*Geologic Evaluation of Six Nonwelded Tuff Sites
in the Vicinity of Yucca Mountain, Nevada
for a Surface-Based Test Facility for the
Yucca Mountain Project*

D. E. Broxton
S. J. Chipera
F. M. Byers, Jr.
C. A. Rautman*

*Sandia National Laboratories, Geoscience Analysis Division,
Organization 6115, P.O. Box 5800, Albuquerque, NM 87185.

Los Alamos
NATIONAL LABORATORY

Los Alamos, New Mexico 87545

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

sq

GEOLOGIC EVALUATION OF SIX NONWELDED TUFF SITES IN THE VICINITY OF YUCCA MOUNTAIN, NEVADA FOR A SURFACE-BASED TEST FACILITY FOR THE YUCCA MOUNTAIN PROJECT

by

**D. E. Broxton, S. J. Chipera, F. M. Byers, Jr.,
and C. A. Rautman**

ABSTRACT

Outcrops of nonwelded tuff at six locations in the vicinity of Yucca Mountain, Nevada, were examined to determine their suitability for hosting a surface-based test facility for the Yucca Mountain Project. Investigators will use this facility to test equipment and procedures for the Exploratory Studies Facility and to conduct site characterization field experiments. The outcrops investigated contain rocks that include or are similar to the tuffaceous beds of Calico Hills, an important geologic and hydrologic barrier between the potential repository and the water table. The tuffaceous beds of Calico Hills at the site of the potential repository consist of both vitric and zeolitic tuffs, thus three of the outcrops examined are vitric tuffs and three are zeolitic tuffs. New data were collected to determine the lithology, chemistry, mineralogy, and modal petrography of the outcrops. Some preliminary data on hydrologic properties are also presented. Evaluation of suitability of the six sites is based on a comparison of their geologic characteristics to those found in the tuffaceous beds of Calico Hills within the exploration block.

Vitric tuffs at Busted Butte are excellent analogs to the geologic conditions in the vitric Calico Hills unit within the exploration block. Bedded vitric tuffs at Busted Butte include, in ascending order, the nonwelded top of the Prow Pass Member, the Wahmonie Formation, the tuffaceous beds of Calico Hills, and the nonwelded base of the Topopah Spring Member. A second site, in the northeastern part of Yucca Mountain, also has characteristics suitable for a surface-based test facility in vitric tuffs. Rocks at this site include the nonwelded top of the Pah Canyon Member and overlying bedded tuffs. A third site, in tuffs of the Prow Pass Member 5 km southwest of Busted Butte, is unsuitable for surface-based testing.

Zeolitic tuffs cropping out at Prow Pass are good analogs to the zeolitic tuffaceous beds of Calico Hills within the exploration block. Except for minor differences in mineralogy and chemistry, these zeolitic tuffs, which include the tuffaceous beds of Calico Hills and the nonwelded base of the Topopah Spring Member, are similar to the zeolitic tuffs within the exploration block. A second site in the northeastern part of Yucca Mountain is also a suitable location for a surface-based test facility in zeolitic tuffs. Rocks at this site include the nonwelded base of the Pah Canyon Member and underlying bedded tuffs. A third site at Calico Hills is unsuitable for surface-based testing.

Outcrops of nonwelded tuff at Yucca Mountain provide suitable host rocks for a surface-based test facility. The recommended host rocks for a such a facility are vitric tuffs at Busted Butte and/or zeolitic tuffs at Prow Pass. Additional site screening can take place when data for hydrologic properties become available for all of the sites investigated in this study.

Contents

ABSTRACT	1
I. INTRODUCTION	2
II. METHODS	3
III. RESULTS	5
A. Vitric Bedded Tuffs at Busted Butte	5
1. Lithology and Modal Petrography	5
a. Northern Outcrop	5
b. Southeastern Outcrop	8
2. Mineralogy.	9
3. Chemistry.	10
4. Hydrologic Properties.	10
B. Vitric and Zeolitic Bedded Tuffs, NE Side of Yucca Mt.	10
1. Lithology and Modal Petrography.	11
2. Mineralogy.	13
3. Chemistry.	13
4. Hydrologic Properties.	15
C. Vitric Ash-Flow Tuffs, South of Stagecoach Road	17
2. Mineralogy.	18
3. Chemistry.	18
4. Hydrologic Properties.	18
D. Zeolitic Tuffaceous Beds of Calico Hills at Prow Pass	18
1. Lithology and Modal Petrography.	19
2. Mineralogy.	19
3. Chemistry.	22
4. Hydrologic Properties.	24
E. Zeolitic Tuffaceous Beds of Calico Hills at Calico Hills	25
1. Lithology and Modal Petrography.	26
2. Mineralogy.	26
3. Chemistry.	26
4. Hydrologic Properties.	28
IV. DISCUSSION	29
A. Vitric Bedded Tuffs at Busted Butte	31
B. Vitric Bedded Tuffs, Northeast Side of Yucca Mountain	32
C. Vitric Ash-Flow Tuffs, South of Stagecoach Road	33
D. Zeolitic Tuffaceous Beds of Calico Hills at Prow Pass	34
E. Zeolitic Tuffaceous Beds of Calico Hills at Calico Hills	34
V. RECOMMENDATIONS	35
VI. CONCLUSIONS	36
VII. ACKNOWLEDGMENTS	37

VIII. REFERENCES	38
APPENDIX A. PETROGRAPHIC MODAL ANALYSES OF NONWELDED TUFFS FROM OUTCROP, YUCCA MOUNTAIN, NEVADA	43
APPENDIX B. X-RAY DIFFRACTION ANALYSES OF NONWELDED TUFFS FROM OUTCROP, YUCCA MOUNTAIN, NEVADA	56
APPENDIX C. MAJOR- AND TRACE-ELEMENT ANALYSES OF NONWELDED TUFFS FROM OUTCROP, YUCCA MOUNTAIN, NEVADA	60
APPENDIX D. SAMPLE KEY AND LOCATIONS FOR VITRIC AND ZEOLITIC TUFFS INVESTIGATED FOR A SURFACE-BASED TEST FACILITY, YUCCA MOUNTAIN, NEVADA	75
APPENDIX E. DATA SOURCES.	80

List of Figures

Figure 1.	Locations of outcrops of nonwelded vitric and zeolitic tuffs investigated for a potential surface-based test facility in the vicinity of Yucca Mountain	3
Figure 2.	Location of vitric bedded tuffs sampled at Busted Butte.....	5
Figure 3.	Stratigraphic section showing sample locations within vitric bedded tuffs at the north end of Busted Butte	6
Figure 4.	Variation diagrams summarizing petrographic, mineralogic, and chemical characteristics of vitric bedded tuffs at the north end of Busted Butte	7
Figure 5.	Stratigraphic section and sample locations within vitric bedded tuffs on the southeast side of Busted Butte	9
Figure 6.	Location of composite section of vitric tuffs and zeolitic tuffs sampled at northeastern Yucca Mountain	11
Figure 7.	Composite stratigraphic section and sample locations for vitric tuffs and zeolitic tuffs at northeastern Yucca Mountain	12
Figure 8.	Variations diagrams summarizing petrographic, mineralogic, and chemical characteristics of vitric tuffs and zeolitic tuffs at the northeastern Yucca Mountain	14
Figure 9.	Stacked histograms of porosity, bulk density, and particle density for vitric and zeolitic tuffs at the northeastern Yucca Mountain	16
Figure 10.	Location of vitric ash-flow tuffs sampled at outcrops 5 km SW of Busted Butte, in the vicinity of Stagecoach Road.....	17
Figure 11.	Location of zeolitic tuffs sampled at outcrops in the vicinity of Prow Pass	19
Figure 12.	Stratigraphic section and sample locations for zeolitic tuffs in the southern part of the Prow Pass area	20
Figure 13.	Stratigraphic section and sample locations for zeolitic tuffs in the central part of the Prow Pass area	21
Figure 14.	Variation diagrams summarizing petrographic, mineralogic, and chemical characteristics of zeolitic tuffs sampled in the stratigraphic section at the southern end of the Prow Pass area.....	23
Figure 15.	Compositional variations along the lateral traverse within the tuffaceous beds of Calico Hills in the Prow Pass area	24
Figure 16.	Histograms of porosity, bulk density, and particle density for zeolitic tuffaceous beds of Calico Hills sampled in a vertical stratigraphic section at the southern end of the Prow Pass area	25
Figure 17.	Location of zeolitic tuffs sampled in a lateral traverse in the southwestern part of Calico Hills	26
Figure 18.	Histograms comparing the mineralogy of zeolitic tuffaceous beds of Calico Hills within the exploration block at Yucca Mountain to zeolitic tuffs of the same unit at Prow Pass and Calico Hills	27
Figure 19.	Histograms comparing the chemistry of the zeolitic tuffaceous beds of Calico Hills within the exploration block at Yucca Mountain to the same unit at Prow Pass and Calico Hills	28
Figure 20.	Histograms of porosity and bulk density for zeolitic tuffaceous beds of Calico Hills sampled in a lateral traverse at Calico Hills	29
Figure 21.	Histograms of porosity, bulk density, and particle density for vitric tuffaceous beds of Calico Hills in the exploration block and for zeolitic tuffs of the same unit in the exploration block	30

List of Tables

Table I.	Hydrologic properties of the Pah Canyon Member and bedded tuffs on the northeast side of Yucca Mountain, Nevada	16
Table II.	Hydrologic properties of the zeolitic tuffaceous beds of Calico Hills and Topopah Spring Member at Prow Pass, Yucca Mountain, Nevada	25
Table III.	Hydrologic properties of the zeolitic tuffaceous beds of Calico Hills at Calico Hills, Yucca Mountain, Nevada	29
Table IV.	Hydrologic properties of the tuffaceous beds of Calico Hills in the vicinity of the potential repository, Yucca Mountain, Nevada	30
Table V.	Ranking of vitric and zeolitic tuff sites to host a surface-based test facility, Yucca Mountain, Nevada	36

GEOLOGIC EVALUATION OF SIX NONWELDED TUFF SITES IN THE VICINITY OF YUCCA MOUNTAIN, NEVADA FOR A SURFACE-BASED TEST FACILITY FOR THE YUCCA MOUNTAIN PROJECT

by

**D. E. Broxton, S. J. Chipera, F. M. Byers, Jr.,
and C. A. Rautman**

ABSTRACT

Outcrops of nonwelded tuff at six locations in the vicinity of Yucca Mountain, Nevada, were examined to determine their suitability for hosting a surface-based test facility for the Yucca Mountain Project. Investigators will use this facility to test equipment and procedures for the Exploratory Studies Facility and to conduct site characterization field experiments. The outcrops investigated contain rocks that include or are similar to the tuffaceous beds of Calico Hills, an important geologic and hydrologic barrier between the potential repository and the water table. The tuffaceous beds of Calico Hills at the site of the potential repository consist of both vitric and zeolitic tuffs, thus three of the outcrops examined are vitric tuffs and three are zeolitic tuffs. New data were collected to determine the lithology, chemistry, mineralogy, and modal petrography of the outcrops. Some preliminary data on hydrologic properties are also presented. Evaluation of suitability of the six sites is based on a comparison of their geologic characteristics to those found in the tuffaceous beds of Calico Hills within the exploration block.

Vitric tuffs at Busted Butte are excellent analogs to the geologic conditions in the vitric Calico Hills unit within the exploration block. Bedded vitric tuffs at Busted Butte include, in ascending order, the nonwelded top of the Prow Pass Member, the Wahmonie Formation, the tuffaceous beds of Calico Hills, and the nonwelded base of the Topopah Spring Member. A second site, in the northeastern part of Yucca Mountain, also has characteristics suitable for a surface-based test facility in vitric tuffs. Rocks at this site include the nonwelded top of the Pah Canyon Member and overlying bedded tuffs. A third site, in tuffs of the Prow Pass Member 5 km southwest of Busted Butte, is unsuitable for surface-based testing.

Zeolitic tuffs cropping out at Prow Pass are good analogs to the zeolitic tuffaceous beds of Calico Hills within the exploration block. Except for minor differences in mineralogy and chemistry, these zeolitic tuffs, which include the tuffaceous beds of Calico Hills and the nonwelded base of the Topopah Spring Member, are similar to the zeolitic tuffs within the exploration block. A second site in the northeastern part of Yucca Mountain is also a suitable location for a surface-based test facility in zeolitic tuffs. Rocks at this site include the nonwelded base of the Pah Canyon Member and underlying bedded tuffs. A third site at Calico Hills is unsuitable for surface-based testing.

Outcrops of nonwelded tuff at Yucca Mountain provide suitable host rocks for a surface-based test facility. The recommended host rocks for a such a facility are vitric tuffs at Busted Butte and/or zeolitic tuffs at Prow Pass. Additional site screening can take place when data for hydrologic properties become available for all of the sites investigated in this study.

I. INTRODUCTION

Outcrops of nonwelded vitric and zeolitic tuffs at six sites in the vicinity of Yucca Mountain were examined as possible locations for a surface-based test facility for the Yucca Mountain Project. The purpose of a surface-based test facility is to examine testing and construction methodologies for the underground Exploratory Studies Facility (ESF) at Yucca Mountain and to provide a suitable testing environment for scientific experiments in rocks that are similar to key components of the radionuclide barrier beneath the potential repository.

The surface-based test facility should be sited in rocks that are similar to the repository host rock or to key components of the natural geologic barrier system between the repository and the water table. At the time the surface-based test facility was first proposed in 1988, the ESF (then called the Exploratory Shaft Facility) was designed to penetrate geologic units to the depth of the potential repository horizon in the lower part of the Topopah Spring Member of the Paintbrush Tuff. Because extensive testing and site characterization were planned for the repository horizon but not for underlying units, this study emphasizes siting a surface-based test facility in a geologic setting similar to the tuffaceous beds of Calico Hills, an important geologic and hydrologic barrier between the repository and the water table.

The tuffaceous beds of Calico Hills within the exploration block are made up of two dissimilar lithologies that grade laterally into one another. In the eastern part of the exploration block these tuffs are thoroughly altered to zeolites and have distinct mineralogic, chemical, and hydrologic properties when compared to the vitric tuffs that make up the same unit in the western part of the exploration block. Six sites containing either nonwelded vitric tuffs or nonwelded zeolitic tuffs were selected for study based on their similarity to the tuffaceous beds of Calico Hills within the exploration block (Fig. 1). These sites are:

- 1) vitric bedded tuffs at Busted Butte,
- 2) vitric bedded tuffs, northeast side of Yucca Mountain,
- 3) vitric ash-flow tuffs, south of Stagecoach Road,
- 4) zeolitic ash-flow tuffs, northeast side of Yucca Mountain (same location as #2, but lower part of section),
- 5) zeolitic tuffaceous beds of Calico Hills at Prow Pass,
- 6) zeolitic tuffaceous beds of Calico Hills at Calico Hills.

This report presents lithologic, modal petrographic, chemical, mineralogic, and limited hydrologic data for outcrop samples collected from the sites described above. These data are compared to similar existing data sets for the tuffaceous beds of Calico Hills within the exploration block. A preliminary evaluation of the suitability of these sites to host a surface-based test facility is made based on the similarity of rocks at these sites to the two principal rock lithologies found in the tuffaceous beds of Calico Hills within the exploration block.

Fig. 1. Locations of outcrops of nonwelded vitric and zeolitic tuffs investigated for a potential surface-based test facility in the vicinity of Yucca Mountain. Sites investigated include: 1) vitric bedded tuffs at Busted Butte, 2) vitric bedded tuffs, northeast side of Yucca Mountain, 3) vitric ash-flow tuffs, 5 km SW of Busted Butte, 4) zeolitic ash-flow and bedded tuffs, northeast side of Yucca Mountain (same location as #2), 5) zeolitic tuffaceous beds of Calico Hills at Prow Pass, 6) zeolitic tuffaceous beds of Calico Hills at Calico Hills, and 7) the same stratigraphic sequence as at sites 2 and 4 but 2.2 km. northwest.

This work is a cooperative effort between Los Alamos National Laboratory, Sandia National Laboratory, and the U.S. Geological Survey. Los Alamos National Laboratory was responsible for selecting the sites that were investigated and for producing the lithologic, modal petrographic, chemical, mineralogic data presented in this report. Some of the samples and hydrologic information used in this study were collected as part of a Sandia National Laboratory investigation to estimate the spatial correlation structure of hydrologic properties in tuff (for example, Rautman, 1991). Additional hydrologic information for these and other sites are being determined by the U.S. Geological Survey and Sandia National Laboratory.

II. METHODS

Bulk rock samples were analysed for SiO_2 , TiO_2 , Al_2O_3 , Fe_2O_3 (total), MnO , MgO , and CaO by X-ray fluorescence (XRF). Na_2O , K_2O , Sr , Ba ,

and some Fe_2O_3 (total) abundances were determined by atomic absorption (AA) spectrophotometry. Abundances for P_2O_5 were determined by phosphomolybdate colorimetry (PMC) or by XRF. XRF P_2O_5 results below 0.08 wt. % were rejected because of poor analytical precision. Relative accuracies (2σ) for elements in rhyolitic standards analyzed with our unknowns are SiO_2 (2%), TiO_2 (5%), Al_2O_3 (3%), Fe_2O_3 (10%), MnO (5%), MgO (20%), CaO (5%), P_2O_5 (30%), Na_2O (5%), K_2O (5%), Sr (20%) and Ba (20%). All XRF, AA, and PMC analyses were made by J. Husler at the University of New Mexico. Additional major and trace-element abundances were determined by neutron activation analyses (NAA) by S. Garcia of the Research Reactor Group at Los Alamos and by R. Korotev at Washington University in St. Louis. Uncertainties in the measured trace-element concentrations by NAA are usually less than 10% at concentrations 1 order of magnitude above the detection limit. Korotev (1991), Minor et al. (1982), and Garcia et al. (1982) provide additional information about analytical uncertainties at various concentration levels, conditions of analysis, and detection limits for elements analyzed by NAA. Loss on ignition (LOI) was determined by measuring the difference in sample weight at room temperature and after heating at 1000°C for one hour.

Samples used for X-ray diffraction analyses (XRD) were first powdered in a tungsten-carbide shatter box and then mixed with an internal standard of 1 μm metallurgical grade Al_2O_3 (corundum) powder in a ratio of 80% sample to 20% internal standard. The samples were then ground under acetone in an automatic Brinkmann-Retsch mill fitted with an agate mortar and pestle to produce an average particle size of less than 5 μm . This fine particle size is necessary to ensure adequate particle statistics and to minimize primary extinction (Klug and Alexander 1974, pp. 365-367). Particle size distributions have been verified using a Horiba CAPA-500 centrifugal particle size distribution analyzer calibrated with Duke Scientific glass microsphere standards.

X-ray diffraction (XRD) data were collected on a Siemens D-500 theta-theta diffractometer using copper- $\text{K}\alpha$ radiation, incident- and diffracted-beam Soller slits, and a Kevex solid-state (SiLi) detector. Data were typically collected from 2.0 to 50.0° 2 θ using a 0.02° step size for at least 2.0 s per step. Quantitative analyses employed the internal standard or "matrix-flushing" method of Chung (1974a,b), which requires that an internal standard has been added to each sample. Details for analysis can be found in Bish and Chipera (1988; 1989).

Thin-section modal analyses (Appendix A) for percentages of phenocrysts, lithic fragments, pumice, shards, perlitic chips (solid glass or altered glass fragments), and voids were performed following the procedures described in Byers (1985, p. 8-10; 1990a). Opaque oxide minerals in Appendix A were qualitatively identified using criteria outlined in Byers (1990b). These minerals are grouped together in the "Remarks" row of Appendix A.

A number of hydrologic properties have been determined for samples collected in several of these locations as part of a transect-sampling program being conducted jointly by the U.S. Geological Survey and Sandia National Laboratories (Rautman et al., 1991; Rautman and Flint, 1992). The bulk hydrologic properties discussed in this report (porosity, bulk density, and particle density) were determined by gravimetry using Archimede's principle for volume determinations. Samples were saturated with water under a vacuum after displacement of air by CO_2 gas to facilitate movement of water into small pores. Samples were weighed in their fully saturated state, both in air to determine the mass of rock plus water, and submerged to determine sample volume (Archimede's principle). Samples were then dried in a relative humidity oven at 60°C and 45 percent relative humidity and reweighed to determine the mass of rock without pore water. Drying samples under these conditions prevents the removal of water contained in the zeolite mineral structure or otherwise adsorbed on the pore walls (Bush and Jenkins, 1970; Soeder et al., 1991). The mass (volume) of water thus removed represents the volume of the pore space that is available for free movement of groundwater. These measurements allow direct calculation of porosity and bulk density. Particle density is then computed from the other two bulk properties.

III. RESULTS

Appendix A summarizes modal petrographic data for samples investigated in this study.

Petrographic data for some of the samples from the Prow Pass area were previously reported by Broxton et al. (1989a) and are not repeated here. Appendix B presents mineralogic data determined by XRD. Major- and trace-element chemistry for these tuffs are presented in Appendix C. Sample locations and a key to sample field numbers, laboratory numbers, and Yucca Mountain sample tracking numbers are given in Appendix D.

Available hydrologic data for the sites investigated are summarized in tables and figures in this report. Numerical summaries of hydrologic data will be published by Sandia National Laboratory and the U.S. Geological Survey in a separate report.

A. Vitric Bedded Tuffs at Busted Butte (Site #1 in Fig. 1)

Vitric bedded tuffs crop out beneath the Topopah Spring Member in two locations at Busted Butte (Fig. 2). One of these locations is at the north end of Busted Butte, just east of the prominent north-trending fault that gives the butte its distinctive appearance. The second outcrop is on the southeastern side of the butte. Both outcrops are mapped as undivided tuffs (Lipman and McKay, 1965). Eight samples were collected from the northern outcrop and seven samples were collected from the southeastern outcrop.

1. Lithology and Modal Petrography.

a. Northern Outcrop. The outcrop at the north end of Busted Butte consists of a sequence of nonwelded ash-flow tuffs and bedded tuffs that include, in ascending order, the Prow Pass Member of the Crater Flat Tuff, the Wahmonie Formation, the tuffaceous beds of Calico Hills, and the Topopah Spring Member (Fig. 3). This volcanic sequence has an aggregate thickness of 85 ft. from the lowermost exposures in the Prow Pass Member to the basal contact of the Topopah Spring Member. Outcrops of these tuffs are largely covered by Quaternary deposits

Fig. 2. Location of vitric bedded tuffs sampled at Busted Butte (Site 1 in Fig. 1). Samples were collected from the two outcrops labeled Tt at the north and southeast sides of Busted Butte. Geologic units shown on this figure include: (Tt) undivided bedded tuffs, (Tpt) Topopah Spring Member, (Tpc) Tiva Canyon Member, (Tmr) Rainier Mesa Member, and (Qal) Quaternary alluvium.

Fig. 3. Stratigraphic section showing and sample locations within vitric bedded tuffs at the north end of Busted Butte (Site 1 in Fig. 1).

except in a deep north-trending gulch, which exposes bedrock beneath a blanket of colluvium and sand ramp deposits.

About 3 ft. of the upper part of Prow Pass Member is exposed at the base of the section in a small exposure of bedrock in the bottom of the north-trending gulch. The Prow Pass Member consists of nonwelded ash-flow tuff with brown pumice lapilli in a yellow to tan ashy matrix. The base and top of this Member are not exposed. The Prow Pass Member is approximately 130 ft. thick in outcrops 6 km to the southwest (McKay and Sargent, 1970). The one sample of Prow Pass Member collected at Busted Butte contains 9.2% phenocrysts comprised of sanidine, plagioclase, and wormy quartz with minor biotite, hornblende, and orthopyroxene (Appendix A, Fig. 4a). Accessory minerals include Fe-Ti oxides,

Fig. 4. Variation diagrams summarizing petrographic, mineralogic, and chemical characteristics of vitric bedded tuffs at the north end of Busted Butte (Site 1 in Fig. 1). The data are plotted as a function of stratigraphic position and include: a) modal petrography, b) total water contents (as loss on ignition), c) mineralogy, and d) chemistry. All samples are vitric tuffs excepted for the uppermost sample in the Topopah Spring Member which is a zeolitic next to a major N-S trending fault.

allanite, apatite, and zircon.

Approximately 14 ft. of Wahmonie Formation is exposed at this location. The base of the unit is covered and the thickness of this tuff is probably closer to 40 ft. The Wahmonie Formation consists of a single ash-flow(?) tuff with sparse pink pumice lapilli in a tan ashy matrix. Phenocrysts make up 18% of the rock and consist of plagioclase, biotite, orthopyroxene, hornblende, and clinopyroxene (Appendix A, Fig. 4a). Accessory minerals include Fe-Ti oxides, apatite, and zircon. On the basis of its petrographic characteristics and stratigraphic position, this tuff correlates either with the lower part of the Wahmonie Formation or with the Salyer Formation as described by Poole et al. (1965) and Warren and Broxton (1986). The Wahmonie and Salyer Formations are very similar in their petrographic and chemical characteristics. All of the dacitic tuffs between the Prow Pass Member and the tuffaceous beds of Calico Hills are provisionally assigned to Wahmonie Formation until additional work can be done to resolve their stratigraphic assignment.

The tuffaceous beds of Calico Hills are a sequence of intercalated white ash-fall tuffs and light-brown to pinkish-brown massive nonwelded tuffs and stratified reworked tuffs. This unit is 41 ft. thick with individual tuff layers ranging from a few inches to 4 ft. in thickness. The lower two-thirds of this unit is relatively crystal-rich containing 6 to 21% phenocrysts whereas the upper part contains only 3% phenocrysts (Appendix A, Fig. 4a). Phenocrysts throughout the unit consist predominately of quartz, sanidine, plagioclase, and biotite. Minor amounts of hornblende and pyroxene are present in tuffs near the base of the unit. Accessory minerals include Fe-Ti oxides, allanite, apatite, and zircon.

The base of the Topopah Spring Member is a white to tan nonwelded vitric ash-flow tuff. The thickness of this member below the basal vitrophyre is approximately 50 ft. The nonwelded tuffs at the base of the the Topopah Spring Member contain about 1% phenocrysts consisting predominately of plagioclase and sanidine. Quartz occurs in small quantities and may be xenocrystic. Mafic phenocrysts consist of biotite and trace amounts of hornblende. Accessory minerals include Fe-Ti oxides, allanite, apatite, and zircon.

b. Southeastern Outcrop. The outcrop on the southeastern side of Busted Butte is a sequence of nonwelded ash-flow tuffs and bedded tuffs that include, in ascending order, the Wahmonie Formation, the tuffaceous beds of Calico Hills, and the Topopah Spring Member of the Paintbrush Tuff (Fig. 5). This volcanic sequence has an aggregate thickness of 32 ft. from the lowermost exposures in the Wahmonie Formation to the basal contact of the Topopah Spring Member.

The Wahmonie Formation consists of light-colored massive to poorly-stratified ash-flow(?) tuffs. Approximately 11 ft. of Wahmonie tuff is exposed in this location. The base of the unit is covered and the actual thickness of this tuff may be much greater. The Wahmonie tuffs at this location are similar to the Wahmonie Formation described for the north end of Busted Butte. The unit contains 15% phenocrysts of plagioclase, biotite, orthopyroxene, and clinopyroxene (Appendix A). Accessory minerals include Fe-Ti oxides, apatite, and zircon.

Fig. 5. Stratigraphic section and sample locations within vitric bedded tuffs on the southeast side of Busted Butte (Site 1 in Fig. 1).

The tuffaceous beds of Calico Hills are a sequence of intercalated, white ash-fall tuffs and light-brown and light-orange nonwelded tuffs and stratified reworked tuffs. This unit is 21 ft. thick with individual tuff layers ranging from a few inches to 12 ft. in thickness. The lower one-third of the unit is relatively crystal-rich as elsewhere and contains 7 to 9% phenocrysts, whereas the upper two-thirds of the unit contains less than 3% phenocrysts. Phenocrysts throughout the unit consist predominately of quartz, sanidine, plagioclase, and biotite (Appendix A). Minor amounts of hornblende and pyroxene are present in tuffs near the base of the unit.

Accessory minerals include Fe-Ti oxides, allanite, apatite, and zircon.

The base of the Topopah Spring Member is a white to tan nonwelded ash-flow tuff. No samples of the Topopah Spring Member were collected at this location, but its lithologic characteristics are similar to those described above for exposures at the north end of Busted Butte.

2. Mineralogy.

The nonwelded tuffs at both outcrops studied at Busted Butte contain large amounts of volcanic glass and relatively few secondary minerals (Appendix B, Fig. 4c). The Prow Pass Member, tuffaceous beds of Calico Hills, and Topopah Spring Member generally contain 70-97% glass whereas the phenocryst- and lithic-rich Wahmonie tuffs contain 46-54% glass. In some samples, incipient diagenetic alteration of volcanic glass is indicated by the presence of small amounts of smectite (0-7%) and clinoptilolite (0-12%). Feldspar abundances range from 1 to 26% with the higher contents found in phenocryst- and lithic-rich tuffs. Together, quartz and cristobalite make up 1-10% of the tuffs.

Although the nonwelded tuffs at Busted Butte are largely unaltered, there is a local zone of zeolitization next to the major fault that bounds the western side of the northern outcrop. Next to this fault, the nonwelded base of the Topopah Spring Member is thoroughly altered to clinoptilolite (~98%) and minor opal. Zeolitization extends downward to the base of the Topopah Spring Member but does not affect the underlying vitric tuffaceous beds of Calico Hills except in the westernmost part of the outcrop where this unit is closest to the fault. Zeolitization dies out eastward away from the fault.

3. Chemistry.

The Prow Pass Member, the upper part of the tuffaceous beds of Calico Hills, and the Topopah Spring Member are high-silica rhyolites. The major-element chemistry of these tuffs is similar and their compositions are typical of these units elsewhere in the NTS region (Lipman et al., 1966; Quinlivan and Byers, 1977; Scott and Castellanos, 1984; Broxton et al., 1989b; Schuraytz et al., 1989; Spengler and Peterman, 1991). They generally contain 75.2-77.6% SiO₂, 4.6-5.2% K₂O, 2.6-3.4% Na₂O, and 0.5-1.6% CaO, normalized to an anhydrous basis (Appendix C, Fig. 4d). The phenocryst-rich base of the tuffaceous beds of Calico Hills is less silicic (72.2% SiO₂) than the upper part of the unit. Volcanic glasses within the rhyolitic tuffs are hydrated, and whole-rock water contents average about 4% by weight (Fig. 4 b).

The Wahmonie Formation consists of calcic to calc-alkalic tuffs and lavas that grade upward chemically from dacite to dacite and andesite (Poole et al., 1965; Warren and Broxton, 1986; Broxton et al., 1989b). The Wahmonie tuffs at Busted Butte are dacites and are characterized by 66.6-67.0% SiO₂, 2.9-3.5% K₂O, 2.8-3.4% Na₂O, and 3.4-4.6% CaO, on an anhydrous basis (Appendix C, Fig. 4d). Whole-rock water contents of these tuffs range from 2.8 to 7.1% by weight (Fig. 4b).

The zeolitic Topopah Spring Member next to the fault at the north end of Busted Butte is enriched in calcium (3.2% CaO) and magnesium (1.1% MgO) and depleted in potassium (3.4% K₂O) and sodium (0.6% Na₂O) when compared to the vitric tuffs of the same unit on an anhydrous basis (e.g. compare samples DEB 4/90-1 and DEB 3/90-50, Appendix C). The water content of the zeolitic tuff is 12.8%, assuming that the entire loss on ignition is due to water loss (Fig. 4b).

4. Hydrologic Properties.

Hydrologic properties have not been determined for the vitric tuffs at Busted Butte.

B. Vitric and Zeolitic Bedded Tuffs, NE Side of Yucca Mt. (Sites #2 and #4 in Fig.1)

Nonwelded bedded tuffs crop out between the Topopah Spring and Yucca Mountain Members of the Paintbrush Tuff on the northeast side of Yucca Mountain (Fig. 6). These tuffs were included in this study because the upper part of this stratigraphic sequence (Fig. 1, Site #2) is similar to the vitric portion of the tuffaceous beds of Calico Hills at Yucca Mountain and because these Paintbrush bedded tuffs are of general interest to hydrologists studying the movement of ground water in the unsaturated zone. The lower part of this sequence (Fig. 1, Site #4) is zeolitized and may be suitable host rock for a surface-based

Fig. 6. Location of composite section of vitric tuffs (Site 2 in Fig. 1) and zeolitic tuffs (Site 4 in Fig. 1) sampled at northeastern Yucca Mountain. Samples (indicated by dots) were collected from the bedded tuff beneath the Pah Canyon Member (not shown at this scale), the Pah Canyon Member, and bedded tuffs above the Pah Canyon Member. Geologic units include: (Tpt) Topopah Spring Member, (Tpp) Pah Canyon Member, (Tb) bedded tuffs, (Tpy) Yucca Mountain Member, (Tpc) Tiva Canyon Member, and (Qac) Quaternary alluvium and colluvium.

measured section. Pumice lapilli within this tuff are generally small (0.5-1 cm) and there is little or no ashy matrix between the clasts suggesting a pumice fall origin. The upper contact with the Pah Canyon Member is covered but the estimated thickness of the lapilli tuff is 10 ft. Phenocrysts make up <1% of the tuff and consist of plagioclase, sanidine, and biotite (Appendix A, Fig. 8a). Accessory minerals include Fe-Ti oxides, apatite, and zircon. The modal petrography of this tuff matches the lower, dominantly rhyolitic portion of the Topopah Spring Member.

The Pah Canyon Member is a simple ash-flow tuff cooling unit that is 245 ft. thick at this location. The lower 50 ft. of the tuff is nonwelded to partially welded and is pervasively altered to zeolites, the upper 50 ft. is nonwelded and is vitric, and the remainder of the unit is partially to moderately welded and is devitrified to an assemblage of high-temperature nonhydrous minerals (Fig. 7). Vapor-

test facility in zeolitic tuff. Though treated as two separate sites in their evaluation as potential host rocks for a surface-based test facility, these zeolitic and vitric tuffs are described together in ascending stratigraphic order because of their occurrence in the same continuous stratigraphic succession.

Samples of these vitric and zeolitic tuffs were collected west of the drill hole UE25WT-6 in a composite section which includes, in ascending order, a bedded tuff associated with the uppermost part of the Topopah Spring Member (Christiansen and Lipman; 1965), the Pah Canyon Member of the Paintbrush Tuff, and a thick section of unnamed bedded tuffs above the Pah Canyon Member (Fig. 7). The upper bedded tuff units are the same as those designated as map unit Tpb (Paintbrush bedded tuffs) on the geologic map of Christiansen and Lipman (1965). A total of 17 samples were collected in the composite section.

1. Lithology and Modal Petrography.

A thin zeolitic bedded lapilli tuff overlies the quartz latitic caprock of the Topopah Spring Member at the base of the

Fig. 7. Composite stratigraphic section and sample locations for vitric tuffs (Site 2 in Fig. 1) and zeolitic tuffs (Site 4 in Fig. 1) at northeastern Yucca Mountain. Potential host rocks for a surface-based test facility include zeolitic tuffs at the base of this stratigraphic sequence and vitric tuffs at the top.

phase alteration occurs in two zones in the middle, partially- to moderately-welded subunit. The upper vapor phase zone forms a resistant ledge 30 ft. thick 190 to 210 ft. above the base of the unit. The lower zone of vapor phase alteration is located 75 and 100 ft. above the base of the member. The Pah Canyon Member contains 3.6-11.3% phenocrysts of sanidine, plagioclase, biotite, and clinopyroxene (Appendix A, Fig. 8a). Accessory minerals include Fe-Ti oxides, sphene, perrierite, apatite, and zircon.

Bedded tuffs above the Pah Canyon Member have an aggregate thickness of 125 ft. and consist of vitric ash-fall tuffs, reworked tuffs (?), and ash-flow tuffs. They are subdivided into 10 informal subunits based on differences in bedding features and mode of deposition (Fig. 7). The ash-fall and reworked tuffs are generally thin (0.5-5 ft.) and are characterized by well-defined stratification imparted by grading and sorting of clasts. Four tuffs are clast-supported lapilli tuffs and contain little or no ashy matrix; these tuffs are probably pumice-fall deposits. Four ash-flow tuffs are intercalated with the bedded tuffs in this sequence; three of ash flows are thin (3.7 to 7 ft.) and the fourth is relatively thick (95 ft.). All four of the ash-flow tuffs are nonwelded and massive. All subunits in the bedded tuff sequence above the Pah Canyon Member are phenocryst poor (2-3%) and contain sanidine, plagioclase, hornblende, and biotite as primary phenocrysts (Appendix A, Fig. 8a). The plagioclase content of the lowermost ash-flow tuff is significantly greater than in the upper three ash-flows, which are nearly plagioclase free. Hornblende to biotite ratios increase in the upper three ash-flows relative to the lowermost one. Fe-Ti oxides, sphene, perrierite, apatite, and zircon comprise the accessory minerals in all four ash-flows.

2. Mineralogy.

The base of the Pah Canyon Member and the underlying lapilli tuff are altered to clinoptilolite (68-75%), mordenite (0-13%), and opal (Appendix B, Fig. 8c). The zeolitic zone gives way upsection to a zone of high-temperature devitrification and vapor-phase alteration which is dominated by alkali feldspar and cristobalite; tridymite is detected in one sample from the lower vapor-phase zone. Small amounts of clinoptilolite and mordenite are found in both upper and lower vapor-phase zones. The upper part of the Pah Canyon Member is a nonwelded vitric tuff that contains 68-85% volcanic glass. Incipient alteration of these vitric tuffs is suggested by the presence of 1-11% smectite.

The bedded tuffs above the Pah Canyon Member consist predominately of volcanic glass (63-82%) and alkali feldspar (9-27%). The principal silica phases are quartz and cristobalite, which together make up less than 4% of the tuffs. Incipient alteration is indicated by the presence of small amounts of smectite (1-17%) and clinoptilolite (0-2%).

3. Chemistry.

The zeolitic lapilli tuff at the base of the section (DEB 5/91-7) has the immobile major- and trace-element chemistry of a high-silica rhyolite (Appendix C, Fig. 8d). Concentrations of TiO_2 (0.10%), Hf (4.9 ppm), Sc (2.4), Nd (28 ppm), and Eu (0.3 ppm) closely match the rhyolitic portion of the Topopah Spring Member. The lapilli tuff overlies the quartz latitic caprock of the Topopah Spring Member and probably represents a late eruptive phase that tapped Topopah Spring rhyolitic magma that remained in

Fig. 8. Variation diagrams summarizing petrographic, mineralogic, and chemical characteristics of vitric tuffs (Site 2 in Fig. 1) and zeolitic tuffs (Site 4 in Fig. 1) at the northeastern Yucca Mountain. Data plotted as a function of stratigraphic position include: a) modal petrography, b) total water contents (as loss on ignition), c) mineralogy, and d) chemistry (normalized to an anhydrous basis).

the magma chamber after the main ash-flow tuffs were emplaced. Christiansen and Lipman (1965) include this bedded tuff in the Topopah Spring Member.

The Pah Canyon Member is intermediate in chemical composition between the high-silica rhyolite and quartz latite of the Topopah Spring Member (Byers et al., 1976; Quinlivan and Byers, 1977; Flood et al., 1989; Broxton et al., 1989b). Vitric and devitrified tuffs of the Pah Canyon Member are characterized by 72.4-73.7% SiO₂, 4.6-6.4% K₂O, 3.2-4.0% Na₂O, 0.8-1.1% CaO, 1184-1611 ppm Ba, 78-94 ppm La, 54-78 ppm Nd, 1.7-2.0 ppm Eu, 2.8-3.7 ppm U, and 20.1-23.9 ppm Th, on an anhydrous basis (Appendix C, Fig. 8d). On average, the vitric tuffs contain about 12% less Na₂O than the devitrified tuffs, probably because of incipient smectitic alteration in the vitric tuffs. The zeolitic tuffs at the base of the Pah Canyon Member and the underlying lapilli tuff are calcium-rich (1.24-3.23% CaO) and sodium-poor (0.96-2.14% Na₂O) compared to the vitric tuffs (Appendix C, Fig. 8d). Zeolitic tuffs with similar compositions are found in the Pah Canyon Member in drill hole USW G-2, one kilometer to the west (Broxton et al., 1986).

