RABBIT, AN ELECTRON MICROPROBE DATA-REDUCTION PROGRAM USING EMPIRICAL CORRECTIONS

by

Fraser E. Goff
U.S. Geological Survey
Menlo Park, CA 94025

U.S. Geological Survey
OPEN FILE REPORT 77-351

ABSTRACT

RABBIT is a FORTRAN IV computer program that uses Bence-Albee empirical corrections for the reduction of electron microprobe data of silicates, oxides, sulphates, carbonates, and phosphates. RABBIT efficiently reduces large volumes of data collected on 3-11 channel microprobes.

INTRODUCTION

RABBIT is a high volume computer program written in FORTRAN IV that is designed to reduce electron microprobe data in counts to quantitative chemical analyses in weight-percent. Refinements correct the data for instrumental drift, deadtime, and background. RABBIT uses empirical correction schemes (Bence and Albee, 1968; Albee and Ray, 1970) for matrix corrections of silicates, oxides, sulphates, carbonates, and phosphates. Data sets may contain 150 individual analyses, and any number of data sets can be processed back to back. Optional routines: 1) calculate cations/unit cell; 2) normalize any three elements in terms of their atomic proportions; and 3) print tables of analyses. RABBIT was designed to be convenient, flexible, and capable of handling large amounts of data.

METHODS

Data Handling. A flow chart (Figure 1) will aid in the following discussions, and Table 1 defines unfamiliar terms. RABBIT can reduce data sets containing as many as 150 analyses and can reduce any number of data sets back to back. Space is allocated in RABBIT for 11 elements, but more could easily be accomodated. Up to 40 counts per unknown make up the count set for each analysis. The standard deviation of the counting statistics is computed from

$$\sigma = \left[\sum_{i=1}^{n} \frac{(\bar{K} - K_i)^2}{n - 1} \right]^{\frac{1}{2}}$$

where σ = standard deviation
$\bar{K}$ = average counts of count set
K_i = the value of the ith count
n = number of counts in count set.

Figure 1: Flow chart for program RABBIT.

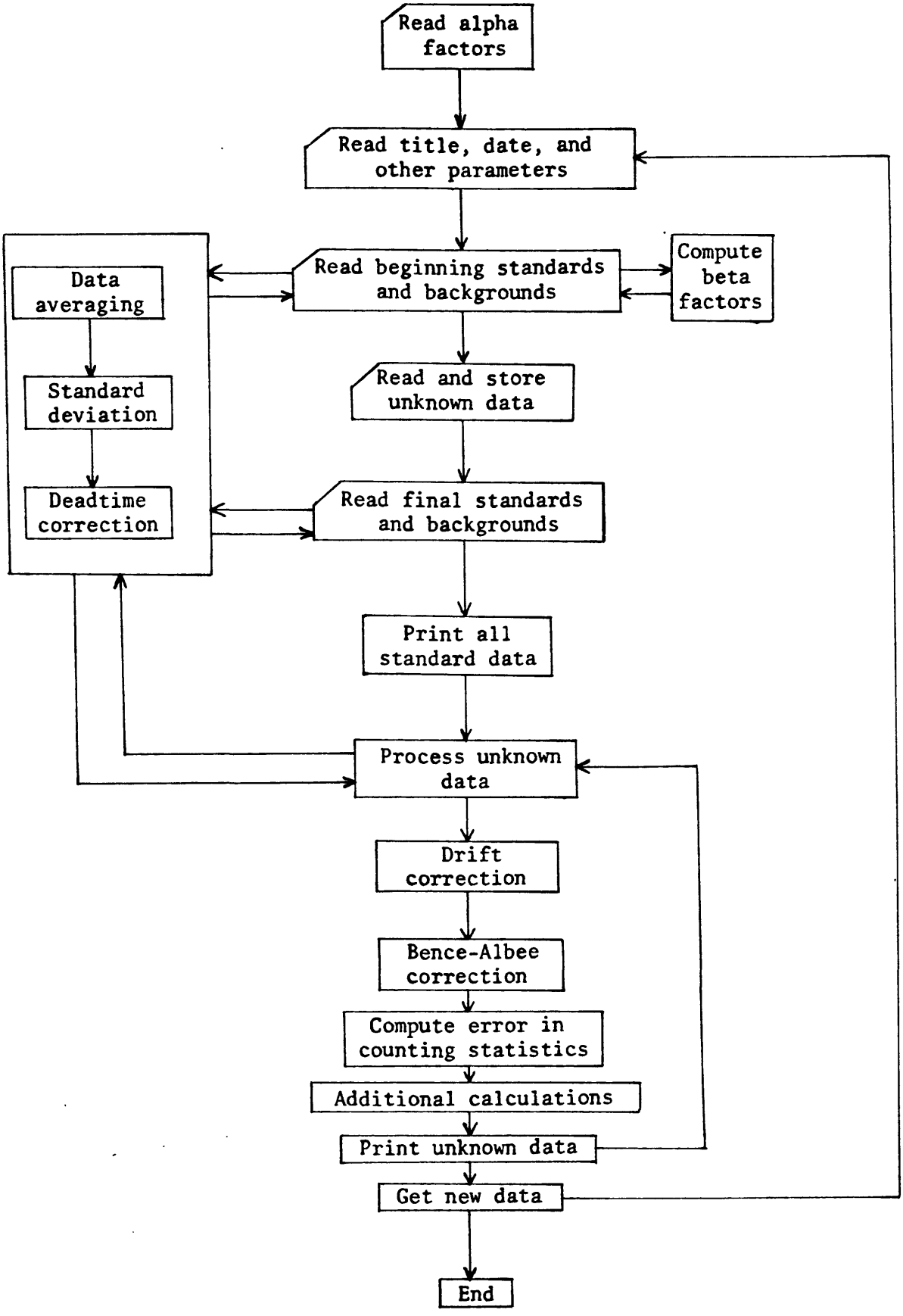

Table 1: Definition of terms

channel - the X-ray energy for each element is detected on a separate channel.

counting interval - the length of time (in sec.) that X-ray energy is counted.

counts - the energy counted during one counting interval.

count set - all the counts accumulated for each unknown; the data for one unknown makes up a count set.

data set - all the count sets accumulated for the run; the data for all the unknowns being analyzed in the run make up a data set.

run - all the data for the job; includes standard, background, and unknown data.

Deadtime. Averaged counts are next corrected for deadtime. This correction will vary from probe to probe depending on the equipment and the operating parameters in use. RABBIT is designed to function with three wavelength dispersive (WDS) channels and eight energy dispersive (EDS) channels. No deadtime correction is presently made to the three WDS channels. Counts from the EDS system are corrected for deadtime relative to the total energy stimulating the EDS detector, as measured on a ninth EDS channel. The routine that follows is adapted form Beaman and others (1972). Let

$$X_1 = \frac{E}{\bar{t}} \tag{2}$$

$$X_2 = \frac{E}{\bar{t}} (\exp (-X_1 d)) \tag{3}$$

where E = average counts from EDS system

$\bar{t}$ = average counting interval in sec.

d = deadtime of detector in sec.

For ease of manipulation we have

$$X_3 = \left| X_2 - X_1 \right| \tag{4}$$

$$X_4 = X_2 Z \tag{5}$$

where Z = upper limit of convergence in sec

If $X_3 \geq X_4$, we make $X_1 = X_2$ and substitute this new value of X_1 into Equation (3) for iteration. The routine rapidly converges until $X_3 < X_4$. The counts for each individual channel are then deadtime corrected by letting

$$\bar{K}_c = \bar{K}\left(\frac{E}{\bar{t}X_2}\right) \tag{6}$$

where $\bar{K}_c$ = deadtime corrected average counts/sec.

Values of d and Z currently built into RABBIT are 7.5×10^{-5} sec. and 1.0×10^{-5} respectively when using specimen currents less than 3.0×10^{-8} amp., but these values should be modified for individual needs.

Standards and Backgrounds. Standard and background data are read into the program before and after the unknown data just as they are collected on the probe. Standard and background data are averaged and deadtime corrected in the same manner as unknown data but no counting statistics are computed for backgrounds. The program reads number flags from the data cards to differentiate standards from backgrounds. Backgrounds are treated as standards which contain 0% of the unknown elements, thus background data does not need any special editing. RABBIT allows a maximum of 20 standards plus backgrounds to be used per run.

Instrument Drift and Background Corrections: Instrument drift is assumed to be linear with time. Standard and background counts are drift corrected by linear equations to the time of observation of each unknown. The standard counts are background corrected by subtracting the background counts. The unknown counts are then compared to the corrected standard counts and equated to values of weight percent. These corrections are repeated for each element to produce a raw analysis.

Bence-Albee Corrections. Because of their simplicity empirical correction schemes are used for interelement matrix effects which reduce programing costs and computer time. RABBIT incorporates the measured alpha-factors of Bence and Albee (1968) and uses the computer generated alpha-factors of Albee and Ray (1970) where measured values are not available (Table 2). The alpha-factors for 36 elements are read into the program as data and stored as a 36 x 36 matrix. The alpha factors listed in Appendix II are for probes with

a take-off angle of 52.5° and operating voltages of 15 KV. Alpha factors for other take-off angles and operating voltages may be obtained from Albee and Ray (1970) and Amli and Griffin (1975).

Beta-factors are computed from the standards using a computer routine adapted from Eq. (3) of Albee and Ray (1970). The program allows compensation to be made for elements present in the standard which are not to be analyzed in the run. For example, if benitoite ($BaTiSi_3O_9$) is used as a titanium standard, the beta-factors from benitoite must take into account the matrix effects of barium even though barium may not be included in the analysis.

Raw analyses are corrected using a computer routing following Bence and Albee (1968, p. 402) which iterates through the calculations twice.

Error in Counting Statistics. Once corrected oxide values are computed, the overall error in counting statistics is calculated from the standard deviations of counts in both standards and unknowns using partial differential equations. We have the basic relationship

$$U = \frac{C_u S}{C_s} \tag{7}$$

where U = Unknown weight percent

S = Standard weight percent

C_u = Counts of unknown

C_s = Counts of standard

Because the total uncertainty of U is a function of the standard deviations of the counts for both unknown and standard, W_u and W_s (ignoring the backgrounds), the solution for the uncertainty, W_T, is obtained with partial differential

equations (for example, Holman (1966), p. 38). We have

$$W_T^2 = \left[\left(\frac{\delta U}{\delta C_u} W_u\right)^2 + \left(\frac{\delta U}{\delta C_s} W_s\right)^2\right] \tag{8}$$

$$\frac{\delta U}{\delta C_u} = \frac{S}{C_s} \tag{9}$$

$$\frac{\delta U}{\delta C_s} = -\frac{C_u S}{C_s^2} \tag{10}$$

$$W_T = \left[\left(\frac{S}{C_s} W_u\right)^2 + \left(-\frac{C_u S W_s}{C_s^2}\right)^2\right]^{\frac{1}{2}} \tag{11}$$

The final equation is used to solve for the total standard deviation.

