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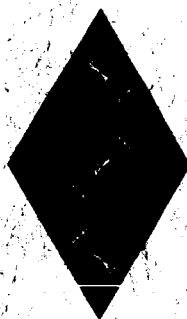
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IBM FORTRAN PROGRAM
FOR THE CALCULATION
OF CIPW IGNEOUS ROCK NORMS

IBM FORTRAN PROGRAM FOR THE CALCULATION
OF CIPW IGNEOUS ROCK NORMS

by

Peter Deines

Technical Report .

Prepared under Contract No. NASW-1062

by

Nuclide Corporation
State College, Pennsylvania

for

National Aeronautics and Space Administration

IBM FORTRAN PROGRAM FOR THE CALCULATION OF CIPW IGNEOUS ROCK NORMS

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INTRODUCTION

An IBM FULL FORTRAN computer program has been designed to calculate the normative composition of igneous rocks ("igneous rock norms") from chemical analyses containing up to 23 elements. It uses the method given by Johannsen(1) and first proposed by Cross, Iddings, Pirsson, and Washington (2). The print-out of the program comprises:

1. Self-explanatory headings and sample identification,
2. a list of the oxides used in the computation, and the sum of these oxides,
3. the weight percent of the 12 salic and 19 femic normative minerals (listed in Figure 3) and the sum of the salic and the sum of the femic minerals, and
4. the molecular ratio of MgO/FeO , in hypersthene, diopside and olivine, as calculated.

Carbon dioxide appearing in a given chemical analysis may be recalculated either as sodium carbonate or as calcite, but not both simultaneously, at the option of the user.

INPUT

One parameter card and three cards for the analytical data contain all the information required to make a rock norm calculation for one sample.

Parameter Card

Columns 1 to 10 - Sample identification. These columns may contain alphabetic characters, numerical digits, special characters permitted by processor, and up to 9 blank spaces or zeros. Ten zeros or blanks in this field signify end-of-file and stop the program.

Columns 11 to 13 - Calculation of CO_2 as sodium carbonate.
Punch +1, CO_2 is recalculated as sodium carbonate.
Punch 00, no sodium carbonate is calculated.

Columns 14 to 16 - Calculation of CO_2 as calcium carbonate.
Punch +1, CO_2 is recalculated as calcium carbonate.
Punch 00, no calcium carbonate is calculated.

It is not possible to calculate sodium carbonate and calcite simultaneously with this program; hence, one of the two sets of columns has always to be zero. If CO_2 is present in the analysis but one does not wish to calculate Na_2CO_3 or CaCO_3 he may set both sets to contain blanks; in this case the program ignores the CO_2 .

Data Cards

The weight percentages of the oxides and elements listed in the analysis to be recalculated as a rock norm are punched on three data cards in floating point notation (decimal points must be punched).

Data card 1: Ten columns for each oxide in the following sequence:
 SiO_2 , Al_2O_3 , Fe_2O_3 , FeO , MgO , CaO , Na_2O , K_2O .

Data card 2: Ten columns for each oxide and element in the following sequence: TiO_2 , P_2O_5 , MnO , ZrO , CO_2 , SO_3 , Cl_2 , F_2

Data card 3: Ten columns for each element and oxide in the following sequence: S, Cr_2O_3 , NiO , CoO , BaO , SrO , Li_2O

If analytical data are not available for certain elements, 0.0 should be entered in the appropriate field.

There is no limit to the number of rock norms which may be calculated in one run or execution of the program. A parameter card precedes each set of 3 data cards, and a blank card at the end of the input deck will terminate the calculation procedure.

PROGRAM TESTING

A flow chart indicating the logical circuits, i.e. the sequence of computation for all possible conditions, is shown in Figure 1. The FORTRAN program is given in Figure 2. Wherever possible, standard chemical symbols and mineralogical abbreviations have been used. If the standard abbreviation begins with a letter I to N reserved by FORTRAN for fixed point variables, the

abbreviation is prefixed by A to make floating point calculation possible. An example of the print-out provided by the program is shown in Figure 3.

The program was tested with 50 rock analyses, covering a wide range of chemical and mineralogical compositions, taken from Clarke (3). The IBM 7074 Computer in The Pennsylvania State University Computation Center was used. Norms produced by this program were found to be in close agreement with those of Clarke except in cases where discrepancies were traced to errors in Clarke's computation or were shown to arise from differences in the type of norm calculation used. The execute time for calculation of one chemical analysis was 2 sec.

