1972

Trend-Surface Analysis of the Trunk Lake Granitic Pluton, Maine

Bruce Ramsey

TREND-SURFACE ANALYSIS

of the

TUNK LAKE GRANITIC PLUTON, MAINE

by

Bruce Ramsey

A Thesis

Submitted to the Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Bachelor of Science in Geology

Grand Forks, North Dakota

May 1972

This thesis submitted by Bruce Ramsey in partial full-fillment of the requirements for the degree of Bachelor of Science in Geology from the University of North Dakota is hereby approved by the Faculty Advisor under whom the work has been done.

(advisor)

TABLE OF CONTENTS

ABSTRACT

A trend-surface modal analysis of the Tunk Lake granitic pluton was performed using a program for the IBM 36/40 computer (Appendix 1) by Heiner and Geller (MIRL Report No. 9) and data from Karner (1968). The quartz, total mafics, oligoclase, perthite, and albite in perthite percentages were analysed.

All the trends show a southwest-northeast alignment, with the perthite, albite-in-perthite, and total mafic values increasing towards the margin of the pluton and quartz and oligoclase values decreasing outward to the margin. There is an area in the northwest part of the pluton which is an area of high values for total mafics, perthite, and albite-in-perthite, and an area of low values for quartz and oligoclase.

For the sixth-degree surfaces, the total mafics accounted for 49 percent of the total variation, quartz for 40 percent, oligoclase for 71 percent, perthite for 67 percent, and albite-in-perthite for 75 percent. The difference in the percentages points to two different types of trend. The quartz and total mafics trends are not as distinct as the oligoclase, perthite, and albite in perthite trends. This is a reflection of different processes involved in the formation of the pluton resulting in different trends. Water vapor pressure and cooling temperature govern the trends of oligoclase, perthite, and albite-in-perthite and magma differentiation and movement govern the trends of quartz and total mafics.

INTRODUCTION

This study was done in fulfillment of the senior thesis requirement for the University of North Dakota Bachelor of Science in Geology Degree. There are two objectives of this study, (1) to adapt and catolog for future use a trend-surface program that will run on the University's 360/40 computer, (2) to aid in interpretation of the geologic history of the Tunk Lake granitic pluton by an analysis of the variation of modal quartz, total mafics, perthite, albite in perthite, and oligoclase described by Karner (1968).

METHODS

The systematic change of some variate noted on a contour map is referred to as a trend. Trends of a certain variate are common characteristics of rocks exposed in outcrop belts or over a map area. Establishment of mineralogic, chemical, sedimentologic, or geophysical trends is important in interpreting geologic history and can have economic significance in that they can provide information in exploration for ore bodies, oil and gas accumulation and other natural resources.

The trend of some variate of a large number of data points can be assessed by drawing contour lines of equal value. The equal-value line represents the dependent variate, z, plotted on an x, y, grid which represents the independent, geographic variables. This method can be very subjective, especially if the census of data points is incomplete or if z shows much local variation or "noise".

Through use of a statistical method for determining the trend and plotting the contour lines one can extract the most information possible from the data while eliminating the subjective error encountered by drawing contour lines. Polynomial functions can be computed which give useful approximations of the trend. The method of computation involves the principle of "least squares" (Krumbein and Graybill 1965). Data points are located with respect to rectangular x, y coordinates. Ordinates for the dependent variable z are constructed for each location. With respect to these ordinates, the three dimensional linear surface, $z = a + bx + cy$, is computed which minimizes the sum of squares of the residual values ($S = \sum_{i=1}^{n} (z_{i\,observed} - z_{i\,calculated})^2$). By computing equations of higher degrees a surface of better "fit" or a reduction in the sum of squares is obtained.

Digital computers must be used for computation of the higher degree equations. There are several programs which will perform the necessary computations and plot the contours and residual ($z_{i\,observed} - z_{i\,calculated}$). The program used in the Tunk Lake analysis was adapted from Good's (1964) program for the IBM 1620 by Heiner and Geller (MIRL Report No. 9) for the IBM 360/40. The only change made was the elimination of the Alpha Subroutine which performs logical IF operations. The University's compiler is capable of supporting logical IF statements, eliminating the necessity for the Alpha Subroutine.

This program will evaluate, for a maximum of five hundred data points, the first- through sixth-degree equations; list the x, y, and z values and their corresponding z calculated and residual values; compute the error measurements; and plot the z calculated and residual values for each equation. The error measures consist of:

Total variation, $V=\sum_{i=1}^{n}(z_i - \bar{z})^2$ where i is the ith data point and $\bar{z}=\frac{1}{n} z_i$, and n= number of data points.

Variation not explained by the surface, $S=\sum_{i=1}^{n}(z_{i\,observed} - z_{i\,calculated})^2$

Variation explained by the surface, E=V-S

The coeffecient of determination, $T=\frac{E}{V}$

The coeffecient of correlation, $L= T^{\frac{1}{2}}$

Standard deviation, $D=\left(\frac{S}{N}\right)^{\frac{1}{2}}$.

The percentage of the total variation accounted for by a certain surface is equal to the coeffecient of determination multiplied by one hundred.

Modal data for the Tunk Lake pluton rocks are taken from Karner (1968), who used one hundred and thirty-two irregularly spaced data points and contoured the quartz, total mafics, perthite, albite-in-perthite, and oligoclase percentages (Fig. 1). This trend-surface analysis uses the same modal variates. The first- through sixth-degree surfaces were calculated and contoured for each, their corresponding residuals were plotted and their error measures were computed.

RESULTS

The lower degree residual plots accentuate the anomalous areas, but their corresponding contour surfaces are poor. Since the higher degree surfaces account for a larger percentage of total variation and reduce the residual values, resulting in a more "accurate" contoured surface, these areas don't show as distinctly or at all on the higher degree residual plots.

A point is reached in the calculation of higher degree equations where a large percentage of the total variation is already accounted for, and the calculation of higher degree equations results in a small increase in this percentage. But with the higher degree equations, the contour surfaces become more complex and harder to read and it is dubious whether or not the calculation of progressively higher degree surfaces, after a large percentage of total variation has been accounted for, is meaningful.

With the above in mind, the author included (1) the first-degree contour surface and residual plots and (2) the sixth-degree contour surface and residual plot or (3) the fourth-degree surface and residual plot and the sixth-degree surface, in hopes of showing the trend and anomalous areas clearly.

TOTAL MAFICS

The contoured first-degree surface reveals a total mafic trend oriented southwest-northeast and increasing in value towards the northwest (Fig. 2a). Its corresponding residual plot shows a strong positive area in the northwest and a less distinct positive area towards the east edge of the pluton (Fig. 2b). The second-through sixth-degree contour surfaces show an increasing complexity of the trend, with the sixth-degree surface (Fig. 2c), accounting for 49 percent of the total variation (Table 1). Each surface shows a northeast orientation of the trend with values increasing outward from the center of the pluton, and an area of high values in the northwest part of the pluton. The contour of the sixth-degree surface closley resembles Karner's (1968) contour of the total mafics percentage (Fig. 1), and its residual plot shows no distinct areas of positive or negative values.

QUARTZ

The contoured first-degree surface for quartz shows the same southwest-northeast orientation of the trend as total mafics, and also increases in value towards the northwest (Fig. 3a). The first degree residual plot shows two general positive areas, one in the center and one towards the southern part of the pluton (Fig. 3b).

As with total mafics, the second- through sixth-degree surfaces show an increasing complexity of the trend, with the progressively higher degree surfaces accounting for a progressively larger percentage of the total variation. The sixth degree surface accounts for 40 percent of the total variation (Table 1). The trend is oriented northwest; the values decrease outward and there is an area of low values in the northwest corner of the pluton (Fig. 3c). The sixth-degree residual plot shows no areas of positive or negative values (Fig. 3d).

OLIGOCLASE

The first-degree linear surface is limited geometricaly to an "average" which minimizes the sum of squares. Consequently, if there is a distinct trend, the residual plot of the first-degree surface will show distinct positive and negative areas. For oligoclase, the contoured first-degree surface is an "average" of the oligoclase values (Fig. 4c), and its residual plot shows marginal negative values and positive values in the center (Fig.

4b). The fourth-degree surface (Fig. 4c) shows the trend (oriented northeast with decreasing values towards the margins of the pluton and an area of low values in the northwest) more clearly than the sixth-degree surface (Fig. 4e). From Table 1, the coefficient of determination for the fourth-degree surface is .62 and for the sixth-degree surface is .71. Both account for a high percentage of the total variation, but the sixth-degree is more complex and bears a closer resemblance to Karner's (1968) contour map. The fourth-degree residual plot shows no distinct positive or negative areas (Fig. 4d).

PERTHITE

The contoured first-degree surface of the perthite values is also an average of sorts (Fig. 5a), and its residual plot also shows distinct positive and negative areas (Fig. 5b). The positive area lies towards the outside of the pluton and the negative values lie in the center. The second- through sixth-degree surfaces show a northeast trend with values increasing toward the margin of the pluton, and an area of high values in the northwest part of the pluton. Again, the higher degree surfaces become increasingly complex. The fourth-degree surface (Fig. 5c) shows the trend most clearly and accounts for 62 percent of the variability. The sixth-degree surface accounts for 67 percent of the variability, is more complex than the fourth, but bears a closer resemblance to Karner's(1968) contour of the perthite values (Fig. 5e). The fourth-degree residual plot shows no distinct areas of positive or negative values (Fig. 5d).

ALBITE-IN-PERTHITE

The albite-in-perthite contoured surfaces closely resemble those of the perthite. The first-degree contour surface (Fig. 6a), is an "average" of the albite-in-perthite values, and its residual plot show the same positive and negative areas as the perthite residual plot (Fig. 6b). The fourth-degree surface accounts for 70 percent of the total variation; the sixth-degree surface accounts for 75 percent. The second-through sixth-degree surfaces all show the northeast orientation of the trend, values increasing outward, and an area of high positive values in the northwest part of the pluton. Again, the fourth-degree contour surface (Fig. 6c) is clearer than the fifth or sixth, but the sixth more closely resembles Karner's (1968) map of albite-in-perthite. The higher degree residual plots show no distinct positive or negative areas. The fourth is included (Fig. 6d) for comparison with the first.

INTERPRETATION

All of the trends are orientated in a southwest-northeast direction and show an anomalous area in the northwest corner of the pluton. This is an area of high values for total mafics, perthite, and albite-in-perthite and of low values for quartz and oligoclase. The total mafics, perthite, and albite-in-perthite values increase from the center of the pluton outwards, and the quartz and oligoclase values decrease towards the margins.

All this agrees very well with Karner's study, and for fur- interpretation the author will refer you to his work. The most significant result of the study was the seemingly low coefficient of determination for quartz and total mafics compared to those of oligoclase, perthite, and albite-in-perthite. This is a reflection of the different processes involved in the formation of the pluton. There were likely several processes occuring during the cooling of the pluton which could affect the mineralogic trends. Those which affect the oligoclase, perthite, and albite-in-perthite trends (cooling temperatures and water vapor pressure) produced more distinct trends than those which affect quartz and total mafics trends (magma differentiation and movement).

DISCUSSION

The trend-surface analysis of any variate with respect to geographical coordinates will yield quick and accurate results from a minimum of data points and establishment of the trend of the variate will yield "target" areas for closer study. Establishment of the trend of some variate —lithologic, sedimentary, chemical, mineralogic, geochemical or geophysical — is important in interpreting the geologic history of some rock body. They also have economic significance in providing information which will further aid in exploration for ore bodies, oil and gas accumulation, and other natural resources.

ACKNOWLEDGMENTS

The author would like to express his thanks to Dr. Karner for suggesting this study, for help and advice given throughout the study, and for the use of his data, and would like to thank Dr. Ting for help given in running the computer program.

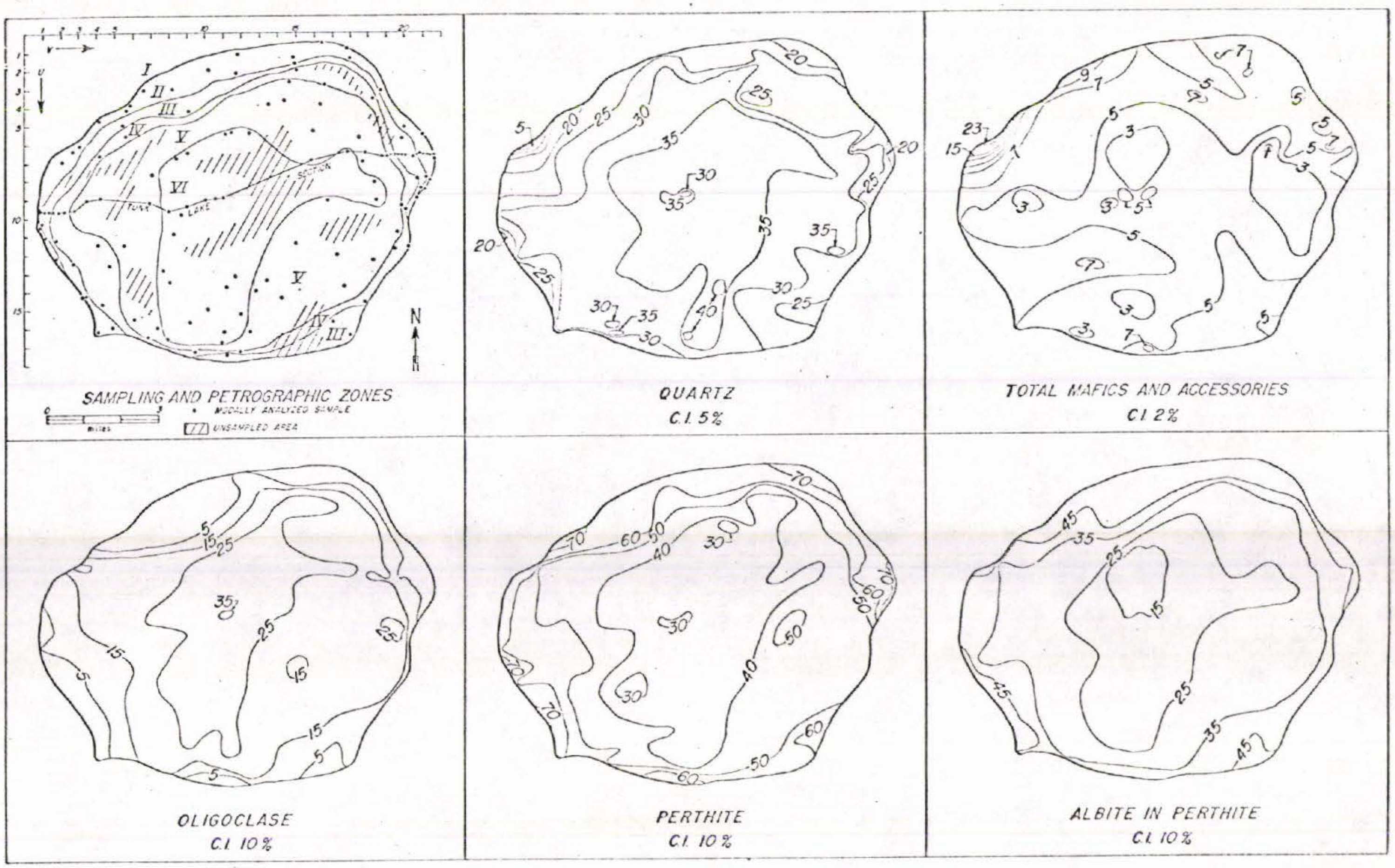


Figure 2. Modal variation in the Tunk Lake granite pluton. Mineral data are in volume percent (Karner 1968).

Table 1. Error measures for the first through sixth-degree surfaces for total mafics, quartz, oligoclase, perthite, and albite in perthite.

Total Mafics						
Surface	1	2	3	4	5	6
D	2.53	2.44	2.35	2.26	2.12	1.95
T	.141	.200	.259	.314	.399	.490
L	.375	.445	.509	.560	.632	.700
Quartz						
Surface	1	2	3	4	5	6
D	6.09	5.65	5.61	5.49	5.34	5.01
T	.122	.243	.252	.285	.325	.404
L	.347	.493	.503	.534	.570	.636
Oligoclase						
Surface	1	2	3	4	5	6
D	9.98	7.31	6.99	6.21	6.04	5.43
T	.006	.466	.512	.615	.635	.705
L	.077	.683	.716	.784	.797	.840
Perthite						
Surface	1	2	3	4	5	6
D	12.14	8.57	8.29	7.62	7.46	7.03
T	.027	.515	.547	.619	.633	.674
L	.169	.718	.740	.786	.796	.821
Albite in perthite						
Surface	1	2	3	4	5	6
D	9.57	6.24	5.88	5.33	5.12	4.84
T	.028	.586	.633	.698	.721	.751
L	.169	.766	.800	.836	.849	.867

```
K LAKE TREND-SURFACE ANALYSIS PROGRAMME

FOURED FIRST-DEGREE SURFACE

OTTING LIMITS
IMUM X =        22.799988    MINIMUM X =        0.800000
MAXIMUM Y =     17.599991    MINIMUM Y =        0.700000

X-SCALE IS HORIZONTAL
ALUE =    0.60 + 0.2115 X (SCALE VALUE)

CALE IS VERTICAL

NTOUR INTERVAL =                       1.00
FERENCE CONTOUR (.....) =              3.00
```

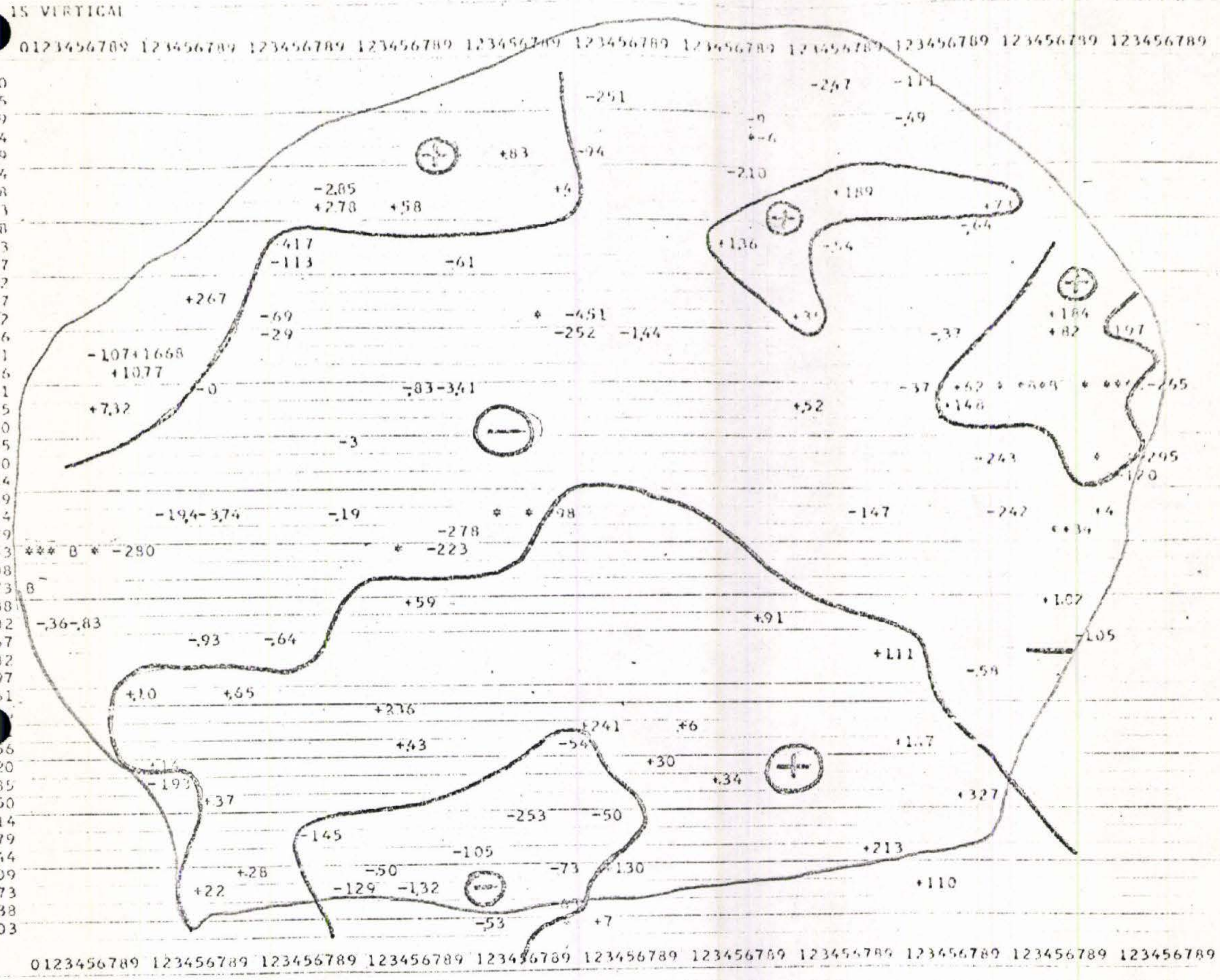
Figure 2a. Contour of first-degree surface for total mafics (see appendix, p. 54 for instructions on how to read the contours.)

...ING LIMITS
...MUM X = 22.799998 MINIMUM X = 0.800000
...MUM Y = 17.599991 MINIMUM Y = 0.700000

...TED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

...ALE IS HORIZONTAL
...UE = 0.80 + 0.2115 X (SCALE VALUE)

...ALE IS VERTICAL



...RPRINT VALUES

447
-218
19
231
-105
155
46
69
331
219
242
244
75
-180
-110
-200
213
94
118
-317
-139
-94
-20
12

B -163
-241
* 53
-106
B -183
21
* 360

Figure 2b. Plot of first-degree residuals (see appendix, p. 55-56, for instructions on how to read residual plots.)

NK LAKE TREND-SURFACE ANALYSIS PROGRAMME

CONTOURED SIXTH-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 1.00
REFERENCE CONTOUR (......) = 3.00

Figure 2c. Contour of sixth-degree surface for total mafics.

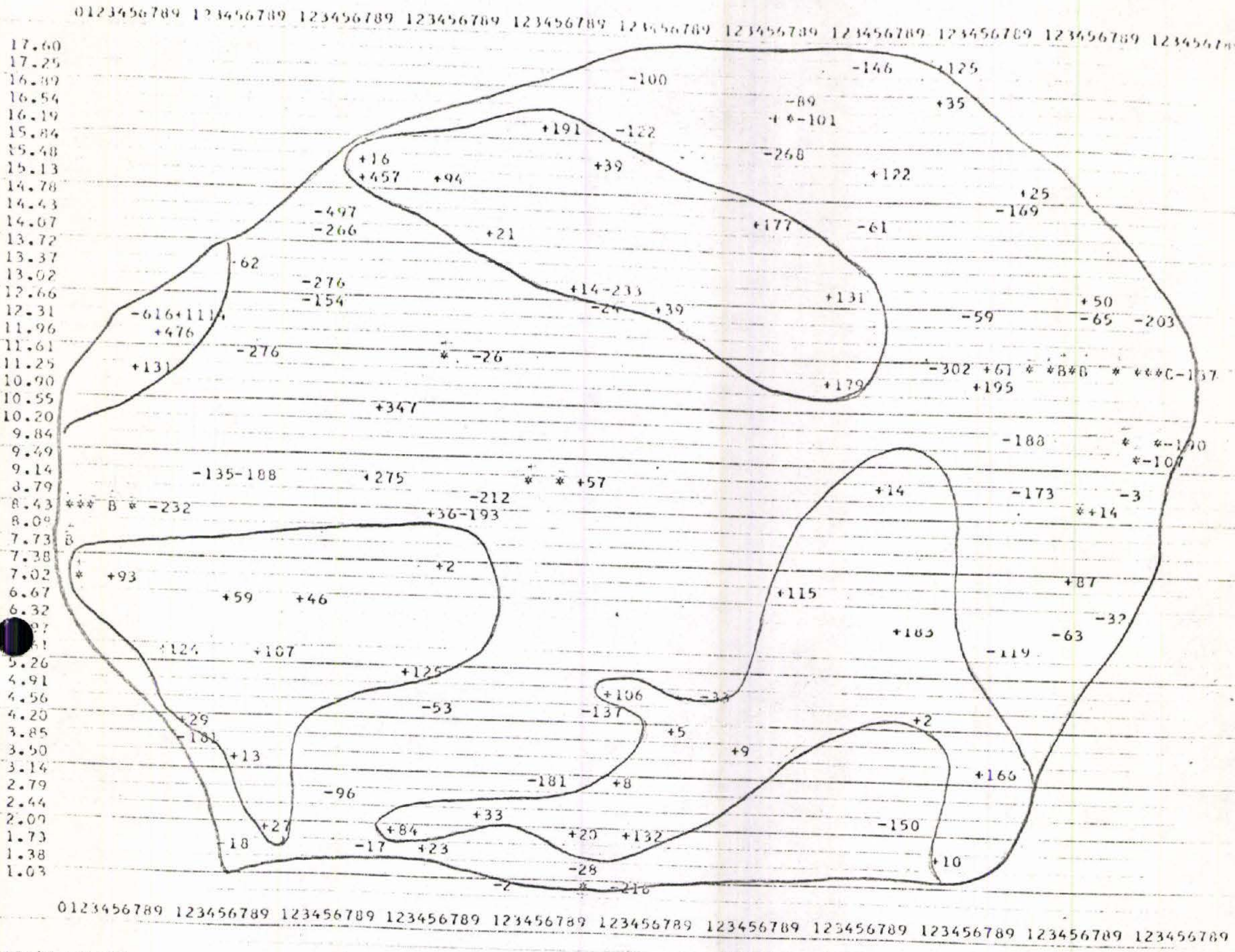
PLOT OF SIXTH DEGREE RESIDUALS

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL



OVERPRINT VALUES

351 B -200
-275
248 * 47
-43
140 B -23
-209 203
46
-68 * 179
-53
205 * 200
107
184
246
82
-82
-17
-102
…
89
133
-327
-158
-119
-43

Figure 2d. Plot of sixth-degree residuals for total mafics.

TONK LAKE TREND SURFACE ANALYSIS PROGRAMME

CONTOURED FIRST-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 5.00
REFERENCE CONTOUR (.....) = 20.00

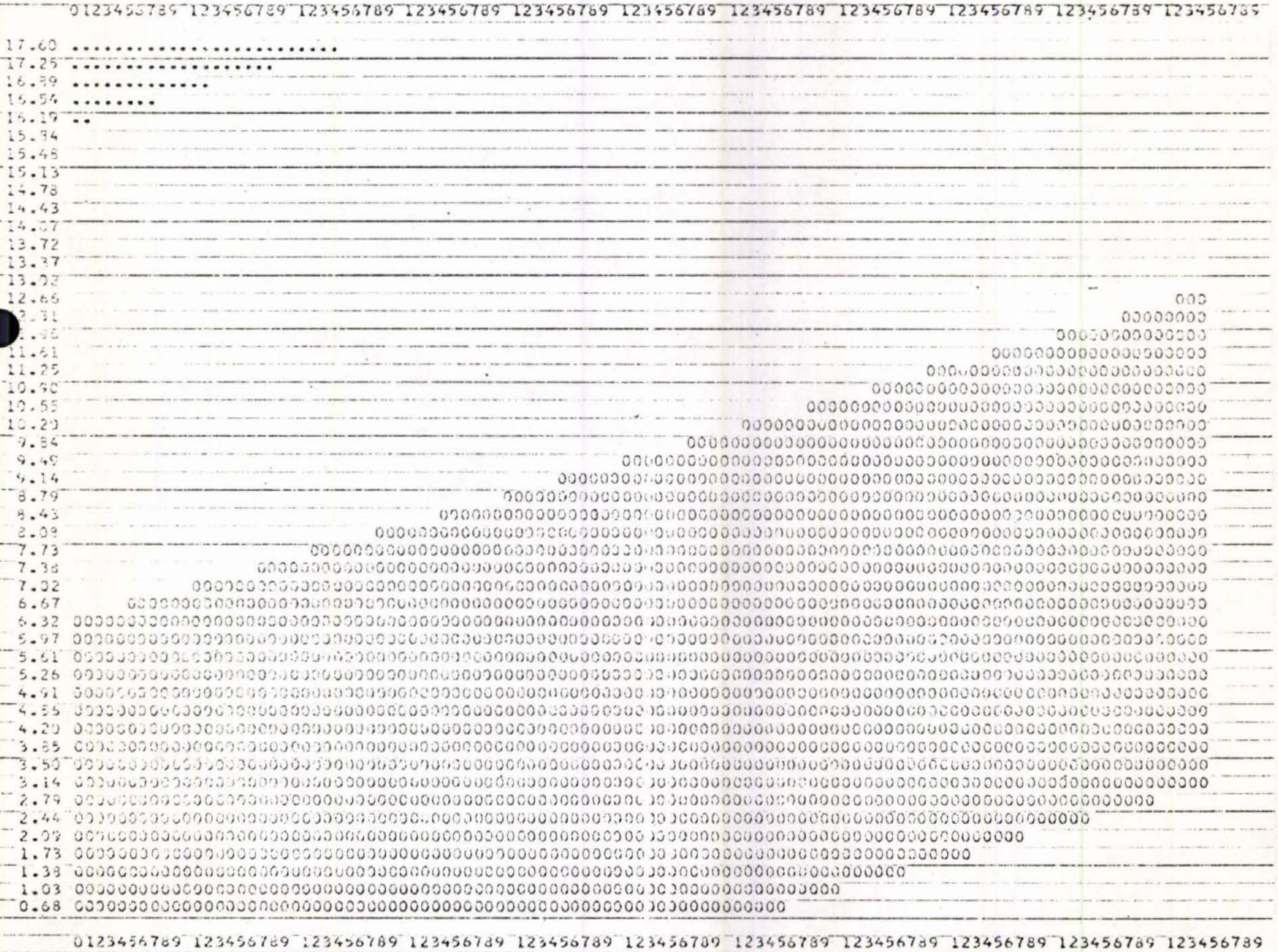


Figure 3a. Contour of first-degree surface for quartz.

TREND SURFACE ANALYSIS PROGRAMME

... OF FIRST-DEGREE RESIDUALS

PLOTTING LIMITS

MAXIMUM X = 22.799998 MINIMUM X = 0.800000

MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

X-SCALE IS HORIZONTAL

X-VALUE = 0.80 + 0.2115 x (SCALE VALUE)

Y-SCALE IS VERTICAL

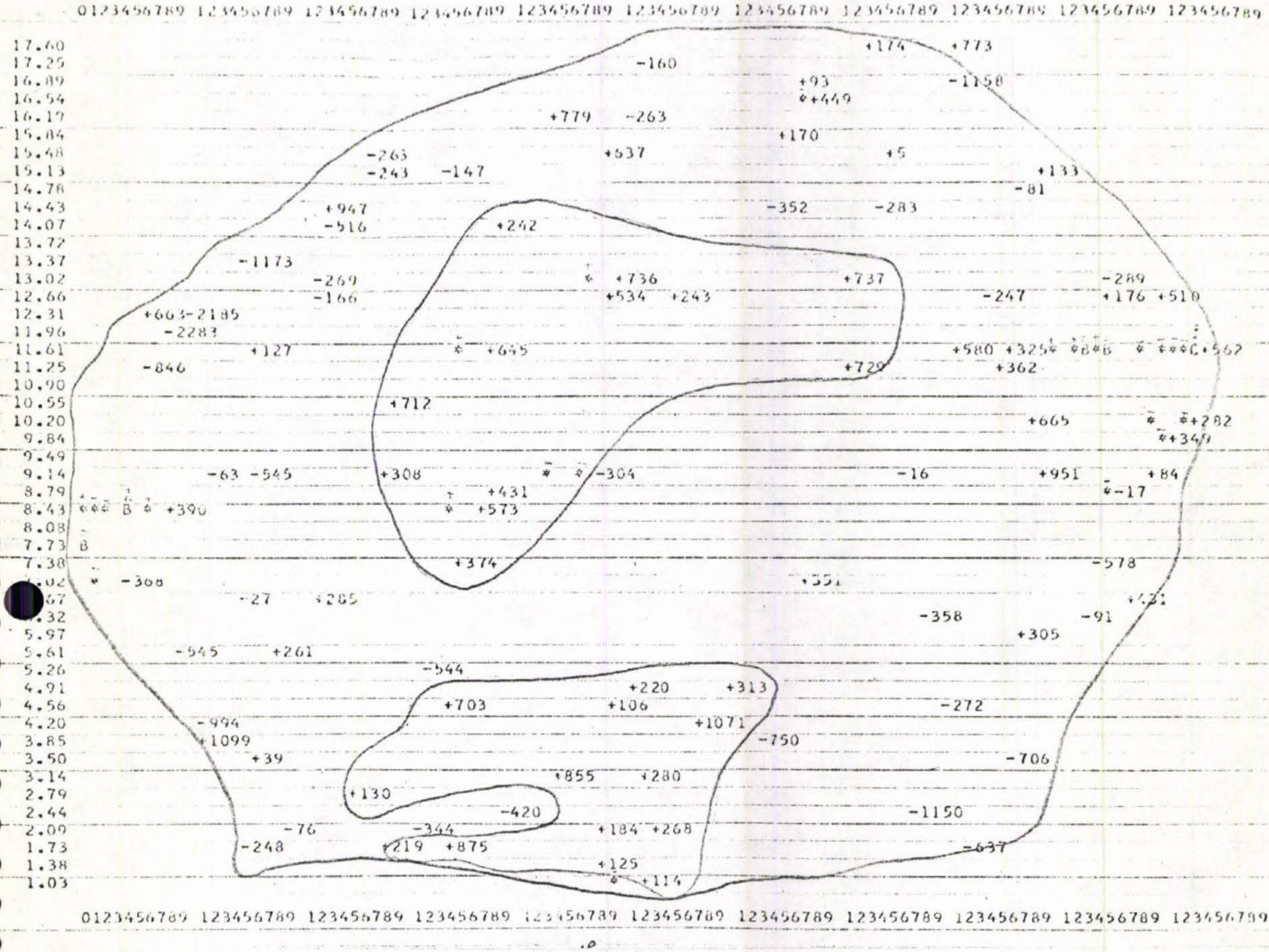


Figure 3b. Plot of first-degree residuals for quartz.

