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Programs for filing and X-Y plotting of isotopic and other data using an HP-9830 computer and HP-9862 plotter

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INTRODUCTION

These programs are derived from ones written for the Hewlett-Packard (HP) model 9831 computer and model 9872 plotter, (Ludwig, 1979a, b), but are written specifically for the HP-9830 computer and HP-9862 plotter, and are optimized for these slower and less powerful machines.

The programs require at least 8K words of memory, a plotter ROM, string-variables ROM, and a printer set to a select code of 15. The data-file program (appendix I) requires a file at least 3300 words in length for storage, and the three segments of the plotter program (appendix II) should be stored sequentially in files of 2400, 3000, and 3300 words in length.

INSTRUCTIONS: DATA-FILE PROGRAM

General Comments

This program permits the user to use a 40 x 20 array to store split-precision (6-digit accuracy) data for up to 40 samples ('sets') and up to 20 variables ('parameters') per sample, with user-defined sample and parameter names. Once stored, the data may be edited, printed out, added to, manipulated, and plotted via subroutines and plotting programs.

If you intend to store a data file, make sure a premarked, empty or expendable file at least 2400 words in length is available.

CREATING A DATA-FILE (OPTION 1)

DISPLAY: FILE NAME?

Input a name (up to 50 characters long) to be assigned to the file.

DISPLAY: PARAMETER 1 NAME?

The parameter names may be up to 2 lines of 12 characters, so this query requires two responses. A question mark will prompt input of the second line. If, using the X-Y plotting programs, you wish the parameter name to be lettered with all numerals as superscripts, input ↑ as the first character of the first line (e.g., ↑87Rb/86Sr). If numbers are to be lettered as subscripts, input as the first character of the first line (e.g., *A1203). Superscripts and subscripts will only appear on plotter-drawn plots. After each parameter name has been entered, the display will request the name of the next parameter. When no more parameters are to be named, answer the two parameter-name queries with a space.

DISPLAY: SET # 1 NAME?

The set (sample) names may contain up to 12 characters each. When no more sets are to be named, simply answer the query with a space. Set names are requested before the data for each set is to be entered.

DISPLAY: SET # 1, PARAMETER # 1

Input a value for the particular set and parameter requested. The next query will be the next-numbered parameter for that set, and so on until the query will ask for data for the next-numbered set. To cease data input, enter a space in response to the request for a set name. If no value for this data element is known or relevant, enter the number 1E50 (10^{50}). The printout for this number will then be three dashes (---).

DISPLAY: STORE IN FILE #?

If you do not wish to store the data yet, input a space. Otherwise, enter the file number of the already-marked, 2400 word file.

TO CREATE A DATA FILE USING PARAMETERS DEFINED IN AN EXISTING DATA FILE (OPTION 4)

This option permits the use of parameters whose name and numbers have already been defined in the creation of a previous data-file. Operation is similar to option 1, except that the parameter names are taken from an existing data-file.

PRINTOUT OF THE DATA-FILE (OPTION 4)

Option 4 prints out the data as input, with numbered parameters and sets.

DISPLAY: DATA FROM FILE #?

If the data-file is already in memory, answer with a space. If not, make sure that the tape cartridge of interest is in the computer. Input the appropriate file number.

DISPLAY: PARAMETER #?

You may print up to 4 parameters on a single sheet of paper. Enter the parameter numbers, separated by commas, that you wish printed out.

DISPLAY: SET(S) TO BE PRINTED OUT?

If sets are to be printed out in serial order, input first and last set numbers, separated by a comma. If sets are to be printed out in arbitrary order, input the set numbers in the desired order of printout, separated by semicolons. The two modes may be combined in one response- e.g., an input of 2,5;24;11,9;16;1 would result in printout of sets in the order 2,3,4,5,24,11,10,9,16,1. Note that sets may be printed out in descending as well as ascending serial order. If ALL is the response to the query, all of the defined sets will be printed out in serial order. Data from different data files (with the same parameters and parameter numbers) can be printed out in the same table by placing an asterisk followed by the file number of the new data file before the set numbers of interest. Thus if sets 7 through 12 from the data in file 10 were to be added to the printout following sets 19 and 12 of the data-file in memory, the resonse to the set 'SET(S)' query would be 19;12;*10,7,12.

TO EDIT DATA (OPTION 3)

DISPLAY: EDIT SET #S?

Enter the set numbers, separated by commas, of the sets to be edited. Thus if you wanted to change some or all of the values of sets 2, 17, and 16, the input would be 2,17,16.

DISPLAY: EDIT PARAMETER #S?

Enter the parameter numbers whose values (for the sets chosen above) are to be changed, separated by commas. To edit a sample name, 0 must be the first number entered. To change all of the parameter values, enter ALL. Thus to edit the sample name and all of the parameter values, the input would be 0, ALL. Enter a space to escape.

TO DELETE DATA SETS (OPTION 5)

DISPLAY; SET(S) TO BE DELETED?

If only one set is to be deleted, input that set number. If a block of sets in sequence are to be deleted, input the first and last numbers of the sequence, with a comma separating the two. The sets are renumbered after each deletion. Input a space after the desired deletions have been accomplished.

TO INSERT A DATA-SET (OPTION 6)

DISPLAY: INSERT DATA BEFORE SET #?

Input the number of the set before which the new set is to be placed. The usual data-input routine then occurs, and the sets that follow the new entry are renumbered.

TO ADD A PARAMETER NAME (OPTION 9)

This option permits you to increase the number of defined parameters by defining additional parameter names (up to 20 total). After adding a parameter name, all the values of the new parameter will be zero. To input the corresponding data, you will need to do the following:

CHANGE ALL VALUES OF ONE PARAMETER (OPTION 10)

This option permits you to change the values of a given parameter for all of the sets--i.e., to enter data by column instead of by row.

TO PRINT OUT A LIST OF PARAMETER NAMES (OPTION 12)

TO PRINT OUT A LIST OF SET NAMES (OPTION 13)

TO PRINT OUT A LIST OF OPTIONS (OPTION 15)

Just enter the option number, then the appropriate data-file number (or space if already in memory) when requested.

INSTRUCTIONS: X-Y PLOTTING PROGRAM

General Comments:

Data to be plotted by this program may be entered either from the keyboard or from data files (40 x 20 array) created by the data-file program. Data points may be plotted using a variety of symbols, including open or solid polygons (or circles), error boxes, error crosses, or error ellipses. Plot size and relative dimensions may be adjusted over a wide range without distortion of symbols. Once data points have been plotted, a least-squares regression line may be calculated and plotted using either a standard York-type algorithm, or using one of two modified York-type algorithms. Isochron ages and errors for most isotope-ratio plots (including $^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$) may be calculated from the slope of the regression line.

The program is split into three segments to conserve computer memory, and is stored in three different files, preferably adjacent to one another. These file numbers must appear in line 80 of the first program segment (appendix II).

Operation of Program:

Load the first program segment into memory (type RUN, EXECUTE). The display will be, DATA FROM FILE #?. If you do not wish to plot data from a data file, input a space in response (press space bar, EXECUTE).[1] If you wish to plot data from a data file, enter the number of that data file, making sure that the cassette containing that file is in the computer. The data file will then be loaded into memory, and identifying information (file number, name, and number of data sets and parameters) printed out. Replace the cassette with the plotting program in the computer, if necessary.

[1] If the data file of interest has already been loaded, enter 100 to avoid unnecessary re-load of the file.

The display will then be X-AXIS (NAME OR PARAMETER #)?. If you wish the name for the X-axis to come from a data file (which must already be loaded into memory), simply enter the appropriate parameter number, and that parameter name will be used. Alternatively, you may type in a label. Numbers will be plotted as super scripts if the first character of the axis label is ↑, or as sub-scripts if the first character is *. Thus ↑87SR/86SR will appear as $^{87}Sr/^{86}Sr$ on the plot, and *S203 as S_2O_3. Leading and trailing spaces in the axis names will automatically be trimmed. The next display, Y-AXIS (NAME OR PARAMETER #)?, requires a similar response. The display, HEIGHT, WIDTH OF PLOT (CM)?, asks for the height and width, in centimeters, of the plotter limits, as set by the "lower left" and "upper right" controls on the plotter itself. Slight deviations from accurate estimates will result in slight distortions of the plotting symbols, though accuracy of the plotted locations will not be affected. Enter the two values.

