgement is made to the many individuals and mining companies active within the area for confidential material to which we were allowed access. This valuable information aided in the meaningful interpretation of data within the area. The personnel of the Bureau of Land Management aided in this survey by their support and assistance with land access, air photographs, and additional rock chip and talus sampling programs.

Stream sediment sampling was carried out by Barringer field crews made up of geologists M. Robinson, J. Bukofski, D. Noe, G. Van Gaalen and J.L. Smith. The sampling crews were supervised in the field by E.F. Weiland.

GENERAL GEOLOGIC SETTING

The American Flats-Silverton Planning Units are located within the northwestern portion of the San Juan Mountains of south-central Colorado. The San Juan Mountains are a dissected volcanic plateau and form the largest remnant of an extensive middle Tertiary volcanic field. The San Juan Mountains are also referred to as the "San Juan Volcanic Province."

As a general statement, the San Juan Volcanic Province consists of a Precambrian terrane covered in part by the extensive development of Tertiary volcanic and volcanoclastic units. Some Paleozoic rocks are recognized within the province but no Mesozoic rocks are known.

The Precambrian terrane within the planning units consists of an extensive metamorphic complex generally referred to as the Irving Formation. This metamorphic complex is intruded by a series of plutonic rocks known collectively as the Granite of Cataract Canyon. This entire series of metamorphic and plutonic rocks is intruded by a series of mafic dykes of Cambrian or Ordovician age.

The Irving Formation consists of a sequence of interlayered amphibolitic and plagioclase rich gneiss and schist with quartzites, biotite-muscovite schists and minor iron formation. This pre-1700 million year age (Precambrian X) group of rocks is part of an extensive province irregularly exposed from southeastern Wyoming through Colorado into New Mexico. The minimum age of the complex is set by granitic intrusion dated at approximately 1.7 billion years. Metamorphism and folding both preceded and accompanied the plutonic activity. The age of the metamorphic protoliths apparently does not greatly exceed the age of metamorphism. Diverse protolith stratigraphy is apparent with volcanic and sedimentary origins suggested.

The Granite of Cataract Canyon is a medium- to coarse-grained, massive, light pink granite or quartz monzonite with local development of foliation or lineation. These plutonic rocks represent an approximate 1.4 billion year (Precambrian Y) magmatic event apparent throughout the Southern Rocky Mountains. On a regional basis the rocks are post-tectonic in nature and tend to exhibit enrichment with regard to uranium and thorium. Contact aureoles can be well developed consisting of feldspar destructive alteration within metamorphic host rocks and are often accompanied by extensive pegmatite units.

Paleozoic rocks recognized within the planning units consist of conglomerate, shale, limestone, and dolomite units. These Paleozoic units represent a probable transgressive sequence which on-laps the peneplained surface resultant from extensive erosion at the end of Precambrian time. Paleozoic units were probably more widely developed than present outcrop suggests; but uplift and erosion associated with the Laramide Orogenic activity resulted in removal of a large percentage of the Paleozoic lithologies. There is evidence suggesting that the San Juan Province was the site of igneous activity associated with early Laramide uplifts but much of this material was eroded before mid-Tertiary volcanic activity.

As noted above, much of the American Flats-Silverton Planning Units are underlain by volcanic rocks of Cenozoic age. Two distinct suites of intrusive igneous rocks are recognized within the province; lavas and breccias of intermediate composition with associated silicic differentiation characterized by ash-flow tuffs of Oligocene age and a bimodal group of rhyolites and mafic alkalic lavas of Miocene-Pliocene age. A detailed history of volcanic activity during this period may be found in S.A. Johnson's (1980) "Preliminary Results, Mineral Resource Inventory" report to the Bureau of Land Management.

The western San Juan Mountain area is one of the richest and most intensely mineralized regions in the southern Rocky Mountains. This area has produced more than three-quarters of a billion dollars worth of base and precious metals over the last 100 years (Lipman, et.al., 1976). The ore deposits are strongly fracture controlled, located proximal to calderas and associated volcanic structural features. Mineralization occurs as fissure veins, breccia pipes, carbonate replacements, and as disseminations within a variety of host rocks.

The major mining operations within the American Flats-Silverton Planning Units produced principally from fissure veins within volcanic units and include some of the largest and deepest veins in the state (Burbank and Luedke, 1968). The principle metals produced were gold and silver with subordinate amounts of copper, lead, and zinc. Gold occurs both in the native, late stage form and as tellurides associated with argentiferous tetrahedrite and ruby silver (proustite). Base metal sulphides consist of pyrite, sphalerite, galena, chalcopyrite and tetrahedrite. The predominant gangue mineral is quartz with lesser amounts of barite, calcite, and fluorspar. Locally, manganese silicate (rhodonite) is common.

Mineralization within vertical breccia pipes is less common and appears to be confined to the northwestern portion of the fracture zone associated with the Silverton Caldera. A genetic association with small stocks and plugs of quartz latite porphyry is suggested. Ore bodies within the breccia pipes are irregular and usually consist of open-space filling changing to replacement deposits at depth (Lipman, et.al., 1976). The ores contain a higher proportion of copper minerals than the vein-type deposits, with enargite and massive sphalerite and galena representing the common sulphides. Some of the ore bodies become pyritic and of lower grade with depth (Burbank, et al, 1947).

Propylitic, solfataric, and argillic/sericitic alteration are common within the area. Propylitic alteration has affected many cubic miles of volcanic rocks throughout and beyond the caldera systems. Propylitic alteration grades from a quartz-carbonate-chlorite association to a more pronounced quartz-carbonate-albite-epidote-chlorite suite at depth. Solutions dominated by carbon dioxide were forced into fractured rock and fissure systems generally preceeding vein formation and the introduction of metals and sulphur (Burbank 1960).

Two areas within the planning unit have been subjected to solfataric alteration. One area is in the Red Mountain district north of Silverton, and the other also called Red Mountain is located one mile south of Lake City. In areas of solfataric alteration, silica and sulphur have been added to the mineral suites. Silicification is particularly characteristic in association with some of the chimney ore deposits in the Red Mountain district. The typical mineral assemblage associated with this type of alteration is quartz, dickite, other clay minerals, pyrophyllite, zunyite, diaspore and alunite (Burbank and Luedke, 1968). Essentially, all the original iron has been converted to pyrite.

The planning units contain numerous large areas exhibiting argillic and/or sericitic (phyllic) alteration having associated color anomalies. These color anomalies are caused by thin coatings of iron compounds on fracture surfaces, usually goethite and/or jarosite with minor hematite. Lipman (1976), Burbank and Luedke (1964), and Luedke (1972) have outlined areas which show pervasive alteration of this nature. Mineral assemblages in these areas include quartz-pyrite-sericite, quartz-sericite-clay and pyrite-quartz-sericite-clay-chlorite.

Work by Burbank and Luedke (1961) suggests two periods of alteration and mineralization. The older period is dated as late Cretaceous to early Tertiary (Laramide) with the younger, principle period considered to be middle to late Tertiary in age and related to the San Juan volcanic activity.

Lipman, et al., (1976), present radiometric dates of alteration and ore mineralization suggesting that these processes acted 5 to 15 m.y. after caldera formation. The mineralization would therefore be more likely related to the small acid intrusives rather than the caldera forming events themselves.

GEOLOGIC MODELS

At the request of the Bureau of Land Management, three models having specific characteristics of possible mineral deposition were evaluated for the American Flats-Silverton Planning Units. The models include: 1) vein and vein-related precious and base metals; 2) porphyry-type sulphide mineralization; and 3) volcanic and volcanic associated uranium within the caldera environment.

VEIN-TYPE AND VEIN RELATED MINERALIZATION

The greater proportion of metal production from the Silverton and Lake City areas has been associated with vein deposits. Lipman (1976) suggests at least two distinct periods of vein mineralization. The older period relates to the Uncompahgre Caldera formation represented by the Golden Fleece mine, one mile south of Lake City, and a second period by the majority of other veins studied within the planning unit. Casadevall and Ohmoto (1977) believe there are six mineralizing phases found in the Sunnyside Mine north of Silverton. The following model is based largely on the work done by Casadevall and Ohmoto (1977) on the Sunnyside deposit. The Golden Fleece vein, though unique in mineralogy and time period, may be described by a similar mechanism of formation.

Geological and Structural Constraints

Vein type mineralization may be related to, or follow the formation of a volcanic pile and caldera. Generally this late stage resurgent activity provides an excellent environment for mineral deposition. Calderas having long complex histories of post subsidence, igneous, and tectonic activity can provide the geologic setting and hydrothermal system required for the concentration and deposition of various metals. Intrusive bodies occurring at depth may provide a heat source enhancing solution circulation and metal solubility.

Hydrothermal Solutions

Hydrothermal solutions have two modes of origin: meteoric and magmatic, however, most are some combination of the two. Magmatic solutions result from the dewatering of plutonic or possibly subvolcanic bodies. Because de-watering generally occurs during the final stages of crystallization, metals and other elements with high partitioning coefficients will be expelled with the solutions. This process therefore may be one source of the metals deposited within veins. Meteoric water, however, has its source from the surrounding prevolcanic sediments, meta-sediments, and intrusives. Meteoric waters passing through these peripheral units under the influence of a heat differential resulting from plutonic or subvolcanic intrusion would exhibit increased levels of K, Na, CO_2 and S. These hot saline solutions would then be capable of leaching the metals (Cu, Fe, Zn, Mn, Ag, Au) from the underlying Precambrian metasediments and Tertiary volcanic units within the area. Solutions would migrate in a direction dictated by fractures, hydrologic pressure, and convection. Metal precipitation from this sulphate-dominate solution may then occur when: 1) activity of chlorine is decreased; 2) the oxygen fugacity is decreased; 3) an increase in the total reduced sulphur content occurs; 4) there is an increase in the pH; and/or 5) a decrease in temperature (Casadevall and Ohmoto, 1977). When one or more of these conditions exist, metal solubility would decrease and metal precipitation would occur. Commonly a change in rock type, depth, or fracturing would cause the required solution changes for metal deposition.

Discussion

Casadevall and Ohmoto (1977) studied the vein mineralization in the Sunnyside mine and proposed a model that is consistent with the known geological, geochemical, and theoretical information from the area. Their model suggests that the mineralizing fluids were composed predominantly of meteoric water. Paleozoic/Mesozoic evaporites adjacent to the caldera provided the required sulphur and salts and subsequent interaction with the Tertiary volcanics, Paleozoic/Mesozoic sediments, and Precambrian rocks increased the metal content and K/Na ratio. Fluid inclusion studies suggest metal contents ranging from 10-1,000 ppm in the solution. The meteoric water may have been funneled into the caldera from higher volcanic areas located to the south and west. The solutions were then channeled by the graben-related fracture systems to the northeast and northwest radial structures. Two mechanisms, temperature drop and pH increase, probably led to the decreased metal solubility. Hypogene and/or supergene enrichment of several veins has been suggested by Stevens (1970). Where wall rocks attained adequate susceptability, replacement type mineralization would have occured. Although this model is specific to the Sunnyside mine, the mechanism described here influenced, if not mirrored, the deposition of other vein and vein related deposits within the area. While the Golden Fleece may have different source fluids and source rocks, a general analogy may be made with these other areas.

PORPHYRY-TYPE SULPHIDE MINERALIZATION

As part of the overall assessment of the planning units, the possibility of the presence of large scale-low grade sulphide mineralization was examined. The following model has been constructed based on porphyry copper/molybdenum deposits in North and South America.

Geological Constraints

Porphyry-type sulphide mineralization is generally believed to be associated with high-level, calc-alkaline stocks. A gradational change downward into a granodiorite pluton and an upward progression to a calc-alkaline volcanic pile with a possible andesitic stratovolcano cap would be observed. Mineral emplacement would generally begin at 2-3 km beneath the surface and may extend to a depth of 8 km. The upper part of the intrusive would be on the order of 2-3 km in diameter, oval or circular in plan, and may be associated with late stage dikes above and surrounding it.

Mineralization Control

Late in the progression of the volcanic development, postdating more explosive activity and possible caldera formation, de-watering of the remaining intrusives would provide the hydrothermal solutions responsible for mineralization and alteration. Retrograde boiling of these solutions and intermixing with meteoric waters would control mineral deposition, alteration types and their spatial relationships. These fluids would be rich in metals and ions excluded from crystal growth in the magma and would be highly saline. Mineralization and alteration would form concentric halos surrounding the apical portions of the intrusive (see Sillitoe, 1973 and Lowell and Guilbert, 1970).

Discussion and Recognition Criteria

Analogy with known deposits found elsewhere in North and South America (see Table 2) suggests that a wet granodiorite to quartz latite melt would be emplaced at moderate depth during mid-Tertiary time, with the intrusive vent and resulting stock

TABLE 2

CHARACTERISTICS OF KNOWN PORPHYRY DEPOSITS AND MODEL DEVELOPED FOR THE WEST SAN JUAN MOUNTAINS

DEPOSIT:	AJO, ARIZONA (Lowell & Guilbert, 1970)	CANANEA, SONORA, MEXICO (Lowell & Guilbert, 1970)	ESPERANZA, ARIZONA (Lowell & Guilbert, 1970)	QUESTA, NEW MEXICO (Lowell & Guilbert, 1970)	SAFFORD, ARIZONA Lowell & Guilbert, 1970)
ROCKS:	Precambrian gneiss Mesozoic quartz monzonite Andesite & tuff	Paleozoic sediments "Laramide" volcanics "Laramide" intrusives	Tuffs Welded tuffs Quartzite	Tertiary andesite Latite Rhyolite	Quartz monzonite Quartz diorite Rhyolite Quartz latite Dacite dikes & plugs
PLAN SHAPE:	Oval	Irregular-stocks plugs	Irregular elongate	Very irregular domelike	Irregular-dike swarm
CONTROLLING STRUCTURES:	Faults	Faults	Faults	Faults	Faults & shears
GRADE OVERALL:	0.75% Cu	0.8% Cu	0.51% Cu 0.028% Mo	0.18% Mo	0.5% Cu
EXTENT OF ALTERATION BEYOND ORE BODY:	5000'+	5000'	1500'+	2000'+	12,000'±
	PERIPHERAL ZONE				
ALTERATION:	not reported	not reported	not reported	sericite calcite kaolinite epidote chlorite	not reported
MINERALIZATION:	specularite, barite in veins.	galena, sphalerite topaz, silver minerals in veins.	galena, sphalerite, silver minerals in veins.	pyrite, molybdenite, galena, sphalerite in veins.	silver minerals, chalcopyrite in veins.
	OUTER ZONE				
ALTERATION:	albite, chlorite, zeolite, sericite, quartz, ankerite	chlorite, epidote	chlorite, epidote	serite, quartz, pyrite, calcite, kaolinite, illite, fluorite	epidote, chlorite.
MINERALIZATION:	not reported	not reported	pyrite in veins & veinlets	pyrite, molybdenite, chalcopyrite, galena, sphalerite fracture coatings.	gold, chalocopyrite in shears, veins & dikes.
	INNER ZONE				
ALTERATION:	quartz, sericite pyrite	quartz, sericite	quartz, sericite, kaolinite	quartz, K-feldspar biotite, calcite, kaolinite, illite.	quartz, sericite, pyrite.
MINERALIZATION:	pyrite, chalcopyrite disseminated & in microveinlets.	pyrite, chalcopyrite, molybdenite, disseminated & in veinlets.	pyrite, chalcopyrite molybdenite disseminated & in veinlets.	pyrite, molybdenite, chalcopyrite, huebnerite in in veinlets & veins.	pyrite, magnetite, topaz, galena, sphalerite in veins, veinlets & disseminated.
	INNERMOST ZONE				
ALTERATION:	quartz, K-feldspar, chlorite, anhydrite.	quartz, molybdenite biotite, tourmaline.	K-feldspar, biotite, sericite.	quartz, K-feldspar anhydrite.	K-feldspar, biotite, quartz, sericite.
MINERALIZATION:	magnetite, chalcopyrite, pyrite, bornite disseminated & in microveinlets; low total sulfides.	pyrite, chalcopyrite, bornite, molybdenite in veinlets & disseminated.	pyrite, chalopyrite, molybdenite(?), disseminated & in veinlets.	molybdenite, pyrite, chalcopyrite, huebnerite in veins & veinlets.	chalcopyrite, pyrite, bornite, molybdenite, magnetite, topaz, galena, spnalerite in veins, veinlets, & disseminated.
	LATERAL ZONING (From Center Outward)				
ALTERATION:	potassic phyllic propylitic	phyllic argillic	potassic phyllic argillic	not reported	potassic phyllic argillic propylitic
MINERALIZATION:	molybdenite chalcopyrite pyrite specularite barite	not reported	chalcopyrite, molybdenite pyrite	molybdenite chalcopyrite, pyrite, galena, sphalerite molybdenite	chalcopyrite molybdenite pyrite gold
COMMENTS:	Gold, silver-bearing veins and/or breccia pipes not reported. Chalcocite, covelite present.	Numerous mineralized breccia pipes. Chalcocite, covelite present.	Breccia pipes present. Chalcocite, covelite present.	Breccia pipes present. No supergene sulfides.	Mineralized breccia pipes present. Chalcocite & cbvelite present.

being emplaced partially in its own ejecta. The apical portions would likely display porphyritic textures which would grade to phaneritic equigranular textures with increasing depth.

Hydrothermal activity would accompany and follow the emplacement of the stock thus creating zoned alteration and mineralization shells within and surrounding the stock in the host rocks. Table 3 lists the probable mineralogical and chemical changes through these zones. It is possible, indeed likely, that multiple intrusive and/or hydrothermal events would take place.

As development of a porphyry-type deposit or prospect has not taken place in the planning units, it may be assumed that such a deposit must be wholly buried if indeed present. Since much of the area is propylitically altered (Lipman, 1976; Luedke and Burbank, 1975a, b, c), the depth of burial could be shallow. Depending on the level of exposure, predictions of the surface characteristics will differ. If the outer shell of alteration has been breached, geochemical zoning, particularly of calcium, potassium, rubidium and strontium, may be of particular importance. If the level of exposure were outside the outer alteration shell, zoning may be highly irregular. Zoning may consist of differences in intensity of alteration, or types of alteration centered on veins, fractures or pipes.

It would be likely that this type of deposit would have associated with it peripheral base and precious metal-bearing veinlets, veins, and pipes. The prevalence of such occurrences within the planning units may or may not be related to a deeper porphyry system.

Geophysically, such a deposit may have both a magnetic and gravity expression. Magnetite/pyrite relationships in the

TABLE 3

PROBABLE MINERALOGICAL AND CHEMICAL CHANGES
FOR THE ALTERATION ZONES ASSOCIATED WITH
PORPHYRY TYPE SULPHIDE MINERALIZATION

	Unaltered Rock	Propylitic Zone	Argillic Zone	Phyllic Zone	Potassic Zone	Reference
Alteration products:		chlorite epidote calcite	quartz kaolinite chlorite	quartz sericite pyrite	quartz K-feldspar biotite sericite anhydrite	Meyer & Hemley, 1967 Lowell & Guilbert, 1970 Creasey, 1966
Metallic mineralization:	Trace Pyrite	2% pyrite, trace chalcopyrite, galena, sphalerite, Au-Ag.	10% pyrite, 1-3% chalcopyrite, trace molybdenite, trace galena, sphalerite, Au-Ag.	1% pyrite, 1-3% chalcopyrite, 1% molybdenite	low total sulfides	Lowell & Guilbert, 1970
Changes in host rock mineral constituents	Quartz	no change	increased	increased	increased	Lowell & Guilbert, 1970
	K-feldspar	no change	mildly sericitized	sericitized	recrystallized	
	Plagioclase	decreasing An, partially with epidote, calcite, chlorite.	decreasing An, converted to montmorillonite & kaolinite	decreasing An sericitized	decreasing An, converted to biotite, sericite.	" "
	Biotite	partially replaced with chlorite	montmorillonite & kaolinite, chlorite & quartz.	sericite, quartz, & rutile(?)	biotite & K-feldspar	" "
	Hornblende	partially replaced by epidote & chlorite	chlorite	sericite, pyrite pyrite, rutile	biotite chlorite, rutile	" "
	Magnetite	trace pyrite	pyrite	pyrite	pyrite	" "
Changes in chemical constituents:	CaO	+	-	-	--	Lanier, 1978 & Meyers & Hemley, 1967
	K_2O	-	-	+	+	
	Fe_2O_3	+	-	-	-	" "
	TiO_2	?	?	+	+	" "
	MgO	+	+	+	+	Lanier et al, 1978
	Na_2O	-	-	-	-	" "
	SiO_2	0	+	+	++	Meyer & Hemley, 1967; Moore, 1978
	$CaO+Na_2O$	-	-	-	-	
	Na_2O/CaO	+	+	++	++	" "
	Cu	+	++	++	+	Lowell & Guilbert, 1970
	Mo	0	+	++	+	" "
	Au	+	++	0	0	" "
	Pb	+	++	+	0	" "
	Zn	+	++	+	0	" "
	Rb	+	+	++	High	Armbrust, et al 1977
	K/Rb	-	-	-	Low	" "
	Rb/Sr	+	+	+	+	" "

- = depleted relative to unaltered rock
0 = no change compared to unaltered rock
+ = increased relative to unaltered rock
++ = markedly increased
? = no data

propylitic zone might be detected by airborne or ground level magnetic surveys. Density contrasts between mineralized zones and altered zones could possibly provide gravity expression, however, because this type of deposit, if present, is likely to be at depth, symetrical ring-like anomalies would not necessarily be anticipated in geophysical data.

URANIUM IN THE VOLCANIC ENVIRONMENT

Source Rocks

In general, there appears to be an association of increased levels of uranium with alkalic (peralkaline) volcanic rocks, especially those exhibiting volatile-rich phases. These volcanic rocks take the form of ashes, tuffs, and ash flow tuffs.

The associated uranium is considered to be of magmatic origin and it is of interest to note that comagmatic intrusives may also contain anomalous amounts of uranium and associated molybdenum, tungsten and tin. An anatectic origin of the felsic magma which fed the volcanism has been postulated in at least a single case (Locardi, 1977).

Host Rocks

Economic concentrations of uranium appear to have developed in a wide range of volcanic and volcano-sedimentary environments. These environments range from proximal synvolcanic rocks to distal tuffaceous and clastic rocks. Uranium may be concentrated within fluvial sediments intercalated with volcanic rocks, water reworked volcanic sands and pumices, subaqueous (lacustrine) sediment peripheral to volcanic centers, and permeable sandstones beneath pre-volcanic erosion surfaces. Uranium concentration within structurally disrupted zones such as fault and joint zones has also been documented.

