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THREE COMPUTER PROGRAMS FOR CALCULATION OF PETROLOGICAL AND GEOCHEMICAL PARAMETERS FROM SILICATE ANALYSES

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CONTENTS

SUMMARY

Three programs are described. The first, CIPWNORM, computes the CIPW norm and a number of petrochemical indices, and also computes and plots values for a number of triangular and tetrahedral diagrams of petrological importance. The second program, NIGGBART, computes Niggli values, the Niggli 'basis' (an intermediate step in the calculation of any of the Niggli-Barth norms), and the Barth 'standard cell' (useful in studies of metasomatism). The third program, ZAVSKY, computes parameters devised by Zavaritsky, and plots their values on the orthotetrahedral projection which has now become standard in Russian petrological literature.

DATA PREPARATION

The format of silicate analysis data on 80-column punched cards is identical for all three programs. An eleven-column identification field is followed by 14 four-column fields containing analysed values for the major oxides usually determined, and a five-column field optionally containing the total. The last eight columns on the card are free, and may be used for any comments or identification for sorting purposes.

(a) Identification field. The first 8 columns are occupied by the standard BMR registered number (of the format yy pp ssss, where yy are the last two digits of the year of sample submission, pp is a unique project code within that year, and ssss is a serial number assigned by the geologist). If the analysis is extracted from the literature, or any other source outside the BMR system, any alphanumeric label may be inserted in this space. The 9th column is reserved for a fraction letter (if any) indicating that separate portions of an original sample have been analysed independently. Columns 10 and 11 are filled in only if the analysis is to be included in the BMR geochemical data storage system, in which case the number 20 is inserted.

(b) Analysis fields. Chemical data are inserted in the format bbaa or Obaa where b represents a digit before the decimal point, and a represents a digit after the decimal point. The numbers inserted are weight percent of the oxide in every case. Data are inserted in the fixed order SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, $H_2O(+)$, $H_2O(-)$, CO_2. If data for any oxides are missing, blanks may be left in the appropriate columns. If data for total H_2O are quoted, the value may be coded in the H_2O+ columns; problems arise, however, if iron is quoted simply as 'total iron as Fe_2O_3' or 'total iron as FeO', since the oxidation ratio of iron significantly affects the CIPW norm and many of the other parameters. If this problem is encountered in an analysis of a volcanic rock, it may be useful to apply the transformation suggested by Irvine and Baragar (1971); $Fe_2O_3 = TiO_2 + 1.5$, and correct the FeO value accordingly.

(c) Total. This field is optional, but if the total is not filled in, columns 68-72 must be left blank. The format is bbbaa, the decimal point being assumed after the third digit.

CIPWNORM

(a) Purpose

CIPWNORM is a FORTRAN program for the CSIRO CDC 3600 computer, to calculate CIPW norms from chemical analyses of igneous rocks; it also computes the Solidification Index (Kuno et al., 1957), the Differentiation Index (Thornton & Tuttle, 1960), the Peralkalinity or Agpaitic Index, the potash/soda ration, total iron as weight percent Fe_2O_3, calculated density (based on mineral densities quoted by Berry & Mason, 1959), and data on various three-component systems (quartz-albite-orthoclase, quartz-plagioclase-orthoclase, orthoclase-albite-anorthite, K_2O-Na_2O-CaO, wollastonite-ferrosilite-enstatite, iron-magnesium-alkali, and quartz-nepheline-olivine).

Optionally, plots of these various triangles may be obtained on the lineprinter for each batch of analyses processed, and graph-plotter routines optionally give accurate plots of orthoclase-albite-anorthite triangles and either iron-magnesium-alkali or quartz-albite-orthoclase triangles, plus orthoclase-albite-anorthite-femics tetrahedra and either iron-magnesium-alkali-quartz or quartz-albite-orthoclase-corundum tetrahedra. All triangular and tetrahedral data are computed in terms of weight proportions.

(b) Program Operation

The program reads a chemical analysis, optionally including trace element data, and computes the norm by a method analogous to hand computation, using FORTRAN 'IF' statements to determine the choice of minerals formed, according to the presence or absence of an element at the current state of computation.

Triangular and tetrahedral data, together with the other indices, are then computed, and the results for each sample printed on a single page of lineprinter output. Triangular and tetrahedral data are stored on scratch drum units for plotting at the end of the run.

The program is listed in Appendix A, and examples of the printout and plots are shown in Figures 1-4.

(c) Treatment of trace element data

The elements F, S, Cl, V, Cr, Co, Ni, Cu, Zn, Rb, Sr, Zr, and Ba may be included in the norm computation if desired. Their treatment is described below.

F and Cl are incorporated into apatite. Any excess F is made into fluorite, and after this, if there is any excess Cl, it is made into halite.

V is combined with Fe_2O_3.

Co, Ni, and Cu are combined with FeO.

Cr is used to make chromite.

Zn is used to make sphalerite if there is sufficient sulphur, any excess Zn being combined with FeO. Any excess sulphur is used to make pyrite.

Rb is combined with K_2O.

Sr is combined with CaO.

Zr is used to make zircon.

Ba is combined with K_2O.

(d) Input Cards

Job deck structure is given below.

```
*JOB, chargecode, ident, timelimit          (total time in minutes)
*EQUIP, 1=PL, 2=PL, 3=PL, 4=PL
*FTN, L, X
     Fortran deck inserted here
*LOAD
*RUN, timelimit, printlimit                 (run time in minutes)
  TRIANGLE                                  (from col.3; if lineprinter
                                             plots of triangles required)
  PLOTTRIA                                  (if graph-plotter plots of
                                             triangles required)
  TETRAHED                                  (if tetrahedral plots
                                             required)
blank card inserted here if trace element cards to be included.
Chemical analysis cards inserted here. Standard silicate analysis card
followed by an optional trace element card, for each sample.
7
8EOF                                        (7 overpunching 8 in column 1)
*EOD
```

Notes

(i) Total time = run time + 4 minutes.
Run time = n/10 + 2 minutes, where n is the number of samples.
Print limit = 60n + 500 lines.

(ii) On PLOTTRIA card: if an accurate FMA triangle is desired, leave column 12 blank; if the Q-Ab-Or triangle is desired, punch a 1 in column 12.

(iii) On TETRAHED card: if an FMA-quartz tetrahedron is desired, leave column 12 blank; if a Q-Ab-Or-corundum triangle is required, punch a 1 in column 12.

(iv) Format of the optional trace element card is similar to the major oxide card.

Columns 1-8 :	registered number
Column 9 :	fraction letter
Columns 10-11:	blank
Columns 12-63:	trace element data in fields of four columns each. Values are quoted in integer numbers of ppm, right justified within the field. If values above 9999ppm occur, they are quoted in weight percent of the element, with the decimal point explicitly coded (e.g. 1.23, occupying all 4 columns). Elements are coded in the order F, S, Cl, V, Cr, Co, Ni, Cu, Zn, Rb, Sr, Zr, Ba.

NIGGBART

(a) Purpose

Program NIGGBART computes Niggli values, the Barth 'Standard Cell', the Basis (of the various Niggli norms), and data for plotting the four triangular diagrams, Q-L-M, Q-Kp-Ne, K-Na-Ca, and Fe-Mg-Ca (the last two are not the normal ternary diagrams but represent the element contents in aluminosilicates and in alumina-free silicates respectively). All the computation methods are given in detail by Burri (1964). Optionally the program plots the triangles on the lineprinter and graph plotter.

(b) Program Operation

The structure of the program is very simple, with the Niggli values, Barth Standard Cell, and Niggli Basis computed consecutively for each sample; scratch drum storage is used for retention of triangular diagram data until the end of the job, when triangles are plotted if desired. A listing of the program is given in Appendix B.

(c) Input Cards

Job deck structure is given below.

```
*JOB, chargecode, ident, timelimit
*EQUIP, 1=PL, 2=PL, 5=60
*FTN, X, L
     Fortran deck inserted here
*LOAD
*RUN, timelimit, printlimit
  TRIANGLE                        (if triangular plots required; start in
                                   col. 3)
   Silicate analysis cards inserted here
7
8EOF
*EOD
```

Notes

Total time = run time + 2 minutes

Run time = n/20 + 1 minute

Print limit = 60n + 250 lines

ZAVSKY

(a) Purpose

This program computes Zavaritsky parameters (Zavaritsky, 1950, 1964; Coats, 1968) and plots their values on the orthotetrahedral projection proposed by Zavaritsky and now generally adopted in the Soviet petrological literature. The method of calculation is given by Zavaritsky (1964), and Coats (1968) provides a rare example of the use of the method in the English-language literature.

The parameters are divided into four 'principal' numbers and ten 'supplementary' numbers. The principal numbers, a, c, b, and s sum to 100, and have the following significance:

a is the relative number of alkali atoms combined with aluminium (i.e. in aluminosilicates)

c is the relative number of calcium atoms combined with aluminium (i.e. in aluminosilicates)

b is the relative number of all the remaining metal atoms, excluding Silicon and titanium and not combined with aluminium; it includes any aluminium excess over alkalis and calcium or any excess of calcium and alkalis over aluminium.

s is the relative number of silicon and titanium atoms.

There are ten supplementary numbers (or 'numerical characteristics'):

f', m', and c' represent the proportions of iron, magnesium, and calcium respectively in simple silicates

n represents the ratio of sodium atoms to the total number of alkali atoms

t indicates the content of titanium

ϕ represents the amount of ferric iron in simple silicates

Q indicates the excess (if positive) or deficiency (if negative) of free silica

In rocks with an excess of aluminium over alkalis and calcium, c' is replaced by a value a' which indicates the surplus of alumina over that required for alumino-silicates.

In rocks with an excess of sodium, the value n' is obtained, indicating the sodium excess after formation of aluminosilicates and ferrisilicates (e.g. aegirine). If there is an excess of alkalis over aluminium, the value of c becomes negative, and an additional parameter, $\bar{c}$, indicates the number of excess alkaline atoms.

The principal values a, c, b and s may be plotted in a tetrahedron; each rock composition may be represented by its projections on to two of the triangular facies, and Fig. 5 shows the conventional presentation of this plot as suggested by Zavaritsky. The equilateral triangles are transformed to right-angled isosceles triangles for ease of plotting.

Supplementary characters may also be indicated in the same diagram by vectors constructed from the plotted points x_1 and x_2.

The vector on point x_1 represents the alkali relationships (Fig. ´a), its length being proportional to total alkali content, and its direction depending on the K/Na ratio.

The vector on x_2 indicates the relationships in the f'm'c' or f'm'a' system, and its construction is illustrated in Fig. 6b. The end of the vector is the point within the appropriate triangle at which the rock composition plots.

(b) Program Operation

For each silicate analysis input, the program computes the Zavaritsky values exactly as directed by Zavaritsky (1964). Scratch drum storage is required to store the values until the end of the job, when the orthotetrahedral diagram is plotted.

(c) Input Cards

Job deck structure is given below.

```
*JOB, chargecode, timelimit

*EQUIP, 1=PL, 5=60

*FTN, X, L

    Fortran deck inserted here

*LOAD

*RUN, timelimit, printlimit
    Silicate analysis cards inserted here

7
8EOF

*EOD
```

Notes

Total time = run time + 1 minute

Run time = n/30 minutes

Print limit = 40n lines

There is no limit to the number n of analyses that can be processed in one run, but the diagram can look very crowded if more than about 20 rocks of similar composition are included.

