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Chemistry of Diagenetically Altered Tuffs at a Potential Nuclear Waste Repository, Yucca Mountain, Nye County, Nevada

David E. Broxton
Richard G. Warren
Roland C. Hagan
Gary Luedemann

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CHEMISTRY OF DIAGENETICALLY ALTERED TUFFS AT A POTENTIAL NUCLEAR WASTE REPOSITORY, YUCCA MOUNTAIN, NYE COUNTY, NEVADA

by

David E. Broxton, Richard G. Warren, Roland C. Hagan, and Gary Luedemann

ABSTRACT

This report describes the chemistry of diagenetically altered tuffs at a potential nuclear waste repository, Yucca Mountain, Nevada. These tuffs contain substantial amounts of zeolites that are highly sorptive of certain radionuclides. Because of their widespread distribution, the zeolitic tuffs could provide important barriers to radionuclide migration. Physical properties of these tuffs and of their constituent zeolites are influenced by their chemical compositions. This study defines the amount of chemical variability within diagenetically altered tuffs and within diagenetic minerals at Yucca Mountain.

Major- and trace-element compositions in whole-rock samples were determined by a combination of x-ray fluorescence, neutron activation, atomic absorption, and plasma-source emission spectrophotometry methods. Glass, clinoptilolite, analcime, and authigenic feldspar compositions were determined by electron microprobe. Mordenite, an important zeolite at Yucca Mountain, is too fine grained and intergrown with other diagenetic minerals for accurate determinations of compositions. New whole-rock and mineral compositions as well as previously published analyses for mineral chemistry are summarized in the appendices of this report.

Zeolitic tuffs at Yucca Mountain formed by diagenetic alteration of rhyolitic vitric tuffs. Despite their similar starting compositions, these tuffs developed compositions that vary both vertically and laterally. Widespread chemical variations were the result of open-system chemical diagenesis in which chemical components of the tuffs were mobilized and redistributed by groundwaters. Alkalies, alkaline earths, and silica were the most mobile elements during diagenesis.

The zeolitic tuffs can be divided into three compositional groups: (1) calcium- and magnesium-rich tuffs associated with relatively thin zones of alteration in the unsaturated zone, (2) tuffs in thick zones of alteration at and below the water table that grade laterally from sodic compositions on the western side of Yucca Mountain to calcic compositions on the eastern side, and (3) potassic tuffs at the north end of Yucca Mountain. Similar chemical variations

are found in the clinoptilolites that make up these tuffs. Other diagenetic minerals such as analcime, potassium feldspar, and albite have uniform compositions.

Physical properties of tuffs and their constituent zeolites at Yucca Mountain may be affected by variations in compositions. Properties important for assessment of repository performance include behavior and ion exchange. The data presented in this report can be used in conjunction with experimental data to model the behavior of Yucca Mountain tuffs surrounding a high-level nuclear waste repository.

I. INTRODUCTION

Yucca Mountain is located along the southwest border of the Nevada Test Site in south-central Nevada (Fig. 1). The U.S. Department of Energy (DOE) and its subcontractors are conducting detailed studies of the ash-flow and bedded tuffs at Yucca Mountain to determine the suitability of the tuffs as a high-level nuclear waste repository. These studies are supported by the Nevada Nuclear Waste Storage Investigations (NNWSI) Project as part of the DOE Civilian Radioactive Waste Management Program. The NNWSI Project is managed by the Waste Management Project Office of the DOE Nevada Operations Office.

The presence of thick zeolitic tuffs in continuous zones throughout the region (Fig. 2) was a major consideration for choosing Yucca Mountain as a potential repository site (Johnstone and Wolfsberg 1980). The zeolites could provide important geologic barriers to nuclear waste migration because they can sorb some important radionuclides from groundwaters and thus retard movement of radioactivity away from the repository site. The potential repository horizon is sited within the unsaturated zone in the lower half of the Topopah Spring Member of the Paintbrush Tuff (Fig. 3). The repository host rock is a densely welded and devitrified tuff consisting predominantly of alkali feldspars and silica minerals. Below, zeolitic tuffs occur within several stratigraphic intervals between the repository and the water table, providing probable barriers to downward radionuclide migration in the unsaturated zone. Additional zeolitic tuffs below the water table provide potential barriers to lateral radionuclide migration through the saturated zone.

Fig. 1.

Location and generalized geologic map of Yucca Mountain, Nevada, showing location of drill holes (adapted from Scott and Castellanos 1984).

STRATIGRAPHIC CONTACTS FROM SPENGLER *et al*, 1979; SPENGLER *et al*, 1981; MALDONADO AND KOETHER, 1983; SCOTT AND CASTELLANOS, 1983. PRELIMINARY STRATIGRAPHIC CONTACTS FOR DRILL HOLES H3, H4, H5, AND G4 PROVIDED BY SPENGLER (PERSONAL COMMUNICATION, 1983). STATIC WATER LEVEL DATA FROM NUCLEAR HYDROLOGY GROUP, USGS.

Fig. 2.
Fence diagram showing distribution of principal zeolitic tuffs at Yucca Mountain, Nevada.

NUMBERS I THROUGH IV REFER TO ZEOLITIC - TUFF INTERVAL NOMENCLATURE OF VANIMAN et al (1984, TABLE III).

Fig. 3.

Schematic cross section of Yucca Mountain, Nevada, showing position of potential repository and principal zeolitic tuffs.

This report describes the chemistry of diagenetically altered tuffs and their constituent authigenic minerals at Yucca Mountain. The compositions of these tuffs vary considerably across the repository exploration block and along potential pathways to the accessible environment. Experimental studies show that physical properties of zeolites vary with composition (Bish 1984; 1985). Compositionally dependent zeolite properties important for repository performance assessment include expansion/contraction behavior, hydration/dehydration behavior, and ion exchange. Used in conjunction with experimental results, data presented here can be used to model thermal and sorptive properties of tuffs in the repository environment.

II. GEOLOGIC SETTING

Yucca Mountain lies within the southwest Nevada volcanic field in the southern Great Basin. It is a north-trending, east-tilted, fault-bounded mountain range that is a remnant of a formerly extensive Miocene-Pliocene volcanic plateau centered around the Timber Mountain-Oasis Valley caldera complex (Christiansen et al. 1965, 1977; Byers et al. 1976). The predominant lithologies at Yucca Mountain are high-silica rhyolitic ash-flow tuffs (Table I). However, two large-volume ash-flow cooling units in the upper part of the sequence, the Tiva Canyon and Topopah Spring Members of Paintbrush Tuff, are compositionally zoned and grade upward from rhyolite to quartz latite (Lipman et al. 1966; Byers et al. 1976). Minor lithologies at Yucca Mountain include bedded tuffs and intermediate to silicic lavas and breccias. The volcanic rocks in this region have an aggregate thickness of over 1.8 km.

Diagenetic alteration is best developed in stratigraphic units that are nonwelded throughout or in the nonwelded tops and bottoms of ash-flow cooling units having densely welded, devitrified interiors. The nonwelded tuffs remained largely vitric after emplacement and were highly susceptible to alteration because of the instability of glass in the presence of groundwater. During diagenesis, glass was replaced primarily by the zeolites clinoptilolite, heulandite, and mordenite. Analcime and authigenic feldspars replace clinoptilolite and mordenite in the deeper parts of the volcanic sequence. These authigenic minerals form four diagenetic mineral zones that become progressively less hydrous with depth. These mineralogic zones are similar to those described by Iijima (1975, 1978, and 1980) for burial diagenesis of volcanic ash beds in thick sedimentary sequences.

TABLE I

STRATIGRAPHY OF VOLCANIC UNITS AT YUCCA MOUNTAIN, NEVADA^a

	Stratigraphic Unit ^b	Unit Symbol	Thickness (m)	Lithology
Paintbrush Tuff	Tiva Canyon Member	Tpc	45-150	Ash-flow tuff; compound cooling unit; nonwelded vitric base; moderately to densely welded, devitrified interior with some vapor-phase crystallization.
	Yucca Mountain Member	Tpy	0-30	Ash-flow tuff; nonwelded vitric top and base; partially welded devitrified interior with some vapor-phase crystallization; present under northern half of Yucca Mountain.
	Pah Canyon Member	Tpp	0-80	Ash-flow tuff; nonwelded and vitric throughout; present under northern half of Yucca Mountain.
	Topopah Spring Member	Tpt	240-365	Ash-flow tuff; compositionally zoned, compound cooling unit; nonwelded zones at top and base and moderately to densely welded, devitrified interior with zones of vapor-phase crystallization; vitrophyses at top and base of unit. Zeolites occur both on top of basal vitrophyre and in nonwelded base of unit.
	Tuff of Calico Hills	Tht	35-290	Ash-flow tuff; nonwelded to partially welded; thoroughly zeolitized at north end of exploration block; becomes vitric southward.
Crater Flat Tuff	Prow Pass Member	Tcp	85-190	Ash-flow tuff; nonwelded zones at top and base; moderately welded, devitrified interior with minor vapor-phase crystallization; nonwelded base is zeolitic; nonwelded top zeolitic in northern part of Yucca Mountain, but vitric to the south.
	Bullfrog Member	Tcb	90-190	Ash-flow tuff; compound cooling unit; nonwelded top and base, nonwelded to densely welded interior with thickness and occurrence of welding zones highly variable; zeolitic in nonwelded zones.
	Tram Member	Tct	155-385	Ash-flow tuff; compound cooling unit; zones of partial to dense welding vary from drill hole to drill hole; zeolitic in its nonwelded to partially welded parts; otherwise devitrified.
	Dacite Flow Breccia	Tfb	0-120	Flow breccia, lava, and tuffs; occurrence restricted to USW G-1; zeolites irregularly distributed throughout the unit.
	Lithic Ridge Tuff	Tlr	185-305	Ash-flow tuff; nonwelded to moderately welded; devitrified, contains few zeolite horizons.
	Unnamed Older Tuffs and Lavas	Tot	365+	Ash-flow tuffs, lavas, reworked volcanic sediments; dacitic to rhyolitic compositions; contains few zeolite horizons. Includes units a, b, and c of USW G-1.

^aSpengler et al. 1979, 1981; Maldonado and Koether, 1983; Scott and Castellanos, 1984.^bVolumetrically minor bedded tuffs (Tb) between major stratigraphic units not shown.

Zone I, the shallowest zone, is characterized by tuffs that contain substantial unaltered volcanic glass. Smectite, opal, heulandite, and calcic clinoptilolite are minor alteration phases and concentrate in fractures and in thin discontinuous zones parallel to bedding. Two notable occurrences of zeolites in Zone I include (1) thin but widespread accumulations of smectites, calcic clinoptilolites, and heulandite at the top of the basal vitrophyre of the Topopah Spring Member and (2) a 130-m-thick sequence of smectite- and calcic clinoptilolite-rich tuffs in the Yucca Mountain, Pah Canyon, and upper Topopah Spring Members in drill hole USW G-2. Despite their different stratigraphic and lithologic settings, both zeolite occurrences are similar in mineralogy and chemistry.

Zone II is characterized by complete replacement of volcanic glass by clinoptilolite $\pm$ mordenite, with minor opal, quartz, potassium feldspar, and smectite. Clinoptilolite is the most abundant zeolite in this zone and commonly makes up 50-75% of tuffs. These zeolite-rich tuffs occur at well-defined intervals including (1) the interval extending from the base of the Topopah Spring Member, through the tuff of Calico Hills, and into the top of the Prow Pass Member; (2) the interval at the base of the Prow Pass Member and top of the Bullfrog Member; and (3) the interval at the base of the Bullfrog Member and top of the Tram Member. These intervals are equivalent to Zeolitic Intervals II, III, and IV, respectively, of Vaniman et al. (1984, Table III) and are shown diagrammatically in Fig. 3. There are no significant mineralogic or chemical changes in authigenic minerals across stratigraphic contacts within these intervals, suggesting that lithology rather than stratigraphy controls sites of zeolitic alteration. Individual zeolitized beds range in thickness from 10 to 150 m. These beds are major sorptive barriers for radionuclide migration because they occur along potential groundwater pathways below the repository in the unsaturated and saturated zones.

Diagenetic Zones III and IV are confined to the deeper structural levels of Yucca Mountain. Zone III is characterized by the progressive replacement of clinoptilolite and mordenite by analcime, potassium feldspar, quartz, and minor calcite and smectite. Zone IV, the deepest diagenetic zone penetrated by drill holes, is characterized by the replacement of analcime by authigenic albite.

III. METHODS

A. Whole-Rock Compositions by X-Ray Fluorescence, Atomic Absorption, and Emission Spectrophotometry

Whole-rock major-element analyses (Appendix A) were determined by x-ray fluorescence (XRF) for samples from drill holes UE-25a#1, UE-25b#1(H), UE-25p#1, USW G-2, USW G-3, USW GU-3, USW G-4, and J-13 (Fig. 1). Most samples are from continuously cored exploratory drill holes; samples from UE-25p#1 are from bit cuttings that were collected at 3-m (10-ft) intervals. Two additional samples were collected from outcrop at Prow Pass, located at the northern end of Yucca Mountain (Fig. 1). Many of these samples were also analyzed for mineral contents by x-ray diffraction (Bish and Vaniman 1985).

Samples were prepared by powdering and homogenizing 15-20 g of material in a shatterbox. Duplicate 10-g sample splits were dried to 1000°C, for 4 hours, and then 1-g splits were fused with 9 g of lithium tetraborate flux. Drying at 1000°C destroys the zeolitic crystal structures and eliminates gross weighing errors introduced by rapid rehydration of zeolites upon cooling. Volatile contents (primarily water) were determined by differences in sample weights at room temperature and after heating at 1000°C.

Major elements were determined with an automated Rigaku wavelength dispersive XRF spectrophotometer. A library of x-ray intensities for rock standards was used to calculate elemental concentrations (Valentine 1983). A fundamental parameters program made matrix corrections for x-ray absorption and secondary fluorescence.

Splits of 20 zeolitic tuff samples were also analyzed by John Husler of the University of New Mexico and Norman Suhr of Pennsylvania State University to determine the reliability of the XRF results and specifically to evaluate a problem of sodium loss introduced by the XRF sample preparation technique. Husler and Suhr determined silica gravimetrically and iron titrimetrically. Husler analyzed all other elements, including total iron, by atomic absorption (AA), and Suhr determined all other elements by plasma-source emission spectrophotometry (ES).

Comparison of XRF analyses with those determined by AA and ES (Appendix B) shows that the three analytical methods agree well except for sodium (Fig. 4). Elemental concentrations determined by the three laboratories at Los Alamos, Pennsylvania State University, and the University of New Mexico generally agree within 5% for major components and 20% for minor components.

Fig. 4.

Comparison of whole-rock analyses determined by x-ray fluorescence vs. analyses by atomic absorption and emission spectrophotometry. Solid diagonal lines have a slope of one, indicating perfect correlations between analytical methods. Dashed diagonal lines represent percent deviation of x-ray fluorescence analysis from atomic absorption and emission spectrophotometry analyses.

COMPARISON METHODS:

- ATOMIC ABSORPTION SPECTROPHOTOMETRY (UNM)
- DC. PLASMA EMISSION SPECTROPHOTOMETRY (PENN STATE)

However, XRF analyses of sodium are systematically 22% lower than sodium concentrations determined by AA or ES. Because sodium concentrations can be accurately duplicated in well-characterized standards, we believe the systematically lower sodium concentrations in samples analyzed by XRF result from partial loss of sodium along with water when the samples are dried at 1000°C. As a result of these interlaboratory comparisons, sodium concentrations were redetermined in new samples by AA and/or ES for all samples in Appendix A. Potassium also appears to be systematically lower (2-5%) in XRF analyses compared to AA or ES; however, this difference is relatively minor and the XRF analyses for K_2O are retained in Appendix A. Aluminum concentrations determined by XRF agree well with those by ES. However, there is a 4-6% systematic deviation in AA aluminum concentrations compared to XRF and ES (Fig. 4); these differences are probably due to a calibration bias in the AA analyses.

B. Whole-Rock Compositions by Automated Neutron Activation Analysis

Whole-rock analyses for 32 major and trace elements were determined by automated neutron activation analyses (ANAA), according to the procedures of Minor et al. (1982). ANAA analyses were performed for 86 samples from drill hole USW G-1, 3 samples from USW G-2, 2 samples from USW GU-3, and 3 samples from tuff of Calico Hills outcrops at Prow Pass in the northern part of Yucca Mountain (Appendix C). Most samples were lightly ground in a steel mortar; those few samples without cobalt values were powdered in a shatterbox, which introduces substantial (unreported) cobalt and tungsten contamination into the sample.

Approximately 4 g of air-dried material were analyzed for each sample. Analyses were performed under the same conditions as those described by Garcia et al. (1982) for NBS standards. Therefore, analytical uncertainties for values of each element in Appendix C should be similar to the standard deviation for this element in the NBS standards (Appendix D), where elemental concentrations of the unknown and NBS standard match closely. Analytical uncertainties provided for certain elements and for select samples in Appendix C are the result of either an additional count 6 months after irradiation or of longer irradiation and count times. Those uncertainties were calculated from count rates obtained from raw spectra, which were not available for most samples.

C. Mineral and Glass Compositions Determined by Electron Microprobe

Volcanic glass, clinoptilolite, analcime, and authigenic feldspar compositions (Appendices F-H, respectively) were determined with an automated Cameca electron microprobe operated at 15 keV and 15- to 20-nA beam currents. Calibration standards included feldspars for Si, Al, Na, K, Ca, and Ba, and amphibole and pyroxene for Mg, Fe, and Ti. Wavelength dispersive x-ray counts for each element were collected for 15 to 20 seconds or less if 10 000 counts were acquired. Compositions are corrected for differential matrix effects using the methods of Bence and Albee (1968). Sodium was counted first during analysis because it tends to migrate from the region excited by the electron beam. Use of a square rastered electron beam with an edge of 15 to 25 μm minimized sodium migration, water loss, and structural decomposition of zeolites. When possible, the sample was moved beneath the electron beam to minimize sodium loss during analysis.

Despite the precautions taken, sodium loss remained a significant problem during the analysis of clinoptilolite. Figure 5 shows a progressive decline in sodium counts during a 50-second count. Calculated errors for a typical 15- to 20-second analysis range from 5 to 12% of the sodium present. Efforts to reduce sodium loss by lowering beam currents were unsatisfactory because poorer counting statistics for all elements outweighs the small improvement in retention of sodium. The structural formula of all zeolites, including clinoptilolite, requires $(\text{Al}+\text{Fe}) = (\text{Na}+\text{K}+2\text{Ca}+2\text{Mg})$ for electrical neutrality, assuming the small amount of Fe occurs as Fe(III). Zeolite analyses were considered acceptable if the ratio $(\text{Al}+\text{Fe})/(\text{Na}+\text{K}+2\text{Ca}+2\text{Mg})$ was less than 1.15. Ratios less than 1.0 are uncommon because of problems with sodium loss. Analcime does not lose sodium when analyzed under the conditions used in this study (Fig. 5).

Mordenite has been identified in many altered tuffs at Yucca Mountain by x-ray diffraction (Bish and Vaniman 1985), but its chemistry has not been studied. Individual mordenite crystals are so fine grained and intergrown with other authigenic phases that analysis by electron microprobe is not feasible. Determination of mordenite compositions by whole-rock methods are not feasible because monomineralic beds of mordenite do not occur at Yucca Mountain.

Glass and mineral compositions in Appendices E through F include new unpublished data as well as analyses compiled from previously published drill

Fig. 5.

Semilogarithmic plot showing sodium count rates as a function of time for a variety of zeolites. Analyses were performed using a stationary electron microprobe beam with an accelerating potential of 15 keV. The beam was rastered with a 20- μ m edge.

hole reports (Sykes et al. 1979; Heiken and Bevier 1979; Caporuscio et al. 1982; Broxton et al. 1982; Vaniman et al. 1984; Levy 1984; and Caporuscio et al. 1985). Data from these previous reports were not included if $(Al+Fe)/(Na+K+2Ca+2Mg)$ was greater than 1.15 for zeolites or if other problems with mineral stoichiometry were suspected. In some cases secondary minerals were re-analyzed because earlier data sets included analyses of mixed mineral phases along with analyses of single minerals.

IV. RESULTS

All analyses in the appendices are grouped by drill hole, with individual analyses for each drill hole arranged by increasing depth. Table II compares representative zeolitic and unaltered tuff compositions for each of the principal stratigraphic units of Fig. 3. Table II also provides a comparison of zeolitic tuff compositions on the eastern side of Yucca Mountain (calcic suite) with those occurring on the west (alkalic suite). Table III compares representative clinoptilolite compositions from the eastern and western side of Yucca Mountain.

Whole-Rock Compositions: Whole-rock compositions for volcanic rocks of Yucca Mountain are presented in Appendices A through C. Additional whole-rock compositions for tuffs in drill hole USW G-1 are published in Zielinski (1983; Table 2) and Spengler et al. (1981; Table 5). Scott and Castellanos (1984; Table 5) present whole-rock compositions for selected samples from USW G-1, USW G-2, USW GU-3/G-3, and for outcrop samples.

Relative chemical changes associated with diagenesis are evaluated by comparing unaltered and altered tuff compositions on a constant-aluminum basis. This method assumes that aluminum is relatively insoluble and does not migrate significantly during diagenesis (Hay 1963). The low aluminum contents for groundwaters in volcanic rocks of the arid southwest suggest this assumption is valid (Lipman 1965). Figure 6 shows the logarithmic ratio of major elements in zeolitic tuffs to those in unaltered tuffs, normalized to the same aluminum content, for a representative suite of samples (Table II). Devitrified and vitric tuffs were used to represent unaltered tuff compositions.

Alkalies and alkaline earths were the elements most strongly affected in zeolitic tuffs by diagenetic alteration (Fig. 6). Sodium, potassium, calcium, and magnesium contents of zeolitic tuff deviate from those of unaltered tuff

TABLE II

REPRESENTATIVE BULK ROCK COMPOSITIONS FOR TUFFS AT YUCCA MOUNTAIN, NEVADA^a

	Pah Canyon Member, Paintbrush Tuff		Topopah Spring Member, Paintbrush Tuff		Tuff of Calico Hills		
	1A	1B	2A	2B	3A	3B	3C
	Densely welded devitrified tuff	Partially welded, clay- and zeolitic-rich tuff	Unaltered lower vitrophyre	Altered lower vitrophyre	Nonwelded vitric tuff	Nonwelded zeolitic tuff, alkalic suite	Nonwelded zeolitic tuff, calcic suite
Diagenetic Zone	I		I		II		II
Sample No. ^b	67FB-3E	G2-675	25A1-1280	G4-1314	G03-1498	G4-1544C	25A1-1323
SiO ₂	72.9	64.3	74.0	70.2	74.5	69.1	69.1
TiO ₂	0.28	0.33	0.10	0.14	0.10	0.06	0.11
Al ₂ O ₃	13.9	16.8	12.4	16.7	11.7	11.5	13.4
Fe ₂ O ₃	1.4	1.83 ^c	1.07 ^c	1.44 ^c	1.10 ^c	0.81	1.13 ^c
FeO	0.04					0.04	
MnO	0.06	0.17	0.08	0.09	0.08	0.03	0.05
MgO	0.33	1.77	0.31	0.90	0.12	0.03	0.94
CaO	0.92	2.60	0.66	3.51	0.77	0.75	3.22
Na ₂ O	3.8	1.38	3.40	1.90	3.20	2.82	1.23
K ₂ O	5.1	2.72	4.00	0.72	4.34	4.10	2.64
P ₂ O ₅	0.02	0.05	0.01	0.02	0.01	0.00	0.01
LOI ^d	0.97	8.0	3.79	5.91	3.58	10.6	8.90
Total	99.7	100.0	99.8	101.5	99.5	99.8	100.7
Element Percent							
Si	68.4	66.0	72.2	69.6	73.0	72.8	71.6
Ti	0.20	0.25	0.07	0.10	0.07	0.04	0.09
Al	15.4	20.3	14.3	19.5	13.5	14.3	16.3
Fe ⁺³	0.98					0.64	
Fe ⁺²	0.03	1.41 ^c	0.78 ^c	1.07 ^c	0.81 ^c	0.03	0.88 ^c
Mn	0.04	0.12	0.05	0.06	0.05	0.02	0.04
Mg	0.46	2.71	0.45	1.33	0.17	0.05	1.45
Ca	0.93	2.86	0.69	3.73	0.81	0.84	3.58
Na	6.93	2.74	6.43	3.65	6.08	5.76	2.47
K	6.68	3.56	4.98	0.91	5.43	5.51	3.49
P	0.02	0.04	0.01	0.02	0.01	0.00	0.01

^aAnalyses by combination of x-ray fluorescence and atomic absorption and plasma emission spectrophotometry.^bAnalysis of sample 67FB-3E from Ovinlivan and Byers (1977) and G1-2557 from Zielinski (1933).^cTotal Fe as Fe₂O₃.^dLoss on ignition, decrease in sample weight at heating at 1000°C for 4 h. LOI for G2-675 not measured but determined by difference in analytical total from 100%.

TABLE II (cont)

	Prow Pass Member, Crater Flat Tuff			Bullfrog Member, Crater Flat Tuff			Tram Member, Crater Flat Tuff		
	4A	4B	4C	5A	5B	5C	6A	6B	6C
	Nonwelded vitric tuff	Nonwelded zeolitic tuff, alkalic suite	Nonwelded zeolitic tuff, calcic suite	Partially welded devitrified tuff	Nonwelded zeolitic tuff, alkalic suite	Nonwelded zeolitic tuff, calcic suite	Partially welded devitrified tuff	Nonwelded zeolitic tuff, alkalic suite	Nonwelded zeolitic tuff, calcic suite
Diagenetic Zone		II	II		II	II		II	II
Sample No. ^b	GU3-159B	GU3-1986B	G4-2131C	J13-2133	G1-2557	25B1H-2879C	J13-2982	G3-3589C	G4-2792B
SiO ₂	73.1	67.9	65.7	75.3	69.0	66.9	74.8	66.5	67.9
TiO ₂	0.11	0.10	0.12	0.11	0.11	0.26	0.16	0.49	0.15
Al ₂ O ₃	12.2	12.4	13.2	12.6	12.4	13.2	12.2	13.8	12.3
Fe ₂ O ₃	1.41 ^c	1.20	1.12	1.44 ^c	1.51 ^c	1.48	1.41 ^c	2.59	1.04
FeO		0.03	0.12			0.24		0.26	0.13
MnO	0.10	0.07	0.02	0.09	0.05	0.04	0.05	0.06	0.03
MgO	0.20	0.11	0.15	0.23	0.22	1.32	0.21	0.57	0.11
CaO	0.83	0.87	2.63	0.75	1.33	3.24	0.89	1.82	2.93
Na ₂ O	3.29	3.44	2.46	4.02	3.60	1.18	3.70	2.98	2.68
K ₂ O	4.37	3.72	3.52	4.38	3.05	3.90	4.46	3.65	1.68
P ₂ O ₅	0.02	0.02	0.00	0.03	0.00	0.00	0.02	0.00	0.03
LOI ^d	3.41	10.2	11.1	0.30	7.88	7.86	0.94	7.23	10.9
Total	99.0	100.1	100.1	99.3	99.1	99.7	98.8	100.0	100.1

Element Percent

Si	71.7	70.7	69.4	71.1	70.8	69.2	71.5	67.4	72.0
Ti	0.08	0.08	0.09	0.08	0.08	0.20	0.11	0.37	0.12
Al	14.1	15.2	16.4	14.0	15.0	16.1	13.8	16.5	15.4
Fe ⁺³		0.94	0.89			1.15		1.98	0.83
Fe ⁺²	1.04 ^c	0.03	1.11	1.02 ^c	1.17 ^c	0.21	1.01 ^c	0.22	0.11
Mn	0.07	0.05	0.01	0.06	0.03	0.03	0.03	0.04	0.02
Mg	0.29	0.17	0.24	0.32	0.34	2.03	0.30	0.86	0.28
Ca	0.87	0.97	2.98	0.76	1.46	3.59	0.91	1.98	3.33
Na	6.26	6.94	5.04	7.36	7.16	2.37	6.86	5.86	5.51
K	5.47	4.94	4.75	5.27	3.99	5.15	5.44	4.72	2.27
P	0.02	0.02	0.00	0.02	0.00	0.00	0.02	0.00	0.03

TABLE III
 REPRESENTATIVE ELECTRON MICROPROBE ANALYSES OF CLINOPTILOLITE, YUCCA MOUNTAIN, NEVADA

Rock Unit	Diagenetic Zone I		Diagenetic Zones II and III								
	Pah Canyon Member	Topopah Spring Member	CALCIC SUITE, EASTERN YUCCA MOUNTAIN				ALKALIC SUITE, WESTERN YUCCA MOUNTAIN				
			Tuff of Calico Hills	Prow Pass Member	Bullfrog Member	Tuff of Lithic Ridge	Tuff of Calico Hills	Prow Pass Member	Bullfrog Member	Tram Member	Tuff of Lithic Ridge
Sample No. ^a	G2-584	H5-1666	25p1-1250	25p1-1700	25a1-2879	25p1-3330	G1-1774	G3-1874	G3-2615	G3-3589	G3-4423
SiO ₂	65.5	65.5	68.6	67.1	56.1	60.6	68.1	68.2	63.9	65.1	65.3
TiO ₂	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	13.8	13.1	12.4	12.9	16.9	16.0	12.2	11.9	11.7	11.4	12.6
Fe ₂ O ₃ ^b	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.51	0.12
MnO	1.47	0.86	0.07	0.32	0.22	0.08	0.09	0.00	0.00	0.12	0.22
CaO	4.21	5.19	3.59	4.37	6.77	7.22	1.11	1.95	1.57	0.79	2.35
BaO	0.02	0.00	0.00	0.05	0.21	0.19	0.03	0.00	0.00	0.19	0.27
Na ₂ O	0.18	0.17	1.13	1.55	0.89	0.85	2.84	1.69	2.88	2.23	3.21
K ₂ O	1.09	0.21	3.01	1.23	1.43	0.41	4.20	5.20	2.71	5.55	1.15
Total	86.3	85.2	88.8	87.5	82.6	85.4	88.5	88.9	82.8	85.9	85.2
Unit-Cell Composition Based on 72 (O)											
Si	28.9	29.2	29.7	29.4	26.7	27.5	29.8	29.8	29.7	29.7	29.4
Ti	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	7.17	6.98	6.35	6.67	9.44	8.59	6.28	6.14	6.43	6.12	6.70
Fe ⁺³	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.17	0.04
Mg	0.97	0.57	0.04	0.21	0.16	0.05	0.06	0.00	0.00	0.08	0.15
Ca	2.00	2.48	1.67	2.05	3.44	3.51	0.52	0.91	0.78	0.39	1.13
Ba	0.00	0.00	0.00	0.01	0.04	0.03	0.01	0.00	0.00	0.03	0.05
Na	0.15	0.15	0.95	1.32	0.82	0.75	2.41	1.43	2.60	1.47	2.80
K	0.61	0.12	1.66	0.69	0.87	0.24	2.35	2.90	1.61	3.23	0.66
	1.07	1.10	1.05	1.02	1.05	1.05	1.06	1.00	1.11	0.99	1.09
	4.03	4.18	4.68	4.41	2.82	3.20	4.75	4.85	4.62	4.72	4.36
Mol% Exchangeable Cations											
K	16	4	38	16	16	5	44	54	32	57	14
Na	4	4	22	31	15	17	45	27	52	35	59
Ca+Mg	80	92	40	53	69	78	11	19	16	8	27

^a Sample H5-1666 from Levy (1984a) and samples G3-2615, G3-3589, and G3-4423 from Vaniman et al. (1984).
^b Total Iron calculated as Fe₂O₃.

by as much as a factor of 10. Sodium and potassium are generally strongly depleted in the zeolitic tuffs, whereas calcium is strongly enriched. Magnesium is strongly enriched in diagenetic Zone I but is highly variable in Zone II. These elemental enrichments and depletions in alkalis and alkaline earths vary in detail and depend on the location of the tuff within Yucca Mountain. Silicon is systematically depleted in zeolitic tuffs, whereas iron and titanium show less systematic compositional changes. Iron in the zeolitic tuffs is strongly oxidized, with 90-100% of the iron in the (III) oxidation state in most zeolitic samples (Appendix B).

Triangular plots of whole-rock alkalis and alkaline earths (Fig. 7) show that the zeolitic tuff compositions change systematically across Yucca Mountain. These whole-rock chemical variations are mirrored in clinoptilolites that occur in these tuffs.

Based upon mode of occurrence and compositional characteristics, zeolitic tuffs at Yucca Mountain can be divided into three compositional groups:

- (1) calcium- and magnesium-rich tuffs associated with relatively thin zones of alteration in diagenetic Zone I;
- (2) zeolitic tuffs of extremely variable composition in thick zones of alteration in diagenetic Zones II, III, and IV beneath the exploration block; and
- (3) highly potassic zeolitic tuffs in Zone II at the northern end of Yucca Mountain.

Three whole-rock samples from the calcium- and magnesium-rich tuffs in Zone I were analyzed by a combination of XRF and ANAA techniques. Two of these samples (sample #26, Appendix A; depth 1286 ft in USW G-1, Appendix C) were collected from altered zone at the top of the basal vitrophyre of the Topopah Spring Member. The other sample (sample #1, Appendix A) was collected from a smectite- and zeolite-rich tuff in the Pah Canyon Member in USW G-2. All three samples are characterized by ≥ 2.84 wt% CaO and ≥ 0.94 wt% MgO when normalized to volatile-free compositions. Unaltered Topopah Spring and Pah Canyon tuffs typically contain less than 0.65 wt% CaO and 0.30 wt% MgO (Table II). Trace-element abundances in the altered tuffs are little affected by diagenetic alteration except for strontium, rubidium, and uranium. Strontium is concentrated in the zeolitic tuffs by a factor of 5 or more compared with that in unaltered tuff compositions. Rubidium and uranium are both depleted by a factor of 2 in the zeolitic tuffs (Table IV).

TABLE IV

COMPARISON OF SELECTED TRACE ELEMENTS BETWEEN UNALTERED AND ALTERED TUFFS
IN DIAGENETIC ZONE I, YUCCA MOUNTAIN, NEVADA^a

	Pah Canyon Member, Paintbrush Tuff		Topopah Spring Member Paintbrush Tuff	
	Partially welded vitric tuff	Partially welded clay- and zeolite- rich tuff	Unaltered basal vitrophyre	Clay- and zeolite- rich altered basal vitrophyre
Sample No.	G2-547	G2-675	G1-1319	G1-1286
Sr	290	1600	22 ^b	1650
Rb	141	87	1.54	52
U	3.2	1.54	4.70	1.37

^aAll concentrations in parts per million (ppm); data taken from Appendix C.

^bSr value from Noble and Hedge (1969, Table I); the ANAA value for Sr in this sample is 760 ppm.

The altered tuffs in diagenetic Zones II, III, and IV are chemically more diverse than those of Zone I. Alkalies and alkaline earths in these tuffs vary systematically across Yucca Mountain. Tuffs on the eastern side of Yucca Mountain are characterized by calcium-rich compositions, whereas altered tuffs on the western side of Yucca Mountain are more alkali rich (Fig. 7). A transitional zone, characterized by samples from drill holes USW G-2 and G-4, separates the two compositional suites. The calcium-rich tuffs on the eastern side of Yucca Mountain deviate most from original tuff compositions, being strongly enriched in calcium and magnesium and depleted in sodium and potassium. Alkali-rich tuffs from the western part of Yucca Mountain overlap original compositions to some extent, but many samples have higher sodium/potassium and calcium/sodium+potassium ratios than the unaltered tuffs. Although fewer compositions were determined for analcime-bearing tuffs in Zone III and authigenic albite-bearing tuffs in Zone IV, these deeper zones of alteration show compositional variations similar to those found in Zone II. On the eastern side of Yucca Mountain, excess calcium in Zones III and IV is not incorporated into the primary authigenic minerals such as analcime and authigenic feldspar but instead results in a greater abundance of calcite.

Potassium-rich tuffs crop out at Prow Pass, located at the northern end of Yucca Mountain. Two samples from tuff of Calico Hills outcrops (sample #62 and 63, Appendix A) contain 7.2 and 8.7 wt% K_2O (on a volatile-free basis), respectively; by comparison, zeolitic tuffs beneath the exploration block, including those of the tuff of Calico Hills, generally contain less than 5.0 wt% K_2O . The potassic tuffs occur in the structurally highest portion of diagenetic Zone II, which rises and thins northward at Yucca Mountain (Broxton et al. 1986). This unusual potassium enrichment appears to be confined to the extreme northern end of Yucca Mountain because tuffs from the same stratigraphic horizon 3 km to the southeast, in drill hole USW G-2, contain only 3-4 wt% K_2O .

Glass and Mineral Compositions: Glass compositions were obtained for all members of the Paintbrush Tuff, the tuff of Calico Hills, and the Prow Pass Member of the Crater Flat Tuff (Appendix E). These glasses are high-silica rhyolites containing subequal potassium and sodium (Fig. 8). Si/Al ratios for these glasses are relatively high (5.2 to 5.6) compared with those of clinoptilolites that replaced them (2.6 to 5.4).

The compositions of glasses largely control the chemistry of pore waters during diagenesis. Selective leaching of sodium from glasses by groundwater during the initial stages of hydration and diagenesis has been described by Lipman (1965), Noble (1967), and White et al. (1980). Though hydrated, the glasses in Zone I show no evidence for massive alkali exchange with groundwaters, suggesting that alteration by groundwater has been limited and that most exchange is confined to the fine-grained dusty matrix where glass particles have much larger surface areas. The similarity of glass compositions throughout the stratigraphic sequence suggests that factors other than original glass compositions are responsible for the chemical and mineralogic variations in diagenetically altered tuffs at Yucca Mountain.

Clinoptilolite compositions (Appendix F) parallel the chemical trends described above for whole-rock compositions. Clinoptilolites in diagenetic Zone I are invariably calcium rich (Fig. 9) and have Si/Al ratios between 4.0 and 5.0 (Fig. 10). Magnesium contents of these zeolites are relatively high, ranging from 0.6 to 1.5% MgO by weight. Levy (1984) has shown that some of these zeolites have the thermal stability of heulandite (Mumpton 1960), but

Fig. 8.

Triangular diagram showing relative alkali and alkaline-earth contents for glasses from diagenetic Zone I, Yucca Mountain, Nevada.

others have a thermal stability intermediate between heulandite and clinoptilolite (Group 2 of Boles 1972). Calcic clinoptilolites at the top of the basal vitrophyre of the Topopah Spring Member are slightly more sodic than clinoptilolites within the shallow zeolite occurrence of the Pah Canyon Member in USW G-2 (Fig. 9).

Clinoptilolite compositions in Zone II vary systematically both vertically and laterally at Yucca Mountain (Fig. 11). On the eastern side of Yucca Mountain, clinoptilolite compositions are calcic-potassic and show strong calcium enrichment with depth (Table III). Clinoptilolites on the western side of Yucca Mountain are sodic-potassic and tend towards sodium

Fig. 9.

Triangular diagram showing relative alkali and alkaline-earth contents for clinoptilolites of diagenetic Zone I, Yucca Mountain, Nevada.

enrichment with depth. A transitional zone, consisting of drill holes USW G-2, USW G-4, and USW H-4, has compositions that overlap both suites.

Clinoptilolites for the one sample reported for drill hole USW H-3 are unusual in that they occur on the western side of Yucca Mountain, yet contain substantial calcium and little sodium. These clinoptilolites occur in the uppermost part of diagenetic Zone II and may reflect exchange of Zone II clinoptilolites with relatively calcium-rich solutions moving downward through Zone I (Levy 1984). The compositions of clinoptilolites from deeper portions of Zone II were also analyzed by Levy (1984), but those results were not included in Appendix F or in Fig. 11 of this report because the ratio of $(Al+Fe)/(Na+K+2Ca+2Mg)$ for these minerals was greater than 1.15. However, the

CLINOPTILOLITES AND HEULANDITES IN DIAGENETIC ZONE I

EASTERN GROUP OF CALCIC CLINOPTILOLITES

DIAGENETIC
ZONE II

WESTERN GROUP OF ALKALI CLINOPTILOLITES

Fig. 10.

Histogram comparing Si/Al ratios for clinoptilolites of Yucca Mountain, Nevada.

Fig. 11.

Triangular diagrams showing relative alkali and alkaline-earth contents for clinoptilolites of diagenetic Zones II and III, Yucca Mountain, Nevada.

analyses by Levy clearly showed that the compositions of most clinoptilolites in Zone II of drill hole USW H-3 are sodic-potassic. In nearby drill hole USW G-3, a more complete suite of samples for diagenetic Zone II shows that analyses by Levy clearly showed that the compositions of most clinoptilolites in Zone II of drill hole USW H-3 are sodic-potassic. In nearby drill hole USW G-3, a more complete suite of samples for diagenetic Zone II shows that clinoptilolites in this part of Yucca Mountain are dominantly sodic-potassic in composition.

Si/Al ratios within clinoptilolites of diagenetic Zone II (Fig. 10) generally range between 3.8 and 5.4. However, Si/Al ratios within the eastern group of calcic clinoptilolites are bimodal with a small group of samples having Si/Al ratios between 2.6 and 3.6 (Fig. 10). This small group of silica-poor compositions is associated with the most calcic clinoptilolites in the deepest parts of Zone II.

Clinoptilolites associated with the potassic tuffs at the northern end of Yucca Mountain also have potassium-rich compositions. Clinoptilolite compositions were determined for three samples within the tuff of Calico Hills and for one sample in the overlying Topopah Spring Member, which is also zeolitic below the basal vitrophyre. These clinoptilolites tend to be potassic-calcic within the base of the Topopah Spring Member and the upper part of the tuff of Calico Hills. The clinoptilolites become increasingly potassic toward the center and base of the tuff of Calico Hills (Fig. 12). Si/Al ratios are similar to those of other Zone II clinoptilolites, ranging between 4.0 and 5.0. Mordenite and adularia are common authigenic phases associated with these potassic clinoptilolites.

