A REVISED VERSION OF GRAPHIC NORMATIVE ANALYSIS PROGRAM (GNAP) WITH EXAMPLES OF PETROLOGIC PROBLEM SOLVING

by

J.S. Stuckless and G. VanTrump, Jr.

U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT

79-1237

1979

CONTENTS

PAGE

ABSTRACT 1

INTRODUCTION 2

PROGRAM DESCRIPTION 4

CIPW COMPUTATIONS 6

PROGRAM USE 14

TITLE CARD 15

FLAG COMMANDS 16

PPS-NØPPS 16

WATER-NØWATER 16

CANCRINITE-NØCANCRINITE 17

BARITE-NØBARITE and KSPAR -NØKSPAR 18

SET FLAGS 19

MODIFIED INPUT COMMANDS 20

MØDIFY FØRMAT 20

ØXIDES 22

ANALYSIS CARDS 23

OUTPUT COMMANDS 24

Define 25

PLØT and PLØT(R) 27

TERNARY 28

CØNVERT VALUES 29

PRINT 31

RECALCULATE NØRMS 31

DEVICE 32

SCALE command and user scaling with dummy cards 32

SUMMARY 34

CLEAR 35

ERROR MESSAGES 37

EXAMPLES 41

GNAP PRØBLEM 1 41

GNAP PRØBLEM 2 46

REFERENCES 49

APPENDIX I-SAMPLE PROBLEMS 50

APPENDIX II-PROGRAM LISTING 75

ABSTRACT

A revised version of Graphic Normative Analysis Program (GNAP) has been developed to allow maximum flexibility in the evaluation of chemical data by the occasional computer user. GNAP calculates CIPW norms, Thornton and Tuttle's differentiation index, Barth's cations, Niggli values and values for variables defined by the user. Calculated values can be displayed graphically in X-Y plots or ternary diagrams. Plotting can be done on a line printer or Calcomp plotter with either weight percent or mole percent data.

Modifications in the original program give the user some control over normative calculations for each sample. The number of user-defined variables that can be created from the data has been increased from ten to fifteen. Plotting and calculations can be based on the original data, data adjusted to sum to 100 percent, or data adjusted to sum to 100 percent without water. Analyses for which norms were previously not computable are now computed with footnotes that show excesses or deficiencies in oxides (or volatiles) not accounted for by the norm. This report contains a listing of the computer program, an explanation of the use of the program, and the two sample problems.

INTRODUCTION

The Graphic Normative Analysis Program (GNAP) written by Roger Bowen (1971) has proved to be an extremely useful petrologic program. It offered comsiderable flexibility to the non-computer specialist and could provide graphic output in publishable form. The revised version of GNAP presented here, provides more flixibility, removes some of the restrictions of the original program, and provides more information to the user. This report also reviews the principles of normative calculations particularly as they apply to some special situations.

The CIPW norm was originally introduced as the basis of classificiation and nomenclature of igneous rocks (Cross and others, 1902). The proposed taxonomy based on normative analysis is no longer used, but the normative minerals are still used by petrologists to charcterize rocks or suites of rocks (e.g. Irvine and Baragar, 1971), and the molecular approach to the calculations has formed the basis for other methods of petrologic characterizations (e.g. Niggli, 1920).

The revised version of GNAP provides a more publishable form of output and a larger degree of user control, particularly in the calculation of the norm. User controlled flags are available that allow elements to be combined in alternate forms (such as those suggested by Washington, 1917) for samples with an unusual mineralogy. Also the complete original analysis can be printed with calculations made on a water-free basis. The original analysis was important to Washington (1917) and is still important to most chemists inasmuch as the analytical sum is an indication of the accuracy and completeness of the analysis.

As a note of historical interest, Washington (1917) stated that with practice and writing down as few results as possible, one can do an average normative calculation in five minutes. He points out that ten minutes may be required for silica-deficient rocks and 15 minutes for the most complex samples. The two examples used in this report are made up of 24 samples including several samples in Washington's complex category. The computer time (CPU) needed to do both problems (including plots and other calculations that are not part of the norm) was less than 50 seconds. Additionally, the mathematical precision is far better than that of the hand calculations.

PROGRAM DESCRIPTION

GNAP is composed of main driver, 18 subroutines and the Calcomp[1] software package. All coding is in standard ANSI Fortran IV with the exception of one subroutine (FILES) and parts of the Calcomp package which are in assembler language.

The functions of the main driver are the scanning of input for recognizable commands and preliminary data manipulation prior to calls to the other subroutines. Executable statements are consturcted from the user-supplied input (blanks or spaces are ignored). These statements are then identified and the indicated action if performed by the appropriate subroutine.

Subroutine NØRM uses the exact formulae of Washington (1917) to calculate the CIPW norm. This computation closely parallels the computations that were first developed for the General Rock Norm program except that certain functions (normalization of oxides, Niggli values and Barth's cations) which were optional are now performed every norm calculation. Subroutine NØRM contains two additional entry points; (1) RECALC is used to recalculate a norm from previously stored oxide values; (2) CØNVER is used to convert weight percent data to molecular amounts. NØRM also employs user-supplied flag commands as discussed below.

Subroutine EVAL evaluates all arithmetic expressions, and is a Fortran version of a procedure previously developed by R.W. Bowen of the U.S.G.S. A transition matrix technique is used to parse the expression to be evaluated.

---

1 Use of trade names is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

Using this transition matrix subroutine PARSE creates the Reverse Polish form of the expression, which is then evaluated using a pushdown stack. EVAL has the advantage of not requiring actual comparisons to accomplish the parse, hence execution time is considerable improved over procedures using a less sophisticate technique.

Subroutine SUMPNT is used to create the summary printout. An area of output is constructed according to instructions supplied by the user. After this area has been constructed, the summary is printed.

Subroutine PRNT is used for creation of X-Y plots. A standard grid is determined from the range of values to be plotted as described below. If the Calcomp plotter is specified, calls are made to a Calcomp software package to generate a magnetic tape containing the plotter commands. Otherwise, calls to entries of PLØT2 are made which create a printer plot. Subroutine PLØT2 is used to create printer plots and is a modified version of a subroutine developed at the University of Michigan by P. Smidinger.

Subroutine TRIANG is used for creation of ternary diagrams. If the Calcomp plotter is specified, then calls are made to the Calcomp software package. Otherwise calls are made which create diagrams on the printer.

Subroutine SIDE is used to construct one annotated side of a ternary diagram when the Calcomp plotter has been specified.

The remaining subroutines provide a degree of character manipulation and conversion in Fortran. MØVE is used to move characters from one string to another. CØNV, INIT, and FIND convert data from character form to numeric form. INDEX determines the position of a given character in a given string. NØTEQ determines if two strings are equal (i.e., contain the same characters); CLEAR provides for the construction of pages of output prior to printing. FILES is used to open and close data files as necessary; this subroutine is machine-dependent, written for execution on a Honeywell 6880 computer.

CIPW COMPUTATIONS

The CIPW norms produced by revised GNAP are computed according to the rules of Washington (1917) except that excess CO_2 is cast as magnesite and then, if CO_2 is still in excess, as siderite. The resulting normative minerals are reported in weight percent, but the data can be obtained in mole percent by use of the PPS or CONVERT plus SUMMARY command. Some investigators prefer reporting normative mineral mole percents because they more closely approximate modal abundances (Irvine and Baragar, 1971).

The specific methodology and mathematics of CIPW calculations can be found in Washington (1917) or Johannsen (1939), but as these publications are no longer easily available to many users, a summary of the method with modifications used by GNAP, is given here. The oxides used and the normative minerals calculated by the subroutine NØRM and the chemical formulae of the normative minerals are given in table 1.

Table 1 near here.

---

1. The arithmetic sum of the analyzed elements is adjusted for F and Cl because these are actually combined with some of the cations that are reported in the analysis as oxides. (Usually this adjustment changes the total by only a few tenths of a percent, and this step was omitted from the original GNAP program). No attempt is made to adjust the sum for S because such an adjustment requires assumptions about the analytical methods used for S and FeO; for most analyses the correction would be negligible. For rocks with a high content of S, the effect of this correction should be checked. The sum, corrected for F and Cl is used to normalize the analysis to 100 percent, and the adjusted oxides (and

Table 1.--List of variable names used in GNAP

Oxides and Elements

1. SiO_2
2. Al_2O_3
3. Fe_2O_3
4. FeO
5. MgO
6. CaO
7. Na_2O
8. K_2O
9. H_2O (+, -, or total)
10. TiO_2
11. P_2O_5
12. MnO
13. ZrO_2
14. CO_2
15. SO_3
16. Cl
17. F
18. S
19. Cr_2O_3
20. NiO
21. BaO

Minerals

1. Q = quartz (SiO_2)
2. C = corundum (Al_2O_3)
3. Z = zircon ($ZrSiO_4$)
4. OR = orthoclase ($KAlSi_3O_8$)
5. AB = albite ($NaAlSi_3O_8$)
6. AN = anorthite ($CaAl_2Si_2O_8$)
7. LC = leucite ($K_2Al_2Si_4O_{12}$)
8. NE = nepheline ($Na_2Al_2Si_2O_8$)
9. KP = kaliophilite ($K_2Al_2Si_2O_8$)
10. HL = halite (NaCl)
11. TH = thenardite (Na_2SO_4)
12. NC = sodium carbonate (Na_2CO_3)
13. AC = acmite ($Na_2Fe_2Si_4O_{12}$)
14. NS = sodium metasilicate (Na_2SiO_3)
15. KS = potassium metasilicate (K_2SiO_3)
16. WO = wollastonite ($CaSiO_3$)
17. EN = enstatite ($MgSiO_3$)
18. FS = ferrosilite ($FeSiO_3$)
19. FO = forsterite (Mg_2SiO_4)
20. FA = fayalite (Fe_2SiO_4)
21. CS = calcium orthosilicate (Ca_2SiO_4)
22. MT = magnetite (Fe_3O_4)
23. CM = chromite ($FeCr_2O_4$)
24. HM = hematite (Fe_2O_3)
25. IL = ilmenite ($FeTiO_3$)
26. TN = titanite=sphene ($CaTiSiO_5$)
27. PF = perovskite ($CaTiO_3$)
28. RU = rutile (TiO_2)
29. AP = apatite ($Ca_5F(PO_4)_3$)
30. FR = fluorite (CaF_2)
31. PR = pyrite (FeS_2)
32. CC = calcite ($CaCO_3$)
33. MG = magnesite ($MgCO_3$)
34. SD = siderite ($FeCO_3$)
35. DI = diopside (EN+FS+WØ-WØL)
36. HY = hypersthene (EN+FS)
37. OL = olivine (FO+FA)

elements) are converted to molar amounts by dividing each by its molecular wwight. In the following discussion, oxides should be understood as oxides and elements, and amounts as molar amounts. (Washington (1917) ignored amounts less than .002, but they are used by GNAP).

2. The amounts of MnO and NiO are added to FeO, and BaO and SrO are added to CaO. The automatic addition of BaO to CaO can be overridden by the revised version of Gnap, as described below. No standard provision is made for the input of SrO, but it can be accomodated by the use of a series of user defined commands as shown below. The addition of BaO to CaO (or K_2O or Na_2O) has the effect of yielding a low total for the normative minerals relative to the oxide total because the conversion of the calcium-bearing minerals from mole percent (in which they are calculated) to weight percent does not take into account the much heavier barium component of the mineral.

3. In the nine steps of rule 3, amounts of minor oxides are combined with amounts of major oxides to form trace minerals. In the earlier version of GNAP, excess of minor constitutents caused termination of the calculation and generation of an error message. The revised version uses as much of the minor constituent as possible and then reports the weight percent excess in an error message. In this case, the normative total is lower than the oxide total. Minor oxides are apportioned as follows:

3a. CaO equal to 3.33 times P_2O_5 is used for apatite.

3b. Na_2O equal to 0.5 times Cl is used for halite.

3c. Equal amounts of Na_2O and SO_3 are combined for thenardite.

3d. FeO equal to 0.5 times S is used for pyrite.

3e. Equal amounts of FeO and Cr_2O_3 are used for chromite.

3f. Equal amounts of FeO and TiO_2 are used for ilmenite. CaO equal to any excess TiO_2 is provisionally allotted to titanite. (If there is not enough CaO to use up the Al_2O_3 in the anorthite calculations (4d) titanite is not calculated.) Excess TiO_2 is calculated as rutile.

3g. F equal to 2/3 the amount of apatite (3a) is considered to be contained in apatite. Any excess is used with half as much CaO for fluorite.

3h. If the rock contains modal cancrinite, equal amounts of Na_2O and CO_2 are combined for sodium carbonate. Excess CO_2 is first combined with an equal amount of CaO for calcite. Any excess CO_2 is subsequently combined with equal amounts of MgO for magnesite, and then with FeO for siderite.

3i. Equal amounts of SiO_2 and ZrO are used for zircon.

4. Alumina and potash are apportioned as follows:

4a. Equal amounts of K_2O and Al_2O_3 are used for orthoclase.

4b. Excess K_2O is equal to the amount of potassium metasilicate.

4c. Excess Al_2O_3 is combined with an equal amount of Na_2O and is equal to the amount of albite.

4d. Excess Al_2O_3 is combined with an equal amount of CaO (including the CaO that had been provisionally assigned to titanite if necessary) to make anorthite.

4e. Any excess Al_2O_3 is equal to the amount of corundum.

5. Sodium oxide and ferric iron are apportioned as follows:

5a. Fe_2O_3 equal to the excess of Na_2O is used for acmite.

5b. Any excess Na_2O is equal to the amount of sodium metasilicate.

5c. Excess Fe_2O_3 and an equal amount of FeO are used for magnetite.

5d. Any excess Fe_2O_3 is equal to the amount of hematite.

6. The relative proportion of any remaining FeO and MgO are determined.

7. Lime, ferrous iron and magnesia are approtioned as follows:

7a. CaO equal to the sum of FeO and MgO is used for diopside.

7b. Excess CaO is equal to the amount of wollastonite.

7c. Excess MgO + FeO is equal to the amount of hyperthene. The proportions of enstatite and ferrosilite are the same as the MgO-FeO proportions determined in (6).

8. Silica is adjusted for the minerals calculated in steps 3 thorough 7. If there is a deficiency in silica, the silica-rich minerals are recalculated as silica-poor minerals.

8a. The SiO_2 remaining after (3i) is decreased by the amount of titanite, 4 times the amount of acmite, the amount of sodium metasilicate, the amount of potassium metasilicate, 6 times the amount of orthoclase, 6 times the amount of albite, the amount of wollastonite, twice the amount of anorthite, twice the amount of diopside, and the amount of hypersthene.

8b. Excess SiO_2 is equal to the amount of quartz.

8c. If there is a silica deficiency after (8a), hypersthene is converted to olivine (forsterite and fayalite proportions are as determined in rule (6) and SiO_2 is increased by 1/2 the amount of hypersthene. If this results in a SiO_2 excess, hypersthene is increased (from zero) and olivine is decreased until SiO_2 is equal to zero.

d. If there is still a silica deficiency titanite is converted to perovskite and silica is increased by the amount of titanite.

8e. If there is still a silica deficiency, albite is converted to nepheline and SiO_2 is increased by 3 times the amount of albite. If this results in a silica excess, albite is increased (from zero) and nephiline is decreased until SiO_2 is equal to zero.

8f. If there is still a silica deficiency, orthoclase is converted to leucite and SiO_2 is increased by 1/3 the amount of orthoclase. If this results in a silica excess, orthoclase is increased (from zero) and leucite is decreased until SiO_2 equals zero.

8g. If there is still a silica deficiency, the clinopyroxenes are converted to calcium orthosilicate and olivine. Wollastonite is converted first then diopside. SiO_2 is increased by twice the amount of clinopyroxene and the clinopyroxene is changed to orthosilicate. If an excess in silica results, clinopyroxene is increased from zero and orthosilicate is decreased until silica equals zero.

8h. If there is still a silica deficiency, leucite is converted to kaliophilite and silica is increased by the amount of leucite. If a silica excess results, leucite is increased from zero and kaliophilite is decreased until silica equals zero.

9. Molecular amounts of minerals are converted to weight percent by multiplying molar amounts by molecular weights.

10. The total normative minerals are then calculated and divided into two categories. Salic minerals include quartz, corundum, zircon, orthoclase,

albite, anorthite, leucite, nepheline, kaliophilite, halite, thenardite, and sodium carbonate. All other minerals listed in Table 1 are Femic. In the original version of GNAP, if silica was still deficient after step (8h), an error message was printed out and no output was generated. The revised version of GNAP follows the convention of Washington (1917) and reports silica deficiencies after step (8h) as excesses of MgO and FeO (in weight percent) with normative olivine decreased. This has the effect of yielding a low normative total.

The output of approximate norms and excess oxides provides sets of usable information. The approximate norm allows data from the sample to be evaluated in the same manner as samples for which an accurate norm could be calculated. The excess oxides can then be evaluated in terms of analytical error or the existence of modal minerals that are not considered in the normative calculations. For example, an analysis with a low analytical total (e.g. 98.98%) and a large excess of P_2O_5 beyond that used in the norm (e.g. 0.50%) could result from abundant rare earth phosphates in the rock. Alternatively, an analytical total near 100 percent and an excess of P_2O_5 beyond that used in the norm of 0.01 percent indicates that the norm is accurate within the limits of analytical uncertainty. As a second example, the analysis of a dunite may have an analytical total near 100 percent but contain a large excess of MgO beyond that used in the normative calculation. This could indicate the existence of periclase or brucite in the rock.

The only major difference in the normative calculations by GNAP and the rules proposed by Washington is in the treatment of CO_2. Washington proposed that CO_2 be treated three different ways depending on petrographic results: (1) if cancrinite was present, CO_2 was first used for sodium carbonate and added to the salic component with any excess CO_2 used for

calcite, (2) if primary calcite was present, CO_2 was calculated as calcite and added to the femic component, and (3) if secondary calcite was present, CO_2 was calculated as calcite, but calcite was not used in either the femic or salic totals. The revised version of GNAP provides for a user-initiated calculation of sodium carbonate which is added to the salic component. After sodium carbonate is calculated, or if this calculation is not requested, CO_2 is assigned to calcite, with excess CO_2 used for magnesite, and if necessary, siderite. These three carbonates are added to the femic total regardless of whether they are primary or secondary.

PROGRAM USE

The input for the revised version of GNAP is much more flexible than that of the original version. GNAP input now includes a series of flag commands that allow the user to control the actual normative calculations. Errors in setting or removing flags can produce an output with errors that may not be readily apparent. For this reason, it is critical that the user provide input in exactly the form necessary to create the desired output.

The general sequence of the imput card is:

1. Title Card.
2. Flag commands for normative calculations.
3. Modified input commands.
4. Analysis cards.
5. Output commands.

Cards from steps 2 and 3 above affect the data cards that follow them. They can either precede all the data, or be interspersed with the analysis cards at the user's discretion. If they are to be interspersed, it is suggested that a page of output per sample be requested (as described below) so that the output can be checked carefully.

TITLE CARD

A title card is identified by the word TITLE punched in columns 1 through 5. Title cards are the only cards that may contain TITLE in the first five columns. For example, a variable named TITLED would be illegal. All of the remaining spaces (6 through 80) can be used for any alpha-numeric characters, symbols or blanks. If the title card contains: TITLE PRØBLEM I, all pages of output generated after the title card is read will be headed by PRØBLEM I. For this reason, a title card is generally the first card in the deck, but new title cards can be used anywhere. For example, the user may wish to title a specific plot with a particular publication reference. A new title card immediately before the plot command and a different title card immediately after the plot command will accomplish labeling of a single plot. It is generally advisable to annotate any specially-created output. The phrase MØLAR DATA is automatically added to the user's title after a CØNVERT VALUES command as discussed below. If no title card is suplied, GRAPHIC NØRMATIVE ANALYSIS PRØGRAM is printed at the top of each page.

FLAG COMMANDS

The revised version of GNAP provides pairs of flag commands that can be used to control the calculation and output of normative information. Each flag must operate in one of two modes. Each will automatically start in one mode and remain there until changed by the user. All flag commands must end with a semicolon. They can be given before and after a single data card if necessary.

PPS-NØPPS commands

If the command PPS (page per sample) is given, a single page of output is generated for each subsequent analysis. This page of output contains: The sample number, the plotting symbol used for this sample, the original analysis in weight percent, the original total, the original total adjusted for Cl and F, the analysis adjusted to 100 weight percent and mole percent (with or without H_2O as discussed below), the normative analysis in mole and weight percent (based on the adjusted sum), the weight percent ratios of Al_2O_3/SiO_2 and FeO/Fe_2O_3, the Thornton and Tuttle differentiation index, the total, femic and salic normative minerals (if H_2O is used, the total will be less than 100%), Barth's cations, and Niggli values.

The default (or normal) mode for the PPS-NØPPS pair is NØPPS. If the PPS command is not given or if the NØPPS is given following a PPS command, single-page output is not generated.

WATER-NØWATER commands

The NØWATER command allows the user to enter H_2O as one of the analyzed oxides (either H_2O^+, H_2O^- or the sum of the two; the latter is preferable in most cases because it preserves the original analytical total.), but to ignore H_2O as a variable in all subsequent calculations and graphic output. In the NØWATER mode, the complete analysis and the total (adjusted for F and Cl) are shown in the summary output, but all calculations and

plotting are based on a water-free analysis, normalized to 100 percent. Plots and calculations are labeled as based on adjusted oxides. Normative minerals and adjusted oxides summaries are labeled as water-free in the summary table. These labels tell the user that the NØWATER flag is set. The default (or normal) mode for the WATER-NØWATER pair is WATER.

If the NØWATER command is used for only a few samples, and if these samples are followed by a WATER command, the normative calculations for the samples between the NØWATER and WATER commands will be on a water-free basis. There will be no label on the summary table to indicate that a few samples were treated as water-free, but the samples that were treated as water-free will be identified on the page of run conditions and error messages and on the single-page output per sample. In the summary table, the water value for these samples will be blank in the adjusted oxides and their normative totals will be 100 percent. Normative totals for samples with water will be less than 100 percent (the difference being equal to the normalized weight percent water).

Once all of the data cards have been read and the norms hae been calcualted, the effect of the WATER-NØWATER command is to direct the output commands to the original or adjusted oxide data sets. WATER is the default (normal) mode for this command pair. If the NØWATER command is not given, or if the WATER command is given after a NØWATER command, plots and user-defined calculations are based on the original oxides. If the NØWATER command is in operation, the plots and calculations will be based on the adjusted oxides.

CANCRINITE-NØCANCRINITE commands

This pair of commands allows the user to treat CO_2 according to the method suggested by Washington (1917). The CANCRINITE command should be given for all rock analyses which have cancrinite as a modal constituent. This

causes the normative calculation to add a step to calculate sodium carbonate before any other carbonates are calculated. Sodium carbonate is added to the salic total whereas all other carbonates are added to the femic total.

If the CANCRINITE command is not given or if NØCANCRINITE is given after a CANCRINITE command, the calculation of sodium carbonate is automatically skipped. If only one analyzed sample in a data set contains cancrinite, the data card for that sample can be preceded by a CANCRINITE command, and followed by a NØCANCRINITE command, and sodium carbonate will be calculate for that sample only. A message will note that the sodium carbonate calculation was attempted. The default (normal) mode for the CANCRINITE-NØCANCRINITE pair is NØCANCRINITE.

BARITE-NØBARITE and KSPAR-NØKSPAR commands.

These two pairs of commands allow the user to control the use of barium in the normative calculations. In the default (normal) mode, BaO is added to CaO as suggested by Washington (1917). If a given sample is known to contain barite and if SO_3 is given in the analysis, the BARITE command should precede the analysis card. This command adds BaO to Na_2O for the purpose of normative calculations for the next and all subsequent analyses until a NØBARITE card is encountered. This step can be important for rock in which CO_2 is reported, and for which barite is an important trace mineral because otherwise Ca normative minerals are increased and Na normative minerals are decreased (because of the calculation of thenardite). The NØBARITE command returns the program to the default mode and allows the program to look for the KSPAR command. The KSPAR command adds BaO to K_2O for the purpose of normative calculations, and should be used if a high-barium, potassium feldspar or barium feldspar is present in the analyzed rock. This command will not override a BARITE command, and if the latter has been given, a

NØBARITE command must precede the KSPAR command. (Although a BARITE command will override a KSPAR command, it is best to set the flag to NØKSPAR after the last analysis of a barium-bearing-feldspar rock in order to avoid possible complications further on in the data set.) The addition of barium to calcium or potassium is indicated by a note on the run condition and error message page.

SET FLAGS command

The SET FLAGS command returns all flags to their default condition. This command would be used before a RECALCULATE NØRMS command if norms are desired by two different modes of calculation.

MODIFIED INPUT COMMANDS

MØDIFY FØRMAT command

The user may specify an input format different from the standard format indicated in figure 1. The user prescribed format must follow Fortran IV object-time specifications and may use up to three cards per sample. The format is restricted to a form of (4X,.....,5X) for each card as discussed in the Analysis card section. The format modification is expressed as:

MØDIFY FØRMAT= (4X,.....,5X), NCS=n;

Where the dots represent columns 5 through 75 for each card, and n is the number of cards per sample up to a maximum of 3. If n is not specified, it is assumed to be 1. A maximum of 96 characters can be used to describe the format.

The order in which oxides are read follows the order given in table 1 unless this order is overridden by an ØXIDES command.

The following example of MØDIFY FØRMAT is from Bowen (1971). If the user wishes to specify ten oxides per card with each value having 5 digits before the decimal and 2 digits after the decimal, the data would be preceded by:

MØDIFY FØRMAT= (4X,10F7.2,1X,5X), NCS=3;

note that as with all commands, this one ends with a semicolon. In this modified format, each analysis requires 3 cards. Each of the three cards must start with NRM (or STØ) and plotting symbol in columns 1 through 4 and end with the sample identification in columns 75 through 80 (as discussed in the Analysis card section below). Although space is provided for 30 variables, the program will use only the first 21. If during the same run the user wishes to use data cards that are punched in the standard format, these cards would be preceded by:

MØDIFY FØRMAT= (4X,9F4.2,3F3.2,F2.2,F4.2,5F3.2,F2.2,F3.2,5X), NCS = 1;

Form 9-1651
(April 68)

FIGURE 1.--Normative Analyses Data Form

1 2 3 4	5 6 7 8	9 10 11 12	13 14 15 16	17 18 19 20	21 22 23 24	25 26 27 28	29 30 31 32	33 34 35 36	37 38 39 40	41 42 43	44 45 46	47 48	49 50 51	52 53 54 55	56 57 58	59 60 61	62 63 64	65 66 67	68 69 70	71 72	73 74 75	76 77 78 79 80
Options	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	TiO_2	P_2O_5	MnO	ZrO_2	CO_2	SO_3	Cl	F	S	Cr_2O_3	NiO	BaO	IDENT.
	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

ØXIDES command

The ØXIDES command is usually used in conjunction with the MØDIFY FØRMAT command. The ØXIDES card must precede all analysis cards to which it refers. The ØXIDES command indicates which oxides are to be read, and in what order. (Note that for the sake of brevity, the volatile elements are included under the term oxides.) If no ØXIDES command is given, the oxides will be read in the order given in table 1. If the order of oxides has been changed, it can be returned to the standard order by:

ØXIDES SIØ2,AL2Ø3,FE2Ø3,FEØ,MGØ,CAØ,NA2Ø,K2Ø,H2Ø,TIØ2,P2Ø5,MNØ,
ZRØ2,CØ2,SØ3,CL,F,S,CR2Ø3,NIØ,BAØ;

If any one of the oxide names is incorrectly given, an error message is printed giving a list of acceptable oxide names foillowed by the incorrect oxide name. The run is then terminated.

The ØXIDE command only allows the user to choose which of the 21 acceptable oxides (table 1) will be read and in what order. If the user has Rb, Sr, and Ba data which are to be used in plotting, they must be read in as acceptable oxides, and then defined by their correct names by use of a define command. For example, they may be read in as CR2Ø3, NIØ, and BAØ. A series of commands are needed to instruct the computer to label CR2Ø3 as RB, NIØ as Sr, and BAØ as BA (see example below).

ANALYSIS CARDS

The analysis cards may be set in a standard format (fig. 1) or in a user-prescribed format. The analysis card (or cards if more that on card per sample is used) may contain a maximum of twenty-one variables. The first three columns must contain either NRM or STØ. NRM places all of the original and calculated variables in a data array for future use in printing, plotting, or subsequent data manipulations. STØ bypasses all normative calculations and places only the original data in storage. This command would be used most commonly for setting and evenly divisible line printer scale for X-Y type plots, or to store non-chemical data for future plotting. Only analysis cards may have NRM or STØ in the first three columns, hence a variable named NRML or STØRM would be illegal if they started in column 1. Column 4 should contain the character that is to be used in displaying the sample on X-Y and ternary plots. The characters + and - are used to delineate axes and boundaries on plots and should, therefore, be avoided as plotting symbols. The underscore is used to delineate duplicate points, and is therefore a poor choice as a plotting symbol. The user may find that some symbols (such as #, @, and &) which have special meaning for particular machines, may not print. Columns 76-80 should contain the sample identification. Any alphanumeric and symbol combination up to 5 characters in length is permissable. A maximum of 99 samples can be processed as a group.

The identification columns 76-79 can be used for a special purpose. The RECALCULATE NØRMS command uses all values in storage including those entered directly into storage by use of a STØ command. This means that cards used for the purpose of scaling of plots only may generate meaningless norms, and may have their scaling values changed during the recalculation. To avoid this problem, the user can identify cards for which a norm or normalization to 100

percent is not desired by DUMM in columns 76-79. Cards thus identified will be entered into both adjusted and original data sets exactly as coded and will not be used in any normative calculations or normalizations. They will be used for all plotting, printing and calculating commands. Cards for which data are to be stored for later normative calculations are identified by STØ in columns 1 to 3, and an identifications other than DUMM in columns 76-79.

OUTPUT COMMANDS

The revised version of GNAP used the same ten output commands as the original version. The discussion of these commands is based on the description by Bowen (1971).

Expressions are basic to all the output commands. These are rules by which the computer obtains and uses values. Expressions are composed of variable names, arithmetic operators, constants, and the grouping symbols the left and right parenthesis. Expressions must by syntactically and semantically correct in the Fortran sense. Thus, each left parenthesis must have a matching right parenthesis. No two arithimetic operators can be used immediately adjacent to one another. All variable names must be known to the computer before evaluation of the expression is requested. For example, the computer cannot be instructed to multiple A times 2 and then told that A is silica. Reversing the order of these two instructions make the operation permissible.

Variable names may be any of the alphanumeric combinations associated with values calculated in the norm subroutine (tables 1 and 2). Note that Niggli values, Barth's cations, and Thornton and Tuttle's differentiation index cannot be addressed by their standard abbreviations except for the purpose of

a summary printout. Up to fifteen additional variable names can be provided by user-defined commands as discussed below. Variable names must start with a letter.

Table 2 near here

The four arithmetic operators are:

(1) division (e.g. AL2Ø3/SiØ2, (2) multiplication (e.g. .8998* FE2Ø3), (3) subtraction (e.g. SIØ2-40), and (4) addition (e.g. CAØ + BAØ). These operators are listed in the order of the priority. Multiplication and division are performed before subtraction and addition. Operations of equal priority are performed left to right. The order of operations is changed by the use of parentheses such that operations within parentheses are done first. Hence, if variable A=6/3*2, A is equal to 4, but if A=6/(3*2), A is equal to 1.

Constants are decimal numbers with or without a decimal point. They must be less than eight characters in length including the decimal point as a character. For example, the half-life for ^{238}U= 4468300000 is not a usable constant because it contains 10 characters, but 4468300*100 is usable because it contains only 7 characters.

Define command

The define command is used to create new variable names (up to a maximum of 15) or to redefine the basic names in tables 1 and 2. The define command only operates on data that are in storage. Therefore, all define command cards must be placed after the analysis cards for which they are to be used. The define command takes the form:

Variable name=expression:

Table 2.--Variable names for partitioning of normative clinopyroxene, orthopyroxene, and olivine

DI = diopside ($Ca(Fe,Mg)(SiO_3)_2$)

DIWØ - calcium component of diopside

DIEN - magnesium component of diopside

DIFS - iron component of diopside

WØL - excess calcium clinopyroxene beyond that needed for diopside

HY = hypersthene $(Mg, Fe)SiO_3$

HYEN = magnesium component of hypersthene

HYFS = iron component of hypersthene

ØL = olivine $(Fe,Mg)_2SiO_4$

ØLFØ = magnesium component of olivine

ØLFA = iron component of olivine

Note: Results are expressed as either weight percent of mole percent of the total norm and not as percent of the mineral class.

e.g. TØTALFE= .77732*(FEØ+ .8998*FE2Ø3);

In this example, total metallic iron (for which the variable name is TØTALFE) is defined as the converted oxides of iron. This is calculated by first calculating all the iron oxide as FeO (within the parentheses) and the multiplying the FeO by a conversion factor. An alternate way to define the same variable would be:

TØTALFE= .77732*FEØ + .69943*FE2Ø3;

Note that in both examples an arithmetic operator is between the constant and variable name for each iron oxide. (The expression .8998FE2Ø3 is meaningless). Also note that both commands end with a semicolon. The number of characters to the left of the equal sign must be eight or less. No operators can be used to the left of the equal sign (e.g. +, -, *, /, ()). The number of characters to the right of the equal sign must be forty or less. If a longer expression is necessary, it must be done in steps (e.g. X= part of the expression; variable name=X + the rest of the expression). Each define command is printed when it is executed. Numbers printed for user-defined variables in the summary table are limited to the range 999.999 to 000.001. Larger numbers are printed as ******** and smaller as 0.000.