The display X AND Y LIMITS? requests four values; the minimum and maximum Y-axis values and the minimum and maximum Y-axis values, in that order. Thus if one wished the X-axis to go from 0 to 80 units and the Y-axis from 0.7 to 1.2 units, the response would be 0, 80, .7, 1.2.

The framework for the plot will now be drawn, including a plot-box with interior tick marks, tick labels (every other tick) and axis labels. Tick intervals will be calculated by the computer, and the tick labels will be automatically centered (X-axis) or left justifed (Y-axis). A printout of plotting and calculation options will appear, and the next (second) segment of the program will be loaded into memory.

The next display, DATA SYMBOL OR CODE?, is keyed to the option list just printed out. Any response but R, L, or A will be assumed to define a plotting symbol, as defined below:

P -- The plotting symbol will be a regular polygon of specified size, rotational orientation, and number of sides. The display # SIDES, ROTATION, SIZE (1-10)? requests three values: the number of sides of the polygon (e.g., 3 for a triangle), the angular rotation (in degrees center clockwise from the 3 o'clock position) of a vertex, and the relative size of the polygon (sizes of 2-4 are most useful). Upper-case P gives a solid symbol, lower-case P an open symbol.

E -- The plotting symbol will be an open (lower-case E) or filled-in (upper-case E) rectangle whose dimensions correspond to the X- and Y-errors of the data point.

. -- the plotting symbol will be an upright cross whose dimensions again correspond to the X- and Y-errors.

C -- the plotting symbol will be an open (lower-case C) or filled-in (upper-case C) ellipse whose area corresponds to the locus of points within a 2σ probability limit of the data point, as defined by the X- and Y-errors and the correlation between these errors.

*,O,X,+ especially suitable symbols which will be plotted as input, as will any other keyboard symbol not mentioned in this section.

Other options are:

R -- The first segment of the program will be reloaded and run.

L -- Permits lettering of an arbitrary phrase of arbitrary size to be drafted anywhere on the plot. The subsequent LETTER SIZE? display requests a number defining the relative size of the letters (0.5 is rather small, 3 is rather large. Try 1). When the POSITION

PEN-PRESS STOP WHEN OK display appears, use the four arrow-symbol keys at the top of the keyboard to position the pen (one up-arrow stroke moves the pen up one line, one left-arrow stroke moves it to the left one character, etc.). Press the STOP key when pen is positioned. In response to the display STATEMENT FOR LETTERS?, type in the phrase to be drafted on the plot. The ± (plus-or-minus) symbol may be obtained by typing in +/- in the statement.

A -- will calculate an isochron age and associated uncertainties from the data from a linear regression, using a modified York-type algorithm (York, 1969; Titterington and Halliday, 1979). The regression must have already been performed to use his option. Enter the decay constant, in decays per atom per year, in response to the displayed request. If the symbols 206 and 204 appear in the X-axis name and 207 and 204 in the Y-axis name, a Pb-Pb isochron age will be calculated.

Data Input:

The display X, (ERR,)Y,(ERR,)(CORRELATION)? requests input of data for plotting. Data to be entered from the keyboard may be entered in any of the following ways: X- and Y-values only (e.g. 2.049, .0473); X- and Y-values with errors, in percent 2σ (e.g. 2.049, 1.3, .0473, 1.3); or X- and Y-values with errors and the X- and Y-error correlation (e.g. 2.049, 1.3, .0473, 1.3, .95). If either the errors are not required for the plotting symbol and no linear regression will be done, or if all of the errors and error correlations are the same, the first method (X- and Y-values only) is the simplest.

If the data are to be entered from a data file, and that data file has already been loaded into memory, then the input should be an asterisk followed by the first and last set numbers of the samples in the data file. For

example, if set numbers 5 through 12, inclusive (from a data file in memory) are to be plotted, the input would be *5,12. To input only one set, use only one number after the asterisk.

If data from a data file not in memory are wanted, input DF in response to the data-request display. The display will request the file number of the data file, and then load it into memory.

When no more data are to be entered, enter a space (press space bar, EXECUTE) in response to the data-request. Note that data from different data-files and keyboard-input data can all be mixed. The display will then be ?EDIT ENTRY#? (0 IF OK)? which permits editing of any incorrectly entered data. Enter the entry # (from the data printout) of the incorrectly entered set, then enter the correct values from the keyboard. When all data are correct, enter zero in response to the ?EDIT ENTRY#? query. The data will then be plotted using the symbol chosen previously, if all necessary error (for error-cross, error-rectangle, and error-ellipse symbols) and error correlation (for error-ellipse symbol) information has been entered. If this information has not been entered, the display X-ERRORS, Y-ERRORS (LAST BLOCK)? will appear. If two numbers separated by a comma are entered (e.g. 1.3, 2.6) the first will be assigned as the X-errors and the second as the Y-errors (in percent 2σ) for all the data of this block (i.e., for the data which has not yet been plotted). If the two numbers are preceded by an asterisk (e.g. *7, 11), the X-errors will be taken from the data file in memory, from the parameter number indicated by the number immediately following the asterisk. Similarly, the Y-errors will be from the parameter number following the comma. In other words, if the errors for a given pair of parameters in a data file are also stored as two other parameters in that data file, they can be entered simply by preceding the error-parameter numbers with an asterisk.

Error correlations are entered in an analogous manner. If nothing is known about the error correlations, enter zero.

After plotting the data, the display will be YORKFIT? 1=YES?. If no regression line is requred, enter zero. The display will then be DATA TO BE RETAINED? (1=YES)? If you wish the just-plotted data to be grouped with more data using a different plotting symbol or color for a subsequent regression-line calculation, enter 1 and the just-plotted data will be retained. Otherwise, enter zero. If either the Yorkfit query or data-retention query is answered with a 1, any missing error and error-correlation information will be requested.

If a Yorkfit is requested, the third program segment will be loaded into memory, and a MODEL 1 Yorkfit calculated. This is essentially York's original algorithm (York, 1969; also similar to the Model 1 of McIntyre and other, 1966), which weights each point according to analytical variance, and assumes that the only cause for scatter from a straight line is this variance. The 95%-confidence level slope and intercept errors are calculated from the assigned analytical errors only, and a Student's-t factor of 1.96 is applied regardless of the number of data points.

If the probability that the observed scatter about the regression line is due to analytical error is less than 30%, either a MODEL 2 or MODEL 3 Yorkfit is also calculated. MODEL 2 assumes that nothing is known about the cause of the scatter, and weights all the points equally (with zero error correlation). MODEL 3 is is similar to a McIntyre Model 3 fit, and calculated if the plot is an 87Sr/86Sr - 87Rb/86Rb,144Nd/143Nd - 144Nd/143Nd, 206Pb/204Pb - 238U/204Pb, or 207Pb/204Pb - 235U/204Pb isochron (recognized in the program by the presence of the appropriate isotope numbers in the axis names). In this case, the scatter is assumed to be caused by analytical error plus a

normally distributed random variation in the initial-Y value. The variation in the initial-Y value required to explain the observed scatter is calculated, and used together with the analytical errors in weighting the points. For both the MODEL 2 and MODEL 3 calculations, the slope and intercept uncertainties are calculated from the observed scatter of the points and include a Student's-t factor for N-2 degrees of freedom.

If the probability of the MODEL 1 solution is between 5% and 30%, the user may choose which solution to use (though for probabilities less than 15-20%, a choice of MODEL 1 would probably be regarded as over-optimistic in most cases); for probabilities <5%, the MODEL 1 solution cannot be chosen.

REFERENCES

Ludwig, K. R., 1979d, A generalized program in Hewlett-packard BASIC for creating, editing, and printing out data-files for geochemical applications: U.S. Survey Open-File Report 79-1434, 33p.

