STATE OF ALASKA

Keith H. Miller - Governor

DEPARTMENT OF NATURAL RESOURCES

Thomas E. Kelly - Commissioner

DIVISION OF MINES AND GEOLOGY

James A. Williams - Director

GEOLOGIC REPORT NO. 34

Geology and Geochemistry
Diana Lakes Area
Western Talkeetna Mountains, Alaska

By

Robert E. Anderson

College, Alaska

June 1969

CONTENTS

ILLUSTRATIONS

CONTENTS

TABLES

APPENDICES

GEOLOGY AND GEOCHEMISTRY OF THE DIANA LAKES AREA WESTERN TALKEETNA MOUNTAINS, ALASKA

By

Robert E. Anderson

ABSTRACT

Highly fractured granodiorite and greenstone with some later volcanic and related rocks lie along the western edge of the Talkeetna Mountains between Iron Creek and Sheep River, west of Rainbow Lake.

The granodiorite forms a discordant northwest-trending stock which interrupts the general northeast structural trend of the Talkeetna Mountains.

Results from geochemical sampling of stream sediments and rock exposures were put into the University of Alaska's IBM 360 computer for statistical calculations. Trend surface analyses through the fifth degree from the rock sample data were drawn. Comparison of the stream sediment samples with the rock sample trend surfaces and their residuals indicate possible hydrothermal mineralization at depth in several locations. These are viewed as possible target areas for future ore mineral exploration.

INTRODUCTION

An area located on the western edge of the Talkeetna Mountains between Sheep River on the southwest and Iron Creek on the northeast, called the Diana Lakes area, was selected for geologic and geochemical investigation as a continuation of a project to examine the iron stained areas in the Talkeetna Mountains reported by Rose (1965). Iron staining or capping has been indicative of a number of hydrothermal and porphyry mineral deposits in the western United States. Another encouraging feature for possible mineralization came from a study of aerial photos of the area which indicated several major faults near the iron stained sections. The southeast side of the mapped area (fig 1) lies about seven miles north-northwest of a known area of copper mineralization along Iron Creek.

Before the work of Rose (in 1965 and 1967), very little geologic work had been done in the western Talkeetna Mountains. The earliest geologic map of the area was done by S. R. Capps in 1919 (p 187-205). That map is very generalized and on a scale of 1 to 500,000. In 1925 some of the prospects in the Talkeetna Mountains were visited and a brief report accompanied by sketches of the properties were submitted to the Alaska Railroad (Townsend, 1925). A more complete report but still quite general was made by Capps in 1940. The geologic map in that report is on a 1:250,000 scale. There has been no other geologic mapping on a broad scale since Capps' 1940 report. Grantz (1960 A & B) investigated the southeastern corner of the Talkeetna Mountains quadrangle putting out two geologic maps on a 1:48,000 scale.

The Diana Lakes area has been highly fractured and faulted and there are numerous 25 to 75 foot scarps making good rock exposures above 2500 feet elevation. Stream sediment sampling was difficult below the 2500 foot level because of heavy growth of alder and willow brush.

The Division of Mines and Geology field party was in the Diana Lakes area for a total of 26 days from July 11 to August 26, 1968.

The writer was assisted by Gardner F. Gillespie, III, who collected the stream sediment samples and assisted in collecting rock samples. Access to the area was by float plane. Don Sheldon of Talkeetna Air Service worked out the transportation and support problems.

G E N E R A L G E O L O G Y

A highly fractured area of principally greenstone and intrusive rock lies between Iron Creek and Sheep River (fig 1). Earlier geologic maps (Capps, 1940 and Dutro and Payne, 1957), show all but the southeast side of this area as part of a batholith trending NE through the Talkeetna Mountains. The present work shows that part of what was previously mapped as a granitic batholith is in fact greenstone with minor thin interbedded meta-argillite and pyroclastic rocks. The intrusive forms a discordant stock trending NW. It is probably separate from the concordant NE trending granitic batholith shown by Capp (1940) for the Talkeetna area. Emplacement of the stock resulted in doming of the overlying lavas and associated sills which nearly erased the general NE structural trend of the Talkeetna Mountains. During or following emplacement of the stock, faulting occurred which placed the country rock into isolated contact with the intrusive rocks. Magmatic stoping may have been the mechanism for the fracturing and isolation of large blocks of country rock in the intrusive. Metamorphism of the country rock to greenstone probably occurred during emplacement of the stock. The greenstone is generally blocky, showing little shistosity or bedding, i. e., a hornfels, and in places grading into an andesite granofel or a gabbro granofel. The most recent magmatic rocks in the area are rhyolite volcanic flows and several rhyolite dikes. Associated with the volcanic activity is a tuffaceous sandstone.

Glacial advances covered the area during middle to late Pleistocene (Coulter and others, 1965). Much of the southeast portion of the mapped area (fig 1) is rounded and smoothed with numerous glacially-transported boulders appearing in the tundra. In much of the area north of Rusty Creek (fig 1) numerous scarps and sharp ridges indicate post-glacial movement along the northwest and east-west trending fault zones.

STRUCTURAL GEOLOGY

Faults

Two major fault directions are apparent in the mapped area. Steeply-dipping, nearly east-west trending faults and fractures appear from aerial photographic study to be restricted to the area around the intrusive stock and appear to have been caused by the stock emplacement. Dips range from vertical to 55°S; no north dips were found. The other prominent faults of the area trend northwest with nearly vertical dips ranging from 80°SW to 75°NE. At many places dips on the northwest trending faults were impossible to measure.

Structures trending northwest are of a more regional nature than the east-west faults. Northwest trending structures are apparent on aerial photographs and on topographic maps in many places throughout the central to southwestern part of the Talkeetna Mountains quadrangle. The northeast trending regional structure so apparent along the upper Talkeetna River (Anderson, 1969) was almost obliterated by the stock emplacement in all but the southeast portion of the mapped area (fig 1). The greenstone-granite contact in the southeast side of the map (fig 1) follows the regional northeast trend. One fault and an associated rhyolite dike southeast of Diana Lakes may also reflect the northeast regional trend.

Intense faulting and fracturing parallels both the northwest and the east-west structural trends. Only the major faults are plotted on the map (fig 1).

Joints

A study of jointing in the area shows that most of the joints measured are steeply dipping with no particular directional trend indicated. Rock exposures along the perimeter of the mapped area (fig 1) are infrequent, but jointing in the exposures observed tend to outline the doming effect of the stock emplacement.

PETROLOGY

No age dating on any of the rocks in this area was done. Ages tentatively assigned to the various formations are arrived at by the inference that similar rock types correlate with the dated rocks in the southeast part of the Talkeetna Mountains quadrangle (Grantz, 1960).

To aid the petrologic discussion, various rock samples were studied in thin section by polarizing microscope and selected samples were analyzed by x-ray diffraction for major minerals by the Division of Mines and Geology Laboratory, College, Alaska.

Metamorphic Rocks

Greenstone (g) -- Greenstone is the principal metamorphic rock in the mapped area. The greenstone in this area is tentatively placed in the Talkeetna formation of lower Jurassic age. The greenstone varies from an orthoandesite granofel which shows good flow structure in a few places and is porphyritic or porphyroblastic in many places, to an orthodiorite granofel. In most places metamorphism of the volcanic and near-surface intrusive andesite and diorite is low order. In a few places, interbedded with the granofels, are thin outcrops of rock showing phyllitic texture.

In thin section the orthodiorite shows abundant plagioclase feldspar, moderate to abundant green hornblende (tremolite?), moderate to abundant epidote, moderate chlorite, and moderate to minor quartz. Accessory pyrite was noted in several places in the field and accessory sphene was observed in thin section. In thin section the orthoandesite shows abundant feldspar, probably plagioclase but difficult to determine due to metamorphism, moderate to abundant green hornblende (tremolite?), moderate chlorite, and moderate epidote. Quartz is a minor constituent of the orthoandesite. Accessory pyrite was noted. In places pyrite is surrounded by accessory hematite. In the northwest section of the mapped area hematite veinlets were also observed.

In a number of places interbedded with the greenstone, but not shown on the map (fig 1), are thin beds of slightly metamorphosed arkose and pyroclastic rocks. Neither the arkose or the pyroclastic rocks contain any optically apparent pyrite or other sulfide minerals.

Intrusive Rocks

Granodiorite (gd) -- The intrusive stock ranges from quartz monzonite, through granodiorite to quartz diorite. No contacts or distinct changes were observed, so the rocks are considered all part of a single intrusive stock and are referred to as granodiorite in the text and on the map (fig 1). In age, the stock may be related to the Talkeetna Mountains batholith, placing it between lower and middle Jurassic in age. However, the author feels that the stock is slightly younger than the batholith since the stock breaks up the general NE structural and stratigraphic trend probably caused by emplacement of the batholith.

In thin section a sample of quartz monzonite from the vicinity of the Diana Lakes contains in decreasing abundance; plagioclase showing albite and Carlsbad twinning; abundant to moderate amounts of quartz; moderate green hornblende showing good cleavage and strong pleochroism; moderate epidote and chlorite; moderate to minor orthoclase(?); accessory apatite; sphene; and pyrite.

Quartz diorite in thin section from samples taken near the center of the mapped area, (fig 1) contains in decreasing abundance; plagioclase showing excellent albite and Carlsbad twinning in addition to normal zoning; anhedral quartz; strongly pleochroic green hornblende, in places showing brown alteration rims; augite(?) showing moderate relief, and faint green color, strongly pleochroic, brown biotite; and abundant accessory pyrite, altered in places to hematite.

In several places greenstone inclusions were noted in the granodiorite rocks. At most places they are only a few inches across, and in a few places they are a foot or over in longest dimension. One very large dike-shaped inclusion of greenstone is shown in the northwest portion of the map (fig 1).

Volcanic and Related Rocks

Rhyolite(?) (rh) -- The volcanic rocks and dike rocks observed are porphyritic rhyolite, possibly middle to upper Tertiary in age. The dikes are generally a drab, medium dark, grayish brown, while the lavas are tan and frequently iron stained, particularly along Rusty Creek (fig 1). Due to the fine grained nature of these rocks, thin section mineral identification was difficult. Many of the phenocrysts were identified as plagioclase crystals. One point that was noted in all of the samples collected is the conspicuous shortage of mafic minerals. Examination of the rhyolite by x-ray diffraction showed the following minerals listed in decreasing order of abundance; quartz; feldspar (in some places feldspar was slightly more abundant than quartz); muscovite; and chlorite. In the field, accessory pyrite up to 10% was noted in places along Rusty Creek which accounts for the prominent iron staining. Pyrite in such abundance is not normal in rhyolite and may be of epigenetic origin.

Tuffaceous Sandstone (ts) -- Tuffaceous sandstone is an irregular bed confined to the central eastern part of the mapped area (fig 1). The tuffaceous sandstone shows mostly quartz, minor feldspar, and sercite in a quartz matrix giving the appearance of a subgraywacke. In some places toward the greenstone contact (fig 1) limonite staining which results from weathering of amphibole and biotite is apparent. In other places toward the granite contacts, the amphiboles and biotite are not weathered and form as much as 1% of the rock. Some quartz has been recrystallized.

GEOCHEMICAL INVESTIGATIONS

The results of the stream sediment sample analyses were put into a computer to tabulate the data and to calculate the statistical characteristics. The program for this was written by L. E. Heiner, Mining Engineer, Mineral Industry Research Laboratory, University of Alaska. Rock sample values were put into the computer on a program to calculate trend surface analyses. The IBM 360 Model 40 computer at the University of Alaska performed the computations. To compare stream sediment geochemical results with rock sample geochemical results, threshold and anomalous stream sediment values were plotted on the fifth degree trend surface analysis maps computed from the rock sample values. All samples were given numbers in the field and no changes were made for the maps or the computer programs.