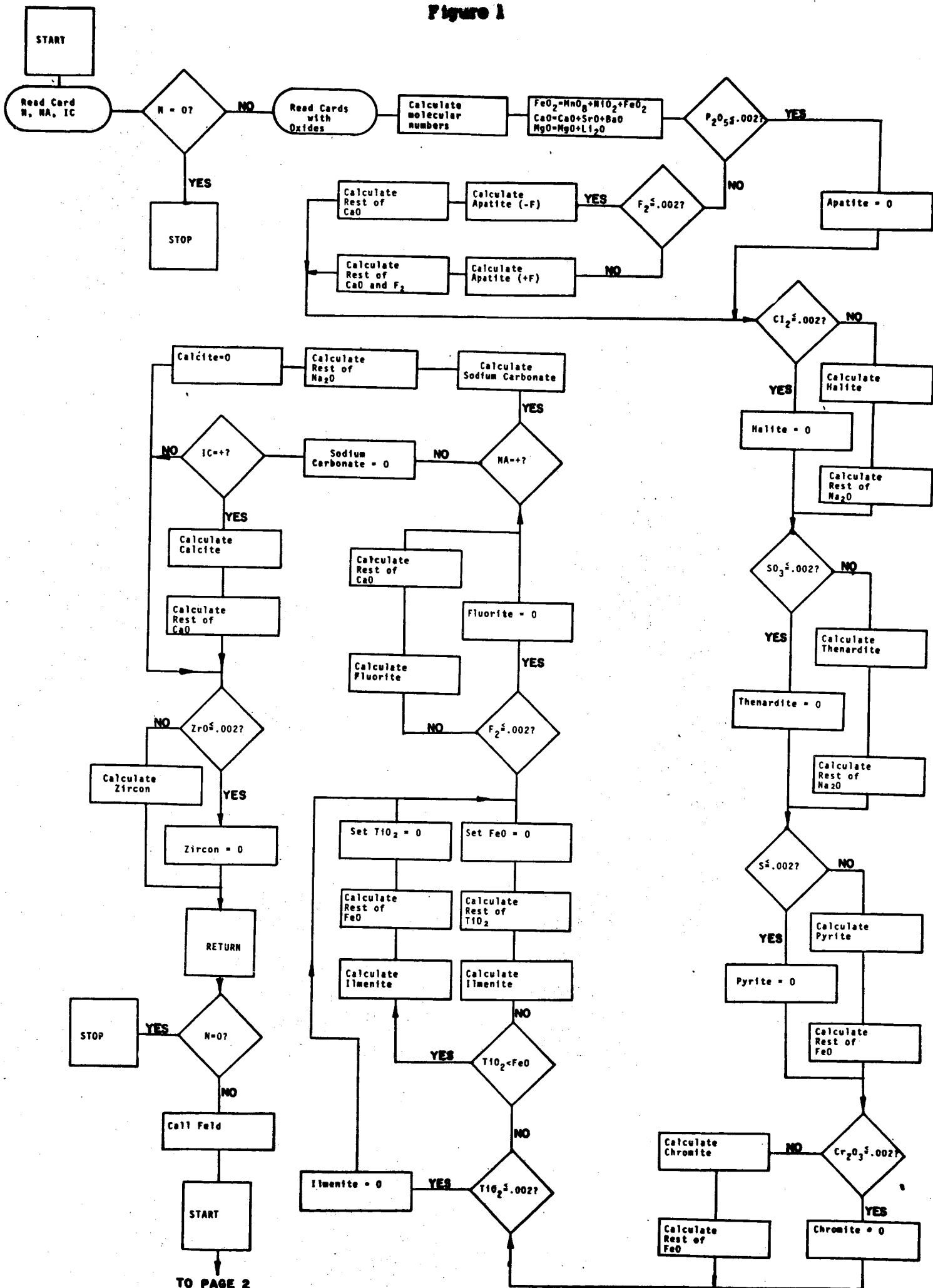
ACKNOWLEDGEMENTS

This work was made possible by the National Aeronautics and Space Agency under Contract NASW-1062 and by the Computation Center of The Pennsylvania State University which provided support for the computer time. This support is gratefully acknowledged. The helpful suggestions of Dr. L. F. Herzog are also appreciated.