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McIntyre, G. A., Brooks, C., Compston, W., and Turek, A., 1966, The statistical assessment of Rb-Sr isochrons; Jour. Geophys. Res. v. 71, p. 5459.

Titterington, D. M. and Halliday, A. N., 1979, On the fitting of parallel isochrons and the method of maximum likelihood: Chemical Geology, v. 26, p. 183-195.

York, Derek, 1969, Least squares fitting of a straight line with correlated errors: Earth Planet. Science Letters, v. 5, p. 320-324.

APPENDIX I--LIST

OF DATA-FILE PROGRAM

```
10 COM AI[40,6],CI[40,13],DS[40,20],I2,M,B$[50]
20 REM DATA-FILE PROGRAM FOR 8K HP-9830/9862;  K.R. LUDWIG, 1982
30 REM TAKES UP TO 40 SETS WITH 20 PARAMETERS
40 DIM GI[40],A$[12],C$[25],T$[72],ES[40],E$[36],S$[72],Z$[10],L$[58]
50 DATA " ABCDEFGHIJKLMNOPQRSTUVWXYZ-.0123456789!#$%&´();:,/<>?+*/^"
60 DATA "0123456789"
70 DATA 15,40,20
80 READ L$,Z$,P1,I0,M0
90 C=P1
100 GOTO 240
110 DEF FNL(H)
120 E=1+POS(T$,",")
130 IF POS(Z$,T$[1,1]) THEN 160
140 T=-1
150 GOTO 170
160 T=VAL(T$)
170 IF POS(Z$,T$[E,E]) THEN 200
180 F=-1
190 GOTO 210
200 F=VAL(T$[E])
210 RETURN T
220 PRINT LIN1,TAB3,T$"  -??   IMPROPER SYNTAX.  TRY AGAIN. ***"LIN2
230 RETURN
240 PRINT "CREATE USING ´OLD´ PARAMETERS (0)"
250 PRINT "CREATE USING ´NEW´ PARAMETERS (1)"
260 PRINT "ADD DATA TO EXISTING FILE (2)"TAB90"EDIT DATA (3)"
270 PRINT "PRINT OUT  (4)"TAB90"DELETE DATA-SET  (5)"
280 PRINT "INSERT DATA-SET  (6)"TAB90"EXCHANGE DATA-SETS  (7)"
290 PRINT "EDIT PARAMETER NAME (8)"TAB90"ADD PARAMETER NAME (9)"
300 PRINT "CHANGE ALL VALUES OF ONE PARAMETER (10)"
310 PRINT "PRINTOUT LIST OF PARAMETER NAMES  (12)"
320 PRINT "PRINTOUT LIST OF SAMPLE NAMES (13)"
330 PRINT "ENTER 15 TO OBTAIN LIST OF POSSIBLE OPERATIONS"LIN2
340 DISP "CREATE(1)ADD(2)EDIT(3)PRINT(4)  DELETE(5)INSERT(6)EXCHANGE(7)";
350 INPUT F0
360 STANDARD
370 GOTO (F0=1)+2*(F0=15) OF 420,240
380 GOSUB 3190
390 IF F0=0 THEN 500
400 GOTO F0-1 OF 620,650,2470,1540,1730,1950,2240,2120,2180,340,2340
410 GOTO F0=13+2*(F0#13) OF 2400,340
420 M=0
430 FOR I=1 TO I0
440 FOR J=1 TO M0
450 D[I,J]=0
460 IF J>13 THEN 480
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470 C[I,J]=0
480 NEXT J
490 NEXT I
500 I2=0
510 FOR I=1 TO I0
520 FOR J=1 TO 6
530 A[I,J]=0
540 NEXT J
550 NEXT I
560 GOSUB 1230
570 IF  NOT F0 THEN 590
580 GOSUB 1030
590 GOSUB 1260
600 GOSUB 970
610 GOTO 590
620 GOSUB 1260
630 GOSUB 970
640 GOTO 620
650 DISP "SET(S) TO BE EDITED";
660 INPUT S$
670 IF S$=" " THEN 340
680 S$[1+LEN(S$)]=",999"
690 T$=S$
700 IF FNL0#-1 THEN 730
710 GOSUB 220
720 GOTO 650
730 IF T=999 THEN 1440
740 I=T
750 IF I <= I2 THEN 780
760 GOSUB 3340
770 GOTO 650
780 S$=S$[1+POS(S$,",")]
790 DISP "SET"I"-EDIT PARAMETER #S";
800 INPUT T$
810 T$[1+LEN(T$)]=",999"
820 IF  NOT POS(T$[1,3],"ALL") AND  NOT POS(T$[1,3],"all") THEN 860
830 GOSUB 970
840 I2=I2-1
850 T$=T$[1+POS(T$,",")]
860 IF FNL0<0 OR T=999 THEN 690
870 IF T#0 THEN 900
880 GOSUB 1270
890 GOTO 950
900 J=T
910 IF J <= M THEN 940
920 GOSUB 2100
930 GOTO 790
940 GOSUB 1370
950 T$=T$[1+POS(T$,",")]
960 GOTO 820
```

```
970 FOR J=1 TO M
980 GOSUB 1370
990 IF M=M0 THEN 340
1000 NEXT J
1010 I2=1+I2
1020 RETURN
1030 IF M <= M0 THEN 1060
1040 GOSUB 3320
1050 GOTO 340
1060 J=1+M
1070 GOSUB 1100
1080 GOTO 1060
1090 RETURN
1100 STANDARD
1110 DISP "PARAMETER "J"NAME";
1120 INPUT C$[1,13]
1130 INPUT C$[14,25]
1140 IF C$[14,19]#"       " THEN 1210
1150 IF C$[1,7]#"        " THEN 1210
1160 GOTO 1+(F0=1) OF 1220,590
1170 FOR K=25 TO 1 STEP -1
1180 IF C$[K,K]#" " THEN 1210
1190 C$=C$[1,K]
1200 NEXT K
1210 M=M+(F0#8)+FNDJ
1220 RETURN
1230 DISP "FILE NAME";
1240 INPUT B$[1,50]
1250 RETURN
1260 I=I2+1
1270 IF I>I0 THEN 1740
1280 DISP "SET#"I"NAME";
1290 INPUT A$[1,12]
1300 IF A$="            " THEN 1440
1310 FOR K=12 TO 1 STEP -1
1320 IF A$[K,K]#" " THEN 1350
1330 A$=A$[1,K-1]
1340 NEXT K
1350 Y=FNCI
1360 RETURN
1370 DISP "SET#"I;"PARAMETER#"J;
1380 INPUT D[I,J]
1390 RETURN
1400 NEXT J
1410 I2=I2+1
1420 RETURN
1430 GOTO 1260
1440 DISP "STORE IN FILE#";
1450 INPUT T$
1460 B=2
```

```
1470 IF T$=" " THEN 340
1480 IF FNL0 >= 0 THEN 1510
1490 GOSUB 220
1500 GOTO 1440
1510 STORE  DATA T
1520 B=0
1530 GOTO 340
1540 DISP "SET(S) TO BE DELETED";
1550 INPUT T$
1560 IF T$=" " THEN 1440
1570 IF FNL0>0 AND F>0 THEN 1600
1580 GOSUB 220
1590 GOTO 1540
1600 FOR K=1 TO 1+F-T
1610 GOSUB 1640
1620 NEXT K
1630 GOTO 1540
1640 FOR I=T TO I2
1650 IF I=I0 THEN 1710
