

Microprobe analyses of hornblendes from 5 calc-alkalic intrusive complexes,
with data tables for other calcic amphiboles and BASIC computer programs
for data manipulation.

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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INTRODUCTION

Microprobe analyses of hornblendes from 5 calc-alkalic intrusive complexes were obtained at the U.S.G.S. facility in Reston, Virginia, in conjunction with mapping and petrologic studies on granitoids. These analyses, together with calcic amphibole analyses drawn from the literature, were used in assessing the compositional variations in calcic igneous amphiboles from well-studied natural occurrences and from controlled experiments on natural rock compositions as a function of pressure (Hammarstrom and Zen, 1983). This report contains the data base for that study including previously unreported microprobe results, a tabulation of analyses from the literature, and listings of BASIC computer programs written for a Tektronix 4052 with 64K RAM for calculation of mineral formulae from chemical data entered in terms of oxide weight percents, with cation site partitioning and data tabulation.

DESCRIPTION OF THE DATA SET

The data set consists of 8 tables of amphibole analyses. The first three rows of each column contain coded information about the analysis. A unique number for each analysis in the data set appears at the bottom of each column. Each table is preceded by a key which relates analysis numbers and sample codes to actual sample numbers assigned by the collector and to rock types. A brief description of the intrusive complex and pertinent references are cited in each key. Weight percents for 13 oxides and elements are listed with sums, correction for the oxygen-equivalent of other anions, a theoretical estimation of permissible water content as a check on the sum, and cations calculated on the anhydrous basis of 23 oxygens per formula unit. Cations are partitioned into tetrahedral (T), octahedral M1-M3 and M4, sites and A-site based on an idealized scheme assuming no vacancies in the M sites. Details of calculations are given below. Cations are summed; the final entry in each column is the ratio $Fe/Fe+Mg$. Since the microprobe can not distinguish between ferrous and ferric iron, total iron is treated as FeO .

Tables 1-5 contain microprobe data acquired by the author. A separate table is given for hornblende analyses from each of the plutonic complexes - the Mount Princeton Complex in the Sawatch Range of Colorado (Table 1), the Pioneer Batholith of southwestern Montana (Table 2), various plutons in the vicinity of Ketchikan, southeastern Alaska (Table 3), the pluton at Round Valley near Riggins, Idaho (Table 4), and the Ecstall Pluton, British Columbia (Table 5). The key to each table lists the sample codes along with the actual rock sample number assigned by the collector, rock type, a brief description of the complex and pertinent references. In addition to the analysis number and sample code, the column headers for tables 1-5 include information on the grain number within a given sample and in some cases a descriptor for the point at which the analysis was taken within the grain ("c" for core; "r" for rim). Due to the heterogeneity of the hornblendes in these rocks (exhibited optically by zoning or color patchiness), individual analyses or averages of 2-3 points taken in close proximity to each other (on the order of 15 microns apart) are presented rather than averages for whole grains or samples. In several instances, traverses were made across grains at regular step intervals or grains were mapped out in detail giving rise to a large number of analyses (10 or more) for a single grain.

Table 6 contains published amphibole analyses from other plutonic complexes, including data from the SW Japan Batholith, the Sierra Nevada Batholith, the Teutonia Batholith, the Finnmarka Complex and intrusives of the Pliny Range, New Hampshire. References are cited in the key to Table 6, along with rock type descriptions. Due to the variety of calculation schemes and rounding errors, analyses taken from the literature were recalculated for direct comparison with data in Tables 1-5. All of the analyses in table 6 are microprobe data and most analyses represent averages for a single sample or for a number of samples from a given rock type.

Table 7 lists analyses of calcic amphiboles from rocks thought to have formed at pressures of 5 kbar or higher. Analyses from lower crustal xenoliths, eclogites and granulites are included. Analyses are grouped by occurrence.

Analyses of calcic amphiboles reported from experiments on natural rock compositions at a variety of pressure, temperature and oxygen fugacity conditions are presented in Table 8. Analyses are coded by experimentalist, and column headers give conditions under which a given amphibole equilibrated.

The data set includes only those analyses deemed to represent calcic amphiboles of probable igneous compositions by the following criteria:

$$\begin{array}{ll} \text{Si (cations per 23 oxygens)} & \leq 7.50 \\ \text{Ca}_{\text{M4}} + \text{Na}_{\text{M4}} & \geq 1.34 \\ \text{Na}_{\text{M4}} & < 0.67 \end{array}$$

(after Leake, 1971, 1978)

ANALYTICAL TECHNIQUE FOR DATA IN TABLES 1-5

Tables 1-5 contain previously unreported hornblende analyses obtained on three ARL (Applied Research Laboratories) electron microprobes over a period of about 5 years. Most of the data in Tables 1 & 2 were collected on an automated 3-channel wavelength dispersive ARL-EMX microprobe with energy dispersive capability whereas most of the data in Tables 3-5 was acquired on an automated 9-channel wavelength dispersive ARL-SEMQ (Scanning Electron Microprobe Quantometer) microprobe with 6 fixed spectrometers and 3 scanners. About 1/3 of the analyses in Tables 1 and 2 were made using a combined 3-channel wavelength dispersive and energy dispersive system (Wiggins and Huebner, 1981). A 9-channel ARL-SEMQ microprobe at Virginia Polytechnic Institute and State University Geology Department was used to obtain about 1/3 of the analyses in Table 2. All analyses were made at an operating voltage of 15 kilovolts with a beam current of 0.10 microamp; spot size was on the order of 5-10 microns. Count times varied from 10 to 20 seconds or more for each element. Natural and synthetic mineral standards were used for all analyses and backgrounds were measured by peak offset or by counting on well-characterized materials with mean atomic number similar to hornblende, but devoid of the element of interest. Chemically analysed amphiboles and micas were run as working standards during each session to check accuracy, and replicate analyses on standards throughout a session provide an estimate of analytical precision

- generally $\pm 2\%$ of the amount present for major elements, $\pm 10\%$ of the amount present for minor elements. In all cases, data were reduced on-line with Bence-Albee correction procedures (Bence and Albee, 1968; McGee, 1983) incorporating alpha factors reported by Albee and Ray (1970).

Identical operating conditions and working standards on all three microprobe systems, and data collection by a single operator help minimize analytical errors.

METHOD OF CALCULATION

DATA ENTRY

Oxide weight percents from microprobe output or from other tabulated chemical analyses are entered as Tektronix data files using an interactive program called DATAIN. This program prompts the user for the number of analyses to be entered, 3 lines of alphanumeric identifiers (SAMPLE, GRAIN, POINT), which may be left blank, and 17 oxide/element weight percents. The number of oxides/elements and order of entry are compatible with the usual order of elements in analytical reports on rocks and minerals, so this program may be used to generate files for a wide variety of rock and mineral compositions. The user has the option of proofreading and modifying data before the file is stored on tape.

A second option is provided to convert a complete chemical analysis to its "microprobe equivalent" by converting Fe_2O_3 to FeO and eliminating H_2O . The resulting file can be input to the formula-calculating procedure for comparison with formulae calculated for microprobe analyses, e.g., to see the effect of Fe^{+3} on the calculated formula, or compare analytical H_2O with theoretical calculated H_2O .

MINERAL FORMULA CALCULATION, SITE PARTITIONING, DATA TABULATION

Data files created with DATAIN are read by an interactive program called HBCAT, which prompts the user for an input data tape file number, a title, the formula basis for the cation calculation (23 oxygens for anhydrous basis, 24 oxygens for analyses with H_2O), the fraction of total iron to be treated as ferric iron (which may be ignored if Fe_2O_3 is included in the input file or if total iron as ferrous iron is desired), and the number of analyses to be printed on a single page.

The program sums oxides and calculates ions on the basis of 23 or 24 oxygens following the scheme described by Deer, Howie and Zussman (1967, Appendix a, p. 515). Corrections for excess oxygen are made when other anions are present (F, Cl) and an estimate of maximum H_2O content is made by assuming a fully occupied (2 anions) OH site in the amphibole structure, so that $2.00 - \text{F} - \text{Cl} = \text{OH}$. Weight per cent H_2O is calculated from OH and printed as a check on the oxide sum. This method does not provide an accurate measure of the actual H_2O content of the mineral, but only provides a check on the analysis sum; errors from other sources such as analytical errors, missing elements, or inaccurate ferric/ferrous iron partitioning will usually be less than $\pm 2\%$, giving this " H_2O -corrected sum" a value between 98 and 102.

Ions are partitioned into sites in the amphibole structure on the basis of the following scheme, which assumes no vacancies in the M sites (after Goff and Czamanske, 1972).

Cations are assigned to sites in the order listed until the site is filled.

| site | <u>full site occupancy</u> |
|--|----------------------------|
| <u>tetrahedral (T)</u> | 8.00 |
| Si | |
| $Al^{iv} = 8 - Si$ | |
| <u>M1-M3</u> | 5.00 |
| $Al^{vi} = Al - Al^{iv}$ | |
| Ti | |
| Fe ⁺³ | |
| Mg | |
| Fe ⁺² | |
| Mn | |
| <u>M4</u> | 2.00 |
| Ca | |
| Mg | |
| Fe ⁺² (excess after M1-M3 filled to 5.00) | |
| Mn | |
| Na | |
| <u>A</u> | 0 - 1.00 |
| K | |
| Na | |

Cations and anions are summed and the ratio Fe/Fe + Mg is calculated.

At this point the program asks if the user wants the data table printed to a tape file in a format compatible with the program MICRO-GRASP (Bowen, 1982; Bowen and Botbal, 1975). MICRO-GRASP is a powerful program for manipulation of large files of data. Files created by HBCAT can be readily catenated, edited or attached to data definitions for use with MICRO-GRASP to obtain statistics, x-y and ternary plots, lists of selected items, etc.

The program then asks the user if a printout of the data table is desired and if so, what device is to be used (tape, or printer). Printing the table to tape allows the user to edit the file before final tables are printed. These tables were edited to eliminate extra lines for elements for which no data was collected (e.g., Fe₂O₃, P₂O₅, S, etc.).

The title is printed on each page, followed by the 3 alphanumeric column headers, the oxide weight per cents, sums, site-partitioned cation table,

anions, and Fe/Fe + Mg ratio. The user chooses the number of analyses to appear per page so that the table format may be used on both narrow and wide printers.

Memory requirements for HBCAT limit the number of analyses to < 30 per run. However, large data bases for input with MICRO-GRASP (up to 99 analyses) can be created by using the editor to catenate files created by the HBCAT program. Program listings and data definition for use with MICRO-GRASP are given in Appendices A-C.

Other programs of interest in amphibole calculations such as those described by Papike and others (1974) and Goff and Czamanske (1972) are useful and provide alternate calculation schemes, ferric iron estimates and built-in data evaluation but either fail to include all elements of interest or fail to provide a table format. Recent developments in on-line microprobe data storage at the U.S.G.S., Reston (McGee, 1983) allow direct data tabulations from microprobe output stored on disk using a DEC system (Huebner, 1983; Flohr, 1983); these programs produce tables similar to HBCAT output but are not compatible with MICRO-GRASP.

DATA EVALUATION

The following criteria are used to evaluate each analysis:

oxide sum + estimated H₂O = 98 - 102

T-site sum = 8.00 ± 0.02

M1-M3 site sum = 5.00 ± 0.02

M4 site sum = 2.00 ± 0.02

A-site sum ≤ 1.02 (in part, after Papike and others, 1974)

This does not insure reliability of reported analyses but tends to eliminate those that are truly inaccurate.

All the data in Tables 1 to 5 meet these requirements. Data from the literature (Tables 6-8) were eliminated only if 2 or more tests were failed, on the assumption that the author deemed the analysis worthy of publication.

KEY TO TABLE 1

| ANALYSIS # | SAMPLE CODE | SAMPLE # | ROCK DESCRIPTION |
|------------|----------------|----------|--|
| 1-4 | C01 | 7179 | Mount Princeton quartz monzonite |
| 5-15 | C02 | 7570 | " |
| 16 | C03 | 7574 | " |
| 17-21 | C04 | 7706 | " |
| 22-56 | C05 | 7707 | " |
| 57-61 | C06 | 7812 | " |
| 62-63 | C07 | 8000 | " |
| 64-69 | C08 | 8006 | " |
| 70-71 | C09 | 8044 | " |
| 72-73 | C010 | 8050 | " |
| 74-76 | C011 | 8057 | " |
| 77-81 | C012 | 7814 | " |
| 82-87 | C013 | 7999 | " |
| 88-90 | C014 | 7219 | Mount Aetna quartz monzonite porphyry |
| 91-93 | C015 | 7220 | " |
| 94-98 | C016 | 7435 | " |
| 99-101 | C017 | 7456 | " |
| 102 | C018 | 8023 | Mount Pomeroy quartz monzonite |
| 103-111 | C019 | 82013 | " |
| 112 | C020 | 7975 | " |
| 113-115 | C021 | 7671 | Sewanee Peak Volcanics (quartz latite porphyry) |
| 116-118 | C022 | 7723 | " |
| 119-121 | C023 | 7833 | " |
| 122-125 | C024 | 7878 | " |

The Mount Princeton complex is a Tertiary composite plutonic volcanic complex in the Sawatch Range of central Colorado.

Samples were collected by Priestley Toulmin III in conjunction with detailed mapping and petrologic studies (Toulmin, 1976; Toulmin, in preparation) of the intrusive-volcanic complex and reference sample numbers refer to his collection. The area was mapped by Crawford (1913) and by Dings and Robinson (1957) and descriptions of the various rock units can be found in those publications.

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE GRAIN | C01 | | | C02 | | | | | | | |
|-----------------|-------|-------|--------|-------|-------|-------|-------|-------|-------|--------|--------|
| | 1 | 2 | 3 | 1 | | | | | | | |
| | | | | | C | | | | C | C | F |
| SiO2 | 49.34 | 50.40 | 52.19 | 49.42 | 52.10 | 49.09 | 49.16 | 49.47 | 49.63 | 51.74 | 51.01 |
| Al2O3 | 4.79 | 3.47 | 3.75 | 4.73 | 4.22 | 6.58 | 5.63 | 6.14 | 6.01 | 5.07 | 5.68 |
| FeO | 12.16 | 11.92 | 11.75 | 11.97 | 10.61 | 12.10 | 11.52 | 11.91 | 12.48 | 11.92 | 12.73 |
| MgO | 15.50 | 16.51 | 16.15 | 15.43 | 15.88 | 14.07 | 14.29 | 14.08 | 14.39 | 15.10 | 14.59 |
| CaO | 12.40 | 12.60 | 12.52 | 12.60 | 12.32 | 12.49 | 12.21 | 12.30 | 11.70 | 11.96 | 11.89 |
| Na2O | n | n | 0.78 | 1.14 | 0.55 | 1.08 | 0.90 | 1.04 | 1.26 | 1.04 | 1.14 |
| K2O | 0.52 | 0.29 | 0.30 | 0.52 | 0.56 | 0.68 | 0.77 | 0.76 | 0.58 | 0.53 | 0.55 |
| TiO2 | 0.51 | 0.43 | 0.32 | 0.73 | 0.73 | 1.17 | 1.13 | 1.09 | 1.14 | 0.85 | 0.96 |
| MnO | 0.78 | 0.72 | 0.67 | 0.83 | 0.59 | 0.57 | 0.50 | 0.50 | 0.54 | 0.71 | 0.46 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | n | n | 0.04 | n | n | n | n | n | 0.11 | 0.11 | 0.11 |
| F | 0.30 | 0.36 | 0.50 | 0.65 | 0.51 | 0.49 | 0.54 | 0.57 | n | n | n |
| SUBSUM | 96.30 | 96.70 | 98.97 | 98.02 | 97.96 | 98.32 | 96.65 | 97.86 | 97.84 | 99.03 | 99.12 |
| Cl=O | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 |
| F=O | 0.13 | 0.15 | 0.21 | 0.27 | 0.21 | 0.21 | 0.23 | 0.24 | 0.00 | 0.00 | 0.00 |
| SUM | 96.17 | 96.55 | 98.75 | 97.75 | 97.75 | 98.11 | 96.42 | 97.62 | 97.82 | 99.01 | 99.10 |
| H2Ocalc | 1.88 | 1.87 | 1.84 | 1.74 | 1.84 | 1.83 | 1.77 | 1.78 | 2.03 | 2.07 | 2.06 |
| SUM | 98.06 | 98.42 | 100.59 | 99.48 | 99.59 | 99.94 | 98.20 | 99.40 | 99.85 | 101.08 | 101.16 |
| Si | 7.30 | 7.41 | 7.49 | 7.24 | 7.50 | 7.15 | 7.26 | 7.23 | 7.22 | 7.39 | 7.31 |
| Aliv | 0.70 | 0.59 | 0.51 | 0.76 | 0.50 | 0.85 | 0.74 | 0.77 | 0.78 | 0.61 | 0.69 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.13 | 0.01 | 0.12 | 0.06 | 0.22 | 0.27 | 0.24 | 0.28 | 0.25 | 0.25 | 0.27 |
| Fe+2 | 1.39 | 1.32 | 1.39 | 1.47 | 1.28 | 1.47 | 1.42 | 1.45 | 1.50 | 1.42 | 1.51 |
| Mg | 3.42 | 3.62 | 3.45 | 3.37 | 3.41 | 3.05 | 3.14 | 3.06 | 3.12 | 3.22 | 3.12 |
| Ti | 0.06 | 0.05 | 0.03 | 0.08 | 0.08 | 0.13 | 0.13 | 0.12 | 0.12 | 0.09 | 0.10 |
| Mn | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.07 | 0.06 | 0.06 | 0.00 | 0.02 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 4.99 | 4.98 | 5.00 | 5.00 | 5.00 |
| Mn | 0.10 | 0.09 | 0.08 | 0.08 | 0.05 | 0.00 | 0.00 | 0.00 | 0.07 | 0.06 | 0.06 |
| Fe+2 | 0.11 | 0.14 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.02 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.79 | 1.77 | 1.90 | 1.92 | 1.90 | 1.95 | 1.93 | 1.92 | 1.82 | 1.83 | 1.83 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.07 | 0.08 | 0.09 | 0.10 | 0.10 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.00 | 0.00 | 0.22 | 0.32 | 0.11 | 0.25 | 0.19 | 0.22 | 0.26 | 0.18 | 0.21 |
| K | 0.10 | 0.05 | 0.05 | 0.10 | 0.10 | 0.13 | 0.15 | 0.14 | 0.11 | 0.10 | 0.10 |
| Ca | 0.18 | 0.22 | 0.03 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.28 | 0.27 | 0.30 | 0.48 | 0.21 | 0.38 | 0.33 | 0.36 | 0.37 | 0.28 | 0.31 |
| CATSUM | 15.28 | 15.27 | 15.30 | 15.48 | 15.19 | 15.38 | 15.33 | 15.34 | 15.37 | 15.28 | 15.31 |
| F | 0.14 | 0.17 | 0.23 | 0.30 | 0.23 | 0.23 | 0.25 | 0.26 | 0.00 | 0.00 | 0.00 |
| Cl | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 |
| OHcalc | 1.86 | 1.83 | 1.76 | 1.70 | 1.77 | 1.77 | 1.75 | 1.74 | 1.97 | 1.97 | 1.97 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.31 | 0.29 | 0.29 | 0.30 | 0.27 | 0.33 | 0.31 | 0.32 | 0.33 | 0.31 | 0.33 |
| # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE | C02 | | | | C03 | C04 | | | | C05 | |
|----------|-------|--------|-------|-------|-------|--------|-------|-------|-------|--------|--------|
| GRAIN | 2 | 3 | 4 | | 1 | 1 | | | | 1 | |
| | C | F | C | C | | | | | | | |
| SiO2 | 48.93 | 49.57 | 48.87 | 49.13 | 50.25 | 50.07 | 47.19 | 49.75 | 47.23 | 47.91 | 46.89 |
| Al2O3 | 5.92 | 5.89 | 6.33 | 5.68 | 5.54 | 5.91 | 5.80 | 4.66 | 6.69 | 7.69 | 6.77 |
| FeO | 12.04 | 12.18 | 12.02 | 12.48 | 11.62 | 14.15 | 14.80 | 12.85 | 14.89 | 15.19 | 14.45 |
| MgO | 14.18 | 14.41 | 14.17 | 14.17 | 14.12 | 13.43 | 14.06 | 15.07 | 13.33 | 11.93 | 15.18 |
| CaO | 12.39 | 12.45 | 12.28 | 11.62 | 11.86 | 11.88 | 11.94 | 12.57 | 11.93 | 11.96 | 11.95 |
| Na2O | 0.86 | 1.00 | 1.03 | 1.23 | 1.23 | 1.02 | 1.11 | 0.88 | 1.13 | 1.18 | 1.33 |
| K2O | 0.79 | 0.75 | 0.80 | 0.60 | 0.42 | 0.58 | 0.53 | 0.33 | 0.52 | 0.65 | 0.72 |
| TiO2 | 1.02 | 1.12 | 1.21 | 1.19 | 0.77 | 0.71 | 0.73 | 0.39 | 0.77 | 0.90 | 1.22 |
| MnO | 0.58 | 0.65 | 0.51 | 0.59 | 0.98 | 0.74 | 0.72 | 0.77 | 0.82 | 0.78 | 0.78 |
| BaO | n | n | n | n | 0.00 | n | n | n | n | n | n |
| Cl | n | n | n | 0.13 | n | 0.13 | 0.02 | 0.07 | 0.08 | 0.11 | 0.13 |
| F | 0.52 | 0.57 | 0.75 | n | 0.46 | 0.58 | 0.88 | 0.29 | 0.52 | 1.07 | 0.48 |
| SUBSUM | 97.23 | 98.59 | 97.97 | 96.82 | 97.25 | 99.20 | 97.78 | 97.63 | 97.91 | 99.37 | 99.90 |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.03 | 0.00 | 0.02 | 0.02 | 0.02 | 0.03 |
| F=O | 0.22 | 0.24 | 0.32 | 0.00 | 0.19 | 0.24 | 0.37 | 0.12 | 0.22 | 0.45 | 0.20 |
| SUM | 97.01 | 98.35 | 97.65 | 96.79 | 97.06 | 98.93 | 97.40 | 97.49 | 97.67 | 98.89 | 99.67 |
| H2Ocalc | 1.79 | 1.79 | 1.69 | 2.00 | 1.83 | 1.75 | 1.58 | 1.89 | 1.75 | 1.50 | 1.79 |
| SUM | 98.80 | 100.14 | 99.35 | 98.79 | 98.89 | 100.68 | 98.99 | 99.38 | 99.42 | 100.40 | 101.46 |
| Si | 7.21 | 7.20 | 7.16 | 7.24 | 7.35 | 7.28 | 7.05 | 7.30 | 7.02 | 7.05 | 6.85 |
| Aliv | 0.79 | 0.80 | 0.84 | 0.76 | 0.65 | 0.72 | 0.95 | 0.70 | 0.98 | 0.95 | 1.15 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.23 | 0.21 | 0.25 | 0.22 | 0.31 | 0.29 | 0.08 | 0.11 | 0.20 | 0.38 | 0.01 |
| Fe+2 | 1.48 | 1.48 | 1.47 | 1.54 | 1.42 | 1.72 | 1.71 | 1.55 | 1.76 | 1.87 | 1.55 |
| Mg | 3.11 | 3.12 | 3.09 | 3.11 | 3.08 | 2.91 | 3.13 | 3.30 | 2.95 | 2.62 | 3.30 |
| Ti | 0.11 | 0.12 | 0.13 | 0.13 | 0.08 | 0.08 | 0.08 | 0.04 | 0.09 | 0.10 | 0.13 |
| Mn | 0.06 | 0.06 | 0.05 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.01 | 0.02 | 0.01 | 0.07 | 0.01 | 0.09 | 0.09 | 0.10 | 0.10 | 0.07 | 0.10 |
| Fe+2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.02 | 0.09 | 0.00 | 0.21 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.96 | 1.94 | 1.93 | 1.83 | 1.86 | 1.85 | 1.77 | 1.88 | 1.81 | 1.89 | 1.69 |
| Na | 0.03 | 0.04 | 0.06 | 0.09 | 0.13 | 0.06 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.22 | 0.24 | 0.23 | 0.26 | 0.22 | 0.23 | 0.32 | 0.25 | 0.33 | 0.29 | 0.38 |
| K | 0.15 | 0.14 | 0.15 | 0.11 | 0.08 | 0.11 | 0.10 | 0.06 | 0.10 | 0.12 | 0.13 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.10 | 0.09 | 0.00 | 0.18 |
| A | 0.36 | 0.38 | 0.38 | 0.37 | 0.30 | 0.34 | 0.57 | 0.41 | 0.52 | 0.41 | 0.69 |
| CATSUM | 15.36 | 15.38 | 15.38 | 15.37 | 15.30 | 15.34 | 15.57 | 15.41 | 15.52 | 15.41 | 15.69 |
| F | 0.24 | 0.26 | 0.35 | 0.00 | 0.21 | 0.27 | 0.42 | 0.13 | 0.24 | 0.50 | 0.22 |
| Cl | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.03 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 |
| OHcalc | 1.76 | 1.74 | 1.65 | 1.97 | 1.79 | 1.70 | 1.58 | 1.85 | 1.74 | 1.47 | 1.75 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.32 | 0.32 | 0.32 | 0.33 | 0.32 | 0.37 | 0.37 | 0.32 | 0.39 | 0.42 | 0.35 |
| # | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE GRAIN | C05 1 | | | | | | | | | | |
|-----------------|----------|--------|--------|-------|--------|--------|--------|-------|-------|--------|--------|
| SiO2 | 46.94 | 47.45 | 46.36 | 49.33 | 50.01 | 45.89 | 49.46 | 47.82 | 48.03 | 46.73 | 48.08 |
| Al2O3 | 6.85 | 6.46 | 7.58 | 4.76 | 4.94 | 7.86 | 5.80 | 6.23 | 6.36 | 6.63 | 6.33 |
| FeO | 14.73 | 15.19 | 15.75 | 13.56 | 13.40 | 15.61 | 14.11 | 14.85 | 15.14 | 15.06 | 15.08 |
| MgO | 14.64 | 14.18 | 13.15 | 14.91 | 15.08 | 13.21 | 14.61 | 12.98 | 12.44 | 14.12 | 13.08 |
| CaO | 11.55 | 11.83 | 11.75 | 12.13 | 11.98 | 11.79 | 11.88 | 12.08 | 11.88 | 11.76 | 11.89 |
| Na2O | 1.35 | 1.24 | 1.46 | 1.02 | 1.05 | 1.50 | 1.17 | 1.20 | 1.26 | 1.29 | 1.27 |
| K2O | 0.91 | 0.61 | 0.99 | 0.60 | 0.55 | 0.99 | 0.69 | 0.75 | 0.82 | 0.69 | 0.71 |
| TiO2 | 0.94 | 1.03 | 1.18 | 0.57 | 0.86 | 1.43 | 1.05 | 0.88 | 0.94 | 0.95 | 0.89 |
| MnO | 0.73 | 0.89 | 0.78 | 0.77 | 0.75 | 0.73 | 0.85 | 0.79 | 0.81 | 0.76 | 0.77 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.09 | 0.01 | 0.10 | 0.00 | 0.00 | 0.12 | 0.12 | 0.14 | 0.16 | 0.04 | 0.08 |
| F | 0.35 | 0.48 | 0.73 | 0.41 | 0.51 | 0.51 | 0.34 | 0.51 | 0.45 | 0.52 | 0.38 |
| SUBSUM | 98.98 | 99.37 | 99.83 | 98.06 | 99.93 | 99.64 | 100.08 | 98.23 | 98.29 | 98.55 | 98.56 |
| Cl=O | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.04 | 0.01 | 0.02 |
| F=O | 0.15 | 0.20 | 0.31 | 0.17 | 0.21 | 0.21 | 0.14 | 0.21 | 0.19 | 0.22 | 0.16 |
| SUM | 98.81 | 99.17 | 99.50 | 97.89 | 99.72 | 99.40 | 99.91 | 97.98 | 98.06 | 98.32 | 98.38 |
| H2Ocalc | 1.85 | 1.81 | 1.66 | 1.85 | 1.85 | 1.76 | 1.89 | 1.74 | 1.77 | 1.77 | 1.83 |
| SUM | 100.66 | 100.98 | 101.16 | 99.73 | 101.56 | 101.16 | 101.80 | 99.73 | 99.83 | 100.09 | 100.21 |
| Si | 6.90 | 6.96 | 6.84 | 7.25 | 7.30 | 6.77 | 7.14 | 7.10 | 7.12 | 6.93 | 7.09 |
| Aliv | 1.10 | 1.04 | 1.16 | 0.75 | 0.70 | 1.23 | 0.86 | 0.90 | 0.88 | 1.07 | 0.91 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.09 | 0.08 | 0.15 | 0.07 | 0.13 | 0.14 | 0.13 | 0.19 | 0.24 | 0.08 | 0.20 |
| Fe+2 | 1.59 | 1.70 | 1.82 | 1.60 | 1.55 | 1.80 | 1.62 | 1.84 | 1.88 | 1.69 | 1.83 |
| Mg | 3.21 | 3.10 | 2.89 | 3.27 | 3.23 | 2.90 | 3.14 | 2.87 | 2.75 | 3.12 | 2.88 |
| Ti | 0.10 | 0.11 | 0.13 | 0.06 | 0.09 | 0.16 | 0.11 | 0.10 | 0.10 | 0.11 | 0.10 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.09 | 0.11 | 0.10 | 0.10 | 0.09 | 0.09 | 0.10 | 0.10 | 0.07 | 0.10 | 0.10 |
| Fe+2 | 0.22 | 0.16 | 0.12 | 0.07 | 0.06 | 0.13 | 0.09 | 0.00 | 0.00 | 0.18 | 0.03 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.69 | 1.73 | 1.78 | 1.84 | 1.84 | 1.78 | 1.81 | 1.90 | 1.89 | 1.73 | 1.87 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.39 | 0.35 | 0.42 | 0.29 | 0.29 | 0.43 | 0.33 | 0.35 | 0.32 | 0.37 | 0.36 |
| K | 0.15 | 0.11 | 0.19 | 0.11 | 0.10 | 0.19 | 0.13 | 0.14 | 0.16 | 0.13 | 0.13 |
| Ca | 0.13 | 0.13 | 0.07 | 0.07 | 0.00 | 0.08 | 0.03 | 0.02 | 0.00 | 0.14 | 0.01 |
| A | 0.67 | 0.60 | 0.68 | 0.48 | 0.39 | 0.70 | 0.48 | 0.50 | 0.47 | 0.64 | 0.50 |
| CATSUM | 15.67 | 15.60 | 15.68 | 15.48 | 15.39 | 15.70 | 15.48 | 15.50 | 15.47 | 15.64 | 15.50 |
| F | 0.16 | 0.22 | 0.34 | 0.19 | 0.23 | 0.24 | 0.16 | 0.24 | 0.21 | 0.24 | 0.18 |
| Cl | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.03 | 0.03 | 0.04 | 0.04 | 0.01 | 0.02 |
| OHcalc | 1.81 | 1.77 | 1.63 | 1.81 | 1.77 | 1.73 | 1.82 | 1.73 | 1.75 | 1.75 | 1.80 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.36 | 0.38 | 0.40 | 0.34 | 0.33 | 0.40 | 0.35 | 0.39 | 0.41 | 0.37 | 0.39 |
| # | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE GRAIN | COS 1 | | | | | | | | | | |
|--------------------------------|----------|-------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| SiO ₂ | 48.60 | 50.77 | 49.75 | 48.00 | 50.36 | 49.90 | 50.36 | 50.68 | 50.48 | 50.58 | 47.98 |
| Al ₂ O ₃ | 6.23 | 4.63 | 5.65 | 5.86 | 4.65 | 4.54 | 5.28 | 4.70 | 4.79 | 4.65 | 6.11 |
| FeO | 15.11 | 13.62 | 14.63 | 14.85 | 13.80 | 14.07 | 14.75 | 13.94 | 13.92 | 13.59 | 14.69 |
| MgO | 12.91 | 14.04 | 13.99 | 13.83 | 14.65 | 14.61 | 14.42 | 14.62 | 14.48 | 14.85 | 13.09 |
| CaO | 11.80 | 11.84 | 11.86 | 11.92 | 12.12 | 12.04 | 11.85 | 11.79 | 12.17 | 12.03 | 11.76 |
| Na ₂ O | 1.27 | 0.91 | 1.20 | 1.21 | 0.76 | 0.85 | 0.97 | 0.87 | 0.89 | 0.95 | 1.02 |
| K ₂ O | 0.70 | 0.26 | 0.65 | 0.68 | 0.44 | 0.38 | 0.47 | 0.45 | 0.37 | 0.37 | 0.80 |
| TiO ₂ | 0.76 | 0.49 | 0.72 | 1.00 | 0.65 | 0.68 | 0.63 | 0.46 | 0.71 | 0.52 | 0.91 |
| MnO | 0.77 | 0.90 | 0.92 | 0.91 | 0.84 | 0.86 | 0.98 | 0.91 | 0.83 | 0.91 | 0.80 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.04 | 0.00 | 0.06 | 0.09 | 0.12 | 0.00 | 0.02 | 0.00 | 0.03 | 0.01 | 0.17 |
| F | 0.23 | 0.00 | 0.32 | 0.46 | 0.32 | 0.65 | 0.50 | 0.26 | 0.54 | 0.52 | 0.30 |
| SUBSUM | 98.42 | 97.54 | 99.75 | 98.89 | 98.71 | 98.58 | 100.23 | 98.68 | 99.21 | 98.98 | 97.63 |
| Cl=O | 0.01 | 0.00 | 0.01 | 0.02 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 |
| F=O | 0.10 | 0.03 | 0.13 | 0.19 | 0.13 | 0.27 | 0.21 | 0.11 | 0.23 | 0.22 | 0.13 |
| SUM | 98.31 | 97.51 | 99.60 | 98.68 | 98.55 | 98.31 | 100.01 | 98.57 | 98.98 | 98.76 | 97.47 |
| H ₂ Ocalc | 1.92 | 2.01 | 1.90 | 1.80 | 1.88 | 1.74 | 1.84 | 1.94 | 1.80 | 1.82 | 1.83 |
| SUM | 100.23 | 99.52 | 101.50 | 100.48 | 100.43 | 100.05 | 101.85 | 100.51 | 100.78 | 100.58 | 99.30 |
| Si | 7.16 | 7.42 | 7.21 | 7.08 | 7.33 | 7.31 | 7.26 | 7.36 | 7.32 | 7.34 | 7.13 |
| Aliv | 0.84 | 0.58 | 0.79 | 0.92 | 0.67 | 0.69 | 0.74 | 0.64 | 0.68 | 0.66 | 0.87 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.24 | 0.22 | 0.17 | 0.10 | 0.13 | 0.09 | 0.15 | 0.17 | 0.14 | 0.14 | 0.20 |
| Fe+2 | 1.85 | 1.66 | 1.73 | 1.76 | 1.62 | 1.65 | 1.68 | 1.62 | 1.65 | 1.60 | 1.79 |
| Mg | 2.83 | 3.06 | 3.02 | 3.03 | 3.18 | 3.19 | 3.10 | 3.16 | 3.13 | 3.21 | 2.90 |
| Ti | 0.08 | 0.05 | 0.08 | 0.11 | 0.07 | 0.07 | 0.07 | 0.05 | 0.08 | 0.06 | 0.10 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.10 | 0.11 | 0.11 | 0.11 | 0.10 | 0.11 | 0.12 | 0.11 | 0.10 | 0.11 | 0.10 |
| Fe+2 | 0.01 | 0.00 | 0.05 | 0.07 | 0.06 | 0.08 | 0.10 | 0.07 | 0.04 | 0.05 | 0.03 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.86 | 1.86 | 1.84 | 1.82 | 1.84 | 1.82 | 1.78 | 1.81 | 1.86 | 1.83 | 1.87 |
| Na | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.33 | 0.23 | 0.34 | 0.35 | 0.21 | 0.24 | 0.27 | 0.25 | 0.25 | 0.27 | 0.29 |
| K | 0.13 | 0.05 | 0.12 | 0.13 | 0.08 | 0.07 | 0.09 | 0.08 | 0.07 | 0.07 | 0.15 |
| Ca | 0.00 | 0.00 | 0.00 | 0.06 | 0.05 | 0.07 | 0.05 | 0.02 | 0.03 | 0.04 | 0.01 |
| A | 0.47 | 0.28 | 0.46 | 0.54 | 0.35 | 0.38 | 0.40 | 0.35 | 0.35 | 0.37 | 0.45 |
| CATSUM | 15.47 | 15.28 | 15.46 | 15.54 | 15.35 | 15.38 | 15.40 | 15.35 | 15.35 | 15.37 | 15.45 |
| F | 0.11 | 0.04 | 0.15 | 0.21 | 0.15 | 0.30 | 0.23 | 0.12 | 0.25 | 0.24 | 0.14 |
| Cl | 0.01 | 0.00 | 0.01 | 0.02 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 |
| OHcalc | 1.88 | 1.96 | 1.84 | 1.76 | 1.82 | 1.70 | 1.77 | 1.88 | 1.74 | 1.76 | 1.82 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.40 | 0.35 | 0.37 | 0.38 | 0.35 | 0.35 | 0.36 | 0.35 | 0.35 | 0.34 | 0.39 |
| # | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE | 005 | | | | | | | | | | |
|--------------------------------|-------|-------|--------|--------|--------|--------|--------|-------|-------|--------|--------|
| GRAIN | 1 | 2 | | | | 3 | | 4 | | 5 | |
| | r | c | | | | r | | r | | r | |
| SiO ₂ | 47.49 | 45.03 | 48.46 | 48.84 | 49.75 | 48.69 | 50.82 | 48.85 | 46.65 | 48.82 | 50.11 |
| Al ₂ O ₃ | 6.59 | 8.20 | 7.15 | 6.73 | 5.48 | 6.38 | 5.14 | 5.86 | 6.69 | 5.71 | 5.81 |
| FeO | 14.54 | 15.59 | 15.73 | 14.08 | 14.18 | 14.80 | 12.93 | 14.49 | 15.74 | 14.11 | 13.76 |
| MgO | 13.17 | 12.31 | 12.64 | 13.58 | 14.09 | 13.85 | 14.89 | 13.50 | 12.74 | 14.31 | 14.39 |
| CaO | 12.19 | 11.95 | 12.04 | 11.88 | 12.03 | 12.02 | 12.48 | 12.07 | 11.68 | 12.13 | 12.39 |
| Na ₂ O | 1.19 | 1.34 | 1.16 | 1.27 | 1.20 | 1.39 | 0.86 | 0.99 | 1.42 | 1.13 | 1.04 |
| K ₂ O | 0.70 | 0.85 | 0.76 | 0.70 | 0.61 | 0.66 | 0.37 | 0.39 | 0.87 | 0.40 | 0.36 |
| TiO ₂ | 0.98 | 1.18 | 0.98 | 0.89 | 0.86 | 0.95 | 0.54 | 0.39 | 1.14 | 0.70 | 0.70 |
| MnO | 0.64 | 0.82 | 0.86 | 0.68 | 0.68 | 0.59 | 0.82 | 0.82 | 0.90 | 0.80 | 0.85 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.09 | 0.13 | 0.12 | 0.08 | 0.14 | 0.14 | 0.00 | 0.00 | 0.03 | 0.02 | 0.02 |
| F | 0.70 | 0.49 | 0.55 | 0.14 | 0.67 | 0.72 | 0.52 | 0.71 | 0.76 | 0.51 | 0.46 |
| SUBSUM | 98.28 | 97.79 | 100.45 | 98.87 | 99.69 | 100.19 | 99.37 | 98.07 | 98.62 | 98.64 | 99.89 |
| Cl=O | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| F=O | 0.29 | 0.21 | 0.23 | 0.06 | 0.28 | 0.30 | 0.22 | 0.30 | 0.32 | 0.21 | 0.19 |
| SUM | 97.96 | 97.55 | 100.19 | 98.79 | 99.38 | 99.86 | 99.15 | 97.77 | 98.29 | 98.42 | 99.69 |
| H ₂ Ocalc | 1.67 | 1.73 | 1.77 | 1.97 | 1.71 | 1.69 | 1.84 | 1.69 | 1.64 | 1.80 | 1.86 |
| SUM | 99.63 | 99.28 | 101.96 | 100.76 | 101.09 | 101.54 | 100.99 | 99.46 | 99.94 | 100.22 | 101.55 |
| Si | 7.04 | 6.77 | 7.04 | 7.11 | 7.23 | 7.08 | 7.32 | 7.22 | 6.96 | 7.15 | 7.22 |
| Aliv | 0.96 | 1.23 | 0.96 | 0.89 | 0.77 | 0.92 | 0.68 | 0.78 | 1.04 | 0.85 | 0.78 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.19 | 0.22 | 0.27 | 0.27 | 0.16 | 0.17 | 0.19 | 0.24 | 0.13 | 0.14 | 0.20 |
| Fe+2 | 1.79 | 1.88 | 1.89 | 1.69 | 1.69 | 1.73 | 1.55 | 1.75 | 1.91 | 1.66 | 1.63 |
| Mg | 2.91 | 2.76 | 2.74 | 2.95 | 3.05 | 3.00 | 3.20 | 2.97 | 2.83 | 3.13 | 3.09 |
| Ti | 0.11 | 0.13 | 0.11 | 0.10 | 0.09 | 0.10 | 0.06 | 0.04 | 0.13 | 0.08 | 0.08 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.08 | 0.10 | 0.11 | 0.08 | 0.08 | 0.07 | 0.10 | 0.10 | 0.11 | 0.10 | 0.10 |
| Fe+2 | 0.02 | 0.08 | 0.02 | 0.03 | 0.03 | 0.07 | 0.01 | 0.04 | 0.06 | 0.07 | 0.02 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.90 | 1.82 | 1.87 | 1.85 | 1.87 | 1.86 | 1.89 | 1.86 | 1.83 | 1.83 | 1.87 |
| Na | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.34 | 0.39 | 0.33 | 0.33 | 0.32 | 0.39 | 0.24 | 0.28 | 0.41 | 0.32 | 0.29 |
| K | 0.13 | 0.16 | 0.14 | 0.13 | 0.11 | 0.12 | 0.07 | 0.07 | 0.17 | 0.07 | 0.07 |
| Ca | 0.03 | 0.09 | 0.00 | 0.00 | 0.00 | 0.02 | 0.03 | 0.05 | 0.04 | 0.08 | 0.04 |
| A | 0.51 | 0.65 | 0.47 | 0.46 | 0.44 | 0.53 | 0.34 | 0.41 | 0.61 | 0.47 | 0.39 |
| CATSUM | 15.51 | 15.65 | 15.47 | 15.46 | 15.44 | 15.53 | 15.34 | 15.41 | 15.61 | 15.47 | 15.39 |
| F | 0.33 | 0.23 | 0.25 | 0.06 | 0.31 | 0.33 | 0.24 | 0.33 | 0.36 | 0.24 | 0.21 |
| Cl | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| OHcalc | 1.65 | 1.73 | 1.72 | 1.92 | 1.66 | 1.63 | 1.76 | 1.67 | 1.63 | 1.76 | 1.79 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.38 | 0.42 | 0.41 | 0.37 | 0.36 | 0.37 | 0.33 | 0.38 | 0.41 | 0.36 | 0.35 |
| # | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE | C05 | | C06 | | | | C07 | | C08 | | | |
|----------|--------|--------|-------|--------|-------|--------|--------|--------|--------|--------|--------|--|
| GRAIN | 5 | 1 | 2 | | | 3 | 1 | 2 | 1 | 2 | | |
| | | | r | r | | | | r | | | | |
| SiO2 | 51.13 | 52.82 | 50.38 | 52.73 | 49.60 | 46.67 | 51.42 | 51.62 | 52.46 | 50.74 | 50.97 | |
| Al2O3 | 5.89 | 4.06 | 4.78 | 3.43 | 4.70 | 7.41 | 4.24 | 4.64 | 4.35 | 4.46 | 5.01 | |
| FeO | 14.79 | 9.25 | 12.02 | 9.69 | 12.18 | 13.06 | 12.02 | 12.05 | 11.20 | 11.65 | 11.82 | |
| MgO | 13.56 | 17.74 | 15.22 | 18.22 | 16.70 | 14.06 | 15.58 | 15.61 | 15.74 | 16.66 | 16.17 | |
| CaO | 12.04 | 11.76 | 12.43 | 12.29 | 11.73 | 11.66 | 12.50 | 12.20 | 11.75 | 11.68 | 11.58 | |
| Na2O | 0.77 | 1.32 | 1.49 | 1.27 | 0.51 | 2.28 | 0.95 | 1.32 | 0.99 | 1.05 | 1.15 | |
| K2O | 0.40 | 0.54 | 0.27 | 0.43 | 0.12 | 0.62 | 0.44 | 0.55 | 0.54 | 0.37 | 0.52 | |
| TiO2 | 0.61 | 0.78 | 1.02 | 0.59 | 0.23 | 1.96 | 0.68 | 0.77 | 0.62 | 0.94 | 1.14 | |
| MnO | 0.93 | 0.56 | 0.20 | 0.37 | 0.38 | 0.22 | 0.64 | 0.60 | 0.79 | 0.63 | 0.50 | |
| BaO | n | n | n | n | n | n | n | n | n | n | n | |
| Cl | 0.04 | n | n | n | n | n | n | n | 0.19 | n | n | |
| F | 0.18 | 0.80 | 0.57 | 0.73 | 0.50 | 0.63 | n | n | n | n | n | |
| SUBSUM | 100.34 | 99.63 | 98.38 | 99.75 | 96.65 | 98.57 | 98.47 | 99.36 | 98.63 | 98.23 | 98.94 | |
| Cl=O | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | |
| F=O | 0.08 | 0.34 | 0.24 | 0.31 | 0.21 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| SUM | 100.26 | 99.29 | 98.14 | 99.44 | 96.44 | 98.30 | 98.47 | 99.36 | 98.59 | 98.23 | 98.94 | |
| H2Ocalc | 2.00 | 1.74 | 1.80 | 1.77 | 1.80 | 1.74 | 2.08 | 2.10 | 2.05 | 2.08 | 2.10 | |
| SUM | 102.26 | 101.04 | 99.94 | 101.22 | 98.24 | 100.05 | 100.55 | 101.46 | 100.64 | 100.31 | 101.04 | |
| Si | 7.31 | 7.46 | 7.31 | 7.46 | 7.29 | 6.86 | 7.40 | 7.37 | 7.50 | 7.31 | 7.29 | |
| Aliv | 0.69 | 0.54 | 0.69 | 0.54 | 0.71 | 1.14 | 0.60 | 0.63 | 0.50 | 0.69 | 0.71 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.30 | 0.14 | 0.12 | 0.03 | 0.11 | 0.14 | 0.12 | 0.15 | 0.23 | 0.06 | 0.13 | |
| Fe+2 | 1.74 | 1.05 | 1.46 | 1.07 | 1.21 | 1.57 | 1.45 | 1.44 | 1.34 | 1.26 | 1.30 | |
| Mg | 2.09 | 3.73 | 3.29 | 3.84 | 3.66 | 3.08 | 3.34 | 3.32 | 3.35 | 3.58 | 3.45 | |
| Ti | 0.07 | 0.08 | 0.11 | 0.06 | 0.03 | 0.22 | 0.07 | 0.08 | 0.07 | 0.10 | 0.12 | |
| Mn | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.11 | 0.07 | 0.01 | 0.04 | 0.05 | 0.03 | 0.06 | 0.06 | 0.08 | 0.08 | 0.06 | |
| Fe+2 | 0.03 | 0.04 | 0.00 | 0.08 | 0.29 | 0.04 | 0.00 | 0.00 | 0.00 | 0.14 | 0.11 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.84 | 1.78 | 1.93 | 1.86 | 1.66 | 1.84 | 1.93 | 1.87 | 1.80 | 1.78 | 1.77 | |
| Na | 0.02 | 0.11 | 0.06 | 0.02 | 0.00 | 0.10 | 0.01 | 0.07 | 0.12 | 0.00 | 0.05 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.20 | 0.25 | 0.36 | 0.33 | 0.15 | 0.55 | 0.26 | 0.29 | 0.16 | 0.29 | 0.27 | |
| K | 0.07 | 0.10 | 0.05 | 0.08 | 0.02 | 0.12 | 0.08 | 0.10 | 0.10 | 0.07 | 0.09 | |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | |
| A | 0.27 | 0.35 | 0.41 | 0.41 | 0.36 | 0.67 | 0.34 | 0.39 | 0.26 | 0.38 | 0.36 | |
| CATSUM | 15.27 | 15.35 | 15.41 | 15.41 | 15.36 | 15.67 | 15.34 | 15.39 | 15.26 | 15.38 | 15.36 | |
| F | 0.08 | 0.36 | 0.26 | 0.33 | 0.23 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Cl | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | |
| OHcalc | 1.91 | 1.64 | 1.74 | 1.67 | 1.77 | 1.71 | 2.00 | 2.00 | 1.95 | 2.00 | 2.00 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.38 | 0.23 | 0.31 | 0.23 | 0.29 | 0.34 | 0.30 | 0.30 | 0.29 | 0.28 | 0.29 | |
| # | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE | C08 | | C09 | | C010 | | C011 | | C012 | | |
|----------|--------|--------|-------|-------|--------|--------|-------|-------|--------|--------|-------|
| GRAIN | 3 | 4 | 1 | 2 | 1 | 2 | 1 | 2 | 3 | 1 | |
| SiO2 | 50.36 | 49.96 | 50.40 | 49.75 | 50.71 | 52.16 | 51.36 | 51.51 | 52.27 | 48.44 | 50.72 |
| Al2O3 | 4.96 | 5.12 | 4.63 | 5.16 | 5.07 | 3.50 | 4.17 | 4.89 | 4.08 | 7.88 | 4.60 |
| FeO | 11.72 | 12.32 | 11.98 | 12.13 | 11.76 | 11.99 | 12.01 | 10.87 | 10.56 | 10.91 | 10.89 |
| MgO | 16.11 | 15.84 | 15.91 | 15.62 | 16.00 | 16.91 | 16.04 | 15.96 | 16.27 | 15.81 | 15.55 |
| CaO | 11.56 | 12.38 | 11.54 | 11.58 | 11.85 | 11.92 | 11.44 | 11.90 | 11.80 | 11.75 | 12.18 |
| Na2O | 1.19 | 1.27 | 1.17 | 1.10 | 1.13 | 0.78 | 0.95 | 1.04 | 1.03 | 1.51 | 1.20 |
| K2O | 0.46 | 0.46 | 0.34 | 0.59 | 0.57 | 0.24 | 0.42 | 0.43 | 0.35 | 0.72 | 0.45 |
| TiO2 | 1.04 | 0.97 | 1.31 | 0.81 | 0.86 | 0.19 | 0.40 | 0.67 | 0.93 | 0.78 | 0.91 |
| MnO | 0.72 | 0.59 | 0.52 | 0.60 | 0.57 | 0.54 | 0.51 | 0.51 | 0.67 | 0.44 | 0.60 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | n | 0.23 | 0.16 | n | n | n | n | n | n | n | n |
| F | n | 0.55 | n | n | n | n | n | n | n | n | 0.50 |
| SUBSUM | 98.12 | 99.69 | 97.96 | 97.42 | 98.67 | 98.34 | 97.39 | 97.78 | 97.96 | 98.33 | 97.60 |
| Cl=O | 0.00 | 0.05 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F=O | 0.00 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 |
| SUM | 98.12 | 99.41 | 97.92 | 97.42 | 98.67 | 98.34 | 97.39 | 97.78 | 97.96 | 98.33 | 97.39 |
| H2Ocalc | 2.08 | 1.76 | 2.03 | 2.06 | 2.09 | 2.09 | 2.07 | 2.09 | 2.09 | 2.08 | 1.83 |
| SUM | 100.20 | 101.17 | 99.95 | 99.48 | 100.76 | 100.43 | 99.46 | 99.87 | 100.05 | 100.41 | 99.22 |
| Si | 7.27 | 7.20 | 7.30 | 7.25 | 7.28 | 7.48 | 7.45 | 7.40 | 7.48 | 6.98 | 7.37 |
| Aliv | 0.73 | 0.80 | 0.70 | 0.75 | 0.72 | 0.52 | 0.55 | 0.60 | 0.52 | 1.02 | 0.63 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.11 | 0.07 | 0.09 | 0.14 | 0.14 | 0.08 | 0.16 | 0.23 | 0.17 | 0.32 | 0.16 |
| Fe+2 | 1.31 | 1.43 | 1.34 | 1.37 | 1.34 | 1.29 | 1.33 | 1.28 | 1.26 | 1.21 | 1.32 |
| Mg | 3.47 | 3.40 | 3.43 | 3.39 | 3.42 | 3.62 | 3.47 | 3.42 | 3.47 | 3.39 | 3.37 |
| Ti | 0.11 | 0.11 | 0.14 | 0.09 | 0.09 | 0.02 | 0.04 | 0.07 | 0.10 | 0.08 | 0.10 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.09 | 0.07 | 0.06 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.08 | 0.05 | 0.03 |
| Fe+2 | 0.11 | 0.06 | 0.11 | 0.10 | 0.07 | 0.15 | 0.13 | 0.03 | 0.01 | 0.11 | 0.00 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.79 | 1.87 | 1.79 | 1.81 | 1.82 | 1.78 | 1.78 | 1.83 | 1.81 | 1.81 | 1.90 |
| Na | 0.01 | 0.00 | 0.03 | 0.01 | 0.04 | 0.00 | 0.03 | 0.07 | 0.10 | 0.02 | 0.08 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.30 | 0.35 | 0.30 | 0.30 | 0.28 | 0.22 | 0.23 | 0.21 | 0.18 | 0.40 | 0.26 |
| K | 0.08 | 0.08 | 0.06 | 0.11 | 0.10 | 0.04 | 0.08 | 0.08 | 0.06 | 0.13 | 0.08 |
| Ca | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.40 | 0.48 | 0.36 | 0.41 | 0.38 | 0.31 | 0.31 | 0.29 | 0.25 | 0.53 | 0.34 |
| CATSUM | 15.40 | 15.48 | 15.36 | 15.41 | 15.38 | 15.31 | 15.31 | 15.29 | 15.25 | 15.53 | 15.34 |
| F | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 |
| Cl | 0.00 | 0.06 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OHcalc | 2.00 | 1.69 | 1.96 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.77 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.29 | 0.30 | 0.30 | 0.30 | 0.29 | 0.28 | 0.30 | 0.28 | 0.27 | 0.28 | 0.28 |
| # | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE GRAIN | C012 | | | | C013 | | | | C014 | | | |
|--------------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|--------|---|
| | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 |
| SiO2 | 51.19 | 52.07 | 52.46 | 50.40 | 48.24 | 46.71 | 48.60 | 46.39 | 52.19 | 46.59 | 48.57 | |
| Al2O3 | 5.21 | 4.83 | 4.35 | 4.63 | 4.94 | 5.54 | 4.95 | 6.21 | 2.35 | 5.56 | 7.68 | |
| FeO | 11.96 | 11.38 | 11.19 | 11.97 | 13.93 | 14.64 | 13.88 | 15.44 | 13.45 | 14.46 | 14.41 | |
| MgO | 14.92 | 15.39 | 15.74 | 15.91 | 14.57 | 13.97 | 14.61 | 13.31 | 15.34 | 13.94 | 13.66 | |
| CaO | 12.29 | 12.13 | 11.75 | 11.54 | 11.75 | 11.60 | 11.72 | 11.82 | 12.64 | 11.86 | 11.37 | |
| Na2O | 1.21 | 1.22 | 0.99 | 1.17 | 1.32 | 1.40 | 1.18 | 1.50 | 0.44 | 1.40 | 1.48 | |
| K2O | 0.60 | 0.51 | 0.54 | 0.34 | 0.73 | 0.91 | 0.57 | 0.84 | 0.15 | 0.82 | 0.68 | |
| TiO2 | 0.78 | 0.93 | 0.62 | 1.31 | 0.91 | 1.10 | 0.70 | 1.42 | 0.12 | 1.20 | 0.97 | |
| MnO | 0.52 | 0.96 | 0.79 | 0.52 | 0.45 | 0.43 | 0.42 | 0.45 | 0.40 | 0.45 | 0.84 | |
| BaO | n | n | n | n | 0.00 | 0.02 | 0.00 | 0.00 | 0.09 | 0.09 | n | |
| Cl | n | n | 0.19 | 0.16 | 0.16 | 0.23 | 0.17 | 0.20 | 0.05 | 0.24 | n | |
| F | 0.42 | 0.57 | n | n | 0.90 | 0.90 | 0.90 | 1.02 | 0.54 | 1.07 | 0.55 | |
| SUBSUM | 99.10 | 99.99 | 98.62 | 97.95 | 97.90 | 97.35 | 97.70 | 98.60 | 97.76 | 97.68 | 100.26 | |
| Cl=O | 0.00 | 0.00 | 0.04 | 0.04 | 0.04 | 0.05 | 0.04 | 0.05 | 0.01 | 0.05 | 0.00 | |
| F=O | 0.18 | 0.24 | 0.00 | 0.00 | 0.38 | 0.38 | 0.38 | 0.43 | 0.23 | 0.45 | 0.23 | |
| SUM | 98.92 | 99.75 | 98.58 | 97.91 | 97.48 | 96.92 | 97.28 | 98.13 | 97.52 | 97.18 | 100.03 | |
| H2Ocalc | 1.89 | 1.84 | 2.05 | 2.03 | 1.55 | 1.50 | 1.55 | 1.47 | 1.78 | 1.42 | 1.82 | |
| SUM | 100.81 | 101.59 | 100.63 | 99.94 | 99.03 | 98.42 | 98.83 | 99.59 | 99.30 | 98.60 | 101.85 | |
| Si | 7.35 | 7.40 | 7.50 | 7.30 | 7.17 | 7.04 | 7.22 | 6.94 | 7.63 | 7.02 | 7.01 | |
| Aliv | 0.65 | 0.60 | 0.50 | 0.70 | 0.83 | 0.96 | 0.78 | 1.06 | 0.37 | 0.98 | 0.99 | |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Alv1 | 0.23 | 0.21 | 0.23 | 0.09 | 0.04 | 0.02 | 0.09 | 0.04 | 0.04 | 0.01 | 0.31 | |
| Fe+2 | 1.44 | 1.35 | 1.34 | 1.34 | 1.63 | 1.71 | 1.60 | 1.83 | 1.61 | 1.73 | 1.64 | |
| Mg | 3.19 | 3.26 | 3.35 | 3.43 | 3.23 | 3.14 | 3.23 | 2.97 | 3.34 | 3.13 | 2.94 | |
| Ti | 0.08 | 0.10 | 0.07 | 0.14 | 0.10 | 0.12 | 0.08 | 0.16 | 0.01 | 0.14 | 0.11 | |
| Mn | 0.05 | 0.08 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.01 | 0.04 | 0.08 | 0.06 | 0.06 | 0.05 | 0.05 | 0.06 | 0.05 | 0.06 | 0.10 | |
| Fe+2 | 0.00 | 0.00 | 0.00 | 0.11 | 0.10 | 0.13 | 0.13 | 0.10 | 0.04 | 0.09 | 0.10 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.89 | 1.85 | 1.80 | 1.79 | 1.84 | 1.81 | 1.82 | 1.84 | 1.91 | 1.85 | 1.76 | |
| Na | 0.10 | 0.12 | 0.12 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.24 | 0.22 | 0.16 | 0.30 | 0.38 | 0.41 | 0.34 | 0.44 | 0.12 | 0.41 | 0.37 | |
| K | 0.11 | 0.09 | 0.10 | 0.06 | 0.14 | 0.16 | 0.11 | 0.16 | 0.03 | 0.16 | 0.13 | |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.06 | 0.04 | 0.05 | 0.07 | 0.06 | 0.00 | |
| A | 0.35 | 0.31 | 0.26 | 0.36 | 0.55 | 0.62 | 0.49 | 0.65 | 0.22 | 0.63 | 0.49 | |
| CATSUM | 15.35 | 15.31 | 15.26 | 15.36 | 15.55 | 15.62 | 15.49 | 15.65 | 15.22 | 15.63 | 15.49 | |
| F | 0.19 | 0.26 | 0.00 | 0.00 | 0.42 | 0.43 | 0.42 | 0.48 | 0.25 | 0.51 | 0.25 | |
| Cl | 0.00 | 0.00 | 0.05 | 0.04 | 0.04 | 0.06 | 0.04 | 0.05 | 0.01 | 0.06 | 0.00 | |
| OHcalc | 1.81 | 1.74 | 1.95 | 1.96 | 1.54 | 1.51 | 1.53 | 1.47 | 1.74 | 1.43 | 1.75 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.31 | 0.29 | 0.29 | 0.30 | 0.35 | 0.37 | 0.35 | 0.39 | 0.33 | 0.37 | 0.37 | |
| # | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE GRAIN | C014 | | C015 | | | C016 | | C017 | | | |
|-----------------|--------|-------|-------|-------|-------|--------|--------|-------|--------|-------|-------|
| | 1 | 2 | 1 | | r | 1 | | 2 | 3 | 4 | 1 |
| SiO2 | 48.00 | 43.40 | 45.42 | 45.24 | 43.91 | 47.77 | 45.56 | 46.78 | 48.37 | 46.12 | 47.18 |
| Al2O3 | 7.40 | 9.16 | 8.07 | 8.65 | 9.47 | 6.77 | 8.07 | 5.75 | 6.41 | 7.49 | 7.06 |
| FeO | 15.25 | 16.18 | 14.46 | 14.68 | 15.13 | 14.67 | 15.84 | 15.30 | 15.04 | 15.77 | 13.85 |
| MgO | 12.99 | 12.02 | 12.81 | 12.15 | 11.75 | 14.19 | 13.70 | 13.56 | 13.83 | 12.86 | 12.39 |
| CaO | 11.68 | 11.45 | 12.04 | 11.82 | 11.73 | 12.34 | 12.11 | 11.95 | 11.70 | 11.51 | 12.27 |
| Na2O | 1.63 | 1.72 | 1.41 | 1.53 | 1.76 | 1.58 | 1.71 | 1.66 | 1.50 | 1.72 | 1.20 |
| K2O | 0.80 | 0.81 | 0.75 | 0.86 | 0.93 | 0.62 | 0.69 | 0.70 | 0.58 | 0.73 | 0.97 |
| TiO2 | 1.12 | 1.10 | 0.98 | 0.99 | 1.18 | 0.83 | 1.16 | 0.77 | 0.80 | 0.97 | 1.16 |
| MnO | 0.54 | 0.64 | 0.63 | 0.62 | 0.52 | 0.63 | 0.56 | 0.52 | 0.61 | 0.59 | 0.74 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | n | n | 0.06 | 0.15 | 0.07 | 0.05 | 0.07 | 0.05 | 0.02 | 0.03 | n |
| F | 0.64 | 0.71 | 0.72 | 0.78 | 0.74 | 0.61 | 0.76 | 0.94 | 0.74 | 0.82 | 0.55 |
| SUBSUM | 100.06 | 97.19 | 97.35 | 97.47 | 97.20 | 100.06 | 100.31 | 98.06 | 99.61 | 98.61 | 97.37 |
| Cl=O | 0.00 | 0.00 | 0.01 | 0.03 | 0.02 | 0.01 | 0.02 | 0.01 | 0.00 | 0.01 | 0.00 |
| F=O | 0.27 | 0.30 | 0.30 | 0.33 | 0.31 | 0.26 | 0.32 | 0.40 | 0.31 | 0.35 | 0.23 |
| SUM | 99.79 | 96.89 | 97.03 | 97.11 | 96.87 | 99.79 | 99.97 | 97.65 | 99.29 | 98.26 | 97.14 |
| H2Ocalc | 1.76 | 1.63 | 1.64 | 1.58 | 1.61 | 1.76 | 1.66 | 1.54 | 1.70 | 1.61 | 1.75 |
| SUM | 101.55 | 98.52 | 98.67 | 98.69 | 98.48 | 101.55 | 101.64 | 99.19 | 100.99 | 99.87 | 98.89 |
| Si | 6.99 | 6.61 | 6.83 | 6.81 | 6.65 | 6.96 | 6.70 | 7.02 | 7.07 | 6.88 | 7.04 |
| Aliv | 1.01 | 1.39 | 1.17 | 1.19 | 1.35 | 1.04 | 1.30 | 0.98 | 0.93 | 1.12 | 0.96 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.26 | 0.25 | 0.26 | 0.34 | 0.34 | 0.12 | 0.10 | 0.04 | 0.17 | 0.19 | 0.28 |
| Fe+2 | 1.80 | 1.90 | 1.76 | 1.82 | 1.87 | 1.70 | 1.77 | 1.84 | 1.72 | 1.84 | 1.73 |
| Mg | 2.82 | 2.73 | 2.87 | 2.72 | 2.65 | 3.08 | 3.00 | 3.03 | 3.01 | 2.86 | 2.75 |
| Ti | 0.12 | 0.13 | 0.11 | 0.11 | 0.13 | 0.09 | 0.13 | 0.09 | 0.09 | 0.11 | 0.13 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 4.98 |
| Mn | 0.07 | 0.08 | 0.08 | 0.08 | 0.07 | 0.08 | 0.07 | 0.07 | 0.08 | 0.07 | 0.00 |
| Fe+2 | 0.06 | 0.16 | 0.05 | 0.02 | 0.05 | 0.08 | 0.17 | 0.08 | 0.11 | 0.13 | 0.00 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.82 | 1.75 | 1.87 | 1.90 | 1.89 | 1.84 | 1.76 | 1.86 | 1.81 | 1.80 | 1.96 |
| Na | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.41 | 0.51 | 0.41 | 0.45 | 0.52 | 0.45 | 0.49 | 0.48 | 0.43 | 0.50 | 0.31 |
| K | 0.15 | 0.16 | 0.14 | 0.17 | 0.18 | 0.12 | 0.13 | 0.13 | 0.11 | 0.14 | 0.18 |
| Ca | 0.00 | 0.11 | 0.07 | 0.01 | 0.02 | 0.09 | 0.15 | 0.06 | 0.02 | 0.04 | 0.00 |
| A | 0.56 | 0.78 | 0.63 | 0.62 | 0.71 | 0.65 | 0.77 | 0.68 | 0.55 | 0.67 | 0.49 |
| CATSUM | 15.56 | 15.78 | 15.63 | 15.62 | 15.71 | 15.65 | 15.77 | 15.68 | 15.55 | 15.67 | 15.48 |
| F | 0.29 | 0.34 | 0.34 | 0.37 | 0.35 | 0.28 | 0.35 | 0.45 | 0.34 | 0.39 | 0.26 |
| Cl | 0.00 | 0.00 | 0.02 | 0.04 | 0.02 | 0.01 | 0.02 | 0.01 | 0.00 | 0.01 | 0.00 |
| OHcalc | 1.71 | 1.66 | 1.64 | 1.59 | 1.63 | 1.71 | 1.63 | 1.54 | 1.65 | 1.61 | 1.74 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.40 | 0.43 | 0.39 | 0.40 | 0.42 | 0.37 | 0.39 | 0.39 | 0.38 | 0.41 | 0.39 |
| # | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE GRAIN | C017 | | C018 | | C019 | | | | 2 | | 3 | 4 |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| | 2 | c | 1 | c | | r | r | | | | | |
| SiO2 | 47.40 | 47.97 | 51.74 | 47.07 | 51.10 | 47.78 | 49.49 | 49.05 | 50.47 | 42.11 | 45.67 | |
| Al2O3 | 6.54 | 6.82 | 3.21 | 6.90 | 4.05 | 5.20 | 5.06 | 4.81 | 4.42 | 9.76 | 8.65 | |
| FeO | 13.86 | 13.58 | 11.23 | 15.45 | 12.92 | 13.85 | 13.25 | 13.51 | 13.02 | 17.22 | 15.16 | |
| MgO | 12.92 | 13.26 | 17.54 | 12.82 | 15.52 | 14.31 | 14.63 | 15.13 | 15.35 | 11.89 | 11.98 | |
| CaO | 12.40 | 12.00 | 11.82 | 11.36 | 11.84 | 11.39 | 11.52 | 11.80 | 11.85 | 11.77 | 13.28 | |
| Na2O | 1.13 | 1.35 | 0.97 | 1.27 | 0.77 | 1.09 | 1.00 | 0.96 | 0.93 | 1.52 | 1.01 | |
| K2O | 0.92 | 0.84 | 0.27 | 0.66 | 0.45 | 0.90 | 0.79 | 0.46 | 0.46 | 1.45 | 0.89 | |
| TiO2 | 1.01 | 0.76 | 0.50 | 1.34 | 0.31 | 0.99 | 0.88 | 0.12 | 0.21 | 0.66 | 0.32 | |
| MnO | 0.64 | 0.60 | 0.41 | 0.71 | 0.62 | 0.63 | 0.64 | 0.61 | 0.60 | 0.55 | 0.44 | |
| BaO | n | 0.00 | n | 0.14 | 0.13 | 0.15 | 0.13 | 0.14 | 0.14 | 0.12 | 0.00 | |
| Cl | n | n | 0.26 | 0.19 | 0.07 | 0.12 | 0.10 | 0.01 | 0.02 | 0.11 | 0.20 | |
| F | 0.72 | 0.57 | 0.72 | 0.51 | 0.40 | 0.60 | 0.54 | 0.59 | 0.68 | 0.76 | 0.51 | |
| SUBSUM | 97.54 | 97.75 | 98.67 | 98.42 | 98.17 | 97.00 | 98.02 | 97.19 | 98.15 | 97.92 | 98.11 | |
| Cl=O | 0.00 | 0.00 | 0.06 | 0.04 | 0.02 | 0.03 | 0.02 | 0.00 | 0.00 | 0.03 | 0.04 | |
| F=O | 0.30 | 0.24 | 0.30 | 0.22 | 0.17 | 0.25 | 0.23 | 0.25 | 0.29 | 0.32 | 0.21 | |
| SUM | 97.24 | 97.51 | 98.31 | 98.16 | 97.98 | 96.72 | 97.77 | 96.94 | 97.86 | 97.57 | 97.85 | |
| H2Ocalc | 1.67 | 1.76 | 1.67 | 1.73 | 1.85 | 1.69 | 1.76 | 1.74 | 1.72 | 1.57 | 1.71 | |
| SUM | 98.91 | 99.27 | 99.98 | 99.89 | 99.84 | 98.40 | 99.53 | 98.68 | 99.58 | 99.14 | 99.56 | |
| Si | 7.07 | 7.10 | 7.46 | 6.99 | 7.44 | 7.16 | 7.27 | 7.27 | 7.38 | 6.45 | 6.83 | |
| Aliv | 0.93 | 0.90 | 0.54 | 1.01 | 0.56 | 0.84 | 0.73 | 0.73 | 0.62 | 1.55 | 1.17 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.22 | 0.29 | 0.00 | 0.20 | 0.13 | 0.07 | 0.15 | 0.12 | 0.14 | 0.21 | 0.35 | |
| Fe+2 | 1.73 | 1.68 | 1.17 | 1.81 | 1.47 | 1.62 | 1.55 | 1.53 | 1.49 | 1.99 | 1.90 | |
| Mg | 2.87 | 2.92 | 3.77 | 2.84 | 3.37 | 3.19 | 3.20 | 3.34 | 3.35 | 2.71 | 2.67 | |
| Ti | 0.11 | 0.08 | 0.05 | 0.15 | 0.03 | 0.11 | 0.10 | 0.01 | 0.02 | 0.08 | 0.04 | |
| Mn | 0.07 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.01 | 0.05 | 0.05 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.01 | |
| Fe+2 | 0.00 | 0.00 | 0.18 | 0.10 | 0.10 | 0.11 | 0.08 | 0.15 | 0.10 | 0.21 | 0.00 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.98 | 1.98 | 1.77 | 1.81 | 1.82 | 1.81 | 1.81 | 1.77 | 1.82 | 1.72 | 1.99 | |
| Na | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.32 | 0.34 | 0.27 | 0.37 | 0.22 | 0.32 | 0.25 | 0.28 | 0.26 | 0.45 | 0.29 | |
| K | 0.18 | 0.16 | 0.05 | 0.13 | 0.08 | 0.17 | 0.15 | 0.09 | 0.09 | 0.28 | 0.17 | |
| Ca | 0.00 | 0.00 | 0.05 | 0.00 | 0.03 | 0.02 | 0.00 | 0.10 | 0.03 | 0.22 | 0.14 | |
| A | 0.49 | 0.50 | 0.38 | 0.49 | 0.33 | 0.51 | 0.40 | 0.46 | 0.38 | 0.95 | 0.60 | |
| CATSUM | 15.49 | 15.50 | 15.38 | 15.47 | 15.33 | 15.51 | 15.40 | 15.46 | 15.38 | 15.95 | 15.60 | |
| F | 0.34 | 0.27 | 0.33 | 0.24 | 0.18 | 0.28 | 0.25 | 0.28 | 0.31 | 0.37 | 0.24 | |
| Cl | 0.00 | 0.00 | 0.06 | 0.05 | 0.02 | 0.03 | 0.02 | 0.00 | 0.00 | 0.03 | 0.05 | |
| OHcalc | 1.66 | 1.73 | 1.61 | 1.71 | 1.80 | 1.68 | 1.72 | 1.72 | 1.68 | 1.61 | 1.71 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.38 | 0.36 | 0.26 | 0.40 | 0.32 | 0.35 | 0.34 | 0.33 | 0.32 | 0.45 | 0.42 | |
| # | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE GRAIN | C019 4 | C020 1 c | C021 1 | | 2 | C022 1 | | 2 | C023 1 | | |
|-----------------|-----------|----------------|-----------|-------|-------|-----------|-------|-------|-----------|--------|-------|
| SiO2 | 47.25 | 51.78 | 46.75 | 47.08 | 47.18 | 42.24 | 46.09 | 47.37 | 45.91 | 44.26 | 45.45 |
| Al2O3 | 6.77 | 3.60 | 6.90 | 7.07 | 6.90 | 10.93 | 8.20 | 7.32 | 7.42 | 10.04 | 7.64 |
| FeO | 14.92 | 12.46 | 13.94 | 13.79 | 13.78 | 14.52 | 13.94 | 13.49 | 14.94 | 16.14 | 14.98 |
| MgO | 13.00 | 16.17 | 12.96 | 12.72 | 13.11 | 10.95 | 12.64 | 12.73 | 12.41 | 11.85 | 12.24 |
| CaO | 12.50 | 12.38 | 11.86 | 12.04 | 12.04 | 11.83 | 11.74 | 11.95 | 11.82 | 11.57 | 11.50 |
| Na2O | 0.86 | 0.51 | 1.76 | 1.85 | 1.88 | 1.99 | 1.59 | 1.53 | 1.45 | 1.55 | 1.48 |
| K2O | 0.86 | 0.27 | 0.71 | 0.65 | 0.70 | 1.13 | 0.84 | 0.74 | 0.86 | 1.02 | 0.89 |
| TiO2 | 0.21 | 0.20 | 0.89 | 0.94 | 1.04 | 2.57 | 1.31 | 1.26 | 1.29 | 1.59 | 1.17 |
| MnO | 0.43 | 0.46 | 0.49 | 0.77 | 0.62 | 0.52 | 0.72 | 0.42 | 0.62 | 0.53 | 0.62 |
| BaO | 0.00 | 0.08 | n | n | n | 0.00 | 0.00 | 0.00 | n | n | n |
| Cl | 0.15 | 0.06 | n | n | n | n | n | n | n | n | n |
| F | 0.53 | 0.48 | 0.79 | 0.87 | 0.72 | 0.44 | 0.45 | 0.70 | 0.54 | 0.20 | 0.55 |
| SUBSUM | 97.47 | 98.44 | 97.05 | 97.78 | 97.97 | 97.12 | 97.52 | 97.51 | 97.26 | 98.75 | 96.52 |
| Cl=O | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F=O | 0.22 | 0.20 | 0.33 | 0.37 | 0.30 | 0.19 | 0.19 | 0.29 | 0.23 | 0.08 | 0.23 |
| SUM | 97.21 | 98.23 | 96.72 | 97.41 | 97.67 | 96.93 | 97.33 | 97.22 | 97.03 | 98.67 | 96.29 |
| H2Ocalc | 1.72 | 1.83 | 1.62 | 1.60 | 1.68 | 1.77 | 1.80 | 1.69 | 1.74 | 1.92 | 1.72 |
| SUM | 98.92 | 100.06 | 98.34 | 99.01 | 99.34 | 98.71 | 99.13 | 98.90 | 98.77 | 100.59 | 98.01 |
| Si | 7.07 | 7.49 | 7.01 | 7.02 | 7.01 | 6.40 | 6.87 | 7.03 | 6.90 | 6.58 | 6.89 |
| Aliv | 0.93 | 0.51 | 0.99 | 0.98 | 0.99 | 1.60 | 1.13 | 0.97 | 1.10 | 1.42 | 1.11 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.26 | 0.10 | 0.23 | 0.26 | 0.21 | 0.35 | 0.31 | 0.31 | 0.22 | 0.33 | 0.25 |
| Fe+2 | 1.82 | 1.40 | 1.75 | 1.72 | 1.71 | 1.84 | 1.74 | 1.67 | 1.86 | 1.87 | 1.85 |
| Mg | 2.90 | 3.48 | 2.90 | 2.83 | 2.90 | 2.47 | 2.81 | 2.82 | 2.78 | 2.62 | 2.76 |
| Ti | 0.02 | 0.02 | 0.10 | 0.11 | 0.12 | 0.29 | 0.15 | 0.14 | 0.15 | 0.18 | 0.13 |
| Mn | 0.00 | 0.00 | 0.02 | 0.09 | 0.06 | 0.05 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.05 | 0.06 | 0.04 | 0.01 | 0.02 | 0.02 | 0.09 | 0.00 | 0.08 | 0.07 | 0.08 |
| Fe+2 | 0.05 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.14 | 0.05 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.90 | 1.83 | 1.91 | 1.92 | 1.92 | 1.92 | 1.87 | 1.90 | 1.90 | 1.79 | 1.87 |
| Na | 0.00 | 0.00 | 0.05 | 0.07 | 0.06 | 0.07 | 0.04 | 0.10 | 0.00 | 0.00 | 0.01 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.25 | 0.14 | 0.46 | 0.46 | 0.48 | 0.52 | 0.42 | 0.34 | 0.42 | 0.45 | 0.43 |
| K | 0.16 | 0.05 | 0.14 | 0.12 | 0.13 | 0.22 | 0.16 | 0.14 | 0.16 | 0.19 | 0.17 |
| Ca | 0.11 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| A | 0.52 | 0.28 | 0.60 | 0.59 | 0.61 | 0.74 | 0.58 | 0.48 | 0.59 | 0.69 | 0.60 |
| CATSUM | 15.52 | 15.28 | 15.60 | 15.59 | 15.61 | 15.74 | 15.58 | 15.48 | 15.59 | 15.69 | 15.60 |
| F | 0.25 | 0.22 | 0.37 | 0.41 | 0.34 | 0.21 | 0.21 | 0.33 | 0.26 | 0.09 | 0.26 |
| Cl | 0.04 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OHcalc | 1.71 | 1.76 | 1.63 | 1.59 | 1.66 | 1.79 | 1.79 | 1.67 | 1.74 | 1.91 | 1.74 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.39 | 0.30 | 0.38 | 0.38 | 0.37 | 0.43 | 0.38 | 0.37 | 0.40 | 0.43 | 0.41 |
| # | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 |

