Portland State University

PDXScholar

Dissertations and Theses

Dissertations and Theses

Winter 3-14-2018

The Wildcat Creek Tuff, Eastern Oregon: Co-eruption of Crystal-poor Rhyolite and Fe-rich Andesite with Implication for Mafic Underpinnings to Voluminous A-type Rhyolites

Hillarie Jaye Sales

Portland State University

Follow this and additional works at: https://pdxscholar.library.pdx.edu/open_access_etds

Part of the [Geology Commons](#)

Let us know how access to this document benefits you.

Recommended Citation

Sales, Hillarie Jaye, "The Wildcat Creek Tuff, Eastern Oregon: Co-eruption of Crystal-poor Rhyolite and Fe-rich Andesite with Implication for Mafic Underpinnings to Voluminous A-type Rhyolites" (2018).

Dissertations and Theses. Paper 4352.

<https://doi.org/10.15760/etd.6245>

This Thesis is brought to you for free and open access. It has been accepted for inclusion in Dissertations and Theses by an authorized administrator of PDXScholar. Please contact us if we can make this document more accessible: pdxscholar@pdx.edu.

The Wildcat Creek Tuff, Eastern Oregon:
Co-eruption of Crystal-poor Rhyolite and Fe-rich Andesite with Implication for
Mafic Underpinnings to Voluminous A-type Rhyolites

by

Hillarie Jaye Sales

A thesis submitted in partial fulfillment of the
requirements for the degree of

Master of Science
in
Geology

Thesis Committee:
Martin J. Streck, Chair
Nancy A. Price
Richard C. Hugo

Portland State University
2018

ABSTRACT

The Wildcat Creek Tuff is a thin (~3-12 m), rhyolite to andesitic ash-flow tuff with a minimal extent of 1500 km² in Malheur county, eastern Oregon. The previously undated tuff yielded a single crystal, anorthoclase ⁴⁰Ar/³⁹Ar age of 15.49±0.02 Ma and thus is closely related to mafic and silicic volcanism of the Columbia River Province. The tuff texturally stands out by its high proportion of co-mingled mafic inclusions appearing as dark, scoriaceous, and phenocryst-poor fragments, and their proportion dictate bulk tuff compositions ranging from rhyolite (74% SiO₂) to andesite (59% SiO₂). Glass analyses confirm rhyolite end member at 74-75 wt.% SiO₂ and two mafic members, one at 59-60 wt.% SiO₂ and the other at 56-57 wt.% SiO₂. Rare plagioclase and even rarer pyroxene phenocrysts with compositions clustering at An60-74 and An35-45, and Mg17-19 and Mg80-84, respectively, similarly suggest two andesitic magmas with the 60% member being the dominant mafic composition. It has distinctly lower TiO₂ and CaO, slightly lower FeO, and comparable Al₂O₃, MgO, and alkalis.

Eruption of crystal-poor dacitic to basaltic-andesitic cognate components is also observed in other Miocene ash-flow tuffs from eastern Oregon, like the Rattlesnake, Dinner Creek, and the Devine Canyon Tuffs, as well as other less voluminous tuffs. However, the high proportion of mafic components in the Wildcat Creek tuff seems currently unrivaled. The co-eruption of intermediate magmas with rhyolite implies that mafic magmas were tapped from a common reservoir, and these magmas increased in

proportion during the course of the eruption(s). This continued up to the point where nearly all deposited tuff material consisted of andesite. This is consistent with progressively deeper magma withdrawal, in turn implying that mafic magmas resided below the rhyolites as a discrete magma batch. Dacitic components of voluminous rhyolitic tuffs have been recently interpreted as remelted samples of a crystal mush after crystal-poor rhyolites were extracted. Dacitic Wildcat Creek Tuff samples do not bear any evidence of this. To the contrary, small negative Eu anomalies, normal Ba and Sr concentrations, and nearly aphyric nature are consistent with a large portion of mixing between Wildcat Creek Tuff rhyolites and regional mid Miocene, Fe-rich, and crystal poor basaltic andesite magmas that occur ubiquitously as lava flows.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Martin Streck, for his patience and guidance throughout this journey, and for sparking my love of volcanics. I would also like to thank my committee members. Dr. Nancy Price, thank you for your help and encouragement throughout this process. Dr. Richard Hugo, thanks for showing me the ropes in SEM.

I am so grateful for the help of my friends at PSU, especially Ellie. Without your brilliance and willingness to help I would have been lost. Love you, Brown Bear!

To my LabCor family, your understanding that “school comes first” allowed me to pursue my career while completing this crazy journey. Thanks for keeping me grounded, guys.

Most importantly, I would like to thank my boyfriend, Max, and my family for their love and support throughout this project.

TABLE OF CONTENTS

Abstract.....	i
Acknowledgements.....	iii
List of Figures.....	vii
Introduction.....	1
Background.....	3
Select Prior Case Studies on Mafic Inclusions.....	6
Methods.....	10
Sample Collection.....	10
Preparation and Analysis of Samples.....	11
Results.....	14
Lithologic Characteristics.....	14
Petrographic Analysis.....	26
Glass Composition.....	43
Geochemical Analysis of Bulk Samples.....	46
Mineral Composition.....	53
Isotopic Age Dating.....	55
Discussion.....	57
Magmatic Components in the Wildcat Creek Tuff.....	57
Magma Mixing.....	64
Inclusions as Evidence for Magma Mixing.....	68
Wildcat Creek Tuff in the Context of Nearby Units.....	69
Stratification of the Magma Reservoir.....	71

Conclusion.....	75
References.....	77
Appendix A: Field Site Locations.....	79
Appendix B: Petrography of Thin Sections.....	80
Appendix C: Bulk Geochemistry, XRF.....	81
Appendix D: Bulk Geochemistry, ICP-MS.....	88
Appendix E: Glass Geochemistry, EMP.....	89
Appendix F: Feldspar Geochemistry, SEM.....	92
Appendix G: Pyroxene Geochemistry, SEM.....	94
Appendix H: SEM Spectra.....	96
H1: HS-15-04a.....	96
H2: HS-15-04c.....	98
H3: HS-15-04d.....	101
H4: HS-15-04e.....	104
H5: HS-15-05.....	107
H6: MS-13-07.....	111
H7: MS-14-03.....	113
H8: MS-14-05.....	114
H9: MS-14-06.....	116
Appendix I: SEM and EMP Data for Feldspar Calculations.....	119
Appendix J: SEM and EMP Data for Pyroxene Calculations.....	126
Appendix K: Major Element Comparison Plots.....	135
Appendix L: Major and Trace Element Comparison Plots.....	142

Appendix M: Trace Element Comparison Plots.....	144
Appendix N: Stratigraphic Column of Site 4.....	152

LIST OF FIGURES

Figure 1: Thin section of MS-14-06.....	4
Figure 2: Modified map of the study area.....	5
Figure 3: Model of rhyolite extraction from crystal mush.....	7
Figure 4: Schematic of the Rattlesnake Tuff magma chamber.....	8
Figure 5: Geologic map of the Vale Quadrangle.....	10
Figure 6: Site location map of the Wildcat Creek Tuff.....	15
Figure 7: Site 1 of the Wildcat Creek Tuff.....	16
Figure 8: Hand sample from Site 1.....	17
Figure 9: Site 4 of the Wildcat Creek Tuff.....	18
Figure 10: Hand sample of HS-15-04a.....	19
Figure 11: Site 4 of the Wildcat Creek Tuff, close-up of the contact with underlying unit.....	20
Figure 12: Site 4 of the Wildcat Creek Tuff, view of the contact showing erosion.....	21
Figure 13: Hand sample of HS-15-04c in the field.....	22
Figure 14: Hand sample of HS-15-04c in the lab.....	22
Figure 15: Hand sample of HS-15-04d in the lab.....	23
Figure 16: Site 5 of the Wildcat Creek Tuff, hand sample in the field.....	24
Figure 17: Site 6 of the Wildcat Creek Tuff.....	25
Figure 18: Pyroxene mineral, P19 from sample HS-15-04c.....	27
Figure 19: Feldspar mineral, F6 from sample HS-15-04c.....	28
Figure 20: Thin section of HS-15-04c.....	28
Figure 21: Feldspar mineral, F6 from sample HS-15-04d.....	29
Figure 22: Thin section of HS-15-04d.....	30

Figure 23: Pyroxene mineral, P4 from sample HS-15-04e.....	31
Figure 24: Olivine mineral, P11 from sample HS-15-04e.....	32
Figure 25: Feldspar mineral, F5 from sample HS-15-04e.....	32
Figure 26: Thin section of HS-15-04a.....	33
Figure 27: Pyroxene mineral, P5 from HS-15-04a.....	34
Figure 28: Feldspar mineral, F6 from sample HS-15-04a.....	35
Figure 29: Thin section of HS-15-04a.....	35
Figure 30: Feldspar mineral, F16 from sample HS-15-04.....	37
Figure 31: Pyroxene mineral, P22 from sample HS-15-05.....	37
Figure 32: Thin section of HS-15-05.....	38
Figure 33: Thin section of MS-14-03.....	39
Figure 34: Pyroxene mineral, P17 from sample MS-14-06.....	40
Figure 35: Feldspar mineral, F4 from sample MS-14-06.....	41
Figure 36: Feldspar mineral, F3 from sample MS-14-06.....	41
Figure 37: Thin section of MS-14-06 showing glass analyses.....	42
Figure 38: Thin section of MS-14-05.....	43
Figure 39: Glass analyses from MS-14-06.....	44
Figure 40: Plot of EMP glass analyses, FeO vs. SiO ₂	45
Figure 41: Total alkali-silica classification diagram.....	46
Figure 42: Trace element diagram.....	47
Figure 43: Rare earth element diagram.....	48
Figure 44: Major element variation diagram of FeO vs. SiO ₂	49
Figure 45: Major element variation diagram of TiO ₂ vs. SiO ₂	49
Figure 46: Major element variation diagram of P ₂ O ₅ vs. SiO ₂	50
Figure 47: Major vs. trace element comparison plot of Sr vs. SiO ₂	50

Figure 48: Trace element comparison plot of Th vs. Nb.....	51
Figure 49: Glass composition analyses for mafic samples, FeO vs. SiO ₂	52
Figure 50: Handpicked mafic material and mafic glass analyses, FeO vs. SiO ₂	52
Figure 51: Ternary diagram showing feldspar minerals.....	54
Figure 52: Ternary diagram showing pyroxene minerals.....	55
Figure 53: Plot of the ⁴⁰ Ar/ ³⁹ Ar isotopic age date analyses of the Wildcat Creek Tuff.....	56
Figure 54: Major element comparison plot of rhyolitic bulk samples and rhyolitic glass analyses, FeO vs. SiO ₂	59
Figure 55: Pyroxene mineral, P3 from sample MS-14-06.....	60
Figure 56: Pyroxene mineral P15 from MS-14-06.....	61
Figure 57a and 57b: EMP glass analyses for MS-14-05 and MS-14-06.....	62
Figure 58: Averaged glass analyses by EMP and XRF, FeO vs. SiO ₂	63
Figure 59: Trace element diagram including plotted mixing calculations.....	65
Figure 60: Trace element diagram, hypothetical mixture of samples HS-15-04c and HS-15-06a vs. intermediate sample HS-15-05.....	67
Figure 61: Trace element diagram, hypothetical mixture of samples HS-15-04e and MS-14-05 vs. intermediate sample HS-15-05.....	68
Figure 62: Rare earth element diagram of the Wildcat Creek Tuff vs. the Rattlesnake Tuff as a crystal cumulate.....	69
Figure 63: Trace element diagram of the Wildcat Creek Tuff and the Buchanan Tuff...	70

INTRODUCTION

Basaltic magmas are critical to the production of rhyolitic magmas, either as a material source of rhyolite production via fractional crystallization or as a heat source to partially melt the crust (Johnson, 1991). Mafic magmas are also important because they can maintain temperature for large batches of rhyolitic magmas stored under near surface conditions (~3-6 km) for long durations as essentially pure liquids (<5% phenocrysts), thus preventing solidification, which would produce granite. For these reasons, natural examples demonstrating a close temporal and spatial relationship of rhyolites and more mafic magmas are important for studying rhyolite evolution models. Examples of systems where intermediate magma co-erupted with rhyolites are mostly reported from ash-flow tuffs (e.g. Streck & Gruner, 1999; Deering et al., 2011; Bachmann et al., 2014). The origin of these mafic components may vary as suggested by different interpretations. A mafic magma may underlie rhyolite and mixing may occur. Streck and Gruner (1999) described such a system where a dacite is produced due to the disturbance of the boundary between the rhyolite and basaltic-andesite that lie within the same magma chamber (see Fig. 4). Another example outlines intermediate magma formation in a zoned magma reservoir due to in-situ differentiation and re-melting of a crystal cumulate (Deering et al., 2011; Bachmann et al., 2014). In both cases, the system requires a recharge of hot mafic magma – in one case to provide the material source for mixing with rhyolites to produce dacitic magmas, and in the other case as thermal input for remobilization and melting of the crystal mush that will ultimately lead to crystal-poor dacitic magma.

The mid-Miocene Wildcat Creek Tuff in Malheur County, Eastern Oregon is an ideal unit to investigate again the relationship between rhyolite and mafic magma, rhyolite petrogenesis, and the development of intermediate magma. The tuff contains abundant inclusions of dark, scoriaceous mafic material. The purpose of this study was to determine the origin of mafic inclusions in the Wildcat Creek Tuff and their petrogenetic relationship to the co-erupted rhyolites. It determined how the tuff was formed and the absolute age of the unit. This was accomplished by studying the composition and mineralogy of eruptive products found within the Wildcat Creek Tuff.

BACKGROUND

The Wildcat Creek Tuff has been known to be a rhyolitic ash-flow tuff that erupted during the mid-Miocene and is part of a volcanic field in Malheur County, eastern Oregon (Hooper et al., 2000) (see Figure 2). No precise source area has been determined for the Wildcat Creek Tuff. Based on distribution of the tuff, a source near the center of its outcrop area is likely. This is located roughly where samples HS-15-05 and MS-14-03 were taken (see Table 1 for latitude/longitude). There was no radiometric age of the tuff and its age was only constrained by its stratigraphic position above the Littlefield Rhyolite (Cummings et al., 2000; Hooper et al., 2000). The tuff is characterized by abundant, dark scoriaceous inclusions ranging in size from the smallest at <1 mm to the largest at ~15 mm. Although tuffs with similar mafic inclusions are preserved elsewhere (e.g., the Ammonia Tanks Tuff of Southwest Nevada (Deering et. al., 2011), the Carpenter Ridge Tuff of Colorado (Bachmann et. al., 2014), and the Rattlesnake Tuff of Eastern Oregon (Streck & Grunder, 1999)), the high abundance (~45 % vol) of mafic inclusions in the Wildcat Creek Tuff is exceptional (see Fig. 1).

Figure 1. Sample MS1406 is characterized by bulk composition as trachydacite. This thin section scan (46mm in horizontal dimension), shown in plain light, displays one of the least welded samples of Wildcat Creek Tuff in the set, allowing for the analysis of individual components within the sample for silica content. The darkest sections of the sample are the most mafic. All of the scoriaceous inclusions are phenocryst-poor and darker than the surrounding groundmass.

Figure 2. Modified map of the study area in Malheur County, Eastern Oregon (Webb, 2014). The Wildcat Creek Tuff (pink) was mapped by M.L. Ferns (1993) and J.P. Stimac (1988). Surrounding units, such as the Littlefield Rhyolite and the Hunter Creek Basalt, which may be of stratigraphic importance, or compositionally compared to the Wildcat Creek Tuff, have been included. Sample sites from fieldwork are noted.

Select Prior Case Studies on Mafic Inclusions

The Ammonia Tanks rhyolitic tuff of the Southwest Nevada Volcanic Field displays compositional and thermal zoning that can be explained as a system where rhyolites were produced by extraction of interstitial liquid from a crystal mush (Deering et al., 2011). Once the melt was extracted, a crystal cumulate was left behind with only a small portion of melt (Deering et al., 2011). A late influx of hot mafic magma remobilized and remelted the crystal cumulate, allowing the cumulate to become eruptible, and this resulted in a phenocryst-poor dacitic magma that erupted along with rhyolites, forming mafic inclusions (Deering et al., 2011).

Similarly, Bachmann et al. (2014) considers the Carpenter Ridge rhyolite tuff to have been formed by in-situ differentiation and melt extraction from an upper-crustal mush zone. After extraction of the rhyolite from a crystal mush, a silicic crystal cumulate was again left behind below the rhyolite, recharged by mafic magma and remobilized (Bachmann et al., 2014). A zoned ignimbrite such as the Carpenter Ridge Tuff is likely to be the result of both mixing and fractionation, and mafic recharge is an important part of the remobilization process (Bachmann et al., 2014).

Figure 3. Modified figure from Hildreth & Wilson (2007) shows the mush model of rhyolite melt extraction from a crystal mush. As the mafic recharge (black) accumulates beneath the silicic mush (blue), it remobilizes the crystal cumulate, decreasing crystallinity. Some mingling may occur between the recharged mafic magma and the rhyolite mush zone, but according to Deering et al. (2011) this process is secondary to in-situ differentiation and melt extraction. The crystal-poor area of the magma chamber is denoted by “xp”; the crystal-rich portion by “xr”, and intermediate crystal content is represented by “xm”.

The Rattlesnake Tuff of Eastern Oregon contains mafic (basalt to basaltic-andesite) inclusions as well as dacite pumices (Streck & Grunder, 1999). Components of the tuff indicate the magma chamber was zoned, highly silicic at the top and less so further at depth (Streck & Grunder, 1999). Mafic inclusions have trace element enriched compositions that were the product of multiple cycles of mafic recharge and fractionation (Streck & Grunder, 1999). Intermediate inclusions of dacite pumice are thought to be due to mixing of basaltic-andesite and high-silica rhyolite prior to eruption (Streck &

Grunder, 1999). Rhyolites create a density trap for mafic materials beneath, and the basalt thermally maintains the rhyolite, consequently allowing both members to differentiate inside the magma chamber (Streck & Grunder, 1999).

Figure 4. Schematic cross-section of the Rattlesnake Tuff magma chamber, prior to eruption, identifying the mafic root zone and high-silica rhyolite lens. The production of dacite (the intermediate member of this system) is attributed to the disturbance of the boundary between the rhyolite and basaltic-andesite. Figure from Streck & Grunder (1999).

All three studies envision the intrusion of hotter, mafic magma into the system before eruption, creating (1) chemical exchanges and mingling of rhyolite and basalt resulting in the creation of dacite inclusions (Streck & Grunder, 1999), or (2) remobilization of a crystal cumulate through recharged hotter magmas, leading to melting

of crystals and the generation of an intermediate magma composition (Deering et al., 2011; Bachmann et al., 2014).

METHODS

SAMPLE COLLECTION

Fieldwork to collect samples for this study was undertaken in August 2015. The area covered, from east to west, includes 43°34'22.26"N, 117°49'55.56"W to 43°33'19.30"N, 117°56'58.46"W. Ranging north to south it includes 43°35'41.52"N, 117°49'37.74"W to 43°27'17.64"N, 117°49'3.48"W. Samples of the Wildcat Creek Tuff were collected from outcrops at six locations around the field area, as determined by geologic maps of the area (See Fig. 5, below, and Table 1 in Appendix A).

Figure 5. Geologic map of Malheur County, OR including the Wildcat Creek Tuff. On this map, the unit of interest is Ttwc and is yellow with orange dots. It falls into the category of Oregon-Idaho Graben Deposits emplaced during the mid-Miocene. (Ferns, 1993)

In addition, samples of underlying basalt and other, nearby units were collected for comparison. Field notes about the Wildcat Creek Tuff include lithological

characteristics such as welding, devitrification, porosity, phenocryst abundance, and mafic inclusions. In total, seventeen samples from six sites were collected for this study. Three rock samples of the Wildcat Creek Tuff and one rock sample of the Buchanan Tuff, collected by Martin Streck in 2014 and 2013 respectively, were also included in this study for comparison. Sample locations for welded tuff includes Sites 5 and 6, located near 43.558350°, -117.904619°. The least welded samples were located at Site 4, located near 43.540133°, -117.822269°.

Samples were labeled with a unique identifier including initials, the year, and the site number. Notations were made regarding each site location and any additional information, including GPS coordinates. This information was recorded in a field notebook and each site was also plotted on Google Earth (Google Earth, 2014) for easy reference. All geographic data were collected using a Garmin eTrex 30.

A geologic map of the area was created using ArcGIS software (ESRI, 2014) (Fig. 2, above).

PREPARATION AND ANALYSIS OF SAMPLES

Eight rock samples were selected for bulk analysis (See Appendix B, Appendix C). These were individually chipped into a size fraction of approximately 0.5cm using facilities at Portland State University. These samples were then taken to the Peter Hooper GeoAnalytical Laboratory of Washington State University (Pullman, WA), where further processing broke the samples down into rock powders and finally fused into glass beads and acid-dissolved solutions. Glass beads were used to analyze major and some trace-elemental concentrations using the Thermal –ARL automated x-ray fluorescence

spectrometer (XRF) and the rock solutions were analyzed for trace elemental concentrations with the Agilent inductively coupled plasma mass spectrometer (ICP-MS). XRF data are available in Appendix B, and ICP-MS data are available in Appendix C. Additional samples were crushed further at Portland State University, using an iron mortar and pestle to achieve a size fraction of either 1.18mm to 2.00 mm for larger grains, and 0.991mm to 1.18mm for smaller grains. The samples were then picked by hand using a binocular microscope to separate mafic inclusions from the otherwise felsic materials. The mafic material was then taken to the Peter Hooper Geoanalytical Lab at Washington State University for analysis separate from whole rock bulk composition. At Washington State University, approximately 12 grams of each sample were crushed into powder using a tungsten carbide ring mill. Three and a half grams of a flux agent, dilithium tetraborate ($\text{Li}_2\text{B}_4\text{O}_7$), was then added to 1.25g of rock powder for a 2:1 ratio (Flux agent: Sample). The rock-flux was mixed thoroughly, transferred to a carbon crucible, placed in a 1000°C muffle furnace, and fused into 15mm glass beads. Once cool, these beads were then polished using isopropyl alcohol and sand paper to remove excess carbon. The glass beads were then re-crushed individually, ground into a powder, and fused again at 1000°C to ensure complete homogenization for both XRF and ICP-MS analysis. Staff at the WSU Peter Hooper GeoAnalytical Lab performed all XRF and ICP-MS analyses. Analysis of 10 major elements and 19 trace elements was performed using XRF. Analysis of 23 additional trace elements was performed using ICP-MS.

While hand picking mafic material from the samples, feldspar phenocrysts were also hand selected from sample MS-14-5 in the size range of 600 to 991 μm . These were sent to New Mexico Tech where William McIntosh and his team conducted $^{40}\text{Ar}/^{39}\text{Ar}$ age

dating experiments in the NMT Geochronology Research Laboratory. To determine the absolute age of the sample, the argon extraction method was conducted with a 50 watt CO₂ laser. Individual feldspars were heated incrementally to release stored Ar that yielded then individual crystal age from which a average age was derived.

Thin sections were prepared and work at PSU consisted of cutting billets of each rock. These were sent to Spectrum Petrographics, a local petrographic company, for completing thin sections with a microprobe polish.

Petrographic analysis was completed at Portland State University using a Leica MZ 9.5 stereoscope and a Zeiss Primotech polarized light microscope. Detailed assessments of textures, mineral assemblages, phenocryst sizes, and proportions, were made. The thin sections were then carbon coated using an Electron Microscopy Sciences carbon evaporator, and scanning electron microscopy was conducted in the Center for Electron Microscopy and Nanofabrication located at Portland State University. The Zeiss Sigma VP FEG SEM was used to take back-scattered electron images and to determine composition of individual minerals within the samples. Specific sites in each thin section were selected for analysis, including minerals like feldspars and pyroxenes, and both mafic and felsic glass. The images and data were processed using AzTEC software at Portland State University.

Microprobe analysis was conducted remotely by using the electron microprobe at Oregon State University (Corvallis, Oregon). Feldspars, pyroxenes, and glass were analyzed on a Cameca SX-100 Electron Microprobe. Pyroxenes were analyzed with a sample current of 20 nA, a 2µm magnification beam, and 15 kV voltage. Feldspars were analyzed with a sample current of 8 nA, a 5µm magnification beam, and 15 kV voltage.

RESULTS

LITHOLOGIC CHARACTERISTICS

Macroscopic analysis of the Wildcat Creek Tuff was performed while in the field in August 2015. The overall appearance of the unit is dark, ranging from black to brown, with some lighter outcrops where the felsic component of the system is more prevalent than the intermediate component. Site 4, in particular, stands out, as it shows the distinct contact with the underlying stratigraphic unit. Throughout the Wildcat Creek Tuff site locations, the most welded samples are located close to the bottom of the stratigraphic unit, while the least welded are near the top. Typically, the less welded portions of the unit are somewhat darker in color, ranging from reddish-brown dark grey and even to black. The more welded sites are lighter in color, both macro- and microscopically. This is somewhat contrary to increasing welding in vitric facies, but could be explained by crystallization of felsic groundmass crystals during devitrification. A map of the site locations is below (Fig. 6)

Figure 6. Site location map of the Wildcat Creek Tuff (green), including sites 1 through 6. The Google Earth image is overlain by a map showing the Wildcat Creek Tuff, created in Arc GIS. (Google Earth, 2014; ESRI, 2014)

Site 1

Located at 43.556356° , -117.920808° , Site 1 was the first Wildcat Creek Tuff location sampled during fieldwork. This outcrop was pre-selected and plotted in Google Earth. After a short hike of ~0.25 miles from Shumway Cutoff Road, several photographs were taken of the site and samples selected from the location (Figs. 7 and 8, below). The outcrop appears reddish-brown with many inclusions of scoria. In hand-sample once broken open, the rocks have both reddish-brown and dark grey components, fiamme, and angular clasts.

Figure 7. Site 1 of the Wildcat Creek Tuff. The darkest portion of the unit, located in the foreground of the photo, is not associated with the Wildcat Creek Tuff, but with the Littlefield Rhyolite that lies stratigraphically beneath it. Above, with geologist for scale, the Wildcat Creek Tuff rhyolite can be seen. It is reddish-brown to dark gray in color and phenocryst-poor.

Figure 8. Hand sample obtained at Site 1 during fieldwork. A weathering rind is seen, but on the fresh face of the rock the color ranges from reddish-brown to dark grey. The rock is phenocryst-poor.

Site 2

Site 2 was located at 43.552022°, -117.898569° on Monument Rock Road. This outcrop was pre-selected and plotted on Google Earth. Once fieldwork began at the site, the actual outcrop of the unit was difficult to locate. What little rock cropped out was dark grey to black in color and phenocryst-poor, resembling a basalt lava. In hand sample, however, the pyroclastic texture of the rock was apparent. This sample of the Wildcat Creek Tuff is similar to those located at Site 1, phenocryst poor and reddish-brown to dark grey in color. Obsidian was identified just below Site 2 as float.

Site 3

Site 3 is located at 43.498144°, -117.804903°. Tabular, reddish rock was located below the Wildcat Creek Tuff outcrop near the top of the ridge. The outcropping portion of the WCT unit was dark grey to black in appearance and phenocryst-poor, containing red, vesicular pumice.

Site 4

Located at 43.540133°, -117.822269°, Site 4 is the best exposed and complete of all sites sampled during fieldwork. The full petrography of samples is described in Appendix A. The site is pictured in Fig. 9. Overall, the color variation of this outcrop ranges from light near the bottom of the unit to dark at the top, relating to changes in bulk composition. A full stratigraphic column of Site 4 can be seen in Appendix N.

Figure 9. This outcrop of Wildcat Creek Tuff (WCT) was designated as Site 4. Near the center of the picture, a section of light-colored, ash-like material can be seen and this material was sampled as HS-15-04f. The contact to the Wildcat Creek Tuff lies immediately above light tuffaceous layer (Fig. 5).

Above the contact, the Wildcat Creek Tuff varies from densely welded near the bottom, to partially welded at the top of the cliff.

The first sample was taken immediately above the contact the underlying tan tuffaceous unit at an elevation of 1302m. Sample HS-15-04a contains black pumice up to 2 centimeters in length. Sample 04a is highly vesicular and displays low degree of welding, and it is phenocryst poor. This can be seen in hand sample, pictured below in Fig. 10.

Figure 10. Hand sample of sample HS-15-04a shows the dark coloration, multiple colors of mafic scoria throughout the sample, suggesting compositional differences of magmas that comingled during eruption.

HS-15-04b was taken above the contact between the WCT and the underlying unit, taken at an elevation of 1305m, it is 3 meters above the contact.(see Figs. 10 and 11, below). This part of the outcrop was somewhat eroded back, allowing observation of the

contact in plane view. This section of the stratigraphic unit is highly welded and displays large, dark fiamme inside a red-to-brown matrix. Just below the contact, in the light material, HS-15-04f was sampled. This is a dacitic sample and it is much lighter than the surrounding rock.

Figure 11. Image of the contact between the Wildcat Creek Tuff and the underlying tuffaceous unit at Site 4. In this close-up picture, a high degree of welding is visible with abundant fiamme above the contact. Dark grey to black fiamme can be seen, as well as a distinct color change between the two units. The light material at the bottom of the picture was sampled as HS-15-04f, while the dark red with black pumice, above, was sampled as HS-15-04b.

Figure 12. Another view of the contact between the Wildcat Creek Tuff (darker) and the underlying tuffaceous unit (lighter) at Site 4. The contact is eroded back exposing contact in plane view. The Wildcat Creek Tuff is red-brown to black in color, while the dacitic composition beneath is light grey to white with colorful inclusions of scoria.

Moving upwards in the stratigraphic unit, sample HS-15-04c was sampled 7m above the base of the tuff. It is light grey to brown in hand sample, appearing mostly dark brown on the outcrop. It appears mostly phenocryst poor, with many colors of scoria. Few phenocrysts are visible to the naked eye. (See Figs. 13 and 14, below.)

Figure 13. Sample HS-15-04c is light grey with many different sizes and colors of scoria.

Figure 14. Sample HS-15-04c, in hand sample. Several colors of scoria are present amidst the felsic groundmass appearing as dark inclusions. The sample appears phenocryst poor.

Sample HS-15-04e was taken below the top of the outcrop, 9m above the contact. It again appears dark brown to light brown in hand sample with large brown pumice measuring up to 6cm. The matrix appears purple with no obvious phenocrysts.

Sample HS-15-04d was taken at the very top of the unit. The outcrop measures a total of 12 meters in thickness is continuous for roughly 80 meters. This sample appears black in the outcrop, and a swirl of red and black components in hand sample (Fig. 15, below). As with all other Wildcat Creek Tuff samples, it is phenocryst poor, and to the naked eye, this sample appears to be the most mafic, containing fewer crystals than any other taken from the same site.

Figure 15. Swirls of red and black mingle in this sample of the Wildcat Creek Tuff. Sample HS-15-04d is the least welded, showing the obvious contrast of mafic and felsic components. It is phenocryst poor.

Site 5

Site 5 was pre-selected and plotted on Google Earth at 43.558350°, -117.904619°. It is where both samples HS-15-05 and MS-14-06 were taken. The unit is red colored and partially welded with black pumices, reddish-brown pumice, and some small white pumices that are not fully collapsed to fiamme. This section of the Wildcat Creek Tuff is also phenocryst-poor. Outcrop thickness is roughly 18m.

Figure 16. Site 5 Wildcat Creek Tuff samples and outcrop are red. The Tuff at this site is more welded than at site 4 based on the occurrence of fiamme versus pumice. This rock is sample HS-15-05.

Site 6

Site 6 is located at 43.557389°, -117.925567°. The outcrop is red in color with abundant dark scoria scattered throughout. This site was comprised of rock that was

highly welded. A view of the outcrop can be seen below in Fig. 17. Of all the sites, the tuff appears to be the most phenocryst-rich, although phenocryst content is below 10%.

Figure 17. Site 6 from fieldwork to sample the Wildcat Creek Tuff is seen here. The rocks appear red with some dark scoriaceous inclusions.

PETROGRAPHIC ANALYSIS

Petrography was performed on the eight thin sections that were prepared from the total of twenty tuff samples collected from the Wildcat Creek Tuff outcrops. Criteria for

the selection of samples for petrographic analysis are that they cover the range of observed lithofacies and geographic area. A full table of petrographic analyses can be found in Appendix A, including phenocryst abundance, major and minor phenocryst phases, and texture. Overall the samples are phenocryst poor, containing only 1% to 5% phenocrysts, and contain an abundance of mafic scoria comingled with rhyolite. The samples range from andesite to rhyolite.

All samples contain both feldspars and pyroxenes, and the scoria present in each sample differs in color, ranging from light brown to black, red, and even green. The rhyolite varies from light grey to dark reddish-brown, and the scoria is vesiculated and commonly displays mingling textures with the rhyolites. Furthermore, welded samples indicate rhyolitic tuff material and scoria have welded together. These data indicate that scoria represent a cognate component to the rhyolites and represent more mafic magmas, likely stored below rhyolitic magmas prior to eruption. Samples will be discussed from the most mafic to the most silicic samples (see Geochemistry below).

HS-15-04c

The sample is incipiently welded with a high abundance of mafic scoria nearing 45% to 50%. Phenocryst abundance is approximately 4%. This intermediate sample is the most mafic in the entire Wildcat Creek Tuff sample set, containing just 59.7% SiO₂. Pyroxenes are the most abundant phenocryst found in sample HS-15-04c. All of the pyroxenes in this sample are clinopyroxene. Few fayalitic olivine are also found. Both clinopyroxene and fayalite minerals are associated with the felsic portion of the sample. Pyroxenes appear subhedral as seen in Figure 18, below.

Figure 18. Mineral P19 from sample HS-15-04c, shown in crossed polars with 100x magnification in an optical microscope. This is a clinopyroxene, determined by the vibrant interference colors and the two directional cleavage at 89°.

Plagioclase feldspars are euhedral and pitted, while alkali-feldspar is more fractured and appears to be embedded in felsic material, though nearby mafic material tends to intrude.

The sample is incipiently welded, which can be seen in Fig. 19, below.

Figure 19. Plagioclase feldspar F6 from sample HS-15-04c is pictured in plain light (A) and polarized light (B), and magnified 100x in an optical microscope. It has a euhedral shape, polysynthetic

twinning, obvious cleavage, and is pitted with melt inclusions. F6 is surrounded mainly by mafic material.

Figure 20. Thin section scan of HS-15-04c is shown in plain light with highlighted locations of pyroxene P19 and feldspar F6. Observable textural features include aphanitic rhyolite and intermediate scoria, strongly comingled, as well as high vesicularity indicating low degree of welding in this sample. See text for full description of the sample.

HS-15-04d

This trachyandesite sample was taken from the same outcrop as sample HS-15-04c (above). Silica content in this sample is 62.4% and is slightly higher than sample 04c, and located vertically highest in the outcrop. Scoria proportionality is roughly 65%, and this sample is the least welded. There is no true welding foliation within this sample, and it is phenocryst poor. Rare feldspar phenocrysts include rhyolitic anorthoclase and very few augite, clinopyroxene crystals associated with the felsic material within the magma.

A few acicular feldspars are seen in Figure 21, below. These are phenocrysts belonging to the ~60% SiO₂ icelandite that make up part of the mafic component of the magma system (see below, Fig. 21).

Figure 21. Plagioclase feldspar F6 from sample HS-15-04d is shown in plain light, magnified 50x in an optical microscope. It is embedded in an icelandite, appearing thin and needle-like compared to other feldspars in the sample. It is surrounded by mafic material, is euhedral in shape with cleavage. In polarized light, polysynthetic twinning is visible.

Figure 22. Plain light thin section scan of HS-15-04d shows the location of feldspar F6 (above in Figure 21). The sample shows a high proportion of scoriaceous material, the darkest, black material in this image, roughly 65%. The sample is highly vesicular, with no fiamme present, and is phenocryst-poor. A full description is in the text above.

HS-15-04e

Sample 04e is located 3m vertically below sample 04d. Though it has an incipient degree of welding, a welding compaction direction can be observed (see Fig.26).

Scoriaceous material accounts for approximately 70% of the sample. Scoria is dark and very phenocryst poor, while the rhyolitic glass in the sample is slightly lighter brown with abundant vesicles. Most of the pyroxenes in this sample are clinopyroxene associated with the rhyolite. There are a few fayalitic olivine specimens observed as a part of the rhyolite. The pyroxenes found in this sample are very fractured and subhedral in shape (see Fig. 23). Feldspar F5 is shown below (Fig. 24). It is euhedral, but broken, and inter-grown with pyroxenes which are anhedral in shape.

Figure 23. Clinopyroxene P4 from sample HS-15-04e is seen here surrounded by mafic material. It is magnified 100x and shown in plain light in this image taken by an optical microscope.

Figure 24. Fayalitic olivine, P11 from sample HS-15-04e, is seen here in the center of the photo in plain light, magnified 50x in an optical microscope. It is anhedral and fractured.

Figure 25. Plagioclase feldspar F5 from sample HS-15-04e is shown in plain light and magnified 50x in an optical microscope. It is surrounded by mafic material and contains intergrown pyroxenes P5.

Figure 26. Thin section scan of HS-15-04e is shown in plain light with feldspar F5 and pyroxenes P4, P5, and P11 noted. The minerals can be seen above in Figs. 22, 23, and 24. The sample has a very low degree of welding and contains a mixture of both mafic and felsic components. The felsic components are light to dark brown materials that are found between the very dark brown to black scoria clasts representing the mafic components. Welding compaction can be seen from the NW corner of the slide to the SE corner.

HS-15-04a

Located at the lowest point of the outcrop at Site 4, closest to the Littlefield Rhyolite, which is a slightly older unit positioned stratigraphically below the Wildcat Creek Tuff, is sample HS-15-04a. This sample contains a bulk silica composition of 63.47% SiO₂. This hand sample was selected from the bottom of the outcrop, just above a light colored, ash-like material located at site 4. Scoriaceous material is more welded, the highest degree of welding in this outcrop, though no true direction can be distinguished. Very few pyroxenes can be found in this sample. Those that have been identified are

euhedral to subhedral in shape, and are felsic-associated augite clinopyroxene as seen in Figure 27, below.

Figure 27. Euhedral, 8-sided pyroxene P5 from sample HS-15-04a as seen in plain light, magnified 100x in an optical microscope. It has cleavage in two directions, intersecting at 89° and fractures. The mineral has high relief and a green tint. It is surrounded by felsic material and is thus, associated with the felsic component of the magma.

Rare feldspar phenocrysts are also euhedral to subhedral in shape, and primarily consist of anorthoclase, an alkali-feldspar associated with the rhyolite component of the magma system. Scoria proportionality of this sample is roughly 50%, and can be seen as the darkest material in Figure 28, below.

Figure 28. Feldspar F6 from sample HS-15-04a shown magnified 50x in plain light in an optical microscope. The feldspar is relatively low relief and surrounded by rhyolite material. It is subhedral to anhedral in shape and fractured.

Figure 29. A thin section scan from sample HS-15-04a is shown in plain light. Pyroxene P5 and feldspar F6, as shown in Figures 26 and 27 above, are highlighted within the slide. The sample is the

most welded of all those acquired from Site 4 and is positioned stratigraphically lowest in this outcrop.

HS-15-05

Sample HS-15-05 was taken from 43.558350°, -117.904619°. This trachydacite sample is partially welded, and contains 25% to 30% scoria. At 66.26% SiO₂ content in the bulk composition, it is the lightest color of the intermediate samples in the Wildcat Creek Tuff set. Slight welding foliation can be discerned as the phenocrysts and fiamme run generally in the same direction. The sample contains large lithic fragments and rare phenocrysts. The phenocrysts that are found in the sample consist largely of felsic alkali-feldspar and very few mafic pyroxenes. The feldspars are slightly fractured and with intergrown apatite and oxides, as seen below in Figure 30. Pyroxenes are highly altered, but present in felsic material as clinopyroxene. An example can be seen below in Figure 31.

Figure 30. Feldspar F16 from sample HS-15-05 is seen in plain light, magnified 100x in a petrographic microscope. Inside the feldspar are needle-like minerals. These are apatite. Oxides minerals are found as inclusions as well, and the phenocryst are surrounded by a mixture of mafic and felsic material. The crystal has obvious cleavage and is subhedral to anhedral in shape. There is minimal cracking and pitting.

Figure 31. Clinopyroxene P22 from sample HS-15-05 is seen in plain light, magnified 200x in an optical microscope. The crystal is surrounded by felsic material and appears in high relief.

Figure 32. Thin section scan from sample HS-15-05 is seen in plain light. It is the most colorful and the lightest in overall color of the intermediate samples. Abundant fiamme of felsic glass, that are light grey, are seen throughout thin sections. Scoria of mafic composition is seen in light reddish-brown to dark reddish-brown. Lithic fragments are visible throughout the sample. Pyroxene P22, from Fig. 30 above, and feldspar F16, from Fig. 29 above, is noted. In hand sample, this sample is red in color, while in thin section, it appears very light brown and grey.

MS-14-03

Sample MS-14-03 was sampled from location 43.557967°, -117.905650°. It is a trachydacite with a silica content of 66.87%, and it is lightly welded with an abundance of lithic fragments. Phenocryst abundance is approximately 4%, while scoria abundance is roughly 40%. In the Wildcat Creek Tuff sample set, this is an intermediate sample containing 66.87% SiO₂. Some welding foliation can be seen in that the sample is

moderately welded. Very few phenocrysts are present, mostly notable are fiamme and scoriaceous inclusions. Plagioclase feldspars are fractured and pitted and are interspersed throughout mafic material. Few pyroxenes are present and they are mainly associated with felsic material, presenting as clinopyroxene.