Additional and Optional Calculations. The atom weight-percent of the elements is determined from the oxides by letting

$$W_a = \frac{(W_o f_a)}{\left(f_a + \frac{V_a 15.9994}{2.0}\right)} \tag{12}$$

where W_a = atom weight-percent of element a

W_o = oxide weight-percent of element a

f_a = atomic weight of element a

V_a = valence of element a

Cations/unit cell (mineral norms) are calculated for all unknowns in a given data set on the same basis. Therefore, this option is best used for

runs in which all the unknowns have the same structural formula (e.g., all pyroxenes, all feldspars, etc.). We have

$$T_{ox} = T_o - T_a \tag{13}$$

$$C = \left(\frac{W_a}{f_a}\right)\left(\frac{15.9994\ N_o}{T_{ox}}\right) \tag{14}$$

where T_{ox} = total weight-percent oxygen

T_o = total oxide weight-percent

C = cations/unit cell

N_o = number of oxygens/unit cell

RABBIT will calculate the normalized atomic proportions of any three prechosen elements for each analysis. This option is convenient for later construction of ternary plots and is most effective when a run consists of all feldspars or all pyroxenes, etc.

Each analysis is printed with complete information on raw counts, counting statistics, raw analysis, corrected analysis, and atomic proportions. A final option prints a table of all analyses with the calculated cations/unit cell underneath.

DECK SET-UP

A ready-to-run deck is shown diagramatically in Figure 2. Note that the data consists of two parts: 1) the Bence-Albee alpha factors (listed in Appendix II) and 2) the parameter cards and count data which are described in the following sections (an example is listed in the second half of Appendix II).

Figure 2: Deck set-up for program RABBIT.

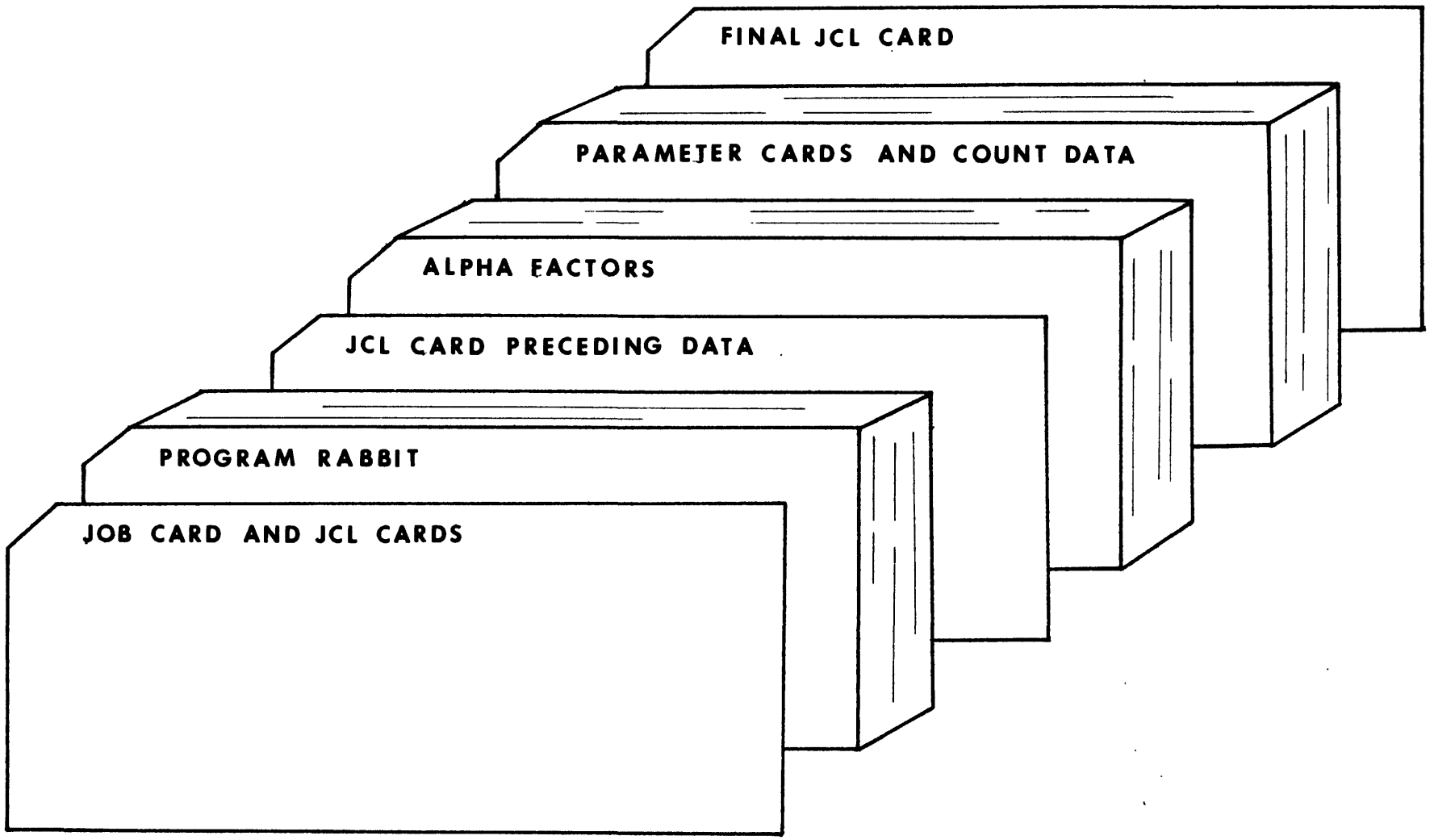

Table 2: Matrix numbers and valences of oxides and elements which can be analyzed by RABBIT (adapted from Albee and Ray, 1970).

Matrix Number	Oxide or Element	Valence	Matrix Number	Oxide or Element	Valence
1	O	2	19	CuO	2
2	CO_2	2	20	ZnO	2
3	F	1	21	Rb_2O	1
4	Na_2O	1	22	SrO	2
5	MgO	2	23	Y_2O_3	3
6	Al_2O_3	3	24	ZrO_2	4
7	SiO_2	4	25	BaO	2
8	P_2O_5	5	26	La_2O_3	3
9	SO_3	2	27	Ce_2O_3	3
10	Cl	1	28	Pr_2O_3	3
11	K_2O	1	29	Nd_2O_3	3
12	CaO	2	30	Sm_2O_3	3
13	TiO_2	4	31	Gd_2O_3	3
14	Cr_2O_3	3	32	Dy_2O_3	3
15	MnO	2	33	Er_2O_3	3
16	FeO	2	34	HfO_2	4
17	CoO	2	35	ThO_2	4
18	NiO	2	36	UO_2	4

PARAMETER CARD FORMATS

Columns	Name	Format	Description
Card 1			
1-80	LABEL	20A4	Title, any characters may be used
Card 2			
1-2	L	I2	Number of standards plus backgrounds, maximum = 20
3-4	M	I2	Number of elements to be analyzed, maximum = 11
5-7	N	I3	Number of unknowns to be analyzed, maximum = 150
8-11	OX	F4.1	Number of oxygens/unit cell (for example, 8.0 for feldspars); use 1.0 if option is ignored
12-13	MSTD	I2	Number of standard elements (for beta-factor calculations); maximum = 11
14-15	NORM(1)	I2	First element to be normalized for ternary plot; elements are identified by their channel number; program will accept numbers 1-11; use 0 in space 14 if option is ignored
15-17	NORM(2)	I2	Second element to be normalized for ternary plot
18-19	NORM(3)	I2	Third element to be normalized for ternary plot
20-21	ITAB	I2	Option to print analyses in tabular form; blank means *no*, 1 means *yes*
Card 3			
1-8	ROW(1),ATWT(1)	A2,F6.3	Element label and atomic weight for element in first channel (for example, FE55.847); an additional card must be used for elements in eleventh channel

Columns	Name	Format	Description
9-16,...,	ROW(2),ATWT(2),	A2,F6.3	Second channel - tenth channel
73-80	...ROW(10),ATWT(10)		
Card 4			
1-8	ROW(11),ATWT(11)	A2,F6.3	Eleventh channel; remove this card if 10 or less elements are analyzed
Card 5			
1-2	MFLAG(1)	I2	Bence-Albee matrix number (from Table 1); numbers must be in same order as data are taken from microprobe. There must be as many matrix numbers as standard elements (item 5, card 2)
3-4,...,	MFLAG(2),...,	I2	Second matrix number - eleventh matrix number
21-22	MFLAG(11)		
Card 6			
1-2	VAL(1)	I2	Valences (from Table 1); must be in same order as data are taken from microprobe
3-4,...,	VAL(2),...,	I2	Second valence - eleventh valence
21-22	VAL(11)		
Card 7			
1-16	OXID2(1),OXID1(1)	A8,A8	Oxide and element headings to be used for table (for example; FEO FE); must be in same order as data are taken from microprobe; last pair of headings must read TOTAL TOTAL; maximum number of heading pairs = 12; remove cards 7-9 if ITAB = 0 (item 9, card 2)
17-32,...,	OXID2(2),OXID1(2),	A8,A8	Second pair - fifth pair of headings
65-80	...,OXID2(5),OXID1(5)		

Columns	Name	Format	Description
Card 8			
1-16,...,	OXID2(6),OXID1(6),	A8,A8	Sixth pair - tenth pair of headings
65-80	...,OXID2(10),OXID1(10)		
Card 9			
1-16,	OXID2(11),OXID1(11)	A8,A8	Eleventh and twelfth pairs of headings
17-32	OXID2(12),OXID1(12)		

STANDARD CARD FORMATS

Card 1			
1-52	HEAD	A52	Title of standard or background; any characters may be used
53-54	M1(J,1)	I2	Flag for first channel that declares how data are to be used in calculations; 0 = channel is ignored, 1 = channel is used for background, 2 = channel used for standard
55-56,...,	M1(J,2),...,	I2	Flags for second - eleventh channels
57-58	M1(J,11)		
Card 2			
1-6	WT(J,1)	F6.3	Oxide weight-percent of element in first channel
7-12,...,	WT(J,2),...,	F6.3	Second - eleventh channels
61-66	WT(J,11)		