OVERPRINT VALUES

-547	* -869
645	* 232
429	* -105
184	* -58
105	B 715
-707	594
-948	* 98
149	* 1086
-763	B -101
-516	-33
-169	
-506	* -1023
-439	
-350	* -219
...	
424	
-195	
-193	
-772	
-974	
-204	
302	

TUNK LAKE TREND SURFACE ANALYSIS PROGRAMME

CONTOURED SIXTH-DEGREE SURFACE

PLOTTING LIMITS

MAXIMUM X = 22.799988 MINIMUM X = 0.800000

MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

X-SCALE IS HORIZONTAL

X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 5.00

REFERENCE CONTOUR (.....) = 20.00

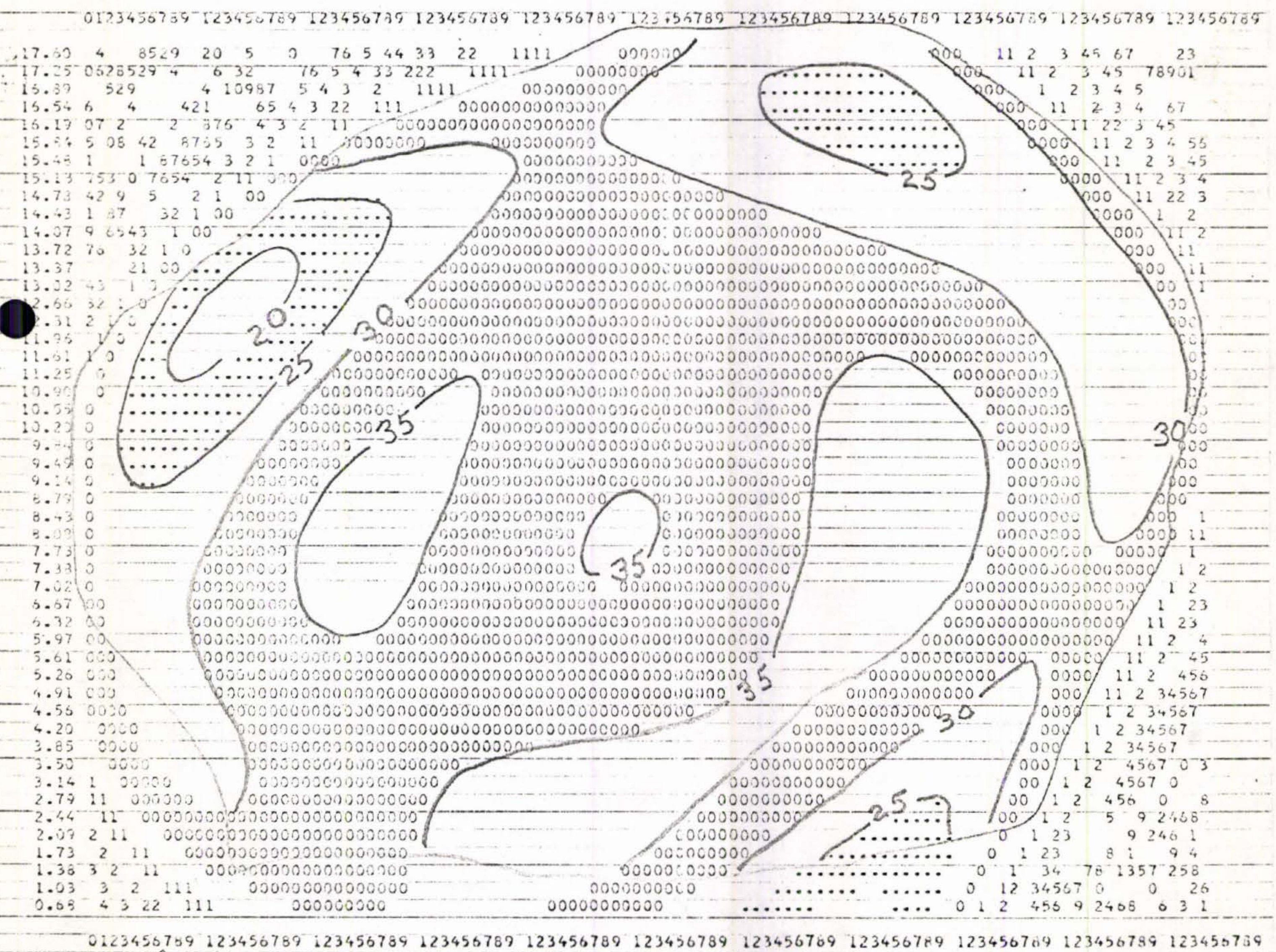


Figure 3c. Contour of sixth-degree surface for quartz.

ING LIMITS
MUM X = 22.799998 MINIMUM X = 0.800000
MUM Y = 17.599991 MINIMUM Y = 0.700000

TED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

ALE IS HORIZONTAL
LUE = 0.80 + 0.2115 X (SCALE VALUE)

ALE IS VERTICAL

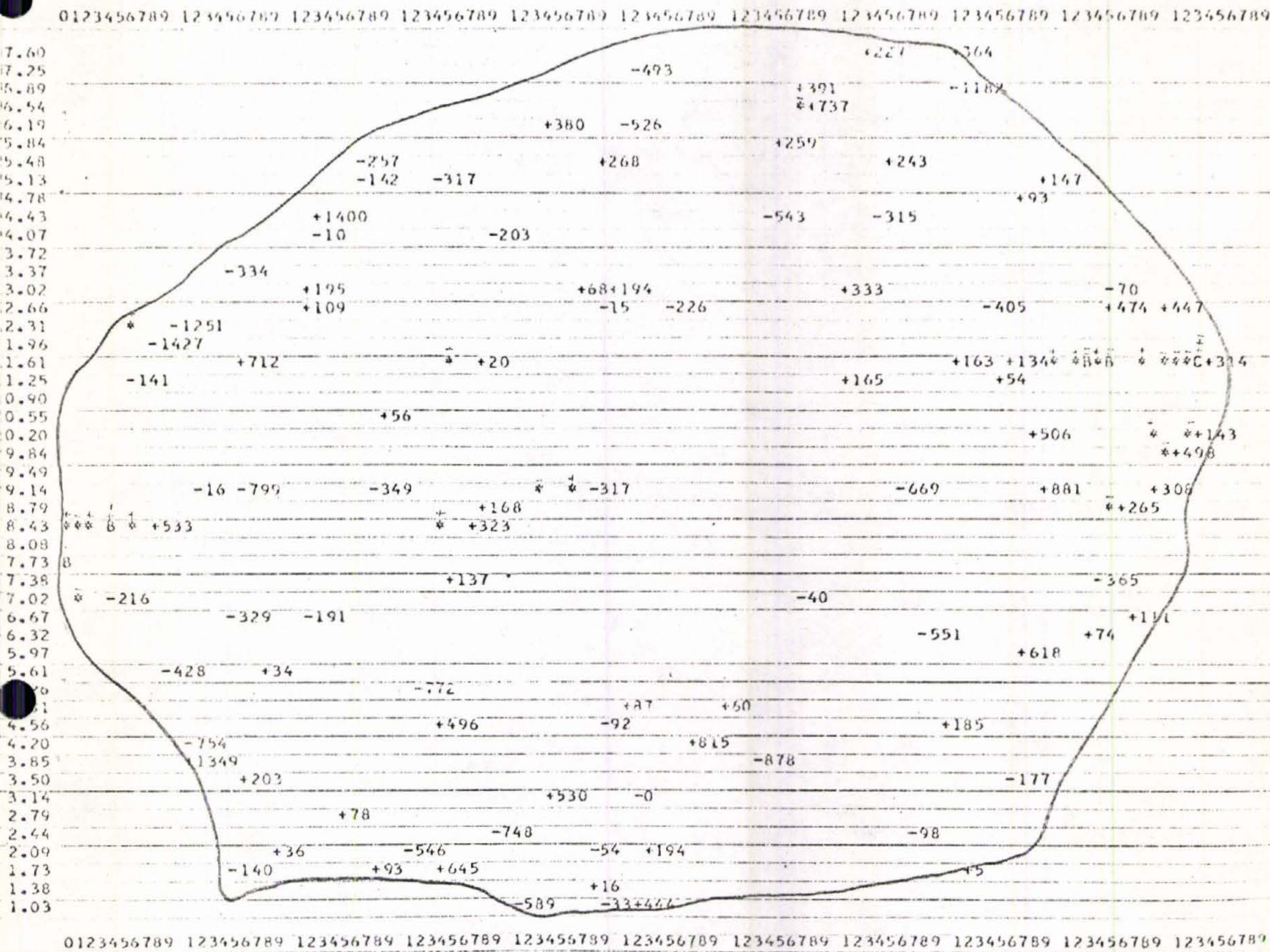


Figure 3d. Plot of sixth-degree surface for quartz.

RPRINT VALUES

-260 B 986
871
1057 * 351
* 639
-210
268 B -235
287 -104
-470
-686 * -969
435
-436
-158
206
-272
-357
1082
131
1241
-378

-756

-319
241

-583

194
-16

```
TUNK LAKE TREND-SURFACE ANALYSIS PROGRAMME

CONTOURED FIRST-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X =        22.799988      MINIMUM X =        0.800000
MAXIMUM Y =        17.599991      MINIMUM Y =        0.700000

X-SCALE IS HORIZONTAL
X-VALUE =     0.80 +  0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL =                          5.00
REFERENCE CONTOUR (.....) =                20.00
```

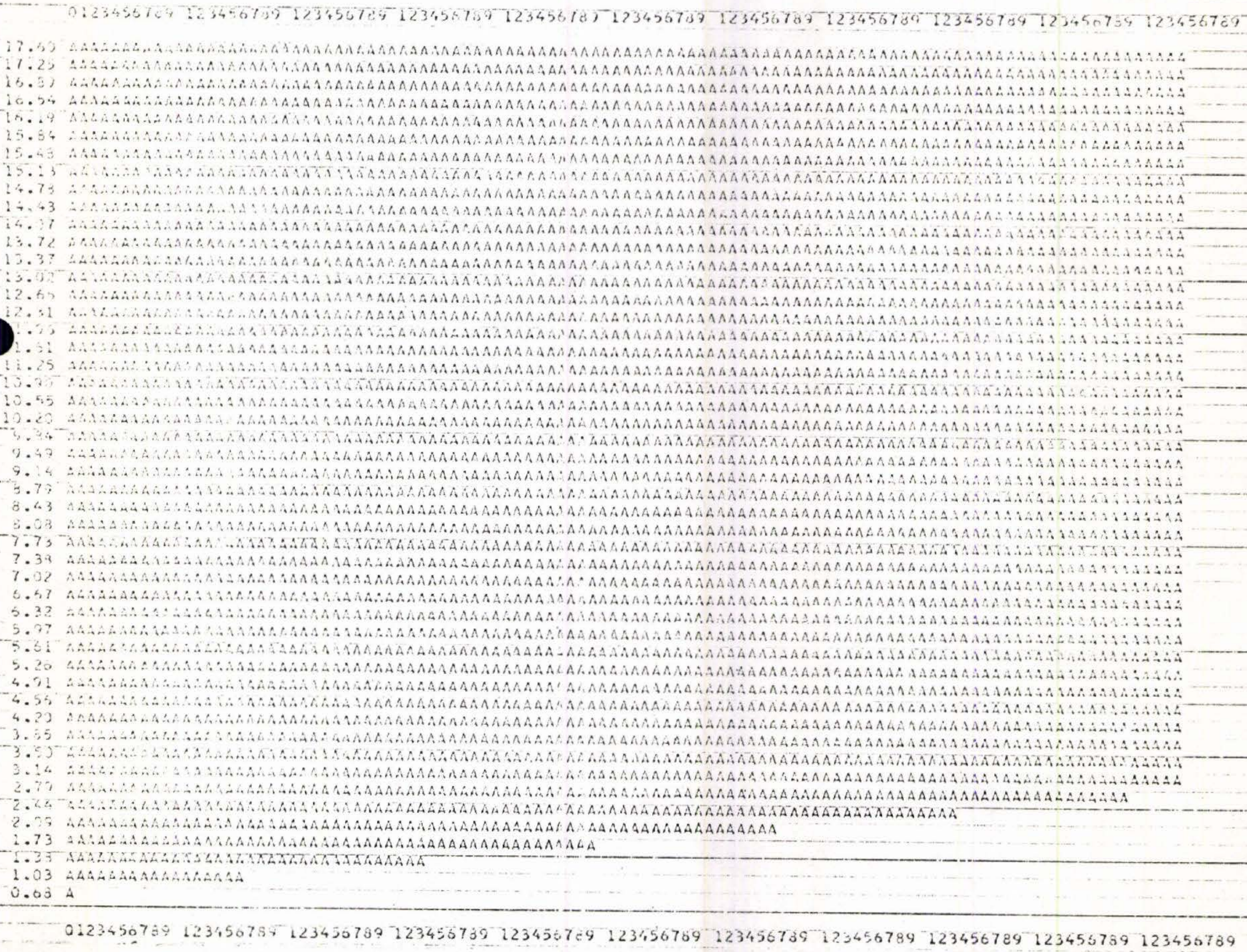


Figure 4a. Contour of first-degree surface for oligoclase.

T OF FIRST-DEGREE RESIDUALS

TTING LIMITS
XIMUM X = 22.699988 MINIMUM X = 0.800000
XIMUM Y = 17.599991 MINIMUM Y = 0.700000

OTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2. POWER

SCALE IS HORIZONTAL
UE = 0.80 + 0.2115 X (SCALE VALUE)

SCALE IS VERTICAL

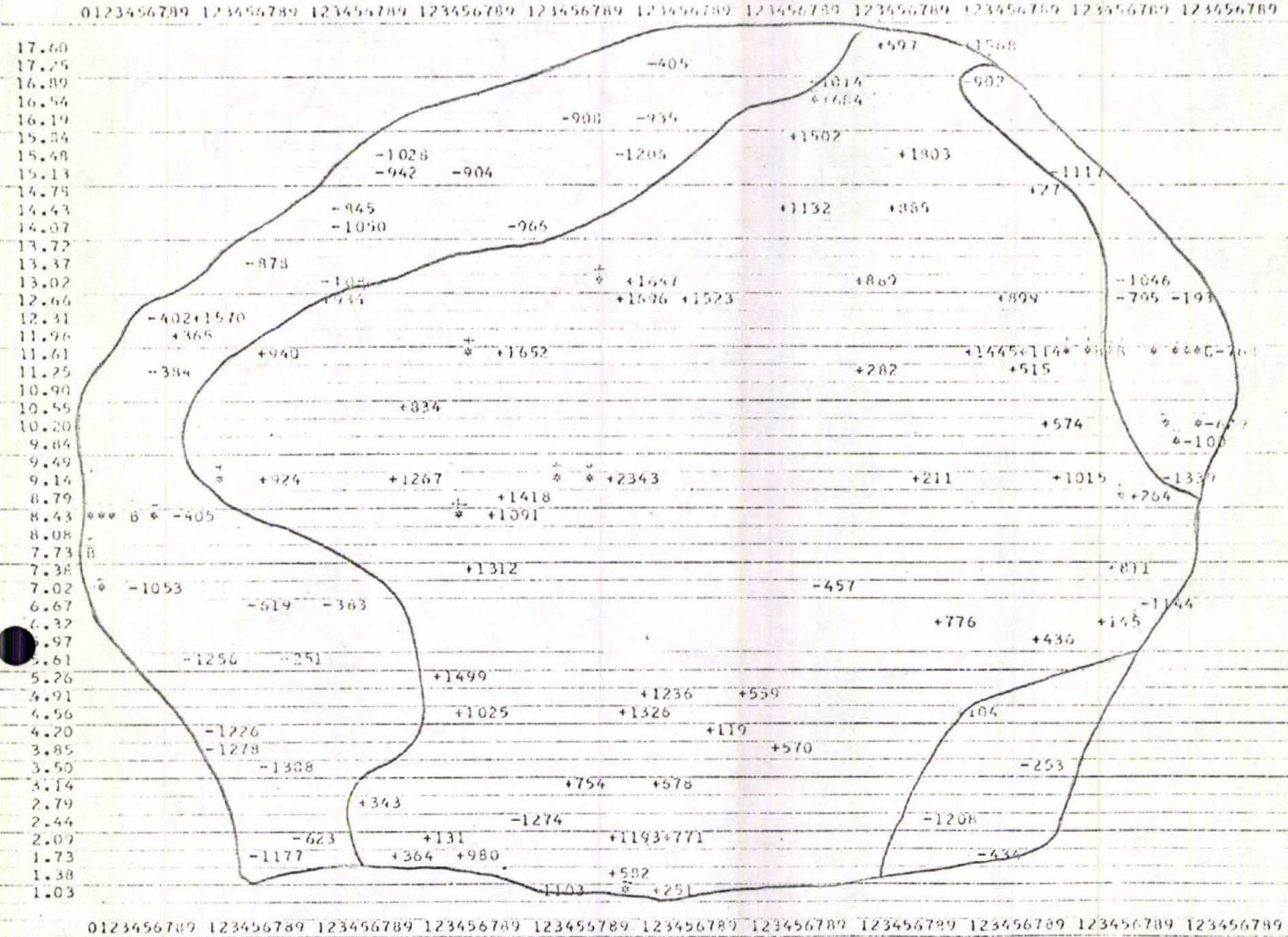


Figure 4b. Plot of first-degree residuals for oligoclase.

OVERPRINT VALUES

* -851
* 1518
* 1027
* 376
* 718
B -152
97
* -872
B -772
-1063
* -895
* -1163
* -1053
* -1153
C -594
1094
1014
* -457
* -1089
* -1107
* 1095
* 1903
* 1444
* 1206

* 1206
* -1230
* -1252
* -1273
B - 674
- 434
* - 494
* 586
B - 123
-1147
* -1256
* -1328

TUNK LAKE TREND-SURFACE ANALYSIS PROGRAMME

CONTOURED FOURTH DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 22.793988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 5.00
REFERENCE CONTOUR (.....) = 20.00

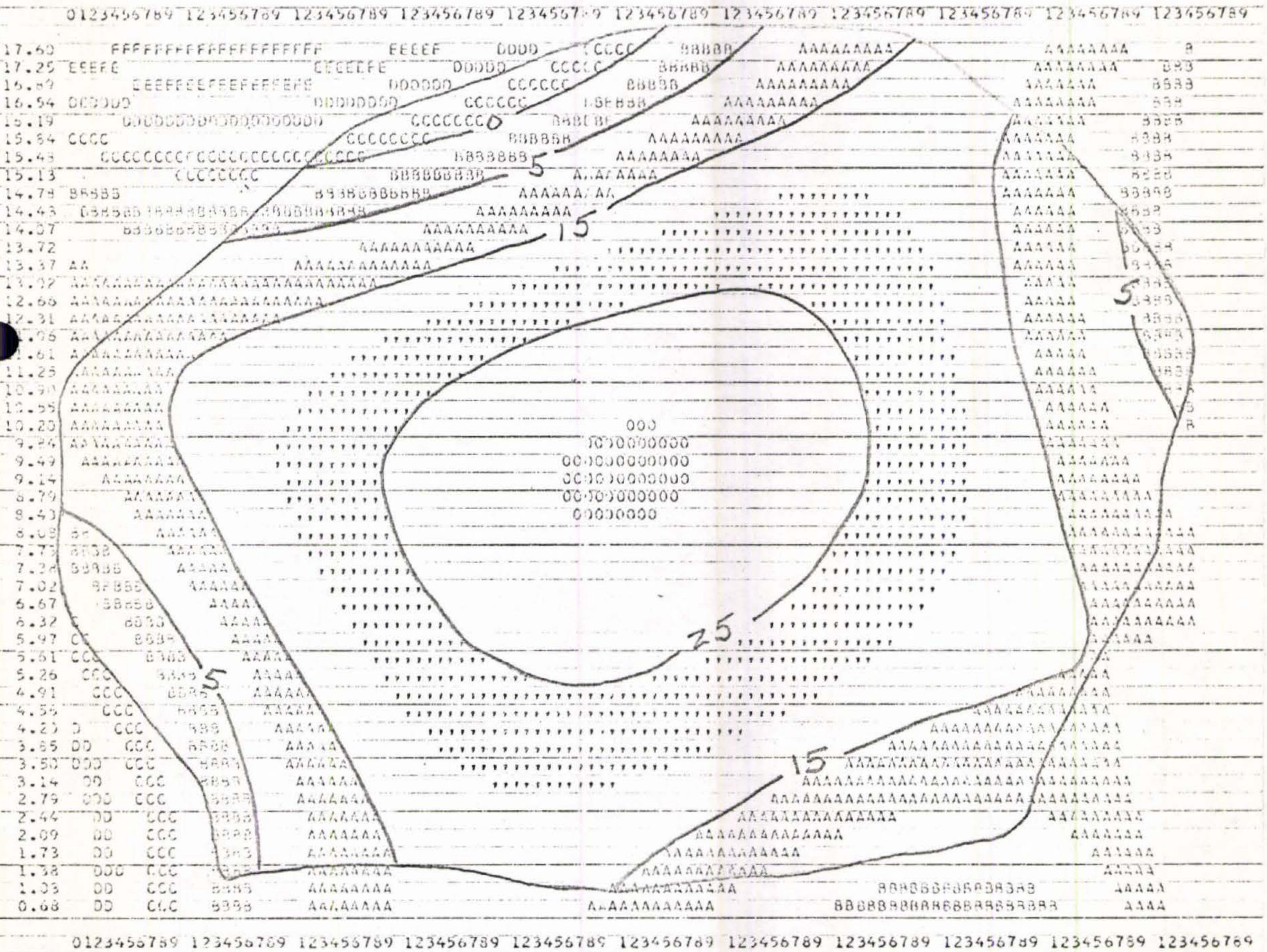


Figure 4c. Contour of fourth-degree surface for oligoclase.

LONG LAKE TREND-SURFACE ANALYSIS PROGRAMME

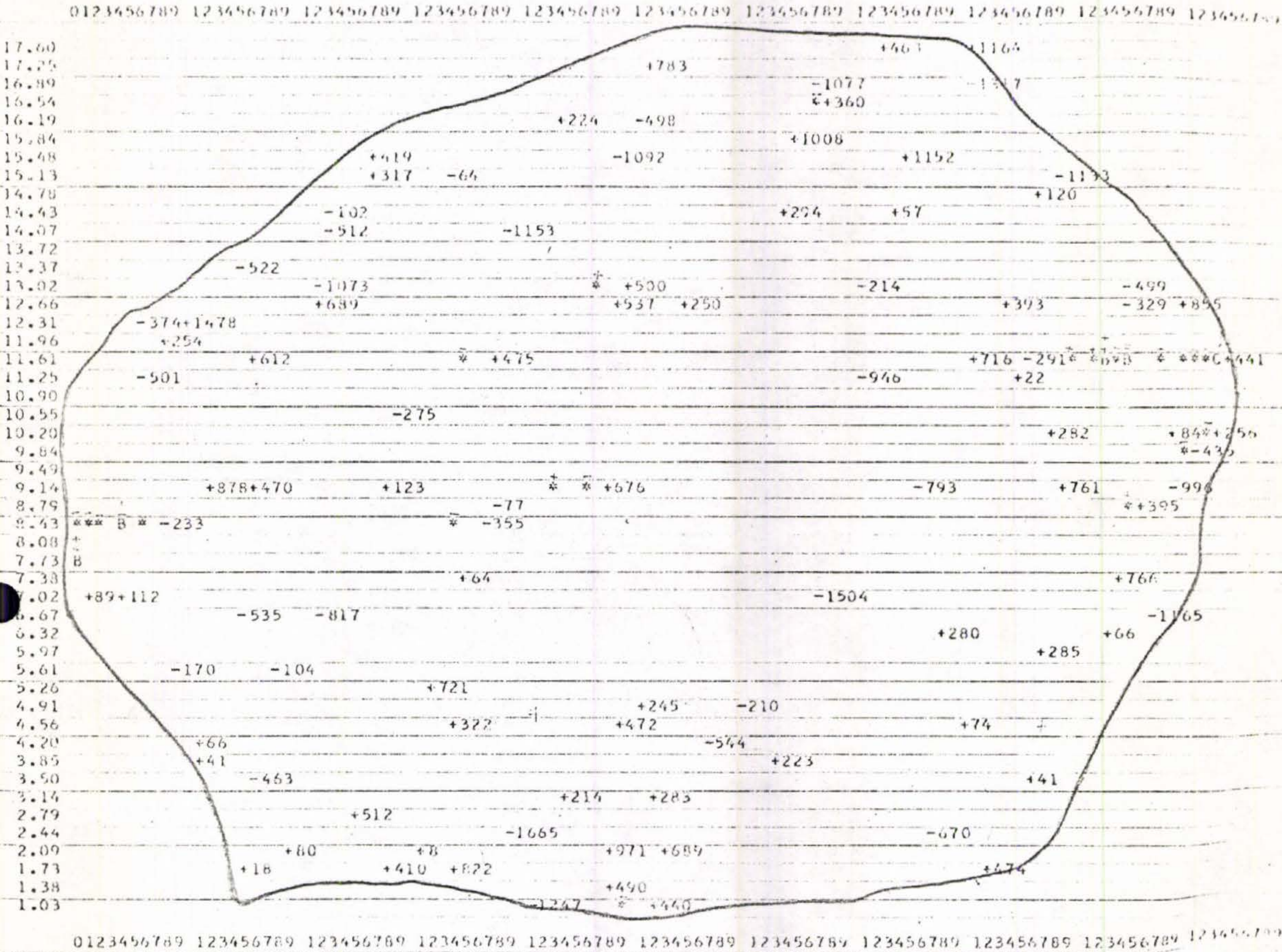
PLOT OF FOURTH-DEGREE RESIDUALS

PLOTTING LIMITS
MAXIMUM X = 22.799988   MINIMUM X = 0.800000
MAXIMUM Y = 17.599991   MINIMUM Y = 0.700000

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL



OVERPRINT VALUES

* -1067	*-203
* 444	*1295
* -134	*-428
* 280	*-480
* 798	*-577
11	B-129
303	72
* -623	*-138
-437	*-750
-639	
* 258	B1063
* -260	96
* -52	
103	*-1245
606	
106	
186	
* 317	
* 566	
* 287	

Figure 4d. Plot of fourth-degree surface for oligoclase.

TUNK LAKE TREND-SURFACE ANALYSIS PROGRAMME

CONTOURED SIXTH-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 5.00
REFERENCE CONTOUR (.....) = 20.00

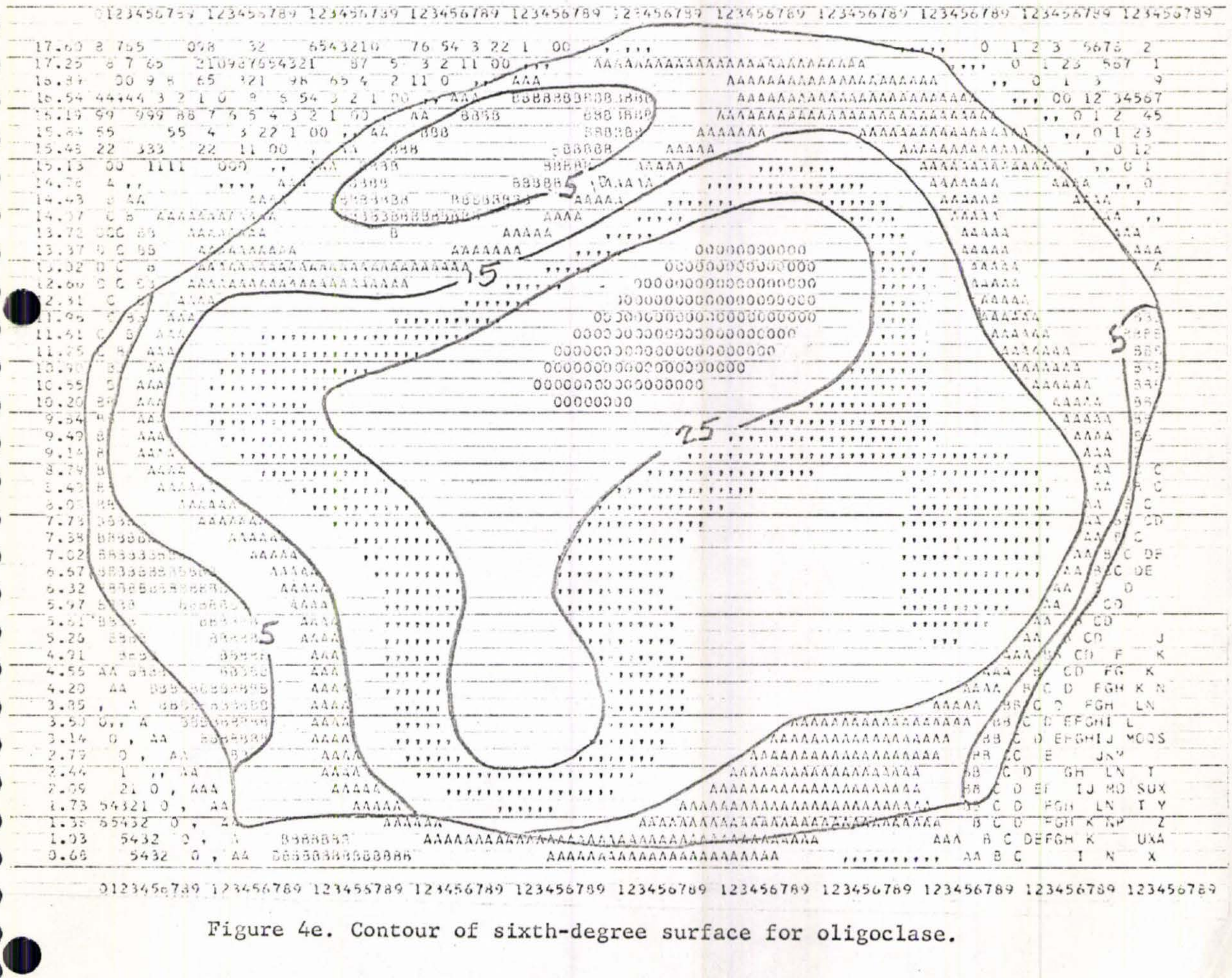


Figure 4e. Contour of sixth-degree surface for oligoclase.

```
TURK LAKE TREND SURFACE ANALYSIS PROGRAMME

CONTOURED FIRST-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X =        22.797988      MINIMUM X =        0.800000
MAXIMUM Y =        17.599991      MINIMUM Y =        0.700000

X-SCALE IS HORIZONTAL
X-VALUE =     0.80 +  0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL =                          5.00
REFERENCE CONTOUR (......) =               20.00
```

