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Programs in Hewlett-Packard BASIC for Storing, Retrieving, and

Plotting Rare-Earth Element Data for Geochemical Studies,

Using HP-9831/9872 Desk Top Computers and Plotters

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## INTRODUCTION

Rare-earth element (REE) abundance data are used extensively in petrologic and geochemical studies (see Hanson, 1978, for examples). REE data are used to place constraints on parent materials and degrees of partial melting, on amount and type of fractional crystallization, and on oxygen fugacity of igneous rocks. Conclusions are usually supported by plots of the data, graphed as the log of the normalized REE abundances versus either the atomic number of the REE or its ionic radius. One of the programs given here permits filing and retrieval of raw REE abundance data in a form permitting various types of editing, and the other program plots such data normalized to either standard chondrite abundances or a data-set chosen by the user. Features of the plotting program permit data-input either from 50-set data files or from the computer keyboard, and can interpolate or extrapolate certain types of missing data points where necessary. The plot may be scaled to arbitrary sizes and dimensions, and is satisfactory for either publication as a reduced figure or as an original for colored transparencies.

## EQUIPMENT REQUIRED

The programs were written for a Hewlett-Packard 9831 computer with at least 8K words of memory, and a Hewlett-Packard 9872 plotter[1]. The 9830 model computer and 9862 plotter may also be used, with some modifications.

## OPERATION OF DATA-FILE PROGRAM

The data-file program (appendix I) permits data to be stored in files of as much as 50 data sets in 3000-word files. Seven options are available for manipulating the data. The first four options are displayed upon running the program, and the last three may be seen by pressing the left-pointing arrow on the "display" portion of the keyboard. The user must enter the number corresponding to the desired option.

CREATE (1):

To create a new data file, use option 1. Enter a file name (a maximum of 40 characters) for this data file when requested. The computer will then request a sample name (as many as 60 characters), and the abundances in ppm of all the REE except promethium. If no data are available for a particular REE, enter zero. If the data are tentative or calculated, the user may enter the value as a negative number, in which case the plotting program will use dashed lines to and from the point. After all REE data have been entered for a sample, name and data for the next data set will be requested. When data for all desired samples have been entered, enter a space in response to the sample-name request. The display will then be, "STORE IN TRACK #, FILE #?". If the data are to be stored, the appropriate track and file numbers are entered. The user should make sure that the tab on the data tape is in the

[1] The use of trade names in this paper are for descriptive purposes only and do not necessarily constitute endorsement by the U.S. Geological Survey.

store position, and that the file is marked and at least 3K words large. If
the data are not yet to be stored, input a space.

ADD (2):

To add data for additional samples, use option 2. Enter the track and
file numbers when requested (or a space if already in memory) of the data file
to which data are to be added, and proceed as outlined above.

EDIT (3):

To edit (correct) data for any of the data sets, use option 3. Enter the
appropriate track and file number when requested (or a space if already in
memory). Enter the set number to be edited, making sure that the number
corresponds to an existing set. The display will then be "REE TO BE
EDITED?". If you wish to edit just a few of the REE data, input the elements
to be corrected, separated by commas, for example, "Ce, LU, pr, YB". Note
that either capital or lower-case letters may be used. The display will then
request data for these elements. If all REE are to be edited, simply enter
the word "all". If the sample name is to be edited, enter "name", followed by
the REE (or "all") to be edited.

When all the sets to be edited are done, enter a space in response to the
"SET # TO BE EDITED?" display.

PRINT (4):

To obtain a print-out of the data in a data file, use option 4 (fig. 1).
Enter the appropriate track and file number when requested (or a space if
already in memory). The display will then be "SET(S) TO BE PRINTED OUT?". If
a single number is entered, the data from that set will be printed. If two
numbers separated by a comma are input (for example, 2, 17), all the sets from
the first number through the second number will be printed in consecutive
order. When all the desired sets have been printed, enter a space.

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In addition to the raw numbers in the data file, three other values may be printed out. If Gd and Sm data are available, a value indicating the degree of Eu anomaly compared to chondritic values, labeled as Eu/Eu*, will be calculated. This value is calculated from

$$Eu/Eu^* = \frac{Eu_s/Eu_c}{10^{[LOG(Sm_s/Sm_c)+LOG(Gd_s/Gd_c)]/2}}$$

where s and c refer to sample and chondrite, respectively. This expression corresponds to the ratio of observed, chondrite-normalized Eu and the no-anomaly chondrite-normalized Eu calculated by interpolating between the logs of the chondrite-normalized Sm and Gd values.

If La and Lu data are available, the value labeled (La/Lu)e.f. will be calculated. This value (La/Lu enrichment factor) is simply the ratio of the chondrite-normalized La and Lu values, and reflects the degree of relative REE fractionation. If a Yb value is available but not an Lu value, a (La/Yb)e.f. value is calculated. The chondrite REE abundances used are the best estimates of unfractionated chondritic abundances suggested by Evensen and others (1978, p. 1203, column 4).

DELETE (5):

To delete any data set from the data file, use option 5. All higher numbered sets will then be renumbered to one-lower set number.

INSERT (6):

To insert a new data set in between existing numbered sets, use option 6. All higher-numbered sets will then be renumbered to one higher set number.

