U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Electron microprobe analyses of zeolite minerals from Neogene volcanic rocks in the Breitenbush-Austin Hot Springs area, Oregon

By Robert L. Oscarson[1] and Keith E. Bargar[2]

Open-File Report 96-41

U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025. [1]M/S 916; [2]M/S 910.

CONTENTS

FIGURES

TABLES

INTRODUCTION

Zeolites are a group of hydrated aluminosilicate minerals that contain one or more alkali or alkaline earth cations (Mumpton, 1977). These minerals can act as catalysts for chemical reactions; they have the unique ability to gain or lose liquids (generally water) and gases (such as ammonia); and they can act as cation exchangers without significant alteration of their structures (Barrer, 1978). For these reasons, there are very many commercial uses for both natural and synthetic zeolites. The applications for these minerals are extensive and range from additives useful in various types of pollution abatement, agriculture and aquaculture, energy conservation, metallurgy, and even as a polishing agent in toothpaste (Mumpton, 1978).

Zeolites form in a wide-range of low-temperature (generally <200°C) water-rich environments such as alkaline lakes, deep-sea sediments, cooling lava flows, and hydrothermal systems (Tschernich, 1992). The cations present in zeolites usually reflect the elements contained in the mineralizing solutions which in turn are influenced by the rocks through which the waters flow (Barrer, 1982). Chemistry, X-ray diffraction data, and optical and physical properties used in identification of the many zeolite minerals are summarized by Gottardi and Galli (1985) and Tschernich (1992).

Previous to this report there has been no systematic study of the zeolite group of minerals in the Cascade Mountains of Oregon even though a substantial number of these minerals occur in the late Tertiary volcanic rocks of the region. In this report we present electron microprobe analyses for sixteen zeolites that were collected during the past 15 years from the Breitenbush-Austin Hot Springs area in northern Oregon. In a later report (Bargar and Oscarson, in preparation), we provide somewhat detailed descriptions of the occurrence and morphology of these zeolites plus a few other zeolite minerals which we were unable to analyze by electron microprobe.

GEOLOGIC SETTING

Late Tertiary volcanic rocks in the Breitenbush-Austin Hot Springs area in northwestern Oregon (Figure 1) comprise a more than 2,000 m-thick sequence of andesitic lava flows,

Figure 1 near here

pyroclastic flows, and volcaniclastic deposits (Hammond and others, 1980; Hammond and others, 1982). Zeolite minerals are widespread throughout the area filling open spaces of fractures, vesicles, and between breccia fragments; also, volcanic glass commonly is altered to zeolite and clay minerals. While zeolites in this area are not of economic importance, one mineral (stilbite/stellerite?) is a significant gangue mineral in a cinnabar-bearing vein called the "zeolite vein" located in the Oak Grove Fork of the Clackamas River mining area (Brooks, 1963).

Over the past several decades, numerous reports have been published on the geology and mineralization of several regions within the Breitenbush-Austin Hot Springs area. In the majority of these reports, if zeolite minerals are mentioned at all, their presence mostly is acknowledged simply by a statement to the effect that "zeolites" were observed. In the few cases where the author went to the trouble of identifying individual zeolite minerals, the reports merely list those minerals. However, some information on four zeolite minerals (gismondine, thomsonite, chabazite, and levyne) from an outcrop in this area was provided by Tschernich and Howard (1988). Because of their unique properties, the large number of identified minerals, and their wide-spread abundance in the altered late Tertiary volcanic rocks, these zeolites constitute a significant mineral group in the Western Cascades of Oregon that largely has been overlooked.

Since the late 1970's, several geothermal test drill holes have been completed in the Breitenbush-Austin Hot Springs area to aid evaluation of the geothermal energy potential of this part of the Cascade Range. Several of these drill holes yielded diverse suites of hydrothermal zeolite minerals (Boden, 1985; Bargar, 1990, 1994). This report provides additional information

on the chemistry of zeolite minerals from two of these drill holes and from numerous outcrops in the Breitenbush-Austin Hot Springs area.

ANALYTICAL METHODS

Some zeolite mineral identifications were made by routine binocular microscope inspections; however, heavy reliance was placed on X-ray diffraction using a Norelco X-ray unit and Cu-Kα radiation. Semiquantitative chemical analyses were obtained for several zeolites during scanning electron microscope (using a Cambridge Stereoscan 250 scanning electron microscope equipped with an energy dispersive spectrometer) studies of the paragenesis and morphology of the zeolites and related minerals. Quantitative chemical analyses for several zeolite minerals were obtained with an JEOL JXA-8900L electron probe microanalyzer using natural and synthetic mineral standards. Conditions employed for all carbon-coated, polished, thin-section zeolite minerals analyzed by the microprobe include: a sample current of 7.5 nA, a beam diameter of 20 μm, count times of 20 seconds, and an accelerating voltage of 15 kV. Possible errors in the analyses might be as great as $\pm$20% for concentrations <1% and as high as $\pm$100% for concentrations <0.1% (L. Calk, personal commun., 1996).

In the tables of microprobe analyses a dash (–) indicates that no analysis was attempted for that element (oxide). The balance error shown at the bottom of each page of chemical analyses provides a method of judging the validity of microprobe analyses of zeolite minerals based on a formula provided by Passaglia (1970). Balance errors of $<\pm$10% for zeolite microprobe analyses are generally reported to be a valid. Other ratios and values relating to the Si, Al, and Fe contents of the zeolite minerals, listed at the bottom of each page, also are widely reported parameters for comparison of zeolite chemical analyses. In Table 10 the mineral name is given as stilbite/stellerite, even though the International Mineralogical Association recognizes both mineral names; the two minerals are very nearly identical and at least one authority on zeolite minerals recommends abandoning the stellerite mineral name (Tschernich, 1992).

CHEMISTRY OF HYDROTHERMAL ZEOLITE MINERALS

Nineteen zeolite minerals were identified from drill hole or outcrop specimens obtained from the Breitenbush-Austin Hot Springs area. Fifteen of these minerals occur in the two studied drill holes (CTGH-1 and SUNEDCO 58-28) (Figures 2 and 3) and are discussed by Bargar (1990;

Figures 2 and 3 near here

1994). Bargar (1990) reported only scanning electron microscope qualitative chemistry for the eleven zeolite minerals (wellsite, phillipsite, thomsonite, analcime-wairakite, chabazite, scolecite, erionite, heulandite, clinoptilolite, and mordenite) identified from CTGH-1 (Figure 2); however, quantitative analyses were given for analcime, heulandite, laumontite, and stilbite/stellerite from SUNEDCO 58-28 (Bargar, 1994). Mordenite, epistilbite, and scolecite also are present in SUNEDCO 58-28 (Figure 3) but were not analyzed. Many of the zeolite minerals from the two geothermal drill holes are present only in trace amounts. Accordingly, outcrop specimens from the Breitenbush-Austin Hot Springs area were obtained to provide chemical information for several of the zeolites. These outcrops yielded additional zeolite minerals not identified in the two drill holes: gismondine, ferrierite, mesolite, and yugawaralite. The electron microprobe analyses for seventeen of the hydrothermal zeolites are listed in Tables 1 to 14 and exchangeable cation data

Tables 1 to 14 near here

from these analyses are shown in ternary diagrams of Figures 4 through 16.

Figures 4 through 16 near here

Several attempts at obtaining reliable microprobe analyses for mordenite specimens were unsuccessful; semiquantitative scanning electron microscope chemical data for one mordenite specimen just shows the presence of Ca, Al, and Si (Figure 17). Similarly, the only chemical data

Figure 17 near here

obtained for gismondine in this study shows that it too consists of Ca, Al, and Si (Figure 18).

Figure 18 near here

ACKNOWLEDGMENTS

We are grateful to L. C. Calk and J. E. Fierstein for helpful reviews of the manuscript. L. C. Calk also provided guidance and much assistance in obtaining the microprobe analyses.

REFERENCES CITED

Bargar, K. E., 1990, Hydrothermal alteration in geothermal drill hole CTGH-1, High Cascade Range, Oregon: Oregon Geology, v. 52, no. 4, p.75-81.

Bargar, K. E., 1994, Hydrothermal alteration in the SUNEDCO 58-28 geothermal drill hole near Breitenbush Hot Springs, Oregon: Oregon Geology, v. 56, no. 4, p. 75- 87.

Bargar, K. E., Keith, T. E. C., and Beeson, M. H., 1993, Hydrothermal alteration in the Mount Hood area, Oregon: U.S. Geological Survey Bulletin 2054, 70 p.

Barrer, R. M., 1978, Zeolites and clay minerals as sorbents and molecular sieves: Academic Press, San Francisco, 497 p.

Barrer, R. M., 1982, Hydrothermal chemistry of zeolites: Academic Press, San Francisco, 360 p.

Blackwell, D. D., Black, G. L., and Priest, G. R., 1986, Geothermal-gradient data for Oregon (1982-1984): Oregon Department of Geology and Mineral Industries Open-File Report O-86-2, 107 p.

Blackwell, D. D., and Steele, J. L., 1987, Geothermal data from deep holes in the Oregon Cascade Range: Geothermal Resources Council Transactions, v. 11, p. 317-322.

Boden, J. R., 1985, Lithology, hydrothermal petrology and stable isotope geochemistry of three geothermal exploration drill holes, upper Clackamas River area, Cascade Range, Oregon: unpublished M.S. thesis, University of California Riverside, 137 p.

Brooks, H. C., 1963, Quicksilver in Oregon: Oregon Department of Geology and Mineral Industries Bulletin 55, 223 p.

Cerny, P., Rinaldi, R. and Surdam, R. C., 1977, Wellsite and its status in the phillipsite-harmotome group: Neues Jahrbuch fur Mineralogie Abhandlungen, v. 128, p. 312-330.

Conrey, R. M., and Sherrod, D. R., 1988, Stratigraphy of drill holes and geochemistry of surface rocks, Breitenbush Hot Springs 15-minute quadrangle, Cascade Range, Oregon, *in* Sherrod, D. R., ed., Geology and geothermal resources of the Breitenbush-Austin Hot Springs area, Clackamas and Marion Counties, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-88-5, p. 15-29.

Gottardi, Glauco, and Galli, Ermanno, 1985, Natural Zeolites: Springer-Verlag, New York, 409 p.

Hammond, P. E., Anderson, J. L., and Manning, K. J., 1980, Guide to the geology of the upper Clackamas and North Santiam Rivers area, northern Oregon Cascade Range, *in* Oles, K. F., Johnson, J. G., Niem, A. R., and Niem, W. A., eds., Geologic field trips in western Oregon and southwestern Washington: Oregon Department of Geology and Mineral Industries Bulletin 10l, p. 133-167.

Hammond, P. E., Geyer, K. M., and Anderson, J. L., 1982, Preliminary geologic map and cross sections of the upper Clackamas and North Santiam Rivers area, northern Oregon Cascade Range: Portland Oregon, Portland State University Department of Earth Sciences, scale 1:62,500.

Mumpton, F. A., 1977, Natural zeolites, *in* Mumpton, F. A., ed., Mineralogy and Geology of Natural Zeolites: Mineralogical Society of America Reviews in Mineralogy, v. 4, p.1-17.

Mumpton, F. A., 1978, Natural zeolites: a new industrial mineral commodity, *in* Sand, L. B., and Mumpton, F. A., eds., Natural Zeolites: Occurrence, Properties, Use: Pergamon Press, New York, p. 3-27.

Passaglia, Elio, 1970, The crystal chemistry of chabazites: American Mineralogist, v. 55, p. 1278-1301.

Tschernich, R. W., 1992, Zeolites of the world: Geoscience Press, Inc., Phoenix, 563 p.

Tschernich, R. W., and Howard, D., 1988, Gismondine from the Oak Grove Fork of the Clackamas River, Oregon: Micro Probe, v. 6, no. 6, p. 1-3.

Figure 1. Map showing the location of hot springs and geothermal drill holes in the Breitenbush-Austin Hot Springs area of northern Oregon.

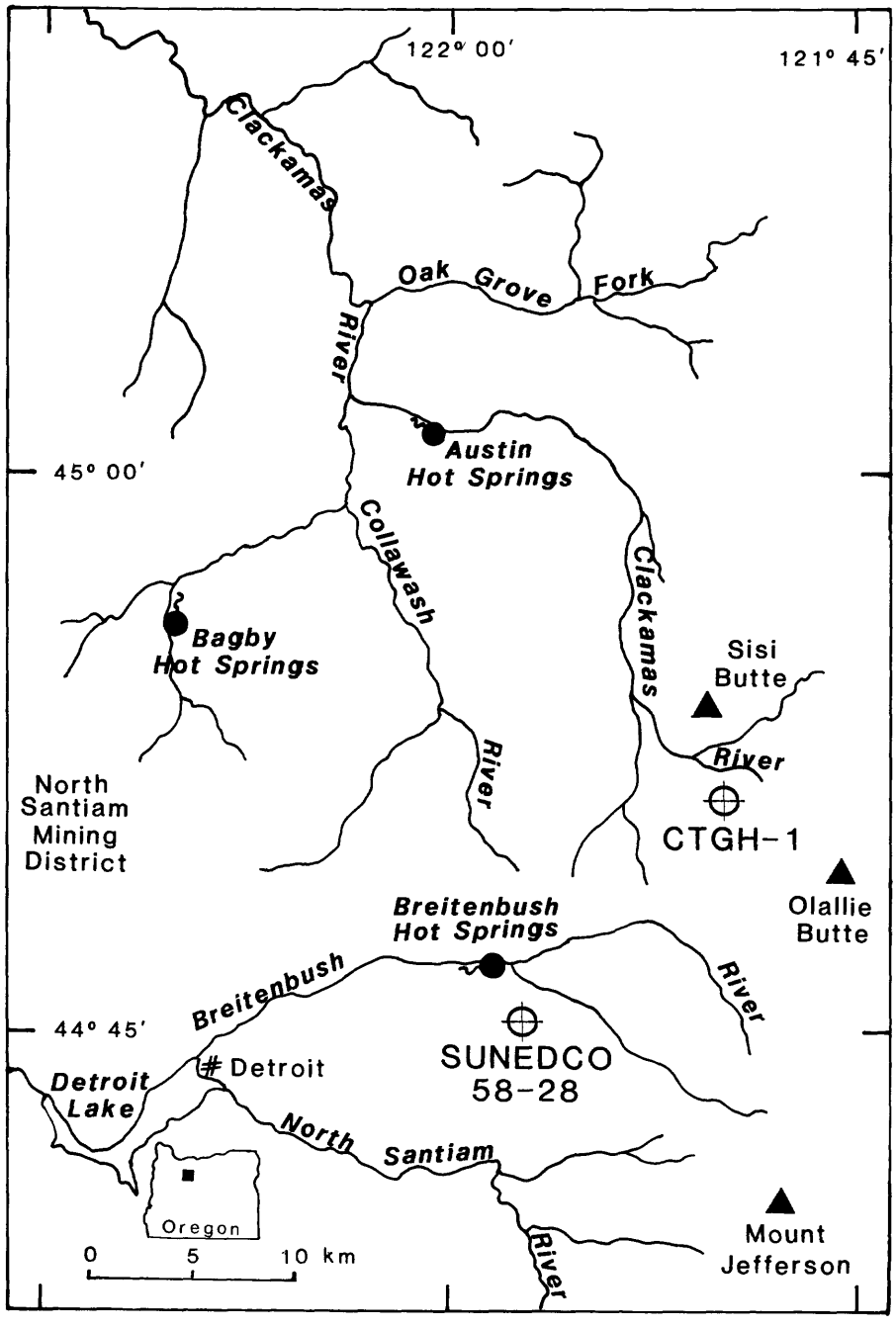


Figure 2. Distribution of hydrothermal alteration minerals with depth in CTGH-1 (Bargar, 1990). Temperature data from Blackwell and Steele (1987).

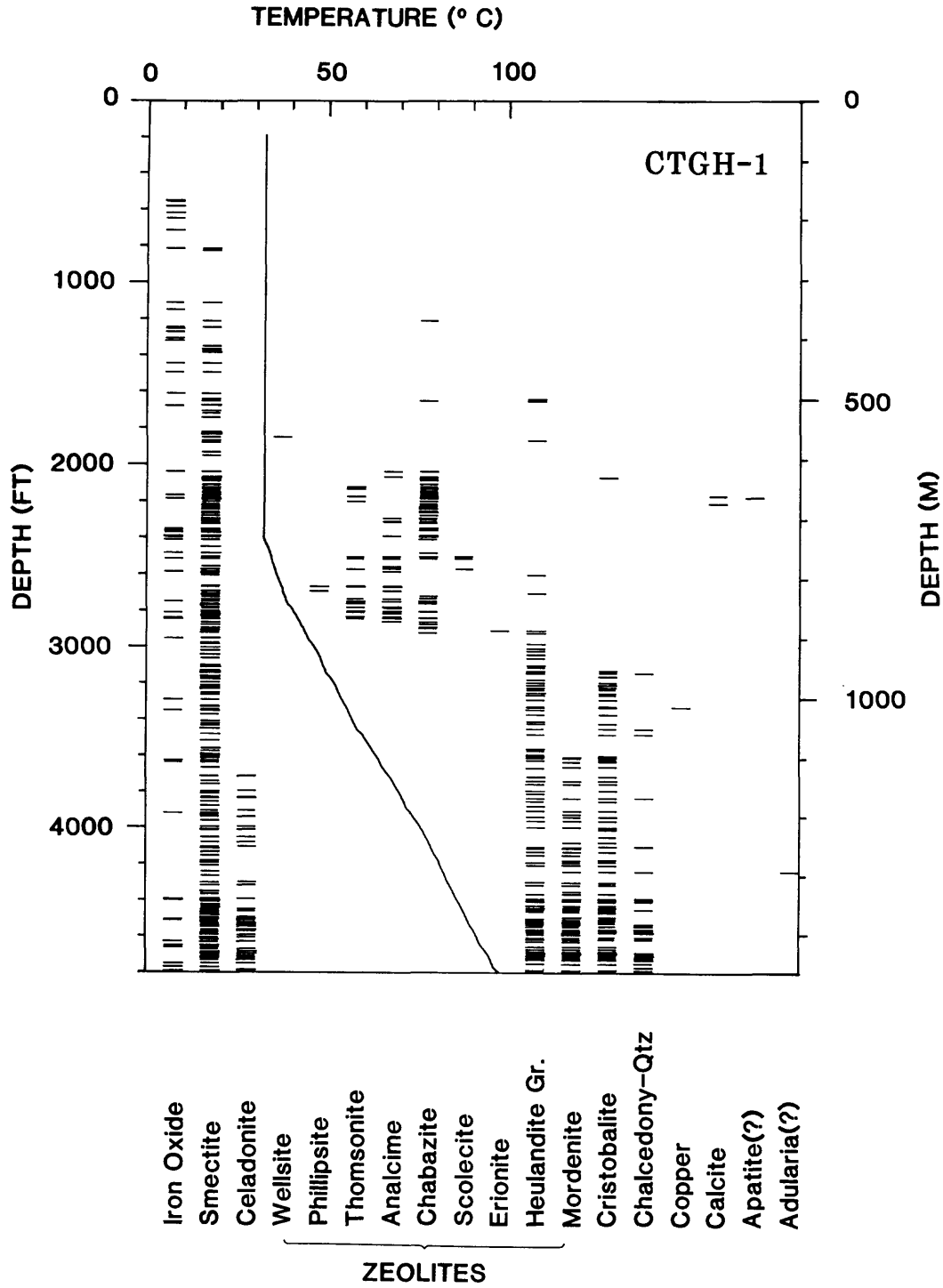


Figure 3. Distribution of hydrothermal alteration minerals with depth in SUNEDCO 58-28 (Bargar, 1994). Left column shows a stratigraphic section of rock units penetrated by the drill hole (modified from Conrey and Sherrod, 1988). Right column shows the distribution of samples studied. Solid temperature curve is from Blackwell and others (1986); dashed part of the temperature curve connects the data from Blackwell and others with a bottom-temperature measurement of 141°C reported by A.F. Waibel (unpublished data, 1982).