Table 1. Hornblendes from the Mt. Princeton Complex, Colorado.

| SAMPLE | C024 | | | |
|----------|-------|-------|-------|-------|
| GRAIN | 1 | 2 | 3 | 4 |
| SiO2 | 46.99 | 46.88 | 46.50 | 46.25 |
| Al2O3 | 6.80 | 7.60 | 7.88 | 7.66 |
| FeO | 14.20 | 13.50 | 13.81 | 14.75 |
| MgO | 14.23 | 12.74 | 12.44 | 12.60 |
| CaO | 11.67 | 12.06 | 12.19 | 11.97 |
| Na2O | 1.25 | 1.65 | 1.47 | 1.47 |
| K2O | 0.58 | 1.06 | 1.05 | 0.97 |
| TiO2 | 0.80 | 1.57 | 1.33 | 1.52 |
| MnO | 0.60 | 0.77 | 0.52 | 0.66 |
| BaO | n | n | n | n |
| Cl | 0.02 | n | n | 0.13 |
| F | 0.67 | 0.74 | 0.78 | 0.53 |
| SUBSUM | 97.81 | 98.57 | 97.96 | 98.51 |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.03 |
| F=O | 0.28 | 0.31 | 0.33 | 0.22 |
| SUM | 97.52 | 98.26 | 97.63 | 98.26 |
| H2Ocalc | 1.70 | 1.68 | 1.65 | 1.73 |
| SUM | 99.22 | 99.94 | 99.28 | 99.99 |
| Si | 6.98 | 6.93 | 6.92 | 6.87 |
| Aliv | 1.02 | 1.07 | 1.08 | 1.13 |
| T | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.17 | 0.25 | 0.30 | 0.21 |
| Fe+2 | 1.59 | 1.67 | 1.72 | 1.83 |
| Mg | 3.15 | 2.80 | 2.76 | 2.79 |
| Ti | 0.09 | 0.17 | 0.15 | 0.17 |
| Mn | 0.00 | 0.10 | 0.07 | 0.00 |
| M1-M3 | 5.00 | 4.99 | 4.99 | 5.00 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 |
| Fe+2 | 0.17 | 0.00 | 0.00 | 0.00 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.75 | 1.91 | 1.94 | 1.90 |
| Na | 0.00 | 0.09 | 0.06 | 0.01 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.36 | 0.38 | 0.37 | 0.41 |
| K | 0.11 | 0.20 | 0.20 | 0.18 |
| Ca | 0.10 | 0.00 | 0.00 | 0.00 |
| A | 0.57 | 0.58 | 0.57 | 0.59 |
| CATSUM | 15.57 | 15.57 | 15.55 | 15.59 |
| F | 0.31 | 0.35 | 0.37 | 0.25 |
| Cl | 0.01 | 0.00 | 0.00 | 0.03 |
| OHcalc | 1.68 | 1.65 | 1.63 | 1.72 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.36 | 0.37 | 0.38 | 0.40 |
| # | 122 | 123 | 124 | 125 |

KEY TO TABLE 2

| ANALYSIS # | SAMPLE CODE | SAMPLE # | ROCK DESCRIPTION |
|------------|-------------|--------------|-----------------------------|
| 126-134 | MT1 | BH9800 | contaminated quartz diorite |
| 135-144 | MT2 | BH9850 | granodiorite |
| 145-155 | MT3 | M107-1 | Trapper tonalite |
| 156-165 | MT4 | M547-1 | " |
| 166-177 | MT5 | M313-1 | Keokirk quartz diorite |
| 178-186 | MT6 | M984-1 | Lime Kiln Gulch tonalite |
| 187-195 | MT7 | Mono Creek | granodiorite |
| 196-208 | MT8 | Farlin Gulch | Uphill Creek Granodiorite |
| 209-213 | MT9 | M342-1 | " |
| 214-221 | MT10 | M121-1-78 | " |
| 222-247 | MT11 | M1345-1 | " |
| 248-260 | MT12 | Ivanhoe Pit | " |
| 261-265 | MT13 | M881-1-78 | " |
| 266-267 | MT14 | M1272-2 | " |
| 270-276 | MT15 | M704-1 | " |
| 277-283 | MT16 | M697-1 | " |
| 284-286 | MT17 | M1228-1 | Grayling Lake Granite |
| 287-293 | MT18 | M1119-1 | " |
| 294-300 | MT19 | M1293-1 | " |

The Pioneer Batholith is a Late Cretaceous complex in the Pioneer Mountains of SW Montana. Samples were collected by E-an Zen in conjunction with mapping and petrologic studies and reference sample numbers refer to his collection. General geology of the batholith and descriptions of individual rock units are given in Zen (1984), Zen and others (1980, 1975), Snee (1982, 1978). Hammarstrom (1982) described the mineralogy and summarized hornblende data included here.