Uranium Source/Supply

The uranium content of volcanic rocks is from 1.5 to 2 times greater than their plutonic equivalents and therefore, volcanic rocks, especially felsic volcanic rocks, offer an excellent source of readily leachable uranium. Glass shards and glassy matrices are considered the prime source of easily mobilized uranium. The uranium is probably adsorbed on the surface of glass shards from which it is uniquely leachable, often within a matter of hours or days after formation. Uranium within glassy matrices is in a disseminated form and is released upon devitrification or dissolution. Ground water within tuffs and tuffaceous sediments may contain significant levels of uranium derived from adsorbed material and/or from solution/devitrification of disseminated material in glasses: 20 to 200 ppb has been documented (DeVoto, 1978).

Mineralizing Processes/Mechanisms

The uranium mineralizing process within volcanic or volcano-sedimentary rocks is fundamentally a diagenetic process that releases, mobilizes and then precipitates uranium. Basically one is looking at sediment diagenesis and uranium concentration by supergene processes.

<u>Release Phase</u>: The release of elements during hydrologic flow and/or devitrification of volcanic glasses introduces uranium into the gound water system. Therefore, any process that breaks down or dissolves volcanic glass releases uranium; probably the most important agent/process is low temperature solution of glass by ground water. Lithologic-hydrologic

systems that should release uranium are those in which complexing agents are available and have not been removed by reactions within the system itself. The release phase can be considered as a diagenetic process, a supergene process, an auto-metasomatic process or a combination of one or all of these processes.

Mobilization/Transportation Phase: Uranium is probably transported by fluorine and carbon dioxide-rich, low to moderate temperature hydrothermal fluids percolating through the volcanic pile. Systems open to CO_2 are probably most suitable for release of uranium for long distance migration. Walton (1978), suggests that the simplest and most reliable are soil systems in which plant-root respiration and decay of organic matter provides excellent renewable supplies of CO_2. Considering the markedly young age of some volcanogenic uranium mineralization, sufficient time may not be available for extensive development of soils and the organic material contained therein. It should, however, be noted that CO_2 as well as H_2S, are constituents of the active volcanic environment.

As noted, geochemical systems most conducive to transport of released uranium are those in which complexing agents are available and have not been removed by reactions within the system itself. The presence of early calcite precipitated before extensive dissolution of glass, and indicators of high pH such as zeolite suggest that uranium, though released from the glass, could not migrate to form economic uranium concentrations (Walton, 1978). Diagenetic and/or alternative systems in which complexing agents are not depleted are more efficient at releasing uranium than are systems where complexing agents are not present, even though large amounts of uranium (9 ppm is indicated in some cases) may initially have been present in systems depleted by complexing agents.

The mobilization/transportation of uranium in complexed form is very much a function of ground water hydrology and ground water chemistry. An open hydrologic system is required and hydrologic channels must be present for solution movement in the form of fractures, faults, joints, pumice zones, altered vitrophyres or lithophysal zones. The effectiveness of ground water geochemistry is basically a function of length of time the water has been in contact with a volcanic glass source.

Precipitation/Concentration Phases: Uranium mineralization tends to be concentrated in permeable or structurally disrupted zones within the volcanic pile or associated sediments, often times in the form of low-grade peneconcordant uranium oxide dissemination inside kaolinized and iron-sulphide impregnated rocks. Generally, there are indications of the presence of CO_2 and H_2S. Exhalative gases are generally considered to be the most significant reductant within the volcanogenic environment, although the presence of carbon and/or hydrocarbon in associated sedimentary sequences may be of importance locally.

Submarine venting of fluids may provide a source for distal deposits contained in reducing sedimentary facies. These facies are often rich in sulphur or pyrite with precipitation of uranium influenced by H_2S exhalation (Curtis, 1978).

Discussion: Uranium mineralization within the volcanogenic environment is basically controlled by two phenomena: large quantities of uranium mobilized from volcanic rocks and a tectonic regime favorable for release of H_2S and CO_2 to act as a precipitant of uranium. The entire mineralizing process is best viewed as a dynamic, diagenetic process, although a specialized one that specifically concentrates uranium. The diagenetic process is basically zeolitic alteration with devitrification comprising an initial, uranium liberating phase. This progressive diagenetic zeolitization is superimposed on a given volcanic pile with an idealized sequence consisting of remnant glassy tuff, a montmorillonite zone, a clinoptiolite zone, an analcite zone, and finally an albite zone (Goodell, 1977). Uranium mineralization occurs within sediments that contain the mobile part of the present ground water system and the attitude of mineralized zones tends to follow a hydrostatic level, not a stratigraphic horizon. The presence of uranium, therefore, is closely related to the distribution of the present aquifer. Strong paleotopographic control is often suggested; this paleotopographic control affects volcanic stratigraphy, ground water diagenesis and uranium mineralization, and associated alteration.

Geochemical Enrichment

Volcanic rocks in general tend to be enriched in uranium compared to their plutonic equivalents: some 1.5 to 2 fold. Volcanic rocks, especially felsic volcanic rocks tend to show higher levels of radioactivity when compared to their plutonic counterparts.

General review of the literature pertaining to volcanogenic uranium mineralization indicates increased levels of molybdenum, mercury, fluorine, selenium and above average amounts of lead, barium, zinc, strontium, titanium, zirconium and phosphorous. Trace element enrichment with regard to antimony, tungsten, lithium, and tin is also indicated.

Considering the genetic importance of H_2S and CO_2, both of these gases would exhibit elevated levels in favorable volcanogenic environments.

Recognition Criteria

1. Zones of anomalous radioactivity within felsic volcanics or related volcano-clastic sediments, especially in association with structural elements or stratigraphic zones related to present or paleowater tables.

2. The presence of silicification and albitization as alteration products accompanied by zeolitization, sericitization, argillization and/or hematization.

3. General trace element enrichment of the following:

   a. Uranium
   b. Molybdenum
   c. Mercury
   d. Fluorine
   e. Selenium
   f. Lead
   g. Barium
   h. Zinc
   i. Strontium
   j. Titanium
   k. Zirconium
   l. Phosphorous
   m. Antimony
   n. Tungsten
   o. Lithium
   p. Tin
   q. Hydrogen Disulphide
   r. Carbon Dioxide

4. Topographic relief and indications of an active paleohydrologic regime. Such past or present ground water regime could be influenced by porosity/permeability of host lithologies and/or structural elements.

GEOCHEMISTRY

GENERAL PRINCIPLES

Stream sediment geochemistry is accepted as one of the principle methods of low-cost reconnaissance exploration in areas of adequate relief where an integrated drainage system has developed (Meyer, Theobald and Bloom, 1979). The composition of stream sediments is a function of the composition of the rocks, sediments and waters making up the upstream catchment area, and if mineral deposits are present in the drainage basin their presence can be detected through systematic sampling and analysis of the sediments. Multi-element analysis enhances the ability of the geochemist to provide a meaningful interpretation of stream sediment survey results, and this approach was adopted in the assessment of the American Flats-Silverton Planning Units.

The unbiased interpretation of areas contaminated by present and past mining activities compared to areas with little or no previous activity presents minor complications. However, many of these complications were overcome in this study by proper definition of parameters in the geostatistical analysis. It should be noted that the geostatistical analysis does not give definitive answers to "economic" mineral deposits, however, this approach gives an indication of "statistically meaningful" potential mineralization. Detailed follow-up work would be required in each area showing mineral potential to address the "economics" of such mineralization.

SAMPLING METHODS

Stream Sediment Samples

Barringer Resources Inc. personnel collected 1195 stream sediment samples from the study area. Samples were collected by trained field crews consisting of one geologist and one assistant. The active portion of the stream was sampled and field sieved to -30 mesh size fraction. The "active portion" of the stream being that sediment which is below the lower water levels of the stream or in the case of dry streams that sediment from the "main" channel developed by the stream. Waterproof paper bags were used for storage and air drying of the samples with sample numbers marked directly on each bag. Sample locations were marked and numbered on U.S. Geological Survey quadrangle topographic sheets in the field. A stream sediment location map was compiled at a scale of 1:50,000 (Plate #1). Field notes taken at each sampling site by the geologist included:

Sample Number
Stream Type (activity, size, gradient)
Sediment Type (size, description, coatings)
pH
Organics (amount, type)
General Comments (contamination, vegetation, etc.)

Transportation within the area was provided by four wheel drive vehicles and by foot. A number of areas required extended back country trips of several days duration to obtain the necessary sample coverage.

Rock Chip and Talus Samples

Personnel of the Bureau of Land Management collected 157 talus and 89 rock chip samples. Following are excerpts pertaining to the talus and rock chip sampling contained in the April 2, 1980 Bureau of Land Management Mineral Report entitled "Preliminary Results, Mineral Resource Inventory" authored by Stephen Johnson.

> "Despite widespread utilization of stream sediment surveys in mountainous terrain, local conditions may adversely affect the probability of discovering mineralization using stream sediment geochemistry. The use of talus fines for reconnaissance has been discussed by Hoffman (1977). He suggested that talus sampling could be considered in areas where more than two samples per m. were to be taken, and in steep terrain where regionally enhanced metal values might mask relatively small mineralized areas. Talus fine sampling does not suffer from the mixing effects that are inherent in stream sediment sampling so that smaller, better defined targets can be located. Due to the reconnaissance nature of the project, only areas which showed extensive hydrothermal alteration and strong color anomalies were sampled. There was no attempt to determine if the metals in the talus samples were of hydromorphic origin.
>
> Composite samples were taken from very shallow trenches dug in the talus slopes at roughly equal distances, approximately every 10 feet, with the entire composite sample encompassing approximately 50 to 300 feet. The samples were taken as close as possible to the base of the talus slopes, however, in most places the base of the slope was composed of large boulders with resultant loss of fines so that the samples were usually taken moderately far up the talus slope. The sample material taken in vegetated areas was found to be composed of mostly forest cover material with very little lithic-derived sediment so that these areas could not be representatively sampled.

Rock chip samples were taken in vein material and in altered rock. Vein material generally consisted of small (less than 250 gram) chip channel samples of vein material, which was usually quartz plus any associated ore minerals. The total sample weight was from 1-2 kilograms. Samples of altered rock were also taken and the technique was similar to the vein samples."

SAMPLE PREPARATION

Stream sediment samples were dried at room temperature for 24 hours then split into three representative samples. One sample split was used for all subsequent analyses and the two remaining splits were held until released by the Bureau of Land Management to the Colorado School of Mines for further investigations. The sample split was sieved to -80 mesh and portions of fine fraction were weighed for the respective analyses. In all cases a .25 gram subsample was analyzed.

Talus samples were sieved to -35 mesh and a .25 gram subsample used for analysis. This coarser sieve size was decided upon by Steve Johnson of the Bureau of Land Management in order to minimize the potential effect of variable organic content. Consequently, analytical results of the stream sediment and talus are not directly comparable.

Rock chip samples collected by the Bureau of Land Management were crushed and pulverized to -200 mesh using alloyed pulverizing plates. Subsamples of .25 grams were analyzed except in the case of Au analysis where a 10 gram subsample was required.

ANALYTICAL METHODS

All stream sediment, talus, and rock chip samples were analyzed for 30 elements; 25 elements by induction coupled argon plasma emission (ICP) and an additional 5 by standard analytical methods specific to each element.

Procedures

The ICP multielement analysis used has detection limits, precision, and accuracy similiar to atomic absorption spectroscopy techniques. The 25 elements monitored by the instrument include Ag, Al, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, Sn, Sr, Ti, V, Zn, Zr, and Th. The samples were digested using an HF - $HClO_4$ acid leach brought to dryness. This was then brought up to volume using .58 normal HCl. Automated samplers aspirated the sample into the argon plasma where the sample was subjected to 2000° F + heat while analyzing the emission spectra from the sample. The emission spectra data was further processed by computer software programs to correct for interfering spectra and calculate the ppm value for the various elements and oxides.

Fluorimetry was used to obtain the uranium values. The sample was digested in a HNO_3 + $HClO_4$ + HF acid solution and taken to dryness. This was then brought up to volume with HNO_3 and the uranium extraction completed using ethyl acetate. An ethyl acetate aliquot was added to a Na_2CO_3 + K_2CO_3 + NaF flux and fused at 650°C for 25 minutes. Upon cooling the values were compared with standards on the fluorimeter.

Arsene generation was the method used to analyze for arsenic. Sample dissolution was completed using a potassium pyrosulfate fusion with a 6 M HCl leach. The mixture was placed in a reaction vessel and 6M HCl, 15% KI, 40% $SnCl_2$ and H_2O was added and left standing for 1/2 hour. Then Ag DDC, brucine, and chloroform was transferred into a second flask. Mossy zinc was then added to the reaction vessel which was immediately corked. The reaction was allowed to continue for 1 hour then read on a spectrophotometer against standards.

Tungsten was analyzed by visual comparison techniques. The samples were weighed into a $NaCO_3$ + NaCl + KNO_3 flux and fused at 800°C in a muffle furnace. Upon cooling the fused mixture was brought to volume with H_2O and an aliquot of the supernate removed. To this aliquot $SnCl_2$, Zn dithiol, and stoddard-ethanol mixture were added. The solution was then compared visually with standards to determine the ppm value of tungsten.

Analysis for molybdenum was carried out by atomic absorption spectroscopy. Here a HNO_3 + $HClO_4$ + HF acid digestion was taken to dryness then brought up to volume with HNO_3. This was then aspirated into a dual beam background corrected atomic absorption spectrograph, using a nitrous oxide flame.

Quality Control

Quality control was maintained throughout the entire procedure using the following guidelines. Every twentieth sample represented a repeat (weighing through analysis) of a previous sample. Every 40 samples analyzed contained one standard (NBS, USGS, Canadian Government, or in-house) and one reagent blank. Standards were checked to ensure that the proper reported range was being attained. Reagent blanks were checked to ensure no reagent contamination had occurred. Repeats were used to minimize the effect of subsampling errors and monitor the precision of analyses. From the results shown by the quality control procedures, precision was well within the ±15% at the 95% confidence level generally accepted for geochemical analysis. All analyzed standards gave results within the accepted value reported by the issuing authority.

DATA HANDLING AND PROCESSING

Data processing for this mineral survey was based on the digitizing of all sample locations, geology, and known mineral activity. Sample site descriptions were numerically coded for magnetic tape storage. Geochemical results were compiled into a large data base from which standard statistics, normalized values, grid averages, contour plots, perspective graphics, and geostatistical processing was undertaken. The geophysical data supplied by the U.S. Geological Survey was not incorporated into any of the geostatistical processing due to lack of uniform/continuous coverage and minor inconsistencies found within this data.

METHODOLOGY

Sample sites were digitized from the U.S. Geological Survey quadrangles used in the field. These digitized sites were later combined with the site descriptions and the geochemical results for further processing. Field descriptions from each sample location were numerically coded so the information could be readily available on magnetic tape (N.T.I.S. report in press). A detailed review of the numeric coding, data file, and translation program (in standard Fortran) can be found in the N.T.I.S. report in press and U.S.G.S. Open File #80-541.

Analytical results from the stream sediment, talus, and rock chip samples were incorporated into a data base from which statistical information was compiled. Mean, standard deviation, range, minimum, maximum, correlation matrix, frequency distribution plots, and cumulative frequency diagrams were constructed for the analytical results within each of the three sample types. Stream sediment statistics can be found in Appendix A. From the data base and the statistical information, data sets containing standard normalized values and average values for grid blocks (1 km^2 areas) were calculated. From these data sets contour maps, perspective maps, and the geostatistical programs were compiled. As previously noted a complete listing of the unprocessed geochemical results may be found in U.S. Geological Survey Open File #80-541.

Published geologic information was compiled on a map base at the scale of 1:50,000 (Plate # 2). Based on this information, 12 major units were distinguished and numerically coded for inclusion in the geostatistical processing. This data set was used mainly in the multiple regression and discriminant analyses. The 12 geologic units chosen are as follows:

CODE #	ROCK TYPE (at surface)
0	Alluvium (and surficial deposits)
1	Andesite
2	Basalt
3	Granite (Precambrian)
4	Granite (Tertiary)
5	Monzonite
6	Metavolcanics & Metasediments (Precambrian)
7	Quartz Latite & Rhyodacite
8	Rhyolite
9	Volcanic Sediments
10	Paleozoic Sediments
11	Undifferentiated Volcanic Rocks (predominately quartz latite & rhyodacite)

A grid having 1 km^2 cells was placed over the geologic map and the four (4) geologic units with the greatest surface expression were assigned to each cell location as well as the relative percentage surface area each unit covers within that grid block. Fracture lengths (total) and directions were also calculated for each cell and combined with the geologic information. Two levels of fracture data were used with directions being given to the nearest 45^o interval.

Several geostatistical approaches were used to aid in the interpretation of this large data base. The various geostatistical packages and their results are explained in a following section dealing specifically with individual statistical analyses.

RESULTS OF CONTOUR AND SYMBOL MAPS

Contour maps for twelve elements selected by the Bureau of Land Management were created. The elements contoured include As, Ba, Be, Co, Cu, Mo, Ni, Pb, U, U/Th ratio, V, and Zn. The maps may be found in Appendix B. Symbol maps for As, U, and Mo (Plate numbers B-13 thru B-15) may also be found in Appendix B. The symbol maps are useful in that they allow an interpretation on a sample by sample basis.

Arsenic (Plate # B-1) tends to concentrate toward the Silverton Caldera. Strong anomalies occur at the Hoff mines in Palmetto Gulch and in Burns, Grouse, and Picayne Gulch's areas. Drainage from the Golden Fleece mine just south of Lake City also contains anomalous arsenic values.

Barium (Plate # B-2) highs tend to be associated with vein type mineralization. There is a regional trend to higher barium values with the change in rock types (volcanics to sediments) to the south. One isolated high occurs at Red Mountain Gulch just west of Lake San Cristobal and may be caused by alteration effects.

Beryllium (Plate # B-3) is stronger in the Lake City Caldera and northeast boundary of the Silverton Caldera. This would seem to relate to the later stage rhyolitic phases. The 25ppm contour outlines the Lake City Caldera extremely well.

Cobalt (Plate # B-4) relates more to lithological changes than to specific mineralized areas. The Denver Hill area, however, does show anomalous cobalt and it is not known at this time if this increase is due to rock units or the mineralization in the area.

Copper (Plate # B-5) has a dramatic regional trend with high levels in the Silverton Caldera and lows with only isolated high values in the Lake City Caldera. Most of the known vein mineralization is reflected in the copper geochemistry. Burns Gulch again appears to be markedly anomalous, as is Cascade Gulch.

Molybdenum (Plate # B-6) reflects low values to the east and higher values toward the western Silverton Caldera. The only striking anomaly is in the Hazelton Mountain area where previous mining activity has occurred. The entire area, however, tends to be regionally anomalous.

Nickel (Plate # B-7) values correlate well with rock lithologies. Handies Peak indicates a change in rock type towards more intermediate mega-breccia type units.

Lead (Plate # B-8) values, as with copper and zinc, are regionally elevated in the Silverton Caldera when compared to the Lake City Caldera and the surrounding areas. Again, good correlation with known mineralization is observed. Regionally speaking, the area of the planning units would be considered anomalous with respect to Pb, Cu, Mo, and Zn.

The association of the Lake City acidic volcanics and uranium (Plate # B-9) are well illustrated here. The western half of the Lake City Caldera forms an anomalous pattern. Houghton Mountain is quite interesting as it not only has high uranium values but also is anomalous in beryllium, lead, copper, cobalt, barium, and has a high uranium/thorium ratio. Uranium mineralization associated with vein deposits in the Woodchuck Basin area is the probable explanation of this grouping of anomalous elements.

The uranium-thorium (Plate # B-10) ratio must be looked at with regard to the airborne geophysics for useful interpretation. The U/Th anomaly at Houghton Mountain correlates well with a beryllium and uranium high and therefore this area deserves further investigation. It is of interest to note that the uranium-thorium ratio determined from geochemical data indicates significant areas within the Lake City Caldera that suggest uranium partitioning with regard to thorium. The uranium-thorium data based on the radiometric survey does not suggest significant uranium-thorium partitioning. This discrepancy is probably best explained by considering the disequilbrium phenomenon so characteristic of younger uranium mineralization.

Vanadium (Plate # B-11), as with nickel, is controlled by the litho-chemistry. The more basic Uncompahgre volcanics to the north and the more intermediate rocks and sediments in the south show elevated background levels as compared to the Lake City acidic volcanics.

Zinc (Plate # B-12) results show the same trends and mineralized areas as do Cu and Pb.

GEOSTATISTICS

The use of geostatistical analysis in the geological sciences has been gaining increased recognition as more applications have been added. Geostatistics has become an essential and effective tool in the understanding and interpretation of geological, geochemical, and geophysical data applied to mineral and energy exploration. Four different geostatistical approaches have been used here to aid in the interpretation for the American Flats-Silverton Planning Units mineral survey. The four analyses included: 1) Factor; 2) Discriminant; 3) Multiple Regression; and 4) Characteristic. Following is a description of each analysis, input parameters and models, and the general results for each.

FACTOR ANALYSIS

Methodology

The handling and interpretation of a large number of geochemical results can become a very time consuming task if all the data are to be considered individually. Factor analysis is an approach whereby many geochemical parameters may be simplified into a substantially lessor number of "factors" that contain the same information as the entire data set. Two types of factor analyses are commonly used. The first is termed R-mode, where the purpose is to determine the inter-relationships between the variables (geochemical results). The second analysis type is called Q-mode, here the correlation and interdependency between the samples is determined.

R-mode factor analysis was used for this study. A "factor" refers to the product derived from the multiplication of a number of weighted variables, in this case the geochemical results. The program then sequentially determines the factor that accounts for the largest variance within the data set. Factor "loadings", the weighting of the variable in that factor, are determined for each variable. Factor loadings are numbers from -1.0 to + 1.0 with +1.0 being a perfect correlation between that variable and the factor, and a -1.0 is a perfect negative correlation. Factor loadings near 0.0 indicate no correlation between the factor and that variable. Factor scores may be determined for each sample once all the factors and the factor loadings have been calculated. The factor scores indicate the relative correspondence of that sample with the factor. These factor scores may then be plotted, contoured, and graphed in similar fashion as the original stream sediment geochemistry results. In this study it was determined that seven factors would essentially contain the same amount of information as the initial 30 elements.

Results

Factor loadings (Table # C-1) and Factor Scores (Table # C-2) for each element by factor can be found with the plotted factor scores for each factor in Appendix C.

Upon inspection, it can be seen that Factor 1 (Plate # C-1) shows an inverse relationship with Zn, Cu, Pb, Ag. Factor scores having values less than -1.0 for this factor would indicate the presence of base and precious metal mineralization or areas contaminated from previous base and precious metal mining.