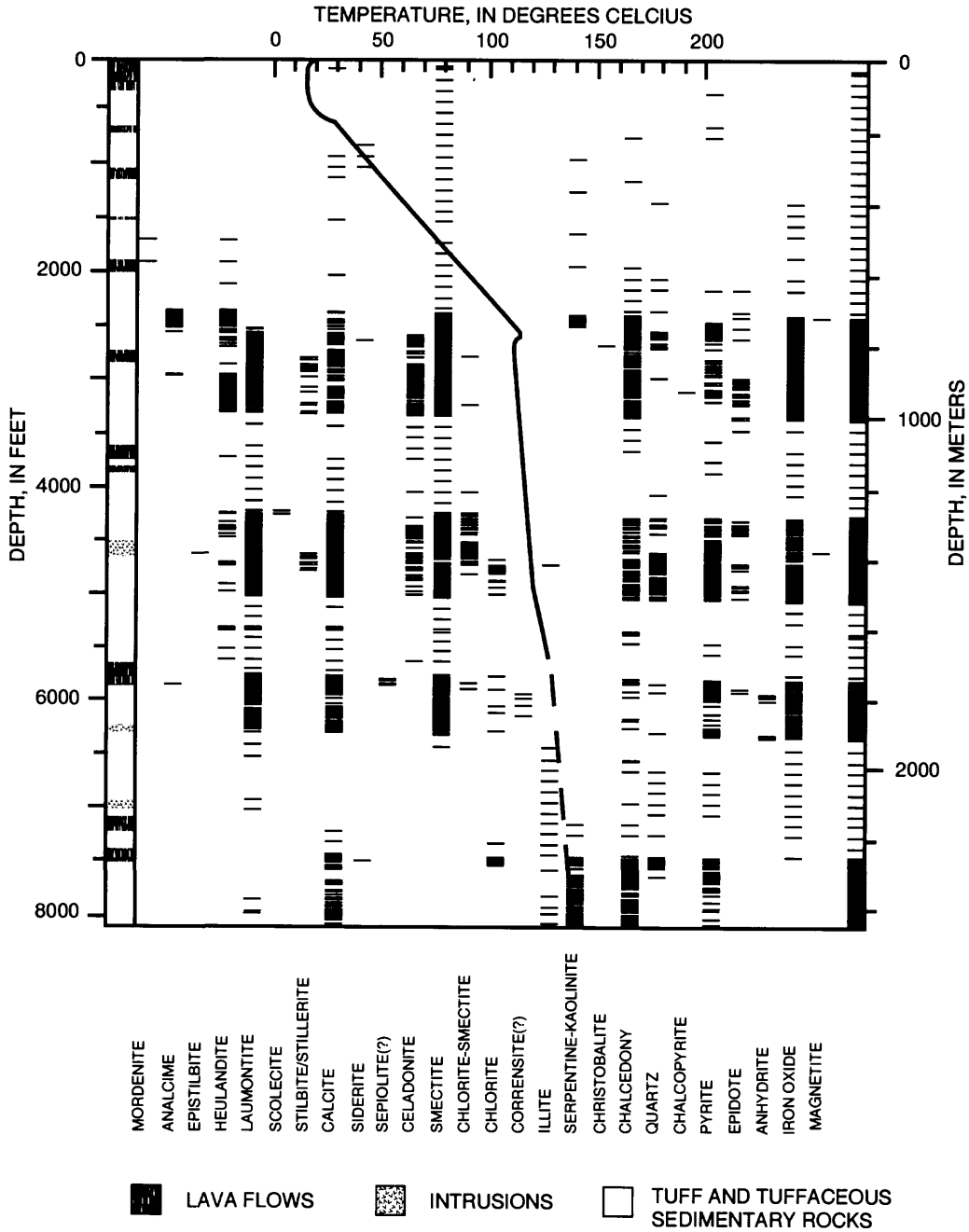


Figure 4. Ca+Mg-Na-K+Ba+Sr ternary diagram (after Cerny, Rinaldi, and Surdam, 1977) showing the distribution of exchangeable cations in analcime and wairakite from the Breitenbush-Austin Hot Springs area.

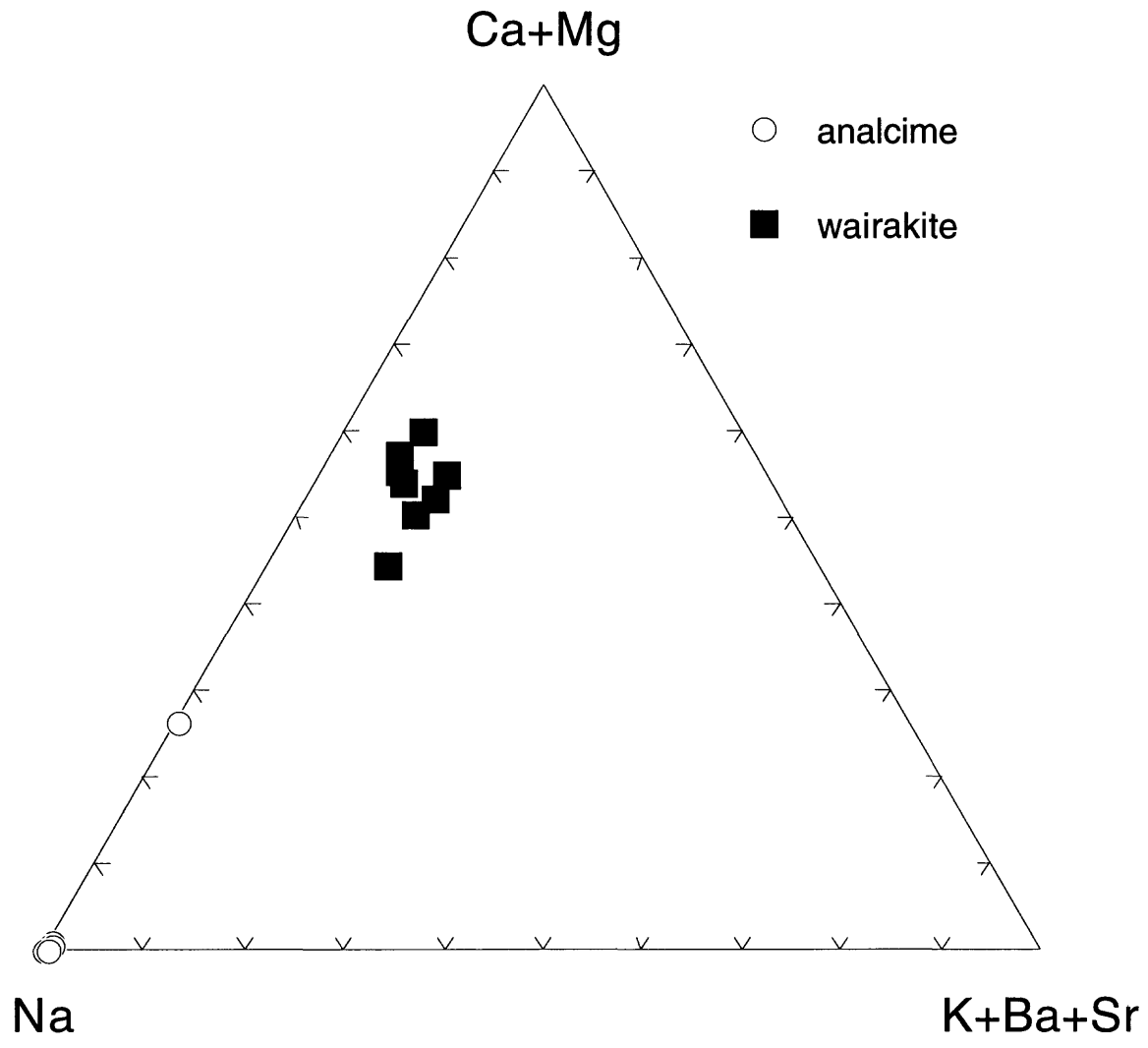


Figure 5. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in laumontite from the Breitenbush-Austin Hot Springs area.

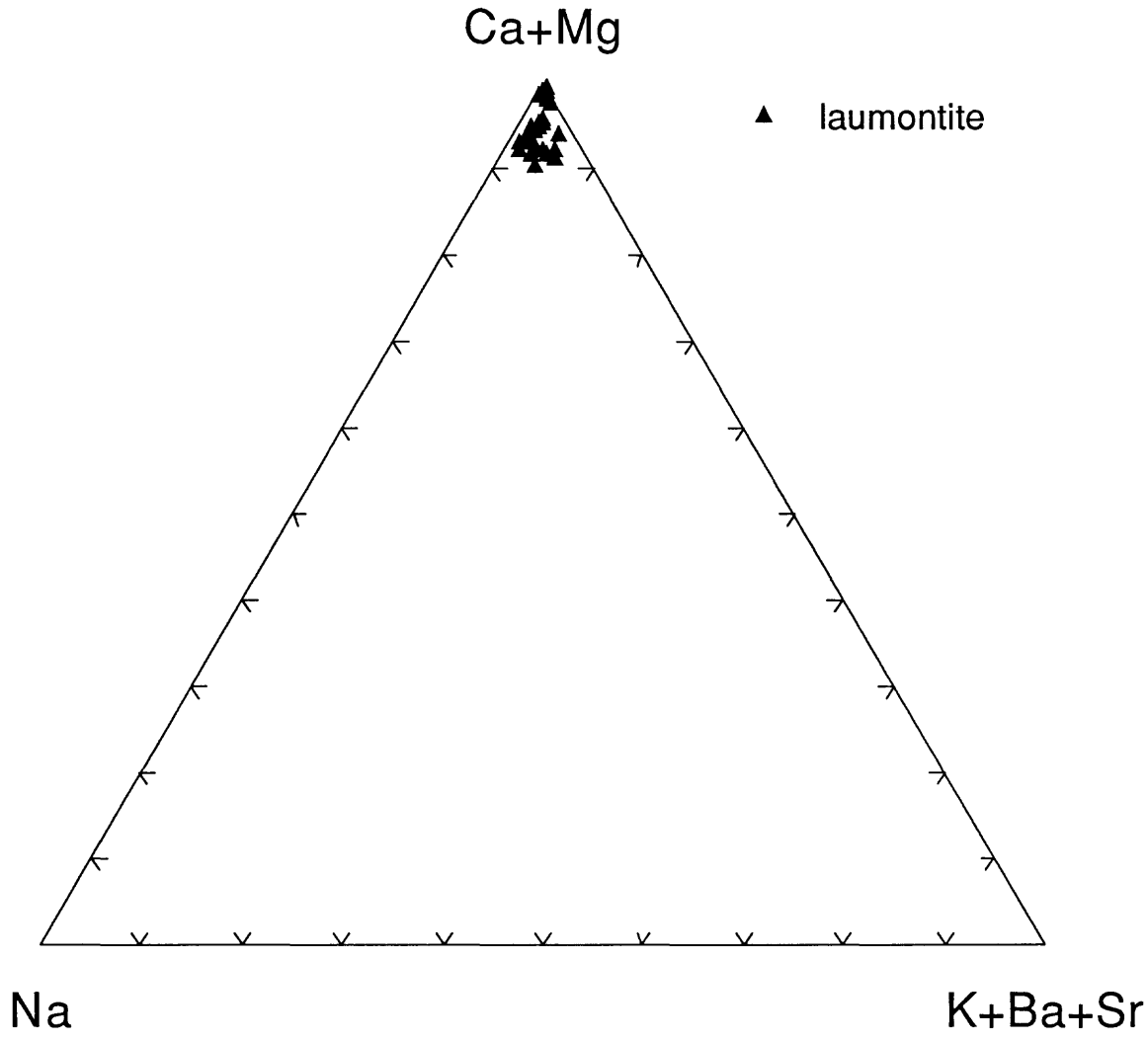


Figure 6. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in mesolite from the Breitenbush-Austin Hot Springs area.

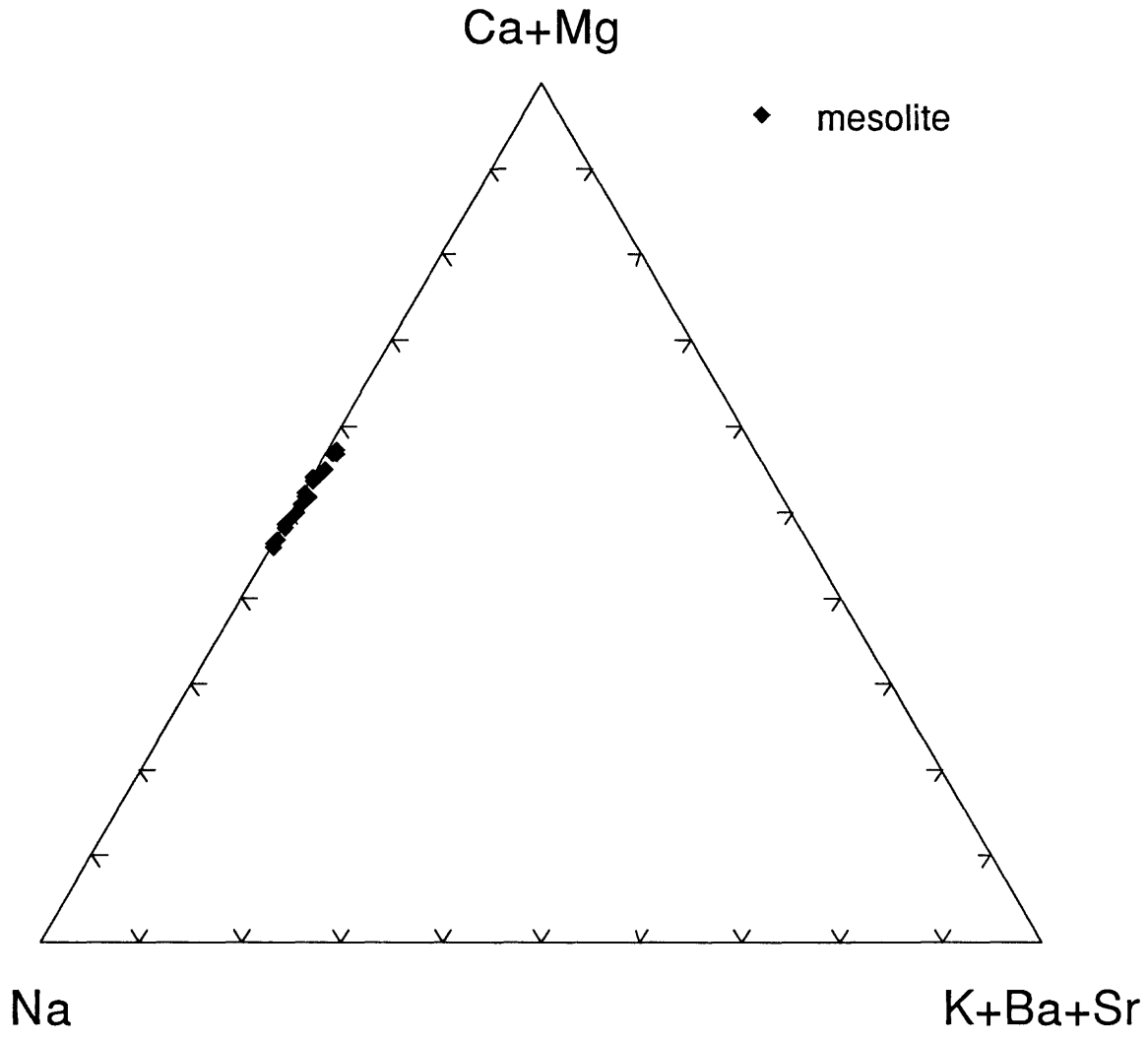
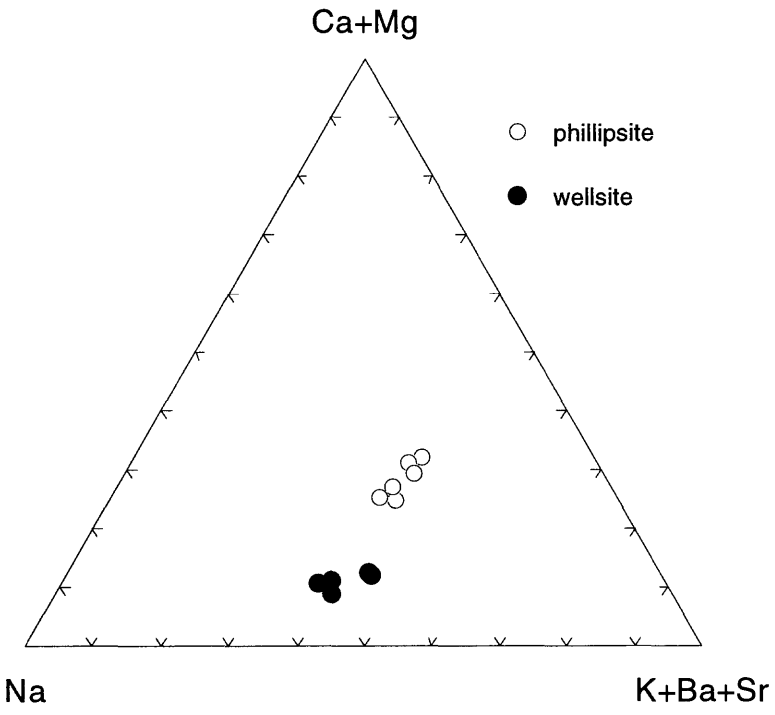


Figure 7. (A) Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in wellsite and phillipsite from the Breitenbush-Austin Hot Springs area; (B) Ba+Sr-Ca+Mg+Na-K ternary diagram (after Cerny, Rinaldi, and Surdam, 1977) showing the distribution of exchangeable cations in harmotome from near Mount Hood compared with phillipsite and wellsite from the Breitenbush-Austin Hot Springs area.



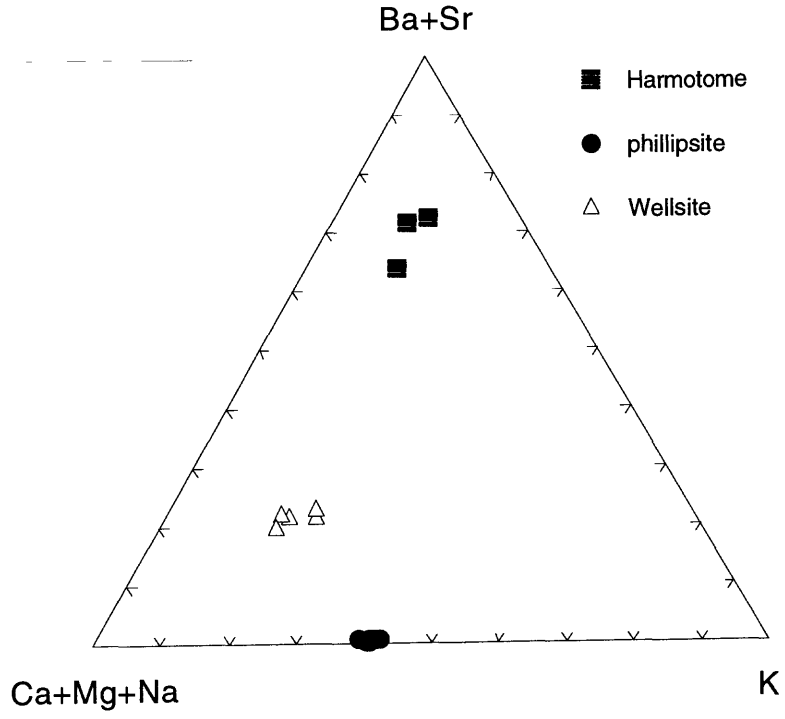


Figure 8. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in erionite from the Breitenbush-Austin Hot Springs area.