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT1 | | | | | | | | MT2 | | |
|--------------------------------|-------|--------|-------|-------|-------|--------|-------|-------|-------|--------|-------|
| | 1 | | 2 | 3 | 4 | | 5 | | 6 | 1 | 2 |
| | | | C | F | F | | | F | | | |
| SiO ₂ | 44.59 | 43.54 | 42.14 | 42.63 | 45.32 | 45.36 | 46.93 | 45.91 | 42.68 | 44.83 | 43.79 |
| Al ₂ O ₃ | 10.36 | 11.50 | 11.93 | 11.87 | 8.92 | 9.87 | 7.34 | 8.42 | 11.32 | 8.95 | 8.41 |
| FeO | 13.91 | 16.24 | 14.09 | 14.75 | 15.08 | 15.57 | 14.24 | 14.89 | 14.84 | 17.29 | 16.96 |
| MgO | 12.96 | 11.20 | 11.86 | 11.63 | 12.98 | 12.02 | 13.88 | 13.14 | 11.83 | 11.34 | 11.40 |
| CaO | 11.73 | 11.60 | 11.63 | 11.86 | 11.51 | 11.29 | 11.37 | 11.46 | 11.66 | 11.89 | 12.09 |
| Na ₂ O | 1.17 | 1.26 | 1.35 | 1.25 | 1.25 | 1.35 | 0.87 | 0.96 | 1.22 | 1.23 | 1.24 |
| K ₂ O | 0.74 | 0.89 | 0.95 | 1.00 | 0.40 | 0.98 | 0.65 | 0.57 | 1.00 | 1.03 | 0.84 |
| TiO ₂ | 1.33 | 1.98 | 3.11 | 2.42 | 0.98 | 2.09 | 1.45 | 0.87 | 2.45 | 1.29 | 1.24 |
| MnO | 0.27 | 0.33 | 0.29 | 0.30 | 0.35 | 0.33 | 0.35 | 0.36 | 0.30 | 0.73 | 0.68 |
| BaO | n | n | n | n | n | n | 0.11 | 0.09 | 0.30 | n | n |
| Cl | 0.04 | 0.08 | 0.06 | 0.05 | 0.03 | 0.02 | 0.03 | 0.06 | 0.06 | n | 0.09 |
| F | n | n | n | n | n | n | 0.10 | 0.06 | n | n | 0.21 |
| SUBSUM | 97.10 | 98.62 | 97.41 | 97.76 | 96.82 | 98.88 | 97.32 | 96.79 | 97.66 | 98.58 | 96.95 |
| Cl=O | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.02 |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.03 | 0.00 | 0.00 | 0.09 |
| SUM | 97.09 | 98.60 | 97.40 | 97.75 | 96.81 | 98.88 | 97.27 | 96.75 | 97.65 | 98.58 | 96.84 |
| H ₂ Ocalc | 2.01 | 2.00 | 1.99 | 2.00 | 2.00 | 2.04 | 1.97 | 1.96 | 1.99 | 2.01 | 1.84 |
| SUM | 99.10 | 100.60 | 99.39 | 99.75 | 98.81 | 100.91 | 99.24 | 98.71 | 99.64 | 100.59 | 98.68 |
| Si | 6.62 | 6.45 | 6.29 | 6.35 | 6.77 | 6.66 | 6.95 | 6.86 | 6.38 | 6.70 | 6.68 |
| Aliv | 1.38 | 1.55 | 1.71 | 1.65 | 1.23 | 1.34 | 1.05 | 1.14 | 1.62 | 1.30 | 1.32 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.44 | 0.46 | 0.39 | 0.44 | 0.34 | 0.37 | 0.23 | 0.34 | 0.38 | 0.27 | 0.19 |
| Fe+2 | 1.55 | 1.84 | 1.63 | 1.71 | 1.66 | 1.76 | 1.55 | 1.64 | 1.71 | 2.06 | 2.07 |
| Mg | 2.87 | 2.47 | 2.64 | 2.58 | 2.89 | 2.63 | 3.06 | 2.93 | 2.64 | 2.52 | 2.59 |
| Ti | 0.15 | 0.22 | 0.35 | 0.27 | 0.11 | 0.23 | 0.16 | 0.10 | 0.28 | 0.14 | 0.14 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.04 | 0.09 | 0.09 |
| Fe+2 | 0.18 | 0.17 | 0.13 | 0.13 | 0.23 | 0.15 | 0.21 | 0.22 | 0.15 | 0.10 | 0.09 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.78 | 1.79 | 1.83 | 1.83 | 1.73 | 1.78 | 1.74 | 1.73 | 1.81 | 1.81 | 1.82 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.34 | 0.36 | 0.39 | 0.36 | 0.36 | 0.35 | 0.25 | 0.28 | 0.35 | 0.36 | 0.37 |
| K | 0.14 | 0.17 | 0.18 | 0.19 | 0.08 | 0.18 | 0.12 | 0.11 | 0.19 | 0.20 | 0.16 |
| Ca | 0.00 | 0.06 | 0.03 | 0.06 | 0.11 | 0.00 | 0.06 | 0.10 | 0.05 | 0.10 | 0.16 |
| A | 0.56 | 0.59 | 0.60 | 0.61 | 0.55 | 0.53 | 0.43 | 0.49 | 0.60 | 0.65 | 0.69 |
| CATSUM | 15.56 | 15.59 | 15.60 | 15.61 | 15.55 | 15.53 | 15.43 | 15.49 | 15.60 | 15.65 | 15.69 |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.03 | 0.00 | 0.00 | 0.10 |
| Cl | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 | 0.01 | 0.02 | 0.02 | 0.00 | 0.02 |
| OHcalc | 1.99 | 1.98 | 1.98 | 1.99 | 1.99 | 2.00 | 1.95 | 1.96 | 1.98 | 2.00 | 1.88 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.38 | 0.45 | 0.40 | 0.42 | 0.39 | 0.42 | 0.37 | 0.39 | 0.41 | 0.46 | 0.45 |
| # | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT2 | | | | | MT3 | | | | | |
|-----------------|--------|--------|--------|--------|-------|--------|-------|--------|--------|--------|-------|
| | 3 | 4 | | | 5 | 6 | | 1 | | | |
| | | | | r | | | | r | c | c | |
| SiO2 | 44.98 | 44.91 | 45.22 | 46.70 | 44.49 | 46.45 | 45.68 | 44.55 | 46.24 | 42.47 | 45.74 |
| Al2O3 | 8.44 | 8.92 | 8.55 | 8.34 | 8.36 | 8.43 | 8.23 | 8.38 | 8.34 | 11.07 | 8.04 |
| FeO | 17.53 | 17.98 | 18.08 | 16.56 | 17.73 | 16.89 | 17.04 | 17.77 | 14.55 | 16.41 | 15.38 |
| MgO | 11.33 | 11.01 | 11.29 | 11.73 | 11.21 | 11.26 | 11.39 | 11.42 | 13.30 | 10.68 | 12.86 |
| CaO | 11.88 | 12.25 | 12.14 | 12.34 | 12.40 | 11.98 | 11.93 | 11.84 | 11.58 | 11.64 | 11.71 |
| Na2O | 1.21 | 1.06 | 1.22 | 0.87 | 1.08 | 1.34 | 1.02 | 1.16 | 1.17 | 1.62 | 1.05 |
| K2O | 0.88 | 1.02 | 1.15 | 0.69 | 0.93 | 0.82 | 0.78 | 0.99 | 0.81 | 1.12 | 0.77 |
| TiO2 | 1.44 | 1.27 | 1.37 | 0.94 | 1.20 | 1.39 | 1.13 | 1.48 | 1.66 | 2.53 | 1.66 |
| MnO | 0.53 | 0.67 | 0.66 | 0.69 | 0.54 | 0.58 | 0.52 | 0.81 | 0.46 | 0.46 | 0.49 |
| BaO | n | n | n | n | n | n | n | n | 0.21 | 0.22 | 0.22 |
| Cl | 0.04 | n | n | n | 0.03 | 0.04 | 0.11 | n | 0.10 | 0.13 | 0.10 |
| F | 0.12 | n | n | 0.16 | 0.27 | 0.14 | n | n | n | n | n |
| SUBSUM | 98.38 | 99.09 | 99.68 | 99.02 | 98.24 | 99.32 | 97.83 | 98.40 | 98.42 | 98.35 | 98.02 |
| Cl=O | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.00 | 0.02 | 0.03 | 0.02 |
| F=O | 0.05 | 0.00 | 0.00 | 0.07 | 0.11 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SUM | 98.32 | 99.09 | 99.68 | 98.95 | 98.12 | 99.25 | 97.81 | 98.40 | 98.40 | 98.32 | 98.00 |
| H2Ocalc | 1.93 | 2.01 | 2.02 | 1.96 | 1.85 | 1.96 | 1.97 | 2.00 | 2.01 | 1.96 | 1.99 |
| SUM | 100.25 | 101.10 | 101.70 | 100.91 | 99.97 | 101.21 | 99.78 | 100.40 | 100.41 | 100.28 | 99.99 |
| Si | 6.74 | 6.69 | 6.71 | 6.89 | 6.71 | 6.85 | 6.84 | 6.69 | 6.81 | 6.38 | 6.80 |
| Aliv | 1.26 | 1.31 | 1.29 | 1.11 | 1.29 | 1.15 | 1.16 | 1.31 | 1.19 | 1.62 | 1.20 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.23 | 0.26 | 0.20 | 0.34 | 0.20 | 0.32 | 0.30 | 0.17 | 0.25 | 0.34 | 0.21 |
| Fe+2 | 2.08 | 2.15 | 2.15 | 1.98 | 2.15 | 2.05 | 2.03 | 2.10 | 1.64 | 1.99 | 1.76 |
| Mg | 2.53 | 2.45 | 2.50 | 2.58 | 2.52 | 2.47 | 2.54 | 2.56 | 2.92 | 2.39 | 2.85 |
| Ti | 0.16 | 0.14 | 0.15 | 0.10 | 0.14 | 0.15 | 0.13 | 0.17 | 0.18 | 0.29 | 0.19 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.07 | 0.08 | 0.08 | 0.09 | 0.07 | 0.07 | 0.07 | 0.10 | 0.06 | 0.06 | 0.06 |
| Fe+2 | 0.12 | 0.09 | 0.09 | 0.06 | 0.09 | 0.03 | 0.10 | 0.13 | 0.15 | 0.07 | 0.15 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.81 | 1.83 | 1.82 | 1.85 | 1.84 | 1.89 | 1.83 | 1.77 | 1.80 | 1.87 | 1.79 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.35 | 0.31 | 0.35 | 0.25 | 0.32 | 0.38 | 0.30 | 0.34 | 0.33 | 0.47 | 0.30 |
| K | 0.17 | 0.19 | 0.22 | 0.13 | 0.18 | 0.15 | 0.15 | 0.19 | 0.15 | 0.21 | 0.15 |
| Ca | 0.09 | 0.13 | 0.11 | 0.10 | 0.16 | 0.00 | 0.08 | 0.14 | 0.03 | 0.00 | 0.08 |
| A | 0.61 | 0.63 | 0.68 | 0.47 | 0.66 | 0.53 | 0.53 | 0.66 | 0.52 | 0.69 | 0.52 |
| CATSUM | 15.61 | 15.63 | 15.68 | 15.47 | 15.66 | 15.53 | 15.53 | 15.66 | 15.52 | 15.69 | 15.52 |
| F | 0.06 | 0.00 | 0.00 | 0.07 | 0.13 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cl | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.03 | 0.00 | 0.02 | 0.03 | 0.03 |
| OHcalc | 1.93 | 2.00 | 2.00 | 1.93 | 1.86 | 1.92 | 1.97 | 2.00 | 1.98 | 1.97 | 1.97 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.46 | 0.48 | 0.47 | 0.44 | 0.47 | 0.46 | 0.46 | 0.47 | 0.38 | 0.46 | 0.40 |
| # | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT3 | | | | | MT4 | | | | | |
|-----------------|-------|-------|-------|--------|-------|--------|--------|-------|--------|--------|-------|
| | 2 | 3 | 4 | | | 5 | 6 | | 1 | 2 | |
| | | | r | r | c | | | | c | r | c |
| SiO2 | 47.64 | 44.89 | 46.04 | 45.76 | 44.83 | 47.34 | 49.44 | 44.58 | 46.14 | 45.55 | 43.32 |
| Al2O3 | 6.98 | 8.14 | 9.05 | 9.49 | 10.22 | 7.41 | 6.91 | 9.45 | 8.39 | 8.46 | 8.79 |
| FeO | 15.41 | 16.43 | 16.78 | 14.26 | 12.81 | 14.93 | 14.04 | 18.57 | 16.34 | 17.89 | 17.90 |
| MgO | 12.02 | 11.49 | 10.66 | 12.53 | 13.09 | 13.30 | 13.82 | 9.54 | 12.79 | 11.06 | 10.15 |
| CaO | 11.60 | 11.25 | 12.25 | 11.73 | 11.54 | 12.02 | 12.64 | 11.84 | 10.90 | 10.72 | 12.28 |
| Na2O | 0.95 | 1.08 | 0.75 | 1.14 | 1.33 | 0.80 | 0.59 | 0.90 | 1.29 | 1.45 | 1.71 |
| K2O | 0.79 | 1.05 | 0.54 | 0.80 | 0.67 | 0.61 | 0.34 | 0.81 | 0.83 | 0.87 | 0.98 |
| TiO2 | 1.33 | 1.51 | 0.32 | 1.89 | 2.56 | 1.41 | 0.34 | 0.24 | 1.76 | 1.62 | 1.38 |
| MnO | 0.42 | 0.22 | 0.38 | 0.50 | 0.37 | 0.65 | 0.39 | 0.65 | 0.39 | 0.64 | 0.42 |
| BaO | n | n | n | n | n | n | n | n | 0.21 | 0.10 | n |
| Cl | 0.04 | 0.33 | n | n | n | n | n | 0.19 | 0.09 | 0.15 | n |
| F | n | n | n | n | n | n | n | n | 0.04 | 0.26 | n |
| SUBSUM | 97.18 | 96.39 | 96.77 | 98.10 | 97.42 | 98.27 | 98.47 | 96.77 | 99.17 | 98.77 | 96.93 |
| Cl=O | 0.01 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.02 | 0.03 | 0.00 |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.11 | 0.00 |
| SUM | 97.17 | 96.32 | 96.77 | 98.10 | 97.42 | 98.27 | 98.47 | 96.73 | 99.13 | 98.63 | 96.93 |
| H2Ocalc | 2.01 | 1.89 | 1.99 | 2.04 | 2.04 | 2.04 | 2.07 | 1.91 | 2.00 | 1.85 | 1.96 |
| SUM | 99.18 | 98.20 | 98.76 | 100.14 | 99.46 | 100.31 | 100.54 | 98.64 | 101.13 | 100.47 | 98.89 |
| Si | 7.09 | 6.83 | 6.92 | 6.73 | 6.60 | 6.94 | 7.17 | 6.81 | 6.79 | 6.80 | 6.64 |
| Aliv | 0.91 | 1.17 | 1.08 | 1.27 | 1.40 | 1.06 | 0.83 | 1.19 | 1.21 | 1.20 | 1.36 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.31 | 0.28 | 0.52 | 0.38 | 0.38 | 0.23 | 0.35 | 0.51 | 0.24 | 0.29 | 0.22 |
| Fe+2 | 1.88 | 1.94 | 2.05 | 1.67 | 1.47 | 1.71 | 1.62 | 2.29 | 1.76 | 2.06 | 2.29 |
| Mg | 2.66 | 2.60 | 2.39 | 2.75 | 2.87 | 2.91 | 2.99 | 2.17 | 2.80 | 2.46 | 2.32 |
| Ti | 0.15 | 0.17 | 0.04 | 0.21 | 0.28 | 0.16 | 0.04 | 0.03 | 0.19 | 0.18 | 0.16 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.05 | 0.03 | 0.05 | 0.06 | 0.05 | 0.08 | 0.05 | 0.08 | 0.05 | 0.08 | 0.05 |
| Fe+2 | 0.04 | 0.15 | 0.06 | 0.09 | 0.11 | 0.12 | 0.07 | 0.08 | 0.25 | 0.17 | 0.00 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.85 | 1.82 | 1.89 | 1.85 | 1.82 | 1.88 | 1.88 | 1.84 | 1.70 | 1.72 | 1.95 |
| Na | 0.06 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.22 | 0.32 | 0.22 | 0.32 | 0.36 | 0.23 | 0.17 | 0.27 | 0.37 | 0.39 | 0.51 |
| K | 0.15 | 0.20 | 0.10 | 0.15 | 0.13 | 0.11 | 0.06 | 0.16 | 0.16 | 0.17 | 0.19 |
| Ca | 0.00 | 0.01 | 0.08 | 0.00 | 0.00 | 0.09 | 0.09 | 0.10 | 0.02 | 0.00 | 0.06 |
| A | 0.37 | 0.53 | 0.40 | 0.47 | 0.48 | 0.43 | 0.32 | 0.53 | 0.54 | 0.56 | 0.76 |
| CATSUM | 15.37 | 15.53 | 15.40 | 15.47 | 15.48 | 15.43 | 15.32 | 15.53 | 15.54 | 15.56 | 15.76 |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.12 | 0.00 |
| Cl | 0.01 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.02 | 0.04 | 0.00 |
| OHcalc | 1.99 | 1.91 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.95 | 1.96 | 1.84 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.42 | 0.45 | 0.47 | 0.39 | 0.35 | 0.39 | 0.36 | 0.52 | 0.42 | 0.48 | 0.50 |
| # | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT4 | | | | MT5 | | | | | | | |
|--------------------------------|-------|-------|-------|--------|-------|-------|--------|-------|-------|-------|--------|---|
| | 2 | | 3 | | 4 | | 5 | | 1 | 2 | 3 | 4 |
| | r | | | | r | | c | | s | c | r | r |
| SiO ₂ | 44.30 | 44.21 | 46.17 | 45.46 | 44.23 | 44.24 | 45.72 | 44.36 | 44.78 | 46.29 | 46.16 | |
| Al ₂ O ₃ | 9.02 | 9.03 | 7.87 | 8.27 | 8.77 | 8.32 | 8.28 | 10.30 | 8.92 | 9.00 | 9.55 | |
| FeO | 17.32 | 17.25 | 14.22 | 15.71 | 17.68 | 14.42 | 15.56 | 15.43 | 15.37 | 13.04 | 14.83 | |
| MgO | 10.00 | 10.06 | 12.83 | 11.63 | 10.47 | 12.41 | 13.10 | 11.53 | 12.22 | 13.09 | 13.29 | |
| CaO | 11.96 | 12.25 | 11.99 | 11.89 | 12.13 | 11.67 | 10.83 | 11.44 | 11.53 | 11.48 | 12.02 | |
| Na ₂ O | 1.18 | 1.33 | 1.01 | 2.14 | 1.64 | 1.99 | 1.21 | 1.20 | 1.34 | 1.32 | 1.18 | |
| K ₂ O | 0.79 | 0.92 | 0.76 | 0.88 | 1.00 | 0.88 | 0.89 | 0.86 | 0.73 | 0.43 | 0.56 | |
| TiO ₂ | 1.28 | 1.30 | 1.87 | 1.96 | 1.40 | 2.07 | 1.78 | 1.92 | 1.86 | 1.21 | 1.13 | |
| MnO | 0.35 | 0.62 | 0.00 | 0.36 | 0.61 | 0.09 | 0.45 | 0.40 | 0.55 | 0.37 | 0.24 | |
| BaO | n | n | n | n | n | n | 0.21 | n | n | n | n | |
| Cl | n | n | n | n | n | n | 0.13 | n | n | 0.10 | 0.08 | |
| F | n | n | n | n | n | n | 0.00 | n | n | 0.16 | 0.00 | |
| SUBSUM | 96.20 | 96.97 | 97.52 | 98.30 | 97.93 | 96.09 | 98.16 | 97.44 | 97.30 | 96.49 | 98.04 | |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.02 | 0.02 | |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | |
| SUM | 96.20 | 96.97 | 97.52 | 98.30 | 97.93 | 96.09 | 98.13 | 97.44 | 97.30 | 96.40 | 98.02 | |
| H ₂ Ocalc | 1.96 | 1.97 | 2.02 | 2.02 | 1.98 | 1.98 | 1.99 | 2.01 | 2.00 | 1.92 | 2.01 | |
| SUM | 98.16 | 98.94 | 99.54 | 100.32 | 99.91 | 98.07 | 100.12 | 99.45 | 99.30 | 98.32 | 100.03 | |
| Si | 6.76 | 6.72 | 6.84 | 6.76 | 6.68 | 6.70 | 6.78 | 6.62 | 6.70 | 6.87 | 6.81 | |
| Aliv | 1.24 | 1.28 | 1.16 | 1.24 | 1.32 | 1.30 | 1.22 | 1.38 | 1.30 | 1.13 | 1.19 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.39 | 0.34 | 0.22 | 0.21 | 0.25 | 0.18 | 0.23 | 0.43 | 0.27 | 0.45 | 0.30 | |
| Fe+2 | 2.19 | 2.19 | 1.74 | 1.95 | 2.23 | 1.78 | 1.68 | 1.80 | 1.80 | 1.52 | 1.66 | |
| Mg | 2.28 | 2.28 | 2.83 | 2.58 | 2.36 | 2.80 | 2.90 | 2.56 | 2.72 | 2.90 | 2.92 | |
| Ti | 0.15 | 0.15 | 0.21 | 0.22 | 0.16 | 0.24 | 0.20 | 0.22 | 0.21 | 0.14 | 0.13 | |
| Mn | 0.00 | 0.04 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.05 | 0.04 | 0.00 | 0.01 | 0.08 | 0.01 | 0.06 | 0.05 | 0.07 | 0.05 | 0.03 | |
| Fe+2 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.04 | 0.25 | 0.13 | 0.13 | 0.10 | 0.17 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.93 | 1.96 | 1.90 | 1.89 | 1.92 | 1.89 | 1.69 | 1.82 | 1.80 | 1.83 | 1.80 | |
| Na | 0.00 | 0.00 | 0.07 | 0.10 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.35 | 0.39 | 0.45 | 0.52 | 0.48 | 0.53 | 0.35 | 0.35 | 0.39 | 0.35 | 0.34 | |
| K | 0.15 | 0.18 | 0.14 | 0.17 | 0.19 | 0.17 | 0.17 | 0.16 | 0.14 | 0.08 | 0.11 | |
| Ca | 0.02 | 0.04 | 0.00 | 0.00 | 0.04 | 0.00 | 0.03 | 0.01 | 0.04 | 0.00 | 0.10 | |
| A | 0.53 | 0.61 | 0.59 | 0.69 | 0.71 | 0.70 | 0.54 | 0.52 | 0.57 | 0.43 | 0.54 | |
| CATSUM | 15.53 | 15.61 | 15.59 | 15.69 | 15.71 | 15.70 | 15.54 | 15.52 | 15.57 | 15.43 | 15.54 | |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.03 | 0.02 | |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.97 | 2.00 | 2.00 | 1.90 | 1.98 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.49 | 0.49 | 0.38 | 0.43 | 0.49 | 0.39 | 0.40 | 0.43 | 0.41 | 0.36 | 0.39 | |
| # | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE BRAIN | MT5 | | | | | | | | MT6 | | |
|-----------------|--------|-------|-------|--------|-------|--------|-------|-------|-------|--------|-------|
| | 5 | 6 | 7 | 8 | 9 | 1 | 2 | | | | |
| | | | | | | c | r | c | | | |
| SiO2 | 42.60 | 44.49 | 43.16 | 44.96 | 47.25 | 45.19 | 42.88 | 43.15 | 42.53 | 44.01 | 41.33 |
| Al2O3 | 11.91 | 10.10 | 10.06 | 10.28 | 7.59 | 10.61 | 15.14 | 11.35 | 10.64 | 10.18 | 10.70 |
| FeO | 15.67 | 13.60 | 13.35 | 13.66 | 14.71 | 14.51 | 14.42 | 12.03 | 14.32 | 15.89 | 15.43 |
| MgO | 11.57 | 13.00 | 12.28 | 13.03 | 12.97 | 11.96 | 10.16 | 13.54 | 11.97 | 11.35 | 11.66 |
| CaO | 11.61 | 11.64 | 11.44 | 11.03 | 11.55 | 11.16 | 11.03 | 11.39 | 11.06 | 10.52 | 10.04 |
| Na2O | 1.80 | 1.53 | 2.14 | 1.63 | 0.99 | 1.33 | 1.11 | 2.16 | 2.14 | 1.98 | 2.05 |
| K2O | 0.66 | 0.69 | 0.59 | 0.52 | 0.82 | 0.73 | 0.94 | 0.70 | 0.96 | 0.96 | 0.95 |
| TiO2 | 2.28 | 2.00 | 2.11 | 2.59 | 1.39 | 2.48 | 1.79 | 3.30 | 3.67 | 2.90 | 3.23 |
| MnO | 0.36 | 0.47 | 0.27 | 0.29 | 0.25 | 0.36 | 0.30 | 0.19 | 0.45 | 0.47 | 0.31 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.00 | 0.07 | 0.00 | n | n | n | n | n | n | n | n |
| F | 0.05 | 0.09 | 0.36 | n | n | n | n | n | n | n | n |
| SUBSUM | 98.51 | 97.68 | 96.56 | 97.99 | 97.52 | 98.33 | 97.93 | 97.92 | 97.74 | 98.26 | 96.50 |
| Cl=O | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F=O | 0.02 | 0.04 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SUM | 98.49 | 97.63 | 96.41 | 97.99 | 97.52 | 98.33 | 97.93 | 97.92 | 97.74 | 98.26 | 96.50 |
| H2Ocalc | 2.00 | 1.97 | 1.83 | 2.04 | 2.03 | 2.04 | 2.04 | 2.04 | 2.01 | 2.02 | 1.97 |
| SUM | 100.49 | 99.59 | 98.23 | 100.03 | 99.55 | 100.37 | 99.97 | 99.96 | 99.75 | 100.28 | 98.47 |
| Si | 6.32 | 6.59 | 6.48 | 6.59 | 6.99 | 6.63 | 6.31 | 6.34 | 6.35 | 6.54 | 6.29 |
| Aliv | 1.68 | 1.41 | 1.52 | 1.41 | 1.02 | 1.37 | 1.69 | 1.66 | 1.65 | 1.46 | 1.71 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.41 | 0.35 | 0.41 | 0.37 | 0.30 | 0.46 | 0.93 | 0.30 | 0.22 | 0.32 | 0.21 |
| Fe+2 | 1.78 | 1.56 | 1.61 | 1.49 | 1.69 | 1.65 | 1.64 | 1.37 | 1.71 | 1.84 | 1.78 |
| Mg | 2.56 | 2.87 | 2.75 | 2.85 | 2.86 | 2.61 | 2.23 | 2.96 | 2.66 | 2.51 | 2.64 |
| Ti | 0.25 | 0.22 | 0.24 | 0.29 | 0.15 | 0.27 | 0.20 | 0.36 | 0.41 | 0.32 | 0.37 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.05 | 0.06 | 0.03 | 0.04 | 0.03 | 0.04 | 0.04 | 0.02 | 0.06 | 0.06 | 0.04 |
| Fe+2 | 0.17 | 0.12 | 0.07 | 0.18 | 0.13 | 0.13 | 0.13 | 0.11 | 0.08 | 0.13 | 0.18 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.79 | 1.82 | 1.84 | 1.73 | 1.83 | 1.75 | 1.74 | 1.79 | 1.77 | 1.67 | 1.77 |
| Na | 0.00 | 0.00 | 0.05 | 0.05 | 0.01 | 0.07 | 0.09 | 0.08 | 0.10 | 0.13 | 0.01 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.52 | 0.44 | 0.57 | 0.41 | 0.27 | 0.30 | 0.22 | 0.54 | 0.52 | 0.44 | 0.59 |
| K | 0.12 | 0.13 | 0.11 | 0.10 | 0.15 | 0.14 | 0.18 | 0.13 | 0.18 | 0.18 | 0.18 |
| Ca | 0.06 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.70 | 0.60 | 0.60 | 0.51 | 0.42 | 0.44 | 0.40 | 0.67 | 0.71 | 0.62 | 0.78 |
| CATSUM | 15.70 | 15.60 | 15.68 | 15.51 | 15.42 | 15.44 | 15.40 | 15.67 | 15.71 | 15.62 | 15.78 |
| F | 0.02 | 0.04 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cl | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OHcalc | 1.98 | 1.94 | 1.83 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.43 | 0.37 | 0.38 | 0.37 | 0.39 | 0.41 | 0.44 | 0.33 | 0.40 | 0.44 | 0.43 |
| # | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT6 | | | | | | MT7 | | | | | |
|-----------------|-------|--------|-------|-------|-------|-------|-------|-------|--------|-------|-------|--|
| | 2 | | 3 | | | | 1 | | 2 | | 3 | |
| | r | c | | | | | c | r | r | c | c | |
| SiO2 | 45.99 | 42.19 | 41.94 | 46.40 | 44.49 | 46.34 | 47.38 | 46.71 | 46.66 | 44.82 | 48.19 | |
| Al2O3 | 7.35 | 10.58 | 10.98 | 6.78 | 8.61 | 7.74 | 5.59 | 6.85 | 7.79 | 7.95 | 5.79 | |
| FeO | 17.51 | 16.12 | 15.22 | 17.14 | 16.98 | 16.59 | 14.66 | 15.48 | 15.85 | 16.98 | 14.84 | |
| MgO | 11.29 | 11.18 | 11.82 | 12.52 | 12.06 | 12.28 | 13.90 | 13.04 | 12.11 | 11.33 | 13.28 | |
| CaO | 11.11 | 11.17 | 10.88 | 10.21 | 10.90 | 10.65 | 12.37 | 12.36 | 12.52 | 12.59 | 12.52 | |
| Na2O | 1.19 | 2.07 | 2.01 | 1.43 | 1.72 | 1.56 | 0.47 | 0.78 | 0.94 | 0.87 | 0.42 | |
| K2O | 0.60 | 0.90 | 0.87 | 0.48 | 0.72 | 0.61 | 0.64 | 0.69 | 0.93 | 0.92 | 0.76 | |
| TiO2 | 1.29 | 3.31 | 3.42 | 1.30 | 1.93 | 1.66 | 0.83 | 0.83 | 1.29 | 1.02 | 0.93 | |
| MnO | 0.66 | 0.51 | 0.43 | 0.63 | 0.56 | 0.54 | 0.80 | 0.80 | 0.79 | 0.67 | 0.89 | |
| BaO | n | n | n | n | n | n | n | n | n | n | n | |
| Cl | n | n | n | n | n | n | n | n | n | n | n | |
| F | n | n | n | n | n | n | n | n | n | n | n | |
| SUBSUM | 96.99 | 98.03 | 97.57 | 96.89 | 97.97 | 97.97 | 96.64 | 97.54 | 98.88 | 97.15 | 97.62 | |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| SUM | 96.99 | 98.03 | 97.57 | 96.89 | 97.97 | 97.97 | 96.64 | 97.54 | 98.88 | 97.15 | 97.62 | |
| H2Ocalc | 1.99 | 2.00 | 2.00 | 1.99 | 2.00 | 2.02 | 2.00 | 2.01 | 2.03 | 1.98 | 2.02 | |
| SUM | 98.98 | 100.03 | 99.57 | 98.88 | 99.97 | 99.99 | 98.64 | 99.55 | 100.91 | 99.13 | 99.64 | |
| Si | 6.94 | 6.33 | 6.29 | 6.98 | 6.66 | 6.88 | 7.09 | 6.96 | 6.88 | 6.79 | 7.14 | |
| Aliv | 1.06 | 1.67 | 1.71 | 1.02 | 1.34 | 1.12 | 0.91 | 1.04 | 1.12 | 1.21 | 0.86 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.25 | 0.21 | 0.23 | 0.18 | 0.18 | 0.24 | 0.08 | 0.17 | 0.24 | 0.21 | 0.15 | |
| Fe+2 | 2.06 | 1.92 | 1.74 | 1.86 | 1.91 | 1.86 | 1.73 | 1.84 | 1.96 | 2.11 | 1.82 | |
| Mg | 2.54 | 2.50 | 2.64 | 2.81 | 2.69 | 2.72 | 3.10 | 2.90 | 2.66 | 2.56 | 2.93 | |
| Ti | 0.15 | 0.37 | 0.39 | 0.15 | 0.22 | 0.19 | 0.09 | 0.09 | 0.14 | 0.12 | 0.10 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.08 | 0.06 | 0.05 | 0.08 | 0.07 | 0.07 | 0.10 | 0.10 | 0.10 | 0.09 | 0.11 | |
| Fe+2 | 0.15 | 0.11 | 0.17 | 0.29 | 0.22 | 0.21 | 0.11 | 0.09 | 0.00 | 0.04 | 0.02 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.77 | 1.80 | 1.75 | 1.63 | 1.71 | 1.70 | 1.79 | 1.81 | 1.90 | 1.88 | 1.87 | |
| Na | 0.00 | 0.03 | 0.02 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.35 | 0.57 | 0.56 | 0.42 | 0.50 | 0.42 | 0.14 | 0.23 | 0.27 | 0.26 | 0.12 | |
| K | 0.12 | 0.17 | 0.17 | 0.09 | 0.14 | 0.12 | 0.12 | 0.13 | 0.18 | 0.18 | 0.14 | |
| Ca | 0.03 | 0.00 | 0.00 | 0.02 | 0.04 | 0.00 | 0.19 | 0.16 | 0.08 | 0.17 | 0.12 | |
| A | 0.49 | 0.74 | 0.73 | 0.53 | 0.68 | 0.53 | 0.45 | 0.52 | 0.52 | 0.60 | 0.39 | |
| CATSUM | 15.49 | 15.74 | 15.73 | 15.53 | 15.68 | 15.53 | 15.45 | 15.52 | 15.52 | 15.60 | 15.39 | |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.47 | 0.45 | 0.42 | 0.43 | 0.44 | 0.43 | 0.37 | 0.40 | 0.42 | 0.46 | 0.39 | |
| # | 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT7 | | | | MT8 | | | | | | |
|--------------------------------|-------|-------|--------|-------|--------|--------|-------|--------|--------|--------|-------|
| | 3 | | 4 | | 1 | 2 | 3 | 4 | 5 | 6 | |
| | r | r | c | r | s | s | s | s | s | | r |
| SiO ₂ | 46.91 | 46.10 | 46.26 | 45.59 | 49.31 | 45.34 | 47.82 | 50.52 | 47.61 | 50.70 | 49.45 |
| Al ₂ O ₃ | 6.54 | 7.62 | 7.77 | 7.48 | 6.54 | 8.81 | 6.81 | 4.85 | 7.12 | 4.34 | 5.14 |
| FeO | 15.31 | 15.91 | 16.38 | 16.22 | 13.42 | 14.51 | 12.97 | 12.20 | 14.20 | 12.28 | 12.76 |
| MgO | 13.15 | 12.12 | 12.04 | 12.08 | 14.89 | 12.83 | 14.53 | 15.41 | 14.15 | 16.35 | 15.30 |
| CaO | 12.48 | 12.51 | 12.68 | 12.44 | 12.58 | 11.69 | 10.97 | 12.24 | 11.80 | 11.94 | 11.55 |
| Na ₂ O | 0.89 | 0.68 | 0.63 | 0.70 | 0.49 | 1.70 | 1.26 | 0.98 | 1.19 | 0.87 | 0.92 |
| K ₂ O | 0.73 | 0.85 | 0.95 | 0.95 | 0.44 | 0.75 | 0.86 | 0.34 | 0.47 | 0.38 | 0.45 |
| TiO ₂ | 0.88 | 1.09 | 1.29 | 1.16 | 0.91 | 1.56 | 1.26 | 0.66 | 1.36 | 0.71 | 0.89 |
| MnO | 0.83 | 0.74 | 0.63 | 0.49 | 0.79 | 0.74 | 0.68 | 0.86 | 0.63 | 0.84 | 0.83 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | n | n | n | n | 0.15 | 0.16 | 0.15 | 0.00 | 0.16 | n | n |
| F | n | n | n | n | 0.46 | 0.30 | 0.38 | 0.34 | 0.02 | n | n |
| SUBSUM | 97.72 | 97.62 | 98.63 | 97.11 | 100.05 | 98.39 | 97.69 | 98.62 | 98.71 | 98.41 | 97.29 |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.04 | 0.03 | 0.00 | 0.04 | 0.00 | 0.00 |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.13 | 0.16 | 0.14 | 0.01 | 0.00 | 0.00 |
| SUM | 97.72 | 97.62 | 98.63 | 97.11 | 99.82 | 98.23 | 97.50 | 98.48 | 98.67 | 98.41 | 97.29 |
| H ₂ Ocalc | 2.01 | 2.01 | 2.02 | 1.99 | 1.83 | 1.84 | 1.82 | 1.91 | 2.00 | 2.08 | 2.05 |
| SUM | 99.73 | 99.63 | 100.65 | 99.10 | 101.65 | 100.07 | 99.32 | 100.39 | 100.67 | 100.49 | 99.34 |
| Si | 6.98 | 6.89 | 6.86 | 6.86 | 7.09 | 6.72 | 7.04 | 7.30 | 6.95 | 7.32 | 7.24 |
| Aliv | 1.02 | 1.11 | 1.14 | 1.14 | 0.91 | 1.28 | 0.96 | 0.70 | 1.05 | 0.68 | 0.76 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.13 | 0.23 | 0.21 | 0.19 | 0.20 | 0.26 | 0.22 | 0.13 | 0.18 | 0.06 | 0.13 |
| Fe+2 | 1.95 | 1.95 | 1.98 | 1.97 | 1.51 | 1.73 | 1.45 | 1.47 | 1.59 | 1.35 | 1.43 |
| Mg | 2.92 | 2.70 | 2.66 | 2.71 | 3.19 | 2.83 | 3.19 | 3.32 | 3.08 | 3.52 | 3.34 |
| Ti | 0.10 | 0.12 | 0.14 | 0.13 | 0.10 | 0.17 | 0.14 | 0.07 | 0.15 | 0.08 | 0.10 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.10 | 0.09 | 0.08 | 0.06 | 0.10 | 0.09 | 0.08 | 0.10 | 0.08 | 0.10 | 0.10 |
| Fe+2 | 0.05 | 0.04 | 0.05 | 0.08 | 0.10 | 0.07 | 0.15 | 0.00 | 0.15 | 0.13 | 0.13 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.84 | 1.87 | 1.87 | 1.86 | 1.80 | 1.84 | 1.73 | 1.90 | 1.78 | 1.77 | 1.77 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.26 | 0.20 | 0.18 | 0.20 | 0.14 | 0.49 | 0.33 | 0.27 | 0.34 | 0.24 | 0.26 |
| K | 0.14 | 0.16 | 0.18 | 0.18 | 0.08 | 0.14 | 0.16 | 0.06 | 0.09 | 0.07 | 0.08 |
| Ca | 0.15 | 0.14 | 0.14 | 0.15 | 0.14 | 0.02 | 0.00 | 0.00 | 0.04 | 0.08 | 0.04 |
| A | 0.54 | 0.50 | 0.50 | 0.53 | 0.35 | 0.65 | 0.49 | 0.33 | 0.50 | 0.39 | 0.39 |
| CATSUM | 15.54 | 15.50 | 15.50 | 15.53 | 15.35 | 15.65 | 15.49 | 15.33 | 15.50 | 15.39 | 15.39 |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.14 | 0.18 | 0.16 | 0.01 | 0.00 | 0.00 |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.04 | 0.00 | 0.04 | 0.00 | 0.00 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 1.75 | 1.82 | 1.79 | 1.84 | 1.95 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.40 | 0.42 | 0.43 | 0.43 | 0.34 | 0.39 | 0.33 | 0.31 | 0.36 | 0.30 | 0.32 |
| # | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT8 7 | | | | | MT9 1 | | | | | 2 | |
|--------------------------------|----------|-------|--------|--------|--------|----------|-------|-------|-------|-------|-------|---|
| | r | r | r | r | c | c | c | r | r | r | r | r |
| SiO ₂ | 47.27 | 49.55 | 50.09 | 46.82 | 50.65 | 51.32 | 45.86 | 46.28 | 48.01 | 45.66 | 47.54 | |
| Al ₂ O ₃ | 6.99 | 5.07 | 4.81 | 7.38 | 4.65 | 4.58 | 7.59 | 7.45 | 6.72 | 7.08 | 7.21 | |
| FeO | 13.77 | 13.09 | 12.28 | 14.50 | 12.41 | 12.25 | 14.93 | 14.91 | 14.95 | 15.12 | 14.62 | |
| MgO | 14.28 | 15.36 | 16.51 | 14.02 | 16.04 | 16.58 | 12.82 | 13.21 | 12.72 | 13.28 | 13.00 | |
| CaO | 11.69 | 11.56 | 12.15 | 11.52 | 12.29 | 12.25 | 11.39 | 12.05 | 12.43 | 12.00 | 11.71 | |
| Na ₂ O | 1.30 | 0.93 | 0.91 | 1.24 | 0.93 | 0.83 | 1.13 | 0.97 | 0.95 | 1.22 | 1.10 | |
| K ₂ O | 0.65 | 0.47 | 0.44 | 0.73 | 0.43 | 0.41 | 0.75 | 0.57 | 0.52 | 0.78 | 0.67 | |
| TiO ₂ | 1.28 | 0.84 | 0.78 | 1.23 | 0.73 | 0.70 | 1.00 | 0.83 | 0.68 | 1.23 | 0.88 | |
| MnO | 0.91 | 0.92 | 0.71 | 0.84 | 0.88 | 0.89 | 1.02 | 0.90 | 0.96 | 1.02 | 0.85 | |
| BaO | n | n | n | n | n | n | n | n | n | n | n | |
| Cl | n | n | n | n | n | n | n | n | n | n | n | |
| F | n | n | n | n | n | n | n | 0.70 | 0.13 | n | n | |
| SUBSUM | 98.14 | 97.79 | 98.68 | 98.28 | 99.01 | 99.81 | 96.49 | 97.87 | 98.07 | 97.39 | 97.58 | |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.05 | 0.00 | 0.00 | |
| SUM | 98.14 | 97.79 | 98.68 | 98.28 | 99.01 | 99.81 | 96.49 | 97.58 | 98.02 | 97.39 | 97.58 | |
| H ₂ Ocalc | 2.04 | 2.05 | 2.08 | 2.04 | 2.09 | 2.11 | 1.99 | 1.68 | 1.97 | 2.00 | 2.03 | |
| SUM | 100.18 | 99.84 | 100.76 | 100.32 | 101.10 | 101.92 | 98.48 | 99.25 | 99.98 | 99.39 | 99.61 | |
| Si | 6.94 | 7.23 | 7.22 | 6.89 | 7.28 | 7.30 | 6.90 | 6.91 | 7.09 | 6.84 | 7.03 | |
| Aliv | 1.06 | 0.77 | 0.78 | 1.11 | 0.72 | 0.70 | 1.10 | 1.09 | 0.91 | 1.16 | 0.97 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.15 | 0.11 | 0.04 | 0.17 | 0.07 | 0.07 | 0.25 | 0.22 | 0.26 | 0.09 | 0.29 | |
| Fe+2 | 1.58 | 1.46 | 1.33 | 1.62 | 1.42 | 1.34 | 1.77 | 1.75 | 1.85 | 1.81 | 1.75 | |
| Mg | 3.13 | 3.34 | 3.55 | 3.07 | 3.44 | 3.51 | 2.87 | 2.94 | 2.88 | 2.96 | 2.87 | |
| Ti | 0.14 | 0.09 | 0.08 | 0.14 | 0.08 | 0.07 | 0.11 | 0.09 | 0.08 | 0.14 | 0.10 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.11 | 0.11 | 0.09 | 0.10 | 0.11 | 0.11 | 0.13 | 0.11 | 0.10 | 0.13 | 0.11 | |
| Fe+2 | 0.11 | 0.14 | 0.15 | 0.17 | 0.08 | 0.12 | 0.11 | 0.11 | 0.00 | 0.09 | 0.06 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.78 | 1.75 | 1.76 | 1.73 | 1.82 | 1.78 | 1.76 | 1.78 | 1.90 | 1.78 | 1.83 | |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.37 | 0.26 | 0.25 | 0.35 | 0.26 | 0.23 | 0.33 | 0.28 | 0.27 | 0.35 | 0.32 | |
| K | 0.12 | 0.09 | 0.08 | 0.14 | 0.08 | 0.07 | 0.14 | 0.11 | 0.10 | 0.15 | 0.13 | |
| Ca | 0.06 | 0.06 | 0.12 | 0.09 | 0.08 | 0.09 | 0.08 | 0.15 | 0.07 | 0.14 | 0.02 | |
| A | 0.56 | 0.41 | 0.45 | 0.58 | 0.41 | 0.39 | 0.55 | 0.54 | 0.44 | 0.66 | 0.46 | |
| CATSUM | 15.56 | 15.41 | 15.45 | 15.58 | 15.41 | 15.39 | 15.55 | 15.54 | 15.44 | 15.65 | 15.46 | |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.06 | 0.00 | 0.00 | |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.67 | 1.94 | 2.00 | 2.00 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.35 | 0.32 | 0.29 | 0.37 | 0.30 | 0.29 | 0.40 | 0.39 | 0.40 | 0.39 | 0.39 | |
| # | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 | 211 | 212 | 213 | |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT10 | | | | | | | MT11 | | | |
|-----------------|--------|--------|-------|-------|-------|--------|--------|-------|--------|-------|-------|
| | 1 | | | | 2 | 3 | | F | C | C | C |
| SiO2 | 43.66 | 48.15 | 46.00 | 45.36 | 44.47 | 44.42 | 44.36 | 43.79 | 47.35 | 45.09 | 45.84 |
| Al2O3 | 10.23 | 6.38 | 7.89 | 8.64 | 9.11 | 9.39 | 9.70 | 8.75 | 6.57 | 7.63 | 6.98 |
| FeO | 16.00 | 14.10 | 14.29 | 15.52 | 15.26 | 16.13 | 16.47 | 15.61 | 15.28 | 15.73 | 15.06 |
| MgO | 11.01 | 14.56 | 12.82 | 12.15 | 11.94 | 11.94 | 11.70 | 11.54 | 13.98 | 13.13 | 13.49 |
| CaO | 12.38 | 12.37 | 12.69 | 12.12 | 12.33 | 12.40 | 12.37 | 12.20 | 11.85 | 11.47 | 11.68 |
| Na2O | 1.51 | 1.04 | 1.12 | 1.30 | 1.38 | 1.35 | 1.43 | 1.24 | 0.91 | 1.05 | 1.09 |
| K2O | 1.18 | 0.56 | 0.75 | 1.06 | 0.91 | 1.00 | 1.12 | 1.19 | 0.52 | 0.70 | 0.67 |
| TiO2 | 1.34 | 0.67 | 0.77 | 0.97 | 1.27 | 1.22 | 1.33 | 0.91 | 0.66 | 0.94 | 0.87 |
| MnO | 0.83 | 0.69 | 1.02 | 0.78 | 0.72 | 0.78 | 0.80 | 0.87 | 0.80 | 0.84 | 0.85 |
| BaO | n | n | n | n | n | n | n | n | 0.07 | 0.12 | 0.11 |
| Cl | n | n | n | n | n | n | n | n | 0.01 | n | 0.07 |
| F | 0.25 | 0.30 | 0.23 | 0.31 | 0.28 | 0.30 | 0.30 | 0.22 | 0.07 | 0.05 | 0.14 |
| SUBSUM | 98.39 | 98.82 | 97.58 | 98.21 | 97.67 | 98.93 | 99.58 | 96.32 | 98.07 | 96.75 | 96.85 |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| F=O | 0.11 | 0.13 | 0.10 | 0.13 | 0.12 | 0.13 | 0.13 | 0.07 | 0.03 | 0.02 | 0.06 |
| SUM | 98.28 | 98.69 | 97.48 | 98.00 | 97.55 | 98.00 | 99.45 | 96.23 | 98.04 | 96.73 | 96.78 |
| H2Ocalc | 1.88 | 1.91 | 1.90 | 1.86 | 1.87 | 1.87 | 1.88 | 1.86 | 1.99 | 1.96 | 1.91 |
| SUM | 100.17 | 100.60 | 99.38 | 99.94 | 99.42 | 100.67 | 101.33 | 98.08 | 100.03 | 98.69 | 98.68 |
| Si | 6.55 | 7.04 | 6.86 | 6.77 | 6.67 | 6.61 | 6.58 | 6.69 | 7.00 | 6.81 | 6.90 |
| Aliv | 1.45 | 0.96 | 1.14 | 1.23 | 1.33 | 1.39 | 1.42 | 1.31 | 1.00 | 1.19 | 1.10 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.35 | 0.14 | 0.25 | 0.29 | 0.29 | 0.26 | 0.27 | 0.27 | 0.15 | 0.17 | 0.14 |
| Fe+2 | 2.01 | 1.61 | 1.78 | 1.90 | 1.90 | 1.95 | 1.99 | 1.99 | 1.70 | 1.77 | 1.74 |
| Mg | 2.46 | 3.17 | 2.85 | 2.70 | 2.67 | 2.65 | 2.59 | 2.63 | 3.08 | 2.95 | 3.03 |
| Ti | 0.15 | 0.07 | 0.09 | 0.11 | 0.14 | 0.14 | 0.15 | 0.10 | 0.07 | 0.11 | 0.10 |
| Mn | 0.03 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.08 | 0.09 | 0.10 | 0.10 | 0.09 | 0.10 | 0.10 | 0.11 | 0.10 | 0.11 | 0.11 |
| Fe+2 | 0.00 | 0.11 | 0.00 | 0.04 | 0.01 | 0.06 | 0.05 | 0.00 | 0.19 | 0.21 | 0.16 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.92 | 1.80 | 1.90 | 1.86 | 1.89 | 1.84 | 1.85 | 1.89 | 1.71 | 1.68 | 1.73 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.44 | 0.29 | 0.32 | 0.38 | 0.40 | 0.39 | 0.41 | 0.37 | 0.26 | 0.31 | 0.32 |
| K | 0.23 | 0.10 | 0.14 | 0.20 | 0.17 | 0.19 | 0.21 | 0.23 | 0.10 | 0.13 | 0.13 |
| Ca | 0.07 | 0.14 | 0.13 | 0.07 | 0.09 | 0.13 | 0.11 | 0.11 | 0.17 | 0.18 | 0.15 |
| A | 0.73 | 0.54 | 0.59 | 0.65 | 0.66 | 0.71 | 0.74 | 0.71 | 0.53 | 0.62 | 0.60 |
| CATSUM | 15.73 | 15.54 | 15.59 | 15.65 | 15.66 | 15.71 | 15.74 | 15.71 | 15.53 | 15.62 | 15.60 |
| F | 0.12 | 0.14 | 0.11 | 0.15 | 0.13 | 0.14 | 0.14 | 0.11 | 0.03 | 0.02 | 0.07 |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| OHcalc | 1.88 | 1.86 | 1.89 | 1.85 | 1.87 | 1.86 | 1.86 | 1.89 | 1.96 | 1.98 | 1.92 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.45 | 0.35 | 0.38 | 0.42 | 0.42 | 0.43 | 0.44 | 0.43 | 0.38 | 0.40 | 0.39 |
| # | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT11 1 | | | | | 2 | | | | | |
|-----------------|-----------|-------|-------|-------|-------|--------|-------|-------|--------|-------|-------|
| | r | c | c | c | c | c | r | c | r | | |
| SiO2 | 46.64 | 45.39 | 44.01 | 46.46 | 47.96 | 46.77 | 47.43 | 42.95 | 44.37 | 44.02 | 46.51 |
| Al2O3 | 7.04 | 7.24 | 8.79 | 6.20 | 5.66 | 7.61 | 6.17 | 9.27 | 9.01 | 9.11 | 7.09 |
| FeO | 15.72 | 15.54 | 16.94 | 14.79 | 14.08 | 15.68 | 14.80 | 17.31 | 16.92 | 16.37 | 15.13 |
| MgO | 13.43 | 13.14 | 12.00 | 13.75 | 14.51 | 12.97 | 14.07 | 11.11 | 11.80 | 11.53 | 13.33 |
| CaO | 11.59 | 11.56 | 11.68 | 11.77 | 12.00 | 11.65 | 11.60 | 11.31 | 11.62 | 11.48 | 11.89 |
| Na2O | 1.07 | 1.11 | 1.21 | 1.06 | 0.92 | 1.20 | 1.01 | 1.32 | 1.34 | 1.36 | 1.14 |
| K2O | 0.69 | 0.60 | 0.92 | 0.44 | 0.46 | 0.60 | 0.50 | 1.00 | 0.94 | 0.94 | 0.56 |
| TiO2 | 0.98 | 1.00 | 1.18 | 0.82 | 0.77 | 1.21 | 0.57 | 1.12 | 1.11 | 1.14 | 0.87 |
| MnO | 0.85 | 0.82 | 0.83 | 0.91 | 0.76 | 0.87 | 0.81 | 0.80 | 0.82 | 0.79 | 0.79 |
| BaO | 0.06 | 0.16 | 0.11 | 0.05 | 0.11 | 0.00 | 0.11 | 0.15 | 0.16 | 0.07 | 0.06 |
| Cl | 0.05 | 0.07 | 0.08 | 0.03 | 0.02 | 0.00 | 0.01 | 0.04 | 0.05 | 0.06 | 0.03 |
| F | 0.00 | 0.07 | 0.00 | 0.03 | 0.08 | 0.00 | 0.05 | 0.01 | 0.20 | 0.19 | 0.11 |
| SUBSUM | 98.12 | 96.70 | 97.75 | 96.31 | 97.33 | 98.57 | 97.13 | 96.39 | 98.34 | 97.06 | 97.51 |
| Cl=O | 0.01 | 0.02 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| F=O | 0.00 | 0.03 | 0.00 | 0.01 | 0.03 | 0.00 | 0.02 | 0.00 | 0.08 | 0.08 | 0.05 |
| SUM | 98.11 | 96.65 | 97.73 | 96.29 | 97.29 | 98.57 | 97.11 | 96.38 | 98.24 | 96.97 | 97.46 |
| H2Ocalc | 2.01 | 1.93 | 1.97 | 1.97 | 1.98 | 2.03 | 1.99 | 1.94 | 1.89 | 1.87 | 1.95 |
| SUM | 100.12 | 98.59 | 99.70 | 98.26 | 99.27 | 100.60 | 99.09 | 98.31 | 100.13 | 98.84 | 99.41 |
| Si | 6.92 | 6.86 | 6.64 | 7.00 | 7.11 | 6.89 | 7.06 | 6.60 | 6.66 | 6.68 | 6.93 |
| Aliv | 1.08 | 1.14 | 1.36 | 1.00 | 0.89 | 1.11 | 0.94 | 1.40 | 1.34 | 1.32 | 1.07 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.15 | 0.15 | 0.21 | 0.10 | 0.10 | 0.22 | 0.15 | 0.27 | 0.26 | 0.30 | 0.18 |
| Fe+2 | 1.77 | 1.78 | 1.96 | 1.72 | 1.61 | 1.80 | 1.67 | 2.05 | 1.98 | 1.96 | 1.76 |
| Mg | 2.97 | 2.96 | 2.70 | 3.09 | 3.20 | 2.85 | 3.12 | 2.54 | 2.64 | 2.61 | 2.96 |
| Ti | 0.11 | 0.11 | 0.13 | 0.09 | 0.09 | 0.13 | 0.06 | 0.13 | 0.13 | 0.13 | 0.10 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.11 | 0.10 | 0.11 | 0.12 | 0.10 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Fe+2 | 0.18 | 0.18 | 0.18 | 0.14 | 0.13 | 0.13 | 0.18 | 0.17 | 0.15 | 0.12 | 0.13 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.71 | 1.72 | 1.72 | 1.74 | 1.77 | 1.76 | 1.72 | 1.73 | 1.75 | 1.78 | 1.78 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.31 | 0.33 | 0.35 | 0.31 | 0.26 | 0.34 | 0.29 | 0.39 | 0.39 | 0.40 | 0.33 |
| K | 0.13 | 0.12 | 0.18 | 0.08 | 0.09 | 0.11 | 0.10 | 0.20 | 0.18 | 0.18 | 0.11 |
| Ca | 0.13 | 0.16 | 0.17 | 0.16 | 0.13 | 0.08 | 0.13 | 0.13 | 0.12 | 0.08 | 0.12 |
| A | 0.57 | 0.60 | 0.70 | 0.55 | 0.48 | 0.54 | 0.52 | 0.72 | 0.69 | 0.67 | 0.56 |
| CATSUM | 15.57 | 15.60 | 15.70 | 15.55 | 15.48 | 15.54 | 15.52 | 15.72 | 15.69 | 15.67 | 15.56 |
| F | 0.00 | 0.03 | 0.00 | 0.01 | 0.04 | 0.00 | 0.02 | 0.00 | 0.09 | 0.09 | 0.05 |
| Cl | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 |
| OHcalc | 1.99 | 1.95 | 1.98 | 1.98 | 1.96 | 2.00 | 1.97 | 1.98 | 1.89 | 1.89 | 1.94 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.40 | 0.40 | 0.44 | 0.38 | 0.35 | 0.40 | 0.37 | 0.47 | 0.45 | 0.44 | 0.39 |
| # | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT11 | | | | | | 3 | | | | | |
|-----------------|-------|-------|-------|-------|-------|-------|-------|--------|-------|-------|--------|---|
| | C | F | C | F | C | F | C | F | C | F | C | F |
| SiO2 | 47.80 | 47.21 | 47.19 | 42.31 | 47.15 | 46.63 | 43.86 | 46.08 | 43.61 | 45.27 | 46.78 | |
| Al2O3 | 5.74 | 6.60 | 6.33 | 9.74 | 6.79 | 7.05 | 9.07 | 8.02 | 9.21 | 8.44 | 7.07 | |
| FeO | 14.69 | 15.15 | 14.90 | 17.65 | 15.12 | 15.10 | 16.63 | 15.77 | 16.97 | 16.10 | 15.57 | |
| MgO | 14.09 | 13.48 | 14.07 | 10.95 | 13.54 | 13.36 | 11.63 | 12.59 | 11.73 | 12.16 | 13.66 | |
| CaO | 11.63 | 11.61 | 11.38 | 11.62 | 11.53 | 11.58 | 11.69 | 11.86 | 11.79 | 11.43 | 12.08 | |
| Na2O | 0.96 | 1.10 | 1.11 | 1.47 | 1.05 | 1.01 | 1.24 | 1.25 | 1.24 | 1.38 | 0.84 | |
| K2O | 0.49 | 0.54 | 0.54 | 1.04 | 0.65 | 0.66 | 0.90 | 0.67 | 0.92 | 0.59 | 0.45 | |
| TiO2 | 0.99 | 0.77 | 0.71 | 1.23 | 0.78 | 0.81 | 1.03 | 1.08 | 1.02 | 1.06 | 0.72 | |
| MnO | 0.02 | 0.91 | 0.81 | 0.77 | 0.79 | 0.77 | 0.78 | 0.75 | 0.80 | 0.82 | 0.83 | |
| BaO | 0.12 | 0.14 | 0.06 | 0.05 | 0.10 | 0.17 | 0.13 | 0.17 | 0.09 | 0.13 | 0.12 | |
| Cl | 0.01 | 0.04 | 0.04 | 0.08 | 0.03 | 0.03 | 0.11 | 0.05 | 0.06 | 0.03 | 0.03 | |
| F | 0.00 | 0.02 | 0.14 | 0.05 | 0.00 | 0.09 | 0.16 | 0.11 | 0.15 | 0.00 | 0.01 | |
| SUBSUM | 97.34 | 97.57 | 97.28 | 96.96 | 97.53 | 97.26 | 97.23 | 98.40 | 97.59 | 97.41 | 98.16 | |
| Cl=O | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | |
| F=O | 0.00 | 0.01 | 0.06 | 0.02 | 0.00 | 0.04 | 0.07 | 0.05 | 0.06 | 0.00 | 0.00 | |
| SUM | 97.34 | 97.55 | 97.21 | 96.92 | 97.52 | 97.22 | 97.14 | 98.34 | 97.51 | 97.40 | 98.15 | |
| H2Ocalc | 2.02 | 2.00 | 1.94 | 1.91 | 2.01 | 1.96 | 1.87 | 1.96 | 1.89 | 1.99 | 2.01 | |
| SUM | 99.36 | 99.55 | 99.15 | 98.83 | 99.53 | 99.17 | 99.01 | 100.30 | 99.41 | 99.39 | 100.16 | |
| Si | 7.09 | 7.02 | 7.03 | 6.49 | 7.01 | 6.96 | 6.66 | 6.84 | 6.61 | 6.79 | 6.93 | |
| Aliv | 0.91 | 0.98 | 0.97 | 1.51 | 0.99 | 1.04 | 1.34 | 1.16 | 1.39 | 1.21 | 1.07 | |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Alvi | 0.10 | 0.18 | 0.14 | 0.25 | 0.19 | 0.20 | 0.28 | 0.24 | 0.25 | 0.28 | 0.16 | |
| Fe+2 | 1.67 | 1.75 | 1.66 | 2.11 | 1.72 | 1.73 | 1.97 | 1.85 | 1.99 | 1.88 | 1.74 | |
| Mg | 3.12 | 2.99 | 3.12 | 2.50 | 3.00 | 2.97 | 2.63 | 2.78 | 2.65 | 2.72 | 3.01 | |
| Ti | 0.11 | 0.09 | 0.08 | 0.14 | 0.09 | 0.09 | 0.12 | 0.12 | 0.12 | 0.12 | 0.08 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.10 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.10 | 0.10 | 0.10 | |
| Fe+2 | 0.15 | 0.13 | 0.20 | 0.16 | 0.16 | 0.16 | 0.14 | 0.11 | 0.16 | 0.14 | 0.18 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.75 | 1.75 | 1.70 | 1.74 | 1.74 | 1.75 | 1.76 | 1.80 | 1.73 | 1.76 | 1.71 | |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.28 | 0.32 | 0.32 | 0.44 | 0.30 | 0.29 | 0.36 | 0.36 | 0.36 | 0.40 | 0.24 | |
| K | 0.09 | 0.10 | 0.10 | 0.20 | 0.12 | 0.13 | 0.17 | 0.13 | 0.18 | 0.11 | 0.09 | |
| Ca | 0.10 | 0.10 | 0.12 | 0.17 | 0.09 | 0.11 | 0.14 | 0.09 | 0.18 | 0.08 | 0.21 | |
| A | 0.47 | 0.52 | 0.54 | 0.81 | 0.52 | 0.52 | 0.68 | 0.57 | 0.72 | 0.59 | 0.53 | |
| CATSUM | 15.47 | 15.52 | 15.54 | 15.81 | 15.52 | 15.52 | 15.68 | 15.57 | 15.72 | 15.59 | 15.53 | |
| F | 0.00 | 0.01 | 0.07 | 0.02 | 0.00 | 0.04 | 0.08 | 0.05 | 0.07 | 0.00 | 0.00 | |
| Cl | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.03 | 0.01 | 0.02 | 0.01 | 0.01 | |
| OHcalc | 2.00 | 1.98 | 1.92 | 1.95 | 1.99 | 1.95 | 1.89 | 1.94 | 1.91 | 1.99 | 1.99 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.37 | 0.39 | 0.37 | 0.47 | 0.39 | 0.39 | 0.45 | 0.41 | 0.45 | 0.43 | 0.39 | |
| # | 236 | 237 | 238 | 239 | 240 | 241 | 242 | 243 | 244 | 245 | 246 | |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT11 3 | MT12 CHEM | 1 | 2 | 3 | 4 | 5 | 6 | | | |
|-----------------|-----------|--------------|-------|--------|-------|-------|-------|--------|--------|--------|-------|
| | r | | | | | r | c | | | c | |
| SiO2 | 45.76 | 47.56 | 47.12 | 47.42 | 47.94 | 45.78 | 46.61 | 46.66 | 48.73 | 46.91 | 49.10 |
| Al2O3 | 7.94 | 7.21 | 7.60 | 7.29 | 6.69 | 7.43 | 8.05 | 8.03 | 7.30 | 8.13 | 6.28 |
| FeO | 16.29 | 13.78 | 13.48 | 14.88 | 14.63 | 14.88 | 15.02 | 14.34 | 14.03 | 15.07 | 13.91 |
| MgO | 12.60 | 13.39 | 13.58 | 13.44 | 13.38 | 12.42 | 12.63 | 13.16 | 13.46 | 12.91 | 13.24 |
| CaO | 11.99 | 11.88 | 12.15 | 11.98 | 11.77 | 12.09 | 11.93 | 12.25 | 12.23 | 12.30 | 12.13 |
| Na2O | 1.09 | 0.97 | 1.32 | 1.29 | 0.75 | 1.18 | 1.09 | 1.23 | 1.16 | 1.25 | 0.91 |
| K2O | 0.69 | 0.61 | 0.50 | 0.60 | 0.55 | 0.52 | 0.45 | 0.45 | 0.53 | 0.68 | 0.55 |
| TiO2 | 0.97 | 1.07 | 0.93 | 0.92 | 0.94 | 1.23 | 1.14 | 1.16 | 1.09 | 1.22 | 0.83 |
| MnO | 0.79 | 0.75 | 0.74 | 0.72 | 0.72 | 0.90 | 0.89 | 0.78 | 0.75 | 0.73 | 0.91 |
| BaO | 0.08 | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.08 | n | 0.13 | 0.09 | 0.00 | 0.09 | 0.03 | 0.11 | 0.11 | 0.09 | n |
| F | 0.13 | n | 0.24 | 0.15 | 0.32 | 0.25 | 0.30 | n | 0.40 | 0.27 | 0.33 |
| SUBSUM | 98.41 | 97.39 | 97.79 | 98.88 | 97.69 | 96.77 | 98.14 | 98.17 | 99.79 | 99.56 | 98.19 |
| Cl=O | 0.02 | 0.00 | 0.03 | 0.02 | 0.00 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.00 |
| F=O | 0.05 | 0.00 | 0.10 | 0.06 | 0.13 | 0.11 | 0.13 | 0.00 | 0.17 | 0.11 | 0.14 |
| SUM | 98.34 | 97.39 | 97.66 | 98.80 | 97.56 | 96.64 | 98.01 | 98.15 | 99.60 | 99.43 | 98.05 |
| H2Ocalc | 1.93 | 2.03 | 1.88 | 1.95 | 1.88 | 1.85 | 1.88 | 2.01 | 1.86 | 1.90 | 1.89 |
| SUM | 100.27 | 99.42 | 99.54 | 100.75 | 99.43 | 98.49 | 99.88 | 100.15 | 101.45 | 101.33 | 99.94 |
| Si | 6.81 | 7.01 | 6.95 | 6.96 | 7.09 | 6.90 | 6.90 | 6.87 | 7.05 | 6.86 | 7.20 |
| Aliv | 1.19 | 0.99 | 1.05 | 1.04 | 0.91 | 1.10 | 1.10 | 1.13 | 0.95 | 1.14 | 0.80 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.21 | 0.26 | 0.28 | 0.22 | 0.25 | 0.22 | 0.30 | 0.27 | 0.29 | 0.26 | 0.28 |
| Fe+2 | 1.89 | 1.67 | 1.63 | 1.74 | 1.70 | 1.86 | 1.79 | 1.71 | 1.69 | 1.79 | 1.71 |
| Mg | 2.80 | 2.94 | 2.99 | 2.94 | 2.95 | 2.79 | 2.79 | 2.89 | 2.90 | 2.81 | 2.89 |
| Ti | 0.11 | 0.12 | 0.10 | 0.10 | 0.10 | 0.14 | 0.13 | 0.13 | 0.12 | 0.13 | 0.09 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 | 0.11 | 0.11 | 0.10 | 0.09 | 0.09 | 0.08 |
| Fe+2 | 0.14 | 0.02 | 0.03 | 0.08 | 0.11 | 0.02 | 0.07 | 0.05 | 0.01 | 0.05 | 0.00 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.76 | 1.88 | 1.88 | 1.83 | 1.80 | 1.87 | 1.82 | 1.85 | 1.90 | 1.86 | 1.91 |
| Na | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.31 | 0.27 | 0.38 | 0.37 | 0.21 | 0.34 | 0.31 | 0.35 | 0.32 | 0.35 | 0.25 |
| K | 0.13 | 0.11 | 0.09 | 0.11 | 0.10 | 0.10 | 0.08 | 0.08 | 0.10 | 0.13 | 0.10 |
| Ca | 0.15 | 0.00 | 0.05 | 0.05 | 0.07 | 0.08 | 0.08 | 0.08 | 0.00 | 0.07 | 0.00 |
| A | 0.60 | 0.39 | 0.52 | 0.53 | 0.39 | 0.53 | 0.47 | 0.52 | 0.42 | 0.55 | 0.35 |
| CATSUM | 15.60 | 15.39 | 15.52 | 15.53 | 15.39 | 15.53 | 15.47 | 15.52 | 15.42 | 15.55 | 15.35 |
| F | 0.06 | 0.00 | 0.11 | 0.07 | 0.15 | 0.12 | 0.14 | 0.00 | 0.18 | 0.12 | 0.15 |
| Cl | 0.02 | 0.00 | 0.03 | 0.02 | 0.00 | 0.02 | 0.01 | 0.03 | 0.03 | 0.02 | 0.00 |
| OHcalc | 1.92 | 2.00 | 1.86 | 1.91 | 1.85 | 1.86 | 1.85 | 1.97 | 1.79 | 1.85 | 1.85 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.42 | 0.37 | 0.36 | 0.38 | 0.38 | 0.40 | 0.40 | 0.38 | 0.37 | 0.40 | 0.37 |
| # | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 | 257 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE | MT12 | | | MT13 | | | | MT14 | | | |
|--------------------------------|--------|-------|--------|-------|--------|--------|--------|--------|-------|--------|--------|
| GRAIN | 6 | 7 | | 1 | 2 | 3 | 4 | 1 | 2 | | |
| | r | | | s | c | r | | c | | | |
| SiO ₂ | 46.41 | 47.70 | 50.30 | 46.27 | 47.60 | 46.73 | 47.62 | 47.28 | 47.16 | 47.25 | 47.10 |
| Al ₂ O ₃ | 7.63 | 6.66 | 5.60 | 7.05 | 6.88 | 8.14 | 6.98 | 7.66 | 7.43 | 7.47 | 7.89 |
| FeO | 15.01 | 14.27 | 13.54 | 15.27 | 15.42 | 15.56 | 15.20 | 15.38 | 15.95 | 15.87 | 16.03 |
| MgO | 13.21 | 12.87 | 14.05 | 12.88 | 12.69 | 12.59 | 13.05 | 12.56 | 12.23 | 12.35 | 12.56 |
| CaO | 12.29 | 12.15 | 12.43 | 11.71 | 11.81 | 11.57 | 11.61 | 11.51 | 11.90 | 12.17 | 11.93 |
| Na ₂ O | 1.14 | 1.10 | 0.80 | 1.08 | 1.07 | 1.26 | 1.13 | 1.33 | 0.92 | 1.16 | 1.40 |
| K ₂ O | 0.64 | 0.43 | 0.43 | 0.72 | 0.62 | 0.73 | 0.80 | 0.87 | 0.66 | 0.50 | 0.59 |
| TiO ₂ | 0.90 | 0.97 | 0.56 | 0.85 | 0.69 | 1.32 | 0.90 | 1.35 | 0.66 | 1.14 | 1.14 |
| MnO | 0.83 | 0.85 | 0.92 | 0.94 | 1.12 | 0.71 | 0.75 | 0.79 | 0.65 | 0.90 | 0.90 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.18 | 0.03 | 0.03 | n | n | n | n | n | n | 0.13 | 0.06 |
| F | 1.37 | 0.17 | 0.30 | n | n | n | n | n | 0.01 | 0.17 | 0.02 |
| SUBSUM | 99.61 | 97.20 | 98.96 | 96.77 | 98.10 | 98.61 | 98.24 | 98.73 | 97.88 | 99.27 | 99.70 |
| Cl=O | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 |
| F=O | 0.58 | 0.07 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.01 |
| SUM | 98.99 | 97.12 | 98.83 | 96.77 | 98.10 | 98.61 | 98.24 | 98.73 | 97.88 | 99.17 | 99.68 |
| H ₂ Ocalc | 1.33 | 1.93 | 1.92 | 2.00 | 2.03 | 2.04 | 2.04 | 2.04 | 2.02 | 1.93 | 2.03 |
| SUM | 100.32 | 99.05 | 100.75 | 98.77 | 100.13 | 100.65 | 100.28 | 100.77 | 99.89 | 101.10 | 101.70 |
| Si | 6.87 | 7.09 | 7.29 | 6.95 | 7.06 | 6.88 | 7.04 | 6.95 | 7.00 | 6.94 | 6.88 |
| Aliv | 1.13 | 0.91 | 0.71 | 1.05 | 0.94 | 1.12 | 0.96 | 1.05 | 1.00 | 1.06 | 1.12 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.21 | 0.25 | 0.24 | 0.20 | 0.26 | 0.29 | 0.25 | 0.27 | 0.30 | 0.24 | 0.24 |
| Fe+2 | 1.78 | 1.77 | 1.64 | 1.82 | 1.87 | 1.80 | 1.78 | 1.83 | 1.92 | 1.93 | 1.90 |
| Mg | 2.92 | 2.85 | 3.03 | 2.88 | 2.79 | 2.76 | 2.86 | 2.75 | 2.70 | 2.70 | 2.74 |
| Ti | 0.10 | 0.11 | 0.06 | 0.10 | 0.08 | 0.15 | 0.10 | 0.15 | 0.07 | 0.13 | 0.13 |
| Mn | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.10 | 0.09 | 0.09 | 0.12 | 0.14 | 0.09 | 0.09 | 0.10 | 0.08 | 0.11 | 0.11 |
| Fe+2 | 0.08 | 0.00 | 0.00 | 0.10 | 0.04 | 0.11 | 0.09 | 0.06 | 0.06 | 0.02 | 0.06 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.81 | 1.91 | 1.91 | 1.78 | 1.82 | 1.80 | 1.82 | 1.81 | 1.86 | 1.87 | 1.82 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.33 | 0.32 | 0.22 | 0.31 | 0.31 | 0.36 | 0.32 | 0.35 | 0.26 | 0.33 | 0.40 |
| K | 0.12 | 0.08 | 0.08 | 0.14 | 0.12 | 0.14 | 0.15 | 0.16 | 0.12 | 0.09 | 0.11 |
| Ca | 0.14 | 0.02 | 0.02 | 0.10 | 0.05 | 0.02 | 0.02 | 0.00 | 0.03 | 0.04 | 0.04 |
| A | 0.58 | 0.42 | 0.33 | 0.55 | 0.47 | 0.52 | 0.49 | 0.51 | 0.42 | 0.47 | 0.55 |
| CATSUM | 15.58 | 15.42 | 15.33 | 15.55 | 15.47 | 15.52 | 15.49 | 15.51 | 15.42 | 15.47 | 15.55 |
| F | 0.64 | 0.08 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.01 |
| Cl | 0.05 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 |
| ORcalc | 1.31 | 1.91 | 1.86 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.89 | 1.98 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.39 | 0.38 | 0.35 | 0.40 | 0.41 | 0.41 | 0.40 | 0.41 | 0.42 | 0.42 | 0.42 |
| # | 258 | 259 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE | MT14 | MT15 | | | | | | | MT16 | | |
|--------------------------------|-------|--------|--------|-------|--------|-------|--------|--------|-------|--------|-------|
| GRAIN | 3 | 1 | 2 | 3 | | 4 | | | 1 | | |
| | | | | c | r | r | r | | c | | r |
| SiO ₂ | 44.58 | 45.37 | 45.28 | 44.38 | 46.55 | 44.47 | 46.52 | 46.01 | 46.74 | 45.54 | 45.64 |
| Al ₂ O ₃ | 8.77 | 8.19 | 8.16 | 8.02 | 7.95 | 8.10 | 7.75 | 7.74 | 6.90 | 8.39 | 7.74 |
| FeO | 17.05 | 16.73 | 17.09 | 16.23 | 16.48 | 16.18 | 16.01 | 16.25 | 14.35 | 15.22 | 14.99 |
| MgO | 11.07 | 11.31 | 12.01 | 11.61 | 11.93 | 12.45 | 12.41 | 12.66 | 13.72 | 13.33 | 13.05 |
| CaO | 12.05 | 12.17 | 11.95 | 11.47 | 11.66 | 11.76 | 11.49 | 11.86 | 12.12 | 11.40 | 11.94 |
| Na ₂ O | 0.81 | 1.30 | 1.22 | 1.30 | 1.18 | 1.38 | 1.26 | 1.29 | 0.82 | 1.27 | 1.05 |
| K ₂ O | 0.83 | 1.05 | 0.96 | 0.85 | 0.77 | 0.84 | 0.77 | 0.76 | 0.51 | 0.67 | 0.62 |
| TiO ₂ | 1.19 | 1.28 | 1.29 | 1.36 | 1.12 | 1.34 | 0.96 | 0.94 | 0.81 | 1.28 | 1.09 |
| MnO | 1.02 | 0.84 | 0.77 | 0.98 | 0.99 | 1.12 | 0.88 | 1.00 | 0.59 | 0.65 | 0.66 |
| BaO | n | n | n | n | n | n | n | n | 0.06 | 0.22 | 0.15 |
| Cl | 0.17 | n | n | n | n | n | n | n | 0.01 | 0.09 | 0.03 |
| F | 0.32 | n | n | n | n | n | n | n | 0.02 | 0.06 | 0.05 |
| SUBSUM | 97.86 | 98.24 | 98.65 | 96.20 | 98.63 | 97.64 | 98.05 | 98.51 | 96.65 | 98.12 | 97.00 |
| Cl=O | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 |
| F=O | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.02 |
| SUM | 97.69 | 98.24 | 98.65 | 96.20 | 98.63 | 97.64 | 98.05 | 98.51 | 96.64 | 98.07 | 96.97 |
| H ₂ Ocalc | 1.79 | 2.00 | 2.01 | 1.97 | 2.03 | 1.99 | 2.02 | 2.02 | 2.00 | 1.97 | 1.97 |
| SUM | 99.48 | 100.24 | 100.66 | 98.17 | 100.66 | 99.63 | 100.07 | 100.53 | 98.63 | 100.04 | 98.94 |
| Si | 6.73 | 6.79 | 6.74 | 6.77 | 6.89 | 6.69 | 6.91 | 6.83 | 6.98 | 6.76 | 6.84 |
| Aliv | 1.27 | 1.21 | 1.26 | 1.23 | 1.11 | 1.31 | 1.09 | 1.17 | 1.02 | 1.24 | 1.16 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.29 | 0.24 | 0.18 | 0.21 | 0.28 | 0.13 | 0.27 | 0.19 | 0.20 | 0.23 | 0.21 |
| Fe+2 | 2.00 | 2.09 | 2.01 | 1.99 | 1.97 | 1.92 | 1.88 | 1.90 | 1.66 | 1.68 | 1.75 |
| Mg | 2.49 | 2.52 | 2.67 | 2.64 | 2.63 | 2.79 | 2.75 | 2.80 | 3.05 | 2.95 | 2.92 |
| Ti | 0.14 | 0.14 | 0.14 | 0.16 | 0.12 | 0.15 | 0.11 | 0.10 | 0.09 | 0.14 | 0.12 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.13 | 0.10 | 0.10 | 0.13 | 0.12 | 0.14 | 0.11 | 0.13 | 0.07 | 0.08 | 0.08 |
| Fe+2 | 0.07 | 0.00 | 0.12 | 0.08 | 0.08 | 0.11 | 0.11 | 0.11 | 0.13 | 0.21 | 0.13 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.80 | 1.90 | 1.78 | 1.80 | 1.80 | 1.74 | 1.78 | 1.76 | 1.79 | 1.71 | 1.79 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.24 | 0.38 | 0.35 | 0.38 | 0.34 | 0.40 | 0.36 | 0.37 | 0.24 | 0.37 | 0.31 |
| K | 0.16 | 0.20 | 0.18 | 0.17 | 0.15 | 0.16 | 0.15 | 0.14 | 0.10 | 0.13 | 0.12 |
| Ca | 0.15 | 0.05 | 0.13 | 0.08 | 0.05 | 0.15 | 0.05 | 0.13 | 0.15 | 0.10 | 0.13 |
| A | 0.55 | 0.63 | 0.66 | 0.63 | 0.53 | 0.72 | 0.56 | 0.64 | 0.48 | 0.60 | 0.55 |
| CATSUM | 15.55 | 15.63 | 15.66 | 15.63 | 15.53 | 15.72 | 15.56 | 15.64 | 15.48 | 15.60 | 15.55 |
| F | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.02 |
| Cl | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 |
| OHcalc | 1.80 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.99 | 1.95 | 1.97 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.46 | 0.45 | 0.44 | 0.44 | 0.44 | 0.42 | 0.42 | 0.42 | 0.37 | 0.39 | 0.39 |
| # | 269 | 270 | 271 | 272 | 273 | 274 | 275 | 276 | 277 | 278 | 279 |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE | MT16 | | | | MT17 | | | | MT18 | | | |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
| GRAIN | 2 | | 3 | | 1 | | 2 | | 1 | | 2 | |
| | c | r | | | c | | | | c | r | | |
| SiO ₂ | 47.39 | 43.89 | 48.00 | 45.74 | 44.60 | 46.56 | 46.32 | 43.71 | 45.10 | 45.51 | 44.70 | |
| Al ₂ O ₃ | 7.28 | 9.65 | 6.07 | 7.99 | 9.14 | 7.91 | 7.66 | 9.52 | 8.07 | 8.10 | 8.43 | |
| FeO | 13.73 | 15.32 | 14.15 | 15.16 | 17.59 | 16.83 | 16.76 | 17.73 | 16.59 | 16.26 | 16.25 | |
| MgO | 14.19 | 12.66 | 14.32 | 12.95 | 10.62 | 11.52 | 11.75 | 9.88 | 10.96 | 10.79 | 11.36 | |
| CaO | 11.52 | 11.48 | 11.90 | 11.77 | 11.89 | 11.98 | 11.89 | 12.29 | 12.13 | 12.34 | 12.56 | |
| Na ₂ O | 1.23 | 1.50 | 0.81 | 1.16 | 0.41 | 0.45 | 0.33 | 1.08 | 1.35 | 1.22 | 1.20 | |
| K ₂ O | 0.46 | 0.83 | 0.39 | 0.59 | 0.74 | 0.56 | 0.78 | 0.93 | 0.73 | 1.04 | 0.81 | |
| TiO ₂ | 1.07 | 1.52 | 0.50 | 1.28 | 1.06 | 0.79 | 1.02 | 0.53 | 1.26 | 1.18 | 1.13 | |
| MnO | 0.60 | 0.56 | 0.62 | 0.68 | 0.76 | 0.68 | 0.92 | 0.83 | 0.76 | 0.68 | 0.87 | |
| BaO | 0.10 | 0.11 | 0.15 | 0.14 | n | n | n | n | n | n | n | |
| Cl | 0.08 | 0.12 | 0.02 | 0.13 | 0.14 | 0.05 | 0.00 | n | n | n | n | |
| F | 0.01 | 0.08 | 0.00 | 0.02 | 0.28 | 0.27 | 0.38 | n | n | n | n | |
| SUBSUM | 97.66 | 97.72 | 96.93 | 97.61 | 97.23 | 97.60 | 97.81 | 96.50 | 96.95 | 97.12 | 97.31 | |
| Cl=O | 0.02 | 0.03 | 0.00 | 0.03 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| F=O | 0.00 | 0.03 | 0.00 | 0.01 | 0.12 | 0.11 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | |
| SUM | 97.64 | 97.66 | 96.93 | 97.57 | 97.08 | 97.48 | 97.65 | 96.50 | 96.95 | 97.12 | 97.31 | |
| H ₂ Ocalc | 2.01 | 1.93 | 2.02 | 1.97 | 1.81 | 1.86 | 1.82 | 1.96 | 1.98 | 1.99 | 1.99 | |
| SUM | 99.65 | 99.59 | 98.94 | 99.54 | 98.89 | 99.34 | 99.47 | 98.46 | 98.93 | 99.11 | 99.30 | |
| Si | 6.97 | 6.57 | 7.12 | 6.82 | 6.76 | 6.97 | 6.94 | 6.70 | 6.82 | 6.87 | 6.75 | |
| Aliv | 1.03 | 1.43 | 0.88 | 1.18 | 1.24 | 1.03 | 1.06 | 1.30 | 1.18 | 1.13 | 1.25 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.24 | 0.27 | 0.18 | 0.22 | 0.39 | 0.36 | 0.29 | 0.42 | 0.26 | 0.31 | 0.25 | |
| Fe+2 | 1.53 | 1.73 | 1.60 | 1.75 | 2.09 | 1.98 | 1.97 | 2.27 | 2.10 | 2.05 | 2.05 | |
| Mg | 3.11 | 2.82 | 3.17 | 2.88 | 2.40 | 2.57 | 2.62 | 2.26 | 2.47 | 2.43 | 2.56 | |
| Ti | 0.12 | 0.17 | 0.06 | 0.14 | 0.12 | 0.09 | 0.11 | 0.06 | 0.14 | 0.13 | 0.13 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.07 | 0.07 | 0.08 | 0.09 | 0.10 | 0.09 | 0.12 | 0.11 | 0.08 | 0.01 | 0.09 | |
| Fe+2 | 0.16 | 0.19 | 0.16 | 0.14 | 0.14 | 0.12 | 0.13 | 0.01 | 0.00 | 0.00 | 0.00 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.77 | 1.74 | 1.76 | 1.78 | 1.76 | 1.79 | 1.76 | 1.89 | 1.92 | 1.99 | 1.91 | |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.35 | 0.44 | 0.23 | 0.34 | 0.12 | 0.13 | 0.10 | 0.32 | 0.40 | 0.36 | 0.35 | |
| K | 0.09 | 0.16 | 0.07 | 0.11 | 0.14 | 0.11 | 0.15 | 0.18 | 0.14 | 0.20 | 0.16 | |
| Ca | 0.05 | 0.10 | 0.13 | 0.10 | 0.17 | 0.13 | 0.15 | 0.13 | 0.04 | 0.00 | 0.12 | |
| A | 0.49 | 0.70 | 0.44 | 0.55 | 0.43 | 0.37 | 0.39 | 0.63 | 0.58 | 0.56 | 0.63 | |
| CATSUM | 15.49 | 15.70 | 15.44 | 15.55 | 15.43 | 15.37 | 15.39 | 15.63 | 15.58 | 15.56 | 15.63 | |
| F | 0.00 | 0.04 | 0.00 | 0.01 | 0.13 | 0.13 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Cl | 0.02 | 0.03 | 0.01 | 0.03 | 0.04 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| OHcalc | 1.98 | 1.93 | 1.99 | 1.96 | 1.83 | 1.86 | 1.82 | 2.00 | 2.00 | 2.00 | 2.00 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.35 | 0.40 | 0.36 | 0.40 | 0.48 | 0.45 | 0.44 | 0.50 | 0.46 | 0.46 | 0.45 | |
| # | 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | |

Table 2. Hornblendes from the Pioneer Batholith, Montana.

| SAMPLE GRAIN | MT18 | | | MT19 | | | | | | |
|-----------------|-------|-------|-------|-------|-------|--------|-------|--------|--------|-------|
| | 4 | | | 1 | 2 | | 3 | | 4 | |
| | c | r | r | | | | c | c | r | |
| SiO2 | 43.04 | 44.67 | 46.03 | 46.70 | 47.30 | 46.60 | 46.51 | 47.31 | 47.25 | 46.85 |
| Al2O3 | 10.23 | 8.74 | 7.07 | 7.64 | 7.66 | 7.85 | 7.74 | 8.16 | 8.23 | 8.33 |
| FeO | 17.77 | 15.87 | 15.16 | 15.36 | 15.05 | 15.73 | 15.10 | 14.75 | 15.85 | 16.40 |
| MgO | 9.47 | 11.18 | 12.05 | 11.95 | 12.19 | 11.95 | 11.57 | 12.10 | 11.96 | 11.06 |
| CaO | 12.32 | 12.26 | 12.30 | 11.98 | 11.80 | 12.02 | 11.95 | 12.01 | 11.60 | 11.78 |
| Na2O | 1.45 | 1.48 | 1.29 | 1.13 | 1.13 | 1.23 | 1.21 | 1.29 | 1.28 | 1.16 |
| K2O | 1.01 | 0.80 | 0.74 | 0.93 | 0.84 | 1.03 | 0.89 | 0.95 | 0.96 | 0.84 |
| TiO2 | 1.29 | 1.34 | 1.10 | 1.06 | 1.03 | 0.93 | 1.28 | 1.05 | 1.08 | 0.77 |
| MnO | 0.66 | 0.75 | 0.69 | 0.94 | 0.54 | 0.75 | 0.83 | 0.87 | 1.01 | 0.68 |
| BaO | n | n | n | n | n | n | n | n | n | n |
| Cl | n | n | n | n | n | n | n | n | n | n |
| F | n | n | n | 0.22 | 0.22 | 0.25 | 0.16 | 0.11 | 0.19 | 0.18 |
| SUBSUM | 97.24 | 97.09 | 96.43 | 97.91 | 97.76 | 98.34 | 97.24 | 98.60 | 99.41 | 98.05 |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F=O | 0.00 | 0.00 | 0.00 | 0.09 | 0.09 | 0.11 | 0.07 | 0.05 | 0.08 | 0.08 |
| SUM | 97.24 | 97.09 | 96.43 | 97.82 | 97.67 | 98.23 | 97.17 | 98.55 | 99.33 | 97.97 |
| H2Ocalc | 1.97 | 1.99 | 1.99 | 1.91 | 1.92 | 1.90 | 1.93 | 1.99 | 1.96 | 1.93 |
| SUM | 99.21 | 99.08 | 98.42 | 99.73 | 99.59 | 100.13 | 99.10 | 100.54 | 101.29 | 99.90 |
| Si | 6.56 | 6.74 | 6.95 | 6.95 | 7.01 | 6.92 | 6.96 | 6.95 | 6.93 | 6.97 |
| Aliv | 1.44 | 1.26 | 1.05 | 1.05 | 0.99 | 1.08 | 1.04 | 1.05 | 1.07 | 1.03 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.40 | 0.29 | 0.21 | 0.29 | 0.35 | 0.30 | 0.32 | 0.37 | 0.35 | 0.43 |
| Fe+2 | 2.27 | 2.00 | 1.91 | 1.91 | 1.84 | 1.95 | 1.89 | 1.81 | 1.92 | 2.03 |
| Mg | 2.15 | 2.51 | 2.71 | 2.65 | 2.69 | 2.65 | 2.58 | 2.65 | 2.61 | 2.45 |
| Ti | 0.15 | 0.15 | 0.12 | 0.12 | 0.11 | 0.10 | 0.14 | 0.12 | 0.12 | 0.09 |
| Mn | 0.04 | 0.04 | 0.04 | 0.02 | 0.00 | 0.00 | 0.06 | 0.05 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.05 | 0.06 | 0.05 | 0.10 | 0.07 | 0.09 | 0.04 | 0.06 | 0.13 | 0.09 |
| Fe+2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.95 | 1.94 | 1.95 | 1.90 | 1.87 | 1.90 | 1.92 | 1.89 | 1.82 | 1.88 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.04 | 0.05 | 0.03 | 0.03 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.43 | 0.43 | 0.38 | 0.33 | 0.29 | 0.35 | 0.31 | 0.32 | 0.34 | 0.30 |
| K | 0.20 | 0.15 | 0.14 | 0.18 | 0.16 | 0.20 | 0.17 | 0.18 | 0.18 | 0.16 |
| Ca | 0.06 | 0.04 | 0.04 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.69 | 0.63 | 0.56 | 0.51 | 0.45 | 0.56 | 0.48 | 0.50 | 0.51 | 0.46 |
| CATSUM | 15.69 | 15.63 | 15.56 | 15.51 | 15.45 | 15.56 | 15.48 | 15.50 | 15.51 | 15.46 |
| F | 0.00 | 0.00 | 0.00 | 0.10 | 0.10 | 0.12 | 0.08 | 0.05 | 0.09 | 0.08 |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OHcalc | 2.00 | 2.00 | 2.00 | 1.90 | 1.90 | 1.88 | 1.92 | 1.95 | 1.91 | 1.92 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.51 | 0.44 | 0.41 | 0.42 | 0.41 | 0.42 | 0.42 | 0.41 | 0.43 | 0.45 |
| # | 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 |

KEY TO TABLE 3

| ANALYSIS # | SAMPLE CODE | SAMPLE # | ROCK DESCRIPTION |
|------------|-------------|-----------|---|
| 301-335 | AK1 | AK-1 | Moth Bay granodiorite pluton Ketchikan quad |
| 336-346 | AK2 | EZ82-10-7 | " |
| 347-369 | AK3 | EZ82-10-8 | " |
| 370 | AK4 | AK-30 | Bushy Point granodiorite pluton (garnet-bearing) |
| 371-381 | AK5 | EZ82-7-5 | " collected at AK-30 locality |
| 382-383 | AK6 | AK-31 | granite at Behm Canal |
| 384-385 | AK7 | AK-32 | " |
| 386-389 | AK8 | EZ82-5-5 | garnet-plagioclase-hornblende tonalite |

These rocks are from primary, magmatic epidote-bearing plutons which crop out near Moth Bay, east of Ketchikan, Alaska. The area was mapped by Berg and others (1978). Several samples were supplied by Joe Arth (AK-1, AK-30, AK-31, AK-32); others were collected by E-an Zen. Aspects of the mineralogy of these rocks are described in Zen and Hammarstrom (in press); the Bushy Point pluton is described in Zen and Hammarstrom (1983).

Table 3. Hornblendes from SE Alaskan plutons.

| SAMPLE GRAIN | AK1 1 | 2 | 3 | | | 4 | 5 | 6 | 7 | 8 r | |
|-----------------|----------|-------|--------|-------|--------|--------|--------|-------|--------|--------|--------|
| SiO2 | 43.24 | 43.12 | 38.74 | 38.95 | 41.48 | 42.14 | 42.07 | 41.52 | 42.50 | 41.58 | 41.88 |
| Al2O3 | 11.22 | 10.16 | 14.47 | 13.71 | 11.88 | 11.48 | 12.64 | 12.04 | 12.23 | 12.08 | 12.41 |
| FeO | 17.81 | 18.46 | 23.15 | 23.58 | 21.65 | 20.97 | 20.57 | 20.83 | 19.47 | 20.04 | 19.43 |
| MgO | 9.20 | 9.00 | 4.83 | 5.13 | 6.88 | 7.21 | 7.40 | 7.03 | 7.95 | 7.67 | 8.54 |
| CaO | 11.57 | 11.64 | 11.17 | 11.42 | 11.44 | 11.10 | 11.19 | 10.89 | 11.61 | 11.54 | 10.69 |
| Na2O | 1.94 | 1.94 | 1.89 | 1.90 | 2.02 | 2.12 | 1.96 | 1.86 | 1.84 | 2.03 | 1.90 |
| K2O | 1.22 | 1.16 | 2.13 | 1.99 | 1.39 | 1.18 | 1.76 | 1.56 | 1.66 | 1.35 | 1.69 |
| TiO2 | 0.68 | 1.02 | 0.42 | 0.27 | 0.87 | 1.05 | 0.68 | 0.71 | 0.56 | 1.09 | 0.93 |
| MnO | 0.79 | 1.05 | 1.18 | 0.59 | 0.76 | 0.86 | 0.83 | 0.95 | 0.81 | 1.00 | 0.84 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.14 | 0.24 | 0.59 | 0.37 | 0.31 | 0.23 | 0.07 | 0.19 | 0.20 | 0.19 | 0.31 |
| F | 0.43 | 0.20 | 0.16 | 0.22 | 0.07 | 0.10 | 0.15 | 0.25 | 0.00 | 0.20 | 0.16 |
| SUBSUM | 98.24 | 98.14 | 98.80 | 98.23 | 98.81 | 98.55 | 99.33 | 97.94 | 98.95 | 98.88 | 98.77 |
| Cl=O | 0.03 | 0.05 | 0.13 | 0.08 | 0.07 | 0.05 | 0.02 | 0.04 | 0.05 | 0.04 | 0.07 |
| F=O | 0.18 | 0.08 | 0.07 | 0.09 | 0.03 | 0.04 | 0.06 | 0.11 | 0.00 | 0.08 | 0.07 |
| SUM | 98.03 | 98.00 | 98.60 | 98.05 | 98.71 | 98.46 | 99.25 | 97.79 | 98.90 | 98.75 | 98.63 |
| H2Ocalc | 1.74 | 1.81 | 1.68 | 1.70 | 1.84 | 1.85 | 1.89 | 1.77 | 1.93 | 1.82 | 1.82 |
| SUM | 99.77 | 99.81 | 100.28 | 99.76 | 100.55 | 100.31 | 101.14 | 99.56 | 100.83 | 100.57 | 100.45 |
| Si | 6.56 | 6.58 | 6.08 | 6.14 | 6.38 | 6.46 | 6.39 | 6.42 | 6.44 | 6.35 | 6.37 |
| Aliv | 1.44 | 1.42 | 1.92 | 1.86 | 1.62 | 1.54 | 1.61 | 1.58 | 1.56 | 1.65 | 1.63 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.56 | 0.41 | 0.76 | 0.69 | 0.54 | 0.54 | 0.65 | 0.62 | 0.63 | 0.53 | 0.60 |
| Fe+2 | 2.26 | 2.36 | 3.04 | 3.07 | 2.78 | 2.69 | 2.60 | 2.68 | 2.47 | 2.56 | 2.36 |
| Mg | 2.08 | 2.05 | 1.13 | 1.21 | 1.58 | 1.65 | 1.67 | 1.62 | 1.80 | 1.75 | 1.94 |
| Ti | 0.08 | 0.12 | 0.05 | 0.03 | 0.10 | 0.12 | 0.08 | 0.08 | 0.06 | 0.13 | 0.11 |
| Mn | 0.02 | 0.08 | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.04 | 0.04 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.08 | 0.06 | 0.14 | 0.08 | 0.10 | 0.11 | 0.11 | 0.12 | 0.06 | 0.09 | 0.11 |
| Fe+2 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.11 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.88 | 1.90 | 1.86 | 1.89 | 1.89 | 1.82 | 1.82 | 1.80 | 1.89 | 1.89 | 1.74 |
| Na | 0.04 | 0.04 | 0.00 | 0.00 | 0.01 | 0.07 | 0.06 | 0.06 | 0.05 | 0.02 | 0.04 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.53 | 0.54 | 0.58 | 0.58 | 0.59 | 0.56 | 0.52 | 0.50 | 0.49 | 0.58 | 0.52 |
| K | 0.24 | 0.23 | 0.43 | 0.40 | 0.27 | 0.23 | 0.34 | 0.31 | 0.32 | 0.26 | 0.33 |
| Ca | 0.00 | 0.00 | 0.02 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.77 | 0.76 | 1.02 | 1.02 | 0.87 | 0.79 | 0.86 | 0.81 | 0.81 | 0.85 | 0.85 |
| CATSUM | 15.77 | 15.76 | 16.02 | 16.02 | 15.87 | 15.79 | 15.86 | 15.81 | 15.81 | 15.85 | 15.85 |
| F | 0.21 | 0.10 | 0.08 | 0.11 | 0.03 | 0.05 | 0.07 | 0.12 | 0.00 | 0.10 | 0.08 |
| Cl | 0.04 | 0.06 | 0.16 | 0.10 | 0.08 | 0.06 | 0.02 | 0.05 | 0.05 | 0.05 | 0.08 |
| OHcalc | 1.76 | 1.84 | 1.76 | 1.79 | 1.89 | 1.89 | 1.91 | 1.83 | 1.95 | 1.85 | 1.85 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.52 | 0.54 | 0.73 | 0.72 | 0.64 | 0.62 | 0.61 | 0.62 | 0.58 | 0.59 | 0.56 |
| # | 301 | 302 | 303 | 304 | 305 | 306 | 307 | 308 | 309 | 310 | 311 |

Table 3. Hornblendes from SE Alaskan plutons.

| SAMPLE GRAIN | AK1 8 | | | | | | | | | | |
|-----------------|----------|--------|--------|--------|--------|-------|--------|--------|-------|--------|-------|
| SiO2 | 41.82 | 41.91 | 41.95 | 41.91 | 42.00 | 42.32 | 42.49 | 42.28 | 42.21 | 42.53 | 42.17 |
| Al2O3 | 11.36 | 11.46 | 11.49 | 11.59 | 10.79 | 11.00 | 10.89 | 10.96 | 10.94 | 11.02 | 11.04 |
| FeO | 19.20 | 19.40 | 19.68 | 19.71 | 19.17 | 19.09 | 19.53 | 19.38 | 19.42 | 19.22 | 18.78 |
| MgO | 8.95 | 8.87 | 8.67 | 8.77 | 9.27 | 8.96 | 9.13 | 9.14 | 9.08 | 9.13 | 8.50 |
| CaO | 10.74 | 10.85 | 10.76 | 10.75 | 10.82 | 10.55 | 10.73 | 10.92 | 10.71 | 10.82 | 10.49 |
| Na2O | 1.98 | 2.03 | 2.05 | 2.05 | 2.03 | 1.98 | 2.03 | 2.07 | 2.04 | 2.05 | 1.85 |
| K2O | 1.47 | 1.60 | 1.56 | 1.58 | 1.36 | 1.47 | 1.51 | 1.60 | 1.42 | 1.42 | 1.42 |
| TiO2 | 1.19 | 1.27 | 1.21 | 1.30 | 1.16 | 1.11 | 1.30 | 1.14 | 1.14 | 1.21 | 1.21 |
| MnO | 0.87 | 0.87 | 0.82 | 0.85 | 0.83 | 0.83 | 0.87 | 0.85 | 0.84 | 0.82 | 0.83 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.25 | 0.19 | 0.21 | 0.24 | 0.14 | 0.25 | 0.24 | 0.26 | 0.29 | 0.22 | 0.26 |
| F | 0.12 | 0.26 | 0.24 | 0.29 | 0.27 | 0.17 | 0.17 | 0.07 | 0.23 | 0.27 | 0.13 |
| SUBSUM | 97.96 | 98.70 | 98.63 | 99.03 | 98.65 | 97.71 | 98.89 | 98.68 | 98.36 | 98.71 | 96.68 |
| Cl=O | 0.06 | 0.04 | 0.05 | 0.05 | 0.03 | 0.06 | 0.05 | 0.06 | 0.06 | 0.05 | 0.06 |
| F=O | 0.05 | 0.11 | 0.10 | 0.12 | 0.12 | 0.07 | 0.07 | 0.03 | 0.10 | 0.12 | 0.05 |
| SUM | 97.86 | 98.54 | 98.48 | 98.86 | 98.50 | 97.59 | 98.76 | 98.59 | 98.20 | 98.55 | 96.57 |
| H2Ocalc | 1.84 | 1.79 | 1.80 | 1.77 | 1.81 | 1.81 | 1.83 | 1.87 | 1.78 | 1.78 | 1.81 |
| SUM | 99.70 | 100.34 | 100.28 | 100.63 | 100.31 | 99.39 | 100.59 | 100.46 | 99.98 | 100.33 | 98.38 |
| Si | 6.41 | 6.39 | 6.41 | 6.38 | 6.50 | 6.49 | 6.46 | 6.44 | 6.46 | 6.47 | 6.52 |
| Aliv | 1.59 | 1.61 | 1.59 | 1.62 | 1.50 | 1.51 | 1.54 | 1.56 | 1.54 | 1.53 | 1.48 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.46 | 0.45 | 0.47 | 0.46 | 0.43 | 0.48 | 0.41 | 0.41 | 0.43 | 0.44 | 0.53 |
| Fe+2 | 2.35 | 2.38 | 2.41 | 2.40 | 2.33 | 2.34 | 2.37 | 2.38 | 2.37 | 2.35 | 2.36 |
| Mg | 2.05 | 2.02 | 1.97 | 1.99 | 2.10 | 2.05 | 2.07 | 2.07 | 2.07 | 2.07 | 1.96 |
| Ti | 0.14 | 0.15 | 0.14 | 0.15 | 0.13 | 0.13 | 0.15 | 0.13 | 0.13 | 0.14 | 0.14 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| Fe+2 | 0.11 | 0.09 | 0.10 | 0.11 | 0.10 | 0.11 | 0.11 | 0.09 | 0.11 | 0.10 | 0.06 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.76 | 1.77 | 1.76 | 1.75 | 1.76 | 1.73 | 1.75 | 1.78 | 1.76 | 1.76 | 1.74 |
| Na | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.05 | 0.03 | 0.02 | 0.02 | 0.03 | 0.09 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.57 | 0.58 | 0.57 | 0.58 | 0.57 | 0.54 | 0.57 | 0.59 | 0.58 | 0.57 | 0.47 |
| K | 0.29 | 0.31 | 0.30 | 0.31 | 0.26 | 0.29 | 0.29 | 0.31 | 0.28 | 0.28 | 0.28 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.86 | 0.89 | 0.88 | 0.89 | 0.83 | 0.82 | 0.86 | 0.90 | 0.86 | 0.85 | 0.75 |
| CATSUM | 15.86 | 15.89 | 15.88 | 15.89 | 15.83 | 15.82 | 15.86 | 15.90 | 15.86 | 15.85 | 15.75 |
| F | 0.06 | 0.13 | 0.11 | 0.14 | 0.13 | 0.08 | 0.08 | 0.03 | 0.11 | 0.13 | 0.06 |
| Cl | 0.06 | 0.05 | 0.05 | 0.06 | 0.04 | 0.06 | 0.06 | 0.07 | 0.07 | 0.06 | 0.07 |
| DHcalc | 1.88 | 1.82 | 1.83 | 1.80 | 1.83 | 1.85 | 1.85 | 1.90 | 1.81 | 1.81 | 1.87 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.55 | 0.55 | 0.56 | 0.56 | 0.54 | 0.54 | 0.55 | 0.54 | 0.55 | 0.54 | 0.55 |
| # | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 | 321 | 322 |

Table 3. Hornblendes from SE Alaskan plutons.

| SAMPLE GRAIN | AK1 B | | | | | | | | | | | |
|-----------------|----------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--|
| | C | | F | | | | | | | | | |
| SiO2 | 42.47 | 43.13 | 41.48 | 42.68 | 41.35 | 41.76 | 41.65 | 41.86 | 42.07 | 42.08 | 42.88 | |
| Al2O3 | 10.86 | 10.86 | 11.48 | 12.66 | 12.94 | 11.93 | 11.78 | 11.65 | 11.39 | 11.45 | 10.68 | |
| FeO | 19.40 | 19.45 | 19.57 | 18.91 | 19.23 | 19.55 | 19.67 | 19.77 | 19.31 | 19.54 | 18.99 | |
| MgO | 9.12 | 9.23 | 8.79 | 7.97 | 8.47 | 8.68 | 8.70 | 8.66 | 8.77 | 8.92 | 9.40 | |
| CaO | 10.80 | 10.81 | 10.74 | 10.37 | 10.62 | 10.82 | 10.77 | 10.99 | 10.77 | 10.80 | 10.97 | |
| Na2O | 1.98 | 1.85 | 1.89 | 1.81 | 1.97 | 2.02 | 2.11 | 1.99 | 2.08 | 2.01 | 1.97 | |
| K2O | 1.50 | 1.56 | 1.76 | 1.98 | 1.87 | 1.69 | 1.46 | 1.61 | 1.48 | 1.47 | 1.26 | |
| TiO2 | 1.24 | 1.00 | 1.06 | 0.73 | 0.97 | 1.16 | 1.27 | 1.28 | 1.23 | 1.21 | 1.19 | |
| MnO | 0.84 | 0.83 | 0.88 | 0.79 | 0.83 | 0.86 | 0.82 | 0.86 | 0.84 | 0.85 | 0.85 | |
| BaO | n | n | n | n | n | n | n | n | n | n | n | |
| Cl | 0.25 | 0.22 | 0.35 | 0.39 | 0.19 | 0.22 | 0.22 | 0.37 | 0.26 | 0.23 | 0.25 | |
| F | 0.13 | 0.05 | 0.26 | 0.17 | 0.11 | 0.28 | 0.13 | 0.13 | 0.15 | 0.25 | 0.29 | |
| SUBSUM | 98.60 | 98.98 | 98.26 | 98.44 | 98.58 | 99.00 | 98.57 | 99.16 | 98.36 | 98.80 | 98.73 | |
| Cl=O | 0.06 | 0.05 | 0.08 | 0.09 | 0.04 | 0.05 | 0.05 | 0.08 | 0.06 | 0.05 | 0.06 | |
| F=O | 0.05 | 0.02 | 0.11 | 0.07 | 0.05 | 0.12 | 0.05 | 0.05 | 0.06 | 0.10 | 0.12 | |
| SUM | 98.49 | 98.91 | 98.07 | 98.28 | 98.49 | 98.83 | 98.47 | 99.03 | 98.23 | 98.64 | 98.55 | |
| H2Ocalc | 1.84 | 1.90 | 1.74 | 1.79 | 1.87 | 1.78 | 1.85 | 1.82 | 1.82 | 1.79 | 1.77 | |
| SUM | 100.33 | 100.82 | 99.81 | 100.08 | 100.36 | 100.61 | 100.31 | 100.84 | 100.06 | 100.43 | 100.32 | |
| Si | 6.47 | 6.52 | 6.38 | 6.49 | 6.30 | 6.36 | 6.36 | 6.37 | 6.43 | 6.41 | 6.51 | |
| Aliv | 1.53 | 1.48 | 1.62 | 1.51 | 1.70 | 1.64 | 1.64 | 1.63 | 1.57 | 1.59 | 1.49 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.42 | 0.46 | 0.46 | 0.75 | 0.62 | 0.50 | 0.48 | 0.46 | 0.48 | 0.46 | 0.42 | |
| Fe+2 | 2.37 | 2.35 | 2.40 | 2.36 | 2.34 | 2.40 | 2.40 | 2.43 | 2.38 | 2.37 | 2.32 | |
| Mg | 2.07 | 2.00 | 2.02 | 1.81 | 1.92 | 1.97 | 1.98 | 1.96 | 2.00 | 2.02 | 2.13 | |
| Ti | 0.14 | 0.11 | 0.12 | 0.08 | 0.11 | 0.13 | 0.15 | 0.15 | 0.14 | 0.14 | 0.14 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.11 | 0.11 | 0.11 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | |
| Fe+2 | 0.10 | 0.12 | 0.12 | 0.05 | 0.11 | 0.09 | 0.11 | 0.09 | 0.08 | 0.11 | 0.09 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.76 | 1.75 | 1.77 | 1.69 | 1.73 | 1.77 | 1.76 | 1.79 | 1.76 | 1.76 | 1.78 | |
| Na | 0.03 | 0.03 | 0.00 | 0.16 | 0.05 | 0.03 | 0.02 | 0.01 | 0.05 | 0.01 | 0.01 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.56 | 0.51 | 0.56 | 0.37 | 0.53 | 0.57 | 0.60 | 0.58 | 0.57 | 0.58 | 0.57 | |
| K | 0.29 | 0.30 | 0.35 | 0.38 | 0.36 | 0.33 | 0.28 | 0.31 | 0.29 | 0.29 | 0.24 | |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| A | 0.85 | 0.82 | 0.91 | 0.75 | 0.90 | 0.89 | 0.89 | 0.89 | 0.86 | 0.87 | 0.81 | |
| CATSUM | 15.85 | 15.82 | 15.91 | 15.75 | 15.90 | 15.89 | 15.89 | 15.89 | 15.86 | 15.87 | 15.81 | |
| F | 0.06 | 0.02 | 0.13 | 0.08 | 0.05 | 0.14 | 0.06 | 0.06 | 0.07 | 0.12 | 0.14 | |
| Cl | 0.06 | 0.06 | 0.09 | 0.10 | 0.05 | 0.06 | 0.06 | 0.09 | 0.07 | 0.06 | 0.06 | |
| OHcalc | 1.87 | 1.92 | 1.78 | 1.82 | 1.90 | 1.81 | 1.88 | 1.84 | 1.86 | 1.82 | 1.80 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.54 | 0.54 | 0.56 | 0.57 | 0.56 | 0.56 | 0.56 | 0.56 | 0.55 | 0.55 | 0.53 | |
| # | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 | 331 | 332 | 333 | |

Table 3. Hornblendes from SE Alaskan plutons.

| SAMPLE GRAIN | AK1 | | AK2 | | | | | | | | |
|--------------------------------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | B | | 1 | | 2 | | | | 3 | | |
| | | | c | c | c | c | | | c | | |
| SiO ₂ | 42.97 | 43.06 | 41.18 | 41.75 | 41.38 | 40.98 | 40.90 | 41.11 | 40.70 | 41.00 | 40.98 |
| Al ₂ O ₃ | 10.45 | 10.61 | 12.46 | 12.70 | 11.98 | 12.83 | 12.50 | 12.34 | 13.04 | 12.16 | 12.12 |
| FeO | 18.86 | 19.07 | 18.98 | 18.83 | 19.15 | 18.23 | 18.54 | 18.75 | 18.39 | 19.93 | 19.67 |
| MgO | 9.53 | 9.45 | 9.17 | 8.96 | 9.23 | 9.09 | 8.83 | 9.02 | 8.61 | 8.47 | 8.59 |
| CaO | 10.86 | 10.83 | 10.70 | 10.72 | 11.07 | 10.75 | 11.03 | 10.79 | 10.86 | 10.99 | 10.91 |
| Na ₂ O | 2.01 | 2.03 | 1.67 | 1.64 | 1.68 | 1.66 | 1.88 | 1.90 | 1.97 | 1.83 | 1.86 |
| K ₂ O | 1.31 | 1.26 | 1.59 | 1.66 | 1.49 | 1.50 | 1.40 | 1.50 | 1.46 | 1.47 | 1.42 |
| TiO ₂ | 1.20 | 1.13 | 0.79 | 0.78 | 0.77 | 0.85 | 0.76 | 0.89 | 0.71 | 0.88 | 1.01 |
| MnO | 0.86 | 0.84 | 0.73 | 0.76 | 0.74 | 0.74 | 0.73 | 0.68 | 0.65 | 0.71 | 0.67 |
| BaO | n | n | 0.11 | 0.08 | 0.04 | n | 0.04 | 0.06 | 0.03 | 0.07 | 0.00 |
| Cl | 0.16 | 0.16 | 0.13 | 0.13 | 0.17 | 0.14 | 0.12 | 0.09 | 0.11 | 0.10 | 0.10 |
| F | 0.21 | 0.14 | 0.18 | 0.19 | 0.11 | 0.20 | 0.08 | 0.07 | 0.22 | 0.19 | 0.26 |
| SUBSUM | 98.41 | 98.57 | 97.68 | 98.20 | 97.70 | 96.96 | 97.12 | 97.20 | 96.64 | 97.79 | 97.57 |
| Cl=O | 0.04 | 0.04 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 |
| F=O | 0.09 | 0.06 | 0.08 | 0.08 | 0.05 | 0.08 | 0.03 | 0.03 | 0.09 | 0.08 | 0.11 |
| SUM | 98.29 | 98.48 | 97.57 | 98.10 | 97.61 | 96.84 | 97.06 | 97.15 | 96.53 | 97.69 | 97.44 |
| H ₂ Ocalc | 1.83 | 1.87 | 1.84 | 1.85 | 1.86 | 1.82 | 1.87 | 1.89 | 1.81 | 1.83 | 1.80 |
| SUM | 100.12 | 100.35 | 99.41 | 99.94 | 99.47 | 98.66 | 98.93 | 99.04 | 98.34 | 99.51 | 99.24 |
| Si | 6.53 | 6.53 | 6.32 | 6.36 | 6.35 | 6.31 | 6.31 | 6.33 | 6.30 | 6.32 | 6.32 |
| Aliv | 1.47 | 1.47 | 1.68 | 1.64 | 1.65 | 1.69 | 1.69 | 1.67 | 1.70 | 1.68 | 1.68 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.40 | 0.43 | 0.57 | 0.64 | 0.51 | 0.64 | 0.58 | 0.56 | 0.67 | 0.53 | 0.52 |
| Fe+2 | 2.30 | 2.31 | 2.24 | 2.24 | 2.29 | 2.18 | 2.30 | 2.26 | 2.26 | 2.42 | 2.38 |
| Mg | 2.16 | 2.13 | 2.10 | 2.03 | 2.11 | 2.08 | 2.03 | 2.07 | 1.98 | 1.95 | 1.98 |
| Ti | 0.14 | 0.13 | 0.09 | 0.09 | 0.09 | 0.10 | 0.09 | 0.10 | 0.08 | 0.10 | 0.12 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.11 | 0.11 | 0.09 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| Fe+2 | 0.09 | 0.11 | 0.20 | 0.16 | 0.17 | 0.17 | 0.13 | 0.15 | 0.12 | 0.15 | 0.15 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.77 | 1.76 | 1.71 | 1.74 | 1.74 | 1.74 | 1.78 | 1.76 | 1.79 | 1.76 | 1.76 |
| Na | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.56 | 0.57 | 0.50 | 0.48 | 0.50 | 0.49 | 0.56 | 0.57 | 0.56 | 0.55 | 0.55 |
| K | 0.25 | 0.24 | 0.31 | 0.32 | 0.29 | 0.30 | 0.28 | 0.30 | 0.29 | 0.29 | 0.28 |
| Ca | 0.00 | 0.00 | 0.05 | 0.00 | 0.08 | 0.03 | 0.05 | 0.02 | 0.01 | 0.05 | 0.04 |
| A | 0.82 | 0.81 | 0.86 | 0.81 | 0.87 | 0.83 | 0.88 | 0.88 | 0.86 | 0.89 | 0.88 |
| CATSUM | 15.82 | 15.81 | 15.86 | 15.81 | 15.87 | 15.83 | 15.88 | 15.88 | 15.86 | 15.89 | 15.88 |
| F | 0.10 | 0.07 | 0.09 | 0.09 | 0.05 | 0.10 | 0.04 | 0.03 | 0.11 | 0.09 | 0.13 |
| Cl | 0.04 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.02 | 0.03 | 0.03 | 0.02 |
| OHcalc | 1.86 | 1.89 | 1.88 | 1.87 | 1.90 | 1.87 | 1.93 | 1.94 | 1.86 | 1.88 | 1.85 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.53 | 0.53 | 0.54 | 0.54 | 0.54 | 0.53 | 0.54 | 0.54 | 0.55 | 0.57 | 0.56 |
| # | 334 | 335 | 336 | 337 | 338 | 339 | 340 | 341 | 342 | 343 | 344 |