EXCHANGE (7):

To exchange the set numbers of any two sets, use option 7. Operation is straightforward.

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## OPERATION OF PLOTTING PROGRAM

The first display upon running the program (appendix II) is "SIZE-STD(1) SMALL(2) OTHER(∅)?". The standard size (1) is an 8-1/2 x 11 inch sheet of paper placed vertically at the lower left corner of the plotter. The small size (2), particularly suitable because of the greater apparent line-thickness, for transparencies or figures to be highly reduced, occupies a smaller portion of the same paper. If other (∅) is chosen, the user must position the P1 and P2 points which define the extremes of the plot by using the controls on the plotter himself.

The next display, "LABEL FOR THIS PLOT?", requests a ≤40-character label which will be lettered at the top of the plot. Enter a space if no label is desired. The next display, "CHONDRITE NORMALIZED (1=YES)?", should be answered with a 1 if the data file or other REE data (in ppm) are to be normalized to chondrite abundances, and with a ∅ if the data are to be normalized in some other way. If the data are not to be chondrite-normalized, the display will request an 18-character label for the Y-axis (for example, MINERAL/WHOLE-ROCK). The next display, for example "SAMPLE/CHONDRITE LIMITS?" (or "MINERAL/WHOLE-ROCK LIMITS?", and so on) requests the range of Y-axis values that the plot must accomodate. Enter the minimum and maximum values, separated by a comma (for example, 20, 2400). The plotter will then draw the framework of the plot.

The next display, "(*TRACK#, FILE#,) SET#?", can be answered in several ways.

If the data to be plotted are <u>not</u> to be chondrite-normalized using the default values in the program, then the correct normalizing values must be entered (see below).

The default, standard unfractionated chondritic REE abundances are those suggested by Evensen and others (1978, p. 1203). If the data to be plotted are in a data file but not yet in memory (as would be the case for the first set to be plotted), then the input must be in the form of the track number and file number of the appropriate data file, and the set number of interest. Thus if the user wished to plot data from set 17 of the data file in track 1, file 18, the input would be 1,18,17. Note the mandatory commas. Once a data-file is in memory, however, only the set number need be specified, for example, 17. In other words, the track and file numbers need be specified in the input only when the data file of interest has not been loaded into memory.

If the REE data to be plotted do not exist in a data file, the user may input data from the keyboard by a response of K (or k). The computer will then request the REE data by element. As in the data-file program, input zero for elements with no data, and key any hypothetical or calculated values by inputting the values as a negative number. These keyboard entered data will replace the data of set 50, whether defined or not, in the computer memory.

To input data to be used for normalization, use N (or n) as the first character of the "(*TRACK#, FILE#,) SET#?" response. If the normalizing data are in a data file, the rest of the response follows the same format as for the usual data input, for example, an input of N0,4,6 will result in the REE data of set 6, data file of track 0, file 4, being used as the normalizing values. If the normalizing data are not available in a file, an input of simply N (or n) will permit keyboard input of the data for normalization. The display which follows will be "ELEMENT; NORMAL PPM?". Answer with the element symbol, comma, ppm of that element, for example, Ce,10.6. The element symbol may be both upper case, both lower case; or upper and lower case. Any element not defined will be assigned a value of zero. When all known values have been entered, input a space.

After data input, the next display will be "PLOTTING SYMBOL (,PEN#)?".
Any upper-case symmetric keyboard symbol may be used as a plotting symbol, for
example, O, *, +, X, or no symbol at all (space). Alternatively, an arbitrary
equilateral polygon may be used, in which case enter P or p (for solid or open
polygons, respectively) as the plotting symbol. A pen number (corresponding
to the pen numbers on the plotter) may also be specified. If no pen number is
specified, the pen which is currently in the holder will be used. If P or p
is entered for the plotting symbol, the display will be "# SIDES, ROTATION
(degrees)?". Enter the number of sides the polygon is to have (must be >2),
and the angular position of one of its vertices. For example, an input of
4,45 will give a square with sides parallel to the sides of the plotting paper
(vertices at $45^O$). The angle is measured counter-clockwise from the X-axis.

If L or l is entered as the plotting symbol, the program permits drafting
of a phrase of arbitrary letter size anywhere in the plot. The first display
will be "LETTER SIZE (1-3)?". Enter a number to define the relative size of
the letters. Numbers within a range of 1 to 3 work best. A question mark
will then appear on the display. The pen may then be positioned using the
four "DISPLAY" arrows on the keyboard. Each keystroke will move the pen one
character width or line height. Press the STOP key when the pen is
positioned. "PHRASE TO BE LETTERED?" will then appear in the display. Type
in the phrase, press the EXECUTE key.

PLOTTING PROCEDURE:

After the data are input, they are normalized and each non-zero and
positive data-point is plotted with the plotting-symbol and pen-color chosen
by the user. These points are then connected with a solid line. If the Sm
value is missing (that is, zero) but the Pr, Nd, and Eu values are present, a
value will be calculated from extrapolated Pr-Nd trend and a line dashed into

and out of this extrapolated Sm value. A similar procedure occurs for Gd where Eu, Tb, and Dy data exist. Negative values are automatically converted to absolute values, and the lines connecting such values dashed. An example of a typical plot is shown in figure 2.

