CABFAC/USGS, a FORTRAN program for Q-mode factor analysis of stratigraphically ordered samples

by

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ABSTRACT

This program is a revision of the CABFAC program of Kovan and Imbrie (1971) which incorporates the following improvements: each factor is plotted against depth on the printer; samples are ordered stratigraphically by the program, so that input data need not be ordered stratigraphically; an option has been added to transform all variables to zero means before calculating the cosine-theta matrix; and all subroutines are variable-dimensioned, so that the size of the program may be changed by simply altering the main program.

INTRODUCTION

The CABFAC program of Klovan and Imbrie (1971) was designed to perform a Q-mode factor analysis of data sets with a large number of samples (N) and a smaller number of variables (n). A direct solutions of a Q-mode factor analysis involves manipulating an N x N matrix of numbers; this approach is not possible when N is large. CABFAC uses matrix transformations to reduce the problem to perform Q-mode analyses involving hundreds of samples.

I wished to use CABFAC to study pollen samples from sediment cores in order to compare the results with those obtained by using principal component analysis (Adam, 1973). A card deck and listing of the program were provided by John Imbrie and N. Kipp for CABFAC DELUXE, their own version of the program which provides graphical printout of the factors not available in the published version (Klovan and Imbrie 1971).

The program as supplied by Imbrie and Kipp works well for pollen data. In the course of my work I have made several modifications to the program that make it easier to use, easier to change, and more economical to run. This report describes those changes and provides a listing of the program. The reader is referrred to the original published version of the program (Klovan and Imbrie, 1971) for a full discussion of the mathematical procedures followed and the input variables used. Only the modifications are described here.

Graphical output

CABFAC DELUXE used a general-purpose graphical output subroutine, PLOT, which is very inefficient. Data values were simply scaled from minimum to maximum, with the result that there is no plotted zero y-axis and the values chosen for scale marks are completely arbitrary and not symmetrical about zero; numeric data values are not printed on the graph either.

For CABFAC/USGS this routine has been completely rewritten as PLOTTA. Each factor is plotted about a zero y-axis, and the scaling factor used is easy to read. Each data point may be plotted either as a single point (default) or as a bar extending from the data point to the zero axis. Any character may be used for plotting; default character is a plus (+). In addition to the graphical versio n of the data, the sample identification, sample depth and the plotted data value are printed.

PLOTTA is also much faster than PLOT. In one test run using the 46 x 42 Osgood Swamp data matrix (Adam, 1974), use of PLOTTA resulted in

a program execution time decrease of about 5% as compared with PLOT.

Zero-mean data transformation

In working with pollen data, I have found it useful to transform each variable to a zero mean before calculating the similarity-coefficient matrix (Adam, 1974). This option has been added to the program, and may be selected by punching a '3' in column 16 of control card number 2.

Stratigraphic ordering of samples

CABFAC DELUXE lists output in the same order in which it appears in the input deck. CABFAC/USGS eliminates this restriction, at the added cost of requiring that sample depth be punched with the input data for each sample. Depth is considered to increase downward, but an option is provided for depth to increase upwards, as might occur using elevational data from outcrop sampling.

Ordering is done only once, just after the data has been read, using subroutine THREAD. This routine creates a threaded list that specifies the order in which samples are to be listedfor output, and this list is referred to for all subsequent printing and punching operations.

Dimensioning

CABFAC DELUXE is dimensioned to handle up to 60 variables and 500 samples; any changes in these limits requires redimensioning all subroutines. IN CABRAC/USGS I have changed all subroutines to variable dimensions, so that changes may be made by simply changing the main program.

CABFAC/USGS is currently dimensioned to handle up to 200 samples and 60 variables; this may be changed by changing the main program dimension statements and also changing the statements that define values for MAXSAM and MAXVARX in the first executable statements after the dimension statements. When increasing the maximum number of samples, be particularly careful in changing the EQUIVALENCE statements; mistakes here can lead to subtle but significant errors.

Resequencing of statements

CABFAC DELUXE shows the usual signs of a mature program in that the FORTRAN statement numbers are rather haphazard. CABFAC/USGS has been run through another program, TIDY, that has renumbered the program deck so that statement numbers are in numerical order and FORMAT statements are grouped together at the end of each program or subroutine.

References cited

Adam, David P., 1970, Some palynological applications of multivariate statistics: Tucson, Arizona Univ., Ph.D. thesis, 132 p.

---, 1974, Palynological applications of principal component and cluster analyses: Jour. Research U.S. Geol. Survey, v. 2, no. 6, p. 727-741.

Klovan, J.E., and Imbrie, J., 1971, An algorithm and FORTRAN-IV program for large-scale Q-mode factor analysis and calculation of factor scores: Mathematical Geology, v. 3, n. 1, p. 61-77.

APPENDIX A

INPUT DATA PREPARATION

Control card 1:

Cols. 1- 2 - Number of jobs to be run. For each job, there must must be a data deck, as defined below.

Each data deck consists of the following:

Job title card
Job control card
Variable name cards
Variable format cards (3 cards, always)
Sample data cards

These are described in detail below:

Job title card:

Cols. 1-80- Any job title

Job control card:

Cols. 1- 3- NV, the number of variables
Cols. 4- 7- NS, the number of samples
Cols. 8-12- Percent of information required, F5.0
Col. 14- If greater than zero, input data will be transformed to percentages before analysis.
Col. 16- ITRANS, values as follows:
0= no transformation
1= transform each variable to % of maximum value
2= transform each variable to % of range
3= transform each variable to zero mean
Cols. 17-18- NROT, number of factors to be rotated. If NROT=0, the program will select enough factors to describe the percent of information required or 10 factors, whichever is less, and will then produce VARIMAX factor sets for that set of factors and for all smaller sets down to 2 factors. If NROT is specified, only one set of VARIMAX factors will be produced.
Cols. 19-20- IFPUN, punch control, values as follows:
-2= punch everything (not reco-mended; this will punch your data again)
-1= punch VARIMAX factor and factor score matrices
0= no punch
1= punch raw data only
2= punch percentage data only
3= punch transformed data only
4= punch normalized data only
5= punch VARIMAX factor matrix only
6= punch factor score matrix only

Job control card, continued:

Cols. 26-27- Plot option, as follows:
-1= Plot VARIMAX factor scores only
0= No plot
1= Plot data and VARIMAX factor scores

Col. 29: MEND, exit control, as follows:
0= complete analysis of data deck
1= exit after printing raw data
2= exit after printing sample percentage data
3= exit after printing transformed data
4= exit after printing normalized data

Col. 30: stratigraphic order, as follows:
blank= depth increases downward
1= depth increases upward (If you use the wrong value, your graphical output will be printed upside down.)

Col. 34: point/bar control for plots:
blank= data points plotted with a single character
non-blank= data points plotted as a bar between the data point and the zero axis.

Col. 35: character used for plotting. If left blank, '+' will be used.

Variable name cards: punch variable names, 10 per card in 2A4 format. Use only as many cards as you need.

Variable format cards: 3 cards containing the variable data format, starting in col. 1 of the first card with a left parenthesis.

Sample data cards: for each sample, as many cards as are required to contain the data in the format given on the variable format cards. Data items must appear in the following order:

Items 1-3: sample identification, up to 12 characters total. These will be printed on the output in 3A4 format.

Item 4: sample depth

Items 5-(n+4): data values for items 1 through n.