Columns	Name	Format	Description
Card 3	(Data card; must be re-formated for different microprobes)		
1-6	DATA(NUM,1)	I6	Count data for first channel
7-8	---	--	Blank
9-14	DATA(NUM,2)	I6	Count data for second channel
15-16	---	--	Blank
17-22	DATA(NUM,3)	I6	Count data for third channel
23-24	---	--	Blank
25-30	JTIME	I6	Counting interval (in 10^{-3} sec)
31-32	---	--	Blank
33-38	ITIME	I6	Total beam current energy in counts
Card 4	(Data card; must be re-formated for different microprobes)		
1-6	DATA(NUM,4)	I6	Count data for fourth channel
7-8,	---	--	Blank
...,			
57-62	DATA(NUM,11)	I6	Count data for eleventh channel
63-64	---	--	Blank
65-70	DATA(NUM,12)	I6	Total energy in counts for energy-dispersive system (for deadtime corrections)

Cards 3 and 4 are repeated for each count; maximum = 40 counts

Cards 5 and 6 Two blank cards end the count data for the first standard or background. Repeat cards 1-6 for each additional standard or background; maximum = 20

UNKNOWN CARD FORMATS

Columns	Name	Format	Description
Card 1			
1-52	NAME(J,I)	13A4	Title of unknown; any characters may be used
Cards 2 and 3	Data cards; same format as cards 3 and 4 in Standard Card Formats above		
Cards 4 and 5	Blank cards; same procedure as cards 5 and 6 in Standard Card Formats above		

STANDARD CARD FORMATS

(End of Run)

All standards and backgrounds are arranged in the same order before and after the unknowns; card format is the same as in Standard Card Formats above; the last pair of data cards ends with 4 blank cards.

VARIABLE DESCRIPTIONS

ALPHA(36,36)	- matrix for storage of alpha-factors (element, oxide) listed in Appendix II
ATPRO(12)	- atomic proportions of elements in an unknown
ATWT(12)	- atomic weight of elements to be analyzed
AVE(12)	- average counts for each channel
BETA(12)	- beta-factors calculated for each element in an unknown
DATA(40,12)	- counts for each channel; 40 counts per channel
DEV(150,12)	- standard deviation of unknown data for each channel; maximum = 150 unknowns; values in weight percent
DIFF(40,12)	- difference between the average counts and the individual counts; used in standard deviation calculation, maximum = 40
DV(12)	- total standard deviation for each element used in Error in Counting Statistics routine
ENERGY	- total counts stimulating EDS system; used for deadtime correction
FLAG	- counter used to limit the number of iterations through Bence-Albee correction routine
HEAD(13)	- heading for standard and background identification; field is 13(A4) or 52 characters wide
IFLAG	- holds information in intermediate storage for calculation in Bence-Albee routine
INORM	- holds information in intermediate storage for calculation in ternary ratio routine
ITAB	- option variable to print data in tabular form
ITIME	- counting interval in 1×10^{-3}
JFLAG	- holds information in intermediate storage for calculation in Bence-Albee routine
JTIME	- absolute time in 1×10^{-3} sec for use in drift correction
KK	- counter to control entry into various routines
KR(12)	- final Bence-Albee corrected weight percent for each element
KX	- counter to control the total number of unknowns printed in final output table
LABEL	- title of job being run
L	- number of standards plus backgrounds
L1	- counter used to calculate standard data at beginning and end of run; L1 = 1 at beginning; L1 = L + 1 at end

M	- number of elements (channels) to be analyzed
MF	- counter used to print final output table
MFLAG(12)	- Bence-Albee matrix number (from Table 1)
MG	- counter used to print final output table
MSTD	- number of standard elements; used for beta-factor calculation
MZ	- number of elements plus one; MZ = M + 1
M1(20,12)	- flags that control whether data will be used as standard, background, or ignored; standard = 2, background = 1, ignored = 0
M2	- counter to control entry into routine that calculates unknown data
N	- number of unknowns to be analyzed
NAME(150,13)	- title of unknown data; maximum = 150; field width = 13(A4)
NORM(3)	- three cations to be normalized for ternary plot (in mol-percent)
NUM	- counter whose maximum value equals the number of counts per unknown analysis
OX	- number of oxygens per unit cell
OXID1(12)	- oxide labels used in final output table
OXID2(12)	- element labels used in final output table
R	- counts in energy dispersive system during one counting interval; used for deadtime correction
ROW(12)	- element headings for each channel; used to label output
S	- average counting interval in 1 x 10^{-3} sec
SBETA(12)	- standard beta factors for each element
SDEV(20,12)	- standard deviation of standard data for each element (channel); values in weight percent
SLOPE(12)	- slope determined by linear equation which measures change of standard value from beginning to end of run; used for drift correction; calculated for each element (channel)
STD(20,12)	- standard value in counts for each element
STIME(20)	- absolute time when standard data was read from microprobe
SUM(12)	- standard deviation of count data
T	- average absolute time when data was read from microprobe
TAB1(150,12)	- element values in weight percent to be printed in final output table
TAB2(150,12)	- element values in cations per unit cell to be printed in final output table

THOLD	- average absolute time of first data read from microprobe; used for drift correction
TIME(150)	- average absolute time of all unknown data
TNORM	- total of three cations in mol-percent for use in calculation of ternary plots
TOT	- total atom weight percent
TOTKR	- total oxide weight percent
TOTOX	- total oxygen in weight percent for an unknown
TOTWT	- total oxide weight percent for standards and backgrounds
T1	- counter to control THOLD
UNKNWN(150,12)	- average unknown count data for each element; maximum = 150 unknowns
UKWT(13)	- average unknown data in weight percent for each element; Bence-Albee corrected
VAL(12)	- valences of elements for each channel
WT(20,12)	- oxide weight percent of each element for every standard and background
X1,...,X4	- used for calculating deadtime correction
XR(12)	- first Bence-Albee corrected values in weight percent for each element of an unknown; stored for final Bence-Albee correction on last iteration

ACKNOWLEDGEMENTS

RABBIT was conceived after much urging from G. K. Czamanske. C. R. Bacon and Julie M. Donnelly encouraged adoption of empirical corrections. Mel Beeson, C. R. Bacon, and Vic Adams reviewed the manuscript. Sue Kendall kindly typed the manuscript.

REFERENCES

Albee, A. L., and Ray, L. 1970, Correction factors for electron probe microanalysis of silicates, oxides, carbonates, phosphates, and sulfates, Analytical Chemistry, 42, pp. 1408-1414.

Amli, R., and Griffin, W. L., 1975, Microprobe analysis of REE minerals using empirical correction factors: Amer. Mineral., vol. 60, p. 599-606.

Beaman, D. R., Isasi, J. A., Birnbaum, H. K., and Lewis, R., 1972, The source and nature of deadtime in X-ray counting systems used in electron microprobe analysis, Journal of Physics E, 5, pp. 767-776.

Bence, A. E., and Albee, A. L., 1968, Empirical correction factors for the electron microanalysis of silicates and oxides, Journal of Geology, 76, pp. 382-403.

Holman, J. P., 1966, Experimental Methods for Engineers, McGraw-Hill, Inc., New York, 412 pp.

