GEOCHEMICAL - GEOPHYSICAL INVESTIGATIONS
FAIRBANKS DISTRICT
ALASKA

MIRL Report #12

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ABSTRACT

Trace element distribution in a subarctic valley in the Cleary Hill area of the Fairbanks gold district has been studied. Zinc and arsenic have been found excellent pathfinder elements for auriferous deposits. Methods of analysis for copper, lead, zinc, molybdenum, silver and arsenic as well as heavy metals are discussed. The University of Alaska method #2 has been improved. Terrain, slope, and frozen ground have little effect upon the distribution of trace elements associated with the Cleary Hill vein. A new method for the determination of zinc using dilute acid is proposed. Analysis of geochemical data by trend surface procedures proved effective for localization of anomalies.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation for the cooperation of the mine owners who granted access to their properties for this study.

Appreciation is extended to the University of Alaska Computer Center which donated computer time and facilities.

FOREWORD

This investigation was initiated by Professor Donald Moody under the direction of Dean Earl H. Beistline, in 1963. Working with Professor Moody were two chemistry students and two mining engineering students. Sampling and mapping were carried out during the summers of 1963 and 1964. Analyses for copper, lead, zinc, molybdenum and silver were made during the winter of 1963-1964, as well as computer plotting and study of the data. Mr. Moody left the University of Alaska in May of 1964. The 1964 summer work on heavy metal analysis of Area "A" was conducted by Mr. James Wallis and Mr. Robert Peterson under the direction of Dean Earl H. Beistline. During the summer of 1965 Mr. Heiner and Mr. Wallis made electromagnetic and self potential surveys in Area "A". The United States Bureau of Mines trenched the geochemical anomalies during this field season. Development of an ion exchange method for zinc was initiated. Studies of trace element content of soil horizons and of trend surface procedures were conducted during this season by Mr. Heiner.

This report is the work of many people, but the principal author is primarily responsible for its compilation.

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CHAPTER ONE

INTRODUCTION

The search for mineralized areas in the Fairbanks district is hampered by climate and topography. Much of the landmass is permanently frozen and contains heavy overburden of residual soil, silt, and muck. Old techniques of prospecting are inefficient and ineffective in such an environment.

Ore deposits of the district are mostly hydrothermal quartz veins and lenses confined to the Birch Creek schist. This schist has been identified by Brown (1962) as "pelitic schists, calcareous-magnesian schists and marbles, and diaphthoritic gneiss." A few gold deposits as well as lead-antimony ores also occur in quartz diorite and quartz monzonite intrusions of the district. Mineralization occurred in stages, starting with deposition of white quartz from hydrothermal solutions into faults and joints of the country rock. Subsequent brecciation of the quartz veins was followed by a second deposition of quartz and auriferous solutions. Later stages of brecciation and fissure fillings resulted in both barren and auriferous quartz veins. Narrow veins, up to three feet in width, have been the most productive sources of gold. Oxides of antimony and arsenic accompany many of the auriferous lodes, which are also marked by limonite stain and gouge.

Until recently, prospecting for gold lodes has consisted of panning and hand trenching. Trenching was often accomplished by hand, without the aid of machinery, and much prospecting was done by drifting on quartz stringers. Later, some prospecting by crawler type tractor and diamond drilling was done in the area. A few prospectors have utilized citrate soluble techniques of geochemistry. This technique is reported as responsible for the discovery of the Keystone lode on Cleary Hill. Self potential has been used in the district with little or no success.

Purpose of the Investigation

This investigation is primarily concerned with developing modern methods of prospecting for gold lodes in the Fairbanks district. To achieve this the following objectives were established:

(a) Determine the geochemical environment in the Fairbanks district.

(b) Determine trace element distribution over a known lode.

(c) Determine the effects of terrain and slope upon trace element distribution over known lodes.

(d) Determine the effects of frozen ground upon trace element distribution.

(e) Confirm the validity of the University of Alaska Method #2 for heavy metal soil analyses.

(f) Test inexpensive geophysical equipment.

(g) Test and develop methods of analysis for prospecting based upon trace element distribution.

It was necessary to establish objective (a), above, in order to determine which, if any, elements could be used for ore tracers. Results are discussed in Chapter Two. Objectives (b) through (f) are discussed in Chapter Three. Results reported in Chapters Two and Three led to the development of a technique of prospecting given in Chapter V (objective g). This study is unique in concept in that a method was sought which would result in a minimum of contamination, stability of reagents and ease of use by untrained personnel.

CHAPTER TWO

GEOCHEMICAL ENVIRONMENT STUDY

A thorough knowledge of the geochemical environment of the area to be prospected is needed prior to deciding upon the method(s) used to prospect for ore. It was decided to acquire this knowledge by investigating a typical subarctic valley in the Fairbanks district.

Field Procedures

An area approximately 3000' x 8000', encompassing Bedrock Creek and the ridges between Chatham and Willow Creeks in the heart of the Cleary Hill mining area, was selected for the study. (Figure 1) It is considered typical of gold lode areas in the Fairbanks district. The ridges and slopes are covered chiefly by residual soil which supports moss, birch, aspen, and black spruce. Extensive permafrost zones exist in the valley and on the lower slopes of the ridges, and seasonal frost lasts until late July or August.

The boundaries of the area were established by transit and stadia survey, and east-west cross lines were cut every 1000 feet. Soil samples were taken with a 1½ horsepower Feldman power auger along the perimeter of the traverse and on each cross line at 25 foot intervals. This interval was selected to insure an adequate number of data points for an investigation of trace element associations. Five pounds of the auger cuttings were taken as the drill penetrated the soil. Collected samples were placed in polyethylene bags, sealed, identified and stored for laboratory analysis. Samples were allowed to dry and a small

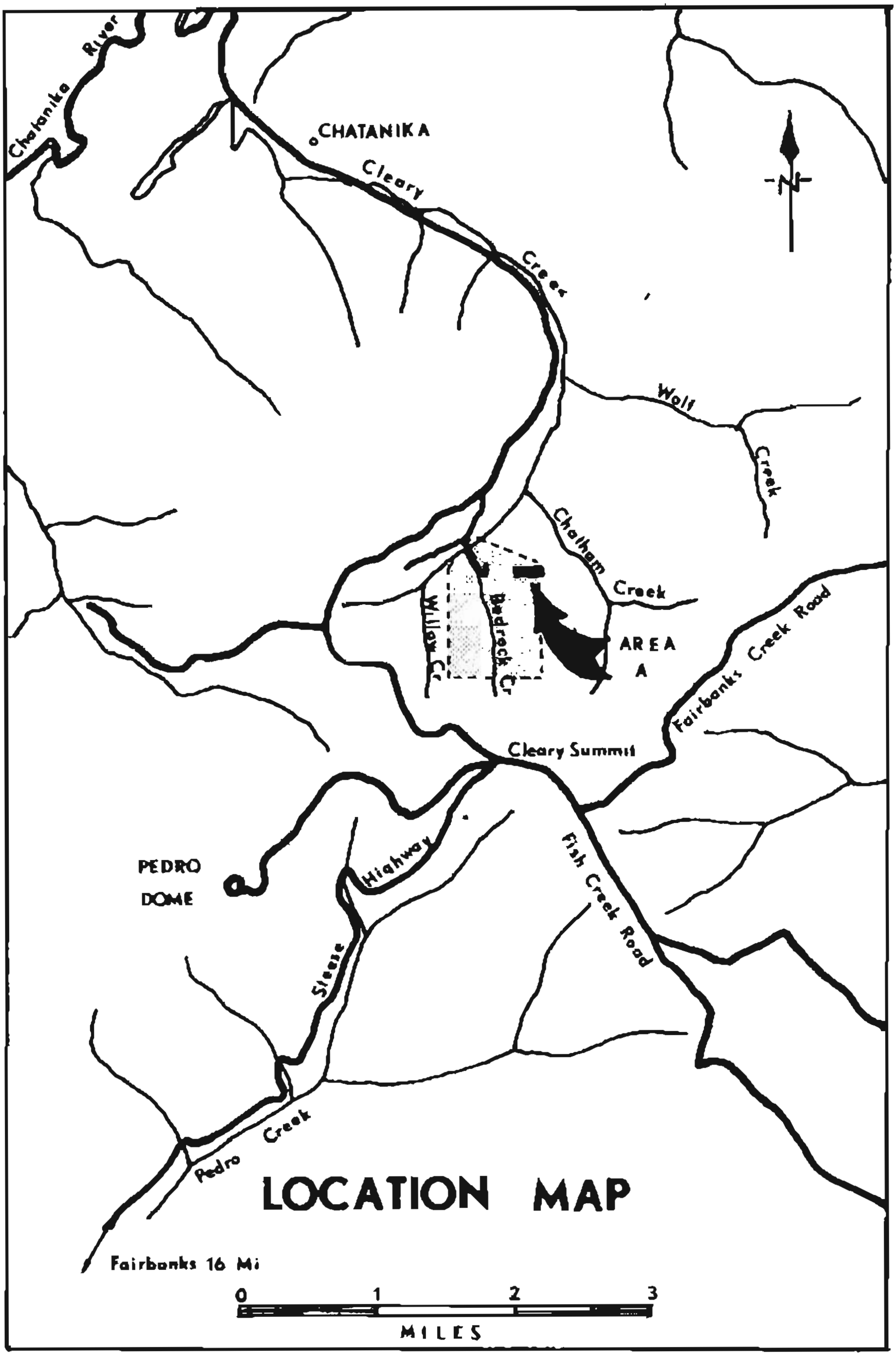

Chatanika River
CHATANIKA
Cleary Creek
N
Wolf Creek
Chatham Creek
Willow Cr
Bedrock Cr
AREA A
Fairbanks Creek Road
Cleary Summit
PEDRO DOME
Highway
Steese
Fish Creek Road
Pedro Creek
LOCATION MAP
Fairbanks 16 Mi
0
1
2
3
MILES

Fig. 1

portion of each was screened through 80 mesh silk organza and transferred to a paper bag to await chemical analysis for copper, lead, zinc, molybdenum and silver. A total of 2200 samples were taken by this process.

Analytical Procedures

Since there were 2,200 soil samples to be analyzed, each for copper, lead, molybdenum, silver, and zinc, the methods of digestion and subsequent analysis of the soils were chosen so as to allow mass production. These procedures are described in the appendix of this paper.

The soil samples were digested a few hundred at a time, to the stage of the final evaporation. At this point the beakers were covered with polyethylene and stored until needed. They were then taken fifty at a time, and 50 ml of the sample solutions were made. These solutions were analyzed for copper, lead, molybdenum, silver, and zinc. The process was repeated until all samples were analyzed.

The method of digestion presented by Ginzburg (1960) was modified in order to effect near total solution of the elements sought. Digestion was more thorough in some soils than in others due to variability of composition. It is believed that variability introduced into the subsequent analyses was not of sufficient degree to mask the anomalies.

The procedures for the determination of copper, lead, and zinc were those of the U. S. Geological Survey (Ward, 1963); for molybdenum, those of Ginzburg (1960); and for silver, adapted from procedures of Ginzburg (1960) and Sandell (1959). All of these methods are colorimetric, and are based upon the development of a colored complex with the element being determined, and subsequent visual comparison to similarly prepared standards. The procedures are straightforward, and with proper precautions taken to minimize contamination, an accuracy of ± 50 ppm was attained.

Data Analysis

Because of the large number of data points involved, the University's IBM 1620 computer and data processing facilities proved to be indispensable tools for data analysis.

Programs were written to compute the mean, median, mode, averages and other statistics. These are now common to most computer centers and have not been included in this paper. Five programs have been included in the Appendix. These are: (1) Five variable trend comparisons; (2) Curve profiler; (3) Five point running average; (4) Numerical point plot and grid system; (5) Grid label for IBM automatic contouring program.

The results of the trace element analyses were profiled rather than contoured because of the unbalanced sample interval of 1000 feet by 25 feet. The effects of extraneous values were effectively eliminated by using MIRL program RAVE, a five point running average profiler, to profile the individual element data.

Comparison of the individual element profiles indicates definite inter-element relationships. The association between elements was determined by counting the number of times an element pair followed the same trend. For example, if copper followed the trend of lead more often than not, it was considered to have a positive trend; similarly if it did not, it was considered a negative trend. Table 1 shows the results of the trend comparisons, indicating the percentage distribution of each trend. Zinc followed the trend of molybdenum, silver, lead and copper more than 60% of the time. The copper-lead and molybdenum-silver association follow the same trend in more than 84% of the analyses.

TABLE 1

PERCENTAGE DISTRIBUTIONS OF TRENDS

Trace Elements	Percentage of Time Following Same Trend
Zinc and Molybdenum	60.14%
Zinc and Silver	67.89%
Zinc and Lead	68.71%
Zinc and Copper	77.55%
Copper and Lead	84.81%
Copper and Zinc	77.55%
Copper and Molybdenum	41.96%
Copper and Silver	51.81%
Lead and Zinc	68.71%
Lead and Molybdenum	46.26%
Lead and Silver	39.09%
Molybdenum and Silver	84.05%

Frequency distributions of each trace element concentration are illustrated graphically in Figures 2 - 6. The ordinate, or relative frequency, was derived by dividing the number of samples in each interval by the total number taken. These curves illustrate the statistical occurrence of values in the study area. They are susceptible to both sampling and analytical errors, and caution must be exercised in their interpretation. Frequency distributions for copper, lead, molybdenum and silver closely

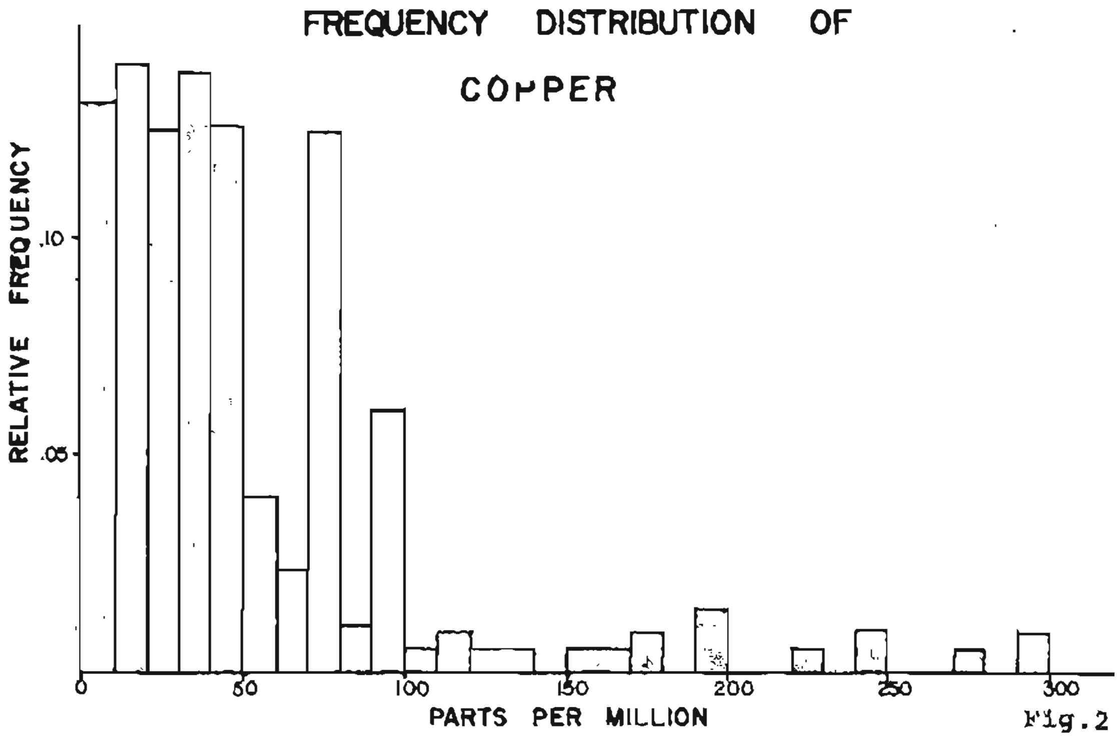

FREQUENCY DISTRIBUTION OF
COPPER
RELATIVE FREQUENCY
.10
.05
0
50
100
150
200
250
300
PARTS PER MILLION

Fig.2

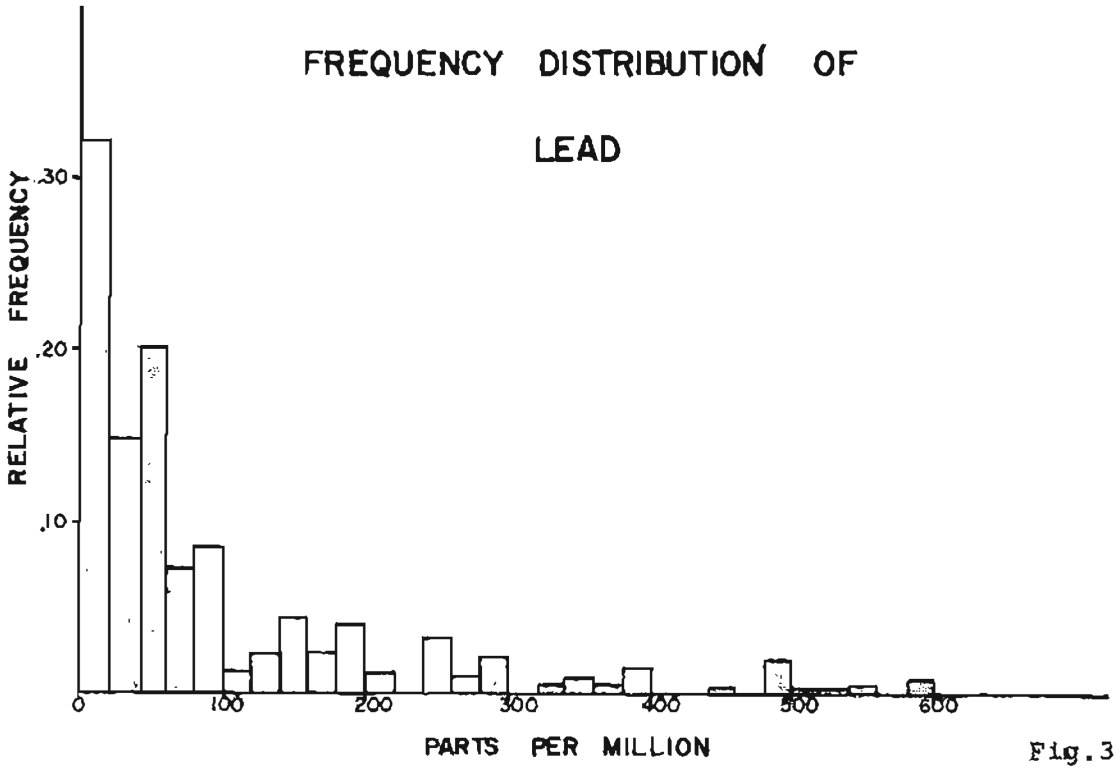

FREQUENCY DISTRIBUTION OF
LEAD
RELATIVE FREQUENCY
.30
.20
.10
0
100
200
300
400
500
600
PARTS PER MILLION

Fig.3

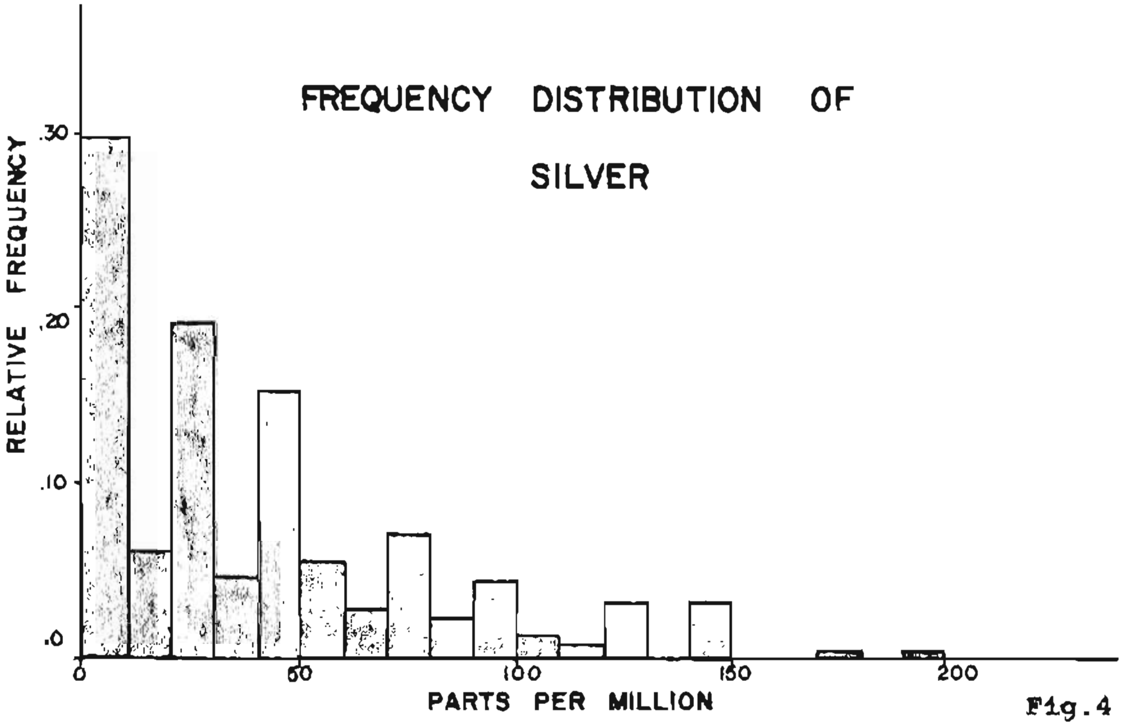

FREQUENCY DISTRIBUTION OF
SILVER
RELATIVE FREQUENCY
.30
.20
.10
.0
0
50
100
150
200
PARTS PER MILLION

Fig.4

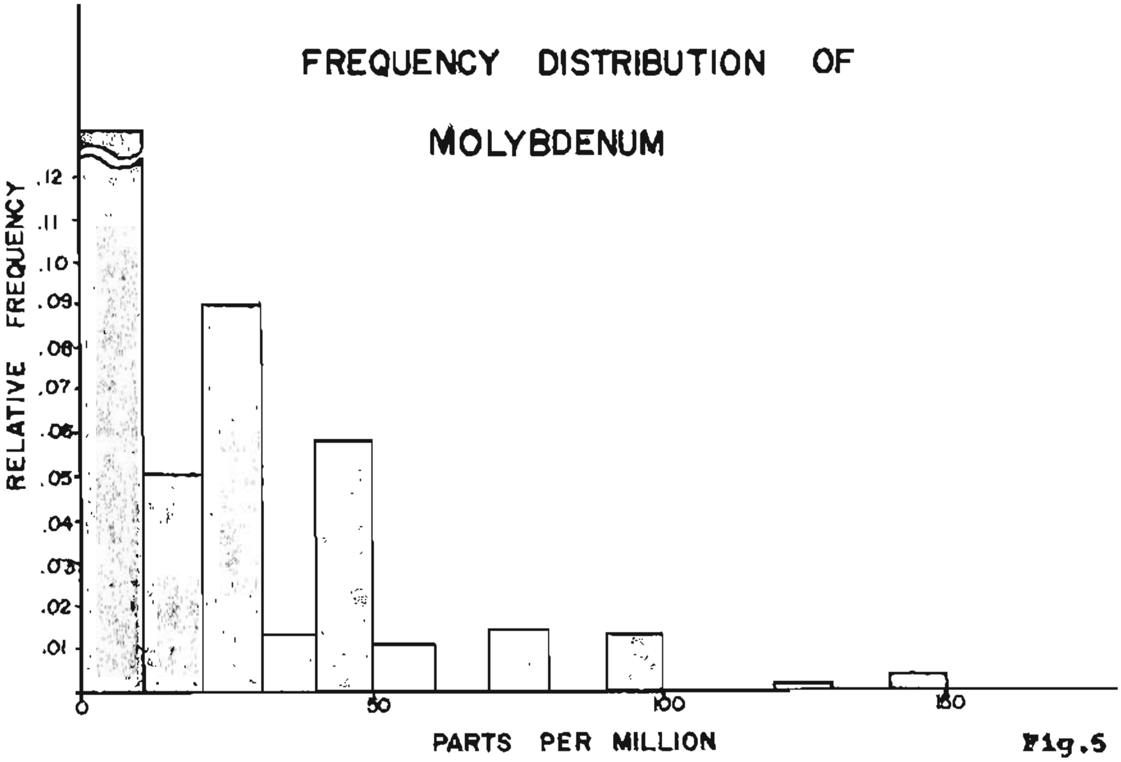

FREQUENCY DISTRIBUTION OF
MOLYBDENUM
RELATIVE FREQUENCY
.12
.11
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
50
100
150
PARTS PER MILLION

Fig.5

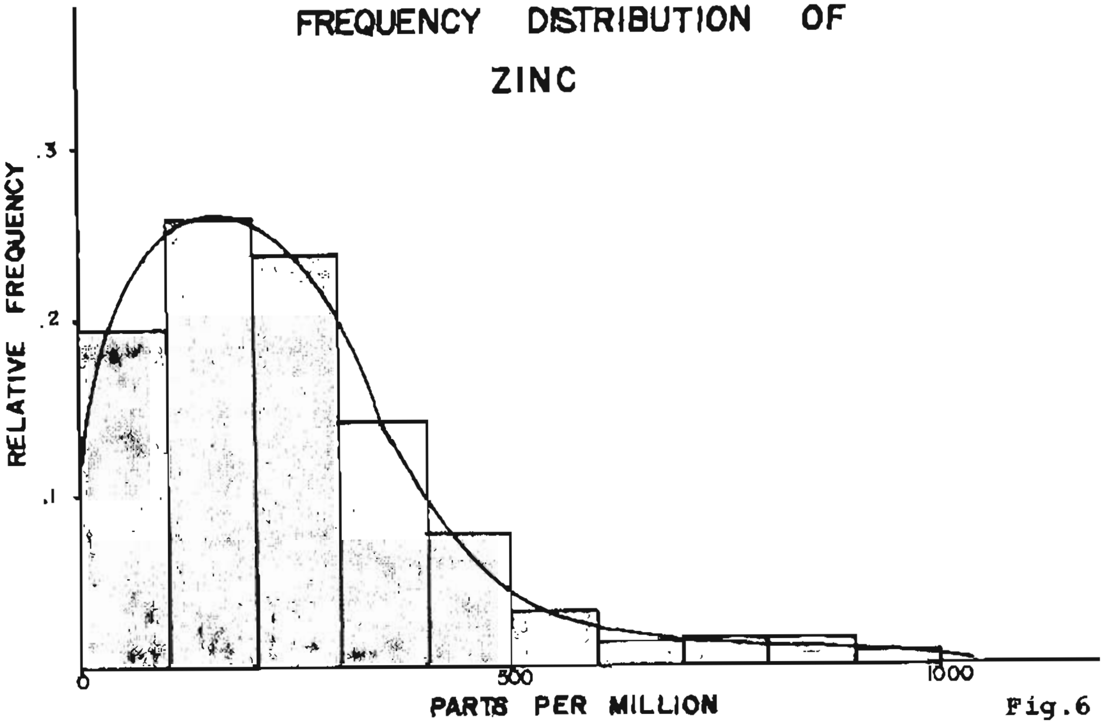


Fig.6

approximate a reverse "J" distribution. In each case, the majority of analyses were low, ranging from 0 to 100 ppm with a few sporadic highs. The zinc distribution is positively skewed, and shows the maximum number of values in the range of 100 to 199 parts per million.