Analcimes in samples from Yucca Mountain range in molecular composition from $(\text{NaAl})_{14.3} \text{Si}_{33.7} \text{O}_{96} \cdot n\text{H}_2\text{O}$ to $(\text{NaAl})_{12.3} \text{Si}_{35.6} \text{O}_{96} \cdot n\text{H}_2\text{O}$. All analcimes have nearly pure end-member compositions with only trace amounts of calcium and potassium substituting for sodium (Appendix G). Si/Al ratios for these analcimes range from 2.3 to 2.9 (Fig. 13). The distribution of Si/Al ratios appears to be bimodal, with the primary mode between 2.4 and 2.6 and a secondary mode between 2.7 and 2.8. The significance of bimodal Si/Al ratios in these analcimes is not known. However, these ranges of Si/Al ratios are typical of analcimes associated with siliceous volcanic rocks (Coombs and Whetten 1967; Sheppard and Gude 1973).

Fig. 12.

Triangular diagram showing relative alkali and alkaline-earth contents for clinoptilolites in the tuff of Calico Hills at Prow Pass, northern Yucca Mountain.

Authigenic potassium feldspar and albite compositions (Appendix H) are also characterized by nearly pure end-member compositions. These end-member compositions are typical for feldspars formed under diagenetic conditions (Kastner and Siever 1979). Most potassium feldspar compositions yield molecular formulae with 0.88 to 0.96 nontetrahedral cations per 8-oxygens (Fig. 14) rather than the ideal one nontetrahedral cation per 8-oxygens. Charge balance within these potassium feldspars is maintained because the tetrahedral framework is correspondingly aluminum poor and silicon rich. Si/Al ratios are 3.35 to 3.45 compared with an ideal ratio of ≤ 3.00 . Sub-microscopic intergrowths of quartz and feldspars might account for the silica-rich chemistry of the feldspars. However, examination of several potassium feldspar grains by electron microscope revealed no evidence of intergrown quartz.

Fig. 13.
Histogram showing distribution of Si/Al ratios for analcimes, Yucca Mountain, Nevada.

Fig. 14.
Histogram showing distribution for sum of cations in nontetrahedral sites within authigenic feldspar, Yucca Mountain, Nevada.

V. DISCUSSION

Vitric tuffs that were precursors to the major zeolite deposits of Yucca Mountain were generally high-silica rhyolites with similar major-element chemistries (Table II). Despite similar starting compositions, the principal zeolite deposits have extremely variable major-element chemistries. Individual stratigraphic units such as the tuff of Calico Hills display a wide range of compositions laterally across Yucca Mountain. Evidently diagenesis was accompanied by widespread mobilization and redistribution of chemical constituents within these tuffs. This widespread redistribution of elements within the tuffs supports Hoover's (1968) concept of diagenesis of tuffs at the Nevada Test Site within a chemically open system.

Groundwater is the likely medium through which chemical transport occurred. Cations in zeolites within the tuffs, particularly alkalis and alkaline earths, are readily exchanged with those in groundwaters. Therefore, systematic variations in the compositions of zeolitic tuffs probably reflect variable groundwater compositions during diagenesis. It is unclear, however, whether present-day tuff compositions represent original compositions acquired at the time of diagenetic crystallization or compositions acquired at a later date through ion exchange with younger groundwaters. Broxton et al. (1986) discuss possible origins of the chemical variability of tuffs at Yucca Mountain.

The zeolite occurrence at the top of the basal vitrophyre of the Topopah Spring member is the first major zeolite barrier that radioactive waste-bearing solutions will encounter as they move downward through the unsaturated zone. The proximity of the zeolites within this interval to the potential repository makes them susceptible to contraction and dehydration during the thermal pulse expected after repository closure. This study and Levy's (1984) work indicate that this zeolite interval consistently bears calcium-rich clinoptilolite and heulandite. Calcium-rich clinoptilolites can lose up to 27% of their original water and contract in volume by 3% when heated to 100°C (Bish 1984, 1985).

The sorptive behavior of Zone I zeolites also may be compositionally dependent. Clay- and zeolite-rich tuffs in Zone I are enriched in calcium, magnesium, and strontium and depleted in sodium, potassium, rubidium, and uranium. This may simply reflect the relative abundances of these elements in groundwaters of the unsaturated zone. However, it is also possible that Zone

I clinoptilolites are significantly more selective for bivalent cations than for cations in other valence states. White et al. (1980) noted that groundwaters increase in sodium and decrease in calcium and magnesium after passing through zeolitic tuffs in the unsaturated zone at Rainier Mesa, located 50 km NNE of Yucca Mountain. They concluded that zeolites and clays selectively removed bivalent cations from the groundwater system. Similarly, zeolites on top of the basal vitrophyre in the Topopah Spring Member may have a greater selectivity for bivalent cations.

Clinoptilolite-bearing tuffs in Zone II are the most important sorptive barriers to radionuclide migration at Yucca Mountain because of their great thicknesses, their abundant zeolites, and their position along potential groundwater pathways to the accessible environment. The thermal properties of Zone II zeolites are probably relatively unimportant for assessing repository performance because these zeolites lie a great distance below the repository level. Nonwelded tuffs at the base of the Topopah Spring Member and at the top of the tuff of Calico Hills are 75 to 100 m below the repository centerline and should not be significantly heated during the thermal pulse. Furthermore, these uppermost zeolites of Zone II contain substantial potassium, which minimizes thermal contraction and dehydration (Bish 1984, 1985).

Sorptive properties of clinoptilolites in Zone II, particularly in the vicinity of the exploration block, are important for assessing repository performance because these zeolites occur along potential groundwater pathways from the repository to the accessible environment. These sorptive properties could vary with composition laterally and vertically across Yucca Mountain. Both sodium and calcium in clinoptilolite exchange readily with a wide range of potential radionuclides, including cesium, rubidium, strontium, and barium (Ames 1960; Breck 1974). Potassium, on the other hand, is more difficult to remove from the clinoptilolite structure, exchanging well with cesium and rubidium but exchanging poorly with strontium and barium (Ames 1960).

In the unsaturated zone, exchangeable cations within clinoptilolites on the western side of the exploration block consist primarily of sodium and potassium (Fig. 15). Clinoptilolites in the unsaturated zone on the eastern side of the exploratory block have mixed sodium-potassium and calcium-potassium compositions. In the saturated zone, clinoptilolite compositions tend to become more sodic with depth on the western side of Yucca Mountain and more calcic with depth to the east. Unfortunately, it is not possible to

Fig. 15.

Triangular diagram showing alkali and alkaline-earth contents for clinoptilolites in the unsaturated zone below the exploration block, Yucca Mountain, Nevada.

accurately evaluate the sorption behavior of clinoptilolite as a function of its chemistry from published sorption experiments (Daniels et al. 1982; U.S. Department of Energy 1984). These experiments were designed to determine bulk sorption characteristics of Yucca Mountain tuffs and used whole-rock samples containing variable proportions of sorptive and nonsorptive minerals. In addition, the sorptive minerals had variable compositions. Further experiments are planned to determine the effect of exchangeable cation compositions on clinoptilolite sorption using monomineralic samples and end-member compositions.

Potassic clinoptilolites are abundant only in outcrop at the north end of Yucca Mountain. These potassic clinoptilolites may have relatively poor sorption characteristics because of the difficulty in removing potassium from the zeolite structure. However, these potassic clinoptilolites do not occur along potential groundwater pathways from the repository to the accessible environment and their sorptive properties are not important for assessment of repository performance.

VI. SUMMARY AND CONCLUSIONS

Major zeolite deposits at Yucca Mountain developed within thick sequences of nonwelded tuffs that were initially vitric. Alteration of these vitric tuffs resulted in the dissolution of the glass and precipitation of heulandite, clinoptilolite, and mordenite. These zeolite deposits are laterally extensive beneath much of Yucca Mountain and could provide important barriers to radionuclide migration.

The precursor vitric tuffs were primarily high-silica rhyolites with similar major element chemistry. However, zeolite deposits developed in these tuffs have variable compositions. Significant mobilization and redistribution of sodium, potassium, calcium, magnesium, and silicon during zeolitization indicates that diagenesis took place in an open chemical system.

Yucca Mountain tuffs can be divided into three compositional groups. (1) In diagenetic Zone I, tuffs in thin zones of alteration have calcium- and magnesium-rich compositions. (2) In Zones II, III, and IV, diagenetically altered tuffs have compositions that vary laterally. These tuffs are calcic-potassic on the east side of Yucca Mountain but become increasingly sodic-potassic in stratigraphically equivalent units to the west. (3) Potassium-rich tuffs occur where Zone II crops out at Prow Pass in the northern part of Yucca Mountain. Clinoptilolites within each of these three compositional groups follow chemical trends similar to those found in their host tuffs.

Experimental studies have shown that variations in zeolite compositions can affect their thermal and exchange properties. At Yucca Mountain, clinoptilolites have exchangeable-cation compositions that span the entire compositional range between sodium, potassium, and calcium end members. Because of these compositional variations, the thermal expansion/contraction behavior, hydration/dehydration behavior, and ion-exchange properties of these

zeolites and of their host tuffs may vary at Yucca Mountain. Data presented in this study can be used in conjunction with experimental results to model the effects of mineral chemical variations on the physical properties of zeolites and their host tuffs in a repository environment.

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REFERENCES

- Ames, L. L., Jr., "The Cation Sieve Properties of Clinoptilolite," *Am. Mineral.* 45, 689-700 (1960).
- Bence, A. E., and A. L. Albee, "Empirical Correction Factors for Electron Microanalysis of Silicates and Oxides," *J. Geol.* 76, 382-403 (1968).
- Bish, D. L., "Effects of Exchangeable Cation Composition on the Thermal Expansion/Contraction of Clinoptilolite," *Clays and Clay Miner.*, 32, no. 6, 444-462 (1984).
- Bish, D. L., "Effects of Composition on the Dehydration Behavior of Clinoptilolite and Heulandite," in "Proceedings for the International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites," Budapest, Hungary (1985).
- Bish, D. L., and D. T. Vaniman, "Mineralogic Summary of Yucca Mountain, Nevada," Los Alamos National Laboratory report LA-10543-MS, 55 pp. (October 1985).
- Boles, J. R., "Composition, Optical Properties, Cell Dimensions, and Thermal Stability of Some Heulandite Group Zeolites," *Am. Mineral.* 57, 1463-1493 (1972).
- Breck, D. W., Zeolite Molecular Sieves: Structure, Chemistry, and Use (John Wiley and Sons, New York, 1974).
- Broxton, D. E., D. T. Vaniman, F. A. Caporuscio, B. H. Arney, and G. H. Heiken, "Detailed Petrographic and Microprobe Data for Drill Holes USW G-2 and UE25b-1H, Yucca Mountain, Nevada," Los Alamos National Laboratory report LA-9324-MS, 168 pp. (October 1982).

- Broxton, D. E., D. L. Bish, and R. G. Warren, "Distribution and Chemistry of Diagenetic Minerals at Yucca Mountain, Nye County, Nevada," Los Alamos National Laboratory document LA-UR-85-4032 (submitted to Clays and Clay Miner.).
- Byers, F. M., Jr., W. J. Carr, P. P. Orkild, W. D. Quinlivan, and K. A. Sargent, "Volcanic Suites and Related Cauldrons of Timber Mountain-Oasis Valley Caldera Complex, Southern Nevada," US Geological Survey Professional Paper 919, 70 pp. (1976).
- Caporuscio, F., D. Vaniman, D. Bish, D. Broxton, B. Arney, G. Heiken, F. Byers, R. Gooley, and E. Semarge, "Petrologic Studies of Drill Cores USW G-2 and UE25b-1H, Yucca Mountain, Nevada," Los Alamos National Laboratory report LA-9255-MS, 111 pp. (April 1982).
- Caporuscio, F. A., R. G. Warren, and D. E. Broxton, "Detailed Petrographic Descriptions and Microprobe Data for Tertiary Silicic Volcanic Rocks in Drill Hole USW G-1, Yucca Mountain, Nevada," Los Alamos National Laboratory report LA-9323-MS, 76 pp. (July 1985).
- Christiansen, R. L., P. W. Lipman, P. P. Orkild, and F. M. Byers, Jr., "Structure of the Timber Mountain Caldera, Southern Nevada, and Its Relation to Basin-Range Structure," in "Geological Survey Research 1965," US Geological Survey Professional Paper 525B, B43-B48 (1965).
- Christiansen, R. L., P. W. Lipman, W. J. Carr, F. M. Byers, Jr., P. P. Orkild, and K. A. Sargent, "Timber Mountain-Oasis Valley Caldera Complex of Southern Nevada," *Geol. Soc. Am. Bull.* 88, 943-959 (1977).
- Coombs, D. S., and J. T. Whetten, "Composition of Analcime from Sedimentary and Burial Metamorphic Rocks," *Geol. Soc. Am. Bull.* 78, 269-282 (1967).
- Daniels, W. R., K. Wolfsberg, R. S. Rundberg, A. E. Ogard, J. F. Kerrisk, et al., "Summary Report on the Geochemistry of Yucca Mountain and Environs," Los Alamos National Laboratory report LA-9328-MS, 364 pp. (December 1982).
- Garcia, S. R., W. K. Hensley, M. M. Minor, M. M. Denton, and M. A. Fuka, "An Automated Multidetector System for Instrumental Neutron Activation Analysis of Geological and Environmental Materials," in Atomic and Nuclear Methods in Fossil Energy Research, R. H. Filby, B. S. Carpenter, and R. C. Ragaini, Eds. (Plenum Press, New York, 1982) 133-140.
- Hay, R. L., "Stratigraphy and Zeolite Diagenesis of the John Day Formation of Oregon," *Univ. Calif. Publ. Geol. Sci.* 42, 199-262 (1963).
- Heiken, G. H., and M. L. Bevier, "Petrology of Tuff Units from the J-13 Drill Site, Jackass Flats, Nevada," Los Alamos Scientific Laboratory report LA-7563-MS, 55 pp. (February 1979).
- Hoover, D. L., "Genesis of Zeolites, Nevada Test Site," E. B. Eckel, Ed., *Geol. Soc. Am. Mem.* 110, 275-284 (1968).
- Iijima, A., "Effect of Pore Water to Clinoptilolite - Analcime - Albite Reaction Series," *J. Fac. Sci., Univ. Tokyo, Sec. II*, 19, 133-147 (1975).

- Iijima, A., "Geologic Occurrences of Zeolites in Marine Environments," in Natural Zeolites, Occurrence, Properties, Use, L. B. Sand and F. A. Mumpton, Eds. (Pergamon Press, Elmsford, New York, 1978) 175-198.
- Iijima A., "Geology of Natural Zeolites and Zeolitic Rocks," in Proceedings of the Fifth International Conference on Zeolites, L. V. Rees, Ed. (Heyden, London, 1980) 103-118.
- Johnstone, J. K. and K. Wolfsberg, Eds., "Evaluation of Tuff as a Medium for a Nuclear Waste Repository: Interim Status Report on the Properties of Tuff," Sandia National Laboratories report SAND 80-1464 (1980).
- Kastner, M., and R. Siever, "Low Temperature Feldspars in Sedimentary Rocks," Am. J. Sci. 279, 435-479 (1979).
- Levy, S. S., "Petrology of Samples from Drill Holes USW H-3, H-4, and H-5, Yucca Mountain, Nevada," Los Alamos National Laboratory report LA-9706-MS, 77 pp. (June 1984).
- Lipman, P. W., R. L. Christiansen, and J. T. O'Conner, "A Compositionally Zoned Ash-Flow Sheet in Southern Nevada," US Geological Survey Professional Paper 524-F, F1-F47 (1966).
- Lipman, P. W., "Chemical Comparison of Glassy and Crystalline Volcanic Rocks," US Geological Survey Bulletin 1201-D, 24 pp. (1965).
- Maldonado, F., and S. L. Koether, "Stratigraphy, Structure, and Some Petrographic Features of Tertiary Volcanic Rocks at the USW G-2 Drill Hole, Yucca Mountain, Nye County, Nevada," US Geological Survey open-file report 83-732, 83 pp. (1983).
- Minor, M. M., W. K. Hensley, M. M. Denton, and S. R. Garcia, "An Automated Activation Analysis System," J. Radioanal. Chem. 70, 459-471 (1982).
- Mumpton, F. A., "Clinoptilolite Redefined," Am. Mineral. 45, 351-369 (1960).
- Noble, D. C., "Sodium, Potassium, and Ferrous Iron Contents of Some Secondarily Hydrated Natural Silicic Glasses," Am. Mineral. 52, 280-286 (1967).
- Noble, D. C., and C. E. Hedge, "⁸⁷Sr/⁸⁶Sr Variations Within Individual Ash-Flow Sheets," US Geological Survey Professional Paper 650-C, C133-C139 (1969).
- Quinlivan, W. D., and F. M. Byers, Jr., "Chemical Data and Variation Diagrams of Igneous Rocks from the Timber Mountain-Oasis Valley Caldera Complex, Southern Nevada," US Geological Survey open-file report 77-724, 9 pp. (1977).
- Scott, R., and M. Castellanos, "Preliminary Report on the Geologic Character of the Drill Holes USW GU-3 and USW G-3," US Geological Survey open-file report 84-491, 121 pp. (1984).

- Sheppard, R. A., and A. J. Gude, 3rd., "Zeolites and Associated Authigenic Silicate Minerals in Tuffaceous Rocks of the Big Sandy Formation, Mohave County, Arizona," US Geological Survey Professional Paper 830, 36 pp. (1973).
- Spengler, R. W., D. C. Muller, and R. B. Livermore, "Preliminary Report on the Geology and Geophysics of Drill Hole UE25a-1, Yucca Mountain, Nevada," US Geological Survey open-file report 79-1244, 43 pp. (1979).
- Spengler, R. W., F. M. Byers, Jr., and J. B. Warner, "Stratigraphy and Structure of Volcanic Rocks in Drill Hole USW G1, Yucca Mountain, Nye County, Nevada," US Geological Survey open-file report 81-1349, 50 pp. (1981).
- Sykes, M. L., G. H. Heiken, and J. R. Smyth, "Mineralogy and Petrology of Tuff Units from the UE25a-1 Drill Site, Yucca Mountain, Nevada," Los Alamos Scientific Laboratory report LA-8139-MS, 76 pp. (November 1979).
- US Department of Energy, "Draft Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, Nevada," Office of Civilian Radioactive Waste Management report, DOE/RW-0012 (1984).
- Valentine, G., "Procedures for Analysis of Silicate Rocks and Minerals at Los Alamos National Laboratory by X-Ray Fluorescence," Los Alamos National Laboratory report LA-9663-MS, 33 pp. (May 1983).
- Vaniman, D., D. Bish, D. Broxton, F. Byers, G. Heiken, B. Carlos, E. Semarge, F. Caporuscio, and R. Gooley, "Variations in Authigenic Mineralogy and Sorptive Zeolite Abundance at Yucca Mountain, Nevada, Based on Studies of Drill Cores USW GU-3 and G3," Los Alamos National Laboratory report LA-9707-MS, 71 pp. (June 1984).
- White, A. F., H. C. Claassen, and L. V. Benson, "The Effect of Dissolution of Volcanic Glass on the Water Chemistry in a Tuffaceous Aquifer, Rainier Mesa, Nevada," US Geological Survey Water-Supply Paper 1535-Q, Q1-Q34 (1980).
- Zielinski, R. A., "Evaluation of Ash-Flow Tuffs as Hosts for Radioactive Waste: Criteria Based on Selective Leaching of Manganese Oxides," US Geological Survey open-file report 83-480, 21 pp. (1983).

APPENDIX A

MAJOR-ELEMENT ANALYSES OF TUFFS BY X-RAY FLUORESCENCE YUCCA MOUNTAIN, NEVADA^a

Sample Number	Drill Hole USW G-2						
	1.	2.	3.	4.	5.	6.	7.
Depth (ft)	675	2430	2667	3067	3192	3454	3541
SiO ₂	64.3	76.5	75.6	73.3	76.0	75.0	73.8
TiO ₂	0.33	0.14	0.11	0.16	0.12	0.14	0.20
Al ₂ O ₃	16.8	11.9	12.7	13.1	11.9	14.3	14.0
Fe ₂ O ₃	1.83	1.24	1.38	1.44	1.34	1.60	1.96
MnO	0.17	0.13	0.08	0.04	0.08	0.04	0.08
MgO	1.77	0.41	0.14	0.29	0.14	0.57	0.45
CaO	2.60	1.98	1.59	2.25	1.11	1.49	0.74
Na ₂ O	1.38	1.68	2.51	3.37	2.63	2.96	4.17
K ₂ O	2.72	3.95	3.04	3.34	3.89	2.12	3.37
P ₂ O ₅	0.05	0.01	0.02	0.05	0.02	0.02	0.03
LOI	8.0 ^b	3.49	2.44	3.61	2.89	2.73	2.14
Total	100.0	101.4	99.5	101.0	100.2	100.9	100.9
Cation Percent							
Si	66.0	74.5	73.8	70.7	74.0	72.0	69.7
Ti	0.25	0.10	0.08	0.12	0.09	0.10	0.14
Al	20.3	13.7	14.6	14.9	13.7	16.2	15.6
Fe+3	1.41	0.91	1.01	1.04	0.98	1.16	1.39
Mn	0.12	0.09	0.05	0.03	0.05	0.03	0.05
Mg	2.71	0.59	0.20	0.42	0.20	0.82	0.63
Ca	2.86	2.07	1.66	2.32	1.16	1.53	0.75
Na	2.75	3.17	4.75	6.30	4.96	5.51	7.64
K	3.56	4.91	3.79	4.11	4.83	2.60	4.06
F	0.04	0.01	0.02	0.04	0.02	0.02	0.02
Ca+Mg	46.9	24.8	17.9	20.8	12.2	22.5	10.6
K	30.0	45.7	36.4	31.2	43.3	24.8	31.0
Na	23.1	29.5	45.7	47.9	44.5	52.7	58.4

Sample Descriptions:

1. Pah Canyon Member, Paintbrush Tuff. Clinoptilolite- and smectite-bearing nonwelded tuff in diagenetic Zone I.
2. Tuff of Calico Hills. Clinoptilolite- and mordenite-bearing nonwelded tuff in diagenetic Zone II.
3. Tuff of Calico Hills. Clinoptilolite- and mordenite-bearing nonwelded tuff in diagenetic Zone II.
4. Prow Pass Member, Crater Flat Tuff. Mordenite-bearing tuff in diagenetic Zone II.
5. Prow Pass Member, Crater Flat Tuff. Clinoptilolite- and mordenite-bearing tuff in diagenetic Zone II.
6. Bullfrog Member, Crater Flat Tuff. Mordenite-bearing tuff in diagenetic Zone III.
7. Bullfrog Member, Crater Flat Tuff. Analcime-bearing tuff in diagenetic Zone III.

^a All sodium concentrations determined by atomic absorption or plasma source emission spectrophotometry.

^b LOI not measured but determined by difference in analytical total from 100%.

APPENDIX A (cont)

Drill Hole USW G-2

Sample Number	8.	9.	10.	11.	12.	13.
Depth (ft)	3795	3933	4090	4805	5895	5992
SiO ₂	71.8	75.1	63.0	74.2	66.2	72.0
TiO ₂	0.55	0.12	0.68	0.25	0.37	0.27
Al ₂ O ₃	14.4	12.4	14.1	14.1	12.0	13.6
Fe ₂ O ₃	4.35	1.17	5.30	1.77	3.05	1.96
MnO	0.03	0.07	0.17	0.02	0.14	0.10
MgO	0.69	0.25	1.72	0.66	0.93	0.47
CaO	0.55	0.95	5.25	0.24	5.29	1.31
Na ₂ O	1.17	2.77	2.19	2.51	2.26	3.68
K ₂ O	3.49	4.31	2.70	4.77	2.76	4.00
P ₂ O ₅	0.22	0.02	0.35	0.05	0.08	0.07
LOI	2.72	2.27	3.82	1.57	6.16	2.26
Total	99.9	99.4	99.3	100.2	99.3	99.8

Cation Percent

Si	71.1	73.0	62.7	70.9	67.6	69.1
Ti	0.41	0.09	0.51	0.18	0.28	0.19
Al	16.8	14.1	16.6	15.9	14.4	15.4
Fe+3	3.24	0.85	3.97	1.27	2.34	1.42
Mn	0.02	0.05	0.12	0.01	0.10	0.07
Mg	1.02	0.36	2.55	0.94	1.41	0.67
Ca	0.58	0.99	5.60	0.25	5.78	1.35
Na	2.25	5.22	4.23	4.65	4.47	6.85
K	4.41	5.34	3.43	5.82	3.59	4.90
P	0.18	0.02	0.30	0.04	0.07	0.06
Ca+Mg	19.4	11.3	51.6	10.2	47.2	14.7
K	53.4	44.9	21.7	49.9	23.5	35.6
Na	27.2	43.8	26.7	39.9	29.3	49.7

Sample Descriptions:

8. Tram Member, Crater Flat Tuff. Alcalcime- and kaolinite-bearing nonwelded tuff in diagenetic Zone III.
9. Tram Member, Crater Flat Tuff. Alcalcime-bearing tuff in diagenetic Zone III.
10. Rhyodacite Lava. Alcalcime- and calcite-bearing lava in diagenetic Zone III.
11. Tuff of Lithic Ridge. Authigenic albite- and alcalcime-bearing nonwelded tuff in diagenetic Zone IV.
12. Bedded Tuff. Calcite- and chlorite-bearing bedded tuff in diagenetic Zone IV.
13. Older Tuff Sequence. Calcite- and chlorite-bearing nonwelded tuff in diagenetic Zone IV.

APPENDIX A (cont)

Drill Holes USW GU-3 and USW G-3

Sample Number	14.	15.	16.	17.	18.	19.	20.
Depth (ft)	1498	1598	1986	2577	3207	3589	3854
SiO ₂	74.5	73.1	68.3	66.3	74.9	66.5	69.4
TiO ₂	0.10	0.11	0.12	0.12	0.24	0.48	0.16
Al ₂ O ₃	11.7	12.2	11.3	12.9	12.6	13.8	12.4
Fe ₂ O ₃	1.10	1.41	1.35	1.32	2.03	2.85	1.33
MnO	0.08	0.10	0.07	0.10	0.57	0.06	0.03
MgO	0.12	0.20	0.23	0.27	0.44	0.61	0.66
CaO	0.77	0.83	0.82	2.34	1.41	1.83	1.15
Na ₂ O	3.20	3.29	3.44	2.43	3.12	2.98	3.32
K ₂ O	4.34	4.37	3.61	3.61	4.12	3.42	2.98
P ₂ O ₅	0.01	0.02	0.02	0.02	0.07	0.16	0.02
LOI	3.58	3.41	10.32	9.83	1.19	6.86	8.05
Total	99.5	99.0	99.6	99.3	100.7	99.5	99.5
Cation Percent							
Si	73.0	71.7	71.6	69.8	71.1	67.6	71.1
Ti	0.07	0.08	0.09	0.10	0.17	0.37	0.12
Al	13.5	14.1	14.0	16.1	14.1	16.5	15.0
Fe+3	0.81	1.04	1.07	1.05	1.45	2.18	1.03
Mn	0.05	0.07	0.05	0.07	0.37	0.04	0.02
Mg	0.18	0.29	0.36	0.42	0.62	0.92	1.01
Ca	0.81	0.87	0.92	2.64	1.43	1.99	1.26
Na	6.08	6.26	7.00	4.96	5.74	5.87	6.59
K	5.43	5.47	4.83	4.85	4.99	4.43	3.89
P	0.01	0.02	0.02	0.02	0.06	0.14	0.02
Ca+Mg	7.9	9.0	9.8	23.8	16.1	22.1	17.8
K	43.4	42.4	36.9	37.7	39.0	33.5	30.5
Na	48.7	48.5	53.4	38.5	44.9	44.4	51.7

Sample Descriptions:

14. Tuff of Calico Hills. Vitric nonwelded tuff in diagenetic Zone I.
15. Prow Pass Member, Crater Flat Tuff. Vitric nonwelded tuff in diagenetic Zone I.
16. Prow Pass Member, Crater Flat Tuff. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
17. Bullfrog Member, Crater Flat Tuff. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
18. Tram Member, Crater Flat Tuff. Clinoptilolite-bearing partially welded tuff in diagenetic Zone II.
19. Tram Member, Crater Flat Tuff. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
20. Tuff of Lithic Ridge. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.

APPENDIX A (cont)

Drill Hole USW G-3

Sample Number	21.	22.	23.	24.	25.
Depth (ft)	4008	4263	4568	4786	4869
SiO ₂	69.8	73.2	67.8	72.2	71.0
TiO ₂	0.34	0.26	0.43	0.26	0.23
Al ₂ O ₃	14.4	12.7	13.7	13.6	12.9
Fe ₂ O ₃	2.29	1.75	2.96	1.77	1.58
MnO	0.07	0.07	0.08	0.11	0.05
MgO	0.60	0.48	1.08	0.61	0.50
CaO	1.31	1.27	1.80	1.25	0.96
Na ₂ O	3.44	4.00	3.56	3.39	4.70
K ₂ O	4.85	3.55	2.40	4.23	2.57
P ₂ O ₅	0.09	0.05	0.11	0.05	0.04
LOI	1.83	2.61	5.25	2.41	4.11
Total	99.0	99.9	99.2	99.9	98.6
Cation Percent					
Si	67.1	70.3	67.7	69.3	69.8
Ti	0.25	0.19	0.32	0.19	0.17
Al	16.3	14.4	16.1	15.4	14.9
Fe+3	1.66	1.27	2.22	1.28	1.17
Mn	0.05	0.05	0.06	0.07	0.03
Mg	0.86	0.69	1.61	0.87	0.73
Ca	1.35	1.31	1.93	1.29	1.01
Na	6.41	7.45	6.89	6.31	8.95
K	5.95	4.35	3.06	5.18	3.22
P	0.07	0.04	0.09	0.04	0.03
Ca+Mg	15.2	14.5	26.2	15.8	12.5
K	40.8	31.5	22.7	38.0	23.1
Na	44.0	54.0	51.1	46.2	64.3

Sample Descriptions:

21. Tuff of Lithic Ridge. Alncime-bearing nonwelded tuff in diagenetic Zone III.
22. Tuff of Lithic Ridge. Alncime-bearing nonwelded tuff in diagenetic Zone III.
23. Tuff of Lithic Ridge. Alncime-bearing nonwelded tuff in diagenetic Zone III.
24. Older Tuff Sequence. Alncime-bearing nonwelded tuff in diagenetic Zone III.
25. Older Tuff Sequence. Alncime-bearing nonwelded tuff in diagenetic Zone III.

APPENDIX A (cont)

Drill Hole USW G-4

Sample Number	26.	27.	28.	29.	30.	31.	32.
Depth (ft)	1314	1470	1544	2131	2226	2716	2792
SiO ₂	70.2	69.5	69.3	65.1	66.4	67.7	68.3
TiO ₂	0.14	0.07	0.07	0.11	0.14	0.13	0.16
Al ₂ O ₃	16.7	10.9	11.3	13.0	13.1	12.2	11.6
Fe ₂ O ₃	1.44	0.90	0.96	1.33	1.45	1.24	1.32
MnO	0.09	0.05	0.04	0.02	0.05	0.04	0.03
MgO	0.90	0.05	0.06	0.17	0.25	0.20	0.24
CaO	3.51	0.89	0.84	2.62	2.43	2.57	2.94
Na ₂ O	1.90	2.53	2.85	2.46	2.15	2.81	2.68
K ₂ O	0.72	4.31	4.00	3.39	3.78	2.40	1.63
P ₂ O ₅	0.02	0.02	0.02	0.01	0.01	0.01	0.02
LOI	5.91	10.10	9.90	10.56	9.40	10.11	10.98
Total	101.5	99.3	99.4	98.8	99.2	99.5	99.9

Cation Percent

Si	69.6	73.5	72.9	69.5	69.8	71.5	72.7
Ti	0.10	0.06	0.06	0.09	0.11	0.10	0.13
Al	19.5	13.6	14.1	16.4	16.3	15.2	14.6
Fe+3	1.07	0.72	0.76	1.07	1.15	0.98	1.06
Mn	0.06	0.04	0.03	0.01	0.04	0.03	0.02
Mg	1.33	0.08	0.09	0.27	0.39	0.31	0.38
Ca	3.73	1.01	0.95	3.00	2.74	2.91	3.35
Na	3.65	5.19	5.81	5.09	4.38	5.75	5.53
K	0.91	5.82	5.36	4.62	5.07	3.23	2.21
P	0.02	0.02	0.02	0.01	0.01	0.01	0.02
Ca+Mg	52.6	9.0	8.5	25.2	24.9	26.4	32.5
K	9.5	48.1	43.9	35.6	40.3	26.5	19.3
Na	38.0	42.9	47.6	39.2	34.8	47.1	48.2

Sample Descriptions:

26. Topopah Spring Member, Paintbrush Tuff. Smectite- and clinoptilolite-bearing tuff at top of Topopah Spring vitrophyre in diagenetic Zone I.
27. Tuff of Calico Hills. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
28. Tuff of Calico Hills. Clinoptilolite- and mordenite-bearing nonwelded tuff in diagenetic Zone II.
29. Prow Pass Member, Crater Flat Tuff. Clinoptilolite- and mordenite-bearing nonwelded tuff in diagenetic Zone II.
30. Prow Pass Member, Crater Flat Tuff. Clinoptilolite- and mordenite-bearing nonwelded tuff in diagenetic Zone II.
31. Bullfrog Member, Crater Flat Tuff. Mordenite-bearing nonwelded tuff in diagenetic Zone II.
32. Tram Member, Crater Flat Tuff. Mordenite-bearing nonwelded tuff in diagenetic Zone II.

APPENDIX A (cont)

Drill Hole USW G-4

Sample Number	33.	34.	35.	36.	37.	38.	39.
Depth (ft)	1279	1323	1381	1505	1667	2087	2304
SiO ₂	74.0	69.1	72.9	73.2	72.1	71.3	70.9
TiO ₂	0.10	0.11	0.09	0.09	0.08	0.16	0.13
Al ₂ O ₃	12.4	13.4	11.3	12.1	11.3	12.6	12.3
Fe ₂ O ₃	1.07	1.13	1.04	1.02	1.00	1.67	1.55
MnO	0.08	0.05	0.05	0.03	0.05	0.08	0.05
MgO	0.31	0.94	0.49	0.20	0.12	0.54	0.41
CaO	0.66	3.22	3.09	2.46	2.67	1.93	2.62
Na ₂ O	3.40	1.23	1.64	1.29	1.47	1.92	1.69
K ₂ O	4.00	2.64	1.88	3.32	3.47	4.35	3.46
P ₂ O ₅	0.01	0.01	0.02	0.00	0.02	0.03	0.03
LOI	3.79	8.90	8.79	6.70	7.68	5.16	6.58
Total	99.8	100.7	101.3	100.4	99.9	99.7	99.8
Cation Percent							
Si	72.2	71.6	75.3	74.7	74.7	71.5	72.5
Ti	0.07	0.09	0.07	0.07	0.06	0.12	0.10
Al	14.3	16.3	13.8	14.5	13.7	14.8	14.8
Fe+3	0.79	0.88	0.81	0.78	0.78	1.26	1.19
Mn	0.05	0.04	0.04	0.02	0.04	0.06	0.04
Mg	0.45	1.45	0.75	0.30	0.19	0.81	0.62
Ca	0.69	3.58	3.42	2.69	2.96	2.07	2.87
Na	6.43	2.47	3.28	2.55	2.95	3.73	3.35
K	4.98	3.49	2.48	4.32	4.59	5.56	4.51
P	0.01	0.01	0.02	0.00	0.02	0.03	0.03
Ca+Mg	9.1	45.7	42.0	30.3	29.5	23.7	30.8
K	39.7	31.8	24.9	43.8	42.9	45.7	39.7
Na	51.2	22.5	33.1	25.9	27.6	30.7	29.5

Sample Descriptions:

33. Topopah Spring Member, Paintbrush Tuff. Vitric basal vitrophyre.
34. Topopah Spring Member, Paintbrush Tuff. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
35. Tuff of Calico Hills. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
36. Tuff of Calico Hills. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
37. Tuff of Calico Hills. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
38. Prow Pass Member, Crater Flat Tuff. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
39. Bullfrog Member, Crater Flat Tuff. Clinoptilolite- and mordenite(?) -bearing nonwelded tuff in diagenetic Zone II.

APPENDIX A (cont)

Drill Hole UE-25b#1(H)

Sample Number	40.	41.	42.	43.	44.	45.	46.
Depth (ft)	2832	2879	3393	3602	3767	3835	3963
SiO ₂	73.0	67.3	67.1	66.3	68.6	69.3	69.6
TiO ₂	0.12	0.25	0.37	0.53	0.48	0.47	0.34
Al ₂ O ₃	12.9	13.2	13.4	14.3	12.8	13.8	13.8
Fe ₂ O ₃	1.32	1.82	2.65	3.66	3.25	3.21	2.16
MnO	0.13	0.04	0.12	0.12	0.12	0.08	0.03
MgO	0.69	1.30	0.76	0.83	0.77	1.01	1.06
CaO	2.46	3.13	3.04	2.78	2.51	2.02	1.73
Na ₂ O	2.07	1.18	2.88	2.80	2.28	2.67	2.49
K ₂ O	2.96	3.75	3.50	3.60	3.51	3.34	3.18
P ₂ O ₅	0.03	0.09	0.11	0.18	0.16	0.17	0.07
LOI	4.53	7.24	4.43	4.10	3.63	3.34	4.98
Total	100.3	99.2	98.3	99.2	98.0	99.4	99.5
Cation Percent							
Si	72.4	69.5	67.2	65.8	69.0	68.2	69.5
Ti	0.09	0.19	0.28	0.40	0.36	0.35	0.26
Al	15.1	16.0	15.8	16.8	15.1	16.0	16.2
Fe+3	0.98	1.41	2.00	2.73	2.46	2.38	1.62
Mn	0.09	0.03	0.08	0.08	0.08	0.05	0.02
Mg	1.02	2.00	1.14	1.23	1.16	1.48	1.58
Ca	2.61	3.46	3.27	2.96	2.71	2.13	1.85
Na	3.98	2.36	5.60	5.39	4.45	5.09	4.82
K	3.74	4.94	4.48	4.56	4.51	4.19	4.05
P	0.03	0.08	0.09	0.15	0.14	0.14	0.06
Ca+Mg	32.0	42.8	30.4	29.6	30.1	28.0	27.9
K	33.0	38.7	30.9	32.3	35.2	32.5	32.9
Na	35.0	18.5	38.7	38.1	34.7	39.5	39.2

Sample Descriptions:

40. Bullfrog Member, Crater Flat Tuff. Mordenite- and clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
41. Bullfrog Member, Crater Flat Tuff. Mordenite- and clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
42. Tram Member, Crater Flat Tuff. Analcime- and calcite-bearing nonwelded tuff in diagenetic Zone III.
43. Tram Member, Crater Flat Tuff. Analcime- and calcite-bearing nonwelded tuff in diagenetic Zone III.
44. Tram Member, Crater Flat Tuff. Analcime-, calcite-, and kaolinite-bearing nonwelded tuff in diagenetic Zone III.
45. Tram Member, Crater Flat Tuff. Analcime- and calcite-bearing nonwelded tuff in diagenetic Zone III.
46. Tuff of Lithic Ridge. Analcime- and calcite-bearing nonwelded tuff in diagenetic Zone III.

APPENDIX A (cont)

Drill Hole UE-25p#1 Cuttings

Sample Number	47.	48.	49.	50.	51.	52.	53.	54.
Depth (ft)	1700-1710	1730-1740	1790-1800	2280-2290	2650-2660	2760-2770	3430-3440	3560-3570
SiO ₂	73.2	73.3	72.6	72.7	71.5	72.7	74.3	75.1
TiO ₂	0.11	0.12	0.14	0.17	0.32	0.28	0.17	0.1
Al ₂ O ₃	12.3	12.7	12.4	12.2	12.9	12.8	12.6	11.9
Fe ₂ O ₃	1.36	1.43	1.57	1.44	2.28	2.29	1.23	1.34
MnO	0.05	0.09	0.06	0.10	0.11	0.11	0.05	0.05
MgO	0.36	0.30	0.44	0.40	1.10	0.92	0.29	0.50
CaO	2.37	2.10	2.17	2.07	1.73	1.93	0.81	1.48
Na ₂ O	2.38	2.40	2.25	2.25	2.72	2.00	3.00	1.77
K ₂ O	2.70	2.91	2.28	4.25	4.43	3.34	5.22	5.07
P ₂ O ₅	0.02	0.02	0.03	0.03	0.10	0.03	0.03	0.03
LOI	6.83	6.15	5.34	4.11	2.74	3.23	1.99	1.78
Total	101.6	101.5	99.3	99.8	99.9	99.6	99.7	99.2
Cation Percent								
Si	73.2	72.9	73.5	72.0	69.3	71.7	71.4	73.2
Ti	0.08	0.09	0.11	0.13	0.23	0.21	0.12	0.13
Al	14.5	14.9	14.8	14.3	14.7	14.9	14.3	13.7
Fe+3	1.02	1.07	1.20	1.07	1.66	1.70	0.89	0.98
Mn	0.03	0.06	0.04	0.07	0.07	0.07	0.03	0.03
Mg	0.54	0.44	0.66	0.59	1.59	1.35	0.42	0.73
Ca	2.54	2.24	2.35	2.20	1.80	2.04	0.83	1.55
Na	4.62	4.63	4.41	4.32	5.11	3.82	5.59	3.35
K	3.45	3.69	2.94	5.37	5.48	4.20	6.40	6.30
P	0.02	0.02	0.03	0.03	0.08	0.03	0.02	0.02
Ca+Mg	27.6	24.4	29.1	22.3	24.2	29.7	9.4	19.1
K	30.9	33.6	28.4	43.0	39.2	36.8	48.3	52.9
Na	41.4	42.1	42.6	34.6	36.6	33.5	42.2	28.1

Sample Descriptions:

47. Prow Pass Member, Crater Flat Tuff. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
48. Prow Pass Member, Crater Flat Tuff. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
49. Prow Pass Member, Crater Flat Tuff. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
50. Bullfrog Member, Crater Flat Tuff. Analcime-bearing nonwelded tuff in diagenetic Zone III.
51. Bullfrog Member, Crater Flat Tuff. Analcime-bearing nonwelded tuff in diagenetic Zone III.
52. Bullfrog Member, Crater Flat Tuff. Analcime-bearing nonwelded tuff in diagenetic Zone III.
53. Older Tuff Sequence. Authigenic albite-bearing nonwelded tuff in diagenetic Zone IV.
54. Older Tuff Sequence. Authigenic albite-bearing nonwelded tuff in diagenetic Zone IV.