APPENDIX B

PROGRAM LISTING

```
C     CABFAC/USGS * QUASI-Q-MODE FACTOR ANALYSIS                                A    1
C                                                                               A    2
C     THE ORIGINAL PROGRAM ON WHICH THIS VERSION IS BASED IS DESCRIBED          A    3
C       IN                                                                      A    4
C                                                                               A    5
C         KLOVAN, J. E., AND IMBRIE, JOHN, 1971 -                               A    6
C         AN ALGORITHM AND FORTRAN-IV PROGRAM FOR LARGE-SCALE Q-MODE            A    7
C           FACTOR ANALYSIS AND CALCULATION OF FACTOR SCORES:                   A    8
C         MATHEMATICAL GEOLOGY, VOL. 3, NO. 1, PP. 61-77.                       A    9
C                                                                               A   10
C     THE MODIFICATIONS INCORPORATED IN THIS VERSION ARE DESCRIBED IN -          A   11
C                                                                               A   12
C       ADAM, DAVID P., 1976                                                    A   13
C       CABFAC/USGS, A FORTRAN PROGRAM FOR Q-MODE FACTOR ANALYSIS OF            A   14
C         STRATIGRAPHICALLY ORDERED SAMPLES                                     A   15
C       U. S. GEOLOGICAL SURVEY OPEN-FILE REPORT NUMBER 76-216                  A   16
C                                                                               A   17
C                                                                               A  250
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -     A  260
C                                                                               A  270
C     CONTROL CARD SET-UP                                                       A  280
C     ------------------------------------------------------------------------  A  290
C                                                                               A  300
C   FIRST CARD COLS 1-2 : THE NUMBER OF JOBS TO BE RUN                          A  310
C                                                                               A  320
C   FOR EACH JOB THE FOLLOWING CONTROL CARDS ARE NEEDED                         A  330
C                                                                               A  340
C     CONTROL CARD 1:                                                           A  350
C        COLUMNS 1 - 80:  ANY JOB TITLE                                         A  360
C     CONTROL CARD 2:                                                           A  370
C        COLS 1-3 = NV = NUMBER OF VARIABLES (MAX. OF 60)                       A  380
C        COLS 4-7 = NS = THE NUMBER OF SAMPLE POINTS (MAX OF  500)              A  390
C        COLS 8-12 = PERCENT INFORMATION REQUIRED,F5.0                          A  400
C        COL 14 = PERCENT SAMPLE CALCULATION OPTION                             A  410
C        COL 16 = ITRANS = 0 FOR NO TRANSFORMATION, = 1 FOR % MAXIMUM           A  420
C            TRANSFORMATION, = 2 FOR % RANGE TRANSFORMATION,                    A  430
C            = 3 FOR ZERO MEAN TRANSFORMATION ON VARIABLES.                     A  440
C     COL 17,18=NROT, FOR SPECIFIED ROTATION                                    A  450
C     COL 19-20:  IFPUN= PUNCH CONTROL                                          A  460
C         -2=PUNCH EVERYTHING                                                   A  470
C         -1=PUNCH VARIMAX FACTOR AND F MATRICES ONLY                           A  480
C          0=NO PUNCH                                                           A  490
C          1=RAW DATA ONLY                                                      A  500
C          2=% SAMPLE DATA ONLY                                                 A  510
C          3= TRANSFORMED DATA ONLY (% MAXIMUM WHEN ITRANS = 1,                 A  520
C                                    % RANGE WHEN ITRANS = 2,                   A  530
C                                    ZERO MEAN WHEN ITRANS = 3)                 A  540
C          4=NORMALIZED DATA ONLY                                               A  550
C          5=VARIMAX FACTOR MATRIX ONLY                                         A  560
C          6=F MATRIX ONLY                                                      A  570
C      COLS 26-27: PLOT OPTION, -1=VARIMAX;0=SKIP;+1= DATA + VARIMAX            A  580
C     COL 29:  MEND = EXIT CONTROL                                              A  590
C          0=SUPPRESS OPTION                                                    A  600
C          1=EXIT AFTER PRINTING RAW DATA                                       A  610
C          2=EXIT AFTER % SAMPLE                                                A  620
C          3=EXIT AFTER % RANGE OR % MAXIMUM                                    A  630
C          4=EXIT AFTER NORMALIZED DATA                                         A  640
C     COL.30-STRATIGRAPHIC ORDER. IF DEPTH INCREASES DOWNWARDS,                 A  650
C     LEAVE BLANK, ELSE PUNCH A"1".                                             A  660
C     COL. 34 - BLANK FOR POINT PLOTS, NON-BLANK FOR BAR HISTOGRAMS.            A  670
C     COL. 35 - CHARACTER TO BE USED FOR DATA POINTS OR HISTOGRAM BARS          A  680
C        ON PLOTS.  IF BLANK, '+' WILL BE USED.                                 A  690
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```
C      CD(S) 3: VAR. NAMES,10 PER CD IN 2A4 FMT                                  A 700
C        CONTROL CDS 4:  THREE CDS CONTAINING DATA FORMAT                        A 710
C      THE FIRST 12 CHARACTERS ON THE DATA CARD ARE RESERVED FOR IDENT,          A 720
C      AND THE NEXT FIELD IS RESERVED FOR SAMPLE DEPTH                           A 730
C                                                                                A 740
C      ------------------------------------------------------------------        A 750
C                                                                                A 760
       DIMENSION F(250,10), COM(250), DEPTH(250)
       DIMENSION X(60), R(60,60), A(60,60), FS(60,10), AA(60), BB(60), CC        A 780
      1(60), DD(60)                                                              A 790
       DIMENSION Q(10), VAR(10), XX(10), T(10,10), SIGMA(60), COMAL(250)         A 800
       DIMENSION XXX(250,60), TAG(250,3), VNAME(60,2)                            A 810
       REAL MAX(60),MIN(60),MEAN(60)                                             A 820
       DIMENSION TITLE(20), FMT(60)                                              A 830
       INTEGER PSAM,UPP,ORDER(250)                                               A 840
       LOGICAL PUNCH,UP,BAR                                                      A 850
       DATA BLANK/' '/,PLUS/'+'/                                                 A 860
       COMMON KT1,KT2,KT3,KT4,KT5,IFPUN,PLOT,BAR,CHAR                            A 870
       EQUIVALENCE (XXX(1,1),F(1,1)), (XXX(1,5),R(1,1)), (XXX(1,23),A(1,1        A 880
      1)), (XXX(1,41),AA(1)), (XXX(1,42),BB(1)), (XXX(1,43),CC(1)), (XXX(        A 890
      21,44),DD(1)), (XXX(1,45),FS(1,1)), (IFPUN,IPUN)                           A 900
       EQUIVALENCE (COMAL(1),XXX(1,60))                                          A 910
C                                                                                A 920
C      ------------------------------------------------------------------        A 930
C                                                                                A 940
C      KT1 = CARD READER                                                         A 950
C      KT2 = CARD PUNCH                                                          A 960
C       KT3= PRINTER                                                             A 970
C       KT4 & KT5 = SCRATCH TAPES                                                A 980
C                                                                                A 990
       MAXSAM=250                                                               A1000
       MAXVAR=60                                                                A1010
       KT1=5                                                                    A1020
       KT2=7                                                                    A1030
       KT3=6                                                                    A1040
       KT4=9                                                                    A1050
       KT5=8                                                                    A1060
       I3=3                                                                     A1070
       I10=10                                                                   A1080
       READ (KT1,330) NJOBS                                                     A1090
     5 NJOBS=NJOBS-1                                                            A1100
       IF (NJOBS) 325,10,10                                                     A1110
    10 REWIND KT4                                                               A1120
       REWIND KT5                                                               A1130
       CHAR=PLUS                                                                A1140
       BAR=.FALSE.                                                              A1150
       READ (KT1,335) TITLE                                                     A1160
       WRITE (KT3,340) TITLE                                                    A1170
       READ (KT1,345) NV,NS,QUIT,PSAM,ITRANS,NROT,IFPUN,PLOT,MEND,UPP,HIS       A1180
      1T,PBAR                                                                   A1190
       UP=.FALSE.                                                               A1200
       IF (HIST.NE.BLANK) BAR=.TRUE.                                            A1210
       IF (PBAR.NE.BLANK) CHAR=PBAR                                             A1220
       IF (UPP.NE.0) UP=.TRUE.                                                  A1230
       READ (KT1,335) ((VNAME(J,I),I=1,2),J=1,NV)                               A1240
       READ (KT1,335) FMT                                                       A1250
       WRITE (KT3,350) NV,NS                                                    A1260
       WRITE (KT3,540) FMT                                                      A1270
       TRACE=0.                                                                 A1280
       SN=NS                                                                    A1290
       VN=NV                                                                    A1300
       SSN=SQRT(SN)                                                             A1310
       SVN=SQRT(VN)                                                             A1320
       IF (PSAM.EQ.0.AND.ITRANS.EQ.0) GO TO 15                                  A1330
       WRITE (KT3,360)                                                          A1340
C                                                                               A1350
```

```
C      ------------------------------------------------------------------  A1360
C      READ RAW DATA AND STORE IN XXX; TAG                                 A1370
C      ------------------------------------------------------------------  A1380
   15 DO 20 K=1,NS                                                         A1390
   20 READ (KT1,FMT) (TAG(K,I),I=1,3),DEPTH(K),(XXX(K,I),I=1,NV)           A1400
C                                                                          A1410
C      ------------------------------------------------------------------  A1420
C                                                                          A1430
      CALL THREAD(DEPTH,ORDER,NS,ITOP,UP)                                  A1440
      WRITE (KT3,365) TITLE                                                A1450
      IF (IPUN.NE.1.AND.IPUN.NE.-2) GO TO 30                               A1460
      K=ITOP                                                               A1470
      WRITE (KT2,335) TITLE                                                A1480
      WRITE (KT2,505)                                                      A1490
      DO 25 KA=1,NS                                                        A1500
      WRITE (KT2,370) K,(TAG(K,I),I=1,3),DEPTH(K),(XXX(K,I),I=1,NV)        A1510
   25 K=ORDER(K)                                                           A1520
   30 CONTINUE                                                             A1530
      CALL WRITE(XXX,TAG,NS,NV,VNAME,MAXVAR,MAXSAM,ORDER,ITOP,DEPTH)       A1540
C                                                                          A1550
C------------------------------------------------------------------------  A1560
C     PLOT     ROUTINE  FOR  DATA                                          A1570
C                                                                          A1580
C------------------------------------------------------------------------  A1590
C                                                                          A1600
      IF (PLOT.LE.0.0) GO TO 40                                            A1610
      DO 35 K=1,NV                                                         A1620
      WRITE (KT3,535) (VNAME(K,J),J=1,2),TITLE                             A1630
   35 CALL PLOTTA(XXX(1,K),NS,TAG,K,MAXSAM,DEPTH,ORDER,ITOP,I3)            A1640
   40 IF (MEND.EQ.1) GO TO 5                                               A1650
C                                                                          A1660