The four ash-flow tuffs of the bedded tuff sequence above the Pah Canyon Member were sampled for major- and trace-element chemistry. The lowermost ash-flow tuff (Informal unit 2 in Fig. 7) is characterized by 71.8% SiO₂, 4.2% K₂O, 3.3% Na₂O, 1.46% CaO, 370 ppm Ba, 179 ppm Sr, 60 ppm La, 47 ppm Nd, 0.96 ppm Eu, 24.6 ppm Th, and 4.45 ppm U, on an anhydrous basis (Appendix C, Fig. 8d). This lowermost ash-flow tuff is generally similar in major-element chemistry to the low-silica rhyolite of the Pah Canyon Member, but it has trace element characteristics (e.g., higher U and Th and lower Ba and LREE) that clearly distinguish it from the Pah Canyon. Based on its distinctive chemistry and petrography, this lowermost ash-flow tuff probably is correlative with the rhyolite of Delirium Canyon (Christiansen and Lipman, 1965; Warren et al., 1988; R. G. Warren, personal communication). The upper three ash-flow tuffs (Informal units 5, 7, and 9 in Fig. 7) have similar chemical and petrographic characteristics and are more evolved chemically than the lowermost ash-flow tuff. For example, the uppermost ash-flow tuff contains 76.1% SiO₂, 4.9% K₂O, 3.2% Na₂O, 0.6% CaO, 19 ppm Ba, 25 ppm Sr, 29 ppm La, 20 ppm Nd, 0.27 ppm Eu, 25.6 ppm Th, and 4.9 ppm U, on an anhydrous basis (Appendix C, Fig. 8d). Based on a comparison of chemistry and petrography, these three ash-flow tuffs probably are correlative with the rhyolite of Black Glass Canyon (Christiansen and Lipman, 1965; Warren et al., 1988; R. G. Warren, 1992 personal communication).

4. Hydrologic Properties.

Hydrologic properties were measured for samples from a laterally equivalent section of tuffs (site #7) located approximately 2.2 km northwest of the sites #2 and #4. Hydrologic data from site #7 should closely approximate the hydrologic properties of the tuffs comprising the composite stratigraphic section at sites #2 and #4.

Tuffs in this stratigraphic interval vary in porosity from 12 to 55%, with an average porosity value of 35% and a standard deviation of 11%. The average bulk density is 1.55g/cm³ and particle

TABLE 1.
HYDROLOGIC PROPERTIES OF THE PAH CANYON MEMBER AND BEDDED TUFS
ON THE NORTHEAST SIDE OF YUCCA MOUNTAIN, NEVADA^a

Hydrologic Property with Mean $\pm$ Std. Dev.	Combined Section (n = 44)	Pah Canyon Member (n = 33)	Bedded Tufts Above Pah Canyon Mbr. (n = 9)
Porosity %	35 $\pm$ 11	33 $\pm$ 12	39 $\pm$ 4
Range	12 - 55 (44)	12 - 55	33 - 51
Bulk Density g/cm ³	1.55 $\pm$ 0.30	1.61 $\pm$ 0.33	1.41 $\pm$ 0.11
Range	1.05 - 2.17	1.05 - 2.17	1.13 - 1.57
Particle Density g/cm ³	2.38 $\pm$ 0.11	2.41 $\pm$ 0.12	2.29 $\pm$ 0.04
Range ^b	2.13 - 2.58	2.13 - 2.58	2.23 - 2.35

a. Site #7 in Fig. 1.

densities are between 2.13 and 2.58 g/cm³ (Table 1). Hydrologic properties vary complexly as a function of vertical stratigraphic position (Fig. 9). These variations are controlled by vertical changes in lithology both between and within individual stratigraphic units.

Porosities for the Pah Canyon Member vary from 12 to 55% and average 33% (Table 1). Porosity values for the unit reflect a classical welding profile, ranging from 37 to 38% at the zeolitic nonwelded base, 12 to 43% in the partially- to moderately-welded devitrified interior, and 47 to 55% in the vitric nonwelded top (Fig. 9). By contrast, porosities of the bedded tuff units vary between 33 and 51% and

Fig. 9. Stacked histograms of porosity, bulk density, and particle density for vitric and zeolitic tufts at the northeastern Yucca Mountain (Site 7 in Fig. 1).

average 39%. The more limited variability of all hydrologic properties measured for bedded tuffs above and below the Pah Canyon Member reflects a lack of welding. Zeolitic samples from the the bedded tuff beneath the Pah Canyon Member and from the lower part of the Pah Canyon Member have porosities (~38%) and particle densities (~2.24 g/cm³) that are similar to the vitric bedded tuffs above the Pah Canyon Member (39% and ~2.33 g/cm³ respectively), although the data set to support this conclusion is small.

C. Vitric Ash-Flow Tuffs, South of Stagecoach Road (Site #3 in Fig. 1)

The Prow Pass Member is exposed in north-trending outcrops south of Stagecoach road, 5 km southwest of Busted Butte (Fig. 10). Samples were collected from nonwelded tuffs at the base of the Member and from thin overlying bedded tuffs of the Wahmonie Formation. Only three samples (two from the Prow Pass Member and one from the Wahmonie Formation) were collected from this location because it was evident from our preliminary examination of the site that less altered vitric tuffs, which better represent the tuffaceous beds of Calico Hills, could be found at other locations.

1. Lithology and Modal Petrography.

The Prow Pass Member is a simple cooling unit approximately 130 ft. thick at this location. The lower 50 ft. of the unit is nonwelded tuff that is partially vitric, but it contains beds and cylindrical to irregular enclaves that are partially zeolitic. The upper part of the unit is a partially- to moderately-welded tuff that has undergone high-temperature devitrification. The base of the moderately-welded tuffs forms a resistant ledge that is a useful marker bed. Nonwelded tuffs sampled from the base of the unit contain 6.5-6.9% phenocrysts of sanidine, plagioclase, quartz, biotite, and orthopyroxene (Appendix A). Accessory minerals include Fe-Ti oxides, allanite, apatite, and zircon.

The Prow Pass Member is overlain by 10 ft. of light-colored massive to poorly-bedded tuff of the Wahmonie Formation. Tuffs of the Wahmonie Formation at this location are similar to those at Busted

Fig. 10. Location of vitric ash-flow tuffs sampled at outcrops 5 km SW of Busted Butte, in the vicinity of Stagecoach Road (Site 3 in Fig. 1). Samples were collected from the lower part of the Prow Pass Member. Geologic units shown on this figure include: (Tcb) Bullfrog Member, (Tpc) Prow Pass Member, (Twp) Wahmonie Formation (lower part), (Tpt) Topopah Spring Member, (Tb) bedded tuff, (Tpc) Tiva Canyon Member, and (Qac) Quaternary alluvium and colluvium.

Butte and have petrographic characteristics typical of the lower part of the formation. The sample collected from this unit contains 14% phenocrysts of plagioclase, biotite, orthopyroxene, and clinopyroxene (Appendix A). Accessory minerals include Fe-Ti oxides, apatite, and zircon.

2. Mineralogy.

The lowermost sample collected at the base of the exposed section is altered to clinoptilolite (64%), mordenite (3%) and opal (Appendix B). A second sample collected 25 ft. higher in the sequence is a slightly altered vitric tuff (68% glass and 5% clinoptilolite) that is locally altered to zeolites (see Lab. # 158, P2A in Appendix B). In this sample, zeolitization occurs as a cylindrical zone of alteration 2 to 3 in. in diameter within a vitric host rock. The zeolitic tuffs probably represent zones of greater alteration along preferred ground water pathways. No clear boundary separates tuffs that are dominantly zeolitic from those that are dominantly vitric.

No XRD analysis was made for the bedded Wahmonie tuff above the Prow Pass Member. This unit is largely vitric based on the petrographic examination (Sample DEB 3/90-3 in Appendix A).

3. Chemistry.

The vitric tuff in the lower part of the Prow Pass Member (Lab. # 158, P1 in Appendix C) is a high-silica rhyolite that is typical of the Prow Pass Member at other locations within the NTS region (Scott and Castellanos, 1984; Broxton et al., 1989b). A local zone of zeolitization within the same sample block (Lab. # 158, P2 in Appendix C) has the same major element chemistry as the host vitric tuff; however, concentrations of mobile trace elements such as uranium and rubidium are lower and concentrations of Sr are higher in the zeolitic tuff. In contrast, concentrations of major and trace elements in the thoroughly zeolitized tuff at the base of the section (Lab. # 157, P1 in Appendix C) are similar to those found in the vitric tuff.

4. Hydrologic Properties.

Hydrologic properties have not been determined for the lower part of the Prow Pass Member south of Stagecoach road.

D. Zeolitic Tuffaceous Beds of Calico Hills at Prow Pass (Site #5 in Fig. 1)

Zeolitic tuffaceous beds of Calico Hills and lower Topopah Spring Member crop out at Prow Pass, at the north end of Yucca Mountain (Fig. 11). The large number of samples (73) examined at Prow Pass provide an unique opportunity to investigate both vertical and lateral changes in mineralogy and chemistry within the continuous exposures of these zeolitic tuffs. South of Prow Pass, samples were collected from two vertical measured sections 0.5 km. apart (Figs. 12 and 13) and from a lateral sample traverse that followed the north-trending strike of the tuffaceous beds of Calico Hills outcrop for a distance of one kilometer before turning eastward (Fig. 11). Additional samples of tuffaceous beds of Calico Hills were collected in a vertical section 0.8 km north of Prow Pass (Fig. 11). Petrographic data for one of the vertical sections south of Prow Pass (3-15-82- series samples) and for the vertical section

Fig. 11. Location of zeolitic tuffs sampled at outcrops in the vicinity of Prow Pass (Site 5 in Fig. 1). Samples were collected from the tuffaceous beds of Calico Hills and the lower part of the Topopah Spring Member. Geologic units shown on this figure include: (Tcb) Bullfrog Member, (Tep) Prow Pass Member, (Th) tuffaceous beds and lavas of Calico Hills, (Tpt) Topopah Spring Member, (Tpu) upper Paintbrush tuffs, (Tmr) rhyolite lava of Windy Wash, (Tmr) Rainier Mesa Member, and (Qac) Quaternary alluvium and colluvium.

north of Prow Pass (82FB- series samples) are published in Broxton et al. (1989a) and are not repeated in Appendix A. Whole-rock mineralogy and chemistry for all samples from Prow Pass are given in Appendixes B and C, respectively.

1. Lithology and Modal Petrography.

The tuffaceous beds of Calico Hills at Prow Pass are a sequence of yellow-white to pinkish-tan intercalated nonwelded ash-flow tuffs and bedded ash-fall and reworked tuffs (Fig. 12 and 13). At Prow Pass, the thickness of this unit is about 370 ft. with individual tuff layers ranging from a few inches to 65 ft. in thickness. The lower 50 ft. of this unit is relatively crystal-rich, containing 7 to 18% phenocrysts (Appendix A, Fig. 14a). The remainder of the unit contains less than 3% phenocrysts, except locally where crystals accumulated in reworked tuffs.

Phenocrysts throughout the unit consist of quartz, sanidine, plagioclase, and biotite.

Accessory minerals include Fe-Ti oxides, allanite, apatite, and zircon.

The Topopah Spring Member overlies the tuffaceous beds of Calico Hills at Prow

Pass. The lower 20 ft. of this Member is a pink nonwelded zeolitic ash-flow tuff. The nonwelded zeolitic tuffs grade abruptly upwards into medium-gray to black moderately-welded vitrophyre, which is up to 50 ft. thick at this location. Phenocrysts are sparse (0.4-1.1%) and consist predominately of plagioclase and sanidine (Appendix A, Fig. 14a). Quartz is present in trace amounts. Mafic phenocrysts consist of biotite and trace amounts of hornblende. Accessory minerals include Fe-Ti oxides, allanite, apatite, and zircon.

2. Mineralogy.

The tuffaceous beds of Calico Hills and the nonwelded base of the Topopah Spring Member are thoroughly altered to clinoptilolite (15-71%), mordenite (2-38%), opal-CT (0-40%), and smectite (0-5%) (Appendix B, Fig. 14c). These tuffs typically contain 1-16% feldspar, some of which have potassic end-member compositions (Or₉₉₋₁₀₀) and represent low-temperature alteration products (Broxton et al., 1986 and 1987). Except for the basal vitrophyre of the Topopah Spring Member and for partially-welded tuffs

Fig. 12. Stratigraphic section and sample locations for zeolitic tuffs in the southern part of the Prow Pass area (Site 5 in Fig. 1).

Fig. 13. Stratigraphic section and sample locations for zeolitic tuffs in the central part of the Prow Pass area (Site 5 in Fig. 1).

Immediately below the vitrophyre, all of the original volcanic glass in the nonwelded tuffs at Prow Pass was destroyed during alteration (Fig. 14c).

In vertical section, the abundance of total zeolites decreases from 70-80% at the top of zeolitic tuff sequence to 30-40% at the base of the sequence. Clinoptilolite abundances decrease down section in all three vertical sections whereas alkali feldspar, quartz, and opal-CT abundances generally increase with depth (Fig. 14c). In the lowermost part of the tuff sequence, increases in feldspar and quartz contents correlate in part with higher phenocryst abundances at the base of the tuffaceous beds of Calico Hills. However, in the central and northern vertical sections, feldspar and quartz abundances also increase with depth in the phenocryst-poor upper and middle parts of the tuff sequence; this suggests that at least part of the feldspar and quartz in these tuffs formed by secondary alteration processes.

The mineralogy of tuffs in the lateral traverse at Prow Pass does not vary appreciably except at the extreme north end where total zeolites tend to be lower and feldspar and quartz abundances tend to be higher than to the south. The decrease in zeolite abundance and increase in feldspar and quartz correlate with an increase in phenocryst content and suggest that mineralogic zonations within the tuffaceous beds of Calico Hills occur laterally as well as vertically. Alternatively, the lateral traverse may not follow a single stratigraphic horizon as intended but instead cuts down section into phenocryst-rich tuffs northward; if this is the case, the mineralogic zonations observed for the traverse are at least partially caused by vertical changes in mineralogy as a function of stratigraphic position.

3. Chemistry.

The chemistry of zeolitic tuffs at Prow Pass differs substantially from the compositions of vitric tuffaceous beds of Calico Hills and lower Topopah Spring Member at Busted Butte. These zeolitic tuffs contain higher calcium (up to 3.5%) and lower sodium (0.5-2.4%) than the vitric tuffs, when compared on an anhydrous basis (Appendix C). Potassium content is highly variable but generally tends to be higher than in the vitric tuffs. Potassium content varies antithetically with the concentration of sodium and to a lesser degree with calcium. Concentrations of mobile trace elements are also highly variable, and although there is some overlap with concentrations found in the vitric tuffs, U, Sr, and Ba contents are mostly lower in the zeolitic tuffs. Rb and Cs concentrations overlap those of the vitric tuffs, but the range of values in the zeolitic tuffs is much greater. Concentrations of immobile elements such as Al_2O_3 , TiO_2 , Zr, Hf, and Th closely match those of the vitric tuffs. Water contents of the zeolitic tuffs, as inferred from LOI, decreases systematically from 11-13% at the top of the sequence to 5-8% near the base (Appendix C, Fig. 14b). The decrease in water content correlates with a decrease in total zeolites with depth.

Mobile major elements such as Na_2O , K_2O , CaO , and MgO form complicated patterns of elemental enrichment or depletion with respect to vertical stratigraphic position in the measured sections. For example, calcium concentrations are greatest in the upper of the zeolitic tuffs in the southernmost

Fig. 14. Variation diagrams summarizing petrographic, mineralogic, and chemical characteristics of zeolitic tuffs sampled in the stratigraphic section at the southern end of the Prow Pass area (Site 5 in Fig. 1). Data are plotted as a function of stratigraphic position and include: a) modal petrography, b) total water contents (as loss on ignition), c) mineralogy, and d) chemistry (normalized to an anhydrous basis).

vertical section at Prow Pass (Fig. 14d) whereas 0.5 km to the north calcium concentrations are greatest in the middle of the altered tuff sequence. Similarly, the altered tuffs are most potassic in the middle of the sequence in the southernmost vertical section (Fig. 14d), and 0.5 km to the north the most potassic tuffs are near the top and bottom of the altered tuff sequence.

Mobile trace elements also show a great deal of variability with respect to vertical position within the altered tuffs. For example, in the southernmost measured section, U and As are concentrated in a well

defined zone within the central part of the tuffaceous beds of Calico Hills, and U is also concentrated in an upper zone (Fig. 14d). In the same section, Sr is concentrated between the upper and lower zones of U enrichment. Other mobile trace elements such as Cs and Rb show no correlation with stratigraphic position.

Although compositions are variable, tuffs in the northern part of the Prow Pass area are generally more potassic than tuffs to the south (Fig. 15). Silica, sodium, and strontium concentrations are higher in the southernmost outcrops. Whereas the chemical composition of tuffs is relatively uniform in the northern part of the Prow Pass area, tuffs from the southern part of the area are characterized by highly variable chemistry (Fig. 15).

4. Hydrologic Properties.

Hydrologic properties were measured in samples from the southern vertical measured section and the lateral transect (Fig. 11). Hydrologic properties for the lateral transect are reported by Rautman (1991). Data from Rautman (1991) and from the U.S. Geological Survey/Sandia systematic sampling program for the southern vertical section are summarized in Table II and Fig. 16. The following discussion focuses on the results from the southern vertical section because the systematic sampling from this location should yield values representative of the unit as a whole. Porosity values for the zeolitic tuffs at Prow Pass range from 18 to 38% and average 27%. There is a significant amount of variability in porosity throughout the tuff sequence, but in general the lower part of the section has a somewhat higher porosity (mean = 30%) than the

Fig. 15. Compositional variations along the lateral traverse within the tuffaceous beds of Calico Hills in the Prow Pass area (Site 5 in Fig. 1).

TABLE II.
HYDROLOGIC PROPERTIES OF THE ZEOLITIC TUFFACEOUS BEDS OF CALICO
HILLS AND TOPOPAH SPRING MEMBER AT PROW PASS, YUCCA MOUNTAIN,
NEVADA^a

Hydrologic Property with Mean $\pm$ Std. Dev.	Southern Vertical Section ^b (n = 61)	Lateral Transect ^b
Porosity %	27 $\pm$ 5	33 $\pm$ 5 (n = 28)
Range	18 - 38	22 - 41
Bulk Density g/cm ³	1.59 $\pm$ 0.23	n/d
Range	1.37 - 1.93	n/d
Particle Density g/cm ³	2.20 $\pm$ 0.07	n/d
Range	2.05 - 2.38	n/d
Air Permeability ^c , md	n/d	0.60 $\pm$ 0.45 (n = 27)
Range	n/d	0.11 - 1.5

a. Site #5 in Fig. 1.

b. n/d - not determined.

c. matrix permeability only; excludes data for fractured sample.

upper part (mean = 25%). Bulk densities average 1.59 g/cm³, and particle densities average 2.20 g/cm³. All three properties form relatively unimodal distributions (Fig. 16). The average value for porosity in the southern vertical section is similar to the value for the lateral transect (Rautman, 1991), though the lateral transect appears to be more closely related to the lower, higher porosity portion of the unit.

E. Zeolitic Tuffaceous Beds of Calico Hills at Calico Hills (Site #6 in Fig. 1)

Zeolitic tuffaceous beds of Calico Hills crop out at the type locality for this unit at Calico Hills, north of Jackass Flats. A total of 10 samples were investigated from a single tuff bed in an east-west

Fig. 16. Histograms of porosity, bulk density, and particle density for zeolitic tuffaceous beds of Calico Hills sampled in a vertical stratigraphic section at the southern end of the Prow Pass area (Site 5 in Fig. 1).

Fig. 17. Location of zeolitic tuffs sampled in a lateral traverse in the southwestern part of Calico Hills (Site 6 in Fig. 1). Samples were collected from a single ash-flow tuff within the tuffaceous beds of Calico Hills (Rautman, 1991). Geologic units shown include: ((Th) tuffaceous beds and lavas of Calico Hills, (Tpt) Topopah Spring Member, and (Qac) Quaternary alluvium and colluvium.

deposited in vugs in the groundmass or forms overgrowths on plagioclase. Several of the alkali feldspars were analyzed by electron microprobe and are potassic end-member compositions (Or₉₉₋₁₀₀). Other major alteration phases include mordenite (6-32%), clinoptilolite (0-31%), opal-CT (0-20%), kaolinite (0-5%), and calcite (0-1%). Clinoptilolite occurs only in the three easternmost samples. Small amounts of smectite were detected in only one sample.

3. Chemistry.

The feldspathic and zeolitic tuff at Calico Hills is significantly more potassic and less sodic than any of the other vitric or zeolitic tuffs investigated in this study, when compared on a normalized anhydrous basis (Fig. 19). Potassium concentrations range from 5.4 to 9.4 wt.%, whereas sodium concentrations range from 0.4 to 0.8 wt.% (Appendix C). Concentrations of mobile trace elements are highly variable, and U, Sr, and Cs contents are generally lower than in the vitric tuffs at Busted Butte. Rb and Ba concentrations overlap those of the vitric tuffs, but the range of values is much greater in this feldspathic and zeolitic tuff. Concentrations of immobile elements such as Al₂O₃, TiO₂, Zr, Hf, and Th

lateral traverse (Fig. 17). The 0.5 km long traverse follows the strike of the unit, thus the samples are not representative of the entire Calico Hills unit at this locality. Samples for this traverse were originally collected to determine the spatial variability of hydrologic properties in a single tuff unit (Rautman, 1991).

1. Lithology and Modal Petrography.

The tuff is a pinkish-tan to light green nonwelded ignimbrite that is part of a tuffaceous sequence approximately 200-300 ft. thick. The tuffaceous sequence intertongues with thick lava flows to the north. The ignimbrite sampled in the lateral traverse is relatively crystal-poor (1-4%) with phenocrysts of quartz, sanidine, plagioclase, and biotite (Appendix A).

2. Mineralogy.

The tuff investigated at Calico Hills is feldspathic and zeolitic (Appendix B). Alkali feldspar, which makes up 25-67% of the rock, is significantly more abundant in this tuff than in the vitric tuffs at Busted Butte or the zeolitic tuffs at Prow Pass (Fig. 18). Much of the feldspar was

Fig. 18. Histograms comparing the mineralogy of zeolitic tuffaceous beds of Calico Hills within the exploration block at Yucca Mountain (YM) to zeolitic tuffs of the same unit at Prow Pass (PP), and Calico Hills (CH). Mineralogic data for Yucca Mountain taken from Bish and Chipera (1985).

closely match those of the phenocryst-poor portion of the vitric tuffs. No systematic variations in chemistry occur along the traverse. Water content of the tuff (3.2-7.1%) is generally lower than in the tuffs at Prow Pass (5-13%), reflecting the slightly greater alteration and lower abundance of zeolites in the tuff at Calico Hills.

Fig. 19. Histograms comparing the chemistry of the zeolitic tuffaceous beds of Calico Hills within the exploration block at Yucca Mountain (YM) to the same unit at Prow Pass (PP) and Calico Hills (CH). Compositions of vitric tuffs at Busted Butte included to illustrate how open-system diagenetic alteration has mobilized and re-arranged the chemical constituents of the zeolitic tuffs. Only tuffs containing less than 4% phenocrysts are included so that chemical variations due to relative phenocryst abundances are minimized. Chemical data for Yucca Mountain taken from Broxton et al. (1986). All elemental concentrations are normalized to an anhydrous basis.

4. Hydrologic Properties.

Hydrologic properties of the tuff at Calico Hills are reported by Rautman (1991) and are summarized in Table III and Fig. 20. Porosity values range from 23 to 38% and average 29%. Bulk densities for these altered tuffs range from 1.55 to 1.89 g/cm³ and average 1.72 g/cm³. Permeabilities to air average 0.57 md. None of the hydrologic properties show systematic changes along strike.

Fig. 20. Histograms of porosity and bulk density for zeolitic tuffaceous beds of Calico Hills sampled in a lateral traverse at Calico Hills (Site 6 in Fig. 1). Data from Rautman (1991).

IV. DISCUSSION

The tuffaceous beds of Calico Hills in the vicinity of the potential repository are a sequence of stratified tuffs comprised of intercalated nonwelded ash-flow tuffs, bedded ash-fall, and reworked tuffs. These tuffs are high-silica rhyolites and form a compositional continuum with the overlying rhyolitic tuffs of the Topopah

Spring Member (Broxton et al., 1989b; this report). The nonwelded tuffs of the Calico Hills unit and the nonwelded tuffs in the lowermost part of the Topopah Spring Member have similar thermal and mechanical properties and together comprise the thermal-mechanical unit CHn of Ortiz et al. (1985). Whole-rock mineralogic properties of this tuff interval vary across the exploration block, and the thermal-mechanical unit is further subdivided into CHnv for vitric tuffs and CHnz for zeolitic tuffs. The sites investigated for a surface-based test facility were selected for study because they belong to the same stratigraphic sequence as CHnv or CHnz, or because the sites contain rocks that are similar to one or both of these two thermal-mechanical units.

The hydrologic properties of the tuffaceous beds of Calico Hills in the vicinity of the potential repository have been summarized by Flint and Flint (1990). These data are summarized in Table IV and Fig. 21. Although these data represent geographically distributed samples, they do not represent unbiased sampling of the unit as a whole. For comparison, a more systematic sampling of the vitric tuffs of Calico Hills just south of the potential repository was conducted using core from drill hole USW GU-3. The

TABLE III.
HYDROLOGIC PROPERTIES OF THE ZEOLITIC TUFFACEOUS BEDS OF CALICO
HILLS AT CALICO HILLS, YUCCA MOUNTAIN, NEVADA^a

Hydrologic Property with Mean $\pm$ Std. Dev.	Lateral Transect (n = 10)
Porosity %	29 $\pm$ 5
Range	23 - 38
Air Permeability, md	0.57 $\pm$ 0.35
Range	0.073 - 1.2

a. Site #6 in Fig. 1.

TABLE IV.
HYDROLOGIC PROPERTIES OF THE TUFFACEOUS BEDS OF CALICO HILLS IN THE
VICINITY OF THE POTENTIAL REPOSITORY, YUCCA MOUNTAIN, NEVADA ^a

Hydrologic Property with Mean $\pm$ Std. Dev.	Calico Hills vitric tuffs ^b	Vitric Tuffs at Drill Hole USW GU-3 ^c	Calico Hills zeolitic tuffs ^b
Porosity %	33	35 $\pm$ 9	28
Range	27 - 39	10 - 51	14 - 36
Bulk Density g/cm ³	1.67	1.51 $\pm$ 0.24	1.62
Range	n/a	1.05 - 2.13	1.44 - 1.87
Permeability to Water, md	0.63	n/d	0.015
Range	0.01-1.7 (47) ^d	n/d	0 - 0.07 (9.9) ^d

a. n/a - not applicable, only one sample reported; n/d - not determined.

b. extracted from Flint and Flint (1990); standard deviation not computed.

c. data collected by A.L. Flint and C. A. Rautman, see Yucca Mountain Project (1992).

d. parenthetical value represents a single extreme value not included in mean.

results, which should be more representative statistically of the vitric material within the Calico Hills unit, are also presented in Table IV for comparison with the smaller vitric data set of Flint and Flint (1990).

The hydrologic, geochemical, and mechanical properties within the tuffaceous beds of Calico Hills in the vicinity of the potential repository are spatially variable. For instance, on the eastern side of the exploration block the tuffaceous beds of Calico Hills consist of nonwelded zeolitic tuffs that are

Fig. 21. Histograms of porosity, bulk density, and particle density for vitric tuffaceous beds of Calico Hills in the exploration block (represented by data for drill hole USW GU-3) and for zeolitic tuffs of the same unit in the exploration block (represented by data for drill holes USW G-1, UB25a #1, UB25c #1, and UB25c #2). Data from Flint and Flint (1990).

relatively impermeable to water movement, highly sorptive of cationic radionuclides, and strongly indurated. These rocks are supplanted westward by vitric tuffs that are very similar in bedding and welding characteristics but are relatively unaltered when compared to tuffs on the east. The vitric tuffs in the west have high permeability to water movement, are less sorptive of cationic radionuclides, and are poorly indurated.

A surface-based test facility designed to access rocks similar to those that make up the tuffaceous beds of Calico Hills within the exploration block could be sited in either vitric or zeolitic nonwelded ash-flow and bedded tuffs, based on the characteristics described above. Selection between a vitric and zeolitic host rock will be governed largely by testing requirements of investigators who will use the facility. The following discussion compares data collected for the sites examined in this study to similar data for the tuffaceous beds of Calico Hills within the exploration block. A preliminary evaluation of the suitability of these sites to host a surface-based test facility is made based on the similarity of the rocks at the sites to the two principal rock lithologies (vitric and zeolitic) found within the exploration block.

A. Vitric Bedded Tuffs at Busted Butte

The vitric bedded tuffs exposed at Busted Butte and the vitric facies of the tuffaceous beds of Calico Hills within the exploration block (thermal-mechanical unit CHnv) at Yucca Mountain are similar lithology, mineralogy, and chemistry. Except for the inclusion of the Wahmonie Formation, the stratigraphic succession at Busted Butte (Figs. 3 and 5) matches the stratigraphic units that make up thermal-mechanical unit CHnv at Yucca Mountain. In both locations, the tuffs consist of intercalated ash-flow tuffs and bedded ash-fall and reworked tuffs. Well-developed stratification and lack of welding characterize tuffs in both locations. The vitric tuffs at Busted Butte are thinner (a maximum of 125 ft. thick from the top of the Prow Pass Member to the basal vitrophyre of the Topopah Spring Member) than unit CHnv at Yucca Mountain (~332 ft. in USW GU-3), but there is ample stratigraphic thickness to site a horizontal adit at Busted Butte, particularly at the north end.

The chemistry and mineralogy of the vitric tuffs at Busted Butte are very similar to equivalent tuffs at Yucca Mountain. The tuffs in both locations are high-silica rhyolites, and except for zeolitization localized along the fault at the north end of Busted Butte, have undergone only minor chemical and mineralogic alteration. The Wahmonie Formation is made up of dacites that contain significantly more mafic phenocrysts and accessory minerals than the rhyolites that lie above and below. Investigators planning experiments involving rock-water interactions, particularly for radionuclide migration studies, should be aware that the unique chemical characteristics of this tuff may be a significant variable if tests are sited in this unit. Lithologic properties of the Wahmonie Formation are very similar to those of unit CHnv at Yucca Mountain. Hydrologic properties have not been determined for the nonwelded vitric tuffs at Busted Butte.

B. Vitric Bedded Tuffs, Northeast Side of Yucca Mountain

Nonwelded tuffs between the Topopah Spring and Yucca Mountain Members at the northeast side of Yucca Mountain include 1) the zeolitic lapilli tuff and ash-flow tuff at the base of the Pah Canyon Member and 2) vitric ash-flow and bedded tuffs that make up the top of the Pah Canyon Member and the overlying sequence of bedded tuffs (Fig. 7). These nonwelded zeolitic and vitric tuffs are similar tuffs that make up thermal-mechanical units CHnz and CHnv, respectively, at Yucca Mountain.

Although comprised of different stratigraphic units, the zeolitic tuffs at northeastern Yucca Mountain have similar lithologic characteristics to CHnz at Yucca Mountain. The major lithologic difference between the tuffs at these two locations is the presence of only one depositional break in the zeolitic tuffs at northeast Yucca Mountain whereas the tuffaceous beds of Calico Hills typically contains numerous depositional breaks. The stratification resulting from the presence of numerous depositional breaks may affect the hydrologic properties of the tuffaceous beds of Calico Hills. Juxtaposition of units with contrasting grain sizes across deposition boundaries can affect permeability pathways along which water moves through the tuff. Available hydrologic data suggest that the tuffaceous beds of Calico Hills are slightly less porous and have a lower bulk density than the zeolitic tuffs at the base of the Pah Canyon Member (compare Figs. 9 and 21). Investigators who intend to investigate water movement in zeolitic tuffs should take into account the general lack of stratification in the zeolitic tuffs at this location. The zeolitic tuffs at northeast Yucca Mountain are ~60 ft. thick.

The mineralogy of zeolitic tuffs at northeast Yucca Mountain is very similar to that found in the tuffaceous beds of Calico Hills at Yucca Mountain, but there are some significant differences in chemistry. Both tuffs are altered to an assemblage of clinoptilolite and subordinate amounts of mordenite. However, the zeolitic tuffs (and presumably the zeolites themselves) at northeast Yucca Mountain are much more calcic than the zeolitic tuffaceous beds of Calico Hills at western Yucca Mountain (Fig. 19). Calcium-rich zeolites can strongly affect the expansion/contraction, hydration/dehydration, and ion-exchange properties of tuff (Bish, 1984 and 1985; Ames, 1960; Vaughan, 1978). Thus, the difference in chemistry between this outcrop location and the tuffaceous beds of Calico Hills is a variable that should be evaluated in any planned tests.

Vitric tuffs at the top of the section at northeast Yucca Mountain closely match the lithology of vitric tuffaceous beds of Calico Hills within the exploration block. Vitric tuffs at both locations consist of intercalated nonwelded ash-flow tuffs and bedded ash-fall and reworked tuffs. Stratification is well developed at both locations because of the presence of numerous individual depositional units. Although part of thermal-mechanical unit PTn, the lithologic properties of the vitric tuffs at northeast Yucca Mountain are very similar to those of thermal-mechanical unit CHnv within the exploration block. The vitric tuffs at northeast Yucca Mountain are ~170 ft. thick.

In general, the chemistry and mineralogy of the vitric tuffs at northeastern Yucca Mountain are very similar to that found in the vitric tuffaceous beds of Calico Hills within the exploration block. Both

tuff sequences are rhyolites, which have undergone little diagenetic alteration, and hydrated glassy pyroclasts are their primary mineralogical constituents. Although the chemistry of tuffs in both locations is similar, the Pah Canyon Member and the rhyolite of Delirium Canyon of the bedded tuff sequence are not as highly evolved as the high-silica rhyolite of the tuffaceous beds of Calico Hills. Differences in chemistry between these tuffs are relatively minor for major elements but are greater for trace elements. When considering the lower part of the vitric bedded tuffs at northeast Yucca Mountain for a surface-based test facility, investigators should evaluate whether these chemical differences could have an effect on their experiments. The rhyolite of Black Glass Canyon, which makes up the greater part of the bedded tuff sequence above the Pah Canyon Member, is a high-silica rhyolite that is very similar in major- and trace-element chemistry to the tuffaceous beds of Calico Hills.

Hydrologic properties of the vitric bedded tuffs above the Pah Canyon Member appear quite similar to those of the vitric tuffaceous beds of Calico Hills at USW GU-3 (compare Tables I and IV and Figs. 9 and 21). Porosities are between 35 and 40% at both locations. The bedded tuffs at northeast Yucca Mountain are slightly more porous than the more widely-distributed but potentially-biased data of Flint and Flint (1990). Bulk densities of the vitric bedded tuffs are similar to values for USW GU-3 and from Flint and Flint (1990), and are distinct from the more welded portions of the Pah Canyon Member at this location and from zeolitic tuffs elsewhere. These upper tuffs appear to be good analogs to the vitric tuffaceous beds of Calico Hills within the exploration block.

C. Vitric Ash-Flow Tuffs, South of Stagecoach Road

The vitric tuffs in the lower part of the Prow Pass Member are generally similar in lithology to the nonwelded ash-flow tuffs commonly found in the tuffaceous beds of Calico Hills at Yucca Mountain. The major lithologic difference between these two tuffs is that Prow Pass tuffs south of Stagecoach Road are comprised of a single ash-flow tuff whereas the tuffaceous beds of Calico Hills typically contain numerous depositional units separated by prominent stratigraphic breaks. Hydrologic properties have not been determined on samples from the Stagecoach Road locality. However, the lack of stratification within the tuffs at Stagecoach Road probably means that the hydrologic properties of these tuffs differ substantially from the tuffaceous beds of Calico Hills within the exploration block.

The degree of alteration found in the vitric tuffs at Stagecoach Road preclude them from being selected as host rocks for a surface-based test facility in vitric tuff. Diagenetic alteration of vitric tuffs at Stagecoach Road outcrops is more extensive than what is usually found in the vitric tuffaceous beds of Calico Hills within the exploration block. The vitric tuffs in the lower part of the Prow Pass Member contain numerous local zones of zeolitization and the base of the unit is thoroughly zeolitized. Alteration is unevenly distributed throughout the vitric zone and probably results in nonuniform hydrologic and geochemical properties over the scale of any proposed experiments in a surface-based test facility.

D. Zeolitic Tuffaceous Beds of Calico Hills at Prow Pass

The lithology of zeolitic tuffaceous beds of Calico Hills and lower Topopah Spring Member at Prow Pass (Figs. 12 and 13) closely matches that of equivalent units within the exploration block. Tuffs at both locations consist of well-stratified, intercalated, nonwelded ash-flow tuffs and bedded ash-fall and reworked tuffs. The zeolitic tuffs at Prow Pass are laterally equivalent to thermal-mechanical unit CHnz at Yucca Mountain. The section of zeolitic tuffs at Prow Pass is relatively thick (~390 ft.) and well exposed.

The chemistry of the zeolitic tuffs at Prow Pass differs substantially from the zeolitic tuffs at Yucca Mountain. Concentrations of mobile exchangeable cations such as K₂O, CaO, and MgO are strongly enriched and Na₂O, U, and Cs are depleted in the zeolitic tuffs Prow Pass relative to equivalent tuffs at Yucca Mountain (Fig. 19). Despite these differences in chemistry, the mineralogy of tuffs at both locations is very similar. Both tuff sequences are thoroughly altered to an assemblage of clinoptilolite and mordenite and total zeolite abundances are about the same (Fig. 19). Clinoptilolite is the dominant alteration product at both locations although mordenite abundances are somewhat higher at Prow Pass (Fig. 18). The differences in chemistry and mineralogy between tuffs at Prow Pass and at Yucca Mountain probably have little effect on the hydrologic and mechanical properties of the tuffs. Indeed, the average bulk hydrologic properties in Tables II and IV are very similar. The average porosities are 27 and 28% respectively, and the average bulk density of both is 1.6 g/cm³. The range of values for these parameters is similar as well, which could be equally informative, given the nonsystematic data in Table IV. However, differences in chemistry and mineralogy should be carefully evaluated by investigators because these factors could have a significant effect on experiments involving rock-water interactions.

E. Zeolitic Tuffaceous Beds of Calico Hills at Calico Hills

The lithology of zeolitic tuffs at Calico Hills is similar to that of equivalent units within the exploration block. Although the lateral section at Calico Hills sampled only one ash-flow unit, this ash-flow unit is part of a stratified sequence that includes intercalated nonwelded ash-flow tuffs and bedded tuffs that are very similar to those found at Yucca Mountain. The zeolitic tuffs at Calico Hills are stratigraphically equivalent to thermal-mechanical unit CHnz at Yucca Mountain. The section of zeolitic tuffs at Calico Hills is relatively thick (200-300 ft.) and well exposed.

Like at Prow Pass, the chemistry of the zeolitic tuffs at Calico Hills differs substantially from the zeolitic tuffs at Yucca Mountain. Concentrations of K₂O and MgO are strongly enriched in the zeolitic tuffs at Prow Pass relative to equivalent tuffs at Yucca Mountain whereas Na₂O, U, and Cs are depleted (Fig. 19). Unlike at Prow Pass, the mineralogy of tuffs also differs substantially when compared to tuffs at Yucca Mountain. At Calico Hills, the alteration assemblage primarily consists of authigenic potassium feldspar and mordenite (Fig. 18). Clinoptilolite was detected in only three of the ten samples examined.

Because of greater authigenic potassium feldspar crystallization, total zeolite abundances are much lower for the tuffs at Calico Hills (<50%) than for similar tuffs at Yucca Mountain (Fig. 18). Because of the magnitude of chemical and mineralogic differences between tuffs at Calico Hills and at Yucca Mountain, there also may be substantial differences in mechanical properties between the two tuff sequences. Differences in hydrologic properties are difficult to judge because of the limited and potentially non-representative sampling at Calico Hills. The average porosity of 29% for the sampled unit at Calico Hills (Table III) is very similar to 28% for the potential repository area (Table IV) and 27% for the southern vertical section of the Calico Hills unit at Prow Pass (Table II), suggesting the differences in the bulk hydrologic properties may not be extremes. However, investigators planning experiments involving rock-water interactions should be particularly aware of the large chemical and mineralogic differences between the two sites.

V. RECOMMENDATIONS

A ranking of the sites investigated in this study to host a surface-based test facility is given in Table V. Each site was evaluated for its similarity to the geologic setting of the tuffaceous beds of Calico Hills at Yucca Mountain. The evaluation is based on how well the sites investigated mimic the lithologic, mineralogic, and chemical conditions of the vitric and zeolitic tuffs that make up the Calico Hills unit within the exploration block. The grading of rock characteristics for each site is based on the discussions above. All characteristics received equal weighting in the evaluation; it might be appropriate to re-grade these sites at some time in the future after assigning higher weighting factors to rock characteristics of particular interest, such as lithology or mineralogy for example, if the suite of tests developed for the surface-based test facility emphasize mechanical or hydrologic properties of the tuff over rock/water interactions. The evaluation does not take into account hydrologic properties, because these types of data are not available for all of the sites investigated.

The vitric tuffs most closely approximating the geologic properties of the tuffaceous beds of Calico Hills within the exploration block are 1) those at Busted Butte and 2) those in the upper part of the Pah Canyon Member and the overlying bedded tuff sequence at northeast Yucca Mountain. Tuffs at both locations are excellent analogs to the tuffs at Yucca Mountain and each received 11 out of a possible 12 points (Table V). Both locations were rated excellent in the categories of lithology and mineralogy and were rated good in the category of chemistry. Chemistry was graded no higher than good because both locations contain some tuffs that are less chemically-evolved than the high-silica rhyolites of the tuffaceous beds of Calico Hills. These less-evolved tuffs are found in the lower parts of both sections, whereas tuffs with compositions more typical of the tuffaceous beds of Calico Hills beneath the exploration block are found in the upper part of the sections. Presumably, a surface-based test facility would be sited in the upper parts of these tuff sequences if rock chemistry is identified as an important variable in the tests to be performed.