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APPENDIX 1

Listing of program CIPWNORM and the subroutines TRIGDIG, TRIGPLOT, and TETRPLOT.
TRIGDIG and TRIGPLOT are used also by program NIGGBART.

```
      PROGRAM CIPWNORM
C     TO CALCULATE THE CIPW NORM OF A ROCK FROM A SILICATE ANALYSIS
C     WRITTEN BY W.R. MORGAN
C   REVISED BY S.HENLEY BMR 1971 TO INCLUDE TRACE ELEMENT AND TRIANGULAR
C   DIAGRAM + RATIO DATA.   ALL RATIOS ARE IN WEIGHT PERCENT,
C
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      DIMENSION  IELM(28),MINL(49),T(27)
      DIMENSION NTITLE(2)
      INTEGER Z1
      COMMON IJKLMN
      DATA (IELM= 6HSIO2   ,6HTIO2   ,6HAL2O3 ,6HFE2O3 ,6HFEO    ,6HMNO    ,
     1              6HMGO    ,6HCAO    ,6HNA2O   ,6HK2O    ,6HP2O5   ,6HH2O(+),
     2              6HH2O(-),6HCO2    ,6HTOTAL ,6HF      ,6HS      ,6HCL     ,
     3              6HV      ,6HCR     ,6HCO     ,6HNI     ,6HCU     ,6HZN     ,
     4              6HRB     ,6HSR     ,6HZR     ,6HBA     )
      DATA (MINL= 8HQUARTZ   ,8HACMITE   ,8HCORUNDUM,8HZIRCON   ,
     1             8HWOLLASTO,6HNITE     ,8HORTHOCLA,8HSE       ,8HDIOPSIDE,
     2             8HWO      ,8HALBITE   ,8HEN      ,8HANORTHIT,8HE       ,
     3             8HFS      ,8HNEPHELIN,8HE       ,8HHYPERSTH,8HENE     ,
     4             8HLEUCITE ,8HKALIOPHI,8HLITE    ,8HOLIVINE ,8HFO      ,
     5             8HHALITE  ,8HFA      ,8HMAGNETIT,8HCHROMITE,8HHEMATITE,
     6             8HILMENITE,8HPLAGIOCL,8HASE - AN,8HRUTILE  ,8HTITANITE,
     7             8HPEROVSKI,8HTE      ,8HCOLOUR I,8HNDEX IS ,8HAPATITE ,
     8             8HFLOURITE,8HPYRITE  ,8HCALCITE ,8HBARITE  ,8HWITHERIT,
     9             8HSPHALERI,8H        ,8H        ,8HTOTAL   ,8H        )
   10 FORMAT (2X,A8,1X,14F4.2/11X,13F4.3)
   15 FORMAT (2X,A8,1X,14F4.2/11X,13F4.4)
   20 FORMAT(2X,A8,1X,14F4.2)
   30 FORMAT (1H1,60X,8HPAGE NO.,I6)
   40 FORMAT(1H-,5X,*CIPW NORM OF SAMPLE NO. *,A8)
   50 FORMAT(1H-,9X,*SILICATE ANALYSIS*,26X,*FEMIC CONSTITUENTS*,29X,*SA
     1LIC CONSTITUENTS*,/10X,*OXIDE*,5X,*PERCENT*,11X,*MINERAL*,8X,
     2*PERCENT*,4X,*COMPONENT  PERCENT*,16X,*MINERAL*,8X,*PERCENT*)
   60 FORMAT(10X,A6,4X,F7.2,11X,2A8,F6.2,4X,A8,3X,F7.2,16X,2A8,F6.2)
   65 FORMAT(10X,A6,4X,F7.4,11X,2A8,F6.2)
   80 FORMAT(10X,A6,4X,F7.2,11X,2A8,F6.2,38X,2A8,F6.2)
   90 FORMAT(10X,A6,4X,F7.2,37X,A8,3X,F7.2,16X,2A8,F6.2)
  100 FORMAT(10X,A6,4X,F7.2,71X,2A8,F6.2)
   70 FORMAT(38X,2A8,F6.2,/38X,2A8,F6.2)
  110 FORMAT(//20X,*TRIANGULAR DATA DIAGRAM*,///    7X,*Q - PLAG - OR*,
     15X,*K2O - NA2O - CAO*,
     1                       5X,*WO - FS - EN*,30X,*PLAGIOCLASE - AN*,10X,F6.2
     2,/1H0,6X,
     2        *Q*,F12.2,5X,*K2O*,F13.2,5X,*WO*,F10.2,30X,*COLOUR INDEX IS*,
     311X,F6.2,/7X,*PLAG*,F9.2,5X,*NA2O*,F12.2,5X,*FS*,F10.2,/7X,*OR*,
     4F11.2,5X,*CAO*,F13.2,5X,*EN*,F10.2,30X,*CALC. DENSITY*,12X,F6.2)
  120 FORMAT(//88X,*SOLIDIFICATION INDEX*,6X,F6.2,/7X,*Q -   AB   - OR*,5X
     1,*OR  =  AB  -  AN*,5X,*F  -  M  - A*,5X,*OL - NE -  Q*,13X,*THORN
     2TON - TUTTLE*,/88X,*DIFFERENTIATION INDEX*,5X,F6.2)
  130 FORMAT(7X,*Q*,F12.2,5X,*OR*,F14.2,5X,*F*,F11.2,5X,*OL*,F10.2,13X,
     1*PERALKALITY INDEX*,9X,F6.2,/7X,*AB*,F11.2,5X,*AB*,F14,2,5X,*M*,
     2F11.2,5X,*NE*,F10.2,13X,*K2O/NA2O*,18X,F6.2,/7X,*OR*,F11.2,5X,*AN*
     3,F14.2, 5X,*A*,F11.2,5X,*Q*,F11.2,13X,*TOTAL FE AS FEO*,11X,F6.2)
  300 FORMAT(2A8)
  310 IJKLMN=0
      ITHR=0
      IBLANK=8H
      ICD=14
      ITRIG=8HPLOTTRIA
```

```
      TETRA=8HTETRAHED
      IITRIA=IITRIG=0
      LABQ=8HQUARTZ
      LABCO=8HCORUNDUM
      LABA=8HALBITE
      LABO=8HORTHCLSE
      LABP =8HPLAGCLSE
      LABAN=8HANORTHTE
      LABK=8H    K2O
      LABN=8H  NA2O
      LABC=8H    CAO
      LABW=8H    WO
      LABF=8H    FS
      LABE=8H    EN
      LABI =8H  IRON
      LABAA=8H ALKALI
      LABM = 8HMAGNESIA
      LABSI=8H  SIO2
      LABAL=8H  AL2O3
      LABFM=8H FEMICS
      ITRIA=8HTRIANGLE
      JKL=0
      NPAGE=1
  320 CONTINUE
C READ CHEMICAL DATA FROM CARDS, EITHER 14 OR 27 ELEMENTS
      IF (ICD,EQ.27) 330 ,340
  330 IF (ITHR.EQ.1) 331,332
  331 READ 10,NAME,(T(J),J=1,ICD)
      IF (EOF,60) 1250,350
  332 READ 15,NAME,(T(J),J=1,ICD)
      IF (EOF,60) 1250,350
  340 READ 20 , NAME, (T(J),J=1,ICD)
      IF (EOF,60)1250,350
  350 IF (NAME.EQ.ITRIA)390 ,360
  360 IF (NAME.EQ.ITRIG)400 ,370
  370 IF (NAME.EQ.TETRA) 380,385
  385 IF (NAME.EQ.8HSPECIAL ) 386,420
  386 ITHR=1
      GO TO 410
  380 ITET=1
      IF (T(1).GT.0.0) NOPQ=1
  390 IITRIA=1
      GO TO 410
  400 IITRIG=1
      IF(T(1).GT.0.0) JOAN=1
      GO TO 410
C
C
  410 CONTINUE
      GO TO 320
  420 IF (NAME.EQ.IBLANK) 430 ,440
  430 ICD=27
      GO TO 320
  440 CONTINUE
      JKL=JKL+1
      SUM=0.0
      DO 450 I=1,ICD
      IF (I.NE.12.AND.I.NE.13) SUM=SUM+T(I)
  450 CONTINUE
      DO 455 I=1,ICD
```

```
      IF (I.EQ.12.OR.I.EQ.13) 455,453
  453 T(I)=T(I)*100./SUM
  455 CONTINUE
      SI=T(1)/60.06
      TI=T(2)/79.9
      AL=T(3)/101.94
      F3=T(4)/159.68
      F2=T(5)/71.84
      FMN=T(6)/70.93
      FMG=T(7)/40.32
      CA=T(8)/56.08
      ZNA=T(9)/61.99
      YK=T(10)/94.19
      P=T(11)/141.96
      C=T(14)/44.01
      TF  = T(15)/19.0
      TS  = T(16)/32.056
      TCL = T(17)/35.457
      TV = T(18)/50.95
      TCR = T(19)/52.01
      TFCO= T(20)/58.94
      TFNI= T(21)/58.69
      TFCU= T(22)/63.54
      TFZN= T(23)/65.38
      TRB = T(24)/85.48
      TSR = T(25)/87.63
      TZR = T(26)/91.32
      TBA = T(27)/137.36
      CA=CA+TSR
      FMG=FMG+TFNI
      F2=F2+TFCO+FMN+TFCU
      YK=YK+TRB
      XONA= T(10)/T(9)
      PERIND=(YK+ZNA)/AL
      F3=F3+TV
      PRINT 30 ,NPAGE
      NPAGE=NPAGE+1
  460 CONTINUE
      DO 465, I=1,ICD
  465 IF (I.NE.12.AND.I.NE.13) T(I)=T(I)*SUM/100.
      POP=0.0
       ZIR=CHR=FLU=PYR=SPHAL=HAL=BAR=WITH=0.0
      IF(TZR)480 ,480 ,470
  470 ZIR=TZR*1.5
      SI=SI-TZR*0.5
  480 IF (TCR) 500 ,500 ,490
  490 CHR=TCR*2.0
      F2=F2-CHR
  500 IF(TF)540 ,540 ,510
  510 IF(TF-P*0.1)530 ,530 ,520
  520 TF=TF-0.1*P
      POP=TF
      FLU=TF*1.5
      CA=CA-TF*0.5
      TF=0.0
      GO TO 540
  530 TF=0.0
      POP=0.0
  540 IF(TCL)560 ,560 ,550
  550 TCL=TCL-POP
```

```
      HAL=TCL*2.0
      ZNA=ZNA-TCL
  560 IF (TZN-TS) 570 ,570 ,580
  570 SPHAL=TZN*2
      TS=TS-TZN
      GO TO 590
  580 SPHAL=TS*2
      TZN=TZN-TS
      F2=F2+TZN
  590 CONTINUE
  600 YK=YK+TBA
  610 PYR=TS*1.5
  620 TS=0.0
      IF(F2-TI)630,640,640
  630 XIL=F2
      TI=TI-F2
      F2=0.
      GO TO 650
  640 XIL=TI
      F2=F2-TI
      TI=0.
  650 AP=P
      CA=CA-3.33*P
      IF(C-0.)660,660,670
  660 CC=0.
      GO TO 680
  670 CC=C
      CA=CA-C
  680 IF(AL-YK)690,700,700
  690 POR=AL
      PM=YK-AL
      AL=0.
      GO TO 710
  700 POR=YK
      AL=AL-YK
      PM=0.
  710 IF(AL-ZNA)790,780,720
  720 I=1
      PAB=ZNA
      AL=AL-ZNA
      IF(AL-CA)740,730,730
  730 J=1
      AN=CA
      CO=AL-CA
      RU=TI
      PF=0.
      GO TO 850
  740 J=2
      AN=AL
      CA=CA-AL
      CO=0.
  750 IF(CA-TI)760,760,770
  760 K=1
      PF=CA
      RU=TI-CA
      CA=0.
      GO TO 850
  770 K=2
      PF=TI
      RU=0.
```

```
      CA=CA-TI
      GO TO 850
  780 I=2
      J=2
      PAB=ZNA
      AL=0.
      AN=0.
      CO=0.
      GO TO 750
  790 I=3
      J=2
      PAB=AL
      ZNA=ZNA-AL
      AN=0.
      CO=0.
      IF(ZNA-F3)800,810,810
  800 L=1
      AC=ZNA
      SM=0.
      F3=F3-ZNA
      GO TO 820
  810 L=2
      AC=F3
      SM=ZNA-F3
      F3=0.
  820 IF(CA-TI)830,830,840
  830 K=1
      PF=CA
      RU=TI-CA
      CA=0.
      GO TO 860
  840 K=2