Figure 33. Thin section scan of sample MS-14-03, shown in plain light. This sample shows partial welding, abundant scoriaceous inclusions, fiamme, and very few phenocrysts.

MS-14-06

MS-14-06 was taken from location 43.572850°, -117.832100°. It is a trachydacite with a modal abundance of ~5% phenocrysts. The texture is vitrophyric with 35% to 40% scoria. This sample has a moderate degree of welding, and pumices have partially collapsed to fiamme, but retained some vesicularity. There is a clear welding foliation visible. Phenocrysts mostly lack an apparent zonation. Some of the clinopyroxene

crystals are associated with the rhyolitic portion of the sample. These are anhedral to subhedral and sometimes intergrown with the feldspars, as seen in Figure 34, below.

Figure 34. Pyroxenes P17 from MS-14-06, magnified 25x in a petrographic microscope, are intergrown with alkali feldspar and surrounded by rhyolitic glass. The feldspar appears subhedral, as do the pyroxenes.

Feldspars are located in both the mafic and felsic constituents, with plagioclase associated with mafic material, seen in Figure 35, and alkali-feldspar in the rhyolite, as in Figure 36.

Figure 35. Intergrown plagioclase feldspar phenocrysts, F4, from sample MS-14-06, magnified 50x and shown in plain light in a petrographic microscope, are euhedral to subhedral and surrounded by dark, mafic material.

Figure 36. Two feldspar phenocrysts are shown. Alkali-feldspar F3, on the left, is surrounded by rhyolitic glass. It is magnified 50x and shown in plain light in a petrographic microscope. The feldspar is subhedral in shape, but pitted and partially resorbed.

Figure 37. Scan of sample MS-14-06 is characterized by trachydacitic bulk composition with 65 wt% SiO₂. It is one of the glassiest samples of Wildcat Creek Tuff in the set, allowing for the analysis of individual components within the sample for silica content. The darkest glass of the sample is the most mafic, with ~56 wt% SiO₂, while the lighter glass ranges from 59 wt% to 75 wt% SiO₂. The largest scoriaceous inclusion measures 15 mm across. All of the scoriaceous inclusions are phenocryst-poor. Glass shards in the groundmass are mostly high silica rhyolite.

MS-14-05

Rhyolite sample MS1405 was taken from location 43.571700°, -117.834200°.

This sample is a densely welded vitrophyre from the base of the outcrop with approximately 20% scoria. There are very few vesicles in this sample. There is clear welding compaction observable in thin section (Figure 38). The major minerals in this sample consist of feldspar and pyroxene with a modal abundance of 5%. Fiamme and glass shards of rhyolitic glass can be seen throughout the sample. The most abundant

mineral is alkali-feldspar, specifically anorthoclase and there are some pyroxene phenocrysts.

Figure 38. MS-14-05 thin section scan shown in plain light. A moderate degree of welding is apparent, as well as welding foliation. Some phenocrysts are present, mostly felsic-related alkali-feldspar, though few pyroxenes do exist in the sample.

GLASS COMPOSITION

Microprobe data were acquired for glass in two of the Wildcat Creek Tuff samples. Sample MS-14-05 is a rhyolite in bulk composition, and the SiO_2 content of the two analyzed areas was averaged to 75% and 74%. Sample MS-14-06 contained a mixture of rhyolitic glass and andesitic glass. Six sites were analyzed, G1 through G6 (Fig. 38 shows G1-G4). The comingled textures are evident in sample MS-14-06. (Fig. 37 in the previous sample). The EMP data confirmed that G1, the darkest in color, is the least silicic, and at 55% SiO_2 is basaltic-andesite. G2 a medium brown glass, yielded

60% SiO₂. G3, another dark, andesitic glass is 57% SiO₂. The last, G4, is the lightest glass analyzed by EMP and at 75% SiO₂ and it is therefore a rhyolite glass. The composition and complexities of the mingling textures are most obvious in this thin section, and the bulk composition reflects the mixture. It is an intermediate trachydacite with 66% SiO₂. All glass analyses are available in Appendix D, and the EMP glass is plotted in Figure 40.

Figure 39. Magnified at 25x, this plain light image from a petrographic microscope of MS-14-06 shows the comingling textures of andesitic and rhyolitic glass. One of the least welded samples in the Wildcat Creek Tuff data set, the varied glass colors show andesite (G1, the darkest at 55% SiO₂ and G3 at 57% SiO₂), dacite (G2 at 60% SiO₂), and rhyolite (G4, the lightest at 74% SiO₂).

Figure 40. Plot of all EMP analyzed glass. Analysis of glass compositions by electron microprobe for two of the Wildcat Creek Tuff samples show that there is rhyolite glass present in the samples as well as mafic glass. The mafic glass falls into two categories: basaltic andesite ranging from 55% to 56% SiO₂ (wt%) and andesite ranging from 58% to 61% SiO₂ (wt%). The silicic glass ranges from 74% SiO₂ (wt%) to 76% SiO₂ (wt%) close to the rhyolite bulk composition.

GEOCHEMISTRY OF BULK SAMPLES

The samples collected from the Wildcat Creek Tuff range from andesite to rhyolite. The most mafic rocks are trachyandesite and the most felsic are rhyolite. The silica content ranges from ~60% SiO₂ in the most mafic sample, HS-15-04e, to ~74% SiO₂ in the most rhyolitic sample, HS-15-06a. This can be seen in the Total Alkali Silica diagram of Fig. 41. Data of bulk analyses can be found in Appendices B and C.

Figure 41. Total Alkali-Silica classification diagram (LeBas, 1986) for all Wildcat Creek Tuff samples. Samples range from trachyandesite to Rhyolite straddling the alkali/subalkalic boundary. One sample with a dacitic bulk composition falls off the trend. This outlier is sample HS154F.

Figure 42 shows the normalized trace element concentrations of the Wildcat Creek Tuff samples for which ICP-MS data were acquired. Although patterns are vertically offset there is an overall great similarity confirming they are sampling a single

magma batch. All samples indicate a relative depletion at Sr, P, and Ti and all have a peak at lead and potassium. The range of Sr of all samples is from just 65 ppm Sr in sample HS-15-06a to 295 ppm in sample HS-15-04e. The lowest level is associated with the highest silica rhyolitic sample, and the highest with the most mafic.

Figure 42. Primitive mantle normalized (Sun & McDonough, 1989) incompatible trace element diagram displaying compositions of Wildcat Creek Tuff samples.

Rare earth elements were plotted for the Wildcat Creek Tuff samples (Fig. 43) to further illustrate elemental patterns of mafic and felsic components of the system using C1 chondrite normalization values (McDonough & Sun, 1995). These include the most mafic samples, HS-15-04e, with ~60% SiO₂, and HS-15-05, MS-14-03, and MS-14-06, all at ~66% SiO₂ (Fig. 43).

Figure 43. C1 chondrite normalized (McDonough & Sun, 1995) Wildcat Creek Tuff samples. All samples show a general decrease in enrichment until Er, including a negative europium anomaly. This is similar to other rhyolites from eastern Oregon. HS-15-04e is the most mafic sample in the set, showing less depletion in all elements than the more silicic samples.

Major element variation diagrams were generated to determine patterns and trends in the data. All major elements (TiO_2 , Al_2O_3 , FeO , MnO , MgO , CaO , Na_2O , K_2O , and P_2O_5) were plotted against SiO_2 . Clear negative correlations are evident in plots of FeO and TiO_2 , and P_2O_5 versus SiO_2 , seen in figures 44, 45, and 46, below. As silica increases, FeO , TiO_2 , and P_2O_5 all decrease. Included in these diagrams are also Wildcat Creek Tuff data collected by Hooper et al. (2002). The full range of major element variation diagrams can be found in Appendix J.

Figure 44. Major element variation diagram of FeO vs. SiO₂. As silica content increases, iron content decreases, moving from the most mafic samples to the most rhyolitic. The orange circles are data by Hooper et. al. (2002).

Figure 45. Major element variation diagram of TiO₂ vs. SiO₂. As silica increases Ti decreases in Ti from the most mafic to the most felsic sample. Orange circles are data by Hooper et. al. (2002).

Figure 46. Major element comparison diagram featuring P_2O_5 vs. SiO_2 . As silica increases from least to most felsic, phosphorous decreases. Orange circles are data by Hooper et. al. (2002).

Major elements were also compared to some trace elements to further determine any patterns present in the data. The most linear correlation is between strontium and silica (Sr vs. SiO_2). Seen below in Fig. 47, Sr decreases as SiO_2 increases.

Figure 47. Sr vs. SiO_2 plot featuring Sr ppm plot. As silica increases from mafic to felsic, Sr decreases. The range of Sr is from 295ppm in an andesitic sample to as low as just 65ppm in a rhyolitic sample.

Variations diagrams using trace elements were plotted for many combinations, all of which are available in Appendices K and L. Relationships were found to be especially linear in the case of Th vs. Nb.

Figure 48. Trace element comparison plot of Th vs. Nb. There is a strong positive correlation to observe, as niobium increases so does thorium. The range includes trachyandesite at 20.9 ppm Nb and 5.75 ppm Th to rhyolite at 27.01 ppm Nb, 8.61 ppm Th.

The mafic end member of the system appears to be consist into two distinct types, one at 57% SiO₂ and the other at 60% SiO₂. Fig. 49 is used to illustrate this distinction. Basaltic andesite is higher in iron content than the more intermediate andesitic end member. Mafic material that was hand picked and analyzed by XRF was found to contain only slightly higher silica than the glass analyzed by EMP (Fig. 50). If separation was perfect and no rhyolite was part of the separated material, then the silica content of these “bulk scoria” samples can be use to estimate the approximate end member composition.

Figure 49. Composition of glass of the Wildcat Creek Tuff, plotted for only mafic samples. The mafic glass falls into two clusters. Basaltic-andesite is the most mafic, ranging from 55% to 56% SiO₂, while the andesitic glass falls between 58% and 61% SiO₂. These two compositions represent the mafic end member of the magma system. Basaltic andesite ranges from 10.03 wt% FeO to 11.72 wt% FeO, while andesite falls short of that range at just 9.29 wt% to 11.01 wt% FeO*.

Figure 50. Plot of normalized mafic material, handpicked from four Wildcat Creek Tuff samples: HS-15-04a, HS-15-04c, HS-15-04d, HS-15-04e, analyzed by XRF. These samples (blue diamonds) are shown plotted against the mafic glass analyzed by EMP (red squares) from samples MS-14-05 and MS-14-06. The EMP analyzed glass falls into the basaltic-andesite to andesite category, while the

handpicked mafic material is slightly more silicic andesite. Iron content varies, becoming lower as SiO₂ content increases.

MINERAL COMPOSITION

Individual minerals were analyzed by both electron microprobe and scanning electron microscopy to aid in categorization and compositional identification. This included feldspars, pyroxenes, and occasionally Fe-Ti oxides. Glass composition of shards and pumices were analyzed by the electron microprobe. Tables of the full analyses can be found in Appendix D, and for SEM data in Appendix G, H, and I, sorted according to sample number. Feldspars fall into two major categories, including those associated with the mafic end member of the magma system, and those associated with the rhyolite. Alkali-feldspars ranging from mostly anorthoclase to sanidine belong to the felsic portion of the system and plagioclase feldspars are associated with the mafic portion of the system ranging from dacitic to andesitic. The spread can be seen below in the feldspar ternary diagram shown in Figure 51. Far fewer pyroxene minerals were found throughout the sample set, and they consist largely of clinopyroxene, those with high Fe belong to the rhyolitic portion while Mg richer are associated with mafic melt. Few fayalitic olivines were also identified in the rhyolitic samples. The pyroxene ternary diagram can be seen below in Figure 52.

Figure 51. Ternary diagram showing feldspar minerals, based on EMP data. Alkali-feldspar is associated with the silica-rich rhyolitic end member of the magma system, where plagioclase is associated with the silica-poor trachyandesite end member. Far more phenocrysts occur in the rhyolitic portion of the tuff.

Figure 52. Ternary diagram of pyroxene minerals, based on EMP data. This diagram shows all analyzed pyroxenes for all samples within the set. Fe-rich clinopyroxene is associated with the rhyolitic end member. Fayalitic olivine crystals are associated with the silicic component of the magma system.

ISOTOPIC AGE DATING

$^{40}\text{Ar}/^{39}\text{Ar}$ age dating was performed on sample MS-14-05 of the Wildcat Creek Tuff resulting in a single-crystal, anorthoclase $^{40}\text{Ar}/^{39}\text{Ar}$ age date of 15.49 ± 0.02 Ma. The results are listed in Appendix M, and shown below in Figure 53. Isotopic ratios of Ar are used to constrain the final age date.

Figure 53. Age in millions of years for rhyolite sample MS1405 from the Wildcat Creek Tuff. This date of ~15.5 Ma was acquired by $^{40}\text{Ar}/^{39}\text{Ar}$ age dating. The curve at the bottom of this diagram indicates that the most probable age for this sample is 15.49 +/- 0.02 Ma, (McIntosh, 2016).

DISCUSSION

This discussion first considers the magmatic components of the Wildcat Creek Tuff (WCT), and then how compositionally intermediate WCT compositions can be explained by a two-component mixing model, and finally evaluating the results of this study in light of existing petrogenetic models of tuffs with similar mafic inclusions.

MAGMATIC COMPONENTS IN THE WILDCAT CREEK TUFF

Bulk composition of the Wildcat Creek Tuff range nearly continuously from 59 to 74 wt.% SiO₂. However, results of this study have shown that compositions of actual magmatic components are much more restricted than the range of bulk compositions would indicate. Based on glass analyses combined with mineral data indicate that magmatic components of the Wildcat Creek Tuff consist of rhyolite and andesite. Glass appearing next to select phenocrysts were analyzed to associate which mineral crystallized from which magma and mutual mineral inclusions were analyzed to cross correlate mineral compositions. For example, in sample MS-14-06 there are pyroxenes surrounded by rhyolite, andesite and basaltic andesite. Fe-rich augite, P3, (below, Fig. 55) is included in an anorthoclase alkali-feldspar phenocryst. Electron microprobe glass analyses for this sample are listed in Figures 56a and 56b, below, and the mineral analyses by both EMP and SEM can be found in Appendix G, H, and I. Pyroxene P15 from the same sample is seen below in Fig. 56. It is a fayalitic olivine enclosed within a mafic fiamme. The glass immediately surrounding the crystal however, is light colored rhyolitic glass.

The rhyolite of the Wildcat Creek Tuff contains about 74% SiO₂ but no more than 5% phenocrysts. This rhyolite crystallized anorthoclase feldspar, Fe-rich augite, and Fe-Ti oxide and $\pm$ fayalitic olivine. The abundant scoria inclusions record the andesite. Based on glass analyses, the andesite, in fact, consist of a minimum of two magmatic components. One component is basaltic-andesite with approximately 56% SiO₂ and an andesitic component with roughly 60% SiO₂. Typical mineral phases for intermediate magmas include plagioclase feldspar, pyroxenes, hornblende, and oxides. The Wildcat Creek Tuff basaltic andesite and andesite are phenocryst-poor much like the rhyolitic end-member, containing no more than 1-2% phenocrysts dominated by clinopyroxene, plagioclase feldspar, and minor oxides.

Plagioclase feldspar ranges in composition from An₇₀ to An₂₀ with a distinct gap from An₆₀ to $\sim$ An₄₀. It appears that high An plagioclase (An₆₀₋₇₀) crystallized from the basaltic andesite and lower An plagioclase (An₂₀₋₄₀) from the andesite. Both magmas crystallized augite. Crystals yielding slightly higher En and Wo components may have crystallized from basaltic andesite and those with higher Fs, from andesite. The small number of crystals to analyze makes this interpretation tentative.

Rhyolite glass analyses by EMP indicate a narrow range from 74 to 76 wt% SiO₂. This indicates that comingling of mafic magmas of the Wildcat Creek during eruption has lowered bulk samples to compositions of 70-71 wt.%. A comparison of the XRF data for rhyolite samples and the EMP data for rhyolitic glass can be seen below in Fig. 54.

Figure 54. Comparison plot of rhyolitic samples of bulk composition HS-15-01b, HS-15-06a, MS-13-07, and MS-14-05), as analyzed by XRF (blue diamonds) and rhyolitic glass analyses by EMP (red squares). The EMP analyses provide a range in silica content from 73% to 76%, while the XRF bulk analyses range from ~71% to 73% SiO₂ wt%. The bulk samples are compositionally higher in FeO wt%, but the full range is relatively small, only 1.77% to 4.33% FeO*.

Visually, the rhyolite is lighter in color and contains more phenocrysts than the mafic components of each sample. Rhyolitic glass is light brown under the microscope in most samples. The most abundant phenocryst is anorthoclase alkali-feldspar although some sanidine crystals occur as well.

The mafic components of the magmatic system are darker in color than the rhyolite, ranging from middle to dark brown to nearly opaque under the microscope. Far fewer phenocrysts belong to basaltic andesite and andesite, but those present include clinopyroxene and plagioclase feldspar.

Figure 55. Pyroxenes P3 from sample MS-14-06 are intergrown with a large resorbed anorthoclase alkali-feldspar. The pyroxenes are subhedral and fractured Fe-augite. Both are associated with the rhyolitic magma. The image is taken in plain light from a petrographic microscope and magnified 100x.

Figure 56. Pyroxene P15 from sample MS-14-06 is seen in the middle of a mafic fiamme. Dark, mafic material surrounds the subhedral to euhedral phenocryst, but the lighter, rhyolitic glass immediately surrounds the pyroxene. The image is taken in a petrographic microscope, in plain light, and magnified 100x.

A

Sample Glass#	MS-14-05 1-1	MS-14-05 1-2	MS-14-05 1-3	MS-14-05 2-1	MS-14-05 2-2
Glass Type	Rhyolite	Rhyolite	Rhyolite	Rhyolite	Rhyolite
SiO ₂	74.98	74.55	75.93	74.32	73.95
Al ₂ O ₃	13.20	13.00	13.29	13.44	13.17
FeO	2.49	2.58	1.77	2.50	3.44
MgO	0.02	0.04	0.02	0.07	0.06
CaO	0.05	0.10	0.07	0.75	0.14
Na ₂ O	2.60	3.18	2.32	2.47	3.16
K ₂ O	6.58	6.47	6.53	6.35	5.99
BaO	0.08	0.09	0.09	0.09	0.09
Total	100.00	100.00	100.00	100.00	100.00

Sample Glass#	MS-14-05 2-3	MS-14-06 5-1	MS-14-06 5-2	MS-14-06 6-1	MS-14-06 6-2
Glass Type	Rhyolite	Andesite	Andesite	Rhyolite	Rhyolite
SiO ₂	75.21	60.21	59.56	78.25	75.12
Al ₂ O ₃	13.17	15.15	14.83	13.67	13.88
FeO	2.19	10.38	11.01	2.71	2.78
MgO	0.03	3.35	3.54	0.08	0.10
CaO	0.14	6.63	6.50	0.40	0.46
Na ₂ O	2.82	1.62	2.03	3.66	3.56
K ₂ O	6.35	2.51	2.41	4.09	4.00
BaO	0.09	0.13	0.12	0.11	0.10
Total	100.00	100.00	100.00	102.97	100.00

B

Sample Glass#	MS-14-06 1-1	MS-14-06 1-2	MS-14-06 2-1	MS-14-06 2-2	MS-14-06 3-1
Glass Type	Basaltic Andesite	Basaltic Andesite	Andesite	Andesite	Andesite
SiO ₂	56.47	55.64	60.10	61.24	58.16
TiO ₂	2.36	2.23	1.78	1.84	2.21
Al ₂ O ₃	14.28	14.13	14.12	14.62	14.39
FeO	10.30	10.91	9.47	9.29	10.96
MnO	0.22	0.22	0.29	0.20	0.19
MgO	3.99	3.91	3.10	2.75	3.50
CaO	7.85	8.00	6.24	5.39	5.86
Na ₂ O	2.19	2.62	2.01	1.88	2.06
K ₂ O	2.28	2.25	2.86	2.75	2.68
Cr ₂ O ₃	0.00	0.04	0.01	0.01	0.00
ZnO	0.07	0.05	0.01	0.02	0.00
Total	100.00	100.00	100.00	100.00	100.00

Sample Glass#	MS-14-06 3-2	MS-14-06 4-1	MS-14-06 4-2
Glass Type	Andesite	Rhyolite	Rhyolite
SiO ₂	56.29	75.12	75.41
TiO ₂	2.25	0.30	0.25
Al ₂ O ₃	14.04	13.28	13.41
FeO	11.72	2.65	2.74
MnO	0.27	0.12	0.16
MgO	4.09	0.09	0.07
CaO	7.20	0.82	0.67
Na ₂ O	1.82	2.90	3.01
K ₂ O	2.28	4.70	4.24
Cr ₂ O ₃	0.03	0.00	0.00
ZnO	0.00	0.02	0.05
Total	100.00	100.00	100.00

Figures 57a and 57b. Tables of electron microprobe glass analyses for samples MS-14-05 and MS-14-06. Most glass analyzed falls into the rhyolite category of 74-75% SiO₂, but some intermediate glass is andesitic at 60% SiO₂, and basaltic andesite at 56% SiO₂. FeO is higher in the intermediate andesitic glass and lower in silicic glass.

EMP glass analyses were plotted to determine the extent of the differences (Fig. X) of the rhyolitic and andesitic end members of the magmatic system. Figure 58 shows the averaged XRF bulk data for Hooper's Wildcat Creek Tuff rhyolitic sample set (Hooper et. al., 2002) along with the EMP glass values of the samples used for this study. The table of these values is available in Appendix D.

Figure 58. Averaged glass analyses by EMP and bulk analyses by XRF (Hooper et. al., 2002). Hooper's samples are all rhyolitic in bulk composition, while samples of the Wildcat Creek Tuff of this study falls between basaltic-andesite and rhyolite.

MAGMA MIXING

All magmatic components identified above were distinct magmas in the subsurface before eruption. During eruption, these magmas co-mingled to produce bulk tuff samples with variable compositions of dacite to low-silica rhyolite and spanning the compositional range between the rhyolite to andesite magmatic components. We can use mixing calculations to explore if bulk compositions could indeed be explained by mixing of the identified components, or whether additional components need to be considered. Given the linear array between the 60% and 56% SiO₂ component (see Figs. 57 and 58, above, for glass compositions), we can simplify the mixing model from a three-component to a two-component magma system. This is desirable as it simplifies the calculations, and because we have only major elemental compositions for each of the two mafic components, but we lack the full suite of trace elements.

For modeling mixtures between rhyolite and andesite, I used a standard mixing equation (equation 1):

$$m = Ax + B(1 - x)$$

“A” is the concentration of one element of mafic (andesite) end member, “B” is concentration of the element of the high silica (rhyolite) end member, “x” is the mixing proportion, and “m” is the concentration of the element in the resulting mixture. The mixing calculations were completed using two representative end member samples, the most silicic and the most intermediate. These are rhyolite HS-15-06a (73.93% SiO₂) and basaltic-andesite HS-15-04e (60.28% SiO₂). All samples in the WCT suite fall within the

range of these two silica values, thus the two samples are an accurate representation of the extreme end members of the magmatic system. Figure 59 displays results for a 50% mixture along with two compositionally intermediate WCT dacites.

Figure 59. This mantle normalized (Sun & McDonough, 1989) spider diagram shows trace element compositions for the sample with the highest SiO₂ content, rhyolite HS-15-06a at ~74%, the sample with a very low SiO₂ content, trachyandesite HS-15-04e at ~60%, and two trachydacite samples, MS-14-06 and HS-15-05, both at ~66% SiO₂. The green line shows a 50% mixture of the two end members of this system. All samples dip at Ti and Sr, peaking at Pb. HS-15-06a shows a P anomaly, dipping while the other samples all increase, and MS-14-06 shows a slight La anomaly, dipping further than the rest of the samples.

To further evaluate that mixing of these two end members yields results consistent with compositional data of all samples, I devised a two-step scenario. In step 1, the silica

content of a sample was used to derive the proportion of mixing that produces exactly this silica value using the following rearranged mixing equation (equation 2):

$$x = \frac{m - B}{A - B}$$

where “A” is the mafic end member, “B” is the silicic end member, “m” is the concentration of the element in the mixture, and “x” is the percent mixing. In the second step, this mixing proportion was used to calculate the resulting mixture for all trace elements shown in Figure 60. The calculated trace element concentration was then compared to those of the natural sample. The table of all values for these calculations can be found in Appendix C. Using the two end members of the system (HS-15-06a, rhyolite; HS-15-04c, basaltic andesite) as explained above, $m \approx 46\%$. That percentage was then applied to the end members and normalized according to primitive mantle values (Sun & McDonough, 1989). These calculated trace element values were then plotted as seen below in Figure 60, the theoretical mixture is extremely close in composition to the actual dacitic sample, HS-15-05.

A second calculation was completed using samples MS-14-05 as the rhyolitic end member, and HS-15-04e as the basaltic andesite. The comparison was again made to sample HS-15-05 and the results are shown in Figure 61.

Figure 60. Plot of trace elements, normalized with primitive mantle values (Sun & McDonough, 1989). In blue (circles) you see the calculated trace elements of the theoretical mixture, combining rhyolite HS-15-06a (bulk composition 74% SiO₂) with trachyandesite HS-15-04c (bulk composition 59% SiO₂). The values are very close to those of actual sample HS-15-05, a trachydacite that falls in the middle of the SiO₂ range of Wildcat Creek Tuff samples at 66%. Both plots dip at Nb, Ta, Sr, and Ti, and peak at Pb. Minor differences occur between Nd and Eu; the theoretical mixture is more enriched in these elements than the observed sample.

Figure 61. Plot of trace elements, normalized with primitive mantle values (Sun & McDonough, 1989). In blue (circles) you see the calculated trace elements of the theoretical mixture, combining rhyolite MS-14-05 (bulk composition 71% SiO₂) with trachyandesite HS-15-04e (bulk composition 60% SiO₂). The values are very close to those of actual sample, again trachyandesite HS-15-05 with bulk composition 66%. Both plots again dip at Nb, Ta, Sr, and Ti, and peak at Pb. Minor differences occur between Nd and Eu; the theoretical mixture is more enriched in these elements than the observed sample. In this example, the theoretical mixture is even closer to the natural, dacitic sample.

Inclusions as Evidence for Magma Mixing

When compared to the Rattlesnake Tuff of eastern Oregon, the andesites of the Wildcat Creek Tuff show a general trend of decreasing from La to Lu, with a slight negative Eu anomaly (Fig. 62, below). The cumulate model of the Rattlesnake Tuff shows a slight depletion from La to Ce, but a large positive Eu anomaly, and again, a

positive trend from Yb to Lu. Although the Eu depletion in the WCT is small, it indicates a mixing of magmas, rather than being a crystal cumulate.

Figure 62. C1 chondrite normalized (Sun & McDonough, 1989) REE plot comparing Wildcat Creek Tuff andesite sample HS-15-04e to Rattlesnake Creek Tuff crystal fractionation model E to D (Streck & Grunder, 1997). The Rattlesnake Tuff model presents a crystal cumulate, while the Wildcat Creek Tuff samples do not follow the same patterns, presenting as a binary mixed magma system. Pr to Nd and Gd to Tm are interpolated for the RST cumulate model.

Wildcat Creek Tuff in the Context of Nearby Units

There is some lithological and compositional resemblance between the Wildcat Creek Tuff and the Tuff of Buchanan east of the town of Buchanan, OR roughly 50 km west of the main WCT outcrop area. Data from Large (2016) indicate that the two units share similarities in concentrations of trace elements (Fig. 63, below). The estimated age of the Tuff of Buchanan is 15.9 Ma (Large, 2016) while the Wildcat Creek Tuff has an age of 15.5 Ma (this study). Large's data of the Buchanan rhyolites closely follows data collected for the Wildcat Creek Tuff. One sample of the Buchanan Tuff was included

with the Wildcat Creek Tuff set. This is MS-13-07. The rhyolitic sample falls well within the Wildcat Creek Tuff trends, based on major elements and many trace elements, but falls off the trend in some elements, notably Nb, Zr, and Th. This suggests that, although similar, the tuff of Buchanan is a distinct unit.

The Littlefield Rhyolite (LFR) underlies the Wildcat Creek Tuff. They outcrop together near 43.572850°, -117.832100°, in the northeast corner of the WCT unit, as mapped by Ferns for the Vale Quadrangle map (Ferns, 1993). Sample MS-14-06 was collected at this site, and it is one of the trachydacite samples. Single crystal $^{40}\text{Ar}/^{39}\text{Ar}$ ages place the LFR at 16.05 to 16.20 Ma (Webb, 2017). Although rhyolites of the WCT are slightly younger, they may have evolved from residual magmas of the Littlefield Rhyolite.

Figure 63. Multi-element diagram of Buchanan rhyolite samples (Large, 2016) overlain on Wildcat Creek Tuff samples (grayed). Concentrations normalized to primitive mantle values of Sun and McDonough (1989).

STRATIFICATION OF THE MAGMA RESERVOIR

The formation of dacitic magma can occur by partial melting, fractional crystallization, magma mixing, or magma assimilation. In the case of the Wildcat Creek Tuff, it is likely that magma mixing occurred, due to the presence of mingling textures throughout the unit. The mafic inclusions in the Wildcat Creek Tuff are a window into the interaction of basaltic magmas with rhyolites where basalt serves as heat source in a bimodal system. Large tuffs with similar mafic inclusions are found in other areas, such as the Ammonia Tanks Tuff of Southwest Nevada (Deering et. al., 2011), the Carpenter Ridge Tuff of Colorado (Bachman et. al., 2014), and the Rattlesnake Tuff of Eastern Oregon (Streck & Grunder, 1999).

The crystal mush method is proposed in the case of the Ammonia Tanks Tuff. The eruption created a large ignimbrite, roughly 900 km^3 , from a shallow, thermally and chemically zoned reservoir. The mixture of the two magmas is due to in-situ differentiation driven by crystal liquid separation (Deering et. al., 2011). The most silicic portion of the magma (rhyolite) rises to the top of the reservoir, leaving behind a crystal mush at 50% or greater crystallinity at the bottom (Deering et. al., 2011). After remelting the crustal mush with an overall dacitic composition, this magma and the differentiated magma erupted jointly, accounting for the chemical zonation and the mixture of rhyolite with a hotter, more mafic recharge magma (Deering et. al., 2011). The heating and the late recharge partially melted the crystals and triggered the eruption. Though this model

partially fits this study, the Wildcat Creek Tuff samples contain a negative Eu anomaly that would not be present in a crystal cumulate.

Another large ignimbrite, the Carpenter Ridge Tuff of Colorado is strongly zoned. The lower zone is a phenocryst-poor rhyolite, and the upper zone is a more crystal-rich, less silicic, trachydacite (Bachman et. al., 2014). Variations in the major and trace elements imply in-situ differentiation due to interstitial melt extraction from the upper zone of the magma chamber (Bachman et. al., 2014). Inclusions of trachydacite are believed to be the remobilized crystal cumulate. Mafic clasts and high aluminum amphiboles points to a late recharge event (Bachman et. al., 2014). The mafic material mixed with the crystal cumulate and thermally remobilized the silicic crystal cumulate in the upper zone, creating a gradient in the crystal cumulate and masking the in-situ differentiation (Bachman et. al., 2014). The Carpenter Ridge Tuff provides information about in-situ crystal liquid separation and zoned magma chambers containing crystal rich lower zones and liquid, eruptible, upper zones. This is thought to be common in upper-crustal magma reservoirs, though may not account fully for the exceptional mixture of mafic material in the Wildcat Creek Tuff.

The Rattlesnake Tuff of eastern Oregon is known for mafic inclusions, providing insight into mafic processes beneath large, silicic magma chambers. Inclusions contain both rhyolitic and basaltic phenocrysts, supporting a mixing model of genesis for the unit (Streck & Grunder, 1999). The low-density rhyolite trapped the hot, mafic magma below, causing fractionation along with the recharge of hot, mafic magma. This entered incompatible elements into the primitive magma, while the mafic root zone thermally maintained the rhyolite and promoted zonation and differentiation (Streck & Grunder,

1999). The authors envisioned a zoned magma chamber, silicic at the top and mafic at depth, similar to the Wildcat Creek Tuff. Both tuff units contain mafic inclusions that are trace element enriched due to mafic fractionation. In both units, the basaltic andesite mixed with rhyolite to create exceptional mingling textures and trace element analyses indicate mixing rather than a crystal cumulate.

The Wildcat Creek Tuff contains rhyolite, andesite, and basaltic andesite, comingled during eruption to create an intermediate-to-felsic unit. The eruption created a tuff that is partially-to-densely welded at the bottom and non-welded at the top, with the most rhyolitic samples appearing at the bottom of the unit. Rhyolite erupted first, having been at the top of the stratified reservoir. This created the lowest part of the unit, containing mafic, scoriaceous inclusions of andesite. As more magma continued to erupt, it became less silicic. The lower magma reservoir contained progressively hotter, andesitic magma, leading to phenocryst-poor, andesitic lava emplaced above the rhyolite, containing increasingly more mafic material. This is consistent with progressively deeper withdrawal, implying that the mafic magmas resided beneath the rhyolites.

The rhyolitic component of this unit is phenocryst-poor, but contains alkali-feldspar and glass at 74-75 wt% SiO₂. Few plagioclase feldspar phenocrysts are found in the andesitic component, along with fewer pyroxenes. Clinopyroxene is the primary phenocryst associated with the mafic portion of the magma. A few fayalitic olivine crystals are observed in the rhyolite. The presence of these crystals, along with multiple glass analyses, implies that two mafic end members are present within the system. These include an andesite with a bulk composition of 60% SiO₂, and a basaltic-andesite with a bulk composition of 56% SiO₂. The prevalent mafic component, andesite at 60 wt% SiO₂,

contains lower TiO_2 and CaO , lower FeO , and comparable Al_2O_3 , MgO , and alkalis.

Together, these mafic magmas range from dacite to basaltic-andesite components due to mixing.

The models of the Ammonia Tanks Tuff and the Carpenter Ridge Tuff imply that the dacitic components of the magmas were crystal mush, remelted after the extraction of rhyolitic magma. These models do not explain the observed features of the Wildcat Creek Tuff due to small Eu anomalies and normal concentrations of Ba and Sr. These features, along with the aphyric texture of the Wildcat Creek Tuff, suggest that magma mixing of rhyolite and a basaltic-andesite created this unit.

CONCLUSION

The Wildcat Creek Tuff is a thin, but voluminous ignimbrite, formed in Malheur County, eastern Oregon. It is related to the silicic and mafic volcanism of the Columbia River Province, and this particular unit is due to the mixing and co-eruption of rhyolite with andesite. The andesite of the WCT unit is variable, and divided into two magmas, including basaltic andesite at 57% SiO₂ and andesite at 60% SiO₂. Glass analyses confirm the range of both intermediate and rhyolitic glass to be close in silica content to the bulk composition of each end member. The mixture of the two magma types, despite the variable mafic end member, can be considered a binary system. The andesite components of the system all contain patterns suggestive of magma mixing, such as a negative Eu anomaly and troughs in Sr and Ti. The most abundant phenocryst phase in a cumulate is feldspar, and when melted, would lead to enrichment of Eu and Sr that have preferentially partitioned into feldspar. The Wildcat Creek Tuff is depleted in these trace elements, arguing for magma mixing, evolved from a basaltic parent, rather than a remelted crystal cumulate which would present a positive Eu anomaly. Fractional crystallization, in-situ differentiation, and the remelting of a crystal cumulate are often the factors in the creation of similar rhyolite tuffs containing mafic inclusions, but these scenarios are unlikely in the formation of this unit. It is likely that extensive magma mixing of hot, andesitic recharge with the rhyolitic magma created the eruption of the Wildcat Creek Tuff as we see it today. Previously dated by only stratigraphic constraints, the here obtained single-crystal, anorthoclase ⁴⁰Ar/³⁹Ar radiometric age date of

15.49±0.02 Ma for the Wildcat Creek Tuff provides now a precise absolute age for this tuff .

REFERENCES

- Bachman, O., Deering, C. D., Lipman, P. W., & Plummer, C. (2014). Building zoned ignimbrites by recycling silicic cumulates: insight from the 1,000 km³ Carpenter Ridge Tuff, CO. *Contributions to Mineralogy and Petrology*, 167.
- Deering, C. D., Bachman, O., & Vogel, T. A. (2011). The Ammonia Tanks Tuff: Erupting a melt-rich rhyolite cap and its remobilized crystal cumulate. *Earth and Planetary Science Letters*.
- ESRI. (2014, April 15). ArcGIS 10.2.2.
- Ferns, M. L. (1993). Geologic Map of the Vale 30x60 Quadrangle, Malheur County, Oregon, and Owyhee County, Idaho. Oregon Department of Geology and Mineral Industries.
- Google Earth. (2014). Retrieved from Google Earth: <http://www.google.com/earth/>
- Hildreth, W., & Wilson, C. (2007). Compositional Zoning of the Bishop Tuff. *Journal of Petrology*, 48, 951-999.
- Hooper, P., Binger, G., & Lees, K.R. (2002). Ages of the Steens and Columbia River flood basalts and their relationship to extension-related calc-alkalic volcanism in eastern Oregon. *Geological Society of America Bulletin* (114), 43-50.
- Large, A. M. (2016). *Silicic Volcanism at the Northern and Western Extent of the Columbia River Basalt Rhyolite Flare-up: Rhyolites of the Buchanan Volcanic Complex and Dooley Mountain Volcanic Complex, Oregon*. Portland State University, Department of Geology.
- LeBas, M. L. (1986). A chemical classification of volcanic-rocks based on the total alkali silica diagram. *Journal of Petrology*, 27 (3), 745-750.
- McDonough, W., & Sun, S. (1995). The composition of the Earth. *Chemical Geology*, 120, 223-253.
- McDougall, I., & Harrison, T. (1999). *Geochronology and Thermochronology by the ⁴⁰Ar/³⁹Ar Method* (2nd ed.). Oxford: Oxford University Press.
- Stimac, J. (1988). Geology of the Stockade Mountain 15' Quadrangle, Malheur and Harney Counties, Oregon. Fort Hayes State University.
- Streck, M. J., & Grunder, A. L. (1997). Compositional Gradients and Gaps in High-silica Rhyolites of the Rattlesnake Tuff, Oregon. *Journal of Petrology*, 38 (1), 133-163.

Streck, M. J., & Grunder, A. L. (1999). Enrichment of basalt and mixing of dacite in the root zone of a large rhyolite chamber: inclusions and pumices from the Rattlesnake Tuff, Oregon. *Contributions to Mineralogy and Petrology* , 136, 193-212.

Sun, S., & McDonough, W. (1989). Chemical and isotopic systematics of oceanic basalts; implications for mantle composition and processes. 42 , 313-345. London: Geological Society.

Webb, B. M. (2017). *The Littlefield Rhyolite, Eastern Oregon: Distinct Flow Units and Their Constrains on Age and Storage Sites of Grande Ronde Basalt Magmas*. Portland State University, Department of Geology.

APPENDIX A: Field Site Locations

Table 1. GPS coordinates for each sample selected during fieldwork. Sample MS-13-07 is not included because GPS coordinates are not available. Stop number and satellite variations in GPS are not included for all MS- samples because these are not available.