Factor 2 (Plate # C-2) shows a good positive correlation with Ni, Mg, Cr, P_2O_5 and Ba. This factor would therefore refer to the more mafic rocks within the planning units. This relation is observed when comparing the geologic map (Plate 2) and the plotted factor scores.

Factor 3 (Plate # C-3) is indicative of the uranium-thorium rich areas based on the high factor loadings of Be, U, Th, and K. This suite of elements may be fracture controlled, pegmatite-related, or associated with the acid-intermediate magmatic rocks in the area.

Factor 4 (Plate # C-4) tends to show an alteration pattern or at least a change in rock chemistry to higher Ca, Na, Sr and Ti with a decrease in As and Mo.

Factors 5, 6, and 7 (Plates # C-5 thru C-7) represent lesser amounts of variability within the data and do not show a clear picture as to their correlation with specific rock types, mineralization, or alteration. Factor 5 has very high positive correlation with V, TiO_2, Fe and Sr. Factor 6 shows a high inverse factor loading to Co and B. Factor 7 again not only has high inverse correlation with B but also correlates with Ba, Al, K, and to a lesser extent Na.

DISCRIMINANT ANALYSIS

Methodology

The classification of geological and geochemical data for reconnaissance mapping and mineral exploration has been greatly enhanced by the use of discriminant analysis. This method has the advantage of allowing the investigator use of his a priori knowledge of selected areas to aid in the classification of surrounding areas with limited or no information.
Investigators such as Griffiths (1966), Haynes (1972), Howarth (1971a, 1971b, 1972, 1973), Whitehead and Govett (1974),

Castillo (1973),and Rose (1972), have helped to develop the many applications of this geostatistical method.

The method's approach is based on statistical selection of observed characteristics from a "training set", containing that information required to classify any new sample or sample set of unknown affinity. The exponential form of the polynomial discriminant method of Specht (1967) and further applied by Howarth (1973) has been used here. Areas of specific interest (rock types, mineralization, alteration) are selected to be used as "training sets." The program then sets up decision rules from the data within the training set. Upon setting up the decision rules for all training areas, the program systematically classifies each sample in the entire set. A listing of the sample classifications are printed out as well as a map showing these sample classifications through use of symbols (See Appendix D).

Discriminant Model (Training areas and control parameters)

Eleven (11) major training areas were chosen for classification in the discriminant analysis (Figure 2 and Appendix Figures D-1 thru D-11). Four of the training areas selected were mineralized and demonstrated different characteristics of known ore deposits within the planning units. These areas with their associated characteristics are presented in Table 4, where they are compared on the basis of: 1) fault and other structural trends; 2) lithology; 3) type and age of deposit; 4) type and mineralogy of alteration; 5) ore and gangue mineralogy; 6) metals present and metal ratios. In the case of alteration, the quality of information varies among the areas, and comparison is necessarily subjective.

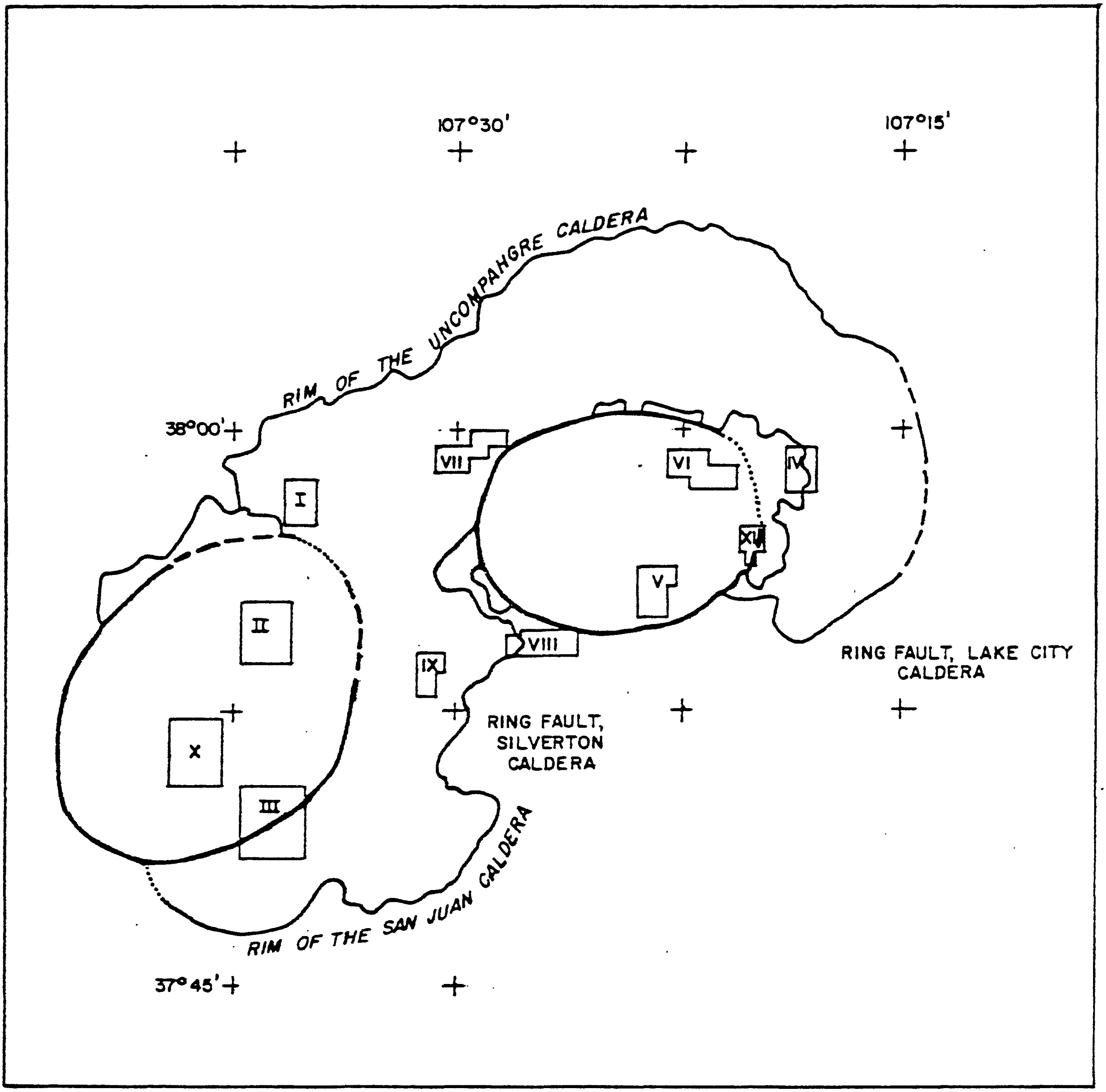


FIGURE 2

SKETCH MAP SHOWING LOCATION OF THE TRAINING AREAS USED IN THE DISCRIMINANT ANALYSES RELATIVE TO THE SILVERTON AND LAKE CITY CALDERAS.

The shallow hydrothermal ore bodies presently exploited in the planning units have been described as fissure veins, replacement and chimney deposits. The preponderance of ore, however, is from veins (Burbank and Luedke, 1968). Because these types of deposits are interrelated by process and location, replacement processes are active in the formation of chimney deposits, and fissure veins often widen into replacement bodies in favorable horizons. Since the training areas are necessarily rather large, a single deposit type in each training area was not practical. Thus Area I shows chimney deposit characteristics best; however, it also contains fissure vein and replacement deposit characteristics. Areas II and IV principally contain vein deposits and Area III is composed of replacement and vein deposits.

Lipman, et al., (1976), present radiometric dates of alteration and ore mineralization which suggest that these processes acted 5 to 15 m.y. after caldera activity. Therefore, ore mineralization seems related to the small acid intrusives rather than the caldera forming events. Lipman's study suggests that ore deposits in Areas I, II and III formed 15 to 17 m.y. ago. Dates of 13.0 to 16.6 m.y. from the Sunnyside Mine in Area II (Casadevall and Ohmoto, 1977) support this interpretation. Area IV containing the Golden Fleece Vein represents an older episode of mineralization related to the Uncompahgre Caldera cycle (Lipman, et al., 1976, p. 578).

Propylitic alteration affects all four test areas. Solfateric alteration affects rocks in Area I and, to a lesser extent, Area IV. Vein related argillic and/or sericitic alteration affects all four test areas, but is most significant in Areas II and III.

TABLE 4

CHARACTERISTICS OF THE FOUR MINERALIZED TRAINING AREAS
USED IN THE DISCRIMINANT ANALYSIS

	Area I	Area II	Area III	Area IV
DISTRICT	Lake Fork	Eureka	South Silverton	Lake Fork (Lake San Cristobal)
METRIC CORNER COORDINATES: (clockwise from NW corner)	272000 X 4208000 275000 X 4208000 275000 X 4204000 272000 X 4204000	269000 X 4201000 273000 X 4201000 273000 X 4197000 269000 X 4197000	270000 X 4190000 275000 X 4190000 275000 X 4185000 270000 X 4185000	297000 X 4209000 300000 X 4209000 300000 X 4204000 297000 X 4204000
PRINCIPAL MINE(S) IN TEST AREA: Ransome, 1901 Kelly, 1946 Irving & Bancroft, 1911	Frank Hough M. Palmetto M.	Sunnyside M.	Pride of the West M. Osceola M. Green Mountain M. March Cross Cut M.	Golden Fleece M.
FAULT TRENDS AT SURFACE: Lipman, 1976 Luedke & Burbank, 1975, a,b,& c. A.G. Varnes, 1963	NE Steep Angle	a) NE Steep Angle b) W to WNW Steep Angle	a) NW Steep Angle b) ENE Steep Angle	Not prominant: 1 fault trends ENE. Steep angle slump of differential compaction features in Grassy Mountain quartz latite
OTHER STRUCTURAL TRENDS:	Palmetto M. Vein N23E75SE	Upper Portion Sunnyside Vein: N50E65-70SE irregular.	Pride of the West Vein: N50 to 70W N32W 80SW Ransome, 1931	Angular unconformity between Burns member and Grassy Mountain quartz latite
GROSS LITHOLOGY:	Intermediate to acid volcanic and volcaniclastics	Rhyolite & other volcanics, small acid intrusives	Precambrian gneiss & schist, acid ash flow tuffs, acid & intermediate volcanics, acid plugs and dikes.	Andesite & quartz latite volcanic & volcaniclastic rocks.
DEPOSIT TYPE: Burbank & Luedke, 1961, 1968, 1969 Casadevall & Ohmoto 1977. Varnes, 1963	Replacement/ fissure veins/ chimney.	Fissure veins	Replacement/ fissure veins	Fissure vein
AGE OF DEPOSIT:	15 - 17 mya inferred from Lipman, et al, 1976	13.0 - 16.6 mya Casadevall & Ohmoto 1977	15 - 17 mya inferred from Lipman, et al, 1976	17 mya inferred from Lipman, et al, 1976
ALTERATION TYPE: Lipman, et al, 1976 Varnes, 1963 Burbank & Luedke, 1969 Ransome, 1901 Casadevall & Ohmoto, 1977	a) Regional propylitic b) Solfateric	a) Regional propylitization b) "Vein related" alteration	a) Regional propylitic*	a) Regional Propylitic* b) Solfateric (suggested by Lipman, 1976.)
ORE MINERALS:	chalcocite, chalcopyrite, tetrahedrite.	sphalerite, galena, chalcopyrite, tetrahedrite, gold, petzite,	galena, tetrahedrite, wire silver, pyrite, chalcopyrite	gold, petzite, tetrahedrite, galena, hinsdalite, pyrargite
MINOR VEIN MINERALS:	galena, hessite	hematite, alabandite, huebnerite, tephroite. friedelite, helvite, anhydrite, sericite aikinite, bornite, barite, gypsum, molybdenite.	wire silver	petzite, hinsdalite, pyrargite
GANGUE MINERALS:	pyrite, quartz, spalerite	quartz, pyroxmangite, pyrite, rhodochrosite, fluorite, calcite rhodonite	quartz	gray & white quartz rhodochrosite
ALTERATION MINERALS:	a) quartz, calcite, chlorite, epidote b) quartz, kaolinite, diaspore, pyrite, sericite, alunite(?)*	a) epidote, chlorite, calcite, sericite, zunyite, pyrite.	a) quartz*, calcite, chlorite, epidote*.	a) quartz*, calcite, chlorite, epidote, diaspore, pyrite, sericite, alunite.
METALS PRODUCED:	copper, gold, silver, lead Ransome, 1901 Kelly, 1946 Irving & Bancroft, 1911	gold, silver, lead, zinc, copper, cadmium Casadevall & Ohmoto, 1977	gold, silver, copper, zinc Varnes, 1963 Ransome, 1901	gold, silver Burbank & Luedke, 1969 Ransome, 1901 Irving & Bancroft, 1911
Au/Ag RATIO:	0.00431 Hough M. 0.00586 0.00167 hand cobbed ore 0.00109 from nearby mines Ransome, 1911	0.03792 Sunnyside M. Casadevall & Ohmoto, 1977	0.01933 Pride of the West 0.05 Osceola Varnes, 1963	0.03175 Irving & Bancroft, 1911
Cu/Zn/Pb RATIO:	Cu/Pb = 6.937 Hough M. sphalerite present, but Zn not recovered. Ransome, 1911	0.08995/1.39296/1.00000 Casadevall & Ohmoto, 1977	0.3491/0.11764/1.00000 Varnes, 1963	

*Undocumented Observation

With the exception of surficial deposits and limited Precambrian exposures, the rocks of the study area are volcanic, volcanoclastic, or hypabyssal intrusive in nature. These rocks can be related to the history of caldera formation in the San Juan volcanic field.

Seven lithologic training areas were also selected for use in discriminant analysis. Table 5 presents the location, lithologic unit, and characteristics of these areas. Within the limits imposed by existing geologic mapping, the seven areas were selected to be relatively unaltered, unmineralized examples of the major lithologic and stratigraphic units.

The test areas have been selected to be somewhat evenly distributed as well as representative of lithologic and mineralization types. The areas are shown in Figure 1 relative to the principle caldera structures.

Samples not having sufficient similarity to these training areas based on the calculated decision rules, are placed into an "unknown" class. This unknown class may represent contamination, unrepresented mineralization, or an unusual lithology. Approximately 10% of the samples were placed into this unknown class for this set of data.

Thirty (30) geochemical parameters were considered in making the decision rules. The data was not log-transformed prior to running the discriminant analysis. There are occasions, however, when log transformation may increase the accuracy of the results.

A smoothing parameter of 10 was used in this analysis. This smoothing parameter allows the estimation of the empirical density factor for each variable in each class. The proper

TABLE 5

CHARACTERISTICS OF THE SEVEN LITHOLOGIC TRAINING AREAS USED IN THE DISCRIMINANT ANALYSIS

AREA	V	VI	VII	VIII	IX	X	XI
CORNER COORDINATES	288500 4202500 291000 4202500 292000 4202500 292000 4201000 291000 4201000 291000 4198500 288500 4198500	290000 4207000 291000 4207000 292000 4207000 292000 4206500 293000 4206500 293000 4205000 292000 4205000 291000 4205000 291000 4206000 290000 4205000	278000 4206000 280000 4206000 280000 4206500 281000 4206500 281500 4206500 281500 4206000 281000 4206000 281000 4205000 280000 4205000 280000 4204500 278000 4204500	282000 4197000 283000 4197000 283000 4198000 287000 4198000 287000 4196000 283000 4196000 282000 4196000	278000 4197000 279500 4197000 280000 4197000 280000 4196000 279500 4196000 279500 4194000 278000 4194000	265500 4195000 269000 4195000 269000 4190000 265500 4190000	294000 4203500 295500 4203500 295500 4201500 294800 4201500 294800 4200600 294300 4200600 294300 4201500 294000 4201500
UNIT	Sunshine Peak Tuff. Ash flow member.	Sunshine Peak Tuff. Megabreccia member.	Sapinero Mesa Tuff. Eureka Rhyolite Member.	Cataract Canyon Granite. (Precambrain Y)	Silverton volcanics. Aphanitic andesite member.	Younger volcanics (includes rocks of the Burns & Henson members, & the Sapinero Mesa Tuff).	Grassy Mountain quartz latite.
LITHOLOGY	Silicic alkalic rhyolitic tuff containing 20-30% phenocrysts of quartz, sanadine, & biotite, light tan to dark gray, 50 m to 1000 m thick. Extensively propropylitic alteration.	Chaotic large masses of pre Lake City caldera rock, primarily intermediate lavas, & ash flow tuffs, blocks up to 100 m long. Matrix is Sunshine Peak ash flow material.	welded red-brown tuff containing 5-10% phenocrysts of plagioclase, sanadine, & biotite. Lower part is extremely propylitized. Unit is up to 800 m thick. This unit is intracaldera only.	Massive, coarse grained, pink, two feldspar granite. Locally weak foliation.	Dense, dark gray aphanitic andesite. Occurs in flows up to 100 m thick. Interfingers with rocks of the Burns Member.	Lava flows, flow breccias, welded ash flow tuffs	Single, unaltered flow sheet up to 250 m thick, light gray porphyritic quartz latite containing about 30% phenocrysts of feldspar, biotite & augite. K/Ar age of 22.8 m.y.
STRUCTURES	Two NE trending faults.	None mapped.	NE trending faults.	WNW trending mafic dikes.	N & NW trending faults.	NE & NW trending faults.	Curved slump & compaction features.
REFERENCE	Lipman,1976	Lipman, 1976	Lipman, 1976	Lipman, 1976	Lipman, 1976	Luedke & Burbank 1975	Lipman, 1976

selection of the smoothing parameter allows classification of samples without interference from background geochemical noise and yet misclassification of samples belonging to a specific training set does not occur.

Appendix D contains a listing of sample classification and their relative probabilities (Table D-1), along with a map (Plate # D-1) showing the classifications.

Results

The results of the discriminant analysis are consistent in terms of the training areas. This suggests that the training areas selected are unique and geochemically different. Only one of the training samples was reclassified by the decision process which is quite reasonable for this type of survey. A map showing the classifications using symbols and a listing of the data with probability charts may be found in Appendix D.

Training areas I, II, and III showed excellent results while the fourth mineralized training area (IV) was less discrete than intended. The broad classification of area IV is the reason for the Ute Mine's inclusion in the apparent association with the Golden Fleece Mine even though the Ute Mine mineralogy is probably more closely related to the other three mineralized training sets. Areas outside the training area, with similar geochemical characteristics, having four or more samples are found in Table 6.

TABLE 6

Areas Showing Favorable Results from Discriminant Analysis for Known Mineralization

Area	Number of Anomalous Samples
Cement Creek (Henrietta to Minnesota Gulch's)	12
North of Dome and Tower Mountains	8
Picayne Gulch	4
Cinnamon Pass	6
Redcloud Gulch (Lower part)	4
Whitecross Mtn (2 miles west)	4
Burrows Park (east of Edith Mtn.)	13
Capital City	10

Four of the training sets for lithologies were very successful. These include areas VII, X, XI, and especially IX. Areas V and VI proved to be very similar and therefore when interpreting the data they should be looked at as one unit. Lithologic unit VII did not yield clear results.

Those samples that did not fit into the selected training areas based on their geochemical character, were placed into a twelveth "unknown" classification. These most likely relate to untested lithologic units or, in most cases, to areas contaminated by previous and present mining activity. The "unknown" samples should however be evaluated individually as there is the potential for untested types of mineralization and /or varied geochemical response to the known mineralization. Downstream displacement of the "unknown" samples from the anomalous source should be taken into account when investigating the reason why samples were not classified.

MULTIPLE REGRESSION ANALYSIS

Methodology

Various aspects of multiple regression analysis have been used in the past to forecast the mineral potential of exploration areas (Cruzat and Meyer, 1974; Allais, 1957; and DeGeoffrey and Wignall, 1970). Methods that have been developed for the design of forecasting models have been based on the distribution of known mineral wealth, or on more advanced models that include multivariate data incorporating geology and geochemistry. This latter approach was applied in the development of a model for forecasting the distribution of mineral prospects in the American Flats-Silverton survey area.

The weighted number of known prospects, workings and mines per square kilometer was used as a measure of the past mineral exploration and mining activity in the survey area. This data base was derived by digitizing the locations of prospects, workings and mines marked on the 1:24,000 topographic maps of the area and applying a progressive weighting of 1, 4 or 16 depending on the assigned category. The sum of these values was then considered to be an index of historical mineral exploitation activity in the cell.

Stepwise multiple regression was then used to compare the mineral exploitation index (dependent variable) with a series of structural, lithological and geochemical parameters (independent variables) and to develop a forecasting model to predict potential for exploration in cells not having a past history of mineral exploitation. For this study, twelve (12) lithological units, four (4) structural parameters, and seven (7) geochemical factor scores, obtained in the factor analysis, were used as the independent variables. The twenty one independent variables are listed in Table 7.

TABLE 7

Independent Variables used in Defining Multiple Regression Equation.

Code	Variable
RT0	Alluvial and surficial deposits
RT1	Andesite
RT2	Basalt
RT3	Granite (Precambrian)
RT4	Granite (Tertiary)
RT5	Monzonite
RT6	Metavolcanics and Metasediments (Precambrian)
RT7	Quartz latite and Rhyodacite
RT8	Rhyolite
RT9	Volcanic sediments
FD1	North-south fractures
FD2	Northeast-southwest fractures
FD3	East-West fractures
FD4	Northwest-southeast fractures
FS1	Geochemical Factor 1:Neg. Zn, Cu, Pb, Ag
FS2	Geochemical Factor 2:Mg, Ni, Cr
FS3	Geochemical Factor 3:Be, Th, U, K
FS4	Geochemical Factor 4:Ca, Na, Sr; (Neg. As, Mo)
FS5	Geochemical Factor 5:V, Ti, Fe, Sr
FS6	Geochemical Factor 6:Neg. Cd, B, Ni
FS7	Geochemical Factor 7:Neg. Al, K, B

Results

Coefficients (Table E-1) for the independent variables in the multiple regression equation defining the forecasting model can be found in Appendix E along with a list of predictions, and potential residuals (Table E-2) for each cell. The independent variables having the greatest influence in forecasting the dependent variable were FD4, the total length of northwest-southeast fractures mapped in the cell; RT6, the area within the cell underlain by Precambrian metavolcanics and metasediments; RT10, Paleozoic sediments; FD2, northeast-southwest fracture length; FS4, factor scores for Factor # 4 (Ca, Na, Sr and Ti, negative As and Mo); FS1, Factor # 1 (negative Zn, Cu, Pb and Ag).