Figure Captions

Figure 1:

Typical printout of the REE data-file program. Values of zero result in dashed-line output.

Figure 2:

Example of REE plot of data in 1. Set 1, space as plotting symbol, no negative data; set 2, solid, 15-sided polygon as plotting symbol, negative Ce, zero Gd; set 3, three-sided, open polygon with vertex at $270^{o}$, no negative data; set 4, space as plotting symbol, all nonzero values negative; set 5, asterisk as plotting symbol, no negative data.

## References

Evensen, N. M., Hamilton, P. J., and O'Nions, R. K., 1978, Rare-earth
abundances in chondritic meteorites: Geochim. Cosmochim. Acta, v. 42, p.
1199-1212.

Hanson, G. N., 1978, The application of trace elements to the petrogenesis of
igneous rocks of granitic composition: Earth Planet. Science Letters,
v. 38, p. 26-43.

FIGURE 1

DATA FROM TRACK# 0    FILE 0                    5    SETS DEFINED

(data in ppm)

SET# 1    PD-5epi

Eu/Eu*= 0.073    (La/Lu)e.f.= 273.843

| La | Ce | Pr | Nd | Sm | Eu | Gd |
|------|-------|-----|------|-------|-------|-------|
| 7334 | 12683 | -- | 4982 | 660.5 | 10.09 | 267.9 |

| Tb | Dy | Ho | Er | Tm | Yb | Lu |
|-------|-------|-----|-----|------|------|------|
| 29.53 | 130.6 | -- | -- | 4.71 | 24.2 | 2.78 |

--------------------------------------------------------------------

SET# 2    MS-1epi

(La/Lu)e.f.= 141.522

| La | Ce | Pr | Nd | Sm | Eu | Gd |
|------|-------|-----|------|-------|------|-----|
| 1936 | -3568 | -- | 1276 | 218.2 | 6.17 | -- |

| Tb | Dy | Ho | Er | Tm | Yb | Lu |
|-------|-------|-----|-----|------|------|------|
| 19.32 | 88.11 | -- | -- | 2.91 | 15.4 | 1.42 |

--------------------------------------------------------------------

SET# 3    GM-2-1550bio

Eu/Eu*= 0.323    (La/Lu)e.f.= 21.629

| La | Ce | Pr | Nd | Sm | Eu | Gd |
|-------|------|-----|------|------|------|-----|
| 45.84 | 71.8 | -- | 31.5 | 6.11 | 0.59 | 5.1 |

| Tb | Dy | Ho | Er | Tm | Yb | Lu |
|------|------|-----|-----|-------|------|------|
| 0.69 | 4.02 | -- | -- | 0.234 | 1.54 | 0.22 |

--------------------------------------------------------------------

SET# 4    PD-5

| La | Ce | Pr | Nd | Sm | Eu | Gd |
|--------|--------|-----|-------|-----|-------|------|
| -133.3 | -237.3 | -- | -84.8 | -12 | -0.68 | -7.8 |

| Tb | Dy | Ho | Er | Tm | Yb | Lu |
|-------|------|-----|-----|-------|-------|--------|
| -0.91 | -4.5 | -- | -- | -0.19 | -1.06 | -0.148 |

--------------------------------------------------------------------

SET# 5    PD-5bio

Eu/Eu*= 0.198    (La/Lu)e.f.= 44.282

| La | Ce | Pr | Nd | Sm | Eu | Gd |
|------|------|-----|-------|------|-----|------|
| 40.1 | 65.2 | -- | 22.82 | 3.78 | 0.2 | 2.53 |

| Tb | Dy | Ho | Er | Tm | Yb | Lu |
|------|------|-----|-----|-------|-------|-------|
| 0.32 | 1.84 | -- | -- | 0.097 | 0.649 | 0.094 |