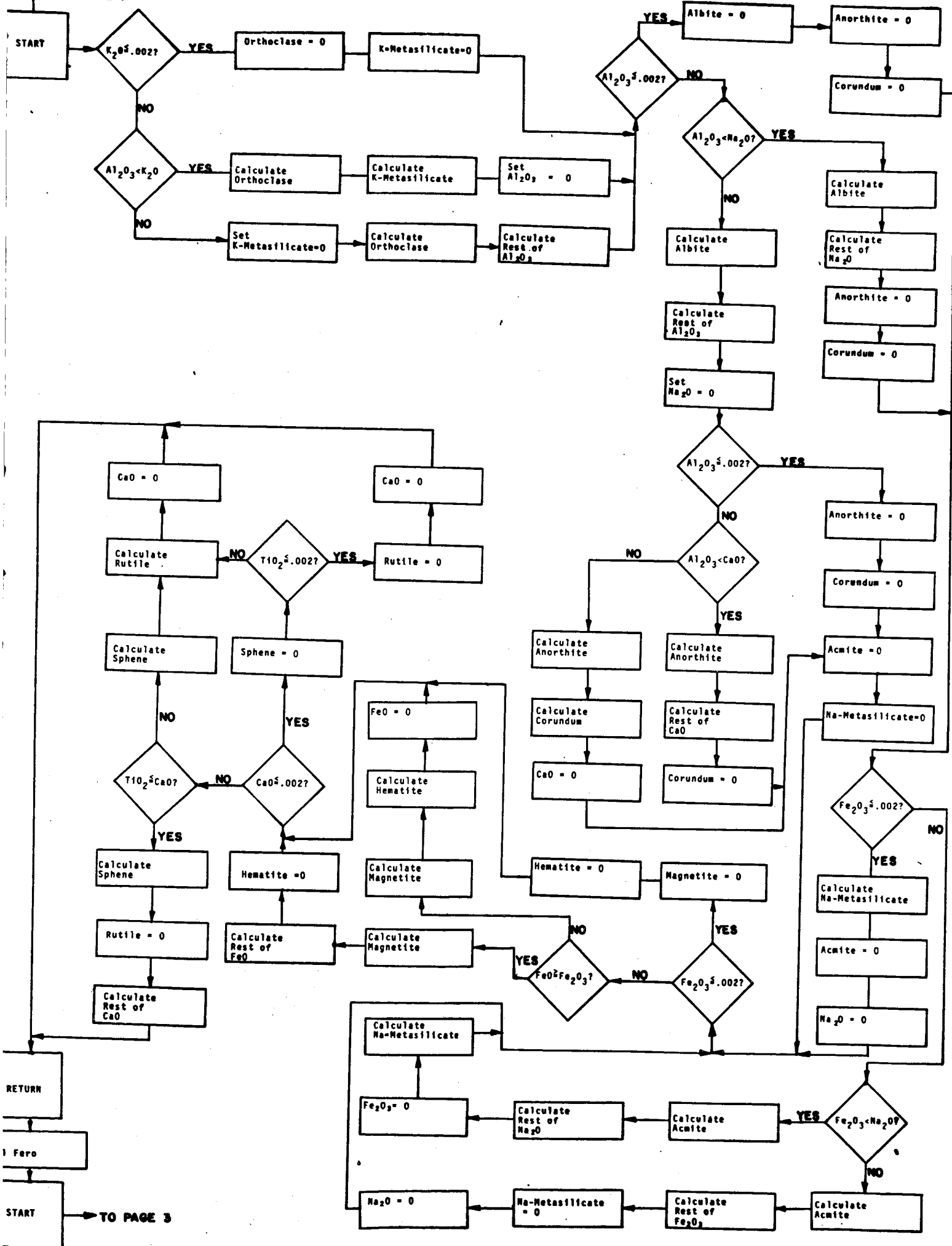
REFERENCES

1. Johannsen, A., Manual of Petrographic Methods, 2nd Ed., McGraw Hill (1918).
2. Washington, H. S., Chemical Analysis of Igneous Rocks, U.S. Geol. Survey Prof. Paper 99, p. 1162 (1917).
3. Clarke, F. W., The Data of Geochemistry, Geol. Survey Bull. 770, 841 pp (1924).