Table 3. Hornblendes from SE Alaskan plutons.

| SAMPLE GRAIN | AK2 | | AK3 | | | | | | | | | |
|--------------------------------|-------|--------|-------|--------|--------|--------|-------|--------|--------|--------|--------|--|
| | 3 | | 1 | | | | | | | | 2 | |
| | r | | r | | | | | | | | r | |
| SiO ₂ | 40.66 | 42.61 | 41.09 | 40.80 | 42.06 | 41.69 | 41.32 | 40.68 | 39.49 | 40.17 | 40.13 | |
| Al ₂ O ₃ | 12.67 | 11.37 | 12.62 | 12.62 | 10.97 | 11.27 | 11.56 | 12.63 | 14.66 | 14.26 | 13.43 | |
| FeO | 18.96 | 19.99 | 20.35 | 20.70 | 20.34 | 20.69 | 20.87 | 21.07 | 21.17 | 20.83 | 21.49 | |
| MgO | 8.68 | 9.53 | 7.92 | 7.95 | 8.94 | 8.61 | 8.17 | 7.64 | 7.26 | 7.46 | 7.57 | |
| CaO | 11.10 | 10.86 | 10.87 | 11.07 | 10.95 | 10.66 | 10.63 | 10.88 | 10.71 | 11.02 | 11.05 | |
| Na ₂ O | 1.89 | 1.82 | 1.93 | 1.94 | 1.93 | 2.01 | 2.03 | 2.00 | 1.94 | 1.97 | 1.95 | |
| K ₂ O | 1.31 | 1.27 | 1.64 | 1.69 | 1.40 | 1.54 | 1.63 | 1.82 | 2.00 | 2.01 | 2.02 | |
| TiO ₂ | 0.92 | 1.04 | 0.86 | 1.34 | 1.26 | 1.18 | 1.02 | 1.17 | 0.34 | 0.64 | 0.79 | |
| MnO | 0.67 | 0.73 | 0.65 | 0.65 | 0.70 | 0.68 | 0.70 | 0.69 | 0.70 | 0.65 | 0.59 | |
| BaO | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Cl | 0.13 | 0.10 | 0.16 | 0.16 | 0.15 | 0.14 | 0.15 | 0.14 | 0.27 | 0.15 | 0.16 | |
| F | 0.16 | 0.18 | 0.09 | 0.12 | 0.08 | 0.09 | 0.12 | 0.15 | 0.18 | 0.21 | 0.07 | |
| SUBSUM | 97.14 | 98.58 | 98.18 | 99.03 | 98.79 | 98.54 | 98.19 | 98.85 | 98.73 | 99.36 | 99.24 | |
| Cl=O | 0.03 | 0.02 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.06 | 0.03 | 0.04 | |
| F=O | 0.07 | 0.07 | 0.04 | 0.05 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.09 | 0.03 | |
| SUM | 97.04 | 98.49 | 98.11 | 98.95 | 98.72 | 98.47 | 98.11 | 98.76 | 98.59 | 99.24 | 99.18 | |
| H ₂ Ocalc | 1.83 | 1.87 | 1.87 | 1.86 | 1.89 | 1.88 | 1.85 | 1.85 | 1.79 | 1.83 | 1.88 | |
| SUM | 98.88 | 100.36 | 99.98 | 100.81 | 100.61 | 100.35 | 99.96 | 100.61 | 100.38 | 101.07 | 101.06 | |
| Si | 6.28 | 6.45 | 6.31 | 6.24 | 6.41 | 6.39 | 6.37 | 6.25 | 6.09 | 6.13 | 6.15 | |
| Aliv | 1.72 | 1.55 | 1.69 | 1.76 | 1.59 | 1.61 | 1.63 | 1.75 | 1.91 | 1.87 | 1.85 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.58 | 0.48 | 0.60 | 0.51 | 0.39 | 0.42 | 0.47 | 0.53 | 0.75 | 0.70 | 0.58 | |
| Fe+2 | 2.32 | 2.25 | 2.49 | 2.52 | 2.44 | 2.48 | 2.54 | 2.58 | 2.54 | 2.53 | 2.60 | |
| Mg | 2.00 | 2.15 | 1.81 | 1.81 | 2.03 | 1.97 | 1.88 | 1.75 | 1.67 | 1.70 | 1.73 | |
| Ti | 0.11 | 0.12 | 0.10 | 0.15 | 0.14 | 0.14 | 0.12 | 0.14 | 0.04 | 0.07 | 0.09 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.09 | 0.09 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | |
| Fe+2 | 0.13 | 0.16 | 0.12 | 0.12 | 0.15 | 0.17 | 0.15 | 0.12 | 0.19 | 0.13 | 0.16 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.78 | 1.75 | 1.79 | 1.79 | 1.75 | 1.74 | 1.75 | 1.79 | 1.72 | 1.78 | 1.76 | |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.56 | 0.53 | 0.57 | 0.58 | 0.57 | 0.60 | 0.61 | 0.59 | 0.58 | 0.58 | 0.58 | |
| K | 0.26 | 0.24 | 0.32 | 0.33 | 0.27 | 0.30 | 0.32 | 0.36 | 0.39 | 0.39 | 0.39 | |
| Ca | 0.05 | 0.02 | 0.00 | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 | 0.05 | 0.02 | 0.05 | |
| A | 0.88 | 0.80 | 0.89 | 0.92 | 0.88 | 0.91 | 0.93 | 0.95 | 1.03 | 1.00 | 1.03 | |
| CATSUM | 15.88 | 15.80 | 15.89 | 15.92 | 15.88 | 15.91 | 15.93 | 15.95 | 16.03 | 16.00 | 16.03 | |
| F | 0.08 | 0.08 | 0.04 | 0.06 | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 | 0.10 | 0.03 | |
| Cl | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.07 | 0.04 | 0.04 | |
| OHcalc | 1.89 | 1.89 | 1.92 | 1.90 | 1.93 | 1.92 | 1.90 | 1.89 | 1.84 | 1.86 | 1.93 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.55 | 0.53 | 0.59 | 0.59 | 0.56 | 0.57 | 0.59 | 0.61 | 0.62 | 0.61 | 0.61 | |
| # | 345 | 346 | 347 | 348 | 349 | 350 | 351 | 352 | 353 | 354 | 355 | |

Table 3. Hornblendes from SE Alaskan plutons.

| SAMPLE GRAIN | AK3 | | | | | | | | | | | |
|-----------------|--------|--------|--------|-------|-------|-------|-------|-------|--------|--------|--------|--|
| | 2 | | 3 | | 4 | | 5 | | 5 | | 5 | |
| | C | r | | | r | C | C | C | | r | | |
| SiO2 | 41.11 | 40.18 | 41.64 | 43.49 | 42.66 | 41.71 | 42.29 | 41.40 | 44.95 | 44.62 | 42.41 | |
| Al2O3 | 12.18 | 13.64 | 11.29 | 10.09 | 10.40 | 10.83 | 10.34 | 10.68 | 10.19 | 10.26 | 11.96 | |
| FeO | 20.83 | 20.82 | 21.15 | 18.82 | 18.99 | 20.36 | 18.25 | 19.63 | 16.67 | 16.51 | 17.04 | |
| MgO | 8.08 | 7.37 | 8.39 | 9.55 | 9.38 | 8.13 | 9.75 | 8.77 | 10.94 | 11.21 | 10.17 | |
| CaO | 10.83 | 10.75 | 10.86 | 10.90 | 10.73 | 10.61 | 11.20 | 10.97 | 11.51 | 11.21 | 11.30 | |
| Na2O | 2.00 | 1.96 | 1.98 | 1.95 | 1.96 | 2.04 | 2.04 | 2.00 | 1.86 | 1.82 | 1.93 | |
| K2O | 1.73 | 1.87 | 1.47 | 1.06 | 1.17 | 1.31 | 1.24 | 1.40 | 1.17 | 1.19 | 1.49 | |
| TiO2 | 1.20 | 0.82 | 1.11 | 1.04 | 1.15 | 1.16 | 1.16 | 1.37 | 1.07 | 1.07 | 1.17 | |
| MnO | 0.67 | 0.65 | 0.70 | 0.70 | 0.72 | 0.67 | 0.64 | 0.65 | 0.60 | 0.61 | 0.61 | |
| BaO | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.11 | 0.09 | 0.00 | 0.00 | 0.03 | |
| Cl | 0.15 | 0.19 | 0.15 | 0.20 | 0.15 | 0.12 | 0.14 | 0.12 | 0.09 | 0.11 | 0.15 | |
| F | 0.02 | 0.08 | 0.13 | 0.07 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| SUBSUM | 98.79 | 98.32 | 98.86 | 97.87 | 97.53 | 97.03 | 97.14 | 97.07 | 99.04 | 98.62 | 98.24 | |
| Cl=O | 0.03 | 0.04 | 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | |
| F=O | 0.01 | 0.03 | 0.05 | 0.03 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| SUM | 98.75 | 98.24 | 98.77 | 97.79 | 97.40 | 97.00 | 97.11 | 97.04 | 99.02 | 98.59 | 98.21 | |
| H2Ocalc | 1.91 | 1.86 | 1.86 | 1.89 | 1.81 | 1.90 | 1.92 | 1.90 | 2.00 | 1.99 | 1.95 | |
| SUM | 100.66 | 100.10 | 100.63 | 99.68 | 99.21 | 98.90 | 99.02 | 98.95 | 101.02 | 100.58 | 100.16 | |
| Si | 6.29 | 6.19 | 6.38 | 6.62 | 6.54 | 6.47 | 6.50 | 6.42 | 6.66 | 6.64 | 6.39 | |
| Aliv | 1.71 | 1.81 | 1.62 | 1.38 | 1.46 | 1.53 | 1.50 | 1.58 | 1.34 | 1.36 | 1.61 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.49 | 0.67 | 0.42 | 0.43 | 0.42 | 0.45 | 0.37 | 0.37 | 0.44 | 0.44 | 0.52 | |
| Fe+2 | 2.53 | 2.54 | 2.54 | 2.29 | 2.31 | 2.53 | 2.27 | 2.45 | 2.02 | 1.95 | 2.07 | |
| Mg | 1.84 | 1.69 | 1.91 | 2.17 | 2.14 | 1.88 | 2.23 | 2.03 | 2.42 | 2.49 | 2.28 | |
| Ti | 0.14 | 0.10 | 0.13 | 0.12 | 0.13 | 0.14 | 0.13 | 0.16 | 0.12 | 0.12 | 0.13 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.07 | 0.08 | 0.08 | |
| Fe+2 | 0.14 | 0.14 | 0.17 | 0.10 | 0.13 | 0.11 | 0.08 | 0.10 | 0.05 | 0.10 | 0.08 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.77 | 1.77 | 1.74 | 1.78 | 1.76 | 1.76 | 1.84 | 1.82 | 1.83 | 1.79 | 1.83 | |
| Na | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 | 0.04 | 0.00 | 0.00 | 0.05 | 0.04 | 0.01 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.59 | 0.58 | 0.59 | 0.55 | 0.57 | 0.58 | 0.61 | 0.60 | 0.48 | 0.49 | 0.55 | |
| K | 0.34 | 0.37 | 0.29 | 0.21 | 0.23 | 0.26 | 0.24 | 0.28 | 0.22 | 0.23 | 0.29 | |
| Ca | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| A | 0.94 | 0.95 | 0.91 | 0.75 | 0.79 | 0.83 | 0.85 | 0.88 | 0.71 | 0.72 | 0.83 | |
| CATSUM | 15.94 | 15.95 | 15.91 | 15.75 | 15.79 | 15.83 | 15.85 | 15.88 | 15.71 | 15.72 | 15.83 | |
| F | 0.01 | 0.04 | 0.06 | 0.03 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Cl | 0.04 | 0.05 | 0.04 | 0.05 | 0.04 | 0.03 | 0.04 | 0.03 | 0.02 | 0.03 | 0.04 | |
| OHcalc | 1.95 | 1.91 | 1.90 | 1.92 | 1.85 | 1.97 | 1.96 | 1.97 | 1.98 | 1.97 | 1.96 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.59 | 0.61 | 0.59 | 0.53 | 0.53 | 0.58 | 0.51 | 0.56 | 0.46 | 0.45 | 0.48 | |
| # | 356 | 357 | 358 | 359 | 360 | 361 | 362 | 363 | 364 | 365 | 366 | |

Table 3. Hornblendes from SE Alaskan plutons.

| SAMPLE | AK3 | | | AK4 | | AK5 | | 2 | | | |
|--------------------------------|-------|--------|--------|--------|--------|--------|--------|-------|-------|-------|--------|
| GRAIN | 6 | 7 | | 1 | 1 | | | | | | |
| | | c | r | | | | | r | | c | |
| SiO ₂ | 40.94 | 40.48 | 40.47 | 42.52 | 40.98 | 40.36 | 40.58 | 39.68 | 40.08 | 40.92 | 40.44 |
| Al ₂ O ₃ | 12.94 | 12.29 | 13.07 | 13.10 | 13.50 | 13.74 | 13.94 | 14.59 | 13.82 | 12.54 | 13.64 |
| FeO | 19.09 | 21.87 | 21.67 | 20.61 | 21.19 | 21.32 | 21.24 | 21.26 | 21.16 | 20.33 | 21.32 |
| MgO | 8.01 | 7.05 | 6.96 | 6.46 | 6.33 | 6.32 | 6.08 | 5.88 | 6.31 | 7.20 | 6.50 |
| CaO | 11.25 | 10.99 | 10.97 | 11.79 | 11.14 | 11.10 | 11.35 | 11.07 | 11.23 | 11.39 | 11.33 |
| Na ₂ O | 1.83 | 1.99 | 2.00 | 1.53 | 1.62 | 1.62 | 1.56 | 1.67 | 1.50 | 1.39 | 1.45 |
| K ₂ O | 1.98 | 1.71 | 1.83 | 1.41 | 1.58 | 1.69 | 1.96 | 1.67 | 2.01 | 1.61 | 1.83 |
| TiO ₂ | 1.08 | 1.17 | 0.94 | 1.54 | 1.50 | 1.63 | 0.99 | 1.51 | 1.21 | 1.05 | 1.40 |
| MnO | 0.66 | 0.66 | 0.68 | 0.26 | 0.35 | 0.35 | 0.33 | 0.37 | 0.39 | 0.37 | 0.34 |
| BaO | 0.09 | 0.07 | 0.02 | 0.00 | 0.01 | 0.12 | 0.00 | 0.05 | 0.00 | 0.00 | 0.03 |
| Cl | 0.10 | 0.15 | 0.16 | 0.16 | 0.13 | 0.12 | 0.09 | 0.12 | 0.13 | 0.06 | 0.07 |
| F | 0.00 | 0.00 | 0.00 | 0.24 | 0.02 | 0.17 | 0.11 | 0.02 | 0.38 | 0.12 | 0.05 |
| SUBSUM | 97.78 | 98.42 | 98.77 | 99.61 | 98.35 | 98.53 | 98.23 | 97.88 | 98.22 | 96.96 | 98.41 |
| Cl=O | 0.02 | 0.03 | 0.04 | 0.04 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.01 | 0.02 |
| F=O | 0.00 | 0.00 | 0.00 | 0.10 | 0.01 | 0.07 | 0.04 | 0.01 | 0.16 | 0.05 | 0.02 |
| SUM | 97.76 | 98.39 | 98.74 | 99.47 | 98.31 | 98.43 | 98.16 | 97.85 | 98.03 | 96.98 | 98.37 |
| H ₂ Ocalc | 1.93 | 1.90 | 1.91 | 1.83 | 1.92 | 1.84 | 1.87 | 1.90 | 1.72 | 1.86 | 1.91 |
| SUM | 99.69 | 100.29 | 100.64 | 101.31 | 100.23 | 100.27 | 100.04 | 99.75 | 99.76 | 98.76 | 100.28 |
| Si | 6.28 | 6.26 | 6.23 | 6.41 | 6.28 | 6.21 | 6.25 | 6.13 | 6.20 | 6.35 | 6.22 |
| Aliv | 1.72 | 1.74 | 1.77 | 1.59 | 1.72 | 1.79 | 1.75 | 1.87 | 1.80 | 1.65 | 1.78 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.63 | 0.51 | 0.60 | 0.74 | 0.72 | 0.70 | 0.78 | 0.79 | 0.72 | 0.64 | 0.69 |
| Fe+2 | 2.42 | 2.73 | 2.69 | 2.60 | 2.66 | 2.67 | 2.71 | 2.68 | 2.68 | 2.57 | 2.66 |
| Mg | 1.83 | 1.63 | 1.60 | 1.45 | 1.45 | 1.45 | 1.39 | 1.35 | 1.46 | 1.67 | 1.49 |
| Ti | 0.12 | 0.14 | 0.11 | 0.17 | 0.17 | 0.19 | 0.12 | 0.18 | 0.14 | 0.12 | 0.16 |
| Mn | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 4.99 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.09 | 0.09 | 0.09 | 0.00 | 0.05 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.04 |
| Fe+2 | 0.03 | 0.10 | 0.10 | 0.00 | 0.06 | 0.07 | 0.03 | 0.07 | 0.06 | 0.07 | 0.08 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.85 | 1.82 | 1.81 | 1.90 | 1.83 | 1.83 | 1.87 | 1.83 | 1.86 | 1.88 | 1.87 |
| Na | 0.03 | 0.00 | 0.00 | 0.10 | 0.07 | 0.05 | 0.06 | 0.05 | 0.03 | 0.00 | 0.01 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.51 | 0.60 | 0.59 | 0.35 | 0.41 | 0.43 | 0.41 | 0.45 | 0.42 | 0.42 | 0.42 |
| K | 0.35 | 0.34 | 0.36 | 0.27 | 0.31 | 0.33 | 0.39 | 0.33 | 0.40 | 0.32 | 0.36 |
| Ca | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| A | 0.86 | 0.94 | 0.95 | 0.62 | 0.72 | 0.76 | 0.79 | 0.78 | 0.82 | 0.75 | 0.78 |
| CATSUM | 15.86 | 15.94 | 15.95 | 15.61 | 15.72 | 15.76 | 15.79 | 15.78 | 15.82 | 15.75 | 15.78 |
| F | 0.00 | 0.00 | 0.00 | 0.11 | 0.01 | 0.08 | 0.05 | 0.01 | 0.19 | 0.06 | 0.02 |
| Cl | 0.03 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 |
| OHcalc | 1.97 | 1.96 | 1.96 | 1.84 | 1.96 | 1.89 | 1.92 | 1.96 | 1.78 | 1.93 | 1.96 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.57 | 0.64 | 0.64 | 0.64 | 0.65 | 0.65 | 0.66 | 0.67 | 0.65 | 0.61 | 0.65 |
| # | 367 | 368 | 369 | 370 | 371 | 372 | 373 | 374 | 375 | 376 | 377 |

Table 3. Hornblendes from SE Alaskan plutons.

| SAMPLE | AK5 | | | | AK6 | | AK7 | | AK8 | | |
|----------|-------|-------|--------|-------|--------|--------|--------|--------|-------|-------|-------|
| GRAIN | 2 | 3 | | | 1 | 2 | 1 | | 1 | | |
| | r | c | | r | | | | | c | c | r |
| SiO2 | 40.09 | 40.07 | 40.34 | 40.34 | 45.59 | 42.71 | 43.18 | 42.61 | 41.19 | 41.14 | 40.57 |
| Al2O3 | 13.95 | 13.44 | 14.24 | 13.96 | 10.46 | 12.72 | 13.14 | 13.75 | 13.52 | 13.24 | 15.98 |
| FeO | 21.69 | 19.59 | 21.00 | 21.24 | 16.79 | 17.39 | 18.21 | 18.62 | 20.57 | 21.17 | 21.05 |
| MgO | 6.13 | 7.21 | 6.58 | 6.18 | 10.38 | 8.84 | 8.04 | 7.95 | 7.01 | 6.76 | 5.74 |
| CaO | 11.19 | 11.24 | 11.11 | 11.40 | 12.38 | 11.94 | 12.17 | 12.15 | 10.96 | 10.96 | 10.30 |
| Na2O | 1.41 | 1.70 | 1.51 | 1.49 | 1.15 | 1.34 | 1.41 | 1.36 | 1.90 | 1.76 | 2.35 |
| K2O | 1.98 | 1.36 | 1.93 | 1.80 | 1.29 | 1.61 | 1.25 | 1.28 | 1.11 | 1.33 | 0.89 |
| TiO2 | 1.13 | 1.50 | 1.01 | 0.87 | 1.05 | 1.12 | 1.04 | 0.90 | 1.34 | 1.22 | 0.48 |
| MnO | 0.37 | 0.34 | 0.35 | 0.36 | 0.56 | 0.49 | 0.20 | 0.17 | 0.32 | 0.21 | 0.23 |
| BaO | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 |
| Cl | 0.13 | 0.10 | 0.06 | 0.03 | 0.05 | 0.26 | 0.21 | 0.17 | 0.05 | 0.12 | 0.23 |
| F | 0.00 | 0.07 | 0.13 | 0.12 | 0.20 | 0.00 | 0.14 | 0.16 | 0.16 | 0.17 | 0.03 |
| SUBSUM | 98.07 | 97.51 | 98.25 | 97.78 | 99.92 | 98.43 | 99.20 | 99.24 | 98.13 | 98.07 | 97.92 |
| Cl=O | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 | 0.06 | 0.05 | 0.04 | 0.01 | 0.03 | 0.05 |
| F=O | 0.00 | 0.03 | 0.05 | 0.05 | 0.00 | 0.00 | 0.06 | 0.07 | 0.07 | 0.07 | 0.01 |
| SUM | 98.04 | 97.46 | 98.19 | 97.73 | 99.82 | 98.37 | 99.09 | 99.13 | 98.05 | 97.97 | 97.86 |
| H2Ocalc | 1.91 | 1.90 | 1.88 | 1.88 | 1.93 | 1.93 | 1.89 | 1.89 | 1.88 | 1.84 | 1.89 |
| SUM | 99.94 | 99.35 | 100.06 | 99.60 | 101.76 | 100.30 | 100.98 | 101.02 | 99.93 | 99.82 | 99.74 |
| Si | 6.20 | 6.28 | 6.20 | 6.24 | 6.70 | 6.43 | 6.45 | 6.37 | 6.29 | 6.32 | 6.20 |
| Aliv | 1.80 | 1.72 | 1.80 | 1.76 | 1.30 | 1.57 | 1.55 | 1.63 | 1.71 | 1.68 | 1.80 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.74 | 0.71 | 0.78 | 0.78 | 0.51 | 0.68 | 0.76 | 0.80 | 0.73 | 0.71 | 1.09 |
| Fe+2 | 2.71 | 2.47 | 2.60 | 2.69 | 2.06 | 2.19 | 2.27 | 2.33 | 2.52 | 2.60 | 2.55 |
| Mg | 1.41 | 1.65 | 1.51 | 1.42 | 2.27 | 1.98 | 1.79 | 1.77 | 1.60 | 1.55 | 1.31 |
| Ti | 0.13 | 0.17 | 0.12 | 0.10 | 0.12 | 0.13 | 0.12 | 0.10 | 0.15 | 0.14 | 0.06 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 4.97 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | 0.04 | 0.00 | 0.02 | 0.04 | 0.03 | 0.03 |
| Fe+2 | 0.09 | 0.05 | 0.10 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.12 | 0.14 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.85 | 1.85 | 1.83 | 1.89 | 1.95 | 1.92 | 1.95 | 1.95 | 1.79 | 1.80 | 1.69 |
| Na | 0.01 | 0.06 | 0.02 | 0.01 | 0.01 | 0.03 | 0.05 | 0.03 | 0.06 | 0.05 | 0.14 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.41 | 0.45 | 0.43 | 0.43 | 0.32 | 0.36 | 0.36 | 0.37 | 0.51 | 0.47 | 0.56 |
| K | 0.39 | 0.27 | 0.38 | 0.36 | 0.24 | 0.31 | 0.24 | 0.24 | 0.22 | 0.26 | 0.17 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.80 | 0.72 | 0.81 | 0.79 | 0.56 | 0.67 | 0.59 | 0.61 | 0.72 | 0.73 | 0.73 |
| CATSUM | 15.80 | 15.72 | 15.81 | 15.79 | 15.56 | 15.67 | 15.56 | 15.61 | 15.72 | 15.73 | 15.73 |
| F | 0.00 | 0.03 | 0.06 | 0.06 | 0.09 | 0.00 | 0.07 | 0.08 | 0.08 | 0.08 | 0.01 |
| Cl | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.07 | 0.05 | 0.04 | 0.01 | 0.03 | 0.06 |
| OHcalc | 1.97 | 1.94 | 1.92 | 1.93 | 1.89 | 1.93 | 1.88 | 1.88 | 1.91 | 1.89 | 1.93 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.66 | 0.60 | 0.64 | 0.66 | 0.48 | 0.52 | 0.56 | 0.57 | 0.62 | 0.64 | 0.67 |
| # | 378 | 379 | 380 | 381 | 382 | 383 | 384 | 385 | 386 | 387 | 388 |

Table 3. Hornblendes from SE Alaskan plutons.

| | |
|----------|-------|
| SAMPLE | AK8 |
| GRAIN | 1 |
| | r |
| SiO2 | 42.16 |
| Al2O3 | 14.54 |
| FeO | 20.51 |
| MgO | 6.62 |
| CaO | 10.37 |
| Na2O | 2.23 |
| K2O | 0.75 |
| TiO2 | 0.20 |
| MnO | 0.20 |
| BaO | 0.05 |
| Cl | 0.20 |
| F | 0.01 |
| SUBSUM | 97.85 |
| Cl=O | 0.04 |
| F=O | 0.00 |
| SUM | 97.80 |
| H2Ocalc | 1.92 |
| SUM | 99.72 |
| Si | 6.41 |
| Aliv | 1.59 |
| T | 8.00 |
| Alvi | 1.01 |
| Fe+2 | 2.46 |
| Mg | 1.50 |
| Ti | 0.02 |
| Mn | 0.00 |
| M1-M3 | 5.00 |
| Mn | 0.03 |
| Fe+2 | 0.14 |
| Mg | 0.00 |
| Ca | 1.69 |
| Na | 0.14 |
| M4 | 2.00 |
| Na | 0.52 |
| K | 0.15 |
| Ca | 0.00 |
| A | 0.66 |
| CATSUM | 15.66 |
| F | 0.01 |
| Cl | 0.05 |
| OHcalc | 1.94 |
| ANSUM | 2.00 |
| Fe/Fe+Mg | 0.63 |
| # | 389 |

KEY TO TABLE 4

| ANALYSIS # | SAMPLE CODE | SAMPLE # | ROCK DESCRIPTION |
|------------|----------------|----------|------------------|
| 390-395 | ID1 | 7-30-5 | tonalite |
| 396-401 | ID2 | Riggins | trondhjemite #3 |
| 402-405 | ID3 | Riggins | trondhjemite #1 |

Samples were collected by E-an Zen at roadcuts along U.S. Rt. 95 in the Indian Mountain quadrangle, west-central Idaho, near Round Valley in an area mapped as trondhjemite by Hamilton (1969). These are epidote-bearing tonalite intrusives described in Zen and Hammarstrom (1984). Trondhjemites near Riggins are described in Barker and others (1979) and Hamilton (1963).

Table 4. Hornblendes from the Round Valley area, Idaho.

| SAMPLE GRAIN | ID1 | | | | | | ID2 | | | | | |
|-----------------|--------|-------|-------|-------|--------|--------|--------|--------|--------|--------|-------|--|
| | 1 | | | 2 | | | 1 | | | 3 | | |
| | r | c | c | r | c | | | | | | | |
| SiO2 | 40.78 | 40.64 | 40.95 | 41.51 | 40.73 | 40.84 | 42.23 | 41.67 | 41.59 | 40.98 | 40.06 | |
| Al2O3 | 14.14 | 13.95 | 13.14 | 12.79 | 14.01 | 13.93 | 13.19 | 13.78 | 13.39 | 14.13 | 13.90 | |
| FeO | 19.45 | 19.46 | 18.94 | 19.06 | 19.78 | 19.54 | 19.81 | 19.99 | 19.84 | 20.32 | 20.10 | |
| MgO | 7.58 | 7.53 | 8.32 | 8.34 | 7.64 | 8.02 | 7.43 | 7.31 | 7.51 | 7.70 | 7.67 | |
| CaO | 11.63 | 11.70 | 11.60 | 11.82 | 11.32 | 11.67 | 12.30 | 12.06 | 12.21 | 11.25 | 11.30 | |
| Na2O | 1.55 | 1.57 | 1.58 | 1.56 | 1.74 | 1.66 | 1.66 | 1.84 | 1.52 | 1.65 | 1.68 | |
| K2O | 1.43 | 1.41 | 1.31 | 1.25 | 1.24 | 1.17 | 1.23 | 1.32 | 1.48 | 1.58 | 1.55 | |
| TiO2 | 1.03 | 1.00 | 0.79 | 0.87 | 1.02 | 0.94 | 0.97 | 1.10 | 0.69 | 0.76 | 0.70 | |
| MnO | 0.57 | 0.58 | 0.60 | 0.54 | 0.65 | 0.62 | 0.74 | 0.67 | 0.47 | 0.60 | 0.60 | |
| BaO | 0.15 | 0.11 | 0.15 | 0.14 | 0.19 | 0.13 | n | n | n | 0.04 | 0.04 | |
| Cl | 0.04 | 0.03 | 0.03 | 0.02 | 0.07 | 0.03 | 0.04 | 0.00 | 0.00 | 0.07 | 0.06 | |
| F | 0.33 | 0.23 | 0.19 | 0.23 | 0.16 | 0.25 | 0.00 | 0.00 | 0.05 | 0.05 | 0.02 | |
| SUBSUM | 98.68 | 98.21 | 97.60 | 98.13 | 98.55 | 98.80 | 99.61 | 99.86 | 98.83 | 99.13 | 97.68 | |
| Cl=O | 0.01 | 0.01 | 0.01 | 0.00 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 | 0.01 | |
| F=O | 0.14 | 0.10 | 0.08 | 0.10 | 0.07 | 0.11 | 0.00 | 0.00 | 0.02 | 0.02 | 0.01 | |
| SUM | 98.53 | 98.11 | 97.51 | 98.03 | 98.47 | 98.69 | 99.60 | 99.86 | 98.81 | 99.09 | 97.66 | |
| H2Ocalc | 1.00 | 1.84 | 1.86 | 1.85 | 1.87 | 1.85 | 1.99 | 2.00 | 1.95 | 1.94 | 1.92 | |
| SUM | 100.34 | 99.95 | 99.37 | 99.88 | 100.34 | 100.54 | 101.59 | 101.86 | 100.76 | 101.03 | 99.58 | |
| Si | 6.21 | 6.21 | 6.28 | 6.33 | 6.21 | 6.20 | 6.34 | 6.25 | 6.31 | 6.21 | 6.17 | |
| Aliv | 1.79 | 1.79 | 1.72 | 1.67 | 1.79 | 1.80 | 1.66 | 1.75 | 1.69 | 1.79 | 1.83 | |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Alvi | 0.75 | 0.73 | 0.66 | 0.63 | 0.72 | 0.70 | 0.68 | 0.69 | 0.70 | 0.74 | 0.70 | |
| Fe+2 | 2.42 | 2.44 | 2.35 | 2.37 | 2.42 | 2.38 | 2.49 | 2.51 | 2.52 | 2.44 | 2.46 | |
| Mg | 1.72 | 1.72 | 1.90 | 1.90 | 1.74 | 1.82 | 1.66 | 1.64 | 1.70 | 1.74 | 1.76 | |
| Ti | 0.12 | 0.11 | 0.09 | 0.10 | 0.12 | 0.11 | 0.11 | 0.12 | 0.08 | 0.09 | 0.08 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.04 | 0.01 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | |
| Mn | 0.07 | 0.08 | 0.08 | 0.07 | 0.08 | 0.08 | 0.04 | 0.05 | 0.05 | 0.08 | 0.08 | |
| Fe+2 | 0.06 | 0.05 | 0.08 | 0.06 | 0.10 | 0.10 | 0.00 | 0.00 | 0.00 | 0.14 | 0.13 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.87 | 1.88 | 1.84 | 1.87 | 1.82 | 1.82 | 1.96 | 1.94 | 1.95 | 1.79 | 1.79 | |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.46 | 0.47 | 0.47 | 0.46 | 0.51 | 0.49 | 0.48 | 0.52 | 0.45 | 0.48 | 0.50 | |
| K | 0.28 | 0.28 | 0.26 | 0.24 | 0.24 | 0.23 | 0.24 | 0.25 | 0.29 | 0.31 | 0.30 | |
| Ca | 0.03 | 0.04 | 0.07 | 0.06 | 0.03 | 0.08 | 0.02 | 0.00 | 0.04 | 0.04 | 0.08 | |
| A | 0.76 | 0.78 | 0.79 | 0.76 | 0.78 | 0.79 | 0.74 | 0.77 | 0.77 | 0.83 | 0.88 | |
| CATSUM | 15.76 | 15.78 | 15.79 | 15.76 | 15.78 | 15.79 | 15.74 | 15.77 | 15.77 | 15.83 | 15.88 | |
| F | 0.16 | 0.11 | 0.09 | 0.11 | 0.08 | 0.12 | 0.00 | 0.00 | 0.02 | 0.02 | 0.01 | |
| Cl | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 | 0.02 | |
| OHcalc | 1.83 | 1.88 | 1.90 | 1.88 | 1.90 | 1.87 | 1.99 | 2.00 | 1.98 | 1.96 | 1.97 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.59 | 0.59 | 0.56 | 0.56 | 0.59 | 0.58 | 0.60 | 0.61 | 0.60 | 0.60 | 0.60 | |
| # | 390 | 391 | 392 | 393 | 394 | 395 | 396 | 397 | 398 | 399 | 400 | |

Table 4. Hornblendes from the Round Valley area, Idaho.

| SAMPLE | ID2 | ID3 | | | |
|----------|--------|-------|--------|--------|-------|
| GRAIN | 3 | 1 | 2 | | |
| | | c | r | | |
| SiO2 | 41.11 | 40.08 | 40.80 | 40.31 | 41.47 |
| Al2O3 | 14.33 | 13.49 | 14.03 | 13.70 | 12.61 |
| FeO | 20.38 | 19.93 | 19.90 | 20.07 | 19.66 |
| MgO | 7.46 | 7.98 | 7.88 | 8.12 | 8.69 |
| CaO | 11.21 | 11.36 | 11.39 | 11.20 | 11.33 |
| Na2O | 1.71 | 1.83 | 1.78 | 1.87 | 1.83 |
| K2O | 1.44 | 1.11 | 1.09 | 1.08 | 0.55 |
| TiO2 | 0.77 | 0.88 | 0.80 | 0.98 | 0.92 |
| MnO | 0.57 | 0.54 | 0.54 | 0.56 | 0.55 |
| BaO | 0.04 | 0.07 | 0.09 | 0.15 | 0.11 |
| Cl | 0.09 | 0.00 | 0.02 | 0.02 | 0.00 |
| F | 0.03 | 0.21 | 0.20 | 0.15 | 0.17 |
| SUBSUM | 99.14 | 97.48 | 98.52 | 98.21 | 97.89 |
| Cl=0 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| F=0 | 0.01 | 0.09 | 0.08 | 0.06 | 0.07 |
| SUM | 99.11 | 97.39 | 98.43 | 98.14 | 97.82 |
| H2Ocalc | 1.94 | 1.84 | 1.87 | 1.88 | 1.89 |
| SUM | 101.05 | 99.23 | 100.30 | 100.02 | 99.70 |
| Si | 6.22 | 6.19 | 6.21 | 6.17 | 6.33 |
| Aliv | 1.78 | 1.81 | 1.79 | 1.83 | 1.67 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.78 | 0.64 | 0.73 | 0.64 | 0.59 |
| Fe+2 | 2.45 | 2.42 | 2.39 | 2.39 | 2.33 |
| Mg | 1.68 | 1.84 | 1.79 | 1.85 | 1.98 |
| Ti | 0.09 | 0.10 | 0.09 | 0.11 | 0.11 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Fe+2 | 0.13 | 0.15 | 0.14 | 0.18 | 0.18 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.80 | 1.78 | 1.79 | 1.75 | 1.75 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.50 | 0.55 | 0.53 | 0.56 | 0.54 |
| K | 0.28 | 0.22 | 0.21 | 0.21 | 0.11 |
| Ca | 0.02 | 0.10 | 0.07 | 0.09 | 0.10 |
| A | 0.80 | 0.86 | 0.80 | 0.85 | 0.75 |
| CATSUM | 15.80 | 15.86 | 15.80 | 15.85 | 15.75 |
| F | 0.01 | 0.10 | 0.10 | 0.07 | 0.08 |
| Cl | 0.02 | 0.00 | 0.01 | 0.01 | 0.00 |
| OHcalc | 1.96 | 1.90 | 1.90 | 1.92 | 1.92 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.61 | 0.58 | 0.59 | 0.58 | 0.56 |
| # | 401 | 402 | 403 | 404 | 405 |

KEY TO TABLE 5

| ANALYSIS # | SAMPLE CODE | SAMPLE # | ROCK DESCRIPTION |
|------------|----------------|----------|------------------|
| 406-426 | BC1 | JS-E2 | granodiorite |

The Ecstall pluton is a Late Cretaceous epidote-bearing intrusive near Prince Rupert, British Columbia (Hutchison, 1982; Woodsworth and others, 1983). Jinny Sisson of Princeton University provided us with JS-E2, a sample of Ecstall granodiorite. Estimate of emplacement pressure for these rocks is given by Crawford and Hollister (1982).

Table 5. Hornblendes from the Ecstall Pluton, British Columbia.

| SAMPLE GRAIN | BC1 | | | | | | | | | | |
|----------------------------------|--------|--------|--------|--------|-------|-------|--------|-------|--------|-------|--------|
| | 1 | 2 | 3 | | | | | | | | |
| | r | | | | | | | | | | |
| SiO ₂ | 41.48 | 42.05 | 41.99 | 41.38 | 40.96 | 41.41 | 41.49 | 41.56 | 41.80 | 41.93 | 41.78 |
| Al ₂ O ₃ | 12.33 | 12.21 | 12.52 | 12.18 | 12.55 | 11.97 | 12.62 | 12.33 | 12.54 | 12.21 | 12.52 |
| FeO | 18.15 | 17.72 | 17.42 | 17.88 | 17.91 | 17.83 | 18.03 | 17.94 | 18.22 | 17.73 | 18.39 |
| MgO | 9.48 | 9.42 | 9.75 | 9.40 | 9.49 | 9.67 | 9.67 | 9.66 | 9.50 | 9.71 | 9.55 |
| CaO | 12.01 | 12.18 | 12.27 | 12.16 | 11.15 | 11.13 | 11.28 | 11.37 | 11.19 | 11.30 | 11.28 |
| Na ₂ O | 1.82 | 1.86 | 1.90 | 1.86 | 1.82 | 1.79 | 1.90 | 1.85 | 1.80 | 1.83 | 1.88 |
| K ₂ O | 1.66 | 1.68 | 1.72 | 1.72 | 1.64 | 1.56 | 1.67 | 1.69 | 1.67 | 1.64 | 1.76 |
| TiO ₂ | 0.75 | 1.02 | 1.01 | 1.02 | 0.84 | 0.83 | 0.96 | 0.83 | 0.88 | 0.80 | 0.82 |
| MnO | 0.48 | 0.53 | 0.46 | 0.48 | 0.54 | 0.53 | 0.57 | 0.57 | 0.54 | 0.56 | 0.61 |
| BaO | n | n | n | n | 0.04 | 0.00 | 0.00 | 0.03 | 0.13 | 0.00 | 0.09 |
| Cl | 0.22 | 0.15 | 0.17 | 0.20 | 0.20 | 0.19 | 0.17 | 0.20 | 0.23 | 0.23 | 0.23 |
| F | 0.06 | 0.00 | 0.00 | 0.04 | 0.31 | 0.07 | 0.14 | 0.24 | 0.37 | 0.27 | 0.13 |
| SUBSUM | 98.56 | 98.82 | 99.21 | 98.50 | 97.45 | 96.98 | 98.50 | 98.27 | 98.87 | 98.21 | 99.04 |
| Cl=O | 0.05 | 0.03 | 0.04 | 0.05 | 0.05 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 |
| F=O | 0.03 | 0.00 | 0.00 | 0.02 | 0.13 | 0.03 | 0.06 | 0.10 | 0.16 | 0.11 | 0.05 |
| SUM | 98.49 | 98.79 | 99.17 | 98.44 | 97.27 | 96.91 | 98.40 | 98.12 | 98.66 | 98.04 | 98.93 |
| H ₂ O _{calc} | 1.89 | 1.95 | 1.95 | 1.90 | 1.75 | 1.87 | 1.87 | 1.81 | 1.74 | 1.79 | 1.86 |
| SUM | 100.37 | 100.74 | 101.13 | 100.34 | 99.03 | 98.78 | 100.27 | 99.93 | 100.41 | 99.83 | 100.80 |
| Si | 6.30 | 6.34 | 6.30 | 6.29 | 6.29 | 6.36 | 6.29 | 6.33 | 6.33 | 6.37 | 6.32 |
| Al _{iv} | 1.70 | 1.66 | 1.70 | 1.71 | 1.71 | 1.64 | 1.71 | 1.67 | 1.67 | 1.63 | 1.68 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Al _{vi} | 0.51 | 0.52 | 0.52 | 0.47 | 0.56 | 0.53 | 0.55 | 0.54 | 0.57 | 0.56 | 0.55 |
| Fe ⁺² | 2.26 | 2.24 | 2.19 | 2.27 | 2.17 | 2.16 | 2.16 | 2.18 | 2.18 | 2.15 | 2.21 |
| Mg | 2.15 | 2.12 | 2.18 | 2.13 | 2.17 | 2.21 | 2.18 | 2.19 | 2.15 | 2.20 | 2.15 |
| Ti | 0.09 | 0.12 | 0.11 | 0.12 | 0.10 | 0.10 | 0.11 | 0.10 | 0.10 | 0.09 | 0.09 |
| Mn | 0.00 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.06 | 0.05 | 0.06 | 0.05 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 |
| Fe ⁺² | 0.04 | 0.00 | 0.00 | 0.00 | 0.14 | 0.13 | 0.13 | 0.11 | 0.13 | 0.10 | 0.12 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.89 | 1.95 | 1.94 | 1.95 | 1.79 | 1.80 | 1.80 | 1.82 | 1.80 | 1.83 | 1.80 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.54 | 0.54 | 0.55 | 0.55 | 0.54 | 0.53 | 0.56 | 0.55 | 0.53 | 0.54 | 0.55 |
| K | 0.32 | 0.32 | 0.33 | 0.33 | 0.32 | 0.31 | 0.32 | 0.33 | 0.32 | 0.32 | 0.34 |
| Ca | 0.06 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.03 | 0.01 | 0.01 | 0.02 |
| A | 0.92 | 0.89 | 0.92 | 0.91 | 0.90 | 0.88 | 0.91 | 0.91 | 0.86 | 0.87 | 0.91 |
| CATSUM | 15.92 | 15.89 | 15.92 | 15.91 | 15.90 | 15.88 | 15.91 | 15.91 | 15.86 | 15.87 | 15.91 |
| F | 0.03 | 0.00 | 0.00 | 0.02 | 0.15 | 0.03 | 0.07 | 0.12 | 0.18 | 0.13 | 0.06 |
| Cl | 0.06 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.04 | 0.05 | 0.06 | 0.06 | 0.06 |
| OH _{calc} | 1.91 | 1.96 | 1.96 | 1.93 | 1.80 | 1.92 | 1.89 | 1.83 | 1.76 | 1.81 | 1.88 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.52 | 0.51 | 0.50 | 0.52 | 0.51 | 0.51 | 0.51 | 0.51 | 0.52 | 0.51 | 0.52 |
| # | 406 | 407 | 408 | 409 | 410 | 411 | 412 | 413 | 414 | 415 | 416 |

Table 5. Hornblendes from the Ecstall Pluton, British Columbia.

| SAMPLE GRAIN | BC1 3 | | | | | | | | | |
|-----------------|----------|--------|--------|-------|--------|--------|-------|--------|--------|--------|
| SiO2 | 41.86 | 41.31 | 41.24 | 41.21 | 42.05 | 42.51 | 41.34 | 41.72 | 41.24 | 41.93 |
| Al2O3 | 12.27 | 12.69 | 12.76 | 12.54 | 12.45 | 12.31 | 12.65 | 12.61 | 12.69 | 12.53 |
| FeO | 18.56 | 18.62 | 18.31 | 18.45 | 18.49 | 18.32 | 18.18 | 18.44 | 18.25 | 18.19 |
| MgO | 9.52 | 9.57 | 9.60 | 9.51 | 9.71 | 9.92 | 9.54 | 9.58 | 9.76 | 9.56 |
| CaO | 11.24 | 11.07 | 11.15 | 11.18 | 11.25 | 11.12 | 11.08 | 11.41 | 11.36 | 11.15 |
| Na2O | 1.88 | 1.90 | 1.88 | 1.86 | 1.85 | 1.89 | 1.90 | 1.79 | 1.82 | 1.86 |
| K2O | 1.73 | 1.68 | 1.76 | 1.66 | 1.66 | 1.62 | 1.71 | 1.64 | 1.62 | 1.58 |
| TiO2 | 0.98 | 0.89 | 1.01 | 0.83 | 0.88 | 0.92 | 0.89 | 0.84 | 0.89 | 0.88 |
| MnO | 0.56 | 0.56 | 0.52 | 0.55 | 0.59 | 0.57 | 0.54 | 0.56 | 0.58 | 0.55 |
| BaO | 0.09 | 0.06 | 0.00 | 0.07 | 0.00 | 0.09 | 0.00 | 0.12 | 0.00 | 0.09 |
| Cl | 0.21 | 0.24 | 0.22 | 0.18 | 0.20 | 0.16 | 0.24 | 0.22 | 0.18 | 0.25 |
| F | 0.06 | 0.11 | 0.03 | 0.05 | 0.12 | 0.11 | 0.00 | 0.06 | 0.13 | 0.05 |
| SUBSUM | 98.96 | 98.70 | 98.48 | 98.09 | 99.25 | 99.54 | 98.07 | 98.99 | 98.52 | 98.62 |
| Cl=O | 0.05 | 0.05 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 | 0.06 |
| F=O | 0.03 | 0.05 | 0.01 | 0.02 | 0.05 | 0.05 | 0.00 | 0.03 | 0.05 | 0.02 |
| SUM | 98.89 | 98.60 | 98.42 | 98.03 | 99.15 | 99.46 | 98.02 | 98.92 | 98.42 | 98.54 |
| H2Ocalc | 1.90 | 1.86 | 1.90 | 1.90 | 1.88 | 1.91 | 1.91 | 1.90 | 1.87 | 1.89 |
| SUM | 100.79 | 100.46 | 100.32 | 99.92 | 101.04 | 101.37 | 99.92 | 100.82 | 100.29 | 100.44 |
| Si | 6.33 | 6.27 | 6.26 | 6.29 | 6.33 | 6.37 | 6.29 | 6.30 | 6.26 | 6.34 |
| Aliv | 1.67 | 1.73 | 1.74 | 1.71 | 1.67 | 1.63 | 1.71 | 1.70 | 1.74 | 1.66 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.52 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.56 | 0.55 | 0.53 | 0.58 |
| Fe+2 | 2.22 | 2.19 | 2.17 | 2.20 | 2.18 | 2.14 | 2.17 | 2.20 | 2.16 | 2.17 |
| Mg | 2.15 | 2.17 | 2.17 | 2.16 | 2.18 | 2.21 | 2.16 | 2.16 | 2.21 | 2.16 |
| Ti | 0.11 | 0.10 | 0.12 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Fe+2 | 0.12 | 0.17 | 0.16 | 0.15 | 0.15 | 0.15 | 0.15 | 0.13 | 0.16 | 0.13 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.81 | 1.75 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 1.80 | 1.77 | 1.80 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.55 | 0.56 | 0.55 | 0.55 | 0.54 | 0.55 | 0.56 | 0.52 | 0.54 | 0.55 |
| K | 0.33 | 0.33 | 0.34 | 0.32 | 0.32 | 0.31 | 0.33 | 0.32 | 0.31 | 0.30 |
| Ca | 0.02 | 0.05 | 0.04 | 0.05 | 0.04 | 0.01 | 0.02 | 0.05 | 0.00 | 0.01 |
| A | 0.90 | 0.93 | 0.93 | 0.92 | 0.89 | 0.87 | 0.92 | 0.89 | 0.93 | 0.86 |
| CATSUM | 15.90 | 15.93 | 15.93 | 15.92 | 15.89 | 15.87 | 15.92 | 15.89 | 15.93 | 15.86 |
| F | 0.03 | 0.05 | 0.01 | 0.02 | 0.06 | 0.05 | 0.00 | 0.03 | 0.06 | 0.02 |
| Cl | 0.05 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.06 | 0.06 | 0.05 | 0.06 |
| OHcalc | 1.92 | 1.89 | 1.93 | 1.93 | 1.89 | 1.91 | 1.94 | 1.91 | 1.89 | 1.91 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.51 | 0.52 | 0.52 | 0.51 | 0.52 |
| # | 417 | 418 | 419 | 420 | 421 | 422 | 423 | 424 | 425 | 426 |

