CHARACTERIZATION AND PETROGENESIS OF ADAKITIC PYROCLASTIC ROCKS ERUPTED DURING THE HOLOCENE FROM SHIVELUCH VOLCANO, KAMCHATKA, RUSSIA

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INDEPENDENT STUDY submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology
August 26, 2002

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ABSTRACT

The variation of magma compositions at Shiveluch volcano, the northernmost and most active andesitic volcano on the Kamchatka Peninsula, was examined in Holocene eruptive products (8900 ^{14}C year BP to 1964). Pumice clasts and tephra samples from 48 pyroclastic eruptions were analyzed by X-ray fluorescence and electron microprobe methods. Medium-K, hornblende-bearing andesite has been the dominant eruptive product from Shiveluch volcano. Four basaltic andesite and one dacite eruption have been recognized. Rhyolites are absent in the Holocene eruptive products. Analyses of single pumice from individual eruptive units show no evidence for chemical zonation suggesting the magma chambers were well mixed and uniform throughout. Bulk analyses of pumice show coherent geochemical trends consistent with either mixing and/or fractional crystallization.

The Shiveluch andesites have high MgO (2.3-6.8 wt %), Cr (65-358 ppm), Ni (18-106 ppm) and Sr (471-615 ppm) and low Y (<18 ppm). They are geochemically similar to adakites, which are derived by partial melting of eclogite subducted oceanic crust. Slab melt is usually associated with subduction of young, relatively warm oceanic slab; this is not the situation for Shiveluch which involves subduction of the old, relatively cold Pacific slab. The slab melt component in Shiveluch magmas is attributed to tearing of the downgoing slab at the junction of the Aleutian and Kamchatkan subduction zones, causing the edge of the slab to be warmed by mantle flow. Analyses of the pumice samples help constrain the chemical contribution of a slab melt component in the generation of Shiveluch magmas.

ACKNOWLEDGEMENTS

The September 2000 fieldwork was supported by National Geographic Society grant #6831-00 to Vera Ponomareva. Travel to Kamchatka was paid for by a summer research fellowship from the New Mexico Institute of Mining and Technology Graduate office. Lab analyses were funded in part by research grants from the Geological Society of America and the New Mexico Institute of Mining and Technology. Credit must be given to my advisor, Philip Kyle, for his guidance and assistance in carrying out this research. Vera Ponomareva's contributions to the project are invaluable: she obtained the grant that funded the fieldwork, organized an excellent field crew, led us in the field for sample collection, and provided ages and other important information about the Shiveluch eruptions. Thanks to the field crew for their help: Masha Pevzner, Natasha Zaretskaia, Maksim Stolyarov, Gennadii Novikov, and Serei Rozhkov. Many thanks to Alexei Oserov for his kindness while we were in Petropavlovsk and much applause to him for helping us return from Kamchatka with samples in hand. I am grateful to Nelia Dunbar and Lynn Heizler for answering my many questions and guiding me in use of the electron microprobe. Thanks to Chris McKee for the training in preparing samples for X-ray fluorescence analyses. Professor Bruce Harrison's encouragement and letter for the GSA research grant were a great help. I appreciate the useful discussions and proofreading provided by Jessie Crain, Tina Calvin, Erin Phillips, and Joy Rosen. Committee members Kent Condie and Nelia Dunbar were helpful in critiquing this work. My family deserves endless gratitude for the support and encouragement they always offer. Thanks to Joe for hanging in there.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

The processes involved in subduction-related volcanism are the subject of continuous debate. Early studies suggested that melting of the downgoing oceanic slab was the source of arc magmas. Over the past 30 years there has been growing evidence that this is not generally the case. Geochemical, isotopic, and petrologic data indicate that most arc magmas are generated by partial melting of the mantle wedge above the subducting slab due to the release of hydrous fluids from the depth at which the phase change from amphibolite to eclogite occurs in the slab. Recently, however, research shows that the pressure-temperature conditions of some volcanic arcs may result in partial melting of subducted oceanic lithosphere.

The principal objective of this work is to examine magma petrogenesis of Shiveluch Volcano through the Holocene in order to determine the role of slab melting versus conventional mantle partial melting in the generation of arc magmas at this locale. This study involves the examination of samples that are well-dated, allowing an investigation on the magmatic evolution of Shiveluch with time. Pumice and ash samples were collected from 48 eruptions ranging from 8600 ^{14}C y B.P. to the year 1964. X-ray fluorescence and electron microprobe analyses were used to analyze the samples. Shiveluch geochemistry was then compared with geochemistry of typical arc magmas and that of slab melt to ascertain whether Shiveluch magmas preserve a slab melt signature as opposed to the typical arc magma signature.

CHAPTER TWO

ADAKITES

Kay (1978) recognized geochemically distinct high-magnesian andesitic magmas at Adak Island (Aleutian Islands, Alaska) as possible slab melts. These magmas are referred to as *adakites* because this is the locale where they were first documented (Defant and Drummond, 1990). In at least 13 volcanic arcs worldwide, geochemical, isotopic, and petrographic data provide a characteristic slab melt signature (Defant and Drummond, 1993). Drummond et al. (1996) interpret this geochemical signature to be due to partial melting of a basaltic source leaving a restite assemblage that ranges from garnet amphibolite to eclogite in composition. The adakite signature is found in volcanic or intrusive Cenozoic arcs generally associated with subduction of young ($\leq$ 25 Ma) oceanic lithosphere (Defant and Drummond, 1990), but adakites are also thought to be generated in areas where high shear stresses and slow subduction occur due to highly oblique convergence (Drummond et al., 1996; Yogodzinksi et al., 1995).

Slab melts or adakites are enriched in Sr, Na, Eu, and depleted in Sc, Y ($\leq$18 ppm), and the Heavy Rare Earth Elements (HREEs) such as Yb ($\leq$ 1.9 ppm) (Defant and Drummond, 1993), which is atypical of arc volcanics derived from the mantle wedge (Defant and Kepezhinskas, 2001). Positive Sr and Eu anomalies may indicate that plagioclase is not stable in the source and/or did not fractionate extensively during magma ascent (Defant and Drummond, 1993; Martin, 1999). A mid-ocean ridge basalt (MORB) partial melting model of Defant and Drummond (1993) exhibits strong positive Sr and Eu anomalies and depletions in Y and Yb, pointing to a MORB-like source for

adakites. Low HREE content is thought to be due to the presence of garnet in the solid residue (Peacock et al., 1994). Adakites have SiO_2 > 56 wt%, Al_2O_3 > 15 wt%, and Na_2O_3 > 3.5% (Defant and Kepezhinskas, 2001). They display high Sr/Y (up to 100-120), La/Ta, La/Sm, and Zr/Y ratios; low Ti/Sr (3-4), Ti/Hf, K/La, FeO/MgO, $^{87}Sr/^{86}Sr$ (usually <0.7040), and Cr/Ni ratios (Defant and Drummond, 1990). Although some adakites have relatively high Mg concentrations (up to 6% MgO) they contain much less than boninites (high magnesian andesites with MgO >10%) (Defant and Drummond, 1990). Pristine adakites display low Cr/Ni ratios but this ratio increases with progressive enrichment in Cr and Ni due to interaction with peridotite and/or basalt in the mantle wedge (Yogodzinksi et al., 1995). Petrographically, adakites contain abundant plagioclase and amphibole phenocrysts (Defant and Kepezhinskas, 2001), common clinopyroxene and orthopyroxene and somewhat common biotite and opaque minerals (Defant and Drummond, 1990).

Although the generation of slab melt at subduction zones may be atypical today, evidence suggests that this process was quite common in the past. The formation of adakites may be considered a modern analogue of Archean magmatism (Defant and Drummond, 1990). Archean Trondhjemites-tonalite-dacites (TTDs) and Trondhjemites-tonalite-granitoids (TTGs), believed to have been formed by partial melting of subducted crust, have compositions similar to adakites, especially with regard to their trace element and REE characteristics (Martin, 1999; Drummond, et al., 1996; Peacock, et al. 1994).

Because magnesian andesites (adakites) are the most common magma type formed during slab melting circumstances, it is significant that they were more common in the Archean than today (Yogodzinksi et al., 1995). Slab melting is considered to be an

important occurrence in the Archean because the warmer mantle led to faster plate movement (Defant and Kepezhinskas, 2001), thus the average age of subducting oceanic lithosphere was younger in the Archean than today (Yogodzinksi et al., 1995). Slab melting has continued to take place through time but has slowed considerably since the Archean (Drummond et al., 1996).

There are a number of hypotheses concerning the formation of adakites including the age (and therefore temperature), speed, and incoming angle of the down-going slab, the initiation of subduction (slab melt is more likely at the onset of subduction) (Peacock, et al. 1994), the intensity of mantle convection induced by the subducting slab (Peacock, 1990), possible slab tears (allowing the slab edge to be heated by mantle flow) (Yogodzinksi et al., 2001), melting of remnant slabs incorporated into the mantle, and slab melt produced in arc-arc collision (Defant and Kepezhinskas, 2001). In the following discussion, adakite formation will mainly be addressed in terms of the factors that are the most widely accepted, which are the age, speed, and incoming angle of the subducting slab.

Any plausible model used to describe slab melt processes must address the conditions under which partial melting of the oceanic slab occurs. This is achieved by investigation of pressure-temperature-time (P-T-t) paths experienced within subduction zones. Currently, the most popular theory relates the production of adakitic melt to the subduction of young (<25 Ma), relatively hot oceanic lithosphere (Defant and Drummond, 1993). Parson and Sclater (1977) plotted standard heat flow units (HFU) as a function of oceanic crust age, showing that crust younger than 25 Ma has a heat flow ranging from ~ 2.8 to ~8.0 HFU and older crust has a fairly constant heat flow of 1.0-2.5

HFU. Approximately 50 Ma is required for oceanic lithosphere to approach steady state, but the oceanic crust (the upper 7 km of the lithosphere) falls below 300º C in less than 20 Ma (Peacock et al., 1994). Experimental data indicate that slab melting is likely to occur at shallower depths than normal dehydration melting (Defant and Kepezhinskas, 2001).

Subduction of young (hot) oceanic lithosphere results in warmer P-T-t paths than subduction of old (cold) oceanic lithosphere (Peacock et al., 1994). Partial melting of an oceanic slab (basalt) requires temperatures greater than 650º C, the temperature of the wet solidus (Peacock et al., 1994).

The P, T, and P_{H2O} under which partial melting of basalt will produce an adakite melt composition and a garnet + clinopyroxene + hornblende residue assemblage has been determined by Peacock et al. (1994) through combining experimental partial melting data on amphibolite and olivine tholeiitic basalt compositions with trace element and REE geochemical modeling. According to Peacock (1990), P-T-t paths for warm, young subducting slabs intersect the wet solidus at pressures of 10 to 28 kbar. The amount of melt generated is determined by the quantity of water present in the rock as a free fluid phase. Metabasalt will contain hornblende at pressures <28 kbar; when the rock crosses the hornblende out curve, fluid-absent partial melting occurs associated with the breakdown of hornblende (i.e., any H_2O bound in the crystal lattice partitions directly into the partial melt without forming a separate aqueous phase). P-T-t paths of cooler, older subducting slabs do not intersect the wet solidus at pressures of <50 kbar, suggesting that slab melt is not likely in the case of cool subduction zones.

Adakite generation is thought to be possible where movement of the incoming slab is rapid (8-10 cm/yr) (Defant and Kepezhinskas, 2001). The thermal structure of the down-going slab is to some extent dependent on the rate of shear heating, Q_{sh} (W/m^2), which is expressed by: $Q_{sh} = \tau V$, where τ = shear stress (Pa) and V = convergence rate (m/s). High shear stress combined with fast convergence rates may result in adakite production. Some researchers believe that partial melting of older oceanic lithosphere is possible under these conditions.

In addition, the incoming angle of the subducting slab may have an important effect on the initiation of slab partial melting. Highly oblique convergence is likely to produce a very slow subduction path into the mantle (Yogodzinksi et al., 1995). In the absence of shear heating, slower subduction produces a relatively warm P-T-t path for the subducting slab. Yogodzinksi et al. (1995) believe that oblique subduction may promote slab melting even in relatively old oceanic lithosphere.

Adakitic high-magnesian andesites found in the western Aleutian Komandorsky region of Alaska and Russia are believed to be the result of highly oblique, slow subduction leading to a P-T-t path that allows partial melting of the relatively old, cold oceanic lithosphere. A strong slab melt signature is expressed in all Miocene-Holocene volcanic rocks of this area (Yogodzinksi et al., 1995). Two types of adakitic magnesian andesites are recognized: the Adak-type in the central and western Aleutians and the Piip type named for their occurrence at Piip Volcano, a hydrothermally active seamount north of the far western Aleutian Komandorsky Islands (Yogodzinksi et al., 1995). The Adak-type high-magnesian andesites represent the ideal adakite in which there is little interaction of slab melt with the mantle (Defant and Kepezhinskas, 2001). The Piip-type

magnesian andesites appear to have relatively little slab melt contribution, or the slab melt signature has been diluted by interaction between slab melt and the mantle peridotite or basalt (Yogodzinksi et al., 1995).

The Cascade region in North America shows evidence for the occurrence of slab melting processes. Mount St. Helens mainly produces adakites, while the nearby Mount Adams erupts typical arc magmas (Defant and Kepezhinskas, 2001). Oceanic lithosphere ~3 Ma subducts obliquely beneath North America at 3.4 cm/yr (Peacock et al., 1994). It appears that location above the subducting slab is the controlling factor in the type of volcanism generated here. Mount Adams is located ~120-150 km above the slab, which is typical of most volcanic arcs (Defant and Drummond, 1993). Mount St. Helens is located ~78 km above the slab (Defant and Drummond, 1993). This depth corresponds to the depth of the amphibolite to eclogite transition, where slab melt is likely to occur.

At the Kamchatka Peninsula in Russia chemically distinctive eruptive products from Shiveluch volcano have been recognized as possessing a slab melt component. Shiveluch lavas exhibit an adakitic signature with high values of Sr (Kepezhinskas et al.1997; Melekestsev et al., 1991), Mg (Volynets et al., 1997), SiO_2, K_2O, Na_2O, and Sr/Y ratios (Churikova et al., 2001), while showing depletions in Y and Yb (Kepezhinskas et al., 1997). Typical arc volcanics are found at Klyuchevskoi Volcano, which lies 20 km to the south. It is interesting to note that seismic data implies that the upper boundary of the subducting slab is at a depth of ~100 km beneath Shiveluch volcano and ~160 km beneath Klyuchevskoi volcano (Volynets et al., 2000). This supports the Defant and Kepezhinskas theory (2001) that slab melting is likely to occur at shallower depths than normal dehydration melting. The geometry of the slab (e.g.,

possible slab tear) and tectonic processes occurring beneath Shiveluch may be responsible for the generation of slab-derived melts seen at Shiveluch.

CHAPTER THREE

REGIONAL GEOLOGY

Introduction

The Kamchatka Peninsula, Russia, is a volcanic arc formed by subduction of the Pacific Plate in the northwest corner of the Pacific Rim. It is unique in that it is located at the junction of two subduction zones where the Pacific, Okhotsk, and North American plates meet (Fig. 3.1). Kamchatka forms the northern end of the Kurile arc and is associated with subduction of the Pacific plate. Subduction beneath the Kamchatka arc is estimated to have commenced 30 Ma (Kersting and Arculus, 1995) and the age of the slab subducting beneath Kamchatka is 87-105 Ma (Gorbatov et al., 1997). Over 200 Quaternary volcanoes have been mapped in Kamchatka (Tatsumi et al., 1995), with more than 60 having been active recently (Braitseva et al., 1995). These volcanoes lie 100-340 km above the subducting slab (Turner et al., 1998).

Kamchatka is comprised of the three subparallel volcanic belts, known as the Eastern Volcanic Front (EVF), the Central Kamchatka Depression (CKD), and the Sredinny Ridge area (SR) (Refer to Fig. 3.1). Most of the active volcanoes in Kamchatka occur within the CKD and the EVF, with the CKD being the more active of the two. The CKD and EVF together form one of the world's most active volcanic areas (Turner et al., 1998). The Sredinny Ridge (SR) zone is fairly inactive; Ichinsky is its only active volcano.

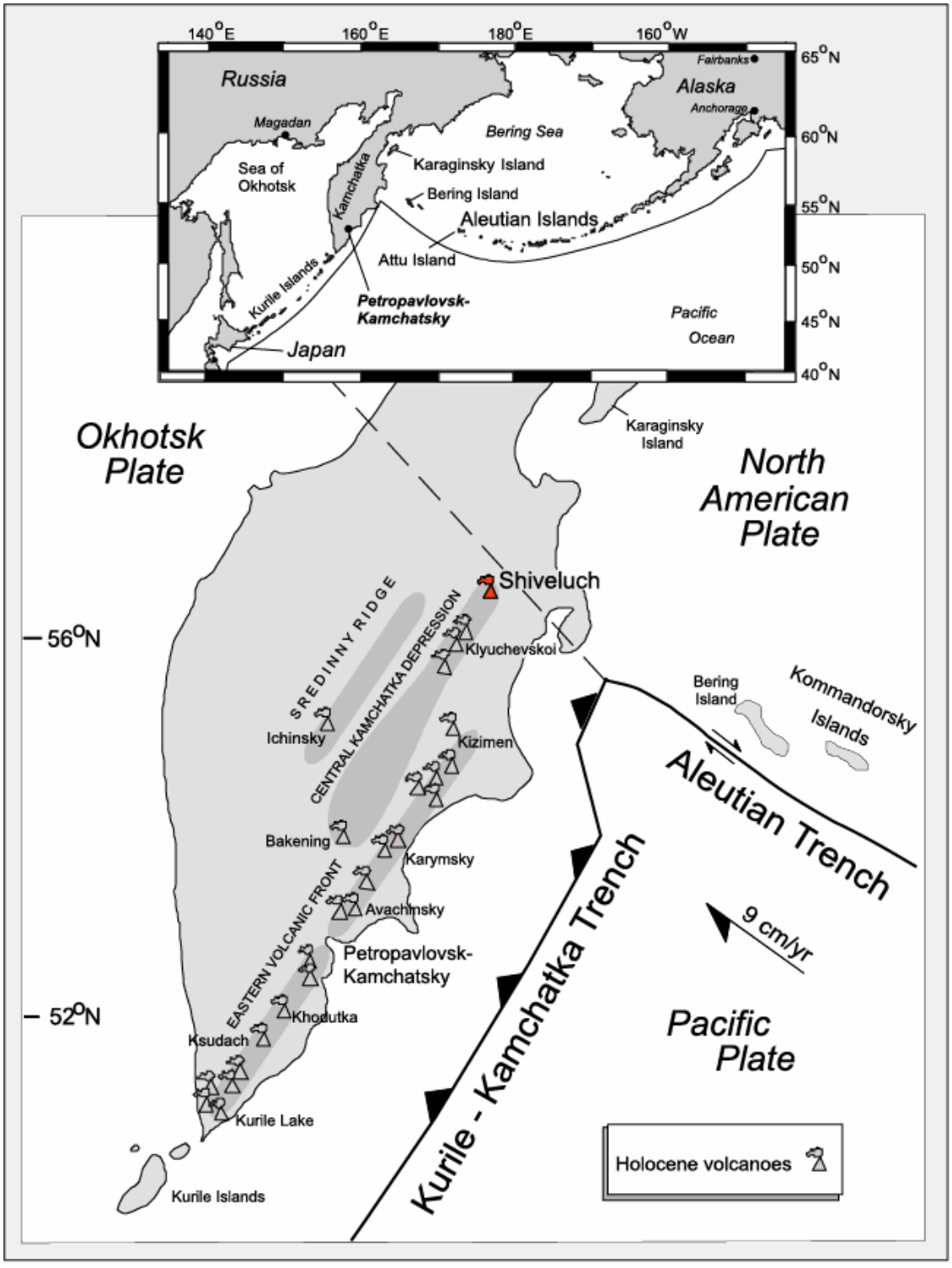

Figure 3.1. Tectonics and geological associations of the Kamchatka Peninsula, Russia. Modified from Turner et al., 1998.

Subduction occurs orthogonal to the arc at a rate of 9 cm per year (Kepezhinskas et al., 1997). The Wadati-Benioff zone dips at 40-50° reaching depths of ~170-220 km below the EVF and ~200-260 km below the CKD (Turner et al., 1998). The magmas of Kamchatka fractionate along a number of paths that range from tholeiitic to calc-alkaline, and they are often highly magnesian (Hochstaedter et al., 1996). Thus, the composition of rocks produced varies from basalt to rhyolite, with basalts and basaltic andesites dominating (Volynets, 1994).

The CKD is a large graben lying parallel to the trench that extends from Shiveluch volcano in the north to Bakening volcano in the south and is bounded by SR to the west and the EVF to the southeast. It is 5-100 km wide and 350 km in length (Kepezhinskas et al., 1997). The CKD is characterized by differentiation trends ranging from tholeiitic in volcanoes such as Tolbachik, Ushkovsky, and Klyuchevskoi, to calc-alkaline in volcanoes such as Shiveluch and Kharchinsky (Hochstaedter et al., 1996).

The EVF is located south and east of the CKD and is closer to the trench. It is 15-70 km wide and 270 km in length (Kepezhinskas et al., 1997). Differentiation trends of the EVF are in the region intermediate between the tholeiitic and calc-alkaline trends that are defined by the CKD lavas (Hochstaedter et al., 1996).

The SR is 60-130 km wide and 450 km in length (Kepezhinskas et al., 1997). This volcanic belt lies the farthest from the trench and has produced dacites and rhyolites (Kepezhinskas et al., 1997). There are many examples of volcanic arcs that have two volcanic chains, but the existence of a third chain is an unusual occurrence (Tatsumi et al., 1995).

Shiveluch Volcano

Shiveluch (also spelled Sheveluch) volcano is the northernmost and most active andesitic volcano on the Kamchatka Peninsula. It is located at the northern end of the CKD at the junction of the Kurile-Kamchatka and Aleutian island arcs (refer to Fig. 3.1). There have been at least 60 large eruptions during the last 10,000 years, with a magma discharge of approximately 36×10^6 tons per year (Ponomareva et al., 1998). The Holocene eruptive history of this 60-70 thousand year old volcano is characterized by two eruption types: plinian eruptions that occur over periods of a few days or hours; slight or moderate eruptions that take place coincident with the growth of extrusive domes, with activity lasting up to several years.

The composite edifice of Shiveluch volcano consists two main units: 1) Stary (Old) Shiveluch, the remnants of a massive Pleistocene stratovolcano that collapsed, forming a horseshoe-shaped caldera that opens toward the south. The elevation of the old edifice is 3283 m above sea level. 2) Molodoy (Young) Shiveluch rises as an extrusive dome complex within the Old Shiveluch crater. An explosive eruption of Young Shiveluch in 1854 resulted in the formation of a horseshoe-shaped crater that opens toward the south (Belousov, 1995). A number of extrusive domes have since grown in this crater (Fig. 3.2). The summit of the active Young Shiveluch is 2800 m above sea level.

The volcanic front along the Kamchatka subduction zone exhibits a sharp shift landward north of 55ºN (Gorbatov et al., 1997). The depth and dip angle of the Pacific plate subducted beneath the peninsula reflect this shift. South of this latitude, the dip

angle is a constant ~55º and the maximum depth of seismicity ranges from ~500 km at 50ºN to ~300 km at 55ºN (Gorbatov et al., 1997). According to Volynets et al. (2000) seismic data indicates that the upper edge of the subducting oceanic slab is no deeper than 100 km beneath Shiveluch (~56º N) and the dip angle is approximately 35º (Gorbatov et al., 1997). This is the shallowest depth among all of the active volcanoes of Kamchatka. Gorelchik et al. (1997) believe that the Shiveluch magma feeding system consists of a crustal magma chamber that is periodically recharged with mantle material from depths of at least 90-120 km.

Figure 3.2. Shiveluch consists of two horseshoe-shaped calderas that open toward the south. The outer, older one is the remnants of a massive Pleistocene volcano that collapsed. The dome complex that began growing within that crater was similarly deformed in 1854 by a large explosive eruption that again resulted in a horse-shoe shaped crater that opens toward the south. A number of extrusive domes have since grown within the active crater (pictured above).

CHAPTER 4

FIELD RELATIONSHIPS AT SHIVELUCH

Stratigraphic sections were measured at several locations on the flanks of Shiveluch in an attempt to cover the Holocene eruptive history. Plinian eruptions during this period of time have produced fall, surge, and pyroclastic flow deposits. This work focuses on these deposits but does not address the minor eruptive products from extrusive domes.

Pumice clasts and tephra samples from 48 pyroclastic eruptions were collected at outcrops exposed through down-cutting by streams. The outer ~20 cm of the exposure was removed before samples were taken in order to avoid the collection of weathered or contaminated material. Pumice and ash layers were then described and carefully collected. Where single pumice clasts were not of sufficient size for bulk analysis multiple clasts were collected to be combined for analysis. Sample locations were recorded using a GPS (Fig. 4.1). While some units are preserved only in one of the sample locations, a number of units are present at more than one of the sample sites (Fig. 4.2). Units that are absent in some locations are likely missing as a result of erosion or from dispersion of tephra that did not spread out in all directions from the volcano. Unit numbers and/or eruption names (e.g., SH1, SH1450, SHsp) are assigned to Shiveluch deposits. These designations follow those given in Braitseva et al. (1997) and Ponomareva, personal communication (2000). Shiveluch deposits are intermingled with paleosols and deposits from other Kamchatka volcanoes such as Khangar (KHG),

Kizimen (KZ), and Klyuchevskoi. Complete descriptions of measured sections and a composite section of Holocene deposits are given in Appendix B.

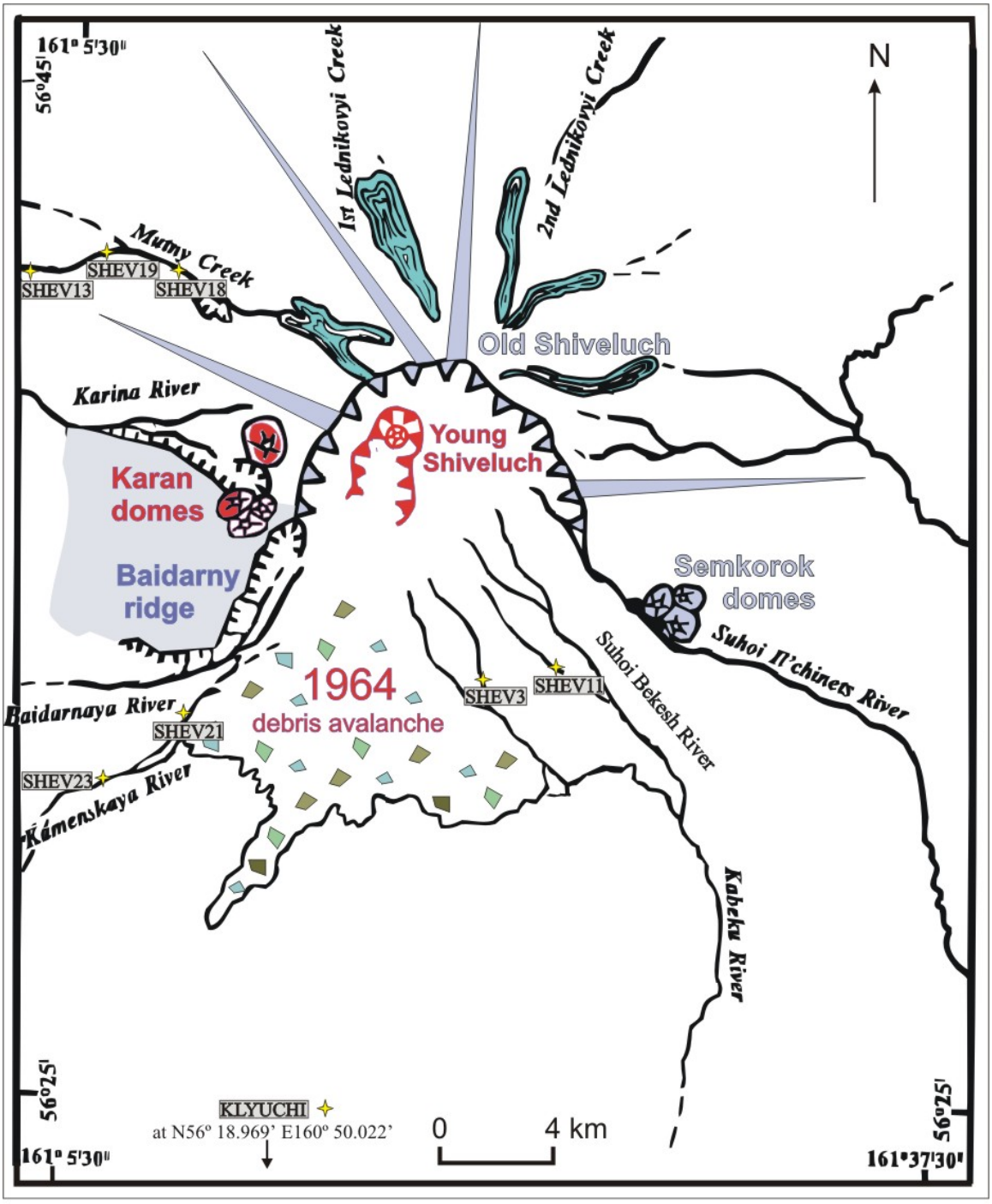

Figure 4.1. Location map of Shiveluch. GPS locations of measured sections correspond to Figure 4.2 and are indicated by stars (✦). Modified from Ponomareva et al., 2002.

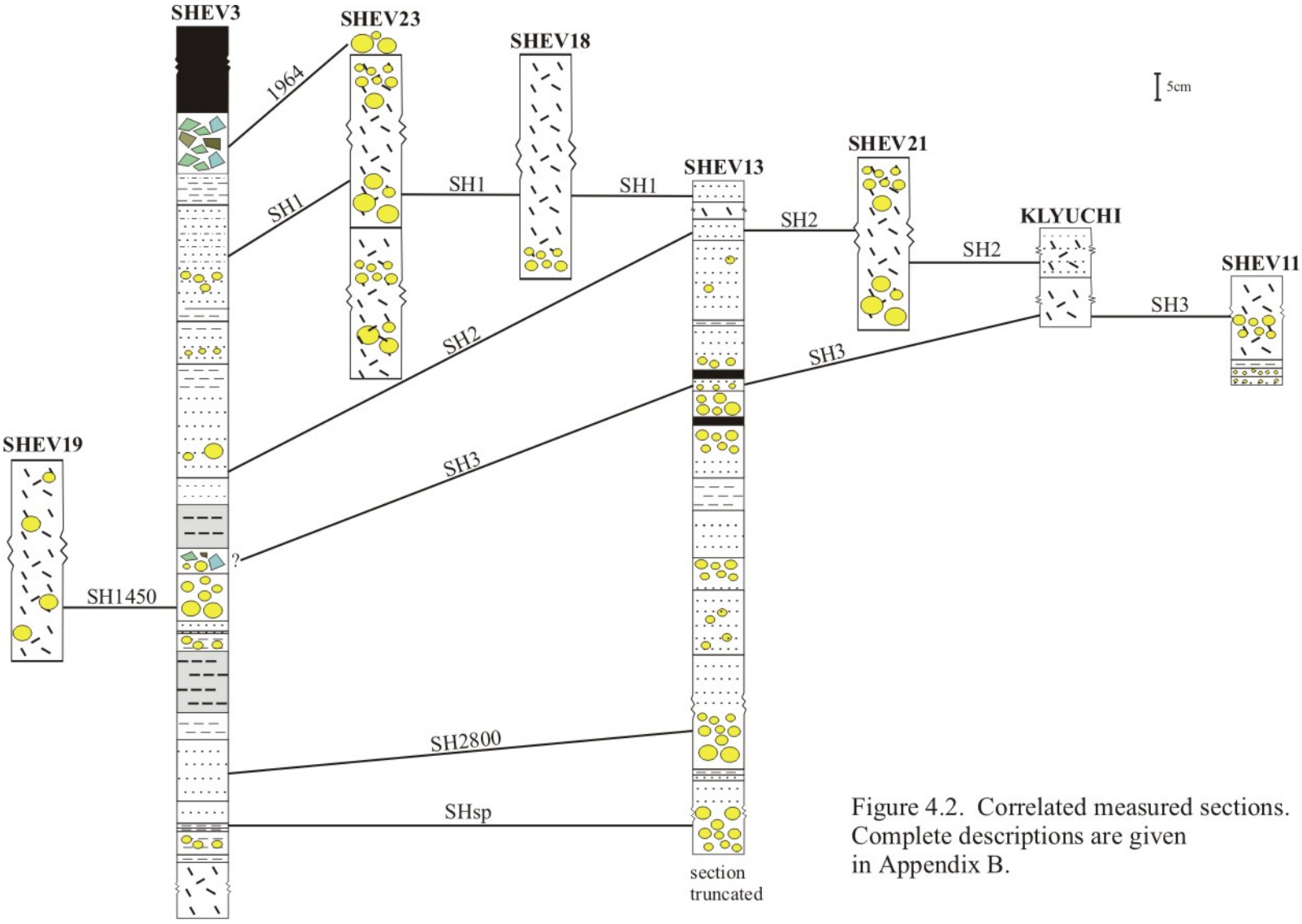

Figure 4.2. Correlated measured sections. Complete descriptions are given in Appendix B.

CHAPTER 5

PETROLOGY AND MINERAL CHEMISTRY

Introduction

Pumice clasts and tephra samples from 48 pyroclastic eruptions were examined in thin section and by grain mount. Mineral compositions were determined in selected samples by electron microprobe analysis and petrographic descriptions were made of thin sections. The main mineral species observed were feldspar, amphibole, and magnetite, which occur in a glassy groundmass. Pyroxene is quite rare and was found in only eight samples. One tephra sample (00K12) contains ilmenite. Mineral analyses were made by electron microprobe at New Mexico Institute of Mining and Technology. A suite of mineral phases was analyzed in all the main rock types and a selection of tephra samples. A complete listing of electron microprobe analyses is given in Appendix C. Petrographic descriptions are given of thin sections from selected pumice used for whole rock analysis. One basaltic andesite, one dacite, and ten andesites were optically examined.

Petrography

In thin section the samples are uniform with only minor variations from sample to sample. There is no visible distinction between basaltic andesite, andesite, and dacite. All are pumiceous and porphyritic, containing ~40% phenocrysts that lie within a highly vesiculated glassy matrix. Phenocryst content is predominantly plagioclase (~80%), which are generally anhedral to subhedral and rarely euhedral. The average phenocryst size is ~50mm but can reach 150mm. Twinning and zoning are very common; fluid inclusions are observed on old growth faces of some crystals. Plagioclase commonly

exhibits oscillatory zoning and less frequently, corroded cores containing inclusions of amphibole, magnetite, and glass. Amphibole makes up ~10% of the total crystal content, and is subhedral to euhedral and averages 80mm but reaches up to 120mm. Frequent corroded cores contain plagioclase and glass inclusions. Magnetite makes up ~3% of the phenocryst content, is anhedral, and averages 14mm in size with the largest crystals being 30mm. Where present, pyroxene makes up less than 1% of total crystal content, measures up to 20mm and is anhedral to subhedral.

Mineralogy

Feldspar

Plagioclase is the only feldspar phase present in Shiveluch pyroclastic materials. It is the most abundant mineral in all samples. Broken crystals are found more frequently in tephra samples than in pumice samples. Twinning and zoning are observed in both tephra and pumice; zoning is more clear and recognizable in the pumice samples, while it is irregular, mottled, and often absent from phenocrysts in tephra samples. Normal, reverse, and oscillatory zoning are observed (Fig. 5.1.). The prevalence of reverse and oscillatory zoning may suggest that processes such as magma mixing, magma recharge, or degassing are occurring in the system.

The method of Deer et al. (1966) was used to calculate feldspar end members. Representative feldspar analyses are given in Table 5.1. A complete listing of feldspar analyses is given in Appendix C. Compositions range continuously as follows: rim An_{29-59}, intermediate An_{27-70}, and core An_{30-67} (Fig. 5.2a, b). In typical plagioclase crystals, normal zoning is generally accompanied by compositions in which rims are albite rich and cores are anorthite rich. This compositional trend is rarely found in

Shiveluch samples due to the oscillatory, reverse, and mottled irregularity of zoning in plagioclase phenocrysts.

Amphibole

Amphibole is common in all samples and sample types. Amphiboles within tephra samples are often broken and/or are anhedral to subhedral. Those within pumice are subhedral to euhedral and frequently possess corroded cores that contain inclusions of magnetite, plagioclase, and glass (Fig. 5.3). Representative amphibole analyses are presented in Table 5.2. A complete listing of amphibole analyses is given in Appendix C.

Amphibole analyses were recalculated in Minpet 2.02 using the 15-NK method. In this method the total number of cations is 15, excluding Na and K. Cations are recalculated to 23 oxygens then summed (excluding F and Cl) and finally reassigned by dividing each value by the factor [(sum-Na-K)/15]. The method described by Robinson, et al. (1981) is used to recalculate Fe^{3+}.

All Shiveluch samples analyzed contain calcic group amphiboles. Edenite and edenitic hornblende dominate (Fig. 5.4). There is no apparent connection between rock type and the variety of amphibole. The relatively small degree of variation can be seen in a ternary plot of Ca, Mg, and Fe (Fig. 5.5).

Magnetite and Ilmenite

Magnetite and ilmenite data are poor and therefore not used to calculate temperature nor are they covered in detail here. High Ti magnetite is somewhat common but a true ilmenite was found only in sample 00K12 (tephra). Magnetite data is not to be

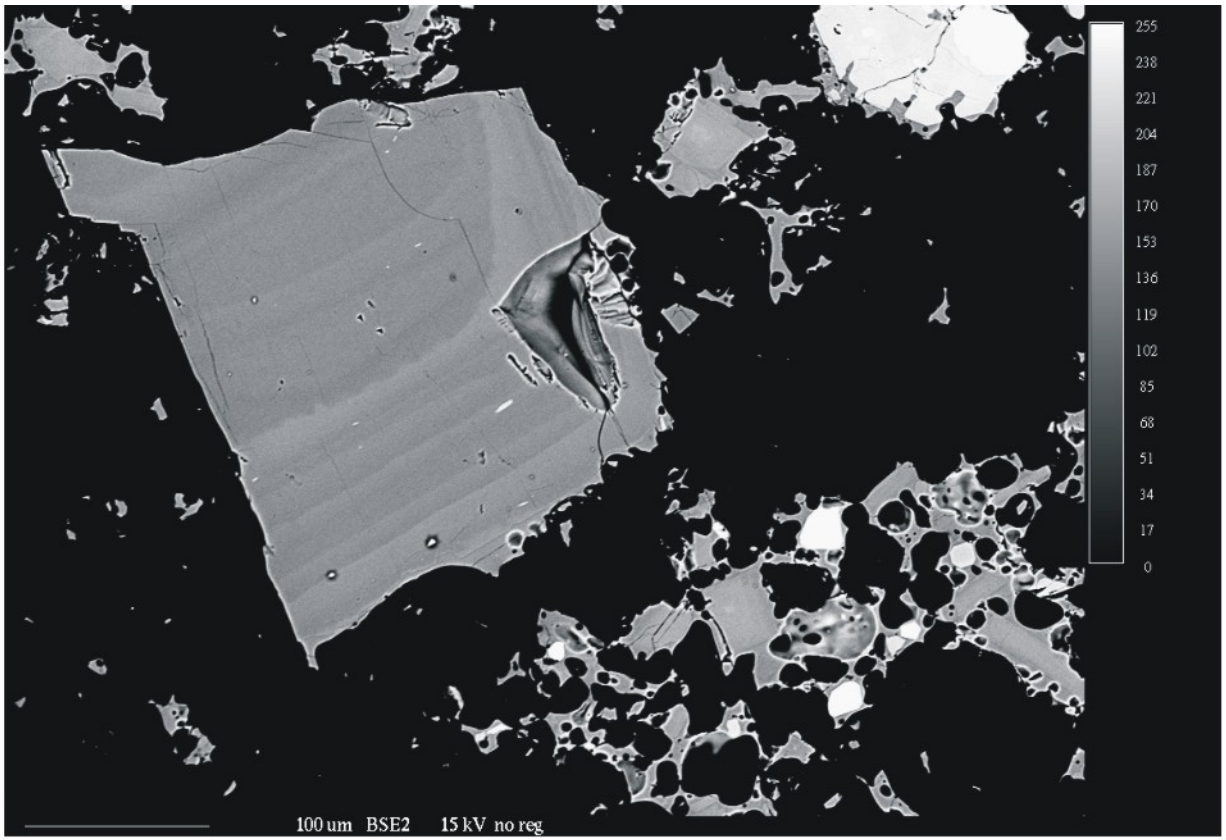

Figure 5.1. Electron microprobe backscatter image of a plagioclase crystal from sample 00K71 which exhibits oscillatory zoning. Reverse zoning is also common in the Shiveluch samples, while normal zoning occurs less frequently.