Stop	Sample Number	Zone	Easting	Northing	GPS Variation (+/-)	Lat	Long	Decimal Degrees	
1a	HS-15-01a	11T	425572	4823081	2m	43° 33.418'N 117° 55.290'W	43.556972°	-117.921497°	
1b	HS-15-01b	11T	425627	4823012	2m	43° 33.381'N 117° 55.248'W	43.556356°	-117.920808°	
1c	HS-15-01c	11T	425639	4823006	2m	43° 33.378'N 117° 55.240'W	43.556303°	-117.920658°	
1d	HS-15-01d	11T	425646	4823002	2m	43° 33.376'N 117° 55.234'W	43.555950°	-117.920875°	
1e	HS-15-01e	11T	425621	4822967	2m	43° 33.357'N 117° 55.252'W	43.555950°	-117.920875°	
2a	HS-15-02a	11T	427218	4822511	2m	43° 33.121'N 117° 53.914'W	43.552022°	-117.898569°	
2b	HS-15-02b	11T	427253	4822964	2m	43° 33.365'N 117° 54.040'W	43.556083°	-117.900672°	
3	HS-15-03a	11T	435258	4816522	3m	43° 29.889'N 117° 48.294'W	43.498144°	-117.804903°	
4a	HS-15-04a	11T	433568	4821127	9m	43° 32.408'N 117° 49.336'W	43.540133°	-117.822269°	
4b	HS-15-04b	11T	433570	4821160	3m	43° 32.426'N 117° 49.335'W	43.540431°	-117.822250°	
4c	HS-15-04c	11T	433558	4821158	3m	43° 32.425'N 117° 49.344'W	43.540411°	-117.822397°	
4d	HS-15-04d	11T	433538	4821170	3m	43° 32.431'N 117° 49.359'W	43.540519°	-117.822647°	
4e	HS-15-04e	11T	433551	4821164	3m	43° 32.428'N 117° 49.349'W	43.540467°	-117.822486°	
4f	HS-15-04f	11T	433571	4821130	3m	43° 32.410'N 117° 49.334'W	43.540161°	-117.822233°	
5	HS-15-05	11T	426936	4823219	3m	43° 33.501'N 117° 54.278'W	43.558350°	-117.904619°	
6	HS-15-06a	11T	425243	4823131	2m	43° 33.443'N 117° 55.535'W	43.557389°	-117.925567°	
6	HS-15-06b	11T	425243	4823197	2m	43° 33.479'N 117° 55.535'W	43.557983°	-117.925586°	
	MS-14-03	11T	426853	4823177		43° 33.478'N 117° 54.339'W	43.557967°	-117.905650°	
	MS-14-05	11T	432639	4824642		43° 34.302'N 117° 50.052'W	43.571700°	-117.834200°	
	MS-14-06	11T	432810	4824768		43° 34.371'N 117° 49.926'W	43.572850°	-117.832100°	

APPENDIX B: Petrography of Thin Sections

Sample	Total Phenocryst Abundance (%)	Major Phases	Phase Abundance (%)	Phase Characteristics	Scoria Abundance (%)	General Texture	Degree of Welding
HS-15-04a	2%	Alkali Feldspar	~1	Euhedral, cracked	50	Aphyric, frothy, vesicular	Partial
		Plagioclase	<1	Euhedral, acicular			
		Clinopyroxene	<1	Subhedral, cracked			
HS-15-04c	4%	Clinopyroxene	2	Anhedral, cracked	45-50	Aphyric, vesicular	Incipient
		Plagioclase Alkali	1	Euhedral, pitted			
		Feldspar Olivine	1	Anhedral, cracked			
HS-15-04d	1%	Alkali Feldspar	<1	Anhedral	65	Aphyric, vesicular	Incipient
		Plagioclase	<1	Subhedral, cracked			
		Clinopyroxene	<1	Euhedral			
HS-15-04e	1%	Clinopyroxene	<1	Subhedral, cracked	70%	Aphyric, vesicular	Incipient
		Plagioclase	<1	Euhedral, cracked			
		Alkali Feldspar	<1	Euhedral/Subhedral			
HS-15-05	5%	Alkali Feldspar	<1	Subhedral, cracked	30%	Vesicular	Partial
		Plagioclase	4	Subhedral			
		Clinopyroxene	1	Anhedral			
MS-14-03	4%	Plagioclase	3	Subhedral, cracked	40%	Aphyric, frothy, vesicular	Partial
		Clinopyroxene	1	Anhedral			
		Olivine	<1	Anhedral			
MS-14-05	5%	Plagioclase	2	Euhedral, cracked	20%	Glassy	Dense
		Alkali Feldspar	1	Euhedral, cracked			
		Clinopyroxene	1	Anhedral			
MS-14-06	5%	Alkali Feldspar	1	Anhedral	40%	Perlitic, vesicular	Incipient
		Plagioclase	4	Subhedral, pitted			
		Clinopyroxene	1	Anhedral, cracked			

APPENDIX C: Bulk Geochemistry, XRF

Data Set		Sales Wildcat Creek Tuff						
Sample ID	HS-15-01b	HS-15-04a	HS-15-04c	HS-15-04d	HS-15-04e	HS-15-04f	HS-15-05	HS-15-06a
Unit	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT
Unnormalized Major Elements (Weight %):								
SiO ₂	69.18	61.20	56.97	60.76	57.67	57.87	63.25	72.05
TiO ₂	0.56	1.30	1.47	1.40	1.46	0.38	0.81	0.31
Al ₂ O ₃	13.09	13.31	16.07	13.81	15.42	16.61	12.61	12.50
FeO*	4.20	7.27	8.32	7.68	8.20	4.64	5.35	3.01
MnO	0.19	0.19	0.23	0.21	0.23	0.13	0.16	0.16
MgO	0.34	1.75	1.62	1.85	1.60	0.79	1.45	0.17
CaO	0.68	3.85	3.97	4.15	3.96	0.93	4.14	0.21
Na ₂ O	4.74	4.19	4.31	4.35	4.36	1.61	4.01	4.75
K ₂ O	3.96	2.89	1.85	2.64	2.15	3.20	3.35	4.24
P ₂ O ₅	0.14	0.46	0.59	0.53	0.63	0.04	0.32	0.05
Sum	97.09	96.42	95.40	97.37	95.68	86.20	95.46	97.45
LOI %	1.91	1.85	3.92	1.83	2.98	12.38	3.66	1.57
XRF Data								
Normalized Major Elements (Weight %):								
SiO ₂	71.25	63.47	59.71	62.40	60.28	67.14	66.26	73.93
TiO ₂	0.57	1.35	1.54	1.44	1.53	0.44	0.85	0.32
Al ₂ O ₃	13.49	13.81	16.84	14.18	16.12	19.27	13.21	12.83
FeO*	4.33	7.54	8.73	7.89	8.57	5.38	5.61	3.09
MnO	0.19	0.20	0.24	0.21	0.24	0.15	0.17	0.16
MgO	0.35	1.82	1.70	1.90	1.67	0.91	1.52	0.18
CaO	0.70	3.99	4.16	4.26	4.14	1.08	4.34	0.22
Na ₂ O	4.89	4.34	4.51	4.47	4.56	1.87	4.20	4.87
K ₂ O	4.08	3.00	1.94	2.71	2.25	3.71	3.51	4.35
P ₂ O ₅	0.15	0.48	0.62	0.54	0.65	0.04	0.34	0.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Data Set		Sales Wildcat Creek Tuff						
Sample ID	HS-15-01b	HS-15-04a	HS-15-04c	HS-15-04d	HS-15-04e	HS-15-04f	HS-15-05	HS-15-06a
Unit	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT
XRF Data		Unnormalized Trace Elements (ppm):						
Ni	8.06	9.85	12.04	12.74	11.84	3.68	13.33	7.46
Cr	10.55	9.45	15.12	12.44	12.74	1.19	10.65	5.37
Sc	10.45	20.60	24.18	22.69	23.58	8.46	13.93	6.77
V	45.37	138.50	147.56	137.01	141.39	17.31	77.91	22.29
Ba	1298.67	1012.21	1226.44	975.60	1049.13	523.47	1373.30	1870.30
Rb	89.45	55.22	25.87	51.84	34.43	59.70	70.55	95.12
Sr	100.79	257.61	292.83	264.07	281.49	56.22	184.77	63.08
Zr	427.03	316.43	359.56	316.13	353.20	628.32	358.35	450.86
Y	79.80	58.80	62.19	59.90	68.85	91.14	65.47	59.10
Nb	25.97	21.29	21.49	21.39	23.08	39.00	23.18	27.86
Ga	21.39	20.80	23.58	21.19	23.28	28.66	19.20	21.19
Cu	11.84	21.79	23.58	24.38	24.97	7.36	19.40	9.25
Zn	125.47	134.82	146.76	138.70	151.74	174.82	125.07	118.01
Pb	14.43	11.54	13.43	11.54	12.94	22.39	15.02	13.93
La	60.20	38.81	43.58	40.89	45.67	75.32	47.16	55.62
Ce	91.64	80.79	94.23	81.89	96.71	140.20	86.96	75.02
Th	8.26	5.77	7.26	6.27	6.07	12.54	7.06	8.06

Data Set	Streck Buchanan/Wildcat Creek Tuff				Sales WCT Hand Selected Mafics			
Sample ID	MS-13-07	MS-14-03	MS-14-05	MS-14-06	HS1504a	HS1504c	HS1504d	HS1504e
Unit	BT	WCT	WCT	WCT	WCT	WCT	WCT	WCT
Unnormalized Major Elements (Weight %):								
SiO2					57.13	62.31	59.33	57.78
TiO2					1.79	1.11	1.33	1.54
Al2O3					14.18	14.63	13.25	13.90
FeO*					9.31	6.67	7.55	8.34
MnO					0.21	0.20	0.21	0.18
MgO					2.44	1.35	1.89	2.02
CaO					5.33	3.21	4.06	5.46
Na2O					4.84	4.21	3.75	3.83
K2O					1.66	3.14	4.15	2.83
P2O5					0.72	0.47	0.47	0.71
Sum					97.62	97.31	95.99	96.58
LOI %					1.64	2.48	3.60	2.57
XRF Data								
Normalized Major Elements (Weight %):								
SiO2	71.12	66.87	71.44	65.93	58.52	64.04	61.81	59.82
TiO2	0.55	0.89	0.49	1.06	1.83	1.14	1.39	1.59
Al2O3	13.42	13.59	13.36	13.76	14.53	15.03	13.81	14.39
FeO*	3.90	5.91	3.98	6.40	9.54	6.85	7.86	8.63
MnO	0.07	0.17	0.15	0.18	0.21	0.20	0.22	0.19
MgO	0.51	1.15	0.38	1.45	2.50	1.39	1.97	2.09
CaO	1.60	3.11	1.04	3.15	5.46	3.30	4.23	5.65
Na2O	3.72	4.46	3.63	3.67	4.96	4.32	3.90	3.97
K2O	4.91	3.57	5.44	3.98	1.70	3.23	4.32	2.93
P2O5	0.18	0.28	0.10	0.41	0.73	0.49	0.49	0.73
Total	95.48	97.11	95.93	96.37	100.00	100.00	100.00	100.00

Data Set	Streck Buchanan/Wildcat Creek Tuff				Sales WCT Hand Selected Mafics			
Sample ID	MS-13-07	MS-14-03	MS-14-05	MS-14-06	HS1504a	HS1504c	HS1504d	HS1504e
Unit	BT	WCT	WCT	WCT	WCT	WCT	WCT	WCT
XRF Data					Unnormalized Trace Elements (ppm):			
Ni	2.89	8.46	5.17	7.46	10.85	5.80	13.70	3.22
Cr	3.88	12.54	8.66	12.84	15.28	12.40	12.30	2.61
Sc	7.46	16.72	8.96	17.81	27.54	17.70	22.30	22.91
V	26.47	83.78	33.33	90.35	165.72	102.20	152.40	103.82
Ba	1539.66	1033.01	906.94	929.43	928.12	1142.40	909.00	1025.60
Rb	68.36	72.24	89.95	67.96	23.54	53.61	94.67	42.55
Sr	123.18	161.29	70.65	188.06	365.32	226.10	227.90	374.16
Zr	357.11	376.91	429.44	347.75	259.59	369.87	300.95	209.61
Y	58.80	63.08	66.67	60.00	61.41	76.40	60.50	50.35
Nb	21.99	24.08	26.57	23.68	18.69	23.40	20.80	14.77
Ga	21.49	20.30	21.29	20.40	21.11	22.30	19.10	20.80
Cu	2.89	15.82	7.16	18.81	29.25	18.10	29.90	4.82
Zn	151.04	132.14	133.23	139.40	146.53	136.40	166.50	226.63
Pb	13.43	13.83	16.02	12.54	10.15	12.20	16.30	25.33
La	38.51	42.69	46.27	40.20	39.60	49.10	37.80	31.46
Ce	81.59	87.76	95.72	87.76	75.38	87.70	78.10	67.84
Th	6.67	7.06	9.45	6.17	4.12	6.60	4.60	3.32

Data Set			Hooper et. al. (2002)										Data Set	
Sample ID	KL281	KL256	BB161	AL-82	MP-41B	SK-43	SK46	SK-98A	TP-115	TP-119	JJFB12	AYB424	Sample ID	AYB425
Unit	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	Unit	WCT
Unnormalized Major Elements (Weight %):														
SiO2													SiO2	
TiO2													TiO2	
Al2O3													Al2O3	
FeO*													FeO*	
MnO													MnO	
MgO													MgO	
CaO													CaO	
Na2O													Na2O	
K2O													K2O	
P2O5													P2O5	
Sum													Sum	
LOI %													LOI %	
XRF Data			Normalized Major Elements (Weight %):										XRF Data	
SiO2	73.40	73.44	72.48	73.90	72.80	71.63	72.86	74.75	71.71	72.07	74.59	72.11	SiO2	69.89
TiO2	0.22	0.65	0.41	0.26	0.33	0.55	0.31	0.22	0.37	0.47	0.22	0.58	TiO2	0.56
Al2O3	13.79	13.96	13.22	12.66	13.49	13.55	13.40	13.67	14.17	13.48	13.43	13.33	Al2O3	13.01
FeO*	1.79	3.52	3.26	2.67	2.91	3.73	2.89	1.39	3.28	3.38	2.18	4.41	FeO*	4.21
MnO	0.07	0.10	0.11	0.12	0.12	0.15	0.11	0.04	0.15	0.13	0.08	0.19	MnO	0.15
MgO	0.00	0.35	0.32	0.04	0.26	0.36	0.06	0.00	0.32	0.46	0.21	0.82	MgO	0.91
CaO	0.59	1.31	0.83	0.47	0.77	0.74	0.58	0.45	0.74	1.10	0.92	1.34	CaO	3.33
Na2O	5.08	1.58	3.65	5.29	3.41	5.02	4.05	4.30	3.83	3.89	4.18	2.52	Na2O	2.91
K2O	5.04	5.03	5.63	4.57	5.75	4.12	5.71	5.15	5.38	4.90	4.14	4.56	K2O	4.83
P2O5	0.03	0.06	0.08	0.03	0.16	0.14	0.04	0.03	0.05	0.12	0.05	0.14	P2O5	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	Total	100.00

Hooper et. al. (2002)										
MP 12	MP121	AL72	AL96	AL174	SC16	SC22	SC54	SC108	SK37	SK81
WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT

Unnormalized Major Elements (Weight %):

Normalized Major Elements (Weight %):										
72.91	72.94	72.28	72.94	73.92	76.74	73.77	73.34	73.53	73.15	75.94
0.30	0.35	0.39	0.37	0.37	0.29	0.32	0.36	0.33	0.31	0.21
13.09	13.55	13.27	13.33	12.93	11.36	13.23	13.19	13.02	13.19	12.55
2.91	2.89	3.22	2.92	2.99	2.66	2.46	3.06	3.05	3.16	1.49
0.10	0.08	0.12	0.08	0.03	0.09	0.04	0.07	0.10	0.12	0.02
0.13	0.10	0.27	0.14	0.29	0.29	0.32	0.41	0.23	0.18	0.35
0.53	0.53	0.83	0.44	0.27	0.21	0.14	0.28	0.20	0.53	0.49
3.66	3.89	3.73	5.39	4.95	4.51	5.23	4.98	5.08	3.91	4.53
6.30	5.61	5.81	4.27	4.17	3.81	4.46	4.28	4.40	5.41	4.37
0.05	0.05	0.10	0.11	0.08	0.04	0.03	0.04	0.05	0.04	0.05
100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Hooper et. al. (2002)										
MP 12	MP121	AL72	AL96	AL174	SC16	SC22	SC54	SC108	SK37	SK81
WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT
Unnormalized Trace Elements (ppm):										
8.00	10.00	11.00	12.00	12.00	10.00	14.00	9.00	10.00	7.00	11.00
1.00	5.00	8.00	3.00	5.00	5.00	3.00	5.00	7.00	2.00	0.00
2.00	1.00	6.00	3.00	2.00	4.00	0.00	2.00	4.00	7.00	0.00
1.00	10.00	17.00	28.00	16.00	24.00	16.00	29.00	24.00	4.00	11.00
968.00	1191.00	1065.00	1064.00	925.00	853.00	859.00	972.00	1006.00	1051.00	950.00
101.00	108.00	95.00	92.00	92.00	86.00	100.00	94.00	100.00	97.00	110.00
33.00	49.00	53.00	47.00	50.00	42.00	29.00	45.00	38.00	38.00	36.00
410.00	405.00	398.00	392.00	390.00	355.00	417.00	405.00	416.00	411.00	337.00
69.00	65.00	73.00	75.00	66.00	51.00	54.00	47.00	53.00	69.00	65.00
30.68	31.19	30.83	30.17	29.59	27.14	29.51	30.74	31.12	32.16	29.80
22.00	21.00	24.00	25.00	22.00	18.00	22.00	22.00	22.00	22.00	18.00
1.00	0.00	3.00	7.00	3.00	3.00	0.00	5.00	2.00	0.00	0.00
122.00	117.00	127.00	121.00	120.00	106.00	121.00	95.00	125.00	125.00	64.00
16.00	16.00	15.00	15.00	11.00	12.00	13.00	12.00	15.00	15.00	14.00
58.00	51.00	44.00	60.00	47.00	46.00	50.00	47.00	37.00	67.00	50.00
99.00	97.00	98.00	118.00	78.00	95.00	77.00	61.00	75.00	100.00	121.00
7.00	8.00	7.00	7.00	7.00	6.00	6.00	6.00	7.00	8.00	10.00

APPENDIX D: Bulk Geochemistry, ICP-MS

Data Set		Sales Wildcat Creek Tuff						Streck Buchanan/Wildcat Creek Tuff					
Sample ID	Unit	HS1501b	HS1504a	HS1504c	HS1504d	HS1504e	HS1504f	HS1505	HS1506a	MS-13-07	MS-14-03	MS-14-05	MS-14-06
		WCT	WCT	WCT	WCT	WCT	WCT	WCT	WCT	BT	WCT	WCT	WCT
La ppm		59.23	40.70	44.45	41.97	47.85	76.70	48.56	60.26	39.91	44.97	48.23	41.92
Ce ppm		93.43	83.63	97.57	85.02	95.37	146.58	88.65	82.21	83.35	88.75	99.28	86.56
Pr ppm		13.60	10.89	12.75	11.45	13.22	19.61	11.70	15.41	10.61	11.82	12.32	11.06
Nd ppm		53.45	44.52	51.77	47.14	53.78	76.28	46.74	58.65	42.21	47.00	47.65	44.13
Sm ppm		11.88	10.37	12.16	10.89	12.74	16.93	10.51	12.42	9.68	10.54	10.45	10.00
Eu ppm		2.17	2.42	3.08	2.71	3.06	2.17	2.12	1.99	2.08	2.20	1.78	2.34
Gd ppm		11.76	9.85	11.33	10.48	12.19	15.22	10.14	10.37	9.49	10.35	10.27	9.94
Tb ppm		2.05	1.70	1.95	1.81	2.08	2.69	1.76	1.84	1.68	1.79	1.83	1.73
Dy ppm		13.55	10.94	12.36	11.41	13.21	17.67	11.35	11.59	10.52	11.24	11.68	10.76
Ho ppm		2.89	2.24	2.55	2.34	2.73	3.64	2.41	2.36	2.23	2.37	2.50	2.31
Er ppm		8.20	6.25	6.97	6.41	7.65	10.20	6.88	6.65	6.29	6.65	7.18	6.45
Tm ppm		1.24	0.93	1.02	0.94	1.12	1.57	1.01	1.00	0.95	1.01	1.11	0.98
Yb ppm		7.86	5.99	6.65	6.12	7.20	10.21	6.49	6.88	6.14	6.50	7.14	6.20
Lu ppm		1.26	0.95	1.07	0.95	1.14	1.60	1.04	1.06	0.96	1.02	1.14	0.99
Ba ppm		1308	1017	1234	970	1051	533	1373	1911	1586	1042	924	934
Th ppm		8.21	5.79	7.01	5.75	6.64	12.79	6.98	8.80	6.62	7.11	8.29	6.29
Nb ppm		24.71	20.72	22.24	20.90	22.61	37.89	22.29	27.31	21.63	23.17	25.85	22.08
Y ppm		77.99	58.16	61.79	59.91	69.33	89.59	65.24	58.37	57.45	61.86	64.87	59.69
Hf ppm		11.04	8.30	9.98	8.31	9.54	16.57	9.33	11.77	9.25	9.60	11.07	8.79
Ta ppm		1.50	1.22	1.50	1.24	1.42	2.25	1.35	1.63	1.35	1.38	1.54	1.30
U ppm		3.16	1.97	1.44	1.92	1.76	2.98	2.47	3.01	2.99	2.44	3.00	2.41
Pb ppm		13.97	11.41	13.79	11.03	12.75	20.89	15.67	12.74	13.47	13.85	15.66	12.56
Rb ppm		85.9	54.3	24.8	49.7	33.5	58.1	68.5	93.0	67.0	70.5	87.7	64.6
Cs ppm		1.80	1.45	0.78	1.37	1.04	1.95	2.00	1.78	2.61	2.01	2.54	2.00
Sr ppm		103	263	295	266	284	57	188	65	126	162	72	188
Sc ppm		10.4	20.3	23.3	21.2	22.9	7.1	14.4	6.5	7.7	17.0	9.3	17.0
Zr ppm		430	324	369	320	360	642	365	459	360	374	429	345

APPENDIX E: Glass Geochemistry, EMP

		EMP Glass Values									
Date	12/2/16 23:23	12/2/16 23:26	12/2/16 23:29	12/2/16 23:31	12/2/16 23:34	12/2/16 23:36	12/2/16 23:59	12/3/16 0:02	12/3/16 0:04	12/3/16 0:07	
Sample	MS-14-05	MS-14-05	MS-14-05	MS-14-05	MS-14-05	MS-14-05	MS-14-06	MS-14-06	MS-14-06	MS-14-06	
Site/Glass	20/1	20/1	20/1	20/2	20/2	20/2	10/5	10/5	10/6	10/6	
SiO2	70.58	69.74	70.24	69.19	69.24	69.89	56.41	56.29	73.67	73.49	
Al2O3	12.43	12.16	12.30	12.51	12.33	12.23	14.19	14.02	13.38	13.58	
FeO	2.34	2.41	1.63	2.33	3.22	2.03	9.73	10.41	2.65	2.72	
MgO	0.02	0.04	0.02	0.06	0.06	0.03	3.14	3.34	0.07	0.09	
CaO	0.05	0.09	0.06	0.70	0.13	0.13	6.21	6.15	0.39	0.45	
Na2O	2.45	2.98	2.15	2.30	2.96	2.62	1.52	1.92	3.59	3.48	
K2O	6.19	6.05	6.04	5.91	5.61	5.90	2.35	2.28	4.00	3.92	
BaO	0.07	0.08	0.08	0.09	0.09	0.08	0.12	0.12	0.10	0.10	
Total	94.14	93.55	92.52	93.10	93.62	92.93	93.68	94.52	97.85	97.83	

		EMP Glass Values (cont'd)							
Date	2/24/17 21:40	2/24/17 21:43	2/24/17 21:46	2/24/17 21:49	2/24/17 21:52	2/24/17 21:54	2/24/17 21:57	2/24/17 22:00	
Sample	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06	
Site/Glass	11/1	11/1	11/2	11/2	11/3	11/3	11/4	11/4	
SiO2	55.90	55.68	59.83	59.50	57.39	55.49	74.01	74.09	
TiO2	2.34	2.23	1.77	1.79	2.18	2.21	0.29	0.25	
Al2O3	14.13	14.14	14.06	14.21	14.20	13.84	13.08	13.18	
FeO	10.19	10.92	9.43	9.02	10.82	11.55	2.61	2.69	
MnO	0.21	0.22	0.29	0.20	0.19	0.27	0.11	0.16	
MgO	3.95	3.92	3.09	2.67	3.45	4.03	0.09	0.07	
CaO	7.78	8.01	6.21	5.24	5.78	7.09	0.80	0.66	
Na2O	2.16	2.62	2.00	1.83	2.03	1.79	2.86	2.96	
K2O	2.26	2.26	2.84	2.67	2.64	2.25	4.63	4.16	
Cr2O3	0.00	0.04	0.01	0.01	0.00	0.03	0.00	0.00	
ZnO	0.07	0.05	0.01	0.02	0.00	0.00	0.02	0.04	
Total	98.99	100.07	99.54	97.17	98.68	98.58	98.52	98.25	

		Normalized EMP Glass Values									
Date	12/2/16 23:23	12/2/16 23:26	12/2/16 23:29	12/2/16 23:31	12/2/16 23:34	12/2/16 23:36	12/2/16 23:59	12/3/16 0:02	12/3/16 0:04	12/3/16 0:07	
Sample	MS-14-05	MS-14-05	MS-14-05	MS-14-05	MS-14-05	MS-14-05	MS-14-06	MS-14-06	MS-14-06	MS-14-06	
Site/Glass	20/1	20/1	20/1	20/2	20/2	20/2	10/5	10/5	10/6	10/6	
SiO2	74.98	74.55	75.93	74.32	73.95	75.21	60.21	59.56	75.28	75.12	
Al2O3	13.20	13.00	13.29	13.44	13.17	13.17	15.15	14.83	13.67	13.88	
FeO	2.49	2.58	1.77	2.50	3.44	2.19	10.38	11.01	2.71	2.78	
MgO	0.02	0.04	0.02	0.07	0.06	0.03	3.35	3.54	0.08	0.10	
CaO	0.05	0.10	0.07	0.75	0.14	0.14	6.63	6.50	0.40	0.46	
Na2O	2.60	3.18	2.32	2.47	3.16	2.82	1.62	2.03	3.66	3.56	
K2O	6.58	6.47	6.53	6.35	5.99	6.35	2.51	2.41	4.09	4.00	
BaO	0.08	0.09	0.09	0.09	0.09	0.09	0.13	0.12	0.11	0.10	
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

		Normalized EMP Glass Values (cont'd)							
Date	2/24/17 21:40	2/24/17 21:43	2/24/17 21:46	2/24/17 21:49	2/24/17 21:52	2/24/17 21:54	2/24/17 21:57	2/24/17 22:00	
Sample	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06	
Site/Glass	11/1	11/1	11/2	11/2	11/3	11/3	11/4	11/4	
SiO2	56.47	55.64	60.10	61.24	58.16	56.29	75.12	75.41	
TiO2	2.36	2.23	1.78	1.84	2.21	2.25	0.30	0.25	
Al2O3	14.28	14.13	14.12	14.62	14.39	14.04	13.28	13.41	
FeO	10.30	10.91	9.47	9.29	10.96	11.72	2.65	2.74	
MnO	0.22	0.22	0.29	0.20	0.19	0.27	0.12	0.16	
MgO	3.99	3.91	3.10	2.75	3.50	4.09	0.09	0.07	
CaO	7.85	8.00	6.24	5.39	5.86	7.20	0.82	0.67	
Na2O	2.19	2.62	2.01	1.88	2.06	1.82	2.90	3.01	
K2O	2.28	2.25	2.86	2.75	2.68	2.28	4.70	4.24	
Cr2O3	0.00	0.04	0.01	0.01	0.00	0.03	0.00	0.00	
ZnO	0.07	0.05	0.01	0.02	0.00	0.00	0.02	0.05	
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

Sample Glass#	MS-14-05 1-1	MS-14-05 1-2	MS-14-05 1-3	MS-14-05 2-1	MS-14-05 2-2
Glass Type	Rhyolite	Rhyolite	Rhyolite	Rhyolite	Rhyolite
SiO2	74.98	74.55	75.93	74.32	73.95
Al2O3	13.20	13.00	13.29	13.44	13.17
FeO	2.49	2.58	1.77	2.50	3.44
MgO	0.02	0.04	0.02	0.07	0.06
CaO	0.05	0.10	0.07	0.75	0.14
Na2O	2.60	3.18	2.32	2.47	3.16
K2O	6.58	6.47	6.53	6.35	5.99
BaO	0.08	0.09	0.09	0.09	0.09
Total	100.00	100.00	100.00	100.00	100.00

Sample Glass#	MS-14-05 2-3	MS-14-06 5-1	MS-14-06 5-2	MS-14-06 6-1	MS-14-06 6-2
Glass Type	Rhyolite	Andesite	Andesite	Rhyolite	Rhyolite
SiO2	75.21	60.21	59.56	75.28	75.12
Al2O3	13.17	15.15	14.83	13.67	13.88
FeO	2.19	10.38	11.01	2.71	2.78
MgO	0.03	3.35	3.54	0.08	0.10
CaO	0.14	6.63	6.50	0.40	0.46
Na2O	2.82	1.62	2.03	3.66	3.56
K2O	6.35	2.51	2.41	4.09	4.00
BaO	0.09	0.13	0.12	0.11	0.10
Total	100.00	100.00	100.00	102.97	100.00

Sample	MS-14-06	MS-14-06	MS-14-06	MS-14-06	MS-14-06
Glass#	1-1	1-2	2-1	2-2	3-1
Glass Type	Basaltic Andesite	Basaltic Andesite	Andesite	Andesite	Andesite
SiO2	56.47	55.64	60.10	61.24	58.16
TiO2	2.36	2.23	1.78	1.84	2.21
Al2O3	14.28	14.13	14.12	14.62	14.39
FeO	10.30	10.91	9.47	9.29	10.96
MnO	0.22	0.22	0.29	0.20	0.19
MgO	3.99	3.91	3.10	2.75	3.50
CaO	7.85	8.00	6.24	5.39	5.86
Na2O	2.19	2.62	2.01	1.88	2.06
K2O	2.28	2.25	2.86	2.75	2.68
Cr2O3	0.00	0.04	0.01	0.01	0.00
ZnO	0.07	0.05	0.01	0.02	0.00
Total	100.00	100.00	100.00	100.00	100.00

Sample	MS-14-06	MS-14-06	MS-14-06
Glass#	3-2	4-1	4-2
Glass Type	Andesite	Rhyolite	Rhyolite
SiO2	56.29	75.12	75.41
TiO2	2.25	0.30	0.25
Al2O3	14.04	13.28	13.41
FeO	11.72	2.65	2.74
MnO	0.27	0.12	0.16
MgO	4.09	0.09	0.07
CaO	7.20	0.82	0.67
Na2O	1.82	2.90	3.01
K2O	2.28	4.70	4.24
Cr2O3	0.03	0.00	0.00
ZnO	0.00	0.02	0.05
Total	100.00	100.00	100.00

APPENDIX F: Feldspar Geochemistry, SEM

Sample	Site	Spectra	K (Atomic%)	K (wt%)	Ca (Atomic%)	Ca (wt%)	Na (Atomic%)	Na (wt%)	(High K) (High Ca) (High Na)			Total
									Or	An	Ab	
HS154a	3	1	1.52	2.77	0.48	0.9	6.02	6.46	18.953	5.985	75.062	100
HS154a	4	1	0.44	0.76	2.65	4.62	4.15	4.14	6.077	36.602	57.320	100
HS154a	5	3	0.68	1.25	1.49	2.8	6.24	6.74	8.086	17.717	74.197	100
HS154a	5	6	1.8	3.29	0.53	0.99	5.96	6.41	21.713	6.393	71.894	100
HS154a	6	1	1.51	2.75	0.54	1	6.16	6.6	18.392	6.577	75.030	100
HS154a	6	2	1.53	2.79	0.57	1.07	6.15	6.6	18.545	6.909	74.545	100
HS1505	2	1	0.28	0.51	3.08	5.71	5.35	5.7	3.215	35.362	61.424	100
HS1505	2	3	0.2	0.38	2.76	5.38	4.83	5.4	2.567	35.430	62.003	100
HS1505	3	4	3.08	5.87	0	0	3.32	3.71	48.125	0.000	51.875	100
HS1505	3	6	0.83	1.59	0.27	0.53	4.23	4.8	15.572	5.066	79.362	100
HS1505	3	7	0.17	0.32	3.63	7.06	3.95	4.4	2.194	46.839	50.968	100
HS1505	4	1	1.59	2.9	0.51	0.54	6.23	6.66	19.088	6.122	74.790	100
HS1505	4	2	1.55	2.81	0.58	1.07	6.26	6.68	18.474	6.913	74.613	100
HS1505	5	1	0	0	5.68	10.95	1.99	2.2	0.000	74.055	25.945	100
HS1505	5	2	0	0	5.39	10.45	2.2	2.45	0.000	71.014	28.986	100
HS1505	7	2	0.76	1.39	1.91	3.57	5.93	6.35	8.837	22.209	68.953	100
HS1505	9	1	1.41	2.7	0.48	0.94	5.44	6.15	19.236	6.548	74.216	100
HS1505	10	1	3.67	6.71	0	0	1.16	1.25	75.983	0.000	24.017	100
HS1505	11	1	1.45	2.78	0.45	0.89	5.53	6.23	19.515	6.057	74.428	100
HS1505	11	2	0.95	2.22	0.14	0.34	0.68	0.94	53.672	7.910	38.418	100
HS154D	1	1	2.14	4.14	0.39	0.77	4.57	5.21	30.141	5.493	64.366	100
HS154D	2	1	0.29	0.57	0.11	0.23	0.37	0.43	37.662	14.286	48.052	100
HS154D	2	2	4.17	7.98	0.24	0.48	2.24	2.52	62.707	3.609	33.684	100
HS154D	3	2	3.38	6.42	0	0	3.73	4.16	47.539	0.000	52.461	100
HS154D	4	1	0.24	0.47	1.52	3.02	1.36	1.54	7.692	48.718	43.590	100
HS154D	5	3	3.53	6.72	0	0	3.39	3.79	51.012	0.000	48.988	100
HS154D	6	1	0.13	0.24	4.54	8.98	2.63	2.98	1.781	62.192	36.027	100
HS154D	6	2	0.1	0.18	4.34	8.17	3.34	3.6	1.285	55.784	42.931	100

Sample	Site	Spectra	K (Atomic%)	K (wt%)	Ca (Atomic%)	Ca (wt%)	Na (Atomic%)	Na (wt%)	(High K) (High Ca) (High Na)			Total
									Or	An	Ab	
HS154D	6	3	0.11	0.2	3.99	7.87	2.93	3.31	1.56472	56.75676	41.67852	100
HS154D	6	4	0.12	0.23	4.6	9.08	2.65	3	1.62822	62.4152	35.95658	100
HS154D	9	1	1.29	2.52	0.44	0.88	5.15	5.94	18.75	6.395349	74.85465	100
HS154D	9	4	1.38	2.68	0.46	0.92	5.36	6.11	19.1667	6.388889	74.44444	100
HS154D	10	1	2.48	4.79	0.39	0.76	4.23	4.8	34.9296	5.492958	59.57746	100
HS154D	11	1	0.17	0.33	2.92	5.84	4.09	4.69	2.36769	40.66852	56.96379	100
HS154D	11	2	0.16	0.31	3.22	6.37	4.05	4.6	2.15343	43.33782	54.50875	100
HS154E	1	3	2.55	4.87	0.37	0.72	3.68	4.13	38.6364	5.606061	55.75758	100
HS154E	1	4	2.5	4.77	0.27	0.53	2.95	3.31	43.7063	4.72028	51.57343	100
HS154E	2	5	2.64	5.08	0.3	0.59	3.83	4.34	38.9956	4.431315	56.57312	100
HS154E	3	1	3.9	7.01	0.32	0.59	3.78	3.99	48.75	4	47.25	100
HS154E	4	4	1.78	3.45	0.56	1.12	4.46	5.09	26.1765	8.235294	65.58824	100
HS154E	5	1	1.36	2.59	0.53	1.04	5.57	6.22	18.2306	7.104558	74.66488	100
HS154E	6	1	1.51	2.75	0.59	1.1	6.27	6.72	18.0406	7.048984	74.91039	100
HS154E	6	3	3.07	5.81	0.28	0.54	1.3	1.45	66.0215	6.021505	27.95699	100
HS154E	7	2	1.26	2.42	0.58	1.15	5.42	6.13	17.3554	7.988981	74.65565	100
HS154E	8	3	0.23	0.41	3.48	6.45	4.96	5.27	2.65283	40.13841	57.20877	100
HS154E	9	1	1.6	2.91	0.57	1.06	6.23	6.65	19.0476	6.785714	74.16667	100
HS154E	9	2	1.59	2.88	0.55	1.03	6.28	6.7	18.8836	6.532067	74.58432	100
HS154E	10	1	0.1	0.18	5	9.55	2.82	3.09	1.26263	63.13131	35.60606	100
HS154E	10	2	0.1	0.19	5.15	9.83	2.76	3.03	1.24844	64.29463	34.45693	100
HS154C	1	1	1.4	0.74	0.52	0.28	5.03	1.56	20.1439	7.482014	72.3741	100
HS154C	1	2	1.34	0.69	0.7	0.37	5.06	1.55	18.8732	9.859155	71.26761	100
HS154C	3	7	0	0	8.46	3.79	0.34	0.09	0	96.13636	3.863636	100
HS154C	3	8	1.24	0.65	0.59	0.32	5.4	1.66	17.1508	8.160443	74.6888	100
HS154C	4	11	1.3	0.69	0.47	0.25	5.35	1.67	18.2584	6.601124	75.14045	100
HS154C	5	17	1.37	0.71	0.43	0.23	5.26	1.6	19.4051	6.090652	74.50425	100
HS154C	6	21	0.18	0.09	2.89	1.52	4.32	1.31	2.43572	39.1069	58.45737	100

Sample	Site	Spectra	K (Atomic%)	K (wt%)	Ca (Atomic%)	Ca (wt%)	Na (Atomic%)	Na (wt%)	(High K)	(High Ca)	(High Na)	Total
									Or	An	Ab	
HS154C	6	22	0.16	0.08	3.26	1.68	4.12	1.22	2.122	43.236	54.642	100
MS137	1	1	0.27	0.1	1.03	0.38	0	0	20.769	79.231	0.000	100
MS137	1	2	0.3	0.11	1.21	0.46	0	0	19.868	80.132	0.000	100
MS137	1	3	0.29	0.11	1.06	0.42	0	0	21.481	78.519	0.000	100
MS137	2	5	1.29	0.55	0.29	0.13	6.52	1.65	15.926	3.580	80.494	100
MS137	2	6	0.59	0.25	0.68	0.03	4.68	1.19	9.916	11.429	78.655	100
MS137	2	7	0.51	0.25	0	0.3	5.32	1.19	8.748	0.000	91.252	100
MS137	3	8	1.24	0.55	0.3	0.14	6.53	1.7	15.366	3.717	80.917	100
MS137	3	9	1.25	0.54	0.26	0.11	6.53	1.65	15.547	3.234	81.219	100
MS137	3	10	0.28	0.1	1.13	0.41	0	0	19.858	80.142	0.000	100
MS137	6	14	1.39	0.6	0.23	0.1	6.41	1.62	17.310	2.864	79.826	100
MS137	6	15	1.43	0.61	0.21	0.09	6.47	1.63	17.633	2.589	79.778	100
MS137	7	16	1.13	0.47	0.31	0.13	6.54	1.62	14.160	3.885	81.955	100
MS137	7	17	2.84	1.82	0.24	0.1	2.02	0.5	55.686	4.706	39.608	100
MS137	7	18	1.24	0.52	0.3	0.13	6.52	1.6	15.385	3.722	80.893	100
MS137	8	19	1.34	0.54	0.24	0.1	6.5	1.54	16.584	2.970	80.446	100
MS137	8	20	1.25	0.48	0.29	0.11	6.49	1.46	15.567	3.611	80.822	100
MS137	8	21	1.19	0.51	0.3	0.13	6.49	1.62	14.912	3.759	81.328	100
MS137	9	22	1.14	0.49	0.33	0.14	6.64	1.68	14.057	4.069	81.874	100
MS143	1	1	1.72	0.89	0.18	0.1	2.95	0.9	35.464	3.711	60.825	100
MS143	2	2	1.3	0.69	0.47	0.25	5.07	1.58	19.006	6.871	74.123	100
MS143	2	3	1.18	0.62	0.46	0.25	5.58	1.72	16.343	6.371	77.285	100
MS143	2	4	1.27	0.7	0.43	0.24	5.09	1.66	18.704	6.333	74.963	100
MS143	3	5	0.08	0.04	5.01	2.57	2.76	0.81	1.019	63.822	35.159	100
MS143	3	7	0.07	0.04	6.37	3.33	1.5	0.45	0.882	80.227	18.892	100
MS143	3	8	0.1	0.05	4.9	2.58	2.65	0.8	1.307	64.052	34.641	100
MS143	3	10	0.08	0.04	5.07	2.64	2.56	0.76	1.038	65.759	33.204	100
MS143	4	11	0.57	0.26	1.03	0.49	0.08	0.02	33.929	61.310	4.762	100

Sample	Site	Spectra	K (Atomic%)	K (wt%)	Ca (Atomic%)	Ca (wt%)	Na (Atomic%)	Na (wt%)	(High K)	(High Ca)	(High Na)	Total
									Or	An	Ab	
MS143	4	13	0.37	0.17	1.86	0.89	0.39	0.11	14.122	70.992	14.885	100
MS143	5	14	0.31	0.16	1.76	0.94	5.15	1.58	4.294	24.377	71.330	100
MS143	6	16	1.33	0.7	0.44	0.24	5.22	1.62	19.027	6.295	74.678	100
MS143	6	17	1.54	0.69	0.64	0.29	6.33	1.67	18.096	7.521	74.383	100
MS143	7	18	0.42	0.32	1.07	0.84	3.19	1.44	8.974	22.863	68.162	100
MS143	7	19	0.58	0.3	1.82	0.97	4.85	1.47	8.000	25.103	66.897	100
MS143	7	20	0.55	0.28	1.8	0.93	4.86	1.44	7.628	24.965	67.406	100
MS145	2	5	1.3	0.67	0.45	0.24	5.39	1.64	18.207	6.303	75.490	100
MS145	2	7	1.28	0.69	0.54	0.3	5.52	1.75	17.439	7.357	75.204	100
MS145	3	8	0.03	0.02	8.43	3.86	0.36	0.09	0.340	95.578	4.082	100
MS145	3	10	0	0	25.13	10.7	0.09	0.02	0.000	99.643	0.357	100
MS145	4	11	0	0	8.03	3.85	0.29	0.08	0.000	96.514	3.486	100
MS145	4	12	0	0	7.87	3.81	0.25	0.07	0.000	96.921	3.079	100
MS146	3	9	1.55	0.68	0.58	0.26	6.32	1.62	18.343	6.864	74.793	100
MS146	4	14	0.13	0.07	4.84	2.49	2.81	0.83	1.671	62.211	36.118	100
MS146	4	15	0.11	0.06	4.85	2.53	2.73	0.82	1.430	63.069	35.501	100
MS146	4	17	0.86	0.42	3.43	1.73	0.82	0.24	16.830	67.123	16.047	100
MS146	5	19	1.36	0.75	0.44	0.25	5.08	1.63	19.767	6.395	73.837	100
MS146	5	20	1.33	0.63	0.52	0.25	5.32	1.47	18.550	7.252	74.198	100
MS146	5	21	0.83	0.43	11.77	6.31	1.45	0.45	5.907	83.772	10.320	100
MS146	6	23	1.35	0.7	0.29	0.02	5.44	1.66	19.068	4.096	76.836	100
MS146	7	24	0.03	0.02	8	3.84	0.28	0.08	0.361	96.270	3.369	100
MS146	7	25	0.04	0.02	5.8	2.95	2.01	0.59	0.510	73.885	25.605	100
MS146	7	26	0.13	0.05	6.62	2.86	0.27	0.07	1.852	94.302	3.846	100
MS146	7	27	0	0	7.3	3.6	0.11	0.03	0.000	98.516	1.484	100
MS146	7	28	0.14	0.07	4.57	2.33	2.88	0.84	1.845	60.211	37.945	100
MS146	8	31	0.95	0.48	2.56	1.33	1.28	0.38	19.833	53.445	26.722	100
MS146	8	32	1.32	0.7	1.61	0.86	1.96	0.61	26.994	32.924	40.082	100
MS146	8	33	1.64	0.89	1.17	0.65	2	0.64	34.096	24.324	41.580	100