KEY TO TABLE 6

| ANALYSIS # | SAMPLE CODE | LOCATION | ROCK TYPES | REFERENCE |
|------------|-------------|--|---|----------------------------------|
| 427-446 | A | SW Japan Batholith Chubu - Central Chugoku transects | gabbro, quartz monzonite, quartz monzodiorite, granodiorite, monzogranite | Czamanske and others, 1981 |
| 447-452 | B | Teutonia Batholith Mojave Desert, CA | hornblende gabbro, adamellite, monzodiorite, quartz-monzodiorite | Beckerman and others, 1982 |
| 443-469 | C | Pliny Range, New New Hampshire | syenite, diorite, quartz monzonite, granite | Czamanske and others, 1977 |
| 470-477 | D | Finnmarka Complex, Norway | monzonite, granodiorite | Czamanske & Wones, 1973 |
| 478-483 | E | Dinkey Creek Intrusive Series Sierra Nevada Batholith, CA | quartz diorite, tonalite, granodiorite | Guy, 1980 |

Table 6. Hornblendes from other plutonic complexes.

| SAMPLE | A | | | | | | | | | | |
|----------|-------|-------|-------|--------|-------|--------|--------|--------|--------|-------|-------|
| SiO2 | 43.90 | 48.30 | 48.80 | 50.40 | 47.80 | 44.10 | 43.10 | 44.20 | 44.90 | 42.10 | 45.00 |
| Al2O3 | 9.82 | 6.08 | 5.65 | 3.47 | 6.10 | 7.85 | 8.63 | 9.95 | 8.84 | 10.30 | 8.20 |
| FeO | 16.54 | 14.10 | 12.50 | 22.50 | 15.93 | 25.08 | 24.67 | 17.07 | 21.43 | 20.52 | 18.43 |
| MgO | 11.20 | 13.80 | 15.00 | 9.84 | 13.30 | 6.15 | 5.92 | 10.90 | 7.50 | 8.05 | 10.10 |
| CaO | 11.50 | 11.50 | 11.30 | 10.70 | 10.70 | 10.20 | 10.30 | 11.10 | 11.40 | 11.10 | 11.20 |
| Na2O | 1.45 | 1.07 | 1.19 | 0.39 | 1.54 | 1.69 | 1.85 | 1.33 | 1.05 | 1.61 | 1.60 |
| K2O | 0.52 | 0.49 | 0.48 | 0.17 | 0.53 | 0.83 | 1.05 | 0.74 | 1.13 | 0.91 | 0.97 |
| TiO2 | 2.43 | 1.28 | 1.10 | 0.08 | 1.26 | 1.07 | 1.28 | 2.49 | 1.16 | 1.06 | 1.71 |
| MnO | 0.60 | 0.51 | 0.78 | 0.50 | 0.26 | 1.53 | 1.22 | 0.30 | 0.64 | 0.92 | 0.50 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.02 | 0.04 | 0.09 | 0.00 | 0.06 | 0.07 | 0.10 | 0.02 | 0.03 | 0.14 | 0.08 |
| F | 0.09 | 0.16 | 0.26 | 0.10 | 0.45 | 0.49 | 0.58 | 0.11 | 0.23 | 0.34 | 0.24 |
| SUBSUM | 98.07 | 97.33 | 97.15 | 98.15 | 97.93 | 99.06 | 98.70 | 98.21 | 98.31 | 97.85 | 98.83 |
| Cl=O | 0.00 | 0.01 | 0.02 | 0.00 | 0.01 | 0.02 | 0.02 | 0.00 | 0.01 | 0.03 | 0.02 |
| F=O | 0.04 | 0.07 | 0.11 | 0.04 | 0.19 | 0.21 | 0.24 | 0.05 | 0.10 | 0.14 | 0.10 |
| SUM | 98.03 | 97.26 | 97.02 | 98.11 | 97.73 | 98.84 | 98.43 | 98.16 | 98.21 | 97.68 | 97.91 |
| H2Ocalc | 1.96 | 1.94 | 1.89 | 1.95 | 1.79 | 1.68 | 1.62 | 1.95 | 1.85 | 1.75 | 1.85 |
| SUM | 99.98 | 99.20 | 98.91 | 100.06 | 99.52 | 100.52 | 100.05 | 100.11 | 100.06 | 99.42 | 99.76 |
| Si | 6.56 | 7.13 | 7.18 | 7.58 | 7.10 | 6.84 | 6.73 | 6.59 | 6.85 | 6.49 | 6.80 |
| Aliv | 1.44 | 0.87 | 0.82 | 0.42 | 0.90 | 1.16 | 1.27 | 1.41 | 1.15 | 1.51 | 1.20 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.29 | 0.19 | 0.16 | 0.20 | 0.16 | 0.28 | 0.31 | 0.34 | 0.44 | 0.36 | 0.26 |
| Fe+2 | 1.94 | 1.63 | 1.43 | 2.59 | 1.75 | 3.17 | 3.16 | 1.95 | 2.72 | 2.57 | 2.26 |
| Mg | 2.49 | 3.04 | 3.29 | 2.21 | 2.94 | 1.42 | 1.38 | 2.42 | 1.71 | 1.85 | 2.28 |
| Ti | 0.27 | 0.14 | 0.12 | 0.01 | 0.14 | 0.12 | 0.15 | 0.28 | 0.13 | 0.22 | 0.19 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.08 | 0.06 | 0.10 | 0.06 | 0.03 | 0.20 | 0.16 | 0.04 | 0.08 | 0.12 | 0.06 |
| Fe+2 | 0.12 | 0.11 | 0.11 | 0.24 | 0.22 | 0.08 | 0.06 | 0.18 | 0.01 | 0.07 | 0.06 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.80 | 1.82 | 1.78 | 1.69 | 1.70 | 1.70 | 1.72 | 1.77 | 1.86 | 1.81 | 1.81 |
| Na | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.02 | 0.06 | 0.01 | 0.04 | 0.00 | 0.06 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.42 | 0.38 | 0.33 | 0.11 | 0.40 | 0.49 | 0.50 | 0.37 | 0.27 | 0.48 | 0.41 |
| K | 0.10 | 0.09 | 0.09 | 0.03 | 0.10 | 0.16 | 0.21 | 0.14 | 0.22 | 0.18 | 0.19 |
| Ca | 0.04 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| A | 0.56 | 0.40 | 0.42 | 0.18 | 0.50 | 0.65 | 0.71 | 0.51 | 0.49 | 0.69 | 0.60 |
| CATSUM | 15.56 | 15.40 | 15.42 | 15.18 | 15.50 | 15.65 | 15.71 | 15.51 | 15.49 | 15.69 | 15.60 |
| F | 0.04 | 0.07 | 0.12 | 0.05 | 0.21 | 0.24 | 0.29 | 0.05 | 0.11 | 0.17 | 0.11 |
| Cl | 0.01 | 0.01 | 0.02 | 0.00 | 0.02 | 0.02 | 0.03 | 0.01 | 0.01 | 0.04 | 0.02 |
| OHcalc | 1.95 | 1.92 | 1.86 | 1.95 | 1.77 | 1.74 | 1.69 | 1.94 | 1.88 | 1.80 | 1.86 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.45 | 0.36 | 0.32 | 0.56 | 0.40 | 0.70 | 0.70 | 0.47 | 0.62 | 0.59 | 0.51 |
| # | 427 | 428 | 429 | 430 | 431 | 432 | 433 | 434 | 435 | 436 | 437 |

Table 6. Hornblendes from other plutonic complexes.

| SAMPLE | A | | | | | | | | | | B |
|--------------------------------|-------|-------|-------|-------|-------|--------|-------|-------|-------|--------|-------|
| SiO ₂ | 41.70 | 47.20 | 45.30 | 45.50 | 42.40 | 44.90 | 46.70 | 43.40 | 44.80 | 45.44 | 47.41 |
| Al ₂ O ₃ | 11.40 | 6.32 | 7.74 | 7.91 | 9.06 | 9.61 | 7.56 | 9.94 | 9.41 | 9.10 | 5.57 |
| FeO | 16.54 | 22.20 | 21.36 | 21.26 | 24.13 | 21.98 | 18.85 | 23.03 | 21.40 | 14.92 | 14.53 |
| MgO | 10.20 | 8.15 | 7.86 | 7.92 | 5.08 | 7.22 | 9.34 | 5.85 | 7.11 | 12.99 | 13.04 |
| CaO | 10.90 | 9.96 | 10.70 | 10.70 | 10.70 | 10.70 | 11.20 | 11.10 | 11.20 | 11.73 | 11.39 |
| Na ₂ O | 2.58 | 1.09 | 1.42 | 1.31 | 1.85 | 1.24 | 1.10 | 1.30 | 1.09 | 1.18 | 1.55 |
| K ₂ O | 0.65 | 0.57 | 0.88 | 0.80 | 1.14 | 0.61 | 0.76 | 1.27 | 1.11 | 0.75 | 0.63 |
| TiO ₂ | 2.76 | 0.60 | 1.29 | 1.59 | 1.37 | 1.25 | 1.51 | 1.40 | 1.10 | 1.73 | 0.95 |
| MnO | 0.67 | 0.65 | 1.08 | 0.74 | 1.50 | 0.51 | 0.51 | 0.60 | 0.65 | 0.31 | 1.71 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.03 | 0.10 | 0.19 | 0.08 | 0.13 | 0.04 | 0.06 | 0.10 | 0.06 | 0.09 | 0.04 |
| F | 0.53 | 0.41 | 0.45 | 0.28 | 0.80 | 0.14 | 0.19 | 0.38 | 0.23 | 0.03 | 0.63 |
| SUBSUM | 97.96 | 97.25 | 98.27 | 98.09 | 98.16 | 98.21 | 97.78 | 98.37 | 98.16 | 98.27 | 97.45 |
| Cl=O | 0.01 | 0.02 | 0.04 | 0.02 | 0.03 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 |
| F=O | 0.22 | 0.17 | 0.19 | 0.12 | 0.34 | 0.06 | 0.08 | 0.16 | 0.10 | 0.01 | 0.27 |
| SUM | 97.73 | 97.05 | 98.04 | 97.96 | 97.80 | 98.14 | 97.69 | 98.19 | 98.05 | 98.24 | 97.18 |
| H ₂ Ocalc | 1.72 | 1.73 | 1.70 | 1.81 | 1.49 | 1.90 | 1.89 | 1.74 | 1.84 | 1.99 | 1.69 |
| SUM | 99.46 | 98.79 | 99.74 | 99.77 | 99.29 | 100.04 | 99.57 | 99.93 | 99.89 | 100.23 | 98.86 |
| Si | 6.31 | 7.25 | 6.94 | 6.94 | 6.68 | 6.82 | 7.03 | 6.70 | 6.84 | 6.71 | 7.12 |
| Aliv | 1.69 | 0.75 | 1.06 | 1.06 | 1.32 | 1.18 | 0.97 | 1.30 | 1.16 | 1.29 | 0.88 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.35 | 0.39 | 0.34 | 0.36 | 0.37 | 0.55 | 0.38 | 0.51 | 0.53 | 0.29 | 0.10 |
| Fe+2 | 2.04 | 2.68 | 2.72 | 2.66 | 3.18 | 2.67 | 2.36 | 2.97 | 2.73 | 1.66 | 1.82 |
| Mg | 2.30 | 1.86 | 1.79 | 1.80 | 1.19 | 1.64 | 2.10 | 1.35 | 1.62 | 2.86 | 2.92 |
| Ti | 0.31 | 0.07 | 0.15 | 0.18 | 0.16 | 0.14 | 0.17 | 0.16 | 0.13 | 0.19 | 0.11 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.09 | 0.08 | 0.14 | 0.10 | 0.11 | 0.07 | 0.07 | 0.07 | 0.08 | 0.04 | 0.17 |
| Fe+2 | 0.06 | 0.17 | 0.02 | 0.05 | 0.00 | 0.12 | 0.02 | 0.00 | 0.00 | 0.18 | 0.00 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.77 | 1.64 | 1.76 | 1.75 | 1.81 | 1.74 | 1.81 | 1.84 | 1.83 | 1.78 | 1.83 |
| Na | 0.09 | 0.10 | 0.08 | 0.10 | 0.09 | 0.07 | 0.11 | 0.09 | 0.08 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.67 | 0.22 | 0.34 | 0.28 | 0.48 | 0.29 | 0.21 | 0.30 | 0.24 | 0.34 | 0.45 |
| K | 0.13 | 0.11 | 0.17 | 0.16 | 0.23 | 0.12 | 0.15 | 0.25 | 0.22 | 0.14 | 0.12 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 |
| A | 0.80 | 0.33 | 0.51 | 0.44 | 0.71 | 0.41 | 0.36 | 0.55 | 0.46 | 0.55 | 0.57 |
| CATSUM | 15.80 | 15.33 | 15.51 | 15.44 | 15.71 | 15.41 | 15.36 | 15.55 | 15.46 | 15.55 | 15.57 |
| F | 0.25 | 0.20 | 0.22 | 0.14 | 0.40 | 0.07 | 0.09 | 0.19 | 0.11 | 0.01 | 0.30 |
| Cl | 0.01 | 0.03 | 0.05 | 0.02 | 0.03 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.01 |
| OHcalc | 1.74 | 1.77 | 1.73 | 1.84 | 1.57 | 1.92 | 1.89 | 1.79 | 1.87 | 1.96 | 1.69 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.48 | 0.60 | 0.60 | 0.60 | 0.73 | 0.63 | 0.53 | 0.69 | 0.63 | 0.39 | 0.38 |
| # | 438 | 439 | 440 | 441 | 442 | 443 | 444 | 445 | 446 | 447 | 448 |

Table 6. Hornblendes from other plutonic complexes.

| SAMPLE | B | | | | C | | | | | | |
|----------|-------|-------|--------|--------|-------|-------|--------|-------|-------|--------|--------|
| SiO2 | 47.97 | 44.71 | 45.75 | 49.83 | 41.90 | 42.10 | 49.20 | 46.50 | 41.80 | 41.00 | 39.60 |
| Al2O3 | 6.87 | 7.92 | 8.25 | 4.85 | 10.60 | 10.10 | 5.22 | 6.57 | 10.70 | 8.94 | 8.91 |
| FeO | 15.05 | 16.36 | 16.92 | 14.47 | 20.02 | 19.88 | 12.79 | 17.51 | 15.82 | 25.19 | 28.49 |
| MgO | 13.11 | 11.65 | 11.56 | 14.32 | 9.01 | 9.63 | 14.80 | 12.00 | 10.80 | 5.39 | 3.96 |
| CaO | 11.26 | 11.96 | 11.64 | 11.73 | 11.50 | 11.40 | 11.50 | 10.70 | 11.20 | 10.60 | 11.00 |
| Na2O | 1.13 | 1.26 | 1.05 | 1.13 | 1.69 | 1.93 | 1.86 | 1.66 | 2.37 | 2.10 | 1.66 |
| K2O | 0.80 | 1.09 | 1.04 | 0.54 | 1.31 | 1.34 | 0.66 | 0.62 | 1.08 | 1.30 | 2.03 |
| TiO2 | 0.81 | 1.57 | 1.20 | 0.54 | 0.42 | 0.35 | 0.97 | 1.83 | 3.89 | 2.68 | 0.59 |
| MnO | 0.63 | 0.54 | 0.66 | 0.83 | 0.61 | 0.97 | 0.90 | 0.41 | 0.31 | 0.83 | 0.72 |
| BaO | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cl | 0.04 | 0.16 | 0.15 | 0.01 | 0.07 | 0.07 | 0.10 | 0.10 | 0.00 | 0.24 | 2.44 |
| F | 0.02 | 0.02 | 0.13 | 0.51 | 1.00 | 0.90 | 1.20 | 0.30 | 0.00 | 0.50 | 0.30 |
| SUBSUM | 97.69 | 97.24 | 98.35 | 98.76 | 98.13 | 98.67 | 99.20 | 98.20 | 97.97 | 98.77 | 99.70 |
| Cl=O | 0.01 | 0.04 | 0.03 | 0.00 | 0.02 | 0.02 | 0.02 | 0.02 | 0.00 | 0.05 | 0.55 |
| F=O | 0.01 | 0.01 | 0.05 | 0.21 | 0.42 | 0.38 | 0.51 | 0.13 | 0.00 | 0.21 | 0.13 |
| SUM | 97.67 | 97.20 | 98.26 | 98.54 | 97.69 | 98.27 | 98.67 | 98.05 | 97.97 | 98.50 | 99.03 |
| H2Ocalc | 2.01 | 1.93 | 1.91 | 1.80 | 1.45 | 1.50 | 1.45 | 1.84 | 1.99 | 1.60 | 1.07 |
| SUM | 99.60 | 99.13 | 100.17 | 100.35 | 99.13 | 99.77 | 100.13 | 99.89 | 99.96 | 100.11 | 100.10 |
| Si | 7.09 | 6.76 | 6.83 | 7.29 | 6.48 | 6.48 | 7.20 | 6.96 | 6.29 | 6.46 | 6.47 |
| Aliv | 0.91 | 1.24 | 1.17 | 0.71 | 1.52 | 1.52 | 0.80 | 1.04 | 1.71 | 1.54 | 1.53 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.29 | 0.18 | 0.29 | 0.13 | 0.42 | 0.32 | 0.10 | 0.12 | 0.18 | 0.13 | 0.18 |
| Fe+2 | 1.74 | 2.02 | 2.01 | 1.69 | 2.46 | 2.43 | 1.56 | 2.00 | 1.96 | 3.29 | 3.78 |
| Mg | 2.89 | 2.63 | 2.57 | 3.12 | 2.00 | 2.21 | 3.23 | 2.68 | 2.42 | 1.27 | 0.96 |
| Ti | 0.09 | 0.18 | 0.13 | 0.06 | 0.05 | 0.04 | 0.11 | 0.21 | 0.44 | 0.32 | 0.07 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.00 | 0.07 | 0.08 | 0.10 | 0.00 | 0.13 | 0.11 | 0.05 | 0.04 | 0.11 | 0.10 |
| Fe+2 | 0.12 | 0.05 | 0.11 | 0.08 | 0.13 | 0.13 | 0.00 | 0.19 | 0.03 | 0.03 | 0.11 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.78 | 1.88 | 1.81 | 1.82 | 1.79 | 1.74 | 1.80 | 1.72 | 1.80 | 1.79 | 1.79 |
| Na | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.04 | 0.12 | 0.07 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.31 | 0.37 | 0.30 | 0.32 | 0.51 | 0.58 | 0.44 | 0.44 | 0.57 | 0.58 | 0.53 |
| K | 0.15 | 0.21 | 0.20 | 0.10 | 0.26 | 0.26 | 0.12 | 0.12 | 0.21 | 0.26 | 0.42 |
| Ca | 0.00 | 0.06 | 0.05 | 0.02 | 0.12 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| A | 0.46 | 0.64 | 0.56 | 0.44 | 0.88 | 0.98 | 0.57 | 0.56 | 0.77 | 0.84 | 1.08 |
| CATSUM | 15.46 | 15.64 | 15.56 | 15.44 | 15.88 | 15.98 | 15.57 | 15.56 | 15.77 | 15.84 | 16.08 |
| F | 0.01 | 0.01 | 0.06 | 0.24 | 0.49 | 0.44 | 0.56 | 0.14 | 0.00 | 0.25 | 0.15 |
| Cl | 0.01 | 0.04 | 0.04 | 0.00 | 0.02 | 0.02 | 0.02 | 0.03 | 0.00 | 0.06 | 0.68 |
| OHcalc | 1.98 | 1.95 | 1.90 | 1.76 | 1.49 | 1.54 | 1.42 | 1.83 | 2.00 | 1.69 | 1.17 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.39 | 0.44 | 0.45 | 0.36 | 0.55 | 0.54 | 0.33 | 0.45 | 0.45 | 0.72 | 0.80 |
| # | 449 | 450 | 451 | 452 | 453 | 454 | 455 | 456 | 457 | 458 | 459 |

Table 6. Hornblendes from other plutonic complexes.

| SAMPLE | C | | | | | | | | | | D |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| SiO2 | 39.80 | 40.60 | 40.40 | 40.40 | 41.70 | 41.10 | 39.80 | 40.80 | 40.40 | 39.40 | 44.10 |
| Al2O3 | 7.00 | 6.77 | 5.92 | 5.87 | 6.94 | 7.79 | 7.92 | 6.61 | 7.67 | 7.95 | 7.17 |
| FeO | 32.10 | 32.20 | 13.59 | 14.10 | 20.66 | 27.65 | 29.36 | 32.97 | 29.08 | 31.13 | 22.50 |
| MgO | 0.87 | 1.06 | 13.70 | 13.90 | 3.53 | 3.79 | 2.97 | 1.36 | 2.68 | 2.00 | 8.92 |
| CaO | 10.20 | 9.71 | 11.70 | 11.90 | 9.88 | 9.89 | 10.50 | 9.77 | 9.64 | 10.20 | 10.20 |
| Na2O | 2.25 | 2.36 | 1.56 | 1.21 | 2.28 | 2.46 | 1.76 | 2.13 | 2.26 | 2.06 | 1.74 |
| K2O | 1.27 | 1.22 | 0.76 | 0.76 | 1.14 | 1.00 | 1.60 | 1.19 | 1.08 | 1.38 | 0.78 |
| TiO2 | 1.71 | 1.37 | 0.97 | 1.08 | 1.56 | 1.84 | 0.51 | 1.60 | 1.80 | 1.27 | 1.78 |
| MnO | 1.11 | 0.95 | 1.10 | 0.62 | 1.62 | 1.70 | 1.85 | 0.86 | 1.37 | 1.34 | 0.65 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | 0.47 | 0.39 | 0.10 | 0.11 | 0.34 | 0.25 | 0.96 | 0.39 | 0.37 | 0.58 | 0.00 |
| F | 0.70 | 1.00 | 0.60 | 0.40 | 1.00 | 0.70 | 0.50 | 0.60 | 0.60 | 0.70 | 0.30 |
| SUBSUM | 98.28 | 98.43 | 98.40 | 98.35 | 98.65 | 98.17 | 97.73 | 98.28 | 97.75 | 98.01 | 98.14 |
| Cl=O | 0.11 | 0.09 | 0.02 | 0.02 | 0.08 | 0.06 | 0.22 | 0.09 | 0.08 | 0.13 | 0.00 |
| F=O | 0.29 | 0.42 | 0.25 | 0.17 | 0.42 | 0.29 | 0.21 | 0.25 | 0.25 | 0.29 | 0.13 |
| SUM | 97.88 | 97.92 | 98.13 | 98.15 | 98.15 | 97.82 | 97.31 | 97.94 | 97.41 | 97.58 | 98.01 |
| H2Ocalc | 1.36 | 1.24 | 1.72 | 1.82 | 1.29 | 1.46 | 1.33 | 1.43 | 1.45 | 1.33 | 1.80 |
| SUM | 99.24 | 99.16 | 99.85 | 99.97 | 99.44 | 99.28 | 98.64 | 99.37 | 98.87 | 98.91 | 99.81 |
| Si | 6.59 | 6.71 | 7.14 | 7.12 | 6.75 | 6.63 | 6.59 | 6.74 | 6.62 | 6.53 | 6.79 |
| Aliv | 1.41 | 1.29 | 0.86 | 0.88 | 1.25 | 1.37 | 1.41 | 1.26 | 1.38 | 1.47 | 1.21 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.11 | 0.03 | 0.17 | 0.14 | 0.07 | 0.11 | 0.14 | 0.02 | 0.10 | 0.09 | 0.09 |
| Fe+2 | 4.44 | 4.35 | 1.68 | 1.69 | 3.88 | 3.73 | 4.07 | 4.44 | 4.03 | 4.26 | 2.65 |
| Mg | 0.21 | 0.46 | 3.01 | 3.05 | 0.85 | 0.91 | 0.73 | 0.33 | 0.65 | 0.49 | 2.05 |
| Ti | 0.21 | 0.17 | 0.11 | 0.12 | 0.19 | 0.22 | 0.06 | 0.20 | 0.22 | 0.16 | 0.21 |
| Mn | 0.02 | 0.00 | 0.04 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.14 | 0.13 | 0.10 | 0.08 | 0.21 | 0.21 | 0.26 | 0.12 | 0.19 | 0.19 | 0.08 |
| Fe+2 | 0.00 | 0.10 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.11 | 0.07 | 0.06 | 0.25 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.81 | 1.72 | 1.85 | 1.87 | 1.71 | 1.71 | 1.74 | 1.73 | 1.69 | 1.76 | 1.67 |
| Na | 0.06 | 0.04 | 0.05 | 0.00 | 0.07 | 0.08 | 0.00 | 0.04 | 0.05 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.67 | 0.71 | 0.39 | 0.35 | 0.64 | 0.69 | 0.57 | 0.64 | 0.67 | 0.66 | 0.52 |
| K | 0.27 | 0.26 | 0.14 | 0.14 | 0.24 | 0.21 | 0.34 | 0.25 | 0.23 | 0.29 | 0.15 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.06 | 0.01 |
| A | 0.93 | 0.97 | 0.54 | 0.49 | 0.88 | 0.89 | 1.02 | 0.89 | 0.89 | 1.01 | 0.69 |
| CATSUM | 15.93 | 15.97 | 15.54 | 15.49 | 15.88 | 15.89 | 16.02 | 15.89 | 15.89 | 16.01 | 15.69 |
| F | 0.37 | 0.52 | 0.28 | 0.19 | 0.51 | 0.36 | 0.26 | 0.31 | 0.31 | 0.37 | 0.15 |
| Cl | 0.13 | 0.11 | 0.02 | 0.03 | 0.09 | 0.07 | 0.27 | 0.11 | 0.10 | 0.16 | 0.00 |
| OHcalc | 1.50 | 1.37 | 1.70 | 1.79 | 1.40 | 1.57 | 1.47 | 1.58 | 1.59 | 1.47 | 1.85 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.95 | 0.91 | 0.36 | 0.36 | 0.82 | 0.80 | 0.85 | 0.93 | 0.86 | 0.90 | 0.59 |
| # | 460 | 461 | 462 | 463 | 464 | 465 | 466 | 467 | 468 | 469 | 470 |

Table 6. Hornblendes from other plutonic complexes.

| SAMPLE | D | | | | | | | | | | | E |
|--------------------------------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|-------|---|
| SiO ₂ | 45.20 | 45.10 | 45.20 | 50.10 | 50.20 | 51.10 | 51.40 | 46.40 | 45.40 | 46.59 | 44.96 | |
| Al ₂ O ₃ | 6.61 | 6.29 | 6.07 | 4.71 | 4.33 | 4.11 | 3.80 | 7.76 | 8.05 | 7.71 | 8.19 | |
| FeO | 22.30 | 22.01 | 22.40 | 11.50 | 11.40 | 11.40 | 11.50 | 13.54 | 15.17 | 13.58 | 14.12 | |
| MgO | 9.16 | 9.26 | 8.90 | 15.30 | 15.20 | 15.20 | 15.80 | 11.14 | 9.82 | 11.57 | 10.78 | |
| CaO | 10.20 | 10.10 | 10.00 | 10.70 | 10.80 | 10.80 | 11.30 | 12.27 | 11.77 | 11.53 | 11.75 | |
| Na ₂ O | 1.45 | 1.69 | 1.52 | 1.66 | 1.32 | 1.36 | 1.20 | 1.06 | 1.21 | 1.05 | 1.10 | |
| K ₂ O | 0.67 | 0.86 | 0.87 | 0.67 | 0.49 | 0.52 | 0.40 | 0.79 | 0.95 | 0.69 | 0.85 | |
| TiO ₂ | 1.55 | 1.55 | 1.55 | 1.00 | 0.73 | 0.82 | 0.50 | 1.49 | 1.41 | 1.34 | 1.21 | |
| MnO | 0.65 | 0.55 | 0.58 | 1.46 | 1.87 | 1.54 | 1.97 | 0.52 | 0.68 | 0.53 | 0.49 | |
| BaO | n | n | n | n | n | n | n | n | n | n | n | |
| Cl | n | n | n | n | n | n | n | 0.09 | 0.11 | 0.09 | 0.09 | |
| F | 0.30 | 0.30 | 0.30 | 0.60 | 0.60 | 0.60 | 0.60 | 0.10 | 0.25 | 0.15 | 0.18 | |
| SUBSUM | 98.09 | 97.71 | 97.39 | 97.70 | 96.94 | 97.45 | 98.47 | 98.55 | 98.62 | 98.22 | 97.24 | |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | 0.02 | |
| F=O | 0.13 | 0.13 | 0.13 | 0.25 | 0.25 | 0.25 | 0.25 | 0.04 | 0.11 | 0.06 | 0.08 | |
| SUM | 97.96 | 97.58 | 97.26 | 97.45 | 96.69 | 97.20 | 98.22 | 98.49 | 98.49 | 98.14 | 97.14 | |
| H ₂ Ocalc | 1.81 | 1.80 | 1.80 | 1.76 | 1.75 | 1.77 | 1.78 | 1.96 | 1.86 | 1.93 | 1.88 | |
| SUM | 99.77 | 99.38 | 99.06 | 99.21 | 98.44 | 98.96 | 100.00 | 100.45 | 100.35 | 100.07 | 99.03 | |
| Si | 6.93 | 6.95 | 6.99 | 7.33 | 7.40 | 7.47 | 7.45 | 6.86 | 6.79 | 6.89 | 6.77 | |
| Aliv | 1.07 | 1.05 | 1.01 | 0.67 | 0.60 | 0.53 | 0.55 | 1.14 | 1.21 | 1.11 | 1.23 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.12 | 0.09 | 0.10 | 0.14 | 0.15 | 0.17 | 0.10 | 0.21 | 0.21 | 0.23 | 0.23 | |
| Fe+2 | 2.60 | 2.61 | 2.67 | 1.41 | 1.40 | 1.39 | 1.39 | 1.67 | 1.90 | 1.68 | 1.78 | |
| Mg | 2.09 | 2.13 | 2.05 | 3.34 | 3.34 | 3.31 | 3.41 | 2.45 | 2.19 | 2.55 | 2.42 | |
| Ti | 0.18 | 0.18 | 0.18 | 0.11 | 0.08 | 0.09 | 0.05 | 0.17 | 0.16 | 0.15 | 0.14 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.04 | 0.07 | 0.09 | 0.01 | 0.04 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 4.94 | 4.97 | 5.00 | 5.00 | |
| Mn | 0.00 | 0.07 | 0.08 | 0.18 | 0.21 | 0.16 | 0.21 | 0.00 | 0.00 | 0.06 | 0.02 | |
| Fe+2 | 0.25 | 0.23 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.66 | 1.67 | 1.66 | 1.68 | 1.71 | 1.69 | 1.76 | 1.94 | 1.89 | 1.83 | 1.90 | |
| Na | 0.00 | 0.03 | 0.04 | 0.14 | 0.09 | 0.15 | 0.04 | 0.06 | 0.11 | 0.12 | 0.08 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.43 | 0.47 | 0.42 | 0.33 | 0.29 | 0.23 | 0.30 | 0.25 | 0.24 | 0.19 | 0.24 | |
| K | 0.13 | 0.17 | 0.17 | 0.13 | 0.09 | 0.10 | 0.07 | 0.15 | 0.18 | 0.13 | 0.16 | |
| Ca | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| A | 0.58 | 0.64 | 0.59 | 0.45 | 0.38 | 0.33 | 0.37 | 0.40 | 0.42 | 0.32 | 0.41 | |
| CATSUM | 15.58 | 15.64 | 15.59 | 15.45 | 15.38 | 15.33 | 15.37 | 15.34 | 15.39 | 15.32 | 15.41 | |
| F | 0.15 | 0.15 | 0.15 | 0.28 | 0.28 | 0.28 | 0.28 | 0.05 | 0.12 | 0.07 | 0.09 | |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.03 | 0.02 | 0.02 | |
| OHcalc | 1.85 | 1.85 | 1.85 | 1.72 | 1.72 | 1.72 | 1.72 | 1.93 | 1.85 | 1.91 | 1.89 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.58 | 0.57 | 0.59 | 0.30 | 0.30 | 0.30 | 0.29 | 0.46 | 0.52 | 0.45 | 0.47 | |
| # | 471 | 472 | 473 | 474 | 475 | 476 | 477 | 478 | 479 | 480 | 481 | |

Table 6. Hornblendes from other plutonic complexes.

| SAMPLE | D | |
|----------|-------|-------|
| SiO2 | 40.64 | 47.95 |
| Al2O3 | 9.20 | 6.64 |
| FeO | 23.24 | 13.19 |
| MgO | 2.78 | 11.22 |
| CaO | 10.66 | 11.49 |
| Na2O | 1.72 | 0.98 |
| K2O | 1.45 | 0.54 |
| TiO2 | 0.97 | 0.78 |
| MnO | 1.21 | 0.44 |
| BaO | n | n |
| Cl | 0.10 | 0.10 |
| F | 0.20 | 0.21 |
| SUBSUM | 97.98 | 96.84 |
| Cl=O | 0.02 | 0.02 |
| F=O | 0.08 | 0.09 |
| SUM | 97.87 | 96.73 |
| H2Ocalc | 1.76 | 1.89 |
| SUM | 99.63 | 98.62 |
| Si | 6.48 | 7.15 |
| Aliv | 1.52 | 0.85 |
| T | 8.00 | 8.00 |
| Alvi | 0.21 | 0.32 |
| Fe+2 | 3.10 | 1.64 |
| Mg | 0.66 | 2.49 |
| Ti | 0.12 | 0.09 |
| Mn | 0.16 | 0.06 |
| M1-M3 | 4.95 | 4.97 |
| Mn | 0.00 | 0.00 |
| Fe+2 | 0.00 | 0.00 |
| Mg | 0.00 | 0.00 |
| Ca | 1.82 | 1.84 |
| Na | 0.18 | 0.16 |
| M4 | 2.00 | 2.00 |
| Na | 0.35 | 0.12 |
| K | 0.30 | 0.10 |
| Ca | 0.00 | 0.00 |
| A | 0.65 | 0.22 |
| CATSUM | 15.60 | 15.19 |
| F | 0.10 | 0.10 |
| Cl | 0.03 | 0.03 |
| OHcalc | 1.87 | 1.88 |
| ANSUM | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.85 | 0.45 |
| # | 482 | 483 |

KEY TO TABLE 7

| ANALYSIS # | SAMPLE CODE | OCCURRENCE | REFERENCE |
|------------|----------------|--|--|
| 484-487 | F | garnet-pyroxenite xenoliths in Sullivan Buttes Latite, Chino Valley, Arizona | Schulze & Helmstaedt, 1979 |
| 488-492 | G | lower crustal eclogitic and granulitic xenoliths, SE Australia | Wass & Hollis, 1983 |
| 493-497 | H | cumulate inclusions Grand Canyon, Arizona | Best, 1975 |
| 498-518 | I | upper mantle xenoliths from many localities | Dawson & Smith, 1982 |
| 519-522 | J | granulite xenoliths, Queensland, Australia | Kay & Kay, 1983 |
| 523-530 | K | charnockite from S Karnataka, India | Janardhan and others, 1983 Raith and others, 1983 |
| 531-547 | L | ultramafic and mafic inclusions from Adak Island, Aleutian Arc | Conrad & Kay, 1984 |

Table 7. Hornblendes from xenoliths, eclogites and granulites.

| SAMPLE | F | | | | | G | | | | | H | | | | |
|--------------------------------|--------|-------|-------|-------|--------|--------|-------|-------|--------|-------|--------|--|--|--|--|
| SiO ₂ | 49.80 | 48.60 | 37.30 | 40.90 | 42.40 | 41.20 | 39.10 | 41.40 | 41.20 | 41.70 | 42.20 | | | | |
| Al ₂ O ₃ | 9.10 | 11.50 | 17.50 | 15.40 | 14.30 | 14.60 | 15.20 | 13.80 | 13.70 | 14.90 | 16.00 | | | | |
| FeO | 9.00 | 6.90 | 14.60 | 12.60 | 8.92 | 6.27 | 13.50 | 10.80 | 12.30 | 7.20 | 8.10 | | | | |
| MgO | 15.30 | 15.00 | 10.50 | 12.00 | 14.00 | 15.90 | 11.40 | 12.70 | 12.00 | 16.10 | 15.60 | | | | |
| CaO | 10.10 | 9.80 | 12.40 | 11.20 | 10.30 | 11.10 | 9.47 | 10.20 | 10.50 | 11.30 | 11.10 | | | | |
| Na ₂ O | 3.50 | 3.90 | 1.90 | 3.10 | 3.15 | 2.68 | 3.23 | 3.10 | 2.79 | 2.40 | 2.90 | | | | |
| K ₂ O | 0.70 | 0.40 | 1.50 | 1.10 | 1.41 | 1.45 | 1.53 | 1.11 | 1.31 | 1.30 | 0.40 | | | | |
| TiO ₂ | 0.30 | 0.30 | 0.20 | 1.10 | 3.86 | 5.12 | 3.87 | 4.36 | 4.65 | 2.70 | 1.90 | | | | |
| MnO | 0.10 | 0.00 | 0.20 | 0.10 | 0.09 | 0.10 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | | | | |
| BaO | n | n | n | n | n | n | n | n | n | n | n | | | | |
| Cl | n | n | n | n | n | n | n | n | n | n | n | | | | |
| F | n | n | n | n | n | n | n | n | n | n | n | | | | |
| Cr ₂ O ₃ | 0.10 | 0.10 | 0.10 | 0.10 | 0.19 | 0.12 | 0.00 | 0.00 | 0.00 | 0.10 | 0.10 | | | | |
| SUBSUM | 98.00 | 96.50 | 96.20 | 97.60 | 98.62 | 98.54 | 97.41 | 97.57 | 98.55 | 97.80 | 98.40 | | | | |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| SUM | 98.00 | 96.50 | 96.20 | 97.60 | 98.62 | 98.54 | 97.41 | 97.57 | 98.55 | 97.80 | 98.40 | | | | |
| H ₂ Ocalc | 2.10 | 2.10 | 1.96 | 2.02 | 2.08 | 2.09 | 2.00 | 2.04 | 2.04 | 2.08 | 2.10 | | | | |
| SUM | 100.10 | 98.60 | 98.16 | 99.62 | 100.70 | 100.63 | 99.41 | 99.61 | 100.59 | 99.88 | 100.50 | | | | |
| Si | 7.10 | 6.95 | 5.72 | 6.07 | 6.11 | 5.90 | 5.86 | 6.09 | 6.05 | 6.02 | 6.04 | | | | |
| Aliv | 0.90 | 1.05 | 2.28 | 1.93 | 1.89 | 2.10 | 2.14 | 1.91 | 1.95 | 1.98 | 1.96 | | | | |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| Alvi | 0.63 | 0.89 | 0.88 | 0.76 | 0.54 | 0.37 | 0.54 | 0.48 | 0.42 | 0.56 | 0.74 | | | | |
| Fe+2 | 1.07 | 0.83 | 1.70 | 1.46 | 1.03 | 0.68 | 1.48 | 1.26 | 1.44 | 0.69 | 0.73 | | | | |
| Mg | 3.25 | 3.20 | 2.40 | 2.65 | 3.01 | 3.40 | 2.55 | 2.78 | 2.63 | 3.46 | 3.33 | | | | |
| Ti | 0.03 | 0.03 | 0.02 | 0.12 | 0.42 | 0.55 | 0.44 | 0.48 | 0.51 | 0.29 | 0.20 | | | | |
| Mn | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| M1-M3 | 5.00 | 4.95 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | | | | |
| Mn | 0.00 | 0.00 | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | | | | |
| Fe+2 | 0.00 | 0.00 | 0.17 | 0.10 | 0.05 | 0.07 | 0.21 | 0.07 | 0.07 | 0.18 | 0.24 | | | | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| Ca | 1.54 | 1.50 | 1.80 | 1.78 | 1.59 | 1.70 | 1.52 | 1.61 | 1.65 | 1.75 | 1.70 | | | | |
| Na | 0.46 | 0.50 | 0.00 | 0.11 | 0.35 | 0.21 | 0.25 | 0.31 | 0.27 | 0.06 | 0.05 | | | | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | | | | |
| Na | 0.51 | 0.58 | 0.56 | 0.79 | 0.53 | 0.53 | 0.69 | 0.57 | 0.53 | 0.62 | 0.76 | | | | |
| K | 0.13 | 0.07 | 0.29 | 0.21 | 0.26 | 0.27 | 0.29 | 0.21 | 0.25 | 0.24 | 0.07 | | | | |
| Ca | 0.00 | 0.00 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| A | 0.64 | 0.66 | 1.09 | 0.99 | 0.79 | 0.80 | 0.98 | 0.78 | 0.77 | 0.86 | 0.83 | | | | |
| CATSUM | 15.63 | 15.61 | 16.09 | 15.99 | 15.79 | 15.80 | 15.98 | 15.78 | 15.77 | 15.86 | 15.83 | | | | |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | | | | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | | | | |
| Fe/Fe+Mg | 0.25 | 0.21 | 0.44 | 0.37 | 0.26 | 0.18 | 0.40 | 0.32 | 0.37 | 0.20 | 0.23 | | | | |
| # | 484 | 485 | 486 | 487 | 488 | 489 | 490 | 491 | 492 | 493 | 494 | | | | |

Table 7. Hornblendes from xenoliths, eclogites and granulites.

| SAMPLE | H | | | I | | | | | | | | |
|--------------------------------|--------|--------|--------|-------|-------|--------|-------|--------|-------|--------|--------|--|
| SiO ₂ | 40.70 | 41.00 | 40.30 | 45.70 | 45.40 | 43.51 | 44.73 | 48.28 | 49.00 | 43.18 | 41.35 | |
| Al ₂ O ₃ | 15.80 | 15.80 | 15.30 | 11.10 | 11.71 | 14.74 | 12.58 | 10.33 | 7.50 | 14.87 | 14.62 | |
| FeO | 7.30 | 8.90 | 9.80 | 2.64 | 3.34 | 4.00 | 2.37 | 3.35 | 2.80 | 4.40 | 11.34 | |
| MgO | 15.00 | 14.40 | 13.00 | 11.10 | 18.96 | 19.18 | 19.17 | 20.83 | 20.80 | 18.00 | 12.79 | |
| CaO | 10.70 | 11.10 | 10.30 | 20.20 | 9.85 | 10.70 | 10.95 | 10.98 | 9.60 | 10.57 | 9.37 | |
| Na ₂ O | 2.80 | 3.10 | 2.80 | 3.20 | 4.31 | 3.93 | 3.84 | 1.75 | 4.10 | 3.09 | 3.28 | |
| K ₂ O | 1.60 | 0.70 | 1.60 | 1.34 | 1.20 | 0.19 | 0.43 | 0.19 | 1.00 | 1.63 | 1.37 | |
| TiO ₂ | 4.00 | 3.40 | 5.20 | 0.01 | 0.42 | 0.49 | 0.29 | 0.44 | 0.90 | 1.67 | 4.58 | |
| MnO | 0.00 | 0.00 | 0.00 | 0.18 | 0.07 | 0.09 | 0.11 | 0.01 | 0.06 | 0.10 | 0.11 | |
| BaO | n | n | n | n | n | n | n | n | n | n | n | |
| Cl | n | n | n | n | n | n | n | n | n | n | n | |
| F | n | n | n | n | n | n | n | n | n | n | n | |
| Cr ₂ O ₃ | 0.30 | 0.00 | 0.00 | 2.10 | 1.53 | 1.07 | 2.43 | 1.79 | 2.10 | 1.18 | 0.40 | |
| SUBSUM | 98.20 | 98.40 | 98.30 | 97.57 | 96.79 | 97.90 | 96.90 | 97.95 | 97.86 | 98.69 | 99.21 | |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| SUM | 98.20 | 98.40 | 98.30 | 97.57 | 96.79 | 97.90 | 96.90 | 97.95 | 97.86 | 98.69 | 99.21 | |
| H ₂ Ocalc | 2.08 | 2.08 | 2.06 | 2.06 | 2.09 | 2.12 | 2.10 | 2.15 | 2.13 | 2.12 | 2.07 | |
| SUM | 100.28 | 100.48 | 100.36 | 99.63 | 98.88 | 100.02 | 99.00 | 100.10 | 99.99 | 100.81 | 101.28 | |
| Si | 5.87 | 5.92 | 5.87 | 6.65 | 6.50 | 6.16 | 6.37 | 6.73 | 6.90 | 6.11 | 5.99 | |
| Aliv | 2.13 | 2.08 | 2.13 | 1.35 | 1.50 | 1.84 | 1.63 | 1.27 | 1.10 | 1.89 | 2.01 | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Alvi | 0.56 | 0.61 | 0.50 | 0.56 | 0.48 | 0.62 | 0.49 | 0.43 | 0.14 | 0.59 | 0.49 | |
| Fe+2 | 0.78 | 0.92 | 1.10 | 0.32 | 0.40 | 0.28 | 0.28 | 0.20 | 0.33 | 0.43 | 1.24 | |
| Mg | 3.23 | 3.10 | 2.92 | 2.41 | 4.05 | 4.05 | 4.07 | 4.33 | 4.36 | 3.88 | 2.76 | |
| Ti | 0.43 | 0.37 | 0.57 | 0.00 | 0.05 | 0.05 | 0.03 | 0.05 | 0.10 | 0.18 | 0.50 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 3.31 | 4.98 | 5.00 | 4.89 | 5.00 | 4.94 | 5.00 | 5.00 | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | |
| Fe+2 | 0.10 | 0.15 | 0.09 | 0.00 | 0.00 | 0.19 | 0.00 | 0.19 | 0.00 | 0.09 | 0.13 | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Ca | 1.65 | 1.72 | 1.61 | 2.00 | 1.51 | 1.62 | 1.67 | 1.64 | 1.45 | 1.60 | 1.46 | |
| Na | 0.24 | 0.13 | 0.30 | 0.00 | 0.49 | 0.18 | 0.33 | 0.17 | 0.55 | 0.30 | 0.40 | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Na | 0.54 | 0.74 | 0.49 | 0.90 | 0.71 | 0.90 | 0.73 | 0.30 | 0.57 | 0.55 | 0.52 | |
| K | 0.29 | 0.13 | 0.30 | 0.25 | 0.22 | 0.03 | 0.08 | 0.03 | 0.18 | 0.29 | 0.25 | |
| Ca | 0.00 | 0.00 | 0.00 | 1.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| A | 0.84 | 0.87 | 0.79 | 2.30 | 0.93 | 0.94 | 0.81 | 0.33 | 0.75 | 0.84 | 0.78 | |
| CATSUM | 15.84 | 15.87 | 15.79 | 15.61 | 15.91 | 15.94 | 15.70 | 15.33 | 15.68 | 15.84 | 15.78 | |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | |
| Fe/Fe+Mg | 0.21 | 0.26 | 0.30 | 0.12 | 0.09 | 0.10 | 0.06 | 0.08 | 0.07 | 0.12 | 0.33 | |
| # | 495 | 496 | 497 | 498 | 499 | 500 | 501 | 502 | 503 | 504 | 505 | |

Table 7. Hornblendes from xenoliths, eclogites and granulites.

| SAMPLE | I | | | | | | | | | | |
|--------------------------------|-------|--------|--------|--------|--------|-------|--------|-------|--------|-------|--------|
| SiO ₂ | 41.50 | 43.30 | 40.40 | 43.20 | 40.00 | 41.20 | 39.50 | 39.87 | 40.28 | 40.00 | 39.60 |
| Al ₂ O ₃ | 13.20 | 15.40 | 14.70 | 13.20 | 14.64 | 13.50 | 14.29 | 14.71 | 14.53 | 13.60 | 12.90 |
| FeO | 8.50 | 4.70 | 10.20 | 7.90 | 11.70 | 9.55 | 17.69 | 8.89 | 9.84 | 11.00 | 10.20 |
| MgO | 15.00 | 17.30 | 13.60 | 15.80 | 11.52 | 13.80 | 7.96 | 13.25 | 13.78 | 13.40 | 13.80 |
| CaO | 10.90 | 10.80 | 10.40 | 11.30 | 10.91 | 10.90 | 9.02 | 10.75 | 11.42 | 10.70 | 12.30 |
| Na ₂ O | 2.80 | 3.50 | 2.70 | 3.10 | 2.59 | 2.24 | 2.64 | 2.31 | 2.47 | 3.10 | 2.60 |
| K ₂ O | 1.30 | 0.02 | 1.50 | 0.84 | 1.36 | 2.17 | 2.12 | 2.39 | 2.16 | 1.70 | 1.30 |
| TiO ₂ | 3.40 | 1.80 | 4.70 | 4.90 | 5.67 | 4.16 | 5.40 | 4.43 | 4.85 | 4.30 | 5.40 |
| MnO | n | n | 0.10 | 0.08 | n | n | 0.13 | 0.12 | n | n | n |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | n | n | n | n | n | n | n | n | n | n | n |
| F | n | n | n | n | n | n | n | n | n | n | n |
| Cr ₂ O ₃ | 0.25 | 1.13 | 0.10 | n | n | n | n | n | n | n | n |
| SUBSUM | 96.85 | 97.95 | 98.40 | 100.32 | 98.39 | 97.52 | 98.75 | 96.72 | 99.33 | 97.80 | 98.10 |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SUM | 96.85 | 97.95 | 98.40 | 100.32 | 98.39 | 97.52 | 98.75 | 96.72 | 99.33 | 97.80 | 98.10 |
| H ₂ Ocalc | 2.04 | 2.12 | 2.05 | 2.12 | 2.04 | 2.04 | 1.99 | 2.02 | 2.06 | 2.02 | 2.03 |
| SUM | 98.89 | 100.07 | 100.45 | 102.44 | 100.43 | 99.56 | 100.74 | 98.74 | 101.39 | 99.82 | 100.13 |
| Si | 6.10 | 6.13 | 5.90 | 6.10 | 5.88 | 6.06 | 5.95 | 5.92 | 5.85 | 5.93 | 5.85 |
| Aliv | 1.90 | 1.87 | 2.10 | 1.90 | 2.12 | 1.94 | 2.05 | 2.08 | 2.15 | 2.07 | 2.15 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.39 | 0.69 | 0.43 | 0.29 | 0.42 | 0.40 | 0.49 | 0.49 | 0.34 | 0.30 | 0.09 |
| Fe+2 | 0.95 | 0.47 | 1.10 | 0.86 | 1.43 | 1.11 | 2.12 | 1.08 | 1.15 | 1.26 | 1.26 |
| Mg | 3.29 | 3.65 | 2.96 | 3.32 | 2.52 | 3.03 | 1.79 | 2.93 | 2.98 | 2.96 | 3.04 |
| Ti | 0.38 | 0.19 | 0.52 | 0.52 | 0.63 | 0.46 | 0.61 | 0.49 | 0.53 | 0.48 | 0.60 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 4.99 |
| Mn | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 |
| Fe+2 | 0.10 | 0.09 | 0.15 | 0.07 | 0.01 | 0.07 | 0.11 | 0.02 | 0.05 | 0.10 | 0.00 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.72 | 1.64 | 1.63 | 1.71 | 1.72 | 1.72 | 1.46 | 1.71 | 1.78 | 1.70 | 1.95 |
| Na | 0.19 | 0.27 | 0.22 | 0.21 | 0.27 | 0.22 | 0.42 | 0.26 | 0.17 | 0.20 | 0.05 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.61 | 0.69 | 0.55 | 0.63 | 0.47 | 0.42 | 0.35 | 0.41 | 0.52 | 0.69 | 0.69 |
| K | 0.24 | 0.00 | 0.28 | 0.15 | 0.26 | 0.41 | 0.41 | 0.45 | 0.40 | 0.32 | 0.24 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.86 | 0.69 | 0.83 | 0.79 | 0.72 | 0.83 | 0.76 | 0.86 | 0.92 | 1.01 | 0.94 |
| CATSUM | 15.86 | 15.69 | 15.83 | 15.79 | 15.72 | 15.83 | 15.76 | 15.86 | 15.92 | 16.01 | 15.92 |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.24 | 0.13 | 0.30 | 0.22 | 0.36 | 0.28 | 0.55 | 0.27 | 0.29 | 0.32 | 0.29 |
| # | 506 | 507 | 508 | 509 | 510 | 511 | 512 | 513 | 514 | 515 | 516 |