STREAM SEDIMENT SAMPLES

Stream sediment samples were collected from all flowing creeks in the mapped area (fig 1). The samples were dried in the College Laboratory of the Division of Mines and Geology, then forwarded to the U. S. Geological Survey Field Laboratory in Anchorage to be analyzed for thirty elements by semiquantitative spectrographic methods. Only twenty-three elements were detected and the results are shown in Appendix 1. Intervals of estimate and detection limit for this method of analysis are shown in Appendix 2. Eliminated from Appendix 1, which shows the computer calculation results of threshold and anomalous values, are silver (Ag), titanium (Ti), and beryllium (Be), because not enough of the samples showed these elements to be of statistical significance. For the remaining twenty elements the mean and the standard deviation were calculated. From these measures of central tendency, the threshold value, or upper limit of normal background fluctuation, and anomalous values were determined for each element. The computer also plotted a histogram of frequency distribution for copper (Appendix 3).

The threshold and anomalous values for each element were computed by methods described in Hawkes and Webb (1962, p 30). The threshold value is taken as the mean plus twice the standard deviation; anomalous values are taken as the mean plus three standard deviations. These values are meaningful for a normal distribution, the further the data departs from normalcy the less reliable are the computed threshold and anomalous value. Appendix 1, for stream sediment samples, shows the calculated average, standard deviation, threshold, and anomalous values for each element detected.

The concentration of an element in a given sample is either in the background range, between the threshold value and anomalous value, or greater than the anomalous value. Samples are considered possibly anomalous if the concentration is between the threshold value and the anomalous value and probably anomalous if the concentration of an element is above the anomalous value. A listing of all possible and probable anomalous values is shown on Table 1. Locations of all samples taken are shown on the map (fig 1). Stream sediment samples containing probable anomalous amounts of copper, lead, zinc, nickel, chromium, cobalt, and molybdenum are indicated, and samples which have two or more of the above listed elements in possible anomalous concentrations are also indicated.

Discussion of Major Elements

Copper -- The average copper content of 50 ppm (Appendix 1) is in the range of what would normally be expected from soil samples (Hawkes & Webb, p 365). The average of 50 ppm is slightly below another section of the Talkeetna Mountains, (Rose, 1967), where, by discounting two very high copper anomalies, the average copper content is 80 ppm. In the Diana Lakes area the highest concentration of copper lies in the northwest part (fig 1). The samples were taken near the point of convergence of three faults. Bedrock in the vicinity of the samples is greenstone, which in this vicinity is higher in quartz content than most of the other greenstone observed.

Lead -- The lead average of 22 ppm (Appendix 1) is about what would be expected from soil samples (Hawkes & Webb, p 367) and is well above the lead average of 7.57 ppm in another section of the Talkeetna Mountains (Rose, 1967). There are no probable lead anomalies, but nine samples are above threshold and are considered possibly anomalous. Most of the possibly anomalous samples come from the Rusty Creek drainage (fig 1). Bedrock crossed by this drainage is granodiorite and rhyolite. The rhyolite in places shows abundant accessory pyrite.

Manganese -- Two manganese anomalies occur with high lead, zinc, molybdenum, and other elements in sample numbers 81 and 82 (table 1).

Zinc -- The zinc average of 52 ppm (Appendix 1) is below the average of 93 ppm obtained in another section of the Talkeetna Mountains (Rose, 1967). It is about average for soil samples as defined by Hawkes and Webb (p 376). Threshold samples 76, 78, 82, and anomalous sample 81, are from the Rusty Creek drainage and are apparently associated with lead occurrences.

Molybdenum -- The molybdenum average of 6 ppm (Appendix 1) is well above the average of 2 ppm from another section of the Talkeetna Mountains (Rose, 1967). The average of 2 ppm is also what would be expected from normal soils (Hawkes & Webb, p 369). The single probable molybdenum anomaly, sample 70, occurs on Rusty Creek, upstream from the lead and zinc concentrations (fig 1) and is not associated with any other threshold or anomalous metal concentration (fig 2). Of the threshold molybdenum samples, numbers 38 and 73 are not associated with other metals, number 50 is associated with threshold copper and threshold lead; numbers 81 and 82 are associated with lead and zinc along Rusty Creek.

Nickel -- The nickel average of 25 ppm (Appendix 1) is just slightly lower than the average of 33 ppm obtained in the other section of the Talkeetna Mountains (Rose, 1967) and well below what would be expected from streams cutting greenstone (Hawkes & Webb, p 371). Only two samples lie above threshold value (Appendix 1) and both of these are probable anomalous samples 31 and 61. Both of these samples are associated with anomalous chromium. Sample 31 is also associated with threshold copper in the northwest section of the mapped area (fig 1). Sample 61 is on Gard Creek which drains the lowest of Diana Lakes.

Chromium -- The chromium analysis average of 56 ppm (Appendix 1) is far below what would normally be expected. Soil sample average is given at 200 ppm (Hawkes & Webb, p 363). Three anomalous chromium samples are recorded (Appendix 1). Sample 31 is associated with threshold nickel, cobalt, and copper; sample 32 is associated with above threshold copper and cobalt; and sample 61 is associated with above threshold nickel.

Cobalt -- The cobalt average of 15 ppm (Appendix 1) is slightly above the average given for cobalt soil samples (Hawkes & Webb, p 363). Samples 31 and 32 are anomalous (Appendix 1) and are associated with above threshold values of copper and chromium (table 2). Sample 82 is a threshold reading and is associated with threshold lead, molybdenum, and zinc.

Discussion of Trace Element Associations

Geochemical mineral associations are specific for some rock types, both sedimentary and igneous, and for most hydrothermal sulfide ores. At the surface, supergene mobility of the existing elements is dependent on the minerals in which they occur and the conditions of weathering (Andrews-Jones, 1968, p 5). Consequently, stream sediment samples are a result of both weathering and the original rock element associations.

Table 2 shows the possible and probable anomalous occurrence of element associations from the stream sediment samples. A few of the associations may reflect their origin. The base metals in sediment samples 31, 32, and 61 are associations which are found in either a hydrothermal sulfide ore or in some ultramafic rocks. The associations of molybdenum with lead, copper and/or zinc in samples 50, 81, and 82 reflect hydrothermal sulfide mineralization (Andrews-Jones, 1968, p 7).

TABLE 1

Threshold and Anomalous Stream Sediment Samples

Chemical Symbol not underlined = Possible Anomalous Value

Chemical Symbol underlined = Probable Anomalous Value

(Underlined symbols are shown in bold.)

Chemical Symbol		Element
Ag	=	Silver
B	=	Boron
Ba	=	Barium
Be	=	Beryllium
Ca	=	Calcium
Co	=	Cobalt
Cr	=	Chromium
Cu	=	Copper
Fe	=	Iron
La	=	Lanthanum
Mg	=	Magnesium
Mo	=	Molybdenum
Mn	=	Manganese
Nb	=	Niobium
Ni	=	Nickel
Pb	=	Lead
Sc	=	Scandium
Sr	=	Strontium
Ti	=	Titanium
V	=	Vanadium
Y	=	Yttrium
Zn	=	Zinc
Zr	=	Zirconium

Sample No.		Elements
23	-	Mg, Sr
24	-	B
25	-	Fe, Sc, V
31	-	**Co**, **Cr**, Cu, Fe, Mg, **Ni**, Sc, Sr, V
32	-	**Co**, **Cr**, **Cu**, Mg
33	-	**Cu**, Mg, Sr
35	-	Sc
38	-	B, Mo
41	-	B
43	-	Sr
44	-	Fe, Mg, Mn, Sr, V
45	-	Zn
47	-	Fe, Zn
48	-	Ba, Fe
49	-	Nb
50	-	Ba, Cu, La, Mo, Pb
51	-	Ba
54	-	Ba, Cu, Fe
55	-	Nb
56	-	Zn
60	-	Mg, Sr
61	-	**Cr**, **Ni**, Sc, V, **Zr**
65	-	B
66	-	B
69	-	Nb
70	-	**Mo**
72	-	Nb
73	-	Mo
75	-	Pb
76	-	Pb, Zn
77	-	B, Pb
78	-	Fe, **La**, Mn, **Y**, Zn
79	-	Fe, Sc
81	-	**La**, **Mn**, Mo, Pb, Y, **Zn**
82	-	Ba, Co, Fe, **Mn**, Mo, Pb, Sc, **Y**, Zn
84	-	Pb
85	-	Pb
89	-	Pb

ROCK SAMPLES

Rock grab samples taken throughout the area are shown on figure 1. Samples were taken of every rock type and 75 samples were analyzed by quantitative atomic absorption by the Division of Mines and Geology laboratory for gold, copper, lead, and zinc (Appendix 4). The geochemical data were programmed through the University of Alaska IBM computer as described previously to calculate and plot trend surfaces through the fifth degree. The first four degrees of each element are shown in figures 3 through 6 in greatly reduced scale to allow the reader to see the development of the fifth degree trend surfaces in figures 7 through 10.

Table 2 shows the average gold, copper, lead, and zinc concentrations in each of the generalized rock types in the area and comparisons with the average concentrations that would be expected from these rock types as described by Hawkes & Webb (p 359-367).

Discussion of Metal Analyses

Copper -- The average copper found in both granodiorite and rhyolite in this area is about average for felsic rocks according to Hawkes and Webb (1965, p 364). The highest copper sample in the granodiorite (no. 119) shows 173 ppm. The highest copper sample in the rhyolite (G-3) shows 80 ppm. Most of the high copper values lie in the greenstone. The greenstone has a very wide range of copper occurrences from a low of 3 ppm to a high of 240 ppm. The average copper content in the greenstone is just a little over one-half of the average for mafic rocks, according to Hawkes and Webb (1965, p 364). Fifth degree trend surface analysis (fig 7) shows the highest background in the northwest portion of the mapped area.

Lead -- The average lead content for the area is slightly below average for both mafic and felsic rocks (Hawkes & Webb, 1965, p 367) with granodiorite (sample 138) carrying the highest content of 242 ppm. The lead content in the rhyolite rocks is only one-third of normal lead occurrence in felsic rocks. Fifth degree trend surface analysis (fig 8) shows the highest background on the west side of the mapped area trending in a northwest-southeast direction.

Zinc -- Granodiorite and rhyolite are about average in zinc content for felsic rocks while the greenstone is less than one half the normal average for mafic rocks (Hawkes & Webb, 1965, p 376). Fifth degree trend surface analysis (fig 9) shows the highest background in the southern portion of the mapped area.

Gold -- The average for gold is very roughly calculated, using a figure of .004 ppm where gold was not detected since the detection limit is .008 ppm on the Division of Mines and Geology atomic absorption equipment. Granodiorite in the Diana Lakes area runs over twice as high in gold as would normally be expected (Hawkes & Webb, 1965, p 365). The average is high because of one sample, G-37, which contains .38 ppm gold. Without sample G-37 the average would be about .013 ppm which is only slightly above average. Greenstone in the area is generally metamorphosed mafic volcanic rocks and the figure from Hawkes and Webb (1965, p 365) that is used here (.035 ppm) comes from mafic igneous rocks. From this standard, the greenstone is below average in gold content. Rhyolite in both flows and dikes, is very slightly above average. Fifth degree trend surface analysis (fig 10) shows the highest background of gold in the central-eastern portion of the mapped area.

TABLE 2

Comparison of Diana Lakes Rock Type Mineral Averages
With Rock Type Mineral Averages from Hawkes and Webb

Parts Per Million

	Gold		Copper		Lead		Zinc	
	Diana Lakes	Hawkes & Webb	Diana Lakes	Hawkes & Webb	Diana Lakes	Hawkes & Webb	Diana Lakes	Hawkes & Webb
Granodiorite 33 samples	.025	.01	27	30	26	48	65	60
Greenstone 30 samples	.020	.035	76	140	17	12	52	130
Volcanic Flows & Associated Rocks 12 samples	.015	.01	31	30	14	48	52	60

Trend Surface Analysis

In order to outline area trends and point to the best possible target areas for future mineral exploration the computer was called upon to make a statistical analysis of the geochemical data in terms of location and concentration of the following elements. For trend surface analysis, the method of least squares has the best general application for surface fitting (Crow and others, p 151). By using this technique a planar surface is established for geochemical data such that positive and negative measurement from the surface are at a minimum.