      PF=TI
      RU=0.
      CA=CA-TI
      GO TO 860
  850 L=1
      AC=0.
      SM=0.
  860 GO TO(870,900),L
  870 IF(F2-F3)880,890,890
  880 EMT=F2
      HE=F3-F2
      F2=0.
      GO TO 910
  890 EMT=F3
      F2=F2-F3
      HE=0.
      GO TO 910
  900 EMT=0.
      HE=0.
  910 GO TO(920,930),J
  920 PEN=FMG
      PFS=F2
      WO=0.
      DWO=0.
      DEN=0.
      DFS=0.
      GO TO 970
  930 GO TO(920,940),K
```

```
  940 PEN=FMG
      PFS=F2
      XWO=CA
      IF(XWO-(PFS+PEN))950,960,960
  950 M=1
      DWO=XWO
      DFS=PFS*DWO/(PFS+PEN)
      DEN=PEN*DWO/(PFS+PEN)
      PFS=PFS-DFS
      PEN=PEN-DEN
      WO=0.
      GO TO 970
  960 M=2
      DWO=PEN+PFS
      WO=XWO-DWO
      DEN=PEN
      DFS=PFS
      PEN=0.
      PFS=0.
  970 SA=6.*PAB+6.*POR+2.*AN+DWO+DEN+DFS+PEN+PFS+4.*AC+PM+SM*WO+PF
      IF(SI-SA)990,980,980
  980 QZ=SI-SA
      AB=PAB
      OR=POR
      EN=PEN
      FS=PFS
      TN=PF
      PF=0.
      AK=0.
      VKA=0.
      XNE=0.
      PLE=0.
      FO=0.
      FA=0.
      GO TO 1130
  990 SB=6.*PAB+6.*POR+2.*AN+DWO+DFS+DEN+.5*PEN+.5*PFS+WO+4.*AC+PM+SM
      IF(SI-SB)1010,1000,1000
 1000 QZ=0.
      TN=0.
      AB=PAB
      OR=POR
      SL=SI-(6.*AB+6.*OR+2.*AN+DWO+DEN+DFS+4.*AC+PM+SM+WO)
      PHY=PFS+PEN
      OL=2.*PHY-2.*SL
      PHY=PHY-OL
      FO=PEN*OL/(PEN+PFS)
      FA=PFS*OL/(PEN+PFS)
      EN=PEN-FO
      FS=PFS-FA
      AK=0.
      VKA=0.
      XNE=0.
      PLE=0.
      GO TO 1130
 1010 SC=6.*POR+2.*AN+DWO+DFS+DEN+.5*PEN+.5*PFS+2.*PAB+WO+4.*AC+SM+PM
      IF(SI-SC)1030,1020,1020
 1020 QZ=0.
      TN=0.
      OR=POR
      FO=PEN
```

```
      FA=PFS
      EN=0.
      FS=0.
      SV=SI-(6.*OR+2.*AN+DWO+DFS+DEN+.5*FO+.5*FA+WO+4.*AC+SM*PM)
      PNE=6.*PAB-SV
      XNE=PNE/4.
      AB=PAB-XNE
      AK=0.
      VKA=0.
      PLE=0.
      GO TO 1130
 1030 SD=4.*POR+2.*PAB+2.*AN+DWO+DEN+DFS+.5*PEN+.5*PFS+WO+4.*AC+PM+SM
      IF(SI-SD)1050,1040,1040
 1040 QZ=0.
      TN=0.
      XNE=PAB
      AB=0.
      FO=PEN
      FA=PFS
      EN=0.
      FS=0.
      SN=SI-(2.*AN+2.*XNE+DWO+DFS+DEN+WO+.5*FA+.5*FO+SM+PM+4.*AC)
      PLE=(6.*POR-SN)/2.
      OR=POR-PLE
      AK=0.
      VKA=0.
      GO TO 1130
 1050 GO TO(1060,1080),M
 1060 SE=4.*POR+2.*PAB+2.*AN+.5*DWO+.5*DFS+.5*DEN+.5*PFS+.5*PEN+4.*AC
      SE=SE+SM+PM
      IF(SI-SE)1120,1070,1070
 1070 QZ=0.
      TN=0.
      PLE=POR
      OR=0.
      XNE=PAB
      AB=0.
      FO=PEN
      FA=PFS
      EN=0.
      FS=0.
      SO=SI-(4.*PLE+2.*XNE+2.*AN+4.*AC+.5*FA+.5*FO+SM+PM)
      RDI=(2.*SO-(DEN+DFS+DWO))/2.
      XOL=(DEN+DFS)-RDI
      AK=DWO-RDI
      DWO=RDI
      XHY=RDI
      GFS=DFS*XHY/(DEN+DFS)
      GEN=DEN*XHY/(DEN+DFS)
      XFA=DFS*XOL/(DEN+DFS)
      XFO=DEN*XOL/(DEN+DFS)
      DEN=GEN
      DFS=GFS
      FA=FA+XFA
      FO=FO+XFO
      VKA=0.
      GO TO 1130
 1080 SF=4.*POR+2.*PAB+2.*AN+.5*WO+DWO+DFS+DEN+.5*PEN+.5*PFS*4.*AC+SM+PM
      IF(SI-SF)1100,1090,1090
 1090 SR=4.*POR+2.*PAB+2.*AN+4.*AC+DWO+DFS+DEN+.5*PFS+.5*PEN+WO+SM+PM
```

```
      XSI=SR-SI
      AK=2.*XSI
      WO=WO-AK
      QZ=0.
      TN=0.
      PLE=POR
      OR=0.
      XNE=PAB
      AB=0.
      FO=0.
      FA=0.
      EN=0.
      FS=0.
      VKA=0.
      GO TO 1130
 1100 SG=4.*POR+2.*AN+2.*PAB+.5*WO+.5*DWO+.5*DEN+.5*DFS+.5*PEN+.5*PFS
      SG=SG+4.*AC+SM+PM
      IF(SI-SG)1120,1110,1110
 1110 QZ=0.
      TN=0.
      OR=0.
      PLE=POR
      XNE=PAB
      AB=0.
      EN=0.
      FS=0.
      FO=0.
      FA=0.
      SQ=SI-(4.*PLE+2.*XNE+2.*AN+4.*AC+.5*FA+.5*FO+SM+PM)
      RDI=(2.*SQ-(DEN+DFS+DWO+WO))/2.
      XOL=(DEN+DFS)-RDI
      AK=(DWO+WO)-RDI
      DWO=RDI
      WO=0.
      XHY=RDI
      GFS=DFS*XHY/(DEN+DFS)
      GEN=DEN*XHY/(DEN+DFS)
      XFA=DFS*XOL/(DEN+DFS)
      XFO=DEN*XOL/(DEN+DFS)
      FA=FA+XFA
      FO=FO+XFO
      DEN=GEN
      DFS=GFS
      VKA=0.
      GO TO 1130
 1120 QZ=0.
      TN=0.
      OR=0.
      XNE=PAB
      AB=0.
      EN=0.
      FS=0.
      FO=PEN
      FA=PFS
      AK=DWO+WO
      FO=FO+DEN
      FA=FA+DFS
      WO=0.
      DWO=0.
      DEN=0.
```

```
      DFS=0,
      ST=2,*XNE+2,*AN+4,*AC+SM+,5*FA+,5*FO+,5*AK+PM
      YSI=SI-ST
      PLE=(YSI-2,*POR)/2,
      VKA=(4,*POR-YSI)/2,
 1130 AQ=T(12)+T(13)
      QZ=QZ*60,06
      OR=OR*556,49
      AB=AB*524,29
      AN=AN*278,14
      XNE=XNE*284,05
      PLE=PLE*436,37
      VKA=VKA*316,25
      CO=CO*101.94
      AC=AC*461,91
      WO=WO*116,14
      DWO=DWO*116,14
      DEN=DEN*100,38
      DFS=DFS*131,90
      EN=EN*100.38
      FS=FS*131,90
      AK=(AK/2,)*172.22
      FO=(FO/2,)*140.7
      FA=(FA/2.)*203.74
      EMT=EMT*231,52
      HE=HE*159,68
      XIL=XIL*151,74
      RU=RU*79,90
      TN=TN*196,04
      PF=PF*135,98
      SM=SM*122,05
      PM=PM*154,25
      AP=AP*336,61
      CC=CC*100,09
      CHR=CHR*259,7/2,
      SPHAL=SPHAL*97.4/2,
      ZIR=ZIR*306,5/3,
      HAL=HAL*63,45/2,
      FLU=FLU*78,1/3,
      PYR=PYR*120,0/3,
      IF (AN) 1140,1150,1150
 1140 AN=0,0
 1150 CONTINUE
      SUM2=XIL+AP+CC+PM+AN+CO+RU+PF+AC+TN+EMT+AB+HE+WO+EN+FS+DEN+DFS+DWO
      SUM2=SUM2+QZ+OR+FO+FA+XNE+PLE+AK+VKA+AQ
      DENTY=XIL/4,79+AP/3,1+CC/2,711+AN/2,76+CO/3,98+RU/4,25
     1      +PF/3,98+AC/3,55+EMT/5,20+AB/2,62+HE/5,256+WO/3,85
     2      +EN/3,18+FS/3.95+DEN/3,18+DFS/3,95+DWO/3,25+QZ/2,65
     3      +OR/2,56+FO/3,22+FA/4,39+XNE/2,55+PLE/2,47
     4      +VKA/2,59+CHR/5,09+SPHAL/4,096+ZIR/4,65+HAL/2,164
     5      +FLU/3,18+PYR/5,01+TN/3,5
C                     ALKALI - Q - G  TRIANGLE
      TOT=T(1)+T(3)+T(9)+T(10)
      ZAT=(T(10)+T(9))/TOT*100
      ZQZT=T(1)/TOT*100
      ZCOT=T(3)/TOT*100
      OLNEW=XOLIV+EN*140,7/200,76 +FS*203,74/263,8
      QNEW=QZ+(EN/200,76+FS/263.80+AB/131,07)*60,06
      XNENEW=XNE+AB*142,02/262,14
      TOT=OLNEW+QNEW+XNENEW
```

```
      OLNEW=OLNEW*100./TOT
      QNEW=QNEW*100./TOT
      XNENEW=XNENEW*100./TOT
      TOT= T(5)+0.9*T(4)+ T(7)+ T(9)+ T(10)
C                                   FMA DIAGRAM
      TOTFE=T(5)+0.9*T(4)
      FMAF=TOTFE/TOT *100.
      FMAM= T(7)/TOT   *100.
      FMAA= (T(9)+T(10))/TOT    *100.
      TOT= T(10)+ T(9) + T(8)
C                                    K/NA/CA WT PCT
      XKT= T(10)*100.0/TOT
      XNT= T(9) *100.0/TOT
      XCT= T(8) *100.0/TOT
      TOT= QZ+ AB+ OR
C                                    Q/AB/OR WT PCT
      XQT= QZ *100.0/TOT
      XAT= AB *100.0/TOT
      XOT= OR *100.0/TOT
      TOT= TOT +AN
C                                    Q/PLAG/OR  WT PCT
      XQQT= QZ *100.0/TOT
      XPLT= (AB+AN)*100.0/TOT
      XOOT= OR *100.0/TOT
      TOT= TOT -QZ
C                                    AB/AN/OR   WT PCT
      XABT= AB *100.0/TOT
      XORT= OR *100.0/TOT
      XANT= AN *100.0/TOT
      DIFIND=QZ+ AB+ OR+ XNE+ PLE
      SOLIND= T(7)*100.0/(T(7)+T(5)+T(4)+T(9)+T(10))
      FFFF= T(4)*0.9 +T(5)
      FOFM= FFFF/(FFFF+T(7))
C                                    WO - FS - EN  TRIGDIG
      TOT= WO + FS + EN + DWO + DFS + DEN
      XWOT= (WO+DWO)*100.0/TOT
      XFST= (FS+DFS)*100.0/TOT
      XENT= (EN+DEN)*100.0/TOT
C
C  TRANSFER TRIANGLE DATA TO DRUM UNITS
C
 1160 WRITE (21) ZAT,ZCOT

      WRITE (22) FMAF,FMAA
      WRITE (23) XKT,XNT
      WRITE (24) XQT,XAT
      WRITE (25) XQQT,XPLT
      WRITE (26) XORT,XABT
      WRITE (27) XWOT,XENT
      WRITE (30) QNEW,OLNEW
 1170 PLAG=100*AN/(AN+AB)
      IF (PLAG) 1180,1190,1190
 1180 PLAG=0.0
 1190 CONTINUE
      PRINT 40 ,NAME
      SUM2=SUM2+CHR+SPHAL+ZIR+HAL+FLU+PYR
      SUM3=AN+AB+OR+QZ+CO+HAL+AK+VKA+XNE
      SUM3=SUM3+ZIR
      COLIND=1-(SUM3/SUM2)
      DENTY=SUM2/DENTY
```

```
          PRINT 50