C------------------------------------------------------------------------  A1670
C                                                                          A1680
C      ------------------------------------------------------------------  A1690
C      MAIN DATA OPTION BRANCH                                             A1700
C      ------------------------------------------------------------------  A1710
C                                                                          A1720
      IF (PSAM.LE.0) GO TO 70                                              A1730
      WRITE (KT3,375)                                                      A1740
C                                                                          A1750
C      ------------------------------------------------------------------  A1760
C      PER CENT  SAMPLE  COMPUTATIONS                                      A1770
C      ----------------------------------------                            A1780
C                                                                          A1790
      WRITE (KT3,340) TITLE                                                A1800
      DO 55 K=1,NS                                                         A1810
      TOT=0.0                                                              A1820
      DO 45 I=1,NV                                                         A1830
   45 TOT=TOT+XXX(K,I)                                                     A1840
      WRITE (KT3,380) K,TOT                                                A1850
      DO 50 I=1,NV                                                         A1860
   50 XXX(K,I)=XXX(K,I)*100./TOT                                           A1870
   55 CONTINUE                                                             A1880
      WRITE (KT3,385) TITLE                                                A1890
      IF (IFPUN.NE.2.AND.IFPUN.NE.-2) GO TO 65                             A1900
      K=ITOP                                                               A1910
      WRITE (KT2,335) TITLE                                                A1920
      WRITE (KT2,510)                                                      A1930
      DO 60 KA=1,NS                                                        A1940
   60 K=ORDER(K)                                                           A1950
      WRITE (KT2,370) K,(TAG(K,I),I=1,3),DEPTH(K),(XXX(K,I),I=1,NV)        A1960
   65 CALL WRITE(XXX,TAG,NS,NV,VNAME,MAXVAR,MAXSAM,ORDER,ITOP,DEPTH)       A1970
      IF (MEND.EQ.2) GO TO 5                                               A1980
C                                                                          A1990
C      ----------------------------------------                            A2000
C                                                                          A2010
```

```
C     TRANSFORMATION TO % RANGE OR % MAXIMUM OR ZERO VARIABLE MEANS.      A2020
C                                                                         A2030
C      ---------------------------------------------------------------    A2040
C                                                                         A2050
   70 IF (ITRANS.LE.0) GO TO 155                                          A2060
      IF (ITRANS.NE.3) GO TO 75                                           A2070
      WRITE (KT3,390) TITLE                                               A2080
   75 DO 125 J=1,NV                                                       A2090
      XMAX=XXX(1,J)                                                       A2100
      XMIN=XMAX                                                           A2110
      DO 85 K=2,NS                                                        A2120
      IF (XXX(K,J).GE.XMIN) GO TO 80                                      A2130
      XMIN=XXX(K,J)                                                       A2140
   80 IF (XXX(K,J).LE.XMAX) GO TO 85                                      A2150
      XMAX=XXX(K,J)                                                       A2160
   85 CONTINUE                                                            A2170
      IF (ITRANS.GT.1) GO TO 100                                          A2180
   90 DO 95 K=1,NS                                                        A2190
   95 XXX(K,J)=XXX(K,J)/XMAX                                              A2200
      GO TO 125                                                           A2210
  100 IF (ITRANS.GT.2) GO TO 110                                          A2220
      RANGE=XMAX-XMIN                                                     A2225
      DO 105 K=1,NS                                                       A2230
  105 XXX(K,J)=(XXX(K,J)-XMIN)/RANGE                                      A2240
      GO TO 125                                                           A2250
  110 ASUM=0.0                                                            A2260
      DO 115 K=1,NS                                                       A2270
  115 ASUM=ASUM+XXX(K,J)                                                  A2280
      ASUM=ASUM/NS                                                        A2290
      DO 120 K=1,NS                                                       A2300
  120 XXX(K,J)=XXX(K,J)-ASUM                                              A2310
      WRITE (KT3,395) J,(VNAME(J,K),K=1,2),ASUM                           A2320
  125 CONTINUE                                                            A2330
      PUNCH=.FALSE.                                                       A2340
      IF (IFPUN.EQ.-2.OR.IFPUN.EQ.3) PUNCH=.TRUE.                         A2350
      IF (PUNCH) WRITE (KT2,335) TITLE                                    A2360
      IF (ITRANS.GT.1) GO TO 130                                          A2370
      WRITE (KT3,400) TITLE                                               A2380
      IF (PUNCH) WRITE (KT2,515)                                          A2390
      GO TO 140                                                           A2400
  130 IF (ITRANS.EQ.3) GO TO 135                                          A2410
      WRITE (KT3,410) TITLE                                               A2420
      IF (PUNCH) WRITE (KT2,520)                                          A2430
      GO TO 140                                                           A2440
  135 WRITE (KT3,405) TITLE                                               A2450
      IF (PUNCH) WRITE (KT2,525)                                          A2460
  140 CONTINUE                                                            A2470
      IF (.NOT.PUNCH) GO TO 150                                           A2480
      K=ITOP                                                              A2490
      DO 145 KA=1,NS                                                      A2500
      WRITE (KT2,370) K,(TAG(K,I),I=1,3),DEPTH(K),(XXX(K,I),I=1,NV)       A2520
  145 K=ORDER(K)                                                          A2510
  150 CALL WRITE(XXX,TAG,NS,NV,VNAME,MAXVAR,MAXSAM,ORDER,ITOP,DEPTH)      A2530
      IF (MEND.EQ.3) GO TO 5                                              A2540
C                                                                         A2550
C      ---------------------------------------------------------------    A2560
C                                                                         A2570
C     PUB XXX ON KT5                                                      A2580
C      ---------------------------------------------------------------    A2590
C                                                                         A2600
  155 DO 160 K=1,NS                                                       A2610
  160 WRITE (KT5) (XXX(K,J),J=1,NV)                                       A2620
      REWIND KT5                                                          A2630
C                                                                         A2640
C     ------------------------------------------------------------------  A2650
C     MEAN=VARIABLE MEANS                                                 A2660
```

```
C      SIGMA=VARIABLE STD.DEVS.                                          A2670
C      MIN=VARIABLE MINIMUMS                                             A2680
C      MAX=VARIABLE MAXIMUMS                                             A2690
C                                                                        A2700
C      ----------------------------------------------------------------- A2710
C                                                                        A2720
       DO 165 J=1,NV                                                     A2730
       MEAN(J)=0.0                                                       A2740
       SIGMA(J)=0.0                                                      A2750
       MIN(J)=1.0E30                                                     A2760
       MAX(J)=-1.0E30                                                    A2770
C                                                                        A2780
C      ----------------------------------------------------------------- A2790
       DO 165 I=1,NV                                                     A2800
  165  R(I,J)=0.                                                         A2810
C                                                                        A2820
C      BEGIN READ IN LOOP AND COMPUTATION OF BASIC STATS.                A2830
C                                                                        A2840
       DO 185 K=1,NS                                                     A2850
       COM(K)=0.                                                         A2860
       SAMSSQ=0.0                                                        A2870
       READ (KT5) (X(I),I=1,NV)                                          A2880
       DO 175 J=1,NV                                                     A2890
C                                                                        A2900
       MEAN(J)=MEAN(J)+X(J)                                              A2910
       SIGMA(J)=SIGMA(J)+X(J)**2                                         A2920
       IF (X(J).GT.MIN(J)) GO TO 170                                     A2930
       MIN(J)=X(J)                                                       A2940
       GO TO 175                                                         A2950
  170  IF (X(J).LT.MAX(J)) GO TO 175                                     A2960
       MAX(J)=X(J)                                                       A2970
C                                                                        A2980
C                                                                        A2990
C      ----------------------------------------------------------------- A3000
C                                                                        A3010
C      COMPUTING VECTOR LENGTHS                                          A3020
C                                                                        A3030
  175  SAMSSQ=SAMSSQ+X(J)*X(J)                                           A3040
       SAMSSQ=SQRT(SAMSSQ)                                               A3050
       COM(K)=SAMSSQ                                                     A3060
C                                                                        A3070
C      ----------------------------------------------------------------- A3080
C      NORMALIZE THE DATA AND PUT IT ON KT4                              A3090
C                                                                        A3100
       DO 180 J=1,NV                                                     A3110
       X(J)=X(J)/SAMSSQ                                                  A3120
  180  XXX(K,J)=X(J)                                                     A3130
C      ----------------------------------------------------------------- A3140
       WRITE (KT4) (X(J),J=1,NV)                                         A3150
C      ----------------------------------------------------------------- A3160
C                                                                        A3170
C      COMPUTE PSEUDO COS THETA MATRIX                                   A3180
C      ----------------------------------------------------------------- A3190
C                                                                        A3200
  185  CONTINUE                                                          A3210
       IF (IFPUN.NE.4.AND.IFPUN.NE.-2) GO TO 195                         A3220
       WRITE (KT2,335) TITLE                                             A3230
       WRITE (KT2,530)                                                   A3240
       K=ITOP                                                            A3250
       DO 190 KA=1,NS                                                    A3260
       WRITE (KT2,370) K,(TAG(K,I),I=1,3),DEPTH(K),(XXX(K,I),I=1,NV)     A3270
  190  K=ORDER(K)                                                        A3280
  195  CONTINUE                                                          A3290
       WRITE (KT3,415) TITLE                                             A3300
       CALL WRITE(XXX,TAG,NS,NV,VNAME,MAXVAR,MAXSAM,ORDER,ITOP,DEPTH)    A3310
C                                                                        A3320
```

```
C     ------------------------------------------------------------------  A3330
C                                                                         A3340
      IF (MEND.EQ.4) GO TO 5                                              A3350
      REWIND KT4                                                          A3360