APPENDIX G: Pyroxene Geochemistry, SEM

Sample	Site	Spectra	Ca (Atomic%)	Mg (Atomic%)	Fe (Atomic%)	High Ca High Mg High Fe			Total
						Wo	En	Fs	
HS154a	2	1	8.85	9.32	4.62	38.83	40.90	20.27	100
HS154a	3	5	9.43	4.46	8.55	42.02	19.88	38.10	100
HS154a	4	3	3.13	1.84	4.68	32.44	19.07	48.50	100
HS154a	5	1	9.61	4.48	8.74	42.09	19.62	38.28	100
HS154a	5	2	9.57	4.45	8.75	42.03	19.54	38.43	100
HS154a	7	1	9.52	4.47	8.56	42.22	19.82	37.96	100
HS154a	7	6	9.41	4.41	8.64	41.90	19.63	38.47	100
HS1505	5	4	3.72	3.23	4.09	33.70	29.26	37.05	100
HS1505	6	3	7.59	7.12	4.46	39.59	37.14	23.27	100
HS1505	8	1	0.93	11.08	1.69	6.79	80.88	12.34	100
HS1505	8	2	0.73	9.92	1.22	6.15	83.57	10.28	100
HS1505	8	3	0.54	9.93	1.22	4.62	84.94	10.44	100
HS154d	7	1	8.02	3.72	7.19	42.37	19.65	37.98	100
HS154d	7	2	8.24	3.79	7.19	42.87	19.72	37.41	100
HS154e	2	4	6.37	0.96	9.64	37.54	5.66	56.81	100
HS154e	4	1	7.85	3.69	7.05	42.23	19.85	37.92	100
HS154e	4	3	8.2	3.49	7.28	43.23	18.40	38.38	100
HS154e	5	3	8.19	3.81	7.59	41.81	19.45	38.74	100
HS154e	5	4	8.31	3.77	7.67	42.08	19.09	38.84	100
HS154e	5	5	8.66	4.02	7.75	42.39	19.68	37.93	100
HS154e	5	6	8.55	3.94	7.39	43.01	19.82	37.17	100
HS154e	8	1	8.58	3.61	8.37	41.73	17.56	40.71	100
HS154e	11	4	8.67	3.99	7.66	42.67	19.64	37.70	100
HS154c	2	3	4.7	1.91	21.54	16.70	6.79	76.52	100
HS154c	2	4	8.58	3.72	7.85	42.58	18.46	38.96	100
HS154c	3	7	8.46	3.8	7.61	42.58	19.12	38.30	100
HS154c	7	25	8.18	3.89	7.57	41.65	19.81	38.54	100
HS154c	7	27	8.36	3.91	7.58	42.12	19.70	38.19	100
HS154c	9	33	8.42	3.8	7.52	42.65	19.25	38.10	100

Sample	Site	Spectra	Ca (Atomic%)	Mg (Atomic%)	Fe (Atomic%)	High Ca	High Mg	High Fe	Total
						Wo	En	Fs	
HS154c	10	36	8.6	3.91	7.5	42.98	19.54	37.48	100
HS154c	10	37	8.35	3.79	7.57	42.36	19.23	38.41	100
MS137	4	11	8.59	0	9	48.83	0.00	51.17	100
MS143	3	9	0.42	11.01	8.7	2.09	54.69	43.22	100
MS143	4	11	1.03	1.58	7.57	10.12	15.52	74.36	100
MS143	4	13	1.86	1.48	6.61	18.69	14.87	66.43	100
MS145	3	8	8.43	3.9	7.68	42.13	19.49	38.38	100
MS145	4	11	8.03	3.68	7.34	42.15	19.32	38.53	100
MS145	4	12	7.87	3.64	7	42.52	19.67	37.82	100
MS145	5	13	8.23	3.91	7.44	42.03	19.97	38.00	100
MS145	5	14	8.32	3.83	7.47	42.41	19.52	38.07	100
MS146	3	8	8.44	3.73	7.36	43.22	19.10	37.69	100
MS146	3	10	7.95	3.41	7.78	41.54	17.82	40.65	100
MS146	3	12	19.21	1.09	2.6	83.89	4.76	11.35	100
MS146	3	13	8.37	3.98	7.64	41.87	19.91	38.22	100
MS146	5	18	7.82	3.97	7.69	40.14	20.38	39.48	100
MS146	7	24	8	8.32	3.39	40.59	42.21	17.20	100
MS146	7	26	6.62	2.48	6.94	41.27	15.46	43.27	100
MS146	7	27	7.3	8.15	3.94	37.65	42.03	20.32	100
MS146	8	29	8.14	3.7	7.45	42.20	19.18	38.62	100

APPENDIX H: SEM Spectra

H1. HS-15-04a

Site 1 Spectra 1				Site 1 Spectra 2				Site 2 Spectra 1				Site 2 Spectra 2			
Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma	
O	54.79 O	40.6	0.17	O	54.5 O	38.8	0.17	O	52.92 O	35.68	0.17	O	50.98 O	32.26	0.21
Na	5.41 Na	5.76	0.07	Na	3.96 Na	4.05	0.06	Na	0.32 Na	0.31	0.04	F	4.49 F	3.38	0.13
Al	9.57 Al	11.96	0.09	Mg	1.05 Mg	1.14	0.04	Mg	9.32 Mg	9.55	0.08	Mg	0.17 Mg	0.16	0.03
Si	27.22 Si	35.41	0.14	Al	7.52 Al	9.03	0.08	Al	0.31 Al	0.35	0.04	Si	0.2 Si	0.22	0.03
K	2.14 K	3.88	0.07	Si	26.28 Si	32.85	0.14	Si	23.4 Si	27.69	0.13	P	16.56 P	20.29	0.12
Ca	0.69 Ca	1.29	0.06	K	1.01 K	1.76	0.05	Ca	8.85 Ca	14.94	0.11	Cl	0.24 Cl	0.34	0.04
Ba	0.17 Ba	1.1	0.14	Ca	2.16 Ca	3.85	0.07	Mn	0.27 Mn	0.62	0.08	Ca	27.36 Ca	43.36	0.18
Total	100 Total	100		Ti	0.6 Ti	1.29	0.07	Fe	4.62 Fe	10.86	0.17	Total	100 Total	100	
				Fe	2.91 Fe	7.23	0.15	Total	100 Total	100					
				Total	100 Total	100									

Site 3 Spectra 1				Site 3 Spectra 2				Site 3 Spectra 3				Site 3 Spectra 4			
Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma	
O	55.06 O	41.11	0.17	O	48.63 O	21.92	0.14	O	49.52 O	22.57	0.15	O	51.39 O	31.99	0.23
Na	6.02 Na	6.46	0.07	Al	0.73 Al	0.55	0.04	Al	0.79 Al	0.6	0.04	F	4.04 F	2.98	0.17
Al	9.49 Al	11.95	0.09	Ti	9.6 Ti	12.95	0.11	Ti	9.71 Ti	13.24	0.11	Na	0.16 Na	0.15	0.04
Si	27.26 Si	35.72	0.14	Mn	0.93 Mn	1.44	0.09	Mn	0.96 Mn	1.5	0.09	Si	0.55 Si	0.6	0.04
K	1.52 K	2.77	0.06	Fe	40.12 Fe	63.13	0.18	Fe	39.03 Fe	62.08	0.19	P	16.17 P	19.48	0.13
Ca	0.48 Ca	0.9	0.05	Total	100 Total	100		Total	100 Total	100		Cl	0.1 Cl	0.13	0.03
Ba	0.17 Ba	1.09	0.14									Ca	27.03 Ca	42.14	0.23
Total	100 Total	100										Y	0.31 Y	1.06	0.21
												Ce	0.15 Ce	0.81	0.15
												Eu	0.11 Eu	0.66	0.19
												Total	100 Total	100	

Site 3 Spectra 5				Site 3 Spectra 6				Site 3 Spectra 7				Site 3 Spectra 8			
Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma	
O	52.89 O	33.5	0.18	O	48.67 O	21.95	0.14	O	50.04 O	22.93	0.15	O	49.29 O	22.38	0.14
Mg	4.46 Mg	4.29	0.06	Al	0.7 Al	0.53	0.04	Al	0.78 Al	0.6	0.04	Al	0.8 Al	0.61	0.04
Al	0.31 Al	0.33	0.04	Ti	9.5 Ti	12.83	0.11	Ti	9.55 Ti	13.1	0.11	Ti	9.1 Ti	12.37	0.11
Si	23.46 Si	26.09	0.13	Mn	1.02 Mn	1.58	0.09	Mn	0.94 Mn	1.48	0.09	Mn	0.86 Mn	1.33	0.09
Ca	9.43 Ca	14.96	0.11	Fe	40.1 Fe	63.11	0.18	Fe	38.7 Fe	61.89	0.19	Fe	39.95 Fe	63.31	0.18
Ti	0.13 Ti	0.25	0.05	Total	100 Total	100		Total	100 Total	100		Total	100 Total	100	
Mn	0.77 Mn	1.67	0.1												
Fe	8.55 Fe	18.91	0.19												
Total	100 Total	100													

Site 4 Spectra 1				Site 4 Spectra 2				Site 4 Spectra 3				Site 5 Spectra 1			
Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma	
O	54.59 O	37.95	0.17	O	57.13 O	29.51	0.2	O	53.38 O	36.78	0.17	O	52.24 O	32.86	0.18
Na	4.15 Na	4.14	0.06	Mg	0.98 Mg	0.77	0.04	Na	4.33 Na	4.28	0.07	Mg	4.48 Mg	4.29	0.06
Mg	1.93 Mg	2.04	0.05	Al	0.16 Al	0.14	0.04	Mg	1.84 Mg	1.93	0.05	Al	0.27 Al	0.29	0.04
Al	7.01 Al	8.22	0.07	Si	0.54 Si	0.49	0.03	Al	7.47 Al	8.68	0.08	Si	23.63 Si	26.09	0.13
Si	22.99 Si	28.05	0.13	Ca	0.18 Ca	0.23	0.04	Si	23.21 Si	28.08	0.13	Ca	9.61 Ca	15.14	0.11
P	0.27 P	0.36	0.04	Ti	19.69 Ti	30.45	0.17	P	0.31 P	0.42	0.04	Sc	0.14 Sc	0.25	0.07
K	0.44 K	0.76	0.04	V	0.26 V	0.42	0.09	K	0.6 K	1.01	0.05	Ti	0.11 Ti	0.2	0.05
Ca	2.65 Ca	4.62	0.07	Mn	0.26 Mn	0.47	0.08	Ca	3.13 Ca	5.4	0.08	Mn	0.78 Mn	1.69	0.1
Ti	1.81 Ti	3.77	0.08	Fe	20.81 Fe	37.53	0.21	Ti	1.05 Ti	2.16	0.07	Fe	8.74 Fe	19.19	0.19
Fe	4.16 Fe	10.1	0.16	Total	100 Total	100		Fe	4.68 Fe	11.26	0.17	Total	100 Total	100	
Total	100 Total	100						Total	100 Total	100					

Site 5 Spectra 2				Site 5 Spectra 3				Site 5 Spectra 4				Site 5 Spectra 5			
Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma	
O	52.29 O	32.91	0.18	O	54.81 O	41.15	0.16	O	48.44 O	21.74	0.14	O	52.52 O	24.74	0.15
Mg	4.45 Mg	4.25	0.06	Na	6.24 Na	6.74	0.07	Al	0.73 Al	0.55	0.04	Al	0.77 Al	0.61	0.04
Al	0.32 Al	0.34	0.04	Al	10.5 Al	13.29	0.09	Ti	8.48 Ti	11.4	0.11	Ti	9.18 Ti	12.95	0.11
Si	23.67 Si	26.16	0.13	Si	26.18 Si	34.5	0.14	Mn	0.83 Mn	1.27	0.09	Mn	0.71 Mn	1.14	0.09
Ca	9.57 Ca	15.09	0.11	K	0.68 K	1.25	0.05	Fe	41.52 Fe	65.04	0.18	Fe	36.82 Fe	60.55	0.19
Ti	0.13 Ti	0.24	0.05	Ca	1.49 Ca	2.8	0.07	Total	100 Total	100		Total	100 Total	100	
Mn	0.82 Mn	1.78	0.1	Fe	0.11 Fe	0.28	0.09								
Fe	8.75 Fe	19.23	0.19	Total	100 Total	100									
Total	100 Total	100													

Site 5 Spectra 6				Site 6 Spectra 1				Site 6 Spectra 2				Site 6 Spectra 3			
Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma	
O	55.19 O	41.31	0.17	O	54.78 O	40.81	0.17	O	54.95 O	41.07	0.17	O	54.53 O	37.78	0.17
Na	5.96 Na	6.41	0.07	Na	6.16 Na	6.6	0.07	Na	6.15 Na	6.6	0.07	Na	3.47 Na	3.46	0.06
Al	9.46 Al	11.94	0.09	Al	9.65 Al	12.13	0.09	Al	9.59 Al	12.09	0.09	Mg	2.97 Mg	3.13	0.05
Si	26.96 Si	35.43	0.14	Si	27.06 Si	35.39	0.15	Si	27.07 Si	35.52	0.14	Al	6.36 Al	7.44	0.07
K	1.8 K	3.29	0.07	K	1.51 K	2.75	0.06	K	1.53 K	2.79	0.06	Si	22.69 Si	27.59	0.13
Ca	0.53 Ca	0.99	0.05	Ca	0.54 Ca	1	0.05	Ca	0.57 Ca	1.07	0.05	P	0.24 P	0.32	0.04
Ba	0.1 Ba	0.63	0.13	Fe	0.14 Fe	0.35	0.09	Ba	0.13 Ba	0.86	0.14	K	0.43 K	0.73	0.04
Total	100 Total	100		Ba	0.15 Ba	0.97	0.14	Total	100 Total	100		Ca	3.91 Ca	6.79	0.08
				Total	100 Total	100						Ti	0.73 Ti	1.51	0.07
												Mn	0.15 Mn	0.36	0.08
												Fe	4.5 Fe	10.89	0.17
												Total	100 Total	100	

Site 7 Spectra 1				Site 7 Spectra 2				Site 7 Spectra 3				Site 7 Spectra 4			
Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma	
O	52.92 O	33.54	0.17	O	58.15 O	30.13	0.15	O	56.55 O	29.69	0.15	O	51.18 O	32.44	0.21
Mg	4.47 Mg	4.31	0.06	Si	5.83 Si	5.3	0.07	Si	5.99 Si	5.52	0.07	F	4.96 F	3.73	0.14
Al	0.28 Al	0.29	0.04	P	0.12 P	0.12	0.04	S	4.5 S	4.73	0.06	Si	0.39 Si	0.43	0.03
Si	23.48 Si	26.13	0.13	S	0.18 S	0.19	0.04	Ca	0.64 Ca	0.85	0.05	P	16.11 P	19.77	0.12
Ca	9.52 Ca	15.12	0.11	Ca	0.66 Ca	0.86	0.05	Fe	32.32 Fe	59.22	0.18	Ca	27.1 Ca	43.03	0.18
Mn	0.76 Mn	1.65	0.1	Fe	35.06 Fe	63.4	0.17	Total	100 Total	100		Fe	0.27 Fe	0.59	0.1
Fe	8.56 Fe	18.95	0.19	Total	100 Total	100						Total	100 Total	100	
Total	100 Total	100													

Site 7 Spectra 5				Site 7 Spectra 6				Site 7 Spectra 7				Site 7 Spectra 8			
Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma	
O	51.53 O	24.11	0.15	O	52.62 O	33.23	0.18	O	51.43 O	23.91	0.15	O	49.71 O	30.96	0.22
Al	0.7 Al	0.55	0.04	Mg	4.41 Mg	4.23	0.06	Al	0.8 Al	0.63	0.04	F	5.45 F	4.03	0.17
Si	0.64 Si	0.52	0.04	Al	0.34 Al	0.36	0.04	Ti	8.82 Ti	12.28	0.11	Na	0.14 Na	0.12	0.04
Ti	9.27 Ti	12.99	0.11	Si	23.6 Si	26.16	0.13	Mn	0.56 Mn	0.89	0.09	Si	0.48 Si	0.52	0.03
Mn	0.51 Mn	0.82	0.09	Ca	9.41 Ca	14.89	0.11	Fe	38.39 Fe	62.3	0.19	P	16.24 P	19.58	0.12
Fe	37.35 Fe	61.01	0.19	Ti	0.13 Ti	0.25	0.05	Total	100 Total	100		Cl	0.16 Cl	0.22	0.03
Total	100 Total	100		Mn	0.85 Mn	1.84	0.1					Ca	26.93 Ca	42.03	0.2
				Fe	8.64 Fe	19.04	0.19					Fe	0.73 Fe	1.58	0.11
				Total	100 Total	100						Ce	0.17 Ce	0.95	0.15
												Total	100 Total	100	

Site 7 Spectra 9				Site 7 Spectra 10				Site 7 Spectra 11				Site 7 Spectra 12							
Atomic %		Wt%	Sigma	Atomic %		Wt%	Sigma	Atomic %		Wt%	Sigma	Atomic %		Wt%	Sigma				
O	52.35	O	32.95	0.22	O	51.53	O	23.94	0.15	O	50.37	O	49.9	O	23.22	0.14			
F	3.41	F	2.55	0.17	Al	0.83	Al	0.65	0.04	F	5.08	F	0.14	Al	0.69	Al	0.54	0.04	
Al	0.18	Al	0.2	0.03	Ti	7.86	Ti	10.93	0.11	Si	0.34	Si	0.38	0.03	Si	4.22	Si	3.45	0.06
Si	1.3	Si	1.43	0.04	Mn	0.41	Mn	0.65	0.08	P	16.36	P	19.93	0.12	S	0.26	S	0.24	0.04
P	15.63	P	19.05	0.12	Fe	39.37	Fe	63.83	0.18	Ca	27.39	Ca	43.18	0.18	Ca	0.52	Ca	0.61	0.05
Ca	26.23	Ca	41.37	0.2	Total	100	Total	100		Fe	0.46	Fe	1.01	0.1	Ti	1.09	Ti	1.51	0.06
Fe	0.75	Fe	1.65	0.11						Total	100	Total	100		Mn	0.45	Mn	0.72	0.09
Ce	0.15	Ce	0.81	0.15											Fe	42.6	Fe	69.21	0.2
Total	100	Total	100												Cu	0.27	Cu	0.49	0.15
															Total	100	Total	100	

H2. HS-15-04c

Site 1					Site 1					Site 2				
Spectra 1	Atomic %	Spectrum 1	Wt%	Wt% Sigma	Spectrum 2	Atomic %	Spectrum 2	Wt%	Wt% Sigma	Spectrum 3	Atomic %	Spectrum 3	Wt%	Wt% Sigma
O	55.5672	O	10.31	0.08	O	55.33295	O	10.15	0.07	O	52.28139	O	7.62	0.06
Na	5.858374	Na	1.56	0.02	Na	5.859873	Na	1.55	0.02	Na	0.25413	Na	0.05	0.02
Mg	0	Mg	0	0	Mg	0	Mg	0	0	Mg	2.206307	Mg	0.49	0.02
Al	9.550431	Al	2.99	0.03	Al	9.484655	Al	2.93	0.03	Al	0.369643	Al	0.09	0.01
Si	26.48498	Si	8.63	0.05	Si	26.61262	Si	8.57	0.05	Si	13.04147	Si	3.34	0.03
P	0	P	0	0	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	1.630561	K	0.74	0.02	K	1.551824	K	0.69	0.02	K	0	K	0	0
Ca	0.605637	Ca	0.28	0.02	Ca	0.810654	Ca	0.37	0.02	Ca	5.429132	Ca	1.98	0.03
Ti	0	Ti	0	0	Ti	0.138969	Ti	0.08	0.02	Ti	0.60067	Ti	0.26	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0	Mn	0	0	Mn	0.935659	Mn	0.47	0.03
Fe	0.174703	Fe	0.11	0.03	Fe	0.15055	Fe	0.1	0.03	Fe	24.8816	Fe	12.66	0.11
Ni	0	Ni	0	0	Ni	0.057904	Ni	0.04	0.04	Ni	0	Ni	0	0
Ba	0.128116	Ba	0.21	0.05	Total	100	Total	24.48		Total	100	Total	26.96	
Total	100	Total	24.83											

Site 2					Site 2					Site 3				
Spectrum 4	Atomic %	Spectrum 4	Wt%	Wt% Sigma	Spectrum 5	Atomic %	Spectrum 5	Wt%	Wt% Sigma	Spectrum 6	Atomic %	Spectrum 6	Wt%	Wt% Sigma
O	52.04586	O	8.22	0.07	O	49.45355	O	7.23	0.09	O	47.67904	O	5.57	0.05
Na	0.483363	Na	0.11	0.01	F	3.85929	F	0.67	0.04	Na	0.170242	Na	0.03	0.02
Mg	4.181655	Mg	1	0.02	Na	0.159381	Na	0.03	0.01	Mg	0.488026	Mg	0.09	0.01
Al	0.258543	Al	0.07	0.01	Mg	0	Mg	0	0	Al	0.692316	Al	0.14	0.01
Si	23.67356	Si	6.57	0.04	Al	0.273224	Al	0.07	0.01	Si	0.090796	Si	0.02	0.01
P	0	P	0	0	Si	0.899362	Si	0.23	0.01	P	0	P	0	0
S	0.044964	S	0.01	0.01	P	16.54144	P	4.68	0.03	S	0	S	0	0
K	0	K	0	0	S	0	S	0	0	K	0	K	0	0
Ca	9.644784	Ca	3.82	0.04	K	0	K	0	0	Ca	0	Ca	0	0
Ti	0.134892	Ti	0.06	0.02	Ca	28.38115	Ca	10.39	0.06	Ti	9.783226	Ti	3.42	0.04
Cr	0	Cr	0	0	Ti	0.045537	Ti	0.02	0.02	Cr	0	Cr	0	0
Mn	0.708183	Mn	0.38	0.03	Cr	0	Cr	0	0	Mn	0.964703	Mn	0.39	0.03
Fe	8.824191	Fe	4.87	0.07	Mn	0	Mn	0	0	Fe	40.02951	Fe	16.32	0.11
Ni	0	Ni	0	0	Fe	0.387067	Fe	0.2	0.03	Ni	0.102145	Ni	0.04	0.04
Total	100	Total	25.11		Ni	0	Ni	0	0	Total	100	Total	26.02	
					Total	100	Total	23.52						

Site 3					Site 3					Site 3				
Spectrum 7	Atomic %	Spectrum 7	Wt%	Wt% Sigma	Spectrum 8	Atomic %	Spectrum 8	Wt%	Wt% Sigma	Spectrum 9	Atomic %	Spectrum 9	Wt%	Wt% Sigma
O	52.05916	O	8.2	0.07	O	55.27518	O	10.34	0.08	Na	0	Na	0	0
Na	0.386803	Na	0.09	0.01	Na	6.165791	Na	1.66	0.02	Mg	0	Mg	0	0
Mg	4.323094	Mg	1.03	0.02	Mg	0	Mg	0	0	Al	0.112962	Al	0.02	0.01
Al	0.238908	Al	0.06	0.01	Al	9.47705	Al	2.99	0.03	Si	0	Si	0	0
Si	23.6405	Si	6.53	0.04	Si	26.77552	Si	8.79	0.05	P	0.098842	P	0.02	0.01
P	0	P	0	0	P	0	P	0	0	S	49.46343	S	10.29	0.06
S	0	S	0	0	S	0	S	0	0	K	0	K	0	0
K	0	K	0	0	K	1.415848	K	0.65	0.02	Ca	0	Ca	0	0
Ca	9.624573	Ca	3.79	0.04	Ca	0.67367	Ca	0.32	0.02	Ti	0.790737	Ti	0.24	0.02
Ti	0.136519	Ti	0.07	0.02	Ti	0	Ti	0	0	Cr	0	Cr	0	0
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Mn	0	Mn	0	0
Mn	0.830489	Mn	0.45	0.03	Mn	0	Mn	0	0	Fe	49.33635	Fe	17.88	0.14
Fe	8.657565	Fe	4.76	0.07	Fe	0.079927	Fe	0.05	0.03	Ni	0.197684	Ni	0.08	0.05
Ni	0.102389	Ni	0.06	0.04	Ni	0	Ni	0	0	Total	100	Total	28.53	
Total	100	Total	25.04		Ba	0.137018	Ba	0.23	0.05					
					Total	100	Total	25.03						

Site 3					Site 4					Site 4				
Spectrum 10	Atomic %	Spectrum 10	Wt%	Wt% Sigma	Spectrum 11	Atomic %	Spectrum 11	Wt%	Wt% Sigma	Spectrum 12	Atomic %	Spectrum 12	Wt%	Wt% Sigma
O	59.62264	O	7.63	0.05	O	55.45089	O	10.49	0.08	O	48.21043	O	5.77	0.05
Na	0.080046	Na	0.02	0.01	Na	6.145893	Na	1.67	0.02	Na	0.14771	Na	0.03	0.02
Mg	0.297313	Mg	0.06	0.01	Mg	0	Mg	0	0	Mg	0.53403	Mg	0.1	0.01
Al	1.02916	Al	0.22	0.05	Al	9.350948	Al	2.98	0.03	Al	0.806727	Al	0.16	0.01
Si	13.02459	Si	2.93	0.03	Si	26.75474	Si	8.89	0.05	Si	0.056812	Si	0.01	0.01
P	0.125786	P	0.03	0.01	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	0.057176	K	0.02	0.01	K	1.493395	K	0.69	0.02	K	0	K	0	0
Ca	1.223556	Ca	0.39	0.02	Ca	0.53992	Ca	0.25	0.02	Ca	0	Ca	0	0
Ti	0.080046	Ti	0.03	0.01	Ti	0	Ti	0	0	Ti	9.873878	Ti	3.54	0.04
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0.057176	Mn	0.02	0.02	Mn	0	Mn	0	0	Mn	0.988524	Mn	0.41	0.03
Fe	24.40252	Fe	10.91	0.09	Fe	0.114877	Fe	0.08	0.03	Fe	39.38189	Fe	16.44	0.12
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Br	0	Br	0	0	Ba	0.149339	Ba	0.23	0.05	Total	100	Total	26.46	
Total	100	Total	22.26		Total	100	Total	25.28						

Site 4					Site 4					Site 4				
Spectrum 13	Atomic %	Spectrum 13	Wt%	Wt% Sigma	Spectrum 14	Atomic %	Spectrum 14	Wt%	Wt% Sigma	Spectrum 15	Atomic %	Spectrum 15	Wt%	Wt% Sigma
O	50.77187	O	7.86	0.09	O	49.95451	O	7.6	0.09	O	49.78994	O	7.43	0.09
F	4.139508	F	0.76	0.04	F	4.070957	F	0.74	0.04	F	4.01953	F	0.71	0.06
Na	0.137221	Na	0.03	0.01	Na	0.147828	Na	0.03	0.01	Na	0.113546	Na	0.03	0.01
Mg	0	Mg	0	0	Mg	0	Mg	0	0	Mg	0	Mg	0	0
Al	0.04574	Al	0.01	0.01	Al	0.0796	Al	0.02	0.01	Al	0.124901	Al	0.03	0.01
Si	0.365923	Si	0.1	0.01	Si	0.352513	Si	0.09	0.01	Si	0.476893	Si	0.12	0.01
P	16.3179	P	4.89	0.04	P	16.64771	P	4.91	0.04	P	15.82832	P	4.57	0.04
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	0.068611	K	0.03	0.01	K	0.0796	K	0.03	0.01	K	0	K	0	0
Ca	27.9817	Ca	10.85	0.06	Ca	28.24653	Ca	10.77	0.06	Ca	26.52436	Ca	9.91	0.06
Ti	0	Ti	0	0	Ti	0	Ti	0	0	Ti	0.533666	Ti	0.24	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0.125085	Mn	0.06	0.03	Mn	0.249801	Mn	0.13	0.03
Fe	0.171527	Fe	0.09	0.03	Fe	0.295656	Fe	0.16	0.03	Fe	2.100602	Fe	1.09	0.05
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	24.62		Total	100	Total	24.41		Total	100	Total	24.57	

Site 5					Site 5					Site 5				
Spectrum 16	Atomic %	Spectrum 16	Wt%	Wt% Sigma	Spectrum 17	Atomic %	Spectrum 17	Wt%	Wt% Sigma	Spectrum 18	Atomic %	Spectrum 18	Wt%	Wt% Sigma
O	50.16972	O	7.58	0.09	O	55.36348	O	10.22	0.08	O	60.45423	O	8.62	0.07
F	4.356189	F	0.78	0.04	Na	6.021752	Na	1.6	0.02	Na	0	Na	0	0
Na	0.169722	Na	0.04	0.01	Mg	0	Mg	0	0	Mg	0.667291	Mg	0.14	0.01
Mg	0.056574	Mg	0.01	0.01	Al	9.410418	Al	2.93	0.03	Al	4.987122	Al	1.2	0.02
Al	0.282869	Al	0.07	0.01	Si	26.88037	Si	8.71	0.05	Si	11.01616	Si	2.76	0.03
Si	1.120163	Si	0.3	0.01	P	0	P	0	0	P	0.210723	P	0.06	0.01
P	15.99909	P	4.68	0.04	S	0	S	0	0	S	0.046827	S	0.01	0.01
S	0	S	0	0	K	1.568403	K	0.71	0.02	K	0.140482	K	0.05	0.01
K	0.067889	K	0.03	0.01	Ca	0.492272	Ca	0.23	0.02	Ca	1.685788	Ca	0.6	0.02
Ca	27.40439	Ca	10.38	0.06	Ti	0.068689	Ti	0.04	0.02	Ti	0.550222	Ti	0.24	0.03
Ti	0	Ti	0	0	Cr	0	Cr	0	0	Cr	0.070241	Cr	0.03	0.02
Cr	0	Cr	0	0	Mn	0	Mn	0	0	Mn	15.80426	Mn	7.73	0.08
Mn	0.101833	Mn	0.05	0.03	Fe	0.114482	Fe	0.07	0.03	Fe	2.891594	Fe	1.44	0.06
Fe	0.271555	Fe	0.15	0.03	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Ni	0	Ni	0	0	Ba	0.080137	Ba	0.13	0.05	Ba	1.252634	Ba	1.54	0.07
Total	100	Total	24.07		Total	100	Total	24.64		Total	100	Total	24.7	

Site 5					Site 5					Site 6				
Spectrum 19	Atomic %	Spectrum 19	Wt%	Wt% Sigma	Spectrum 20	Atomic %	Spectrum 20	Wt%	Wt% Sigma	Spectrum 21	Atomic %	Spectrum 21	Wt%	Wt% Sigma
O	61.3896	O	9.86	0.08	O	61.96852	O	9.71	0.07	O	55.37143	O	10.18	0.07
Na	0.093262	Na	0.02	0.01	Na	0	Na	0	0	Na	4.937143	Na	1.31	0.02
Mg	0.524598	Mg	0.13	0.01	Mg	0.610759	Mg	0.15	0.01	Mg	0.045714	Mg	0.01	0.01
Al	6.283516	Al	1.7	0.02	Al	6.037115	Al	1.59	0.02	Al	12.04571	Al	3.73	0.03
Si	16.69387	Si	4.71	0.03	Si	16.22034	Si	4.46	0.03	Si	23.90857	Si	7.72	0.04
P	0.209839	P	0.07	0.01	P	0.199671	P	0.06	0.01	P	0	P	0	0
S	0.046631	S	0.02	0.01	S	0	S	0	0	S	0	S	0	0
K	0.163208	K	0.06	0.01	K	0.15269	K	0.06	0.01	K	0.205714	K	0.09	0.01
Ca	1.445558	Ca	0.58	0.02	Ca	1.632605	Ca	0.64	0.02	Ca	3.302857	Ca	1.52	0.03
Ti	1.28235	Ti	0.62	0.03	Ti	1.127555	Ti	0.53	0.03	Ti	0	Ti	0	0
Cr	0.058289	Cr	0.03	0.02	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	5.560737	Mn	3.07	0.06	Mn	6.600893	Mn	3.55	0.06	Mn	0.08	Mn	0.05	0.02
Fe	5.910469	Fe	3.32	0.07	Fe	4.991778	Fe	2.73	0.06	Fe	0.102857	Fe	0.06	0.03
Ni	0	Ni	0	0	Ni	0.070472	Ni	0.04	0.04	Ni	0	Ni	0	0
Ba	0.174866	Ba	0.24	0.07	Ba	0.387597	Ba	0.52	0.06	Total	100	Total	24.67	
Ce	0.163208	Ce	0.23	0.06	Total	100	Total	24.04						
Total	100	Total	24.66											

Site 6					Site 7					Site 7				
Spectrum 22	Atomic %	Spectrum 22	Wt%	Wt% Sigma	Spectrum 23	Atomic %	Spectrum 23	Wt%	Wt% Sigma	Spectrum 24	Atomic %	Spectrum 24	Wt%	Wt% Sigma
O	54.80813	O	9.87	0.07	O	49.38102	O	6	0.05	O	49.89189	O	7.65	0.09
Na	4.705345	Na	1.22	0.02	Na	0.114626	Na	0.02	0.02	F	4.700125	F	0.86	0.04
Mg	0	Mg	0	0	Mg	0.469968	Mg	0.09	0.01	Na	0	Na	0	0
Al	12.42577	Al	3.77	0.03	Al	0.687758	Al	0.14	0.01	Mg	0	Mg	0	0
Si	23.88077	Si	7.54	0.04	Si	0.103164	Si	0.02	0.01	Al	0	Al	0	0
P	0	P	0	0	P	0	P	0	0	Si	0.489359	Si	0.13	0.01
S	0	S	0	0	S	0	S	0	0	P	16.01229	P	4.75	0.04
K	0.182732	K	0.08	0.01	K	0	K	0	0	S	0	S	0	0
Ca	3.723161	Ca	1.68	0.03	Ca	0	Ca	0	0	Cl	0.159326	Cl	0.06	0.01
Ti	0	Ti	0	0	Ti	9.468134	Ti	3.44	0.04	K	0	K	0	0
Cr	0.045683	Cr	0.02	0.02	Cr	0	Cr	0	0	Ca	27.50654	Ca	10.57	0.06
Mn	0	Mn	0	0	Mn	0.859697	Mn	0.36	0.03	Ti	0.182087	Ti	0.08	0.02
Fe	0.228415	Fe	0.14	0.03	Fe	38.91564	Fe	16.49	0.12	Cr	0	Cr	0	0
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Mn	0.113804	Mn	0.06	0.03
Total	100	Total	24.32		Total	100	Total	26.56		Fe	0.944577	Fe	0.51	0.04
										Ni	0	Ni	0	0
										Total	100	Total	24.67	

Site 7					Site 7					Site 7				
Spectrum 25	Atomic %	Spectrum 25	Wt%	Wt% Sigma	Spectrum 26	Atomic %	Spectrum 26	Wt%	Wt% Sigma	Spectrum 27	Atomic %	Spectrum 27	Wt%	Wt% Sigma
O	52.67969	O	8.61	0.07	O	49.69195	O	7.31	0.09	O	52.9193	O	8.57	0.07
Na	0.3771	Na	0.09	0.01	F	3.898286	F	0.68	0.06	Na	0.405771	Na	0.09	0.01
Mg	4.445206	Mg	1.1	0.02	Na	0.067212	Na	0.01	0.01	Mg	4.407124	Mg	1.08	0.02
Al	0.2514	Al	0.07	0.01	Mg	0	Mg	0	0	Al	0.2367	Al	0.07	0.01
Si	23.3459	Si	6.7	0.04	Al	0.100818	Al	0.02	0.01	Si	23.2642	Si	6.61	0.04
P	0	P	0	0	Si	0.526493	Si	0.14	0.01	P	0	P	0	0
S	0	S	0	0	P	16.82536	P	4.79	0.04	S	0	S	0	0
K	0	K	0	0	S	0	S	0	0	K	0	K	0	0
Ca	9.347503	Ca	3.83	0.04	K	0	K	0	0	Ca	9.422904	Ca	3.82	0.04
Ti	0.114273	Ti	0.06	0.02	Ca	28.29618	Ca	10.43	0.06	Ti	0.123986	Ti	0.06	0.02
Cr	0	Cr	0	0	Ti	0	Ti	0	0	Cr	0	Cr	0	0
Mn	0.788481	Mn	0.44	0.03	Cr	0	Cr	0	0	Mn	0.676285	Mn	0.37	0.03
Fe	8.65044	Fe	4.94	0.08	Mn	0.067212	Mn	0.03	0.03	Fe	8.543733	Fe	4.83	0.07
Ni	0	Ni	0	0	Fe	0.313655	Fe	0.16	0.03	Ni	0	Ni	0	0
Total	100	Total	25.84		Ni	0	Ni	0	0	Total	100	Total	25.5	
					Ce	0.212837	Ce	0.27	0.05					
					Total	100	Total	23.84						

Site 8					Site 8					Site 8				
Spectrum 28	Atomic %	Spectrum 28	Wt%	Wt% Sigma	Spectrum 29	Atomic %	Spectrum 29	Wt%	Wt% Sigma	Spectrum 30	Atomic %	Spectrum 30	Wt%	Wt% Sigma
O	54.63016	O	9.76	0.07	O	50.72046	O	6.15	0.05	O	55.09997	O	10.03	0.08
Na	3.117451	Na	0.8	0.02	Na	0.177344	Na	0.03	0.02	Na	4.100305	Na	1.07	0.02
Mg	2.013114	Mg	0.55	0.02	Mg	0.864553	Mg	0.16	0.01	Mg	0.056478	Mg	0.02	0.01
Al	10.08858	Al	3.04	0.03	Al	2.172467	Al	0.44	0.02	Al	12.37998	Al	3.8	0.03
Si	22.6274	Si	7.09	0.04	Si	3.347373	Si	0.71	0.02	Si	23.26895	Si	7.44	0.04
P	0.138042	P	0.05	0.01	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	0.402623	K	0.18	0.01	K	0.133008	K	0.04	0.01	K	0.474415	K	0.21	0.01
Ca	4.796963	Ca	2.14	0.03	Ca	0.299268	Ca	0.09	0.01	Ca	3.806619	Ca	1.73	0.03
Ti	0.207063	Ti	0.11	0.02	Ti	8.379517	Ti	3.04	0.04	Ti	0.090365	Ti	0.05	0.02
Cr	0	Cr	0	0	V	0.288184	V	0.11	0.02	Cr	0	Cr	0	0
Mn	0.046014	Mn	0.03	0.02	Cr	0.177344	Cr	0.07	0.02	Mn	0.067774	Mn	0.04	0.02
Fe	1.932589	Fe	1.21	0.04	Mn	0.343605	Mn	0.14	0.03	Fe	0.655145	Fe	0.42	0.03
Ni	0	Ni	0	0	Fe	33.09687	Fe	14.02	0.11	Ni	0	Ni	0	0
Total	100	Total	24.96		Ni	0	Ni	0	0	Total	100	Total	24.81	
					Total	100	Total	25						

Site 8					Site 9					Site 9				
Spectrum 31	Atomic %	Spectrum 31	Wt%	Wt% Sigma	Spectrum 32	Atomic %	Spectrum 32	Wt%	Wt% Sigma	Spectrum 33	Atomic %	Spectrum 33	Wt%	Wt% Sigma
O	52.67193	O	8.97	0.07	O	60.89535	O	8.33	0.05	O	52.20277	O	8.33	0.07
Na	0.202931	Na	0.05	0.01	Na	0	Na	0	0	Na	0.446275	Na	0.1	0.01
Mg	9.605411	Mg	2.49	0.03	Mg	0.418605	Mg	0.09	0.01	Mg	4.348324	Mg	1.06	0.02
Al	1.127396	Al	0.32	0.01	Al	2.348837	Al	0.54	0.02	Al	0.286074	Al	0.08	0.01
Si	23.01015	Si	6.88	0.04	Si	9.27907	Si	2.23	0.02	Si	23.56105	Si	6.6	0.04
P	0	P	0	0	P	0.081395	P	0.02	0.01	P	0	P	0	0
S	0	S	0	0	S	0.151163	S	0.04	0.01	S	0	S	0	0
K	0.033822	K	0.01	0.01	K	0.069767	K	0.02	0.01	K	0	K	0	0
Ca	7.880496	Ca	3.36	0.04	Ca	0.674419	Ca	0.23	0.01	Ca	9.63497	Ca	3.85	0.04
Ti	0.349493	Ti	0.18	0.02	Ti	0.744186	Ti	0.3	0.02	Ti	0.102987	Ti	0.05	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0.045772	Cr	0.02	0.02
Mn	0.157835	Mn	0.09	0.03	Mn	0.069767	Mn	0.04	0.02	Mn	0.766678	Mn	0.42	0.03
Fe	4.802706	Fe	2.85	0.06	Fe	25.11628	Fe	11.99	0.1	Fe	8.605104	Fe	4.79	0.07
Ni	0.157835	Ni	0.1	0.04	Ni	0.151163	Ni	0.07	0.04	Ni	0	Ni	0	0
Total	100	Total	25.3		Total	100	Total	23.9		Total	100	Total	25.3	