--------------------------------------------------------------------

# FIGURE 2



MINERAL/WHOLE-ROCK

REE ATOMIC NUMBER

La Ce Pr Nd Sm Eu Gd Tb Dy Ho Er Tm Yb Lu

100

10

1

0.1
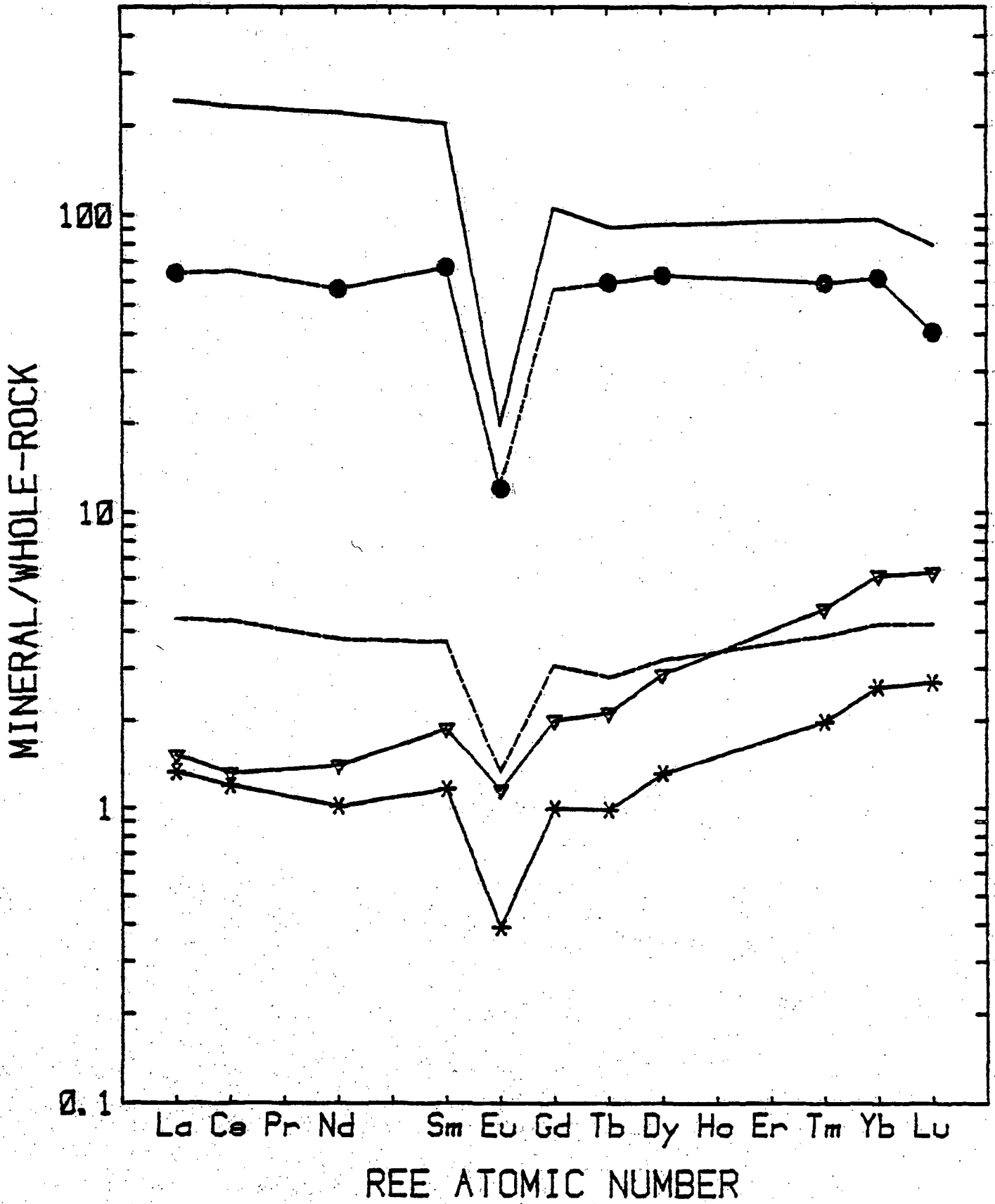
```
10  COM YS[50,14],T$[40],NI[50,30],I2
20  REM REE DATA-FILE PROGRAM, 50 SETS MAX, K.R. LUDWIG, 2/79
30  DIM D$[2],N$[60],A$[80],M$[2],Z$[10],S[14]
40  DATA "La","Ce","Pr","Nd","Sm","Eu","Gd","Tb","Dy","Ho","Er","Tm","Yb","Lu"
50  DATA "LA","CE","PR","ND","SM","EU","GD","TB","DY","HO","ER","TM","YB","LU"
60  DATA "la","ce","pr","nd","sm","eu","gd","tb","dy","ho","er","tm","yb","lu"
70  REM STANDARD UNFRACTIONATED CHONDRITE REE ABUNDANCES
80  REM EVENSEN AND OTHERS, 1978, GEOCHIM. COSMOCHIM. ACTA, V.42, P. 1199-1212
90  DATA 0.2446,0.6379,0.09637,0.4738,0.154,0.05802,0.2043
100 DATA 0.3745,0.2541,0.0567,0.166,0.02561,0.1651,0.02539
110 Z$="0123456789"
120 RESTORE 90
130 MAT READ S
140 DISP "CREATE(1)ADD(2)EDIT(3)PRINT(4)      (5)DELETE (6)INSERT (7)EXCHANGE
150 INPUT F0
160 IF F0<1 OR F0>7 THEN 140
170 GOTO F0 OF 180,480,570,960,1440,1600,1990
180 I2=0
190 DISP "FILE NAME";
200 INPUT T$[1,40]
210 MAT Y=ZER
220 MAT N=ZER
230 N$=" "
240 FOR I=1 TO 50
250 GOSUB 290
260 I2=I2+1
270 NEXT I
280 GOTO 880
290 GOSUB 310
300 GOTO 360
310 DISP "SAMPLE NAME";
320 INPUT N$
330 IF N$=" " THEN 880
340 TRANSFER N$ TO N[I,1]
350 RETURN
360 RESTORE 40
370 FOR M=1 TO 14
380 READ D$
390 GOSUB 410
400 GOTO 440
410 DISP "SET #"I"-- PPM "D$;
420 INPUT Y[I,M]
430 RETURN
440 NEXT M
450 RETURN
460 I2=I2+1
470 RETURN
480 GOSUB 1780
490 IF I2<50 THEN 520
500 PRINT LIN1"**** DATA-FILE IS FULL ****"LIN3
```

```
1010 T=1
1020 F=I2
1030 GOTO 1070
1040 GOSUB 1880
1050 IF F=-1 THEN 970
1060 T=T+ NOT T*F
1070 FOR I=T TO F STEP  NOT (F-T)+SGN(F-T)
1080 IF I>I2 THEN 1410
1090 RESTORE 40
1100 TRANSFER N[I,1] TO N$
1110 PRINT "SET# "I;N$;LIN1
1120 FIXED 3
1130 IF  NOT ((Y[I,5]>0)*(Y[I,6]>0)*(Y[I,7]>0)) THEN 1150
1140 PRINT "Eu/Eu*="(Y[I,6]/S[6])/(10^((LGT(Y[I,5]/S[5])+LGT(Y[I,7]/S[7]))/2)
1150 IF  NOT ((Y[I,1]>0)*(Y[I,14]>0)) THEN 1180
1160 PRINT "(La/Lu)e.f.="Y[I,1]*S[14]/(Y[I,14]*S[1]);
1170 GOTO 1200
1180 IF  NOT ((Y[I,1]>0)*(Y[I,13]>0)) THEN 1200
1190 PRINT "(La/Yb)e.f.="Y[I,1]*S[13]/(Y[I,13]*S[1]);
1200 PRINT
1210 FOR Q=1 TO 8 STEP 7
1220 PRINT
1230 FOR M=Q TO Q+6
1240 READ D$
1250 PRINT SPA(M=1 OR M=8);D$;TAB11*(M-Q+1);
1260 NEXT M
1270 FOR M=Q TO Q+6
1280 IF Y[I,M] THEN 1310
1290 PRINT TAB11*(M-Q)"--";
1300 GOTO 1360
1310 IF ABSY[I,M] >= 0.01 THEN 1340
1320 FLOAT 1
1330 GOTO 1350
1340 STANDARD
1350 PRINT TAB(11*(M-Q)-1);Y[I,M];
1360 NEXT M
1370 PRINT
1380 NEXT Q