Tables 2 through 6 show the class intervals and corresponding frequencies of the data used to develop frequency distribution curves. Table 7 presents the arithmetic mean, geometric mean, harmonic mean, quadratic mean, median, and the mode. Threshold values for anomalous concentrations of an element in the study area may be computed from this table.

TABLE 2

FREQUENCY DISTRIBUTION OF COPPER

Class Interval	Frequency	Relative Frequency	Cumulative Frequency	Cumulative Relative Frequency
0-10	178	0.1258	178	0.1259
11-20	183	0.1294	361	0.2553
21-30	173	0.1223	534	0.3776
31-40	181	0.1280	715	0.5056
41-50	171	0.1209	886	0.6256
51-60	64	0.0452	950	0.6718
61-70	31	0.0219	981	0.6937
71-80	169	0.1195	1150	0.8132
81-90	12	0.0084	1162	0.8217
91-100	87	0.0615	1249	0.8833
101-110	1	0.0008	1250	0.8840
111-120	3	0.0021	1253	0.8861
121-130	24	0.0169	1277	0.9031
131-140	1	0.0007	1278	0.9038
141-150	60	0.0424	1338	0.9462
151-160	1	0.0008	1339	0.9469
161-170	1	0.0008	1340	0.9476
171-180	8	0.0056	1348	0.9533
181-190	0	0.0000	1348	0.9533
191-200	20	0.0141	1368	0.9674
201-210	0	0.0000	1368	0.9674
211-220	0	0.0000	1368	0.9674
221-230	1	0.0008	1369	0.9681
231-240	0	0.0000	1369	0.9681
241-250	22	0.0155	1391	0.9837
275	1	0.0008	1392	0.9844
300	17	0.0120	1409	0.9964
350*	1	0.0008	1410	0.9971
400*	3	0.0022	1413	0.9992
600*	1	0.0008	1414	1.0000
TOTAL	1414	1.0000		

*Note: These values are not plotted on diagrams.

TABLE 3

FREQUENCY DISTRIBUTION OF LEAD

Class Interval	Frequency	Relative Frequency	Cumulative Frequency	Cumulative Relative Frequency
0-20	446	0.3154	446	0.3154
21-40	200	0.1414	646	0.4568
41-60	290	0.2050	936	0.6619
61-80	99	0.0700	1035	0.7319
81-100	112	0.0792	1147	0.8111
101-120	2	0.0014	1149	0.8125
121-140	14	0.0099	1163	0.8224
141-160	61	0.0431	1224	0.8656
161-180	10	0.0070	1234	0.8727
181-200	50	0.0353	1284	0.9080
201-220	2	0.0014	1286	0.9094
221-240	0	0.0000	1286	0.9094
241-260	39	0.0275	1325	0.9370
261-280	1	0.0007	1326	0.9377
281-300	20	0.0141	1346	0.9519
301-320	0	0.0000	1346	0.9519
321-340	1	0.0007	1347	0.9526
341-360	6	0.0042	1353	0.9568
361-380	1	0.0007	1354	0.9575
381-400	16	0.0113	1370	0.9688
401-420	0	0.0000	1370	0.9688
421-440	0	0.0000	1370	0.9688
441-460	1	0.0007	1371	0.9695
461-480	0	0.0000	1371	0.9695
481-500	14	0.0099	1385	0.9794
501-520	0	0.0000	1385	0.9794
521-540	0	0.0000	1385	0.9794
541-560	2	0.0014	1387	0.9809
561-580	0	0.0000	1387	0.9809
581-600	4	0.0029	1391	0.9837
700*	5	0.0035	1396	0.9872
800*	4	0.0028	1400	0.9900
900*	3	0.0021	1403	0.9922
1000*	2	0.0014	1405	0.9936
1100*	0	0.0000	1405	0.9936
1200*	9	0.0092	1414	1.0000
TOTAL	1414	1.0000		

*Note: These values are not plotted on diagrams.

TABLE 4

FREQUENCY DISTRIBUTION OF ZINC

Class Interval	Frequency	Relative Frequency	Cumulative Frequency	Cumulative Relative Frequency
0-50	103	0.0728	103	0.0729
51-100	169	0.1195	272	0.1923
101-150	136	0.0960	408	0.2885
151-200	237	0.1676	645	0.4561
201-250	155	0.1096	800	0.5657
251-300	192	0.1357	992	0.7015
301-350	45	0.0318	1037	0.7333
351-400	159	0.1123	1196	0.8458
401-450	32	0.0226	1228	0.8684
451-500	75	0.0530	1303	0.9214
501-550	6	0.0042	1309	0.9257
551-600	41	0.0290	1350	0.9547
601-650	3	0.0021	1353	0.9568
651-700	15	0.0115	1368	0.9674
701-750	3	0.0021	1371	0.9695
751-800	19	0.0134	1390	0.9830
801-850	1	0.0007	1391	0.9837
851-900	5	0.0035	1396	0.9872
901-950	1	0.0007	1397	0.9879
951-1000	10	0.0070	1407	0.9950
1001-1050	0	0.0000	1407	0.9950
1051-1100	1	0.0007	1408	0.9957
1101-1150	0	0.0000	1408	0.9957
1151-1200	3	0.0021	1411	0.9978
1201-1230	0	0.0000	1411	0.9978
1251-15000*	3	0.0021	1414	1.0000
TOTAL	1414	1.0000		

*Note: These values are not plotted on diagrams.

TABLE 5

FREQUENCY DISTRIBUTION OF MOLYBDENUM

Class Interval	Frequency	Relative Frequency	Cumulative Frequency	Cumulative Relative Frequency
0-10	1053	0.7446	1053	0.7447
11-20	72	0.0509	1125	0.7956
21-30	134	0.0947	1259	0.8903
31-40	19	0.0134	1278	0.9038
41-50	95	0.0671	1373	0.9710
51-60	6	0.0042	1379	0.9752
61-70	0	0.0000	1379	0.9752
71-80	16	0.0113	1395	0.9865
81-90	0	0.0000	1395	0.9865
91-100	13	0.0092	1408	0.9958
125	1	0.0008	1409	0.9964
150	3	0.0022	1412	0.9985
250*	1	0.0008	1413	0.9992
350*	1	0.0008	1414	1.0000
TOTAL	1414	1.0000		

*Note: These values are not plotted on diagrams.

TABLE 6

FREQUENCY DISTRIBUTION OF SILVER

Class Interval	Frequency	Relative Frequency	Cumulative Frequency	Cumulative Relative Frequency
0-10	415	0.2934	415	0.2935
11-20	95	0.0671	510	0.3606
21-30	282	0.1994	792	0.5601
31-40	52	0.0367	844	0.5968
41-50	228	0.1612	1072	0.7581
51-60	56	0.0396	1128	0.7977
61-70	27	0.0191	1155	0.8168
71-80	112	0.0792	1267	0.8960
81-90	15	0.0106	1282	0.9066
91-100	54	0.0381	1336	0.9448
101-110	9	0.0064	1345	0.9512
111-120	4	0.0029	1349	0.9540
121-130	28	0.0199	1377	0.9738
131-140	0	0.0000	1377	0.9738
141-150	29	0.0205	1406	0.9943
151-160	1	0.0008	1407	0.9950
161-170	0	0.0000	1407	0.9950
171-180	4	0.0029	1411	0.9978
181-190	0	0.0000	1411	0.9978
190-200	3	0.0022	1414	1.0000
	1414	1.0000		

TABLE 7

MEANS, MEDIAN, AND MODES OF TRACE ELEMENT DISTRIBUTION IN BEDROCK CREEK WATERSHED (PARTS PER MILLION)

	Copper	Lead	Zinc	Molybdenum	Silver
Arithmetic Mean	60.17	150.95	290.36	10.86	37.97
Geometric Mean	40.39	26.04	217.29	3.00	15.93
Harmonic Mean	24.93	40.51	148.96	46.12	39.73
Quadratic Mean	84.45	20.21	536.433	25.20	53.18
Median	40.00	50.00	250.00	0	25
Mode	50	0	200	0	0

Note: Determined by Moody, 1964.

Further statistical studies based upon non-normal distributions were not attempted. The frequency distribution curves obtained will be of value in future studies in the development of geochemical sampling models for computer investigation.

Plates 1 through 5 show trace element profiles. Examination of the trace element data indicates that at least three anomalous areas are within the survey boundaries. These areas are designated as Areas A, B, and C, on Figure 1. Resampling and analyzing the samples by the University of Alaska total heavy metals method verified the anomalous readings in these areas.

Area A encompasses a portion of the ridge top and west slope between Chatham and Bedrock Creeks. The original line across this area is cross line 700. Several concentrations of heavy metals occur along this cross line which is an area relatively free from early-day trenching.

Area B is on a 30% slope extending to the west. Crushed rock from the Cleary Hill Mine used on the road bed has washed out and been transported over this area. The effect of the transported material has been to distribute metallic ions down the slope, completely disguising the significance of the sample analyses.

Area C is crisscrossed with a series of narrow trenches. The two largest trenches are approximately 100 feet long, 20 feet wide and 6 to 10 feet deep. Local residents indicate that these trenches were completed some 30 years ago and uncovered a narrow zone of mineralization containing some gold and sulfides.

Transported material from these trenches probably affected the values of the samples, and distorted the pattern of the sample lines across an area where little trenching is evident. This anomaly is probably non-significant.

Note on Contamination and Nonsignificant Anomalies

Contamination may result from a variety of man-made conditions. Trash, fertilizer, oxidized spoil and mine dumps, sheet metal, metaliferous insecticides and drainage from old mine workings can seriously influence trace element content of the soil and water. Any such conditions should be searched for to safeguard against false anomalies. Less commonly false anomalies may be obtained over high background source rocks. Ultramafic rocks are commonly high in chromium, nickel, cobalt and magnesium. Mafic rocks are high in iron, titanium and copper. Soils high in calcium may restrict mobility of ions, thereby concentrating them into nonsignificant anomalies. Clays and humus have high exchange capacities and can also produce nonsignificant anomalies.

CHAPTER THREE

STUDIES IN AREA "A"

Area "A" provided a good setting for studying the relationships between trace elements, frozen ground, terrain slope, and known mineralization. Preliminary work in Area "A" established the presence of anomalous zones away from any known ore; for this reason it was picked to obtain objectives (b) through (f), Chapter 1. At this stage of the study the U. S. Bureau of Mines entered into a cooperative agreement to trench the anomalies. The Bureau trenched and mapped the bedrock geology of the area and assisted in the field work and interpretation of data.

For areal control, a grid was surveyed, consisting of 100 foot lines with sample locations at 50 foot intervals along the lines. Elevations were established by level survey and contour maps were prepared by stadia measurements, the latter being done by the U. S. Bureau of Mines. Local claim corners were tied in to the area to enable use of the existing Cleary Hill Mine maps.

Soil samples should be taken from identical soil horizons so as not to introduce significant variations in metallic ion concentration. Variations in depth of overburden and localized permafrost lenses over the sample area made this impossible in some cases, most notably on the north portion of Line 714 and on Lines 715 and 716. Soil sampling procedure consisted of sampling at a depth of 18 inches near every picket over the grid, a procedure which placed most samples in the B horizon. Samples were placed in polyethylene bags marked with the sample location.

Later they were dried, transferred to 4 x 7 inch paper sample envelopes and retained for analysis. In order to compare analytical methods, each sample was analyzed by:

1. University of Alaska Method #2
2. Wet chemical methods for Cu, Pb, Zn

In the University of Alaska method, of analyzing for the citrate soluble metals of copper, lead and zinc, results are given in milliliters of reagent required to reach an end point. (See Appendix).

Initially, the University of Alaska Geochemical Prospecting Method No. 2 was employed both in the field and in the laboratory to determine citrate-soluble heavy metal concentrations. During the last phases of the study, this method was modified to eliminate some of the potential variables from the original method. (See Appendix)

Figure 7 illustrates the variability of the index value (milliliters reagent) as a function of the pH of the analytical solution. The curve was obtained by determining the index value of a soil sample at various pH levels. When the pH is at the proper level, 8.5, the index value of the soil sample is 5.4, while at a pH of 7.5, the index value of the sample drops to 3.0, a difference of 2.4 ml. The greater the index value of a sample, the greater the difference for a given pH range. This difference is the error due to variation of pH from the proper level.

In order to eliminate possible errors due to inhomogeneities in the conditioning mixture, the mixture was dissolved in demineralized water. In this manner the proper amount of each

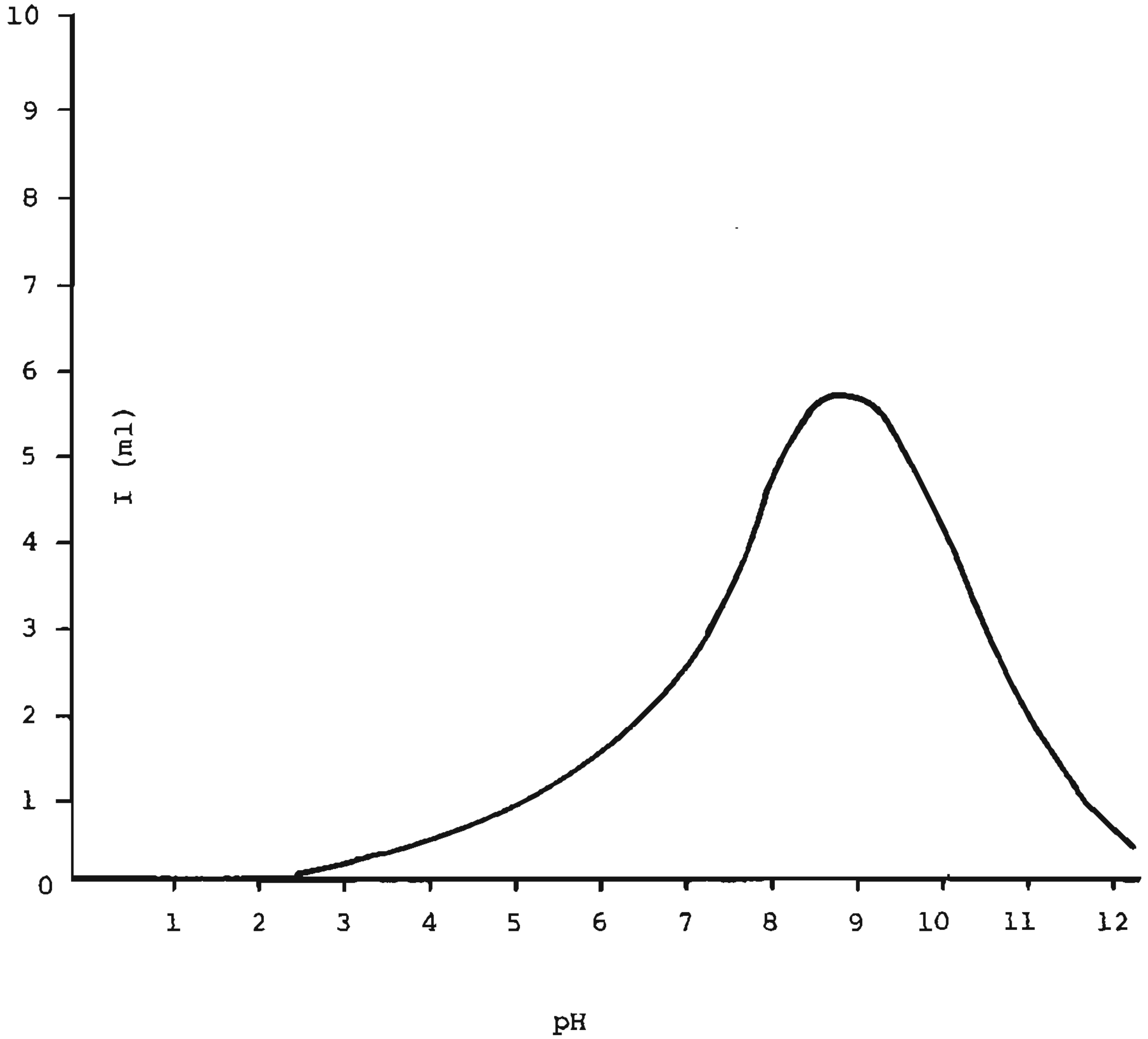


Fig.7 pH versus index value, I, for the University of Alaska. Geochemical Prospecting Method No. 2

reagent is employed in all analyses by employing a fixed volume of conditioning solution. This modification together with the elimination of reagent contamination, has been incorporated into the Modified University of Alaska Geochemical Prospecting Method #2. (See Appendix)

It should be emphasized that the most common source of error in both the modified and original versions of the University of Alaska Geochemical Prospecting Method No. 2 is the dithizone solution employed. This solution must be a saturated solution of dithizone in unleaded gasoline if optimum results are to be obtained. The solution should also be free of floating particles of dithizone when used. Heat, light, and oxidizing agents decompose dithizone solutions readily, and for this reason it is imperative that only fresh dithizone solutions be used.

Profiles of the heavy metal values were drawn on a map of the grid system and the axes of the heavy metal zones sketched, Figure 8.

Analysis of Heavy-Metal Anomalies

To determine what constitutes a significant anomaly, it is first necessary to establish the normal background or "threshold value" for the district. Values within the sampled area, but away from the mineralized zones, ranged from 1 to 2 ml. This value, 2 ml, was taken to represent the local background as defined by Hawkes and Webb (1962), above which values might be anomalous. In order to avoid interpretation of random variations as anomalies, only those samples having index values three times this threshold were considered significant.

Examination of the heavy metal profiles (Figure 8) shows a heavy metal zone trending approximately N80°W and passing through station 711. Lines 707A, 707B, 715, and 716 were cut and sampled at fifty foot intervals to check the continuity of this zone. The samples from Lines 707A and 707B verified the extension of the zone to the west; however, the zone appeared to terminate near Line 715.

Individual wet chemical analyses for copper, lead and zinc were performed as described previously. Copper analyses were all low, indicating no trend. Lead analyses were sporadic. Zinc confirmed the heavy metal trend in most instances. (See Appendix)

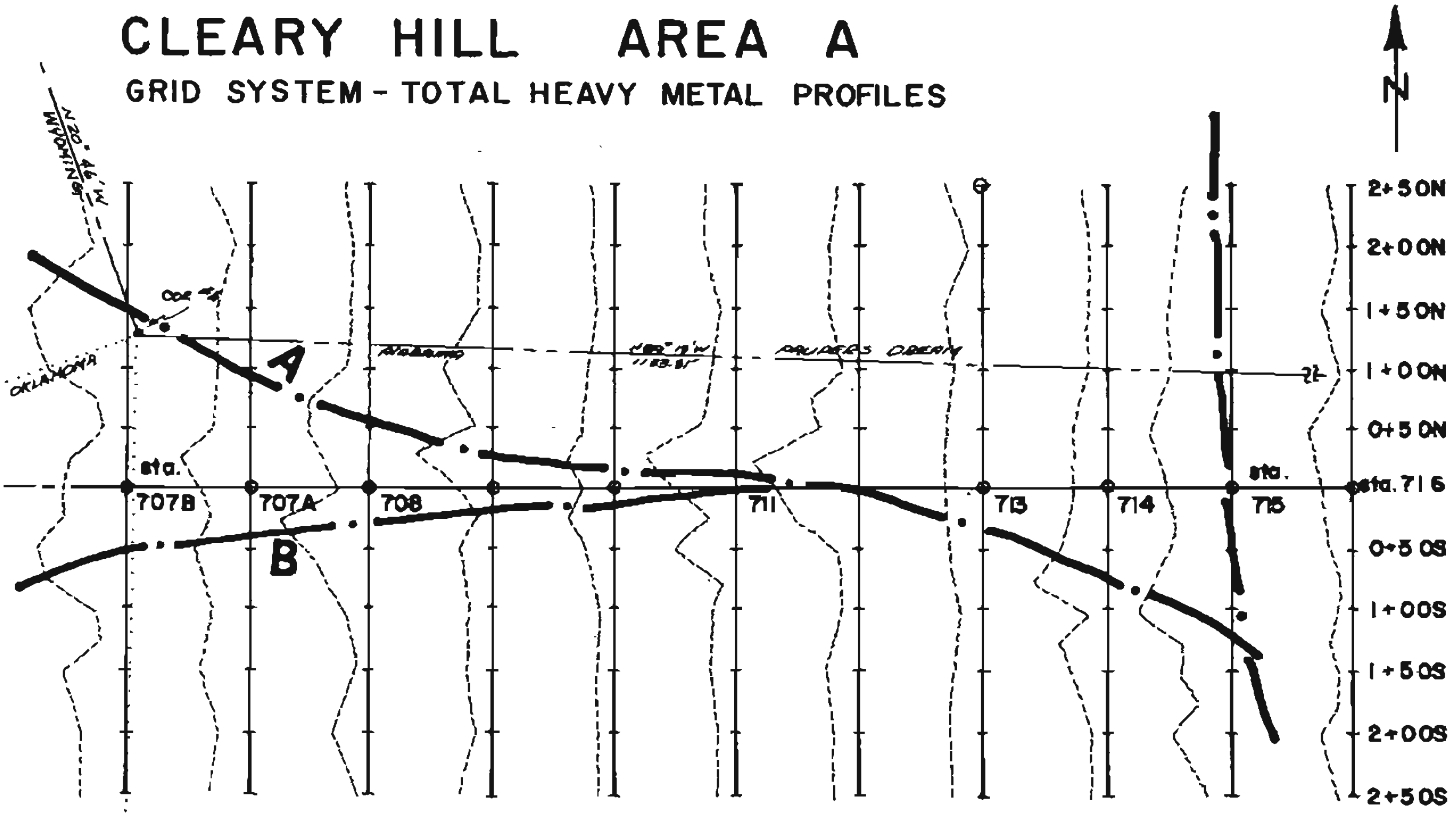
Geophysical Correlation

Although the geochemical anomalies were small and considered to represent quartz veins rather than sulfide bodies, various geophysical methods were applied to see if the geochemical anomalies could be detected. It was hoped that reconnaissance surveys with various inexpensive geophysical instruments might indicate a unit which could be used to trace or correlate with a known geochemical anomaly in this area. Two hand-held magnetometers, one self potential unit, and one vertical loop electromagnetic unit were tested over the grid area.

The electromagnetic unit showed a number of weak conductors, the axes of which agreed well with the location of heavy metal trends A and B, Figure 9. Trenching revealed these anomalies to be limonitic gosson zones associated with extensive faulting and

CLEARY HILL AREA A

GRID SYSTEM - TOTAL HEAVY METAL PROFILES



TREND OF HEAVY METAL ANOMALY ▬ • ▬ • ▬

Fig.8

CLEARY HILL AREA A

ELECTROMAGNETIC CONDUCTOR AXES

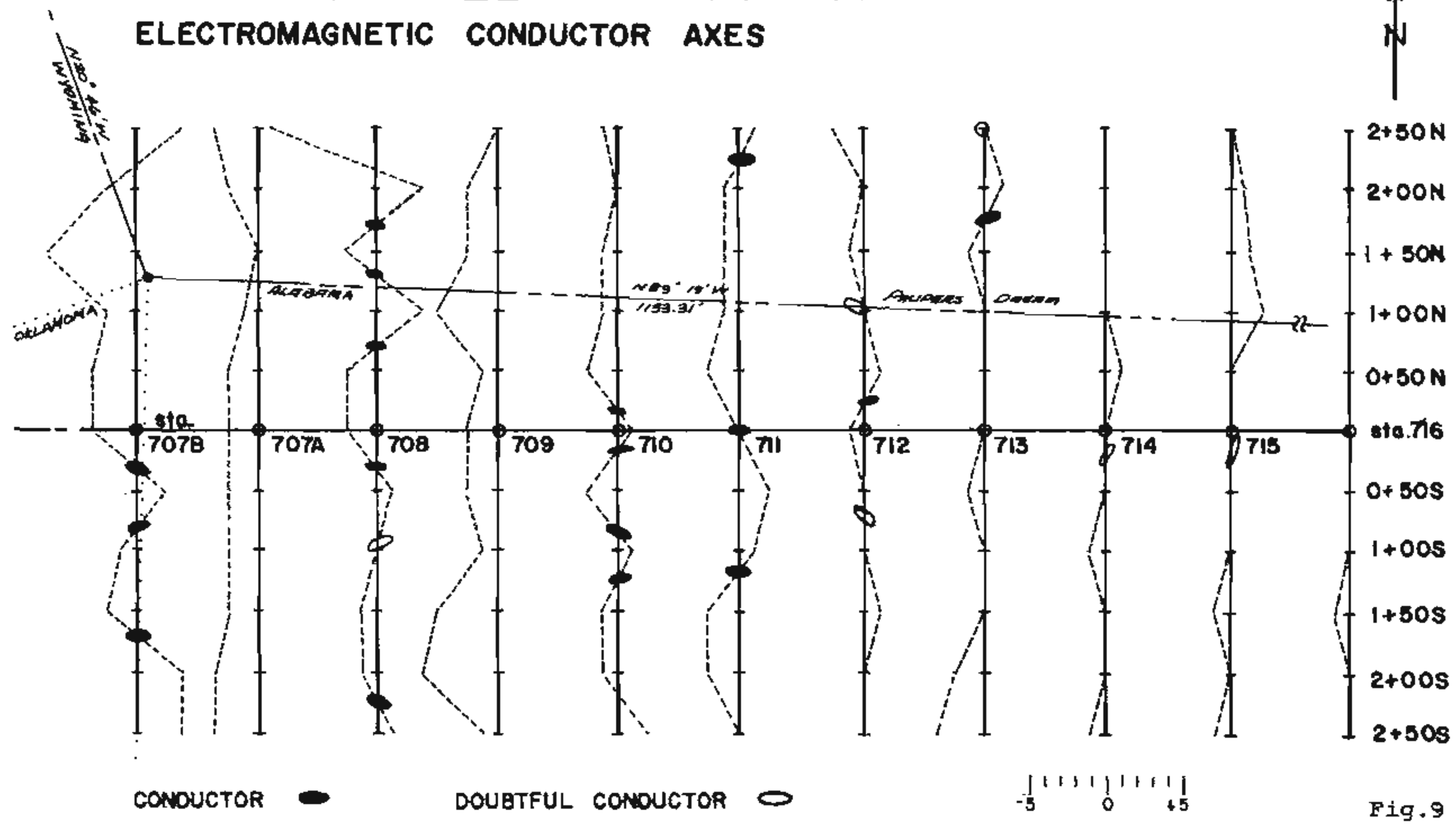


Fig.9

in some cases, quartz mineralization. Several quartz stringers carried enough iron mineralization to produce electromagnetic anomalies. The readings obtained were of low strength and poor quality and use of these readings without a corresponding geochemical anomaly would have produced many "dry holes." The instrument is of value, however, in confirming geochemical anomalies in the Cleary district.