PLØT AND PLØT(R) commands

The command PLØT and PLØT(R) are used to generate X-Y plots on either the line printer or Calcomp plotter(as described under the DEVICE command). These commands take the form:

PLØT expression 1, expression 2;

or

PLØT(R) expression 1, expresion 2;

where expression 1 and expression 2 are valid arithmetic expressions as discussed above, separated by commas and followed by a semicolon. For example:

PLØT SIØ2, AL2Ø3;

instructs the computer to construct an X-Y plot with silica on the abscissa increasing from left to right, and alumina on the ordinate increasing bottom to top. A command of PLØT(R) A, B; instructs the computer to create an X-Y plot with the abscissa values increasing from right to left and ordinate values increasing from bottom to top. The computer uses all values in storage at the time the command is given including those for which no plotting symbol is given. Although the latter will not print, they will be used to determine the minimum and maximum values for abscissa and ordinate. They may show as an underscore of a data point that has the same value or as a blank space in the axis marking. It should be noted that unless otherwise specified (e.g. by a define or CØNVERT or NØWATER command as discussed above), the oxide values used will be the weight percent values in the unadjusted input data set and the normative minerals will be in weight percent. Plots that follow a CØNVERT command will be based on adjusted mole percent data set. Plots that follow a NØWATER command will be labeled as based on adjusted oxides. These will be normalized to 100 percent and water-free if the NØWATER command preceded the data. Duplicate data points are indicated by an underscore.

One special plot command is available. This command takes the form:

PLØT HARKER;

This command instructs the computer to create a series of X-Y plots with silica on the abscissa and all other oxides with non-zero values on the ordinate.

TERNARY command

The ternary command instructs the computer to construct a ternary diagram for either lineprinter or Calcomp output. This command takes the form:

TERNARY expression 1, expression 2, expression 3;

where the expressions are valid as described above, separated by commas, and followed by a semicolon. For ternary plots, all expressions must be equal to or greater than zero; if the computer encounters an expression that is less than zero, it will set it equal to zero. If all expressions are zero for a particular sample, the point is plotted in the lower left apex. Expression 1 describes the upper apex; expression 2 describes the lower left apex; and expression 3 describes the lower right apex. For example:

TERNARY Q,AB,OR;

instructs the computer to construct the familiar granite system diagram of Tuttle and Bowen (1958).

The ternary command uses all values in storage, but plots a blank space if no plotting symbol is given. The command also generates a printout of values for the three expressions normalized to 100 percent on the page that precedes the plot, including those values which are plotted as a space. A list of duplicate data points is also printed. These points are indicated by an underscore on the diagram. It should be noted that the ternary plot generated by the line printer is not exactly accurate. Also note that the original and adjusted data sets produce equivalent ternary diagrams because of the normalization step taken in calculating ternary proportions.

CØNVERT VALUES command

The CØNVERT VALUES command changes all of the weight percent values of the variables listed in table 1 and 2 to mole percent. It is important to note that user-defined variables are not automatically converted to mole percent. Also, only one CØNVERT VALUES command can be used in each data analysis because the command only causes division of stored values my molecular weights. With the exception of user-defined variables, values which do not

convert will not print if requested by a summary command. For example, no constant exists that changes total weight to total moles. Hence, summaries after a CØNVERT VALUES command have no totals. If the user wishes to use his defined variables in mole percent, he must redefine them by use of a define command that contains the appropriate conversion factors. For example, if the user defined a variable FEØT to include all the iron as FeO and then converted values by use of a CØNVERT VALUES command, FEØT would still be in weight percent.

FEØT could be converted to mole percent by either

```
FEØT = FEØT * 0.0139086;
```

or

```
FEØT = FEØ +2.0 *FE2Ø3;.
```

PRINT command

The PRINT command instructs the computer to evaluate and print one or more expressions. This command takes the form:

```
PRINT  expression 1, expression 2;
```

where expressions 1 and 2 are valid as described above. There is no limit on the number of expressions that can be printed. Each expression will be printed with the sample number followed by the value. All expressions must be followed by a comma except the last, which must be followed by a semicolon. The PRINT command will use the original oxide values unless otherwise specified. Refer to the discussion of the PLØT command for details of the values used in printing under various flag conditions.

RECALCULATE NØRMS command

The RECALCULATE NØRMS command is used to recalculate norms for each sample in storage (except samples identified by DUMM in columns 76-79). This command takes the form:

```
RECALCULATE NØRMS;
```

This command allows the user to modify the stored data (e.g. by use of a define command) and to then calculate a norm on the basis of the modified data. For example, the user may wish to compare the norms of the original data with those of volatile-free analyses with all iron expressed as ferrous iron. To do this, a summary card would be placed after the analysis cards, followed by a series of define cards that set each volatile equal to zero, a define card to calculate all the iron as FeO, a define card to set Fe_2O_3

equal to zero (this card cannot precede the card that redefines FeO as all the iron recalculated as ferrous iron) and finally, a RECALCULATE NØRMS command. The RECALCULATE NØRMS command cannot be used after a CØNVERT VALUES command, because the norm subroutine requires weight percent data as input, and the weight percent data are destroyed by the CØNVERT VALUES command.

DEVICE command

The DEVICE command is used to specify plotting on either the line printer or Calcomp plotter. If no device is specified, approximate plotting will be done on the line printer. Both line printer and Calcomp plotter can be used in a single run. The device command takes the form:

```
DEVICE = CALCØMP;
     or
DEVICE = PRINTER;
```

This command affects all PLOT and TERNARY commands that follow it in the card deck until a new device command is encountered.

SCALE command and user scaling with dummy cards

The scale command affects only those plots which are to be produced by the Calcomp plotter. Line printer plots have a fixed size which occupies one full page of computer paper. For X-Y plots, the line printer divides the abscissa into 10 equal intervals, and the oridinate into 5 equal intervals on the basis of the minimum and maximum values in storage for each coordinate. This will generally produce axes scales that differ widely from one data set to another, and which may be difficult to interpret within any given data set. For example, if silica in a series of basalts varies from 43.2 to 49.6, and Harker variation diagrams (SiO_2 versus each oxide) are requested by the plot commands, the abscisa will be divided into units of 0.46 weight percent silica. This is an inconvenient unit, and it is unlikely that it could be

used in an overlay comparison with data from other basalt suites. For these reasons, both line printer and Calcomp plots should be scaled by the user.

User scaling is most easily accomplished by use of dummy analysis cards. One, two, or three cards can be used such that the range from minimum to maximum values is divisible by 5. If plotting of adjusted or water-free oxides is anticipated, each dummy card should sum to 100 percent (water-free if need be). The dummy cards should be included with the analysis cards (usually as the last cards of the data set) with STØ in the first three columns, and the fourth column left blank. All dummy cards must have some sort of unique identification in columns 75 through 80, such as DUMM1, DUMM2, etc. The identification DUMM in columns 76 to 79 prevents attempted norm calculation and normalization of the data to 100 percent in the event a RECALCULATE NØRMS command is given.

When the Calcomp plotter is specified, the abscissa is divided into 10 equal units, and ordinate into 8 equal units. Unlike to line printer, the Calcomp scaling subroutines set the interval values equal to 1, 2, 4, 5, or 8 x 10^n, where n is a whole number. As a result of this internal scaling, the Calcomp plots may not start with the actual minimum value and end with the actual maximum value. Nonetheless, dummy cards are advisable to insure consistent scaling among data sets.

In addition to setting ranges that can be incremented by whole numbers, the user may vary the absolute size of Calcomp plots by use of a SCALE command. This command takes the form:

SCALE = n;

where n can be any number from 0.0 to 3.0. If no SCALE command is given, ternary plots will have sides of 230.6mm (9.08 in) in length. This scale allows direct overlay of plots on Keuffel and Esser triangular coordinate

paper (K and E No. 46 4490). Two-dimensional plots will have an abscissa of 254 mm (10 in) and an ordinate of 203.2 mm (8 in) which will overlay on standard 10 divisions per inch graph paper (e.g. K and E No. 46 0702). The scale factor for standard size plots is 1.0. Scale factors between 0.0 and 1.0 decrease the size of the plots, and scale factor between 1.0 and 3.0 increase the size of plots such that 3.0 produces a plot of 762 mm (30 in) maximum width. Scale factors greater than 3.0 exceed the capabilities of the Calcomp plotter, and generate an error message. The SCALE command does not affect the size of lettering and plotting symbols which remain fixed at 3.56 mm (.14 in).

SUMMARY command

This command produces a summary printout for all of the samples in storage. Nine separate groups of numbers can be obtained by us of this command:

(1) The oxides as originally entered.

(2) Oxides normalized to 100% (with or without water).

(3) Normative minerals.

(4) Partitioning of normative clinopyroxene, orthopyroxene, and olivine.

(5) Barth's cations.

(6) Niggli values

(7) Thornton and Tuttle's differentiation index.

(8) The ratios Al_2O_3/SiO_2 and FeO/Fe_2O_3

(9) User-defined values.

The order in which these nine categories are printed, as well as which ones are printed are under user control. Note that this is the only command that can access categories 5 through 8 without the use of a define command. The

summary values will be printed in weight percent unless the summary command has been preceded by a CØNVERT VALUES command. In this case, the summary of values in categories one through four will be in mole percent; but the user-defined variables will still be in weight percent, unless converted through the use of a define command. Values in categories 5 through 8 are not converted, and will not print even if requested. This is also true of the various totals.

The SUMMARY command takes the form:

SUMMARY (list of category keywords);

where the category key words are ØXIDES, ADJUSTED, MINERALS, PARTITIØNS, BARTH, NIGGLI, D.I., RATIØS, and USER. The key words used must be in the order desired by the user, separated by commas, and contained within parentheses. The summary printout will automatically contain the last title, sample numbers, and plotting symbols. Zero values will be left blank. Any variables, except ratios and D.I., for which all values are zero will be omitted from the summary printout. For example, a summary of the normative minerals for 60 samples will generate five pages of printout. If NC(sodium carbonate) is zero for all 60 samples, NC will be omitted from all five pages. However, if NC is non-zero for one sample, it will be printed for all five pages even though it will have no associated values on four of the five pages.

Note that these key words are only understood in the context of a SUMMARY command. If the differentiation index is to be used for plotting it must first be defined as:

D.I. = Q+ØR+AB+NE+KP+LC;

CLEAR STØRAGE command

The CLEAR STØRAGE command is used to remove all previously stored values and to reset all flags to their default mode. This command takes the form:

CLEAR STØRAGE;

Typically, this command would be used if calculations and plotting for two different data sets were desired. The clear command would be placed after the last command card for the first data set, and would be followed by all the command and analysis cards for the next data set.

ERROR MESSAGES AND PROGRAM CONDITIONS

GNAP is designed to recover from those errors that are due to incorrect or inadequate input. The program is also designed to recover from errors that result from special case data. When an error is detected, an error message is sent to a file that prints as a summary at the end of the run, and the computer resumes scanning the input for commands to execute. In addition to errors, the program keeps track of special conditions that are imposed by the user during the run. These are printed with the error messages at the conclusion of the run. A list of messages and probable causes follows.

1. NØ MØRE THAN 99 NØRMS MAY BE STØRED. THE LAST NØRM WILL BE WIPED ØUT.

   More than 99 analysis cards have been processed without an intervening clear command. Only the first 99 analyses are in storage.

2. NØ MØRE THAN 15 NAMES MAY BE DEFINED. DEFINITIØN IGNØRED FOR NAME = ( ).

   More than 15 new variable names have been given. Consider redefining variable names.

3. PLØT CØMMAND ERRØR ØN ( ).

   The two expressions for abscissa and ordinate, respectively, are not separated by a comma.

4. TERNARY CØMMAND ERRØR ØN ( ).

   The expression giving the apices of the desired ternary diagram are not separated by commas.

5. SCALE MUST BE PØSITIVE AND LESS THAN ØR EQUAL TO 3.0.

   An illegal scale was requested, possibly due to a misplaced decimal point.

6. "DEVICE = CALCØMP" MUST BE SPECIFIED BEFØRE SETTING SCALE.

   A scale command has been misplaced in the deck. It has no effect on the line printer output and is recognized only by the Calcomp software.

7. STATEMENT LENGTH (160) EXCEEDED ØN CARD ( ). DID YOU FØRGET A SEMICØLØN?

   Message is generated most often by a missing semicolon after a command, but may be due to an error in a user-supplied format.

8. FØRMAT CØMMAND ERRØR (MISSING PARENTHESES) IN ( ).

   A user-defined format is lacking a parentheses.

9. ERRØR IN MØDIFY CØMMAND GIVEN AS ( ).

   The modify keyword was not followed by format or NCS (number of cards).

10. UNRECØGNIZED CØMMAND GIVEN AS ( ).

    The most common causes for failure to recognize commands are misspellings and errors in user-defined formats.

11. ERRØR IN EXPRESSIØN ( ).

    This message is usually caused by syntax errors such as unmatched parentheses or adjacent arithmetic operaters.

12. UNDEFINED NAME ( ).

    This is most often generated by a spelling error, but could be generated by reversing a definition such that the new variable is to the right of the equal sign.

13. FIRST WØRD ILLEGAL IN ( ).

    A key word is misspelled in the summary command or an unrecognized variable has been requested.

14. THE FØLLØWING CØMMAND CØNTAINS EXCESSIVE CHARACTERS. DID YØU FØRGET A SEMICØLØN

    A semicolon is probably missing. The defined variable may not exceed 8 characters, and the definition may not exceed 40.

15. ØXIDE CØMMAND CØNTAINS A NAME WHICH IS NØT IN THE LIST OF ACCEPTABLE ØXIDES. ACCEPTABLE ØXIDES ARE: ( ).

    Error is most likely due to a misspelling or use of an oxide name not used in the program.

16. GRAPHIC NØRMATIVE ANALYSIS PRØGRAM.

    This is printed in place of a title if no title is supplied.

17. MØLAR DATA.

    This is appended to the users title for all output that follows a convert command.

18. SAMPLE ( ) CØNTAINS AN EXCESS ØF ( ) WEIGHT PERCENT ( ) BEYØND THAT USED IN NØRMATIVE CALCULATIØNS.

    The blanks contain sample number, amount, and element name, respectively. Elements that can occur in excess are P2Ø5, CL, S, CR2Ø3, F, CØ2, or ZRØ.

19. SAMPLE ( ) CONTAINS TØØ LITTLE SIØ2 TO COMPUTE A NØRM. SIØ2 DEFIECIENCY IS EQUIVALENT TØ AN EXCESS OF MGØ ØF ( ) WT% AND AN EXCESS ØF FEØ ØF ( ) WT%.

    The reported norm is only an approximation based on the assumption that too much olivine was calculated.

20. DATA HAVE ALREADY BEEN CØNVERTED TØ MØLES. NØRMS CANNØT BE RECALCULATED FRØM DATA EXPRESSED IN MØLES.

    The user converted the data and then asked for a recalculation of the norms.

21. NØ SIØ2 GIVEN FØR HARKER SUITE OF PLØTS.

Silica is zero for all samples, and hence no plots are generated.

22. SAMPLE ( )--NA2CØ3 CALCULATIØN ATTEMPTED.

The CANCRINITE flag was set for sample ( ).

24. SAMPLE ( ) -- BAØ ADDED TO K2Ø.

The KSPAR flag was set for sample ( ).

25. NØTE: PLØT IS BASED ØN ADJUSTED ØXIDES.

This is printed on plots for which the NØH2Ø flag was set.

26. SAMPLE ( ) --NØRM CØMPUTED ØN WATER FREE BASIS.

The NØWATER flag was set for sample ( ).

EXAMPLE

GNAP PRØBLEM 1

The first problem demonstrates the use of all the flag commands and several output commands. Seven pairs of samples are entered such that the sample A computes normally and sample B generates an error message for an excess in a minor constitutent or used a new loop of the program. Two rocks with too little silica for a normative computation are also included. The range of samples in this problem also uses all possible input oxides, and computes all possible output minerals.

The first page of appendix 1 is a printout of all the cards used in the first problem in the order read by the computer. The first card is a title card which causes GNAP PRØBLEM 1 to be printed at the top of each page until the CØNVERT VALUES card is encountered at which point the title is changed to GNAP PRØBLEM 1, MØLAR DATA. The second card is a PPS command which causes a single page per sample to be printed until the NØPPS is encountered (after the third sample).

Three analyses of sample MNØ6 are shown in the first three pages of output. MNØ6A and MNØ6H are identical analyses but MNØ6H is preceded by a NØWATER command. Sample MNØ6B contains more Cl than can be combined with the available $Na_2Ø$ and an error statement is printed for this sample on the last page of output for the problem that shows an excess of 0.09 weight percent Cl. Note that the increased Cl in MNØ6B removes albite from the norm, increases anorthite and halite relative to MNØ6A, and decreases to total minerals relative to MNØ6A. The difference in the two totals is not 0.09, but (0.09-0.23x0.09). This difference is due to the effect of using Cl instead of oxygen as an anion and can be seen in the totals relative to the adjusted totals of the three samples. The effect of calculating the norm with and

without water can be seen by comparing samples MNØ6A and MNØ6H. The minerals calculated do not change, but the absolute amounts are greater in the water-free analysis.

The remaining 21 samples of problem 1 are preceded by a NØPPS command which suppresses the page per sample output. Results for these and the first 3 samples are shown in the summary table for GNAP PRØBLEM 1 (Appendix 1). Error statements and flag conditions for the last 21 samples appear on the last page of output for problem 1.

The sample pair 1201A and 1201B differs in the amounts of MgO, CaO and CO_2. Sample 1201B would not have produced a norm in the original version of GNAP, but it does not cause an error statement to be generated in the revised version because siderite is calculated to use up the excess CO_2 after magnesite has been calculated. Although samples 1201A and 1201B are chemically very similar, there are several differences in the normative mineralogy which could relate to several differences in their trace mineral modes.

Sample 1165 has three similar analyses (A, B, and C). Sample 1165B and 1165C are chemically identical and differ from 1165A in contents of MgO, CaO, and CO_2. The three norms have several differences. Sample 1165B generates an error message of .13 weight percent excess CO_2 beyond that used in the norm (for calcite, magnesite, and siderite). Sample 1165C is preceded by a CANCRINITE command and all of the CO_2 is used to calculate thenardite. The CANCRINITE command causes sample 1165C to have a very different normative mineralogy from that of sample 1165B (the chemically identical sample). The difference in the normative totals for samples 1165A and 1165B is equal to the excess CO_2 (.09 wt%).

The sample pair 1101A and 1101B differs only in the F content which causes sample 1101B to generate an error message of 0.04 weight percent F in excess, removes anorthite and calcite from the norm, and adds fluorite and magnesite to the norm. The totals differ by (.04 - .04 * .42), which is due to the difference in weight of oxygen and fluorine.

The sample pair 344 A and 344 B differ in their amounts of CaO and $P_2Ø_5$. Sample 344 B generates an error message of .09 weight percent P205 which is equal to the difference in the total of the normative minerals. Although CaO was used up before the calculation of fluorite was attempted, the increase in apatite was sufficient to accommodate the F so no secondary error message was generated for excess F.

The sample pair 278 A and 278 B differs in amounts of FeO and Cr_2O_3. Sample 278#B generates an error message of .06 weight percent CR2Ø3 which is equal to the difference in the total of the normative minerals. Note that the addition of chromium to the analysis affects the amounts of all the minerals calculated after step 3e of the rules for CIPW calculations.

The sample pair 339 A and 339 B differs only in the S added to the analysis for sample 339 B. The 0.2 weight percent increase of S causes an error message to be generated which shows an excess of S of 0.09 weight percent. This amount is equal to the difference in total weight percent normative mineralogy because no attempt is made to adjust analyses for the differences in O^{-2} and S^{-1} or S^{-2} or SO_3^{-2} incorrectly reported as S. Note that the addition of S to the analysis makes only a few, generally small differences in the normative mineralogy.

Analysis EC2-9 is an unpublished analysis of an ultramafic nodule (Robert Forbes, written communication, 1973). The sample does not have a computable norm by the original version of GNAP. It contains an excess of P_2O_5 and a

large excess of the olivine molecule which could be interpreted as a large analytical error or the existence of oxide minerals not considered by the normative calculations. However, spinel, which could occur in the norm as any alumino-silicate or corundum, does exist in the sample, and probably explains most of the excess iron and magnesium. The excess P_2O_5 seems large relative to analytical error and may suggest the presence of a phosphate other than apatite.

The next three samples are taken from Washington (1917) and provide a comparison with hand calculated norms. Sample A2.II generates an error message of excess MGØ and FEØ of 1.87 and 0.52 weight percent, respectively. In his calculated norm, Washington reports an excess of 2.31 percent MgO plus FeO. The norm for sample A3III is very similar to that reported by Washington.

The next three samples, A1.I, A1.IS, and A1.IK, demonstrate the changes in normative mineralogy that occur as a result of allocating BaO to CaO, Na_2O, and K_2O (SrO in the original analysis has been added to BaO on the input card for the purpose of the example). Note that all of the normative totals (even with water added) are all less than 100, and that they are all different. The effects of allocating BaO in different ways is small, but could be important in special cases.

The last two samples are included because they have reported ZrO which causes the calculation of zircon and because they have excess Ca-clinopyroxene beyond that needed to equal the Fe and Mg components of diopside. This causes WØL (wollasonite in excess of that used in diopside) to be calculated and printed. The last sample is the only sample in the problem that causes perovskite to be calculated.

The weight percent data are used to create two commonly used ternary diagrams. The first diagram which uses normative quartz, albite and

orthoclase, is commonly used for the classification of quartz-bearing plutonic rocks or to compare the chemical composition of a granite with Tuttle and Bowen's (1958) granite minimum. (It should be noted the Tuttle and Bowen's plot is a phase diagram and that the plot generated by GNAP is not.) The second ternary diagram used the imput oxides to create an AMF diagram. The upper apex is the sum of the total iron as FeO (shown as the user-defined variable FEØT) plus MNØ. If a NØWATER command had been given before the ternary command, the oxides adjusted to 100 percent would have been used. This would have resulted in a slightly different diagram unless FEØT was redefined on the basis of the adjusted oxides. The ternary ratios are shown on both diagrams. In the actual computer output, these are printed on the page that precedes the ternary diagram.

The second half of the problem is carried out using molar data. This is acomplished by use of a CØNVERT VALUES command. FEØT is redefined so that it will be in moles and a new summary is created. Subsequent pages are automatically labeled with the user's title and molar data.

The molar data are used to create two ternary diagrams. The first is based on the molar quantities of nepheline, quartz, albite, hypersthene and olivine (after Irvine and Baragar, 1971) and allows the user to evaluate silica saturation. Lines that divide undersaturated, saturated, and oversaturated fields have been drawn on the computer output. The second ternary plot is based on the molar amounts of Al_2O_3, total alkalies, and CaO. This allows the user to evaluate the alumina saturation according to the classification of Shand (1951). Lines have been drawn on the output to indicate the fields of peraluminous, metaluminous, and peralkaline. The printout for the ternary ratios has been superimposed on the diagrams by hand.

These two ternary diagrams were chosen to demonstrate the advantage of plotting molar data. The superimposed lines for field boundaries could be shown on weight percent diagrams, but they would have to be calculated by hand, and they would be more difficult to locate on the line printer output. In Shand's classification (1951), peraluminous refers to analyses in which there is more aluminum than that needed to make feldspar. The molar ratio of K_2O or Na_2O to Al_2O_3 in alkali feldspar (e.g. $K_2O*Al_2O_3*6SiO_2$) is 1:1 or mid-point on the left side line. For anorthite ($CaO*Al_2O_3*2SiO_2$) the mid-points also indicate the point at which there is an exact mixture for feldspar. Hence, peraluminous is the field above the line that joins the mid-points.

Problem 1 ends with a SET FLAGS, and a CLEAR command (page 50). This returns the flags to their default modes and clears all of the storage registers so that a new problem can be started.

GNAP PRØBLEM 2

The second problem demonstrates the input of data in a user-defined format, manipulation of user-defined data, X-Y plotting, and plotting with the Calcomp plotter. The samples used in this problem are cogenetic and generate a more typical number of normative minerals than the analyses used in problem 1.

The first card is again a title card (page 50) which labels every page with GNAP PRØBLEM 2. The next card gives the new format, and the following card identifies which of the 21 oxides will be read by the computer and in what order (note that all 21 oxides are not needed). The analytical data are given in the next 12 cards. The number of cards per sample is not specified in the MØDIFY FØRMAT command, and hence, 1 card per sample is assumed.

Immediately after the data and two dummy cards, three new variables are defines (BAPPM, UPPM, and THPPM). These were originally read in as BAØ, NIØ, and CR2Ø3 and were used as such in the normative calculations as can be seen in the first summary table of problem 2 (p. 68-70). Chromite (CM) is reported for all of the samples in spite of the fact that there is no real chromium in any of the samples. In order to obtain the correct norms, BAØ (which was read in as elemental Ba) is converted to BaO by using a define command. NIØ and CR2Ø3 are set equal to zero, and the RECALCULATE NØRMS command is given. The second summary table and the storage registers now contain the true norms and correct chemical data.

BaO was added to CaO (by default) for the normative calculations. The user may wish to have a quick visual check that BaO is varying with CaO rather than K_2O. This is accomplished by plotting BAØ versus K2Ø. An inverse relationship is expected, and the user may wish to have a positive slope for the plot. Therefore, K_2O is plotted with values increasing to the left by the command: PLOT(R) K2Ø,BAØ;. Scaling for this and other plots in problem 2 is accomplished through the use of dummy cards. These can be seen in the input data (page 51), but because they generated a separated page of output for the summary tables (only 12 samples are printed per page), printout for these samples has been omitted. Note that their identification is DUMM1 and DUMM2 so that the scaling factors will not be normalized to 100 percent by the recalculated command. A second X-Y plot (Th versus U) is created, this time with values along the abscissa increasing to the right.

The next command sends plotted output to the Calcomp plotter and requests plotting at 3/4 of the normal scale. The requested plot is a ternary plot of the radioelements. Superimposed manually beside the plot is the printout of the ternary ratios. Three lines that describe the commonly accepted averages

for each of the radioelement ratios are superimposed on the diagram. In this example, most of the samples vary greatly from the normal Th/U, U/K and Th/K ratios.

The last series of commands converts the stored data to mole percent. Next a new variable (PERAL) is defined (which is greater than 1 for peraluminous rocks,) and the values of PERAL are printed. Defining PERAL prior to printing is not necessary. The command:

```
PRINT AL2Ø3/(NA2Ø+K2Ø+CAØ);
```

would have generated the same output. Defining the variable first merely places it in storage so that it could be used for purposes other than printing. For example, the user may wish to examine the peraluminous variable as a function of differentiation in an X-Y plot.

REFERENCES

Bowen, R. W., 1971, Graphic normative analysis program: U.S. Geol. Survey Computer Contribution No. 13, 80 p.

Cross, C. W., Iddings, J. P., Pirsson, L. V., and Washington, H. S., 1902, Quantitative chemico-mineralogical classification and nomenclature of igneous rocks: Jour. Geol., v. 10, p. 555-690.

Irvine, T. N., and Baragar, W. R. A., 1971, A guide to the chemical classification of the common volcanic rocks: Can. Jour. of Earth Science, v. 8, p. 523.

Johannsen, Albert, 1939, A descriptive petrography of the igneous rocks; Vol. I Introduction, textures, classifications and glossary: Univ. Chicago Press, Chicago, 318 p.

Niggli, Paul, 1920, Lehrbuch der mineralogie, Berline, 476 p.

Shand, S. J., 1951, Eruptive rocks; John Wiley, New York, 488 p.

Tuttle, O. F., and Bowen, N. L., 1958, Origin of granites in the light of experimental studies in the system $NaAlSi_3O_8$-$KAlSi_3O_8$-$CaAl_2Si_2O_8$-H_2O: Geol. Soc. America Mem. 74, 153 p.

Washington, H. S., 1917, Chemical analysis of igneous rocks: U.S. Geol. Survey Prof. Paper 99, 1201 p.