Table 5.1. Representative Feldspar Analysis

Sample	K-12	K-12	K-12	K-31	K-31	K-31	K-32	K-32	K-32
Point	18	19	22	8	13	28	2	3	36
SiO2	59.10	57.24	58.20	55.88	58.16	55.11	57.19	58.84	59.13
Al2O3	25.10	25.32	24.82	27.08	25.09	27.66	26.61	26.08	25.56
FeO	0.40	0.43	0.47	0.52	0.56	0.32	0.11	0.15	0.10
CaO	7.16	7.44	6.75	9.23	6.89	9.75	8.31	7.62	7.07
Na2O	7.38	7.05	7.34	6.11	7.27	5.76	6.69	7.07	7.33
K2O	0.37	0.31	0.38	0.22	0.35	0.18	0.14	0.17	0.29
SrO	0.13	0.19	0.14	0.17	0.14	0.18	0.17	0.15	0.15
BaO	0.02	0.04	0.06	0.07	0.11	0.04	0.02	0.00	0.02
Total	99.66	98.01	98.15	99.28	98.57	99.01	99.23	100.09	99.64
Number of ions on the basis of 32O									
Si	10.62	10.48	10.62	10.15	10.58	10.04	10.33	10.51	10.60
Al	5.32	5.46	5.34	5.80	5.38	5.94	5.67	5.49	5.40
Fe	0.06	0.07	0.07	0.08	0.09	0.05	0.02	0.02	0.02
Ca	1.38	1.46	1.32	1.80	1.34	1.90	1.61	1.46	1.36
Na	2.57	2.50	2.60	2.15	2.56	2.04	2.34	2.45	2.55
K	0.09	0.07	0.09	0.05	0.08	0.04	0.03	0.04	0.07
Sr	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Total	20.05	20.07	20.05	20.05	20.05	20.03	20.02	19.99	20.01
Ab	63.7	62.0	64.9	53.8	64.3	51.1	58.8	62.1	64.1
An	34.2	36.2	33.0	44.9	33.7	47.8	40.4	37.0	34.2
Or	2.1	1.8	2.2	1.3	2.0	1.1	0.8	1.0	1.7

Sample	K-46	K-46	K-46	K-49	K-49	K-49	K-52	K-52	K-52
Point	3	7	8	3	9	10	6	13	19
SiO2	57.24	59.18	57.31	57.21	58.60	58.59	55.39	57.01	56.44
Al2O3	25.93	25.54	26.35	25.41	25.65	25.49	27.55	26.84	27.34
FeO	0.19	0.42	0.39	0.45	0.34	0.37	0.43	0.42	0.36
CaO	7.49	7.34	8.53	7.32	7.93	7.48	9.92	8.77	9.39
Na2O	7.04	7.18	6.35	7.05	6.79	7.03	5.74	6.42	5.95
K2O	0.24	0.30	0.22	0.68	0.26	0.33	0.23	0.24	0.20
SrO	0.20	0.22	0.21	0.21	0.19	0.15	0.20	0.13	0.19
BaO	0.04	0.04	0.04	0.05	0.04	0.05	0.04	0.07	0.00
Total	98.37	100.21	99.39	98.38	99.79	99.48	99.50	99.89	99.87
Number of ions on the basis of 32O									
Si	10.43	10.58	10.36	10.46	10.52	10.55	10.05	10.27	10.17
Al	5.57	5.38	5.61	5.48	5.43	5.41	5.89	5.70	5.81
Fe	0.03	0.06	0.06	0.07	0.05	0.06	0.07	0.06	0.05
Ca	1.46	1.40	1.65	1.43	1.53	1.44	1.93	1.69	1.81
Na	2.49	2.49	2.23	2.50	2.36	2.45	2.02	2.24	2.08
K	0.06	0.07	0.05	0.16	0.06	0.08	0.05	0.05	0.05
Sr	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Total	20.06	20.01	19.98	20.13	19.97	20.01	20.04	20.03	19.99
Ab	62.1	62.8	56.7	61.1	59.9	61.8	50.5	56.2	52.8
An	36.5	35.5	42.0	35.0	38.7	36.3	48.2	42.4	46.1
Or	1.4	1.7	1.3	3.9	1.5	1.9	1.3	1.4	1.2

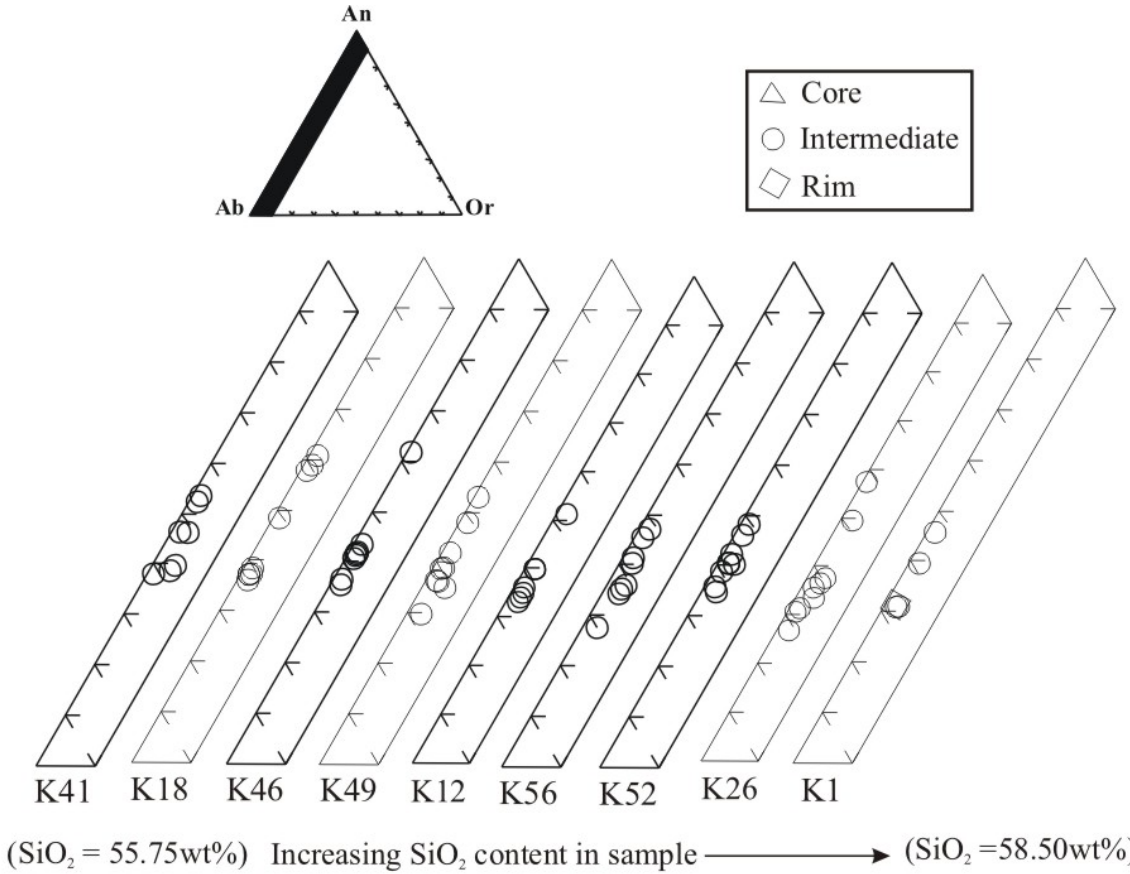

Figure 5.2a. Ternary diagrams for analyses of feldspar crystals found in Shiveluch tehpra samples. Diagrams are arranged in order of increasing SiO_2 content within feldspar in each sample. Symbols for core, intermediate, and rim indicate location at which each analysis point was taken. Tephra samples were prepared for microprobe in grain mounts.

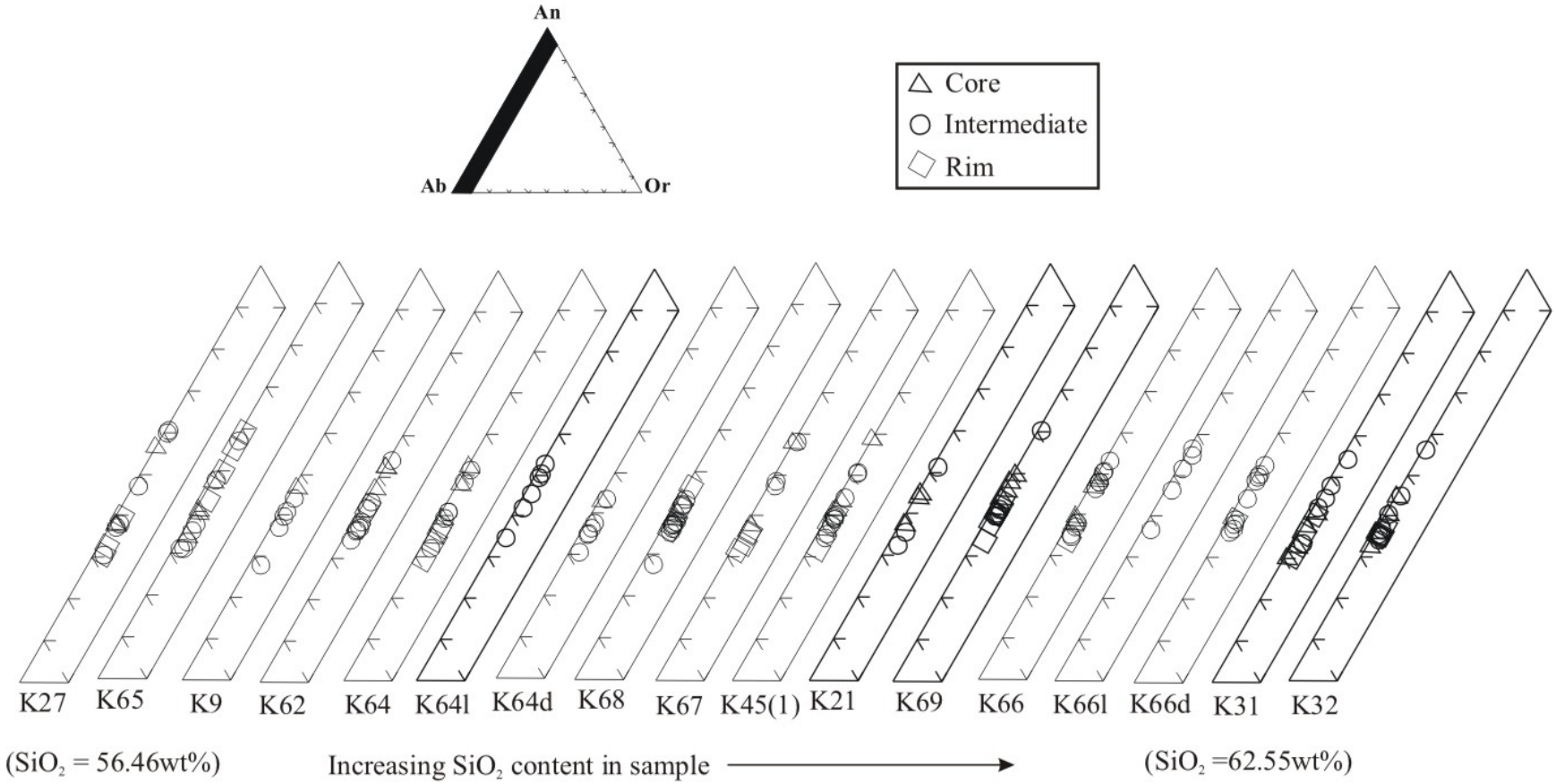

Figure 5.2b. Ternary diagrams for analyses of Shiveluch whole rock samples. Diagrams are arranged in order of increasing SiO_2 content within each sample. Symbols for core, intermediate, and rim indicate location at which each analysis point was taken. With the exception of K64l, K64d, K66l, and K66d, whole rock samples were prepared for microprobe in polished thin sections. These four exceptions were prepared in grain mounts and were derived from samples K64 and K66 which both contained relatively mafic inclusions. The designations 'l' and 'd' refer to a lighter matrix and a darker inclusion, respectively.

relied upon due to the exsolved nature of many magnetites in the Shiveluch samples. Magnetite and ilmenite data are given in Appendix C.

Pyroxene

Few pyroxene points were analyzed due to the very low number of pyroxenes that Shiveluch samples contain. Pyroxene data are given in Appendix C.

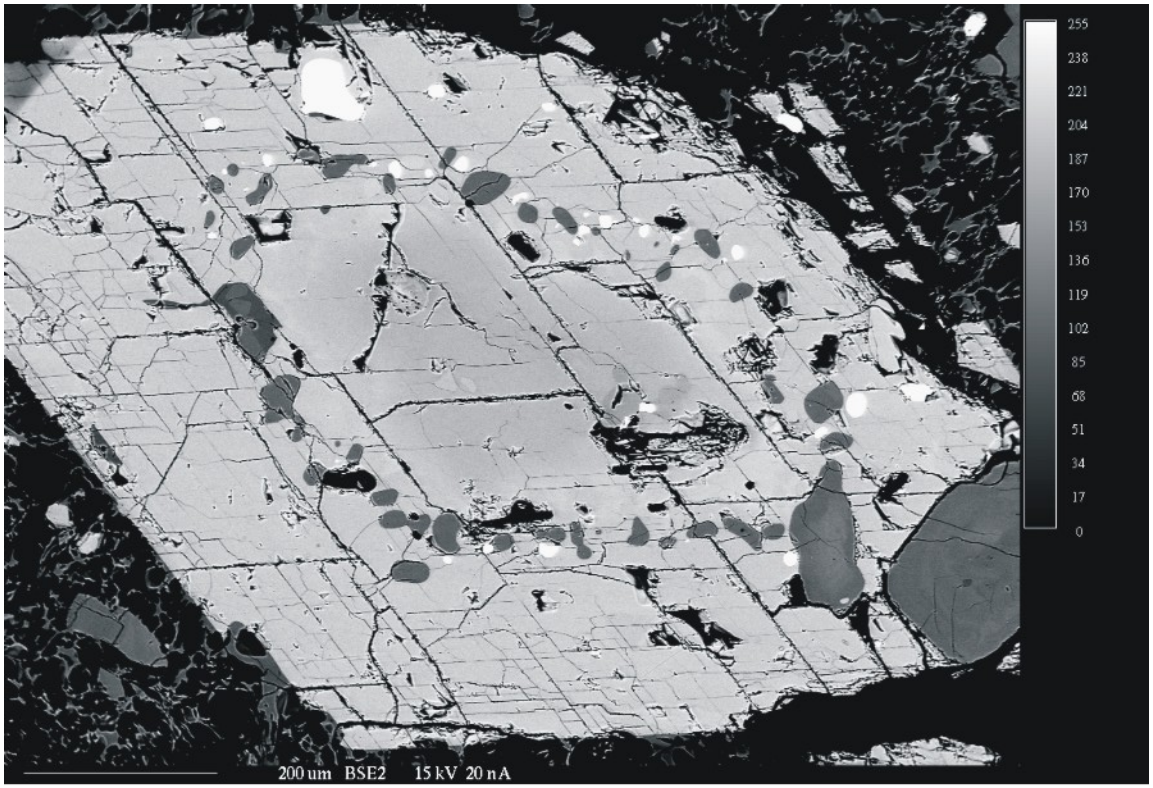

Figure 5.3. Electron microprobe backscatter image of an amphibole crystal from sample 00K27. Plagioclase, magnetite, and glass inclusions fill a zone that has corroded.

Table 5.2. Representative Amphibole Analysis

Sample	K-21	K-21	K-21	K-32	K-32	K-32	K-49	K-49	K-49	K-68	K-68	K-68
Point	1	17	25	15	21	31	1	2	7	10	22	29
SiO2	45.39	44.79	45.80	45.46	39.61	44.33	43.11	42.98	41.19	46.65	44.69	47.58
TiO2	2.33	1.21	2.27	2.50	2.34	2.98	1.75	1.77	1.96	1.69	2.18	1.58
Al2O3	8.88	10.60	8.43	8.82	8.78	10.01	12.55	12.54	13.60	7.73	9.09	7.61
FeO	12.18	11.46	11.80	11.91	12.35	12.24	11.26	11.17	14.66	11.90	12.04	12.14
MnO	0.30	0.22	0.26	0.25	0.34	0.24	0.17	0.15	0.25	0.32	0.26	0.32
MgO	15.34	15.12	15.79	15.36	13.58	14.71	15.42	14.99	11.76	15.83	15.47	15.98
CaO	11.08	11.30	11.12	11.10	14.82	10.96	11.06	11.28	11.44	11.12	10.96	10.76
Na2O	2.19	2.18	3.32	1.85	1.71	1.93	2.44	2.46	2.30	1.69	2.07	1.76
K2O	0.47	0.30	0.38	0.48	0.39	0.47	0.50	0.50	0.68	0.36	0.41	0.34
F	0.25	0.10	0.18	0.08	0.07	0.08	0.00	0.15	0.07	0.17	0.09	0.13
Total	98.42	97.27	99.35	97.79	93.98	97.94	98.25	97.98	97.92	97.46	97.24	98.19
TSi	6.62	6.55	6.67	6.64	6.04	6.49	6.24	6.26	6.12	6.81	6.57	6.90
TAl	1.38	1.45	1.33	1.36	1.58	1.51	1.76	1.74	1.88	1.19	1.44	1.10
TFe3	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
CAl	0.15	0.37	0.12	0.16	0.00	0.22	0.38	0.41	0.50	0.14	0.14	0.20
CFe3	0.01	0.14	0.00	0.04	0.85	0.01	0.22	0.15	0.15	0.13	0.15	0.01
CTi	0.26	0.13	0.25	0.27	0.27	0.33	0.19	0.19	0.22	0.19	0.24	0.17
CMg	3.34	3.30	3.43	3.34	3.08	3.21	3.33	3.26	2.61	3.45	3.39	3.45
CFe2	1.25	1.06	1.20	1.19	0.34	1.24	0.88	0.99	1.53	1.10	1.09	1.17
CMn	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BFe2	0.23	0.20	0.23	0.23	0.00	0.25	0.26	0.22	0.15	0.22	0.24	0.29
BMn	0.04	0.03	0.03	0.03	0.00	0.03	0.02	0.02	0.03	0.04	0.03	0.04
BCa	1.73	1.77	1.74	1.74	2.00	1.72	1.72	1.76	1.82	1.74	1.72	1.67
BNa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ANa	0.62	0.62	0.94	0.52	0.50	0.55	0.69	0.69	0.66	0.48	0.59	0.50
AK	0.09	0.06	0.07	0.09	0.08	0.09	0.09	0.09	0.13	0.07	0.08	0.06
Sum_A	0.71	0.67	1.01	0.61	0.58	0.64	0.78	0.79	0.79	0.55	0.67	0.56
Sum_cat	15.71	15.67	16.01	15.61	15.58	15.64	15.78	15.79	15.79	15.55	15.67	15.56

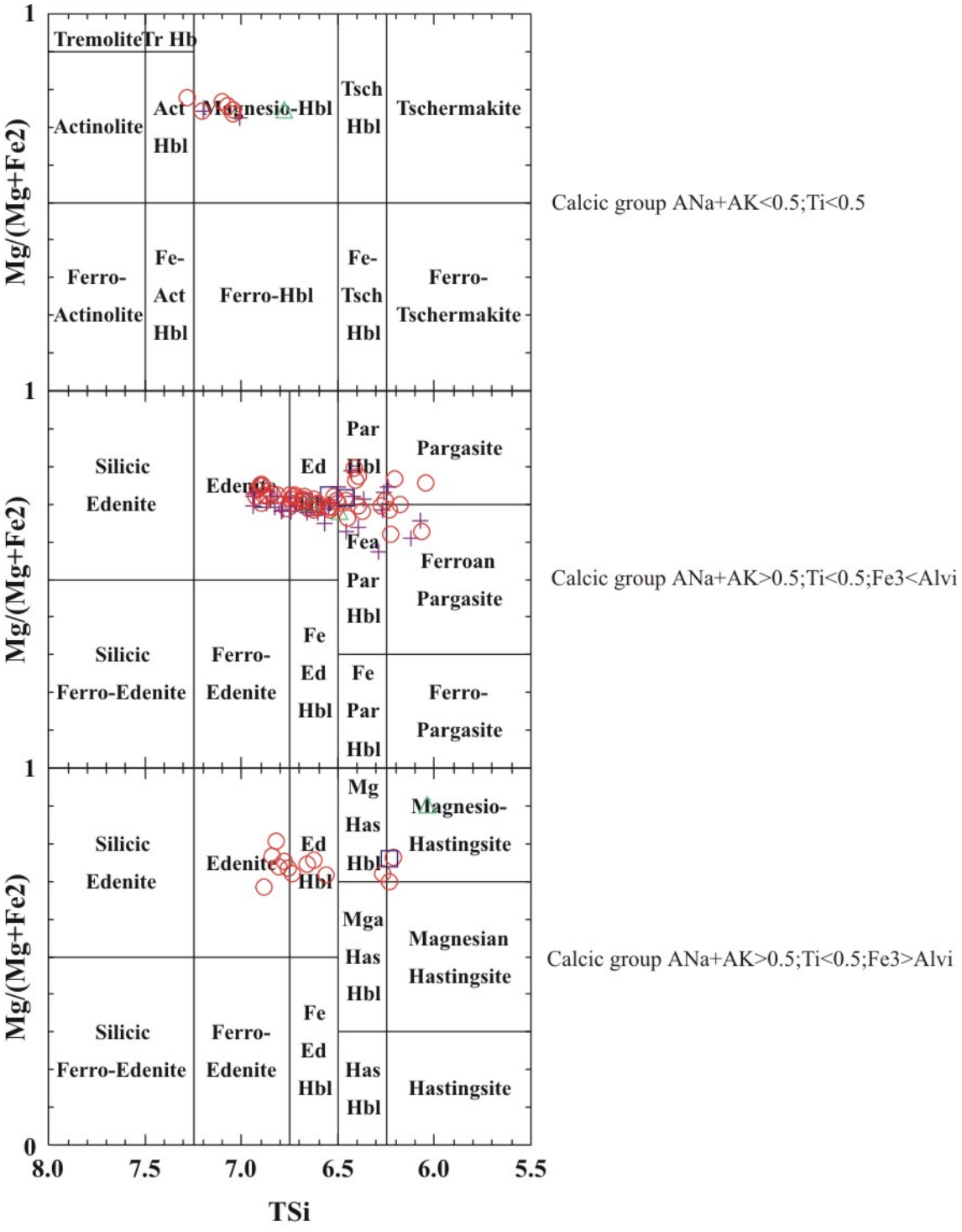

Figure 5.4. Classification diagrams for amphiboles. Symbols are as follows: basaltic andesite (□), andesite (○), dacite (△), tephra (+).

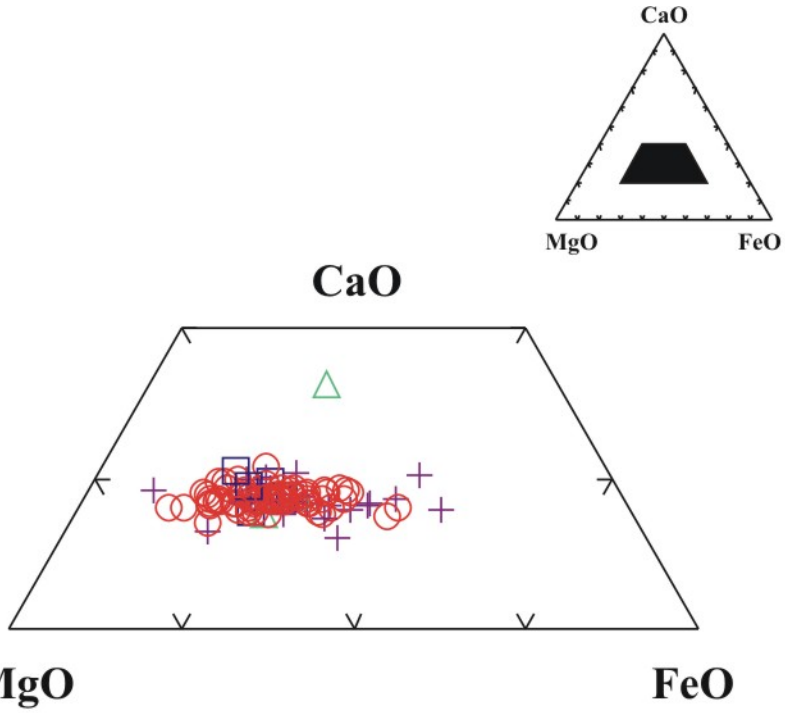

Figure 5.5. Ternary plot of Ca, Mg, and Fe (based on O=23) for amphiboles. Shiveluch amphiboles show little variation, even in samples from different rock types. Symbols for basaltic andesite, andesite, dacite, and tephra follow those of Figure 5.4. Amphibole analyses are given in Appendix C.

CHAPTER 6

GEOCHEMISTRY

Introduction

Major and trace elements were analyzed in selected pumice samples by X-ray fluorescence. Glass chemistry of selected pumice and tephra samples were determined by electron microprobe. These analyses were performed at New Mexico Institute of Mining and Technology. Representative whole rock analyses are given in Table 6.1. All whole rock data are presented in Appendix D. Representative glass analyses are given in Table 6.2. A complete listing of glass analyses can be found in Appendix C.

Whole Rock Analyses

Pumice clasts and tephra from 48 pyroclastic eruptions were analyzed. Multiple pumices were collected from different depths within selected deposits to determine whether compositional zoning was present. The minimum size of a single pumice clast was 20 grams for XRF analysis. If a clast was less than 20 grams several clasts were combined to provide enough material for analysis.

Samples 90116/9, 90119/1, 96025/4, 96030/1, 97048/5, 97049/1, 97049/3, and 97058/2 are taken from Shiveluch eruptions and were provided by Vera Ponomareva. These samples were analyzed and included in this study to ensure coverage of the major eruptions from Shiveluch during the Holocene. These samples are documented in the unit list in Appendix A.

Table 6.1. Representative Whole Rock Major and Trace Element Analysis

Sample	00K69	00K6	00K67	00K50	00K51	00K55	00K15	00K22	00K58	00K30	00K32	00K44
Age ybp	38	950	1100	1600	1750	2800	3600	3700	3800	5600	7700	8900
SiO2	60.59	60.16	60.41	57.65	60.71	59.72	51.43	55.96	57.11	61.16	62.55	58.80
TiO2	0.54	0.57	0.54	0.66	0.50	0.54	0.83	0.60	0.62	0.53	0.48	0.63
Al2O3	16.59	16.46	16.39	16.42	16.67	16.30	13.69	14.93	15.73	16.69	16.67	16.43
Fe2O3	5.19	5.63	5.29	6.23	4.80	5.27	9.43	7.03	6.23	4.90	4.49	6.01
MnO	0.10	0.11	0.10	0.12	0.09	0.10	0.16	0.12	0.11	0.10	0.09	0.11
MgO	3.73	4.05	3.77	4.67	3.19	3.85	10.58	8.50	5.62	3.18	2.35	3.91
CaO	5.97	6.14	5.91	6.54	5.47	5.83	8.36	7.22	6.52	5.72	5.12	6.23
Na2O	4.59	4.33	4.51	4.35	4.66	4.30	2.71	3.67	4.02	4.55	4.40	4.20
K2O	1.29	1.30	1.39	1.22	1.30	1.34	1.70	1.06	1.40	1.36	1.46	1.43
P2O5	0.17	0.18	0.18	0.21	0.17	0.18	0.36	0.16	0.20	0.18	0.18	0.20
L.O.I.	0.47	1.27	0.92	1.44	2.09	1.85	0.78	0.23	1.41	1.89	2.02	1.78
Total	99.22	100.21	99.42	99.51	99.65	99.27	100.03	99.50	98.98	100.25	99.80	99.73
S	265	299	514	410	99	278	588	199	235	484	274	1200
Cl	538	574	353	878	569	519	224	292	527	475	316	547
V	116	111	106	129	98	106	261	165	127	106	70	122
Cr	117	141	111	136	94	123	591	508	254	85	52	104
Ni	29	36	30	45	25	33	157	146	61	25	15	27
Cu	37	35	27	47	25	28	54	63	48	33	15	41
Zn	54	60	51	60	52	55	77	64	61	58	54	59
Ga	18	18	17	19	19	19	16	16	18	18	18	19
As	7	6	7	5	6	6	2	3	5	6	6	6
Rb	21	21	23	20	21	23	38	16	23	22	30	25
Sr	556	549	580	539	568	537	482	459	552	586	544	528
Y	13	14	14	16	12	13	21	14	14	13	12	17
Zr	111	111	110	123	119	115	93	89	109	112	119	122
Nb	2	2	1	2	2	2	2	2	1	2	2	2
Mo	1	1	1	1	1	1	1	0	0	1	1	2
Ba	408	428	465	399	431	447	467	341	473	404	456	443
W	96	211	63	51	78	58	44	78	79	717	98	92
Pb	6	6	9	7	6	7	7	5	8	9	7	8
Th	1	0	4	1		0	1	0		1		1
U	1	1	2	1	2	1	1	1	1	0	1	0

Table 6.2. Representative Electron Microprobe Analysis of Glass

Sample	K1 avg	K9 avg	K12 avg	K18 avg	K21 avg	K26 avg	K27 avg	K31 avg	K32 avg	K41 avg	K45 avg
SiO2	74.68	76.75	76.86	75.23	74.35	77.07	75.19	75.59	78.06	74.27	75.46
TiO2	0.26	0.26	0.32	0.34	0.33	0.18	0.23	0.22	0.17	0.35	0.24
Al2O3	14.01	12.96	12.83	13.42	14.12	12.99	13.77	13.46	12.72	14.25	13.94
FeO	0.87	1.07	1.06	1.28	1.52	0.86	1.24	1.06	0.76	1.48	1.25
MnO	0.00	0.01	0.01	0.01	0.04	0.00	0.02	0.02	0.01	0.03	0.02
MgO	0.29	0.15	0.17	0.41	0.41	0.14	0.29	0.22	0.19	0.32	0.30
CaO	0.91	0.87	0.73	1.09	1.37	0.78	1.13	0.96	0.97	1.33	1.27
Na2O	4.51	4.46	4.46	4.80	4.93	4.82	4.47	5.44	4.01	4.41	4.35
K2O	4.35	3.19	3.45	3.29	2.74	3.09	2.81	2.87	2.82	3.37	2.95
F	0.03	0.04	0.02	0.03	0.04	0.01	0.68	0.05	0.19	0.03	0.03
Cl	0.05	0.18	0.06	0.07	0.12	0.04	0.12	0.10	0.05	0.12	0.15
P2O5	0.04	0.05	0.04	0.07	0.04	0.04	0.03	0.03	0.04	0.05	0.03
SO2	0.01	0.03	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02
Total	100.02	100.01	100.02	100.03	100.04	100.02	100.02	100.04	100.02	100.03	100.01

Sample	K46 avg	K49 avg	K52 avg	K56 avg	K62 avg	K64 avg	K65 avg	K66 avg	K67 avg	K68 avg	K69 avg
SiO2	74.84	74.50	73.72	74.25	75.86	75.88	74.26	75.52	76.06	74.86	75.06
TiO2	0.25	0.26	0.25	0.39	0.22	0.26	0.23	0.26	0.23	0.24	0.25
Al2O3	13.99	14.14	14.21	14.00	13.77	13.33	13.97	13.84	13.24	14.08	13.89
FeO	0.98	1.36	1.25	1.14	1.09	1.19	1.40	1.11	0.92	1.04	1.24
MnO	0.02	0.01	0.01	0.03	0.03	0.02	0.03	0.01	0.04	0.03	0.03
MgO	0.17	0.22	0.43	0.24	0.25	0.29	0.39	0.22	0.13	0.31	0.31
CaO	1.30	1.45	1.76	0.91	1.16	1.10	1.47	1.16	0.90	1.32	1.27
Na2O	5.04	4.55	5.21	4.78	4.50	4.67	5.11	4.60	4.80	4.89	5.03
K2O	3.31	3.34	3.08	4.14	2.92	2.99	2.92	3.07	3.38	2.98	2.75
F	0.02	0.00	0.01	0.01	0.05	0.04	0.05	0.04	0.18	0.06	0.03
Cl	0.04	0.09	0.04	0.07	0.11	0.17	0.15	0.11	0.09	0.13	0.11
P2O5	0.04	0.07	0.04	0.05	0.03	0.04	0.04	0.07	0.04	0.06	0.04
SO2	0.01	0.00	0.01	0.01	0.01	0.04	0.02	0.02	0.01	0.01	0.03
Total	100.02	99.83	100.02	100.02	100.01	100.01	100.03	100.01	100.03	100.01	100.03

Individual glass analyses from homogeneous samples are averaged where multiple determinations are available
See Appendix C.1 for a complete listing of glass analyses

Shiveluch magmas follow a calc-alkaline trend (Fig. 6.1) and include basaltic andesites, andesites, and dacites according to classification on the total alkali versus silica diagram of LeBas at al. (1986) (Fig. 6.2). The eruptive products of Shiveluch are mainly medium-K andesites, as defined by Gill (1981) (Fig. 6.3). Four basaltic andesites and one dacite eruption are also documented. Rhyolites are absent in the Holocene eruptive products. The absence of chemical zonation in analyses of single pumice from individual eruptive units implies well-mixed magma chambers that were uniform throughout (Table 6.3). Bulk analyses of single pumice from individual eruptive units show coherent geochemical trends consistent with either magma mixing and/or fractional crystallization (Figs. 6.4 and 6.5). The lack of mixing in any individual eruptive unit argues for fractional crystallization.

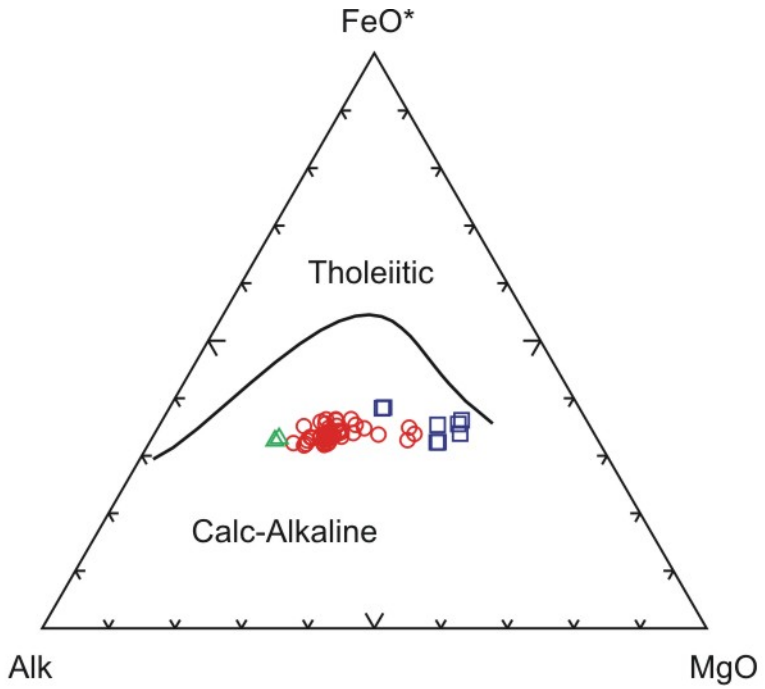

Figure 6.1. Shiveluch whole rock samples plotted on an AFM diagram follow a calc-alkaline trend. Symbols are as follows: basaltic andesite (□), andesite (○), dacite (△).

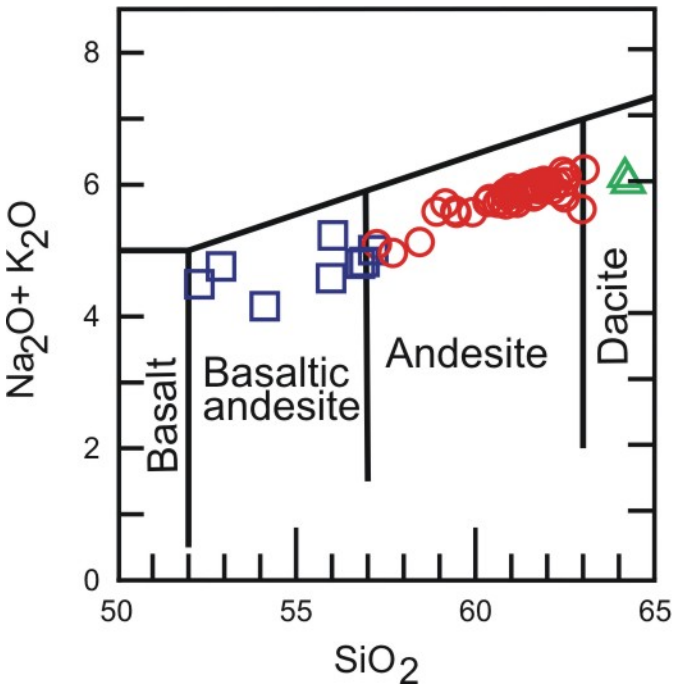

Figure 6.2. Shiveluch samples plotted on the total alkali versus silica (TAS) diagram of LeBas et al. (1986) are classified as basaltic andesite, andesite, and dacite. Andesite is the dominant rock type. Symbols follow those of Figure 6.1. All analyses are normalized to 100% on a volatile free basis. Whole rock analyses are given in Appendix D.

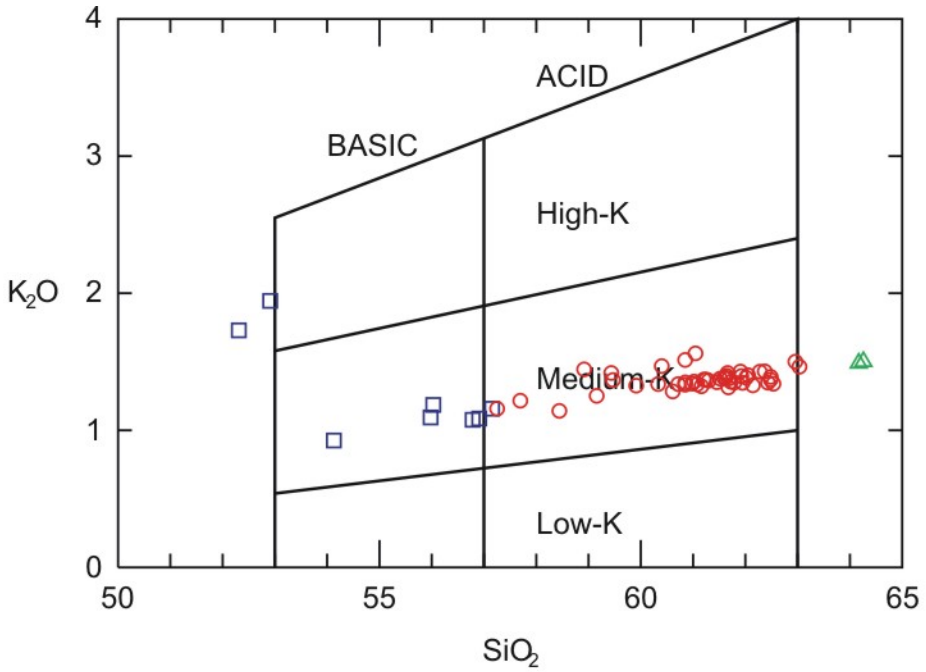

Figure 6.3. Shiveluch andesites are medium-K according to the Gill (1981) diagram of andesite types. Symbols follow those of Figure 6.1. All analyses are normalized to 100% on a volatile free basis. Whole rock analyses are given in Appendix D.