Symbol maps of the predicted mineral exploitation index (Plate # E-1) and the residuals (Plate # E-2) indicating areas of potential exploration interest are shown in Appendix E. The concentration of past mining activity toward the vein-type deposits of the Silverton Caldera creates a bias in the model towards forecasting areas most favorable for vein-type mineralization.

CHARACTERISTIC ANALYSIS

Methodology

All exploration geologists make use of conceptual models in their search for mineralization, but as the data become more complex, assimilation of multi-parameter models becomes more and more difficult. Geochemical associations that represent or are characteristic of certain types of mineralization are well known and have been described in the literature (Boyle, 1974). Examples of metal associations that can be used to form the basis for a conceptual model are:

Sn Skarn Deposits: Sn, W, B, F, Mo, Fe, Zn
U Sandstone Deposits: U, V, Se, Mo
Ni Sulphides: Ni, Co, Fe, Cu, Pt metals

Ratios can add substantially to the development of a geochemical model. For example, a high value for Cu/Ni could be a favorable indicator of sulphide mineralization in a mafic environment.

Barringer Resources Fortran program CONCEPT was developed on the assumption that the exploration geologist would be presented with a set of analyses for 30 or more elements on a series of samples covering a specified map area. Assuming the geologist has an a priori concept of the type of mineralization to be found in the area, or would like to attempt a speculative search for a particular type of mineralization, the program will request an interactive response from the operator to enter the set of elements and ratios considered to be crucial to the model. The program then searches the entire data set and compares the characteristics of each cell within the map area with the characteristics of the conceptual model. The model is based not only on the presence of the selected elements, but each element is given a weight by the geologist as to its significance in the model. This is achieved by entering probabilities from 0 to 1.0 for each element, representing the likelihood of anomalous occurrence for each variable in the zone of mineralization. The CONCEPT program will in a single pass examine up to ten (10) different element variables and five (5) ratios formed from selected variables.

Algorithm

Characteristic analysis makes use of Boolean algebra to develop the geochemical model and determine the degree of association between 'unknown' cells and the conceptual model. Boolean representation refers to the designation of items of positive interest as "1's" and items of undefined interest as "0's". In order to develop the conceptual model an array of ten (10) cells by n variables is developed from the probabilities entered into the program. When the degree of common occurrence for each variable with other variables is tabulated in an array, this array represents the product matrix obtained by multiplying the original binary matrix by its transpose. Each row of the product matrix represents the degree of common occurrence between each variable and the other variables. Considering the rows of the product matrix as vectors, the length of each vector is equal to the square root of the sum of the squares of the components. If these vectors are regarded as being at right angles to each other in n dimensional space where n equals the number of variables, the vector which maximizes the projections of the variable vectors is the eigenvector associated with the largest characteristic root of the product matrix. Its length is arbitarily set to one and the coefficients of the eigenvector define the weights of each variable selected for the model.

Computation of the eigenvector is achieved using a method described by Cooley and Lohnes (1962). The eigenvector is arrived at after a series of iterations which give smaller and smaller changes in the coefficients of the eigenvector. The change is measured as the sum of the absolute differences between the coefficients of the eigenvector obtained by successive approximations. CONCEPT prints out the sums of the differences and the final eigenvector. Further details on the method of characteristic analysis can be found in Botbol (1971), and Botbol, et. al (1977).

Evaluation of Regional Cells

The favorability for each variable in cells within the map area is established by determining whether the variable is enriched in the cell with respect to a "picture frame" of surrounding cells. In this arrangement the central cell is compared with 16 cells making up the annulus of surrounding cells of the "picture frame," one cell removed from the central cell. The program sorts all the analytical results into appropriate cells based on their coordinates and determines the sum of all the values and the number of samples per cell. Means for each cell are calculated and tested against the mean and standard deviation of the means of the annulus cells. This results in a score for the central cell which is represented as the difference between the mean of the central cell and the mean of the annulus cells, divided by the standard deviation of the annulus cell means. If the central cell has a score of one or more for a particular element or ratio, the cell is assigned a role of one for the variable, while a score of less than one results in the binary notation of zero. The result is a vector consisting of the binary representation of the favorability of each variable in the cell. Cell size is dependent on the area to be covered, the size of the map and the density of sampling.

Computation of the degree of association between the model and the cells in the map area is achieved by multiplying the binary vector for the cell by the eigenvector of the model. The resultant values are written to a file which can then be used for plotting or contouring of the data.

Development of Characteristic Geochemical Models

Geochemical characteristics for porphyry, vein and uranium sandstone-type mineralization were defined and tested on a 1 km^2 grid of cells covering the American Flats-Silverton survey area. Elements and ratios used in defining the models, and the probabilities assigned to each variable, are shown in Table 8.

TABLE 8

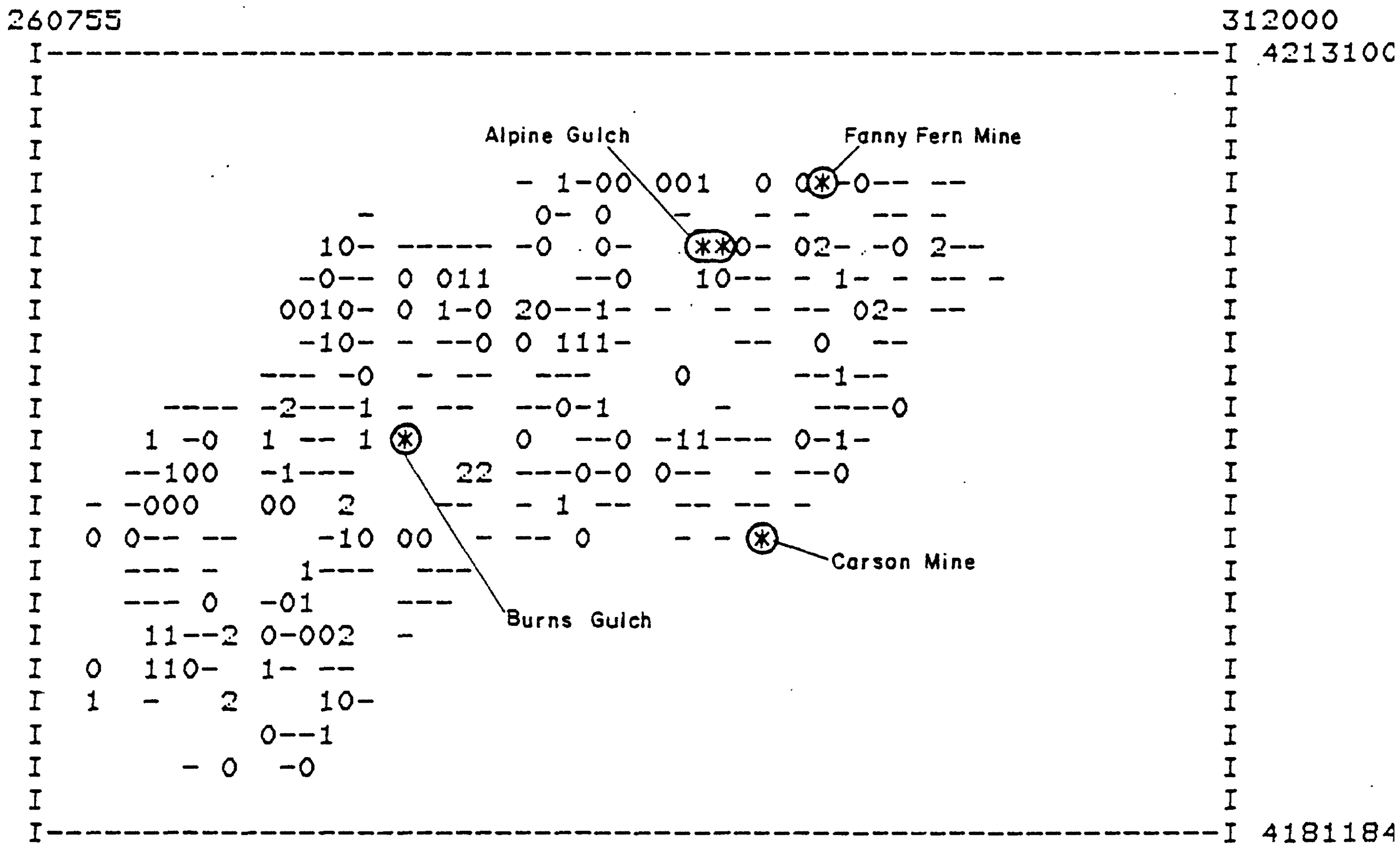
Variables and Probabilities used to Define the Geochemical Models for the Characteristic Analysis

Porphyry		Vein		Uranium-Volcanics	
Ca	0.1	Ag	0.8	Ba	0.5
Cu	0.9	Ba	0.5	K	0.7
K	0.7	Cu	0.7	P	0.5
Na	0.1	Mn	0.5	Th	0.2
Pb	0.5	Pb	0.8	Mo	0.6
Zn	0.5	Zn	0.9	U	1.0
Mo	1.0	As	0.4	U/Th	0.8
Na/Ca	0.8				

Results

Porphyry Model: A test of the porphyry model shows that the greatest degree of association with the conceptual model was found to be restricted to four areas of the planning unit. These areas are (1) Alpine Gulch; (2) Burns Gulch; (3) Carson Mine; and (4) Fanny Fera Mine. The locations of these areas are shown in Figure 3, and on the symbol map (Plate # F-1) in Appendix F.

DATA GENERATED FOR 370 CELLS
CELL SCORES MEAN= .330 SD= .438
BLM TEST OF CHARACTERISTIC ANALYSIS
SYMBOLIC MAP OF ASSOCIATION WITH CONCEPTUAL MODEL



LEGEND

SYMBOL FOR CELL SCORES AS FOLLOWS:
-= CELL SCORE BELOW AVERAGE FOR MODEL
0= SCORE BETWEEN 0 AND .99 SD
1= SCORE BETWEEN 1 AND 1.99 SD
2= SCORE BETWEEN 2 AND 2.99 SD
STAR=SCORE GREATER THAN 3 SD ABOVE MEAN

APPROXIMATE SCALE IS 1: 336220

FIGURE 3

RESULTS OF CHARACTERISTIC ANALYSIS - PORPHYRY MODEL

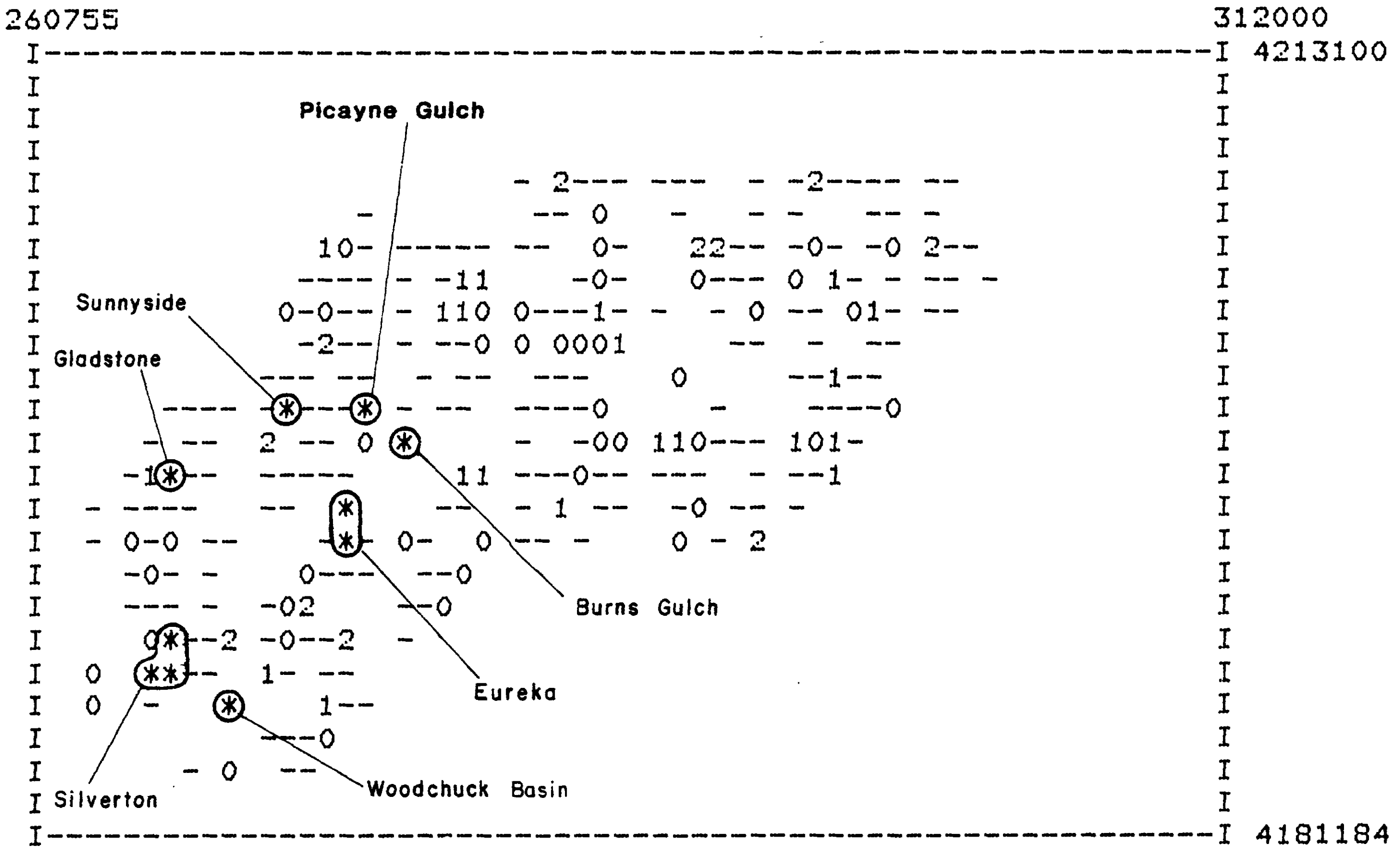
Vein Model: The vein mining districts of the Silverton Caldera were outlined clearly by the characteristic analysis based on a vein-model. The highlighted areas are: (1) Sunnyside; (2) Picayne Gulch; (3) Burns Gulch; (4) Gladstone; (5) Eureka; (6) Silverton; and (7) Woodchuck Basin. These areas are shown in Figure 4 and can also be found on the symbol map (Plate # F-2)in Appendix F, at a scale of 1:50,000.

Volcanic-Uranium Model: Three areas were selected as having a strong association with the characteristic suite of uranium-volcanic variables. These are (1) Middle Fork Alpine Gulch; (2) North Star Mine; and (3) the northwest slope of King Solomon's Mountain. Figure 5 shows the locations of these areas, which can also be found on the map (Plate # F-3) in Appendix F.

Discussion

The characteristic analysis method appears to have effectively outlined known vein areas, but investigation of the porphyry and uranium-volcanic targets should proceed with caution. The fact that a matching geochemical "fingerprint" exists in a particular area should only be taken as a lead, which may be so subtle that it might be difficult to confirm the presence of the geochemical signature using normal ground investigations. It should also be noted that the suite of elements used in the vein model could also highlight areas of contamination from off-site mills and town sites.

DATA GENERATED FOR 370 CELLS
CELL SCORES MEAN= .368 SD= .551
BLM TEST OF CHARACTERISTIC ANALYSIS
SYMBOLIC MAP OF ASSOCIATION WITH CONCEPTUAL MODEL



LEGEND

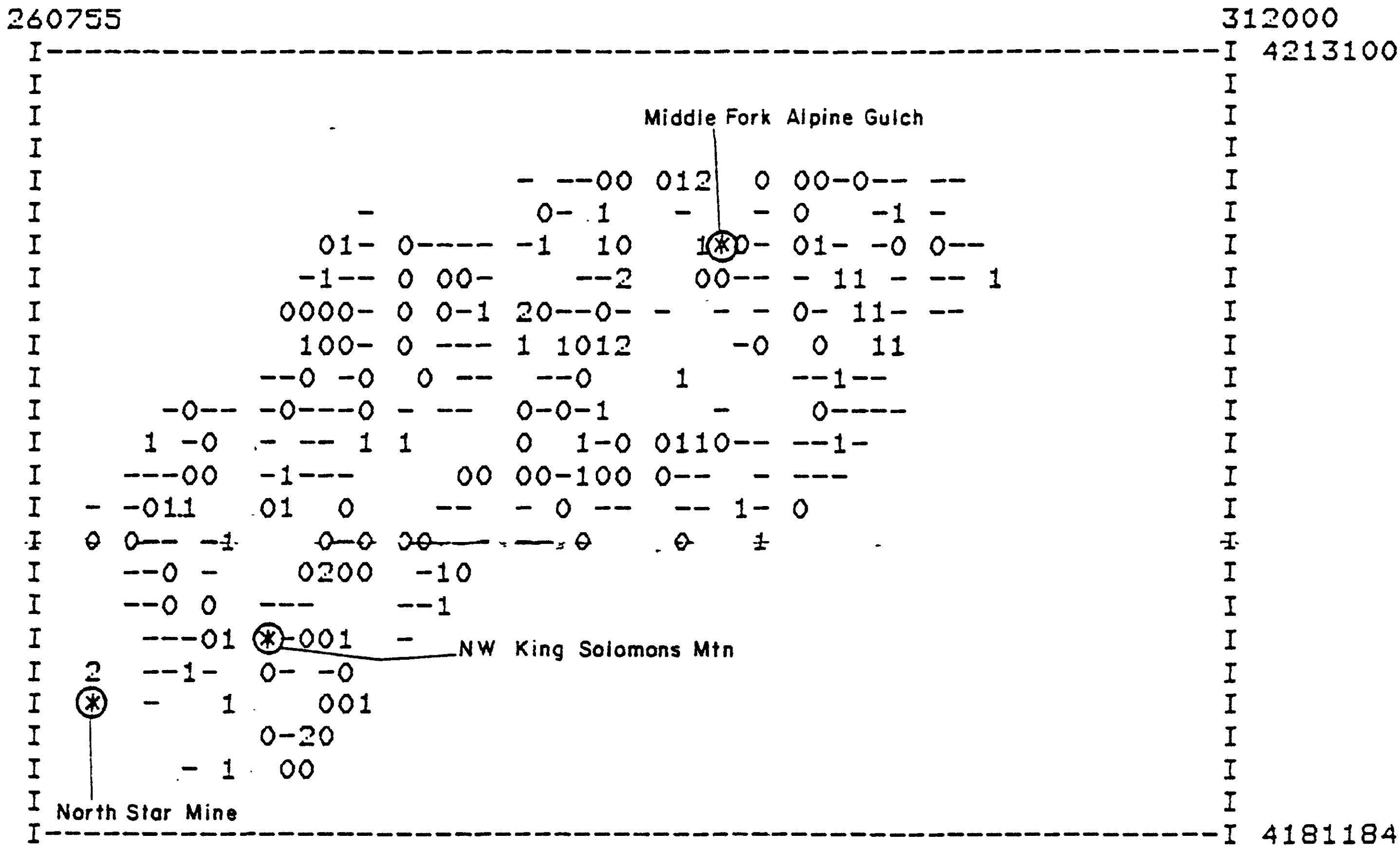
SYMBOL FOR CELL SCORES AS FOLLOWS:
-= CELL SCORE BELOW AVERAGE FOR MODEL
0= SCORE BETWEEN 0 AND .99 SD
1= SCORE BETWEEN 1 AND 1.99 SD
2= SCORE BETWEEN 2 AND 2.99 SD
STAR=SCORE GREATER THAN 3 SD ABOVE MEAN

APPROXIMATE SCALE IS 1: 336220

FIGURE 4

RESULTS OF CHARACTERISTIC ANALYSIS - VEIN MODEL

DATA GENERATED FOR 370 CELLS
CELL SCORES MEAN= .348 SD= .361
BLM TEST OF CHARACTERISTIC ANALYSIS
SYMBOLIC MAP OF ASSOCIATION WITH CONCEPTUAL MODEL



LEGEND

SYMBOL FOR CELL SCORES AS FOLLOWS:
-= CELL SCORE BELOW AVERAGE FOR MODEL
0= SCORE BETWEEN 0 AND .99 SD
1= SCORE BETWEEN 1 AND 1.99 SD
2= SCORE BETWEEN 2 AND 2.99 SD
STAR=SCORE GREATER THAN 3 SD ABOVE MEAN

APPROXIMATE SCALE IS 1: 336220

FIGURE 5

RESULTS OF CHARACTERISTIC ANALYSIS - URANIUM VOLCANIC MODEL

DISCUSSION

1. Due to the nature of stream sediment sampling, geochemical anomalies are displaced downstream from the metal's source and no attempt has been made in this study to project the geochemical values to the center of the drainage basin covered by the sample. The factor, characteristic, and multiple regression analyses were not adversely affected by this as each used grid cell and picture frame averages thereby increasing the size of area influenced by a sample. However, when interpreting individual discriminant analysis results or geochemical values, projection upstream may be required to fully understand the results.

2. Due to the large area having present and past mining activity, contamination influenced the contouring and interpretation of the geochemical results. The Animas River sediments where Silver values are extremely high are the most obviously affected area. The result of this is a regional bias from one area to the next. Using a geostatistical approach as in this study most of this contamination bias was effectively filtered out. The moving "picture frame" window allows a sample or area to be evaluated in comparison with samples in close proximity, therefore, a relatively weak anomaly may still be high-lighted within the areas containing lower regional values. For this reason, single element regional threshold values were not applied in defining anomalous samples. Obviously care should be taken when evaluating any of the raw values or the means and standard deviations determined on the entire data set.

3. The results shown by the geochemical survey and the subsequent geostatistical analysis relate closely to the known regional geology and mineralogy. The lithologic "training" sets used in the discriminant analysis showed the effectiveness of this approach to geochemical mapping of major rock units in large areas of little or no geologic data if at least some portion of the area has geologic control. Most of the major rock units in this area proved to be geochemically unique on a gross basis and future work may want to include soil sampling with multielement geochemical analysis with similar "finger printing" being used to help better define rock units acting as hosts to mineralization.

4. Dominating the previous mining activity within the planning units is the vein or vein-related precious and base metal mineralization. Because of the extensive activity related to these types of mineralization, the discriminant and multiple regression analyses are heavily weighted towards this mineralization. The models used throughout the statistical analysis are necessarily general due to the diversity of host rocks and mineralogy of the known deposits. Therefore, the Ute Mine was classified as being similar to the Golden Fleece when it may actually be more closely related to the Sunnyside type deposit. It is beyond the scope of a regional study such as this however, to differentiate between the individual vein systems found in the area. This study does show the value of the geochemical-geostatistical approach used to highlight and select areas where more detailed investigations should begin. The approaches used here rely on surface data and no attempt has been made to characterize the geochemical expressions and zonation that could be found associated with the vein related deposits which may exist at moderate

to considerable depth within the planning unit. No significant difference in the sediment geochemistry was seen as a function of vein directions which are primarily along northeast-southwest or northwest-southeast trends.