1660 FOR J=1 TO M
1670 D[I,J]=D[I+1,J]
1680 NEXT J
1690 Y=FNE(I+1)+FNCI
1700 NEXT I
1710 I2=I2-1
1720 RETURN
1730 IF I2<I0 THEN 1760
1740 PRINT TAB10"**** DATA-FILE IS FULL ****"LIN2
1750 GOTO 340
1760 DISP "INSERT DATA BEFORE SET #";
1770 INPUT T$
1780 IF T$=" " THEN 1440
1790 IF FNL0>0 AND F>0 THEN 1820
1800 GOSUB 220
1810 GOTO 1760
1820 FOR I=I2 TO T STEP -1
1830 FOR J=1 TO M
1840 D[I+1,J]=D[I,J]
1850 NEXT J
1860 Y=FNEI+FNC(I+1)
1870 NEXT I
1880 I=T
1890 GOSUB 1270
1900 FOR J=1 TO M
1910 GOSUB 1370
1920 NEXT J
1930 I2=1+I2
1940 GOTO 1730
1950 DISP "EXCHANGE SET NUMBERS";
1960 INPUT T$
```

```
1970 IF T$=" " THEN 1440
1980 IF FNL0>0 AND (F>0 AND F <= I2) THEN 2010
1990 GOSUB 220
2000 GOTO 1950
2010 FOR J=1 TO M
2020 E[J]=D[T,J]
2030 D[T,J]=D[F,J]
2040 D[F,J]=E[J]
2050 NEXT J
2060 E$=A$[1+FNET]
2070 A$=E$[1+FNEF+FNCT]
2080 Y=FNCF
2090 GOTO 1950
2100 PRINT TAB10"**** ONLY"M"PARAMETERS DEFINED ****"LIN2
2110 RETURN
2120 IF M<M0 THEN 2150
2130 GOSUB 3320
2140 GOTO 340
2150 J=1+M
2160 GOSUB 1100
2170 GOTO 340
2180 DISP "PARAMETER #";
2190 INPUT J
2200 FOR I=1 TO I2
2210 GOSUB 1370
2220 NEXT I
2230 GOTO 330
2240 DISP "EDIT PARAMETER# ? NAME";
2250 INPUT T$
2260 IF T$=" " THEN 2330
2270 J=FNL0
2280 IF FNL0>0 AND F>0 THEN 2310
2290 GOSUB 220
2300 GOTO 2240
2310 J=T
2320 GOSUB 1100
2330 GOTO 340
2340 PRINT "PARAMETER #"TAB20"PARAMETER NAME"LIN2
2350 FOR J=1 TO M
2360 PRINT J;"-----";TAB18+FNFJ;C$
2370 NEXT J
2380 PRINT
2390 GOTO 330
2400 PRINT "SAMPLE #"TAB20"SAMPLE NAME"LIN2
2410 FOR I=1 TO I2
2420 PRINT I;"-----";TAB14+FNEI;A$
2430 NEXT I
2440 PRINT
2450 GOTO 330
2460 REM PRINTOUT ROUTINE
```

```
2470 Z=0
2480 DISP "PARAMETER NUMBERS";
2490 INPUT T$
2500 T$[1+LEN(T$)]=","
2510 FOR K=1 TO 4
2520 G[K]=FNL0
2530 IF G[K]<1 THEN 2600
2540 IF G[K] >= 1 AND G[K] <= M THEN 2570
2550 GOSUB 2100
2560 GOTO 2470
2570 T$=T$[1+POS(T$,",")]
2580 Z=Z+1
2590 NEXT K
2600 PRINT "(parameter #)";
2610 STANDARD
2620 FOR K=1 TO Z
2630 PRINT TAB(9+13*K);G[K];
2640 NEXT K
2650 PRINT LIN2
2660 FOR K=1 TO Z
2670 S=(C[G[K],1]=56)+(C[G[K],1]=58)
2680 PRINT TABFNFG[K]+5+13*K;C$[1+S,12+S];
2690 NEXT K
2700 PRINT LIN1"SET#  SAMPLE NAME";
2710 FOR K=1 TO Z
2720 PPINT TABFNFG[K]+5+13*K;C$[14,25];
2730 NEXT K
2740 PRINT LIN1"----";
2750 FOR K=1 TO Z+1
2760 PRINT "+------------";
2770 NEXT K
2780 PRINT "+";LIN2
2790 GOTO 2800
2800 DISP "SET(S) TO BE PRINTED OUT";
2810 INPUT T$
2820 IF POS(T$,"ALL") THEN 2970
2830 IF T$[1,1]#"*" THEN 2880
2840 T$=T$[2]
2850 GOSUB 3210
2860 K=1+POS(T$,",")
2870 T$=T$[K+POS(T$[K],",")]
2880 IF FNL0<0 THEN 3170
2890 T$[1+LEN(T$)]=";999"
2900 IF  NOT POS(T$[2,3],",") THEN 2930
2910 T$=T$[1+POS(T$,";")]
2920 GOTO 2990
2930 IF T=999 THEN 3170
2940 F=FNL0
2950 T$=T$[1+POS(T$,";")]
2960 GOTO 2990
```

```
2970 T=1
2980 F=I2
2990 FOR I=T TO F STEP (F >= T)-(F<T)
3000 IF I>I2 THEN 3170
3010 STANDARD
3020 PRINT FNEI+I;
3030 PRINT TAB6;A$;
3040 FOR K=1 TO Z
3050 STANDARD
3060 N=D[I,G[K]]
3070 IF N#1E+50 THEN 3100
3080 PRINT TAB(13*K+8)"---";
3090 GOTO 3130
3100 IF (ABSN >= 0.01)*(ABSN<1E+10)+ NOT N THEN 3120
3110 FLOAT 3
3120 PRINT TAB13*K+6;N;
3130 NEXT K
3140 PRINT LIN1
3150 NEXT I
3160 GOTO 2830
3170 PRINT LIN3
3180 GOTO 340
3190 DISP "DATA FROM FILE #";
3200 INPUT T$
3210 B=1
3220 IF T$=" " THEN 3310
3230 IF FNL0#-1 THEN 3260
3240 GOSUB 220
3250 GOTO 3190
3260 LOAD  DATA T
3270 B=0
3280 STANDARD
3290 PRINT "DATA FROM FILE"T" ("I2"SETS,"M"PARAMETERS DEFINED)";
3300 PRINT LIN2,B$,LIN3
3310 RETURN
3320 PRINT "****** PARAMETER LIMIT IS"M0"******"LIN2
3330 RETURN
3340 PRINT TAB10"**** ONLY"I2"SETS DEFINED"LIN2
3350 RETURN
3360 DEF FNC(H)
3370 FOR A=1 TO INT(0.5+LEN(A$)/2)
3380 A[H,A]=100*POS(L$,A$[2*A-1,2*A-1])+POS(L$,A$[2*A,2*A])
3390 NEXT A
3400 FOR A=A TO 6
3410 A[H,A]=0
3420 NEXT A
3430 RETURN 0
3440 DEF FND(H)
3450 FOR A=1 TO INT(0.5+LEN(C$)/2)
3460 C[H,A]=100*POS(L$,C$[2*A-1,2*A-1])+POS(L$,C$[2*A,2*A])
```

```
3470 NEXT A
3480 FOR A=A TO 13
3490 A[H,A]=0
3500 NEXT A
3510 RETURN 0
3520 DEF FNE(H)
3530 A$=""
3540 FOR A=1 TO 6
3550 P=INT(A[H,A]/100)
3560 IF P=0 THEN 3620
3570 Q=A[H,A]-100*P
3580 A$[2*A-1,2*A-1]=L$[P,P]
3590 IF Q=0 THEN 3620
3600 A$[2*A,2*A]=L$[Q,Q]
3610 NEXT A
3620 RETURN 0
3630 DEF FNF(H)
3640 C$=""
3650 FOR A=1 TO 13
3660 P=INT(C[H,A]/100)
3670 IF P=0 THEN 3730
3680 Q=C[H,A]-100*P
3690 C$[2*A-1,2*A-1]=L$[P,P]
3700 IF Q=0 THEN 3730
3710 C$[2*A,2*A]=L$[Q,Q]
3720 NEXT A
3730 RETURN 0
3740 END
```