Table 6.3. Whole Rock Major and Trace Element Analysis of Multiple Pumice Clasts Taken from Individual Eruptive Units

Sample	00K45(1)	00K45(2)	00K65-1	00K65-2	00K62-1	00K62-2	00K20A1
Age ybp	1400	1400	1600	1600	2200	2200	3700
SiO2	60.45	60.47	59.58	59.23	60.99	60.91	56.28
TiO2	0.53	0.54	0.58	0.56	0.52	0.53	0.60
Al2O3	16.41	16.44	16.40	16.21	16.28	16.26	14.94
Fe2O3	5.16	5.24	5.53	5.40	5.03	5.03	6.97
MnO	0.10	0.10	0.10	0.10	0.10	0.10	0.12
MgO	3.73	3.76	4.00	3.99	3.77	3.78	8.36
CaO	5.91	5.95	6.13	6.04	5.70	5.72	7.19
Na2O	4.50	4.46	4.46	4.48	4.47	4.45	3.71
K2O	1.34	1.30	1.32	1.33	1.39	1.39	1.07
P2O5	0.17	0.17	0.18	0.17	0.17	0.17	0.16
L.O.I.	1.03	2.05	1.14	1.67	1.58	1.61	0.24
Total	99.33	100.48	99.43	99.19	100.00	99.95	99.66
S	227	264	2521	3391	282	276	239
Cl	785	848	670	1341	536	508	247
V	86	81	117	126	108	105	159
Cr	114	116	132	123	127	129	520
Ni	30	29	33	30	33	37	148
Cu	27	30	21	24	30	32	65
Zn	52	50	54	53	51	53	65
Ga	18	18	18	17	18	18	17
As	7	8	6	7	6	5	4
Rb	23	23	22	22	23	23	16
Sr	558	549	554	538	565	561	463
Y	13	13	14	14	13	13	15
Zr	113	114	118	110	108	110	89
Nb	2	2	2	2	1	2	2
Mo	1	1	1	2	1	1	0
Ba	444	472	424	441	456	451	345
W	56	43	58	58	102	161	130
Pb	7	7	8	6	7	8	6
Th			1	0			0
U	2	1	1	1	1	1	2

Sample	00K20A2	00K19-1	00K19-2	00K21-1	00K21-2	00K31-1	00K31-2
Age ybp	3700	3800	3800	3800	3800	7500	7500
SiO2	56.15	60.24	60.21	60.49	60.52	61.60	62.05
TiO2	0.60	0.52	0.53	0.52	0.52	0.51	0.52
Al2O3	14.93	16.40	16.48	16.23	16.29	16.68	16.67
Fe2O3	6.99	4.97	5.15	5.03	5.12	4.65	4.69
MnO	0.12	0.09	0.10	0.09	0.10	0.09	0.09
MgO	8.42	3.60	3.85	3.78	3.85	2.80	2.81
CaO	7.22	5.65	5.69	5.76	5.82	5.36	5.37
Na2O	3.70	4.55	4.45	4.50	4.47	4.69	4.69
K2O	1.06	1.39	1.38	1.35	1.35	1.42	1.43
P2O5	0.16	0.13	0.17	0.16	0.17	0.17	0.17
L.O.I.	0.14	1.56	1.57	1.50	1.55	1.35	1.43
Total	99.50	99.10	99.58	99.42	99.76	99.33	99.92
S		695	118	161	177	214	212
Cl		562	466	541	573	486	452
V	162	87	89	92	90	69	75
Cr	508	110	133	123	128	65	72
Ni	148	28	32	34	37	18	21
Cu	60	30	30	48	53	27	26
Zn	63	51	53	51	51	49	51
Ga	17	18	18	18	18	19	18
As	3	6	6	6	6	7	7
Rb	16	24	25	22	22	28	25
Sr	459	563	541	576	574	573	569
Y	14	13	13	13	13	12	12
Zr	90	112	111	109	111	117	122
Nb	2	2	2	2	2	2	2
Mo	0	1	1	1	1	1	1
Ba	352	458	466	456	461	465	451
W	102	60	58	64	41	46	82
Pb	5	8	7	8	7	7	8
Th	1	2	2	1	0	0	1
U	1	0	1	1	1	1	2

Major elements

Major element variation diagrams for whole rock analyses form relatively smooth continuous trends for most major elements (Fig. 6.4). Plots of Al_2O_3 and MgO versus SiO_2 have the most scatter; there is some variation observed in andesites but the scatter is seen particularly in basaltic andesites. Plots of K_2O and P_2O_5 versus SiO_2 are fairly smooth apart from basaltic andesite samples 00K15 and 00K57, both of Unit 28, eruption SHsp 3600 y BP. Al_2O_3, Na2O, and K_2O increase as SiO_2 increases. MgO, FeO, TiO_2, and CaO decrease with increasing SiO_2. P_2O_5 remains constant as SiO_2 increases.

Trace elements

Trace elements plotted versus SiO_2 show trends similar to those of major elements although slightly more scatter is observed (Fig. 6.5). Again, basaltic andesites show great variation whereas andesites have a more linear trend. Andesites for all trace elements presented cluster at SiO_2 60-63 wt%. Ba, Sr, and Rb increase with increasing SiO_2. Cr, V, and Ni decrease as SiO_2 increases. Ba, Sr, Cr, and Ni display non-linear trends, while Rb and V plots are relatively linear.

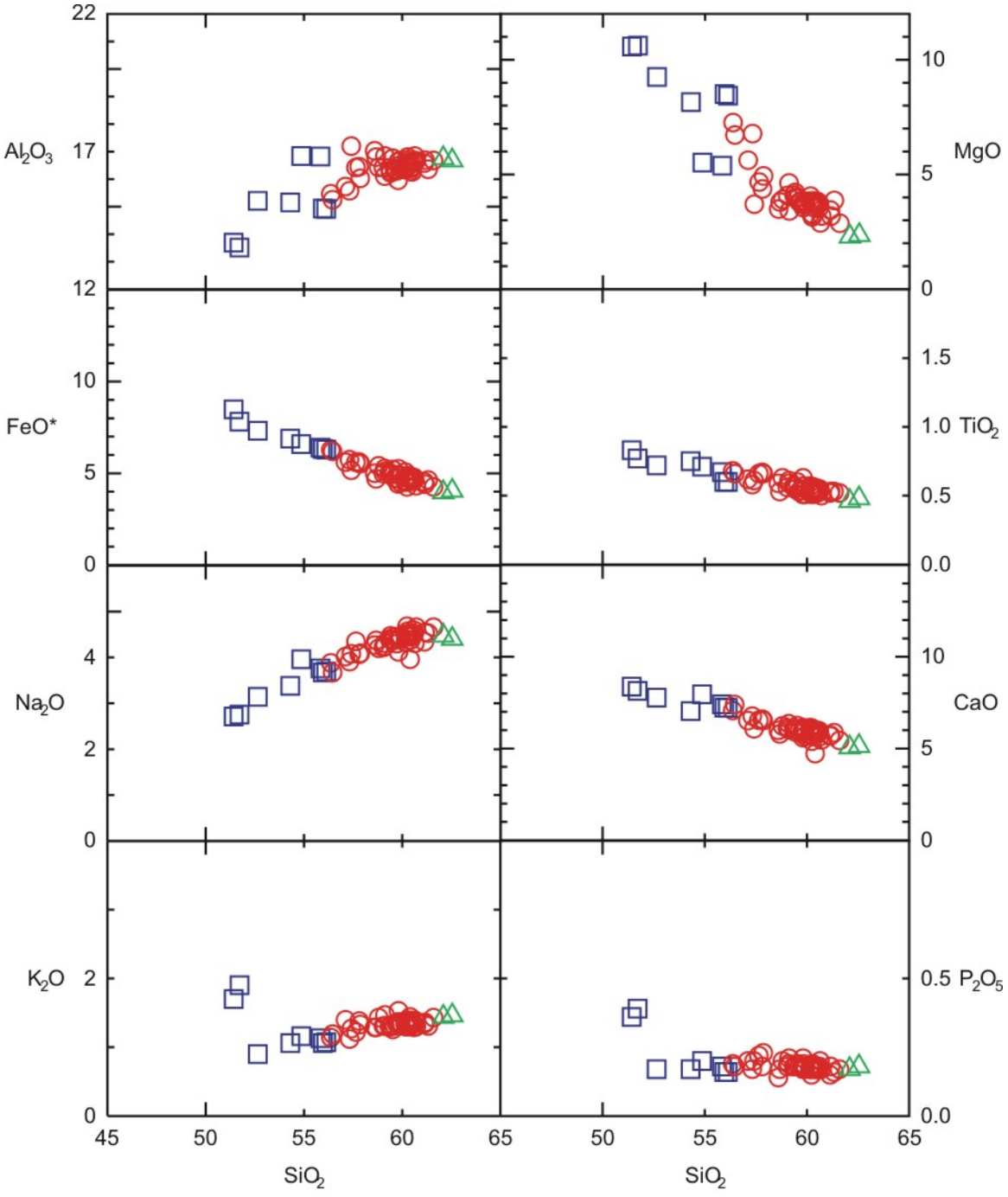

Figure 6.4. Major element versus silica variation diagrams for whole rock analyses. All analyses are normalized to 100% on a volatile free basis. Symbols follow those of Figure 6.1. Representative whole rock analyses are listed in Table 6.1. Complete whole rock analyses are given in Appendix D.

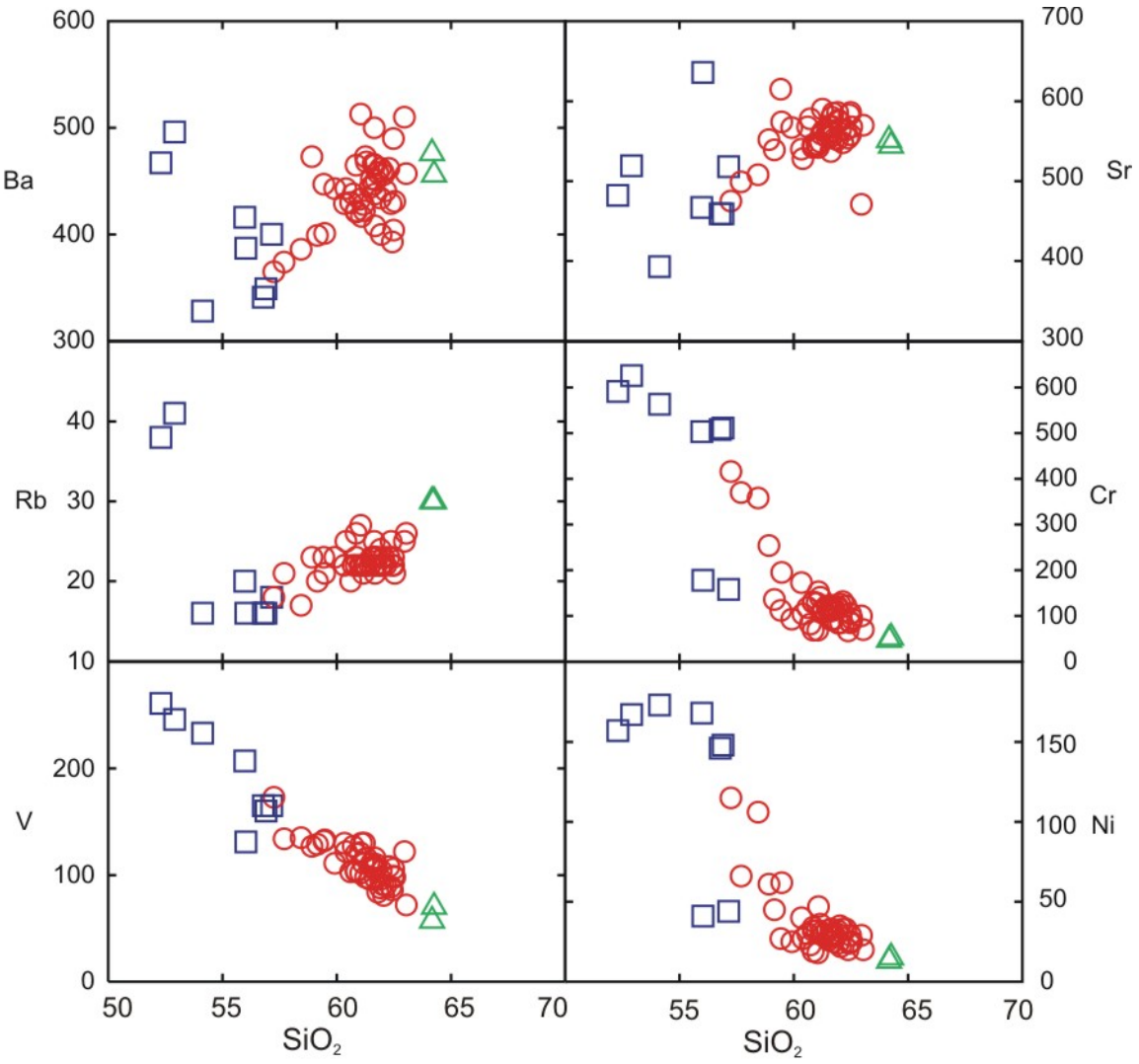

Figure 6.5. Selected trace element (in ppm) versus silica variation diagrams for whole rock analyses. All analyses are normalized to 100% on a volatile free basis. Symbols follow those of Figure 6.1. Representative whole rock analyses are listed in Table 6.1. Complete whole rock analyses are given in Appendix D.

Adakites

"Adak-type" magnesian andesites are characterized by geochemical signatures with high MgO, Cr, Ni, and Sr, and low Y. Shiveluch andesites have high MgO (2.3-6.8 wt%), Cr (65-358 ppm), Ni (18-106 ppm), and Sr (471-615 ppm), and low Y (<18 ppm). They are geochemically similar to adakites, which are derived by partial melting of

eclogite subducted oceanic crust. Figure 6.6 is a plot of Sr/Y versus Y with the adakite field and the andesite-dacite-rhyolite field delineated. Shiveluch andesites plot within the adakite field.

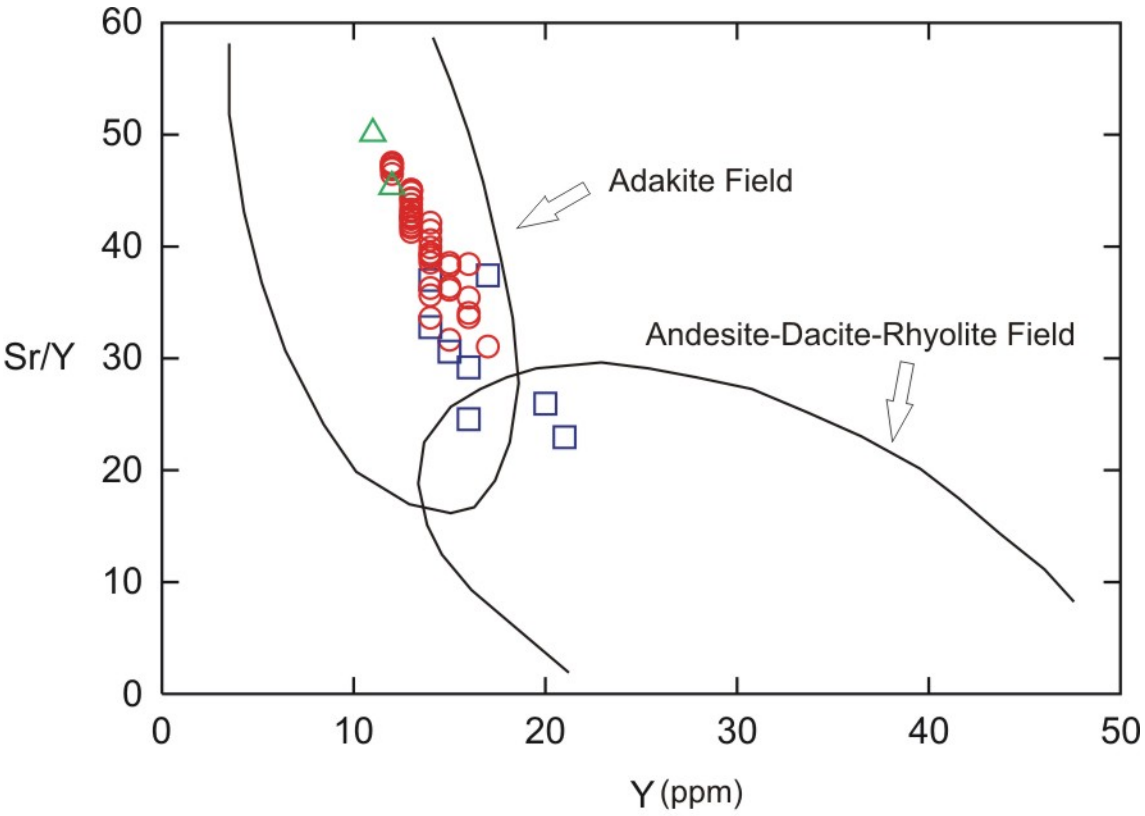

Figure 6.6. Sr/Y graph of Shiveluch samples. Adakite and andesite-dacite-rhyolite fields are superimposed (after Defant and Drummond, 1993). Shiveluch andesites plot within the adakite field. Symbols follow those of Figure 6.1.

Eruption age

The collection and analysis of samples from major Shiveluch eruptions during the Holocene allow an inspection of magma variation over time. Major elements and trace elements plotted against eruption age show similar trends (Fig. 6.7). Apart from more basaltic eruptions at 3600 (Unit 28, eruption SHsp) and 7600 (Unit 46, eruption "dark package") ^{14}C y BP, Shiveluch magmas show relatively little variation through the

Holocene. Volynets et al. (1997) concluded that these eruptions occurred in conjunction with a period of intensified volcanic activity in Kamchatka. This was thought to be associated with tectonic events which promoted the rise of magma to the surface, perhaps from magma chambers located in differently enriched mantle regions than those that supply the usual Shiveluch andesites.

Glass chemistry

Electron microprobe broad-beam (5-25μm) analysis reveals glass compositions with SiO_2 contents that range from 73.72 wt% to 78.06 wt%. The microprobe data was normalized to 100% then normalized to a fixed Na_2O content to correct for its volatilization. All the analyzed glasses are rhyolitic according to the TAS classification (LeBas et al., 1986) (Fig. 6.8). The glasses are thus more silicic than their andesitic parent rocks (Fig. 6.9). In general, glass analyses are 10-12 wt% SiO_2 higher than their host whole rock analyses. The glass analyses plot in semi-linear clusters for Al_2O_3, MgO, FeO, and CaO. There is a wider distribution for clusters of TiO_2, P_2O_5, Na_2O, and K_2O. The spread for Na_2O and K_2O are likely due to loss of these elements during bombardment of the electron beam. Mobilization of alkalis is a common concern in electron microprobe analyses, particularly for sodium and less so for potassium (Hunt and Hill, 1993). The cause of spread in TiO_2 and P_2O_5 data points is uncertain.

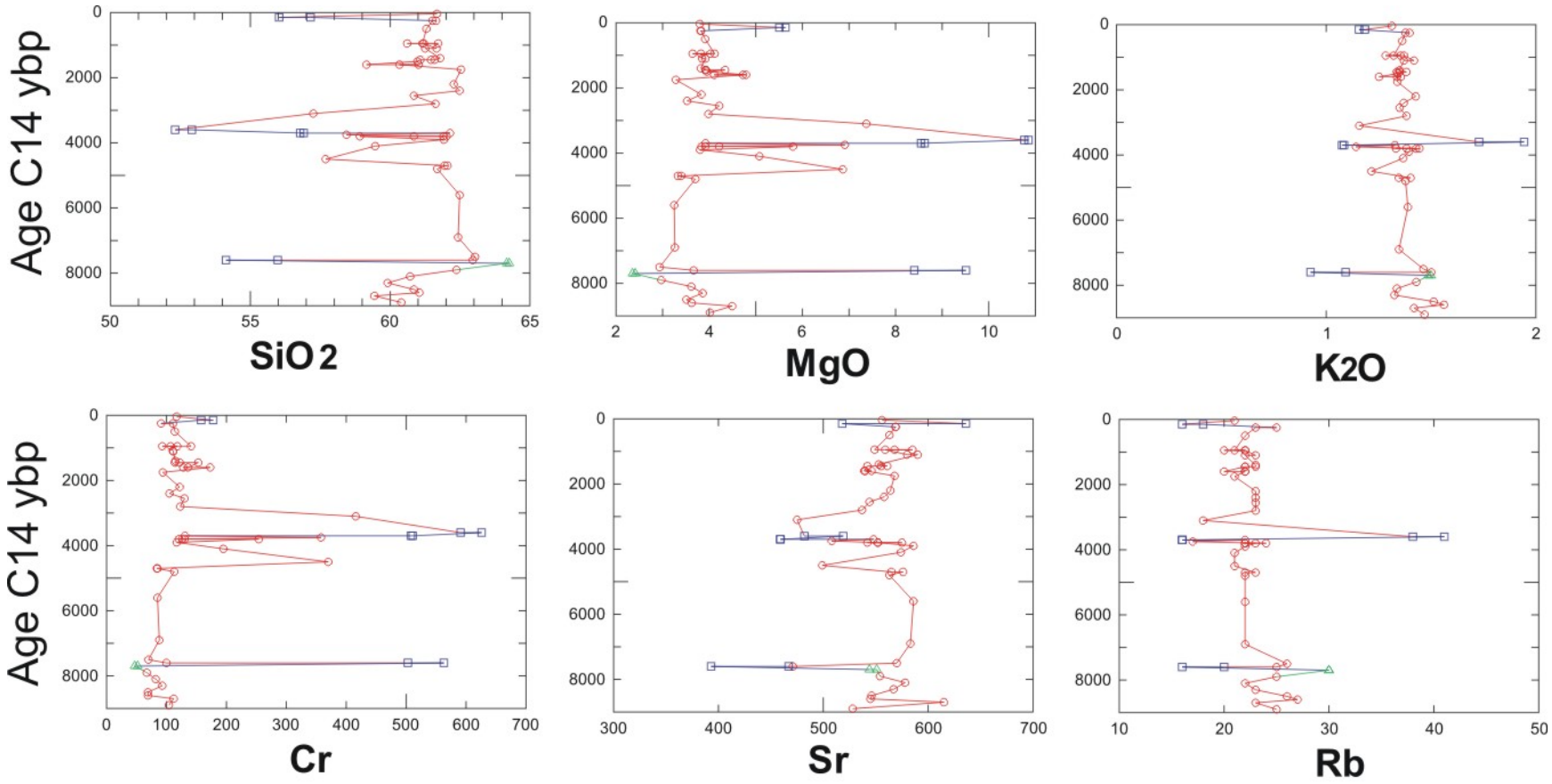

Figure 6.7. Major (in wt%) and trace (in ppm) elements versus eruption age (in years BP) for whole rock samples. All analyses are normalized to 100% on a volatile free basis. Symbols follow those of Figure 6.1. A complete listing of Shiveluch eruptions and their respective ages is given in Appendix A.

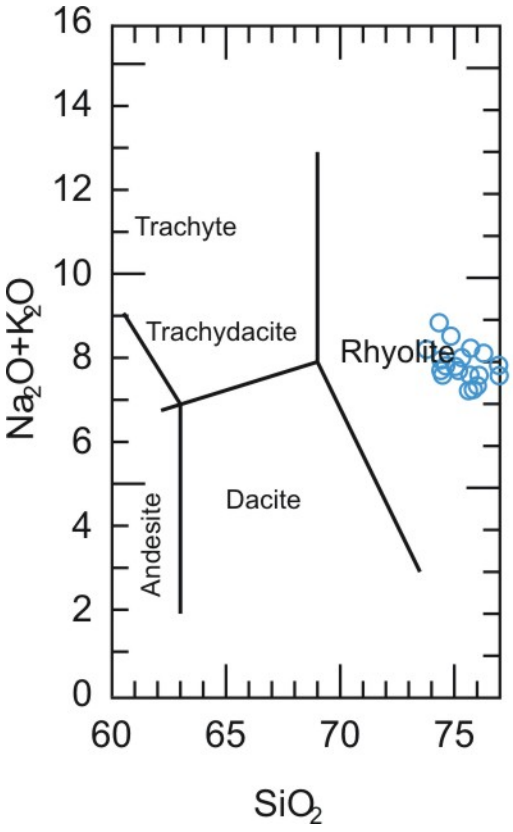

Figure 6.8. Shiveluch glass plotted on the total alkali versus silica diagram (TAS) of LeBas et al. (1986) are classified as rhyolite. All analyses are normalized to 100% on a volatile free basis. Glass analyses are given in Appendix C.

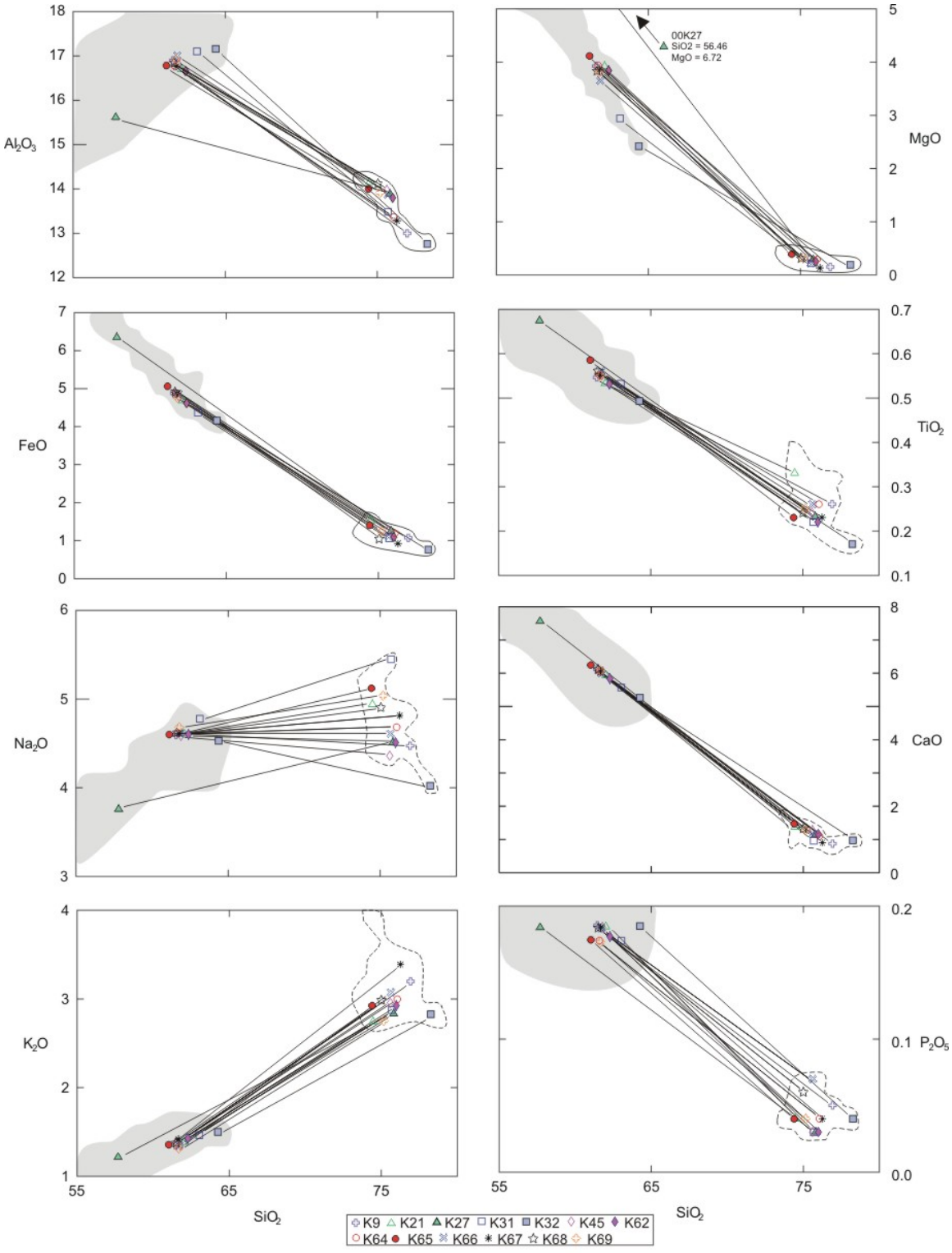

Figure 6.9. Major element vs. SiO_2 variation diagrams for glass. All analyses are normalized to 100% on a volatile free basis. Glass analyses from homogeneous samples are averaged and connected by tie-lines to the host lithology composition. Field of whole rock compositions indicated by gray filled areas. Field of glasses from tephra samples defined by dashed lines.

CHAPTER 7

DISCUSSION

Shiveluch eruptive products are determined to be mainly medium-K, hornblende-bearing andesites. These andesites exhibit a slab melt signature and are relatively uniform through the Holocene. Gorelchik et al. (1997) believe source magma chambers are periodically recharged. Reverse and oscillatory zoning in plagioclase crystals support this. The absence of chemical zonation in analyses of single pumice from individual eruptive units implies well-mixed magma chambers that were uniform throughout. Bulk analyses of pumice show coherent geochemical trends consistent with either magma mixing and/or fractional crystallization. The lack of mixing in any individual eruptive unit points toward fractional crystallization.

Partial melting and magma genesis in volcanic arc settings are generally associated with the lowering of the peridotite solidus due to the addition of aqueous fluids derived by dehydration of the subducting slab (Turner et al., 1998). Shiveluch Volcano is not characteristic of the typical model of arc magma genesis. The eruptive products of Shiveluch are mainly andesites and basaltic andesites but also include magnesian andesites called adakites (Yogodzinski et al., 2001). Studies of Shiveluch and the Aleutian and Komandorsky islands have examined these geochemically distinctive "Adak-type" magnesian andesites known as adakites. Trace element and isotopic characteristics offer evidence that these adakites originated as partial melts of the subducting oceanic crust (Yogodzinski et al., 2001). However, melting of the downgoing slab is not common. It is generally thought to be controlled by the subduction of young ($\leq$25 Ma), relatively warm lithosphere. This is clearly not the case for Shiveluch. The

Pacific Plate is old (87-105 Ma at the Kamchatka trench), therefore relatively cold and unlikely to be warmed enough to partially melt under normal subduction conditions (Yogodzinski et al., 1995).

Factors such as the incoming angle and speed of the subducting slab are thought to cause partial melting even in cases of a relatively cool slab. Shear heating caused by transverse movement is believed to produce an adakitic signature in rocks of the western Aleutian and Komandorsky Islands (Yogodzinski et al., 2001). This transverse movement does not extend into the Kamchatka Peninsula; the Pacific Plate travels orthogonally to the peninsula as it subducts below Shiveluch. Shear heating is thus not likely to be the principal contributor to adakite formation at Shiveluch. However, some warmth gained through shear heating in the region of transverse movement is probably retained as the slab moves toward the peninsula. The speed of the Pacific Plate as it descends below Kamchatka, approximately 9 cm/year (Turner et al., 1998), may help to promote slab melt. According to Defant and Kepezhinskas (2001), the generation of adakites is possible where movement of the incoming slab is rapid (8-10 cm/yr). The fact that adakites are located only at Shiveluch and not at other Kamchatka volcanoes indicates that if the speed with which the slab subducts at this locale does have an affect on slab melt, it is not the only factor at work. The subducting slab beneath Kamchatka is shallowest below Shiveluch; this may also play a role in the generation of adakites.

Shiveluch's unique tectonic situation may account for this unusual case of slab melt. Shiveluch is located in close proximity to an area of transform movement where the Pacific Plate passes beneath the Aleutian-Kamchatka junction. The northern edge of the plate is exposed to shearing and mantle flow, likely causing this edge to be

anomalously hot. Yogodzinski et al. (2001) concluded that adakites are likely to form when the edge of a subducting plate is warmed by mantle flow. A 'slab window' results as a torn Pacific Plate subducts to the north beneath the Aleutians and to the west beneath Kamchatka (Fig. 7.1). Seismic data of Peyton et al. (2001) are in agreement with this slab-edge mantle flow hypothesis. Such a process may be taking place at Shiveluch volcano, perhaps combined with a shallow slab beneath the volcano, a rapid subduction rate, and shear heating from the area of transform movement, consequently resulting in eruptive products with an adakitic signature.

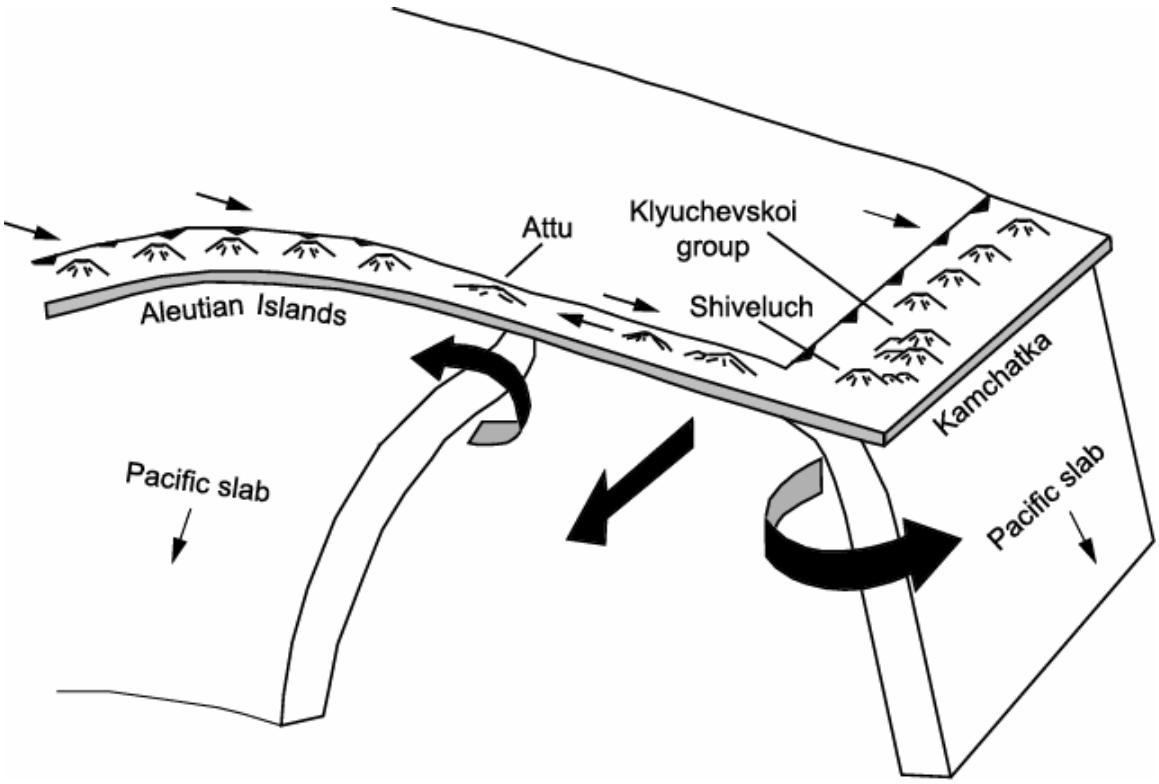

Fig. 7.1. A perspective drawing showing a torn Pacific plate subducting to the north beneath the central Aleutians and to the west beneath Kamchatka. The large, curved arrows indicate mantle flow which heats and physically ablates the plate edges. Adapted from Yogodzinski et al., 2001.

CHAPTER 8

CONCLUSIONS

The variation through the Holocene in magma composition of Shiveluch Volcano, Kamchatka, Russia was examined to determine the role of slab melting as opposed to typical mantle partial melting in the production of magmas. Pumice and ash samples were collected from 48 Shiveluch eruptions spanning the time from 8600 ^{14}C y B.P. to the year 1964. Whole rock, mineral, and glass compositions in these Holocene pyroclastic deposits were analyzed by X-ray fluorescence and electron microprobe.

The eruptive products of Shiveluch are mainly medium-K, hornblende-bearing andesites; 4 basaltic andesite and 1 dacite eruption are also documented. Rhyolites are absent in the Holocene eruptive sequence. The lack of zoning in analyses of single pumice from individual eruptive units infers well-mixed magma chambers that are uniform throughout. Bulk analyses of pumice show coherent geochemical trends consistent with either magma mixing or fractional crystallization. The latter is preferred due to the lack of mixing in any individual eruptive unit.

Shiveluch andesites have a slab melt or adakitic geochemical signature, as opposed to the typical arc magma signature. This slab melt signature is recognized through the high MgO (2.3-6.8 wt%), Cr (65-358 ppm), Ni (18-106 ppm), and Sr (471-615 ppm), and low Y (<18 ppm) of Shiveluch andesites. Adakites are derived by partial melting of eclogite subducted oceanic crust and are relatively rare, especially in arcs with an older and thus relatively cold downgoing slab. In the case of Shiveluch and the cold pacific slab descending below Kamchatka, there are likely several factors working jointly to induce partial melting in the slab. These include the shallow depth of the slab, its

incoming angle and speed, and a possible ‘slab window’ caused by a torn Pacific plate as it descends to the north beneath the Aleutians and to the west beneath Kamchatka. The edge of the slab is then warmed and physically ablated by mantle flow, resulting in the adakitic geochemical signature recognized in Shiveluch andesites.

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APPENDIX A

SAMPLE AND UNIT LISTS

Table A.1 is organized by sample number and includes unit number, name of eruption, latitude and longitude of collection site descriptive location of collection site, and type of material taken. Table A.2 is organized by unit number and includes name of eruption, age of eruption, sample number, other samples, and deposit type. The “other samples” were provided by V. V. Ponomareva to ensure complete coverage in the analysis of major Holocene eruptions from Shiveluch. Unit numbers and/or eruption names (e.g., SH1, SH1450, SHsp) are assigned to Shiveluch deposits. These designations follow those given in Braitseva et al. (1997) and Ponomareva, personal communication (2000).