5. The possibilities of a mineralized porphyry system (large scale, low grade) in the study area was addressed. To date there is no known deposit present, however, similarities may be made with known deposits outside this study area. Crested Butte, also contained within the San Juan Volcanic Province, features a mineralized porphyry system. If a system exists in the area it would probably be found at depth since the presently exposed rocks are still high in the section of a volcanic pile. The pervasive propolytic alteration seen in the study area may imply the possible depth of such a system. Based on a literature review of associated characteristics of porphyry systems, models were chosen for the geostatistical analysis. Characteristic analysis was the only method used to define the most likely areas for future investigations toward porphyry mineralization. The method used alteration and mineralization changes in the geochemistry to interpret the statistically best areas of interest. Because many of the vein deposits reflect similar geochemistry as our projected models, areas of known vein mineralization associated with the calderas gave positive results in the porphyry statistical analysis in addition to areas defined by low-order geochemical patterns. Again, due to the regional nature of this study a critical assessment of the existence of a porphyry system may not be made. A more detailed program addressing the geology and geochemistry of selected areas would be necessary. This program does suggest that future work of a detailed nature is warranted and indicates those areas where work may yield the most information.

Alteration studies would be of primary concern with the emphasis on determination of origin (i.e., porphyry, vein emplacement, or regional association with volcanic environment).

6. Historically, uranium has received little attention, but currently industry activity is being seen. Modeling of potential mineralization has been developed with regard to uranium in the volcanic environment and considers the relation to the associated sediments within the calderas. Due to the high mobility of uranium, regional data may not be easily interpreted. The characteristic analysis results are generally valuable in that areas where more detailed work would be required have been emphasized.

   The present model relies heavily on elements such as K and Ba which may not necessarily be unique to uranium and may reflect alteration or lithological changes. The contoured uranium geochemical values correlate best with present exploration activity while the airborne geophysics due to its questionable quality does not allow quantitative comparison with the geochemistry. The element Be generally correlates statistically with the uranium and favorable lithologic units. The best pathfinder for uranium seems to be uranium itself. Better knowledge of the area would be necessary for modeling the unique parameters required to adequately delineate potential mineralized areas. Fluorine would be an element that may help in future work. Addressing possible geologic controls specific to this area would be essential to further refinement of the mineral potential for uranium.

7. Airborne geophysical data supplied by the Bureau of Land Management consisted of spectrometric data, magnetic data,

and electromagnetic/resistivity data (DIGHEM^{II} data). This data was reviewed in context with the geochemical data but inconsistencies in coverage and scale prevented total integration of the two data packages for geostatistical processing.

The airborne magnetic data provides a strong reflection of lithology. Magnetic lows appear to coincide with areas of extensive feldspar destructive alteration. There is a suggestion of a NE-SW element characterized by a line of irregular highs in the northwestern corner of the survey area. This feature could either be a tectonic/structural element or a bounding feature related to the Lake City Caldera. A similar linear element is suggested from the airborne spectrometric (equivalent uranium contour map) data.

The airborne spectrometric data consists of two contour maps; one showing the distribution of equivalent uranium in ppm eU and the other showing the ratio of equivalent uranium to equivalent thorium in ppm eU/ppm eTh. The equivalent uranium contour map shows a good correlation with the geochemical contour map of uranium. These data serve to highlight the lithologic units of the Lake City Caldera as potential hosts for anomalous uranium mineralization. This conclusion is supported by the geochemical data.

The equivalent uranium-equivalent thorium ratio contour map reflects in a general sense, the lithologic distribution of the area. It is of interest to note that the ratio map does not highlight the Lake City Caldera lithologies as potential hosts for uranium.

8. Review of the total uranium data, both geochemical and geophysical , provides an interesting insight into the behavior of uranium within the geochemical environment. The airborne spectrometric work within the Lake City Caldera served to highlight the inter caldera volcaniclastic rocks as a potential uranium host based upon the contouring of the equivalent uranium data. The airborne data relating to the ratioing of equivalent uranium and equivalent thorium failed however, to delineate this area as anomalous in any way. Viewing the airborne data the only conclusions to be drawn would be that uranium was in the geologic/geochemical system but effective uranium-thorium partitioning was not apparent. Such a combination of radiometric signatures might be expected from a magmatic environment and therefore interest from an economic point of view might be less than enthusiastic.

   In contrast, the geochemical data provides a different interpretation. The contoured uranium data highlights an area identical with that highlighted by the radiometric data. In addition, the geochemical data relating to the uranium-thorium ratio also highlights the Lake City Caldera area as an area of potential uranium-thorium partitioning and uranium concentration. The economic consequences of this data are significantly different than those based entirely on the radiometric data.

   The resolution of this apparent discrepency in interpretation probably involves consideration of the disequilibrium phenomenon characteristic of uranium particularly uranium in young sedimentary environments.

9. The planning units have seen extensive mining activity in the past. Based on this there is no reason to believe that this interest will not continue. With the general increase

in metal prices and the desire for less foreign dependency on metals, industry will continue to redefine the economic and political factors where areas now possibly considered marginal, become economically viable for exploration and possible mineral production. Commodities found in the study area that may now or in the future be of value might include barite, fluorspar, Ag-Au, Cu-Pb, Zn, Mo and U.

10. The present study shows the effectiveness of the geochemical-geological-geostatistical approach to the mineral potential assessment of large areas. This method allows the incorporation of large amounts of data to be used in more specific interpretations. The various geostatistical analyses effectively allow the investigator to define and model known and unknown mineralization that can be assessed within the study. These packages also allow areas to be specified which would require futher work to interpret completely. The statistical packages are most effective when good quality quantitative data is used as opposed to the use of semi-quantitative or qualitative data.

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Geochemical and Geostatistical Evaluation of American Flats-Silverton Planning Units, San Juan Volcanic Province, Colorado

by

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With an introduction by William D. Heran

U.S. Geological Survey

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VOLUME II

Appendix A

Stream Sediment Statistics

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

VARIABLE	MEAN	SD	MIN	MAX	RANGE	NO.SA
AG	.719E+01	.758E+01	.100E+01	.960E+02	.950E+02	1191
ALO	.138E+02	.213E+01	.800E+00	.216E+02	.208E+02	1192
BA	.144E+04	.444E+03	.490E+02	.365E+04	.360E+04	1192
BE	.255E+01	.162E+01	.100E+00	.171E+02	.170E+02	1192
B	.139E+04	.532E+03	.140E+02	.492E+04	.490E+04	1192
CAO	.129E+01	.971E+00	.800E-01	.801E+01	.793E+01	1192
CD	.745E+01	.395E+01	.700E+01	.830E+02	.760E+02	1192
CO	.231E+02	.155E+02	.200E+01	.247E+03	.245E+03	1192
CR	.255E+02	.165E+02	.800E+00	.156E+03	.156E+03	1192
CU	.156E+03	.492E+03	.100E+01	.113E+05	.113E+05	1192
FEO	.764E+01	.329E+01	.800E+00	.374E+02	.366E+02	1192
K2O	.306E+01	.890E+00	.130E+00	.694E+01	.681E+01	1192
MGO	.125E+01	.460E+00	.800E-01	.549E+01	.541E+01	1192
MNO	.516E+00	.129E+01	.100E+00	.122E+02	.121E+02	1148
NAO	.163E+01	.709E+00	.100E-01	.374E+01	.373E+01	1192
PO	.269E+00	.940E-01	.100E-01	.133E+01	.132E+01	1192
ANI	.136E+02	.631E+01	.100E+01	.102E+03	.101E+03	1192
PB	.553E+03	.169E+04	.500E+01	.297E+05	.297E+05	1192
SR	.247E+03	.134E+03	.170E+02	.790E+03	.773E+03	1192
TH	.197E+02	.120E+02	.600E+01	.117E+03	.111E+03	1192
TIO2	.868E+00	.379E+00	.600E-01	.398E+01	.392E+01	1192
V	.126E+03	.722E+02	.130E+02	.102E+04	.101E+04	1192
ZN	.893E+03	.245E+04	.110E+02	.436E+05	.436E+05	1192
ZR	.104E+03	.365E+02	.110E+02	.257E+03	.246E+03	1192
AS	.212E+02	.298E+02	.100E+01	.480E+03	.479E+03	1194
MO	.558E+01	.147E+02	.100E+01	.320E+03	.319E+03	1194
U	.320E+01	.840E+01	.200E+00	.220E+03	.220E+03	1194
W	.970E+01	.238E+02	.400E+01	.320E+03	.316E+03	596
SN	.603E+02	.554E+02	.100E+02	.427E+03	.417E+03	1192

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

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DATA ANALYSIS FOR CU

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR CU

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....PPM...............            .    .    .    .    .    .    .    .    .    .
                                  5    10   15   20   25   30   35   40   45   50 PERCENT
          7.8[illegible]    III
          8.477[illegible]  III
          9.174[illegible]  II
          9.9[illegible]    III
         10.7464   IIII
         11.6311   IIIIII
         12.5841   IIIIIIIIIIII
         13.6234   IIIIIIIIIIIIIIIIIIIIIIIIIII
         14.7447   IIIIIIIIIIIIIIIIIIIIIIIIII
         15.9582   IIIIIIIIIIIIIIII
         17.2713   IIIII
         18.6724   II
         20.2305   I
         21.8951   I
         23.6964   I
         25.6466   I
         27.7569   I
         30.0405   I
         32.5127   I
         35.1874   I

CU          PROBABILITY PLOT OF CUM.FRE .DISTRIBUTION

    CLASS   CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98   99.99
    PPM

LESS THAN               I   I    I  I  I   I    I   I    I  I  I      I

    8.149   1.678 -.    .    .●  .  .   .    .   .    .  .  .      .
    8.819   3.523 -.    .    . ●.   .   .    .   .    .  .  .      .
    9.545   4.950 -.    .    .  ●   .   .    .   .    .  .  .      .
   10.330   7.293 -.    .    .  .●  .   .    .   .    .  .  .      .
   11.180   9.815 -.    .    .  .   ●   .    .   .    .  .  .      .
   12.100  14.765 -.    .    .  .   .●  .    .   .    .  .  .      .
   13.096  25.755 -.    .    .  .   .   ●    .   .    .  .  .      .
   14.173  52.685 -.    .    .  .   .   .    ●   .    .  .  .      .
   15.340  73.859 -.    .    .  .   .   .    .   .●   .  .  .      .
   16.602  94.715 -.    .    .  .   .   .    .   .    .  ●  .      .
   17.968  97.077 -.    .    .  .   .   .    .   .    .  .  .  ●   .
   19.446  99.916 -.    .    .  .   .   .    .   .    .  .  .      ●
   21.046  99.916 -.    .    .  .   .   .    .   .    .  .  .      ●
   22.778 100.000 -.    .    .  .   .   .    .   .    .  .  .      .
   24.652 100.000 -.    .    .  .   .   .    .   .    .  .  .      .
   26.681 100.000 -.    .    .  .   .   .    .   .    .  .  .      .
   28.876 100.000 -.    .    .  .   .   .    .   .    .  .  .      .
   31.252 100.084 -.    .    .  .   .   .    .   .    .  .  .      .
   33.824 100.084 -.    .    .  .   .   .    .   .    .  .  .      .
   36.607 100.000 -.    .    .  .   .   .    .   .    .  .  .      .

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    CLASS   CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98   99.99
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DATA ANALYSIS FOR AG

LOWER LIMIT..NUM FR....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR AG


                 0    I    I    I    I    I    I    I    I    I    I

....PPM...............    .    .    .    .    .    .    .    .    .    .
                          5   10   15   20   25   30   35   40   45   50 PERCENT
         1.5307  I
         1.8674  I
         2.2532  I
         2.7344  I
         3.3185  I
         4.0276  I
         4.8865  IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
         5.9245  III
         7.1962  II
         8.7309  III
        10.5945  II
        12.8658  II
        15.5933  I
        18.9295  II
        22.9699  III
        27.8727  III
        33.8214  II
        41.0410  II
        49.8019  II
        60.4306  I

  AG        PROBABILITY PLOT OF COM.FREQ.DISTRIBUTION

     CLASS   COM.PCT..01  .1    1    5   10   25    50   75 90 95 98    99.99
     PPM

LESS THAN                 I    I    I  I  I    I     I    I    I I  I      I

     1.586    0.000 -●    .    .  .  .    .     .    .    . .  .      .
     2.146    0.000 -●    .    .  .  .    .     .    .    . .  .      .
     2.443    0.000 -●    .    .  .  .    .     .    .    . .  .      .
     3.013    0.000 -●    .    .  .  .    .     .    .    . .  .      .
     3.656    0.000 -●    .    .  .  .    .     .    .    . .  .      .
     4.436    0.000 -●    .    .  .  .    .     .    .    . .  .      .
     5.383   84.706 -.    .    .  .  .    .     .    .  ● . .  .      .
     6.532   85.471 -.    .    .  .  .    .     .    .  ● . .  .      .
     7.922   87.899 -.    .    .  .  .    .     .    .   ●. .  .      .
     9.613   90.184 -.    .    .  .  .    .     .    .   ●. .  .      .
    11.671   91.345 -.    .    .  .  .    .     .    .    ● .  .      .
    14.162   92.437 -.    .    .  .  .    .     .    .    ● .  .      .
    17.184   92.857 -.    .    .  .  .    .     .    .    .●.  .      .
    20.852   93.950 -.    .    .  .  .    .     .    .    .●.  .      .
    25.303   95.462 -.    .    .  .  .    .     .    .    . ●  .      .
    30.704   97.227 -.    .    .  .  .    .     .    .    . . ●.      .
    37.257   98.319 -.    .    .  .  .    .     .    .    . .  .●     .
    45.209   99.160 -.    .    .  .  .    .     .    .    . .  . ●    .
    54.859   99.664 -.    .    .  .  .    .     .    .    . .  .    ● .
    66.568  100.000 -.    .    .  .  .    .     .    .    . .  .      .

LESS THAN                 I    I    I  I  I    I     I    I    I I  I      I

     CLASS   COM.PCT..01  .1    1    5   10   25    50   75 90 95 98    99.99
     PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

DATA ANALYSIS FOR [illegible]

LOWER LIMIT..NUMBER...PERCENT...CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR [illegible]

```
                      I    I    I    I    I    I    I    I    I    I    I
....PPM...............     .    .    .    .    .    .    .    .    .    .
                           5   10   15   20   25   30   35   40   45   50 PERCENT
     377.8[illegible]43   IIIII
     452.5723   II
     542.1[illegible]44   III
     649.36[illegible]8   II
     777.83[illegible]2   II
     931.71[illegible]    IIIII
    1116.[illegible]496   IIIIIIIIIIIIII
    1336.445[illegible]   IIIIIIIIIIIIIIIIIIIIIIIIIII
    1601.3262   IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
    1916.1324   IIIIIIIIIIIIIIIII
    2297.[illegible]153   IIIII
    2752.1751   II
    3296.[illegible]   I
    3946.8765   I
    4730.1215   I
    5665.9279   I
    6780.8741   I
    8129.[illegible]881   I
    9737.9444   I
   11664.4975   I
```

[illegible] PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

CLASS PPM	CUM.PCT.
413.513	3.775
[illegible]	[illegible]
593.317	6.2[illegible]
71[illegible].[illegible]49	7.131
851.[illegible]3	7.846
1013.725	12.245
1221.367	24.916
1463.122	49.832
1752.985	6[illegible].117
2093.317	94.983
2514.645	98.493
3012.142	99.746
3603.064	99.915
4321.[illegible]2	100.000
5176.[illegible]23	100.000
5231.124	100.000
7427.953	100.000
8897.498	100.000
10657.778	100.000
12766.311	100.000

CLASS PPM CUM.PCT..01 .1 1 5 10 25 50 75 90 95 98 99.99

```
DATA ANALYSIS FOR BE

LOWER LIMIT..NUM FR....PERCENT....CU .PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR BE

                       I    I    I    I    I    I    I    I    I    I

....PPM...............  .    .    .    .    .    .    .    .    .    .
                        5   10   15   20   25   30   35   40   45   50 PERCENT
          .5832  I
          .7078  I
          .8541  II
         1.0425  III
         1.2654  IIIIIIIIII
         1.5347  IIIIIIIIIIIIIIII
         1.8638  IIIIIIIIIIIIIIIIIIII
         2.2620  IIIIIIIIIIIIIIIII
         2.7452  IIIIIIIIIIIIIIIII
         3.3317  IIIIIIIII
         4.0435  IIIIII
         4.9074  IIIII
         5.9558  III
         7.2283  II
         8.7725  II
        10.6467  II
        12.9213  I
        15.6813  I
        19.0322  I
        23.0983  I

BE          PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

   CLASS   CUM.PCT..01  .1   1   5  10  25   50  75 90 95 98   99.99
    PPM

LESS THAN          I    I    I   I   I   I    I   I   I  I  I     I

     .643     .065 -.
     .780     .065 -.
     .946     .645 -.
    1.149    3.157 -.
    1.394   12.623 -.
    1.692   27.941 -.
    2.053   45.941 -.
    2.492   62.031 -.
    3.024   77.986 -.
    3.670   85.435 -.
    4.455   93.614 -.
    5.406   96.454 -.
    6.561   96.733 -.
    7.963   99.123 -.
    9.664   99.481 -.
   11.729   99.829 -.
   14.235   99.915 -.
   17.276  100.000 -.
   20.967  100.000 -.
   25.446  100.000 -.

LESS THAN          I    I    I   I   I   I    I   I   I  I  I     I

   CLASS   CUM.PCT..01  .1   1   5  10  25   50  75 90 95 98   99.99
    PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

DATA ANALYSIS FOR B

LOWER LIMIT.. UPPER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR B

```
                       0    I    I    I    I    I    I    I    I    I    I
....PPM...............      .    .    .    .    .    .    .    .    .    .
                            5   10   15   20   25   30   35   40   45   50 PERCENT
        291.16?    IIII
        350.8155   II
        442.1911   III
        544.?4?1   II
        671.5642   IIIII
        827.6111   IIIIIII
       1019.9177   IIIIIIIIIII
       1256.9092   IIIIIIIIIIIIIIIIIIIIII
       1548.9649   IIIIIIIIIIIIIIIIIIIIIIIIIIIIII
       1908.8925   IIIIIIIIIIIIIIIII
       2352.4443   IIIII
       2899.?725   II
       3572.7108   II
       4402.8780   I
       5425.?457   I
       6686.7?6?   I
       8240.4899   I
      10155.2781   I
      12514.?93    I
      15423.1?3    I
```

B PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

```
   CLASS    CUM.PCT..01  .1    1  5  10  25   50  75 90 95 98   99.99
    PPM
LESS THAN              I    I    I  I   I   I    I   I   I I I      I
   323.223   2.6?1  -.  .    .●  .   .   .    .   .   . . .      .
   398.328   4.027  -.  .    . ●.    .   .    .   .   . . .      .
   491.385   6.063  -.  .    .  .●   .   .    .   .   . . .      .
   606.?48   7.551  -.  .    .  . ●.     .    .   .   . . .      .
   745.516  11.158  -.  .    .  .    ●   .    .   .   . . .      .
   918.747  17.114  -.  .    .  .   .  ●.     .   .   . . .      .
  1132.?30  27.097  -.  .    .  .   .   .●    .   .   . . .      .
  1395.318  48.574  -.  .    .  .   .   .    ●    .   . . .      .
  1719.539  77.34?  -.  .    .  .   .   .    .   .●   . . .      .
  2119.097  94.211  -.  .    .  .   .   .    .   .   .●.  .      .
  2611.498  98.65?  -.  .    .  .   .   .    .   .   . . .●     .
  3218.314  99.32?  -.  .    .  .   .   .    .   .   . . . ●    .
  3966.133  99.832  -.  .    .  .   .   .    .   .   . . .     ●.
  4887.717  99.916  -.  .    .  .   .   .    .   .   . . .      ●
  6023.444 100.000  -.  .    .  .   .   .    .   .   . . .      .
  7423.?71 100.000   .  .    .  .   .   .    .   .   . . .      .
  9147.921 100.000  -.  .    .  .   .   .    .   .   . . .      .
 11273.?63 100.000  -.  .    .  .   .   .    .   .   . . .      .
 13893.127 100.000  -.  .    .  .   .   .    .   .   . . .      .
 17121.381 100.000  -.  .    .  .   .   .    .   .   . . .      .
LESS THAN              I    I    I. I   I  .I.   I   I  .I I I.     I
   CLASS    CUM.PCT..01  .1    1  5  10  25   50  75 90 95 98   99.99
    PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

```
    DATA ANALYSIS FOR  CAO

    LOWER LIMIT..PPM FR....PERCENT....CUM.PERC

  FREQUENCY DISTRIBUTION HISTOGRAM  FOR  CAO

                            .    I    I    I    I    I    I    I    I    I    I
....PPM.............        .    .    .    .    .    .    .    .    .    .    .
                                 5   10   15   20   25   30   35   40   45   50 PERCENT
              .1441   II
              .1783   III
              .2384   III
              .3179   IIII
              .4238   IIIIII
              .5653   IIIIIIIIIIIII
              .7537   IIIIIIIIIIIIIIIIIII
             1.0050   IIIIIIIIIIIIIIIIIII
             1.3402   IIIIIIIIIIIII
             1.7871   IIIIIIIIII
             2.3831   IIIIIIII
             3.1778   IIIIIIII
             4.2375   IIII
             5.6507   I
             7.5351   I
            10.0474   I
            13.3985   I
            17.8685   I
            23.8251   I
            31.7702   I

      CAO         PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

      CLASS  CUM.PCT...01  .1   1   5   10   25   50   75  90  95  98    99.99
       PPM

  LESS THAN              I    I    I   I   I    I     I    I     I  I  I      I

      .155   1.130 -.    .    *    .   .   .    .     .    .     .  .  .      .
      .206   3.130 -.    .    .   *.   .   .    .     .    .     .  .  .      .
      .275   4.653 -.    .    .    *   .   .    .     .    .     .  .  .      .
      .367   7.276 -.    .    .   .*   .   .    .     .    .     .  .  .      .
      .489  12.183 -.    .    .    .   *   .    .     .    .     .  .  .      .
      .653  24.619 -.    .    .    .   .   *    .     .    .     .  .  .      .
      .871  43.232 -.    .    .    .   .   .    *.    .    .     .  .  .      .
     1.161  62.[illegible] -.    .    .    .   .   .    .    .*    .     .  .  .      .
     1.548  73.773 -.    .    .    .   .   .    .     .    *     .  .  .      .
     2.064  82.741 -.    .    .    .   .   .    .     .    .  *  .  .  .      .
     2.752  89.932 -.    .    .    .   .   .    .     .    .     *. .  .      .
     3.670  96.531 -.    .    .    .   .   .    .     .    .     .  .* .      .
     4.893  99.662 -.    .    .    .   .   .    .     .    .     .  .  .   *  .
     6.525  99.831 -.    .    .    .   .   .    .     .    .     .  .  .     *.
     8.701 100.000 -.    .    .    .   .   .    .     .    .     .  .  .      .
    11.613 100.000 -.    .    .    .   .   .    .     .    .     .  .  .      .
    15.472 100.000 -.    .    .    .   .   .    .     .    .     .  .  .      .
    20.632 100.000 -.    .    .    .   .   .    .     .    .     .  .  .      .
    27.512 100.000 -.    .    .    .   .   .    .     .    .     .  .  .      .
    36.687 100.000 -.    .    .    .   .   .    .     .    .     .  .  .      .
  LESS THAN              I    I    I   I   I    I     I    I     I  I  I      I

      CLASS  CUM.PCT...01  .1   1   5   10   25   50   75  90  95  98    99.99
       PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