APPENDIX 1

SAMPLE PROBLEMS

```
TITLE GNAP PROBLEM 1
PPS;
NRM*48301480 240 910 8101000 126 012 36306801321          140                MN06A
NRM#48301480 240 910 8101000 126 012 36306801321          153                MN06B
NOWATER;
NRMS48301480 240 910 8101000 126 012 36306801321          140                MN06H
WATER;
NOPPS;
NRM*678 179   45  80  61  25 96   53 178 23  5 2      3     3 0400           1201A
NRM#678 179   45  80  30  10 96   53 178 23  5 2     60     3 0000           1201B
NRM*749 143    9  26  20  24 76    3  066 13  3 2     2062  300              1165A
NRM#749 143    9  26  10  12 76    3  066 13  3 2    40062  300              1165B
CANCRINITE;
NRMS749 143    9  26  10  12 76    3  066 13  3 2    40062  300              1165C
NOCANCRINITE;
NRM*759 138    1  68  11  18 3    7    47 14  2 5      3     100 00           1101A
NRM#759 138    1  68  11  18 3    7    47 14  2 5      3     101500           1101B
NRM*73801330 130  04  45  44 240 580 150021008 02     06       02            344 A
NRM#73801330 130  04  45  22 240 580 150021026 02     06       01            344 B
NRM*52101660 830  80 450 660 370 240 300170 8110     02       03            278 A
NRM#52101660 830  20 450 660 370 240 300170 8110     02       03     70     278 B
NRM*729013500190  08  36 120 360 460  85 37 1004     01       02            339 A
NRM#729013500190  08  36 120 360 460  85 37 1004     01       02 20         339 B
NRMX3751 241 133 8954859  07  05  05  13 33 1717                             EC2-9
NRMW3117 625 322 964199 1776 203 251 249296169                               A2.II
NRMW3498108  14221331930  43  17 542 128518                                  A3III
NRMW53701116 310 121 644 346 1671116 341192175 4       006003 44      4    81A1.I
BARITE;
NRMW53701116 310 121 644 346 1671116 341192175 4       006003 44      4    81A1.IS
NOBARITE;
KSPAR;
NRMW53701116 310 121 644 346 1671116 341192175 4       006003 44      4    81A1.IK
NOKSPAR;
NRMA55902050 265 158  87 298 904 426 039076 172 013   1       11          1    25
NRMA488 177  716 18  311 684 642 364 141242 5622 1   03       11           8   46
FEOT=FEO+0.8998*FE203;
SUMMARY (OXIDES,ADJUSTED,MINERALS,PARTITIONS,USER);
TERNARY Q,AB,OR;
TERNARY FEOT+MNO,NA2O+K2O,MGO;
CONVERT VALUES;
FEOT=FEO+2*FE2O3;
SUMMARY (OXIDES,ADJUSTED,MINERALS,PARTITIONS,USER);
TERNARY NE+.6*AB,Q+.4*AB+.25*HY,OL+.75*HY;
TERNARY AL2O3,NA2O+K2O,CAO;
SETFLAGS;
CLEAR;
TITLE GNAP PROBLEM 2
MODIFY FORMAT (4X,9F4.2,2F3.2,5F2.2,2F6.6,F4.4,3X,5X);
OXIDES SIO2,AL2O3,FE2O3,FEO,MGO,CAO,NA2O,K2O,H2O,TIO2,P2O5,MNO,CL,F,S,CO2,
NIO,CR2O3,BAO;
NRMB670 159  14  26  12  28  40  31   79 72 24 3 5     2   101  388 1840      1
NRMB685 152  18  10  10  24  36  44   50 32 140  4     3   227  454 1280      2
NRMB685 155  10  28  11  29  41  28   61 64 19 3 7     3    86  436 1490      3
NRMB709 148  11   72  56 22  42  38   66 20 110  3     1   177  292  974      4
NRMB718 141  11  11   27  91 35  50   65 15 10 2 3     8  123   643  583      5
NRMB72  145   6  13   39  74 35  50   70 20  2 5 20000 2  11   689  532      6
NRMB724 142  12   24  4   51 37  5   123 14  1 2 2 2  00  10   55   459      7
NRMB726 152   33  84  40 22  42  34   38 19  5 1 4     6    96   4671120     8
NRMB72611449  76 112  41  75 331 534  58 12  6 3 3 200 1   994  613  698      9
NRMB728 138   50  88  28  93 33  52   63 19 0502        2   692  685  513     10
```

```
NRMB733 135    27 23    13   97 30   57    51 10 0702        8  172   234   271       11
NRMB735 138    64  52   18   73 32   56    56  8  8 2 2     2   262   382   388       12
STO                                 1                                              DUMM1
STO                                 6                          20    7    2        DUMM2
BAPPM=10000*BAO;
UPPM=10000*NIO;
THPPM=10000*CR203;
SUMMARY (ADJUSTED,MINERALS,USER);
BAO=1.1168*BAO;
NIO=0.0;
CR203=0.0;
RECALCULATE NORMS;
SUMMARY (OXIDES,ADJUSTED,MINERALS,D.I.,BARTH,NIGGLI,RATIOS,USER);
PLOT(R) K20,BAO;
PLOT UPPM,THPPM;
DEVICE= CALCOMP ;
TERNARY UPPM,THPPM,0.83*K20;
DEVICE=PRINTER;
CONVERT VALUES;
PERAL=AL203/(NA20+K20+CAO);
PRINT PERAL;
```

GNAP PROBLEM 1

SAMPLE NO. MN06A PLOTTING SYMBOL IS *

ORIGINAL WT.PCT. OXIDES

SIO2	AL203	FE203	FEO	MGO	CAO	NA2O	K2O	H2O	TIO2	P2O5	MNO	ZRO2	CO2	SO3	CL	F	S	CR2O3	NIO	BAO
48.30	14.80	2.40	9.10	8.10	10.00	1.26	0.12	3.63	0.68	0.13	0.21	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00

SUM OF ORIGINAL OXIDES= 100.13

SUM ADJUSTED FOR F & CL= 99.81

OXIDES NORMALIZED TO 100 PERCENT :

CONSTITUENTS	SIO2	AL203	FE203	FEO	MGO	CAO	NA2O	K2O	H2O	TIO2	P2O5	AL203/SIO2
PERCENTAGES	48.30	14.80	2.40	9.10	8.10	10.00	1.26	0.12	3.63	0.68	0.13	0.306
MOL. AMTS.	0.8054	0.1454	0.0151	0.1269	0.2013	0.1787	0.0204	0.0013	0.2019	0.0085	0.0009	

CONSTITUENTS	MNO	ZRO2	CO2	SO3	CL	F	S	CR2O3	NIO	BAO	FEO/FE2O3
PERCENTAGES	0.21	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	3.792
MOL. AMTS.	0.0030	0.0000	0.0000	0.0000	0.0396	0.0000	0.0000	0.0000	0.0000	0.0000	

CIPW NORM :

MINERALS	Q	C	Z	OR	AB	AN	LC	NE	KP	HL	TH	NC
MOL. AMTS.	0.1675	0.0000	0.0000	0.0013	0.0006	0.1436	0.0000	0.0000	0.0000	0.0198	0.0000	0.0000
PERCENTAGES	10.062	0.000	0.000	0.710	0.307	39.943	0.000	0.000	0.000	2.312	0.000	0.000

MINERALS	AC	NS	KS	WO	EN	FS	FO	FA	CS	MT	CM	HM
MOL. AMTS.	0.0000	0.0000	0.0000	0.0320	0.2013	0.1063	0.0000	0.0000	0.0000	0.0151	0.0000	0.0000
PERCENTAGES	0.000	0.000	0.000	3.721	20.212	14.022	0.000	0.000	0.000	3.486	0.000	0.000

MINERALS	IL	TN	PF	RU	AP	FR	PR	CC	MG	SD	TOTAL	SALIC	FEMIC
MOL. AMTS.	0.0085	0.0000	0.0000	0.0000	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000			
PERCENTAGES	1.294	0.000	0.000	0.000	0.309	0.000	0.000	0.000	0.000	0.000	96.379	53.334	43.044

MINERALS	DI	DI-WO	DI-EN	DI-FS	HY	HY-EN	HY-FS	OL	OL-FO	OL-FA	WOL
MOL. AMTS.	0.0320	0.0320	0.0210	0.0111	0.2756	0.1804	0.0952	0.0000	0.0000	0.0000	0.0000
PERCENTAGES	7.286	3.721	2.105	1.460	30.669	18.107	12.562	0.000	0.000	0.000	0.000

THORNTON + TUTTLE DIFFERENTIATION INDEX = 11.079

BARTHS CATIONS	SI	AL	FE+3	FE+2	MG	CA	NA	K	H	TI	P	MN
	47.66	17.21	1.78	7.51	11.91	10.57	2.41	0.15	23.89	0.50	0.11	0.18

	ZR	C	S1	CL	F	S2	CR	NI	BA
	0.00	0.00	0.00	2.34	0.00	0.00	0.00	0.00	0.00

NIGGLI VALUES	AL*	FM*	C*	ALK*	SI	RI	P	H	K	MG	SI*	QZ
	20.57	51.10	25.27	3.06	113.91	1.21	0.13	28.55	0.06	0.56	112.25	1.67

GNAP PROBLEM 1

SAMPLE NO. MN06B PLOTTING SYMBOL IS #

ORIGINAL WT.PCT. OXIDES

SIO2	AL203	FE203	FEO	MGO	CAO	NA2O	K2O	H2O	TIO2	P2O5	MNO	ZRO2	CO2	SO3	CL	F	S	CR2O3	NIO	BAO
48.30	14.80	2.40	9.10	8.10	10.00	1.26	0.12	3.63	0.68	0.13	0.21	0.00	0.00	0.00	1.53	0.00	0.00	0.00	0.00	0.00

SUM OF ORIGINAL OXIDES= 100.26

SUM ADJUSTED FOR F & CL= 99.91

OXIDES NORMALIZED TO 100 PERCENT :

CONSTITUENTS	SIO2	AL203	FE203	FEO	MGO	CAO	NA2O	K2O	H2O	TIO2	P2O5	AL203/SIO2
PERCENTAGES	48.30	14.80	2.40	9.10	8.10	10.00	1.26	0.12	3.63	0.68	0.13	0.306
MOL. AMTS.	0.8046	0.1453	0.0150	0.1268	0.2011	0.1785	0.0203	0.0013	0.2017	0.0085	0.0009	

CONSTITUENTS	MNO	ZRO2	CO2	SO3	CL	F	S	CR2O3	NIO	BAO	FEO/FE2O3
PERCENTAGES	0.21	0.00	0.00	0.00	1.53	0.00	0.00	0.00	0.00	0.00	3.792
MOL. AMTS.	0.0030	0.0000	0.0000	0.0000	0.0432	0.0000	0.0000	0.0000	0.0000	0.0000	

CIPW NORM :

MINERALS	Q	C	Z	OR	AB	AN	LC	NE	KP	HL	TH	NC
MOL. AMTS.	0.1702	0.0000	0.0000	0.0013	0.0000	0.1440	0.0000	0.0000	0.0000	0.0203	0.0000	0.0000
PERCENTAGES	10.227	0.000	0.000	0.710	0.000	40.066	0.000	0.000	0.000	2.378	0.000	0.000

MINERALS	AC	NS	KS	WO	EN	FS	FO	FA	CS	MT	CM	HM
MOL. AMTS.	0.0000	0.0000	0.0000	0.0314	0.2011	0.1062	0.0000	0.0000	0.0000	0.0150	0.0000	0.0000
PERCENTAGES	0.000	0.000	0.000	3.649	20.192	14.008	0.000	0.000	0.000	3.483	0.000	0.000

MINERALS	IL	TN	PF	RU	AP	FR	PR	CC	MG	SD	TOTAL	SALIC	FEMIC
MOL. AMTS.	0.0085	0.0000	0.0000	0.0000	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000			
PERCENTAGES	1.293	0.000	0.000	0.000	0.308	0.000	0.000	0.000	0.000	0.000	96.314	53.381	42.933

MINERALS	DI	DI-WO	DI-EN	DI-FS	HY	HY-EN	HY-FS	OL	OL-FO	OL-FA	WOL
MOL. AMTS.	0.0314	0.0314	0.0206	0.0109	0.2759	0.1806	0.0953	0.0000	0.0000	0.0000	0.0000
PERCENTAGES	7.146	3.649	2.064	1.432	30.704	18.128	12.576	0.000	0.000	0.000	0.000

THORNTON + TUTTLE DIFFERENTIATION INDEX = 10.937

BARTHS CATIONS	SI	AL	FE+3	FE+2	MG	CA	NA	K	H	TI	P	MN
	47.66	17.21	1.78	7.51	11.91	10.57	2.41	0.15	23.89	0.50	0.11	0.18

	ZR	C	S1	CL	F	S2	CR	NI	BA
	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00

NIGGLI VALUES	AL*	FM*	C*	ALK*	SI	RI	P	H	K	MG	SI'	QZ
	20.57	51.10	25.27	3.06	113.91	1.21	0.13	28.55	0.06	0.56	112.25	1.67

GNAP PROBLEM 1

SAMPLE NO. MN06H PLOTTING SYMBOL IS S

ORIGINAL WT.PCT. OXIDES

SIO2	AL2O3	FE2O3	FEO	MGO	CAO	NA2O	K2O	H2O	TIO2	P2O5	MNO	ZRO2	CO2	SO3	CL	F	S	CR2O3	NIO	BAO
48.30	14.80	2.40	9.10	8.10	10.00	1.26	0.12	3.63	0.68	0.13	0.21	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00

SUM OF ORIGINAL OXIDES= 100.13

SUM ADJUSTED FOR F & CL= 99.81

OXIDES NORMALIZED TO 100 PERCENT : (H2O FREE)

CONSTITUENTS	SIO2	AL2O3	FE2O3	FEO	MGO	CAO	NA2O	K2O	H2O	TIO2	P2O5	AL2O3/SIO2
PERCENTAGES	50.22	15.39	2.50	9.46	8.42	10.40	1.31	0.12	0.00	0.71	0.14	0.306
MOL. AMTS.	0.8358	0.1509	0.0156	0.1317	0.2089	0.1854	0.0211	0.0013	0.0000	0.0088	0.0010	

CONSTITUENTS	MNO	ZRO2	CO2	SO3	CL	F	S	CR2O3	NIO	BAO	FEO/FE2O3
PERCENTAGES	0.22	0.00	0.00	0.00	1.46	0.00	0.00	0.00	0.00	0.00	3.792
MOL. AMTS.	0.0031	0.0000	0.0000	0.0000	0.0411	0.0000	0.0000	0.0000	0.0000	0.0000	

CIPW NORM : (H2O FREE)

MINERALS	Q	C	Z	OR	AB	AN	LC	NE	KP	HL	TH	NC
MOL. AMTS.	0.1738	0.0000	0.0000	0.0013	0.0006	0.1490	0.0000	0.0000	0.0000	0.0205	0.0000	0.0000
PERCENTAGES	10.441	0.000	0.000	0.737	0.319	41.450	0.300	0.000	0.000	2.400	0.000	0.000

MINERALS	AC	NS	KS	WO	EN	FS	FO	FA	CS	MT	CM	HM
MOL. AMTS.	0.0000	0.0000	0.0000	0.0332	0.2089	0.1103	0.0000	0.0000	0.0000	0.0156	0.0000	0.0000
PERCENTAGES	0.000	0.000	0.000	3.862	20.975	14.551	0.300	0.000	0.000	3.618	0.000	0.000

MINERALS	IL	TN	PF	RU	AP	FR	PR	CC	MG	SD	TOTAL	SALIC	FEMIC
MOL. AMTS.	0.0088	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000			
PERCENTAGES	1.343	0.000	0.000	0.000	0.320	0.000	0.000	0.000	0.000	0.000	100.016	55.347	44.669

MINERALS	DI	DI-WO	DI-EN	DI-FS	HY	HY-EN	HY-FS	OL	OL-FO	OL-FA	WOL
MOL. AMTS.	0.0332	0.0332	0.0218	0.0115	0.2860	0.1872	0.0988	0.0000	0.0000	0.0000	0.0000
PERCENTAGES	7.561	3.862	2.184	1.515	31.827	18.791	13.036	0.000	0.000	0.000	0.000

THORNTON + TUTTLE DIFFERENTIATION INDEX = 11.498

BARTHS CATIONS	SI	AL	FE+3	FE+2	MG	CA	NA	K	H	TI	P	MN
	47.66	17.21	1.78	7.51	11.91	10.57	2.41	0.15	0.00	0.50	0.11	0.18

	ZR	C	S1	CL	F	S2	CR	NI	BA
	0.00	0.00	0.00	2.34	0.00	0.00	0.00	0.00	0.00

NIGGLI VALUES	AL*	FM*	C*	ALK*	SI	RI	P	H	K	MG	SI'	QZ
	20.57	51.10	25.27	3.06	113.91	1.21	0.13	0.00	0.06	0.56	112.25	1.67

(45)

GNAP PROBLEM 1

FEOT DEFINED AS FEO+0.8999*FE2O3

GNAP PROBLEM 1

SYMBOL	MN06A *	MN06B #	MN06H S	1201A *	1201B #	1165A *	1165B #	1165C S	1101A *	1101B #	344 A *	344 B #
SIO2	48.30	48.30	48.30	67.80	67.80	74.90	74.90	74.90	75.90	75.90	73.80	73.80
AL203	14.80	14.80	14.80	17.90	17.90	14.30	14.30	14.30	13.80	13.80	13.30	13.30
FE203	2.40	2.40	2.40	0.45	0.45	0.90	0.90	0.90	0.10	0.10	1.30	1.30
FEO	9.10	9.10	9.10	0.80	0.80	0.26	0.26	0.26	0.68	0.68	0.04	0.04
MGO	8.10	8.10	8.10	0.61	0.30	0.20	0.10	0.10	0.11	0.11	0.45	0.45
CAO	10.00	10.00	10.00	0.25	0.10	0.24	0.12	0.12	0.18	0.18	0.44	0.22
NA20	1.26	1.26	1.26	9.60	9.60	7.60	7.60	7.60	3.00	3.00	2.40	2.40
K20	0.12	0.12	0.12	0.53	0.53	0.30	0.30	0.30	7.00	7.00	5.80	5.80
H20	3.63	3.63	3.63	1.78	1.78	0.66	0.66	0.66	0.47	0.47	1.50	1.50
TIO2	0.68	0.68	0.68	0.23	0.23	0.13	0.13	0.13	0.14	0.14	0.21	0.21
P205	0.13	0.13	0.13	0.05	0.05	0.03	0.03	0.03	0.02	0.02	0.08	0.26
MNO	0.21	0.21	0.21	0.02	0.02	0.02	0.02	0.02	0.05	0.05	0.02	0.02
ZRO2												
CO2				0.03	0.60	0.02	0.40	0.40	0.03	0.03	0.06	0.06
SO3						0.62	0.62	0.62				
CL	1.40	1.53	1.40	0.03	0.03	0.03	0.03	0.03	0.01	0.01		
F				0.04						0.15	0.02	0.01
S												
CR203												
BAO												
TOTAL(-O)	99.81	99.91	99.81	100.10	100.18	100.20	100.36	100.36	101.49	101.57	99.41	99.37
ADJUSTED OXIDES												
SIO2	48.39	48.34	50.22	67.73	67.68	74.75	74.63	74.63	74.79	74.72	74.24	74.27
AL203	14.83	14.81	15.39	17.88	17.87	14.27	14.25	14.25	13.60	13.59	13.38	13.38
FE203	2.40	2.40	2.50	0.45	0.45	0.90	0.90	0.90	0.10	0.10	1.31	1.31
FEO	9.12	9.11	9.46	0.80	0.80	0.26	0.26	0.26	0.67	0.67	0.04	0.04
MGO	8.12	8.11	8.42	0.61	0.30	0.20	0.10	0.10	0.11	0.11	0.45	0.45
CAO	10.02	10.01	10.40	0.25	0.10	0.24	0.12	0.12	0.18	0.18	0.44	0.22
NA20	1.26	1.26	1.31	9.59	9.58	7.58	7.57	7.57	2.96	2.95	2.41	2.42
K20	0.12	0.12	0.12	0.53	0.53	0.30	0.30	0.30	6.90	6.89	5.83	5.84
H20	3.64	3.63		1.78	1.78	0.66	0.66	0.66	0.46	0.46	1.51	1.51
TIO2	0.68	0.68	0.71	0.23	0.23	0.13	0.13	0.13	0.14	0.14	0.21	0.21
P205	0.13	0.13	0.14	0.05	0.05	0.03	0.03	0.03	0.02	0.02	0.08	0.26
MNO	0.21	0.21	0.22	0.02	0.02	0.02	0.02	0.02	0.05	0.05	0.02	0.02
ZRO2												
CO2				0.03	0.60	0.02	0.40	0.40	0.03	0.03	0.06	0.06
SO3						0.62	0.62	0.62				
CL	1.40	1.53	1.46	0.03	0.03	0.03	0.03	0.03	0.01	0.01		
F				0.04						0.15	0.02	0.01
S												
CR203												
BAO												
NORMATIVE MINERALS												
Q	10.062	10.227	10.441	8.623	10.058	31.752	32.372	35.317	30.381	30.639	36.676	37.292
C				1.405	1.574	1.983	2.297	3.075	1.077	1.282	2.655	3.094
Z												
OR	0.710	0.710	0.737	3.129	3.126	1.769	1.766	1.766	40.759	40.724	34.477	34.493
AB	0.307		0.319	80.933	80.863	59.904	59.809	55.059	24.940	24.919	20.428	20.438
AN	39.943	40.066	41.450	0.463		0.866		0.398	0.564		1.194	
LC												
NE												
KP												

HL	2.312	2.378	2.400	0.049	0.049	0.049	0.049	0.049	0.016	0.016		
TH						1.098	1.096	1.096				
NC								0.960				
AC												
NS												
KS												
WO	3.721	3.649	3.862									
EN	20.212	20.192	20.975	1.518		0.497		0.248	0.270	0.202	1.127	0.990
FS	14.022	14.008	14.551	0.754	0.018				1.013	1.012		
TO												
FA												
CS												
MT	3.486	3.483	3.618	0.652	0.651	0.525		0.525	0.143	0.143		
CM												
HM						0.536	0.897	0.535			1.308	1.308
IL	1.294	1.293	1.343	0.436	0.436	0.246	0.246	0.246	0.262	0.262	0.128	0.128
TN												
PF												
RU											0.144	0.144
AP	0.309	0.308	0.320	0.118	0.118	0.071	0.071	0.071	0.047	0.047	0.191	0.398
FR				0.073						0.211	0.027	
PR												
CC				0.068	0.061	0.045	0.143		0.067		0.137	
MG					0.626		0.208			0.057		0.116
SD					0.646		0.262					
TOTAL	96.379	96.314	100.016	98.222	98.226	99.343	99.217	99.344	99.539	99.513	98.491	98.400
SALIC	53.334	53.381	55.347	94.603	95.670	97.422	97.390	97.720	97.737	97.580	95.430	95.316
FEMIC	43.044	42.933	44.669	3.619	2.556	1.921	1.828	1.624	1.802	1.933	3.061	3.084
DI	7.286	7.146	7.561									
DIWO	3.721	3.649	3.862									
DIEN	2.105	2.064	2.184									
DIFS	1.460	1.432	1.515									
HY	30.669	30.704	31.827	2.272	0.018	0.497		0.248	1.283	1.214	1.127	0.990
HYEN	18.107	18.128	18.791	1.518		0.497		0.248	0.270	0.202	1.127	0.990
HYFS	12.562	12.576	13.036	0.754	0.018				1.013	1.012		
OL												
OLFO												
OLFA												
WOL												
USER DEFINED VARIABLES												
FEOT	11.260	11.260	11.260	1.205	1.205	1.070	1.070	1.070	0.770	0.770	1.210	1.210

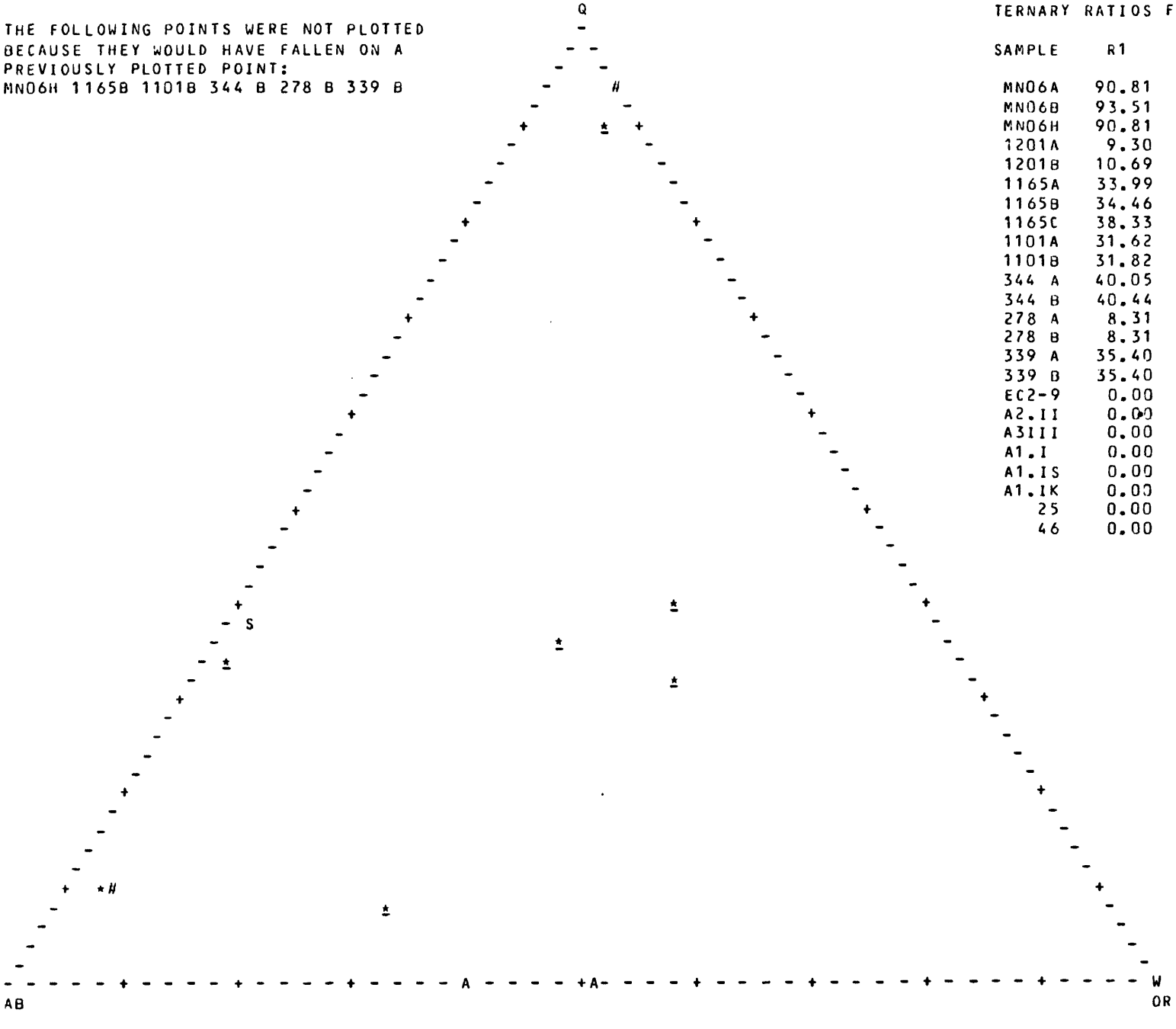
GNAP PROBLEM 1

SYMBOL	278 A *	278 B #	339 A *	339 B #	EC2-9 X	A2.II W	A3III W	A1.I W	A1.IS W	A1.IK W	25 A	46 A
SIO2	52.10	52.10	72.90	72.90	37.51	31.17	34.98	53.70	53.70	53.70	55.90	48.80
AL203	16.60	16.60	13.50	13.50	2.41	6.25	10.80	11.16	11.16	11.16	20.50	17.70
FE203	8.30	8.30	1.90	1.90	1.83	3.22	1.42	3.10	3.10	3.10	2.65	7.16
FEO	0.80	0.20	0.08	0.08	8.95	9.64	21.33	1.21	1.21	1.21	1.58	1.80
MGO	4.50	4.50	0.36	0.36	48.59	19.90	19.30	6.44	6.44	6.44	0.87	3.11
CAO	6.60	6.60	1.20	1.20	0.07	17.76	0.43	3.46	3.46	3.46	2.98	6.84
NA20	3.70	3.70	3.60	3.60	0.05	2.03	0.17	1.67	1.67	1.67	9.04	6.42
K20	2.40	2.40	4.60	4.60	0.05	2.51	5.42	11.16	11.16	11.16	4.26	3.64
H20	3.00	3.00	0.85	0.85	0.13	2.49	1.28	3.41	3.41	3.41	0.39	1.41
TIO2	1.70	1.70	0.37	0.37	0.33	2.96	5.18	1.92	1.92	1.92	0.76	2.42
P205	0.81	0.81	0.10	0.10	0.17	1.69		1.75	1.75	1.75	0.17	0.56
MNO	0.10	0.10	0.04	0.04	0.17			0.04	0.04	0.04	0.20	0.22
ZRO2											0.13	0.10
CO2	0.02	0.02	0.01	0.01							0.01	0.03
SO3								0.06	0.06	0.06		
CL								0.03	0.03	0.03		
F	0.03	0.03	0.02	0.02				0.44	0.44	0.44	0.11	0.11
S				0.20								
CR203		0.70						0.04	0.04	0.04		
BAO								0.81	0.81	0.81	0.10	0.08
TOTAL(-O)	100.65	100.75	99.52	99.72	100.26	99.62	100.31	100.21	100.21	100.21	99.60	100.35
ADJUSTED OXIDES												
SIO2	51.76	51.71	73.25	73.10	37.41	31.29	34.87	53.59	53.59	53.59	56.12	48.63
AL203	16.49	16.48	13.56	13.54	2.40	6.27	10.77	11.14	11.14	11.14	20.58	17.64
FE203	8.25	8.24	1.91	1.91	1.83	3.23	1.42	3.09	3.09	3.09	2.66	7.13
FEO	0.79	0.20	0.08	0.08	8.93	9.68	21.26	1.21	1.21	1.21	1.59	1.79
MGO	4.47	4.47	0.36	0.36	48.46	19.98	19.24	6.43	6.43	6.43	0.87	3.10
CAO	6.56	6.55	1.21	1.20	0.07	17.83	0.43	3.45	3.45	3.45	2.99	6.82
NA20	3.68	3.67	3.62	3.61	0.05	2.04	0.17	1.67	1.67	1.67	9.08	6.40
K20	2.38	2.38	4.62	4.61	0.05	2.52	5.40	11.14	11.14	11.14	4.28	3.63
H20	2.98	2.98	0.85	0.85	0.13	2.50	1.28	3.40	3.40	3.40	0.39	1.41
TIO2	1.69	1.69	0.37	0.37	0.33	2.97	5.16	1.92	1.92	1.92	0.76	2.41
P205	0.80	0.80	0.10	0.10	0.17	1.70		1.75	1.75	1.75	0.17	0.56
MNO	0.10	0.10	0.04	0.04	0.17			0.04	0.04	0.04	0.20	0.22
ZRO2											0.13	0.10
CO2	0.02	0.02	0.01	0.01							0.01	0.03
SO3								0.06	0.06	0.06		
CL								0.03	0.03	0.03		
F	0.03	0.03	0.02	0.02				0.44	0.44	0.44	0.11	0.11
S				0.20								
CR203		0.69						0.04	0.04	0.04		
BAO								0.81	0.81	0.81	0.10	0.08
NORMATIVE MINERALS												
Q	4.094	4.090	31.745	31.681								
C			0.713	0.711	2.268		3.860					
Z											0.194	0.148
OR	14.091	14.077	27.313	27.259				60.803	60.803	60.803	25.274	21.434
AB	31.107	31.076	30.609	30.547							37.860	20.994
AN	21.459	21.438	5.180	5.170		0.531	2.127				2.787	8.697
LC							20.739					
NE					0.229	9.341	0.777				21.094	17.952
KP					0.167	8.461	3.114					

HL								0.049	0.049	0.049		
TH								0.106	0.106	0.106		
NC												
AC								8.950	8.950	8.950		
NS								0.775	1.418	0.775		
KS								1.388	1.388	2.201		
WO	1.368							1.336	0.724	0.724	4.326	8.517
EN	11.135	11.124	0.901	0.899				9.157	9.157	9.157	2.175	7.360
FS												
FO					79.859	31.601	33.579	4.799	4.799	4.799		0.251
FA					10.687	7.135	22.667					
CS						23.783						
MT					2.646	4.686	2.053				3.556	
CM		0.932						0.059	0.059	0.059		
HM	8.247	8.238	1.909	1.905							0.208	7.135
IL	1.891		0.256		0.625	5.643	9.808	2.596	2.596	2.596	1.449	4.257
TN	1.701	4.005						1.348	1.348	1.348		
PF												0.289
RU		0.055	0.237	0.371								
AP	1.906	1.904	0.238	0.238	0.126	4.018		4.136	4.136	4.136	0.404	1.322
FR			0.023	0.023				0.582	0.582	0.582	0.196	0.123
PR				0.202								
CC	0.045	0.045	0.023	0.023							0.023	0.068
MG												
SD												
TOTAL	97.045	96.986	99.146	99.028	96.607	95.200	98.724	96.085	96.116	96.286	99.547	98.547
SALIC	70.752	70.681	95.560	95.368	2.664	18.332	30.617	60.959	60.959	60.959	87.209	69.226
FEMIC	26.293	26.304	3.587	3.660	93.943	76.868	68.107	35.126	35.157	35.327	12.338	29.321
DI	2.550							2.491	1.349	1.349	4.692	15.877
DIWO	1.368							1.336	0.724	0.724	2.517	8.517
DIEN	1.182							1.155	0.626	0.626	2.175	7.360
DIFS												
HY	9.953	11.124	0.901	0.899				8.003	8.532	8.532		
HYEN	9.953	11.124	0.901	0.899				8.003	8.532	8.532		
HYFS												
OL					90.546	38.737	56.247	4.799	4.799	4.799		0.251
OLFO					79.859	31.601	33.579	4.799	4.799	4.799		0.251
OLFA					10.687	7.135	22.667					
WOL											1.809	
USER DEFINED VARIABLES												
FEOT	8.268	7.668	1.790	1.790	10.597	12.537	22.608	3.999	3.999	3.999	3.964	8.243

GNAP PROBLEM 1

THE FOLLOWING POINTS WERE NOT PLOTTED
BECAUSE THEY WOULD HAVE FALLEN ON A
PREVIOUSLY PLOTTED POINT:
MN06H 1165B 1101B 344 B 278 B 339 B