The capabilities of the electromagnetic instrument were tested over known leached lead-silver veins in the Fox area. The readings in this case were strong and of good quality. It was later used to delineate the strike of a lead-silver showing which was confirmed by trenching.

Analysis of Anomalies

Trenching revealed the anomalous North-South structure through station 715 to be false. The samples were rerun for total heavy metals with a decontaminated liquid buffer and found to contain low heavy metal values. Error was due to contamination of the analytical apparatus, or to segregation of the solid buffer employed.

Mapping of the trenches and sampling of the veins, gossans, limonitic zones and possible solution transport areas were accomplished by the Bureau of Mines. Description of the samples and gold-silver content are presented as Tables 8 through 11. Plates 6 through 11 indicate bedrock geology, sample locations, heavy metal values and topography.

TABLE 8

SAMPLE ANALYSES TRENCHES 1, 1A, 4 and 4A

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
1-Tr. 1	Channel	0.20	0.78	Trace	Red-brown granulated goethite with inclusions of quartz and mica schist, vein 0.20 feet wide, strike N56°W, dip 34°SE.
2-Tr. 1	"	0.28	Trace	"	Same as 1-Tr. 1, 0.28 feet wide.
3-Tr. 1	"	0.15	0.68	"	Iron stained quartz and schist with granular goethite and quartz in fractures, 0.15 feet wide, strike N55°W, dip 56°SE.
4-Tr. 1	"	0.20	0.78	"	Same as 3-Tr. 1, 0.20 feet wide.
5-Tr. 1	"	0.25	Trace	"	Coarse fragments of iron stained crushed quartz and mica schist, granular goethite filling partings, 0.25 feet wide, strike N35°W, dip 23°NE
6-Tr. 1	"	0.60	Trace	"	Iron stained coarse fragments of mica schist imbedded in gradular goethite and some gouge, 0.60 feet wide, strike N75°W, vertical.
7-Tr. 1	"	0.40	Trace	"	Iron stained coarse and fine fragments of quartz imbedded in granular goethite, strike N75°W, vertical.
8-Tr. 1A	"	0.20	0.16	"	Crushed quartz and iron stained mica schist in granulated goethite, 0.20 feet wide, strike N56°W, dip 37°SW.
9-Tr. 1A	"	0.30	0.02	"	Same as 8-Tr. 1A.
10-Tr. 1A	"	0.18	0.08	"	Iron stained crushed altered mica schist and granulated goethite, 0.18 feet wide, strike N80°W, dip 55°SW.
11-Tr. 1A	"	0.30	0.12	"	Iron stained altered mica schist, some granulated quartz in granulated geothite 0.30 feet wide, strike N80°W, dip 55°SW.
12-Tr. 4	"	0.30	1.46	"	Iron stained quartz and mica schist with granulated goethite in partings, 0.30 feet wide, strike N75°, dip 38°SW.
13-Tr. 4	"	0.30	0.12	"	Same as 12-Tr. 4.
14A-Tr. 4A	"	0.45	0.12	0.08	Iron stained schist, hanging wall.
14B-Tr. 4A	"	0.54	nil	nil	Hydrothermally (?) altered quartzite, 0.58 feet wide, strike N80°W, dip 29°NE
14C-Tr. 4A	"	0.58	"	"	Altered banded quartzite, 0.58 feet wide, dip 29°NE.
14D-Tr. 4A	"	1.00	"	"	Altered quartzite with bands of talcy mica schist, 1.00 foot wide, strike N80°W, dip 29°NE.
14E-Tr. 4A	"	0.56	"	"	Altered iron stained mica schist, foot wall.

TABLE 8 (Continued)

SAMPLE ANALYSES TRENCHES 1, 1A, 4 and 4A

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
15A-Tr. 4	Channel	0.50	nil	nil	Altered iron stained mica schist, hanging wall, 0.50 feet wide.
15B-Tr. 4	"	1.20	"	"	Bands of altered iron stained quartzite and grey mica schist, 1.20 feet wide, strike N83°W, dip 24°NE.
15C-Tr. 4	"	0.65	0.02	Trace	Intensely iron stained altered quartzite, 0.65 feet wide, strike N83°W, dip 24°NE.
15D-Tr. 4	"	0.55	nil	nil	Grey to grey blue talcy mica schist with thin quartz seams parallel to cleavage, gouge along foot wall, 0.55 feet wide, strike N83°W, dip 24°NE.
16A-Tr. 4	"	0.52	"	"	Iron stained altered banded sugary quartzite, hanging wall segment, 0.52 feet wide, strike N84°W, dip 34°NE.
16B-Tr. 4	"	1.05	"	"	Iron stained alternate bands of quartzite and mica schist, 0.05 feet of gouge on foot wall of sample, strike N84°W, dip 34°NE.
16C-Tr. 4	"	1.10	"	"	Banded grey sugary quartzite with some iron staining, numerous iron stained fractures parallel to banding, 1.10 feet wide, strike N84°W, dip 34°NE.
17-Tr. 4	Chip	1.95	"	"	Quartz, probably a lens, enclosed by mica schist, 1.95 feet wide, strike N41°W, dip 46°NE.

TABLE 9

SAMPLE ANALYSES TRENCH 2

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
18-Tr. 2	Grab	0.10	0.76	3.62	Hydrothermally altered zone enclosed by graphitic schist, 0.10 feet wide, strike N88°E, dip 34°NW.
19-Tr. 2	Specimen		n/a*	n/a*	Blocky quartzite schist
20-Tr. 2	"		"	"	Iron stained grey quartzite schist
21-Tr. 2	"		"	"	Chloritic schist
22-Tr. 2	"		"	"	Iron stained chloritic mica schist
23-Tr. 2	"		"	"	Iron stained mica schist
24-Tr. 2	"		"	"	Chloritic iron stained along cleavage planes.
25-Tr. 2	Chip	0.80	0.28	Nil	Quartz lens, 0.80 feet wide, strike N77°E, dip 30°NW.
26-Tr. 2	Channel	1.80	0.16	"	Iron stained crushed quartz on hanging wall of fault, 1.80 feet wide, strike N38°W, dip 59°SW.
27-Tr. 2	Specimen		n/a	n/a	Quartzite schist
28-Tr. 2	"		"	"	Mica schist
29-Tr. 2	"		"	"	Chlorite schist
30-Tr. 2	Channel	0.10	0.14	Nil	Gossaniferous schist from foot wall of fault, 0.10 feet wide, strike N44°E, dip 83°SE.
31-Tr. 2	Specimen		n/a	n/a	Chloritic mica schist
32-Tr. 2	"		"	"	Mica schist
33-Tr. 2	Channel	2.10	0.02	Nil	Iron stained crushed quartz and schist and grey gouge as fault filling, 2.10 feet wide, strike N57°W, dip 53°NE.
34-Tr. 2	Specimen		n/a	n/a	Dark grey to black mica schist
35-Tr. 2	Channel	0.70	0.04	Nil	Crushed quartz and some granulated goethite in footwall of fault, 0.70 feet wide, strike N80°E, dip 61°SE.
36-Tr. 2	Specimen		n/a	n/a	Iron stained talcy sericite schist
37-Tr. 2	Channel	0.30	Trace	Nil	Crushed quartz parallel to fault, 0.30 feet wide, strike N80°E, dip 61°SE.
38-Tr. 2	Specimen		n/a*	n/a*	Iron stained quartzite schist
39-Tr. 2	Channel	2.30	0.06	0.06	Iron stained crushed and blocky schist and some quartz as fault filling, 2.30 feet wide, strike N57°W, dip 27°NE.
40-Tr. 2	Specimen		n/a	n/a	Light grey partially iron stained quartzite schist.

*n/a = no analysis

TABLE 9 (Continued)

SAMPLE ANALYSES TRENCH 2

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
41-Tr. 2	Specimen		n/a	n/a	Quartzite schist with slight green color.
42-Tr. 2	"		"	"	Iron stained sericite schist
43-Tr. 2	"		"	"	Iron stained crushed schist and quartz and grey gouge (should assay).
44-Tr. 2	Grab		0.04	12.58	Iron stained lead-antimony oxides and drusy intensely fractured quartz with lead-antimony sulfides and sulfasalts occurring as drag in foot wall of fault
45-Tr. 2	Specimen		n/a	n/a	Iron stained blocky mica schist.
46-Tr. 2	"		"	"	Intensely iron stained (brown to black) blocky mica schist.
47-Tr. 2	"		"	"	Iron stained chloritic schist.
48-Tr. 2	Grab		0.06	0.16	Hydrothermally altered zone in schist.
49-Tr. 2	Specimen		n/a	n/a	Talcy iron stained sericite schist.
50-Tr. 2	"		"	"	Partially iron stained dark grey to green mica schist.
51-Tr. 2	"		"	"	Chloritic schist.
52-Tr. 2	Channel	3.10	Trace	Nil	Crushed quartz, goethite, and quartzite? Schist, 2.73 feet wide, strike N, dip 61°E.
53-Tr. 2	"	3.40	"	"	Foot wall of sample granulated goethite and schist 0.53 feet wide, crushed quartz 1.58 feet wide, granular goethite, hanging wall, 0.88 feet wide, total width 2.99 feet, strike N, dip 61°E.
54-Tr. 2	Specimen		n/a*	n/a*	Iron stained sericite schist
55-Tr. 2	Channel	0.62	Nil	Nil	Crushed quartz enclosed by intensely iron stained schist, 0.62 feet wide, strike N77°W, dip 51°NE.
56-Tr. 2	"	0.70	"	"	Fault gouge, 0.70 feet wide, footwall altered iron stained chlorite schist, hanging wall iron stained mica schist, strike N64°W, dip 44°SW.
57-Tr. 2	"	0.14	Trace	0.10	Fault gouge 0.14 feet wide, strike N72°W, dip 36°NE.
58-Tr. 2	Specimen		n/a	n/a	Iron stained mica schist.
59-Tr. 2	"		"	"	Chloritic schist.
60-Tr. 2	Grab	0.30	0.24	0.16	Sulfide-bearing blue colored sericite-talcy schist occurring as small lenticular shaped bodies of hydrothermally altered material, 0.30 feet wide.

*n/a = no analysis

TABLE 9 (Continued)

SAMPLE ANALYSES TRENCH 2

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
61-Tr. 2	Channel	0.54	Nil	Nil	Quartz vein, 0.54 feet wide, strike N84°W, dip 32°NE.

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*n/a = no analysis

TABLE 10

SAMPLE ANALYSES TRENCH 3 and 5

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
62-Tr. 3	Specimen		n/a*	n/a*	Dark grey quartzite schist with iron stain along cleavage planes.
63-Tr. 3	"		"	"	Grey shaley mica schist.
64-Tr. 3	"		"	"	Grey hard gneissic schist.
65-Tr. 3	"		"	"	Shaley mica schist.
66-Tr. 3	Channel	0.13	0.06	Nil	Granular goethite with some grey gouge, 0.13 wide, strike N77°W, dip 56°SE.
67-Tr. 3	Grab		0.04	"	Iron stained from foot wall at 66-Tr. 3.
68-Tr. 3	Channel	0.20	0.04	0.02	Granular goethite and manganese oxide in cleavage plane of schist, 0.20 feet wide, strike N69°E, dip 27°NW.
69-Tr. 3	Specimen		n/a	n/a	Intensely iron stained schist.
70-Tr. 3	Channel	0.63	0.02	Nil	Crushed goethite, quartz and schist 0.63 feet wide, strike S76°W, dip 53°SE.
71-Tr. 3	Specimen		n/a	n/a	Iron stained mica schist.
72-Tr. 3	"		"	"	Intensely iron stained mica schist.
73-Tr. 3	Grab		0.16	6.24	Granular lead-antimony oxide, drag from fault.
74-Tr. 3	Channel	0.45	0.04	0.08	Hydrothermally altered schist, 0.45 feet wide, strike N87°E, dip 54°NW.
75-Tr. 3	Chip	2.50	0.02	0.08	Hydrothermally altered quartzite, 2.50 feet wide, strike N87°E, dip 54°SE.

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*n/a = no analysis

TABLE 10 (Continued)

Sample Analyses Trench 3 and 5

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
76-Tr. 3	Specimen		n/a	n/a	Iron stained mica schist
77-Tr. 3	"		"	"	Intensely iron stained quartz mica schist.
78-Tr. 3	"		"	"	Intensely fractured, iron stained mica schist.
79A-Tr. 3	Channel	0.63	0.04	1.66	Yellow lead-antimony oxide and hydrothermally altered schist, some gouge, 0.63 feet wide, hanging wall.
79B-Tr. 3	"	2.40	0.02	0.08	Intensely iron stained crushed quartz and schist, 2.40 feet wide.
79C-Tr. 3	"	0.63	0.02	0.54	Crushed quartz and altered schist, 0.63 feet wide, foot wall.
80A-Tr. 3	Channel	0.93	0.04	0.04	Granular lead-antimony oxide, yellow-green stained quartzite, and quartz in gouge, hanging wall, 0.93 feet wide.
80B-Tr. 3	"	1.65	0.48	62.68	Intensely iron stained crushed quartz and schist, 1.65 feet wide.
80C-Tr. 3	"	0.48	0.06	1.30	Gouge and iron stained crushed schist, 0.48 feet wide, foot wall.
81-Tr. 3	Grab	0.14	0.04	Nil	Lead-antimony sulfides and oxides as drag in fault, 0.14 feet wide.
82A-Tr. 3	Channel	0.68	Trace	0.04	Gouge and iron stained crushed schist, 0.68 feet wide, hanging wall.
82B-Tr. 3	"	2.00	"	Nil	Crushed, intensely iron stained schist and quartz, 2.00 feet wide.
82C-Tr. 3	"	0.61	Nil	"	Gouge and intensely iron stained schist 0.61 feet wide, foot wall.
83-Tr. 3	Specimen		n/a*	n/a*	Quartzite schist.
84A-Tr. 5	Channel	0.30	0.12	18.62	Intensely iron stained gouge, 0.30 feet wide, strike N86°W, dip 39°NE.
84B-Tr. 5	"	1.45	Trace	0.46	Grey-brown crushed mica schist, 1.45 feet wide.
84C-Tr. 5	"	1.20	0.02	Nil	Crushed iron stained gouge and schist, hanging wall, strike N86°W, dip 51°NE, 1.20 feet wide.
85-Tr. 5	"	0.50	Nil	Nil	Crushed iron stained quartz and schist, 0.50 feet wide, strike N58°W, dip 27°NE.
86-Tr. 5	"	1.10	0.02	0.08	Iron stained crushed schist, 1.10 feet wide, strike N49°E, dip 22°NW.
87-Tr. 5	Specimen		n/a*	n/a*	Chloritic schist.
88-Tr. 5	Channel	2.00	Nil	Nil	Granular goethite, iron stained schist and some crushed quartz, 2.00 feet wide.

*n/a = no analysis

TABLE 10 (Continued)

SAMPLE ANALYSES TRENCH 3 and 5

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
89-Tr. 5	Channel	1.80	Nil	Nil	Same as 88-Tr. 5, 1.80 feet wide.
90-Tr. 5	"	2.20	0.02	"	" " " " ", 2.20 " "
91-Tr. 5	"	1.40	Nil	"	" " " " ", 1.40 " "
92-Tr. 5	"	1.90	Trace	0.94	" " " " ", 1.90 " "
93-Tr. 5	"	2.00	Nil	Nil	" " " " ", 2.00 " "
94-Tr. 5	"	1.40	Trace	"	" " " " ", 1.40 " "
95-Tr. 5	"	1.20	Nil	Nil	" " " " ", 1.20 " "
96-Tr. 5	"	1.20	"	"	" " " " ", 1.20 " "
97-Tr. 5	"	1.00	0.34	"	" " " " ", 1.00 " "
98-Tr. 5	"	1.80	Trace	"	" " " " ", 1.80 " "
99-Tr. 5	"	1.60	"	0.04	" " " " ", 1.60 " "
95A-Tr. 5	Grab		Nil	Nil	Altered granite (?)
100-Tr. 5	Specimen		n/a	n/a	Chloritic schist.
101-Tr. 5	Channel	2.30	0.02	Nil	Granular goethite, crushed schist and quartz and gouge, 2.30 feet wide.
102-Tr. 5	"	3.40	0.06	"	Same as 101-Tr. 5, 3.40 feet wide.
103-Tr. 5	"	2.30	0.06	"	" " " " ", 2.30 " "
104-Tr. 5	"	1.70	0.04	"	" " " " ", 1.70 " "
105-Tr. 5	"	1.70	0.02	"	" " " " ", 1.70 " "
106-Tr. 5	"	2.40	0.02	"	" " " " ", 2.40 " "
107-Tr. 5	"	2.20	0.02	"	" " " " ", 2.20 " "
108-Tr. 5	Grab		0.06	19.60	Lead-antimony oxide occurring as drag in fault.
109-Tr. 5	"		0.10	14.50	Lead-antimony oxide and sulfide occurring as drag in fault.
110-Tr. 5	Channel	3.20	Trace	Nil	Granular goethite crushed iron stained schist and quartz and gouge 3.20 feet wide.
111-Tr. 5	"	2.90	"	"	Same as 110-Tr. 5, 2.90 feet wide.
112-Tr. 5	"	3.40	"	"	" " " " ", 3.40 " "
113-Tr. 5	"	1.60	"	"	" " " " ", 1.60 " "
114-Tr. 5	"	2.80	0.02	0.04	" " " " ", 2.80 " "
115-Tr. 5	"	3.20	Trace	Nil	" " " " ", 3.20 " "
116-Tr. 5	"	1.70	Nil	"	" " " " ", 1.70 " "
117-Tr. 5	Specimen				Shaley chloritic schist.

TABLE 11

SAMPLE ANALYSES TRENCH 6

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
118-Tr. 6	Specimen		n/a*	n/a*	Specimen quartzite schist.
119-Tr. 6	"		"	"	" " "
120-Tr. 6	"		"	"	" " "
121-Tr. 6	Channel	0.05	Trace	Nil	Quartz veinlet, 0.05 feet wide, strike N03°E, dip 51°W.
122-Tr. 6	"	3.50	0.02	0.02	Crushed iron stained quartz and fragments of schist; appears to be remnant of a small faulted segment of a vein on east wall of trench. 3.50 feet wide.
123-Tr. 6	"	2.00	Trace	Nil	Iron stained gouge and crushed quartz, goethite and granular goethite, 2.00 feet wide, strike N83°E, vertical.
124-Tr. 6	"	1.50	"	"	Fault gouge and iron stained schist, 1.50 feet wide, strike S60°E, dip 69°SW.
125-Tr. 6	"	2.30	"	"	Fault gouge, crushed iron stained quartz and schist, strike S83°W, dip 51°SE, 2.30 feet wide.
126-Tr. 6	"	1.50	"	"	Crushed quartz and schist in foot wall of fault, 1.50 feet wide, strike S83°W, dip 51°SE.
127-Tr. 6	"	1.60	"	"	Crushed iron stained quartz in foot wall of fault, strike S60°E, dip 51°SW.
128-Tr. 6	"	0.10	Trace	0.66	Crushed iron stained quartz vein, terminated by fault at center line of trench, vein 0.10 feet wide, strike S88°E, dip 34°SW.
129-Tr. 6	"	0.20	"	Nil	Lenticular pods iron stained crushed quartz, 0.20 feet wide, strike E-W verical (?)
130-Tr. 6	"	0.20	"	"	Lenticular pods crushed quartz in iron stained zone in schist, zone strike E-W, dip vertical, pods 0.20 feet wide.
131-Tr. 6	"	0.10	0.26	0.06	Vein of crushed iron stained quartz, 0.10 feet wide, strike S86°W, dip 54°SE.
132-Tr. 6	"	0.20	0.56	Nil	Iron stained fractured quartz in vein 0.20 feet wide, strike N35°E, dip 42°NW.
133-Tr. 6	"	0.20	Trace	"	Crushed quartz and granular goethite and schist, 0.20 feet wide, strike S82°E, dip 51°SW.
134-Tr. 6	"	1.50	"	"	Gossaniferous blocky schist, 1.50 feet wide, zone strike S47°W, dip 43°SE.

*n/a = no analysis

TABLE 11 (Continued)

SAMPLE ANALYSES TRENCH 6

Sample			Ounces Per Ton		
No.	Type	Length Ft.	Gold	Silver	Field Identification and Description
135-Tr. 6	Channel	0.25	Trace	Nil	Blue gouge and iron stained quartz, 0.25 feet wide, strike S65°W, dip 36°SE.
137-Tr. 6	"	0.35	"	"	Fault gouge and iron stained schist 0.35 feet wide, strike S86°W, dip 41°SE.
138-Tr. 6	"	0.10	"	"	Fault gouge, 0.10 feet wide, strike S58°W, dip 63°SE.
139-Tr. 6	"	0.20	"	"	Fault gouge, 0.20 feet wide, strike S76°W, dip 33°SW.
140-Tr. 6	"	3.25	0.02	"	Iron stained schist, zone 3.25 feet wide, strike S76°E, dip 33°SW.
141-Tr. 6	"	0.55	Trace	"	Fault gouge and iron stained schist, 0.55 feet wide, strike S76°E, dip 33°SW.
142-Tr. 6	"	0.60	"	"	Crushed, goethite, iron stained quartz and schist, and fault gouge, 0.60 feet wide, strike S69°E, dip 57°SW.
143-Tr. 6	"	0.20	0.66	"	Crushed quartz, goethite and schist, 0.20 feet wide, strike N76°W, dip 32°NE.
144-Tr. 6	"	0.15	0.02	0.14	Same as 143-Tr. 6, 0.15 feet wide.
145-Tr. 6	"	0.15	0.02	0.02	Crushed quartz and goethite, 0.15 feet wide, strike N65°E, dip 65°SE.

Analysis of Heavy Metal Data

Considerable error was introduced in the initial stages of the study as a result of mixing soil horizons. Figures 10, 11, and 12 illustrate variation of heavy metal readings with respect to soil horizon and slope. It can be seen that if alternate horizons are sampled it would be possible to produce displaced anomalies. Trace element content of each horizon varies with slope. However, if one horizon is consistently sampled, slope does not significantly displace the anomaly. This may also be observed in Figure 13.

Trace Element Distribution Over Known Mine

A control line was extended from line 714 a sufficient distance to cross the Cleary Hill auriferous vein. Soil samples were taken with a hand auger at intervals of 50 feet along this line and analyzed for heavy metals, copper, lead, zinc and arsenic. Copper, lead and zinc analyses were performed by wet chemical methods and arsenic by x-ray fluorescence. All samples were taken from the "C" horizon. Plate 11 shows the surface profile, and Figure 13 shows the location of frozen samples and trace element profiles. Arsenic contents were determined with a Norelco Vacuum X-ray Spectrometer using K Beta radiation, 45 kilovolts, 40 milliamperes, lithium fluoride crystal, gas flow detector and vacuum. The determinations obtained were not compared to standards, the values being expressed as counts per second minus background count. Samples were prepared by simply pouring the minus 80 mesh powder into the specimen holder, covering with cotton and milar and subsequent insertion into

LONGITUDINAL SECTION OF A TRENCH
ON THE NORTH SLOPE INDICATING
HEAVY METAL VALUES WITH RESPECT
TO SOIL HORIZON AND SOURCE

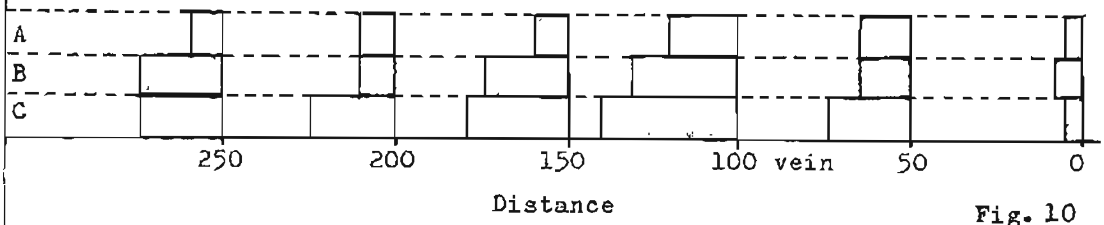
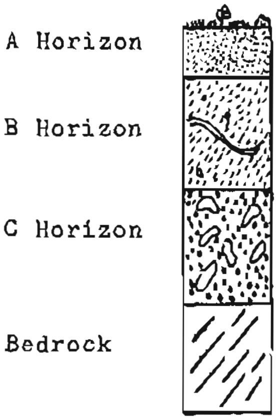


Fig. 10



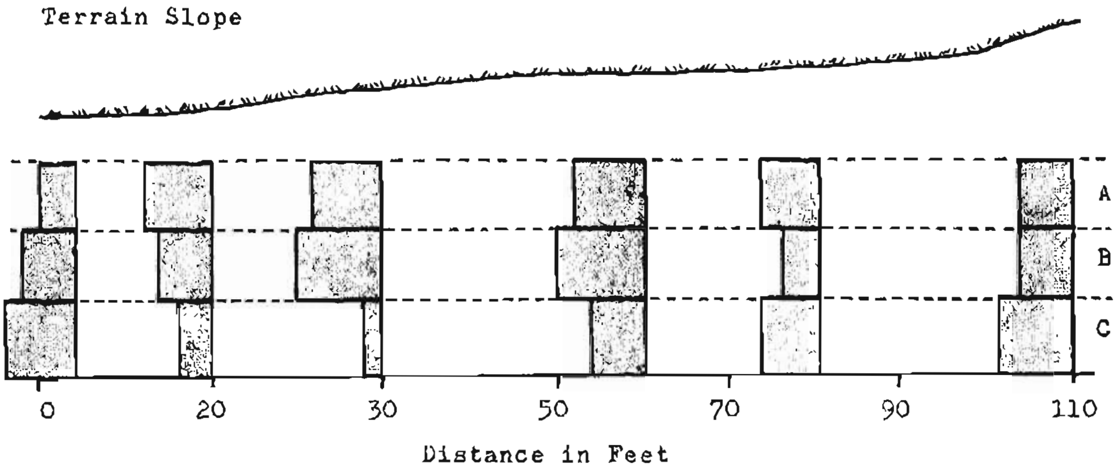
Top soil characterized by heavy organic cover. Generally black and rich in organic matter.