TABLE V.
RANKING OF VITRIC AND ZEOLITIC TUFF SITES TO HOST A SURFACE-BASED TEST
FACILITY, YUCCA MOUNTAIN, NEVADA

Site (Site # in Fig. 1)	Vitric (V) or Zeolitic (Z)	Degree of Similarity to Tuffs at Yucca Mountain			
		1 = Poor	2 = Fair	3 = Good	4 = Excellent
		Lithology	Chemistry	Mineralogy	Total Score (out of 12)
Busted Butte (Site #1)	V	4	3	4	11
NE Yucca Mt. (Site #2)	V	4	3	4	11
Stagecoach Rd. (Site #3)	V	2	3	1	6
NE Yucca Mt. (Site #4)	Z	2	2	4	8
Prow Pass (Site #5)	Z	4	2	3	9
Calico Hills (Site #6)	Z	3	1	1	5

The zeolitic tuffs most similar to the zeolitic facies of the tuffaceous beds of Calico Hills at Yucca Mountain are 1) those at Prow Pass and 2) those in the lower part of the Pah Canyon Member at northeast Yucca Mountain. Zeolitic tuffs at both locations are very similar to the tuffs at Yucca Mountain and received 8 to 9 points out of a possible 12 points (Table V). The Prow Pass site received good to excellent marks for lithology and mineralogy, but only a fair rating for chemistry. The fair rating in chemistry reflects the potassic chemistry of tuffs at Prow Pass relative to Yucca Mountain. The tuffs in the lower part of the Pah Canyon Member received an excellent rating for mineralogy, but only fair marks for lithology and chemistry. Lithology was graded as fair because the Pah Canyon is a single massive ash-flow tuff and lacks the stratification that results from the deposition of numerous individual tuff units; such well-stratified bedded tuffs are typical of the tuffaceous beds of Calico Hills. The fair rating in chemistry reflects the unique calcic chemistry of tuffs at Prow Pass relative to Yucca Mountain.

VI. CONCLUSIONS

Outcrops of nonwelded vitric and zeolitic tuffs in the vicinity of Yucca Mountain were examined as possible locations for a surface-based prototype test facility for the Yucca Mountain Project. In this

report, emphasis is placed on examining sites with rocks similar to the tuffaceous beds of Calico Hills, an important geologic and hydrologic barrier between the potential repository and the water table. The tuffaceous beds of Calico Hills within the exploration block are made up of both vitric and zeolitic tuffs whose mineralogic, chemical, and hydrologic properties are quite dissimilar. Three of the six sites investigated in this study are in vitric tuffs, and three sites are in zeolitic tuffs.

Lithologic, chemical, mineralogic, and modal petrographic data were collected for samples collected from all of the sites investigated. These data were compared to similar existing data sets for the tuffaceous beds of Calico Hills within the exploration block. Some hydrologic information for several of the locations investigated is also presented but was not considered in the evaluation process because hydrologic data are not available for all of the sites. Based on these comparisons, the sites best approximating the geologic conditions of the vitric Calico Hills unit within the exploration block are at Busted Butte and in the northeastern part of Yucca Mountain. Bedded tuffs at Busted Butte include, in ascending order, the nonwelded top of the Prow Pass Member, the Wahmonie Formation, the tuffaceous beds of Calico Hills, and the nonwelded base of the Topopah Spring Member. Bedded tuffs in the northeastern part of Yucca Mountain include the nonwelded top of the Pah Canyon Member and overlying bedded tuffs. Although part of a different stratigraphic succession, these tuffs have lithologic, mineralogic, and chemical properties that make them good analogs to the tuffaceous beds of Calico Hills within the exploration block.

The sites best approximating the geologic conditions within the zeolitic tuffaceous beds of Calico Hills within the exploration block are at Prow Pass and in the northeastern part of Yucca Mountain. The thick sequence of zeolitic tuffs exposed at Prow Pass consists of the tuffaceous beds of Calico Hills and nonwelded base of the Topopah Spring Member and are exposed in continuous vertical section for several kilometers along a N-striking outcrop. The zeolitic tuffs making up these outcrops are generally similar to the zeolitic tuffs within the exploration block except for some differences in mineralogy and chemistry. Tuffs in the northeastern part of Yucca Mountain include the nonwelded base of the Pah Canyon Member and underlying bedded tuffs. These zeolitic tuffs also are generally similar to the zeolitic tuffs within the exploration block except for some differences in mineralogy and chemistry.

Additional screening should take place when hydrologic property data become available for the sites investigated in this study, although hydrologic properties are largely controlled by lithologic and mineralogic characteristics of the tuffs. Most likely, the range of hydrologic properties within the four favorable sites identified in this report will overlap those of the vitric and zeolitic tuffs within the exploration block.

VII. ACKNOWLEDGMENTS

A.L. Flint of the U. S. Geological Survey kindly provided hydrologic data used in this report. R. G. Warren and D. Buesch provided a critical review of the manuscript. We thank Carol White for her

help with word processing on the text and tables.

This work was supported by the U. S. Department of Energy Yucca Mountain Site Characterization Project Office as part of the Civilian Radioactive Waste Management Program. This project is managed by the U. S. Department of Energy, Yucca Mountain Site Characterization Office.

VIII. REFERENCES

- Ames, L. L., Jr., 1960, The cation sieve properties of clinoptilolite: *Amer. Mineral.*, v. 45, p. 689-700. NNA.921026.0010
- Bish, D. L., 1984, Effects of exchangeable cation composition on the thermal expansion/contraction of clinoptilolite, *Clays and Clay Miner.*, v. 32, p. 444-462. NNA.921026.0009
- Bish, D. L., 1985, 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*, p. 565-576. NNA.890525.0001
- Bish, D. L. and Chipera, S. J., 1988, Problems and solutions in quantitative analysis of complex mixtures by X-ray powder diffraction, *In Advances in X-Ray Analysis (Plenum Press, New York, 1988)*, v. 31, p. 295-308. NNA.890405.0178
- Bish, D. L. and Chipera, S. J., 1989, Revised mineralogic summary of Yucca Mountain, Nevada, Los Alamos National Laboratory Report LA-11497-MS. NNA.891019.0029
- Broxton, D. E., Warren, R. G., Hagan, R. C., and Luedemann, G., 1986, Chemistry of diagenetically altered tuffs at a potential nuclear waste repository, Yucca Mountain, Nye County, Nevada, Los Alamos National Laboratory Report LA-10802-MS, 160 p. NNA.890327.0036
- Broxton, D. E., Bish, D. L., Warren, R. G., 1987, Distribution and chemistry of diagenetic minerals at Yucca Mountain, Nye County, Nevada, *Clays and Clay Miner.*, v. 35, p. 89-110. NNA.890222.0053
- Broxton, D. E., Byers, F. M. Jr., and Warren, R. G., 1989a, Petrography and phenocryst chemistry of volcanic units at Yucca Mountain, Nevada: A comparison of outcrop and drill hole samples, Los Alamos National Laboratory Report LA-11503-MS, 66 p. NNA.890224.0089
- Broxton, D. E., Warren, R. G., Byers, F. M., Jr., and Scott, R. B., 1989b, Chemical and mineralogic

- trends within the Timber Mountain-Oasis Valley caldera complex: Evidence for multiple cycles of chemical evolution in a long-lived silicic magma system, *J. Geophys. Res.*, v. 94, p. 5961-5985. NNA.920319.0004
- Bush, D. and Jenkins, R. E., 1970, Proper hydration of clays for rock property determination, *J. Petroleum Technology*, July issue, p. 800-804. NNA.921026.0003
- Byers, F. M., Jr., Carr, W. J., Orkild, P. P., Quinlivan, W. D., and Sargent, K. A., 1976, Volcanic suites and related cauldrons of Timber Mountain-Oasis Valley caldera complex, southern Nevada, U. S. Geol. Surv. Prof. Paper 919, 70 p. NNA.870406.0239
- Byers, F. M., Jr., 1985, Petrochemical variation of the Topopah Spring Tuff matrix with depth (stratigraphic level), drill hole USW G-4, Yucca Mountain, Nevada, Los Alamos National Laboratory Report LA-11503-MS, 38p. NNA.890224.0089
- Byers, F. M., Jr., 1990a, Procedure for determination of volume constituents in thin section, Los Alamos National Laboratory detailed procedure TWS-ESS-DP-102. NNA.890710.0152
- Byers, F. M., Jr., 1990b, Procedure for counting opaque minerals in polished thin sections, Los Alamos National Laboratory detailed procedure TWS-ESS-DP-128. NNA.900809.0032
- Christiansen, R. L. and Lipman, P. W., 1965, Geologic map of the Topopah Spring NW quadrangle, Nye County, Nevada, U. S. Geol. Surv. Geol. Quad. Map, GQ-444. NNA.921026.0008
- Chung, F. H., 1974a, Quantitative interpretation of X-ray diffraction patterns of mixtures. I. Matrix-flushing method for quantitative multicomponent analysis, *Jour. of App. Crystallography*, v. 7, p. 519-525. NNA.890405.0179
- Chung, F. H., 1974b, Quantitative interpretation of X-ray diffraction patterns of mixtures. II. Adiabatic principle of X-ray diffraction analysis of mixtures, *Jour. of App. Crystallography*, v. 7, p. 526-531. NNA.890405.0180
- Flint, L. E. and Flint A. L., 1990, Preliminary permeability and water-retention data for nonwelded and bedded tuff samples, Yucca Mountain area, Nye County, Nevada, U. S. Geol. Surv. Open-File Rept. 90-569, 56 p. NNA.901015.0200

- Flood, T. P., Vogel, T. A., and Schuraytz, B. C., 1989, Chemical evolution of a magmatic system: The Paintbrush Tuff, southwestern Nevada volcanic field, *J. Geophys. Res.*, v. 94, No. 85, p. 5943-5960. NNA.921026.0013
- Garcia, S. R., Hensley, W. K., Minor, M. M., Denton, M. M., Fuka, M. A., 1982, 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), p. 133-140. NNA.921026.0001
- Klug, H. P. and Alexander, L. E., 1974, *X-Ray Diffraction Procedures for Polycrystalline and Amorphous Materials*, John Wiley & Sons, Inc, New York. Readily Available
- Korotev, R. L., 1991, Geochemical stratigraphy of two regolith cores from the central highlands of the moon, *Procs. of Lunar and Planet. Sci.*, v. 21, p. 229-289. NNA.921019.0162
- Lipman, P. W. and McKay, E. J., 1965, Geologic map of the Topopah Spring SW quadrangle, Nye County, Nevada, U. S. Geol. Surv. Geol. Quad. Map, GQ-439. NNA.900720.0032
- Lipman, P. W., Christiansen, R. L., and O'Conner, J. T., 1966, A compositionally zoned ash-flow sheet in southern Nevada, U. S. Geol. Surv. Prof. Paper 524-F, p. F1-F47. NNA.870519.0035
- Maldonado, F., 1985, Geologic map of the Jackass Flats area, Nye County, Nevada, U. S. Geol. Surv. Misc. Inv. Map I-1519. Readily Available
- McKay, E. J. and Sargent, K. A., 1970, Geologic map of the Lathrop Wells quadrangle, Nye County, Nevada, U. S. Geol. Surv. Geol. Quad. Map, GQ-883. NNA.910215.0250
- Minor, M. M., Hensley, W. K., Denton, M. M., and Garcia, S. R., 1982, An automated activation analyses system, *J. Radioanal. Chem.*, v. 70, p. 459-471. NNA.921026.0004
- Ortiz, T. S., Williams, R. L., Nimick, F. B., Whittet, B. C., and South, D. L., 1985, A three-dimensional model of reference thermal-mechanical stratigraphy at Yucca Mountain, southern Nevada, Sandia National Laboratory Report, SAND84-1076, 71 p. NNA.890315.0013

Poole, F. G., Carr, W. J., and Elston, D. P., 1965, Salyer and Wahmonie formations of southern Nye County, Nevada, *in* Changes in Stratigraphic Nomenclature by the U. S. Geological Survey, 1964, G. V. Cohee, and W. S. West, eds., U. S. Geol. Surv. Bull. 1224-A, p. 36-44.
NNA.921026.0007

Quinnlivan, W.D. and Byers, F.M., Jr., 1977, Chemical data and variation diagrams of igneous rocks from the Timber Mountain-Oasis Valley caldera complex, southern Nevada, U. S. Geol. Surv. Open-File Rept. 77-724, 9 p. NNA.920921.0110

Rautman, C. A., 1991, Estimates of spatial correlation in volcanic tuff, Yucca Mountain, Nevada, Sandia National Laboratory Report, SAND89-2270, 117 p. NNA.901213.0067

Rautman, C. A., Flint, A. L., Chornack, M. P., and McGraw, M. P., 1991, Microstratigraphic units and spatial correlation of hydrologic properties in tuff, Yucca Mountain, Nevada, Geol. Soc. America Programs with Abstracts, v.23, no.5, p. A119. NNA.920102.0081

Rautman, C. A. and Flint, A. L., 1992, Deterministic geologic processes and stochastic modeling, *in* Proceedings of the 3rd High-Level Radioactive Waste Management Conference, American Nuclear Society, p. 1617-1624. NNA.920219.0016

Schuraytz, B. C., Vogel, T. A., Younker, L. W., 1989, Evidence for dynamic withdrawal from a layered magma body: The Topopah Spring Tuff, southwestern Nevada, J. Geophys. Res., v. 94, No. 85, p. 5925-5942. NNA.921026.0012

Scott, R. and Castellanos, M., 1984, Preliminary report on the geologic character of the drill holes USW GU-3 and USW G-3, U. S. Geol. Surv. Open-File Rept. 84-491, 121 p. NNA.890804.0017

Soeder, D. J., Flint, L. E., and Flint, A. L., 1991, Effects of sample handling and measurement methodology on the determination of porosity in volcanic rock samples, Agronomy Abstracts, 1991 Annual Mtgs., Amer. Soc. of Agronomy, Crop Science Soc. of Amer., and Soil Science Soc. of Amer., p. 232. NNA.920707.0070

Spengler, R. W. and Peterman, Z. E., 1991, Distribution of rubidium, strontium, and zirconium in tuff from two deep coreholes at Yucca Mountain, Nevada, *in* Proceedings of the 2nd High-Level Radioactive Waste Management Conference, American Nuclear Society, p. 1416-1422.
NNA.911003.0095

Vaughn, D. E. W., 1978, Properties of natural zeolites: in Natural Zeolites: Occurrences, Properties, Use, L. B. Sand and F. A. Mumpton, eds., Pergamon Press, Elmsford, New York, p. 353-371.

NNA.921026.0011

Warren, R. G. and Broxton, D. E., 1986, Mixing of silicic and basaltic magmas in the Wahmonie Formation, southwestern Nevada volcanic field, Nevada, EOS Trans. AGU, 67, p. 1261.

NNA.921026.0005

Warren, R. G., McDowell, F. W., Byers, F. M. Jr., Broxton, D. E., Carr, W. J., and Orkild, P. P., 1988, Episodic leaks from Timber Mountain caldera: New evidence from rhyolite lavas of Fortymile Canyon, SW Nevada volcanic field, Geol. Soc. Am. Abstr. Programs, 20, p. 241.

NNA.900308.0333

Warren, R. G., 1992, personal communication documented in notebook TWS-EES-1-2-92-5, p. 46-47.

Yucca Mountain Project, 1992, Data resulting from data aquisition, Technical Data Information Form, DTN GS920508312231.011, 5p.

APPENDIX A. PETROGRAPHIC MODAL ANALYSES OF NONWELDED TUFFS FROM OUTCROP, YUCCA MOUNTAIN, NEVADA

Busted Butte Area (Southeast Side; Site 1 on Fig. 1)

Field Number	DEB 3/90-4	DEB 3/90-5	DEB 3/90-6	DEB 3/90-7	DEB 3/90-8	DEB 3/90-9	DEB 3/90-10
LANL Number	160	161	162	163	164	166	168
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Twl	Twl	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	nwt	nwt	b	nwt	b
Major Alteration ³	Ql	Ql	Ql, Zc	Ql	Ql	Ql	Ql
Minor Alteration ³	Sm	Sm	Sm	Sm, Zc		Sm	Sm
Matrix Materials (counts)⁴							
Groundmass ⁵	2037	2123	5436	5588	1599	5027	5258
Lithics	510	158	291	348	156	164	222
Voids >30μ	nd	nd	nd	1070	p	nd	nd
Colloidal Silica	—	—	—	—	—	—	—
Pumice Lapilli	—	—	—	nd	3767	—	—
Perlite Chips	—	—	372	866	83	243	602
Calcite	—	—	—	—	63	—	—
Phenocrysts (counts)⁴							
Quartz	—	—	147	214	8	55	57
Alkali Feldspar	—	—	89	148	25	51	62
Plagioclase	340	279	250	174	14	51	49
Biotite	74	110	36	10	—	8	9
Amphibole	—	—	16	1	—	—	—
Orthopyroxene	—	p?	—	1	—	—	—
Clinopyroxene	p	p?	1	1	—	—	—
Other (Pseudo-morphs)	—	—	—	—	—	—	—
Accessory Minerals (counts)⁶							
Fe-Ti Oxides	18	9	11	1	1	4	8
Apatite	p	p	—	—	—	—	—
Allanite	—	—	p	1	—	—	—
Perrierite	—	—	—	—	—	—	—
Zircon	p	1	p	p	p	p	p
Sphene	—	—	—	—	—	—	—
Total Counts	2984	2651	6277	6422	5717	5600	6267
Remarks	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite; epidote	Hematite after magnetite; tridymite
Phenocryst Summary⁷							
% Phenocrysts	14.5	14.8	8.8	6.5	0.9	3.0	3.0
Rel. % Quartz	0	0	30	40	19	35	34
Rel. % Alk. Feld.	0	0	18	28	52	32	37
Rel. % Plag.	100	100	51	32	29	32	29

APPENDIX A. (cont)

Busted Butte Area (Northern End, Site 1 on Fig 1)

Field Number	DEB 3/90-44	DEB 3/90-45	DEB 3/90-46	DEB 3/90-47	DEB 3/90-48	DEB 3/90-49	DEB 3/90-50	DEB 4/91-1
LANL Number	200	201	202	203	204	205	206	432
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Top	Twl	Thl	Thl	Thl	Thl	Tpl	Tpl
Lithology ²	nwt	nwt	b	b	nwt	nwt	nwt	nwt
Major Alteration ³	Ql	Ql	Ql	Ql	Ql	Ql	Ql	Zc
Minor Alteration ³	Sm	Sm	Sm, Zc	Sm	Sm, Zc	Sm		Op
Matrix Materials (counts)⁴								
Groundmass ⁵	6662	2601	4736	667	2712	4676	6170	7914
Lithics	18	631	269	276	300	609	88	660
Voids >30µ	666	304	nd	nd	660	670	712	904
Colloidal Silica	—	—	—	—	—	—	—	—
Pumice Lapilli	3144	1555	nd	3319	2226	6317	968	1340
Perlite Chips	—	—	—	361	604	911	360	606
Calcite	—	—	—	—	—	—	—	—
Phenocrysts (counts)⁴								
Quartz	211	16	360	192	170	143	14	18
Alkali Feldspar	636	9	201	162	116	101	36	21
Plagioclase	312	637	646	304	104	104	49	69
Biotite	4	162	64	63	10	11	1	p
Amphibole	p	12	10	—	1	2	p	—
Orthopyroxene	36	36	8	—	p	—	—	—
Clinopyroxene	—	9	—	—	—	p	—	—
Other (Pseudo-morphs)	—	—	—	—	—	—	—	—
Accessory Minerals (counts)⁶								
Fe-Ti Oxides	10	26	23	6	8	2	4	1
Apatite	—	2	—	—	—	—	—	—
Allanite	4	—	—	—	p	p	—	p
Perthite	—	—	—	—	—	—	—	—
Zircon	p	p	p	p	p	p	p	p
Sphene	—	—	p	—	—	—	—	—
Total Counts	11991	6090	6326	6219	7111	12446	10411	11443
Remarks	Hematite after magnetite; opx pseudomorphs	Hematite after magnetite; opx relicts	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite; rutile aggregates after ilmenite	Hematite after magnetite; rutile aggregates
Phenocryst Summary⁷								
% Phenocrysts	9.2	16.0	20.6	13.5	6.8	2.9	1.0	0.9
Rel. % Quartz	20	2	29	30	44	41	14	18
Rel. % Alk. Feld	61	1	17	23	30	29	36	21
Rel. % Plag.	29	97	64	47	27	30	50	60

APPENDIX A. (cont)

NE Yucca Mountain Area (Bites 2 and 4 on Fig. 1)

Field Number	DEB 5/91-7	DEB 5/91-8	DEB 5/91-9	DEB 5/91-10	DEB 5/91-12	DEB 5/91-11	DEB 3/90-36	DEB 3/90-37
LANL Number	438	439	440	441	443	442	182	183
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Tpt	Tpp	Tpp	Tpp	Tpp	Tpp	Tpp	Tpp
Lithology ²	b	nwt	nwt	pwt	nwt	pwt	pwt	nwt
Major Alteration ³	Zc, Zm, Op	Zc, Op	Zc, Op	Cx	Cx, Zm	Cx	Cx, Zc	Ol
Minor Alteration ³	Sm	Zm	Sm	Zm	Sm	Sm		Sm
Matrix Materials (counts)⁴								
Groundmass ⁵	6400	2796	3363	3218	3086	2732	3997	6636
Lithics	140	80	188	218	17	27	78	323
Voids >30µ	nd	210	188	242	369	318	360	nd
Colloidal Silica	—	—	—	—	—	—	—	—
Pumice Lapilli	4838	1347	1384	667	1136	1203	1128	—
Perlite Chips	98	10	6	41	38	8	36	73
Calcite	p	87	—	—	—	19	—	—
Phenocrysts (counts)⁴								
Quartz	5	10	—	4	7	4	7	22
Alkali Feldspar	27	208	142	182	267	126	221	169
Plagioclase	54	308	206	140	211	135	180	113
Biotite	4	33	16	24	18	10	19	28
Amphibole	—	—	—	—	—	—	—	—
Orthopyroxene	—	—	—	—	—	—	—	—
Clinopyroxene	—	4	—	2	1	—	2	6
Other (Pseudo-morphs)	—	—	—	—	31	—	—	—
Accessory Minerals (counts)⁶								
Fe-Ti Oxides	5	14	14	6	16	2	9	6
Apatite	—	—	—	—	—	—	—	—
Allanite	—	—	—	—	—	—	—	—
Perrierite	—	p	p	p	p	p	p	p
Zircon	p	p	p	p	p	p	p	p
Sphene	—	2	1	1	p	p	—	—
Total Counts	11560	5109	5487	4606	5168	4584	6036	6374
Remarks	Hematite after magnetite; rutile aggregates	Hematite after magnetite; rutile after ilmenite	Hematite after magnetite; rutile after ilmenite	Hematite after magnetite; rutile after ilmenite	Hematite and ilmenite	Hematite after magnetite; pseudobrookite(?) after ilmenite	Hematite after magnetite; rutile after ilmenite	Hematite after magnetite; rutile after ilmenite
Phenocryst Summary⁷								
% Phenocrysts	0.8	11.3	6.9	7.1	10.1	6.0	7.3	5.4
Rel. % Quartz	6	2	0	1	1	2	2	7
Rel. % Alk. Feld	31	40	41	51	55	48	54	56
Rel. % Plag.	63	59	59	47	44	51	44	37

APPENDIX A. (cont)

NE Yucca Mountain Area Cont

Field Number	DEB 3/90-38	DEB 3/90-39	DEB 3/90-40	DEB 3/90-41	DEB 3/90-42	DEB 3/90-43	DEB 3/91-13	DEB 3/91-14	DEB 3/91-15
LANE Number	184	186	188	187	188	189	444	445	446
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Tpp	Tpp	Tpp	Tpp	Ttd	T1b	T1b	T1b	T1b
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Major Alteration ³	Ql	Ql	Ql	Ql, Sm	Ql, Sm	Ql	Ql	Ql	Ql
Minor Alteration ³	Sm	Sm	Sm			Sm, Zc	Sm	Sm	Sm
Matrix Materials (counts)⁴									
Groundmass ⁵	5184	5587	9784	9634	8800	10871	7010	5384	4336
Lithics	8	30	133	34	230	589	871	40	14
Voids >30µ	nd	nd	nd	nd	nd	nd	37	nd	nd
Colloidal Silica	—	—	—	—	—	—	—	—	—
Pumice Lapilli	—	—	—	—	—	—	1800	4882	8884
Perlite Chips	22	7	16	44	405	218	525	588	288
Calotte	—	—	—	—	—	—	—	—	78
Phenocrysts (counts)⁴									
Quartz	3	1	8	1	5	11	8	7	0
Alkali Feldspar	188	140	207	120	135	202	288	308	308
Plagioclase	139	78	214	215	37	20	6	2	2
Biotite	17	18	26	19	4	2	—	—	—
Amphibole	—	—	—	p	2	4	3	7	5
Orthopyroxene	—	—	—	—	—	—	—	—	—
Clinopyroxene	p	3	1	1	1	—	—	—	—
Other (Pseudo-morphs)	—	—	2	—	—	—	—	—	—
Accessory Minerals (counts)⁶									
Fe-Ti Oxides	13	4	8	2	6	4	2	5	1
Apatite	p	—	—	—	—	—	—	—	—
Allanite	—	—	—	—	—	—	—	—	—
Perrierite	p	p	—	p	p	—	p	p	p
Zircon	p	p	p	p	p	p	p	p(?)	p(?)
Sphene	—	p	p	p	7	4	2	7	3
Total Counts	5525	5885	10400	10070	6332	11825	9950	10881	10717
Remarks	Hematite after magnetite, rutile after ilmenite	Hematite after magnetite, rutile	Hematite after magnetite, rutile	Hematite after magnetite, rutile	Hematite after magnetite, rutile	Magnetite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite
Phenocryst Summary⁷									
% Phenocrysts	6.2	4.1	4.5	3.6	3.0	2.0	3.1	3.0	2.9
Rel. % Quartz	1	0	2	0	3	5	3	2	0
Rel. % Alk. Feld	54	65	48	36	78	87	95	97	99
Rel. % Plag	45	35	50	64	21	9	2	1	1

APPENDIX A. (cont)

Stagecoach Road Area (Site 3 on Fig. 1)					Prow Pass Area (Southern Vertical Section; Site 5 on Fig. 1)			
Field Number	DES 3/80-1	DES 3/80-2	DES 3/80-2	DES 3/80-3	DES 3/80-11	DES 3/80-12	DES 3/80-13	DES 3/80-14
LANL Number	157	158	158	158	157	158	158	170
Split Number	T1A	T1A	T2A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Top	Top	Top	Twl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	nwt	nwt	b	b	nwt	nwt
Major Alteration ³	Zc, Op	Gl	Zc, Op	Cx	Zc, Op	Zc, Zm, Op	Zc, Op	Zc, Zm, Op
Minor Alteration ³	Zm, Sm	Zc, Sm, Op	Sm		Zm, Sm	Sm	Zm, Sm	Sm
Matrix Materials (counts)⁴								
Groundmass ⁵	4703	9706	4386	2000	2637	4066	4083	7178
Lithics	79	78	306	164	303	606	468	368
Voids >30μ	637	1608	421	nd	—	408	—	1192
Colloidal Silica	p	—	—	—	338	61	6	—
Pumice Lapilli	nd	nd	—	—	—	nd	—	2530
Perlite Chips	—	8	—	—	63	—	44	419
Calcite	24	p	3	—	—	p	—	p
Phenocrysts (counts)⁴								
Quartz	78	134	31	—	238	183	164	137
Alkali Feldspar	151	320	146	—	125	162	113	67
Plagioclase	167	315	169	243	327	254	71	78
Biotite	1	2	—	78	36	19	23	4
Amphibole	1	2	7	6	—	—	—	—
Orthopyroxene	8	6	4	1	—	—	—	—
Clinopyroxene	—	—	—	1	—	—	—	—
Other (Pseudo-morphs)	—	—	8	—	—	—	—	—
Accessory Minerals (counts)⁶								
Fe-Ti Oxides	12	9	7	15	3	2	7	p
Apatite	p	—	—	p	—	—	—	—
Allanite	p	p	p	—	—	—	—	—
Perovskite	—	—	—	—	—	—	—	—
Zircon	p	p	p	1	p	p	p	p
Sphene	—	p	—	—	—	—	—	—
Total Counts	6061	12187	5487	2509	4061	5689	4969	11963
Remarks	Mafic Pseudo-morphs; Hematite after magnetite; secondary opaques	Hematite after magnetite	Hematite after magnetite; bladed red-brown semi-opaque	Hematite after magnetite	Hematite; rutile aggregate	Hematite after magnetite	Hematite; rutile aggregate after limonite	Hematite
Phenocryst Summary⁷								
% Phenocrysts	6.9	6.5	6.6	13.7	18.0	11.1	7.6	2.4
Rel. % Quartz	20	17	9	0	34	32	47	49
Rel. % Alk. Feld	38	42	42	0	18	27	32	24
Rel. % Plag.	42	41	49	100	47	42	20	26

APPENDIX A. (cont)

Prox Pass Area (Southern Vertical Section) Cont.

Field Number	DEB 3/90-15	DEB 3/90-16	DEB 3/90-17	DEB 3/90-18	DEB 3/90-19	DEB 3/90-20	DEB 3/90-21	DEB 3/90-22	DEB 3/90-23
LANL Number	171	172	173	174	175	176	177	178	179
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Thl	Thl	Thl	Thl	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwl	nwl	nwl	nwl	nwl	nwl	nwl	nwl	nwl
Major Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Minor Alteration ³	Sm	Sm	Sm	Sm	Sm	Sm	Sm	Sm	Sm

Matrix Materials (counts)⁴

Groundmass ⁵	2783	3237	10626	6090	3301	4177	4257	3319	6134
Lithics	114	401	568	276	90	133	125	889	310
Voids >30µ	—	30	700	850	317	10	17	206	176
Colloidal Silica	8	30	8	298	317	10	17	206	—
Pumice Lapilli	1358	2284	nd	2540	2132	1547	1198	967	2296
Perlite Chips	318	428	136	338	84	143	119	148	968
Calcite	—	—	—	—	—	—	—	—	—

Phenocrysts (counts)⁴

Quartz	62	77	111	71	47	44	80	66	87
Alkali Feldspar	53	50	71	93	40	27	34	42	64
Plagioclase	63	35	64	123	30	16	33	29	74
Biotite	2	2	6	6	4	2	2	1	5
Amphibole	—	—	—	—	—	—	—	—	—
Orthopyroxene	—	—	—	—	—	—	—	—	—
Clinopyroxene	—	—	—	—	—	—	—	—	—
Other (Pseudomorphs)	—	—	18	—	—	—	—	—	—

Accessory Minerals (counts)⁶

Fe-Ti Oxides	3	p	3	3	—	1	1	2	3
Apatite	—	—	—	—	—	—	—	—	—
Albite	—	—	2	—	—	—	—	—	p
Perovskite	—	—	—	—	—	—	—	—	—
Zircon	p	p	p	p	—	p	p	—	p
Sphene	—	—	—	—	—	—	—	—	—

Total Counts	4772	6544	12213	10888	6046	6100	5866	5689	12117
--------------	------	------	-------	-------	------	------	------	------	-------

Remarks	Hematite after magnetite; rutile after ilmenite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Magnetite	Hematite	Hematite after magnetite
---------	---	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	-----------	----------	--------------------------

Phenocryst Summary⁷

% Phenocrysts	3.8	2.5	2.1	2.8	2.0	1.5	2.6	2.5	1.9
Rel. % Quartz	35	48	45	25	40	51	54	48	39
Rel. % Alk. Feld	30	31	29	32	34	31	23	31	28
Rel. % Plag.	35	22	26	43	26	18	22	21	33

APPENDIX A. (cont)

Prow Pass Area (Southern Vertical Section) Cont.

Field Number	DEB 3/90-24	DEB 3/90-25	DEB 3/90-26	DEB 3/90-27	DEB 3/90-28	DEB 3/90-29	DEB 3/90-30	DEB 3/90-31
LANL Number	180	181	182	183	184	185	186	187
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
Lithology ²	nwt	nwt	b	nwt	nwt	nwt	b	nwt
Major Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Minor Alteration ³	Sm	Sm	Sm	Sm	Sm	Sm	Sm	Sm
<u>Matrix Materials (counts)⁴</u>								
Groundmass ⁵	4158	5640	4358	6133	5565	3324	5127	7350
Lithics	138	83	725	414	161	376	175	134
Voids >30μ	nd	nd	nd	150	82	48	nd	656
Colloidal Silica	183	—	57	p	—	—	14	—
Pumice Lapilli	1795	—	—	3555	—	1247	—	2682
Perlite Chips	—	243	481	348	197	556	113	290
Calcite	—	—	—	—	—	—	—	—
<u>Phenocrysts (counts)⁴</u>								
Quartz	36	64	142	123	45	77	67	29
Alkali Feldspar	8	91	76	110	51	62	74	33
Plagioclase	15	26	41	19	33	16	36	39
Biotite	1	2	5	8	9	4	2	5
Amphibole	—	—	—	—	—	—	—	—
Orthopyroxene	—	—	—	—	—	—	—	—
Clinopyroxene	—	p	—	—	—	—	—	—
Other (Pseudo-morphs)	—	—	—	—	—	—	—	—
<u>Accessory Minerals (counts)⁶</u>								
Fe-Ti Oxides	p	1	2	2	5	1	2	4
Apatite	—	—	—	—	—	—	—	—
Allanite	—	—	p	—	4	p	—	—
Perrierite	—	—	—	—	—	—	—	—
Zircon	p	p	p	p	p	p	p	p
Sphene	—	—	—	—	—	—	—	—
Total Counts	6334	6150	5887	10862	6152	5711	5610	11222
Remarks	Hematite after magnetite	Hematite	Hematite and goethite	Hematite after magnetite	Hematite	Hematite after magnetite	Hematite after magnetite; rutile after ilmenite	Hematite after magnetite; ilmenite
<u>Phenocryst Summary⁷</u>								
% Phenocrysts	0.9	3.0	4.5	2.4	2.3	2.8	3.2	1.0
Rel. % Quartz	61	35	55	49	35	50	38	29
Rel. % Alk. Feld	14	50	29	44	40	40	42	33
Rel. % Plag.	25	14	16	8	26	10	20	39

APPENDIX A. (cont)

Prow Pass Area (Southern Vertical Section) Cont.					Prow Pass Area (N-S Lateral Section; Site 5 on Fig. 1)				
Field Number	DEB 3/90-32	DEB 3/90-33	DEB 3/90-34	DEB 3/90-35	CRPP-1-SNL	CRPP-2-SNL	CRPP-3-SNL	CRPP-4-SNL	CRPP-5-SNL
LANL Number	188	189	190	191	126	127	128	129	130
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Thl	Tpt	Tpt	Tpt	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	vt	vt	nwt	nwt	nwt	nwt	nwt
Major Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Gl, Zc, Zm, Op	Gl	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Minor Alteration ³	Sm	Sm		Op				Sm	Sm
Matrix Materials (counts)⁴									
Groundmass ⁵	8558	10248	11172	11759	10578	3796	5190	3458	3052
Lithics	582	60	230	69	942	720	470	76	59
Voids >30μ	870	nd	nd	nd	344	346	208	nd	nd
Colloidal Silica	—	—	—	—	—	—	—	64	356
Pumice Lapilli	2242	—	—	—	nd	3872	5582	2213	1726
Perlite Chips	194	80	—	—	554	1876	524	153	116
Calcite	—	—	—	—	—	68	16	—	—
Phenocrysts (counts)⁴									
Quartz	39	0	7	9	128	109	115	18	39
Alkali Feldspar	30	5	15	26	114	113	101	56	24
Plagioclase	119	25	20	91	74	56	37	31	19
Biotite	4	3	1	1	4	3	4	6	3
Amphibole	—	—	p	—	p	—	—	—	—
Orthopyroxene	—	—	—	—	—	—	—	—	—
Clinopyroxene	—	—	—	—	—	—	—	—	—
Other (Pseudomorphs)	—	—	—	—	—	—	—	—	—
Accessory Minerals (counts)⁶									
Fe-Ti Oxides	5	5	3	5	1	1	1	1	p
Apatite	—	—	—	—	—	—	—	—	—
Albite	p	p	—	p	5	—	—	—	1
Perrierite	—	—	—	—	—	—	—	—	—
Zircon	p	p	p	p	p	p	p	p	p
Sphene	—	—	—	—	—	—	—	—	—
Total Counts	12643	10426	11448	11960	12744	10960	12248	6076	5395
Remarks	Hematite after magnetite; maghemite(?)	Hematite after magnetite; rutile with ilmenite relicts	Hematite after magnetite; rutile after ilmenite	Hematite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite
Phenocryst Summary⁷									
% Phenocrysts	1.6	0.4	0.4	1.1	2.5	2.6	2.1	1.8	1.6
Rel. % Quartz	21	0	17	7	41	39	45	17	48
Rel. % Alk. Feld	16	17	36	21	36	41	40	53	29
Rel. % Plag.	63	83	48	72	23	20	15	30	23

APPENDIX A. (cont)

Pross Pass Area (N-S Lateral Section) Cont.

Field Number	CRPP-6-SNL	CRPP-7-SNL	CRPP-8-SNL	CRPP-9-SNL	CRPP-10-SNL	CRPP-11-SNL	CRPP-12-SNL	CRPP-13-SNL	CRPP-14-SNL
LANL Number	131	132	133	134	135	136	137	138	139
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Major Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Minor Alteration ³	Sm	Sm		Sm	Sm	Sm	Sm	Sm	Sm
<u>Matrix Materials (counts)⁴</u>									
Groundmass ⁵	3195	5752	6896	5976	7533	5464	6018	6288	6296
Lithics	617	270	677	268	225	334	396	198	187
Voids >30µ	nd	nd	nd	nd	nd	nd	nd	nd	nd
Colloidal Silica	3	317	92	1204	68	46	—	242	12
Pumice Lapilli	1545	4660	2780	3414	3494	4524	4144	3758	3095
Perlite Chips	266	184	279	232	235	990	336	396	213
Calcite	42	—	—	98	—	—	p	—	—
<u>Phenocrysts (counts)⁴</u>									
Quartz	49	111	69	59	79	122	140	74	78
Alkali Feldspar	49	64	60	47	65	79	83	64	112
Plagioclase	17	39	64	26	25	83	22	25	61
Biotite	1	7	14	7	4	4	1	1	6
Amphibole	—	—	—	—	—	—	—	—	—
Orthopyroxene	—	—	—	—	—	—	—	—	—
Clinopyroxene	—	—	—	—	—	—	—	—	—
Other (Pseudo-morphs)	—	—	—	—	—	—	—	—	—
<u>Accessory Minerals (counts)⁶</u>									
Fe-Ti Oxides	p	1	1	p	1	p	2	2	5
Apatite	—	—	—	—	—	—	—	—	—
Allanite	—	—	—	—	—	—	—	—	—
Perrierite	—	—	—	—	—	—	—	—	—
Zircon	p	p	p	—	p	p	p	—	—
Sphene	—	—	—	—	—	—	—	—	—
Total Counts	5784	11405	10932	11331	11729	11646	11142	11048	10065
Remarks	Hematite after magnetite	Hematite after magnetite and maghemite (?)	Hematite after magnetite and maghemite (?)	Hematite after magnetite and maghemite (?)	Hematite after magnetite; maghemite (?)	Hematite after magnetite and maghemite (?)	Hematite after magnetite and maghemite (?)	Hematite after magnetite and maghemite (?)	Hematite after magnetite and maghemite (?)
<u>Phenocryst Summary⁷</u>									
% Phenocrysts	2	1.9	1.9	1.2	1.5	2.5	2.2	1.5	2.6
Rel. % Quartz	43			45	47	43	57	45	31
Rel. % Alk. Feld	43	52	36	36	38	28	34	39	45
Rel. % Plag.	15	30	31	20	15	29	9	15	24
		18	33						

APPENDIX A. (cont)

Prox Pass Area (N-S Lateral Section) Cont.