Figure 1



FROM PAGE 1



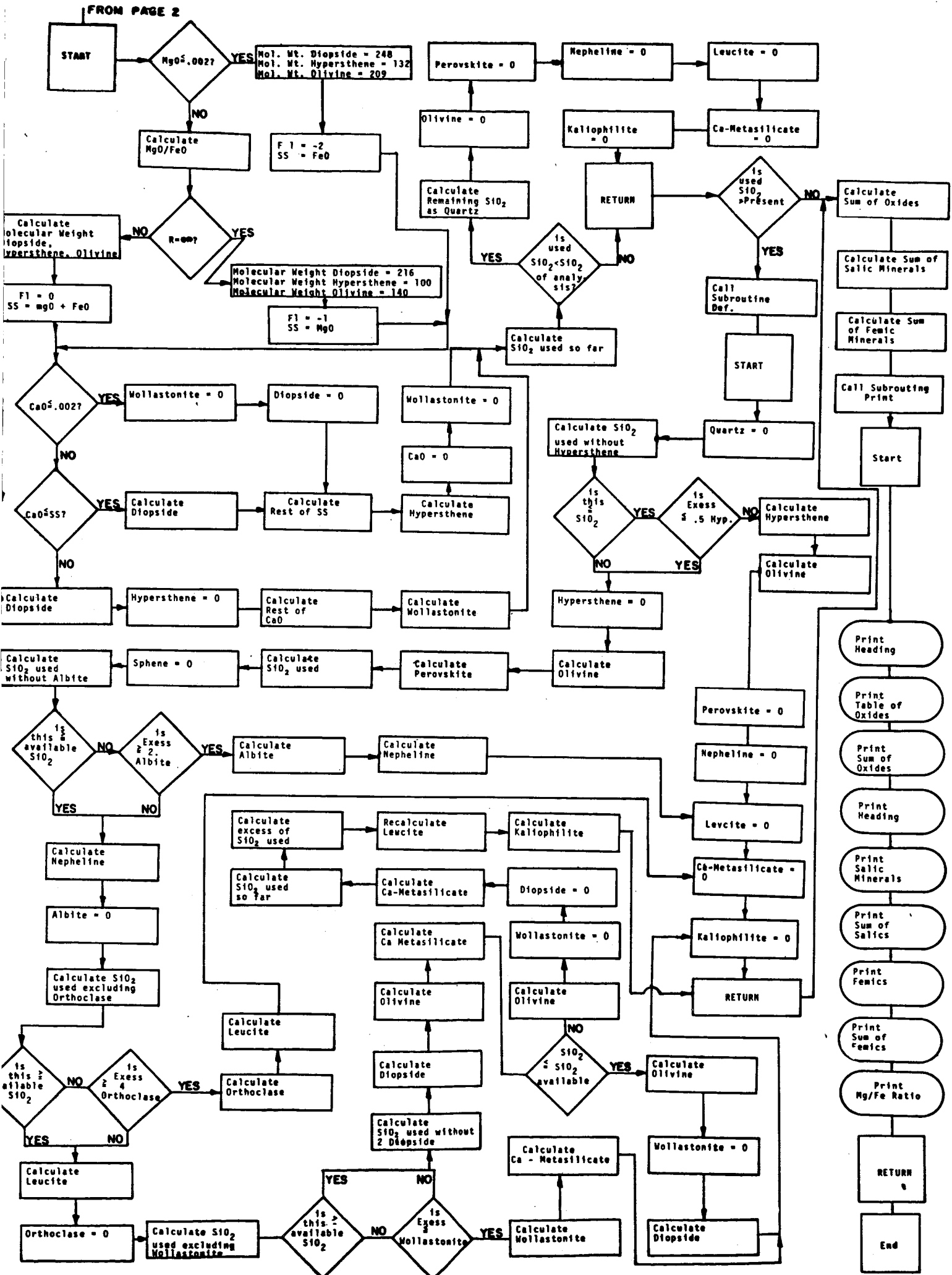


Figure 2

```

C  OMPILE  RUN  FORTRAN
C  CIPW NORM CACULATION MAIN PROGRAM
  DIMENSION N(2)
  COMMON N,NA,IC,SIO,ALO,FE03,FE02,AMGO,CAO,ANAO,AKO,TIO,PO,AMNO,ZRO
1  ,CC,CL,F,S,CRO,ANIO,COO,SRO,ALIO,SIO1,ALO1,FE031,FE021,AMGO1,CAO1,
2  ANAO1,AKO1,TIO1,PO1,AMNO1,ZRO1,CO1,SO1,CL1,F1,S1,CRO1,ANIO1,COO1,
3  SRO1,ALIO1,AP,HL,TH,PR,CM,AIL,FR,ANC,CC,Z,OR,AKS,AB,AN,C,AC,ANS,AM
4  T,HM,SP,RU,R,SS,SS1,HY,AMWDI,AMWHY,AMWOL,WO,DI,OL,SIOC,PF,ANE,AB1,
5  ORI,CS,DI1,GI1,ALC,SALG,FEMG,ALC1,SO,SIOC1,BAO,BAO1,AKP,Q,SUM
1  CALL ACCESS
  IF (N(2)) 2222,2222,2
2  CALL FELD
  CALL FERO
  IF(SIO1-SIOC1)73,1118,1118
73  CALL DEF
1118 SUM = SIO+ALO+FE03+AMGO+CAO+ANAO+AKO+TIO+PO+AMNO+ZRO+CO+SO+
1  CL+F+CRO+ANIO+COO+BAO+SRO+ALIO +S+FE02
  SALG = Q+C+Z+OR+AB+AN+ALC+ANE+AKP+HL+TH+ANC
  FEMG = AC+ANS+AKS+DI+WO+HY+OL+CS+AMT+CM+HM+AIL+SP+PF+RU+AP+FR+
1  PR+CC
  CALL PRINT
3333 GO TO 1
2222 STOP
  END

```

```

C OMPILE RUN FORTRAN
SUBROUTINE ACCESS
DIMENSION N(2)
COMMON N,NA,IC,SIO,ALO,FE03,FE02,AMGO,CAO,ANAO,AKO,TIO,PO,AMNO,ZRO
1 ,CO,CL,F,S,CRO,ANIO,COO,SRO,ALIO,SIO1,ALO1,FE031,FE021,AMGO1,CAO1,
2 ANAO1,AKO1,TIO1,PO1,AMNO1,ZRO1,CO1,SO1,CL1,F1,S1,CRO1,ANIO1,COO1,
3 SRO1,ALIO1,AP,HL,TH,PR,CM,AIL,FR,ANC,CC,Z,OR,AKS,AB,AN,C,AC,ANS,AM
4 T,HM,SP,RU,R,SS,SS1,HY,AMWDI,AMWHY,AMWOL,WO,DI,OL,SIOC,PF,ANE,AB1,
5 OR1,CS,DII,OLI,ALC,SALG,FEMG,ALC1,SO,SIOC1,BAO,BAO1,AKP,Q,SUM
READ 1,N(1),N(2),NA,IC
1 FORMAT ( 2A5,2I3)
IF (N(2)) 2222,2222,2221
2222 STOP
2221 READ 2,SIO,ALO,FE03,FE02,AMGO,CAO,ANAO,AKO,TIO,PO,AMNO,ZRO,CO,SO,C
1 L,F,S,CRO,ANIO,COO,BAO,SRO,ALIO
2 FORMAT (8F10.0)
SIO1 = SIO/60.
ALO1 = ALO/102.
FE031 = FE03/160.
FE021 = FE02/72.
AMGO1 = AMGO/40.
CAO1 = CAO/56.
ANAO1 = ANAO/62.
AKO1 = AKO/94.
TIO1 = TIO/80.
PO1 = PO/142.
AMNO1 = AMNO/71.
ZRO1 = ZRO/123.
CO1 = CO/44.
SO1 = SO/80.
CL1 = CL/71.
F1 = F/38.
S1 = S/32.
CRO1 = CRO/152.
ANIO1 = ANIO/75.
COO1 = COO/75.
BAO1 = BAO/153.5
SRO1 = SRO/103.5
ALIO1 = ALIO/30.
FE021 = AMNO1 + ANIO1 + FE021
CAO1 = CAO1 + SRO1 + BAO1
AMGO1 = AMGO1 + ALIO1
IF(PO1-.002)3,3,4
4 IF(F1-.002)141,141,142
141 AP = PO1*310.
CAO1 = CAO1-3.*PO1
GO TO 5
142 AP = PO1*336.
CAO1 = CAO1-3.3333*PO1
F1 = F1-.3333*PO1
GO TO 5
3 AP = 0.
5 IF(CL1-.002)6,6,7
6 HL = 0.
GO TO 8
7 HL = 2.*CL1*117.
ANAO1 = ANAO1-CL1
8 IF(SO1-.002)9,9,10
10 TH = SO1*142.