APPENDIX A (cont)

Drill Hole J-13

Sample Number	55.	56.	57.	58.	59.	60.	61.
Depth (ft)	1457	1519	1883	2001	2133	2982	2999
SiO ₂	69.6	69.5	75.2	70.1	75.3	74.8	70.0
TiO ₂	0.08	0.08	0.11	0.19	0.11	0.16	0.30
Al ₂ O ₃	10.6	12.1	12.6	13.9	12.6	12.2	12.4
Fe ₂ O ₃	0.94	1.01	1.44	1.67	1.44	1.41	2.18
MnO	0.05	0.04	0.10	0.02	0.09	0.05	0.10
MgO	0.50	0.39	0.11	0.14	0.23	0.21	0.51
CaO	1.96	1.87	0.68	0.41	0.75	0.89	2.52
Na ₂ O	0.88	1.22	3.91	5.55	4.02	3.70	2.55
K ₂ O	3.55	3.94	4.39	2.94	4.38	4.46	4.18
P ₂ O ₅	0.02	0.02	0.02	0.02	0.03	0.02	0.10
LOI	10.14	8.65	0.77	3.74	0.30	0.94	3.81
Total	98.3	98.9	99.3	98.7	99.3	98.8	98.6
Cation Percent							
Si	75.7	73.4	71.4	68.0	71.1	71.5	69.8
Ti	0.07	0.06	0.08	0.14	0.08	0.12	0.22
Al	13.6	15.1	14.1	15.9	14.0	13.8	14.5
Fe ⁺³	0.77	0.80	1.03	1.22	1.02	1.02	1.63
Mn	0.04	0.03	0.07	0.01	0.06	0.03	0.07
Mg	0.81	0.61	0.16	0.20	0.32	0.30	0.76
Ca	2.28	2.12	0.69	0.43	0.76	0.91	2.69
Na	1.85	2.50	7.19	10.44	7.36	6.86	4.93
K	4.92	5.31	5.31	3.64	5.27	5.44	5.31
P	0.02	0.02	0.02	0.02	0.02	0.02	0.08
Ca+Mg	31.3	25.9	6.3	4.3	7.9	9.0	25.2
K	49.9	50.4	39.8	24.7	38.5	40.3	38.8
Na	18.8	23.7	53.9	71.0	53.6	50.8	36.0

Sample Descriptions:

55. Tuff of Calico Hills. Clinoptilolite-bearing nonwelded tuff in Zone II.
56. Tuff of Calico Hills. Clinoptilolite-bearing nonwelded tuff in diagenetic Zone II.
57. Prow Pass Member, Crater Flat Tuff. Devitrified partially welded tuff.
58. Prow Pass Member, Crater Flat Tuff. Analcime-bearing nonwelded tuff in diagenetic Zone III.
59. Bullfrog Member, Crater Flat Tuff. Devitrified partially welded tuff.
60. Tram Member, Crater Flat Tuff. Authigenic albite-bearing nonwelded tuff in diagenetic Zone IV.
61. Tram Member, Crater Flat Tuff. Analcime- and authigenic albite-bearing nonwelded tuff in diagenetic Zone IV.

APPENDIX A (cont)

Outcrop Samples from Prow Pass, Northern Yucca Mountain^a

Sample Number	62.	63.
Field Number	3-15-82-5	3-15-82-9
SiO ₂	69.5	66.6
TiO ₂	0.08	0.10
Al ₂ O ₃	12.3	12.4
Fe ₂ O ₃	0.75	1.05
FeO	0.07	0.04
MnO	0.04	0.04
MgO	0.10	0.15
CaO	1.08	0.61
Na ₂ O	0.68	0.59
K ₂ O	6.57	7.81
P ₂ O ₅	0.01	0.01
LOI	8.42	10.04
Total	99.7	99.5

	Cation Percent	
Si	72.6	70.7
Ti	0.06	0.08
Al	15.2	15.6
Fe+3	0.59	0.84
Fe+2	0.06	0.04
Mn	0.03	0.03
Mg	0.16	0.24
Ca	1.21	0.69
Na	1.38	1.21
K	8.75	10.58
P	0.01	0.01
Ca+Mg	11.9	7.3
K	76.2	83.1
Na	12.0	9.5

Sample Descriptions:

62. Tuff of Calico Hills. Clinoptilolite- and mordenite-bearing nonwelded tuff in Zone II. Nevada State Coordinates 786500N, 551000E.
63. Tuff of Calico Hills. Clinoptilolite- and mordenite-bearing nonwelded tuff in Zone II. Nevada State Coordinates 786700N, 551400E.

^a These samples analyzed by atomic absorption spectrophotometry; J. Husler, analyst.

APPENDIX B

COMPARISON OF ANALYSES DETERMINED BY X-RAY FLUORESCENCE (XRF), ATOMIC ABSORPTION (AA), AND EMISSION SPECTROPHOTOMETRY (ES) FOR DRILL CORE SAMPLES FROM YUCCA MOUNTAIN, NEVADA

<u>Drill Hole USW GU-3 and USW G-3</u>								
Method	XRF	AA	XRF	AA	ES	XRF	ES	XRF
Depth (ft)	1986	1986	2577	2577	2577	3589	3589	3854
SiO ₂	68.3	67.9	66.3	66.5	66.2	66.5	66.5	69.4
TiO ₂	0.12	0.10	0.12	0.11	0.14	0.48	0.49	0.16
Al ₂ O ₃	11.3	12.4	12.9	13.6	12.8	13.8	13.8	12.4
Fe ₂ O ₃	1.35 ^a	1.20	1.32 ^a	1.17	1.31	2.85 ^a	2.59	1.33 ^a
FeO		0.03		0.03	0.01		0.26	
MnO	0.07	0.07	0.10	0.09	0.10	0.06	0.06	0.03
MgO	0.23	0.11	0.27	0.24	0.26	0.61	0.57	0.66
CaO	0.82	0.87	2.34	2.29	2.27	1.83	1.82	1.15
Na ₂ O	2.96	3.44	1.90	2.48	2.38	2.32	2.98	2.60
K ₂ O	3.61	3.72	3.61	3.68	3.75	3.42	3.65	2.98
P ₂ O ₅	0.02	0.02	0.02	0.02		0.16		0.02
LOI	10.32	10.20	9.83	9.60	10.39	6.86	7.23	8.05
Total	99.1	100.1	98.8	99.9	99.6	98.8	100.0	98.8
Trace Elements (ppm)								
Ba		233		367	330		705	
Sr		51		255	300		306	

<u>Drill Hole USW G-3</u>			
Method	ES	XRF	ES
Depth (ft)	3854	4869	4869
SiO ₂	69.2	71.0	71.7
TiO ₂	0.16	0.23	0.23
Al ₂ O ₃	12.6	12.9	13.1
Fe ₂ O ₃	0.81	1.58	0.97
FeO	0.46		0.57
MnO	0.02	0.05	0.06
MgO	0.49	0.50	0.50
CaO	1.10	0.96	1.04
Na ₂ O	3.32	3.62	4.70
K ₂ O	3.18	2.57	2.68
P ₂ O ₅		0.04	
LOI	8.40	4.11	4.26
Total	99.8	97.5	99.9
Trace Elements (ppm)			
Ba	1130		520
Sr	240		200

^aTotal iron, reported as Fe₂O₃.

APPENDIX B (cont)

Drill Hole USW G-4

Method	XRF	AA	ES	XRF	AA	ES	XRF	ES
Depth (ft)	1470	1470	1470	1544	1544	1544	2131	2131
SiO2	69.5	69.1	69.2	69.3	69.0	69.1	65.1	65.7
TiO2	0.07	0.09	0.08	0.07	0.07	0.06	0.11	0.12
Al2O3	10.9	11.6	11.2	11.3	11.9	11.5	13.0	13.2
Fe2O3	0.90 ^a	0.74	0.72	0.96 ^a	0.77	0.81	1.33 ^a	1.12
FeO		0.01	0.07		0.02	0.04		0.12
MnO	0.05	0.05	0.05	0.04	0.03	0.03	0.02	0.02
MgO	0.05	0.04	0.03	0.06	0.04	0.03	0.17	0.15
CaO	0.89	0.88	0.88	0.84	0.68	0.75	2.62	2.63
Na2O	2.18	2.54	2.53	2.38	2.87	2.82	1.96	2.46
K2O	4.31	4.50	4.40	4.00	4.13	4.10	3.39	3.52
P2O5	0.02	0.01		0.02	0.01		0.01	
LOI	10.10	10.15	10.82	9.90	9.79	10.56	10.56	11.08
Total	98.9	99.7	100.0	98.9	99.4	99.8	98.3	100.1

Trace Elements (ppm)

Ba	90	80	81	60	170
Sr	25	30	25	30	64

Drill Hole USW G-4

Method	XRF	AA	XRF	AA	ES	XRF	AA
Depth (ft)	2226	2226	2716	2716	2716	2792	2792
SiO2	66.4	66.7	67.7	67.8	67.8	68.3	67.9
TiO2	0.14	0.17	0.13	0.12	0.13	0.16	0.15
Al2O3	13.1	13.4	12.2	13.0	12.5	11.6	12.4
Fe2O3	1.45 ^a	1.33	1.24 ^a	0.98	1.29	1.32 ^a	1.04
FeO		0.00		0.07	0.14		0.13
MnO	0.05	0.04	0.04	0.04	0.04	0.03	0.03
MgO	0.25	0.22	0.20	0.11	0.19	0.24	0.18
CaO	2.43	2.46	2.57	2.60	2.70	2.94	2.93
Na2O	1.65	2.15	2.18	2.81	2.82	2.03	2.68
K2O	3.78	3.92	2.40	2.47	2.55	1.63	1.68
P2O5	0.01	0.02	0.01	0.02		0.02	0.03
LOI	9.40	9.27	10.11	10.08	10.20	10.98	10.93
Total	98.7	99.7	98.8	100.2	100.4	99.3	100.1

Trace Elements (ppm)

Ba	269	349	350	564
Sr	153	102	122	170

APPENDIX B (cont)

Drill Hole J-13

Method	XRF	AA	XRF	AA	ES	XRF	AA
Depth (ft)	1457	1457	1519	1519	1519	2001	2001
SiO ₂	69.6	70.3	69.5	70.0	70.0	70.1	70.5
TiO ₂	0.08	0.08	0.08	0.09	0.08	0.19	0.19
Al ₂ O ₃	10.6	11.3	12.1	12.8	12.2	13.9	14.8
Fe ₂ O ₃	0.94 ^a	0.70	1.01 ^a	0.83	0.74	1.67 ^a	1.53
FeO		0.08		0.04	0.14		0.03
MnO	0.05	0.06	0.04	0.05	0.04	0.02	0.02
MgO	0.50	0.52	0.39	0.38	0.37	0.14	0.18
CaO	1.96	1.93	1.87	1.86	1.86	0.41	0.38
Na ₂ O	0.77	0.88	1.04	1.26	1.18	4.88	5.55
K ₂ O	3.55	3.68	3.94	4.14	4.13	2.94	3.02
P ₂ O ₅	0.02	0.01	0.02	0.01		0.02	0.02
LOI	10.14	10.20	8.65	8.58	9.29	3.74	3.92
Total	98.3	99.7	98.7	100.1	100.0	98.0	100.5

Trace Elements (ppm)

Ba	72	134	120	340
Sr	17	51	60	68

Drill Hole UE-25b/1(H)

Method	XRF	ES
Depth (ft)	2879	2879
SiO ₂	67.3	66.9
TiO ₂	0.25	0.26
Al ₂ O ₃	13.2	13.2
Fe ₂ O ₃	1.82 ^a	1.48
FeO		0.24
MnO	0.04	0.04
MgO	1.30	1.32
CaO	3.13	3.24
Na ₂ O	1.05	1.18
K ₂ O	3.75	3.90
P ₂ O ₅	0.09	
LOI	7.24	7.86
Total	99.1	99.7

Trace Elements (ppm)

Ba	1040
Sr	1060

APPENDIX C

MAJOR- AND TRACE-ELEMENT CONCENTRATIONS DETERMINED BY NEUTRON ACTIVATION ANALYSIS IN WHOLE-ROCK SAMPLES FROM DRILL CORE IN DRILL HOLES USW G-1, USW G-2, USW GU-3, AND FROM TUFF OF CALICO HILLS SAMPLES COLLECTED IN OUTCROP AT PROW PASS, NORTHERN YUCCA MOUNTAIN

All elemental concentrations in parts per million (ppm) by weight; values in parenthesis are $\pm 2\sigma$ analytical uncertainties in percent. Stratigraphic unit symbols defined in Table 1. Sample lithology: 1) nonwelded to moderately welded vitric tuff, 2) moderately densely welded devitrified tuff, 3) unaltered vitrophyre, 4) smectite- and zeolite-rich vitrophyric tuff, 5) smectite- and zeolite-rich nonwelded tuff, 6) nonwelded to partially welded zeolite-rich tuff, 7) devitrified flow breccia or lava, 8) flow breccia or lava with smectite or zeolite alteration, 9) unaltered vitrophyric lava.

USW G-1

Depth (ft)	1191	1240	1286	1319	1341	1357	1392	1436	1492	1561	1639	1693	1748	1774
Unit	Tpt	Tpt	Tot	Tpt	Tpt	Tpt	Tpt	Tht	Tht	Tht	Tht	Tht	Tht	Tht
Sample Lithology	2	2	4	3	3	1	1	6	6	6	6	6	6	6
Al	68700	68400	87300	66700	65800	68500	63300	60800	61100	61100	66100	6290 ⁺	52300	67000
Au	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12		<0.12	<0.36	<0.12	<0.12	<0.12	<0.12
Ba	<360	<380	<290	<400	<380	<390	<350		<300	<390	<330	<230	160	650
Ca	2800	3800	16100	4000	4100	5000	6200	5000	3900	4900	3900	4800	4800	9100
Ce	74	74	120	74	77	99	77	42	46	85	49	94	45	85
Cl	<210	<240	<170	570	460	280	290		<230	<240	<220	<180	<220	<240
Co	<1.6	<0.67	<2.1	<0.66	<1.8	<2.4	<0.60		<0.66	<2.4	<0.74	<1.8	<2.1	2.0
Cr	<13	1.0(60)	<13	<13	<13	<16	<16	1.2(99)	<13	<16	1.0(60)	<13	<13	<16
Cs	4.5	3.75(8)	8.5	5.8(11)	7.6	10.0	11.3(9)	8.6(21)	6.7(10)	6.9	5.1(10)	6.0	5.1	4.9
Dy	4.7	4.9	5.2	5.2	5.0	4.1	6.0	3.2	4.0	5.0	3.9	6.4	1.5	4.4
Eu		0.30(15)		0.21(23)			0.30(17)	0.11(73)	0.26(17)		0.22(17)			
Fe	6300	6800(10)	8900	6300(24)	6200	6800	7200(20)	5800(13)	5700(23)	6000	6900(11)	6000	6500	9900
Hf	4.3	5.3	7.5	4.3	4.3	4.3	6.4	4.5(22)	4.3	3.2	5.3	3.2	3.2	3.2
K	37100	36400	9030	33500	32200	31100	33000		31300	34500	30600	36800	23700	27300
La	35	41	52	30	32	47	30	24	27	33	31	44	27	37
Lu	0.37	0.48	0.61	0.37	0.37	0.37	0.48		0.37	0.60	0.24	0.48	0.11	0.48
Mg	<5800	420	5600	<7300	<6300	<6400	<5900	<180	<5900	<6700	<180	<4700	<5700	<6600
Mn	490	490	500	470	490	520	540	330	196	270	250	104	126	620
Na	22800	25900	10100	26000	26100	24000	20000	22900	21500	22100	22500	19800	19100	22400
Rb	195	184	<52	154	160	187	176		193	157	157	194	166	131
Sb	<1.5	<1.5	<4.3	<4.3	<1.5	<4.3	<4.3		<4.3	<4.3	<4.3	<1.5	<1.5	<4.3
Sc	2.3	2.42(9)	3.4	2.34(11)	2.2	2.3	2.84(9)		2.33(9)	2.4	2.48(9)	2.4	2.1	2.6
Sm	5.6	6.0(20)	<8.2	<6.7	5.2	4.9	<7.1	3.6(22)	<5.8	5.8	5.6(22)	8.1	<4.6	<5.5
Sr	<67 ⁺	43	1650	<760	<720	<720	<660	43	<550	<720	54	<420	<510	<800
Ta	<1.7	3.1(50)	2.2	<1.5	1.1(100)	<5	2.1(48)		2.55(31)	<5	<1.4	1.1(100)	<1.7	<1.7
Tb	<2.3	<1.6	<2.3	<1.6	<2.3	<2.3	<1.7		<1.7	<2.3	<1.7	<2.3	<2.3	<2.3
Th	24.7	25.2	35.1	22.8	24.4	27.0	27.7	22	24.9	28.0	22.8	29.2	19.5	18.1
Ti	<1700	600	860	<1900	<1800	<1800	<1600	450	<1400	<1800	430	410	<1300	980
U	4.18	4.50	1.37	4.70	4.52	4.05	3.46	4.7(21)	3.69	3.87	4.01	4.48	4.28	4.59
V	<18	<19	<16	<22	<19	<20	<19		<17	<18	<17	<13	<15	<21
Yb	2.9	3.5(29)	3.3	3.3	2.3	2.8	3.4	1.7(35)	2.3	4.5	2.6(31)	3.5	1.3	2.6
Zn		37(53)		37(69)			47(48)		35(69)		26(98)			

APPENDIX C (cont)

USW G-1

Depth (ft)	1820	1942	1983	2041	2083	2136	2173	2233	2247	2291	2318	2436	2486	2555
Unit	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb
Sample Lithology	6	2	2	6	6	6	6	6	6	6	6	2	2	6
Al...	66400	72700	70800	65600	62700	64100	73000	70300	72000	67700	93600	69600	72200	66700
Au	<0.12	<0.12		<0.12	<0.12	<0.12	<0.12	<0.12	0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Ba	<430	<640		<320	190	<430	500	560	540	440	700	410	350	420
Ca	7000	<5200	3400	6100	5100	5100	6400	7200	7700	15000	7600	<3500	4400	9000
Ce	87	122	77	66	88	79	138	114	139	109	127	93	98	89
Cl	<260	<380		<250	<220	<270	<240	<260	<280	<300	<290	<290	<270	<230
Co	2.0	<2.0		<2.0	<2.0	<2.2	<2.8		<2.2	<2.8	<0.63	<2.0	<0.60	<2.2
Cr	<18	<15	4.5	<15	<15	<18	<18	3.4	<15	<15	<15	<15	3.6	<15
Cs	7.0	1.6	4.0	5.1	5.4	5.4	3.6	3.7	5.3	3.4	0.66(44)	3.2	4.6	5.9
Dy	4.7	7.9	6.6	4.1	4.4	2.7	4.6	4.8	4.0	6.9	4.8	5.1	5.3	5.3
Eu			0.33					0.51			0.68(13)		0.52	
Fe	9200	8500	9500	9600	8100	9400	13200	9700	10400	8900	11600	8900	9900	7800
Hf	6.4	6.4	7.5	6.4	5.4	6.4	6.4	7.2	6.4	5.4	10.2	5.4	7.3	4.3
K	29900	36400		30400	27900	26700	46900	41900	36600	17700	50400	37800	34000	19900
La	68	51	51	38	38	34	83	59	70	77	71	48	58	38
Lu	0.38	0.63		0.38	0.51	0.25	0.38	0.45	0.38	0.51	0.38	0.63	0.63	0.51
Mg	<6900	<9300	180	<6700	<6300	<7200	<6200	<180	<7300	<7600	<7300	<8100	<180	<7400
Mn	440	1890	260	125	138	420	274	490	1040	610	283	840	620	320
Na	22000	28600	24800	25300	24300	24500	20600	21000	21800	25700	25900	25400	29700	28000
Rb	155	134	148	156	137	159	170	152	190	81	118	187	174	97
Sb	<4.3	4.3		<1.5	<1.5	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<1.5
Sc	1.7	1.8		1.8	1.4	1.8	2.8	1.09	1.2	1.2	1.36	1.0	1.90	0.9
Sm	10.3	7.7	6.6	6.1	6.5	5.5	7.6	7.6	8.8	8.7	8.3	7.4	6.3	5.2
Sr	<770	<1300	48	<580	<600	<780	<620	120	<940	<860	<690	<1000	100	<720
Ta	<5	<5		<5	<5	<5	<5	<3.2	<5	<5	3.0(38)	<1.7	2.2	<1.7
Tb	<2.3	<2.3		<2.3	<2.3	<2.3	<2.3	<2.0	<2.3	<2.3	<1.7	<2.3	<1.5	<2.3
Th	23.1	21.9	22	21.3	20.5	22.2	19.2	22.1	25.5	22.7	29.3	21.9	22.5	18.6
Ti	<1900	<3100	840	<1500	700	<1900	1400	980	<2300	1100	1340	<2500	880	<1800
U	4.33	4.57	3.1	2.75	3.48	2.65	2.17	3.20	3.07	3.68	4.08	4.86	4.09	3.71
V	<21	<35		<18	<16	<21	<18	<22	<25	<24	<22	<26	<22	<21
Yb	3.4	3.8	4.5	2.3	2.7	2.4	2.7	3.2	3.7	3.7	2.4	4.6	4.4	3.2
Zn								<120			79(34)		76(31)	
Zr														

APPENDIX C (cont)

USW G-1

Depth (ft)	2601	2641.5	2869	2966	3001	3053	3137	3197	3258	3321	3372	3433	3501
Unit	Tcb	Tct	Tct	Tct	Tct	Tct	Tct	Tct	Tct	Tct	Tct	Tct	Tct
Sample Lithology	4	6	2	2	2	6	5	5	5	5	5	5	5
Al	65000	73500	69900	75000	69000	69200	81500	69200	71700	70500	77300	81800	73000
Au	<0.12	<0.36	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.36	<0.36	<0.12
Ba	470	1050	570	810	570	1050	770	880	900	830	770	900	750
Ca	8200	8400	5200	8800	6300	11700	14600	9400	15000	6700	12200	14900	9200
Ce	87	255	103	140	117	147	105	96	101	90	101	99	105
Cl	<300	<220	<260	<230	<250	<250	<220	<190	<230	<180	130	<190	<210
Co	<2.0	1.7(26)	1.9	2.5	1.67	3.3	7.4	4.8	4.0	3.9	6.6	6.4	7.2
Cr	<12	<21	<12	<15	3.0	<15	27	9	4.9	<15	11	23	15
Cs	9.2	2.9(18)	6.4	3.1	1.86	8.6	7.0	4.9	4.0	7.3	11.4(13)	10.4	8.0
Dy	3.3	5.6	3.0	5.4	3.9	3.6	5.9	3.3	3.9	3.5	3.3	4.6	3.9
Eu		1.01(12)			0.59				1.11		1.33(12)		1.18
Fe	10200	14000	9700	12300	9100	15700	24900	20300	18100	14700	25000	29300	25100
Hf	5.4	8.7	5.4	5.4	5.9	5.4	5.4	5.4	6.0	4.3	6.2	6.4	5.8
K	15400	48500	34900	42100	39700	28800	27800	21200	27100	30900	29400	25700	28100
La	46	143	61	76	64	74	56	55	55	40	66	52	58
Lu	0.38	0.38	0.38	0.51	0.38	0.38	0.51	0.25	0.38	0.38	0.38	0.51	0.38
Mg	<7500	<6100	<6700	<5800	1200	<6800	4500	4300	3400	4200	4900	6600	5800
Mn	278	360	940	410	500	580	490	253	430	193	510	284	500
Na	34100	18600	24200	23000	21600	25300	24000	22300	21700	19300	22000	20300	16400
Rb	145	163	145	170	99	101	122	125	118	133	111	107	130
Sb	<1.5	<4.3	<1.5	<4.3	<1.5	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3
Sc	1.1	2.57	2.2	3.2	2.43	2.7	6.3	4.7	4.31	3.8	6.72	9.3	6.94
Sm	6.2	12.8	6.1	8.8	5.6	8.5	10.0	6.4	5.6	5.7	6.7	7.6	5.4
Sr	<700	<710	<820	<610	130	<810	460	270	320	<520	<640	460	250
Ta	1.1	<2.6	<1.7	<1.7	1.1	<5	<5	<1.7	<1.4	1.1	<2.9	<5	<2.8
Tb	<2.3	0.65(53)	<2.3	<2.3	<1.6	<2.3	<2.3	<2.3	0.77(47)	<2.3	<1.9	<2.3	<1.9
Th	22.3	25.4	20.0	25.1	23.7	20.0	17.4	18.5	18.9	20.1	19.5	17.5	17.2
Ti	<1700	1700	<2000	1600	1140	1900	3200	2160	2120	1440	2660	3700	2800
U	3.22	4.22	4.01	4.25	4.14	3.76	2.52	1.51	3.38	3.12	3.17	3.02	3.16
V	<21	13	<22	16	<19	22	57	33	37	22	52	71	61
Yb	2.2	3.8	2.4	2.8	3.0	2.5	3.6	2.5	2.7	2.7	2.7	2.5	2.5
Zn		46(46)			<110				47(34)		92(28)		62(36)
Zr													

APPENDIX C (cont)

USW G-1

Depth (ft)	3549	3598	3659	3706	3755	3810	3850	3914	3954	3997	4052	4095	4208
Unit	Tct	Tfb	Tfb	Tfb	Tfb	Tfb	Tfb	Tfb	Tlr	Tlr	Tlr	Tlr	Tlr
Sample Lithology	4	7	8	8	8	8	8	8	5	6	6	6	6
Al	79300	78500	84100(5)	96500	81300	95500	84400	101000	80600	78800	76400	76200	72600
Au	<0.36	<0.36	0.0030(90)	<0.36	<0.36	<0.36	<0.36	<0.36	<0.12	<0.36	<0.12	<0.12	<0.12
Ba	390	1380	1380(5)	1160	2700	910	1330	1680	1760	1370	1040	970	960
Ca	3500	21400	21900(8)	25500	25200	32200	29600	31800	9800	9900	12300	7400	9200
Ce	110	130	129(5)	147	132	156	146	162	161	154	125	125	110
Cl	<260	<210	<200	<190	<270	<230	<280	<270	<240	<260	<310	<250	<260
Co	0.76(47)	3.2	4.1(6)	5.9	4.8	7.1(10)	6.0	7.2	2.4	2.7	2.4	3.0	3.9(11)
Cr	<21	<19	2.6(45)	<19	<19	5.4(63)	<22	<22	<19	<19	<16	<13	4.8(33)
Cs	48(13)	3.9	2.9(9)	3.4	3.9	4.2(10)	7.4	2.3	10.6	10.4	5.3	6.5	3.04(11)
Dy	5.8	4.9	5.2(15)	5.6	5.5	6.3	4.1	5.8	5.4	5.2	4.8	5.5	4.5
Eu	0.61(15)		2.06(5)			2.84(10)							1.20(11)
Fe	11100	20300	21000(5)	27600	27200	47800(6)	28200	39800	14600	18700	14700	13100	16500(8)
Hf	6.4	8.6	7.5(5)	9.7	7.5	13.2	8.6	10.7	8.6	7.5	6.4	6.4	6.8
K	22500	24700	33600(15)	27600	27400	3900	11900	9700	41100	28700	25100	28400	30200
La	52	73	65(7)	79	73	80	74	85	94	79	71	64	63
Lu	0.51	0.49	0.41(6)	0.37	0.48	0.37	0.48	0.48	0.48	0.60	0.37	0.37	0.37
Mg	<7500	<5500	2700(45)	9300	4600	15400	6000	9300	5300	<7100	<7600	3500	3300
Mn	122	310	515(6)	193	660	340	1040	720	270	410	650	400	400
Na	31800	25100	26300(4)	21900	25200	24700	26400	29400	18400	32400	30300	32500	25600
Rb	118	129	114(6)	170	79	<92	65	47	177	103	118	119	136
Sb	<4.3	<4.3	0.25(51)	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<1.5	<4.3
Sc	2.57	8.8	8.1(6)	10.1	9.0	11.5(8)	10.6	11.9	2.7	2.9	2.7	2.8	4.1(8)
Sm	7.4	8.1	10.2(7)	9.1	8.9	9.1(20)	9.6	9.7	7.7	9.1	4.6	3.4	4.8(21)
Sr	<710	<520	570(33)	670	560	870	750	800	410	<740	<810	<620	230
Ta	<3.4	<5	0.81(13)	<5	<5	<3.0	<5	<5	<5	<5	<5	<1.7	2.9(45)
Tb	<1.9	<2.3	1.05(11)	<2.3	<2.3	<1.7	<2.3	<2.3	<2.3	<2.3	<2.3	2.3	<1.8
Th	28.5	14.9	15.3(4)	18.6	15.3	17.8	15.5	19.6	18.5	17.3	19.0	18.9	17.6
Ti	<1800	4300	4400(11)	5500	4100	5500	4500	5500	2310	2220	1420	1400	2070
U	4.07	2.66	2.88(6)	4.51	2.82	3.43	4.08	3.69	4.21	3.27	2.97	4.71	2.85
V	<19	37	40(12)	52	43	53	47	60	16	30	22	22	39
Yb	3.7	3.3	2.70(5)	2.2	4.1	3.1(32)	4.1	4.5	3.9	3.4	2.9	3.2	2.4(33)
Zn	<92		114(14)			116(25)							89(27)
Zr			275(19)										

APPENDIX C (cont)

Depth (ft)	USW G-1										
	4296	4401	4451	4504	4612	4652	4700	4750	4805	4848	4913
Unit	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr
Sample Lithology	6	5	6	6	6	6	6	6	6	6	6
Al	74300	77500	68700	70600	73000	73400	71300	70500	73300	72100	67900
Au	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Ba	780	770	850	690	810	750	760	850	930	840	720
Ca	7400	9700	8800	7600	7100	7000	6000	6500	9700	7100	7600
Ce	110	99	98	88	106	109	107	101	126	124	92
Cl	<240	<220	<230	<240	<220	<210	<190	<230	<220	<200	<180
Co	2.3	2.6	1.5	2.3	3.3	2.8	2.7(13)	2.9	2.3	2.9	2.1
Cr	<16	<13	<13	<13	<16	<16	4.2(38)	<13	<16	<16	<13
Cs	4.6	3.2	5.7	4.7	4.7	4.3	3.67(10)	4.1	4.1	4.6	3.8
Oy	3.8	3.5	3.8	3.8	3.9	3.6	3.7	3.7	4.3	4.6	3.9
Eu							0.81(11)				
Fe	12900	12100	9600	12000	15000	13500	12100(8)	14000	12100	13200	11200
Hf	5.4	6.4	5.4	5.4	5.4	5.4	6.0	6.4	5.4	6.4	5.4
K	33800	34100	26500	31900	31700	32300	35600	33600	34000	35300	38100
La	54	57	54	54	54	63	56	56	63	73	53
Lu	0.49	0.37	0.37	0.38	0.37	0.37	0.37	0.37	0.37	0.37	0.48
Mg	5100	3900	<5900	3700	5300	<5400	3300	3600	4300	3600	4000
Mn	520	380	320	350	340	390	300	330	410	320	380
Na	26700	26000	31100	24400	24300	22000	21400	21600	21400	21800	14200
Rb	129	125	117	113	115	155	171	146	135	145	168
Sb	<4.3	<1.5	<1.5	<1.5	<4.3	<4.3	<1.5	<1.5	<4.3	<4.3	<1.5
Sc	2.7	2.7	2.0	2.7	3.0	3.1	2.75(9)	2.7	2.3	3.0	2.0
Sm	4.0	3.8	3.1	3.4	4.5	4.1	4.5(22)	4.0	5.3	4.4	3.0
Sr	<690	<620	<580	<610	300	<600	220	<600	<670	<560	<540
Ta	<1.7	<1.7	<1.7	1.1(100)	<1.7	2.2	1.1(100)	<1.7	<1.7	1.1(100)	<1.7
Tb	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<1.7	<2.3	<2.3	<2.3	<2.3
Th	19.4	17.8	17.4	17.6	16.7	20.0	18.7	18.1	19.9	21.5	19.9
Ti	1220	1590	1130	1710	1840	1360	1560	1510	1340	1210	1540
U	2.61	2.95	3.07	1.69	2.57	2.80	3.06	2.89	2.67	2.99	2.93
V	16	21	16	19	29	17	20	17	18	18	13
Yb	2.7	2.7	2.1	2.9	2.6	3.1	2.2(36)	2.3	3.8	2.8	3.6
Zn							49(43)				
Zr							260(62)				

APPENDIX C (cont)

USW G-1

Depth (ft)	4958	4998	5049	5094	5167	5213	5252	5296	5413
Unit ^a	Tot(a)	Tot(a)	Tot(a)	Tot(a)	Tot(a)	Tot(a)	Tot(a)	Tot(a)	Tot(b)
Sample Lithology	6	5	5	2	6	6	6	6	6
Al	64400	72000	124000	69300	70100	75000	74500	71300	67700
Au	<0.12	<0.12	<0.36	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Ba	460	560	1820	790	890	840	690	860	1000
Ca	4600	11900	10500	9900	5700	5300	9000	6500	5900
Ce	107	113	202	104	109	120	116	125	109
Cl	<260	<190	<240	<230	<210	<240	<220	<240	<190
Co	1.0	0.93(26)	4.1(11)		1.1	1.3	1.4	1.17(19)	1.6
Cr	<13	<13	<19	3.3(49)	<13	<13	<13	3.9(72)	<13
Cs	6.8	1.47(14)	1.08(35)	1.0(40)	3.2	5.0	5.9	8.5(12)	6.0
Dy	4.1	4.7	5.2	4.5	4.1	3.9	4.6	4.4	3.7
Eu		0.70(12)	1.05(12)	0.68				0.84(11)	
Fe	9000	11000(14)	24700(12)	10200	9900	11500	9700	10200(10)	11000
Hf	5.4	5.9	10.8	5.9(20)	5.4	6.4	5.3	6.2	5.4
K	27500	19100	41400	43300	38200	31300	34800	32300	31200
La	65	55	98	54	57	70	70	64	59
Lu	0.49	0.49	0.59	0.60	0.37	0.37	0.42	0.48	0.37
Mg	3700	7400	14900	2300	<5800	<6400	<5700	720	4600
Mn	550	650	1350	640	360	400	520	440	287
Na	23200	12500	12000	17900	22900	30300	30800	30600	20100
Rb	113	79	328	157	153	146	170	140	141
Sb	<4.3	<1.5	<4.3	<4.3	<1.5	<1.5	<1.5	<4.3	<1.5
Sc	1.3	1.59(9)	5.9(8)	1.56	1.6	1.9	1.5	1.85(10)	1.4
Sm	4.7	5.4	<12	4.1	5.6	4.2	3.8	4.8(21)	3.9
Sr	<690	<720	<980	220	<630	<660	<660	190	<540
Ta	1.1(100)	2.09(25)	2.61(26)	2.24(37)	<1.7	1.1(100)	<1.7	<1.5	<1.7
Tb	<2.3	<1.5	<1.9	<2.0	<2.3	<2.3	<2.3	<1.6	
Th	20.1	19.0	54.0	17.5	17.4	21.8	18.6	18.5	18.7
Ti	1160	1490	<2400	1220	1070	1320	1100	1260	800
U	1.71	2.64	8.63	4.56	3.61	4.11	3.56	2.75	3.07
V	<20	<18	34	<20	11	13	<19	19	8.6
Yb	3.5	3.0	4.3	3.7	2.9	2.9	2.8	3.2(31)	3.4
Zn		58(30)	235(20)	49(47)				59(38)	
Zr		210(55)							

^a Letters in parentheses indicate subunits with the sequence of older tuffs and lavas identified in drill hole USW G-1 by Spengler et al. (1981). Thus far, these subunits have not been correlated to equivalent units in other Yucca Mountain drill holes.

APPENDIX C (cont)

USW G-1

Depth (ft)	5458	5499	5560	5596	5637	5699	5747	5803	5848	5898	5948	5980
Unit ^a	Tot(c)	Tot(c)	Tot(c)	Tot(c)	Tot(c)	Tot(c)	Tot(c)	Tot(c)	Tot(c)	Tot(c)	Tot(c)	Tot(c)
Sample Lithology	5	6	5	6	6	6	6	2	2	2	6	5
Al	83500	72800	81200	82700	77900	88500	85000	85900	84800	112000	85900	88400
Au	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.36	<0.12	<0.12
Ba	1960	1210	3120	1740	1450	1570	1710	1570	1950	1130	1530	1800
Ca	14400	12100	21000	18500	15200	21200	17000	27500	14600	20000	19100	22100
Ce	125	115	118	101	119	117	134	119	121	148	113	121
Cl	<200	<260	<230	<260	<250	<240	<240	<300	<270	<250	<270	<300
Co	2.35(12)	2.3	4.0	3.7	3.6(11)	6.0	5.8	4.4(10)	6.8	5.2	8.2(10)	7.3(10)
Cr	<16	<13	<16	<13	5.5(40)	<16	<13	<16	<16	<22	<16	8
Cs	7.9(9)	9.7	2.2	6.4	9.2	3.8	6.0	1.24(28)	1.8	9.9	10.4(10)	1.48(30)
Dy	6.0	2.6	3.2	1.9	3.1	2.1	3.7	3.5	3.0	4.2	4.1	4.2
Eu	1.21(12)				1.28			1.41(12)			1.40(12)	1.75(12)
Fe	19200(12)	14100	19600	18600	18200	23200	23200	20300(12)	24200	23900	24800(13)	28400(12)
Hf	11.9	6.4	6.4	6.4	8.0	7.5	7.5		7.5	8.6	7.7	
K	20900	25700	22400	23500	25200	24900	25400	17900	22200	31400	17700	23400
La	75	74	60	63	69	78	80	83	65	96	66	71
Lu	0.48	0.25	0.38	0.25	0.33	0.25	0.37	0.25	0.37	0.38	0.38	0.37
Mg	11300	5400	6100	5900	5200	5700	7100	2900	9300	9300	7800	10300
Mn	510	420	690	630	517	640	550	630	550	590	780	560
Na	18900	27000	20800	31600	33700	29800	28600	32300	33000	19500	33100	31200
Rb	145	120	118	124	125	133	145	113	134	318	128	136
Sb	<4.3	<4.3	<4.3	<4.3	<1.5	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3	<4.3
Sc	3.06(8)	2.3	3.0	2.7	3.0	4.4	4.5	3.64(8)	4.2	4.3	5.8(8)	6.6(8)
Sm	6.6	4.0	5.0	3.9	4.5	4.9	4.9	4.7	5.5	5.7	5.4	5.9
Sr	650	440	1420	<750	360	860	600	630	560	580	610	710
Ta	1.9(38)	<1.7	<1.7	<1.7	<1.5	<5	<1.7	<1.5	<1.7	<5	1.1(100)	<2.8
Tb	<1.6	<2.3	<2.3	<2.3	<1.5	<2.3	<2.3	<1.8	<2.3	<2.3	<1.8	<1.8
Th	21.0	17.4	17.7	13.4	17.2	14.7	17.1	14.7	13.9	24.0	15.7	14.5
Ti	2020	1620	2860	1280	2200	2290	2440	2950	2960	3090	2640	3140
U	3.24	2.27	2.16	2.11	2.88	2.39	2.56	2.52	3.06	1.57	2.10	2.50
V	18	19	33	30	33	45	40	39	47	53	60	56
Yb	3.2	2.3	2.9	2.4	2.3	2.4	2.3	2.2	2.4	3.9	3.0	2.3
Zn	99(26)				63(69)			57(35)			<35	

^a Letters in parentheses indicate subunits with the sequence of older tuffs and lavas identified in drill hole USW G-1 by Spengler et al. (1981). Thus far, these subunits have not been correlated to equivalent units in other Yucca Mountain drill holes.