Field Number	CRPP-15-SNL	CRPP-16-SNL	CRPP-17-SNL	CRPP-18-SNL	CRPP-19-SNL	CRPP-20-SNL	CRPP-21-SNL	CRPP-22-SNL	CRPP-23-SNL
LANL Number	140	141	142	143	144	145	146	147	148
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Thl	Thl	Thl	Thl	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Major Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Minor Alteration ³	Sm	Sm	Sm	Sm	Sm	Sm	Sm	Sm	Sm
<u>Matrix Materials (counts)⁴</u>									
Groundmass ⁵	5412	5314	8034	5348	5862	5834	6260	4792	3641
Lithics	170	216	456	158	504	388	1538	584	232
Voids >30µ	nd	nd	nd	nd	nd	168	nd	nd	nd
Colloidal Silica	8	—	—	2	54	—	50	2	—
Pumice Lapilli	5915	2922	3454	2918	3982	3108	3672	4524	1350
Perlite Chips	215	286	436	314	236	162	342	228	143
Calcite	—	—	88	—	24	14	p	p	—
<u>Phenocrysts (counts)⁴</u>									
Quartz	73	65	116	72	118	125	101	111	198
Alkali Feldspar	58	66	112	78	98	72	62	142	160
Plagioclase	56	52	84	14	72	75	48	61	52
Biotite	3	8	7	3	7	7	5	4	8
Amphibole	—	—	—	—	—	—	—	—	—
Orthopyroxene	—	—	—	—	—	—	—	—	—
Clinopyroxene	—	p(?)	—	—	—	—	—	—	—
Other (Pseudo-morphs)	—	—	—	—	—	—	—	—	6
<u>Accessory Minerals (counts)⁶</u>									
Fe-Ti Oxides	2	1	2	2	6	5	p	2	3
Apatite	—	—	—	—	—	—	—	—	—
Albite	—	p	—	—	—	—	—	—	p
Perrierite	—	—	—	—	—	—	—	—	—
Zircon	—	—	—	p	p	p	p	—	—
Sphene	—	—	—	—	—	—	—	—	—
Total Counts	11910	8930	12779	8909	10963	9958	12078	10450	5793
Remarks	Hematite after magnetite; rutile and magnetite (?)	Hematite after magnetite and magnetite (?)	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite; goethite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite	Hematite after magnetite; goethite (?)
<u>Phenocryst Summary⁷</u>									
% Phenocrysts	1.6	2.2	2.5	1.9	2.7	2.9	1.8	3.1	7.3
Rel. % Quartz	39	36	37	44	41	46	48	35	48
Rel. % Alk. Feld	31	36	36	48	34	26	29	45	39
Rel. % Plag.	30	28	27	9	25	28	23	19	13

APPENDIX A. (cont)

Prow Pass Area (N-S Lateral Section) Cont.

Field Number	CRPP-24-SNL	CRPP-25-SNL	CRPP-26-SNL	CRPP-27-SNL	CRPP-28-SNL	CRPP-29-SNL	CRPP-30-SNL	CRPP-31-SNL
LANL Number	149	150	151	152	153	154	155	156
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Thl	Thl	Thl	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Major Alteration ³	Zc, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Minor Alteration ³	Zm, Sm	Sm	Sm		Sm	Sm	Sm	Sm

Matrix Materials (counts)⁴

Groundmass ⁵	3300	4730	4639	9154	3275	5432	2851	5792
Lithics	62	782	449	996	393	1122	252	626
Voids >30μ	nd	nd	nd	540	nd	nd	nd	nd
Colloidal Silica	1	—	96	—	21	4	—	150
Pumice Lapilli	2346	3614	4551	nd	1777	3504	2106	3164
Perlite Chips	171	792	336	844	214	736	139	666
Calclite	—	—	—	—	—	—	—	—

Phenocrysts (counts)⁴

Quartz	139	307	192	290	208	268	118	257
Alkali Feldspar	69	237	160	208	151	166	142	191
Plagioclase	132	65	82	115	60	121	62	70
Biotite	30	21	19	13	13	21	5	19
Amphibole	—	—	—	—	—	—	—	—
Orthopyroxene	—	—	—	—	—	—	—	—
Clinopyroxene	p	—	—	—	—	—	—	—
Other (Pseudo-morphs)	—	32	—	—	—	—	—	—

Accessory Minerals (counts)⁶

Fe-Ti Oxides	5	5	3	7	2	1	2	4
Apatite	—	—	—	—	—	—	—	—
Allanite	—	p	—	—	—	—	—	p
Perrierite	—	—	—	—	—	—	—	—
Zircon	p	p	p	p	p	p	p	p
Sphene	—	—	—	—	—	—	—	—

Total Counts	6255	10585	10527	12165	6114	11377	5677	10941
--------------	------	-------	-------	-------	------	-------	------	-------

Remarks	Hematite after magnetite	Hematite and rutile aggregate	Hematite and rutile aggregate; epidote crystal	Hematite after magnetite; rutile aggregate after ilmenite; chalcedony	Hematite; rutile and goethite aggregate	Hematite and rutile aggregate	Hematite and rutile aggregate; white mica crystal	Hematite and rutile aggregate
---------	--------------------------	-------------------------------	--	---	---	-------------------------------	---	-------------------------------

Phenocryst Summary⁷

% Phenocrysts	6.0	6.0	4.3	5.2	7.1	5.1	5.8	4.9
Rel. % Quartz	41	50	44	47	50	48	37	50
Rel. % Alk. Feld	20	39	37	34	36	30	44	37
Rel. % Plag.	39	11	19	19	14	22	19	14

APPENDIX A. (cont)

Calico Hills Area (E-W Lateral Section; Site 6 on Fig. 1)

Field Number	CRCH-1-SNL	CRCH-2-SNL	CRCH-3-SNL	CRCH-4-SNL	CRCH-5-SNL	CRCH-6-SNL	CRCH-7-SNL
LANL Number	116	117	118	119	120	121	122
Split Number	T1A	T1A	T1A	T1A	T1A	T1A	T1A
Geol. Unit ¹	Tht	Tht	Tht	Tht	Tht	Tht	Tht
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Major Alteration ³	Kf, Zm, Op,	Kf, Zm, Op,	Kf, Zm, Op,	Kf, Zm, Op	Kf, Zm, Op	Kf, Op	Kf, Zm
Minor Alteration ³	Ka	Ka	Ka			Zm, Ka	Ka
Matrix Materials (counts)⁴							
Groundmass ⁵	10276	8973	10062	6774	4620	5956	5076
Lithics	310	1079	764	206	512	994	690
Voids >30μ	300	648	152	504	406	554	1004
Colloidal Silica	—	—	—	—	—	—	—
Pumice Lapilli	nd	nd	nd	2946	4810	4196	4760
Perlite Chips	—	—	—	—	70	190	50
Calcite	230	12	110	146	62	44	18
Phenocrysts (counts)⁴							
Quartz	25	63	41	72	49	40	43
Alkali Feldspar	34	64	50	30	91	67	62
Plagioclase	42	154	63	72	96	62	65
Biotite	4	4	2	11	5	6	1
Amphibole	—	—	—	—	—	—	—
Orthopyroxene	—	—	—	—	—	—	—
Clinopyroxene	—	—	—	—	—	—	—
Other (Pseudo-morphs)	14	2	5	—	1	4	2
Accessory Minerals (counts)⁶							
Fe-Ti Oxides	6	p	p	p	11	4	2
Apatite	—	—	—	—	—	—	—
Albite	—	—	—	—	—	—	—
Perrierite	—	—	—	—	—	—	—
Zircon	—	p	p	—	p	p	p
Sphene	—	—	—	—	—	—	—
Total Counts	11241	10999	11249	10761	10733	12117	11773
Remarks	Adularia overgrowth on plagioclase phenocrysts	Mafic Pseudo-morphs; altered opaques	Mafic Pseudo-morphs; altered opaques	Altered opaques	Mafic Pseudo-morphs; altered opaques	Mafic Pseudo-morphs; secondary opaques	Pyroxene (?); secondary opaques (?)
Phenocryst Summary⁷							
% Phenocrysts	1.1	2.6	1.4	1.7	2.4	1.5	1.5
Rel. % Quartz	25	22	27	41	21	24	25
Rel. % Alk. Feld.	34	23	32	17	39	40	36
Rel. % Plag.	42	55	41	41	41	37	38

APPENDIX A. (cont)

Calico Hills Area (E-W Lateral Section) Cont.

Field Number	CRCH-8-SNL	CRCH-9-SNL	CRCH-10-SNL
LANL Number	123	124	125
Split Number	T1A	T1A	T1A
Geol. Unit ¹	Tht	Tht	Tht
Lithology ²	nwt	nwt	nwt
Major Alteration ³	Kf, Zc, Zm, Op,	Kf, Zm, Op,	Kf, Zc, Zm, Op,
Minor Alteration ³	Ka	Zc, Ka	Ka

Matrix Materials (counts)⁴

Groundmass ⁵	9616	5234	4614
Lithics	182	470	632
Voids >30μ	390	610	18
Colloidal Silica	—	—	—
Pumice Lapilli	nd	3852	3380
Perlite Chips	30	362	508
Calcite	6	322	—

Phenocrysts (counts)⁴

Quartz	142	105	68
Alkali Feldspar	161	66	58
Plagioclase	112	132	50
Biotite	1	—	2
Amphibole	—	—	—
Orthopyroxene	—	—	—
Clinopyroxene	—	—	—
Other (Pseudo-morphs)	20	5	6

Accessory Minerals (counts)⁶

Fe-Ti Oxides	9	4	2
Apatite	—	—	—
Allanite	—	—	—
Perrierite	—	—	—
Zircon	p	p	p
Sphene	—	—	—

Total Counts	10668	11163	9372
--------------	-------	-------	------

Remarks	Fe-Mn oxides (?); secondary opaques (?)	Mafic Pseudo- morphs; secondary opaques	Mafic Pseudo- morphs; secondary opaques
---------	---	--	--

Phenocryst Summary⁷

% Phenocrysts	4.0	2.8	1.9
Rel. % Quartz	34	35	39
Rel. % Alk. Feld.	39	22	33
Rel. % Plag.	27	44	28

¹ Geol. Unit: Ttp = Prow Pass Member, Twl = Wahmonie Formation (lower part), Tht = tuffaceous beds of Calico Hills, Tpt = Topopah Spring Member, Tpp = Pah Canyon Member, Tfd = rhyolite of Delirium Canyon, Tfb = rhyolite of Black Glass Canyon.

² Lithology: nwt = nonwelded tuff, mostly pyroclastic flows but may include massive ash-fall and reworked tuffs; pwt = partially-welded ash-flow tuff; mwt = moderately-welded ash-flow tuff; vt = vitrophyric tuff; b = bedded tuff, individual beds characterized by internal stratification.

³ Major and Minor Alteration: Gl = glassy, Zc = clinoptilolite zeolites, Zm = mordenite zeolites, Sm = smectite, Op = opal-CT, Kf = adularia, Ka = kaolinite, Cx = post-emplacement, high-temperature crystallization.

⁴ Numbers in columns indicate the number of times these matrix materials and phenocrysts were hit in the point count; p = present but not hit during point counted; nd = not determined; — = not present.

⁵ Includes both shards and pumice in samples where pumice is not counted separately.

⁶ For Fe-Ti oxides, numbers in columns indicate the number of times these minerals were hit in the point count; for all other accessory minerals, the number in the columns is a tally of all grains seen in thin section; p = present but not hit during point count or counted as part of tally; — = not present.

⁷ Relative percents are percents of felsic phenocrysts (quartz + alkali feldspar + plagioclase).

APPENDIX B. X-RAY DIFFRACTION ANALYSES OF NONWELDED TUFFS FROM OUTCROP, YUCCA MOUNTAIN, NEVADA¹

Field Number	Lab. Number	Geol. Unit	Liht- ology	Smeo- the	Clinop- the	Morden- the	Quartz	Cristo- balle	Opal- CT	Trid- mils	Feldspar	Mica	Horn- blende	Catche	Hem- sille	Glass	Kaolin- the	Gypsum	Total
Busted Butte Area (Southeastern Side; Site 1 on Fig. 1)																			
DEB 390-4	180.P1A	Twl	net	4 ± 1	—	—	2 ± 1	5 ± 1	—	—	24 ± 3	17 ± 5	—	—	2 ± 1	46 ± 6	—	—	100 ± 6
DEB 390-5	161.P1A	Twl	net	5 ± 2	—	—	1 ± 1	4 ± 1	—	—	28 ± 3	9 ± 3	—	—	1 ± 1	54 ± 5	—	—	100 ± 5
DEB 390-6	162.P1A	Th	net	1 ± 1	12 ± 1	—	7 ± 1	1 ± 1	—	—	16 ± 2	1 ± 1	—	—	—	62 ± 3	—	—	100 ± 3
DEB 390-7	163.P1A	Th	net	3 ± 1	1 ± 1	—	7 ± 1	1 ± 1	—	—	12 ± 1	—	—	—	—	76 ± 2	—	—	100 ± 2
DEB 390-8	164.P1A	Th	b	—	—	—	1 ± 1	1 ± 1	—	—	1 ± 1	—	—	—	—	97 ± 2	—	—	100 ± 2
DEB 390-9	164.P2A	Th	b	1 ± 1	—	—	4 ± 1	1 ± 1	—	—	7 ± 1	—	—	1 ± 1	—	86 ± 2	—	—	100 ± 2
DEB 390-10	165.P1A	Th	net	6 ± 2	—	—	4 ± 1	1 ± 1	—	—	15 ± 2	—	—	—	—	74 ± 3	—	—	100 ± 3
DEB 390-11	166.P1A	Th	b	1 ± 1	—	—	2 ± 1	—	—	—	11 ± 1	—	—	—	—	86 ± 2	Tr	—	100 ± 2
Busted Butte Area (Northern End; Site 1 on Fig. 1)																			
DEB 390-44	200.P1A	Top	net	6 ± 2	—	—	3 ± 1	—	—	—	21 ± 2	—	—	—	—	70 ± 3	—	—	100 ± 3
DEB 390-45	201.P1A	Twl	net	7 ± 2	—	—	4 ± 1	6 ± 1	—	—	26 ± 3	4 ± 1	—	—	1 ± 1	52 ± 4	—	—	100 ± 4
DEB 390-46	202.P1A	Th	b	1 ± 1	—	—	8 ± 1	2 ± 1	—	—	23 ± 2	2 ± 1	—	—	—	57 ± 4	—	—	100 ± 4
DEB 390-47	203.P1A	Th	b	2 ± 1	—	—	7 ± 1	—	—	—	16 ± 2	—	—	—	—	74 ± 3	—	—	100 ± 3
DEB 390-48	204.P1A	Th	net	4 ± 1	1 ± 1	—	6 ± 1	1 ± 1	—	—	10 ± 1	—	—	—	—	78 ± 2	—	—	100 ± 2
DEB 390-49	205.P1A	Th	net	5 ± 2	—	—	4 ± 1	1 ± 1	—	—	11 ± 1	—	—	—	—	79 ± 3	—	—	100 ± 3
DEB 390-50	206.P1A	Tpt	net	—	—	—	1 ± 1	—	—	—	4 ± 1	—	—	—	—	95 ± 1	—	—	100 ± 1
DEB 491-1	432.P1	Tpt	net	96 ± 6	—	—	Tr	—	4 ± 1	—	—	—	—	—	—	—	—	—	102 ± 6
Northwest Yucca Mountain Area (Sites 2 and 4 on Fig. 1)																			
DEB 591-7	438.P1	Tpt	b	1 ± 1	74 ± 10	13 ± 4	3 ± 1	—	11 ± 2	—	2 ± 1	—	—	Tr	—	—	—	—	104 ± 11
DEB 591-8	439.P1	Tpp	net	Tr	68 ± 8	8 ± 2	Tr	—	11 ± 3	—	7 ± 2	1 ± 1	—	Tr	—	—	—	—	95 ± 9
DEB 591-9	440.P1	Tpp	net	2 ± 1	75 ± 5	—	Tr	—	11 ± 3	—	10 ± 2	—	—	Tr	—	—	—	—	99 ± 6
DEB 591-10	441.P1	Tpp	net	Tr	—	2 ± 1	2 ± 1	22 ± 2	—	2 ± 1	72 ± 10	2 ± 1	—	Tr	Tr	—	—	—	102 ± 10
DEB 591-12	443.P1	Tpp	net	1 ± 1	—	10 ± 3	1 ± 1	24 ± 2	—	—	68 ± 1	1 ± 1	—	Tr	Tr	—	—	—	105 ± 12
DEB 591-11	442.P1	Tpp	net	2 ± 1	—	—	1 ± 1	20 ± 2	—	—	69 ± 6	1 ± 1	—	Tr	Tr	—	—	—	96 ± 8
DEB 390-36	192.P1A	Tpp	net	Tr	37 ± 2	—	Tr	18 ± 1	—	—	42 ± 7	1 ± 1	—	Tr	—	—	—	—	98 ± 7
DEB 390-37	193.P1A	Tpp	net	1 ± 1	—	—	Tr	1 ± 1	—	—	13 ± 2	1 ± 1	—	Tr	1 ± 1	83 ± 3	—	—	100 ± 3
DEB 390-38	194.P1A	Tpp	net	2 ± 1	—	—	Tr	Tr	—	—	12 ± 1	2 ± 1	—	Tr	Tr	84 ± 2	—	—	100 ± 2
DEB 390-39	195.P1A	Tpp	net	4 ± 1	—	—	Tr	Tr	—	—	10 ± 1	1 ± 1	—	Tr	Tr	85 ± 2	—	—	100 ± 2
DEB 390-40	196.P1A	Tpp	net	7 ± 2	—	—	Tr	Tr	—	—	14 ± 2	2 ± 1	—	Tr	Tr	77 ± 3	—	—	100 ± 3
DEB 390-41	197.P1A	Tpp	net	11 ± 3	—	—	1 ± 1	1 ± 1	—	—	17 ± 2	2 ± 1	—	Tr	Tr	68 ± 4	—	—	100 ± 4
DEB 390-42	198.P1A	Ttd	net	17 ± 5	—	—	3 ± 1	1 ± 1	—	—	16 ± 2	Tr	—	Tr	Tr	63 ± 6	—	—	100 ± 6
DEB 390-43	199.P1A	Ttd	net	1 ± 1	2 ± 1	—	3 ± 1	Tr	—	—	27 ± 3	Tr	—	Tr	Tr	67 ± 3	—	—	100 ± 3
DEB 591-13	444.P1	Ttd	net	9 ± 3	—	—	Tr	Tr	—	—	11 ± 1	—	—	Tr	Tr	80 ± 3	—	—	100 ± 3
DEB 591-14	445.P1	Ttd	net	8 ± 2	—	—	Tr	Tr	—	—	10 ± 1	—	—	Tr	Tr	81 ± 2	—	—	100 ± 2
DEB 591-15	446.P1	Ttd	net	9 ± 3	—	—	Tr	Tr	—	—	9 ± 1	—	—	Tr	Tr	82 ± 3	—	—	100 ± 3
Stagecoach Road Area (Site 3 on Fig. 1)																			
DEB 390-1	157.P1A	Top	net	3 ± 1	64 ± 6	3 ± 1	3 ± 1	—	15 ± 4	—	10 ± 2	—	—	Tr	Tr	—	—	—	98 ± 8
DEB 390-2	158.P1A	Top	net	6 ± 2	5 ± 1	—	4 ± 1	—	2 ± 1	—	14 ± 2	—	—	Tr	Tr	68 ± 3	—	—	100 ± 3
DEB 390-2	158.P2A	Top	net	5 ± 2	68 ± 5	—	2 ± 1	—	13 ± 3	—	9 ± 2	—	—	Tr	Tr	—	—	—	97 ± 7

APPENDIX B. (cont)

Field Number	Lab. Number	Geol. Unit	Lithology	Smectite	Chlorite	Mordenite	Quartz	Cristobalite	Opal-CT	Tridymite	Feldspar	Mica	Hornblende	Calcite	Hemimorphite	Glass	Kaolinite	Gypsum	Total
<i>Prow Pass Area (Southern Vertical Section; Site 6 on Fig. 1)</i>																			
DEB 390-11	167.P1A	Thd	b	2 ± 1	33 ± 3	5 ± 2	15 ± 1	4 ± 1	20 ± 6	—	22 ± 4	3 ± 1	—	—	—	—	—	—	104 ± 8
DEB 390-12	168.P1A	Thd	b	5 ± 2	34 ± 5	10 ± 4	10 ± 1	—	25 ± 7	—	16 ± 3	2 ± 1	—	—	—	—	—	—	102 ± 10
DEB 390-13	169.P1A	Thd	net	1 ± 1	51 ± 6	7 ± 2	8 ± 1	—	23 ± 6	—	11 ± 2	1 ± 1	—	—	—	—	—	—	102 ± 9
DEB 390-14	170.P1A	Thd	net	3 ± 1	36 ± 7	25 ± 8	5 ± 1	—	20 ± 5	—	12 ± 3	Tr	—	—	—	—	—	—	101 ± 12
DEB 390-15	171.P1A	Thd	net	3 ± 1	40 ± 8	24 ± 8	5 ± 1	—	19 ± 5	—	13 ± 4	Tr	—	—	—	—	—	—	104 ± 13
DEB 390-16	172.P1A	Thd	net	1 ± 1	37 ± 8	29 ± 7	5 ± 1	—	20 ± 5	—	5 ± 2	Tr	—	—	—	—	—	—	97 ± 12
DEB 390-17	173.P1A	Thd	net	2 ± 1	41 ± 9	31 ± 9	4 ± 1	—	15 ± 3	—	3 ± 1	Tr	—	—	—	—	—	—	96 ± 13
DEB 390-18	174.P1A	Thd	net	1 ± 1	44 ± 9	24 ± 6	3 ± 1	—	19 ± 4	—	5 ± 1	Tr	—	—	—	—	—	—	96 ± 12
DEB 390-19	175.P1A	Thd	net	1 ± 1	49 ± 10	24 ± 7	3 ± 1	—	17 ± 4	—	6 ± 2	—	—	—	—	—	—	—	100 ± 13
DEB 390-20	176.P1A	Thd	net	1 ± 1	36 ± 8	30 ± 8	3 ± 1	—	16 ± 4	—	10 ± 3	—	—	—	—	—	—	—	96 ± 12
DEB 390-21	177.P1A	Thd	net	2 ± 1	42 ± 10	31 ± 9	4 ± 1	—	15 ± 3	—	6 ± 2	Tr	—	—	—	—	—	—	100 ± 14
DEB 390-22	178.P1A	Thd	net	1 ± 1	39 ± 8	16 ± 4	6 ± 1	—	26 ± 7	—	11 ± 3	—	—	—	—	—	—	—	99 ± 11
DEB 390-23	179.P1A	Thd	net	1 ± 1	51 ± 8	15 ± 4	4 ± 1	—	20 ± 5	—	6 ± 1	—	—	—	—	—	—	—	97 ± 10
DEB 390-24	180.P1A	Thd	net	1 ± 1	54 ± 8	15 ± 4	1 ± 1	—	22 ± 5	—	3 ± 1	—	—	—	—	—	—	—	96 ± 10
DEB 390-25	181.P1A	Thd	net	2 ± 1	54 ± 9	16 ± 5	1 ± 1	—	19 ± 4	—	3 ± 1	—	—	—	—	—	—	—	95 ± 11
DEB 390-26	182.P1A	Thd	b	1 ± 1	55 ± 8	13 ± 4	6 ± 1	—	20 ± 5	—	9 ± 2	—	—	—	—	—	—	—	104 ± 11
DEB 390-27	183.P1A	Thd	net	2 ± 1	43 ± 9	28 ± 6	4 ± 1	—	14 ± 3	—	7 ± 2	—	—	—	—	—	—	—	98 ± 13
DEB 390-28	184.P1A	Thd	net	2 ± 1	47 ± 9	24 ± 7	4 ± 1	—	15 ± 3	—	5 ± 1	Tr	—	—	—	—	—	—	97 ± 12
DEB 390-29	185.P1A	Thd	net	—	48 ± 9	22 ± 6	4 ± 1	—	17 ± 4	—	5 ± 1	—	—	—	—	—	—	—	96 ± 12
DEB 390-30	186.P1A	Thd	b	—	41 ± 7	18 ± 4	5 ± 1	—	32 ± 7	—	6 ± 1	Tr	—	—	—	—	—	—	102 ± 11
DEB 390-31	187.P1A	Thd	net	1 ± 1	58 ± 11	25 ± 7	Tr	—	10 ± 2	—	2 ± 1	—	—	—	—	—	—	—	96 ± 13
DEB 390-32	188.P1A	Thd	net	2 ± 1	60 ± 12	25 ± 8	2 ± 1	—	11 ± 2	—	—	—	—	—	—	—	—	—	100 ± 15
DEB 390-33	189.P1A	Tpt	net	1 ± 1	71 ± 11	16 ± 5	—	—	13 ± 3	—	—	—	—	—	—	—	—	—	101 ± 12
DEB 390-34	190.P1A	Tpt	vt	—	17 ± 2	9 ± 2	1 ± 1	—	12 ± 3	—	7 ± 1	—	—	—	—	54 ± 4	—	—	100 ± 4
DEB 390-35	191.P1A	Tpt	vt	Tr	—	—	Tr	—	6 ± 1	—	5 ± 1	Tr	—	—	—	89 ± 1	—	—	100 ± 1
<i>Prow Pass Area (Central Vertical Section; Site 5 on Fig. 1)</i>																			
3-15-82-1	82.P1A	Thd	net	1 ± 1	24 ± 3	10 ± 3	17 ± 1	—	20 ± 7	—	27 ± 5	3 ± 1	—	—	—	—	—	—	102 ± 10
3-15-82-2	83.P1A	Thd	b	1 ± 1	42 ± 3	12 ± 3	6 ± 1	—	30 ± 9	—	4 ± 1	Tr	—	—	—	—	—	—	104 ± 12
3-15-82-3	84.P1A	Thd	b	2 ± 1	39 ± 7	18 ± 5	9 ± 1	—	19 ± 5	—	13 ± 3	—	—	—	—	—	—	—	100 ± 10
3-15-82-4	85.P1A	Thd	b	4 ± 1	29 ± 6	27 ± 9	5 ± 1	—	16 ± 4	—	18 ± 5	—	—	—	—	—	—	1 ± 1	98 ± 13
3-15-82-5	86.P1A	Thd	net	1 ± 1	16 ± 4	38 ± 9	5 ± 1	—	28 ± 8	—	15 ± 5	Tr	—	—	—	—	—	—	103 ± 14
3-15-82-6	87.P1A	Thd	net	5 ± 2	50 ± 9	22 ± 8	4 ± 1	—	13 ± 3	—	5 ± 1	Tr	—	—	—	—	—	—	98 ± 13
3-15-82-7	88.P1A	Thd	net	1 ± 1	45 ± 11	33 ± 9	3 ± 1	—	14 ± 3	—	2 ± 1	—	—	—	—	—	—	—	98 ± 15
3-15-82-8	89.P1A	Thd	net	1 ± 1	48 ± 10	31 ± 8	3 ± 1	—	11 ± 2	—	3 ± 1	Tr	—	—	—	—	—	—	95 ± 13
3-15-82-9	90.P1A	Thd	net	4 ± 1	82 ± 7	9 ± 3	2 ± 1	—	13 ± 3	—	4 ± 1	—	—	—	—	—	—	—	94 ± 8
3-15-82-10	91.P1A	Tpt	net	Tr	59 ± 10	18 ± 5	1 ± 1	—	16 ± 4	—	—	—	—	—	—	—	—	—	98 ± 12
3-15-82-11	92.P1A	Tpt	net	Tr	43 ± 5	8 ± 2	1 ± 1	—	9 ± 2	—	—	—	—	—	—	38 ± 6	—	—	100 ± 6

APPENDIX B. (cont.)

Field Number	Lab Number	Grid Unit	Lat-Lon	Specimen No.	Chert Bed No.	Mudstone No.	Quartz	Calcite	Opal CT	Totally milled	Feldspar	Mica	Heavy Minerals	Catche	Ham- mite	Glass	Minerals	Total
<i>From Pine Area (Northern Vertical Section; Site 8 on Fig. 1)</i>																		
B2FB-1	110.P1A	Th	not	—	—	30 ± 8	10 ± 1	—	—	—	41 ± 13	1 ± 1	—	—	—	—	—	100 ± 10
B2FB-2	111.P1A	Th	not	—	33 ± 5	14 ± 4	9 ± 1	—	23 ± 7	—	20 ± 4	2 ± 1	—	—	—	—	—	101 ± 10
B2FB-3A	112.P1A	Th	not	—	40 ± 7	22 ± 6	8 ± 1	—	14 ± 4	—	17 ± 5	2 ± 1	—	—	—	—	—	103 ± 11
B2FB-3B	113.P1A	Th	not	2 ± 1	41 ± 6	17 ± 5	8 ± 1	—	13 ± 4	—	15 ± 4	1 ± 1	—	—	—	—	—	99 ± 10
B2FB-4	114.P1A	Th	not	2 ± 1	35 ± 7	28 ± 8	4 ± 1	—	14 ± 4	—	16 ± 5	Tr	—	2 ± 1	—	—	—	97 ± 12
B2FB-5	115.P1A	Th	not	1 ± 1	54 ± 9	17 ± 5	2 ± 1	—	20 ± 5	—	8 ± 2	—	—	—	—	—	—	100 ± 12
<i>From Pine Area (N-S Lateral Section; Site 8 on Fig. 1)</i>																		
CRPP-1-SNL	126.P1A	Th	not	—	40 ± 8	23 ± 6	7 ± 1	—	18 ± 4	—	8 ± 2	—	—	—	—	—	—	97 ± 11
CRPP-2-SNL	127.P1A	Th	not	—	61 ± 10	17 ± 5	4 ± 1	—	12 ± 3	—	5 ± 1	—	—	—	—	—	—	99 ± 12
CRPP-3-SNL	128.P1A	Th	not	—	60 ± 11	24 ± 7	4 ± 1	—	8 ± 2	—	1 ± 1	—	—	—	—	—	—	97 ± 13
CRPP-4-SNL	129.P1A	Th	not	1 ± 1	49 ± 12	37 ± 10	1 ± 1	—	10 ± 2	—	Tr	—	—	—	—	—	—	99 ± 16
CRPP-5-SNL	130.P1A	Th	not	1 ± 1	33 ± 6	28 ± 7	2 ± 1	—	32 ± 6	—	—	—	—	—	—	—	—	96 ± 12
CRPP-6-SNL	131.P1A	Th	not	2 ± 1	37 ± 8	27 ± 8	6 ± 1	—	18 ± 5	—	13 ± 4	—	—	—	—	—	—	103 ± 13
CRPP-7-SNL	132.P1A	Th	not	1 ± 1	48 ± 10	28 ± 8	2 ± 1	—	14 ± 3	—	8 ± 2	—	—	—	—	—	—	101 ± 13
CRPP-8-SNL	133.P1A	Th	not	—	46 ± 10	28 ± 6	5 ± 1	—	22 ± 5	—	3 ± 1	—	—	—	—	—	—	102 ± 13
CRPP-9-SNL	134.P1A	Th	not	1 ± 1	43 ± 9	23 ± 6	3 ± 1	—	23 ± 5	—	3 ± 1	—	—	—	—	—	—	96 ± 12
CRPP-10-SNL	135.P1A	Th	not	1 ± 1	48 ± 11	32 ± 8	4 ± 1	—	11 ± 2	—	3 ± 1	—	—	—	—	—	—	99 ± 14
CRPP-11-SNL	136.P1A	Th	not	2 ± 1	46 ± 10	31 ± 9	5 ± 1	—	11 ± 3	—	9 ± 3	—	—	—	—	—	—	104 ± 14
CRPP-12-SNL	137.P1A	Th	not	1 ± 1	44 ± 10	31 ± 8	4 ± 1	—	13 ± 3	—	5 ± 2	—	—	—	—	—	—	99 ± 13
CRPP-13-SNL	138.P1A	Th	not	1 ± 1	52 ± 10	24 ± 7	3 ± 1	—	14 ± 3	—	4 ± 1	—	—	—	—	—	—	98 ± 13
CRPP-14-SNL	139.P1A	Th	not	1 ± 1	55 ± 10	20 ± 6	3 ± 1	—	13 ± 3	—	4 ± 1	—	—	—	—	—	—	96 ± 12
CRPP-15-SNL	140.P1A	Th	not	1 ± 1	50 ± 10	19 ± 6	4 ± 1	—	12 ± 3	—	4 ± 1	—	—	—	—	—	—	99 ± 12
CRPP-16-SNL	141.P1A	Th	not	2 ± 1	48 ± 9	20 ± 6	4 ± 1	—	17 ± 4	—	7 ± 2	—	—	—	—	—	—	99 ± 12
CRPP-17-SNL	142.P1A	Th	not	2 ± 1	43 ± 8	24 ± 7	5 ± 1	—	15 ± 4	—	7 ± 2	—	—	—	—	—	—	96 ± 12
CRPP-18-SNL	143.P1A	Th	not	1 ± 1	48 ± 10	28 ± 8	3 ± 1	—	15 ± 3	—	7 ± 2	—	—	—	—	—	—	98 ± 13
CRPP-19-SNL	144.P1A	Th	not	1 ± 1	45 ± 9	24 ± 6	3 ± 1	—	19 ± 4	—	5 ± 1	—	—	—	—	—	—	97 ± 12
CRPP-20-SNL	145.P1A	Th	not	2 ± 1	45 ± 9	26 ± 8	2 ± 1	—	16 ± 4	—	6 ± 2	Tr	—	—	—	—	—	99 ± 13
CRPP-21-SNL	146.P1A	Th	not	1 ± 1	46 ± 10	26 ± 7	3 ± 1	—	17 ± 4	—	6 ± 2	—	—	—	—	—	—	99 ± 13
CRPP-22-SNL	147.P1A	Th	not	1 ± 1	43 ± 9	27 ± 7	4 ± 1	—	17 ± 4	—	6 ± 2	Tr	—	—	—	—	—	98 ± 12
CRPP-23-SNL	148.P1A	Th	not	2 ± 1	43 ± 8	20 ± 6	8 ± 1	—	15 ± 4	—	8 ± 2	Tr	—	—	—	—	—	96 ± 11
CRPP-24-SNL	149.P1A	Th	not	3 ± 1	38 ± 4	2 ± 1	7 ± 1	—	32 ± 9	—	16 ± 3	1 ± 1	—	—	—	—	—	99 ± 10
CRPP-25-SNL	150.P1A	Th	not	4 ± 1	59 ± 7	9 ± 3	8 ± 1	—	12 ± 3	—	9 ± 2	—	—	—	—	—	—	101 ± 9
CRPP-26-SNL	151.P1A	Th	not	4 ± 1	47 ± 6	9 ± 3	6 ± 1	—	20 ± 5	—	12 ± 3	—	—	—	—	—	—	98 ± 9
CRPP-27-SNL	152.P1A	Th	not	—	15 ± 2	19 ± 5	26 ± 2	—	—	—	44 ± 10	—	—	—	—	—	—	104 ± 12
CRPP-28-SNL	153.P1A	Th	not	1 ± 1	33 ± 6	17 ± 4	7 ± 1	—	32 ± 8	—	10 ± 2	—	—	—	—	—	—	103 ± 11
CRPP-29-SNL	154.P1A	Th	not	2 ± 1	39 ± 5	13 ± 4	10 ± 1	—	9 ± 3	—	28 ± 6	—	—	—	—	—	—	101 ± 9
CRPP-30-SNL	155.P1A	Th	not	1 ± 1	42 ± 6	13 ± 4	7 ± 1	—	24 ± 6	—	12 ± 3	—	—	—	—	—	—	100 ± 10
CRPP-31-SNL	156.P1A	Th	not	2 ± 1	41 ± 6	15 ± 5	7 ± 1	—	21 ± 6	—	16 ± 4	Tr	—	—	—	—	—	102 ± 11

Cuñco Hills Area (E-W Lateral Section; Site 6 on Fig. 1)

Field Number	Lab Number	Grail 2 Unit	Lab 3 Unit	Synoc. No.	Clasp. No.	Morden. No.	Quartz	Calcite	Quartz. CT	Trid. mls	Feldspar	Mica	Mon. blende	Calcite	Mon. silite	Glass	Knobs. No.	Gypsum	Total
CROH-1-SNL	116 PIA	Th	nat	—	—	32 ± 7	—	—	20 ± 6	—	38 ± 11	Tr	—	Tr	—	—	5 ± 1	—	95 ± 15
CROH-2-SNL	117 PIA	Th	nat	—	—	11 ± 3	3 ± 2	—	19 ± 9	—	52 ± 12	Tr	—	Tr	—	—	2 ± 1	—	97 ± 16
CROH-3-SNL	118 PIA	Th	nat	—	—	11 ± 3	10 ± 1	—	14 ± 7	—	61 ± 11	Tr	—	Tr	—	—	1 ± 1	—	97 ± 13
CROH-4-SNL	119 PIA	Th	nat	—	—	25 ± 6	7 ± 1	—	15 ± 6	—	48 ± 11	Tr	—	1 ± 1	—	—	—	—	94 ± 14
CROH-5-SNL	120 PIA	Th	nat	—	—	20 ± 6	3 ± 1	—	8 ± 5	—	67 ± 15	—	—	—	—	—	—	Tr	98 ± 17
CROH-6-SNL	121 PIA	Th	nat	—	—	6 ± 2	12 ± 1	—	15 ± 8	—	68 ± 10	Tr	—	—	—	—	1 ± 1	—	109 ± 13
CROH-7-SNL	122 PIA	Th	nat	—	—	18 ± 5	28 ± 2	—	—	—	58 ± 12	—	—	—	—	—	1 ± 1	—	103 ± 13
CROH-8-SNL	123 PIA	Th	nat	1 ± 1	25 ± 3	10 ± 3	5 ± 1	—	16 ± 7	—	43 ± 8	—	—	—	—	—	1 ± 1	—	101 ± 12
CROH-9-SNL	124 PIA	Th	nat	—	6 ± 1	16 ± 5	3 ± 1	—	13 ± 7	—	63 ± 13	—	—	Tr	—	—	2 ± 1	—	103 ± 16
CROH-10-SNL	125 PIA	Th	nat	—	31 ± 4	13 ± 3	6 ± 1	—	18 ± 6	—	25 ± 5	—	—	—	—	—	2 ± 1	—	95 ± 9

! Measured abundances reported as weight percent. uncertainties are two standard deviations of unreplicated analysis. -- indicates amount not detected. Tr = trace abundances (<0.5 wt %).

General references refer to topics pertinent, immediate or two months previous to completion of project. If no exact reference (NCR) is given, assume it is from the general literature.

2. Card Unit: Top = Floor Plan Member; Tot = Warehouse Foundation (lower part); Th = sufficient bank of Culture Hills; Tip = Telegraph Spring Member; Ttp = deposits of Delatium Canyon; Trb = dyke of Black Glass Canyon.

³ Legend: net = netted net, mostly pyroclastic. Sums but may include massive sub-fall and rounded tuff. pot = partially-rotated sub-fall tuff. med = moderately-rotated sub-fall tuff. v = very-pyritic tuff. b = boulders tuff, individual beds characterized by normal stratification.