Olive brown to orange, fine grained soil containing clay and in some cases small rocks.

Residual soil derived from weathering of parent bedrock. Dark brown to red brown, gritty and containing large pieces of parent material.

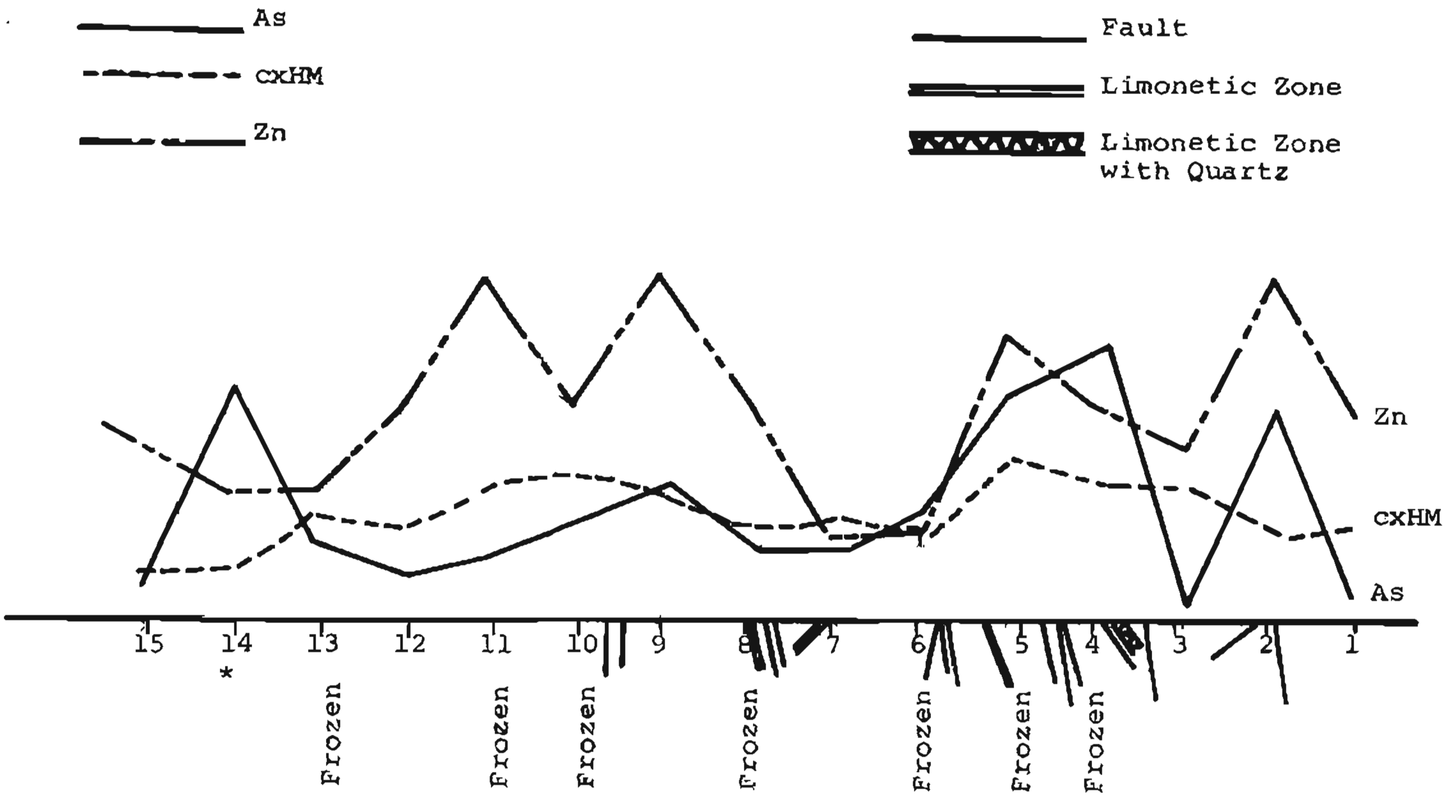
SOIL HORIZONS

Fig. 11



Section through trench No. 5 showing variation in citrate extractible heavy metal values with respect to soil horizons.

Fig. 12



*"B" Horizon Sample

Fig. 13 Comparison between Zn, cxHM and As content of "C" Horizon soil samples over Cleary Hill Mine.

the x-ray unit. Approximately two minutes were required per determination.

Table 12 tabulates comparisons obtained by analysis of the soil for total zinc, total arsenic (relative; counts per second minus background) and heavy metals (CxHm). Arsenic is an excellent indicator element for this type mineralization. Zinc also points to the zones but has a slightly larger dispersion pattern, a fact which enables a larger sampling interval. It may be seen that copper and lead are of no value in tracing gold veins in this area. The University of Alaska Method #2 successfully located the Cleary Hill vein.

The presence of frozen ground did not make impossible the localization of the Cleary Hill zone. More testing, on steeper slopes and in more frozen areas is needed before it can be concluded that the two variables slope and permafrost are nonsignificant in the area.

Analysis by x-ray for arsenic was by far the fastest method employed. Prospectors attempting to locate gold veins in the Cleary district should investigate this method of analysis. The two x-ray units in the State of Alaska are located at Anchorage and at College, being the property of the State Division of Mines and Minerals and the University of Alaska, respectively.

Trend Surface Analysis

Zinc content and heavy metal values were studied by trend surface analysis. In this technique, an equation in x, y, and z form is chosen and coefficients are picked so that the surface generated approximates most closely the actual surface defined

TABLE 12

COMPARISON BETWEEN Cu, Pb, Zn, As, & cxHM

OVER THE CLEARY HILL MINE

Sample #	Cu ppm	Pb ppm	Zn ppm	As cps	cxHM index
A	15	50	200	862	12
B	15	50	125	837	14
C	15	25	375	632	10
D	15	50	125	754	11
oA	15	50	50	1000	11
1	15	50	125	634	12
2	15	50	200	852	11
3	15	25	100	614	16
4	15	125	125	924	17
5	15	50	175	867	18
6	15	50	50	731	10
7	15	50	50	683	12
8	15	50	125	689	11
9	15	25	200	762	14
10	15	50	125	725	17
11	15	25	200	682	16
12	15	25	125	651	11
13	15	25	75	693	12
14	15	25	75	875	6
15	15	25	100	635	5

by a set of values and their respective x, y coordinates. These surfaces represent the "trend" of the data being studied. The trends are contoured; data "noise" or anomalies are found when the calculated value at any particular grid coordinate is subtracted from the measured value. These residuals may be plotted or contoured.

The application of trend surface analysis of geologic data is not new. Geophysicists have utilized the method for years. Some papers which deal with application of trend surface analysis to geologic and geochemical data are: Allen and Krumbein, 1962; Baird, McIntyre, and Welday, 1963; Cain, 1964; Chayes and Suzuki, 1963; Connor and Miesch, 1964a, 1964b; Dawson and Whitten, 1962; Harbaugh, 1962; Jenness, 1963; Kofoed and Gorsline, 1963; Krumbein, 1956, 1958, 1959a, 1959b, 1960, 1962a, 1962b, 1963; Krumbein and Imbrie, 1963; Lippitt, 1959; Miesh and Connor, 1964; Miller, 1956, 1964; Nordeng, Ensign, and Uolin, 1964; Peikert, 1962; Whitten, 1959, 1960a, 1960b, 1961a, 1961b, 1961c, 1961d, 1962a, 1962b, 1962c, 1963a, 1963b, 1963c.

Trend surfaces were obtained by fitting polynomial equations with geochemical value as the dependent variable and x, y coordinates as independent variables by the least squares criterian. A first degree equation describes the best plane, in 3 dimensional space. A second degree surface is the best quadratic; third degree, the best cubic, etc. Mathematics describing the technique have been published and may be found in the above references.

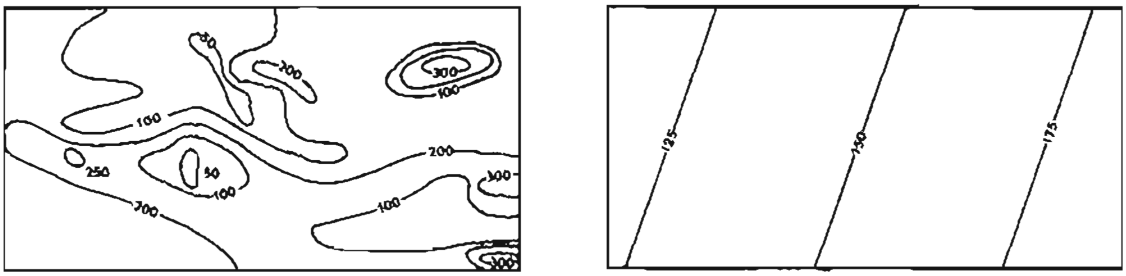
Surfaces for first through sixth degree polynomials were computed and contoured, and residuals were plotted and contoured.

Calculation of the surfaces and corresponding statistics was done with the IBM 360 Model 40 Disk Operating Computer.

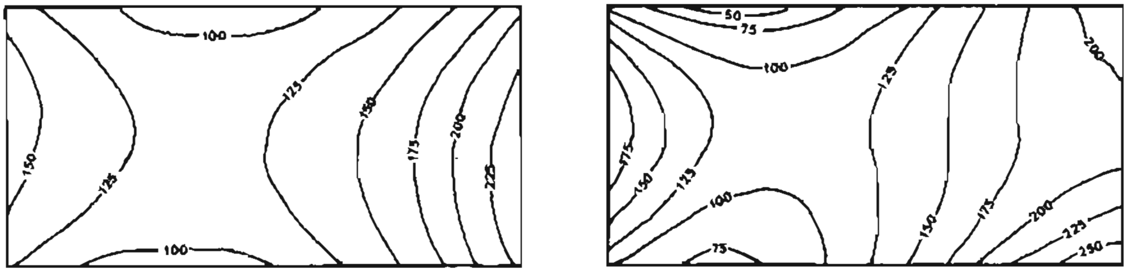
Contour maps of first through fifth degree surfaces for zinc are presented as Figure 14. These denote areal trends of zinc content in the study area. Figure 14a is a contour map of the original zinc values. Figure 15 presents residual maps for each surface. Plots of residuals after subtraction of the standard error are shown as Figure 16. The residual maps and residual minus error maps enhance the anomalies of the original data. Anomalous zinc areas were sharply localized by subtracting the error measure for each surface prior to plotting residuals.

Figure 15 illustrates that residual anomalies become more definitive as the degree of the polynomial increases. This is due to decreasing standard deviation coinciding with a better fit of the surface to the original data. Anomalous zones are marked on the residual maps. Values and descriptions of bedrock samples in the vicinity of these areas are tabulated in Table 13.

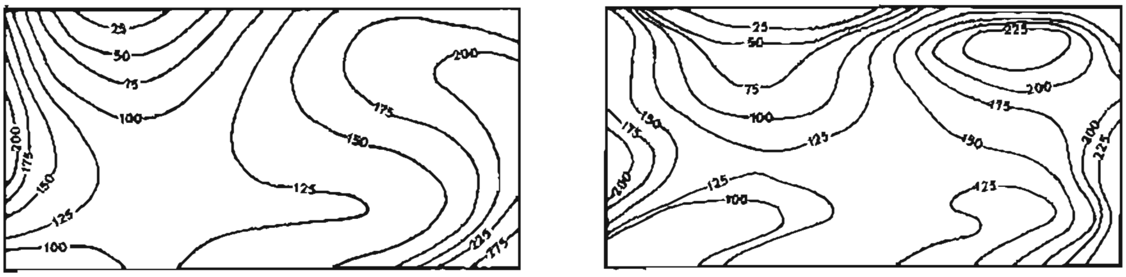
Contour maps of original heavy metal values, and first through sixth degree trends, are presented as Figure 17. Maps of residuals and residual minus standard deviation are shown as Figures 18 and 19. Comparison of these maps indicates that trend surface analysis of the heavy metal values did not indicate any anomalous zones not readily apparent from a contour map of the original data. The trend surfaces tend to duplicate the trend whereas the residual plots eliminate portions of the



A. ORIGINAL DATA B. FIRST DEGREE SURFACE



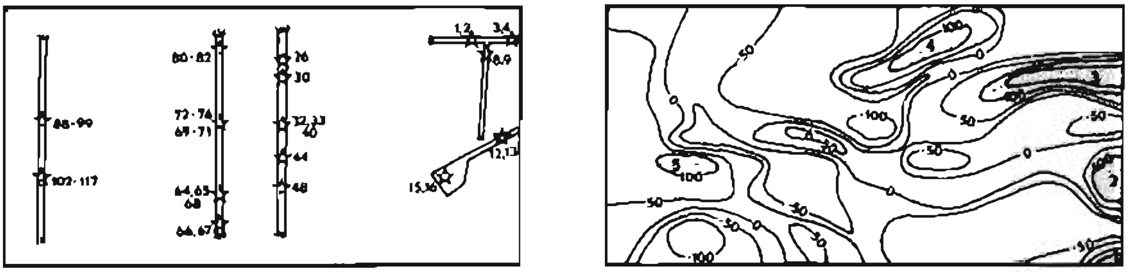
C. SECOND DEGREE SURFACE D. THIRD DEGREE SURFACE



E. FOURTH DEGREE SURFACE F. FIFTH DEGREE SURFACE

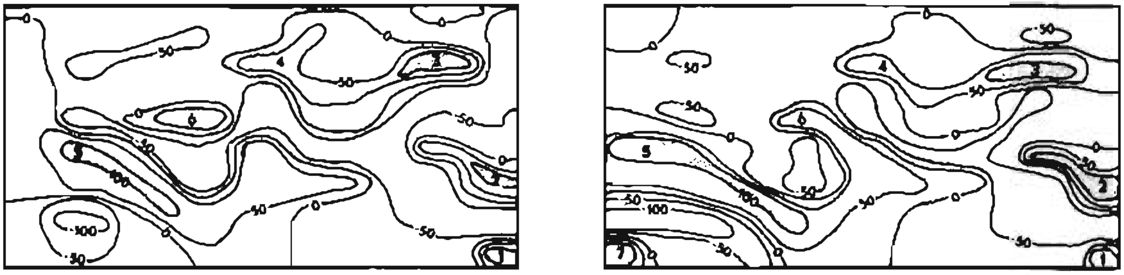
CLEARY HILL AREA "A" ZINC TREND SURFACES
VALUES IN PARTS PER MILLION

Figure 14



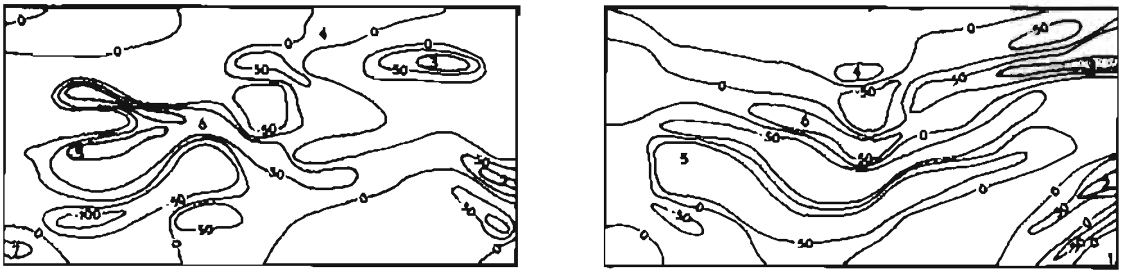
A. TRENCHES SHOWING ANOMALOUS SAMPLE LOCATIONS

B. FIRST DEGREE RESIDUALS



C. SECOND DEGREE RESIDUALS

D. THIRD DEGREE RESIDUALS

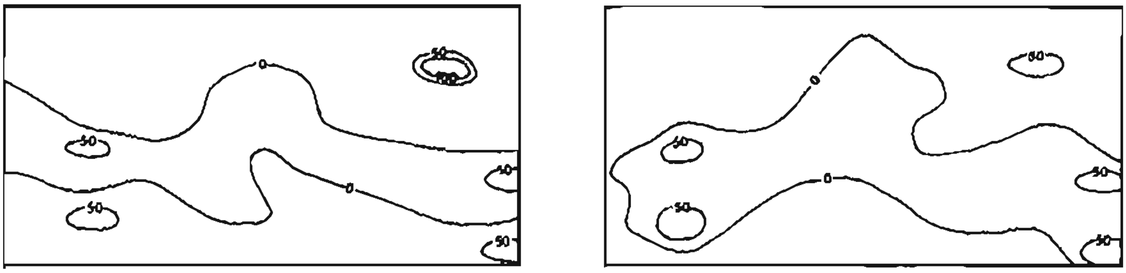


E. FOURTH DEGREE RESIDUALS

F. FIFTH DEGREE RESIDUALS

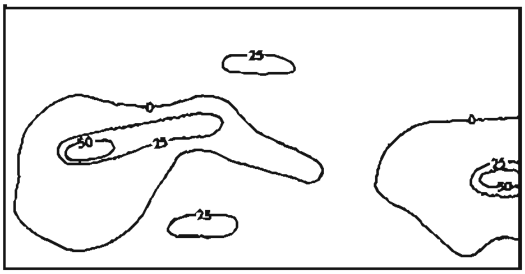
CLEARY HILL AREA "A"
ZINC TREND SURFACE RESIDUALS

Figure 15

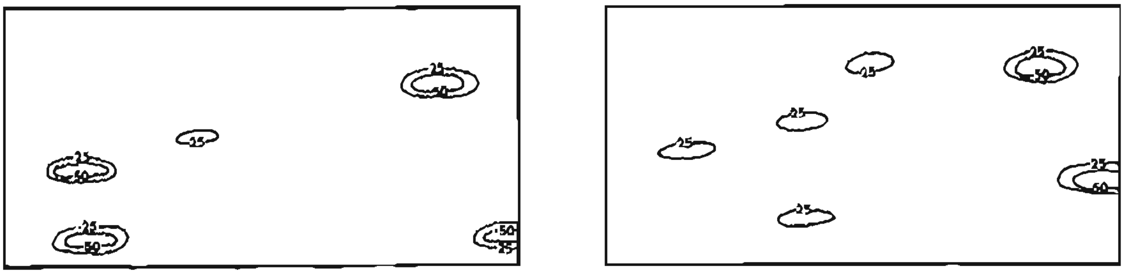


A. FIRST DEGREE RESIDUALS
MINUS STANDARD DEVIATION

B. SECOND DEGREE RESIDUALS
MINUS STANDARD DEVIATION



C. THIRD DEGREE RESIDUALS
MINUS STANDARD DEVIATION

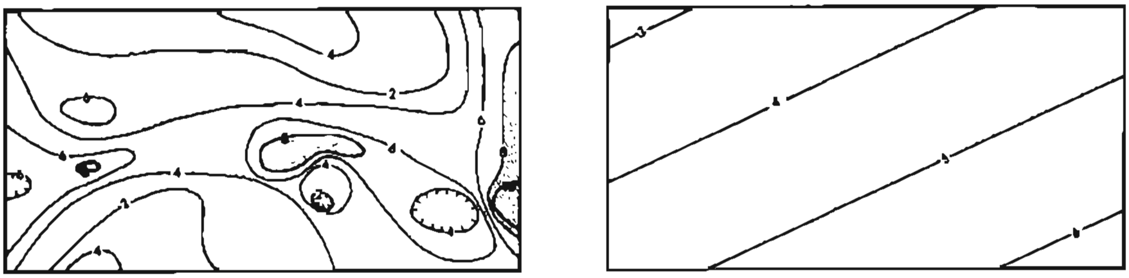


D. FOURTH DEGREE RESIDUALS
MINUS STANDARD DEVIATION

E. FIFTH DEGREE RESIDUALS
MINUS STANDARD DEVIATION

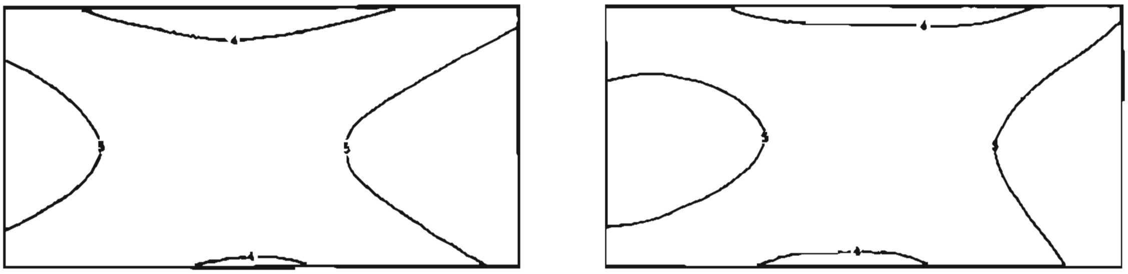
CLEARY HILL AREA "A"
ZINC ANOMALY MAPS

Figure 16



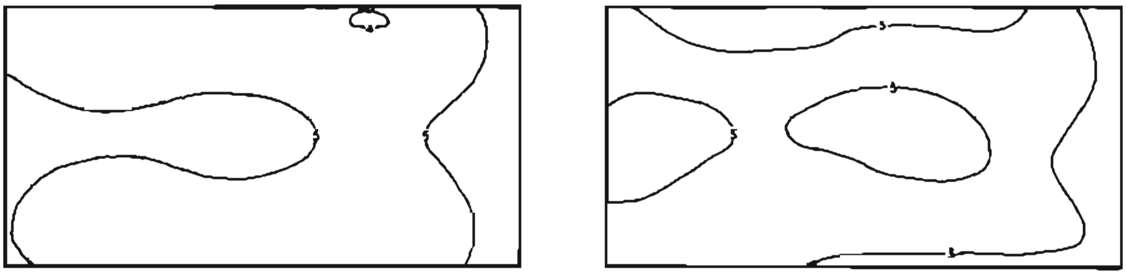
A. ORIGINAL DATA

B. FIRST DEGREE SURFACE



C. SECOND DEGREE SURFACE

D. THIRD DEGREE SURFACE

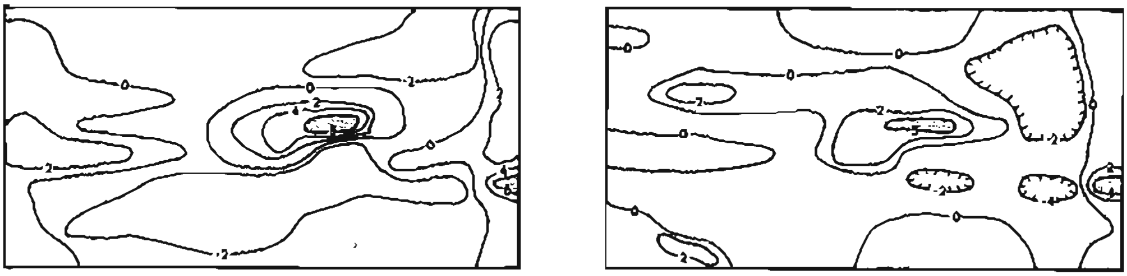


E. FOURTH DEGREE SURFACE

F. FIFTH DEGREE SURFACE

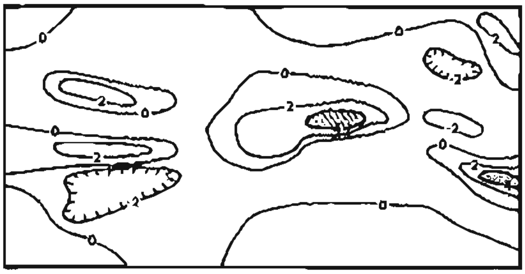
CLEARY HILL AREA "A" HEAVY METAL TREND SURFACES

Figure 17

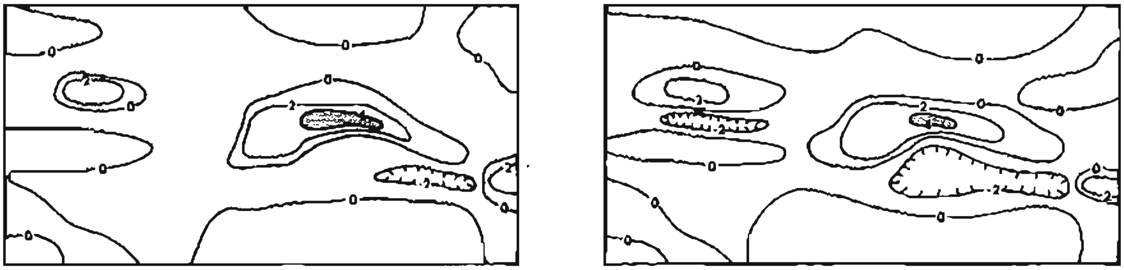


A. FIRST DEGREE RESIDUALS

B. SECOND DEGREE RESIDUALS



C. THIRD DEGREE RESIDUALS



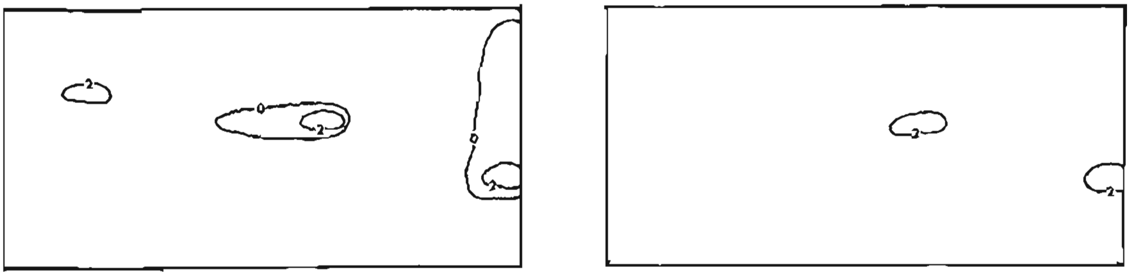
D. FOURTH DEGREE RESIDUALS

E. FIFTH DEGREE RESIDUALS

CLEARY HILL AREA "A"