TERNARY RATIOS FOR Q,AB,CR

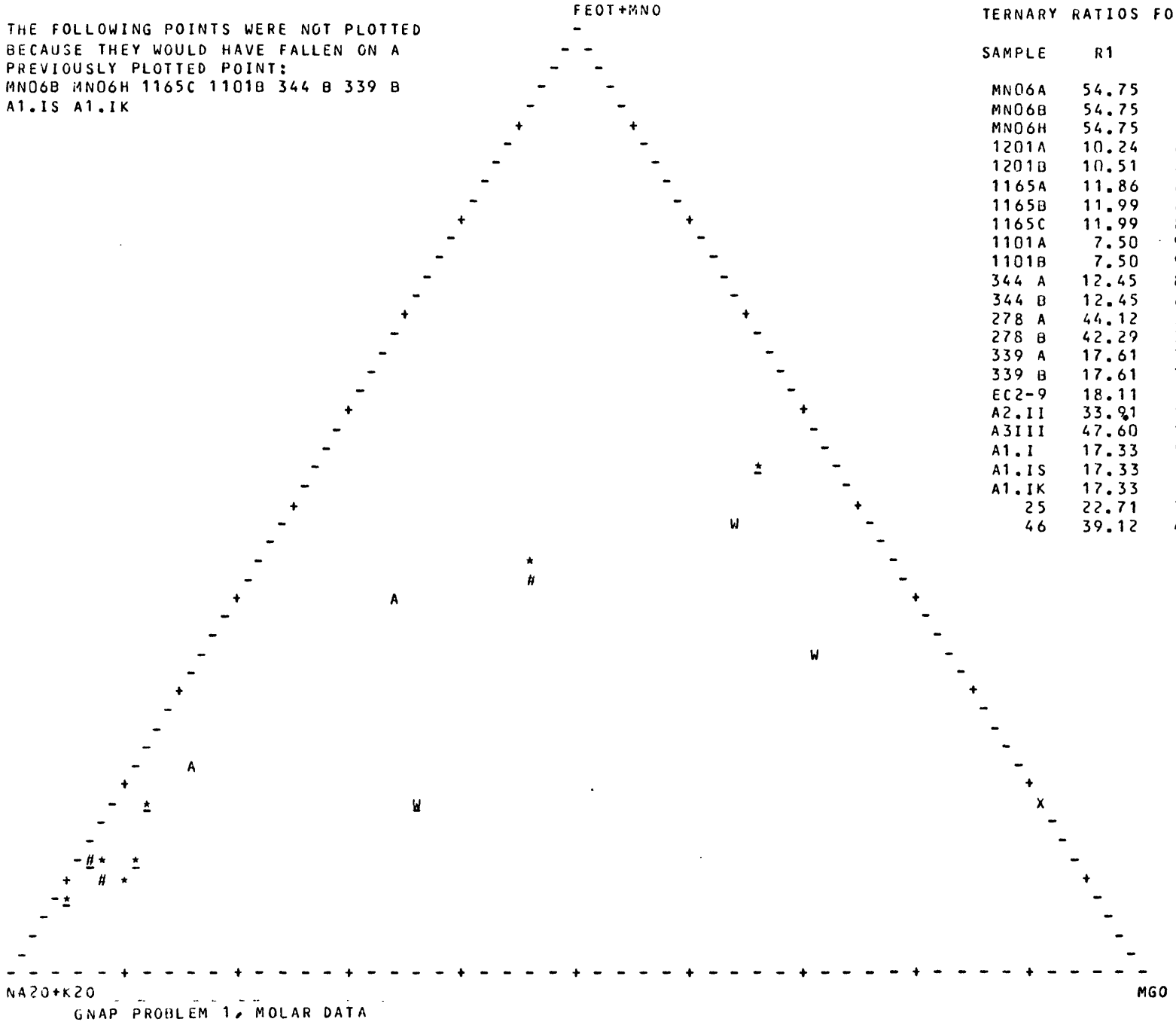
SAMPLE	R1	R2	R3	SYMBOL
MN06A	90.81	2.77	6.41	*
MN06B	93.51	0.00	6.49	#
MN06H	90.81	2.77	6.41	S
1201A	9.30	87.32	3.38	*
1201B	10.69	85.98	3.32	#
1165A	33.99	64.12	1.89	*
1165B	34.46	63.66	1.88	#
1165C	38.33	59.75	1.92	S
1101A	31.62	25.96	42.42	*
1101B	31.82	25.88	42.30	#
344 A	40.05	22.31	37.65	*
344 B	40.44	22.16	37.40	#
278 A	8.31	63.11	28.59	*
278 B	8.31	63.11	28.59	#
339 A	35.40	34.14	30.46	*
339 B	35.40	34.14	30.46	#
EC2-9	0.00	100.00	0.00	X
A2.II	0.00	100.00	0.00	W
A3III	0.00	100.00	0.00	W
A1.I	0.00	0.00	100.00	W
A1.IS	0.00	0.00	100.00	W
A1.IK	0.00	0.00	100.00	W
25	0.00	59.97	40.03	A
46	0.00	49.48	50.52	A

GNAP PROBLEM 1

THE FOLLOWING POINTS WERE NOT PLOTTED
BECAUSE THEY WOULD HAVE FALLEN ON A
PREVIOUSLY PLOTTED POINT:
MN06B MN06H 1165C 1101B 344 B 339 B
A1.IS A1.IK

TERNARY RATIOS FOR FEOT+MNO,NA2O+K2O,MGO

SAMPLE	R1	R2	R3	SYMBOL
MN06A	54.75	6.59	38.66	*
MN06B	54.75	6.59	38.66	#
MN06H	54.75	6.59	38.66	S
1201A	10.24	84.66	5.10	*
1201B	10.51	86.92	2.57	#
1165A	11.86	85.96	2.18	*
1165B	11.99	86.91	1.10	#
1165C	11.99	86.91	1.10	S
1101A	7.50	91.49	1.01	*
1101B	7.50	91.49	1.01	#
344 A	12.45	83.00	4.55	*
344 B	12.45	83.00	4.55	#
278 A	44.12	32.16	23.72	*
278 B	42.29	33.21	24.50	#
339 A	17.61	78.92	3.46	*
339 B	17.61	78.92	3.46	#
EC2-9	18.11	0.17	81.72	X
A2.II	33.91	12.28	53.82	W
A3III	47.60	11.77	40.63	W
A1.I	17.33	55.04	27.63	W
A1.IS	17.33	55.04	27.63	W
A1.IK	17.33	55.04	27.63	W
25	22.71	72.54	4.75	A
46	39.12	46.50	14.38	A



GNAP PROBLEM 1, MOLAR DATA

FEOT DEFINED AS FEO+2*FE2O3

GNAP PROBLEM 1, MOLAR DATA

SYMBOL	MN06A *	MN06B #	MN06H S	1201A *	1201B #	1165A *	1165B #	1165C S	1101A *	1101B #	344 A *	344 B #
SIO2	0.80	0.80	0.80	1.13	1.13	1.25	1.25	1.25	1.26	1.26	1.23	1.23
AL203	0.15	0.15	0.15	0.18	0.18	0.14	0.14	0.14	0.14	0.14	0.13	0.13
FE203	0.02	0.02	0.02	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01
FEO	0.13	0.13	0.13	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00
MGO	0.20	0.20	0.20	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
CAO	0.18	0.18	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
NA20	0.02	0.02	0.02	0.15	0.15	0.12	0.12	0.12	0.05	0.05	0.04	0.04
K20	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.07	0.07	0.06	0.06
H20	0.20	0.20	0.20	0.10	0.10	0.04	0.04	0.04	0.03	0.03	0.08	0.08
TIG2	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P205	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZRO2												
CO2				0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00
SO3						0.01	0.01	0.01				
CL	0.04	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
F				0.00						0.01	0.00	0.00
S												
CR203												
BAO												
ADJUSTED OXIDES												
SIO2	0.81	0.80	0.84	1.13	1.13	1.24	1.24	1.24	1.24	1.24	1.24	1.24
AL203	0.15	0.15	0.15	0.18	0.18	0.14	0.14	0.14	0.13	0.13	0.13	0.13
FE203	0.02	0.02	0.02	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01
FEO	0.13	0.13	0.13	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00
MGO	0.20	0.20	0.21	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
CAO	0.18	0.18	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
NA20	0.02	0.02	0.02	0.15	0.15	0.12	0.12	0.12	0.05	0.05	0.04	0.04
K20	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.07	0.07	0.06	0.06
H20	0.20	0.20		0.10	0.10	0.04	0.04	0.04	0.03	0.03	0.08	0.08
TIO2	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P205	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZRO2												
CO2				0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00
SO3						0.01	0.01	0.01				
CL	0.04	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
F				0.00						0.01	0.00	0.00
S												
CR203												
BAO												
NORMATIVE MINERALS												
Q	0.167	0.170	0.174	0.144	0.167	0.528	0.539	0.588	0.506	0.510	0.610	0.621
C				0.014	0.015	0.019	0.023	0.030	0.011	0.013	0.026	0.030
Z												
OR	0.001	0.001	0.001	0.006	0.006	0.003	0.003	0.003	0.073	0.073	0.062	0.062
AB	0.001		0.001	0.154	0.154	0.114	0.114	0.105	0.048	0.048	0.039	0.039
AN	0.144	0.144	0.149	0.002		0.003		0.001	0.002		0.004	
LC												
NE												
KP												
HL	0.020	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000		

TH						0.008	0.008	0.008					
NC								0.009					
AC													
NS													
KS													
WO	0.032	0.031	0.033										
EN	0.201	0.201	0.209	0.015		0.005		0.002	0.003	0.002	0.011	0.010	
FS	0.106	0.106	0.110	0.006	0.000				0.008	0.008			
FO													
FA													
CS													
MT	0.015	0.015	0.016	0.003	0.003	0.002		0.002	0.001	0.001			
CM													
HM						0.003	0.006	0.003			0.008	0.008	
IL	0.009	0.009	0.009	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	
TN													
PF													
RU											0.002	0.002	
AP	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	
FR				0.001						0.003	0.000		
PR													
CC				0.001	0.001	0.000	0.001		0.001		0.001		
MG					0.007		0.002			0.001		0.001	
SD					0.006		0.002						
DI	0.064	0.063	0.066										
DIWO	0.032	0.031	0.033										
DIEN	0.021	0.021	0.022										
DIFS	0.011	0.011	0.011										
HY	0.276	0.276	0.286	0.021	0.000	0.005		0.002	0.010	0.010	0.011	0.010	
HYEN	0.180	0.181	0.187	0.015		0.005		0.002	0.003	0.002	0.011	0.010	
HYFS	0.095	0.095	0.099	0.006	0.000				0.008	0.008			
OL													
OLFO													
OLFA													
WOL													
USER DEFINED VARIABLES													
FEOT	0.157	0.157	0.157	0.017	0.017	0.015	0.015	0.015	0.011	0.011	0.017	0.017	

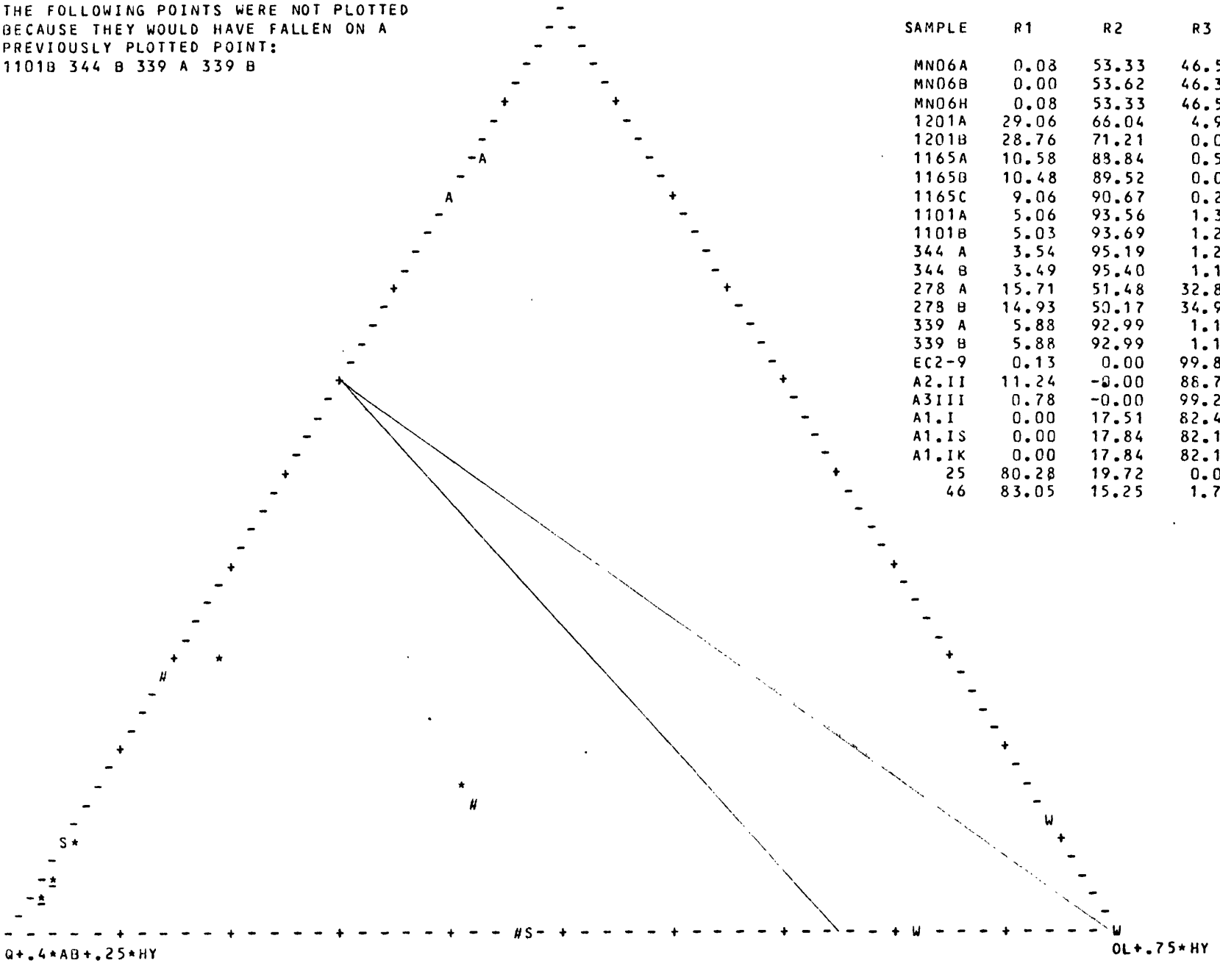
GNAP PROBLEM 1, MOLAR DATA

SYMBOL	278 A *	278 B #	339 A *	339 B #	EC2-9 X	A2.II W	A3III W	A1.I W	A1.IS W	A1.IK W	25 A	46 A
SIO2	0.87	0.87	1.21	1.21	0.62	0.52	0.58	0.89	0.89	0.89	0.93	0.81
AL203	0.16	0.16	0.13	0.13	0.02	0.06	0.11	0.11	0.11	0.11	0.20	0.17
FE203	0.05	0.05	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.04
FEO	0.01	0.00	0.00	0.00	0.12	0.13	0.30	0.02	0.02	0.02	0.02	0.03
MGO	0.11	0.11	0.01	0.01	1.21	0.49	0.48	0.16	0.16	0.16	0.02	0.08
CAO	0.12	0.12	0.02	0.02	0.00	0.32	0.01	0.06	0.06	0.06	0.05	0.12
NA20	0.06	0.06	0.06	0.06	0.00	0.03	0.00	0.03	0.03	0.03	0.15	0.10
K20	0.03	0.03	0.05	0.05	0.00	0.03	0.06	0.12	0.12	0.12	0.05	0.04
H20	0.17	0.17	0.05	0.05	0.01	0.14	0.07	0.19	0.19	0.19	0.02	0.08
TIO2	0.02	0.02	0.00	0.00	0.00	0.04	0.06	0.02	0.02	0.02	0.01	0.03
P205	0.01	0.01	0.00	0.00	0.00	0.01		0.01	0.01	0.01	0.00	0.00
MNO	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00
ZRO2											0.00	0.00
CO2	0.00	0.00	0.00	0.00							0.00	0.00
SO3								0.00	0.00	0.00		
CL								0.00	0.00	0.00		
F	0.00	0.00	0.00	0.00				0.02	0.02	0.02	0.01	0.01
S				0.01								
CR203		0.00						0.00	0.00	0.00		
BAO								0.01	0.01	0.01	0.00	0.00
ADJUSTED OXIDES												
SIO2	0.86	0.86	1.22	1.22	0.62	0.52	0.58	0.89	0.89	0.89	0.93	0.81
AL203	0.16	0.16	0.13	0.13	0.02	0.06	0.11	0.11	0.11	0.11	0.20	0.17
FE203	0.05	0.05	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.04
FEO	0.01	0.00	0.00	0.00	0.12	0.13	0.30	0.02	0.02	0.02	0.02	0.02
MGO	0.11	0.11	0.01	0.01	1.20	0.50	0.48	0.16	0.16	0.16	0.02	0.08
CAO	0.12	0.12	0.02	0.02	0.00	0.32	0.01	0.06	0.06	0.06	0.05	0.12
NA20	0.06	0.06	0.06	0.06	0.00	0.03	0.00	0.03	0.03	0.03	0.15	0.10
K20	0.03	0.03	0.05	0.05	0.00	0.03	0.06	0.12	0.12	0.12	0.05	0.04
H20	0.17	0.17	0.05	0.05	0.01	0.14	0.07	0.19	0.19	0.19	0.02	0.08
TIO2	0.02	0.02	0.00	0.00	0.00	0.04	0.06	0.02	0.02	0.02	0.01	0.03
P205	0.01	0.01	0.00	0.00	0.00	0.01		0.01	0.01	0.01	0.00	0.00
MNO	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00
ZRO2											0.00	0.00
CO2	0.00	0.00	0.00	0.00							0.00	0.00
SO3								0.00	0.00	0.00		
CL								0.00	0.00	0.00		
F	0.00	0.00	0.00	0.00				0.02	0.02	0.02	0.01	0.01
S				0.01								
CR203		0.00						0.00	0.00	0.00		
BAO								0.01	0.01	0.01	0.00	0.00
NORMATIVE MINERALS												
Q	0.068	0.068	0.528	0.527								
C			0.007	0.007	0.022		0.038					
Z											0.001	0.001
OR	0.025	0.025	0.049	0.049				0.109	0.109	0.109	0.045	0.039
AB	0.059	0.059	0.058	0.058							0.072	0.040
AN	0.077	0.077	0.019	0.019		0.002	0.008				0.010	0.031
LC							0.048					
NE					0.001	0.033	0.003				0.074	0.063
KP					0.001	0.027	0.010					
HL								0.000	0.000	0.000		

TH								0.001	0.001	0.001			
NC													
AC								0.019	0.019	0.019			
NS								0.006	0.012	0.006			
KS								0.009	0.009	0.014			
WO	0.012							0.012	0.006	0.006	0.037	0.073	
EN	0.111	0.111	0.009	0.009				0.091	0.091	0.091	0.022	0.073	
FS													
FO					0.568	0.225	0.239	0.034	0.034	0.034		0.002	
FA					0.052	0.035	0.111						
CS						0.138							
MT					0.011	0.020	0.009				0.015		
CM		0.004						0.000	0.000	0.000			
HM	0.052	0.052	0.012	0.012							0.001	0.045	
IL	0.012		0.002		0.004	0.037	0.065	0.017	0.017	0.017	0.010	0.028	
TN	0.009	0.020						0.007	0.007	0.007			
PF												0.002	
RU		0.001	0.003	0.005									
AP	0.006	0.006	0.001	0.001	0.000	0.012		0.012	0.012	0.012	0.001	0.004	
FR			0.000	0.000				0.007	0.007	0.007	0.003	0.002	
PR				0.002									
CC	0.000	0.000	0.000	0.000							0.000	0.001	
MC													
SD													
DI	0.024							0.023	0.012	0.012	0.043	0.147	
DIWO	0.012							0.012	0.006	0.006	0.022	0.073	
DIEN	0.012							0.012	0.006	0.006	0.022	0.073	
DIFS													
HY	0.099	0.111	0.009	0.009				0.080	0.085	0.085			
HYEN	0.099	0.111	0.009	0.009				0.080	0.085	0.085			
HYFS													
OL					0.620	0.260	0.350	0.034	0.034	0.034		0.002	
OLFO					0.568	0.225	0.239	0.034	0.034	0.034		0.002	
OLFA					0.052	0.035	0.111						
WOL											0.016		
USER DEFINED VARIABLES													
FEOT	0.115	0.107	0.025	0.025	0.147	0.175	0.315	0.056	0.056	0.056	0.055	0.115	

GNAP PROBLEM 1, MOLAR DATA

THE FOLLOWING POINTS WERE NOT PLOTTED
BECAUSE THEY WOULD HAVE FALLEN ON A
PREVIOUSLY PLOTTED POINT:
1101B 344 B 339 A 339 B

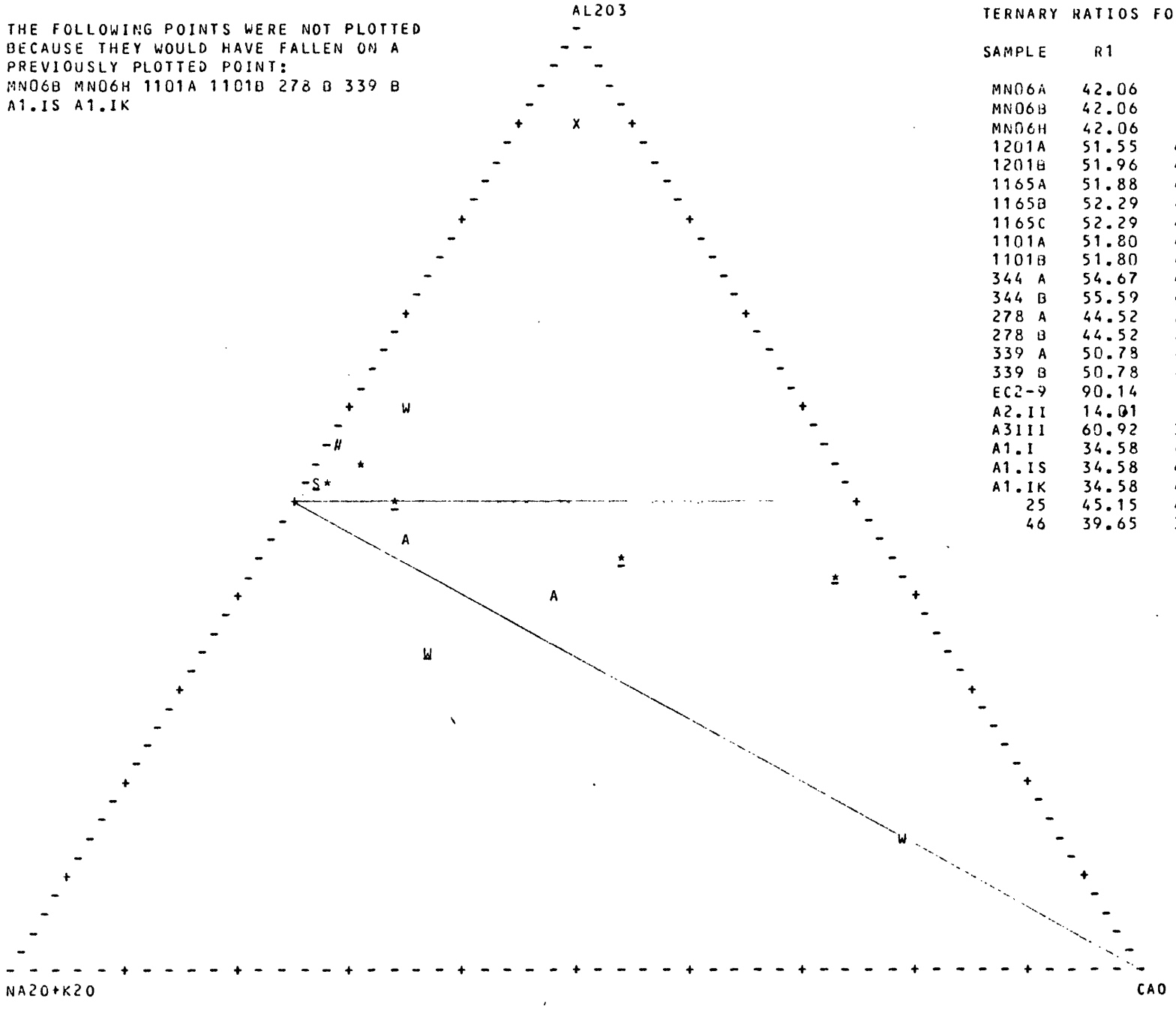


TERNARY RATIOS FOR NE+.6*AB,Q+.4*AB+.25*HY,OL+.75*HY

SAMPLE	R1	R2	R3	SYMBOL
MN06A	0.08	53.33	46.59	*
MN06B	0.00	53.62	46.38	#
MN06H	0.08	53.33	46.59	S
1201A	29.06	66.04	4.90	*
1201B	28.76	71.21	0.03	#
1165A	10.58	88.84	0.57	*
1165B	10.48	89.52	0.00	#
1165C	9.06	90.67	0.27	S
1101A	5.06	93.56	1.38	*
1101B	5.03	93.69	1.28	#
344 A	3.54	95.19	1.27	*
344 B	3.49	95.40	1.10	#
278 A	15.71	51.48	32.81	*
278 B	14.93	50.17	34.90	#
339 A	5.88	92.99	1.13	*
339 B	5.88	92.99	1.13	#
EC2-9	0.13	0.00	99.87	X
A2.II	11.24	-0.00	88.76	W
A3III	0.78	-0.00	99.22	W
A1.I	0.00	17.51	82.49	W
A1.IS	0.00	17.84	82.16	W
A1.IK	0.00	17.84	82.16	W
25	80.28	19.72	0.00	A
46	83.05	15.25	1.70	A

GNAP PROBLEM 1, MOLAR DATA

THE FOLLOWING POINTS WERE NOT PLOTTED
BECAUSE THEY WOULD HAVE FALLEN ON A
PREVIOUSLY PLOTTED POINT:
MN06B MN06H 1101A 1101B 278 B 339 B
A1.IS A1.IK



TERNARY RATIOS FOR AL203,NA20+K20,CAO

SAMPLE	R1	R2	R3	SYMBOL
MN06A	42.06	6.26	51.68	*
MN06B	42.06	6.26	51.68	#
MN06H	42.06	6.26	51.68	S
1201A	51.55	47.14	1.31	*
1201B	51.96	47.51	0.53	#
1165A	51.88	46.54	1.58	*
1165B	52.29	46.91	0.80	#
1165C	52.29	46.91	0.80	S
1101A	51.80	46.97	1.23	*
1101B	51.80	46.97	1.23	#
344 A	54.67	42.04	3.29	*
344 B	55.59	42.74	1.67	#
278 A	44.52	23.29	32.18	*
278 B	44.52	23.29	32.18	#
339 A	50.78	41.01	8.21	*
339 B	50.78	41.01	8.21	#
EC2-9	90.14	5.10	4.76	X
A2.II	14.01	13.58	72.41	W
A3III	60.92	34.67	4.41	W
A1.I	34.58	45.93	19.49	W
A1.IS	34.58	45.93	19.49	W
A1.IK	34.58	45.93	19.49	W
25	45.15	42.91	11.93	A
46	39.65	32.49	27.86	A

GNAP PROBLEM 1, MOLAR DATA

ERROR MESSAGES AND RUN CONDITIONS

SAMPLE MN06B CONTAINS AN EXCESS OF 0.09 WEIGHT PERCENT CL
BEYOND THAT USED IN NORMATIVE CALCULATIONS

SAMPLE MN06H--NORM COMPUTED ON WATER FREE BASES.

SAMPLE 1165B CONTAINS AN EXCESS OF 0.13 WEIGHT PERCENT CO2
BEYOND THAT USED IN NORMATIVE CALCULATIONS

SAMPLE 1165C--NA2CO3 CALCULATION ATTEMPTED.

SAMPLE 1101B CONTAINS AN EXCESS OF 0.04 WEIGHT PERCENT F
BEYOND THAT USED IN NORMATIVE CALCULATIONS

SAMPLE 344 B CONTAINS AN EXCESS OF 0.09 WEIGHT PERCENT P2O5
BEYOND THAT USED IN NORMATIVE CALCULATIONS

SAMPLE 278 B CONTAINS AN EXCESS OF 0.06 WEIGHT PERCENT CR2O3
BEYOND THAT USED IN NORMATIVE CALCULATIONS

SAMPLE 339 B CONTAINS AN EXCESS OF 0.09 WEIGHT PERCENT S
BEYOND THAT USED IN NORMATIVE CALCULATIONS

SAMPLE EC?-9 CONTAINS AN EXCESS OF 0.12 WEIGHT PERCENT P2O5
BEYOND THAT USED IN NORMATIVE CALCULATIONS

SAMPLE EC?-9 CONTAINS TOO LITTLE SIO? TO COMPUTE NORM
SIO2 DEFICIENCY IS EQUIVALENT TO AN EXCESS OF MGO OF 2.71 WT %
AND AN EXCESS OF FEO OF 0.45 WT %.

SAMPLE A2.II CONTAINS TOO LITTLE SIO? TO COMPUTE NORM
SIO2 DEFICIENCY IS EQUIVALENT TO AN EXCESS OF MGO OF 1.87 WT %
AND AN EXCESS OF FEO OF 0.52 WT %.

SAMPLE A1.IS--BAO ADDED TO NA2O.

SAMPLE A1.IK--BAO ADED TO K2O.