APPENDIX C (cont)

	USW G-2			USW GU-3		Tuff of Calico Hills in outcrop, Prow Pass, northern Yucca Mountain ^a		
	547	675	1691	1322	1498	3-15-82-5	3-15-82-9	RWG2a-1
Depth	Top	Top	Top	Top	Top	Top	Top	Top
Unit	Top	Top	Top	Top	Top	Top	Top	Top
Sample	1	5	6	1	1	6	6	9
Lithology	1	5	6	1	1	6	6	9
Al	75000	85000	62000	68000	66000	65000	61000	63000
Au	<0.02	<0.02	0.06(15)	<0.02	<0.02	<0.01	<0.01	<0.02
Ba	1750	2150	<140	<200	235	330	160	355
Ca	9000	16000	16000	3200	6000	8000	4600	5200
Ce	161	185	35	76	106	53	73	81
Cl	260	<110	<90	580	840	<70	<60	330
Co								
Cr	<2	4	<2	<2	6	<2	4.3	<2
Cs	4.5	6.8	11.1	6.2	3.7	6.6	3.8	5.5
Dy	6.2	8.3	3.5	5.2	7.5	4.2	3.6	4.7
Eu	1.50	1.92	0.24	0.24	0.24	0.25	0.27	0.33
Fe	10400	12100	6100	6100	8500	5700	7500	6500
HF	8.3	9.1	4.2	4.6	6.2	3.6	4.1	3.2
K	34000	21500	29500	44000	40500	55000	66500	45000
La	87	116	23.9	43	68	30.3	37	44
Lu	0.50	0.49	0.17	0.5	0.8	0.30	0.24	0.67
Mg	8000	9000	<2000	<3000	3000	<1000	2000	<2000
Mn	620	680	141	520	560	290	260	380
Na	26150	10000	8300	27000	25350	4600	3805	17450
Rb	141	87	161	188	160	220	196	206
Sb	<0.8	<1.0			<0.5	<0.4	<0.4	<0.6
Sc	4.2	4.8	2.3	2.3	1.8	2.5	2.8	2.5
Sm	10.1	12.2	4.6	<7	9.5	5.0	5.2	5.2
Sr	290	1600	<100	<300	<300	<200	<200	<200
Ta								
Tb	0.5	0.7	0.29	0.5	0.7	0.19	0.34	0.5
Th	22.3	26	24	24.3	21.3	23.1	20.9	26.0
Ti	2100	2100	<600	<700	1000	<500	800	<500
U	3.2	1.54	2.44	4.6	4.2	3.02	2.61	4.6
V	12	21	<6	<7	<8	<5	<6	<6
Yb	3.8	4.4	<2.4	2.9	3.4	2.3	1.8	2.3
Zn								
Zr	430	380	<300	260	<300	<100	<100	<100

^aNevada State Coordinates (ft) for sample locations: 3-15-82-5=786500N, 551000E; 3-15-82-9=786700N, 551400E; RWG2a-1=787400N, 553250E.

APPENDIX D

ANALYTICAL VALUES FOR NBS STANDARDS
BY AUTOMATED NEUTRON ACTIVATION ANALYSIS

Values are from Tables 1 and 2 of Garcia et al. (1982). Analyses were under conditions identical to those for values of Appendix C. Values provided by the NBS in parentheses are uncertified. Standard deviations are based on 24 analyses of SRM 1632a and 50 analyses of SRM 1633a.

Element	SRM 1632a Coal			SRM 1633a Coal Fly Ash		
	Average (ppm)	$\pm 2\sigma$ (%)	NBS (ppm)	Average (ppm)	$\pm 2\sigma$ (%)	NBS (ppm)
Al	30700	8.2	(30700)	142000	4.4	(140000)
Ba	150	34		1500	12	(1500)
Ca	2700	13		11200	14	11100
Ce	31.1	22	(30)	183	22	(180)
Cl	897	5.2				
Co	6.6	34	(6.8)	46.2	7.6	(46)
Cr	36	34	34	197	13	196
Cs	2.4	70	(2.4)	10.6	21	(11)
Dy	2.56	20				
Eu	0.51	32	(0.54)	2.98	22	
Fe	11200	16	11100	95000	6.4	94000
Hf	1.8	36	(1.6)	7.78	22	(7.6)
K	4300	30		18400	15	18800
La	15	34		100	46	
Lu	0.18	74		0.93	21	
Mg	1400	32		4500	22	4550
Mn	33.7	7.2	28	191	4.5	(190)
Na	884	7.2		1720	5.6	1700
Rb				130	40	131
Sb				7.8	40	(7)
Sc	6.56	7.0	(6.3)	40.6	6.3	(40)
Sm	2.5	28		20	44	
Sr				819	13	830
Ta				2.0	46	
Tb				2.3	58	
Th	4.8	24	4.5	24.8	13	24.7
Ti	1720	20	(1750)	8060	9.2	(8000)
U	1.28	12	1.28	10.2	4.2	10.2
V	46.9	11	44	301	5.2	(300)
Yb				10	36	
Zn				220	46	220

APPENDIX E

GLASS COMPOSITIONS DETERMINED BY ELECTRON MICROPROBE
FOR TUFFS OF YUCCA MOUNTAIN, NEVADA

Drill Hole USW G-2

Depth (ft) ^a	331	331	331	331	331	331	331	331
Unit ^a	Tpy	Tpy	Tpy	Tpy	Tpy	Tpy	Tpy	Tpy
SiO ₂	73.7	72.5	72.9	72.4	72.2	73.3	73.0	73.1
TiO ₂	0.14	0.18	0.15	0.16	0.13	0.10	0.13	0.10
Al ₂ O ₃	12.1	12.3	11.8	12.2	12.1	12.1	11.9	11.3
Fe ₂ O ₃	0.91	0.88	0.89	0.88	0.69	0.81	0.84	0.65
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.28	0.26	0.25	0.26	0.26	0.27	0.24	0.23
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	4.26	4.56	4.45	4.62	4.68	4.55	4.59	4.52
K ₂ O	4.64	4.43	4.53	4.34	4.35	4.37	4.00	3.92
Total	96.0	95.1	95.0	94.9	94.4	95.5	94.8	93.8
Cation Percent								
Si	71.4	70.7	71.3	70.8	70.8	71.2	71.5	72.4
Ti	0.10	0.13	0.11	0.12	0.10	0.07	0.10	0.07
Al	13.8	14.1	13.6	14.0	14.0	13.8	13.8	13.2
Fe	0.66	0.65	0.65	0.65	0.51	0.59	0.62	0.48
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.29	0.27	0.26	0.27	0.27	0.28	0.25	0.24
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	8.01	8.62	8.44	8.75	8.90	8.57	8.72	8.68
K	5.74	5.51	5.65	5.41	5.44	5.42	5.00	4.95
Si/(Al+Fe)								
	4.94	4.78	5.02	4.83	4.90	4.94	4.97	5.29
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.01	1.01	0.97	1.00	0.97	0.99	1.01	0.97
Mol% Exchangeable Cations								
K	40.9	38.3	39.4	37.5	37.2	38.0	35.8	35.7
Na	57.0	59.9	58.8	60.6	60.9	60.1	62.4	62.5
Ca+Mg	2.1	1.9	1.8	1.9	1.9	2.0	1.8	1.8
Oxides Recalculated to 100%								
SiO ₂	76.8	76.2	76.8	76.4	76.5	76.8	77.1	77.9
TiO ₂	0.15	0.19	0.16	0.17	0.14	0.10	0.14	0.11
Al ₂ O ₃	12.6	12.9	12.4	12.8	12.8	12.6	12.6	12.1
Fe ₂ O ₃	0.95	0.93	0.94	0.93	0.73	0.85	0.89	0.69
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.29	0.27	0.26	0.27	0.28	0.28	0.25	0.25
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	4.44	4.80	4.69	4.87	4.96	4.77	4.84	4.82
K ₂ O	4.83	4.66	4.77	4.58	4.61	4.58	4.22	4.18

^aUnit symbols defined in Table I.

APPENDIX E (cont)

Drill Hole USW G-2

Depth (ft) Unit ^a	331	358	358	358	358	358	547	547
	Tpy	Tb	Tb	Tb	Tb	Tb	Tpp	Tpp
SiO ₂	72.0	72.0	72.5	74.1	73.2	73.4	71.1	73.0
TiO ₂	0.16	0.16	0.13	0.10	0.13	0.11	0.13	0.09
Al ₂ O ₃	12.2	11.7	11.6	11.8	11.9	11.9	11.8	11.9
Fe ₂ O ₃	0.91	0.83	0.77	0.62	0.66	0.81	0.85	0.73
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.25	0.19	0.18	0.21	0.24	0.22	0.56	0.54
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	4.43	3.99	4.33	4.40	4.54	4.38	3.24	3.36
K ₂ O	4.23	4.22	4.22	3.99	3.95	4.06	4.71	4.84
Total	94.2	93.1	93.7	95.2	94.6	94.8	92.3	94.5
Cation Percent								
Si	71.0	72.1	71.9	72.3	71.8	72.0	72.1	72.3
Ti	0.12	0.12	0.10	0.07	0.10	0.08	0.10	0.07
Al	14.2	13.8	13.6	13.6	13.7	13.7	14.1	14.0
Fe	0.68	0.63	0.57	0.46	0.49	0.60	0.65	0.54
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.26	0.20	0.19	0.22	0.25	0.23	0.61	0.57
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	8.47	7.75	8.33	8.33	8.64	8.33	6.37	6.45
K	5.32	5.39	5.34	4.97	4.94	5.08	6.10	6.12
Si/(Al+Fe)								
	4.78	5.01	5.08	5.13	5.05	5.03	4.89	4.99
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.04	1.06	1.01	1.03	1.01	1.03	1.08	1.06
Mol% Exchangeable Cations								
K	37.9	40.4	38.5	36.8	35.7	37.2	46.6	46.5
Na	60.3	58.1	60.1	61.6	62.4	61.1	48.7	49.1
Ca+Mg	1.9	1.5	1.4	1.6	1.8	1.7	4.7	4.4
Oxides Recalculated to 100%								
SiO ₂	76.4	77.4	77.3	77.8	77.4	77.4	77.0	77.2
TiO ₂	0.17	0.17	0.14	0.11	0.14	0.12	0.14	0.10
Al ₂ O ₃	12.9	12.5	12.4	12.4	12.5	12.5	12.7	12.6
Fe ₂ O ₃	0.97	0.89	0.82	0.65	0.70	0.85	0.92	0.77
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.27	0.20	0.19	0.22	0.25	0.23	0.61	0.57
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	4.70	4.29	4.62	4.62	4.80	4.62	3.51	3.56
K ₂ O	4.49	4.53	4.50	4.19	4.17	4.28	5.10	5.12

APPENDIX E (cont)

Drill Hole USW G-2

Depth (ft) ^a	547
Unit ^a	Tpp

SiO ₂	72.2
TiO ₂	0.09
Al ₂ O ₃	12.2
Fe ₂ O ₃	0.76
MgO	0.00
CaO	0.51
BaO	0.00
Na ₂ O	3.67
K ₂ O	5.07

Total	94.5
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Cation Percent	
Si	71.3
Ti	0.07
Al	14.1
Fe	0.56
Mg	0.00
Ca	0.54
Ba	0.00
Na	7.02
K	6.39

Si/(Al+Fe)	4.84
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)	1.02
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Mol% Exchangeable Cations	
K	45.8
Na	50.4
Ca+Mg	3.9

Oxides Recalculated to 100%	
SiO ₂	76.4
TiO ₂	0.10
Al ₂ O ₃	12.9
Fe ₂ O ₃	0.80
MgO	0.00
CaO	0.54
BaO	0.00
Na ₂ O	3.89
K ₂ O	5.37

APPENDIX E (cont)

Drill Hole USW GU-3

Depth (ft) Unit ^a	356	356	356	1195	1227	1227	1227	1227
	Tpc	Tpc	Tpc	Tpt	Tpt	Tpt	Tpt	Tpt
SiO ₂	74.1	74.4	73.7	74.9	74.2	73.7	73.4	73.5
TiO ₂	0.13	0.05	0.03	0.10	0.09	0.04	0.05	0.08
Al ₂ O ₃	12.2	11.9	11.2	11.9	11.7	12.0	11.7	11.7
Fe ₂ O ₃	0.73	0.40	1.23	0.74	0.14	0.60	0.91	0.83
MgO	0.00	0.00	0.11	0.00	0.00	0.00	0.05	0.00
CaO	0.05	0.05	0.89	0.21	0.34	0.40	0.59	0.27
BaO	0.11	0.02	0.00	0.19	0.00	0.00	0.16	0.13
Na ₂ O	4.00	3.78	4.43	3.40	3.36	3.39	3.40	3.31
K ₂ O	5.05	5.30	2.77	5.78	5.31	5.61	5.45	5.63
Total	96.4	95.9	94.4	97.2	95.1	95.7	95.7	95.4
Cation Percent								
Si	71.7	72.3	72.9	72.2	72.8	71.9	71.8	72.2
Ti	0.09	0.04	0.02	0.07	0.07	0.03	0.04	0.06
Al	13.9	13.6	13.1	13.5	13.6	13.8	13.5	13.5
Fe	0.53	0.29	0.92	0.54	0.10	0.44	0.67	0.61
Mg	0.00	0.00	0.16	0.00	0.00	0.00	0.07	0.00
Ca	0.05	0.05	0.94	0.22	0.36	0.42	0.62	0.28
Ba	0.04	0.01	0.00	0.07	0.00	0.00	0.06	0.05
Na	7.50	7.12	8.49	6.35	6.40	6.41	6.45	6.30
K	6.23	6.57	3.49	7.10	6.65	6.98	6.80	7.05
Si/(Al+Fe)								
	4.98	5.21	5.20	5.15	5.32	5.06	5.07	5.12
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.04	1.01	0.99	1.00	0.99	1.00	0.96	1.01
Mol% Exchangeable Cations								
K	45.2	47.8	26.7	52.0	49.6	50.5	48.8	51.7
Na	54.4	51.8	64.9	46.5	47.7	46.4	46.3	46.2
Ca+Mg	0.4	0.4	8.4	1.6	2.7	3.0	5.0	2.1
Oxides Recalculated to 100%								
SiO ₂	76.9	77.6	78.1	77.1	78.0	77.0	76.7	77.0
TiO ₂	0.13	0.05	0.03	0.10	0.09	0.04	0.05	0.08
Al ₂ O ₃	12.6	12.4	11.9	12.2	12.3	12.5	12.2	12.2
Fe ₂ O ₃	0.76	0.42	1.30	0.76	0.15	0.63	0.95	0.87
MgO	0.00	0.00	0.12	0.00	0.00	0.00	0.05	0.00
CaO	0.05	0.05	0.94	0.22	0.36	0.42	0.62	0.28
BaO	0.11	0.02	0.00	0.20	0.00	0.00	0.17	0.14
Na ₂ O	4.15	3.94	4.69	3.50	3.53	3.54	3.55	3.47
K ₂ O	5.24	5.53	2.93	5.94	5.58	5.86	5.69	5.90

APPENDIX E (cont)

Drill Hole USW GU-3

Depth (ft) Unit ^a	1227	1227	1227	1227	1227	1303	1303	1303
	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt
SiO ₂	74.1	74.4	74.0	73.8	74.2	74.6	75.4	73.4
TiO ₂	0.11	0.09	0.08	0.07	0.04	0.09	0.01	0.04
Al ₂ O ₃	11.8	11.5	11.8	11.7	11.7	11.9	11.6	12.0
Fe ₂ O ₃	0.73	0.81	0.95	0.46	0.20	0.77	0.38	0.69
MgO	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.04
CaO	0.24	0.22	0.37	0.52	0.31	0.29	0.36	0.32
BaO	0.07	0.04	0.00	0.13	0.00	0.00	0.00	0.12
Na ₂ O	3.41	3.27	3.24	3.13	3.47	3.42	3.32	3.39
K ₂ O	5.55	5.58	5.50	5.72	5.58	5.59	5.50	5.49
Total	96.0	96.0	95.9	95.5	95.5	96.7	96.5	95.5
Cation Percent								
Si	72.2	72.7	72.2	72.4	72.5	72.2	73.1	71.9
Ti	0.08	0.07	0.06	0.05	0.03	0.07	0.01	0.03
Al	13.6	13.3	13.6	13.5	13.5	13.5	13.2	13.8
Fe	0.54	0.60	0.70	0.34	0.15	0.56	0.28	0.51
Mg	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.06
Ca	0.25	0.23	0.39	0.55	0.32	0.30	0.37	0.34
Ba	0.03	0.02	0.00	0.05	0.00	0.00	0.00	0.05
Na	6.44	6.19	6.14	5.95	6.57	6.41	6.24	6.44
K	6.90	6.95	6.85	7.16	6.95	6.90	6.80	6.86
Si/(Al+Fe)								
	5.12	5.24	5.04	5.23	5.30	5.12	5.41	5.01
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.02	1.02	1.04	0.97	0.96	1.01	0.98	1.01
Mol% Exchangeable Cations								
K	50.8	52.0	51.2	52.4	50.2	50.6	50.7	50.1
Na	47.4	46.3	45.9	43.5	47.5	47.0	46.5	47.0
Ca+Mg	1.8	1.7	2.9	4.1	2.3	2.4	2.8	2.9
Oxides Recalculated to 100%								
SiO ₂	77.2	77.5	77.1	77.3	77.7	77.2	78.1	76.9
TiO ₂	0.11	0.09	0.08	0.07	0.04	0.09	0.01	0.04
Al ₂ O ₃	12.3	12.0	12.3	12.2	12.3	12.3	12.0	12.5
Fe ₂ O ₃	0.76	0.84	0.99	0.48	0.21	0.80	0.39	0.72
MgO	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.04
CaO	0.25	0.23	0.39	0.54	0.32	0.30	0.37	0.34
BaO	0.07	0.04	0.00	0.14	0.00	0.00	0.00	0.13
Na ₂ O	3.55	3.41	3.38	3.28	3.63	3.54	3.44	3.55
K ₂ O	5.78	5.81	5.73	5.99	5.84	5.78	5.70	5.75

APPENDIX E (cont)

Drill Hole USW GU-3

Depth (ft) Unit ^a	1303	1303	1303	1394	1394	1394	1537	1537
	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tht	Tnt
SiO ₂	74.1	74.4	74.1	73.9	72.4	73.6	74.5	73.9
TiO ₂	0.04	0.07	0.03	0.00	0.05	0.05	0.01	0.07
Al ₂ O ₃	12.1	11.9	11.7	11.8	11.7	12.0	12.1	11.8
Fe ₂ O ₃	0.66	0.55	0.54	0.85	0.80	0.78	0.63	0.71
MgO	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00
CaO	0.34	0.29	0.36	0.43	0.43	0.43	0.60	0.57
BaO	0.00	0.12	0.00	0.00	0.00	0.06	0.75	0.00
Na ₂ O	3.58	3.44	3.20	3.49	3.41	3.69	3.21	3.06
K ₂ O	5.66	5.66	5.68	4.93	4.89	4.80	4.92	5.13
Total	96.5	96.5	95.6	95.4	93.7	95.4	96.7	95.3
Cation Percent								
Si	71.6	72.1	72.6	72.4	72.3	72.1	72.5	72.8
Ti	0.03	0.05	0.02	0.00	0.04	0.04	0.01	0.05
Al	13.8	13.6	13.5	13.6	13.7	13.8	13.9	13.7
Fe	0.48	0.40	0.40	0.63	0.60	0.57	0.46	0.53
Mg	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00
Ca	0.35	0.30	0.38	0.45	0.46	0.45	0.63	0.60
Ba	0.00	0.05	0.00	0.00	0.00	0.02	0.29	0.00
Na	6.71	6.46	6.07	6.64	6.60	7.01	6.06	5.84
K	6.98	7.00	7.09	6.17	6.23	6.00	6.11	6.44
Si/(Al+Fe)								
	5.01	5.14	5.23	5.08	5.05	5.01	5.04	5.10
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.99	0.99	1.00	1.04	1.04	1.03	1.03	1.06
Mol% Exchangeable Cations								
K	49.7	50.8	52.4	46.4	46.8	44.6	47.8	50.0
Na	47.8	47.0	44.8	50.0	49.6	52.1	47.4	45.3
Ca+Mg	2.5	2.2	2.8	3.6	3.7	3.4	4.9	4.7
Oxides Recalculated to 100%								
SiO ₂	76.8	77.1	77.5	77.4	77.3	77.2	77.0	77.6
TiO ₂	0.04	0.07	0.03	0.00	0.05	0.05	0.01	0.07
Al ₂ O ₃	12.6	12.4	12.2	12.4	12.4	12.5	12.5	12.4
Fe ₂ O ₃	0.68	0.57	0.56	0.89	0.85	0.82	0.65	0.74
MgO	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00
CaO	0.35	0.30	0.38	0.45	0.46	0.45	0.62	0.60
BaO	0.00	0.12	0.00	0.00	0.00	0.06	0.78	0.00
Na ₂ O	3.71	3.56	3.35	3.66	3.64	3.87	3.32	3.21
K ₂ O	5.86	5.87	5.94	5.17	5.22	5.03	5.09	5.38

APPENDIX E (cont)

Drill Hole USW GU-3

Depth (ft) ^a	1537	1537	1537	1571
Unit ^a	Tht	Tht	Tht	Tcp
SiO ₂	73.9	73.1	73.9	74.6
TiO ₂	0.07	0.04	0.07	0.05
Al ₂ O ₃	11.8	12.1	11.8	11.9
Fe ₂ O ₃	0.55	0.58	0.71	0.75
MgO	0.00	0.00	0.00	0.00
CaO	0.60	0.52	0.57	0.40
BaO	0.00	0.00	0.00	1.57
Na ₂ O	3.13	3.38	3.06	3.35
K ₂ O	5.00	5.05	5.13	4.86
Total	95.1	94.8	95.3	97.5
Cation Percent				
Si	72.9	72.1	72.8	72.5
Ti	0.05	0.03	0.05	0.04
Al	13.7	14.0	13.7	13.6
Fe	0.41	0.43	0.53	0.55
Mg	0.00	0.00	0.00	0.00
Ca	0.63	0.55	0.60	0.42
Ba	0.00	0.00	0.00	0.60
Na	5.98	6.46	5.84	6.31
K	6.29	6.35	6.44	6.02
Si/(Al+Fe)				
	5.15	4.98	5.10	5.12
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)				
	1.04	1.04	1.06	0.98
Mol% Exchangeable Cations				
K	48.7	47.5	50.0	47.2
Na	46.4	48.4	45.3	49.5
Ca+Mg	4.9	4.1	4.7	3.3
Oxides Recalculated to 100%				
SiO ₂	77.7	77.1	77.6	76.5
TiO ₂	0.07	0.04	0.07	0.05
Al ₂ O ₃	12.4	12.7	12.4	12.2
Fe ₂ O ₃	0.58	0.61	0.74	0.77
MgO	0.00	0.00	0.00	0.00
CaO	0.63	0.55	0.60	0.41
BaO	0.00	0.00	0.00	1.61
Na ₂ O	3.29	3.57	3.21	3.44
K ₂ O	5.26	5.33	5.38	4.99

APPENDIX E (cont)

Drill Hole USW G-4

Depth (ft) Unit ^a	1432	1432	1432
	Tht	Tht	Tht
SiO ₂	73.7	74.3	73.8
TiO ₂	0.11	0.06	0.07
Al ₂ O ₃	11.9	11.9	11.7
Fe ₂ O ₃	0.69	0.74	0.79
MgO	0.02	0.07	0.05
CaO	0.49	0.53	0.44
BaO	0.00	0.18	0.00
Na ₂ O	3.38	3.35	3.33
K ₂ O	4.98	5.01	4.99
Total	95.3	96.2	95.2
Cation Percent			
Si	72.4	72.4	72.6
Ti	0.08	0.04	0.05
Al	13.8	13.7	13.6
Fe	0.51	0.54	0.59
Mg	0.03	0.10	0.07
Ca	0.52	0.55	0.46
Ba	0.00	0.07	0.00
Na	6.43	6.33	6.35
K	6.24	6.23	6.27
Si/(Al+Fe)			
	5.06	5.09	5.11
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)			
	1.04	1.01	1.04
Mol% Exchangeable Cations			
K	47.2	47.1	47.6
Na	48.7	47.9	48.3
Ca+Mg	4.1	5.0	4.1
Oxides Recalculated to 100%			
SiO ₂	77.3	77.3	77.5
TiO ₂	0.12	0.06	0.07
Al ₂ O ₃	12.5	12.4	12.3
Fe ₂ O ₃	0.72	0.77	0.83
MgO	0.02	0.07	0.05
CaO	0.51	0.55	0.46
BaO	0.00	0.19	0.00
Na ₂ O	3.55	3.48	3.50
K ₂ O	5.22	5.21	5.24

APPENDIX E (cont)

Drill Hole USW H-4

Depth (ft) ^a	1312	1312	1312	1312	1312	1312
Unit ^a	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	73.9	74.3	73.4	74.0	74.0	74.0
TiO ₂	0.04	0.04	0.02	0.05	0.05	0.01
Al ₂ O ₃	12.0	12.1	12.0	12.3	12.0	12.0
Fe ₂ O ₃	0.67	0.83	0.86	0.77	0.83	0.73
MgO	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.43	0.41	0.43	0.45	0.49	0.43
BaO	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	3.27	3.29	3.03	3.38	3.28	3.16
K ₂ O	4.91	5.09	5.39	4.96	5.37	5.25
Total	95.2	96.1	95.1	95.9	96.0	95.6
Cation Percent						
Si	72.7	72.5	72.4	72.2	72.2	72.6
Ti	0.03	0.03	0.01	0.04	0.04	0.01
Al	13.92	13.91	13.95	14.15	13.80	13.87
Fe	0.50	0.61	0.64	0.57	0.61	0.54
Mg	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.45	0.43	0.45	0.47	0.51	0.45
Ba	0.00	0.00	0.00	0.00	0.00	0.00
Na	6.24	6.22	5.79	6.39	6.20	6.01
K	6.16	6.33	6.78	6.17	6.68	6.57
Si/(Al+Fe)						
	5.04	4.99	4.96	4.91	5.01	5.03
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)						
	1.08	1.08	1.08	1.09	1.04	1.07
Mol% Exchangeable Cations						
K	47.9	48.8	52.0	47.4	49.9	50.4
Na	48.5	47.9	44.5	49.0	46.3	46.1
Ca+Mg	3.5	3.3	3.5	3.6	3.8	3.5
Oxides Recalculated to 100%						
SiO ₂	77.61	77.35	77.16	77.16	77.07	77.42
TiO ₂	0.04	0.04	0.02	0.05	0.05	0.01
Al ₂ O ₃	12.60	12.60	12.61	12.82	12.50	12.55
Fe ₂ O ₃	0.70	0.86	0.90	0.80	0.86	0.76
MgO	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.45	0.43	0.45	0.47	0.51	0.45
BaO	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	3.43	3.42	3.19	3.52	3.42	3.31
K ₂ O	5.16	5.30	5.67	5.17	5.59	5.49

APPENDIX E (cont)

Drill Hole USW H-5

Depth (ft) ^a	450	450	450	450	1610	1762	1762	1762
Unit ^a	Tpc	Tpc	Tpc	Tpc	Tpt	Tht	Tht	Tht
SiO ₂	74.6	73.6	72.3	73.7	74.3	73.7	73.7	72.8
TiO ₂	0.09	0.10	0.09	0.05	0.03	0.05	0.05	0.07
Al ₂ O ₃	11.9	11.8	11.8	11.6	12.0	11.8	11.7	12.0
Fe ₂ O ₃	0.71	0.77	0.62	0.83	0.73	0.76	0.64	0.66
MgO	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00
CaO	0.14	0.18	0.20	0.20	0.45	0.49	0.48	0.48
BaO	0.04	0.11	0.20	0.20	0.06	0.00	0.14	0.00
Na ₂ O	4.21	4.28	4.24	4.34	3.42	3.32	3.52	3.47
K ₂ O	4.90	4.66	4.65	4.64	5.05	4.96	4.96	4.75
Total	96.6	95.5	94.1	95.6	96.1	95.1	95.2	94.2
Cation Percent								
Si	71.9	71.7	71.4	71.8	72.4	72.6	72.4	72.2
Ti	0.07	0.07	0.07	0.04	0.02	0.04	0.04	0.05
Al	13.5	13.5	13.7	13.3	13.8	13.7	13.6	14.0
Fe	0.51	0.56	0.46	0.61	0.54	0.56	0.47	0.49
Mg	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00
Ca	0.14	0.19	0.21	0.21	0.47	0.52	0.51	0.51
Ba	0.02	0.04	0.08	0.08	0.02	0.00	0.05	0.00
Na	7.86	8.08	8.12	8.20	6.46	6.34	6.71	6.67
K	6.02	5.79	5.86	5.77	6.28	6.23	6.22	6.01
Si/(Al+Fe)								
	5.12	5.08	5.03	5.15	5.06	5.09	5.16	4.97
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.99	0.98	0.98	0.96	1.04	1.05	1.00	1.06
Mol% Exchangeable Cations								
K	42.9	41.2	41.3	40.6	47.4	47.6	46.3	45.6
Na	56.0	57.5	57.2	57.8	48.8	48.4	49.9	50.6
Ca+Mg	1.0	1.3	1.5	1.6	3.8	4.0	3.8	3.9
Oxides Recalculated to 100%								
SiO ₂	77.2	77.1	76.8	77.1	77.3	77.5	77.4	77.3
TiO ₂	0.09	0.10	0.10	0.05	0.03	0.05	0.05	0.07
Al ₂ O ₃	12.3	12.4	12.5	12.1	12.5	12.4	12.3	12.7
Fe ₂ O ₃	0.74	0.81	0.66	0.87	0.76	0.80	0.67	0.70
MgO	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00
CaO	0.14	0.19	0.21	0.21	0.47	0.52	0.50	0.51
BaO	0.04	0.12	0.21	0.21	0.06	0.00	0.15	0.00
Na ₂ O	4.36	4.48	4.51	4.54	3.56	3.49	3.70	3.68
K ₂ O	5.07	4.88	4.94	4.86	5.26	5.22	5.21	5.04

APPENDIX E (cont)

Drill Hole USW H-5

Depth (ft) Unit ^a	1762	1800	1800	1966	1966	1966
	Tht	Tht	Tht	Tcp	Tcp	Tcp
SiO ₂	73.0	74.4	74.6	72.7	72.5	72.3
TiO ₂	0.02	0.02	0.00	0.03	0.04	0.05
Al ₂ O ₃	12.0	11.8	11.7	11.7	11.7	11.8
Fe ₂ O ₃	0.71	0.69	0.47	0.79	0.80	0.84
MgO	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.45	0.53	0.52	0.46	0.39	0.38
BaO	0.00	0.23	0.00	0.00	0.00	0.00
Na ₂ O	3.41	3.30	3.48	3.04	2.92	2.99
K ₂ O	4.90	5.13	5.18	5.02	5.15	5.00
Total	94.5	96.1	95.9	93.7	93.5	93.4
Cation Percent						
Si	72.2	72.6	72.7	72.8	72.8	72.7
Ti	0.01	0.01	0.00	0.02	0.03	0.04
Al	14.00	13.58	13.44	13.81	13.85	13.99
Fe	0.53	0.51	0.34	0.60	0.60	0.64
Mg	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.48	0.55	0.54	0.49	0.42	0.41
Ba	0.00	0.09	0.00	0.00	0.00	0.00
Na	6.54	6.25	6.57	5.90	5.69	5.83
K	6.19	6.39	6.44	6.41	6.60	6.41
Si/(Al+Fe)						
	4.97	5.16	5.27	5.05	5.04	4.97
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)						
	1.06	1.01	0.98	1.08	1.10	1.12
Mol% Exchangeable Cations						
K	46.8	48.4	47.5	50.1	51.9	50.7
Na	49.5	47.4	48.5	46.1	44.8	46.1
Ca+Mg	3.6	4.2	4.0	3.9	3.3	3.2
Oxides Recalculated to 100%						
SiO ₂	77.26	77.42	77.75	77.55	77.54	0.00
TiO ₂	0.02	0.02	0.00	0.03	0.04	0.00
Al ₂ O ₃	12.70	12.28	12.19	12.48	12.51	0.00
Fe ₂ O ₃	0.75	0.72	0.49	0.84	0.86	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.48	0.55	0.54	0.49	0.42	0.00
BaO	0.00	0.24	0.00	0.00	0.00	0.00
Na ₂ O	3.61	3.43	3.63	3.24	3.12	0.00
K ₂ O	5.19	5.34	5.40	5.36	5.51	0.00

APPENDIX E (cont)

Drill Hole UE-25a#1

Depth (ft) Unit ^a	226	226	251	251	251	251	251	277
	Tpc	Tpc	Tb	Tb	Tb	Tb	Tb	Tb
SiO ₂	73.7	73.9	72.5	72.5	73.1	68.4	73.0	70.5
TiO ₂	0.16	0.21	0.14	0.07	0.10	0.00	0.08	0.00
Al ₂ O ₃	12.6	12.6	11.3	11.5	11.4	14.3	11.3	13.4
Fe ₂ O ₃	0.77	0.75	0.71	0.81	0.67	1.76	0.69	0.92
MgO	0.05	0.02	0.00	0.00	0.02	0.18	0.00	0.05
CaO	0.42	0.47	0.47	0.43	0.39	0.75	0.38	0.43
BaO	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.07
Na ₂ O	4.05	4.04	2.79	3.24	3.19	3.89	3.33	3.48
K ₂ O	5.24	5.43	5.58	5.06	5.42	5.72	5.05	5.92
Total	97.0	97.5	93.5	93.6	94.3	95.0	93.8	94.7
Cation Percent								
Si	70.6	70.5	72.9	72.5	72.6	66.7	72.9	69.2
Ti	0.12	0.15	0.11	0.05	0.07	0.00	0.06	0.00
Al	14.3	14.2	13.4	13.6	13.3	16.5	13.3	15.5
Fe	0.56	0.54	0.54	0.61	0.50	1.29	0.52	0.68
Mg	0.07	0.03	0.00	0.00	0.03	0.26	0.00	0.07
Ca	0.43	0.48	0.51	0.46	0.42	0.78	0.41	0.45
Ba	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.03
Na	7.53	7.47	5.44	6.29	6.15	7.36	6.45	6.63
K	6.41	6.61	7.15	6.46	6.87	7.12	6.43	7.42
Si/(Al+Fe)								
	4.76	4.78	5.23	5.11	5.26	3.76	5.28	4.28
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.99	0.98	1.02	1.04	0.99	1.07	1.01	1.07
Mol% Exchangeable Cations								
K	44.4	45.3	54.6	48.9	51.0	45.9	48.4	50.9
Na	52.1	51.2	41.5	47.6	45.7	47.4	48.5	45.5
Ca+Mg	3.5	3.5	3.9	3.5	3.3	6.7	3.1	3.6
Oxides Recalculated to 100%								
SiO ₂	76.0	75.8	77.5	77.4	77.5	71.9	77.8	74.4
TiO ₂	0.16	0.22	0.15	0.07	0.11	0.00	0.09	0.00
Al ₂ O ₃	13.0	13.0	12.1	12.3	12.1	15.1	12.0	14.1
Fe ₂ O ₃	0.79	0.77	0.76	0.87	0.71	1.85	0.74	0.97
MgO	0.05	0.02	0.00	0.00	0.02	0.19	0.00	0.05
CaO	0.43	0.48	0.50	0.46	0.41	0.79	0.41	0.45
BaO	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.07
Na ₂ O	4.18	4.14	2.98	3.46	3.38	4.09	3.55	3.67
K ₂ O	5.40	5.57	5.97	5.41	5.75	6.02	5.38	6.25

APPENDIX E (cont)

Drill Hole UE-25a#1

Depth (ft) Unit ^a	277	277	277	277	277	277	277	277
	Tb	Tb	Tb	Tb	Tb	Tb	Tb	Tb
SiO ₂	67.1	67.3	73.4	72.7	72.8	72.6	71.7	68.7
TiO ₂	0.00	0.00	0.00	0.01	0.07	0.07	0.08	0.18
Al ₂ O ₃	15.1	15.0	11.6	11.6	11.5	11.5	11.6	13.5
Fe ₂ O ₃	0.89	0.86	0.37	0.46	0.47	0.36	0.75	0.73
MgO	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.78	0.75	0.13	0.15	0.15	0.14	0.15	0.38
BaO	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	3.95	3.67	2.82	2.64	3.50	3.02	2.84	3.88
K ₂ O	5.90	6.64	6.42	6.59	5.81	6.39	6.17	5.98
Total	93.8	94.5	94.8	94.2	94.3	94.1	93.2	93.3
Cation Percent								
Si	65.9	65.8	72.6	72.4	72.0	72.1	72.1	68.1
Ti	0.00	0.00	0.00	0.01	0.05	0.05	0.06	0.13
Al	17.5	17.3	13.5	13.6	13.4	13.5	13.7	15.8
Fe	0.66	0.63	0.28	0.34	0.35	0.27	0.57	0.54
Mg	0.21	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.82	0.79	0.14	0.16	0.16	0.15	0.16	0.40
Ba	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Na	7.53	6.95	5.40	5.10	6.71	5.82	5.54	7.46
K	7.40	8.28	8.09	8.37	7.33	8.10	7.91	7.56
Si/(Al+Fe)								
	3.63	3.66	5.25	5.19	5.22	5.25	5.05	4.17
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.07	1.04	1.00	1.01	0.96	0.97	1.04	1.03
Mol% Exchangeable Cations								
K	46.4	51.0	59.4	61.4	51.6	57.6	58.1	49.0
Na	47.2	42.9	39.6	37.4	47.3	41.4	40.7	48.4
Ca+Mg	6.4	6.1	1.0	1.2	1.1	1.1	1.2	2.6
Oxides Recalculated to 100%								
SiO ₂	71.5	71.3	77.5	77.2	77.2	77.2	76.9	73.6
TiO ₂	0.00	0.00	0.00	0.01	0.07	0.07	0.09	0.19
Al ₂ O ₃	16.1	15.9	12.3	12.3	12.2	12.2	12.4	14.5
Fe ₂ O ₃	0.95	0.91	0.39	0.49	0.50	0.38	0.80	0.78
MgO	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.83	0.79	0.14	0.16	0.16	0.15	0.16	0.41
BaO	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	4.21	3.88	2.97	2.80	3.71	3.21	3.05	4.16
K ₂ O	6.29	7.03	6.77	7.00	6.16	6.79	6.62	6.41

APPENDIX E (cont)

Drill Hole UE-25a#1

Depth (ft) Unit ^a	277	277	1279	2113
	Tb	Tb	Tpt	Tcp
SiO2	68.7	68.2	74.4	75.1
TiO2	0.20	0.21	0.00	0.00
Al2O3	13.4	13.5	11.4	11.4
Fe2O3	0.73	0.56	0.47	0.29
MgO	0.00	0.00	0.00	0.00
CaO	0.37	0.35	0.38	0.87
BaO	0.00	0.00	0.00	0.00
Na2O	3.48	4.16	3.69	3.11
K2O	6.60	6.24	4.57	4.59
Total	93.5	93.2	94.9	95.4
Cation Percent				
Si	68.2	67.4	73.2	73.9
Ti	0.15	0.16	0.00	0.00
Al	15.7	15.8	13.3	13.2
Fe	0.54	0.42	0.35	0.21
Mg	0.00	0.00	0.00	0.00
Ca	0.39	0.37	0.40	0.92
Ba	0.00	0.00	0.00	0.00
Na	6.69	7.98	7.04	5.93
K	8.35	7.88	5.74	5.76
Si/(Al+Fe)				
	4.19	4.17	5.38	5.50
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)				
	1.03	0.98	1.00	0.99
Mol% Exchangeable Cations				
K	54.1	48.5	43.5	45.7
Na	43.4	49.2	53.4	47.0
Ca+Mg	2.5	2.3	3.0	7.3
Oxides Recalculated to 100%				
SiO2	73.5	73.1	78.4	78.8
TiO2	0.21	0.23	0.00	0.00
Al2O3	14.4	14.5	12.0	11.9
Fe2O3	0.78	0.60	0.50	0.30
MgO	0.00	0.00	0.00	0.00
CaO	0.40	0.38	0.40	0.91
BaO	0.00	0.00	0.00	0.00
Na2O	3.72	4.46	3.89	3.26
K2O	7.06	6.69	4.81	4.81

APPENDIX E (cont)

Drill Hole J-13

Depth (ft) Unit ^a	1421	1421	1421	1421	1427	1427	1427	1427
	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt
SiO ₂	75.9	77.5	76.8	76.6	74.2	75.3	75.3	73.8
TiO ₂	0.08	0.11	0.09	0.11	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.4	12.2	12.1	12.5	11.8	11.9	12.1	12.1
Fe ₂ O ₃	0.31	0.81	0.76	0.82	0.75	0.81	0.21	0.43
MgO	0.00	0.04	0.03	0.05	0.00	0.00	0.00	0.00
CaO	0.28	0.29	0.27	0.31	0.23	0.24	0.15	0.15
BaO	0.00	0.17	0.07	0.07	0.07	0.00	0.12	0.21
Na ₂ O	3.36	3.27	3.28	3.48	3.88	3.98	3.94	3.95
K ₂ O	5.78	6.00	5.87	5.76	4.87	4.91	4.97	4.92
Total	98.1	100.3	99.3	99.7	95.8	97.1	96.8	95.6

Cation Percent

Si	72.3	72.4	72.5	71.9	72.3	72.3	72.5	72.0
Ti	0.06	0.08	0.06	0.08	0.00	0.00	0.00	0.00
Al	13.9	13.4	13.4	13.8	13.5	13.5	13.7	13.8
Fe	0.22	0.57	0.54	0.58	0.55	0.59	0.15	0.32
Mg	0.00	0.06	0.04	0.07	0.00	0.00	0.00	0.00
Ca	0.29	0.29	0.27	0.31	0.24	0.25	0.15	0.16
Ba	0.00	0.06	0.03	0.03	0.03	0.00	0.05	0.08
Na	6.21	5.93	6.01	6.33	7.33	7.41	7.35	7.47
K	7.02	7.16	7.07	6.90	6.05	6.01	6.10	6.12

Si/(Al+Fe)

5.13	5.17	5.19	5.00	5.15	5.13	5.23	5.08
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.02	1.01	1.02	1.02	1.01	1.01	1.00	1.01
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Mol% Exchangeable Cations