          PRINT 60,IELM(1),T(1),MINL(27,MINL(49),AC
          PRINT 100,IELM(2),T(2),MINL(1),MINL(49),QZ
          PRINT 80,IELM(3),T(3),MINL(57,MINL(6),WO,MINL(3),MINL(49),CO
          PRINT 100,IELM(4),T(4),MINL(4),MINL(49),ZIR
          PYROX=DWO+DEN+DFS
          PRINT 60,IELM(5),T(5),MINL(97,MINL(49),PYROX,MINL(107,DWO
          PRINT 90,IELM(6),T(6),MINL(12),DEN,MINL(7),MINL(8),OR
          PRINT 90,IELM(7),T(7),MINL(15),DFS,MINL(11),MINL(49),AB
          PRINT 100,IELM(8),T(8),MINL(13),MINL(14),AN
          PYROX=EN+FS
          PRINT 60,IELM(9),T(9),MINL(18),MINL(19),PYROX,MINL(12),EN
          PRINT 90,IELM(10),T(10),MINL(15),FS,MINL(16),MINL(17),XNE
          PRINT 100,IELM(11),T(11),MINL(20),MINL(49),PLE
          XOLIV=FO+FA
          PRINT 60,IELM(12),T(12),MINL(23),MINL(49),XOLIV,MINL(24),FO,
         1MINL(21),MINL(22),VKA
          PRINT 90,IELM(13),T(13),MINL(26),FA
          PRINT 100,IELM(14),T(14),MINL(25),MINL(49),HAL
          PRINT 70,MINL(27),MINL(14),EMT,MINL(28),MINL(49),CHR
          PRINT 60,IELM(15),SUM,MINL(29),MINL(49),HE
          PRINT 70,MINL(30),MINL(49),XIL,MINL(33),MINL(49),RU
          PRINT 65,IELM(16),T(15),MINL(34),MINL(49),TN
          PRINT 65,IELM(17),T(16),MINL(35),MINL(36),PF
          PRINT 65,IELM(18),T(17),MINL(39),MINL(49),AP
          PRINT 65,IELM(19),T(18),MINL(40),MINL(49),FLU
          PRINT 65,IELM(20),T(19),MINL(42),MINL(49),CC
          PRINT 65,IELM(21),T(20),MINL(41),MINL(49),PYR
          PRINT 65,IELM(22),T(21),MINL(45),MINL(36),SPHAL
          DO 765 IJK=23,28
          JKL=IJK-1
      765 PRINT 65,IELM(IJK),T(JKL)
          PRINT 110,PLAG,XQUT,XKT,XWOT,COLIND,XPLT,XNT,XFST,XOOT,XCT,XENT,
         1DENTY
          PRINT 120,SOLIND,DIFIND
          PRINT 130,XQT,XORT,FMAF,OLNEW,PERIND,XAT,XABT,FMAM,XNENEW,XONA,
         1XOT,XANT,FMAA,ONEW,TOTFE
          FEMICS=SUM2-SUM3
          Z1=2
          IF (ITET.EQ.1)1200,1240
     1200 IF (NOPQ.EQ.1) 1210,1220
     1210 WRITE (28) QZ,AB,OR,CO
          GO TO 1230
     1220 WRITE (28) FMAF,FMAA,FMAM,QZ
     1230 WRITE (29) FEMICS,OR,AB,AN
     1240 GO TO 320
     1250 DO 1260 LUN= 21,30
     1260 REWIND LUN
          IF (ITET.NE.1) GO TO 1280
          CALL TETRPLOT(LABFM,LABO,LABA,LABAN,29,JKL,2)
          IF (NOPQ.EQ.1) GO TO 1270
          CALL TETRPLOT(LABI,LABAA,LABM,LABQ,28,JKL,1)
          GO TO 1280
     1270 CALL TETRPLOT(LABQ,LABA,LABO,LABCO,28,JKL,1)
    C      BEGIN TRIANGLE PLOTTING
     1280 IF (IITRIG.NE.1) GO TO 1330
          READ 300 , (NTITLE(I),I=1,27
          IF (EOF,60) 1290,1300
     1290 NTITLE(1)=NTITLE(2)=8H
     1300 CONTINUE
```

```
      IF(JOAN.EQ.1) GO TO 1310
      CALL TRIGPLOT (LABI,LABAA,LABM,22,JKL,NTITLE,3)

      GO TO 1320
 1310 CALL TRIGPLOT (LABQ,LABA,LABO,24,JKL,NTITLE,3)
 1320 CALL TRIGPLOT(LABO,LABA,LABAN,26,JKL,NTITLE,4)

 1330 IF (IITRIA.NE.1) GO TO 1340
      CALL TRIGDIG(LABQ,LABA,LABO;24,JKL)
      CALL TRIGDIG(LABQ,LABP,LABO;25,JKL)
      CALL TRIGDIG(LABAA,LABAL,LABSI,21,JKL)
      CALL TRIGDIG(LABO,LABA,LABAN,26,JKL)
      CALL TRIGDIG(LABK,LABN,LABC;23,JKL)
      CALL TRIGDIG(LABI,LABAA,LABM,22,JKL)
      CALL TRIGDIG(LABW,LABE,LABF,27,JKL)
      CALL TRIGDIG (2HQZ,2HOL,2HNE,30,JKL)
 1340 CALL EXIT
      END
```

```
      SUBROUTINE TRIGDIG (LAB1,LAB2,LAB3,LUN,N)
      DIMENSION LINE (51,101)
      INTEGER SYM(36)
      INTEGER DOT,PLUS,STAR
      INTEGER SPACE
      DATA (DOT=1H.), (PLUS=1H+), (STAR=1H*)
      DATA (SYM=1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1HA,1HB,1HC,1HD,1HE,
     1          1HF,1HG,1HH,1HJ,1HK,1HL,1HM,1HN,1HP,1HQ,1HR,1HS,1HT,1HU,
     2          1HV,1HW,1HX,1HY,1HZ,1H-,1H+,1H*)
      SPACE = 1H
      DO 1 I=1,51
      DO 1  J=1,101
C   INITIALISE ARRAY LINE
    1 LINE(I,J)=1H
      LINE(1,51)=DOT
      DO 2 I=2,51
      J1=52-I
      J2=50+I
      LINE(I,J1)=DOT
    2 LINE(I,J2)=DOT
      DO 3 J=1,101,2
    3 LINE(51,J)=DOT
      DO 4 I=1,N
      READ (LUN) A,B
      ALEVEL = 51.0 - 0.50 * A+ 0.5
      LEVEL=INT(ALEVEL)
      ALONG = 101.5 - 0.505 * A - B
      LONG=INT(ALONG)
      IF(LONG.GT.101.OR.LONG.LE.0.OR.LEVEL.GT.51.OR.
     1LEVEL.LE.0) GO TO 35
      LINO=LINE(LEVEL,LONG)
      IF(LINO.EQ.1H ) 34,31
   31 IF(LINO.EQ.SYM(36))GO TO 4
      DO 33 J=1,35
      IF (LINO.EQ.SYM(J))32,33
   33 CONTINUE
   34 J=0
   32 J=J+1
      LINE(LEVEL,LONG)=SYM(J)
      GO TO 4
   35 PRINT 902,A,B,LONG,LEVEL
    4 CONTINUE
      PRINT 899,LAB1,LAB2,LAB3,LAB1
      PRINT 900, ((LINE(I,J),J=1,101),I=1,51)
      PRINT 901, LAB2,LAB3
      REWIND LUN
C
  899 FORMAT(1H1,A8,1H-,A8,1H-,A8,3X,*TERNARY  DIAGRAM*/1H0,56X,A8)
  900 FORMAT(1H ,10X,101A1)
  901 FORMAT(1H ,6X,A8,93X,A8)
  902 FORMAT(1H ,*PT OUT OF TRIANGLE*,2F8.2,2I4)
      RETURN
      END
```

```
      SUBROUTINE TRIGPLOT (LAB1,LAB2,LAB3,LUN,N,NTITLE,IZ)
      DIMENSION ISYM(3)
      DIMENSION NTITLE(2)
      COMMON IJKLMN
      DATA(ISYM=2100011213242536B,3736454453526160B,0070000000000000B)
  900 FORMAT(1H1,*SUBROUTINE TRIGPLOT TEMPORARILY DISABLED, END C
     1,* FILE,   EOF READ ON *,I3,*TH ITERATION, TOTAL NO, OF POINTS*
     2,* SHOULD BE *,I3)
      IFLAG=0
      Q=20./SQRT(3.)
      CALL PLOT(10.,Q,2,IZ)
      CALL PLOT(0.,-25.,1,IZ)
      CALL PLOT(0.,0.,3,IZ)
      CALL PLOT(50.,100.,4,IZ)
      CALL PLOT(100.,0.,4,IZ)
      CALL PLOT(0.,0.,4,IZ)
      CALL PLOT (0.0,-5.0,3,IZ)
      CALL TEXT(LAB2,8,2,IZ)
      CALL PLOT (92.0,-5.0,3,IZ)
      CALL TEXT(LAB3,8,2,IZ)
      CALL PLOT (46.0,103.0,3,IZ)
      CALL TEXT(LAB1,8,2,IZ)
    2 DO 1 J=1,N
    8 READ (LUN)  B,A
      IF (EOF,LUN) 6,7
    6 PRINT 900, J,N
      IF (IFLAG.EQ.1) GO TO 9
      IFLAG=1
      GO TO 8
    7 IFLAG=0
      Y=B
      X=100.-A-0.5*B
      IF (X.GT.100.0.OR.X.LT.0.0.OR.Y.GT.100.0.OR.Y.LT.0.0) 3,4
    3 PRINT 5, A,B,X,Y,NTITLE(1),NTITLE(2)
    5 FORMAT(1H0,*PLOT OUT OF TRIANGLE*,F8.3,2X,F8.3,4X,F8.3,F8.3,3X,2A8
     1)
      GO TO 1
    4 CALL PLOT(X,Y,3,IZ)
      CALL TEXT(ISYM,1,-1)
    1 CONTINUE
      YPOS=90.
      CALL PLOT(75.,YPOS,3,IZ)
      CALL TEXT(ISYM,1,-1)
      CALL PLOT(80.,YPOS,3,IZ)
      CALL TEXT(NTITLE,16,2,IZ)
    9 REWIND LUN
      RETURN
      END
```

```
      SUBROUTINE TETRPLOT (L1,L2,L3,L4,LUN,N,Z)
      INTEGER Z
      QQ=20./SQRT(3.)
      CALL PLOT(10.,QQ,2,Z)
      CALL PLOT (0.,-40.,1,Z)
      CALL PLOT (0.,0.,3,Z)

      CALL PLOT (50.,100.,4,Z)
      CALL PLOT (100.,0.,4,Z)
      CALL PLOT (0.,0.,4,Z)
      CALL PLOT (70.,-33.33,4,Z)
      CALL PLOT (100.,0.,4,Z)
      CALL PLOT (70.,-33.33,3,Z)
      CALL PLOT (50.,100.,4,Z)
      CALL PLOT(46.0,103.0,3,Z)
      CALL TEXT(L1,8,2,Z)
      CALL PLOT(0.0,-5.0,3,Z)
      CALL TEXT(L2,8,2,Z)
      CALL PLOT(92.0,-5.0,3,Z)
      CALL TEXT(L3,8,2,Z)
      CALL PLOT(66.0,-38.0,3,Z)
      CALL TEXT(L4,8,2,Z)
      DO 2 I=1,N

      READ (LUN) A,B,C,D
      TOT=A+B+C
      AB=A*100./TOT
      BB=B*100./TOT
      TOT=B+C+D
      DD = D*100./TOT
      BD=  B*100./TOT
      TOT=A+B+D
      AL= A*100./TOT
      BL= B*100./TOT
      TOT=A+C+D
      AR=A*100./TOT
      CR=C*100./TOT
    1 YB= AB
      XB =100.-BB-0.5*AB
      XD =100.-BD-DD*0.3
      YD =-DD/3.
      YL =(AL*4.+BL-100.)/3.
      XL = 70.-AL*0.2-BL*0.7
      YR=(AR*4.+CR-100.)/3.
      XR = 70.+CR*0.3-AR*0.2
C
      TOT=A+B+C+D
      AA =A*100./TOT
      BA =B*100./TOT
      CA =C*100./TOT
      DA=D*100./TOT
      Y=AA-DA/3.
      X=100.-0.3*DA-0.5*AA-BA
      CALL PLOT(XB,YB,3,Z)
      CALL PLOT(X,Y,4,Z)
      CALL PLOT(XL,YL,4,Z)
      CALL PLOT(XD,YD,3,Z)
      CALL PLOT(X,Y,4,Z)
    2 CALL PLOT(XR,YR,4,Z)
      RETURN
```

```
      END
```