APPENDIX I: PROGRAM LISTING

```
/*RELAY  PRINT REMOTE4  MG8536          MENLO PARK                          J 3 578
//MG9513FG JOB (971000303,C923,6,20),'CZAMZNSKE',CLASS=F
//  EXEC FORTGCLG,REGION.GO=150K
//FORT.SYSIN DD *
C
C      PROGRAM 'RABBIT' BY FRASER E. GOFF IS A FAST, HIGH VOLUME PROGRAM THAT
C      REDUCES ELECTRON MICROPROBE DATA FROM RAW SCALER COUNTS TO
C      ELEMENTAL COMPOSITIONS IN WEIGHT PERCENT.
C
C      THIS IS A BENCE-ALBEE VERSION FOR OXIDES, SILICATES, CARBONATES,
C      SULFATES, AND PHOSPHATES.
C
C      OUTPUT CONSISTS OF (1) AVERAGED COUNTS CORRECTED FOR BACKGROUND,
C      DEADTIME, AND DRIFT, (2) OXIDE WEIGHT PERCENT, (3) BENCE-ALBEE
C      CORRECTED OXIDE PERCENT, (4) STD DEVIATION OF ALL COUNTING STATISTICS
C      (5) ATOM WT PERCENT (6) ATOMIC PROPORTIONS (7)CATIONS/UNIT CELL
C      (8) NORMALIZED CATIONS FOR TERNARY PLOT
C
C
C
      DIMENSION UKWT(13),UNKNWN(150,12),STD(20,12),SLOPE(20,12),ROW(12),
     1NAME(150,13),HEAD(13),WT(20,12),DATA(40,12),AVE(12),ATWT(12),
     2LABEL(20),KR(12),COUNT(2),WAIT(2),STIME(20),TIME(150),ATPRO(12),
     3DIFF(40,12),SUM(12),DEV(150,12),DV(12),VAL(12),M1(20,12),BETA(12),
     4SBETA(12),SDEV(20,12),MFLAG(12),NORM(3),ALPHA(36,36) ,XR(12)
      DIMENSION TAB1(150,12),TAB2(150,12),OXID1(12),OXID2(12)
      INTEGER DATA,VAL,R
      REAL*8 KR,OXID1,OXID2
C
C     READ IN BENCE-ALBEE ALPHA FACTORS
C
      DO 4443 J=1,36
      READ 4444,(ALPHA(I,J),I=1,9)
      READ 4444,(ALPHA(I,J),I=10,18)
      READ 4444,(ALPHA(I,J),I=19,27)
      READ 4444,(ALPHA(I,J),I=28,36)
 4444 FORMAT(6X,9(F6.3,1X))
 4443 CONTINUE
C
C     READ IN PARAMETERS AND PROBE DATA
C
 501  READ 299,LABEL
 299  FORMAT (20A4)
      READ 300,L,M,N,OX,MSTD,(NORM(I),I=1,3),ITAB
 300  FORMAT (2I2,I3,F4.1,5I2)
      IF (L)  500,500,502
 502  READ 302,(ROW(I),ATWT(I),I=1,MSTD)
 302  FORMAT (12(A2,F6.3))
      READ 506,(MFLAG(I),I=1,MSTD)
  506 FORMAT (12I2)
      READ 305,(VAL(I),I=1,M)
 305  FORMAT (12I2)
      MZ=M+1
      IF (ITAB) 303,303,716
 716  READ 701,(OXID2(I),OXID1(I),I=1,MZ)
 701  FORMAT (30A8)
 303  PRINT 298,LABEL,L,M,N,MSTD,OX
 298  FORMAT (1H1,20A4,//,5X,9HNO. STDS=,I2,5X,9HNO. ELEM=,I2,5X,
     113HNO. UNKNOWNS=,I3,5X,13HNO. STD ELEM=,I2,5X,12HNO. OXYGENS=,
     2F4.1,//)
      PRINT 297
```

```
 297  FORMAT (1H ,32HSTANDARD COUNTS AND COMPOSITIONS,/)
      T1=0
      L1=1
      M2=0
      KK=-1
 10   DO 5 J=L1,L
C
C     READ STANDARDS AND BACKGROUNDS
C
      READ 6,HEAD,(M1(J,I),I=1,MSTD)
   6  FORMAT (13A4,12I2)
      READ 301,(WT(J,I),I=1,MSTD)
 301  FORMAT (12F6.3)
C
C    COMPUTE STANDARD BETA FACTORS
C
      IF (KK) 419,104,104
 419  DO 422 I=1,MSTD
      IF (M1(J,I)-1) 422,422,423
 423  JFLAG = MFLAG(I)
      SBETA(I)= 0.0
      TOTWT = 0.0
      DO 424 K=1,MSTD
      IFLAG= MFLAG(K)
      SBETA(I)= WT(J,K) * ALPHA(JFLAG,IFLAG) + SBETA(I)
      TOTWT= TOTWT + WT(J,K)
 424  CONTINUE
      SBETA(I)= SBETA(I)/TOTWT
 422  CONTINUE
C
C     AVERAGING SECTION
C
 104  DO 105 I=1,12
      AVE (I)=0.0
      SUM(I)=0.0
 105  CONTINUE
      ENERGY=0
      S=0
      T=0
      NUM=0
 109  NUM=NUM+1
      READ 110,(DATA(NUM,I),I=1,3),JTIME,ITIME
 110  FORMAT (I6,4(2X,I6))
      READ 111,(DATA(NUM,I),I=4,11),R
 111  FORMAT (I6,8(2X,I6))
      IF (DATA(NUM,1))  500,112,113
 113  DO 114 I=1,12
      AVE(I)=AVE(I)+DATA(NUM,I)
 114  CONTINUE
      S=S+ITIME
      ENERGY=ENERGY+R
      T=T+JTIME
      GO TO 109
 112  NUM=NUM-1
      DO 115 I=1,12
      AVE(I)=AVE(I)/NUM
 115  CONTINUE
      T=T/NUM
      ENERGY=ENERGY/NUM
      S=(S/NUM)*0.001
C
```

```
C     COMPUTE STANDARD DEVIATION OF COUNTS
C
      IF (NUM-1) 63,63,62
   62 DO 69 K=1,NUM
      DO 68 I=1,M
      DIFF(NUM,I)=(AVE(I)-DATA(NUM,I))*(AVE(I)-DATA(NUM,I))
      SUM(I)=SUM(I)+DIFF(NUM,I)
   68 CONTINUE
   69 CONTINUE
      DO 67 I=1,M
      SUM(I)=SQRT(SUM(I)/(NUM-1))
   67 CONTINUE
      GO TO 61
   63 DO 66 I=1,M
      SUM(I)= 0.0
   66 CONTINUE
   61 IF (T1)  38,38,39
   38 THOLD=T
   39 T1=T1+1
C
C     APPLY DEADTIME CORRECTION TO ENERGY DISPERSIVE SYSTEM
C
      DO 160 I=1,M
      IF (I-3) 160,160,161
  161 X1=ENERGY/S
  165 X2=(ENERGY/S)*EXP(-X1*7.5E-05)
      X3=ABS(X2-X1)
      X4=X2*1.0E-05
      IF (X3-X4) 162,163,163
  163 X1=X2
      GO TO 165
  162 AVE(I)=AVE(I)*((ENERGY/S)/X2)
  160 CONTINUE
      IF (KK) 20,20,21
C
C     PRINT STANDARD INFORMATION
C
   20 DO 32 I=1,M
      IF (M1(J,I)) 30,30,31
   31 STD (J,I)=AVE(I)
      SDEV(J,I)=(SUM(I)*WT(J,I))/STD(J,I)
      GO TO 32
   30 STD(J,I)=0.0
      SDEV(J,I)= 0.0
   32 CONTINUE
      STIME(J)=T-THOLD
      IF (KK) 46,47,47
   46 PRINT 45
   45 FORMAT (1H0,5X,5HSTART)
      GO TO 48
   47 PRINT 49
   49 FORMAT (1H0,5X,6HFINISH)
   48 PRINT 25,HEAD,STIME(J)
   25 FORMAT (1H0,/,5X,13A4,5HTIME=,F9.3,/)
      PRINT 220,(ROW(I),I=1,MSTD)
  220 FORMAT (1H ,17X,12(A4,6X))
      PRINT 28,(STD(J,I),I=1,M)
   28 FORMAT (1H0,11HAVE COUNTS=,12(F10.3))
      PRINT 26,(WT(J,I),I=1,MSTD)
   26 FORMAT (1H ,11HWT PERCENT=,12(F10.3))
      PRINT 65,(SDEV(J,I),I=1,M)
```

```
   65  FORMAT (1H ,11H   STD DEV=,12(F10.3))