K	52.0	53.3	52.8	50.7	44.4	44.0	44.8	44.5
Na	45.9	44.1	44.8	46.5	53.8	54.2	54.0	54.3
Ca+Mg	2.1	2.6	2.4	2.8	1.8	1.8	1.1	1.1

Oxides Recalculated to 100%

SiO ₂	77.4	77.2	77.4	76.8	77.5	77.5	77.8	77.3
TiO ₂	0.08	0.11	0.09	0.11	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.6	12.1	12.2	12.5	12.3	12.3	12.5	12.6
Fe ₂ O ₃	0.32	0.81	0.77	0.82	0.78	0.83	0.22	0.45
MgO	0.00	0.04	0.03	0.05	0.00	0.00	0.00	0.00
CaO	0.29	0.29	0.27	0.31	0.24	0.25	0.16	0.16
BaO	0.00	0.17	0.07	0.07	0.07	0.00	0.12	0.22
Na ₂ O	3.43	3.26	3.30	3.49	4.05	4.10	4.07	4.13
K ₂ O	5.89	5.98	5.91	5.78	5.09	5.06	5.14	5.15

APPENDIX E (cont)

Drill Hole J-13

Depth (ft) ^a	1507	1507	1507	1575	1575
Unit ^a	Tht	Tht	Tht	Tht	Tht
SiO ₂	74.2	74.4	74.9	74.3	72.3
TiO ₂	0.00	0.00	0.00	0.08	0.08
Al ₂ O ₃	12.0	12.1	12.0	11.9	11.6
Fe ₂ O ₃	0.73	0.73	0.83	0.58	0.74
MgO	0.00	0.00	0.00	0.04	0.05
CaO	0.40	0.42	0.35	0.46	0.45
BaO	0.00	0.02	0.00	0.09	0.00
Na ₂ O	3.33	3.37	3.36	3.21	3.25
K ₂ O	5.78	5.73	5.86	4.98	5.01
Total	96.5	96.7	97.3	95.7	93.5
Cation Percent					
Si	71.9	71.9	72.0	72.9	72.4
Ti	0.00	0.00	0.00	0.06	0.06
Al	13.7	13.8	13.6	13.8	13.7
Fe	0.53	0.53	0.60	0.43	0.56
Mg	0.00	0.00	0.00	0.06	0.07
Ca	0.42	0.44	0.36	0.48	0.48
Ba	0.00	0.01	0.00	0.03	0.00
Na	6.26	6.32	6.26	6.10	6.31
K	7.15	7.07	7.18	6.23	6.40
Si/(Al+Fe)					
	5.05	5.03	5.06	5.13	5.07
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)					
	1.00	1.00	1.00	1.05	1.03
Mol% Exchangeable Cations					
K	51.7	51.1	52.0	48.4	48.2
Na	45.3	45.7	45.3	47.4	47.6
Ca+Mg	3.0	3.1	2.6	4.2	4.2
Oxides Recalculated to 100%					
SiO ₂	76.9	76.9	76.9	77.7	77.3
TiO ₂	0.00	0.00	0.00	0.08	0.09
Al ₂ O ₃	12.4	12.5	12.4	12.4	12.4
Fe ₂ O ₃	0.76	0.75	0.85	0.61	0.79
MgO	0.00	0.00	0.00	0.04	0.05
CaO	0.41	0.43	0.36	0.48	0.48
BaO	0.00	0.02	0.00	0.09	0.00
Na ₂ O	3.45	3.49	3.45	3.35	3.48
K ₂ O	5.99	5.93	6.02	5.20	5.36

APPENDIX E (cont)

Outcrop at Prov Pass, Northern Yucca Mountain

Sample Number: 3-15-82-11; Nevada State Coordinates (ft) 786550N, 551400E

Partially welded tuff near base of Topopah Spring Member, Paintbrush Tuff

SiO ₂	72.4	72.7	74.6	73.8	72.6	72.7	72.7	72.3
TiO ₂	0.02	0.05	0.05	0.03	0.03	0.00	0.00	0.03
Al ₂ O ₃	11.6	11.6	11.5	11.8	11.5	11.6	11.7	11.7
Fe ₂ O ₃	0.54	0.46	0.35	0.44	0.47	0.66	0.52	0.61
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
CaO	0.40	0.41	0.43	0.45	0.40	0.45	0.42	0.41
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	3.52	3.53	3.46	3.58	3.33	3.54	3.68	3.52
K ₂ O	4.73	4.77	4.44	4.58	4.70	4.79	4.75	4.82
Total	93.1	93.5	94.9	94.6	93.0	93.7	93.8	93.3

Cation Percent

Si	72.6	72.6	73.6	72.9	73.1	72.5	72.3	72.3
Ti	0.02	0.04	0.04	0.02	0.02	0.00	0.00	0.02
Al	13.7	13.6	13.4	13.7	13.6	13.6	13.7	13.8
Fe	0.41	0.35	0.26	0.33	0.36	0.50	0.39	0.46
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Ca	0.43	0.44	0.45	0.48	0.43	0.48	0.45	0.44
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	6.85	6.84	6.62	6.85	6.49	6.85	7.10	6.83
K	6.05	6.08	5.59	5.77	6.03	6.10	6.03	6.15

Si/(Al+Fe)

5.16	5.20	5.39	5.20	5.23	5.15	5.13	5.08
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.02	1.01	1.04	1.03	1.04	1.01	1.00	1.03
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Mol% Exchangeable Cations

K	45.4	45.5	44.1	44.0	46.5	45.4	44.4	45.8
Na	51.4	51.2	52.3	52.3	50.1	51.0	52.2	50.9
Ca+Mg	3.2	3.3	3.6	3.6	3.3	3.6	3.4	3.3

Oxides Recalculated to 100%

SiO ₂	77.7	77.8	78.7	78.0	78.1	77.6	77.5	77.4
TiO ₂	0.02	0.05	0.05	0.03	0.03	0.00	0.00	0.03
Al ₂ O ₃	12.4	12.3	12.1	12.4	12.3	12.3	12.5	12.5
Fe ₂ O ₃	0.58	0.49	0.37	0.46	0.51	0.70	0.55	0.65
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
CaO	0.43	0.44	0.45	0.48	0.43	0.48	0.45	0.44
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	3.78	3.78	3.65	3.78	3.58	3.78	3.92	3.77
K ₂ O	5.08	5.10	4.68	4.84	5.05	5.11	5.06	5.16

APPENDIX E (cont)

Outcrop at Prow Pass, Northern Yucca Mountain

Sample Number: 3-15-82-11

Partially welded tuff near base of Topopah Spring Member, Paintbrush Tuff

SiO2	70.9	72.3	71.6
TiO2	0.04	0.04	0.00
Al2O3	11.8	11.9	11.6
Fe2O3	0.69	0.35	0.63
MgO	0.00	0.00	0.00
CaO	0.43	0.39	0.48
BaO	0.00	0.00	0.00
Na2O	3.38	3.48	3.31
K2O	4.74	4.72	4.72
Total	92.0	93.2	92.3

	Cation Percent		
Si	72.1	72.4	72.5
Ti	0.03	0.03	0.00
Al	14.1	14.1	13.9
Fe	0.53	0.26	0.48
Mg	0.00	0.00	0.00
Ca	0.47	0.42	0.52
Ba	0.00	0.00	0.00
Na	6.66	6.76	6.50
K	6.14	6.03	6.10

	Si/(Al+Fe)		
	4.92	5.04	5.04

	(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)		
	1.07	1.05	1.06

	Mol% Exchangeable Cations		
K	46.3	45.7	46.5
Na	50.2	51.2	49.5
Ca+Mg	3.5	3.2	4.0

	Oxides Recalculated to 100%		
SiO2	77.1	77.5	77.5
TiO2	0.04	0.04	0.00
Al2O3	12.8	12.8	12.6
Fe2O3	0.75	0.38	0.68
MgO	0.00	0.00	0.00
CaO	0.47	0.42	0.52
BaO	0.00	0.00	0.00
Na2O	3.67	3.74	3.58
K2O	5.15	5.07	5.11

APPENDIX F

CLINOPTILOLITE COMPOSITIONS DETERMINED BY ELECTRON MICROPROBE,
YUCCA MOUNTAIN, NEVADA

Drill Hole USW G-1								
Depth (ft)	1286	1436	1561	1561	1561	1639	1774	1774
Unit ^a	Tpt	Tht	Tht	Tht	Tht	Tht	Tht	Tht
iO ₂	63.5	68.9	65.7	69.5	63.4	66.5	68.1	63.8
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.6	12.4	11.6	11.8	10.9	11.5	12.2	11.9
Fe ₂ O ₃	0.00	0.00	0.02	0.18	0.00	0.00	0.00	0.00
MgO	0.28	0.00	0.00	0.00	0.00	0.02	0.09	0.12
CaO	5.09	0.88	0.62	0.56	0.57	0.73	1.11	1.43
BaO	0.00	0.00	0.00	0.00	0.00	0.09	0.03	0.12
Na ₂ O	0.87	2.29	2.60	2.30	2.29	2.59	2.84	3.18
K ₂ O	0.57	5.89	4.87	5.64	4.99	4.56	4.20	2.25
Total	82.9	90.4	85.4	90.1	82.1	86.1	88.5	82.8
Unit-Cell Composition Based on 72 (O)								
Si	29.2	29.8	29.9	30.0	30.0	30.0	29.8	29.7
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.86	6.32	6.22	6.03	6.09	6.13	6.28	6.50
Fe	0.00	0.00	0.01	0.06	0.00	0.00	0.00	0.00
Mg	0.19	0.00	0.00	0.00	0.00	0.01	0.06	0.08
Ca	2.51	0.41	0.30	0.26	0.29	0.35	0.52	0.71
Ba	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.02
Na	0.78	1.92	2.29	1.93	2.10	2.26	2.41	2.87
K	0.33	3.25	2.83	3.11	3.01	2.62	2.35	1.33
Si/(Al+Fe)								
	4.26	4.71	4.80	4.93	4.93	4.89	4.74	4.57
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.05	1.06	1.09	1.10	1.07	1.09	1.06	1.11
Mol% Exchangeable Cations								
K	8.8	58.3	52.1	58.7	55.8	49.9	44.0	26.7
Na	20.4	34.4	42.3	36.4	38.9	43.1	45.2	57.4
Ca+Mg	70.9	7.3	5.6	4.9	5.3	7.0	10.9	15.9

^a Unit symbols defined in Table 1.

APPENDIX F (cont)

Drill Hole USW G-1

Depth (ft)	1819	1819	2083	2166	2290	3598	3598	3598
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcb	Tfb	Tfb	Tfb
SiO ₂	68.2	66.4	67.3	68.9	70.2	66.2	63.0	64.3
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.19
Al ₂ O ₃	11.8	11.3	11.7	12.7	13.4	12.5	12.7	12.5
Fe ₂ O ₃	0.00	0.37	0.00	0.23	0.00	0.76	0.44	0.91
MgO	0.07	0.09	0.07	0.09	0.18	0.00	0.04	0.12
CaO	1.07	1.14	0.78	0.71	2.11	1.56	1.59	1.51
BaO	0.00	0.08	0.08	0.08	0.00	1.12	0.98	0.86
Na ₂ O	2.63	2.68	3.13	3.84	2.56	4.25	4.75	4.57
K ₂ O	3.86	3.02	3.34	3.77	2.96	0.69	0.57	0.53
Total	87.6	85.1	86.4	90.3	91.4	87.1	84.2	85.5
Unit-Cell Composition Based on 72 (O)								
Si	30.0	30.0	30.0	29.6	29.5	29.4	29.0	29.1
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06
Al	6.10	6.03	6.16	6.41	6.68	6.55	6.90	6.68
Fe	0.00	0.13	0.00	0.07	0.00	0.25	0.15	0.31
Mg	0.05	0.06	0.05	0.06	0.11	0.00	0.03	0.08
Ca	0.51	0.55	0.37	0.33	0.95	0.74	0.79	0.73
Ba	0.00	0.01	0.01	0.01	0.00	0.20	0.18	0.15
Na	2.25	2.35	2.71	3.20	2.09	3.66	4.25	4.01
K	2.17	1.74	1.90	2.07	1.59	0.39	0.34	0.31
Si/(Al+Fe)								
	4.92	4.88	4.88	4.57	4.43	4.32	4.12	4.17
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.11	1.15	1.12	1.07	1.15	1.15	1.08	1.12
Mol% Exchangeable Cations								
K	43.7	37.0	37.8	36.6	33.5	8.2	6.2	6.0
Na	45.2	49.9	53.8	56.6	44.0	76.4	78.7	78.2
Ca+Mg	11.1	13.0	8.3	6.8	22.4	15.5	15.1	15.9

APPENDIX F (cont)

Drill Hole USW G-1

Depth	3706
(ft)	
Unit ^a	Tfb

SiO2	69.6
TiO2	0.00
Al2O3	10.7
Fe2O3	0.06
MgO	0.00
CaO	1.90
BaO	0.14
Na2O	3.50
K2O	0.07

Total	86.0
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Unit-Cell Composition Based on 72 (O)

Si	30.6
Ti	0.00
Al	5.55
Fe	0.02
Mg	0.00
Ca	0.90
Ba	0.02
Na	2.98
K	0.04

Si/(Al+Fe)	5.50
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)	1.14
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Mol% Exchangeable Cations

K	1.0
Na	76.2
Ca+Mg	22.8

APPENDIX F (cont)

Drill Hole USW G-2

Depth (ft)	561	561	561	561	561	561	584	584
Unit ^a	Top	Top	Top	Top	Top	Top	Top	Top
SiO ₂	68.6	67.5	67.7	65.6	67.6	66.8	62.6	65.6
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Al ₂ O ₃	12.4	13.0	12.8	12.9	12.4	12.6	13.3	13.8
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	1.05	1.17	0.98	0.93	1.03	0.99	1.41	1.47
CaO	3.97	4.29	4.18	4.41	3.86	4.23	4.41	4.23
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02
Na ₂ O	0.22	0.21	0.28	0.26	0.23	0.19	0.02	0.18
K ₂ O	1.31	0.98	1.37	1.06	1.18	1.27	0.63	1.09
Total	87.6	87.2	87.4	85.1	86.4	86.0	82.6	86.3
Unit-Cell Composition Based on 72 (O)								
Si	29.7	29.4	29.5	29.3	29.7	29.5	28.9	28.9
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Al	6.35	6.70	6.59	6.78	6.45	6.57	7.25	7.17
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.68	0.76	0.64	0.62	0.67	0.65	0.97	0.97
Ca	1.84	2.00	1.95	2.11	1.82	2.00	2.18	2.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Na	0.18	0.18	0.24	0.23	0.20	0.16	0.02	0.15
K	0.72	0.54	0.76	0.60	0.66	0.72	0.37	0.61
Si/(Al+Fe)								
	4.68	4.39	4.48	4.33	4.61	4.49	3.98	4.03
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.07	1.07	1.07	1.08	1.10	1.06	1.08	1.07
Mol% Exchangeable Cations								
K	21.1	15.6	21.2	17.0	19.8	20.3	10.5	16.4
Na	5.4	5.1	6.6	6.3	5.9	4.6	0.5	4.1
Ca+Mg	73.5	79.3	72.2	76.7	74.4	75.1	89.0	79.4

APPENDIX F (cont)

Drill Hole USW G-2

Depth (ft)	584	584	584	584	584	657	657	657
Unit ^a	Tpp	Tpp	Tpp	Tpp	Tpp	Tpp	Tpp	Tpp
SiO ₂	67.0	62.1	61.1	61.6	62.9	67.5	67.2	65.4
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Al ₂ O ₃	13.6	13.6	13.5	14.0	14.0	13.3	13.4	13.3
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.03	0.33	0.26
MgO	1.35	1.53	1.55	1.75	1.86	0.98	0.95	0.97
CaO	4.16	4.03	3.98	4.09	4.08	4.11	4.07	3.95
BaO	0.00	0.00	0.07	0.00	0.09	0.51	0.42	0.22
Na ₂ O	0.03	0.13	0.14	0.12	0.10	0.11	0.25	0.14
K ₂ O	0.75	0.97	0.95	0.59	0.54	1.28	1.62	1.68
Total	86.9	82.3	81.3	82.2	83.5	87.8	88.2	86.0

Unit-Cell Composition Based on 72 (O)

Si	29.2	28.7	28.7	28.5	28.6	29.4	29.2	29.1
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Al	6.99	7.42	7.45	7.66	7.53	6.81	6.86	6.97
Fe	0.00	0.00	0.00	0.00	0.00	0.01	0.11	0.09
Mg	0.88	1.06	1.08	1.21	1.26	0.64	0.62	0.64
Ca	1.95	2.00	2.00	2.03	1.99	1.92	1.90	1.88
Ba	0.00	0.00	0.01	0.00	0.02	0.09	0.07	0.04
Na	0.03	0.12	0.13	0.11	0.09	0.09	0.21	0.12
K	0.42	0.57	0.57	0.35	0.31	0.71	0.90	0.95

Si/(Al+Fe)

4.18	3.87	3.85	3.72	3.80	4.30	4.19	4.13
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.15	1.09	1.08	1.11	1.09	1.12	1.11	1.14
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Mol% Exchangeable Cations

K	12.8	15.3	15.0	9.4	8.6	21.2	24.8	26.5
Na	0.8	3.1	3.4	2.9	2.4	2.8	5.8	3.4
Ca+Mg	86.4	81.6	81.6	87.6	89.0	76.1	69.4	70.2

APPENDIX F (cont)

Drill Hole USW G-2

Depth (ft)	657	762	1691	1691	1745	1745	1745	1745
Unit ^a	Tpp	Tpt	Tpt	Tpt	Tht	Tht	Tht	Tht
SiO2	67.2	68.4	67.9	66.3	64.6	64.9	66.7	65.0
TiO2	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.04
Al2O3	13.1	11.7	12.4	12.3	12.6	12.6	12.0	12.6
Fe2O3	0.03	0.24	0.02	0.01	0.04	0.01	0.00	0.01
MgO	0.90	0.78	0.04	0.00	0.00	0.00	0.00	0.00
CaO	3.90	2.94	2.97	3.14	3.57	3.41	3.52	3.20
BaO	0.40	0.00	0.00	0.07	0.16	0.16	0.14	0.03
Na2O	0.36	0.23	0.96	0.84	1.02	1.32	0.96	1.32
K2O	1.86	2.39	3.79	3.55	2.78	3.26	3.77	3.45
Total	87.7	86.8	88.1	86.2	84.8	85.6	87.1	85.7
Unit-Cell Composition Based on 72 (O)								
Si	29.4	30.0	29.7	29.7	29.4	29.4	29.7	29.4
Ti	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01
Al	6.72	6.07	6.42	6.49	6.77	6.70	6.31	6.72
Fe	0.01	0.08	0.01	0.00	0.01	0.00	0.00	0.00
Mg	0.59	0.51	0.03	0.00	0.00	0.00	0.00	0.00
Ca	1.83	1.38	1.39	1.51	1.74	1.65	1.68	1.55
Ba	0.07	0.00	0.00	0.01	0.03	0.03	0.02	0.01
Na	0.31	0.20	0.82	0.73	0.90	1.16	0.83	1.16
K	1.04	1.34	2.12	2.03	1.61	1.88	2.14	1.99
Si/(Al+Fe)								
	4.36	4.88	4.63	4.57	4.34	4.39	4.70	4.37
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.07	1.16	1.11	1.12	1.12	1.05	0.99	1.07
Mol% Exchangeable Cations								
K	27.6	39.1	48.7	47.6	37.9	40.1	46.1	42.4
Na	8.1	5.7	18.7	17.1	21.2	24.7	17.8	24.6
Ca+Mg	64.3	55.2	32.6	35.3	40.9	35.2	36.1	33.0

APPENDIX F (cont)

Drill Hole USW G-2

Depth (ft) ^a	1745	1745	2078	2078	2158	2158	2158	2158
Unit ^a	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	65.5	64.6	70.0	66.1	66.6	67.6	68.3	68.0
TiO ₂	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Al ₂ O ₃	12.4	12.5	11.4	11.8	12.7	12.2	12.7	12.9
Fe ₂ O ₃	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.45	0.46	0.56	0.48	0.52	0.54
CaO	3.48	3.49	2.88	2.81	3.13	3.43	3.36	3.50
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	1.23	1.13	0.66	0.65	0.97	0.79	0.94	0.58
K ₂ O	3.01	3.20	2.62	2.72	2.91	2.51	2.84	2.45
Total	85.6	84.9	88.1	84.6	86.9	87.0	88.6	88.0
Unit-Cell Composition Based on 72 (O)								
Si	29.5	29.4	30.3	29.9	29.5	29.8	29.6	29.6
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.61	6.71	5.83	6.31	6.62	6.34	6.47	6.62
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.00	0.00	0.29	0.31	0.37	0.32	0.34	0.35
Ca	1.68	1.70	1.34	1.36	1.49	1.62	1.56	1.63
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	1.07	1.00	0.55	0.57	0.83	0.67	0.79	0.49
K	1.73	1.86	1.45	1.57	1.64	1.41	1.57	1.36
Si/(Al+Fe)								
	4.47	4.38	5.20	4.74	4.45	4.70	4.58	4.47
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.07	1.07	1.11	1.15	1.07	1.06	1.05	1.14
Mol% Exchangeable Cations								
K	38.6	40.8	39.9	41.2	38.0	35.1	36.9	35.5
Na	24.0	21.9	15.3	15.0	19.2	16.8	18.6	12.8
Ca+Mg	37.5	37.3	44.8	43.9	42.8	48.1	44.5	51.7

APPENDIX F (cont)

Drill Hole USW G-2

Depth (ft) Unit ^a	2158	2158	2325	2325	2430	2430	3067	3067
	Tht	Tht	Tht	Tht	Tht	Tht	Tcp	Tcp
SiO ₂	68.6	66.6	69.4	70.1	70.2	71.3	74.1	74.7
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
Al ₂ O ₃	11.4	11.6	12.0	12.7	11.6	12.0	11.4	11.7
Fe ₂ O ₃	0.00	0.00	0.03	0.03	0.01	0.00	0.52	0.73
MgO	0.41	0.51	0.30	0.28	0.36	0.31	0.00	0.03
CaO	3.23	3.23	3.45	3.53	2.77	3.08	0.34	0.32
BaO	0.00	0.00	0.00	0.00	0.15	0.00	0.11	0.16
Na ₂ O	0.42	0.77	1.07	0.95	0.64	0.72	4.60	4.66
K ₂ O	2.23	2.64	2.36	2.45	2.81	2.71	3.04	3.06
Total	86.3	85.4	88.6	90.0	88.5	90.1	94.2	95.5

Unit-Cell Composition Based on 72 (O)

Si	30.2	29.9	30.0	29.8	30.3	30.2	30.3	30.2
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03
Al	5.94	6.16	6.11	6.35	5.92	6.01	5.50	5.58
Fe	0.00	0.00	0.01	0.01	0.00	0.00	0.16	0.22
Mg	0.27	0.34	0.19	0.18	0.23	0.20	0.00	0.02
Ca	1.53	1.55	1.60	1.61	1.28	1.40	0.15	0.14
Ba	0.00	0.00	0.00	0.00	0.03	0.00	0.02	0.03
Na	0.36	0.67	0.90	0.78	0.54	0.59	3.65	3.66
K	1.25	1.51	1.30	1.33	1.55	1.46	1.59	1.58

Si/(Al+Fe)

5.09	4.85	4.90	4.69	5.11	5.02	5.36	5.21
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.14	1.03	1.06	1.12	1.15	1.15	1.02	1.04
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Mol% Exchangeable Cations

K	36.8	37.1	32.6	34.1	43.0	40.1	29.5	29.3
Na	10.5	16.4	22.5	20.1	14.9	16.2	67.8	67.8
Ca+Mg	52.7	46.5	44.9	45.8	42.1	43.7	2.8	2.9

APPENDIX F (cont)

Drill Hole USW G-2

Depth (ft)	3067	3067	3067	3067	3192	3192	3192	3192
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	74.5	73.4	74.3	69.7	63.2	64.2	63.7	65.0
TiO ₂	0.07	0.10	0.09	0.00	0.00	0.03	0.03	0.00
Al ₂ O ₃	11.6	11.6	11.7	10.5	12.2	12.5	12.2	12.5
Fe ₂ O ₃	0.80	0.18	0.71	0.00	0.05	0.18	0.11	0.11
MgO	0.30	0.00	0.00	0.00	0.00	0.02	0.00	0.02
CaO	0.29	0.29	0.34	2.70	2.06	2.25	2.05	1.91
BaO	0.08	0.11	0.18	0.18	0.00	0.00	0.00	0.00
Na ₂ O	4.48	4.74	4.77	2.48	3.20	3.26	3.51	3.61
K ₂ O	2.86	3.17	2.87	0.51	1.85	2.15	1.61	1.77
Total	94.7	93.6	95.0	86.1	82.6	84.6	83.3	84.9

Unit-Cell Composition Based on 72 (O)

Si	30.3	30.3	30.2	30.7	29.4	29.3	29.4	29.4
Ti	0.02	0.03	0.03	0.00	0.00	0.01	0.01	0.00
Al	5.56	5.64	5.61	5.45	6.70	6.73	6.64	6.68
Fe	0.24	0.06	0.22	0.00	0.02	0.06	0.04	0.04
Mg	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Ca	0.13	0.13	0.15	1.27	1.03	1.10	1.01	0.93
Ba	0.01	0.02	0.03	0.03	0.00	0.00	0.00	0.00
Na	3.53	3.79	3.76	2.12	2.89	2.89	3.23	3.17
K	1.48	1.67	1.49	0.29	1.10	1.25	0.95	1.02

Si/(Al+Fe)

	5.22	5.31	5.19	5.63	4.38	4.32	4.40	4.39
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

	1.10	0.99	1.04	1.09	1.11	1.07	1.08	1.11
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Mol% Exchangeable Cations

K	28.9	29.9	27.6	7.8	21.9	23.8	18.3	19.9
Na	68.7	67.8	69.7	57.6	57.6	54.9	62.2	61.8
Ca+Mg	2.5	2.3	2.7	34.6	20.5	21.2	19.5	18.3

APPENDIX F (cont)

Drill Hole USW G-2

Depth (ft) Unit ^a	3192	3192	3192	3192	3250	3250
	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	63.0	66.0	66.2	65.4	66.9	68.2
TiO ₂	0.05	0.04	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.8	12.6	12.8	12.2	11.6	12.0
Fe ₂ O ₃	0.54	0.17	0.17	0.29	0.08	0.13
MgO	0.05	0.00	0.05	0.00	0.00	0.02
CaO	2.16	2.09	2.43	1.72	2.33	2.37
BaO	0.17	0.00	0.05	0.00	0.02	0.04
Na ₂ O	3.33	3.26	3.08	3.32	3.73	4.20
K ₂ O	1.73	2.00	1.99	2.32	0.04	0.13
Total	83.8	86.2	86.8	85.3	84.7	87.1
Unit-Cell Composition Based on 72 (O)						
Si	29.1	29.5	29.4	29.6	30.0	29.8
Ti	0.02	0.01	0.00	0.00	0.00	0.00
Al	6.96	6.63	6.70	6.50	6.13	6.19
Fe	0.19	0.06	0.06	0.10	0.03	0.04
Mg	0.03	0.00	0.03	0.00	0.00	0.01
Ca	1.07	1.00	1.16	0.83	1.12	1.11
Ba	0.03	0.00	0.01	0.00	0.00	0.01
Na	2.98	2.82	2.65	2.91	3.24	3.56
K	1.02	1.14	1.13	1.34	0.02	0.07
	Si/(Al+Fe)					
	4.07	4.40	4.35	4.48	4.87	4.79
	(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)					
	1.14	1.12	1.09	1.12	1.12	1.06
Mol% Exchangeable Cations						
K	20.0	23.0	22.7	26.3	0.5	1.5
Na	58.4	56.9	53.4	57.3	74.0	74.9
Ca+Mg	21.6	20.2	23.9	16.4	25.5	23.6

APPENDIX F (cont)

Drill Hole USW G-3

Depth (ft)	1195	1195	1195	1195	1195	1195	1874	1874
Unit ^a	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tcp	Tcp
SiO ₂	64.7	67.0	62.6	64.9	63.1	70.0	69.5	66.5
TiO ₂	0.03	0.04	0.02	0.00	0.05	0.00	0.00	0.00
Al ₂ O ₃	13.2	12.3	12.4	12.1	11.8	12.4	12.1	11.2
Fe ₂ O ₃	0.30	0.25	0.00	0.00	0.83	0.00	0.04	0.02
MgO	0.91	0.72	0.85	0.79	0.93	0.56	0.00	0.00
CaO	4.28	4.00	4.03	3.96	3.85	3.94	1.62	1.69
BaO	0.04	0.13	0.00	0.01	0.19	0.00	0.00	0.00
Na ₂ O	0.70	0.77	0.54	0.59	0.48	0.70	1.46	1.76
K ₂ O	0.36	0.78	0.48	0.64	0.94	1.19	4.91	3.95
Total	84.5	86.0	80.9	82.9	82.2	88.8	89.7	85.1
Unit-Cell Composition Based on 72 (O)								
Si	29.1	29.6	29.4	29.7	29.4	29.9	30.0	30.1
Ti	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.00
Al	6.99	6.44	6.84	6.51	6.46	6.24	6.18	5.99
Fe	0.10	0.08	0.00	0.00	0.29	0.00	0.01	0.01
Mg	0.61	0.47	0.59	0.54	0.64	0.36	0.00	0.00
Ca	2.06	1.90	2.03	1.94	1.92	1.80	0.75	0.82
Ba	0.01	0.02	0.00	0.00	0.03	0.00	0.00	0.00
Na	0.61	0.66	0.49	0.52	0.43	0.58	1.22	1.55
K	0.21	0.44	0.29	0.37	0.56	0.65	2.70	2.28
Si/(Al+Fe)								
	4.11	4.54	4.29	4.56	4.35	4.80	4.85	5.03
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.15	1.11	1.14	1.11	1.09	1.12	1.14	1.09
Mol% Exchangeable Cations								
K	5.9	12.7	8.5	11.1	15.7	19.1	57.8	49.1
Na	17.5	19.0	14.5	15.5	12.2	17.1	26.1	33.3
Ca+Mg	76.6	68.3	77.1	73.4	72.1	63.7	16.0	17.6

APPENDIX F (cont)

Drill Hole USW G-3

Depth (ft)	1874	1874	1874	1874	1874	1874	1874	1986
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	67.7	67.3	67.6	65.9	68.2	68.2	69.0	64.2
TiO ₂	0.00	0.01	0.04	0.00	0.00	0.00	0.03	0.00
Al ₂ O ₃	12.0	12.0	12.0	11.5	11.9	11.9	11.8	11.4
Fe ₂ O ₃	0.05	0.05	0.09	0.00	0.00	0.00	0.03	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	1.65	1.57	1.84	1.59	1.66	1.95	1.59	0.59
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	1.58	1.84	1.64	1.53	1.68	1.69	1.52	1.65
K ₂ O	4.61	5.04	5.44	4.61	4.30	5.20	5.05	6.51
Total	87.6	87.8	88.6	85.2	87.8	88.9	89.0	84.4
Unit-Cell Composition Based on 72 (O)								
Si	29.9	29.8	29.8	30.0	30.0	29.9	30.0	29.8
Ti	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
Al	6.25	6.26	6.22	6.18	6.19	6.14	6.07	6.24
Fe	0.02	0.02	0.03	0.00	0.00	0.00	0.01	0.00
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.78	0.75	0.87	0.77	0.78	0.91	0.74	0.29
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	1.35	1.58	1.40	1.35	1.43	1.43	1.28	1.49
K	2.60	2.85	3.06	2.67	2.41	2.90	2.81	3.86
Si/(Al+Fe)								
	4.77	4.75	4.76	4.85	4.84	4.86	4.94	4.78
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.14	1.06	1.01	1.11	1.15	1.00	1.09	1.05
Mol% Exchangeable Cations								
K	54.9	55.1	57.4	55.7	52.1	55.3	58.1	68.4
Na	28.6	30.5	26.3	28.1	31.0	27.3	26.6	26.4
Ca+Mg	16.5	14.4	16.3	16.1	16.9	17.4	15.4	5.2

APPENDIX F (cont)

Drill Hole USW G-3

Depth (ft) Unit ^a	1986	1986	1986	1986	1986	1986	1986	1986
	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	66.6	66.9	66.7	68.0	67.5	69.1	65.1	65.6
TiO ₂	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00
Al ₂ O ₃	11.6	11.9	11.9	11.7	11.9	12.3	12.0	11.7
Fe ₂ O ₃	0.01	0.06	0.00	0.00	0.06	0.00	0.14	0.05
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.64	0.60	0.68	0.59	0.63	0.61	0.59	0.66
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	2.10	1.96	2.18	2.13	2.54	2.60	2.41	2.11
K ₂ O	6.12	6.49	5.68	5.74	5.45	5.51	6.06	5.91
Total	87.0	87.9	87.1	88.1	88.1	90.1	86.3	86.0

Unit-Cell Composition Based on 72 (O)

Si	29.9	29.8	29.8	30.0	29.9	29.9	29.6	29.8
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.13	6.25	6.28	6.07	6.18	6.26	6.41	6.28
Fe	0.00	0.02	0.00	0.00	0.02	0.00	0.05	0.02
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.31	0.29	0.33	0.28	0.30	0.28	0.29	0.32
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	1.83	1.69	1.89	1.82	2.18	2.18	2.12	1.86
K	3.51	3.69	3.24	3.24	3.08	3.04	3.51	3.43

Si/(Al+Fe)

4.88	4.75	4.75	4.95	4.82	4.77	4.58	4.73
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.03	1.05	1.09	1.08	1.06	1.08	1.04	1.06
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Mol% Exchangeable Cations

K	62.1	65.1	59.4	60.6	55.4	55.2	59.3	61.1
Na	32.4	29.9	34.6	34.2	39.2	39.6	35.8	33.2
Ca+Mg	5.5	5.1	6.0	5.2	5.4	5.1	4.8	5.7

APPENDIX F (cont)

Drill Hole USW G-3

Depth (ft) Unit ^a	1986	1993	2577	2577	2577	2577	2577	2577
	Tcp	Tcp	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb
SiO ₂	65.8	67.8	67.3	67.0	68.1	70.8	69.8	66.3
TiO ₂	0.00	0.00	0.00	0.02	0.03	0.01	0.02	0.03
Al ₂ O ₃	11.3	12.1	12.1	12.7	12.6	12.7	12.8	12.9
Fe ₂ O ₃	0.20	0.00	0.00	0.00	0.00	0.00	0.02	0.03
MgO	0.00	0.00	0.18	0.27	0.27	0.22	0.25	0.20
CaO	0.66	0.64	3.02	3.09	3.28	3.28	3.05	3.51
BaO	0.00	0.00	0.11	0.00	0.00	0.11	0.59	0.05
Na ₂ O	2.05	2.40	1.83	1.66	1.71	1.56	1.56	1.69
K ₂ O	5.56	5.86	1.74	1.87	1.74	1.94	1.97	1.84
Total	85.5	88.8	86.3	86.6	87.7	90.6	90.0	86.6
Unit-Cell Composition Based on 72 (O)								
Si	30.0	29.8	29.8	29.6	29.7	29.9	29.8	29.4
Ti	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
Al	6.08	6.29	6.33	6.60	6.49	6.30	6.41	6.75
Fe	0.07	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Mg	0.00	0.00	0.12	0.18	0.18	0.14	0.16	0.13
Ca	0.32	0.30	1.43	1.46	1.53	1.48	1.39	1.67
Ba	0.00	0.00	0.02	0.00	0.00	0.02	0.10	0.01
Na	1.81	2.05	1.57	1.42	1.45	1.28	1.29	1.45
K	3.23	3.29	0.98	1.05	0.97	1.04	1.07	1.04
Si/(Al+Fe)								
	4.87	4.73	4.72	4.49	4.57	4.74	4.64	4.35
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.08	1.06	1.11	1.15	1.11	1.12	1.13	1.11
Mol% Exchangeable Cations								
K	60.2	58.3	23.9	25.6	23.5	26.5	27.4	24.2
Na	33.8	36.3	38.3	34.5	35.1	32.4	33.0	33.8
Ca+Mg	6.0	5.4	37.8	39.9	41.4	41.1	39.7	41.9

APPENDIX F (cont)

Drill Hole USW G-3

Depth (ft) Unit ^a	2577	2577	2615	2615	2656	2656	2695	3226
	Tcb	Tcb	Tcb	Tcb	Tct	Tct	Tct	Tct
SiO ₂	68.3	68.8	63.9	62.9	67.7	67.7	65.8	66.7
TiO ₂	0.00	0.02	0.00	0.00	0.02	0.02	0.01	0.00
Al ₂ O ₃	12.9	12.7	11.7	11.3	11.9	12.6	12.0	12.1
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.01	0.12	0.36	0.29
MgO	0.24	0.22	0.00	0.00	0.00	0.00	0.00	0.04
CaO	3.27	3.19	1.57	1.53	1.82	1.86	1.98	1.96
BaO	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	1.70	1.53	2.88	2.91	2.07	2.48	2.54	2.43
K ₂ O	2.10	2.18	2.71	2.97	3.45	3.46	3.19	2.88
Total	88.5	88.6	82.8	81.6	86.9	88.2	85.9	86.4

Unit-Cell Composition Based on 72 (O)

Si	29.6	29.7	29.7	29.8	30.0	29.6	29.6	29.8
Ti	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00
Al	6.61	6.45	6.43	6.31	6.21	6.51	6.36	6.34
Fe	0.00	0.00	0.00	0.00	0.00	0.04	0.12	0.10
Mg	0.15	0.14	0.00	0.00	0.00	0.00	0.00	0.03
Ca	1.52	1.48	0.78	0.78	0.86	0.87	0.96	0.94
Ba	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Na	1.43	1.28	2.60	2.67	1.78	2.11	2.22	2.10
K	1.16	1.20	1.61	1.79	1.95	1.93	1.83	1.64

Si/(Al+Fe)

4.47	4.61	4.62	4.71	4.82	4.52	4.57	4.62
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.11	1.12	1.11	1.05	1.14	1.13	1.09	1.14
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Mol% Exchangeable Cations

K	27.2	29.3	32.2	34.2	42.5	39.4	36.6	34.8
Na	33.5	31.2	52.1	51.0	38.7	42.9	44.3	44.7
Ca+Mg	39.3	39.5	15.7	14.8	18.8	17.8	19.1	20.5

APPENDIX F (cont)

Drill Hole USW G-3

Depth (ft) ^a	3226	3475	3589	3589	3589	3672	3672	3672
Unit ^a	Tct	Tct	Tct	Tct	Tct	Tct	Tct	Tct
SiO ₂	65.8	66.9	65.1	67.0	64.7	64.8	64.4	64.7
TiO ₂	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.1	12.3	11.4	11.4	12.2	12.3	11.8	12.7
Fe ₂ O ₃	0.68	0.07	0.51	0.26	0.00	0.00	0.22	0.00
MgO	0.03	0.30	0.12	0.00	0.00	0.00	0.04	0.02
CaO	1.91	1.19	0.79	0.88	1.19	1.12	1.07	1.09
BaO	0.00	0.07	0.19	0.13	0.10	0.13	0.00	0.32
Na ₂ O	2.78	2.89	2.23	2.20	2.42	2.80	2.98	2.81
K ₂ O	2.93	3.57	5.55	4.47	4.38	3.85	3.93	4.46
Total	86.3	87.3	85.9	86.3	85.0	84.9	84.5	86.1
Unit-Cell Composition Based on 72 (O)								
Si	29.5	29.6	29.7	30.1	29.6	29.6	29.6	29.3
Ti	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.43	6.42	6.12	6.02	6.57	6.60	6.41	6.80
Fe	0.23	0.02	0.18	0.09	0.00	0.00	0.08	0.00
Mg	0.02	0.20	0.08	0.00	0.00	0.00	0.03	0.01
Ca	0.92	0.57	0.39	0.42	0.58	0.55	0.53	0.53
Ba	0.00	0.01	0.03	0.02	0.02	0.02	0.00	0.06
Na	2.42	2.48	1.97	1.91	2.15	2.48	2.66	2.47
K	1.68	2.02	3.23	2.56	2.56	2.24	2.30	2.58
Si/(Al+Fe)								
	4.44	4.60	4.72	4.93	4.50	4.49	4.56	4.32
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.11	1.06	1.01	1.14	1.11	1.12	1.07	1.09
Mol% Exchangeable Cations								
K	33.3	38.3	57.0	52.3	48.4	42.6	41.8	46.1
Na	48.0	47.2	34.8	39.1	40.6	47.0	48.2	44.2
Ca+Mg	18.6	14.5	8.2	8.6	11.0	10.4	10.1	9.7

APPENDIX F (cont)