APPENDIX 2

Listing of program NIGGBART.

KPD†34D

```
      PROGRAM NIGBAR
      DIMENSION T(14),TT(14),TTT(14),NIG(14),BARTH(14),BASIS(16)
      DIMENSION WT(14),OX(14),CA(14),NI(14),BAR(14),BAS(16)
      REAL NIG
      DATA( WT=60.06,79.90,101.94,159.68,71.84,70.93,40.32,56.08,61.994,
     1 94.192,141.96,18.016,18.016,44.01)
      DATA(OX=8HSIO2    ,8HTIO2    ,8HAL2O3   ,8HFE2O3   ,8HFEO     ,
     1    8HMNO     ,8HMGO     ,8HCAO     ,8HNA2O    ,8HK2O     ,
     2    8HP2O5    ,8HH2O(+)  ,8HH2O(-)  ,8HCO2     )
      DATA(CA=8HSI      ,8HTI      ,8HAL      ,8HFE(3)   ,8HFE(2)   ,
     1    8HMN      ,8HMG      ,8HCA      ,8HNA      ,8HK       ,
     2    8HP       ,8H        ,8H        ,8HC       )
      DATA(NI=8HSI      ,8HAL      ,8HFM      ,8HC       ,8HALK     ,
     1    8HTI      ,8HP       ,8HCO2     ,8HK       ,8HMG      ,
     2    8HW       ,8HAL-ALK=T,8HT-C     ,8HAL+ALK=F)
      DATA(BAR=8HSI      ,8HTI      ,8HAL      ,8HFE      ,8HMN      ,
     1     8HMG      ,8HCA      ,8HNA      ,8HK       ,8HP       ,
     2     8HC       ,8HOXY*    ,8HOH**    ,8HCAT***  )
      DATA(BAS=8HCP      ,8HKP      ,8HKS      ,8HNE      ,8HNS      ,
     1     8HCAL     ,8HCS      ,8HSP      ,8HHZ      ,8HC       ,
     2     8HFS      ,8HFO      ,8HFA      ,8HRU      ,8HQ       ,
     3     8HCC      )
  901 FORMAT(1H1,*CALCULATION OF NIGGLI VALUES,BARTH STANDARD *,
     1*CELL, NIGGLI BASIS VALUES AND COMPOSITION TRIANGLES FOR *,
     2*SAMPLE  *,A8////1H ,*SILICATE ANALYSIS*,8X,*CATION PERCENT*,
     311X,*NIGGLI VALUES*,12X,*BARTH STANDARD CELL*,6X,*NIGGLI BASIS*/)
  900 FORMAT(2X,A8,1X,14F4.2)
  902 FORMAT(1H ,5(A8,F12.2,5X))
  903 FORMAT(1H ,A8,F12.2,30X,3(A8,F12.2,5X))
  904 FORMAT(1H ,100X,A8,F12.2)
  905 FORMAT(////1H0,*TRIANGULAR DIAGRAMS*,18X,*Q - L - M*/)
  906 FORMAT(1H ,37X,A2,18X,F10.2)
  907 FORMAT(//1H0,37X,*K - NA - CA (BOUND TO AL)*/)
  908 FORMAT(//1H0,37X,*MG - FE - CA (NOT BOUND TO AL)*/)
  909 FORMAT(//1H0,37X,*Q - KP - NE*/)
      JKL=IT=SUM=0.0
    1 READ(5, 900),ID,TT
      IF(EOF,60) 99,98
   98 IF(ID.EQ.8HTRIANGLE)2,3
    2 IT=1
      GO TO 1
    3 DO 4 I=1,14
      T(I)=TT(I)/WT(I)
    4 IF(I.NE.12.AND.I.NE.13)SUM=SUM+T(I)
      JKL=JKL+1
      DO 5 I=1,14
    5 TTT(I)=T(I)=T(I)*100.0/SUM
C
C CALCULATION OF NIGGLI VALUES
C
      TEMP=T(5)+2.*T(4)
      TOT=T(3)+TEMP+T(6)+T(7)+T(8)+T(9)+T(10)
      F=100./TOT
      NIG(2)=T(3)*F
      NIG(3)=(TEMP+T(5)+T(6)+T(7))*F
      NIG(4)=T(8)*F
      NIG(5)=(T(9)+T(10))*F
      NIG(1)=T(1)*F
      NIG(9)=T(10)/(T(9)+T(10))
      NIG(6)=T(2)*F
```

```
      NIG(10)=T(7)/(TEMP+T(6)+T(7))
      NIG(11)=2*T(4)/TEMP
      NIG(7)=T(11)*F
      NIG(8)=T(14)*F
      NIG(12)=NIG(2)-NIG(5)
      NIG(13)=NIG(12)-NIG(4)
      NIG(14)=NIG(2)+NIG(5)
C
C CALCULATION OF BARTH STANDARD CELL
C
      TTT(4)=T(4)*2.
      TTT(3)=T(3)*2.
      TTT(9)=T(9)*2.
      TTT(10)=T(10)*2.
      TTT(11)=T(11)*2.
      SUM=100.+T(4)+T(3)+T(9)+T(10)+T(11)
      DO 19 I=1,14
   19 T(I)=TTT(I)=TTT(I)*100./SUM
      OXY=2.*T(1)+1.5*T(3)+2.*T(2)+1.5*T(4)+T(5)+T(6)+T(7)+T(8)+0.5*T(9)
     1+0.5*T(10)+2.5*T(11)+2.*T(14)
      OXY=OXY+T(12)
      CAT=160.*100./OXY
      OH=2.*T(12)*CAT/100.0
      DO 6 I=1,10
      J=I
      IF(I.GT.4) J=J+1
    6 BARTH(I)=T(J)*CAT/100.
      BARTH(4)=BARTH(4)+T(5)*CAT/100.
      BARTH(11)=T(14)*CAT/100.
      BARTH(12)=OXY
      BARTH(13)=OH
      BARTH(14)=CAT
C
C  CALCULATION OF NIGGLI BASIS
C
      BASIS(16)=T(14)
      T(8)=T(8)-T(14)
      T(14)=0.0
      BASIS(1)=T(11)*2.5
      T(8)=T(8)-1.5*T(11)
      T(11)=0.0
      IF (T(10).GT.T(3)) GO TO 7
      BASIS(2)=T(10)*3.0
      T(1)=T(1)-T(10)
      T(3)=T(3)-T(10)
      T(10)=0.0
      GO TO 8
    7 BASIS(2)=T(3)*3.0
      T(1)=T(1)-T(3)
      T(10)=T(10)-T(3)
      T(3)=0.0
      BASIS(3)=1.5*T(10)
      T(1)=T(1)-0.5*T(10)
      T(10)=0.0
      GO TO 10
    8 IF (T(9).GT.T(3)) GO TO 9
      BASIS(4)=3.0*T(9)
      T(3)=T(3)-T(9)
      T(1)=T(1)-T(9)
      T(9)=0.0
```

```
      GO TO 11
    9 BASIS(4)=3,0*T(3)
      T(9)=T(9)-T(3)
      T(1)=T(1)-T(3)
      T(3)=0,0
   10 BASIS(5)=T(9)*1,5
      T(1)=T(1)-0,5*T(9)
      T(9)=0,0
      GO TO 13
   11 TEMP=0,5*T(3)
      IF (TEMP,LT,T(8)) GO TO 12
      BASIS(6)=3,0*T(8)
      T(3)=T(3)-2,0*T(8)
      T(8)=0,0
      GO TO 14
   12 BASIS(6)=1,5*T(3)
      T(8)=T(8)-0,5*T(3)
      T(3)=0,0
   13 BASIS(7)=1,5*T(8)
      T(1)=T(1)-0,5*T(8)
      T(8)=0,0
      GO TO 20
   14 TEMP=0,5*T(3)
      IF(TEMP,LT,T(7)) GO TO 15
      BASIS(8)=3,0*T(7)
      T(3)=T(3)-2,0*T(7)
      T(7)=0,0
      GO TO 16
   15 BASIS(8)=1,5*T(3)
      T(7)=T(7)-0,5*T(3)
      T(3)=0,0
      GO TO 20
   16 TEMP=0,5*T(3)
      IF(TEMP,LT,T(5)) GO TO 17
      BASIS(9)=3,0*T(5)
      T(3)=T(3)-2,*T(5)
      T(5)=0,0
      BASIS(10)=T(3)
      T(3)=0,0
      GO TO 20
   17 BASIS(9)=1,5*T(3)
      T(5)=T(5)-0,5*T(3)
      T(3)=0,0
   20 BASIS(11)=1,5*T(4)
      T(1)=T(1)-0,5*T(4)
      T(4)=0,0
      IF (T(5),LT,0,001,AND,T(7);LT,0,001)GO TO 21
      BASIS(12)=1,5*T(7)
      T(1)=T(1)-0,5*T(7)
      T(7)=0,0
      BASIS(13)=1,5*T(5)
      T(1)=T(1)-0,5*T(5)
      T(5)=0,0
   21 BASIS(14)=T(2)
      BASIS(15)=T(1)
C
C     CALCULATION OF TRIANGLES
C
      TL=BASIS(2)+BASIS(4)+BASIS(6)
      TM=BASIS(7)+BASIS(12)+BASIS(13)+BASIS(11)+BASIS(5)+BASIS(3)
```

```
      1*BASIS(14)+BASIS(1)+BASIS(16)
       TQ=BASIS(15)
       TOT=TL+TQ+TM
       F=100./TOT
       TL=TL*F
       TM=TM*F
       TQ=TQ*F
       TOT=BASIS(2)+BASIS(4)+BASIS(6)
       F=100./TOT
       TK=BASIS(2)*F
       TNA=BASIS(4)*F
       TCA=BASIS(6)*F
       TOT=BASIS(11)+BASIS(12)+BASIS(13)+BASIS(7)
       F=100./TOT
       TMG=BASIS(12)*F
       TFE=(BASIS(11)+BASIS(13))*F
       TCS=BASIS(7)*F
       TOT=BASIS(15)+BASIS(2)+BASIS(4)
       F=100./TOT
       TQQ=BASIS(15)*F
       TKP=BASIS(2)*F
       TNE=BASIS(4)*F
       PRINT 901,ID
       DO 23 I=1,14
       IF(I.EQ.12.OR.I.EQ.13) GO TO 22
       PRINT 902,OX(I),TT(I),CA(I),TTT(I),NI(I),NIG(I),BAR(I),BARTH(I),
      1BAS(I),BASIS(I)
       GO TO 23
    22 PRINT 903,OX(I),TT(I),NI(I),NIG(I),BAR(I),BARTH(I),BAS(I),
      1BASIS(I)
    23 CONTINUE
       PRINT 904,BAS(15),BASIS(15)
       PRINT 904,BAS(16),BASIS(16)
       PRINT 905
       PRINT 906,2HQ ,TQ,2HL ,TL,2HM ,TM
       PRINT907
       PRINT 906,2HK ,TK,2HNA,TNA,2HCA,TCA
       PRINT 908
       PRINT 906,2HMG,TMG,2HFE,TFE,2HCA,TCS
       PRINT 909
       PRINT 906,2HQ ,TQQ,2HKP,TKP,2HNE,TNE
       SUM=0.0
C
C   CHECK FOR TRIANGLE PLOTTING
C   AND COPY DATA TO DRUM IF
C   REQUIRED
C
       IF (IT.NE.1) GO TO 1
       WRITE (21) TQQ,TNE
       WRITE (22) TCS,TMG
       WRITE(23) TCA,TNA
       WRITE(24) TQ,TM
       GO TO 1
    99 CONTINUE
       IF(IT.NE.1) STOP
       DO 100 I=21,24
  100   REWIND I
       CALL TRIGDIG(8HQ       ,8HM       ,8HL       ,24,JKL)
       CALL TRIGDIG(8H   Q    ,8H   NE   ,8H   KP   ,21,JKL)
       CALL EXIT
```

```
KF5,34D
        END
```