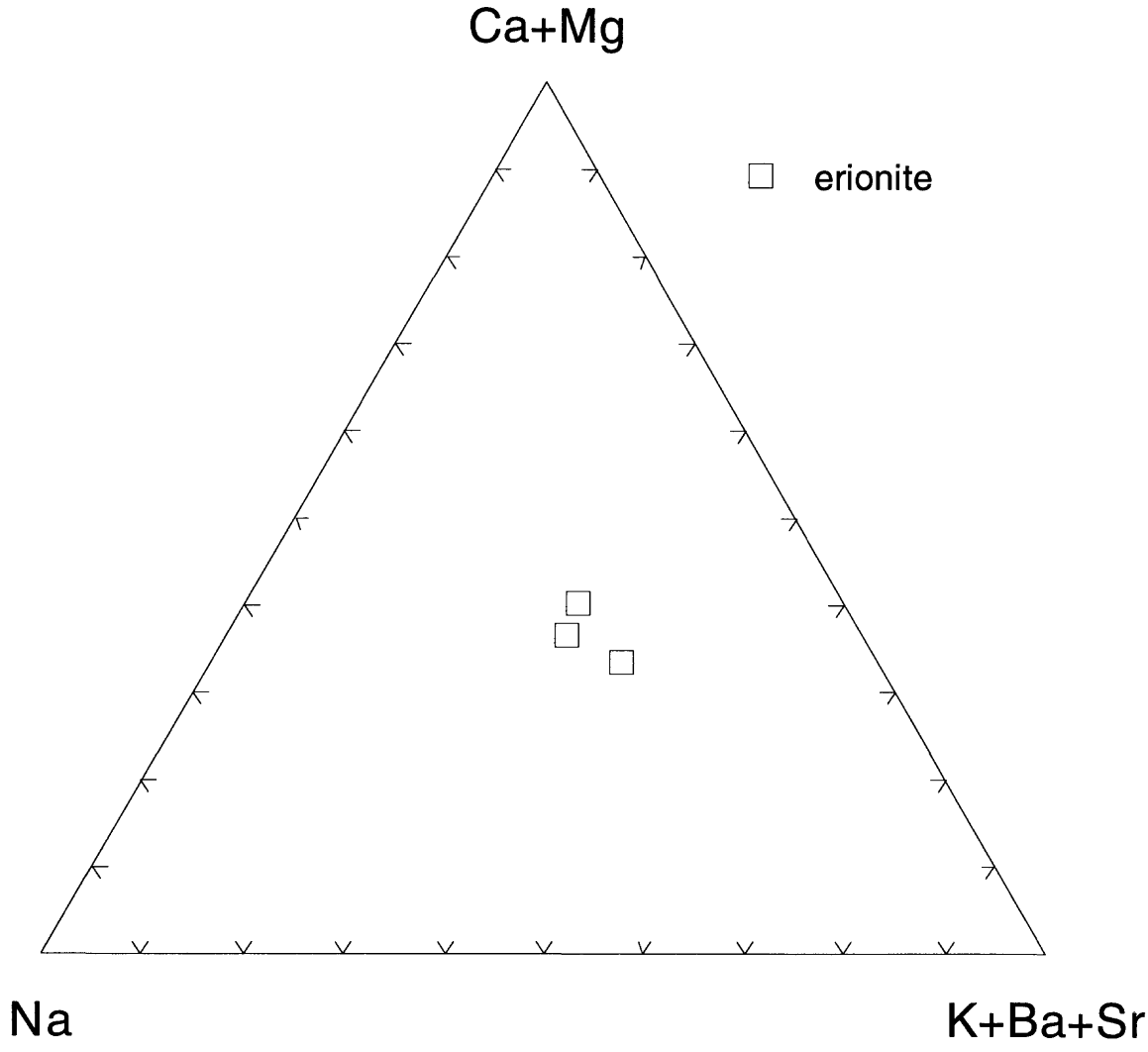


Figure 9. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in epistilbite from the Breitenbush-Austin Hot Springs area.

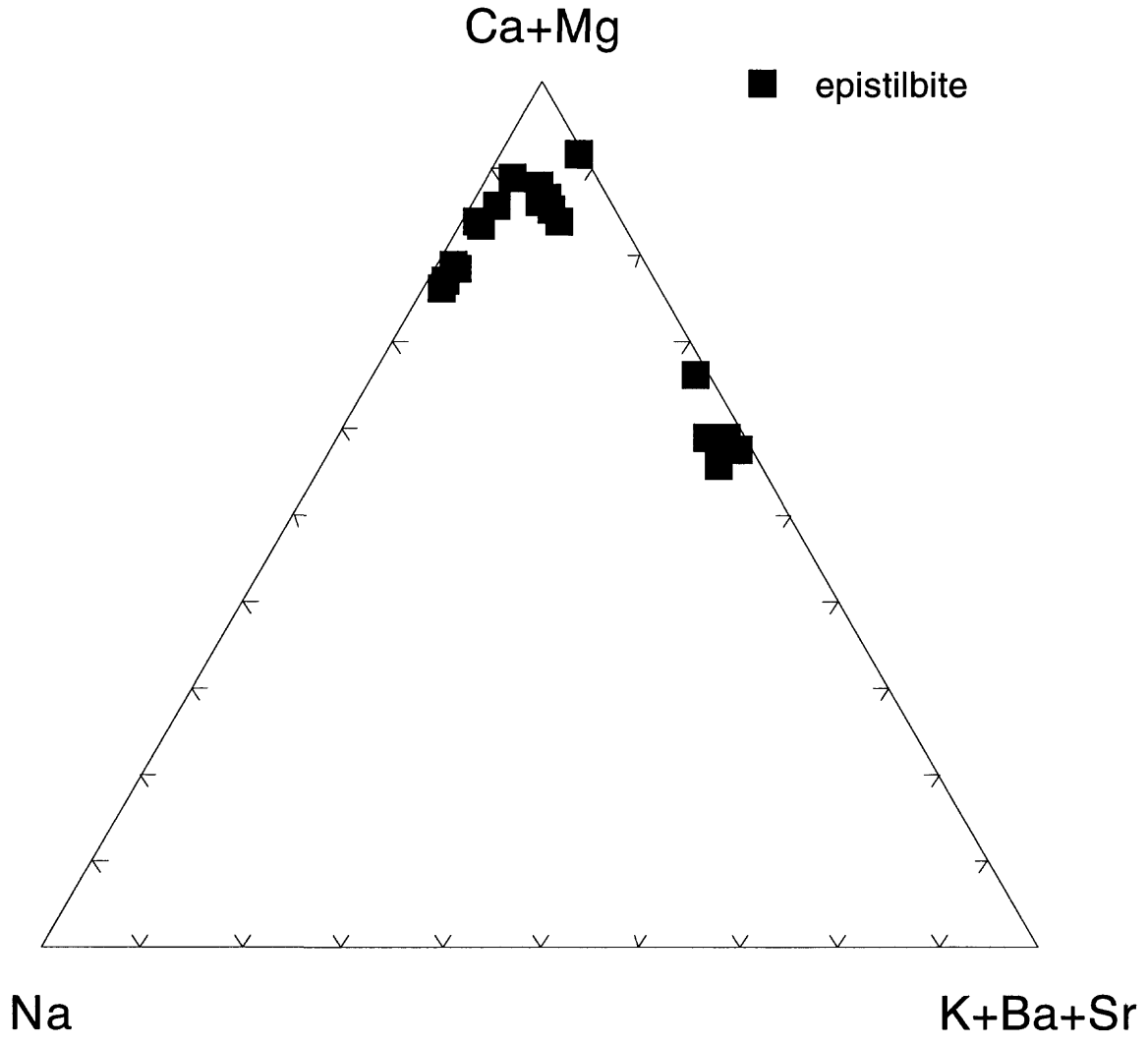


Figure 10. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in ferrierite from near Mount Hood (Bargar, Keith, and Beeson, 1993).

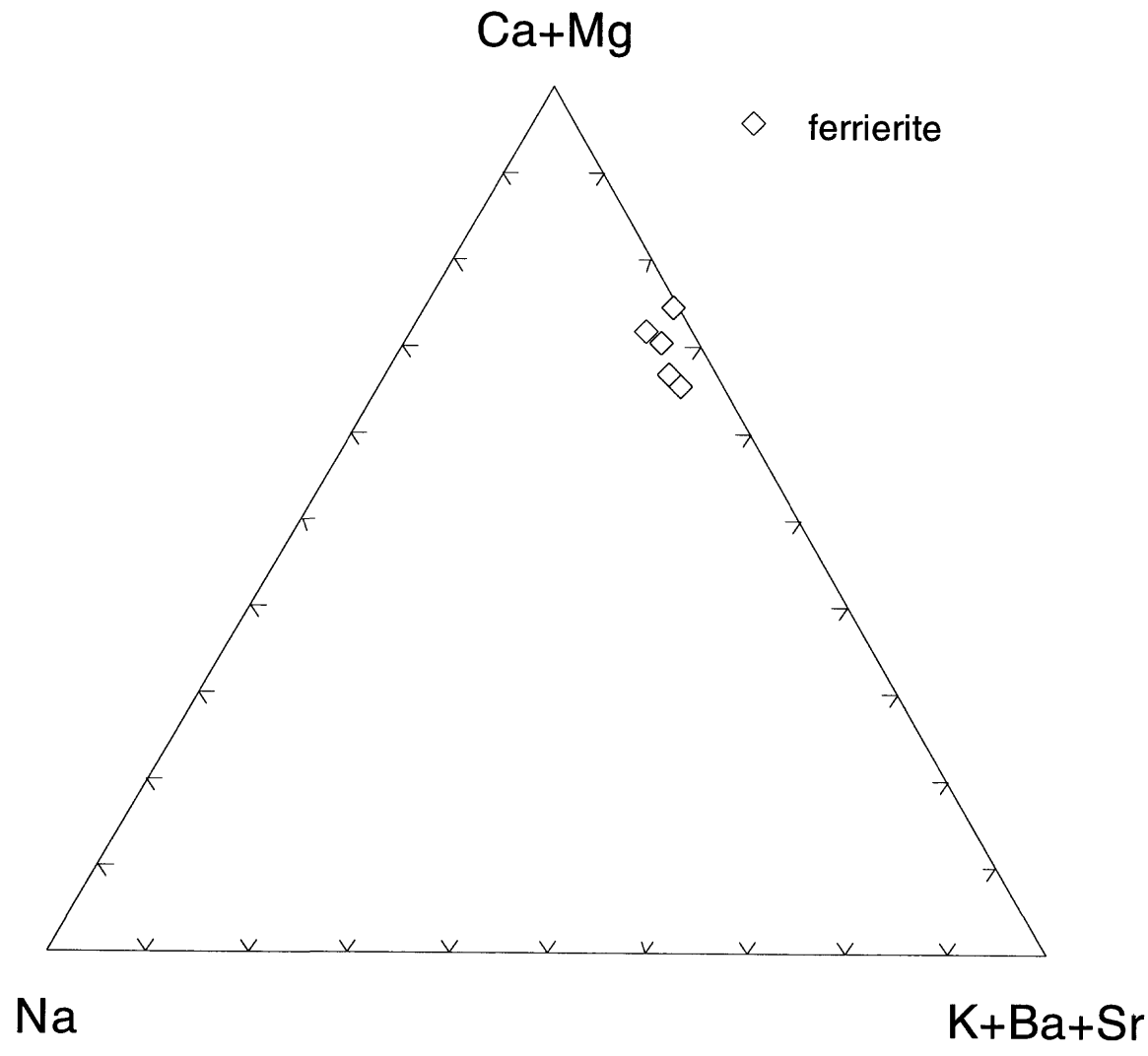


Figure 11. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in heulandite group minerals from the Breitenbush-Austin Hot Springs area.

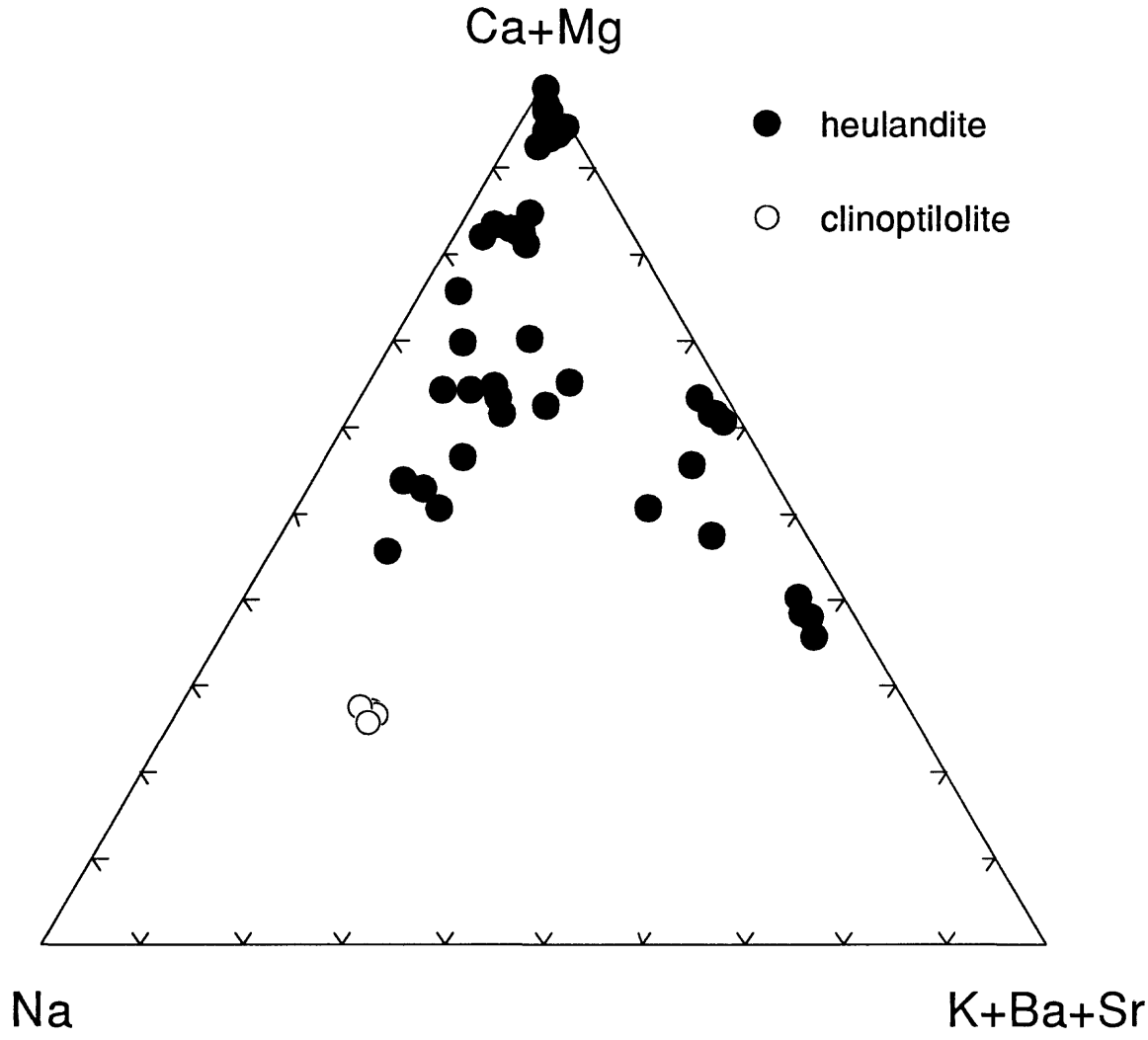


Figure 12. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in chabazite from the Breitenbush-Austin Hot Springs area.

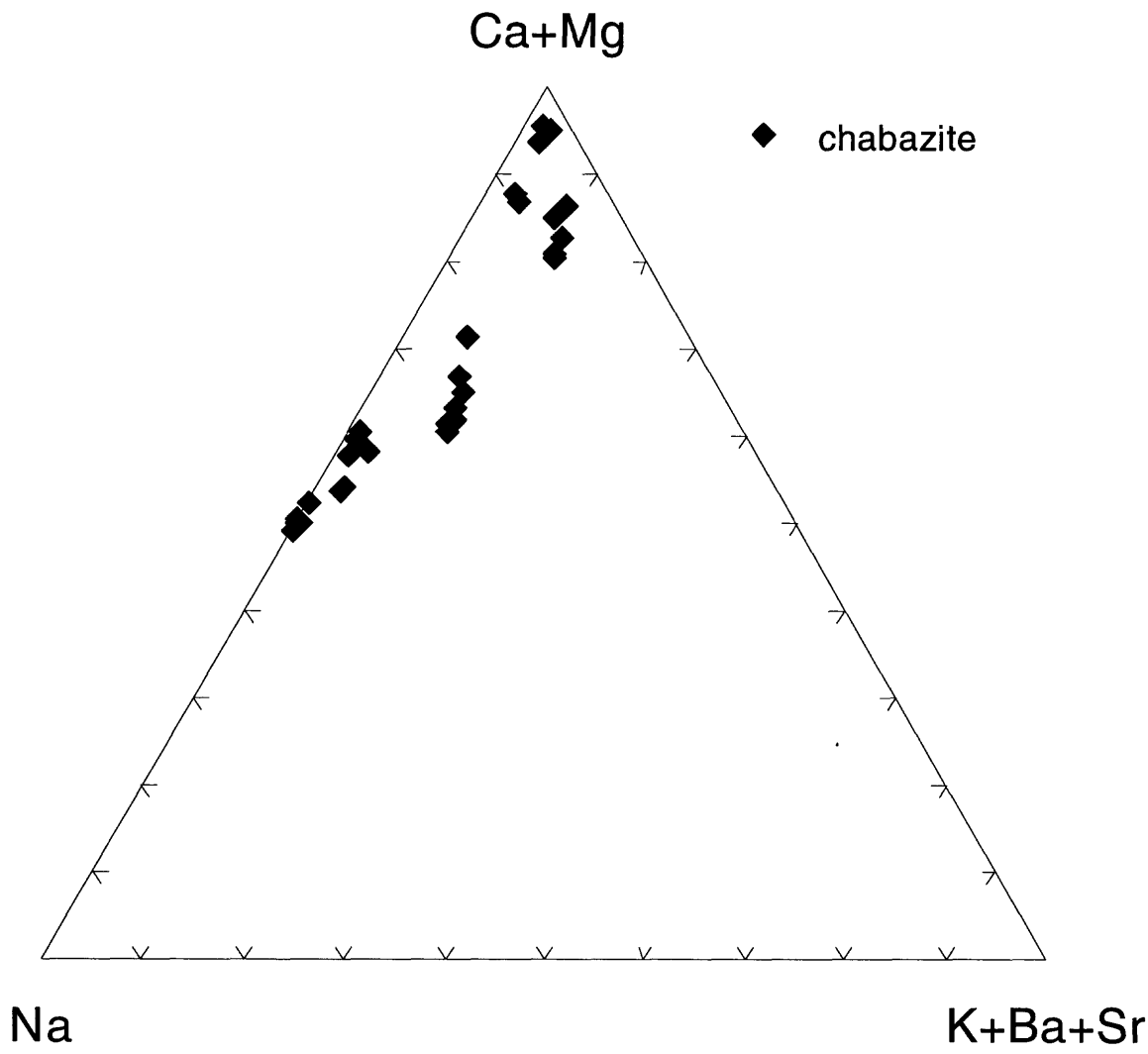


Figure 13. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in scolecite from the Breitenbush-Austin Hot Springs area.

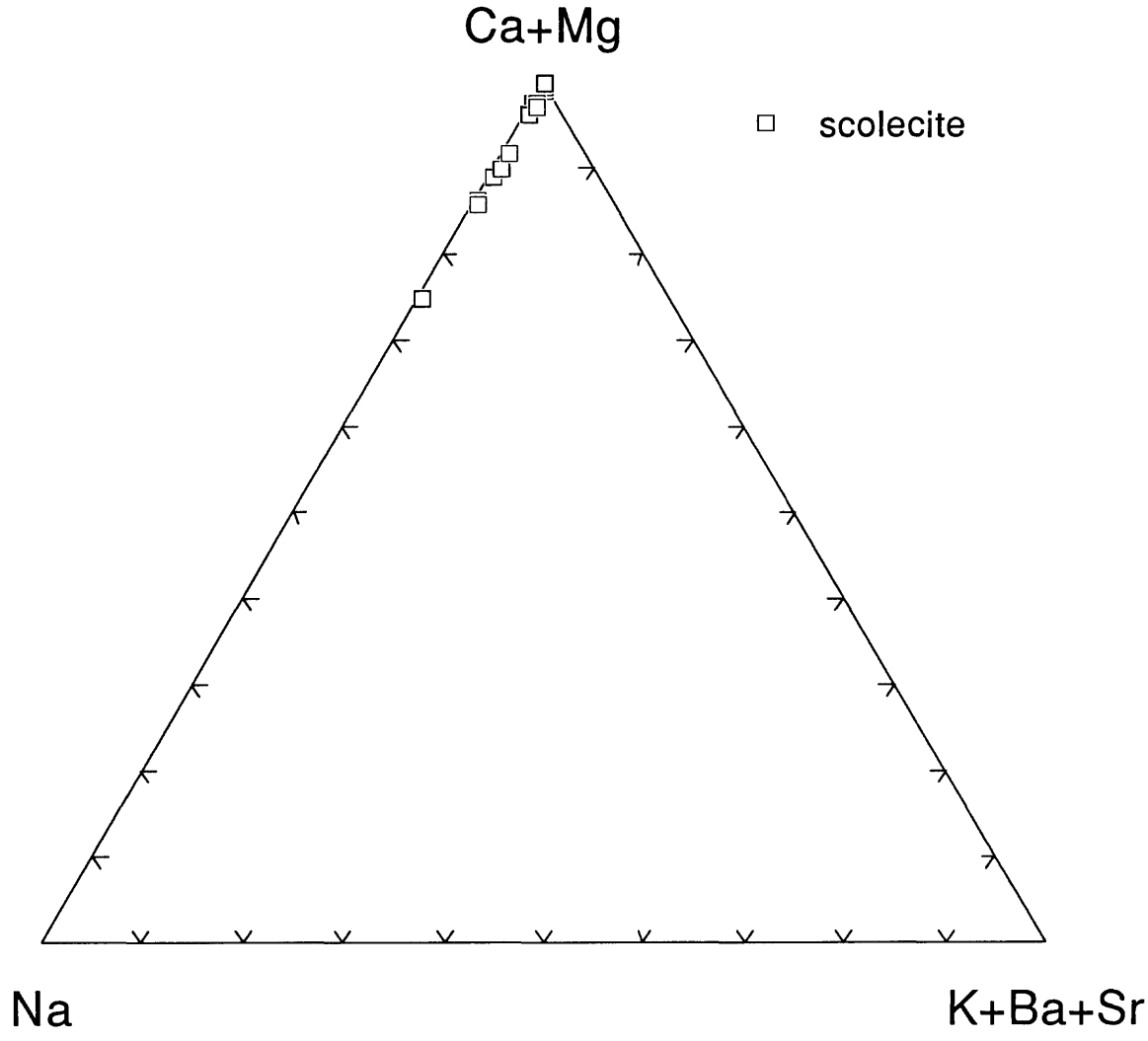


Figure 14. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in stilbite/stellerite from the Breitenbush-Austin Hot Springs area.