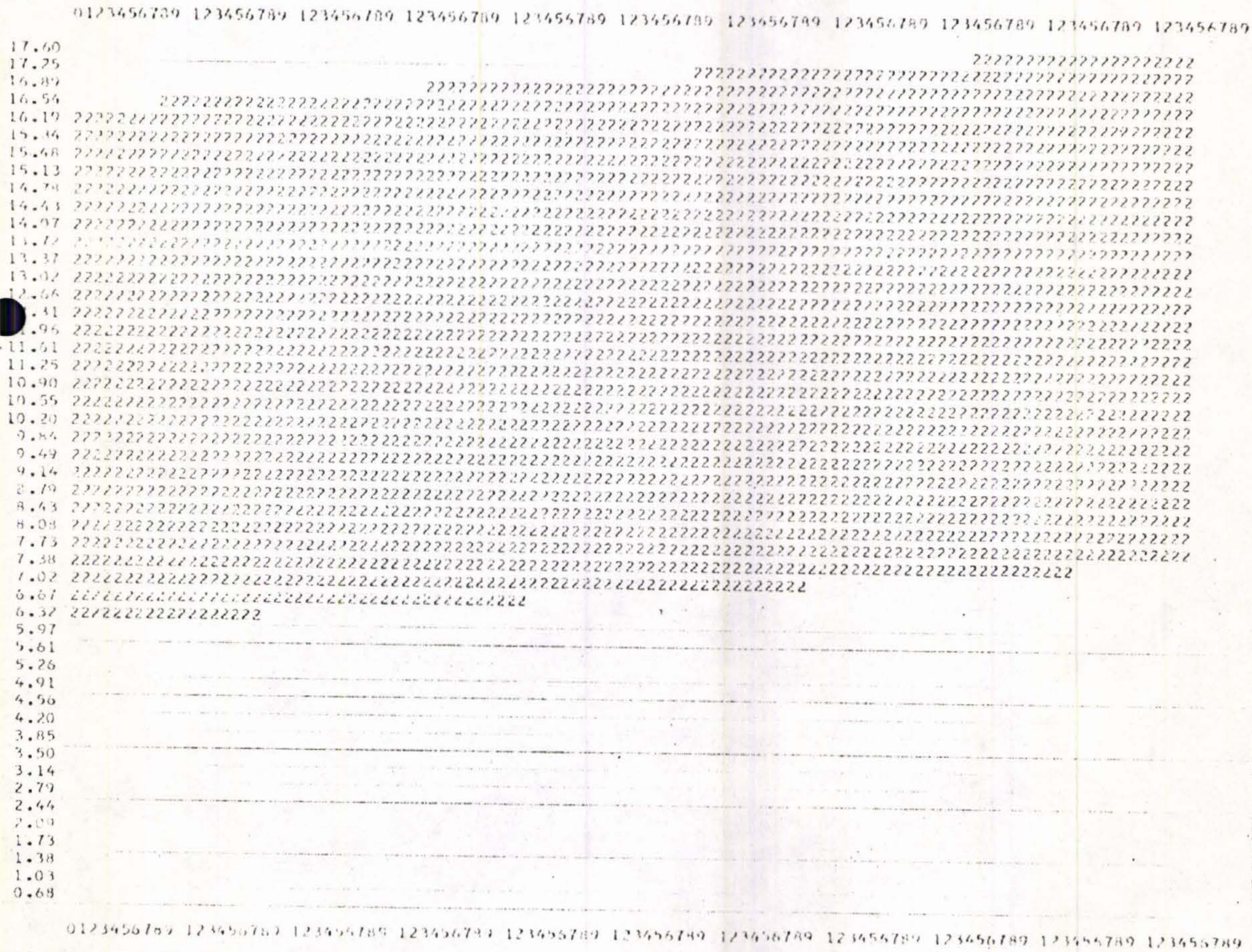


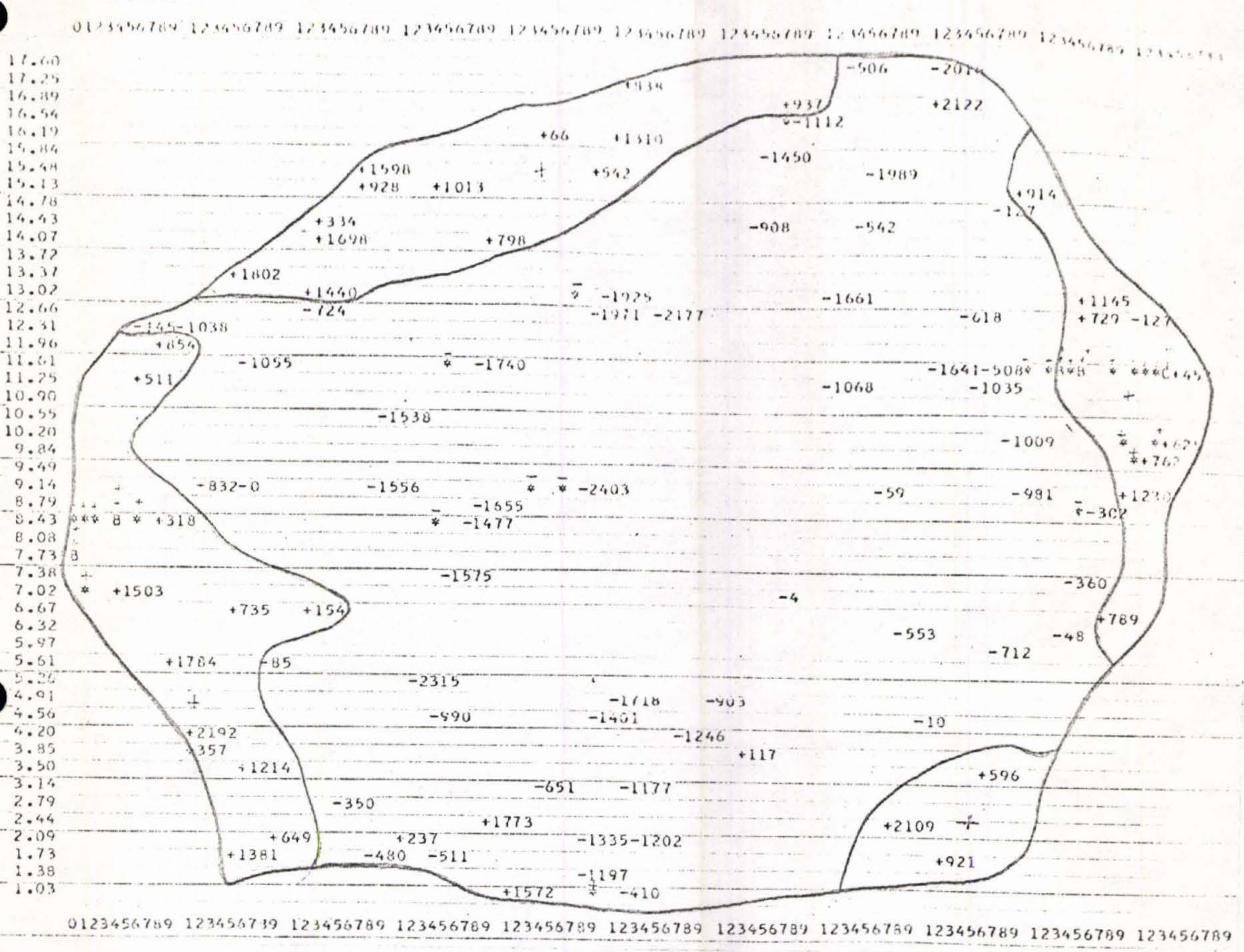
Figure 5a. Contour of first-degree surface for perthite.

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800001
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700001

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL



OVERPRINT VALUES

*	1167	B	125
			85
*	-1937		347
			-999
*	-1957		
*	-541	B	411
*	-1064		1161
B	955		
	686	*	2316
*	666		
B	1456	*	1152
	1237		
*	634		
*	1425		
*	1266		
*	2216		
C	447		
	-232		
	1387		
	422		
	584		
*	1767		
*	-2311		
*	-1804		
*	-217		
*	1098		
*	1383		
*	1124		

Figure 5b. Plot of first-degree residual for perthite.

```
PINK LAKE TREND-SURFACE ANALYSIS PROGRAMME
CONTOURED FOURTH DEGREE SURFACE
PLOTTING LIMITS
MAXIMUM X =        22.799998        MINIMUM X =        0.800000
MAXIMUM Y =        17.599991        MINIMUM Y =        0.700000
X-SCALE IS HORIZONTAL
X-VALUE =    0.[illegible] +  0.2115 X (SCALE VALUE)
Y-SCALE IS VERTICAL
CONTOUR INTERVAL =                       5.00
REFERENCE CONTOUR (.....) =             20.00
```

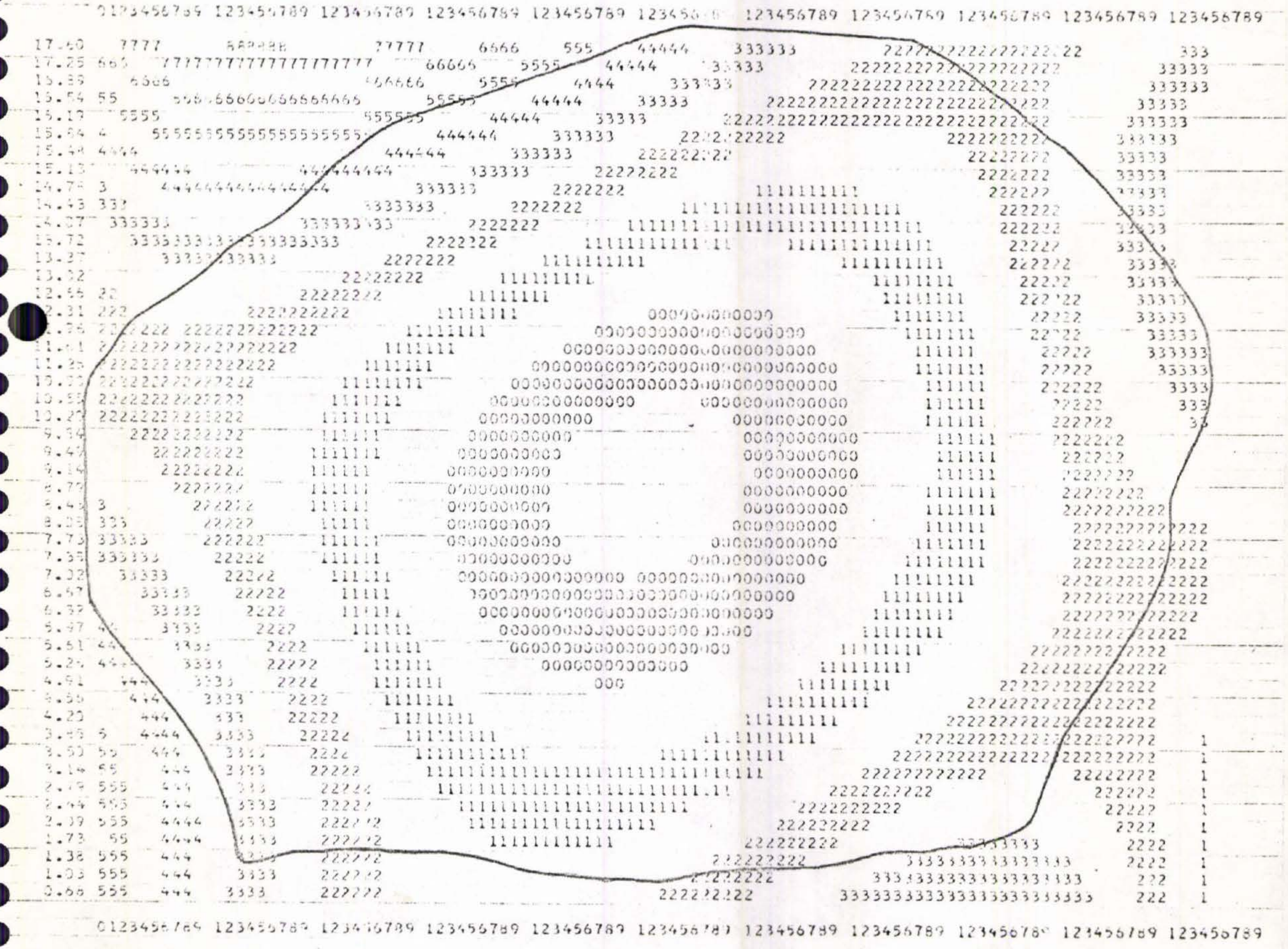


Figure 5c. Contour of fourth-degree surface for perthite.

TREND SURFACE ANALYSIS PROGRAM

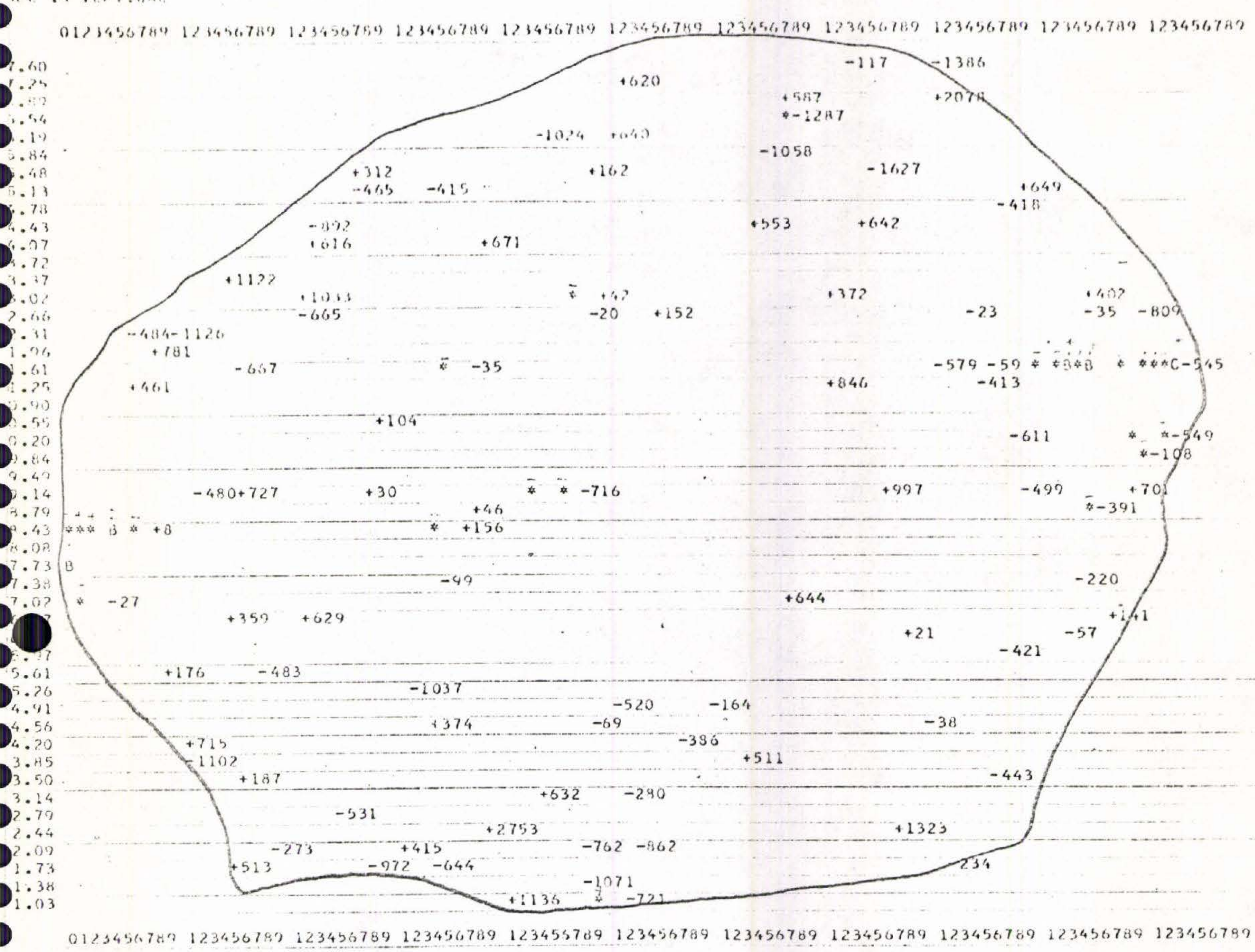
OF SIXTH-DEGREE RESIDUALS

ING LIMITS
UM X = 22.799988 MINIMUM X = 0.800000
UM Y = 17.599991 MINIMUM Y = 0.700000

ED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

S HORIZONTAL
0.80 + 0.2115 X (SCALE VALUE)

LE IS VERTICAL



PRINT VALUES

890	*	198 *
		470 *
183	*	452 *
		-627 B
269	*	-630
-654	*	-203 *
373	*	645 *
538	B	-764 B
215		-97
142	*	
834	B	845 *
525		
-52	*	777 *
430	*	
264	*	
213	*	
	C	
433		
-335	*	
541		
	*	
1152	*	
-574	*	
-76	*	
	*	
-07	*	

Figure 5d. Plot of fourth-degree residuals for perthite.

TUNK LAKE TREND-SURFACE ANALYSIS PROGRAMME

CONTOURED SIXTH-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 5.00
REFERENCE CONTOUR (......) = 20.00

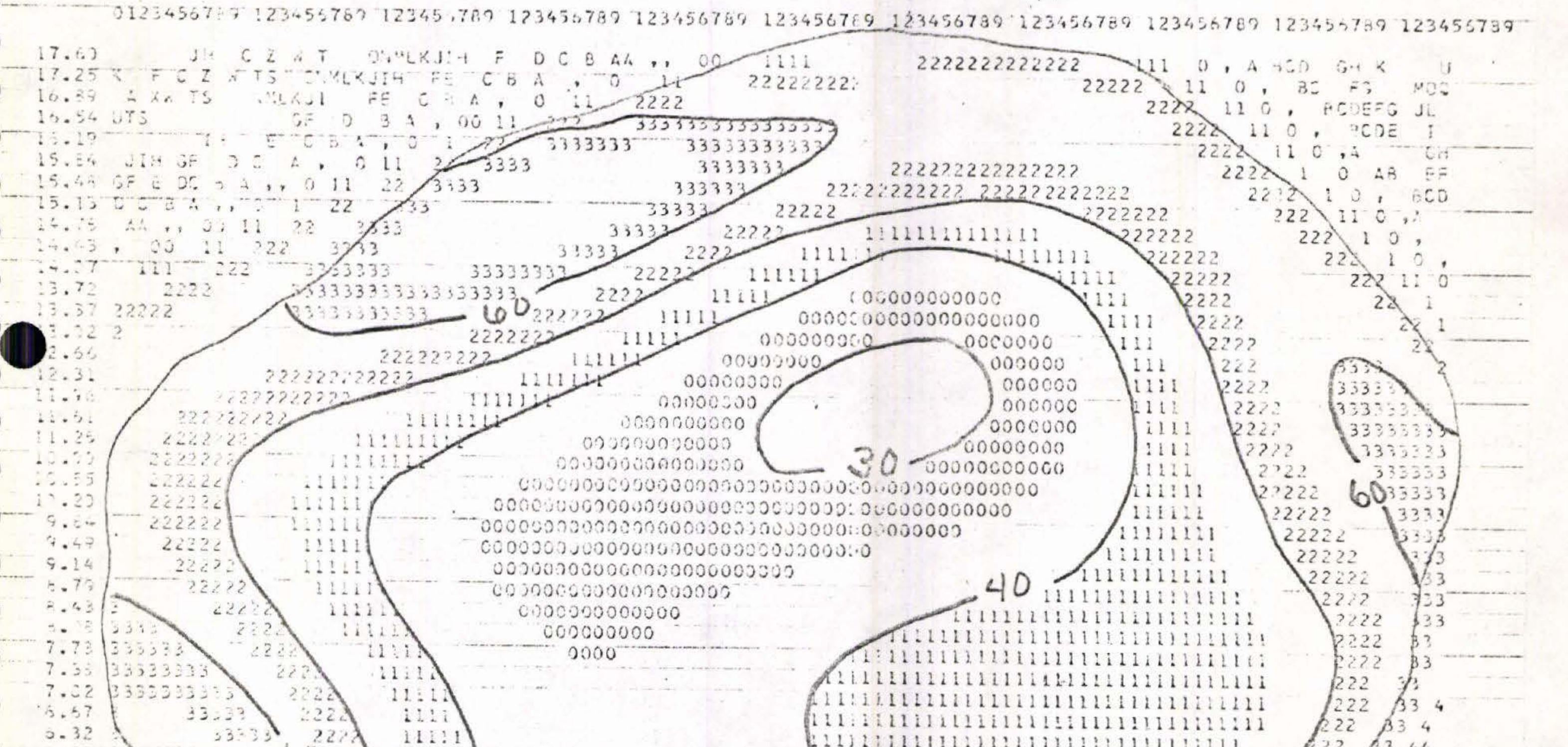


Figure 5e. Contour of sixth-degree surface for perthite.

```
TUNK LAKE TREND-SURFACE ANALYSIS PROGRAMME

CONTOURED FIRST-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X =      22.799988      MINIMUM X =      0.800000
MAXIMUM Y =      17.599991      MINIMUM Y =      0.700000

X-SCALE IS HORIZONTAL
X-VALUE =    0.80 +  0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL =                  5.00
REFERENCE CONTOUR (......) =       20.00
```

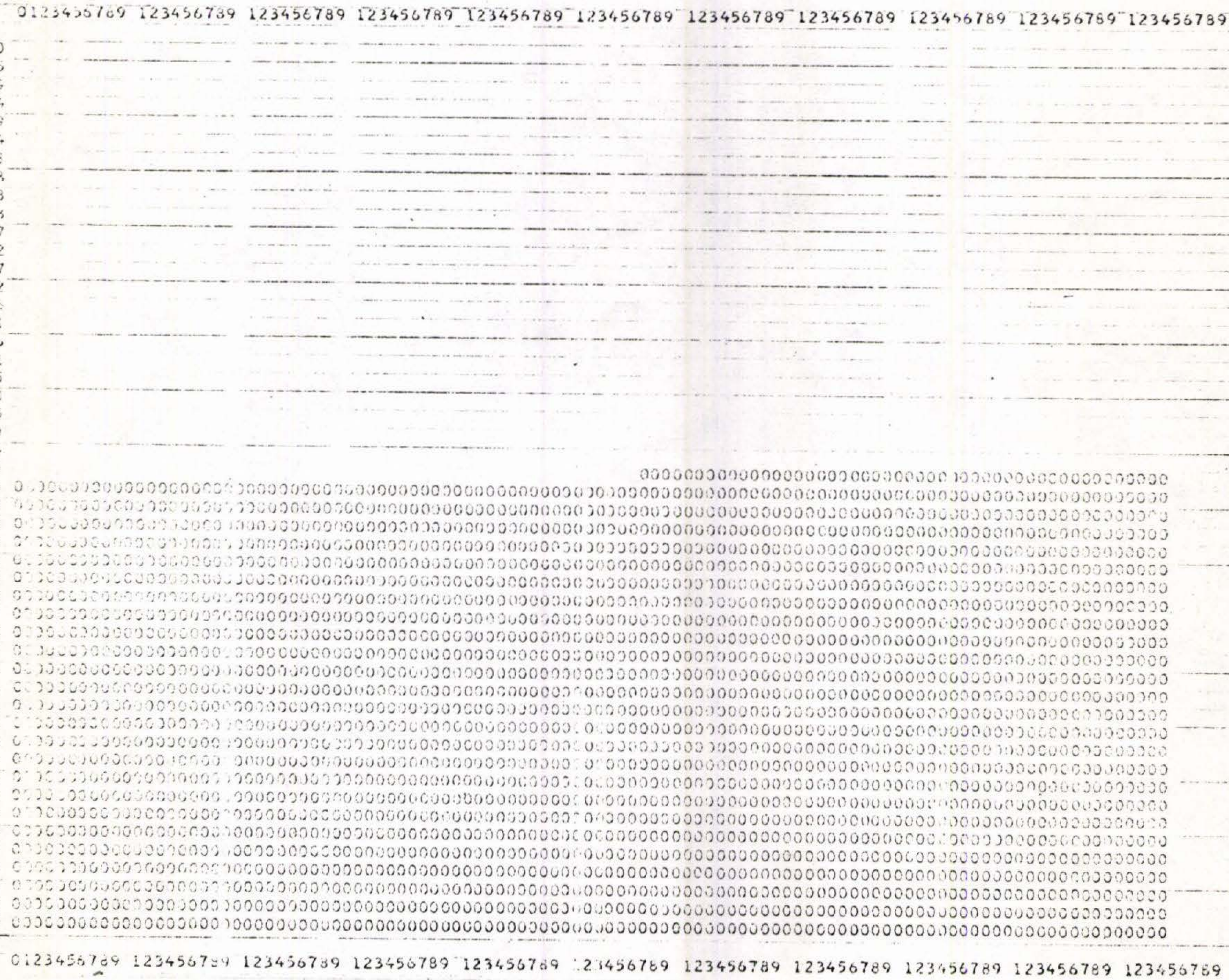


Figure 6a. Contour surface for the first-degree albite-in-perthite.

[illegible] TREND-SURFACE ANALYSIS PROGRAMME

PLOT OF FIRST-DEGREE RESIDUALS

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

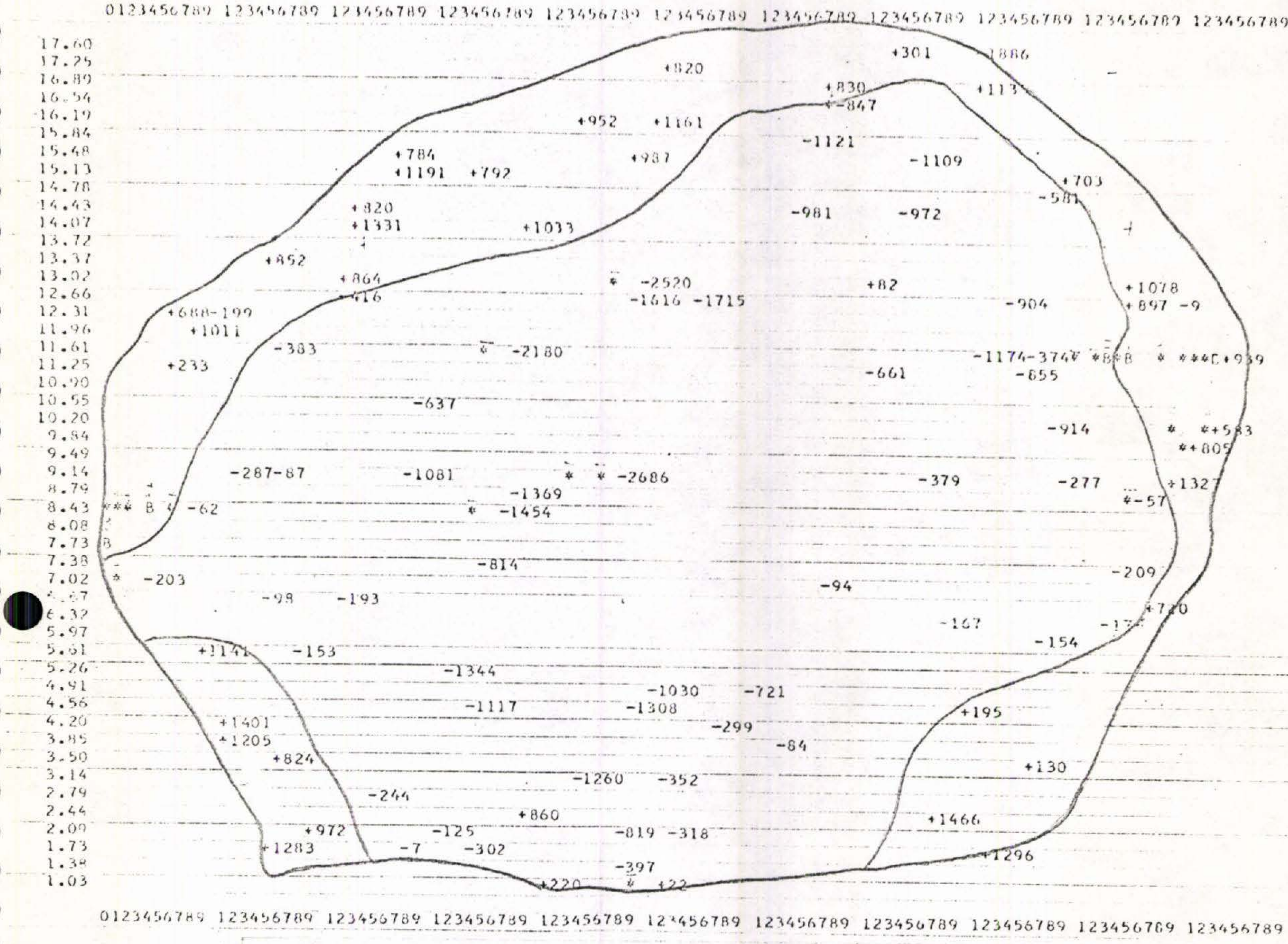


Figure 6b. Plot of first-degree residuals, albite-in perthite.

OVERPRINT VALUES

* 744	* 932
* -2220	* 836
* -1070	* 836
* -62	B 36
* -365	337
B -765	237
-65	* 1462
* 734	B 658
B 534	1166
1234	* 1184
* 938	* 1025
* 1131	
* 431	
* 531	
931	
531	
431	
* 783	
* 1083	
* 1002	
* -2683	
* -1686	

TUNK LAKE TREND-SURFACE ANALYSIS PROGRAMME

CONTOURED FOURTH DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 5.00
REFERENCE CONTOUR (.....) = 20.00

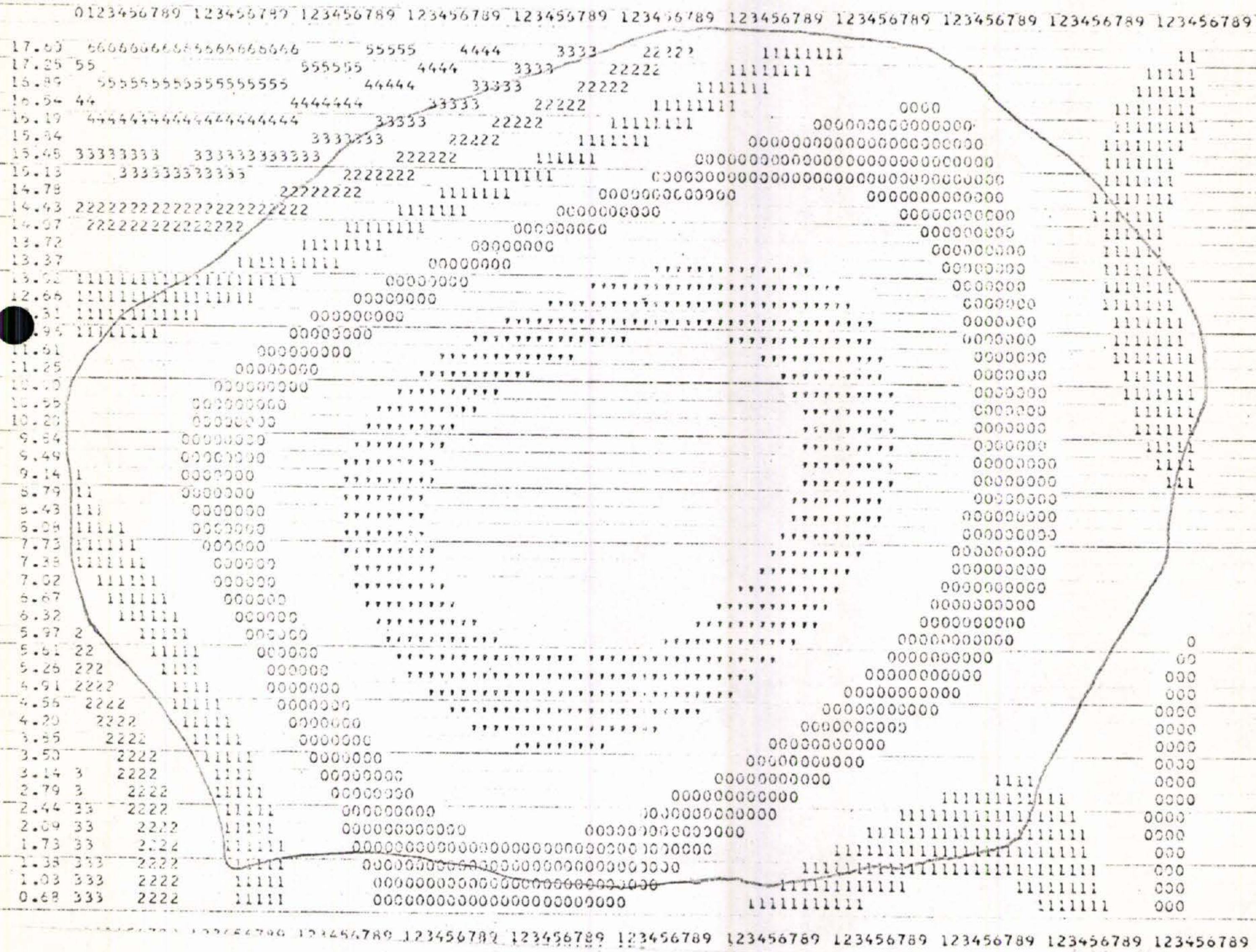


Figure 6c. Contour of fourth-degree surface for albite-in-perthite.