Site 9					Site 9					Site 10				
Spectrum 34	Atomic %	Spectrum 34	Wt%	Wt% Sigma	Spectrum 35	Atomic %	Spectrum 35	Wt%	Wt% Sigma	Spectrum 36	Atomic %	Spectrum 36	Wt%	Wt% Sigma
O	48.79908	O	5.86	0.05	O	49.29401	O	7.46	0.09	O	51.73706	O	8.22	0.08
Na	0.150115	Na	0.03	0.02	F	4.554771	F	0.82	0.04	Na	0.408719	Na	0.09	0.01
Mg	0.508083	Mg	0.09	0.01	Na	0.182191	Na	0.04	0.01	Mg	4.439146	Mg	1.07	0.02
Al	0.681293	Al	0.14	0.01	Mg	0	Mg	0	0	Al	0.261126	Al	0.07	0.01
Si	0	Si	0	0	Al	0	Al	0	0	Si	23.84196	Si	6.65	0.04
P	0	P	0	0	Si	0.387156	Si	0.1	0.01	P	0	P	0	0
S	0	S	0	0	P	16.64769	P	4.87	0.04	S	0	S	0	0
K	0	K	0	0	S	0	S	0	0	K	0	K	0	0
Ca	0	Ca	0	0	K	0.034161	K	0.01	0.01	Ca	9.763851	Ca	3.89	0.04
Ti	9.630485	Ti	3.46	0.04	Ca	28.046	Ca	10.63	0.06	Ti	0.06812	Ti	0.03	0.02
Cr	0	Cr	0	0	Ti	0.079708	Ti	0.04	0.02	Cr	0.06812	Cr	0.03	0.02
Mn	1.073903	Mn	0.44	0.03	Cr	0	Cr	0	0	Mn	0.817439	Mn	0.45	0.03
Fe	39.15704	Fe	16.41	0.11	Mn	0	Mn	0	0	Fe	8.514986	Fe	4.72	0.07
Ni	0	Ni	0	0	Fe	0.774311	Fe	0.41	0.03	Ni	0	Ni	0	0
Total	100	Total	26.43		Ni	0	Ni	0	0	Ba	0.079473	Ba	0.11	0.05
					Total	100	Total	24.38		Total	100	Total	25.33	

Site 10					Site 11					Site 11				
Spectrum 37	Atomic %	Spectrum 37	Wt%	Wt% Sigma	Spectrum 38	Atomic %	Spectrum 38	Wt%	Wt% Sigma	Spectrum 39	Atomic %	Spectrum 39	Wt%	Wt% Sigma
O	52.42873	O	8.44	0.07	O	51.61401	O	6.88	0.05	O	55.19308	O	9.85	0.07
Na	0.399088	Na	0.09	0.01	Na	0	Na	0	0	Na	5.913545	Na	1.52	0.02
Mg	4.321551	Mg	1.06	0.02	Mg	5.479609	Mg	1.11	0.02	Mg	0	Mg	0	0
Al	0.307868	Al	0.08	0.01	Al	0.068926	Al	0.02	0.01	Al	10.84726	Al	3.27	0.03
Si	23.53478	Si	6.65	0.04	Si	17.13957	Si	4.01	0.03	Si	25.41787	Si	7.96	0.04
P	0	P	0	0	P	0.045951	P	0.01	0.01	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	0	K	0	0	K	0	K	0	0	K	0.368876	K	0.16	0.01
Ca	9.521095	Ca	3.84	0.04	Ca	0.19529	Ca	0.07	0.01	Ca	2.051873	Ca	0.92	0.02
Ti	0.068415	Ti	0.04	0.02	Ti	0	Ti	0	0	Ti	0	Ti	0	0
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0.786773	Mn	0.43	0.03	Mn	1.504882	Mn	0.69	0.03	Mn	0.057637	Mn	0.03	0.02
Fe	8.631699	Fe	4.85	0.07	Fe	23.95175	Fe	11.15	0.1	Fe	0.149856	Fe	0.09	0.03
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	25.48		Total	100	Total	23.94		Total	100	Total	23.8	

Site 11					Site 11				
Spectrum 40	Atomic %	Spectrum 40	Wt%	Wt% Sigma	Spectrum 41	Atomic %	Spectrum 41	Wt%	Wt% Sigma
O	49.44771	O	7.23	0.05	O	55.63218	O	8.59	0.06
Na	0.12926	Na	0.03	0.02	Na	0	Na	0	0
Mg	6.451234	Mg	1.43	0.02	Mg	4.390805	Mg	1.03	0.02
Al	0	Al	0	0	Al	0.310345	Al	0.08	0.05
Si	16.59224	Si	4.26	0.03	Si	16.28736	Si	4.42	0.03
P	0	P	0	0	P	0.137931	P	0.04	0.01
S	0	S	0	0	S	0	S	0	0
K	0	K	0	0	K	0	K	0	0
Ca	0.188014	Ca	0.07	0.01	Ca	0.229885	Ca	0.09	0.01
Ti	0	Ti	0	0	Ti	0.16092	Ti	0.08	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	1.527615	Mn	0.77	0.04	Mn	1.241379	Mn	0.66	0.04
Fe	25.66392	Fe	13.1	0.11	Fe	21.49425	Fe	11.59	0.11
Ni	0	Ni	0	0	Ni	0.114943	Ni	0.06	0.04
Total	100	Total	26.89		Br	0	Br	0	0
					Total	100	Total	26.64	

H3. HS-15-04d

Site 1					Site 1					Site 2				
Spectra 1					Spectra 2					Spectra 1				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	55.37622	O	41.26	0.25	O	59.03173	O	39	0.22	O	59.9856	O	45.125	0.26
Na	5.306549	Na	5.681	0.07	Mg	1.084893	Mg	1.0941	0.04	Na	0.444071	Na	0.4786	0.03
Al	9.138412	Al	11.482	0.09	Al	3.959859	Al	4.4118	0.05	Al	2.592415	Al	3.2947	0.05
Si	27.02044	Si	35.34	0.21	Si	22.82343	Si	26.471	0.15	Si	34.94959	Si	46.149	0.26
K	2.484905	K	4.5142	0.07	K	0.678058	K	1.0941	0.04	K	0.348056	K	0.6345	0.04
Ca	0.452856	Ca	0.8396	0.05	Ca	1.044209	Ca	1.7294	0.05	Ca	0.132021	Ca	0.256	0.04
Fe	0.13934	Fe	0.3598	0.08	Ti	0.108489	Ti	0.2235	0.05	Fe	1.548248	Fe	4.0628	0.12
Ba	0.081282	Ba	0.5234	0.12	Fe	11.26932	Fe	25.976	0.21	Total	100	Total	100	
Total	100	Total	100		Total	100	Total	100						

Site 2				Site 2				Site 3			
Spectra 2		Spectra 3		Spectra 1		Spectra 2		Spectra 3		Spectra 1	
Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma
O 48.95	O 41.637	0.24		Fe 16.09565	Fe 30.462	0.21		O 51.14	O 42.39	0.22	
Si 22.91	Si 34.214	0.2		O 59.89883	O 32.488	0.2		Si 32.66	Si 47.53	0.23	
Fe 0.6	Fe 1.7824	0.1		Ti 17.55576	Ti 28.499	0.17		Total 100	Total 100		
K 4.17	K 8.673	0.09		Zr 0.919752	Zr 2.8541	0.12					
Al 7.27	Al 10.434	0.09		Mn 0.471373	Mn 0.87	0.08					
Na 2.24	Na 2.7388	0.05		Si 3.104162	Si 2.9602	0.05					
Ca 0.24	Ca 0.5217	0.05		Mg 0.689814	Mg 0.5729	0.04					
Total 100	Total 100			Al 0.919752	Al 0.8382	0.04					
				K 0.252932	K 0.3289	0.03					
				Ca 0.091975	Ca 0.1273	0.03					
				Total 100	Total 100						

Site 3				Site 3				Site 4			
Spectra 2		Spectra 3		Spectra 1		Spectra 2		Spectra 3		Spectra 1	
Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma
O 54.88212	O 40.731	0.24		O 54.58294	O 26.165	0.15		O 55.42344	O 38.852	0.23	
Na 4.148132	Na 4.4194	0.06		Al 0.43591	Al 0.3511	0.04		Na 1.796803	Na 1.8005	0.04	
Al 9.019128	Al 11.293	0.09		Si 0.43591	Si 0.3724	0.03		Mg 3.038711	Mg 3.2269	0.05	
Si 28.19173	Si 36.736	0.21		Ti 5.914232	Ti 8.4912	0.09		Al 7.636412	Al 9.0261	0.08	
K 3.758897	K 6.8204	0.08		Mn 0.471254	Mn 0.7768	0.08		Si 24.52107	Si 30.177	0.17	
Total 100	Total 100			Fe 38.15975	Fe 63.843	0.21		K 0.317083	K 0.5495	0.04	
				Total 100	Total 100			Ca 2.008191	Ca 3.5309	0.06	
								Ti 0.118906	Ti 0.2572	0.05	
								Fe 5.139384	Fe 12.58	0.16	
								Total 100	Total 100		

Site 5				Site 5				Site 5			
Spectra 1		Spectra 2		Spectra 3		Spectra 1		Spectra 2		Spectra 3	
Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma
O 60.91817	O 47.152	0.22		O 58.73101	O 42.489	0.25		O 55.24546	O 40.918	0.24	
Na 0.713606	Na 0.7883	0.04		Mg 1.039723	Mg 1.1455	0.04		Na 3.799597	Na 4.0448	0.06	
Al 1.129876	Al 1.4655	0.04		Al 11.9968	Al 14.632	0.1		Al 8.8321	Al 11.025	0.09	
Si 37.23834	Si 50.594	0.22		Si 23.02053	Si 29.239	0.18		Si 27.99821	Si 36.403	0.2	
Total 100	Total 100			K 0.253266	K 0.4487	0.04		K 3.956512	K 7.1718	0.09	
				Ca 0.533191	Ca 0.9565	0.04		Fe 0.168124	Fe 0.4376	0.08	
				Ti 0.279925	Ti 0.6023	0.05		Total 100	Total 100		
				Fe 4.145561	Fe 10.487	0.16					
				Total 100	Total 100						

Site 5				Site 5				Site 6			
Spectra 4		Spectra 5		Spectra 1		Spectra 4		Spectra 5		Spectra 1	
Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma
O 55.94923	O 38.921	0.23		O 61.37273	O 47.507	0.22		O 55.46588	O 40.664	0.23	
Mg 1.308831	Mg 1.3783	0.04		Si 38.62727	Si 52.493	0.23		Na 3.121662	Na 3.2866	0.05	
Al 11.18456	Al 13.118	0.1		Total 100	Total 100			Al 13.87537	Al 17.161	0.11	
Si 24.16711	Si 29.518	0.17						Si 21.67359	Si 27.892	0.16	
K 0.304072	K 0.5256	0.04						K 0.154303	K 0.2647	0.03	
Ca 0.700687	Ca 1.2148	0.05						Ca 5.388724	Ca 9.904	0.1	
Ti 0.542041	Ti 1.1447	0.06						Fe 0.320475	Fe 0.8272	0.08	
Fe 5.843469	Fe 14.181	0.17						Total 100	Total 100		
Total 100	Total 100										

Site 6				Site 6				Site 6			
Spectra 2		Spectra 3		Spectra 4		Spectra 2		Spectra 3		Spectra 4	
Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma	Atomic %	Wt%	Wt%	Sigma
K 0.1	K 0.18	0.04		K 0.11	K 0.2	0.04		K 0.12	K 0.23	0.03	
Na 3.34	Na 3.6	0.06		Na 2.93	Na 3.31	0.06		Na 2.65	Na 3	0.05	
Fe 0.17	Fe 0.43	0.08		Fe 0.16	Fe 0.43	0.08		Fe 0.23	Fe 0.63	0.08	
Ca 4.34	Ca 8.17	0.09		Ca 3.99	Ca 7.87	0.09		Ca 4.6	Ca 9.08	0.1	
Al 13.2	Al 16.71	0.1		Al 11.75	Al 15.6	0.11		Al 11.77	Al 15.63	0.11	
Si 20.66	Si 27.23	0.12		Si 18.2	Si 25.14	0.16		Si 18.4	Si 25.44	0.16	
O 58.2	O 43.69	0.16		O 52.54	O 41.34	0.24		O 46.84	O 36.89	0.23	
Total 100	Total 100			C 10.32	C 6.09	0.41		C 15.39	C 9.1	0.43	
				Total 100	Total 100			Total 100	Total 100		

Site 7					Site 7					Site 8				
Spectra 1					Spectra 2					Spectra 1				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	52.56154	O	33.257	0.18	O	52.95768	O	33.578	0.18	O	55.03426	O	39.031	0.23
Na	0.506419	Na	0.4663	0.04	Mg	4.430676	Mg	4.2675	0.05	Na	4.436186	Na	4.5178	0.06
Mg	4.381109	Mg	4.2073	0.05	Al	0.292261	Al	0.3133	0.03	Mg	1.428406	Mg	1.5421	0.04
Al	0.282652	Al	0.2928	0.03	Si	23.41595	Si	26.07	0.13	Al	7.525258	Al	9.003	0.08
Si	23.31881	Si	25.895	0.13	Ca	9.63292	Ca	15.309	0.11	Si	23.80676	Si	29.648	0.18
Ca	9.445295	Ca	14.975	0.11	Ti	0.116904	Ti	0.2161	0.05	P	0.2671	P	0.3584	0.04
Ti	0.16488	Ti	0.3036	0.05	Mn	0.748188	Mn	1.6422	0.09	K	0.545813	K	0.9448	0.04
Mn	0.871511	Mn	1.8976	0.09	Fe	8.405424	Fe	18.604	0.18	Ca	2.880037	Ca	5.1151	0.07
Fe	8.467789	Fe	18.705	0.18	Total	100	Total	100		Ti	0.661944	Ti	1.3901	0.06
Total	100	Total	100							Mn	0.116131	Mn	0.2824	0.07
										Fe	3.298107	Fe	8.1668	0.15
										Total	100	Total	100	
Site 8					Site 9					Site 9				
Spectra 2					Spectra 1					Spectra 2				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	55.04221	O	38.628	0.23	O	55.76015	O	41.776	0.25	O	49.76852	O	31.25	0.22
Na	3.787523	Na	3.818	0.06	Na	6.078848	Na	6.544	0.07	F	5	F	3.728	0.13
Mg	2.204503	Mg	2.3454	0.05	Al	9.324835	Al	11.788	0.09	Na	0.150463	Na	0.14	0.04
Al	6.695591	Al	7.9197	0.07	Si	26.49906	Si	34.857	0.2	Si	0.3125	Si	0.344	0.03
Si	23.44043	Si	28.864	0.17	K	1.522663	K	2.7762	0.06	P	16.66667	P	20.25	0.12
P	0.2697	P	0.3709	0.04	Ca	0.519358	Ca	0.9695	0.05	Cl	0.162037	Cl	0.226	0.03
K	0.504221	K	0.8618	0.04	Fe	0.153447	Fe	0.4186	0.08	Ca	27.7662	Ca	43.68	0.2
Ca	3.224672	Ca	5.6725	0.08	Ba	0.141643	Ba	0.8703	0.12	Fe	0.173611	Fe	0.387	0.09
Ti	0.914634	Ti	1.9308	0.07	Total	100	Total	100		Total	100	Total	100	
Mn	0.175891	Mn	0.4254	0.07										
Fe	3.740619	Fe	9.1633	0.15										
Total	100	Total	100											
0														
Site 9					Site 9					Site 10				
Spectra 3					Spectra 4					Spectra 1				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	50.87267	O	32.205	0.21	O	55.41504	O	41.451	0.25	O	55.64926	O	41.38	0.25
F	4.755769	F	3.5795	0.12	Na	6.162336	Na	6.6247	0.07	Na	4.886784	Na	5.217	0.06
Si	0.50369	Si	0.5623	0.03	Al	9.450448	Al	11.916	0.1	Al	9.068854	Al	11.37	0.09
P	16.41092	P	20.104	0.12	Si	26.60382	Si	34.934	0.21	Si	26.87153	Si	35.08	0.2
Ca	27.45695	Ca	43.549	0.19	K	1.586572	K	2.9058	0.06	K	2.865065	K	5.206	0.07
Total	100	Total	100		Ca	0.528857	Ca	0.9975	0.05	Ca	0.450555	Ca	0.826	0.05
					Fe	0.114969	Fe	0.2819	0.08	Fe	0.115527	Fe	0.315	0.08
					Ba	0.137963	Ba	0.8891	0.13	Ba	0.092421	Ba	0.609	0.12
					Total	100	Total	100		Total	100	Total	100	
Site 10					Site 10					Site 11				
Spectra 2					Spectra 3					Spectra 1				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	52.93978	O	25.067	0.15	O	53.1276	O	25.213	0.15	O	55.57379	O	41.407	0.24
Al	0.629528	Al	0.5013	0.04	Al	0.534125	Al	0.4266	0.04	Na	4.79428	Na	5.1403	0.06
Si	0.213802	Si	0.1813	0.03	Si	0.356083	Si	0.2986	0.03	Al	12.1205	Al	15.235	0.11
Ti	8.967811	Ti	12.715	0.11	Ti	8.937685	Ti	12.703	0.11	Si	23.73696	Si	31.05	0.18
Mn	0.938354	Mn	1.5253	0.09	Mn	0.985163	Mn	1.5998	0.09	K	0.199273	K	0.3617	0.04
Fe	36.31073	Fe	60.011	0.21	Fe	35.90504	Fe	59.46	0.22	Ca	3.422811	Ca	6.4007	0.08
Total	100	Total	100		Zn	0.154303	Zn	0.2986	0.1	Fe	0.152385	Fe	0.4055	0.08
					Total	100	Total	100		Total	100	Total	100	
Site 11														
Spectra 2														
	Atomic %		Wt%	Wt% Sigma										
O	55.33902	O	41.144	0.24										
Na	4.670203	Na	4.9924	0.06										
Al	12.37315	Al	15.509	0.11										
Si	23.6047	Si	30.812	0.18										
K	0.184502	K	0.3364	0.04										
Ca	3.7131	Ca	6.9134	0.08										
Fe	0.115314	Fe	0.293	0.08										
Total	100	Total	100											

H4. HS-15-04e

Site 1					Site 1					Site 1				
Spectra 1					Spectra 2					Spectra 3				
Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma	
O	60.6772	O	46.78	0.21	O	53.46	O	43.55	0.21	O	56.2507	O	42.02	0.24
Si	39.3228	Si	53.22	0.22	Si	34.21	Si	48.91	0.22	Na	4.096627	Na	4.392	0.06
Total	100	Total	100		Total	100	Total	100		Al	7.85929	Al	9.911	0.09
										Si	28.33129	Si	37.17	0.21
										K	2.838695	K	5.179	0.07
										Ca	0.411889	Ca	0.766	0.05
										Fe	0.211511	Fe	0.564	0.09
										Total	100	Total	100	

Site 1					Site 1					Site 2				
Spectra 4					Spectra 5					Spectra 1				
Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma	
O	56.59876	O	42.3	0.25	O	61.09832	O	47.22	0.22	O	55.61259	O	39.33	0.23
Na	3.266165	Na	3.509	0.06	Si	38.90168	Si	52.78	0.23	Na	3.49076	Na	3.556	0.06
Al	6.698406	Al	8.449	0.08	Total	100	Total	100		Mg	1.74538	Mg	1.88	0.04
Si	30.14836	Si	39.55	0.22						Al	7.209674	Al	8.606	0.08
K	2.767936	K	5.057	0.07						Si	23.04358	Si	28.61	0.17
Ca	0.298937	Ca	0.562	0.05						P	0.616016	P	0.849	0.04
Fe	0.221435	Fe	0.572	0.09						S	0.091262	S	0.14	0.03
Total	100	Total	100							K	0.593201	K	1.021	0.04
										Ca	3.582021	Ca	6.339	0.08
										Ti	0.604609	Ti	1.279	0.06
										Mn	0.125485	Mn	0.29	0.07
										Fe	3.285421	Fe	8.101	0.15
										Total	100	Total	100	

Site 2					Site 2					Site 2				
Spectra 2					Spectra 3					Spectra 4				
Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma	
O	61.88179	O	48.05	0.22	O	62.18754	O	48.36	0.22	O	53.11936	O	32.25	0.18
Si	38.11821	Si	51.95	0.22	Si	37.81246	Si	51.64	0.22	Mg	1.237432	Mg	1.143	0.04
Total	100	Total	100		Total	100	Total	100		Al	0.373808	Al	0.373	0.03
										Si	23.45965	Si	25	0.13
										Ca	8.210879	Ca	12.49	0.1
										Ti	0.128899	Ti	0.226	0.05
										Mn	1.044084	Mn	2.184	0.09
										Fe	12.42588	Fe	26.33	0.2
										Total	100	Total	100	

Site 2					Site 3					Site 3				
Spectra 5					Spectra 1					Spectra 2				
Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma	
O	55.93644	O	41.78	0.24	Na	8.271335	Na	6.638	0.06	O	54.78114	O	38.48	0.23
Na	4.347333	Na	4.669	0.06	Al	19.16849	Al	18.05	0.08	Na	3.984287	Na	4.023	0.06
Al	8.694665	Al	10.95	0.09	Si	62.75711	Si	61.54	0.14	Mg	1.447811	Mg	1.543	0.04
Si	27.52554	Si	36.09	0.2	K	8.533917	K	11.66	0.08	Al	7.418631	Al	8.781	0.08
K	2.996595	K	5.465	0.07	Ca	0.700219	Ca	0.982	0.05	Si	23.81594	Si	29.37	0.17
Ca	0.340522	Ca	0.635	0.05	Fe	0.568928	Fe	1.131	0.1	P	0.415264	P	0.564	0.04
Fe	0.15891	Fe	0.409	0.08	Total	100	Total	100		K	0.628507	K	1.075	0.04
Total	100	Total	100							Ca	2.91807	Ca	5.13	0.07
										Ti	0.695847	Ti	1.469	0.06
										Mn	0.145903	Mn	0.362	0.08
										Fe	3.748597	Fe	9.207	0.16
										Total	100	Total	100	

Site 3					Site 4					Site 4				
Spectra 3					Spectra 1					Spectra 2				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
O	55.68889	O	39.57	0.23	O	53.69994	O	34.19	0.19	O	51.44166	O	32.4	0.22
Na	3.366667	Na	3.432	0.06	Mg	4.411237	Mg	4.265	0.05	F	3.911489	F	2.924	0.12
Mg	2.3	Mg	2.479	0.05	Al	0.274955	Al	0.295	0.03	Si	0.447027	Si	0.496	0.03
Al	6.633333	Al	7.944	0.08	Si	22.89301	Si	25.59	0.13	P	16.3165	P	19.9	0.12
Si	24.36667	Si	30.4	0.18	Ca	9.38434	Ca	14.97	0.11	Ca	27.44747	Ca	43.32	0.2
P	0.255556	P	0.35	0.04	Ti	0.143455	Ti	0.273	0.05	Fe	0.435852	Fe	0.961	0.1
K	0.522222	K	0.911	0.04	Mn	0.765093	Mn	1.684	0.09	Total	100	Total	100	
Ca	2.844444	Ca	5.074	0.07	Fe	8.427974	Fe	18.73	0.18					
Ti	0.377778	Ti	0.805	0.06	Total	100	Total	100						
Mn	0.166667	Mn	0.402	0.08										
Fe	3.477778	Fe	8.633	0.16										
Total	100	Total	100											

Site 4					Site 4					Site 5				
Spectra 3					Spectra 4					Spectra 1				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
O	52.21357	O	32.73	0.18	O	56.15331	O	41.94	0.25	O	55.42419	O	41.45	0.24
Mg	4.244709	Mg	4.044	0.05	Na	5.148926	Na	5.531	0.07	Na	6.097427	Na	6.551	0.07
Al	0.255412	Al	0.275	0.03	Al	9.351189	Al	11.78	0.09	Al	9.512863	Al	12.01	0.1
Si	23.47361	Si	25.83	0.13	Si	26.36804	Si	34.58	0.2	Si	26.64477	Si	34.99	0.2
Ca	9.973243	Ca	15.66	0.11	K	2.054953	K	3.749	0.06	K	1.488779	K	2.728	0.06
Ti	0.14595	Ti	0.275	0.05	Ca	0.646502	Ca	1.217	0.05	Ca	0.580186	Ca	1.095	0.05
Mn	0.839212	Mn	1.807	0.09	Fe	0.150081	Fe	0.38	0.08	Fe	0.109469	Fe	0.274	0.08
Fe	8.854293	Fe	19.38	0.19	Ba	0.126991	Ba	0.826	0.12	Ba	0.14231	Ba	0.906	0.13
Total	100	Total	100		Total	100	Total	100		Total	100	Total	100	

Site 5					Site 5					Site 5				
Spectra 2					Spectra 3					Spectra 4				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
O	16.38847	O	4.723	0.07	O	52.89945	O	33.57	0.19	O	53.14662	O	33.64	0.19
Fe	2.048558	Fe	2.062	0.1	Na	0.43914	Na	0.392	0.04	Mg	4.274861	Mg	4.116	0.06
Cu	81.56297	Cu	93.22	0.28	Mg	4.290057	Mg	4.134	0.06	Al	0.283479	Al	0.308	0.03
Total	100	Total	100		Al	0.36032	Al	0.382	0.03	Si	23.27928	Si	25.87	0.13
					Si	23.35323	Si	26.02	0.13	Ca	9.422837	Ca	14.94	0.11
					Ca	9.221934	Ca	14.67	0.11	Ti	0.124731	Ti	0.234	0.05
					Ti	0.15764	Ti	0.297	0.05	Mn	0.771062	Mn	1.67	0.09
					Mn	0.7319	Mn	1.601	0.09	Fe	8.697131	Fe	19.22	0.19
					Fe	8.546335	Fe	18.93	0.19	Total	100	Total	100	
					Total	100	Total	100						

Site 5					Site 5					Site 5				
Spectra 5					Spectra 6					Spectra 7				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
O	52.66659	O	33.29	0.19	O	53.60143	O	34.18	0.19	O	19.78435	O	5.898	0.08
Mg	4.457257	Mg	4.29	0.06	Mg	4.413577	Mg	4.283	0.06	Si	0.325978	Si	0.174	0.03
Al	0.277193	Al	0.294	0.03	Si	23.37851	Si	26.17	0.13	S	0.300903	S	0.174	0.03
Si	23.56137	Si	26.15	0.13	Ca	9.577686	Ca	15.29	0.11	Ca	0.351053	Ca	0.254	0.04
Ca	9.601951	Ca	15.21	0.11	Mn	0.750532	Mn	1.65	0.09	Fe	2.081244	Fe	2.18	0.1
Ti	0.099789	Ti	0.189	0.05	Fe	8.278257	Fe	18.42	0.19	Cu	77.15647	Cu	91.32	0.28
Mn	0.742876	Mn	1.609	0.09	Total	100	Total	100		Total	100	Total	100	
Fe	8.59297	Fe	18.97	0.19										
Total	100	Total	100											

Site 6					Site 6					Site 6				
Spectra 1					Spectra 2					Spectra 3				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
Na	13.72592	Na	11.3	0.07	O	50.64791	O	31.46	0.22	O	57.28465	O	41.86	0.25
Al	21.27846	Al	20.59	0.09	F	3.488758	F	2.573	0.16	Na	1.483172	Na	1.562	0.04
Si	60.17951	Si	60.58	0.14	Si	0.343338	Si	0.368	0.03	Al	5.464917	Al	6.733	0.07
K	3.305604	K	4.625	0.06	P	16.82357	P	20.23	0.13	Si	30.30234	Si	38.88	0.22
Ca	1.291594	Ca	1.85	0.05	Ca	28.36416	Ca	44.14	0.21	K	3.502567	K	6.259	0.08
Ba	0.218914	Ba	1.06	0.14	Fe	0.177207	Fe	0.378	0.09	Ca	0.319452	Ca	0.582	0.05
Total	100	Total	100		Ce	0.155056	Ce	0.851	0.15	Ti	0.11409	Ti	0.237	0.05
					Total	100	Total	100		Fe	1.528808	Fe	3.889	0.12
										Total	100	Total	100	

Site 7					Site 7					Site 7				
Spectra 1					Spectra 2					Spectra 3				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
O	49.61127	O	22.61	0.14	O	55.72981	O	41.85	0.24	O	51.06023	O	32.58	0.21
Al	0.709859	Al	0.543	0.04	Na	6.071469	Na	6.546	0.07	F	4.252199	F	3.226	0.12
Ti	9.509859	Ti	12.97	0.11	Al	9.398454	Al	11.91	0.09	Na	0.518836	Na	0.478	0.04
Mn	1.025352	Mn	1.607	0.09	Si	26.60468	Si	35.06	0.2	Al	0.744417	Al	0.806	0.03
Fe	39.14366	Fe	62.27	0.21	K	1.411448	K	2.584	0.06	Si	2.165576	Si	2.419	0.04
Total	100	Total	100		Ca	0.649714	Ca	1.228	0.05	P	15.24927	P	18.83	0.12
					Ba	0.134424	Ba	0.833	0.12	Ca	25.85157	Ca	41.32	0.19
					Total	100	Total	100		Fe	0.157907	Fe	0.34	0.09
										Total	100	Total	100	

Site 8					Site 8					Site 8				
Spectra 1					Spectra 2					Spectra 3				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
O	52.64849	O	32.99	0.18	O	51.05384	O	32.35	0.22	O	54.26	O	40.15	0.16
Mg	4.000443	Mg	3.804	0.05	F	4.029704	F	3.027	0.13	Na	4.96	Na	5.27	0.07
Si	23.58156	Si	25.92	0.13	Na	0.207492	Na	0.188	0.04	Al	12.33	Al	15.39	0.09
Ca	9.507979	Ca	14.91	0.11	Al	0.644316	Al	0.689	0.03	Si	24.59	Si	31.94	0.13
Ti	0.132979	Ti	0.252	0.05	Si	1.299552	Si	1.451	0.04	K	0.23	K	0.41	0.04
Mn	0.85328	Mn	1.828	0.09	P	15.86764	P	19.47	0.12	Ca	3.48	Ca	6.45	0.08
Fe	9.275266	Fe	20.29	0.19	Ca	26.70088	Ca	42.38	0.19	Fe	0.15	Fe	0.39	0.09
Total	100	Total	100		Fe	0.196571	Fe	0.449	0.09	Total	100	Total	100	
					Total	100	Total	100						

Site 9					Site 9					Site 9				
Spectra 1					Spectra 2					Spectra 3				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
O	54.26543	O	40.3	0.17	O	54.02	O	40.11	0.17	O	59.78162	O	45.6	0.27
Na	6.230623	Na	6.65	0.07	Na	6.28	Na	6.7	0.07	Na	0.568699	Na	0.626	0.04
Al	9.620962	Al	12.05	0.09	Al	9.65	Al	12.08	0.09	Al	1.262511	Al	1.618	0.04
Si	27.45275	Si	35.79	0.14	Si	27.65	Si	36.04	0.15	Si	37.63649	Si	50.39	0.29
K	1.60016	K	2.91	0.06	K	1.59	K	2.88	0.06	K	0.307097	K	0.583	0.04
Ca	0.570057	Ca	1.06	0.05	Ca	0.55	Ca	1.03	0.05	Fe	0.443585	Fe	1.187	0.1
Fe	0.110011	Fe	0.29	0.09	Fe	0.13	Fe	0.34	0.09	Total	100	Total	100	
Ba	0.150015	Ba	0.95	0.14	Ba	0.13	Ba	0.82	0.14					
Total	100	Total	100		Total	100	Total	100						

Site 9					Site 10					Site 10				
Spectra 4					Spectra 1					Spectra 2				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
Na	13.31587	Na	10.9	0.07	O	55.18681	O	40.38	0.22	O	54.92896	O	40.13	0.22
Al	21.19625	Al	20.36	0.09	Na	3.098901	Na	3.258	0.05	Na	3.039982	Na	3.198	0.05
Si	59.81227	Si	59.84	0.15	Al	14.03297	Al	17.31	0.11	Mg	0.110144	Mg	0.116	0.03
K	3.841956	K	5.341	0.07	Si	21.73626	Si	27.92	0.16	Al	14.09847	Al	17.38	0.11
Ca	1.331587	Ca	1.909	0.06	K	0.10989	K	0.19	0.04	Si	21.78654	Si	27.95	0.16
Fe	0.261952	Fe	0.536	0.09	Ca	5.494505	Ca	10.07	0.1	K	0.110144	K	0.201	0.04
Ba	0.240122	Ba	1.122	0.14	Fe	0.340659	Fe	0.875	0.09	Ca	5.672431	Ca	10.38	0.1
Total	100	Total	100		Total	100	Total	100		Fe	0.253332	Fe	0.644	0.09
										Total	100	Total	100	

Site 10					Site 11					Site 11				
Spectra 3					Spectra 1					Spectra 2				
	Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma		Atomic %	Wt%	Wt% Sigma			
O	59.95293	O	45.29	0.23	O	49.97738	O	31.06	0.22	O	49.37619	O	22.45	0.14
Na	2.000392	Na	2.163	0.03	F	4.603031	F	3.396	0.16	Al	0.764303	Al	0.584	0.04
Al	6.236517	Al	7.926	0.06	Si	0.373219	Si	0.414	0.03	Ti	9.508823	Ti	12.95	0.11
Si	27.80937	Si	36.87	0.18	P	16.53472	P	19.9	0.12	Mn	0.831741	Mn	1.303	0.09
Cl	0.176505	Cl	0.309	0.02	Ca	27.71997	Ca	43.16	0.21	Fe	39.51894	Fe	62.72	0.2
K	2.941753	K	5.423	0.06	Mn	0.124406	Mn	0.255	0.08	Total	100	Total	100	
Ca	0.313787	Ca	0.603	0.03	Fe	0.542864	Fe	1.167	0.1					
Ti	0.137282	Ti	0.294	0.04	Ce	0.124406	Ce	0.647	0.14					
Fe	0.431457	Fe	1.128	0.07	Total	100	Total	100						
Total	100	Total	100											

Site 11					Site 11					Site 11				
Spectra 3					Spectra 4					Spectra 5				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	50.28921	O	23.26	0.15	O	52.6652	O	33.38	0.19	O	50.24981	O	31.26	0.22
Al	0.941363	Al	0.733	0.04	Na	0.473568	Na	0.43	0.04	F	4.607527	F	3.407	0.16
Si	0.703187	Si	0.565	0.04	Mg	4.394273	Mg	4.225	0.06	Si	0.488509	Si	0.526	0.03
Ca	0.249518	Ca	0.283	0.04	Al	0.27533	Al	0.294	0.03	P	16.39836	P	19.76	0.12
Ti	8.699104	Ti	12.04	0.11	Si	23.2489	Si	25.86	0.14	Ca	27.43422	Ca	42.77	0.21
Mn	0.91868	Mn	1.455	0.09	Ca	9.548458	Ca	15.16	0.11	Fe	0.677251	Fe	1.483	0.1
Fe	38.19893	Fe	61.67	0.21	Sc	0.121145	Sc	0.21	0.06	Ce	0.144332	Ce	0.799	0.15
Total	100	Total	100		Ti	0.110132	Ti	0.21	0.05	Total	100	Total	100	
					Mn	0.726872	Mn	1.583	0.09					
					Fe	8.436123	Fe	18.65	0.19					
					Total	100	Total	100						

H5. HS-15-05

Site 1					Site 1					Site 1				
Spectra 1					Spectra 2					Spectra 3				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	61.21870572	O	47.35	0.22	O	54.45455	O	40.4	0.16	O	55.38291	O	41.31	0.24
Si	38.78129428	Si	52.65	0.22	Na	5.279472	Na	5.621	0.07	Na	5.138735	Na	5.51	0.07
Total	100	Total	100		Al	8.709129	Al	10.89	0.08	Al	8.557159	Al	10.76	0.09
					Si	28.0472	Si	36.53	0.14	Si	27.51387	Si	36.02	0.2
					K	3.269673	K	5.931	0.08	K	3.163152	K	5.764	0.08
					Fe	0.239976	Fe	0.62	0.09	Fe	0.244173	Fe	0.637	0.09
					Total	100	Total	100		Total	100	Total	100	

Site 1					Site 1					Site 1				
Spectra 4					Spectra 5					Spectra 6				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	61.85633	O	48.03	0.22	O	54.73086	O	26.3	0.15	O	50.67295	O	31.79	0.21
Al	0.368722	Al	0.475	0.03	Al	0.624095	Al	0.51	0.04	F	4.149843	F	3.098	0.12
Si	37.77495	Si	51.49	0.22	Si	0.144879	Si	0.125	0.03	Na	0.168237	Na	0.159	0.04
Total	100	Total	100		Ti	6.59757	Ti	9.486	0.1	Si	0.684163	Si	0.751	0.03
					Mn	0.557227	Mn	0.927	0.08	P	16.45357	P	19.98	0.12
					Fe	37.34537	Fe	62.65	0.21	Ca	27.17586	Ca	42.7	0.19
					Total	100	Total	100		Fe	0.695379	Fe	1.522	0.1
										Total	100	Total	100	

Site 1					Site 1					Site 1				
Spectra 7					Spectra 8					Spectra 9				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	49.54452	O	30.58	0.23	O	51.69367	O	32.68	0.21	O	58.34471	O	22.14	0.16
F	5.237987	F	3.842	0.16	F	4.497564	F	3.37	0.13	Si	1.737188	Si	1.154	0.06
Na	0.193578	Na	0.17	0.04	Si	0.453155	Si	0.5	0.03	S	18.99739	S	14.44	0.11
Si	0.478251	Si	0.521	0.03	P	15.96239	P	19.54	0.12	Ca	1.22844	Ca	1.165	0.05
P	16.22637	P	19.4	0.13	Ca	26.58888	Ca	42.11	0.19	Fe	0.40948	Fe	0.545	0.12
Ca	26.9187	Ca	41.64	0.22	Fe	0.668404	Fe	1.467	0.1	Sr	1.910907	Sr	3.965	0.16
Sc	0.193578	Sc	0.341	0.08	Zn	0.135947	Zn	0.34	0.08	Ba	17.37188	Ba	56.59	0.27
Mn	0.136643	Mn	0.298	0.08	Total	100	Total	100		Tb	0	Tb	0	0
Fe	0.785698	Fe	1.692	0.1						Total	100	Total	100	
Ce	0.182191	Ce	0.958	0.14										
Nd	0.102482	Nd	0.553	0.17										
Total	100	Total	100											

Site 1					Site 2					Site 2				
Spectra 10					Spectra 1					Spectra 2				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	55.97772	O	37.51	0.22	O	54.37	O	40.31	0.16	O	54.24778	O	25.76	0.15
Na	2.818942	Na	2.707	0.06	Na	5.35	Na	5.7	0.07	Ti	6.661416	Ti	9.464	0.1
Mg	2.551532	Mg	2.591	0.05	Al	11.96	Al	14.95	0.09	Mn	0.326319	Mn	0.533	0.08
Al	6.139276	Al	6.926	0.07	Si	24.71	Si	32.16	0.13	Fe	38.76449	Fe	64.24	0.21
Si	20.70195	Si	24.35	0.15	K	0.28	K	0.51	0.04	Total	100	Total	100	
S	0.200557	S	0.275	0.03	Ca	3.08	Ca	5.71	0.08					
K	0.37883	K	0.624	0.04	Fe	0.26	Fe	0.67	0.09					
Ca	1.805014	Ca	3.024	0.06	Total	100	Total	100						
Ti	0.111421	Ti	0.222	0.05										
Mn	0.200557	Mn	0.465	0.08										
Fe	9.114206	Fe	21.31	0.21										
Total	100	Total	100											

Site 2					Site 2					Site 2				
Spectra 3					Spectra 4					Spectra 5				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	55.75651	O	41.63	0.24	O	54.14926	O	25.57	0.15	O	58.23517	O	41.82	0.22
Na	5.326423	Na	5.711	0.07	Ti	4.866208	Ti	6.881	0.09	Na	0.289316	Na	0.299	0.03
Al	11.12704	Al	14.01	0.1	Mn	0.530654	Mn	0.868	0.09	Mg	2.459186	Mg	2.693	0.04
Si	23.94133	Si	31.38	0.18	Fe	40.45388	Fe	66.68	0.21	Al	5.083695	Al	6.158	0.05
S	0.319806	S	0.476	0.04	Total	100	Total	100		Si	24.9225	Si	31.42	0.16
K	0.220556	K	0.402	0.04						S	1.694565	S	2.441	0.04
Ca	3.04367	Ca	5.69	0.08						Cl	0.95061	Cl	1.512	0.03
Fe	0.264667	Fe	0.698	0.09						K	0.516636	K	0.914	0.03
Total	100	Total	100							Ca	2.603844	Ca	4.678	0.06
										Ti	0.247985	Ti	0.551	0.05
										Mn	0.454639	Mn	1.134	0.07
										Fe	2.541847	Fe	6.379	0.11
										Total	100	Total	100	