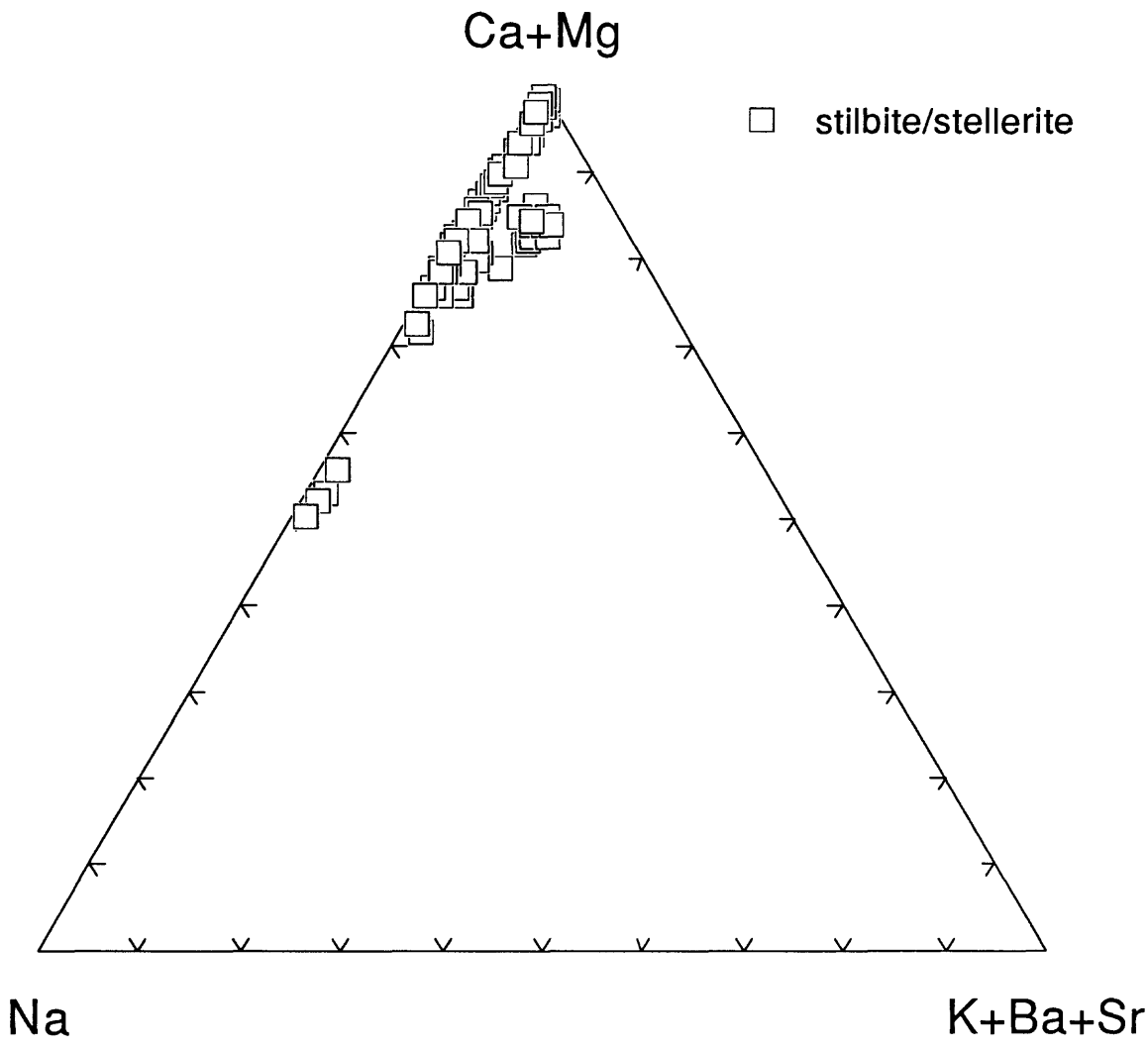


Figure 15. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in thomsonite from the Breitenbush-Austin Hot Springs area.

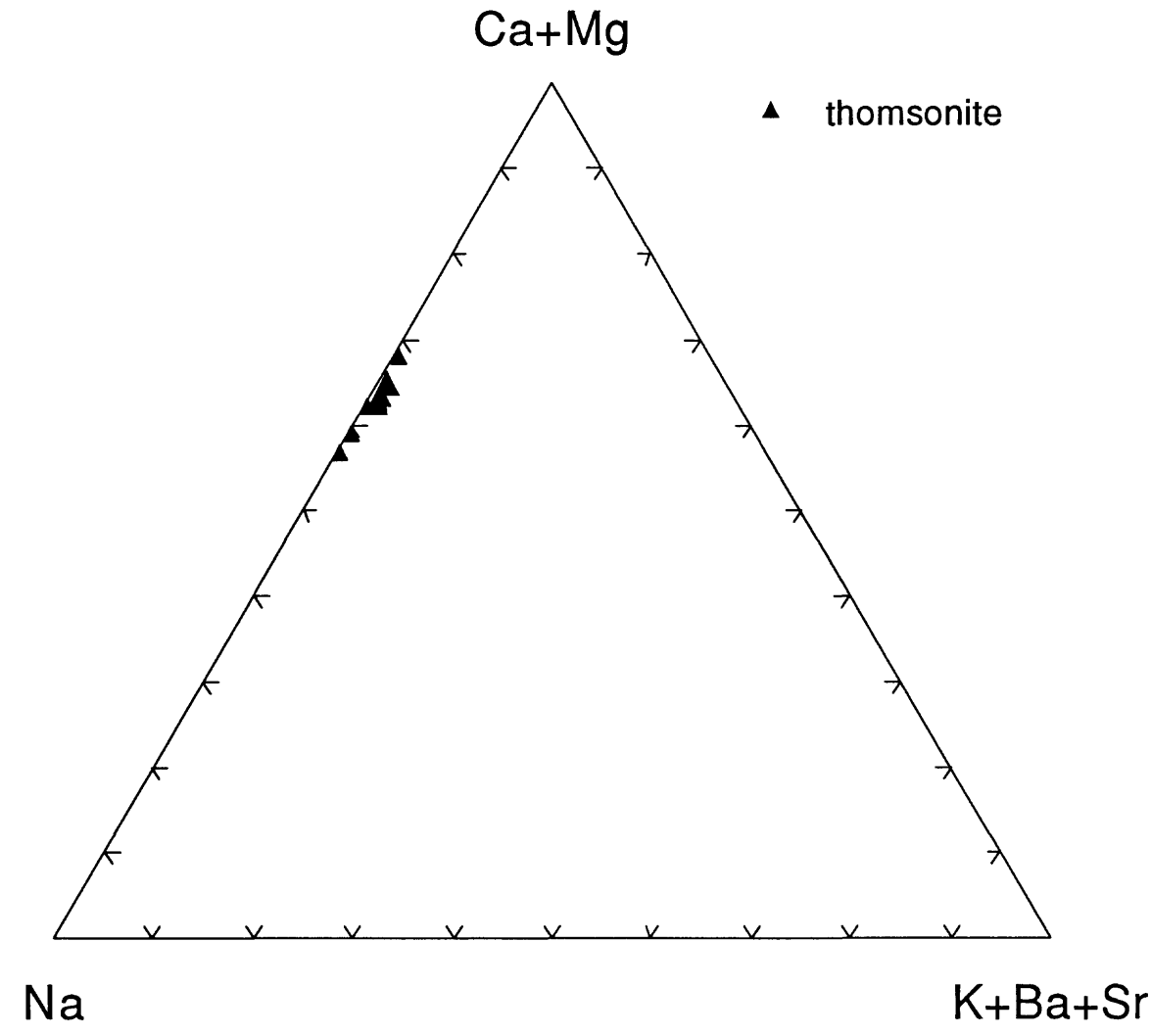


Figure 16. Ca+Mg-Na-K+Ba+Sr ternary diagram showing the distribution of exchangeable cations in yugawaralite from the Breitenbush-Austin Hot Springs area.

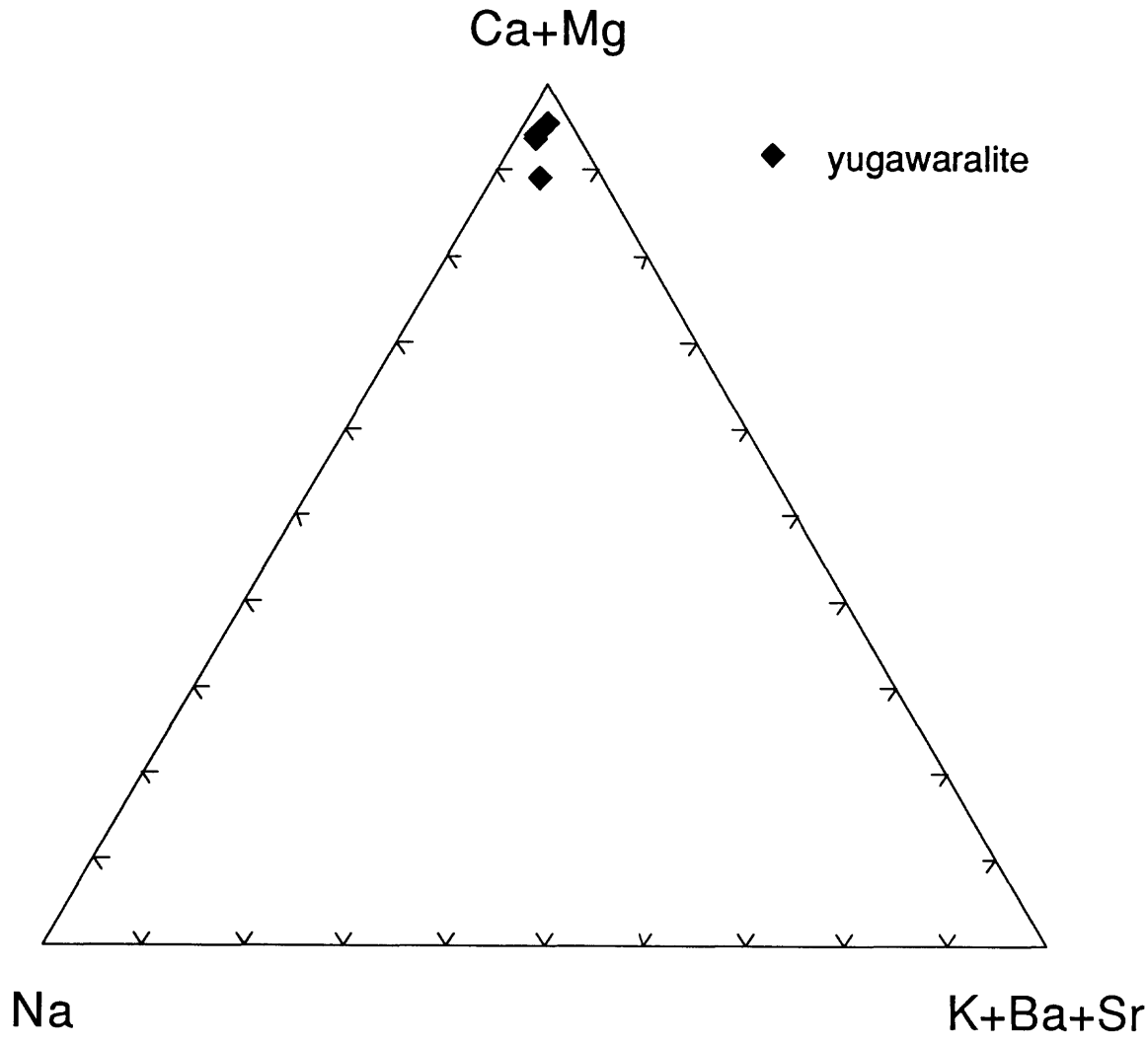


Figure 17. Scanning electron microscope qualitative chemical analysis of mordenite from an outcrop specimen in the Breitenbush-Austin Hot Springs area.

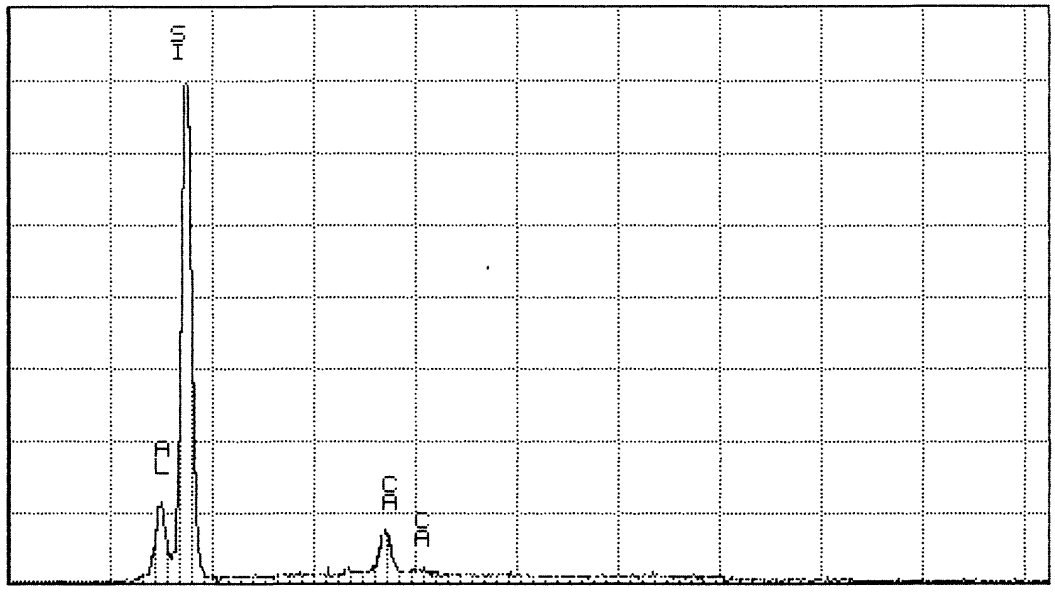


Figure 18. Scanning electron microscope qualitative chemical analysis of gismondine from an outcrop specimen in the Breitenbush-Austin Hot Springs area.

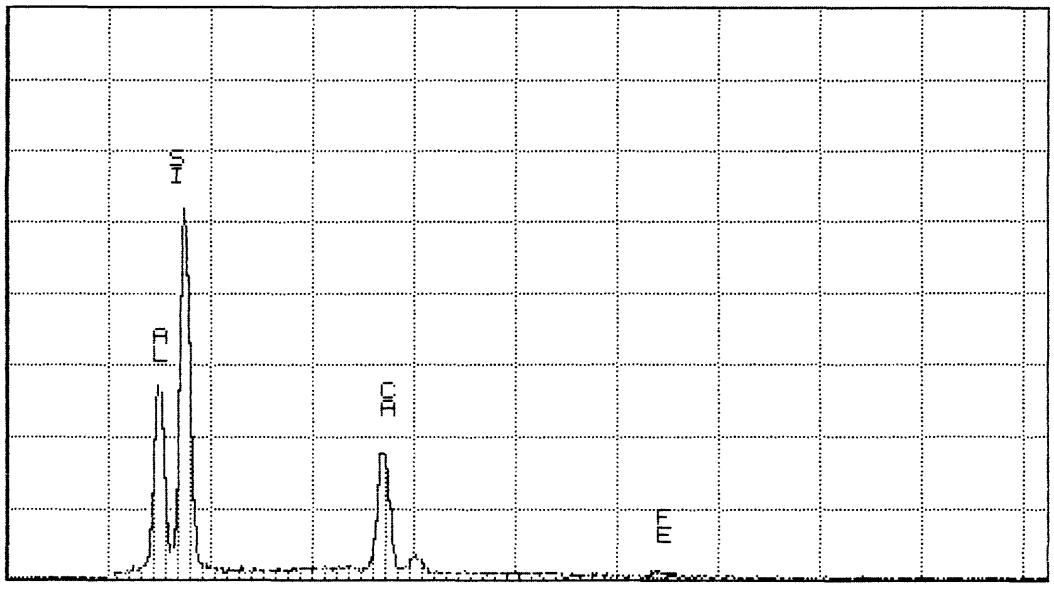


Table 1. Electron microprobe analyses of analcime.

Sample no.	SUNEDCO 58-28-2440					80CLAK-2024B				
Analysis no.	1	2	3	4	5	1	2	3	4	5
	Major-element chemical analyses(weight percent oxides)									
SiO_2	59.44	59.33	59.28	59.38	59.74	55.83	55.54	55.12	55.32	55.77
Al_2O_3	22.24	22.01	21.98	22.09	21.79	21.59	21.48	21.89	21.66	21.52
Fe_2O_3	0.10	0.02	0.11	0.11	0.07	0.00	0.03	0.04	0.01	0.05
MgO	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
CaO	0.17	0.15	0.14	0.15	0.13	0.00	0.00	0.02	0.03	0.03
Na_2O	14.32	13.59	14.22	14.26	13.99	12.97	13.11	12.85	13.03	12.95
K_2O	0.02	0.03	0.02	0.03	0.02	0.03	0.04	0.02	0.02	0.04
MnO	0.03	0.02	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00
SrO	0.11	0.15	0.13	0.16	0.12	0.00	0.00	0.00	0.00	0.02
BaO	0.07	0.01	0.00	0.00	0.00	0.02	0.00	0.05	0.07	0.09
Total	96.50	95.34	95.88	96.18	95.87	90.44	90.20	90.02	90.15	90.48
	Number of atoms on the basis of 96 oxygens									
Si	33.09	33.29	33.17	33.14	33.37	33.00	32.95	32.76	32.85	32.99
Al	14.59	14.56	14.50	14.53	14.35	15.04	15.02	15.34	15.16	15.00
Fe	0.04	0.01	0.05	0.05	0.03	0.00	0.01	0.02	0.01	0.02
Mg	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Ca	0.10	0.09	0.08	0.09	0.08	0.00	0.00	0.01	0.02	0.02
Na	15.46	14.78	15.43	15.43	15.15	14.86	15.08	14.80	15.01	14.85
K	0.01	0.02	0.01	0.02	0.01	0.02	0.03	0.02	0.01	0.03
Mn	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Sr	0.00	0.05	0.04	0.05	0.04	0.00	0.00	0.00	0.00	0.01
Ba	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02
Si+Al	47.68	47.85	47.67	47.67	47.72	48.04	47.97	48.10	48.01	47.99
Si/(Al+Fe)	2.26	2.28	2.28	2.27	2.32	2.19	2.19	2.13	2.17	2.20
Si/(Si+Al+Fe)	0.69	0.70	0.70	0.69	0.70	0.69	0.69	0.68	0.68	0.69
Balance Error	-6.99	-4.02	-7.21	-7.31	-6.62	1.00	-0.52	3.10	0.46	0.19

Table 1. Continued.