Multiple regression trend surface analyses of geochemical data have been examined in a number of the known mineral deposits in the United States (M. P. Nackowski and others, p 1077) and frequently have been shown to outline the known mineralized area as well as point to petrologic contacts, faults, folds, or indicate possible topographic relationships.

"Trend surfaces applied to geological (and geochemical) data....are described by arithmetic equations in which the geologic data represent the dependent variable stated as a function of two independent variables which establish the areal sample locations. The mathematical operations of trend-surface fitting consist of finding the constants to the arithmetic equations such that the least-squares criterion is satisfied. In fitting a trend surface to geochemical data, the dependent variable z, represents quantity of indicator element in each sample and the independent variables, x and y, represent the planar sample location coordinates. These equations for linear, quadratic and cubic components are shown on table 3.

"Trend surfaces classified according to degree are more complex as the number of components in the equations describing them increases....... The first degree surface is a plane and contains only linear terms, whereas the generalized second degree surfaces, which contain both quadratic and linear terms, are either positive or negative bowl-shaped paraboloids. Third degree surfaces include an inflection, are more complex and contain cubic, quadratic, and linear terms". (Nackowski and others, 1967, p 1078)

TABLE 3

Classification of Trend Surface Equations Illustrating
Three Components and Three Degrees
(from Nackowski and others, 1967, p 1078, Table 2)

Trend Surface Classification	Dependent Variable	Linear Component	Quadratic Component	Cubic Component
First degree plane surface	z=	$A+B_x+C_y$		
Second degree paraboloid	z=	$A+B_x+C_y+$	$D_x{}^2+E_{xy}+F_y{}^2$	
Three degree surface	z=	$A+B_x+C_y+$	$D_x{}^2+E_{xy}+F_y{}^2+$	$G_x{}^3xH_x{}^2y+I_{xy}{}^2+J_y{}^3$

Letters A through J represent constants.

Each increasing degree adds another inflection in the trend surface and each equation representing this becomes more complex; the independent variables, x and y, are increased in power and new constants are fit into this part of the equation which is simply added on to the lower power equations, following the pattern shown in table 3.

Figure 2 shows the generalized trend surfaces for the first three degrees and variables.

Figure 2 shows generalized trend surfaces for the first three degrees and variables.

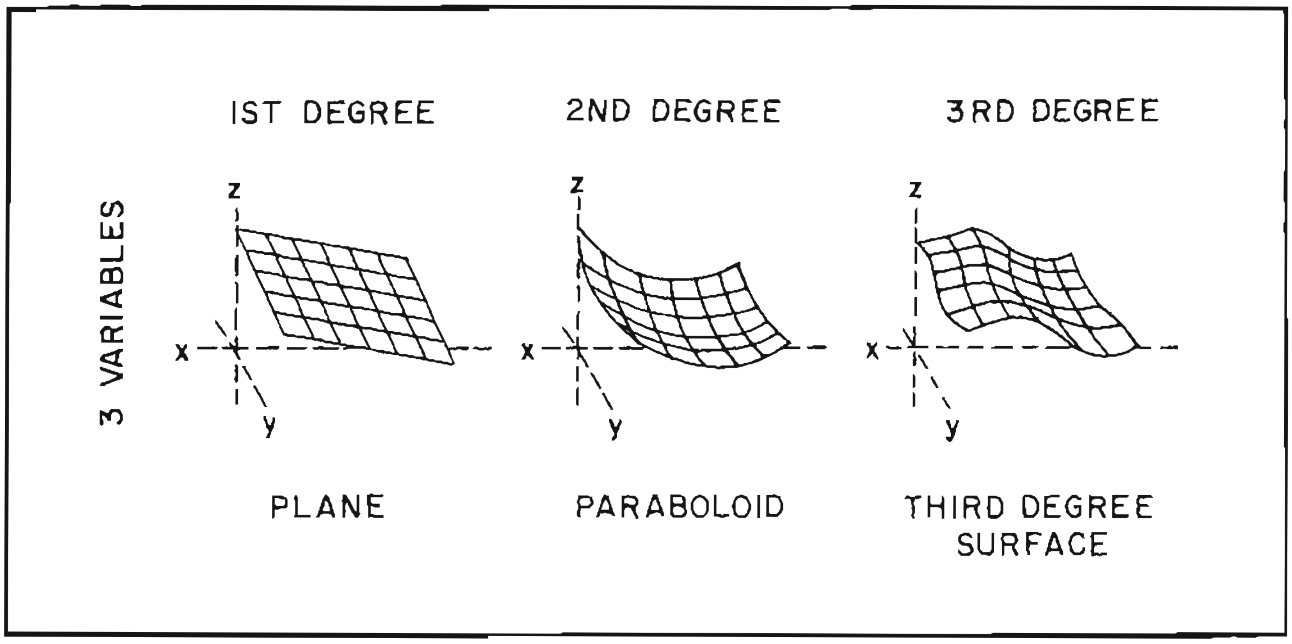


Figure 2

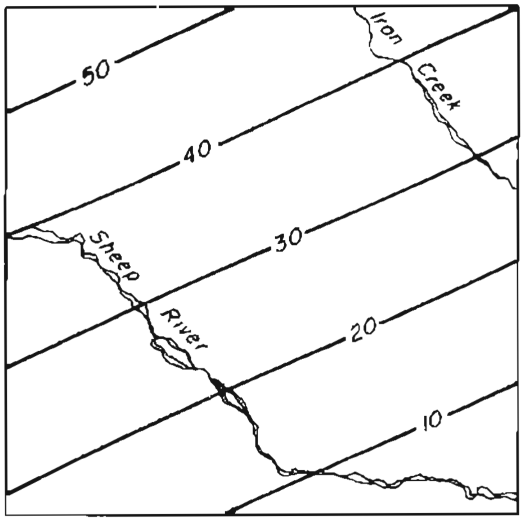
Generalized trend surfaces for three surfaces for three degrees and other variables. (After Nackowski and others, 1967.)

> "The trend surface itself represents the regional component or geochemical trend. This surface, or the value of any point on the surface represents a threshold value which is variable across the map area." (Heiner, written communication, 3-25-69)

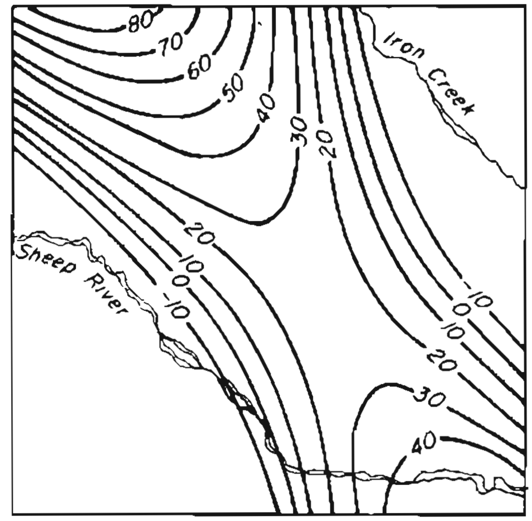
Values which fall above or below the trend surface in any degree are termed residuals. Each advancing trend surface degree will generally cover some of the residuals from the degree below it.

Persistent residuals through increasing trend surface degrees are considered possible target areas for future prospecting and mineral exploration. Residuals standing well above the fourth and fifth degree trend surfaces for each of the four elements are shown in the following figures. On the fifth degree trend surfaces for copper, lead, and zinc, in addition to the residuals, probable and possible stream sediment anomalous values are plotted. Discussion and comparison of the results are included on the figure for each different element.

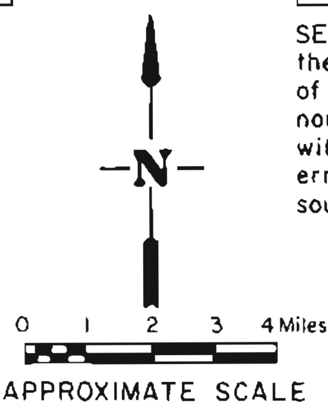
REFERENCE CONTOUR = 30 PPM

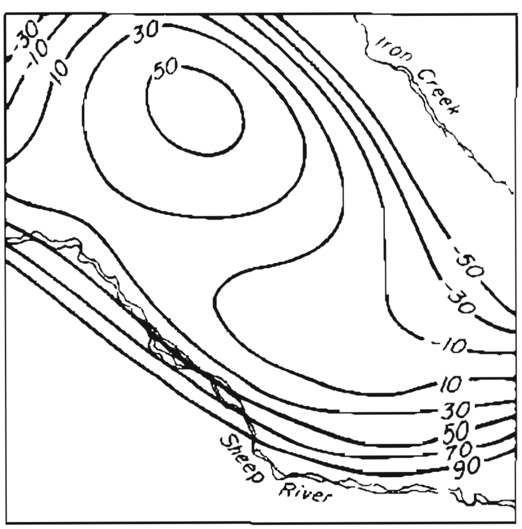


FIRST DEGREE — indicates a general increase in values to the northwest.

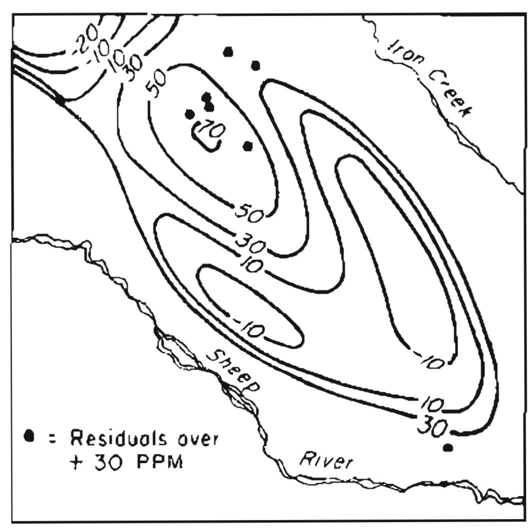


SECOND DEGREE — continues to outline the general northwest structural trend of the area. A high is indicated in the northwest section of the mapped area, with a low running through the southern one third and an increase to the southeast.





THIRD DEGREE — still outlines the northwest trend, and shows the high in the northwest section slightly southeast of the second degree high. The trend decreases to the extreme northwest. Increased values are shown toward Sheep River.

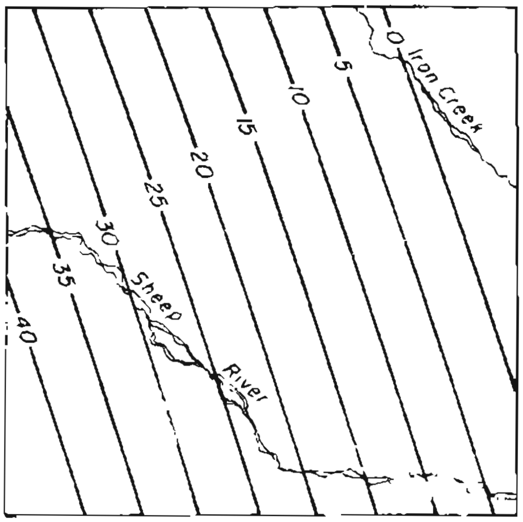


FOURTH DEGREE — the highest copper values continue in the northwest portion. Fourth degree is similar in many ways to third degree except that the increase toward Sheep River declines. At this degree the strong positive residuals are considered significant.