APPENDIX C. MAJOR- AND TRACE-ELEMENT ANALYSES OF NONWELDED TUFFS FROM OUTCROP, YUCCA MOUNTAIN, NEVADA

Busted Butte Area (Southeast Side; Site 1 on Fig. 1)

Field No.	DEB 3/90-4	DEB 3/90-5	DEB 3/90-6	DEB 3/90-7	DEB 3/90-8	DEB 3/90-8	DEB 3/90-9	DEB 3/90-10
Geol. Unit ¹	Twl	Twl	Thl	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	nwt	nwt	b	b	nwt	b
Alteration ³	Ql	Ql	Ql, Zc	Ql	Ql	Ql	Ql	Ql
Lab. No.	160, P1	161, P1	162, P1	163, P1	164, P1	164, P2	165, P1	166, P1
XRF and AA Results (wt %)								
SiO ₂	64.4	64.2	72.3	73.2	76.6	74.6	72.6	73.1
TiO ₂	0.53	0.51	0.19	0.16	0.08	0.08	0.15	0.13
Al ₂ O ₃	15.9	16.0	12.5	12.7	10.9	11.6	12.9	12.9
Fe ₂ O ₃ T	4.13	4.00	1.69	1.40	0.84	0.93	1.41	1.25
MnO	0.08	0.07	0.07	0.08	0.04	0.04	0.07	0.08
MgO	1.14	1.22	0.49	0.49	0.16	0.29	0.49	0.32
CaO	3.22	3.77	1.53	0.94	0.63	1.07	0.80	0.70
Na ₂ O	3.22	3.29	2.46	3.09	2.18	2.63	2.54	2.74
K ₂ O	3.32	3.17	4.78	4.53	4.79	4.79	4.43	4.72
P ₂ O ₅	0.17	0.19	0.11	0.08	0.07	0.07	0.07	0.07
LOI	2.8	2.9	4.1	3.8	3.6	3.9	4.7	4.2
Total	99.9	99.3	100.3	100.4	100.0	99.9	100.2	100.1
Ba ppm	1379	1666	697	270	108	115	130	110
Sr ppm	512	800	237	135	30	67	62	54
INAA Results⁴ (all values ppm unless otherwise noted)								
Na ₂ O (%)	3.30 ± 0.15	3.30 ± 0.14	2.57 ± 0.11	3.15 ± 0.14	2.23 ± 0.03	2.56 ± 0.05	2.75 ± 0.12	2.90 ± 0.13
MgO (%)	1.40 ± 0.15	1.10 ± 0.13	0.49 ± 0.09	0.52 ± 0.10	nd	nd	< 0.42	< 0.50
Al ₂ O ₃ (%)	16.8 ± 0.5	16.1 ± 0.5	12.6 ± 0.4	12.6 ± 0.4	nd	nd	13.2 ± 0.4	12.8 ± 0.4
Cl	156 ± 22	387 ± 47	342 ± 33	817 ± 102	nd	nd	812 ± 64	227 ± 26
K ₂ O (%)	3.16 ± 0.25	3.26 ± 0.22	4.99 ± 0.32	4.66 ± 0.41	nd	nd	4.77 ± 0.31	4.99 ± 0.32
CaO (%)	3.42 ± 0.18	3.86 ± 0.20	1.45 ± 0.10	0.99 ± 0.08	0.45 ± 0.10	1.05 ± 0.08	0.81 ± 0.07	0.71 ± 0.07
Sc	6.90 ± 0.40	6.71 ± 0.36	3.29 ± 0.17	3.11 ± 0.16	2.31 ± 0.03	2.35 ± 0.03	3.44 ± 0.18	2.66 ± 0.14
Ti	3000 ± 400	3224 ± 471	958 ± 214	845 ± 226	nd	nd	636 ± 192	< 4557
V	49 ± 3	50 ± 3	14 ± 2	< 7	nd	nd	< 7	< 7
Cr	11.2 ± 0.9	12.8 ± 1.0	3.6 ± 0.5	4.6 ± 0.5	< 5	1.8 ± 0.1	4.5 ± 0.5	2.5 ± 0.4
Mn	596 ± 24	605 ± 24	573 ± 24	420 ± 17	nd	nd	534 ± 21	592 ± 24
Fe ₂ O ₃ (%)	4.02 ± 0.24	4.02 ± 0.23	1.66 ± 0.09	1.34 ± 0.09	0.74 ± 0.04	0.82 ± 0.01	1.38 ± 0.08	1.14 ± 0.07
Co	12.10 ± 0.70	11.96 ± 0.63	10.79 ± 0.57	8.47 ± 0.46	21.5 ± 0.3	14.2 ± 0.2	11.50 ± 0.61	8.27 ± 0.45
Cu	< 300	< 295	< 299	< 259	nd	nd	< 297	< 256
Zn	65 ± 9	72 ± 10	50 ± 7	42 ± 6	nd	nd	69 ± 9	59 ± 8
Ga	< 40.0	17.0 ± 4.6	< 21.3	< 23.8	nd	nd	< 22.2	< 23.5
As	2.5 ± 0.5	2.6 ± 0.4	3.2 ± 0.5	3.5 ± 0.5	3.7 ± 0.2	4.8 ± 0.7	3.6 ± 0.5	3.4 ± 0.5
Se	< 3.0	< 3.6	< 3.0	< 3.4	nd	nd	< 2.9	< 3.4
Br	0.81 ± 0.18	< 1.55	< 2.93	< 3.79	1.21 ± 0.15	1.26 ± 0.17	2.23 ± 0.47	3.30 ± 1.24
Rb	136 ± 7	121 ± 7	155 ± 8	173 ± 8	223 ± 6	214 ± 5	174 ± 8	167 ± 8
Sr	680 ± 30	< 300	249 ± 80	< 308	37 ± 6	79 ± 5	< 268	< 327
Zr	250 ± 50	311 ± 66	150 ± 27	116 ± 25	71 ± 7	95 ± 4	201 ± 31	144 ± 26
Mo	< 100	9 ± 3	< 100	< 93	nd	nd	< 3	< 91
Ag	< 3.0	< 3.1	< 1.9	< 2.0	nd	nd	< 1.9	< 1.8
In	< 0.30	< 0.26	< 0.22	< 0.25	nd	nd	< 0.21	< 0.25
Sb	0.32 ± 0.02	< 0.40	0.45 ± 0.10	< 0.38	0.37 ± 0.01	0.42 ± 0.01	0.48 ± 0.11	0.38 ± 0.09
I	< 19	< 19	< 17	< 19	nd	nd	< 16	< 20
Cs	5.10 ± 0.70	5.13 ± 0.34	5.69 ± 0.32	6.23 ± 0.37	5.75 ± 0.08	5.38 ± 0.08	6.08 ± 0.36	4.80 ± 0.34
Ba	1360 ± 70	1633 ± 77	852 ± 46	314 ± 84	87 ± 5	109 ± 4	196 ± 31	165 ± 52
La	73.0 ± 4.0	72.5 ± 4.5	44.0 ± 2.9	46.1 ± 2.4	32.3 ± 0.5	28.8 ± 0.4	41.4 ± 2.6	45.4 ± 2.7
Ce	105.0 ± 5.0	136.5 ± 6.1	87.6 ± 3.9	72.7 ± 3.3	54.9 ± 0.8	59.6 ± 0.8	101.7 ± 4.5	92.0 ± 4.1
Nd	50.0 ± 4.0	51.2 ± 4.1	33.4 ± 2.7	40.3 ± 3.3	23.7 ± 1.5	23.8 ± 1.2	37.3 ± 3.0	41.0 ± 3.4
Sm	7.1 ± 0.3	7.4 ± 0.3	5.6 ± 0.3	5.9 ± 0.3	5.3 ± 0.1	5.4 ± 0.1	7.1 ± 0.3	6.5 ± 0.3
Eu	1.64 ± 0.10	1.80 ± 0.09	0.69 ± 0.06	0.83 ± 0.04	0.24 ± 0.01	0.28 ± 0.01	0.48 ± 0.04	0.35 ± 0.03
Tb	0.71 ± 0.08	0.64 ± 0.07	0.58 ± 0.06	0.69 ± 0.07	0.67 ± 0.02	0.72 ± 0.01	0.83 ± 0.08	0.74 ± 0.07
Dy	3.90 ± 0.45	< 5.89	3.75 ± 0.38	4.79 ± 0.45	nd	nd	5.05 ± 0.44	4.89 ± 0.45
Yb	2.11 ± 0.21	2.20 ± 0.21	2.06 ± 0.18	2.73 ± 0.21	2.37 ± 0.03	2.64 ± 0.04	2.80 ± 0.27	2.90 ± 0.21
Lu	0.27 ± 0.02	0.25 ± 0.02	0.33 ± 0.02	0.39 ± 0.02	0.35 ± 0.01	0.38 ± 0.01	0.44 ± 0.02	0.39 ± 0.02
Hf	6.60 ± 0.30	7.37 ± 0.58	4.39 ± 0.52	4.20 ± 0.40	3.15 ± 0.05	3.60 ± 0.05	4.55 ± 0.29	4.60 ± 0.37
Ta	2.03 ± 0.14	1.63 ± 0.12	2.21 ± 0.14	2.65 ± 0.17	1.59 ± 0.04	2.39 ± 0.04	2.37 ± 0.16	2.08 ± 0.14
W	92 ± 12	78 ± 10	131 ± 16	101 ± 12	27 ± 1	109 ± 2	102 ± 13	104 ± 13
Au	< 0.014	< 0.014	< 0.014	< 0.016	nd	nd	0.054 ± 0.006	< 0.015
Hg	< 0.6	< 0.6	< 0.3	< 0.4	nd	nd	< 0.3	< 0.4
Th	14.7 ± 0.6	14.6 ± 0.6	21.7 ± 0.8	21.9 ± 0.9	20.2 ± 0.3	21.7 ± 0.3	24.5 ± 1.0	23.6 ± 0.9
U	3.30 ± 0.12	3.20 ± 0.10	3.80 ± 0.10	5.00 ± 0.20	4.71 ± 0.12	5.01 ± 0.15	4.50 ± 0.20	4.60 ± 0.20

APPENDIX C. (cont)

Busted Butte Area (Northern End: Site 1 on Fig. 1)

Field No.	DEB 3/90-44	DEB 3/90-45	DEB 3/90-46	DEB 3/90-47	DEB 3/90-48	DEB 3/90-49	DEB 3/90-50	DEB 4/91-1
Geol. Unit ¹	Top	Twl	Twl	Thl	Thl	Thl	Tpl	Tpl
Lithology ²	nwt	nwt	b	b	nwt	nwt	nwt	nwt
Alteration ³	Ql	Ql	Ql	Ql	Ql	Ql	Ql	Zo
Lab. No.	200,P1	201,P1	202,P1	203,P1	204,P1	205,P1	206,P1	432, P1
XRF and AA Results (wt.%)								
SiO ₂	72.6	61.8	68.5	74.1	72.7	72.8	73.4	67.6
TiO ₂	0.10	0.49	0.27	0.15	0.15	0.14	0.11	0.10
Al ₂ O ₃	12.6	15.2	14.2	11.9	12.7	12.4	12.3	11.4
Fe ₂ O ₃ T	1.32	4.01	2.32	1.31	1.39	1.31	1.01	0.83
MnO	0.05	0.10	0.06	0.05	0.06	0.15	0.09	0.07
MgO	0.28	1.34	0.79	0.44	0.51	0.38	0.18	0.94
CaO	1.06	4.29	2.66	1.12	1.00	0.78	0.53	2.80
Na ₂ O	2.25	2.63	2.73	2.61	2.73	2.72	2.96	0.56
K ₂ O	4.29	2.64	3.18	4.45	4.57	4.52	4.97	3.00
P ₂ O ₅	0.08	0.18	0.11	0.10	0.08	0.07	0.07	0.01
LOI	4.9	7.1	5.1	3.4	4.1	4.1	3.7	12.8
Total	99.5	99.8	99.9	99.7	99.9	99.4	99.3	100.0
Ba ppm	233	1191	620	524	218	136	40	45
Sr ppm	106	702	400	158	110	70	15	583
INAA Results⁴ (all values ppm unless otherwise noted)								
Na ₂ O (%)	2.46 ± 0.11	2.60 ± 0.11	2.78 ± 0.12	2.55 ± 0.11	2.87 ± 0.13	2.76 ± 0.12	3.14 ± 0.13	0.52 ± 0.01
MgO (%)	< 0.31	1.11 ± 0.12	0.78 ± 0.09	0.38 ± 0.08	0.26 ± 0.07	< 0.30	< 0.27	nd
Al ₂ O ₃ (%)	13.0 ± 0.5	15.3 ± 0.4	14.3 ± 0.4	12.0 ± 0.3	13.2 ± 0.4	12.7 ± 0.4	12.8 ± 0.4	nd
Cl	400 ± 43	9990 ± 719	2561 ± 198	425 ± 38	421 ± 36	383 ± 38	606 ± 64	nd
K ₂ O (%)	4.71 ± 0.33	2.57 ± 0.21	3.04 ± 0.23	4.57 ± 0.32	5.27 ± 0.37	4.70 ± 0.33	5.10 ± 0.36	nd
CaO (%)	1.14 ± 0.09	4.42 ± 0.22	2.62 ± 0.14	1.38 ± 0.09	1.02 ± 0.08	0.58 ± 0.06	0.52 ± 0.06	2.71 ± 0.10
Sc	1.60 ± 0.08	6.58 ± 0.35	4.28 ± 0.23	2.39 ± 0.13	3.10 ± 0.16	2.94 ± 0.16	2.22 ± 0.12	2.07 ± 0.02
Ti	< 4268	2805 ± 412	1791 ± 281	936 ± 201	757 ± 182	649 ± 180	< 3822	nd
V	< 7	48 ± 3	27 ± 2	< 6	6 ± 2	< 6	< 7	nd
Cr	2.2 ± 0.4	13.8 ± 1.0	9.3 ± 0.7	3.5 ± 0.4	4.0 ± 0.5	4.2 ± 0.5	< 0.9	0.54 ± 0.24
Mn	423 ± 17	673 ± 27	504 ± 20	371 ± 15	466 ± 19	1130 ± 45	675 ± 26	nd
Fe ₂ O ₃ (%)	1.23 ± 0.07	3.87 ± 0.22	2.46 ± 0.14	1.26 ± 0.07	1.29 ± 0.08	1.23 ± 0.07	0.95 ± 0.06	0.73 ± 0.01
Co	4.49 ± 0.26	13.69 ± 0.74	15.85 ± 0.84	12.29 ± 0.64	9.29 ± 0.49	13.27 ± 0.69	11.13 ± 0.62	5.12 ± 0.06
Cu	< 267	< 280	< 278	< 239	< 266	< 284	< 299	nd
Zn	57 ± 8	67 ± 9	< 30	45 ± 6	40 ± 6	108 ± 14	< 6	nd
Ga	< 39.2	< 40.1	< 38.9	< 36.4	< 39.0	< 39.9	< 41.3	nd
As	3.2 ± 0.5	2.3 ± 0.4	4.6 ± 0.6	4.3 ± 0.6	4.4 ± 0.6	4.2 ± 0.6	3.1 ± 0.5	1.0 ± 0.1
Se	< 3.3	< 3.4	< 2.4	< 2.6	< 3.4	< 2.6	< 2.0	nd
Br	2.90 ± 1.02	1.20 ± 0.37	7.28 ± 0.82	< 2.67	< 1.76	2.19 ± 1.07	1.01 ± 0.33	0.11 ± 0.02
Rb	158 ± 8	95 ± 5	112 ± 6	171 ± 8	174 ± 8	168 ± 8	189 ± 9	121 ± 2
Sr	< 301	669 ± 105	410 ± 94	< 284	< 297	< 315	< 268	556 ± 15
Zr	173 ± 26	267 ± 38	187 ± 39	144 ± 23	113 ± 23	121 ± 22	150 ± 26	111 ± 6
Mo	< 78	< 81	< 69	< 82	< 72	< 3	< 70	nd
Ag	< 1.6	< 2.8	< 2.1	< 1.6	< 1.9	< 2.0	< 1.6	nd
In	< 0.25	< 0.25	< 0.20	< 0.23	< 0.25	< 0.26	< 0.22	nd
Sb	< 0.29	0.42 ± 0.08	0.36 ± 0.08	0.45 ± 0.08	0.54 ± 0.09	0.29 ± 0.08	0.26 ± 0.07	0.19 ± 0.01
I	< 18	< 19	< 15	< 17	< 17	< 21	< 16	nd
Cs	3.25 ± 0.20	3.43 ± 0.22	4.07 ± 0.24	4.39 ± 0.26	5.92 ± 0.34	5.18 ± 0.29	4.92 ± 0.29	4.28 ± 0.04
Ba	291 ± 95	1266 ± 87	749 ± 104	581 ± 48	259 ± 80	177 ± 66	106 ± 14	44 ± 3
La	59.9 ± 3.1	59.0 ± 3.3	44.7 ± 2.5	49.0 ± 3.0	36.9 ± 2.0	37.8 ± 2.1	34.7 ± 2.1	30.6 ± 0.3
Ce	105.4 ± 4.7	122.2 ± 5.5	93.7 ± 4.2	100.4 ± 4.5	70.9 ± 3.3	82.6 ± 3.8	77.1 ± 3.4	78.0 ± 0.8
Nd	44.2 ± 3.4	43.9 ± 3.5	35.8 ± 2.8	37.1 ± 2.9	33.3 ± 2.8	29.5 ± 2.5	34.3 ± 2.7	24.2 ± 1.1
Sm	5.1 ± 0.4	5.6 ± 0.3	5.1 ± 0.2	5.1 ± 0.2	6.0 ± 0.3	6.2 ± 0.3	5.8 ± 0.3	5.3 ± 0.1
Eu	0.32 ± 0.04	1.63 ± 0.08	1.03 ± 0.06	0.53 ± 0.04	0.44 ± 0.04	0.38 ± 0.03	0.29 ± 0.03	0.23
Tb	0.92 ± 0.08	0.59 ± 0.06	0.55 ± 0.06	0.56 ± 0.06	0.69 ± 0.07	0.72 ± 0.07	0.77 ± 0.07	0.62 ± 0.01
Dy	5.77 ± 0.52	3.92 ± 0.40	3.64 ± 0.35	3.43 ± 0.34	5.34 ± 0.96	4.48 ± 0.41	5.27 ± 0.58	nd
Yb	3.49 ± 0.35	1.85 ± 0.15	2.40 ± 0.18	2.11 ± 0.21	2.56 ± 0.18	2.68 ± 0.21	2.99 ± 0.20	2.16 ± 0.02
Lu	0.44 ± 0.02	0.31 ± 0.02	0.33 ± 0.02	0.34 ± 0.02	0.40 ± 0.02	0.40 ± 0.02	0.43 ± 0.02	0.34 ± 0.01
Hf	6.00 ± 0.31	6.94 ± 0.45	5.17 ± 0.40	4.00 ± 0.28	4.33 ± 0.38	4.42 ± 0.27	4.84 ± 0.22	4.25 ± 0.04
Ta	2.12 ± 0.13	0.92 ± 0.07	1.79 ± 0.13	2.19 ± 0.16	2.19 ± 0.15	2.11 ± 0.14	2.66 ± 0.17	1.71 ± 0.03
W	41 ± 5	21 ± 3	107 ± 13	96 ± 12	64 ± 8	101 ± 13	106 ± 13	38 ± 0
Au	< 0.012	< 0.011	< 0.009	< 0.011	< 0.012	< 0.012	< 0.009	nd
Hg	< 0.4	< 0.5	< 0.3	< 0.3	< 0.4	< 0.3	< 0.3	nd
Th	21.3 ± 0.9	13.0 ± 0.5	17.6 ± 0.7	24.1 ± 0.9	24.1 ± 0.9	23.1 ± 0.9	24.5 ± 1.0	22.4 ± 0.2
U	3.44 ± 0.13	2.40 ± 0.09	2.85 ± 0.11	3.75 ± 0.13	4.76 ± 0.17	4.29 ± 0.15	4.63 ± 0.17	2.25 ± 0.05

APPENDIX C. (cont)

Northeast Yucca Mountain Area (Sites 2 and 4 on Fig. 1)

Field No.	DEB 5/91-7	DEB 5/91-8	DEB 5/91-9	DEB 5/91-10	DEB 5/91-12	DEB 5/91-11	DEB 3/90-36	DEB 3/90-37
Geol. Unit ¹	Tpl	Tpp	Tpp	Tpp	Tpp	Tpp	Tpp	Tpp
Lithology ²	nwt	nwt	nwt	pwt	mwt	pwt	nwt	nwt
Alteration ³	Zc, Zm, Op	Zc, Op	Zc, Op	Cx	Cx, Zm	Cx	Cx, Zc	GI
Lab. No.	438, P1	439, P1	440, P1	441, P1	443, P1	442, P1	192, P1	193, P1
XRF and AA Results (wt %)								
SiO ₂	68.46	68.77	68.71	72.07	72.22	68.85	70.6	68.4
TiO ₂	0.098	0.246	0.286	0.286	0.288	0.275	0.26	0.28
Al ₂ O ₃	11.07	12.39	12.61	14.28	14.01	14.18	12.6	14.2
Fe ₂ O ₃ T	0.9	1.24	1.33	1.45	1.48	1.54	1.39	1.52
MnO	0.084	0.088	0.078	0.08	0.082	0.092	0.08	0.09
MgO	0.7	0.45	0.67	0.14	0.23	0.45	0.41	0.45
CaO	2.88	2.31	2.7	0.742	0.915	2.5	1.17	0.91
Na ₂ O	0.88	1.25	1.34	3.8	3.9	3.82	2.02	2.99
K ₂ O	3.6	5.5	3.72	6.35	5.34	5.54	5.90	5.54
P ₂ O ₅	0.013	0.02	0.018	0.021	0.025	0.068	0.08	0.08
LOI	11.58	10.37	11.04	0.69	1.18	2.41	4.7	5.4
Total	100.2	99.6	99.6	99.6	99.7	99.7	99.2	99.9
Ba ppm	367	1209	1388	1478	1460	1567	1290	1397
Sr ppm	558	408	1632	127	165	178	981	224
INAA Results⁴ (all values ppm unless otherwise noted)								
Na ₂ O (%)	0.81 ± 0.02	1.22 ± 0.01	1.24 ± 0.01	3.52 ± 0.04	3.68 ± 0.04	3.68 ± 0.04	2.04 ± 0.09	3.02 ± 0.13
MgO (%)	nd	nd	nd	nd	nd	nd	0.39 ± 0.08	0.42 ± 0.12
Al ₂ O ₃ (%)	nd	nd	nd	nd	nd	nd	13.3 ± 0.6	14.8 ± 0.4
Cl	nd	nd	nd	nd	nd	nd	< 84	649 ± 68
K ₂ O (%)	nd	nd	nd	nd	nd	nd	6.41 ± 0.43	5.69 ± 0.40
CaO (%)	2.88 ± 0.13	2.69 ± 0.22	2.66 ± 0.14	0.67 ± 0.15	1.03 ± 0.23	2.67 ± 0.23	1.31 ± 0.10	0.76 ± 0.07
Sc	2.09 ± 0.02	3.39 ± 0.03	3.39 ± 0.03	3.77 ± 0.04	3.88 ± 0.04	4.01 ± 0.04	3.51 ± 0.19	4.08 ± 0.22
Ti	nd	nd	nd	nd	nd	nd	1498 ± 280	1224 ± 252
V	nd	nd	nd	nd	nd	nd	7 ± 1	6 ± 2
Cr	< 5	< 5	< 5	< 5	< 5	< 5	1.6 ± 0.4	1.8 ± 0.5
Mn	nd	nd	nd	nd	nd	nd	620 ± 26	707 ± 28
Fe ₂ O ₃ (%)	0.78 ± 0.01	1.08 ± 0.01	1.11 ± 0.01	1.25 ± 0.01	1.24 ± 0.01	1.29 ± 0.01	1.32 ± 0.07	1.53 ± 0.08
Co	16.45 ± 0.16	12.98 ± 0.13	3.31 ± 0.03	10.38 ± 0.10	5.25 ± 0.05	5.25 ± 0.05	4.30 ± 0.24	11.91 ± 0.67
Cu	nd	nd	nd	nd	nd	nd	< 262	< 314
Zn	nd	nd	nd	nd	nd	nd	59 ± 8	< 7
Ga	nd	nd	nd	nd	nd	nd	< 35.9	< 47.6
As	4.8 ± 0.4	4.3 ± 0.2	3.0 ± 0.2	1.6 ± 0.3	2.6 ± 0.4	5.2 ± 0.6	2.1 ± 0.4	2.6 ± 0.5
Se	nd	nd	nd	nd	nd	nd	< 3.1	< 3.0
Br	0.21 ± 0.09	0.15 ± 0.07	0.17 ± 0.07	< 0.20	0.25 ± 0.11	0.46 ± 0.19	< 1.56	1.25 ± 0.46
Rb	158 ± 3	167 ± 5	57 ± 2	179 ± 5	153 ± 4	161 ± 3	112 ± 6	160 ± 8
Sr	493 ± 18	415 ± 21	1660 ± 60	137 ± 12	195 ± 10	163 ± 7	1065 ± 130	< 321
Zr	132 ± 8	250 ± 13	269 ± 12	277 ± 14	286 ± 10	287 ± 7	226 ± 33	343 ± 60
Mo	nd	nd	nd	nd	nd	nd	< 78	< 4
Ag	nd	nd	nd	nd	nd	nd	< 2.2	1.8 ± 0.5
In	nd	nd	nd	nd	nd	nd	< 0.25	< 0.28
Sb	0.28 ± 0.01	0.18 ± 0.01	0.19 ± 0.01	0.14 ± 0.01	0.18 ± 0.01	0.12 ± 0.01	< 0.29	< 0.37
I	nd	nd	nd	nd	nd	nd	< 19	< 21
Cs	6.57 ± 0.07	6.27 ± 0.06	3.47 ± 0.04	1.509 ± 0.03	1.303 ± 0.02	1.304 ± 0.01	0.81 ± 0.09	3.42 ± 0.25
Ba	358 ± 7	1181 ± 19	1309 ± 16	1411 ± 24	1531 ± 22	1584 ± 22	1443 ± 136	1649 ± 143
La	31.1 ± 0.3	69.8 ± 0.7	68.8 ± 0.7	79.6 ± 0.8	79.9 ± 0.8	81.8 ± 0.8	82.7 ± 4.5	82.3 ± 4.5
Ce	66.3 ± 0.7	137.6 ± 1.4	131.1 ± 1.3	154.7 ± 1.6	153.6 ± 1.5	157.6 ± 1.6	150.3 ± 6.81	71.4 ± 7.5
Nd	24.5 ± 1.4	48.3 ± 2.9	50.2 ± 2.1	57.0 ± 3.2	60.3 ± 2.8	63.0 ± 2.8	62.7 ± 5.0	64.7 ± 4.9
Sm	5.2 ± 0.1	8.6 ± 0.1	8.6 ± 0.1	9.5 ± 0.1	10.1 ± 0.1	10.0 ± 0.1	9.0 ± 0.4	10.1 ± 0.5
Eu	0.29 ± 0.01	1.49 ± 0.02	1.49 ± 0.02	1.70 ± 0.02	1.84 ± 0.02	1.82 ± 0.02	1.65 ± 0.09	1.81 ± 0.11
Tb	0.64 ± 0.01	0.91 ± 0.01	0.90 ± 0.01	0.98 ± 0.02	1.02 ± 0.01	1.07 ± 0.01	0.84 ± 0.09	1.08 ± 0.11
Dy	nd	nd	nd	nd	nd	nd	5.70 ± 0.65	6.26 ± 0.54
Yb	2.37 ± 0.02	2.69 ± 0.03	2.71 ± 0.03	3.07 ± 0.03	3.07 ± 0.03	3.00 ± 0.03	2.90 ± 0.19	3.16 ± 0.22
Lu	0.34 ± 0.01	0.39 ± 0.01	0.40 ± 0.01	0.43 ± 0.01	0.44 ± 0.01	0.43 ± 0.01	0.43 ± 0.02	0.49 ± 0.03
Hf	4.32 ± 0.05	6.60 ± 0.06	6.89 ± 0.07	7.55 ± 0.10	7.66 ± 0.08	7.80 ± 0.08	7.17 ± 0.52	6.31 ± 0.75
Ta	2.12 ± 0.04	1.88 ± 0.05	1.70 ± 0.04	3.84 ± 0.08	2.83 ± 0.05	2.20 ± 0.03	1.40 ± 0.09	1.71 ± 0.11
W	77 ± 1	66 ± 1	51 ± 1	184 ± 2	118 ± 1	78 ± 2	22 ± 3	49 ± 6
Au	nd	nd	nd	nd	nd	nd	< 0.012	< 0.015
Hg	nd	nd	nd	nd	nd	nd	< 0.4	< 0.4
Th	18.3 ± 0.2	18.1 ± 0.2	17.8 ± 0.2	20.9 ± 0.2	20.3 ± 0.2	20.4 ± 0.2	19.3 ± 0.8	22.6 ± 0.9
U	2.16 ± 0.07	4.92 ± 0.12	2.75 ± 0.07	2.78 ± 0.11	3.26 ± 0.11	3.56 ± 0.13	3.12 ± 0.12	3.88 ± 0.14

APPENDIX C. (cont)

Northeast Yucca Mountain Area Cont. (Sites 2 and 4 on Fig. 1)

Field No.	DEB 3/90-38	DEB 3/90-39	DEB 3/90-40	DEB 3/90-41	DEB 3/90-42	DEB 3/90-43	DEB 5/91-13	DEB 5/91-14	DEB 5/91-15
Geol. Unit ¹	Tpp	Tpp	Tpp	Tpp	Tfd	Tfb	Tfb	Tfb	Tfb
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Alteration ³	Gl	Gl	Gl	Gl, Sm	Gl, Sm	Gl	Gl	Gl	Gl
Lab. No.	194,P1	195,P1	196,P1	197,P1	198,P1	199,P1	444,P1	445,P1	446,P1
XRF and AA Results (wt.%)									
SiO ₂	69.6	69.1	68.4	67.7	66.0	73.0	65.25	71.0	72.1
TiO ₂	0.28	0.28	0.29	0.31	0.29	0.16	0.14	0.15	0.14
Al ₂ O ₃	14.0	13.9	14.1	14.1	14.0	12.5	12.1	12.5	12.5
Fe ₂ O ₃ T	1.48	1.49	1.54	1.62	1.91	1.11	0.95	1.00	0.96
MnO	0.10	0.10	0.09	0.09	0.15	0.10	0.09	0.11	0.11
MgO	0.38	0.52	0.67	0.85	1.15	0.29	1.31	0.66	0.67
CaO	0.81	0.84	0.91	1.07	1.34	0.48	2.25	1.07	0.59
Na ₂ O	3.45	3.21	3.24	2.93	3.03	3.27	2.75	3.05	3.02
K ₂ O	5.02	4.92	4.75	4.30	3.87	4.58	3.8	4.57	4.61
P ₂ O ₅	0.08	0.09	0.09	0.07	0.07	0.07	0.01	0.01	0.01
LOI	4.1	4.9	5.3	6.5	8.0	4.1	11.7	5.9	5.5
Total	99.2	99.3	99.3	99.5	99.7	99.6	100.3	100.1	100.2
Ba ppm	1343	1290	1299	1102	340	170	45	27	18
Sr ppm	104	107	112	136	164	63	507	41	24
INAA Results⁴ (all values ppm unless otherwise noted)									
Na ₂ O (%)	3.58 ± 0.15	3.33 ± 0.14	3.57 ± 0.16	2.96 ± 0.12	3.00 ± 0.13	3.45 ± 0.15	2.73 ± 0.03	3.08 ± 0.04	2.97 ± 0.04
MgO (%)	< 0.31	< 0.48	0.45 ± 0.10	0.86 ± 0.11	0.93 ± 0.11	< 0.45	nd	nd	nd
Al ₂ O ₃ (%)	14.4 ± 0.4	14.3 ± 0.4	14.7 ± 0.4	14.5 ± 0.4	14.3 ± 0.4	12.8 ± 0.4	nd	nd	nd
Cl	315 ± 32	346 ± 35	323 ± 33	360 ± 36	1017 ± 78	507 ± 94	nd	nd	nd
K ₂ O (%)	5.28 ± 0.36	5.40 ± 0.38	5.13 ± 0.36	4.05 ± 0.30	3.77 ± 0.28	5.11 ± 0.36	nd	nd	nd
CaO (%)	0.29 ± 0.04	0.89 ± 0.08	0.87 ± 0.08	1.05 ± 0.09	1.31 ± 0.10	0.55 ± 0.06	2.10 ± 0.15	0.94 ± 0.13	0.55 ± 0.10
Sc	3.92 ± 0.21	4.02 ± 0.22	3.96 ± 0.21	4.08 ± 0.22	3.96 ± 0.21	2.05 ± 0.11	1.64 ± 0.02	1.71 ± 0.02	1.67 ± 0.02
Ti	1657 ± 285	1784 ± 321	1789 ± 311	1607 ± 281	1470 ± 272	< 5015	nd	nd	nd
V	< 8	< 8	6 ± 2	9 ± 2	13 ± 2	< 8	nd	nd	nd
Cr	2.5 ± 0.4	< 1.3	< 1.6	3.0 ± 0.5	9.3 ± 0.8	2.0 ± 0.4	< 5	< 5	< 5
Mn	794 ± 36	783 ± 31	747 ± 29	673 ± 28	1166 ± 48	753 ± 30	nd	nd	nd
Fe ₂ O ₃ (%)	1.43 ± 0.08	1.48 ± 0.08	1.46 ± 0.07	1.52 ± 0.08	1.82 ± 0.10	1.04 ± 0.05	0.79 ± 0.01	0.84 ± 0.01	0.81 ± 0.01
Co	10.71 ± 0.57	7.29 ± 0.39	8.85 ± 0.49	5.54 ± 0.30	7.85 ± 0.44	27.10 ± 1.41	3.50 ± 0.03	2.73 ± 0.03	2.81 ± 0.03
Cu	< 324	< 298	< 322	< 282	< 325	< 278	nd	nd	nd
Zn	59 ± 8	72 ± 10	61 ± 9	56 ± 8	< 49	76 ± 10	nd	nd	nd
Ga	< 40.0	< 41.7	< 46.6	< 44.3	< 40.1	< 39.3 ±	nd	nd	nd
As	2.4 ± 0.4	2.2 ± 0.5	2.5 ± 0.5	2.5 ± 0.5	3.8 ± 0.6	2.8 ± 0.5	2.5 ± 0.4	3.7 ± 0.5	3.0 ± 0.4
Se	< 3.7	< 3.1	< 4.2	< 3.0	< 2.4	< 2.7	nd	nd	nd
Br	< 3.66	3.60 ± 1.11	< 4.15	2.59 ± 1.11	< 1.30	1.29 ± 0.34	8.10 ± 0.78	1.30 ± 0.18	1.39 ± 0.18
Rb	157 ± 8	157 ± 8	153 ± 7	162 ± 8	154 ± 8	193 ± 9	143 ± 3	179 ± 5	190 ± 5
Sr	< 301	< 385	< 381	< 288	< 329	< 359	500 ± 16	52 ± 6	47 ± 7
Zr	260 ± 46	305 ± 79	288 ± 41	277 ± 37	240 ± 34	213 ± 36	193 ± 6	205 ± 8	187 ± 8
Mo	< 81	< 4	< 92	< 95	< 71	< 4	nd	nd	nd
Ag	< 2.1	< 2.0	< 2.3	< 2.4	< 1.9	< 1.6	nd	nd	nd
In	< 0.24	< 0.29	< 0.31	< 0.26	< 0.24	< 0.28	nd	nd	nd
Sb	0.33 ± 0.06	< 0.31	< 0.36	< 0.33	0.39 ± 0.09	< 0.28	0.29 ± 0.01	0.30 ± 0.01	0.31 ± 0.01
I	< 18	< 23	< 22	< 19	< 20	< 22	nd	nd	nd
Cs	3.46 ± 0.22	3.82 ± 0.22	3.44 ± 0.20	4.35 ± 0.25	5.71 ± 0.33	5.70 ± 0.32	4.96 ± 0.05	5.75 ± 0.06	6.45 ± 0.06
Ba	1506 ± 114	1566 ± 102	1522 ± 93	1330 ± 153	414 ± 93	276 ± 19	54 ± 4	31 ± 5	< 8
La	90.4 ± 5.0	84.2 ± 5.1	90.3 ± 5.0	79.1 ± 4.1	54.6 ± 3.1	38.6 ± 2.3	31.9 ± 0.3	34.4 ± 0.3	28.6 ± 0.3
Ce	165.1 ± 7.3	173.0 ± 7.6	164.9 ± 7.3	160.7 ± 7.2	104.6 ± 4.6	83.1 ± 3.7	63.7 ± 0.6	65.7 ± 0.7	63.4 ± 0.6
Nd	74.2 ± 5.8	72.3 ± 5.5	70.7 ± 5.5	63.7 ± 5.0	43.4 ± 3.3	33.5 ± 2.7	21.4 ± 1.2	23.2 ± 1.5	20.1 ± 1.3
Sm	11.0 ± 0.5	10.0 ± 0.5	10.9 ± 0.5	9.4 ± 0.4	7.5 ± 0.3	6.1 ± 0.3	4.9 ± 0.1	5.4 ± 0.1	5.0 ± 0.1
Eu	1.80 ± 0.09	1.84 ± 0.11	1.89 ± 0.09	1.58 ± 0.09	0.88 ± 0.06	0.51 ± 0.05	0.30 ± 0.01	0.31 ± 0.01	0.27 ± 0.01
Tb	.94 ± 0.09	1.00 ± 0.10	0.94 ± 0.09	0.99 ± 0.09	1.01 ± 0.10	0.83 ± 0.08	0.78 ± 0.01	0.82 ± 0.02	0.79 ± 0.02
Dy	6.04 ± 0.53	< 7.80	5.74 ± 0.57	5.76 ± 0.49	6.44 ± 0.58	5.65 ± 0.51	nd	nd	nd
Yb	3.35 ± 0.22	3.25 ± 0.27	3.60 ± 0.23	2.96 ± 0.21	3.62 ± 0.22	3.72 ± 0.23	3.12 ± 0.03	3.37 ± 0.03	3.35 ± 0.03
Lu	0.47 ± 0.03	0.49 ± 0.03	0.50 ± 0.03	0.46 ± 0.02	0.52 ± 0.03	0.51 ± 0.06	0.46 ± 0.01	0.48 ± 0.01	0.48 ± 0.01
Hf	7.73 ± 0.53	7.98 ± 0.74	8.04 ± 0.34	8.00 ± 0.60	7.51 ± 0.47	6.97 ± 0.45	6.93 ± 0.07	7.32 ± 0.08	7.17 ± 0.09
Ta	1.90 ± 0.13	1.84 ± 0.12	1.66 ± 0.11	1.56 ± 0.10	1.68 ± 0.10	2.32 ± 0.16	1.56 ± 0.02	2.59 ± 0.05	2.48 ± 0.05
W	46 ± 6	55 ± 7	60 ± 7	21 ± 3	26 ± 3	98 ± 12	54 ± 1	92 ± 1	77 ± 1
Au	< 0.013	< 0.013	< 0.015	< 0.013	< 0.009	< 0.012	nd	nd	nd
Hg	< 0.4	< 0.4	< 0.5	< 0.5	< 0.3	< 0.3	nd	nd	nd
Th	21.0 ± 0.8	22.5 ± 0.9	21.2 ± 0.8	21.6 ± 0.9	22.6 ± 0.9	25.8 ± 1.0	23.8 ± 0.2	25.3 ± 0.3	25.6 ± 0.3
U	4.10 ± 0.15	4.00 ± 0.14	3.74 ± 0.14	3.70 ± 0.14	4.09 ± 0.15	4.73 ± 0.17	3.80 ± 0.10	4.82 ± 0.12	4.91 ± 0.12

APPENDIX C. (cont)