APPENDIX II--LIST

OF PLOTTER PROGRAM

First Segment:

```
10 COM AI[40,6],CI[40,13],DS[40,20],I2,M,B$[50]
20 REM PART 1 (SET-UP PLOT),  HP-9830/9862 X-Y PLOTTER PROGRAM, K.R LUDWIG, 19
30 REM CAN TAKE DATA FROM 40X20 DATA-FILE ARRAYS CREATED BY DATA-FILE PROGRAM
40 DIM A$[38],E$[25],F$[25],XS[40],YS[40],PS[40],FS[40],II[3]
50 DIM QS[40],US[40],MS[40],ZS[40],RS[40],T$[45],G$[1],L$[58],SS[40]
60 DATA " ABCDEFGHIJKLMNOPQRSTUVWXYZ-.0123456789!#$%&´();:,/<>?+*/^",0,0,0,0
70 REM FILE #S OF PARTS 1,2,3
80 DATA 0,1,2
90 READ L$,P1,H1,L1,L2,I[1],I[2],I[3]
100 DEG
110 GOTO 740
120 FIXED 0
130 RETURN
140 FIXED 1
150 RETURN
160 FIXED 2
170 RETURN
180 FIXED 3
190 RETURN
200 FIXED 4
210 RETURN
220 FIXED 5
230 RETURN
240 E=POS(A$,"  ")
250 IF  NOT E THEN 280
260 A$[1+E]=A$[2+E]
270 GOTO 240
280 RETURN
290 DEF FNA(X)=INTLGTABSX
300 DEF FNB(X)
310 Q=10^FNAX/8
320 IF ABS(X/Q) <= 12 THEN 350
330 Q=2*Q
340 GOTO 320
350 A=ABSQ/10^FNAQ
360 IF A=INTA THEN 380
370 Q=INTA*10^FNAQ
380 RETURN Q
390 DEF FNF(X)
400 S=E=0
410 N=X
420 N=10*(ABSN-INTABSN)
430 IF N=0 THEN 470
440 S=S+1
450 E=1
460 GOTO 420
```

```
470 RETURN S
480 DEF FNK(X)=1+(X#INTX)+(ABSX >= 1)*FNA(ABSX+ NOT X)+FNFX
490 DEF FNC(I)=POS(L$[30,39],A$[I,I])
500 DEF FNQ(I)=FNC1*(LEN(A$)=1) OR FNC1*FNC2*(LEN(A$)=2)
510 DEF FNJ(X)=-( NOT X)-(X#0)*(FNKX+J-FNFX+(X=INTX)*(J#0))
520 DEF FND(X)
530 FOR I=1 TO C5/A8
540 IPLOT X*A8,0
550 IPLOT 0,X*D5/S
560 IPLOT 0,-X*D5/S
570 NEXT I
580 RETURN 0
590 DEF FNM(X)
600 FOR I=1 TO D5/A5
610 IPLOT 0,X*A5
620 IPLOT -X*C5*P/S,0
630 IPLOT X*C5*P/S,0
640 NEXT I
650 RETURN 0
660 J=POS(A$[1,1],"^")-POS(A$[1,1],"*")
670 FOR I=1+ABSJ TO LEN(A$)
680 K=(POS(L$[30,39],A$[I,I])#0)
690 CPLOT 0,J*K*0.3
700 LABEL (*)A$[I,I];
710 CPLOT 0,-J*K*0.3
720 NEXT I
730 RETURN
740 DISP "DATA FROM FILE#";
750 INPUT T$
760 IF T$=" " THEN 840
770 IF  NOT POS(L$[30,39],T$[1,1]) THEN 740
780 F=VAL(T$)
790 IF F=100 THEN 820
800 LOAD  DATA F
810 FIND I[2]
820 PRINT LIN1"DATA FROM FILE"F" - "B$
830 PRINT I2"SETS, "M"PARAMETERS DEFINED"LIN2
840 DISP "X-AXIS (NAME OR PARAMETER #";
850 INPUT A$
860 IF  NOT FNQ0 THEN 920
870 L1=VAL(A$)
880 IF L1 >= 1 AND L1 <= M THEN 910
890 GOSUB 1860
900 GOTO 840
910 GOSUB FNWL1 OF 240
920 E$=A$
930 DISP "Y-AXIS (NAME OR PARAMETER #)";
940 INPUT A$
950 IF  NOT FNQ0 THEN 1010
960 L2=VAL(A$)
```

```
970 IF L2 >= 1 AND L2 <= M THEN 1000
980 GOSUB 1860
990 GOTO 930
1000 GOSUB FNWL2 OF 240
1010 F$=A$
1020 DISP "HEIGHT, WIDTH OF PLOT (CM)";
1030 INPUT I4,I5
1040 P=I4/I5
1050 F3=3*(1+(I4<15)/2-(I4>23)/3)
1060 F4=2*F3/3
1070 DISP "X AND Y LIMITS";
1080 INPUT A1,B1,A2,B2
1090 REM CALCULATE TIC INTERVALS, MAX. # DIGITS IN TIC LABELS
1100 A8=FNB(B1-A1)
1110 A5=FNB(B2-A2)
1120 FOR Y=A2 TO B2 STEP 2*A5
1130 IF ((Y<0)+FNKY)<P1 THEN 1150
1140 P1=(Y<0)+FNKY
1150 NEXT Y
1160 FOR X=A1 TO B1 STEP 2*A8
1170 IF ((X<0)+FNKY)<H1 THEN 1190
1180 H1=(X<0)+FNKX
1190 NEXT X
1200 B1=A1+A8*INT(1+0.99*(B1-A1)/A8)
1210 B2=A2+A5*INT(1+0.99*(B2-A2)/A5)
1220 C5=B1-A1
1230 D5=B2-A2
1240 A6=POS(E$[1,1],"^")-POS(E$[1,1],"*")
1250 B5=POS(F$[1,1],"^")-POS(F$[1,1],"*")
1260 Y=F3*I4/100
1270 I1=Y*((P1+0.3)/1.53+(2+0.3*ABSB5)/0.6)
1280 I3=I5-4*Y/1.53
1290 Z3=Y*(1/0.9+(1.6+0.3*ABSA6)/0.6)
1300 Z4=I4-1.5*Y/0.9
1310 P2=A1-C5*I1/(I3-I1)
1320 L=B1+C5*(I5-I3)/(I3-I1)
1330 I0=A2-D5*Z3/(Z4-Z3)
1340 P0=B2+D5*(I4-Z4)/(Z4-Z3)
1350 P5=L-P2
1360 SCALE P2,L,I0,P0
1370 PLOT A1,A2
1380 S=150+50*((I4*I5)>900)-70*((I4*I5)<500)
1390 J=FND1+FNM1+FND(-1)+FNM(-1)
1400 Y=2*(1+((H1>5) OR I5 <= 18))*A8
1410 FOR X=A1 TO B1 STEP Y
1420 IF FNFX<J THEN 1440
1430 J=FNFX
1440 NEXT X
1450 FOR X=A1 TO B1 STEP Y
1460 LABEL (*,F4,1.7,0,P)
```

```
1470 PLOT X,A2,1
1480 CPLOT FNJX/2-0.9,-1
1490 GOSUB 1+J*(1- NOT X) OF 120,140,160,180,200,220
1500 LABEL (*)X;
1510 NEXT X
1520 J=0
1530 FOR Y=A2 TO B2 STEP 2*A5
1540 IF FNFY<J THEN 1560
1550 J=FNFY
1560 NEXT Y
1570 FOR Y=A2 TO B2 STEP 2*A5
1580 PLOT A1,Y,1
1590 CPLOT FNJY-1.3,-0.3
1600 GOSUB 1+J*(1- NOT Y) OF 120,140,160,180,200,220
1610 LABEL (*)Y;
1620 NEXT Y
1630 REM LABEL AXES
1640 PLOT A1+C5/2,A2,1
1650 CPLOT 0,-1
1660 LABEL (*,F3,1.7,0,P)
1670 CPLOT -(LEN(E$)-ABSA6)/4,-0.9-0.3*(A6=1)
1680 CPLOT -(LEN(E$)-ABSA6)/4,0
1690 A$=E$
1700 GOSUB 660
1710 PLOT A1,A2+D5/2,1
1720 LABEL (*,F4,1.7,0,P)
1730 CPLOT -P1-0.3,0
1740 LABEL (*,F3,1.7,90,P)
1750 CPLOT -(LEN(F$)-ABSB5)/4,0.9+0.3*(B5<0)
1760 CPLOT -(LEN(F$)-ABSB5)/4,0
1770 A$=F$
1780 GOSUB 660
1790 PLOT L,P0,1
1800 PRINT LIN2"INPUT"TAB9"TO OBTAIN"LIN2"R ---- TO REDEFINE/RE";
1810 PRINT "DRAW PLOT-BOX"LIN1"E ---- SOLID/OPEN ERROR-BOX"LIN1"C ---- ";
1820 PRINT "SOLID/OPEN ERROR-ELLIPSE"LIN1". ---- ERROR-CROSS"LIN1"P ---- ";
1830 PRINT "SOLID/OPEN POLYGON"LIN1"L ---- TO LETTER ON PLOT"
1840 PRINT "A ---- TO CALCULATE AN ISOCHRON AGE"LIN3
1850 LINK I[2]
1860 PRINT LIN1"ONLY"M"PARAMETERS DEFINED"LIN2
1870 RETURN
1880 DEF FNW(I)
1890 A$=""
1900 FOR E=1 TO 13
1910 G=INT(C[I,E]/100)
1920 IF G=0 THEN 1980
1930 H=C[I,E]-100*G
1940 A$[2*E-1,2*E-1]=L$[G,G]
1950 IF H=0 THEN 1980
1960 A$[2*E,2*E]=L$[H,H]
```

```
1970 NEXT E
1980 RETURN 1
1990 END
```