Table A.1. Sample List

Sample #	Unit #	Eruption	Latitude	Longitude	Location	Type	Micro probe
00K1	No unit	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Fine ash	gm
00K2	4	SH1	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K3	4	SH1	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K4	4	SH1	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K5	5	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K6	6	SH2	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Fine ash	
00K7	6	SH2	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K8	8	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K9	12	SH1450	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	ts
00K10	13	SH1450	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K11	16	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K12	No unit name	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Fine ash	gm
00K13	25	SH2800	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K14	27	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	gm
00K15	28	SHsp	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Basaltic ash/lapilli tuff	
00K16	Klyuchevskoi	Klyuchevskoi	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Basaltic ash	gm
00K17	30	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Coarse ash/lapilli tuff	
00K18	No unit name	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Fine ash	gm
00K19-1	32	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Pumice	
00K19-2	32	No name	N56° 31.392'	E161° 24.385'	Upper Kabeku River	Pumice	
00K20A1	29	No name	N56° 31.592'	E161° 23.944'	Upper Kabeku River	Basalt scoria	
00K20A2	29	No name	N56° 31.592'	E161° 23.944'	Upper Kabeku River	Basalt scoria	
00K20B	29	No name	N56° 31.592'	E161° 23.944'	Upper Kabeku River	Basalt scoria	
00K21-1	32	No name	N56° 31.594'	E161° 23.890'	Upper Kabeku River	Pumice	ts
00K21-2	32	No name	N56° 31.594'	E161° 23.890'	Upper Kabeku River	Pumice	
00K22	29	No name	N56° 31.699'	E161° 23.731'	Upper reaches of River N	Basalt scoria	
00K23	29	No name	N56° 31.699'	E161° 23.731'	Upper reaches of River N	Pumice	
00K24	34	SHdv	N56° 31.367	E161°24.404'	Upper reaches of River N	Fine ash	
00K25	34	SHdv	N56° 31.367	E161°24.404'	Upper reaches of River N	Coarse ash/lapilli tuff	
00K26	No unit name	No name	N56° 31.367	E161°24.404'	Upper reaches of River N	Coarse ash/lapilli tuff	gm
00K27	35	No name	N56° 31.367	E161°24.404'	Upper reaches of River N	Pumice	ts

Table A.1. Sample List continued

Sample #	Unit #	Eruption	Latitude	Longitude	Location	Type	Micro probe
00K28	36	No name	N56° 31.367	E161°24.404'	Upper reaches of River N	Coarse ash/lapilli tuff	
00K29	37	No name	N56° 31.367	E161°24.404'	Upper reaches of River N	Coarse ash/lapilli tuff	
00K30	39	No name	N56° 31.367	E161°24.404'	Upper reaches of River N	Coarse ash/lapilli tuff	
00K31-1	44	No name	N56° 31.210'	E161° 24.715'	Upper reaches of River N	Pumice	ts
00K31-2	44	No name	N56° 31.210'	E161° 24.715'	Upper reaches of River N	Pumice	
00K31-3	44	No name	N56° 31.210'	E161° 24.715'	Upper reaches of River N	Pumice	
00K32	47	No name	N56° 31.210'	E161° 24.715'	Upper reaches of River N	Coarse ash/lapilli tuff	ts
00K33	54	No name	N56° 31.210'	E161° 24.715'	Upper reaches of River N	Coarse ash/lapilli tuff	
00K34	56	No name	N56° 31.210'	E161° 24.715'	Upper reaches of River N	Coarse ash/lapilli tuff	
00K35	42	No name	N56° 31.210'	E161° 24.715'	Upper reaches of River N	Coarse ash/lapilli tuff	
00K36	Khangar	Khangar	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Fine ash	
00K37	46	Dark package	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Fine ash	
00K38	No unit name	No name	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Coarse ash/lapilli tuff	
00K39	47	No name	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Coarse ash/lapilli tuff	
00K40	48	No name	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Coarse ash/lapilli tuff	
00K41	51	No name	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Coarse ash/lapilli tuff	gm
00K42	Plosky	Plosky	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Coarse ash/lapilli tuff	
00K43	57	No name	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Coarse ash/lapilli tuff	
00K44	58	No name	N56° 30.363'	E161° 28.702'	Kabeku River; across from camp	Coarse ash/lapilli tuff	
00K45(1)	11	SH3	N56° 31.988'	E161° 27.718'	Offshoot of Kabeku River River	Pumice	ts
00K45(2)	11	SH3	N56° 31.988'	E161° 27.718'	Offshoot of Kabeku River River	Pumice	
00K46	No unit name	No name	N56° 31.988'	E161° 27.718'	Offshoot of Kabeku River	Fine ash	gm
00K47	32	No name	N56° 31.988'	E161° 27.718'	Offshoot of Kabeku River	Pumice	
00K48	33	No name	N56° 31.988'	E161° 27.718'	Offshoot of Kabeku River	Coarse ash/lapilli tuff	
00K49	9	No name	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	gm
00K50	16	No name	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	
00K51	18	No name	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	
00K52	No unit name	Dark surge	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	gm
00K53	23	No name	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	
00K54	24	SH5	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	
00K55	25	SH2800	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	

Table A.1. Sample List continued

Sample #	Unit #	Eruption	Latitude	Longitude	Location	Type	Micro probe
00K56	No unit name	No name	N56° 41.457'	E161° 05.922'	Mutny River	Fine ash	gm
00K57	28	SHsp	N56° 41.457'	E161° 05.922'	Mutny River	Basaltic ash	
00K58	32	No name	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	
00K59	36	No name	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	
00K60	50	No name	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	
00K61	52	No name	N56° 41.457'	E161° 05.922'	Mutny River	Coarse ash/lapilli tuff	
00K62-1	22	No name	N56° 40.551'	E161° 12.991'	Upper Mutny River	Pumice	ts
00K62-2	22	No name	N56° 40.551'	E161° 12.991'	Upper Mutny River	Pumice	
00K62(2)	22	No name	N56° 40.551'	E161° 12.991'	Upper Mutny River	Pumice	
00K63	4	SH1	N56° 40.790'	E161° 12.430'	Upper Mutny River	Pumice	
00K64	13 (?)	SH1450	N56° 41.282'	E161° 11.312'	Upper Mutny River	Pumice	ts
00K64D	13 (?)	SH1450	N56° 41.282'	E161° 11.312'	Upper Mutny River	Pumice	gm
00K64L	13 (?)	SH1450	N56° 41.282'	E161° 11.312'	Upper Mutny River	Pumice	gm
00K65-1	16 (?)	No name	N56° 33.766'	E161° 13.094'	Upper Karmynsky River	Pumice	ts
00K65-2	16 (?)	No name	N56° 33.766'	E161° 13.094'	Upper Karmynsky River	Pumice	
00K66	6	SH2	N56° 33.776	E161° 13.122	Upper Karmynsky River	Pumice	ts
00K66D	6	SH2	N56° 33.776	E161° 13.122	Upper Karmynsky River	Pumice	gm
00K66L	6	SH2	N56° 33.776	E161° 13.122	Upper Karmynsky River	Pumice	gm
00K67	8	No name	N56° 33.390'	E161° 12.376'	Upper Karmynsky River	Pumice	ts
00K68	4	SH1	N56° 31.493'	E161° 09.162'	Upper Karmynsky River	Pumice	ts
00K69	1	1964	N56° 31.493'	E161° 09.162'	Upper Karmynsky River	Pumice	ts
00K70	5	No name	N56° 31.493'	E161° 09.162'	Upper Karmynsky River	Pumice	
00K71	2 (?)	1854	N56° 32.823	E161° 11.215	Upper Karmynsky River	Pumice	gm
00K72	6	SH2	N56° 18.969'	E160° 50.022'	Within Klyuchi town	Coarse ash/lapilli tuff	
00K73	11	SH3	N56° 18.969'	E160° 50.022'	Within Klyuchi town	Coarse ash/lapilli tuff	
00K100-1	No unit name	No name	N56° 39.920'	E161° 14.480'	West flank of Shiveluch	Andesite dike	
00K100-2	No unit name	No name	N56° 39.920'	E161° 14.480'	West flank of Shiveluch	Andesite dike	
00K101	No unit name	No name	N56° 21.826'	E160° 53.620'	~3km from Klyuchi ferry	Basalt	
00K102	Klyuchevskoi	Klyuchevskoi	N56° 08.689'	E160° 48.174'	Near Podkova hut on Klyuchevskoi	Basalt	
00K102-2	Klyuchevskoi	Klyuchevskoi	N56° 08.689'	E160° 48.174'	Near Podkova hut on Klyuchevskoi	Basalt	
90116/9	14	No name				Coarse ash/lapilli tuff	

Table A.1. Sample List continued

Sample #	Unit #	Eruption	Latitude	Longitude	Location	Type	Micro probe
90119/1	2	1854				Coarse ash/lapilli tuff	
96025/2	4	SH1	N56.57°	E161.51°	Il'chinets River	Coarse ash/lapilli tuff	
96025/4	6	SH2			Il'chinets River	Coarse ash/lapilli tuff	
96030/1	46	dark package				Fine ash	
97044/1	1	1964	N56.65°	E161.46°		Coarse ash/lapilli tuff	
97048/5	26	No name				Coarse ash/lapilli tuff	
97049/1	12	SH1450				Coarse ash/lapilli tuff	
97049/2	14	No name	N56.65°	E161.46°		Coarse ash/lapilli tuff	
97049/3	16	No name				Coarse ash/lapilli tuff	
97051/2	25	SH2800	N56.65°	E161.46°		Coarse ash/lapilli tuff	
97052/4	34	SHdv	N56.65°	E161.46°		Fine ash	
97058/2	46	dark package				Fine ash	

Question marks indicate uncertainty whether a particular eruption is associated with the correct unit

Micropobe column indicates manner of sample prep for analyses: gm = grain mount, ts = thin section

Table A.2. Unit list

Unit	Eruption	14C yrs BP	Sample # 00K	Other Samples	Deposit Type
1	1964		69	97044/1	pyroclastic flow deposit
2	1854		71 (?)	90119/1	pyroclastic flow deposit
no unit		200	1,46		fine ash fall
4	SH1	250	2,3,4,63,68	96025/2	pyroclastic flow deposit
5		500	5, 70		pyroclastic flow deposit
6	SH2	950	6,7,66,72	96025/4, SH2	pyroclastic flow deposit
8		1100	8,67		8-coarse ash/lapilli tuff; 67-pyroclastic flow deposit
9		1300	49		fall - coarse ash/lapilli tuff
11	SH3	1400	45(1), 45(2), 73	SH3	pyroclastic flow deposit
12	SH1450	1450	9	97049/1	coarse ash/lapilli tuff
13	SH1450	1450	10, 64 (?)		10:Surge - coarse ash; 64: pyroclastic flow deposit
14		1500		90116/9, 97049/2	90116/9: Pumice fall; 97049/2:Pumice fall
16		1600	11,50,65 (?)	97049/3	pyroclastic flow deposit? coarse ash/lapilli tuff
18		1750	51		coarse ash/lapilli tuff
no unit		1850	12		fine ash fall
no unit	dark surge	2050	52		coarse ash fall
22		2200	62		pyroclastic flow deposit
23		2400	53		coarse ash/lapilli tuff
24	SH5	2550	54		coarse ash/lapilli tuff
25	SH2800	2800	13,55	97051/2	coarse ash/lapilli tuff
no unit		2950	56		fine ash fall
26		3100		97048/5	Fall following debris Av
27		3550	14		coarse ash/lapilli tuff
28	SHsp	3600	15,57		basaltic ash fall
no unit	Klyuchevskoi		16		basaltic ash fall
29		3700	20A,20B,22,23		black and white bombs from PFD, overlying debris avalanche IV
30		3750	17		coarse ash/lapilli tuff
no unit			18		fine ash fall
32		3800	19, 21, 47,58		pyroclastic flow deposit
33		3900	48		coarse ash/lapilli tuff
34	SHdv	4100	24,25	97052/4	coarse ash/lapilli tuff
no unit			26		coarse ash/lapilli tuff
35		4500	27		pyroclastic flow deposit
36		4700	28,59		coarse ash/lapilli tuff
37		4800	29		coarse ash/lapilli tuff
39		5600	30		coarse ash/lapilli tuff
42		6900	35		coarse ash/lapilli tuff; lapilli & block fall
Khangar		6900	36		fine ash fall
44		7500	31		pyroclastic flow deposit
46	dark package	7600	37	96030/1,97058/2	fine ash fall
no unit		7600	38		fine ash fall
47		7700	32,39		coarse ash/lapilli tuff
48		7900	40		coarse ash/lapilli tuff
50		8100	60		coarse ash/lapilli tuff
51		8200	41		coarse ash/lapilli tuff
52		8300	61		coarse ash/lapilli tuff
54		8500	33		pyroclastic flow deposit
56		8600	34		coarse ash/lapilli tuff
Plosky		8600	42		coarse ash/lapilli tuff
57		8700	43		coarse ash/lapilli tuff
58		8900	44		coarse ash/lapilli tuff

APPENDIX B

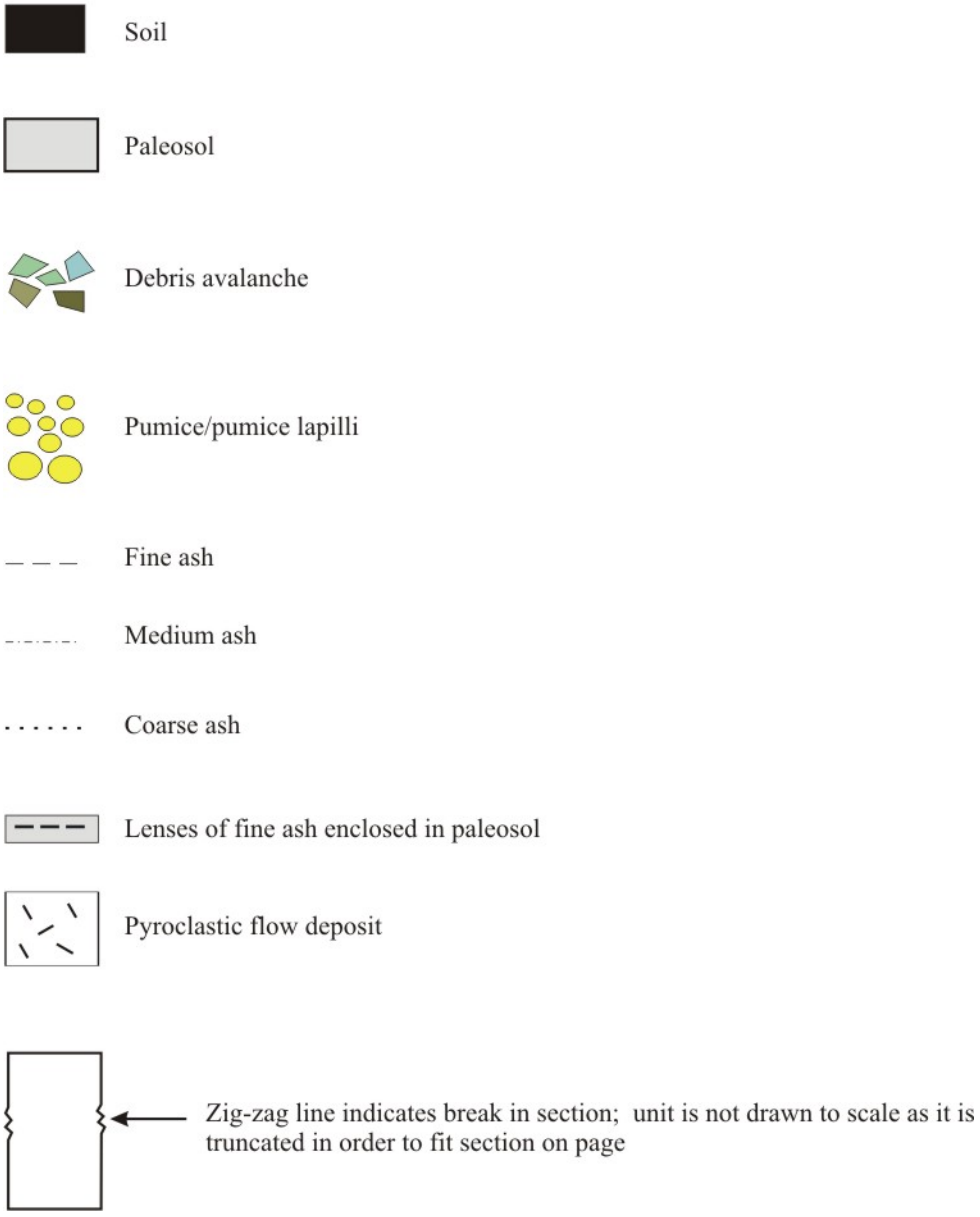
SECTION SUMMARIES

Stratigraphic sections were measured at outcrops exposed along streambeds at several locations on the flanks of Shiveluch. This appendix contains illustrations of measured sections with field descriptions. Samples were collected at sites in various streambeds in an attempt to cover the Holocene eruptive history. Often units that are not present at one location can be found at another. This is probably due to of erosion or dispersion of material that did not spread out in all directions from the volcano. A complete summary section of Shiveluch Holocene deposits can be found at the end of this appendix.

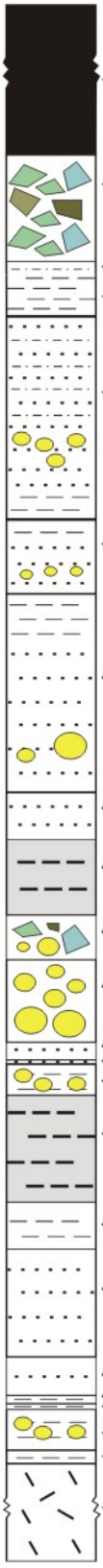
The outer ~20 cm of the exposure was removed before samples were taken in order to avoid the collection of weathered or contaminated material. Pumice and ash layers were then described and carefully collected. Sample locations were recorded using a GPS; these locations were given arbitrary names for convenience in the field (e.g., SHEV8, SHEV13).

Unit numbers and/or eruption names (e.g., SH1, SH1450, SHsp) are assigned to Shiveluch deposits. These designations follow those given in Braitseva et al. (1997) and Ponomareva, personal communication (2000). Shiveluch deposits are intermingled with paleosols and deposits from other Kamchatka volcanoes such as Khangar (KHG), Kizimen (KZ), and Klyuchevskoi.

Symbol legend for summary sections



Location **SHEV3**
N56º 31.392’ E161º 24.385’



5cm

25cm soil cover

12cm alluvial from Shiveluch debris avalanche 1964

2cm medium-grained Bezimianny 1956 tephra

4cm fine pink ash tephra; local; dome derived ash(?) [00K1]

22cm Unit 4, eruption SH1, consists of 3 distinct layers: 13cm yellow-brown coarse ash & ash tephra [00K2]; 6cm pumice rich & lithic rich coarse ash, very crystalline [00K3]; 3cm fine brown ash [00K4]

8cm section: 3cm light brown to yellowish fine ash underlain by 5cm light gray coarse ash tephra containing rare 1cm pumice clasts, lower 1.5cm slightly coarser [00K5]

22cm Unit 6, eruption SH2, 5cm light gray mottled & iron stained fine ash [00K6] underlain by 17cm dark gray crystal rich coarse ash, 5% andesitic lithics, rare pumice lapilli to 5cm, fining upward [00K7]

5cm Unit 8, coarse ash tephra [00K8]

8cm mixed mixed paleosol/pink ash; also minor basaltic ash

5cm ambiguous layer, irregular, possible surge; crossbedding, rare pumice to 5cm, occasional lithics, possibly associated with SH3 pyroclastic flow deposit

9cm Unit 12, eruption SH12, lapilli tuff, well sorted, angular pumice to 10cm, 10% lithics to 3cm [00K9]

2cm Unit 13, gray ash tephra [00K10]

2-5mm coarse black basaltic tephra containing red oxidized grains

3cm Unit 16, pumice lapilli rich tephra [00K11]

12cm KS1 (Ksudach eruption 1) blended with a paleosol

5cm fine pink ash, irregular, slightly reworked (?)

12cm Unit 25, eruption SH2800, coarse ash tephra, white pumice, black crystals, lithics light salt & pepper [00K13]

4cm Unit 27, coarse ash, dark salt & pepper [00K14]

1cm Unit 28, eruption SHsp, basalt tephra, basalt lapilli, well sorted, some iron-stained bands [00K15]

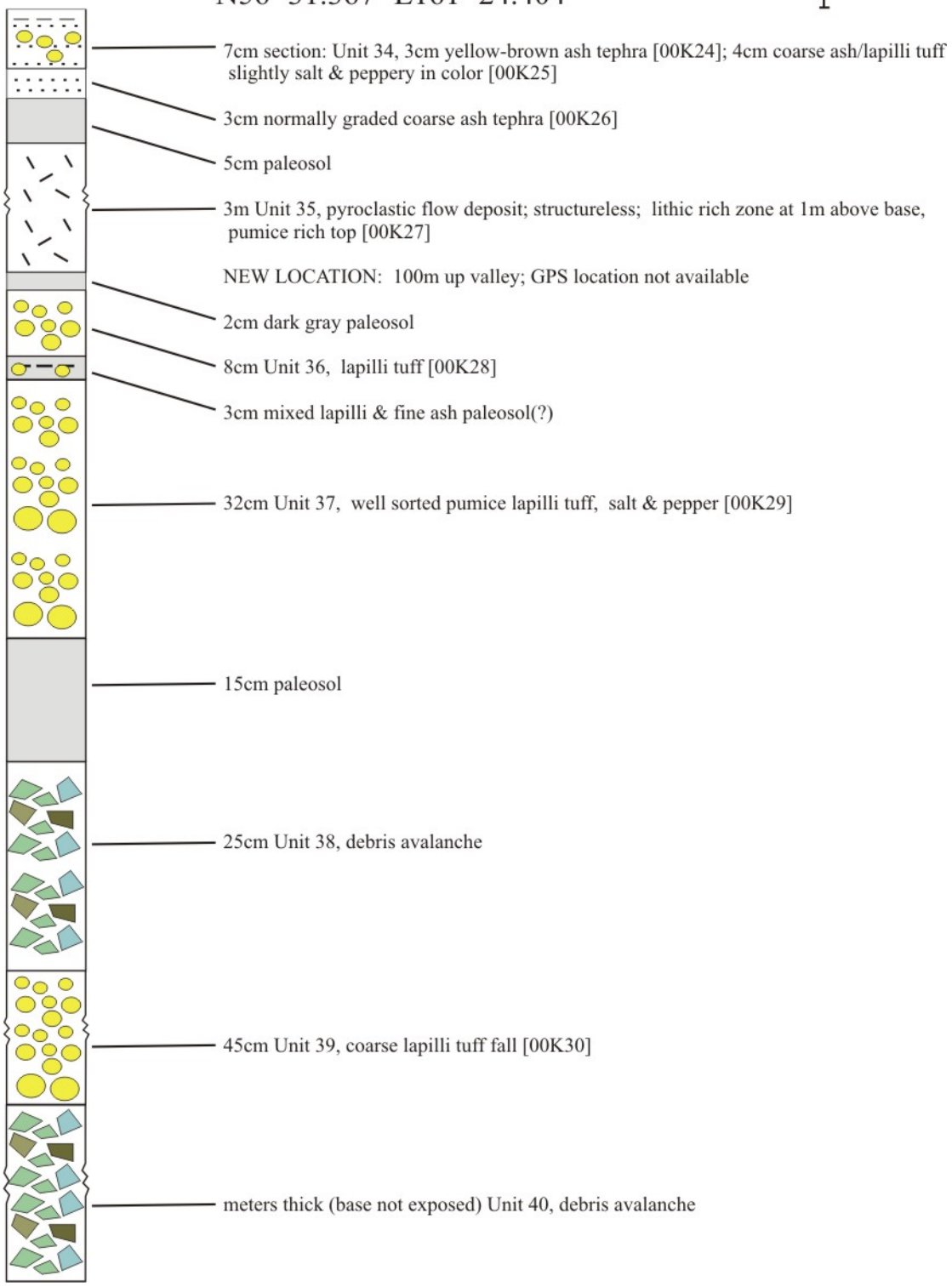
0.5-2cm Klyuchevskoi eruption, dark gray basaltic ash [00K16]

4cm lapilli tuf tephra [00K17]

2cm fine gray ash containing irregular 2mm whitish layer [00K18]

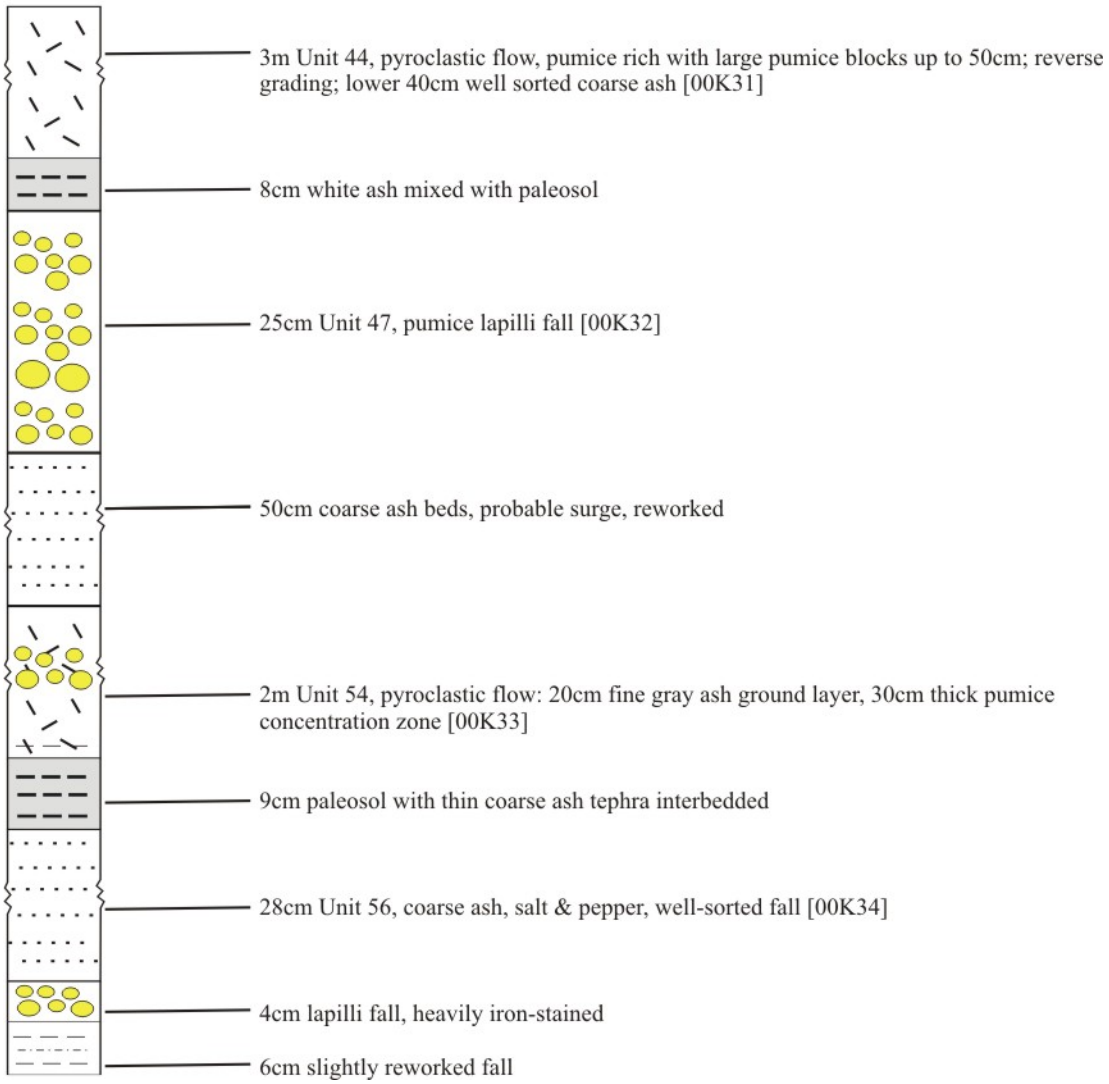
6m Unit 32, pyroclastic flow deposit, structureless apart from pumice lenses at the base and irregular lenses at top; weakly pinkish in places, lithic rich in lower half [00K19]

Location **SHEV7**
N56º 31.367' E161º 24.404'



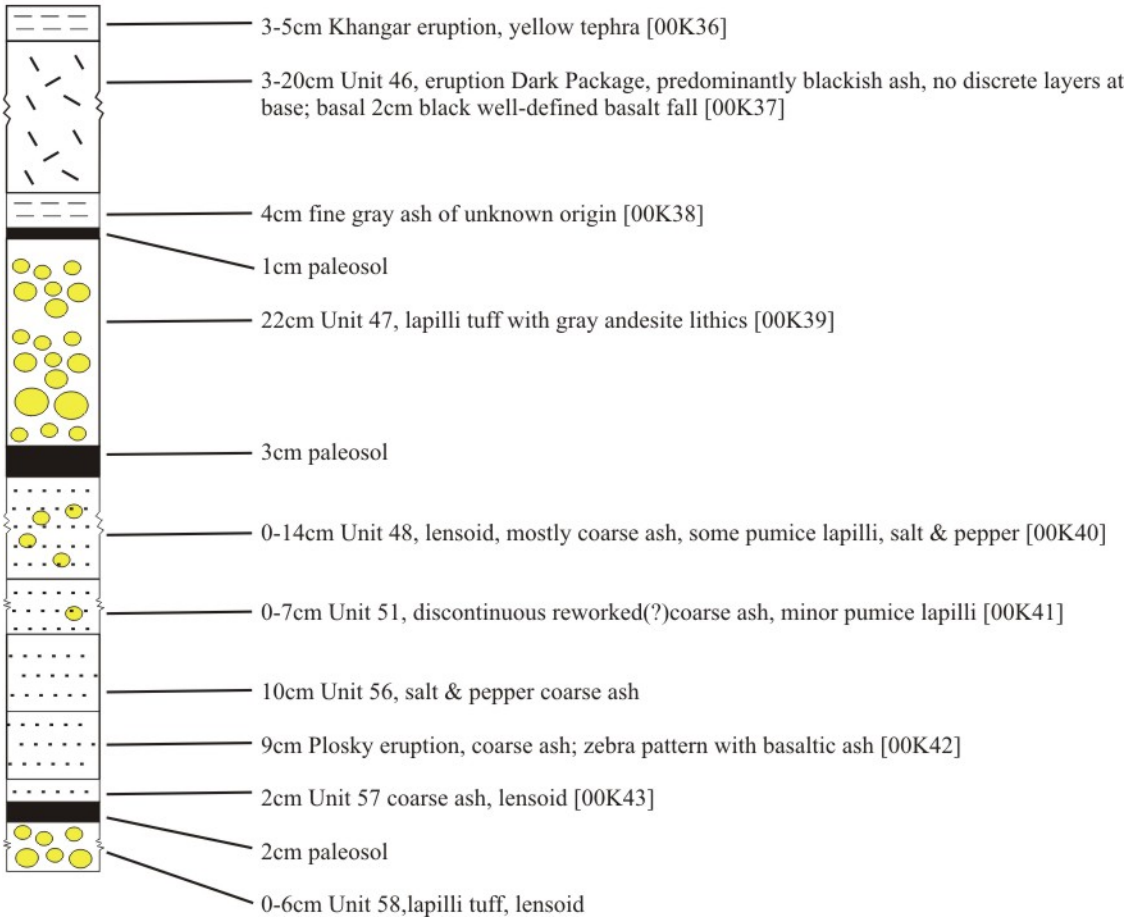
Location **SHEV8**
N56º 31.210' E161º 24.715'

5cm



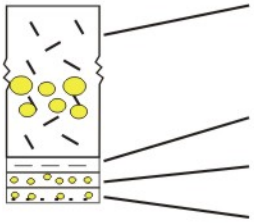
Location 15m downstream from **SHEV10**
N56º 30.363' E161º 28.702'

5cm



Location **SHEV11**
N56º 31.988’ E161º 27.718’

5cm

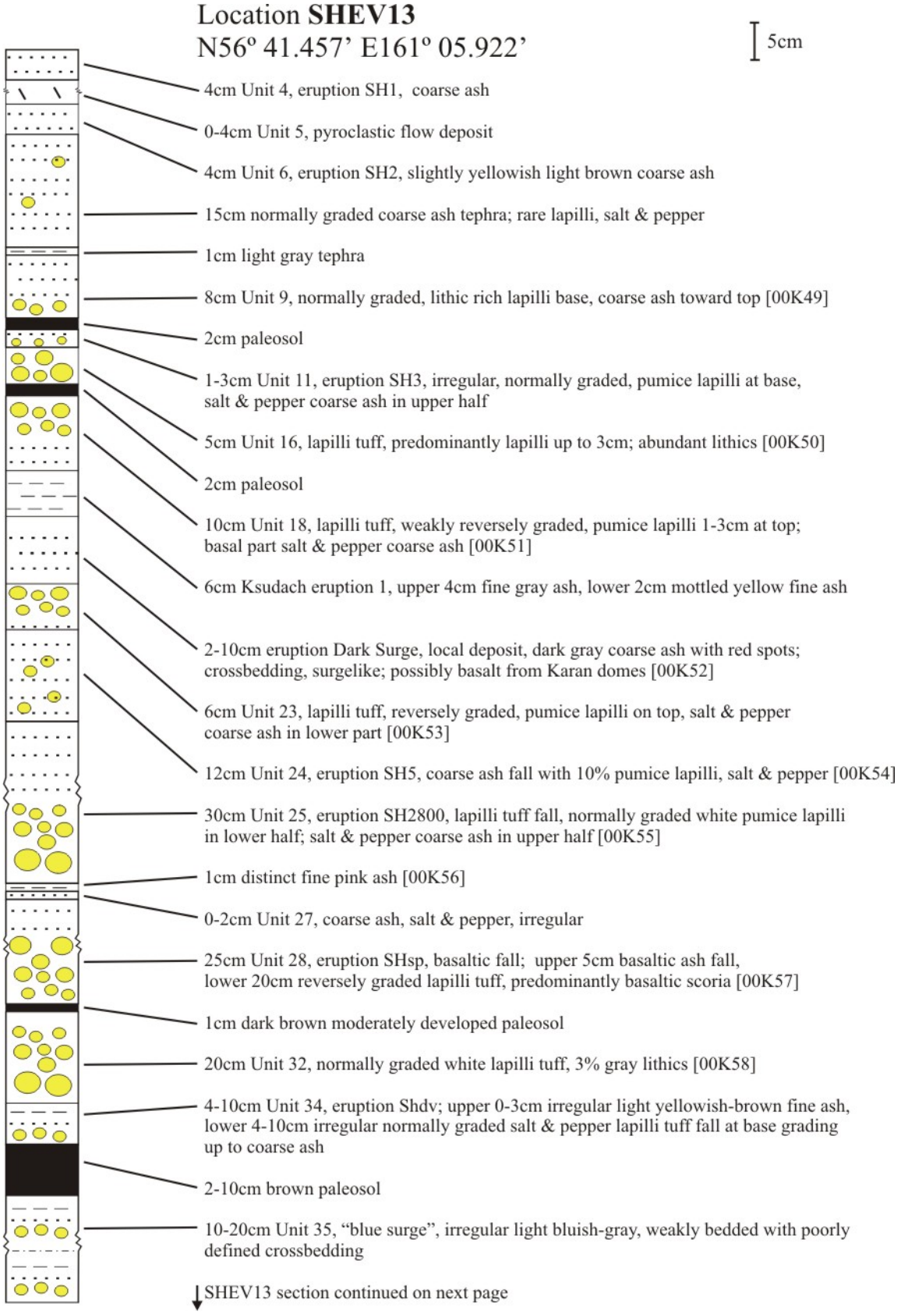


50cm Unit 11, eruption SH3, pyroclastic flow, upper half extensively reworked with pockets of waterlain sediment and possibly aeolian sediment; lower half is reversely graded ash tuff, upper 20cm bands of pumice lapilli [00K45]

2cm fine pink ash [00K46]

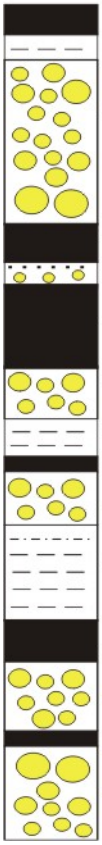
2cm Unit 32, irregular lapilli rich, slightly reworked(?), origin unclear [00K47]

0-3cm Unit 33, lapilli rich with coarse dark ash base, very discontinuous, origin unclear [00K48]


Location **SHEV13**
N56º 41.457' E161º 05.922'
5cm
4cm Unit 4, eruption SH1, coarse ash
0-4cm Unit 5, pyroclastic flow deposit
4cm Unit 6, eruption SH2, slightly yellowish light brown coarse ash
15cm normally graded coarse ash tephra; rare lapilli, salt & pepper
1cm light gray tephra
8cm Unit 9, normally graded, lithic rich lapilli base, coarse ash toward top [00K49]
2cm paleosol
1-3cm Unit 11, eruption SH3, irregular, normally graded, pumice lapilli at base, salt & pepper coarse ash in upper half
5cm Unit 16, lapilli tuff, predominantly lapilli up to 3cm; abundant lithics [00K50]
2cm paleosol
10cm Unit 18, lapilli tuff, weakly reversely graded, pumice lapilli 1-3cm at top; basal part salt & pepper coarse ash [00K51]
6cm Ksudach eruption 1, upper 4cm fine gray ash, lower 2cm mottled yellow fine ash
2-10cm eruption Dark Surge, local deposit, dark gray coarse ash with red spots; crossbedding, surgelike; possibly basalt from Karan domes [00K52]
6cm Unit 23, lapilli tuff, reversely graded, pumice lapilli on top, salt & pepper coarse ash in lower part [00K53]
12cm Unit 24, eruption SH5, coarse ash fall with 10% pumice lapilli, salt & pepper [00K54]
30cm Unit 25, eruption SH2800, lapilli tuff fall, normally graded white pumice lapilli in lower half; salt & pepper coarse ash in upper half [00K55]
1cm distinct fine pink ash [00K56]
0-2cm Unit 27, coarse ash, salt & pepper, irregular
25cm Unit 28, eruption SHsp, basaltic fall; upper 5cm basaltic ash fall, lower 20cm reversely graded lapilli tuff, predominantly basaltic scoria [00K57]
1cm dark brown moderately developed paleosol
20cm Unit 32, normally graded white lapilli tuff, 3% gray lithics [00K58]
4-10cm Unit 34, eruption Shdv; upper 0-3cm irregular light yellowish-brown fine ash, lower 4-10cm irregular normally graded salt & pepper lapilli tuff fall at base grading up to coarse ash
2-10cm brown paleosol
10-20cm Unit 35, "blue surge", irregular light bluish-gray, weakly bedded with poorly defined crossbedding
SHEV13 section continued on next page

Location **SHEV13** continued
N56º 41.457' E161º 05.922'

5cm



6cm section: upper 3cm dark brown to blackish paleosol, well developed; lower 3cm fine gray ash, probably reworked from underlying unit

18cm Unit 36, uniform lapilli tuff, 2% gray lithics [00K59]

2.5cm paleosol

1-3cm Unit 37, white lapilli tuff, coarse salt & pepper ash, lensoid

8cm brown to dark brown paleosol

5-9cm Unit 39, irregular lapilli stone

4cm Khangar eruption

2cm black paleosol

1-6cm Unit 45, pumice lapilli, irregular

10cm Unit 45, eruption Dark Package, fine black ash, slightly coarser in upper 2cm

4cm dark brown paleosol

7cm Unit 50, lapilli tuff fall [00K60]

2cm dark brown paleosol

10cm Unit 52 lapilli fall, reversely graded

Location **SHEV18**
N56º 40.790’ E161º 12.430’

5cm

8m Unit 4, SH1, uniform pyroclastic flow deposit, rare pumice concentration zone [00K63]

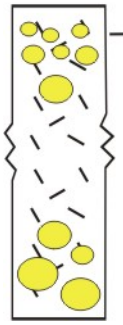
Location **SHEV19**
N56º 41.282’ E161º 11.312’

5cm

6m Unit 13, SH1450, uniform pyroclastic flow deposit, pumice blocks throughout [00K64]

Location 45m upstream from SHEV21
56º 33.776’ E161º 13.122’

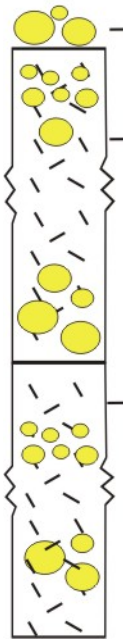
5cm



2-3m Unit 6, SH2, pyroclastic flow deposit, irregular, lower 1m pumice concentration zone with pumice blocks to 80cm, clast supported, fines depleted; upper section lapilli tuff with pumice blocks [00K69]

Location SHEV23
56º 31.493’ E161º 09.162’

5cm



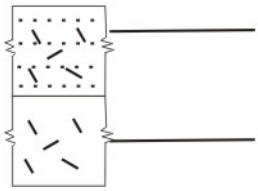
Pumice clasts from top of Unit 1, 1964 pyroclastic flow deposit [00K69]

5-10+m Unit 4, SH1, pyroclastic flow deposit exposed over 4km along valley walls, characterized by carbonized logs in both vertical and horizontal positions; pumice concentration zones abundant [00K68]

5m Unit 5, pyroclastic flow deposit, pumice concentration zones to 50cm thick; in places pumice looks slightly imbricated [00K70]