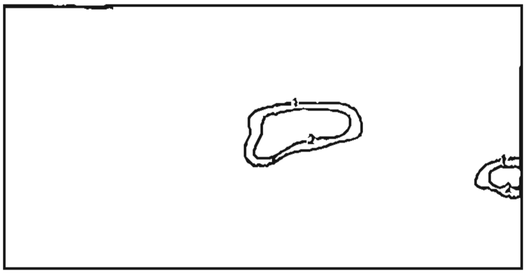
HEAVY METAL TREND SURFACE RESIDUALS

Figure 18

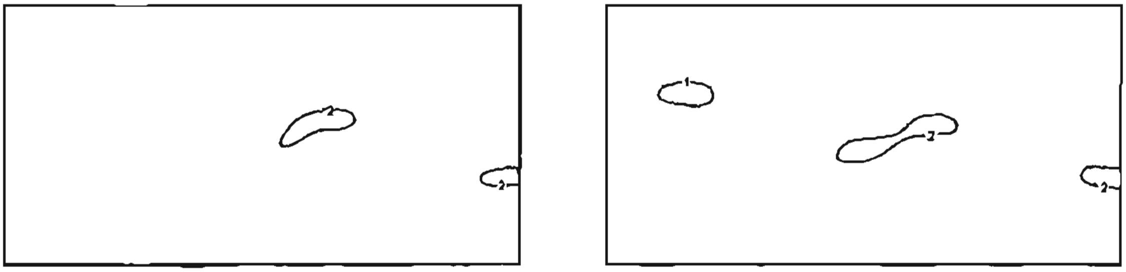


A. FIRST DEGREE RESIDUALS
MINUS STANDARD DEVIATION

B. SECOND DEGREE RESIDUALS
MINUS STANDARD DEVIATION



C. THIRD DEGREE RESIDUALS
MINUS STANDARD DEVIATION



D. FOURTH DEGREE RESIDUALS
MINUS STANDARD DEVIATION

E. FIFTH DEGREE RESIDUALS
MINUS STANDARD DEVIATION

CLEARY HILL AREA "A"
HEAVY METAL ANOMALY MAPS

Figure 19

TABLE 13

BEDROCK SAMPLES NEAR TREND ANOMALIES

Anomaly	OZ Au	OZ Ag		Bedrock Samples
1				None
2	1.46	0.04	12-Tr. 4	Iron stained quartz and mica schist with granulated goethite in partings, 0.30 feet wide, strike N75°W, dip 38°SW.
2	0.12	Tr.	13-Tr. 4	Same as 12-Tr. 4.
3	0.78	Tr.	4-Tr. 1	Red-brown granulated goethite with inclusions of quartz and mica schist, vein 0.20 feet wide, strike N56°W, dip 34°SE.
3			2-Tr. 1	Same as 4-Tr. 1, 0.28 feet wide.
3	Tr.	Tr.	5-Tr. 1	Coarse fragments of iron stained crushed quartz and mica schist, granular geothite filling partings, 0.25 feet wide, strike N35°W, dip 23°NE.
3	Tr.	Tr.	6-Tr. 1	Iron stained coarse fragments of mica schist imbedded in granular goethite and some gouge, 0.60 feet wide, strike N75°W, vertical.
3	Tr.	Tr.	7-Tr. 1	Iron stained coarse and fine fragments of quartz imbedded in granular goethite, strike N75°W, vertical.
3	.16	Tr.	8-Tr. 1	Crushed quartz and iron stained mica schist in granulated goethite, 0.20 feet wide, strike N56°W, dip 37°SW.
3	.08	Tr.	10-Tr. 1	Iron stained crushed altered mica schist, some granulated quartz in granulated goethite, 0.30 feet wide, strike N80°W, dip 55°SW.
3	.12	Tr.	11-Tr. 1	Iron stained altered mica schist some granulated quartz in granulated goethite, 0.30 feet wide, strike N80°W, dip 55°SW.
4	0.76	3.62	18-Tr. 2	Grab, hydrothermally altered zone enclosed by graphitic schist, 0.10 feet wide, strike N88°E, dip 34°NW.
4	0.28	Nil	25-Tr. 2	Quartz lens, 0.80 feet wide, strike N77°E, dip 30°NW.
4	0.16	Nil	26-Tr. 2	Iron stained crushed quartz on hanging wall of fault, 1.80 feet wide, strike N38°W, dip 59°SW.
4	0.14	Nil	30-Tr. 2	Gossaniferous schist from foot wall of fault, 0.10 feet wide, strike N44°E, dip 83°SE.
4	0.16	6.24	73-Tr. 3	Grab, granular lead-antimony-oxide, drag from fault.

TABLE 13 (Continued)

BEDROCK SAMPLES NEAR TREND ANOMALIES

Anomaly	OZ Au	OZ Ag		Bedrock Samples
4	0.08	0.08	74-Tr. 3	Hydrothermally altered schist, 0.45 feet wide, strike N87°E, dip 54°NW.
5	0.04	12.58	44-Tr. 2	Iron stained lead-antimony oxides and drusy intensely fractured quartz with lead-antimony sulfides and sulfosalts occurring as drag in foot wall of fault.
5	.06	0.16	48-Tr. 2	Hydrothermally altered zone in schist.
5	.06	Nil	66-Tr. 3	Granulated goethite with some grey gouge, 0.13 feet wide, strike N77°W, dip 56°SE.
5	.04	.02	68-Tr. 3	Granulated goethite and manganese oxide in cleavage plane of schist, 0.20 feet wide, strike N69°E, dip 27°NW.
5	0.06	19.60	108-Tr. 5	Grab, lead antimony oxide occurring as drag in fault.
5	0.10	14.50	109-Tr. 5	Same as 108-Tr. 5.
5	0.02	Nil	101-Tr. 5	Granulated goethite, crushed schist and quartz and gouge, 2.30 feet wide.
6	0.02	Nil	33-Tr. 2	Iron stained crushed quartz and schist and grey gouge as fault filling, 2.10 feet wide, strike N57°W, dip 53°NE.
6	0.04	Nil	35-Tr. 2	Crushed quartz and some granulated goethite in footwall of fault, 0.70 feet wide, strike N80°E, dip 61°SE.
7				None

anomalous zone indicated by the original data. The residuals do, however, point to anomalies #2 and #6, which are associated principally with iron stained quartz, schist, fault filling, and geothite.

Comparison of Trend Surfaces

Original data maps for zinc content and citrate-soluble heavy metal content were prepared. The contour map for heavy metal values defines the anomalous zones better than do the trend surfaces. The contour map for zinc values, however, does not enhance anomalous areas as well as the residual maps. Residual minus standard deviation maps for zinc further localize the anomalies. The most significant heavy metal values are confined to a fault containing a quartz-iron-goethite assemblage. Anomalies for zinc follow the same pattern but include hydrothermally altered areas and areas containing lead-antimony compounds as drag in faults.

A continuous heavy metal trend is indicated by profiles of heavy metal data (see Figure 8). Trenching shows that this is not true; trend surface procedures also show this. It may be concluded that trend surfaces are an aid to geochemical prospecting.

Comparison of Cost of Methods

Of prime importance to a geochemical survey is the choice of method and resultant cost of the analyses. For some surveys there is no choice available, e.g., those of a reconnaissance nature for one specific element. Surveys which require analytical determinations of more than one element, however, require a method and cost decision.

For comparative purposes, cost and time studies were made of wet chemical, spectrographic, and heavy metal methods. Quantitative spectrographic procedures were not developed by the laboratory; figures for this procedure were taken from the literature (Cruft, 1964). Table 14 lists the cost of reagents for the five elements, determined on a cost per 1000 analyses basis.

TABLE 14

COSTS OF REAGENTS FOR ANALYSES

Element	Cost/1000 Analyses
Copper	$43.44
Lead	32.22
Zinc	29.45
Silver	8.78
Molybdenum	19.40

Total reagent cost to chemically analyze 1000 samples for five elements is $133.29 or 13.3 cents per element. These costs are a little misleading as the smallest reagent bottle possible was used in each case and credit was given for reagent not used. Reagent costs would be somewhat lower if enough was purchased to buy at a more economical figure.

The laboratory averaged 15.6 element determinations by wet methods per man-hour. This figure is based upon an average of 50 samples per day for five elements, utilizing two people full-time.

The cost of supplies for spectrographic analyses ranges from 16 cents to 49 cents per analysis depending upon the type of electrodes needed for a firing. This cost varies on a cost per element basis as it is possible to process many elements with only one firing. If five elements are determined, the supply cost ranges from 3.2 cents to 9.8 cents per element. It is possible to analyze stream sediment samples at the rate of 49 elemental determinations per man-hour (Cruft, 1964). More elements in each sample may be analyzed with little increase in time but it is not possible to decrease the number of elements and save time. The samples still require mixing and arcing, whether one or twenty elements are photometered.

Heavy metal determinations are by far the cheapest, reagents costing slightly more than a tenth of a cent apiece based upon cost of reagents for 1000 analyses. The Laboratory analyst was able to run 100 heavy metal determinations in an eight hour day or 12.5 per man-hour.

Table 15 contrasts the total cost of analyses per 1000 samples for copper, lead, molybdenum, silver and zinc by wet chemical and by spectrographic procedures. Salaries of two analysts are assumed to cost $10 per hour

TABLE 15

TOTAL COST PER 1000 ANALYSES - FIVE ELEMENTS

	Chemical	Spectrographic
Wages	$1,600	$ 600
Supplies	650	490
Total	$2,250	$1,090
Cost/element	$ 0.45	$ 0.22

CHAPTER FOUR

CONCLUSIONS

This investigation established the frequency distribution of copper, lead, zinc, molybdenum and silver in the Cleary Valley. Copper, lead, molybdenum and silver have reverse J distributions. Zinc distribution is positively skewed. Zinc follows the trend of copper, molybdenum, silver, and lead more than 60% of the time, indicating its potential as a heavy metal tracer in this area.

Area B, covering a 30% slope to the west of the project area, and Area C, which includes the ridge between Chatham and Bedrock Creeks, are both postulated to contain nonsignificant anomalies. Area B is salted due to mine dump material which has been used to build a road through it. Area C is contaminated due to salting from a series of hand dug trenches.

Tests indicate that poor results obtained from the University of Alaska Method No. 2 (citrate soluble analyses for heavy metals) may be due to four possible causes. (1) The method is pH sensitive; pH control must be used. (2) Commercial reagents often contain excessive amounts of heavy metals. (3) The powdered buffer utilized in the method may segregate, thereby invalidating the analysis. (4) The dithizone solution is not saturated; it is imperative that the dithizone solution is saturated. Possibly the most common problem is number three. This has been corrected by developing a liquid buffer (Appendix).

The University of Alaska Method No. 2 has been found sensitive enough to be used to trace gold quartz veins in the Cleary

Valley. Careful control must be utilized to insure that each sample is taken in the same horizon.

Zinc and arsenic are pathfinders for hydrothermal mineralization in the Cleary Valley. These elements both occur in high concentrations over the Cleary Hill vein. Channel samples at the surface, assayed for gold and silver, were low. This vein is, however, known to have produced considerable amounts of gold.

Testing indicates that degree of slope and presence of frozen ground have little effect upon the distribution of trace elements around the Cleary Hill vein.

Verification of geochemical anomalies was possible with a Sharpe S.E. 200 vertical loop electromagnetic unit.

The fastest method of instrumental analysis used was X-ray fluorescence for arsenic. This method has considerable application to the search for gold in the Fairbanks district.

The use of the IBM 1620 computer for routine analysis of large quantities of data and the IBM 360 Model 40 for trend surface analysis proved very effective. Trend surface analysis was used to localize zinc anomalies and reduce apparent citrate soluble heavy metal anomalies.

CHAPTER FIVE

ION-EXCHANGE FIELD METHOD FOR DILUTE ACID SOLUBLE ZINC

There is a need for a geochemical prospecting method which is sensitive enough to locate areas of high mineralization, yet simple enough so that persons with no technical training can use it reliably. Such a method must be within the economic means of the prospector and must employ reagents and apparatus which are readily accessible. Also, since the prospector normally does not have access to accurate laboratory apparatus, a simple pan balance and a minimum of graduated glassware must suffice for preparing solutions without sacrificing the sensitivity of the method. Finally, the reagents employed must be stable under field conditions and the overall method of analysis must be compatible with field use.

Indicator Elements

Within or near any area of mineralization, there are three groups of elements - principal elements, transient elements, and indicator elements. Principal elements are those elements which comprise the mineral deposit. Transient elements are those found everywhere, independent of an area of mineralization. Indicator elements are those elements associated with the mineralization in such a manner that they may serve as sensitive indicators of the presence of mineralization.

Ginzburg, et al (1960), have prepared a table of indicator elements (Table 16) whose presence in rocks, soils, and waters may indicate mineralization. The elements tabulated are those most commonly found at sites of polymetallic and rare metallic mineralization.

Ideally, when a tract of land is to be explored for areas of high mineralization, as many samples as possible should be taken and analyzed for all elements present. However, this normally is impractical, especially for the small prospector. Therefore, it is desirable to have a general reconnaissance method that can reveal an anomaly with a minimum number of samples and be sensitive to an element, or elements, indicative of all or nearly all types of mineralization. Of the elements tabulated in Table 16, those which appear to be more or less universally applicable as indicators of mineralized areas are zinc, copper, lead, nickel and possibly silver, molybdenum, tungsten, mercury, arsenic, cobalt and vanadium.

Vinogradov (1959) found concentrations of these elements in Russian rocks and soils as shown in Table 17. These values compare favorably with those given in the literature for the same elements in North American rocks and soils.

Since many samples taken for geochemical analysis are from soils, it is unwise to employ as an indicator an element which is not always present in soils in sufficient quantities to serve as the indicator. As readily seen in Table 17, silver, molybdenum, tungsten, arsenic, cobalt and vanadium, whose average concentrations in soils are 0, 1, 2, 1, 5, 8 and 1 ppm respectively, are not present in great enough concentrations to readily detect anomalies. In specific instances, however, these elements serve well as indicators of mineralization. For example, molybdenum

TABLE 16

INDICATOR ELEMENTS (AFTER GINZBURG)

Rocks, Soils, Minerals, Waters, Coal Ash, Vegetation.	Zn	Pb	Cu	Ag	Au	Mo	W	Sn	Bi	Cd	In	Hg	As	Sb	Se
Igneous, metamorphic, hydrothermally altered rocks	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sedimentary carbonate rocks	+	+	+	+	-	0	-	-	+	+	?	?	?	?	?
Sedimentary clayey-sandy rocks	+	+	+	+	-	+	-	?	+	+	?	+	+	+	+
Residual products of weathering of silicate rocks	0	+	-	-	0	-	+	+	?	?	?	?	?	?	+
Residual products of leaching of carbonate rocks	+	+	+	+	0	0	0	0	?	?	0	0	?	?	?
Gossans of sulfide deposits and oxidized zones	+	+	+	+	+	+	+	?	+	+	-	+	+	+	+
Bleached zones	?	+	-	+	-	-	?	?	0	0	0	0	0	0	0
Diluvial sediments	+	+	+	-	+	+	+	+	?	0	0	+	+	?	0
Alluvial sediments	+	+	+	-	+	-	+	+	0	0	0	+	0	?	0
Takyrs	?	+	-	-	-	0	0	0	0	0	0	+	+	+	0
Surficial quaternary sediments up to 2 m thick	+	+	+	+	+	+	+	+	?	0	0	?	+	0	0
Surficial quaternary sediments thicker than 2 m	-	-	-	+	-	-	+	+	0	0	0	?	+	0	0
Soils	+	+	+	-	-	+	?	?	?	?	0	?	+	0	+
Glacial deposits	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0
Iron hydroxides of oxidized zones, weathering, and metamorphic ore deposits	-	+	-	?	0	?	+	0	0	0	0	+	+	?	+
Manganese hydroxides of oxidized zones and weathering	+	+	-	+	-	?	?	0	0	0	0	+	0	0	0
Coal ash	-	-	-	-	-	+	?	?	-	?	0	0	+	0	?
Sulfides of sedimentary deposits	-	-	-	-	?	-	0	0	-	-	0	0	+	0	+
Ash of plants	+	+	+	+	+	+	+	0	0	0	0	?	+	0	0
Ground waters	+	+	+	+	-	+	0	0	0	0	0	0	0	0	0
Surface waters	+	-	+	0	0	0	0	0	0	0	0	0	0	0	0
Waters of sulfide ore deposits	+	+	+	+	+	+	+	?	+	+	0	?	+	-	+
Shallow lakes	?	-	0	-	0	0	0	?	0	0	0	0	0	0	0
Marshes	+	?	+	0	0	0	0	0	0	0	0	0	0	0	0
Indicator plants	+	?	+	+	0	+	0	0	0	0	0	0	0	0	+

TABLE 16 (Continued)

INDICATOR ELEMENTS (AFTER GINZBURG)

Rocks, Soils, Minerals, Waters, Coal Ash, Vegetation.	Te	Ni	Co	Cr	U	Sc	Ba	Sr	Ge	B	F	$SO_4^=$	Ti	V	P
Igneous, metamorphic, hydrothermally altered rocks	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Sedimentary carbonate rocks	?	+	0	0	+	0	+	+	0	0	+	-	0	+	+
Sedimentary clayey-sandy rocks	?	-	0	-	+	0	+	-	0	0	-	-	+	+	+
Residual products of weathering of silicate rocks	0	+	+	+	+	0	+	-	+	-	+	-	+	0	-
Residual products of leaching of carbonate rocks	0	+	+	0	0	0	-	-	0	0	-	-	0	0	-
Gossans of sulfide deposits and oxidized zones	0	+	+	+	+	0	+	-	0	?	+	+	0	+	+
Bleached zones	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0
Diluvial sediments	0	+	+	+	+	0	+	0	0	0	?	-	+	0	0
Alluvial sediments	0	+	+	+	0	0	+	0	0	0	?	0	+	0	0
Takyrs	+	+	0	+	+	0	+	0	0	0	?	-	+	0	0
Surficial quaternary sediments up to 2 m thick	0	0	0	+	?	0	?	0	0	0	?	-	+	0	0
Surficial quaternary sediments thicker than 2 m	0	0	0	+	?	0	?	0	0	0	?	-	+	0	0
Soils	0	+	+	0	-	+	+	-	0	+	-	-	+	0	+
Glacial deposits	0	+	-	+	0	0	0	0	0	0	0	0	-	0	0
Iron hydroxides of oxidized zones, weathering, and metamorphic ore deposits	+	+	+	-	-	0	0	0	+	0	0	+	0	0	+
Manganese hydroxides of oxidized zones and weathering	0	+	+	0	-	0	-	-	0	0	0	-	0	0	0
Coal ash	?	-	-	-	+	-	-	0	+	-	0	-	-	0	-
Sulfides of sedimentary deposits	0	+	+	-	+	0	-	-	0	0	0	-	-	0	-
Ash of plants	0	+	+	-	+	0	-	0	+	+	0	-	0	0	+
Ground waters	0	+	?	-	+	0	0	0	0	+	0	+	0	0	-
Surface waters	0	0	0	0	0	0	0	0	0	0	-	+	0	0	0
Waters of sulfide ore deposits	?	+	+	0	+	-	-	-	0	+	+	+	0	0	0
Shallow lakes	0	0	0	0	0	0	0	?	0	0	0	-	0	0	0
Marshes	0	0	0	0	0	0	0	?	0	0	0	-	0	0	0
Indicator plants	0	0	+	0	+	0	0	0	0	0	0	+	0	0	0

Explanation: +, present commonly in quantities sufficient to serve as indicators of mineralization; -, present generally in quantities insufficient to serve as indicators of mineralization; ?, insufficient data; 0, not stated.

TABLE 16 (Continued)

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TABLE 17

CONCENTRATION OF THE ELEMENTS IN RUSSIAN ROCKS AND SOILS

Element	Ultrabasic Rocks (dunites peridotites, pyroxenites)		Basic Rocks (basalts, gabbres, norites, diabases, etc.)		Intermediate Rocks (diorites, andesites)		Acid Rocks (granites, liparites, rhyolites, etc.)		Sedimentary Rocks (clays and shales)		Composition of Soils	
	%	= ppm	%	= ppm	%	= ppm	%	= ppm	%	= ppm	%	= ppm
Zn	5.0x10^{-3}	50	1.3x10^{-2}	130	7.2x10^{-3}	72	6.0x10^{-3}	60	8.0x10^{-3}	80	5.0x10^{-3}	50
Cu	8.0x10^{-3}	80	1.4x10^{-2}	140	3.5x10^{-3}	35	3.0x10^{-3}	30	5.7x10^{-3}	57	2.0x10^{-3}	20
Pb	----		8.0x10^{-4}	8	1.5x10^{-3}	15	2.0x10^{-4}	2	2.0x10^{-3}	20	1.0x10^{-3}	10
Ni	1.2x10^{-1}	1200	1.6x10^{-2}	160	5.5x10^{-3}	55	8.0x10^{-4}	8	9.5x10^{-3}	95	4.0x10^{-3}	40
Ag	3.0x10^{-5}	0.3	3.0x10^{-5}	0.3	----		1.5x10^{-5}	0.15	9.0x10^{-5}	0.9	1.0x10^{-5}	0.1
Mo	4.0x10^{-5}	0.4	1.4x10^{-4}	1.4	9.0x10^{-5}	0.9	1.9x10^{-4}	1.9	2.0x10^{-4}	2.0	2.0x10^{-4}	2.0
W	----		1.0x10^{-3}	10	1.0x10^{-4}	1	----		----		1.0x10^{-4}	1
Hg	----		9.0x10^{-6}	0.09	----		4.0x10^{-6}	0.04	4.0x10^{-5}	0.4	1.0x10^{-6}	0.01
As	2.8x10^{-4}	2.8	2.0x10^{-4}	2	2.4x10^{-4}	2.4	1.5x10^{-4}	1.5	6.6x10^{-4}	6.6	5.0x10^{-4}	5
Co	2.0x10^{-2}	200	4.5x10^{-3}	45	2.0x10^{-3}	20	5.0x10^{-4}	5	2.3x10^{-3}	23	8.0x10^{-4}	8
U	3.0x10^{-6}	.03	8.0x10^{-5}	0.8	1.8x10^{-4}	1.8	3.5x10^{-4}	3.5	3.2x10^{-4}	3.2	1.0x10^{-4}	1

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serves very well as an indicator element for mineralization due to copper, and similarly, silver for lead, arsenic for antimony, cobalt for chromium, tungsten for tin and uranium for the rare earths. However, these elements, do not have distributions widespread enough to be suitable as general indicators of mineralization.

Mercury, though its average concentration in soils is 0.01 ppm, is suitable as a geochemical indicator for many areas of mineralization primarily because the mercury atom is very mobile. Generally, the lower the temperature of deposition of the mineralization, the better mercury will serve as an indicator. However, due to the low concentrations of mercury in soils, detection equipment is beyond the means of the ordinary prospector. Another disadvantage of using mercury as an indicator element is that the concentration of mercury present will vary significantly from day to day with variations in temperature, humidity, wind, and barometric pressure.

Comparatively little work has been done with nickel as a geochemical indicator. Though it is present in rocks and soils in sufficient quantities to serve as an indicator, nickel does not appear to reveal anomalies for most areas of mineralization. This is probably due to its low solubility in water and hence low mobility. It has been demonstrated that a large part of the nickel in soils is dispersed in crystal lattices of aluminosilicates and another part is more loosely bound to the silicates as the result of base exchange. There are also water soluble nickel compounds in the soil but their concentrations are practically indeterminable.

Copper as a geochemical indicator, though generally better than the above mentioned elements, also has its disadvantages, primarily in that it is not uniformly distributed. It is found bound in organic compounds, in crystal lattices of aluminosilicates, and as water soluble salts. At a pH above 4.5, copper precipitates out of solution as a hydroxide, phosphate, sulfide, or carbonate. Thus, copper is not very mobile even in neutral soils, which accounts at least in part, for its nonuniform distribution. In acidic soils, however, copper serves well as a geochemical indicator for areas of high mineralization.

Lead, more than other metals, has an affinity for humus. In regions where humus is found, lead is readily dispersed and forms dispersion patterns around areas of high mineralization. However, where no humus is present, lead is not readily dispersed. The chemical form of lead in rocks and soils is uncertain but it is commonly associated with many areas of mineralization.

Zinc also is commonly associated with many areas of high mineralization, but unlike lead it is very mobile. In rocks or soils where carbon dioxide is dissolved, as much as 50% of the zinc present may be in the mobile state. Zinc is more uniformly distributed than other elements, its average concentration being around 60 ppm in acidic and neutral soils and slightly higher in basic soils where it is precipitated as the carbonate. The dispersion patterns of zinc around areas of mineralization are normally distinct and are not spread over too wide an area. (Ahrens and Taylor, 1960)

Citrate-soluble heavy metal methods of geochemical prospecting which employ copper, lead and zinc as the indicator elements have been successfully employed. A method employing zinc alone, or zinc and lead together, as the indicator elements, will serve sufficiently well for locating areas of mineralization due to most types of hydrothermal deposits.

Determination of Zinc

In the field, the quickest and easiest way of simultaneously making qualitative and semiquantitative analyses is by developing a color with the analytical species and comparing the developed color to a standard. Ideally, the colorimetric reagent employed should be specific for the analytical species, and sensitive to ppm concentrations.