      DO 200 K=1,NS                                                       A3370
      READ (KT4) (X(J),J=1,NV)                                            A3380
      DO 200 I=1,NV                                                       A3390
      DO 200 J=I,NV                                                       A3400
  200 R(I,J)=R(I,J)+X(I)*X(J)                                             A3410
      REWIND KT5                                                          A3420
      REWIND KT4                                                          A3430
C                                                                         A3440
      IF (ITRANS.GT.0) GO TO 205                                          A3450
      WRITE (KT3,420) TITLE                                               A3460
      GO TO 210                                                           A3470
  205 WRITE (KT3,425) TITLE                                               A3480
  210 WRITE (KT3,430)                                                     A3490
C                                                                         A3500
C     ------------------------------------------------------------------  A3510
C                                                                         A3520
      DO 220 I=1,NV                                                       A3530
      DO 215 J=I,NV                                                       A3540
  215 R(J,I)=R(I,J)                                                       A3550
C                                                                         A3560
      MEAN(I)=MEAN(I)/NS                                                  A3570
      SIGMA(I)=SQRT((SIGMA(I)/NS)-MEAN(I)**2)                             A3580
      WRITE (KT3,435) (VNAME(I,K),K=1,2),MEAN(I),SIGMA(I),MIN(I),MAX(I)   A3590
C                                                                         A3600
C     ------------------------------------------------------------------  A3610
C                                                                         A3620
  220 TRACE=TRACE+R(I,I)                                                  A3630
C     ------------------------------------------------------------------  A3640
C     CALL THE EIGEN VALUE ROUTINE                                        A3650
C     ------------------------------------------------------------------  A3660
      CALL HDIAG(R,NV,A,X,MAXVAR,AA,BB,CC,DD)                             A3670
C                                                                         A3680
C     ------------------------------------------------------------------  A3690
C     R(I,I) CONTAINS THE EIGENVALUES                                     A3700
C     A CONTAINS THE EIGENVECTORS                                         A3710
C                                                                         A3720
C     NOW DETERMINE THE RIGHT NUMBER OF EIGENVALUES                       A3730
C                                                                         A3740
C     ------------------------------------------------------------------  A3750
C                                                                         A3760
      WRITE (KT3,440) TITLE                                               A3770
      EVSUM=0.                                                            A3780
      DO 225 I=1,NV                                                       A3790
      IF (R(I,I).LT.0.0001) GO TO 230                                     A3800
      NF=I                                                                A3810
      EVSUM=EVSUM+R(I,I)*100./TRACE                                       A3820
      WRITE (KT3,445) I,R(I,I),EVSUM                                      A3830
      IF (NF.GE.10) GO TO 230                                             A3840
      IF (EVSUM.GE.QUIT) GO TO 230                                        A3850
  225 CONTINUE                                                            A3860
C                                                                         A3870
C     ------------------------------------------------------------------  A3880
C                                                                         A3890
C     TRANSFER EIGENVECTORS TO FS; EIGENVALUES TO Q                       A3900
C                                                                         A3910
  230 DO 235 J=1,NF                                                       A3920
      Q(J)=R(J,J)                                                         A3930
      DO 235 I=1,NV                                                       A3940
  235 FS(I,J)=A(I,J)                                                      A3950
      WRITE (KT3,450) TITLE,(J,J=1,NF)                                    A3960
C                                                                         A3970
C     ------------------------------------------------------------------  A3980
```

```
C     BEGIN MAJOR LOOP COMPUTING THE PRINCIPAL FACTOR MATRIX                A3990
C     ------------------------------------------------------------------    A4000
C                                                                           A4010
      DO 240 I=1,NF                                                         A4020
  240 VAR(I)=0.                                                             A4030
      DO 255 K=1,NS                                                         A4040
      READ (KT4) (X(I),I=1,NV)                                              A4050
      DO 245 J=1,NF                                                         A4060
      F(K,J)=0.                                                             A4070
      DO 245 I=1,NV                                                         A4080
  245 F(K,J)=X(I)*FS(I,J)+F(K,J)                                            A4090
      COMAL(K)=0.0                                                          A4100
      DO 250 J=1,NF                                                         A4110
      DPA=F(K,J)**2                                                         A4120
      COMAL(K)=COMAL(K)+DPA                                                 A4130
  250 VAR(J)=VAR(J)+DPA                                                     A4140
      WRITE (KT5) (F(K,I),I=1,NF)                                           A4150
  255 CONTINUE                                                              A4160
      K=ITOP                                                                A4170
      DO 260 KA=1,NS                                                        A4180
      WRITE (KT3,455) (TAG(K,J),J=1,3),DEPTH(K),COMAL(K),(F(K,I),I=1,NF)    A4190
  260 K=ORDER(K)                                                            A4200
C                                                                           A4210
C     ------------------------------------------------------------------    A4220
C                                                                           A4230
C     EXPRESS COLUMN SUM OF SQUARES AS A PERCENT OF TOTAL VARIANCE          A4240
C                                                                           A4250
      DO 265 I=1,NF                                                         A4260
  265 VAR(I)=VAR(I)/TRACE*100.                                              A4270
      X(1)=VAR(1)                                                           A4280
      DO 270 J=2,NF                                                         A4290
      K=J-1                                                                 A4300
  270 X(J)=X(K)+VAR(J)                                                      A4310
      WRITE (KT3,460) (VAR(I),I=1,NF)                                       A4320
      WRITE (KT3,465) (X(I),I=1,NF)                                         A4330
C                                                                           A4340
C                                                                           A4350
C     ------------------------------------------------------------------    A4360
C                                                                           A4370
C     COMPUTE PRINCIPAL FACTOR SCORES                                       A4380
C                                                                           A4390
      WRITE (KT3,470) TITLE,(J,J=1,NF)                                      A4400
      WRITE (KT3,355)                                                       A4410
      DO 275 I=1,NV                                                         A4420
  275 WRITE (KT3,475) (VNAME(I,K),K=1,2),(FS(I,J),J=1,NF)                   A4430
C                                                                           A4440
C     COMPUTE SCALED PRINCIPAL FACTOR SCORE MATRIX                          A4450
C     ------------------------------------------------------------------    A4460
C                                                                           A4470
      WRITE (KT3,480) TITLE,(J,J=1,NF)                                      A4480
      WRITE (KT3,355)                                                       A4490
      DO 285 I=1,NV                                                         A4500
      DO 280 J=1,NF                                                         A4510
  280 XX(J)=FS(I,J)*SVN                                                     A4520
  285 WRITE (KT3,475) (VNAME(I,K),K=1,2),(XX(J),J=1,NF)                     A4530
C                                                                           A4540
C     ------------------------------------------------------------------    A4550
C                                                                           A4560
      NFF=NF                                                                A4570
      IF (NROT.EQ.0) GO TO 295                                              A4580
      NF=NROT                                                               A4590
  290 CONTINUE                                                              A4600
C                                                                           A4610
C     ------------------------------------------------------------------    A4620
C                                                                           A4630
C     CALL VARIMAX ROTATION PROCEDURE                                       A4640
```

```
C                                                                       A4650
  295 CALL VARMAX(NF,NS,NV,TITLE,F,T,COM,TAG,NROT,MAXSAM,DEPTH,ORDER,ITO  A4660
     1P,I3,I10)                                                         A4670
C                                                                       A4680
C     ------------------------------------------------------------------A4690
C                                                                       A4700
C      COMPUTE VARIMAX F. SCORE MATRIX                                  A4710
C                                                                       A4720
      WRITE (KT3,485) TITLE,(J,J=1,NF)                                  A4730
      WRITE (KT3,355)                                                   A4740
      PUNCH=.FALSE.                                                     A4750
      IF (IPUN.EQ.(-2).OR.IPUN.EQ.(-1).OR.IPUN.EQ.6) PUNCH=.TRUE.       A4760
      DO 310 K=1,NV                                                     A4770
      DO 300 I=1,NF                                                     A4780
      XX(I)=0.                                                          A4790
      DO 300 J=1,NF                                                     A4800
  300 XX(I)=FS(K,J)*T(J,I)+XX(I)                                        A4810
C                                                                       A4820
C     COMPUTE SCALED VARIMAX FACTOR SCORE MATRIX                        A4830
C     ------------------------------------------------------------------A4840
C                                                                       A4850
      DO 305 J=1,NF                                                     A4860
  305 A(K,J)=XX(J)*SVN                                                  A4870
      IF (PUNCH) WRITE (KT2,490) K,(VNAME(K,I),I=1,2),(XX(J),J=1,NF)    A4880
  310 WRITE (KT3,475) (VNAME(K,I),I=1,2),(XX(J),J=1,NF)                 A4890
C                                                                       A4900
C                                                                       A4910
C     WRITE SCALED VARIMAX FACTOR SCORE MATRIX                          A4920
C     ------------------------------------------------------------------A4930
      WRITE (KT3,495) TITLE,(J,J=1,NF)                                  A4940
      WRITE (KT3,355)                                                   A4950
      DO 315 I=1,NV                                                     A4960
  315 WRITE (KT3,475) (VNAME(I,K),K=1,2),(A(I,J),J=1,NF)                A4970
C                                                                       A4980
C     ------------------------------------------------------------------A4990
C                                                                       A5000
C     CHECK TO SEE IF ADDITIONAL ROTATIONS ARE REQUIRED                 A5010
C                                                                       A5020
      IF (NROT.GT.0) GO TO 5                                            A5030
      NF=NF-1                                                           A5040
      IF (NF.LT.2) GO TO 5                                              A5050