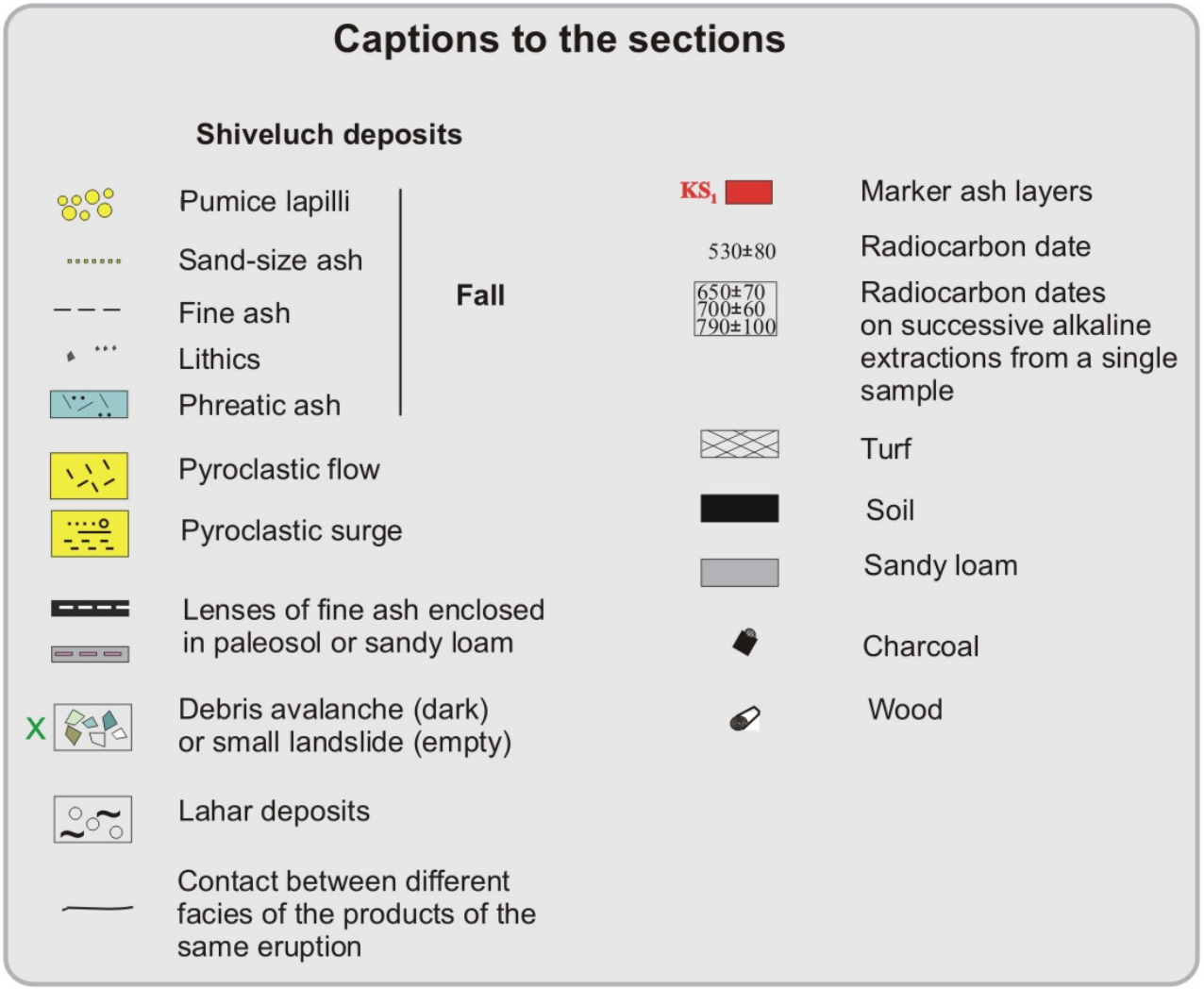
Location Klyuchi
56º 18.969’ E160º 50.022’

5cm

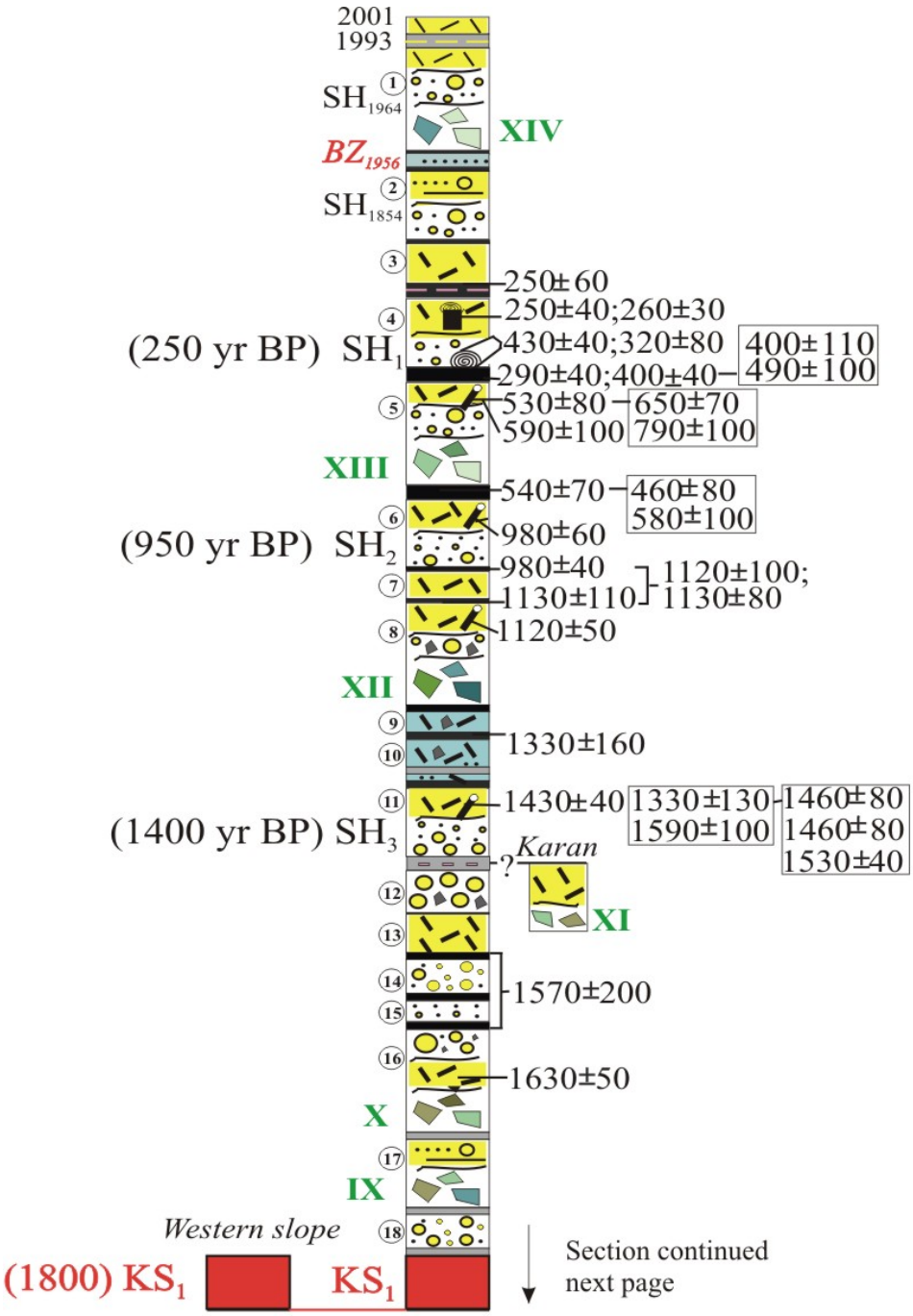


~10cm Unit 6, SH2, pyroclastic flow deposit, coarse ash from base of unit, extensive reworking: thickness is highly exaggerated [00K72]

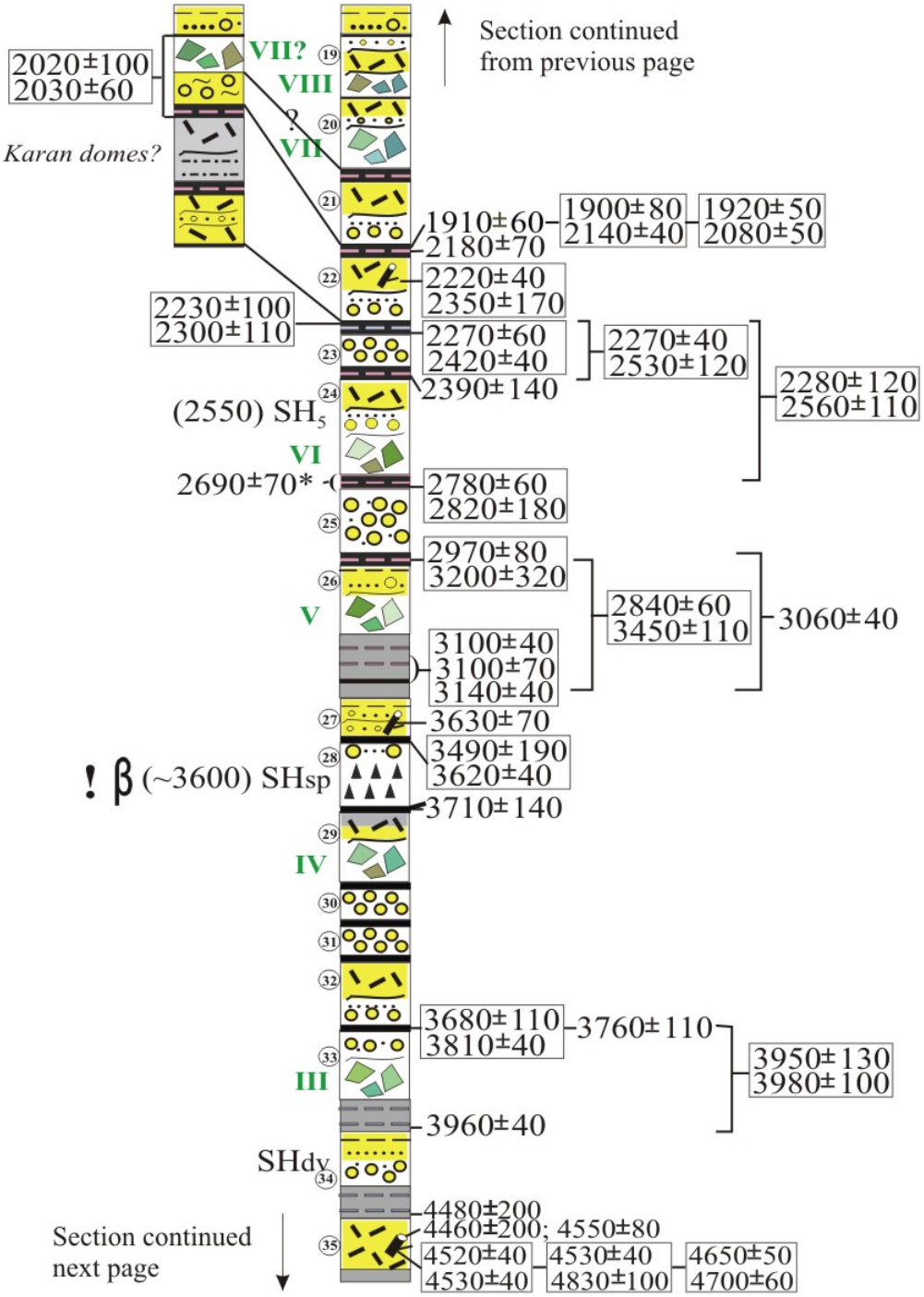
~10cm Unit 11, SH3, pyroclastic flow deposit, extensive reworking: thickness is highly exaggerated [00K73]



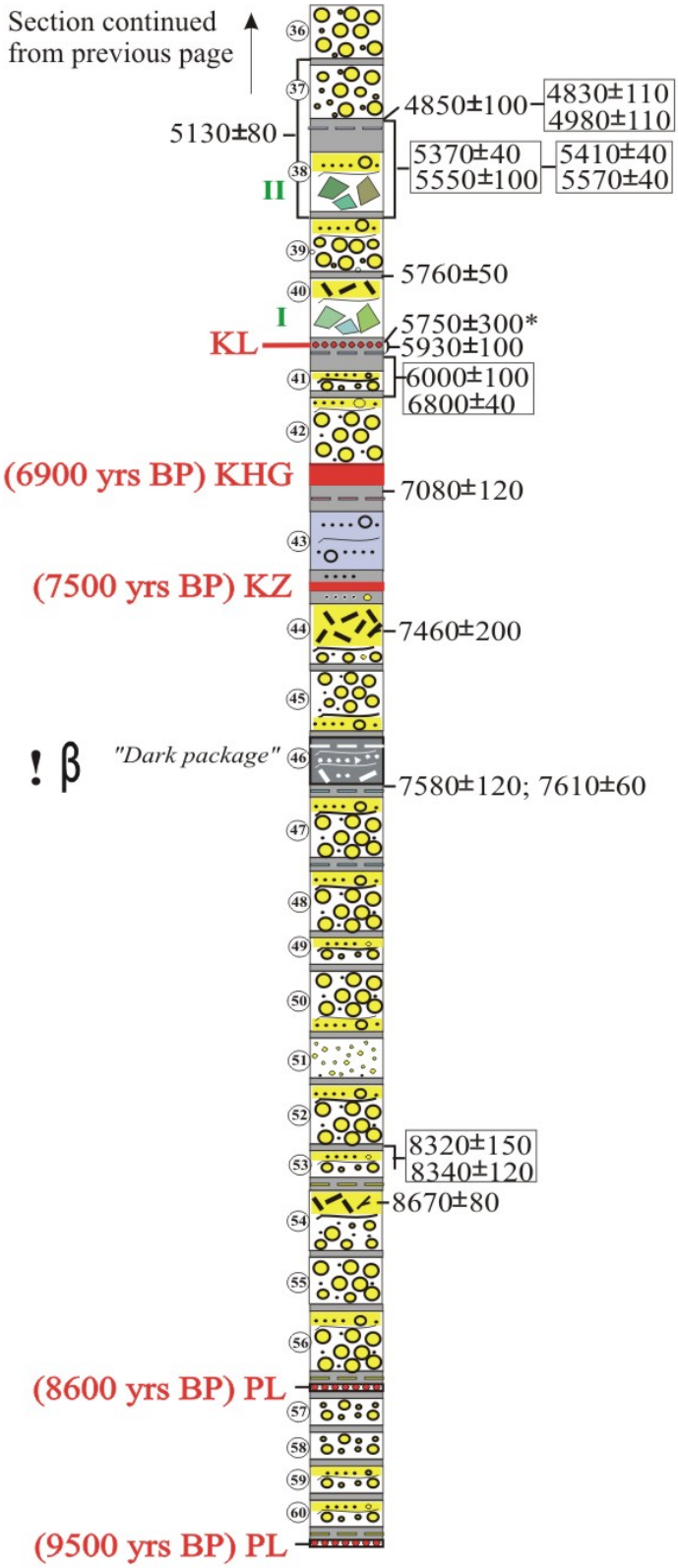
Legend for composite Shiveluch sections shown on next three pages. After Ponomareva et al. (2002).



Summary section through Holocene pyroclastic deposits of Shiveluch volcano. After Ponomareva et al. (2002).



Continuation of summary section through Holocene pyroclastic deposits of Shiveluch volcano. After Ponomareva et al. (2002).



Continuation of summary section through Holocene pyroclastic deposits of Shiveluch volcano. After Ponomareva et al. (2002).

APPENDIX C

ELECTRON MICROPROBE ANALYSES

Major element quantities of mineral and glass phases were measured by a Cameca SX-100 electron microprobe at New Mexico Institute of Mining and Technology. Billets were cut from pumice samples and sent to High Mesa Petrographic Service in Los Alamos, New Mexico where polished thin sections were prepared for electron microprobe analysis and petrography. Ash samples were prepared through wet-sieving to obtain sand-size portions which were then dried and embedded in epoxy/leucite microprobe sample mounts. The sample mounts were cured in a drying oven, polished, and carbon coated to ensure electrical conductivity.

Where glass points are poor, analyses are not normalized to sodium and these analyses not used in examining data. Feldspar locations are c = core, i = intermediate, r = rim. Sample 00K16 is from Klyuchevskoi Volcano; analyses for this sample can be found at the end of each section.

Table C.1. Glass Analysis

Sample K-1

Point	19	23	24	26	27	Average	St. Dev.
Beam size	5	5	5	10	10		
SiO2	71.51	76.12	68.42	74.53	75.46	73.21	3.21
TiO2	0.18	0.24	0.76	0.30	0.29	0.36	0.23
Al2O3	14.72	13.77	10.81	13.42	13.90	13.32	1.48
FeO	0.70	0.77	4.47	1.00	1.00	1.59	1.61
MnO	0.00	0.00	0.15	0.01	0.00	0.03	0.07
MgO	0.20	0.45	4.49	0.17	0.35	1.13	1.88
CaO	1.00	0.76	3.64	0.83	1.04	1.45	1.23
Na2O	3.43	3.58	2.78	4.35	4.54	3.73	0.72
K2O	4.81	4.84	2.50	3.77	3.93	3.97	0.96
F	0.00	0.11	0.15	0.00	0.01	0.05	0.07
Cl	0.13	0.03	0.07	0.03	0.01	0.06	0.05
P2O5	0.09	0.00	0.07	0.02	0.04	0.04	0.03
SO2	0.04	0.01	0.04	0.00	0.00	0.02	0.02
Total	96.81	100.68	98.33	98.44	100.59	98.97	1.65
Normalized to 100%							
SiO2	73.86	75.61	69.58	75.72	75.02	75.05	0.85
TiO2	0.19	0.24	0.77	0.31	0.29	0.26	0.05
Al2O3	15.20	13.67	10.99	13.63	13.82	14.08	0.75
FeO	0.72	0.77	4.54	1.02	1.00	0.87	0.15
MnO	0.00	0.00	0.15	0.01	0.00	0.00	0.01
MgO	0.21	0.44	4.56	0.17	0.34	0.29	0.13
CaO	1.03	0.75	3.70	0.84	1.03	0.92	0.14
Na2O	3.54	3.55	2.83	4.42	4.51	4.01	0.53
K2O	4.97	4.81	2.54	3.83	3.91	4.38	0.59
F	0.00	0.11	0.15	0.00	0.01	0.03	0.05
Cl	0.14	0.03	0.07	0.03	0.01	0.05	0.06
P2O5	0.09	0.00	0.07	0.02	0.04	0.04	0.04
SO2	0.04	0.01	0.04	0.00	0.00	0.01	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na							
SiO2	73.15	74.88		75.65	75.02	74.68	1.07
TiO2	0.19	0.24		0.31	0.29	0.26	0.06
Al2O3	15.06	13.54		13.62	13.82	14.01	0.71
FeO	0.71	0.76		1.02	1.00	0.87	0.16
MnO	0.00	0.00		0.01	0.00	0.00	0.01
MgO	0.21	0.44		0.17	0.34	0.29	0.13
CaO	1.02	0.74		0.84	1.03	0.91	0.14
Na2O	4.51	4.51		4.51	4.51	4.51	0.00
K2O	4.92	4.76		3.82	3.91	4.35	0.57
F	0.00	0.11		0.00	0.01	0.03	0.05
Cl	0.14	0.03		0.03	0.01	0.05	0.06
P2O5	0.09	0.00		0.02	0.04	0.04	0.04
SO2	0.04	0.01		0.00	0.00	0.01	0.02
Total	100.03	100.03		100.00	100.00	100.02	0.02

Table C.1. Glass Analysis
Sample K-9

Point	2	5	12	14	22	23	Average	St. Dev.
Beam size	20	10	10	10	10	10		
SiO2	76.97	73.17	76.50	77.27	63.81	76.18	73.98	5.19
TiO2	0.29	0.25	0.28	0.24	0.22	0.25	0.26	0.03
Al2O3	12.95	12.36	13.07	13.26	10.48	12.91	12.51	1.04
FeO	1.08	1.02	0.98	1.02	0.97	1.13	1.03	0.06
MnO	0.00	0.04	0.02	0.00	0.01	0.03	0.01	0.02
MgO	0.22	0.05	0.21	0.20	0.16	0.00	0.14	0.09
CaO	0.89	0.84	0.84	0.84	0.75	0.87	0.84	0.05
Na2O	4.47	3.79	4.34	4.46	3.00	4.28	4.06	0.57
K2O	3.12	3.06	3.21	3.27	2.57	3.21	3.07	0.26
F	0.01	0.03	0.07	0.07	0.04	0.00	0.04	0.03
Cl	0.16	0.15	0.14	0.18	0.23	0.16	0.17	0.03
P2O5	0.04	0.05	0.03	0.04	0.04	0.10	0.05	0.03
SO2	0.01	0.02	0.04	0.02	0.02	0.04	0.02	0.01
Total	100.20	94.81	99.72	100.86	82.30	99.15	96.17	7.13
Normalized to 100%								
SiO2	76.81	77.17	76.71	76.61	77.54	76.83	76.95	0.35
TiO2	0.29	0.27	0.28	0.23	0.27	0.25	0.27	0.02
Al2O3	12.93	13.03	13.11	13.14	12.74	13.02	12.99	0.15
FeO	1.08	1.07	0.98	1.01	1.18	1.14	1.08	0.07
MnO	0.00	0.04	0.02	0.00	0.01	0.03	0.01	0.02
MgO	0.22	0.06	0.21	0.20	0.20	0.00	0.15	0.09
CaO	0.89	0.88	0.84	0.83	0.91	0.87	0.87	0.03
Na2O	4.46	4.00	4.35	4.42	3.65	4.32	4.20	0.32
K2O	3.11	3.23	3.22	3.24	3.13	3.24	3.19	0.06
F	0.01	0.03	0.07	0.07	0.04	0.00	0.04	0.03
Cl	0.16	0.16	0.14	0.18	0.28	0.16	0.18	0.05
P2O5	0.03	0.05	0.03	0.03	0.04	0.10	0.05	0.03
SO2	0.01	0.02	0.04	0.02	0.03	0.04	0.03	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na								
SiO2	76.81	76.82	76.63	76.58	76.91	76.72	76.75	0.12
TiO2	0.29	0.27	0.28	0.23	0.27	0.25	0.26	0.02
Al2O3	12.93	12.97	13.09	13.14	12.63	13.00	12.96	0.18
FeO	1.08	1.07	0.98	1.01	1.17	1.14	1.07	0.07
MnO	0.00	0.04	0.02	0.00	0.01	0.03	0.01	0.02
MgO	0.22	0.06	0.21	0.20	0.20	0.00	0.15	0.09
CaO	0.89	0.88	0.84	0.83	0.91	0.87	0.87	0.03
Na2O	4.46	4.46	4.46	4.46	4.46	4.46	4.46	0.00
K2O	3.11	3.22	3.21	3.24	3.10	3.23	3.19	0.06
F	0.01	0.03	0.07	0.07	0.04	0.00	0.04	0.03
Cl	0.16	0.16	0.14	0.18	0.28	0.16	0.18	0.05
P2O5	0.03	0.05	0.03	0.03	0.04	0.10	0.05	0.03
SO2	0.01	0.02	0.04	0.02	0.03	0.04	0.03	0.01
Total	100.00	100.02	100.00	100.00	100.03	100.01	100.01	0.01

Table C.1. Glass Analysis
Sample K-12

Point	11	16	20	21	24	25	26	27	29	Average	St. Dev.
Beam size	10	20	20	10	20	10	20	20	15		
SiO2	74.31	75.85	75.06	73.99	75.76	74.44	75.23	78.14	74.89	75.29	1.24
TiO2	0.63	0.26	0.23	0.32	0.25	0.19	0.27	0.32	0.25	0.30	0.13
Al2O3	14.01	12.17	12.68	11.10	12.92	15.39	11.86	12.75	13.31	12.91	1.25
FeO	1.64	0.84	1.22	1.15	0.75	0.64	0.96	1.00	0.77	0.99	0.31
MnO	0.02	0.00	0.00	0.00	0.04	0.00	0.00	0.03	0.03	0.01	0.02
MgO	0.46	0.13	0.12	0.14	0.12	0.10	0.14	0.11	0.11	0.16	0.11
CaO	0.36	0.75	0.80	0.51	0.95	2.11	0.51	0.78	1.07	0.87	0.52
Na2O	4.44	3.48	4.01	2.65	4.10	5.89	3.59	3.72	3.98	3.98	0.87
K2O	3.66	3.44	3.02	3.14	3.38	1.58	3.69	3.43	3.37	3.19	0.64
F	0.03	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.01	0.02
Cl	0.05	0.06	0.11	0.17	0.01	0.02	0.04	0.00	0.01	0.05	0.06
P2O5	0.07	0.07	0.00	0.03	0.04	0.05	0.04	0.04	0.02	0.04	0.02
SO2	0.03	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.01
Total	99.69	97.06	97.24	93.22	98.38	100.41	96.33	100.32	97.81	97.83	2.26
Normalized to 100%											
SiO2	74.54	78.15	77.19	79.36	77.01	74.13	78.09	77.89	76.57	76.99	1.71
TiO2	0.63	0.27	0.23	0.34	0.25	0.19	0.28	0.32	0.26	0.31	0.13
Al2O3	14.05	12.54	13.04	11.90	13.13	15.33	12.31	12.71	13.61	13.18	1.04
FeO	1.65	0.86	1.25	1.23	0.76	0.63	0.99	1.00	0.78	1.02	0.31
MnO	0.02	0.00	0.00	0.00	0.04	0.00	0.00	0.03	0.03	0.01	0.02
MgO	0.46	0.13	0.12	0.15	0.12	0.10	0.14	0.11	0.11	0.16	0.11
CaO	0.36	0.77	0.82	0.55	0.96	2.10	0.53	0.78	1.10	0.89	0.51
Na2O	4.46	3.58	4.13	2.84	4.17	5.86	3.73	3.71	4.06	4.06	0.82
K2O	3.67	3.54	3.10	3.37	3.43	1.58	3.83	3.41	3.45	3.26	0.66
F	0.03	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.02	0.02
Cl	0.05	0.06	0.11	0.18	0.01	0.02	0.04	0.00	0.01	0.05	0.06
P2O5	0.07	0.08	0.00	0.03	0.04	0.05	0.04	0.04	0.02	0.04	0.02
SO2	0.03	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na											
SiO2	74.54	77.47	76.93	78.08	76.79		77.52	77.30	76.27	76.86	1.09
TiO2	0.63	0.27	0.23	0.33	0.25		0.28	0.32	0.26	0.32	0.13
Al2O3	14.05	12.43	12.99	11.71	13.10		12.23	12.61	13.55	12.83	0.75
FeO	1.65	0.85	1.25	1.21	0.76		0.99	0.99	0.78	1.06	0.30
MnO	0.02	0.00	0.00	0.00	0.04		0.00	0.03	0.03	0.01	0.02
MgO	0.46	0.13	0.12	0.14	0.12		0.14	0.11	0.11	0.17	0.12
CaO	0.36	0.77	0.82	0.54	0.96		0.52	0.77	1.09	0.73	0.24
Na2O	4.46	4.46	4.46	4.46	4.46		4.46	4.46	4.46	4.46	0.00
K2O	3.67	3.51	3.09	3.31	3.42		3.80	3.39	3.43	3.45	0.22
F	0.03	0.00	0.00	0.05	0.05		0.00	0.00	0.00	0.02	0.02
Cl	0.05	0.06	0.11	0.18	0.01		0.04	0.00	0.01	0.06	0.06
P2O5	0.07	0.08	0.00	0.03	0.04		0.04	0.04	0.02	0.04	0.02
SO2	0.03	0.01	0.00	0.00	0.01		0.01	0.00	0.00	0.01	0.01
Total	100.00	100.03	100.01	100.05	100.01		100.03	100.03	100.02	100.02	0.01

Table C.1. Glass Analysis
Sample K-14

Point	4	6	8	13	14	15	19	31	33	Average	St. Dev.
Beam size	5	5	5	5	5	5	5	5	5		
SiO2	74.63	80.62	79.45	79.01	80.49	79.59	80.10	79.51	80.11	79.28	1.82
TiO2	0.24	0.25	0.26	0.36	0.26	0.21	0.25	0.25	0.13	0.25	0.06
Al2O3	12.57	12.08	13.88	13.74	13.76	13.20	13.38	13.46	11.71	13.09	0.78
FeO	1.23	1.04	1.37	2.20	1.40	1.25	1.21	1.58	1.01	1.36	0.36
MnO	0.01	0.04	0.04	0.01	0.00	0.06	0.00	0.06	0.00	0.02	0.03
MgO	0.23	0.22	0.24	0.22	0.24	0.15	0.17	0.20	0.08	0.19	0.05
CaO	0.89	0.50	1.04	1.01	0.95	0.82	0.89	1.00	0.37	0.83	0.24
Na2O	1.15	1.40	1.43	1.75	1.19	1.36	1.81	1.62	1.31	1.45	0.23
K2O	0.88	0.85	1.22	1.49	0.88	1.22	1.26	0.95	1.17	1.10	0.22
F	0.00	1.16	0.01	0.00	0.14	0.00	0.02	0.00	0.00	0.15	0.38
Cl	0.15	0.09	0.10	0.11	0.11	0.10	0.11	0.10	0.15	0.11	0.02
P2O5	0.06	0.04	0.02	0.02	0.00	0.02	0.00	0.00	0.04	0.02	0.02
SO2	0.02	0.01	0.00	0.03	0.03	0.03	0.00	0.03	0.02	0.02	0.01
Total	92.06	98.31	99.06	99.94	99.45	98.00	99.22	98.76	96.10	97.88	2.45
Normalized to 100%											
SiO2	81.06	82.01	80.20	79.06	80.94	81.21	80.73	80.51	83.36	81.01	1.12
TiO2	0.26	0.26	0.26	0.36	0.26	0.22	0.25	0.25	0.14	0.25	0.05
Al2O3	13.66	12.29	14.01	13.75	13.84	13.47	13.49	13.63	12.19	13.37	0.63
FeO	1.33	1.05	1.39	2.20	1.41	1.27	1.22	1.59	1.05	1.39	0.33
MnO	0.02	0.04	0.04	0.01	0.00	0.06	0.00	0.06	0.00	0.03	0.02
MgO	0.25	0.22	0.25	0.22	0.24	0.15	0.18	0.20	0.08	0.20	0.05
CaO	0.96	0.51	1.05	1.01	0.96	0.84	0.90	1.01	0.39	0.85	0.22
Na2O	1.25	1.43	1.45	1.75	1.20	1.39	1.83	1.64	1.37	1.48	0.20
K2O	0.96	0.87	1.23	1.49	0.88	1.24	1.27	0.96	1.22	1.13	0.20
F	0.00	1.18	0.01	0.00	0.14	0.00	0.02	0.00	0.00	0.15	0.37
Cl	0.16	0.09	0.10	0.11	0.11	0.10	0.11	0.11	0.16	0.12	0.02
P2O5	0.06	0.04	0.02	0.02	0.00	0.02	0.00	0.00	0.04	0.02	0.02
SO2	0.02	0.01	0.00	0.03	0.03	0.03	0.00	0.03	0.02	0.02	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na											
SiO2	80.59	81.68	79.89	78.99	80.43	80.86	80.73	80.35	82.98	80.72	1.11
TiO2	0.26	0.26	0.26	0.36	0.26	0.22	0.25	0.25	0.14	0.25	0.06
Al2O3	13.58	12.24	13.96	13.74	13.75	13.41	13.49	13.60	12.13	13.32	0.66
FeO	1.33	1.05	1.38	2.20	1.40	1.26	1.22	1.59	1.04	1.39	0.35
MnO	0.02	0.04	0.04	0.00	0.00	0.06	0.00	0.06	0.00	0.02	0.03
MgO	0.25	0.22	0.25	0.22	0.24	0.15	0.18	0.20	0.08	0.20	0.06
CaO	0.96	0.51	1.05	1.01	0.95	0.83	0.90	1.01	0.39	0.85	0.24
Na2O	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	0.00
K2O	0.95	0.86	1.23	1.49	0.88	1.24	1.27	0.96	1.21	1.12	0.22
F	0.00	1.18	0.01	0.00	0.14	0.00	0.02	0.00	0.00	0.15	0.39
Cl	0.16	0.09	0.10	0.11	0.11	0.10	0.11	0.11	0.16	0.12	0.02
P2O5	0.06	0.04	0.02	0.02	0.00	0.02	0.00	0.00	0.04	0.02	0.02
SO2	0.02	0.01	0.00	0.03	0.03	0.03	0.00	0.03	0.02	0.02	0.01
Total	99.42	99.60	99.62	99.92	99.37	99.56	100.00	99.81	99.54	99.65	0.21

Table C.1. Glass Analysis
Sample K-18

Point	1	6	11	15	17	20	22	24	26	27	Average	St. Dev.
Beam size	10	10	15	10	25	20	25	20	10	15		
SiO2	76.66	75.94	74.94	75.29	73.11	75.22	77.03	71.39	76.63	76.00	75.22	1.75
TiO2	0.38	0.33	0.29	0.29	0.34	0.29	0.34	1.21	0.47	0.32	0.43	0.28
Al2O3	14.77	14.63	12.73	14.09	14.09	10.96	13.45	13.94	13.21	13.61	13.55	1.10
FeO	1.67	1.44	1.29	0.52	1.14	1.16	1.26	3.67	1.89	1.22	1.53	0.84
MnO	0.00	0.00	0.00	0.00	0.06	0.00	0.03	0.02	0.04	0.00	0.01	0.02
MgO	0.36	0.39	0.25	0.06	0.43	0.26	0.30	0.60	1.34	0.31	0.43	0.35
CaO	1.50	1.37	0.99	0.79	1.07	0.52	0.89	1.55	1.76	1.01	1.15	0.39
Na2O	4.16	4.04	3.91	3.03	4.73	3.50	4.36	3.56	3.65	4.02	3.90	0.48
K2O	2.71	2.88	4.78	3.29	3.50	3.38	3.33	4.61	2.84	3.05	3.44	0.71
F	0.00	0.00	0.01	0.03	0.00	0.00	0.14	0.00	0.05	0.00	0.02	0.05
Cl	0.09	0.11	0.01	0.08	0.01	0.06	0.09	0.09	0.05	0.09	0.07	0.03
P2O5	0.06	0.07	0.05	0.05	0.14	0.12	0.03	0.26	0.04	0.08	0.09	0.07
SO2	0.01	0.03	0.01	0.03	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01
Total	102.37	101.22	99.28	97.54	98.61	95.47	101.25	100.90	101.96	99.69	99.83	2.16
Normalized to 100%												
SiO2	74.88	75.02	75.49	77.18	74.14	78.79	76.08	70.75	75.16	76.23	75.37	2.09
TiO2	0.37	0.33	0.29	0.30	0.34	0.31	0.33	1.20	0.46	0.32	0.42	0.28
Al2O3	14.42	14.46	12.83	14.44	14.29	11.48	13.29	13.82	12.95	13.65	13.56	0.96
FeO	1.63	1.42	1.30	0.53	1.15	1.21	1.25	3.64	1.85	1.23	1.52	0.82
MnO	0.00	0.00	0.00	0.00	0.06	0.00	0.03	0.02	0.04	0.00	0.01	0.02
MgO	0.36	0.38	0.26	0.06	0.44	0.27	0.29	0.60	1.32	0.31	0.43	0.34
CaO	1.47	1.35	1.00	0.81	1.09	0.54	0.87	1.54	1.73	1.01	1.14	0.37
Na2O	4.06	3.99	3.94	3.11	4.80	3.66	4.31	3.53	3.57	4.03	3.90	0.47
K2O	2.65	2.85	4.81	3.37	3.55	3.54	3.29	4.57	2.78	3.06	3.45	0.73
F	0.00	0.00	0.01	0.03	0.00	0.00	0.14	0.00	0.05	0.00	0.02	0.04
Cl	0.09	0.11	0.01	0.09	0.01	0.06	0.09	0.09	0.05	0.09	0.07	0.03
P2O5	0.06	0.07	0.05	0.06	0.14	0.13	0.03	0.26	0.04	0.08	0.09	0.07
SO2	0.01	0.02	0.01	0.03	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na												
SiO2	74.33	74.42	74.84	75.88	74.14	77.90	75.71		74.24	75.65	75.23	1.21
TiO2	0.36	0.33	0.29	0.29	0.34	0.30	0.33		0.46	0.31	0.34	0.05
Al2O3	14.32	14.34	12.72	14.20	14.29	11.35	13.22		12.79	13.55	13.42	1.01
FeO	1.62	1.41	1.29	0.52	1.15	1.20	1.24		1.83	1.22	1.28	0.36
MnO	0.00	0.00	0.00	0.00	0.06	0.00	0.03		0.04	0.00	0.01	0.02
MgO	0.35	0.38	0.25	0.06	0.44	0.26	0.29		1.30	0.31	0.41	0.35
CaO	1.46	1.34	0.99	0.80	1.09	0.53	0.87		1.71	1.00	1.09	0.36
Na2O	4.80	4.80	4.80	4.80	4.80	4.80	4.80		4.80	4.80	4.80	0.00
K2O	2.63	2.82	4.77	3.31	3.55	3.50	3.27		2.75	3.03	3.29	0.64
F	0.00	0.00	0.01	0.03	0.00	0.00	0.14		0.04	0.00	0.03	0.05
Cl	0.09	0.11	0.01	0.08	0.01	0.06	0.09		0.04	0.09	0.07	0.04
P2O5	0.06	0.06	0.05	0.05	0.14	0.13	0.03		0.04	0.08	0.07	0.04
SO2	0.01	0.02	0.01	0.03	0.00	0.01	0.00		0.01	0.00	0.01	0.01
Total	100.03	100.03	100.03	100.05	100.00	100.04	100.02		100.04	100.03	100.03	0.02

Table C.1. Glass Analysis
Sample K-21

Point	8	9	14	18	19	23	24	32	Average	St. Dev.
Beam size	10	10	10	10	10	15	10	10		
SiO2	75.34	74.86	66.58	75.81	75.69	74.37	73.14	74.89	73.83	3.05
TiO2	0.41	0.30	0.31	0.32	0.33	0.37	0.28	0.27	0.32	0.05
Al2O3	13.99	14.13	12.66	14.59	14.48	14.37	14.12	13.80	14.02	0.61
FeO	1.84	1.39	1.39	1.63	1.58	1.34	1.37	1.51	1.51	0.17
MnO	0.02	0.06	0.00	0.00	0.12	0.04	0.05	0.03	0.04	0.04
MgO	0.37	0.36	0.25	0.25	0.26	0.39	0.26	1.10	0.41	0.29
CaO	1.21	1.45	1.17	1.30	1.30	1.32	1.37	1.80	1.36	0.19
Na2O	3.05	4.46	3.81	2.79	2.70	4.65	4.85	3.48	3.73	0.86
K2O	2.87	2.83	2.47	3.04	2.82	2.93	2.78	2.04	2.72	0.32
F	0.07	0.00	0.10	0.00	0.01	0.16	0.00	0.01	0.04	0.06
Cl	0.12	0.12	0.14	0.13	0.12	0.11	0.11	0.12	0.12	0.01
P2O5	0.00	0.05	0.01	0.03	0.10	0.06	0.06	0.04	0.04	0.03
SO2	0.02	0.02	0.03	0.04	0.02	0.02	0.01	0.01	0.02	0.01
Total	99.30	100.05	88.92	99.92	99.50	100.13	98.40	99.10	98.17	3.78
Normalized to 100%										
SiO2	75.87	74.82	74.88	75.87	76.07	74.27	74.33	75.57	75.21	0.72
TiO2	0.41	0.30	0.35	0.32	0.33	0.37	0.28	0.28	0.33	0.05
Al2O3	14.09	14.13	14.24	14.60	14.55	14.35	14.35	13.92	14.28	0.23
FeO	1.85	1.39	1.56	1.63	1.59	1.34	1.40	1.52	1.53	0.16
MnO	0.02	0.06	0.00	0.00	0.12	0.04	0.05	0.03	0.04	0.04
MgO	0.37	0.36	0.29	0.25	0.26	0.39	0.27	1.11	0.41	0.29
CaO	1.22	1.45	1.32	1.30	1.30	1.32	1.39	1.81	1.39	0.18
Na2O	3.08	4.46	4.29	2.79	2.71	4.65	4.93	3.51	3.80	0.89
K2O	2.89	2.83	2.77	3.04	2.83	2.93	2.82	2.06	2.77	0.30
F	0.07	0.00	0.11	0.00	0.01	0.16	0.00	0.01	0.04	0.06
Cl	0.12	0.12	0.15	0.13	0.12	0.11	0.11	0.12	0.12	0.01
P2O5	0.00	0.05	0.01	0.03	0.10	0.06	0.06	0.04	0.04	0.03
SO2	0.02	0.02	0.04	0.04	0.02	0.02	0.01	0.01	0.02	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na										
SiO2	74.46	74.47	74.40	74.24	74.38	74.06	74.33	74.50	74.35	0.15
TiO2	0.40	0.30	0.35	0.31	0.32	0.37	0.28	0.27	0.33	0.05
Al2O3	13.83	14.06	14.15	14.29	14.23	14.30	14.35	13.73	14.12	0.23
FeO	1.81	1.39	1.55	1.59	1.55	1.34	1.40	1.50	1.52	0.15
MnO	0.02	0.06	0.00	0.00	0.11	0.04	0.05	0.03	0.04	0.04
MgO	0.37	0.36	0.28	0.25	0.26	0.39	0.27	1.10	0.41	0.28
CaO	1.20	1.45	1.31	1.28	1.27	1.31	1.39	1.79	1.37	0.18
Na2O	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	0.00
K2O	2.83	2.82	2.76	2.98	2.77	2.92	2.82	2.03	2.74	0.30
F	0.07	0.00	0.11	0.00	0.01	0.16	0.00	0.01	0.04	0.06
Cl	0.12	0.12	0.15	0.13	0.12	0.11	0.11	0.12	0.12	0.01
P2O5	0.00	0.05	0.01	0.03	0.10	0.06	0.06	0.04	0.04	0.03
SO2	0.02	0.02	0.04	0.04	0.02	0.02	0.01	0.01	0.02	0.01
Total	100.06	100.02	100.03	100.06	100.06	100.01	100.00	100.05	100.04	0.02