TREND-SURFACE ANALYSES PROGRAMME

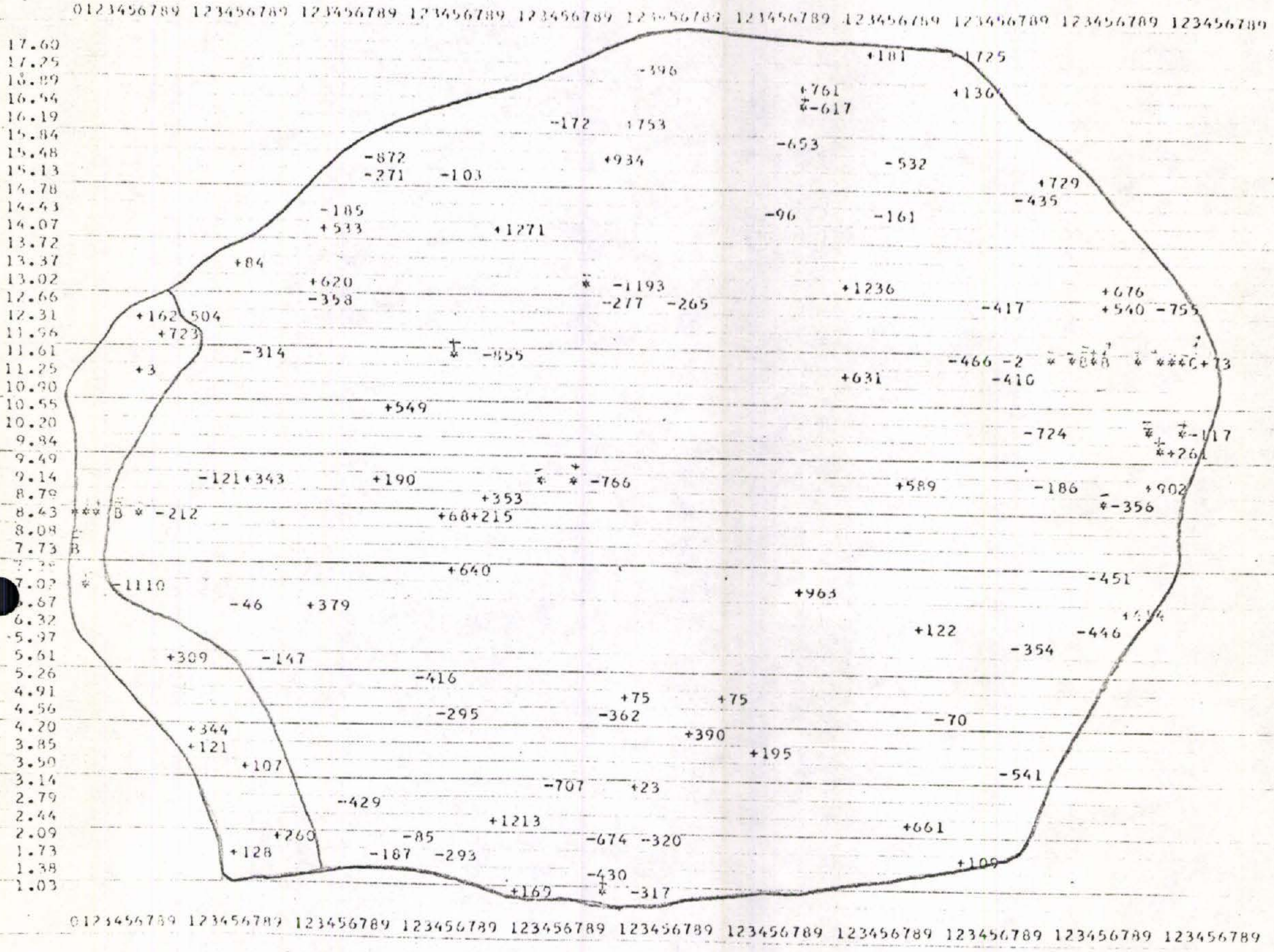
PLOT OF FOURTH-DEGREE RESIDUALS

PLOTTING LIMITS
MAXIMUM X = 22.797980 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 2 POWER

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL



OVERPRINT VALUES

* 859	* 320
* -974	* 246
	* 175
* 217	* 233
* -39	B -495
* -450	113
B -921	-83
-255	
* 509	B -281
B 240	187
872	
* 316	* 136
* 442	
* -316	* 775
744	
71	
-426	
-428	
* -223	
* 439	
* 467	
* -218	
214	

Figure 6d. Plot of fourth-degree residuals for albite-in-perthite.

TUNK LAKE TREND-SURFACE ANALYSIS PROGRAMME

CONTOURED SIXTH-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 22.799988 MINIMUM X = 0.800000
MAXIMUM Y = 17.599991 MINIMUM Y = 0.700000

X-SCALE IS HORIZONTAL
X-VALUE = 0.80 + 0.2115 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 5.00
REFERENCE CONTOUR (......) = 20.00

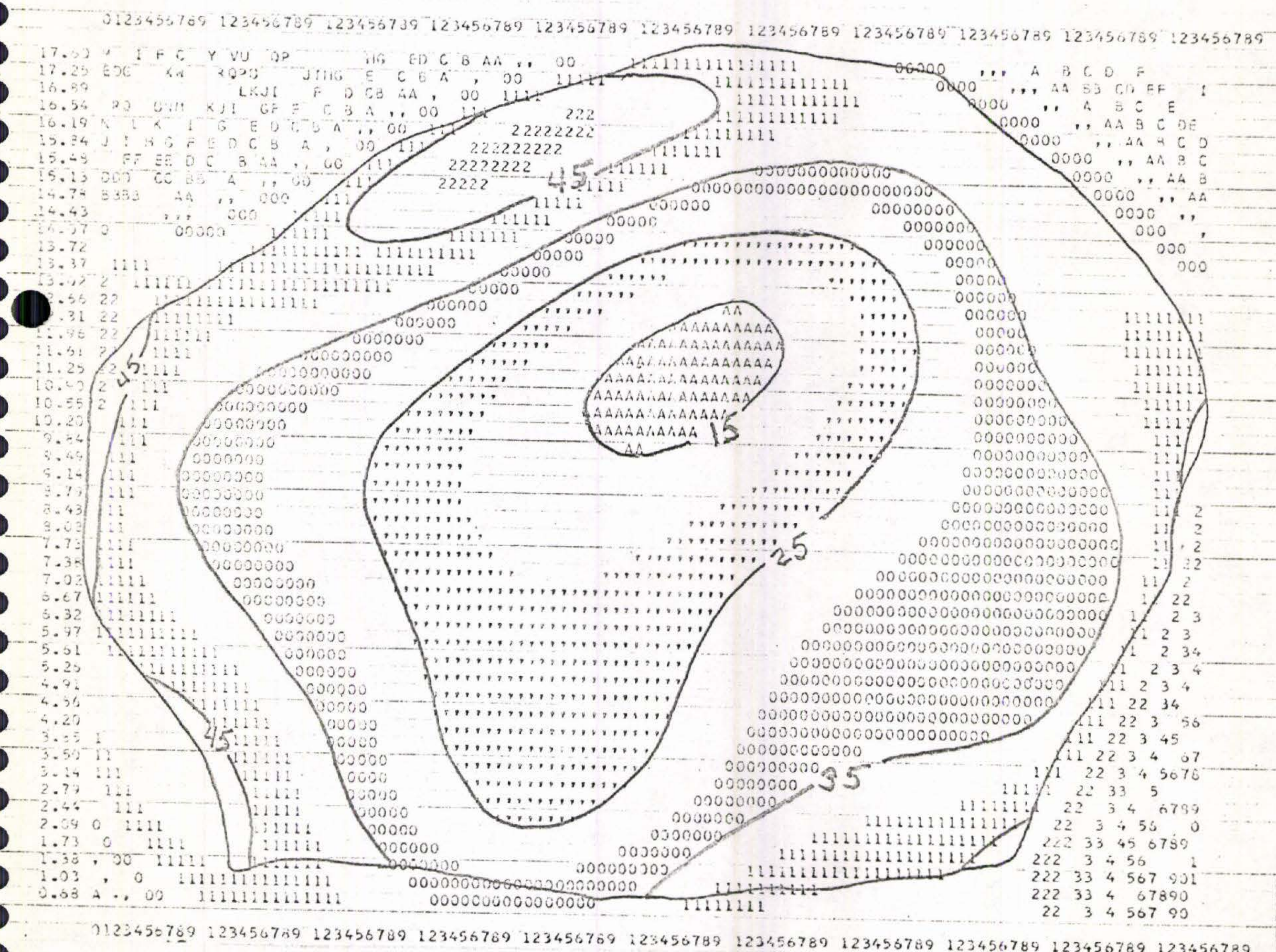


Figure 6e. Contour of sixth-degree surface for albite-in-perthite.

REFERENCES

Baird, A.K., Baird, K.W. & Morton, D.M., 1971, On deciding whether trend surfaces of progressively higher order are meaningful: discussion: Geol. Soc. of Am. Bull., v. 82, p. 1219-1234.

Chayes, F. and Suzuki, Y., June, 1963, Geological Contours and Trend Surfaces: Journal of Petrology, Vol. 4, No. 2, p. 307-312.

Chayes, Felix, 1970, On deciding whether trend surfaces of progressively higher order are meaningful: Geol. Soc. America Bull. v. 81, no. 4, p. 1273-1278, tables.

Dawson, K.R. and Whitten, E.H.T., 1962, The Quantitative Mineralogic Composition and Variation of the Lacorne, La Motte, and Preissac Granitic Complex, Quebec, Canada: Jour. of Petrology, Vol. 3, Part 1, pp. 1-37.

Exley, C.S., 1963, Quantitative Areal Modal Analysis of Granitic Complexes: A Further Contribution: Geol. Soc. of Am. Bull., Vol. 74, pp. 649-653.

Heiner, L.E. and Geller, S.P., Fortran IV Trend-Surface Program for the IBM 360 Model 40 Computer: Mineral Industry Research Laboratory, University of Alaska.

Karner, F.R., 1968, Compositional variation in the Tunk Lake Granite Pluton, Southeastern Maine: Geol. Soc. of Am. Bull., Vol. 79, pp. 193-222, 7 figs.

Krumbein, W.C. 1959, Trend-surface analysis of contour-type maps with irregular control point spacing: Jour. of Geophy. Res., Vol. 64, No. 7, pp. 823-834.

Krumbein, W.C. and Graybill, F.A., 1965, An Introduction to Statistical Models in Geology: McGraw-Hill, New York, 475 p.

Peikert, E.W., March, 1965, Model for Three-Dimensional Mineralogic Variation in Granitic Plutons Based on the Glen Alpine Stock, Sierra Nevada, California: Geol. Soc. of Am. Bull., Vol. 76, No. 3, pp. 331-348.

Whitten, E.H.T., January, 1963, Systematic Quantitative Areal Variation in Five Granitic Massifs: A Reply: Journ of Geol., Vol. 71, No. 1, pp. 119-121.

Whitten, E.H.T., June, 1963, A Reply to Chayes and Suzuki: Jour. of Petrology, Vol. 4, No. 2, pp. 313-316.

APPENDIX

Included in the appendix is a sample of the cataloging input and MIRL Report No. 9 (Heiner and Geller) which contains all the necessary information on how to punch control cards for the program and the program itself.

The program was cataloged in the following manner:

```
// JOB     (acc. & user no.)  (name)
   ASSGN SYSCLB,U.A.
   ASSNG SYSCLB,A'131'
// OPTION CATALOG
   PHASE TRENMAIN,ROOT
// EXEC FFORTRAN
   (source deck of main program, range)
/* INCLUDE
   (object deck of phase fetching subroutine, p. 49)
/*
   PHASE TRENLNKL,*
// EXEC FFORTRAN
   (source decks of linkl, t2, contur, emslvr)
/*
   PHASE TRENLNK2,TRENLNK1
// EXEC FFORTRAN
   (source decks of link2, order3, plot3)
/*
// EXEC LNKEDT
/&
   ASSGN SYSCLB,UA
```

The rest of the input followed directly from Heiner and Geller, except for the changed IF statements using the ALPHA subroutine, which has been eliminated. The card deck as it was programmed and used has been entrusted to the care of Dr. Francis Ting, and any one interested in using it should contact him.

Before cataloging, a check should be made with the computer center, 4th floor Twamley Hall. The program will be erased after May 1, 1972.

M. I. R. L.
Report No 9

FORTRAN IV TREND-SURFACE PROGRAM for the IBM 360 MODEL 40 COMPUTER

By Lawrence E. Heiner
Stephen P. Geller

Mineral Industry Research Laboratory
University of Alaska
College, Alaska 99710

ABSTRACT

A Fortran IV trend surface program with polynomial contouring and residual plotting has been adapted to the University of Alaska IBM 360 Model 40 Computer. The program will compute equations of polynomials of the first through sixth degree, measures of the goodness of fit of the surfaces, tabulate original data, x y coordinates and corresponding residuals for each surface; contour each polynomial, and plot original values and residuals for each surface computed.

ACKNOWLEDGEMENTS

The authors wish to acknowledge their debt to the members of the State Geological Survey of Kansas who wrote the original program and who helped in its conversion by giving helpful suggestions and advice through correspondence. The University of Kansas version is published as "Computer Contribution 3" by Daniel F. Merriam, editor, and Mont O'Leary, R. H. Lippert, and Owen T. Spitz.

Funds for computer time and programming assistance were obtained through a grant from the Computer Fund Committee of the University of Alaska.

Subroutine ALPHA was donated by Mr. Bruce Morton of the Geophysical Institute, University of Alaska.

The authors also wish to extend their appreciation to Mr. Edward Gauss who was instrumental in obtaining funds necessary for program conversion, and to Ernest Wolff, who was working with one of the authors on the application of the program to Alaskan mineral deposits.

INTRODUCTION

Purpose of Program

The program has been written to facilitate understanding of various types of geologic, geochemical, geophysical and other data through the use of trend surface analysis. The program is designed for use by exploration firms, other organizations and individuals interested in rapid analysis of field data. It will indicate "target" areas, thereby localizing the search area. Polynomial surfaces are fitted to data (geochemical, geophysical or geological) which are expressed in x, y, z form; x and y being the map coordinates of the data and z being the measured parameter. Successive orders of polynomial equations (e.g. $z = a + bx + cy + \ldots.$) are fitted to x y z data by the method of least squares. Contouring of these polynomials produce "trend" maps. Residuals (observed data minus computed values) are plotted at each data station to produce anomaly maps. Hence regional trends of data, with anomolous highs and lows eliminated, and anomolous areas (data "noise"), with the regional trend eliminated, may be contoured and mapped. This latter process sharpens anomolies.

The procedure is not new, but the advent of high speed electronic computers have spurred investigations of the use of trend surfaces to aid in mineral exploration and analysis of geologic data. Several investigators are noted in the bibliography.

History

The history of the program development may best be presented by quoting Merriam (1966).

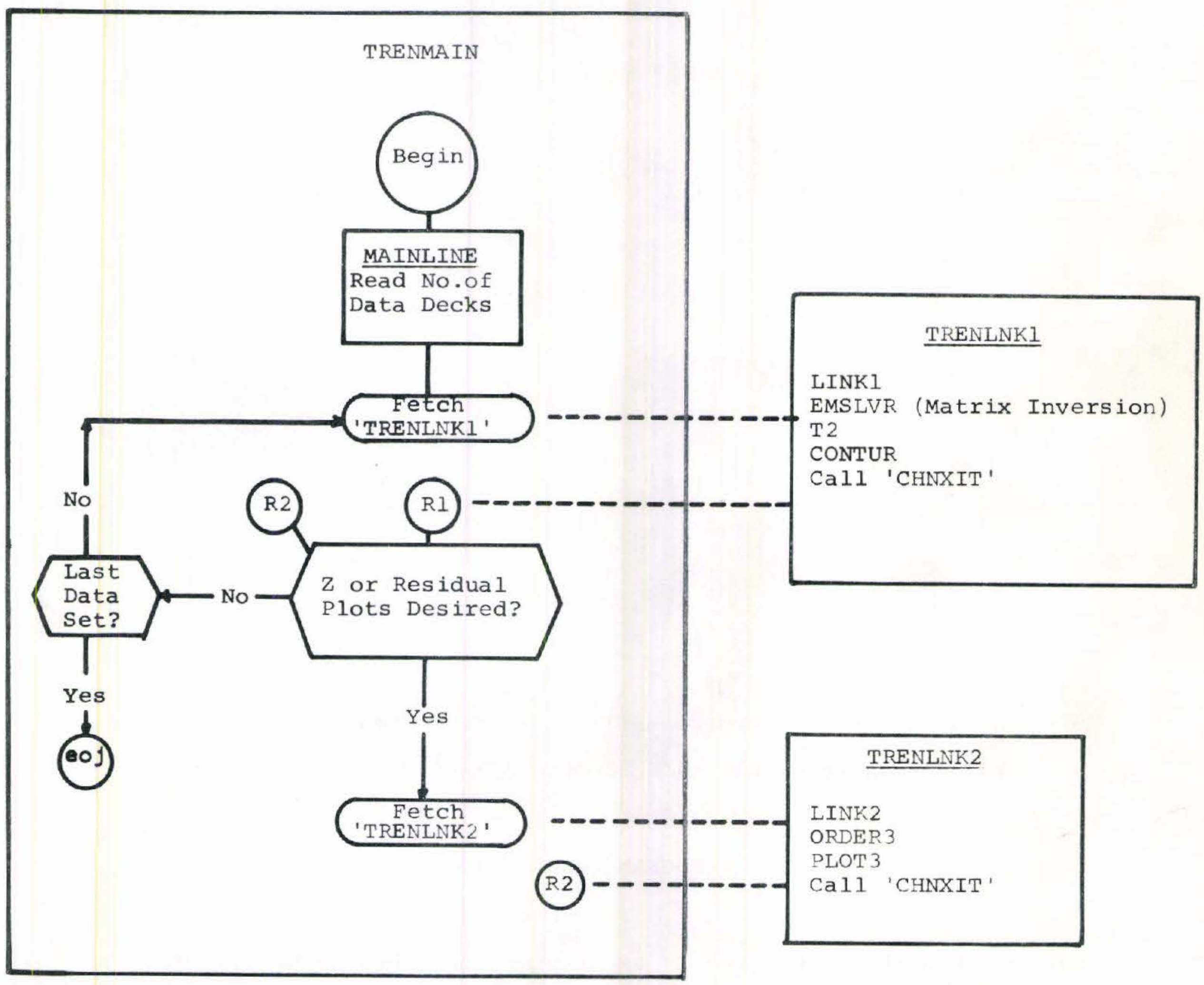
"The original version of this program was published by John W. Harbaugh (1963) in BALGOL for the IBM 7090. In late 1963, Donald I. Good translated the program into FORTRAN II for the IBM 1620, but vast differences in language and hardware necessitated a complete rewriting. Good's program was published in 1964 as Kansas Geological Survey Special Distribution Publication 14. Shortly after publication of this program, the University of Kansas replaced the 1620 with a larger IBM 7040. In September, 1964, Owen T. Spitz converted the program to FORTRAN IV, revising it to its present two-link chain program form for adaptation to the IBM 7040 with 16K."

Conversion to the IBM 360/40 at the University of Alaska was not too difficult. The University's FORTRAN IV compiler is the E-Level Subset version which does not support reading of FORMAT statements as data, and logical IF statements. An appropriate FORMAT statement, written into the program, solved the first problem; the second was solved by the use of an Assembler-Written FUNCTION, Subroutine 'ALPHA' which performs logical compares on two variables, returning a result of floating-point -1, zero, or +1 for .LT., .EQ., and .GT. respectively.

The Chaining was implemented by using the DOS operating system's program-fetch facilities, and breaking the program into three phases: A root phase containing the mainline and common subroutines, and two overlay phases which replace each other in core (see Figure 1). An assembler subroutine 'CHAIN' was written to effect the overlays. CHAIN accepts an argument of either fixed-point 1 or 2, calling for respectively TRENLNK1 or TRENLNK2 to be fetched. After the fetch, control is passed to the entry point of the called overlay phase. Return to the mainline is accomplished by calling 'CHNXIT', an alternate entry-point of 'CHAIN', which located the stored return address to the mainline and branches to it. This preserves the original logic of the 7040 program, which called a subrouting 'CHAIN' in this manner.

Another modification was the reading in of a card to define A-Format representations of all the plot characters, which had been done before by setting variables equal to previously calculated numbers, at execution time.

FIGURE I


TRENMAIN
Begin
MAINLINE
Read No.of
Data Decks
Fetch
'TRENLNK1'
No
R2
R1
Last
Data
Set?
No
Z or Residual
Plots Desired?
Yes
eoj
Yes
Fetch
'TRENLNK2'
TRENLNK1
LINK1
EMSLVR (Matrix Inversion)
T2
CONTUR
Call 'CHNXIT'
TRENLNK2
LINK2
ORDER3
PLOT3
Call 'CHNXIT'
R2

PROGRAM STRUCTURE

Root Phase 'TRENMAIN'

Includes:	The Mainline Program
	RANGE
	ALPHA
	CHAIN
	FORTRAN IOCS & Subroutines

Overlay Phase 'TRENLNK1'

Includes:	LINK1
	T2
	CONTUR
	EMSLVR

Overlay Phase 'TRENLNK2'

Includes:	LINK2
	ORDER3
	PLOT3

The program and DOS Supervisor fill about 50K bytes (12K words) of 360 storage. The University of Alaska's 360 has 65K bytes of storage available.

PROGRAM DESCRIPTION

Control through the program is exactly as described by Merriam (1966). "Flow of control through the chained program and various subroutines is briefly illustrated in Figure 1. The main steps within each chain link are listed below in order of occurrence:

LINK 1

Plotting symbols are generated.

Data parameters are read into the program and checked.

x y z coordinaces are read in.

Coefficient matrices are generated and solved.

Subroutine T2 is called.

Subroutine T2

Trend surface z values, residuals, error measures, and equations of surfaces are calculated and printed.

Link 1 control cards are read in and checked.

Map titles are printed.

Subroutine CONTUR is called.

Subroutine CONTUR

Trend surfaces are calculated and printed.

(At this point, control of the program returns to mainline. Link 2 option is interrogated and Link 2 is called if so indicated by option.)

LINK 2

Link 2 control cards are read in and partially checked.

Map titles are printed.

Subroutine PLOT 3 is called.

Subroutine PLOT 3

Remainder of Link 2 control cards are checked.

z and residual values are ordered and plotted."

INPUT DATA PREPARATION

Much of the following input data specifications is again taken verbatim from Merriam (1966) as much of it was not altered during the conversion. All numbers on control cards are integers unless mention is made of a decimal point. Figure 2 shows diagramatically that input to the program consists of an initial "N" card which specifies the number of data decks to be run. Each Data Deck is composed of:

1. Three lead control cards which contain information concerning the data cards to follow.
2. Data cards containing one x y z coordinate triplet per card.
3. Link 1 and 2 control cards which specify contouring and plotting.

Control and Data Cards

"N" Card: The first card immediately following the source, object deck of // EXEC TRENMAIN which specifies the number of data decks (1 to 99) which are to be processed. This number is punched in columns 1 and 2 of the "N" card and is right justified.

Lead Control Cards:

Card 1: Begin in column one and punch:
ABCDEFGHIJKLMNOPQRSTUVWXYZ.0123456789*+-

Card 2: This card is a 79 character title card used to identify the data being processed. It is repeated in each section of the output. Column one is blank and the title is placed in Columns 2-80.

Card 3: Column 1 Blank
Columns 2-4 contain the number of sets of x y z coordinates that are read in as data. This value may range from 1 to

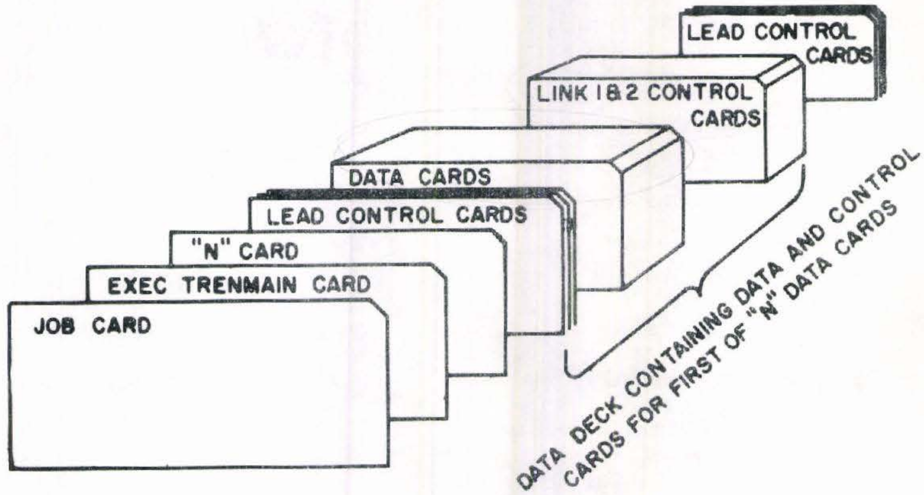


Figure 2.- Make-up of trend-surface program package

500 and must be right justified.

Column 5 Blank

Columns 6-11 contain the indicators for calculation of the first through sixth degree equations respectively. For each equation to be fitted to the data, a one (1) must be punched in the column assigned to that equation. Otherwise, that column must be punched zero or left blank.

Data Cards: The data cards contain the x y z coordinates of each control point (normally, one control point or coordinate triplet per card).

The x and y values define the location of cartesian coordinates of each control point, while the z value refers to the numerical value of the point itself. The x and y values may be scaled in inches and tenths of an inch, centimeters, or any convenient unit. To keep all x and y values positive, origin must be taken as the lower left-hand corner of the map.

The number of points (cards) must agree with the number specified in columns 2-4 on card 3 of the lead control cards. The maximum number of points which may be handled by this program is 500. The minimum allowable number of points is determined by the highest order of trend surface to be computed. This minimum number may be computed by the formula

$$N = \frac{(P+1)\ (P+2)}{2}$$

where N is the minimum number of points allowable and P is the highest order of trend surface to be computed. Computation of a sixth-degree trend surface, for example, requires a minimum of 28 control points. Surfaces computed with a minimum number of control points are "trend" surfaces as the surface is not a best fit but an exact fit (i.e. the residuals are zero).

Location of the coordinate values on the data cards must be of the format: 1X,2F7.0,F8.0.

Link 1 and 2 control cards: The control cards described in this section specify printing of the contour maps (Link 1) and plotting of z values and residuals (Link 2). An option is provided whereby Link 2 is not called if residual or data plots are not desired.

Link 1

Card 1

Columns 1-5: Contain the total number of contour maps to be printed from this data deck. This value must be right justified.

Column 6: Blank

Column 7: Contains the option for Link 2. If plots of the z values and/or the residual values are desired, this column contains a 1 (one); otherwise, it must be a 0 (zero) or blank.

Card 2

This is the first of a set of M cards which contain the contouring parameters of each map to be contoured. (M is the number specified in columns 1-5 of card 1).

Column 1: Blank

Column 2: Contains the contour map indicator, MP, which designates the degree of the equation of the map to be contoured. If MP is 1, the first-degree is contoured; if 2, the second-degree surface is contoured, etc. This number cannot be larger than 6.

Column 3: Contains the orientation indicator, IOR. This variable controls the orientation of the printed map on the paper. If IOR is 1, the x axis is horizontal. If IOR is 2, the y axis is horizontal. If IOR is 3, the contoured map is oriented so that it occupies as much space as possible. For instance, if an interval of 10 units on the x axis and an interval of 5 units on the y axis is to be contoured, the map is oriented with the x axis vertical. If IOR is 4, the contoured map is oriented so that it occupies as little space as possible.

Column 4: Contains the plotting limit indicator, M3. If M3 is 1, the x-plotting interval is the interval between the maximum and minimum values of the X data array, and the y-plotting interval is the interval between the maximum and minimum values of the Y data array.

If M3 is 0 (zero), the plotting limits are read in on a card that immediately follows <u>this card</u> (not this set of cards). These limits are on the card in the form:

Column 1: Blank

Columns 2-16: Contain the maximum x-plotting limit. If no decimal is punched it is assumed to be between columns 10 and 11.

Columns 17-31: Contain the minimum x-plotting limit. If no decimal point is punched, it is assumed to be between columns 25 and 26.

Columns 32-46: Contain the maximum y-plotting limit. If no decimal point is punched, it is assumed to be between columns 40 and 41.

Columns 47-61: Contain the minimum y-plotting limit. If no decimal point is punched, it is assumed to be between columns 55 and 56.

Column 5: Contains the card tabulator indicator, MT. If MT is 1, the output is to be listed at six lines per inch. If MT is 0 (zero) the output is to be listed at ten lines per inch.

Columns 6-9: Contain the program variable NCOL, which indicates the number of horizontal columns of output. The value of NCOL may range from 12-120 inclusive and must be right justified. The contour map occupies NCOL - 10 columns.

Columns 10-19: Contain the program variable CON which is the contour interval of the contour map. This value must not be zero or negative. If no decimal point is punched, it is assumed to be between columns 17 and 18.

Columns 20-29: Contain the program variable REF which is the reference contour. This value regulates the placement of the reference symbol (.....) on the contour map. If no decimal point is punched, it is assumed to be between columns 27 and 28.

The remaining cards control the plotting of the original data and the residuals. If this output is not desired, column 7 of card 1 in the previous section must be zero or blank, and the following control cards are omitted.

Link 2

Card 1

Column 1-5 contain the total number of plots to be made. This value must be right justified.

Card 2

This is the first of a set of M cards that contain the plotting parameters for each set of values to be plotted. (M is the number specified on card 1).

Column 1: Blank

Column 2: Contains the residual plot indicator, MP. If MP is 0 (zero), the original data are plotted. If MP is 1, the first-degree residuals are plotted; if 2, the second-degree residuals are plotted, etc. This indicator cannot be larger than 6.

Column 3: Contains the orientation indicator, IOR. IOR has the same function here as described in Link 1, card 2, column 3.

Column 4: Contains the plotting limit indicator, M3. M3 has the same function here as described in Link 1, card 2, column 4.

Column 5: Contains the card tabulator indicator, MT. MT has the same function here as described in Link 1, card 2, column 5.

Columns 6-9: Contain the value of the program variable NCOL. NCOL has the same function here as described in Link 1, card 2, columns 6-9 except that the value of NCOL in Link 2 may range from 16-120 inclusive and the plot occupies NCOL - 15 columns. (Note: for the contour maps and the residual plots to have the same scale, the value of NCOL for Link 2 should be four greater than NCOL for a corresponding contour map in Link 1).

Comments

Each letter occupies approximately 1/10 of an inch of space while each line requires about 1/6 of an inch. If output is listed at 6 lines per inch the vertical scale is scaled to conform to actual dimensions. To calculate the number of columns needed to produce "N" lines of map when the X coordinate is horizontal substitute into the following:

$$\# \text{ Columns} = \frac{(1.666667)(\# \text{ Lines})(\text{Xmax-Xmin})}{\text{ymax - ymin}} + 11$$

For output at 10 lines per inch and X coordinate horizontal, # of columns may be found by:

$$\# \text{ Columns} = \frac{(\# \text{ Lines})(\text{Xmax-Xmin})}{\text{ymax - ymin}} + 11$$

When the y axis is selected as the horizontal the above formulas apply if change in x and change in y are reversed. In this instance however the vertical increment is positive. This means that the vertical coordinates should increase in a negative direction from the lower left hand edge of the map area; otherwise the output does not properly represent data originally scaled as increasing positively in the x and y directions from this origin.

EXECUTION

The IBM 360 Model 40 requires that the FORTRAN program and data be punched with the Model 029 key punch. The program deck as received from the Kansas Geological Survey was punched with an 026 key punch. The University of Alaska computer center has written a "CONVERT" program which may be used each time the program is executed to correct differences between the two key punches. Therefore, changes in the original deck were made with the available key punch at the time of correction resulting in a mixed deck. Converted decks (029) can be produced by the computer center.