      IF (X(NF).LT.75.0) GO TO 5                                        A5060
      REWIND KT5                                                        A5070
      DO 320 K=1,NS                                                     A5080
  320 READ (KT5) (F(K,I),I=1,NFF)                                       A5090
      GO TO 290                                                         A5100
C     ------------------------------------------------------------------A5110
  325 WRITE (KT3,500)                                                   A5120
      STOP                                                              A5130
C                                                                       A5140
C                                                                       A5150
  330 FORMAT (I2)                                                       A5160
  335 FORMAT (20A4)                                                     A5170
  340 FORMAT (1H1,20A4)                                                 A5180
  345 FORMAT (I3,I4,F5.0,4I2,5X,F2.0,I2,I1,T34,2A1)                     A5190
  350 FORMAT (23H0NUMBER OF VARIABLES = ,I3,4X,21H NUMBER OF SAMPLES = ,  A5200
     *I4)                                                               A5210
  355 FORMAT (1H0)                                                      A5220
  360 FORMAT (29H0NO DATA TRANSFORMATIONS MADE)                         A5230
  365 FORMAT (15H1INPUT DATA -- ,20A4)                                  A5240
  370 FORMAT (1X,I3,2X,3A4,2X,6F10.4,/,(8F10.4))                        A5250
  375 FORMAT (69H0SAMPLES HAVE BEEN RECALCULATED TO PERCENT BEFORE ANY O  A5260
     1THER OPERATION)                                                   A5270
  380 FORMAT (15H SAMPLE  NUMBER,2X,I4,3X,5HTOTAL,F10.2)                A5280
  385 FORMAT (41H1DATA EXPRESSED AS PER CENT OF SAMPLE -- ,20A4)        A5290
  390 FORMAT (44H1VARIABLE MEANS SUBTRACTED FROM RAW DATA -- ,20A4)     A5300
```

```
  395 FORMAT (1X,I5,5X,2A4,F10.3)                                          A5310
  400 FORMAT (48H1VARIABLES TRANSFORMED TO % OF MAXIMUM VALUE -- ,20A4)    A5320
  405 FORMAT (40H1VARIABLES TRANSFORMED TO ZERO MEANS -- ,20A4)            A5330
  410 FORMAT (46H1VARIABLES TRANSFORMED TO % OF THEIR RANGE -- ,20A4)      A5340
  415 FORMAT (20H1NORMALIZED DATA -- ,20A4)                                A5350
  420 FORMAT (36H1GENERAL STATISTICS FOR RAW DATA -- ,20A4)                A5360
  425 FORMAT (44H1GENERAL STATISTICS FOR TRANSFORMED DATA -- ,20A4)        A5370
  430 FORMAT (1H0,T35,8HSTANDARD,/,3X,8HVARIABLE,T20,7HAVERAGE,T34,9HDEV   A5380
     1IATION,T50,7HMINIMUM,T65,7HMAXIMUM,/)                                A5390
  435 FORMAT (3X,2A4,4F15.4)                                               A5400
  440 FORMAT (16H1EIGENVALUES -- ,20A4,//,T23,10HCUMULATIVE,/,7H NUMBER,   A5410
     13X,10HEIGENVALUE,3X,9HVARIANCE ,/)                                   A5420
  445 FORMAT (I5,F14.4,F11.3)                                              A5430
  450 FORMAT (30H1PRINCIPAL FACTOR LOADINGS -- ,20A4,//,4X,6HSAMPLE,5X,5   A5440
     1HDEPTH,4X,5HCOMM,,I6,9I8)                                            A5450
  455 FORMAT (1H ,3A4,12F8.4)                                              A5460
  460 FORMAT (9H0VARIANCE,20X,10F8.2)                                      A5470
  465 FORMAT (14H CUM. VARIANCE,15X,10F8.2)                                A5480
  470 FORMAT (34H1PRINCIPAL FACTOR SCORE MATRIX -- ,20A4,//,9X,8HVARIABL   A5490
     1E,3X,10I9)                                                           A5500
  475 FORMAT (1H ,8X,2A4,4X,10F9.3)                                        A5510
  480 FORMAT (41H1SCALED PRINCIPAL FACTOR SCORE MATRIX -- ,20A4,//,9X,8H   A5520
     1VARIABLE,3X,10I9)                                                    A5530
  485 FORMAT (32H1VARIMAX FACTOR SCORE MATRIX -- ,20A4,//,6X,8HVARIABLE,   A5540
     16X,10I9)                                                             A5550
  490 FORMAT (1H ,I3,2X,2A4,6X,6F10.4/4F10.4)                              A5560
  495 FORMAT (33H1SCALED VARIMAX FACTOR SCORES -- ,20A4,//,9X,8HVARIABLE   A5570
     1,3X,10I9)                                                            A5580
  500 FORMAT (18H1NORMAL END OF JOB)                                       A5590
  505 FORMAT (31HRAW DATA IN STRATIGRAPHIC ORDER)                          A5600
  510 FORMAT (34HPERCENTAGES IN STRATIGRAPHIC ORDER)                       A5610
  515 FORMAT (46HPERCENT OF MAXIMUM DATA IN STRATIGRAPHIC ORDER)           A5620
  520 FORMAT (44HPERCENT OF RANGE DATA IN STRATIGRAPHIC ORDER)             A5630
  525 FORMAT (37HZERO MEAN DATA IN STRATIGRAPHIC ORDER)                    A5640
  530 FORMAT (38HNORMALIZED DATA IN STRATIGRAPHIC ORDER)                   A5650
  535 FORMAT (13H1RAW DATA -- ,2A4,4H -- ,20A4)                            A5660
  540 FORMAT (25H0VARIABLE DATA FORMAT -- ,20A4,/,(T26,20A4))              A5670
      END                                                                  A5680-
      SUBROUTINE WRITE(XXX,TAG,NS,NV,VNAME,MV,MS,ORDER,FIRST,DEPTH)        B  10
C-------------------------------------------------------------           B  20
C      SUBROUTINE WRITE: WRITES NS X NV MATRIX XXX (XXX,TAG,NS,NV)       B  30
C                                                                        B  40
C-----------------------------------------------------------------------  B  50
C                                                                        B  60
      DIMENSION XXX(MS,MV), TAG(MS,3), VNAME(MV,2), DEPTH(MS)            B  70
      INTEGER ORDER(MS),FIRST                                            B  80
      COMMON KT1,KT2,KT3,KT4,KT5,IFPUN                                   B  90
      KT3=6                                                              B 100
      IF (IFPUN+2) 15,5,15                                               B 110
    5 K=FIRST                                                            B 120
      DO 10 KA=1,NS                                                      B 130
      WRITE (KT2,30) K,(TAG(K,I),I=1,3),DEPTH(K),(XXX(K,I),I=1,NV)       B 140
   10 K=ORDER(K)                                                         B 150
   15 IA=1                                                               B 160
      IB=10                                                              B 170
   20 IF (IB.GT.NV) IB=NV                                                B 180
      WRITE (KT3,35) ((VNAME(J,I),I=1,2),J=IA,IB)                        B 190
      WRITE (KT3,40)                                                     B 200
      K=FIRST                                                            B 210
      DO 25 KA=1,NS                                                      B 220
      WRITE (KT3,45) K,(TAG(K,I),I=1,3),DEPTH(K),(XXX(K,I),I=IA,IB)      B 230
   25 K=ORDER(K)                                                         B 240
      IF (NV.LE.IB) RETURN                                               B 250
      WRITE (KT3,50)                                                     B 260
      IA=IA+10                                                           B 270
      IB=IB+10                                                           B 280
```

```
      GO TO 20                                                          B 290
C                                                                       B 300
C                                                                       B 310
   30 FORMAT (1H,I3,2X,3A4,2X,6F10.4,/,(8F10.4))                        B 320
   35 FORMAT (1H0,4H NO.,3X,11HSAMPLE NAME,8X,5HDEPTH,T35,9(2A4,2X),2A4) B 330
   40 FORMAT (1H )                                                      B 340
   45 FORMAT (1X,I4,3X,3A4,2X,11F10.3)                                  B 350
   50 FORMAT (1H1)                                                      B 360
      END                                                               B 370-
      SUBROUTINE PLOTTA(A,N,TAG,ICOL,MAXN,DEPTH,ORDER,ITOP,I3)          C  10
C                                                                       C  20
C     SUBROUTINE PLOTTA - REPLACES PLOTT IN CABFAC                      C  30
C                                                                       C  40
C     PROGRAMMED BY - DAVID P. ADAM                                     C  50
C                     U. S. GEOLOGICAL SURVEY                           C  60
C                     345 MIDDLEFIELD ROAD                              C  70
C                     MENLO PARK, CALIFORNIA 94025                      C  80
C                                                                       C  90
C     - - - - - - - - - - - - - - - - - -                               C 100
C                                                                       C 110
C                                                                       C 120
      DIMENSION A(N), TAG(MAXN,I3), OUT(61), REF(7), DEPTH(N), SAVE(61) C 130
      INTEGER ORDER(N)                                                  C 140
      LOGICAL ABAR                                                      C 150
      COMMON KT1,KT2,KT3,KT4,KT5,IFPUN,PLOT,ABAR,CHAR                   C 160
      DATA ZERO/'.'/,PLUS/'+'/,OUT/'|',9*' ','|',9*' ','|',9*' ','|',9*' C 170
     1 ','|',9*' ','|',9*' ','|'/,X/'X'/                                C 180
C                                                                       C 190
C     FIND MAXIMUM, MINIMUM, RANGE, AND SCALE FACTORS                   C 200
C                                                                       C 210
      APLUS=CHAR                                                        C 220
      AMAX=0.0                                                          C 230
      AMIN=0.0                                                          C 240
      DO 10 I=1,N                                                       C 250
      IF (AMAX.GT.A(I)) GO TO 5                                         C 260
      AMAX=A(I)                                                         C 270
      GO TO 10                                                          C 280
    5 IF (AMIN.LT.A(I)) GO TO 10                                        C 290
      AMIN=A(I)                                                         C 300
   10 CONTINUE                                                          C 310
      RANGE=AMAX-AMIN                                                   C 320
      SINC=0.001                                                        C 330
   15 IF (SINC.GT.RANGE/1000.) GO TO 20                                 C 340
      SINC=SINC*10.0                                                    C 350
      GO TO 15                                                          C 360
   20 SCALE=0.0                                                         C 370
   25 SCALE=SCALE+SINC                                                  C 380
      IF (50.0*SCALE.GT.RANGE) GO TO 30                                 C 390
      GO TO 25                                                          C 400
   30 IZERO=ABS(AMIN)/SCALE+0.5                                         C 410
      IA=MOD(IZERO,10)                                                  C 420
      IF (IA.NE.0) GO TO 35                                             C 430
      IZERO=IZERO+1                                                     C 440
      GO TO 40                                                          C 450
   35 IZERO=IZERO-IA+11                                                 C 460
   40 IF (IZERO.LE.0.OR.IZERO.GE.62) GO TO 45                           C 470
      ZSAVE=OUT(IZERO)                                                  C 480
      OUT(IZERO)=ZERO                                                   C 490
C                                                                       C 500
C     FIND VALUES FOR SCALE REFERENCE POINTS                            C 510
C                                                                       C 520
   45 DO 50 IA=1,7                                                      C 530
      IB=10*(IA-1)-IZERO+1                                              C 540
   50 REF(IA)=IB*SCALE                                                  C 550
C                                                                       C 560
C     PRINT HEADING                                                     C 570
```

```
C                                                                       C 580
      WRITE (KT3,90) REF                                                C 590
C                                                                       C 600
C     PRINT GRAPH                                                       C 610
C                                                                       C 620
      ZZ=SCALE/2.0                                                      C 630
      I=ITOP                                                            C 640
      DO 85 IA=1,N                                                      C 650
C                                                                       C 660
C     FIND PRINT POSITION                                               C 670
C                                                                       C 680
      IX=IZERO+(A(I)+ZZ)/SCALE                                          C 690
      IF (ABAR) GO TO 60                                                C 700
   55 JA=IX                                                             C 710
      JB=IX                                                             C 720
      GO TO 70                                                          C 730