    5  CONTINUE
C
C      READ IN UNKNOWN DATA
C
       KK=1
       IF (M2)  36,36,37
   36  DO 42 J=1,N
       READ 40,(NAME(J,I),I=1,13)
   40  FORMAT (13A4)
       GO TO 104
   21  DO 41 I=1,M
       UNKNWN(J,I)=AVE(I)
       DEV(J,I)=SUM(I)
   41  CONTINUE
       TIME (J)=T-THOLD
   42  CONTINUE
       KK=0
       M2=1
       L1=L+1
       L=2*L
       GO TO 10
   37  L=L/2
       PRINT 8
    8  FORMAT (1H1,21HSTANDARD BETA FACTORS,/)
       PRINT 4,(SBETA(I),I=1,MSTD)
    4  FORMAT (1H0,11H BETA FACT=,12(F10.3),////)
C
C      CALCULATE DRIFT IN STDS BY LINEAR EQUATIONS
C
       DO 215 J=1,L
       DO 216 I=1,M
       IF (STD(J,I)) 217,217,218
  218  SLOPE(J,I)=(STD(J+L,I)-STD(J,I))/(STIME(J+L)-STIME(J))
       GO TO 216
  217  SLOPE(J,I)=0.0
  216  CONTINUE
  215  CONTINUE
C
C      INTERPOLATE BETWEEN STD AND BKGD VALUE. . . CALCULATE RAW COMPOSITIONS
C
       PRINT 257
  257  FORMAT (1H0,31HUNKNOWN COUNTS AND COMPOSITIONS,/)
       DO 280 K=1,N
       DO 265 I=1,M
       N2=1
       DO 266 J=1,L
       IF (SLOPE(J,I))  267,266,267
  267  COUNT(N2)=SLOPE(J,I)* TIME(K)    +STD(J,I)-SLOPE(J,I)*STIME(J)
       WAIT(N2)=WT(J,I)
       N2=N2+1
  266  CONTINUE
       SLOP=(COUNT(2)-COUNT(1))/(WAIT(2)-WAIT(1))
       UKWT(I)=    ((UNKNWN(K,I)-COUNT(1)+SLOP*WAIT(1))/SLOP)
       IF (UKWT(I)) 3,265,265
    3  UKWT(I)= 0.0
  265  CONTINUE
C
C      COMPUTE BENCE-ALBEE CORRECTED COMPOSITIONS
C
       TOTKR= 0.0
```

```
      DO 440 I=1,M
      KR(I)= (UKWT(I)/SBETA(I))
      XR(I)= KR(I)
      TOTKR= KR(I) + TOTKR
 440  CONTINUE
      FLAG= 0.0
 444  DO 445 I=1,M
      BETA(I)= 0.0
 445  CONTINUE
      DO 441 J=1,M
      JFLAG= MFLAG(J)
      DO 442 I=1,M
      IFLAG= MFLAG(I)
      BETA(J)= KR(I)* ALPHA(JFLAG,IFLAG) + BETA(J)
 442  CONTINUE
 447  BETA(J)= BETA(J)/TOTKR
 441  CONTINUE
      TOTKR=0.0
      DO 443 J=1,M
      KR(J)= BETA(J) * XR(J)
      TAB1(K,J)= KR(J)
      TOTKR= KR(J) + TOTKR
 443  CONTINUE
      TAB1(K,M+1)= TOTKR
      FLAG= FLAG + 1.0
      IF (FLAG-2.0) 444,444,446
C
C     PRINT ANALYSES
C
 446  PRINT 268,(NAME(K,JJ),JJ=1,13),TIME(K)
 268  FORMAT (1H0,/,3X,13A4,2X, 5HTIME=,F9.3,/)
      PRINT 258,(ROW(I),I=1,M)
 258  FORMAT (1H ,17X,12(A4,6X))
      PRINT 269,(UNKNWN(K,I),I=1,M)
 269  FORMAT (1H0,11HAVE COUNTS=,12(F10.3))
      PRINT 270,(UKWT(I),I=1,M)
 270  FORMAT (1H ,11H OXIDE PER=,12(F10.3))
      PRINT 292,(BETA(I),I=1,M)
 292  FORMAT (1H ,11H BETA FACT=,12(F10.3))
      PRINT 408,(KR(I),I=1,M)
 408  FORMAT (1H ,11H  B=A CORR=,12(F10.3))
      PRINT 272,TOTKR
 272  FORMAT (1H ,11HTOT WT PER=,F10.3)
C
C    COMPUTE TOTAL STD DEVIATION W/ PARTIAL DIFFERENTIALS
C
      DO 64 J=1,L
      DO 431 I=1,M
      IF (M1(J,I)-1) 432,432,433
 432  GO TO 431
 433  DV(I)= ((WT(J,I) * DEV(K,I))/STD(J,I))**2.0 + (( UNKNWN(K,I)
     1 * WT(J,I) * SDEV(J,I)) /(STD(J,I) *  STD(J,I))) **2.0
      DV(I)= SQRT(DV(I))
 431  CONTINUE
  64  CONTINUE
      PRINT 271,(  DV(I),I=1,M)
 271  FORMAT (1H0,11H   STD DEV=,12(F10.3))
C
C     COMPUTE ATOM-WT PERCENT, ATOM PROPOR,, CATIONS/UNIT CELL (OPTIONAL)
C
      TOT=0.0
```

```
      DO 409 I=1,M
      UKWT(I)= KR(I)
      UKWT(I)= (UKWT(I)*ATWT(I))/(ATWT(I)+((VAL(I)*15.9994)/2.0))
      ATPRO(I)= (UKWT(I)/ATWT(I))
      TOT=TOT+UKWT(I)
  409 CONTINUE
      PRINT 276,(UKWT(I),I=1,M)
  276 FORMAT (1H ,11H AT WT PER=,12(F10.3))
      PRINT 277,TOT
  277 FORMAT (1H ,11HTOT ATOMPC=,F10.3)
      PRINT 283,(ATPRO(I),I=1,M)
  283 FORMAT (1H ,11HATOMIC PRO=,12(F10.5))
      IF (OX) 280,280,274
  274 TOTOX= (TOTKR-TOT)/(15.9994*OX)
      TAB2(K,M+1)= 0.0
      DO 291 I=1,M
      UKWT(I)= ATPRO(I)/TOTOX
      TAB2(K,I)= UKWT(I)
      TAB2(K,M+1)= TAB2(K,M+1) + UKWT(I)
  291 CONTINUE
      PRINT 412,(UKWT(I),I=1,M)
  412 FORMAT (1H ,11HATOMS/CELL=,12(F10.5))
C
C     NORMALIZE THREE ELEMENTS FOR TERNARY DIAGRAMS
C
      IF (NORM(1)) 280,280,464
  464 TNORM=0.0
      DO 460 I=1,3
      INORM= NORM(I)
      TNORM= TNORM + UKWT(INORM)
  460 CONTINUE
      IF (TNORM) 280,280,465
  465 DO 461 I=1,3
      INORM= NORM(I)
      UKWT(INORM)= (UKWT(INORM) * 100.0)/TNORM
  461 CONTINUE
      PRINT 462,( ROW(I),UKWT(NORM(I)),I=1,3)
  462 FORMAT (1H0,52HNORMALIZED ATOM RATIOS FOR TERNARY PLOT OF ELEMENTS
     1:,A2,1H=,F5.1,6X,A2,1H=,F5.1,6X,A2,1H=,F5.1)
  280 CONTINUE
      IF (ITAB) 720,720,721
  720 GO TO 501
C
C     PRINT DATA IN TABULAR FORM
C
  721 MG=0
      MF= -11
      KX= N
  710 IF (KX-12) 708,708,709
  708 MF= MF+12
      MG= N
      GO TO 711
  709 MF= MF+12
      MG= MG+12
  711 PRINT 700
  700 FORMAT (1H1,//////)
      PRINT 718,((NAME(K,JJ),JJ=1,2),K=MF,MG)
  718 FORMAT (11X,12(2X,2A4))
      DO 712 I=1,MZ
      PRINT 713, OXID1(I),(TAB1(K,I),K=MF,MG)
  713 FORMAT (1H ,1X,A8,12(F10,3))
```

```
  712  CONTINUE
       PRINT 714,OX
  714  FORMAT (1H0,/,1X,26HCATIONS/UNIT CELL: OXYGEN=,F4.1,//)
       DO 715 I=1,MZ
       PRINT 713, OXID2(I),(TAB2(K,I),K=MF,MG)
  715  CONTINUE
       IF (KX-12) 501,501,717
  717  KX= KX-12
       GO TO 710
  500  STOP
       END
/*
//GO.SYSIN DD *
```