Sample no.	80COL-2040A					80COL-2040B					
Analysis no.	1	2	3	4	5	1	2	3	4	5	6
	Major-element chemical analyses (weight percent oxides)										
SiO_2	57.80	57.36	57.63	55.36	57.82	52.79	57.56	57.61	57.00	56.94	56.99
Al_2O_3	20.84	21.25	20.88	20.58	20.69	20.55	21.34	21.45	22.31	22.48	22.13
Fe_2O_3	0.02	0.02	0.05	0.00	0.01	0.00	0.04	0.00	0.02	0.00	0.01
MgO	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01
CaO	0.00	0.03	0.02	0.00	0.01	0.02	0.00	0.01	0.00	0.00	0.00
Na_2O	12.04	12.92	12.72	11.71	12.40	12.19	13.15	13.23	12.66	13.07	13.24
K_2O	0.04	0.03	0.04	0.05	0.04	0.02	0.00	0.03	0.01	0.00	0.01
MnO	0.00	0.00	0.00	0.06	0.00	0.04	0.01	0.00	0.00	0.00	0.00
SrO	0.01	0.00	0.00	0.00	0.06	-	-	-	-	-	-
BaO	0.02	0.04	0.03	0.00	0.09	-	-	-	-	-	-
Total	90.77	91.65	91.37	87.76	91.13	85.61	92.10	92.34	92.01	92.49	92.39
	Number of atoms on the basis of 96 oxygens										
Si	33.80	33.39	33.61	33.52	33.77	32.95	33.36	33.32	33.01	32.87	32.96
Al	14.36	14.58	14.35	14.69	14.24	15.12	14.58	14.62	15.23	15.29	15.09
Fe	0.01	0.01	0.02	0.00	0.00	0.00	0.02	0.00	0.09	0.00	0.00
Mg	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Ca	0.00	0.02	0.01	0.00	0.01	0.10	0.00	0.00	0.00	0.00	0.00
Na	13.66	14.58	14.39	13.75	14.04	14.75	14.77	14.84	14.22	14.63	14.85
K	0.03	0.02	0.03	0.04	0.03	0.01	0.01	0.02	0.01	0.00	0.01
Mn	0.00	0.00	0.00	0.03	0.00	0.02	0.01	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.02	-	-	-	-	-	-
Ba	0.00	0.01	0.01	0.00	0.02	-	-	-	-	-	-
Si+Al	48.16	47.98	47.96	48.21	48.01	48.07	47.94	47.94	48.24	48.17	48.05
Si/(Al+Fe)	2.35	2.29	2.34	2.28	2.37	2.18	2.29	2.28	2.15	2.15	2.18
Si/(Si+Al+Fe)	0.70	0.70	0.70	0.70	0.70	0.69	0.70	0.70	0.68	0.68	0.69
Balance Error	4.95	-0.41	-0.56	6.11	0.44	1.06	-1.23	-1.73	7.63	4.54	1.54

Table 1. Continued.

Sample no.	80COL-2039A					
Analysis no.	1	2	3	4	5	6
	Major-element chemical analyses(weight percent oxides)					
SiO_2	57.90	57.40	58.20	56.96	58.28	57.37
Al_2O_3	20.61	21.44	20.54	20.94	19.99	20.92
Fe_2O_3	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.01	0.00	0.02	0.00	0.00
CaO	0.13	0.02	0.01	0.01	0.03	0.00
Na_2O	11.89	12.60	11.64	12.47	11.81	11.91
K_2O	0.05	0.04	0.01	0.02	0.01	0.01
MnO	0.04	0.01	0.00	0.03	0.00	0.03
SrO	0.04	0.03	0.03	0.00	0.04	0.07
BaO	0.00	0.06	0.11	0.00	0.00	0.00
Total	90.66	91.61	90.54	90.43	90.16	90.31
	Number of atoms on the basis of 96 oxygens					
Si	33.89	33.39	34.05	33.52	34.24	33.72
Al	14.22	14.70	14.17	14.53	13.84	14.49
Fe	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.00	0.01	0.00	0.01	0.00	0.00
Ca	0.08	0.01	0.01	0.01	0.02	0.00
Na	13.49	14.21	13.20	14.23	13.46	13.57
K	0.04	0.03	0.01	0.01	0.01	0.01
Mn	0.02	0.00	0.00	0.02	0.00	0.02
Sr	0.01	0.01	0.01	0.00	0.01	0.02
Ba	0.00	0.01	0.02	0.00	0.00	0.00
Si+Al	48.12	48.09	48.22	48.05	48.08	48.21
Si/(Al+Fe)	2.38	2.27	2.40	2.31	2.47	2.33
Si/(Si+Al+Fe)	0.70	0.69	0.71	0.70	0.71	0.70
Balance Error	3.41	2.60	6.58	1.49	2.38	6.09

Table 2. Electron microprobe analyses of chabazite.

Sample no.	CTGH-1 2057					CTGH-1 2090.5							
Analysis no.	1	2	3	4	5	1	2	3	4	5	6	7	8
	Major-element chemical analyses (weight percent oxides)												
SiO_2	45.95	45.98	45.63	45.42	46.16	54.56	53.37	54.71	53.07	53.08	51.83	51.84	51.80
Al_2O_3	25.33	25.10	25.34	24.56	24.63	21.74	20.18	20.64	20.00	20.29	22.45	22.21	22.23
Fe_2O_3	0.05	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
CaO	9.25	9.42	9.44	9.45	9.41	9.75	8.79	9.33	9.36	9.12	10.01	10.14	10.20
Na_2O	5.02	5.36	5.09	5.13	5.17	1.67	2.10	1.95	2.05	2.31	2.71	2.68	2.77
K_2O	0.01	0.01	0.02	0.03	0.04	0.70	1.08	0.86	1.05	1.19	1.23	1.22	1.24
MnO	0.01	0.02	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
SrO	0.02	0.09	0.00	0.00	0.11	0.13	0.08	0.13	0.03	0.03	0.15	0.16	0.19
BaO	0.04	0.07	0.03	0.08	0.04	0.02	0.00	0.00	0.11	0.01	0.14	0.10	0.09
Total	85.68	86.05	85.55	84.67	85.61	88.59	85.63	87.62	85.67	86.04	88.54	88.35	88.52
	Number of atoms on the basis of 24 oxygens												
Si	7.28	7.27	7.25	7.30	7.33	8.18	8.28	8.29	8.26	8.23	7.89	7.91	7.90
Al	4.73	4.68	4.74	4.65	4.61	3.84	3.69	3.68	3.67	3.71	4.03	3.99	3.99
Fe	0.01	0.00	0.00	0.00	0.01	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	0.00	0.00
Ca	1.57	1.60	1.61	1.63	1.60	1.57	1.46	1.52	1.56	1.51	1.63	1.66	1.67
Na	1.54	1.64	1.57	1.60	1.59	0.49	0.63	0.57	0.62	0.69	0.80	0.79	0.82
K	0.00	0.00	0.00	0.01	0.01	0.13	0.21	0.17	0.21	0.24	0.24	0.24	0.24
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.02
Ba	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Si+Al	12.01	11.95	11.99	11.95	11.94	12.01	11.98	11.97	11.93	11.93	11.92	11.90	11.89
Si/(Al+Fe)	1.54	1.55	1.53	1.57	1.59	2.13	2.24	2.25	2.25	2.22	1.96	1.98	1.98
Si/(Si+Al+Fe)	0.61	0.61	0.60	0.61	0.61	0.68	0.69	0.69	0.69	0.69	0.66	0.66	0.66
Balance Error	0.88	-3.95	-0.89	-4.42	-4.32	1.70	-2.59	-2.78	-7.56	-6.66	-7.40	-8.99	-9.97

Table 2. Continued.

Sample no.	CTGH-1 2515					81FC-2027K				
Analysis no.	1	2	3	4	5	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)									
SiO_2	45.27	46.14	45.28	45.11	46.15	56.02	56.78	56.76	56.33	57.01
Al_2O_3	25.09	25.59	24.83	25.57	25.74	19.20	19.18	19.68	18.89	19.46
Fe_2O_3	0.05	0.02	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00
MgO	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00
CaO	9.53	9.59	9.37	9.46	9.46	9.46	9.97	9.60	9.27	10.03
Na_2O	5.28	5.40	5.20	5.17	4.73	0.56	0.25	0.14	0.55	0.25
K_2O	0.02	0.03	0.03	0.05	0.03	0.21	0.11	0.04	0.14	0.05
MnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
SrO	0.00	0.00	0.00	0.02	0.00	0.21	0.20	0.26	0.25	0.29
BaO	0.02	0.00	0.00	0.02	0.03	0.16	0.00	0.03	0.00	0.06
Total	85.27	86.77	84.74	85.41	86.14	85.84	86.49	86.52	85.43	87.18
	Number of atoms on the basis of 24 oxygens									
Si	7.23	7.23	7.26	7.19	7.26	8.56	8.59	8.57	8.62	8.57
Al	4.72	4.73	4.69	4.80	4.77	3.46	3.42	3.50	3.41	3.45
Fe	0.01	0.00	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
Ca	1.63	1.61	1.61	1.62	1.60	1.55	1.62	1.55	1.52	1.62
Na	1.63	1.64	1.62	1.60	1.44	0.17	0.07	0.04	0.16	0.07
K	0.00	0.01	0.01	0.01	0.01	0.04	0.02	0.01	0.03	0.01
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.03
Ba	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Si+Al	11.95	11.96	11.96	11.99	12.03	12.02	12.01	12.07	12.03	12.02
Si/(Al+Fe)	1.53	1.53	1.55	1.50	1.52	2.47	2.51	2.45	2.53	2.49
Si/(Si+Al+Fe)	0.60	0.60	0.61	0.60	0.60	0.71	0.72	0.71	0.72	0.71
Balance Error	-3.57	-2.88	-3.15	-0.92	2.80	2.90	1.72	9.11	4.15	2.05

Table 2. Continued.

Sample no.	81 FC-2027M					81 FC-2027N				
Analysis no.	1	2	3	4	5	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)									
SiO_2	53.05	54.13	54.43	53.21	52.23	55.39	55.48	55.19	54.88	64.78
Al_2O_3	18.25	18.65	18.92	18.70	18.02	19.32	19.38	19.64	19.14	17.06
Fe_2O_3	0.00	0.00	0.02	0.01	0.00	0.05	0.00	0.00	0.00	0.00
MgO	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.02
CaO	7.70	7.84	7.79	7.83	7.57	8.20	8.05	7.95	7.96	8.75
Na_2O	3.47	3.47	3.46	3.54	2.76	2.98	3.18	2.78	2.91	0.09
K_2O	0.19	0.20	0.19	0.18	0.15	0.18	0.16	0.16	0.17	0.25
MnO	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.01	0.00	0.00
SrO	0.27	0.30	0.38	0.37	0.43	-	-	-	-	-
BaO	0.05	0.00	0.00	0.00	0.00	-	-	-	-	-
Total	82.98	84.60	85.26	83.90	81.17	86.12	86.25	85.73	85.06	90.95
	Number of atoms on the basis of 24 oxygens									
Si	8.47	8.47	8.46	8.42	8.50	8.48	8.48	8.47	8.49	9.18
Al	3.43	3.44	3.47	3.49	3.46	3.49	3.49	3.55	3.49	2.85
Fe	0.00	0.00	0.00	0.00	0.00	0.01	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	0.01
Ca	1.32	1.31	1.30	1.33	1.32	1.35	1.32	1.31	1.32	1.33
Na	1.07	1.05	1.04	1.09	0.87	0.89	0.94	0.83	0.87	0.03
K	0.04	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.04
Mn	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.03	0.03	0.03	0.03	0.04	-	-	-	-	-
Ba	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-
Si+Al	11.91	11.92	11.92	11.91	11.96	11.96	11.97	12.02	11.99	12.03
Si/(Al+Fe)	2.47	2.46	2.67	2.41	2.46	2.43	2.43	2.38	2.43	3.22
Si/(Si+Al+Fe)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.70	0.71	0.76
Balance Error	9.74	8.91	7.84	9.65	4.63	-3.30	-3.30	2.28	-1.50	4.09

Table 2. Continued.

Sample no.	81DL 2083B				
Analysis no.	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)				
SiO_2	53.92	54.20	54.10	54.37	54.45
Al_2O_3	18.71	19.13	19.21	19.49	19.72
Fe_2O_3	0.00	0.00	0.04	0.03	0.00
MgO	0.02	0.00	0.00	0.01	0.01
CaO	9.87	9.92	9.81	9.77	10.36
Na_2O	0.31	0.46	0.42	0.60	0.61
K_2O	0.48	0.71	0.58	0.81	0.80
MnO	0.00	0.02	0.04	0.02	0.02
SrO	0.67	0.75	0.50	0.58	0.63
BaO	0.13	0.06	0.07	0.00	0.00
Total	84.11	85.25	84.77	85.68	86.60
	Number of atoms on the basis of 24 oxygens				
Si	8.48	8.43	8.44	8.41	8.36
Al	3.47	3.51	3.53	3.55	3.57
Fe	0.00	0.00	0.00	0.00	0.00
Mg	0.00	0.00	0.00	0.00	0.00
Ca	1.66	1.65	1.64	1.62	1.70
Na	0.09	0.14	0.13	0.18	0.18
K	0.10	0.14	0.11	0.16	0.16
Mn	0.00	0.00	0.01	0.00	0.00
Sr	0.06	0.07	0.05	0.05	0.06
Ba	0.01	0.00	0.00	0.00	0.00
Si+Al	11.95	11.94	11.97	11.96	11.93
Si/(Al+Fe)	2.44	2.40	2.39	2.36	2.34
Si/(Si+Al+Fe)	0.71	0.71	0.70	0.70	0.70
Balance Error	-5.29	-5.99	-2.53	-3.70	-7.73

Table 3. Electron microprobe analyses of erionite, and ferrierite.

Sample no.	CTGH-1 2912.5 Erionite			79BP 2043B ferrierite					
Analysis no.	1	2	4	1	2	3	4	5	6
				Major-element chemical analyses (weight percent oxides)					
SiO_2	58.12	60.17	57.42	66.50	66.21	57.18	66.32	47.82	49.48
Al_2O_3	15.55	15.63	15.23	11.40	10.73	10.38	11.25	7.39	7.80
Fe_2O_3	0.07	0.04	0.06	0	0.01	0	0.01	0.07	0.01
MgO	0.12	0.17	0.23	3.13	2.81	2.78	2.87	1.76	1.85
CaO	3.99	3.85	4.62	0.71	0.78	0.69	0.84	0.73	0.78
Na_2O	1.86	1.73	1.81	0.18	0.17	0.14	0.20	0.11	0.02
K_2O	3.12	4.07	3.32	1.57	1.46	1.10	1.41	0.80	0.75
MnO	0.01	0.02	0	0.03	0	0.08	0.01	0.04	0.03
SrO	0.15	0.09	0.09	0.27	0.25	0.22	0.26	0.08	0.28
BaO	0	0.04	0.03	0.73	0.74	0.62	0.64	0.16	0.20
Total	82.98	85.80	82.79	84.53	83.16	73.19	83.83	58.95	61.20
				Number of atoms on the basis of 72 oxygens					
Si	27.51	27.64	27.37	29.88	30.18	29.65	29.99	30.49	30.42
Al	8.67	8.46	8.56	6.04	5.77	6.34	6.00	5.56	5.65
Fe	0.03	0.01	0.02	0	0	0	0	0.03	0
Mg	0.09	0.12	0.16	2.10	1.91	2.15	1.94	1.67	1.70
Ca	2.02	1.89	2.36	0.34	0.38	0.38	0.41	0.50	0.51
Na	1.71	1.54	1.67	0.16	0.15	0.14	0.18	0.14	0.02
K	1.88	2.39	2.02	0.90	0.85	0.73	0.82	0.65	0.59
Mn	0	0.01	0	0.01	0	0.03	0.01	0.02	0.01
Sr	0.04	0.02	0.02	0.07	0.07	0.07	0.07	0.03	0.10
Ba	0	0.01	0.01	0.13	0.13	0.13	0.11	0.04	0.05
Si+Al	36.18	36.1	35.93	35.92	35.95	35.99	35.98	36.05	36.07
Si/(Al+Fe)	3.16	3.26	3.19	4.95	5.23	4.67	5.00	5.46	5.38
Si/(Si+Al+Fe)	0.76	0.77	0.76	0.83	0.84	0.82	0.83	0.85	0.84
Balance Error	10.22	5.67	-2.43	-5.04	-3.34	-0.64	-1.00	5.37	5.65

Table 4. Electron microprobe analyses of epistilbite.

Sample no.	80OGF 2019B				80COL 2063A					
Analysis no.	1	2	3	4	1	2	3	4	5	6
				Major-element chemical analyses (weight percent oxides)						
SiO2	67.94	66.53	67.19	67.19	55.88	57.72	58.03	57.88	61.01	60.49
Al2O3	13.36	12.73	13.24	13.19	16.59	17.12	17.64	17.20	17.43	17.96
Fe2O3	0.00	0.00	0.09	0.05	0.00	0.03	0.02	0.02	0.00	0.00
MgO	0.59	0.17	0.15	0.17	0.01	0.00	0.00	0.01	0.00	0.00
CaO	4.99	4.70	5.34	5.00	8.99	8.96	9.36	8.33	8.88	9.11
Na2O	0.08	0.09	0.20	0.22	0.36	0.04	0.38	0.35	0.36	0.41
K2O	2.26	2.62	2.82	3.00	0.54	0.42	0.38	0.59	0.77	0.51
MnO	0.01	0.00	0.05	0.00	0.00	0.00	0.00	0.03	0.00	0.04
SrO	0.15	0.20	0.22	0.15	0.13	0.42	0.23	0.15	0.14	0.08
BaO	0.04	0.03	0.03	0.22	0.03	0.03	0.00	0.00	0.06	0.09
Total	89.42	87.07	89.33	89.19	82.53	84.74	86.04	84.56	88.65	88.59
				Number of atoms on the basis of 48 oxygens						
Si	19.49	19.62	19.43	19.47	17.70	17.77	17.62	17.82	17.93	17.78
Al	4.52	4.43	4.51	4.50	6.20	6.21	6.32	6.24	6.04	6.22
Fe	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Mg	0.25	0.07	0.06	0.08	0.01	0.00	0.00	0.00	0.00	0.00
Ca	1.53	1.49	1.65	1.55	3.05	2.96	3.04	2.75	2.80	2.87
Na	0.04	0.05	0.11	0.13	0.22	0.02	0.23	0.21	0.20	0.23
K	0.83	0.99	1.04	1.11	0.22	0.16	0.15	0.23	0.29	0.19
Mn	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Sr	0.03	0.03	0.04	0.03	0.02	0.07	0.04	0.03	0.02	0.01
Ba	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.01
Si+Al	24.00	24.05	23.94	23.97	23.90	23.99	23.94	24.06	23.97	24.00
Si/(Al+Fe)	4.31	4.43	4.29	4.31	2.86	2.86	2.79	2.85	2.97	2.86
Si/(Si+Al+Fe)	0.81	0.82	0.81	0.81	0.74	0.74	0.74	0.74	0.75	0.74
Balance Error	0.24	4.65	-3.48	-1.58	-6.20	-0.53	-3.43	3.93	1.73	-0.06

Table 4. continued.

Sample no.	80COL 2031F									
Analysis no.	1	2	3	4	5	6	7	8	9	10
	Major-element chemical analyses (weight percent oxides)									
SiO2	68.48	56.87	55.77	56.56	60.29	61.18	58.63	59.94	61.08	58.97
Al2O3	12.66	16.34	16.06	16.63	17.79	17.14	17.08	17.91	17.20	17.78
Fe2O3	0.04	0.00	0.04	0.05	0.00	0.01	0.02	0.00	0.00	0.00
MgO	0.13	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02
CaO	4.75	7.85	7.66	7.86	8.30	8.11	8.25	8.53	8.43	8.40
Na2O	0.08	0.76	0.58	0.42	0.78	1.12	1.12	1.29	1.37	1.16
K2O	2.81	0.11	0.10	0.08	0.10	0.13	0.10	0.11	0.09	0.08
MnO	0.00	0.05	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.03
SrO	0.19	0.00	0.11	0.16	0.11	0.10	0.05	0.08	0.08	0.10
BaO	0.14	0.03	0.03	0.11	0.04	0.00	0.00	0.00	0.05	0.04
Total	89.28	82.02	80.35	81.87	87.42	87.80	85.25	87.86	88.33	86.56
	Number of atoms on the basis of 48 oxygens									
Si	19.72	17.97	17.98	17.91	17.88	18.06	17.87	17.75	17.98	17.73
Al	4.30	6.08	6.10	6.21	6.22	5.96	6.13	6.25	5.97	6.30
Fe	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Mg	0.06	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
Ca	1.47	2.66	2.65	2.67	2.64	2.57	2.69	2.71	2.66	2.70
Na	0.04	0.46	0.36	0.26	0.45	0.64	0.66	0.74	0.78	0.67
K	1.03	0.04	0.04	0.03	0.04	0.05	0.04	0.04	0.03	0.03
Mn	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Sr	0.03	0.00	0.02	0.03	0.02	0.02	0.01	0.01	0.01	0.02
Ba	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00
Si+Al	24.02	24.05	24.08	24.12	24.10	24.03	24.00	24.01	23.95	24.03
Si/(Al+Fe)	4.59	2.95	2.94	2.88	2.89	3.03	2.91	2.84	3.01	2.81
Si/(Si+Al+Fe)	0.82	0.75	0.75	0.74	0.74	0.75	0.74	0.74	0.75	0.74
Balance Error	2.22	3.69	6.32	8.97	6.86	1.86	0.47	0.39	-3.44	1.86

Table 5. Electron microprobe analyses of heulandite-group minerals.