   60 IF (IX.GT.IZERO) GO TO 65                                         C 740
      IF (IX.EQ.IZERO) GO TO 55                                         C 750
      JA=IX                                                             C 760
      JB=IZERO-1                                                        C 770
      GO TO 70                                                          C 780
   65 JA=IZERO+1                                                        C 790
      JB=IX                                                             C 800
   70 DO 75 J=JA,JB                                                     C 810
      SAVE(J)=OUT(J)                                                    C 820
   75 OUT(J)=APLUS                                                      C 830
      WRITE (KT3,95) (TAG(I,J),J=1,3),DEPTH(I),A(I),OUT                 C 840
      DO 80 J=JA,JB                                                     C 850
   80 OUT(J)=SAVE(J)                                                    C 860
      I=ORDER(I)                                                        C 870
   85 CONTINUE                                                          C 880
      WRITE (KT3,100) REF                                               C 890
      IF (IZERO.GT.0.AND.IZERO.LT.62) OUT(IZERO)=ZSAVE                  C 900
      RETURN                                                            C 910
C                                                                       C 920
C                                                                       C 930
   90 FORMAT (1H0,3X,6HSAMPLE,8X,5HDEPTH,10X,4HDATA,4X,7F10.2,/)        C 940
   95 FORMAT (1X,3A4,F10.3,F15.4,10X,61A1)                              C 950
  100 FORMAT (1H0,40X,7F10.2)                                           C 960
      END                                                               C 970-
      SUBROUTINE HDIAG(R,M,SS,X,MV,D2,D3,D4,E)                          D  10
C     ------------------------------------------------------------------D  20
      DIMENSION R(MV,MV), SS(MV,MV), X(MV), D2(MV), D3(MV), D4(MV), E(MV D  30
     1)                                                                 D  40
C     ------------------------------------------------------------------D  50
      MVSQ=MV*MV                                                        D  60
      CALL HOW(M,MV,M,R,E,SS,X,D2,D3,D4,MV,MVSQ)                        D  70
      DO 15 J=1,M                                                       D  80
      SM=0.0                                                            D  90
      DO 5 I=1,M                                                        D 100
    5 SM=SM+SS(I,J)                                                     D 110
      IF (SM.GE.0.0) GO TO 15                                           D 120
      DO 10 I=1,M                                                       D 130
   10 SS(I,J)=-SS(I,J)                                                  D 140
   15 CONTINUE                                                          D 150
      DO 20 I=1,M                                                       D 160
   20 R(I,I)=E(I)                                                       D 170
      RETURN                                                            D 180
      END                                                               D 190-
      SUBROUTINE HOW(LP,NM,M,R,E,V,A,B,W1,W2,MV,MVSQ)                   E  10
C     ------------------------------------------------------------------F  20
      DIMENSION R(MVSQ), E(MV), V(MVSQ), A(MV), B(MV), W1(MV), W2(MV)   E  30
C     ------------------------------------------------------------------E  40
      IF (LP-1) 35,30,5                                                 E  50
    5 CALL TRIDI(LP,NM,R,A,B,W1,W2,MV,MVSQ)                             E  60
      CALL EIGVAL(LP,NM,M,E,A,B,W1,W2,MV)                               E  70
```

```
      IF (M.EQ.0) GO TO 15                                                  E  80
      K=IABS(M)                                                             E  90
      J=1                                                                   E 100
      DO 10 I=1,K                                                           E 110
      CALL EIGVEC(LP,NM,R,A,B,E(I),V(J),W1,W2,MV,MVSQ)                      E 120
   10 J=J+NM                                                                E 130
   15 NM1=NM+1                                                              E 140
      JJ=NM1                                                                E 150
      LP2=LP*NM                                                             E 160
      DO 25 I=2,LP2,NM1                                                     E 170
      K=I                                                                   E 180
      DO 20 J=JJ,LP2,NM                                                     E 190
      R(K)=R(J)                                                             E 200
   20 K=K+1                                                                 E 210
   25 JJ=JJ+NM1                                                             E 220
      RETURN                                                                E 230
   30 E(1)=R(1)                                                             E 240
      V(1)=1.0                                                              E 250
      A(1)=R(1)                                                             E 260
      B(1)=0.0                                                              E 270
   35 RETURN                                                                E 280
      END                                                                   E 290-
      SUBROUTINE TRIDI(LP,NM,R,A,B,W,Q,MV,MVSQ)                             F  10
C     ------------------------------------------------------------------    F  20
      DIMENSION R(MVSQ), A(MV), B(MV), W(MV), Q(MV)                         F  30
C     ------------------------------------------------------------------    F  40
      LP1=LP-1                                                              F  50
      LP2=LP1*NM+LP                                                         F  60
      LPP=LP2-NM                                                            F  70
      NM1=NM+1                                                              F  80
      L=0                                                                   F  90
      DO 5 I=1,LP2,NM1                                                      F 100
      L=L+1                                                                 F 110
    5 A(L)=R(I)                                                             F 120
      B(1)=0.0                                                              F 130
      IF (LP-2) 65,60,10                                                    F 140
   10 KK=0                                                                  F 150
      DO 50 K=2,LP1                                                         F 160
      KL=KK+K                                                               F 170
      KV=KK+LP                                                              F 180
      KJ=K+1                                                                F 190
      SUM=0.0                                                               F 200
      DO 15 J=KL,KV                                                         F 210
   15 SUM=SUM+R(J)**2                                                       F 220
      S=SQRT(SUM)                                                           F 230
      R(K)=SIGN(S,-R(KL))                                                   F 240
      S=1.0/S                                                               F 250
      W(K)=SQRT(ABS(R(KL))*S+1.0)                                           F 260
      X=SIGN(S/W(K),R(KL))                                                  F 270
      R(KL)=W(K)                                                            F 280
      DO 20 I=KJ,LP                                                         F 290
      JJ=I+KK                                                               F 300
      W(I)=X*R(JJ)                                                          F 310
   20 R(JJ)=W(I)                                                            F 320
      DO 30 J=K,LP                                                          F 330
      JJ=J+1                                                                F 340
      Q(J)=0.0                                                              F 350
      L=KK+J                                                                F 360
      DO 25 I=K,J                                                           F 370
      L=L+NM                                                                F 380
   25 Q(J)=Q(J)+R(L)*W(I)                                                   F 390
      IF (JJ.GT.LP) GO TO 35                                                F 400
      DO 30 I=JJ,LP                                                         F 410
      L=L+1                                                                 F 420
   30 Q(J)=Q(J)+R(L)*W(I)                                                   F 430
   35 X=0.0                                                                 F 440
```

```
      DO 40 J=K,LP                                                        F 450
   40 X=X+W(J)*Q(J)                                                       F 460
      X=0.5*X                                                             F 470
      DO 45 I=K,LP                                                        F 480
   45 Q(I)=X*W(I)-Q(I)                                                    F 490
      LL=KK                                                               F 500
      KK=KK+NM                                                            F 510
      DO 50 I=K,LP                                                        F 520
      LL=LL+NM                                                            F 530
      DO 50 J=I,LP                                                        F 540
      L=LL+J                                                              F 550
   50 R(L)=R(L)+Q(I)*W(J)+Q(J)*W(I)                                       F 560
      L=1                                                                 F 570
      DO 55 I=1,LP                                                        F 580
      X=A(I)                                                              F 590
      A(I)=R(L)                                                           F 600
      R(L)=X                                                              F 610
   55 L=L+NM1                                                             F 620
   60 B(LP)=R(LPP)                                                        F 630
   65 RETURN                                                             F 640
      END                                                                 F 650-
      SUBROUTINE EIGVAL(LP,NM,M,E,A,B,F,W,MV)                             G  10
C                                                                         G  20
      DIMENSION E(60), A(60), B(60), F(60), W(60)                         G  30
C                                                                         G  40
      BD=ABS(A(1))                                                        G  50
      DO 5 I=2,LP                                                         G  60
      BD=BD+1.0                                                           G  70
    5 BD=AMAX1(BD,ABS(A(I))+B(I)**2)                                      G  80
      DO 10 I=1,LP                                                        G  90
      A(I)=A(I)/BD                                                        G 100
      B(I)=B(I)/BD                                                        G 110
      W(I)=1.0                                                            G 120
   10 E(I)=-1.0                                                           G 130
      DO 80 K=1,LP                                                        G 140
   15 IF ((W(K)-E(K))/AMAX1(ABS(W(K)),ABS(E(K)),1.0E-7)-1.0E-5) 80,80,20  G 150
   20 X=(W(K)+E(K))*0.5                                                   G 160
      IS2=1                                                               G 170
      F(1)=A(1)-X                                                         G 180
      IF (F(1).GE.0.0) GO TO 25                                           G 190
      IS1=-1                                                              G 200
      N=0                                                                 G 210
      GO TO 30                                                            G 220
   25 IS1=1                                                               G 230
      N=1                                                                 G 240
   30 DO 60 I=2,LP                                                        G 250
      IF (B(I).EQ.0.0) GO TO 40                                           G 260
      IF (B(I-1).EQ.0.0) GO TO 45                                         G 270
      IF (ABS(F(I-1))+ABS(F(I-2))-1.0E-7.GE.0.0) GO TO 35                 G 280
      F(I-1)=F(I-1)*1.0E7                                                 G 290
      F(I-2)=F(I-2)*1.0E7                                                 G 300
   35 F(I)=(A(I)-X)*F(I-1)-B(I)**2*F(I-2)                                 G 310
      GO TO 50                                                            G 320
   40 F(I)=(A(I)-X)*ISIGN(1,IS1)                                          G 330