APPENDIX 3

Listing of program ZAVSKY.

```
      PROGRAM ZAVSKY
C
C     PROGRAM WRITTEN BY S.HENLEY   BMR   JUNE 1971
C     CALCULATES AND PLOTS ZAVARITSKY NUMBERS
C     REF -  INT.GEOL.REV. 1964 P.1-17
C
      DIMENSION WT(14),CA(14),CROSS(2),ID(2)
      DIMENSION OXIDES(14),CATIONS(14),ZAVS(14),VAL(14),T(14)
      REAL NAPR,MPR,N,NPR
      DATA (WT=60.06,79.90,101.94,159.68,71.84,70.93,40.32,
     *           56.08,61.994,94.192,141.96,18.016,18.016,44.01)
      DATA (OXIDES=6HSIO2  ,6HTIO2  ,6HAL2O3 ,6HFE2O3 ,6HFEO   ,
     *              6HMNO   ,6HMGO   ,6HCAO   ,6HNA2O  ,6HK2O   ,
     *              6HP2O5  ,6HH2O(+),6HH2O(-),6HCO2    )
      DATA (CATIONS=6HSI    ,6HTI    ,6HAL    ,6HFE(3) ,6HFE(2) ,
     *               6HMN    ,6HMG    ,6HCA    ,6HNA    ,6HK     ,
     *               6HP     ,6HH(+)  ,6HH(-)  ,6HC     )
      DATA (ZAVS=4HA    ,4HC    ,4HB    ,4HS    ,4H/C   ,4HF'   ,4HM'   ,
     *           4HC'   ,4HA'   ,4HN    ,4HT    ,4HPHI  ,4HN'   )
      DATA (CROSS=1202052747656240B,2002700000000000B)
      ISUPP = 1
      GO TO 70
   10 READ (5,901) ID,T
      IF (ID(1).EQ.8HSUPPRESS) 101,102
  101 ISUPP=(-1)
      GO TO  10
  102 CONTINUE
      IF(EOF,5) 99,11
   11 II=II+1
C
C     CALCULATE CATION PERCENT
C
      SUM=0.0
      DO 20 I=1,14
      CA(I)=T(I)/WT(I)
   20 SUM=SUM+CA(I)
      DO 21 I=1,14
   21 CA(I)=CA(I)*100./SUM
C
C     CALCULATE ZAVARITSKY NUMBERS
C
      ALPR=FEPR=CBAR=CAPR=NAPR=0.0
      ALKS=CA(9)+CA(10)
      FEO=CA(5)+CA(6)
      SS=CA(1)+CA(2)
      IF (ALKS.LE.CA(3)) 30,40
   30 AA=ALKS
      Z=(CA(3)-ALKS)/2.
      GO TO 50
   40 AA=CA(3)
      CBAR=ALKS-A
      Z=(-CBAR/2.)
   50 IF(Z.LE.CA(8)) 51,56
   51 CC=Z
      GO TO 60
   56 CC=CA(8)
      ALPR=CA(3)-CC-CC-ALKS
   60 FEPR=CA(4)+FEO-CBAR
      IF (FEPR.LT.0.0)  61,62
   61 NAPR=CC+FEPR
```

```
      FEPR=0.0
   62 CAPR=CA(8)-CC
      BB=FEPR+CA(7)+CAPR+ALPR
      SUM=AA+BB+CC+SS
      SUM=100./SUM
      A=AA*SUM
      C=CC*SUM
      B=BB*SUM
      S=SS*SUM
C
C    SUPPLEMENT
C     -ARY CHARACTERS
C
      FPR=FEPR*100./BB
      MPR=CA(7)*100./BB
      CPR=CAPR*100./BB
      N=CA(9)*100./AA
      TI=CA(2)*100./SS
      PHI=CA(4)*100./BB
      APR=ALPR*100./BB
      NPR=NAPR*100./BB
C
C    PRINT RESULTS
C
      PRINT 900, II,ID
      PRINT 903, (OXIDES(I),T(I),CATIONS(I),CA(I),I=1,14)
      PRINT 905
      VAL(1)=A
      VAL(2)=C
      VAL(3)=B
      VAL(4)=S
      VAL(5)=CBAR
      VAL(6)=FPR
      VAL(7)=MPR
      VAL(8)=CPR
      VAL(9)=APR
      VAL(10)=N
      VAL(11)=TI
      VAL(12)=PHI
      VAL(13)=NPR
      PRINT 906, (ZAVS(I),VAL(I),I=1,13)
      GO TO 80
C
C    PLOTTING
C
   70 CALL PLOT (-50.,-150.,1)
      CALL PLOT (10.,10.,2)
      CALL PLOT(-50.,2.,3)
      CALL TEXT (1HC,1,2)
      CALL TEXT (3H 50,3,2)
      CALL PLOT (-50.,0.,3)
      CALL PLOT (50.,0.,4)
      CALL PLOT (46.0,2.,3)
      CALL TEXT (3H50 ,3,2)
      CALL TEXT (1HA,1,2)
      CALL PLOT (-0,3,2.,3)
      CALL TEXT (1HS,1,2)
      LA=8HZAVARITS
      LB=8HKY NUMBE
      LC=8HRS
```

```
      CALL PLOT (-15.,15.,3)
      CALL TEXT (LA,8,3)
      CALL TEXT (LB,8,3)
      CALL TEXT (LC,8,3)
      CALL PLOT (0.0,0.0,3)
      CALL PLOT (0.0,-100.0,4)
      CALL PLOT (-4.0,-100.0,3)
      CALL TEXT (5H100  ,5,2)
      CALL TEXT (1HB,1,2)
      II=0
      GO TO 10
   80 HA=A
      V=(-8)
      IF (CBAR.GT.0.) 81,82
   81 HC=CBAR
      GO TO 83
   82 HC=(-C)
   83 IF (CPR) 831,831,84
  831 RA=HA-0.1*APR
      GO TO 85
   84 RA=HA+0.1*CPR
   85 RB=V-0.1*MPR
      RB2=V-CA(9)
      RC=HC-CA(10)
      ENCODE (3,902,LL) II
      WRITE (2) HA,V,RA,RB,HC,V,RC,RB2,LL,II
      CALL PLOT((HA-0.3),(V-0.4),3)
      CALL TEXT (CROSS,1,-1)
      CALL PLOT(( HA+0.8),V,3)
      IF (ISUPP.GT.0)  CALL TEXT(LL,3,1)
      CALL PLOT (HA,V,3)
      CALL PLOT (RA,RB,4)
      CALL PLOT((HC-0.3),(V-0.4),3)
      CALL TEXT (CROSS,1,-1)
      CALL PLOT((HC+0.8),V,3)
      IF (ISUPP.GT.0) CALL TEXT (LL,3,1)
      CALL PLOT (HC,V,3)
      CALL PLOT(RC,RB2,4)
      GO TO 10
  900 FORMAT (1H1,*ZAVARITSKY NUMBERS CALCULATED FOR SAMPLE*,
     *I3,2X,1H,,2X,A8,A3/1H0,*SILICATE ANALYSIS*,64X,*CATION PERCENT*)
  901 FORMAT (A8,A3,14F4.2)
  902 FORMAT(I3)
  903 FORMAT (1H0/(5X,A6,10X,F10.2,55X,A6,10X,F10.2))
  905 FORMAT (1H0,*ZAVARITSKY NUMBERS*)
  906 FORMAT (1H0,50X,A4,F16.2)
   99 REWIND 2
  999 READ (2) X,Y,X1,Y1,A,B,A1,B1,LAB,II
      IF (EOF,2) 998,997
  998 CALL EXIT
  997 IF (Y+50.) 999,999,150
  150 IF (X-25.) 151,999,999
  151 IF (A+25.) 999,999,152
  152 IF (X1.GT.25.) 153,154
  153 Y1=(25.-X)/(X1-X) * (Y1-Y) + Y
      X1=25.
  154 IF (Y1.LT.(-50.)) 155,156

  155 X1=(-50.-Y)/(Y1-Y) * (X1-X) + X
      A1=(-50.-B)/(B1-B) * (A1-A) + A
```

```
      Y1=B1=(-50.)
156   IF (A1.LT.(-25.)) 157,158
157   B1= (-25.-A)/(A1-A) * (B1-B) + B
      A1=(-25.)
158   IF (II.EQ.1) 159,160
159   CALL PLOT(-50.,0.,3)
      CALL PLOT (-25.,-100.,1)
      CALL PLOT (5.,5.,2)
      CALL PLOT (-25.,1.,3)
      CALL TEXT(4HC 25,4,2)
      CALL PLOT(-25.,0.,3)
      CALL PLOT(25.,0.,4)
      CALL PLOT (23.,1.,3)
      CALL TEXT(4H25 A,4,2)
      CALL PLOT(-0.15,1.,3)
      CALL TEXT(1HS,1,2)
      CALL PLOT(0.,0.,3)
      CALL PLOT(0.,-50.,4)
      CALL PLOT(-1.5,-50.,3)
      CALL TEXT(5H50  B,4,2)
160   CALL PLOT((X-0.15),(Y-0.2),3)
      CALL TEXT(CROSS,1,-1)
      CALL PLOT((X+0.4),Y,3)
      ENCODE (3,902,LL) II
      CALL TEXT(LL,3,1)
      CALL PLOT(X,Y,3)
      CALL PLOT(X1,Y1,4)
      CALL PLOT((A-0.15),(B-0.2),3)
      CALL TEXT(CROSS,1,-1)
      CALL PLOT((A+0.4),B,3)
      CALL TEXT(LL,3,1)
      CALL PLOT(A,B,3)
      CALL PLOT(A1,B1,4)
      GO TO 999
      END
```

Fig. 1

CIPW NORM OF SAMPLE NO. 69201028

SILICATE ANALYSIS OXIDE	PERCENT	FEMIC CONSTITUENTS MINERAL	PERCENT	COMPONENT	PERCENT	SALIC CONSTITUENTS MINERAL	PERCENT
SIO2	48,16	ACMITE	0,00				
TIO2	1,38					QUARTZ	0,00
AL2O3	13,76	WOLLASTONITE	0,00			CORUNDUM	0,00
FE2O3	2,67					ZIRCON	0,00
FEO	11,70	DIOPSIDE	24,08	WO	12,14		
MNO	0,23			EN	5,87	ORTHOCLASE	1,56
MGO	6,77			FS	6,07	ALBITE	17,06
CAO	11,58					ANORTHITE	28,23
NA2O	1,99	HYPERSTHENE	20,34	EN	10,00		
K2O	0,26			FS	10,34	NEPHELINE	0,00
P2O5	0,14					LEUCITE	0,00
H2O(+)	0,46	OLIVINE	1,82	FO	0,85	KALIOPHILITE	0,00
H2O(-)	0,00			FA	0,97		
CO2	0,00					HALITE	0,00
		MAGNETITE	3,92				
		CHROMITE	0,00				
TOTAL	98,64	HEMATITE	0,00				
		ILMENITE	2,66				
		RUTILE	0,00				
F	0,0000	TITANITE	0,00				
S	0,0000	PEROVSKITE	0,00				
CL	0,0000	APATITE	0,34				
V	0,0000	FLOURITE	0,00				
CR	0,0000	CALCITE	0,00				
CO	0,0000	PYRITE	0,00				
NI	0,0000	SPHALERITE	0,00				
CU	0,0000						
ZN	0,0000						
RB	0,0000						
SR	0,0000						
ZR	0,0000						
BA	0,0000						