```

```

      ANAO1 = ANAO1-SO1
      GO TO 11
9      TH = 0.
11     IF(S1-.002)12,12,13
13     PR = S1*60.
      FE021 = FE021-.5*S1
      GO TO 14
12     PR = 0.
14     IF(CR01 - .002)15,15,16
16     CM = CR01*224.
      FE021 = FE021-CR01
      GO TO 17
15     CM = 0.
17     IF(TI01-.002)18,18,19
18     AIL = 0.
      GO TO 20
19     IF(FE021-TI01)21,22,22
21     AIL = FE021*152.
      TI01 = TI01-FE021
      FE021 = 0.
      GO TO 20
22     AIL = TI01*152.
      FE021 = FE021-TI01
      TI01 = 0.
20     IF(F1-.002)23,23,24
23     FR = 0.
      GO TO 25
24     FR = F1*78.
      CA01 = CA01-F1
25     IF(NA)26,26,27
27     ANC = C01*106.
      ANAO1 = ANAO1-C01
      CC = 0.
      GO TO 28
26     ANC = 0.
      IF(IC)29,29,30
30     CC = C01*100.
      CA01 = CA01-C01
      GO TO 28
29     CC = 0.
28     IF(ZR01-.002)31,31,32
31     Z = 0.
      GO TO 33
32     Z = ZR01*183.
33     RETURN
      END

```

C OMPILE RUN FORTRAN

SUBROUTINE FERO

DIMENSION N(2)

COMMON N,NA,IC,SIO,ALO,FEO3,FEO2,AMGO,CAO,ANAO,AKO,TIO,PO,AMNO,ZRO

1 ,CC,CL,F,S,CRO,ANIO,COO,SRD,ALIO,SIO1,ALO1,FEO31,FEO21,AMGO1,CAO1,

2 ANAO1,AKO1,TIO1,PO1,AMNO1,ZRO1,CO1,SO1,CL1,F1,S1,CRO1,ANIO1,COO1,

3 SRC1,ALIO1,AP,HL,TH,PR,CY,HI,FR,ANC,CC,Z,OR,AKS,AB,AN,C,AC,ANS,AM

4 T,HM,SP,RU,R,SS,SS1,HY,AMWDI,AMWHY,AMWOL,WO,DI,OL,SIOC,PF,ANE,AB1,

5 OR1,CS,DII,OLI,ALC,SALG,FEMG,ALC1,SO,SIOC1,BAO,BAO1,AKP,Q,SUM

64 IF(AMGO1-.002)643,643,644

644 R= AMGO1/FEO21

IF DIVIDE CHECK 641,642

641 AMWDI = 216.

AMWHY = 100.

AMWOL = 140.

F1 = -1.

SS = AMGO1

GO TO 645

643 AMWDI = 248.

AMWHY = 132.

F1 = -2.

SS = FEO21

AMWOL = 204.

GO TO 645

642 AMWDI = 56.+2.*60.+(40.*R+72.)/(R+1.)

AMWHY = (40.*R+72.)/(R+1.)+60.

AMWOL = 2.*(40.*R+72.)/(R+1.)+60.

F1 = 0.

SS = AMGO1 + FEO21

645 IF(CAO1-.002)66,66,65

65 IF(CAO1-SS)68,68,67

67 DI = SS*AMWDI

HY = 0.

SS1 = 0.

CAO1 = CAO1-SS

WO = CAO1*116.

GO TO 69

68 DI = CAO1*AMWDI

671 SS1 = SS-CAO1

HY = SS1*AMWHY

CAO1 = 0.

WO = 0.

GO TO 69

66 WO = 0.

DI = 0.

GO TO 671

69 SIOC = Z/183.+SP/196.+4.*AC/462.+AKS/154.+ANS/122.+6.*OR/556.+6.*A

1 B/524.+2.*AN/278.+2.*DI/AMWDI+WO/116.+HY/AMWHY

SIOC1 = SIOC

71 IF(SIO1-SIOC1)73,72,72

72 Q = (SIO1-SIOC1)*60.

OL = 0.

PF = 0.

ANE = 0.

ALC = 0.

CS = 0.

AKP = 0.