Site 3					Site 3					Site 3				
Spectra 1					Spectra 2					Spectra 3				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	56.72034	O	40.67	0.23	O	57.20603	O	41.43	0.24	O	48.83	O	26.43	0.15
Na	2.820601	Na	2.906	0.05	Na	2.403901	Na	2.499	0.05	Al	1.14	Al	1.044	0.04
Mg	1.22188	Mg	1.335	0.04	Mg	0.839097	Mg	0.923	0.04	Ti	6.47	Ti	10.48	0.11
Al	6.794564	Al	8.212	0.08	Al	6.769475	Al	8.271	0.08	V	0.29	V	0.501	0.07
Si	25.0314	Si	31.51	0.18	Si	25.89863	Si	32.92	0.19	Fe	32.57	Fe	61.55	0.21
K	2.22679	K	3.907	0.06	K	2.982198	K	5.278	0.07	Total	100	Total	100	
Ca	1.884207	Ca	3.38	0.07	Ca	1.485429	Ca	2.693	0.06					
Ti	0.502455	Ti	1.087	0.06	Ti	0.374192	Ti	0.815	0.06					
Mn	0.114194	Mn	0.269	0.07	Fe	2.041048	Fe	5.171	0.13					
Fe	2.683567	Fe	6.716	0.14	Total	100	Total	100						
Total	100	Total	100											

Site 3					Site 3					Site 3				
Spectra 4					Spectra 5					Spectra 6				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	56.54881	O	42.12	0.24	O	61.04431	O	47.16	0.21	O	57.36322	O	43.37	0.25
Na	3.69135	Na	3.942	0.06	Si	38.95569	Si	52.84	0.22	Na	4.694263	Na	5.099	0.07
Al	7.00467	Al	8.808	0.08	Total	100	Total	100		Al	6.281212	Al	8.01	0.08
Si	28.89704	Si	37.77	0.21						Si	29.76362	Si	39.49	0.22
K	3.424505	K	6.237	0.08						K	0.921096	K	1.689	0.05
Fe	0.433622	Fe	1.126	0.09						Ca	0.299634	Ca	0.563	0.04
Total	100	Total	100							Fe	0.67695	Fe	1.785	0.1
										Total	100	Total	100	

Site 3					Site 3					Site 4				
Spectra 7					Spectra 8					Spectra 1				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	55.54936	O	41.16	0.23	O	55.16891	O	38.88	0.23	O	54.42	O	40.48	0.17
Na	4.406023	Na	4.683	0.06	Na	3.163484	Na	3.195	0.06	Na	6.23	Na	6.66	0.07
Al	12.40379	Al	15.5	0.11	Mg	3.547622	Mg	3.794	0.06	Al	9.65	Al	12.1	0.09
Si	23.12326	Si	30.08	0.17	Al	7.761835	Al	9.222	0.08	Si	27.35	Si	35.71	0.15
K	0.189626	K	0.341	0.04	Si	21.62468	Si	26.76	0.16	K	1.59	K	2.9	0.06
Ca	4.04908	Ca	7.514	0.09	P	0.192069	P	0.267	0.04	Ca	0.51	Ca	0.94	0.05
Fe	0.278862	Fe	0.734	0.09	K	0.248559	K	0.438	0.04	Fe	0.11	Fe	0.28	0.09
Total	100	Total	100		Ca	3.999548	Ca	7.053	0.08	Ba	0.15	Ba	0.93	0.14
					Ti	0.463224	Ti	0.972	0.06	Total	100	Total	100	
					Mn	0.112982	Mn	0.289	0.07					
					Fe	3.717094	Fe	9.137	0.16					
					Total	100	Total	100						

Site 4					Site 4					Site 5				
Spectra 2					Spectra 3					Spectra 1				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	t% Sigma		Atomic %		Wt%	t% Sigma
O	54.26	O	40.27	0.17	O	54.204	O	26.262	0.16	O	55.631	O	40.635	0.2
Na	6.26	Na	6.68	0.07	Al	0.3372	Al	0.2822	0.03	Na	2.241	Na	2.3519	0.05
Al	9.65	Al	12.08	0.09	Si	0.1686	Si	0.1359	0.03	Al	15	Al	18.473	0.11
Si	27.43	Si	35.74	0.15	Ti	13.59	Ti	19.709	0.13	Si	20.541	Si	26.342	0.14
K	1.55	K	2.81	0.06	Mn	0.3822	Mn	0.6479	0.08	Ca	6.3964	Ca	11.706	0.1
Ca	0.58	Ca	1.07	0.05	Fe	31.317	Fe	52.963	0.21	Fe	0.1914	Fe	0.4918	0.08
Fe	0.11	Fe	0.28	0.09	Total	100	Total	100		Total	100	Total	100	
Ba	0.17	Ba	1.07	0.14										
Total	100	Total	100											

Site 5					Site 5					Site 5				
Spectra 2					Spectra 3					Spectra 4				
na	Atomic %		Wt%	t% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	55.6	O	40.66	0.2	O	57.13715	O	20.94	0.16	O	54.74387	O	37.95	0.22
Na	2.5117	Na	2.6409	0.05	Al	0.59976	Al	0.371	0.04	Na	2.600927	Na	2.585	0.05
Al	14.556	Al	17.948	0.1	Si	1.905904	Si	1.233	0.06	Mg	3.652607	Mg	3.845	0.06
Si	20.927	Si	26.862	0.14	S	18.7525	S	13.78	0.11	Al	7.452222	Al	8.716	0.08
Ca	6.1537	Ca	11.264	0.1	K	0.186592	K	0.175	0.04	Si	21.62162	Si	26.31	0.16
Fe	0.2512	Fe	0.6252	0.08	Ca	0.519792	Ca	0.469	0.05	P	0.214859	P	0.288	0.04
Total	100	Total	100		Fe	0.626416	Fe	0.797	0.11	K	0.158317	K	0.267	0.04
					Sr	1.3328	Sr	2.674	0.14	Ca	4.206717	Ca	7.317	0.08
					Ba	18.93909	Ba	59.57	0.3	Ti	0.621961	Ti	1.292	0.06
					Total	100	Total	100		Mn	0.101775	Mn	0.246	0.07
										Fe	4.625127	Fe	11.18	0.17
										Total	100	Total	100	

Site 6					Site 6					Site 6				
Spectra 1					Spectra 2					Spectra 3				
	Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma		Atomic %		Wt%	Wt% Sigma
O	58.12045	O	42.51	0.24	O	52.68215	O	35.48	0.19	O	53.40421	O	35.77	0.21
Na	1.757022	Na	1.846	0.05	Na	0.40032	Na	0.397	0.04	Na	0.373219	Na	0.352	0.04
Mg	1.398682	Mg	1.552	0.04	Mg	9.241679	Mg	9.459	0.08	Mg	8.052477	Mg	8.197	0.07
Al	7.085886	Al	8.74	0.08	Al	2.024477	Al	2.306	0.05	Al	2.838724	Al	3.209	0.05
Si	25.06069	Si	32.18	0.18	Si	22.0748	Si	26.09	0.13	Si	20.71929	Si	24.36	0.14
P	0.242747	P	0.337	0.04	Ca	8.23516	Ca	13.9	0.11	K	0.079168	K	0.128	0.03
K	2.358109	K	4.212	0.07	Ti	0.491822	Ti	0.987	0.06	Ca	8.584031	Ca	14.39	0.11
Ca	1.826378	Ca	3.355	0.07	Mn	0.183004	Mn	0.418	0.08	Ti	0.904773	Ti	1.812	0.07
Ti	0.624205	Ti	1.368	0.06	Fe	4.66659	Fe	10.96	0.16	Fe	5.044108	Fe	11.78	0.17
Fe	1.525835	Fe	3.898	0.12	Total	100	Total	100		Total	100	Total	100	
Total	100	Total	100											

Site 6					Site 6					Site 7				
Spectra 4					Spectra 5					Spectra 1				
	Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma
O	57.08174	O	40.39	0.23	O	54.0707	O	26.28	0.15	O	49.93797	O	31.54	0.21
Na	1.891466	Na	1.92	0.05	Mg	0.729761	Mg	0.536	0.04	F	5.582497	F	4.179	0.13
Mg	1.441117	Mg	1.557	0.04	Al	1.881414	Al	1.545	0.04	Si	0.383444	Si	0.424	0.03
Al	6.766494	Al	8.075	0.08	Si	0.216648	Si	0.189	0.03	P	16.49938	P	20.18	0.12
Si	24.0599	Si	29.9	0.17	Ti	6.72748	Ti	9.787	0.1	Ca	27.59671	Ca	43.67	0.19
K	2.251745	K	3.893	0.06	V	0.216648	V	0.336	0.07	Total	100	Total	100	
Ca	2.364332	Ca	4.203	0.07	Cr	0.125428	Cr	0.2	0.06					
Ti	0.562936	Ti	1.205	0.06	Mn	0.159635	Mn	0.273	0.08					
Mn	0.112587	Mn	0.277	0.07	Fe	35.87229	Fe	60.85	0.22					
Fe	3.467687	Fe	8.576	0.15	Total	100	Total	100						
Total	100	Total	100											
Site 7					Site 7					Site 7				
Spectra 2					Spectra 3					Spectra 4				
	Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma
O	54.3	O	40.48	0.16	O	50.16356	O	31.46	0.22	O	67.90777	O	53.11	0.26
Na	5.93	Na	6.35	0.07	F	5.267908	F	3.922	0.16	Na	1.339773	Na	1.514	0.04
Al	10.94	Al	13.76	0.09	Si	0.541455	Si	0.604	0.03	Mg	0.342733	Mg	0.412	0.02
Si	26	Si	34.03	0.14	P	16.28878	P	19.78	0.12	Al	6.496339	Al	8.563	0.06
K	0.76	K	1.39	0.05	Ca	27.58037	Ca	43.33	0.2	Si	20.40816	Si	28.01	0.15
Ca	1.91	Ca	3.57	0.07	Ce	0.157924	Ce	0.901	0.14	K	0.732201	K	1.407	0.04
Fe	0.16	Fe	0.41	0.09	Total	100	Total	100		Ca	0.685465	Ca	1.341	0.04
Total	100	Total	100							Ti	0.12463	Ti	0.292	0.04
										Fe	1.962923	Fe	5.351	0.11
										Total	100	Total	100	
Site 8					Site 8					Site 8				
Spectra 1					Spectra 2					Spectra 3				
	Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma
O	47.40671	O	33.92	0.22	O	50.68904	O	37.35	0.23	O	50.12967	O	36.69	0.22
F	5.303919	F	4.504	0.12	F	5.548232	F	4.86	0.12	F	5.718361	F	4.966	0.12
Mg	13.00164	Mg	14.15	0.11	Mg	11.76753	Mg	13.18	0.1	Mg	12.87604	Mg	14.33	0.1
Al	6.395212	Al	7.718	0.08	Al	6.482924	Al	8.055	0.08	Al	6.2889	Al	7.768	0.07
Si	21.68505	Si	27.24	0.17	Si	20.75494	Si	26.84	0.16	Si	19.38537	Si	24.91	0.15
Cl	0.117343	Cl	0.186	0.03	Cl	0.071899	Cl	0.122	0.03	K	3.215768	K	5.745	0.07
K	2.886646	K	5.051	0.07	K	2.348712	K	4.216	0.07	Ca	0.700207	Ca	1.291	0.05
Ca	1.091293	Ca	1.968	0.06	Ca	0.874775	Ca	1.62	0.05	Mn	0.103734	Mn	0.267	0.07
Mn	0.129078	Mn	0.306	0.08	Fe	1.461953	Fe	3.761	0.12	Fe	1.58195	Fe	4.035	0.11
Fe	1.983103	Fe	4.952	0.13	Total	100	Total	100		Total	100	Total	100	
Total	100	Total	100											
Site 8					Site 8					Site 9				
Spectra 4					Spectra 5					Spectra 1				
	Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma
O	51.65813	O	31.3	0.19	O	51.25342	O	23.3	0.13	O	55.67435	O	41.79	0.25
Mg	5.014829	Mg	4.622	0.06	Al	0.307657	Al	0.23	0.04	Na	6.058581	Na	6.544	0.07
Al	4.691291	Al	4.785	0.06	Si	0.524157	Si	0.419	0.04	Al	9.388573	Al	11.87	0.1
Si	19.89755	Si	21.17	0.13	Fe	47.91477	Fe	76.05	0.19	Si	26.65107	Si	35.1	0.21
Cl	0.202211	Cl	0.266	0.03	Total	100	Total	100		K	1.570331	K	2.873	0.06
K	1.482879	K	2.19	0.05						Ca	0.534581	Ca	1	0.05
Ca	0.606633	Ca	0.915	0.04						Ba	0.122508	Ba	0.819	0.13
Ti	0.121327	Ti	0.232	0.05						Total	100	Total	100	
Mn	0.18873	Mn	0.382	0.07										
Fe	16.13642	Fe	34.14	0.23										
Total	100	Total	100											
Site 9					Site 9					Site 10				
Spectra 2					Spectra 3					Spectra 1				
	Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma		Atomic %	Wt%	Wt%	Sigma
O	52.5867	O	24.59	0.13	O	53.8874	O	25.55	0.15	O	58.49	O	43.74	0.17
Al	0.625355	Al	0.494	0.03	Si	0.163189	Si	0.138	0.03	Na	1.16	Na	1.25	0.05
Si	1.691302	Si	1.389	0.04	Ti	7.250262	Ti	10.28	0.1	Al	6.22	Al	7.85	0.07
Ca	0.142126	Ca	0.172	0.03	Mn	0.594475	Mn	0.964	0.08	Si	30.09	Si	39.51	0.15
Mn	0.241615	Mn	0.379	0.07	Fe	38.10467	Fe	63.07	0.21	K	3.67	K	6.71	0.08
Fe	44.71291	Fe	72.98	0.21	Total	100	Total	100		Mn	0.1	Mn	0.27	0.08
Total	100	Total	100							Fe	0.26	Fe	0.67	0.1
										Total	100	Total	100	

Site 10					Site 10					Site 11				
Spectra 2					Spectra 3					Spectra 1				
	Atomic %	Wt%	Wt% Sigma			Atomic %	Wt%	Wt% Sigma			Atomic %	Wt%	Wt% Sigma	
O	57.2919	O	40.58	0.23	O	10.33025	O	4.093	0.08	O	55.69648	O	41.76	0.24
Na	1.920089	Na	1.958	0.05	Al	0.528402	Al	0.357	0.03	Na	6.152648	Na	6.625	0.07
Mg	0.554939	Mg	0.603	0.04	Si	2.351387	Si	1.637	0.03	Al	9.256787	Al	11.71	0.09
Al	6.526082	Al	7.799	0.08	S	44.41215	S	35.28	0.15	Si	26.53538	Si	34.93	0.2
Si	25.12764	Si	31.24	0.18	Fe	42.37781	Fe	58.63	0.24	K	1.613262	K	2.956	0.06
K	3.251942	K	5.619	0.08	Total	100	Total	100		Ca	0.500668	Ca	0.946	0.05
Ca	1.08768	Ca	1.926	0.06						Fe	0.133511	Fe	0.351	0.08
Ti	0.654828	Ti	1.397	0.06						Ba	0.111259	Ba	0.723	0.12
Mn	0.199778	Mn	0.497	0.08						Total	100	Total	100	
Fe	3.385128	Fe	8.381	0.15										
Total	100	Total	100											

Site 11				
Spectra 2				
	Atomic %	Wt%	Wt% Sigma	
O	64.12681	O	49.68	0.23
Na	1.26066	Na	1.407	0.03
Al	5.265109	Al	6.87	0.05
Si	26.52948	Si	36.07	0.16
K	1.761216	K	3.323	0.04
Ca	0.259548	Ca	0.509	0.03
Fe	0.797182	Fe	2.14	0.08
Total	100	Total	100	

H6. MS-13-07

Site 1					Site 1					Site 1				
Spectrum 1	Atomic %	Spectrum 1	Wt%	Wt% Sigma	Spectrum 2	Atomic %	Spectrum 2	Wt%	Wt% Sigma	Spectrum 3	Atomic %	Spectrum 3	Wt%	Wt% Sigma
O	61.9	O	9.19	0.06	O	62.43	O	9.43	0.06	O	63.06	O	9.96	0.06
Mg	1.61	Mg	0.36	0.01	Mg	1.6	Mg	0.37	0.01	Mg	1.58	Mg	0.38	0.01
Al	4.45	Al	1.11	0.02	Al	4.24	Al	1.08	0.02	Al	4.4	Al	1.17	0.02
Si	25.39	Si	6.62	0.04	Si	24.76	Si	6.56	0.04	Si	24.31	Si	6.74	0.04
K	0.27	K	0.1	0.01	K	0.3	K	0.11	0.01	K	0.29	K	0.11	0.01
Ca	1.03	Ca	0.38	0.02	Ca	1.21	Ca	0.46	0.02	Ca	1.06	Ca	0.42	0.02
Ti	0.17	Ti	0.08	0.02	Ti	0.21	Ti	0.1	0.02	Ti	0.16	Ti	0.08	0.02
Fe	5.18	Fe	2.69	0.05	Fe	5.25	Fe	2.77	0.06	Fe	5.14	Fe	2.83	0.06
Total	100	Total	20.53		Total	100	Total	20.86		Total	100	Total	21.69	

Site 1					Site 2					Site 2				
Spectrum 4	Atomic %	Spectrum 4	Wt%	Wt% Sigma	Spectrum 5	Atomic %	Spectrum 5	Wt%	Wt% Sigma	Spectrum 6	Atomic %	Spectrum 6	Wt%	Wt% Sigma
O	57.23	O	9.56	0.07	O	57.81	O	10.18	0.07	O	59.92	O	10.58	0.07
Na	5.53	Na	1.33	0.02	Na	6.52	Na	1.65	0.02	Na	4.68	Na	1.19	0.02
Mg	0.67	Mg	0.17	0.01	Al	8.8	Al	2.61	0.03	Al	5.42	Al	1.61	0.02
Al	7.24	Al	2.04	0.02	Si	25.17	Si	7.78	0.04	Si	26.89	Si	8.33	0.04
Si	23.3	Si	6.83	0.04	K	1.29	K	0.55	0.02	K	0.59	K	0.25	0.01
P	0.23	P	0.07	0.01	Ca	0.29	Ca	0.13	0.01	Ca	0.68	Ca	0.3	0.02
S	0.86	S	0.29	0.01	Ba	0.11	Ba	0.17	0.04	Fe	1.82	Fe	1.12	0.04
K	0.35	K	0.14	0.01	Total	100	Total	23.07		Total	100	Total	23.39	
Ca	1.78	Ca	0.75	0.02										
Ti	0.45	Ti	0.22	0.03										
Fe	1.64	Fe	0.96	0.04										
Ba	0.73	Ba	1.05	0.06										
Total	100	Total	23.41											

Site 2					Site 3					Site 3				
Spectrum 7	Atomic %	Spectrum 6	Wt%	Wt% Sigma	Spectrum 8	Atomic %	Spectrum 8	Wt%	Wt% Sigma	Spectrum 9	Atomic %	Spectrum 9	Wt%	Wt% Sigma
O	60.44	O	10.58	0.07	O	58.71	O	10.66	0.07	O	57.97	O	10.2	0.07
Na	5.32	Na	1.19	0.02	Na	6.53	Na	1.7	0.02	Na	6.53	Na	1.65	0.02
Al	5.58	Al	1.61	0.02	Al	8.58	Al	2.63	0.03	Al	8.95	Al	2.65	0.03
Si	27.78	Si	8.33	0.04	Si	24.51	Si	7.81	0.04	Si	24.89	Si	7.68	0.04
K	0.51	K	0.25	0.01	K	1.24	K	0.55	0.02	K	1.25	K	0.54	0.02
Fe	0.26	Ca	0.3	0.02	Ca	0.3	Ca	0.14	0.01	Ca	0.26	Ca	0.11	0.01
Sn	0.11	Fe	1.12	0.04	Ba	0.13	Ba	0.2	0.04	Ba	0.15	Ba	0.23	0.04
Total	100	Total	23.39		Total	100	Total	23.7		Total	100	Total	23.07	

Site 3					Site 4					Site 4				
Spectrum 10	Atomic %	Spectrum 10	Wt%	Wt% Sigma	Spectrum 11	Atomic %	Spectrum 11	Wt%	Wt% Sigma	Spectrum 12	Atomic %	Spectrum 12	Wt%	Wt% Sigma
O	64.32	O	9.25	0.06	O	59.41	O	8.15	0.06	O	63.86	O	7.14	0.07
Mg	1.59	Mg	0.35	0.01	Si	22.42	Si	5.4	0.03	Ti	18.87	Ti	6.31	0.05
Al	4.22	Al	1.02	0.02	Ca	8.59	Ca	2.95	0.03	Mn	0.7	Mn	0.27	0.02
Si	23.78	Si	6	0.03	Ti	0.11	Ti	0.05	0.02	Fe	16.57	Fe	6.46	0.07
K	0.28	K	0.1	0.01	Mn	0.47	Mn	0.22	0.03	Total	100	Total	20.18	
Ca	1.13	Ca	0.41	0.02	Fe	9	Fe	4.31	0.06					
Ti	0.17	Ti	0.07	0.01	Total	100	Total	21.07						
Fe	4.52	Fe	2.27	0.05										
Total	100	Total	19.47											

Site 4					Site 6					Site 6				
Spectrum 13	Atomic %	Spectrum 13	Wt%	Wt% Sigma	Spectrum 14	Atomic %	Spectrum 14	Wt%	Wt% Sigma	Spectrum 15	Atomic %	Spectrum 15	Wt%	Wt% Sigma
O	62.91	O	8.94	0.06	O	57.92	O	10.18	0.07	O	57.97	O	10.19	0.07
Mg	1.96	Mg	0.42	0.01	Na	6.41	Na	1.62	0.02	Na	6.47	Na	1.63	0.02
Al	3.33	Al	0.8	0.02	Al	8.84	Al	2.62	0.02	Al	8.94	Al	2.65	0.03
Si	23.91	Si	5.97	0.03	Si	25.07	Si	7.74	0.04	Si	24.79	Si	7.65	0.04
K	0.29	K	0.1	0.01	K	1.39	K	0.6	0.02	K	1.43	K	0.61	0.02
Ca	1.32	Ca	0.47	0.02	Ca	0.23	Ca	0.1	0.01	Ba	0.2	Ba	0.3	0.04
Ti	0.43	Ti	0.18	0.02	Ba	0.15	Ba	0.22	0.04	Ca	0.21	Ca	0.09	0.01
Fe	5.86	Fe	2.91	0.06	Total	100	Total	23.08		Total	100	Total	23.12	
Total	100	Total	19.79											

Site 7					Site 7					Site 7				
Spectrum 16	Atomic %	Spectrum 16	Wt%	Wt% Sigma	Spectrum 17	Atomic %	Spectrum 17	Wt%	Wt% Sigma	Spectrum 18	Atomic %	Spectrum 18	Wt%	Wt% Sigma
O	57.77	O	9.93	0.07	O	61.66	O	10.65	0.07	O	57.86	O	9.91	0.07
Na	6.54	Na	1.62	0.02	Na	2.02	Na	0.5	0.02	Na	6.52	Na	1.6	0.02
Al	9.01	Al	2.61	0.02	Al	5.35	Al	1.56	0.02	Al	9.03	Al	2.61	0.03
Si	25.09	Si	7.57	0.04	Si	27.39	Si	8.3	0.04	Si	24.86	Si	7.48	0.04
K	1.13	K	0.47	0.02	K	2.84	K	1.2	0.02	K	1.24	K	0.52	0.02
Ca	0.31	Ca	0.13	0.01	Fe	0.51	Fe	0.31	0.03	Ca	0.3	Ca	0.13	0.01
Ba	0.15	Ba	0.23	0.04	Ca	0.24	Ca	0.1	0.01	Ba	0.18	Ba	0.27	0.04
Total	100	Total	22.56		Total	100	Total	22.62		Total	100	Total	22.52	

Site 8					Site 8					Site 8				
Spectrum 19	Atomic %	Spectrum 19	Wt%	Wt% Sigma	Spectrum 20	Atomic %	Spectrum 20	Wt%	Wt% Sigma	Spectrum 21	Atomic %	Spectrum 21	Wt%	Wt% Sigma
O	58.01	O	9.55	0.06	O	57.93	O	9.08	0.06	O	58.15	O	10.09	0.07
Na	6.5	Na	1.54	0.02	Na	6.49	Na	1.46	0.02	Na	6.49	Na	1.62	0.02
Al	8.84	Al	2.45	0.02	Al	9.01	Al	2.38	0.02	Al	8.97	Al	2.62	0.03
Si	24.93	Si	7.2	0.04	Si	24.91	Si	6.86	0.04	Si	24.79	Si	7.55	0.04
K	1.34	K	0.54	0.02	K	1.25	K	0.48	0.02	K	1.19	K	0.51	0.02
Ca	0.24	Ca	0.1	0.01	Ca	0.29	Ca	0.11	0.01	Ca	0.3	Ca	0.13	0.01
Ba	0.13	Ba	0.18	0.04	Ba	0.12	Ba	0.16	0.03	Ba	0.11	Ba	0.16	0.04
Total	100	Total	21.56		Total	100	Total	20.53		Total	100	Total	22.69	

Site 9					Site 10					Site 10				
Spectrum 22	Atomic %	Spectrum 22	Wt%	Wt% Sigma	Spectrum 23	Atomic %	Spectrum 23	Wt%	Wt% Sigma	Spectrum 24	Atomic %	Spectrum 24	Wt%	Wt% Sigma
O	58.04	O	10.2	0.07	O	66.39	O	7.53	0.07	O	63.51	O	9	0.06
Na	6.64	Na	1.68	0.02	Ti	18.18	Ti	6.17	0.04	Mg	1.52	Mg	0.33	0.01
Al	8.96	Al	2.66	0.03	Fe	14.67	Fe	5.81	0.07	Al	4.8	Al	1.15	0.02
Si	24.77	Si	7.64	0.04	Mn	0.56	Mn	0.22	0.02	Si	24.27	Si	6.04	0.03
K	1.14	K	0.49	0.02	Si	0.19	Si	0.04	0.01	Ca	0.93	Ca	0.33	0.01
Ca	0.33	Ca	0.14	0.01	Total	100	Total	19.76		Fe	4.61	Fe	2.28	0.05
Ba	0.12	Ba	0.19	0.04						K	0.24	K	0.08	0.01
Total	100	Total	22.98							Ti	0.11	Ti	0.05	0.01
										Total	100	Total	19.26	

Site 10					Site 10				
Spectrum 25	Atomic %	Spectrum 25	Wt%	Wt% Sigma	Spectrum 26	Atomic %	Spectrum 26	Wt%	Wt% Sigma
O	61.88	O	7.94	0.05	O	58.84	O	8.8	0.08
Mg	1.78	Mg	0.35	0.01	F	4.66	F	0.83	0.04
Al	4.53	Al	0.98	0.02	P	14.54	P	4.21	0.03
Si	25.31	Si	5.7	0.03	Ca	21.43	Ca	8.03	0.05
Ca	1.22	Ca	0.39	0.01	Si	0.37	Si	0.1	0.01
Fe	4.88	Fe	2.19	0.05	Fe	0.15	Fe	0.08	0.02
K	0.24	K	0.08	0.01	Total	100	Total	22.06	
Ti	0.16	Ti	0.06	0.01					
Total	100	Total	17.68						

H7. MS-14-03

Site 1					Site 2					Site 2				
Spectrum 1	Atomic %	Spectrum 1	Wt%	Wt% Sigma	Spectrum 2	Atomic %	Spectrum 2	Wt%	Wt% Sigma	Spectrum 3	Atomic %	Spectrum 3	Wt%	Wt% Sigma
O	56.8982	O	42.329	0.07	O	55.14413	O	41.188	0.08	O	56.72917	O	42.839	0.08
Na	3.532934	Na	3.7831	0.02	Na	5.940942	Na	6.3864	0.02	Na	6.622359	Na	7.1816	0.02
Mg		Mg	0	0	Mg		Mg	0	0	Mg	0.047472	Mg	0.0418	0.01
Al	5.712575	Al	7.1459	0.02	Al	9.608624	Al	12.086	0.03	Al	9.102777	Al	11.608	0.03
Si	30.56287	Si	39.933	0.04	Si	27.07992	Si	35.53	0.05	Si	25.20769	Si	33.403	0.04
P		P	0	0	P		P	0	0	P		P	0	0
S		S	0	0	S		S	0	0	S		S	0	0
K	2.05988	K	3.7411	0.02	K	1.523318	K	2.789	0.02	K	1.400427	K	2.5887	0.02
Ca	0.215569	Ca	0.4203	0.01	Ca	0.550738	Ca	1.0105	0.02	Ca	0.545929	Ca	1.0438	0.02
Ti	0.107784	Ti	0.2522	0.02	Ti		Ti	0	0	Ti	0.035604	Ti	0.0835	0.02
Cr		Cr	0	0	Cr		Cr	0	0	Cr		Cr	0	0
Mn		Mn	0	0	Mn		Mn	0	0	Mn	0.047472	Mn	0.1253	0.02
Fe	0.91018	Fe	2.396	0.04	Fe		Fe	0	0	Fe	0.154284	Fe	0.4175	0.03
Ni		Ni	0	0	Ni		Ni	0	0	Ni		Ni	0	0
Total	100	Total	100		Ba	0.152332	Ba	1.0105	0.05	Ba	0.106812	Ba	0.6681	0.05
					Total	100	Total	100		Total	100	Total	100	

[illegible]

Site 3					Site 3					Site 3				
Spectrum 7	Atomic %	Spectrum 7	Wt%	Wt% Sigma	Spectrum 8	Atomic %	Spectrum 8	Wt%	Wt% Sigma	Spectrum 9	Atomic %	Spectrum 9	Wt%	Wt% Sigma
O	54.61565	O	39.355	0.08	O	54.79483	O	39.992	0.08	O	56.47275	O	37.824	0.06
Na	1.728708	Na	1.7907	0.02	Na	3.028918	Na	3.1771	0.02	Na	0	Na	0	0
Mg	0	Mg	0	0	Mg	0.114299	Mg	0.1191	0.01	Mg	13.48438	Mg	13.724	0.03
Al	15.83497	Al	19.26	0.03	Al	14.16162	Al	17.434	0.03	Al	0.710349	Al	0.795	0.01
Si	20.07606	Si	25.388	0.04	Si	21.83107	Si	27.959	0.04	Si	17.50153	Si	20.586	0.03
P	0	P	0	0	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	0.080673	K	0.1592	0.01	K	0.114299	K	0.1986	0.01	K	0.146969	K	0.251	0.01
Ca	7.341247	Ca	13.251	0.04	Ca	5.60064	Ca	10.246	0.03	Ca	0.514391	Ca	0.8787	0.01
Ti	0.046099	Ti	0.1194	0.02	Ti	0	Ti	0	0	Ti	0.367422	Ti	0.7113	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0	Mn	0	0	Mn	0.146969	Mn	0.3347	0.03
Fe	0.276593	Fe	0.6765	0.03	Fe	0.354326	Fe	0.8737	0.03	Fe	10.65524	Fe	24.895	0.08
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	100		Total	100	Total	100		Total	100	Total	100	

Site 3					Site 4					Site 4				
Spectrum 10	Atomic %	Spectrum 10	Wt%	Wt% Sigma	Spectrum 11	Atomic %	Spectrum 11	Wt%	Wt% Sigma	Spectrum 12	Atomic %	Spectrum 12	Wt%	Wt% Sigma
O	54.64331	O	39.77	0.08	O	61.39112	O	42.046	0.06	O	48.32477	O	30.028	0.09
Na	2.93141	Na	3.05	0.02	Na	0.095774	Na	0.0867	0.01	F	5.371901	F	3.9821	0.05
Mg		Mg	0	0	Mg	1.891536	Mg	1.9939	0.01	Na	0.111682	Na	0.0813	0.01
Al	14.38223	Al	17.66	0.03	Al	2.621813	Al	3.0342	0.02	Mg		Mg	0	0
Si	21.79091	Si	27.85	0.04	Si	22.73435	Si	27.308	0.04	Al		Al	0	0
P		P	0	0	P		P	0	0	Si	0.335046	Si	0.3657	0.01
S		S	0	0	S		S	0	0	P	17.10967	P	20.601	0.04
K	0.091607	K	0.161	0.01	K	0.68239	K	1.127	0.01	S		S	0	0
Ca	5.805565	Ca	10.59	0.03	Ca	1.23309	Ca	2.124	0.02	K		K	0	0
Ti		Ti	0	0	Ti	0.215491	Ti	0.4335	0.02	Ca	28.38955	Ca	44.21	0.06
Cr		Cr	0	0	Cr		Cr	0	0	Ti		Ti	0	0
Mn		Mn	0	0	Mn	0.07183	Mn	0.1734	0.02	Cr		Cr	0	0
Fe	0.28627	Fe	0.722	0.03	Fe	9.062612	Fe	21.673	0.07	Mn	0.067009	Mn	0.1219	0.03
Ni	0.068705	Ni	0.201	0.04	Ni	0	Ni	0	0	Fe	0.290373	Fe	0.6095	0.03
Total	100	Total	100		Total	100	Total	100		Ni	0	Ni	0	0
										Total	100	Total	100	

Site 4					Site 5					Site 5				
Spectrum 13	Atomic %	Spectrum 13	Wt%	Wt% Sigma	Spectrum 14	Atomic %	Spectrum 14	Wt%	Wt% Sigma	Spectrum 15	Atomic %	Spectrum 15	Wt%	Wt% Sigma
O	57.53731 O		38.857	0.06	O	55.52865 O		41.832	0.07	O	50.38392 O		31.514	0.09
Na	0.485075 Na		0.4835	0.01	Na	5.937968 Na		6.4045	0.02	F	3.906956 F		2.895	0.04
Mg	1.840796 Mg		1.8901	0.01	Mg	0 Mg		0	0	Na	0.101626 Na		0.0827	0.01
Al	2.5 Al		2.8571	0.02	Al	10.68834 Al		13.579	0.03	Mg	0 Mg		0	0
Si	26.35572 Si		31.253	0.04	Si	25.38914 Si		33.563	0.04	Al	0.045167 Al		0.0414	0.01
P	0 P		0	0	P	0 P		0	0	Si	0.395212 Si		0.4136	0.01
S	0 S		0	0	S	0 S		0	0	P	16.70054 P		20.223	0.04
K	0.460199 K		0.7473	0.01	K	0.357431 K		0.6486	0.01	S	0 S		0	0
Ca	2.313433 Ca		3.9121	0.02	Ca	2.029286 Ca		3.8103	0.02	K	0.079042 K		0.1241	0.01
Ti	0.149254 Ti		0.3077	0.02	Ti	0 Ti		0	0	Ca	28.04878 Ca		43.962	0.06
Cr	0 Cr		0	0	Cr	0 Cr		0	0	Ti	0 Ti		0	0
Mn	0.136816 Mn		0.3077	0.02	Mn	0 Mn		0	0	Cr	0 Cr		0	0
Fe	8.221393 Fe		19.385	0.07	Fe	0.06918 Fe		0.1621	0.03	Mn	0.135501 Mn		0.2895	0.03
Ni	0 Ni		0	0	Ni	0 Ni		0	0	Fe	0.203252 Fe		0.4549	0.03
Total	100 Total		100		Total	100 Total		100		Ni	0 Ni		0	0
										Total	100 Total		100	

Site 6					Site 6					Site 7				
Spectrum 16	Atomic %	Spectrum 16	Wt%	Wt% Sigma	Spectrum 17	Atomic %	Spectrum 17	Wt%	Wt% Sigma	Spectrum 18	Atomic %	Spectrum 18	Wt%	Wt% Sigma
O	55.44991	O	41.503	0.08	O	53.63	O	9.81	0.08	O	55.36842	O	41.476	0.08
Na	6.052876	Na	6.5086	0.02	Na	6.33	Na	1.67	0.02	Na	5.596491	Na	6.0025	0.02
Mg	0	Mg	0	0	Mg	0	Mg	0	0	Mg	0	Mg	0	0
Al	9.438776	Al	11.892	0.03	Al	9.72	Al	3	0.03	Al	10.47368	Al	13.256	0.03
Si	26.75093	Si	35.155	0.05	Si	27.75	Si	8.91	0.05	Si	25.70175	Si	33.806	0.04
P	0	P	0	0	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	1.542208	K	2.8124	0.02	K	1.54	K	0.69	0.02	K	0.736842	K	1.3339	0.02
Ca	0.510204	Ca	0.9642	0.02	Ca	0.64	Ca	0.29	0.02	Ca	1.877193	Ca	3.5015	0.02
Ti	0	Ti	0	0	Ti	0.07	Ti	0.04	0.02	Ti	0	Ti	0	0
Cr	0.034787	Cr	0.0804	0.02	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0.04	Mn	0.03	0.02	Mn	0.070175	Mn	0.1667	0.02
Fe	0.092764	Fe	0.2411	0.03	Fe	0.09	Fe	0.06	0.03	Fe	0.175439	Fe	0.4585	0.03
Ni	0	Ni	0	0	Ni	0.1	Ni	0.07	0.04	Ni	0	Ni	0	0
Ba	0.127551	Ba	0.8437	0.05	Ba	0.08	Ba	0.13	0.05	Total	100	Total	100	
Total	100	Total	100		Total	100	Total	24.7		Total	100	Total	100	

Site 7					Site 7					Site 7				
Spectrum 19	Atomic %	Spectrum 19	Wt%	Wt% Sigma	Spectrum 20	Atomic %	Spectrum 20	Wt%	Wt% Sigma	Spectrum 21	Atomic %	Spectrum 21	Wt%	Wt% Sigma
O	54.93493	O	40.883	0.08	O	55.31448	O	41.42	0.07	O	49.6082	O	31.109	0.09
Na	5.585627	Na	5.9562	0.02	Na	5.608771	Na	6.043	0.02	F	5.093339	F	3.7948	0.05
Mg		Mg	0	0	Mg	0	Mg	0	0	Na	0	Na	0	0
Al	11.01002	Al	13.817	0.03	Al	10.72129	Al	13.51	0.03	Mg	0	Mg	0	0
Si	25.44052	Si	33.225	0.05	Si	25.42412	Si	33.4	0.04	Al	0.103711	Al	0.1251	0.01
P		P	0	0	P		P	0	0	Si	0.553123	Si	0.6255	0.01
S		S	0	0	S		S	0	0	P	16.4554	P	19.975	0.04
K	0.667972	K	1.2156	0.02	K	0.634737	K	1.175	0.02	S		S	0	0
Ca	2.09605	Ca	3.9303	0.02	Ca	2.077323	Ca	3.903	0.02	K	0.06914	K	0.0834	0.01
Ti		Ti	0	0	Ti	0.034622	Ti	0.084	0.02	Ca	27.86356	Ca	43.745	0.06
Cr		Cr	0	0	Cr	0	Cr	0	0	Ti		Ti	0	0
Mn		Mn	0	0	Mn	0	Mn	0	0	Cr		Cr	0	0
Fe	0.184268	Fe	0.4862	0.03	Fe	0.184651	Fe	0.462	0.03	Mn	0	Mn	0	0
Ni		Ni	0	0	Ni	0	Ni	0	0	Fe	0.253515	Fe	0.5421	0.03
Ba	0.080617	Ba	0.4862	0.05	Total	100	Total	100		Ni	0	Ni	0	0
Total	100	Total	100		Total	100	Total	100		Total	100	Total	100	

H8. MS-14-05

Site 1					Site 1					Site 1				
Spectrum 1	Atomic %	Spectrum 1	Wt%	Wt% Sigma	Spectrum 2	Atomic %	Spectrum 2	Wt%	Wt% Sigma	Spectrum 3	Atomic %	Spectrum 3	Wt%	Wt% Sigma
O	60.78736	O	11.88	0.08	O	55.94931	O	10.62	0.08	O	49.81313	O	5.85	0.05
Na	0	Na	0	0	Na	6.371744	Na	1.74	0.02	Na	0.221911	Na	0.04	0.02
Mg	0	Mg	0	0	Mg	0	Mg	0	0	Mg	0	Mg	0	0
Al	0.131626	Al	0.04	0.01	Al	8.425252	Al	2.7	0.03	Al	0.198552	Al	0.04	0.01
Si	38.99725	Si	13.38	0.05	Si	27.41141	Si	9.13	0.05	Si	0.256949	Si	0.05	0.01
P	0	P	0	0	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	0.023932	K	0.01	0.01	K	1.431589	K	0.66	0.02	K	0	K	0	0
Ca	0	Ca	0	0	Ca	0.035203	Ca	0.01	0.01	Ca	0.046718	Ca	0.01	0.01
Ti	0	Ti	0	0	Ti	0.035203	Ti	0.02	0.02	Ti	6.540528	Ti	2.3	0.03
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0	Mn	0	0	Mn	0.875964	Mn	0.35	0.03
Fe	0	Fe	0	0	Fe	0.340296	Fe	0.22	0.03	Fe	42.04625	Fe	17.25	0.12
Ni	0.05983	Ni	0.04	0.04	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	25.35		Total	100	Total	25.1		Total	100	Total	25.89	