Table 7. Hornblendes from xenoliths, eclogites and granulites.

| SAMPLE | I | | | | | J | | | | | K | | | | |
|----------|-------|-------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--|--|--|--|
| SiO2 | 42.10 | 41.80 | 44.07 | 41.64 | 39.58 | 40.74 | 43.40 | 42.40 | 45.50 | 42.00 | 42.70 | | | | |
| Al2O3 | 11.60 | 15.80 | 14.19 | 14.53 | 15.27 | 14.92 | 10.10 | 10.00 | 10.20 | 12.60 | 13.00 | | | | |
| FeO | 9.05 | 5.80 | 8.51 | 11.19 | 14.63 | 12.70 | 20.60 | 21.10 | 16.20 | 19.50 | 16.50 | | | | |
| MgO | 16.90 | 17.20 | 14.74 | 12.72 | 10.52 | 11.14 | 9.30 | 8.60 | 11.80 | 8.40 | 10.00 | | | | |
| CaO | 10.20 | 10.90 | 12.05 | 11.06 | 10.99 | 11.07 | 10.40 | 10.70 | 12.10 | 11.70 | 11.60 | | | | |
| Na2O | 2.80 | 2.70 | 1.98 | 2.78 | 2.74 | 2.54 | 0.80 | 1.40 | 1.40 | 1.40 | 1.20 | | | | |
| K2O | 1.70 | 1.60 | 1.15 | 1.12 | 1.50 | 1.18 | 1.20 | 1.30 | 1.50 | 1.30 | 1.60 | | | | |
| TiO2 | 2.90 | 0.20 | 2.09 | 3.48 | 3.12 | 3.36 | 0.60 | 1.90 | 1.40 | 1.30 | 1.60 | | | | |
| MnO | 0.11 | 0.20 | 0.08 | 0.07 | 0.17 | 0.20 | 0.00 | 0.40 | 0.30 | 0.00 | 0.00 | | | | |
| BaO | n | n | n | n | n | n | n | n | n | n | n | | | | |
| Cl | n | n | n | n | n | n | n | n | 0.10 | 0.30 | 0.10 | | | | |
| F | n | n | n | n | n | n | n | 0.80 | 0.60 | n | n | | | | |
| Cr2O3 | 0.00 | 1.20 | 0.38 | 0.19 | 0.00 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| SUBSUM | 97.36 | 97.40 | 99.24 | 98.78 | 98.52 | 98.08 | 96.40 | 98.60 | 101.10 | 98.50 | 98.30 | | | | |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.07 | 0.02 | | | | |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.25 | 0.00 | 0.00 | | | | |
| SUM | 97.36 | 97.40 | 99.24 | 98.78 | 98.52 | 98.08 | 96.40 | 98.26 | 100.82 | 98.43 | 98.28 | | | | |
| H2Ocalc | 2.04 | 2.08 | 2.11 | 2.06 | 2.01 | 2.03 | 1.95 | 1.57 | 1.75 | 1.90 | 1.98 | | | | |
| SUM | 99.40 | 99.48 | 101.35 | 100.84 | 100.53 | 100.11 | 98.35 | 99.84 | 102.57 | 100.33 | 100.26 | | | | |
| Si | 6.18 | 6.04 | 6.27 | 6.06 | 5.90 | 6.02 | 6.60 | 6.51 | 6.63 | 6.36 | 6.37 | | | | |
| Aliv | 1.82 | 1.96 | 1.73 | 1.94 | 2.10 | 1.98 | 1.32 | 1.49 | 1.37 | 1.64 | 1.63 | | | | |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | | | | |
| Alvi | 0.19 | 0.73 | 0.66 | 0.55 | 0.58 | 0.62 | 0.52 | 0.32 | 0.38 | 0.62 | 0.66 | | | | |
| Fe+2 | 0.79 | 0.55 | 0.99 | 1.31 | 1.73 | 1.55 | 2.28 | 2.49 | 1.90 | 2.34 | 1.94 | | | | |
| Mg | 3.70 | 3.70 | 3.13 | 2.76 | 2.34 | 2.45 | 2.13 | 1.97 | 2.56 | 1.90 | 2.22 | | | | |
| Ti | 0.32 | 0.02 | 0.22 | 0.38 | 0.35 | 0.37 | 0.07 | 0.22 | 0.15 | 0.15 | 0.18 | | | | |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | | | | |
| Mn | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.03 | 0.00 | 0.05 | 0.04 | 0.00 | 0.00 | | | | |
| Fe+2 | 0.32 | 0.15 | 0.02 | 0.05 | 0.09 | 0.01 | 0.38 | 0.22 | 0.08 | 0.13 | 0.12 | | | | |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| Ca | 1.60 | 1.69 | 1.84 | 1.72 | 1.76 | 1.75 | 1.62 | 1.73 | 1.89 | 1.87 | 1.86 | | | | |
| Na | 0.06 | 0.14 | 0.13 | 0.21 | 0.13 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | | | | |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | | | | |
| Na | 0.73 | 0.62 | 0.42 | 0.57 | 0.66 | 0.52 | 0.24 | 0.42 | 0.40 | 0.41 | 0.33 | | | | |
| K | 0.32 | 0.29 | 0.21 | 0.21 | 0.29 | 0.22 | 0.24 | 0.25 | 0.28 | 0.25 | 0.30 | | | | |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.03 | 0.00 | 0.03 | 0.00 | | | | |
| A | 1.05 | 0.92 | 0.62 | 0.78 | 0.95 | 0.74 | 0.57 | 0.70 | 0.68 | 0.69 | 0.63 | | | | |
| CATSUM | 16.05 | 15.92 | 15.62 | 15.78 | 15.95 | 15.74 | 15.57 | 15.70 | 15.68 | 15.69 | 15.63 | | | | |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.28 | 0.00 | 0.00 | | | | |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.08 | 0.03 | | | | |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.61 | 1.70 | 1.92 | 1.97 | | | | |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | | | | |
| Fe/Fe+Mg | 0.23 | 0.16 | 0.24 | 0.33 | 0.44 | 0.39 | 0.55 | 0.58 | 0.44 | 0.57 | 0.48 | | | | |
| # | 517 | 518 | 519 | 520 | 521 | 522 | 523 | 524 | 525 | 526 | 527 | | | | |

Table 7. Hornblendes from xenoliths, eclogites and granulites.

| SAMPLE | K | | | L | | | | | | | |
|----------|--------|-------|--------|-------|-------|-------|-------|-------|-------|-------|--------|
| SiO2 | 41.60 | 42.50 | 42.30 | 42.62 | 42.58 | 43.29 | 42.36 | 42.62 | 39.17 | 39.40 | 41.18 |
| Al2O3 | 14.70 | 12.30 | 14.30 | 12.21 | 12.32 | 12.36 | 12.02 | 12.62 | 16.17 | 15.78 | 15.28 |
| FeO | 16.00 | 16.40 | 15.60 | 9.94 | 9.94 | 10.13 | 9.84 | 11.70 | 10.93 | 10.81 | 10.40 |
| MgO | 10.40 | 10.70 | 10.20 | 15.82 | 15.75 | 16.06 | 15.99 | 14.55 | 13.82 | 13.78 | 14.49 |
| CaO | 11.80 | 11.50 | 12.20 | 11.45 | 11.56 | 11.46 | 11.43 | 10.98 | 12.42 | 12.43 | 12.25 |
| Na2O | 1.40 | 0.90 | 0.90 | 2.48 | 2.32 | 2.26 | 2.33 | 2.44 | 2.45 | 2.49 | 2.49 |
| K2O | 2.10 | 1.60 | 1.80 | 0.81 | 0.85 | 0.83 | 0.82 | 0.70 | 0.92 | 0.94 | 0.65 |
| TiO2 | 1.70 | 1.60 | 1.30 | 1.01 | 1.10 | 0.91 | 1.08 | 2.02 | 1.93 | 1.91 | 2.02 |
| MnO | 0.00 | 0.00 | 0.00 | 0.16 | 0.16 | 0.20 | 0.15 | 0.24 | 0.09 | 0.05 | 0.07 |
| BaO | n | n | n | n | n | n | n | n | n | n | n |
| Cl | n | n | n | n | 0.19 | 0.20 | n | n | n | 0.01 | 0.02 |
| F | 0.20 | n | n | n | n | n | n | n | n | n | n |
| Cr2O3 | n | n | n | 0.47 | 0.18 | 0.17 | 0.55 | 0.04 | 0.03 | 0.01 | 0.01 |
| SUBSUM | 99.90 | 97.50 | 98.60 | 96.97 | 96.95 | 97.87 | 96.57 | 97.91 | 97.93 | 97.61 | 98.86 |
| Cl=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F=O | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SUM | 99.82 | 97.50 | 98.60 | 96.97 | 96.91 | 97.82 | 96.57 | 97.91 | 97.93 | 97.61 | 98.86 |
| H2Ocalc | 1.94 | 1.99 | 2.02 | 2.04 | 1.98 | 2.00 | 2.03 | 2.05 | 2.03 | 2.03 | 2.06 |
| SUM | 101.75 | 99.49 | 100.62 | 99.01 | 98.89 | 99.83 | 98.60 | 99.96 | 99.96 | 99.63 | 100.92 |
| Si | 6.13 | 6.39 | 6.27 | 6.28 | 6.28 | 6.32 | 6.27 | 6.25 | 5.78 | 5.83 | 5.97 |
| Aliv | 1.87 | 1.61 | 1.73 | 1.72 | 1.72 | 1.68 | 1.73 | 1.75 | 2.22 | 2.17 | 2.03 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.69 | 0.57 | 0.77 | 0.40 | 0.42 | 0.45 | 0.36 | 0.43 | 0.59 | 0.58 | 0.58 |
| Fe+2 | 1.84 | 1.86 | 1.83 | 1.02 | 0.99 | 0.96 | 0.99 | 1.17 | 1.16 | 1.17 | 1.07 |
| Mg | 2.29 | 2.40 | 2.25 | 3.47 | 3.46 | 3.49 | 3.53 | 3.18 | 3.04 | 3.04 | 3.13 |
| Ti | 0.19 | 0.18 | 0.14 | 0.11 | 0.12 | 0.10 | 0.12 | 0.22 | 0.21 | 0.21 | 0.22 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.01 | 0.01 | 0.01 |
| Fe+2 | 0.14 | 0.21 | 0.10 | 0.21 | 0.23 | 0.27 | 0.23 | 0.27 | 0.19 | 0.16 | 0.19 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.86 | 1.79 | 1.90 | 1.77 | 1.75 | 1.70 | 1.75 | 1.71 | 1.80 | 1.83 | 1.81 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.40 | 0.26 | 0.26 | 0.71 | 0.66 | 0.64 | 0.67 | 0.69 | 0.70 | 0.71 | 0.70 |
| K | 0.40 | 0.31 | 0.34 | 0.15 | 0.16 | 0.15 | 0.15 | 0.13 | 0.17 | 0.18 | 0.12 |
| Ca | 0.00 | 0.06 | 0.04 | 0.04 | 0.08 | 0.09 | 0.06 | 0.02 | 0.16 | 0.14 | 0.10 |
| A | 0.80 | 0.63 | 0.64 | 0.90 | 0.91 | 0.89 | 0.88 | 0.84 | 1.04 | 1.03 | 0.92 |
| CATSUM | 15.80 | 15.63 | 15.64 | 15.90 | 15.91 | 15.89 | 15.88 | 15.84 | 16.04 | 16.03 | 15.92 |
| F | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cl | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OHcalc | 1.91 | 2.02 | 2.00 | 2.00 | 1.95 | 1.95 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.46 | 0.46 | 0.46 | 0.26 | 0.26 | 0.26 | 0.26 | 0.31 | 0.31 | 0.31 | 0.29 |
| # | 528 | 529 | 530 | 531 | 532 | 533 | 534 | 535 | 536 | 537 | 538 |

Table 7. Hornblendes from xenoliths, eclogites and granulites.

| SAMPLE | L | | | | | | | | |
|----------|--------|--------|-------|-------|-------|-------|-------|-------|-------|
| SiO2 | 39.76 | 41.67 | 40.86 | 41.72 | 41.94 | 41.61 | 42.24 | 41.00 | 40.85 |
| Al2O3 | 15.86 | 12.79 | 13.26 | 12.49 | 12.43 | 13.37 | 12.96 | 13.84 | 13.73 |
| FeO | 11.27 | 10.56 | 11.27 | 10.55 | 11.00 | 11.40 | 10.83 | 12.70 | 10.84 |
| MgO | 13.75 | 15.66 | 15.32 | 15.89 | 15.19 | 14.46 | 14.75 | 13.98 | 14.75 |
| CaO | 12.53 | 11.83 | 11.59 | 11.47 | 11.29 | 11.83 | 11.57 | 11.06 | 11.68 |
| Na2O | 2.52 | 2.77 | 2.63 | 2.90 | 2.76 | 2.33 | 2.55 | 2.47 | 2.44 |
| K2O | 0.89 | 0.92 | 0.88 | 0.89 | 0.85 | 0.74 | 0.72 | 0.36 | 0.89 |
| TiO2 | 2.01 | 2.06 | 1.93 | 1.51 | 1.70 | 1.75 | 1.59 | 1.60 | 2.17 |
| MnO | 0.10 | 0.17 | 0.15 | 0.13 | 0.22 | 0.18 | 0.16 | 0.21 | 0.10 |
| BaO | n | n | n | n | n | n | n | n | n |
| Cl | 0.02 | 0.03 | 0.03 | 0.11 | 0.14 | 0.03 | 0.03 | 0.24 | 0.02 |
| F | n | n | n | n | n | n | n | n | n |
| Cr2O3 | 0.03 | 0.03 | 0.03 | 0.06 | 0.02 | 0.09 | 0.07 | 0.03 | 0.02 |
| SUBSUM | 98.74 | 98.49 | 97.95 | 97.72 | 97.62 | 97.79 | 97.47 | 97.49 | 97.49 |
| Cl=O | 0.00 | 0.01 | 0.01 | 0.02 | 0.03 | 0.01 | 0.01 | 0.05 | 0.00 |
| F=O | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SUM | 98.74 | 98.48 | 97.94 | 97.70 | 97.59 | 97.78 | 97.46 | 97.44 | 97.49 |
| H2Ocalc | 2.04 | 2.04 | 2.03 | 2.01 | 2.00 | 2.03 | 2.03 | 1.96 | 2.03 |
| SUM | 100.78 | 100.53 | 99.97 | 99.70 | 99.58 | 99.81 | 99.49 | 99.40 | 99.51 |
| Si | 5.82 | 6.09 | 6.02 | 6.14 | 6.19 | 6.13 | 6.21 | 6.08 | 6.03 |
| Aliv | 2.18 | 1.91 | 1.98 | 1.86 | 1.81 | 1.87 | 1.79 | 1.92 | 1.97 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.56 | 0.29 | 0.33 | 0.31 | 0.35 | 0.45 | 0.46 | 0.50 | 0.42 |
| Fe+2 | 1.22 | 1.07 | 1.09 | 1.03 | 1.12 | 1.19 | 1.13 | 1.23 | 1.10 |
| Mg | 3.00 | 3.41 | 3.37 | 3.49 | 3.34 | 3.17 | 3.23 | 3.09 | 3.24 |
| Ti | 0.22 | 0.23 | 0.21 | 0.17 | 0.19 | 0.19 | 0.18 | 0.18 | 0.24 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.01 |
| Fe+2 | 0.16 | 0.22 | 0.30 | 0.27 | 0.25 | 0.21 | 0.20 | 0.35 | 0.24 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.82 | 1.76 | 1.68 | 1.72 | 1.72 | 1.76 | 1.78 | 1.62 | 1.75 |
| Na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.72 | 0.79 | 0.75 | 0.83 | 0.79 | 0.67 | 0.73 | 0.71 | 0.70 |
| K | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.14 | 0.14 | 0.07 | 0.17 |
| Ca | 0.14 | 0.10 | 0.15 | 0.10 | 0.06 | 0.10 | 0.04 | 0.13 | 0.10 |
| A | 1.02 | 1.05 | 1.06 | 1.09 | 1.01 | 0.91 | 0.91 | 0.91 | 0.97 |
| CATSUM | 16.02 | 16.05 | 16.06 | 16.09 | 16.01 | 15.91 | 15.91 | 15.91 | 15.97 |
| F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cl | 0.00 | 0.01 | 0.01 | 0.03 | 0.04 | 0.01 | 0.01 | 0.06 | 0.01 |
| OHcalc | 2.00 | 1.99 | 1.99 | 1.97 | 1.96 | 1.99 | 1.99 | 1.94 | 1.99 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.32 | 0.27 | 0.29 | 0.27 | 0.29 | 0.31 | 0.29 | 0.34 | 0.29 |
| # | 539 | 540 | 541 | 542 | 543 | 544 | 545 | 546 | 547 |

KEY TO TABLE 8

| ANALYSIS # | SAMPLE CODE | STARTING MATERIAL | REFERENCE |
|-------------------------------|-------------|---|-------------------------|
| 548-558 559-563 | EX1 | Mt. Hood andesite 1921 Kilauea olivine basalt | Allen & Boettcher, 1983 |
| 564-567 | EX2 | synthetic granodiorite | Naney, 1983 |
| 568-573 574-582 583-588 | EX3 | Picture Gorge tholeiite 1921 Kilauea olivine basalt 1801 Hualalai alkali basalt | Helz, 1973 |
| 589-594 | EX4 | granodiorite | Sykes, 1979 |
| 595-616 617-619 | EX5 | olivine tholeiite synthetic amphibolite with excess SiO ₂ (quartz added) | Spear, 1981 |

Table heading reports run temperature (T) in degrees Centigrade, run pressure (P) in kilobars, and oxygen fugacity buffer conditions. * denotes approximate buffer conditions in experiments where H₂ membrane was used.

Table 6. Hornblandes from experiments.

REFERENCE EX1

| T | 900 | 900 | 900 | 900 | 900 | 940 | 940 | 940 | 900 | 900 | 900 |
|--------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| P | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 16 | 16 | 16 |
| BUFFER | NNO | NNO | NNO | NNO | NNO | NNO | NNO | NNO | NNO | NNO | NNO |
| SiO ₂ | 43.58 | 43.23 | 44.36 | 43.51 | 43.35 | 43.84 | 43.95 | 43.71 | 43.28 | 44.07 | 43.52 |
| Al ₂ O ₃ | 14.86 | 14.26 | 13.81 | 14.15 | 14.23 | 13.40 | 13.47 | 13.20 | 15.28 | 13.62 | 14.47 |
| FeO | 9.74 | 9.21 | 9.51 | 9.60 | 9.49 | 8.16 | 8.17 | 7.90 | 9.34 | 9.74 | 9.16 |
| MgO | 12.66 | 12.70 | 12.93 | 12.46 | 12.61 | 14.22 | 14.54 | 14.80 | 12.55 | 12.94 | 12.36 |
| CaO | 10.30 | 10.52 | 10.22 | 10.43 | 10.05 | 10.15 | 10.25 | 10.36 | 10.10 | 9.49 | 10.39 |
| Na ₂ O | 2.69 | 2.67 | 2.67 | 2.60 | 2.63 | 2.63 | 2.67 | 2.72 | 2.81 | 2.66 | 2.65 |
| K ₂ O | 0.50 | 0.50 | 0.45 | 0.48 | 0.55 | 0.52 | 0.54 | 0.49 | 0.52 | 0.40 | 0.48 |
| TiO ₂ | 1.65 | 1.97 | 1.82 | 1.75 | 1.65 | 1.69 | 1.76 | 1.72 | 1.64 | 1.59 | 1.76 |
| MnO | 0.18 | 0.14 | 0.18 | 0.17 | 0.19 | 0.15 | 0.15 | 0.15 | 0.21 | 0.22 | 0.14 |
| SUM | 100.05 | 98.88 | 99.75 | 98.99 | 98.54 | 98.03 | 98.77 | 98.21 | 99.54 | 98.62 | 98.51 |
| H ₂ Ocalc | 2.10 | 2.08 | 2.10 | 2.08 | 2.08 | 2.08 | 2.09 | 2.08 | 2.10 | 2.08 | 2.08 |
| SUM | 102.15 | 100.96 | 101.85 | 101.07 | 100.62 | 100.11 | 100.86 | 100.29 | 101.64 | 100.70 | 100.59 |
| Si | 6.21 | 6.23 | 6.32 | 6.26 | 6.26 | 6.32 | 6.29 | 6.29 | 6.19 | 6.35 | 6.27 |
| Aliv | 1.79 | 1.77 | 1.68 | 1.74 | 1.74 | 1.68 | 1.71 | 1.71 | 1.81 | 1.65 | 1.73 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.70 | 0.65 | 0.64 | 0.67 | 0.69 | 0.60 | 0.57 | 0.53 | 0.76 | 0.66 | 0.73 |
| Fe+2 | 1.01 | 1.02 | 1.01 | 1.06 | 1.01 | 0.81 | 0.79 | 0.76 | 0.99 | 0.96 | 1.03 |
| Mg | 2.69 | 2.73 | 2.75 | 2.67 | 2.72 | 3.06 | 3.10 | 3.18 | 2.67 | 2.78 | 2.66 |
| Ti | 0.18 | 0.21 | 0.20 | 0.19 | 0.18 | 0.18 | 0.19 | 0.19 | 0.18 | 0.17 | 0.19 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 |
| Fe+2 | 0.15 | 0.09 | 0.13 | 0.10 | 0.14 | 0.18 | 0.19 | 0.19 | 0.13 | 0.21 | 0.07 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.57 | 1.62 | 1.56 | 1.61 | 1.56 | 1.57 | 1.57 | 1.60 | 1.56 | 1.47 | 1.60 |
| Na | 0.26 | 0.27 | 0.29 | 0.27 | 0.28 | 0.24 | 0.22 | 0.20 | 0.29 | 0.30 | 0.31 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.48 | 0.48 | 0.45 | 0.46 | 0.46 | 0.50 | 0.52 | 0.56 | 0.49 | 0.44 | 0.43 |
| K | 0.09 | 0.09 | 0.08 | 0.09 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.07 | 0.09 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.57 | 0.57 | 0.53 | 0.54 | 0.56 | 0.59 | 0.62 | 0.65 | 0.59 | 0.52 | 0.52 |
| CATSUM | 15.57 | 15.57 | 15.53 | 15.54 | 15.56 | 15.59 | 15.62 | 15.65 | 15.59 | 15.52 | 15.52 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.37 | 0.36 | 0.36 | 0.37 | 0.36 | 0.30 | 0.30 | 0.29 | 0.36 | 0.36 | 0.36 |
| # | 548 | 549 | 550 | 551 | 552 | 553 | 554 | 555 | 556 | 557 | 558 |

Table 8. Hornblendes from experiments.

| REFERENCE | EX1 | | | | | EX2 | | | | EX3 | |
|-----------|-------|--------|--------|--------|-------|-------|--------|--------|-------|-------|--------|
| T | 1040 | 1040 | 1040 | 1040 | 1040 | 900 | 900 | 900 | 900 | 700 | 750 |
| P | 22 | 22 | 23 | 25 | 25 | 8 | 8 | 8 | 8 | 5 | 5 |
| BUFFER | NNO | NNO | NNO | NNO | NNO | NNO* | NNO* | NNO* | NNO* | QFM | QFM |
| SiO2 | 40.18 | 40.66 | 41.02 | 42.08 | 41.65 | 45.12 | 42.56 | 43.49 | 42.81 | 45.35 | 43.58 |
| Al2O3 | 12.19 | 13.81 | 14.21 | 13.59 | 13.25 | 13.06 | 13.86 | 13.18 | 12.23 | 8.16 | 11.41 |
| FeO | 8.44 | 10.24 | 11.94 | 10.89 | 10.21 | 8.97 | 12.39 | 11.38 | 11.50 | 18.70 | 20.11 |
| MgO | 12.38 | 13.45 | 9.83 | 9.91 | 11.21 | 15.29 | 14.56 | 15.78 | 14.85 | 10.37 | 8.03 |
| CaO | 12.17 | 9.16 | 9.19 | 9.84 | 9.83 | 11.60 | 11.72 | 11.68 | 11.71 | 11.69 | 11.26 |
| Na2O | 2.57 | 2.38 | 2.29 | 2.35 | 2.50 | 2.31 | 2.39 | 2.24 | 2.11 | 2.03 | 2.66 |
| K2O | 0.74 | 0.67 | 0.75 | 0.73 | 0.76 | 1.09 | 1.12 | 1.12 | 1.25 | 0.62 | 0.49 |
| TiO2 | 4.23 | 3.59 | 4.02 | 4.23 | 3.76 | 0.00 | 0.00 | 0.00 | 0.00 | 1.03 | 1.37 |
| MnO | 0.20 | 0.21 | 0.19 | 0.15 | 0.17 | n | n | n | n | n | n |
| SUM | 96.47 | 98.27 | 98.21 | 98.13 | 97.42 | 97.44 | 98.60 | 98.87 | 96.46 | 97.95 | 98.91 |
| H2Ocalc | 2.00 | 2.05 | 2.03 | 2.04 | 2.03 | 2.07 | 2.05 | 2.07 | 2.01 | 1.99 | 2.00 |
| SUM | 98.47 | 100.32 | 100.24 | 100.17 | 99.45 | 99.51 | 100.65 | 100.94 | 98.47 | 99.94 | 100.91 |
| Si | 6.01 | 5.35 | 6.05 | 6.17 | 6.15 | 6.53 | 6.22 | 6.30 | 6.38 | 6.03 | 6.55 |
| Aliv | 1.99 | 2.05 | 1.95 | 1.83 | 1.85 | 1.47 | 1.78 | 1.70 | 1.62 | 1.17 | 1.45 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.16 | 0.34 | 0.52 | 0.52 | 0.45 | 0.75 | 0.61 | 0.55 | 0.53 | 0.28 | 0.57 |
| Fe+2 | 1.06 | 0.88 | 1.34 | 1.34 | 1.21 | 0.95 | 1.21 | 1.04 | 1.18 | 2.27 | 2.48 |
| Mg | 2.76 | 2.93 | 2.16 | 2.17 | 2.47 | 3.30 | 3.17 | 3.41 | 3.30 | 2.33 | 1.80 |
| Ti | 0.48 | 0.40 | 0.45 | 0.47 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.15 |
| Mn | 0.03 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 4.86 | 5.00 | 5.00 | 4.99 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.00 | 0.03 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fe+2 | 0.00 | 0.37 | 0.13 | 0.00 | 0.05 | 0.14 | 0.30 | 0.34 | 0.26 | 0.08 | 0.04 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.95 | 1.44 | 1.45 | 1.55 | 1.55 | 1.60 | 1.70 | 1.66 | 1.74 | 1.89 | 1.81 |
| Na | 0.05 | 0.17 | 0.39 | 0.45 | 0.37 | 0.07 | 0.00 | 0.00 | 0.00 | 0.03 | 0.14 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.70 | 0.51 | 0.26 | 0.22 | 0.34 | 0.58 | 0.68 | 0.63 | 0.61 | 0.56 | 0.63 |
| K | 0.14 | 0.13 | 0.14 | 0.14 | 0.14 | 0.20 | 0.21 | 0.21 | 0.24 | 0.12 | 0.09 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.15 | 0.12 | 0.00 | 0.00 |
| A | 0.84 | 0.63 | 0.40 | 0.35 | 0.48 | 0.78 | 1.02 | 0.99 | 0.97 | 0.68 | 0.72 |
| CATSUM | 15.69 | 15.63 | 15.40 | 15.35 | 15.48 | 15.78 | 16.02 | 15.99 | 15.97 | 15.68 | 15.72 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.34 | 0.37 | 0.48 | 0.46 | 0.41 | 0.25 | 0.32 | 0.29 | 0.30 | 0.50 | 0.58 |
| # | 559 | 560 | 561 | 562 | 563 | 564 | 565 | 566 | 567 | 568 | 569 |

Table 8. Hornblendes from experiments.

REFERENCE EX3

| T | 825 | 875 | 930 | 1000 | 700 | 725 | 825 | 875 | 930 | 1000 | 725 |
|--------------------------------|-------|-------|-------|--------|-------|--------|--------|-------|-------|-------|-------|
| P | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| BUFFER | QFM | QFM | QFM | QFM | QFM | QFM | QFM | QFM | QFM | QFM | HM |
| SiO ₂ | 42.38 | 42.42 | 41.97 | 40.44 | 47.61 | 46.71 | 44.58 | 43.36 | 42.81 | 40.08 | 47.43 |
| Al ₂ O ₃ | 11.96 | 11.94 | 11.62 | 11.73 | 7.04 | 9.42 | 11.19 | 11.80 | 12.34 | 13.34 | 9.26 |
| FeO | 17.62 | 16.80 | 14.48 | 18.41 | 14.50 | 13.50 | 13.95 | 11.88 | 10.40 | 15.68 | 11.35 |
| MgO | 8.60 | 9.68 | 11.54 | 9.20 | 13.23 | 12.78 | 12.67 | 13.45 | 14.12 | 9.92 | 14.33 |
| CaO | 11.70 | 11.20 | 11.30 | 11.14 | 12.22 | 12.30 | 11.61 | 11.80 | 11.51 | 11.24 | 11.79 |
| Na ₂ O | 2.45 | 2.70 | 2.73 | 2.72 | 1.45 | 1.61 | 1.95 | 2.10 | 2.22 | 2.30 | 1.73 |
| K ₂ O | 0.51 | 0.48 | 0.48 | 0.81 | 0.47 | 0.50 | 0.52 | 0.44 | 0.40 | 0.50 | 0.48 |
| TiO ₂ | 2.09 | 2.45 | 2.73 | 3.98 | 1.23 | 1.43 | 2.23 | 2.63 | 3.12 | 4.27 | 1.23 |
| MnO | n | n | 0.26 | 0.16 | n | n | n | n | 0.18 | 0.15 | n |
| SUM | 97.31 | 97.67 | 97.31 | 98.59 | 97.75 | 98.25 | 98.70 | 97.46 | 97.10 | 97.48 | 97.60 |
| H ₂ Ocalc | 1.98 | 1.99 | 2.00 | 1.98 | 2.04 | 2.05 | 2.05 | 2.04 | 2.04 | 1.99 | 2.07 |
| SUM | 99.29 | 99.66 | 99.31 | 100.57 | 99.79 | 100.30 | 100.75 | 99.50 | 99.14 | 99.47 | 99.67 |
| Si | 6.42 | 6.38 | 6.29 | 6.12 | 7.01 | 6.82 | 6.51 | 6.37 | 6.28 | 6.03 | 6.88 |
| Aliv | 1.58 | 1.62 | 1.71 | 1.88 | 0.99 | 1.18 | 1.49 | 1.63 | 1.72 | 1.97 | 1.12 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.56 | 0.49 | 0.37 | 0.21 | 0.23 | 0.44 | 0.44 | 0.42 | 0.42 | 0.40 | 0.46 |
| Fe+2 | 2.23 | 2.06 | 1.74 | 2.26 | 1.73 | 1.63 | 1.56 | 1.35 | 1.15 | 1.89 | 1.30 |
| Mg | 1.94 | 2.17 | 2.58 | 2.00 | 2.90 | 2.78 | 2.76 | 2.95 | 3.09 | 2.23 | 3.10 |
| Ti | 0.24 | 0.28 | 0.31 | 0.45 | 0.14 | 0.16 | 0.24 | 0.29 | 0.34 | 0.48 | 0.13 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 4.97 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.00 | 0.00 | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.00 |
| Fe+2 | 0.00 | 0.05 | 0.07 | 0.07 | 0.06 | 0.02 | 0.14 | 0.12 | 0.12 | 0.08 | 0.07 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.90 | 1.80 | 1.81 | 1.81 | 1.93 | 1.92 | 1.82 | 1.86 | 1.81 | 1.81 | 1.83 |
| Na | 0.10 | 0.15 | 0.08 | 0.10 | 0.01 | 0.06 | 0.04 | 0.03 | 0.05 | 0.08 | 0.09 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.62 | 0.64 | 0.71 | 0.70 | 0.40 | 0.40 | 0.51 | 0.57 | 0.59 | 0.59 | 0.39 |
| K | 0.10 | 0.09 | 0.09 | 0.16 | 0.09 | 0.09 | 0.10 | 0.08 | 0.07 | 0.10 | 0.09 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.72 | 0.73 | 0.80 | 0.86 | 0.49 | 0.49 | 0.61 | 0.65 | 0.66 | 0.68 | 0.48 |
| CATSUM | 15.68 | 15.73 | 15.80 | 15.86 | 15.49 | 15.49 | 15.61 | 15.65 | 15.66 | 15.68 | 15.48 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.53 | 0.49 | 0.41 | 0.53 | 0.38 | 0.37 | 0.38 | 0.33 | 0.29 | 0.47 | 0.31 |
| # | 570 | 571 | 572 | 573 | 574 | 575 | 576 | 577 | 578 | 579 | 580 |

Table 8. Hornblendes from experiments.

| REFERENCE | EX3 | | | | | | | | EX4 | | |
|--------------------------------|-------|-------|-------|-------|--------|-------|-------|-------|-------|-------|-------|
| T | 825 | 925 | 725 | 825 | 875 | 930 | 970 | 1000 | 825 | 862 | 914 |
| P | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 2 | 2 |
| BUFFER | HM | HM | QFM | QFM | QFM | QFM | QFM | QFM | QFM* | QFM* | QFM* |
| SiO ₂ | 46.60 | 46.30 | 44.77 | 42.77 | 42.68 | 41.92 | 41.77 | 40.40 | 44.75 | 45.08 | 44.33 |
| Al ₂ O ₃ | 10.69 | 11.29 | 10.01 | 12.62 | 12.16 | 12.56 | 12.51 | 11.66 | 8.38 | 9.68 | 10.13 |
| FeO | 11.26 | 8.53 | 16.41 | 15.20 | 14.12 | 11.46 | 12.85 | 17.19 | 16.75 | 13.29 | 12.97 |
| MgO | 13.95 | 15.82 | 10.44 | 10.50 | 11.20 | 13.10 | 12.65 | 10.01 | 11.32 | 13.26 | 12.26 |
| CaO | 11.48 | 11.76 | 10.87 | 10.99 | 11.06 | 11.84 | 11.61 | 11.13 | 11.61 | 10.80 | 10.94 |
| Na ₂ O | 1.86 | 1.82 | 2.77 | 2.59 | 2.60 | 2.57 | 2.57 | 2.56 | 1.16 | 1.48 | 1.70 |
| K ₂ O | 0.45 | 0.41 | 0.66 | 0.74 | 0.69 | 0.71 | 0.66 | 0.83 | 0.83 | 0.49 | 0.93 |
| TiO ₂ | 1.38 | 1.50 | 1.47 | 2.14 | 2.47 | 2.65 | 2.79 | 3.64 | 1.04 | 1.81 | 1.28 |
| MnO | n | n | n | n | 0.24 | 0.24 | n | 0.33 | 0.44 | 0.11 | 0.23 |
| SUM | 97.67 | 97.43 | 97.40 | 97.55 | 98.04 | 97.05 | 97.41 | 97.75 | 96.28 | 96.00 | 94.77 |
| H ₂ Ocalc | 2.07 | 2.09 | 2.00 | 2.01 | 2.02 | 2.02 | 2.02 | 1.97 | 1.97 | 2.01 | 1.98 |
| SUM | 99.74 | 99.52 | 99.40 | 99.56 | 100.06 | 99.07 | 99.43 | 99.72 | 98.25 | 98.01 | 96.75 |
| Si | 6.75 | 6.65 | 6.71 | 6.38 | 6.33 | 6.22 | 6.21 | 6.14 | 6.81 | 6.72 | 6.72 |
| Aliv | 1.25 | 1.35 | 1.29 | 1.62 | 1.67 | 1.78 | 1.79 | 1.86 | 1.19 | 1.28 | 1.28 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.58 | 0.56 | 0.48 | 0.60 | 0.46 | 0.42 | 0.40 | 0.23 | 0.31 | 0.42 | 0.53 |
| Fe+2 | 1.26 | 0.89 | 2.03 | 1.83 | 1.75 | 1.39 | 1.49 | 2.09 | 2.01 | 1.43 | 1.56 |
| Mg | 3.01 | 3.39 | 2.33 | 2.33 | 2.48 | 2.90 | 2.80 | 2.27 | 2.57 | 2.95 | 2.77 |
| Ti | 0.15 | 0.16 | 0.17 | 0.24 | 0.28 | 0.30 | 0.31 | 0.42 | 0.12 | 0.20 | 0.15 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.04 | 0.06 | 0.01 | 0.03 |
| Fe+2 | 0.10 | 0.13 | 0.03 | 0.07 | 0.00 | 0.03 | 0.11 | 0.09 | 0.12 | 0.23 | 0.09 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.78 | 1.81 | 1.75 | 1.76 | 1.89 | 1.88 | 1.85 | 1.81 | 1.82 | 1.73 | 1.78 |
| Na | 0.12 | 0.06 | 0.22 | 0.17 | 0.11 | 0.05 | 0.05 | 0.05 | 0.00 | 0.03 | 0.11 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.41 | 0.45 | 0.58 | 0.57 | 0.63 | 0.69 | 0.69 | 0.70 | 0.34 | 0.39 | 0.39 |
| K | 0.08 | 0.08 | 0.13 | 0.14 | 0.13 | 0.13 | 0.13 | 0.16 | 0.16 | 0.09 | 0.18 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 |
| A | 0.49 | 0.52 | 0.71 | 0.72 | 0.76 | 0.82 | 0.82 | 0.86 | 0.58 | 0.49 | 0.57 |
| CATSUM | 15.49 | 15.52 | 15.71 | 15.72 | 15.76 | 15.82 | 15.82 | 15.86 | 15.58 | 15.49 | 15.57 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.31 | 0.23 | 0.47 | 0.45 | 0.41 | 0.33 | 0.36 | 0.49 | 0.45 | 0.36 | 0.37 |
| # | 581 | 582 | 583 | 584 | 585 | 586 | 587 | 588 | 589 | 590 | 591 |

Table 8. Hornblendes from experiments.

| REFERENCE | EX4 | | | EX5 | | | | | | | |
|-----------|-------|-------|--------|--------|--------|--------|--------|-------|-------|--------|--------|
| T | 765 | 786 | 800 | 650 | 706 | 754 | 883 | 599 | 651 | 707 | 750 |
| P | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| BUFFER | QFM* | QFM* | QFM* | HM | HM | HM | HM | QFM | QFM | QFM | QFM |
| SiO2 | 44.50 | 43.96 | 46.76 | 52.30 | 52.00 | 52.30 | 49.70 | 49.30 | 48.90 | 49.20 | 48.80 |
| Al2O3 | 8.48 | 10.82 | 12.09 | 6.20 | 5.50 | 6.10 | 8.50 | 6.60 | 7.30 | 7.70 | 7.80 |
| FeO | 15.62 | 15.43 | 14.17 | 7.30 | 6.90 | 7.20 | 6.50 | 16.00 | 14.90 | 14.70 | 14.20 |
| MgO | 11.45 | 10.43 | 12.09 | 19.00 | 20.90 | 20.80 | 19.50 | 14.50 | 15.10 | 14.00 | 13.90 |
| CaO | 10.93 | 10.18 | 10.69 | 11.30 | 10.60 | 9.40 | 9.30 | 9.10 | 9.10 | 9.10 | 9.70 |
| Na2O | 1.16 | 1.28 | 1.41 | 1.20 | 1.00 | 1.20 | 2.30 | 1.40 | 1.60 | 1.90 | 1.80 |
| K2O | 0.79 | 0.83 | 0.80 | 0.10 | 0.10 | 0.10 | 0.30 | 0.00 | 0.10 | 0.10 | 0.10 |
| TiO2 | 1.10 | 1.03 | 1.14 | 0.40 | 0.50 | 0.50 | 1.40 | 0.80 | 0.20 | 1.10 | 1.40 |
| MnO | 0.44 | 0.34 | 0.25 | 0.20 | 0.50 | 0.40 | 0.50 | 0.20 | 0.20 | 0.20 | 0.30 |
| SUM | 94.47 | 94.30 | 99.40 | 98.00 | 98.00 | 98.00 | 98.00 | 97.90 | 97.40 | 98.00 | 98.00 |
| H2Ocalc | 1.95 | 1.96 | 2.09 | 2.14 | 2.14 | 2.15 | 2.14 | 2.06 | 2.05 | 2.07 | 2.07 |
| SUM | 96.42 | 96.26 | 101.49 | 100.14 | 100.14 | 100.15 | 100.14 | 99.96 | 99.45 | 100.07 | 100.07 |
| Si | 6.85 | 6.74 | 6.72 | 7.33 | 7.28 | 7.30 | 6.98 | 7.19 | 7.14 | 7.13 | 7.08 |
| Aliv | 1.15 | 1.26 | 1.28 | 0.67 | 0.72 | 0.70 | 1.02 | 0.81 | 0.86 | 0.87 | 0.92 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.38 | 0.70 | 0.77 | 0.36 | 0.19 | 0.30 | 0.38 | 0.32 | 0.40 | 0.45 | 0.41 |
| Fe+2 | 1.86 | 1.80 | 1.52 | 0.63 | 0.39 | 0.32 | 0.39 | 1.44 | 1.29 | 1.41 | 1.43 |
| Mg | 2.63 | 2.38 | 2.59 | 3.97 | 4.36 | 4.33 | 4.08 | 3.15 | 3.29 | 3.02 | 3.01 |
| Ti | 0.13 | 0.12 | 0.12 | 0.04 | 0.05 | 0.05 | 0.15 | 0.09 | 0.02 | 0.12 | 0.15 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.06 | 0.04 | 0.03 | 0.02 | 0.06 | 0.05 | 0.06 | 0.02 | 0.02 | 0.02 | 0.04 |
| Fe+2 | 0.15 | 0.18 | 0.19 | 0.22 | 0.42 | 0.52 | 0.37 | 0.51 | 0.52 | 0.38 | 0.29 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.80 | 1.67 | 1.65 | 1.70 | 1.53 | 1.41 | 1.40 | 1.42 | 1.42 | 1.41 | 1.51 |
| Na | 0.00 | 0.11 | 0.14 | 0.06 | 0.00 | 0.02 | 0.17 | 0.04 | 0.03 | 0.19 | 0.16 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.35 | 0.27 | 0.25 | 0.27 | 0.27 | 0.30 | 0.46 | 0.35 | 0.43 | 0.35 | 0.34 |
| K | 0.16 | 0.16 | 0.15 | 0.02 | 0.02 | 0.02 | 0.05 | 0.00 | 0.02 | 0.02 | 0.02 |
| Ca | 0.01 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.51 | 0.44 | 0.40 | 0.29 | 0.35 | 0.32 | 0.51 | 0.35 | 0.45 | 0.37 | 0.36 |
| CATSUM | 15.51 | 15.44 | 15.40 | 15.29 | 15.35 | 15.32 | 15.51 | 15.35 | 15.45 | 15.37 | 15.36 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.43 | 0.45 | 0.40 | 0.18 | 0.16 | 0.16 | 0.16 | 0.38 | 0.36 | 0.37 | 0.36 |
| # | 592 | 593 | 594 | 595 | 596 | 597 | 598 | 599 | 600 | 601 | 602 |

Table 8. Hornblendes from experiments.

REFERENCE EX5

| T | 802 | 850 | 550 | 605 | 647 | 701 | 752 | 551 | 610 | 655 | 699 |
|--------------------------------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| P | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| BUFFER | QFM | QFM | QFM | QFM | QFM | QFM | HM | HM | HM | HM | HM |
| SiO ₂ | 46.60 | 46.70 | 54.50 | 54.50 | 52.70 | 51.10 | 50.90 | 51.20 | 51.00 | 49.80 | 48.80 |
| Al ₂ O ₃ | 9.00 | 9.70 | 5.20 | 5.60 | 6.30 | 6.70 | 7.70 | 5.20 | 5.70 | 7.20 | 8.30 |
| FeO | 13.90 | 13.70 | 7.90 | 8.00 | 7.90 | 7.80 | 8.00 | 18.00 | 17.50 | 15.10 | 14.70 |
| MgO | 13.80 | 12.60 | 18.60 | 18.00 | 18.00 | 18.70 | 17.60 | 12.90 | 13.10 | 13.30 | 13.70 |
| CaO | 10.40 | 10.30 | 10.30 | 10.10 | 10.80 | 10.90 | 11.00 | 9.20 | 8.80 | 9.80 | 9.30 |
| Na ₂ O | 2.00 | 2.20 | 0.70 | 1.00 | 1.10 | 1.40 | 1.60 | 0.70 | 1.00 | 1.60 | 1.90 |
| K ₂ O | 0.20 | 0.30 | 0.10 | 0.10 | 0.10 | 0.20 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| TiO ₂ | 1.80 | 2.20 | 0.20 | 0.40 | 0.60 | 0.80 | 0.60 | 0.40 | 0.50 | 0.80 | 1.00 |
| MnO | 0.30 | 0.20 | 0.40 | 0.50 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.30 | 0.30 |
| SUM | 98.00 | 97.90 | 97.90 | 98.20 | 97.90 | 98.00 | 97.90 | 98.10 | 98.10 | 98.00 | 98.10 |
| H ₂ Ocalc | 2.05 | 2.05 | 2.15 | 2.15 | 2.14 | 2.13 | 2.12 | 2.05 | 2.06 | 2.06 | 2.07 |
| SUM | 100.05 | 99.95 | 100.05 | 100.35 | 100.04 | 100.13 | 100.02 | 100.15 | 100.16 | 100.06 | 100.17 |
| Si | 6.81 | 6.81 | 7.60 | 7.58 | 7.39 | 7.20 | 7.18 | 7.48 | 7.43 | 7.23 | 7.08 |
| Aliv | 1.19 | 1.19 | 0.40 | 0.42 | 0.61 | 0.80 | 0.82 | 0.52 | 0.57 | 0.77 | 0.92 |
| T | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Alvi | 0.36 | 0.48 | 0.45 | 0.50 | 0.44 | 0.32 | 0.46 | 0.38 | 0.41 | 0.47 | 0.49 |
| Fe+2 | 1.44 | 1.54 | 0.66 | 0.72 | 0.74 | 0.67 | 0.77 | 1.77 | 1.69 | 1.57 | 1.44 |
| Mg | 3.00 | 2.74 | 3.87 | 3.73 | 3.76 | 3.93 | 3.70 | 2.81 | 2.85 | 2.88 | 2.96 |
| Ti | 0.20 | 0.24 | 0.02 | 0.04 | 0.06 | 0.08 | 0.06 | 0.04 | 0.05 | 0.09 | 0.11 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.04 | 0.02 | 0.05 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 |
| Fe+2 | 0.25 | 0.14 | 0.26 | 0.21 | 0.19 | 0.25 | 0.17 | 0.43 | 0.45 | 0.27 | 0.35 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.63 | 1.61 | 1.54 | 1.51 | 1.62 | 1.65 | 1.66 | 1.44 | 1.37 | 1.53 | 1.44 |
| Na | 0.00 | 0.23 | 0.15 | 0.23 | 0.14 | 0.05 | 0.12 | 0.08 | 0.13 | 0.17 | 0.17 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.49 | 0.39 | 0.04 | 0.04 | 0.16 | 0.33 | 0.32 | 0.12 | 0.15 | 0.28 | 0.36 |
| K | 0.04 | 0.06 | 0.02 | 0.02 | 0.02 | 0.04 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.52 | 0.45 | 0.06 | 0.06 | 0.18 | 0.36 | 0.34 | 0.14 | 0.17 | 0.30 | 0.38 |
| CATSUM | 15.52 | 15.45 | 15.06 | 15.06 | 15.18 | 15.36 | 15.34 | 15.14 | 15.17 | 15.30 | 15.38 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.36 | 0.38 | 0.19 | 0.20 | 0.20 | 0.19 | 0.20 | 0.44 | 0.43 | 0.39 | 0.38 |
| # | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 | 611 | 612 | 613 |

Table 8. Hornblendes from experiments.