Drill Hole USW G-3

Depth (ft) Unit ^a	3672	3672	3672	3759	3759	3759	4423	4423
	Tct	Tct	Tct	Tct	Tct	Tct	Tlr	Tlr
SiO2	65.7	66.9	67.2	67.3	65.3	66.8	65.3	65.3
TiO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al2O3	12.5	11.8	12.5	12.5	12.2	12.2	12.9	12.6
Fe2O3	0.04	0.07	0.00	0.00	0.02	0.08	0.00	0.12
MgO	0.07	0.00	0.00	0.00	0.00	0.00	0.40	0.22
CaO	0.96	1.12	1.04	1.18	1.05	1.09	2.43	2.35
BaO	0.23	0.01	0.91	0.39	0.00	0.00	0.30	0.27
Na2O	2.63	2.42	2.27	3.22	2.96	3.69	3.19	3.21
K2O	5.61	4.36	5.02	3.33	3.99	3.20	0.59	1.15
Total	87.8	86.7	89.0	87.8	85.5	87.0	85.1	85.2
Unit-Cell Composition Based on 72 (O)								
Si	29.4	29.9	29.6	29.7	29.6	29.7	29.3	29.4
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.60	6.21	6.51	6.48	6.53	6.37	6.84	6.70
Fe	0.01	0.02	0.00	0.00	0.01	0.03	0.00	0.04
Mg	0.05	0.00	0.00	0.00	0.00	0.00	0.27	0.15
Ca	0.46	0.54	0.49	0.56	0.51	0.52	1.17	1.13
Ba	0.04	0.00	0.16	0.07	0.00	0.00	0.05	0.05
Na	2.28	2.10	1.94	2.75	2.60	3.18	2.78	2.80
K	3.20	2.49	2.82	1.87	2.31	1.81	0.34	0.66
Si/(Al+Fe)								
	4.44	4.80	4.55	4.58	4.53	4.64	4.29	4.36
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.01	1.10	1.07	1.10	1.10	1.06	1.12	1.10
Mol% Exchangeable Cations								
K	53.5	48.6	53.7	36.1	42.6	32.9	7.4	13.9
Na	38.1	41.0	36.9	53.1	48.0	57.7	61.0	59.1
Ca+Mg	8.5	10.5	9.3	10.8	9.4	9.4	31.6	27.0

APPENDIX F (cont)

Drill Hole USW G-4

Depth (ft) Unit ^a	1432	1432	1470	1470	1470	1470	1470	1470
	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	67.1	67.4	68.4	66.0	67.1	67.8	67.4	67.1
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.2	12.4	11.8	12.3	12.4	12.0	11.8	12.4
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	1.53	1.39	0.84	0.98	1.06	0.89	0.87	1.08
BaO	0.18	1.03	0.00	0.00	0.00	0.00	0.08	0.00
Na ₂ O	2.34	2.42	2.50	2.15	2.55	2.35	2.13	2.24
K ₂ O	5.42	4.93	5.43	5.41	5.54	5.68	5.03	4.97
Total	88.8	89.5	88.9	86.8	88.6	88.7	87.3	87.8
Unit-Cell Composition Based on 72 (O)								
Si	29.6	29.6	30.0	29.6	29.6	29.8	30.0	29.7
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.35	6.40	6.08	6.51	6.45	6.23	6.16	6.49
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.72	0.65	0.39	0.47	0.50	0.42	0.41	0.51
Ba	0.03	0.18	0.00	0.00	0.00	0.00	0.01	0.00
Na	2.00	2.06	2.12	1.87	2.18	2.01	1.84	1.92
K	3.05	2.76	3.03	3.10	3.12	3.19	2.85	2.81
Si/(Al+Fe)								
	4.66	4.62	4.92	4.56	4.58	4.78	4.87	4.58
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.96	0.99	1.02	1.10	1.02	1.03	1.11	1.13
Mol% Exchangeable Cations								
K	52.7	50.4	54.7	56.9	53.8	56.8	55.9	53.5
Na	34.6	37.6	38.2	34.4	37.6	35.7	36.0	36.7
Ca+Mg	12.7	11.9	7.1	8.7	8.6	7.5	8.1	9.8

APPENDIX F (cont)

Drill Hole USW G-4

Depth (ft)	1544	1544	1544	1544	1544	1707	1707	1707
Unit ^a	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	64.1	66.0	65.5	64.5	68.9	67.3	55.9	67.2
TiO ₂	0.00	0.00	0.01	0.02	0.02	0.00	0.00	0.00
Al ₂ O ₃	12.7	12.8	12.5	12.0	13.0	12.8	13.1	12.3
Fe ₂ O ₃	0.05	0.11	0.13	0.09	0.12	0.00	0.03	0.00
MgO	0.00	0.00	0.02	0.00	0.02	0.01	0.05	0.02
CaO	0.94	1.09	0.95	0.79	0.81	0.94	1.09	0.93
BaO	0.09	0.06	0.11	0.05	0.10	0.02	0.10	0.05
Na ₂ O	2.88	3.01	3.08	3.10	3.25	2.67	2.67	2.61
K ₂ O	5.36	5.26	5.45	5.66	5.62	5.45	5.72	6.28
Total	86.1	88.3	87.8	86.3	91.8	89.2	88.6	89.4
Unit-Cell Composition Based on 72 (O)								
Si	29.2	29.3	29.3	29.4	29.4	29.5	29.2	29.6
Ti	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Al	6.81	6.70	6.62	6.46	6.53	6.61	6.83	6.38
Fe	0.02	0.04	0.04	0.03	0.04	0.00	0.01	0.00
Mg	0.00	0.00	0.01	0.00	0.01	0.01	0.03	0.01
Ca	0.46	0.52	0.46	0.39	0.37	0.44	0.52	0.44
Ba	0.02	0.01	0.02	0.01	0.02	0.00	0.02	0.01
Na	2.55	2.59	2.67	2.74	2.69	2.27	2.29	2.22
K	3.12	2.98	3.11	3.29	3.06	3.04	3.23	3.52
Si/(Al+Fe)								
	4.28	4.35	4.40	4.53	4.48	4.46	4.27	4.64
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.03	1.02	0.99	0.95	1.00	1.06	1.03	0.96
Mol% Exchangeable Cations								
K	50.9	48.9	49.8	51.3	49.9	52.9	53.2	56.8
Na	41.6	42.6	42.7	42.7	43.9	39.4	37.7	35.9
Ca+Mg	7.5	8.5	7.5	6.0	6.2	7.8	9.1	7.3

APPENDIX F (cont)

Drill Hole USW G-4

Depth (ft)	1707	1707	1762	1762	1762	1762	1762	1762
Unit ^a	Tht	Tht	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	64.4	68.1	69.3	68.0	68.8	69.5	67.0	67.3
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
Al ₂ O ₃	12.7	12.6	12.9	13.0	13.4	13.3	13.4	13.0
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.00
MgO	0.05	0.06	0.07	0.09	0.08	0.09	0.12	0.15
CaO	0.84	1.05	1.74	1.60	1.65	1.73	1.79	1.65
BaO	0.05	0.04	0.00	0.00	0.21	0.10	0.16	0.18
Na ₂ O	1.91	2.42	3.46	2.71	3.17	3.33	3.45	3.19
K ₂ O	6.59	5.78	3.86	3.67	3.87	3.74	3.77	3.90
Total	86.6	90.0	91.3	89.0	91.2	91.8	89.7	89.4
Unit-Cell Composition Based on 72 (O)								
Si	29.3	29.6	29.5	29.5	29.4	29.4	29.1	29.3
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Al	6.83	6.46	6.47	6.65	6.72	6.62	6.85	6.67
Fe	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00
Mg	0.03	0.04	0.04	0.06	0.05	0.06	0.08	0.10
Ca	0.41	0.49	0.79	0.75	0.75	0.78	0.83	0.77
Ba	0.01	0.01	0.00	0.00	0.04	0.02	0.03	0.03
Na	1.68	2.04	2.86	2.28	2.62	2.73	2.91	2.70
K	3.82	3.20	2.10	2.03	2.11	2.02	2.09	2.17
Si/(Al+Fe)								
	4.29	4.58	4.56	4.44	4.37	4.43	4.24	4.39
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.07	1.02	0.98	1.12	1.05	1.03	1.00	1.00
Mol% Exchangeable Cations								
K	64.3	55.5	36.2	39.7	38.1	36.1	35.4	37.8
Na	28.3	35.3	49.3	44.6	47.4	48.9	49.2	47.0
Ca+Mg	7.4	9.1	14.5	15.7	14.5	15.0	15.4	15.1

APPENDIX F (cont)

Drill Hole USW G-4

Depth (ft)	1762	2132	2132	2132	2132	2132	2132	2132
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	66.0	64.5	65.5	65.0	65.6	65.1	65.1	66.3
TiO ₂	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	13.2	11.8	11.7	11.1	12.1	11.8	12.3	11.6
Fe ₂ O ₃	0.04	0.00	0.00	0.07	0.04	0.00	0.01	0.00
MgO	0.09	0.05	0.04	0.06	0.05	0.05	0.03	0.03
CaO	1.70	3.45	3.44	3.50	3.42	3.58	3.59	3.63
BaO	0.24	0.11	0.00	0.00	0.16	0.03	0.00	0.00
Na ₂ O	3.08	1.02	0.93	1.35	1.07	0.92	1.18	1.11
K ₂ O	4.29	2.14	2.36	2.21	2.31	2.30	1.69	1.98
Total	88.7	83.0	84.0	83.2	84.8	83.8	84.0	84.7
Unit-Cell Composition Based on 72 (O)								
Si	29.1	29.8	29.9	30.0	29.7	29.8	29.6	29.9
Ti	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.88	6.40	6.28	6.01	6.47	6.38	6.62	6.20
Fe	0.01	0.00	0.00	0.02	0.01	0.00	0.00	0.00
Mg	0.06	0.03	0.03	0.04	0.03	0.03	0.02	0.02
Ca	0.80	1.71	1.68	1.73	1.66	1.75	1.75	1.76
Ba	0.04	0.02	0.00	0.00	0.03	0.01	0.00	0.00
Na	2.63	0.91	0.82	1.21	0.94	0.82	1.04	0.97
K	2.41	1.26	1.37	1.30	1.33	1.34	0.98	1.14
Si/(Al+Fe)								
	4.22	4.65	4.76	4.97	4.58	4.67	4.48	4.82
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.01	1.12	1.12	1.00	1.13	1.11	1.19	1.09
Mol% Exchangeable Cations								
K	40.8	32.2	35.2	30.4	33.6	34.0	25.9	29.3
Na	44.6	23.3	21.1	28.2	23.7	20.7	27.4	25.0
Ca+Mg	14.6	44.5	43.8	41.4	42.7	45.3	46.7	45.7

APPENDIX F (cont)

Drill Hole USW G-4

Depth (ft)	2132	2132	2132	2227	2227	2227	2227	2227
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	65.1	65.4	64.3	64.0	65.8	64.1	64.7	65.8
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	11.1	12.0	12.1	12.1	12.4	12.1	12.2	12.3
Fe ₂ O ₃	0.04	0.01	0.06	0.02	0.00	0.04	0.02	0.03
MgO	0.04	0.02	0.03	0.11	0.14	0.11	0.19	0.10
CaO	3.59	3.48	3.78	3.69	3.92	3.88	4.02	3.51
BaO	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Na ₂ O	0.97	1.18	1.33	1.22	0.84	1.21	1.15	1.38
K ₂ O	1.93	2.05	1.78	1.42	1.62	1.14	1.67	1.85
Total	82.8	84.2	83.4	82.5	84.6	82.6	84.0	84.9
Unit-Cell Composition Based on 72 (O)								
Si	30.0	29.7	29.6	29.6	29.7	29.6	29.5	29.7
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.05	6.45	6.55	6.58	6.57	6.59	6.57	6.51
Fe	0.01	0.00	0.02	0.01	0.00	0.01	0.01	0.01
Mg	0.03	0.01	0.02	0.08	0.09	0.08	0.13	0.07
Ca	1.77	1.70	1.86	1.83	1.89	1.92	1.96	1.70
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.87	1.04	1.19	1.09	0.73	1.08	1.02	1.21
K	1.14	1.19	1.04	0.84	0.93	0.67	0.97	1.06
Si/(Al+Fe)								
	4.95	4.61	4.50	4.50	4.52	4.49	4.49	4.55
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.08	1.14	1.10	1.15	1.16	1.15	1.06	1.13
Mol% Exchangeable Cations								
K	29.8	30.2	25.4	21.9	25.5	17.9	23.8	26.4
Na	22.8	26.4	28.8	28.5	20.1	28.9	24.9	29.9
Ca+Mg	47.4	43.4	45.8	49.6	54.4	53.2	51.3	43.7

APPENDIX F (cont)

Drill Hole USW G-4

Depth (ft)	2227	2227	2239	2239	2239	2239	2239	2239
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	65.5	67.1	66.3	64.6	65.7	66.9	65.4	65.2
TiO ₂	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00
Al ₂ O ₃	11.7	11.6	12.0	12.1	12.2	12.1	10.9	12.0
Fe ₂ O ₃	0.10	0.01	0.01	0.05	0.06	0.12	0.08	0.09
MgO	0.19	0.13	0.37	0.31	0.37	0.45	0.45	0.37
CaO	3.72	3.38	4.02	4.09	4.01	3.89	3.65	3.97
BaO	0.16	0.03	0.29	0.03	0.10	0.06	0.00	0.04
Na ₂ O	0.80	1.02	0.96	0.52	0.83	0.39	0.80	0.50
K ₂ O	1.33	1.84	1.43	1.11	1.68	1.49	1.91	1.29
Total	83.5	85.1	85.3	82.8	85.0	85.5	83.2	83.4
Unit-Cell Composition Based on 72 (O)								
Si	29.9	30.1	29.7	29.7	29.6	29.8	30.0	29.8
Ti	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Al	6.31	6.13	6.34	6.53	6.49	6.36	5.93	6.43
Fe	0.03	0.00	0.00	0.02	0.02	0.04	0.03	0.03
Mg	0.13	0.09	0.25	0.21	0.25	0.30	0.31	0.25
Ca	1.82	1.62	1.93	2.01	1.94	1.86	1.80	1.94
Ba	0.03	0.01	0.05	0.01	0.02	0.01	0.00	0.01
Na	0.71	0.89	0.83	0.46	0.73	0.34	0.71	0.44
K	0.77	1.05	0.82	0.65	0.97	0.85	1.12	0.75
Si/(Al+Fe)								
	4.71	4.90	4.68	4.54	4.55	4.66	5.04	4.60
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.17	1.14	1.04	1.17	1.07	1.16	0.99	1.16
Mol% Exchangeable Cations								
K	22.6	28.8	21.4	19.5	24.9	25.4	28.4	22.2
Na	20.6	24.3	21.8	13.9	18.7	10.1	18.1	13.1
Ca+Mg	56.8	46.9	56.9	66.6	56.4	64.6	53.5	64.8

APPENDIX F (cont)

Drill Hole USW G-4

Depth (ft) ^a	2239	2738	2738	2738	2738	2738	2738	2738
Unit ^a	Tcp	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb
SiO ₂	66.6	65.9	64.9	66.5	65.8	64.9	66.9	64.9
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	11.9	11.8	12.6	12.8	12.4	11.6	12.4	10.6
Fe ₂ O ₃	0.07	0.00	0.00	0.00	0.02	0.00	0.05	0.00
MgO	0.37	0.29	0.30	0.37	0.24	0.26	0.27	0.29
CaO	3.59	4.32	4.34	4.49	4.26	4.14	4.31	4.15
BaO	0.00	0.04	0.20	0.03	0.00	0.14	0.17	0.10
Na ₂ O	0.63	0.80	0.56	0.87	0.83	1.10	0.57	0.58
K ₂ O	1.71	0.91	1.10	1.06	1.02	1.80	1.17	0.63
Total	84.9	84.1	84.1	86.1	84.5	84.0	85.9	81.3
Unit-Cell Composition Based on 72 (O)								
Si	29.9	29.8	29.5	29.5	29.6	29.7	29.7	30.2
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.32	6.30	6.77	6.66	6.57	6.26	6.49	5.85
Fe	0.02	0.00	0.00	0.00	0.01	0.00	0.02	0.00
Mg	0.25	0.20	0.20	0.24	0.16	0.18	0.18	0.20
Ca	1.73	2.09	2.11	2.13	2.06	2.03	2.05	2.07
Ba	0.00	0.01	0.04	0.01	0.00	0.03	0.03	0.02
Na	0.55	0.70	0.49	0.75	0.72	0.98	0.49	0.52
K	0.98	0.52	0.64	0.60	0.59	1.05	0.66	0.37
Si/(Al+Fe)								
	4.71	4.73	4.35	4.43	4.50	4.74	4.57	5.17
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.16	1.08	1.16	1.09	1.15	0.96	1.15	1.07
Mol% Exchangeable Cations								
K	28.0	14.9	18.5	16.1	16.6	24.8	19.6	11.8
Na	15.7	20.0	14.3	20.1	20.5	23.1	14.5	16.5
Ca+Mg	56.4	65.1	67.2	63.8	62.8	52.1	65.9	71.7

APPENDIX F (cont)

Drill Hole USW G-4

Depth (ft)	2738	2738	2738
Unit ^a	Tcb	Tcb	Tcb
SiO ₂	65.9	66.7	64.2
TiO ₂	0.02	0.00	0.00
Al ₂ O ₃	12.2	12.7	12.0
Fe ₂ O ₃	0.09	0.06	0.04
MgO	0.33	0.38	0.33
CaO	4.48	4.40	4.18
BaO	0.23	0.13	0.15
Na ₂ O	0.49	0.82	0.59
K ₂ O	1.05	1.23	1.12
Total	84.8	86.4	82.6

Unit-Cell Composition Based on 72 (O)

Si	29.6	29.5	29.6
Ti	0.01	0.00	0.00
Al	6.47	6.64	6.52
Fe	0.03	0.02	0.01
Mg	0.22	0.25	0.23
Ca	2.16	2.08	2.07
Ba	0.04	0.02	0.03
Na	0.43	0.70	0.53
K	0.60	0.69	0.66

CSi/(Al+Fe)

4.56	4.43	4.53
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C(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.11	1.09	1.12
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Mol% Exchangeable Cations

K	17.7	18.6	18.9
Na	12.5	18.8	15.2
Ca+Mg	69.8	62.6	65.9

APPENDIX F (cont)

Drill Hole USW H-3

Depth (ft)	1800	1800	1800	1800	1800
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	68.9	70.7	64.5	58.5	67.8
TiO ₂	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	11.9	11.7	11.5	9.6	12.1
Fe ₂ O ₃	0.05	0.03	0.04	0.11	0.04
MgO	0.04	0.02	0.02	0.01	0.02
CaO	3.61	3.52	3.19	2.85	3.79
BaO	0.00	0.07	0.00	0.00	0.06
Na ₂ O	0.84	0.84	0.85	0.66	0.98
K ₂ O	2.87	2.75	3.13	2.45	2.89
Total	88.2	89.6	83.2	74.2	87.7
Unit-Cell Composition Based on 72 (O)					
Si	30.0	30.2	29.8	30.2	29.8
Ti	0.00	0.00	0.00	0.00	0.00
Al	6.10	5.89	6.27	5.85	6.26
Fe	0.02	0.01	0.01	0.04	0.01
Mg	0.03	0.01	0.01	0.01	0.01
Ca	1.68	1.61	1.58	1.58	1.78
Ba	0.00	0.01	0.00	0.00	0.01
Na	0.71	0.70	0.76	0.66	0.83
K	1.59	1.50	1.85	1.61	1.62
Si/(Al+Fe)					
	4.90	5.12	4.75	5.13	4.74
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)					
	1.07	1.08	1.08	1.08	1.03
Mol% Exchangeable Cations					
K	39.7	39.3	43.9	41.8	38.1
Na	17.7	18.2	18.1	17.1	19.6
Ca+Mg	42.6	42.5	37.9	41.1	42.3

APPENDIX F (cont)

Drill Hole USW H-4

Depth (ft)	1420	1420	1420	1420	1420	1420	1455	1455
Unit ^a	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	63.0	66.6	67.4	68.5	68.0	67.9	62.6	67.4
TiO ₂	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00
Al ₂ O ₃	9.2	12.3	12.2	12.2	12.2	12.2	11.2	11.5
Fe ₂ O ₃	0.03	0.01	0.00	0.05	0.00	0.00	0.08	0.00
MgO	0.08	0.26	0.25	0.22	0.23	0.18	0.61	0.76
CaO	2.71	3.37	3.20	3.21	3.22	3.24	3.28	3.59
BaO	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.02
Na ₂ O	0.58	0.55	0.66	0.63	0.72	0.68	0.53	0.43
K ₂ O	2.75	2.92	3.10	3.38	2.93	3.10	1.82	1.88
Total	78.3	86.0	86.8	88.3	87.3	87.3	80.1	85.6
Unit-Cell Composition Based on 72 (O)								
Si	30.7	29.7	29.8	29.9	29.9	29.9	29.8	30.0
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	5.29	6.47	6.36	6.27	6.32	6.32	6.29	6.04
Fe	0.01	0.00	0.00	0.02	0.00	0.00	0.03	0.00
Mg	0.06	0.17	0.16	0.14	0.15	0.12	0.43	0.50
Ca	1.42	1.61	1.52	1.50	1.52	1.53	1.67	1.71
Ba	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Na	0.55	0.48	0.57	0.53	0.61	0.58	0.49	0.37
K	1.71	1.66	1.75	1.88	1.64	1.74	1.11	1.07
Si/(Al+Fe)								
	5.80	4.59	4.69	4.75	4.73	4.72	4.72	4.97
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.02	1.13	1.12	1.10	1.13	1.13	1.09	1.03
Mol% Exchangeable Cations								
K	45.8	42.4	43.8	46.4	41.9	43.9	29.9	29.2
Na	14.7	12.1	14.2	13.1	15.6	14.6	13.2	10.2
Ca+Mg	39.5	45.5	42.1	40.5	42.5	41.5	56.9	60.6

APPENDIX F (cont)

Drill Hole USW H-4

Depth (ft)	1455	1455	1550	1550	1550	1550	1550	1550
Unit ^a	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	64.5	66.4	65.5	63.9	57.9	64.9	67.2	68.8
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	11.9	12.2	12.2	11.9	12.2	11.7	12.9	12.9
Fe ₂ O ₃	0.00	0.00	0.00	0.04	0.03	0.16	0.02	0.00
MgO	0.76	0.77	0.00	0.00	0.00	0.00	0.00	0.00
CaO	3.53	3.73	2.20	2.15	2.26	2.18	2.44	2.25
BaO	0.00	0.03	0.00	0.09	0.00	0.00	0.15	0.15
Na ₂ O	0.42	0.38	1.54	1.46	1.79	1.45	1.30	1.32
K ₂ O	1.88	1.40	5.08	4.61	3.31	4.52	4.42	4.54
Total	83.0	84.9	87.5	84.2	77.5	84.9	88.4	90.0

Unit-Cell Composition Based on 72 (O)

Si	29.7	29.7	29.6	29.6	29.0	29.7	29.5	29.7
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.45	6.44	6.41	6.49	7.21	6.31	6.68	6.55
Fe	0.00	0.00	0.00	0.01	0.01	0.06	0.01	0.00
Mg	0.52	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Ca	1.74	1.79	1.05	1.07	1.21	1.07	1.15	1.04
Ba	0.00	0.01	0.00	0.02	0.00	0.00	0.03	0.03
Na	0.37	0.33	1.33	1.31	1.74	1.29	1.11	1.10
K	1.10	0.80	2.89	2.72	2.12	2.64	2.48	2.50

Si/(Al+Fe)

4.60	4.62	4.62	4.54	4.02	4.66	4.41	4.52
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.08	1.12	1.01	1.05	1.15	1.05	1.13	1.14
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Mol% Exchangeable Cations

K	29.5	23.3	54.8	53.4	41.7	52.8	52.3	53.8
Na	10.0	9.6	25.3	25.7	34.3	25.8	23.4	23.8
Ca+Mg	60.5	67.1	19.9	20.9	23.9	21.4	24.3	22.4

APPENDIX F (cont)

Drill Hole USW H-4

Depth (ft) Unit ^a	1980	1980	1980	1980	1980	1980	1980
	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	66.4	68.5	67.5	73.4	67.4	67.6	67.5
TiO ₂	0.00	0.00	0.00	0.02	0.00	0.00	0.02
Al ₂ O ₃	11.8	12.3	12.1	11.6	11.9	11.9	11.5
Fe ₂ O ₃	0.05	0.00	0.00	0.48	0.09	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.27	0.30	0.29	0.25	0.32	0.32	0.31
BaO	0.00	0.07	0.00	0.00	0.16	0.00	0.00
Na ₂ O	3.39	3.49	4.18	3.32	3.66	3.05	3.09
K ₂ O	4.32	4.72	4.19	4.73	4.04	5.34	5.14
Total	86.3	89.4	88.2	93.8	87.6	88.2	87.6
Unit-Cell Composition Based on 72 (O)							
Si	29.9	29.8	29.7	30.3	29.9	29.9	30.0
Ti	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Al	6.25	6.31	6.28	5.63	6.22	6.22	6.04
Fe	0.02	0.00	0.00	0.15	0.03	0.00	0.00
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.13	0.14	0.14	0.11	0.15	0.15	0.15
Ba	0.00	0.01	0.00	0.00	0.03	0.00	0.00
Na	2.96	2.94	3.57	2.66	3.15	2.61	2.66
K	2.48	2.62	2.36	2.49	2.28	3.01	2.91
Si/(Al+Fe)							
	4.77	4.72	4.73	5.25	4.78	4.80	4.96
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)							
	1.10	1.08	1.01	1.08	1.08	1.05	1.03
Mol% Exchangeable Cations							
K	44.5	45.9	38.8	47.4	40.3	52.1	50.9
Na	53.1	51.6	58.9	50.5	56.4	45.2	46.5
Ca+Mg	2.3	2.5	2.3	2.1	2.7	2.6	2.6

APPENDIX F (cont)

Drill Hole USW H-5

Depth (ft) Unit ^a	1666	1666	1917	1917	1917	1917	1917	1917
	Tpt	Tpt	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	66.4	65.5	70.1	69.6	70.9	66.5	67.1	61.3
TiO ₂	0.00	0.02	0.01	0.00	0.00	0.00	0.01	0.00
Al ₂ O ₃	13.0	13.3	12.4	12.8	12.9	12.8	12.7	10.8
Fe ₂ O ₃	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.78	0.86	0.00	0.00	0.00	0.00	0.00	0.00
CaO	4.39	5.19	1.76	1.57	1.66	1.73	1.49	1.59
BaO	0.00	0.00	0.00	0.04	0.04	0.00	0.22	0.03
Na ₂ O	0.43	0.17	1.87	2.03	1.86	2.07	1.98	1.70
K ₂ O	0.56	0.21	4.59	4.95	4.96	5.45	5.56	3.84
Total	85.6	85.3	90.7	91.0	92.3	88.6	89.1	79.3
Unit-Cell Composition Based on 72 (O)								
Si	29.4	29.2	29.9	29.7	29.3	29.4	29.5	29.9
Ti	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.79	6.98	6.24	6.44	6.39	6.67	6.58	6.21
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.52	0.57	0.00	0.00	0.00	0.00	0.00	0.00
Ca	2.08	2.48	0.80	0.72	0.75	0.82	0.70	0.83
Ba	0.00	0.00	0.00	0.01	0.01	0.00	0.04	0.01
Na	0.37	0.15	1.55	1.68	1.52	1.77	1.69	1.61
K	0.32	0.12	2.50	2.70	2.66	3.07	3.12	2.39
Si/(Al+Fe)								
	4.33	4.18	4.79	4.61	4.66	4.41	4.48	4.81
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.15	1.10	1.10	1.11	1.12	1.03	1.05	1.10
Mol% Exchangeable Cations								
K	9.6	3.6	51.5	52.9	54.0	54.2	56.6	49.5
Na	11.2	4.4	31.9	33.0	30.8	31.3	30.6	33.3
Ca+Mg	79.1	92.0	16.6	14.1	15.2	14.5	12.7	17.2

APPENDIX F (cont)

Drill Hole USW H-5

Depth (ft) Unit ^a	1917	1917	1917	1917	1930	1930	1930	1930
	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	61.1	62.1	62.7	63.7	64.0	67.4	67.3	72.0
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	10.1	10.5	10.8	10.7	10.6	12.1	12.1	11.4
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.04
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	1.56	1.50	1.64	1.61	1.87	2.05	2.18	1.93
BaO	0.00	0.00	0.03	0.18	0.07	0.00	0.00	0.79
Na ₂ O	1.51	1.84	1.66	1.61	1.66	1.71	1.44	2.31
K ₂ O	3.80	3.95	4.14	4.25	4.05	4.14	4.24	3.67
Total	78.1	79.9	81.0	82.1	82.7	87.4	87.3	92.1

Unit-Cell Composition Based on 72 (O)

Si	30.2	30.1	30.0	30.1	30.0	29.8	29.8	30.3
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	5.89	5.99	6.09	5.96	5.86	6.31	6.32	5.65
Fe	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.01
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.83	0.78	0.84	0.82	0.94	0.97	1.04	0.87
Ba	0.00	0.00	0.01	0.03	0.01	0.00	0.00	0.13
Na	1.45	1.73	1.54	1.47	1.51	1.47	1.24	1.88
K	2.40	2.44	2.53	2.56	2.42	2.34	2.40	1.97

Si/(Al+Fe)

5.13	5.02	4.92	5.05	4.99	4.72	4.72	5.34
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.07	1.05	1.06	1.04	1.03	1.10	1.11	0.97
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Mol% Exchangeable Cations

K	51.3	49.3	51.5	52.8	49.7	48.9	51.3	41.7
Na	31.0	34.9	31.4	30.4	31.0	30.7	26.5	39.9
Ca+Mg	17.7	15.7	17.1	16.8	19.3	20.4	22.2	18.4

APPENDIX F (cont)

Drill Hole USW H-5

Depth (ft) Unit ^a	2200 Tcp	2200 Tco	2200 Tcp	2200 Tcp
SiO2	71.3	62.2	68.8	71.4
TiO2	0.00	0.00	0.00	0.00
Al2O3	11.0	12.4	11.0	12.4
Fe2O3	0.00	0.01	0.00	0.00
MgO	0.04	0.00	0.00	0.00
CaO	1.31	1.34	1.55	1.62
BaO	0.01	0.00	0.00	0.23
Na2O	2.49	2.80	2.22	2.20
K2O	3.24	3.89	3.63	4.53
Total	89.4	82.6	87.2	92.4

Unit-Cell Composition Based on 72 (0)

Si	30.6	29.3	30.4	30.0
Ti	0.00	0.00	0.00	0.00
Al	5.56	6.88	5.72	6.13
Fe	0.00	0.00	0.00	0.00
Mg	0.03	0.00	0.00	0.00
Ca	0.60	0.68	0.73	0.73
Ba	0.00	0.00	0.00	0.04
Na	2.07	2.56	1.90	1.79
K	1.77	2.34	2.04	2.43

Si/(Al+Fe)

5.50	4.25	5.31	4.88
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.09	1.10	1.06	1.07
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Mol% Exchangeable Cations

K	39.7	42.0	43.7	49.1
Na	46.3	45.9	40.6	36.2
Ca+Mg	14.0	12.1	15.7	14.7

APPENDIX F (cont)

Drill Hole UE-25a#1

Depth (ft) ^a	1279	1323	1323	1323	1323	1323	1323	1323
Unit ^a	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt
SiO ₂	55.7	65.8	68.9	69.0	68.7	68.7	66.1	66.4
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03
Al ₂ O ₃	14.1	11.4	12.0	12.3	12.0	12.3	11.6	12.0
Fe ₂ O ₃	0.82	0.00	0.02	0.08	0.02	0.04	0.02	0.02
MgO	3.30	0.74	0.62	0.60	0.57	0.53	0.38	0.67
CaO	2.10	3.87	3.80	3.85	3.92	4.20	4.01	3.92
BaO	0.00	0.00	0.13	0.00	0.00	0.06	0.15	0.20
Na ₂ O	0.62	0.50	0.55	0.52	0.56	0.56	0.67	0.60
K ₂ O	0.85	1.75	2.02	1.81	1.76	1.43	1.78	1.80
Total	77.4	84.1	88.1	88.1	87.6	87.8	84.7	85.6
Unit-Cell Composition Based on 72 (O)								
Si	27.6	29.9	29.9	29.8	29.9	29.8	29.8	29.7
Ti	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Al	8.22	6.09	6.14	6.25	6.17	6.28	6.20	6.30
Fe	0.31	0.00	0.01	0.03	0.01	0.01	0.01	0.01
Mg	2.43	0.50	0.40	0.39	0.37	0.34	0.26	0.45
Ca	1.11	1.88	1.77	1.79	1.83	1.95	1.94	1.88
Ba	0.00	0.00	0.02	0.00	0.00	0.01	0.03	0.04
Na	0.59	0.44	0.46	0.44	0.47	0.47	0.59	0.52
K	0.54	1.01	1.12	1.00	0.98	0.79	1.03	1.03
Si/(Al+Fe)								
	3.23	4.91	4.87	4.76	4.84	4.74	4.81	4.71
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.04	0.98	1.03	1.09	1.06	1.07	1.02	1.01
Mol% Exchangeable Cations								
K	11.5	26.4	29.8	27.7	26.8	22.2	26.9	26.5
Na	12.7	11.5	12.3	12.1	13.0	13.2	15.4	13.4
Ca+Mg	75.8	62.1	57.8	60.2	60.3	64.5	57.7	60.0

APPENDIX F (cont)

Drill Hole UE-25a#1

Depth (ft) Unit ^a	1358	1358	1358	1381	1384	1384	1384	1384
	Tpt	Tpt	Tpt	Tht	Tht	Tht	Tht	Tht
SiO ₂	67.7	63.8	66.7	67.0	65.9	66.5	65.4	67.6
TiO ₂	0.00	0.00	0.00	0.03	0.02	0.02	0.00	0.04
Al ₂ O ₃	11.2	10.3	11.2	11.9	11.8	11.6	11.7	10.9
Fe ₂ O ₃	0.03	0.23	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.31	0.22	0.30	0.69	0.68	0.75	0.68	0.62
CaO	3.71	3.07	3.80	3.74	3.50	3.73	4.09	3.96
BaO	0.07	0.03	0.10	0.09	0.12	0.00	0.08	0.00
Na ₂ O	0.57	0.56	0.35	0.48	0.60	0.51	0.49	0.50
K ₂ O	1.79	2.05	1.78	1.83	2.23	1.86	1.53	1.65
Total	85.4	80.2	84.2	85.7	84.8	85.0	84.0	85.2
Unit-Cell Composition Based on 72 (O)								
Si	30.2	30.3	30.2	29.8	29.7	29.9	29.7	30.2
Ti	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01
Al	5.91	5.74	5.98	5.22	6.27	6.13	6.25	5.73
Fe	0.01	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.21	0.16	0.20	0.46	0.46	0.50	0.46	0.41
Ca	1.77	1.56	1.84	1.78	1.69	1.80	1.99	1.90
Ba	0.01	0.01	0.02	0.02	0.02	0.00	0.01	0.00
Na	0.49	0.52	0.31	0.41	0.53	0.44	0.43	0.43
K	1.02	1.24	1.03	1.04	1.28	1.07	0.92	0.94
Si/(Al+Fe)								
	5.10	5.20	5.04	4.79	4.74	4.88	4.76	5.27
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.08	1.12	1.10	1.04	1.02	1.00	0.99	0.96
Mol% Exchangeable Cations								
K	29.2	35.7	30.4	28.1	32.4	28.0	24.1	25.5
Na	14.1	14.8	9.1	11.2	13.3	11.7	11.4	11.8
Ca+Mg	56.7	49.4	60.5	60.7	54.3	60.3	64.5	62.7

APPENDIX F (cont)

Drill Hole UE-25a#1

Depth (ft)	1384	1465	1465	1505	1584	1584	1584	1667
Unit ^a	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	56.0	65.4	68.5	65.6	66.7	66.2	66.5	66.7
TiO ₂	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Al ₂ O ₃	11.5	11.1	11.3	11.4	11.9	12.2	12.1	12.8
Fe ₂ O ₃	0.00	0.37	0.01	0.04	0.04	0.01	0.00	0.03
MgO	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	4.02	2.76	3.66	3.46	3.92	3.82	4.13	3.71
BaO	0.14	0.04	0.01	0.14	0.01	0.00	0.07	0.00
Na ₂ O	0.48	0.50	0.67	0.78	0.92	0.83	0.42	0.91
K ₂ O	1.61	4.05	2.14	3.07	2.25	2.78	2.30	3.01
Total	86.4	84.3	86.3	84.5	85.8	85.8	85.4	87.2
Unit-Cell Composition Based on 72 (O)								
Si	30.0	30.0	30.3	29.9	29.8	29.7	29.8	29.5
Ti	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Al	5.96	6.02	5.90	6.14	6.30	6.45	6.37	6.65
Fe	0.00	0.13	0.00	0.01	0.01	0.00	0.00	0.01
Mg	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	1.90	1.36	1.73	1.69	1.88	1.84	1.98	1.76
Ba	0.02	0.01	0.00	0.03	0.00	0.00	0.01	0.00
Na	0.41	0.44	0.57	0.69	0.80	0.72	0.37	0.78
K	0.91	2.37	1.21	1.79	1.28	1.59	1.32	1.70
Si/(Al+Fe)								
	5.03	4.88	5.12	4.86	4.72	4.60	4.67	4.43
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.99	1.11	1.12	1.04	1.08	1.08	1.12	1.11
Mol% Exchangeable Cations								
K	24.8	56.8	34.3	42.9	32.4	38.3	35.9	40.1
Na	11.2	10.7	16.3	16.6	20.1	17.4	10.0	18.4
Ca+Mg	63.9	32.5	49.3	40.6	47.4	44.3	54.1	41.5

APPENDIX F (cont)

Drill Hole UE-25a#1

Depth (ft) Unit ^a	1667	1667	1667	1667	1667	1667	1667	1667
	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO2	66.7	66.5	63.5	65.1	65.8	65.5	63.6	65.4
TiO2	0.05	0.00	0.01	0.04	0.05	0.02	0.00	0.02
Al2O3	12.1	12.7	12.6	13.1	12.6	12.6	12.1	12.4
Fe2O3	0.02	0.04	0.03	0.01	0.06	0.05	0.03	0.05
MgO	0.01	0.03	0.02	0.03	0.03	0.01	0.04	0.01
CaO	3.61	3.71	3.66	3.98	3.97	3.63	3.54	3.86
BaO	0.00	0.00	0.00	0.07	0.00	0.05	0.06	0.00
Na2O	0.79	1.01	1.05	0.94	0.80	0.89	0.82	1.05
K2O	2.79	3.30	3.60	3.29	3.01	3.40	2.96	3.30
Total	86.0	87.3	84.5	86.5	86.3	86.2	83.1	86.1

Unit-Cell Composition Based on 72 (O)

Si	29.8	29.5	29.2	29.2	29.4	29.4	29.5	29.4
Ti	0.02	0.00	0.00	0.01	0.02	0.01	0.00	0.01
Al	6.36	6.62	6.85	6.90	6.65	6.68	6.59	6.57
Fe	0.01	0.01	0.01	0.00	0.02	0.02	0.01	0.02
Mg	0.01	0.02	0.01	0.02	0.02	0.01	0.03	0.01
Ca	1.73	1.76	1.80	1.91	1.90	1.75	1.76	1.86
Ba	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00
Na	0.68	0.87	0.94	0.82	0.69	0.77	0.74	0.92
K	1.59	1.86	2.11	1.88	1.72	1.95	1.75	1.89

Si/(Al+Fe)

4.68	4.44	4.26	4.22	4.41	4.40	4.47	4.47
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.11	1.05	1.03	1.05	1.07	1.07	1.08	1.01
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Mol% Exchangeable Cations

K	39.7	41.3	43.4	40.6	39.6	43.5	41.0	40.5
Na	17.1	19.2	19.2	17.6	16.0	17.3	17.2	19.6
Ca+Mg	43.3	39.5	37.3	41.7	44.4	39.2	41.8	39.9

APPENDIX F (cont)

Drill Hole UE-25a#1

Depth (ft)	1667	1667	1667	1824	1824	1824	1824	2087
Unit ^a	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tcp
SiO ₂	66.6	69.2	67.1	62.5	66.1	68.8	66.8	65.3
TiO ₂	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Al ₂ O ₃	12.6	13.3	12.6	12.6	13.9	13.4	13.6	11.6
Fe ₂ O ₃	0.06	0.08	0.06	0.05	0.03	0.02	0.00	0.00
MgO	0.03	0.04	0.02	0.08	0.15	0.14	0.15	0.52
CaO	3.97	4.03	3.84	4.78	5.43	5.12	4.96	3.93
BaO	0.00	0.04	0.32	0.00	0.21	0.19	0.02	0.00
Na ₂ O	0.80	0.89	1.02	0.62	1.13	0.99	1.22	0.26
K ₂ O	3.01	2.82	2.92	1.00	1.33	1.44	1.29	1.40
Total	87.2	90.4	87.8	81.6	88.3	90.2	88.1	83.0

Unit-Cell Composition Based on 72 (O)

Si	29.5	29.5	29.5	29.3	28.9	29.3	29.1	29.9
Ti	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Al	6.59	6.68	6.52	6.94	7.17	6.73	6.98	6.28
Fe	0.02	0.03	0.02	0.02	0.01	0.01	0.00	0.00
Mg	0.02	0.03	0.01	0.06	0.10	0.09	0.10	0.35
Ca	1.88	1.84	1.81	2.40	2.54	2.34	2.31	1.93
Ba	0.00	0.01	0.06	0.00	0.04	0.03	0.00	0.00
Na	0.69	0.73	0.87	0.56	0.96	0.82	1.03	0.23
K	1.70	1.53	1.64	0.60	0.74	0.78	0.72	0.82

Si/(Al+Fe)

	4.46	4.39	4.51	4.20	4.02	4.35	4.17	4.76
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

	1.07	1.12	1.04	1.15	1.02	1.03	1.06	1.12
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Mol% Exchangeable Cations

K	39.6	37.1	37.8	16.5	17.1	19.4	17.2	24.5
Na	16.0	17.8	20.1	15.6	22.1	20.3	24.8	6.9
Ca+Mg	44.4	45.1	42.1	67.9	60.8	60.3	58.0	68.5

APPENDIX F (cont)