APPENDIX II: SAMPLE DATA LISTING

The following data consist of 1) alpha factors (as described in text above) and 2) microprobe data. This example is for a run of five unknown pyroxenes using three standards and one background (assembled from several compounds as noted on title-card below). The elements were compared against the standards as follows:

Ca, Mg, Si	--	Diopside CPX-1
Fe, Mn	--	Hedenbergite C-9
Al, Ti	--	Amphibole 52-4

Calculated beta factors for amphibole 52-4 included compensation for Na and K. The elements were read off the microprobe in the order Fe, Ca, Mg, Si, Al, Mn, Ti.

```
1 1.000, 1.150, 5.730, 1.670, 1.290, 1.170, 1.080, 1.060, 1.030,
2 1.100, 1.060, 1.030, 1.080, 1.110, 1.150, 1.140, 1.160, 1.140,
3 1.190, 1.190, 1.410, 1.340, 1.280, 1.240, 1.460, 1.420, 1.420,
4 1.420, 1.440, 1.470, 1.520, 1.540, 1.570, 1.580, 1.630, 1.116,
1 1.750, 1.000, 5.190, 1.510, 1.180, 1.090, 1.030, 1.020, 1.000,
2 1.070, 1.040, 1.010, 1.060, 1.090, 1.130, 1.120, 1.140, 1.120,
3 1.170, 1.180, 1.340, 1.270, 1.230, 1.190, 1.420, 1.390, 1.390,
4 1.390, 1.410, 1.440, 1.490, 1.510, 1.540, 1.550, 1.570, 1.098,
1 1.050, 1.430, 1.000, 1.890, 1.400, 1.230, 1.110, 1.070, 1.020,
2 1.080, 1.030, 1.000, 1.050, 1.070, 1.100, 1.100, 1.120, 1.090,
3 1.140, 1.150, 1.410, 1.330, 1.270, 1.230, 1.390, 1.360, 1.360,
4 1.350, 1.370, 1.410, 1.450, 1.480, 1.500, 1.510, 1.560, 1.077,
1 1.400, 2.840, 2.290, 1.000, 1.850, 1.510, 1.310, 1.210, 1.130,
2 1.170, 1.090, 1.050, 1.090, 1.100, 1.140, 1.130, 1.150, 1.130,
3 1.180, 1.180, 1.600, 1.510, 1.420, 1.360, 1.420, 1.400, 1.400,
4 1.390, 1.410, 1.440, 1.490, 1.510, 1.530, 1.540, 1.600, 1.115/
1 1.670, 3.930, 3.120, 1.180, 1.000, 1.563, 1.320, 1.270, 1.180,
2 1.210, 1.120, 1.080, 1.110, 1.130, 1.160, 1.150, 1.180, 1.150,
3 1.200, 1.210, 1.690, 1.590, 1.480, 1.420, 1.470, 1.440, 1.430,
4 1.430, 1.450, 1.480, 1.520, 1.550, 1.570, 1.580, 1.670, 1.140,
1 1.820, 4.930, 3.660, 1.250, 1.023, 1.000, 1.346, 1.290, 1.190,
2 1.210, 1.110, 1.123, 1.100, 1.110, 1.140, 1.130, 1.150, 1.130,
3 1.180, 1.180, 1.740, 1.630, 1.510, 1.440, 1.420, 1.400, 1.390,
4 1.390, 1.410, 1.440, 1.480, 1.510, 1.530, 1.540, 1.610, 1.121,
1 2.010, 5.750, 4.110, 1.350, 1.102, 1.036, 1.000, 1.340, 1.220,
2 1.240, 1.130, 1.188, 1.110, 1.120, 1.160, 1.160, 1.170, 1.140,
3 1.190, 1.270, 1.300, 1.240, 1.560, 1.490, 1.460, 1.430, 1.420,
```

```
4 1.420, 1.440, 1.470, 1.510, 1.530, 1.560, 1.560, 1.660, 1.137,
1 2.240, 7.490, 4.510, 1.390, 1.110, 1.050,  .990, 1.000, 1.250,
2 1.250, 1.130, 1.080, 1.100, 1.110, 1.140, 1.130, 1.150, 1.120,
3 1.170, 1.180, 1.270, 1.210, 1.180, 1.150, 1.420, 1.390, 1.390,
4 1.380, 1.400, 1.430, 1.470, 1.500, 1.520, 1.520, 1.610, 1.122/
1 2.480, 8.600, 4.650, 1.460, 1.160, 1.080, 1.020, 1.010, 1.000,
2 1.280, 1.150, 1.090, 1.110, 1.120, 1.150, 1.140, 1.160, 1.130,
3 1.180, 1.190, 1.320, 1.250, 1.210, 1.170, 1.450, 1.420, 1.410,
4 1.410, 1.430, 1.460, 1.500, 1.520, 1.540, 1.550, 1.670, 1.136,
1 5.950,31.460, 3.260, 1.190,  .980,  .950,  .910,  .920,  .900,
2 1.000, 1.260, 1.160, 1.130, 1.100, 1.120, 1.100, 1.110, 1.080,
3 1.130, 1.130, 1.180, 1.130, 1.090, 1.070, 1.430, 1.390, 1.380,
4 1.360, 1.370, 1.400, 1.420, 1.440, 1.460, 1.460, 1.770, 1.119,
1 7.690, 3.240, 4.870, 1.480, 1.150, 1.070, 1.000,  .980,  .950,
2 1.010, 1.000, 1.200, 1.150, 1.120, 1.140, 1.120, 1.130, 1.100,
3 1.140, 1.140, 1.260, 1.200, 1.160, 1.120, 1.460, 1.410, 1.400,
4 1.380, 1.390, 1.410, 1.440, 1.460, 1.470, 1.470, 1.430, 1.150,
1 8.140, 3.100, 5.750, 1.650, 1.260, 1.172, 1.029, 1.030,  .990,
2 1.050,  .990, 1.000, 1.170, 1.140, 1.160, 1.140, 1.150, 1.120,
3 1.160, 1.170, 1.330, 1.260, 1.210, 1.180, 1.490, 1.450, 1.430,
4 1.420, 1.430, 1.450, 1.480, 1.490, 1.510, 1.510, 1.500, 1.171/
1 9.360, 3.120, 7.200, 1.830, 1.340, 1.180, 1.060, 1.030,  .980,
2 1.020,  .960,  .920, 1.000, 1.090, 1.110, 1.090, 1.100, 1.070,
3 1.110, 1.110, 1.320, 1.250, 1.190, 1.150, 1.290, 1.270, 1.270,
4 1.350, 1.360, 1.380, 1.400, 1.420, 1.430, 1.430, 1.410, 1.027,
1 1.670, 4.180, 8.700, 2.140, 1.500, 1.280, 1.120, 1.060, 1.000,
2 1.030,  .960,  .910,  .900, 1.000, 1.030, 1.080, 1.090, 1.060,
3 1.090, 1.090, 1.380, 1.300, 1.230, 1.180, 1.210, 1.230, 1.230,
4 1.230, 1.250, 1.280, 1.390, 1.400, 1.410, 1.400, 1.370, 0.987,
1 1.860, 5.250, 9.740, 2.390, 1.630, 1.370, 1.170, 1.090, 1.000,
2 1.030,  .940,  .900,  .890,  .940, 1.000,  .990, 1.070, 1.030,
3 1.070, 1.060, 1.400, 1.320, 1.240, 1.190, 1.190, 1.160, 1.160,
4 1.180, 1.200, 1.240, 1.280, 1.300, 1.370, 1.370, 1.350, 0.893,
1 2.040, 6.070, 2.320, 2.620, 1.760, 1.460, 1.190, 1.130, 1.040,
2 1.050,  .960,  .920,  .910,  .880,  .980, 1.000, 1.020, 1.040,
3 1.080, 1.070, 1.470, 1.380, 1.290, 1.230, 1.210, 1.180, 1.180,
4 1.170, 1.180, 1.250, 1.290, 1.320, 1.340, 1.380, 1.380, 0.914/
1 2.180, 6.960, 2.340, 2.860, 1.890, 1.530, 1.270, 1.160, 1.050,
2 1.050,  .960,  .910,  .900,  .870,  .860,  .940, 1.000,  .980,
3 1.060, 1.050, 1.510, 1.410, 1.310, 1.250, 1.190, 1.160, 1.150,
4 1.140, 1.160, 1.180, 1.250, 1.290, 1.310, 1.360, 1.350, 0.909,
1 2.430, 8.170, 2.500, 3.180, 2.070, 1.650, 1.350, 1.220, 1.100,
2 1.100,  .990,  .940,  .940,  .910,  .900,  .840,  .970, 1.000,
3 1.040, 1.080, 1.600, 1.490, 1.380, 1.310, 1.230, 1.200, 1.190,
4 1.180, 1.190, 1.210, 1.240, 1.310, 1.340, 1.350, 1.410, 0.942,
1 2.600, 9.500, 2.510, 2.980, 2.180, 1.720, 1.380, 1.230, 1.090,
2 1.080,  .960,  .910,  .910,  .890,  .880,  .830,  .800,  .900,
3 1.000, 1.000, 1.620, 1.500, 1.390, 1.310, 1.180, 1.150, 1.140,
4 1.140, 1.150, 1.160, 1.190, 1.200, 1.270, 1.290, 1.350, 0.916,
1 2.860,11.110, 2.620, 2.450, 2.360, 1.830, 1.330, 1.280, 1.120,
2 1.100,  .970,  .920,  .920,  .900,  .900,  .850,  .830,  .750,
3  .930, 1.000, 1.690, 1.570, 1.440, 1.350, 1.180, 1.150, 1.150,
4 1.140, 1.150, 1.170, 1.190, 1.200, 1.200, 1.270, 1.360, 0.924/
1 5.720,21.820, 3.510, 1.200,  .930,  .880,  .820, 1.570, 1.390,
2 1.250, 1.030,  .940,  .920,  .900,  .910,  .900,  .910,  .890,
3  .920,  .920, 1.000, 1.600, 1.740, 1.600, 1.130, 1.090, 1.080,
4 1.080, 1.080, 1.100, 1.120, 1.130, 1.150, 1.160, 1.370, 0.925,
1 6.260,18.140, 4.060, 1.320, 1.000,  .940,  .860, 1.650, 1.460,
2 1.300, 1.060,  .970,  .950,  .920,  .940,  .920,  .930,  .910,
3  .940,  .940, 1.040, 1.000,  .960, 1.650, 1.160, 1.120, 1.110,
4 1.100, 1.110, 1.120, 1.150, 1.160, 1.170, 1.180, 1.410, 0.948,
```

```
     1 6.490,14.660, 4.450, 1.380, 1.050,  .970,  .890,  .880, 1.350,
     2 1.330, 1.080,  .990,  .960,  .940,  .960,  .940,  .950,  .930,
     3  .960,  .970, 1.090, 1.040, 1.000,  .970, 1.190, 1.150, 1.150,
     4 1.130, 1.140, 1.160, 1.180, 1.200, 1.210, 1.220, 1.460, 0.968,
     1 7.010,16.340, 4.960, 1.480, 1.110, 1.020,  .924,  .910, 1.410,
     2 1.370, 1.110, 1.020,  .980,  .960,  .970,  .960,  .970,  .940,
     3  .980,  .980, 1.120, 1.070, 1.030, 1.000, 1.210, 1.180, 1.170,
     4 1.160, 1.160, 1.180, 1.200, 1.220, 1.230, 1.240, 1.490, 0.987/
     1 2.560, 7.380, 2.120, 1.950, 1.730, 1.610, 1.260, 1.150,  .990,
     2  .950,  .840,  .780,  .820,  .900,  .930,  .910,  .900,  .870,
     3  .890,  .890, 1.480, 1.360, 1.270, 1.180, 1.000,  .980,  .970,
     4  .970,  .980, 1.110, 1.130, 1.120, 1.120, 1.110, 1.110, 0.838,
     1 2.570, 7.070, 2.270, 1.960, 1.740, 1.590, 1.260, 1.140,  .990,
     2  .970,  .850,  .790,  .800,  .840,  .940,  .920,  .920,  .880,
     3  .910,  .900, 1.530, 1.400, 1.290, 1.210, 1.030, 1.000, 1.000,
     4  .990, 1.000, 1.090, 1.130, 1.150, 1.150, 1.140, 1.140, 0.849,
     1 2.660, 7.440, 2.320, 2.100, 1.580, 1.650, 1.300, 1.170, 1.010,
     2  .980,  .860,  .800,  .810,  .840,  .910,  .910,  .920,  .880,
     3  .910,  .900, 1.580, 1.440, 1.330, 1.240, 1.010, 1.000, 1.000,
     4  .990, 1.010, 1.020, 1.110, 1.140, 1.150, 1.140, 1.160, 0.851,
     1 2.760, 7.840, 2.380, 2.190, 1.640, 1.550, 1.340, 1.200, 1.040,
     2 1.000,  .870,  .810,  .780,  .840,  .860,  .890,  .930,  .890,
     3  .910,  .910, 1.630, 1.480, 1.360, 1.270, 1.020,  .990, 1.010,
     4 1.000, 1.010, 1.030, 1.110, 1.150, 1.160, 1.150, 1.170, 0.815/
     1 2.830, 8.210, 2.400, 2.260, 1.520, 1.590, 1.370, 1.220, 1.040,
     2 1.000,  .870,  .810,  .780,  .830,  .850,  .880,  .910,  .880,
     3  .900,  .900, 1.660, 1.510, 1.390, 1.280, 1.010,  .980, 1.000,
     4  .990, 1.000, 1.020, 1.040, 1.110, 1.130, 1.130, 1.170, 0.813,
     1 2.990, 8.970, 2.460, 1.000, 1.600, 1.480, 1.430, 1.270, 1.070,
     2 1.010,  .870,  .810,  .780,  .780,  .830,  .820,  .870,  .860,
     3  .890,  .880, 1.590, 1.570, 1.440, 1.320,  .970,  .950,  .960,
     4  .960,  .980, 1.000, 1.020, 1.040, 1.090, 1.120, 1.170, 0.764,
     1 3.180, 9.980, 2.530, 1.010, 1.690, 1.400, 1.360, 1.310, 1.090,
     2 1.020,  .870,  .800,  .770,  .720,  .770,  .800,  .810,  .820,
     3  .860,  .860, 1.650, 1.490, 1.490, 1.360,  .960,  .930,  .930,
     4  .920,  .950,  .980, 1.000, 1.010, 1.030, 1.070, 1.160, 0.762,
     1 3.350,10.820, 2.600, 1.030,  .830, 1.470, 1.260, 1.250, 1.120,
     2 1.040,  .880,  .800,  .770,  .730,  .770,  .740,  .800,  .780,
     3  .840,  .840, 1.540, 1.400, 1.420, 1.300,  .960,  .930,  .920,
     4  .900,  .910,  .950,  .960, 1.000, 1.010, 1.050, 1.170, 0.766/
     1 3.510,11.680, 2.680, 1.040,  .840, 1.550, 1.210, 1.300, 1.160,
     2 1.060,  .880,  .810,  .780,  .730,  .720,  .750,  .740,  .770,
     3  .800,  .820, 1.480, 1.340, 1.340, 1.350,  .960,  .930,  .910,
     4  .900,  .900,  .910,  .950,  .960, 1.000, 1.010, 1.180, 0.770,
     1 4.030,14.990, 3.050, 1.140,  .890,  .850, 1.360, 1.210, 1.080,
     2 1.130,  .930,  .840,  .800,  .750,  .740,  .710,  .680,  .720,
     3  .720,  .790, 1.100, 1.460, 1.350, 1.240,  .970,  .940,  .930,
     4  .910,  .910,  .920,  .930,  .930,  .970, 1.000, 1.220, 0.790,
     1  .570,35.330, 4.840, 1.650, 1.200, 1.120,  .960,  .940,  .850,
     2  .850,  .800,  .940,  .910,  .910,  .880,  .850,  .850,  .820,
     3  .840,  .840, 1.150, 1.070, 1.030,  .980, 1.080, 1.050, 1.070,
     4 1.050, 1.070, 1.050, 1.050, 1.050, 1.050, 1.040, 1.000, 0.932,
     112.453, 3.708, 8.144, 1.960, 1.400, 1.215, 1.077, 1.028, 0.971,
     2 1.011, 0.941, 0.894, 0.958, 0.992, 1.095, 1.069, 1.078, 1.045,
     3 1.084, 1.083, 1.330, 1.256, 1.190, 1.147, 1.236, 1.222, 1.222,
     4 1.219, 1.237, 1.348, 1.370, 1.382, 1.392, 1.391, 1.346, 1.000/
 PYROXENES OF  15 DEC 75I  15 KV .03 MA   SECOND BATCH
 4 7 29 6.0 9 1 2 3 1
FE55.847CA40.08 MG24.312SI28.086AL26.981MN54.938TI47.90 NA22.990K 39.102
1612 5 7 61513 411
 2 2 2 4 3 2 4 1 1
```