1390 FORMAT 90"-"
1400 WRITE (2,1390)
1410 NEXT I
1420 PRINT LIN1
1430 GOTO 970
1440 GOSUB 1780
1450 DISP "SET# TO BE DELETED";
1460 INPUT A$
1470 IF A$=" " THEN 880
1480 GOSUB 1880
1490 IF F=-1 THEN 1450
1500 IF F<1 OR F>I2 THEN 1450
```

```
1010 T=1
1020 F=I2
1030 GOTO 1070
1040 GOSUB 1880
1050 IF F=-1 THEN 970
1060 T=T+ NOT T*F
1070 FOR I=T TO F STEP  NOT (F-T)+SGN(F-T)
1080 IF I>I2 THEN 1410
1090 RESTORE 40
1100 TRANSFER N[I,1] TO N$
1110 PRINT "SET# "I;N$;LIN1
1120 FIXED 3
1130 IF   NOT ((Y[I,5]>0)*(Y[I,6]>0)*(Y[I,7]>0)) THEN 1150
1140 PRINT "Eu/Eu*="(Y[I,6]/S[6])/(10^((LGT(Y[I,5]/S[5])+LGT(Y[I,7]/S[7]))/2)
1150 IF   NOT ((Y[I,1]>0)*(Y[I,14]>0)) THEN 1180
1160 PRINT "(La/Lu)e.f.="Y[I,1]*S[14]/(Y[I,14]*S[1]);
1170 GOTO 1200
1180 IF   NOT ((Y[I,1]>0)*(Y[I,13]>0)) THEN 1200
1190 PRINT "(La/Yb)e.f.="Y[I,1]*S[13]/(Y[I,13]*S[1]);
1200 PRINT
1210 FOR Q=1 TO 8 STEP 7
1220 PRINT
1230 FOR M=Q TO Q+6
1240 READ D$
1250 PRINT SPA(M=1 OR M=8);D$;TAB11*(M-Q+1);
1260 NEXT M
1270 FOR M=Q TO Q+6
1280 IF Y[I,M] THEN 1310
1290 PRINT TAB11*(M-Q)"--";
1300 GOTO 1360
1310 IF ABSY[I,M] >= 0.01 THEN 1340
1320 FLOAT 1
1330 GOTO 1350
1340 STANDARD
1350 PRINT TAB(11*(M-Q)-1);Y[I,M];
1360 NEXT M
1370 PRINT
1380 NEXT Q
1390 FORMAT 90"-"
1400 WRITE (2,1390)
1410 NEXT I
1420 PRINT LIN1
1430 GOTO 970
1440 GOSUB 1780
1450 DISP "SET# TO BE DELETED";
1460 INPUT A$
1470 IF A$=" " THEN 880
1480 GOSUB 1880
1490 IF F=-1 THEN 1450
1500 IF F<1 OR F>I2 THEN 1450
```

```
1510 FOR I=F TO I2-(I2=50)
1520 FOR M=1 TO 14
1530 Y[I,M]=Y[I+1,M]
1540 NEXT M
1550 TRANSFER N[I+1,1] TO N$
1560 TRANSFER N$ TO N[I,1]
1570 NEXT I
1580 I2=I2-1
1590 GOTO 1450
1600 GOSUB 1780
1610 IF I2=50 THEN 500
1620 DISP "INSERT BEFORE SET #";
1630 INPUT A$
1640 IF A$=" " THEN 880
1650 IF F=-1 THEN 1620
1660 IF F<1 OR F>I2 THEN 1620
1670 FOR I=I2 TO F STEP -1
1680 FOR M=1 TO 14
1690 Y[I+1,M]=Y[I,M]
1700 NEXT M
1710 TRANSFER N[I,1] TO N$
1720 TRANSFER N$ TO N[I+1,1]
1730 NEXT I
1740 I=F
1750 GOSUB 290
1760 I2=I2+1
1770 GOTO 1610
1780 DISP "DATA FROM TRACK #, FILE #";
1790 INPUT A$
1800 IF A$=" " THEN 1860
1810 GOSUB 1880
1820 IF F=-1 THEN 1780
1830 LOAD  DATA #T,F
1840 PRINT "DATA FROM TRACK#"T"FILE"F;TAB45;I2"SETS DEFINED"LIN2,T$,LIN1
1850 PRINT "(data in ppm)"LIN2
1860 RETURN
1870 END
1880 T=0
1890 F=-1
1900 IF  NOT POS(Z$,A$[1,1]) THEN 1970
1910 IF  NOT POS(A$,",") THEN 1950
1920 T=VAL(A$)
1930 A$=A$[1+POS(A$,",")]
1940 IF  NOT POS(Z$,A$[1,1]) THEN 1970
1950 F=VAL(A$)
1960 RETURN
1970 PRINT LIN1,A$"???? - INCORRECT SYNTAX.  TRY AGAIN"LIN3
1980 RETURN
1990 DISP "SET NUMBERS TO BE EXCHANGED";
2000 INPUT A$
```