Though there are many colorimetric reagents which are sensitive to zinc in ppm concentrations, none are specific. (Bryson and Lenzer, 1953; Miller and Hunter, 1954). However, by employing analytical techniques which will separate interfering ions from zinc, or complex the interfering ions so as to preclude interference (Cheng, 1961), it is possible to use nonspecific colorimetric reagents to determine zinc.

On the basis of cost, availability, stability under field condition, purity of reagent as purchased commercially, specificity, selectivity and sensitivity, 8-hydroxyquinoline (oxine) was chosen as the colorimetric reagent. Oxine is but slightly soluble in water and at pH 13 will quantitatively precipitate zinc from solution (Sandel, 1959). Umland, (1962) has demonstrated that such complexes are nearly completely extracted into an organic phase to form green-yellow solutions. Medline (1960) determined trace quantities of zinc in the presence of large amounts of calcium by extracting the zinc-quinolinate into chloroform from aqueous solutions buffered from pH 5-13 with ammonium hydroxide. At pH 13 significantly interfering elements are antimony (III), calcium, cadimum, chromum (III), cobalt, copper (II), lead, magnesium, iridium, iron (III) and nickel (Sandell 1959). However, preliminary separation via ion exchange precludes the interference of all of the above except for iridium, iron (III) and lead.

Moore and Kraus (1950, 1952, 1953) studied the anion exchange behavior of iron, cobalt, nickel, copper, manganese and zinc in hydrochloric acid solutions on the strong base anion exchange resin, Dowexl. They found that the spearation of these elements from one another should be possible on a comparatively short resin column. All the metals except nickel were adsorbed from concentrated hydrochloric acid solution. By examining the behavior of the various elements in different concentrations of hydrochloric acid, they found that only zinc was very strongly adsorbed from 2N acid. Elution of zinc was affected readily with 0.005N hydrochloric acid.

It is reported (Kallmann, Steele and Chu, 1956) that in the presence of large amounts of sodium chloride, the hydrochloric acid concentration can be lowered from 2N to 0.12N without adversely affecting the adsorption of zinc by the resin. Maximum adsorption of zinc is obtained in 0.12N hydrochloric acid containing 100 grams of sodium chloride per liter. It was also found that zinc is eluted quantitatively as sodium zincate by 2N sodium hydroxide and that addition of sodium chloride to the sodium hydroxide solution speeds up the elution of zinc. According to Kallmann et al., elements with which zinc is often associated in metals and minerals, such as iron (III), manganese, aluminum, beryllium, nickel, cobalt, chromium, copper, titanium, cadmium, the rare earths, and the alkaline earths, are not adsorbed on the resin in the hydrochloric acid-sodium chloride medium.

Anion exchange techniques have been successfully employed by Bradford, Pratt, Bair and Goulben (1965), to determine the aluminum, magnesium, nickel, manganese, cobalt, copper, iron, molybdenum, and zinc content in soils.

In lieu of the requirements specified in the introduction to this chapter, it is felt that anion exchange will lend itself readily to geochemical prospecting.

Reagents and Apparatus*

The following reagents and apparatus are needed for the ion-exchange field method:

COLUMN:	A 10 cm. length of polyethylene tubing of 5/8 in. I.D. was used for the column. The length of tubing was fitted with a nozzled polyethylene cap which had an opening of 2.5 mm, I.D.
DOWEX 1-X8:	200-400 mesh, chloride form.
OXINE SOLUTION:	0.5% 8-hydroxyquinoline in ethylacetate.
SOLUTION A:	0.012N hydrochloric acid containing 100 grams of sodium chloride and 15 grams of potassium citrate per liter.
SOLUTION B:	0.800N sodium hydroxide containing 10 grams of sodium per liter.
WASHING SOLUTION:	0.0096N hydrochloric acid.

*All chemicals reagent grade.

Procedure

Refer to the list above. The length of polyethylene tubing is fitted with the nozzled cap and a glass wool plug, approximately 3 mm thick, is inserted. One gram of the Dowex 1-X8 anion exchange resin is slurried with demineralized water and transferred to the plugged tube. Another plug of glass wool is inserted over the settled resin. At least 25 ml of the washing solution is then passed through the column.

Ten ml of solution A is added to 0.1-.5 grams of the finely divided soil sample to be analyzed. The slurry is stirred for one minute, filtered with Whatman No. 41 filter paper, and the filtrate passed through the column. The eluate is discarded.

An additional 10 ml of solution A is then passed through the column and the eluate again discarded.

Ten ml of solution B is passed through the column and the first 2 ml of the eluate discarded. The last 8 ml of the eluate is collected in a graduated hard glass test tube.

To the collected eluate is added 2 ml of the oxine solution and it is shaken for 30 seconds. After the aqueous and organic phases separate, note the color of the latter.

The column is reconditioned for the next soil sample by passing 25 ml of the washing solution through it.

Experimental

More often than not, chloroform is employed as an extracting solvent for oxinates. In the field, however, where exposure to sunlight is of greater concern than in the laboratory, a solvent which is not so adversely affected by sunlight is desired. It is also desirable to employ a solvent in which the zinc-oxinate develops a color of maximum intensity.

In order to determine a suitable solvent, zinc-oxinate was prepared and 5 mg of the zinc-oxinate added to 5 ml of the solvent to be tested. The intensity of the color developed was rated on an arbitrary scale relative to chloroform as fair. The results are given in Table 18. Of those solvents where good color intensity was developed (i.e. better than chloroform) ethylacetate was chosen on the basis of price and availability.

Due to the dead volume of the column, the total eluate of the solution B passing through the column can not be taken for analysis. The first portion of the eluate contains trace quantities of iron which, if included in that portion of the eluate tested with oxine, will mask the green-yellow color of the zinc-oxinate by the green-black color of the iron-oxinate. The dead volume of the column is determined by studying the pH of the eluate as a function of volume eluted. A typical plot is illustrated in Figure 20. The pH changes very abruptly between 1.5 and 2.5 ml of eluate. Satisfactory and reproducible results have been obtained by discarding the first 2 ml of eluate and testing only the last 8 ml with the oxine solution.

In the absence of potassium citrate it is necessary to pass 50 ml of solution A through the column after passing the sample solution through in order to remove the iron. In the presence of potassium citrate, however, 10 ml of solution A suffices to remove the iron from the column to the extent that it does not interfere in the determination of zinc.

TABLE 18

DETERMINATION OF A SUITABLE SOLVENT FOR ZINC-OXINATE

SOLVENT	COLOR DEVELOPED	INTENSITY*
Benzene	green	fair
Blazo (unleaded white gasoline)	none	----
Carbon disulfide	yel-grn	fair
Chloroform	grn-yel	fair
Cyclohexanone?	yellow	good
O-Dichlorobenzene	green	poor
Ethyl acetate	grn-yel	good
Isoamyl acetate	yel-grn	poor
Isopropyl ether	green	poor
Methylethylketone?	yel-grn	good
Toluene	yel-grn	fair
O-Tolidine solution?	yellow	poor
m-Xylene	yellow	poor
p-Xylene	yellow	poor

*(Relative to Chloroform as fair)

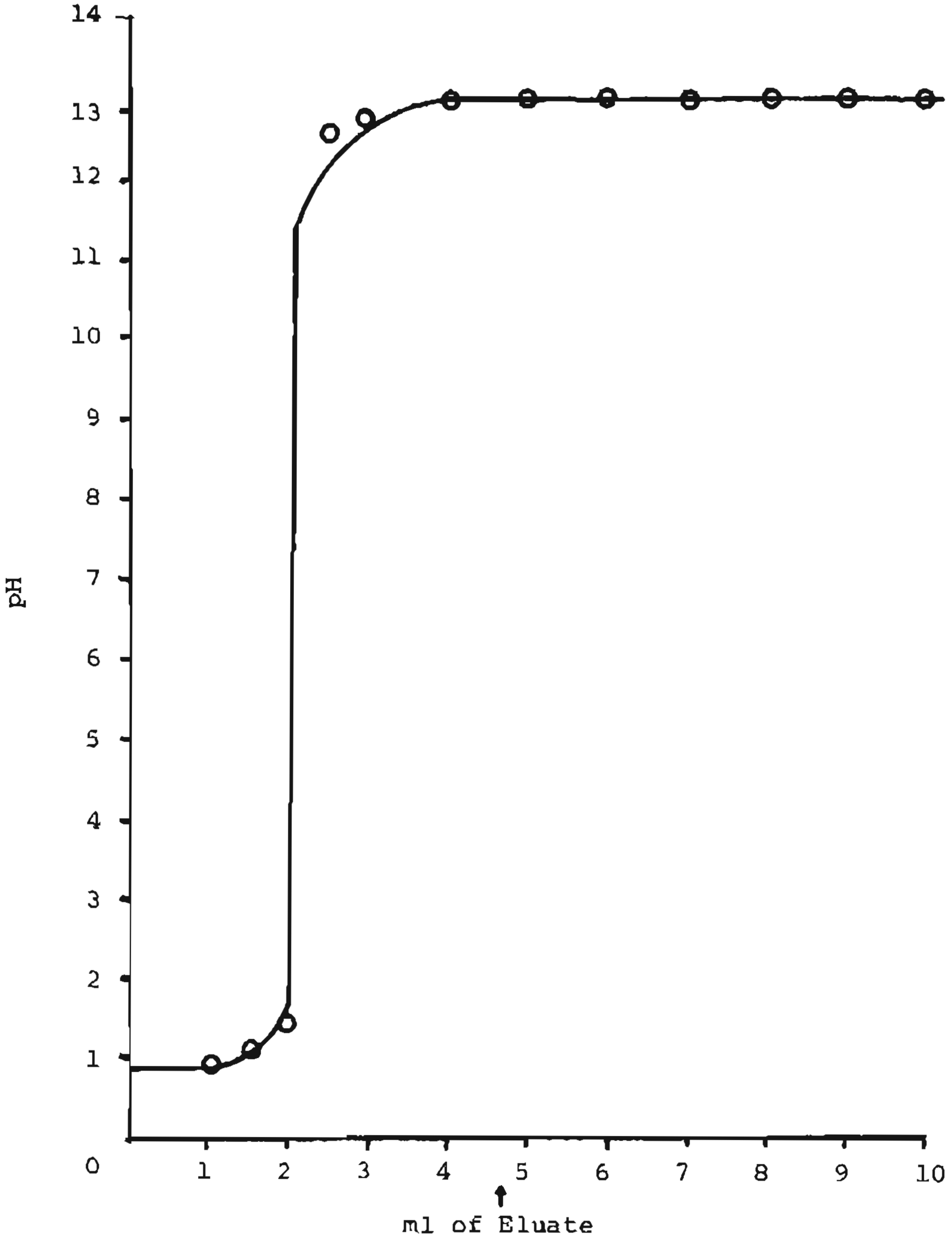

Fig. 20 pH vs. Volume Eluted During Solution B Pass.

Microgram quantities of various metal ions were passed through the column according to the procedure presented above. Up to 500 mg of antimony (III), cadmium, chromium, cobalt, mercury, silver and gold were passed through the column with no color noted in the oxine layer upon testing the eluate. One thousand mg of iron (III) through the column yielded no color in the oxine layer after testing. It was found that 500 mg of copper caused a faint coloration while only 100 mg of indium, 50 mg of lead and 50 mg of zinc, respectively, were needed to produce a detectable color.

Samples were taken along a line known to be anomalous, using the modified University of Alaska Geochemical Prospecting Method #2. The samples were analyzed by the above procedure, first using 0.1 gram samples and than 0.5 gram samples. The profiles obtained are shown in Figure 21. It is readily seen that the two major anomalies were detected when 0.5 gram samples were taken, but not when 0.1 gram samples were used. By the above procedure it is possible to adjust the sample size taken for analysis, such that background concentrations of zinc are not detected. It is then possible to develop coloration only in definitely anomalous areas, hence eliminating, in part, anomalies which show up due to experimental variation.

Discussion of Method

Though far from perfected, it appears that a geochemical prospecting method based upon the proposed procedure will work. However, before it can be adapted to field use a more efficient means of filtering must be devised and the time required for the

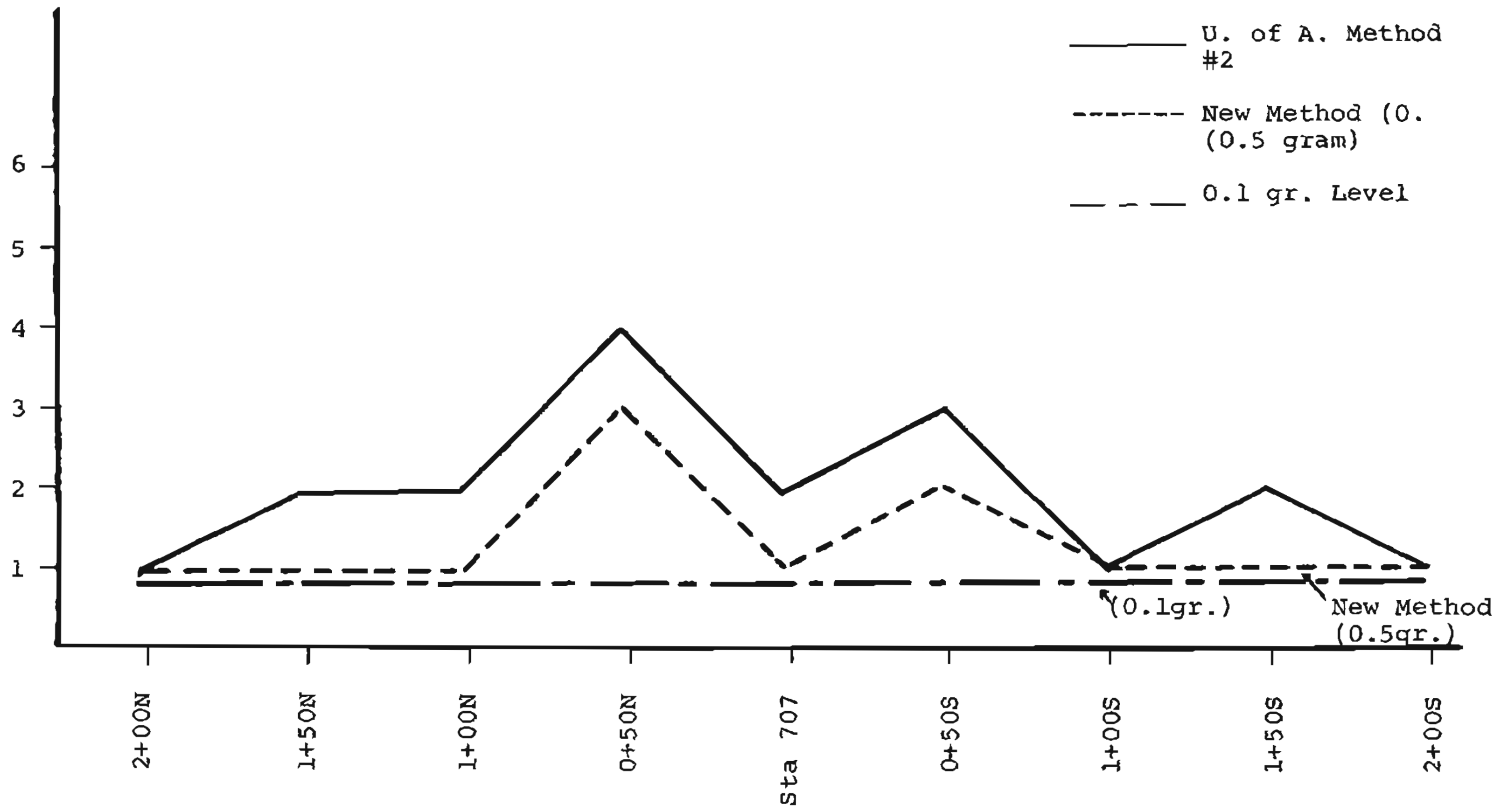

Fig. 21 Comparison of University of Alaska Method #2 and New Method.

analyses must be reduced. It takes 15 minutes to run one analysis; in a laboratory where a large number of columns may be set up and samples analyzed simultaneously, this is not a problem, but in the field, 15 minutes is too long. If the same diameter tubing is employed, with less resin, erratic results are obtained and if less resin is used with a smaller diameter column the flow rate decreases and the time increases.

The answer to the problem may possibly be suggested in a recent article by Campbell, Spano and Green (1966). They used paper disks loaded with an ion exchange agent for collecting microgram quantities of cations and anions from solution during the filtering process. These disks may conceivably be adapted to the above procedure in such a manner as to eliminate both objections set forth above.

However, in spite of the objections, the procedure is still advantageous for the nontechnically trained prospector. Great accuracy is not necessary in preparing the reagents, for slight weighing errors even for the preparation of the oxine solution, will not affect the ultimate analysis significantly. So long as one starts with a good grade of reagents and is careful to eliminate external contamination, consistent results will be obtained.

CHAPTER SIX

SUMMARY AND RECOMMENDATIONS

Summary

A study has been conducted to:

1. Determine the geochemical environment in the Fairbanks district.
2. Determine the trace element distribution over a known lode.
3. Determine the effects of terrain slope upon trace element distribution over known lodes.
4. Determine the effects of frozen ground upon trace element distribution.
5. Test and develop methods of analysis for prospecting based upon trace element distribution.
6. Test inexpensive geophysical equipment.
7. Confirm the validity of the University of Alaska Method #2 for heavy metal soil analyses.

It has been determined that zinc distribution is positively skewed while reverse "J" distributions prevail for copper, lead, silver and molybdenum. Zinc and arsenic are established as tracers for gold mineralization. Degree of slope and presence of frozen ground do not appear to influence the location of the geochemical halo over the Cleary vein. Careful control of the sample soil horizon in the district is necessary.

The University of Alaska method of geochemical prospecting has been improved. Possible remedies for sources of error in the method are suggested. Analysis of soil samples for arsenic by x-ray fluorescence was found to be the fastest method used.

A dilute acid method for zinc is proposed, however, further testing of the method is needed. Also needed is a faster procedure of effecting the ion exchange step of the method.

Analysis of geochemical data by trend surface procedures was shown as an invaluable tool. Anomalies may be localized by this procedure.

Recommendations

Analysis of the geochemical data obtained by trend surface analysis should continue to be investigated. This is a method for subtracting the "noise" from data to accentuate regional and local trace element effects.

Analysis of soil samples by atomic absorption for gold and other trace elements should be studied.

Further work needs to be done to study the effects of terrain slope and frozen ground upon trace element migration.

Work should continue toward more efficient field methods of analysis. The cold acid method discussed in Chapter Five needs further refinement.

The Alaskan prospector should be made aware of geochemical and geophysical techniques of prospecting.

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APPENDIX

ELEMENTAL ANALYSES

AREA "A"

Sample	Cu (± 10 ppm)	Pb (± 75 ppm)	Zn (± 100 ppm)	HM
L 707 A 2 + 00 N	10	75	125	2
L " " 1 + 50 N	10	200	175	4
L " " 1 + 00 N Trench	10	2000	175	4
L " " 0 + 50 N	20	25	175	5
L " " Baseline	10	25	200	6
L " " 0 + 50 S	10	50	200	7
L " " 1 + 00 S	10	25	175	5
L " " 1 + 50 S	10	25	125	6
L " " 2 + 00 S	10	0	125	4
L 708 2 + 00 N	--	--	---	2
L " 1 + 50 N	10	50	100	2
L " 1 + 00 N	10	100	75	3
L " 0 + 50 N	10	175	125	8
L " Baseline	10	25	75	4
L " 0 + 50 S Ditch	10	25	250	8
L " 1 + 00 S	10	0	200	3
L " 1 + 50 S	10	0	0	2
L " 2 + 00 S	10	0	50	5
L 710 1 + 50 N	10	75	50	2
L " 1 + 00 N	10	75	75	3
L " 0 + 50 N	10	100	75	4
L " Baseline	10	200	200	4
L " 0 + 50 S	10	0	50	4
L " 1 + 00 S	10	0	50	2
L " 1 + 50 S	10	25	200	2
L 711 1 + 50 N	10	150	75	2
L " 1 + 00 N	10	25	200	3
L " 0 + 50 N	20	25	50	5
L " Baseline	10	250	50	8
L " 0 + 50 S	10	200	200	8
L " 1 + 00 S	10	25	125	2
L " 1 + 50 S	10	25	150	3
L 712 1 + 50 N	10	75	175	4
L " 1 + 00 N	20	50	150	2
L " 0 + 50 N	10	50	200	5
L " Baseline	10	50	175	10
L " 0 + 50 S	10	400	75	3
L " 1 + 00 S	10	200	200	2
L " 1 + 50 S	10	75	100	4

Sample		Cu (± 10 ppm)	Pb (± 75 ppm)	Zn (± 100 ppm)	HM
L 714	2 + 50 N	15	75	0	3
L "	2 + 00 N	10	500	175	2
L "	1 + 50 N	10	200	125	2
L "	1 + 00 N	10	75	350	2
L "	0 + 50 N	10	50	125	4
L "	Baseline	15	75	150	4
L "	0 + 50 S	10	175	200	6
L "	1 + 00 S	10	0	100	2
L "	1 + 50 S	10	75	125	5
L "	2 + 00 S	10	0	350	2
L "	2 + 00 N	20	75	200	6
L "	2 + 25 N	10	75	125	5
L "	2 + 50 N	10	75	125	6
L "	2 + 75 N	10	75	150	7
L "	3 + 00 N	10	75	150	6
L "	3 + 25 N	10	50	150	5
L "	3 + 50 N	10	50	125	6
L "	3 + 75 N	10	50	125	5
L "	4 + 00 N	10	50	175	5
L "	4 + 25 N	10	50	200	6
L "	4 + 50 N	10	75	225	6
L "	4 + 75 N	10	50	275	7
L "	5 + 00 N	10	100	200	7
L 715	1 + 50 N	10	0	175	8
L "	1 + 00 N	10	25	200	8
L "	0 + 50 N	--	--	---	10
L "	Baseline	10	50	175	8
L "	0 + 50 SB	10	75	200	8
L "	1 + 00 S	10	100	350	12
L "	1 + 50 S	10	200	125	6
L "	2 + 00 S	10	50	350	7
L "	1 + 50 N	10	0	175	8
L "	1 + 00 N	10	25	200	8
L "	0 + 50 N	--	--	---	10
L "	Baseline	10	50	175	8
L "	0 + 50 SB	10	75	200	8
L "	1 + 00 S	10	100	350	12
L "	1 + 50 S	10	200	125	6
L "	2 + 00 S	10	50	350	7
L 716	1 + 50 N	10	25	125	4
L "	1 + 00 N	10	25	125	2
L "	0 + 50 N	10	25	200	6
L "	Baseline	10	75	175	4
L "	0 + 50 S	10	75	175	3
L "	1 + 00 S	10	50	125	2
L "	1 + 50 S	10	25	150	2
L "	2 + 00 S	10	50	175	4

ANALYTICAL PROCEDURES

Introduction, Precautions

The analytical procedures presented below were employed in the laboratory to determine the concentration of copper, lead, molybdenum, silver, and zinc in the soil samples collected during the Cleary Hill study. The University of Alaska Geochemical Prospecting Method #2 and the modified Method #2 are also presented. The latter methods were employed both in the field and in the laboratory for cold extractible heavy metal determinations.

In the determination of metals in trace concentrations, contamination due to reagents, apparatus and comparable sources of contamination introduce a significant degree of error. Hence, it is appropriate to discuss means of reducing error due to such sources of contamination.

Only analytical reagent grade reagents should be employed with each of the following procedures. When ordering the reagents, it will be advantageous to request those reagents whose lot analysis indicates the lowest heavy metal concentration of those lots available. Once received, proper precautions should be taken to prevent contamination.

All apparatus brought into direct contact with the analytical solutions and/or reagents employed must be scrupulously clean. A hot chromic acid cleaning solution or any comparable cleaning solution should be employed to clean all glassware prior to use. After thorough cleaning, glassware left in contact with a slightly acidified (HCl) solution of demineralized water will remain clean.

Glassware made of soft glass should never be employed in trace element determinations. It has been demonstrated that soft glass provides a significant source of error; borosilicate glass such as Pyrex is best.

Polyethylene containers should be used if solutions are to be stored for any length of time. However, for those solutions containing organic solvents, Pyrex containers must be employed.

Following the above suggestions will largely prevent significant errors due to adsorption of the container material, desorption of previously absorbed materials on the container walls and adsorption of material from the analytical solutions onto the container walls.

Contamination which would ordinarily be introduced by rubber stoppers, stopcock lubricants, and the water employed throughout the determinations, may be prevented by using polyethylene caps, teflon stopcocks, and demineralized water, respectively.

Certain of the solutions employed in the following procedures decompose or change concentration upon standing and hence should be prepared daily, immediately prior to use. Dithizone solutions, especially in dilute concentrations, decompose readily in the presence of heat, light, and mild oxydizing agents. When prepared, dithizone solutions should be properly protected against such factors in order that incorrect results due to decomposition of the dithizone are precluded as much as possible.

The stannous chloride solution as employed in the procedure for the determination of molybdenum is also susceptible to degradation from heat, light, and oxydizing agents, though not to the extent that dithizone solutions are. Nevertheless, it is advantageous to prepare the solution only in quantities sufficient for the days work.

Standard solutions from which the colorimetric standards are prepared should be prepared immediately prior to use. For concentrations of 10 mg/ml, adsorption of the analytical ions onto the container walls of the volumetric glassware is enough to induce significant error into the preparation of the colorimetric standards.

In each of the following procedures the analytical ion (or ions) being determined is made to develop a colored complex with an appropriate colorimetric reagent. Once the color has been developed, a quantitative estimate of the concentration of the metal in the analytical sample is determined by visual comparison to standards. Best results will be attained if all comparisons are made under a source of good lighting against a white background. Since color development is dependent upon the proximity of the analytical system to equilibrium, it is necessary that factors such as shaking time and intensity of shaking be standardized in order that optimum results are realized.

Digestion of Analytical Samples Prior to the Determination of Copper, Lead, Molybdenum, Silver, and Zinc

The following digestive procedure was employed to dissolve the samples for the subsequent analysis of copper, lead, molybdenum, silver and zinc. The final solutions were diluted to a volume of 50 ml and approximate aliquots taken for the determination of each metal. The procedure has been adapted from that presented by Ginzburg.

Reagents:

Hydrochloric acid, 6 N - To a volume of demineralized water, add an equal volume of concentrated hydrochloric acid.