GNAP PROBLEM 2

BAPPM DEFINED AS 10000*BAO

UPPM DEFINED AS 10000*NIO

THPPM DEFINED AS 10000*CR2O3

GNAP PROBLEM 2

	1	2	3	4	5	6	7	8	9	10	11	12
SYMBOL	B	B	B	B	B	B	B	B	B	B	B	B
ADJUSTED OXIDES												
SIO2	66.98	69.15	68.22	71.34	72.62	72.66	73.04	72.60	72.83	73.79	73.31	74.25
AL203	15.90	15.35	15.44	14.89	14.26	14.63	14.32	15.20	14.53	13.99	13.50	13.94
FE203	1.40	1.82	1.00	1.11	1.11	0.61	1.21	0.33	0.76	0.51	0.27	0.65
FEO	2.60	1.01	2.79	0.72	1.11	1.31	0.24	0.84	1.12	0.89	2.30	0.53
MGO	1.20	1.01	1.10	0.56	0.27	0.39	0.40	0.40	0.41	0.28	0.13	0.18
CAO	2.80	2.42	2.89	2.21	0.92	0.75	0.51	2.20	0.75	0.94	0.97	0.74
NA20	4.00	3.63	4.08	4.23	3.54	3.53	3.73	4.20	3.32	3.34	3.00	3.23
K20	3.10	4.44	2.79	3.82	5.06	5.05	5.04	3.40	5.36	5.27	5.70	5.66
H20	0.79	0.50	0.61	0.66	0.66	0.71	1.24	0.38	0.58	0.64	0.51	0.57
TIO2	0.72	0.32	0.64	0.20	0.15	0.20	0.14	0.19	0.12	0.19	0.10	0.08
P205	0.24	0.14	0.19	0.11	0.10	0.02	0.01	0.05	0.06	0.05	0.07	0.08
MNO	0.03		0.03		0.02	0.05	0.02	0.01	0.03	0.02	0.02	0.02
CL	0.05	0.04	0.07	0.03	0.03	0.02	0.02	0.04	0.03			0.02
F							0.02		0.02			
C02	0.02	0.03	0.03	0.01	0.08	0.02		0.06	0.01	0.02	0.08	0.02
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR203	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00
BAO	0.18	0.13	0.15	0.10	0.06	0.05	0.05	0.11	0.07	0.05	0.03	0.04
NORMATIVE MINERALS												
Q	23.787	24.904	25.329	26.922	30.499	30.031	30.474	29.824	30.551	31.453	30.401	32.151
C	1.444	0.534	0.974	0.043	1.725	2.091	1.864	0.852	2.111	1.200	0.967	1.402
OR	18.314	26.249	16.479	22.595	29.884	29.816	29.806	20.091	31.650	31.146	33.689	33.430
AB	33.468	30.455	34.037	35.536	29.730	29.737	31.434	35.242	27.870	28.303	25.390	27.205
AN	12.527	11.140	13.173	10.373	3.501	3.543	2.429	10.411	3.295	4.312	3.899	3.074
HL	0.082	0.067	0.115	0.050	0.050	0.033	0.033	0.066	0.050			0.033
EN	2.988	2.514	2.728	1.403	0.680	0.980	1.005	0.996	1.024	0.707	0.324	0.453
FS	2.481		3.297	0.081	0.908	1.665		0.974	1.287	0.934	3.874	0.332
MT	2.029	2.311	1.444	1.605	1.613	0.878	0.431	0.478	1.105	0.735	0.392	0.937
CM	0.006	0.007	0.006	0.004	0.010	0.010	0.008	0.001	0.009	0.010	0.003	0.006
HM		0.223					0.913					
IL	1.367	0.614	1.211	0.382	0.288	0.383	0.268	0.361	0.229	0.366	0.190	0.153
AP	0.568	0.335	0.448	0.262	0.240	0.048	0.024	0.118	0.143	0.120	0.166	0.191
FR							0.040		0.030			
CC	0.045	0.069	0.068	0.023	0.184	0.046		0.136	0.023	0.046	0.182	0.046
TOTAL	99.107	99.421	99.309	99.280	99.311	99.261	98.730	99.552	99.374	99.331	99.476	99.414
SALIC	89.622	93.348	90.106	95.518	95.389	95.251	96.041	96.486	95.525	96.413	94.346	97.295
FEMIC	9.485	6.073	9.203	3.761	3.922	4.011	2.689	3.065	3.849	2.918	5.131	2.119
USER DEFINED VARIABLES												
BAPPM	*******	*******	*******	974.000	583.000	532.000	459.000	*******	698.000	513.000	271.000	388.000
UPPM	1.010	2.270	0.860	1.770	12.300	11.000	10.000	0.960	9.940	6.920	17.200	2.620
THPPM	38.800	45.400	43.600	29.200	64.300	68.900	55.000	4.670	61.300	68.500	23.400	38.200

GNAP PROBLEM 2

BAO DEFINED AS 1.1168*BAO

NIO DEFINED AS 0.0

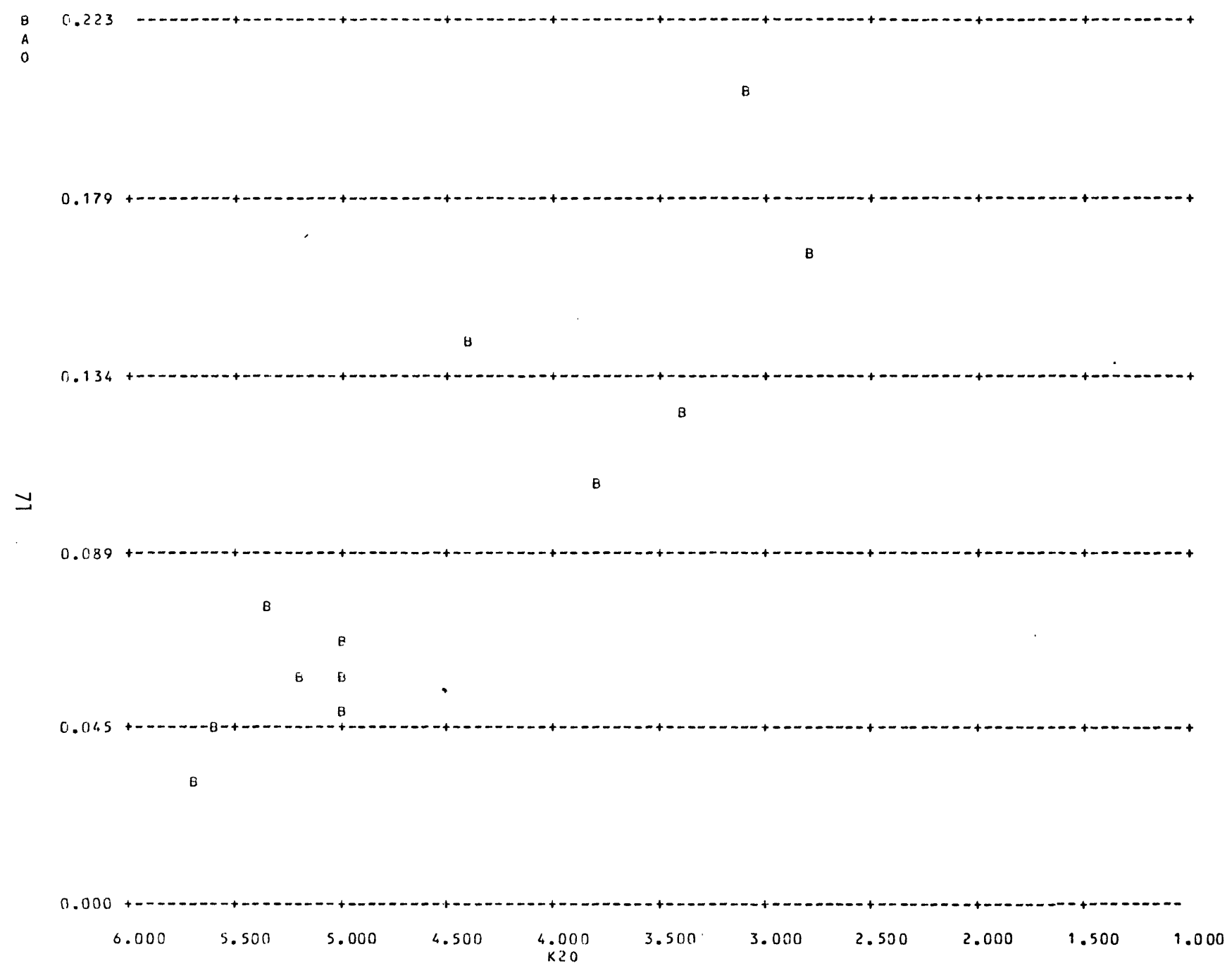
CR203 DEFINED AS 0.0

GNAP PROBLEM 2

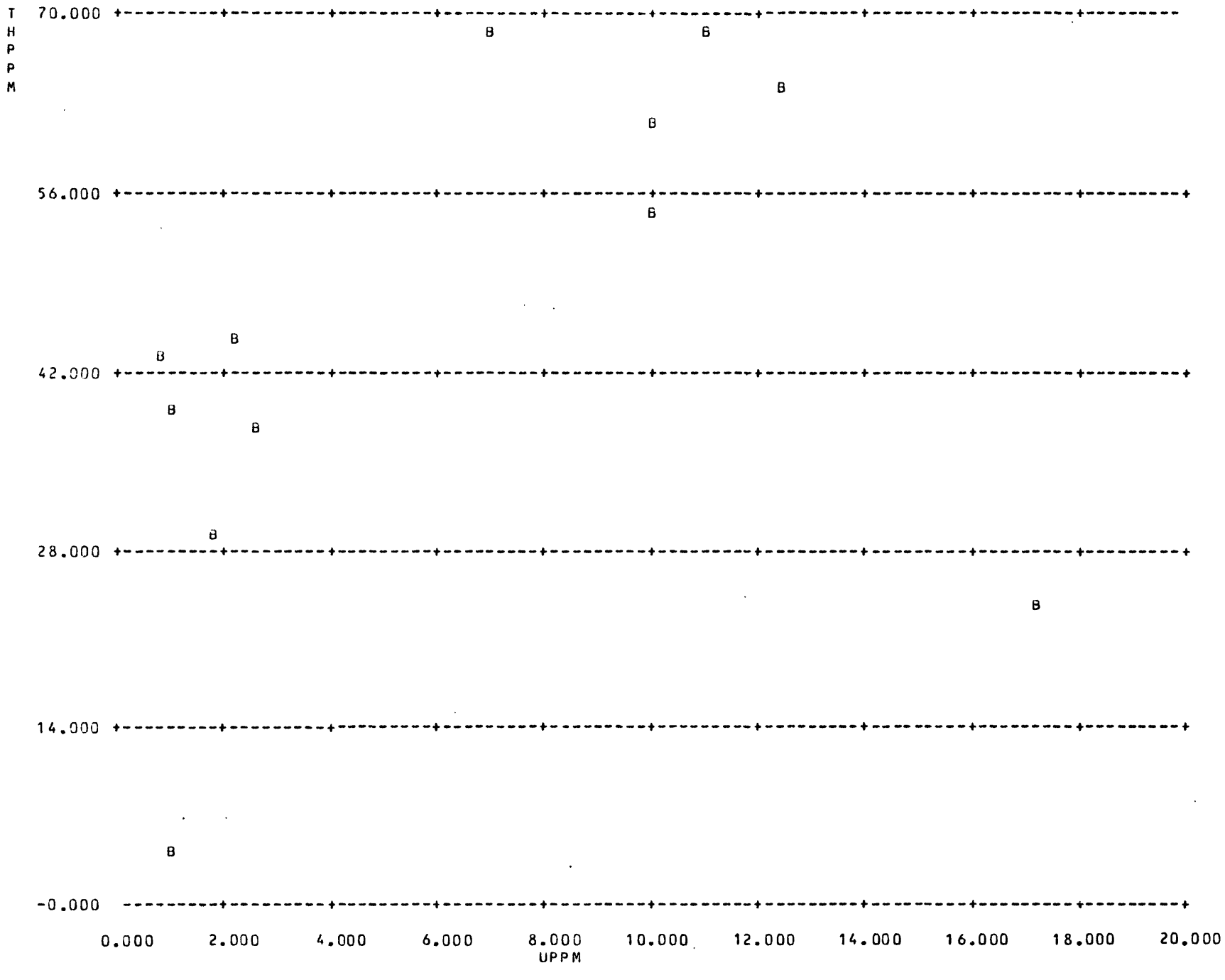
	1	2	3	4	5	6	7	8	9	10	11	12
SYMBOL	B	B	B	B	B	B	B	B	B	B	B	B
SIO2	67.00	68.50	68.50	70.90	71.80	72.00	72.40	72.60	72.61	72.80	73.30	73.50
AL203	15.90	15.20	15.50	14.80	14.10	14.50	14.20	15.20	14.49	13.80	13.50	13.80
FE203	1.40	1.80	1.00	1.10	1.10	0.60	1.20	0.33	0.76	0.50	0.27	0.64
FEO	2.60	1.00	2.80	0.72	1.10	1.30	0.24	0.84	1.12	0.88	2.30	0.52
MGO	1.20	1.00	1.10	0.56	0.27	0.39	0.40	0.40	0.41	0.28	0.13	0.18
CAO	2.80	2.40	2.90	2.20	0.91	0.74	0.51	2.20	0.75	0.93	0.97	0.73
NA20	4.00	3.60	4.10	4.20	3.50	3.50	3.70	4.20	3.31	3.30	3.00	3.20
K20	3.10	4.40	2.80	3.80	5.00	5.00	5.00	3.40	5.34	5.20	5.70	5.60
H20	0.79	0.50	0.61	0.66	0.65	0.70	1.23	0.38	0.58	0.63	0.51	0.56
TIO2	0.72	0.32	0.64	0.20	0.15	0.20	0.14	0.19	0.12	0.19	0.10	0.08
P205	0.24	0.14	0.19	0.11	0.10	0.02	0.01	0.05	0.06	0.05	0.07	0.08
MNO	0.03		0.03		0.02	0.05	0.02	0.01	0.03	0.02	0.02	0.02
CL	0.05	0.04	0.07	0.03	0.03	0.02	0.02	0.04	0.03			0.02
F							0.02		0.02			
CO2	0.02	0.03	0.03	0.01	0.08	0.02		0.06	0.01	0.02	0.08	0.02
BAO	0.21	0.14	0.17	0.11	0.07	0.06	0.05	0.13	0.08	0.06	0.03	0.04
TOTAL(-O)	100.04	99.06	100.42	99.39	98.87	99.09	99.13	100.02	99.70	98.66	99.98	98.99
ADJUSTED OXIDES												
SIO2	66.97	69.15	68.21	71.33	72.62	72.66	73.04	72.59	72.83	73.79	73.31	74.25
AL203	15.89	15.34	15.44	14.89	14.26	14.63	14.32	15.20	14.53	13.99	13.50	13.94
FE203	1.40	1.82	1.00	1.11	1.11	0.61	1.21	0.33	0.76	0.51	0.27	0.65
FEO	2.60	1.01	2.79	0.72	1.11	1.31	0.24	0.84	1.12	0.89	2.30	0.53
MGO	1.20	1.01	1.10	0.56	0.27	0.39	0.40	0.40	0.41	0.28	0.13	0.18
CAO	2.80	2.42	2.89	2.21	0.92	0.75	0.51	2.20	0.75	0.94	0.97	0.74
NA20	4.00	3.63	4.08	4.23	3.54	3.53	3.73	4.20	3.32	3.34	3.00	3.23
K20	3.10	4.44	2.79	3.82	5.06	5.05	5.04	3.40	5.36	5.27	5.70	5.66
H20	0.79	0.50	0.61	0.66	0.66	0.71	1.24	0.38	0.58	0.64	0.51	0.57
TIO2	0.72	0.32	0.64	0.20	0.15	0.20	0.14	0.19	0.12	0.19	0.10	0.08
P205	0.24	0.14	0.19	0.11	0.10	0.02	0.01	0.05	0.06	0.05	0.07	0.08
MNO	0.03		0.03		0.02	0.05	0.02	0.01	0.03	0.02	0.02	0.02
CL	0.05	0.04	0.07	0.03	0.03	0.02	0.02	0.04	0.03			0.02
F							0.02		0.02			
CO2	0.02	0.03	0.03	0.01	0.08	0.02		0.06	0.01	0.02	0.08	0.02
NIO												
CR203												
BAO	0.21	0.14	0.17	0.11	0.07	0.06	0.05	0.13	0.08	0.06	0.03	0.04
NORMATIVE MINERALS												
Q	23.764	24.890	25.310	26.910	30.492	30.025	30.471	29.810	30.542	31.446	30.399	32.146
C	1.429	0.524	0.962	0.035	1.720	2.087	1.860	0.844	2.105	1.196	0.965	1.399
OR	18.311	26.247	16.477	22.593	29.885	29.816	29.806	20.088	31.650	31.146	33.689	33.430
AB	33.462	30.451	34.032	35.533	29.731	29.737	31.434	35.238	27.869	28.304	25.390	27.205
AN	12.564	11.166	13.202	10.393	3.513	3.554	2.439	10.434	3.310	4.323	3.905	3.082
HL	0.082	0.067	0.115	0.050	0.050	0.033	0.033	0.066	0.050			0.033
EN	2.987	2.514	2.728	1.403	0.680	0.980	1.005	0.996	1.024	0.707	0.324	0.453
FS	2.484		3.301	0.084	0.911	1.669		0.975	1.290	0.939	3.873	0.335
MT	2.029	2.317	1.444	1.605	1.613	0.878	0.437	0.478	1.105	0.735	0.392	0.937
HM		0.219					0.909					
IL	1.367	0.613	1.210	0.382	0.288	0.383	0.268	0.361	0.229	0.366	0.190	0.153
AP	0.568	0.335	0.448	0.262	0.240	0.048	0.024	0.118	0.143	0.120	0.166	0.191
FR							0.040		0.030			
CC	0.045	0.069	0.068	0.023	0.184	0.046		0.136	0.023	0.046	0.182	0.046
TOTAL	99.093	99.411	99.298	99.272	99.306	99.257	98.727	99.544	99.369	99.327	99.475	99.411

SALIC	89.613	93.344	90.099	95.514	95.390	95.253	96.044	96.479	95.525	96.415	94.348	97.295
FEMIC	9.480	6.067	9.199	3.759	3.916	4.004	2.683	3.065	3.844	2.912	5.126	2.116
D.I.	75.537	81.588	75.819	85.036	90.107	89.578	91.711	85.136	90.061	90.896	89.479	92.780
BARTH'S CATIONS												
SI	63.00	64.80	64.08	66.73	68.34	68.29	68.90	67.71	68.47	69.42	69.20	69.82
AL	17.62	16.95	17.09	16.42	15.82	16.21	15.93	16.71	16.10	15.51	15.02	15.45
FE+3	0.99	1.28	0.70	0.78	0.79	0.43	0.86	0.23	0.54	0.36	0.19	0.46
FE+2	2.04	0.79	2.19	0.57	0.88	1.03	0.19	0.66	0.88	0.70	1.82	0.41
MG	1.68	1.41	1.53	0.79	0.38	0.55	0.57	0.56	0.58	0.40	0.18	0.25
CA	2.82	2.43	2.91	2.22	0.93	0.75	0.52	2.20	0.76	0.95	0.98	0.74
NA	7.29	6.60	7.44	7.66	6.46	6.44	6.83	7.59	6.05	6.10	5.49	5.89
K	3.72	5.31	3.34	4.56	6.07	6.05	6.07	4.04	6.42	6.33	6.86	6.79
H	4.96	3.15	3.81	4.14	4.13	4.43	7.81	2.36	3.65	4.01	3.21	3.55
TI	0.51	0.23	0.45	0.14	0.11	0.14	0.10	0.13	0.09	0.14	0.07	0.06
P	0.19	0.11	0.15	0.09	0.08	0.02	0.01	0.04	0.05	0.04	0.06	0.06
MN	0.02		0.02		0.02	0.04	0.02	0.01	0.02	0.02	0.02	0.02
C	0.03	0.04	0.04	0.01	0.10	0.03		0.08	0.01	0.03	0.10	0.03
CL	0.08	0.06	0.11	0.05	0.05	0.03	0.03	0.06	0.05			0.03
F							0.06		0.06			
BA	0.08	0.05	0.06	0.04	0.02	0.02	0.02	0.05	0.03	0.02	0.01	0.02
NIGGLI VALUES												
AL*	40.13	41.54	40.02	43.87	46.01	47.19	48.02	46.75	47.09	47.24	44.47	48.39
FM*	21.60	17.07	20.85	11.39	12.00	11.94	9.85	8.12	11.83	8.98	13.07	7.15
C*	13.19	12.19	13.90	12.07	5.54	4.51	3.25	12.56	4.60	5.92	5.88	4.75
ALK*	25.08	29.20	25.24	32.67	36.45	36.35	38.88	32.57	36.48	37.85	36.58	39.71
SI	286.97	317.68	300.10	356.62	397.59	397.67	415.44	378.93	400.43	422.93	409.78	437.32
RI	2.32	1.12	2.11	0.76	0.62	0.83	0.60	0.75	0.50	0.83	0.42	0.36
P	0.44	0.27	0.35	0.23	0.23	0.05	0.02	0.11	0.14	0.12	0.17	0.20
H	11.29	7.73	8.91	11.07	12.00	12.89	23.54	6.62	10.67	12.21	9.51	11.11
K	0.34	0.45	0.31	0.37	0.48	0.48	0.47	0.35	0.51	0.51	0.56	0.54
MG	0.35	0.40	0.34	0.37	0.19	0.27	0.35	0.38	0.28	0.27	0.08	0.22
SI'	200.31	216.80	200.95	230.68	245.79	245.42	255.53	230.28	245.92	251.41	246.33	258.84
QZ	86.66	100.88	99.15	125.93	151.80	152.25	159.91	148.65	154.52	171.51	163.44	178.48
AL203/SI02	0.237	0.222	0.226	0.209	0.196	0.201	0.196	0.209	0.200	0.190	0.184	0.188
FE0/FE203	1.857	0.556	2.800	0.655	1.000	2.167	0.200	2.545	1.474	1.760	8.519	0.813
USER DEFINED VARIABLES												
BAPPM	*******	*******	*******	974.000	583.000	532.000	459.000	*******	698.000	513.000	271.000	388.000
UPPM	1.010	2.270	0.860	1.770	12.300	11.000	10.000	0.960	9.940	6.920	17.200	2.620
THPPM	38.800	45.400	43.600	29.200	64.300	68.900	55.000	4.670	61.300	68.500	23.400	38.200

GNAP PROBLEM 2



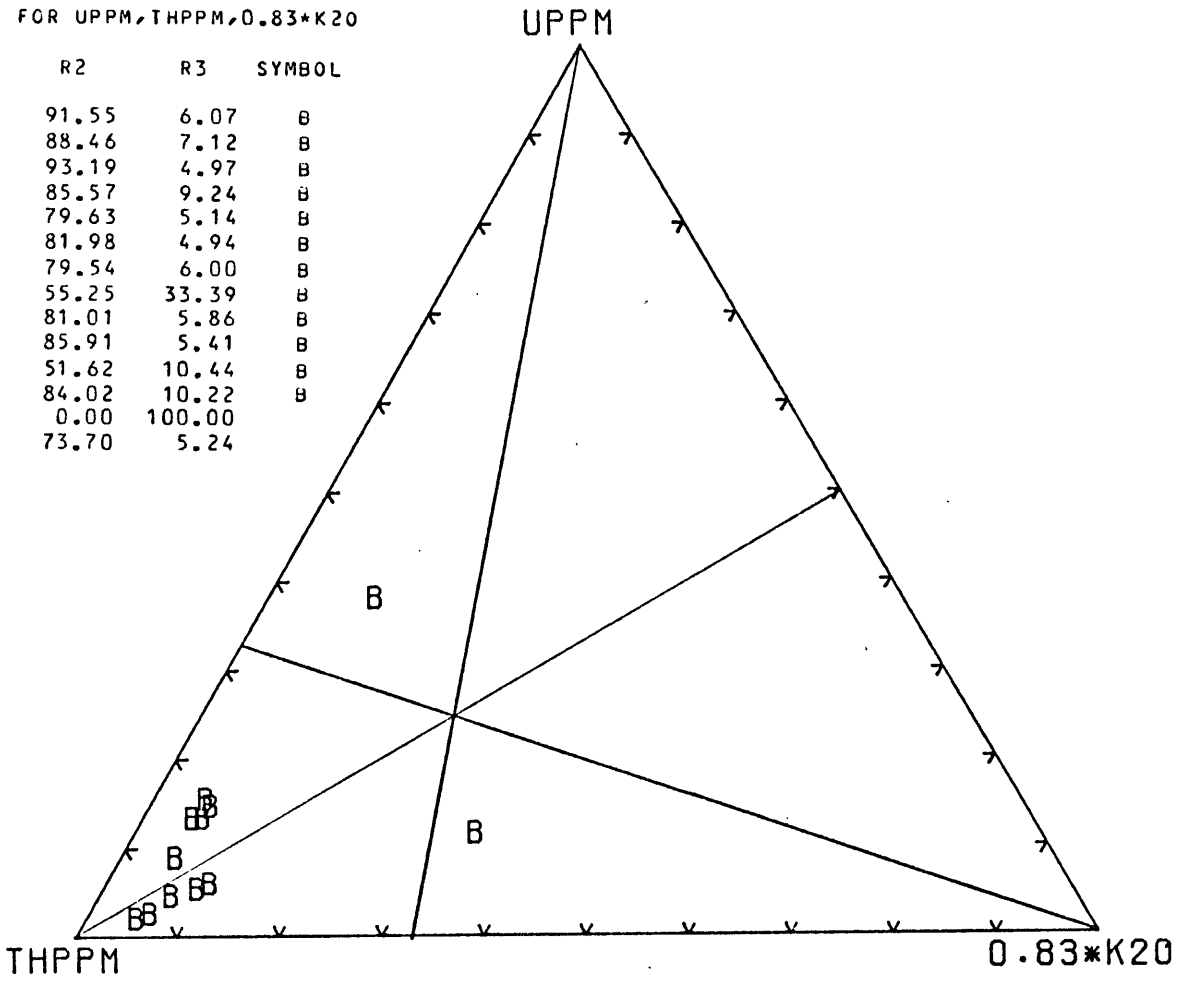
GNAP PROBLEM 2



GNAP PROBLEM 2

TERNARY RATIOS FOR UPPM,THPPM,0.83*K20

SAMPLE	R1	R2	R3	SYMBOL
1	2.38	91.55	6.07	B
2	4.42	88.46	7.12	B
3	1.84	93.19	4.97	B
4	5.19	85.57	9.24	B
5	15.23	79.63	5.14	B
6	13.09	81.98	4.94	B
7	14.46	79.54	6.00	B
8	11.36	55.25	33.39	B
9	13.14	81.01	5.86	B
10	8.68	85.91	5.41	B
11	37.94	51.62	10.44	B
12	5.76	84.02	10.22	B
DUMM1	0.00	0.00	100.00	
DUMM2	21.06	73.70	5.24	



GNAP PROBLEM 2, MOLAR DATA

PERAL DEFINED AS AL2O3/(NA2O+K2O+CAO)

GNAP PROBLEM 2, MOLAR DATA

EVALUATION OF PERAL

ID	VALUE	ID	VALUE	ID	VALUE	ID	VALUE	ID	VALUE	ID	VALUE
1	1.058	2	1.010	3	1.030	4	0.985	5	1.099	6	1.159
7	1.143	8	1.042	9	1.151	10	1.083	11	1.049	12	1.091
DUMM1	0.000	DUMM2	0.000								