Drill Hole UE-25a#1

Depth (ft) Unit ^a	2087	2087	2087	2087	2113	2220	2220	2220
	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	64.1	60.8	66.3	63.5	75.1	64.8	65.4	65.0
TiO ₂	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.0	12.0	12.0	12.4	11.4	11.5	11.7	11.6
Fe ₂ O ₃	0.00	0.05	0.05	0.02	0.29	0.00	0.00	0.00
MgO	0.71	0.71	0.68	0.60	0.00	0.60	0.61	0.54
CaO	3.78	3.92	3.94	4.09	0.87	3.70	3.76	3.87
BaO	0.05	0.18	0.05	0.19	0.00	0.00	0.00	0.00
Na ₂ O	0.47	0.59	0.36	0.70	3.11	0.41	0.33	0.35
K ₂ O	1.54	1.49	1.29	2.14	4.59	1.48	1.33	1.25
Total	82.7	79.7	84.7	83.6	95.4	82.5	83.2	82.6
Unit-Cell Composition Based on 72 (O)								
Si	29.6	29.2	29.8	29.2	3.4	29.9	29.9	29.9
Ti	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Al	6.52	6.80	6.37	6.72	0.61	6.25	6.29	6.29
Fe	0.00	0.02	0.02	0.01	0.01	0.00	0.00	0.00
Mg	0.49	0.51	0.46	0.41	0.00	0.41	0.42	0.37
Ca	1.87	2.02	1.90	2.02	0.04	1.83	1.84	1.91
Ba	0.01	0.03	0.01	0.03	0.00	0.00	0.00	0.00
Na	0.42	0.55	0.31	0.63	0.27	0.37	0.29	0.31
K	0.91	0.91	0.74	1.26	0.26	0.87	0.78	0.73
Si/(Al+Fe)								
	4.54	4.29	4.66	4.34	5.50	4.78	4.75	4.75
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.08	1.03	1.11	0.99	0.99	1.09	1.13	1.12
Mol% Exchangeable Cations								
K	24.6	22.9	21.7	29.2	45.7	25.0	23.3	22.1
Na	11.4	13.8	9.2	14.5	47.0	10.5	8.8	9.4
Ca+Mg	64.0	63.3	69.1	56.3	7.3	64.4	67.9	68.5

APPENDIX F (cont)

Drill Hole UE-25a#1

Depth (ft) Unit ^a	2220	2220	2220	2220	2220	2304	2304	2304
	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	66.0	64.2	63.3	62.2	63.4	67.7	67.4	67.3
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Al ₂ O ₃	11.8	12.1	11.5	11.4	11.4	11.9	12.2	11.3
Fe ₂ O ₃	0.00	0.02	0.03	0.06	0.00	0.00	0.00	0.05
MgO	0.56	0.64	0.55	0.55	0.56	0.13	0.15	0.22
CaO	3.79	3.87	3.78	3.72	3.80	4.19	4.15	4.20
BaO	0.00	0.00	0.00	0.02	0.07	0.20	0.14	0.00
Na ₂ O	0.34	0.31	0.36	0.35	0.52	0.94	0.89	0.99
K ₂ O	1.33	1.48	1.40	1.39	1.42	1.49	1.45	1.68
Total	83.8	82.6	81.0	79.6	81.2	86.5	86.4	85.8
Unit-Cell Composition Based on 72 (O)								
Si	29.9	29.6	29.8	29.7	29.8	29.9	29.8	30.0
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Al	6.29	6.60	6.37	6.40	6.33	6.17	6.36	5.95
Fe	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.02
Mg	0.38	0.44	0.39	0.39	0.39	0.09	0.10	0.15
Ca	1.84	1.91	1.90	1.91	1.91	1.98	1.96	2.00
Ba	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.00
Na	0.30	0.28	0.33	0.32	0.47	0.81	0.76	0.85
K	0.77	0.87	0.84	0.85	0.85	0.84	0.82	0.95
Si/(Al+Fe)								
	4.76	4.48	4.67	4.63	4.70	4.84	4.68	5.03
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.14	1.13	1.11	1.11	1.06	1.05	1.11	0.98
Mol% Exchangeable Cations								
K	23.4	24.9	24.3	24.4	23.4	22.6	22.4	24.1
Na	9.1	7.9	9.5	9.4	13.0	21.7	20.9	21.6
Ca+Mg	67.5	67.2	66.2	66.2	63.5	55.7	56.6	54.3

APPENDIX F (cont)

Drill Hole UE-25a#1

Depth (ft) ^a Unit ^a	2304 Tcp	2304 Tcp	2304 Tcp	2304 Tcp	2304 Tcp	2304 Tcp	2304 Tcp	2304 Tcp
SiO ₂	67.4	64.2	67.2	64.9	64.1	66.4	68.8	68.1
TiO ₂	0.00	0.02	0.00	0.01	0.01	0.02	0.01	0.03
Al ₂ O ₃	11.7	11.9	12.1	12.1	12.1	12.5	11.9	12.1
Fe ₂ O ₃	0.03	0.00	0.01	0.03	0.00	0.02	0.07	0.04
MgO	0.16	0.19	0.19	0.21	0.15	0.17	0.15	0.17
CaO	4.46	4.24	4.31	4.26	4.07	4.25	4.19	4.31
BaO	0.02	0.07	0.00	0.00	0.00	0.03	0.00	0.00
Na ₂ O	0.99	0.76	0.77	0.89	0.78	0.73	1.08	0.89
K ₂ O	1.37	1.60	1.62	1.69	1.55	1.64	1.60	1.60
Total	86.2	83.0	86.9	84.1	82.7	85.7	87.8	87.3
Unit-Cell Composition Based on 72 (O)								
Si	29.9	29.6	29.8	29.6	29.6	29.6	29.9	29.8
Ti	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01
Al	6.13	6.47	6.24	6.51	6.58	6.57	6.13	6.26
Fe	0.01	0.00	0.00	0.01	0.00	0.01	0.02	0.01
Mg	0.11	0.13	0.12	0.14	0.10	0.11	0.10	0.11
Ca	2.12	2.09	2.03	2.08	2.02	2.03	1.95	2.02
Ba	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
Na	0.85	0.68	0.66	0.79	0.70	0.63	0.91	0.75
K	0.77	0.94	0.91	0.98	0.91	0.93	0.89	0.89
Si/(Al+Fe)								
	4.87	4.57	4.78	4.53	4.50	4.50	4.86	4.75
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.01	1.06	1.06	1.05	1.13	1.12	1.04	1.06
Mol% Exchangeable Cations								
K	20.1	24.5	24.4	24.6	24.5	25.2	23.1	23.6
Na	22.1	17.7	17.6	19.7	18.7	17.0	23.7	20.0
Ca+Mg	57.8	57.9	57.9	55.7	56.8	57.8	53.3	56.4

APPENDIX F (cont)

Drill Hole UE-25b#1(H)

Depth (ft) ^a	2832	2832	2832	2832	2832	2832	2832	2832
Unit ^a	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb
SiO ₂	58.1	58.3	58.2	58.2	59.9	58.3	59.0	58.2
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	16.5	16.2	15.8	15.8	16.5	16.2	16.0	16.2
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
MgO	0.69	0.82	0.86	0.84	0.91	0.91	0.86	0.86
CaO	5.79	5.93	5.79	5.86	6.06	5.91	5.70	5.75
BaO	0.00	0.00	0.03	0.00	0.00	0.00	0.11	0.08
Na ₂ O	0.59	0.70	0.76	0.67	0.23	0.36	0.74	0.72
K ₂ O	1.01	1.33	1.29	1.26	1.41	1.38	1.36	1.08
Total	82.7	83.3	82.7	82.6	85.0	83.1	83.8	82.9

Unit-Cell Composition Based on 72 (O)

Si	27.2	27.2	27.3	27.3	27.3	27.2	27.4	27.2
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	9.11	8.91	8.74	8.75	8.87	8.92	8.74	8.93
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Mg	0.48	0.57	0.60	0.59	0.62	0.63	0.59	0.60
Ca	2.90	2.96	2.91	2.95	2.96	2.96	2.83	2.88
Ba	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.01
Na	0.54	0.63	0.69	0.61	0.20	0.33	0.67	0.65
K	0.60	0.79	0.77	0.75	0.82	0.82	0.80	0.64

Si/(Al+Fe)

2.99	3.05	3.12	3.12	3.08	3.05	3.13	3.04
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.15	1.05	1.03	1.04	1.08	1.07	1.05	1.08
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Mol% Exchangeable

K	13.3	16.0	15.5	15.4	17.8	17.4	16.4	13.5
Na	11.8	12.8	13.9	12.4	4.4	6.9	13.6	13.7
Ca+Mg	74.8	71.3	70.6	72.2	77.8	75.8	70.0	72.8

APPENDIX F (cont)

Drill Hole UE-25b#1(H)

Depth (ft) Unit ^a	2832	2832	2832	2832	2832	2879	2879	2879
	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb
SiO ₂	55.5	57.0	57.8	55.8	56.7	55.1	56.5	54.8
TiO ₂	0.00	0.03	0.04	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	16.2	16.3	15.1	15.1	15.0	16.3	16.5	17.0
Fe ₂ O ₃	0.00	0.04	0.02	0.05	0.02	0.00	0.00	0.00
MgO	0.62	0.67	0.86	0.81	0.79	0.67	0.45	0.34
CaO	5.95	5.88	5.92	5.74	5.73	6.07	6.30	6.31
BaO	0.15	0.21	0.07	0.17	0.19	0.00	0.00	0.06
Na ₂ O	0.86	0.59	0.35	0.49	0.50	0.24	0.51	0.66
K ₂ O	1.28	1.32	1.30	1.29	1.37	1.54	1.49	1.55
Total	80.5	82.1	81.5	79.5	80.3	79.9	81.7	80.8
Unit-Cell Composition Based on 72 (O)								
Si	26.9	27.0	27.5	27.3	27.5	26.8	26.9	26.5
Ti	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Al	9.24	9.13	8.47	8.73	8.56	9.37	9.27	9.73
Fe	0.00	0.01	0.01	0.02	0.01	0.00	0.00	0.00
Mg	0.45	0.47	0.61	0.59	0.57	0.49	0.32	0.25
Ca	3.09	2.99	3.02	3.01	2.97	3.17	3.22	3.27
Ba	0.03	0.04	0.01	0.03	0.04	0.00	0.00	0.01
Na	0.81	0.54	0.32	0.46	0.47	0.23	0.47	0.62
K	0.79	0.80	0.79	0.81	0.85	0.96	0.91	0.96
Si/(Al+Fe)								
	2.91	2.96	3.25	3.12	3.21	2.87	2.90	2.73
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.06	1.10	1.01	1.03	1.01	1.10	1.10	1.13
Mol% Exchangeable Cations								
K	15.4	16.6	16.6	16.5	17.4	19.8	18.4	18.8
Na	15.7	11.3	6.8	9.5	9.7	4.7	9.6	12.2
Ca+Mg	68.9	72.1	76.5	73.9	72.9	75.5	72.0	69.1

APPENDIX F (cont)

Drill Hole UE-25b#1(H)

Depth (ft) Unit ^a	2879	2879	2879	2879	2879	2879
	Tcb	Tcb	Tcb	Tcb	Tcb	Tcb
SiO ₂	55.9	56.1	56.5	56.1	58.0	56.1
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	16.4	16.4	16.9	16.9	16.9	17.6
Fe ₂ O ₃	0.00	0.00	0.00	0.05	0.07	0.03
MgO	0.41	0.43	0.33	0.22	0.27	0.22
CaO	6.50	6.37	6.66	6.77	6.59	6.96
BaO	0.00	0.02	0.10	0.21	0.14	0.25
Na ₂ O	0.75	0.46	0.57	0.89	0.86	0.63
K ₂ O	1.47	1.50	1.49	1.43	1.53	1.60
Total	81.7	81.3	82.6	82.6	84.3	83.4

Unit-Cell Composition Based on 72 (O)

Si	26.8	26.9	26.7	26.7	26.9	26.4
Ti	0.00	0.00	0.00	0.00	0.00	0.00
Al	9.27	9.29	9.44	9.44	9.25	9.79
Fe	0.00	0.00	0.00	0.02	0.02	0.01
Mg	0.29	0.31	0.23	0.16	0.19	0.15
Ca	3.34	3.28	3.38	3.45	3.27	3.51
Ba	0.00	0.00	0.02	0.04	0.03	0.05
Na	0.88	0.43	0.52	0.82	0.77	0.58
K	0.90	0.92	0.90	0.87	0.91	0.96

Si/(Al+Fe)

2.89	2.90	2.83	2.82	2.90	2.69
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.03	1.09	1.09	1.05	1.07	1.09
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Mol% Exchangeable Cations

K	16.6	18.6	17.9	16.4	17.6	18.5
Na	16.3	8.7	10.4	15.5	15.0	11.1
Ca+Mg	67.1	72.7	71.7	68.1	67.3	70.5

APPENDIX F (cont)

Drill Hole UE-25p#1

Depth (ft) Unit ^a	1250	1250	1250	1250	1250	1250	1250	1250
	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	67.8	65.9	67.8	69.2	69.5	68.6	69.8	69.2
TiO ₂	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.8	12.4	12.4	12.4	13.0	12.4	12.5	12.4
Fe ₂ O ₃	0.00	0.01	0.06	0.05	0.04	0.00	0.02	0.03
MgO	0.07	0.07	0.07	0.05	0.07	0.07	0.06	0.06
CaO	3.73	3.58	3.76	3.66	3.61	3.59	3.64	3.57
BaO	0.11	0.07	0.02	0.06	0.07	0.00	0.02	0.00
Na ₂ O	1.08	1.01	0.96	1.00	1.39	1.13	1.40	1.05
K ₂ O	2.54	2.60	2.48	2.62	3.09	3.01	3.03	2.67
Total	88.1	85.7	87.6	89.1	90.7	88.8	90.5	89.0

Unit-Cell Composition Based on 72 (O)

Si	29.6	29.6	29.7	29.8	29.6	29.7	29.7	29.8
Ti	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.56	6.59	6.40	6.31	6.51	6.35	6.29	6.30
Fe	0.00	0.00	0.02	0.02	0.01	0.00	0.01	0.01
Mg	0.05	0.05	0.05	0.03	0.04	0.05	0.04	0.04
Ca	1.74	1.72	1.77	1.69	1.65	1.67	1.66	1.65
Ba	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00
Na	0.91	0.88	0.82	0.84	1.15	0.95	1.16	0.88
K	1.41	1.49	1.39	1.44	1.68	1.66	1.65	1.47

Si/(Al+Fe)

4.51	4.49	4.63	4.72	4.53	4.68	4.72	4.73
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.10	1.11	1.10	1.10	1.05	1.05	1.01	1.10
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Mol% Exchangeable Cations

K	34.3	36.0	34.5	36.0	37.2	38.5	36.6	36.4
Na	22.2	21.2	20.3	20.9	25.4	21.9	25.7	21.8
Ca+Mg	43.5	42.8	45.1	43.1	37.4	39.6	37.7	41.8

APPENDIX F (cont)

Drill Hole UE-25p#1

Depth (ft) Unit ^a	1250	1350	1350	1350	1400	1400	1400	1700
	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tcp
SiO ₂	68.9	69.2	68.7	68.3	66.0	66.5	67.4	64.9
TiO ₂	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.4	12.2	12.5	11.9	13.5	12.9	12.2	12.6
Fe ₂ O ₃	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.02
MgO	0.01	0.08	0.08	0.11	0.07	0.08	0.05	0.24
CaO	3.47	3.76	3.87	3.58	4.39	4.08	3.80	3.91
BaO	0.04	0.00	0.09	0.13	0.18	0.14	0.12	0.05
Na ₂ O	1.10	1.11	0.87	0.69	1.23	1.43	1.16	1.33
K ₂ O	2.62	2.38	2.27	2.42	1.39	1.52	1.94	1.42
Total	88.6	88.7	88.4	87.2	86.8	86.6	86.7	84.5
Unit-Cell Composition Based on 72 (O)								
Si	29.8	29.9	29.8	30.0	29.2	29.4	29.8	29.4
Ti	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Al	6.33	6.20	6.38	6.13	7.04	6.73	6.37	6.72
Fe	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
Mg	0.01	0.05	0.05	0.07	0.05	0.05	0.03	0.16
Ca	1.61	1.74	1.80	1.68	2.08	1.94	1.80	1.90
Ba	0.01	0.00	0.02	0.02	0.03	0.02	0.02	0.01
Na	0.92	0.93	0.73	0.59	1.05	1.23	0.99	1.17
K	1.45	1.31	1.25	1.36	0.78	0.86	1.09	0.82
Si/(Al+Fe)								
	4.71	4.82	4.67	4.89	4.15	4.37	4.67	4.37
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.13	1.06	1.12	1.12	1.14	1.10	1.10	1.10
Mol% Exchangeable Cations								
K	36.3	32.5	32.7	36.6	19.8	21.1	27.9	20.3
Na	23.2	23.1	19.1	15.9	26.6	30.1	25.4	28.9
Ca+Mg	40.5	44.4	48.2	47.5	53.6	48.8	46.7	50.9

APPENDIX F (cont)

Drill Hole UE-25p#1

Depth (ft)	1700	1700	1700	1700	1700	1700	1700	1700
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	68.0	71.5	69.5	67.1	67.5	63.7	68.9	68.2
TiO ₂	0.00	0.00	0.02	0.00	0.03	0.02	0.02	0.02
Al ₂ O ₃	13.0	13.0	12.7	12.9	13.0	12.3	12.9	12.8
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.22	0.27	0.21	0.32	0.28	0.27	0.28	0.33
CaO	4.19	4.06	3.83	4.37	3.94	4.00	4.20	4.11
BaO	0.11	0.07	0.13	0.05	0.21	0.07	0.04	0.14
Na ₂ O	1.32	1.53	1.62	1.55	1.66	1.57	1.58	1.44
K ₂ O	1.18	1.30	1.31	1.23	1.26	1.22	1.34	1.39
Total	88.0	91.7	89.3	87.6	87.9	83.1	89.2	88.4
Unit-Cell Composition Based on 72 (O)								
Si	29.5	29.7	29.7	29.4	29.4	29.4	29.5	29.5
Ti	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
Al	6.65	6.37	6.40	6.67	6.68	6.70	6.51	6.54
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.14	0.17	0.13	0.21	0.18	0.19	0.18	0.21
Ca	1.95	1.81	1.76	2.05	1.84	1.98	1.93	1.91
Ba	0.02	0.01	0.02	0.01	0.04	0.01	0.01	0.02
Na	1.11	1.23	1.34	1.32	1.40	1.40	1.31	1.21
K	0.65	0.69	0.71	0.69	0.70	0.72	0.73	0.77
Si/(Al+Fe)								
	4.44	4.67	4.64	4.41	4.41	4.38	4.54	4.52
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.11	1.08	1.09	1.02	1.07	1.04	1.04	1.04
Mol% Exchangeable Cations								
K	16.9	17.7	18.1	16.1	17.0	16.8	17.6	18.7
Na	28.8	31.6	34.0	30.9	34.0	32.8	31.6	29.5
Ca+Mg	54.2	50.7	47.9	53.0	49.0	50.5	50.7	51.7

APPENDIX F (cont)

Drill Hole UE-25p#1

Depth (ft)	1700	1700	1800	1800	1800	1800	1800	1800
Unit ^a	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp	Tcp
SiO ₂	70.0	67.2	65.7	67.2	65.5	63.1	61.2	70.4
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	13.2	12.7	11.8	11.1	11.8	11.8	11.8	12.5
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.04
MgO	0.29	0.28	0.20	0.20	0.19	0.26	0.23	0.24
CaO	4.09	3.95	3.50	3.18	3.68	3.84	3.48	3.70
BaO	0.62	0.04	0.00	0.00	0.16	0.08	0.16	0.09
Na ₂ O	1.54	1.71	1.60	1.18	1.13	1.13	1.33	1.39
K ₂ O	1.34	1.56	1.22	1.30	1.02	1.02	1.34	1.36
Total	91.1	87.5	83.9	84.2	83.5	81.2	79.5	89.7

Unit-Cell Composition Based on 72 (O)

Si	29.5	29.5	29.8	30.3	29.9	29.6	29.5	29.9
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.56	6.58	6.30	5.89	6.33	6.55	6.69	6.25
Fe	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01
Mg	0.18	0.18	0.14	0.13	0.13	0.18	0.17	0.15
Ca	1.85	1.86	1.70	1.54	1.80	1.93	1.80	1.68
Ba	0.10	0.01	0.00	0.00	0.03	0.01	0.03	0.01
Na	1.26	1.45	1.41	1.03	1.00	1.03	1.24	1.15
K	0.72	0.87	0.71	0.75	0.59	0.61	0.82	0.74

Si/(Al+Fe)

4.50	4.47	4.73	5.15	4.70	4.52	4.40	4.77
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.05	1.03	1.09	1.15	1.15	1.11	1.11	1.12
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Mol% Exchangeable Cations

K	18.0	20.0	17.9	21.7	16.9	16.3	20.4	19.8
Na	31.4	33.3	35.6	29.9	28.4	27.4	30.8	30.8
Ca+Mg	50.6	46.7	46.5	48.4	54.8	56.3	48.7	49.4

APPENDIX F (cont)

Drill Hole UE-25p#1

Depth (ft)	1800	2760	2760	2760	3330	3330	3330	3330
Unit ^d	Tcp	Tct	Tct	Tct	Tlr	Tlr	Tlr	Tlr
SiO ₂	68.7	69.4	69.1	68.5	60.3	60.6	63.5	60.4
TiO ₂	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01
Al ₂ O ₃	11.8	13.4	13.7	13.6	15.0	16.0	15.5	15.1
Fe ₂ O ₃	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.23	0.04	0.03	0.00	0.12	0.08	0.06	0.08
CaO	3.40	5.30	5.32	5.21	7.12	7.22	6.76	6.57
BaO	0.11	0.08	0.15	0.23	0.32	0.19	0.22	0.07
Na ₂ O	1.38	0.90	0.91	1.13	0.76	0.85	1.02	1.34
K ₂ O	1.58	0.51	0.48	0.47	0.28	0.41	0.43	0.38
Total	87.3	89.8	89.7	89.1	83.9	85.4	87.5	84.0
Unit-Cell Composition Based on 72 (O)								
Si	30.0	29.5	29.4	29.4	27.8	27.5	28.0	27.8
Ti	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Al	6.09	6.72	6.86	6.85	8.14	8.59	8.07	8.22
Fe	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.15	0.03	0.02	0.00	0.08	0.05	0.04	0.05
Ca	1.59	2.41	2.42	2.39	3.52	3.51	3.20	3.24
Ba	0.02	0.01	0.02	0.04	0.06	0.03	0.04	0.01
Na	1.17	0.74	0.75	0.94	0.68	0.75	0.87	1.20
K	0.88	0.28	0.26	0.26	0.16	0.24	0.24	0.22
Si/(Al+Fe)								
	4.92	4.37	4.28	4.29	3.42	3.20	3.47	3.38
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.10	1.14	1.15	1.13	1.00	1.05	1.05	1.02
Mol% Exchangeable Cations								
K	23.2	8.0	7.5	7.2	3.7	5.2	5.6	4.7
Na	30.8	21.5	21.7	26.2	15.3	16.4	20.1	25.4
Ca+Mg	45.9	70.5	70.7	66.7	81.0	78.3	74.4	69.9

APPENDIX F (cont)

Drill Hole UE-25p#1

Depth (ft) Unit ^a	3330	3330	3330	3330	3330	3330	3330	3330
	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr
SiO ₂	63.3	63.3	63.2	63.0	63.4	64.7	62.8	64.1
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Al ₂ O ₃	15.3	15.0	14.9	14.9	15.5	15.3	15.2	15.5
Fe ₂ O ₃	0.00	0.00	0.00	0.02	0.04	0.05	0.00	0.02
MgO	0.08	0.06	0.08	0.06	0.15	0.12	0.19	0.10
CaO	6.58	6.84	6.47	6.59	6.66	6.83	6.82	6.60
BaO	0.08	0.16	0.27	0.14	0.05	0.00	0.16	0.00
Na ₂ O	1.03	0.85	0.99	1.03	0.92	0.67	0.73	1.31
K ₂ O	0.48	0.42	0.48	0.47	0.51	0.47	0.47	0.51
Total	86.9	86.7	86.4	86.1	87.2	88.1	86.4	88.1
Unit-Cell Composition Based on 72 (O)								
Si	28.1	28.2	28.2	28.2	28.0	28.2	28.0	28.1
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Al	8.01	7.87	7.87	7.86	8.07	7.87	8.01	7.98
Fe	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.01
Mg	0.05	0.04	0.05	0.04	0.10	0.08	0.13	0.07
Ca	3.13	3.26	3.10	3.16	3.16	3.20	3.27	3.10
Ba	0.01	0.03	0.05	0.02	0.01	0.00	0.03	0.00
Na	0.89	0.73	0.86	0.89	0.79	0.57	0.63	1.11
K	0.27	0.24	0.27	0.27	0.29	0.26	0.27	0.28
Si/(Al+Fe)								
	3.51	3.58	3.59	3.59	3.47	3.58	3.50	3.51
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.06	1.03	1.05	1.03	1.06	1.07	1.03	1.04
Mol% Exchangeable Cations								
K	6.3	5.6	6.4	6.2	6.6	6.4	6.2	6.2
Na	20.4	17.2	20.0	20.5	18.2	13.8	14.7	24.4
Ca+Mg	73.3	77.3	73.6	73.4	75.1	79.8	79.0	69.4

APPENDIX F (cont)

Drill Hole J-13

Depth (ft)	1335	1335	1335	1335	1421	1421	1421	1421
Unit ^a	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt
SiO ₂	66.0	60.4	64.1	59.9	66.3	68.0	70.9	70.3
TiO ₂	0.02	0.04	0.03	0.02	0.02	0.03	0.00	0.00
Al ₂ O ₃	13.1	13.3	13.0	13.2	10.9	11.8	12.3	12.1
Fe ₂ O ₃	0.47	0.47	0.47	0.57	0.00	0.00	0.00	0.00
MgO	0.51	0.39	0.56	0.66	0.00	0.00	0.00	0.00
CaO	4.49	4.64	4.42	4.39	2.47	2.65	2.63	2.63
BaO	0.04	0.04	0.00	0.00	0.06	0.00	0.00	0.00
Na ₂ O	1.07	0.95	0.75	1.43	1.09	1.21	1.38	1.23
K ₂ O	1.05	1.06	1.00	0.99	4.30	4.02	4.89	4.11
Total	86.8	81.3	84.3	81.2	85.1	87.7	92.1	90.3
Unit-Cell Composition Based on 72 (O)								
Si	29.1	28.6	29.1	28.5	30.1	29.9	29.9	30.0
Ti	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Al	6.84	7.44	6.95	7.41	5.85	6.15	6.12	6.09
Fe	0.16	0.17	0.16	0.20	0.00	0.00	0.00	0.00
Mg	0.34	0.28	0.38	0.47	0.00	0.00	0.00	0.00
Ca	2.12	2.35	2.15	2.23	1.20	1.25	1.19	1.20
Ba	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Na	0.92	0.87	0.66	1.32	0.96	1.03	1.13	1.02
K	0.59	0.64	0.58	0.60	2.49	2.26	2.63	2.24
Si/(Al+Fe)								
	4.17	3.76	4.09	3.74	5.15	4.87	4.88	4.93
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.09	1.12	1.13	1.04	0.99	1.06	1.00	1.07
Mol% Exchangeable Cations								
K	14.9	15.5	15.4	13.0	53.5	49.7	53.2	50.2
Na	23.1	21.1	17.5	28.5	20.6	22.7	22.8	22.8
Ca+Mg	62.0	63.5	67.1	58.5	25.8	27.5	24.0	27.0

APPENDIX F (cont)

Drill Hole J-13

Depth (ft)	1421	1421	1421	1421	1421	1457	1457	1457
Unit ^a	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt
SiO ₂	71.8	70.1	67.8	69.2	69.4	63.6	62.7	64.9
TiO ₂	0.03	0.05	0.04	0.03	0.03	0.03	0.02	0.03
Al ₂ O ₃	12.6	12.0	11.4	11.5	11.8	12.1	11.3	11.9
Fe ₂ O ₃	0.00	0.37	0.00	0.00	0.00	0.00	0.04	0.00
MgO	0.00	0.03	0.00	0.00	0.01	0.99	0.92	0.94
CaO	2.77	2.84	2.45	2.56	2.30	3.48	2.85	3.05
BaO	0.00	0.10	0.03	0.00	0.12	0.10	0.08	0.03
Na ₂ O	1.16	1.22	1.22	1.19	1.30	0.38	0.34	0.41
K ₂ O	4.25	4.09	3.93	4.53	4.86	2.02	2.52	2.41
Total	92.5	90.9	86.9	88.9	89.8	82.6	80.8	83.7
Unit-Cell Composition Based on 72 (O)								
Si	29.9	29.9	30.1	30.1	30.0	29.4	29.7	29.7
Ti	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Al	6.18	6.04	5.98	5.88	6.00	6.59	6.29	6.40
Fe	0.00	0.12	0.00	0.00	0.00	0.00	0.01	0.00
Mg	0.00	0.02	0.00	0.00	0.01	0.68	0.65	0.64
Ca	1.24	1.30	1.17	1.19	1.06	1.73	1.45	1.49
Ba	0.00	0.02	0.01	0.00	0.02	0.02	0.01	0.01
Na	0.94	1.01	1.05	1.00	1.09	0.34	0.31	0.36
K	2.26	2.22	2.23	2.52	2.68	1.19	1.52	1.41
Si/(Al+Fe)								
	4.85	4.85	5.03	5.12	5.00	4.47	4.71	4.64
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.09	1.04	1.06	1.00	1.01	1.03	1.04	1.06
Mol% Exchangeable Cations								
K	51.0	48.9	50.1	53.4	55.4	30.3	38.7	36.0
Na	21.1	22.2	23.6	21.3	22.5	8.6	7.9	9.3
Ca+Mg	27.9	28.9	26.2	25.3	22.1	61.1	53.3	54.7

APPENDIX F (cont)

Drill Hole J-13

Depth (ft) Unit ^a	1457	1457	1457	1457	1457	1457	1519	1519
	Tpt	Tpt	Tpt	Tpt	Tpt	Tpt	Tht	Tht
SiO ₂	65.4	64.1	65.3	65.4	65.5	63.9	66.1	65.5
TiO ₂	0.03	0.00	0.00	0.00	0.00	0.03	0.02	0.02
Al ₂ O ₃	11.9	11.7	11.5	11.9	11.8	11.7	11.9	12.2
Fe ₂ O ₃	0.00	0.06	0.08	0.18	0.04	0.16	0.00	0.03
MgO	0.89	0.92	0.93	0.88	0.94	0.94	0.40	0.51
CaO	3.07	2.95	2.76	3.10	3.01	2.83	3.50	3.22
BaO	0.00	0.05	0.10	0.16	0.09	0.19	0.00	0.00
Na ₂ O	0.49	0.46	0.39	0.50	0.59	0.31	0.53	0.66
K ₂ O	2.62	2.52	2.57	2.58	2.88	2.42	2.85	3.10
Total	84.4	82.8	83.7	84.7	84.8	82.5	85.3	85.3
Unit-Cell Composition Based on 72 (O)								
Si	29.7	29.7	29.9	29.7	29.7	29.7	29.8	29.6
Ti	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Al	6.36	6.37	6.22	6.34	6.28	6.42	6.30	6.51
Fe	0.00	0.02	0.03	0.06	0.01	0.06	0.00	0.01
Mg	0.60	0.63	0.63	0.59	0.63	0.65	0.27	0.34
Ca	1.49	1.46	1.35	1.51	1.46	1.41	1.69	1.56
Ba	0.00	0.01	0.02	0.03	0.02	0.03	0.00	0.00
Na	0.43	0.41	0.35	0.44	0.52	0.28	0.46	0.58
K	1.52	1.49	1.50	1.49	1.66	1.43	1.64	1.79
Si/(Al+Fe)								
	4.67	4.64	4.78	4.64	4.72	4.58	4.72	4.53
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.04	1.05	1.07	1.03	0.98	1.10	1.05	1.06
Mol% Exchangeable Cations								
K	37.5	37.2	39.1	37.0	38.9	38.0	40.4	41.9
Na	10.7	10.3	9.0	10.9	12.1	7.4	11.4	13.5
Ca+Mg	51.8	52.5	51.8	52.1	49.0	54.6	48.2	44.6

APPENDIX F (cont)

Drill Hole J-13

Depth (ft)	1519	1519	1519	1519	1519	1519	1519	1519
Unit ^a	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
SiO ₂	65.9	64.0	64.0	66.0	66.8	66.4	66.8	67.6
TiO ₂	0.00	0.03	0.03	0.02	0.00	0.02	0.03	0.00
Al ₂ O ₃	12.6	12.2	12.3	12.1	12.5	12.7	12.7	11.8
Fe ₂ O ₃	0.00	0.02	0.08	0.07	0.01	0.02	0.04	0.00
MgO	0.53	0.38	0.47	0.50	0.45	0.47	0.52	0.42
CaO	3.79	3.82	3.74	3.59	3.49	3.63	3.66	3.42
BaO	0.08	0.10	0.00	0.07	0.00	0.00	0.00	0.00
Na ₂ O	0.52	0.63	0.77	0.56	0.72	0.75	0.71	0.63
K ₂ O	2.71	2.40	3.19	2.91	3.35	3.22	3.60	3.27
Total	86.1	83.5	84.6	85.9	87.3	87.2	88.0	87.2
Unit-Cell Composition Based on 72 (O)								
Si	29.4	29.4	29.3	29.6	29.5	29.4	29.3	29.8
Ti	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00
Al	6.65	6.62	6.62	6.42	6.52	6.62	6.59	6.15
Fe	0.00	0.01	0.03	0.02	0.00	0.01	0.01	0.00
Mg	0.35	0.26	0.32	0.33	0.30	0.31	0.34	0.28
Ca	1.81	1.88	1.83	1.72	1.65	1.72	1.72	1.62
Ba	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00
Na	0.45	0.56	0.68	0.49	0.62	0.64	0.61	0.54
K	1.54	1.41	1.86	1.66	1.89	1.82	2.02	1.84
Si/(Al+Fe)								
	4.43	4.45	4.40	4.59	4.53	4.43	4.44	4.86
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.05	1.05	0.97	1.02	1.02	1.02	0.98	1.00
Mol% Exchangeable Cations								
K	37.1	34.2	39.6	39.5	42.4	40.5	43.1	43.1
Na	10.8	13.7	14.5	11.6	13.8	14.3	12.9	12.6
Ca+Mg	52.1	52.1	45.8	48.9	43.8	45.2	44.0	44.3

APPENDIX F (cont)

Drill Hole J-13

Depth (ft)	1546	1546	1612	1612
Unit ^a	Tht	Tht	Tht	Tht
SiO ₂	64.6	65.5	68.1	67.6
TiO ₂	0.00	0.00	0.00	0.00
Al ₂ O ₃	9.7	12.3	12.2	12.4
Fe ₂ O ₃	0.00	0.00	0.13	0.08
MgO	0.00	0.00	0.00	0.00
CaO	3.91	4.44	4.39	4.56
BaO	0.10	0.05	0.05	0.00
Na ₂ O	0.19	0.50	0.30	0.30
K ₂ O	<u>1.82</u>	<u>2.93</u>	<u>2.55</u>	<u>2.42</u>
Total	80.3	85.8	87.7	87.4

Unit-Cell Composition Based on 72 (O)

Si	30.6	29.5	29.8	29.7
Ti	0.00	0.00	0.00	0.00
Al	5.40	6.53	6.29	6.45
Fe	0.00	0.00	0.04	0.03
Mg	0.00	0.00	0.00	0.00
Ca	1.99	2.14	2.06	2.15
Ba	0.02	0.01	0.01	0.00
Na	0.17	0.44	0.25	0.26
K	1.10	1.68	1.42	1.36

Si/(Al+Fe)

5.67	4.52	4.71	4.58
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.02	1.02	1.09	1.10
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Mol% Exchangeable Cations

K	33.7	39.5	38.1	36.1
Na	5.4	10.2	6.8	6.8
Ca+Mg	60.9	50.3	55.1	57.1

APPENDIX F (cont)

Outcrop at Prow Pass, Northern Yucca Mountain

Sample Number: 3-15-82-11; Nevada State Coordinates (ft) 786550N, 551400E

Partially welded tuff near base of Topopah Spring Member, Paintbrush Tuff

SiO ₂	63.5	63.5	63.8	66.8	66.4	67.6	68.9	63.8
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	11.2	11.1	11.3	11.9	11.9	12.3	12.1	12.7
Fe ₂ O ₃	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00
MgO	0.68	0.63	0.68	0.60	0.55	0.61	0.68	0.61
CaO	2.13	2.18	2.09	2.41	2.47	2.47	2.11	2.67
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	0.89	0.84	0.86	0.89	0.95	0.89	0.76	0.99
K ₂ O	3.16	3.13	3.41	3.33	3.27	3.39	3.43	3.16
Total	81.5	81.5	82.1	86.6	85.5	87.2	88.0	83.9

Unit-Cell Composition Based on 72 (O)

Si	29.9	29.9	29.9	29.7	29.8	29.8	30.0	29.3
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.22	6.18	6.23	6.26	6.29	6.39	6.23	6.85
Fe	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00
Mg	0.48	0.44	0.47	0.40	0.37	0.40	0.44	0.42
Ca	1.07	1.10	1.05	1.15	1.19	1.17	0.98	1.31
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.81	0.77	0.78	0.77	0.83	0.76	0.64	0.88
K	1.90	1.88	2.04	1.89	1.87	1.91	1.91	1.85

Si/(Al+Fe)

4.80	4.85	4.79	4.61	4.74	4.66	4.82	4.28
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.07	1.08	1.06	1.12	1.08	1.10	1.15	1.11
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Mol% Exchangeable Cations

K	44.5	44.9	46.9	45.0	44.0	45.0	48.0	41.5
Na	19.1	18.3	18.0	18.3	19.4	18.0	16.2	19.7
Ca+Mg	36.4	36.8	35.1	36.8	36.6	37.0	35.9	38.8

APPENDIX F (cont)

Outcrop at Prow Pass, Northern Yucca MountainSample
Number

5-6-81-1

3-15-82-6

Nonwelded zeolitic tuff in upper and central part of tuff of Calico Hills.
Nevada State Coordinates (ft) for sample locations 5-6-86-1=782850N, 550625E;
3-15-82-6=786400N, 551100E.

SiO ₂	63.3	63.4	67.3	65.5	64.7	64.4	65.3	64.0
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.6	12.4	11.9	12.8	12.7	12.6	12.9	12.3
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.74	0.81	0.38	0.81	1.13	0.76	0.70	0.50
CaO	2.77	2.69	2.37	2.55	2.37	2.82	2.76	2.33
BaO	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	0.34	0.29	0.52	0.43	0.35	0.43	0.38	0.36
K ₂ O	3.80	3.68	5.27	4.14	3.77	3.99	3.94	5.68
Total	83.5	83.4	87.7	86.2	85.0	85.0	86.0	85.1

Unit-Cell Composition Based on 72 (O)

Si	29.3	29.4	29.8	29.4	29.3	29.3	29.3	29.4
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.88	6.76	6.20	6.75	6.78	6.75	6.82	6.63
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.51	0.56	0.25	0.54	0.76	0.52	0.47	0.34
Ca	1.37	1.33	1.12	1.22	1.15	1.37	1.33	1.15
Ba	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.30	0.26	0.45	0.37	0.31	0.38	0.33	0.32
K	2.24	2.17	2.98	2.37	2.18	2.32	2.26	3.33

Si/(Al+Fe)

4.25	4.34	4.81	4.35	4.33	4.35	4.30	4.43
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.09	1.07	1.00	1.08	1.07	1.04	1.10	1.00
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Mol% Exchangeable Cations

K	50.6	50.2	62.0	52.5	49.5	50.5	51.5	64.8
Na	6.9	6.0	9.3	8.3	7.0	8.3	7.5	6.2
Ca+Mg	42.5	43.8	28.7	39.2	43.5	41.2	41.0	29.0

APPENDIX F (cont)

Outcrop at Prow Pass, Northern Yucca Mountain

Sample Number: 3-15-82-6; Nevada State Coordinates (ft) 782850N, 550625E

Nonwelded zeolitic tuff in central part of tuff of Calico Hills

SiO ₂	61.0	65.8	64.2	61.0	66.8	65.5	66.7	63.3
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	12.4	12.4	12.0	12.6	12.8	12.7	11.7	11.9
Fe ₂ O ₃	0.54	0.00	0.00	0.18	0.00	0.00	0.00	0.00
MgO	0.45	0.50	0.51	0.46	0.52	0.43	0.38	0.42
CaO	2.27	2.36	2.20	2.25	2.41	2.38	2.08	2.14
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	0.18	0.29	0.30	0.32	0.26	0.39	0.26	0.32
K ₂ O	5.61	5.69	6.03	4.86	4.83	6.12	4.76	6.09
Total	82.5	87.1	85.3	81.6	87.6	87.5	85.9	84.2

Unit-Cell Composition Based on 72 (O)								
Si	29.0	29.5	29.5	29.1	29.5	29.3	30.0	29.5
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.97	6.57	6.50	7.07	6.65	6.69	6.22	6.52
Fe	0.19	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Mg	0.32	0.33	0.35	0.33	0.34	0.29	0.25	0.29
Ca	1.16	1.13	1.08	1.15	1.14	1.14	1.00	1.07
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.17	0.25	0.27	0.30	0.22	0.34	0.23	0.29
K	3.40	3.25	3.53	2.96	2.72	3.49	2.73	3.61
Si/(Al+Fe)								
	4.05	4.49	4.54	4.08	4.44	4.38	4.82	4.52
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.10	1.02	0.98	1.15	1.12	1.00	1.14	0.99
Mol% Exchangeable Cations								
K	67.5	65.4	67.5	62.5	61.5	66.4	64.8	68.7
Na	3.3	5.1	5.1	6.3	5.0	6.4	5.4	5.5
Ca+Mg	29.2	29.5	27.4	31.2	33.5	27.1	29.8	25.8

APPENDIX F (cont)

Compositions of Clinoptilolites in Outcrop at Prow Pass, Northern Yucca Mt.