Second Segment:

```
10 REM PART 2 (PLOT DATA) OF HP-9830/9862 X-Y PLOTTER PROGRAM; K.R. LUDWIG, 198
20 GOTO 140
30 DEF FNU(J)=J+POS(T$,",")
40 DEF FNP(J)
50 IF FNU0 THEN 70
60 T$[1+LEN(T$)]=",0"
70 A$=T$
80 T$=T$[FNU1]
90 IF POS(L$[28,39],A$[J,J]) THEN 110
100 RETURN 0
110 RETURN VAL(A$[J])
120 DEF FNO(F)=Y[I]+(-B3*X+F*SQRF1)/(2*S3)
130 LOAD I[1]
140 PLOT L,P0,1
150 K=1
160 N=0
170 STANDARD
180 A$="RL1AaPpEeCc.+*"
190 DISP ""
200 DISP "DATA SYMBOL OR CODE";
210 INPUT G$[1,1]
220 G=POS(A$,G$[1,1])
230 GOTO G OF 130,2330,2330,2510,2510,1260,1260
240 PRINT "USE * PREFIX FOR INPUT OF DATA-FILE SETS"LIN1
250 PRINT "ENTRY#"TAB8"SET#"TAB16;E$[1,10];TAB28"% ERR"TAB44;F$[1,10];TAB56;
260 PRINT "% ERR"TAB65"CORR"LIN2
270 GOSUB 290
280 GOTO 320
290 DISP "X,(ERR,) Y,(ERR,)(CORRELATION)";
300 INPUT T$
310 RETURN
320 IF T$=" " THEN 1180
330 IF T$[1,1]="*" THEN 590
340 IF T$="DF" THEN 490
350 REM KEYBOARD DATA-INPUT ROUTINE
360 I=N=1+N
370 GOSUB 390
380 GOTO 270
390 X[I]=FNP1
400 IF FNU0#0 THEN 430
410 U[I]=0
420 GOTO 440
430 U[I]=FNP1
440 Y[I]=FNP1
450 S[I]=FNP1
460 R[I]=FNP1
```

```
470 PRINT I;TAB16;X[I];TAB28;U[I];TAB44;Y[I];TAB56;S[I];TAB65;R[I]
480 RETURN
490 T$=T$[3]
500 DISP "DATA FROM FILE #";
510 INPUT F
520 LOAD  DATA F
530 FIND I[3]
540 PRINT LIN1"TRACK"F"DATA",B$,LIN1,I2"SETS,"M"PARAMETERS DEFINED"LIN2
550 GOTO 270
560 IF L1 AND L2 THEN 590
570 PRINT LIN1"NC DATA-FILE IN MEMORY"LIN2
580 GOTO 270
590 T$=T$[1+POS(T$,"*")]
600 IF T$="0" THEN 1180
610 S1=FNP1
620 S2=FNP1
630 S2=S2+S1* NOT S2
640 S1=S1*(S1 >= 1)*(S1 <= I2)+(S1<1)+I2*(S1>I2)
650 S2=S2*(S2 >= 1)*(S2 <= I2)+(S2<1)+I2*(S2>I2)
660 N=1+N+S2-S1
670 FOR I=N-(S2-S1) TO N
680 Z[I]=I-N+S2
690 GOSUB 710
700 GOTO 760
710 X[I]=D[Z[I],L1]
720 Y[I]=D[Z[I],L2]
730 U[I]=S[I]=R[I]=0
740 PRINT I;TAB8;Z[I];TAB16;X[I];TAB44;Y[I]
750 RETURN
760 NEXT I
770 PRINT LIN1
780 GOTO 270
790 GOSUB 1980
800 IF A=0 THEN 820
810 GOSUB 980
820 IF G#10 AND G#11 OR J=0 THEN 840
830 GOSUB 2040
840 FOR I=K TO N
850 IF (X[I] >= A1)*(X[I] <= B1)*(Y[I] >= A2)*(Y[I] <= B2) THEN 880
860 PRINT "SET"I"LIES OUTSIDE PLOT LIMITS"LIN1
870 GOTO 950
880 PLOT X[I],Y[I],1
890 GOTO G-5 OF 1290,1290,1560,1560,1560,1560,1560
900 REM KEYBOARD-SYMBOL DATA PLOTTING
910 LABEL (*,2-0.9* NOT G,1.7-0.7* NOT G,0,P)
920 CPLOT -0.3,-0.3
930 LABEL (*)G$[1,1];
940 PEN
950 NEXT I
960 PLOT L,P0,1
```

```
970 GOTO 1790
980 DISP "X-ERRORS, Y-ERRORS (LAST BLOCK)";
990 INPUT T$
1000 IF T$[1,1]="*" THEN 1080
1010 F=FNP1
1020 F4=FNP1
1030 FOR I=K TO N
1040 U[I]=F
1050 S[I]=F4
1060 NEXT I
1070 RETURN
1080 P1=FNP2
1090 P2=FNP1
1100 IF (P1 >= 1)*(P1 <= M)*(P2 >= 1)*(P2 <= M) THEN 1130
1110 GOSUB 2810
1120 GOTO 980
1130 FOR I=K TO N
1140 U[I]=D[Z[I],P1]
1150 S[I]=D[Z[I],P2]
1160 NEXT I
1170 RETURN
1180 PRINT LIN1
1190 DISP "?EDIT ENTRY#? (0 IF OK)";
1200 INPUT I
1210 GOTO  NOT I*(1+(G>7)*(G<13)) OF 840,790
1220 GOSUB 290
1230 GOSUB 390
1240 GOTO 1180
1250 REM POLYGON-SYMBOL PLOT ROUTINE
1260 DISP "# SIDES, ROTATION, SIZE (1-10)";
1270 INPUT B3,A9,S3
1280 GOTO 240
1290 FOR U=0 TO (S3>2.5)+50*(G=7)
1300 A7=P5*(S3-U/2)/400
1310 IF A7<0 THEN 940
1320 FOR J=A9 TO A9+360 STEP 360/B3
1330 PLOT X[I]+A7*COSJ,Y[I]+A7*D5*SINJ/(P*C5)
1340 NEXT J
1350 NEXT U
1360 GOTO 940
1370 REM ERROR-ELLIPSE PLOT ROUTINE
1380 U=1-R[I]^2+1E-10*(R[I]=1)
1390 B3=-2*R[I]/(P[I]*Q[I]*U)
1400 S3=1/(U*Q[I]^2)
1410 FOR J=1 TO 1+(G=11)
1420 FOR F=-1 TO 1 STEP 2
1430 F4=-F*P[I]/(1+INT(600*P[I]/P5))
1440 FOR X=F*P[I] TO -F*P[I]+F4/2 STEP F4