APPENDIX II

PROGRAM LISTING

Main Program

```
C      * * * * * * GRAPHICAL NORMATIVE ANALYSIS PROGRAM (GNAP) * * * * * *
C                              U.S. GEOLOGICAL SURVEY
C                        GEOLOGIC DIVISION, DENVER, COLORADO
C                              WRITTEN BY ROGER W. BOWEN
C                                 ON JANUARY 15, 1971
C                           MODIFIED BY GEORGE VANTRUMP, JR.
C                                 ON MARCH 12, 1979
C      ------------------------------------------------------------------
       EXTERNAL NOTEQ(DESCRIPTORS)
       REAL NIGGLI(12, 99)
       LOGICAL ERR,STORE,NOTEQ,STAND,DEFINE,PRNTER,SWCC,NORMAL,
      1 SWITCH(5),CONVTD
       INTEGER SYMBOL,CARD(80),STMT(160),FORMAT(60),BLANK,FARMAT(15),
      1 HEADG(92),TFORM(4),SYM(99),RASSYM,DUMMY(15),SPFMT(15),EXTN(12),
      2 SEMIC,CNT,PT,BUFFER(1000),ORDER(21),RNAME(2),ASK,NMX(5),NMY(5),
      3 IDENT(2,99),NAMES(2,81),DEFTLE(20),PAGE(132,180),COMAND(4,12)
       DIMENSION X(101),Y(101),ADJUST(21,99),VALUES(81,99),AREA(14058),
      1 TTDI(99),RATIOS(2,99),TOTALS(2,99),TYPES(2,99),BARTHS(21,99)
       COMMON /UNITS/ HEADG,TFORM,INPUT,LISTPR,LISTTY,LISTERR
       COMMON /FLAGS/ SWITCH,CONVTD,STORE,NORMAL,PRNTER
       COMMON /BULKSTOR/ PAGE,RASSYM
       COMMON /MASK/ TTDI,ADJUST,VALUES,NIGGLI,BARTHS,RATIOS,TOTALS,TYPES
       EQUIVALENCE (TTDI(1),AREA(1)),(BUFFER(1),PAGE(1,1))
       DATA PT,BLANK,SEMIC,ASK,SWCC/80,' ',';','*',.false./
       DATA DEFTLE/'GRAP','HIC ','NORM','ATIV','E AN','ALYS','IS P',
      1 'ROGR','AM  ',11*'    '/
       DATA EXTN/',',' ','M','O','L','A','R',' ','D','A','T','A'/
       DATA DUMMY/'(4x9','f4.2',',2f3','.2,f','2.2,',',f3.2',',f4 ',
      1           '.2,5','f3.2',',f2.','2,f3',',.2,5','x)  ',2*'    '/
       DATA SPFMT/
      1 '(10(','1x,f','6.0)',',10x',',10(','1x,f','6.0)',',10x',
      2 ',10(','1x,f','6.0)',')   ',3*'    '/
       DATA NAMES/
      1 'SIO2',' ','AL2O','3','FE2O','3','FEO ',' ','MGO ',' ',
      2 'CAO ',' ','NA2O',' ','K2O ',' ','H2O ',' ','TIO2',' ',
      3 'P2O5',' ','MNO ',' ','ZRO2',' ','CO2 ',' ','SO3 ',' ',
      4 'CL  ',' ','F   ',' ','S   ',' ','CR2O','3','NIO ',' ',
      5 'BAO ',' ','Q   ',' ','C   ',' ','Z   ',' ','OR  ',' ',
      6 'AB  ',' ','AN  ',' ','LC  ',' ','NE  ',' ','KP  ',' ',
      7 'HL  ',' ','TH  ',' ','NC  ',' ','AC  ',' ','NS  ',' ',
      8 'KS  ',' ','WO  ',' ','EN  ',' ','FS  ',' ','FO  ',' ',
      9 'FA  ',' ','CS  ',' ','MT  ',' ','CM  ',' ','HM  ',' ',
      A 'IL  ',' ','TN  ',' ','PF  ',' ','RU  ',' ','AP  ',' ',
      B 'FR  ',' ','PR  ',' ','CC  ',' ','MG  ',' ','SD  ',' ',
      C 'DI  ',' ','DIWO',' ','DIEN',' ','DIFS',' ','HY  ',' ',
      D 'HYEN',' ','HYFS',' ','OL  ',' ','OLFO',' ','OLFA',' ',
      E 'WOL ',' ',30*'    '/
       DATA COMAND/
      1  5,'WATE','R   ','    ', 7,'NOWA','TER ','    ',
      2  8,'NOBA','RITE','    ', 6,'BARI','TE  ','    ',
      3  7,'NOKS','PAR ','    ', 5,'KSPA','R   ','    ',
      4 12,'NOCA','NCRI','NITE',10,'CANC','RINI','TE  ',
```

```
      5  5,'NOPP','S   ',','     ', 3,'PPS ',','     ',','     ',
      6  7,'SETF','LAGS',','     ', 0,'    ',','     ',','     '/
C---- OPEN FILES * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      CALL FILES (INPUT,2)
      CALL FILES (LISTPR,1)
      CALL FILES (LISTTY,3)
      CALL FILES (LISTERR,6)
C---- INITIALIZE CONSTANTS TO DEFAULT VALUES * * * * * * * * * * * * * *
  110 CNT=0
      NCS=1
      NUM=66
      NOX=21
      CALL MOVE(DUMMY,FARMAT,15)
      DECODE (DEFTLE,115) (HEADG(I),I=1,80)
  115 FORMAT (80A1)
      DO 117 I=81,92
  117 HEADG(I)=BLANK
      PRNTER=.TRUE.
      NORMAL=.TRUE.
      STORE=.FALSE.
      CONVTD=.FALSE.
      DO 118 I=1,5
  118 SWITCH(I)=.FALSE.
      SCALE=1.0
      DO 120 I=1,21
  120 ORDER(I)=I
C---- ZERO OUT ALL VALUES CALCULATED BY SUBROUTINE NORM * * * * * * * *
C       14058= 99*(1+21+81+12+21+2+2+2)= 99*142
      DO 130 I=1,14058
  130 AREA(I)=0.0
  910 DEFINE = .FALSE.
  140 LSTMT=0
  150 PT=PT+1
      IF (PT.LE.80) GO TO 210
      PT=1
      READ (INPUT,740,END=690) CARD
      IF(NORMAL) GO TO 159
      IF(NOTEQ(CARD,'LAST',4)) GO TO 151
      NORMAL=.TRUE.
      PT=80
      GO TO 910
  151 IF(NOTEQ(CARD,'SYMBOL ',7)) GO TO 152
      PASSYM=CARD(8)
      PT=80
      GO TO 910
  152 CNT=CNT+1
      IF(CNT.LE. 99) GO TO 153
      CNT= 99
      WRITE (LISTTY,750)
      WRITE (LISTERR,750)
  153 SYM(CNT)=PASSYM
      GO TO 201
  159 IF (NOTEQ(CARD,'TITLE',5)) GO TO 170
      DO 160 J=1,75
  160 HEADG(J)=CARD(J+5)
      DO 165 J=76,92
  165 HEADG(J)=BLANK
      PT=80
      GO TO 910
  170 IF (NOTEQ(CARD,'STO',3)) GO TO 180
```

```
113         STORE=.TRUE.
114         GO TO 190
115      180 IF (NOTEQ(CARD,'NRM',3)) GO TO 210
116 C---- NORM PROCESSOR * * * * * * * * * * * * * * * * * * * * * * * * * * * *
117      190 CNT=CNT+1
118         IF (CNT.LE. 99) GO TO 200
119         CNT= 99
120         WRITE (LISTTY,750)
121         WRITE (LISTERR,750)
122      200 SYM(CNT)=CARD(4)
123      201 CALL NORM (CARD,VALUES(1,CNT),FARMAT,NCS,TTDI(CNT),RATIOS(1,CNT),
124         1 TOTALS(1,CNT),TYPES(1,CNT),BARTHS(1,CNT),NIGGLI(1,CNT),
125         2 IDENT(1,CNT),NOX,ORDER,ADJUST(1,CNT),NAMES)
126         PT=80
127         GO TO 910
128 C---- BUILD COMMAND * * * * * * * * * * * * * * * * * * * * * * * * * * * *
129      210 NEXT=CARD(PT)
130         IF (NEXT.EQ.SEMIC) GO TO 230
131         IF (NEXT.EQ.BLANK) GO TO 150
132         LSTMT=LSTMT+1
133         IF (LSTMT.GT.160) GO TO 220
134         STMT(LSTMT)=NEXT
135         GO TO 150
136      220 WRITE (LISTERR,760) STMT
137         WRITE (LISTTY,760) STMT
138         GO TO 910
139 C---- STATEMENT BUILT. DETERMINE TYPE AND PROCESS * * * * * * * * * * * * *
140      230 IF (NOTEQ(STMT,'CLEAR',5)) GO TO 240
141 C---- CLEAR STORAGE PROCESSOR * * * * * * * * * * * * * * * * * * * * * * *
142         IF (LSTMT.GT.12) WRITE (LISTERR,900) (STMT(I),I=1,LSTMT)
143         CALL FILES (LISTERR,7)
144         CALL FILES (LISTERR,8)
145         CALL FILES (LISTERR,6)
146         GO TO 110
147      240 IF (NOTEQ(STMT,'SCALE=',6)) GO TO 270
148 C---- SET THE SCALE FOR THE CALCOMP PLOTTER * * * * * * * * * * * * * * * *
149         IF (LSTMT.GT.14) WRITE (LISTERR,900) (STMT(I),I=1,LSTMT)
150         IF (PRNTER) GO TO 260
151         SCALE=CONV(STMT,7,LSTMT,0,ERR)
152         IF (ERR.OR.SCALE.GT.3.0) GO TO 250
153         CALL FACTOR (SCALE)
154         GO TO 910
155      250 WRITE (LISTERR,700)
156         WRITE (LISTTY,700)
157         GO TO 910
158      260 WRITE (LISTERR,710)
159         WRITE (LISTTY,710)
160         GO TO 910
161      270 IF (NOTEQ(STMT,'OXIDES',6)) GO TO 320
162 C---- OXIDES AND ORDER STATEMENT PROCESSOR * * * * * * * * * * * * * * * * *
163         IF (LSTMT.GT.95) WRITE (LISTERR,900) (STMT(I),I=1,LSTMT)
164         J=7
165         LSTMT=LSTMT-6
166         NOX=0
167 C---- DETERMINE LENGTH (I) OF NEXT OXIDE NAME * * * * * * * * * * * * * * *
168      280 I=INDEX(STMT(J),',',LSTMT)-1
169         IF (I.LT.1) I=LSTMT
170         RNAME(1)=BLANK
171         RNAME(2)=BLANK
172         I=MIN0(I,5)
```

```
173         ENCODE(RNAME,740) (STMT(J+L-1),L=1,I)
174 C       FIND NAME IN LIST OF OXIDES.
175         DO 300 L=1,21
176    300  IF (RNAME(1).EQ.NAMES(1,L).AND.RNAME(2).EQ.NAMES(2,L)) GO TO 310
177 C----- NAME NOT FOUND, PRINT ERROR MESSAGE AND TERMINATE RUN * * * * * *
178         WRITE (LISTERR,890) (NAMES(1,I),NAMES(2,I),I=1,21),RNAME
179         WRITE (LISTTY,890) (NAMES(1,I),NAMES(2,I),I=1,21),RNAME
180         GO TO 690
181 C----- INCREASE NUMBER OF OXIDES AND STORE ORDER * * * * * * * * * * * * *
182    310  NOX=NOX+1
183         ORDER(NOX)=L
184         J=J+I+1
185         LSTMT=LSTMT-I-1
186         IF (LSTMT.GT.0) GO TO 280
187         GO TO 910
188 C----- NORM, H2O, BARITE, KSPAR, CANCRINITE STATEMENT PROCESSOR  * * * *
189    320  DO 325 I=1,11
190         IF (NOTEQ(STMT,COMAND(2,I),COMAND(1,I))) GO TO 325
191         IF (LSTMT.GT.COMAND(1,I)+1) WRITE (LISTERR,900)(STMT(I),I=1,LSTMT)
192         IF (I.GT.10) GO TO 323
193         J=(I+1)/2
194         IF (MOD(I,2).EQ.0) SWITCH(J)=.TRUE.
195         IF (MOD(I,2).NE.0) SWITCH(J)=.FALSE.
196         GO TO 910
197    323  DO 324 J=1,5
198    324  SWITCH(J)=.FALSE.
199         GO TO 910
200    325  CONTINUE
201         IF (NOTEQ(STMT,'DEVICE',6)) GO TO 370
202 C----- PLOTTING DEVICE SELECTION COMMAND PROCESSOR * * * * * * * * * * * *
203         IF (LSTMT.GT.14) WRITE (LISTERR,900) (STMT(I),I=1,LSTMT)
204         IF (NOTEQ(STMT(7),'CALCOMP',7).AND.NOTEQ(STMT(8),'CALCOMP',7)) GO
205        1TO 360
206         PRNTER=.FALSE.
207         IF (SWCC) GO TO 350
208         CALL PLOTS (BUFFER,1000,15)
209         SWCC=.TRUE.
210    350  CALL PLOT (2.0,1.12,-3)
211         GO TO 910
212    360  PRNTER=.TRUE.
213         GO TO 910
214    370  IF (NOTEQ(STMT,'SUMMARY(',8)) GO TO 375
215 C----- SUMMARY PRINT PROCESSOR * * * * * * * * * * * * * * * * * * * * * *
216         IF (LSTMT.GT.74) WRITE (LISTERR,900) (STMT(I),I=1,LSTMT)
217         LSTMT=LSTMT-8
218         CALL SUMPNT (STMT(9),LSTMT,CNT,IDENT,NAMES,NOX,ORDER,SYM,NUM,
219        1 SWITCH(1))
220         GO TO 910
221    375  CONTINUE
222         IF (NOTEQ(STMT,'MODIFY',6)) GO TO 410
223 C----- MODIFY COMMAND PROCESSOR * * * * * * * * * * * * * * * * * * * * * *
224         IF (NOTEQ(STMT(7),'FORMAT',6)) GO TO 390
225         DO 376 J=1,60
226    376  FORMAT(J)=BLANK
227         IF(NOTEQ(STMT(14),'STATPAC',7)) GO TO 378
228         DECODE(SPFMT,740) FORMAT
229         DO 377 I=1,15
230    377  FARMAT(I)=SPFMT(I)
231         NORMAL=.FALSE.
232         RASSYM=ASK
```

```
      NCS=NOX/10
      IF(10*NCS.NE.NOX) NCS=NCS+1
      IF(LSTMT.EQ.20) GO TO 910
      I=14
      J=30
      CALL MOVE(STMT(22),STMT(7),LSTMT-21)
      LSTMT=LSTMT-15
      GO TO 379
  378 IF (INDEX(STMT,')',-LSTMT).EQ.0) GO TO 380
      I=INDEX(STMT,'(',LSTMT)
      IF (I.EQ.0) GO TO 380
      J=INDEX(STMT,')',-LSTMT)
      CALL MOVE (STMT(I),FORMAT,J-I+1)
      IF(J.NE.LSTMT) GO TO 381
      ENCODE(FARMAT,740) FORMAT
      GO TO 910
  381 CALL MOVE(STMT(J+2),STMT(7),LSTMT-J-1)
      LSTMT=LSTMT-J+5
  379 CALL MOVE (FORMAT,BUFFER,J-I+1)
      CALL MOVE (STMT(11),FORMAT(2),LSTMT-10)
      CALL MOVE (BUFFER,FORMAT(LSTMT-8),J-I+1)
      FORMAT(LSTMT-7+J-I)=FORMAT(LSTMT-8+J-I)
      ENCODE(FARMAT,740) FORMAT
      IF(.NOT.NORMAL) GO TO 910
      GO TO 390
  380 WRITE (LISTERR,770) CARD
      WRITE (LISTTY,770) CARD
      GO TO 910
  390 IF (NOTEQ(STMT(7),'NCS=',4)) GO TO 400
      NCS=CONV(STMT,11,LSTMT,0,ERR)+0.1
      IF (ERR) GO TO 400
      GO TO 910
  400 WRITE (LISTERR,780) CARD
      WRITE (LISTTY,780) CARD
      NCS=1
      GO TO 910
  410 I=INDEX(STMT,'=',LSTMT)
      IF (I.EQ.0) GO TO 480
C---- DEFINITION PROCESSOR * * * * * * * * * * * * * * * * * * * * * *
      LSTM=LSTMT
      J=MIN0(8,I-1)
      RNAME(1)=BLANK
      RNAME(2)=BLANK
      ENCODE(RNAME,740) (STMT(L),L=1,J)
      LSTMT=LSTMT-I
      K=I+1
      L=NUM
      DO 430 J=1,NUM
      IF (RNAME(1).EQ.NAMES(1,J).AND.RNAME(2).EQ.NAMES(2,J)) GO TO 450
  430 CONTINUE
      J=NUM+1
      NUM=NUM+1
      IF (J.LE.81) GO TO 440
      NUM=81
      WRITE (LISTERR,790) RNAME
      WRITE (LISTTY,790) RNAME
      GO TO 910
  440 NAMES(1,J)=RNAME(1)
      NAMES(2,J)=RNAME(2)
  450 CALL PARSE (STMT(K),LSTMT,NAMES,L,ERR,LISTTY,LISTERR)
```

```
293         IF (ERR) GO TO 910
294         DO 460 I=1,CNT
295     460 VALUES(J,I)=EVAL(VALUES(1,I))
296         IF (DEFINE) GO TO 470
297         WRITE (LISTPR,TFORM) HEADG
298         DEFINE = .TRUE.
299     470 WRITE (LISTPR,720) RNAME,(STMT(I),I=K,LSTM)
300         GO TO 140
301     480 IF (NOTEQ(STMT,'RECALC',6)) GO TO 500
302 C---- NORM RECALCULATION PROCESSOR * * * * * * * * * * * * * * * * * * * *
303         IF (LSTMT.GT.16) WRITE (LISTERR,900) (STMT(I),I=1,LSTMT)
304         IF (.NOT.CONVTD) GO TO 495
305         WRITE (LISTPR,930)
306         WRITE (LISTERR,930)
307         WRITE (LISTTY,930)
308         GO TO 910
309     495 DO 490 I=1,CNT
310         SYMBOL=SYM(I)
311     490 CALL RECALC (VALUES(1,I),IDENT(1,I),SYMBOL,TTDI(I),RATIOS(1,I),TOT
312        1ALS(1,I),TYPES(1,I),BARTHS(1,I),NIGGLI(1,I),ADJUST(1,I),NAMES)
313         GO TO 910
314     500 IF (NOTEQ(STMT,'PRINT',5)) GO TO 550
315 C---- PRINT PROCESSOR * * * * * * * * * * * * * * * * * * * * * * * * * *
316         J=1
317         LSTMT=LSTMT-5
318         K=6
319         WRITE (LISTPR,TFORM) HEADG
320     510 IF (J.EQ.0) GO TO 910
321         J=INDEX(STMT(K),',',LSTMT)
322         IF (J.NE.0) GO TO 520
323         LE1=LSTMT
324         GO TO 530
325     520 LE1=J-1
326         LSTMT=LSTMT-J
327     530 CALL PARSE (STMT(K),LE1,NAMES,NUM,ERR,LISTTY,LISTERR)
328         IF (ERR) GO TO 910
329         DO 540 I=1,CNT
330     540 X(I)=EVAL(VALUES(1,I))
331         LE1=K+LE1-1
332         WRITE (LISTPR,800) (STMT(I),I=K,LE1)
333         WRITE (LISTPR,810)
334         WRITE (LISTPR,820) (IDENT(1,I),IDENT(2,I),X(I),I=1,CNT)
335         K=K+J
336         GO TO 510
337     550 IF (NOTEQ(STMT,'CONVERT',7)) GO TO 560
338 C---- VALUE CONVERT PROCESSOR * * * * * * * * * * * * * * * * * * * * * *
339         IF (LSTMT.GT.13) WRITE (LISTERR,900) (STMT(I),I=1,LSTMT)
340         IF (.NOT.CONVTD) GO TO 555
341         WRITE (LISTTY,940)
342         WRITE (LISTERR,940)
343         GO TO 910
344     555 CALL CONVER (VALUES,ADJUST,CNT)
345         CONVTD=.TRUE.
346         DO 558 II=1,80
347         I=81-II
348         IF (HEADG(I).EQ.BLANK) GO TO 558
349         DO 557 J=1,12
350     557 HEADG(I+J)=EXTN(J)
351         GO TO 910
352     558 CONTINUE
```

```
      GO TO 910
  560 IF (NOTEQ(STMT,'PLOT',4)) GO TO 610
C---- X-Y PLOT PROCESSOR * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      LSTMT=LSTMT-4
      STAND=NOTEQ(STMT(5),'(R)',3)
      K=5
      IF (STAND) GO TO 570
      LSTMT=LSTMT-3
      K=8
  570 IF (NOTEQ(STMT(K),'HARKER',6)) GO TO 579
C---- HARKER SUITE OF PLOTS * * * * * * * * * * * * * * * * * * * * * * * * * * *
      ENCODE (RNAME,970) NAMES(1,1),NAMES(2,1)
      DECODE (RNAME,740) NMX
      XMIN=+1.0E+35
      XMAX=-1.0E+35
      DO 571 L=1,CNT
      IF (SWITCH(1)) X(L)=ADJUST(1,L)
      IF (.NOT.SWITCH(1)) X(L)=VALUES(1,L)
      XMIN=AMIN1(XMIN,X(L))
  571 XMAX=AMAX1(XMAX,X(L))
      IF (XMAX.GT.XMIN) GO TO 572
      WRITE (LISTTY,950)
      WRITE (LISTERR,950)
      GO TO 910
  572 DO 578 LL=2,21
      XMIN=+1.0E+35
      XMAX=-1.0E+35
      DO 573 L=1,CNT
      IF (SWITCH(1)) Y(L)=ADJUST(LL,L)
      IF (.NOT.SWITCH(1)) Y(L)=VALUES(LL,L)
      XMIN=AMIN1(XMIN,Y(L))
  573 XMAX=AMAX1(XMAX,Y(L))
      IF (XMAX.LE.XMIN) GO TO 578
      ENCODE (RNAME,970) NAMES(1,LL),NAMES(2,LL)
      DECODE (RNAME,740) NMY
      CALL PRNT (X,Y,SYM,CNT,NMX,NMY,5,5,STAND,PRNTER,SCALE)
      IF (PRNTER.AND.SWITCH(1)) WRITE (LISTPR,920)
  578 CONTINUE
      GO TO 910
  579 I=INDEX(STMT(K),',',LSTMT)
      IF (I.NE.0) GO TO 580
      WRITE (LISTERR,830) CARD
      WRITE (LISTTY,830) CARD
      GO TO 910
  580 LF1=I-1
      LF2=LSTMT-I
      J=I+K
      CALL PARSE (STMT(K),LF1,NAMES,NUM,ERR,LISTTY,LISTERR)
      IF (ERR) GO TO 910
      DO 590 I=1,CNT
      IF (SWITCH(1)) X(I)=EVAL(ADJUST(1,I))
  590 IF (.NOT.SWITCH(1)) X(I)=EVAL(VALUES(1,I))
      CALL PARSE (STMT(J),LF2,NAMES,NUM,ERR,LISTTY,LISTERR)
      IF (ERR) GO TO 910
      DO 600 I=1,CNT
      IF (SWITCH(1)) Y(I)=EVAL(ADJUST(1,I))
  600 IF (.NOT.SWITCH(1)) Y(I)=EVAL(VALUES(1,I))
      CALL PRNT(X,Y,SYM,CNT,STMT(K),STMT(J),LF1,LF2,STAND,PRNTER,SCALE)
      IF (PRNTER.AND.SWITCH(1)) WRITE (LISTPR,920)
      GO TO 910
```

```
413   610 IF (NOTEQ(STMT,'TERNARY',7)) GO TO 680
414 C---- TERNARY DIAGRAM PROCESSOR * * * * * * * * * * * * * * * * * * * *
415       LSTMT=LSTMT-7
416       I=INDEX(STMT(8),',',LSTMT)
417       IF (I.NE.0) GO TO 630
418   620 WRITE (LISTERR,840) CARD
419       WRITE (LISTTY,840) CARD
420       GO TO 910
421   630 LE1=I-1
422       LSTMT=LSTMT-I
423       I=INDEX(STMT(I+8),',',LSTMT)
424       IF (I.EQ.0) GO TO 620
425       LE2=I-1
426       LE3=LSTMT-I
427       J=LE1+LE2+10
428       K=LE1+9
429       CALL PARSE (STMT(8),LE1,NAMES,NUM,ERR,LISTTY,LISTERR)
430       IF (ERR) GO TO 910
431       DO 640 I=1,CNT
432   640 Y(I)=AMAX1(0.,EVAL(VALUES(1,I)))
433       CALL PARSE (STMT(J),LE3,NAMES,NUM,ERR,LISTTY,LISTERR)
434       IF (ERR) GO TO 910
435       DO 650 I=1,CNT
436   650 X(I)=AMAX1(0.,EVAL(VALUES(1,I)))
437       CALL PARSE (STMT(K),LE2,NAMES,NUM,ERR,LISTTY,LISTERR)
438       IF (ERR) GO TO 910
439       DO 660 I=1,CNT
440       Y1=Y(I)
441       X1=X(I)
442       SUM=X1+Y1+AMAX1(0.,EVAL(VALUES(1,I)))
443       X(I)=0.0
444       Y(I)=0.0
445       IF (SUM.EQ.0.0) GO TO 660
446       Y(I)=100.0*Y1/SUM
447       X(I)=100.0*X1/SUM
448       IF (X(I).GE.0.0.AND.Y(I).GE.0.0) GO TO 660
449       X(I)=0.0
450       Y(I)=0.0
451   660 CONTINUE
452       LSTMT=LSTMT+LE1+8
453       WRITE (LISTPR,TFORM) HEADG
454       WRITE (LISTPR,850) (STMT(I),I=8,LSTMT)
455       WRITE (LISTPR,860)
456       DO 670 I=1,CNT
457       Y1=Y(I)
458       X1=X(I)
459       SUM=SIGN(1.0,Y1)*(100.0-X1-Y1)
460   670 WRITE (LISTPR,870) IDENT(1,I),IDENT(2,I),Y1,SUM,X1,SYM(I)
461       CALL TRIANG (IDENT,X,Y,CNT,LE1,LE2,LE3,SYM,STMT(8),STMT(K),STMT(J)
462      1,PRNTER,SCALE)
463       GO TO 910
464 C---- UNRECOGNIZED COMMAND * * * * * * * * * * * * * * * * * * * * * *
465   680 WRITE (LISTERR,880) (STMT(I),I=1,LSTMT)
466       WRITE (LISTTY,880) (STMT(I),I=1,LSTMT)
467       GO TO 910
468   690 IF (SWCC) CALL PLOT (0.0,0.0,999)
469       CALL FILES (LISTERR,7)
470       CALL FILES (LISTERR,8)
471       CALL FILES (LISTTY,4)
472       CALL FILES (LISTPR,5)
```

```
      CALL FILES (INPUT,5)
      STOP
  700 FORMAT (/' SCALE MUST BE POSITIVE AND LESS THAN OR EQUAL TO 3.0.')
  710 FORMAT (/' "DEVICE=CALCOMP" MUST BE SPECIFIED BEFORE SETTING SCALE
     1.')
  720 FORMAT (/1X,2A4,' DEFINED AS ',80A1)
  740 FORMAT (80A1)
  750 FORMAT (/' NO MORE THAN 99 NORMS MAY BE STORED. THE LAST NORM WILL
     1 BE WIPED OUT.')
  760 FORMAT (/' STATEMENT LENGTH(160) EXCEEDED ON THE FOLLOWING STATEME
     1NT:'/(1X,80A1)),/' DID YOU FORGET A SEMICLON?')
  770 FORMAT (/' FORMAT COMMAND ERROR (MISSING PARENTHESIS) IN ',80A1)
  780 FORMAT (/' ERROR IN MODIFY COMMAND ON ',80A1)
  790 FORMAT (/' NO MORE THAN 15 NAMES MAY BE DEFINED. DEFINITION IGNORE
     1D FOR NAME=',2A4)
  800 FORMAT (/' EVALUATION OF ',40A1)
  810 FORMAT (/6(6X,'ID',7X,'VALUE ')/)
  820 FORMAT (6(4X,A4,A1,F12.3))
  830 FORMAT (/' PLOT COMMAND ERROR ON ',80A1)
  840 FORMAT (/' TERNARY COMMAND ERROR ON ',80A1)
  850 FORMAT (' TERNARY RATIOS FOR ',100A1)
  860 FORMAT (/' SAMPLE     R1',6X,'R2',6X,'R3    SYMBOL'/)
  870 FORMAT (2X,A4,A1,3F8.2,4X,A1)
  880 FORMAT (/' UNRECOGNIZED COMMAND GIVEN AS:'1X,80A1,(/32X,80A1))
  890 FORMAT (/,' OXIDE COMMAND CONTAINS A NAME WHICH IS NOT IN THE LIST
     1 OF ACCEPTABLE OXIDES. ACCEPTABLE OXIDES ARE:'/1X,22A4/1X,20A4,//,
     2' THE UNRECOGNIZED NAME IS ',2A4)
  900 FORMAT (/' THE FOLLOWING COMMAND CONTAINS EXCESSIVE CHARACTERS.'//
     1 1X,20A1//' DID YOU FORGET A SEMICOLON?')
  920 FORMAT (/38X,' NOTE: PLOT IS BASED ON ADJUSTED OXIDES.')
  930 FORMAT (/' NORMS CANNOT BE RECALCULATED FROM DATA EXPRESSED IN MOL
     1ES.')
  940 FORMAT (/' DATA HAVE ALREADY BEEN CONVERTED TO MOLES.')
  950 FORMAT (/' NO SIO2 GIVEN FOR HARKER SUITE OF PLOTS.')
  970 FORMAT (20A4)
      END
```