Compilation time for the entire program is approximately ten minutes. Object decks for each subroutine were therefore produced which eliminates this time each run. To execute the program at the University of Alaska under DOS, the following is needed: Supervisor

1. Catalog on Core-Image Library

```
1 →  // JOB CATALOG TREND PROGRAM
     // OPTION CATAL
        PHASE TRENMAIN, ROOT
2 →     INCLUDE
           Object decks of
           Mainline, RANGE, ALPHA, CHAIN
```

```
/*
    PHASE TRENLNK1,*
    INCLUDE
       Object Decks of
       LINK1, T2, CONTUR, EMSLVR
/*
    PHASE TRENLNK2, TRENLNK1
    INCLUDE
       Object Decks of
       LINK2, ORDER3, PLOT3
/*
//  EXEC LNKEDT
/&
```

2. Execute: (Scratch tapes on units 8, 9, 14)

```
1 //  JOB TREND
2 //  EXEC TRENMAIN
3     'N' Card
4     'Alphanumeric' Card
5     Lead Control Cards
6     Data
7     LINK1 and 2 Control Cards
      (Repeat 4,5,6,7 for more data)
8 /*
9 /&
```

The following is an example of input needed to execute the program. This data will produce all statistics mentioned, contour surfaces for first through fifth degree polynomials, a plot of original data and residual plots for each surface.

```
// JOB TREND 704 HEINER/WOLFF
// EXEC TRENMAIN
1
ABCDEFGHIJKLMNOPQRSTUVWXYZ.0123456789*+-
 CLEARY HILL AREA A  ZINC VALUES   HEINER / WOLFF
  53 111111
      1.8      4.6      125
      1.8      4.2      175
      1.8      3.8      175
      1.8      3.4      175
      1.8      3.0      200
      1.8      2.6      200
      1.8      2.2      175
      1.8      1.8      125
      1.8      1.4      125
      2.6      4.2      100
      2.6      3.8      075
      2.6      3.4      125
      2.6      3.0      075
      2.6      2.6      250
      2.6      2.2      200
      2.6      1.8      001
      2.6      1.4      050
      4.2      4.2      050
      4.2      3.8      075
      4.2      3.4      075
      4.2      3.0      200
      4.2      2.6      050
      4.2      2.2      050
      4.2      1.8      200
      5.0      4.2      075
      5.0      3.8      200
      5.0      3.4      050
      5.0      3.0      050
      5.0      2.6      200
      5.0      2.2      125
      5.0      1.8      150
      5.8      4.2      175
      5.8      3.8      150
      5.8      3.4      200
      5.8      3.0      175
      5.8      2.6      075
      5.8      2.2      200
      5.8      1.8      100
      7.4      4.6      175
      7.4      4.2      125
      7.4      3.8      350
      7.4      3.4      125
      7.4      3.0      150
      7.4      2.6      200
      7.4      2.2      100
      7.4      1.8      125
      8.2      4.2      175
      8.2      3.8      200
      8.2      3.0      175
      8.2      2.6      200
      8.2      2.2      350
      8.2      1.8      125
      8.2      1.4      350
    6 1
1101 91         25.0      175.0
```

```
               9.0         0.0          5.0          0.0
2101    91       25.0   175.0
               9.0         0.0          5.0          0.0
3101    91       25.0   175.0
               9.0         0.0          5.0          0.0
4101    91       25.0   175.0
               9.0         0.0          5.0          0.0
5101    91       25.0   175.0
               9.0         0.0          5.0          0.0
6101    91       25.0   175.0
               9.0         0.0          5.0          0.0
  7
0101    95
               9.0         0.0          5.0          0.0
1101    95
               9.0         0.0          5.0          0.0
2101    95
               9.0         0.0          5.0          0.0
3101    95
               9.0         0.0          5.0          0.0
4101    95
               9.0         0.0          5.0          0.0
5101    95
               9.0         0.0          5.0          0.0
6101    95
               9.0         0.0          5.0          0.0
```

```
      COMMON NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      DOUBLE PRECISION A(28,6)                                          MAIN 610
      COMMON A,DUMMY(1605),IPLOT                                        MAIN 620
      NTAPE1=8 10
      NTAPE2=9 13
      NTAPE3=14
      NTAPE4 = 4                                                        MAIN 580
      NTAPE5 = 5                                                        MAIN 590
      NTAPE6=1
      READ(1,102) J
  102 FORMAT(I2)
      DO 5 KIK=1,J                                                      MAIN 650
      CALL CHAIN (1)                                                    MAIN 660
      IF(IPLOT) 5,5,4                                                   MAIN 670
    4 CALL CHAIN (2)                                                    MAIN 680
    5 CONTINUE                                                          MAIN 690
      CALL EXIT                                                         MAIN 700
      CALL RANGE(0,0,N,N)                                               MAIN 710
      END                                                               MAIN 720
                                                                        MAIN 730

      SUBROUTINE RANGE(LL,LU,N,NER)                                     RANG 010
C                                                                       RANG 020
C     RANGE DETERMINES WHETHER OR NOT N FALLS IN THE CLOSED             RANG 030
C     INTERVAL (LL,LU)                                                  RANG 040
C                                                                       RANG 050
      NER = 0                                                           RANG 060
      IF(LL - N) 5, 15, 10                                              RANG 070
    5 IF (LU-N) 10, 15, 15                                              RANG 080
   10 NER = 1                                                           RANG 090
   15 RETURN                                                            RANG 100
      END                                                               RANG 110

      SUBROUTINE LINK1
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O'LEARY    LINK 010
      COMMON NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      DOUBLE PRECISION T(28,29),A(28,6),U(28)
      COMMON A,X(500),Y(500),Z(500),JARBO(52),ID(40),MTD(6),N,
     1 SUMZ,FN,IP,DUMB(4)                                               LINK 050
      EQUIVALENCE (MTD(1), M5), (MTD(2), M6), (MTD(3), M7)             LINK 060
      EQUIVALENCE (MTD(4),M8),(MTD(5),M9),(T(1,1),A(1,1))
C                                                                       LINK 080
C     -------------------------                                         LINK 090
C     CREATE PLOTTING CHARACTERS                                        LINK 100
C     -------------------------                                         LINK 110
      READ(1,160) (JARBO(K),K=1,52)
  160 FORMAT(40A1,12A2)
C                                                                       LINK 640
C     -----------------------                                           LINK 650
C     READ IN DATA PARAMETERS                                           LINK 660
C     -----------------------                                           LINK 670
      READ(1,20) (ID(I),I=1,40)
   20 FORMAT (1X, 39A2, A1)                                             LINK 690
      READ(1,95) N,(MTD(I),I=1,6)
   95 FORMAT (1X, I3, 1X, 6I1)                                          LINK 710
C     ---------------------                                             LINK 720
C     CHECK DATA PARAMETERS                                             LINK 730
C     ---------------------                                             LINK 740
      NERR = 0                                                          LINK 750
      CALL RANGE(1,500,N ,NKR)                                          LINK 760
```

```
      KAW=1
      IF(NKR) 600, 600, 700
C
  600 CALL RANGE(0,1,M5,NKR)
      KAW=2
      IF(NKR) 605, 605, 700
  605 CALL RANGE(0,1,M6,NKR)
      KAW=3
      IF(NKR) 610, 610, 700
C
  610 CALL RANGE(0,1,M7,NKR)
      KAW=4
      IF(NKR) 615, 615, 700
C
  615 CALL RANGE(0,1,M8,NKR)
      KAW=5
      IF(NKR)616,616,700
C
  616 CALL RANGE(0,1,M9,NKR)
      KAW=6
      IF(NKR)618,618,700
  618 CALL RANGE (0,1,MTD(6),NKR)
      KAW = 7
C
  620 IA = MTD(1) + MTD(2) + MTD(3)+MTD(4)+MTD(5) + MTD(6)
      KAW = 8
      IF (IA) 700, 700, 710
C
  700 WRITE(3,705) KAW
  705 FORMAT (1X, 13HPROGRAM ERROR I3)
      NERR = 1
      GO TO (600,605,610,615,616, 618,620,706),KAW
C
  710 IF(NERR) 100, 100, 706
  706 WRITE(3,707)
  707 FORMAT(13HOINVALID DATA)
      CALL EXIT
C     ------------------------
C     READ IN XYZ-COORDINATES
C     ------------------------
  100 READ(1,105) (X(I),Y(I),Z(I),I=1,N)
  105 FORMAT( 1X,2F7.0,F8.0)
C     ----------------------------------------------
C     CALCULATE COEFFICIENT MATRIX AND COLUMN VECTOR
C     ----------------------------------------------
      I=7
  107 I = I - 1
      IF(MTD(I) - 1) 107, 108, 108
  108 L = I
C
C     SELECT ORDER OF LARGEST COEFFICIENT MATRIX TO BE GENERATED
C
      GO TO (121, 122, 123,125,126, 127),L
  121 MM = 3
      GO TO 124
  122 MM = 6
      GO TO 124
  123 MM = 10
      GO TO 124
  125 MM=15
```

```
      GO TO 124
  126 MM=21
      GO TO 124
  127 MM = 28
  124 MM1 = MM + 1
C
C     STASH COORDINATE DATA ON TAPE
C
      REWIND NTAPE2
      DO 9998 I=1,N
 9998 WRITE(NTAPE2) X(I), Y(I), Z(I)
      REWIND NTAPE2
      REWIND NTAPE3
C
C     ZERO COEFFICIENT MATRIX AND COLUMN VECTOR
C
      DO 10 I = 1,MM,1
      DO 10 J = 1,MM1,1
   10 T(I,J) = 0.0
C
      DO 185 I = 1,N,1
C
C     PICK UP X,Y,Z COORDINATES  ONE AT A TIME
C
      READ(NTAPE2) P,Q,R
      U(1) = 1.
      U(2) = P
      U(3) = Q
C
      IF (L - 2) 117, 115, 115
  115 U(4) = P*P
      U(5) = P*Q
      U(6) = Q*Q
C
      IF (L - 3) 117, 116, 116
  116 U(7) = U(4) * P
      U(8) = U(4) * Q
      U(9) = P    * U(6)
      U(10) = U(6) * Q
C
      IF(L-4)117,111,111
  111 U(11)=U(7)*P
      U(12)=U(7)*Q
      U(13)=U(4)*U(6)
      U(14)=U(2)*U(10)
      U(15)=U(10)*Q
      IF(L-5)117,112,112
  112 U(16)=U(11)*P
      U(17)=U(11)*Q
      U(18)=U(12)*Q
      U(19)=U(13)*Q
      U(20)=U(14)*Q
      U(21)=U(15)*Q
C
      IF(L-6) 117,110,110
  110 U(22) = U(16) * P
      U(23) = U(16) * Q
      U(24) = U(17) * Q
      U(25) = U(18) * Q
      U(26) = U(19) * Q
```

```
      U(27) = U(20) * Q
      U(28) = U(21) * Q
C
  117 DO 185 J = 1,MM,1
      T(J,MM1) = T(J,MM1) + U(J) * R
      DO 185 K=1,MM
  185 T(K,J)=T(K,J)+U(J)*U(K)
C
C
C
      SUMZ=T(1,MM1)
      FN=T(1,1)
C     --------------
C     SOLVE MATRICES
C     --------------
      IP = 0
  217 IF (IP - L) 218, 580, 580
  218 IP=IP+1
C
C
C
      GO TO (219,220,221,222,223, 224), IP
  219 M=3
      GO TO 234
  220 M=6
      GO TO 234
  221 M=10
      GO TO 234
  222 M=15
      GO TO 234
  223 M=21
      GO TO 234
  224 M = 28
  234 M1=M+1
C
C     SAVE COEFFICIENT MATRIX BEFORE ORDERING EMSLVR
C
      REWIND NTAPE1
      WRITE(NTAPE1) T
C
      DO 250 J = 1,M,1
  250 T(J,M1) = T(J,MM1)
      CALL EMSLVR(T,U,M,MAT)
C
C     REPLACE COEFFICIENT MATRIX IN CORE   CONTINUE CALCULATIONS.
C
      REWIND NTAPE1
      READ(NTAPE1)T
C
      MTD(IP) = MTD(IP) + MAT
C
C     STASH CALCULATED COEFFICIENTS ON TAPE 3
C
      DO 260 J = 1,M,1
  260 WRITE(NTAPE3) U(J)
      GO TO 217
C     REPLACE X,Y,Z COORDINATES IN COMMON
C     ***********************************
C     ***********************************
  580 REWIND NTAPE2
```

```
      DO 9999 I=1,N
 9999 READ(NTAPE2)X(I),Y(I),Z(I)
C
      CALL T2
      CALL CHNXIT
      END
      SUBROUTINE EMSLVR (A,ACOE,N,NPQ)
C     WILL ORDER THE MATRIX BEFORE EACH ELIMINATION IF
C     MORDER=+1
C     N= ORDER OF MATRIX
C     WILL SOLVE AN (N)X(N+1) MATRIX
C     REQUIRES MATRICES OF THE FORM (A)X(COE)=(B)
C     ACOE=VARIABLES TO BE SOLVED FOR
C     A(I,J)= MATRIX ENTRIES
C     COLUMN (I,N+1) OF THE A MATRIX CORRESPONDS TO
C     COLUMN MATRIX B
C     DIMENSIONED VARIABLES MUST BE AT LEAST OF ORDER N
C     OR N+1 AS SHOWN BELOW
C     DIMENSION A(N,N+1), IC(N), COE(N+1), ACOE(N)
C     ANSWERS TO SINGULAR MATRICES ARE ZERO(0)
      DOUBLE PRECISION A(28,29),ACOE(28),COE(29),AB,AX,AY,SUM
      DIMENSION IC(28)
      NPQ=1
   12 NM=N
      NN=0
      KK=0
      MM=0
      NP1=N+1
      NM1=N-1
      DO 3 J=1,N
    3 A(J,NP1)=-A(J,NP1)
C     INITIALIZE SUBSCRIPT COLUMN
  799 DO 800 J=1,N
  800 IC(J)=J
      KKK=0
C     - - - - - - - - - - - - - - - - - - - - - - -
C     MATRIX ORDERING ROUTINE
C     - - - - - - - - - - - - - - - - - - - - - - -
  999 KKK=KKK+1
      AB=DABS(A(KKK,KKK))
      IBIG=KKK
      JBIG=KKK
      DO 901 I=KKK,N
      DO 901 J=KKK,N
      IF(AB-DABS(A(I,J)))900,901,901
  900 AB=DABS(A(I,J))
      IBIG=I
      JBIG=J
  901 CONTINUE
  910 DO 920 I=1, NP1
      AX=A(KKK,I)
      A(KKK,I)=A(IBIG,I)
  920 A(IBIG,I)=AX
      DO 930 J=1,N
      AY=A(J,KKK)
      A(J,KKK)=A(J,JBIG)
  930 A(J,JBIG)=AY
  940 IDUM=IC(KKK)
      IC(KKK)=IC(JBIG)
      IC(JBIG)=IDUM
```

```
      IF(NM1-KKK) 71,71,999
C     - - - - - - - - - - - - - - - - - - - - -
   71 CONTINUE
   75 NN=NN+1
      NNN=NN+1
      MM=MM+1
C     ---------------------------------
C     CHECK FOR SINGULAR MATRIX
C     ---------------------------------
      IF (A(NN,NN)) 77,1700,77
C     ---------------------------------
C     MATRIX SOLUTION ROUTINE
C     - - - - - - - - - - - - - - - - - - - - -
   77 DO 81 I=NN,N
      IF(A(I,NN))79,81,79
   79 DO 80 J=NNN,NP1
      A(I,J)=A(I,J)/A(I,NN)
   80 CONTINUE
   81 CONTINUE
      KK=KK+1
      IF(KK-NM1)85,85,100
   85 DO 95 I=NNN,N
      IF(A(I,NN))89,95,89
   89 DO 90 J=NNN,NP1
      A(I,J)=A(I,J)-A(NN;J)
   90 CONTINUE
   95 CONTINUE
   91 IF(KK-NM1+1)92,92,75
   92 KKK=MM
      GO TO 999
C     ---------------------------------
C     BACK SOLVE UPPER TRIANGULAR MATRIX
C     ---------------------------------
  100 COE(NP1)=1.0
      DO 110 K=1,NM
      SUM=0.0
      J=NP1-K
      L=J+1
      DO 109 I=L,NP1
  109 SUM=SUM-A(J,I)*COE(I)
  110 COE(J)=SUM
C     ---------------------------------
C     REORDER ANSWER MATRIX
C     ---------------------------------
      DO 1005 I=1,NM
      K1=IC(I)
      ACOE(K1)=COE(I)
 1005 CONTINUE
      WRITE(3,2)
      DO 1599 J=1,NM
 1599 WRITE(3,1) ACOE(J),J,IC(J)
 1600 RETURN
    1 FORMAT(1H E15.6,2I8)
    2 FORMAT(1H037H VARIABLE           IDENT    ORDERED COL
     14HUMNS)
 1700 WRITE(3,10)
   10 FORMAT(1H0,16H SINGULAR MATRIX)
      NPQ=-1
 1601 DO 1900 I=1,N
 1900 ACOE(I)=0.
      RETURN
      END
```

```
      SUBROUTINE T2
      COMMON NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
C     PROGRAM - TREND SURFACE  LINK 2
C     LANGUAGE - FORTRAN IV
C     COMPUTER - IBM 7040    16 K CORE
C     PROGRAMMER - DONALD I GOOD
C     DATE COMPLETED - APRIL 1964
C     REVISED SEPT 1964         OWEN T SPITZ
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O'LEARY
C     FOR DOCUMENTATION SEE KANSAS GEOLOGICAL SURVEY SPECIAL
C     DISTRIBUTION PUBLICATION 14 FOR 1620 VERSION
C
C
      DOUBLE PRECISION A(28,6)
      COMMON A,X(500),Y(500),Z(500),JARBO(52),ID(40),MTD(6),N,SUMZ,
     1FN,XMAX,XMIN,YMAX,YMIN,IPLOT
      DIMENSION IREFU(11),IREFL(26),RL(500),RQ(500),RC(500),VAR(6),
     1SQ(6),TVAR(6),SD(6),DET(6),COR(6),RQR(500),RQN(500),RSX(500)
      EQUIVALENCE(JARBO(1),IREFL(1)),(JARBO(27),IREFU(1))
      EQUIVALENCE(X(1),RL(1),RQR(1)),(Y(1),RQ(1),RQN(1)),(XMAX,IP)
C
      DO 9997 K=1,6
      DO 9997 J=1,28
 9997 A(J,K)=0.0
      M=1
      REWIND NTAPE3
      DO 9998 K=1,IP
      M=M+K+1
      DO 9998 J=1,M
 9998 READ(NTAPE3) A(J,K)
      XMAX = X(1)
      XMIN = X(1)
      YMAX = Y(1)
      YMIN = Y(1)
C     ---------------------------------------------
C     WRITE DATA ARRAYS ON INTERMEDIATE TAPE 1
C     ---------------------------------------------
      REWIND NTAPE1
      WRITE(NTAPE1) Z
C     -----------------------------------------------------
C     DETERMINE MAXIMUM AND MINIMUM VALUES OF X AND Y ARRAYS
C     -----------------------------------------------------
      DO 870 I=2,N,1
      IF(XMAX-X(I))835,840,840
  835 XMAX  = X(I)
  840 IF (XMIN - X(I))850,850,845
  845 XMIN = X(I)
  850 IF (YMAX - Y(I))855,860,860
  855 YMAX = Y(I)
  860 IF (YMIN - Y(I))870,870,865
  865 YMIN = Y(I)
  870 CONTINUE
C     ---------------------------------------------------------
C     CALCULATE AND PUNCH TREND SURFACE Z-VALUES, RESIDUALS, AND
C     ERROR TERMS
C     ---------------------------------------------------------
      DO 321 I=1,6,1
  321 SQ(I)=0.0
      ZSQ=0.0
C
```

```
      WRITE(3,319)
  317 FORMAT (1H1 39A2, A1)
  316 WRITE(3,317) (ID(I),I=1,40)
  319 FORMAT (1H0        11H    X-COORD 12H      Y-COORD 12H      Z-VALUE
  319112H     1ST-SURF  12H   1ST-RESID  12H     2ND-SURF
     212H   2ND-RESID 12H     3RD-SURF 12H   3RD-RESID)
C
      DO 465 I = 1,N,1
C
C
      AX = X(I)
      AY = Y(I)
      AZ=Z(I)
C
      IF(MTD(1)) 10,10,5
    5 Z1=A(1,1)+A(2,1)*AX+A(3,1)*AY
      GO TO 15
   10 Z1 = 0.0
C
   15 IF(MTD(2)) 17,17,16
   16 ZQ1 = AX * (A(2,2) + A(4,2) * AX + A(5,2) * AY)
      ZQ2=AY * (A(3,2) + A(6,2) * AY)
      Z2= A(1,2) + ZQ1 + ZQ2
      GO TO 18
   17 Z2 = 0.0
C
   18 IF (MTD(3)) 20,20,19
   19 ZC1 = AX * (A(2,3) + AX * (A(4,3) + A(7,3) * AX))
      ZC2=AY * (A(3,3) + AY * (A(6,3) + A(10,3) * AY))
      ZC3 = AX * AY * (A(5,3) + A(8,3) * AX + A(9,3) * AY)
      Z3= A(1,3)+ZC1 + ZC2 + ZC3
      GO TO 21
   20 Z3 = 0.0
C
   21 IF(MTD(1))334, 334, 330
  330 RL(I)=AZ-Z1
      GO TO 335
  334 RL(I) = 0.0
  335 IF (MTD(2)) 349, 349, 345
  345 RQ(I)=AZ-Z2
      GO TO 350
  349 RQ(I) = 0.0
  350 IF (MTD(3)) 364, 364, 360
  360 RC(I)=AZ-Z3
      GO TO 371
  364 RC(I) = 0.0
C
  371 SQ(1)=SQ(1)+RL(I)*RL(I)
      SQ(2)=SQ(2)+RQ(I)*RQ(I)
      SQ(3)=SQ(3)+RC(I)*RC(I)
      ZSQ=ZSQ+AZ*AZ
C
  465 WRITE(3,470) AX,AY,AZ,Z1,RL(I),Z2,RQ(I),Z3,RC(I)
  470 FORMAT(1X,F11.3,8F12.3)
C
C
C     WRITE RESIDUAL ARRAYS ON INTERMEDIATE TAPE 1
C
      WRITE(NTAPE1) RL
      WRITE(NTAPE1) RQ
```

```
      WRITE(NTAPE1) RC
C
      REWIND NTAPE2
      DO 9292I=1,N
 9292 READ(NTAPE2) X(I),Y(I),Z(I)
  416 WRITE(3,317) (ID(I),I=1,40)
      WRITE(3,419)
  419 FORMAT (1H0         11H    X-COORD 12H      Y-COORD 12H       Z-VALUE
  419112H     4TH-SURF 12H   4TH-RESID12H    5TH-SURF    12H   5TH-RESID
     212H     6TH-SURF   12H   6TH-RESID     )
C
      DO 471 I = 1, N, 1
C
      AX = X(I)
      AY = Y(I)
      AZ=Z(I)
C
      IF (MTD(4)) 200,200,199
  199 ZQR1 = AX*(A(2,4) + AX * (A(4,4) + AY * (A(8,4) + AY * A(13,4))))
      ZQR2 = AY*(A(3,4)+AX*A(5,4)+AY*(A(6,4) + AX*A(9,4)))
      ZQR3 = AX*AX*AX*(A(7,4) + AX *A(11,4) + AY*A(12,4))
      ZQR4 = AY *AY*AY*(A(10,4) + AX * A(14,4) + AY * A(15,4))
      Z4  = A(1,4) + ZQR1 + ZQR2 + ZQR3 + ZQR4
      GO TO 201
  200 Z4 = 0.0
C
  201 IF(MTD(5)) 203,203,202
  202 ZQN1 = AX * (A(2,5)+AX*A(4,5)+AY*(A(5,5) + AX*A(8,5)))
      ZQN2 = AY * (A(3,5) + AY * (A(6,5) + AX * A(9,5)))
      ZQN3 = AX*AX*AY*AY*(A(13,5)+AX*A(18,5)+AY*A(19,5))
      ZQN4 = AX*AX*AX*(A(7,5)+AY*A(12,5)+AX*(A(11,5)+AX*A(16,5)+AY*A(17,
     15)))
      ZQN5=AY*AY*AY*(A(10,5)+AX*A(14,5)+AY*(A(15,5)+AX*A(20,5)+AY*A(21,5
     1)))
      Z5  = A(1,5) + ZQN1 + ZQN2 + ZQN3 + ZQN4 + ZQN5
      GO TO 382
  203 Z5 = 0.0
  382 IF(MTD(6)) 384,384,383
  383 Z61 = AX * (A(2,6) + AY * (A(5,6) + AX * A(8,6)) + AX * (A(4,6) +
     1 AX * A(7,6)))
      Z62 = AY * (A(3,6) + AY * (A(6,6) + AX * (A(9,6) + AX * A(13,6)) +
     1 AY * A(10,6)))
      Z63 = AY*AX*AX*AX*  (A(12,6) + AX * (A(17,6) + AY * A(24,6)) + AY
     1 * (A(18,6) + AY * A(25,6)))
      Z64 = AX*AY*AY*AY* (A(14,6) + AX * A(19,6))
      Z65 = AX*AX*AX*AX* (A(11,6) + AX * (A(16,6) + AY * A(23,6) + AX *
     1 A(22,6)))
      Z66 = AY*AY*AY*AY* (A(15,6) + AX * (A(20,6) + AX * A(26,6) + AY *
     1A(27,6)) + AY * (A(21,6) + AY * A(28,6)))
      Z6 = A(1,6)+ Z61 + Z62 + Z63 + Z64 + Z65 + Z66
      GO TO 365
  384 Z6 = 0.0
C
  365 IF(MTD(4))367,367,366
  366 RQR(I)=AZ-Z4
      GO TO 368
  367 RQR(I)=0.
  368 IF(MTD(5))370,370,369
  369 RQN(I)=AZ-Z5
      GO TO 385
```

```
  370 RQN(I)=0.0
  385 IF(MTD(6)) 387,387,386
  386 RSX(I) = AZ - Z6
      GO TO 381
  387 RSX(I) = 0.0
  381 SQ(4)=SQ(4)+RQR(I)*RQR(I)
      SQ(5)=SQ(5)+RQN(I)*RQN(I)
      SQ(6) = SQ(6) + RSX(I) * RSX(I)
C
  471 WRITE(3,472) AX,AY,AZ,Z4,RQR(I),Z5,RQN(I),Z6,RSX(I)
  472 FORMAT(1X,F11.3,8F12.3)
C
      WRITE(NTAPE1)RQR
      WRITE(NTAPE1)RQN
      WRITE(NTAPE1)RSX
C
C     ------------------------
C     CALCULATE ERROR MEASURES
C     ------------------------
      TVARI=ZSQ-(SUMZ*SUMZ)/FN
      SN=N-1
      RSN=1./SN
C
      DO 520 I=1,6,1
      IF(MTD(I))500,500,480
C
  480 SD(I)=SQRT (RSN*SQ(I))
      VAR(I)=TVARI-SQ(I)
      TVAR(I)=TVARI
      DET(I)=VAR(I)/TVARI
      IF(DET(I))485,490,490
C
  485 COR(I)=-SQRT (-DET(I))
      GO TO 520
  490 COR(I)=SQRT (DET(I))
      GO TO 520
C
  500 SD(I)=0.0
      VAR(I)=0.0
      TVAR(I)=0.0
      DET(I)=0.0
      COR(I)=0.0
C
  520 CONTINUE
C     ---------------------------
C     PUNCH EQUATIONS OF SURFACES
C     ---------------------------
      WRITE(3,317) (ID(I),I=1,40)
C
      IF(MTD(1))40,40,35
   35 WRITE(3,585)
  585 FORMAT(1H0 39HCOEFFICIENTS OF FIRST-DEGREE EQUATION    )
      WRITE(3,595) (A(I,1),I=1,3)
  595 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 2H Y)
C
   40 IF(MTD(2))50,50,45
   45 WRITE(3,605)
  605 FORMAT(1H0 39HCOEFFICIENTS OF SECOND-DEGREE EQUATION   )
      WRITE(3,615) (A(I,2),I=1,6)
  615 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
```

```
     1 5H X2 + , F13.5, 5H XY + F13.5, 3H Y2)
C
   50 IF(MTD(3)) 56, 56,55
   55 WRITE(3,625)
  625 FORMAT(1H0 39HCOEFFICIENTS OF THIRD-DEGREE EQUATION    )
      WRITE(3,635) (A(I,3),I=1,10)
  635 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 5H Y2 +/F13.5, 5H X3 + F13.5,
     2 6H X2Y + , F13.5, 6H XY2 + F13.5, 3H Y3)
C
   56 IF(MTD(4))58,58,57
   57 WRITE(3,626)
  626 FORMAT(1H0 39HCOEFFICIENTS OF FOURTH-DEGREE EQUATION   )
      WRITE(3,627) (A(I,4),I=1,15)
  627 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 5H Y2 +/F13.5, 5H X3 + F13.5,
     2 6H X2Y + , F13.5, 6H XY2 + F13.5, 5H Y3 + F13.5, 5H X4 + F13.5,
     3 6H X3Y + /F13.5, 7H X2Y2 + F13.5, 7H XY3 + F13.5,3H Y4 )
C
   58 IF(MTD(5)) 60, 60, 59
   59 WRITE(3,628)
  628 FORMAT(1H0 39HCOEFFICIENTS OF FIFTH-DEGREE EQUATION    )
      WRITE(3,629) (A(I,5),I=1,21)
  629 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 5H Y2 +/F13.5, 5H X3 + F13.5,
     2 6H X2Y + , F13.5, 6H XY2 + F13.5, 5H Y3 + F13.5, 5H X4 + F13.5,
     3 6H X3Y + /F13.5, 7H X2Y2 + F13.5, 7H XY3 + F13.5,7H Y4 +
     4F13.5,5H X5 + F13.5, 6H X4Y + F13.5, 7H X3Y2 + / F13.5,
     5 7H X2Y3 + F13.5, 6H XY4 + F13.5, 3H Y5 )
C
   60 IF(MTD(6)) 640,640,61
   61 WRITE(3,630)
  630 FORMAT(1H0 39HCOEFFICIENTS OF SIXTH-DEGREE EQUATION    )
      WRITE(3,631) (A(I,6),I=1,28)
  631 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 5H Y2 +/F13.5, 5H X3 + F13.5,
     2 6H X2Y + , F13.5, 6H XY2 + F13.5, 5H Y3 + F13.5, 5H X4 + F13.5,
     3 6H X3Y + /F13.5, 7H X2Y2 + F13.5, 7H XY3 + F13.5,7H Y4 +
     4F13.5,5H X5 + F13.5, 6H X4Y + F13.5, 7H X3Y2 + / F13.5,
     5 7H X2Y3 + F13.5, 6H XY4 + F13.5, 5H Y5 + F13.5, 5H X6 + F13.5,
     66H X5Y + F13.5, 7H X4Y2 + / F13.5,7HX3Y3 + F13.5, 7H X2Y4 +
     7F13.5,6H XY5 + F13.5, 5H Y6  )
C
C     --------------------
C     PUNCH ERROR MEASURES
C     --------------------
  640 WRITE(3,644)
  644 FORMAT(1H0,/1H0,/1H0,/1H0,/1H0)
      WRITE(3,645) (SD(I),I=1,6),(VAR(I),I=1,6),(SQ(I),I=1,6)
  645 FORMAT (1H0 29X, 14HERROR MEASURES / 1H0 7HSURFACE 25X, 12HFIRST-D
     1EGREE 2X, 13HSECOND-DEGREE,3X,12HTHIRD-DEGREE, 2X,13HFOURTH-DEGREE
     23X,12HFIFTH-DEGREE,2X,12HSIXTH-DEGREE/
     3 1H0 18HSTANDARD DEVIATION 11X, 6F15.2 /
     4/ 1H0 19HVARIATION EXPLAINED / 1X, 10HBY SURFACE 19X, 6E15.8 / 1H0
     523HVARIATION NOT EXPLAINED / 1X,10HBY SURFACE 19X, 6E15.8)
C
      WRITE(3,655) (TVAR(I),I=1,6),(DET(I),I=1,6),(COR(I),I=1,6)
  655 FORMAT (1H0 15HTOTAL VARIATION 14X, 6E15.8 / 1H0 14HCOEFFICIENT OF
     1/ 1X, 13HDETERMINATION 16X, 6F15.8 / 1H0 14HCOEFFICIENT OF / 1X,
     211HCORRELATION 18X, 6F15.8)
```

```
C     ----------------------------------------
C     O'LEARY,S LEFT THUMB IS ON BACKWARDS.
C     ----------------------------------------
C     -------------------------------------------------------
C     READ IN NUMBER OF CONTOUR MAPS AND RESIDUAL INDICATOR
C     -------------------------------------------------------
      IK=0
  116 READ(1,117) NUMB,IPLOT
  117 FORMAT (I5, 1X, I1)
      CALL RANGE(0, 1, IPLOT, I)
      IF(I)118,118,741
  741 KAW = 11
      WRITE(3,710) KAW
      GO TO 720
C     -----------------------
C     READ CONTOUR PARAMETERS
C     -----------------------
  118 IK=IK+1
      IF(NUMB-IK)300,119,119
  119 READ(1,125) MP,IOR,M3,MT,NCOL,CON,REF
  125 FORMAT (1X, 4I1, I4, 2F10.2)
C
C     CHECK PLOTTING PARAMETERS FOR VALIDITY
C
      NERR=0
      CALL RANGE (1,6,MP,NKR)
      KAW=13
      IF(NKR)700,700,705
  700 CALL RANGE(0,1,M3,NKR)
      KAW=14
      IF(NKR)715,715,705
  705 WRITE(3,710) KAW
  710 FORMAT(1X, 13HPROGRAM ERROR I3)
      NERR=1
      IF(KAW-8)700,720,720
C
  715 IF(NERR)730,730,720
  720 WRITE(3,725)
  725 FORMAT (13HOINVALID DATA)
      CALL EXIT
C
  730 IF(M3)30,126,30
  126 READ(1,127) XPMAX,XPMIN,YPMAX,YPMIN
  127 FORMAT (1X, 4F15.6)
      GO TO 107
C
   30 XPMAX = XMAX
      XPMIN = XMIN
      YPMAX = YMAX
      YPMIN = YMIN
C
  107 IF(MTD(MP)) 118, 118, 108
C     --------------------------------------------
C     PUNCH MAP TITLES AND CALL SUBROUTINE CONTUR
C     --------------------------------------------
  108 WRITE(3,317) (ID(I),I=1,40)
C
      GO TO (245, 255, 266, 299, 301, 302), MP
C
  245 WRITE(3,251)
```

```
  251 FORMAT (1HO 32HCONTOURED FIRST-DEGREE SURFACE    )              T2  3610
      GO TO 275                                                       T2  3620
  255 WRITE(3,261)
  261 FORMAT (1HO 32HCONTOURED SECOND-DEGREE SURFACE    )             T2  3640
      GO TO 275                                                       T2  3650
  266 WRITE(3,271)
  271 FORMAT (1HO 32HCONTOURED THIRD-DEGREE SURFACE    )              T2  3670
      GO TO 275                                                       T2  3680
  299 WRITE(3,281)
  281 FORMAT (1HO 32HCONTOURED FOURTH DEGREE SURFACE    )             T2  3700
      GO TO 275                                                       T2  3710
  301 WRITE(3,291)
  291 FORMAT (1HO 32HCONTOURED FIFTH-DEGREE SURFACE    )              T2  3730
      GO TO 275                                                       T2  3740
  302 WRITE(3,303)
  303 FORMAT (1HO 31HCONTOURED SIXTH-DEGREE SURFACE    )              T2  3760
C                                                                     T2  3770
  275 CALL CONTUR (MP,IOR,MT,NCOL,CON,REF,XPMAX,XPMIN,YPMAX,          T2  3780
     1 YPMIN,  IREFU,IREFL,JKR)                                       T2  3790
      GO TO 118                                                       T2  3800
C                                                                     T2  3810
  300 REWIND NTAPE2                                                   T2  3820
      DO 9324 I=1,N                                                   T2  3830
 9324 READ(NTAPE2) X(I),Y(I),Z(I)                                     T2  3840
      RETURN                                                          T2  3850
      END                                                             T2  3860
      SUBROUTINE CONTUR (LM,M2,MT,NCOL,R1,R2,XPMAX,XPMIN,YPMAX,       CONT 010
     1 YPMIN,    IREFU,IREFL,KERR)                                    CONT 020
      COMMON NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
C                                                                     CONT 040
C     PROGRAM - SUBROUTINE CONTUR                                     CONT 050
C     LANGUAGE - FORTRAN II                                           CONT 060
C     PROGRAMMER - DONALD I GOOD                                      CONT 070
C     DATE COMPLETED - APRIL 1964                                     CONT 080
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O'LEARY  CONT 090
C                                                                     CONT 100
C                                                                     CONT 110
      DOUBLE PRECISION A(28,6)                                        CONT 120
      COMMON A,MAP(110),DUMMY(1496)                                   CONT 130
      DIMENSION           IREFU(11), IREFL(26)                        CONT 140
C     -------------------------------------                           CONT 150
C     CALCULATE X AND Y PLOTTING DIMENSIONS                           CONT 160
C     -------------------------------------                           CONT 170
      DX = XPMAX - XPMIN                                              CONT 180
      DY = YPMAX - YPMIN                                              CONT 190
      NC = NCOL - 11                                                  CONT 200
      FNC = NC                                                        CONT 210
      NC = NC + 1                                                     CONT 220
C     ---------------                                                 CONT 230
C     CHECK ARGUMENTS                                                 CONT 240
C     ---------------                                                 CONT 250
      KERR=0                                                          CONT 260
C                                                                     CONT 270
      CALL RANGE(1,6,LM,NKR)                                          CONT 280
      KEW=1                                                           CONT 290
      IF(NKR)5,5,50                                                   CONT 300
C                                                                     CONT 310
    5 CALL RANGE(1,4,M2,NKR)                                          CONT 320
      KEW=2                                                           CONT 330
      IF(NKR)10,10,50                                                 CONT 340
```

```
C                                                                        CONT 350
   10 CALL RANGE(0,1,MT,NKR)                                             CONT 360
      KEW=3                                                              CONT 370
      IF(NKR)15,15,50                                                    CONT 380
C                                                                        CONT 390
   15 CALL RANGE(12,120,NCOL,NKR)                                        CONT 400
      KEW=4                                                              CONT 410
      IF(NKR)20,20,50                                                    CONT 420
C                                                                        CONT 430
   20 IF(R1)25,25,30                                                     CONT 440
   25 KEW=5                                                              CONT 450
      GO TO 50                                                           CONT 460
C                                                                        CONT 470
   30 IF(DX)35,35,40                                                     CONT 480
   35 KEW=6                                                              CONT 490
      GO TO 50                                                           CONT 500
C                                                                        CONT 510
   40 IF(DY)45,45,125                                                    CONT 520
   45 KEW=7                                                              CONT 530
C                                                                        CONT 540
   50 WRITE(3,55) KEW
   55 FORMAT (1X, 23HSUBROUTINE CONTUR ERROR I2,  49H,  YOUR CONTROL CARCONT 560
     1DS ARE PROBABLY ALL ////ED UP.)                                    CONT 570
      KERR=1                                                             CONT 580
      GO TO (5,10,15,20,30,40,574),KEW                                   CONT 590
C                                                                        CONT 600
  125 IF(KERR)130,130,574                                                CONT 610
C     ----------------------                                             CONT 620
C     PUNCH PLOTTING LIMITS                                              CONT 630
C     ----------------------                                             CONT 640
  130 WRITE(3,60) XPMAX,XPMIN,YPMAX,YPMIN
   60 FORMAT (1H0 15HPLOTTING LIMITS / 1X, 11HMAXIMUM X = F15.6, 5X,     CONT 660
     1  11HMINIMUM X = F15.6/ 1X, 11HMAXIMUM Y = F15.6, 5X,              CONT 670
     2 11HMINIMUM Y = F15.6)                                             CONT 680
C     ------------------                                                 CONT 690
C     CHOOSE ORIENTATION                                                 CONT 700
C     ------------------                                                 CONT 710
      GO TO (135, 165, 195, 196), M2                                     CONT 720
C                                                                        CONT 730
  135 EXL = XPMIN                                                        CONT 740
      EXR = XPMAX                                                        CONT 750
      EXT = YPMAX                                                        CONT 760
      EXB = YPMIN                                                        CONT 770
      M6 = 0                                                             CONT 780
      GO TO 200                                                          CONT 790
C                                                                        CONT 800
  165 EXL = YPMIN                                                        CONT 810
      EXR = YPMAX                                                        CONT 820
      EXT = XPMIN                                                        CONT 830
      EXB = XPMAX                                                        CONT 840
      M6 = 1                                                             CONT 850
      GO TO 200                                                          CONT 860
C                                                                        CONT 870
  195 IF (DX - DY) 135, 135, 165                                         CONT 880
  196 IF (DX - DY) 165, 135, 135                                         CONT 890
C     ------------------------------------------------------             CONT 900
C     CALCULATE VERTICAL AND HORIZONTAL PLOTTING INCREMENTS              CONT 910
C     ------------------------------------------------------             CONT 920
  200 HINC = (EXR - EXL) / FNC                                           CONT 930
C                                                                        CONT 940
```

```
      IF (MT) 201, 202, 201                                             CONT 950
  201 VINC = HINC * 1.6666667                                           CONT 960
      GO TO 214                                                         CONT 970
  202 VINC = HINC                                                       CONT 980
C                                                                       CONT 990
  214 IF (M6) 220, 215, 220                                             CONT1000
  215 VINC = - VINC                                                     CONT1010
C     --------------------------------                                  CONT1020
C     PUNCH MAP PARAMETERS AND SCALES                                   CONT1030
C     --------------------------------                                  CONT1040
  220 IF (M6) 300, 280, 300                                             CONT1050
  280 WRITE(3,285) EXL,HINC
  285 FORMAT (1H0 21HX-SCALE IS HORIZONTAL / 1X, 9HX-VALUE = F8.2,      CONT1070
     1 2H + F8.4, 16H X (SCALE VALUE))                                  CONT1080
      WRITE(3,295)
  295 FORMAT (1H0 19HY-SCALE IS VERTICAL)                               CONT1100
      GO TO 320                                                         CONT1110
  300 WRITE(3,305) EXL,HINC
  305 FORMAT (1H0 21HY-SCALE IS HORIZONTAL / 1X, 9HY-VALUE = F8.2,      CONT1130
     1 2H + F8.4, 16H X (SCALE VALUE))                                  CONT1140
      WRITE(3,315)
  315 FORMAT (1H0 19HX-SCALE IS VERTICAL)                               CONT1160
  320 WRITE(3,325) R1,R2
  325 FORMAT (1H0 18HCONTOUR INTERVAL = F29.2/ 1X, 17HREFERENCE CONTOUR CONT1180
     1 10H (.....) = F20.2)                                             CONT1190
C                                                                       CONT1200
      IF (NCOL - 80) 340, 340, 330                                      CONT1210
C                                                                       CONT1220
  330 WRITE(3,335)
  335 FORMAT (1H0 9X, 10H0123456789 10H 123456789 10H 123456789         CONT1240
 3351 10H 123456789 10H 123456789 10H 123456789 2H 1                    CONT1250
     2 8H23456789 10H 123456789 10H 123456789 10H 123456789             CONT1260
     3 10H 123456789 /)                                                 CONT1270
      GO TO 344                                                         CONT1280
C                                                                       CONT1290
  340 WRITE(3,341)
  341 FORMAT (1H0 9X, 10H0123456789 10H 123456789 10H 123456789         CONT1310
     2 10H 123456789 10H 123456789 10H 123456789 10H 123456789 /)       CONT1320
C     -------------------------------------------                       CONT1330
C     CHOOSE CHARACTERS FOR LINE BY LINE PLOTTING                       CONT1340
C     -------------------------------------------                       CONT1350
  344 VERT = EXT - VINC                                                 CONT1360
C                                                                       CONT1370
C     INCREMENT VERTICAL INDEX BY ONE LINE                              CONT1380
C                                                                       CONT1390
  345 VERT = VERT + VINC                                                CONT1400
C                                                                       CONT1410
C     ZERO PLOTTING ARRAY, MAP                                          CONT1420
C                                                                       CONT1430
      DO 347 I = 1,NC,1                                                 CONT1440
  347 MAP(I)=IREFU(26)                                                  CONT1450
C                                                                       CONT1460
      HOR = EXL - HINC                                                  CONT1470
      I = 0                                                             CONT1480
C                                                                       CONT1490
C     INCREMENT HORIZONTAL INDEX BY ONE                                 CONT1500
C                                                                       CONT1510