Field No.	Stagecoach Road (Site 3 on Fig. 1)			Prow Pass Area (Southern Vertical Section: Site 5 on Fig. 1)						
	DEB 3/90-1	DEB 3/90-2	DEB 3/90-2	DEB 3/90-11	DEB 3/90-12	DEB 3/90-13	DEB 3/90-14	DEB 3/90-15	DEB 3/90-16	DEB 3/90-17
	Tcp	Tcp	Tcp	Thl	Thl	Thl	Thl	Thl	Thl	Thl
	nwt	nwt	nwt	b	b	nwt	nwt	nwt	nwt	nwt
Geol. Unit ¹	Zc, Op	Gl	Zc, Op	Zc, Op	Zc, Op	Zc, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Lithology ²	157,P1	158,P1	158,P2	167,P1	168,P1	169,P1	170,P1	171,P1	172,P1	173,P1
Alteration ³										
Lab. No.										
XRF and AA Results (wt %)										
SiO ₂	67.5	68.9	67.9	73.4	71.8	70.9	68.5	68.5	69.1	68.7
TiO ₂	0.12	0.19	0.11	0.15	0.11	0.11	0.09	0.08	0.08	0.09
Al ₂ O ₃	12.1	13.1	12.0	11.3	10.9	11.4	11.9	12.0	11.3	11.6
Fe ₂ O ₃ T	1.33	1.83	1.29	1.31	0.93	0.96	0.97	1.01	0.93	0.93
MnO	0.07	0.08	0.06	0.02	0.02	0.03	0.03	0.04	0.04	0.03
MgO	0.29	0.60	0.47	0.60	1.49	0.49	0.42	0.48	0.20	0.37
CaO	0.65	1.18	0.76	2.16	1.95	1.73	1.69	1.94	1.47	1.91
Na ₂ O	3.71	3.28	3.12	1.71	1.54	1.24	1.11	1.27	0.59	1.01
K ₂ O	4.16	4.20	4.24	2.96	3.20	3.77	5.16	4.47	5.80	4.53
P ₂ O ₅	0.07	0.09	0.07	0.07	0.08	0.07	0.07	0.08	0.07	0.08
LOI	10.2	6.1	10.0	6.7	8.5	9.0	10.2	10.4	10.0	11.2
Total	100.1	99.6	100.0	100.4	100.4	99.6	100.1	100.3	99.6	100.4
Ba ppm	187	183	191	451	393	307	122	110	111	84
Sr ppm	288	271	777	292	202	93	85	100	112	130
INAA Results⁴ (all values ppm unless otherwise noted)										
Na ₂ O (%)	3.91 ± 0.16	3.31 ± 0.14	3.23 ± 0.14	1.78 ± 0.07	1.65 ± 0.07	1.34 ± 0.06	1.25 ± 0.06	1.35 ± 0.06	0.68 ± 0.03	1.10 ± 0.05
MgO (%)	< 0.31	0.58 ± 0.09	0.44 ± 0.08	0.50 ± 0.05	1.26 ± 0.08	0.48 ± 0.07	0.38 ± 0.07	0.45 ± 0.09	< 0.19	< 0.21
Al ₂ O ₃ (%)	12.5 ± 0.4	13.6 ± 0.4	12.3 ± 0.3	11.4 ± 0.3	10.9 ± 0.3	11.5 ± 0.5	12.0 ± 0.3	12.0 ± 0.3	11.4 ± 0.3	11.8 ± 0.3
Cl	< 154	391 ± 37	< 114	< 82	563 ± 47	< 81	371 ± 46	1244 ± 97	< 81	636 ± 51
K ₂ O (%)	4.18 ± 0.28	4.46 ± 0.29	4.63 ± 0.30	2.88 ± 0.19	3.32 ± 0.22	4.26 ± 0.28	5.50 ± 0.35	4.78 ± 0.31	5.86 ± 0.37	4.95 ± 0.32
CaO (%)	0.33 ± 0.05	1.29 ± 0.10	0.66 ± 0.07	2.40 ± 0.14	1.77 ± 0.12	1.81 ± 0.12	1.75 ± 0.12	2.11 ± 0.13	1.39 ± 0.10	2.04 ± 0.13
Sc	1.74 ± 0.09	3.32 ± 0.18	1.61 ± 0.09	1.88 ± 0.10	1.85 ± 0.10	2.01 ± 0.11	2.37 ± 0.13	2.31 ± 0.12	2.30 ± 0.12	2.34 ± 0.13
Ti	< 4789	1205 ± 235	< 4113	870 ± 170	< 3205	428 ± 124	< 3433	< 3771	< 3180	619 ± 137
V	< 8	15 ± 2	9 ± 2	7 ± 1	< 6	< 6	< 6	< 6	< 6	< 6
Cr	1.9 ± 0.5	15.2 ± 1.1	3.2 ± 0.4	4.2 ± 0.4	2.1 ± 0.4	< 1.2	< 1.3	< 1.2	< 1.3	< 1.2
Mn	542 ± 24	624 ± 26	485 ± 19	157 ± 7	194 ± 8	269 ± 11	256 ± 10	328 ± 13	289 ± 16	297 ± 12
Fe ₂ O ₃ (%)	1.23 ± 0.07	1.79 ± 0.09	1.18 ± 0.07	1.19 ± 0.06	0.85 ± 0.05	0.93 ± 0.05	0.91 ± 0.05	0.92 ± 0.05	0.86 ± 0.05	0.87 ± 0.05
Co	3.86 ± 0.25	9.32 ± 0.49	4.73 ± 0.26	12.93 ± 0.69	6.28 ± 0.34	10.64 ± 0.56	8.01 ± 0.44	5.31 ± 0.29	6.34 ± 0.36	16.67 ± 0.88
Cu	< 329	< 328	< 245	< 218	< 209	< 245	< 196	< 224	< 178	< 232
Zn	64 ± 9	181 ± 23	47 ± 7	40 ± 7	38 ± 5	46 ± 7	35 ± 6	40 ± 6	33 ± 5	48 ± 6
Ga	< 30.5	< 24.5	< 22.1	< 20.7	< 20.0	< 18.3	17.5 ± 3.4	< 19.3	< 14.5	< 17.0
As	2.5 ± 0.5	3.9 ± 0.5	3.4 ± 0.5	1.4 ± 0.3	2.3 ± 0.4	2.3 ± 0.3	1.9 ± 0.3	2.3 ± 0.4	2.5 ± 0.4	3.0 ± 0.4
Se	< 3.5	< 3.1	< 2.8	< 2.6	< 2.5	< 2.9	< 3.2	< 2.7	< 3.4	< 2.9
Br	< 3.91	< 1.98	< 3.44	< 1.41	4.48 ± 0.57	< 2.49	< 2.71	3.22 ± 0.43	1.39 ± 0.68	1.67 ± 0.31
Rb	143 ± 7	151 ± 7	87 ± 4	93 ± 5	117 ± 6	149 ± 7	180 ± 9	178 ± 9	222 ± 11	252 ± 12
Sr	< 309	402 ± 111	883 ± 100	354 ± 68	< 200	< 218	< 246	< 266	< 191	< 221
Zr	117 ± 22	227 ± 32	135 ± 21	147 ± 25	113 ± 23	110 ± 30	112 ± 22	130 ± 24	114 ± 22	140 ± 27
Mo	< 111	< 113	< 86	< 90	< 3	< 89	< 68	< 80	< 57	< 75
Ag	< 1.8	< 2.0	< 1.4	< 2.0	< 1.5	< 1.8	< 1.9	1.2 ± 0.3	< 1.9	< 1.9
In	< 0.29	< 0.24	< 0.24	< 0.20	< 0.19	< 0.17	< 0.19	< 0.21	< 0.16	< 0.17
Sb	1.22 ± 0.16	< 0.39	< 0.35	< 0.31	0.43 ± 0.09	< 0.29	0.51 ± 0.07	0.48 ± 0.07	0.37 ± 0.07	0.38 ± 0.08
I	< 20	< 18	< 18	< 13	< 14	< 13	< 15	< 16	< 13	< 14
Cs	4.86 ± 0.28	9.26 ± 0.52	6.32 ± 0.36	4.01 ± 0.24	5.88 ± 0.34	4.10 ± 0.24	5.90 ± 0.33	5.08 ± 0.31	5.14 ± 0.30	5.88 ± 0.33
Ba	284 ± 46	299 ± 46	237 ± 50	593 ± 55	540 ± 29	459 ± 52	137 ± 51	126 ± 31	123 ± 25	154 ± 18
La	38.7 ± 2.2	52.2 ± 3.1	37.1 ± 2.0	34.2 ± 2.0	33.4 ± 1.9	51.4 ± 3.1	28.6 ± 1.5	28.1 ± 1.7	22.4 ± 1.4	31.2 ± 2.0
Ce	93.6 ± 4.3	112.1 ± 5.0	77.7 ± 3.5	63.3 ± 3.0	64.5 ± 2.8	95.7 ± 4.2	53.4 ± 2.6	56.1 ± 2.5	48.1 ± 2.3	61.5 ± 2.7
Nd	31.3 ± 2.8	43.0 ± 3.3	25.2 ± 2.0	24.0 ± 2.1	27.4 ± 2.3	36.5 ± 2.9	25.8 ± 2.4	26.5 ± 2.5	21.5 ± 1.9	33.6 ± 2.8
Sm	4.7 ± 0.2	8.6 ± 0.4	4.8 ± 0.2	4.3 ± 0.2	4.0 ± 0.2	6.4 ± 0.3	4.8 ± 0.2	5.0 ± 0.2	3.8 ± 0.2	5.3 ± 0.2
Eu	0.24 ± 0.04	0.42 ± 0.05	0.26 ± 0.03	0.65 ± 0.04	0.45 ± 0.04	0.51 ± 0.03	0.26 ± 0.03	0.26 ± 0.02	0.21 ± 0.03	0.30 ± 0.04
Tb	0.53 ± 0.05	1.13 ± 0.11	0.58 ± 0.07	0.42 ± 0.05	0.54 ± 0.05	0.81 ± 0.09	0.56 ± 0.05	0.63 ± 0.07	0.51 ± 0.06	0.64 ± 0.07
Dy	3.52 ± 0.37	6.74 ± 0.61	4.01 ± 0.38	2.69 ± 0.31	3.64 ± 0.36	4.55 ± 0.97	3.92 ± 0.36	3.82 ± 0.41	3.69 ± 0.42	4.36 ± 0.41
Yb	2.38 ± 0.26	3.94 ± 0.27	1.83 ± 0.18	1.82 ± 0.18	2.03 ± 0.16	2.50 ± 0.19	1.98 ± 0.16	2.32 ± 0.17	2.25 ± 0.15	2.07 ± 0.17
Lu	0.28 ± 0.02	0.56 ± 0.03	0.31 ± 0.02	0.24 ± 0.02	0.31 ± 0.02	0.39 ± 0.02	0.28 ± 0.02	0.37 ± 0.02	0.30 ± 0.02	0.29 ± 0.02
Hf	5.76 ± 0.44	6.27 ± 0.44	5.31 ± 0.32	3.84 ± 0.36	3.06 ± 0.25	3.53 ± 0.30	3.62 ± 0.20	3.74 ± 0.24	3.50 ± 0.18	3.49 ± 0.25
Ta	2.03 ± 0.14	2.39 ± 0.16	1.79 ± 0.12	2.57 ± 0.16	1.63 ± 0.11	2.52 ± 0.18	2.12 ± 0.14	1.61 ± 0.10	2.14 ± 0.14	1.65 ± 0.11
W	42 ± 5	73 ± 9	45 ± 5	136 ± 17	58 ± 7	140 ± 17	65 ± 8	27 ± 3	74 ± 9	35 ± 4
Au	< 0.016	< 0.017	< 0.015	< 0.013	< 0.010	< 0.012	< 0.011	< 0.012	< 0.007	< 0.011
Hg	< 0.4	< 0.4	< 0.3	0.6 ± 0.2	0.3 ± 0.1	0.4 ± 0.1	< 0.4	< 0.4	< 0.4	< 0.4
Th	19.9 ± 0.8	21.8 ± 0.8	19.5 ± 0.7	14.9 ± 0.6	18.1 ± 0.7	21.7 ± 1.1	21.2 ± 0.8	22.4 ± 0.9	19.5 ± 0.8	22.3 ± 0.9
U	4.00 ± 0.10	3.70 ± 0.10	2.40 ± 0.10	2.60 ± 0.10	2.70 ± 0.10	2.80 ± 0.10	2.90 ± 0.10	2.70 ± 0.10	3.10 ± 0.10	3.40 ± 0.10

APPENDIX C. (cont)

Prow Pass Area (Southern Vertical Section Cont.: Site 5 on Fig. 1)

Field No.	DEB 3/90-18	DEB 3/90-19	DEB 3/90-20	DEB 3/90-21	DEB 3/90-22	DEB 3/90-23	DEB 3/90-24	DEB 3/90-25	DEB 3/90-26
Geol. Unit ¹	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt	b
Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Lab. No.	174,P1	175,P1	176,P1	177,P1	178,P1	179,P1	180,P1	181,P1	182,P1
XRF and AA Results (wt.%)									
SiO ₂	69.6	69.8	67.9	68.0	71.6	69.5	68.4	69.2	70.4
TiO ₂	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Al ₂ O ₃	11.8	11.0	11.7	11.9	11.1	11.1	11.2	11.5	11.4
Fe ₂ O ₃ T	0.95	0.88	1.03	0.96	0.91	0.73	0.88	0.82	0.84
MnO	0.03	0.03	0.04	0.04	0.01	0.01	0.05	0.03	0.02
MgO	0.23	0.47	0.21	0.25	0.30	0.26	0.51	0.35	0.55
CaO	1.52	1.73	1.64	1.77	1.67	1.42	2.21	1.68	2.00
Na ₂ O	1.09	1.47	0.59	0.66	1.04	0.56	1.03	0.73	0.97
K ₂ O	4.92	3.82	5.94	5.92	4.68	5.95	3.55	5.09	3.95
P ₂ O ₅	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.08
LOI	10.3	10.7	10.1	10.5	8.8	10.6	11.5	11.1	6.8
Total	100.5	100.0	99.3	100.1	100.2	100.3	99.4	100.6	100.0
Ba ppm	130	84	59	80	91	49	53	67	87
Sr ppm	64	98	35	43	177	64	200	48	180
INAA Results⁴ (all values ppm unless otherwise noted)									
Na ₂ O (%)	1.22 ± 0.05	1.50 ± 0.06	0.65 ± 0.03	0.68 ± 0.03	1.17 ± 0.05	0.58 ± 0.02	1.10 ± 0.05	0.91 ± 0.04	1.08 ± 0.05
MgO (%)	< 0.33	0.55 ± 0.08	< 0.20	< 0.20	0.36 ± 0.07	0.28 ± 0.05	0.61 ± 0.08	0.27 ± 0.06	0.45 ± 0.06
Al ₂ O ₃ (%)	11.9 ± 0.3	11.3 ± 0.3	11.9 ± 0.3	12.1 ± 0.4	11.3 ± 0.3	11.4 ± 0.3	11.5 ± 0.3	11.6 ± 0.5	11.4 ± 0.3
Cl	< 91	124 ± 19	< 82	< 65	< 79	< 60	< 90	< 72	< 80
K ₂ O (%)	5.17 ± 0.33	3.84 ± 0.25	5.99 ± 0.38	6.03 ± 0.38	5.04 ± 0.32	6.12 ± 0.39	3.48 ± 0.23	5.34 ± 0.34	4.21 ± 0.27
CaO (%)	1.80 ± 0.12	1.67 ± 0.12	1.59 ± 0.11	1.91 ± 0.12	1.74 ± 0.11	1.54 ± 0.11	2.29 ± 0.13	1.80 ± 0.12	2.10 ± 0.13
Sc	2.25 ± 0.12	2.21 ± 0.12	2.48 ± 0.13	2.47 ± 0.13	2.20 ± 0.12	2.31 ± 0.12	2.56 ± 0.14	2.51 ± 0.14	2.33 ± 0.12
Ti	< 3722	< 3642	< 3606	307 ± 108	< 2979	< 2719	< 3466	453 ± 122	< 3105
V	< 6	< 6	< 6	< 6	< 5	< 5	< 6	< 5	< 5
Cr	< 1.4	1.3 ± 0.3	< 1.3	< 1.2	< 1.3	1.2 ± 0.4	1.5 ± 0.4	1.6 ± 0.4	< 1.0
Mn	283 ± 11	271 ± 11	368 ± 15	356 ± 15	155 ± 6	119 ± 5	375 ± 15	266 ± 11	221 ± 9
Fe ₂ O ₃ (%)	0.88 ± 0.05	0.80 ± 0.04	0.88 ± 0.04	0.89 ± 0.05	0.82 ± 0.05	0.68 ± 0.04	0.83 ± 0.04	0.77 ± 0.04	0.79 ± 0.04
Co	5.27 ± 0.31	5.40 ± 0.30	5.31 ± 0.29	5.28 ± 0.29	5.54 ± 0.32	4.82 ± 0.27	2.97 ± 0.29	4.47 ± 0.25	6.24 ± 0.34
Cu	< 202	< 237	< 184	< 212	< 181	< 168	< 201	< 202	< 179
Zn	36 ± 6	41 ± 6	43 ± 6	47 ± 6	32 ± 5	33 ± 5	< 5	54 ± 8	49 ± 7
Ga	20.4 ± 3.6	20.0 ± 4.4	14.6 ± 3.5	14.8 ± 2.7	13.1 ± 2.8	12.6 ± 2.8	< 17.5	13.0 ± 3.2	19.9 ± 3.6
As	5.0 ± 0.6	6.0 ± 0.7	6.7 ± 0.7	4.1 ± 0.5	3.6 ± 0.5	1.9 ± 0.3	3.5 ± 0.4	2.4 ± 0.3	2.3 ± 0.3
Se	< 3.5	2.9 ± 0.8	< 2.9	< 3.0	< 3.3	< 2.7	< 2.2	< 2.6	< 2.5
Br	< 2.75	< 3.14	< 1.82	< 1.74	< 2.44	< 2.25	< 2.01	1.27 ± 0.58	< 0.95
Rb	216 ± 10	136 ± 7	223 ± 11	222 ± 11	179 ± 9	195 ± 9	147 ± 7	175 ± 8	146 ± 7
Sr	< 262	< 267	< 210	< 213	303 ± 61	< 183	220 ± 64	< 190	< 227
Zr	74 ± 23	115 ± 23	120 ± 24	99 ± 30	96 ± 26	112 ± 23	87 ± 34	88 ± 19	101 ± 21
Mo	< 1	< 88	< 61	< 65	< 66	< 70	< 60	< 82	< 63
Ag	< 1.9	< 2.0	< 2.2	< 1.7	< 1.8	< 2.0	< 1.8	< 1.6	< 1.6
In	< 0.20	< 0.22	< 0.17	< 0.15	< 0.17	< 0.16	< 0.18	< 0.15	< 0.17
Sb	0.29 ± 0.06	0.48 ± 0.10	0.54 ± 0.07	0.43 ± 0.07	0.56 ± 0.07	0.34 ± 0.07	0.34 ± 0.07	0.27 ± 0.06	0.43 ± 0.07
I	< 16	< 15	< 14	< 13	< 13	< 11	< 15	< 11	< 14
Cs	5.66 ± 0.40	4.00 ± 0.23	5.74 ± 0.36	5.88 ± 0.35	5.06 ± 0.29	4.09 ± 0.25	4.27 ± 0.26	4.51 ± 0.27	3.84 ± 0.23
Ba	190 ± 57	125 ± 18	132 ± 31	139 ± 43	140 ± 28	110 ± 51	96 ± 28	80 ± 15	94 ± 29
La	36.0 ± 2.0	30.3 ± 1.7	30.9 ± 1.8	19.2 ± 1.2	30.2 ± 1.6	33.5 ± 1.8	23.4 ± 1.3	31.9 ± 2.1	26.7 ± 1.4
Ce	67.9 ± 3.2	61.8 ± 3.0	67.9 ± 3.3	48.4 ± 2.3	54.7 ± 2.6	61.8 ± 2.7	55.3 ± 2.4	64.9 ± 2.9	56.3 ± 2.5
Nd	34.6 ± 3.0	25.7 ± 2.3	33.1 ± 3.1	23.9 ± 2.1	32.0 ± 2.7	30.8 ± 2.6	26.0 ± 2.2	31.0 ± 2.4	25.1 ± 2.1
Sm	6.6 ± 0.3	6.0 ± 0.3	5.6 ± 0.3	3.5 ± 0.2	5.6 ± 0.3	6.6 ± 0.3	4.5 ± 0.2	6.3 ± 0.3	4.7 ± 0.2
Eu	0.37 ± 0.04	0.27 ± 0.02	0.26 ± 0.03	0.19 ± 0.03	0.24 ± 0.03	0.27 ± 0.03	0.24 ± 0.03	0.29 ± 0.03	0.25 ± 0.03
Tb	0.80 ± 0.07	0.71 ± 0.07	0.80 ± 0.08	0.52 ± 0.05	0.64 ± 0.07	0.76 ± 0.08	0.61 ± 0.06	0.76 ± 0.07	0.63 ± 0.06
Dy	5.36 ± 0.53	4.35 ± 0.41	5.13 ± 0.49	3.96 ± 0.36	4.73 ± 0.40	4.37 ± 0.41	< 5.32	4.40 ± 0.58	3.90 ± 0.36
Yb	3.12 ± 0.21	2.12 ± 0.20	3.74 ± 0.25	2.60 ± 0.17	3.26 ± 0.37	2.06 ± 0.15	1.86 ± 0.14	2.03 ± 0.17	2.19 ± 0.15
Lu	0.43 ± 0.02	0.32 ± 0.02	0.42 ± 0.02	0.41 ± 0.02	0.40 ± 0.02	0.22 ± 0.02	0.31 ± 0.02	0.30 ± 0.02	0.33 ± 0.02
Hf	3.77 ± 0.38	3.35 ± 0.15	3.72 ± 0.24	3.61 ± 0.23	3.44 ± 0.32	3.22 ± 0.17	3.63 ± 0.22	3.45 ± 0.22	3.61 ± 0.25
Ta	1.77 ± 0.11	1.69 ± 0.12	1.87 ± 0.13	1.75 ± 0.12	1.76 ± 0.13	1.69 ± 0.12	1.59 ± 0.11	1.57 ± 0.11	1.98 ± 0.15
W	40 ± 5	44 ± 5	36 ± 5	36 ± 4	46 ± 6	33 ± 4	26 ± 3	28 ± 3	67 ± 8
Au	< 0.012	< 0.013	< 0.007	< 0.008	< 0.011	< 0.009	< 0.008	< 0.009	< 0.010
Hg	< 0.4	< 0.4	< 0.4	< 0.3	< 0.4	0.7 ± 0.2	< 0.3	< 0.3	< 0.3
Th	23.6 ± 0.9	23.2 ± 0.9	24.1 ± 0.9	23.6 ± 0.9	21.0 ± 0.9	24.1 ± 0.9	22.3 ± 0.9	24.4 ± 1.0	21.3 ± 0.8
U	3.40 ± 0.10	3.90 ± 0.10	4.60 ± 0.20	4.50 ± 0.20	4.30 ± 0.20	3.70 ± 0.10	3.36 ± 0.12	3.06 ± 0.12	2.73 ± 0.10

APPENDIX C. (cont)

Prow Pass Area (Southern Vertical Section Cont.: Site 5 on Fig. 1)

Field No.	DEB 3/90-27	DEB 3/90-28	DEB 3/90-29	DEB 3/90-30	DEB 3/90-31	DEB 3/90-32	DEB 3/90-33	DEB 3/90-34	DEB 3/90-35
Geol. Unit ¹	Tht	Tht	Tht	Tht	Tht	Tht	Tpt	Tpt	Tpt
Lithology ²	nwt	nwt	nwt	b	nwt	nwt	nwt	vt	vt
Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Gl, Zc, Zm, Op	Gl
Lab. No.	183,P1	184,P1	185,P1	186,P1	187,P1	188,P1	189,P1	190,P1	191,P1
XRF and AA Results (wt.%)									
SiO ₂	68.9	68.8	69.2	72.1	67.6	67.9	68.8	71.1	74.2
TiO ₂	0.09	0.09	0.08	0.11	0.08	0.09	0.09	0.10	0.10
Al ₂ O ₃	11.4	11.3	11.3	10.5	11.4	11.3	11.2	11.4	12.4
Fe ₂ O ₃ T	0.89	0.96	0.87	1.03	1.00	0.93	0.82	0.99	1.01
MnO	0.03	0.04	0.03	0.10	0.04	0.05	0.02	0.05	0.06
MgO	0.46	0.51	0.33	0.35	0.38	0.58	0.67	0.46	0.16
CaO	2.30	2.27	2.07	2.00	2.14	3.06	3.07	1.67	0.54
Na ₂ O	1.23	1.10	1.06	1.37	0.93	1.13	0.69	1.84	3.44
K ₂ O	3.41	3.55	3.99	3.31	4.30	1.88	2.29	4.21	4.55
P ₂ O ₅	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.09	0.07
LOI	11.3	11.5	11.3	9.4	12.1	13.4	13.2	8.2	3.7
Total	100.1	100.1	100.1	100.4	100.0	100.3	100.9	100.1	100.2
Ba ppm	63	58	48	178	43	36	28	18	46
Sr ppm	410	600	660	270	82	108	326	122	26
INAA Results⁴ (all values ppm unless otherwise noted)									
Na ₂ O (%)	1.29 ± 0.05	1.19 ± 0.05	1.04 ± 0.04	1.42 ± 0.07	0.96 ± 0.04	1.21 ± 0.05	0.71 ± 0.03	1.90 ± 0.08	3.48 ± 0.15
MgO (%)	0.31 ± 0.07	< 0.21	< 0.19	< 0.39	0.32 ± 0.07	0.49 ± 0.09	0.59 ± 0.05	0.36 ± 0.06	< 0.37
Al ₂ O ₃ (%)	11.7 ± 0.3	11.4 ± 0.3	11.6 ± 0.3	10.4 ± 0.3	11.8 ± 0.3	11.6 ± 0.3	11.6 ± 0.3	12.2 ± 0.3	12.3 ± 0.3
Cl	105 ± 22	< 91	< 74	189 ± 23	< 85	< 89	< 76	157 ± 22	505 ± 43
K ₂ O (%)	3.39 ± 0.22	3.41 ± 0.23	4.26 ± 0.27	3.61 ± 0.23	4.84 ± 0.31	1.91 ± 0.16	2.57 ± 0.19	4.10 ± 0.28	4.89 ± 0.33
CaO (%)	2.51 ± 0.15	2.41 ± 0.14	2.11 ± 0.13	2.03 ± 0.13	2.42 ± 0.15	3.01 ± 0.18	3.10 ± 0.17	1.73 ± 0.11	0.59 ± 0.06
Sc	2.29 ± 0.12	2.29 ± 0.12	2.35 ± 0.12	1.94 ± 0.11	2.06 ± 0.11	2.03 ± 0.11	2.04 ± 0.11	2.28 ± 0.12	2.28 ± 0.12
Ti	< 3442	< 3355	630 ± 154	663 ± 181	< 3764	484 ± 144	< 2871	536 ± 139	< 4033
V	< 6	< 6	< 5	< 7	< 6	< 7	< 5	< 5	< 6
Cr	< 1.3	1.3 ± 0.4	< 1.0	3.0 ± 0.4	< 1.3	< 1.3	< 1.0	< 0.9	< 1.0
Mn	268 ± 11	302 ± 13	289 ± 12	715 ± 29	338 ± 14	389 ± 16	176 ± 7	426 ± 18	504 ± 21
Fe ₂ O ₃ (%)	0.80 ± 0.05	0.86 ± 0.05	0.82 ± 0.04	0.97 ± 0.05	0.92 ± 0.05	0.84 ± 0.04	0.86 ± 0.04	0.95 ± 0.05	0.94 ± 0.05
Co	4.69 ± 0.28	4.40 ± 0.24	4.31 ± 0.32	7.21 ± 0.38	3.99 ± 0.25	5.19 ± 0.32	3.86 ± 0.31	5.55 ± 0.29	6.38 ± 0.34
Cu	< 213	< 199	< 216	< 224	< 182	< 242	< 168	< 233	< 245
Zn	36 ± 6	40 ± 5	< 5	61 ± 8	55 ± 8	48 ± 7	< 5	55 ± 7	47 ± 7
Ga	8.0 ± 2.5	15.6 ± 3.5	11.8 ± 3.1	18.9 ± 3.7	< 22.0	< 30.7	22.8 ± 5.0	< 30.9	< 33.7
As	2.2 ± 0.3	1.8 ± 0.3	1.4 ± 0.3	3.2 ± 0.4	2.5 ± 0.4	< 2.2	2.2 ± 0.4	2.5 ± 0.4	4.3 ± 0.6
Se	< 3.1	< 2.8	< 2.2	< 2.8	< 3.2	< 2.7	< 2.3	< 2.3	< 2.6
Br	< 2.83	< 2.14	< 1.98	< 1.12	< 2.50	< 2.78	< 2.50	< 1.39	< 1.27
Rb	135 ± 7	161 ± 8	203 ± 10	154 ± 8	185 ± 9	159 ± 8	121 ± 6	181 ± 9	179 ± 8
Sr	363 ± 74	654 ± 85	755 ± 85	< 351	< 262	< 299	455 ± 66	< 214	< 290
Zr	160 ± 33	132 ± 25	123 ± 33	154 ± 28	154 ± 26	117 ± 22	149 ± 32	118 ± 20	113 ± 20
Mo	< 3	< 64	< 2	< 74	0	< 66	< 69	< 76	7 ± 4
Ag	< 1.8	< 1.9	< 1.8	< 1.6	< 1.8	< 2.1	< 1.7	< 1.4	< 1.5
In	< 0.20	< 0.17	< 0.15	< 0.23	< 0.19	< 0.23	< 0.15	< 0.17	< 0.23
Sb	0.22 ± 0.07	0.25 ± 0.07	0.24 ± 0.06	0.38 ± 0.08	0.31 ± 0.06	0.20 ± 0.06	0.23 ± 0.06	0.24 ± 0.06	< 0.25
I	< 14	< 13	< 12	< 21	< 16	< 17	< 11	< 13	< 18
Cs	5.90 ± 0.33	5.80 ± 0.34	5.89 ± 0.34	8.32 ± 0.47	6.93 ± 0.39	6.91 ± 0.39	4.91 ± 0.28	7.26 ± 0.41	6.79 ± 0.39
Ba	< 60 ±	69 ± 21	94 ± 20	220 ± 52	< 74	< 200	< 170	93 ± 13	78 ± 32
La	32.9 ± 2.2	32.1 ± 1.8	28.7 ± 1.9	45.4 ± 2.4	39.3 ± 2.2	27.1 ± 1.4	42.0 ± 2.3	27.1 ± 1.6	33.5 ± 2.1
Ce	62.9 ± 2.8	60.9 ± 2.9	63.0 ± 2.9	93.4 ± 4.2	71.4 ± 3.1	55.0 ± 2.8	82.8 ± 3.8	63.1 ± 2.8	71.0 ± 3.1
Nd	28.7 ± 2.6	34.6 ± 3.1	28.5 ± 2.4	41.3 ± 3.3	30.6 ± 2.5	26.0 ± 2.3	41.4 ± 3.2	28.4 ± 2.3	34.0 ± 2.8
Sm	5.8 ± 0.3	5.5 ± 0.2	4.8 ± 0.2	6.4 ± 0.3	6.5 ± 0.3	4.1 ± 0.2	7.4 ± 0.3	4.5 ± 0.2	6.1 ± 0.3
Eu	0.25 ± 0.02	0.24 ± 0.02	0.25 ± 0.02	0.36 ± 0.03	0.29 ± 0.02	0.24 ± 0.03	0.32 ± 0.03	0.25 ± 0.04	0.26 ± 0.03
Tb	0.66 ± 0.07	0.65 ± 0.06	0.55 ± 0.05	0.83 ± 0.08	0.81 ± 0.08	0.47 ± 0.06	0.89 ± 0.09	0.41 ± 0.11	0.71 ± 0.07
Dy	3.66 ± 0.36	4.20 ± 0.37	3.42 ± 0.32	5.25 ± 0.47	5.56 ± 0.56	2.76 ± 0.34	4.75 ± 0.58	3.72 ± 1.06	4.50 ± 0.41
Yb	1.66 ± 0.15	2.21 ± 0.26	1.86 ± 0.16	3.89 ± 0.24	3.63 ± 0.41	2.11 ± 0.14	1.88 ± 0.14	2.22 ± 0.16	2.84 ± 0.20
Lu	0.26 ± 0.02	0.33 ± 0.02	0.24 ± 0.02	0.56 ± 0.05	0.39 ± 0.02	0.28 ± 0.02	0.26 ± 0.02	0.32 ± 0.02	0.39 ± 0.02
Hf	3.56 ± 0.24	3.77 ± 0.18	3.81 ± 0.23	4.18 ± 0.18	4.16 ± 0.31	4.31 ± 0.28	4.11 ± 0.21	4.39 ± 0.29	4.52 ± 0.26
Ta	1.64 ± 0.11	1.70 ± 0.11	1.62 ± 0.11	1.85 ± 0.12	1.44 ± 0.11	1.36 ± 0.11	1.36 ± 0.10	1.81 ± 0.13	2.26 ± 0.14
W	36 ± 5	40 ± 5	43 ± 5	54 ± 7	26 ± 3	16 ± 2	13 ± 2	50 ± 6	73 ± 9
Au	< 0.011	< 0.008	< 0.010	< 0.012	< 0.010	< 0.010	< 0.009	< 0.008	< 0.011
Hg	< 0.4	< 0.4	< 0.3	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3	< 0.3
Th	21.8 ± 0.8	21.9 ± 0.9	22.4 ± 0.9	18.6 ± 0.7	21.4 ± 0.8	21.9 ± 0.9	24.0 ± 1.0	22.2 ± 1.3	23.3 ± 0.9
U	2.97 ± 0.11	2.84 ± 0.11	2.90 ± 0.11	4.38 ± 0.16	4.17 ± 0.15	2.22 ± 0.09	3.82 ± 0.14	3.71 ± 0.13	4.71 ± 0.16

APPENDIX C. (cont)

Prox Pass Area (Central Vertical Section: Site 5 on Fig. 1)

Field No.	3-15-82-1	3-15-82-2	3-15-82-3	3-15-82-4	3-15-82-5	3-15-82-6	3-15-82-7	3-15-82-8	3-15-82-9	3-15-82-10
Geol. Unit ¹	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tpt
Lithology ²	nwt	b	b	b	nwt	nwt	nwt	nwt	nwt	nwt
Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Lab. No.	82, P1	83, P1	84, P1	85, P1	86, P1	87, P1	88, P1	89, P1	90, P1	91, P1
XRF and AA Results (wt.%)										
SiO ₂	72.1	73.8	71.1	67.2	69.7	68.2	69.3	68.0	67.0	70.5
TiO ₂	0.16	0.09	0.10	0.09	0.09	0.09	0.08	0.09	0.13	0.09
Al ₂ O ₃	12.4	10.1	11.5	11.8	12.4	12.1	11.3	11.5	12.3	10.7
Fe ₂ O ₃ T	1.36	0.76	0.86	0.89	0.92	0.98	0.86	0.92	1.13	0.74
MnO	0.04	0.02	0.02	0.03	0.04	0.03	0.03	0.04	0.03	0.06
MgO	0.43	0.14	0.07	0.19	0.07	0.28	0.24	0.28	0.10	0.46
CaO	1.88	1.08	0.98	2.08	1.15	1.88	1.88	2.31	0.71	2.27
Na ₂ O	2.01	1.33	0.88	2.02	0.64	0.77	0.97	1.13	0.55	1.15
K ₂ O	4.00	4.48	6.71	4.63	6.42	5.11	4.68	4.62	7.86	2.94
P ₂ O ₅	0.05	0.01	0.02	0.01	0.01	0.01	0.01	0.09	0.01	0.02
LOI	5.2	8.2	8.0	10.9	8.6	10.6	10.8	11.2	10.5	11.4
Total	99.7	99.9	100.2	99.8	100.1	99.9	100.2	100.2	100.3	100.3
Ba ppm	546	233	251	116	143	116	81	81	90	27
Sr ppm	279	72	65	50	53	70	44	62	42	186
INAA Results⁴ (all values ppm unless otherwise noted)										
Na ₂ O (%)	1.99 ± 0.03	1.30 ± 0.03	0.81 ± 0.01	2.05 ± 0.02	0.57 ± 0.01	0.71 ± 0.01	0.90 ± 0.01	1.06 ± 0.01	0.51 ± 0.01	1.13 ± 0.01
MgO (%)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Al ₂ O ₃ (%)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
K ₂ O (%)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
CaO (%)	1.89 ± 0.16	0.92 ± 0.11	0.92 ± 0.10	1.89 ± 0.20	1.01 ± 0.10	1.82 ± 0.13	1.91 ± 0.13	2.44 ± 0.12	0.62 ± 0.08	2.15 ± 0.12
Sc	2.11 ± 0.02	1.78 ± 0.02	2.05 ± 0.02	2.44 ± 0.02	2.44 ± 0.02	2.55 ± 0.03	2.32 ± 0.02	2.54 ± 0.03	2.81 ± 0.03	1.98 ± 0.02
Ti	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
V	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cr	1.71 ± 0.22	< 5	< 5	< 5	< 5	< 5	< 5	2.05 ± 0.23	2.1 ± 0.15	< 5
Mn	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fe ₂ O ₃ (%)	1.28 ± 0.01	0.72 ± 0.01	0.80 ± 0.01	0.82 ± 0.01	0.84 ± 0.01	0.91 ± 0.01	0.81 ± 0.01	0.88 ± 0.01	1.09 ± 0.01	0.71 ± 0.01
Co	24.13 ± 0.24	19.50 ± 0.19	21.24 ± 0.21	9.35 ± 0.09	6.21 ± 0.06	6.02 ± 0.06	7.78 ± 0.08	9.54 ± 0.10	4.29 ± 0.04	13.59 ± 0.14
Cu	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Zn	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Ga	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
As	3.4 ± 0.4	3.8 ± 0.5	2.3 ± 0.1	2.4 ± 0.2	1.8 ± 0.3	4.1 ± 0.2	5.2 ± 0.2	8.2 ± 0.2	2.8 ± 0.3	1.4 ± 0.2
Se	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Br	0.29 ± 0.11	< 0.30	0.16 ± 0.04	0.60 ± 0.09	< 0.20	0.17 ± 0.05	0.15 ± 0.05	0.32 ± 0.05	< 0.20	0.14 ± 0.06
Rb	132 ± 4	130 ± 3	210 ± 4	160 ± 4	237 ± 5	216 ± 5	232 ± 5	208 ± 4	207 ± 4	150 ± 3
Sr	267 ± 15	63 ± 8	69 ± 7	49 ± 8	44 ± 6	61 ± 7	34 ± 6	50 ± 7	38 ± 6	175 ± 9
Zr	140 ± 12	72 ± 8	82 ± 7	93 ± 9	90 ± 7	86 ± 8	87 ± 7	104 ± 9	117 ± 6	101 ± 6
Mo	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Ag	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
In	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sb	0.50 ± 0.02	0.39 ± 0.01	0.31 ± 0.01	0.42 ± 0.02	0.41 ± 0.01	0.27 ± 0.01	0.37 ± 0.01	0.48 ± 0.01	0.18 ± 0.01	0.09 ± 0.01
I	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cs	4.01 ± 0.04	3.62 ± 0.04	4.78 ± 0.05	6.1 ± 0.06	6.28 ± 0.06	5.66 ± 0.06	6.65 ± 0.07	5.85 ± 0.06	3.73 ± 0.04	5.74 ± 0.06
Ba	533 ± 10	251 ± 7	252 ± 7	95 ± 6	125 ± 5	83 ± 5	74 ± 5	80 ± 5	92 ± 4	38 ± 4
La	36.4 ± 0.4	33.2 ± 0.3	40.0 ± 0.4	48.7 ± 0.5	25.8 ± 0.3	30.4 ± 0.3	27.9 ± 0.3	32.6 ± 0.3	34.1 ± 0.3	26.1 ± 0.3
Ce	73.4 ± 0.7	65.5 ± 0.7	76.6 ± 0.8	88.7 ± 0.9	51.3 ± 0.5	51.2 ± 0.5	50.8 ± 0.5	72.6 ± 0.7	71.7 ± 0.7	59.9 ± 0.6
Nd	26.5 ± 1.8	25.1 ± 1.5	24.3 ± 1.4	41.2 ± 2.4	21.9 ± 1.3	25.8 ± 1.5	20.5 ± 1.3	27.6 ± 1.4	25.1 ± 1.4	19.6 ± 1.2
Sm	4.9 ± 0.1	5.4 ± 0.1	5.0 ± 0.1	9.0 ± 0.1	4.6 ± 0.1	5.5 ± 0.1	5.1 ± 0.1	6.5 ± 0.1	4.8 ± 0.1	4.2 ± 0.1
Eu	0.57 ± 0.01	0.33 ± 0.01	0.34 ± 0.01	0.41 ± 0.01	0.25 ± 0.01	0.28 ± 0.01	0.24 ± 0.01	0.32 ± 0.01	0.32 ± 0.01	0.18 ± 0.01
Tb	0.61 ± 0.02	0.62 ± 0.02	0.55 ± 0.02	1.09 ± 0.03	0.56 ± 0.01	0.61 ± 0.02	0.60 ± 0.01	1.02 ± 0.03	0.49 ± 0.01	0.53 ± 0.01
Dy	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Yb	2.18 ± 0.03	1.60 ± 0.02	1.65 ± 0.02	2.30 ± 0.03	1.91 ± 0.02	1.66 ± 0.02	1.86 ± 0.02	4.84 ± 0.05	1.40 ± 0.02	2.11 ± 0.02
Lu	0.31 ± 0.01	0.22 ± 0.01	0.24	0.31 ± 0.01	0.28 ± 0.01	0.25 ± 0.01	0.28 ± 0.01	0.70 ± 0.01	0.20	0.32 ± 0.01
Hf	4.26 ± 0.06	3.03 ± 0.04	3.38 ± 0.05	3.44 ± 0.05	3.66 ± 0.04	3.51 ± 0.04	3.52 ± 0.04	3.47 ± 0.04	4.13 ± 0.05	3.77 ± 0.04
Ta	2.04 ± 0.04	1.75 ± 0.03	2.07 ± 0.04	1.61 ± 0.04	1.61 ± 0.03	1.53 ± 0.03	1.50 ± 0.03	1.57 ± 0.03	1.29 ± 0.03	1.50 ± 0.03
W	345 ± 3	210 ± 2	315 ± 3	94 ± 1	76 ± 1	61 ± 1	85 ± 1	99 ± 1	42 ± 1	114 ± 1
Au	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hg	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Th	16.4 ± 0.2	20.6 ± 0.2	22.6 ± 0.2	27.3 ± 0.3	22.7 ± 0.2	22.9 ± 0.2	20.3 ± 0.2	18.8 ± 0.2	21.0 ± 0.2	16.5 ± 0.2
U	3.34 ± 0.10	4.44 ± 0.13	2.99 ± 0.08	5.49 ± 0.13	3.06 ± 0.09	2.74 ± 0.07	3.52 ± 0.09	4.21 ± 0.09	2.55 ± 0.08	4.47 ± 0.10

APPENDIX C. (cont)

Prow Pass Area (Northern Vertical Section; Site 5 on Fig. 1)