      GO TO 50                                                            G 340
   45 F(I)=(A(I)-X)*F(I-1)-SIGN(B(I)**2,FLOAT(IS2))                       G 350
   50 IS2=IS1                                                             G 360
      IF (F(I).EQ.0.0) GO TO 55                                           G 370
      FIS1=FLOAT(IS1)                                                     G 380
      FIS1=(FIS1**2+0.1)/FIS1                                             G 390
      IS1=ISIX((SIGN(FIS1,F(I))))                                         G 400
      IF (IS2+IS1.EQ.0) GO TO 60                                          G 410
   55 N=N+1                                                               G 420
   60 CONTINUE                                                            G 430
      N=LP-N                                                              G 440
      IF (N.LT.K) GO TO 70                                                G 450
```

```
      DO 65 J=K,N                                                       G 460
   65 W(J)=X                                                            G 470
   70 N=N+1                                                             G 480
      IF (N.GT.LP) GO TO 15                                             G 490
      DO 75 J=N,LP                                                      G 500
      IF (X.LE.E(J)) GO TO 15                                           G 510
   75 E(J)=X                                                            G 520
      GO TO 15                                                          G 530
   80 CONTINUE                                                          G 540
      DO 85 I=1,LP                                                      G 550
      A(I)=A(I)*BD                                                      G 560
      B(I)=B(I)*BD                                                      G 570
   85 F(I)=(W(I)+E(I))*BD*0.5                                           G 580
      J=LP                                                              G 590
      K=1                                                               G 600
      DO 95 I=1,LP                                                      G 610
      IF (ABS(F(K))-ABS(F(J)).GT.0.0) GO TO 90                          G 620
      E(I)=F(J)                                                         G 630
      J=J-1                                                             G 640
      GO TO 95                                                          G 650
   90 E(I)=F(K)                                                         G 660
      K=K+1                                                             G 670
   95 CONTINUE                                                          G 680
      IF (ISIGN(1,M).GE.0.0) GO TO 110                                  G 690
      DO 100 I=1,LP                                                     G 700
  100 F(I)=E(I)                                                         G 710
      J=LP                                                              G 720
      DO 105 I=1,LP                                                     G 730
      E(I)=F(J)                                                         G 740
  105 J=J-1                                                             G 750
  110 CONTINUE                                                          G 760
      RETURN                                                            G 770
      END                                                               G 780-
      SUBROUTINE EIGVEC(LP,NM,R,A,B,E,V,P,Q,MV,MVSQ)                    H  10
C                                                                       H  20
      DIMENSION R(MVSQ), V(MVSQ), A(MV), B(MV), P(MV), Q(MV)            H  30
C     ------------------------------------------------------------------H  40
      X=A(1)-E                                                          H  50
      Y=B(2)                                                            H  60
      LP1=LP-1                                                          H  70
      DO 20 I=1,LP1                                                     H  80
      IF (ABS(X)-ABS(B(I+1))) 5,10,15                                   H  90
    5 P(I)=B(I+1)                                                       H 100
      Q(I)=A(I+1)-E                                                     H 110
      V(I)=B(I+2)                                                       H 120
      Z=-X/P(I)                                                         H 130
      X=Z*Q(I)+Y                                                        H 140
      IF (LP1.EQ.I) GO TO 20                                            H 150
      Y=Z*V(I)                                                          H 160
      GO TO 20                                                          H 170
   10 IF (X.EQ.0.0) X=1.0E-10                                           H 180
   15 P(I)=X                                                            H 190
      Q(I)=Y                                                            H 200
      V(I)=0.0                                                          H 210
      X=A(I+1)-(B(I+1)/X*Y+E)                                           H 220
      Y=B(I+2)                                                          H 230
   20 CONTINUE                                                          H 240
      IF (X.EQ.0.0) GO TO 35                                            H 250
      V(LP)=1.0/X                                                       H 260
   25 I=LP1                                                             H 270
      V(I)=(1.0-Q(I)*V(LP))/P(I)                                        H 280
      X=V(LP)**2+V(I)**2                                                H 290
   30 I=I-1                                                             H 300
      IF (I.EQ.0) GO TO 40                                              H 310
      V(I)=(1.0-(Q(I)*V(I+1)+V(I)*V(I+2)))/P(I)                         H 320
      X=X+V(I)**2                                                       H 330
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```
   35 R=ABS(QNUM/QDEN)                                                    I 440
      IF (EPS.GT.R) GO TO 40                                              I 450
      CS4TH=COS(ATAN(R))                                                  I 460
      SN4TH=SIN(ATAN(R))                                                  I 470
      GO TO 60                                                            I 480
   40 IF (QDEN.GE.0.0) GO TO 75                                           I 490
      SNPHI=.70710678                                                     I 500
      CSPHI=SNPHI                                                         I 510
      GO TO 80                                                            I 520
   45 R=ABS(QDEN/QNUM)                                                    I 530
      IF (EPS.GT.R) GO TO 50                                              I 540
      SN4TH=1.0/SQRT(1.0+R**2)                                            I 550
      CS4TH=SN4TH*R                                                       I 560
      GO TO 60                                                            I 570
   50 CS4TH=0.0                                                           I 580
      SN4TH=1.0                                                           I 590
      GO TO 60                                                            I 600
   55 CS4TH=.70710678                                                     I 610
      SN4TH=CS4TH                                                         I 620
   60 R=SQRT((1.0+CS4TH)*0.5)                                             I 630
      CSTH=SQRT((1.0+R)*0.5)                                              I 640
      SNTH=SN4TH/(4.0*CSTH*R)                                             I 650
      IF (QDEN.GE.0.0) GO TO 65                                           I 660
      CSPHI=.70710678*(CSTH+SNTH)                                         I 670
      SNPHI=.70710678*(CSTH-SNTH)                                         I 680
      GO TO 70                                                            I 690
   65 CSPHI=CSTH                                                          I 700
      SNPHI=SNTH                                                          I 710
   70 IF (QNUM.GE.0.0) GO TO 80                                           I 720
      SNPHI=-SNPHI                                                        I 730
      GO TO 80                                                            I 740
   75 NOROT=NOROT+1                                                       I 750
      GO TO 90                                                            I 760
   80 DO 85 N=1,MAXT                                                      I 770
      R=F(N,M)*CSPHI+F(N,MONE)*SNPHI                                      I 780
      F(N,MONE)=F(N,MONE)*CSPHI-F(N,M)*SNPHI                              I 790
      F(N,M)=R                                                            I 800
      IF (N.GT.MAXF) GO TO 85                                             I 810
      TP=T(N,M)                                                           I 820
      T(N,M)=TP*CSPHI+T(N,MONE)*SNPHI                                     I 830
      T(N,MONE)=-TP*SNPHI+T(N,MONE)*CSPHI                                 I 840
   85 CONTINUE                                                            I 850
   90 CONTINUE                                                            I 860
      IF (NOROT-(MAXF*L)/2.NE.0) GO TO 25                                 I 870
      DO 100 N=1,MAXT                                                     I 880
      DO 95 M=1,MAXF                                                      I 890
   95 F(N,M)=F(N,M)*COM(N)                                                I 900
  100 COM(N)=COM(N)**2                                                    I 910
      WRITE (KT3,155) TITLE,(J,J=1,MAXF)                                  I 920
      WRITE (KT3,160)                                                     I 930
      N=ITOP                                                              I 940
      IF (PUNCH) WRITE (KT2,190) MAXF                                     I 950
      DO 105 NA=1,MAXT                                                    I 960
C                                                                         I 970
C     PUNCH VARIMAX FACTOR MATRIX IF NEEDED                               I 980
C                                                                         I 990
      IF (PUNCH) WRITE (KT2,165) N,(NAME(N,JK),JK=1,3),DEPTH(N),COM(N),(  I1000
     1F(N,M),M=1,MAXF)                                                    I1010
      WRITE (KT3,170) N,(NAME(N,JK),JK=1,3),DEPTH(N),COM(N),(F(N,M),M=1,  I1020
     1MAXF)                                                               I1030
  105 N=ORDER(N)                                                          I1040
      DO 110 I=1,MAXF                                                     I1050
      VAR(I)=0.                                                           I1060
  110 CUM(I)=0.                                                           I1070
      FN=MAXT                                                             I1080
      DO 115 I=1,MAXF                                                     I1090
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      GO TO 30                                                          H 340
   35 V(LP)=1.0E10                                                      H 350
      GO TO 25                                                          H 360
   40 X=SQRT(X)                                                         H 370
      DO 45 I=1,LP                                                      H 380
   45 V(I)=V(I)/X                                                       H 390
      J=LP1*NM-NM                                                       H 400
      K=LP                                                              H 410
      GO TO 65                                                          H 420
   50 K=K-1                                                             H 430
      J=J-NM                                                            H 440
      Y=0.0                                                             H 450
      DO 55 I=K,LP                                                      H 460
      L=J+I                                                             H 470
   55 Y=Y+V(I)*R(L)                                                     H 480
      DO 60 I=K,LP                                                      H 490
      L=J+I                                                             H 500
   60 V(I)=V(I)-Y*R(L)                                                  H 510
   65 IF (J.NE.0) GO TO 50                                              H 520
      RETURN                                                            H 530
      END                                                               H 540-
      SUBROUTINE VARMAX(MAXF,MAXT,NV,TITLE,F,T,COM,NAME,NROT,MS,DEPTH,  I   0
     1ORDER,ITOP,I3,I10)                                                I   5
C     VARIMAX MATRIX ROTATION                                           I  10
      DIMENSION F(MS,I10), COM(MS), VAR(10), CUM(10), NAME(MS,I3)       I  20
      DIMENSION DEPTH(MS), TITLE(20)                                    I  30
      DIMENSION T(10,10)                                                I  40