73 RETURN

END

```

C OMPILE RUN FORTRAN
SUBROUTINE FELD
DIMENSION N(2)
COMMON N,NA,IC,SIO,ALO,FE03,FE02,AMGO,CAO,ANAO,AKO,TIO,PO,AMNO,ZRO
1 ,CO,CL,F,S,CRO,ANIO,COO,SRO,ALIO,SIO1,ALO1,FE031,FE021,AMGO1,CAO1,
2 ANAO1,AKO1,TIO1,PO1,AMNO1,ZRO1,CO1,SO1,CL1,F1,S1,CRO1,ANIO1,COO1,
3 SRO1,ALIO1,AP,HL,TH,PR,CM,AIL,FR,ANC,CC,Z,OR,AKS,AB,AN,C,AC,ANS,AM
4 T,HM,SP,RU,R,SS,SS1,HY,AMWDI,AMWHY,AMWOL,WO,DI,OL,SIOC,PF,ANE,AB1,
5 OR1,CS,DII,OLI,ALC,SALG,FEMG,ALC1,SO,SIOC1,BAO,BAO1,AKP,Q,SUM
33 IF(AKO1-.002)34,34,35
34 OR = 0.
   AKS = 0.
   GO TO 36
35 IF(ALO1-AKO1)37,37,38
37 OR = ALO1*556.
   AKS = (AKO1-ALO1)*154.
   ALO1 = 0.
   GO TO 36
38 AKS = 0.
   OR = AKO1*556.
   ALO1 = ALO1-AKO1
36 IF(ALO1-.002)39,39,40
40 IF(ALO1-ANAO1)41,41,42
41 AB = ALO1*524.
   ANAO1 = ANAO1-ALO1
   AN = 0.
   C = 0.
   GO TO 49
42 AB = ANAO1*524.
   ALO1 = ALO1-ANAO1
   ANAO1 = 0.
   IF(ALO1-.002)43,43,44
43 AN = 0.
   C = 0.
46 AC = 0.
   ANS = 0.
   GO TO 45
44 IF(ALO1-CAO1)47,47,48
47 AN = ALO1*278.
   CAO1 = CAO1-ALO1
   C = 0.
   GO TO 46
48 AN = CAO1*278.
   C = (ALO1-CAO1)*102.
   CAO1 = 0.
   GO TO 46
39 AB = 0.
   AN = 0.
   C = 0.
49 IF(FE031-.002)50,50,51
51 IF(FE031-ANAO1)521,521,531
531 AC = ANAO1*462.
   FE031 = FE031-ANAO1
   ANS = 0.
   ANAO1 = 0.
   GO TO 45
521 AC = FE031*462.
   ANAO1 = ANAO1-FE031
   FE031 = C.
   ANS = ANAO1 * 122.

```

```
GO TO 45
50  ANS = ANA01*122.
    AC = 0.
    ANA01 = 0.
45  IF(FE031-.002)54,54,55
54  AMT = 0.
    HM = 0.
    GO TO 56
55  IF(FE021-FE031)57,58,58
57  AMT = FE021*232.
    HM = (FE031-FE021)*160.
    FE021 = 0.
    GO TO 56
58  AMT = FE031*232.
    HM = 0.
    FE021 = FE021-FE031
56  IF(CA01-.002)581,581,571
571 IF(TI01-CA01)60,60,59
59  SP = CA01*196.
63  RU = (TI01-CA01)*80.
    CA01 = 0.
    GO TO 64
60  SP = TI01*196.
    RU = 0.
    CA01 = CA01-TI01
    GO TO 64
581 SP = 0.
    IF(TI01-.002)62,62,63
62  RU = 0.
    CA01 = 0.
64  RETURN
    END
```


WO = 0.

SIOC1 = Z/183.+4.*AC/462.+AKS/154.+ANS/122.+2.*AN/278.+OL/AMWOL+

1 CS/172.+2.*ANE/284.

SICC1 = SIOC1-SIOC1

ALC1 = ((SIOC1-2.*ALC/436.)/2.)*436.

AKP = ((4.*ALC /436.-SICC1)/2.)*256.

ALC = ALC1

GO TO 1118

1113 PF = 0.

1114 ANE = 0.

1115 ALC = 0.

1116 CS = 0.

1117 AKP = 0.

1118 RETURN

END

C OMPILE RUN FORTRAN

SUBROUTINE DEF

DIMENSION N(2)

COMMON N,NA,IC,SIO,ALO,FE03,FE02,AMGO,CAO,ANAO,AKO,TIO,PO,AMNO,ZRO

1 ,CO,CL,F,S,CRO,ANIO,COO,SRO,ALIO,SIO1,ALO1,FE031,FE021,AMGO1,CAO1,

2 ANAO1,AKC1,TIO1,PO1,AMNO1,ZRO1,CO1,SO1,CL1,F1,S1,CRO1,ANIO1,COO1,

3 SRO1,ALIO1,AP,HL,TH,PR,CM,AIL,FR,ANC,CC,Z,OR,AKS,AB,AN,C,AC,ANS,AM

4 T,HM,SP,RU,R,SS,SS1,HY,AMWDI,AMWHY,AMWOL,WO,DI,OL,SIOC,PF,ANE,AB1,

5 OR1,CS,DI1,OL1,ALC,SALG,FEMG,ALC1,SO,SIOC1,BAO,BAO1,AKP,Q,SUM

73 Q = 0.

SIOC1 = SIOC1-HY/AMWHY

IF(SIO1-SIOC1)74,75,75

75 IF(SIO1-SIOC1-.5*SS1)74,74,76

76 HY1 = (2.*(SIO1-SIOC1)-SS1)*AMWHY

OL = (SS1-HY1/AMWHY)*AMWOL/2.