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```
2010 IF A$=" " THEN 140
2020 GOSUB 1880
2030 IF F=-1 THEN 1990
2040 FOR I=1 TO 14
2050 Y=Y[T,I]
2060 Y[T,I]=Y[F,I]
2070 Y[F,I]=Y
2080 NEXT I
2090 TRANSFER N[T,1] TO A$[1,40]
2100 TRANSFER N[F,1] TO N$
2110 TRANSFER N$ TO N[T,1]
2120 TRANSFER A$[1,40] TO N[F,1]
2130 GOTO 1990
2140 END
```

```
10 COM YS[50,14],T$[40],NI[50,30],I2
20 REM REE PLOTTING PROGRAM, FOR HP-9831/9872, K.R. LUDWIG, 2/79
30 DIM D$[2],WS[14],A$[12],N$[60],L$[40],KS[14],E$[2],Z$[11]
40 DIM C$[18],KS[7]
50 REM STANDARD UNFRACTIONATED CHONDRITE REE ABUNDANCES
60 REM (EVENSEN AND OTHERS, 1978;  GEOCHIM. COSMOCHIM. ACTA, V.42, P. 1203)
70 DATA 0.2446,0.6379,0.09637,0.4738,0.154,0.05802,0.2043,0.3745
80 DATA 0.2541,0.0567,0.166,0.02561,0.1651,0.02539
90 Z$=".0123456789"
100 KS="Pp *+Ll"
110 I2=0
120 DEG
130 SLANT
140 MAT K=ZER
150 GOTO 420
160 DEF FNA(X)=10^(INT(LGTX))
170 DEF FNB(X)
180 IF X >= -2 THEN 260
190 GOTO -INTX-2 OF 200,220,240
200 FIXED 3
210 GOTO 270
220 FIXED 4
230 GOTO 270
240 FIXED 5
250 GOTO 270
260 STANDARD
270 RETURN 0.3+ABSX+2+(X<0)
280 END
290 DEF FNE(X)
300 E=1+POS(A$,",")
310 IF POS(Z$,A$[1,1]) THEN 340
320 T=-1
330 GOTO 350
340 T=VAL(A$)
350 IF POS(Z$,A$[E,E]) THEN 380
360 F=-1
370 GOTO 390
380 F=VAL(A$[E])
390 RETURN T
400 END
410 DEF FNK(M)=M+(M>4)
420 STANDARD
430 DISP "SIZE- STD(1) SMALL(2) OTHER(0)";
440 INPUT F
450 B=(F=2)
460 IF F#1 AND F#2 THEN 480
470 MAP B*1300,7500-B*1300,B*1350,9500-B*1350
480 DISP "LABEL FOR THIS PLOT";
490 INPUT L$
500 DISP "CHONDRITE NORMALIZED (1=YES)";
```

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```
510 INPUT F0
520 IF F0=1 THEN 560
530 DISP "Y-AXIS LABEL";
540 INPUT C$
550 GOTO 590
560 C$="SAMPLE/CHONDRITE"
570 RESTORE 70
580 MAT READ K
590 DISP C$" LIMITS";
600 INPUT A2,B2
610 IF B2 <= A2 THEN 590
620 A2=LGT((FNAA2)*INT(A2/FNAA2))
630 B2=LGT(FNAB2*((LGTB2#INTLGTB2)*((B2/FNAB2)#INT(B2/FNAB2))+INT(B2/FNAB2)))
640 S4=B2+(B2-A2)/12
650 P1=0
660 FOR I=INTA2 TO INTB2
670 IF FNBI<P1 THEN 690
680 P1=FNBI
690 NEXT I
700 WRITE (705,*)"OP"
710 ENTER (705,*)X1,Y1,X2,Y2
720 X3=X2-X1
730 Y3=Y2-Y1
740 P=Y3/X3
750 Q=P
760 F3=2.1/Q+B+(X3<4500)
770 F4=2.5/Q+B+(X3<4500)
780 F=P*(1.2*F4/50+(P1-1)*F3/(1.7*67))
790 P2=16.5*F/(F-1)
800 F=(0.75*F3+1.3*F4)/50
810 P3=(A2-S4*F)/(1-F)
820 P8=S4-P3
830 LABEL (*,F3,1.7,0,P)
840 SCALE P2,16.5,P3,S4
850 WRITE (705,*)"TL.5"
860 XAXIS A2,1,0,16
870 DATA "La","Ce","Pr","Nd","Sm","Eu","Gd","Tb","Dy","Ho","Er","Tm","Yb","Lu'