  352 I = I + 1                                                         CONT1520
      HOR = HOR + HINC                                                  CONT1530
C                                                                       CONT1540
```

```
C     DETERMINE X AND Y VALUES OF THE PLOTTING POSITION
C
      IF (M6) 380, 365, 380
  365 AX = HOR
      AY = VERT
      GO TO 390
  380 AX = VERT
      AY = HOR
C
C     SELECT PLOTTING FUNCTION AND CALCULATE VALUE OF SURFACE AT THE
C     PLOTTING POSITION
C
  390 GO TO (395, 405, 415, 416, 417, 418),LM
C
  395 C =A(1,1)+A(2,1)*AX+A(3,1)*AY
      GO TO 420
C
  405 ZQ1 = AX * (A(2,2) + A(4,2) * AX + A(5,2) * AY)
      ZQ2=AY * (A(3,2) + A(6,2) * AY)
      C = A(1,2) + ZQ1 + ZQ2
      GO TO 420
C
  415 ZC1 = AX * (A(2,3) + AX * (A(4,3) + A(7,3) * AX))
      ZC2=AY * (A(3,3) + AY * (A(6,3) + A(10,3) * AY))
      ZC3 = AX * AY * (A(5,3) + A(8,3) * AX + A(9,3) * AY)
      C = A(1,3)+ZC1 + ZC2 + ZC3
      GO TO 420
C
  416 ZQR1 = AX*(A(2,4) + AX * (A(4,4) + AY * (A(8,4) + AY * A(13,4))))
      ZQR2 = AY*(A(3,4)+AX*A(5,4)+AY*(A(6,4) + AX*A(9,4)))
      ZQR3 = AX*AX*AX*(A(7,4) + AX *A(11,4) + AY*A(12,4))
      ZQR4 = AY *AY*AY*(A(10,4) + AX * A(14,4) + AY * A(15,4))
      C    = A(1,4) + ZQR1 + ZQR2 + ZQR3 + ZQR4
      GO TO 420
C
  417 ZQN1 = AX * (A(2,5)+AX*A(4,5)+AY*(A(5,5) + AX*A(8,5)))
      ZQN2 = AY * (A(3,5) + AY * (A(6,5) + AX * A(9,5)))
      ZQN3 = AX*AX*AY*AY*(A(13,5)+AX*A(18,5)+AY*A(19,5))
      ZQN4 = AX*AX*AX*(A(7,5)+AY*A(12,5)+AX*(A(11,5)+AX*A(16,5)+AY*A(17,
     15)))
      ZQN5=AY*AY*AY*(A(10,5)+AX*A(14,5)+AY*(A(15,5)+AX*A(20,5)+AY*A(21,5
     1)))
      C    = A(1,5) + ZQN1 + ZQN2 + ZQN3 + ZQN4 + ZQN5
C
      GO TO 420
C
  418 Z61 = AX * (A(2,6) + AY * (A(5,6) + AX * A(8,6)) + AX * (A(4,6) +
     1 AX * A(7,6)))
      Z62 = AY * (A(3,6) + AY * (A(6,6) + AX * (A(9,6) + AX * A(13,6)) +
     1 AY * A(10,6)))
      Z63 = AY*AX*AX*AX*  (A(12,6) + AX * (A(17,6) + AY * A(24,6)) + AY
     1 * (A(18,6) + AY * A(25,6)))
      Z64 = AX*AY*AY*AY* (A(14,6) + AX * A(19,6))
      Z65 = AX*AX*AX*AX* (A(11,6) + AX * (A(16,6) + AY * A(23,6) + AX *
     1 A(22,6)))
      Z66 = AY*AY*AY*AY* (A(15,6) + AX * (A(20,6) + AX * A(26,6) + AY *
     1A(27,6)) + AY * (A(21,6) + AY * A(28,6)))
      C  = A(1,6)+ Z61 + Z62 + Z63 + Z64 + Z65 + Z66
C
C     DETERMINE OF SURFACE VALUE LIES ABOVE OR BELOW REFERENCE CONTOUR
C     (DELZ IS + OR -)
```

```
C
  420 DELZ = C - R2
      IF (DELZ) 480, 421, 421
C
C     DETERMINE IF SURFACE VALUE LIES IN REFERENCE BAND
C
  421 IF (DELZ - R1) 425, 430, 430
  425 MAP(I) = IREFU(1)
      GO TO 535
C
C     SCALE DELZ SO THAT IT FALLS IN RANGE OF PLOTTING SYMBOLS(IREFU)
C
  430 DELZ = DELZ - R1
  431 IF (DELZ - 20. * R1) 445, 435, 435
  435 DELZ = DELZ - 20. * R1
      GO TO 431
C
C     CHOOSE PLOTTING SYMBOL
C
  445 NOD = DELZ / R1
      J = -1
      K = 1
  460 J = J + 2
      K = K + 1
      IF (NOD - J) 535, 475, 460
  475 MAP(I) = IREFU(K)
      GO TO 535
C
C     SCALE DELZ SO THAT IT FALLS IN RANGE OF PLOTTING SYMBOLS(IREFL)
C
  480 DELZ = - DELZ
  485 IF (DELZ - 52. * R1) 500, 490, 490
  490 DELZ = DELZ - 52. * R1
      GO TO 485
C
C     CHOOSE PLOTTING SYMBOL
C
  500 NOD = DELZ / R1
      J = -1
      K = 0
  515 J = J + 2
      K = K + 1
      IF (NOD - J) 535, 530, 515
  530 MAP(I) = IREFL(K)
C
C     DETERMINE IF LAST HORIZONTAL POSITION HAS BEEN PROCESSED
C
  535 IF (I - NC) 352, 540, 540
C
C     PUNCH PLOTTING ARRAY
C
  540 WRITE(3,545) VERT,(MAP(I),I=1,NC)
  545 FORMAT(1X,F8.2,1X,62A1,48A1)
C
C     DETERMINE IF LAST LINE HAS BEEN PROCESSED
C
      IF (M6) 565, 560, 565
  560 IF (VERT - EXB) 570, 570, 345
  565 IF (VERT - EXB) 345, 570, 570
```

```
C
C     PUNCH FINAL SCALES
C
  570 IF (NCOL - 80) 571, 571, 572
C
  571 WRITE(3,341)
      GO TO 574
  572  WRITE(3,335)
C
  574 RETURN
      END
      SUBROUTINE LINK2
C     PROGRAM - TREND SURFACE  LINK 2
C     LANGUAGE - FORTRAN IV
C     COMPUTER - IBM 7040     16 K CORE
C     PROGRAMMER - DONALD I GOOD
C     DATE COMPLETED - APRIL 1964
C     REVISED SEPT 1964        OWEN T SPITZ
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O'LEARY
C     FOR DOCUMENTATION SEE KANSAS GEOLOGICAL SURVEY SPECIAL
C     DISTRIBUTION PUBLICATION 14 FOR 1620 VERSION
C
C
      COMMON NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      DOUBLE PRECISION A(28,6)
      DIMENSION           JREF(12)
      COMMON A,X(500),Y(500),R(500),JARBO(52),ID(40),MTD(6),N,SUMZ,FN,
     1XMAX,XMIN,YMAX,YMIN,IPLOT
      EQUIVALENCE(JARBO(28),JREF(3))
C
C     CHECK LINK 2   INDICATOR
C
      REWIND NTAPE1
      IF (IPLOT - 1) 4, 5, 4
    4 KAW = 12
      WRITE(3,120) KAW
      GO TO 105
C
    5 KN = N + 1
      IP = 0
C
C     CALCULATE PLOTTING SYMBOLS FOR SUBROUTINE PLOT3
      NOP=37
      JARBO(1)=JARBO(26)
      JARBO(27)=JARBO(40)
      JARBO(26)=JARBO(39)
C     ---------------------------
C     READ IN PLOTTING PARAMETERS
C     ---------------------------
      READ(1,10) NUMB
   10 FORMAT (I5)
C
   15 IP = IP + 1
      IF (NUMB - IP) 105, 19, 19
   19 READ(1,20) MP,IOR,M3,MT,NCOL
   20 FORMAT (1X, 4I1, I4)
C     -----------------------------
C     CHECK PARAMETERS FOR VALIDITY
C     -----------------------------
      NERR=0
```

```
      CALL RANGE(0,6,MP,NKR)                                            LINK 490
      KAW=9                                                             LINK 500
      IF(NKR)110,110,115                                                LINK 510
  110 CALL RANGE(0,1,M3,NKR)                                            LINK 520
      KAW=10                                                            LINK 530
      IF(NKR)125,125,115                                                LINK 540
  115 WRITE(3,120) KAW
  120 FORMAT (1X, 13HPROGRAM ERROR I3)                                  LINK 560
      NERR=1                                                            LINK 570
      IF(KAW-10)110,125,125                                             LINK 580
  125 IF(NERR)25,25,130                                                 LINK 590
  130 WRITE(3,135)
  135 FORMAT(13HOINVALID DATA)                                          LINK 610
      CALL EXIT                                                         LINK 620
C                                                                       LINK 630
   25 IF(M3)40,30,40                                                    LINK 640
   30 READ(1,35) XPMAX,XPMIN,YPMAX,YPMIN
   35 FORMAT (1X, 4F15.6)                                               LINK 660
      IF(ALPHA(NOP,MP))50,165,50
C                                                                       LINK 690
   40 XPMAX=XMAX                                                        LINK 700
      XPMIN=XMIN                                                        LINK 710
      YPMAX=YMAX                                                        LINK 720
      YPMIN=YMIN                                                        LINK 730
C                                                                       LINK 740
   50 IF (MP) 51, 52, 51                                                LINK 750
   51 IF(MTD(MP))15,15,52                                               LINK 760
   52 DX = XMAX - XMIN                                                  LINK 770
      DY = YMAX - YMIN                                                  LINK 780
C     ************************************                              LINK 790
C     REPLACE X,Y,Z COORDINATES IN COMMON                               LINK 800
C     ************************************                              LINK 810
      REWIND NTAPE2                                                     LINK 820
      DO 740 I=1,N                                                      LINK 830
  740 READ (NTAPE2) X(I),Y(I),R(I)                                      LINK 840
C     ---------------------------------------------                     LINK 850
C     PLACE RESIDUAL ARRAY FROM TAPE 1 INTO R ARRAY                     LINK 860
C     ---------------------------------------------                     LINK 870
      NRD=MP+1                                                          LINK 880
      REWIND NTAPE1                                                     LINK 890
      DO 9976 ISQU=1,NRD                                                LINK 900
 9976 READ(NTAPE1) R                                                    LINK 910
      GO TO (140, 145, 150, 155), IOR                                   LINK 920
  140 CALL ORDER3(Y,X,R   ,1,N,1)                                       LINK 930
      K = 0                                                             LINK 940
      GO TO 165                                                         LINK 950
  145 CALL ORDER3(X,Y,R   ,1,N,0)                                       LINK 960
      K = 2                                                             LINK 970
      GO TO 165                                                         LINK 980
  150 IF (DX - DY) 140, 140, 145                                        LINK 990
  155 IF (DX - DY) 145, 140, 140                                        LINK1000
C     ------------------------------------------------------            LINK1010
C     PUNCH MAP TITLES AND CALL PLOTTING SUBROUTINE PLOT3               LINK1020
C     ------------------------------------------------------            LINK1030
  165 WRITE(3,55) (ID(I),I=1,40)
   55 FORMAT (1H1 39A2, A1)                                             LINK1050
C                                                                       LINK1060
      IF (MP) 59, 60, 59                                                LINK1070
   59 GO TO (70, 80, 90, 301, 303,305),MP                               LINK1080
C                                                                       LINK1090
```

```
   60 WRITE(3,65)
   65 FORMAT (1HO 37HPLOT OF ORIGINAL DATA (Z-COORDINATES))                LINK1110
      GO TO 160                                                            LINK1120
C                                                                          LINK1130
   70 WRITE(3,75)
   75 FORMAT (1HO 32HPLOT OF FIRST-DEGREE RESIDUALS    )                   LINK1150
      GO TO 160                                                            LINK1160
C                                                                          LINK1170
   80 WRITE(3,85)
   85 FORMAT (1HO 32HPLOT OF SECOND-DEGREE RESIDUALS  )                    LINK1190
      GO TO 160                                                            LINK1200
C                                                                          LINK1210
   90 WRITE(3,95)
   95 FORMAT (1HO 32HPLOT OF THIRD-DEGREE RESIDUALS    )                   LINK1230
      GO TO 160                                                            LINK1240
C                                                                          LINK1250
  301 WRITE(3,302)
  302 FORMAT (1HO 32HPLOT OF FOURTH-DEGREE RESIDUALS  )                    LINK1270
      GO TO 160                                                            LINK1280
C                                                                          LINK1290
  303 WRITE(3,304)
  304 FORMAT (1HO 32HPLOT OF FIFTH-DEGREE RESIDUALS    )                   LINK1310
C                                                                          LINK1320
      GO TO 160                                                            LINK1330
  305 WRITE(3,306)
  306 FORMAT (1HO 32HPLOT OF SIXTH-DEGREE RESIDUALS    )                   LINK1350
  160 CALL PLOT3(X,Y,R,N,IOR,XPMAX,XPMIN,YPMAX,YPMIN,NCOL,MT,K,J,JREF,MELINK1360
     1R,JARBO)                                                             LINK1370
      NOP=MP                                                               LINK1380
      GO TO 15                                                             LINK1390
C                                                                          LINK1400
  105 CONTINUE                                                             LINK1410
      CALL CHNXIT                                                          LINK1420
      END                                                                  LINK1430
      SUBROUTINE ORDER3(A,B,C,NF,NL,KD)                                    ORDE 010
      COMMON NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
C     PROGRAM - SUBROUTINE ORDER3                                          ORDE 030
C     LANGUAGE - FORTRAN II                                                ORDE 040
C     NECESSARY SUBROUTINES - RANGE                                        ORDE 050
C     COMPUTER - IBM 1620     60K CORE                                     ORDE 060
C     PROGRAMMER - DONALD I GOOD                                           ORDE 070
C     DATE COMPLETED - APRIL 1964                                          ORDE 080
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O'LEARY       ORDE 090
C                                                                          ORDE 100
C                                                                          ORDE 110
      DIMENSION A(500), B(500), C(500)                                     ORDE 120
C                                                                          ORDE 130
C     CALCULATE ORDERING PARAMETERS                                        ORDE 140
C                                                                          ORDE 150
      ND=NL-NF                                                             ORDE 160
   15 NP = NF + 1                                                          ORDE 170
      NE = NL + 1                                                          ORDE 180
C     -----------------------------------                                  ORDE 190
C     ORDER ARRAYS IN ASCENDING ORDER ON A                                 ORDE 200
C     -----------------------------------                                  ORDE 210
      DO 90 K = 1,ND,1                                                     ORDE 220
C                                                                          ORDE 230
   30 NE = NE - 1                                                          ORDE 240
      AMAX = A(NF)                                                         ORDE 250
      J = NF                                                               ORDE 260
      DO 50 I = NP,NE,1                                                    ORDE 270
```

```
      IF(AMAX - A(I)) 40, 50, 50
   40 AMAX = A(I)
      J = I
   50 CONTINUE
C
      BAMAX=B(J)
      CAMAX = C(J)
C
      A(J)=A(NE)
      B(J)=B(NE)
      C(J)=C(NE)
C
      A(NE) = AMAX
      B(NE) = BAMAX
      C(NE) = CAMAX
C
   90 CONTINUE
C
C     INVERT ARRAYS IF DESCENDING ORDER IS DESIRED
C
      IF(KD) 110, 110, 100
  100 NS2 = (NL - NF + 1) / 2 + NF - 1
      NT = NL + NF
      DO 105 I = NF, NS2, 1
      AMAX = A(I)
      BAMAX = B(I)
      CAMAX = C(I)
      K = NT - I
      A(I) = A(K)
      B(I) = B(K)
      C(I) = C(K)
      A(K) = AMAX
      B(K) = BAMAX
  105 C(K) = CAMAX
  110 RETURN
      END
C     PROGRAM - SUBROUTINE PLOT3
C     LANGUAGE - FORTRAN IV
C     NECESSARY SUBROUTINES - RANGE, ORDER3.
C     COMPUTER - IBM 1620      60K CORE
C     PROGRAMMER - DONALD I GOOD
C     DATE COMPLETED - APRIL 1964
C     REVISED SEPT 1964        OWEN T SPITZ
C
C
      SUBROUTINE PLOT3(X,Y,Z,N,IOR,XMAX,XMIN,YMAX,YMIN,NCOL,MT,M1,M2,JRE
     1F,NKR,JARBO)
C
      COMMON NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      DIMENSION X(500),Y(500),Z(500), JREF(12),IER(150),ITAB(150),MAP(11
     10),IZD(5),KTAB(150)
      DIMENSION JARBO(52)
C
C     DETERMINE NUMBER OF CHARACTERS, NCC, IN PLOTTING ARRAY
C
      NZ=150
      NCD=NCOL-10
      NCC=NCD-5
      FNC=NCC
C
```

```
C      CALCULATE PLOTTING DIMENSIONS                                    PLOT 250
C                                                                       PLOT 260
       DX=XMAX-XMIN                                                     PLOT 270
       DY=YMAX-YMIN                                                     PLOT 280
C      ----------------------------                                     PLOT 290
C      CHECK ARGUMENTS FOR VALIDITY                                     PLOT 300
C      ----------------------------                                     PLOT 310
       NKR=0                                                            PLOT 320
       CALL RANGE(1,500,N,NAR)                                          PLOT 330
       KAR=1                                                            PLOT 340
       IF(NAR)720,720,759                                               PLOT 350
C                                                                       PLOT 360
  720 CALL RANGE(1,4,IOR,NAR)                                           PLOT 370
       KAR=2                                                            PLOT 380
       IF(NAR)725,725,759                                               PLOT 390
C                                                                       PLOT 400
  725 CALL RANGE(16,120,NCOL,NAR)                                       PLOT 410
       KAR=3                                                            PLOT 420
       IF(NAR)730,730,759                                               PLOT 430
C                                                                       PLOT 440
  730 CALL RANGE(0,1,MT,NAR)                                            PLOT 450
       KAR=4                                                            PLOT 460
       IF(NAR)735,735,759                                               PLOT 470
C                                                                       PLOT 480
  735 CALL RANGE(0,2,M1,NAR)                                            PLOT 490
       KAR=5                                                            PLOT 500
       IF(NAR)740,740,759                                               PLOT 510
C                                                                       PLOT 520
  740 IF(DX)745,745,750                                                 PLOT 530
  745 KAR=6                                                             PLOT 540
       GO TO 759                                                        PLOT 550
C                                                                       PLOT 560
  750 IF(DY)755,755,765                                                 PLOT 570
  755 KAR=7                                                             PLOT 580
  759 WRITE(3,760) KAR
  760 FORMAT(1X, 22HSUBROUTINE PLOT3 ERROR I2)                          PLOT 600
       NKR=1                                                            PLOT 610
       GO TO (720,725,730,735,740,750,710),KAR                          PLOT 620
  765 IF(NKR)5,5,710                                                    PLOT 630
C      ---------------------                                            PLOT 640
C      PUNCH PLOTTING LIMITS                                            PLOT 650
C      ---------------------                                            PLOT 660
    5 WRITE(3,770) XMAX,XMIN,YMAX,YMIN
  770 FORMAT (1H0 15HPLOTTING LIMITS / 1X, 11HMAXIMUM X = F15.6, 5X,    PLOT 680
     1  11HMINIMUM X = F15.6/ 1X, 11HMAXIMUM Y = F15.6, 5X,             PLOT 690
     2 11HMINIMUM Y = F15.6)                                            PLOT 700
C                                                                       PLOT 710
C      ZERO CARRIAGE CONTROL ARRAY FOR OVERPRINT VALUES                 PLOT 720
C                                                                       PLOT 730
       DO 10 I=1,NZ,1                                                   PLOT 740
       KTAB(I)=JARBO(52)                                                PLOT 750
   10 ITAB(I)=JARBO(52)                                                 PLOT 760
C      --------------------------------------                           PLOT 770
C      SCALE PLOTTED VALUES TO 4-DIGIT MAXIMUM                          PLOT 780
C      --------------------------------------                           PLOT 790
       AZMAX=ABS(Z(1))                                                  PLOT 800
       DO 20 I=2,N,1                                                    PLOT 810
       IF(AZMAX-ABS(Z(I))) 15,20,20                                     PLOT 820
   15 AZMAX=ABS(Z(I))                                                   PLOT 830
   20 CONTINUE                                                          PLOT 840
```

```
C                                                                       PLOT 850
      IF (AZMAX) 21, 66, 21                                             PLOT 860
   21 M=(ALOG(9999.0/AZMAX))/ALOG(10.0)                                 PLOT 870
      IF(M)30,66,40                                                     PLOT 880
C                                                                       PLOT 890
   30 ND=-M                                                             PLOT 900
      CON=0.1                                                           PLOT 910
      GO TO 50                                                          PLOT 920
C                                                                       PLOT 930
   40 ND=M                                                              PLOT 940
      CON=10.0                                                          PLOT 950
C                                                                       PLOT 960
   50 DO 60 I=1,ND,1                                                    PLOT 970
      DO 60 J=1,N,1                                                     PLOT 980
   60 Z(J)=Z(J)*CON                                                     PLOT 990
C                                                                       PLOT1000
C     PUNCH SCALE FACTOR                                                PLOT1010
C                                                                       PLOT1020
   61 WRITE(3,65) M
   65 FORMAT (1H0 40HPLOTTED VALUES HAVE BEEN MULTIPLIED BY A 20H FACTORPLOT1040
     1 OF 10 TO THE I5, 6H POWER)                                       PLOT1050
C     ----------------------------------------------------------------- PLOT1060
C     SELECT MAP ORIENTATION, CALCULATE HORIZONTAL PLOTTING INCREMENTS. PLOT1070
C     PUNCH PLOTTING PARAMETERS                                         PLOT1080
C     ----------------------------------------------------------------- PLOT1090
   66 GO TO (70,80,90,100),IOR                                          PLOT1100
C                                                                       PLOT1110
   70 EXT=YMAX                                                          PLOT1120
      M3=0                                                              PLOT1130
      HINC = DX / FNC                                                   PLOT1140
      WRITE(3,75) XMIN,HINC
   75 FORMAT (1H0 21HX-SCALE IS HORIZONTAL / 1X, 9HX-VALUE = F8.2, 2H + PLOT1160
     1 F8.4, 16H X (SCALE VALUE) / 1H0 19HY-SCALE IS VERTICAL)          PLOT1170
      GO TO 110                                                         PLOT1180
C                                                                       PLOT1190
   80 EXT=XMIN                                                          PLOT1200
      M3=1                                                              PLOT1210
      HINC = DY / FNC                                                   PLOT1220
      WRITE(3,85) YMIN,HINC
   85 FORMAT (1H0 21HY-SCALE IS HORIZONTAL / 1X, 9HY-VALUE = F8.2, 2H + PLOT1240
     1 F8.4, 16H X (SCALE VALUE) / 1H0 19HX-SCALE IS VERTICAL)          PLOT1250
      GO TO 110                                                         PLOT1260
C                                                                       PLOT1270
   90 IF(DX-DY)70,70,80                                                 PLOT1280
  100 IF(DX-DY)80,70,70                                                 PLOT1290
C                                                                       PLOT1300
C     PUNCH HORIZONTAL SCALE                                            PLOT1310
C                                                                       PLOT1320
  110 IF(NCOL-80)120,120,130                                            PLOT1330
C                                                                       PLOT1340
  120 WRITE(3,125)
  125 FORMAT (1H0 9X, 10H0123456789 10H 123456789 10H 123456789 10H 1234PLOT1360
     156789 10H 123456789 10H 123456789 10H 123456789 /)                PLOT1370
      GO TO 140                                                         PLOT1380
C                                                                       PLOT1390
  130 WRITE(3,135)
  135 FORMAT (1H0 9X, 10H0123456789 10H 123456789 10H 123456789 10H 1234PLOT1410
     156789 10H 123456789 10H 123456789 2H 1          8H23456789 10H 12PLOT1420
     23456789 10H 123456789 10H 123456789 10H 123456789 /)              PLOT1430
C                                                                       PLOT1440
```

```
C     CALCULATE VERTICAL PLOTTING INCREMENT                             PLOT1450
C                                                                       PLOT1460
  140 IF(MT)160,150,160                                                 PLOT1470
  150 VINC=HINC                                                         PLOT1480
      GO TO 170                                                         PLOT1490
  160 VINC=HINC*1.6666667                                               PLOT1500
C     ----------------                                                  PLOT1510
C     PLOTTING ROUTINE                                                  PLOT1520
C     ----------------                                                  PLOT1530
C                                                                       PLOT1540
C     ORDER X, Y, AND Z ARRAYS ON ARRAY CORRESPONDING TO VERTICAL SCALE PLOT1550
C                                                                       PLOT1560
  170 IF(M3)200,180,200                                                 PLOT1570
C                                                                       PLOT1580
  180 VINC=-VINC                                                        PLOT1590
      IF(M1-1)220,190,190                                               PLOT1600
  190 CALL ORDER3(Y,X,Z,1,N,1)                                          PLOT1610
      M2=0                                                              PLOT1620
      GO TO 220                                                         PLOT1630
C                                                                       PLOT1640
  200 IF(M1-1)210,210,220                                               PLOT1650
  210 CALL ORDER3(X,Y,Z,1,N,0)                                          PLOT1660
      M2=2                                                              PLOT1670
C                                                                       PLOT1680
C     INITIALIZATION STEPS FOR PLOTTING                                 PLOT1690
C                                                                       PLOT1700
  220 PLIM=EXT                                                          PLOT1710
      KER=0                                                             PLOT1720
C                                                                       PLOT1730
C     DETERMINE INDEX OF FIRST DATA POINT THAT FALLS IN VERTICAL        PLOT1740
C     PLOTTING RANGE                                                    PLOT1750
C                                                                       PLOT1760
      IF (M3) 805, 800, 805                                             PLOT1770
  800 IF (YMIN - Y(1)) 221, 221, 226                                    PLOT1780
  221 DO 222 I = 1,N,1                                                  PLOT1790
      IF (YMAX - Y(I)) 222, 228, 228                                    PLOT1800
  222 CONTINUE                                                          PLOT1810
      GO TO 226                                                         PLOT1820
  805 IF (X(1) - XMAX) 223, 223, 226                                    PLOT1830
  223 DO 224 I = 1,N,1                                                  PLOT1840
      IF (XMIN - X(I)) 228, 228, 224                                    PLOT1850
  224 CONTINUE                                                          PLOT1860
  226 WRITE(3,227)
  227 FORMAT (1X, 27HNO POINTS IN VERTICAL RANGE)                       PLOT1880
      GO TO 650                                                         PLOT1890
  228 NL = I - 1                                                        PLOT1900
C                                                                       PLOT1910
C     CALCULATE UPPER (TOWARD TOP OF PAGE) BOUND OF VERTICAL PLOTTING   PLOT1920
C     INTERVAL                                                          PLOT1930
C                                                                       PLOT1940
  225 VERT=PLIM                                                         PLOT1950
C                                                                       PLOT1960
C     INCREMENT OVERPRINT INDEX. BLANK PLOTTING ARRAY                   PLOT1970
C                                                                       PLOT1980
      KERF=KER+1                                                        PLOT1990
      DO 230 I=1,NCD,1                                                  PLOT2000
  230 MAP(I)=JARBO(52)                                                  PLOT2010
C                                                                       PLOT2020
C     CALCULATE LOWER (TOWARD BOTTOM OF PAGE) BOUND OF VERTICAL PLOTTINGPLOT2030
C     INTERVAL                                                          PLOT2040
```

```
C
      PLIM=VERT+VINC
C
C     DETERMINE INDEX OF NEXT DATA POINT, NF
C
      NF=NL+1
      I=NL
C
C     SET UP VALUES FOR VERTICAL INTERVAL
C
      IF(M3)270,240,270
C
C     COUNT NO. OF DATA POINTS IN VERTICAL PLOTTING INTERVAL
C
  240 I=I+1
      IF (I - N) 245, 245, 250
  245 IF(Y(I)-PLIM)250,240,240
C
C     DETERMINE INDEX OF LAST DATA POINT IN VERTICAL PLOTTING INTERVAL,
C     NL. ORDER DATA POINTS IN VERTICAL PLOTTING INTERVAL
C
  250 NL=I-1
      IF(NL-NF)590,300,260
  260 CALL ORDER3(X,Y,Z,NF,NL,1)
      GO TO 300
C
C     COUNT NO. OF DATA POINTS IN VERTICAL PLOTTING INTERVAL
C
  270 I=I+1
      IF (I - N) 275, 275, 280
  275 IF(X(I)-PLIM)270,270,280
C
C     DETERMINE INDEX OF LAST DATA POINT IN VERTICAL PLOTTING INVERVAL,
C     NL. ORDER DATA POINTS IN VERTICAL PLOTTING INTERVAL
C
  280 NL=I-1
      IF(NL-NF)590,300,290
  290 CALL ORDER3(Y,X,Z,NF,NL,1)
C
C     PLACE Z-VALUES FOR VERTICAL INTERVAL IN PLOTTING ARRAY FROM
C     RIGHT TO LEFT
C
  300 I = NF - 1
  305 I = I + 1
C
C     DETERMINE POSITION, IDX, IN PLOTTING ARRAY TO PLACE SIGN OF
C     PLOTTED VALUE
C
      IF(M3)320,310,320
  310 IDX=(X(I)-XMIN)/HINC + 1.0
      GO TO 330
  320 IDX=(Y(I)-YMIN)/HINC + 1.0
C
C
C     DETERMINE IF PLOTTED VALUE LIES IN HORIZONTAL PLOTTING RANGE
C
  330 IF(IDX) 580, 580, 334
  334 IF (IDX - NCC - 1) 335, 335, 580
C
C     DETERMINE IF THIS POSITION IN THE PLOTTING ARRAY IS ALREADY
C     OCCUPIED
```

```
C
  335 IF(MAP(IDX)-JARBO(52)) 470,340,470
C
C     BREAK PLOTTED VALUE INTO 4 SEPARATE DIGITS AND CODE THESE DIGITS
C     IN THE DOUBLE DIGIT CODE
C
  340 LAZ=ABS(Z(I))
      DVD=LAZ
      DSR=10000.0
      J=1
C
  350 J=J+1
      DSR=DSR*0.1
      K=DVD/DSR
      IZD(J)=JREF(K+3)
      FK=K
      REM=DVD-FK*DSR
      IF(J-4)360,370,370
  360 DVD=REM
      GO TO 350
  370 K = REM
      IZD(5) = JREF(K+3)
C
C     DETERMINE LEFT-MOST NON-ZERO DIGIT OF PLOTTED VALUE (EXCEPT ZERO)
C
      J=1
  380 J=J+1
      IF (J - 5) 385, 390, 390
  385 IF(ALPHA(IZD(J),JARBO(28)))390,386,390  IF(IZD.NE.JARBO(28)) go to 390
  386 IZD(J)=JARBO(52)
      GO TO 380
  390 K=J-1
C
C     PLACE SIGN OF PLOTTED VALUE
C
      IF(Z(I))400,410,410
  400 IZD(K)=JREF(2)
      GO TO 420
  410 IZD(K)=JREF(1)
C
C     PLACE DIGITIZED VALUE IN PLOTTING ARRAY
C
  420 IMP=IDX-1
      J = K - 1
  430 J = J + 1
      IF (J - 5) 435, 435, 580
  435 IMP = IMP + 1
      IF(MAP(IMP)-JARBO(52)) 450,440,450
  440 MAP(IMP)=IZD(J)
      GO TO 430
C
C     ERROR ROUTINE FOR OVERLAP PLOTTING
C
  450 MAP(IDX)=JARBO(38)
      L=IDX+1
      IMP = IMP - 1
      J = IDX
  455 J = J + 1
      IF(J - IMP) 460, 460, 465
  460 MAP(J)=JARBO(52)
      GO TO 455
```

```
C
  465 KER=KER+1
      IER(KER)=Z(I)
      ITAB(KER)=JARBO(38)
      GO TO 580
C
C     ERROR ROUTINES FOR MULTIPLE PLOTTING
C
C     CHECK FOR ASTERISK
  470 IF(ALPHA(MAP(IDX),JARBO(38)))471,510,471} IF(MAP(IDX).EQ.JABO(38)) go to 510
  471 DO 472 ICU=1,12
      IF(ALPHA(MAP(IDX),JREF(ICU)))472,473,472} IF(MAP(IDX).NE.JREF(ICU)) go to 472
  473 IF(ICU-3) 490,530,530
  472 CONTINUE
      IF(ALPHA(MAP(IDX),JARBO(52)))530,490,530} IF(MAP(IDX).NE.JARBO(52)) go to 530
C
C    *IF 2 VALUES ARE TO OCCUPY MAP(IDX)
C
  490 KER=KER+2
      IER(KER-1)=Z(I-1)
      IER(KER) = Z(I)
      JAR=2
      ITAB(KER)=JARBO(JAR)
      JAM=2
      MAP(IDX)=JARBO(JAM)
      IMP=IDX
  495 IMP=IMP+1
      IF(ALPHA(MAP(IMP),JARBO(52)))496,580,496} IF(MAP(IMP).EQ.JARBO(52)) go to 580
  496 DO 499 IRE=3,12
      IF(ALPHA(MAP(IMP),JREF(IRE)))499,501,499} IF(MAP(IMP).EQ.JREF(IRE)) go to 501
  499 CONTINUE
      GO TO 580
  501 MAP(IMP)=JARBO(52)
      GO TO 495
C
C     IF MAP(IDX) IS OCCUPIED BY AN *
C
  510 KER=KER+1
  520 IER(KER)=Z(I)
      ITAB(KER-1)=JARBO(52)
      JAR=2
      ITAB(KER)=JARBO(JAR)
      JAM=2
      MAP(IDX)=JARBO(JAM)
      GO TO 580
C
C     IF 3-9 VALUES ARE TO OCCUPY MAP(IDX)
C
  530 DO 531 ICU=2,9
      IF(ALPHA(MAP(IDX),JARBO(ICU)))531,532,531} IF(MAP(IDX).EQ.JABO(ICU)) go to 532
  531 CONTINUE
      GO TO 550
  532 JAR=ICU
      JAM=ICU
  540 JAM=JAM+1
      MAP(IDX)=JARBO(JAM)
      KER = KER + 1
      JAR=JAR+1
```

```
      ITAB(KER)=JARBO(JAR)                                              PLOT3850
      ITAB(KER-1)=JARBO(52)                                             PLOT3860
      IER(KER) = Z(I)                                                   PLOT3870
      GO TO 580                                                         PLOT3880
C                                                                       PLOT3890
C     IF MORE THAN 9 VALUES ARE TO OCCUPY MAP(IDX)                      PLOT3900
C                                                                       PLOT3910
  550 MAP(IDX)=JARBO(1)                                                 PLOT3920
  560 KER=KER+1                                                         PLOT3930
      IER(KER)=Z(I)                                                     PLOT3940
      ITAB(KER-1)=JARBO(52)                                             PLOT3950
      ITAB(KER)=JARBO(1)                                                PLOT3960
C                                                                       PLOT3970
C     DETERMINE IF FINAL VALUE FOR THIS VERTICAL PLOTTING INTERVAL      PLOT3980
C     IS PROCESSED                                                      PLOT3990
C                                                                       PLOT4000
  580 IF(ALPHA(KER,NZ))581,581,920  IF( KER. GT. NZ) go to 920
  581 IF(I-NL)305,590,590
C                                                                       PLOT4030
C     PUNCH PLOTTING ARRAY                                              PLOT4040
C                                                                       PLOT4050
  590 WRITE(3,595) VERT,(MAP(I),I=1,NCD)
  595 FORMAT(1X,F8.2,1X,62A1,48A1)                                      PLOT4070
C                                                                       PLOT4080
C     INVERT LIST OF OVERPRINT AND CARRIAGE CONTROL VALUES IN LAST      PLOT4090
C     VERTICAL PLOTTING INTERVAL                                        PLOT4100
C                                                                       PLOT4110
      IF (KER - KERF) 620, 601, 600                                     PLOT4120
  601 KTAB(KER)=JARBO(28)                                               PLOT4130
      GO TO 620                                                         PLOT4140
  600 KTAB(KERF)=JARBO(28)                                              PLOT4150
      KF=(KER-KERF+1)/2+KERF-1                                          PLOT4160
      J=KER+KERF                                                        PLOT4170
      DO 610 I=KERF,KF,1                                                PLOT4180
      IED=IER(I)                                                        PLOT4190
      ITB=ITAB(I)                                                       PLOT4200
      K=J-I                                                             PLOT4210
      IER(I)=IER(K)                                                     PLOT4220
      ITAB(I)=ITAB(K)                                                   PLOT4230
      IER(K)=IED                                                        PLOT4240
  610 ITAB(K)=ITB                                                       PLOT4250
C                                                                       PLOT4260
C     DETERMINE IF LAST VERTICAL PLOTTING INTERVAL IS PLOTTED           PLOT4270
C                                                                       PLOT4280
  620 IF(M3)640,630,640                                                 PLOT4290
  630 IF(PLIM-YMIN)650,225,225                                          PLOT4300
  640 IF(PLIM-XMAX)225,225,650                                          PLOT4310
C                                                                       PLOT4320
C     PUNCH FINAL SCALE                                                 PLOT4330
C                                                                       PLOT4340
  650 IF(NCOL-80)660,660,670                                            PLOT4350
  660 WRITE(3,125)
      GO TO 680                                                         PLOT4370
  670 WRITE(3,135)
C                                                                       PLOT4390
C     PUNCH OVERPRINT VALUES                                            PLOT4400
C                                                                       PLOT4410
  680 IF(KER)710,710,690                                                PLOT4420
  690 WRITE(3,695)
  695 FORMAT (1H0 16HOVERPRINT VALUES)                                  PLOT4440
      WRITE(3,700) (KTAB(I),ITAB(I),IER(I),I=1,KER)
```

```
700 FORMAT( 2A1, I6)                                          PLOT4460
710 RETURN                                                    PLOT4470
920 WRITE(3,925)
925 FORMAT(1H0, 36HOVERPRINT VALUES HAVE EXCEEDED ARRAY,/     PLOT4490
   11H0, 29HPLOT OF THIS MAP DISCONTINUED)                    PLOT4500
    RETURN                                                    PLOT4510
    END                                                       PLOT4520
```