TRIANGULAR DATA DIAGRAM

Q - PLAG - OR		K2O - NA2O - CAO		WO - FS - EN			
Q	0,00	K2O	1,88	WO	27,32	COLOUR INDEX IS	0,53
PLAG	96,68	NA2O	14,39	FS	36,94		
OR	3,32	CAO	83,73	EN	35,73	CALC. DENSITY	3,13

PLAGIOCLASE - AN 62,33

Q - AB - OR		OR - AB - AN		F - M - A		OL - NE - Q	
Q	0,00	OR	3,32	F	60,99	OL	40,09
AB	91,64	AB	36,42	M	29,28	NE	24,71
OR	8,36	AN	60,26	A	9,73	Q	35,20

SOLIDIFICATION INDEX	28,94
THORNTON - TUTTLE DIFFERENTIATION INDEX	18,62
PERALKALITY INDEX	0,26
K2O/NA2O	0,13
TOTAL FE AS FEO	14,10

QUARTZ -PLAGCLSE-ORTHCLSE TERNARY DIAGRAM

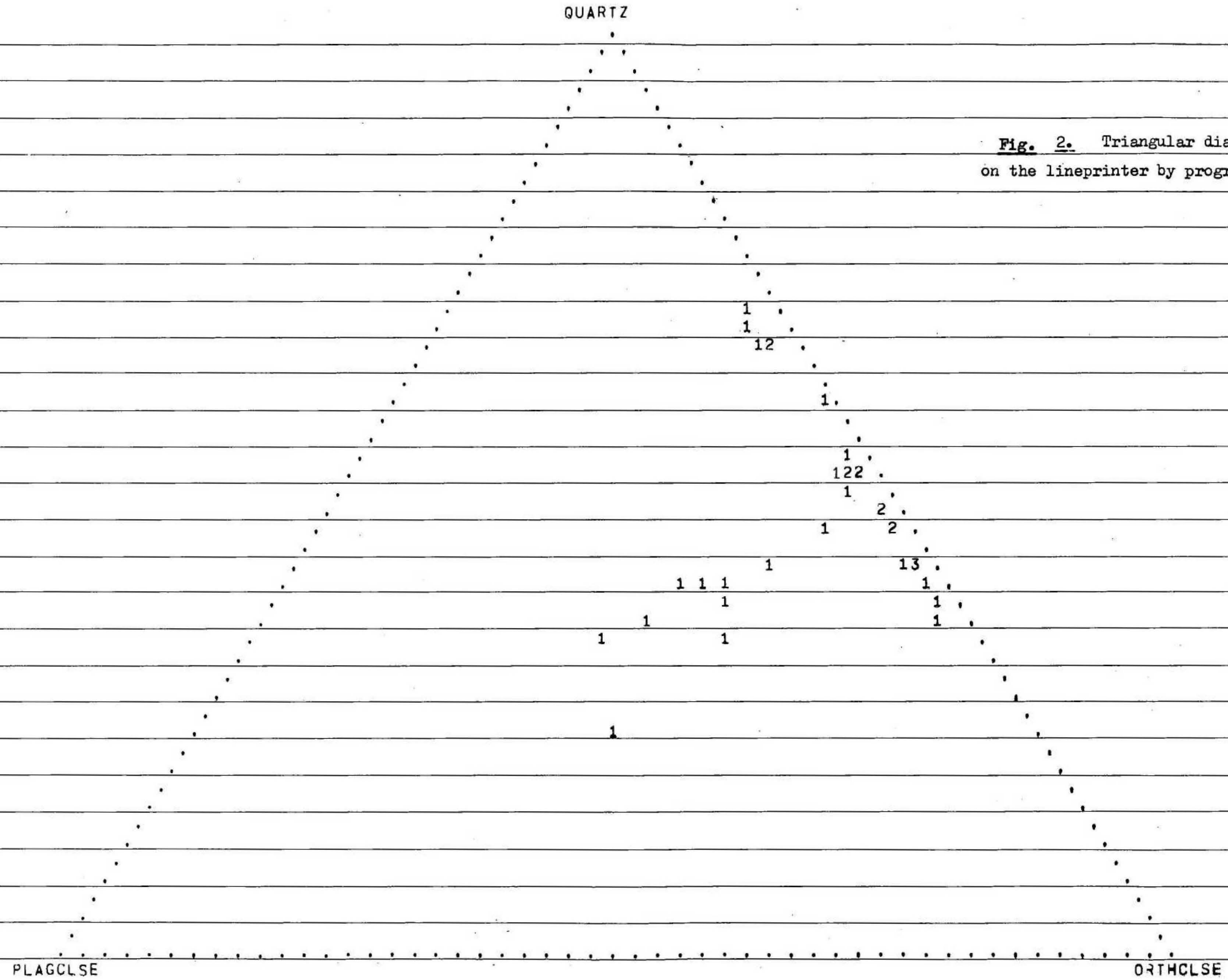


Fig. 2. Triangular diagram plotted on the lineprinter by program CIPWNORM.

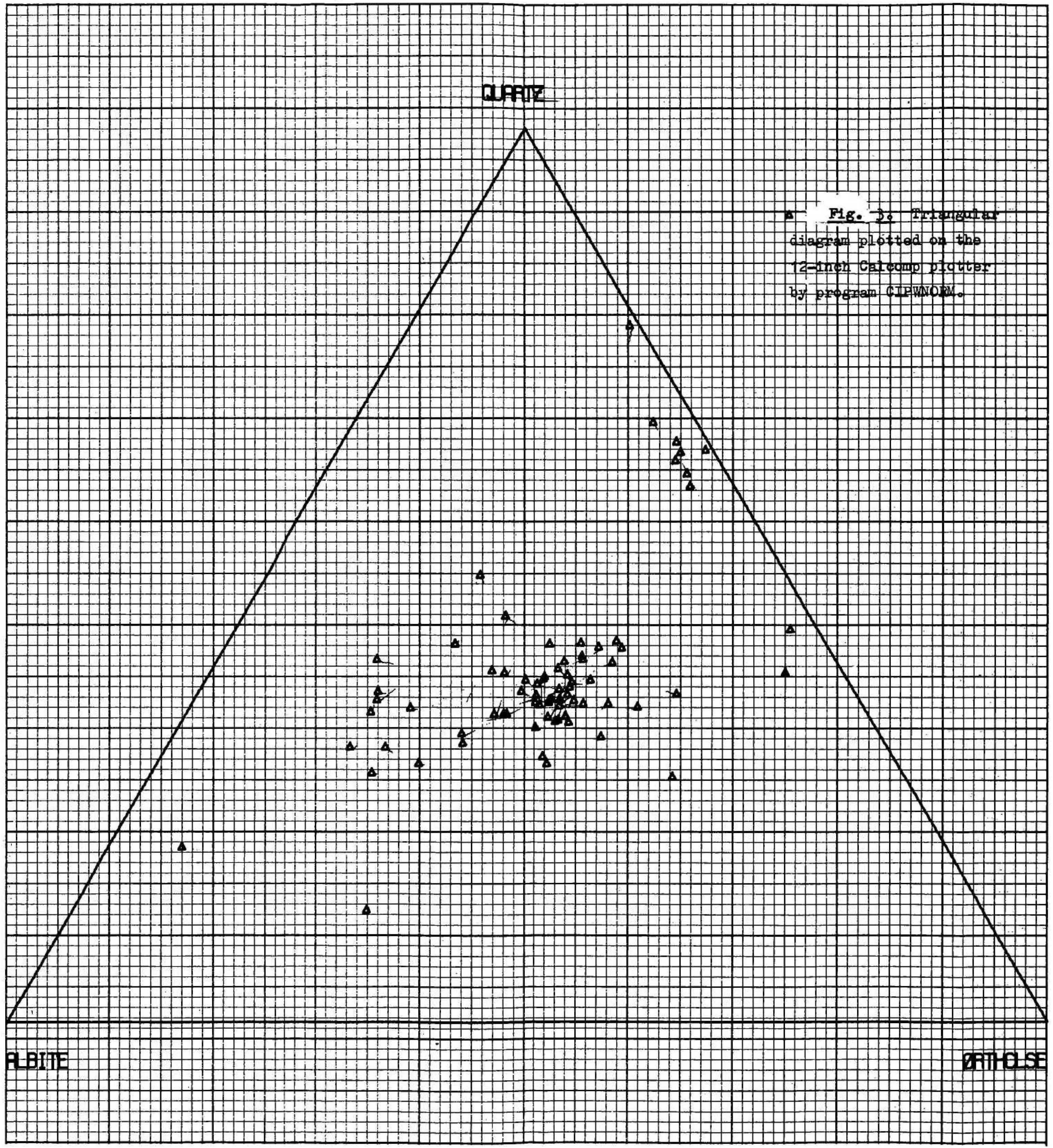


Fig. 3. Triangular diagram plotted on the 12-inch Calcomp plotter by program CIPWNORM.

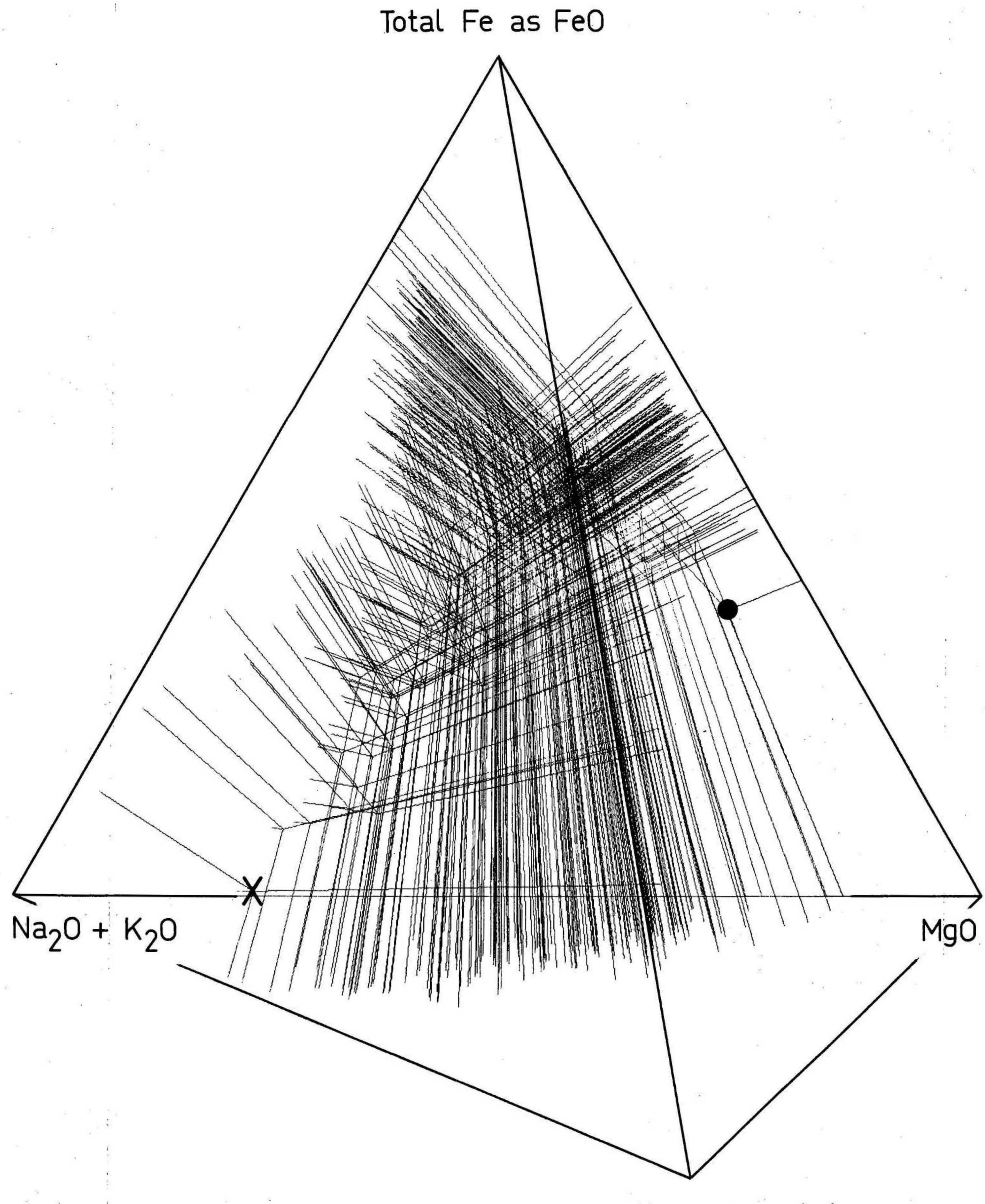
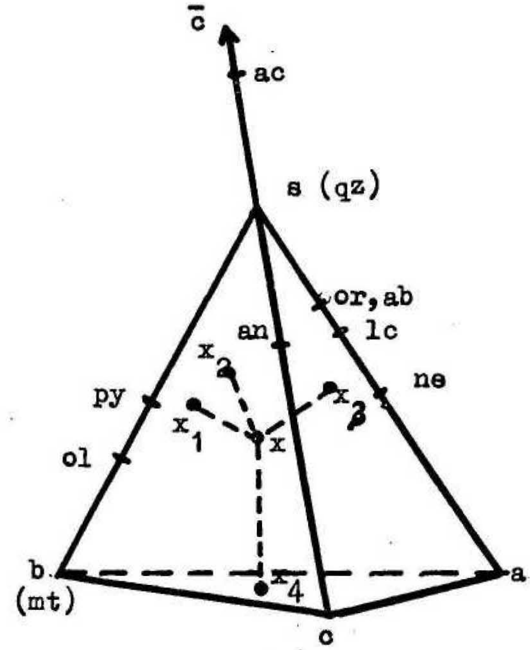