HY = HY1

GO TO 1113

74 HY = 0.

OL = SS1*AMWOL/2.

PF = 136.*SP/196.

SIOC1 = SIOC1-SP/196.

SP = 0.

SIOC1 = SIOC1-6.*AB/524.+OL/AMWOL

IF(SIO1-SIOC1)77,77,78

78 IF(SIO1-SIOC1-2.*AB/524.)77,79,79

79 AB1 = ((SIO1-SIOC1-2.*AB/524.)/4.)*524.

ANE = (AB/524.-AB1/524.)*284.

AB = AB1

GO TO 1115

77 ANE = (AB/524.)*284.

AB = 0.

SIOC1 = SIOC1-6.*OR/556.+2.*ANE/284.

IF(SIO1-SIOC1)80,80,81

81 IF(SIO1-SIOC1-4.*OR/556.)80,82,82

82 OR1 = (SIO1-SIOC1-4.*OR/556.)/2.

ALC = (OR/556.-OR1/556.)*436.

OR = OR1*556.

GO TO 1116

80 ALC = 436.*OR/556.

OR = 0.

SIOC1 = SIOC1-WO/116.+4.*ALC/436.

IF(SIO1-SIOC1)83,83,841

841 IF(WO/116.-(SIO1-SIOC1))83,84,84

84 CS = (WO/116.-(SIO1-SIOC1))*172.

WO = (WO/116.-2.*CS/172.)*116.

GO TO 1117

83 SIOC1 = SIOC1-2.*DI/AMWDI

86 DI1 = (2.*(SIO1-SIOC1)-DI/AMWDI-(DI/AMWDI+WO/116.))/2.

OL1 = ((DI/AMWDI-DI1)/2.)*AMWOL

CS = (DI/AMWDI+WO/116.-DI1)/2.

CS = CS*172.

IF (2.*DI1 +2.*CS/172.+2.*OL1/AMWOL-2.*(SIO1-SIOC1))87,87,85

87 OL = OL+OL1

WO = 0.

DI = DI1*AMWDI

GO TO 1117

85 OL = OL + AMWOL*DI/(2.*AMWDI)

CS = 172.*DI/(2.*AMWDI) + 172.*WO/(2.*116.)