Sample no.	SUNEDCO 58-28 3080 heulandite					CTGH-1 3062.5 clinoptilolite			
Analysis no.	1	2	3	4	5	1	2	3	4
	Major-element chemical analyses (weight percent oxides)								
SiO2	65.04	65.60	66.42	67.87	67.15	68.83	70.36	70.17	71.25
Al2O3	14.41	14.56	15.52	14.49	14.57	12.60	12.64	12.88	12.72
Fe2O3	0.11	0.07	0.00	0.14	0.03	0.00	0.02	0.00	0.00
MgO	0.02	0.03	0.02	0.02	0.02	0.06	0.05	0.05	0.04
CaO	6.81	6.83	7.35	6.89	7.19	2.58	2.68	2.96	2.70
Na2O	0.52	0.41	0.55	0.55	0.55	2.94	3.07	3.33	3.23
K2O	0.33	0.23	0.27	0.21	0.25	1.45	1.63	1.50	1.65
MnO	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03
SrO	0.28	0.24	0.33	0.21	0.27	0.10	0.07	0.18	0.11
BaO	0.25	0.15	0.18	0.15	0.19	0.26	0.15	0.15	0.16
Total	87.78	88.13	90.64	90.53	90.22	88.82	90.67	91.24	91.89
	Number of atoms on the basis of 72 oxygens								
Si	28.56	28.60	28.27	28.78	28.65	29.73	29.77	29.60	29.78
Al	7.46	7.48	7.79	7.24	7.33	6.41	6.30	6.40	6.26
Fe	0.04	0.02	0.00	0.05	0.01	0.00	0.01	0.00	0.00
Mg	0.01	0.02	0.01	0.01	0.01	0.04	0.03	0.03	0.02
Ca	3.20	3.19	3.35	3.13	3.29	1.19	1.22	1.34	1.21
Na	0.44	0.35	0.45	0.45	0.46	2.46	2.52	2.73	2.62
K	0.19	0.13	0.15	0.11	0.14	0.80	0.88	0.81	0.88
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Sr	0.07	0.06	0.08	0.05	0.07	0.02	0.02	0.04	0.03
Ba	0.04	0.03	0.03	0.03	0.03	0.04	0.03	0.02	0.03
Si+Al	36.01	36.09	36.06	36.03	35.98	36.14	36.08	36.00	36.04
Si/(Al+Fe)	3.81	3.81	3.63	3.95	3.90	4.64	4.72	4.62	4.75
Si/(Si+Al+Fe)	0.79	0.79	0.78	0.80	0.80	0.82	0.83	0.82	0.83
Balance Error	2.67	6.06	3.10	4.00	-0.70	9.46	5.34	-0.29	2.77

Table 5. continued.

Sample no.	CTGH-1 2704.5 heulandite			CTGH-1 2912.5 heulandite			80CLAK 2028A huelandite			
Analysis no.	1	2	3	1	2	3	1	2	3	4
	Major-element chemical analyses (weight percent oxides)									
SiO2	64.27	64.52	66.74	64.77	65.83	67.29	65.78	66.41	67.39	68.65
Al2O3	15.21	15.10	14.67	14.15	14.28	14.32	13.61	13.92	14.13	13.47
Fe2O3	0.05	0.05	0.01	0.00	0.00	0.04	0.10	0.07	0.10	0.00
MgO	0.20	0.29	0.35	0.08	0.08	0.06	0.32	0.28	0.29	0.22
CaO	5.22	5.10	4.73	4.68	4.82	4.27	4.91	5.30	5.36	4.87
Na2O	2.09	2.05	1.52	1.76	1.88	2.25	0.08	0.12	0.12	0.14
K2O	0.81	0.64	0.76	0.57	0.40	0.57	2.65	2.57	2.65	2.15
MnO	0.02	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.05	0.00
SrO	0.77	0.60	0.43	0.49	0.46	0.54	0.08	0.21	0.21	0.24
BaO	0.35	0.18	0.30	0.21	0.23	0.33	0.16	0.27	0.23	0.08
Total	88.99	88.56	89.53	86.72	87.98	89.67	87.69	89.15	90.53	89.82
	Number of atoms on the basis of 72 oxygens									
Si	28.13	28.24	28.71	28.76	28.79	28.91	29.00	28.88	28.86	29.36
Al	7.85	7.79	7.44	7.41	7.36	7.25	7.07	7.13	7.13	6.79
Fe	0.02	0.02	0.00	0.00	0.00	0.01	0.03	0.02	0.03	0.00
Mg	0.13	0.19	0.22	0.05	0.05	0.04	0.21	0.18	0.18	0.14
Ca	2.45	2.39	2.18	2.23	2.26	1.97	2.32	2.47	2.46	2.23
Na	1.77	1.74	1.26	1.52	1.60	1.87	0.07	0.10	0.10	0.11
K	0.45	0.36	0.42	0.32	0.22	0.31	1.49	1.43	1.45	1.17
Mn	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Sr	0.20	0.15	0.11	0.13	0.12	0.13	0.02	0.05	0.05	0.06
Ba	0.06	0.03	0.05	0.04	0.04	0.05	0.03	0.05	0.04	0.01
Si+Al	35.98	36.03	36.16	36.17	36.15	36.16	36.07	36.01	36.00	36.15
Si/(Al+Fe)	3.58	3.62	3.86	3.88	3.91	3.98	4.08	4.03	4.03	4.33
Si/(Si+Al+Fe)	0.78	0.78	0.79	0.80	0.80	0.80	0.80	0.80	0.80	0.81
Balance Error	-0.50	2.19	9.35	10.02	9.05	10.36	5.93	1.85	1.57	9.84

Table 5. continued.

Sample no.	80 OGF-2076F F heulandite					80 COL-2063I heulandite			
Analysis no.	1	2	3	4	5	1	2	3	4
	Major-element chemical analyses (weight percent oxides)								
SiO2	65.79	64.78	64.41	63.75	63.93	68.69	70.18	67.04	68.86
Al2O3	16.89	15.89	15.73	16.53	16.77	12.64	12.81	12.80	12.71
Fe2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
MgO	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
CaO	8.92	8.94	8.87	8.70	8.77	3.72	3.67	3.42	3.76
Na2O	0.07	0.06	0.00	0.04	0.08	0.25	0.25	0.28	0.26
K2O	0.13	0.10	0.05	0.34	0.32	4.17	4.48	4.55	4.44
MnO	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
SrO	-	-	-	-	-	0.18	0.37	0.30	0.34
BaO	-	-	-	-	-	0.02	0.05	0.07	0.02
Total	91.80	89.78	89.07	89.36	89.87	89.68	91.83	88.46	90.39
	Number of atoms on the basis of 72 oxygens								
Si	27.68	27.87	27.91	27.60	27.53	29.66	29.67	29.47	29.60
Al	8.37	8.06	8.03	8.43	8.51	6.44	6.38	6.64	6.44
Fe	0.00	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
Ca	4.02	4.12	4.12	4.04	4.04	1.72	1.66	1.61	1.73
Na	0.06	0.05	0.00	0.03	0.07	0.21	0.21	0.24	0.22
K	0.07	0.06	0.02	0.19	0.18	2.30	2.41	2.55	2.44
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	-	-	-	-	-	0.05	0.09	0.08	0.08
Ba	-	-	-	-	-	0.00	0.01	0.01	0.00
Si+Al	36.05	35.93	35.94	36.04	36.04	36.10	36.05	36.11	36.04
Si/(Al+Fe)	3.31	3.46	3.47	3.27	3.23	4.61	4.65	4.44	43.60
Si/(Si+Al+Fe)	0.77	0.78	0.78	0.77	0.76	0.82	0.82	0.82	0.82
Balance Error	2.46	-3.57	-2.64	1.69	4.51	6.33	3.80	7.10	2.30

Table 5. continued.

Sample no.	80COL-2031G heulandite			81CB-2044D heulandite		88DL-11D heulandite				
Analysis no.	1	2	3	1	2	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)									
SiO2	59.30	57.98	58.63	62.65	55.88	63.00	60.81	63.22	63.64	63.99
Al2O3	16.61	16.82	16.49	13.74	20.07	15.48	15.05	15.38	15.47	15.45
Fe2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
MgO	0.00	0.00	0.00	0.11	0.01	0.00	0.01	0.00	0.00	0.00
CaO	6.50	6.28	6.38	5.32	8.65	8.51	8.17	8.53	8.64	8.73
Na2O	0.73	1.05	0.82	0.40	0.21	0.15	0.22	0.13	0.07	0.07
K2O	0.74	0.66	0.63	2.63	4.26	0.18	0.17	0.24	0.11	0.14
MnO	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.00	0.00	0.02
SrO	2.12	1.88	2.10	0.51	1.04	0.05	0.01	0.07	0.05	0.01
BaO	0.00	0.16	0.08	0.50	0.87	0.00	0.10	0.00	0.00	0.00
Total	86.00	84.83	85.13	85.86	90.99	87.40	84.58	87.57	88.01	88.41
	Number of atoms on the basis of 72 oxygens									
Si	27.14	26.93	27.11	28.55	25.09	27.86	27.82	27.91	27.93	27.95
Al	8.96	9.21	8.99	7.38	10.62	8.07	8.12	8.00	8.00	7.95
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Mg	0.00	0.00	0.00	0.07	0.01	0.00	0.00	0.00	0.00	0.00
Ca	3.19	3.13	3.16	2.60	4.16	4.03	4.00	4.03	4.06	4.09
Na	0.65	0.94	0.73	0.35	0.18	0.13	0.20	0.11	0.06	0.06
K	0.43	0.39	0.37	1.53	2.44	0.10	0.10	0.14	0.06	0.08
Mn	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.01
Sr	0.56	0.51	0.56	0.14	0.27	0.01	0.00	0.02	0.01	0.00
Ba	0.00	0.03	0.01	0.09	0.15	0.00	0.02	0.00	0.00	0.00
Si+Al	36.10	36.14	36.10	35.93	35.71	35.93	35.93	35.91	35.93	35.91
Si/(Al+Fe)	3.03	2.93	3.02	3.87	2.36	3.45	3.43	3.49	3.48	3.51
Si/(Si+Al+Fe)	0.75	0.75	0.75	0.79	0.70	0.78	0.77	0.78	0.78	0.78
Balance Error	4.53	6.30	4.71	-3.82	-9.98	-3.23	-3.15	-4.19	-3.07	-4.49

Table 5. continued.

Sample no.	81 FC-2027C heulandite			81 FC-2027K heulandite						
Analysis no.	1	2	3	1	2	3	4	5	6	7
	Major-element chemical analyses (weight percent oxides)									
SiO_2	63.64	62.31	64.07	53.57	54.96	59.30	58.22	53.47	58.98	59.27
Al_2O_3	15.70	15.06	15.53	17.88	18.90	16.81	16.01	18.61	17.26	17.26
Fe_2O_3	0.00	0.02	0.00	0.00	0.01	0.00	0.03	0.06	0.01	0.00
MgO	0.15	0.05	0.16	0.00	0.00	0.03	0.05	0.01	0.03	0.00
CaO	6.06	5.96	5.90	9.30	9.61	6.88	5.87	9.24	6.43	6.59
Na_2O	1.35	1.11	1.47	1.40	0.85	0.89	1.25	0.94	1.29	1.27
K_2O	0.36	0.16	0.17	0.23	0.18	0.27	0.22	0.16	0.18	0.20
MnO	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.04	0.08
SrO	0.97	0.72	0.82	0.22	0.22	1.75	2.10	0.15	2.08	1.83
BaO	0.14	0.02	0.10	0.00	0.05	0.00	0.10	0.02	0.12	0.09
Total	88.37	85.41	88.22	82.60	84.78	85.93	83.89	82.69	86.42	86.59
	Number of atoms on the basis of 72 oxygens									
Si	27.96	28.16	28.09	25.65	25.57	27.06	27.26	25.51	26.87	26.90
Al	8.13	8.02	8.03	10.09	10.37	9.04	8.84	10.46	9.27	9.23
Fe	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00
Mg	0.10	0.04	0.10	0.00	0.00	0.02	0.03	0.00	0.02	0.00
Ca	2.85	2.88	2.77	4.77	4.79	3.36	2.95	4.72	3.14	3.20
Na	1.15	0.97	1.25	1.30	0.77	0.78	1.14	0.87	1.14	1.12
K	0.20	0.09	0.10	0.14	0.10	0.16	0.13	0.10	0.11	0.12
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.02	0.03
Sr	0.25	0.19	0.21	0.06	0.06	0.46	0.57	0.04	0.55	0.48
Ba	0.02	0.00	0.02	0.00	0.01	0.00	0.02	0.00	0.02	0.02
Si+Al	36.09	36.18	36.12	35.75	35.94	36.10	36.10	35.97	36.13	36.14
Si/(Al+Fe)	3.44	3.51	3.50	2.54	2.47	2.99	3.08	2.43	2.90	2.91
Si/(Si+Al+Fe)	0.77	0.78	0.78	0.72	0.70	0.75	0.75	0.71	0.74	0.74
Balance Error	4.48	10.21	6.45	-9.11	-2.08	4.75	4.89	-0.43	6.08	6.22

Table 6. Electron microprobe analysis of laumontite.

Sample no.	SUNEDCO 58-28 4230					80 COL 2050H			
Analysis no.	1	2	3	4	5	1	2	3	4
	Major-element chemical analyses (weight percent oxides)								
SiO_2	51.77	51.71	52.18	53.09	53.11	53.63	51.91	53.75	53.95
Al_2O_3	21.40	20.39	20.63	21.75	21.21	20.93	20.65	20.91	20.22
Fe_2O_3	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.09	0.02
MgO	0.00	0.03	0.00	0.00	0.01	0.01	0.00	0.00	0.00
CaO	11.79	10.98	11.07	11.82	11.45	11.23	11.16	11.34	11.23
Na_2O	0.02	0.14	0.19	0.13	0.17	0.26	0.23	0.42	0.30
K_2O	0.05	0.14	0.13	0.09	0.12	0.37	0.20	0.13	0.27
MnO	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SrO	0.19	0.23	0.12	0.26	0.10	0.09	0.03	0.04	0.00
BaO	0.00	0.01	0.07	0.01	0.10	0.00	0.00	0.00	0.00
Total	85.23	83.64	84.39	87.17	86.27	86.52	84.18	86.68	85.99
	Number of atoms on the basis of 48 oxygens								
Si	16.12	16.37	16.36	16.16	16.31	16.41	16.32	16.41	16.58
Al	7.85	7.61	7.63	7.81	7.68	7.55	7.65	7.53	7.33
Fe	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00
Mg	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	3.93	3.72	3.72	3.86	3.77	3.68	3.76	3.71	3.70
Na	0.01	0.09	0.12	0.08	0.10	0.15	0.14	0.25	0.18
K	0.02	0.06	0.05	0.04	0.05	0.15	0.08	0.05	0.10
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.03	0.04	0.02	0.05	0.01	0.02	0.00	0.01	0.00
Ba	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00
Si+Al	23.97	23.97	23.99	23.97	23.98	23.96	23.98	23.94	23.91
Si/(Al+Fe)	2.05	2.13	2.15	2.07	2.12	2.17	2.13	2.17	2.26
Si/(Si+Al+Fe)	0.67	0.68	0.68	0.67	0.68	0.68	0.68	0.69	0.69
Balance Error	-1.49	-1.32	-0.57	0.05	-0.95	-1.99	-1.18	-2.36	-4.58

Table 6. continued.

Sample no.	80 COL-2033 E								80 COL-2033D
Analysis no.	1	2	3	4	5	6	7	8	1
	Major-element chemical analyses (weight percent oxides)								
SiO_2	52.49	51.28	46.82	51.95	52.42	48.78	48.06	46.30	51.95
Al_2O_3	22.62	21.83	20.56	21.65	21.70	20.57	19.31	19.18	20.32
Fe_2O_3	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.01
MgO	0.00	0.02	0.00	0.01	0.02	0.04	0.06	0.02	0.01
CaO	11.70	11.73	10.53	10.74	10.93	10.44	9.46	9.73	11.44
Na_2O	0.01	0.00	0.01	0.24	0.18	0.06	0.20	0.04	0.04
K_2O	0.11	0.06	0.17	0.42	0.52	0.05	0.48	0.03	0.20
MnO	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.03
SrO	-	-	-	-	-	-	-	-	0.05
BaO	-	-	-	-	-	-	-	-	0.00
Total	86.93	84.94	78.10	85.01	85.80	79.94	77.57	75.31	84.05
	Number of atoms on the basis of 48 oxygens								
Si	15.99	16.00	15.89	16.17	16.18	16.12	16.36	16.22	16.37
Al	8.12	8.03	8.23	7.95	7.90	8.01	7.75	7.92	7.55
Fe	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Mg	0.00	0.01	0.00	0.00	0.01	0.02	0.03	0.01	0.01
Ca	3.82	3.92	3.83	3.58	3.62	3.70	3.45	3.65	3.84
Na	0.01	0.00	0.01	0.14	0.11	0.04	0.13	0.03	0.01
K	0.04	0.03	0.07	0.17	0.20	0.02	0.21	0.01	0.02
Mn	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.08
Sr	-	-	-	-	-	-	-	-	0.01
Ba	-	-	-	-	-	-	-	-	0.00
Si+Al	24.11	24.03	24.12	24.12	24.08	24.13	24.11	24.14	23.92
Si/(Al+Fe)	1.97	1.99	1.93	2.04	2.05	2.01	2.11	2.05	2.17
Si/(Si+Al+Fe)	0.66	0.67	0.66	0.67	0.67	0.67	0.68	0.67	0.68
Balance Error	5.65	1.74	6.24	5.96	4.34	6.86	6.25	7.59	-4.15

Table 6. continued.

Sample no.	81 BP-2102C						88 DL 11C			
Analysis no.	1	2	3	4	5	6	1	2	3	4
	Major-element chemical analyses (weight percent oxides)									
SiO2	53.57	53.95	51.65	53.42	54.24	53.62	54.21	51.94	54.14	52.85
Al2O3	21.55	22.81	20.90	22.19	22.78	22.17	20.60	20.23	20.71	21.44
Fe2O3	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.03
MgO	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00
CaO	11.05	11.34	10.78	11.41	11.48	11.38	11.41	10.83	10.99	11.86
Na2O	0.32	0.33	0.36	0.25	0.38	0.31	0.36	0.09	0.38	0.03
K2O	0.16	0.14	0.12	0.12	0.14	0.13	0.27	0.42	0.37	0.11
MnO	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.02	0.00
SrO	-	-	-	-	-	-	0.04	0.05	0.08	0.09
BaO	-	-	-	-	-	-	0.05	0.03	0.00	0.00
Total	86.65	88.57	83.80	87.40	89.02	87.61	86.99	83.60	86.72	86.41
	Number of atoms on the basis of 48 oxygens									
Si	16.33	16.11	16.29	16.16	16.12	16.19	16.50	16.44	16.51	16.21
Al	7.74	8.03	7.77	7.91	7.98	7.89	7.39	7.55	7.45	7.75
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Mg	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Ca	3.61	3.63	3.64	3.70	3.66	3.68	3.72	3.67	3.59	3.90
Na	0.19	0.19	0.22	0.15	0.22	0.18	0.21	0.05	0.22	0.02
K	0.06	0.05	0.05	0.05	0.05	0.05	0.10	0.17	0.14	0.04
Mn	0.00	0.00	0.00		0.00	0.00	0.01	0.00	0.00	0.00
Sr	-	-	-	-	-	-	0.01	0.01	0.01	0.02
Ba	-	-	-	-	-	-	0.01	0.00	0.00	0.00
Si+Al	24.07	24.13	24.06	24.08	24.10	24.07	23.89	23.99	23.96	23.91
Si/(Al+Fe)	2.11	2.01	2.10	2.04	2.02	2.05	2.23	2.18	2.22	2.09
Si/(Si+Al+Fe)	0.68	0.67	0.68	0.67	0.67	0.67	0.69	0.69	0.69	0.68
Balance Error	3.77	7.07	2.90	4.15	5.15	3.87	-5.39	-0.62	-1.81	-1.71

Table 7. Electron microprobe analyses of mesolite.