```
DATA ANALYSIS FOR CD

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR CD

                          .   I    I    I    I    I    I    I    I    I    I

....PPM...............        .    .    .    .    .    .    .    .    .    .
                              5   10   15   20   25   30   35   40   45   50 PERCENT
         4.3114  I
         4.6467  I
         4.9945  I
         5.3753  I
         5.7852  I
         6.2262  I
         6.7010  I
         7.2119  IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
         7.7617  I
         8.3535  I
         8.9904  I
         9.6759  II
        10.4136  I
        11.2076  II
        12.0622  I
        12.9813  I
        13.9716  I
        15.0364  I
        16.1834  I
        17.4172  II

   CD          PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

   CLASS   CUM.PCT..01  .1    1   5   10   25    50   75 90 95 98     99.99
   PPM

LESS THAN             I    I     I   I   I    I     I    I     I  I  I        I

    4.473   0.000 -●    .     .   .   .    .     .    .     .  .  .        .
    4.814   0.000 -●    .     .   .   .    .     .    .     .  .  .        .
    5.181   0.000 -●    .     .   .   .    .     .    .     .  .  .        .
    5.576   0.000 -●    .     .   .   .    .     .    .     .  .  .        .
    6.002   0.000 -●    .     .   .   .    .     .    .     .  .  .        .
    6.459   0.000 -●    .     .   .   .    .     .    .     .  .  .        .
    6.952   0.000 -●    .     .   .   .    .     .    .     .  ●  .        .
    7.482  95.805 -.    .     .   .   .    .     .    .     .  ●  .        .
    8.052  96.225 -.    .     .   .   .    .     .    .     . .●  .        .
    8.666  96.225 -.    .     .   .   .    .     .    .     . .●  .        .
    9.327  96.644 -.    .     .   .   .    .     .    .     . .●  .        .
   10.038  97.148 -.    .     .   .   .    .     .    .     .  . ●.        .
   10.803  97.148 -.    .     .   .   .    .     .    .     .  . ●.        .
   11.627  97.483 -.    .     .   .   .    .     .    .     .  . ●.        .
   12.514  97.987 -.    .     .   .   .    .     .    .     .  . ●.        .
   13.468  98.238 -.    .     .   .   .    .     .    .     .  .  ●        .
   14.494  98.491 -.    .     .   .   .    .     .    .     .  .  .●       .
   15.600  98.742 -.    .     .   .   .    .     .    .     .  .  .●       .
   16.789  99.077 -.    .     .   .   .    .     .    .     .  .  . ●      .
   18.069 100.000 -.    .     .   .   .    .     .    .     .  .  .        .

LESS THAN             I    I     I   I   I    I     I    I     I  I  I        I

   CLASS   CUM.PCT..01  .1    1   5   10   25    50   75 90 95 98     99.99
   PPM
```

```
DATA ANALYSIS FOR  CO

LOWER LIMIT...[illegible] PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM  FOR  CO

                          I     I     I     I     I     I     I     I     I     I
....PPM...............    .     .     .     .     .     .     .     .     .     .
                          5     10    15    20    25    30    35    40    45    50 PERCENT
        2.1318   IIIIIII
        [illegible].8986   I
        3.[illegible]412   II
        5.[illegible]588   III
        7.286[illegible]   IIII
        9.9970   IIIIIIII
       13.47[illegible]4   IIIIIIIIIIIII
       18.4155   IIIIIIIIIIIIIIIIIIIIIII
       24.[illegible]133   IIIIIIIIIIIIIIIIIIIIIII
       33.86[illegible]   IIIIIIIIIIIIIII
       46.[illegible]398   IIIIIIIII
       62.5946   III
       85.1158   I
      115.73[illegible]7   I
      157.[illegible]574   I
      213.9566   I
      291.9136   I
      395.551[illegible]   I
      537.825[illegible]   I
      731.2723   I

CO          PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

 CLASS  CUM.PCT..01  .1    1   5   10   25   50   75  90 95 98    99.99
  PPM

LESS THAN            I     I    I   I    I    I    I    I  I  I     I

   2.466    5.705  -.  .    . .● .   .    .    .    . .  .     .
   3.300    5.124  -.  .    . .● .   .    .    .    . .  .     .
   4.590    5.711  -.  .    . .● .   .    .    .    . .  .     .
   6.249    8.305  -.  .    . . ●.   .    .    .    . .  .     .
   8.496   11.493  -.  .    . .  ●   .    .    .    . .  .     .
  11.552   18.372  -.  .    . .  .  ●.    .    .    . .  .     .
  15.707   30.453  -.  .    . .  .   .●   .    .    . .  .     .
  21.357   52.517  -.  .    . .  .   .    ●    .    . .  .     .
  29.[illegible]   75.000  -.  .    . .  .   .    .    ●    . .  .     .
  [illegible].483   [illegible]9.094  -.  .    . .  .   .    .    .   ●. .  .     .
  53.685   97.315  -.  .    . .  .   .    .    .    . . ●.     .
  72.995   99.245  -.  .    . .  .   .    .    .    . .  . ●   .
  99.250   99.497  -.  .    . .  .   .    .    .    . .  .  ●  .
 1[illegible].[illegible]43   99.916  -.  .    . .  .   .    .    .    . .  .     ●
 183.447   99.916  -.  .    . .  .   .    .    .    . .  .     ●
 249.[illegible]   100.000  -.  .    . .  .   .    .    .    . .  .     .
 33[illegible].221  100.000  -.  .    . .  .   .    .    .    . .  .     .
 461.234  100.001  -.  .    . .  .   .    .    .    . .  .     .
 627.134  100.000  -.  .    . .  .   .    .    .    . .  .     .
 852.705  100.000  -.  .    . .  .   .    .    .    . .  .     .

LESS THAN            I     I    I   I    I    I    I    I  I  I     I

 CLASS  CUM.PCT..01  .1    1   5   10   25   50   75  90 95 98    99.99
  PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

DATA ANALYSIS FOR CR

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR CR

```
                     I    I    I    I    I    I    I    I    I    I
....PPM..............     .    .    .    .    .    .    .    .    .    .
                          5    10   15   20   25   30   35   40   45   50 PERCENT
       1.4267  IIIII
       2.0663  II
       2.9925  II
       4.3341  III
       6.2771  IIIII
       9.0407  IIIIIIIII
      13.1662  IIIIIIIIIII
      19.1686  IIIIIIIIIIIIIIIIIII
      27.9166  IIIIIIIIIIIIIIIIIIIIIIIIIIII
      39.4468  IIIIIIIIIIIIIIIIIIIIIII
      57.9269  IIIIII
      83.8464  II
     121.5040  I
     175.9728  I
     254.8593  I
     369.1097  I
     534.5772  I
     774.2217  I
    1121.2461  I
    1623.9599  I
```

CR PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

```
CLASS     CUM.PCT..0) .1   1  5  10  25   50  75 90 95 98    99.99
 PPM

LESS THAN            I   I    I  I  I   I     I   I    I I  I       I
    1.717    4.282 -.    .    .  ●  .   .     .   .    . .  .       .
    2.487    5.122 -.    .    .  ●  .   .     .   .    . .  .       .
    3.601    6.045 -.    .    . .●  .   .     .   .    . .  .       .
    5.216    7.443 -.    .    .  . ●.   .     .   .    . .  .       .
    7.554   12.007 -.    .    .  .  ●   .     .   .    . .  .       .
   10.943   17.983 -.    .    .  .  .  ●.     .   .    . .  .       .
   15.845   24.723 -.    .    .  .  .   .●    .   .    . .  .       .
   22.948   47.103 -.    .    .  .  .   .    ●.   .    . .  .       .
   33.235   72.376 -.    .    .  .  .   .     .   ●    . .  .       .
   48.134   93.451 -.    .    .  .  .   .     .   .   .● .  .       .
   69.712   98.415 -.    .    .  .  .   .     .   .    . .  .●      .
  100.963   99.581 -.    .    .  .  .   .     .   .    . .  .   ●   .
  146.224   99.916 -.    .    .  .  .   .     .   .    . .  .       ●
  211.774  100.000 -.    .    .  .  .   .     .   .    . .  .       .
  306.710  100.084 -.    .    .  .  .   .     .   .    . .  .       .
  444.204  100.084 -.    .    .  .  .   .     .   .    . .  .       .
  643.336  100.084 -.    .    .  .  .   .     .   .    . .  .       .
  931.736  100.084 -.    .    .  .  .   .     .   .    . .  .       .
 1349.422  100.084 -.    .    .  .  .   .     .   .    . .  .       .
 1954.352  100.000 -.    .    .  .  .   .     .   .    . .  .       .
LESS THAN            I   I    I  I  I   I     I   I    I I  I       I

CLASS     CUM.PCT..0) .1   1  5  10  25   50  75 90 95 98    99.99
 PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

```
DATA ANALYSIS FOR CU

LOWER LIMIT.. OF FR....PERCENT....CU .PERC

FREQUENCY DISTRIBUTION HISTOGRAM   FOR CU


                    0    I    I    I    I    I    I    I    I    I    I

....PPM..............    .    .    .    .    .    .    .    .    .    .
                         5   10   15   20   25   30   35   40   45   50 PERCENT
       1.0047  I
       1.7343  I
       3.0078  I
       5.2015  III
       6.9465  IIIIIIIIII
      15.5566  IIIIIIIIIIIIIIIIIIIIIIIIII
      26.9031  IIIIIIIIIIIIIIII
      46.5254  IIIIIIIIIIIIIIII
      80.4545  IIIIIIIIIII
     139.1441  IIIIIII
     240.6313  IIIIIII
     416.1402  IIIIII
     719.6496  IIIIII
    1244.5564  II
    2152.2961  II
    3722.1124  I
    6436.9027  I
   11131.7747  I
   19250.9367  I
   33291.3571  I

CU          PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

  CLASS  CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98    99.99
  PPM

LESS THAN            I   I    I  I  I   I    I   I    I  I  I      I

     1.323   0.000 -●   .    .  .  .   .    .   .    .  .  .      .
     2.267   0.000 -●   .    .  .  .   .    .   .    .  .  .      .
     3.955   0.000 -●   .    .  .  .   .    .   .    .  .  .      .
     6.840   1.513 -.   .    .● .  .   .    .   .    .  .  .      .
    11.830  13.672 -.   .    .  .  ●   .    .   .    .  .  .      .
    20.458  35.713 -.   .    .  .  .   . ●  .   .    .  .  .      .
    35.379  53.588 -.   .    .  .  .   .    ●   .    .  .  .      .
    61.183  65.714 -.   .    .  .  .   .    . ● .    .  .  .      .
   105.809  75.546 -.   .    .  .  .   .    .   ●    .  .  .      .
   182.982  82.917 -.   .    .  .  .   .    .   . ●  .  .  .      .
   316.443  87.899 -.   .    .  .  .   .    .   .   ●. .  .      .
   547.247  92.635 -.   .    .  .  .   .    .   .    ●  .  .      .
   945.392  97.563 -.   .    .  .  .   .    .   .    .  . ●.      .
  1636.559  98.992 -.   .    .  .  .   .    .   .    .  .  .●     .
  2830.367  99.496 -.   .    .  .  .   .    .   .    .  .  .   ●  .
  4894.791  99.832 -.   .    .  .  .   .    .   .    .  .  .     ●.
  8464.977  99.916 -.   .    .  .  .   .    .   .    .  .  .      ●
 14638.890 100.000 -.   .    .  .  .   .    .   .    .  .  .      .
 25316.030 100.000 -.   .    .  .  .   .    .   .    .  .  .      .
 43780.736 100.000 -.   .    .  .  .   .    .   .    .  .  .      .

LESS THAN            I   I    I  I  I   I    I   I    I  I  I      I

  CLASS  CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98    99.99
  PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

DATA ANALYSIS FOR FEO

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR FEO

```
                           I    I    I    I    I    I    I    I    I    I
....PPM...............     .    .    .    .    .    .    .    .    .    .
                           5   10   15   20   25   30   35   40   45   50 PERCENT
          2.4311  II
          2.8325  II
          3.3003  II
          3.7454  IIII
          4.4806  IIIIIIIIII
          5.2216  IIIIIIIIIIIIIIII
          6.1229  IIIIIIIIIIIIIII
          7.0876  IIIIIIIIIIIIIII
          8.2542  IIIIIIIIIIIIIIIIIII
          9.6222  IIIIIIIIIIII
         11.2115  IIIIIIII
         13.0433  IIII
         15.2203  III
         17.7341  II
         20.6641  II
         24.0772  I
         28.0541  I
         32.6476  I
         38.0865  I
         44.3771  I
```

FEO PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

CLASS PPM	CUM.PCT..	.01	.1	1	5	10	25	50	75	90	95	98	99.99
LESS THAN		I	I	I	I	I	I	I	I	I	I	I	I
2.624	.671			●									
3.057	1.258			●									
3.562	2.181			●									
4.151	5.621				●								
4.836	14.346					●							
5.635	29.279						●						
6.566	43.372							●					
7.651	57.047							●					
8.914	74.832								●				
10.387	86.326								●				
12.102	93.540									●			
14.101	96.057										●		
16.430	97.819											●	
19.144	99.077											●	
22.305	99.581											●	
25.990	99.664											●	
30.282	99.748											●	
35.284	99.915												●
41.112	100.000												
47.902	100.000												
LESS THAN		I	I	I	I	I	I	I	I	I	I	I	I
CLASS PPM	CUM.PCT..	.01	.1	1	5	10	25	50	75	90	95	98	99.99

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

```
DATA ANALYSIS FOR    K2O

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR    K2O

                      .    I    I    I    I    I    I    I    I    I    I

....PPM..............      .    .    .    .    .    .    .    .    .    .
                           5   10   15   20   25   30   35   40   45   50 PERCENT
          1.1909  II
          1.3577  II
          1.5427  IIII
          1.7524  IIII
          1.9916  IIIIIII
          2.2623  IIIIIIIIIIIII
          2.5712  IIIIIIIIIIIIIII
          2.9214  IIIIIIIIIIIIIIII
          3.3194  IIIIIIIIIIIIIIIIIII
          3.7715  IIIIIIIIIIIIIIIIII
          4.2253  IIIIIIII
          4.8691  IIIII
          5.5323  II
          6.2859  I
          7.1422  I
          8.1151  I
          9.2216  I
         10.4766  I
         11.9047  I
         13.5252  I

   K2O       PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

   CLASS   CUM.PCT..01 .1    1   5  10   25    50  75 90 95 98    99.99
   PPM
```

CLASS PPM (LESS THAN)	CUM.PCT
1.274	.756
1.447	1.847
1.644	4.786
1.868	7.473
2.123	13.514
2.412	25.441
2.741	39.643
3.114	53.652
3.538	71.285
4.020	87.909
4.568	94.626
5.191	98.573
5.897	99.66
6.700	99.916
7.613	100.000
8.650	100.000
9.829	100.000
11.167	100.000
12.689	100.000
14.417	100.000

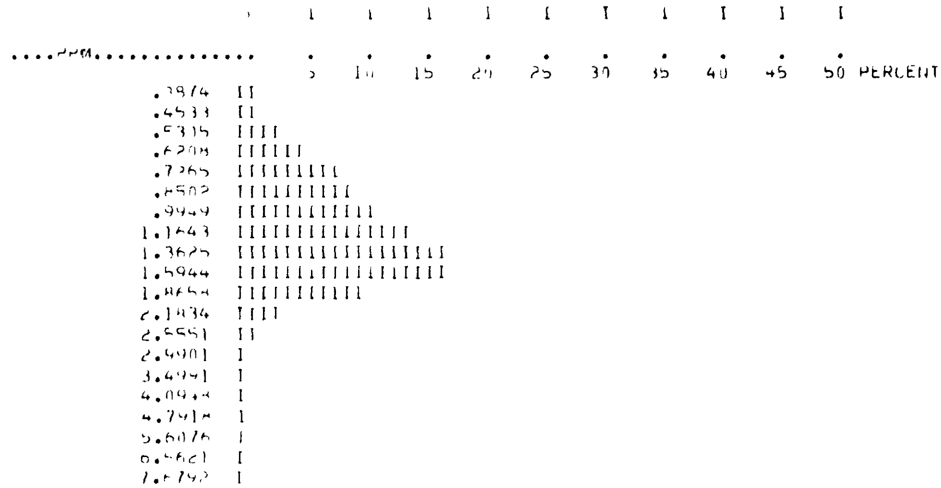
```
   CLASS   CUM.PCT..01 .1    1   5  10   25    50  75 90 95 98    99.99
   PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

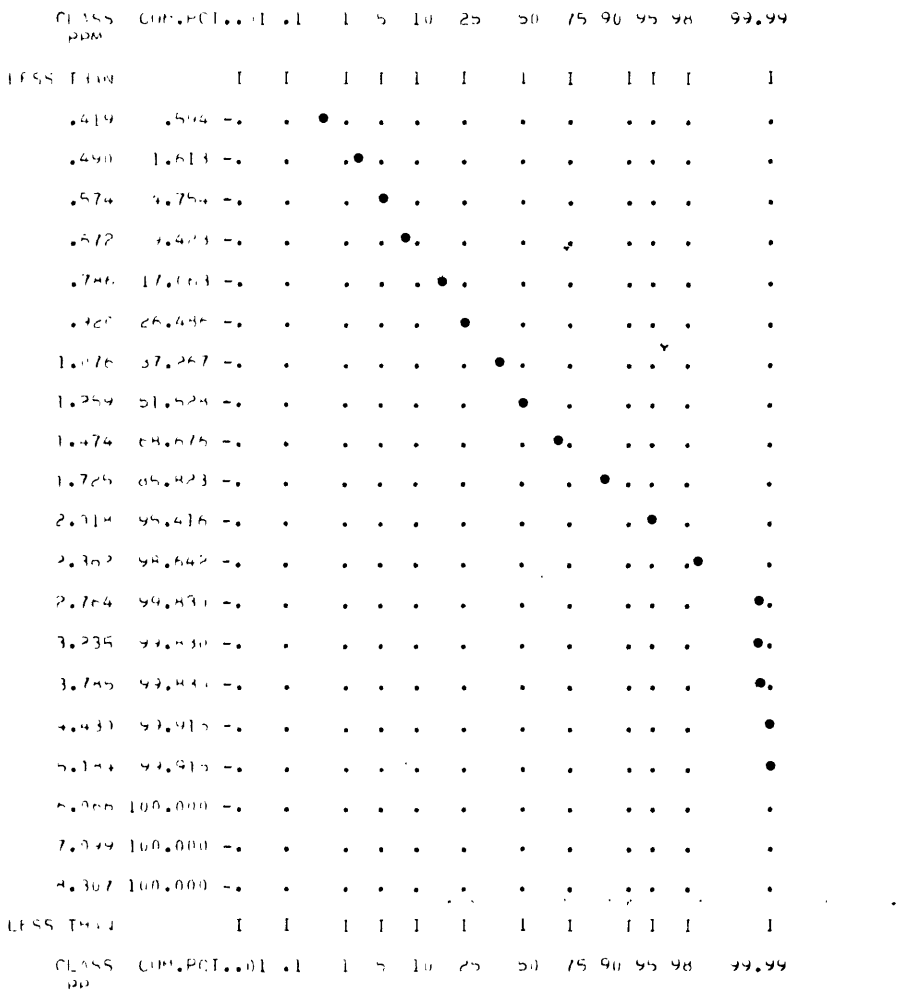
DATA ANALYSIS FOR MGO

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR MGO



MGO PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION



```
DATA ANALYSIS FOR     MNO

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM   FOR     MNO


                     0    I    I    I    I    I    I    I    I    I    I

....PPM.............      .    .    .    .    .    .    .    .    .    .
                          5   10   15   20   25   30   35   40   45   50 PERCENT
        .0140  I
        .0207  I
        .0306  I
        .0452  I
        .0668  I
        .0983  IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
        .146   I
        .2155  IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
        .318   IIIIIIIIIIII
        .4715  IIIIII
        .6971  IIIII
       1.0304  II
       1.5231  II
       2.2503  II
       3.3277  III
       4.9149  III
       7.2709  II
      10.7474  I
      15.8863  I
      23.4823  I

    MNO      PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

  CLASS   CUM.PCT..01 .1    1   5  10  25    50  75 90 95 98     99.99
  PPM

LESS THAN           I   I    I   I   I    I     I   I     I  I  I        I

     .017    0.000 -●   .    .   .   .    .     .   .     .  .  .        .

     .026    0.000 -●   .    .   .   .    .     .   .     .  .  .        .

     .037    0.000 -●   .    .   .   .    .     .   .     .  .  .        .

     .055    0.000 -●   .    .   .   .    .     .   .     .  .  .        .

     .081    0.000 -●   .    .   .   .    .     .   .     .  .  .        .

     .121   37.333 -.   .    .   .   .    .  ●  .   .     .  .  .        .

     .178   37.333 -.   .    .   .   .    .  ●  .   .     .  .  .        .

     .262   73.488 -.   .    .   .   .    .     .   ●     .  .  .        .

     .388   83.955 -.   .    .   .   .    .     .   . ●   .  .  .        .

     .573   88.411 -.   .    .   .   .    .     .   .    ●.  .  .        .

     .847   92.011 -.   .    .   .   .    .     .   .     ●  .  .        .

    1.253   93.241 -.   .    .   .   .    .     .   .     .● .  .        .