Table C.1. Glass Analysis
Sample K-26

Point	2	4	5	10	14	15	18	23	24	25	26	Average	St. Dev.
Beam size	25	20	20	20	10	25	25	15	10	20	10		
SiO2	70.91	68.21	76.78	74.96	78.34	75.31	73.06	75.92	75.15	74.14	69.69	73.86	3.11
TiO2	0.17	0.15	0.13	0.18	0.17	0.15	0.21	0.19	0.23	0.18	0.34	0.19	0.06
Al2O3	12.43	19.12	12.63	13.16	12.10	12.64	14.98	12.86	12.19	13.32	12.92	13.49	2.02
FeO	0.60	1.04	0.79	0.56	0.63	1.04	0.93	0.90	1.36	0.83	1.84	0.96	0.38
MnO	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.06	0.01	0.02
MgO	0.06	0.22	0.11	0.10	0.06	0.32	0.16	0.08	0.09	0.25	2.02	0.31	0.57
CaO	0.70	3.38	0.70	0.81	0.49	0.76	1.81	0.76	0.73	1.11	2.16	1.22	0.88
Na2O	4.45	6.46	4.21	4.38	3.57	4.51	5.15	4.41	3.81	4.64	4.46	4.55	0.76
K2O	2.86	2.02	3.36	2.96	2.84	2.85	2.95	3.22	2.84	3.20	2.62	2.88	0.36
F	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.00	0.03	0.10	0.02	0.03
Cl	0.05	0.00	0.07	0.03	0.03	0.01	0.01	0.03	0.02	0.04	0.03	0.03	0.02
P2O5	0.00	0.00	0.04	0.07	0.04	0.02	0.00	0.06	0.03	0.05	0.03	0.03	0.02
SO2	0.01	0.01	0.00	0.02	0.00	0.01	0.01	0.01	0.00	0.00	0.02	0.01	0.01
Total	92.27	100.60	98.81	97.23	98.26	97.64	99.28	98.47	96.44	97.79	96.28	97.55	2.15
Normalized to 100%													
SiO2	76.85	67.80	77.70	77.10	79.73	77.13	73.59	77.10	77.92	75.82	72.38	75.74	3.32
TiO2	0.18	0.15	0.13	0.18	0.17	0.15	0.21	0.19	0.23	0.19	0.35	0.19	0.06
Al2O3	13.48	19.00	12.78	13.54	12.31	12.95	15.09	13.06	12.64	13.62	13.41	13.81	1.87
FeO	0.65	1.04	0.80	0.57	0.64	1.07	0.93	0.91	1.41	0.84	1.91	0.98	0.39
MnO	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.06	0.01	0.02
MgO	0.07	0.22	0.12	0.10	0.06	0.32	0.16	0.08	0.09	0.26	2.09	0.32	0.59
CaO	0.75	3.36	0.71	0.84	0.49	0.78	1.83	0.77	0.76	1.14	2.25	1.24	0.88
Na2O	4.82	6.42	4.26	4.51	3.63	4.62	5.19	4.47	3.95	4.74	4.64	4.66	0.72
K2O	3.10	2.01	3.40	3.04	2.89	2.92	2.97	3.27	2.94	3.28	2.72	2.96	0.37
F	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.00	0.03	0.10	0.02	0.03
Cl	0.05	0.00	0.07	0.03	0.03	0.01	0.01	0.03	0.02	0.04	0.04	0.03	0.02
P2O5	0.00	0.00	0.04	0.07	0.04	0.02	0.00	0.06	0.03	0.05	0.03	0.03	0.02
SO2	0.01	0.01	0.00	0.02	0.00	0.01	0.01	0.01	0.00	0.00	0.02	0.01	0.01
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	0.00
Normalized to Na													
SiO2	76.85		77.27	76.86	78.78	76.98		76.84	77.24	75.76		77.07	0.83
TiO2	0.18		0.13	0.18	0.17	0.15		0.19	0.23	0.19		0.18	0.03
Al2O3	13.48		12.71	13.50	12.17	12.92		13.02	12.53	13.61		12.99	0.51
FeO	0.65		0.80	0.57	0.63	1.06		0.91	1.40	0.84		0.86	0.27
MnO	0.00		0.00	0.00	0.00	0.01		0.00	0.00	0.00		0.00	0.01
MgO	0.07		0.11	0.10	0.06	0.32		0.08	0.09	0.26		0.14	0.10
CaO	0.75		0.70	0.83	0.49	0.78		0.77	0.75	1.14		0.78	0.18
Na2O	4.82		4.82	4.82	4.82	4.82		4.82	4.82	4.82		4.82	0.00
K2O	3.10		3.38	3.03	2.86	2.92		3.26	2.92	3.27		3.09	0.19
F	0.05		0.00	0.00	0.00	0.00		0.04	0.00	0.03		0.01	0.02
Cl	0.05		0.07	0.03	0.03	0.01		0.03	0.02	0.04		0.04	0.02
P2O5	0.00		0.04	0.07	0.04	0.02		0.06	0.03	0.05		0.04	0.02
SO2	0.01		0.00	0.02	0.00	0.01		0.01	0.00	0.00		0.01	0.01
Total	100.00		100.02	100.01	100.04	100.01		100.02	100.03	100.00		100.02	0.01

Table C.1. Glass Analysis
Sample K-27

Point	8	9	11	13	15	16	21	28	29	30	Average	St. Dev.
Beam size	10	20	10	10	10	10	10	15	10	10		
SiO2	75.01	71.22	72.30	72.18	72.62	73.77	74.86	72.17	73.50	76.68	73.43	1.67
TiO2	0.25	0.20	0.21	0.23	0.18	0.22	0.22	0.28	0.22	0.23	0.22	0.03
Al2O3	13.42	13.04	13.44	13.61	13.32	13.74	13.68	13.09	13.07	14.05	13.44	0.33
FeO	1.10	1.03	1.48	1.41	1.04	1.07	1.41	1.30	1.23	1.09	1.22	0.17
MnO	0.04	0.04	0.00	0.00	0.03	0.04	0.03	0.02	0.01	0.00	0.02	0.02
MgO	0.30	0.24	0.22	0.21	0.24	0.27	0.47	0.33	0.29	0.25	0.28	0.07
CaO	1.07	1.08	1.11	1.14	1.02	1.09	1.20	1.17	1.10	1.07	1.10	0.05
Na2O	4.00	4.24	3.86	3.28	3.77	4.12	4.28	3.80	3.60	4.47	3.94	0.35
K2O	2.57	2.89	2.50	2.62	2.72	2.86	2.78	2.79	2.86	2.83	2.74	0.13
F	0.00	0.27	0.00	0.02	0.19	0.00	4.70	0.00	0.08	1.75	0.70	1.50
Cl	0.15	0.12	0.10	0.11	0.11	0.10	0.11	0.17	0.13	0.10	0.12	0.02
P2O5	0.03	0.03	0.06	0.02	0.04	0.00	0.04	0.02	0.06	0.03	0.03	0.02
SO2	0.03	0.02	0.00	0.05	0.03	0.04	0.00	0.02	0.02	0.01	0.02	0.02
Total	97.95	94.41	95.29	94.88	95.30	97.33	103.77	95.16	96.18	102.56	97.28	3.30
Normalized to 100%												
SiO2	76.58	75.44	75.87	76.07	76.20	75.80	72.14	75.84	76.42	74.77	75.51	1.29
TiO2	0.25	0.21	0.22	0.24	0.19	0.23	0.21	0.30	0.23	0.22	0.23	0.03
Al2O3	13.70	13.81	14.11	14.34	13.97	14.11	13.18	13.76	13.59	13.70	13.83	0.33
FeO	1.12	1.10	1.56	1.48	1.09	1.10	1.35	1.37	1.27	1.06	1.25	0.18
MnO	0.04	0.04	0.00	0.00	0.03	0.05	0.03	0.02	0.01	0.00	0.02	0.02
MgO	0.31	0.26	0.23	0.22	0.25	0.28	0.45	0.35	0.31	0.24	0.29	0.07
CaO	1.09	1.14	1.16	1.21	1.07	1.12	1.15	1.23	1.15	1.05	1.14	0.06
Na2O	4.08	4.49	4.05	3.46	3.95	4.24	4.12	4.00	3.74	4.36	4.05	0.30
K2O	2.63	3.06	2.63	2.76	2.86	2.93	2.68	2.93	2.97	2.76	2.82	0.15
F	0.00	0.29	0.00	0.02	0.20	0.00	4.53	0.00	0.09	1.70	0.68	1.45
Cl	0.15	0.12	0.10	0.11	0.12	0.10	0.11	0.18	0.13	0.09	0.12	0.03
P2O5	0.03	0.03	0.07	0.02	0.04	0.00	0.04	0.02	0.06	0.03	0.03	0.02
SO2	0.03	0.02	0.00	0.05	0.03	0.04	0.00	0.02	0.02	0.01	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na												
SiO2	76.29	75.45	75.55	75.31	75.81	75.62	71.89	75.48	75.87	74.69	75.19	1.23
TiO2	0.25	0.21	0.22	0.24	0.19	0.23	0.21	0.29	0.23	0.22	0.23	0.03
Al2O3	13.65	13.81	14.05	14.20	13.90	14.08	13.13	13.69	13.49	13.68	13.77	0.31
FeO	1.11	1.10	1.55	1.47	1.08	1.10	1.35	1.36	1.26	1.06	1.24	0.18
MnO	0.04	0.04	0.00	0.00	0.03	0.05	0.03	0.02	0.01	0.00	0.02	0.02
MgO	0.31	0.26	0.23	0.22	0.25	0.28	0.45	0.35	0.30	0.24	0.29	0.07
CaO	1.08	1.14	1.16	1.19	1.07	1.12	1.15	1.22	1.14	1.05	1.13	0.05
Na2O	4.47	4.47	4.47	4.47	4.47	4.47	4.47	4.47	4.47	4.47	4.47	0.00
K2O	2.62	3.06	2.62	2.74	2.84	2.93	2.67	2.91	2.95	2.76	2.81	0.15
F	0.00	0.29	0.00	0.02	0.20	0.00	4.52	0.00	0.09	1.70	0.68	1.44
Cl	0.15	0.12	0.10	0.11	0.12	0.10	0.11	0.18	0.13	0.09	0.12	0.03
P2O5	0.03	0.03	0.06	0.02	0.04	0.00	0.04	0.02	0.06	0.03	0.03	0.02
SO2	0.03	0.02	0.00	0.05	0.03	0.04	0.00	0.02	0.02	0.01	0.02	0.02
Total	100.02	100.00	100.02	100.03	100.02	100.01	100.01	100.02	100.03	100.00	100.02	0.01

Table C.1. Glass Analysis
Sample K-31

Point	2	3	4	5	6	9	10	11	16	17	Average	St. Dev.
Beam size	10	10	15	20	10	20	20	15	20	20		
SiO2	76.15	76.56	74.44	71.76	74.92	74.95	73.94	74.02	73.58	74.09	74.44	1.35
TiO2	0.22	0.24	0.26	0.23	0.21	0.20	0.18	0.20	0.23	0.21	0.22	0.02
Al2O3	13.62	13.62	13.27	12.86	13.35	12.84	13.06	13.31	13.38	13.23	13.25	0.27
FeO	1.03	0.96	1.08	0.91	0.99	1.08	0.98	1.09	1.20	1.09	1.04	0.08
MnO	0.05	0.02	0.00	0.07	0.03	0.00	0.00	0.04	0.01	0.00	0.02	0.02
MgO	0.21	0.29	0.22	0.26	0.23	0.24	0.23	0.22	0.03	0.22	0.22	0.07
CaO	0.96	0.98	0.92	0.94	0.94	0.99	0.93	0.91	0.96	0.95	0.95	0.02
Na2O	4.36	4.54	4.46	4.48	4.33	4.28	4.64	4.56	5.32	4.31	4.53	0.30
K2O	2.99	2.87	2.78	2.68	2.83	2.85	2.80	2.83	2.86	2.79	2.83	0.08
F	0.04	0.07	0.00	0.00	0.09	0.07	0.13	0.00	0.05	0.02	0.05	0.04
Cl	0.10	0.11	0.08	0.09	0.10	0.12	0.09	0.10	0.12	0.09	0.10	0.01
P2O5	0.02	0.00	0.02	0.05	0.03	0.01	0.01	0.06	0.04	0.03	0.03	0.02
SO2	0.03	0.00	0.02	0.05	0.02	0.02	0.00	0.03	0.03	0.05	0.02	0.02
Total	99.77	100.25	97.57	94.38	98.06	97.64	96.98	97.38	97.80	97.06	97.69	1.60
Normalized to 100%												
SiO2	76.33	76.36	76.30	76.03	76.40	76.76	76.24	76.02	75.24	76.33	76.20	0.40
TiO2	0.22	0.24	0.27	0.24	0.22	0.20	0.19	0.21	0.24	0.21	0.22	0.02
Al2O3	13.65	13.58	13.60	13.63	13.61	13.15	13.47	13.67	13.68	13.63	13.57	0.16
FeO	1.03	0.95	1.11	0.97	1.01	1.11	1.01	1.12	1.22	1.12	1.07	0.08
MnO	0.05	0.02	0.00	0.07	0.03	0.00	0.00	0.04	0.01	0.00	0.02	0.02
MgO	0.21	0.29	0.23	0.28	0.24	0.25	0.24	0.23	0.03	0.22	0.22	0.07
CaO	0.96	0.98	0.94	0.99	0.96	1.01	0.96	0.94	0.98	0.98	0.97	0.02
Na2O	4.37	4.53	4.57	4.74	4.42	4.38	4.78	4.68	5.44	4.44	4.64	0.32
K2O	2.99	2.86	2.85	2.84	2.88	2.92	2.88	2.90	2.93	2.88	2.89	0.04
F	0.04	0.07	0.00	0.00	0.09	0.07	0.13	0.00	0.05	0.02	0.05	0.04
Cl	0.10	0.11	0.08	0.10	0.10	0.12	0.09	0.11	0.12	0.09	0.10	0.01
P2O5	0.02	0.00	0.02	0.06	0.03	0.01	0.01	0.06	0.04	0.03	0.03	0.02
SO2	0.03	0.00	0.02	0.05	0.02	0.02	0.00	0.03	0.03	0.05	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na												
SiO2	75.51	75.67	75.64	75.50	75.61	75.94	75.74	75.44	75.24	75.56	75.59	0.19
TiO2	0.22	0.24	0.26	0.24	0.22	0.20	0.19	0.20	0.24	0.21	0.22	0.02
Al2O3	13.50	13.46	13.48	13.53	13.47	13.01	13.38	13.56	13.68	13.50	13.46	0.18
FeO	1.02	0.94	1.10	0.96	1.00	1.10	1.00	1.11	1.22	1.11	1.06	0.09
MnO	0.04	0.02	0.00	0.07	0.03	0.00	0.00	0.04	0.01	0.00	0.02	0.02
MgO	0.21	0.28	0.23	0.28	0.24	0.24	0.23	0.23	0.03	0.22	0.22	0.07
CaO	0.95	0.97	0.93	0.98	0.95	1.00	0.95	0.93	0.98	0.97	0.96	0.02
Na2O	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	0.00
K2O	2.96	2.83	2.83	2.82	2.85	2.89	2.86	2.88	2.93	2.85	2.87	0.05
F	0.04	0.07	0.00	0.00	0.09	0.07	0.13	0.00	0.05	0.02	0.05	0.04
Cl	0.10	0.11	0.08	0.10	0.10	0.12	0.09	0.11	0.12	0.09	0.10	0.01
P2O5	0.02	0.00	0.02	0.06	0.03	0.01	0.01	0.06	0.04	0.03	0.03	0.02
SO2	0.03	0.00	0.02	0.05	0.02	0.02	0.00	0.03	0.03	0.05	0.02	0.02
Total	100.05	100.04	100.04	100.03	100.05	100.05	100.03	100.04	100.00	100.04	100.04	0.01

Table C.1. Glass Analysis
Sample K-32

Point	5	6	7	8	13	14	17	23	24	Average	St. Dev.
Beam size	15	10	15	10	10	10	10	20	15		
SiO2	76.86	76.12	74.15	79.00	76.90	77.04	75.73	75.14	74.05	76.11	1.56
TiO2	0.18	0.13	0.14	0.20	0.16	0.13	0.20	0.15	0.20	0.16	0.03
Al2O3	12.21	12.60	12.02	12.98	12.43	12.53	12.64	12.17	12.03	12.40	0.32
FeO	0.75	0.63	0.74	0.74	0.75	0.74	0.81	0.76	0.77	0.74	0.05
MnO	0.00	0.01	0.00	0.01	0.00	0.00	0.05	0.02	0.01	0.01	0.02
MgO	0.17	0.18	0.16	0.21	0.21	0.19	0.21	0.14	0.20	0.19	0.02
CaO	1.00	0.97	0.99	0.99	0.88	0.96	0.95	0.87	0.95	0.95	0.05
Na2O	3.67	3.66	3.68	3.58	2.85	3.06	3.08	3.85	3.59	3.45	0.35
K2O	2.98	2.64	2.84	2.80	2.55	2.61	2.67	2.78	2.91	2.75	0.14
F	0.17	0.00	0.01	0.17	0.00	0.00	0.87	0.02	0.44	0.19	0.30
Cl	0.05	0.04	0.04	0.04	0.06	0.05	0.06	0.03	0.06	0.05	0.01
P2O5	0.07	0.00	0.02	0.07	0.06	0.06	0.07	0.00	0.03	0.04	0.03
SO2	0.02	0.02	0.00	0.04	0.03	0.00	0.03	0.02	0.00	0.02	0.01
Total	98.11	97.00	94.79	100.82	96.87	97.35	97.35	95.95	95.23	97.05	1.77
Normalized to 100%											
SiO2	78.34	78.48	78.22	78.35	79.38	79.14	77.79	78.32	77.76	78.42	0.54
TiO2	0.18	0.14	0.15	0.20	0.16	0.13	0.20	0.16	0.21	0.17	0.03
Al2O3	12.45	12.99	12.68	12.87	12.83	12.87	12.99	12.68	12.63	12.78	0.18
FeO	0.76	0.65	0.78	0.73	0.77	0.76	0.83	0.80	0.80	0.77	0.05
MnO	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.02	0.01	0.01	0.02
MgO	0.18	0.19	0.16	0.21	0.22	0.20	0.21	0.15	0.21	0.19	0.02
CaO	1.02	1.00	1.04	0.98	0.91	0.98	0.97	0.90	1.00	0.98	0.05
Na2O	3.74	3.77	3.89	3.55	2.94	3.14	3.16	4.01	3.77	3.55	0.38
K2O	3.03	2.72	2.99	2.78	2.63	2.68	2.74	2.89	3.05	2.84	0.16
F	0.17	0.00	0.01	0.16	0.00	0.00	0.90	0.02	0.46	0.19	0.31
Cl	0.05	0.04	0.05	0.04	0.06	0.05	0.06	0.03	0.07	0.05	0.01
P2O5	0.08	0.00	0.02	0.07	0.06	0.06	0.07	0.00	0.03	0.04	0.03
SO2	0.02	0.02	0.00	0.04	0.03	0.00	0.03	0.02	0.00	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na											
SiO2	78.13	78.29	78.12	77.99	78.53	78.45	77.13	78.32	77.56	78.06	0.45
TiO2	0.18	0.13	0.15	0.20	0.16	0.13	0.20	0.16	0.21	0.17	0.03
Al2O3	12.41	12.96	12.67	12.81	12.69	12.75	12.88	12.68	12.60	12.72	0.16
FeO	0.76	0.65	0.78	0.73	0.76	0.75	0.82	0.80	0.80	0.76	0.05
MnO	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.02	0.01	0.01	0.02
MgO	0.17	0.19	0.16	0.21	0.22	0.19	0.21	0.15	0.21	0.19	0.02
CaO	1.01	1.00	1.04	0.98	0.90	0.97	0.96	0.90	1.00	0.97	0.05
Na2O	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	0.00
K2O	3.02	2.71	2.99	2.77	2.60	2.65	2.72	2.89	3.04	2.82	0.17
F	0.17	0.00	0.01	0.16	0.00	0.00	0.89	0.02	0.46	0.19	0.30
Cl	0.05	0.04	0.05	0.04	0.06	0.05	0.06	0.03	0.07	0.05	0.01
P2O5	0.08	0.00	0.02	0.07	0.06	0.06	0.07	0.00	0.03	0.04	0.03
SO2	0.02	0.02	0.00	0.04	0.03	0.00	0.03	0.02	0.00	0.02	0.01
Total	100.01	100.01	100.00	100.02	100.03	100.03	100.03	100.00	100.01	100.02	0.01

Table C.1. Glass Analysis
Sample K-41

Point	2	3	4	7	12	18	20	21	27	Average	St. Dev.
Beam size	5	5	5	5	10	5	10	5	5		
SiO2	73.18	73.88	72.78	74.72	74.76	76.50	70.93	71.83	73.61	73.58	1.67
TiO2	0.44	0.30	0.47	0.31	0.34	0.31	0.30	0.32	0.41	0.36	0.07
Al2O3	15.15	14.02	15.06	13.87	14.71	13.44	13.52	14.03	14.36	14.24	0.62
FeO	1.85	1.40	1.80	1.23	1.74	1.35	1.42	1.33	1.44	1.51	0.23
MnO	0.06	0.00	0.02	0.03	0.05	0.06	0.00	0.01	0.00	0.03	0.03
MgO	0.50	0.18	0.21	0.31	0.36	0.30	0.29	0.33	0.28	0.31	0.09
CaO	1.77	1.23	1.43	1.23	1.36	1.19	1.17	1.29	1.37	1.34	0.18
Na2O	4.03	3.19	3.72	3.50	4.48	3.47	3.56	3.61	3.05	3.62	0.43
K2O	3.15	3.46	3.54	3.19	3.52	3.11	3.58	3.49	3.26	3.37	0.19
F	0.07	0.00	4.43	0.00	0.00	0.02	0.10	0.02	0.00	0.52	1.47
Cl	0.14	0.15	0.14	0.09	0.09	0.13	0.11	0.11	0.10	0.12	0.02
P2O5	0.08	0.07	0.08	0.06	0.07	0.06	0.03	0.03	0.02	0.05	0.02
SO2	0.08	0.02	0.01	0.00	0.00	0.01	0.02	0.00	0.02	0.02	0.03
Total	100.50	97.90	103.68	98.53	101.48	99.97	95.01	96.40	97.92	99.04	2.66
Normalized to 100%											
SiO2	72.82	75.46	70.19	75.84	73.67	76.53	74.65	74.52	75.18	74.32	1.91
TiO2	0.44	0.31	0.45	0.31	0.34	0.31	0.32	0.33	0.42	0.36	0.06
Al2O3	15.08	14.32	14.52	14.07	14.50	13.45	14.23	14.56	14.66	14.38	0.45
FeO	1.84	1.42	1.73	1.25	1.72	1.35	1.49	1.37	1.47	1.52	0.20
MnO	0.06	0.00	0.02	0.03	0.05	0.06	0.00	0.01	0.00	0.03	0.03
MgO	0.49	0.19	0.21	0.32	0.36	0.30	0.31	0.34	0.28	0.31	0.09
CaO	1.76	1.26	1.38	1.24	1.34	1.19	1.23	1.34	1.40	1.35	0.17
Na2O	4.01	3.26	3.59	3.55	4.41	3.47	3.75	3.74	3.11	3.65	0.39
K2O	3.14	3.54	3.41	3.23	3.46	3.11	3.76	3.62	3.33	3.40	0.22
F	0.07	0.00	4.27	0.00	0.00	0.02	0.10	0.02	0.00	0.50	1.42
Cl	0.14	0.15	0.13	0.09	0.09	0.13	0.12	0.12	0.11	0.12	0.02
P2O5	0.08	0.07	0.07	0.06	0.07	0.06	0.03	0.03	0.02	0.05	0.02
SO2	0.08	0.02	0.01	0.00	0.00	0.01	0.02	0.00	0.02	0.02	0.03
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na											
SiO2	72.53	74.59		75.18	73.67	75.81	74.15	74.02	74.20	74.27	0.99
TiO2	0.44	0.31		0.31	0.34	0.31	0.32	0.33	0.42	0.35	0.05
Al2O3	15.02	14.16		13.95	14.50	13.32	14.14	14.46	14.47	14.25	0.49
FeO	1.83	1.41		1.24	1.72	1.34	1.48	1.37	1.45	1.48	0.20
MnO	0.06	0.00		0.03	0.05	0.06	0.00	0.01	0.00	0.03	0.03
MgO	0.49	0.18		0.31	0.36	0.30	0.30	0.34	0.28	0.32	0.09
CaO	1.75	1.24		1.23	1.34	1.18	1.22	1.33	1.38	1.33	0.18
Na2O	4.41	4.41		4.41	4.41	4.41	4.41	4.41	4.41	4.41	0.00
K2O	3.12	3.50		3.21	3.46	3.08	3.74	3.60	3.29	3.37	0.24
F	0.07	0.00		0.00	0.00	0.02	0.10	0.02	0.00	0.03	0.04
Cl	0.14	0.15		0.09	0.09	0.13	0.12	0.11	0.10	0.12	0.02
P2O5	0.08	0.07		0.06	0.07	0.06	0.03	0.03	0.02	0.05	0.02
SO2	0.08	0.02		0.00	0.00	0.01	0.02	0.00	0.02	0.02	0.03
Total	100.02	100.04		100.03	100.00	100.03	100.02	100.03	100.04	100.03	0.01

Table C.1. Glass Analysis
Sample K-45(1)

Point	4	12	26	32	33	35	36	Average	St. Dev.
Beam size	10	10	10	10	10	10	10		
SiO2	76.64	77.15	77.90	76.97	76.46	77.31	75.46	76.84	0.77
TiO2	0.26	0.27	0.25	0.25	0.24	0.21	0.22	0.24	0.02
Al2O3	14.13	14.30	14.36	13.89	14.62	14.10	13.97	14.20	0.25
FeO	1.20	1.96	1.20	1.14	1.15	1.16	1.13	1.28	0.30
MnO	0.00	0.00	0.03	0.03	0.00	0.01	0.07	0.02	0.03
MgO	0.33	0.30	0.31	0.27	0.32	0.27	0.31	0.30	0.02
CaO	1.28	1.26	1.27	1.27	1.48	1.26	1.22	1.29	0.08
Na2O	4.09	4.32	4.46	4.12	4.43	4.06	4.02	4.22	0.18
K2O	3.07	3.03	2.92	3.13	2.91	3.00	2.97	3.00	0.08
F	0.02	0.01	0.00	0.00	0.04	0.12	0.04	0.03	0.04
Cl	0.14	0.18	0.13	0.15	0.14	0.16	0.15	0.15	0.02
P2O5	0.01	0.02	0.03	0.08	0.05	0.01	0.01	0.03	0.03
SO2	0.05	0.01	0.02	0.04	0.01	0.02	0.03	0.02	0.02
Total	101.22	102.80	102.87	101.34	101.86	101.69	99.60	101.63	1.11
Normalized to 100%									
SiO2	75.72	75.05	75.73	75.95	75.06	76.03	75.76	75.62	0.40
TiO2	0.26	0.26	0.24	0.25	0.23	0.21	0.22	0.24	0.02
Al2O3	13.96	13.91	13.96	13.71	14.36	13.87	14.02	13.97	0.20
FeO	1.19	1.90	1.17	1.12	1.13	1.14	1.14	1.26	0.29
MnO	0.00	0.00	0.03	0.03	0.00	0.00	0.07	0.02	0.03
MgO	0.33	0.29	0.30	0.26	0.31	0.27	0.31	0.30	0.02
CaO	1.27	1.22	1.23	1.25	1.45	1.24	1.22	1.27	0.08
Na2O	4.04	4.20	4.34	4.07	4.35	3.99	4.04	4.15	0.15
K2O	3.03	2.95	2.84	3.09	2.86	2.95	2.98	2.96	0.09
F	0.02	0.01	0.00	0.00	0.04	0.11	0.04	0.03	0.04
Cl	0.14	0.18	0.13	0.15	0.14	0.16	0.15	0.15	0.02
P2O5	0.01	0.02	0.03	0.08	0.05	0.01	0.01	0.03	0.03
SO2	0.05	0.01	0.01	0.04	0.01	0.02	0.03	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na									
SiO2	75.48	74.94	75.72	75.74	75.06	75.76	75.53	75.46	0.33
TiO2	0.26	0.26	0.24	0.25	0.23	0.21	0.22	0.24	0.02
Al2O3	13.91	13.89	13.96	13.67	14.36	13.82	13.98	13.94	0.21
FeO	1.18	1.90	1.17	1.12	1.13	1.14	1.13	1.27	0.31
MnO	0.00	0.00	0.03	0.03	0.00	0.00	0.07	0.04	0.05
MgO	0.33	0.29	0.30	0.26	0.31	0.27	0.31	0.31	0.05
CaO	1.26	1.22	1.23	1.25	1.45	1.23	1.22	1.28	0.11
Na2O	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	0.00
K2O	3.02	2.94	2.84	3.08	2.86	2.94	2.97	2.95	0.08
F	0.02	0.01	0.00	0.00	0.04	0.11	0.04	0.03	0.04
Cl	0.14	0.17	0.13	0.15	0.14	0.16	0.15	0.15	0.02
P2O5	0.01	0.02	0.03	0.08	0.05	0.01	0.01	0.03	0.03
SO2	0.05	0.01	0.01	0.04	0.01	0.02	0.03	0.02	0.02
Total	100.01	100.01	100.00	100.01	100.00	100.01	100.01	100.01	0.01

Table C.1. Glass Analysis

Sample K-46

Point	4	6	10	11	12	14	16	17	18	21	22	23	Average	St. Dev.
Beam size	20	15	10	10	20	10	10	15	10	20	20	10		
SiO2	76.55	75.73	73.84	75.76	73.83	72.48	72.49	77.08	75.84	74.10	75.65	70.32	74.47	1.99
TiO2	0.26	0.32	0.26	0.31	0.21	0.27	0.29	0.26	0.17	0.21	0.25	0.20	0.25	0.05
Al2O3	12.53	12.94	15.56	11.50	13.93	15.78	14.24	12.70	14.34	14.27	13.77	12.81	13.70	1.26
FeO	1.05	1.25	1.04	1.82	0.85	0.94	0.88	0.91	0.80	0.86	1.07	1.04	1.04	0.27
MnO	0.00	0.03	0.00	0.10	0.01	0.00	0.00	0.05	0.04	0.11	0.00	0.01	0.03	0.04
MgO	0.30	0.34	0.11	1.41	0.12	0.10	0.06	0.09	0.11	0.10	0.22	0.28	0.27	0.37
CaO	0.63	1.16	1.99	1.30	0.93	2.06	1.85	0.66	1.11	1.31	1.45	1.09	1.30	0.47
Na2O	3.72	4.14	4.72	3.53	4.83	5.00	4.35	4.03	4.69	4.94	4.70	3.25	4.32	0.59
K2O	4.63	3.21	2.29	3.20	3.83	2.45	3.17	4.14	3.36	3.04	3.32	2.83	3.29	0.66
F	0.00	0.06	0.04	0.12	0.03	0.00	0.11	0.00	0.03	0.00	0.00	0.00	0.03	0.04
Cl	0.02	0.02	0.03	0.14	0.01	0.07	0.03	0.02	0.04	0.02	0.02	0.21	0.05	0.06
P2O5	0.00	0.12	0.04	0.25	0.05	0.04	0.00	0.02	0.00	0.00	0.09	0.06	0.06	0.07
SO2	0.01	0.00	0.00	0.00	0.02	0.01	0.05	0.00	0.00	0.01	0.02	0.00	0.01	0.01
Total	99.69	99.33	99.92	99.44	98.65	99.21	97.52	99.95	100.51	98.97	100.56	92.09	98.82	2.27
Normalized to 100%														
SiO2	76.78	76.24	73.90	76.19	74.84	73.06	74.33	77.12	75.45	74.87	75.23	76.36	75.36	1.23
TiO2	0.26	0.32	0.26	0.31	0.21	0.27	0.30	0.26	0.17	0.21	0.25	0.22	0.25	0.05
Al2O3	12.57	13.03	15.57	11.56	14.12	15.91	14.60	12.70	14.26	14.42	13.69	13.91	13.86	1.25
FeO	1.05	1.26	1.04	1.83	0.86	0.95	0.90	0.91	0.80	0.87	1.06	1.13	1.05	0.28
MnO	0.00	0.03	0.00	0.10	0.01	0.00	0.00	0.05	0.04	0.11	0.00	0.01	0.03	0.04
MgO	0.30	0.34	0.11	1.42	0.12	0.10	0.06	0.09	0.11	0.10	0.22	0.31	0.27	0.37
CaO	0.63	1.17	1.99	1.31	0.95	2.08	1.90	0.66	1.10	1.32	1.44	1.18	1.31	0.48
Na2O	3.73	4.17	4.72	3.55	4.90	5.04	4.46	4.03	4.66	4.99	4.67	3.53	4.37	0.55
K2O	4.64	3.23	2.29	3.22	3.88	2.47	3.25	4.14	3.34	3.07	3.30	3.07	3.33	0.65
F	0.00	0.06	0.04	0.12	0.03	0.00	0.11	0.00	0.03	0.00	0.00	0.00	0.03	0.04
Cl	0.02	0.02	0.03	0.14	0.01	0.07	0.03	0.02	0.04	0.02	0.02	0.23	0.05	0.07
P2O5	0.00	0.12	0.04	0.26	0.05	0.04	0.00	0.02	0.00	0.00	0.09	0.07	0.06	0.07
SO2	0.01	0.00	0.00	0.00	0.02	0.01	0.05	0.00	0.00	0.01	0.02	0.00	0.01	0.01
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	100.00	0.00
Normalized to Na														
SiO2	75.78	75.58	73.67		74.73	73.06	73.91	76.34	75.17	74.83	74.95	75.20	74.84	0.97
TiO2	0.25	0.32	0.26		0.21	0.27	0.30	0.26	0.16	0.21	0.25	0.22	0.25	0.04
Al2O3	12.40	12.92	15.52		14.10	15.91	14.52	12.57	14.21	14.41	13.64	13.70	13.99	1.11
FeO	1.04	1.25	1.03		0.86	0.95	0.90	0.90	0.79	0.87	1.06	1.11	0.98	0.13
MnO	0.00	0.03	0.00		0.01	0.00	0.00	0.05	0.04	0.11	0.00	0.01	0.02	0.03
MgO	0.30	0.34	0.11		0.12	0.10	0.06	0.09	0.11	0.10	0.22	0.30	0.17	0.10
CaO	0.62	1.16	1.99		0.95	2.08	1.89	0.65	1.10	1.32	1.44	1.16	1.30	0.50
Na2O	5.04	5.04	5.04		5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	0.00
K2O	4.58	3.20	2.29		3.88	2.47	3.23	4.10	3.33	3.07	3.29	3.02	3.31	0.67
F	0.00	0.06	0.04		0.03	0.00	0.11	0.00	0.03	0.00	0.00	0.00	0.02	0.03
Cl	0.02	0.01	0.03		0.01	0.07	0.03	0.02	0.04	0.02	0.02	0.22	0.04	0.06
P2O5	0.00	0.12	0.04		0.05	0.04	0.00	0.02	0.00	0.00	0.09	0.07	0.04	0.04
SO2	0.01	0.00	0.00		0.02	0.01	0.05	0.00	0.00	0.01	0.02	0.00	0.01	0.01
Total	100.05	100.04	100.02		100.01	100.00	100.03	100.04	100.02	100.00	100.02	100.05	100.02	0.02

Table C.1. Glass Analysis

Sample K-49

Point	12	16	20	Average	St. Dev.
Beam size	5	5	10		
SiO2	71.91	66.31	75.47	71.23	4.62
TiO2	0.28	0.89	0.25	0.47	0.36
Al2O3	14.05	15.49	13.92	14.49	0.87
FeO	1.51	2.48	1.18	1.72	0.68
MnO	0.01	0.07	0.01	0.03	0.03
MgO	0.26	1.25	0.18	0.56	0.60
CaO	1.43	1.12	1.43	1.33	0.18
Na2O	4.09	4.44	4.57	4.36	0.25
K2O	3.46	5.97	3.14	4.19	1.55
F	0.00	0.00	0.00	0.00	0.00
Cl	0.09	0.10	0.09	0.09	0.01
P2O5	0.08	0.03	0.05	0.06	0.03
SO2	0.00	0.03	0.01	0.01	0.01
Total	97.16	98.17	100.30	98.54	1.60
Normalized to 100%					
SiO2	74.01	67.55	75.24	72.27	4.13
TiO2	0.28	0.90	0.24	0.48	0.37
Al2O3	14.46	15.77	13.88	14.70	0.97
FeO	1.56	2.53	1.18	1.75	0.70
MnO	0.01	0.07	0.01	0.03	0.03
MgO	0.26	1.28	0.18	0.57	0.61
CaO	1.47	1.14	1.43	1.35	0.18
Na2O	4.20	4.52	4.55	4.43	0.19
K2O	3.57	6.08	3.13	4.26	1.59
F	0.00	0.00	0.00	0.00	0.00
Cl	0.09	0.10	0.09	0.09	0.01
P2O5	0.09	0.03	0.05	0.06	0.03
SO2	0.00	0.03	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00	0.00
Normalized to Na					
SiO2	73.75		75.24	74.50	1.06
TiO2	0.28		0.24	0.26	0.03
Al2O3	14.41		13.88	14.14	0.37
FeO	1.55		1.18	1.36	0.26
MnO	0.01		0.01	0.01	0.00
MgO	0.26		0.18	0.22	0.06
CaO	1.47		1.43	1.45	0.03
Na2O	4.55		4.55	4.55	0.00
K2O	3.55		3.13	3.34	0.30
F	0.00		0.00	0.00	0.00
Cl	0.09		0.09	0.09	0.00
P2O5	0.09		0.05	0.07	0.02
SO2	0.00		0.01	0.00	0.01
Total	99.65		100.00	99.83	0.25