Block Data

```
      BLOCK DATA
      INTEGER TFORM
      COMMON /UNITS/ HEADG(92),TFORM(4),INPUT,LISTPR,LISTTY,LISTERR
      DATA TFORM/'(1h1','0x9','2a1/',')  '/
      DATA INPUT,LISTPR,LISTTY,LISTERR/4,3,0,20/
      END
```

```
      SUBROUTINE NORM (CARD,OUTM,FORMAT,NCS,TTDI,RATIOS,TOTALS,TYP
     1ES,BARTHS,NIGGLI,IDENT,NOX,ORDER,ADJUST,NAMES)
      IMPLICIT REAL(M,N)
      LOGICAL NOH2O,BARITE,KSPAR,CANCRI,NONORM,CONVTD,STORE,NORMAL,
     1 PRNTER
      INTEGER CARD(80),SYM,FORMAT(15),SAM,BUFFER(60),IDENT(2),
     1 HEADG(92),TFORM(4),RASSYM,I,TT,ORDER(21),NOX,NCS,NAMES(2,81)
      COMMON /FLAGS/ NOH2O,BARITE,KSPAR,CANCRI,NONORM,CONVTD,STORE,
     1 NORMAL,PRNTER
      COMMON /UNITS/ HEADG,TFORM,INPUT,LISTPR,LISTTY,LISTERR
      COMMON /BULKSTOR/ PAGE(132,180),RASSYM
C---- WC IS USED FOR THE WEIGHT COMPONENT OF THE 21 OXIDES * * * *
      COMMON /ALIGN1/ WC1,WC2,WC3,WC4,WC5,WC6,WC7,WC8,WC9,WC10,WC11,WC12
     1,WC13,WC14,WC15,WC16,WC17,WC18,WC19,WC20,WC21
C---- MM IS USED FOR THE MOLAR MINERALS 1 TO 37; 35 TO 37 ARE DI, HY,
C      AND OL RESPECTIVELY.
      COMMON /ALIGN3/ MM1,MM2,MM3,MM4,MM5,MM6,MM7,MM8,MM9,MM10,MM11,MM12
     1,MM13,MM14,MM15,MM16,MM17,MM18,MM19,MM20,MM21,MM22,MM23,MM24,MM25,
     2MM26,MM27,MM28,MM29,MM30,MM31,MM32,MM33,MM34,MM35,MM36,MM37
C---- MC IS MOLAR COMPONENT (OXIDES), PM IS WT % MINERALS, PC IS WT %
C      COMPONENT (ADJUSTED OXIDES), NP IS THE NORMATIVE PARTITIONING FOR
C      CPX, OPX, AND OL.
      REAL K,MC(21),OUTM(81),WC(21),PM(34),NP(11),MM(37),PC(21),MG,VALUE
     1S(81, 99),RATIOS(2),TOTALS(2),TYPES(2),BARTHS(21),NIGGLI(12)
     2 ,RM(21),WM(34),ADJUST(21),ADJ(21,99)
      EQUIVALENCE (WC1,WC(1)), (MM1,MM(1))
C---- RM IS MOLECULAR CONVERSION FACTORS FOR CHEMICAL COMPONENTS * * * *
      DATA RM     /1.664314E-2,9.807652E-3,6.262047E-3,1.391858E-2,2.4806
     188E-2,1.783186E-2,1.61345E-2,1.061533E-2,5.550825E-2,1.251583E-2,7
     2.045002E-3,1.409694E-2,8.115645E-3,2.272213E-2,1.249029E-2,2.82063
     36E-2,5.263601E-2,3.118762E-2,6.579372E-3,1.33852E-2,6.521481E-3/
C---- WM IS THE MOLECULAR CONVERSION FOR MINERALS * * * * * * * * * * *
      DATA WM     /60.0848,101.9612,183.3036,556.6734,524.449,278.2102,43
     16.5038,284.1098,316.3342,116.8856,142.0412,105.989,462.0104,122.06
     238,154.2882,116.1642,100.3962,131.9312,140.7076,203.7776,172.2436,
     3231.5383,223.8363,159.6922,151.7449,196.063,135.9732,79.8988,336.2
     4084,78.0768,119.975,100.0894,84.32135,115.8564/
      IF (NORMAL) GO TO 4
      SYM=RASSYM
      ENCODE(IDENT,610) (CARD(I),I=73,77)
      GO TO 8
    4 ENCODE(IDENT,610) (CARD(I),I=76,80)
      SYM=CARD(4)
    8 ENCODE(BUFFER,610) CARD
      IF (NCS.EQ.1) GO TO 20
      READ (INPUT,10) ((BUFFER(20*(J-1)+I),I=1,20),J=2,NCS)
   10 FORMAT(20A4)
   20 DECODE(BUFFER,FORMAT) (PM(I),I=1,NOX)
      DO 30 I=1,21
   30 PC(I)=0.0
      DO 40 I=1,NOX
      J=ORDER(I)
   40 PC(J)=PM(I)
      IF (STORE) GO TO 90
      DO 50 I=1,34
   50 PM(I)=0.0
      DO 60 I=1,11
   60 NP(I)=0.0
```

```
573         GO TO 80
574 C---- RECALCULATE NORMS * * * * * * * * * * * * * * * * * * * * * * * * * * * *
575         ENTRY RECALC(OUTM,IDENT,SAM,TTDI,RATIOS,TOTALS,TYPES,BARTHS,NIGGLI
576        1,ADJUST)
577         IF (IDENT(1).EQ.'DUMM') RETURN
578         SYM=SAM
579         DO 70 I=1,21
580      70 PC(I)=OUTM(I)
581      80 RATIO=0.0
582         R1=0.0
583         IF (PC(3).NE.0.0) RATIO=PC(4)/PC(3)
584         IF (PC(1).NE.0.0) R1=PC(2)/PC(1)
585         RATIOS(1)=R1
586         RATIOS(2)=RATIO
587      90 SUM=0.0
588 C---- CALCULATE ANALYTICAL SUM
589         DO 100 I=1,21
590         OUTM(I)=PC(I)
591         ADJUST(I)=PC(I)
592     100 SUM=SUM+PC(I)
593         SUM1=SUM
594 C---- ADJUST SUM FOR CL AND F
595         SUM=SUM-0.42*PC(17)-0.23*PC(16)
596         TOTALS(1)=SUM
597         IF (STORE) GO TO 570
598         IF (NOH2O) SUM=SUM-PC(9)
599         IF (NOH2O) PC(9)=0.0
600         IF (NOH2O) WRITE (LISTERR,760) IDENT
601         IF (.NOT.NONORM) GO TO 110
602         WRITE (LISTPR,TFORM) HEADG
603         WRITE (LISTPR,615) IDENT,SYM
604         WRITE (LISTPR,620) (OUTM(I),I=1,21),SUM1,TOTALS(1)
605         IF (.NOT.NOH2O) WRITE (LISTPR,625)
606         IF (NOH2O) WRITE (LISTPR,626)
607     110 SUM=100.0/SUM
608         DO 120 I=1,21
609 C---- NORMALIZE OXIDES TO 100%
610         PC(I)=SUM*PC(I)
611         ADJUST(I)=PC(I)
612 C---- CONVERT OXIDES TO MOLECULAR AMOUNTS
613         MC(I)=PC(I)*RM(I)
614     120 WC(I)=MC(I)
615         IF (.NOT.NONORM) GO TO 130
616         WRITE (LISTPR,630)(ADJUST(I),I=1,11),R1,(MC(I),I=1,11),(ADJUST(I),
617        1 I=12,21),RATIO,(MC(I),I=12,21)
618     130 DO 140 I=1,37
619     140 MM(I)=0.0
620 C---- ADD MNO AND NIO TO FEO
621         WC4=WC4+WC12+WC20
622 C---- ADD BAO TO NA2O OR K2O OR CAO
623         IF (.NOT.BARITE) GO TO 144
624         WC7=WC7+WC21
625         WRITE (LISTERR,730) IDENT
626         GO TO 147
627     144 IF (.NOT.KSPAR) GO TO 145
628         WC8=WC8+WC21
629         WRITE (LISTERR,740) IDENT
630         GO TO 147
631     145 WC6=WC6+WC21
632 C---- CALCULATE APATITE
```

```
633    147 WC6=WC6-3.33333*WC11
634        IF (WC6.GE.0.0) GO TO 150
635        PC(11)=ABS(WC6)/3.33333
636        WC11=WC11-PC(11)
637        PC(11)=PC(11)/RM(11)
638        WRITE (LISTERR,710) IDENT,PC(11),NAMES(1,11),NAMES(2,11)
639        WRITE (LISTTY,710) IDENT,PC(11),NAMES(1,11),NAMES(2,11)
640        WC6=0.0
641    150 MM29=WC11
642  C---- CALCULATE HALITE
643        WC7=WC7-0.5*WC16
644        IF (WC7.GE.0.0) GO TO 160
645        PC(16)=ABS(WC7)/0.5
646        WC16=WC16-PC(16)
647        PC(16)=PC(16)/RM(16)
648        WRITE (LISTERR,710) IDENT,PC(16),NAMES(1,16),NAMES(2,16)
649        WRITE (LISTTY,710) IDENT,PC(16),NAMES(1,16),NAMES(2,16)
650        WC7=0.0
651    160 MM10=0.5*WC16
652  C---- CALCULATE THENARDITE
653        MM11=AMIN1(WC7,WC15)
654        WC7=WC7-MM11
655        WC15=WC15-MM11
656  C---- COMBINE S AND SO3
657        WC18=WC18+WC15
658  C---- CALCULATE PYRITE
659        WC4=WC4-0.5*WC18
660        IF (WC4.GE.0.0) GO TO 170
661        PC(18)=ABS(WC4)/0.5
662        WC18=WC18-PC(18)
663        PC(18)=PC(18)/RM(18)
664        WRITE (LISTERR,710) IDENT,PC(18),NAMES(1,18),NAMES(2,18)
665        WRITE (LISTTY,710) IDENT,PC(18),NAMES(1,18),NAMES(2,18)
666        WC4=0.0
667    170 MM31=0.5*WC18
668  C---- CALCULATE CHROMITE
669        WC4=WC4-WC19
670        IF (WC4.GE.0.0) GO TO 180
671        PC(19)=ABS(WC4)
672        WC19=WC19-PC(19)
673        PC(19)=PC(19)/RM(19)
674        WRITE (LISTERR,710) IDENT,PC(19),NAMES(1,19),NAMES(2,19)
675        WRITE (LISTTY,710) IDENT,PC(19),NAMES(1,19),NAMES(2,19)
676        WC4=0.0
677    180 MM23=WC19
678  C---- CALCULATE ILMENITE
679        MM25=AMIN1(WC4,WC10)
680        WC4=WC4-MM25
681        WC10=WC10-MM25
682  C---- ADJUST F FOR APATITE
683        WC17=WC17-0.666667*MM29
684        IF (WC17.LT.0.0) WC17=0.0
685  C---- CALCULATE FLUORITE
686        WC6=WC6-0.5*WC17
687        IF (WC6.GE.0.0) GO TO 190
688        PC(17)=ABS(WC6)/0.5
689        WC17=WC17-PC(17)
690        PC(17)=PC(17)/RM(17)
691        WRITE (LISTERR,710) IDENT,PC(17),NAMES(1,17),NAMES(2,17)
692        WRITE (LISTTY,710) IDENT,PC(17),NAMES(1,17),NAMES(2,17)
```

```
693         WC6=0.0
694    190  MM30=0.5*WC17
695         IF (.NOT.CANCRI) GO TO 194
696         WRITE (LISTERR,750) IDENT
697  C----- CALCULATE SODIUM CARBONATE IF REQUESTED
698         MM12=AMIN1(WC7,WC14)
699         WC7=WC7-MM12
700         WC14=WC14-MM12
701         IF (WC14.LE.0.0) GO TO 195
702  C----- CALCULATE CALCITE
703    194  MM32=AMIN1(WC6,WC14)
704         WC6=WC6-MM32
705         WC14=WC14-MM32
706  C----- CALCULATE MAGNESITE
707         MM33=AMIN1(WC5,WC14)
708         WC5=WC5-MM33
709         WC14=WC14-MM33
710         IF (WC14.LE.0.0) GO TO 195
711  C----- CALCULATE SIDERITE
712         MM34=AMIN1(WC4,WC14)
713         WC4=WC4-MM34
714         WC14=WC14-MM34
715         IF (WC14.LE.0.0) GO TO 200
716         PC(14)=WC14/RM(14)
717         WRITE (LISTERR,710) IDENT,PC(14),NAMES(1,14),NAMES(2,14)
718         WRITE (LISTTY,710) IDENT,PC(14),NAMES(1,14),NAMES(2,14)
719  C----- ASSIGN ALL MGO TO ENSTATITE
720    195  MM17=WC5
721  C----- CALCULATE ZIRCON
722    200  WC1=WC1-WC13
723         IF (WC1.GE.0.0) GO TO 210
724         WC1=ABS(WC1)
725         WC13=WC13-WC1
726         PC(13)=WC1/RM(13)
727         WRITE (LISTERR,710) IDENT,PC(13),NAMES(1,13),NAMES(2,13)
728         WRITE (LISTTY,710) IDENT,PC(13),NAMES(1,13),NAMES(2,13)
729         WC1=0.0
730    210  MM3=WC13
731  C----- CALCULATE ORTHOCLASE
732         DIFF=WC2-WC8
733         IF (DIFF.GE.0.0) GO TO 220
734         MM4=WC2
735  C----- CALCULATE POTASSIUM METASILICATE
736         MM15=-DIFF
737         WC2=0.0
738         WC8=0.0
739         GO TO 250
740    220  MM4=WC8
741         WC2=DIFF
742  C----- CALCULATE ALBITE
743         DIFF=WC2-WC7
744         WC8=0.0
745         IF (DIFF.GE.0.0) GO TO 230
746         MM5=WC2
747         WC7=-DIFF
748         WC2=0.0
749         GO TO 250
750    230  MM5=WC7
751         WC2=DIFF
752  C----- CALCULATE ANORTHITE
```

```
753         DIFF=WC2-WC6
754         WC7=0.0
755         IF (DIFF.GE.0.0) GO TO 240
756         MM6=WC2
757         WC6=-DIFF
758         WC2=0.0
759         GO TO 250
760       240 MM6=WC6
761     C---- CALCULATE CORUNDUM
762         MM2=DIFF
763         WC2=0.0
764         WC6=0.0
765     C---- CALCULATE TITANITE (SPHENE)
766       250 DIFF=WC10-WC6
767         IF (DIFF.GE.0.0) GO TO 260
768         MM26=WC10
769         WC6=-DIFF
770         GO TO 270
771       260 MM26=WC6
772     C---- CALCULATE RUTILE
773         MM28=DIFF
774         WC6=0.0
775     C---- CALCULATE ACMITE
776       270 DIFF=WC3-WC7
777         IF (DIFF.GE.0.0) GO TO 280
778         MM13=WC3
779     C---- CALCULATE SODIUM METASILICATE
780         MM14=-DIFF
781     C---- CALCULATE FERROSILITE
782         MM18=WC4
783         GO TO 300
784       280 MM13=WC7
785         WC3=DIFF
786         WC7=0.0
787     C---- CALCULATE MAGNETITE
788         DIFF=WC3-WC4
789         IF (DIFF.GE.0.0) GO TO 290
790         MM22=WC3
791     C---- ALTENATE CALCULATION OF FERROSILITE
792         MM18=-DIFF
793         GO TO 300
794       290 MM22=WC4
795     C---- CALCULATE HEMATITE
796         MM24=DIFF
797       300 SUMMF=MM17+MM18
798         R1=0.0
799         R2=0.0
800         IF (SUMMF.LE.0.0) GO TO 310
801     C---- DETERMINE PARTITIONING OF FEO & MGO FOR PYROXENES & OLIVINE
802         R1=MM17/SUMMF
803         R2=MM18/SUMMF
804     C---- CALCULATE WOLLASTENITE, DIOPSIDE AND HYPERSTHENE
805       310 DIFF=SUMMF-WC6
806         IF (DIFF.LT.0.0) GO TO 320
807         MM35=WC6
808         MM36=DIFF
809         GO TO 330
810       320 MM35=SUMMF
811         MM16=-DIFF
812     C---- BALANCE SILICA
```

```
  330 WC1=WC1-MM26-4.0*MM13-MM14-MM15-6.0*(MM4+MM5)-MM16-2.0*(MM6+MM35)-
     1MM36
      IF (WC1.LT.0.0) GO TO 340
C---- EXCESS SILICA IS QUARTZ
      MM1=WC1
      GO TO 420
C---- STMTS 340 TO 410-ADJUSTS NORM FOR SILICA DEFICIENCY
C---- CONVERT HYPERSTHENE TO OLIVINE & SIO2
  340 WC1=WC1+MM36
      DIFF=2.0*WC1-MM36
      IF (DIFF.LT.0.0) GO TO 350
      MM37=MM36-WC1
      MM36=DIFF
      GO TO 420
  350 MM37=0.5*MM36
      MM36=0.0
C---- CONVERT TILANITE TO PEROSKITE & SIO2
      WC1=WC1-MM37+MM26
      IF (WC1.LT.0.0) GO TO 360
      MM27=MM26-WC1
      MM26=WC1
      GO TO 420
C---- CONVERT ALBITE TO NEPHELINE & SIO2
  360 WC1=WC1+6.0*MM5
      MM27=MM26
      MM26=0.0
      DIFF=WC1-2.0*MM5
      IF (DIFF.LT.0.0.OR.WC1.GT.6.0*MM5) GO TO 370
      MM8=1.5*MM5-0.25*WC1
      MM5=0.25*DIFF
      GO TO 420
  370 MM8=MM5
      MM5=0.0
C---- CONVERT ORTHOCLASE TO LEUCITE & SIO2
      WC1=WC1-2.0*MM8+6.0*MM4
      DIFF=WC1-4.0*MM4
      IF (DIFF.LT.0.0.OR.WC1.GT.6.0*MM4) GO TO 380
      MM7=3.0*MM4-0.5*WC1
      MM4=0.5*DIFF
      GO TO 420
  380 MM7=MM4
      MM4=0.0
C---- CONVERT WALLATONITE TO CALCIUM ORTHOSILICATE & SIO2
      WC1=WC1-4.0*MM7+MM16
      DIFF1=MM16-WC1
      DIFF2=2.0*WC1-MM16
      IF (DIFF1.LT.0.0.OR.DIFF2.LT.0.0) GO TO 390
      MM21=DIFF1
      MM16=DIFF2
      GO TO 420
C---- CONVERT DIOPSIDE TO CALCIUM ORTHOSILICATE & OLIVINE & SIO2
  390 WC1=WC1+2.0*MM35
      FAC1=2.0*(WC1-MM35)-MM16
      FAC2=4.0*MM35+MM16-2.0*WC1
      FAC3=FAC2+2.0*MM16
      IF (FAC1.LT.0.0.OR.FAC2.LT.0.0.OR.FAC3.LT.0.0) GO TO 400
      MM21=0.25*FAC3
      MM37=MM37+0.25*FAC2
      MM35=0.5*FAC1
      MM16=0.0
```

```
873         GO TO 420
874 C---- CONVERT LEUCITE TO KALIOPHILITE & SIO2
875    400 MM37=MM37+0.5*MM35
876         MM21=0.5*(MM16+MM35)
877         WC1=WC1-MM35-0.5*MM16+4.0*MM7
878         MM35=0.0
879         MM16=0.0
880         DIFF1=WC1-2.0*MM7
881         DIFF2=WC1-2.0*DIFF1
882         IF (DIFF1.GE.0.0) GO TO 410
883 C---- CALCULATE AMOUNT OF SIO2 DEFICIENCY AS EXCESS OLIVINE
884         MM37=MM37+DIFF1
885         WC1=ABS(WC1)
886         WC5=2.0*R1*ABS(DIFF1)/RM(5)
887         WC4=2.0*R2*ABS(DIFF1)/RM(4)
888         WC1=0.0
889         MM9=MM7
890         MM7=0.0
891         WRITE (LISTTY,720) IDENT,WC5,WC4
892         WRITE (LISTERR,720) IDENT,WC5,WC4
893         GO TO 420
894    410 MM9=0.5*DIFF2
895         MM7=0.5*DIFF1
896 C---- CALCULATE PARTITIONINGS IN CPX, OPX AND OL * * * * * * * * * * * * *
897    420 DI=MM35
898         DIWO=DI
899         DIEN=R1*DI
900         DIFS=R2*DI
901         HY=MM36
902         HYEN=R1*HY
903         HYFS=R2*HY
904         OL=MM37
905         OLFO=R1*OL
906         MM19=OLFO
907         OLFA=R2*OL
908         MM20=OLFA
909         MM16=MM16+DIWO
910         MM17=DIEN+HYEN
911         MM18=DIFS+HYFS
912         DO 430 I=1,34
913    430 PM(I)=WM(I)*MM(I)
914         IF (.NOT.NONORM) GO TO 440
915         IF (.NOT.NOH2O) WRITE (LISTPR,635)
916         IF (NOH2O) WRITE (LISTPR,636)
917         WRITE (LISTPR,640) (MM(I),I=1,12),(PM(I),I=1,12),(MM(I),I=13,24),
918        1 (PM(I),I=13,24),(MM(I),I=25,34)
919    440 DIFF2=0.0
920         DO 450 I=1,12
921    450 DIFF2=DIFF2+PM(I)
922         DIFF1=DIFF2
923         DO 460 I=13,34
924    460 DIFF1=DIFF1+PM(I)
925         Y=DIFF1-DIFF2
926 C---- CONVERT PARTITIONINGS TO WT %
927         NP(2)=DIWO*WM(16)
928         NP(3)=DIEN*WM(17)
929         NP(4)=DIFS*WM(18)
930         NP(1)=NP(2)+NP(3)+NP(4)
931         NP(6)=HYEN*WM(17)
932         NP(7)=HYFS*WM(18)
```

```
      NP(5)=NP(6)+NP(7)
      NP(9)=OLFO*WM(19)
      NP(10)=OLFA*WM(20)
      WOL=MM16-DIWO
      NP(11)=WOL*WM(16)
      NP(8)=NP(9)+NP(10)
      TOTALS(2)=DIFF1
      TYPES(1)=DIFF2
      TYPES(2)=Y
      TTDI=PM(1)+PM(4)+PM(5)+AMAX1(PM(7),0.0)+PM(8)+AMAX1(PM(9),0.0)
      IF (.NOT.NONORM) GO TO 480
      WRITE (LISTPR,650) (PM(I),I=25,34),DIFF1,DIFF2,Y,DI,DIWO,DIEN,
     1 DIES,HY,HYEN,HYES,OL,OLFO,OLFA,WOL,(NP(I),I=1,11)
      WRITE (LISTPR,660) TTDI
C---- CALCULATE BARTH'S CATIONS * * * * * * * * * * * * * * * * * * * *
  480 DO 490 I=1,21
  490 WC(I)=MC(I)
      WC2=2.0*WC2
      WC3=2.0*WC3
      WC7=2.0*WC7
      WC8=2.0*WC8
      WC9=2.0*WC9
      WC11=2.0*WC11
      WC19=2.0*WC19
      SUM=0.0
      DO 500 I=1,21
  500 SUM=SUM+WC(I)
      SUM=SUM-WC9-WC16-WC17-WC18
      SUM=100.0/SUM
      DO 510 I=1,21
      WC(I)=SUM*WC(I)
  510 BARTHS(I)=WC(I)
      IF (.NOT.NONORM) GO TO 520
      WRITE (LISTPR,690) WC
C---- NIGGLI'S VALUES * * * * * * * * * * * * * * * * * * * * * * * * *
  520 DO 530 I=1,21
  530 WC(I)=MC(I)
      AL=WC2+WC19
      FM=2.0*WC3+WC4+WC5+WC12+WC20
      C=WC6+WC21
      ALK=WC7+WC8
      SUM=100.0/(AL+FM+C+ALK)
      AL=SUM*AL
      NIGGLI(1)=AL
      FM=SUM*FM
      NIGGLI(2)=FM
      C=SUM*C
      NIGGLI(3)=C
      ALK=SUM*ALK
      NIGGLI(4)=ALK
      SI=SUM*WC1
      NIGGLI(5)=SI
      TI=SUM*WC10
      NIGGLI(6)=TI
      P=SUM*WC11
      NIGGLI(7)=P
      H=SUM*WC9
      NIGGLI(8)=H
      K=0.0
      DIFF1=WC7+WC8
```

```
      IF (DIFF1.NE.0.0) K=WCR/DIFF1
      MG=0.0
      SIP=100.0+4.0*ALK
      IF (FM.NE.0.0) MG=SUM*WCS/FM
      IF (ALK.GT.AL) SIP=100.0+3.0*AL+ALK
      QZ=SI-SIP
      NIGGLI(9)=K
      NIGGLI(10)=MG
      NIGGLI(11)=SIP
      NIGGLI(12)=QZ
      IF (.NOT.NONORM) GO TO 540
      WRITE (LISTPR,700) AL,FM,C,ALK,SI,TI,P,H,K,MG,SIP,QZ
  540 DO 550 I=1,34
  550 OUTM(I+21)=PM(I)
      DO 560 I=1,11
  560 OUTM(I+55)=NP(I)
  570 STORE=.FALSE.
      RETURN
C---- CONVERT VALUES TO MOLAR DATA * * * * * * * * * * * * * * * * * * * *
      ENTRY CONVER (VALUES,ADJ,TT)
      DO 600 I=1,TT
      DO 580 J=1,21
      VALUES(J,I)=VALUES(J,I)*RM(J)
  580 ADJ(J,I)=ADJ(J,I)*RM(J)
      DO 590 J=22,55
  590 VALUES(J,I)=VALUES(J,I)/WM(J-21)
      X1=VALUES(57,I)/WM(16)
      VALUES(57,I)=X1
      Y1=VALUES(58,I)/WM(17)
      VALUES(58,I)=Y1
      SUM=VALUES(59,I)/WM(18)
      VALUES(59,I)=SUM
      VALUES(56,I)=X1+Y1+SUM
      X1=VALUES(61,I)/WM(17)
      VALUES(61,I)=X1
      Y1=VALUES(62,I)/WM(18)
      VALUES(62,I)=Y1
      VALUES(60,I)=X1+Y1
      X1=VALUES(64,I)/WM(19)
      VALUES(64,I)=X1
      Y1=VALUES(65,I)/WM(20)
      VALUES(65,I)=Y1
      VALUES(63,I)=X1+Y1
  600 VALUES(66,I)=VALUES(66,I)/WM(16)
      RETURN
  610 FORMAT (80A1)
  615 FORMAT (' SAMPLE NO. ',A4,A1,10X,'PLOTTING SYMBOL IS ',A1/)
  620 FORMAT (' ORIGINAL WT.PCT. OXIDES'/'0  SIO2 AL2O3 FE2O3   FEO   ',
     1'MGO   CAO   NA2O   K2O   H2O   TIO2  P2O5   MNO   ZRO2   CO2   ','SO
     23    CL     F     S  CR2O3   NIO   BAO'/1X,21F6.2//' SUM OF ORIGINA
     3L OXIDES= ',F6.2//' SUM ADJUSTED FOR F & CL=',F6.2)
  625 FORMAT (/' OXIDES NORMALIZED TO 100 PERCENT :')
  626 FORMAT (/' OXIDES NORMALIZED TO 100 PERCENT :  (H2O FREE)')
  630 FORMAT (/' CONSTITUENTS    SIO2    AL2O3    FE2O3     FEO',6X,'MGO
     1    CAO',6X,'NA2O     K2O',6X,'H2O',6X,'TIO2',5X,'P2O5 AL2O3/SIO2'
     2/' PERCENTAGES',11F9.2,F10.3/' MOL. AMTS. ',11F9.4//' CONSTITUENTS
     3   MNO',6X,'ZRO2     CO2',6X,'SO3',7X,'CL',6X,'F',8X,'S',6X,'CR2O3
     4     NIO     BAO',12X,'FEO/FE2O3'/' PERCENTAGES',10F9.2,F19.3/' MO
     5L. AMTS. ',10F9.4)
  635 FORMAT (/' CIPW NORM :')
```

```
  636 FORMAT (/' CIPW NORM :  (H2O FREE)')
  640 FORMAT (/' MINERALS',9X,'Q',8X,'C',8X,'Z',8X,'OR',7X,'AB',7X,'AN',
     17X,'LC',7X,'NE',7X,'KP',7X,'HL',7X,'TH',7X,'NC'/' MOL. AMTS. ',12F
     2O.4/' PERCENTAGES',12FO.3/'OMINERALS',9X,'AC',7X,'NS',7X,'KS',7X,'
     3WO',7X,'EN',7X,'FS',7X,'FO',7X,'FA',7X,'CS',7X,'MT',7X,'CM',7X,'HM
     4'/' MOL. AMTS. ',12FO.4/' PERCENTAGES',12FO.3/'OMINERALS',9X,'IL',
     57X,'TN',7X,'PF',7X,'RU',7X,'AP',7X,'FR',7X,'PR',7X,'CC',7X,'MG
     6    SD      TOTAL     SALIC     FEMIC'/' MOL. AMTS. ',10FO.4)
  650 FORMAT (' PERCENTAGES',13F9.3/'OMINERALS',9X,'DI      DI-WO',4X,'DI
     1-EN     DI-FS       HY      HY-EN     HY-FS       OL      OL-FO',4X,'OL-
     2FA      WOL'/' MOL. AMTS. ',11FO.4/' PERCENTAGES',11F9.3)
  660 FORMAT (/' THORNTON + TUTTLE DIFFERENTIATION INDEX = ',F7.3)
  690 FORMAT ('OBARTHS CATIONS    SI       AL      FE+3     FE+2      MG',6X,
     1'CA       NA',7X,'K',7X,'H',6X,'TI',7X,'P',6X,'MN'/1X,13X,12F8.2,/'
     20',25X,'ZR',7X,'C',6X,'S1',6X,'CL',7X,'F',6X,'S2',6X,'CR',6X,'NI',
     36X,'BA'/' ',21X,9F8.2)
  700 FORMAT ('ONIGGLI VALUES     AL*      FM*      C*       ALK*     SI',6X,
     1'RI',7X,'P',7X,'H',7X,'K',6X,'MG',6X,3HSI',5X,'QZ'/' ',13X,12F8.2)
  710 FORMAT (/' SAMPLE ',A4,A1,' CONTAINS AN EXCESS OF',F6.2,' WEIGHT P
     1ERCENT ',A4,A1/4X,'BEYOND THAT USED IN NORMATIVE CALCULATIONS')
  720 FORMAT (/' SAMPLE ',A4,A1,' CONTAINS TOO LITTLE SIO2 TO COMPUTE NO
     1RM',/4X,'SIO2 DEFICIENCY IS EQUIVALENT TO AN EXCESS OF MGO OF',
     2F7.2,' WT %'/4X,'AND AN EXCESS OF FEO OF',F7.2,' WT %.')
  730 FORMAT (/' SAMPLE ',A4,A1,'--BAO ADDED TO NA2O.')
  740 FORMAT (/' SAMPLE ',A4,A1,'--BAO ADED TO K2O.')
  750 FORMAT (/' SAMPLE ',A4,A1,'--NA2CO3 CALCULATION ATTEMPTED.')
  760 FORMAT (/' SAMPLE ',A4,A1,'--NORM COMPUTED ON WATER FREE BASES.')
      END
```

```
      SUBROUTINE SUMPNT (STMT,LSTMT,CNT,IDENT,NAMES,NOX,ORDER,SYM,NUM)
      EXTERNAL SAW (descriptors)
      COMMON /FLAGS/ NOH2O,PAD1(4),CONVTD,PAD2(3)
      COMMON /UNITS/ HEADG,TFORM,INPUT,LISTPR,LISTTY,LISTERR
      COMMON /BULKSTOR/ PAGE,PASSYM
      COMMON /MASK/TTDI,ADJUST,VALUES,NIGGLI,BARTHS,RATIOS,TOTALS,TYPES
      LOGICAL NOH2O,CONVTD,NOTEQ
      INTEGER STM(160),STMT(LSTMT),RPAREN,SYM(1),NAMEB(21),NAMEN(12),
     1 HEADG(92),TFORM(4),PAD(2),CNT,ORDER(1),IDENT(2,99),NAMES(2,81),
     2 PAGE(132,180)
      REAL VALUES(81,99),NIGGLI(12,99),TTDI(99),RATIOS(2,99),
     1 TOTALS(2,99),TYPES(2,99),BARTHS(21,99),ADJUST(21,99)
      DATA NAMEB/'SI','AL','FE+3','FE+2','MG','CA','NA','K','H',
     1 'TI','P','MN','ZR','C','S1','CL','F','S2','CR','NI','BA'/
      DATA NAMEN/'AL*','FM*','C*','ALK*','SI','RI','P','H','K','MG',
     1 3HSI','QZ'/,RPAREN/')'/
      K=-12
   10 K=K+12
      IF (K.GE.CNT) RETURN
      CALL MOVE (STMT,STM,LSTMT)
      LSTM=LSTMT
      LAST=12
      IF (K+LAST.GT.CNT) LAST=CNT-K
      CALL CLEAR
      WRITE (LISTPR,TFORM)HEADG
      LENGTH=1
      CALL SAW(2,1,'SYMBOL',6)
      DO 20 J=1,LAST
      PAGE(10*J+ 5,2)=SYM(K+J)
   20 CALL SAW (1, 2+10*J,IDENT(1,K+J),5)
   25 IF (NOTEQ(STM,')',1)) GO TO 31
   30 CALL OUTPUT (LENGTH)
      GO TO 10
   31 IF (NOTEQ(STM,'OXID',4)) GO TO 70
C---- WRITE THE OXIDES * * * * * * * * * * * * * * * * * * * * * * * * * *
      I=INDEX(STM,',',LSTM)
      IF (I.EQ.0) STM(1)=RPAREN
      LSTM=LSTM-I
      CALL MOVE (STM(I + 1),STM,LSTM)
      LENGTH=LENGTH+2
      DO 50 L=1,NOX
      I=ORDER(L)
      DO 51 N=1,CNT
      IF(ABS(VALUES(I,N)) .GT. 1.0E-5) GO TO 52
   51 CONTINUE
      GO TO 50
   52 LENGTH=LENGTH+1
      CALL SAW (LENGTH,1,NAMES(1,I),5)
      DO 40 J=1,LAST
      Z=VALUES(I,K+J)
      IF(ABS(Z) .LT. 1.0E-5) GO TO 40
      CALL RSW (LENGTH,2 + 10*J,Z,'(F5.2)',5)
   40 CONTINUE
   50 CONTINUE
      IF (CONVTD) GO TO 25
      LENGTH=LENGTH+1
      CALL SAW (LENGTH,1,'TOTAL(-O)',9)
      DO 60 J=1,LAST
```

```
   60 CALL RSW (LENGTH, 2+10*J,TOTALS(1,K+J),'(F6.2)',6)
      GO TO 25
   70 CONTINUE
      IF (NOTEQ(STM,'BART',4)) GO TO 100
C---- WRITE BARTH'S CATIONS * * * * * * * * * * * * * * * * * * * * *
      I=INDEX(STM,',',LSTM)
      IF (I.EQ.0) STM(1)=RPAREN
      LSTM=LSTM-I
      CALL MOVE (STM(I + 1),STM,LSTM)
      IF (CONVTD) GO TO 25
      LENGTH=LENGTH+2
      CALL SAW (LENGTH,1,15HBARTH'S CATIONS,15)
      DO 90 I=1,21
      DO 71 N=1,CNT
      IF(ABS(BARTHS(I,N)) .GT. 1.0E-5) GO TO 72
   71 CONTINUE
      GO TO 90
   72 LENGTH=LENGTH+1
      CALL SAW (LENGTH,1,NAMEB(I),4)
      DO 80 J=1,LAST
      Z=BARTHS(I,K+J)
      IF(ABS(Z) .LT. 1.0E-5) GO TO 80
      CALL RSW (LENGTH,2 + 10*J,Z,'(F6.2)',6)
   80 CONTINUE
   90 CONTINUE
      GO TO 25
  100 CONTINUE
      IF (NOTEQ(STM,'NIGG',4)) GO TO 130
C---- WRITE NIGGLI VALUES * * * * * * * * * * * * * * * * * * * * * *
      I=INDEX(STM,',',LSTM)
      IF (I.EQ.0) STM(1)=RPAREN
      LSTM=LSTM-I
      CALL MOVE (STM(I + 1),STM,LSTM)
      IF (CONVTD) GO TO 25
      LENGTH=LENGTH+2
      CALL SAW (LENGTH,1,'NIGGLI VALUES',13)
      DO 120 I=1,12
      DO 101 N=1,CNT
      IF(ABS(NIGGLI(I,N)) .GT. 1.0E-5) GO TO 102
  101 CONTINUE
      GO TO 120
  102 LENGTH=LENGTH+1
      CALL SAW (LENGTH,1,NAMEN(I),4)
      DO 110 J=1,LAST
      Z=NIGGLI(I,K+J)
      IF(ABS(Z) .LT. 1.0E-5) GO TO 110
      CALL RSW (LENGTH,2 + 10*J,Z,'(F7.2)',7)
  110 CONTINUE
  120 CONTINUE
      GO TO 25
  130 CONTINUE
      IF (NOTEQ(STM,'RATI',4)) GO TO 160
C---- WRITE THE RATIOS * * * * * * * * * * * * * * * * * * * * * * * *
      I=INDEX(STM,',',LSTM)
      IF (I.EQ.0) STM(1)=RPAREN
      LSTM=LSTM-I
      CALL MOVE (STM(I + 1),STM,LSTM)
      IF (CONVTD) GO TO 25
      LENGTH=LENGTH+3
      CALL SAW (LENGTH,1,'AL2O3/SIO2',10)
```

```
      DO 140 J=1,LAST
      IF (ABS(RATIOS(1,K+J)).LT.1.0E-5) GO TO 140
      CALL RSW (LENGTH, 2+10*J,RATIOS(1,K+J),'(F6.3)',6)
  140 CONTINUE
      LENGTH=LENGTH+1
      CALL SAW (LENGTH,1,'FEO/FE203',9)
      DO 150 J=1,LAST
      IF (ABS(RATIOS(2,K+J)).LT.1.0E-5) GO TO 150
      CALL RSW (LENGTH, 2+10*J,RATIOS(2,K+J),'(F6.3)',6)
  150 CONTINUE
      GO TO 25
  160 CONTINUE
      IF( NOTEQ(STM,'ADJUST',6) ) GO TO 300
C---- WRITE THE ADJUSTED OXIDES * * * * * * * * * * * * * * * * * * * *
      I=INDEX(STM,',',LSTM)
      IF(I .EQ. 0) STM(1)=RPAREN
      LSTM=LSTM-I
      CALL MOVE (STM(I+1),STM,LSTM)
      LENGTH=LENGTH+2
      IF (.NOT.NOH2O) CALL SAW(LENGTH,1,'ADJUSTED OXIDES',15)
      IF (NOH2O) CALL SAW(LENGTH,1,'ADJUSTED OXIDES - H2O FREE',26)
      DO 301 L=1,NOX
      I=ORDER(L)
      DO 302 N=1,CNT
      IF(ABS(ADJUST(I,N)) .GT. 1.0E-5) GO TO 303
  302 CONTINUE
      GO TO 301
  303 LENGTH=LENGTH+1
      CALL SAW(LENGTH,1,NAMES(1,I),5)
      DO 304 J=1,LAST
      Z=ADJUST(I,J+K)
      IF(ABS(Z) .LE. 1.0E-5) GO TO 304
      CALL RSW(LENGTH, 2+10*J,Z,'(F5.2)',5)
  304 CONTINUE
  301 CONTINUE
      GO TO 25
  300 CONTINUE
      IF (NOTEQ(STM,'D.I.',4)) GO TO 180
C---- WRITE THORNTON AND TUTTLE'S DIFFERENTIATION INDEX * * * * * * * *
      I=INDEX(STM,',',LSTM)
      IF (I.EQ.0) STM(1)=RPAREN
      LSTM=LSTM-I
      CALL MOVE (STM(I + 1),STM,LSTM)
      IF (CONVTD) GO TO 25
      LENGTH=LENGTH+3
      CALL SAW (LENGTH,1,'D.I.',4)
      DO 170 J=1,LAST
      IF (ABS(TTDI(K+J)).LT.1.0E-5) GO TO 170
      CALL RSW (LENGTH, 2+10*J,TTDI(K+J),'(F6.3)',6)
  170 CONTINUE
      GO TO 25
  180 CONTINUE
      IF (NOTEQ(STM,'PART',4)) GO TO 210
C---- WRITE THE PARTITIONING OF DI, HY AND OL  * * * * * * * * * * * * *
      I=INDEX(STM,',',LSTM)
      IF (I.EQ.0) STM(1)=RPAREN
      LSTM=LSTM-I
      CALL MOVE (STM(I + 1),STM,LSTM)
      LENGTH=LENGTH+2
      DO 200 I=56,66
```

```
1259         DO 181 N=1,CNT
1260         IF(ABS(VALUES(I,N)) .GT. 1.0E-5) GO TO 182
1261     181 CONTINUE
1262         GO TO 200
1263     182 LENGTH=LENGTH+1
1264         J=2
1265         IF(I.EQ.56 .OR. I.EQ.60 .OR. I.EQ.63 .OR. I.EQ.66) J=1
1266         CALL SAW (LENGTH,J,NAMES(1,I),5)
1267         DO 190 J=1,LAST
1268         Z=VALUES(I,K+J)
1269         IF(ABS(Z) .LT. 1.0E-5) GO TO 190
1270         CALL RSW (LENGTH,2 + 10*J,Z,'(F6.3)',6)
1271     190 CONTINUE
1272     200 CONTINUE
1273         GO TO 25
1274     210 CONTINUE
1275         IF (NOTEQ(STM,'MINE',4)) GO TO 250
1276 C---- WRITE THE MINERALS * * * * * * * * * * * * * * * * * * * * * * * * * * * *
1277         I=INDEX(STM,',',LSTM)
1278         IF (I.EQ.0) STM(1)=RPAREN
1279         LSTM=LSTM-I
1280         CALL MOVE (STM(I + 1),STM,LSTM)
1281         LENGTH=LENGTH+2
1282         IF (.NOT.NOH2O) CALL SAW(LENGTH,1,'NORMATIVE MINERALS',18)
1283         IF (NOH2O) CALL SAW(LENGTH,1,'NORMATIVE MINERALS - H2O FREE',29)
1284         DO 230 I=22,55
1285         DO 211 N=1,CNT
1286         IF(ABS(VALUES(I,N)) .GT. 1.0E-5) GO TO 212
1287     211 CONTINUE
1288         GO TO 230
1289     212 LENGTH=LENGTH+1
1290         CALL SAW (LENGTH,1,NAMES(1,I),5)
1291         DO 220 J=1,LAST
1292         Z=VALUES(I,K+J)
1293         IF(ABS(Z) .LT. 1.0E-5) GO TO 220
1294         CALL RSW (LENGTH,2 + 10*J,Z,'(F6.3)',6)
1295     220 CONTINUE
1296     230 CONTINUE
1297         IF (CONVTD) GO TO 25
1298         LENGTH=LENGTH+1
1299         CALL SAW (LENGTH,1,'TOTAL',5)
1300         DO 240 J=1,LAST
1301         IF (ABS(TOTALS(2,K+J)).LT.1.0E-5) GO TO 240
1302         CALL RSW (LENGTH, 2+10*J,TOTALS(2,K+J),'(F7.3)',7)
1303     240 CONTINUE
1304         LENGTH=LENGTH+1
1305         CALL SAW(LENGTH,2,'SALIC',5)
1306         DO 241 J=1,LAST
1307         IF (ABS(TYPES(1,K+J)).LT.1.0E-5) GO TO 241
1308         CALL RSW(LENGTH, 2+10*J,TYPES(1,K+J),'(F7.3)',7)
1309     241 CONTINUE
1310         LENGTH=LENGTH+1
1311         CALL SAW(LENGTH,2,'FEMIC',5)
1312         DO 242 J=1,LAST
1313         IF (ABS(TYPES(2,K+J)).LT.1.0E-5) GO TO 242
1314         CALL RSW(LENGTH, 2+10*J,TYPES(2,K+J),'(F7.3)',7)
1315     242 CONTINUE
1316         GO TO 25
1317     250 CONTINUE
1318         IF( NOTEQ(STM,'USER',4) ) GO TO 280
```

```
C---- WRITE THE USER DEFINED VARIABLES * * * * * * * * * * * * * * * * * * *
      I=INDEX(STM,',',LSTM)
      IF(I .EQ. 0) STM(1)=RPAREN
      LSTM=LSTM-I
      CALL MOVE(STM(I+1),STM,LSTM)
      IF(NUM .LE. 66) GO TO 25
      LENGTH=LENGTH+3
      CALL SAW(LENGTH,1,'USER DEFINED VARIABLES',22)
      DO 272 I=67,NUM
      DO 273 N=1,CNT
      IF(ABS(VALUES(I,N)) .GT. 1.0E-5) GO TO 274
  273 CONTINUE
      GO TO 272
  274 LENGTH=LENGTH+1
      CALL SAW(LENGTH,1,NAMES(1,I),8)
      DO 271 J=1,LAST
      Z=VALUES(I,K+J)
      IF(ABS(Z) .LT. 1.E-5) GO TO 271
      CALL RSW(LENGTH, 2+10*J,Z,'(F7.3)',7)
  271 CONTINUE
  272 CONTINUE
      GO TO 25
  280 CONTINUE
      WRITE (LISTERR,270) (STM(I),I=1,LSTM)
      WRITE (LISTTY,270) (STM(I),I=1,LSTM)
      I=INDEX(STM,',',LSTM)
      IF (I.EQ.0) GO TO 30
      LSTM=LSTM-I
      CALL MOVE (STM(I + 1),STM,LSTM)
      GO TO 25
  270 FORMAT (/' FIRST WORD ILLEGAL IN ',80A1)
      END
```