    1.852   93.454 -.   .    .   .   .    .     .   .     .● .  .        .

    2.737   94.732 -.   .    .   .   .    .     .   .     .  ●  .        .

    4.046   96.313 -.   .    .   .   .    .     .   .     .  .● .        .

    5.980   98.507 -.   .    .   .   .    .     .   .     .  .  .●       .

    8.840   99.551 -.   .    .   .   .    .     .   .     .  .  .   ●    .

   13.067  100.000 -.   .    .   .   .    .     .   .     .  .  .        .

   19.314  100.000 -.   .    .   .   .    .     .   .     .  .  .        .

   28.550  100.000 -.   .    .   .   .    .     .   .     .  .  .        .

LESS THAN           I   I    I   I   I    I     I   I     I  I  I        I

  CLASS   CUM.PCT..01 .1    1   5  10  25    50  75 90 95 98     99.99
  PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

```
DATA ANALYSIS FOR  NAO

LOWER LIMIT..PPM FR....PERCENT....CU .PERC

FREQUENCY DISTRIBUTION HISTOGRAM  FOR  NAO

                     0    I    I    I    I    I    I    I    I    I    I

....PP ..............     .    .    .    .    .    .    .    .    .    .
                          5   10   15   20   25   30   35   40   45   50 PERCENT
            .2774  II
            .3511  I
            .4444  II
            .5626  III
            .7122  IIIIIII
            .9016  IIIIIIIIIIIII
           1.1414  IIIIIIIIIIIIIIII
           1.4449  IIIIIIIIIIIIIIII
           1.8291  IIIIIIIIIIIIIIIIIII
           2.3155  IIIIIIIIIIIIIIIIIIII
           2.9313  IIIIIIIIII
           3.7108  II
           4.6977  I
           5.9463  I
           7.5233  I
           9.5303  I
          12.0647  I
          15.2737  I
          19.3345  I
          24.4760  I

  NAO      PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

  CLASS  CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98   99.99
  PPM

LESS THAN          I   I    I  I  I   I    I   I    I  I  I    I

     .312  1.263  -.   .    *  .  .   .    .   .    .  .  .    .
     .395  1.593  -.   .    .* .  .   .    .   .    .  .  .    .
     .500  2.462  -.   .    .* .  .   .    .   .    .  .  .    .
     .633  4.882  -.   .    .  *  .   .    .   .    .  .  .    .
     .801 10.690  -.   .    .  .  *   .    .   .    .  .  .    .
    1.014 22.475  -.   .    .  .  .   *    .   .    .  .  .    .
    1.284 37.205  -.   .    .  .  .   .  * .   .    .  .  .    .
    1.626 52.609  -.   .    .  .  .   .    *   .    .  .  .    .
    2.058 70.623  -.   .    .  .  .   .    .  *.    .  .  .    .
    2.565 87.543  -.   .    .  .  .   .    .   .   *.  .  .    .
    3.294 99.242  -.   .    .  .  .   .    .   .    .  .  . *  .
    4.175 100.000 -.   .    .  .  .   .    .   .    .  .  .    .
    5.285 100.000 -.   .    .  .  .   .    .   .    .  .  .    .
    6.691 100.084 -.   .    .  .  .   .    .   .    .  .  .    .
    8.470 100.084 -.   .    .  .  .   .    .   .    .  .  .    .
   10.723 100.084 -.   .    .  .  .   .    .   .    .  .  .    .
   13.574 100.084 -.   .    .  .  .   .    .   .    .  .  .    .
   17.184 100.084 -.   .    .  .  .   .    .   .    .  .  .    .
   21.754 100.084 -.   .    .  .  .   .    .   .    .  .  .    .
   27.539 100.084 -.   .    .  .  .   .    .   .    .  .  .    .

LESS THAN          I   I    I  I  I   I    I   I    I  I  I    I

  CLASS  CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98   99.99
  PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

```
DATA ANALYSIS FOR  PB

LOWER LIMIT..004 FR....PERCENT....CUM.PERC

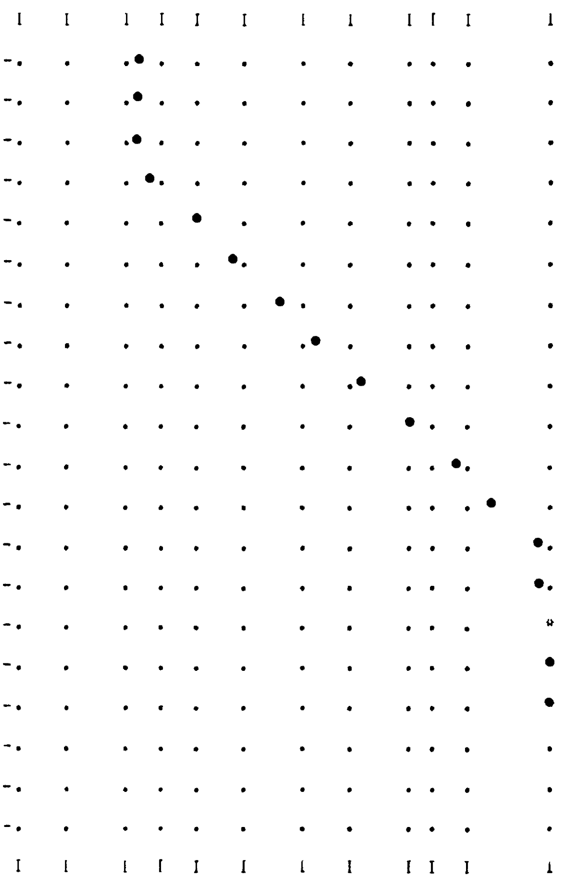
FREQUENCY DISTRIBUTION HISTOGRAM   FOR  PB

                   0    I    I    I    I    I    I    I    I    I    I

....PPM..............   .    .    .    .    .    .    .    .    .    .
                        5   10   15   20   25   30   35   40   45   50 PERCENT
         .0777  III
         .0919  I
         .1087  II
         .1285  II
         .1519  IIIIIII
         .1797  IIIIIIIIII
         .2124  IIIIIIIIIIIIIIIIIII
         .2512  IIIIIIIIIIIIIIIIIIII
         .2971  IIIIIIIIIIIIIIIIIIII
         .3513  IIIIIIIIIIIIIIII
         .4154  IIIIIIII
         .4912  III
         .5808  II
         .6868  I
         .8122  I
         .9604  I
        1.1357  I
        1.3430  I
        1.5881  I
        1.8779  I
```

PB PROBABILITY PLOT OF COM.FREQ.DISTRIBUTION

CLASS PP LESS THAN	COM.PCT.
.084	1.846
.100	1.846
.118	2.601
.140	3.607
.165	10.067
.195	19.463
.231	37.668
.273	57.047
.323	76.174
.382	90.856
.452	97.399
.534	99.077
.632	99.832
.747	99.832
.883	99.916
1.044	99.916
1.235	99.916
1.460	100.000
1.727	100.000
2.042	100.000



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DATA ANALYSIS FOR    NI

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR    NI

                  0     I     I     I     I     I     I     I     I     I     I
....PPM...............  .     .     .     .     .     .     .     .     .     .
                        5    10    15    20    25    30    35    40    45    50 PERCENT
       3.9923  III
       4.7032  II
       5.5405  III
       6.5270  IIII
       7.6891  IIIIII
       9.0581  IIIIIIII
      10.6703  IIIIIIIIIIIIIIIIIII
      12.5708  IIIIIIIIIIIIIIIIIIIIIIII
      14.8091  IIIIIIIIIIIIIIIIII
      17.4457  IIIIIII
      20.5514  IIIIIIIIIII
      24.2111  IIII
      28.5217  III
      33.5999  II
      39.5822  I
      46.6297  I
      54.9313  I
      64.7123  I
      76.2341  I
      89.8073  I

  NI        PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

CLASS   CUM.PCT..01 .1    1  5  10  25   50  75 90 95 98    99.99
PPM

LESS THAN           I   I    I  I  I   I    I   I    I I I      I

   4.333    1.682 -.   .    .● .  .   .    .   .    . . .      .
   5.105    3.023 -.   .    . ●.  .   .    .   .    . . .      .
   6.014    4.952 -.   .    .  ●  .   .    .   .    . . .      .
   7.084    7.906 -.   .    .  . ●.   .    .   .    . . .      .
   8.346   12.447 -.   .    .  .  ●   .    .   .    . . .      .
   9.832   19.425 -.   .    .  .  .  ●.    .   .    . . .      .
  11.582   34.856 -.   .    .  .  .   .  ● .   .    . . .      .
  13.644   51.135 -.   .    .  .  .   .    . ● .    . . .      .
  16.073   77.461 -.   .    .  .  .   .    .   .●   . . .      .
  18.935   83.936 -.   .    .  .  .   .    .   . ●  . . .      .
  22.307   93.860 -.   .    .  .  .   .    .   .    .●. .      .
  26.278   95.804 -.   .    .  .  .   .    .   .    . .● .     .
  30.957   98.318 -.   .    .  .  .   .    .   .    . . .●     .
  36.469   99.243 -.   .    .  .  .   .    .   .    . . . ●    .
  42.962   99.579 -.   .    .  .  .   .    .   .    . . .  ●   .
  50.611   99.748 -.   .    .  .  .   .    .   .    . . .    ● .
  59.622   99.916 -.   .    .  .  .   .    .   .    . . .      ●
  70.237   99.916 -.   .    .  .  .   .    .   .    . . .      ●
  82.743   99.916 -.   .    .  .  .   .    .   .    . . .      ●
  97.475  100.000 -.   .    .  .  .   .    .   .    . . .      .

LESS THAN           I   I    I  I  I   I    I   I    I I I      I

CLASS   CUM.PCT..01 .1    1  5  10  25   50  75 90 95 98    99.99
PPM
```

```
DATA ANALYSIS FOR  PB

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR  PB


                    I    I    I    I    I    I    I    I    I    I

....PPM...............  .    .    .    .    .    .    .    .    .    .
                        5    10   15   20   25   30   35   40   45   50 PERCENT
        .3846  I
       1.2077  I
       2.4782  I
       5.0452  IIII
      10.4347  IIIIII
      21.4115  IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
      43.9358  IIIIIIIIIIIIIIIIIIII
      90.1546  IIIIIIIIIIII
     184.9433  IIIIIIIIIII
     379.6008  IIIIIIIIII
     778.9759  IIIIIIIII
    1596.3295  IIIIII
    3279.7137  IIIIIII
    6729.8525  II
   13809.4113  II
   28330.4059  I
   58145.2677  I
  119311.9611  I
  244523.7772  I
  502369.4300  I

  PB        PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

 CLASS   CUM.PCT...01  .1   1   5  10  25   50  75 90 95 98   99.99
  PPM

LESS THAN            I    I    I   I   I   I    I   I   I  I  I    I

       .343   1.000 -●    .    .   .   .   .    .   .   .  .  .    .
      1.730   0.000 -●    .    .   .   .   .    .   .   .  .  .    .
      3.550   0.000 -●    .    .   .   .   .    .   .   .  .  .    .
      7.284   3.272 -.    .    .  ●.   .   .    .   .   .  .  .    .
     14.947   8.641 -.    .    .   .  ●.   .    .   .   .  .  .    .
     30.671  37.164 -.    .    .   .   .   .  ● .   .   .  .  .    .
     62.937  54.362 -.    .    .   .   .   .   .●   .   .  .  .    .
    129.144  63.926 -.    .    .   .   .   .    . ● .   .  .  .    .
    264.948  72.937 -.    .    .   .   .   .    .   ●   .  .  .    .
    543.766  80.789 -.    .    .   .   .   .    .   . ● .  .  .    .
   1115.768  87.752 -.    .    .   .   .   .    .   .  ●.  .  .    .
   2289.555  92.617 -.    .    .   .   .   .    .   .   ●  .  .    .
   4698.384  98.558 -.    .    .   .   .   .    .   .   .  .  .●   .
   9640.296  99.161 -.    .    .   .   .   .    .   .   .  .  . ●  .
  19781.534  99.916 -.    .    .   .   .   .    .   .   .  .  .    ●
  40590.383 100.000 -.    .    .   .   .   .    .   .   .  .  .    .
  83291.212 100.000 -.    .    .   .   .   .    .   .   .  .  .    .
```

DATA ANALYSIS FOR SR

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR SR

```
                      0    I    I    I    I    I    I    I    I    I    I
....PPM...............     .    .    .    .    .    .    .    .    .    .
                           5   10   15   20   25   30   35   40   45   50 PERCENT
     46.2719  I
     57.5962  II
     71.6893  III
     89.2325  IIIII
    111.0567  IIIIIIIII
    138.2484  IIIIIIIIIIIIIII
    172.0793  IIIIIIIIIIIII
    214.1849  IIIIIIIIIIIIIII
    266.6034  IIIIIIIIIIIII
    331.8442  IIIIIIIIIII
    413.0501  IIIIIIIIII
    514.1281  IIIIIIIII
    639.9418  III
    796.5414  I
    991.4638  I
   1234.1854  I
   1536.0364  I
   1911.9751  I
   2379.8577  I
   2962.2351  I
```

SR PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

CLASS PPM	CUM.PCT.
LESS THAN	
51.624	.412
64.257	.823
79.981	3.272
99.554	7.299
123.916	15.352
154.239	29.866
191.983	42.469
238.963	57.718
297.440	71.057
371.227	81.544
460.826	90.191
573.545	97.651
713.961	99.916
888.674	100.000
1106.143	100.000
1376.828	100.000
1713.753	100.000
2133.127	100.000
2655.127	100.000
3304.866	100.000
LESS THAN	

Probability scale: .01 .1 1 5 10 25 50 75 90 95 98 99.99

```
DATA ANALYSIS FOR  TH

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM  FOR  TH


                   I    I    I    I    I    I    I    I    I    I    I

....PPM...............  .    .    .    .    .    .    .    .    .    .
                        5    10   15   20   25   30   35   40   45   50 PERCENT
        3.3461  I
        4.2131  I
        5.3047  I
        6.6792  IIIIIIIIIIIIII
        8.4099  IIIIIII
       10.5889  IIIIIIII
       13.3325  IIIIIIIIIIII
       16.7871  IIIIIIIIIIIIIIIIII
       21.1367  IIIIIIIIIIIIIIIIII
       26.6133  IIIIIIIIIIIIIIII
       33.5090  IIIIIIIIII
       42.1913  IIIII
       53.1233  III
       66.8878  I
       84.2183  I
      106.0403  I
      133.5159  I
      168.1106  I
      211.6696  I
      266.5135  I
```

```
   TH          PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

   CLASS   CUM.PCT..01 .1    1   5   10   25    50   75 90 95 98     99.99
   PPM

LESS THAN          I    I     I   I   I    I     I    I    I  I  I      I

   3.755    0.000 -●    .     .   .   .    .     .    .    .  .  .      .
   4.728    0.000 -●    .     .   .   .    .     .    .    .  .  .      .
   5.952    0.000 -●    .     .   .   .    .     .    .    .  .  .      .
   7.495   12.584 -.    .     .   .   .●   .     .    .    .  .  .      .
   9.437   18.121 -.    .     .   .   .   ●.     .    .    .  .  .      .
  11.882   25.284 -.    .     .   .   .    ●     .    .    .  .  .      .
  14.960   36.242 -.    .     .   .   .    . ●   .    .    .  .  .      .
  18.837   52.936 -.    .     .   .   .    .     ●    .    .  .  .      .
  23.717   69.547 -.    .     .   .   .    .     .   ●.    .  .  .      .
  29.863   84.815 -.    .     .   .   .    .     .    .  ● .  .  .      .
  37.600   93.708 -.    .     .   .   .    .     .    .    .● .  .      .
  47.343   97.315 -.    .     .   .   .    .     .    .    .  . ●.      .
  59.610   99.077 -.    .     .   .   .    .     .    .    .  .  .  ●   .
  75.055   99.497 -.    .     .   .   .    .     .    .    .  .  .   ●  .
  94.512   99.748 -.    .     .   .   .    .     .    .    .  .  .     ●.
 118.968  100.000 -.    .     .   .   .    .     .    .    .  .  .      .
 149.818  100.000 -.    .     .   .   .    .     .    .    .  .  .      .
 188.637  100.000 -.    .     .   .   .    .     .    .    .  .  .      .
 237.513  100.000 -.    .     .   .   .    .     .    .    .  .  .      .
 299.054  100.000 -.    .     .   .   .    .     .    .    .  .  .      .

LESS THAN          I    I     I   I   I    I     I    I    I  I  I      I

   CLASS   CUM.PCT..01 .1    1   5   10   25    50   75 90 95 98     99.99
   PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

```
DATA ANALYSIS FOR  TIO2

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM  FOR  TIO2

                      0    I    I    I    I    I    I    I    I    I    I

....PPM...............     .    .    .    .    .    .    .    .    .    .
                           5   10   15   20   25   30   35   40   45   50 PERCENT
             .2437  II
             .2885  II
             .3415  II
             .4042  IIII
             .4785  IIIIIIIII
             .5664  IIIIIIIIIIIII
             .6704  IIIIIIIIIIIIIIIIIII
             .7935  IIIIIIIIIIIIIIII
             .9393  IIIIIIIIIIIIIIIIII
            1.1114  IIIIIIIIIIIIIII
            1.3160  IIIIIIII
            1.5578  IIIII
            1.8439  III
            2.1826  II
            2.5835  II
            3.0581  I
            3.6198  I
            4.2847  I
            5.0717  I
            6.0033  I
```

TIO2 PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

CLASS PPM / CUM.PCT. — axis: .01 .1 1 5 10 25 50 75 90 95 98 99.99

CLASS PPM (LESS THAN)	CUM.PCT.
.265	.766
.314	1.532
.372	2.473
.440	5.872
.521	14.294
.616	26.468
.729	43.664
.863	57.021
1.022	73.362
1.210	85.872
1.432	92.596
1.695	96.255
2.006	98.298
2.375	99.319
2.811	99.831
3.327	99.915
3.938	99.915
4.662	100.000
5.518	100.000
6.531	100.000

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STREAM SEDIMENT MULTI-ELEMENT STATISTICS

DATA ANALYSIS FOR V

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR V

```
                     0   I    I    I    I    I    I    I    I    I    I
....PPM.............     .    .    .    .    .    .    .    .    .    .
                         5   10   15   20   25   30   35   40   45   50 PERCENT
     26.9958  II
     35.1539  II
     42.6194  III
     51.6713  IIII
     62.6452  IIIIIIIIII
     75.9496  IIIIIIIIIIIIIII
     92.0796  IIIIIIIIIIIIIIII
    111.6353  IIIIIIIIIIIIII
    135.3442  IIIIIIIIIIIIIIIIII
    164.0884  IIIIIIIIIIIIII
    198.9371  IIIIIII
    241.1870  IIII
    292.4098  III
    354.5112  II
    429.8016  I
    521.0821  I
    631.7485  I
    765.9179  I
    928.5821  I
   1125.7925  I
```

V PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

```
CLASS     CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98   99.99
PPM

LESS THAN         I   I    I  I  I   I    I   I    I I I      I

   31.427    .587 -.  .  ● .  .  .   .    .   .    . . .      .
   38.767   1.091 -.  .    ● .  .   .    .   .    . . .      .
   46.328   3.104 -.  .    . ●.  .   .    .   .    . . .      .
   56.894   5.621 -.  .    .  .●  .   .    .   .    . . .      .
   68.977  14.262 -.  .    .  .  .●  .    .   .    . . .      .
   83.627  28.104 -.  .    .  .  .   .●   .   .    . . .      .
  101.387  43.456 -.  .    .  .  .   .  ●.   .    . . .      .
  122.919  56.711 -.  .    .  .  .   .    .●  .    . . .      .
  149.025  73.658 -.  .    .  .  .   .    .   ●    . . .      .
  180.674  86.745 -.  .    .  .  .   .    .   .  ● . . .      .
  219.046  92.953 -.  .    .  .  .   .    .   .    .●. .      .
  265.566  95.847 -.  .    .  .  .   .    .   .    . ● .      .
  321.367  98.322 -.  .    .  .  .   .    .   .    . . .●     .
  389.345  99.161 -.  .    .  .  .   .    .   .    . . . ●    .
  473.246  99.497 -.  .    .  .  .   .    .   .    . . .  ●   .
  573.753  99.748 -.  .    .  .  .   .    .   .    . . .    ● .
  695.606  99.832 -.  .    .  .  .   .    .   .    . . .     ●.
  843.337  99.916 -.  .    .  .  .   .    .   .    . . .      ●
 1022.444  99.916 -.  .    .  .  .   .    .   .    . . .      ●
 1233.568 100.000 -.  .    .  .  .   .    .   .    . . .      .