880 DATA "LA","CE","PR","ND","SM","EU","GD","TB","DY","HO","ER","TM","YB","LU'
890 DATA "la","ce","pr","nd","sm","eu","gd","tb","dy","ho","er","tm","yb","lu'
900 RESTORE 870
910 FOR I=1 TO 15
920 IF I=5 THEN 980
930 READ D$
940 IF X3<6000 AND I/2=INT(I/2) THEN 980
950 PLOT I,A2,1
960 CPLOT -1,-3/4
970 LABEL (*)D$;
980 NEXT I
990 LABEL (*,F3,1.7,0,P)
1000 FOR I=16 TO 0 STEP -16
```

```
1010 FOR J=INTA2 TO B2
1020 FOR K=1 TO 9
1030 Y=J+LGTK
1040 IF 100*Y<INT(100*A2) THEN 1140
1050 IF 100*Y>INT(100*B2) THEN 1160
1060 PLOT I,Y,2*(J#INTA2)
1070 IPLOT 0.2*SGN(1-I),0
1080 PLOT I,Y
1090 IF (I=16) OR ((K#1)*(K#5)) THEN 1140
1100 IF ((B2-A2)>3 AND (K=5)) THEN 1130
1110 CPLOT -FNBJ,-1/4
1120 LABEL (*)10^Y;
1130 PLOT I,Y
1140 NEXT K
1150 NEXT J
1160 PLOT I,B2,2
1170 PEN
1180 NEXT I
1190 WRITE (705,*)"TL0,.5"
1200 XAXIS B2,1,0,16
1210 PLOT 0,A2+(B2-A2)/2,1
1220 CPLOT -(P1-1),0
1230 LABEL (*,F4,1.7,90,P)
1240 CPLOT -LEN(C$)/2,0.5
1250 LABEL (*)C$;
1260 PLOT 8,A2,1
1270 LABEL (*,F3,1.7,0,P)
1280 CPLOT 0,-3/4
1290 LABEL (*,F4,1.7,0,P)
1300 CPLOT -8.5,-1.2
1310 LABEL (*)"REE ATOMIC NUMBER"
1320 PLOT 8,B2,1
1330 LABEL (*,F4,1.7,0,F)
1340 CPLOT -LEN(L$)/2,0.5
1350 LABEL (*)L$;
1360 PLOT 17,B2,1
1370 PRINT "N FOR NORMALIZATION DATA, K FOR KEYBOARD DATA-INPUT"
1380 PRINT LIN1"CONT 2030 TO RESTART DATA-PLOTTING"LIN3
1390 GOTO 2030
1400 DISP "PLOTTING SYMBOL, (PEN #)";
1410 INPUT A$
1420 B$=A$[1,1]
1430 Z=FNE0
1440 IF E=1 OR F<0 OR F>4 THEN 1460
1450 SPEN F
1460 C=POS(K$,B$)+1
1470 GOTO 1+(C=2 OR C=3)+2*(C=7)+3*(C=8) OF 2370,2610,2760,2750
1480 REM KEYBOARD DATA-INPUT ROUTINE
1490 RESTORE 870
1500 I=50
```

```
1510  PRINT LIN1"ELEMENT              PPM"LIN2
1520  FOR M=1 TO 14
1530  READ D$
1540  DISP "PPM "D$;
1550  INPUT Y[I,M]
1560  PRINT TAB2;D$,Y[I,M]
1570  NEXT M
1580  PRINT LIN2
1590  N$="KEYBOARD INPUT"
1600  TRANSFER N$ TO N[I,1]
1610  GOTO 2300
1620  PRINT "DATA FOR NORMALIZATION"LIN1
1630  TRANSFER N[I,1] TO N$
1640  PRINT "SET#"I;N$;LIN2
1650  FOR M=1 TO 14
1660  K[M]=Y[I,M]
1670  NEXT M
1680  GOTO 2030
1690  REM KEYBOARD NORMAL-VALUE INPUT ROUTINE
1700  MAT K=ZER
1710  PRINT "ELEMENT    NORMAL PPM"LIN1
1720  DISP "ELEMENT, NORMAL PPM";
1730  INPUT A$
1740  REM INPUT SPACE TO ESCAPE
1750  IF A$=" " THEN 1910
1760  Z=FNE0
1770  IF F#-1 THEN 1800
1780  PRINT "NUMERIC INPUT (PPM) REQUIRED"LIN3
1790  GOTO 1700
1800  E$=A$[1,2]
1810  RESTORE 870
1820  FOR M=1 TO 42
1830  READ D$
1840  IF D$=E$ THEN 1880
1850  NEXT M
1860  PRINT E$" --- NOT RECOGNIZED; TRY AGAIN."LIN3
1870  GOTO 1700
1880  K[M*(M<15)+(M-14)*(M<29 AND M>14)+(M-28)*(M>28)]=F