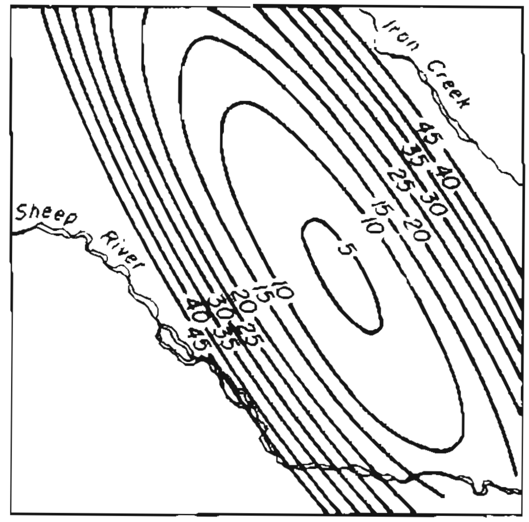
Figure 3

COPPER
TREND SURFACE ANALYSES

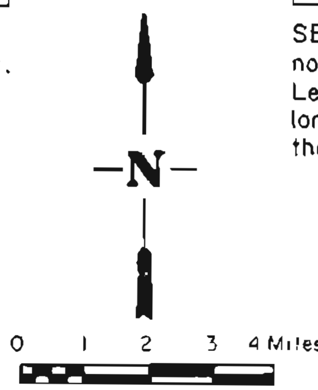
REFERENCE CONTOUR = 25 PPM



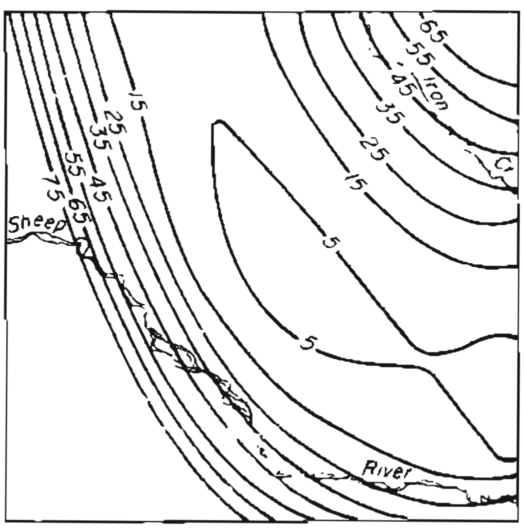
FIRST DEGREE — indicates a general decrease in values to the east-northeast.



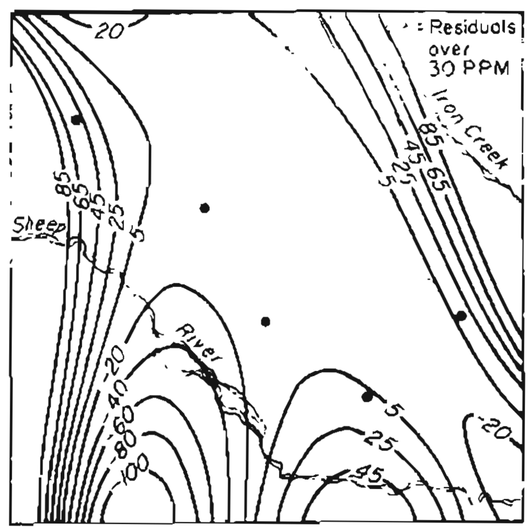
SECOND DEGREE — shows the general northwest structural trend of the area. Lead values form an elongated bowl. The longest values are toward the center of the mapped area.



APPROXIMATE SCALE



THIRD DEGREE — the northwest trend is still outlined. The low values run along the center of the mapped area in a northwesterly direction with increased lead values to the northeast and southwest.

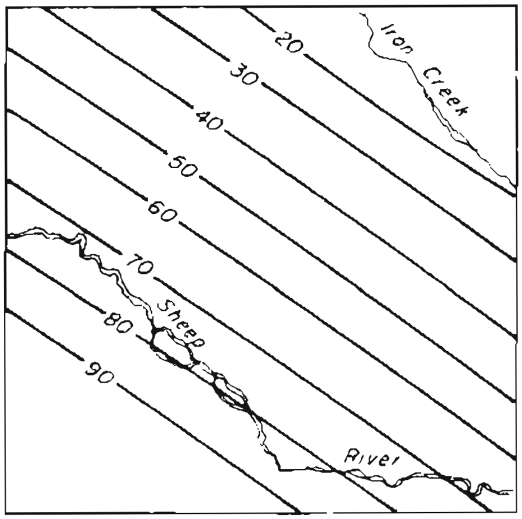


FOURTH DEGREE — the highest lead values continue on the edges and outside of the mapped area. The residuals appear random in relation to the surface trend and do not outline any target areas.

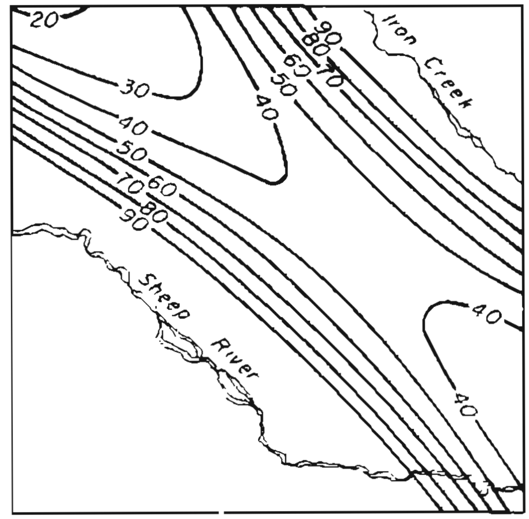
Figure 4

LEAD
TREND SURFACE ANALYSES

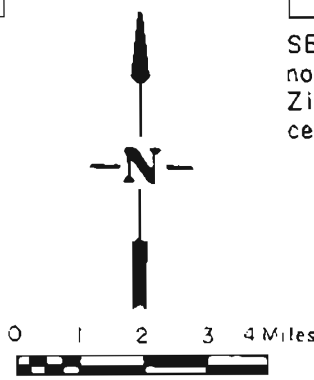
REFERENCE CONTOUR = 50 PPM



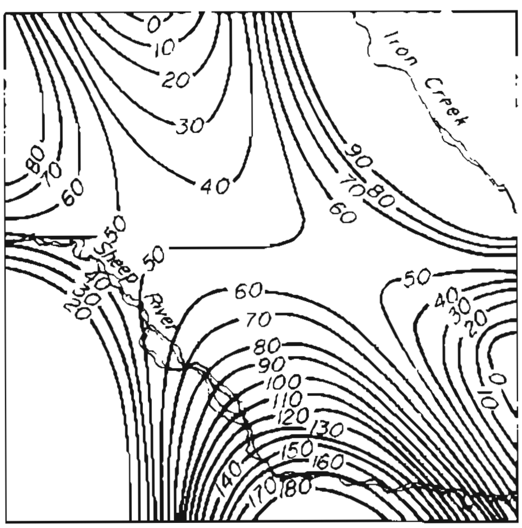
FIRST DEGREE - indicates a general decrease in values to the northeast.



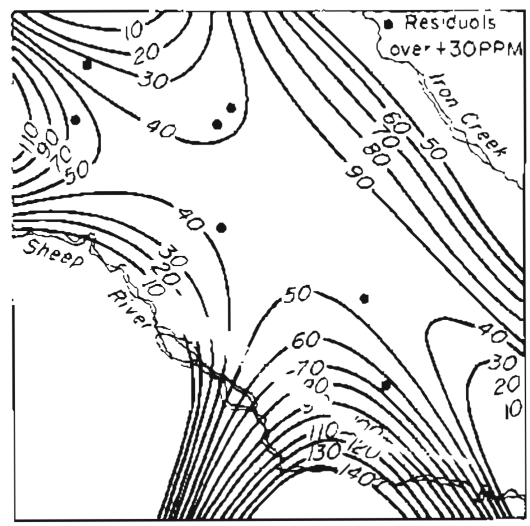
SECOND DEGREE - shows the general northwest structural trend of the area. Zinc values decrease toward toward the center of a northwest dipping 'trough'.



APPROXIMATE SCALE



THIRD DEGREE - the main trend outlines an increase from north to south along the central part of the mapped area. Other trends show increases to the northwest and northeast, with decreases to southwest and southeast along the edges of the mapped area.



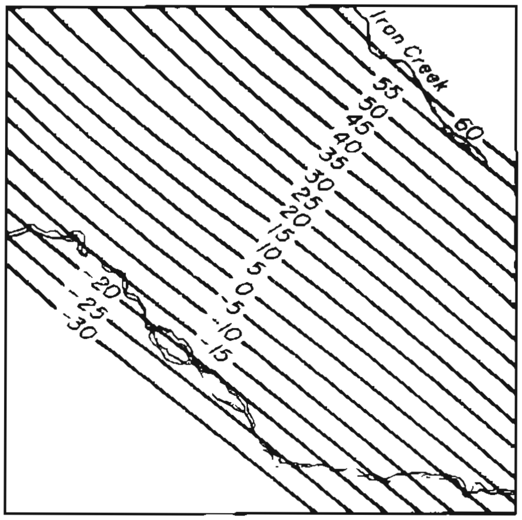
FOURTH DEGREE - is very similar to the third degree. Residuals of possible significance are noted in the northwest section.

Figure 5

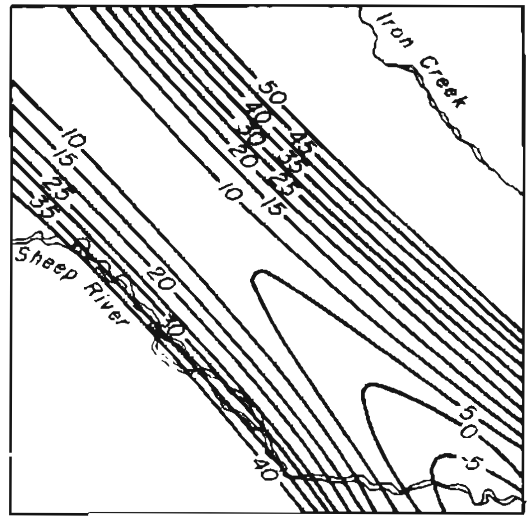
ZINC

TREND SURFACE ANALYSES

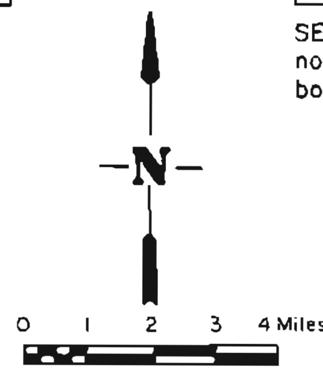
REFERENCE CONTOUR = 50 PPM



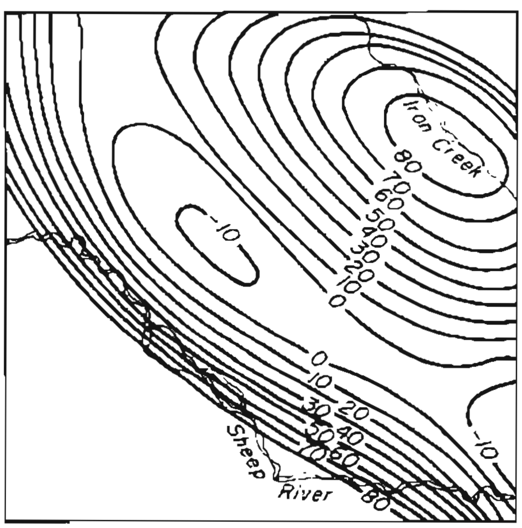
FIRST DEGREE - indicates a general increase in values to the northeast.



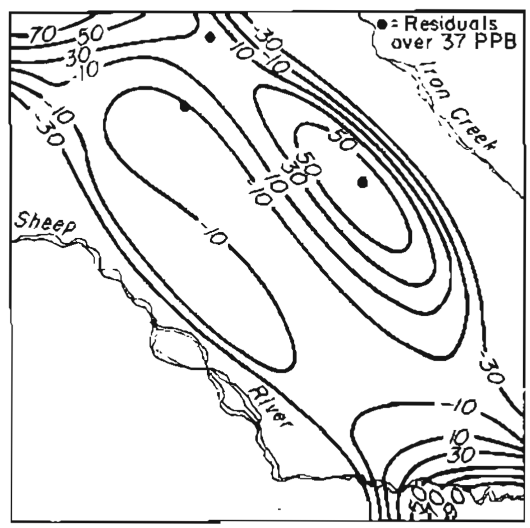
SECOND DEGREE - shows the general northwest structural trend which increase both toward Sheep River and Iron Creek.