Fig. 4. Tetrahedral diagram
plotted by program CPWNORM.



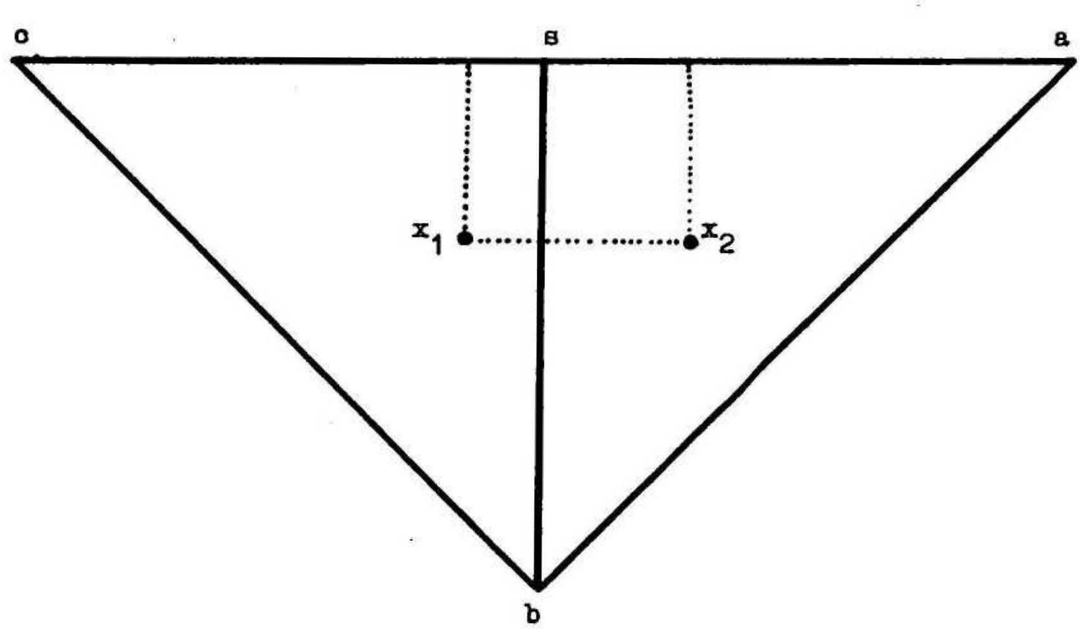


Fig. 5. Method of construction of the orthotetrahedral projection used in plotting the four principal Zavaritsky numbers, a,c,b and s. Point x (upper diagram) within the tetrahedron is projected into planes scb and sab at x_1 and x_2 respectively. The planes are represented by right triangles possessing the common edge sb, and the points are located by measuring 'a' units along direction sa, 'c' units along direction sc, and 'b' units along direction sb.

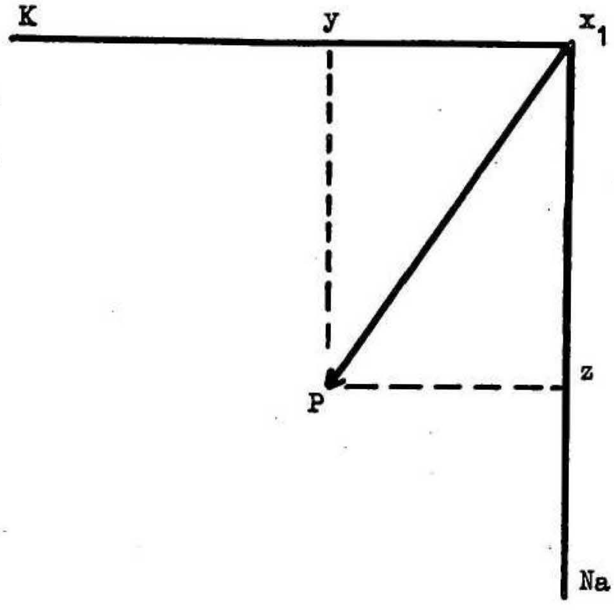


Figure 6a. The method of plotting the alkali vector in the conventional Zavaritsky diagram. Point P is located by measuring a length x_1y proportional to the K content of the rock and a length x_1z proportional to the Na content. Thus the length of x_1P is proportional to the total alkali content and its gradient expresses the K/Na ratio.

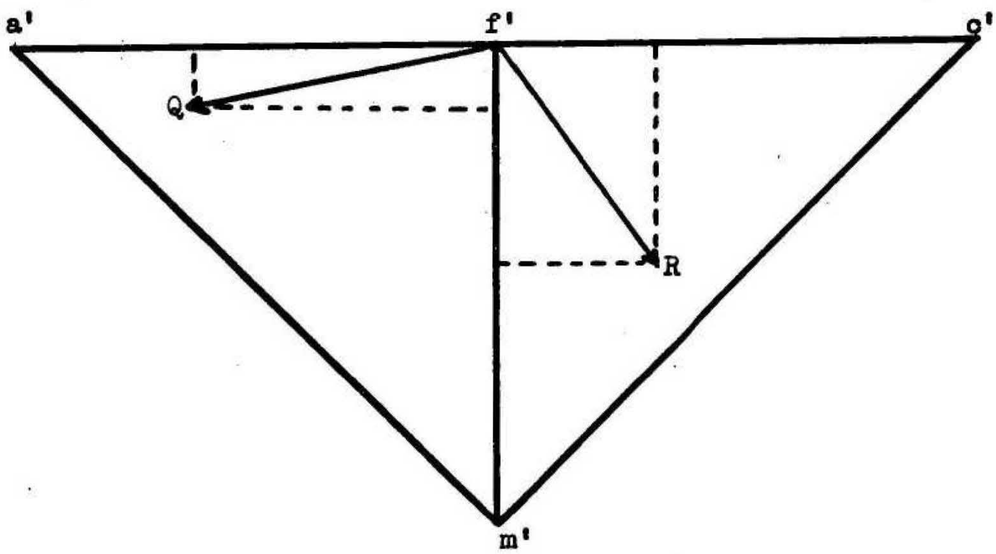


Figure 6b. The method of plotting the f'm'a' or f'm'c' vector in the conventional Zavaritsky diagram. From their definition, f' + m' + c' or f' + m' + a' = 100, and thus a point in either system may be directly plotted in a triangular diagram. If, again, we use right triangles, point Q or R may be located by measuring distance m' along f'm' and either distance a' along direction f'a' or c' along f'c'. A convenient scale for these triangles is 1/10 that of the acbs tetrahedron.

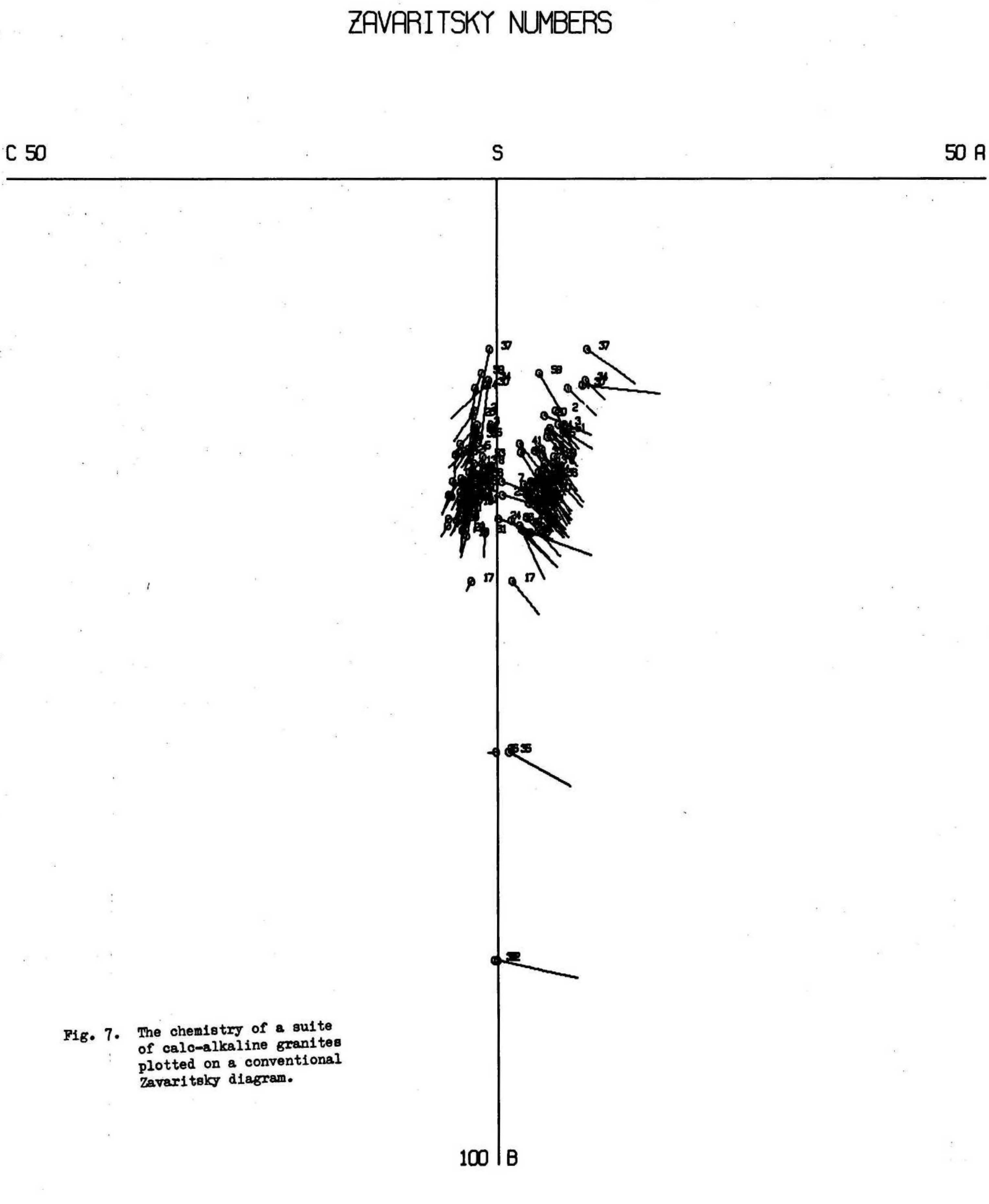


Fig. 7. The chemistry of a suite of calc-alkaline granites plotted on a conventional Zavaritsky diagram.