SUBROUTINE ALPHA

```
                                                * FORTRAN FUNCTIONS TO COMPARE TWO FULL OR DOUBLE WORD ALPHABETIC
                                                * VARIABLES.
                                                * USEAGE..    IF(ALPHA(A,B))1.2,3          FULL WORDS.
                                                *             IF(DALPHA(A,B))1,2.3         DOUBLE WORDS.
                                                * THE IF STATEMENT WILL BRANCH TO 1 IF A IS ALPHABETICALLY BEFORE B
                                                * OR BRANCH TO 2 IF A IS THE SAME AS B, OR TO 3 IF A IS ALPHABETICALLY
                                                * AFTER B. ALPHABETIC SEQUENCE IS BLANK . ( + & $ * ) - / , ( = ' ' =
                                                * A THRU Z AND 0 THRU 9. SEE S/360 MANUAL FOR OTHER CODES.
000000                                          COMALPHA START 0
                                                         ENTRY DALPHA
                                                         ENTRY ALPHA
000000                                                   USING *,15
000000 9207 F01F         0001F                  DALPHA   MVI   COMPAR+1,X'07' SET FOR 8 BYTE COMPARE.
000004 47F0 F012               00012                     B     SAVE
000008 4100 0008               00008            ALPHA    LA    0,ALPHA-DALPHA DECREASE BASE REG
00000C 1BF0                                              SR    15,0           FOR 2ND ENTRY POINT.
00000E 9203 F01F         0001F                           MVI   COMPAR+1,X'03' SET FOR 4 BYTE COMPARE.
000012 9023 D01C               0001C            SAVE     STM   2,3,28(13)     SAVE REG. 2 AND 3 IN CALLING PROG.
000016 9823 1000               00000                     LM    2,3,0(1)       ADDR. OF A AND B TO REG. 2 AND 3.
00001A 6800 F040               00040                     LD    0,ONE          PUT 1. IN FP REG. 0.
00001E D503 2000 3000 00000 00000               COMPAR   CLC   0(4,2),0(3)    COMPARE A WITH B.
000024 4720 F034               00034                     BH    DONE           QUIT IF A IS AFTER B.
000028 4780 F032               00032                     BE    SAME
00002C 2100                                              LNDR  0,0            PUT -1. IN FP REG. 0 IF A BEFORE B.
00002E 47F0 F034               00034                     B     DONE
000032 2B00                                     SAME     SDR   0,0            PUT 0. IN FP REG. 0 IF A SAME AS B.
000034 9823 D01C               0001C            DONE     LM    2,3,28(13)     RESTORE REG. 2 AND 3.
000038 07FE                                              BR    14             RETURN TO CALLING PROGRAM.
00003A 000000000000
000040 4110000000000000                         ONE      DC    D'1.'          FLOATING ONE.
000000                                                   END   DALPHA
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              DOS CL2-0 03/13/67

000000                                 2 CHAIN     START 0
                                       3           SAVE  (14,12)
                                       4+* 360N-CL-453  SAVE      CHANGE LEVEL  2-0
000000 90EC D00C          0000C        5+          STM   14,12,12+4*(14+2-(14+2)/16*16)(13)
000000                                 6           USING CHAIN,15
000004 50D0 F078          00078        7           ST    13,R13
                                       8           LA    13,SAVE (TO AVOID OVERLAYING REGISTER STATUS INFORMATION
000008 41D0 F080          00080                          STORED IN MAINLINE PROGRAM, FOR RETURN BY 'CHNXIT')
00000C 5821 0000          00000        9           L     2,0(1)  GET ADDRESS OF OPERAND OF 'CHAIN'
000010 5822 0000          00000       10           L     2,0(2)  GET OPERAND
000014 5920 F074          00074       11           C     2,CURRENT PHASE        IS SAME AS NOW IN MEMORY
000018 4780 F060          00060       12           BE    BRANCH TO APPROPRIATE ENTRY POINT
00001C 5020 F074          00074       13           ST    2,CURRENT     STORE CURRENT PHASE ID
000020 5920 F0D8          000D8       14           C     2,=F'2'     IS LINK2 DESIRED
000024 4780 F03A          0003A       15           BE    FETCH2
                                      16 FETCH1    LOAD  TRENLNK1
                                      17+* 360N-CL-453  LOAD      CHANGE LEVEL  2-0
000028                                18+FETCH1    DC    0H'0'
000028 4110 F0C8          000C8       19+          LA    1,=CL8'TRENLNK1'
00002C 1B00                           20+          SR    0,0
00002E 0A04                           21+          SVC   4
000030 41D0 F080          00080       22           LA    13,SAVE     TO ENSURE NO DESTRUCTION BY SAVE
000034 58F0 F0DC          000DC       23           L     15,=V(LINK1)
000038 07FF                           24           BR    15
                                      25 FETCH2    LOAD  TRENLNK2
                                      26+* 360N-CL-453  LOAD      CHANGE LEVEL  2-0
00003A                                27+FETCH2    DC    0H'0'
00003A 4110 F0D0          000D0       28+          LA    1,=CL8'TRENLNK2'
00003E 1B00                           29+          SR    0,0
000040 0A04                           30+          SVC   4
000042 41D0 F080          00080       31           LA    13,SAVE     TO ENSURE NO DESTRUCTION BY SAVE
000046 58F0 F0E0          000E0       32           L     15,=V(LINK2)
00004A 07FF                           33           BR    15


                                      35 *   RETURN TO MAINLINE
                                      36 CHNXIT    SAVE  (14,12)
                                      37+* 360N-CL-453  SAVE      CHANGE LEVEL  2-0
00004C 90EC D00C          0000C       38+CHNXIT    STM   14,12,12+4*(14+2-(14+2)/16*16)(13)
000050 4120 004C          0004C       39           LA    2,CHNXIT-CHAIN
000054 1BF2                           40           SR    15,2
000056 58D0 F078          00078       41           L     13,R13
                                      42           RETURN (14,12)
                                      43+* 360N-CL-453  RETURN    CHANGE LEVEL  2-0
00005A 98EC D00C          0000C       44+          LM    14,12,12+4*(14+2-(14+2)/16*16)(13)
00005E 07FE                           45+          BR    14


000060 5920 F0D8          000D8       47 BRANCH    C     2,=F'2'  IDENTIFY PHASE,  GO TO ENTRYPOINT
000064 4780 F06E          0006E       48           BE    BRL2
000068 58E0 F0DC          000DC       49           L     14,=V(LINK1)  PICK UP ENTRY POINT
```

```
  LOC  OBJECT CODE     ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              DOS CL2-0 03/13/67

00006C 07FE                           50            BR     14     BRANCH
00006E 58E0 F0E0              000E0   51 BRL2       L      14,=V(LINK2)
000072 07FE                           52            BR     14
000074 00000000                       53 CURRENT    DC     F'0'        LABEL OF CURRENTLY RETRIEVED PHASE OVERLAY
000078                                54 R13        DS     F
000080                                55 SAVE       DS     9D
0000C8                                56            LTORG
0000C8 E3D9C5D5D3D5D2F1               57                   =CL8'TRENLNK1'
0000D0 E3D9C5D5D3D5D2F2               58                   =CL8'TRENLNK2'
0000D8 00000002                       59                   =F'2'
0000DC 00000000                       60                   =V(LINK1)
0000E0 00000000                       61                   =V(LINK2)
                                      62            ENTRY  CHNXIT
                                      63            END
```

STORAGE MAP

03/13/67	PHASE	XFR-AD	LOCORE	HICORE	DSK-AD	ESD TYPE	LABEL	LOADED	REL-FR
COMMON						COM		002000	001E70
ROOT	TRENMAIN	003E70	003E70	005E2F	2D 3 1	CSECT	FORTMAIN	003E70	003E70
						CSECT	IJTACOM	004260	004260
						ENTRY	IJTSAVE	0047AC	
						CSECT	CHAIN	004130	004130
						ENTRY	CHNXIT	00417C	
						CSECT	IJTFXIT	005E18	005E18
						ENTRY	EXIT	005E1E	
						CSECT	RANGE	003FE8	003FE8
						CSECT	COMALPHA	004218	004218
						* ENTRY	DALPHA	004218	
						ENTRY	ALPHA	004220	
						CSECT	IJTACON	004AC0	004AC0
						* ENTRY	FCVFI	004AC0	
						* ENTRY	FCVFO	004AC4	
						* ENTRY	FCVEI	004AC8	
						* ENTRY	FCVEO	004ACC	
						* ENTRY	FCVII	004AD0	
						* ENTRY	FCVIO	004AD4	
						* ENTRY	FCVDI	004C68	
						* ENTRY	FCVDO	004E58	
						CSECT	IJTFIOS	005408	005408
						ENTRY	UNITABE	005C3E	
						ENTRY	DOIOXXE	005A3E	
						ENTRY	GETUNTE	0057B8	
						ENTRY	OPENUNE	005806	
						ENTRY	SETLGUE	0058FC	
						ENTRY	CCWNO1E	005BE0	
						ENTRY	DSKWTME	005ADC	
						* ENTRY	ASNBUFE	005C7C	
						* ENTRY	FILTABE	005B70	
						ENTRY	IJJCPD1N	005408	
	TRENLNK1	005E30	005E30	00C1D7	2D 5 2	CSECT	LINK1	005E30	005E30
						CSECT	IJTARBE	00BE50	00BE50
						CSECT	IJTAAFR	00BD80	00BD80
						CSECT	EMSLVR	006B90	006B90
						CSECT	T2	007548	007548
						CSECT	IJTSSQT	00C130	00C130
						ENTRY	SQRT	00C136	

STORAGE MAP (Continued)

03/13/67	PHASE	XFR-AD	LOCORE	HICORE	DSK-AD	ESD TYPE	LABEL	LOADED	REL-FR
						CSECT	CONTUR	00AA38	00AA38
	TRENLNK2	005E30	005E30	0093D0	2E 3 1	CSECT	LINK2	005E30	005E30
						CSECT	IJTARBE	008FF0	008FF0
						CSECT	IJTAAFR	008F50	008F50
						CSECT	ORDER3	006770	006770
						CSECT	PLOT3	006AD0	006AD0
						CSECT	IJTSLOG	0092D0	0092D0
						ENTRY	ALOG	0092EE	
						* ENTRY	ALOG10	0092D8	

SAMPLE PROGRAM OUTPUT

Program output is verbatim from Merriam (1966).

Output from the preceding sample data and control cards are listed below and on the following pages.

EXPLANATION OF OUTPUT

"Error measures for the various surfaces are computed from the following formulas:

The "TOTAL VARIATION," V, is given by

$$V = \sum_{i=1}^{N} (z_i - \overline{z})^2$$

where z_i is the ith z data coordinate,

$$\overline{z} = \frac{\sum_{i=1}^{N} z_i}{N}$$

V is calculated entirely from the input data and hence is the same for each surface.

The "VARIATION NOT EXPLAINED BY SURFACE," S, is given by

$$S = \sum_{i=1}^{N} (z_{i\ \text{observed}} - z_{i\ \text{calculated}})^2.$$

This value is obtained by squaring the appropriate order of residuals and summing. The "VARIATION EXPLAINED BY SURFACE," E, is given by

$$E = V - S.$$

The "COEFFICIENT OF DETERMINATION," T, is given by

$$T = \frac{E}{V}.$$

The value E, and hence T, may be negative if S is sufficiently large. The "COEFFICIENT OF CORRELATION," L, is given by

$$L = T^{1/2}.$$

If T is negative, L also is output as a negative number (Spiegel, 1961, p. 252-253). The "STANDARD DEVIATION," D, is given by

$$D = \left(\frac{S}{N}\right)^{1/2}$$

where N is the number of sets of data coordinates. Each of these quantities is calculated for each surface. If the equation of a particular surface is not calculated, the corresponding error measures are printed as zeros.

The scale on the left edge of the contour map reads directly in terms of whichever scale is specified as vertical, but the horizontal scales do not read directly. On the horizontal scales, only the units digits of the scale values are shown; blanks in the scales represent increments of ten. For example, the left-most blank represents ten and the next blank to the right represents 20. After the reading is made on the horizontal scale, the reading must be substituted for "SCALE VALUE" in the formula for the horizontal scale. The value given by this substitution corresponds directly to the original units of the horizontal axis (x or y). Scales are positioned on contour maps so that any character on the map is in direct line with the scales both vertically and horizontally. Any given character is selected from a calculation of the value of the surface of the center of the small region in which the character is plotted.

Contours are read in the following manner. The reference contour runs along the "letter-edge" of the band of dots. From this reference contour each edge of each band of characters represents an increment of one contour interval -- the letter bands proceeding downward (A,B,C,.....) from the reference contour and the number bands upward (0,1,2,.....). Both letter and number bands feature "wrap-around" character selection. For example, if a surface reaches a greater value above the reference contour than can be contoured by using 10 different bands of digits, the next higher band of digits is a band of 0's, the next a band of 1's, the next a band of 2's, etc. The same is true of letter bands. The next band lower than Z is A, the next lower is B, etc. The character selection may "wrap around" any number of times, but the reference band is printed only once. A result of this "wrap-around" feature is that unless the reference band is printed on the contour map, the specific values represented by the other band are not uniquely determined by the character in the band.

Contour maps are printed in the order in which they are encountered in the input data for Link 1. If it is specified that a surface be contoured but the equation of that surface has not been determined, the contouring of that surface is bypassed.

The next section of output is the plotting of the original data and the first through sixth-degree residuals on the x y plane. Again, if a certain order of residual is specified to be plotted but the equation of the corresponding surface has not been determined, the plotting of these residuals is bypassed.

Each residual plot is also preceded by the program title, name of the plot, plotting limits, and orientation of the scales. The plots may contain one additional preliminary statement. The plotting routine is designed so that the number of digits in the largest plotted value is always four. If values to be plotted do not have this property, the entire set of values is multiplied successively either by 10 or 0.1 until this property is attained. If the plotted values are scaled, the scale factor is printed.

The scales for axes residual plots are interpreted somewhat differently from the scales of the contour maps. Conversion of the horizontal scale reading, however, is the same. The position of the plotted number is indicated by the sign of the number. A zero is preceded by a plus sign. In addition, the horizontal scale should be shifted half a space to the left, and the vertical scale half a line upward while the plotted values remain stationary. Thus the scales establish horizontal and vertical limits on the location of the sign of the number rather than defining a unique central position. These limits may be made as small as possible by enlarging the printing area. (It should be noted that by proper manual selection of plotting limits, the total width of the plots and contour maps may be made to occupy more than one page by specifying identical plots with adjacent plotting limits).

Several symbols other than numbers may occur on the plots. These are the "overprint characters;" their meaning is explained below.

* An attempt was made to write a number, but before it was completed another number to the right was encountered.

B Two numbers fall within the limits of the region of this position.

C Three numbers fall within the limits of the region of this position.

D Four numbers fall within the limits of the region of this position.

.
.
.

I Nine numbers fall within the limits of the region of this position.

Z Ten or more numbers fall within the limits of the region of this position.

The "overprint characters" are printed on the plot, and the "OVERPRINT VALUES" that they represent are listed in a single column following the plot. Each time a new line containing overprint values is encountered on the plot, a double space is made in the column of overprint values. Overprint values for this line are then read from left to right across the plot. The table of "OVERPRINT VALUES" is limited to 150 numbers. If control points are clustered or an unfortunate choice of SCALE VALUES results in more than 150 overprint values, the plot is discontinued, overprint values are suppressed, and a message is printed on the incomplete plot.

ERROR MESSAGES

Twenty-eight error messages have been built into the program to indicate that invalid data or control cards have been encountered in the program. These data or control card errors and the messages generated by the erros are listed below:

Program errors

1 Number of sets of data points outside allowable range (1-500).

2 Indicator for calculation of first-degree equation outside allowable range (0-1).

3 Indicator for calculation of second-degree equation outside allowable range (0-1).

4 Indicator for calculation of third-degree equation outside allowable range (0-1).

5 Indicator for calculation of fourth-degree equation outside allowable range (0-1).

6 Indicator for calculation of fifth-degree equation outside allowable range (0-1).

7 Indicator for calculation of sixth-degree equation outside allowable range (0-1).

8 Indicators for calculation of first-, second-, third-, fourth-, fifth-, and sixth-degree equations are all zero.

9 Residual plot indicator outside allowable range (0-6).

10 Plotting limit indicator for residual map outside allowable range (0-1).

11 Indicator for use of Link 2 outside allowable range (0-1).

12 Use of Link 2 attempted without proper specification in Link 1.

13 Contour map indicator outside allowable range (1-6).

14 Plotting limit indicator for contour map outside allowable range (0-1).

Subroutine CONTUR Errors

1 Indicator for evaluation subroutines outside allowable range (1-6).

2 Indicator for orientation outside allowable range (1-4).

3 Card tabulator indicator outside allowable range (0-1).

4 Number of columns of output outside allowable range (12-120).

5 Contour interval negative or zero.

6 Maximum x-plotting limit less than or equal to minimum x-plotting limit.

7 Maximum y-plotting limit less than or equal to minimum y-plotting limit.

Subroutine PLOT3 Errors

1 Number of points to be plotted outside allowable range (1-500).

2 Orientation indicator outside allowable range (1-4).

3 Number of columns of output outside allowable range (16-120).

4 Card tabulator indicator outside allowable range (0-1).

5 Indicator for previous ordering of elements outside allowable range (0-2).

6 Maximum x-plotting limit less than or equal to minimum x-plotting limit.

7 Maximum y-plotting limit less than or equal to minimum y-plotting limit."

SAMPLE OUTPUT

Examples of the output follow. This includes:

1. Tabulated input data, 1st degree through 5th degree surface values with corresponding residuals.
2. Statistical calculations.
3. Contoured 1st, 2nd, 3rd, and 4th surfaces.
4. Plot of original data.
5. Plot of 1st degree residuals.