Function conv

```
      FUNCTION CONV (A,N1,N2,E,ERR)
      INTEGER A(1),D,E,DIGITS(12),CHARS(17),CODES(17)
      LOGICAL ERR,CALLED
      DATA DIGITS/'0','1','2','3','4','5','6','7','8','9','.',' '/,
     1 CALLED/.FALSE./
      IF(CALLED) GO TO 5
      CALLED=.TRUE.
      CALL INIT(CHARS,CODES,17,DIGITS,12)
    5 VALUE=0.0
      D=E
      ERR=.FALSE.
      DO 20 I=N1,N2
      CALL FIND(840,A(I),INDEX,CHARS,CODES,17)
      IF (INDEX-11) 14,10,12
   10 D=I-N2
      GO TO 20
   12 INDEX=1
   14 VALUE=10.*VALUE+INDEX-1.
   20 CONTINUE
   30 CONV=VALUE*10.0**D
      RETURN
   40 ERR=.TRUE.
      VALUE=0.0
      GO TO 30
      END
```

Function index

```
1376        FUNCTION INDEX (STRING,CHAR,N)
1377        INTEGER STRING(N),CHAR(1),TANK
1378        DECODE (CHAR,5) TANK
1379      5 FORMAT (A1)
1380        IF (N.LT.0) GO TO 30
1381        DO 10 I=1,N
1382        IF (STRING(I).EQ.TANK) GO TO 20
1383     10 CONTINUE
1384        I=0
1385     20 INDEX=I
1386        RETURN
1387     30 N=-N
1388        DO 40 II=1,N
1389        I=N+1-II
1390        IF (STRING(I).EQ.TANK) GO TO 50
1391     40 CONTINUE
1392        I=0
1393     50 INDEX=I
1394        RETURN
1395        END
```

Subroutine move

```
1396        SUBROUTINE MOVE (A,B,N)
1397        INTEGER A(1),B(1)
1398        DO 10 I=1,N
1399     10 B(I)=A(I)
1400        RETURN
1401        END
```

Function noteq

```
1402        LOGICAL FUNCTION NOTEQ(A,B,N)
1403        INTEGER A(1),B(8),TANK(30)
1404        DECODE(B,5) (TANK(I),I=1,N)
1405      5 FORMAT(30A1)
1406        DO 10 I=1,N
1407        IF(A(I).NE.TANK(I)) GO TO 30
1408     10 CONTINUE
1409        NOTEQ=.FALSE.
1410     20 RETURN
1411     30 NOTEQ=.TRUE.
1412        RETURN
1413        END
```

```
1414        SUBROUTINE PRNT (X,Y,SYM,CNT,E1,E2,LE1,LE2,STAND,PRNTER,SIZE)
1415        LOGICAL PRNTER,STAND
1416        INTEGER SYM(1),E1(LE1),E2(LE2),CNT
1417        DIMENSION X(1),Y(1)
1418        IF(PRNTER) GO TO 5
1419        I=-1
1420        IF(STAND) I=1
1421        CALL SCALE(X,10.0,CNT,I)
1422        XMIN=X(CNT+1)
1423        XMAX=X(CNT+2)
1424        CALL SCALE(Y,8.0,CNT,1)
1425        YMIN=Y(CNT+1)
1426        YMAX=Y(CNT+2)
1427        GO TO 40
1428      5 XMAX=X(1)
1429        XMIN=XMAX
1430        YMAX=Y(1)
1431        YMIN=YMAX
1432        DO 10 I=2,CNT
1433        XT=X(I)
1434        YT=Y(I)
1435        IF (XT.LT.XMIN) XMIN=XT
1436        IF (XT.GT.XMAX) XMAX=XT
1437        IF (YT.LT.YMIN) YMIN=YT
1438        IF (YT.GT.YMAX) YMAX=YT
1439     10 CONTINUE
1440     30 IF (STAND) GO TO 40
1441        XT=XMAX
1442        XMAX=XMIN
1443        XMIN=XT
1444     40 CALL PLOT2 (XMAX,XMIN,YMAX,YMIN,PRNTER,SIZE)
1445        DO 50 I=1,CNT
1446     50 CALL PLOT3 (SYM(I),X(I),Y(I))
1447        CALL PLOT4 (LE2,E2,LE1,E1)
1448        RETURN
1449        END
```

```
1450        SUBROUTINE TRIANG(IDENT,X,Y,CNT,LE1,LE2,LE3,SYM,E1,E2,E3,
1451       X PRNTER,SIZE)
1452        EXTERNAL SAW (descriptors)
1453        COMMON /UNITS/ HEADG,TFORM,INPUT,LISTPR,LISTTY,LISTERR
1454        COMMON /BULKSTOR/ PAGE,PASSYM
1455        DIMENSION X(1),Y(1)
1456        INTEGER E1(LE1),E2(LE2),SYM(1),STAR,BLNK,MORE(2),CNT,IDENT(2,99),
1457       1 PAD(2,36),E3(1),ZERO,USCORE,HEADG(92),TFORM(4),PAD(2),
1458       2 PE1(15),PE2(15),PE3(15),PAGE(132,180)
1459        LOGICAL PRNTER,MOD5,UNDERS(51)
1460        DATA BLNK,ZERO,STAR,USCORE,MORE/' ','+','-','_','+MOR','E'/
1461        IF (PRNTER) GO TO 70
1462  C---- CONSTRUCT TRIANGLE ON CALCOMP PLOTTER
1463        CALL PACK(E1,PE1,LE1)
1464        CALL PACK(E2,PE2,LE2)
1465        CALL PACK(E3,PE3,LE3)
1466        X1=-0.12*LE2
1467        CALL SYMBOL (X1,-0.3,0.21,PE2,0.0,LE2)
1468        CALL SIDE (0.0,0.0,0.0)
1469        X1=9.08-0.12*LE3
1470        CALL SYMBOL (X1,-0.3,0.21,PE3,0.0,LE3)
1471        CALL SIDE (120.0,9.08,0.0)
1472        X1=4.54-0.12*LE1
1473        CALL SYMBOL (X1,7.96,0.21,PE1,0.0,LE1)
1474        CALL SIDE (-120.0,4.54,7.86)
1475  C---- PLOT POINTS
1476        DO 60 I=1,CNT
1477        Y1=7.864E-2*Y(I)
1478        X1=9.08E-2*X(I)+Y1/1.7321
1479        IF (X1.NE.0.0.OR.Y1.NE.0.0) CALL SYMBOL (X1-0.05,Y1-0.07,0.14/SIZE
1480       X ,SYM(I),0.0,1)
1481     60 CONTINUE
1482        CALL PLOT (15.0,0.0,-3)
1483        RETURN
1484  C---- SUPERIMPOSE TRIANGLE ONTO THE PLOTTING SURFACE PAGE(,).
1485     70 DO 100 I=2,50
1486        LF=51-I
1487        DO 80 J=1,LF
1488     80 PAGE(J,I)=BLNK
1489        LF=LF+1
1490        PAGE(LF,I)=STAR
1491        MOD5=MOD(I-1,5).EQ.0
1492        IF (MOD5) PAGE(LF,I)=ZERO
1493        M=2*I-3
1494        DO 90 J=1,M
1495        LF=LF+1
1496     90 PAGE(LF,I)=BLNK
1497        LF=LF+1
1498        PAGE(LF,I)=STAR
1499        IF (MOD5) PAGE(LF,I)=ZERO
1500        LF=LF+1
1501        DO 100 J=LF,101
1502    100 PAGE(J,I)=BLNK
1503        DO 110 J=1,101
1504        PAGE(J,51)=BLNK
1505    110 PAGE(J,1)=BLNK
1506        PAGE(1,51)=STAR
1507        PAGE(51,1)=STAR
```

```
      DO 120 J=3,99,2
      PAGE(J,51)=STAR
  120 IF (MOD(J,10).EQ.1) PAGE(J,51)=ZERO
      PAGE(101,51)=STAR
      K=0
      DO 121 J=52,102
      UNDERS(J-51)=.FALSE.
      DO 121 I=1,101
  121 PAGE(I,J)=BLNK
C---- START PLOTTING THE POINTS.
      DO 150 I=1,CNT
      XT=X(I)
      YT=Y(I)
      IF (XT.EQ.0.0.AND.YT.EQ.0.0) GO TO 150
      J=0.5*YT+0.5
      J=51-J
      IX=XT+0.5*YT+1.5
      IF (XT.LT.1.0.OR.YT.LT.1.0.OR.XT+YT.GT.99.0) GO TO 140
      NPT=PAGE(IX,J)
      IF (NPT.EQ.BLNK) GO TO 140
      IF(NPT .EQ. STAR) GO TO 140
      IF(NPT .EQ. USCORE) GO TO 140
      K=K+1
      UNDERS(J)=.TRUE.
      PAGE(IX,J+51)=USCORE
      IF (K.LE.35) GO TO 130
      K=36
      BAD(1,36)=MORE(1)
      BAD(2,36)=MORE(2)
      GO TO 150
  130 BAD(1,K)=IDENT(1,I)
      BAD(2,K)=IDENT(2,I)
      GO TO 150
  140 PAGE(IX,J)=SYM(I)
  150 CONTINUE
      IF (K.EQ.0) GO TO 170
      CALL SAW(1,1,'THE FOLLOWING POINTS WERE NOT PLOTTED',37)
      CALL SAW(2,1,'BECAUSE THEY WOULD HAVE FALLEN ON A',35)
      CALL SAW(3,1,'PREVIOUSLY PLOTTED POINT:',25)
      M=3
      DO 160 I=1,K
      J=MOD(I-1,6)
      IF (J.EQ.0) M=M+1
      LF=6*J+1
  160 CALL SAW(M,LF,BAD(1,I),5)
  170 WRITE (LISTPR,TFORM)HEADG
      WRITE (LISTPR,180) (E1(I),I=1,LE1)
      DO 210 J=1,51
      WRITE (LISTPR,190)(PAGE(I,J),I=1,101)
      IF(UNDERS(J)) WRITE (LISTPR,201)(PAGE(I,J+51),I=1,101)
  210 CONTINUE
      WRITE (LISTPR,190) (E2(I),I=1,LE2)
      WRITE (LISTPR,200) (E3(I),I=1,LE3)
      RETURN
  180 FORMAT (' ',55X,40A1)
  190 FORMAT (' ', 5X,101A1)
  200 FORMAT ('+',105X,27A1)
  201 FORMAT('+', 5X,101A1)
        END
```

```
1567        FUNCTION EVAL(VALUES)
1568        INTEGER TYPE(41),TOP
1569        DIMENSION VALUES(1),STACK(41),POLISH(41)
1570        COMMON /EVALPR/ TYPE,ICT,POLISH
1571        COMMON /UNITS/ PAD(98),LISTTY,LISTERR
1572        I=ICT
1573        TOP=0
1574        DO 340 J=1,I
1575        INDEX=TYPE(J)
1576        IF(INDEX) 290,285,280
1577    280 TOP=TOP+1
1578        STACK(TOP)=VALUES(INDEX)
1579        GO TO 340
1580    285 TOP=TOP+1
1581        STACK(TOP)=POLISH(J)
1582        GO TO 340
1583    290 INDEX=5+INDEX
1584        IF(INDEX .EQ. 0) GO TO 295
1585        VT=STACK(TOP)
1586        TOP=TOP-1
1587        GO TO (310,300,330,320),INDEX
1588    295 STACK(TOP)=-STACK(TOP)
1589        GO TO 340
1590    300 STACK(TOP)=STACK(TOP)*VT
1591        GO TO 340
1592    310 IF(VT .NE. 0.0) GO TO 315
1593        WRITE (LISTTY,312)
1594        WRITE (LISTERR,312)
1595    312 FORMAT(/' DIVIDE BY ZERO ATTEMPTED, HENCE')
1596        GO TO 360
1597    315 STACK(TOP)=STACK(TOP)/VT
1598        GO TO 340
1599    320 STACK(TOP)=STACK(TOP)+VT
1600        GO TO 340
1601    330 STACK(TOP)=STACK(TOP)-VT
1602    340 CONTINUE
1603        IF (TOP.NE.1) GO TO 360
1604        EVAL=STACK(1)
1605    350 RETURN
1606    360 EVAL=0.0
1607        RETURN
1608        END
```

```
1609        SUBROUTINE PACK(FROM,TO,LENGTH)
1610        INTEGER FROM(LENGTH),TO(LENGTH),WORD(1)
1611        IPT=0
1612        N=LENGTH/4
1613        LAST=LENGTH-4*N
1614        IF (N.EQ.0) GO TO 10
1615        DO 5 J=1,N
1616        ENCODE (WORD,1) (FROM(IPT+I),I=1,4)
1617      1 FORMAT(4A1)
1618        TO(J)=WORD(1)
1619      5 IPT=IPT+4
1620     10 IF (LAST.EQ.0) GO TO 20
1621        WORD(1)='    '
1622        ENCODE (WORD,1) (FROM(IPT+I),I=1,LAST)
1623        TO(N+1)=WORD(1)
1624     20 RETURN
1625        END
```

```
1626        SUBROUTINE PARSE(EXPR,L,NAMES,N,ERR,LISTTY,LISTERR)
1627        LOGICAL ERR,POP,NUM,CALLED
1628        INTEGER EXPR(1),NAME(8),BLANK,TM(3,9),SYMBOL(44),TOP,ROW,COLUMN,C,
1629       1ELEMNT,SWITCH,INDEX,TYPE(41),COLS(44),NAMES(2,81),VARBLE(2),
1630       2CHARS(47),CODES(47)
1631        COMMON /EVALPR/ TYPE,ICT,POLISH
1632        DIMENSION POLISH(41),STACK(41)
1633        DATA TM/12,32,0,81,2*41,0,2*51,0,2*61,0,2*71,101,3*0,92,93
1634       1,21,22,23,113,32,33/,UNARY,DIV,PROD,DIFF,PLUS/-5.,-4.,-3.,-2.,-1./
1635        DATA COLS/26*1,11*9,8,3,2,5,4,6,7/,SYMBOL/'A','B','C','D',
1636       1 'E','F','G','H','I','J','K','L','M','N','O','P','Q','R','S',
1637       2 'T','U','V','W','X','Y','Z','0','1','2','3','4','5','6','7',
1638       3 '8','9','.',' ','+','-','*','/','(',')'/,PAREN,CALLED/0,.FALSE./
1639       4 ,BLANK/' '/
1640 C      INITIALIZATION
1641        IF(CALLED) GO TO 20
1642        CALLED=.TRUE.
1643        CALL INIT(CHARS,CODES,47,SYMBOL,44)
1644     20 ERR=.FALSE.
1645          ROW=1
1646          TOP=0
1647          I=0
1648          C=0
1649 C      CONSTRUCT POLISH FORM VIA TRANSITION MATRIX TM
1650     30 C=C+1
1651 C      ARE THERE MORE CHARACTERS TO PROCESS IN EXPR ?
1652          IF (C.LE.L) GO TO 50
1653          IF(ROW.EQ.1) GO TO 460
1654          IF (POP) GO TO 250
1655          IF (NUM) GO TO 40
1656          SWITCH=1
1657 C      GO FIND VALUE AND INSERT IN POLISH STRING
1658          GO TO 370
1659     40 SWITCH=2
1660 C      GO EVALUATE CONSTANT AND INSERT IN POLISH STRING
1661          GO TO 420
1662 C      GET THE CHARACTER. DETERMINE TASK (JOB) AND NEXT-STATE (ROW).
1663     50 NEXT=EXPR(C)
1664        CALL FIND(*485,NEXT,J,CHARS,CODES,47)
1665        COLUMN=COLS(J)
1666          ELEMNT=TM(ROW,COLUMN)
1667          JOB=ELEMNT/10
1668          ROW=MOD(ELEMNT,10)
1669          GO TO (60,30,70,130,140,150,160,170,180,230,240), JOB
1670          GO TO 485
1671 C      START AN ITEM
1672     60 NAME(1)=NEXT
1673          NCHAR=1
1674          POP=.FALSE.
1675          NUM=.FALSE.
1676          GO TO 30
1677 C      ADD CURRENT CHARACTER TO PARTIALLY BUILT ITEM
1678     70 NCHAR=NCHAR+1
1679          NAME(NCHAR)=NEXT
1680          GO TO 30
1681     80 IF (POP) GO TO 100
1682          POP=.TRUE.
1683          IF (NUM) GO TO 90
```

```
1684            SWITCH=3
1685 C       GO FIND VALUE AND INSERT IN POLISH STRING
1686            GO TO 370
1687     90  SWITCH=4
1688 C       GO EVALUATE CONSTANT AND INSERT IN POLISH STRING
1689            GO TO 420
1690    100  IF (TOP.EQ.0) GO TO 120
1691            IF (CODE.LT.STACK(TOP)) GO TO 120
1692         SWITCH=5
1693            VALUE=STACK(TOP)
1694            INDEX=VALUE
1695            GO TO 470
1696    110  TOP=TOP-1
1697            GO TO 100
1698    120  TOP=TOP+1
1699            STACK(TOP)=CODE
1700            GO TO 30
1701 C       SET CODE FOR OPERATOR AND GO PROCESS ITEM
1702    130  CODE=DIFF
1703            GO TO 80
1704    140  CODE=PLUS
1705            GO TO 80
1706    150  CODE=DIV
1707            GO TO 80
1708    160  CODE=PROD
1709            GO TO 80
1710    170  CODE=UNARY
1711            GO TO 120
1712 C       RIGHT PAREN SENSED. INSERT ITEM IN POLISH AND POP STACK
1713    180  IF (POP) GO TO 200
1714            POP=.TRUE.
1715            IF (NUM) GO TO 190
1716            SWITCH=6
1717 C       GO FIND VALUE AND INSERT IN POLISH STRING
1718            GO TO 370
1719    190  SWITCH=7
1720 C       GO EVALUATE CONSTANT AND INSERT IN POLISH STRING
1721            GO TO 420
1722    200  IF (TOP.EQ.0) GO TO 460
1723            IF (PAREN.EQ.STACK(TOP)) GO TO 220
1724            SWITCH=8
1725            VALUE=STACK(TOP)
1726            INDEX=VALUE
1727            GO TO 470
1728    210  TOP=TOP-1
1729            GO TO 200
1730    220  TOP=TOP-1
1731            GO TO 30
1732 C       LEFT PAREN SENSED. INSERT IN STACK
1733    230  TOP=TOP+1
1734            STACK(TOP)=PAREN
1735            GO TO 30
1736    240  NAME(1)=NEXT
1737            NCHAR=1
1738            NUM=.TRUE.
1739            POP=.FALSE.
1740            GO TO 30
1741    250  IF (TOP.EQ.0) GO TO 510
1742            SWITCH=9
1743            VALUE=STACK(TOP)
```

```
1744           IF(VALUE.EQ.PAREN) GO TO 460
1745           INDEX=VALUE
1746           GO TO 470
1747    260  TOP=TOP-1
1748           GO TO 250
1749 C      GET INDEX ASSOCIATED WITH NAME
1750    370  NCHAR=NCHAR+1
1751           IF (NCHAR.GT.8) GO TO 390
1752 C      PAD NAME WITH BLANKS
1753           DO 380 J=NCHAR,8
1754    380  NAME(J)=BLANK
1755    390    ENCODE(VARBLE,395) NAME
1756    395    FORMAT(8A1)
1757           DO 400 J=1,N
1758         IF (VARBLE(1).EQ.NAMES(1,J).AND.VARBLE(2).EQ.NAMES(2,J)) GO TO 410
1759    400  CONTINUE
1760           WRITE (LISTTY,490) VARBLE
1761           WRITE (LISTERR,490) VARBLE
1762           GO TO 460
1763    410  INDEX=J
1764           GO TO 470
1765 C      EVALUATE A CONSTANT
1766    420  VALUE=CONV(NAME,1,NCHAR,0,ERR)
1767           INDEX=0
1768           IF (ERR) GO TO 460
1769    470  I=I+1
1770           POLISH(I)=VALUE
1771           TYPE(I)=INDEX
1772           GO TO (250,250,100,100,110,200,200,210,260), SWITCH
1773    460  ERR=.TRUE.
1774 C         PARSE=0.0
1775    485  WRITE (LISTTY,480)(EXPR(J),J=1,L)
1776         WRITE (LISTERR,480)(EXPR(J),J=1,L)
1777    510  ICT=I
1778         RETURN
1779    480  FORMAT (/' ERROR IN EXPRESSION ',80A1)
1780    490  FORMAT (/' UNDEFINED NAME ',2A4)
1781           END
```

```
1782        SUBROUTINE PLOT2(XMAX,XMIN,YMAX,YMIN,WPRNT,SIZE)
1783        LOGICAL KNHOR,WPLOT,UNDERS(51),WPRNT
1784        INTEGER LABEL(1),XLAB(1),PLAB(15),PXLAB(15),CH,WL,USCORE,HEADG,
1785       1 TFORM,HC,BL
1786        DIMENSION ABNOS(11)
1787        COMMON /UNITS/ HEADG(92),TFORM(4),INPUT,LISTPR,LISTTY,LISTERR
1788        COMMON /BULKSTOR/ IMAGE(23760),PASSYM
1789        COMMON /PLOTS/ XMIN1,YMIN1,DV,DH,WPLOT,SCALE,UNDERS,YMX,ABNOS
1790        DATA HC,NC,BL,USCORE/'-','+',' ','_'/
1791        WPLOT=WPRNT
1792        IF (WPRNT) GO TO 130
1793        SCALE=SIZE
1794          XMIN1=XMIN
1795          YMIN1=YMIN
1796          DV=XMAX
1797          DH=YMAX
1798          IF(ABS(DV-XMIN1).LT.1.E-6) DV=XMIN1+1.0
1799          IF(ABS(DH-YMIN1).LT.1.E-6) DH=YMIN1+1.0
1800          RETURN
1801    130 YMX=YMAX
1802        DV=(XMAX-XMIN)/100.
1803          DH=(YMAX-YMIN)/50.
1804          DO 140 I=1,11
1805    140     ABNOS(I)=(XMIN+FLOAT((I-1)*10)*DV)
1806          DO 150 I=1,10302
1807    150 IMAGE(I)=BL
1808          DO 180 I=1,51
1809          UNDERS(I)=.TRUE.
1810          I2=I*101
1811          I1=I2-100
1812          KNHOR=MOD(I-1,10).NE.0
1813        IF (KNHOR) GO TO 170
1814          DO 160 J=I1,I2
1815    160 IMAGE(J)=HC
1816    170 CONTINUE
1817          DO 180 J=I1,I2,10
1818          IF (KNHOR) GO TO 180
1819          IMAGE(J)=NC
1820    180 CONTINUE
1821          XMIN1=XMIN-DV/2.
1822          YMIN1=YMIN-DH/2.
1823          RETURN
1824        ENTRY PLOT3(CH,X,Y)
1825          DUM1=(X-XMIN1)/DV
1826          DUM2=(Y-YMIN1)/DH
1827          IF (WPLOT) GO TO 190
1828          CALL SYMBOL (DUM1-0.05,DUM2-0.07,0.14/SCALE,CH,0.0,1)
1829          RETURN
1830    190 J=(51-INT(DUM2)-1)*101+INT(DUM1)+1
1831          NPT=IMAGE(J)
1832          IF(NPT .EQ. BL) GO TO 191
1833        IF(NPT.EQ.HC) GO TO 191
1834          IF(NPT .EQ. NC) GO TO 191
1835          I=(J-1)/101+1
1836          UNDERS(I)=.FALSE.
1837          IMAGE(J+5151)=USCORE
1838    191 IMAGE(J)=CH
1839          RETURN
```

```
      ENTRY PLOT4(NL,LABEL,NXL,XLAB)
        IF (WPLOT) GO TO 200
      CALL PACK(LABEL,PLAB,NL)
      CALL PACK(XLAB,PXLAB,NXL)
        CALL AXIS (0.0,0.0,PLAB,NL,7.0,90.0,YMIN1,DH)
        CALL AXIS (0.0,0.0,PXLAB,-NXL,10.0,0.0,XMIN1,DV)
      CALL PLOT(15.0,0.0,-3)
        RETURN
  200 WRITE (LISTPR,TFORM)HEADG
        DO 220 I=1,51
        WL=BL
        IF (I.LE.NL) WL=LABEL(I)
        I2=I*101
        I1=I2-100
        IF (MOD(I-1,10).EQ.0) GO TO 210
        WRITE (LISTPR,205) WL,(IMAGE(J),J=I1,I2)
  205   FORMAT(1X,A1,9X,121A1)
        GO TO 221
  210 CONTINUE
        ORDNO=(YMX-FLOAT(I-1)*DH)
        WRITE (LISTPR,215) WL,ORDNO,(IMAGE(J),J=I1,I2)
  215   FORMAT(1X,A1,F8.3,1X,121A1)
  221 IF(UNDERS(I)) GO TO 220
        I1=I1+5151
        I2=I2+5151
        WRITE (LISTPR,222)(IMAGE(J),J=I1,I2)
  222 FORMAT('+',10X,121A1)
  220 CONTINUE
        WRITE (LISTPR,225) (ABNOS(J),J=1,11)
  225   FORMAT(1HOF14.3,10F10.3)
        WRITE (LISTPR,240) (XLAB(J),J=1,NXL)
        RETURN
  240 FORMAT (' ',50X,70A1//)
        END
```

Subroutine clear

```
      SUBROUTINE CLEAR
      INTEGER COLUMN,WIDTH,SIZE,AREA(4),BLANK,PAD(86)
      INTEGER PAGE(132,180),FORMAT(1),STRING(33)
      COMMON /UNITS/ HEADG(92),TFORM(4),INPUT,LISTPR,LISTTY,LISTERR
      COMMON /BULKSTOR/ PAGE,RASSYM
      DATA BLANK/' '/
      DO 10 J=1,180
      DO 10 I=1,132
   10 PAGE(I,J)=BLANK
      GO TO 50
      ENTRY RSW(LINE,COLUMN,RS,FORMAT,SIZE)
      ENCODE(AREA,FORMAT) RS
      DECODE(AREA,15) (PAGE(COLUMN+I-1,LINE),I=1,SIZE)
   15 FORMAT(132A1)
      GO TO 50
      ENTRY SAW(LINE,COLUMN,STRING,SIZE)
      DECODE(STRING,15) (PAGE(COLUMN+I-1,LINE),I=1,SIZE)
      GO TO 50
      ENTRY OUTPUT(LENGTH)
      DO 30 J=1,LENGTH
   30 WRITE (LISTPR,40)(PAGE(I,J),I=1,132)
   40 FORMAT(' ',132A1)
   50 RETURN
      END
```

Subroutine init

```
1898        SUBROUTINE INIT(CHARS,CODES,M,SYMBOL,N)
1899        INTEGER FILLER,CHARS(1),CODES(1),SYMBOL(1)
1900        DATA FILLER/'VOID'/
1901        DO 10 I=1,M
1902     10 CHARS(I)=FILLER
1903        DO 40 ICODE=1,N
1904        ICHAR=SYMBOL(ICODE)
1905        L=IABS(ICHAR)
1906        J=L/M
1907        I=L-M*J
1908        IF (MOD(J,M).EQ.0) J=1
1909     20 IF (CHARS(I+1).EQ.FILLER) GO TO 30
1910        I=MOD(I+J,M)
1911        GO TO 20
1912     30 CHARS(I+1)=ICHAR
1913     40 CODES(I+1)=ICODE
1914        RETURN
1915        END
```

Subroutine find

```
1916        SUBROUTINE FIND(*,ISYMBL,KODE,CHARS,CODES,M)
1917        INTEGER CHARS(1),CODES(1),FILLER
1918        DATA FILLER/'VOID'/
1919        L=IABS(ISYMBL)
1920        J=L/M
1921        I=L-M*J
1922        IF (MOD(J,M).EQ.0) J=1
1923     50 ICHAR=CHARS(I+1)
1924        IF (ICHAR.EQ.ISYMBL) GO TO 60
1925        IF (ICHAR.EQ.FILLER) RETURN 1
1926        I=MOD(I+J,M)
1927        GO TO 50
1928     60 KODE=CODES(I+1)
1929        RETURN
1930        END
```

Subroutine side

```
1931        SUBROUTINE SIDE (T,X,Y)
1932        CT=COS(1.74533E-2*T)
1933        ST=SIN(1.74533E-2*T)
1934        DO 10 I=0,9
1935        AL=0.908*I
1936        BL=AL+0.908
1937        IH=2
1938        IF (I.EQ.0) IH=3
1939        CALL PLOT(X+AL*CT-0.086603*ST-0.05*CT,Y+AL*ST+0.086603*CT-0.05*ST,
1940       X 3)
1941        CALL PLOT(X+AL*CT,Y+AL*ST,IH)
1942        CALL PLOT(X+BL*CT,Y+BL*ST,2)
1943        IF (I.NE.9) CALL PLOT(X+BL*CT-0.086603*ST+0.05*CT,
1944       X Y+BL*ST+0.05*ST+0.086603*CT,2)
1945     10 CONTINUE
1946        RETURN
1947        END
```

```
1948        SUBROUTINE FILES (IN,N)
1949        EXTERNAL SCC(descriptors),DELETE(descriptors)
1950        INTEGER ANSWER,LINES(33),HEADG,TFORM
1951        CHARACTER TAPEPT*6,INFILE*32,PRFILE*32,BLANK*32
1952        COMMON /UNITS/ HEADG(92),TFORM(4),INPUT,LISTPR,LISTTY,LISTERR
1953        DATA BLANK/" "/
1954        GO TO (30,10,50,70,40,90,100,140),N
1955  C---- OPEN INPUT FILE.
1956     10 PRINT 15
1957     15 FORMAT (/'Enter Input File : ',$)
1958        READ 20,INFILE
1959     20 FORMAT (A32)
1960        IF (INFILE.EQ.BLANK) STOP
1961        OPEN (INPUT,FILE=INFILE,FORM="formatted",MODE="in",ERR=18)
1962        RETURN
1963     18 PRINT 19,INFILE
1964     19 FORMAT (/'Cannot attach to file ',a32)
1965        CLOSE (INPUT)
1966        GO TO 10
1967  C---- OPEN PRINTER FILE.
1968     30 PRINT 35
1969     35 FORMAT (/'Enter Printer File : ',$)
1970        READ 20,PRFILE
1971        OPEN (LISTPR,FILE=PRFILE,FORM="formatted",CARRIAGE=.TRUE.,
1972       1 DEFER=.TRUE.,MODE="out")
1973        RETURN
1974  C---- CLOSE FILE.
1975     40 CLOSE (IN)
1976        RETURN
1977  C---- OPEN TAPE UNIT FOR CALCOMP PLOT, IF NEEDED.
1978     50 PRINT 55
1979     55 FORMAT (/'Is any portion of this run going to plot tape ? ',$)
1980        READ 21,ANSWER
1981     21 FORMAT(A3)
1982        IF (ANSWER.NE."yes ") RETURN
1983        PRINT 23
1984     23 FORMAT (/'Enter 6-character plot tape number : ',$)
1985        READ 22,TAPEPT
1986     22 FORMAT(A6)
1987        CALL SCC('-un','15','-tp','-nm',TAPEPT)
1988        RETURN
1989  C---- RESET STATUS OF CALCOMP.
1990     70 IF (ANSWER.EQ."yes ") CALL SCC('-reset')
1991        RETURN
1992  C---- OPEN SCRATCH FILE FOR LISTING ERRORS.
1993     90 OPEN (LISTERR,FILE="ERRORS.list",FORM="formatted",MODE="inout")
1994        RETURN
1995  C---- COPY ERRORS FROM SCRATCH FILE TO PRINTER FILE.
1996    100 REWIND LISTERR
1997        ISW=0
1998    110 READ (LISTERR,120,END=130) LINES
1999    120 FORMAT (33A4)
2000        IF (ISW.NE.0) GO TO 125
2001        ISW=1
2002        WRITE (LISTPR,TFORM) HEADG
2003        WRITE (LISTPR,126)
2004    126 FORMAT (//5X,'ERROR MESSAGES AND RUN CONDITIONS'//)
2005    125 WRITE (LISTPR,120) LINES
```

```
2006           GO TO 110
2007     130   REWIND LISTERR
2008           RETURN
2009  C----    CLOSE AND DELETE SCRATCH FILE.
2010     140   CLOSE (LISTERR)
2011           CALL DELETE ("ERRORS.list")
2012           RETURN
2013           END
```