FE	FFO	CA	CAO	MG	MGO	SI	SIO2	AL	AL2O3
MN	MNO	TI	TIO2	TOTAL	TOTAL				
DIOPSIDE CPX-1						0 2 2 2 0 0 0 0 0			
2.92	24.56	16.93	53.93	0.66	0.0	0.23	0.22	0.22	
000813	011196	007520	119230	010061					
005122	000814	000138	000339	000000	000000	000000	000000	021534	
000760	011302	007618	119243	010061					
005180	000847	000160	000313	000000	000000	000000	000000	021505	
000809	011134	007592	119258	010055					
005254	000828	000152	000310	000000	000000	000000	000000	021638	
000833	011146	007445	119271	009995					
005222	000792	000146	000311	000000	000000	000000	000000	021673	
000815	011113	007564	119287	010014					
005243	000838	000139	000295	000000	000000	000000	000000	021477	
000799	011196	007734	119299	010021					
005319	000799	000155	000304	000000	000000	000000	000000	021846	
000756	011127	007530	119314	009996					
005161	000795	000150	000354	000000	000000	000000	000000	021445	
000790	011034	007460	119329	010023					
005284	000828	000140	000320	000000	000000	000000	000000	021776	
000784	011250	007752	119342	010055					
005109	000810	000145	000312	000000	000000	000000	000000	021532	
000762	011122	007749	119358	010010					
005265	000837	000131	000310	000000	000000	000000	000000	021538	
HEDENBERGITE C-9						2 0 0 0 0 2 0 0 0			
24.29	21.30	1.06	48.34	0.3	3.70	0.0	0.14	0.0	
006589	010696	000585	119418	010044					
004751	000705	000242	000322	000000	000000	000000	000000	021703	
006462	010771	000674	119432	010091					
004763	000715	000281	000337	000000	000000	000000	000000	021766	
006092	010980	000707	119444	010077					
004831	000694	000297	000334	000000	000000	000000	000000	021572	
006452	010772	000665	119456	010071					
004652	000711	000261	000323	000000	000000	000000	000000	021598	
006036	010293	000708	119469	010071					
004732	000713	000364	000335	000000	000000	000000	000000	021677	
006509	010469	000688	119485	010064					
004782	000693	000261	000321	000000	000000	000000	000000	021569	
006260	010900	000588	119498	010028					
004797	000698	000320	000340	000000	000000	000000	000000	021784	
006684	010851	000682	119511	010072					
004695	000691	000277	000335	000000	000000	000000	000000	021670	
006370	009904	000543	119528	010046					
004698	000812	000225	000328	000000	000000	000000	000000	021380	
006337	010618	000514	119543	010056					
004540	000827	000255	000336	000000	000000	000000	000000	021345	
005899	010481	000761	119557	010025					
004711	000751	000297	000343	000000	000000	000000	000000	021623	
006298	010283	000418	119570	010043					
004643	000761	000253	000383	000000	000000	000000	000000	021383	
006440	010508	000464	119582	010026					
004662	000799	000252	000352	000000	000000	000000	000000	021579	
AMPHIBOLE 52-4						0 0 0 0 2 0 2 2 2			
26.28	10.50	4.29	39.50	10.10	0.56	3.08	2.24	1.45	
006889	004943	001794	119609	010125					
004100	001353	000192	000485	000000	000000	000000	000000	020144	
007016	005167	001810	119621	010088					

```
004055  001376  000197  000429  000000  000000  000000  000000  020154
006948  005010  001882  119634  010067
004057  001343  000201  000449  000000  000000  000000  000000  020199
006973  005097  001905  119646  010043
004036  001332  000185  000464  000000  000000  000000  000000  020129
006735  005137  001748  119659  010038
003905  001342  000167  000502  000000  000000  000000  000000  019863
006993  005139  001724  119671  009990
004012  001289  000190  000463  000000  000000  000000  000000  020066
007161  005217  001913  119684  010021
004035  001300  000212  000419  000000  000000  000000  000000  019945
006980  005028  001842  119696  010034
003978  001357  000185  000464  000000  000000  000000  000000  020197
007040  005020  001752  119709  010023
003978  001420  000214  000456  000000  000000  000000  000000  020056
006803  005142  001795  119721  010059
003986  001325  000168  000492  000000  000000  000000  000000  020053

BACKGROUNDS OFF AL203, SIO2, AND CPX-1                  1 1 1 1 1 1 1 1 1
 0.0  0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   51     118      59  119800    10023
  548     822     146     298                                      20100

 CR2S: BEGIN ANALYSES OF SECOND GROUP OF PYROXENES
003507  008773  005273  119818  010135
004727  000929  000153  000398  000000  000000  000000  000000  020645
003462  008858  005254  119831  010050
004594  000961  000172  000405  000000  000000  000000  000000  020741
003420  008734  005487  119843  010123
004721  000910  000176  000354  000000  000000  000000  000000  020506
003438  008690  005397  119856  010109
004791  000904  000161  000419  000000  000000  000000  000000  020945

66
004027  008470  005324  119875  010081
004836  000886  000164  000359  000000  000000  000000  000000  020946
004235  008105  005275  119889  010088
004877  000900  000179  000352  000000  000000  000000  000000  020775
004113  008093  005310  119903  010098
004934  000828  000172  000385  000000  000000  000000  000000  021026
004277  008080  005182  119916  010091
004824  000838  000160  000369  000000  000000  000000  000000  020813

67
003557  008529  005655  119940  010081
004836  000905  000161  000387  000000  000000  000000  000000  020657
003571  008451  005655  119955  010089
004699  000873  000142  000415  000000  000000  000000  000000  020549

68
003621  008704  005575  120022  010057
004797  000861  000171  000400  000000  000000  000000  000000  020643
003751  008109  005692  120036  010060
004809  000902  000188  000390  000000  000000  000000  000000  020741
003747  008414  005612  120048  010021
004771  000975  000179  000394  000000  000000  000000  000000  020819
```

```
69
003461  008A71  005404  120090  010052
004763  000911  000158  000429  000000  000000  000000  000000  020727
003641  008333  005334  120107  010021
004801  000968  000166  000411  000000  000000  000000  000000  021004
00335A  009046  005467  120120  010024
004783  000965  000156  000374  000000  000000  000000  000000  020919

 DIOPSIDE CPX-1                                                 0 2 2 2 0 0 0 0 0
 2.92 24.56 16.93 53.93  0.66  0.0  0.23  0.22  0.22
000770  011149  007724  122020  010110
005104  000785  000110  000321  000000  000000  000000  000000  021247
000915  011295  007309  122034  010094
005207  000845  000139  000310  000000  000000  000000  000000  021703
000832  010991  007534  122047  010109
005205  000843  000155  000283  000000  000000  000000  000000  021264
000814  011051  007698  122061  010056
005227  000904  000138  000311  000000  000000  000000  000000  021700
000754  011149  007709  122074  010048
005228  000A51  000146  000320  000000  000000  000000  000000  021507
000785  011261  007630  122087  010046
005204  000876  000151  000301  000000  000000  000000  000000  021662
000789  011172  007654  122101  010043
005208  000831  000164  000289  000000  000000  000000  000000  021603
001009  011171  007141  122114  010051
005079  000825  000168  000319  000000  000000  000000  000000  021059
000742  011355  007703  122128  010065
005267  000840  000167  000302  000000  000000  000000  000000  021543
000771  011198  007594  122140  010043
005360  000765  000154  000316  000000  000000  000000  000000  021735
000805  010886  007402  122156  010082
005307  000858  000130  000338  000000  000000  000000  000000  021652
000816  011257  007507  122168  010034
005162  000818  000136  000302  000000  000000  000000  000000  021388

 HEDENBERGITE C-9                                               2 0 0 0 0 2 0 0 0
24.29 21.30 1.06  48.34  0.3  3.70  0.0  0.14  0.0
006474  010551  000709  122223  010089
004754  000680  000259  000333  000000  000000  000000  000000  021367
006135  010765  000667  122237  010113
004830  000680  000267  000350  000000  000000  000000  000000  021720
006499  010769  000547  122250  010105
004724  000702  000279  000354  000000  000000  000000  000000  021529
006689  010988  000502  122262  010077
004842  000683  000300  000347  000000  000000  000000  000000  021661
006155  010742  000653  122275  010087
004722  000681  000329  000324  000000  000000  000000  000000  021667
006383  011060  000723  122288  010074
004662  000708  000330  000336  000000  000000  000000  000000  021647
006482  010793  000730  122301  010064
004774  000730  000299  000346  000000  000000  000000  000000  021672
006497  010540  000673  122313  010064
004649  000673  000297  000337  000000  000000  000000  000000  021392
006001  010167  000681  122328  010062
004789  000696  000345  000332  000000  000000  000000  000000  021549
006528  010484  000605  122344  010045
004668  000785  000256  000344  000000  000000  000000  000000  021503
```

```
006519  010243  000471  122357  010076
004630  000851  000237  000341  000000  000000  000000  000000  021373
006434  010194  000438  122370  010065
004704  000746  000275  000345  000000  000000  000000  000000  021677
006409  010339  000492  122382  010053
004665  000838  000252  000335  000000  000000  000000  000000  021517
006429  010354  000490  122395  010049
004671  000773  000226  000337  000000  000000  000000  000000  021489

 AMPHIBOLE 52-4                                              0 0 0 0 2 0 2 2 2
26.28 10.50 4.29  39.50 10.10 0.56  3.08  2.24  1.45
006937  005041  001724  122422  010052
003916  001392  000215  000507  000000  000000  000000  000000  019855
007118  005102  001702  122434  010045
004058  001358  000159  000463  000000  000000  000000  000000  020151
007039  005014  001770  122447  010049
004034  001358  000188  000426  000000  000000  000000  000000  020125
006992  005004  001766  122459  010073
003962  001375  000209  000424  000000  000000  000000  000000  020201
006945  005103  001807  122472  010048
003985  001391  000194  000488  000000  000000  000000  000000  020056
007038  005002  001926  122485  010026
004059  001279  000191  000457  000000  000000  000000  000000  019953
006977  004998  001720  122498  010000
003844  001297  000187  000507  000000  000000  000000  000000  019909
007170  004977  001682  122522  010030
003989  001299  000209  000491  000000  000000  000000  000000  020013
007165  004918  001893  122535  010023
003943  001342  000197  000442  000000  000000  000000  000000  019924
007013  005036  001920  122547  009997
003934  001321  000207  000452  000000  000000  000000  000000  019984
007032  005201  001911  122559  010031
003873  001361  000165  000435  000000  000000  000000  000000  019671

BACKGROUNDS OFF AL203, SIO2, AND CPX-1                      1 1 1 1 1 1 1 1 1
 0.0  0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   50     120      60  122650   10023
  550     821     147     299                                          20100
```