APPROXIMATE SCALE



THIRD DEGREE - shows an increased trend to the southwest and a dome shaped section along the northeastern side of the area.



FOURTH DEGREE - shows a marked change from third degree. Values decrease to the northeast and southwest and increase to the northwest and southeast. A dome with an interesting residual is indicated on the east side.

Figure 6

GOLD

TREND SURFACE ANALYSES

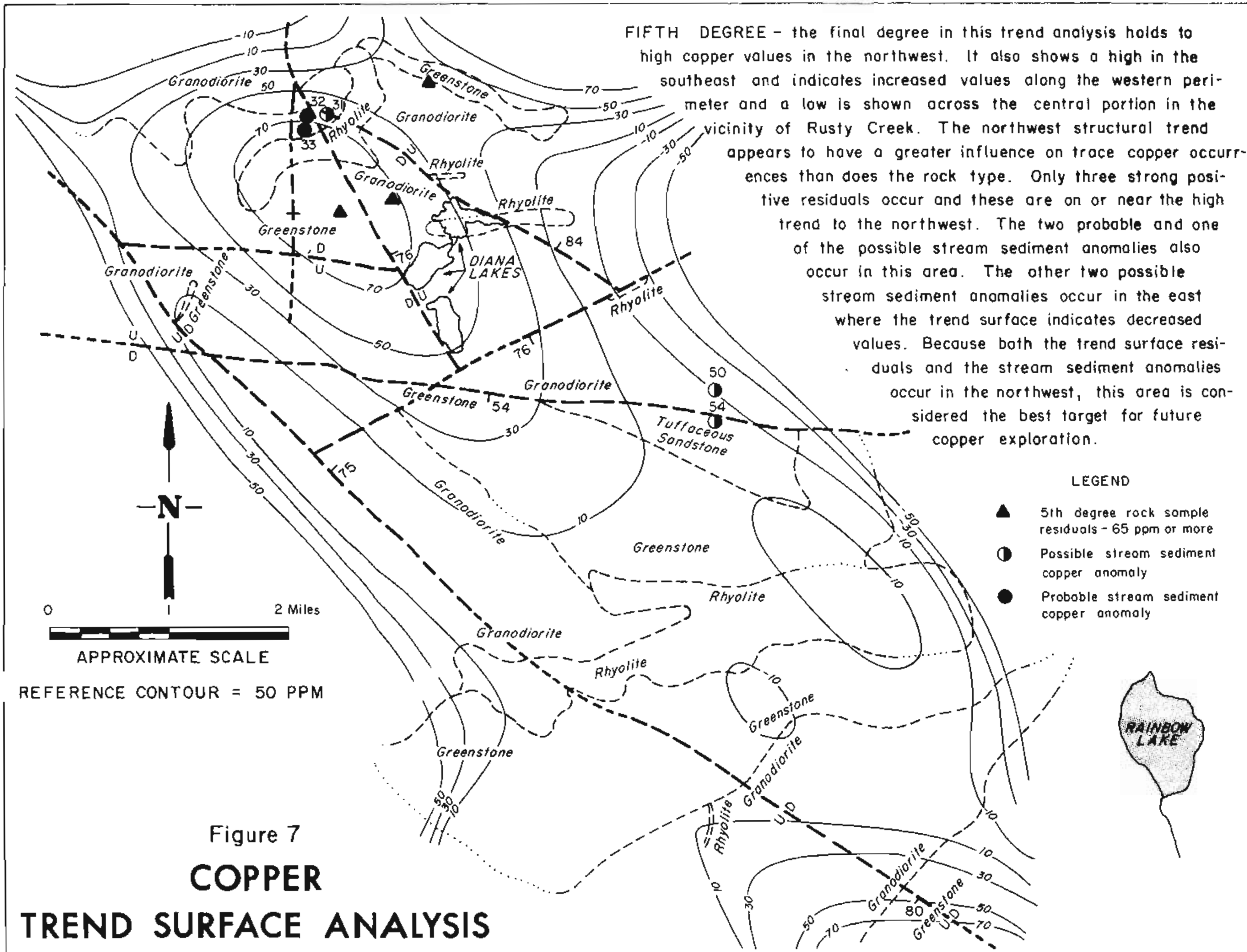


Figure 7

COPPER

TREND SURFACE ANALYSIS

FIFTH DEGREE – the final degree in this trend analysis is strikingly different than the fourth degree. Increased values are indicated on the west. Decreased values are indicated in the south and east. The northwest structural trend appears to have greater influence on trace lead occurrences than does the rock type. The four strongest positive residuals are widely scattered and are not considered significant. Most of the possible stream sediment anomalies occur on Rusty Creek and are not associated with the trend surface or the residuals. There are no probable stream sediment anomalies. Because of the scattered nature of the residuals and the weak nature of the stream sediment anomalies, the area is not considered a target for future lead exploration.

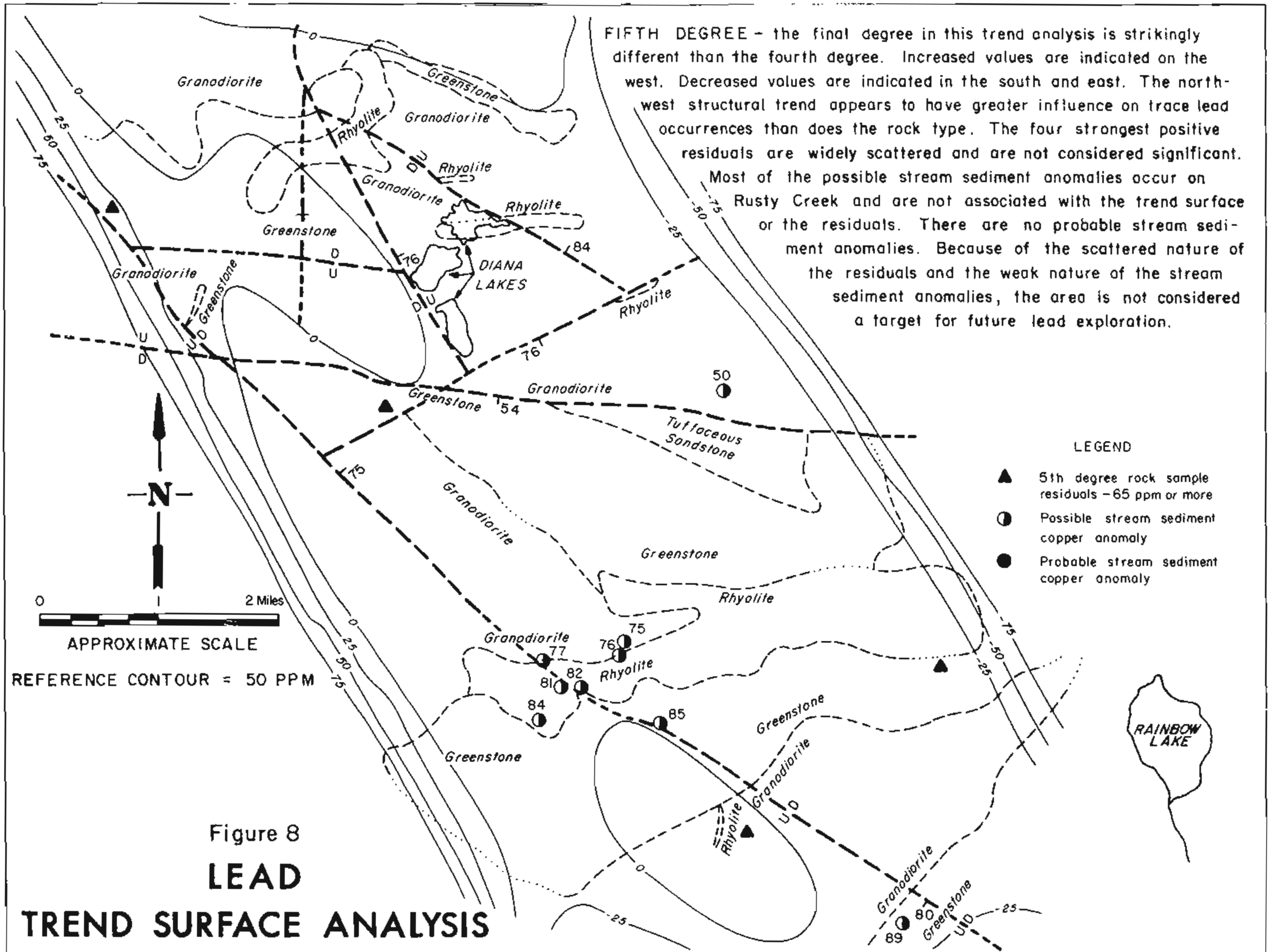


Figure 8

LEAD
TREND SURFACE ANALYSIS

FIFTH DEGREE – the final degree in trend surface analysis indicates that the northwest structural trend has greater influence on trace zinc occurrences than does the rock type. Increased values are indicated on the west, north and southeast and on a dome in the south. Decreased values are indicated on the east and south of the southern dome. The five strongest residuals all lie along the western side of the mapped area. One residual located on the southern dome may be of significance. Another significant residual is located on Rusty Creek and is in an area of stream sediment zinc anomalies. One probable and three possible stream sediment anomalies are all located along Rusty Creek west (downstream) of the trend surface residual. Because of the proximity of the stream sediment anomalies with one trend surface residual in addition to the association with possible lead anomalies, the Rusty Creek area is considered a weak target for future zinc exploration.