Table C.1. Glass Analysis
Sample K-52

Point	4	7	8	9	10	12	14	15	22	23	24	Average	St. Dev.
Beam size	15	25	15	25	25	25	20	20	15	10	20		
SiO2	72.19	73.01	74.35	73.88	73.68	69.62	69.72	75.69	73.06	75.36	71.23	72.89	2.04
TiO2	0.30	0.21	0.19	0.41	0.14	0.36	0.14	0.20	0.43	0.21	0.27	0.26	0.10
Al2O3	15.74	14.13	14.32	12.78	14.68	15.29	16.40	13.89	14.78	11.97	13.90	14.35	1.26
FeO	1.20	1.51	1.05	1.24	0.72	1.50	1.71	0.90	1.57	1.31	1.38	1.28	0.30
MnO	0.02	0.00	0.01	0.03	0.00	0.01	0.03	0.00	0.03	0.00	0.06	0.02	0.02
MgO	0.22	1.00	0.31	0.23	0.19	0.37	1.04	0.17	0.40	0.23	0.72	0.44	0.32
CaO	2.30	2.26	2.19	0.86	1.89	1.88	2.99	1.59	1.26	0.89	2.04	1.83	0.64
Na2O	5.97	4.77	4.74	3.85	5.01	5.07	4.89	4.30	4.81	3.48	4.39	4.66	0.66
K2O	1.93	2.33	2.28	3.84	2.50	3.08	2.60	3.33	4.07	4.19	2.74	2.99	0.77
F	0.04	0.04	0.00	0.00	0.00	0.04	0.70	0.00	0.00	0.00	0.00	0.07	0.21
Cl	0.00	0.03	0.00	0.05	0.01	0.07	0.01	0.05	0.12	0.00	0.05	0.03	0.04
P2O5	0.08	0.02	0.00	0.06	0.02	0.07	0.09	0.06	0.02	0.09	0.05	0.05	0.03
SO2	0.00	0.02	0.01	0.03	0.00	0.00	0.01	0.02	0.00	0.01	0.00	0.01	0.01
Total	100.00	99.32	99.46	97.27	98.83	97.36	100.32	100.19	100.54	97.74	96.83	98.89	1.37
Normalized to 100%													
SiO2	72.19	73.51	74.76	75.95	74.55	71.51	69.49	75.55	72.67	77.10	73.56	73.87	2.24
TiO2	0.30	0.21	0.19	0.42	0.14	0.37	0.14	0.19	0.43	0.21	0.28	0.26	0.11
Al2O3	15.74	14.22	14.40	13.14	14.85	15.70	16.35	13.86	14.70	12.25	14.36	14.38	1.17
FeO	1.20	1.52	1.06	1.27	0.73	1.54	1.71	0.90	1.56	1.34	1.43	1.30	0.32
MnO	0.02	0.00	0.01	0.03	0.00	0.01	0.03	0.00	0.03	0.00	0.06	0.02	0.02
MgO	0.22	1.01	0.32	0.24	0.19	0.38	1.04	0.17	0.39	0.24	0.74	0.47	0.33
CaO	2.30	2.28	2.20	0.89	1.91	1.93	2.98	1.58	1.26	0.91	2.10	1.80	0.65
Na2O	5.97	4.80	4.77	3.96	5.07	5.21	4.88	4.29	4.78	3.56	4.53	4.58	0.51
K2O	1.93	2.35	2.29	3.95	2.53	3.17	2.60	3.32	4.04	4.29	2.83	3.14	0.74
F	0.04	0.04	0.00	0.00	0.00	0.04	0.70	0.00	0.00	0.00	0.00	0.08	0.22
Cl	0.00	0.03	0.00	0.05	0.01	0.07	0.01	0.05	0.12	0.00	0.05	0.04	0.04
P2O5	0.08	0.02	0.00	0.06	0.02	0.07	0.09	0.06	0.02	0.09	0.05	0.05	0.03
SO2	0.00	0.02	0.01	0.03	0.00	0.00	0.01	0.02	0.00	0.01	0.00	0.01	0.01
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	0.00
Normalized to Na													
SiO2		73.21	74.43		74.45	71.51		74.86	72.36	75.83	73.07	73.72	1.43
TiO2		0.21	0.19		0.14	0.37		0.19	0.43	0.21	0.28	0.25	0.10
Al2O3		14.17	14.34		14.83	15.70		13.73	14.64	12.05	14.26	14.21	1.05
FeO		1.51	1.05		0.73	1.54		0.89	1.55	1.31	1.42	1.25	0.32
MnO		0.00	0.01		0.00	0.01		0.00	0.03	0.00	0.06	0.01	0.02
MgO		1.00	0.31		0.19	0.38		0.17	0.39	0.24	0.74	0.43	0.29
CaO		2.27	2.19		1.91	1.93		1.57	1.25	0.90	2.09	1.76	0.48
Na2O		5.21	5.21		5.21	5.21		5.21	5.21	5.21	5.21	5.21	0.00
K2O		2.34	2.28		2.53	3.17		3.29	4.03	4.22	2.81	3.08	0.74
F		0.04	0.00		0.00	0.04		0.00	0.00	0.00	0.00	0.01	0.02
Cl		0.03	0.00		0.01	0.07		0.05	0.12	0.00	0.05	0.04	0.04
P2O5		0.02	0.00		0.02	0.07		0.06	0.02	0.09	0.05	0.04	0.03
SO2		0.02	0.01		0.00	0.00		0.02	0.00	0.01	0.00	0.01	0.01
Total		100.02	100.02		100.01	100.00		100.04	100.02	100.06	100.03	100.02	0.02

Table C.1 Glass Analysis
Sample K-56

Point	3	5	6	11	18	19	Average	St. Dev.
Beam size	15	15	25	10	25	25		
SiO2	73.03	71.43	73.90	76.24	61.42	73.56	71.60	5.22
TiO2	0.39	0.40	0.28	0.25	1.49	0.61	0.57	0.47
Al2O3	14.22	14.30	14.76	13.80	15.51	12.37	14.16	1.05
FeO	1.33	0.99	0.96	1.17	5.60	1.19	1.87	1.83
MnO	0.06	0.02	0.00	0.05	0.03	0.00	0.03	0.03
MgO	0.40	0.29	0.10	0.29	1.09	0.10	0.38	0.37
CaO	0.85	0.87	1.36	1.18	2.08	0.29	1.10	0.60
Na2O	4.07	3.94	4.79	4.09	5.52	4.15	4.43	0.61
K2O	4.46	4.52	3.88	3.06	3.01	4.60	3.92	0.73
F	0.00	0.00	0.04	0.00	0.00	0.01	0.01	0.02
Cl	0.10	0.06	0.01	0.14	0.04	0.04	0.06	0.04
P2O5	0.04	0.07	0.08	0.02	0.02	0.03	0.04	0.03
SO2	0.01	0.01	0.02	0.00	0.03	0.02	0.01	0.01
Total	98.95	96.91	100.17	100.28	95.84	96.98	98.19	1.87
Normalized to 100%								
SiO2	73.80	73.71	73.78	76.03	64.09	75.85	72.88	4.43
TiO2	0.40	0.41	0.28	0.25	1.55	0.63	0.59	0.49
Al2O3	14.37	14.76	14.73	13.76	16.19	12.76	14.43	1.14
FeO	1.35	1.02	0.95	1.17	5.84	1.23	1.93	1.92
MnO	0.06	0.02	0.00	0.05	0.03	0.00	0.03	0.03
MgO	0.40	0.30	0.10	0.29	1.13	0.11	0.39	0.38
CaO	0.86	0.89	1.36	1.18	2.17	0.30	1.13	0.63
Na2O	4.11	4.07	4.78	4.08	5.76	4.28	4.51	0.67
K2O	4.50	4.66	3.87	3.05	3.14	4.74	3.99	0.76
F	0.00	0.00	0.04	0.00	0.00	0.01	0.01	0.02
Cl	0.10	0.06	0.01	0.13	0.05	0.04	0.06	0.04
P2O5	0.04	0.07	0.08	0.01	0.02	0.03	0.04	0.03
SO2	0.01	0.01	0.02	0.00	0.03	0.02	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na								
SiO2	73.31	73.18	73.78	75.49		75.47	74.25	1.15
TiO2	0.40	0.41	0.28	0.25		0.63	0.39	0.15
Al2O3	14.28	14.66	14.73	13.66		12.70	14.00	0.85
FeO	1.34	1.02	0.95	1.16		1.22	1.14	0.15
MnO	0.06	0.02	0.00	0.05		0.00	0.03	0.03
MgO	0.40	0.30	0.10	0.28		0.11	0.24	0.13
CaO	0.85	0.89	1.36	1.17		0.30	0.91	0.40
Na2O	4.78	4.78	4.78	4.78		4.78	4.78	0.00
K2O	4.47	4.63	3.87	3.03		4.72	4.14	0.71
F	0.00	0.00	0.04	0.00		0.01	0.01	0.02
Cl	0.10	0.06	0.01	0.13		0.04	0.07	0.05
P2O5	0.04	0.07	0.08	0.01		0.03	0.05	0.03
SO2	0.01	0.01	0.02	0.00		0.02	0.01	0.01
Total	100.03	100.03	100.00	100.03		100.02	100.02	0.01

Table C.1. Glass Analysis
Sample K-62

Point	4	5	6	16	20	21	24	25	26	Average	St. Dev.
Beam size	10	10	10	10	10	10	10	10	10		
SiO2	75.07	77.14	74.93	73.76	75.66	76.60	75.82	74.52	76.47	75.55	1.09
TiO2	0.24	0.23	0.26	0.20	0.18	0.29	0.17	0.21	0.23	0.22	0.04
Al2O3	13.29	13.63	13.23	15.05	13.77	13.74	13.59	13.55	13.59	13.72	0.53
FeO	1.07	1.04	1.10	0.99	1.07	1.06	1.19	1.15	1.13	1.09	0.06
MnO	0.00	0.07	0.03	0.00	0.04	0.00	0.00	0.03	0.10	0.03	0.04
MgO	0.24	0.24	0.25	0.19	0.26	0.27	0.24	0.27	0.26	0.25	0.02
CaO	1.07	1.08	1.10	1.92	1.00	1.07	1.11	1.03	1.05	1.16	0.29
Na2O	4.07	4.20	4.00	4.46	4.11	3.98	4.49	3.88	3.93	4.12	0.22
K2O	2.90	3.00	2.93	2.56	2.93	2.97	3.03	2.85	3.01	2.91	0.14
F	0.00	0.02	0.07	0.04	0.00	0.00	0.00	0.00	0.31	0.05	0.10
Cl	0.14	0.09	0.10	0.12	0.10	0.13	0.12	0.12	0.12	0.11	0.02
P2O5	0.03	0.00	0.00	0.00	0.04	0.03	0.05	0.05	0.03	0.03	0.02
SO2	0.01	0.04	0.00	0.00	0.00	0.02	0.02	0.03	0.02	0.01	0.01
Total	98.12	100.78	98.01	99.28	99.15	100.16	99.83	97.68	100.25	99.25	1.11
Normalized to 100%											
SiO2	76.51	76.54	76.46	74.29	76.31	76.48	75.95	76.30	76.28	76.12	0.71
TiO2	0.25	0.23	0.26	0.20	0.18	0.29	0.17	0.21	0.23	0.22	0.04
Al2O3	13.54	13.53	13.50	15.16	13.89	13.72	13.61	13.87	13.56	13.82	0.52
FeO	1.09	1.03	1.12	0.99	1.08	1.06	1.19	1.18	1.13	1.10	0.07
MnO	0.00	0.07	0.03	0.00	0.04	0.00	0.00	0.03	0.10	0.03	0.04
MgO	0.24	0.24	0.26	0.19	0.26	0.27	0.24	0.28	0.26	0.25	0.02
CaO	1.09	1.07	1.13	1.93	1.01	1.07	1.11	1.05	1.04	1.17	0.29
Na2O	4.14	4.17	4.08	4.49	4.15	3.97	4.50	3.97	3.92	4.15	0.21
K2O	2.95	2.97	2.99	2.58	2.95	2.96	3.03	2.92	3.01	2.93	0.14
F	0.00	0.02	0.07	0.04	0.00	0.00	0.00	0.00	0.31	0.05	0.10
Cl	0.14	0.09	0.10	0.12	0.10	0.13	0.12	0.12	0.12	0.12	0.02
P2O5	0.03	0.00	0.00	0.00	0.04	0.03	0.05	0.06	0.03	0.03	0.02
SO2	0.01	0.04	0.00	0.00	0.00	0.02	0.02	0.03	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na											
SiO2	76.24	76.29	76.14	74.29	76.04	76.08	75.95	75.89	75.84	75.86	0.61
TiO2	0.25	0.23	0.26	0.20	0.18	0.29	0.17	0.21	0.23	0.22	0.04
Al2O3	13.49	13.48	13.44	15.16	13.84	13.65	13.61	13.80	13.48	13.77	0.54
FeO	1.09	1.03	1.12	0.99	1.07	1.05	1.19	1.18	1.12	1.09	0.07
MnO	0.00	0.07	0.03	0.00	0.04	0.00	0.00	0.03	0.10	0.03	0.04
MgO	0.24	0.24	0.25	0.19	0.26	0.27	0.24	0.27	0.25	0.25	0.02
CaO	1.09	1.07	1.12	1.93	1.01	1.07	1.11	1.04	1.04	1.16	0.29
Na2O	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	0.00
K2O	2.94	2.96	2.98	2.58	2.94	2.95	3.03	2.90	2.99	2.92	0.13
F	0.00	0.02	0.07	0.04	0.00	0.00	0.00	0.00	0.31	0.05	0.10
Cl	0.14	0.09	0.10	0.12	0.10	0.13	0.12	0.12	0.12	0.11	0.02
P2O5	0.03	0.00	0.00	0.00	0.04	0.03	0.05	0.05	0.03	0.03	0.02
SO2	0.01	0.04	0.00	0.00	0.00	0.02	0.02	0.03	0.01	0.01	0.01
Total	100.01	100.01	100.02	100.00	100.01	100.02	100.00	100.02	100.02	100.01	0.01

Table C.1. Glass Analysis
Sample K-64

Point	3	11	12	19	20	21	22	23	26	35	Average	St. Dev.
Beam size	10	10	10	10	10	10	10	10	10	10		
SiO2	74.89	72.95	75.66	75.68	64.98	76.19	75.56	69.96	69.91	74.14	72.99	3.64
TiO2	0.26	0.23	0.27	0.27	0.21	0.28	0.22	0.24	0.29	0.22	0.25	0.03
Al2O3	13.23	13.99	13.42	13.11	10.99	13.23	13.17	12.17	12.01	13.03	12.83	0.87
FeO	1.25	1.03	1.01	1.31	1.01	1.08	1.10	1.05	1.52	1.05	1.14	0.17
MnO	0.04	0.01	0.00	0.00	0.07	0.00	0.01	0.03	0.04	0.01	0.02	0.02
MgO	0.20	0.22	0.33	0.26	0.20	0.24	0.23	0.23	0.59	0.28	0.28	0.12
CaO	1.10	1.50	1.08	0.98	0.91	0.98	1.04	0.89	1.13	0.96	1.05	0.17
Na2O	4.30	4.26	4.52	4.40	3.62	4.43	4.51	4.19	3.90	4.33	4.25	0.28
K2O	2.96	2.76	2.71	3.15	2.62	3.02	3.05	2.83	2.79	2.87	2.87	0.17
F	0.00	0.04	0.01	0.00	0.05	0.09	0.12	0.00	0.04	0.07	0.04	0.04
Cl	0.18	0.12	0.20	0.14	0.20	0.14	0.15	0.19	0.11	0.16	0.16	0.03
P2O5	0.05	0.02	0.06	0.05	0.04	0.07	0.00	0.04	0.02	0.00	0.03	0.02
SO2	0.02	0.01	0.16	0.03	0.03	0.03	0.02	0.03	0.02	0.03	0.04	0.04
Total	98.47	97.14	99.42	99.38	84.92	99.75	99.18	91.85	92.34	97.15	95.96	4.83
Normalized to 100%												
SiO2	76.05	75.10	76.11	76.15	76.52	76.37	76.18	76.17	75.71	76.32	76.07	0.40
TiO2	0.26	0.24	0.27	0.27	0.25	0.28	0.22	0.26	0.31	0.23	0.26	0.03
Al2O3	13.44	14.40	13.49	13.19	12.94	13.26	13.28	13.24	13.01	13.41	13.37	0.40
FeO	1.27	1.06	1.02	1.32	1.19	1.08	1.11	1.14	1.64	1.08	1.19	0.18
MnO	0.04	0.01	0.00	0.00	0.08	0.00	0.01	0.03	0.04	0.01	0.02	0.03
MgO	0.20	0.23	0.33	0.26	0.23	0.24	0.23	0.25	0.64	0.29	0.29	0.13
CaO	1.12	1.54	1.08	0.99	1.07	0.98	1.05	0.96	1.22	0.99	1.10	0.17
Na2O	4.37	4.39	4.54	4.43	4.27	4.44	4.55	4.56	4.22	4.46	4.42	0.11
K2O	3.01	2.84	2.72	3.17	3.08	3.02	3.07	3.08	3.02	2.95	3.00	0.13
F	0.00	0.04	0.01	0.00	0.05	0.09	0.12	0.00	0.04	0.08	0.04	0.04
Cl	0.18	0.12	0.20	0.14	0.23	0.14	0.15	0.21	0.12	0.16	0.17	0.04
P2O5	0.05	0.02	0.06	0.05	0.05	0.07	0.00	0.05	0.02	0.00	0.04	0.02
SO2	0.02	0.01	0.16	0.03	0.04	0.03	0.02	0.03	0.02	0.03	0.04	0.04
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na												
SiO2	75.82	74.89	76.01	75.97	76.22	76.19	76.09	76.09	75.37	76.15	75.88	0.43
TiO2	0.26	0.24	0.27	0.27	0.25	0.28	0.22	0.26	0.31	0.23	0.26	0.03
Al2O3	13.40	14.36	13.48	13.16	12.89	13.23	13.26	13.23	12.95	13.38	13.33	0.41
FeO	1.27	1.06	1.02	1.32	1.18	1.08	1.11	1.14	1.63	1.08	1.19	0.18
MnO	0.04	0.01	0.00	0.00	0.08	0.00	0.01	0.03	0.04	0.01	0.02	0.03
MgO	0.20	0.23	0.33	0.26	0.23	0.24	0.23	0.25	0.63	0.29	0.29	0.13
CaO	1.11	1.54	1.08	0.98	1.07	0.98	1.05	0.96	1.21	0.98	1.10	0.17
Na2O	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	0.00
K2O	3.00	2.83	2.72	3.16	3.07	3.02	3.07	3.08	3.00	2.94	2.99	0.13
F	0.00	0.04	0.01	0.00	0.05	0.09	0.12	0.00	0.04	0.08	0.04	0.04
Cl	0.18	0.12	0.20	0.14	0.23	0.14	0.15	0.21	0.12	0.16	0.17	0.04
P2O5	0.05	0.02	0.06	0.05	0.05	0.07	0.00	0.05	0.02	0.00	0.04	0.02
SO2	0.02	0.01	0.16	0.03	0.04	0.03	0.02	0.03	0.02	0.03	0.04	0.04
Total	100.01	100.01	100.01	100.01	100.02	100.01	100.01	100.00	100.02	100.01	100.01	0.00

Table C.1. Glass Analysis
Sample K-64d

Point	5	6	19	20	21	23	25	26	Average	St. Dev.
Beam size	10	10	5	5	5	5	5	5		
SiO2	77.68	77.79	79.24	78.75	80.38	79.45	78.89	83.56	79.47	1.87
TiO2	0.26	0.26	0.24	0.29	0.23	0.30	0.26	0.20	0.25	0.03
Al2O3	13.60	13.76	13.26	13.14	13.57	13.43	13.40	14.21	13.54	0.33
FeO	1.54	1.41	1.28	1.23	1.21	1.11	1.18	1.21	1.27	0.14
MnO	0.01	0.01	0.01	0.02	0.05	0.00	0.04	0.05	0.02	0.02
MgO	0.22	0.23	0.24	0.20	0.22	0.24	0.21	0.28	0.23	0.03
CaO	1.21	1.13	0.93	0.91	0.96	1.00	0.88	0.89	0.99	0.12
Na2O	3.30	3.65	1.40	1.57	1.38	1.53	1.59	2.06	2.06	0.90
K2O	2.90	2.96	1.03	1.07	1.14	1.05	1.02	1.05	1.53	0.87
F	0.00	0.00	0.11	0.00	0.00	0.11	0.00	0.07	0.04	0.05
Cl	0.16	0.15	0.15	0.13	0.14	0.14	0.14	0.15	0.14	0.01
P2O5	0.03	0.00	0.10	0.00	0.01	0.01	0.06	0.06	0.03	0.03
SO2	0.03	0.03	0.02	0.02	0.01	0.01	0.03	0.01	0.02	0.01
Total	100.92	101.39	98.00	97.31	99.29	98.39	97.69	103.80	99.60	2.26
Normalized to 100%										
SiO2	76.97	76.72	80.85	80.92	80.96	80.76	80.75	80.50	79.80	1.83
TiO2	0.25	0.26	0.24	0.29	0.23	0.30	0.27	0.20	0.26	0.03
Al2O3	13.47	13.57	13.53	13.50	13.67	13.65	13.71	13.69	13.60	0.09
FeO	1.52	1.39	1.31	1.26	1.22	1.13	1.20	1.16	1.28	0.13
MnO	0.01	0.01	0.01	0.02	0.05	0.00	0.04	0.05	0.02	0.02
MgO	0.22	0.23	0.24	0.20	0.22	0.25	0.21	0.27	0.23	0.02
CaO	1.20	1.12	0.95	0.94	0.96	1.02	0.90	0.86	0.99	0.11
Na2O	3.27	3.60	1.43	1.61	1.39	1.56	1.63	1.99	2.06	0.87
K2O	2.87	2.92	1.05	1.10	1.15	1.07	1.04	1.01	1.53	0.85
F	0.00	0.00	0.11	0.00	0.00	0.11	0.00	0.07	0.04	0.05
Cl	0.15	0.15	0.15	0.13	0.14	0.14	0.15	0.14	0.14	0.01
P2O5	0.03	0.00	0.10	0.00	0.01	0.01	0.06	0.06	0.03	0.04
SO2	0.03	0.03	0.02	0.02	0.01	0.01	0.03	0.01	0.02	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na										
SiO2	76.72	76.72							76.72	0.00
TiO2	0.25	0.26							0.25	0.00
Al2O3	13.43	13.57							13.50	0.10
FeO	1.52	1.39							1.46	0.09
MnO	0.01	0.01							0.01	0.00
MgO	0.22	0.23							0.23	0.01
CaO	1.20	1.12							1.16	0.06
Na2O	3.60	3.60							3.60	0.00
K2O	2.86	2.92							2.89	0.04
F	0.00	0.00							0.00	0.00
Cl	0.15	0.15							0.15	0.01
P2O5	0.03	0.00							0.02	0.02
SO2	0.03	0.03							0.03	0.00
Total	100.01	100.00							100.01	0.01

Table C.1. Glass Analysis
Sample K-64l

Point	6	9	11	15	18	27	Average	St. Dev.
Beam size	10	5	5	5	5	5		
SiO2	76.93	82.16	79.60	72.32	77.96	79.62	78.10	3.34
TiO2	0.25	0.25	0.21	0.27	0.27	0.29	0.25	0.03
Al2O3	13.69	13.66	14.21	11.75	12.61	13.16	13.18	0.88
FeO	1.39	1.11	1.08	1.16	1.17	1.17	1.18	0.11
MnO	0.02	0.00	0.00	0.05	0.00	0.03	0.02	0.02
MgO	0.24	0.24	1.06	0.19	0.20	0.22	0.36	0.34
CaO	1.03	0.85	0.92	0.89	0.84	0.97	0.92	0.08
Na2O	3.30	1.52	2.55	1.04	1.31	1.77	1.91	0.85
K2O	2.83	0.96	1.04	0.98	0.99	1.30	1.35	0.74
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl	0.14	0.14	0.20	0.14	0.11	0.15	0.15	0.03
P2O5	0.02	0.00	0.05	0.01	0.03	0.06	0.03	0.02
SO2	0.01	0.06	0.08	0.02	0.02	0.02	0.03	0.03
Total	99.87	100.93	101.00	88.81	95.49	98.75	97.47	4.70
Normalized to 100%								
SiO2	77.03	81.40	78.82	81.43	81.64	80.63	80.16	1.85
TiO2	0.25	0.24	0.21	0.30	0.28	0.29	0.26	0.03
Al2O3	13.71	13.53	14.07	13.23	13.21	13.32	13.51	0.33
FeO	1.39	1.10	1.07	1.31	1.22	1.19	1.21	0.12
MnO	0.02	0.00	0.00	0.05	0.00	0.03	0.02	0.02
MgO	0.24	0.24	1.05	0.22	0.21	0.22	0.36	0.34
CaO	1.04	0.84	0.91	1.00	0.88	0.98	0.94	0.08
Na2O	3.31	1.50	2.52	1.17	1.37	1.80	1.94	0.82
K2O	2.84	0.95	1.03	1.11	1.04	1.31	1.38	0.72
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl	0.14	0.14	0.20	0.16	0.12	0.15	0.15	0.03
P2O5	0.02	0.00	0.05	0.01	0.03	0.06	0.03	0.02
SO2	0.01	0.06	0.08	0.02	0.02	0.02	0.03	0.03
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na								
SiO2	77.03						77.03	0.00
TiO2	0.25						0.25	0.00
Al2O3	13.71						13.71	0.00
FeO	1.39						1.39	0.00
MnO	0.02						0.02	0.00
MgO	0.24						0.24	0.00
CaO	1.04						1.04	0.00
Na2O	3.31						3.31	0.00
K2O	2.84						2.84	0.00
F	0.00						0.00	0.00
Cl	0.14						0.14	0.00
P2O5	0.02						0.02	0.00
SO2	0.01						0.01	0.00
Total	100.00						100.00	0.00

Table C.1. Glass Analysis
Sample K-65

Point	4	5	27	31	35	36	37	39	Average	St. Dev.
Beam size	10	10	25	10	10	10	10	15		
SiO2	69.09	76.04	72.64	73.61	76.24	58.67	73.46	73.49	71.65	5.69
TiO2	0.10	0.26	0.23	0.18	0.27	0.17	0.25	0.33	0.22	0.07
Al2O3	16.38	13.46	14.31	13.30	13.03	10.57	13.14	13.08	13.41	1.61
FeO	0.96	1.25	1.62	1.54	1.29	0.81	1.17	1.91	1.32	0.36
MnO	0.00	0.06	0.02	0.04	0.01	0.08	0.06	0.01	0.03	0.03
MgO	0.21	0.25	0.26	0.30	0.32	0.21	0.22	1.13	0.36	0.31
CaO	2.89	1.06	1.34	0.92	1.02	0.82	1.11	1.80	1.37	0.69
Na2O	4.56	4.11	5.03	4.10	4.05	3.18	4.09	4.51	4.20	0.54
K2O	2.26	3.07	2.84	3.39	3.04	2.16	2.91	2.74	2.80	0.41
F	0.00	0.04	0.09	0.00	0.12	12.31	0.09	0.00	1.58	4.34
Cl	0.14	0.17	0.13	0.18	0.16	0.19	0.15	0.11	0.15	0.03
P2O5	0.03	0.02	0.07	0.01	0.04	0.03	0.07	0.02	0.04	0.02
SO2	0.03	0.02	0.00	0.02	0.00	0.03	0.07	0.00	0.02	0.02
Total	96.65	99.79	98.59	97.59	99.59	89.22	96.77	99.12	97.16	3.43
Normalized to 100%										
SiO2	71.48	76.20	73.67	75.43	76.55	65.76	75.91	74.14	73.64	3.59
TiO2	0.10	0.26	0.23	0.19	0.27	0.19	0.26	0.34	0.23	0.07
Al2O3	16.95	13.49	14.52	13.62	13.08	11.85	13.58	13.19	13.79	1.48
FeO	0.99	1.25	1.64	1.58	1.30	0.91	1.21	1.93	1.35	0.34
MnO	0.00	0.06	0.02	0.04	0.01	0.09	0.06	0.01	0.03	0.03
MgO	0.22	0.25	0.27	0.30	0.32	0.24	0.22	1.14	0.37	0.31
CaO	2.99	1.06	1.36	0.94	1.02	0.91	1.15	1.82	1.41	0.70
Na2O	4.72	4.11	5.10	4.20	4.07	3.57	4.22	4.55	4.32	0.47
K2O	2.34	3.08	2.88	3.48	3.05	2.42	3.01	2.76	2.88	0.37
F	0.00	0.04	0.10	0.00	0.12	13.80	0.09	0.00	1.77	4.86
Cl	0.14	0.17	0.14	0.19	0.16	0.21	0.15	0.11	0.16	0.03
P2O5	0.03	0.02	0.08	0.01	0.04	0.03	0.07	0.02	0.04	0.02
SO2	0.04	0.02	0.00	0.02	0.00	0.03	0.07	0.00	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na										
SiO2	71.20	75.45	73.67	74.75	75.76		75.25	73.73	74.26	1.57
TiO2	0.10	0.26	0.23	0.18	0.27		0.26	0.34	0.23	0.07
Al2O3	16.88	13.36	14.52	13.50	12.95		13.46	13.12	13.97	1.38
FeO	0.99	1.24	1.64	1.57	1.29		1.20	1.92	1.40	0.32
MnO	0.00	0.06	0.02	0.04	0.01		0.06	0.01	0.03	0.02
MgO	0.22	0.25	0.27	0.30	0.32		0.22	1.13	0.39	0.33
CaO	2.98	1.05	1.36	0.93	1.01		1.14	1.81	1.47	0.73
Na2O	5.11	5.11	5.11	5.11	5.11		5.11	5.11	5.11	0.00
K2O	2.33	3.04	2.88	3.44	3.02		2.98	2.75	2.92	0.34
F	0.00	0.04	0.10	0.00	0.12		0.09	0.00	0.05	0.05
Cl	0.14	0.16	0.14	0.18	0.16		0.15	0.11	0.15	0.02
P2O5	0.03	0.02	0.08	0.01	0.04		0.07	0.02	0.04	0.03
SO2	0.04	0.02	0.00	0.02	0.00		0.07	0.00	0.02	0.03
Total	100.02	100.04	100.00	100.04	100.04		100.04	100.03	100.03	0.02

Table C.1. Glass Analysis
Sample K-66

Point	4	5	10	15	25	30	31	Average	St. Dev.
Beam size	10	10	10	10	10	10	10		
SiO2	76.10	76.69	75.33	73.94	74.36	75.84	75.56	75.40	0.96
TiO2	0.27	0.23	0.25	0.23	0.31	0.26	0.25	0.25	0.03
Al2O3	13.99	14.32	13.79	13.45	13.57	13.77	14.11	13.86	0.30
FeO	1.11	1.12	1.04	1.16	1.08	1.05	1.17	1.12	0.07
MnO	0.02	0.01	0.01	0.01	0.00	0.00	0.04	0.03	0.03
MgO	0.20	0.24	0.02	0.29	0.25	0.28	0.27	0.23	0.11
CaO	1.12	1.15	1.15	1.12	1.23	1.15	1.16	1.17	0.05
Na2O	3.89	9.97	4.12	4.51	4.53	4.22	4.24	5.07	2.17
K2O	3.02	3.17	3.05	3.11	3.00	3.10	3.03	3.07	0.06
F	0.00	0.00	0.10	0.03	0.07	0.03	0.00	0.03	0.04
Cl	0.14	0.11	0.09	0.11	0.13	0.12	0.10	0.11	0.02
P2O5	0.05	0.02	0.10	0.11	0.03	0.04	0.07	0.06	0.03
SO2	0.00	0.02	0.03	0.00	0.01	0.04	0.02	0.02	0.01
Total	99.90	107.05	99.08	98.06	98.57	99.88	100.01	100.36	3.04
Normalized to 100%									
SiO2	76.18	71.64	76.03	75.40	75.44	75.93	75.54	75.17	1.59
TiO2	0.27	0.21	0.25	0.23	0.31	0.26	0.25	0.25	0.03
Al2O3	14.00	13.38	13.91	13.72	13.77	13.79	14.11	13.81	0.24
FeO	1.11	1.05	1.04	1.18	1.09	1.05	1.17	1.11	0.07
MnO	0.02	0.01	0.01	0.01	0.00	0.00	0.04	0.03	0.03
MgO	0.20	0.22	0.02	0.30	0.25	0.28	0.27	0.23	0.11
CaO	1.12	1.07	1.16	1.14	1.25	1.15	1.16	1.16	0.07
Na2O	3.90	9.31	4.16	4.60	4.60	4.22	4.24	5.00	1.92
K2O	3.02	2.96	3.08	3.17	3.05	3.10	3.03	3.06	0.07
F	0.00	0.00	0.10	0.03	0.07	0.03	0.00	0.03	0.04
Cl	0.14	0.10	0.09	0.11	0.13	0.12	0.10	0.11	0.02
P2O5	0.05	0.02	0.10	0.11	0.03	0.04	0.07	0.06	0.03
SO2	0.00	0.02	0.03	0.00	0.01	0.04	0.02	0.02	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na									
SiO2	75.64		75.70	75.40	75.44	75.64	75.28	75.52	0.17
TiO2	0.27		0.25	0.23	0.31	0.26	0.25	0.26	0.03
Al2O3	13.91		13.85	13.71	13.77	13.73	14.06	13.84	0.13
FeO	1.10		1.04	1.18	1.09	1.05	1.16	0.01	0.07
MnO	0.02		0.01	0.01	0.00	0.00	0.04	0.01	0.03
MgO	0.20		0.02	0.30	0.25	0.27	0.27	0.01	0.12
CaO	1.11		1.16	1.14	1.25	1.15	1.16	0.01	0.06
Na2O	4.60		4.60	4.60	4.60	4.60	4.60	4.60	0.00
K2O	3.00		3.07	3.17	3.05	3.09	3.02	3.07	0.06
F	0.00		0.10	0.03	0.07	0.02	0.00	0.04	0.04
Cl	0.13		0.09	0.11	0.13	0.12	0.10	0.11	0.02
P2O5	0.05		0.10	0.11	0.03	0.04	0.07	0.07	0.03
SO2	0.00		0.03	0.00	0.01	0.04	0.02	0.02	0.01
Total	100.03		100.02	100.00	100.00	100.02	100.02	100.01	0.01

Table C.1. Glass Analysis
Sample K-66d

Point	1	2	3	4	5	6	10	22	23	24	Average	St. Dev.
Beam size	25	20	20	25	10	10	15	10	20	20		
SiO2	74.69	74.68	74.29	73.97	75.63	75.72	75.33	76.15	74.83	74.80	75.01	0.68
TiO2	0.23	0.24	0.23	0.24	0.22	0.21	0.28	0.25	0.24	0.26	0.24	0.02
Al2O3	13.47	13.97	13.63	13.65	13.87	13.93	13.59	13.58	14.12	13.60	13.74	0.21
FeO	1.12	1.12	1.14	1.14	1.18	1.32	1.26	1.21	1.28	1.32	1.21	0.08
MnO	0.05	0.08	0.02	0.00	0.00	0.09	0.00	0.05	0.03	0.04	0.04	0.03
MgO	0.29	0.30	0.29	0.31	0.28	0.28	0.27	0.23	0.26	0.29	0.28	0.02
CaO	1.16	1.25	1.15	1.26	1.21	1.26	1.20	1.13	1.25	1.08	1.19	0.06
Na2O	6.45	6.24	4.39	4.66	4.17	3.98	4.14	3.79	4.77	4.40	4.70	0.92
K2O	3.13	2.99	3.02	3.06	3.08	3.05	3.16	3.10	3.14	3.13	3.09	0.06
F	0.00	9.75	0.08	0.00	0.00	0.00	0.02	0.00	21.69	0.09	3.16	7.19
Cl	0.14	0.11	0.12	0.12	0.14	0.18	0.14	0.19	0.14	0.14	0.14	0.03
P2O5	0.06	0.08	0.03	0.05	0.03	0.03	0.06	0.03	0.01	0.04	0.04	0.02
SO2	0.02	0.00	0.01	0.00	0.02	0.00	0.00	0.02	0.01	0.03	0.01	0.01
Total	100.80	110.80	98.41	98.46	99.82	100.05	99.44	99.71	121.78	99.21	102.85	7.57
Normalized to 100%												
SiO2	74.10	67.40	75.50	75.13	75.76	75.68	75.75	76.37	61.45	75.40	73.25	4.89
TiO2	0.23	0.22	0.23	0.24	0.22	0.21	0.28	0.25	0.20	0.26	0.23	0.02
Al2O3	13.37	12.61	13.85	13.87	13.89	13.93	13.67	13.62	11.59	13.71	13.41	0.75
FeO	1.11	1.01	1.16	1.15	1.19	1.32	1.26	1.22	1.05	1.33	1.18	0.11
MnO	0.05	0.07	0.02	0.00	0.00	0.09	0.00	0.05	0.03	0.04	0.03	0.03
MgO	0.29	0.27	0.30	0.31	0.28	0.28	0.27	0.23	0.22	0.30	0.27	0.03
CaO	1.15	1.13	1.17	1.27	1.21	1.26	1.21	1.13	1.02	1.09	1.16	0.08
Na2O	6.40	5.63	4.46	4.73	4.18	3.98	4.16	3.80	3.92	4.43	4.57	0.83
K2O	3.10	2.70	3.07	3.11	3.08	3.05	3.18	3.11	2.58	3.16	3.01	0.20
F	0.00	8.80	0.09	0.00	0.00	0.00	0.02	0.00	17.81	0.09	2.68	5.99
Cl	0.13	0.10	0.12	0.12	0.14	0.18	0.14	0.19	0.11	0.14	0.14	0.03
P2O5	0.06	0.07	0.03	0.05	0.03	0.03	0.06	0.03	0.01	0.04	0.04	0.02
SO2	0.02	0.00	0.01	0.00	0.02	0.00	0.00	0.02	0.01	0.03	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na												
SiO2	75.33		75.29	75.13	75.34	75.11	75.32	75.66		75.18	75.30	0.17
TiO2	0.23		0.23	0.24	0.22	0.21	0.27	0.25		0.26	0.24	0.02
Al2O3	13.59		13.81	13.87	13.81	13.82	13.59	13.49		13.67	13.71	0.14
FeO	1.13		1.15	1.15	1.18	1.31	1.25	1.21		1.33	1.21	0.08
MnO	0.05		0.02	0.00	0.00	0.09	0.00	0.05		0.04	0.03	0.03
MgO	0.29		0.29	0.31	0.28	0.28	0.27	0.22		0.30	0.28	0.03
CaO	1.17		1.16	1.27	1.20	1.25	1.20	1.12		1.08	1.18	0.06
Na2O	4.73		4.73	4.73	4.73	4.73	4.73	4.73		4.73	4.73	0.00
K2O	3.15		3.06	3.11	3.07	3.02	3.16	3.08		3.15	3.10	0.05
F	0.00		0.09	0.00	0.00	0.00	0.02	0.00		0.09	0.02	0.04
Cl	0.14		0.12	0.12	0.14	0.18	0.14	0.19		0.14	0.15	0.02
P2O5	0.06		0.03	0.05	0.03	0.03	0.06	0.03		0.04	0.04	0.01
SO2	0.02		0.01	0.00	0.02	0.00	0.00	0.01		0.03	0.01	0.01
Total	99.89		100.01	100.00	100.02	100.03	100.02	100.04		100.01	100.00	0.05

Table C.1. Glass Analysis
Sample K-66l

Point	5	8	10	12	13	14	16	20	23	Average	St. Dev.
Beam size	5	5	5	5	5	10	5	5	5		
SiO2	79.60	78.78	79.26	79.70	77.80	76.67	80.08	77.79	79.81	78.83	1.17
TiO2	0.25	0.27	0.24	0.27	0.23	0.27	0.23	0.26	0.28	0.26	0.02
Al2O3	13.79	13.73	13.76	13.89	13.67	14.09	13.70	13.82	13.99	13.83	0.14
FeO	1.25	1.07	1.04	1.13	1.08	1.16	1.08	1.15	1.13	1.12	0.06
MnO	0.06	0.00	0.00	0.01	0.07	0.08	0.01	0.01	0.02	0.03	0.03
MgO	0.20	0.26	0.20	0.27	0.26	0.25	0.21	0.27	0.26	0.24	0.03
CaO	1.02	1.04	0.90	0.96	1.00	1.19	0.94	0.96	1.00	1.00	0.08
Na2O	1.83	1.34	1.63	1.65	1.76	3.30	1.48	1.48	1.53	1.78	0.59
K2O	1.23	1.10	1.19	1.16	1.17	2.92	1.17	0.99	1.09	1.34	0.60
F	0.00	0.00	0.15	0.00	0.07	0.03	0.17	0.03	0.00	0.05	0.07
Cl	0.15	0.12	0.14	0.11	0.12	0.12	0.12	0.10	0.13	0.12	0.01
P2O5	0.00	0.05	0.06	0.06	0.00	0.00	0.05	0.04	0.07	0.04	0.03
SO2	0.03	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01
Total	99.42	97.77	98.59	99.25	97.24	100.10	99.25	96.90	99.31	98.65	1.10
Normalized to 100%											
SiO2	80.06	80.58	80.39	80.31	80.00	76.59	80.69	80.27	80.36	79.92	1.27
TiO2	0.26	0.28	0.25	0.27	0.23	0.27	0.23	0.27	0.28	0.26	0.02
Al2O3	13.87	14.05	13.96	14.00	14.06	14.07	13.81	14.26	14.09	14.02	0.13
FeO	1.26	1.10	1.06	1.14	1.11	1.16	1.09	1.19	1.13	1.14	0.06
MnO	0.06	0.00	0.00	0.01	0.08	0.08	0.01	0.01	0.02	0.03	0.03
MgO	0.20	0.26	0.20	0.27	0.26	0.25	0.21	0.28	0.26	0.24	0.03
CaO	1.03	1.06	0.91	0.97	1.03	1.19	0.94	0.99	1.01	1.01	0.08
Na2O	1.84	1.37	1.65	1.67	1.80	3.30	1.49	1.53	1.54	1.80	0.58
K2O	1.24	1.12	1.21	1.17	1.20	2.91	1.18	1.02	1.10	1.35	0.59
F	0.00	0.00	0.15	0.00	0.08	0.03	0.17	0.03	0.00	0.05	0.07
Cl	0.15	0.12	0.14	0.11	0.13	0.12	0.12	0.11	0.13	0.13	0.01
P2O5	0.00	0.05	0.06	0.06	0.00	0.00	0.05	0.04	0.07	0.04	0.03
SO2	0.03	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na											
SiO2						76.59				76.59	0.00
TiO2						0.27				0.27	0.00
Al2O3						14.07				14.07	0.00
FeO						1.16				1.16	0.00
MnO						0.08				0.08	0.00
MgO						0.25				0.25	0.00
CaO						1.19				1.19	0.00
Na2O						3.30				3.30	0.00
K2O						2.91				2.91	0.00
F						0.03				0.03	0.00
Cl						0.12				0.12	0.00
P2O5						0.00				0.00	0.00
SO2						0.02				0.02	0.00
Total						100.00				100.00	0.00