      INTEGER ORDER(MS)                                                 I  50
      LOGICAL PUNCH                                                     I  60
C     MAXT = NO. OF SAMPLES, NS = NO. OF VARIABLES,MAXF = NO.OF FACTORS I  70
      COMMON KT1,KT2,KT3,KT4,KT5,IFPUN,PLOT                             I  80
      DO 10 I=1,MAXF                                                    I  90
      DO 5 J=1,MAXF                                                     I 100
    5 T(I,J)=0.0                                                        I 110
   10 T(I,I)=1.0                                                        I 120
      PUNCH=.FALSE.                                                     I 130
      IF (IFPUN.EQ.(-2).OR.IFPUN.EQ.(-1).OR.IFPUN.EQ.5) PUNCH=.TRUE.    I 140
      EPS=0.06993                                                       I 150
      DO 20 N=1,MAXT                                                    I 160
      COM(N)=0.0                                                        I 170
      DO 15 M=1,MAXF                                                    I 180
   15 COM(N)=COM(N)+F(N,M)*F(N,M)                                       I 190
      COM(N)=SQRT(COM(N))                                               I 200
      DO 20 M=1,MAXF                                                    I 210
   20 F(N,M)=F(N,M)/COM(N)                                              I 220
      L=MAXF-1                                                          I 230
   25 NOROT=0                                                           I 240
      DO 90 M=1,L                                                       I 250
      K=M+1                                                             I 260
      DO 90 MONE=K,MAXF                                                 I 270
      A=0.0                                                             I 280
      B=0.0                                                             I 290
      C=0.0                                                             I 300
      D=0.0                                                             I 310
      DO 30 N=1,MAXT                                                    I 320
      U=F(N,M)**2-F(N,MONE)**2                                          I 330
      V=F(N,M)*F(N,MONE)*2.                                             I 340
      A=A+U                                                             I 350
      B=B+V                                                             I 360
      C=C+U**2-V**2                                                     I 370
   30 D=D+U*V*2.0                                                       I 380
      R=MAXT                                                            I 390
      QNUM=D-2.0*A*B/R                                                  I 400
      QDEN=C-(A**2-B**2)/R                                              I 410
      IF (ABS(QNUM)+ABS(QDEN).LE.0.0) GO TO 75                          I 420
      IF (ABS(QNUM)-ABS(QDEN)) 35,55,45                                 I 430
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      DO 115 J=1,MAXT                                                    I1100
  115 VAR(I)=VAR(I)+F(J,I)*F(J,I)                                        I1110
      DO 120 I=1,MAXF                                                    I1120
  120 VAR(I)=(VAR(I)/FN)*100.                                            I1130
      CUM(1)=VAR(1)                                                      I1140
      DO 125 I=2,MAXF                                                    I1150
  125 CUM(I)=CUM(I-1)+VAR(I)                                             I1160
      WRITE (KT3,175) (VAR(I),I=1,MAXF)                                  I1170
      WRITE (KT3,180) (CUM(I),I=1,MAXF)                                  I1180
C                                                                        I1190
C------------------------------------------------------------------------I1200
C     PLOT  ROUTINE  FOR  VARIMAX  MATRIX                                I1210
C                                                                        I1220
C------------------------------------------------------------------------I1230
C                                                                        I1240
      IF (PLOT.EQ.0.0) GO TO 135                                         I1250
      DO 130 K=1,MAXF                                                    I1260
      WRITE (KT3,195) K,MAXF,VAR(K)                                      I1270
  130 CALL PLOTTA(F(1,K),MAXT,NAME,K,MS,DEPTH,ORDER,ITOP,I3)             I1280
  135 IF (MAXF.LT.3) GO TO 150                                           I1290
C                                                                        I1300
C------------------------------------------------------------------      I1310
C                                                                        I1320
      WRITE (KT3,185) TITLE                                              I1330
      WRITE (KT3,155) (J,J=1,MAXF)                                       I1340
      DO 140 N=1,MAXT                                                    I1350
      DO 140 M=1,MAXF                                                    I1360
      S=F(N,M)                                                           I1370
      F(N,M)=(F(N,M)*F(N,M))/COM(N)                                      I1380
  140 IF (S.LT.0.0) F(N,M)=-F(N,M)                                       I1390
      N=ITOP                                                             I1400
      DO 145 NA=1,MAXT                                                   I1410
      WRITE (KT3,170) N,(NAME(N,JK),JK=1,3),DEPTH(N),COM(N),(F(N,M),M=1, I1420
     1MAXF)                                                              I1430
  145 N=ORDER(N)                                                         I1440
  150 CONTINUE                                                           I1450
      RETURN                                                             I1460
C                                                                        I1470
C                                                                        I1480
  155 FORMAT (26H1VARIMAX FACTOR MATRIX -- ,20A4,/,4H0NO.,7X,6HSAMPLE,7X I1490
     1,5HDEPTH,4X,5HCOMM.,I8,9I9)                                        I1500
  160 FORMAT (1H0)                                                       I1510
  165 FORMAT(I4,3A4,F7.2,8F7.3,/,10F7.3)                                 I1520
  170 FORMAT (1X,I5,2X,3A4,12F9.3)                                       I1530
  175 FORMAT (1H0,7X,8HVARIANCE,T39,10F9.3)                              I1540
  180 FORMAT (1H0,7X,19HCUMULATIVE VARIANCE,T39,10F9.3)                  I1550
  185 FORMAT (41H1NORMALIZED VARIMAX FACTOR COMPONENTS -- ,20A4)         I1560
  190 FORMAT (I2,39H VARIMAX FACTORS IN STRATIGRAPHIC ORDER)             I1570
  195 FORMAT (16H1VARIMAX FACTOR ,I2,4H OF ,I2,16H.  ACCOUNTS FOR ,F7.3, I1580
     1 21H PERCENT OF VARIANCE.,/)                                       I1590
      END                                                                I1600-
      SUBROUTINE THREAD(DEPTH,ORDER,N,FIRST,UP)                          J  10
C                                                                        J  20
C     THIS ROUTINE PREPARES A THREADED LIST OF SUBSCRIPTS.  SAMPLES      J  30
C       ARE ORDERED ACCORDING TO VALUES GIVEN IN DEPTH, AND THE THREADED J  40
C       LIST IS RETURNED IN ORDER.                                       J  50
C                                                                        J  60
C     DEPTH(I) GIVES THE STRATIGRAPHIC POSITION OF SAMPLE I.             J  70
C     ORDER(I) GIVES THE SUBSCRIPT OF THE SAMPLE FOLLOWING SAMPLE I.     J  80
C     N IS THE NUMBER OF SAMPLES.                                        J  90
C     FIRST GIVES THE SUBSCRIPT OF THE FIRST (TOP OR BOTTOM) SAMPLE.     J 100
C     UP IS TRUE IF DEPTH INCREASES UPWARDS, FALSE IF DOWNWARDS.         J 110
C       IF UP IS TRUE, FIRST IS THE BOTTOM SAMPLE.                       J 120
C       IF UP IS FALSE, FIRST IS THE TOP SAMPLE.                         J 130
C                                                                        J 140
C     - - - - - - - - - -                                                J 150
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C                                                                       J 160
C     DECLARATIVE SECTION.                                              J 170
C                                                                       J 180
      DIMENSION DEPTH(N)                                                J 190
      INTEGER ORDER(N),FIRST                                            J 200
      LOGICAL UP                                                        J 210
C                                                                       J 220
C     END OF DECLARATIVE SECTION.                                       J 230
C                                                                       J 240
C     - - - - - - - - - -                                               J 250
C                                                                       J 260
C     START OF PROCEDURAL SECTION.                                      J 270
C                                                                       J 280
C     - - - - -                                                         J 290
C                                                                       J 300
C     INITIALIZE POINTERS.                                              J 310
C                                                                       J 320
      ORDER(1)=9999                                                     J 330
      FIRST=1                                                           J 340
C                                                                       J 350
C     IF UP IS TRUE, CHANGE SIGN OF ALL DEPTHS.                         J 360
C                                                                       J 370
      IF (.NOT.UP) GO TO 10                                             J 380
      DO 5 I=1,N                                                        J 390
    5 DEPTH(I)=-DEPTH(I)                                                J 400
C                                                                       J 410
C     BEGIN MAIN LOOP.                                                  J 420
C                                                                       J 430
   10 DO 35 I=2,N                                                       J 440
      INDEX=FIRST                                                       J 450
      IXA=INDEX                                                         J 460
   15 IF (DEPTH(INDEX).GT.DEPTH(I)) GO TO 25                            J 470
      IF (ORDER(INDEX).GE.9999) GO TO 20                                J 480
C                                                                       J 490
C     INCREMENT POINTERS TO LAST SAMPLE AND CURRENT SAMPLE AND REPEAT   J 500
C       DEPTH TEST.                                                     J 510
C                                                                       J 520
      IXA=INDEX                                                         J 530
      INDEX=ORDER(INDEX)                                                J 540
      GO TO 15                                                          J 550
C                                                                       J 560
C     INDEX SAMPLE IS LAST SAMPLE ON CURRENT LIST.  ENTER SAMPLE I AS   J 570
C       NEW BOTTOM SAMPLE.                                              J 580
C                                                                       J 590
   20 ORDER(I)=9999                                                     J 600
      ORDER(INDEX)=I                                                    J 610
      GO TO 35                                                          J 620
C                                                                       J 630
C     SAMPLE I TO BE ENTERED BEFORE INDEX SAMPLE.                       J 640
C                                                                       J 650
   25 IF (INDEX.EQ.FIRST) GO TO 30                                      J 660
      ORDER(IXA)=I                                                      J 670
      ORDER(I)=INDEX                                                    J 680
      GO TO 35                                                          J 690
   30 FIRST=I                                                           J 700
      ORDER(I)=INDEX                                                    J 710
   35 CONTINUE                                                          J 720
                                                                        J 730
      IF(UP)GO TO 7                                                     J 740
                                                                        J 750
      RETURN                                                            J 760
C                                                                       J 770
C     RESTORE SIGNS OF DEPTHS.                                          J 780
C                                                                       J 790
    7 DO 40 I=1,N                                                       J 800
   40 DEPTH(I)=-DEPTH(I)                                                J 810
      RETURN                                                            J 820
      END                                                               J 830-
```