1450 F1=(B3*X)^2-4*S3*(X*X/(U*P[I]^2)-1)
1460 F1=F1*(F1>0)
```

```
1470 PLOT X[I]+X,FNC?
1480 IF J=1 THEN 1510
1490 F=-F
1500 PLOT X[I]+X,FNOF
1510 NEXT X
1520 IF J=2 THEN 940
1530 NEXT F
1540 NEXT J
1550 GOTO 940
1560 IF X[I]*U[I]*Y[I]*S[I] THEN 1590
1570 PRINT LIN1"NONZERO INPUT REQUIRED FOR THIS SYMBOL"LIN1
1580 GOTO 190
1590 P[I]=X[I]*U[I]/100
1600 Q[I]=Y[I]*S[I]/100
1610 GOTO G-7 OF 1630,1630,1380,1380,1740
1620 REM ERROR-BOX PLOT ROUTINE
1630 IPLOT -P[I],Q[I]
1640 IPLOT 0,-2*Q[I]
1650 IPLOT 2*P[I],0
1660 IPLOT 0,2*Q[I]
1670 IPLOT -2*P[I],0
1680 IF G=10 THEN 940
1690 FOR J=1 TO INT(3200*P[I]/P5+1-1E+99)
1700 IPLOT (J/2=INT(J/2))*P5/800,Q[I]*2*SIN(90*(J-2))
1710 NEXT J
1720 GOTO 940
1730 REM ERROR-CROSS PLOT ROUTINE
1740 IPLOT 0,Q[I]
1750 IPLOT 0,-2*Q[I],-1
1760 IPLOT -P[I],Q[I]
1770 IPLOT 2*P[I],0,-1
1780 GOTO 950
1790 DISP ""
1800 IF N<2 THEN 1860
1810 DISP "YORKFIT?  1=YES";
1820 INPUT F
1830 IF F#1 THEN 1860
1840 GOSUB 1920
1850 GOTO 2280
1860 DISP "DATA TO BE RETAINED? (1=YES)";
1870 INPUT J
1880 IF J#1 THEN 150
1890 GOSUB 1920
1900 K=1+N
1910 GOTO 180
1920 GOSUB 1980
1930 IF A=0 THEN 1950
1940 GOSUB 980
1950 IF J=0 OR G=10 OR G=11 THEN 2030
1960 GOSUB 2040
```

```
1970 RETURN
1980 A=J=0
1990 FOR I=K TO N
2000 A=A+ NOT U[I]+ NOT S[I]
2010 J=J+ NOT R[I]
2020 NEXT I
2030 RETURN
2040 DISP "ERROR CORRELATION (LAST BLOCK)";
2050 INPUT T$
2060 IF T$[1,1]#"*" THEN 2200
2070 S=FNP2
2080 IF S >= 1 AND S <= M THEN 2110
2090 GOSUB 2810
2100 GOTO 2040
2110 FOR I=K TO N
2120 F=D[Z[I],S]
2130 IF F >= -1 AND F <= 1 THEN 2170
2140 PRINT LIN1"CHECK PARAMETER # -- ";
2150 PRINT "ERR. CORR. MUST BE BETWEEN -1 AND +1."LIN1
2160 GOTO 2040
2170 R[I]=F
2180 NEXT I
2190 RETURN
2200 F=FNP1
2210 IF F<-1 OR F>1 THEN 2150
2220 FOR I=K TO N
2230 R[I]=F
2240 NEXT I
2250 RETURN
2260 K=1+N
2270 IF F#1 THEN 170
2280 P5=(POS(F$,"87")*POS(F$,"86")*POS(E$,"87")*POS(E$,"86")#0)
2290 P5=P5+(POS(F$,"206")*POS(F$,"204")*POS(E$,"238")*POS(E$,"204")#0)
2300 P5=P5+(POS(F$,"207")*POS(F$,"204")*POS(E$,"235")*POS(E$,"204")#0)
2310 P5=P5+(POS(F$,"144")*POS(F$,"143")*POS(E$,"144")*POS(E$,"143")#0)
2320 LINK I[3]
2330 DISP "LETTER SIZE";
2340 INPUT F
2350 LABEL (*,F*F3*0.8,1.7,0,P)
2360 DISP "POSITION PEN- PRESS STOP WHEN OK"
2370 LETTER
2380 DISP "STATEMENT FOR LETTERING";
2390 INPUT T$
2400 FOR I=1 TO LEN(T$)
2410 IF T$[I,I+2]#"+/-" THEN 2480
2420 CPLOT 0,0.12
2430 LABEL (*)"+";
2440 CPLOT -1,-0.48
2450 LABEL (*)"-";
2460 CPLOT 0,+0.36
```

```
2470 I=I+3
2480 LABEL (*)T$[I,I];
2490 NEXT I
2500 GOTO 150
2510 K=(POS(E$,"206")*POS(E$,"204")*POS(F$,"207")#0)
2520 GOTO K*((POS(F$,"204")#0)+2*(POS(F$,"206")#0)) OF 2630,2610
2530 DISP "DECAY CONSTANT - (1/yr)";
2540 INPUT A
2550 D=1E-06*LOG(1+Q)/A
2560 S3=1E-06*P2/(A*(1+Q))
2570 PRINT "MODEL"I0;"ISOCHRON AGE =";
2580 FORMAT F8.2," +/-",F8.2," M.Y. (DECAY CONST. =",E11.4,"/YR)",/,80"-",/,/
2590 WRITE (15,2580)D,S3,A
2600 GOTO 140
2610 Q=A7
2620 P2=P1
2630 H1=1
2640 D=FNZQ/1E+06
2650 S3=H1*(FNZ(Q+P2)-FNZ(Q-P2))/2E+06
2660 GOTO 2570
2670 DEF FNZ(Q)
2680 A=9.8485E-10
2690 C=1.55125E-10
2700 IF Q>0.0156 AND Q<6.6 THEN 2740
2710 PRINT LIN1"** CANNOT CALCULATE AN AGE FOR 207/206 ="Q,LIN2
2720 H1=0
2730 RETURN 0
2740 S=3E+09*(SGN(-1/2+(Q>A/(C*137.88)))+(Q>0.7))
2750 F=C*EXP(S*(C-A))/A
2760 E=LOG(1+(EXP(S*C)-1-F*(EXP(S*A)-1))/(1/(137.88*Q)-F))/A
2770 IF ABS(E-S)<1000 THEN 2800
2780 S=E
2790 GOTO 2750
2800 RETURN E
2810 PRINT LIN1"**** ONLY"M"PARAMETERS DEFINED ****"LIN2
2820 RETURN
2830 END
```