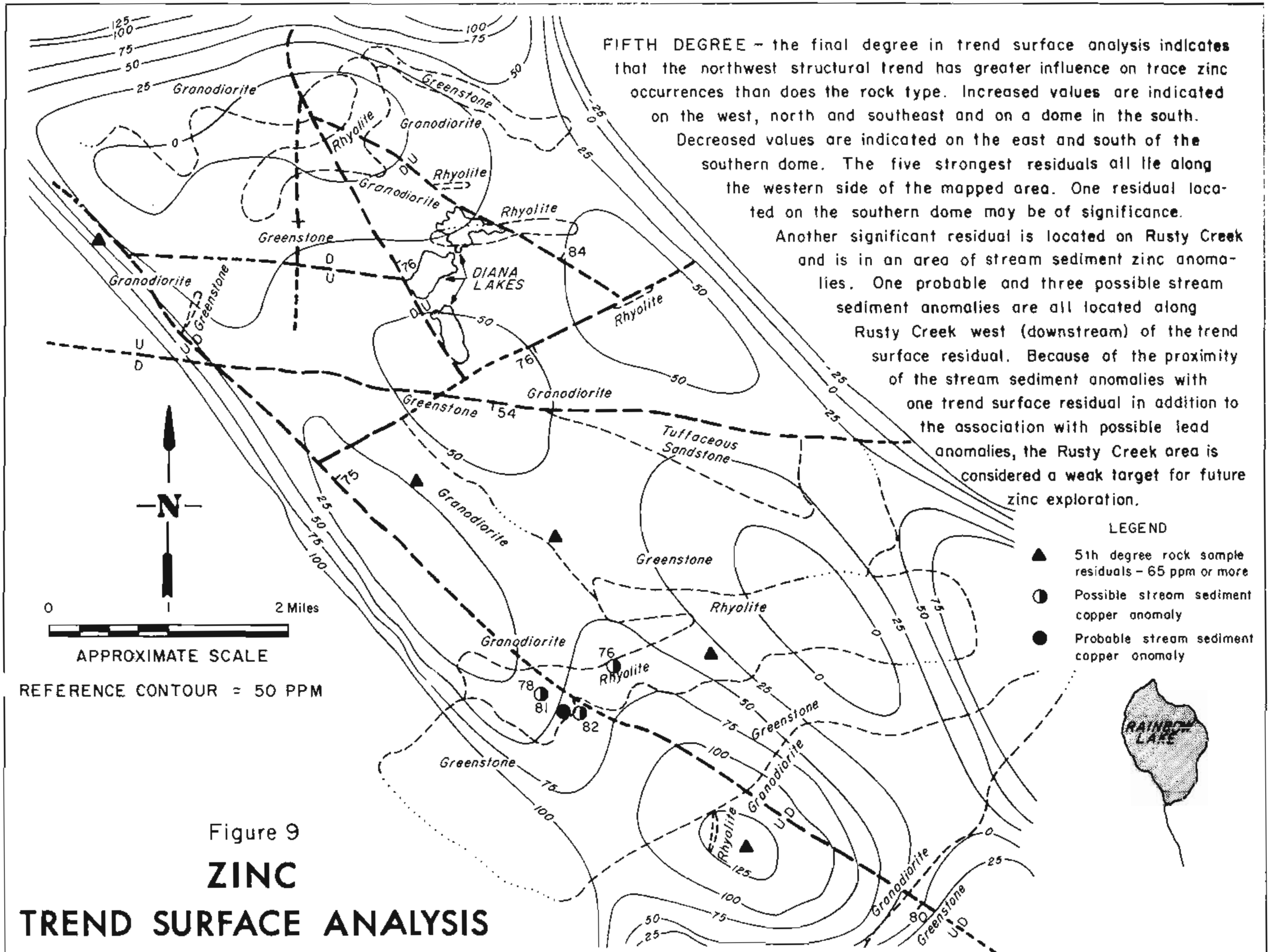


Figure 9

ZINC
TREND SURFACE ANALYSIS

FIFTH DEGREE – the final degree in trend analysis indicates an increased trend toward the north and west and a dome on the eastern side. A decreased trend is indicated on the eastern and southern sides. Two strong positive residuals occur within high trend areas and may be of significance for possible future exploration. Gold was not detected in the stream sediment samples. However, by semiquantitative spectrographic analysis the detection limit for gold is ten parts per million. In other sections of Alaska 0.04 parts per million is the calculated average so a lack of gold detection by semiquantitative spectrographic analysis is not significant. It is noted that copper anomalies show in both areas of strong residuals. The two possible copper anomalies present in the dome area may be good pathfinders for gold particularly since they are not associated with high copper surface trends or residuals.

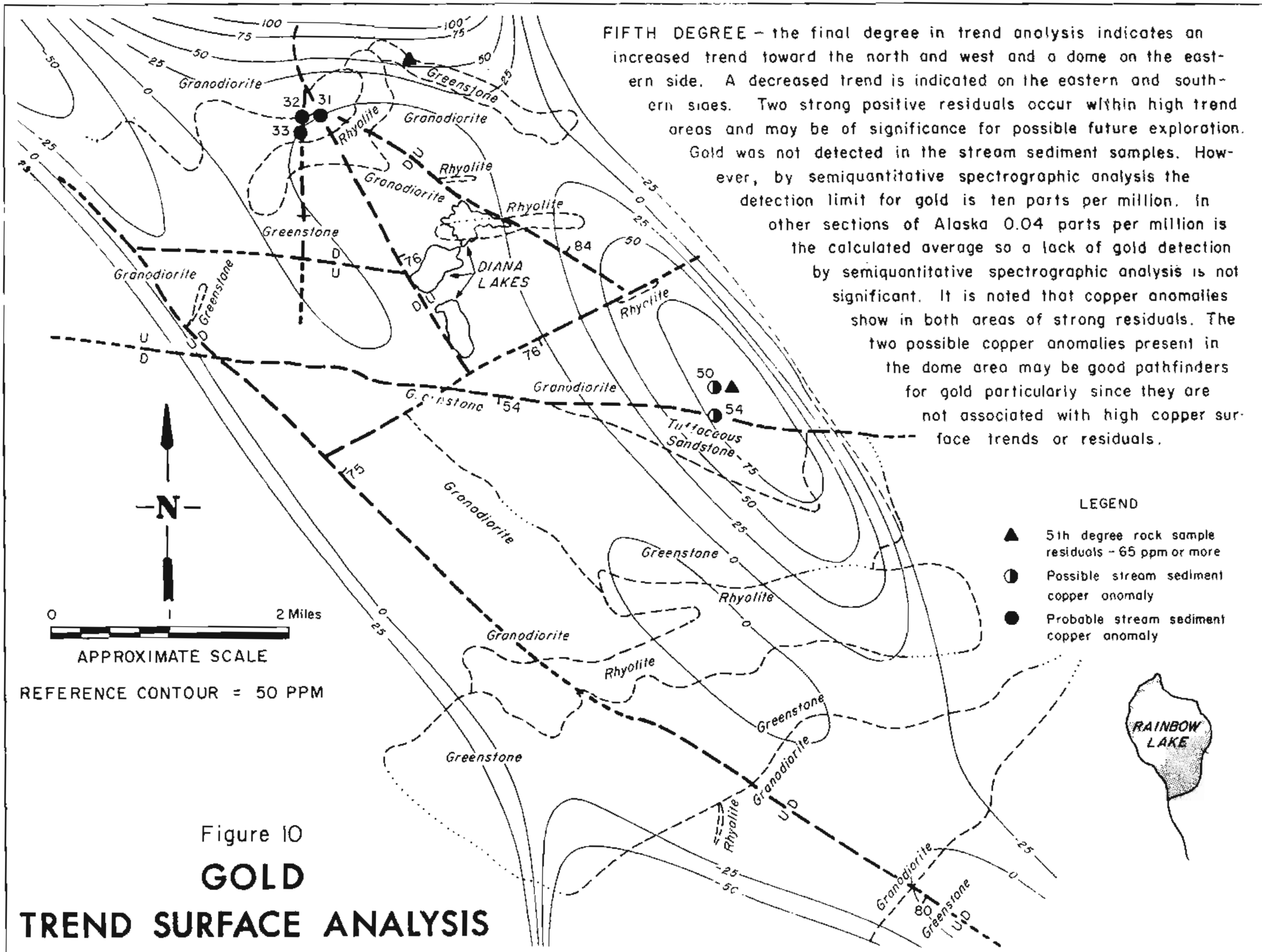


Figure 10

GOLD

TREND SURFACE ANALYSIS

CONCLUSIONS AND SUGGESTIONS

Geochemical analyses of stream sediment samples and rock samples indicate a few target areas for future metal exploration. To determine the significance and economic potential of the target areas which are discussed in figures 7 through 10, further geochemical or geophysical exploration is suggested. The trend surface analyses point to hydrothermal mineralization related to a general northwest structural trend.

No base metal minerals other than pyrite were observed in the field. If the hydrothermal mineralization developed an area of economic interest, it is likely to be found at depth.

REFERENCES CITED

Anderson, R. E., 1969, Preliminary Geochemistry and Geology of the Little Falls Creek Area, Talkeetna Mountains quadrangle, Alaska: Alaska Division of Mines and Geology, Geochemical Report #19

Andrews-Jones, D. A., Nov. 1968, The application of Geochemical techniques to mineral exploration: Mineral Industries Bulletin, vol II, no 6, 31 p

Capps, S. R., 1940, Geology of the Alaska Railroad region: U. S. Geol. Survey Bulletin 907, 201 p

Capps, S. R., 1919, Mineral resources of the western Talkeetna Mountains: U. S. Geol. Survey Bulletin 692-D, p 187-205

Coulter, H. W., Hopkins, D. M., Karlstrom, T. N. V., Pewe, T. L., Wahrhaftig, C., Williams, J. R., 1965, Map showing extent of glaciations in Alaska: U. S. Geol. Survey Miscellaneous Geologic Investigations Map I-415

Crow, E. L., Davis, F. A., Maxfield, M. W., [no date], Statistics manual: New York Dover Publications, p 147-193

Dutro, J. T., Payne, T. G., 1954, Geologic map of Alaska: U. S. Geol. Survey map, scale 1:2,500,000

Grantz, A., 1960-A, Geologic map of Talkeetna Mountains (A-1) quadrangle and the south third of Talkeetna Mountains (B-1) quadrangle, Alaska: U. S. Geol. Survey Miscellaneous Geologic Investigations Map I-314

Grantz, A., 1960-B, Geologic map of Talkeetna Mountains (A-2) quadrangle, Alaska and the contiguous area to the north and northwest: U. S. Geol. Survey, Miscellaneous Geologic Investigations Map I-313

Hawkes, H. E., Webb, J. S., 1962, Geochemistry in mineral exploration: New York, Harper and Row, 415 p

Nackowski, M. P., Mardirosian, C. A., Botbol, J. M., 1967, Trend Surface analysis of trace chemical data, Park City district, Utah: Economic Geology, vol 62, no 8, 23 figs, 4 tables, p 1072-1087

Rose, A. W., 1967, Geology of an area on the upper Talkeetna River, Talkeetna Mountains quadrangle, Alaska: Alaska Division of Mines and Minerals, Geologic Report #32, 7 p

Rose, A. W., 1965, An aerial reconnaissance in the northern Talkeetna Mountains: Alaska Division of Mines and Minerals, Annual Report for 1965, p 57-59

Townsend, H. H., 1925, Confidential report submitted to the Alaska Railroad on the possible mineral resources along the railroad, 4 p, 13 figs

Sample No.	Nb	Sc	Y	V
22	5.00	15.00	15.00	200.00
23	10.00	15.00	15.00	200.00
24	5.00	15.00	15.00	200.00
25	5.00	30.00T	30.00	300.00T
26	5.00	15.00	20.00	150.00
27	5.00	15.00	20.00	150.00
28	5.00	15.00	15.00	200.00
29	5.00	15.00	15.00	150.00
30	0.0	20.00	15.00	200.00
31	5.00	30.00T	30.00	300.00T
32	5.00	20.00	15.00	200.00
33	5.00	15.00	20.00	200.00
34	5.00	20.00	15.00	200.00
35	10.00	30.00T	30.00	150.00
36	10.00	20.00	30.00	150.00
37	5.00	15.00	20.00	200.00
38	5.00	15.00	15.00	150.00
39	5.00	15.00	10.00	200.00
40	5.00	5.00	10.00	100.00
41	5.00	7.00	10.00	100.00
42	5.00	15.00	10.00	150.00
43	5.00	15.00	15.00	150.00
44	5.00	20.00	15.00	300.00T
45	5.00	10.00	20.00	150.00
46	5.00	15.00	15.00	200.00
47	5.00	15.00	15.00	200.00
48	5.00	15.00	30.00	150.00
49	15.00T	10.00	30.00	70.00
50	10.00	15.00	30.00	30.00
51	5.00	15.00	15.00	150.00
52	5.00	15.00	15.00	150.00
53	5.00	20.00	30.00	150.00
54	5.00	20.00	30.00	150.00
55	15.00T	15.00	30.00	150.00
56	10.00	15.00	30.00	150.00
57	5.00	20.00	30.00	150.00
58	5.00	15.00	20.00	100.00
59	10.00	20.00	30.00	150.00
60	10.00	20.00	30.00	150.00
61	5.00	30.00T	30.00	300.00T
62	5.00	15.00	30.00	150.00
63	10.00	20.00	30.00	150.00
64	10.00	20.00	30.00	150.00
65	10.00	20.00	30.00	150.00
66	5.00	20.00	15.00	200.00
67	10.00	10.00	20.00	100.00
68	5.00	15.00	30.00	100.00
69	15.00T	20.00	30.00	150.00
70	15.00	20.00	50.00	150.00
71	10.00	15.00	30.00	100.00
72	15.00T	15.00	20.00	100.00
73	5.00	15.00	30.00	150.00
74	5.00	15.00	30.00	150.00
75	10.00	20.00	50.00	150.00
76	10.00	15.00	30.00	100.00
77	10.00	15.00	30.00	100.00
78	5.00	20.00	150.00	150.00
79	5.00	30.00T	30.00	200.00
80	10.00	15.00	30.00	70.00
81	10.00	20.00	70.00	150.00
82	5.00	30.00T	100.00	200.00
83	5.00	15.00	30.00	150.00
84	5.00	15.00	30.00	150.00
85	5.00	20.00	30.00	150.00
86	5.00	7.00	20.00	70.00
87	10.00	15.00	30.00	70.00
88	5.00	10.00	20.00	100.00
89	10.00	15.00	50.00	100.00
90	5.00	15.00	20.00	70.00
91	5.00	20.00	20.00	150.00
92	5.00	15.00	10.00	100.00
93	5.00	7.00	5.00	30.00
94	10.00	20.00	50.00	150.00