DI = 0.

```

C  OMPILE  RUN  FORTRAN
  SUBROUTINE PRINT
    DIMENSION N(2)
    COMMON N,NA,IC,SIO,ALO,FE03,FE02,AMGO,CAO,ANAO,AKO,TIO,PO,AMNO,ZRO
1   ,CC,CL,F,S,CRO,ANIO,COO,SRO,ALIO,SIO1,ALO1,FE031,FE021,AMGO1,CAO1,
2   ANAO1,AKO1,TIO1,PO1,AMNO1,ZRO1,CO1,SO1,CL1,F1,S1,CRO1,ANIO1,COO1,
3   SRO1,ALIO1,AP,HL,TH,PR,CM,AIL,FR,ANC,CC,Z,OR,AKS,AB,AN,C,AC,ANS,AM
4   T,HM,SP,RU,R,SS,SS1,HY,AMWDI,AMWHY,AMWOL,WO,DI,OL,SIOC.PF,ANE,AB1,
5   OR1,CS,DII,OLI,ALC,SALG,FEMG,ALC1,SO,SIOC1,BAO,BAO1,AKP,Q,SUM
    PRINT 1119,N(1),N(2),SIO,ALO,FE03,FE02,AMGO,CAO,ANAO,AKO,TIO,PO
1119  FORMAT(1H1,52X,18HCHEMICAL ANALYSIS ,2A5/1H /1H /
1     50X,4HSIC2,12X,F6.3/50X,5HAL2O3,11X,F6.3 /
2     50X,5HFE2O3,11X,F6.3/50X,3HFEO,13X,F6.3/
3     50X,3HMGC,13X,F6.3/50X,3HCAO,13X,F6.3/
4     50X,4HNA2O,12X,F6.3/50X,3HK2O,13X,F6.3/
5     50X,4HTIO2,12X,F6.3/50X,4HP2O5,12X,F6.3)
    PRINT 1120,AMNO,ZRO,CO,SO,CL,F,S,CRO,ANIO,COO,BAO,SRO,ALIO,SUM
1120  FORMAT(      50X,3HMNO,13X,F6.3/50X,3HZRO,13X,F6.3/
1     50X,3HCO2,13X,F6.3/50X,3HSO3,13X,F6.3/
2     50X,3HCL2,13X,F6.3/50X,2HF2,14X,F6.3 /
3     50X,1HS,15X,F6.3/50X,5HCR2O3,11X,F6.3/
4     50X,3HNIO,13X,F6.3/50X,3HCOO,13X,F6.3/ 50X,3HBAO,13X,F6.3/
5     50X,3HSRO,13X,F6.3/50X,4HLI2O,12X,F6.3//50X,3HSUM,12X,F7.3/1H0/1H0
6     )
    PRINT 1122,Q,C,Z,OR,AB,AN,ALC
1122  FORMAT(1H1,56X,9HCIPW NORM/54X,16H(WEIGHT PERCENT)/1H0/55X,
1     11HSALIC GROUP/
2     44X,6HQUARTZ,21X,F6.3/
3     44X,8HGORUNDUM,19X,F6.3/
4     44X,6HZIRCON,21X,F6.3/
5     44X,10HORTHOCLEASE,17X,F6.3/
6     44X,6HALBITE,21X,F6.3/
7     44X,9HANORTHITE,18X,F6.3/
8     44X,7HLEUCITE,20X,F6.3)
    PRINT 1123,ANE,AKP,HL,TH,ANC,SALG
1123  FORMAT(      44X,9HNEPHELINE,18X,F6.3/
1     44X,12HKALIOPHILITE,15X,F6.3/
2     44X,6HHALITE,21X,F6.3/
3     44X,10HTHENARDITE,17X,F6.3/
4     44X,16HSODIUM CARBONATE,11X,F6.3//56X,3HSUM,2X,F7.3/1H0/1H0)
    PRINT 1124,AC,ANS,AKS,DI,WO,HY,OL,CS,AMT
1124  FORMAT(1H ,55X,11HFEMIC GROUP/1H0/
1     44X,6HACMITE,21X,F6.3/
2     44X,19HSODIUM METASILICATE,8X,F6.3/
3     44X,22HPCTASSIUM METASILICATE,5X,F6.3/
4     44X,8HDICPSIDE,19X,F6.3/
5     44X,12HWOLLASTONITE,15X,F6.3/
6     44X,11HHYPERSTHENE,16X,F6.3/
7     44X,7HOLIVINE,20X,F6.3/
8     44X,21HCALCIUM ORTHOSILICATE,6X,F6.3/
9     44X,9HMAGNETITE,18X,F6.3)
    PRINT 1125,HM,AIL,SP,PF,RU,AP,FR,PR,CC,CM,FEMG
1125  FORMAT(      44X,8HHEMATITE,19X,F6.3/
1     44X,8HILMENITE,19X,F6.3/
2     44X,6HSPHENE,21X,F6.3/
3     44X,10HPEROVSKITE,17X,F6.3/
4     44X,6HRUTILE,21X,F6.3/
5     44X,7HAPATITE,20X,F6.3/
6     44X,8HFLUORITE,19X,F6.3/

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7 44X,6HPYRITE,21X,F6.3/
8 44X,7HCALCITE,20X,F6.3/
9 44X,8HCHROMITE,19X,F6.3//56X,3HSUM,2X,F7.3)
  IF (1.+F1)1129,1127,1126
1126 PRINT 1131,R
1131 FORMAT(1H /1H /10X,52H RATIO MGO/FEO IN HYPERSTHENE DIOPSIDE AND OL
1  IVINE = ,1PE12.4)
    GO TO 3333
1127 PRINT 1128
1128 FORMAT(1H /1H /10X,43HNC IRON IN HYPERSTHENE DIOPSIDE AND OLIVINE)
    GO TO 3333
1129 PRINT 1130
1130 FORMAT(1H /1H /10X,48HNO MAGNESIUM IN HYPERSTHENE DIOPSIDE AND OLI
1  VINE)
3333 RETURN
    END

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M ULTIFILE END

Figure 3

Chemical Analysis 41.

SiO ₂	55.140	CO ₂	0.000
Al ₂ O ₃	0.660	SO ₃	0.000
Fe ₂ O ₃	3.480	Cl ₂	0.000
FeO	4.730	F ₂	0.000
MgO	26.660	S	0.000
CaO	8.390	Cr ₂ O ₃	0.250
Na ₂ O	0.300	NiO	0.110
K ₂ O	0.000	CoO	0.000
TiO ₂	0.000	BaO	0.000
P ₂ O ₅	0.230	SrO	0.000
MnO	0.030	Li ₂ O	0.000
ZrO	0.000		
	Sum		99.980

CIPW Norm
(Weight Percent)

Salic Group		Femic Group	
Quartz	1.669	Acmite	0.000
Corundum	0.000	Sodium Metasilicate	0.000
Zircon	0.000	Potassium Metasilicate	0.000
Orthoclase	0.000	Diopside	32.670
Albite	2.535	Wollastonite	0.000
Anorthite	0.000	Hypersthene	57.409
Leucite	0.000	Olivine	0.000
Nepheline	0.000	Calcium Orthosilicate	0.000
Kaliophilite	0.000	Magnetite	5.046
Halite	0.000	Hematite	0.000
Thenardite	0.000	Ilmenite	0.000
Sodium Carbonate	0.000	Sphene	0.000
Sum	4.204	Perovskite	0.000
		Rutile	0.000
		Apatite	0.000
		Fluorite	0.000
		Pyrite	0.000
		Calcite	0.000
		Chromite	0.000
		Sum	95.125

Ratio MgO/FeO in hypersthene diopside and olivine = 1.4542E 01