Field No.	3-15-82-11	82FB-1	82FB-2	82FB-3A	82FB-3B	82FB-4	82FB-5
Geol. Unit ¹	Tpt	Tht	Tht	Tht	Tht	Tht	Tht
Lithology ²	pwt	nwt	nwt	nwt	nwt	nwt	nwt
Alteration ³	Gl, Zc, Zm, Op	Zm	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Lab. No.	92,P1	110,P1	111,P1	112, P1	113,P1	114, P1	115,P1
XRF and AA Results (wt.%)							
SiO ₂	68.8	68.7	70.7	69.6	66.6	68.1	68.5
TiO ₂	0.10	0.15	0.15	0.15	0.13	0.17	0.18
Al ₂ O ₃	12.1	12.8	11.8	12.4	10.8	11.5	12.0
Fe ₂ O ₃ T	0.98	1.28	1.28	1.23	1.10	1.00	1.06
MnO	0.08	0.04	0.03	0.06	0.03	0.07	0.07
MgO	0.51	0.42	0.52	0.34	1.05	1.20	0.20
CaO	1.91	2.34	1.76	1.62	3.11	2.54	1.00
Na ₂ O	1.74	1.96	1.80	1.57	2.20	1.60	1.56
K ₂ O	3.43	4.40	4.68	5.12	4.95	4.50	6.11
P ₂ O ₅	0.01	0.06	0.03	0.02	0.04	0.02	0.03
LOI	10.6	7.7	7.3	7.9	9.9	9.3	9.2
Total	100.3	99.9	99.9	99.9	99.9	100.0	99.9
Ba ppm	45	573	573	636	412	143	161
Sr ppm	220	106	254	199	127	237	110
INAA Results⁴ (all values ppm unless otherwise noted)							
Na ₂ O (%)	1.58 ± 0.02	1.88 ± 0.02	1.51 ± 0.02	1.56 ± 0.02	2.11 ± 0.02	1.55 ± 0.02	1.49 ± 0.04
MgO (%)	nd	nd	nd	nd	nd	nd	nd
Al ₂ O ₃ (%)	nd	nd	nd	nd	nd	nd	nd
Cl	nd	nd	nd	nd	nd	nd	nd
K ₂ O (%)	nd	nd	nd	nd	nd	nd	nd
CaO (%)	1.94 ± 0.17	2.43 ± 0.21	1.75 ± 0.19	1.68 ± 0.18	3.20 ± 0.21	2.41 ± 0.16	1.04 ± 0.14
Sc	2.25 ± 0.02	2.32 ± 0.02	2.26 ± 0.02	2.41 ± 0.02	2.15 ± 0.02	1.94 ± 0.02	2.13 ± 0.02
Ti	nd	nd	nd	nd	nd	nd	nd
V	nd	nd	nd	nd	nd	nd	nd
Cr	2.35 ± 0.21	< 5	10.8 ± 0.55	19.4 ± 0.35	2.82 ± 0.11	< 5	< 5
Mn	nd	nd	nd	nd	nd	nd	nd
Fe ₂ O ₃ (%)	0.84 ± 0.01	1.21 ± 0.01	1.21 ± 0.01	1.18 ± 0.01	1.06 ± 0.01	0.99 ± 0.01	0.94 ± 0.01
Co	4.16 ± 0.04	12.44 ± 0.12	12.90 ± 0.13	11.35 ± 0.11	19.92 ± 0.20	5.18 ± 0.05	9.59 ± 0.10
Cu	nd	nd	nd	nd	nd	nd	nd
Zn	nd	nd	nd	nd	nd	nd	nd
Ga	nd	nd	nd	nd	nd	nd	nd
As	1.7 ± 0.2	9.5 ± 0.7	16.8 ± 0.7	7.2 ± 0.4	9.7 ± 0.3	4.1 ± 0.2	3.9 ± 0.4
Se	nd	nd	nd	nd	nd	nd	nd
Br	0.65 ± 0.11	0.33 ± 0.13	2.70 ± 0.31	< 0.30	3.08 ± 0.25	0.42 ± 0.06	< 0.50
Rb	158 ± 4	291 ± 8	134 ± 4	184 ± 4	125 ± 2	143 ± 3	232 ± 5
Sr	242 ± 13	134 ± 21	275 ± 19	205 ± 12	135 ± 8	220 ± 11	121 ± 8
Zr	114 ± 8	119 ± 15	131 ± 13	133 ± 9	121 ± 6	193 ± 8	200 ± 7
Mo	nd	nd	nd	nd	nd	nd	nd
Ag	nd	nd	nd	nd	nd	nd	nd
In	nd	nd	nd	nd	nd	nd	nd
Sb	0.14 ± 0.01	1.85 ± 0.06	1.97 ± 0.05	1.67 ± 0.03	0.55 ± 0.01	1.16 ± 0.02	0.39 ± 0.01
I	nd	nd	nd	nd	nd	nd	nd
Ca	4.99 ± 0.05	355 ± 3.55	100 ± 1	13.98 ± 0.14	8.76 ± 0.09	5.33 ± 0.05	4.76 ± 0.05
Ba	48 ± 5	618 ± 18	529 ± 13	605 ± 11	384 ± 7	157 ± 6	149 ± 5
La	45.8 ± 0.5	50.4 ± 0.5	48.3 ± 0.5	50.3 ± 0.5	44.1 ± 0.4	34.0 ± 0.3	63.2 ± 0.6
Ce	93.0 ± 0.9	94.3 ± 0.9	90.9 ± 0.9	97.9 ± 1.0	84.3 ± 0.8	69.5 ± 0.7	123.3 ± 1.2
Nd	30.9 ± 1.8	34.0 ± 3.1	31.6 ± 2.5	29.5 ± 1.7	28.4 ± 1.5	25.4 ± 1.5	45.0 ± 2.1
Sm	5.8 ± 0.1	5.8 ± 0.1	5.4 ± 0.1	5.6 ± 0.1	5.1 ± 0.1	6.0 ± 0.1	10.5 ± 0.1
Eu	0.23 ± 0.01	0.54 ± 0.02	0.51 ± 0.01	0.51 ± 0.01	0.45 ± 0.01	0.44 ± 0.01	0.63 ± 0.0
Tb	0.63 ± 0.02	0.66 ± 0.03	1.57 ± 0.02	0.61 ± 0.02	0.57 ± 0.01	0.82 ± 0.02	1.44 ± 0.02
Dy	nd	nd	nd	nd	nd	nd	nd
Yb	2.14 ± 0.02	2.29 ± 0.04	2.06 ± 0.03	2.36 ± 0.03	2.04 ± 0.02	2.96 ± 0.03	3.21 ± 0.03
Lu	0.30 ± 0.01	0.36 ± 0.01	0.30 ± 0.01	0.35 ± 0.01	0.30 ± 0.01	0.43 ± 0.01	0.44 ± 0.01
Hf	4.13 ± 0.05	4.14 ± 0.08	4.06 ± 0.06	4.22 ± 0.05	3.89 ± 0.04	6.36 ± 0.07	6.71 ± 0.07
Ta	1.57 ± 0.04	1.57 ± 0.04	1.55 ± 0.04	1.53 ± 0.03	1.50 ± 0.02	1.57 ± 0.03	1.83 ± 0.03
W	28 ± 1	148 ± 2	174 ± 2	148 ± 2	180 ± 2	50 ± 1	98 ± 1
Au	nd	nd	nd	nd	nd	nd	nd
Hg	nd	nd	nd	nd	nd	nd	nd
Th	22.4 ± 0.2	22.1 ± 0.2	20.9 ± 0.2	23.1 ± 0.2	19.7 ± 0.2	20.9 ± 0.2	21.8 ± 0.2
U	3.45 ± 0.09	3.52 ± 0.15	2.96 ± 0.12	4.25 ± 0.13	4.37 ± 0.12	4.12 ± 0.10	4.33 ± 0.12

APPENDIX C. (cont)

Prow Pass Area (N-S Lateral Section; Site 5 on Fig. 1)

Field No.	CRPP-1-SNL	CRPP-2-SNL	CRPP-3-SNL	CRPP-4-SNL	CRPP-5-SNL	CRPP-6-SNL	CRPP-7-SNL	CRPP-8-SNL-A
Geol. Unit ¹	Tht	Tht	Tht	Tht	Tht	Tht	Tht	Tht
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Lab. No.	126,P1	127,P1	128,P1	129,P1	130,P1	131,P1	132,P1	133,P1
XRF and AA Results (wt.%)								
SiO ₂	69.9	68.3	68.0	68.7	72.6	69.4	68.6	69.8
TiO ₂	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.08
Al ₂ O ₃	11.4	11.7	11.3	11.3	9.4	11.7	11.7	10.9
Fe ₂ O ₃ T	0.88	0.89	0.89	0.91	0.87	0.93	0.92	0.95
MnO	0.03	0.03	0.03	0.02	0.06	0.03	0.04	0.03
MgO	0.38	0.53	0.53	0.48	0.25	0.30	0.20	0.37
CaO	1.97	2.25	2.48	2.66	1.73	2.10	1.21	1.78
Na ₂ O	1.19	1.32	1.78	0.92	0.55	1.53	0.57	1.21
K ₂ O	4.26	3.96	3.04	3.26	4.37	4.52	6.77	4.48
P ₂ O ₅	0.07	0.07	0.08	0.07	0.07	0.08	0.07	0.07
LOI	10.0	11.2	12.3	12.3	10.3	9.9	10.3	10.7
Total	100.0	100.3	100.6	100.7	100.3	100.5	100.4	100.4
Ba ppm	93	87	73	62	67	87	104	88
Sr ppm	200	333	213	129	128	188	70	82
INAA Results⁴ (all values ppm unless otherwise noted)								
Na ₂ O (%)	1.22 ± 0.05	1.31 ± 0.06	1.88 ± 0.09	0.98 ± 0.04	0.59 ± 0.02	1.51 ± 0.06	0.62 ± 0.03	1.24 ± 0.05
MgO (%)	< 0.20	0.39 ± 0.07	0.81 ± 0.10	0.51 ± 0.08	0.33 ± 0.06	< 0.20	< 0.24	< 1.08
Al ₂ O ₃ (%)	11.8 ± 0.3	12.1 ± 0.3	11.9 ± 0.3	11.5 ± 0.3	9.7 ± 0.3	12.0 ± 0.3	12.1 ± 0.4	10.6 ± 0.5
Cl	< 91	< 83	< 112	83 ± 13	< 76	463 ± 52	< 70	358 ± 33
K ₂ O (%)	4.05 ± 0.26	4.09 ± 0.27	3.21 ± 0.21	3.15 ± 0.20	4.14 ± 0.27	4.41 ± 0.28	6.99 ± 0.44	4.52 ± 0.29
CaO (%)	2.07 ± 0.13	2.49 ± 0.15	< 0.82 ±	2.70 ± 0.16	1.63 ± 0.11	2.12 ± 0.13	1.31 ± 0.10	1.34 ± 0.10
Sc	2.32 ± 0.12	2.42 ± 0.13	2.23 ± 0.12	2.32 ± 0.12	1.92 ± 0.10	2.45 ± 0.13	2.37 ± 0.13	2.17 ± 0.11
Ti	684 ± 162	< 2980	< 3812	311 ± 110	< 3673	< 2932	< 3610	< 3174
V	< 6	< 5	< 6	< 6	< 6	< 6	< 6	< 6
Cr	1.8 ± 0.4	1.8 ± 0.4	2.1 ± 0.4	2.0 ± 0.5	2.5 ± 0.4	2.1 ± 0.5	< 1.4	4.1 ± 0.5
Mn	227 ± 9	235 ± 11	222 ± 9	221 ± 9	504 ± 20	255 ± 11	356 ± 14	213 ± 10
Fe ₂ O ₃ (%)	0.83 ± 0.04	0.83 ± 0.04	0.79 ± 0.04	0.83 ± 0.04	0.79 ± 0.04	0.87 ± 0.05	0.83 ± 0.04	0.80 ± 0.04
Co	6.23 ± 0.34	5.84 ± 0.32	3.70 ± 0.25	4.51 ± 0.25	4.03 ± 0.25	4.51 ± 0.25	3.40 ± 0.23	4.35 ± 0.24
Cu	< 200	< 242	< 232	< 205	< 173	< 244	< 192	< 203
Zn	43 ± 6	50 ± 7	33 ± 6	38 ± 6	39 ± 6	49 ± 8	37 ± 6	42 ± 7
Ga	14.2 ± 2.8	9.7 ± 2.4	< 21.4	11.5 ± 2.7	7.5 ± 2.1	23.8 ± 4.2	14.9 ± 2.7	11.9 ± 3.0
As	6.0 ± 0.7	2.6 ± 0.4	5.1 ± 0.6	2.6 ± 0.4	6.7 ± 0.7	3.4 ± 0.5	5.7 ± 0.6	5.6 ± 0.7
Se	< 2.8	< 2.8	< 3.4	< 2.7	< 3.2	< 2.9	< 3.6	< 2.5
Br	< 2.22	< 1.15	< 0.95	< 1.26	< 1.60	1.88 ± 0.76	< 2.24	< 0.96
Rb	168 ± 8	156 ± 8	157 ± 8	185 ± 9	219 ± 11	218 ± 10	251 ± 12	177 ± 9
Sr	< 196	406 ± 78	< 276	< 238	< 217	< 210	< 251	< 200
Zr	103 ± 21	126 ± 25	114 ± 29	< 86	117 ± 24	101 ± 22	79 ± 27	87 ± 21
Mo	< 68	< 1	< 86	< 77	< 54	< 3	< 69	< 67
Ag	< 1.6	< 1.8	< 1.9	< 2.1	< 1.7	< 1.7	< 1.9	< 2.0
In	< 0.18	< 0.17	< 0.23	< 0.19	< 0.16	< 0.17	< 0.19	< 0.18
Sb	0.32 ± 0.08	< 0.26	< 0.35	< 0.27	0.27 ± 0.06	0.50 ± 0.08	0.35 ± 0.06	0.41 ± 0.08
I	< 13	< 13	< 17	< 14	< 15	< 13	< 15	< 13
Cs	4.67 ± 0.30	4.09 ± 0.24	5.48 ± 0.32	6.41 ± 0.37	6.12 ± 0.34	5.96 ± 0.35	4.90 ± 0.29	4.73 ± 0.30
Ba	109 ± 17	142 ± 35	< 235	84 ± 25	130 ± 54	97 ± 16	106 ± 43	139 ± 58
La	25.8 ± 1.5	26.4 ± 1.6	34.3 ± 1.8	26.9 ± 1.5	25.5 ± 1.4	35.4 ± 2.2	27.4 ± 1.4	26.1 ± 1.6
Ce	50.9 ± 2.2	59.4 ± 2.8	65.7 ± 2.9	60.3 ± 3.0	56.4 ± 2.5	79.9 ± 3.7	55.9 ± 2.5	55.0 ± 2.7
Nd	22.9 ± 2.0	25.3 ± 2.1	28.8 ± 2.4	27.1 ± 2.4	26.4 ± 2.4	42.5 ± 3.4	26.6 ± 2.2	24.1 ± 2.2
Sm	4.4 ± 0.2	5.2 ± 0.2	6.7 ± 0.3	5.5 ± 0.3	4.6 ± 0.2	7.7 ± 0.4	5.3 ± 0.2	4.5 ± 0.2
Eu	0.24 ± 0.03	0.25 ± 0.02	0.35 ± 0.03	0.27 ± 0.03	0.28 ± 0.04	0.30 ± 0.03	0.24 ± 0.02	0.22 ± 0.02
Tb	0.58 ± 0.06	0.68 ± 0.06	0.75 ± 0.07	0.61 ± 0.07	0.74 ± 0.07	0.99 ± 0.09	0.66 ± 0.06	0.66 ± 0.06
Dy	4.03 ± 0.37	4.94 ± 0.43	5.10 ± 0.67	4.22 ± 0.40	4.79 ± 0.40	6.09 ± 0.54	4.98 ± 0.46	3.70 ± 0.33
Yb	1.95 ± 0.17	2.42 ± 0.22	2.72 ± 0.20	1.87 ± 0.18	3.24 ± 0.19	2.85 ± 0.22	2.91 ± 0.19	2.28 ± 0.19
Lu	0.30 ± 0.02	0.45 ± 0.02	0.36 ± 0.02	0.24 ± 0.02	0.43 ± 0.02	0.35 ± 0.02	0.31 ± 0.02	0.30 ± 0.02
Hf	3.43 ± 0.26	3.58 ± 0.25	3.30 ± 0.25	3.62 ± 0.21	2.90 ± 0.34	3.85 ± 0.20	3.40 ± 0.22	3.34 ± 0.27
Ta	2.07 ± 0.16	1.89 ± 0.13	1.63 ± 0.10	1.75 ± 0.13	1.45 ± 0.11	1.71 ± 0.12	1.65 ± 0.12	1.64 ± 0.10
W	73 ± 9	50 ± 6	28 ± 4	38 ± 5	43 ± 5	31 ± 4	31 ± 4	40 ± 5
Au	< 0.009	< 0.012	< 0.014	< 0.011	< 0.007	< 0.012	< 0.009	< 0.009
Hg	< 0.3	< 0.3	< 0.4	< 0.4	< 0.4	< 0.3	< 0.4	< 0.4
Th	22.5 ± 0.9	23.8 ± 0.9	20.4 ± 0.8	23.4 ± 0.9	17.8 ± 0.7	25.2 ± 1.0	20.7 ± 0.8	19.1 ± 0.7
U	2.90 ± 0.10	4.60 ± 0.20	3.60 ± 0.10	3.20 ± 0.10	5.30 ± 0.20	4.10 ± 0.20	3.90 ± 0.10	3.70 ± 0.10

APPENDIX C. (cont)

Prow Pass Area (N-S Lateral Section Cont.: Site 5 on Fig. 1)

Field No.	CRPP-8-SNL-B	CRPP-9-SNL	CRPP-10-SNL	CRPP-11-SNL	CRPP-12-SNL	CRPP-13-SNL	CRPP-14-SNL	CRPP-15-SNL
Geol. Unit ¹	Thl	Thl	Thl	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Lab. No.	133,P2	134,P1	135,P1	136,P1	137,P1	138,P1	139,P1	140,P1
XRF and AA Results (wt.%)								
SiO ₂	70.3	70.8	67.9	67.1	68.2	67.4	67.6	67.8
TiO ₂	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Al ₂ O ₃	10.9	10.5	11.7	12.1	11.8	11.8	12.0	11.5
Fe ₂ O ₃ T	0.91	0.88	0.98	0.93	0.94	0.96	0.92	0.94
MnO	0.03	0.05	0.04	0.05	0.04	0.03	0.03	0.10
MgO	0.38	0.50	0.46	0.22	0.35	0.45	0.47	0.34
CaO	1.78	2.22	1.86	1.26	1.75	2.15	2.10	2.01
Na ₂ O	1.12	1.44	1.52	0.44	0.81	0.78	0.83	0.85
K ₂ O	4.28	3.12	4.54	7.50	5.62	4.51	4.44	4.90
P ₂ O ₅	0.07	0.08	0.08	0.07	0.07	0.07	0.07	0.07
LOI	10.6	10.8	11.5	10.6	10.8	11.2	11.4	11.1
Total	100.4	100.4	100.6	100.4	100.4	99.4	99.9	99.7
Ba ppm	93	126	207	69	80	75	91	130
Sr ppm	70	198	180	17	100	52	88	42
NAA Results⁴ (all values ppm unless otherwise noted)								
Na ₂ O (%)	1.23 ± 0.05	1.57 ± 0.07	1.52 ± 0.06	0.46 ± 0.02	0.81 ± 0.04	0.82 ± 0.04	0.82 ± 0.03	0.85 ± 0.04
MgO (%)	< 0.21	< 0.37	< 0.31	< 0.23	0.28 ± 0.06	< 0.33	0.46 ± 0.08	< 0.28
Al ₂ O ₃ (%)	11.3 ± 0.3	10.6 ± 0.3	12.0 ± 0.3	12.4 ± 0.4	12.2 ± 0.4	12.2 ± 0.4	12.5 ± 0.4	11.7 ± 0.3
Cl	447 ± 38	< 99	105 ± 21	< 82	144 ± 34	< 84	< 82	< 100
K ₂ O (%)	4.64 ± 0.30	3.32 ± 0.22	4.32 ± 0.28	7.49 ± 0.47	6.18 ± 0.39	4.94 ± 0.32	4.68 ± 0.30	4.82 ± 0.31
CaO (%)	1.88 ± 0.12	2.43 ± 0.15	2.07 ± 0.14	1.23 ± 0.10	1.74 ± 0.12	2.17 ± 0.15	2.17 ± 0.14	1.90 ± 0.14
Sc	2.27 ± 0.12	2.26 ± 0.12	2.30 ± 0.12	2.41 ± 0.13	2.34 ± 0.12	2.68 ± 0.14	2.34 ± 0.12	2.45 ± 0.13
Ti	452 ± 139	< 4146	< 4181	< 3833	520 ± 157	< 3696	< 3884	456 ± 166
V	< 6	< 6	< 7	< 6	< 6	< 6	< 6	< 8
Cr	< 1.1	1.1 ± 0.3	< 1.5	< 1.4	< 1.5	< 1.2	2.0 ± 0.4	< 1.4
Mn	266 ± 11	404 ± 16	317 ± 13	418 ± 17	334 ± 14	276 ± 12	267 ± 11	780 ± 33
Fe ₂ O ₃ (%)	0.84 ± 0.05	0.81 ± 0.04	0.86 ± 0.05	0.85 ± 0.05	0.86 ± 0.05	0.92 ± 0.05	0.84 ± 0.05	0.88 ± 0.05
Co	4.20 ± 0.23	4.59 ± 0.25	3.89 ± 0.26	4.44 ± 0.25	3.41 ± 0.24	6.04 ± 0.33	4.13 ± 0.27	4.46 ± 0.25
Cu	< 230	< 218	< 260	< 190	< 225	< 192	< 214	< 245
Zn	47 ± 7	43 ± 6	29 ± 5	37 ± 6	33 ± 6	54 ± 8	32 ± 6	43 ± 8
Ga	14.0 ± 3.2	< 18.7	16.7 ± 3.7	18.4 ± 3.0	16.3 ± 2.9	15.6 ± 3.0	13.4 ± 3.1	19.2 ± 3.6
As	5.5 ± 0.6	4.5 ± 0.5	5.3 ± 0.6	4.6 ± 0.5	3.9 ± 0.5	3.2 ± 0.4	4.6 ± 0.6	6.7 ± 0.8
Se	< 2.6	< 2.5	< 3.6	< 3.0	< 3.7	< 2.9	< 3.5	< 3.4
Br	< 2.15	2.10 ± 0.92	< 3.43	< 1.27	< 1.92	1.89 ± 0.72	< 2.69	< 2.20
Rb	181 ± 9	142 ± 7	155 ± 8	248 ± 12	181 ± 9	179 ± 9	172 ± 8	187 ± 9
Sr	< 207	< 297	218 ± 77	< 233	< 227	< 260	< 260	< 308
Zr	96 ± 25	126 ± 25	123 ± 25	106 ± 23	113 ± 27	118 ± 28	< 97	121 ± 24
Mo	< 77	< 74	< 6	< 64	< 70	< 64	< 79	< 85
Ag	< 1.7	< 1.7	< 2.1	< 2.3	< 2.0	< 1.9	< 2.1	< 2.3
In	< 0.16	< 0.22	< 0.24	< 0.18	< 0.16	< 0.19	< 0.20	< 0.22
Sb	0.37 ± 0.09	0.37 ± 0.08	0.47 ± 0.09	0.30 ± 0.06	< 0.23	0.29 ± 0.06	0.16 ± 0.05	0.27 ± 0.08
I	< 12	< 18	< 18	< 16	< 13	< 16	< 15	< 21
Ca	5.17 ± 0.29	4.97 ± 0.34	3.78 ± 0.22	5.29 ± 0.33	4.64 ± 0.28	4.78 ± 0.29	4.52 ± 0.26	4.60 ± 0.27
Ba	164 ± 40	158 ± 18	211 ± 86	101 ± 46	< 272	< 81	118 ± 50	< 195
La	25.4 ± 1.5	19.7 ± 1.1	32.3 ± 1.8	34.9 ± 2.0	20.4 ± 1.2	18.9 ± 1.0	26.9 ± 1.8	30.6 ± 2.0
Ce	57.5 ± 2.5	44.8 ± 2.0	60.3 ± 2.9	69.9 ± 3.4	40.0 ± 1.8	40.4 ± 1.8	51.3 ± 2.3	81.4 ± 3.6
Nd	26.2 ± 2.2	21.8 ± 1.9	23.1 ± 2.0	34.9 ± 3.2	22.7 ± 2.3	17.0 ± 1.5	17.9 ± 1.6	31.1 ± 2.7
Sm	4.6 ± 0.2	3.6 ± 0.2	5.8 ± 0.3	6.3 ± 0.3	3.6 ± 0.2	3.3 ± 0.2	6.3 ± 0.2	5.7 ± 0.3
Eu	0.23 ± 0.03	0.21 ± 0.03	0.27 ± 0.03	0.33 ± 0.02	0.19 ± 0.01	0.23 ± 0.03	0.25 ± 0.02	0.31 ± 0.04
Tb	0.60 ± 0.06	0.54 ± 0.06	0.71 ± 0.07	0.80 ± 0.08	0.47 ± 0.06	0.41 ± 0.06	0.54 ± 0.06	0.84 ± 0.10
Dy	4.10 ± 0.37	3.34 ± 0.35	4.38 ± 0.49	5.30 ± 0.69	3.36 ± 0.33	< 5.62	4.73 ± 0.46	6.03 ± 0.54
Yb	2.48 ± 0.30	2.34 ± 0.17	2.46 ± 0.21	2.68 ± 0.18	2.11 ± 0.15	1.62 ± 0.13	2.02 ± 0.15	3.88 ± 0.24
Lu	0.30 ± 0.02	0.33 ± 0.02	0.30 ± 0.02	0.33 ± 0.02	0.28 ± 0.01	0.24 ± 0.01	0.31 ± 0.02	0.49 ± 0.03
Hf	3.43 ± 0.33	3.24 ± 0.17	3.62 ± 0.28	3.68 ± 0.22	3.56 ± 0.38	3.78 ± 0.25	3.47 ± 0.29	3.68 ± 0.17
Ta	1.74 ± 0.12	1.78 ± 0.12	1.66 ± 0.11	1.71 ± 0.11	1.58 ± 0.11	1.86 ± 0.12	1.67 ± 0.12	1.67 ± 0.14
W	40 ± 5	48 ± 6	29 ± 4	37 ± 5	29 ± 4	37 ± 5	39 ± 5	30 ± 4
Au	< 0.011	< 0.013	< 0.014	< 0.007	< 0.010	< 0.010	< 0.011	< 0.008
Hg	< 0.3	< 0.3	< 0.5	< 0.5	< 0.4	< 0.4	< 0.4	< 0.5
Th	19.8 ± 0.8	17.2 ± 0.7	20.7 ± 0.8	23.6 ± 0.9	22.2 ± 0.9	21.5 ± 0.8	20.7 ± 0.8	22.7 ± 0.9
U	3.60 ± 0.10	3.40 ± 0.10	3.60 ± 0.10	3.30 ± 0.10	2.70 ± 0.10	2.50 ± 0.10	2.50 ± 0.10	3.90 ± 0.10

APPENDIX C. (cont)

Prow Pass Area (N-S Lateral Section Cont.: Site 5 on Fig. 1)

Field No.	CRPP-16-SNL	CRPP-17-SNL	CRPP-18-SNL	CRPP-19-SNL	CRPP-20-SNL	CRPP-21-SNL	CRPP-22-SNL	CRPP-23-SNL
Geol. Unit ¹	Thl	Thl	Thl	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Alteration ³	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op	Zc, Zm, Op
Lab. No.	141,P1	142,P1	143,P1	144,P1	145,P1	146,P1	147,P1	148,P1
XRF and AA Results (wt.%)								
SiO ₂	69.0	68.1	67.9	69.4	68.3	69.5	68.6	69.0
TiO ₂	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.10
Al ₂ O ₃	11.6	11.4	11.3	11.2	11.5	11.4	11.3	11.9
Fe ₂ O ₃ T	0.93	0.91	0.95	0.88	0.87	0.88	0.87	0.99
MnO	0.03	0.03	0.03	0.08	0.03	0.03	0.02	0.09
MgO	0.32	0.61	0.34	0.28	0.45	0.24	0.14	0.20
CaO	1.62	2.41	2.12	1.68	2.12	1.39	1.29	1.06
Na ₂ O	0.80	0.97	0.94	0.92	0.81	1.15	0.83	0.83
K ₂ O	5.59	4.60	4.84	5.55	4.94	5.56	7.03	6.82
P ₂ O ₅	0.07	0.08	0.08	0.07	0.07	0.07	0.07	0.08
LOI	10.4	11.1	11.2	10.3	11.3	10.3	10.1	9.2
Total	100.4	100.3	99.8	100.4	100.4	100.5	100.2	100.1
Ba ppm	99	99	91	110	164	80	75	300
Sr ppm	53	63	38	24	70	47	5	65
INAA Results⁴ (all values ppm unless otherwise noted)								
Na ₂ O (%)	0.74 ± 0.03	1.00 ± 0.04	0.93 ± 0.04	0.96 ± 0.04	0.81 ± 0.04	1.18 ± 0.05	0.87 ± 0.03	0.80 ± 0.03
MgO (%)	< 0.19	0.48 ± 0.09	0.26 ± 0.06	< 0.22	0.37 ± 0.07	< 0.35	< 0.21	< 0.26
Al ₂ O ₃ (%)	12.0 ± 0.3	11.5 ± 0.3	11.7 ± 0.3	11.2 ± 0.3	11.5 ± 0.3	11.5 ± 0.3	11.7 ± 0.3	11.8 ± 0.3
Cl	< 73	104 ± 18	< 85	< 96	1833 ± 136	< 101	88 ± 14	< 92
K ₂ O (%)	6.02 ± 0.38	4.98 ± 0.32	4.79 ± 0.31	5.50 ± 0.35	5.17 ± 0.33	5.89 ± 0.38	7.41 ± 0.47	6.37 ± 0.40
CaO (%)	1.67 ± 0.12	2.55 ± 0.16	2.16 ± 0.14	1.66 ± 0.11	2.20 ± 0.14	1.37 ± 0.11	1.35 ± 0.10	0.99 ± 0.08
Sc	2.39 ± 0.13	2.35 ± 0.13	2.34 ± 13	2.23 ± 0.12	2.35 ± 0.12	2.34 ± 0.13	2.26 ± 0.12	2.17 ± 0.12
Ti	522 ± 145	< 3718	651 ± 140	< 3945	710 ± 159	< 3899	426 ± 122	777 ± 166
V	< 5	< 6	< 6	< 7	< 6	< 6	< 5	< 7
Cr	3.1 ± 0.5	3.1 ± 0.5	< 1.4	< 1.2	1.7 ± 0.5	< 1.2	< 1.3	2.7 ± 0.5
Mn	236 ± 10	249 ± 10	224 ± 9	495 ± 26	241 ± 10	251 ± 10	202 ± 8	713 ± 30
Fe ₂ O ₃ (%)	0.87 ± 0.05	0.87 ± 0.04	0.87 ± 0.04	0.81 ± 0.04	0.86 ± 0.04	0.84 ± 0.04	0.80 ± 0.04	0.89 ± 0.05
Co	6.58 ± 0.36	4.73 ± 0.26	2.10 ± 0.19	7.86 ± 0.42	4.99 ± 0.39	4.15 ± 0.24	5.92 ± 0.34	6.43 ± 0.35
Cu	< 211	< 198	< 210	< 208	< 228	< 208	< 172	< 223
Zn	37 ± 5	47 ± 8	37 ± 6	38 ± 6	< 6	54 ± 8	35 ± 6	44 ± 7
Ga	15.0 ± 3.2	< 17.3 ±	< 17.0	10.2 ± 2.4	16.2 ± 3.2	< 18.9	15.6 ± 2.9	8.4 ± 2.8
As	3.7 ± 0.5	4.5 ± 0.5	3.2 ± 0.4	2.5 ± 0.4	2.0 ± 0.3	1.9 ± 0.3	3.1 ± 0.4	2.8 ± 0.4
Se	< 3.3	< 3.1	< 3.6	< 2.8	< 2.8	< 3.0	< 3.3	< 2.8
Br	< 1.93	< 1.58	< 2.63	1.96 ± 0.75	< 2.02	< 1.08	< 2.19	< 1.03
Rb	228 ± 11	163 ± 8	211 ± 10	206 ± 10	178 ± 9	194 ± 10	208 ± 10	194 ± 10
Sr	< 200	< 256	< 237	< 239	< 217	< 264	< 203	< 278
Zr	101 ± 27	108 ± 38	< 91	88 ± 23	102 ± 27	117 ± 24	101 ± 27	120 ± 26
Mo	< 72	< 79	< 76	< 1	< 3	< 73	< 65	< 67
Ag	< 2.2	< 1.8	< 1.9	< 2.0	< 2.0	< 1.9	< 1.8	< 2.1
In	< 0.15	< 0.20	< 0.20	< 0.19	< 0.17	< 0.21	< 0.17	< 0.20
Sb	0.73 ± 0.08	0.32 ± 0.07	0.36 ± 0.07	0.40 ± 0.07	0.44 ± 0.07	0.39 ± 0.06	0.33 ± 0.06	0.50 ± 0.07
I	< 12	< 16	< 14	< 16	< 13	< 17	< 12	< 19
Cs	5.14 ± 0.42	4.69 ± 0.29	5.62 ± 0.32	5.26 ± 0.30	5.31 ± 0.32	4.87 ± 0.28	4.53 ± 0.27	5.00 ± 0.28
Ba	97 ± 17	147 ± 36	150 ± 46	138 ± 24	253 ± 77	125 ± 46	80 ± 28	372 ± 90
La	31.6 ± 2.0	61.9 ± 3.4	23.6 ± 1.3	27.4 ± 1.7	22.1 ± 1.3	22.6 ± 1.2	22.2 ± 1.3	39.9 ± 2.5
Ce	60.6 ± 3.0	118.7 ± 5.2	47.6 ± 2.1	61.8 ± 3.0	50.1 ± 2.3	46.9 ± 2.1	41.1 ± 2.0	81.5 ± 3.8
Nd	30.0 ± 3.0	57.2 ± 4.3	22.8 ± 2.0	28.2 ± 2.7	26.0 ± 2.3	21.7 ± 1.9	23.4 ± 2.2	36.6 ± 3.3
Sm	5.8 ± 0.3	11.3 ± 0.5	4.3 ± 0.2	4.5 ± 0.2	3.8 ± 0.2	4.0 ± 0.2	4.2 ± 0.2	4.6 ± 0.2
Eu	0.32 ± 0.03	0.56 ± 0.04	0.23 ± 0.02	0.29 ± 0.02	0.25 ± 0.05	0.23 ± 0.03	0.23 ± 0.03	0.43 ± 0.03
Tb	0.71 ± 0.07	1.49 ± 0.15	0.55 ± 0.05	0.59 ± 0.06	< 0.21	0.53 ± 0.07	0.49 ± 0.05	0.64 ± 0.06
Dy	4.30 ± 0.37	7.63 ± 0.60	3.59 ± 0.51	3.46 ± 0.33	5.28 ± 0.46	4.51 ± 1.00	3.31 ± 0.33	4.02 ± 0.37
Yb	2.17 ± 0.15	3.12 ± 0.24	2.50 ± 0.18	2.14 ± 0.17	5.20 ± 0.30	1.71 ± 0.33	2.31 ± 0.15	2.44 ± 0.17
Lu	0.25 ± 0.02	0.47 ± 0.03	0.31 ± 0.02	0.32 ± 0.02	0.75 ± 0.04	0.27 ± 0.02	0.31 ± 0.02	0.34 ± 0.02
Hf	3.66 ± 0.28	3.66 ± 0.38	3.46 ± 0.25	3.40 ± 0.18	3.61 ± 0.31	3.47 ± 0.22	3.23 ± 0.35	3.75 ± 0.40
Ta	1.80 ± 0.12	1.65 ± 0.13	1.52 ± 0.11	1.83 ± 0.12	1.68 ± 0.11	1.65 ± 0.11	1.71 ± 0.11	1.83 ± 0.12
W	58 ± 7	39 ± 5	21 ± 3	57 ± 7	40 ± 5	29 ± 4	37 ± 5	62 ± 8
Au	< 0.010	< 0.012	< 0.011	< 0.008	< 0.010	< 0.012	< 0.009	< 0.008
Hg	< 0.5	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	1.4 ± 0.3
Th	24.2 ± 1.0	22.1 ± 2.1	19.9 ± 0.8	22.1 ± 0.9	22.9 ± 1.3	21.0 ± 0.8	21.3 ± 0.8	23.1 ± 0.9
U	2.40 ± 0.10	3.40 ± 0.10	2.70 ± 0.10	3.20 ± 0.10	4.20 ± 0.20	3.00 ± 0.10	4.00 ± 0.10	5.50 ± 0.20

APPENDIX C. (cont)

Prow Pass Area (N-S Lateral Section Cont.: Site 8 on Fig. 1)