Appendix I

TABULATION OF GEOCHEMICAL STREAM SEDIMENT SAMPLES

WITH THEIR THRESHOLD AND ANOMALOUS VALUES

	Cu	Pb	Zn	Mo	Co	Cr	Ni	Mn	Fe%	Mg%	Ca%	Ba	Sr	B	Zr	La	Nb	Sc	Y	V
Average	50.21	22.33	51.85	6.30	14.63	55.78	25.25	1200.29	8.85	1.76	2.19	742.47	362.33	10.69	179.59	29.86	7.08	17.00	27.60	151.51
Standard Deviation	41.15	12.42	110.16	3.96	7.20	30.76	14.20	874.40	3.37	0.59	0.72	289.96	167.19	4.75	132.75	21.02	3.11	5.27	20.24	55.04
Hawkes & Webb Threshold Mean plus 2 standard deviations	132.51	47.17	272.16	14.22	29.02	117.12	53.64	2949.09	15.60	2.94	3.62	1322.38	696.71	20.19	445.10	71.91	13.31	27.54	68.09	261.59
Hawkes & Webb Anomaly Mean plus 3 standard deviations	173.66	59.58	382.32	18.19	36.22	147.80	67.84	3823.50	18.97	3.53	4.34	1612.33	863.91	24.94	577.85	92.93	16.42	32.81	88.33	316.63

For definition of chemical symbols see Table I

The threshold and anomalous values for each element were computed by methods described in Hawkes and Webb (1962, p 30). The threshold value is taken as the mean plus twice the standard deviation; anomalous values are taken as the mean plus three standard deviations. These values are meaningful for a normal distribution, the further the data departs from normalcy the less reliable is the computed threshold and anomalous value.

LEGEND

T - Indicates threshold value.

A - Indicates anomalous value.

E - Indicates number eliminated due to error in assay report or in computer card punching.

Sample No.	Cu	Pb	Zn	Mo	Ag	Co	Cr	Ni	Mn	Ti	Fe	Mg	Ca	Ba	Sr	B	Be	Zr	La
22	70.00	15.00	5.00	7.00	0.0	15.00	70.00	30.00	1000.00	0.70	10.00	2.00	3.00	700.00	500.00	5.00	0.50	300.00	20.00
23	70.00	15.00	5.00	3.00	0.0	15.00	30.00	30.00	1500.00	0.70	10.00	3.00T	3.00	700.00	700.00T	15.00	0.50	300.00	20.00
24	15.00	15.00	5.00	3.00	0.0	15.00	30.00	30.00	1500.00	0.50	10.00	2.00	3.00	500.00	300.00	20.00T	0.0	70.00	10.00
25	30.00	5.00	5.00	3.00	0.0	15.00	70.00	30.00	1000.00	1.00	15.00T	2.00	3.00	700.00	300.00	10.00	0.0	100.00	20.00
26	70.00	15.00	5.00	3.00	0.0	15.00	100.00	50.00	7.00	0.50	7.00	3.00	3.00	500.00	500.00	15.00	0.50	50.00	20.00
27	50.00	15.00	5.00	7.00	0.0	15.00	100.00	50.00	7.00	0.70	10.00	2.00	3.00	700.00	500.00	15.00	0.50	50.00	20.00
28	70.00	15.00	5.00	0.0	0.0	10.00	70.00	30.00	7.00	0.50	7.00	2.00	2.00	500.00	300.00	5.00	0.0	70.00	10.00
29	70.00	15.00	5.00	3.00	0.0	10.00	50.00	30.00	700.00	0.50	7.00	1.50	2.00	500.00	500.00	5.00	0.50	150.00	20.00
30	100.00	15.00	0.0	3.00	0.0	15.00	100.00	50.00	700.00	0.70	10.00	2.00	2.00	700.00	500.00	5.00	0.0	150.00	10.00
31	150.00T	15.00	5.00	5.00	0.0	50.00A	150.00A	70.00A	1500.00	0.70	15.00T	3.00T	3.00	1000.00	700.00T	15.00	0.50	150.00	30.00
32	200.00A	30.00	5.00	7.00	0.0	50.00A	150.00A	50.00	700.00	0.50	10.00	3.00T	3.00	700.00	500.00	10.00	0.50	150.00	30.00
33	200.00A	15.00	5.00	5.00	0.0	20.00	70.00	30.00	700.00	0.50	7.00	3.00T	3.00	1000.00	700.00T	10.00	0.50	100.00	50.00
34	70.00	15.00	5.00	3.00	0.0	20.00	70.00	30.00	1000.00	0.70	15.00T	2.00	3.00	700.00	500.00	10.00	0.50	300.00	10.00
35	70.00	15.00	5.00	3.00	0.0	15.00	50.00	30.00	700.00	0.50	10.00	1.50	3.00	500.00	300.00	10.00	0.0	70.00	10.00
36	50.00	15.00	5.00	7.00	0.0	15.00	70.00	30.00	700.00	0.70	7.00	2.00	2.00	700.00	500.00	10.00	0.50	70.00	30.00
37	30.00	15.00	5.00	3.00	0.0	15.00	70.00	30.00	700.00	0.70	10.00	2.00	2.00	700.00	300.00	10.00	0.0	150.00	20.00
38	30.00	10.00	0.0	15.00T	0.0	15.00	70.00	30.00	700.00	0.30	7.00	1.50	1.50	300.00	300.00	5.00	0.0	70.00	10.00
39	70.00	10.00	0.0	10.00	0.0	15.00	30.00	30.00	700.00	0.30	7.00	1.50	1.50	500.00	200.00	5.00	0.0	150.00	10.00
40	30.00	10.00	5.00	0.0	0.0	3.00	30.00	7.00	700.00	0.20	5.00	1.00	1.50	150.00	25.00	5.00	0.0	30.00	10.00
41	10.00	10.00	5.00	0.0	0.0	7.00	15.00	3.00	700.00	0.15	3.00	0.50	1.00	150.00	25.00	20.00T	0.0	30.00	10.00
42	15.00	5.00	5.00	3.00	0.0	10.00	30.00	15.00	700.00	0.50	7.00	1.50	2.00	500.00	300.00	5.00	0.0	200.00	0.0
43	30.00	15.00	5.00	3.00	0.0	15.00	30.00	30.00	1000.00	0.50	10.00	2.00	3.00	700.00	700.00T	20.00T	0.50	300.00	0.0
44	30.00	5.00	5.00	3.00	0.0	15.00	50.00	30.00	3000.00T	0.70	15.00T	3.00T	3.00	700.00	700.00T	10.00	0.0	150.00	10.00
45	20.00	10.00	300.00T	3.00	0.0	10.00	30.00	15.00	1500.00	0.30	10.00	1.50	1.50	700.00	100.00	15.00	0.50	300.00	20.00
46	15.00	15.00	5.00	3.00	0.0	10.00	30.00	15.00	1500.00	0.30	10.00	1.50	1.50	700.00	200.00	15.00	0.0	300.00	10.00
47	50.00	20.00	300.00T	7.00	0.0	10.00	30.00	15.00	2000.00	0.50	15.00T	1.50	1.50	700.00	200.00	15.00	0.50	300.00	10.00
48	70.00	15.00	5.00	3.00	0.0	10.00	30.00	30.00	2000.00	0.50	15.00T	2.00	3.00	1500.00T	300.00	15.00	0.10	300.00	50.00
49	70.00	30.00	5.00	10.00	0.0	10.00	15.00	7.00	700.00	0.15	7.00	0.50	0.70	1000.00	200.00	15.00	0.15	150.00	50.00
50	150.00T	50.00T	5.00	15.00T	0.30	10.00	15.00	3.00	2000.00	0.15	7.00	0.50	0.50	1500.00T	100.00	15.00	2.00	150.00	100.00A
51	100.00	30.00	5.00	7.00	0.30	10.00	50.00	5.00	1000.00	0.30	10.00	1.00	1.50	1500.00T	200.00	10.00	1.00	300.00	30.00
52	10.00	15.00	5.00	3.00	0.0	10.00	50.00	10.00	700.00	0.30	7.00	1.50	2.00	1000.00	300.00	5.00	0.50	100.00	20.00
53	15.00	15.00	5.00	3.00	0.0	15.00	70.00	20.00	1000.00	0.50	10.00	2.00	2.00	1000.00	300.00	5.00	0.50	300.00	30.00
54	150.00T	15.00	5.00	3.00	0.0	15.00	70.00	30.00	1500.00	0.50	15.00T	2.00	3.00	1500.00T	300.00	15.00	1.00	300.00	20.00
55	50.00	20.00	5.00	3.00	0.0	15.00	70.00	30.00	2000.00	0.50	10.00	2.00	3.00	700.00	500.00	10.00	1.00	100.00	30.00
56	30.00	20.00	300.00T	3.00	0.0	15.00	50.00	30.00	1000.00	0.50	10.00	2.00	2.00	700.00	300.00	10.00	0.50	200.00	50.00
57	20.00	20.00	200.00	5.00	0.0	15.00	50.00	30.00	700.00	0.30	10.00	1.50	2.00	700.00	500.00	10.00	0.50	150.00	30.00
58	10.00	15.00	5.00	3.00	0.0	15.00	50.00	30.00	700.00	0.30	5.00	1.50	1.50	700.00	500.00	5.00	1.00	100.00	20.00
59	20.00	30.00	5.00	7.00	0.0	15.00	70.00	30.00	1500.00	0.30	7.00	2.00	1.50	700.00	500.00	10.00	1.50	150.00	30.00
60	15.00	20.00	5.00	7.00	0.0	15.00	100.00	30.00	1500.00	0.50	10.00	3.00T	3.00	700.00	700.00T	10.00	0.50	150.00	30.00
61	100.00	20.00	0.0	7.00	0.0	20.00	150.00A	70.00A	2000.00	0.30	15.00T	2.00	3.00	300.00	500.00	15.00	0.0	1000.00A	20.00
62	20.00	30.00	5.00	3.00	0.0	15.00	50.00	20.00	1000.00	0.30	7.00	1.50	2.00	700.00	300.00	10.00	0.0	200.00	20.00
63	30.00	20.00	5.00	5.00	0.0	15.00	70.00	20.00	1000.00	0.20	10.00	2.00	3.00	700.00	500.00	10.00	0.0	100.00	20.00
64	100.00	30.00	5.00	7.00	0.30	15.00	100.00	30.00	1000.00	0.20	7.00	2.00	3.00	1000.00	500.00	15.00	0.50	100.00	30.00
65	70.00	15.00	5.00	10.00	0.30	10.00	50.00	20.00	700.00	0.50	10.00	1.50	2.00	700.00	150.00	20.00T	0.50	300.00	30.00
66	70.00	30.00	5.00	7.00	0.0	10.00	30.00	30.00	2000.00	0.70	7.00	2.00	2.00	1000.00	150.00	20.00T	0.0	300.00	30.00
67	15.00	10.00	5.00	5.00	0.0	7.00	20.00	7.00	700.00	0.15	3.00	0.70	1.50	300.00	100.00	10.00	0.50	50.00	20.00
68	20.00	20.00	200.00	7.00	0.0	15.00	70.00	30.00	700.00	0.30	7.00	1.50	2.00	700.00	300.00	0.0	0.0	70.00	50.00
69	30.00	20.00	5.00	7.00	0.0	20.00	50.00	20.00	1500.00	0.50	10.00	2.00	3.00	1000.00	500.00	15.00	1.50	200.00	30.00
70	50.00	30.00	5.00	20.00A	0.30	15.00	50.00	15.00	1500.00	0.50	10.00	2.00	3.00	1000.00	500.00	15.00	0.10	150.00	50.00
71	15.00	30.00	5.00	3.00	0.30	10.00	50.00	20.00	700.00	0.20	5.00	1.00	1.50	700.00	300.00	10.00	2.00	100.00	50.00
72	15.00	20.00	5.00	3.00	0.30	15.00	50.00	20.00	700.00	0.30	5.00	1.50	1.00	700.00	300.00	10.00	1.00	100.00	20.00
73	30.00	30.00	5.00	15.00T	0.0	15.00	70.00	20.00	700.00	0.50	10.00	2.00	2.00	1000.00	200.00	5.00	0.0	300.00	20.00
74	20.00	10.00	5.00	3.00	0.0	15.00	70.00	20.00	1000.00	0.70	10.00	2.00	2.00	700.00	200.00	0.0	0.0	200.00	20.00
75	30.00	50.00T	5.00	10.00	0.0	15.00	50.00	20.00	1500.00	0.50	10.00	2.00	3.00	700.00	300.00	10.00	0.50	200.00	30.00
76	30.00	50.00T	300.00T	10.00	0.0	15.00	70.00	30.00	2000.00	E	7.00	1.50	1.50	700.00	200.00	5.00	1.00	100.00	50.00
77	70.00	50.00T	5.00	10.00	0.0	10.00	20.00	3.00	2000.00	0.30	10.00	1.50	2.00	1000.00	300.00	20.00T	1.50	300.00	70.00
78	50.00	30.00	300.00T	10.00	0.0	20.00	50.00	50.00	3000.00	0.70	15.00T	2.00	2.00	1000.00	300.00	10.00	0.50	200.00	100.00A
79	70.00	30.00	200.00	7.00	0.0	15.00	100.00	15.00	1500.00	0.70	15.00T	2.00	3.00	700.00	500.00	10.00	0.0	300.00	20.00
80	30.00	30.00	5.00	10.00	0.0	7.00	15.00	7.00	1000.00	0.30	5.00	1.50	2.00	1000.00	300.00	0.0	0.0	150.00	30.00
81	50.00	50.00T	500.00A	15.00T	0.0	20.00	50.00	30.00	5000.00A	0.50	10.00	1.50	2.00	700.00	300.00	10.00	0.50	200.00	100.00A
82	50.00	50.00T	300.00T	15.00T	0.0	30.00T	70.00	50.00	5000.00A	0.70	15.00T	2.00	3.00	1500.00T	500.00	15.00	0.0	300.00	70.00
83	50.00	30.00	5.00	7.00	0.0	15.00	70.00	30.00	2000.00	0.70	10.00	2.00	2.00	700.00	300.00	5.00	0.0	200.00	20.00
84	30.00	50.00T	5.00	5.00	0.0	15.00	30.00	30.00	1000.00	0.20	7.00	1.00	1.00	500.00	200.00	0.0	0.50	70.00	20.00
85	20.00	50.00T	5.00	3.00	0.30	15.00	70.00	30.00	1000.00	0.50	10.00	1.50	2.00	700.00	500.00	5.00	0.0	100.00	30.00
86	30.00	15.00	0.0	0.0	0.30	7.00	15.00	7.00	700.00	0.15	3.00	1.00	1.50	700.00	300.00	0.0	0.0	100.00	70.00
87	30.00	20.00	5.00	0.0	0.0	10.00	20.00	7.00	700.00	0.15	5.00	1.50	3.00	700.00	500.00	5.00	0.50	300.00	30.00
88	30.00	15.00	0.0	0.0	0.0	7.00	30.00	10.00	500.00	0.20	5.00	1.00	1.50	500.00	300.00	0.0	0.0	200.00	20.00
89	50.00	50.00T	200.00	3.00	0.0	15.00	50.00	30.00	700.00	0.20	5.00	1.50	1.00	500.00	200.00	5.00	3.00	100.00	30.00
90	15.00	20.00	5.00	7.00	0.50	15.00	50.00	20.00	700.00	0.30	5.00	1.50	2.00	500.00	300.00	5.00	0.0	100.00	30.00
91	10.00	20.00	5.00	0.0	0.0	15.00	50.00	10.00	1000.00	0.50	7.00	2.00	3.00	1000.00	500.00	5.00	0.0	300.00	30.00
92	30.00	20.00	0.0	0.0	0.0	10.00	20.00	10.00	700.00	0.30	5.00	2.00	2.00	700.00	300.00	0.0	0.0	70.00	10.00
93	30.00	15.00	0.0	0.0	0.0	10.00	7.00	7.00	500.00	0.15	2.00	0.50	1.50	500.00	300.00	0.0	0.0	70.00	0.0
94	50.00	20.00	5.00	3.00	0.0	15.00	70.00	30.00	700.00	0.70	7.00	2.00	3.00	300.00	500.00	10.00	E	70.00	10.00