REFERENCE EX5

| T | 763 | 690 | 710 | 720 | 722 | 675 |
|--------------------------------|--------|--------|--------|-------|--------|-------|
| P | 3 | 5 | 5 | 3 | 3 | 3 |
| BUFFER | QFM | HM | QFM | QFM | QFM | QFM |
| SiO ₂ | 47.80 | 49.20 | 48.00 | 48.00 | 50.00 | 49.60 |
| Al ₂ O ₃ | 8.30 | 8.80 | 9.30 | 9.30 | 7.30 | 7.40 |
| FeO | 14.60 | 9.60 | 13.50 | 13.00 | 14.10 | 14.30 |
| MgO | 13.40 | 17.00 | 13.90 | 14.20 | 14.00 | 14.20 |
| CaO | 10.10 | 10.00 | 10.00 | 9.90 | 10.30 | 10.00 |
| Na ₂ O | 1.90 | 1.50 | 1.90 | 1.50 | 1.30 | 1.30 |
| K ₂ O | 0.20 | 0.20 | 0.10 | 0.20 | n | n |
| TiO ₂ | 1.40 | 0.70 | 1.10 | 0.90 | 1.00 | 0.90 |
| MnO | 0.30 | 0.40 | 0.20 | 0.10 | n | n |
| SUM | 98.00 | 98.20 | 98.00 | 97.90 | 98.00 | 97.90 |
| H ₂ Ocalc | 2.05 | 2.11 | 2.07 | 2.08 | 2.08 | 2.07 |
| SUM | 100.05 | 100.31 | 100.07 | 99.98 | 100.08 | 99.97 |
| Si | 6.98 | 6.99 | 6.95 | 7.03 | 7.22 | 7.20 |
| Aliv | 1.02 | 1.01 | 1.05 | 0.97 | 0.78 | 0.80 |
| T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Alvi | 0.40 | 0.46 | 0.53 | 0.61 | 0.46 | 0.46 |
| Fe+2 | 1.53 | 0.86 | 1.35 | 1.25 | 1.42 | 1.39 |
| Mg | 2.91 | 3.60 | 3.00 | 3.05 | 3.01 | 3.06 |
| Ti | 0.15 | 0.07 | 0.12 | 0.10 | 0.11 | 0.10 |
| Mn | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Mn | 0.04 | 0.05 | 0.02 | 0.01 | 0.00 | 0.00 |
| Fe+2 | 0.25 | 0.28 | 0.29 | 0.32 | 0.28 | 0.34 |
| Mg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ca | 1.58 | 1.64 | 1.55 | 1.53 | 1.59 | 1.55 |
| Na | 0.13 | 0.03 | 0.14 | 0.14 | 0.13 | 0.11 |
| M4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Na | 0.41 | 0.39 | 0.40 | 0.28 | 0.24 | 0.26 |
| K | 0.04 | 0.04 | 0.02 | 0.04 | 0.00 | 0.00 |
| Ca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| A | 0.44 | 0.42 | 0.41 | 0.31 | 0.24 | 0.26 |
| CATSUM | 15.44 | 15.42 | 15.41 | 15.31 | 15.24 | 15.26 |
| OHcalc | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| ANSUM | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.38 | 0.24 | 0.35 | 0.34 | 0.36 | 0.36 |
| # | 614 | 615 | 616 | 617 | 618 | 619 |

REFERENCES

- Albee, A.L. and Ray, L., 1970, Correction factors for electron probe microanalysis of silicates, oxides, carbonates, phosphates, and sulfates: *Analytical Chemistry*, v. 42, p. 1408-1414.
- Allen, J.C. and Boettcher, A.L., 1983, The stability of amphibole in andesite and basalt at high pressures: *American Mineralogist*, v. 68, p. 307-314.
- Barker, F., Millard, H.T., Jr., and Lipman, P.W., 1979, Four low-K siliceous rocks of the western U.S.A., in Barker, F., ed., *Trondhjemites, dacites and related rocks*: Amsterdam, Elsevier, p. 415-432.
- Beckerman, G.M., Robinson, J.P., and Anderson, J.L., 1982, The Teutonia Batholith: a large intrusive complex of Jurassic and Cretaceous age in the eastern Mojave Desert, California, in Frost, E.G. and Martin, D.L., eds., *Mesozoic-Cenozoic Tectonic Evolution of the Colorado River Region*: San Diego, CA, Cordilleran Publishers, p. 205-220.
- Bence, A.E. and Albee, A.L., 1968, Empirical correction factors for the electron microanalysis of silicates and oxides: *Journal of Geology*, v. 76, p. 382-403.
- Berg, H.C., Elliott, R.L., Smith, J.G. and Koch, R.D., 1978, Geologic map of the Ketchikan and Prince Rupert quadrangles, Alaska: U.S. Geological Survey Open-File Report 78-73A, scale 1:250,000, 1 sheet.
- Best, M.G., 1975, Amphibole-bearing cumulate inclusions, Grand Canyon, Arizona, and their bearing on silica-undersaturated hydrous magmas in the upper mantle: *Journal of Petrology*, v. 16, p. 212-236.
- Bowen, Roger W. and Botbal, James M., 1975, The geologic retrieval and synopsis program [GRASP]: a portable data-retrieval system requiring minimal user training: U.S Geological Survey Professional Paper 966, 87 p.
- Bowen, Roger, 1983, MICRO-GRASP for Tektronix 4054 system - Users Manual.
- Conrad, W.K. and Kay, R.W. (preprint) Ultramafic and mafic inclusions from Adak Island: Crystallization history, and implications for the nature of primary magmas and crustal evolution in the Aleutian Arc.
- Crawford, M.L. and Hollister, L.S., 1982, Contrast of metamorphic and structural histories across the Work Channel lineament, coast plutonic complex, British Columbia: *Journal of Geophysical Research* v. 87, p. 3849-3860.
- Crawford, R.D., 1913, Geology and ore deposits of the Monarch and Tomichi districts, Colorado: *Colorado Geological Survey Bulletin* 4, 317p.
- Czamanske, G.K., 1965, Petrologic aspects of the Finnmarka igneous complex, Oslo area, Norway: *Journal of Geology*, v. 73, p. 293-322.

- Czamanske, G.K., Ishihara, Shunso and Atkin, S.A., 1981, Chemistry of rock-forming minerals of the Cretaceous-Paleocene Batholith in southwestern Japan and implications for magma genesis: *Journal of Geophysical Research*, v. 86, p. 10431-10469.
- Czamanske, G.K., Wones, D.R. and Eichelberger, J.C., 1977, Mineralogy and petrology of the intrusive complex Pliny Range, New Hampshire: *American Journal Science*, v. 277, p. 1073-1123.
- Czamanske, G.K. and Wones, D.R., 1973, Oxidation during magmatic differentiation, Finnmarka Complex, Oslo area, Norway: Part II, the mafic silicates: *Journal of Petrology*, v. 14, p. 349-380.
- Dawson, J.B. and Smith, J.V., 1982, Upper-mantle amphiboles: A review: *Mineralogical Magazine*, v. 45, p. 35-46.
- Deer, W.A., Howie, R.A. and Zussman, J., 1967, An introduction to the rock-forming minerals. London, Longmans, Green & Co., Ltd., 528 p.
- Dings, M.G. and Robinson, C.S., 1957, Geology and ore deposits of the Garfield quadrangle, Colorado: U.S. Geological Survey Professional Paper 298, 110 p.
- Flohr, Marta J.K., 1983, BASIC programs for calculation of cation site occupancies and plotting of mineral data with applications for evaluation of metamorphic mineral assemblages. U.S Geological Survey Open-File Report 83-905, 65 p.
- Goff, F.E. and Czamanske, G.K., 1972, Calculation of amphibole structural formulae: U.S Geological Survey Computer Center Division. Computer Contribution 16.
- Guy, R.E., 1980, The Dinkey Creek Intrusive Series, Huntington Lake Quadrangle, Fresno County, California: M.S. thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.
- Hamilton, W., 1969, Geologic map of the Riggins Quadrangle, West-Central Idaho: U.S Geological Survey Miscellaneous Geologic Investigations Map I-579, Scale 1:125,000.
- Hamilton, W., 1963, Trondhjemite in the Riggins quadrangle, western Idaho: U.S Geological Survey Professional Paper 450-E, p. E98-E102.
- Hammarstrom, J.M., 1982, Chemical and mineralogical variation in the Pioneer Batholith, southwest Montana: U.S. Geological Survey Open-File Report 82-148, p.
- Hammarstrom J.M. and Zen, E-an, 1983, Possible use of Al content in hornblende as a geobarometer for plutonic rocks: *Geological Society of America Abstracts with programs* v. 15, 6, p. 590.
- Helz, R.T., 1973, Phase relations of basalts in their melting range at $P_{H_2O}=5$ kbar as a function of oxygen fugacity: *Journal of Petrology*,

v. 14, p. 249-302.

- Huebner, J.S., 1983, RDARL4, a FORTRAN interface for transferring analytical data from an Applied Research Laboratories electron microprobe to a PDP-11 computing system: U.S Geological Survey Open-File Report 83-713, 38 p.
- Hutchison, W.W., 1982, Geology of the Prince Rupert-Skeena map area, British Columbia: Geological Survey Canada Memoir 394, 116 p.
- Janardhan, A.S., Newton, R.C., and Hansen, E.C., 1983, Transformation of peninsular gneiss to charnockite in southern Karnataka: Memoir Geological Society of India, v. 4, p. 417-435.
- Kay, S.M. and Kay, R.U., 1983, Thermal history of the deep crust inferred from granulite xenoliths, Queensland, Australia: American Journal of Science, v. 283-A, p. 486-513.
- Leake, B.E., 1978, Nomenclature of amphiboles: Mineralogical Magazine, v. 42, p. 533-563.
- Leake, B.E., 1971, On aluminous and edenitic hornblendes: Mineralogical Magazine, v. 38, p. 389-407.
- McGee, J.J., 1983, \$ANBA - a rapid, combined data acquisition and correction program for the SEMQ electron microprobe: U.S. Geological Survey Open-File Report 83-817, 47 p.
- Naney, M.T., 1983, Phase equilibria of rock-forming ferromagnesian silicates in granitic systems: American Journal of Science, v. 283, p. 993-1033.
- Papike, J.J., Cameron, K.L., and Baldwin, K., 1974, Amphiboles and pyroxenes: Characterization of other than quadrilateral components and estimates of ferric iron from microprobe data: Geological Society of America Abstracts with Programs, v. 6, p. 1054-1054.
- Raith, M., Raase, P., Ackermann, D., and Lal, R.K., 1983, Metamorphic conditions in the charnockite-khondalite zone of south India: Geothermobarometry on garnet-pyroxene-plagioclase rocks: Memoir Geological Society of India v. 4, p. 436-449.
- Schulze, D.J. and Helmstaedt, H., 1979, Garnet pyroxenite and eclogite xenoliths from Sullivan Buttes Latite, Chino Valley, Arizona, in Boyd, F.R. and Meyer, H.O.A. eds., The mantle sample: Inclusions in kimberlite and other volcanics, Proceedings of the Second International Kimberlite Conference, v. 2, American Geophysical Union, p. 318-329.
- Snee, L.W., 1982, Emplacement and cooling of the Pioneer Batholith Southwestern Montana. Ph. D. thesis, Ohio State University.
- Snee, L.W., 1978, Petrography, K-Ar ages, and field relations of the igneous rocks of part of the Pioneer Batholith, southwestern Montana: M.S. thesis, Ohio State University.

- Spear, F.S., 1981, An experimental study of hornblende stability and compositional variability in amphibolite: *American Journal of Science*, v. 281, p. 697-734.
- Sykes, M.L., 1979, Hydrous mineral stability as a function of fluid composition: a biotite melting experiment and a model for melting curves: M.S. thesis, Arizona State University, Tempe, Arizona.
- Toulmin, Priestley, III, 1976, Oligocene volcanism near Mt. Aetna, southern Sawatch Range, Colorado: *Geological Society of America Abstracts with Programs*, v. 8, p. 640.
- Wass, S.Y. and Hollis, J.D., 1983, Crustal growth in south-eastern Australia-evidence from lower crustal eclogitic and granulitic xenoliths: *Journal of Metamorphic Geology*, v. 1, p. 25-45.
- Wiggins, L.B. and Huebner, J.S., 1981, Combined x-ray wavelength and energy-dispersive analysis to increase microprobe efficiency: *U.S Geological Survey Open-File Report 81-1041*, 8 p.
- Woodsworth, G.J., Crawford, M.L. and Hollister, L.S., 1983, Metamorphism and structure of the Coast Plutonic Complex and adjacent belts, Prince Rupert and Terrace areas, British Columbia: *Geological Association of Canada/Mineralogical Association of Canada/Canadian Geophysical Union Joint Annual Meeting, Field Trip Guidebook, Trip 14*.
- Zen, E-an (in prep.) Bedrock geology of the Vipond Park 15-minute, Stine Mountain 7 $\frac{1}{2}$ -minute, Mountain 7 $\frac{1}{2}$ -minute quadrangles, Pioneer Mountains, Beaverhead County, Montana.
- Zen, E-an and Hammarstrom, J.M., 1983, The pluton at Bushy Point, southeastern Alaska: a tonalite of high pressure origin and its tectonic implications: *Geological Association of Canada/Mineralogical Association of Canada/Canadian Geophysical Union program with abstracts v. 8*, p. A76.
- Zen, E-an, Arth, J.C. and Marvin, R.F., 1980, Petrology, age and some isotope geochemistry of the Cretaceous and Paleocene intrusive rocks, Pioneer Batholith, southwest Montana: *Geological Society of America Abstracts with Programs*, v. 12, p. 309.
- Zen, E-an, Marvin, R.F. and Mehnert, H.H., 1975, Preliminary petrographic, chemical and age data on some intrusive and associated contact metamorphic rocks, Pioneer Mountains, southwestern Montana: *Geological Society of America Bulletin*, v. 86, p. 367-370.

Appendices

The following pages include examples of input and output for the programs "DATAIN" and "HBCAT", program listings and a data definition to be catenated to an output file created by "HBCAT" for use as an input file for MICRO-GRASP. Entries typed in by the user are flagged with a "-" in the examples; all other lines are printed by the computer. The programs are called into the computer from tape or disk using the "OLD" command and executed by typing "RUN". The programs require data tapes for writing output files. Tapes are "marked" into blocks of space to accommodate output files during program execution.

Programs were developed on a Tektronix 4052 with 64kRAM equipped with a 4052 Ro6 editor ROM pack and data communications interface. Programs can be run without an editor or data communications interface; an editor facilitates manipulation of large amounts of data.

Appendix A

Two amphibole analyses (taken from Deer, Howie and Zussman, 1967, p. 152) are used throughout the examples. The complete analyses (including Fe_2O_3 and H_2O) are entered in "DATA IN", proofread, corrected and stored on tape as file 18.

Any alphanumeric string (up to 6 characters) or a "return" may be given in response to the analysis identifier prompts. These prompts are labelled SAMPLE, PHOTO/GRAIN and POINTS for the general case of entering microprobe data but can be changed in the editor to suit the user.

Responses to prompts for weight per cent data must be numeric. An entry of "0.00" is carried through the programs as such. An entry of "9999" will be treated as "0.00" in calculations, but will be flagged as an oxide/element which was not analyzed. In the final data table, a "9999" entry will appear as an "n" in the oxide weight per cent listing and as a blank field in the file formatted for MICRO-GRASP.

In the example, the value for fluorine for the first analysis was incorrectly entered as "0". The proofreading routine was used to correct this by setting $X(1,15) = 9999$. The vertical bars in the string arrays are separators added by the program to build string arrays and should be counted as characters in making corrections -- do not remove them during the correction routine.

In the example, a second tape file was created (#19) by opting for the modification routine. This creates a file with Fe_2O_3 converted to FeO and added to the original FeO value. H_2O and Fe_2O_3 are set to 0.00 and all other values are identical to the original file. Thus, the original data is cast into a "microprobe analysis" form so that estimated water and/or ferric iron contents can be compared with analyzed water and/or ferric iron contents.

ENTER NUMBER OF ANALYSES
 -2 ENTER 9999 FOR OXIDES/ELEMENTS NOT ANALYSED FOR
 ENTER SAMPLE
 -TEST
 ENTER PHOTO/GRAIN
 -A
 ENTER POINTS
 -1
 SiO2
 -44.99
 Al2O3
 -11.21
 Fe2O3
 -3.33
 FeO
 -13.17
 MgO
 -10.41
 CaO
 -12.11
 Na2O
 -0.97
 K2O
 -0.76
 H2O
 -1.48
 TiO2
 -1.46
 P2O5
 -0.17
 MnO
 -0.31

| | |
|-------------------|--|
| BaO | |
| -9999 | |
| Cl | |
| -9999 | |
| F | |
| -0 | |
| S | |
| -9999 | |
| Cr2O3 | |
| -9999 | |
| ENTER SAMPLE | |
| -TEST | |
| ENTER PHOTO/GRAIN | |
| -B | |
| ENTER POINTS | |
| -2 | |
| SiO2 | |
| -48.10 | |
| Al2O3 | |
| -11.05 | |
| Fe2O3 | |
| -0.67 | |
| FeO | |
| -1.65 | |
| MgO | |
| -20.60 | |
| CaO | |
| -12.50 | |
| Na2O | |
| -2.54 | |
| K2O | |
| -1.24 | |
| H2O | |
| -0.71 | |

| | | | |
|--|--|-------------|--|
| TiO2 | | | |
| - 0.10 | | | |
| P2O5 | | | |
| - 9999 | | | |
| MnO | | | |
| - 9999 | | | |
| BaO | | | |
| - 9999 | | | |
| Cl | | | |
| - 9999 | | | |
| F | | | |
| - 1.90 | | | |
| S | | | |
| - 9999 | | | |
| Cr2O3 | | | |
| - 9999 | | | |
| DO YOU WANT TO PROOFREAD BEFORE WRITING TO TAPE- Y OR N? | | | |
| - Y | | | |
| FIRST STRING IDENTIFIER= | | ITESTITESTI | |
| OK? - ENTER Y OR N | | | |
| - Y | | | |
| SECOND STRING IDENTIFIER= | | IAIBI | |
| OK? - ENTER Y OR N | | | |
| - Y | | | |
| THIRD STRING IDENTIFIER = | | II12I | |
| OK? - ENTER Y OR N | | | |

| | | | | |
|----|------------|---|--|---|
| -Y | ANALYSIS # | 1 | | 2 |
| | 44.99 | | | |
| | 11.21 | | | |
| | 3.33 | | | |
| | 13.17 | | | |
| | 10.41 | | | |
| | 12.11 | | | |
| | 0.97 | | | |
| | 0.76 | | | |
| | 1.48 | | | |
| | 1.46 | | | |
| | 0.17 | | | |
| | 0.31 | | | |
| | 9999 | | | |
| | 9999 | | | |
| | 0 | | | |
| | 9999 | | | |
| | 9999 | | | |
| | ANALYSIS # | | | |
| | 48.1 | | | |
| | 11.05 | | | |
| | 0.67 | | | |
| | 1.65 | | | |
| | 20.5 | | | |
| | 12.54 | | | |
| | 1.24 | | | |
| | 0.71 | | | |
| | 0.1 | | | |
| | 9999 | | | |
| | 9999 | | | |
| | 9999 | | | |
| | 9999 | | | |
| | 1.9 | | | |

```

9999
9999
OK? - ENTER Y OR N
-N
ENTER CORRECT X AS X<ANALYSIS#,ENTRY>=VALUE
THEN TYPE RUN 1230, AND HIT RETURN

STOP IN LINE 1220 PRIOR TO LINE 1230
-X<1,15>=9999
-RUN 1230
ENTER TAPE FILE NUMBER
-18
DO YOU WANT TO MODIFY FILE FOR FE AND H20?
-Y
FE203= 3.33
FE203= 0.67
ENTER FILE NUMBER
-19

```

PROGRAM LISTING FOR DATAIN

```

100 REM "DATAIN" - a BASIC program for the Tektronix 4052 to enter
110 REM chemical data on minerals or rocks
120 REM The program prompts the user for the number of analyses, 3
130 REM lines of alphanumeric identifiers for each analysis (which
140 REM may be left blank by hitting return), and 17 oxides/elements
150 INIT
160 DIM K$(250)
170 M$="!SiO2!Al2O3!Fe2O3!FeO!MgO!CaO!Na2O!K2O!H2O!TiO2!P2O5!MnO!"
180 L$="BaO!Cl!F!S!Cr2O3!"
190 K$=M$&L$
200 DIM X(30,17),X$(320),Y$(300),Z$(300)
210 X$="!"
220 Y$="!"
230 Z$="!"
240 PRINT "ENTER NUMBER OF ANALYSES"
250 INPUT C1
260 PRINT "ENTER 9999 FOR OXIDES/ELEMENTS NOT ANALYSED FOR "
261 PRINT
270 FOR J=1 TO C1
280 PRINT "ENTER SAMPLE"
290 INPUT A$
300 X$=X$&A$
310 X$=X$&"!"
320 PRINT "ENTER PHOTO/GRAIN"
330 INPUT B$
340 Y$=Y$&B$
350 Y$=Y$&"!"
360 PRINT "ENTER POINTS"
370 INPUT C$
380 Z$=Z$&C$
390 Z$=Z$&"!"
400 FOR I=1 TO 17
410 GOSUB 690
420 PRINT I$
430 INPUT X(J,I)
440 NEXT I
450 NEXT J
460 PRINT "DO YOU WANT TO PROOFREAD BEFORE WRITING TO TAPE- Y OR N?"
470 INPUT R$
480 IF R$="N" THEN 500
490 GOSUB 840
500 PRINT "ENTER TAPE FILE NUMBER"
510 INPUT F1
520 FIND F1
530 MARK 1,2000
540 FIND F1
550 PRINT @33:C1
560 PRINT @33:X$
570 PRINT @33:Y$
580 PRINT @33:Z$

```

```

590 FOR J=1 TO C1
600 FOR I=1 TO 17
610 PRINT @33:X(J,I)
620 NEXT I
630 NEXT J
640 PRINT "DO YOU WANT TO MODIFY FILE FOR FE AND H2O?"
650 INPUT V$
660 IF V$<>"Y" THEN 680
670 GOSUB 1250
680 END
690 REM SUBROUTINE TO CHOOSE OXIDES
700 B1=0
710 N1=0
720 FOR P=1 TO LEN(K$)
730 S$=SEG(K$,P,1)
740 IF S$<>"I" THEN 820
750 N1=N1+1
760 IF N1=I THEN 780
770 IF N1=I+1 THEN 800
780 B1=P+1
790 GO TO 820
800 E1=P-1
810 I$=SEG(K$,B1,E1-B1+1)
820 NEXT P
830 RETURN
840 REM PROOFREADING SUBROUTINE
850 PRINT "FIRST STRING IDENTIFIER=",X$
860 PRINT "OK? - ENTER Y OR N"
870 INPUT Q$
880 IF Q$="Y" THEN 930
890 LET G$=X$
900 GOSUB 1480
910 LET X$=G$
920 DELETE G$,Q$
930 PRINT
940 PRINT "SECOND STRING IDENTIFIER=",Y$
950 PRINT " OK? - ENTER Y OR N"
960 INPUT Q$
970 IF Q$="Y" THEN 1010
980 G$=Y$
990 GOSUB 1480
1000 LET Y$=G$
1010 DELETE Q$,G$
1020 PRINT
1030 PRINT "THIRD STRING IDENTIFIER =",Z$
1040 PRINT "OK? - ENTER Y OR N"
1050 INPUT Q$
1060 IF Q$="Y" THEN 1100
1070 G$=Z$
1080 GOSUB 1480
1090 Z$=G$
1100 DELETE Q$,G$
1110 FOR I=1 TO C1
1120 PRINT "ANALYSIS #",I
1130 FOR J=1 TO 17
1140 PRINT X(I,J)
1150 NEXT J

```



```

1160 NEXT I
1170 PRINT "OK? - ENTER Y OR N"
1180 INPUT Q$
1190 IF Q$="Y" THEN 1240
1200 PRINT "ENTER CORRECT X AS X(ANALYSIS#,ENTRY)=VALUE"
1210 PRINT "THEN TYPE RUN 1230, AND HIT RETURN"
1220 STOP
1230 REM CONTINUE
1240 RETURN
1250 REM SUBROUTINE TO MODIFY DATA
1260 FOR I=1 TO C1
1270 PRINT "FE203=",X(I,3)
1280 LET X(I,4)=X(I,3)*0.899+X(I,4)
1290 LET X(I,3)=0
1300 LET X(I,9)=0
1310 NEXT I
1320 PRINT "ENTER FILE NUMBER"
1330 INPUT F2
1340 FIND F2
1350 MARK 1,5000
1360 FIND F2
1370 PRINT @33:C1
1380 PRINT @33:X$
1390 PRINT @33:Y$
1400 PRINT @33:Z$
1410 FOR I=1 TO C1
1420 FOR J=1 TO 17
1430 PRINT @33:X(I,J)
1440 NEXT J
1450 NEXT I
1460 CLOSE
1470 RETURN
1480 REM PROOFREADING SUBROUTINE - STRING CORRECTION
1490 PRINT "ENTER STARTING CHARACTER, # INCORRECT CHARACTERS"
1500 INPUT A1,A2
1510 LET I$=SEG(G$,A1,A2)
1520 PRINT "IS THIS THE INCORRECT STRING?",I$
1530 PRINT "ENTER Y OR N"
1540 INPUT Q$
1550 IF Q$="N" THEN 1490
1560 PRINT "ENTER CORRECT STRING"
1570 INPUT C$
1580 G$=REP(C$,A1,A2)
1590 PRINT "CORRECTED STRING=",G$
1600 RETURN

```

Appendix B

"HBCAT" prompts the user for the input data tape file. The example uses file 18 created with "DATAIN". Any alphanumeric string may be entered as a title. The formula basis is the number of oxygens per formula unit for amphibole; enter 23 for anhydrous analyses, 24 if water is included as input. When Fe_2O_3 is not included as input, a percentage of total ferrous iron may be converted to ferric iron if the user has an independent estimate of ferric/ferrous ratio. This option may be ignored by entering "0" or pressing "return".

The user enters the number of analyses to appear on each page, and the tape file number for the MICRO-GRASP version of the output file.

The data table may be printed to tape, or another external device.

Output table examples from the test files are given on the following pages. Note that the "microprobe" version of the analyses result in different cation values, and overestimates of water content.

```

- RUN
  WELCOME TO HBCAT WRITTEN BY JANE HAMMARSTROM 5/84
  ENTER INPUT DATA FILE NUMBER
- 18
  ENTER TITLE
- TEST DATA (Deer, Howie & Zussman, 1967, p.152)
  ENTER FORMULA BASIS (23 OR 24)
- 24
  ENTER Fe+3/(Fe+3+Fe+2) AS A DECIMAL
- 0
  ENTER # ANALYSES PER PAGE
- 2
  ENTER TAPE FILE # FOR MICRO-GRASP FILE - WARNING:PROGRAM
  WILL MARK TAPE FOR 10000 CHARACTERS
- 20
  PRINT DATA TABLE - Y OR N?
- Y
  ENTER DEVICE 40 OR 71 PRINTER;33 TAPE
- 40

```

TEST DATA (from Deer, Howie & Zussman, 1967, p.152) - 24 O basis

| SAMPLE GRAIN ANALYSIS 1 | TEST A | TEST B |
|-------------------------|--------|--------|
| SiO2 | 44.99 | 48.10 |
| Al2O3 | 11.21 | 11.05 |
| Fe2O3 | 3.33 | 0.67 |
| FeO | 13.17 | 1.65 |
| MgO | 10.41 | 20.60 |
| CaO | 12.11 | 12.50 |
| Na2O | 0.97 | 2.54 |
| K2O | 0.76 | 1.24 |
| H2O | 1.48 | 0.71 |
| TiO2 | 1.46 | 0.10 |
| P2O5 | 0.17 | n |
| MnO | 0.31 | n |
| BaO | n | n |
| Cl | n | n |
| F | n | 1.90 |
| S | n | n |
| Cr2O3 | n | n |
| SUBSUM | 100.37 | 101.06 |
| Cl=O | 0.00 | 0.00 |
| F=O | 0.00 | 0.00 |
| SUM | 100.37 | 100.26 |
| H2Ocalc | 0.00 | 0.00 |
| SUM | 100.37 | 100.26 |

| | | |
|----------|-------|-------|
| Si | 6.66 | 6.76 |
| Aliv | 1.34 | 1.24 |
| T | 0.00 | 0.00 |
| Alvi | 0.61 | 0.59 |
| Fe+3 | 0.37 | 0.07 |
| Fe+2 | 1.56 | 0.01 |
| Mg | 2.29 | 4.32 |
| Ti | 0.16 | 0.01 |
| Mn | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 |
| Mn | 0.04 | 0.00 |
| Fe+2 | 0.07 | 0.18 |
| Mg | 0.00 | 0.00 |
| Ca | 1.89 | 1.82 |
| Na | 0.00 | 0.00 |
| M4 | 2.00 | 2.00 |
| Na | 0.28 | 0.69 |
| K | 0.14 | 0.22 |
| Ca | 0.03 | 0.07 |
| A | 0.45 | 0.98 |
| CATSUM | 15.45 | 15.98 |
| F | 0.00 | 0.84 |
| Cl | 0.00 | 0.00 |
| OHcalc | 1.46 | 0.67 |
| ANSUM | 1.46 | 1.51 |
| Fe/Fe+Mg | 0.47 | 0.06 |

SAME ANALYSES WITH FE2O3, H2O SET TO 0 - 23 O basis

| SAMPLE GRAIN ANALYSIS 1 | TEST A | TEST B |
|-------------------------|--------|--------|
| SiO2 | 44.99 | 48.10 |
| Al2O3 | 11.21 | 11.05 |
| Fe2O3 | 0.00 | 0.00 |
| FeO | 16.16 | 2.25 |
| MgO | 10.41 | 20.60 |
| CaO | 12.11 | 12.50 |
| Na2O | 0.97 | 2.54 |
| K2O | 0.76 | 1.24 |
| H2O | 0.00 | 0.00 |
| TiO2 | 1.46 | 0.10 |
| P2O5 | 0.17 | n |
| MnO | 0.31 | n |
| BaO | n | n |
| Cl | n | n |
| F | n | 1.90 |
| S | n | n |
| Cr2O3 | n | n |
| SUBSUM | 98.55 | 100.28 |
| Cl=O | 0.00 | 0.00 |
| F=O | 0.00 | 0.00 |
| SUM | 98.55 | 99.48 |
| H2Ocalc | 2.03 | 1.25 |
| SUM | 100.59 | 100.73 |

| | | |
|----------|-------|-------|
| Si | 6.63 | 6.70 |
| Aliv | 1.37 | 1.30 |
| T | 0.00 | 0.00 |
| Alvi | 0.58 | 0.51 |
| Fe+3 | 0.00 | 0.00 |
| Fe+2 | 1.97 | 0.20 |
| Mg | 2.29 | 4.28 |
| Ti | 0.16 | 0.01 |
| Mn | 0.00 | 0.00 |
| M1-M3 | 5.00 | 5.00 |
| Mn | 0.04 | 0.00 |
| Fe+2 | 0.02 | 0.06 |
| Mg | 0.00 | 0.00 |
| Ca | 1.91 | 1.87 |
| Na | 0.03 | 0.07 |
| M4 | 2.00 | 2.00 |
| Na | 0.25 | 0.62 |
| K | 0.14 | 0.22 |
| Ca | 0.00 | 0.00 |
| A | 0.39 | 0.84 |
| CATSUM | 15.39 | 15.84 |
| F | 0.00 | 0.84 |
| Cl | 0.00 | 0.00 |
| OHcalc | 2.00 | 1.16 |
| ANSUM | 2.00 | 2.00 |
| Fe/Fe+Mg | 0.47 | 0.06 |

Output file #20 from HBCAT - This is a file formatted for
 use with the MICRO-GRASP program with the data definition
 listed in Appendix C.

```

:TEST A      1      44.99 11.21 3.33 13.17 10.41 12.11 0.97 0.76 1.48 1.46 0.17 0.31
0.00 0.00 100.37 0.00 100.37 6.66 1.34 8.00 0.61 0.37 1.56 2.29 0.16 0.00 5.00 0.04 0.07 0.00 1.89 0.00 2.00 0.28
0.14 0.03 0.45 15.45 0.00 0.00 1.46 1.46 0.47
:TEST B      2      48.10 11.05 0.67 1.65 20.60 12.50 2.54 1.24 0.71 0.10
0.00 0.00 100.26 0.00 100.26 6.76 1.24 8.00 0.59 0.07 0.01 4.32 0.01 0.00 5.00 0.00 0.18 0.00 1.02 0.00 2.00 0.69
0.22 0.07 0.98 15.98 0.84 0.00 0.67 1.51 0.06

```

```

PROGRAM LISTING FOR HBCAT
90 PRINT "WELCOME TO HBCAT WRITTEN BY JANE HAMMARSTROM 5/84"
100 INIT
110 REM "HBCAT" - a BASIC program for the Tektronix 4052 to
120 REM read a file of amphibole analyses created with "DATAIN"
130 REM This program calculates a formula on the basis of 23 or 24
140 REM oxygens, partitions cations according to the scheme of
150 REM Goff & Czamanske (1972), creates a tape file for use with
160 REM MICRO-GRASP, and prints a data table to printer or to tape
170 DIM B$(100),A$(500),D$(300),L$(600),D(33,17),F(33,17)
180 DIM A(17),B(17),C(17)
190 DATA "1SAMPLE1GRAIN1ANALYSIS1S1O21A12O31Fe2O31FeO1MgO1CaO1Na2O1"
200 DATA "K2O1H2O1TiO21P2O51MnO1BaO1Cl1F1S1Cr2O31SUBSUM1Cl=O1F=O1SUM1"
210 DATA "H2Ocalc1SUM1Si1Aliv1 Ti1Alvi1Fe+31Fe+21Mg1Ti1Mn1 M1-M31Mn1"
220 DATA "Fe+21Mg1Ca1Na1 M41Na1K1Ca1 AlCATSUM1F1Cl1OHcalc1ANSUM1"
230 DATA "Fe/Fe+Mg1"
240 READ A$
250 FOR I=1 TO 4
260 READ B$
270 A$=A$&B$
280 NEXT I
290 DELETE B$
300 DATA 60.09,101.94,159.7,71.85,40.32,56.00,61.902,94.2,18.016
310 DATA 79.9,141.95,70.94,153.36,35.457,19,32.066,152.02
320 READ A
330 DATA 2,3,3,1,1,1,1,1,2,5,1,1,1,1,1,3
340 READ B
350 DATA 1,2,2,1,1,1,2,2,2,1,2,1,1,1,1,2
360 READ C
370 PRINT "ENTER INPUT DATA FILE NUMBER"
380 INPUT N5
390 PRINT "ENTER TITLE"
400 INPUT B$
410 PRINT "ENTER FORMULA BASIS (23 OR 24)"
420 INPUT A1
430 PRINT "ENTER Fe+3/(Fe+3+Fe+2) AS A DECIMAL"
440 INPUT B7
450 PRINT "ENTER # ANALYSES PER PAGE"
460 INPUT N2
470 FIND N5
480 INPUT @33:C2
490 INPUT @33:K$
500 INPUT @33:L$
510 INPUT @33:M$
520 FOR I=1 TO C2
530 FOR J=1 TO 17
540 INPUT @33:D(I,J)
550 LET F(I,J)=D(I,J)
560 IF D(I,J)<>9999 THEN 580
570 LET D(I,J)=0
580 NEXT J
590 NEXT I
600 IF N2<=C2 THEN 620
610 LET N2=C2
620 DIM W(C2,17),B(C2),Q(C2),X(C2),Z(C2,17),T(C2),H(C2),R(C2)
630 DIM M(C2,49),Y(49,C2),G(C2,52),E(C2,8)

```

```

640 REM compute fe2o3 and feo
650 FOR J=1 TO C2
660 IF B7=0 THEN 690
670 LET D(J,3)=D(J,4)*B7*1.111
680 LET D(J,4)=D(J,4)-D(J,4)*B7
690 REM sum oxides and calculate cations
700 LET S(J)=0
710 LET T(J)=0
720 LET Q(J)=0
730 FOR I=1 TO 17
740 LET S(J)=S(J)+D(J,I)
750 LET W(J,I)=D(J,I)/A(I)*B(I)
760 LET Q(J)=Q(J)+W(J,I)
770 NEXT I
780 IF A1=24 AND D(J,9)<>0 THEN 810
790 LET Q(J)=Q(J)-W(J,14)-W(J,15)
800 GO TO 820
810 LET Q(J)=Q(J)-W(J,14)*0.5-W(J,15)*0.5
820 LET X(J)=A1/Q(J)
830 REM x=normalization factor
840 FOR I=1 TO 17
850 LET Z(J,I)=X(J)*(D(J,I)/A(I))*B(I)
860 LET T(J)=T(J)+Z(J,I)
870 NEXT I
880 IF D(J,9)<>0 THEN 920
890 LET Z(J,9)=2-Z(J,14)-Z(J,15)
900 LET H(J)=Z(J,9)/2/X(J)*18.016
910 GO TO 930
920 LET H(J)=0
930 LET T(J)=T(J)-Z(J,14)-Z(J,15)-Z(J,9)
940 REM begin site partitioning for hornblende
950 GDSUB 2230
960 REM calculate fe/fe+mg
970 GDSUB 3040
980 NEXT J
990 REM transfer all data to matrix m
1000 FOR J=1 TO C2
1010 FOR K=1 TO 17
1020 LET M(J,K)=F(J,K)
1030 IF B7=0 THEN 1060
1040 LET M(J,3)=D(J,3)
1050 LET M(J,4)=D(J,4)
1060 NEXT K
1070 LET M(J,18)=S(J)
1080 LET M(J,19)=D(J,14)*0.226
1090 LET M(J,20)=D(J,15)*0.421
1100 LET M(J,21)=S(J)-M(J,19)-M(J,20)
1110 LET M(J,22)=H(J)
1120 LET M(J,23)=M(J,21)+M(J,22)
1130 LET M(J,24)=G(J,1)
1140 LET M(J,25)=G(J,2)
1150 LET M(J,26)=E(J,1)
1160 FOR K=27 TO 32
1170 LET M(J,K)=G(J,K-24)
1180 NEXT K
1190 LET M(J,33)=E(J,4)
1200 FOR K=34 TO 38
1210 LET M(J,K)=G(J,K-25)
1220 NEXT K

```

```

1230 LET M(J,39)=E(J,5)
1240 FOR K=40 TO 42
1250 LET M(J,K)=G(J,K-26)
1260 NEXT K
1270 LET M(J,43)=E(J,6)
1280 LET M(J,44)=E(J,7)
1290 FOR K=45 TO 47
1300 LET M(J,K)=G(J,K-28)
1310 NEXT K
1320 LET M(J,48)=E(J,8)
1330 LET M(J,49)=R(J)
1340 NEXT J
1350 REM reshape matrix m to 51 rows by c1 columns where c1=#analyses
1360 DIM Y(49,C2)
1370 Y=TRN(M)
1380 REM print data table
1390 PRINT "ENTER TAPE FILE # FOR MICRO-GRASP FILE - WARNING:PROGRAM"
1400 PRINT "WILL MARK TAPE FOR 10000 CHARACTERS"
1410 INPUT G1
1420 FIND G1
1430 MARK 1,10000
1440 FIND G1
1450 FOR I=1 TO C2
1460 GOSUB 3220
1470 PRINT @33: USING "6a,s":Z$
1480 GOSUB 3370
1490 PRINT @33: USING "6a,s":U$
1500 GOSUB 3520
1510 PRINT @33: USING "6a,s":Y$
1520 FOR J=1 TO 49
1530 IF M(I,J)<>9999 THEN 1560
1540 PRINT @33: USING "6A,S": " "
1550 GO TO 1570
1560 PRINT @33: USING "3d.2d,s":M(I,J)
1570 NEXT J
1580 PRINT @33:
1590 NEXT I
1600 PRINT "PRINT DATA TABLE - Y OR N?"
1610 INPUT W$
1620 IF W$="N" THEN 2220
1630 PRINT "ENTER DEVICE 40 OR 71 PRINTER;33 TAPE"
1640 INPUT P9
1650 IF P9<>33 THEN 1720
1660 PRINT "ENTER TAPE FILE NUMBER- WARNING:PROGRAM WILL MARK 19000"
1670 PRINT "CHARACTERS ON TAPE"
1680 INPUT T5
1690 FIND T5
1700 MARK 1,19000
1710 FIND T5
1720 IF P9<>40 THEN 1740
1730 PRINT @37,26:1
1740 IMAGE p/111,80a
1750 IMAGE / ,8A,10T ,s
1760 IMAGE 3D.2D,12T ,s
1770 IMAGE 8A,12T,s

```



```

1780 IMAGE 3d,Bx,S
1790 FOR K=1 TO INT(C2/N2)*N2 STEP N2
1800 PRINT @P9: USING 1740:B$
1810 FOR J=1 TO 52
1820 IF J=4 THEN 1850
1830 IF J=27 THEN 1850
1840 GO TO 1860
1850 PRINT @P9:
1860 GOSUB 3070
1870 PRINT @P9: USING 1750:X$
1880 IF J>3 THEN 2070
1890 IF J<>1 THEN 1950
1900 FOR I=K TO K+N2-1
1910 GOSUB 3220
1920 PRINT @P9: USING 1770:Z$
1930 NEXT I
1940 GO TO 2150
1950 IF J<>2 THEN 2020
1960 FOR I=K TO K+N2-1
1970 GOSUB 3370
1980 PRINT @P9: USING 1770:U$
1990 NEXT I
2000 IF J=3 THEN 2020
2010 IF J<>3 THEN 2060
2020 FOR I=K TO K+N2-1
2030 GOSUB 3520
2040 PRINT @P9: USING 1770:Y$
2050 NEXT I
2060 GO TO 2150
2070 FOR I=K TO K+N2-1
2080 IF Y(J-3,I)=0 THEN 2100
2090 LET Y(J-3,I)=0
2100 IF Y(J-3,I)<>9999 THEN 2130
2110 PRINT @P9: USING "6A,12T,S": " n "
2120 GO TO 2140
2130 PRINT @P9: USING 1760:Y(J-3,I)
2140 NEXT I
2150 NEXT J
2160 IF I>C2 THEN 2210
2170 NEXT K
2180 IF K>C2 THEN 2210
2190 N2=C2-K+1
2200 GO TO 1800
2210 PRINT @P9: USING "/1":
2220 END
2230 REM begin site partitioning subroutine
2240 LET G(J,1)=Z(J,1)
2250 IF Z(J,1)+Z(J,2)>8 THEN 2300
2260 LET G(J,1)=Z(J,1)
2270 LET G(J,2)=Z(J,2)
2280 LET G(J,3)=0
2290 GO TO 2320
2300 LET G(J,2)=8-Z(J,1)
2310 LET G(J,3)=Z(J,2)-G(J,2)
2320 LET E(J,1)=G(J,1)+G(J,2)

```

```

2330 LET G(J,4)=Z(J,3)
2340 LET G(J,5)=Z(J,4)
2350 LET G(J,6)=Z(J,5)
2360 LET G(J,7)=Z(J,10)
2370 LET G(J,8)=Z(J,12)
2380 LET E(J,2)=G(J,3)+G(J,4)+G(J,5)+G(J,6)+G(J,7)+G(J,8)
2390 IF E(J,2)>5 THEN 2460
2400 G(J,9)=0
2410 G(J,10)=0
2420 G(J,11)=0
2430 G(J,12)=Z(J,6)
2440 G(J,13)=Z(J,7)
2450 GO TO 2690
2460 IF E(J,2)-G(J,8)>5 THEN 2540
2470 LET G(J,8)=5-(G(J,3)+G(J,4)+G(J,5)+G(J,6)+G(J,7))
2480 LET G(J,9)=Z(J,12)-G(J,8)
2490 LET G(J,10)=0
2500 LET G(J,11)=0
2510 LET G(J,12)=Z(J,6)
2520 LET G(J,13)=Z(J,7)
2530 GO TO 2690
2540 IF E(J,2)-(Z(J,12)+G(J,5))>5 THEN 2630
2550 LET G(J,8)=0
2560 LET G(J,9)=Z(J,12)
2570 LET G(J,5)=5-(G(J,3)+G(J,4)+G(J,6)+G(J,7)+G(J,8))
2580 LET G(J,10)=Z(J,4)-G(J,5)
2590 LET G(J,11)=0
2600 LET G(J,12)=Z(J,6)
2610 LET G(J,13)=Z(J,7)
2620 GO TO 2690
2630 LET G(J,8)=0
2640 LET G(J,5)=0
2650 LET G(J,6)=5-(G(J,3)+G(J,4)+G(J,5)+G(J,7)+G(J,8))
2660 LET G(J,11)=Z(J,5)-G(J,6)
2670 LET G(J,9)=Z(J,12)
2680 LET G(J,10)=G(J,5)
2690 LET E(J,3)=G(J,11)+G(J,9)+G(J,10)+Z(J,6)+Z(J,7)
2700 IF E(J,3)>2 THEN 2770
2710 LET G(J,12)=Z(J,6)
2720 LET G(J,13)=Z(J,7)
2730 LET G(J,14)=0
2740 LET G(J,16)=0
2750 LET G(J,15)=Z(J,8)
2760 GO TO 2960
2770 IF E(J,3)-Z(J,7)>2 THEN 2840
2780 LET G(J,12)=Z(J,6)
2790 LET G(J,13)=2-(G(J,9)+G(J,10)+G(J,11)+G(J,12))
2800 LET G(J,14)=Z(J,7)-G(J,13)
2810 LET G(J,15)=Z(J,8)
2820 LET G(J,16)=Z(J,6)-G(J,12)
2830 GO TO 2960
2840 IF E(J,3)-(Z(J,7)+Z(J,6))>2 THEN 2910
2850 LET G(J,14)=Z(J,7)
2860 LET G(J,13)=0

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2870 LET G(J,16)=E(J,3)-(Z(J,7)+2)
2880 LET G(J,12)=Z(J,6)-G(J,16)
2890 LET G(J,15)=Z(J,8)
2900 GO TO 2960
2910 LET G(J,13)=0
2920 LET G(J,14)=Z(J,7)
2930 LET G(J,16)=Z(J,6)
2940 LET G(J,15)=Z(J,8)
2950 LET G(J,12)=0
2960 LET E(J,4)=G(J,3)+G(J,4)+G(J,5)+G(J,6)+G(J,7)+G(J,8)
2970 LET E(J,5)=G(J,9)+G(J,10)+G(J,11)+G(J,12)+G(J,13)
2980 LET E(J,6)=G(J,14)+G(J,15)+G(J,16)
2990 LET G(J,17)=Z(J,15)
3000 LET G(J,18)=Z(J,14)
3010 LET G(J,19)=Z(J,9)
3020 LET E(J,7)=E(J,1)+E(J,4)+E(J,5)+E(J,6)
3030 LET E(J,8)=G(J,17)+G(J,18)+G(J,19)
3040 REM subroutine to calculate Fe/Fe+Mg
3050 LET R(J)=(Z(J,3)+Z(J,4))/(Z(J,3)+Z(J,4)+Z(J,5))
3060 RETURN
3070 REM subroutine to choose row string headings from string array a$
3080 B1=0
3090 N1=0
3100 FOR I=1 TO LEN(A$)
3110 S$=SEG(A$,I,1)
3120 IF S$(">") THEN 3200
3130 N1=N1+1
3140 IF N1=J THEN 3160
3150 IF N1=J+1 THEN 3180
3160 B1=I+1
3170 GO TO 3200
3180 E1=I-1
3190 X$=SEG(A$,B1,E1-B1+1)
3200 NEXT I
3210 RETURN
3220 REM SUBROUTINE TO CHOOSE SAMPLE
3230 B1=0
3240 N1=0
3250 FOR P1=1 TO LEN(K$)
3260 S$=SEG(K$,P1,1)
3270 IF S$(">") THEN 3350
3280 N1=N1+1
3290 IF N1=I THEN 3310
3300 IF N1=I+1 THEN 3330
3310 B1=P1+1
3320 GO TO 3350
3330 E1=P1-1
3340 Z$=SEG(K$,B1,E1-B1+1)
3350 NEXT P1
3360 RETURN

```

```

3370 REM SUBROUTINE TO CHOOSE PHOTO, GRAIN
3380 B1=0
3390 N1=0
3400 FOR Q1=1 TO LEN(L$)
3410 S$=SEG(L$,Q1,1)
3420 IF S$<>"!" THEN 3500
3430 N1=N1+1
3440 IF N1=I THEN 3460
3450 IF N1=I+1 THEN 3480
3460 B1=Q1+1
3470 GO TO 3500
3480 E1=Q1-1
3490 U$=SEG(L$,B1,E1-B1+1)
3500 NEXT Q1
3510 RETURN
3520 REM SUBROUTINE TO CHOOSE POINTS
3530 B1=0
3540 N1=0
3550 FOR R1=1 TO LEN(M$)
3560 S$=SEG(M$,R1,1)
3570 IF S$<>"!" THEN 3650
3580 N1=N1+1
3590 IF N1=I THEN 3610
3600 IF N1=I+1 THEN 3630
3610 B1=R1+1
3620 GO TO 3650
3630 E1=R1-1
3640 Y$=SEG(M$,B1,E1-B1+1)
3650 NEXT R1
3660 RETURN

```

APPENDIX C

Data definition for use with MICRO-GRASP input files created in HBCAT

Note: There is a unique name for each data field; entries in each field correspond to row headers in data tables.

52 312 (52 fields, 312 characters per line)

| | | |
|--------|-------|-----|
| SAMPLE | C 1 | 6 |
| PHOTO | C 7 | 12 |
| POINTS | C 13 | 18 |
| SiO2 | n 19 | 24 |
| Al2O3 | n 25 | 30 |
| Fe2O3 | n 31 | 36 |
| FeO | n 37 | 42 |
| MgO | n 43 | 48 |
| CaO | n 49 | 54 |
| Na2O | n 55 | 60 |
| K2O | n 61 | 66 |
| H2O | n 67 | 72 |
| TiO2 | n 73 | 78 |
| P2O5 | n 79 | 84 |
| MnO | n 85 | 90 |
| BaO | n 91 | 96 |
| Cl | n 97 | 102 |
| F | n 103 | 108 |
| S | n 109 | 114 |
| Cr2O3 | n 115 | 120 |
| SUM1 | n 121 | 126 |
| ClO | n 127 | 132 |
| FO | n 133 | 138 |
| SUM2 | n 139 | 144 |
| H2Oc | n 145 | 150 |
| SUM3 | n 151 | 156 |
| Si | n 157 | 162 |
| Aliv | n 163 | 168 |
| T | n 169 | 174 |
| Alvi | n 175 | 180 |
| Fe3 | n 181 | 186 |
| Fe2 | n 187 | 192 |
| Mg | n 193 | 198 |
| Ti | n 199 | 204 |
| Mn | n 205 | 210 |
| M1M3 | n 211 | 216 |
| MnM4 | n 217 | 222 |
| Fe2M4 | n 223 | 228 |
| MgM4 | n 229 | 234 |
| CaM4 | n 235 | 240 |
| NaM4 | n 241 | 246 |
| M4 | n 247 | 252 |
| NaA | n 253 | 258 |
| KA | n 259 | 264 |
| CaA | n 265 | 270 |
| A | n 271 | 276 |
| CATS | n 277 | 282 |
| FOH | n 283 | 288 |
| ClOH | n 289 | 294 |
| OH | n 295 | 300 |
| ANS | n 301 | 306 |
| FeMg | n 307 | 312 |