X-COORD	Y-COORD	Z-VALUE	1ST-SURF	1ST-RESID	2ND-SURF	2ND-RESID	3RD-SURF	3RD-RESID
CLEARY HILL AREA	A ZINC VALUES	HEINER & WOLFF						
1.800	4.600	125.000	111.320	13.680	140.505	-15.505	99.568	25.432
1.800	4.200	175.000	112.811	62.189	151.337	23.663	148.172	26.828
1.800	3.800	175.000	114.302	60.698	158.583	16.417	179.236	-4.236
1.800	3.400	175.000	115.793	59.207	162.243	12.757	194.778	-19.778
1.800	3.000	200.000	117.284	82.716	162.318	37.682	196.818	3.182
1.800	2.600	200.000	118.775	81.225	158.807	41.193	187.373	12.627
1.800	2.200	175.000	120.265	54.735	151.710	23.290	168.462	6.538
1.800	1.800	125.000	121.756	3.244	141.027	-16.027	142.103	-17.103
1.800	1.400	125.000	123.247	1.753	126.758	-1.758	110.314	14.686
2.600	4.200	100.000	121.034	-21.034	125.787	-25.787	102.033	-2.033
2.600	3.800	75.000	122.525	-47.525	133.776	-58.776	128.709	-53.709
2.600	3.400	125.000	124.016	0.984	138.179	-13.179	141.986	-16.986
2.600	3.000	75.000	125.507	-50.507	138.996	-63.996	143.884	-68.884
2.600	2.600	250.000	126.998	123.002	136.228	113.772	136.421	113.579
2.600	2.200	200.000	128.489	71.511	129.873	70.127	121.615	78.385
2.600	1.800	1.000	129.980	-128.980	119.933	-118.933	101.485	-100.485
2.600	1.400	50.000	131.470	-81.470	106.408	-56.408	78.049	-28.049
4.200	4.200	50.000	137.480	-87.480	102.125	-52.125	85.226	-35.226
4.200	3.800	75.000	138.971	-63.971	111.600	-36.600	102.920	-27.920
4.200	3.400	75.000	140.462	-65.462	117.488	-42.488	111.463	-36.463
4.200	3.000	200.000	141.953	58.047	119.791	80.209	112.873	87.127
4.200	2.600	50.000	143.444	-93.444	118.508	-68.508	109.169	-59.169
4.200	2.200	50.000	144.935	-94.935	113.639	-63.639	102.369	-52.369
4.200	1.800	200.000	146.426	53.574	105.184	94.816	94.492	105.508
5.000	4.200	75.000	145.703	-70.703	104.014	-29.014	102.576	-27.576
5.000	3.800	200.000	147.194	52.806	114.230	85.770	115.677	84.323
5.000	3.400	50.000	148.685	-98.685	120.861	-70.861	121.751	-71.751
5.000	3.000	50.000	150.176	-100.176	123.907	-73.907	122.815	-72.815
5.000	2.600	200.000	151.667	48.333	123.366	76.634	120.888	79.112
5.000	2.200	125.000	153.158	-28.158	119.240	5.760	117.989	7.011
5.000	1.800	150.000	154.649	-4.649	111.528	38.472	116.135	33.865
5.800	4.200	175.000	153.926	21.074	115.047	59.953	129.108	45.892
5.800	3.800	150.000	155.417	-5.417	126.007	23.993	137.549	12.451
5.800	3.400	200.000	156.908	43.092	133.381	66.619	141.084	58.916
5.800	3.000	175.000	158.399	16.601	137.169	37.831	141.734	33.266
5.800	2.600	75.000	159.890	-84.890	137.371	-62.371	141.516	-66.516
5.800	2.200	200.000	161.381	38.619	133.988	66.012	142.449	57.551
5.800	1.800	100.000	162.872	-62.872	127.018	-27.018	146.552	-46.552
7.400	4.600	175.000	168.882	6.118	148.522	26.478	184.166	-9.166
7.400	4.200	125.000	170.373	-45.373	164.553	-39.553	185.756	-60.756
7.400	3.800	350.000	171.863	178.137	176.998	173.002	184.670	165.330
7.400	3.400	125.000	173.354	-48.354	185.857	-60.857	182.926	-57.926
7.400	3.000	150.000	174.845	-24.845	191.131	-41.131	182.542	-32.542
7.400	2.600	200.000	176.336	23.664	192.818	7.182	185.538	14.462
7.400	2.200	100.000	177.827	-77.827	190.920	-90.920	193.932	-93.932
7.400	1.800	125.000	179.318	-54.318	185.436	-60.436	209.741	-84.741
8.200	4.200	175.000	178.596	-3.596	203.025	-28.025	203.891	-28.891
8.200	3.800	200.000	180.087	19.913	216.212	-16.212	197.939	2.061
8.200	3.000	175.000	183.069	-8.069	231.830	-56.830	192.450	-17.450
8.200	2.600	200.000	184.559	15.441	234.261	-34.261	196.951	3.049
8.200	2.200	350.000	186.050	163.950	233.105	116.895	208.972	141.028
8.200	1.800	125.000	187.541	-62.541	228.364	-103.364	230.533	-105.533
8.200	1.400	350.000	189.032	160.968	220.037	129.963	263.652	86.348

CLEARY HILL AREA A ZINC VALUES HEINER & WOLFF

X-COORD	Y-COORD	Z-VALUE	4TH-SURF	4TH-RESID	5TH-SURF	5TH-RESID	6TH-SURF	6TH-RESID
1.800	4.600	125.000	143.128	-18.128	123.553	1.447	134.124	-9.124
1.800	4.200	175.000	158.146	16.854	183.402	-8.402	145.004	29.996
1.800	3.800	175.000	179.386	-4.386	161.477	13.523	205.830	-30.830
1.800	3.400	175.000	198.561	-23.561	162.956	12.044	172.137	2.863
1.800	3.000	200.000	208.816	-8.816	196.842	3.158	159.797	40.203
1.800	2.600	200.000	204.727	-4.727	223.162	-23.162	210.879	-10.879
1.800	2.200	175.000	182.300	-7.300	199.266	-24.266	224.385	-49.385
1.800	1.800	125.000	138.977	-13.977	126.601	-1.601	99.538	25.462
1.800	1.400	125.000	73.628	51.372	96.982	28.018	120.387	4.613
2.600	4.200	100.000	52.900	47.100	93.577	6.423	76.846	23.154
2.600	3.800	75.000	82.750	-7.750	103.926	-28.926	114.016	-39.016
2.600	3.400	125.000	109.835	15.165	113.868	11.132	111.886	13.114
2.600	3.000	75.000	129.311	-54.311	141.415	-66.415	131.252	-56.252
2.600	2.600	250.000	137.767	112.233	156.747	93.253	185.575	64.425
2.600	2.200	200.000	133.225	66.775	127.573	72.427	171.496	28.504
2.600	1.800	1.000	115.139	-114.139	66.337	-65.337	16.592	-15.592
2.600	1.400	50.000	84.393	-34.393	76.434	-26.434	66.806	-16.806
4.200	4.200	50.000	64.885	-14.885	42.708	7.292	53.475	-3.475
4.200	3.800	75.000	87.326	-12.326	76.700	-1.700	72.944	2.056
4.200	3.400	75.000	104.185	-29.185	90.135	-15.135	75.127	-0.127
4.200	3.000	200.000	114.654	85.346	113.262	86.738	92.139	107.861
4.200	2.600	50.000	119.351	-69.351	129.217	-79.217	139.588	-89.588
4.200	2.200	50.000	120.319	-70.319	119.925	-69.925	147.756	-97.756
4.200	1.800	200.000	121.040	78.960	113.169	86.831	117.041	82.959
5.000	4.200	75.000	112.883	-37.883	97.287	-22.287	97.448	-22.448
5.000	3.800	200.000	126.443	73.557	117.536	82.464	126.830	73.170
5.000	3.400	50.000	132.317	-82.317	116.932	-66.932	112.834	-62.834
5.000	3.000	50.000	131.705	-81.705	128.585	-78.585	101.811	-51.811
5.000	2.600	200.000	127.237	72.763	138.669	61.331	124.397	75.603
5.000	2.200	125.000	122.975	2.025	132.922	-7.922	131.405	-6.405
5.000	1.800	150.000	124.413	25.587	143.433	6.567	153.018	-3.018
5.800	4.200	175.000	157.201	17.799	174.904	0.096	157.006	17.994
5.800	3.800	150.000	163.197	-13.197	170.787	-20.787	204.444	-54.444
5.800	3.400	200.000	158.932	41.068	149.606	50.394	174.506	25.494
5.800	3.000	175.000	147.615	27.385	144.480	30.520	133.819	41.181
5.800	2.600	75.000	133.891	-58.891	142.825	-67.825	127.631	-52.631
5.800	2.200	200.000	123.836	76.164	131.846	68.154	119.768	80.232
5.800	1.800	100.000	124.963	-24.963	145.707	-45.707	155.549	-55.549
7.400	4.600	175.000	160.095	14.905	147.356	27.644	159.944	15.056
7.400	4.200	125.000	191.831	-66.831	245.207	-120.207	178.319	-53.319
7.400	3.800	350.000	200.934	149.066	216.313	133.687	241.256	108.744
7.400	3.400	125.000	193.214	-68.214	180.453	-55.453	203.131	-78.131
7.400	3.000	150.000	175.906	-25.906	165.094	-15.094	162.069	-12.069
7.400	2.600	200.000	157.693	42.307	152.766	47.234	161.569	38.431
7.400	2.200	100.000	148.667	-48.667	127.078	-27.078	139.998	-39.998
7.400	1.800	125.000	160.368	-35.368	119.684	5.316	99.084	25.916
8.200	4.200	175.000	182.357	-7.357	169.867	5.133	182.194	-7.194
8.200	3.800	200.000	209.274	-9.274	182.973	17.027	187.131	12.869
8.200	3.000	175.000	209.949	-34.949	216.742	-41.742	166.444	8.556
8.200	2.600	200.000	203.639	-3.639	235.559	-35.559	245.522	-45.522
8.200	2.200	350.000	208.580	141.420	226.301	123.699	272.791	77.209
8.200	1.800	125.000	238.316	-113.316	216.056	-91.056	176.303	-51.303
8.200	1.400	350.000	307.831	42.169	326.685	23.315	339.229	10.771

CLEARY HILL AREA A ZINC VALUES HEINER & WOLFF

COEFFICIENTS OF FIRST-DEGREE EQUATION

```
Z =      109.96370 +      10.27890 X +      -3.72738 Y
```

COEFFICIENTS OF SECOND-DEGREE EQUATION

```
Z =      121.96134 +     -53.62819 X +      75.70629 Y +       7.14523 X2 +      -2.32092 XY +     -11.20548 Y2
```

COEFFICIENTS OF THIRD-DEGREE EQUATION

```
Z =       82.33379 +    -112.06672 X +     178.89207 Y +      35.86439 X2 +     -53.22859 XY +      -3.51221 Y2 +
      -1.95002 X3 +       0.13318 X2Y +      8.29452 XY2 +     -5.25635 Y3
```

COEFFICIENTS OF FOURTH-DEGREE EQUATION

```
Z =     -900.61790 +     317.38703 X +    1034.09568 Y +      22.64319 X2 +    -466.05490 XY +    -164.62384 Y2 +
     -11.06947 X3 +      50.19601 X2Y +     77.01661 XY2 +     -3.90582 Y3 +       0.88320 X4 +      -2.90731 X3Y +
      -1.14432 X2Y2 +    -6.55479 XY3 +      2.33041 Y4
```

COEFFICIENTS OF FIFTH-DEGREE EQUATION

```
Z =     5437.45318 +    -732.15825 X +   -9879.71934 Y +     502.45234 X2 +    -408.21164 XY +    8026.86923 Y2 +
     -55.30572 X3 +    -221.84234 X2Y +    418.97938 XY2 +  -3114.51078 Y3 +      -1.07526 X4 +      39.46240 X3Y +
     -10.85890 X2Y2 +   -66.61468 XY3 +    561.76284 Y4 +        0.25426 X5 +      -1.51074 X4Y +      -2.10805 X3Y2 +
       4.53431 X2Y3 +     1.13095 XY4 +    -37.86737 Y5
```

COEFFICIENTS OF SIXTH-DEGREE EQUATION

```
Z =    44689.00622 +  -10002.24113 X +  -88899.51056 Y +    5317.79619 X2 +    2680.67309 XY +   80517.50244 Y2 +
    -922.84966 X3 +  -3068.46493 X2Y +   2164.78669 XY2 + -39151.97022 Y3 +      82.59878 X4 +     427.51956 X3Y +
     537.82421 X2Y2 + -1102.22680 XY3 +  10440.25751 Y4 +       -5.05674 X5 +     -15.88500 X4Y +     -89.04009 X3Y2 +
      21.17667 X2Y3 +   146.57134 XY4 +  -1429.20669 Y5 +        0.15649 X6 +       0.21266 X5Y +       1.54851 X4Y2 +
       6.36699X3Y3 +     -9.07100 X2Y4 +     -3.45165 XY5 +     78.18539 Y6
```

ERROR MEASURES

SURFACE	FIRST-DEGREE	SECOND-DEGREE	THIRD-DEGREE	FOURTH-DEGREE	FIFTH-DEGREE	SIXTH-DEGREE
STANDARD DEVIATION	71.55	65.06	62.41	58.52	54.96	49.21
VARIATION EXPLAINED BY SURFACE	0.28445188E 05	0.74562500E 05	0.92103563E 05	0.11655356E 06	0.13759969E 06	0.16872581E 06
VARIATION NOT EXPLAINED BY SURFACE	0.26621081E 06	0.22009350E 06	0.20255244E 06	0.17810244E 06	0.15705631E 06	0.12593019E 06
TOTAL VARIATION	0.29465600E 06	0.29465600E 06	0.29465600E 06	0.29465600E 06	0.29465600E 06	0.29465600E 06
COEFFICIENT OF DETERMINATION	0.09653693	0.25304931	0.31257993	0.39555806	0.46698415	0.57261962
COEFFICIENT OF CORRELATION	0.31070393	0.50304008	0.55908847	0.62893409	0.68336242	0.75671637

CLEARY HILL AREA A ZINC VALUES HEINER & WOLFF

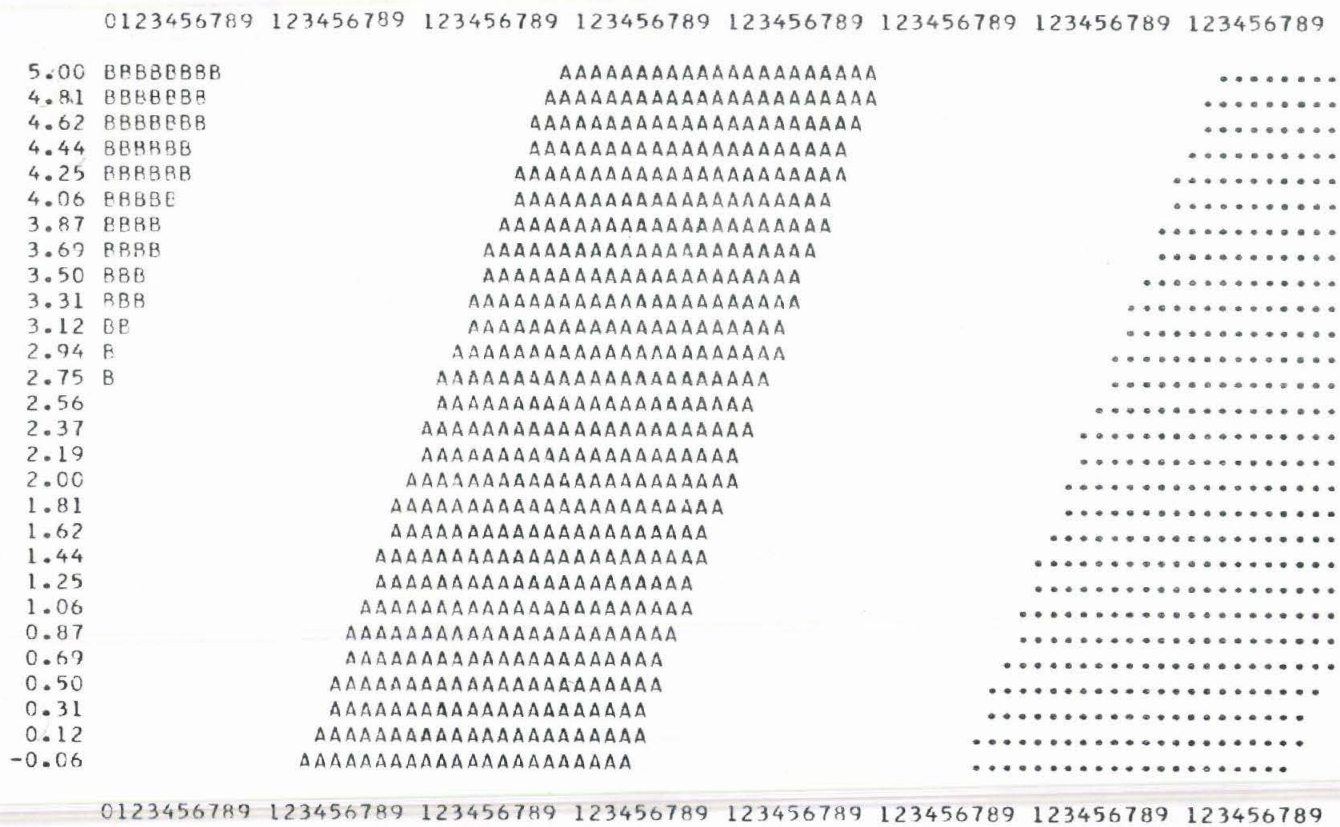
CONTOURED FIRST-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 9.000000 MINIMUM X = 0.0
MAXIMUM Y = 5.000000 MINIMUM Y = 0.0

X-SCALE IS HORIZONTAL
X-VALUE = 0.0 + 0.1125 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 25.00
REFERENCE CONTOUR (.....) = 175.00



CLEARY HILL AREA A ZINC VALUES HEINER & WOLFF

CONTOURED SECOND-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 9.000000 MINIMUM X = 0.0
MAXIMUM Y = 5.000000 MINIMUM Y = 0.0

X-SCALE IS HORIZONTAL
X-VALUE = 0.0 + 0.1125 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 25.00
REFERENCE CONTOUR (.....) = 175.00

```
      0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

 5.00    ....     AAAAA      BBBBBBBBBBBB            BBBBBBBBBBBB      AAAAAA    ....
 4.81 0   ....     AAAAA        BBBBBBBBBBBBBBBBBBBBBBBBBBBBBB       AAAAAA    ....
 4.62 00   ....     AAAAAA         BBBBBBBBBBBBBBBBBBBBBBB         AAAAAA     ....   0
 4.44 00    ....     AAAAAAA          BBBBBBBBBBBBBBBB           AAAAAA     ....   000
 4.25 000    ....      AAAAAA                                  AAAAAA      ....   0000
 4.06 000    .....      AAAAAAA                             AAAAAAAA     .....    0000
 3.87 0000    .....     AAAAAAAAA                         AAAAAAAAA     .....    0000
 3.69 0000    .....      AAAAAAAAA                      AAAAAAAAA      .....    0000
 3.50 0000    .....       AAAAAAAAA                    AAAAAAAAA      .....     000
 3.31 0000     .....      AAAAAAAAAA                 AAAAAAAAAA       .....    0000   1
 3.12 0000     .....      AAAAAAAAAAA               AAAAAAAAAAA      .....     000    1
 2.94 0000    .....       AAAAAAAAAAA               AAAAAAAAAA       .....    0000    1
 2.75 0000    .....      AAAAAAAAAAA                AAAAAAAAAA       .....    0000   11
 2.56 000    .....       AAAAAAAAAA                 AAAAAAAAAA       .....    0000   11
 2.37 000    .....      AAAAAAAAA                    AAAAAAAAAA      .....    0000   11
 2.19 00    .....      AAAAAAAAA                      AAAAAAAAA      .....    0000   11
 2.00 0    .....      AAAAAAAA                          AAAAAAAA      ....    0000   11
 1.81     .....     AAAAAAAA                             AAAAAAAA      .....   000    1
 1.62    ....      AAAAAAA                                 AAAAAAA     ....    0000   1
 1.44   ....     AAAAAA           BBBBBBBBBBBBBBBB          AAAAAAA     ....    000
 1.25 .....    AAAAAA         BBBBBBBBBBBBBBBBBBBBBBBB        AAAAAA     ....    000
 1.06 ...     AAAAA       BBBBBBBBBBBBBBBBBBBBBBBBBBBBBB        AAAAA     ....   0000
 0.87 .     AAAAA      BBBBBBBBBBBB             BBBBBBBBBBB       AAAAA    ....   0000
 0.69     AAAA      BBBBBBBBB                        BBBBBBBB      AAAAA     ....  000
 0.50   AAAA      BBBBBBB                                BBBBBBB     AAAAA   ....  000
 0.31 AAAA     BBBBBB         CCCCCCCCCCCCCCCCCCCC          BBBBBB     AAAA     ...  00
 0.12 AA    BBBBBB       CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC       BBBBBB     AAAA   ...
-0.06    BBBBB       CCCCCCCCC                   CCCCCCCCCC      BBBBB    AAAA    ...

      0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
```

```
CLEARY HILL AREA  A  ZINC VALUES  HEINER & WOLFF

CONTOURED THIRD-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X =        9.000000     MINIMUM X =        0.0
MAXIMUM Y =        5.000000     MINIMUM Y =        0.0

X-SCALE IS HORIZONTAL
X-VALUE =    0.0  +  0.1125 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL =                          25.00
REFERENCE CONTOUR (.....) =                175.00

          0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

     5.00 0 .. AA  BB   CCCC      DDDDDDDDD       CCCCC     BBBB    AAAA    .....      0000
     4.81 1 0  .  AA   BB    CCCCCCC       CCCCCCCCC     BBBBB    AAAA    .....        00
     4.62  11 0  ..  AA   BBBB     CCCCCCCCCC        BBBBBB   AAAAA    ......
     4.44 22 1  0  ..  AAA   BBBBBB              BBBBBBB    AAAAA    .......
     4.25 3 2 11 00  ..   AAA   BBBBBBBBBBBBBBBBBBBBBB     AAAAAA    ........
     4.06 33 2  1  00  ..   AAA    BBBBBBBBBBBBBBB      AAAAAA    .........
     3.87  33 2  1  00  ..   AAAAA        BBBBB        AAAAAAA   ...........
     3.69 4 3 22 11  00  ...   AAAA                   AAAAAAA   ...........      ..
     3.50 4 33 2  11 00   ..   AAAAA                 AAAAAAAA   .................
     3.31 4  3 22 11  00  ...  AAAAAA               AAAAAAAAA   .................
     3.12 4  3 22 11  00  ...   AAAAA               AAAAAAAAA   .................
     2.94 4  3 22 11  00  ...  AAAAAA               AAAAAAAAA   .................
     2.75 4 33 2  11 00   ..   AAAAA                AAAAAAAAA   .................
     2.56 4 3 22 11  00  ...  AAAAA                  AAAAAAAA  ..................
     2.37  33 2  1  00  ...  AAAA                    AAAAAAA  ..........
     2.19  3 2  1  00  ...  AAAA         BBBB        AAAAAAA  .......
     2.00 3 22 1  00  ..  AAAA     BBBBBBBBBBBB      AAAAAA  .......
     1.81  2  1  00  ..  AAA    BBBBBBBBBBBBBBBB     AAAAAA  ......        0000000000
     1.62 2  1  0  ..  AAA   BBBBBBBBBBBBBBBBBBBB    AAAAA  .....      000000000
     1.44  11 00  ..  AAA   BBBBBBB     BBBBBBBBB    AAAA  ....    00000
     1.25 1  0  ..  AAA   BBBBB            BBBBBB   AAAA   ....   00000     111111111
     1.06  00 ..  AAA   BBBB               BBBBB   AAAA   ...   0000    11111
     0.87 0  .  AA   BBB      CCCCCCCCC    BBBBB   AAA   ....  000    111     222222
     0.69  .  AA  BBB    CCCCCCCCCCCCCCC   BBBB   AAA  ...  000   111   2222     3333
     0.50   AA  BB    CCCCCC       CCCCCCC   BBBB  AAA  ..  000  111  222  3333    44
     0.31 A  BBB   CCCC            CCCCC   BBB  AAA ...  000  11   22   333   444
     0.12  BB  CCCC     DDDDDDDD     CCCC   BB  AAA ..  000  11  22   33   44   555
    -0.06   CCC    DDDDDDDDDDDDDDD    CCC   BBB  AA  ...  00  11  22  33  44  555  666   7

          0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
```

```
CLEARY HILL AREA  A  ZINC VALUES  HEINER & WOLFF

CONTOURED FOURTH DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X =       9.000000     MINIMUM X =       0.0
MAXIMUM Y =       5.000000     MINIMUM Y =       0.0

X-SCALE IS HORIZONTAL
X-VALUE =    0.0  +  0.1125 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL =                        25.00
REFERENCE CONTOUR (.....) =               175.00

         0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

 5.00   42 9 6543210  A B  C   DDDDDDDDDDD   CCCC   BBBB                   BBBB  CC  DD  E
 4.81 753 0 76      0  A B  CC   DDDDDDD     CCC    BBB    AAAAAAAAAAAAAAA   BBB   CC
 4.62 64 1 8        0. A BB CCC            CCCC  BBB    AAAAA                AAAAA   BBBB
 4.44   2 9   43    0  A  B  CCC        CCCCC  BBBB   AAAA        ........      AAAAA
 4.25 53 0  65432  0 . A BB   CCCCCCCCCCC   BBB    AAAA     .................
 4.06  310 76543  10 . AA BB   CCCCCCC    BBBB    AAAA     .........................
 3.87 4 1  76543  1  .. A  BBB           BBBBB    AAAA     ...........
 3.69  2 9876543  1 0 . AA  BBBBB     BBBBBB     AAAAA     ...........            0000
 3.50 3 098  543  1 0 .. AA   BBBBBBBBBBBBBB     AAAAAA      ...........         0000
 3.31  10     43  1 0  .  AA     BBBBBBBB       AAAAAAA       ...........      000
 3.12 2  876   3  1 00 ..  AAA                 AAAAAAAAA           .......      000  1
 2.94 10   654 32 1 00 ..  AAAA                AAAAAAAAAAAAA           .....    000  1
 2.75  9876  43 2 1 0  ..   AAAA               AAAAAAAAAAAAAAAAAAA        ....   00  11
 2.56        4  2 1  0  ..   AAAAA              AAAAAAAAAAAAAAAAAAAAA      ...   00  1
 2.37 8   54 32 11 0  ..   AAAAAA                  AAAAAAAAAAAAAAAAAAAA    ...   00 1
 2.19 76  43 2 1  0  ..  AAAAAA                            AAAAAAAAAAA   ...   0  1 2
 2.00  54 32 11 0  ..   AAAAAA                               AAAAAAAA    ..  0  1 2
 1.81 4  2 1 00 ..   AAAAA                              AAAAAAAAAAAA   ...  0  1 2 3
 1.62 2 1 0  ..  AAA                         AAAAAAAAAAAAAAAAAAAAAA    ...  00 1 2 3 4
 1.44 0  .  AA    BBBBBBBBBBBBBBBBB        AAAAAAAAAAAAAAAAAA       ...   00 1  2 34 5
 1.25 A  BB   CCCCCCCCCCC     BBBBB      AAAAAAAAAA           .....   000 11 22 34 5
 1.06   DDDD   DDDDDD    CCCC   BBBB    AAAAA        ........    000   11 22 3 4 56  8
 0.87 F    FFFFF   EEE  DDD  CCC  BBB   AAAA   .....      0000    11   22 33 4 5  7   0
 0.69 IIII   HH  GG FF  EE DD  CC  BB  AAA   ...   0000    1111  222  3  4 5 6 7  90
 0.50  L  KK JJ I  H GG F EE DD CC BB  A  ...  000  111   222  33  44  5 6 7 8  0
 0.31  OO N M L K J I H G F E D  C B  A  .  00  11  22  333  44 55  6 7  89 0  23      9
 0.12 S R QP ON M  K JI H  F E D C B A  . 0  1  2  33 44  55 66 77 8 9 0 1 23  567890
-0.06 W   TS   PO   LK  IH GF ED C B A. 00 1 2 33 4 55 66 7  8 9 00 1  3 45  7890123  7

         0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
```

CLEARY HILL AREA A ZINC VALUES HEINER & WOLFF

PLOT OF ORIGINAL DATA (Z-COORDINATES)

PLOTTING LIMITS
MAXIMUM X = 9.000000 MINIMUM X = 0.0
MAXIMUM Y = 5.000000 MINIMUM Y = 0.0

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 1 POWER

X-SCALE IS HORIZONTAL
X-VALUE = 0.0 + 0.1125 X (SCALE VALUE)

Y-SCALE IS VERTICAL

0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

5.00							
4.81							
4.63	+1250					+1750	
4.44							
4.25	+1750	+1000	+500	+750	+1750	+1250	+1750
4.06							
3.88	+1750	+750	+750	+2000	+1500	+3500	+2000
3.69							
3.50	+1750	+1250	+750	+500	+2000	+1250	
3.31							
3.13	+2000	+750	+2000	+500	+1750	+1500	+1750
2.94							
2.75	+2000	+2500	+500	+2000	+750	+2000	+2000
2.56							
2.38	+1750	+2000	+500	+1250	+2000	+1000	+3500
2.19							
2.00							
1.81	+1250	+10	+2000	+1500	+1000	+1250	+1250
1.63							
1.44	+1250	+500					+3500
1.25							
1.06							
0.88							
0.69							
0.50							
0.31							
0.13							

0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

CLEARY HILL AREA A ZINC VALUES HEINER & WOLFF

PLOT OF FIRST-DEGREE RESIDUALS

PLOTTING LIMITS
MAXIMUM X =   9.000000   MINIMUM X =   0.0
MAXIMUM Y =   5.000000   MINIMUM Y =   0.0

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE   1 POWER

X-SCALE IS HORIZONTAL
X-VALUE =   0.0 + 0.1125 X (SCALE VALUE)

Y-SCALE IS VERTICAL

```
     0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

5.00
4.81
4.63                +136                                            +61
4.44
4.25                +621  -210          -874   -707   +210          -453   -35
4.06
3.88                +606  -475          -639   +528   -54           +1781  +199
3.69
3.50                +592  +9            -654   -986   +430          -483
3.31
3.13                +827  -505          +580   -1001  +166          -248   -80
2.94
2.75                +812  +1230         -934   +483   -848          +236   +154
2.56
2.38                +547  +715          -949   -281   +386          -778   +1639
2.19
2.00
1.81                +32   -1289         +535   -46    -628          -543   -625
1.63
1.44                +17   -814                                             +1609
1 25
1.06
0.88
0.69
0.50
0.31
0.13

     0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
```

REFERENCES

Allen, P., and Krumbein, W.C., 1962, Secondary trend components in the Top Ashdown Pebble Bed: a case history: Jour. Geol., v. 70, no. 5, p. 507-538.

Chayes, F., and Susuki, Y., 1963, Geological contours and trend surfaces: Jour. Petrology, v. 4, p. 307-312.

Connor, J.J., and Miesch, A.T., 1964, Application of trend analysis to geochemical prospecting data from Beaver County, Utah, in Computers in the mineral industries: Stanford Univ. Publ., Geol. Sciences, v. 9, no. 1, p. 110-125.

Forgotson, J.M., Jr., 1963, How computers help find oil: Oil and Gas Jour., v. 61, no. 11, p. 100-109.

Good, D.I., 1964, FORTRAN II trend-surface program for the IBM 1620: Kansas Geol. Survey Sp. Dist. Publ. 14, 54 p.

Harbaugh, J.W., 1963, BALGOL program for trend-surface mapping using an IBM 7090 computer: Kansas Geol. Survey Sp. Dist. Publ. 3, 17 p.

Harbaugh, J.W., 1964a, Application of four-variable trend hyper-surfaces in oil exploration (abs.), in Computers in the mineral industries: Stanford Univ. Publ., Geol. Sciences, v. 9, no. 2, p. 693.

Harbaugh, J.W., 1964b, Trend-surface mapping of hydrodynamic oil traps with the IBM 7090/94 computer: Colorado Sch. Mines Quart., v. 59, no. 4, p. 557-578.

Krumbein, W.C., 1959, Trend surface analysis of contour-type maps with irregular control-point spacing: Jour. Geophysical Res., v. 64, no. 7, p. 823-834.

McIntyre, D.B., 1963, Program for computation of trend surfaces and residuals of degree 1 through 8: Dept. of Geology, Pomona College, Claremont, California, 24 p.

Merriam, D.F., 1964, Use of trend-surface residuals in interpreting geologic structures, in Computers in the mineral industries: Stanford Univ. Publ., Geol. Sciences, v. 9, no. 2, p. 686-692.

Merriam, D.F., and Harbaugh, J.W., 1964, Trend-surface analysis of regional and residual components of geologic structure in Kansas: Kansas Geol. Survey Sp. Dist. Publ. 11, 27 p.

Merriam, D.F. (Editor), Mont O'Leary, R.H. Lippert, and Owen T. Spitz, 1966, Fortran IV and map program for computation and plotting of trend surfaces for degrees 1 through 6, Kansas Geol. Survey Computer Contribution 3, 48 p.

Miller, R.L., 1956, Trend surfaces: their application to analysis and description of environments of sedimentation: Jour. Geol., v. 64, no. 5, p. 425-446.

Peikert, E.W., 1962, Three-dimensional specific-gravity variation in the Glen Alpine Stock, Sierra Nevada, California: Geol. Soc. America Bull., v. 73, no. 11, p. 1437-1442.

Spiegel, M.R., 1961, Theory and problems of statistics: Schaum's Outline Series, Schaum Publishing Co., New York, p. 252-253.

Whitten, E.H.T., 1959, Composition trends in a granite: modal variations and ghost stratigraphy in part of the Donegal Granite, Erie: Jour. Geophysical Res., v. 64, no. 7, p. 835-848.

Whitten, E.H.T., 1961, Quantitative areal modal analysis of granitic complexes: Geol. Soc. America Bull., v. 72, no. 9, p. 1331-1359.

Whitten, E.H.T., 1963, A surface-fitting program suitable for testing geological modals which involve areally-distributed data: Office of Naval Research, Geography Branch, Tech. Rept. no. 2, 56 p.

Wolfe, J.A., 1962, Geostatistics and the exploration economy, _in_ Mathematical Tech. and Computer Appl. in Mining and Expl., v. 1: Univ. Arizona, Tucson, p. H-1 - H-28.