Nitric acid, 8 N - To a volume of demineralized water, add an equal volume of concentrated nitric acid.

Procedure:

Transfer 0.1 g. of the -80 mesh analytical sample to a 100 ml beaker. Wet the sample with 5 ml of demineralized water and add 10 ml of 6 N HCl and 5 ml of 8N HNO_3. Evaporate nearly to dryness on a hotplate. Add 5 ml of 8N HNO_3 and 10 ml of demineralized water. Heat to boiling and filter through a highly retentive filter paper (Blue Ribbon or Whatman No. 42). Wash the filtered residue at least three times with hot demineralized water, collecting the wash water with the filtrate. After the filtered solution has cooled to room temperature, dilute to an appropriate volume with demineralized water.

Copper Determination

The concentration of copper in the soil samples analyzed was determined according to the following procedure. The method of analysis is that proposed by the U.S.G.S. (1963) while the digestive procedure employed was that adapted from Ginzburg as presented previously in this paper. A comprehensive study of the general analytical procedure employed is given by Sandell (1959).

Reagents

2,2'-biquinoline solution, 0.02% - To 900 ml of isoamyl alcohol in a beaker, add 0.200 g. of 2,2'-biquinoline and warm the mixture on a steam bath, under a fume hood away from open flames, until all of the 2,2'-biquinoline is dissolved. Allow the solution to cool to room temperature and dilute to 1 liter in a volumetric flask with isoamyl alcohol. The solution should be colorless; if it is yellow, the 2,2'-biquinoline is impure and should not be used.

Copper buffer solution - In 1 liter of demineralized water in a separatory funnel, dissolve 400 g. of sodium acetate trihydrate, 100 g. of sodium tartrate dihydrate and 20 g. of hydroxylamine hydrochloride. If necessary, adjust the pH of this solution with hydrochloric acid or sodium hydroxide solution to between 6 and 7 using pH test paper. To the solution in the separatory funnel add 50 ml of 0.01% dithizone (diphylthiocarbazone) in carbon tetrachloride and shake. Allow the aqueous and organic phases to separate and discard the latter. Repeat the process with additional 50 ml portions of the dithizone solution until the discarded organic phase is green. To remove the dithizone which is dissolved in the buffer solution, add 50 ml portions of chloroform and extract as above, discarding the organic phase. Repeat the process until the discarded organic phase is colorless. Remove the dissolved chloroform from the buffer solution by extracting with two 50 ml portions of carbon tetrachloride.

Standard copper stock solution, 100 mg/ml - Dissolve 0.200 g. of cupric sulfate pentahydrate in 500 ml of 0.1 N hydrochloric acid.

Standard copper working solution, 10 mg/ml - Transfer 10 ml of the standard copper stock solution to a 100 ml volumetric flask and dilute to volume with 0.1 N hydrochloric acid.

Procedure

To a test tube containing 10 ml of the copper buffer solution, transfer a 2 ml aliquot of the sample solution to be analyzed. Add 2 ml of the 2,2'-biquinoline solution to the test tube, tightly cap and shake vigorously for 45 seconds.

After allowing the aqueous and organic phases to separate, compare the developed color in the latter phase to similarly prepared standards containing 0, 0.2, 0.4, 0.8, 1.5, 3.0, and 6 mg of copper. If the color developed by the analytical sample does not lie within the color range of the standards, repeat the procedure using an appropriate aliquot.

Calculate the amount of copper found, in ppm, according to:

$$\text{ppm Cu} = \frac{V}{W}\,\frac{M}{A}$$

where V is the volume of the original sample solution, in ml; M is the mg of copper found by comparison to the standards; W is the weight of sample digested, in g; and A is the aliquot of sample solution taken for analysis, in ml.

Lead Determination

The following procedure was employed to determine the concentration of lead in the soil samples studied. The method of analysis is that presented by the U.S.G.S. (1963) while the digestive procedure employed was that adapted from Ginzburg as discussed previously. Sandell (1959) treats the general analytical procedure comprehensively.

Reagents

Dithizone stock solution, 0.01% - Dissolve 0.50 g. of dithizone (diphenylthiocarbazone) in 400 ml of carbon tetrachloride in a 500 ml volumetric flask. Dilute to volume with carbon tetrachloride.

Dithizone working solution, 0.001% - Dilute 50 ml of the dithizone stock solution to 500 ml with carbon tetrachloride in a volumetric flask.

Lead buffer solution - Dissolve 50 g. of ammonium citrate, 10 g. of potassium cyanide and 8 g. of hydroxylamine hydrochloride in 800 ml of demineralized water in a two liter separatory funnel. Add 2 ml of thymol blue indicator solution and concentrated ammonium hydroxide, dropwise with shaking, until the pH of the solution is 8.5 as indicated by the color change from yellow to blue.

Add 50 ml of the dithizone stock solution to the separatory funnel and shake vigorously. Allow the aqueous and organic phases to separate and discard the latter. Repeat with additional 50 ml portions of the dithizone stock solution until the discarded organic phase is green.

The dithizone dissolved in the buffer solution is removed by extracting as above with successive 50 ml portions of chloroform. Repeat the extractions until the organic phase is colorless.

Remove the dissolved chloroform from the aqueous phase by extracting, as above, with two 50 ml portions of carbon tetrachloride.

Dilute the decontaminated buffer solution to one liter with demineralized water.

Potassium cyanide, 0.01% - Dissolve 1 g. of potassium cyanide in 1 liter of demineralized water. Note, potassium cyanide is a very toxic reagent, a deadly poison under some conditions, and proper precautions should be taken while working with it. Do not bring it in contact with acid!

Standard lead stock solution, 100 mg/ml - Transfer 0.016 g. of lead nitrate which has been dried for one hour at 110°C. to a 100 ml volumetric flask containing approximately 75 ml of demineralized water and 1 ml of concentrated nitric acid. Dissolve and dilute to volume with demineralized water.

Standard lead working solution, 10 mg/ml - Quantitatively transfer 10 ml of the standard lead stock solution to a 100 ml volumetric flask containing 1 ml of concentrated nitric acid and about 10 ml of demineralized water. Dilute to volume with demineralized water.

Thymol blue, 0.2% - Dissolve 0.2 g. of the sodium salt of thymol blue (thymolsulfaphthalein) in 100 ml of demineralized water.

Procedure

Transfer a 2 ml aliquot of the sample solution to be analyzed to a 125 ml separatory funnel containing 10 ml of lead buffer solution. Add 2 drops of thymol blue indicator and then concentrated ammonium hydroxide, dropwise with shaking, until the pH of the solution is 8.5 - 9 as evidenced by a color change from yellow to blue.

Add 5 ml of the dithizone working solution to the separatory funnel and shake gently for 15 seconds. Allow the aqueous and organic phases to separate and transfer the latter to a glass stoppered 25 ml graduated cylinder containing 10 ml of 0.1% potassium cyanide solution. Shake the cylinder gently for 5 seconds and compare the developed color to similarly prepared standards of 0, 1, 2, and 3 mg of lead. If the color developed by the analytical sample does not lie within the color range of the standards, repeat the analysis using an appropriate aliquot.

Calculate the amount of lead found, in ppm, according to:

$$\text{ppm Pb} = \frac{V\ M}{W\ A}$$

where V is the volume of the original sample solution, in ml; M is the mg of lead found by comparison to the standards; W is the weight of sample digested, in g; and A is the aliquot of sample solution taken for analysis, in ml.

Molybdenum Determination

Soil samples analyzed for molybdenum were digested according to the procedure adapted from Ginzburg (1960). The following procedure, which was employed to determine the concentration of molybdenum, was also taken from Ginzburg (1960). Sandell (1959) treats the general analytical procedure comprehensively.

Reagents

Ammonium thiocyanate, 5% - Dissolve 25 g. of ammonium thiocyanate in 500 ml of demineralized water.

Isopropyl ether, anhydrous - Note, ethers are potentially hazardous materials, and proper precautions should be taken to insure safety. The ether employed must be peroxide free.

Standard molybdenum stock solution, 100 mg/ml - Dissolve 1.000 g. of metallic molybdenum in 10 ml of 8 N nitric acid. Add 20 ml of 18 N sulfuric acid to the solution and evaporate on a hot plate to white fumes of SO_3. After cooling, add 5 ml of demineralized water and repeat the evaporation. To the evaporated solution add 100 ml of 7% (by volume) sulfuric acid and quantitatively transfer the solution to a 1 liter volumetric flask. Dilute to volume with 7% sulfuric acid solution.

Standard molybdenum working solution, 10 mg/ml - Quantitatively transfer 10 ml of the standard molybdenum stock solution to a 100 ml volumetric flask and dilute to volume with demineralized water.

Stannous chloride solution, 10% - Dissolve 10 g of stannous chloride in 100 ml of demineralized water.

Procedure

To a test tube containing 10 ml of demineralized water, transfer a 2 ml aliquot of the sample solution to be analyzed. Shake to mix. Add 2 ml of 5% ammonium thiocyanate solution and mix thoroughly by shaking. Add 2 ml of 10% stannous chloride solution and again shake to mix. Add 5 ml of isopropyl ether, cap the test tube and shake vigorously for 30 seconds. After 15 minutes compare the color of the ether layer to similarly prepared standards containing 0, 0.2, 0.4, 0.8, 1.5, and 3.0 mg of molybdenum. If the color developed by the analytical sample does not lie within the color range of the standards, repeat the analysis using an appropriate aliquot.

Calculate the amount of molybdenum found, in ppm, according to

$$\text{ppm Mo} = \frac{V}{W}\,\frac{M}{R}$$

where V is the volume of the original sample solution, in ml; M is the mg of molybdenum found by comparison to the standards; W is the weight of sample digested, in g.; and A is the aliquot of sample solution taken for analysis, in ml.

Silver Determination

The method presented below has been adapted from Ginzburg (1960) and Sandell (1959) for the determination of silver. The soil samples were digested according to the procedure described previously in this paper.

Reagents

Dithizone stock solution, 0.01% - Dissolve 0.050 g. of dithizone (diphenylthiocarbazone) in 400 ml of carbon tetrachloride in a 500 ml volumetric flask. Dilute to volume with carbon tetrachloride.

Dithizone working solution, 0.001% - Quantitatively trasnfer 10 ml of the dithizone stock solution to a 100 ml volumetric flask and dilute to volume with carbon tetrachloride.

Standard silver stock solution, 100 mg/ml - Dissolve 0.158 g. of silver nitrate in 20 ml of 8 N nitric acid in a one liter volumetric flask. Dilute to volume with demineralized water.

Standard silver working solution, 10 mg/ml - Quantitatively transfer 10 ml of the standard silver stock solution to a 100 ml volumetric flask and dilute to volume with demineralized water.

Sulfuric acid, 4N - To 89 ml of demineralized water add 11 ml of concentrated sulfuric acid and shake to mix thoroughly.

Procedure

Transfer a 2 ml aliquot of the solution to be analyzed to a test tube containing 2 ml of 4N sulfuric acid and dilute to 16 ml with demineralized water. Add 2 ml of the dithizone working solution and shake vigorously for 30 seconds. After the aqueous and organic phases have separated, compare the color developed in the latter to similarly prepared standards containing 0, 1, 2, 3, 4, and 5 mg of silver. If the color developed by the analytical sample does not lie within the color range of the standards, repeat the analysis using an appropriate aliquot.

Calculate the amount of silver found, in ppm, according to

$$\text{ppm Ag} = \frac{V\ M}{W\ A}$$

where V is the volume of the original sample solution, in ml; M is the mg of silver found by comparison to the standards; W is the weight of sample digested, in g; and A is the aliquot of sample solution taken for analysis, in ml.

Zinc Determination

The concentration of zinc in the soil samples studied was determined according to the procedure presented below. The procedure is that employed by the U.S.G.S.(1963). The analytical samples were digested according to the procedure adapted from Ginzburg (1960). A comprehensive treatment of the general analytical procedure has been given by Sandell (1959).

Reagents

Dithizone stock solution, 0.01% - Dissolve 0.05 g. of dithizone (diphenylthiocarbazone) in 400 ml of carbon tetrachloride in a 500 ml volumetric flask. Dilute to volume with carbon tetrachloride.

Dithizone working solution, 0.001% - Quantitatively transfer 50 ml of the dithizone stock solution to a 500 ml volumetric flask and dilute to volume with carbon tetrachloride.

Standard zinc stock solution, 100 mg/ml - Dissolve 0.100 g. of 30 mesh zinc metal in 10 ml of concentrated hydrochloric acid and transfer quantitatively to a 1 liter volumetric flask. Dilute to volume with demineralized water.

Standard zinc working solution, 10 mg/ml - Quantitatively transfer 10 ml of the standard zinc stock solution to a 100 ml volumetric flask and dilute to volume with demineralized water.

Zinc buffer solution - Add 125 g. of sodium thiosulfate pentahydrate to a 1 liter separatory funnel containing about 400 ml of demineralized water. Shake to dissolve.

To another 1 liter separatory funnel containing about 400 ml of demineralized water, add 300 g. of sodium acetate trihydrate. Dissolve by shaking and add 60 ml of glacial acetic acid.

To each solution add 50 ml of the dithizone stock solution and shake vigorously. Allow the aqueous and organic layers to separate and discard the latter. Repeat with additional 50 ml portions of dithizone stock solution until the discarded organic phase is green.

Remove the dissolved dithizone from the aqueous solutions by extracting, as above, with two 50 ml portions of carbon tetrachloride.

Combine the two solutions and dilute to 2 liters with demineralized water.

Procedure

Transfer a 2 ml aliquot of the sample solution to be analyzed to a test tube containing 8 ml of zinc buffer solution. Add 5 ml of the dithizone working solution, cap the tube, and shake vigorously for 30 seconds. Allow the aqueous and organic phases to separate and compare the color developed in the latter phase to similarly prepared standards containing 0, 1, 3, and 4 mg of zinc. If the color developed by the analytical sample does not lie within the color range of the standards, repeat the analysis using an appropriate aliquot.

Calculate the amount of zinc found, in ppm, according to

$$\text{ppm Zn} = \frac{V\ M}{W\ A}$$

where V is the volume of the original sample solution, in ml; M is the mg of zinc found by comparison to the standards; W is the weight of sample digested, in g.; and A is the aliquot of sample solution taken for analysis, in ml.

Geochemical Prospecting: University of Alaska Method No. 2*

Scope

Dithizone will react with many metals, including copper, lead and zinc, from an ammonium citrate solution at a pH of 8.5. Some other reacting metals are cobalt, silver, stannous tin, ferrous iron, and manganese. However, the reaction due to the presence of the latter group of elements is insignificant unless present in large concentrations.

Chloride ion is believed to enhance the extraction of heavy metals into a aqueous medium. In an acidic medium, chloride ion will form metal-chloride complexes, the degree of which for any given metal, is dependent upon the pH of the solution and the concentration of chloride ion.

The solubility of dithizone in branched hydrocarbons is very low. Most unleaded white gasolines consist of a

---

*Method presented by Mukherjee & Anthony (1957).

mixture of branched hydrocarbons which will dissolve dithizone to the extent of around 0.01 g. per liter or 0.001% (w/v). Hence, a saturated solution of dithizone in white unleaded gasolines is of the proper concentration to serve as a conveniently prepared extracting solution at room temperatures.

The following procedure may be employed to determine the relative concentration of citrate-soluble heavy metals in soils and waters. Since the ammonium citrate/sodium bicarbonate system, as employed below, will maintain the pH of the aqueous solution at the proper pH, there is no need for pH adjustment.

Reagents

Conditioning mixture - Fill a 100 ml graduated cylinder to the 10 ml mark with sodium bicarbonate. In the same manner measure out 30 ml of solid sodium chloride and 60 ml of solid potassium citrate. Add all three of the measured out fractions to a clean polyethylene bottle and mix thoroughly by rolling and shaking in such a manner that a homogeneous mixture is affected with respect to particle size distribution. It is imperative that a uniform mixture be obtained.

Dithizone solution, saturated - To approximately 500 ml of a white unleaded gasoline, add approximately 0.1 g. of dithizone (diphenylthiocarbazone) and shake vigorously at frequent intervals over the period of at least one hour. Allow the excess dithizone to settle and decant off the clear saturated solution.

Procedure

To a 25 ml graduated test tube, transfer approximately 0.25 g. of the conditioning mixture (size of half of an adult aspirin) to the test tube and then demineralized water up to the 5 ml mark. Add 1 ml of the saturated dithizone solution, cap the tube with a polyethylene cap and shake vigorously for one minute. Allow the aqueous and organic layers to separate.

If the organic phase, after separating out, is any color other than that of the original green of the dithizone solution, heavy metals are present. Should heavy metals be present, additional one ml portions of the dithizone solution should be added, with shaking after each addition, until a greenish tinge is noted in the organic layer, or until 20 ml have been added.

Calculation

Calculate the "Index Value," I, according to the following formula:

$$I = M - 5$$

where M equals the total volume of liquid contained in the test tube at the end of the determination, in ml.

Note: If 20 ml of the dithizone solution has been added to the test tube without reaching an end point, record the "Index Value" as 20+.

Commentary

All apparatus brought into direct contact with the analytical solution and/or reagents employed, must be scrupulously clean.

Only analytical reagent grade reagents should be employed, as the reagents themselves may be a major source of contamination.

The saturated dithizone solution should be stored in a Pyrex container. If the analyses are to be done in the field where glass containers are impractical, a polyethylene container free from trace metal contamination may be employed. However, whenever possible one should avoid storing organic solvents in polyethylene containers because with time the solvents will dissolve some of the polyethylene. Since modern processes for the preparation of polyethylene employ metal catalysts to effect polymerization, solution of the container will release contaminating metals in trace concentrations. Soft glass containers should be definitely avoided in all trace analysis work.

If a series of samples is to be analyzed and the data subsequently used for exploration work, optimum results will be obtained when background contamination is a constant, preferable zero, for each individual analysis. Hence, it is advantageous to know beforehand the number of samples that are to be analyzed in order that a sufficiently large batch of conditioning mixture may be prepared. By analyzing all of the samples from the same batch of conditioning mixture, factors such as contamination from the mixture itself, pH of the extracting medium and extent of heavy metals extracted from the soil will be held relatively constant provided the same amount of conditioner is employed for each analysis and segregation of particle sizes within the conditioning mixture is prevented.

It is also advantageous, when working with a series of samples, to analyze all of the samples consecutively within one period of time. The greenish end point to which one titrates is not sharp, and hence, the shade of green which is defined as the end point is arbitrarily designated by the analyst. But the appearance of any given end point will vary significantly as the lighting conditions vary. Thus, if all of the samples are analyzed within the same period of time under a constant source of good lighting, significant errors due to titrating each sample to a different end point are greatly reduced.

After shaking, some types of soil samples form an emulsion which precludes determination of the color of the organic layer. Such an emulsion may be broken enough to determine the color of the organic layer by gentle swirling and tapping on the side of the test tube. Normally an emulsion will not persist after the addition of a few ml of the saturated dithizone solution.

The saturated solution of dithizone in unleaded gasoline should be prepared fresh prior to use. Dilute dithizone solutions are readily decomposed by heat, light and oxidizing agents. Once degradation has been initiated, the solution decomposes all the faster due to the effects of the degradation products on the dithizone. The solution should be kept in a cool, dark place.

A common, and not so readily detectable, source of error introduced into this method of analysis is due to not employing a saturated solution of dithizone. Since the solubility of dithizone in unleaded gasoline is so low, saturation is approached at a slow rate. It is imperative that vigorous and frequent shaking be employed while preparing the saturated solution of dithizone in unleaded gasoline.

Though this method of analysis is sensitive to the total citrate-soluble copper, lead, and zinc in a sample, the predominance of one or another of the three metals in a sample may be determined by the color of the organic layer after shaking. A pink or violet coloration may be indicative of zinc. Olive green, violet, brown or yellow-brown may be indicative of copper, and red or pink may be indicative of lead. Ambiguities may be eliminated by adding a few more ml of the dithizone solution after the coloration of the first ml addition has been determined.

If copper is predominant a brownish film will be noted at the interphase between the aqueous and organic layers. If lead is predominant a reddish film will be noted at the interphase. The reddish film of lead dithizonate will "creep" up the side of the tube upon standing. If zinc is predominant no film will be formed at the interphase.

Care must be taken to insure against the interpretation of the olive green copper dithizonate color as an end point. The olive green complex will change to violet upon the addition of more dithizone. Hence, if another ml of dithizone does not change the color to violet an end point has been reached. Conversely, if the color does change, the end point has not been reached and the titration procedure must be continued with further ml additions of the dithizone solution.

Finally, in order to help insure consistant results, all determinations should be made on soil samples of the same texture, preferably -80 mesh. Also the same amount of shaking time should be employed for all determinations.

University of Alaska Geochemical Prospecting Method #2 - Modified

The following procedure has been successfully employed in place of the University of Alaska Geochemical Prospecting Method #2 to determine cold extractible heavy metal content. The U.S.G.S. (1963) procedure for decontaminating buffer solutions has been applied to eliminate background contamination from reagents.

Reagents

Conditioning solution - To 800 ml of demineralized water in a 1 liter separatory funnel, add 5 g. of sodium bicarbonate, 15 g. of potassium citrate and 30 g. of sodium chloride. Shake to dissolve.

Add 50 ml of 0.01% dithizone (diphenylthiocarbazone) in carbon tetrachloride solution to the separatory funnel and shake vigorously. Allow the aqueous and organic phases to separate and discard the latter. Repeat the process with additional 50 ml portions of the dithizone solution until the discarded organic phase is green.

Remove the dissolved dithizone from the aqueous solution by extracting, as above, with 50 ml portions of chloroform. Repeat the extractions with additional 50 ml portions of chloroform until the discarded organic phase is colorless.

Extract the dissolved chloroform from the solution, as above, with two 50 ml portions of carbon tetrachloride.

Dilute the decontaminated conditioning solution to 1 liter.

Dithizone solution - To approximately 500 ml of white unleaded gasoline, add approximately 0.1 g. of dithizone (diphenylthiocarbazone) and shake vigorously at frequent intervals, over a period of at least one hour. Allow the excess dithizone to settle and decant off the clear saturated solution.

Procedure

Transfer approximately 0.1 g. of the finely divided soil to be analyzed, or 1 ml of the water sample to be analyzed, to a 25 ml graduated test tube. Add conditioning solution until the total volume of liquid in the tube is 5 ml. Add 1 ml of the dithizone solution, cap, and shake vigorously for one minute. Allow the aqueous and organic phases to separate and note the color in the latter phase. If a definite green tinge is not noticeable, add another ml of the dithizone solution and shake for another minute. Repeat with additional portions of the dithizone solution followed by shaking until a green end point has been reached.

Calculate the index value, I, according to

$$I = V - 5$$

where V is the total volume of liquid in the tube at the end point.

IBM 1620 FORTRAN II TREND ANALYSIS PROGRAM

By
James E. Wallis
MIRL Research Assistant

GENERAL INFORMATION

This program provides a rapid means of calculating the frequency with which one element tends to increase or decrease in concentration at the same time another mineral is increasing or decreasing in concentration. Output is a listing of equal trends, unequal trends and indefinite trends. Indefinite trends are significant of values which remain equal for a number of points.

DESCRIPTION OF PROGRAM SYMBOLS

DATA(I,J) - Input data, 5 columns of data per card. Maximum word length per column is 8 digits with two decimal places
NUMONE - 1st variable to be tested
NUMTWO - 2nd variable
SECT - Identification number of section tested
LC - Last card test number
TREND - Equal trends
DTREND - Opposite trends
TRIND - Indefinite trends
NPTS - Number of data cards
X - Counter for trend determination
Y - Counter for trend determination
STV - Counter for equal trends
DTV - Counter for opposite trends

DATA CARDS

Data is punched on cards in 5F8.2 format. A maximum of 400 cards may be processed at one time.

LEAD CARD

One lead card preceeds the data. This card indicates the number of data cards following. FORMAT(I4)

VARIABLE CARDS

These cards follow the data cards. The first of these cards contains the first two variables and the identification number of the section to be processed. FORMAT(2I2,F4.0). The cards immediately following contain the remaining variables to be tested - two per card. To signify the end of the program punch a single digit in the 10th column of the last variable card.

SENSE SWITCHES

Sense switch 1 is the only control switch used. The console typewriter types the following message after completion of variable testing: SSW 1 off for new variables, on for new data.

OUTPUT

All output is punched.

MACHINE CONFIGURATION

Minimum requirements are a 1620 system with 40K storage and a 1622 card read punch.

IBM 1620 FORTRAN II LISTING TREND COMPARISON PROGRAM

```
      DIMENSION DATA(400,5)
C     FIVE VARIABLE TREND COMPARISONS
800   READ 101,NPTS
101   FORMAT(I4)
      DO 1  I=1,NPTS
1     READ 99,(DATA(I,J),J=1,5)
99    FORMAT(5F8.2)
900   READ 98,NUMONE,NUMTWO,SECT,LC
98    FORMAT(2I2,F4.0,I2)
      TREND=0.
      DTREND=0.
      L=NPTS-1
      DO 2  I=1,L
      N=I
      M=I+1
      IF(DATA(M,NUMONE)-DATA(N,NUMONE))3,4,5
3     X=-1.
      GO TO 9
4     X=50.
      GO TO 9
5     X=1.
9     IF(DATA(M,NUMTWO)-DATA(N,NUMTWO)) 6,7,8
6     Y=-1.
      GO TO 10
7     Y=50.
      GO TO 10
8     Y=1.
10    IF((X+Y)-20.) 11,13,13
13    GO TO 2
11    IF(X+Y) 12,14,12
12    STV=1.
      TREND=TREND+STV
      GO TO 2
14    DTV=1.
      DTREND=DTREND+DTV
2     CONTINUE
      DL=L
      TRIND=DL-(TREND+DTREND)
      IF(SECT) 15,16,15
15    PUNCH 97,SECT
97    FORMAT(27HTREND ANALYSIS OF SECTION  ,F5.0)
16    PUNCH 96, NUMONE,NUMTWO
96    FORMAT(//18HVARIABLES TESTED  ,213)
      PUNCH 95,TREND
95    FORMAT(/43HNUMBER OF POINTS FOLLOWING AN EQUAL TREND =,F5.0)
      PUNCH 94,DTREND
```

```
94    FORMAT(/36HNUMBER OF POINTS OF OPPOSITE TREND =,F5.0)
      PUNCH 93,TRIND
93    FORMAT(/41HNUMBER OF POINTS WITH INDEFINITE TRENDS =,F5.0)
      IF(LC)19,20,19
19    GO TO 30
20    PRINT 92
92    FORMAT(44HSSW 1 OFF FOR NEW VARIABLES,ON FOR NEW DATA.)
      PAUSE
      IF(SENSE SWITCH 1)17,18
17    GO TO 800
18    GO TO 900
30    STOP
      END
```

IBM 1620 FORTRAN II - CURVE PROFILER
STANDARD AND FIVE POINT RUNNING AVERAGE METHODS

By
James E. Wallis
MIRL Research Assistant

GENERAL INFORMATION

This program profiles by one of two methods

1. Standard Profile Method
2. 5 Point Smoothed Average Method

Sense switch 3 controls the method used; if off it profiles the values directly, if on it profiles using the Standard 5 Point Average Method.