Site 1					Site 2					Site 2				
Spectrum 4	Atomic %	Spectrum 4	Wt%	Wt% Sigma	Spectrum 5	Atomic %	Spectrum 5	Wt%	Wt% Sigma	Spectrum 6	Atomic %	Spectrum 6	Wt%	Wt% Sigma
O	55.08393	O	8.41	0.06	O	55.31094	O	10.35	0.08	O	50.14308	O	7.68	0.09
Na	1.151079	Na	0.25	0.02	Na	6.116659	Na	1.64	0.02	F	4.292318	F	0.78	0.04
Mg	0	Mg	0	0	Mg	0	Mg	0	0	Na	0.110059	Na	0.02	0.01
Al	0.443645	Al	0.11	0.01	Al	9.418974	Al	2.97	0.03	Mg	0	Mg	0	0
Si	23.66906	Si	6.35	0.04	Si	26.90649	Si	8.84	0.05	Al	0	Al	0	0
P	0.059952	P	0.02	0.01	P	0	P	0	0	Si	0.198107	Si	0.05	0.01
S	0	S	0	0	S	0	S	0	0	P	16.93815	P	5.02	0.04
K	0.059952	K	0.02	0.01	K	1.475261	K	0.67	0.02	S	0	S	0	0
Ca	0.263789	Ca	0.1	0.01	Ca	0.510667	Ca	0.24	0.02	K	0.05503	K	0.02	0.01
Ti	3.369305	Ti	1.54	0.03	Ti	0	Ti	0	0	Ca	28.10918	Ca	10.79	0.06
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Ti	0	Ti	0	0
Mn	0.57554	Mn	0.3	0.03	Mn	0	Mn	0	0	Cr	0	Cr	0	0
Fe	15.2518	Fe	8.13	0.09	Fe	0.170222	Fe	0.11	0.03	Mn	0	Mn	0	0
Ni	0.071942	Ni	0.04	0.04	Ni	0	Ni	0	0	Fe	0.154083	Fe	0.08	0.03
Total	100	Total	25.27		Ba	0.090785	Ba	0.14	0.05	Ni	0	Ni	0	0
					Total	100	Total	24.96		Total	100	Total	24.44	

Site 2					Site 3					Site 3				
Spectrum 7	Atomic %	Spectrum 7	Wt%	Wt% Sigma	Spectrum 8	Atomic %	Spectrum 8	Wt%	Wt% Sigma	Spectrum 9	Atomic %	Spectrum 9	Wt%	Wt% Sigma
O	55.50023	O	10.8	0.08	O	52.9155	O	8.63	0.07	O	48.40727	O	5.79	0.05
Na	6.247171	Na	1.75	0.02	Na	0.40291	Na	0.09	0.01	Na	0.162168	Na	0.03	0.02
Mg	0	Mg	0	0	Mg	4.364857	Mg	1.08	0.02	Mg	0.382254	Mg	0.07	0.01
Al	9.461295	Al	3.11	0.03	Al	0.257415	Al	0.07	0.01	Al	0.625507	Al	0.13	0.01
Si	26.44862	Si	9.03	0.05	Si	23.13374	Si	6.63	0.04	Si	0.115835	Si	0.03	0.01
P	0	P	0	0	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0.044768	S	0.02	0.01	S	0	S	0	0
K	1.448619	K	0.69	0.02	K	0.033576	K	0.02	0.01	K	0.046334	K	0.01	0.01
Ca	0.611136	Ca	0.3	0.02	Ca	9.434807	Ca	3.86	0.04	Ca	0	Ca	0	0
Ti	0	Ti	0	0	Ti	0.100727	Ti	0.05	0.02	Ti	9.556354	Ti	3.42	0.04
Cr	0.067904	Cr	0.05	0.02	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0.716284	Mn	0.4	0.03	Mn	1.065678	Mn	0.44	0.03
Fe	0.067904	Fe	0.04	0.03	Fe	8.595411	Fe	4.9	0.07	Fe	39.6386	Fe	16.55	0.12
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Ba	0.147125	Ba	0.25	0.05	Total	100	Total	25.75		Total	100	Total	26.47	
Total	100	Total	26.02											

Site 3					Site 4					Site 4				
Spectrum 10	Atomic %	Spectrum 10	Wt%	Wt% Sigma	Spectrum 11	Atomic %	Spectrum 11	Wt%	Wt% Sigma	Spectrum 12	Atomic %	Spectrum 12	Wt%	Wt% Sigma
O	49.32912	O	7.44	0.09	O	52.53756	O	8.49	0.07	O	52.83769	O	8.48	0.07
F	4.013981	F	0.72	0.06	Na	0.343073	Na	0.08	0.01	Na	0.301241	Na	0.07	0.01
Na	0.101477	Na	0.02	0.01	Mg	4.353484	Mg	1.07	0.02	Mg	4.386071	Mg	1.07	0.02
Mg	0.045101	Mg	0.01	0.01	Al	0.236602	Al	0.06	0.01	Al	0.240993	Al	0.07	0.01
Al	0.045101	Al	0.01	0.01	Si	23.36449	Si	6.63	0.04	Si	23.37631	Si	6.59	0.04
Si	0.338257	Si	0.09	0.01	P	0	P	0	0	P	0	P	0	0
P	17.02559	P	4.97	0.04	S	0	S	0	0	S	0	S	0	0
S	0	S	0	0	K	0	K	0	0	K	0	K	0	0
Cl	0.101477	Cl	0.03	0.01	Ca	9.499586	Ca	3.85	0.04	Ca	9.48307	Ca	3.81	0.04
K	0	K	0	0	Ti	0.165622	Ti	0.08	0.02	Ti	0.120496	Ti	0.06	0.02
Ca	28.33465	Ca	10.7	0.06	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Ti	0	Ti	0	0	Mn	0.816278	Mn	0.45	0.03	Mn	0.819376	Mn	0.45	0.03
Cr	0	Cr	0	0	Fe	8.683308	Fe	4.9	0.07	Fe	8.434751	Fe	4.72	0.07
Mn	0.056376	Mn	0.03	0.03	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Fe	0.451009	Fe	0.24	0.03	Total	100	Total	25.61		Total	100	Total	25.32	
Ni	0	Ni	0	0										
Ce	0.157853	Ce	0.2	0.05										
Total	100	Total	25.9											

Site 5					Site 5				
Spectrum 13	Atomic %	Spectrum 13	Wt%	Wt% Sigma	Spectrum 14	Atomic %	Spectrum 14	Wt%	Wt% Sigma
O	52.24778	O	8.41	0.07	O	52.22566	O	8.33	0.07
Na	0.450711	Na	0.11	0.01	Na	0.377618	Na	0.09	0.01
Mg	4.518664	Mg	1.1	0.02	Mg	4.382652	Mg	1.06	0.02
Al	0.254247	Al	0.07	0.01	Al	0.263188	Al	0.07	0.01
Si	23.49474	Si	6.64	0.04	Si	23.73269	Si	6.64	0.04
P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0
K	0	K	0	0	K	0	K	0	0
Ca	9.511152	Ca	3.84	0.04	Ca	9.52054	Ca	3.8	0.04
Ti	0.115567	Ti	0.06	0.02	Ti	0.160201	Ti	0.08	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0.808968	Mn	0.45	0.03	Mn	0.789564	Mn	0.43	0.03
Fe	8.598174	Fe	4.83	0.07	Fe	8.547889	Fe	4.76	0.07
Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	25.51		Total	100	Total	25.26	

H9. MS-14-06

Site 1					Site 1					Site 1				
Spectrum 2	Atomic %	Spectrum 2	Wt%	Wt% Sigma	Spectrum 3	Atomic %	Spectrum 3	Wt%	Wt% Sigma	Spectrum 4	Atomic %	Spectrum 4	Wt%	Wt% Sigma
O	48.12135	O	5.71	0.05	O	49.19676	O	7.43	0.09	O	59.15017	O	11.11	0.08
Na	0.151692	Na	0.03	0.02	F	4.16999	F	0.75	0.06	Na	2.037253	Na	0.55	0.02
Mg	0.280047	Mg	0.05	0.01	Na	0.056967	Na	0.01	0.01	Mg	0	Mg	0	0
Al	0.711785	Al	0.14	0.01	Mg	0.091147	Mg	0.02	0.01	Al	6.041909	Al	1.91	0.02
Si	0.128355	Si	0.03	0.01	Al	0	Al	0	0	Si	28.95227	Si	9.55	0.05
P	0	P	0	0	Si	0.387376	Si	0.1	0.01	P	0	P	0	0
S	0	S	0	0	P	16.86225	P	4.93	0.04	S	0	S	0	0
K	0	K	0	0	S	0	S	0	0	K	2.759022	K	1.26	0.03
Ca	0	Ca	0	0	K	0	K	0	0	Ca	0.151339	Ca	0.07	0.02
Ti	9.871645	Ti	3.51	0.04	Ca	28.17591	Ca	10.66	0.06	Ti	0.069849	Ti	0.04	0.02
Cr	0	Cr	0	0	Ti	0.091147	Ti	0.04	0.02	Cr	0	Cr	0	0
Mn	0.910152	Mn	0.37	0.03	Cr	0	Cr	0	0	Mn	0	Mn	0	0
Fe	39.82497	Fe	16.5	0.11	Mn	0.091147	Mn	0.05	0.03	Fe	0.838184	Fe	0.55	0.04
Ni	0	Ni	0	0	Fe	0.672211	Fe	0.36	0.04	Ni	0	Ni	0	0
Total	100	Total	26.34		Ni	0	Ni	0	0	Total	100	Total	25.04	
					Ce	0.205081	Ce	0.26	0.05					
					Total	100	Total	24.61						

Site 2					Site 2					Site 2				
Spectrum 5	Atomic %	Spectrum 5	Wt%	Wt% Sigma	Spectrum 6	Atomic %	Spectrum 6	Wt%	Wt% Sigma	Spectrum 7	Atomic %	Spectrum 7	Wt%	Wt% Sigma
O	57.95	O	10.75	0.07	O	58.73397	O	11.11	0.08	O	58.63486	O	10.96	0.08
Na	2.51	Na	0.67	0.02	Na	2.415293	Na	0.66	0.02	Na	2.476886	Na	0.66	0.02
Mg	0	Mg	0	0	Mg	0	Mg	0	0	Mg	0.057071	Mg	0.02	0.01
Al	6.21	Al	1.95	0.02	Al	6.089744	Al	1.94	0.02	Al	6.095195	Al	1.92	0.02
Si	29.68	Si	9.67	0.05	Si	28.6859	Si	9.53	0.05	Si	29.02637	Si	9.53	0.05
P	0	P	0	0	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0.034341	S	0.01	0.01	S	0	S	0	0
K	2.69	K	1.22	0.02	K	2.712912	K	1.25	0.02	K	2.385572	K	1.09	0.02
Ca	0.27	Ca	0.13	0.02	Ca	0.240385	Ca	0.11	0.02	Ca	0.159799	Ca	0.08	0.02
Ti	0.1	Ti	0.05	0.02	Ti	0.125916	Ti	0.07	0.02	Ti	0.091314	Ti	0.05	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0.034243	Cr	0.02	0.02
Mn	0	Mn	0	0	Mn	0.045788	Mn	0.03	0.02	Mn	0.068485	Mn	0.05	0.02
Fe	0.59	Fe	0.38	0.03	Fe	0.915751	Fe	0.6	0.04	Fe	0.890309	Fe	0.58	0.04
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0.0799	Ni	0.06	0.04
Total	100	Total	24.82		Total	100	Total	25.31		Total	100	Total	25.02	

Site 3					Site 3					Site 3				
Spectrum 8	Atomic %	Spectrum 8	Wt%	Wt% Sigma	Spectrum 9	Atomic %	Spectrum 9	Wt%	Wt% Sigma	Spectrum 10	Atomic %	Spectrum 10	Wt%	Wt% Sigma
O	52.31529	O	8.35	0.07	O	53.3	O	9.54	0.08	O	52.6492	O	8.4	0.07
Na	0.448121	Na	0.1	0.01	Na	6.32	Na	1.62	0.02	Na	0.519451	Na	0.12	0.01
Mg	4.285878	Mg	1.04	0.02	Mg	0	Mg	0	0	Mg	3.936281	Mg	0.95	0.02
Al	0.264277	Al	0.07	0.01	Al	9.86	Al	2.98	0.03	Al	0.265497	Al	0.07	0.01
Si	23.57808	Si	6.6	0.04	Si	28.02	Si	8.8	0.05	Si	23.4099	Si	6.56	0.04
P	0	P	0	0	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	0	K	0	0	K	1.55	K	0.68	0.02	K	0.03463	K	0.01	0.01
Ca	9.697805	Ca	3.88	0.04	Ca	0.58	Ca	0.26	0.02	Ca	9.176959	Ca	3.67	0.04
Ti	0.080432	Ti	0.04	0.02	Ti	0	Ti	0	0	Ti	0.17315	Ti	0.08	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0.80432	Mn	0.44	0.03	Mn	0	Mn	0	0	Mn	0.854208	Mn	0.47	0.03
Fe	8.456854	Fe	4.71	0.07	Fe	0.15	Fe	0.1	0.03	Fe	8.980723	Fe	5	0.08
Ni	0.068942	Ni	0.04	0.04	Ni	0.06	Ni	0.04	0.04	Ni	0	Ni	0	0
Total	100	Total	25.27		Ba	0.15	Ba	0.24	0.05	Total	100	Total	25.33	
					Total	100	Total	24.26						

Site 3					Site 3					Site 3				
Spectrum 11	Atomic %	Spectrum 11	Wt%	Wt% Sigma	Spectrum 12	Atomic %	Spectrum 12	Wt%	Wt% Sigma	Spectrum 13	Atomic %	Spectrum 13	Wt%	Wt% Sigma
O	48.95421	O	5.77	0.05	O	51.09348	O	7.45	0.08	O	51.89133	O	8.29	0.07
Na	0.158282	Na	0.03	0.02	F	2.560907	F	0.44	0.05	Na	0.355342	Na	0.08	0.01
Mg	0.293951	Mg	0.05	0.01	Na	0.090652	Na	0.02	0.01	Mg	4.562127	Mg	1.11	0.02
Al	0.655738	Al	0.13	0.01	Mg	1.235127	Mg	0.27	0.01	Al	0.286566	Al	0.08	0.01
Si	0.13567	Si	0.03	0.01	Al	0.090652	Al	0.02	0.01	Si	23.40669	Si	6.56	0.04
P	0.101752	P	0.02	0.01	Si	9.053824	Si	2.32	0.02	P	0	P	0	0
S	0	S	0	0	P	10.5949	P	2.99	0.03	S	0	S	0	0
K	0	K	0	0	S	0	S	0	0	K	0	K	0	0
Ca	0.13567	Ca	0.04	0.01	K	0	K	0	0	Ca	9.594223	Ca	3.84	0.04
Ti	9.666478	Ti	3.41	0.04	Ca	21.76771	Ca	7.95	0.05	Sc	0.160477	Sc	0.07	0.02
Cr	0	Cr	0	0	Ti	0	Ti	0	0	Ti	0.149014	Ti	0.07	0.02
Mn	0.927077	Mn	0.37	0.03	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Fe	38.97117	Fe	16.02	0.11	Mn	0.226629	Mn	0.11	0.03	Mn	0.836772	Mn	0.46	0.03
Ni	0	Ni	0	0	Fe	2.946176	Fe	1.5	0.05	Fe	8.757451	Fe	4.88	0.07
Total	100	Total	25.87		Ni	0	Ni	0	0	Ni	0	Ni	0	0
					Zn	0.124646	Zn	0.07	0.03	Total	100	Total	25.44	
					Ce	0.215297	Ce	0.27	0.05					
					Total	100	Total	23.41						

Site 4					Site 4					Site 4				
Spectrum 14	Atomic %	Spectrum 14	Wt%	Wt% Sigma	Spectrum 15	Atomic %	Spectrum 15	Wt%	Wt% Sigma	Spectrum 16	Atomic %	Spectrum 16	Wt%	Wt% Sigma
O	54.71741	O	9.9	0.07	O	55.15256	O	9.98	0.08	O	48.78355	O	5.75	0.05
Na	3.182693	Na	0.83	0.02	Na	3.143351	Na	0.82	0.02	Na	0	Na	0	0
Mg	0.09061	Mg	0.03	0.01	Mg	0.069085	Mg	0.02	0.01	Mg	0.399772	Mg	0.07	0.01
Al	13.97667	Al	4.26	0.03	Al	13.97812	Al	4.27	0.03	Al	0.696745	Al	0.14	0.01
Si	22.16559	Si	7.04	0.04	Si	21.72712	Si	6.91	0.04	Si	0.102798	Si	0.02	0.01
P	0	P	0	0	P	0	P	0	0	P	0.068532	P	0.01	0.01
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	0.147242	K	0.07	0.01	K	0.126655	K	0.06	0.01	K	0	K	0	0
Ca	5.481935	Ca	2.49	0.03	Ca	5.584341	Ca	2.53	0.03	Ca	0	Ca	0	0
Ti	0	Ti	0	0	Ti	0	Ti	0	0	Ti	9.674472	Ti	3.42	0.04
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0	Mn	0	0	Mn	0.799543	Mn	0.32	0.03
Fe	0.237853	Fe	0.15	0.03	Fe	0.218768	Fe	0.14	0.03	Fe	39.47459	Fe	16.25	0.11
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	24.77		Total	100	Total	24.73		Total	100	Total	25.98	

Site 4					Site 5					Site 5				
Spectrum 17	Atomic %	Spectrum 17	Wt%	Wt% Sigma	Spectrum 18	Atomic %	Spectrum 18	Wt%	Wt% Sigma	Spectrum 19	Atomic %	Spectrum 19	Wt%	Wt% Sigma
O	56.77802	O	10.01	0.07	O	52.77936	O	8.73	0.07	O	55.70298	O	10.71	0.08
Na	0.934899	Na	0.24	0.01	Na	0.388084	Na	0.09	0.01	Na	5.912477	Na	1.63	0.02
Mg	2.759092	Mg	0.74	0.02	Mg	4.531446	Mg	1.14	0.02	Mg	0	Mg	0	0
Al	6.874929	Al	2.05	0.02	Al	0.273941	Al	0.08	0.01	Al	9.345903	Al	3.03	0.03
Si	21.94733	Si	6.79	0.04	Si	23.37633	Si	6.79	0.04	Si	26.60615	Si	8.98	0.05
P	0.387641	P	0.13	0.01	P	0	P	0	0	P	0	P	0	0
S	0.09121	S	0.03	0.01	S	0	S	0	0	S	0	S	0	0
K	0.980504	K	0.42	0.02	K	0	K	0	0	K	1.582868	K	0.75	0.02
Ca	3.910615	Ca	1.73	0.03	Ca	8.925922	Ca	3.7	0.04	Ca	0.512104	Ca	0.25	0.02
Ti	0.855091	Ti	0.45	0.02	Ti	0.125556	Ti	0.06	0.02	Ti	0	Ti	0	0
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0.182419	Mn	0.11	0.03	Mn	0.821824	Mn	0.47	0.03	Mn	0	Mn	0	0
Fe	4.298256	Fe	2.65	0.06	Fe	8.777537	Fe	5.07	0.08	Fe	0.162942	Fe	0.11	0.03
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	25.35		Total	100	Total	26.13		Ba	0.174581	Ba	0.29	0.05
										Total 100 Total 25.75				

Site 5					Site 5					Site 5				
Spectrum 20	Atomic %	Spectrum 20	Wt%	Wt% Sigma	Spectrum 21	Atomic %	Spectrum 21	Wt%	Wt% Sigma	Spectrum 22	Atomic %	Spectrum 22	Wt%	Wt% Sigma
O	55.06452	O	9.3	0.07	O	62.20525	O	11.84	0.09	Be	0	Be	0	0
Na	6.07514	Na	1.47	0.02	Na	1.628116	Na	0.45	0.02	Na	0	Na	0	0
Mg	0	Mg	0	0	Mg	0	Mg	0	0	Mg	0	Mg	0	0
Al	9.603746	Al	2.73	0.03	Al	2.335504	Al	0.75	0.02	Al	0	Al	0	0
Si	26.91561	Si	7.98	0.04	Si	12.25017	Si	4.09	0.03	Si	0.169372	Si	0.03	0.01
P	0	P	0	0	P	7.186167	P	2.65	0.03	P	0.169372	P	0.03	0.01
S	0	S	0	0	S	0	S	0	0	S	49.69654	S	10.05	0.05
K	1.518785	K	0.63	0.02	K	0.931956	K	0.43	0.02	K	0	K	0	0
Ca	0.593811	Ca	0.25	0.02	Ca	13.21581	Ca	6.31	0.05	Ca	0.112915	Ca	0.03	0.02
Ti	0	Ti	0	0	Ti	0	Ti	0	0	Ti	0.084686	Ti	0.03	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0	Mn	0	0	Mn	0.155258	Mn	0.05	0.03
Fe	0.102775	Fe	0.06	0.03	Fe	0.247024	Fe	0.16	0.03	Fe	49.61186	Fe	17.47	0.14
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Ba	0.125614	Ba	0.19	0.05	Total	100	Total	26.68		Total	100	Total	27.69	
Total	100	Total	22.61											

Site 6					Site 7					Site 7				
Spectrum 23	Atomic %	Spectrum 23	Wt%	Wt% Sigma	Spectrum 24	Atomic %	Spectrum 24	Wt%	Wt% Sigma	Spectrum 25	Atomic %	Spectrum 25	Wt%	Wt% Sigma
O	55.12367	O	10.26	0.08	O	52.62978	O	8.84	0.07	O	54.66382	O	9.87	0.08
Na	6.200843	Na	1.66	0.02	Na	0.319452	Na	0.08	0.01	Na	2.256145	Na	0.59	0.02
Mg	0	Mg	0	0	Mg	9.492299	Mg	2.42	0.02	Mg	0.101021	Mg	0.03	0.01
Al	9.483643	Al	2.98	0.03	Al	1.312037	Al	0.37	0.01	Al	15.22056	Al	4.63	0.03
Si	26.78673	Si	8.75	0.05	Si	22.76098	Si	6.71	0.04	Si	21.00123	Si	6.66	0.04
P	0	P	0	0	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0	S	0	0	S	0	S	0	0
K	1.538812	K	0.7	0.02	K	0.034227	K	0.02	0.01	K	0.044898	K	0.02	0.01
Ca	0.626924	Ca	0.29	0.02	Ca	9.12721	Ca	3.84	0.04	Ca	6.510271	Ca	2.95	0.03
Ti	0	Ti	0	0	Ti	0.296634	Ti	0.15	0.02	Ti	0	Ti	0	0
Cr	0	Cr	0	0	Cr	0.11409	Cr	0.06	0.02	Cr	0	Cr	0	0
Mn	0	Mn	0	0	Mn	0.045636	Mn	0.03	0.03	Mn	0	Mn	0	0
Fe	0.102587	Fe	0.07	0.03	Fe	3.867655	Fe	2.26	0.06	Fe	0.202043	Fe	0.13	0.03
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Ba	0.136783	Ba	0.21	0.05	Total	100	Total	24.78		Total	100	Total	24.88	
Total	100	Total	24.92											

Site 7					Site 7					Site 7				
Spectrum 26	Atomic %	Spectrum 26	Wt%	Wt% Sigma	Spectrum 27	Atomic %	Spectrum 27	Wt%	Wt% Sigma	Spectrum 28	Atomic %	Spectrum 28	Wt%	Wt% Sigma
O	53.74296	O	7.73	0.07	O	52.84084	O	8.85	0.07	O	54.79436	O	9.82	0.08
Na	0.323392	Na	0.07	0.01	Na	0.129397	Na	0.03	0.01	Na	3.271984	Na	0.84	0.02
Mg	2.970416	Mg	0.65	0.02	Mg	9.587107	Mg	2.44	0.03	Mg	0.636219	Mg	0.17	0.01
Al	2.623069	Al	0.64	0.02	Al	1.117516	Al	0.32	0.01	Al	12.57669	Al	3.8	0.03
Si	12.73206	Si	3.22	0.03	Si	22.62087	Si	6.65	0.04	Si	22.49489	Si	7.07	0.04
P	1.054018	P	0.29	0.01	P	0	P	0	0	P	0	P	0	0
S	0	S	0	0	S	0.058817	S	0.02	0.01	S	0	S	0	0
K	0.155707	K	0.05	0.01	K	0	K	0	0	K	0.159055	K	0.07	0.01
Ca	7.929093	Ca	2.86	0.03	Ca	8.587225	Ca	3.6	0.04	Ca	5.192002	Ca	2.33	0.03
Ti	9.965265	Ti	4.29	0.04	Ti	0.28232	Ti	0.14	0.02	Ti	0.068166	Ti	0.03	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0.19164	Mn	0.1	0.02	Mn	0.14116	Mn	0.08	0.03	Mn	0	Mn	0	0
Fe	8.312373	Fe	4.17	0.06	Fe	4.634749	Fe	2.71	0.06	Fe	0.806635	Fe	0.5	0.04
Ni	0	Ni	0	0	Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	24.07		Total	100	Total	24.84		Total	100	Total	24.63	

Site 8					Site 8					Site 8				
Spectrum 29	Atomic %	Spectrum 29	Wt%	Wt% Sigma	Spectrum 30	Atomic %	Spectrum 30	Wt%	Wt% Sigma	Spectrum 31	Atomic %	Spectrum 31	Wt%	Wt% Sigma
O	52.12617	O	8.31	0.07	O	49.3505	O	7.42	0.09	O	57.31165	O	10.13	0.07
Na	0.420561	Na	0.1	0.01	F	4.443938	F	0.79	0.06	Na	1.497426	Na	0.38	0.02
Mg	4.32243	Mg	1.05	0.02	Na	0	Na	0	0	Mg	2.047263	Mg	0.55	0.02
Al	0.303738	Al	0.08	0.01	Mg	0	Mg	0	0	Al	6.574637	Al	1.96	0.02
Si	23.65654	Si	6.62	0.04	Al	0.079763	Al	0.02	0.01	Si	23.71315	Si	7.36	0.04
P	0	P	0	0	Si	0.535552	Si	0.14	0.01	P	0.222274	P	0.07	0.01
S	0	S	0	0	P	16.78441	P	4.89	0.04	S	0.116986	S	0.04	0.01
K	0.046729	K	0.02	0.01	S	0	S	0	0	K	1.111371	K	0.48	0.02
Ca	9.509346	Ca	3.8	0.04	K	0.182315	K	0.07	0.01	Ca	2.994853	Ca	1.33	0.03
Ti	0.116822	Ti	0.06	0.02	Ca	28.2361	Ca	10.64	0.06	Ti	0.701919	Ti	0.37	0.02
Cr	0	Cr	0	0	Ti	0	Ti	0	0	Cr	0	Cr	0	0
Mn	0.794393	Mn	0.44	0.03	Cr	0	Cr	0	0	Mn	0.093589	Mn	0.05	0.03
Fe	8.703271	Fe	4.85	0.07	Mn	0	Mn	0	0	Fe	3.614881	Fe	2.23	0.06
Ni	0	Ni	0	0	Fe	0.250684	Fe	0.13	0.03	Ni	0	Ni	0	0
Total	100 Total	25.33			Ni	0	Ni	0	0	Total	100 Total	24.95		
					Ce	0.136737	Ce	0.17	0.05					
					Total	100 Total	24.27							

Site 8					Site 8				
Spectrum 32	Atomic %	Spectrum 32	Wt%	Wt% Sigma	Spectrum 33	Atomic %	Spectrum 33	Wt%	Wt% Sigma
O	58.58253	O	10.7	0.08	O	58.38415	O	11.09	0.08
Na	2.307511	Na	0.61	0.02	Na	2.345216	Na	0.64	0.02
Mg	1.000706	Mg	0.28	0.01	Mg	0.480769	Mg	0.14	0.01
Al	6.604662	Al	2.03	0.02	Al	5.417448	Al	1.73	0.02
Si	25.2178	Si	8.09	0.04	Si	27.83771	Si	9.28	0.05
P	0.153049	P	0.05	0.01	P	0	P	0	0
S	0.058865	S	0.02	0.01	S	0	S	0	0
K	1.554038	K	0.7	0.02	K	1.923077	K	0.89	0.02
Ca	1.895456	Ca	0.86	0.02	Ca	1.371951	Ca	0.65	0.02
Ti	0.423829	Ti	0.23	0.02	Ti	0.105535	Ti	0.06	0.02
Cr	0	Cr	0	0	Cr	0	Cr	0	0
Mn	0.094184	Mn	0.06	0.03	Mn	0.140713	Mn	0.09	0.03
Fe	2.10737	Fe	1.34	0.05	Fe	1.993433	Fe	1.32	0.05
Ni	0	Ni	0	0	Ni	0	Ni	0	0
Total	100	Total	24.97		Total	100	Total	25.89	

APPENDIX I: SEM and EMP Data for Feldspar Calculations

Compare SEM and EMP Feldspar Info									
Sample	Site	SEM			Total	Site-Location	EMP		
		(High K) Or	(High Ca) An	(High Na) Ab			(High K) Or	(High Ca) An	(High Na) Ab
HS154A	3	18.95	5.99	75.06	100	HS-15-4a_site3_ctr-rim	6.7	18.72	74.6
HS154A	3					HS-15-4a_site3_ctr-rim	17.8	6.11	76.1
HS154A	4	6.08	36.60	57.32	100				
HS154A	5	8.09	17.72	74.20	100	HS-15-4a_site5_ctr-rim	13.9	9.47	76.6
HS154A	5	21.71	6.39	71.89	100	HS-15-4a_site5_ctr-rim	28.2	4.07	67.8
HS154A	6	18.39	6.58	75.03	100	HS-15-4a_site6_ctr-rim	19.1	5.92	75.0
HS154A	6	18.55	6.91	74.55	100	HS-15-4a_site6_ctr-rim	22.3	6.78	70.9
HS154A	8					HS-15-4a_site8_ctr-rim	0.9	59.93	39.2
HS154A	8					HS-15-4a_site8_ctr-rim	1.1	61.81	37.1
HS154A	9					HS-15-4a_site9_ctr-rim	4.6	24.48	70.9
HS154A	9					HS-15-4a_site9_ctr-rim	5.7	22.36	71.9
HS154A	10					HS-15-4a_site10_ctr-rim	17.6	5.66	76.8
HS154A	10					HS-15-4a_site10_ctr-rim	18.4	6.60	75.0
HS154A	11					HS-15-4a_site11_ctr-rim	17.1	6.51	76.4
HS154A	11					HS-15-4a_site11_ctr-rim	18.7	6.67	74.6
HS154C	1	20.14	7.48	72.37	100				
HS154C	1	18.87	9.86	71.27	100				
HS154C	3	0.00	96.14	3.86	100				
HS154C	3	17.15	8.16	74.69	100				
HS154C	4	18.26	6.60	75.14	100				
HS154C	5	19.41	6.09	74.50	100				
HS154C	6	2.44	39.11	58.46	100				
HS154C	6	2.12	43.24	54.64	100				
HS154D	1	30.14	5.49	64.37	100	HS-15-4d_site1_ctr-rim	28.00	4.09	67.93
HS154D	1					HS-15-4d_site1_ctr-rim	28.89	4.94	66.20
HS154D	2	37.66	14.29	48.05	100				
HS154D	2	62.71	3.61	33.68	100				
HS154D	3	47.54	0.00	52.46	100	HS-15-4d_site3_ctr-rim	44.43	2.56	53.03
HS154D	3					HS-15-4d_site3_ctr-rim	47.79	3.31	48.93
HS154D	4	7.69	48.72	43.59	100				

Compare SEM and EMP Feldspar Info (Cont'd)									
		SEM				EMP			
		(High K)	(High Ca)	(High Na)			(High K)	(High Ca)	(High Na)
Sample	Site	Or	An	Ab	Total	Site-Location	Or	An	Ab
HS154D	5	51.01	0.00	48.99	100	HS-15-4d_site5_ctr-rim	23.55	6.79	69.68
HS154D	5					HS-15-4d_site5_ctr-rim	25.99	7.94	66.10
HS154D	6	1.78	62.19	36.03	100	HS-15-4d_site6a_ctr-rim	0.96	60.88	38.16
HS154D	6	1.29	55.78	42.93	100	HS-15-4d_site6a_ctr-rim	1.08	61.78	37.14
HS154D	6	1.56	56.76	41.68	100	HS-15-4d_site6b_ctr-rim	1.12	58.97	39.91
HS154D	6	1.63	62.42	35.96	100	HS-15-4d_site6b_ctr-rim	1.02	60.78	38.20
HS154D	9	18.75	6.40	74.85	100	HS-15-4d_site9_ctr-rim	18.01	6.30	75.71
HS154D	9	19.17	6.39	74.44	100	HS-15-4d_site9_ctr-rim	23.67	7.23	69.12
HS154D	10	34.93	5.49	59.58	100	HS-15-4d_site10_ctr-rim	31.28	4.23	64.52
HS154D	10					HS-15-4d_site10_ctr-rim	33.36	5.02	61.65
HS154D	11	2.37	40.67	56.96	100	HS-15-4d_site11_ctr-rim	2.63	37.09	60.29
HS154D	11	2.15	43.34	54.51	100	HS-15-4d_site11_ctr-rim	2.37	42.98	54.65
HS154D	12					HS-15-4d_site12_ctr-rim	1.12	61.16	37.73
HS154D	12					HS-15-4d_site12_ctr-rim	1.03	61.43	37.53
HS154D	13					HS-15-4d_site13_ctr-rim	27.83	3.54	68.65
HS154D	13					HS-15-4d_site13_ctr-rim	31.81	5.12	63.10
HS154E	1	38.64	5.61	55.76	100				
HS154E	1	43.71	4.72	51.57	100				
HS154E	2	39.00	4.43	56.57	100				
HS154E	3	48.75	4.00	47.25	100				
HS154E	4	26.18	8.24	65.59	100				
HS154E	5	18.23	7.10	74.66	100				
HS154E	6	18.04	7.05	74.91	100				
HS154E	6	66.02	6.02	27.96	100				
HS154E	7	17.36	7.99	74.66	100	HS-15-4e_site7_ctr-rim	16.14	6.97	76.91
HS154E	7					HS-15-4e_site7_ctr-rim	18.35	7.25	74.42
HS154E	8	2.65	40.14	57.21	100				
HS154E	9	19.05	6.79	74.17	100	HS-15-4e_site9_ctr-rim	17.66	5.58	76.77
HS154E	9	18.88	6.53	74.58	100	HS-15-4e_site9_ctr-rim	16.94	5.99	77.09
HS154E	10	1.26	63.13	35.61	100	HS-15-4e_site10_ctr-rim	1.10	60.64	38.26

Compare SEM and EMP Feldspar Info (Cont'd)									
Sample	Site	SEM			Total	Site-Location	EMP		
		(High K) Or	(High Ca) An	(High Na) Ab			(High K) Or	(High Ca) An	(High Na) Ab
HS154E	10	1.25	64.29	34.46	100	HS-15-4e_site10_ctr-rim	1.06	60.36	38.58
HS154E	12					HS-15-4e_site12_ctr-rim	3.57	25.82	70.61
HS154E	12					HS-15-4e_site12_ctr-rim	3.00	34.51	62.49
HS154E	13					HS-15-4e_site13_ctr-rim	17.13	6.66	76.23
HS154E	13					HS-15-4e_site13_ctr-rim	19.39	8.12	72.50
MS145	2	18.21	6.30	75.49	100.00	MS-14-5_site2_ctr-rim	5.95	77.51	16.55
MS145	2	17.44	7.36	75.20	100.00	MS-14-5_site2_ctr-rim	5.72	77.77	16.53
MS145	3	0.34	95.58	4.08	100.00	MS-14-5_site3_ctr-rim	5.85	76.93	17.23
MS145	3	0.00	99.64	0.36	100.00	MS-14-5_site3_ctr-rim	6.32	76.93	16.77
MS145	4	0.00	96.51	3.49	100.00	MS-14-5_site4_ctr-rim	5.21	76.17	18.64
MS145	4	0.00	96.92	3.08	100.00	MS-14-5_site4_ctr-rim	6.43	76.52	17.06
MS145	6					MS-14-5_site6_ctr-rim	16.22	76.14	7.65
MS145	6					MS-14-5_site6_ctr-rim	7.11	77.06	15.84
MS145	7					MS-14-5_site7_ctr-rim	5.57	77.25	17.19
MS145	7					MS-14-5_site7_ctr-rim	5.63	77.44	16.94
MS145	8					MS-14-5_site8_ctr-rim	5.93	77.31	16.77
MS145	8					MS-14-5_site8_ctr-rim	6.37	76.91	16.74
MS145	9					MS-14-5_site9_ctr-rim	5.97	76.32	17.73
MS145	9					MS-14-5_site9_ctr-rim	6.76	77.01	16.24
MS145	10					MS-14-5_site10_ctr-rim	2.97	74.39	22.66
MS145	10					MS-14-5_site10_ctr-rim	2.91	73.88	23.23
MS145	11					MS-14-5_site11_ctr-rim	6.10	76.58	17.34
MS145	11					MS-14-5_site11_ctr-rim	6.51	77.18	16.33
MS145	12					MS-14-5_site12_ctr-rim	5.99	76.70	17.33
MS145	12					MS-14-5_site12_ctr-rim	6.34	77.07	16.61
MS145	13					MS-14-5_site13_ctr-rim	2.71	73.50	23.81
MS145	13					MS-14-5_site13_ctr-rim	3.04	73.70	23.28
MS145	14					MS-14-5_site14_ctr-rim	5.00	77.65	17.36
MS145	14					MS-14-5_site14_ctr-rim	6.03	77.13	16.86
MS145	15					MS-14-5_site15_ctr-rim	21.39	72.93	5.68

Compare SEM and EMP Feldspar Info (Cont'd)									
Sample	Site	SEM			Total	Site-Location	EMP		
		(High K) Or	(High Ca) An	(High Na) Ab			(High K) Or	(High Ca) An	(High Na) Ab
MS145	15					MS-14-5_site15_ctr-rim	6.23	76.87	16.92
MS145	16					MS-14-5_site16_ctr-rim	6.04	77.05	16.93
MS145	16					MS-14-5_site16_ctr-rim	6.10	76.75	17.16
MS145	17					MS-14-5_site17_ctr-rim	13.08	78.03	8.90
MS145	17					MS-14-5_site17_ctr-rim	6.04	76.36	17.62
MS145	18					MS-14-5_site18_ctr-rim	66.91	31.63	1.46
MS145	18					MS-14-5_site18_ctr-rim	62.20	36.08	1.72
MS145	19					MS-14-5_site19_ctr-rim	70.61	28.55	0.84
MS145	19					MS-14-5_site19_ctr-rim	70.86	28.51	0.63
MS145	20					MS-14-5_site20_ctr-rim	15.31	77.06	7.64
MS145	20					MS-14-5_site20_ctr-rim	6.06	76.78	17.17
MS145	20					MS-14-5_site20_glass1	0.44	37.30	62.30
MS145	20					MS-14-5_site20_glass1	0.74	42.37	56.92
MS145	20					MS-14-5_site20_glass1	0.54	34.78	64.71
MS145	20					MS-14-5_site20_glass2	5.90	34.85	59.28
MS145	20					MS-14-5_site20_glass2	1.06	43.91	55.06
MS145	20					MS-14-5_site20_glass2	1.12	39.76	59.15
MS143	1	35.46	3.71	60.82	100				
MS143	2	19.01	6.87	74.12	100				
MS143	2	16.34	6.37	77.29	100				
MS143	2	18.70	6.33	74.96	100				
MS143	3	1.02	63.82	35.16	100				
MS143	3	0.88	80.23	18.89	100				
MS143	3	1.31	64.05	34.64	100				
MS143	3	1.04	65.76	33.20	100				
MS143	4	33.93	61.31	4.76	100				
MS143	4	14.12	70.99	14.89	100				
MS143	5	4.29	24.38	71.33	100				
MS143	6	19.03	6.29	74.68	100				
MS143	6	18.10	7.52	74.38	100				

Compare SEM and EMP Feldspar Info (Cont'd)									
Sample	Site	SEM			Total	Site-Location	EMP		
		(High K) Or	(High Ca) An	(High Na) Ab			(High K) Or	(High Ca) An	(High Na) Ab
MS143	7	8.97	22.86	68.16	100				
MS143	7	8.00	25.10	66.90	100				
MS143	7	7.63	24.97	67.41	100				
HS1505	2	3.21	35.36	61.42	100				
HS1505	2	2.57	35.43	62.00	100				
HS1505	3	48.13	0.00	51.88	100				
HS1505	3	15.57	5.07	79.36	100				
HS1505	3	2.19	46.84	50.97	100				
HS1505	4	19.09	6.12	74.79	100				
HS1505	4	18.47	6.91	74.61	100				
HS1505	5	0.00	74.05	25.95	100				
HS1505	5	0.00	71.01	28.99	100				
HS1505	7	8.84	22.21	68.95	100	HS-15-5_site7_ctr-rim	6.66	25.39	67.96
HS1505	7					HS-15-5_site7_ctr-rim	10.06	19.79	70.16
HS1505	7					HS-15-5_site7_ctr-rim	7.33	22.62	70.06
HS1505	9	19.24	6.55	74.22	100				
HS1505	10	75.98	0.00	24.02	100				
HS1505	11	19.52	6.06	74.43	100	HS-15-5_site11_ctr-rim	17.61	5.46	76.94
HS1505	11	53.67	7.91	38.42	100	HS-15-5_site11_ctr-rim	17.52	5.95	76.55
HS1505	14					HS-15-5_site14_ctr-rim	22.95	3	74.07
HS1505	14					HS-15-5_site14_ctr-rim	22.37	2.83	74.83
HS1505	15					HS-15-5_site15_ctr-rim	16.77	6.02	77.23
HS1505	15					HS-15-5_site15_ctr-rim	15.73	6.41	77.87
HS1505	16					HS-15-5_site16_ctr-rim	6.12	20.56	73.32
HS1505	16					HS-15-5_site16_ctr-rim	16.49	7.04	76.48
HS1505	17					HS-15-5_site17_ctr-rim	18.09	5.76	76.16
HS1505	17					HS-15-5_site17_ctr-rim	17.03	6.27	76.72
HS1505	18					HS-15-5_site18_ctr-rim	15.99	7.02	77.01
HS1505	18					HS-15-5_site18_ctr-rim	17.05	6.34	76.63
HS1505	19					HS-15-5_site19_ctr-rim	15.84	6.99	77.18