Third Segment:

```
10 REM PART 3 (YORKFIT) OF HP-9830/9862 X-Y PLOTTER PROGRAM.  K.R. LUDWIG, 1982
20 FIND I[2]
30 STANDARD
40 FORMAT 6X,22"<"," YORKFIT ",22">",/,/
50 WRITE (15,40)
60 PRINT "X = "E$,TAB30"Y = "F$,LIN1"** ERRORS ARE 2-SIGMA **"LIN2
70 PRINT "SET#"TAB12"X"TAB24"% ERR"TAB36"Y";TAB48"% ERR"TAB61"CORRELATION"LIN1
80 I3=I0=I9=0
90 Q=1
100 I1=0
110 S3=Q
120 Q=S3
130 I1=1+I1
140 IF I1>10 THEN 1700
150 IF I1>1 AND I3=0 THEN 330
160 FOR I=1 TO N
170 IF I3=0 THEN 270
180 IF P5=0 THEN 230
190 T=(Y[I]*S[I]/200)^2
200 F[I]=R[I]*SQR(T/(T+S8^2))
210 Q[I]=1/(T+S8^2)
220 GOTO 320
230 P[I]=1
240 Q[I]=1/Q^2
250 F[I]=0
260 GOTO 320
270 P[I]=(200/(X[I]*U[I]))^2
280 Q[I]=(200/(Y[I]*S[I]))^2
290 F[I]=R[I]
300 PRINT I;TAB9;X[I];TAB23;U[I];TAB33;Y[I];TAB47;S[I];TAB63;R[I]
310 M[I]=SQR(P[I]*Q[I])
320 NEXT I
330 S1=B5=D=E=X1=Y1=0
340 FOR I=1 TO N
350 Z[I]=P[I]*Q[I]/(Q^2*Q[I]+P[I]-2*Q*F[I]*M[I])
360 S1=S1+Z[I]
370 X1=X1+Z[I]*X[I]
380 Y1=Y1+Z[I]*Y[I]
390 NEXT I
400 X1=X1/S1
410 Y1=Y1/S1
420 FOR I=1 TO N
430 U=X[I]-X1
440 V=Y[I]-Y1
450 B5=B5+Z[I]^2*(U^2/Q[I]-V^2/P[I])
460 D=D+Z[I]^2*(U*V/P[I]-F[I]*U^2/M[I])
```

```
470 E=E+Z[I]^2*(U*V/Q[I]-F[I]*V^2/M[I])
480 NEXT I
490 S3=B5^2+4*D*E
500 IF S3<0 THEN 1700
510 S3=(SQRS3-B5)/(2*D)
520 IF ABS((S3-Q)/S3)>1E-04 THEN 120
530 Q=S3
540 D=E=S=0
550 A7=Y1-Q*X1
560 I9=1+I9
570 IF I9>30 THEN 1700
580 REM ERROR CALCULATIONS FOLLOW TITTERINGTCN & HALLIDAY
590 REM (CHEM. GEOL. V. 26, P 183, 1979)
600 FOR I=1 TO N
610 Y=Y[I]-Q*X[I]-A7
620 S=S+Z[I]*Y^2
630 X=X[I]-Z[I]*Y*(F[I]*M[I]-Q*Q[I])/(P[I]*Q[I])
640 D=D+Z[I]*X[I]
650 E=E+Z[I]*X[I]^2
660 NEXT I
670 V=N-2
680 K=(V<2)*12.7+(V >= 2)*1.96*V/SQR(V^2-2.43*V+1.696)
690 J=(V#0)*S/(V+ NOT V)
700 IF  NOT P5 OR  NOT I3 OR P5*(ABS(S-V)<0.01) THEN 740
710 S8=S8*SQRJ
720 DISP J
730 GOTO 100
740 B3=SQR(S1/(E*S1-D^2))
750 F1=B3*SQR(E/S1)
760 B5=B3*SQRJ
770 S1=F1*SQRJ
780 GOTO (I3#0)*(1+P5) OF 1140,1100
790 IF S#0 AND ((S<13)+(N>9)*(S<22)+(N>14)*(S<30)) THEN 820
800 F= NOT S
810 GOTO 1000
820 D=F=1
830 IF INT(V/2)=V/2 THEN 950
840 FOR I=2 TO 2000 STEP 2
850 D=D*S/(V+I)
860 F=F+D
870 IF D<1E-06 THEN 890
880 NEXT I
890 D=SQRPI
900 FOR I=0.5 TO V/2
910 D=D*I
920 NEXT I
930 F=1-EXP(-S/2)*(S/2)^(V/2)*F/D
940 GOTO 1000
950 FOR I=1 TO V/2-1
960 D=D*S/(2*I)
```

```
970 F=F+D
980 NEXT I
990 F=F*EXP(-S/2)
1000 I0=1+(F<0.01)+(F<0.05)+(F<0.3)
1010 WRITE (15,1210)
1020 PRINT "**MODEL 1 SOLUTION -- ASSUMES ALL SCATTER DUE TO ANALYTICAL ERROR**
1030 I5=P2=1.96*B3
1040 I4=P1=1.96*F1
1050 X9=X1
1060 Y9=Y1
1070 Q2=Q
1080 A6=A7
1090 GOTO 1190
1100 PRINT "*******MODEL 3 SOLUTION --ASSUMES SCATTER DUE TO ANALYTICAL ERROR"
1110 PRINT "*********PLUS NORMAL VARIATION IN INITIAL "F$"*****"LIN1
1120 PRINT LIN1"CALC. VARIATION IN INITIAL"F$"="2*S8" (2-SIGMA)"
1130 GOTO 1160
1140 PRINT TAB90"*******MODEL 2 SOLUTION -- ASSUMES EQUALLY WEIGHTED POINTS AND
1150 PRINT "*******NORMAL DISTRIBUTION OF RESIDUALS"
1160 P2=K*B5
1170 P1=K*S1
1180 FORMAT /,/,33X,"SLOPE",19X,"INTERCEPT",/,33X,5"-",19X,9"-",/
1190 WRITE (15,1180)
1200 PRINT "BEST-FIT:"TAB31,Q;TAB56;A7
1210 FORMAT 90"-"
1220 WRITE (15,1210)
1230 IF I3 THEN 1250
1240 PRINT "ERROR (1-SIGMA, A PRIORI)"TAB31,B3;TAB56;F1,LIN1
1250 PRINT "ERROR (1-SIGMA, FROM SCATTER) "TAB31,B5;TAB56;S1
1260 PRINT LIN1"ERROR (95% CONFIDENCE LIMITS)"TAB31,P2;TAB56;P1
1270 PRINT LIN1"COORDINATES OF CENTROID: X="X1;"Y="Y1,LIN1
1280 IF I3 THEN 1330
1290 FIXED 2
1300 PRINT "M.S.W.D. ="J" (OBSERVED SCATTER WILL BE CAUSED BY ANALYTICAL"
1310 PRINT TAB21"ERRORS ALONE "100*F"PERCENT OF THE TIME)"
1320 STANDARD
1330 WRITE (15,1210)
1340 I3=1+I3
1350 IF I3=2 OR I0 <= 1 THEN 1390
1360 IF  NOT P5 THEN 100
1370 S8=S1
1380 GOTO 100
1390 D=2+P5
1400 IF I0=2 THEN 1430
1410 I0=(I0=1)+D*(I0=4)
1420 GOTO 1460
1430 DISP "MODEL 1 OR MODEL"D"SOLUTION";
1440 INPUT I0
1450 IF I0#1 AND I0#D THEN 1430
1460 Q=Q2*(I0=1)+Q*(I0=D OR I0=0)
```

```
1470 A7=A6*(I0=1)+A7*(I0=D OR I0=0)
1480 P2=P2*(I0=D OR I0=0)+I5*(I0=1)
1490 P1=P1*(I0=D OR I0=0)+I4*(I0=1)
1500 X1=X1*(I0=D OR I0=0)+X9*(I0=1)
1510 Y1=Y1*(I0=D OR I0=0)+Y9*(I0=1)
1520 DEF FNX(K)=Q*K+A7
1530 DEF FNY(K)=(K-A7)/Q
1540 GOTO 1+(FNXA1>B2)+2*(FNXA1<A2) OF 1550,1570,1590
1550 PLOT A1,FNXA1
1560 GOTO 1600
1570 PLOT FNYB2,B2
1580 GOTO 1600
1590 PLOT FNYA2,A2
1600 GOTO 1+(FNXB1>B2)+2*(A2>FNXB1) OF 1610,1630,1650
1610 PLOT B1-0.01*C5,FNX(B1-0.01*C5),-1
1620 GOTO 1660
1630 PLOT FNY(0.99*D5+A2),0.99*D5+A2,-1
1640 GOTO 1660
1650 PLOT FNY(A2+0.01*D5),A2+0.01*D5,-1
1660 FOR I=1 TO 40
1670 R[I]=S[I]=U[I]=0
1680 NEXT I
1690 LINK I[2]
1700 I3=1+I3
1710 PRINT LIN1"** NO SOLUTION USING MODEL"I3+(I3#1)*P5"YORKFIT**"LIN2
1720 IF I3=1 THEN 90
1730 I0=1
1740 GOTO 1460
1750 END
```