APPENDIX III: SAMPLE OUTPUT LISTING

PYROXENES OF 15 DEC 75! 15 KV .03 MA SECOND BATCH

NO. STDS= 4 NO. ELEM= 7 NO. UNKNOWNS= 5 NO. STD ELEM= 9 NO. OXYGENS= 6.0

STANDARD COUNTS AND COMPOSITIONS

START

DIOPSIDE CPX-1 TIME= 0.0

	FE	CA	MG	SI	AL	MN	TI	NA	K
AVE COUNTS=	0.0	11162.000	7596.398	6001.824	0.0	0.0	0.0		
WT PERCENT=	2.920	24.560	16.930	53.930	0.660	0.0	0.230	0.220	0.220
STD DEV=	0.0	0.093	0.358	0.465	0.0	0.0	0.0		

START

HEDENBERGITE C-9 TIME= 206.375

	FE	CA	MG	SI	AL	MN	TI	NA	K
AVE COUNTS=	6340.613	0.0	0.0	0.0	0.0	317.207	0.0		
WT PERCENT=	24.290	21.300	1.060	48.340	0.300	3.700	0.0	0.140	0.0
STD DEV=	0.396	0.0	0.0	0.0	0.0	0.289	0.0		

START

AMPHIBOLE 52-4 TIME= 371.938

	FE	CA	MG	SI	AL	MN	TI	NA	K
AVE COUNTS=	0.0	0.0	0.0	0.0	1532.412	0.0	527.226		
WT PERCENT=	26.280	10.500	4.290	39.500	10.100	0.560	3.080	2.240	1.450
STD DEV=	0.0	0.0	0.0	0.0	0.130	0.0	0.183		

START

BACKGROUNDS OFF AL203, S102, AND CPX-1 TIME= 506.938

	FE	CA	MG	SI	AL	MN	TI	NA	K
AVE COUNTS=	51.000	118.000	59.000	625.219	937.829	166.573	339.991		
WT PERCENT=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
STD DEV=	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

FINISH

DIOPSIDE CPX-1 TIME= 2801.063

	FE	CA	MG	SI	AL	MN	TI	NA	K
AVE COUNTS=	0.0	11161.250	7550.414	5992.934	0.0	0.0	0.0		
WT PERCENT=	2.920	24.560	16.930	53.930	0.660	0.0	0.230	0.220	0.220

STD DEV=	0.0	0.220	0.102	0.481	0.0	0.0	0.0

FINISH

HEDENBERGITE C-9 TIME= 3015.813

	FE	CA	MG	SI	AL	MN	TI	NA	K
AVE COUNTS=	6402.426	0.0	0.0	0.0	0.0	324.486	0.0		
WT PERCENT=	24.290	21.300	1.060	48.340	0.300	3.700	0.0	0.140	0.0
STD DEV=	0.105	0.0	0.0	0.0	0.0	0.665	0.0		

FINISH

AMPHIBOLE 52-4 TIME= 3196.000

	FE	CA	MG	SI	AL	MN	TI	NA	K
AVE COUNTS=	0.0	0.0	0.0	0.0	1531.033	0.0	527.721		
WT PERCENT=	26.280	10.500	4.290	39.500	10.100	0.560	3.080	2.240	1.450
STD DEV=	0.0	0.0	0.0	0.0	0.125	0.0	0.171		

FINISH

BACKGROUNDS OFF AL203, SIO2, AND CPX-1 TIME= 3356.938

	FE	CA	MG	SI	AL	MN	TI	NA	K
AVE COUNTS=	50.000	120.000	60.000	627.501	936.688	167.714	341.132		
WT PERCENT=	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
STD DEV=	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

STANDARD BETA FACTORS

BETA FACT=	1.110	1.114	1.145	1.070	1.201	1.110	1.057	1.720	1.058

UNKNOWN COUNTS AND COMPOSITIONS

CR2SI BEGIN ANALYSES OF SECOND GROUP OF PYROXENES TIME= 543.938

	FE	CA	MG	SI	AL	MN	TI
AVE COUNTS=	3456.750	8763.750	5352.750	5385.453	1059.190	189.305	450.670
OXIDE PER=	13.137	19.227	11.905	47.763	2.062	0.555	1.820
BETA FACT=	1.130	1.093	1.215	1.082	1.192	1.133	1.091
B-A CORR=	13.375	18.859	12.640	48.309	2.047	0.566	1.878
TOT WT PER=	97.674						
STD DEV=	0.083	0.187	0.114	0.859	0.167	0.061	0.169
AT WT PER=	10.396	13.479	7.623	22.582	1.083	0.439	1.126
TOT ATOMPC=	56.727						
ATOMIC PRO=	0.18616	0.33630	0.31356	0.80401	0.04015	0.00798	0.02350
ATOMS/CELL=	0.43643	0.78843	0.73511	1.88496	0.09412	0.01872	0.05510

NORMALIZED ATOM RATIOS FOR TERNARY PLOT OF ELEMENTS:FE, 22.3 CA, 40.2 MG, 37.5

66 TIME= 602.688

	FE	CA	MG	SI	AL	MN	TI
AVE COUNTS=	4163.000	8187.000	5272.750	5574.625	988.321	193.255	419.435
OXIDE PER=	15.858	17.944	11.726	49.663	0.858	0.650	1.306
BETA FACT=	1.127	1.091	1.230	1.081	1.200	1.129	1.085
B-A CORR=	16.101	17.579	12.597	50.186	0.857	0.661	1.341
TOT WT PER=	99.323						
STD DEV=	0.504	0.272	0.234	0.454	0.190	0.118	0.019
AT WT PER=	12.516	12.564	7.598	23.459	0.454	0.512	0.804
TOT ATOMPC=	57.906						
ATOMIC PRO=	0.22411	0.31347	0.31250	0.83525	0.01681	0.00932	0.01678
ATOMS/CELL=	0.51943	0.72657	0.72431	1.93592	0.03897	0.02161	0.03889

NORMALIZED ATOM RATIOS FOR TERNARY PLOT OF ELEMENTS:FE, 26.4 CA, 36.9 MG, 36.8

67 TIME= 654.438

	FE	CA	MG	SI	AL	MN	TI
AVE COUNTS=	3564.000	8490.000	5655.000	5451.141	1016.479	173.225	458.502
OXIDE PER=	13.546	18.618	12.587	48.425	1.337	0.161	1.949
BETA FACT=	1.130	1.094	1.215	1.082	1.196	1.133	1.090
B-A CORR=	13.794	18.274	13.360	48.963	1.331	0.164	2.010
TOT WT PER=	97.896						
STD DEV=	0.038	0.121	0.001	0.870	0.149	0.157	0.116
AT WT PER=	10.722	13.060	8.058	22.887	0.705	0.127	1.205
TOT ATOMPC=	56.764						
ATOMIC PRO=	0.19199	0.32586	0.33143	0.81491	0.02611	0.00231	0.02515

ATOMS/CELL=	0.44807	0.76050	0.77349	1.90186	0.06094	0.00540	0.05870

NORMALIZED ATOM RATIOS FOR TERNARY PLOT OF ELEMENTS:FE, 22.6 CA, 38.4 MG, 39.0

68 TIME= 742.250

	FE	CA	MG	SI	AL	MN	TI
AVE COUNTS=	3706.333	8409.000	5626.332	5486.188	1044.807	205.298	451.808
OXIDE PER=	14.090	18.438	12.525	48.779	1.819	0.941	1.838
BETA FACT=	1.129	1.092	1.220	1.084	1.197	1.131	1.088
B-A CORR=	14.327	18.072	13.344	49.425	1.813	0.959	1.891
TOT WT PER=	99.832						
STD DEV=	0.191	0.013	0.039	0.235	0.503	0.005	0.005
AT WT PER=	11.137	12.916	8.048	23.103	0.959	0.743	1.134
TOT ATOMPC=	58.040						
ATOMIC PRO=	0.19942	0.32226	0.33103	0.82258	0.03556	0.01352	0.02367
ATOMS/CELL=	0.45806	0.74025	0.76038	1.88949	0.08167	0.03105	0.05437

NORMALIZED ATOM RATIOS FOR TERNARY PLOT OF ELEMENTS:FE, 23.4 CA, 37.8 MG, 38.8

69 TIME= 812.563

	FE	CA	MG	SI	AL	MN	TI
AVE COUNTS=	3486.667	8750.000	5401.664	5480.316	1086.362	183.352	463.728
OXIDE PER=	13.240	19.196	12.022	48.722	2.526	0.405	2.034
BETA FACT=	1.130	1.094	1.213	1.083	1.190	1.133	1.091
B-A CORR=	13.483	18.843	12.743	49.305	2.502	0.414	2.099
TOT WT PER=	99.390						
STD DEV=	0.604	0.798	0.178	0.008	0.137	0.057	0.219
AT WT PER=	10.481	13.467	7.685	23.047	1.324	0.320	1.258
TOT ATOMPC=	57.584						
ATOMIC PRO=	0.18767	0.33601	0.31611	0.82060	0.04909	0.00583	0.02626
ATOMS/CELL=	0.43093	0.77157	0.72586	1.88428	0.11271	0.01340	0.06031

NORMALIZED ATOM RATIOS FOR TERNARY PLOT OF ELEMENTS:FE, 22.3 CA, 40.0 MG, 37.6

	CR2S1 B	66	67	68	69
FEO	13.375	16.101	13.794	14.327	13.483
CAO	18.859	17.579	18.274	18.072	18.843
MGO	12.640	12.597	13.360	13.344	12.743
SIO2	48.309	50.186	48.963	49.425	49.305
AL2O3	2.047	0.857	1.331	1.813	2.502
MNO	0.566	0.661	0.164	0.959	0.414
TIO2	1.878	1.341	2.010	1.891	2.099
TOTAL	97.674	99.323	97.896	99.832	99.390

CATIONS/UNIT CELL: OXYGEN= 6.0

FE	0.436	0.519	0.448	0.458	0.431
CA	0.788	0.727	0.760	0.740	0.772
MG	0.735	0.724	0.773	0.760	0.726
SI	1.885	1.936	1.902	1.889	1.884
AL	0.094	0.039	0.061	0.082	0.113
MN	0.019	0.022	0.005	0.031	0.013
TI	0.055	0.039	0.059	0.054	0.060
TOTAL	4.013	4.006	4.009	4.015	3.999