Sample no.	CTGH 1 2057									
Analysis no.	1	2	3	4	5	6	7	8	9	10
	Major-element chemical analyses (weight percent oxides)									
SiO_2	46.44	45.16	45.89	46.00	43.02	45.01	44.73	45.06	41.53	43.77
Al_2O_3	25.43	25.93	25.59	24.62	26.81	25.26	26.62	26.42	27.16	26.86
Fe_2O_3	0.02	0.05	0.02	0.05	0.00	0.00	0.02	0.01	0.03	0.01
MgO	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02
CaO	9.58	9.43	9.47	9.27	9.82	9.28	9.40	9.27	10.70	9.46
Na_2O	5.06	5.37	5.20	5.18	5.70	5.98	6.03	5.74	5.41	5.60
K_2O	0.02	0.03	0.02	0.02	0.03	0.01	0.02	0.03	0.03	0.02
MnO	0.00	0.00	0.05	0.00	0.05	0.02	0.01	0.00	0.00	0.00
SrO	0.07	0.00	0.02	0.00	0.01	0.08	0.01	0.00	0.00	0.05
BaO	0.03	0.08	0.12	0.07	0.00	0.05	0.04	0.04	0.00	0.04
Total	86.65	86.05	86.38	85.22	85.44	85.69	86.88	86.57	84.86	85.83
	Number of atoms on the basis of 80 oxygens									
Si	24.27	23.84	24.10	24.44	23.01	23.92	23.46	23.66	22.48	23.24
Al	15.66	16.13	15.84	15.42	16.90	15.83	16.46	16.35	17.32	16.81
Fe	0.01	0.02	0.01	0.02	0.00	0.00	0.01	0.00	0.01	0.00
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Ca	5.37	5.33	5.33	5.28	5.63	5.29	5.28	5.21	6.20	5.38
Na	5.13	5.49	5.29	5.33	5.91	6.16	6.13	5.84	5.68	5.77
K	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.01
Mn	0.00	0.00	0.02	0.00	0.02	0.01	0.01	0.00	0.00	0.00
Sr	0.02	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.02
Ba	0.01	0.02	0.02	0.01	0.00	0.01	0.01	0.01	0.00	0.01
Si+Al	39.93	39.97	39.94	39.86	39.92	39.75	39.93	40.00	39.80	40.05
Si/(Al+Fe)	1.55	1.48	1.52	1.58	1.36	1.51	1.42	1.45	1.30	1.38
Si/(Si+Al+Fe)	0.61	0.60	0.60	0.61	0.58	0.60	0.59	0.59	0.56	0.58
Balance Error	-1.60	-0.42	-1.38	-3.12	-1.94	-5.89	-1.62	0.29	-4.22	1.19

Table 7. continued.

Sample no.	CTGH-1 2515					80COL 2033D			
Analysis no.	1	2	3	4	5	1	2	3	4
	Major-element chemical analyses (weight percent oxides)								
SiO2	40.26	40.56	40.32	39.73	42.12	46.00	46.40	44.98	43.26
Al2O3	28.42	27.93	28.35	28.05	27.83	24.66	25.44	24.80	23.58
Fe2O3	0.08	0.02	0.06	0.04	0.05	0.05	0.00	0.00	0.00
MgO	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
CaO	11.36	11.05	11.43	11.29	10.89	9.49	9.73	9.38	8.21
Na2O	4.61	4.92	4.72	4.64	5.04	4.85	4.89	4.39	3.88
K2O	0.02	0.01	0.02	0.04	0.02	0.04	0.03	0.03	0.04
MnO	0.01	0.01	0.00	0.00	0.02	0.00	0.00	0.02	0.00
SrO	0.24	0.30	0.20	0.24	0.11	0.00	0.10	0.03	0.02
BaO	0.00	0.09	0.06	0.00	0.00	0.03	0.10	0.00	0.00
Total	85.00	84.90	85.16	84.03	86.08	85.12	86.69	83.63	79.00
	Number of atoms on the basis of 80 oxygens								
Si	21.82	22.02	21.83	21.79	22.44	24.45	24.25	24.29	24.58
Al	18.16	17.87	18.09	18.13	17.48	15.44	15.67	15.78	15.79
Fe	0.03	0.01	0.02	0.02	0.02	0.02	0.00	0.00	0.00
Mg	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Ca	6.60	6.43	6.63	6.64	6.22	5.41	5.45	5.43	5.00
Na	4.84	5.18	4.95	4.93	5.21	4.99	4.96	4.59	4.27
K	0.02	0.01	0.02	0.03	0.01	0.03	0.02	0.02	0.03
Mn	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
Sr	0.08	0.09	0.06	0.08	0.03	0.00	0.03	0.01	0.01
Ba	0.00	0.02	0.01	0.00	0.00	0.01	0.02	0.00	0.00
Si+Al	39.97	39.89	39.92	39.93	39.92	39.89	39.92	40.07	40.37
Si/(Al+Fe)	1.20	1.23	1.21	1.20	1.28	1.58	1.55	1.54	1.56
Si/(Si+Al+Fe)	0.55	0.55	0.55	0.55	0.56	0.61	0.61	0.61	0.61
Balance Error	-0.14	-2.27	-1.41	-1.27	-1.39	-2.39	-1.88	1.82	10.27

Table 8. Electron microprobe analyses of phillipsite.

Sample no.	CTGH-1 2625				CTGH-1 2665		
Analysis no.	1	2	3	4	1	2	3
	Major-element chemical analyses (weight percent oxides)						
SiO2	52.63	51.10	50.43	52.21	46.03	47.60	51.56
Al2O3	22.63	23.24	21.01	22.55	20.65	20.40	23.16
Fe2O3	0.01	0.01	0.02	0.02	0.07	0.03	0.00
MgO	0.00	0.00	0.01	0.00	0.00	0.01	0.00
CaO	4.82	6.10	5.14	5.07	5.79	4.85	5.65
Na2O	3.59	2.99	3.44	3.87	2.57	2.38	2.94
K2O	6.67	6.58	6.37	6.40	6.25	5.24	6.67
MnO	0.00	0.01	0.05	0.00	0.01	0.00	0.00
SrO	0.08	0.13	0.06	0.05	0.02	0.01	0.13
BaO	0.33	0.29	0.13	0.20	0.39	0.06	0.21
Total	90.76	90.45	86.66	90.37	81.78	80.58	90.32
	Number of atoms on the basis of 32 oxygens						
Si	10.64	10.41	10.68	10.60	10.41	10.71	10.48
Al	5.39	5.58	5.25	5.39	5.51	5.41	5.55
Fe	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	1.04	1.33	1.17	1.10	1.40	1.17	1.23
Na	1.40	1.18	1.41	1.52	1.13	1.04	1.16
K	1.72	1.71	1.72	1.66	1.80	1.51	1.73
Mn	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Sr	0.01	0.02	0.01	0.01	0.00	0.00	0.02
Ba	0.03	0.02	0.01	0.02	0.03	0.01	0.02
Si+Al	16.03	15.98	15.93	15.99	15.92	16.12	16.03
Si/(Al+Fe)	1.97	1.87	2.04	1.96	1.89	1.98	1.89
Si/(Si+Al+Fe)	0.66	0.65	0.67	0.66	0.65	0.66	0.65
Balance Error	2.10	-1.02	-5.07	-0.56	-5.15	10.43	2.50

Table 9. Electron microprobe analyses of scolecite.

Sample no.	80COL 2032B					80FC 2071B
Analysis no.	1	2	3	4	5	1
	Major-element chemical analyses (weight percent oxides)					
SiO2	45.37	45.99	45.65	46.13	45.59	45.94
Al2O3	25.22	25.41	25.10	24.72	25.04	24.69
Fe2O3	0.00	0.00	0.00	0.06	0.01	0.00
MgO	0.00	0.00	0.00	0.02	0.02	0.00
CaO	13.83	12.24	13.28	13.83	13.15	13.95
Na2O	0.17	2.23	0.89	0.26	1.13	0.06
K2O	0.01	0.03	0.03	0.02	0.00	0.02
MnO	0.00	0.05	0.00	0.00	0.00	0.00
SrO	0.00	0.07	0.01	0.00	0.07	0.06
BaO	0.00	0.00	0.00	0.00	0.00	0.00
Total	84.60	86.02	84.96	85.04	85.01	84.72
	Number of atoms on the basis of 80 oxygens					
Si	24.15	24.16	24.22	24.42	24.20	24.41
Al	15.82	15.73	15.69	15.43	15.67	15.46
Fe	0.00	0.00	0.00	0.03	0.00	0.00
Mg	0.00	0.00	0.00	0.01	0.02	0.00
Ca	7.89	6.89	7.55	7.84	7.48	7.94
Na	0.18	2.27	0.91	0.27	1.16	0.06
K	0.01	0.02	0.02	0.01	0.00	0.01
Mn	0.00	0.02	0.00	0.00	0.00	0.00
Sr	0.00	0.02	0.00	0.00	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00
Si+Al	39.96	39.89	39.92	39.85	39.87	39.87
Si/(Al+Fe)	1.53	1.54	1.54	1.58	1.54	1.58
Si/(Si+Al+Fe)	0.60	0.61	0.61	0.61	0.61	0.61
Balance Error	-0.88	-2.63	3.93	-3.38	-3.26	-3.27

Table 9. continued.

Sample no.	81 DL-2082G					88 SH 2				
Analysis no.	1	2	3	4	5	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)									
SiO_2	46.37	45.44	45.50	46.48	46.25	46.58	45.87	45.56	46.17	46.32
Al_2O_3	24.81	24.67	25.10	24.84	25.03	24.91	24.89	23.89	25.08	24.50
Fe_2O_3	0.03	0.00	0.01	0.00	0.04	0.00	0.06	0.00	0.01	0.00
MgO	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.01
CaO	13.80	13.61	14.11	13.43	13.92	12.82	13.06	12.92	13.19	13.40
Na_2O	0.00	0.00	0.00	0.17	0.19	0.58	1.16	0.85	0.75	0.62
K_2O	0.01	0.02	0.02	0.01	0.02	0.01	0.03	0.02	0.03	0.01
MnO	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
SrO	0.05	0.00	0.00	0.04	0.06	0.03	0.00	0.07	0.10	0.00
BaO	0.00	0.10	0.00	0.00	0.03	0.12	0.00	0.00	0.00	0.11
Total	85.08	83.85	84.73	84.99	85.54	85.05	85.10	83.32	85.33	84.97
	Number of atoms on the basis of 80 oxygens									
Si	24.49	24.38	24.19	24.55	24.35	24.59	24.31	24.62	24.36	24.54
Al	15.44	15.60	15.71	15.46	15.53	15.50	15.55	15.21	15.60	15.30
Fe	0.01	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.01	0.00
Mg	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01
Ca	7.81	7.82	8.04	7.60	7.85	7.25	7.42	7.48	7.46	7.61
Na	0.00	0.00	0.00	0.17	0.20	0.59	1.20	0.89	0.76	0.64
K	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.05	0.00	0.00	0.01	0.02	0.01	0.00	0.02	0.03	0.00
Ba	0.00	0.02	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.02
Si+Al	39.94	39.97	39.90	40.01	39.88	40.08	39.85	39.83	39.96	39.84
Si/(Al+Fe)	1.58	1.56	1.54	1.59	1.57	1.59	1.56	1.62	1.56	1.60
Si/(Si+Al+Fe)	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.62	0.61	0.62
Balance Error	-1.39	-0.69	-2.33	0.31	-2.43	2.21	-3.24	-4.39	-0.94	-3.96

Table 10. Electron microprobe analyses of stilbite/stellerite

Sample no.	SUNEDCO 58-28 3220							
Analysis no.	1	2	3	4	5	6	7	8
	Major-element chemical analyses (weight percent oxides)							
SiO2	60.72	62.65	60.86	63.28	62.90	61.82	64.69	64.00
Al2O3	16.22	15.12	13.95	16.14	16.09	16.02	16.75	16.18
Fe2O3	0.00	0.00	0.00	0.02	0.01	0.00	0.08	0.03
MgO	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.05
CaO	7.82	8.55	7.49	8.85	8.60	8.70	7.81	7.85
Na2O	0.86	0.10	0.01	0.20	0.24	0.32	0.60	0.52
K2O	0.05	0.03	0.02	0.05	0.06	0.02	0.26	0.24
MnO	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
SrO	0.00	0.07	0.00	0.13	0.15	0.10	0.46	0.50
BaO	0.01	0.00	0.05	0.00	0.00	0.00	0.33	0.34
Total	85.69	86.52	82.39	88.67	88.05	86.98	91.01	89.71
	Number of atoms on the basis of 72 oxygens							
Si	27.43	27.96	28.37	27.63	27.64	27.53	27.62	27.72
Al	8.64	7.95	7.66	8.31	8.33	8.41	8.43	8.26
Fe	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.01
Mg	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03
Ca	3.78	4.09	3.74	4.14	4.05	4.15	3.57	3.64
Na	0.75	0.09	0.01	0.17	0.20	0.28	0.50	0.44
K	0.03	0.02	0.01	0.03	0.03	0.01	0.14	0.13
Mn	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.02	0.00	0.03	0.04	0.03	0.11	0.13
Ba	0.00	0.00	0.01	0.00	0.00	0.00	0.06	0.06
Si+Al	36.07	35.91	36.03	35.94	35.97	35.94	36.05	35.98
Si/(Al+Fe)	3.18	3.52	3.70	3.32	3.32	3.27	3.27	3.35
Si/(Si+Al+Fe)	0.76	0.78	0.79	0.77	0.77	0.77	0.77	0.77
Balance Error	3.29	-4.34	1.71	-2.58	-0.95	-2.77	3.68	0.49

Table 10. continued.

Sample no.	SUNEDCO 58-28 3300										
Analysis no.	1	2	3	4	5	6	7	8	9	10	11
	Major-element chemical analyses (weight percent oxides)										
SiO2	62.43	60.56	61.15	60.38	60.99	62.79	64.61	62.05	61.78	64.02	66.30
Al2O3	15.02	15.74	15.29	15.74	15.62	16.64	16.12	15.74	16.23	16.25	15.77
Fe2O3	0.08	0.01	0.00	0.06	0.02	0.04	0.05	0.00	0.04	0.00	0.02
MgO	0.02	0.01	0.02	0.03	0.02	0.01	0.02	0.01	0.02	0.02	0.01
CaO	7.03	7.46	7.57	7.56	7.47	7.76	7.71	7.67	7.75	7.89	6.95
Na2O	0.34	0.52	0.51	0.36	0.45	0.43	0.49	0.40	0.40	0.45	0.72
K2O	0.16	0.27	0.24	0.28	0.24	0.32	0.23	0.24	0.28	0.24	0.21
MnO	0.02	0.00	0.03	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01
SrO	0.33	0.34	0.40	0.43	0.31	0.45	0.40	0.49	0.56	0.40	0.34
BaO	0.40	0.50	0.49	0.38	0.39	0.61	0.37	0.45	0.59	0.35	0.29
Total	85.83	85.41	85.70	85.22	85.52	89.06	90.00	87.06	87.66	89.62	90.62
	Number of atoms on the basis of 96 oxygens										
Si	28.13	27.59	27.76	27.57	27.69	27.48	27.85	27.72	27.40	27.73	28.23
Al	7.97	8.45	8.18	8.47	8.36	8.58	8.19	8.29	8.49	8.30	7.91
Fe	0.03	0.00	0.00	0.02	0.01	0.01	0.02	0.00	0.01	0.00	0.01
Mg	0.01	0.00	0.01	0.02	0.02	0.01	0.01	0.01	0.26	0.01	0.01
Ca	3.39	3.64	3.68	3.70	3.63	3.64	3.56	3.67	3.68	3.66	3.17
Na	0.30	0.46	0.45	0.32	0.39	0.37	0.41	0.35	0.34	0.38	0.59
K	0.09	0.15	0.14	0.16	0.14	0.18	0.06	0.14	0.16	0.13	0.11
Mn	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.08	0.09	0.10	0.11	0.08	0.11	0.10	0.13	0.14	0.10	0.08
Ba	0.07	0.09	0.09	0.07	0.07	0.11	0.06	0.08	0.10	0.06	0.05
Si+Al	36.10	36.05	35.96	36.04	36.05	36.07	36.03	36.01	35.89	36.03	36.14
Si/(Al+Fe)	3.52	3.26	3.39	3.25	3.31	3.20	3.39	3.34	3.22	3.34	3.56
Si/(Si+Al+Fe)	0.78	0.77	0.77	0.76	0.77	0.76	0.77	0.77	0.76	0.77	0.78
Balance Error	6.33	2.39	-2.45	2.33	2.81	3.80	3.31	0.35	-4.50	1.44	8.02

Table 10. continued.

Sample no.	80 OGF-2015					80 CLAK-2046A				
Analysis no.	1	2	3	4	5	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)									
SiO2	64.55	65.31	66.10	65.52	64.94	57.41	63.41	55.38	59.30	61.93
Al2O3	15.98	15.82	16.02	15.92	15.71	15.82	16.11	15.68	17.11	16.76
Fe2O3	0.00	0.01	0.03	0.04	0.00	0.00	0.02	0.00	0.02	0.01
MgO	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
CaO	8.62	8.59	8.70	8.38	8.58	8.07	8.58	8.33	8.29	8.31
Na2O	0.06	0.06	0.03	0.02	0.02	0.73	0.39	0.91	0.99	0.78
K2O	0.09	0.07	0.07	0.05	0.08	0.05	0.05	0.02	0.05	0.05
MnO	0.02	0.00	0.04	0.01	0.02	0.00	0.00	0.00	0.01	0.02
SrO	0.07	0.00	0.03	0.08	0.00	0.09	0.10	0.05	0.01	0.04
BaO	0.07	0.00	0.04	0.00	0.00	0.02	0.10	0.00	0.00	0.02
Total	89.46	89.86	91.06	90.02	89.35	82.20	88.76	80.38	85.78	87.92
	Number of atoms on the basis of 72 oxygens									
Si	27.87	28.01	27.99	28.03	28.01	27.15	27.67	26.88	26.89	27.32
Al	8.13	8.00	7.99	8.03	7.99	8.82	8.28	8.97	9.14	8.71
Fe	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Ca	3.99	3.95	3.95	3.84	3.97	4.09	4.01	4.33	4.03	3.93
Na	0.05	0.05	0.02	0.02	0.02	0.67	0.33	0.86	0.87	0.66
K	0.05	0.04	0.04	0.03	0.04	0.03	0.03	0.01	0.03	0.03
Mn	0.01	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.01
Sr	0.02	0.00	0.01	0.02	0.00	0.02	0.03	0.02	0.00	0.01
Ba	0.01	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Si+Al	36.00	36.00	35.99	36.06	35.99	35.97	35.99	35.85	36.04	36.03
Si/(Al+Fe)	3.43	3.50	3.50	3.49	3.51	3.08	3.34	3.00	2.94	3.13
Si/(Si+Al+Fe)	0.77	0.78	0.78	0.78	0.78	0.75	0.77	0.75	0.75	0.76
Balance Error	-0.19	0.13	-0.16	3.55	0.49	-1.42	-2.03	-6.43	2.00	1.52

Table 10. continued.

Sample no.	80 COL-2031 I												
Analysis no.	1	2	3	4	5	6	7	8	9	10	11	12	13
	Major-element chemical analyses (weight percent oxides)												
SiO_2	55.88	55.96	55.54	58.33	56.10	56.56	56.44	54.80	56.35	57.10	57.28	56.68	57.31
Al_2O_3	15.85	14.79	15.17	15.94	15.25	15.09	15.04	15.86	15.96	15.28	15.19	15.56	15.62
Fe_2O_3	0.00	0.02	0.06	0.01	0.00	0.00	0.00	0.00	0.06	0.00	0.04	0.01	0.00
MgO	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.02	0.00	0.01
CaO	7.53	7.55	7.58	7.59	7.66	7.54	7.64	7.56	7.78	7.78	7.82	7.84	7.66
Na_2O	0.63	0.91	0.58	0.76	0.62	0.50	0.56	0.81	0.52	0.49	0.44	0.41	0.44
K_2O	0.09	0.10	0.10	0.06	0.06	0.08	0.05	0.06	0.04	0.04	0.04	0.06	0.05
MnO	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.04
SrO	-	-	-	-	-	-	-	-	-	-	-	-	-
BaO	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	80.01	79.33	79.03	82.69	79.70	79.77	79.94	79.11	80.71	80.69	80.86	80.57	81.13
	Number of atoms on the basis of 72 oxygens												
Si	27.08	27.39	27.26	27.31	27.29	27.44	27.41	26.92	27.08	27.40	27.43	27.26	27.34
Al	9.05	8.53	8.77	8.80	8.75	8.63	8.61	9.18	9.04	8.64	8.58	8.82	8.78
Fe	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
Mg	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.01	0.00	0.01
Ca	3.91	3.96	3.99	3.81	3.99	3.92	3.98	8.98	4.01	4.00	4.01	4.04	3.91
Na	0.59	0.86	0.55	0.69	0.58	0.47	0.53	0.77	0.48	0.46	0.41	0.38	0.40
K	0.05	0.06	0.06	0.04	0.02	0.05	0.03	0.03	0.03	0.03	0.02	0.02	0.03
Mn	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02
Sr	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	-	-	-	-	-	-	-	-	-	-	-	-	-
Si+Al	36.14	35.92	36.03	36.11	36.03	36.07	36.02	36.10	36.11	36.00	36.01	36.08	36.12
Si/(Al+Fe)	2.99	3.21	3.10	3.10	3.12	3.18	3.18	2.93	2.99	3.17	3.19	3.09	3.11
Si/(Si+Al+Fe)	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.75	0.75	0.76	0.76	0.76	0.76
Balance Error	6.49	-3.55	2.38	5.38	1.67	3.22	0.97	4.40	6.16	1.81	0.90	4.06	5.61

Table 10. continued.