Compare SEM and EMP Feldspar Info (Cont'd)									
Sample	Site	SEM				Site-Location	EMP		
		(High K) Or	(High Ca) An	(High Na) Ab	Total		(High K) Or	(High Ca) An	(High Na) Ab
HS1505	19					HS-15-5_site19_ctr-rim	15.6	6.42	78
HS1505	20					HS-15-5_site20_ctr-rim	16.25	6.73	77.03
HS1505	20					HS-15-5_site20_ctr-rim	15.82	5.91	78.29
HS1505	21					HS-15-5_site21_ctr-rim	16.69	6.58	76.74
HS1505	21					HS-15-5_site21_ctr-rim	16.41	6.04	77.57
MS137	1	20.77	79.23	0.00	100				
MS137	1	19.87	80.13	0.00	100				
MS137	1	21.48	78.52	0.00	100				
MS137	2	15.93	3.58	80.49	100				
MS137	2	9.92	11.43	78.66	100				
MS137	2	8.75	0.00	91.25	100				
MS137	3	15.37	3.72	80.92	100				
MS137	3	15.55	3.23	81.22	100				
MS137	3	19.86	80.14	0.00	100				
MS137	6	17.31	2.86	79.83	100				
MS137	6	17.63	2.59	79.78	100				
MS137	7	14.16	3.88	81.95	100				
MS137	7	55.69	4.71	39.61	100				
MS137	7	15.38	3.72	80.89	100				
MS137	8	16.58	2.97	80.45	100				
MS137	8	15.57	3.61	80.82	100				
MS137	8	14.91	3.76	81.33	100				
MS137	9	14.06	4.07	81.87	100				
MS146	3	18.34	6.86	74.79	100	MS-14-6_site3_ctr-rim	17.96	77.49	4.55
MS146	3					MS-14-6_site3_ctr-rim	21.35	74.18	4.48
MS146	4	1.67	62.21	36.12	100	MS-14-6_site4_ctr-rim	60.93	38.06	1.01
MS146	4	1.43	63.07	35.50	100	MS-14-6_site4_ctr-rim	62.03	36.93	1.04
MS146	4	16.83	67.12	16.05	100				
MS146	5	19.77	6.40	73.84	100	MS-14-6_site5_ctr-rim	16.85	75.80	7.36
MS146	5	18.55	7.25	74.20	100	MS-14-6_site5_ctr-rim	6.52	76.75	16.74

Compare SEM and EMP Feldspar Info (Cont'd)									
Sample	Site	SEM				Site-Location	EMP		
		(High K) Or	(High Ca) An	(High Na) Ab	Total		(High K) Or	(High Ca) An	(High Na) Ab
MS146	5	5.91	83.77	10.32	100	MS-14-6_site5_ctr-rim	6.27	76.64	17.11
MS146	5					MS-14-6_site5_ctr-rim	6.18	76.30	17.53
MS146	5					MS-14-6_site5_ctr-rim	2.79	45.96	51.28
MS146	5					MS-14-6_site5_ctr-rim	4.28	48.43	47.31
MS146	6	19.07	4.10	76.84	100	MS-14-6_site6_ctr-rim	5.93	77.25	16.83
MS146	6					MS-14-6_site6_ctr-rim	6.50	76.70	16.82
MS146	7	0.36	96.27	3.37	100				
MS146	7	0.51	73.89	25.61	100				
MS146	7	1.85	94.30	3.85	100				
MS146	7	0.00	98.52	1.48	100				
MS146	7	1.84	60.21	37.94	100				
MS146	8	19.83	53.44	26.72	100	MS-14-6_site8_ctr-rim	6.12	76.82	17.07
MS146	8	26.99	32.92	40.08	100	MS-14-6_site8_ctr-rim	6.22	76.39	17.41
MS146	8	34.10	24.32	41.58	100				
MS146	9					MS-14-6_site9_ctr-rim	6.96	76.26	16.79
MS146	9					MS-14-6_site9_ctr-rim	16.77	76.69	6.55
MS146	10					MS-14-6_site10_ctr-rim	61.75	37.21	1.04
MS146	10					MS-14-6_site10_ctr-rim	63.29	35.58	1.13
MS146	10					MS-14-6_site10_mafic glass	52.86	23.28	23.86
MS146	10					MS-14-6_site10_mafic glass	49.88	28.11	22.02
MS146	10					MS-14-6_site10_silicic glass	3.38	55.60	41.04
MS146	10					MS-14-6_site10_silicic glass	3.96	55.11	40.96
MS146	11					MS-14-6_site11_ctr-rim	18.70	75.95	5.35
MS146	11					MS-14-6_site11_ctr-rim	17.91	76.65	5.44
MS146	11					MS-14-6_site11_ctr-rim	59.40	19.87	20.73
MS146	11					MS-14-6_site11_ctr-rim	49.63	26.16	24.21
MS146	12					MS-14-6_site12_ctr-rim	6.44	82.52	11.05
MS146	12					MS-14-6_site12_ctr-rim	6.44	76.95	16.63
MS146	12					MS-14-6_site12_ctr-rim	4.23	55.36	40.44
MS146	12					MS-14-6_site12_ctr-rim	4.01	53.00	43.01

Compare SEM and EMP Feldspar Info (Cont'd)									
Sample	Site	SEM				Site-Location	EMP		
		(High K)	(High Ca)	(High Na)	Total		(High K)	(High Ca)	(High Na)
		Or	An	Ab			Or	An	Ab
MS146	12					MS-14-6_site12_ctr-rim	35.36	43.46	21.19
MS146	12					MS-14-6_site12_ctr-rim	48.24	36.03	15.74
MS146	13					MS-14-6_site13_ctr-rim	83.94	0.00	16.06
MS146	14					MS-14-6_site14_ctr-rim	24.07	72.18	3.75
MS146	14					MS-14-6_site14_ctr-rim	24.35	71.61	4.05
MS146	15					MS-14-6_site15_ctr-rim	60.63	38.30	1.07
MS146	15					MS-14-6_site15_ctr-rim	62.28	36.77	0.95
MS146	16					MS-14-6_site16_ctr-rim	21.84	74.11	4.06
MS146	16					MS-14-6_site16_ctr-rim	24.05	72.02	3.93

APPENDIX J: SEM and EMP Data for Pyroxene Calculations, Combined

Compare SEM and EMP Pyroxene Info									
Sample	Site	SEM			Total	Site-Location	EMP		
		(High Ca) Wo	(High Mg) En	(High Fe) Fs			(High Ca) Wo	(High Mg) En	(High Fe) Fs
HS154a	2	38.83	40.90	20.27	100				
HS154a	3	42.02	19.88	38.10	100				
HS154a	4	32.44	19.07	48.50	100				
HS154a	5	42.09	19.62	38.28	100				
HS154a	5	42.03	19.54	38.43	100				
HS154a	7	42.22	19.82	37.96	100				
HS154a	7	41.90	19.63	38.47	100				
HS154c	2	16.70	6.79	76.52	100	HS-15-4c_P2_ctr-rim	41.19	15.52	43.29
HS154c	2	42.58	18.46	38.96	100	HS-15-4c_P2_ctr-rim	42.47	20.60	36.94
HS154c	3	42.58	19.12	38.30	100				
HS154c						HS-15-4c_P4_ctr-rim	42.33	20.73	36.94
HS154c						HS-15-4c_P4_ctr-rim	42.47	20.89	36.64
HS154c						HS-15-4c_P4_ctr-rim	42.07	20.37	37.56
HS154c						HS-15-4c_P4_ctr-rim	95.23	0.28	4.49
HS154c						HS-15-4c_P4_ctr-rim	0.02	1.20	98.78
HS154c						HS-15-4c_P4_ctr-rim	0.09	1.23	98.68
HS154c						HS-15-4c_P4_ctr-rim	0.36	1.21	98.43
HS154c						HS-15-4c_P4_ctr-rim	0.05	1.06	98.89
HS154c	7	41.65	19.81	38.54	100	HS-15-4c_P7ab_ctr-rim	42.27	21.23	36.51
HS154c	7	42.12	19.70	38.19	100	HS-15-4c_P7ab_ctr-rim	41.76	20.95	37.29
HS154c						HS-15-4c_P7ab_ctr-rim	0.10	1.41	98.49
HS154c						HS-15-4c_P7ab_ctr-rim	0.03	1.48	98.49
HS154c						HS-15-4c_P7ab_ctr-rim	42.31	19.98	37.71
HS154c						HS-15-4c_P7ab_ctr-rim	42.50	20.25	37.24
HS154c						HS-15-4c_P7ab_ctr-rim	33.17	25.19	41.64
HS154c						HS-15-4c_P7ab_ctr-rim	32.44	24.20	43.36
HS154c	9	42.65	19.25	38.10	100	HS-15-4c_P9_ctr-rim	42.96	20.09	36.95
HS154c						HS-15-4c_P9_ctr-rim	41.97	20.43	37.60
HS154c						HS-15-4c_P9_ctr-rim	0.00	1.27	98.73

Compare SEM and EMP Pyroxene Info (Cont'd)									
Sample	Site	SEM				Site-Location	EMP		
		(High Ca)	(High Mg)	(High Fe)	Total		(High Ca)	(High Mg)	(High Fe)
		Wo	En	Fs			Wo	En	Fs
HS154c	10	42.98	19.54	37.48	100				
HS154c	10	42.36	19.23	38.41	100				
HS154c						HS-15-4c_P12_ctr-rim	41.68	20.67	37.64
HS154c						HS-15-4c_P12_ctr-rim	42.24	20.59	37.17
HS154c						HS-15-4c_P13_ctr-rim	38.32	42.54	19.14
HS154c						HS-15-4c_P13_ctr-rim	40.08	42.02	17.90
HS154c						HS-15-4c_P13_ctr-rim	39.90	42.53	17.58
HS154c						HS-15-4c_P13_ctr-rim	52.57	1.91	45.52
HS154c						HS-15-4c_P13_ctr-rim	39.02	6.54	54.44
HS154c						HS-15-4c_P14_ctr-rim	39.16	37.05	23.79
HS154c						HS-15-4c_P14_ctr-rim	40.35	25.12	34.53
HS154c						HS-15-4c_P14_ctr-rim	0.20	1.66	98.14
HS154c						HS-15-4c_P14_ctr-rim	0.16	1.72	98.12
HS154c						HS-15-4c_P15_ctr-rim	42.78	20.44	36.78
HS154c						HS-15-4c_P15_ctr-rim	42.14	20.76	37.10
HS154c						HS-15-4c_P15_ctr-rim	0.05	1.82	98.13
HS154c						HS-15-4c_P15_ctr-rim	0.06	1.89	98.05
HS154c						HS-15-4c_P15_ctr-rim	16.14	5.64	78.22
HS154c						HS-15-4c_P15_ctr-rim	20.92	5.17	73.91
HS154c						HS-15-4c_P16_ctr-rim	42.03	20.70	37.27
HS154c						HS-15-4c_P16_ctr-rim	42.36	20.47	37.17
HS154c						HS-15-4c_P16_ctr-rim	42.52	20.50	36.98
HS154c						HS-15-4c_P17_ctr-rim	42.44	20.33	37.24
HS154c						HS-15-4c_P17_ctr-rim	41.87	20.46	37.67
HS154c						HS-15-4c_P18abc_ctr-rim	0.58	21.27	78.15
HS154c						HS-15-4c_P18abc_ctr-rim	0.60	20.97	78.43
HS154c						HS-15-4c_P18abc_ctr-rim	0.62	21.36	78.02
HS154c						HS-15-4c_P18abc_ctr-rim	0.57	21.09	78.34
HS154c						HS-15-4c_P18abc_ctr-rim	0.68	20.93	78.39
HS154c						HS-15-4c_P18abc_ctr-rim	0.63	21.16	78.21

Compare SEM and EMP Pyroxene Info (Cont'd)									
Sample	Site	SEM				Site-Location	EMP		
		(High Ca)	(High Mg)	(High Fe)	Total		(High Ca)	(High Mg)	(High Fe)
		Wo	En	Fs			Wo	En	Fs
HS154c						HS-15-4c_P18abc_ctr-rim	0.83	18.82	80.36
HS154c						HS-15-4c_P18abc_ctr-rim	0.59	21.27	78.14
HS154c						HS-15-4c_P18abc_ctr-rim	0.60	21.02	78.38
HS154c						HS-15-4c_P18abc_ctr-rim	0.66	20.44	78.90
HS154c						HS-15-4c_P18abc_ctr-rim	95.18	1.15	3.67
HS154c						HS-15-4c_P18abc_ctr-rim	96.19	0.00	3.81
HS154c						HS-15-4c_P19ab_ctr-rim	42.24	20.60	37.16
HS154c						HS-15-4c_P19ab_ctr-rim	42.25	20.71	37.03
HS154c						HS-15-4c_P19ab_ctr-rim	42.63	20.30	37.07
HS154c						HS-15-4c_P19ab_ctr-rim	41.97	20.53	37.50
HS154c						HS-15-4c_P20_ctr-rim	38.26	37.40	24.34
HS154c						HS-15-4c_P20_ctr-rim	36.03	39.57	24.40
HS154c						HS-15-4c_P20_ctr-rim	0.02	4.36	95.62
HS154c						HS-15-4c_P20_ctr-rim	0.03	3.98	95.99
HS154c						HS-15-4c_P20_ctr-rim	1.40	1.03	97.57
HS154c						HS-15-4c_P20_ctr-rim	1.84	0.99	97.17
HS154d	5					HS-15-4d_P5_ctr-rim	40.59	45.87	13.54
HS154d	5					HS-15-4d_P5_ctr-rim	40.38	45.96	13.65
HS154d	5					HS-15-4d_P5_ctr-rim	40.74	45.64	13.61
HS154d	7	42.37	19.65	37.98	100	HS-15-4d_P7_ctr-rim	42.49	20.83	36.69
HS154d	7	42.87	19.72	37.41	100	HS-15-4d_P7_ctr-rim	42.49	20.35	37.16
HS154d	7					HS-15-4d_P7_ctr-rim	42.25	20.61	37.13
HS154d	12					HS-15-4d_P12_ctr-rim	38.17	26.53	35.30
HS154d	12					HS-15-4d_P12_ctr-rim	36.77	27.00	36.23
HS154d	12					HS-15-4d_P12_ctr-rim	35.39	26.91	37.69
HS154e	2	37.54	5.66	56.81	100				
HS154e	4	42.23	19.85	37.92	100	HS-15-4e_P4_ctr-rim	41.89	20.76	37.36
HS154e	4	43.23	18.40	38.38	100	HS-15-4e_P4_ctr-rim	42.41	20.59	37.00
HS154e						HS-15-4e_P4_ctr-rim	43.01	20.42	36.57
HS154e	5	41.81	19.45	38.74	100	HS-15-4e_P5abc_ctr-rim	42.10	19.78	38.12

Compare SEM and EMP Pyroxene Info (Cont'd)										
SEM						EMP				
		(High Ca)	(High Mg)	(High Fe)	Total			(High Ca)	(High Mg)	(High Fe)
Sample	Site	Wo	En	Fs		Site-Location	Wo	En	Fs	
HS154e	5	42.08	19.09	38.84	100	HS-15-4e_P5abc_ctr-rim	42.29	20.72	36.99	
HS154e	5	42.39	19.68	37.93	100	HS-15-4e_P5abc_ctr-rim	42.32	20.68	37.01	
HS154e	5	43.01	19.82	37.17	100	HS-15-4e_P5abc_ctr-rim	41.49	20.69	37.82	
HS154e						HS-15-4e_P5abc_ctr-rim	42.56	20.47	36.97	
HS154e						HS-15-4e_P5abc_ctr-rim	42.22	20.47	37.30	
HS154e	8	41.73	17.56	40.71	100					
HS154e	11	42.67	19.64	37.70	100	HS-15-4e_P11_ctr-rim	42.03	23.27	34.69	
HS154e						HS-15-4e_P11_ctr-rim	42.36	20.93	36.71	
HS154e						HS-15-4e_P11_ctr-rim	42.40	20.61	36.99	
HS154e						HS-15-4e_P11_ctr-rim	0.06	1.60	98.34	
HS154e						HS-15-4e_P11_ctr-rim	0.05	1.52	98.44	
HS154e						HS-15-4e_P11_ctr-rim	0.05	1.51	98.44	
HS154e						HS-15-4e_P11_ctr-rim	0.01	1.44	98.55	
HS154e						HS-15-4e_P12_ctr-rim	35.13	24.54	40.33	
HS154e						HS-15-4e_P12_ctr-rim	39.33	24.77	35.90	
HS154e						HS-15-4e_P12_ctr-rim	41.03	22.00	36.97	
HS1505	5	33.70	29.26	37.05	100					
HS1505	6	39.59	37.14	23.27	100					
HS1505	8	6.79	80.88	12.34	100					
HS1505	8	6.15	83.57	10.28	100					
HS1505	8	4.62	84.94	10.44	100					
HS1505						HS-15-5_P22_ctr-rim	43.64	42.88	13.48	
HS1505						HS-15-5_P22_ctr-rim	43.81	42.81	13.38	
MS137	4	48.83	0.00	51.17	100	MS-13-7_P3_	95.69	2.33	1.99	
MS137						MS-13-7_P3_	9.31	20.05	70.64	
MS137						MS-13-7_P11_	12.68	15.52	71.80	
MS137						MS-13-7_P11_	16.89	14.99	68.11	
MS137						MS-13-7_P11_	0.16	0.15	99.69	
MS137						MS-13-7_P11_	0.10	0.08	99.82	
MS137						MS-13-7_P12_ctr-rim	48.63	35.33	16.05	

Compare SEM and EMP Pyroxene Info (Cont'd)									
Sample	Site	SEM			Total	Site-Location	EMP		
		(High Ca) Wo	(High Mg) En	(High Fe) Fs			(High Ca) Wo	(High Mg) En	(High Fe) Fs
MS137						MS-13-7_P12_ctr-rim	48.23	34.61	17.16
MS137						MS-13-7_P12_ctr-rim	47.08	29.28	23.64
MS137						MS-13-7_P13_ctr-rim	39.29	42.86	17.85
MS137						MS-13-7_P13_ctr-rim	39.35	40.27	20.38
MS137						MS-13-7_P13_ctr-rim	39.07	43.53	17.40
MS137						MS-13-7_P13_ctr-rim	0.02	8.72	91.25
MS137						MS-13-7_P13_ctr-rim	1.41	3.71	94.88
MS137						MS-13-7_P13_ctr-rim	0.08	8.35	91.57
MS137						MS-13-7_P13_ctr-rim	2.40	1.21	96.40
MS137						MS-13-7_P14_ctr-rim	44.64	0.71	54.65
MS137						MS-13-7_P14_ctr-rim	44.63	0.66	54.71
MS137						MS-13-7_P14_ctr-rim	44.43	0.73	54.84
MS137						MS-13-7_P15_ctr-rim	3.54	68.10	28.37
MS137						MS-13-7_P15_ctr-rim	39.92	43.54	16.55
MS137						MS-13-7_P15_ctr-rim	39.56	43.75	16.68
MS137						MS-13-7_P15_ctr-rim	1.09	14.25	84.66
MS137						MS-13-7_P15_ctr-rim	0.12	9.99	89.89
MS137						MS-13-7_P15_ctr-rim	2.40	1.30	96.30
MS137						MS-13-7_P15_ctr-rim	2.72	1.31	95.98
MS137						MS-13-7_P15_ctr-rim	34.80	23.00	42.21
MS137						MS-13-7_P15_ctr-rim	34.57	22.00	43.43
MS137						MS-13-7_P15_ctr-rim	35.70	22.57	41.73
MS137						MS-13-7_F16_ctr-rim	76.21	2.28	21.50
MS137						MS-13-7_F16_ctr-rim	84.24	0.00	15.76
MS137						MS-13-7_F17_ctr-rim	85.00	0.00	15.00
MS137						MS-13-7_F17_ctr-rim	81.11	1.88	17.01
MS137						MS-13-7_F18_ctr-rim	84.38	0.00	15.62
MS137						MS-13-7_F18_ctr-rim	86.75	0.00	13.25
MS143						MS-14-3_P1_ctr-rim	42.58	20.37	37.05
MS143						MS-14-3_P1_ctr-rim	42.35	20.84	36.81

Compare SEM and EMP Pyroxene Info (Cont'd)									
Sample	Site	SEM				Site-Location	EMP		
		(High Ca) Wo	(High Mg) En	(High Fe) Fs	Total		(High Ca) Wo	(High Mg) En	(High Fe) Fs
MS143						MS-14-3_P1_ctr-rim	42.24	20.48	37.29
MS143	3	2.09	54.69	43.22	100	MS-14-3_P3_ctr-rim	1.57	50.39	48.05
MS143						MS-14-3_P3_ctr-rim	1.84	46.76	51.40
MS143						MS-14-3_P3_ctr-rim	1.87	48.69	49.43
MS143	4	10.12	15.52	74.36	100				
MS143	4	18.69	14.87	66.43	100				
MS143						MS-14-3_P14_ctr-rim	32.46	29.55	37.99
MS143						MS-14-3_P14_ctr-rim	33.95	28.18	37.87
MS143						MS-14-3_P14_ctr-rim	38.72	28.43	32.85
MS143						MS-14-3_P14_ctr-rim	0.03	1.64	98.33
MS143						MS-14-3_P14_ctr-rim	0.05	2.22	97.74
MS143						MS-14-3_P14_ctr-rim	0.07	1.30	98.63
MS143						MS-14-3_P14_ctr-rim	0.09	1.74	98.17
MS143						MS-14-3_P14_ctr-rim	0.17	8.03	91.80
MS143						MS-14-3_P14_ctr-rim	0.19	7.59	92.22
MS145	3	42.13	19.49	38.38	100				
MS145	4	42.15	19.32	38.53	100	MS-14-5_P4ab_ctr-rim	41.00	18.36	40.64
MS145	4	42.52	19.67	37.82	100	MS-14-5_P4ab_ctr-rim	42.47	20.14	37.40
MS145						MS-14-5_P4ab_ctr-rim	81.52	0.24	18.24
MS145						MS-14-5_P4ab_ctr-rim	42.80	20.12	37.08
MS145						MS-14-5_P4ab_ctr-rim	42.59	20.43	36.98
MS145						MS-14-5_P4ab_ctr-rim	71.01	2.18	26.82
MS145	5	42.03	19.97	38.00	100				
MS145	5	42.41	19.52	38.07	100				
MS145						MS-14-5_p21_ctr-rim	42.13	20.36	37.51
MS145						MS-14-5_p21_ctr-rim	41.62	20.75	37.63
MS145						MS-14-5_p21_ctr-rim	0.03	1.13	98.84
MS145						MS-14-5_p21_ctr-rim	0.04	0.87	99.09
MS145						MS-14-5_P22_ctr-rim	42.32	20.62	37.05
MS145						MS-14-5_P22_ctr-rim	41.82	20.06	38.12

Compare SEM and EMP Pyroxene Info (Cont'd)									
Sample	Site	SEM			Total	Site-Location	EMP		
		(High Ca)	(High Mg)	(High Fe)			(High Ca)	(High Mg)	(High Fe)
		Wo	En	Fs			Wo	En	Fs
MS145						MS-14-5_P23_ctr-rim	42.70	20.49	36.81
MS145						MS-14-5_P23_ctr-rim	42.60	20.14	37.25
MS145						MS-14-5_P23_ctr-rim	41.90	20.25	37.84
MS145						MS-14-5_P23_ctr-rim	0.02	0.89	99.09
MS145						MS-14-5_P23_ctr-rim	0.03	0.95	99.03
MS145						MS-14-5_P24_ctr-rim	43.08	20.69	36.24
MS145						MS-14-5_P24_ctr-rim	42.68	20.76	36.57
MS145						MS-14-5_P25_ctr-rim	42.38	20.66	36.96
MS145						MS-14-5_P25_ctr-rim	42.31	20.39	37.31
MS145						MS-14-5_P26_ctr-rim	39.91	22.43	37.66
MS145						MS-14-5_P26_ctr-rim	37.74	22.99	39.27
MS145						MS-14-5_P26_ctr-rim	41.65	20.50	37.85
MS145						MS-14-5_P27_ctr-rim	42.49	20.14	37.37
MS145						MS-14-5_P27_ctr-rim	42.92	20.24	36.84
MS145						MS-14-5_P27_ctr-rim	42.59	20.70	36.71
MS145						MS-14-5_P27_ctr-rim	3.01	3.70	93.29
MS145						MS-14-5_P27_ctr-rim	1.95	0.25	97.80
MS146	3	43.22	19.10	37.69	100	MS-14-6_P3ab_ctr-rim	42.17	20.13	37.70
MS146	3	41.54	17.82	40.65	100	MS-14-6_P3ab_ctr-rim	42.26	20.41	37.33
MS146	3	83.89	4.76	11.35	100	MS-14-6_P3ab_ctr-rim	42.59	20.33	37.08
MS146	3	41.87	19.91	38.22	100	MS-14-6_P3ab_ctr-rim	42.04	18.71	39.25
MS146	5	40.14	20.38	39.48	100	MS-14-6_P3ab_ctr-rim	33.19	24.82	42.00
MS146	7	40.59	42.21	17.20	100	MS-14-6_P3ab_ctr-rim	32.28	26.24	41.48
MS146	7	41.27	15.46	43.27	100				
MS146	7	37.65	42.03	20.32	100				
MS146	8	42.20	19.18	38.62	100				
MS146						MS-14-6_P9_ctr-rim	42.15	20.70	37.15
MS146						MS-14-6_P9_ctr-rim	42.04	21.00	36.96
MS146						MS-14-6_P9_ctr-rim	0.01	1.06	98.93
MS146						MS-14-6_P9_ctr-rim	0.00	1.13	98.87

Compare SEM and EMP Pyroxene Info (Cont'd)									
Sample	Site	SEM				Site-Location	EMP		
		(High Ca) Wo	(High Mg) En	(High Fe) Fs	Total		(High Ca) Wo	(High Mg) En	(High Fe) Fs
MS146						MS-14-6_P9_ctr-rim	15.72	3.82	80.47
MS146						MS-14-6_P9_ctr-rim	20.60	1.60	77.80
MS146						MS-14-6_F10_ctr-rim	95.37	0.37	4.26
MS146						MS-14-6_F10_ctr-rim	95.30	0.66	4.03
MS146						MS-14-6_F10_ctr-rim	94.67	0.72	4.61
MS146						MS-14-6_F10_ctr-rim	84.67	0.00	15.33
MS146						MS-14-6_P11_ctr-rim	42.44	20.43	37.13
MS146						MS-14-6_P11_ctr-rim	42.32	19.99	37.69
MS146						MS-14-6_P11_ctr-rim	21.25	3.41	75.34
MS146						MS-14-6_P11_ctr-rim	18.30	3.19	78.50
MS146						MS-14-6_P11_ctr-rim	33.90	25.11	40.99
MS146						MS-14-6_P11_ctr-rim	34.32	24.63	41.05
MS146						MS-14-6_P11_ctr-rim	0.04	0.94	99.01
MS146						MS-14-6_P11_ctr-rim	0.23	1.15	98.62
MS146						MS-14-6_P12_ctr-rim	42.24	20.80	36.97
MS146						MS-14-6_P12_ctr-rim	42.68	20.37	36.94
MS146						MS-14-6_P12_ctr-rim	0.10	1.12	98.78
MS146						MS-14-6_P12_ctr-rim	0.09	1.16	98.75
MS146						MS-14-6_P13_ctr-rim	37.44	20.85	41.72
MS146						MS-14-6_P13_ctr-rim	36.85	21.29	41.86
MS146						MS-14-6_P13_ctr-rim	32.67	25.69	41.64
MS146						MS-14-6_P13_ctr-rim	33.28	23.59	43.14
MS146						MS-14-6_P14ab_ctr-rim	42.30	20.56	37.15
MS146						MS-14-6_P14ab_ctr-rim	41.91	20.48	37.62
MS146						MS-14-6_P14ab_ctr-rim	43.72	0.54	55.73
MS146						MS-14-6_P14ab_ctr-rim	0.03	0.92	99.05
MS146						MS-14-6_P14ab_ctr-rim	42.56	20.25	37.19
MS146						MS-14-6_P14ab_ctr-rim	42.50	20.21	37.28
MS146						MS-14-6_P14ab_ctr-rim	32.68	22.84	44.48
MS146						MS-14-6_P14ab_ctr-rim	35.40	22.57	42.02

Compare SEM and EMP Pyroxene Info (Cont'd)									
Sample	Site	SEM				Site-Location	EMP		
		(High Ca)	(High Mg)	(High Fe)	Total		(High Ca)	(High Mg)	(High Fe)
		Wo	En	Fs			Wo	En	Fs
MS146						MS-14-6_P15_ctr-rim	42.88	20.32	36.80
MS146						MS-14-6_P15_ctr-rim	41.87	20.52	37.61
MS146						MS-14-6_P15_ctr-rim	1.39	1.14	97.48
MS146						MS-14-6_P15_ctr-rim	0.01	1.08	98.91
MS146						MS-14-6_P15_ctr-rim	22.35	5.35	72.30
MS146						MS-14-6_P15_ctr-rim	26.43	6.48	67.09
MS146						MS-14-6_P15_ctr-rim	31.30	17.53	51.17
MS146						MS-14-6_P15_ctr-rim	34.49	18.18	47.33
MS146						MS-14-6_P16_ctr-rim	36.32	23.51	40.18
MS146						MS-14-6_P16_ctr-rim	39.35	22.61	38.04
MS146						MS-14-6_P17_ctr-rim	41.92	42.05	16.03
MS146						MS-14-6_P17_ctr-rim	41.90	42.05	16.05
MS146						MS-14-6_P17_ctr-rim	0.03	3.40	96.57
MS146						MS-14-6_P17_ctr-rim	0.05	3.27	96.68
MS146						MS-14-6_P18_ctr-rim	32.40	41.90	25.70
MS146						MS-14-6_P18_ctr-rim	26.62	44.37	29.00
MS146						MS-14-6_P18_ctr-rim	34.09	41.25	24.67
MS146						MS-14-6_P18_ctr-rim	28.87	23.32	47.80
MS146						MS-14-6_P18_ctr-rim	31.16	24.96	43.88
MS146						MS-14-6_P19_ctr-rim	39.41	21.47	39.12
MS146						MS-14-6_P19_ctr-rim	42.11	21.02	36.87
MS146						MS-14-6_glass1-4	36.57	26.02	37.41
MS146						MS-14-6_glass1-4	36.38	24.93	38.70
MS146						MS-14-6_glass1-4	34.71	24.17	41.12
MS146						MS-14-6_glass1-4	32.70	23.36	43.94
MS146						MS-14-6_glass1-4	30.35	25.36	44.29
MS146						MS-14-6_glass1-4	32.60	25.97	41.43
MS146						MS-14-6_glass1-4	27.13	4.08	68.79
MS146						MS-14-6_glass1-4	23.08	3.43	73.48

Appendix K: Major Element Comparison Plots

Figure K-1. SiO₂ vs. MgO shows a linear pattern ranging from the least silicic samples (trachyandesite) which contain the highest wt% MgO, to the highest silica samples, rhyolites which have the lowest wt% MgO.

Figure K-2. This major element plot shows SiO₂ wt% vs. FeO wt%. Again, a clear pattern emerges. The most mafic samples (trachyandesite and the hand-separated mafic materials) have the highest amount of FeO. The most silicic samples, rhyolites, have the lowest amount of FeO. The hand separated mafic minerals were taken from samples HS154D (trachyandesite), HS154E (trachyandesite), MS1307 (rhyolite), and MS1403 (trachydacite).

Figure K-3. Major element comparison plot of SiO_2 wt% vs. Na_2O wt%. Not much of a pattern is seen in this comparison. A similar amount of Na_2O is present in each sample despite varying silica compositions.

Figure K-4. A pattern of lower K_2O levels with lower silica content can be seen in this major element plot showing K_2O vs. SiO_2 . Trachyandesite samples are the lowest silica samples with the lowest K_2O content, and rhyolites are the highest silica samples, containing the most K_2O .

Figure K-7. A clear linear relationship can be seen in the major element comparison plot of SiO_2 wt% vs. TiO_2 wt%. The highest silica samples contain the lowest amount of titanium, where the lower silica samples contain the most. The overall sample set ranges from 0.21 wt% TiO_2 to 1.83 wt% TiO_2 . This includes hand separated mafic minerals, taken from samples HS154D (trachyandesite), HS154E (trachyandesite), MS1307 (rhyolite), and MS1403 (trachydacite).

Figure K-8. This major element plot of SiO_2 vs. Al_2O_3 shows an s-shaped curve. Some of the most felsic samples, the rhyolites in Hooper's data set, have lower amounts of Al_2O_3 , where some of the most mafic trachyandesite samples have a relatively high wt% of Al_2O_3 . The total range is from 11.36 to 16.84 wt% Al_2O_3 . Most of the samples fall in the central range of about 13 to 14 wt% Al_2O_3 .

Figure K-9. Although no clear pattern emerges to correlate Na₂O wt% vs. TiO₂ wt%, the relationship between TiO₂ and silica content is clear. The most mafic samples contain the most TiO₂. These are the trachyandesites in the sample set.

Figure K-10. No true trend can be seen comparing major elements Al₂O₃/(CaO + Na₂O + K₂O) wt% vs. Al₂O₃/(Na₂O + K₂O) wt%. Overall, Hooper's sample set contains less Al₂O₃/(Na₂O + K₂O) wt% than the more mafic samples taken in the field. Hooper's data is in line with the rhyolitic samples taken in the field.

Figure K-11. Most samples contain little-to-no FeO/MgO wt%. Although the full range is from 0 to 67.25 wt% FeO/MgO, most of the samples are below 20 wt% FeO/MgO.

Figure K-12. A general linear trend is seen in this major element comparison diagram. Samples with higher silica levels (rhyolites) contain a higher weight percent of FeO/(FeO + MgO). The silicic samples fall between 0.8 and 1.0 wt% FeO/(FeO+MgO), while the mafic samples (trachyandesite and trachydacite) fall between 0.78 and 0.83 wt% FeO/(FeO+MgO).

Figure K-13. A clear linear trend is seen in this major element comparison diagram of SiO_2 vs. P_2O_5 . Samples with lower silica composition contain much higher wt% P_2O_5 . This includes hand separated mafic minerals, taken from samples HS154D (trachyandesite), HS154E (trachyandesite), MS1307 (rhyolite), and MS1403 (trachydacite)

APPENDIX L: Major and Trace Element Comparison Plots

Figure L-1. SiO₂ vs. Nb plots without a detectable pattern. The rhyolites typically show a higher ppm value of Nb than the more mafic samples.

Figure L-2. Major element SiO₂ vs. Trace element Zr shows a slight pattern, as Zr increases along with silica content.

Figure L-3. Major element SiO₂ vs. trace element Sr shows a clear pattern. Sr decreases as SiO₂ increases. The most mafic samples contain around 295ppm Sr, while the rhyolites, the most felsic samples, contain as low as 65ppm Sr.

Figure L-4. No clear pattern emerges in this element plot of major element SiO₂ vs. trace element Ba. The total range of barium is from 924 ppm to 1911 ppm, with no distinction between silica-rich or silica-poor samples.

APPENDIX M: Trace Element Comparison Plots

Figure M-1. Trace element plot of La/Sm ppm vs. U/Nb ppm shows a clear pattern. La/Sm is directly proportional with U/Nb. As silica content increases from trachyandesite to rhyolite, so do the proportions of these trace element ratios.

Figure M-2. Trace element diagram of Th ppm vs. La ppm does not show a distinct linear pattern. Instead, the lower silica samples are grouped together in the lower range of ~40 to 48ppm La and ~6 to 7ppm Th. Rhyolites are more spread out, ranging from ~6.6ppm Th to 8.61ppm Th and from ~40ppm La to as high as ~60ppm La.

Figure M-3. Again, no clear pattern emerges from the trace element diagram plotting Th ppm vs. Ba ppm. More mafic samples typically show a lower amount of both Ba and Th, while the felsic samples display a higher Th and Ba content. The total range is from 5.79ppm Th to 8.61ppm Th and from 924ppm to 1887ppm Ba.

Figure M-4. Though not linear, a pattern is seen in this trace element comparison diagram. U/Th ppm increases with increasing silica content.

Figure M-5. Trace element plot of Nb v. Nb/Ta shows a generally linear pattern of decreasing Nb/Ta with increasing silica. The outlier at Nb 21.63ppm, Nb/Ta 3.27ppm is MS1307, a sample of the Buchanan Tuff. The samples range from ~3 to 3.6ppm Nb/Ta and from ~20 to 27ppm Nb.

Figure M-6. Again, a linear pattern can be seen in this trace element plot of Nb vs. Th. An increase in silica content shows an increase in both Nb and Th. The outlier rhyolite is MS1307 from the Buchanan Tuff.

Figure M-7. Trace element plot of La/Sm vs. Ba/Th shows no distinct pattern. The trachyandesite samples are grouped tightly together, ranging from 3.65 to 3.92 ppm La/Sm and 158 to 175 ppm Ba/Th. Trachydacite samples are spread out ranging from 3.92 to 4.62 ppm La/Sm and 146 to 196 ppm Ba/Th. The rhyolites are the most variable, ranging from 4.1 to 4.98 ppm La/Sm and 111 to 239 ppm Ba/Th.

Figure M-8. Although the Ba variations are very large, these samples show a general trend of higher Eu with decreasing silica content. Rhyolites range from 1.78 to 2.17 ppm Eu, while Trachyandesites range from 2.71 to 3.08 ppm Eu.

Figure M-9. No clear pattern emerges from this trace element diagram of Zr vs. Ba. The full range of the Wildcat Creek Tuff samples is from 924 to 1887ppm Ba, and from 324 to 459 ppm Zr.

Figure M-10. Trace element plot of Y vs. Nb shows only a slight pattern of increasing Nb with increasing SiO₂ content. With the exception of MS1307 (Buchanan Tuff), the Wildcat Creek Tuff rhyolite samples are highest in Nb content, ranging from ~25 to 27ppm. The trachydacite samples are the lowest, containing as low as 20ppm Nb. The samples range from ~57 to 78ppm Y.

Figure M-11. Trace element plot of Ta vs. Tb. These samples range from 1.22 to 1.60 ppm Ta and from 1.68 to 2.08 ppm Tb. No pattern is truly discernable, though a general trend of higher Ta levels can be observed in more silicic samples.

Figure M-12. Trace element chart of Nb/Y vs. Ce/Y. Rhyolites range from 0.3 to 0.47 ppm Nb/Y and from 1.2 to 1.5 ppm Ce/Y, while more mafic samples range from only 0.33 to 0.37 ppm Nb/Y and 1.36 to 1.58 ppm Ce/Y.

Figure M-13. A slightly linear pattern can be seen in the trace element diagram of La/Sm vs. Th. Mafic samples of the Wildcat Creek Tuff (WCT) contain generally less La/Sm and Th than the rhyolite samples. The exception is sample MS1307, from the Buchanan Tuff, which sits in the middle of the range of mafic samples from the WCT. WCT rhyolites contain 8.2 to 8.1ppm Th, while the mafic samples contain between 5.7 and 7.1ppm Th.

Figure M-14. A loose trend can be seen in this trace element plot of La/Sm vs. Th/Nb comparison of the Wildcat Creek Tuff samples. The more felsic rhyolite samples contain higher concentrations of the trace elements, while the more mafic samples contain less. The range of Th/Nb is relatively tight, ranging from 0.27 to 0.33ppm across the entire sample spectrum. The range of La/Sm is slightly larger, ranging from 3.7 to 4.9ppm.

Figure M-15. A general trend of increasing trace element concentrations can be seen with increasing silica values in this trace element plot of La/Sm vs. Pb/Ce. The outlier is HS1505, a trachydacite with a La/Sm value of 4.6ppm, and a Pb/Ce value of 0.18ppm.

APPENDIX N: Stratigraphic Column of Site 4

	Stratigraphic Column	Corresponding Thin Section	Rock Type	Description
1314m	High FeO Low SiO ₂	HS-15-04d	Trachyandesite	HS-15-04d: Black mingled with red, phenocryst poor.
1311m		HS-15-04e	Trachyandesite	HS-15-04e: dark brown, large brown pumice
1309m		HS-15-04c	Trachyandesite	HS-15-04c: light grey/brown, phenocryst poor, colorful scoria
1305m		HS-15-04b	Trachydacite	HS-15-04b: Highly welded, large fiamme, red-brown
1302m	Low FeO High SiO ₂	HS-15-04a	Trachydacite	HS-15-04a: black pumice, highly vesicular, low welding, phenocryst poor