Field No. Geol. Unit ¹ Lithology ² Alteration ³ Lab. No.	CRPP-24-SNL Thi nwt Zc, Op 149,P1	CRPP-25-SNL Thi nwt Zc, Zm, Op 150,P1	CRPP-26-SNL Thi nwt Zc, Zm, Op 151,P1	CRPP-27-SNL Thi nwt Zc, Zm 152,P1	CRPP-28-SNL Thi nwt Zc, Zm, Op 153,P1	CRPP-29-SNL Thi nwt Zc, Zm, Op 154,P1	CRPP-30-SNL Thi nwt Zc, Zm, Op 155,P1	CRPP-31-SNL Thi nwt Zc, Zm, Op 156,P1
XRF and AA Results (wt. %)								
SiO ₂	71.7	67.9	68.4	72.9	72.2	70.3	70.7	69.5
TiO ₂	0.12	0.10	0.18	0.10	0.10	0.15	0.14	0.11
Al ₂ O ₃	12.2	12.7	12.7	11.9	10.8	12.5	11.7	11.8
Fe ₂ O ₃ T	1.22	0.98	1.52	0.95	0.97	1.31	1.27	1.02
MnO	0.07	0.07	0.04	0.05	0.02	0.15	0.02	0.02
MgO	0.50	0.54	0.41	0.18	0.27	0.54	0.23	0.23
CaO	1.41	1.88	1.48	0.70	1.52	1.38	1.32	1.94
Na ₂ O	0.82	1.00	1.08	1.07	1.04	1.23	1.08	1.13
K ₂ O	5.44	4.57	5.56	7.40	5.00	5.73	5.78	6.08
P ₂ O ₅	0.08	0.08	0.07	0.08	0.08	0.09	0.07	0.07
LOI	7.2	10.2	8.9	4.9	8.7	8.7	8.4	8.8
Total	100.6	100.0	100.3	100.3	100.6	100.0	100.7	100.6
Ba ppm	438	285	204	183	196	280	198	183
Sr ppm	213	118	99	37	71	89	69	59
INAA Results⁴ (all values ppm unless otherwise noted)								
Na ₂ O (%)	0.80 ± 0.04	1.05 ± 0.05	1.05 ± 0.04	1.13 ± 0.05	1.03 ± 0.05	1.32 ± 0.08	1.10 ± 0.05	1.11 ± 0.05
MgO (%)	0.49 ± 0.08	0.37 ± 0.08	0.28 ± 0.08	< 0.32	< 0.17	0.57 ± 0.10	< 0.29	0.31 ± 0.07
Al ₂ O ₃ (%)	12.2 ± 0.4	12.5 ± 0.4	12.8 ± 0.4	12.3 ± 0.3	11.0 ± 0.3	12.3 ± 0.4	11.6 ± 0.3	11.6 ± 0.3
Cl	< 82	121 ± 20	< 71	< 100	< 71	< 108	< 90	< 72
K ₂ O (%)	5.95 ± 0.47	4.93 ± 0.32	5.95 ± 0.38	8.07 ± 0.48	5.30 ± 0.34	6.25 ± 0.39	6.30 ± 0.40	6.24 ± 0.47
CaO (%)	1.33 ± 0.10	2.19 ± 0.14	1.54 ± 0.10	0.59 ± 0.08	1.60 ± 0.11	1.60 ± 0.11	1.59 ± 0.11	2.07 ± 0.13
So	2.37 ± 0.13	2.38 ± 0.13	3.38 ± 0.18	2.40 ± 0.12	2.00 ± 0.11	3.04 ± 0.16	2.65 ± 0.14	2.41 ± 0.13
Ti	645 ± 189	847 ± 215	1105 ± 198	< 4000	433 ± 116	< 5777	533 ± 122	693 ± 150
V	< 7	< 7	11 ± 2	< 6	< 5	< 8	< 6	< 6
Cr	2.0 ± 0.4	1.5 ± 0.4	6.2 ± 0.6	< 1.3	1.5 ± 0.4	4.7 ± 0.6	7.4 ± 0.7	4.1 ± 0.5
Mn	586 ± 23	614 ± 25	323 ± 13	359 ± 17	189 ± 8	1156 ± 45	204 ± 8	184 ± 8
Fe ₂ O ₃ (%)	1.19 ± 0.07	0.95 ± 0.05	1.43 ± 0.08	0.93 ± 0.04	0.91 ± 0.05	1.27 ± 0.07	1.19 ± 0.07	0.98 ± 0.05
Co	6.18 ± 0.33	5.73 ± 0.31	3.98 ± 0.24	5.50 ± 0.30	5.10 ± 0.30	6.26 ± 0.34	6.46 ± 0.39	7.04 ± 0.39
Cu	< 233	< 210	< 198	< 200	< 207	< 254	< 189	< 201
Zn	50 ± 7	47 ± 6	43 ± 6	29 ± 5	26 ± 5	50 ± 7	33 ± 6	43 ± 6
Ga	15.7 ± 3.6	16.2 ± 3.6	20.3 ± 3.5	< 30.0	11.9 ± 3.2	< 18.2	< 16.5	12.1 ± 2.7
As	5.7 ± 0.6	3.5 ± 0.5	2.6 ± 0.4	2.3 ± 0.3	2.1 ± 0.3	3.7 ± 0.5	2.7 ± 0.4	4.4 ± 0.5
Se	< 3.0	< 3.0	< 3.5	< 4.0	< 3.2	< 2.9	< 4.0	< 2.8
Br	< 0.99	< 2.77	< 2.51	0.31 ± 0.15	1.28 ± 0.28	2.08 ± 0.90	< 2.69	< 2.74
Rb	194 ± 10	135 ± 7	162 ± 8	277 ± 13	164 ± 8	167 ± 8	197 ± 10	212 ± 10
Sr	214 ± 82	< 334	< 242	51 ± 7	< 178	< 409	< 231	< 215
Zr	127 ± 24	156 ± 27	132 ± 37	100 ± 30	147 ± 26	155 ± 27	126 ± 25	122 ± 23
Mo	< 3	< 74	< 1	< 70	< 73	0	< 1	< 80
Ag	< 1.8	< 1.7	< 2.0	< 2.0	< 1.8	< 1.8	< 2.2	< 2.1
In	< 0.17	< 0.22	< 0.19	< 0.17	< 0.15	< 0.25	< 0.18	< 0.18
Sb	0.55 ± 0.08	0.53 ± 0.07	0.68 ± 0.08	0.42 ± 0.08	0.40 ± 0.07	1.11 ± 0.10	0.51 ± 0.07	0.53 ± 0.08
I	< 16	< 20	< 14	< 16	< 11	< 25	< 14	< 12
Ce	4.11 ± 0.25	3.85 ± 0.26	4.14 ± 0.26	4.40 ± 0.30	4.92 ± 0.28	4.02 ± 0.23	4.61 ± 0.32	5.12 ± 0.29
Ba	573 ± 47	408 ± 31	340 ± 70	275 ± 23	272 ± 58	411 ± 42	285 ± 52	244 ± 59
La	50.4 ± 3.4	47.5 ± 2.6	34.4 ± 1.9	41.1 ± 2.3	33.7 ± 2.1	41.8 ± 2.2	34.7 ± 1.9	31.9 ± 1.7
Ce	103.7 ± 4.7	96.7 ± 4.3	63.7 ± 2.8	78.0 ± 3.0	70.6 ± 3.2	84.1 ± 3.7	61.1 ± 2.7	64.7 ± 3.1
Nd	38.2 ± 3.1	44.3 ± 3.5	30.7 ± 2.7	38.0 ± 3.0	29.3 ± 2.7	33.4 ± 2.6	30.0 ± 2.7	33.4 ± 3.0
Sm	5.6 ± 0.3	6.2 ± 0.3	5.2 ± 0.2	5.8 ± 0.3	4.8 ± 0.2	6.5 ± 0.3	5.1 ± 0.2	5.2 ± 0.2
Eu	0.56 ± 0.05	0.38 ± 0.04	0.41 ± 0.04	0.37 ± 0.02	0.39 ± 0.04	0.41 ± 0.04	0.43 ± 0.04	0.33 ± 0.03
Tb	0.64 ± 0.06	0.72 ± 0.07	0.63 ± 0.07	0.63 ± 0.08	0.62 ± 0.06	0.90 ± 0.12	0.78 ± 0.08	0.64 ± 0.07
Dy	4.36 ± 0.42	4.24 ± 0.44	4.25 ± 0.43	4.20 ± 0.40	4.34 ± 0.39	4.82 ± 0.49	6.25 ± 1.09	3.91 ± 0.37
Yb	2.48 ± 0.21	2.41 ± 0.18	2.72 ± 0.18	2.09 ± 0.15	2.32 ± 0.21	3.54 ± 0.21	4.82 ± 0.35	2.14 ± 0.17
Lu	0.39 ± 0.02	0.32 ± 0.02	0.39 ± 0.02	0.33 ± 0.02	0.35 ± 0.02	0.47 ± 0.02	1.28 ± 0.08	0.32 ± 0.02
Hf	4.03 ± 0.41	4.01 ± 0.20	3.74 ± 0.38	3.67 ± 0.15	3.36 ± 0.35	4.25 ± 0.24	3.69 ± 0.35	3.70 ± 0.26
Ta	1.85 ± 0.12	2.23 ± 0.15	1.62 ± 0.10	2.26 ± 0.16	1.84 ± 0.11	1.97 ± 0.13	1.97 ± 0.13	1.86 ± 0.12
W	59 ± 7	73 ± 9	34 ± 4	74 ± 9	53 ± 7	68 ± 8	59 ± 7	58 ± 7
Au	< 0.010	< 0.012	< 0.010	< 0.010	< 0.010	< 0.012	< 0.012	< 0.011
Hg	< 0.4	1.9 ± 0.4	1.0 ± 0.2	3.6 ± 0.6	0.8 ± 0.2	1.4 ± 0.3	< 0.5	< 0.4
Th	23.5 ± 0.9	26.1 ± 1.0	22.6 ± 0.9	24.8 ± 1.0	19.4 ± 0.8	23.4 ± 1.5	21.4 ± 0.8	23.0 ± 0.9
U	3.80 ± 0.10	2.70 ± 0.10	4.80 ± 0.20	4.05 ± 0.15	5.00 ± 0.20	4.50 ± 0.20	4.60 ± 0.20	3.30 ± 0.10

APPENDIX C. (cont)

Calico Hills Area (E-W Lateral Section: Site 6 on Fig. 1)

Field No.	CRCH-1-SNL	CRCH-2-SNL	CRCH-3-SNL	CRCH-4-SNL	CRCH-5-SNL	CRCH-6-SNL	CRCH-7-SNL	CRCH-8-SNL
Geol. Unit ¹	Thl	Thl	Thl	Thl	Thl	Thl	Thl	Thl
Lithology ²	nwt	nwt	nwt	nwt	nwt	nwt	nwt	nwt
Alteration ³	Kf, Zm, Op	Kf, Zm, Op	Kf, Zm, Op	Kf, Zm, Op	Kf, Zm, Op	Kf, Op	Kf, Zm	Kf, Zc, Zm, Op
Lab. No.	116,P1	117,P1	118,P1	119,P1	120,P1	121,P1	122,P1	123,P1
XRF and AA Results (wt. %)								
SiO ₂	72.2	73.7	73.3	70.7	70.8	74.7	74.8	71.7
TiO ₂	0.11	0.12	0.11	0.11	0.11	0.12	0.10	0.09
Al ₂ O ₃	12.3	11.9	11.9	10.7	12.5	11.9	11.2	12.8
Fe ₂ O ₃ T	1.23	1.12	0.98	1.18	0.79	1.18	1.18	1.36
MnO	0.12	0.04	0.04	0.03	0.18	0.08	0.03	0.18
MgO	0.20	0.34	0.28	0.80	0.19	0.20	0.23	0.28
CaO	1.17	0.68	1.04	2.33	0.98	0.82	0.68	0.93
Na ₂ O	0.70	0.40	0.61	0.81	0.73	0.43	0.48	0.61
K ₂ O	8.01	7.93	8.28	8.73	8.90	7.78	7.73	7.19
P ₂ O ₅	0.07	0.07	0.08	0.09	0.07	0.07	0.08	0.07
LOI	7.1	4.2	3.8	7.1	4.5	3.2	4.1	8.0
Total	100.3	100.8	100.2	100.0	99.7	100.1	100.2	99.9
Ba ppm	70	87	130	117	110	100	97	218
Sr ppm	48	39	37	58	40	23	80	104
INAA Results⁴ (all values ppm unless otherwise noted)								
Na ₂ O (%)	0.78 ± 0.04	0.42 ± 0.02	0.87 ± 0.02	0.53 ± 0.02	0.80 ± 0.03	0.47 ± 0.02	0.48 ± 0.02	0.61 ± 0.03
MgO (%)	< 0.38	0.39 ± 0.06	< 0.18	0.42 ± 0.10	< 0.38	< 0.22	0.31 ± 0.08	< 0.28
Al ₂ O ₃ (%)	12.5 ± 0.5	12.0 ± 0.3	12.1 ± 0.3	10.7 ± 0.3	12.7 ± 0.4	12.4 ± 0.3	11.4 ± 0.3	13.3 ± 0.4
Cl	< 87	< 48	< 64	1387 ± 108	109 ± 18	< 52	< 66	< 72
K ₂ O (%)	5.38 ± 0.34	7.60 ± 0.47	8.19 ± 0.51	8.73 ± 0.42	9.37 ± 0.58	7.92 ± 0.49	7.28 ± 0.48	7.34 ± 0.48
CaO (%)	1.14 ± 0.37	0.72 ± 0.08	< 0.51	2.43 ± 0.15	1.00 ± 0.08	0.41 ± 0.04	0.69 ± 0.08	0.77 ± 0.08
Sc	2.57 ± 0.14	2.49 ± 0.13	2.00 ± 0.11	2.24 ± 0.12	1.81 ± 0.10	2.38 ± 0.13	2.11 ± 0.11	3.14 ± 0.17
Ti	< 5293	653 ± 136	560 ± 141	738 ± 211	824 ± 235	782 ± 178	340 ± 124	< 4810
V	< 7	< 5	< 5	< 8	< 8	< 5	< 8	< 8
Cr	2.7 ± 0.4	2.8 ± 0.5	5.3 ± 0.8	3.9 ± 0.5	2.7 ± 0.4	5.7 ± 0.6	2.5 ± 0.4	2.0 ± 0.4
Mn	940 ± 37	310 ± 12	328 ± 15	631 ± 27	1208 ± 47	419 ± 18	226 ± 10	1181 ± 47
Fe ₂ O ₃ (%)	1.13 ± 0.07	1.02 ± 0.06	0.88 ± 0.06	1.19 ± 0.07	0.78 ± 0.04	1.13 ± 0.08	1.16 ± 0.08	1.31 ± 0.07
Co	3.16 ± 0.21	5.44 ± 0.29	5.42 ± 0.29	3.08 ± 0.18	7.21 ± 0.40	4.73 ± 0.26	3.26 ± 0.25	6.54 ± 0.35
Cu	< 219	< 154	< 183	< 379	< 221	< 183	< 140	< 261
Zn	76 ± 10	40 ± 6	38 ± 6	45 ± 6	25 ± 5	80 ± 7	< 5	44 ± 6
Ga	15.0 ± 2.7	17.3 ± 2.5	17.4 ± 3.1	15.4 ± 2.3	16.3 ± 2.5	22.6 ± 3.1	15.5 ± 2.5	13.5 ± 2.8
As	6.9 ± 0.8	3.7 ± 0.4	3.0 ± 0.4	4.0 ± 0.5	2.8 ± 0.4	3.6 ± 0.4	3.0 ± 0.4	7.0 ± 0.8
Se	< 3.8	< 2.4	< 2.6	< 2.6	< 3.0	< 2.6	< 2.0	< 3.0
Br	< 2.56	1.62 ± 0.73	< 1.82	1.00 ± 0.22	2.37 ± 0.81	1.90 ± 0.71	< 1.53	< 1.68
Rb	279 ± 13	222 ± 10	201 ± 10	196 ± 9	221 ± 11	207 ± 10	200 ± 10	199 ± 10
Sr	< 371	< 203	< 182	< 313	< 404	< 227	< 158	< 331
Zr	95 ± 27	135 ± 25	135 ± 24	146 ± 25	124 ± 21	131 ± 23	126 ± 26	120 ± 35
Mo	< 78	< 66	< 65	< 62	< 64	< 69	< 52	< 66
Ag	< 2.0	< 1.9	< 1.8	< 1.8	< 1.7	< 1.8	< 1.8	< 1.9
In	< 0.22	< 0.15	< 0.15	< 0.27	< 0.23	< 0.16	< 0.13	< 0.19
Sb	< 0.28	0.21 ± 0.06	< 0.23	0.37 ± 0.05	0.31 ± 0.07	< 0.22	0.36 ± 0.06	0.53 ± 0.07
I	< 22	< 12	< 12	< 19	< 25	< 13	< 11	< 20
Cs	8.78 ± 0.49	4.67 ± 0.27	3.83 ± 0.22	5.75 ± 0.32	4.17 ± 0.24	1.82 ± 0.20	3.69 ± 0.24	3.72 ± 0.23
Ba	85 ± 40	134 ± 20	164 ± 51	180 ± 34	130 ± 32	38	< 180	232 ± 53
La	104.8 ± 5.7	67.7 ± 3.7	84.6 ± 5.2	57.8 ± 3.7	53.2 ± 2.9	73.3 ± 4.0	41.2 ± 2.4	27.7 ± 1.6
Ce	110.6 ± 5.0	102.0 ± 4.6	103.2 ± 4.7	99.0 ± 4.5	75.5 ± 3.5	128.2 ± 5.8	82.6 ± 3.7	62.2 ± 2.9
Nd	82.9 ± 6.4	50.3 ± 3.9	110.0 ± 8.5	49.3 ± 3.8	40.1 ± 3.3	65.5 ± 5.1	32.5 ± 2.6	27.1 ± 2.3
Sm	13.4 ± 0.6	8.7 ± 0.4	15.7 ± 0.7	7.7 ± 0.4	6.5 ± 0.3	10.5 ± 0.5	4.4 ± 0.2	5.6 ± 0.3
Eu	0.61 ± 0.04	0.40 ± 0.04	0.80 ± 0.04	0.42 ± 0.03	0.39 ± 0.04	0.60 ± 0.05	0.29 ± 0.02	0.26 ± 0.03
Tb	1.42 ± 0.17	0.89 ± 0.09	1.30 ± 0.12	0.98 ± 0.10	0.83 ± 0.08	1.29 ± 0.12	0.46 ± 0.05	0.68 ± 0.07
Dy	6.83 ± 0.60	5.70 ± 0.48	7.27 ± 0.57	10.88 ± 0.86	3.28 ± 0.40	7.98 ± 0.65	2.77 ± 0.28	4.59 ± 0.46
Yb	2.93 ± 0.20	2.20 ± 0.17	2.57 ± 0.23	2.13 ± 0.15	1.36 ± 0.13	5.41 ± 0.29	1.72 ± 0.13	2.26 ± 0.26
Lu	0.36 ± 0.02	0.28 ± 0.02	0.37 ± 0.02	0.31 ± 0.02	0.22 ± 0.01	0.73 ± 0.04	0.24 ± 0.02	0.38 ± 0.02
Hf	4.24 ± 0.17	4.63 ± 0.26	3.91 ± 0.31	4.04 ± 0.33	4.03 ± 0.44	4.47 ± 0.38	3.80 ± 0.26	4.04 ± 0.28
Ta	1.33 ± 0.10	1.70 ± 0.11	1.73 ± 0.12	1.47 ± 0.10	2.11 ± 0.14	1.72 ± 0.13	1.50 ± 0.10	2.33 ± 0.16
W	24 ± 3	44 ± 6	60 ± 7	25 ± 3	79 ± 10	43 ± 5	37 ± 5	69 ± 8
Au	< 0.012	< 0.008	< 0.008	< 0.008	< 0.010	< 0.009	< 0.008	< 0.009
Hg	< 0.4	< 0.4	< 0.4	< 0.3	< 0.4	< 0.3	< 0.3	0.3 ± 0.1
Th	20.0 ± 2.3	22.7 ± 0.9	19.7 ± 0.8	21.7 ± 0.8	22.5 ± 0.9	23.5 ± 0.9	19.6 ± 0.8	27.2 ± 1.1
U	3.80 ± 0.10	2.50 ± 0.10	3.20 ± 0.10	2.90 ± 0.10	2.60 ± 0.10	3.70 ± 0.10	1.80 ± 0.10	3.30 ± 0.10

APPENDIX C. (cont)

Calico Hills Area (E-W Lateral Section Cont.) (See Fig. 1)

Field No.	CRCH-9-BNL	CRCH-10-BNL
Geol. Unit ¹	Twi	Twi
Lithology ²	nwt	nwt
Alteration ³	Kf, Zn, Op	Kf, Zn, Zm, Op
Lab. No.	124,P1	125,P1
XRF and AA Results (wt. %)		
SiO ₂	70.8	72.2
TiO ₂	0.12	0.10
Al ₂ O ₃	19.0	11.8
Fe ₂ O ₃ T	1.31	1.30
MnO	0.03	0.04
MgO	0.28	0.41
CaO	1.11	1.48
Na ₂ O	0.71	0.77
K ₂ O	7.67	5.31
P ₂ O ₅	0.08	0.08
LOI	4.8	7.1
Total	99.8	100.4
Ba ppm	93	182
Br ppm	48	97

NAA Results⁴ (all values ppm unless otherwise noted)

Na ₂ O (%)	0.77 ± 0.03	0.81 ± 0.03
MgO (%)	< 0.28	0.42 ± 0.08
Al ₂ O ₃ (%)	19.2 ± 0.4	12.0 ± 0.3
Cl	< 61	< 74
K ₂ O (%)	8.20 ± 0.51	5.30 ± 0.33
CaO (%)	1.23 ± 0.08	1.58 ± 0.11
Sc	2.48 ± 0.13	2.36 ± 0.12
Ti	527 ± 141	732 ± 190
V	< 6	< 6
Cr	2.4 ± 0.4	4.6 ± 0.6
Mn	586 ± 11	327 ± 15
Fe ₂ O ₃ (%)	1.21 ± 0.08	1.21 ± 0.08
Co	3.62 ± 0.21	6.90 ± 0.37
Cu	< 153	< 184
Zn	41 ± 6	48 ± 6
As	16.4 ± 2.4	10.1 ± 2.6
Se	2.1 ± 0.3	2.8 ± 0.4
Br	< 3.0	< 2.8
Rb	< 2.00	< 0.99
Sr	212 ± 10	169 ± 8
Y	< 806	< 245
Zr	118 ± 20	129 ± 23
Mo	< 58	< 78
Ag	< 1.6	< 2.1
Cd	< 0.15	< 0.18
In	0.31 ± 0.06	< 0.28
Sn	< 12	< 14
Sb	4.02 ± 0.24	5.95 ± 0.34
Te	< 82	177 ± 69
I	44.4 ± 2.4	44.3 ± 2.6
Ba	84.6 ± 3.8	95.1 ± 4.4
La	33.2 ± 2.8	38.2 ± 3.4
Ce	6.0 ± 0.3	6.6 ± 0.3
Pr	0.43 ± 0.06	0.40 ± 0.03
Nd	0.64 ± 0.07	0.70 ± 0.07
Sm	4.35 ± 0.38	4.41 ± 0.48
Eu	2.43 ± 0.19	2.50 ± 0.19
Gd	0.33 ± 0.02	0.36 ± 0.02
Tb	4.29 ± 0.45	4.15 ± 0.29
Dy	1.55 ± 0.10	1.81 ± 0.12
Ho	38 ± 5	57 ± 7
Er	< 0.009	< 0.010
Tm	< 0.3	< 0.4
Yb	22.8 ± 0.9	23.0 ± 0.9
Lu	2.30 ± 0.10	2.80 ± 0.10

Footnotes

- 1 Geol. Unit: Top = Prow Pass Member, Twi = Wahmonie Formation (lower part), Ttd = tuffaceous beds of Calico Hills, Tpi = Topopah Spring Member, Tpp = Pah Canyon Member, Tld = rhyolite of Delirium Canyon, Tlb = rhyolite of Black Glass Canyon.
- 2 Lithology: nwt = nonwelded tuff, mostly pyroclastic flows but may include massive ash-fall and reworked tuffs; pwt = partially-welded ash-flow tuff; mwt = moderately-welded ash-flow tuff; vt = vitrophyric tuff; b = bedded tuff, individual beds characterized by internal stratification.
- 3 Alteration: Cl = glassy, Zn = clinoptilolite zeolites, Zm = mordenite zeolites, Sm = smectite, Op = Opal-OT, Kf = adularia, Ka = kaolinite, Oe = post-emplacment, high-temperature crystallization.
- 4 NAA performed at Los Alamos National Laboratory (NAA values reported for all trace elements) and at University of Washington at St. Louis (NAA values for MgO, Al₂O₃, Cl, K₂O, Ti, V, Mn, Co, Zn, Ga, Se, Mo, Ag, In, I, Dy, Au, and Hg were not determined). An asterisk next to a reported value indicates that the sample was analyzed by both Los Alamos and the University of Washington on duplicate splits. The asterisked element was determined at the University of Washington; all other elements for that sample were determined at Los Alamos. Uncertainties are one standard deviation, estimates of analytical precision; nd = not determined. Co and W concentrations are artificially elevated due to use of tungsten-carbide mill during preparation of rock powders.

APPENDIX D.

SAMPLE KEY AND LOCATIONS FOR VITRIC AND ZEOLITIC TUFFS INVESTIGATED FOR A SURFACE-BASED TEST FACILITY, YUCCA MOUNTAIN, NEVADA

<u>Field #</u>	<u>LANL Sample Tracking #</u>	<u>Yucca Mountain Project Sample Tracking #</u>	<u>Nevada State Coordinate (E) (ft.)</u>	<u>Nevada State Coordinate (N) (ft.)</u>
<i>Busted Butte (Southeastern End)</i>				
DEB 3/90-4	160	SPC00002129	573123	737356
DEB 3/90-5	161	SPC00002130	573092	737429
DEB 3/90-6	162	SPC00002131	573082	737459
DEB 3/90-7	163	SPC00002132	573047	737526
DEB 3/90-8	164	SPC00002133	573041	737524
DEB 3/90-9	165	SPC00002134	573022	737565
DEB 3/90-10	166	SPC00002135	572971	737616
<i>Busted Butte (Northern End)</i>				
DEB 3/90-44	200	SPC00002169	573319	742622
DEB 3/90-45	201	SPC00002170	573258	742585
DEB 3/90-46	202	SPC00002171	573217	742542
DEB 3/90-47	203	SPC00002172	573218	742497
DEB 3/90-48	204	SPC00002173	573200	742498
DEB 3/90-49	205	SPC00002174	573186	742468
DEB 3/90-50	206	SPC00002175	573173	742456
DEB 4/91-1	432	SPC00005361	573060	742509
<i>Northeast Yucca Mountain Area</i>				
DEB 5/91-7	438	SPC00005367	562285	780373
DEB 5/91-8	439	SPC00005368	562285	780299
DEB 5/91-9	440	SPC00005369	562210	780224
DEB 5/91-10	441	SPC00005370	562135	780224
DEB 5/91-12	443	SPC00005372	562959	779851
DEB 5/91-11	442	SPC00005371	562135	780149
DEB 3/90-36	192	SPC00002161	563110	779585
DEB 3/90-37	193	SPC00002162	562955	779810

APPENDIX D. (cont)

Field #	LANL Sample Tracking #	Yucca Mountain Project Sample Tracking #	Nevada State Coordinate (E) (ft.)	Nevada State Coordinate (N) (ft.)
DEB 3/90-38	194	SPC00002163	562887	779516
DEB 3/90-39	195	SPC00002164	562817	779410
DEB 3/90-40	196	SPC00002165	562743	779317
DEB 3/90-41	197	SPC00002166	562701	779263
DEB 3/90-42	198	SPC00002167	562651	779206
DEB 3/90-43	199	SPC00002168	562703	779156
DEB 5/91-13	444	SPC00005373	563933	778209
DEB 5/91-14	445	SPC00005374	564007	778209
DEB 5/91-15	446	SPC00005375	564007	778134
Stagecoach Road Area				
DEB 3/90-1	157	SPC00002126	564198	724492
DEB 3/90-2	158	SPC00002127	564335	724534
DEB 3/90-3	159	SPC00002128	564614	724945
Prow Pass (Southern Vertical Section)				
DEB 3/90-11	167	SPC00002136	550319	784766
DEB 3/90-12	168	SPC00002137	550373	784774
DEB 3/90-13	169	SPC00002138	550419	784776
DEB 3/90-14	170	SPC00002139	550457	784807
DEB 3/90-15	171	SPC00002140	550496	784831
DEB 3/90-16	172	SPC00002141	550540	784839
DEB 3/90-17	173	SPC00002142	550592	784877
DEB 3/90-18	174	SPC00002143	550620	784904
DEB 3/90-19	175	SPC00002144	550650	784912
DEB 3/90-20	176	SPC00002145	550676	784932
DEB 3/90-21	177	SPC00002146	550714	784948
DEB 3/90-22	178	SPC00002147	550738	784976
DEB 3/90-23	179	SPC00002148	550764	784990
DEB 3/90-24	180	SPC00002149	550790	785009
DEB 3/90-25	181	SPC00002150	550843	785029
DEB 3/90-26	182	SPC00002151	550887	785053
DEB 3/90-27	183	SPC00002152	550919	785057
DEB 3/90-28	184	SPC00002153	550955	785077

APPENDIX D. (cont)

<u>Field #</u>	<u>LANL Sample Tracking #</u>	<u>Yucca Mountain Project Sample Tracking #</u>	<u>Nevada State Coordinate (E) (ft.)</u>	<u>Nevada State Coordinate (N) (ft.)</u>
DEB 3/90-29	185	SPC00002154	550967	785081
DEB 3/90-30	186	SPC00002155	550981	785092
DEB 3/90-31	187	SPC00002156	550999	785084
DEB 3/90-32	188	SPC00002157	551017	785154
DEB 3/90-33	189	SPC00002158	551053	785100
DEB 3/90-34	190	SPC00002159	551096	785102
DEB 3/90-35	191	SPC00002160	551108	785118

Prow Pass Area (Central Vertical Section)

3-15-82-1	82		550749	786716
3-15-82-2	83		550899	786567
3-15-82-3	84		550899	786567
3-15-82-4	85		550974	786493
3-15-82-5	86		550974	786493
3-15-82-6	87		551049	786418
3-15-82-7	88		551124	786343
3-15-82-8	89		551124	786343
3-15-82-9	90		551273	786642
3-15-82-10	91		551348	786493
3-15-82-11	92		551348	786418

Prow Pass Area (Northern Vertical Section)

82FB-1	110		549625	789851
82FB-2	111		549625	790299
82FB-3a	112		549775	790448
82FB-3b	113		549775	790448
82FB-4	114		549925	790672
82FB-5	115		550225	790896

Prow Pass Area (N-S Lateral Section; Locations from Rautman, 1991)

CRPP-1-SNL	126		550696	783540
CRPP-2-SNL	127		550747	783795
CRPP-3-SNL	128		550787	783996

APPENDIX D. (cont)

<u>Field #</u>	<u>LANL Sample Tracking #</u>	<u>Yucca Mountain Project Sample Tracking #</u>	<u>Nevada State Coordinate (E) (ft.)</u>	<u>Nevada State Coordinate (N) (ft.)</u>
CRPP-4-SNL	129		550816	784138
CRPP-5-SNL	130		550857	784344
CRPP-6-SNL	131		550898	784550
CRPP-7-SNL	132		550935	784737
CRPP-8-SNL	133		550995	784835
CRPP-9-SNL	134		550975	784933
CRPP-10-SNL	135		551008	785099
CRPP-11-SNL	136		551086	785492
CRPP-12-SNL	137		551126	785688
CRPP-13-SNL	138		551179	785953
CRPP-14-SNL	139		551210	786110
CRPP-15-SNL	140		551247	786296
CRPP-16-SNL	141		551290	786512
CRPP-17-SNL	142		551333	786727
CRPP-18-SNL	143		551363	786874
CRPP-19-SNL	144		551386	786992
CRPP-20-SNL	145		551416	787139
CRPP-21-SNL	146		551445	787286
CRPP-22-SNL	147		551485	787483
CRPP-23-SNL	148		551524	787678
CRPP-24-SNL	149		551765	788885
CRPP-25-SNL	150		551500	787650
CRPP-26-SNL	151		551584	787596
CRPP-27-SNL	152		551689	787527
CRPP-28-SNL	153		551777	787470
CRPP-29-SNL	154		551827	787437
CRPP-30-SNL	155		551923	787375
CRPP-31-SNL	156		552003	787323
 <i>Calico Hills Area (E-W Lateral Section; Locations from Rautman, 1991)</i>				
CRCH-1-SNL	116		591800	775300
CRCH-2-SNL	117		591700	775300
CRCH-3-SNL	118		591595	775300

APPENDIX D. (cont)

<u>Field #</u>	<u>LANL Sample Tracking #</u>	<u>Yucca Mountain Project Sample Tracking #</u>	<u>Nevada State Coordinate (E) (ft.)</u>	<u>Nevada State Coordinate (N) (ft.)</u>
CRCH-4-SNL	119		591400	775300
CRCH-5-SNL	120		591300	775300
CRCH-6-SNL	121		591203	775300
CRCH-7-SNL	122		591000	775300
CRCH-8-SNL	123		590800	775300
CRCH-9-SNL	124		590695	775300
CRCH-10-SNL	125		590615	775300

APPENDIX E

DATA SOURCES

Field Notebooks:

TWS-ESS-1-6/88-5, pp. 137-160.

TWS-EES-1-9-89-27, pp. 82-92 and p. 101.

Laboratory Notebooks:

TWS-ESS-1-2/88-20, pp. 27-46 and pp. 54-147.

TWS-EES-1-9-90-16, pp. 1-141.

TWS-ESS-1-6-90-7, pp. 1-167.

TWS-EES-1-2-92-5, pp. 32-47.

Maps:

TWS-EES-1-5-92-5

TWS-EES-1-5-92-6

TWS-EES-1-5-92-7

Data File Locations for XRD analyses shown on following pages.

VMS FILE	DIRECTORY	DATE RUN	START	STOP	STEP	TIME	FILE IDENTIFICATION
DEB-170A.RAW	[DIFF500.WASTE.RAW]	27-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-14 170.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-171A.RAW	[DIFF500.WASTE.RAW]	27-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-15 171.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-172A.RAW	[DIFF500.WASTE.RAW]	27-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-16 172.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-173A.RAW	[DIFF500.WASTE.RAW]	29-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-17 173.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-174A.RAW	[DIFF500.WASTE.RAW]	29-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-18 174.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-175A.RAW	[DIFF500.WASTE.RAW]	29-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-19 175.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-176A.RAW	[DIFF500.WASTE.RAW]	29-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-20 176.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-177A.RAW	[DIFF500.WASTE.RAW]	29-AUG-90	2.00	70.00	0.02	16.0	DEB 3/90-21 177.P1A + A1203 80:20, 2-70, 16s, 2-B
DEB-178A.RAW	[DIFF500.WASTE.RAW]	30-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-22 178.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-179A.RAW	[DIFF500.WASTE.RAW]	30-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-23 179.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-180A.RAW	[DIFF500.WASTE.RAW]	30-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-24 180.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-181A.RAW	[DIFF500.WASTE.RAW]	30-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-25 181.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-182A.RAW	[DIFF500.WASTE.RAW]	30-AUG-90	2.00	70.00	0.02	16.0	DEB 3/90-26 182.P1A + A1203 80:20, 2-70, 16s, 2-B
DEB-183A.RAW	[DIFF500.WASTE.RAW]	31-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-27 183.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-184A.RAW	[DIFF500.WASTE.RAW]	31-AUG-90	2.00	50.00	0.02	2.0	DEB 3/90-28 184.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-185A.RAW	[DIFF500.WASTE.RAW]	04-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-29 185.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-186A.RAW	[DIFF500.WASTE.RAW]	04-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-30 186.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-187A.RAW	[DIFF500.WASTE.RAW]	04-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-31 187.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-188A.RAW	[DIFF500.WASTE.RAW]	04-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-32 188.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-189A.RAW	[DIFF500.WASTE.RAW]	04-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-33 189.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-190A.RAW	[DIFF500.WASTE.RAW]	04-SEP-90	2.00	70.00	0.02	16.0	DEB 3/90-34 190.P1A + A1203 80:20, 2-70, 16s, 2-B
DEB-191A.RAW	[DIFF500.WASTE.RAW]	05-SEP-90	2.00	70.00	0.02	16.0	DEB 3/90-35 191.P1A + A1203 80:20, 2-70, 16s, 2-B
DEB-192A.RAW	[DIFF500.WASTE.RAW]	06-SEP-90	2.00	70.00	0.02	16.0	DEB 3/90-36 192.P1A + A1203 80:20, 2-70, 16s, 2-B
DEB-193A.RAW	[DIFF500.WASTE.RAW]	12-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-37 193.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-194A.RAW	[DIFF500.WASTE.RAW]	12-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-38 194.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-195A.RAW	[DIFF500.WASTE.RAW]	12-SEP-90	2.00	70.00	0.02	16.0	DEB 3/90-39 195.P1A + A1203 80:20, 2-70, 16s, 2-B
DEB-196A.RAW	[DIFF500.WASTE.RAW]	13-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-40 196.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-197A.RAW	[DIFF500.WASTE.RAW]	13-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-41 197.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-198A.RAW	[DIFF500.WASTE.RAW]	13-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-42 198.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-199A.RAW	[DIFF500.WASTE.RAW]	14-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-43 199.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-200A.RAW	[DIFF500.WASTE.RAW]	14-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-44 200.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-201A.RAW	[DIFF500.WASTE.RAW]	14-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-45 201.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-202A.RAW	[DIFF500.WASTE.RAW]	14-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-46 202.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-203A.RAW	[DIFF500.WASTE.RAW]	14-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-47 203.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-204A.RAW	[DIFF500.WASTE.RAW]	17-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-48 204.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-205A.RAW	[DIFF500.WASTE.RAW]	17-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-49 205.P1A + A1203 80:20, 2-50, 2s, 2-B
DEB-206A.RAW	[DIFF500.WASTE.RAW]	17-SEP-90	2.00	50.00	0.02	2.0	DEB 3/90-50 206.P1A + A1203 80:20, 2-50, 2s, 2-B
82-P1A.RAW	[DIFF500.WASTE.RAW]	21-MAY-91	2.00	50.00	0.02	2.0	3-15-82-1, LANL 82.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
83-P1A.RAW	[DIFF500.WASTE.RAW]	21-MAY-91	2.00	50.00	0.02	2.0	3-15-82-2, LANL 83.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
84-P1A.RAW	[DIFF500.WASTE.RAW]	21-MAY-91	2.00	50.00	0.02	2.0	3-15-82-3, LANL 84.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
85-P1A.RAW	[DIFF500.WASTE.RAW]	21-MAY-91	2.00	70.00	0.02	16.0	3-15-82-4, LANL 85.P1A + A1203 80:20, 2-70, 16s, 2-B, Broxtor
86-P1A.RAW	[DIFF500.WASTE.RAW]	22-MAY-91	2.00	50.00	0.02	2.0	3-15-82-5, LANL 86.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
87-P1A.RAW	[DIFF500.WASTE.RAW]	22-MAY-91	2.00	50.00	0.02	2.0	3-15-82-6, LANL 87.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
89-P1A.RAW	[DIFF500.WASTE.RAW]	22-MAY-91	2.00	50.00	0.02	2.0	3-15-82-8, LANL 89.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
90-P1A.RAW	[DIFF500.WASTE.RAW]	22-MAY-91	2.00	50.00	0.02	2.0	3-15-82-9, LANL 90.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
91-P1A.RAW	[DIFF500.WASTE.RAW]	22-MAY-91	2.00	70.00	0.02	16.0	3-15-82-10, LANL 91.P1A + A1203 80:20, 2-70, 16s, 2-B, Broxtor
92-P1A.RAW	[DIFF500.WASTE.RAW]	23-MAY-91	2.00	50.00	0.02	4.0	3-15-82-11, LANL 92.P1A + A1203 80:20, 2-50, 4s, 2-B, Broxtor
93-P1A.RAW	[DIFF500.WASTE.RAW]	23-MAY-91	2.00	50.00	0.02	4.0	5-6-82-1, LANL 93.P1A + A1203 80:20, 2-50, 4s, 2-B, Broxtor
82FB-1A.RAW	[DIFF500.WASTE.RAW]	23-MAY-91	2.00	70.00	0.02	16.0	82FB-1, LANL 110.P1A + A1203 80:20, 2-70, 16s, 2-B, Broxtor
82FB-2A.RAW	[DIFF500.WASTE.RAW]	24-MAY-91	2.00	50.00	0.02	4.0	82FB-2, LANL 111.P1A + A1203 80:20, 2-50, 4s, 2-B, Broxtor
82FB-3A.RAW	[DIFF500.WASTE.RAW]	28-MAY-91	2.00	50.00	0.02	2.0	82FB-3a, LANL 112.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
82FB-3B.RAW	[DIFF500.WASTE.RAW]	28-MAY-91	2.00	50.00	0.02	2.0	82FB-3b, LANL 113.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
82FB-4A.RAW	[DIFF500.WASTE.RAW]	28-MAY-91	2.00	50.00	0.02	2.0	82FB-4, LANL 114.P1A + A1203 80:20, 2-50, 2s, 2-B, Broxtor
82FB-5A.RAW	[DIFF500.WASTE.RAW]	28-MAY-91	2.00	70.00	0.02	16.0	82FB-5, LANL 115.P1A + A1203 80:20, 2-70, 16s, 2-B, Broxtor

FILE : broxton01.datoloc

VMS FILE	DIRECTORY	DATE RUN	START	STOP	STEP	TIME	FILE IDENTIFICATION
LANL-432A.RAW	(DIFF500.WASTE.RAW)	26-JUN-91	2.00	50.00	0.02	2.0	LANL 432.PI + A1203 80:20, 2-50, 2s, 2-B, for Broxton
LANL-438A.RAW	(DIFF500.WASTE.RAW)	26-JUN-91	2.00	50.00	0.02	2.0	LANL 438.PI + A1203 80:20, 2-50, 2s, 2-B, for Broxton
LANL-439A.RAW	(DIFF500.WASTE.RAW)	03-JUL-91	2.00	50.00	0.02	2.0	LANL 439.PI + A1203 80:20, 2-50, 2s, 2-B, for Broxton
LANL-440A.RAW	(DIFF500.WASTE.RAW)	03-JUL-91	2.00	50.00	0.02	2.0	LANL 440.PI + A1203 80:20, 2-50, 2s, 2-B, for D. Broxton
LANL-441A.RAW	(DIFF500.WASTE.RAW)	28-AUG-91	2.00	50.00	0.02	2.0	LANL 441.PI + A1203 80:20, 2-50, 2s, 2-B, for D. Broxton
LANL-442A.RAW	(DIFF500.WASTE.RAW)	28-AUG-91	2.00	50.00	0.02	2.0	LANL 442.PI + A1203 80:20, 2-50, 2s, 2-B, for D. Broxton
LANL-443A.RAW	(DIFF500.WASTE.RAW)	29-AUG-91	2.00	50.00	0.02	2.0	LANL 443.PI + A1203 80:20, 2-50, 2s, 2-B, for D. Broxton
LANL-444A.RAW	(DIFF500.WASTE.RAW)	29-AUG-91	2.00	50.00	0.02	2.0	LANL 444.PI + A1203 80:20, 2-50, 2s, 2-B, for D. Broxton
LANL-445A.RAW	(DIFF500.WASTE.RAW)	29-AUG-91	2.00	50.00	0.02	2.0	LANL 445.PI + A1203 80:20, 2-50, 2s, 2-B, for D. Broxton
LANL-446A.RAW	(DIFF500.WASTE.RAW)	29-AUG-91	2.00	50.00	0.02	2.0	LANL 446.PI + A1203 80:20, 2-50, 2s, 2-B, for D. Broxton
DEB432-0A.RAW	(DIFF500.WASTE.RAW)	24-JAN-92	2.00	36.00	0.02	2.0	DEB 4/91-1 432.PI Fract #0, 30 sec settled, 2-36, 2s, 2-B
DEB432-1A.RAW	(DIFF500.WASTE.RAW)	24-JAN-92	2.00	36.00	0.02	2.0	DEB 4/91-1 LANL 432.PI Fract #1, 5min settled, 2-36, 2s, 2-B
DEB432-2A.RAW	(DIFF500.WASTE.RAW)	24-JAN-92	2.00	36.00	0.02	2.0	DEB 4/91-1 432.PI Fract #2, 1 hour Settled, 2-36, 2s, 2-B
DEB432-3A.RAW	(DIFF500.WASTE.RAW)	24-JAN-92	2.00	36.00	0.02	2.0	DEB 4/91-1 #432.PI Fract #3, Overnight Settled, 2-36, 2s, 2-B
DEB432-4A.RAW	(DIFF500.WASTE.RAW)	24-JAN-92	2.00	36.00	0.02	2.0	DEB 4/91-1 432.PI Fract #4, 5000RPM / 5min, 2-36, 2s, 2-B
DEB432-5A.RAW	(DIFF500.WASTE.RAW)	24-JAN-92	2.00	36.00	0.02	2.0	DEB 4/91-1 432.PI Fract #5, 8000RPM / 5min, 2-36, 2s, 2-B
DEB432-6A.RAW	(DIFF500.WASTE.RAW)	05-FEB-92	2.00	70.00	0.02	2.0	DEB 4/91-1 432.PI Fract #6, Supernat., ORI on QTZ, 2-70, 2s

END

**DATE
FILMED**

11/29/93