DESCRIPTION OF PROGRAM SYMBOLS

D(II,JX) - Data cards further read in for the 5 Point Method. II - card number, JX - column numbers 1 through 9.
DATA(K) - Data cards when read in for the Standard Profile Method. K - Columns 1 through 9.
XMAX - Maximum value of X.
SSC - Subscale, controls the spacing of the digits when plotted, may vary from 1 to 5 digits.
ISYM - Number of point plot desired.
XM - X margin value.
YM - Y margin value.
XSC - X scale.
YSC - Y scale.
XSIZE - Size of map in the X direction.
YSIZE - Width of plot in the Y direction.
YSPACE - Value between points on the ordinate axis.
YDIST - Value between distortion points on the ordinate axis.
NYPTS - Number of points (standard) on the ordinate axis.
NDPTS - Number of distortion points on the ordinate axis.
NX - Card column for x coordinate.
NY - Card column for y coordinate.
NN - Card column for value to be profiled.
AVEV - 1st 5 point running average value.
FA - X coordinate of value to be plotted for 5 Point Method.
FB - Y coordinate for 5 Point Method.
VA - 2nd through last running average value.
A - x coordinate.
B - y coordinate.
XMOVE - Corrected distance between points if points vary somewhat from the same elevation.
XRUN - X coordinate of any point corrected for elevation.
VAL - Data to be profiled (Standard Profile Method).

LEAD CARDS

5 lead cards are used.

```
1.   XMAX, SSC, ISYM
   FORMAT (F6.0, F8.3, I1)
2.   XM, YM, XSC, YSC, XSIZE, YSIZE
   FORMAT (2F8.0, 2F8.5, 2 F8.0)
3.   YSPACE, YDIST, NYPTS, NDPTS
   FORMAT (2F8.0, 2I2)
4.   NPTS
   FORMAT (I4)
5.   NX, NY, NN
   FORMAT (3I2)
```

These lead cards must be in this order, and are followed immediately by the data cards.

DATA INPUT

Input is by punch cards. Each data card may have up to 9 columns of data in the following format: (F4.0, IX, 2(F5.0, 1X), F3.0, 1X, F4.0, 1X, 2(F6.0, 1X), 2(F3.0, 1X))

OUTPUT

Output is by on-line plotter. The data fed in is profiled by one of the two methods.

SENSE SWITCHES

Three sense switches are used.

SSW 2: On - Scale lines are drawn.
Off - Scale points are marked on the y axis.

SSW 3: On - Profiles are drawn using the 5 Point Running Average Method.
Off - Standard Profiles are drawn.

SSW 4: The console typewriter types instructions for the use of this switch on completion of the first profile. SSW 4 ON FOR NEW SECTION, OFF FOR MORE DATA and the machine halts.

If the switch is left off the machine is ready for more data to profile on the same section. Leave the first 3 lead cards off. If on, the machine is ready for data for a new section.

RESTRICTIONS

A maximum of 150 data cards can be read in at one time.

MACHINE CONFIGURATION

Minimum requirements are a 1620 system with a 40 K memory, a card read punch and an on-line plotter.

IBM 1620 FORTRAN II LISTING - CURVE PROFILER

```
*0808
      DIMENSION D(150,9),DATA(9)
C     PROFILER..STANDARD AND 5 POINT RUNNING AVERAGE METHODS
200   READ 99,XMAX,SSC,ISYM
99    FORMAT(F6.0,F8.3I1)
      READ 97,XM,YM,XSC,YSC,XSIZE,YSIZE
97    FORMAT(2F8.0,2F8.5,2F8.0)
      CALL INIT(XM,YM,XSC,YSC,XSIZE,YSIZE)
      READ 95, YSPACE,YDIST,NYPTS,NDPTS
95    FORMAT(2F8.0,2I2)
      DO 1  I=1,NYPTS
      R=I
      Y=YSPACE*R
      IF(SENSE SWITCH 2)57,58
57    CALL PLOTU(XM,Y,0)
      CALL PLOTD(XMAX,Y)
      GO TO 1
58    CALL PLOTU(XM,Y,ISYM)
1     CONTINUE
72    READ 120,NPTS
120   FORMAT(I4)
      READ 98,NX,NY,NN
98    FORMAT(3I2)
      IF(SENSE SWITCH 3)81,82
C     5 POINT RUNNING AVERAGE METHOD
81    DO 80  II=1,NPTS
80    READ 999,(D(II,JX), JX=1,9)
999   FORMAT(F4.0,1X,2(F5.0,1X),F3.0,1X,F4.0,1X,2(F6.0,1X),2(F3.0,1X))
      AVEV=(D(1,NN)+D(2,NN)+D(3,NN)+D(4,NN)+D(5,NN))/5.
      FA=D(3,NX)
      FB=D(3,NY)
      CALL PLOTU(FA,AVEV,0)
      K=NPTS-9
      DO 500 IX=1,K
      VA=(D(IX+1,NN)+D(IX+2,NN)+D(IX+3,NN)+D(IX+4,NN)+D(IX+5,NN))/5
      A=D(IX+3,NX)
      B=D(IX+3,NY)
      IF(FB-B)83,84,83
83    XMOVE=SQRTF(((B-FB)*(B-FB))+((A-FA)*(A-FA)))
      XRUN=FA+XMOVE
      GO TO 500
84    XRUN=A
500   CALL PLOTD(XRUN,VA)
      GO TO 59
C     STANDARD PROFILE METHOD
82    READ 93,(DATA(K),K=1,9)
93    FORMAT(F4.0,1X,2(F5.0,1X),F3.0,1X,F4.0,1X,2(F6.0,1X),2(F3.0,1X))
      VAL  =DATA(NN)
      FA=DATA(NX)
      FB=DATA(NN)
74    CALL PLOTU(FA,VAL,0)
188   KPT=NPTS-1
      DO 50  L=1,KPT
```

```
      READ 92,(DATA(N),N=1,9)
92    FORMAT(F4.0,1X,2(F5.0,1X),F3.0,1X,F4.0,1X,2(F6.0,1X),2(F3.0,1X))
      TVAL=DATA(NN)
304   A=DATA(NX)
      B=DATA(NY)
      IF(A-XMAX)51,51,52
52    PRINT 91,A
91    FORMAT(30HPOINT OUT OF RANGE X CO ORD = ,F8.0)
      GO TO 50
51    IF(FB-B)53,54,53
53    XMOVE=SQRTF(((B-FB)*(B-FB))+((A-FA)*(A-FA)))
      XRUN=FA+XMOVE
      GO TO 50
54    XRUN=A
50    CALL PLOTD(XRUN,TVAL)
59    CALL PLOTU(XM,YM,0)
      PRINT 90
90    FORMAT(42HSSW 4 ON FOR NEW SECTION,OFF FOR MORE DATA)
      PAUSE
      IF(SENSE SWITCH 4)55,56
55    GO TO 200
56    GO TO 72
      END
```

IBM 1620 FORTRAN II STANDARD 5 POINT RUNNING AVERAGE PROGRAM

By
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GENERAL INFORMATION

This program calculates a standard 5 point running average for up to five variables at one time.

DESCRIPTION OF PROGRAM SYMBOLS

V(I,J) - Variables - 1 through 5
AVCU - 5 point running average value for the 1st variable
AVPB - 5 point running average value for the 2nd variable
AVZN - 5 point running average value for the 3rd variable
AVMO - 5 point running average value for the 4th variable
AVAG - 5 point running average value for the 5th variable

DATA INPUT

Punch card input, up to 5 variables per card. FORMAT(21X, F4.0,1X,2(F6.0,1X),2(F3.0,1X))

OUTPUT

5 point running averages of up to 5 variables are punched in cards. Same format as input.

MACHINE CONFIGURATION

Minimum requirements are a 1620 system with a 20K storage and a 1622 card read punch.

IBM 1620 FORTRAN II LISTING STANDARD 5 POINT RUNNING AVERAGE

```
      DIMENSION V(5,5)
C     STANDARD 5 POINT RUNNING AVERAGE
      DO 1  I=1,5
1     READ 99,(V(I,J),J=1,5)
99    FORMAT(21X,F4.0,1X,2(F6.0,1X),2(F3.0,1X))
100   AVCU=(V(1,1)+V(2,1)+V(3,1)+V(4,1)+V(5,1))/5.
      AVPB=(V(1,2)+V(2,2)+V(3,2)+V(4,2)+V(5,2))/5.
      AVZN=(V(1,3)+V(2,3)+V(3,3)+V(4,3)+V(5,3))/5.
      AVMO=(V(1,4)+V(2,4)+V(3,4)+V(4,4)+V(5,4))/5.
      AVAG=(V(1,5)+V(2,5)+V(3,5)+V(4,5)+V(5,5))/5.
      PUNCH 98,AVCU,AVPB,AVZN,AVMO,AVAG
98    FORMAT(5F8.2)
      DO 2  I=2,5
      DO 2  J=1,5
2     V(I-1,J)=V(1,J)
      READ 97,(V(5,J),J=1,5)
97    FORMAT(21X,F4.0,1X,2(F6.0,1X),2(F3.0,1X))
      IF(SENSE SWITCH 1)3,4
4     GO TO 100
3     STOP
      END
```

IBM 1620 FORTRAN II - NUMERICAL POINT PLOT AND GRID SYSTEM

By
James E. Wallis

PROGRAM DESCRIPTION

This program draws a grid system and labels the grid values. Data points are then plotted and their values labeled. For greatest plotting speed it is suggested that the data cards be sorted on the basis of increasing x and then resorted on increasing y coordinates.

PROGRAM SYMBOLS

Data(N) - Data cards, up to 10 columns of data per card.
XMAX - Maximum x - coordinate.
SSC - Subscale. This controls the distance apart of the digits when plotted. (100 ft. per inch scale requires a subscale of 7 or 8).
XM - x margin
YM - y margin
XSC - x scale
YSC - y scale
XSIZE - Map length in the x direction
YSIZE - Map length in the y direction
GRID - Grid spacing in feet.
GORIGIN - Grid origin. For grid systems starting at some point other than zero, this should be the next lowest grid value that does not show on the area to be plotted.
NGLIN - Number of grid lines on the x axis.
YSPACE - Grid in feet as measured on the spacing axis.
NX - Card column on data cards for x coordinates.
NY - Card column on data cards for y coordinates.
NX - Card column on data cards for digits to be plotted at a particular data point.
YDIST - Distortion distance for distorted scales on the y axis.
NYPTS - Number of grid points on the y axis.
NDPTS - Number of distortion points on the y axis.
NBR - A single digit as located by truncating.
A - X coordinate.
B - Y coordinate.
KX - Card column for x coordinate on data cards.
KY - Card column for y coordinate on data cards.
XMOVE - The calculated distance between two points when the points lie on different elevations.

XRUN - The calculated value of the x coordinate.
TVAL - Value of the digits to be plotted at a particular data point.
NN - Card column on data cards for digits to be plotted at a particular data point.

LEAD CARDS

9 lead cards are used.

1. XMAX, SSC, ISYM
   FORMAT (F6.0, F8.3, I1)
2. XM, YM, XSC, YSC, XSIZE, YSIZE
   FORMAT (2F8.0, 2F8.5, 2F8.0)
3. GRID, GORIG, NGLIN
   FORMAT (2F6.0, I4)
4. YSPACE, YDIST, NYPTS, NDPTS
   FORMAT (2F8.0, 2I2)
5. NPTS
   FORMAT (I4)
6. KX, KY
   FORMAT (2I2)
7. NX, NY
   FORMAT (2I2)
8. NN
   FORMAT (I2)
9. KN
   FORMAT (I2)

DATA INPUT

Input is by punch cards. Each data card may contain up to 9 columns of data in the following format: FORMAT (F4.0,1X,2(F5.0,1X),F3.0,1X,F4.0,1X,2(F6.0,1X),2(F3.0,1X))

OUTPUT

All results are plotted by the on line plotter. On completion of plotting, the plotter returns to the origin, and the following message is typed by the console typewriter. SSW 4 ON FOR NEW SECTION, OFF FOR MORE DATA and the machine halts.

If sense switch 4 is left off, enter more data preceded by the last 5 leader cards, press start.

SENSE SWITCHES

Three sense switches are used for control. Sense switch 1-off, grid lines are drawn and labeled. On-grid lines are omitted and the data points plotted immediately.

Sense switch 2 - Off, scale points are marked on the y axis.
- On, grid lines are drawn parallel to the x axis.

Sense switch 4 - Instructions are typed via the console typewriter.

MACHINE CONFIGURATION

Minimum requirements are a 1620 system with a 40K memory unit, a card read punch and an on line plotter.

IBM 1620 FORTRAN II - LISTING NUMERICAL POINT PLOT AND GRID SYSTEM

```
*0808
        DIMENSION DATA(10)
C       NUMERICAL POINT PLOT AND GRID SYSTEM
200     READ 99,XMAX,SSC,ISYM
99      FORMAT(F6.0,F8.3,I1)
        READ 97,XM,YM,XSC,YSC,XSIZE,YSIZE
97      FORMAT(2F8.0,2F8.5,2F8.0)
        CALL INIT(XM,YM,XSC,YSC,XSIZE,YSIZE)
        IF(SENSE SWITCH 1)70,71
70      GO TO 72
71      READ 96,GRID,GORIG,NGLIN
96      FORMAT(2F6.0,I4)
        READ 95,YSPACE,YDIST,NYPTS,NDPTS
95      FORMAT(2F8.0,2I2)
        DO 1  I=1,NYPTS
        R=I
        Y=YSPACE*R
        IF(SENSE SWITCH 2)57,58
57      CALL PLOTU(XM,Y,0)
        CALL PLOTD(XMAX,Y)
        GO TO 140
58      CALL PLOTU(XM,Y,ISYM)
140     NY=Y
        IF(NY/10)3,2,3
2       C=XM+SSC
        CALL PLOTU(C,Y,0)
        CALL NUMB(NY)
        GO TO 1
3       IF(NY/100)4,5,4
5       NBR=NY-(NY/10)*10
        C=XM+(2.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/10-(NY/100)*10
        C=XM+SSC
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        GO TO 1
4       IF(NY/1000)6,7,6
7       NBR=NY-(NY/10)*10
        C=XM+(3.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/10-(NY/100)*10
        C=XM+(2.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/100-(NY/1000)*10
```

```
        C=SM+SSC
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        GO TO 1
6       IF(NY/10000)8,9,8
9       NBR=NY-(NY/10)*10
        C=XM+(4.*SCC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/10-(NY/100)*10
        C=XM+(3.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/100-(NY/1000)*10
        C=XM+(2.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=Ny/1000-)NY/10000)*10
        C=XM+SSC
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        GO TO 1
8       IF(NY/100000)10,11,10
11      NBR=NY-(NY/10)*10
        C=XM+(5.*SSC)
        CALL PLOTU (C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/10-(NY/100)*10
        C=XM+(4.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/100-(NY/1000)*10
        C=XM+(3.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/1000-(NY/10000)*10
        C=XM+(2.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/10000-(NY/100000)*10
        C=XM+SSC
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        GO TO 1
10      IF(NY/1000000)12,13,12
13      NBR=NY-(NY/10)*10
        C=XM+(6.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
        NBR=NY/10-(NY/100)*10
        C=XM+(5.*SSC)
        CALL PLOTU(C,Y,0)
        CALL NUMB(NBR)
```

```
      NBR=NY/100-(NY/1000)*10
      C=XM+(4.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/1000-(NY/10000)*10
      C=XM+(3.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/10000-(NY/100000)*10
      C=XM+(2.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/100000-(NY/1000000)*10
      C=XM+SSC
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      GO TO 1
12    NBR=NY-(NY/10)*10
      C=XM+(7.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/10-(NY/100)*10
      C=XM+(6.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/100-(NY/1000)*10
      C=XM+(5.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/1000-(NY/10000)*10
      C=XM+(4.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/10000-(NY/100000)*10
      C=XM+(3.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/100000-(NY/1000000)*10
      C=XM+(2.*SSC)
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
      NBR=NY/1000000-(NY/10000000)*10
      C=XM+SSC
      CALL PLOTU(C,Y,0)
      CALL NUMB(NBR)
1     CONTINUE
      IF(NDPTS-1)88,89,88
88    DO 44  JJ=1,NDPTS
      V=JJ
      YJPT=Y+(YDIST*V)
      CALL PLOTU(XM,YJPT,ISYM)
44    CONTINUE
```

```
89      CONTINUE
        IF(NGLIN)20,21,20
21      GO TO 72
20      DO 22  L=1,NGLIN
        B=L
        X=GORIG+(B*GRID)
        CALL PLOTU(X,YM,ISYM)
        LX=X
        IF(LX/10)23,24,23
24      C=X+SSC
        CALL PLOTU(C,YM,0)
        CALL NUMB(LX)
        GO TO 22
23      IF(LX/100)25,26,25
26      C=X+(2.*SSC)
        NBR=LX-(LX/10)*10
        CALL PLOTU(C,YM,0)
        CALL NUMB(NBR)
        NBR=LX/10-(LX/100)*10
        C=X+SSC
        CALL PLOTU(C,YM,0)
        CALL NUMB(NBR)
        GO TO 22
25      IF(LX/1000)27,28,27
28      NBR=LX-(LX/10)*10
        C=X+(3.*SSC)
        CALL PLOTU(C,YM,0)
        CALL NUMB(NBR)
        NBR=LX/10-(LX/100)*10
        C=X+(2.*SSC)
        CALL PLOTU(C,YM,0)
        CALL NUMB(NBR)
        NBR=LX/100-(LX/1000)*10
        C=X+SSC
        CALL PLOTU(C,YM,0)
        CALL NUMB(NBR)
        GO TO 22
27      IF(LX/10000)29,30,29
30      NBR=LX-(LX/10)*10
        C=X+(4.*SSC)
        CALL PLOTU(C,YM,0)
        CALL NUMB(NBR)
        NBR=LX/10-(LX/100)*10
        C=X+(3.*SSC)
        CALL PLOTU(C,YM,0)
        CALL NUMB(NBR)
        NBR=LX/100-(LX/1000)*10
        C=X+(2.*SSC)
        CALL PLOTU(C,YM,0)
        CALL NUMB(NBR)
        NBR=LX/1000-(LX/10000)*10
        C=X+SSC
        CALL PLOTU(C,YM,0)
```

```
         CALL NUMB(NBR)
         GO TO 22
29       IF(LX/100000)31,32,31
32       NBR=LX-(LX/10)*10
         C=X+(5.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/10-(LX/100)*10
         C=X+(4.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/100-(LX/1000)*10
         C=X+(3.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/1000-(LX/10000)*10
         C=X+(2.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/10000-(LX/100000)*10
         C=X+SSC
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         GO TO 22
31       NBR=LX-(LX/10)*10
         C=X+(6.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/10-(LX/100)*10
         C=X+(5.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/100-(LX/1000)*10
         C=X+(4.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/1000-(LX/10000)*10
         C=X+(3.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/10000-(LX/100000)*10
         C=X+(2.*SSC)
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
         NBR=LX/100000-(LX/1000000)*10
         C=X+SSC
         CALL PLOTU(C,YM,0)
         CALL NUMB(NBR)
22       CONTINUE
72       READ 120,NPTS
120      FORMAT(I4)
199      READ 101,KX,KY
101      FORMAT(2I2)
```

```
          READ 98,NX,NY
98        FORMAT(2I2)
          READ 94,NN
94        FORMAT(I2)
          READ 111, KN
111       FORMAT(I2)
          READ 93,(DATA(K),K=1,9)
93        FORMAT(F4.0,1X,2(F5.0,1X),F3.0,1X,F4.0,1X,2(F6.0,1X),
                 2(F3.0,1X))
          VAL=DATA(KN)
          FA=DATA(KX)
          FB=DATA(KY)
          IF(VAL-2000.)74,74,75
74        CALL PLOTU(FA,VAL,0)
          GO TO 188
75        IF(VAL-5000.)59,59,60
59        YYV=Y+DIST
          CALL PLOTU(FA,YYV,0)
          GO TO 188
60        IF(VAL-25000.)61,61,62
61        SYV=Y+(2.*YDIST)
          CALL PLOTU(FA,SYV,0)
          GO TO 188
62        IF(VAL-100000.)63,63,64
63        TYV=Y+(3.*YDIST)
          CALL PLOTU(FA,TYV,0)
          GO TO 188
64        FYV=Y+(4.*YDIST)
          CALL PLOTU(FA,FYV,0)
188       KPT=NPTS-1
          DO 50  L=1,KPT
          READ 92,(DATA(N),N=1,9)
92        FORMAT(F4.0,1X,2(F5.0,1X),F3.0,1X,F4.0,1X,2(F6.0,1X),
                 2(F3.0,1X))
          TVAL=DATA(NN)
304       A=DATA(NX)
          B=DATA(NY)
          IF(A=XMAX)51,51,52
52        PRINT 91,A
91        FORMAT(30HPOINT OUT OF RANGE X CO ORD = ,F8.0)
          GO TO 50
51        IF(FB-B)53,54,53
53        XMOVE=SQRTF(((B-FB)*(B-FB))+((A-FA)*(A-FA)))
          XRUN=FA+XMOVE
          GO TO 300
54        XRUN=A
80        CALL PLOTD(XRUN,TVAL)
50        CONTINUE
          CALL PLOTU(XM,YM,0)
          PRINT 90
90        FORMAT(42HSSV 4 ON FOR NEW SECTION, OFF FOR MORE DATA)
          PAUSE
          IF(SENSE SWITCH 4)55,56
55        GO TO 200
56        GO TO 72
          END
```

IBM 1620 FORTRAN II GRID LABEL FOR CONTOURING PROGRAM

By

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MIRL Research Assistant

GENERAL INFORMATION

This program uses the 3rd phase output data from the Library Program - "Automatic Grid Contouring" 1620-MP-08X(E-9), it plots the values of the grid points as determined by the computer, making it possible to easily evaluate the contour values.

DESCRIPTION OF PROGRAM SYMBOLS

XM - X margin
YM - Y margin
XSC - X scale
YSC - Y scale
X SIZE - Length of map in the X direction
Y SIZE - Length of map in the Y direction
SSC - Subscale, this number controls the distance apart of digits in the plot.
ISYM - Indicates the number of the symbol to mark grid points.
SIZE - Grid Size
COLS - Columns
ROWS - Rows
CNBR - Column number
FROW - First row
ENDR - End row
VALUE(I) - Grid point values
Z - Number of rows that grid values are located in.
NBR - Digit to be plotted
X - X coordinate
Y - Y coordinate
XX - Corrected X coordinate for the digit plot.
NUMB - Numbers subroutine

DATA CARDS

This program uses the 3rd phase output from the Grid Value Determination program. 1620-MP-08X(E-9).

LEAD CARDS

Two lead cards are used. The first lead card contains margin coordinates, X and Y scale, and X and Y sizes.

FORMAT(2F8.0,2F8.5,2F8.2)

The second lead card contains the subscale and the required point plot symbol.

FORMAT(F4.0,I2)

SWITCH CONTROL

Sense switches 1 and 4 are used. On completion of the first run of data the console typewriter types the following instruction:

SSW 1 on for more data, off if completed.

SSW 4 off for margins, on to begin plot.

OUTPUT

Grid values are plotted, to a maximum of three digits.

MACHINE CONFIGURATION

Minimum requirements are a 1620 system with a 20K storage, a 1622 card read punch, and an on-line plotter.

IBM 1620 FORTRAN II LISTING GRID LABEL FOR CONTOURING

```
      DIMENSION VALUES(15)
C     GRID LABEL FOR CONTOURING
300   IF(SENSE SWITCH 4) 6,7
7     READ 102,XM,YM,XSC,YSC,XSIZE,YSIZE
102   FORMAT(2F8.0,2F8.5,2F8.2)
      CALL INIT(XM,YM,XSC,YSC,XSIZE,YSIZE)
      READ 101,SSC, ISYM
101   FORMAT(F4.0,I2)
6     READ 99,SIZE,COLS,ROWS
99    FORMAT(F5.0,1X,F4.0,1X,F4.0)
200   READ 98,CNBR,FROW,ENDR
98    FORMAT(F4.0,1X,F4.0,1X,F4.0)
      READ 97,(VALUE(I),I=1,15)
97    FORMAT(15F5.0)
      Z=(ENDR-FROW)+1.
      N=Z
      DO 1  J=1,N
      NVAL=VALUE(J)
      T=J
      NBR=NVAL-(NVAL/10*10
      X=XM+(CNBR*SIZE)
      Y=YM+(((FROW-1.)+T)*SIZE)
11    CALL PLOTU(X,Y,ISYM)
      XX=X+(2.*SSC)
      CALL PLOTU(XX,Y,0)
      CALL NUMB(NBR)
      NBR=NVAL/10-(NVAL/100)*10
13    XX=X+SSC
      CALL PLOTU(XX,Y,0)
      CALL NUMB(NBR)
      NBR=NVAL/100-(NVAL/1000)*10
      CALL PLOTU(X,Y,0)
      CALL NUMB(NBR)
1     CONTINUE
      IF(COLS-CNBR)2,3,2
2     GO TO 200
3     CALL PLOTU(XM,YM,1)
      PRINT 96
96    FORMAT(40HSSW 1 ON FOR MORE DATA, OFF IF COMPLETED)
      PRINT 95
95    FORMAT(39HSSW 4 OFF FOR MARGINS, ON TO BEGIN PLOT)
      PAUSE
      IF(SENSE SWITCH 1)4,5
4     GO TO 300
5     STOP
      END
```