Sample no.	80 COL 2050H		80FC 2071B			80 OGF-2076 F-4				
Analysis no.	1	1	2	3	4	1	2	3	4	5
				Major-element chemical analyses (weight percent oxides)						
SiO_2	60.33	61.96	59.71	61.74	61.83	57.23	55.24	55.64	55.97	55.30
Al_2O_3	15.23	17.09	16.93	17.47	17.28	19.55	19.77	20.01	19.73	20.00
Fe_2O_3	0.04	0.04	0.04	0.05	0.00	0.01	0.01	0.02	0.01	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
CaO	8.26	8.68	8.51	8.49	8.64	7.97	7.96	8.25	8.27	8.19
Na_2O	0.26	0.77	0.75	0.98	0.86	3.73	3.38	4.05	4.02	4.34
K_2O	0.02	0.04	0.05	0.02	0.03	0.21	0.18	0.22	0.19	0.19
MnO	0.00	0.03	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.04
SrO	0.07	0.00	0.00	0.00	0.01	-	-	-	-	-
BaO	0.00	0.01	0.05	0.00	0.00	-	-	-	-	-
Total	84.21	88.62	86.04	88.78	88.65	88.70	86.54	88.19	88.20	88.06
				Number of atoms on the basis of 72 oxygens						
Si	27.70	27.16	26.99	27.02	27.09	25.54	25.27	25.10	25.23	25.03
Al	8.24	8.83	9.02	9.01	8.92	10.29	10.67	10.64	10.48	10.67
Fe	0.02	0.01	0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.00
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Ca	4.07	4.08	4.12	3.98	4.06	3.81	3.90	3.99	3.99	3.97
Na	0.24	0.65	0.65	0.83	0.73	3.23	3.00	3.54	3.51	3.81
K	0.01	0.02	0.03	0.01	0.02	0.12	0.11	0.13	0.11	0.11
Mn	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
Sr	0.02	0.00	0.00	0.00	0.00	-	-	-	-	-
Ba	0.00	0.00	0.01	0.00	0.00	-	-	-	-	-
Si+Al	35.95	35.99	36.01	36.03	36.01	35.83	35.94	35.75	35.71	35.70
Si/(Al+Fe)	3.35	3.07	2.99	2.99	3.04	2.48	2.37	2.36	2.41	2.35
Si/(Si+Al+Fe)	0.77	0.75	0.75	0.75	0.75	0.71	0.70	0.70	0.71	0.70
Balance Error	-1.89	-0.11	0.96	2.32	0.65	-6.23	-2.19	-8.56	-9.78	-10.26

Table 10. continued.

Sample no.	81CR-2011B					81CB-2015E				
Analysis no.	1	2	3	4	5	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)									
SiO_2	60.73	60.92	60.61	61.43	59.88	57.13	60.52	61.02	57.71	56.33
Al_2O_3	17.85	17.48	17.74	17.64	18.21	16.32	17.32	16.09	18.20	17.31
Fe_2O_3	0.04	0.00	0.00	0.01	0.03	0.01	0.01	0.01	0.03	0.00
MgO	0.01	0.00	0.01	0.01	0.02	0.00	0.03	0.03	0.00	0.00
CaO	8.34	8.55	8.79	8.33	8.84	8.03	8.59	8.44	8.35	7.94
Na_2O	1.24	0.91	1.24	0.95	1.31	1.09	1.12	0.88	1.70	1.30
K_2O	0.29	0.26	0.25	0.24	0.26	0.04	0.16	0.14	0.15	0.14
MnO	0.04	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
SrO	0.14	0.03	0.05	0.06	0.00	0.10	0.12	0.10	0.11	0.02
BaO	0.00	0.03	0.04	0.10	0.07	0.06	0.20	0.02	0.00	0.01
Total	88.68	88.20	88.73	88.77	88.62	82.80	88.07	86.73	86.25	83.05
	Number of atoms on the basis of 72 oxygens									
Si	26.74	26.91	26.70	26.94	26.46	26.90	26.85	27.36	26.24	26.48
Al	9.27	9.10	9.21	9.12	9.48	9.06	9.06	8.50	9.75	9.59
Fe	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
Mg	0.01	0.00	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.00
Ca	3.94	4.04	4.15	3.92	4.18	4.05	4.08	4.06	4.07	4.00
Na	1.06	0.78	1.06	0.81	1.12	1.00	0.96	0.77	1.49	1.18
K	0.16	0.15	0.14	0.13	0.15	0.03	0.09	0.08	0.09	0.08
Mn	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Sr	0.04	0.01	0.01	0.02	0.00	0.03	0.03	0.03	0.03	0.01
Ba	0.00	0.01	0.01	0.02	0.01	0.01	0.04	0.00	0.00	0.00
Si+Al	36.01	36.01	35.92	36.07	35.95	35.96	35.91	35.86	35.99	36.08
Si/(Al+Fe)	2.88	2.96	2.90	2.95	2.79	2.97	2.96	3.22	2.69	2.76
Si/(Si+Al+Fe)	0.74	0.75	0.74	0.75	0.74	0.75	0.75	0.76	0.73	0.73
Balance Error	0.98	0.37	-3.55	3.07	-1.96	-1.74	-3.58	-6.13	-0.14	3.40

Table 10. continued.

Sample no.	81FC-2052B				81 FC-2052 E					
Analysis no.	1	2	3	4	1	2	3	4	5	6
	Major-element chemical analyses (weight percent oxides)									
SiO_2	57.24	57.27	57.68	57.68	59.12	61.54	61.54	59.18	59.49	62.52
Al_2O_3	16.79	16.39	16.31	17.24	18.01	17.63	17.53	18.31	17.49	15.44
Fe_2O_3	0.00	0.04	0.01	0.00	0.00	0.00	0.03	0.00	0.14	0.00
MgO	0.01	0.00	0.00	0.01	0.01	0.03	0.01	0.02	0.00	0.02
CaO	7.87	8.08	8.29	8.01	8.36	8.13	7.99	8.59	8.51	6.91
Na_2O	1.27	1.11	1.19	1.59	1.02	1.19	1.18	1.00	1.09	1.20
K_2O	0.03	0.04	0.04	0.02	0.01	0.02	0.02	0.02	0.00	0.00
MnO	0.06	0.00	0.00	0.00	0.01	0.00	0.02	0.01	0.10	0.01
SrO	0.03	0.01	0.06	0.06	-	-	-	-	-	-
BaO	0.04	0.00	0.02	0.12	-	-	-	-	-	-
Total	83.34	82.94	83.60	84.73	86.54	88.54	88.32	87.13	86.82	86.10
	Number of atoms on the basis of 72 oxygens									
Si	26.77	26.89	26.91	26.61	26.60	26.99	27.04	26.47	26.74	27.97
Al	9.25	9.07	8.97	9.38	9.55	9.12	9.08	9.65	9.27	8.14
Fe	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
Mg	0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.00	0.01
Ca	3.94	4.07	4.15	3.96	4.03	3.82	3.76	4.12	4.10	3.32
Na	1.15	1.01	1.08	1.42	0.89	1.01	1.01	0.87	0.95	1.04
K	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Mn	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.00
Sr	0.01	0.00	0.02	0.02	-	-	-	-	-	-
Ba	0.01	0.00	0.00	0.02	-	-	-	-	-	-
Si+Al	36.03	35.97	35.88	35.98	36.15	36.11	36.12	36.13	36.01	36.11
Si/(Al+Fe)	2.89	2.96	3.00	2.84	2.79	2.96	2.98	2.74	2.88	3.44
Si/(Si+Al+Fe)	0.74	0.75	0.75	0.74	0.74	0.75	0.75	0.73	0.74	0.77
Balance Error	1.25	-0.91	-4.82	-0.77	6.46	4.88	6.04	5.44	0.46	5.70

Table 10. continued.

Sample no.	88DL 11C		88 CR-18				
Analysis no.	1	2	1	2	3	4	5
			Major-element chemical analyses (weight percent oxides)				
SiO_2	62.08	61.41	66.85	65.97	66.49	64.07	65.51
Al_2O_3	15.24	14.87	16.18	16.37	16.57	16.39	16.24
Fe_2O_3	0.00	0.01	0.00	0.00	0.00	0.01	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	8.18	8.07	8.91	8.97	9.10	8.78	8.99
Na_2O	0.11	0.06	0.02	0.06	0.06	0.17	0.12
K_2O	0.06	0.07	0.02	0.03	0.03	0.04	0.03
MnO	0.00	0.00	0.00	0.01	0.00	0.01	0.00
SrO	0.08	0.03	0.05	0.00	0.04	0.06	0.01
BaO	0.00	0.00	0.00	0.01	0.03	0.00	0.03
Total	85.75	84.52	92.03	91.42	92.32	89.53	90.93
			Number of atoms on the basis of 72 oxygens				
Si	27.93	28.01	28.00	27.84	27.81	27.66	27.83
Al	8.08	7.99	7.99	8.14	8.17	8.34	8.13
Fe	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
Ca	3.94	3.95	4.00	4.06	4.08	4.06	4.09
Na	0.10	0.05	0.01	0.05	0.05	0.14	0.10
K	0.04	0.04	0.01	0.02	0.02	0.02	0.02
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.02	0.01	0.01	0.00	0.01	0.01	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Si+Al	36.01	36.00	35.99	35.99	35.98	36.00	35.96
Si/(Al+Fe)	3.46	3.50	3.50	3.42	3.40	3.31	3.42
Si/(Si+Al+Fe)	0.78	0.78	0.78	0.77	0.77	0.77	0.77
Balance Error	0.22	-0.03	-0.70	-0.68	-0.91	0.36	-2.16

Table 11. Electron microprobe analyses of thomsonite.

Sample no.	CTGH-1 2515					81 CLAK-2024F				
Analysis no.	1	2	3	4	5	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)									
SiO_2	37.34	37.51	38.07	37.78	37.87	40.17	38.68	40.56	38.88	37.80
Al_2O_3	28.69	29.67	29.46	29.02	29.07	28.62	29.57	28.91	29.68	29.86
Fe_2O_3	0.00	0.02	0.00	0.04	0.00	0.00	0.00	0.01	0.02	0.04
MgO	0.00	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00
CaO	12.43	12.95	12.65	12.96	12.98	11.95	13.23	11.61	12.84	13.08
Na_2O	3.85	3.78	3.94	3.73	3.88	4.55	3.33	4.84	4.25	3.77
K_2O	0.05	0.03	0.02	0.03	0.02	0.01	0.01	0.02	0.02	0.02
MnO	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.05	0.00
SrO	0.31	0.42	0.31	0.50	0.22	0.16	0.19	0.14	0.15	0.18
BaO	0.07	0.00	0.00	0.00	0.02	0.01	0.02	0.03	0.00	0.00
Total	82.74	84.38	84.49	84.07	84.07	85.47	85.04	86.12	85.89	84.75
	Number of atoms on the basis of 80 oxygens									
Si	20.93	20.65	20.88	20.89	20.90	21.68	21.02	21.71	20.98	20.68
Al	18.96	19.25	19.05	18.91	18.91	18.20	18.95	18.24	18.87	19.26
Fe	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.02
Mg	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Ca	7.47	7.64	7.43	7.68	7.68	6.91	7.70	6.66	7.42	7.67
Na	4.19	4.04	4.19	4.00	4.15	4.76	3.51	5.03	4.45	3.99
K	0.04	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Mn	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Sr	0.10	0.13	0.10	0.16	0.07	0.05	0.06	0.04	0.05	0.06
Ba	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Si+Al	39.89	39.91	39.93	39.79	39.81	39.88	39.97	39.95	39.85	39.94
Si/(Al+Fe)	1.10	1.07	1.10	1.10	1.11	1.19	1.11	1.19	1.11	1.07
Si/(Si+Al+Fe)	0.52	0.52	0.52	0.52	0.53	0.54	0.53	0.54	0.53	0.52
Balance Error	-2.24	-1.77	-1.42	-3.98	-3.88	-2.62	-0.67	-1.16	-2.87	-0.97

Table 11. continued.

Sample no.	81 CLAK-2024H				
Analysis no.	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)				
SiO2	38.78	39.06	39.12	38.56	38.65
Al2O3	27.78	28.56	28.44	27.95	28.66
Fe2O3	0.02	0.02	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.01	0.01
CaO	12.42	12.39	12.56	12.34	12.31
Na2O	4.00	3.97	3.97	3.94	3.88
K2O	0.03	0.02	0.02	0.02	0.01
MnO	0.00	0.02	0.02	0.00	0.00
SrO	0.51	0.34	0.52	0.41	0.32
BaO	0.02	0.00	0.00	0.00	0.00
Total	83.56	84.38	84.65	83.23	83.84
	Number of atoms on the basis of 80 oxygens				
Si	21.51	21.40	21.41	21.44	21.31
Al	18.17	18.45	18.35	18.32	18.62
Fe	0.01	0.01	0.00	0.00	0.00
Mg	0.00	0.00	0.00	0.01	0.00
Ca	7.38	7.28	7.36	7.35	7.27
Na	4.30	4.21	4.21	4.25	4.15
K	0.02	0.01	0.01	0.01	0.01
Mn	0.00	0.01	0.01	0.00	0.00
Sr	0.16	0.11	0.17	0.13	0.10
Ba	0.00	0.00	0.00	0.00	0.00
Si+Al	39.68	39.85	39.76	39.77	39.93
Si/(Al+Fe)	1.18	1.16	1.17	1.17	1.14
Si/(Si+Al+Fe)	0.54	0.54	0.54	0.54	0.53
Balance Error	-6.41	-2.95	-4.96	-4.85	-1.52

Table 12. Electron microprobe analyses of wairakite.

Sample no.	SUNEDCO 58-28 3220	CTGH-1 2507				CTGH-1 2515				
Analysis no.	1	1	2	3	4	1	2	3	4	5
					Major-element chemical analyses (weight percent oxides)					
SiO_2	57.24	56.67	56.85	54.76	57.11	53.16	51.48	53.77	51.77	54.35
Al_2O_3	20.70	22.86	22.62	21.97	20.33	21.00	21.31	21.55	20.59	21.83
Fe_2O_3	0.01	0.00	0.00	0.02	0.05	0.03	0.07	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
CaO	4.62	8.79	8.53	8.57	8.01	7.81	8.34	8.11	8.18	8.33
Na_2O	7.16	2.62	3.11	2.98	3.02	4.21	3.42	3.02	3.38	2.71
K_2O	0.03	0.78	0.86	0.61	0.93	1.57	1.49	1.54	1.44	1.42
MnO	0.03	0.00	0.01	0.02	0.00	0.02	0.01	0.01	0.03	0.04
SrO	0.03	0.42	0.34	0.50	0.28	0.37	0.35	0.25	0.35	0.46
BaO	0.02	0.00	0.00	0.09	0.08	0.05	0.00	0.00	0.06	0.06
Total	89.84	92.14	92.32	89.52	89.81	88.22	86.47	88.26	85.80	89.21
					Number of atoms on the basis of 96 oxygens					
Si	33.70	32.68	32.76	32.62	33.74	32.47	32.07	32.58	32.45	32.59
Al	14.37	15.54	15.36	15.42	14.16	15.12	15.65	15.39	15.22	15.43
Fe	0.00	0.00	0.00	0.01	0.02	0.01	0.03	0.00	0.00	0.00
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Ca	2.91	5.43	5.26	5.47	5.07	5.11	5.56	5.27	5.49	5.35
Na	8.18	2.93	3.48	3.44	3.46	4.99	4.13	3.55	4.11	3.15
K	0.02	0.57	0.63	0.46	0.70	1.22	1.19	1.19	1.15	1.09
Mn	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.02	0.02
Sr	0.01	0.14	0.11	0.17	0.10	0.13	0.12	0.09	0.13	0.16
Ba	0.01	0.00	0.00	0.02	0.02	0.01	0.00	0.00	0.02	0.01
Si+Al	48.07	48.22	48.12	48.04	47.89	47.59	47.72	47.98	47.66	48.02
Si/(Al+Fe)	2.35	2.10	2.13	2.11	2.38	2.15	2.05	2.12	2.13	2.11
Si/(Si+Al+Fe)	0.70	0.68	0.68	0.68	0.70	0.68	0.67	0.68	0.68	0.68
Balance Error	2.12	6.04	3.27	1.28	-2.43	-9.65	-6.11	-0.60	-8.13	-0.14

Table 13. Electron microprobe analyses of wellsite.

Sample no.	CTGH-1 1852				
Analysis no.	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)				
SiO_2	44.46	53.46	53.30	53.41	49.10
Al_2O_3	16.88	20.53	19.97	20.03	19.36
Fe_2O_3	0.15	0.09	0.10	0.15	0.20
MgO	0.04	0.01	0.01	0.07	0.09
CaO	1.55	1.54	1.80	1.77	1.85
Na_2O	3.06	4.69	4.32	4.84	3.77
K_2O	2.36	2.59	2.26	2.46	2.91
MnO	0.02	0.00	0.00	0.01	0.03
SrO	0.09	0.16	0.00	0.03	0.00
BaO	7.61	9.85	9.59	9.33	9.94
Total	76.22	92.92	91.35	92.10	87.25
	Number of atoms on the basis of 32 oxygens				
Si	11.11	11.03	11.12	11.08	10.90
Al	4.97	4.99	4.91	4.90	5.07
Fe	0.03	0.01	0.02	0.02	0.03
Mg	0.02	0.00	0.00	0.02	0.03
Ca	0.41	0.34	0.40	0.39	0.44
Na	1.48	1.88	1.75	1.95	1.62
K	0.75	0.68	0.60	0.65	0.82
Mn	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.02	0.00	0.00	0.00
Ba	0.74	0.80	0.78	0.76	0.87
Si+Al	16.08	16.02	16.04	15.97	15.97
Si/(Al+Fe)	2.22	2.72	2.26	2.25	2.14
Si/(Si+Al+Fe)	0.69	0.69	0.69	0.69	0.68
Balance Error	8.32	2.72	4.17	-0.65	-0.42

Table 14. Electron microprobe analyses of yugawaralite.

Sample no.	81 DL-2096E				
Analysis no.	1	2	3	4	5
	Major-element chemical analyses (weight percent oxides)				
SiO_2	52.99	52.52	53.14	53.23	52.62
Al_2O_3	21.67	21.59	21.60	20.73	21.75
Fe_2O_3	0.00	0.01	0.04	0.01	0.01
MgO	0.01	0.00	0.01	0.01	0.01
CaO	11.77	11.87	12.00	11.06	12.00
Na_2O	0.16	0.25	0.31	0.45	0.30
K_2O	0.17	0.19	0.22	0.25	0.14
MnO	0.01	0.00	0.00	0.01	0.00
SrO	0.09	0.00	0.01	0.05	0.07
BaO	0.03	0.00	0.00	0.06	0.04
Total	86.90	86.43	87.33	85.86	86.94
	Number of atoms on the basis of 32 oxygens				
Si	10.78	10.75	10.78	10.94	10.72
Al	5.20	5.21	5.16	5.02	5.22
Fe	0.00	0.00	0.01	0.00	0.00
Mg	0.00	0.00	0.00	0.00	0.00
Ca	2.57	2.60	2.61	2.44	2.62
Na	0.06	0.10	0.12	0.18	0.12
K	0.04	0.05	0.06	0.07	0.04
Mn	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.00	0.00	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00
Si+Al	15.98	15.96	15.94	15.97	15.95
Si/(Al+Fe)	2.07	2.06	2.08	2.18	2.05
Si/(Si+Al+Fe)	0.67	0.67	0.68	0.69	0.67
Balance Error	-1.40	-2.74	-4.27	-2.41	-3.71