Sample Number: 3-15-82-2; Nevada State Coordinates (ft) 786600N, 550900E

Nonwelded zeolitic tuff near base of tuff of Calico Hills

SiO2	68.4	70.0	69.6	68.6	64.1	66.5	69.9	67.3
TiO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al2O3	12.2	12.0	12.4	13.0	11.7	12.7	12.2	12.2
Fe2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.01	0.04	0.04	0.04	0.03	0.10	0.04	0.02
CaO	0.91	0.98	0.90	1.05	0.92	0.60	0.61	1.13
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	1.10	1.10	1.16	1.20	1.21	0.99	0.90	1.22
K2O	7.24	6.68	7.95	8.14	7.70	9.03	8.38	6.29
Total	89.9	90.8	92.0	92.1	85.6	89.9	92.1	88.1

Unit-Cell Composition Based on 72 (O)								
Si	29.8	30.0	29.8	29.4	29.6	29.4	29.9	29.8
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	6.27	6.09	6.27	6.58	6.36	6.60	6.16	6.37
Fe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.01	0.03	0.03	0.03	0.02	0.07	0.03	0.01
Ca	0.43	0.45	0.41	0.48	0.46	0.28	0.28	0.54
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.93	0.92	0.96	1.00	1.08	0.85	0.75	1.05
K	4.03	3.66	4.34	4.46	4.54	5.09	4.57	3.55

Si/(Al+Fe)								
	4.76	4.93	4.75	4.48	4.65	4.45	4.85	4.68

(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.08	1.10	1.01	1.02	0.97	0.99	1.04	1.12

Mol% Exchangeable Cations								
K	74.7	72.4	75.6	74.7	74.4	80.9	81.3	69.0
Na	17.3	18.1	16.8	16.7	17.8	13.5	13.3	20.3
Ca+Mg	8.0	9.4	7.6	8.5	7.8	5.6	5.4	10.7

APPENDIX G

ANALCIME COMPOSITIONS DETERMINED BY ELECTRON MICROPROBE,
YUCCA MOUNTAIN, NEVADADrill Hole USW G-1

Depth (ft) Unit ^a	3371	3371	3371	3371	3371	3371	3371	3371
	Tct	Tct	Tct	Tct	Tct	Tct	Tct	Tct
SiO ₂	59.1	58.7	59.6	59.0	59.1	58.9	58.9	57.9
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	19.6	19.6	19.5	19.6	19.7	19.7	19.4	19.5
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.01	0.00	0.00	0.01	0.04	0.01	0.00	0.01
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	12.0	11.9	12.0	12.1	12.1	11.8	12.1	11.9
K ₂ O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	90.6	90.2	91.1	90.7	90.9	90.5	90.4	89.4
Unit-Cell Composition Based on 96 (O)								
Si	34.5	34.4	34.6	34.4	34.4	34.5	34.5	34.3
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	13.5	13.6	13.3	13.5	13.5	13.6	13.4	13.6
Fe	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
Ca	0.01	0.00	0.00	0.01	0.02	0.01	0.00	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	13.6	13.6	13.5	13.7	13.6	13.4	13.7	13.7
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Si/(Al+Fe)								
	2.56	2.54	2.59	2.55	2.54	2.54	2.57	2.52
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.99	1.00	0.99	0.99	0.99	1.02	0.98	0.99
Mol% Exchangeable Cations								
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	100.0	100.0	100.0	100.0	99.8	100.0	100.0	100.0
Ca+Mg	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0

^a Unit symbols defined in Table I.

APPENDIX G (cont)

Drill Hole USW G-1

Depth (ft)	3371	3371	3371	4095	4208	4208	4208	4295
Unit ^a	Tct	Tct	Tct	Tlr	Tlr	Tlr	Tlr	Tlr
SiO ₂	59.0	59.0	58.1	60.2	58.2	57.0	57.2	60.2
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	19.6	19.6	19.1	18.2	19.5	20.0	19.3	18.9
Fe ₂ O ₃	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.07
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.03
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Na ₂ O	12.1	12.2	11.6	11.4	12.1	12.5	12.1	11.3
K ₂ O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	90.7	90.8	88.9	89.8	89.8	89.5	88.6	90.5
Unit-Cell Composition Based on 96 (O)								
Si	34.5	34.4	34.6	35.3	34.4	33.9	34.3	35.0
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	13.5	13.5	13.4	12.6	13.6	14.0	13.6	13.0
Fe	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.03
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Na	13.7	13.8	13.4	13.0	13.9	14.4	14.1	12.8
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Si/(Al+Fe)								
	2.56	2.55	2.57	2.80	2.53	2.42	2.51	2.70
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.99	0.97	1.00	0.97	0.98	0.97	0.97	1.02
Mol% Exchangeable Cations								
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	100.0	99.9	100.0	100.0	100.0	100.0	100.0	99.9
Ca+Mg	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1

APPENDIX G (cont)

Drill Hole USW G-1

Depth (ft)	4295	4295	4295	4341	4341	4400	4503	4503
Unit ^a	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr
SiO ₂	60.5	59.4	59.4	59.6	59.1	61.6	59.8	57.5
TiO ₂	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Al ₂ O ₃	18.8	19.5	19.3	19.4	18.4	19.1	18.6	19.8
Fe ₂ O ₃	0.04	0.04	0.07	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00
CaO	0.04	0.02	0.00	0.01	0.01	0.00	0.02	0.02
BaO	0.03	0.00	0.00	0.07	0.05	0.26	0.00	0.00
Na ₂ O	11.2	11.5	11.5	11.8	11.4	11.6	11.6	12.2
K ₂ O	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04
Total	90.6	90.5	90.3	90.9	89.0	92.6	90.0	89.6

Unit-Cell Composition Based on 96 (O)

Si	35.2	34.7	34.7	34.7	35.1	35.1	35.1	34.1
Ti	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Al	12.9	13.4	13.3	13.3	12.9	12.8	12.9	13.8
Fe	0.02	0.02	0.03	0.00	0.00	0.00	0.00	0.00
Mg	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00
Ca	0.02	0.01	0.00	0.01	0.01	0.00	0.01	0.01
Ba	0.01	0.00	0.00	0.02	0.01	0.06	0.00	0.00
Na	12.6	13.0	13.0	13.3	13.1	12.8	13.2	14.0
K	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03

Si/(Al+Fe)

2.73	2.58	2.60	2.61	2.72	2.74	2.73	2.46
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.02	1.03	1.02	1.00	0.97	0.99	0.97	0.98
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Mol% Exchangeable Cations

K	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Na	99.8	99.9	100.0	99.9	99.7	100.0	99.8	99.7
Ca+Mg	0.2	0.1	0.0	0.1	0.3	0.0	0.1	0.1

APPENDIX G (cont)

Drill Hole USW G-1

Depth (ft)	4700	4700	4700	4876	4876	4876	4876	4912
Unit ^a	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr
SiO ₂	57.8	58.4	58.2	59.1	56.7	59.9	57.3	57.1
TiO ₂	0.00	0.00	0.00	0.05	0.00	0.00	0.02	0.00
Al ₂ O ₃	19.7	19.7	20.0	18.9	20.4	18.8	19.0	19.9
Fe ₂ O ₃	0.04	0.01	0.04	0.00	0.00	0.01	0.00	0.01
MgO	0.00	0.00	0.00	0.02	0.00	0.03	0.00	0.00
CaO	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
BaO	0.05	0.18	0.00	0.00	0.00	0.00	0.00	0.00
Na ₂ O	11.9	11.8	11.8	11.8	12.8	11.7	11.9	11.9
K ₂ O	0.00	0.00	0.00	0.00	0.02	0.03	0.03	0.00
Total	89.5	90.1	90.0	89.9	89.9	90.5	88.3	88.9
Unit-Cell Composition Based on 96 (O)								
Si	34.2	34.4	34.2	34.8	33.6	35.0	34.4	34.1
Ti	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00
Al	13.8	13.7	13.9	13.1	14.3	12.9	13.5	14.0
Fe	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Mg	0.00	0.00	0.00	0.02	0.00	0.03	0.00	0.00
Ca	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Ba	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Na	13.7	13.5	13.5	13.5	14.7	13.2	13.9	13.8
K	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00
Si/(Al+Fe)								
	2.49	2.51	2.47	2.65	2.36	2.70	2.56	2.43
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.01	1.01	1.03	0.97	0.97	0.97	0.97	1.02
Mol% Exchangeable Cations								
K	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.0
Na	100.0	100.0	100.0	99.9	99.9	99.5	99.8	100.0
Ca+Mg	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0

APPENDIX G (cont)

Drill Hole USW G-1

Depth (ft) Unit ^a	4912	4912	5093	5126	5126	5167	5167	5167
	Tlr	Tlr	Tot	Tot	Tot	Tot	Tot	Tot
SiO ₂	58.4	57.0	59.4	58.6	59.3	57.5	57.4	58.4
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	20.0	20.8	20.0	19.5	19.9	19.9	19.7	18.0
Fe ₂ O ₃	0.04	0.00	0.00	0.01	0.03	0.01	0.00	0.01
MgO	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.00
BaO	0.00	0.00	0.00	0.00	0.03	0.05	0.11	0.00
Na ₂ O	11.9	12.5	11.8	12.2	12.5	12.0	11.6	11.2
K ₂ O	0.01	0.00	0.00	0.01	0.02	0.00	0.00	0.00
Total	90.4	90.3	91.2	90.4	91.8	89.5	88.8	87.6

Unit-Cell Composition Based on 96 (O)

Si	34.2	33.6	34.4	34.4	34.3	34.1	34.2	35.1
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	13.8	14.5	13.7	13.5	13.6	13.9	13.9	12.8
Fe	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Mg	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Ca	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00
Ba	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.00
Na	13.5	14.3	13.3	13.9	14.0	13.8	13.4	13.1
K	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00

Si/(Al+Fe)

	2.47	2.32	2.52	2.55	2.53	2.45	2.47	2.75
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

	1.02	1.01	1.03	0.97	0.97	1.01	1.03	0.98
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Mol% Exchangeable Cations

K	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Na	99.9	100.0	100.0	99.7	99.9	100.0	100.0	100.0
Ca+Mg	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0

APPENDIX G (cont)

Drill Hole USW G-1

Depth (ft)	5167	5212	5212	5212	5212	5296	5296	5296
Unit ^a	Tot	Tot	Tot	Tot	Tot	Tot	Tot	Tot
SiO ₂	57.8	60.4	59.4	58.7	59.8	56.5	59.1	59.0
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	20.1	18.6	18.5	19.4	18.9	19.5	20.0	19.8
Fe ₂ O ₃	0.00	0.05	0.00	0.10	0.04	0.02	0.04	0.04
MgO	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
CaO	0.04	0.01	0.02	0.02	0.02	0.00	0.00	0.00
BaO	0.00	0.08	0.13	0.05	0.05	0.12	0.09	0.00
Na ₂ O	12.6	11.3	11.3	11.7	11.7	11.8	11.9	12.0
K ₂ O	0.00	0.03	0.03	0.00	0.02	0.00	0.00	0.00
Total	90.5	90.5	89.4	90.0	90.5	87.9	91.1	90.8
Unit-Cell Composition Based on 96 (O)								
Si	34.0	35.2	35.1	34.5	34.9	34.1	34.3	34.4
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	13.9	12.8	12.9	13.5	13.0	13.9	13.7	13.6
Fe	0.00	0.02	0.00	0.04	0.02	0.01	0.02	0.02
Mg	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
Ca	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Ba	0.00	0.02	0.03	0.01	0.01	0.03	0.02	0.00
Na	14.4	12.8	12.9	13.3	13.2	13.8	13.4	13.6
K	0.00	0.02	0.02	0.00	0.01	0.00	0.00	0.00
Si/(Al+Fe)								
	2.44	2.75	2.72	2.56	2.68	2.46	2.50	2.52
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.97	1.00	0.99	1.01	0.98	1.00	1.02	1.00
Mol% Exchangeable Cations								
K	0.0	0.2	0.2	0.0	0.1	0.0	0.0	0.0
Na	99.8	99.8	99.7	99.8	99.8	100.0	100.0	100.0
Ca+Mg	0.2	0.0	0.2	0.2	0.1	0.0	0.0	0.0

APPENDIX G (cont)

Drill Hole USW G-1

Depth (ft) Unit ^a	5296	5311	5311	5412	5412	5498	5498	5679
	Tot	Tot	Tot	Tot	Tot	Tot	Tot	Tot
SiO ₂	59.2	58.9	59.6	56.4	58.0	57.5	58.1	59.3
TiO ₂	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Al ₂ O ₃	19.5	19.8	19.5	19.9	19.3	20.0	19.9	19.6
Fe ₂ O ₃	0.05	0.03	0.00	0.00	0.01	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.02	0.05	0.00	0.00	0.00	0.00	0.04
BaO	0.70	0.17	0.00	0.00	0.00	0.00	0.00	0.13
Na ₂ O	11.7	12.2	12.7	12.4	12.0	12.0	11.8	12.2
K ₂ O	0.01	0.01	0.01	0.00	0.00	0.00	0.06	0.02
Total	91.2	91.1	91.4	88.7	89.3	89.5	89.9	91.3
Unit-Cell Composition Based on 96 (O)								
Si	34.5	34.3	34.6	33.8	34.4	34.1	34.2	34.5
Ti	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Al	13.4	13.6	13.3	14.1	13.5	14.0	13.8	13.4
Fe	0.02	0.01	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
Ca	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.02
Ba	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.03
Na	13.2	13.8	13.7	14.4	13.8	13.8	13.5	13.7
K	0.01	0.01	0.01	0.00	0.00	0.00	0.05	0.01
Si/(Al+Fe)								
	2.57	2.52	2.59	2.40	2.55	2.44	2.48	2.57
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.99	0.98	0.97	0.98	0.98	1.01	1.02	0.97
Mol% Exchangeable Cations								
K	0.1	0.1	0.1	0.0	0.0	0.0	0.3	0.1
Na	99.9	99.9	99.7	100.0	100.0	100.0	99.7	99.7
Ca+Mg	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.2

APPENDIX G (cont)

Drill Hole USW G-1

Depth (ft)	5746	5746
Unit ^a	Tot	Tot
SiO2	57.7	58.6
TiO2	0.00	0.00
Al2O3	20.0	19.2
Fe2O3	0.00	0.00
MgO	0.00	0.00
CaO	0.04	0.04
BaO	0.00	0.00
Na2O	11.9	11.6
K2O	0.00	0.00
Total	89.6	89.4

Unit-Cell Composition Based on 96 (O)

Si	34.1	34.6
Ti	0.00	0.00
Al	13.9	13.4
Fe	0.00	0.00
Mg	0.00	0.00
Ca	0.03	0.03
Ba	0.00	0.00
Na	13.6	13.3
K	0.00	0.00

Si/(Al+Fe)

2.45	2.59
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.02	1.00
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Mol% Exchangeable Cations

K	0.0	0.0
Na	99.8	99.8
Ca+Mg	0.2	0.2

APPENDIX G (cont)

Drill Hole UE-25b#1(H)

Depth (ft) Unit ^a	3393	3393	3393	3393	3506	3506	3506	3506
	Tct	Tct	Tct	Tct	Tct	Tct	Tct	Tct
SiO2	61.9	61.3	61.5	60.7	61.8	61.6	58.5	57.6
TiO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al2O3	18.2	18.5	18.7	18.6	18.5	19.0	20.6	20.8
Fe2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.00	0.02	0.00	0.00	0.04	0.03	0.00
BaO	0.04	0.00	0.00	0.01	0.00	0.06	0.00	0.01
Na2O	11.3	11.1	11.3	11.4	11.2	11.6	12.7	12.5
K2O	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01
Total	91.3	91.0	91.5	90.8	91.5	92.4	91.8	90.9
Unit-Cell Composition Based on 96 (O)								
Si	35.6	35.4	35.3	35.2	35.5	35.2	33.9	33.7
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	12.3	12.6	12.7	12.8	12.5	12.8	14.1	14.3
Fe	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
Ca	0.00	0.00	0.01	0.00	0.00	0.02	0.02	0.00
Ba	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Na	12.6	12.5	12.6	12.8	12.5	12.8	14.3	14.2
K	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Si/(Al+Fe)								
	2.88	2.80	2.79	2.76	2.84	2.75	2.41	2.35
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.98	1.01	1.00	0.99	1.00	0.99	0.99	1.01
Mol% Exchangeable Cations								
K	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Na	100.0	100.0	99.9	100.0	99.9	99.8	99.9	99.9
Ca+Mg	0.0	0.0	0.1	0.0	0.0	0.2	0.1	0.0

APPENDIX G (cont)

Drill Hole UE-25p#1

Depth (ft)	2220	2220	2220	2220	2290	3453
Unit ^a	Tcb	Tcb	Tcb	Tcb	Tcb	Tlr
SiO ₂	59.9	59.3	59.2	59.6	58.1	62.5
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	19.2	18.8	19.5	19.5	19.6	18.8
Fe ₂ O ₃	0.00	0.00	0.00	0.02	0.02	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.02	0.00	0.00
BaO	0.03	0.00	0.00	0.09	0.13	0.00
Na ₂ O	12.0	11.9	11.9	11.9	12.1	11.3
K ₂ O	0.00	0.00	0.00	0.03	0.00	0.00
Total	91.1	90.0	90.5	91.1	90.0	92.6
Unit-Cell Composition Based on 96 (O)						
Si	34.8	34.8	34.6	34.6	34.3	35.5
Ti	0.00	0.00	0.00	0.00	0.00	0.00
Al	13.1	13.0	13.4	13.4	13.6	12.6
Fe	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
Ca	0.00	0.00	0.00	0.01	0.00	0.00
Ba	0.01	0.00	0.00	0.02	0.03	0.00
Na	13.5	13.5	13.4	13.4	13.9	12.4
°K	0.00	0.00	0.00	0.02	0.00	0.00
Si/(Al+Fe)						
	2.65	2.67	2.58	2.59	2.51	2.81
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)						
	0.97	0.97	1.00	0.99	0.98	1.02
Mol% Exchangeable Cations						
K	0.0	0.0	0.0	0.2	0.0	0.0
Na	100.0	100.0	100.0	99.7	100.0	100.0
Ca+Mg	0.0	0.0	0.0	0.1	0.0	0.0

APPENDIX G (cont)

Drill Hole J-13

Depth (ft) Unit ^a	608	608	608	608	1995	1995	1995	1995
	Tpc	Tpc	Tpc	Tpc	Tcp	Tcp	Tcp	Tcp
SiO ₂	58.6	57.8	57.5	58.1	60.1	61.5	59.2	58.4
TiO ₂	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00
Al ₂ O ₃	19.3	19.9	19.3	18.9	19.3	18.7	20.2	20.2
Fe ₂ O ₃	0.02	0.04	0.00	0.07	0.04	0.05	0.05	0.00
MgO	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.00	0.03	0.00	0.04	0.00
BaO	0.16	0.14	0.00	0.00	0.13	0.12	0.05	0.00
Na ₂ O	11.7	12.0	11.4	11.7	11.6	11.2	12.2	12.1
K ₂ O	0.03	0.04	0.00	0.01	0.03	0.03	0.05	0.01
Total	89.8	89.9	88.2	88.8	91.2	91.6	91.8	90.6

Unit-Cell Composition Based on 96 (O)

Si	34.6	34.1	34.5	34.6	34.8	35.3	34.2	34.1
Ti	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
Al	13.4	13.9	13.6	13.3	13.2	12.7	13.8	13.9
Fe	0.01	0.02	0.00	0.03	0.02	0.02	0.02	0.00
Mg	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00
Ca	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00
Ba	0.04	0.03	0.00	0.00	0.03	0.03	0.01	0.00
Na	13.3	13.7	13.2	13.6	13.0	12.5	13.7	13.7
K	0.02	0.03	0.00	0.01	0.02	0.02	0.04	0.01

Si/(Al+Fe)

2.57	2.46	2.53	2.60	2.64	2.79	2.48	2.45
------	------	------	------	------	------	------	------

(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

1.00	1.01	1.03	0.98	1.00	1.01	1.00	1.01
------	------	------	------	------	------	------	------

Mol% Exchangeable Cations

K	0.2	0.2	0.0	0.1	0.2	0.2	0.3	0.1
Na	99.8	99.8	100.0	99.8	99.6	99.8	99.6	99.9
Ca+Mg	0.0	0.0	0.0	0.1	0.2	0.0	0.2	0.0

APPENDIX G (cont)

Drill Hole J-13

Depth (ft)	1995	1995
Unit ^a	Tcd	Tcd
SiO ₂	61.4	60.3
TiO ₂	0.00	0.00
Al ₂ O ₃	19.1	18.9
Fe ₂ O ₃	0.02	0.00
MgO	0.00	0.00
CaO	0.02	0.00
BaO	0.05	0.09
Na ₂ O	11.2	11.5
K ₂ O	0.00	0.01
Total	91.9	90.9

Unit-Cell Composition Based on 96 (O)

Si	35.2	35.0
Ti	0.00	0.00
Al	12.9	12.9
Fe	0.01	0.00
Mg	0.00	0.00
Ca	0.01	0.00
Ba	0.01	0.02
Na	12.5	13.0
K	0.00	0.01

$$\frac{\text{Si}}{(\text{Al}+\text{Fe})}$$

2.72	2.71
------	------

$$\frac{(\text{Al}+\text{Fe})}{(2\text{Mg}+2\text{Ca}+2\text{Ba}+\text{Na}+\text{K})}$$

1.03	1.00
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Mol% Exchangeable Cations

K	0.0	0.1
Na	99.9	99.9
Ca+Mg	0.1	0.0

APPENDIX H

AUTHIGENIC FELDSPAR COMPOSITIONS DETERMINED BY ELECTRON MICROPROBE, YUCCA MOUNTAIN, NEVADA

Drill Hole USW G-1

Depth (ft)	4208	4341	4400	4400	4503	4912	5026	5026
Unit ^a	Tlr	Tlr	Tlr	Tlr	Tlr	Tlr	Tot	Tot
SiO ₂	66.9	67.8	69.3	69.4	67.3	67.0	68.1	66.2
TiO ₂	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.01
Al ₂ O ₃	16.3	19.6	19.0	19.8	16.4	16.6	19.0	16.4
Fe ₂ O ₃	0.00	0.00	0.00	0.02	0.01	0.04	0.00	0.02
MgO	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00
CaO	0.00	0.16	0.00	0.14	0.04	0.00	0.16	0.01
BaO	0.00	0.00	0.00	0.13	0.05	0.16	0.00	0.00
Na ₂ O	0.04	11.8	11.1	11.6	0.07	0.04	11.2	0.07
K ₂ O	15.0	0.01	0.58	0.05	15.2	14.9	0.09	15.1
Total	98.2	99.4	100.0	101.1	99.1	98.7	98.5	97.8
Unit-Cell Composition Based on 8 (O)								
Si	3.11	2.98	3.02	3.00	3.10	3.10	3.01	3.09
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.89	1.02	0.98	1.01	0.89	0.90	0.99	0.90
Fe	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
Ca	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.00	1.01	0.94	0.97	0.01	0.00	0.96	0.01
K	0.89	0.00	0.03	0.00	0.89	0.88	0.01	0.90
Coordination of Cations								
Tet.	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Other	0.89	1.01	0.97	0.98	0.90	0.89	0.97	0.91
Si/(Al+Fe)								
	3.48	2.93	3.09	2.97	3.48	3.42	3.04	3.42
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.00	0.99	1.01	1.02	0.98	1.02	1.01	1.00
K	99.6	0.1	3.3	0.3	98.9	99.6	0.5	99.2
Na	0.4	99.1	96.7	99.1	0.7	0.4	98.7	0.7
Ca+Mg	0.0	0.8	0.0	0.7	0.4	0.0	0.8	0.1

^aUnit symbols defined in Table I.

APPENDIX H (cont)

Drill Hole USW G-1

Depth (ft) Unit ^a	5093	5093	5093	5093	5093	5093	5093	5093
	Tot	Tot	Tot	Tot	Tot	Tot	Tot	Tot
SiO ₂	69.1	69.5	69.4	70.1	70.0	69.1	68.3	70.5
TiO ₂	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	19.7	19.9	19.9	19.5	20.0	20.4	19.4	19.7
Fe ₂ O ₃	0.08	0.07	0.02	0.01	0.02	0.02	0.09	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.25	0.42	0.36	0.31	0.36	0.74	0.21	0.25
BaO	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00
Na ₂ O	11.4	11.4	11.7	11.5	11.4	11.3	11.5	11.7
K ₂ O	0.07	0.03	0.04	0.05	0.07	0.03	0.05	0.04
Total	100.6	101.3	101.4	101.5	101.8	101.7	99.6	102.2
Unit-Cell Composition Based on 8 (O)								
Si	3.00	2.99	2.99	3.01	3.00	2.97	3.00	3.01
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	1.01	1.01	1.01	0.99	1.01	1.03	1.00	0.99
Fe	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
Ca	0.01	0.02	0.02	0.01	0.02	0.03	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.96	0.95	0.98	0.96	0.95	0.94	0.98	0.97
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coordination of Cations								
Tet.	4.01	4.01	4.00	4.00	4.01	4.01	4.00	4.00
Other	0.97	0.97	1.00	0.97	0.97	0.98	0.99	0.98
Si/(Al+Fe)								
	2.97	2.96	2.96	3.05	2.97	2.87	2.98	3.04
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.02	1.02	1.00	1.00	1.03	1.02	1.01	1.00
K	0.4	0.2	0.2	0.3	0.4	0.2	0.3	0.2
Na	98.4	97.8	98.1	98.3	97.9	96.3	98.7	98.6
Ca+Mg	1.2	2.0	1.7	1.5	1.7	3.5	1.0	1.2

APPENDIX H (cont)

Drill Hole USW G-1

Depth (ft)	5126	5126	5296	5311	5311	5412	5412	5412
Unit ^a	Tot	Tot	Tot	Tot	Tot	Tot	Tot	Tot
SiO ₂	59.0	67.8	68.4	69.5	68.6	66.4	67.4	68.3
TiO ₂	0.04	0.02	0.00	0.03	0.01	0.07	0.02	0.00
Al ₂ O ₃	19.3	17.3	19.7	19.1	19.6	16.8	16.5	19.4
Fe ₂ O ₃	0.01	0.13	0.04	0.04	0.07	0.04	0.01	0.01
MgO	0.00	0.03	0.00	0.00	0.01	0.00	0.02	0.00
CaO	0.00	0.01	0.28	0.34	0.55	0.02	0.02	0.02
BaO	0.05	0.05	0.00	0.13	0.00	0.00	0.10	0.00
Na ₂ O	11.8	0.10	11.6	11.5	11.5	0.32	0.05	11.9
K ₂ O	0.02	16.2	0.04	0.09	0.06	15.0	15.5	0.09
Total	90.2	101.6	100.1	100.7	100.4	98.7	99.6	99.7
Unit-Cell Composition Based on 8 (O)								
Si	2.88	3.07	2.99	3.01	2.99	3.08	3.10	2.99
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	1.11	0.92	1.01	0.98	1.01	0.92	0.89	1.00
Fe	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
Ca	0.00	0.00	0.01	0.02	0.03	0.00	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	1.12	0.01	0.98	0.97	0.97	0.03	0.00	1.01
K	0.00	0.93	0.00	0.00	0.00	0.89	0.91	0.01
Coordination of Cations								
Tet.	4.00	3.99	4.00	3.99	4.00	4.00	3.99	4.00
Other	1.12	0.95	1.00	0.99	1.00	0.92	0.92	1.02
Si/(Al+Fe)								
	2.59	3.31	2.94	3.08	2.96	3.35	3.46	2.99
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.99	0.98	1.00	0.97	0.98	1.00	0.97	0.98
K	0.1	98.8	0.2	0.5	0.3	96.8	99.3	0.5
Na	99.9	0.9	98.5	97.9	97.0	3.1	0.5	99.4
Ca+Mg	0.0	0.3	1.3	1.6	2.6	0.1	0.3	0.1

APPENDIX H (cont)

Drill Hole USW G-1

Depth (ft) Unit ^a	5412	5498	5498	5498	5498	5637	5746	5746
	Tot	Tot	Tot	Tot	Tot	Tot	Tot	Tot
SiO ₂	66.6	67.2	66.9	69.7	69.2	68.4	67.1	69.6
TiO ₂	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	19.1	17.0	17.0	18.9	19.3	19.9	20.3	19.8
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.01	0.11	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.06	0.03	0.00	0.02	0.04	0.42	1.05	0.22
BaO	0.00	0.00	0.00	0.00	0.06	0.03	0.00	0.00
Na ₂ O	11.6	0.03	0.06	11.7	11.9	11.5	10.6	11.9
K ₂ O	0.12	15.3	15.3	0.09	0.09	0.04	0.63	0.04
Total	97.5	99.6	99.3	100.4	100.6	100.3	99.8	101.6

Unit-Cell Composition Based on 8 (O)

Si	2.99	3.08	3.08	3.03	3.01	2.98	2.95	2.99
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	1.01	0.92	0.92	0.97	0.99	1.02	1.05	1.00
Fe	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
Ca	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	1.01	0.00	0.01	0.99	1.00	0.97	0.90	0.99
K	0.01	0.90	0.90	0.00	0.00	0.00	0.04	0.00

Coordination of Cations

Tet.	4.00	4.00	4.00	3.99	3.99	4.00	4.00	4.00
Other	1.02	0.90	0.90	0.99	1.01	0.99	0.99	1.00

Si/(Al+Fe)

	2.96	3.35	3.34	3.13	3.04	2.91	2.79	2.98
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

	0.99	1.02	1.02	0.98	0.98	1.01	1.02	0.99
--	------	------	------	------	------	------	------	------

K	0.7	99.5	99.4	0.5	0.5	0.2	3.6	0.2
Na	99.0	0.3	0.6	99.4	99.3	97.8	91.4	98.8
Ca+Mg	0.3	0.2	0.0	0.1	0.2	2.0	5.0	1.0

APPENDIX H (cont)

Drill Hole USW G-1

Depth (ft) Unit ^a	5746	5746	5746	5847	5847	5847	5847	5947
	Tot	Tot	Tot	Tot	Tot	Tot	Tot	Tot
SiO ₂	66.4	69.1	68.4	69.8	68.4	67.2	68.6	67.3
TiO ₂	0.00	0.00	0.00	0.04	0.03	0.03	0.01	0.00
Al ₂ O ₃	20.1	19.8	19.6	18.8	19.6	19.5	19.5	20.0
Fe ₂ O ₃	0.00	0.04	0.03	0.04	0.05	0.08	0.00	0.01
MgO	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00
CaO	1.13	0.38	0.17	0.13	0.62	1.24	0.95	0.80
BaO	0.00	0.00	0.00	0.05	0.15	0.20	0.00	0.00
Na ₂ O	10.3	11.5	11.3	11.3	11.5	10.8	11.1	11.1
K ₂ O	0.02	0.04	0.07	0.13	0.09	0.10	0.07	0.01
Total	98.4	100.9	99.6	100.3	100.5	99.1	100.2	99.2
Unit-Cell Composition Based on 8 (O)								
Si	2.95	2.99	3.00	3.03	2.98	2.97	2.99	2.96
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	1.05	1.01	1.01	0.96	1.01	1.02	1.00	1.04
Fe	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
Ca	0.05	0.02	0.01	0.01	0.03	0.06	0.04	0.04
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.93	0.97	0.96	0.95	0.97	0.93	0.94	0.95
K	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00
Coordination of Cations								
Tet.	4.00	4.00	4.01	4.00	3.99	3.99	3.99	4.00
Other	0.99	0.98	0.97	0.97	1.01	0.99	0.99	0.99
Si/(Al+Fe)								
	2.80	2.96	2.96	3.14	2.96	2.92	2.98	2.85
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	1.01	1.01	1.03	0.99	0.97	0.97	0.97	1.01
K	0.1	0.2	0.4	0.7	0.5	0.6	0.4	0.1
Na	94.4	98.0	98.8	98.6	96.5	93.5	95.0	96.1
Ca+Mg	5.5	1.8	0.8	0.6	3.0	5.9	4.6	3.8

APPENDIX H (cont)

Drill Hole USW G-2

Depth (ft) Unit ^a	2325	2325	2325	2325	2430	4805	4805	4805
	Tht	Tht	Tht	Tht	Tht	Tlr	Tlr	Tlr
SiO ₂	67.9	68.1	68.7	68.8	67.8	65.5	65.6	66.9
TiO ₂	0.00	0.04	0.00	0.00	0.01	0.00	0.00	0.00
Al ₂ O ₃	16.5	16.4	16.6	16.4	16.8	20.7	16.7	16.5
Fe ₂ O ₃	0.03	0.00	0.00	0.00	0.03	0.10	0.01	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.02	0.00	0.02	0.00	0.00	1.55	0.00	0.00
BaO	0.00	0.00	0.00	0.00	0.00	0.08	0.18	0.10
Na ₂ O	0.03	0.04	0.18	0.05	0.03	10.7	0.32	0.17
K ₂ O	15.5	15.3	15.1	15.2	15.5	0.39	15.2	15.1
Total	99.9	99.9	100.6	100.4	100.1	98.9	98.0	98.7
Unit-Cell Composition Based on 8 (O)								
Si	3.11	3.11	3.11	3.12	3.10	2.91	3.07	3.10
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.89	0.89	0.89	0.88	0.90	1.08	0.92	0.90
Fe	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
Ca	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.00	0.00	0.02	0.00	0.00	0.92	0.03	0.02
K	0.90	0.89	0.87	0.88	0.90	0.02	0.91	0.89
Coordination of Cations								
Tet.	4.00	4.00	4.00	4.00	4.00	4.00	3.99	4.00
Other	0.91	0.89	0.89	0.88	0.91	1.02	0.94	0.91
Si/(Al+Fe)								
	3.49	3.52	3.51	3.56	3.43	2.68	3.33	3.44
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.98	0.99	0.99	0.99	1.00	1.00	0.97	0.99
K	99.6	99.6	98.1	99.5	99.7	2.2	96.9	98.3
Na	0.3	0.4	1.8	0.5	0.3	90.5	3.1	1.7
Ca+Mg	0.1	0.0	0.1	0.0	0.0	7.3	0.0	0.0

APPENDIX H (cont)

Drill Hole USW G-2

Depth (ft) Unit ^a	4838	4838	4838	5696	5820	5895	5895	5992
	Tlr	Tlr	Tlr	Tot	Tot	Tot	Tot	Tot
SiO ₂	68.7	68.7	68.6	67.0	69.8	66.2	66.7	68.3
TiO ₂	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	19.5	19.7	19.1	20.1	19.9	19.8	19.5	19.0
Fe ₂ O ₃	0.03	0.04	0.00	0.04	0.07	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.36	0.68	0.27	0.94	0.36	0.46	0.50	0.00
BaO	0.00	0.00	0.00	0.20	0.00	0.15	0.03	0.05
Na ₂ O	11.7	11.5	11.6	11.5	11.5	11.4	11.4	11.8
K ₂ O	0.06	0.09	0.02	0.02	0.07	0.04	0.04	0.04
Total	100.3	100.7	99.6	99.8	101.8	98.1	98.2	99.2
Unit-Cell Composition Based on 8 (O)								
Si	2.99	2.98	3.01	2.95	2.99	2.96	2.97	3.01
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	1.00	1.01	0.99	1.04	1.01	1.04	1.03	0.98
Fe	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
Ca	0.02	0.03	0.01	0.04	0.02	0.02	0.02	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.99	0.97	0.99	0.98	0.96	0.99	0.98	1.01
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coordination of Cations								
Tet.	3.99	3.99	3.99	3.99	4.00	4.00	4.00	3.99
Other	1.01	1.01	1.00	1.03	0.98	1.02	1.01	1.01
Si/(Al+Fe)								
	2.99	2.96	3.05	2.82	2.97	2.84	2.89	3.06
(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)								
	0.97	0.97	0.97	0.97	1.01	1.00	0.99	0.97
K	0.3	0.5	0.1	0.1	0.4	0.2	0.2	0.2
Na	98.0	96.4	98.6	95.6	97.9	97.6	97.4	99.8
Ca+Mg	1.7	3.1	1.3	4.3	1.7	2.2	2.4	0.0

APPENDIX H (cont)

Drill Hole USW G-2

Depth	5992
(ft)	
Unit ^a	Tot
SiO ₂	63.5
TiO ₂	0.02
Al ₂ O ₃	18.0
Fe ₂ O ₃	0.06
MgO	0.00
CaO	0.08
BaO	1.05
Na ₂ O	0.42
K ₂ O	15.5
Total	98.7

Unit-Cell Composition Based on 8 (O)

Si	2.99
Ti	0.00
Al	1.00
Fe	0.00
Mg	0.00
Ca	0.00
Ba	0.02
Na	0.04
K	0.93

Coordination of Cations

Tet.	4.00
Other	1.00

$$\text{Si}/(\text{Al}+\text{Fe})$$

$$2.98$$

$$(\text{Al}+\text{Fe})/(\text{2Mg}+\text{2Ca}+\text{2Ba}+\text{Na}+\text{K})$$

$$0.98$$

K	95.7
Na	3.9
Ca+Mg	0.4

APPENDIX H (cont)

Drill Hole USW G-3

Depth	4708
(ft)	
Unit ^a	Tlr
SiO ₂	66.8
TiO ₂	0.08
Al ₂ O ₃	17.1
Fe ₂ O ₃	0.00
MgO	0.00
CaO	0.03
BaO	0.07
Na ₂ O	0.03
K ₂ O	15.2
Total	99.3

Unit-Cell Composition Based on 8 (O)

Si	3.08
Ti	0.00
Al	0.93
Fe	0.00
Mg	0.00
Ca	0.00
Ba	0.00
Na	0.00
K	0.90

Coordination of Cations

Tet.	4.01
Other	0.90

$$\text{Si}/(\text{Al}+\text{Fe})$$

$$3.32$$

$$(\text{Al}+\text{Fe})/(\text{2Mg}+\text{2Ca}+\text{2Ba}+\text{Na}+\text{K})$$

$$1.03$$

K	99.5
Na	0.3
Ca+Mg	0.2

APPENDIX H (cont)

Drill Hole USW G-4

Depth 2738
(ft)
Unit^a Tcb

SiO₂ 66.4
TiO₂ 0.00
Al₂O₃ 17.7
Fe₂O₃ 0.00
MgO 0.00
CaO 0.03
BaO 0.05
Na₂O 0.06
K₂O 16.1

Total 100.4

Unit-Cell Composition Based on 8 (O)

Si 3.04
Ti 0.00
Al 0.96
Fe 0.00
Mg 0.00
Ca 0.00
Ba 0.00
Na 0.01
K 0.94

Coordination of Cations

Tet. 4.00
Other 0.95

Si/(Al+Fe)
3.18

(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)
1.01

K 99.3
Na 0.6
Ca+Mg 0.2

APPENDIX H (cont)

Drill Hole J-13

Depth (ft) Unit ^a	2980 Tct	2980 Tct	2980 Tct
SiO ₂	67.3	67.2	68.3
TiO ₂	0.00	0.00	0.00
Al ₂ O ₃	20.1	19.6	19.6
Fe ₂ O ₃	0.00	0.00	0.00
MgO	0.00	0.00	0.00
CaO	0.58	0.15	0.33
BaO	0.00	0.00	0.00
Na ₂ O	11.8	12.0	12.0
K ₂ O	0.06	0.04	0.03
Total	99.8	99.0	100.3

Unit-Cell Composition Based on 8 (O)

Si	2.95	2.97	2.98
Ti	0.00	0.00	0.00
Al	1.04	1.02	1.01
Fe	0.00	0.00	0.00
Mg	0.00	0.00	0.00
Ca	0.03	0.01	0.02
Ba	0.00	0.00	0.00
Na	1.01	1.03	1.02
K	0.00	0.00	0.00

Coordination of Cations

Tet.	3.99	3.99	3.99
Other	1.04	1.04	1.03

Si/(Al+Fe)

2.83	2.91	2.95
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)

0.98	0.98	0.96
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K	0.3	0.2	0.2
Na	97.0	99.1	98.3
Ca+Mg	2.6	0.7	1.5

APPENDIX H (cont)

Outcrop at Prow Pass, Northern Yucca Mountain

Sample Number 3-15-82-4 82FB-1

Both samples are nonwelded tuff near base of tuff of Calico Hills. Nevada State Coordinates (ft) for sample locations: 3-15-82-4=786500N, 551000E; 82FB-1=789700N, 549700E.

SiO2	67.9	67.5
TiO2	0.00	0.00
AL2O3	17.2	17.5
Fe2O3	0.00	0.00
MgO	0.00	0.00
CaO	0.00	0.00
BaO	0.00	0.00
Na2O	0.23	0.17
K2O	15.2	15.4
Total	<u>100.5</u>	<u>100.5</u>

Unit-Cell Composition Based on 8 (O)

Si	3.09	3.07
Ti	0.00	0.00
Al	0.92	0.94
Fe	0.00	0.00
Mg	0.00	0.00
Ca	0.00	0.00
Ba	0.00	0.00
Na	0.02	0.01
K	0.88	0.90

Coordination of Cations

Tet.	4.00	4.01
Other	0.90	0.91

Si/(Al+Fe)	3.36	3.28
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(Al+Fe)/(2Mg+2Ca+2Ba+Na+K)	1.02	1.03
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K	97.8	98.4
Na	2.2	1.6
Ca+Mg	0.0	0.0