1890  PRINT SPA2;E$;TAB13;F
1900  GOTO 1720
1910  PRINT LIN2
1920  GOTO 2030
1930  REM NORMALIZATION OF CONCENTRATION DATA
1940  C=0
1950  FOR M=1 TO 14
1960  IF K[M] THEN 1990
1970  W[M]=0
1980  GOTO 2010
1990  W[M]=Y[I,M]/K[M]
2000  C=1
```

```
2010 NEXT M
2020 RETURN
2030 DISP "(*TRACK#, FILE#,) SET#";
2040 INPUT A$
2050 REM N OR n FOR NON-STD NORMALIZING VALUES, K OR k FOR KEYBOARD DATA-ENTRY
2060 IF POS(A$[1,1],"K") OR POS(A$[1,1],"k") THEN 1490
2070 R=POS(A$[1,1],"N") OR POS(A$[1,1],"n")
2080 A$=A$[1+R]
2090 IF R AND LEN(A$)=0 THEN 1700
2100 Z=FNE0
2110 GOTO 2*R+(E=1) OF 2170,2120,2180
2120 IF FNE0#-1 AND F#-1 THEN 2150
2130 GOSUB 2860
2140 GOTO 2030
2150 LOAD  DATA #T,F
2160 PRINT "TRACK#"T"FILE#"F,T$,LIN1
2170 A$=A$[E]
2180 Z=FNE0
2190 IF F#-1 THEN 2210
2200 GOTO 2130
2210 I=F
2220 IF R THEN 1620
2230 IF I2 THEN 2260
2240 PRINT LIN1"*** DATA-FILE HAS NOT BEEN LOADED INTO MEMORY ***"LIN3
2250 GOTO 2030
2260 IF I>0 AND I <= I2 THEN 2290
2270 PRINT TAB10"**** ONLY"I2"SETS IN THIS DATA-FILE ****"LIN3
2280 GOTO 2030
2290 TRANSFER N[I,1] TO N$
2300 PRINT "SET#"I;N$,LIN1
2310 GOSUB 1940
2320 IF O THEN 2350
2330 PRINT LIN1"***** DATA FOR NORMALIZATION HAS NOT BEEN ENTERED ******"LIN3
2340 GOTO 2030
2350 WINDOW 0,16.5,A2,B2
2360 GOTO 1400
2370 FOR M=1 TO 14
2380 IF W[M] <= 0 THEN 2460
2390 PLOT FNKM,LGTW[M],1
2400 GOTO C OF 2430,2640,2640,2470,2410,2410
2410 LABEL (*,2.2,1.7,0,P)
2420 GOTO 2440
2430 LABEL (*,1,1,0,P)
2440 CPLOT -1/3,-1/4
2450 LABEL (*)B$;
2460 NEXT M
2470 LINE
2480 IF W[5] OR  NOT (W[3]*W[4]) THEN 2500
2490 W[5]=-10^(3*LGTW[4]-2*LGTW[3])
2500 IF W[7] OR  NOT (W[8]*W[9]) THEN 2520
```

```
2510 W[7]=-10^(2*LGTW[8]-LGTW[9])
2520 FOR M=1 TO 14
2530 IF W[M]=0 THEN 2570
2540 PLOT FNKM,LGTABSW[M]
2550 IF M=14 THEN 2580
2560 LINE 3,(1+B)+50*(W[M] >= 0 AND W[1+M-(M=14)] >= 0)
2570 NEXT M
2580 PLOT 16,B2,1
2590 LINE
2600 GOTO 2030
2610 DISP "# SIDES, ROTATION (degrees)";
2620 INPUT B3,A9
2630 GOTO 2370
2640 FOR U=0 TO 50*(C=2)
2650 B9=2.5*0.06-U/20
2660 IF B9<0.002 THEN 2730
2670 FOR J=A9 TO A9+360 STEP 360/B3
2680 X1=B9*COSJ
2690 Y1=(1/B)*B9*SINJ*(S4-P3)/(16.5-P2)
2700 PLOT FNKM+X1,Y1+LGTW[M]
2710 NEXT J
2720 NEXT U
2730 PEN
2740 GOTO 2460
2750 SLANT 20
2760 DISP "LETTER SIZE (1-3)";
2770 INPUT F
2780 LABEL (*,2*F*F3/3,1.7,0,B)
2790 WINDOW
2800 LETTER
2810 DISP "PHRASE TO BE LETTERED";
2820 INPUT A$
2830 LABEL (*)A$;
2840 SLANT
2850 GOTO 1400
2860 PRINT LIN2"****      "A$"???? - INCORRECT SYNTAX; TRY AGAIN ****"LIN3
2870 RETURN
2880 END
```