Appendix 2

Semiquantitative Emission Spectrographic Analyses
Intervals of Estimate and Detection Limit

Parts Per Million

Cu	Zn	Pb	Mo	Ni	Co	Cr	B	Ba	Be
20,000	10,000	20,000	2,000	5,000	2,000	5,000	2,000	5,000	1,000
10,000	5,000	10,000	1,000	2,000	1,000	2,000	1,000	2,000	500
5,000	2,000	5,000	500	1,000	500	1,000	500	1,000	200
2,000	1,000	2,000	200	500	200	500	200	500	100
1,000	500	1,000	100	100	100	200	100	200	50
500	200	500	50	50	50	100	50	100	20
200	L	200	20	20	20	50	20	50	10
100		100	10	10	10	20	10	20	5
50		50	5	5	5	10	L	L	2
20		20	L	L	L	5			1
10		10				L			L
5		L							
2									
L									

Parts Per Million

Ca	Fe	La	Mg	Mn	Sc	Sr	Ti	V	Y	Zr
20	20	1,000	10	5,000	100	5,000	1	10,000	200	1,000
10	10	500	5	2,000	50	2,000	0.5	5,000	100	500
5	5	200	2	1,000	20	1,000	0.2	1,000	50	200
2	2	100	1	500	10	500	0.1	500	20	100
1	1	50	0.5	200	5	200	0.005	200	10	50
0.5	0.5	20	0.2	100	L	100	0.002	100	5	20
0.2	0.2	L	0.1	50		50	0.001	50	L	10
0.1	0.1		0.05	20		L	L	20		L
0.05	0.05		0.02	L				10		
L	L		L					L		

N = Not detected
L - Present, but below determination limit

For definition of chemical symbols see table 1

APPENDIX 3
STREAM SEDIMENT SAMPLE
HISTOGRAM 5 - COPPER

```
FREQUENCY  23   31   15   19    3    3    0    4    0    1    1    0    0    0    0    0    0    0    0    0
----------------------------------------------------------------------------------------------------------
    31           *
    30           *
    29           *
    28           *
    27           *
    26           *
    25           *
    24           *
    23      *    *
    22      *    *
    21      *    *
    20      *    *
    19      *    *         *
    18      *    *         *
    17      *    *         *         |  Possible
    16      *    *         *         |  Anomalous
    15      *    *    *    *         |  Values
    14      *    *    *    *         |
    13      *    *    *    *         |
    12      *    *    *    *         |            |  Probable
    11      *    *    *    *         |            |  Anomalous
    10      *    *    *    *         |            |  Values
     9      *    *    *    *         |            |
     8      *    *    *    *         |            |
     7      *    *    *    *         |            |
     6      *    *    *    *         |            |
     5      *    *    *    *         |            |
     4      *    *    *    *         |         *  |
     3      *    *    *    *    *    *         *  |
     2      *    *    *    *    *    *         *  |
     1      *    *    *    *    *    *         *  |         *    *
----------------------------------------------------------------------------------------------------------
INTERVAL    1    2    3    4    5     6  |  7     8  |  9    10    11    12  13  14  15  16  17  18  19  20
CLASS     (20) (40) (60) (80) (100) (120)|(140) (160)|(180) (200) (220)
```

Threshold - Two standard deviations

Three standard deviations

Appendix 4

Tabulation of Geochemical Rock Samples
with their Threshold and Anomalous Values

Field and Map Sample No.	Rock Type	ppb Gold	ppm Copper	Lead	Zinc
G-3	V	25	80	10	68
G-4	Gr	ND	25	20	61
G-12	Gr	50	32	25	65
G-22	Gr	ND	12	18	52
G-31	Gr	25	10	12	48
G-37	Gr	380A	15	25	56
G-50	Gs	ND	22	14	92
G-74	Gs	ND	55	20	82
G-75	Gr	ND	75	90T	62
G-89	V	ND	25	44	22
G-94	Gs	25	33	17	85
G-100	Gr	ND	15	8	32
G-111	Gs	16	47	17	82
G-113	Gr	8	20	70	312A
G-127 a & b	Gs	ND	23	60	70
G-129	Gr	12	25	14	50
2	Gr	27	25	44	83
4	Gs	16	112	12	55
6	Gs	ND	184A	11	47
9	Gs	16	121	14	50
12	Gr	12	20	18	82
13	Gs	ND	43	21	20
17	Gs	40	240A	14	18
21	Gr	20	52	14	20
23	Gs	44	47	14	20
24	V	20	28	17	52
33	Gs	12	67	34	22
34	Gr	20	22	31	25
36	Gr	20	47	14	30
39	Gr	32	17	38	27
44	V	8	62	12	6
59	Gr	ND	30	12	10
60	Gs	20	43	14	9
62	Gs	130T	52	10	65
63	Gs	64	142T	45	33
67	Gs	28	105	12	53
70	Gr	28	11	22	65
78	Gr	ND	30	9	72
83	V	37	16	13	37
96	Gr	28	18	17	73
103*	V	40	13	32	46
106	V	30	19	17	114
119	Gr	32	173T	7	27
128	Gs	16	32	13	76
136	Gr	10	16	5	51
138	Gr	21	16	242A	172T
144	Gs	13	105	19	32

*Not included in computer calculations

Field and Map Sample No.	Rock Type	ppb Gold	ppm Copper	Lead	Zinc
148	Gr	28	17	12	68
151	Gs	21	22	19	37
155	Gr	ND	19	6	76
159	Gr	ND	19	8	100
162	Gr	ND	13	8	25
164	V	ND	22	10	174T
167	V	ND	35	10	57
168	Gs	16	28	7	26
184	Gr	ND	17	4	47
187	Gr	ND	18	6	65
191	Gr	10	30	15	132
195	V	ND	25	6	8
203	Gs	ND	15	7	7
205	V	23	17	5	8
206	Gs	ND	31	15	71
212	Gs	8	28	17	94
216	Gs	20	31	12	92
223	Gs	IS	40	11	112
233	Gr	10	10	24	90
235	Gr	15	12	5	9
236	Gs	19	16	11	28
240	Gs	19	160T	9	43
244	Gs	13	55	14	32
248	Gr	ND	18	12	36
253	Gr	ND	13	13	19
260	Gs	ND	3	13	76
265	Gs	10	25	5	36
267	V	ND	11	15	31

LEGEND

Gs - Greenstone
Gr - Granodiorite
V - Volcanic

ND for gold means less than 8 PPB
IS means insufficient sample
PPB means parts per billion
PPM means parts per million

T - Threshold or possible anomaly as defined by Hawkes and Webb

A - Anomaly as defined by Hawkes and Webb

	ppb Gold	ppm Copper	ppm Lead	ppm Zinc
Average	22	43	21	58
Standard deviation	46	45	30	46
Threshold (as defined by Hawkes and Webb) average plus two standard deviations	114	133	81	150
Anomaly (as defined by Hawkes and Webb) average plus three standard deviations	160	179	111	196