LESS THAN         I   I    I  I  I   I    I   I    I I I      I

CLASS     CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98   99.99
PPM
```

DATA ANALYSIS FOR ZN

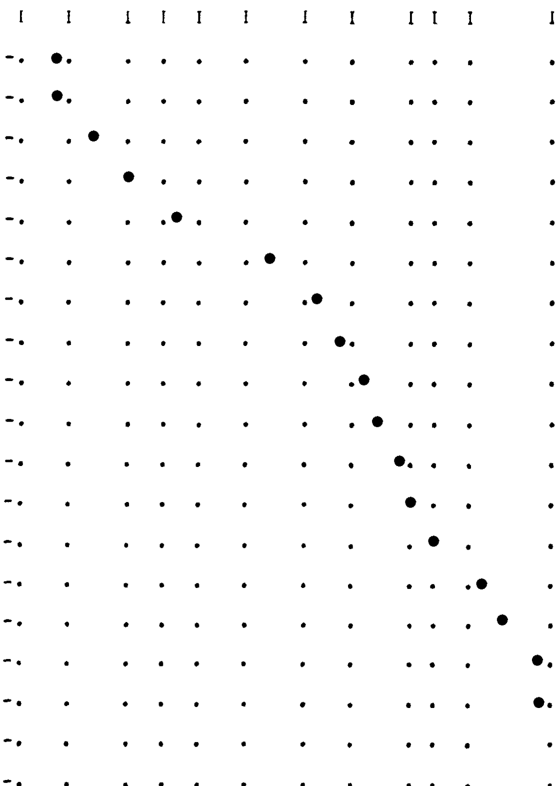
LOWER LIMIT..NUM FR....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR ZN

```
                    0    I    I    I    I    I    I    I    I    I    I
....PPM.............     .    .    .    .    .    .    .    .    .    .
                         5   10   15   20   25   30   35   40   45   50 PERCENT
      9.0802  I
     14.9815  I
     24.7180  I
     40.7822  II
     67.2865  IIIIIII
    111.0160  IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
    183.1653  IIIIIIIIIIIIIIIIIIII
    302.2044  IIIIIIIIIIIIII
    496.6070  IIIIIIIIII
    822.6517  IIIIIIII
   1357.2931  IIIII
   2239.3978  IIIII
   3694.7824  IIII
   6096.0214  IIII
  10057.8255  II
  16594.4060  I
  27379.1101  I
  45172.7929  I
  74530.5898  I
 122968.0182  I
```

ZN PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

CLASS PPM / CUM.PCT. / .01 .1 1 5 10 25 50 75 90 95 98 99.99



LESS THAN (CLASS PPM)	CUM.PCT.
11.663	.084
19.243	.084
31.750	.336
52.384	1.007
86.428	6.544
142.598	36.326
235.273	54.698
388.177	67.451
640.453	75.342
1056.683	83.473
1743.422	87.919
2876.471	92.114
4745.890	95.302
7830.244	98.658
12919.119	99.413
21315.254	99.832
35168.138	99.832
58023.744	100.000
95733.374	100.000

DATA ANALYSIS FOR ZR

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR ZR

....PPM..............	5 10 15 20 25 30 35 40 45 50 PERCENT
30.8139	III
36.2674	III
42.6860	IIII
50.2407	IIIIII
59.1323	IIIIIII
69.5977	IIIIIII
81.9152	IIIIIIIIIII
96.4127	IIIIIIIIIIIIIIIIIIII
113.4760	IIIIIIIIIIIIIIIIIIIIII
133.5592	IIIIIIIIIIIIIIII
157.1967	IIIIIIIIIII
185.0177	IIII
217.7625	II
256.3025	I
301.6633	I
355.0522	I
417.8900	I
491.8489	I
578.8972	I
681.3515	I

ZR PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

CLASS PPM / CUM.PCT..01 .1 1 5 10 25 50 75 90 95 98 99.99

CLASS PPM LESS THAN	CUM.PCT.
33.430	1.594
39.346	3.188
46.310	5.705
54.505	10.403
64.152	16.527
75.506	22.148
88.869	32.383
104.597	51.091
123.109	71.896
144.947	86.745
173.541	96.393
200.723	99.329
236.248	99.916
278.059	100.000
327.271	100.000
385.192	100.000
453.364	100.000
533.601	100.000
628.039	100.000
739.190	100.000

CLASS PPM / CUM.PCT..01 .1 1 5 10 25 50 75 90 95 98 99.99

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

```
DATA ANALYSIS FOR  AS

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM  FOR  AS


                      0    I    I    I    I    I    I    I    I    I    I

....PPM...............     .    .    .    .    .    .    .    .    .    .
                           5   10   15   20   25   30   35   40   45   50 PERCENT
            .8214  I
           1.2221  I
           1.8193  IIIIIII
           2.7083  IIIIII
           4.0315  IIIIIII
           6.0020  IIIIIIIIIIIII
           8.9350  IIIIIIIIIIIII
          13.3013  IIIIIIIIIIIIIIII
          19.8012  IIIIIIIIIIIIIII
          29.4774  IIIIIIIIIIIIIII
          43.8825  IIIIIIIIII
          65.3257  IIIII
          97.2482  II
         144.7702  I
         215.5146  I
         320.8294  I
         477.6080  I
         710.9992  I
        1058.4408  I
        1575.6657  I

   AS          PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

    CLASS   CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98    99.99
    PPM

LESS THAN           I   I    I  I  I   I    I   I     I I I      I

    1.002    0.000 -●   .    .  .  .   .    .   .     . . .      .
    1.491    0.001 -●   .    .  .  .   .    .   .     . . .      .
    2.220    5.712 -.   .    . .●  .   .    .   .     . . .      .
    3.304   10.545 -.   .    .  .  ●   .    .   .     . . .      .
    4.919   15.257 -.   .    .  .  . ● .    .   .     . . .      .
    7.323   28.553 -.   .    .  .  .  .●    .   .     . . .      .
   10.902   40.334 -.   .    .  .  .   .  ● .   .     . . .      .
   16.229   55.448 -.   .    .  .  .   .   .●   .     . . .      .
   24.160   64.859 -.   .    .  .  .   .    .  ●.     . . .      .
   35.966   83.568 -.   .    .  .  .   .    .   . ●   . . .      .
   53.541   93.654 -.   .    .  .  .   .    .   .     .●. .      .
   79.705   97.540 -.   .    .  .  .   .    .   .     ...●.      .
  118.653   99.033 -.   .    .  .  .   .    .   .     . . .●     .
  176.635   99.473 -.   .    .  .  .   .    .   .     . . .   ●  .
  262.951   99.649 -.   .    .  .  .   .    .   .     . . .    ● .
  391.447   99.912 -.   .    .  .  .   .    .   .     . . .      ●
  582.734  100.000 -.   .    .  .  .   .    .   .     . . .      .
  867.497  100.000 -.   .    .  .  .   .    .   .     . . .      .
 1291.414  100.000 -.   .    .  .  .   .    .   .     . . .      .
 1922.444  100.000 -.   .    .  .  .   .    .   .     . . .      .

LESS THAN           I   I    I  I  I   I    I   I     I I I      I

    CLASS   CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98    99.99
    PPM
```

```
DATA ANALYSIS FOR   MO

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM  FOR  AMO


                    (    I    I    I    I    I    I    I    I    I    I

....PPM..............    .    .    .    .    .    .    .    .    .    .
                         5   10   15   20   25   30   35   40   45   50 PERCENT
     .6869  I
     .8949  I
    1.1658  I
    1.5188  I
    1.9787  IIIIIIIIIIIIIIIIIIIIIIII
    2.5779  I
    3.3585  IIIIIIIIIIIIIIIIIIII
    4.3754  IIIIIIIIIIIIIII
    5.7002  IIIIIIIIIIIIIIIIII
    7.4262  IIIIIIIIIIII
    9.6749  IIIIIIIIII
   12.6044  IIII
   16.4211  II
   21.3932  II
   27.8709  I
   36.3112  I
   47.3047  I
   61.6284  I
   80.2993  I
  104.6006  I
```

```
  MO       PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

  CLASS   CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98    99.99
   PPM

LESS THAN          I   I    I  I  I   I    I   I    I I  I      I
     .784   0.000 -●   .    .  .  .   .    .   .    . .  .      .
    1.021   0.000 -●   .    .  .  .   .    .   .    . .  .      .
    1.331   0.000 -●   .    .  .  .   .    .   .    . .  .      .
    1.734   0.000 -●   .    .  .  .   .    .   .    . .  .      .
    2.259  23.016 -.   .    .  .  .   ●    .   .    . .  .      .
    2.942  23.016 -.   .    .  .  .   ●    .   .    . .  .      .
    3.833  41.667 -.   .    .  .  .   .  ● .   .    . .  .      .
    4.994  56.052 -.   .    .  .  .   .    .●  .    . .  .      .
    6.506  73.413 -.   .    .  .  .   .    .   ●    . .  .      .
    8.476  84.425 -.   .    .  .  .   .    .   . ●  . .  .      .
   11.043  93.552 -.   .    .  .  .   .    .   .    .●.  .      .
   14.387  96.528 -.   .    .  .  .   .    .   .    . .● .      .
   18.743  98.016 -.   .    .  .  .   .    .   .    . .  ●      .
   24.418  98.909 -.   .    .  .  .   .    .   .    . .  .●     .
   31.812  99.107 -.   .    .  .  .   .    .   .    . .  . ●    .
   41.444  99.504 -.   .    .  .  .   .    .   .    . .  .  ●   .
   53.994  99.603 -.   .    .  .  .   .    .   .    . .  .   ●  .
   70.343  99.603 -.   .    .  .  .   .    .   .    . .  .   ●  .
   91.642  99.603 -.   .    .  .  .   .    .   .    . .  .   ●  .
  119.391 100.000 -.   .    .  .  .   .    .   .    . .  .      .
LESS THAN          I   I    I  I  I   I    I   I    I I  I      I

  CLASS   CUM.PCT..01 .1   1  5  10  25   50  75 90 95 98    99.99
   PPM
```

STREAM SEDIMENT MULTI-ELEMENT STATISTICS

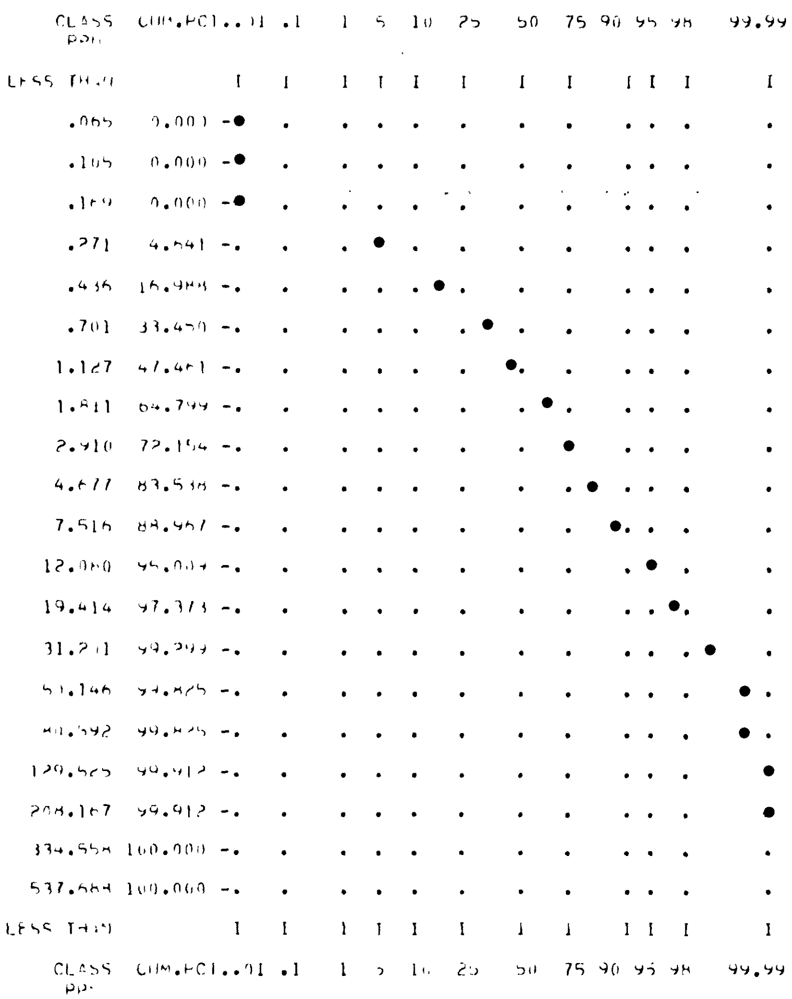
DATA ANALYSIS FOR U

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR U

```
                            I     I     I     I     I     I     I     I     I     I
....PPM...............      .     .     .     .     .     .     .     .     .     .
                            5    10    15    20    25    30    35    40    45    50 PERCENT
          .0516   I
          .0829   I
          .1332   I
          .2141   IIIIII
          .3440   IIIIIIIIIIIII
          .5529   IIIIIIIIIIIIIIII
          .8885   IIIIIIIIIIIIII
         1.4282   IIIIIIIIIIIIIIIII
         2.2953   IIIIIIII
         3.6891   IIIIIIIIIIII
         5.9284   IIIIII
         9.5285   IIIIIII
        15.3137   III
        24.6118   III
        39.5552   II
        63.5716   I
       102.1598   I
       164.2033   I
       263.9012   I
       424.1318   I
```

U PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

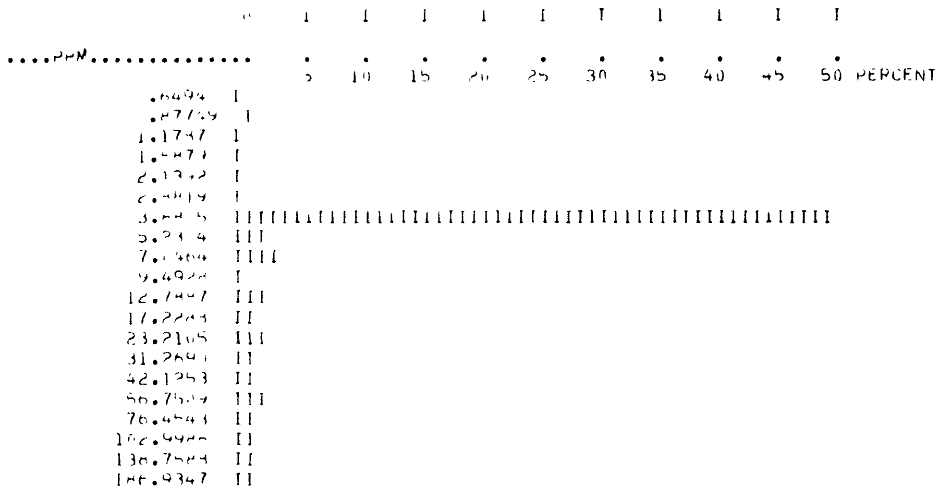


CLASS PPM LESS THAN	CUM.PCT
.065	0.001
.105	0.000
.169	0.000
.271	4.641
.436	16.988
.701	33.450
1.127	47.461
1.811	64.799
2.910	72.154
4.677	83.538
7.516	88.967
12.080	95.004
19.414	97.373
31.201	99.299
51.146	99.825
80.592	99.825
129.525	99.912
208.167	99.912
334.558	100.000
537.668	100.000

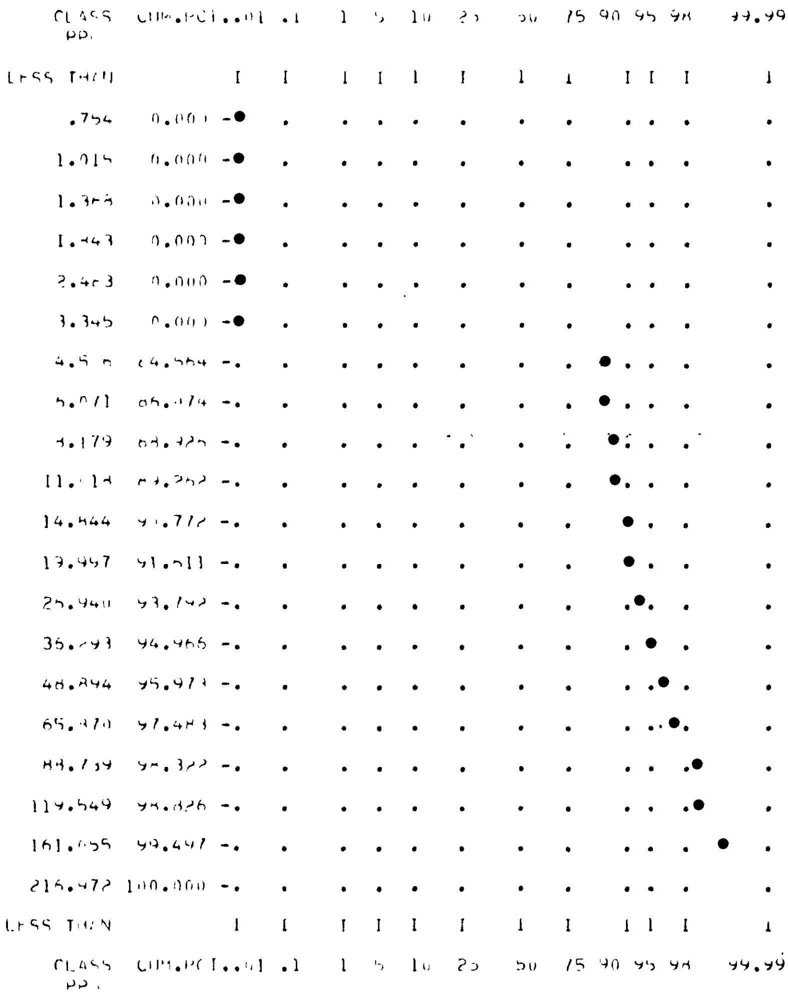
DATA ANALYSIS FOR W

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR W



W PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION



STREAM SEDIMENT MULTI-ELEMENT STATISTICS

DATA ANALYSIS FOR SN

LOWER LIMIT..NUMBER....PERCENT....CUM.PERC

FREQUENCY DISTRIBUTION HISTOGRAM FOR SN

```
                        0    I    I    I    I    I    I    I    I    I    I
....PPM...............       .    .    .    .    .    .    .    .    .    .
                             5    10   15   20   25   30   35   40   45   50 PERCENT
         7.3268   I
         9.5343   I
        12.4064   I
        16.1449   II
        21.0093   II
        27.3392   IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
        35.5762   IIIIII
        46.2955   IIIIIIII
        60.2432   IIIIIIII
        78.3934   IIIIIIIIII
       102.0132   IIIIII
       132.7484   III
       172.7449   IIIIIIIII
       224.7913   III
       292.5188   I
       380.6519   II
       495.3358   I
       644.5797   I
       838.7956   I
      1091.5038   I
```

SN PROBABILITY PLOT OF CUM.FREQ.DISTRIBUTION

CLASS PPM LESS THAN	CUM.PCT.
8.355	0.000
10.876	.419
14.153	.587
18.417	1.678
23.966	2.936
31.187	56.040
40.583	60.570
52.811	67.451
68.722	74.329
89.427	82.886
116.371	87.500
151.432	89.178
197.057	97.232
256.429	99.245
333.688	99.329
434.225	100.000
565.053	100.000
735.299	100.000
956.837	100.000
1245.123	100.000

Probability scale: .01 .1 1 5 10 25 50 75 90 95 98 99.99

APEX REMOTE BATCH

VOLUME II

Appendix B

Plates B I through B XV

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Geochemical and Geostatistical Evaluation of American Flats-Silverton Planning Units, San Juan Volcanic Province, Colorado

by

E. F. Weiland, J. W. Lindemann, R. A. Connors, W. T. Meyers

Barringer Research Inc.

and

S. A. Johnson, U.S. Bureau of Land Management

With an introduction by William D. Heran

U.S. Geological Survey

Open-File Report 81-599 VOLUME III

1981

VOLUME III

Appendix C

Tables C-1 and C-2

Plates C I through C VII

TABLE C-1

FACTOR LOADINGS DETERMINED FROM FACTOR ANALYSIS

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
AG	.75901	.07943	.15878	.11047	.18973	.13087	.22583
AL2O3	.23126	.11379	.18679	.05845	.34154	.25226	.24524
BA	.15301	.45099	.13780	.11700	.14061	.41105	.58719
BE	.02872	.03641	.92057	.25000	.23634	.23704	.14517
B	-.16603	.41652	.06674	.31974	.10116	.01266	.64578
CAO	.18516	.15401	.17693	.92111	.40108	.06772	.11292
CD	.42387	.00410	.00395	.06970	.01304	.05073	.11101
CO	.10879	.19913	.13880	.09372	.32232	.83724	-.22111
CR	.25182	.48824	.31902	.07752	.29990	.33403	.17427
CU	.91368	.27063	.20879	.41547	.07104	.03940	.07249
FE2O3	.13138	.26821	.22191	.30691	.86523	.30878	.01181
K2O	.20501	.06525	.22214	.21378	.07857	.09043	.67613
MGO	.06999	.79604	.25771	.14433	.46090	.24546	.38074
MNO	.67527	.21937	.07566	.10148	.09670	.23319	.15670
NA2O	.45108	.00063	.21811	.65790	.39543	.18170	.47365
P2O5	.05659	.47901	.10351	.05485	.59657	.29479	.31093
[illegible]	.19411	.69270	.05238	.07136	.48127	.50410	.06942
[illegible]	.90597	.13008	.15678	.43807	.14745	.01847	.03918
[illegible]	.78445	.03941	.28488	.75007	.63716	.04038	.11964
[illegible]	.31602	.27544	.67059	.08598	.00125	.39517	.32159
[illegible]	.32326	.07920	.10833	.50879	.88467	.17909	.16406
[illegible]	.01330	.36131	.29901	.37090	.91418	.20326	.12638
[illegible]	[illegible]	.19666	.08831	.31488	.04428	.09617	.16931
[illegible]	.43111	.21357	.37001	.32293	.31339	.14711	.36954
[illegible]	.04036	.23585	.16860	.70462	.23665	.02295	.16480
[illegible]	.64986	.10016	.10664	.50169	.33417	.01167	.05235
[illegible]	.10163	.24246	.67959	.09366	-.36372	.06867	.07829
[illegible]	.15148	.01592	.00405	.12397	.10340	.08392	.07350
SB	.11874	.10872	.09051	.01158	.06727	.30902	.06120

VOLUME III

Appendix D

Table D-1

Figures D-1 through D-11

Plate D I

VOLUME III

Appendix E

Tables E-1 and E-2

Plates E I and E II

TABLE E-1

MULTIPLE REGRESSION EQUATION

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	FD4		154.28992	0	.40573	.16461	.16461	.40573	154.28992	0
2	RT6		48.29881	.000	.46174	.21321	.04859	.31851	105.95447	.000
3	RT10		40.90141	0	.50236	.25236	.03915	.17060	87.87432	0
4	FD2		23.72116	.000	.52386	.27443	.02207	.17200	73.75339	.000
5	FS4		22.35512	.000	.54283	.29467	.02024	-.22133	65.08913	0
6	FS1		5.26660	.022	.54718	.29941	.00474	-.14819	55.41579	.000
7	RT4		3.89842	.049	.55037	.30291	.00350	.03494	48.23312	0
8	FS3		2.29243	.130	.55223	.30496	.00205	.09982	42.56074	.000
9	RT9		1.50339	.221	.55345	.30631	.00135	-.01208	38.02335	0
10	FD1		1.23571	.267	.55445	.30741	.00111	.06824	34.35499	.000
11	RT8		1.25074	.264	.55546	.30853	.00112	-.14105	31.35563	0
12	FS6		1.02640	.311	.55628	.30945	.00092	-.09569	28.82918	.000
13	RT0		.85165	.356	.55697	.31021	.00076	-.11122	26.67195	0
14	RT3		.80214	.371	.55761	.31093	.00072	-.05373	24.81775	.000
15	FS5		.41629	.519	.55795	.31130	.00037	-.08488	23.17343	0
16	FS7		.67898	.410	.55849	.31191	.00061	.00029	21.75845	.000
17	RT2		.26108	.610	.55870	.31215	.00023	-.10698	20.47420	0
18	RT5		.14715	.701	.55882	.31228	.00013	-.03486	19.32342	.000
19	FD3		.10543	.746	.55890	.31237	.00009	-.00140	18.29057	0
20	FS2		.05497	.815	.55895	.31242	.00005	.07575	17.35732	.000
21	RT7		.01706	.896	.55896	.31244	.00002	-.10949	16.51033	0

VOLUME III

Appendix F

Plates F I through F III