Table C.1. Glass Analysis
Sample K-67

Point	7	8	9	10	21	22	28	29	30	32	Average	St. Dev.
Beam size	20	15	15	20	20	10	20	10	20	10		
SiO2	74.43	74.89	72.99	74.93	74.00	77.38	75.72	75.75	74.48	73.62	74.82	1.25
TiO2	0.18	0.23	0.22	0.22	0.23	0.26	0.19	0.22	0.28	0.22	0.22	0.03
Al2O3	13.74	12.88	14.41	12.80	12.14	14.15	12.37	13.23	12.42	12.16	13.03	0.82
FeO	0.82	0.87	0.90	0.91	0.84	0.87	0.89	0.89	0.88	1.17	0.90	0.10
MnO	0.00	0.04	0.01	0.06	0.00	0.06	0.06	0.02	0.03	0.07	0.04	0.03
MgO	0.13	0.12	0.12	0.15	0.10	0.13	0.18	0.13	0.13	0.12	0.13	0.02
CaO	0.84	0.84	1.70	0.72	0.72	0.71	0.79	0.81	0.83	0.84	0.88	0.29
Na2O	4.18	3.85	4.70	4.27	4.08	3.65	4.15	3.68	4.21	3.82	4.06	0.32
K2O	3.24	3.48	2.73	3.43	3.44	3.41	3.45	3.57	3.35	3.20	3.33	0.24
F	0.03	0.41	0.00	0.05	0.48	0.00	0.00	0.39	0.05	0.37	0.18	0.20
Cl	0.05	0.09	0.05	0.10	0.09	0.10	0.11	0.09	0.08	0.11	0.09	0.02
P2O5	0.04	0.05	0.07	0.04	0.02	0.09	0.03	0.00	0.08	0.03	0.04	0.03
SO2	0.02	0.02	0.00	0.01	0.02	0.03	0.01	0.02	0.00	0.01	0.01	0.01
Total	97.69	97.77	97.90	97.67	96.15	100.83	97.94	98.80	96.82	95.73	97.73	1.42
Normalized to 100%												
SiO2	76.19	76.60	74.55	76.72	76.96	76.74	77.31	76.67	76.93	76.91	76.56	0.76
TiO2	0.19	0.24	0.22	0.22	0.24	0.25	0.19	0.23	0.28	0.23	0.23	0.03
Al2O3	14.06	13.17	14.72	13.11	12.63	14.04	12.63	13.39	12.83	12.70	13.33	0.72
FeO	0.84	0.89	0.91	0.93	0.88	0.86	0.90	0.90	0.90	1.22	0.92	0.11
MnO	0.00	0.04	0.01	0.06	0.00	0.06	0.06	0.02	0.03	0.08	0.04	0.03
MgO	0.14	0.13	0.12	0.15	0.11	0.12	0.18	0.13	0.14	0.12	0.13	0.02
CaO	0.86	0.86	1.74	0.73	0.75	0.70	0.81	0.82	0.86	0.87	0.90	0.30
Na2O	4.27	3.94	4.80	4.37	4.24	3.62	4.24	3.73	4.35	3.99	4.15	0.35
K2O	3.31	3.56	2.79	3.51	3.57	3.39	3.52	3.61	3.46	3.34	3.41	0.24
F	0.03	0.42	0.00	0.05	0.50	0.00	0.00	0.40	0.06	0.39	0.18	0.21
Cl	0.05	0.09	0.05	0.10	0.09	0.10	0.11	0.09	0.08	0.12	0.09	0.02
P2O5	0.04	0.06	0.07	0.04	0.02	0.09	0.03	0.00	0.08	0.03	0.04	0.03
SO2	0.02	0.02	0.00	0.01	0.02	0.03	0.01	0.02	0.00	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na												
SiO2	75.79	75.94	74.55	76.39	76.53	75.84	76.88	75.85	76.58	76.28	76.06	0.65
TiO2	0.19	0.23	0.22	0.22	0.24	0.25	0.19	0.22	0.28	0.23	0.23	0.03
Al2O3	13.99	13.06	14.72	13.05	12.56	13.87	12.56	13.24	12.77	12.60	13.24	0.73
FeO	0.83	0.88	0.91	0.93	0.87	0.85	0.90	0.89	0.90	1.21	0.92	0.11
MnO	0.00	0.04	0.01	0.06	0.00	0.05	0.06	0.02	0.03	0.07	0.04	0.03
MgO	0.14	0.13	0.12	0.15	0.11	0.12	0.18	0.13	0.14	0.12	0.13	0.02
CaO	0.86	0.85	1.74	0.73	0.74	0.69	0.80	0.81	0.86	0.87	0.90	0.30
Na2O	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	0.00
K2O	3.30	3.53	2.79	3.50	3.55	3.34	3.50	3.57	3.44	3.31	3.38	0.23
F	0.03	0.41	0.00	0.05	0.49	0.00	0.00	0.39	0.06	0.39	0.18	0.21
Cl	0.05	0.09	0.05	0.10	0.09	0.10	0.11	0.09	0.08	0.12	0.09	0.02
P2O5	0.04	0.05	0.07	0.04	0.02	0.09	0.03	0.00	0.08	0.03	0.04	0.03
SO2	0.02	0.02	0.00	0.01	0.02	0.03	0.01	0.02	0.00	0.01	0.01	0.01
Total	100.02	100.03	100.00	100.02	100.02	100.04	100.02	100.04	100.02	100.03	100.03	0.01

Table C.1. Glass Analysis
Sample K-68

Point	11	12	13	14	15	16	30	Average	St. Dev.
Beam size	20	15	10	10	20	20	20		
SiO2	73.26	73.01	74.81	74.66	72.92	73.43	69.73	73.12	1.68
TiO2	0.28	0.24	0.27	0.18	0.23	0.25	0.22	0.24	0.03
Al2O3	13.95	13.67	14.08	14.03	13.75	13.61	13.20	13.75	0.31
FeO	1.32	0.08	0.82	1.25	1.31	1.19	1.18	1.02	0.45
MnO	0.00	0.02	0.05	0.00	0.00	0.06	0.06	0.03	0.03
MgO	0.26	0.31	0.31	0.31	0.35	0.28	0.33	0.31	0.03
CaO	1.35	1.31	1.34	1.27	1.30	1.32	1.13	1.29	0.07
Na2O	4.73	4.45	4.13	4.37	4.68	4.60	4.57	4.50	0.21
K2O	2.82	2.94	2.99	2.95	2.89	2.95	2.83	2.91	0.07
F	0.00	0.14	0.03	0.00	0.06	0.10	0.07	0.06	0.05
Cl	0.12	0.13	0.15	0.11	0.12	0.10	0.15	0.13	0.02
P2O5	0.06	0.05	0.02	0.07	0.07	0.05	0.10	0.06	0.03
SO2	0.02	0.01	0.03	0.02	0.00	0.00	0.00	0.01	0.01
Total	98.16	96.36	99.02	99.22	97.66	97.93	93.56	97.42	1.94
Normalized to 100%									
SiO2	74.64	75.77	75.55	75.24	74.66	74.98	74.53	75.05	0.48
TiO2	0.29	0.25	0.27	0.18	0.23	0.26	0.23	0.24	0.03
Al2O3	14.22	14.18	14.22	14.14	14.07	13.89	14.10	14.12	0.11
FeO	1.34	0.08	0.82	1.25	1.34	1.22	1.26	1.05	0.46
MnO	0.00	0.02	0.05	0.00	0.00	0.06	0.07	0.03	0.03
MgO	0.26	0.32	0.31	0.31	0.35	0.29	0.35	0.31	0.03
CaO	1.38	1.35	1.36	1.28	1.33	1.35	1.21	1.32	0.06
Na2O	4.81	4.62	4.17	4.41	4.79	4.69	4.89	4.63	0.26
K2O	2.87	3.05	3.02	2.97	2.96	3.01	3.02	2.99	0.06
F	0.00	0.15	0.03	0.00	0.06	0.10	0.07	0.06	0.05
Cl	0.12	0.14	0.15	0.11	0.12	0.10	0.16	0.13	0.02
P2O5	0.06	0.05	0.02	0.07	0.08	0.05	0.11	0.06	0.03
SO2	0.02	0.01	0.03	0.02	0.00	0.00	0.00	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na									
SiO2	74.58	75.57	75.01	74.88	74.59	74.83	74.53	74.86	0.36
TiO2	0.29	0.25	0.27	0.18	0.23	0.26	0.23	0.24	0.03
Al2O3	14.21	14.14	14.11	14.07	14.06	13.87	14.10	14.08	0.11
FeO	1.34	0.08	0.82	1.25	1.34	1.21	1.26	1.04	0.46
MnO	0.00	0.02	0.05	0.00	0.00	0.06	0.07	0.03	0.03
MgO	0.26	0.32	0.31	0.31	0.35	0.29	0.35	0.31	0.03
CaO	1.37	1.35	1.35	1.28	1.33	1.35	1.21	1.32	0.06
Na2O	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	0.00
K2O	2.87	3.04	3.00	2.96	2.96	3.01	3.02	2.98	0.06
F	0.00	0.15	0.03	0.00	0.06	0.10	0.07	0.06	0.05
Cl	0.12	0.14	0.15	0.11	0.12	0.10	0.16	0.13	0.02
P2O5	0.06	0.05	0.02	0.07	0.08	0.05	0.11	0.06	0.03
SO2	0.02	0.01	0.03	0.02	0.00	0.00	0.00	0.01	0.01
Total	100.00	100.01	100.03	100.02	100.00	100.01	100.00	100.01	0.01

Table C.1. Glass Analysis
Sample K-69

Point	4	5	13	24	25	27	31	33	34	35	Average	St. Dev.
Beam size	10	10	20	20	10	20	10	10	10	10		
SiO2	77.57	75.93	74.81	69.48	76.24	75.29	77.20	76.98	77.57	77.66	75.87	2.46
TiO2	0.26	0.29	0.25	0.22	0.22	0.28	0.28	0.23	0.26	0.27	0.25	0.02
Al2O3	14.33	14.28	13.83	12.57	14.10	14.12	14.35	14.13	14.40	14.34	14.04	0.54
FeO	1.28	1.20	1.43	1.21	1.29	1.20	1.20	1.14	1.25	1.30	1.25	0.08
MnO	0.06	0.00	0.00	0.00	0.04	0.05	0.06	0.03	0.04	0.00	0.03	0.03
MgO	0.32	0.32	0.26	0.29	0.35	0.30	0.30	0.31	0.33	0.34	0.31	0.03
CaO	1.32	1.38	1.21	1.07	1.34	1.28	1.27	1.34	1.34	1.26	1.28	0.09
Na2O	4.01	4.13	5.02	4.27	4.16	4.67	3.65	4.19	4.13	3.99	4.22	0.38
K2O	2.84	2.89	2.69	2.50	2.87	2.76	2.90	2.78	2.81	2.75	2.78	0.12
F	0.00	0.04	0.00	0.00	0.00	0.07	0.07	0.02	0.00	0.11	0.03	0.04
Cl	0.11	0.12	0.12	0.15	0.10	0.11	0.10	0.11	0.12	0.11	0.11	0.02
P2O5	0.03	0.04	0.04	0.04	0.00	0.09	0.09	0.01	0.01	0.04	0.04	0.03
SO2	0.02	0.03	0.05	0.01	0.04	0.05	0.02	0.03	0.05	0.01	0.03	0.02
Total	102.15	100.63	99.71	91.80	100.72	100.28	101.48	101.30	102.29	102.17	100.25	3.09
Normalized to 100%												
SiO2	75.94	75.46	75.03	75.69	75.69	75.08	76.08	75.99	75.83	76.01	75.68	0.38
TiO2	0.26	0.28	0.25	0.24	0.22	0.28	0.27	0.23	0.25	0.26	0.25	0.02
Al2O3	14.02	14.19	13.87	13.69	14.00	14.08	14.14	13.95	14.08	14.03	14.01	0.14
FeO	1.26	1.20	1.43	1.31	1.28	1.19	1.18	1.13	1.22	1.27	1.25	0.08
MnO	0.06	0.00	0.00	0.00	0.04	0.05	0.06	0.03	0.03	0.00	0.03	0.03
MgO	0.32	0.31	0.26	0.31	0.34	0.30	0.29	0.31	0.32	0.33	0.31	0.02
CaO	1.29	1.37	1.22	1.17	1.33	1.27	1.25	1.33	1.31	1.23	1.28	0.06
Na2O	3.92	4.10	5.03	4.65	4.13	4.66	3.60	4.14	4.04	3.91	4.22	0.43
K2O	2.78	2.87	2.70	2.73	2.85	2.75	2.86	2.74	2.75	2.69	2.77	0.07
F	0.00	0.04	0.00	0.00	0.00	0.07	0.07	0.02	0.00	0.11	0.03	0.04
Cl	0.11	0.12	0.12	0.17	0.09	0.11	0.10	0.11	0.11	0.11	0.11	0.02
P2O5	0.03	0.04	0.04	0.04	0.00	0.09	0.08	0.01	0.01	0.03	0.04	0.03
SO2	0.02	0.03	0.05	0.01	0.04	0.05	0.02	0.03	0.05	0.01	0.03	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na												
SiO2	75.10	74.76	75.03	75.40	75.01	74.81	74.99	75.31	75.07	75.16	75.06	0.20
TiO2	0.26	0.28	0.25	0.23	0.22	0.28	0.27	0.23	0.25	0.26	0.25	0.02
Al2O3	13.87	14.05	13.87	13.64	13.87	14.03	13.94	13.82	13.94	13.87	13.89	0.12
FeO	1.24	1.18	1.43	1.31	1.27	1.19	1.17	1.12	1.21	1.26	1.24	0.09
MnO	0.06	0.00	0.00	0.00	0.04	0.05	0.05	0.03	0.03	0.00	0.03	0.02
MgO	0.31	0.31	0.26	0.31	0.34	0.30	0.29	0.31	0.31	0.33	0.31	0.02
CaO	1.27	1.36	1.22	1.16	1.31	1.27	1.23	1.31	1.30	1.22	1.27	0.06
Na2O	5.03	5.03	5.03	5.03	5.03	5.03	5.03	5.03	5.03	5.03	5.03	0.00
K2O	2.74	2.84	2.70	2.72	2.82	2.74	2.82	2.72	2.72	2.66	2.75	0.06
F	0.00	0.04	0.00	0.00	0.00	0.07	0.06	0.02	0.00	0.10	0.03	0.04
Cl	0.11	0.12	0.12	0.16	0.09	0.11	0.10	0.10	0.11	0.11	0.11	0.02
P2O5	0.03	0.04	0.04	0.04	0.00	0.09	0.08	0.01	0.01	0.03	0.04	0.03
SO2	0.02	0.03	0.05	0.01	0.04	0.05	0.02	0.03	0.05	0.01	0.03	0.02
Total	100.04	100.04	100.00	100.02	100.04	100.02	100.05	100.04	100.04	100.04	100.03	0.02

Table C.1. Glass Analysis
Sample K-71

Point	22	23	25	26	Average	St. Dev.
Beam size	10	10	10	10		
SiO2	68.48	68.25	56.68	73.80	66.80	7.22
TiO2	0.35	0.32	0.38	0.35	0.35	0.03
Al2O3	16.38	17.79	11.47	14.80	15.11	2.72
FeO	2.48	2.27	1.54	1.79	2.02	0.43
MnO	0.07	0.04	0.04	0.03	0.04	0.02
MgO	0.76	0.65	0.46	0.61	0.62	0.13
CaO	1.92	2.84	1.41	1.86	2.01	0.60
Na2O	4.78	5.09	3.10	4.09	4.26	0.88
K2O	3.19	2.64	2.15	2.87	2.71	0.44
F	0.00	1.07	0.01	0.00	0.27	0.53
Cl	0.10	0.07	0.93	0.10	0.30	0.42
P2O5	0.14	0.18	0.05	0.05	0.10	0.06
SO2	0.05	0.04	0.02	0.02	0.03	0.02
Total	98.70	101.24	78.24	100.36	94.64	10.98
Normalized to 100%						
SiO2	69.38	67.41	72.45	73.53	70.69	2.81
TiO2	0.35	0.31	0.49	0.35	0.37	0.08
Al2O3	16.60	17.57	14.66	14.74	15.89	1.43
FeO	2.51	2.25	1.97	1.79	2.13	0.32
MnO	0.07	0.03	0.04	0.03	0.05	0.02
MgO	0.77	0.65	0.58	0.61	0.65	0.08
CaO	1.95	2.81	1.80	1.85	2.10	0.47
Na2O	4.84	5.02	3.96	4.07	4.47	0.54
K2O	3.23	2.61	2.75	2.86	2.86	0.27
F	0.00	1.05	0.02	0.00	0.27	0.52
Cl	0.10	0.07	1.19	0.09	0.37	0.55
P2O5	0.14	0.17	0.06	0.05	0.11	0.06
SO2	0.05	0.04	0.03	0.02	0.03	0.01
Total	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na						
SiO2	69.39			72.98	71.19	2.53
TiO2	0.35			0.35	0.35	0.00
Al2O3	16.60			14.63	15.62	1.39
FeO	2.51			1.77	2.14	0.52
MnO	0.07			0.03	0.05	0.03
MgO	0.77			0.61	0.69	0.12
CaO	1.95			1.84	1.89	0.08
Na2O	4.82			4.82	4.82	0.00
K2O	3.23			2.84	3.04	0.28
F	0.00			0.00	0.00	0.00
Cl	0.10			0.09	0.10	0.00
P2O5	0.14			0.05	0.10	0.06
SO2	0.05			0.02	0.04	0.02
Total	100.00			100.03	100.01	0.02

Table C.1. Glass Analysis
Sample K-16 Klyuchevskoi

Point	13	23	24	25	36	Average	St. Dev.
Beam size	10	20	20	20	15		
SiO2	76.08	60.56	58.46	61.10	62.03	63.65	7.07
TiO2	0.27	1.49	1.64	1.75	1.62	1.35	0.61
Al2O3	13.84	15.01	14.20	13.92	14.14	14.22	0.47
FeO	1.38	8.34	8.65	8.15	8.03	6.91	3.10
MnO	0.05	0.15	0.17	0.08	0.12	0.11	0.05
MgO	0.27	2.55	2.66	2.26	2.04	1.96	0.97
CaO	1.08	5.15	5.78	4.56	4.63	4.24	1.83
Na2O	3.46	3.56	3.91	4.76	4.52	4.04	0.58
K2O	3.33	2.30	1.71	1.76	1.73	2.17	0.69
F	0.03	0.05	0.04	0.04	0.00	0.03	0.02
Cl	0.14	0.06	0.08	0.05	0.05	0.08	0.04
P2O5	0.05	0.38	0.35	0.28	0.35	0.28	0.14
SO2	0.02	0.02	0.00	0.01	0.00	0.01	0.01
Total	100.00	99.63	97.64	98.72	99.24	99.05	0.92
Normalized to 100%							
SiO2	76.08	60.79	59.87	61.90	62.50	64.23	6.70
TiO2	0.27	1.50	1.68	1.77	1.63	1.37	0.62
Al2O3	13.84	15.07	14.55	14.10	14.25	14.36	0.47
FeO	1.38	8.37	8.85	8.26	8.09	6.99	3.15
MnO	0.05	0.15	0.17	0.08	0.12	0.11	0.05
MgO	0.27	2.56	2.73	2.29	2.06	1.98	0.99
CaO	1.08	5.17	5.92	4.62	4.67	4.29	1.87
Na2O	3.46	3.57	4.00	4.82	4.55	4.08	0.60
K2O	3.33	2.31	1.76	1.78	1.74	2.18	0.68
F	0.03	0.05	0.04	0.04	0.00	0.03	0.02
Cl	0.14	0.06	0.08	0.05	0.05	0.08	0.04
P2O5	0.05	0.39	0.36	0.28	0.35	0.28	0.14
SO2	0.02	0.02	0.00	0.01	0.00	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Normalized to Na							
SiO2		60.03	59.38	61.90	62.33	60.91	1.43
TiO2		1.48	1.66	1.77	1.62	1.63	0.12
Al2O3		14.88	14.43	14.10	14.21	14.40	0.35
FeO		8.26	8.78	8.26	8.07	8.34	0.31
MnO		0.15	0.17	0.08	0.12	0.13	0.04
MgO		2.53	2.70	2.29	2.05	2.39	0.28
CaO		5.10	5.87	4.62	4.65	5.06	0.58
Na2O		4.82	4.82	4.82	4.82	4.82	0.00
K2O		2.28	1.74	1.78	1.74	1.88	0.27
F		0.05	0.04	0.04	0.00	0.03	0.02
Cl		0.06	0.08	0.05	0.05	0.06	0.01
P2O5		0.38	0.35	0.28	0.35	0.34	0.04
SO2		0.02	0.00	0.01	0.00	0.01	0.01
Total		100.04	100.03	100.00	100.01	100.02	0.02

Table C.2. Feldspar Analysis

Sample K-1

Point	10	12	29	5	9
Location	i	i	i	i	r
SiO2	56.52	60.49	55.78	59.70	60.02
Al2O3	26.14	24.54	27.17	24.79	24.82
FeO	0.42	0.29	0.47	0.28	0.20
CaO	8.20	6.41	9.34	6.47	6.44
Na2O	6.67	7.61	6.01	7.70	7.62
K2O	0.31	0.42	0.23	0.39	0.31
SrO	0.21	0.15	0.19	0.14	0.22
BaO	0.02	0.02	0.07	0.08	0.04
Total	98.48	99.91	99.24	99.53	99.67
Number of ions on the basis of 32O					
Si	10.33	10.80	10.14	10.72	10.75
Al	5.63	5.16	5.82	5.25	5.24
Fe	0.06	0.04	0.07	0.04	0.03
Ca	1.61	1.23	1.82	1.24	1.23
Na	2.36	2.63	2.12	2.68	2.65
K	0.07	0.09	0.05	0.09	0.07
Sr	0.02	0.02	0.02	0.01	0.02
Ba	0.00	0.00	0.00	0.01	0.00
Total	20.08	19.98	20.04	20.04	19.99
Ab	58.5	66.6	53.1	66.8	67.0
An	39.8	31.0	45.6	31.0	31.3
Or	1.8	2.4	1.3	2.2	1.8

Table C.2. Feldspar Analysis
Sample K-9

Point	4	7	13	15	17	21
Location	i	c	i	i	i	i
SiO2	57.73	55.54	56.20	58.24	56.78	61.12
Al2O3	26.39	27.73	27.15	25.93	26.57	23.77
FeO	8.17	9.52	9.13	7.72	8.43	5.74
CaO	0.37	0.20	0.27	0.22	0.19	0.62
Na2O	0.16	0.22	0.18	0.21	0.24	0.13
K2O	0.03	0.00	0.07	0.00	0.01	0.03
SrO	6.66	5.94	6.19	7.03	6.55	7.95
BaO	0.26	0.20	0.23	0.28	0.24	0.45
Total	99.77	99.35	99.40	99.63	99.00	99.80
Number of ions on the basis of 32O						
Si	10.65	10.33	10.44	10.75	10.57	11.20
Al	5.74	6.08	5.95	5.64	5.83	5.13
Fe	1.26	1.48	1.42	1.19	1.31	0.88
Ca	0.07	0.04	0.05	0.04	0.04	0.12
Na	0.06	0.08	0.06	0.07	0.09	0.05
K	0.01	0.00	0.02	0.00	0.00	0.01
Sr	0.71	0.64	0.67	0.75	0.71	0.84
Ba	0.02	0.01	0.02	0.02	0.02	0.03
Total	18.52	18.67	18.62	18.47	18.56	18.26
Ab	42.1	66.0	47.5	62.9	69.0	26.2
An	52.4	33.6	40.8	37.1	29.9	70.4
Or	5.5	0.4	11.6	0.0	1.2	3.4

Table C.2. Feldspar Analysis
Sample K-12

Point	5	6	9	14	18	19	22
Location	i	i	i	i	i	i	i
SiO2	57.06	59.03	54.29	57.75	59.10	57.24	58.20
Al2O3	25.98	25.98	28.35	25.97	25.10	25.32	24.82
FeO	0.45	0.50	0.37	0.38	0.40	0.43	0.47
CaO	8.26	7.35	10.41	8.36	7.16	7.44	6.75
Na2O	6.71	7.25	5.33	6.76	7.38	7.05	7.34
K2O	0.30	0.34	0.31	0.28	0.37	0.31	0.38
SrO	0.11	0.17	0.09	0.19	0.13	0.19	0.14
BaO	0.02	0.00	0.01	0.06	0.02	0.04	0.06
Total	98.89	100.62	99.17	99.75	99.66	98.01	98.15
Number of ions on the basis of 32O							
Si	10.37	10.52	9.89	10.41	10.62	10.48	10.62
Al	5.57	5.45	6.09	5.52	5.32	5.46	5.34
Fe	0.07	0.07	0.06	0.06	0.06	0.07	0.07
Ca	1.61	1.40	2.03	1.61	1.38	1.46	1.32
Na	2.37	2.51	1.88	2.36	2.57	2.50	2.60
K	0.07	0.08	0.07	0.06	0.09	0.07	0.09
Sr	0.01	0.02	0.01	0.02	0.01	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.06	20.05	20.04	20.05	20.05	20.07	20.05
Ab	58.5	62.9	47.2	58.5	63.7	62.0	64.9
An	39.8	35.2	51.0	40.0	34.2	36.2	33.0
Or	1.7	2.0	1.8	1.6	2.1	1.8	2.2

Table C.2. Feldspar Analysis
Sample K-14

Point	1	2	3	9	21	22	23	24	25	26	34	35	36
Location	i	i	i	i	i	i	i	i	i	i	i	i	i
SiO2	56.04	57.44	56.78	55.84	58.16	55.01	55.01	53.89	55.65	60.51	57.24	54.17	55.73
Al2O3	27.15	25.96	26.36	27.31	26.72	27.69	27.70	28.46	27.37	25.50	26.54	28.53	26.64
FeO	0.50	0.42	0.37	0.99	0.44	0.42	0.55	0.42	0.41	0.47	0.38	0.44	0.41
CaO	9.35	8.11	8.53	9.56	8.47	9.82	9.67	10.49	9.39	7.20	8.84	10.79	8.57
Na2O	6.05	6.69	6.35	5.63	6.54	5.72	5.71	5.30	5.89	7.20	6.20	5.15	6.33
K2O	0.22	0.26	0.20	0.32	0.20	0.17	0.21	0.14	0.18	0.29	0.31	0.20	0.30
SrO	0.15	0.21	0.22	0.11	0.22	0.18	0.17	0.18	0.18	0.11	0.12	0.18	0.16
BaO	0.07	0.04	0.01	0.09	0.03	0.03	0.05	0.07	0.03	0.05	0.02	0.02	0.04
Total	99.52	99.13	98.82	99.84	100.78	99.03	99.07	98.95	99.11	101.32	99.64	99.48	98.17
Number of ions on the basis of 32O													
Si	10.15	10.41	10.32	10.11	10.36	10.02	10.02	9.85	10.12	10.67	10.32	9.85	10.22
Al	5.80	5.54	5.65	5.83	5.61	5.95	5.95	6.13	5.86	5.30	5.64	6.12	5.76
Fe	0.08	0.06	0.06	0.15	0.06	0.06	0.08	0.06	0.06	0.07	0.06	0.07	0.06
Ca	1.81	1.58	1.66	1.85	1.62	1.92	1.89	2.05	1.83	1.36	1.71	2.10	1.68
Na	2.12	2.35	2.24	1.98	2.26	2.02	2.02	1.88	2.08	2.46	2.17	1.81	2.25
K	0.05	0.06	0.05	0.07	0.05	0.04	0.05	0.03	0.04	0.06	0.07	0.05	0.07
Sr	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02
Ba	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Total	20.04	20.02	20.00	20.00	19.98	20.03	20.03	20.04	20.01	19.94	19.98	20.02	20.06
Ab	53.3	59.0	56.7	50.6	57.6	50.8	51.0	47.4	52.6	63.3	54.9	45.8	56.2
An	45.5	39.5	42.1	47.5	41.2	48.2	47.8	51.8	46.3	35.0	43.3	53.1	42.0
Or	1.3	1.5	1.2	1.9	1.2	1.0	1.2	0.8	1.1	1.7	1.8	1.2	1.8

Table C.2. Feldspar Analysis
Sample K-18

Point	2	4	5	9	10	12	13	14	16
Location	i	i	i	i	i	i	i	i	i
SiO2	59.19	51.68	51.79	55.72	56.88	58.26	53.58	58.96	57.47
Al2O3	25.46	29.71	29.07	27.76	25.70	25.63	29.28	25.61	25.83
FeO	0.52	0.86	0.91	0.40	0.38	0.42	0.47	0.49	0.49
CaO	7.48	12.44	12.01	9.83	7.70	7.71	11.79	7.76	8.00
Na2O	7.14	4.29	4.47	5.69	7.01	7.02	4.65	7.00	6.88
K2O	0.27	0.22	0.22	0.18	0.26	0.27	0.16	0.32	0.25
SrO	0.19	0.11	0.13	0.15	0.17	0.15	0.16	0.14	0.14
BaO	0.03	0.01	0.00	0.02	0.05	0.03	0.03	0.02	0.02
Total	100.27	99.32	98.61	99.76	98.14	99.50	100.10	100.30	99.07
Number of ions on the basis of 32O									
Si	10.58	9.49	9.57	10.07	10.41	10.50	9.71	10.54	10.42
Al	5.36	6.43	6.33	5.91	5.54	5.45	6.25	5.39	5.52
Fe	0.08	0.13	0.14	0.06	0.06	0.06	0.07	0.07	0.07
Ca	1.43	2.45	2.38	1.90	1.51	1.49	2.29	1.49	1.55
Na	2.47	1.53	1.60	1.99	2.49	2.45	1.63	2.43	2.42
K	0.06	0.05	0.05	0.04	0.06	0.06	0.04	0.07	0.06
Sr	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.01	20.09	20.09	20.00	20.09	20.03	20.00	20.01	20.06
Ab	62.3	37.9	39.7	50.6	61.3	61.3	41.3	60.9	60.0
An	36.1	60.8	59.0	48.3	37.2	37.2	57.8	37.3	38.6
Or	1.5	1.3	1.3	1.1	1.5	1.5	0.9	1.8	1.4

Table C.2. Feldspar Analysis
Sample K-21

Point	2	4	5	15	20	26
Location	i	i	c	i	c	c
SiO2	58.49	59.89	56.18	54.61	58.49	56.08
Al2O3	25.60	24.91	27.15	28.39	25.71	26.83
FeO	0.40	0.31	0.32	0.28	0.31	0.35
CaO	7.45	6.78	9.26	10.49	7.64	8.98
Na2O	7.20	7.54	6.20	5.39	7.01	6.29
K2O	0.34	0.39	0.24	0.17	0.29	0.21
SrO	0.16	0.13	0.15	0.18	0.15	0.20
BaO	0.03	0.03	0.07	0.06	0.03	0.05
Total	99.66	99.98	99.57	99.59	99.62	98.99
Number of ions on the basis of 32O						
Si	10.52	10.71	10.17	9.91	10.52	10.20
Al	5.43	5.25	5.79	6.07	5.45	5.75
Fe	0.06	0.05	0.05	0.04	0.05	0.05
Ca	1.44	1.30	1.80	2.04	1.47	1.75
Na	2.51	2.61	2.17	1.90	2.44	2.22
K	0.08	0.09	0.06	0.04	0.07	0.05
Sr	0.02	0.01	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.01	0.00	0.00	0.00
Total	20.06	20.02	20.05	20.02	20.01	20.05
Ab	62.4	65.3	54.0	47.7	61.4	55.2
An	35.7	32.5	44.6	51.3	36.9	43.5
Or	1.9	2.2	1.4	1.0	1.7	1.2

Table C.2. Feldspar Analysis
Sample K-26

Point	3	8	9	11	12	13	16	17	21
Location	i	i	i	i	i	i	i	i	i
SiO2	57.70	58.21	57.72	61.52	55.09	58.75	58.93	53.33	60.49
Al2O3	23.97	25.68	25.71	23.86	27.80	25.15	25.35	29.23	24.96
FeO	0.29	0.45	0.48	0.22	0.32	0.32	0.38	0.48	0.21
CaO	6.30	7.70	7.46	5.62	10.12	6.97	7.27	11.69	6.51
Na2O	7.71	6.70	6.83	8.16	5.46	7.28	7.06	4.73	7.69
K2O	0.21	0.51	0.46	0.33	0.35	0.54	0.38	0.12	0.29
SrO	0.14	0.15	0.14	0.16	0.24	0.11	0.16	0.23	0.21
BaO	0.03	0.01	0.05	0.06	0.03	0.03	0.06	0.00	0.04
Total	96.34	99.42	98.84	99.93	99.42	99.14	99.59	99.81	100.39
Number of ions on the basis of 32O									
Si	10.71	10.50	10.48	10.96	10.01	10.61	10.60	9.69	10.75
Al	5.24	5.46	5.50	5.01	5.95	5.35	5.37	6.26	5.23
Fe	0.04	0.07	0.07	0.03	0.05	0.05	0.06	0.07	0.03
Ca	1.25	1.49	1.45	1.07	1.97	1.35	1.40	2.28	1.24
Na	2.77	2.34	2.40	2.82	1.92	2.55	2.46	1.67	2.65
K	0.05	0.12	0.11	0.08	0.08	0.12	0.09	0.03	0.07
Sr	0.01	0.02	0.01	0.02	0.03	0.01	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.08	20.00	20.03	19.99	20.02	20.05	19.99	20.02	19.99
Ab	68.0	59.4	60.7	71.1	48.4	63.4	62.3	42.0	67.0
An	30.8	37.7	36.6	27.0	49.6	33.5	35.4	57.3	31.3
Or	1.2	2.9	2.7	1.9	2.1	3.1	2.2	0.7	1.7

Table C.2. Feldspar Analysis
Sample K-27

Point	3	5	6	7	14	19	22	23	24	25	26	27
Location	i	c	i	r	i	i	c	i	r	c	i	r
SiO2	55.43	53.54	52.58	60.12	58.59	58.24	57.69	52.51	59.98	58.35	60.18	56.96
Al2O3	27.43	28.91	29.99	25.01	25.60	25.84	25.98	29.50	24.51	25.90	24.30	25.90
FeO	0.54	0.29	0.30	0.38	0.63	0.59	0.29	0.38	0.34	0.30	0.34	0.36
CaO	9.80	11.51	12.24	6.80	7.70	7.93	7.86	12.08	6.35	7.75	6.37	8.16
Na2O	5.94	4.88	4.34	7.53	7.06	6.91	6.97	4.39	7.71	6.98	7.67	6.73
K2O	0.19	0.14	0.12	0.30	0.24	0.27	0.28	0.12	0.35	0.27	0.35	0.25
SrO	0.19	0.21	0.16	0.18	0.17	0.17	0.18	0.21	0.14	0.16	0.12	0.17
BaO	0.01	0.07	0.02	0.01	0.03	0.07	0.04	0.01	0.08	0.07	0.05	0.06
Total	99.52	99.56	99.74	100.33	100.01	99.99	99.29	99.21	99.45	99.77	99.36	98.59
Number of ions on the basis of 32O												
Si	10.06	9.75	9.56	10.71	10.52	10.46	10.43	9.61	10.77	10.48	10.81	10.38
Al	5.87	6.20	6.43	5.25	5.41	5.47	5.53	6.36	5.19	5.49	5.14	5.56
Fe	0.08	0.04	0.05	0.06	0.09	0.09	0.04	0.06	0.05	0.04	0.05	0.05
Ca	1.91	2.25	2.38	1.30	1.48	1.53	1.52	2.37	1.22	1.49	1.22	1.59
Na	2.09	1.72	1.53	2.60	2.45	2.41	2.44	1.56	2.68	2.43	2.67	2.38
K	0.04	0.03	0.03	0.07	0.05	0.06	0.06	0.03	0.08	0.06	0.08	0.06
Sr	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Total	20.07	20.03	20.00	20.00	20.03	20.04	20.06	20.01	20.02	20.02	19.99	20.05
Ab	51.7	43.1	38.8	65.6	61.5	60.2	60.6	39.4	67.3	61.0	67.2	59.0
An	47.2	56.1	60.5	32.7	37.1	38.2	37.8	59.9	30.6	37.4	30.8	39.5
Or	1.1	0.8	0.7	1.7	1.4	1.5	1.6	0.7	2.0	1.6	2.0	1.5

Table C.2. Feldspar Analysis
Sample K-31

Point	8	13	18	20	27	28	29	30	31	32	33	34	35
Location	i	i	c	r	c	i	r	c	i	r	c	i	r
SiO2	55.88	58.16	60.16	58.93	58.56	55.11	59.00	58.24	56.59	57.14	57.09	53.14	58.60
Al2O3	27.08	25.09	24.63	24.63	24.57	27.66	24.78	25.76	26.75	26.44	26.44	28.58	25.51
FeO	0.52	0.56	0.09	0.22	0.31	0.32	0.27	0.38	0.24	0.35	0.32	0.33	0.27
CaO	9.23	6.89	6.20	6.31	6.58	9.75	6.85	7.61	8.67	8.28	8.37	10.86	7.37
Na2O	6.11	7.27	7.97	7.71	7.37	5.76	7.33	6.87	6.36	6.53	6.50	4.93	7.05
K2O	0.22	0.35	0.23	0.30	0.37	0.18	0.28	0.23	0.19	0.20	0.33	0.20	0.25
SrO	0.17	0.14	0.21	0.17	0.18	0.18	0.21	0.14	0.24	0.19	0.12	0.19	0.14
BaO	0.07	0.11	0.03	0.04	0.06	0.04	0.03	0.04	0.00	0.06	0.04	0.02	0.03
Total	99.28	98.57	99.51	98.30	98.01	99.01	98.76	99.25	99.04	99.19	99.20	98.24	99.21
Number of ions on the basis of 32O													
Si	10.15	10.58	10.78	10.71	10.69	10.04	10.68	10.51	10.27	10.34	10.34	9.79	10.56
Al	5.80	5.38	5.20	5.27	5.28	5.94	5.29	5.48	5.72	5.64	5.64	6.20	5.42
Fe	0.08	0.09	0.01	0.03	0.05	0.05	0.04	0.06	0.04	0.05	0.05	0.05	0.04
Ca	1.80	1.34	1.19	1.23	1.29	1.90	1.33	1.47	1.68	1.61	1.62	2.14	1.42
Na	2.15	2.56	2.77	2.71	2.61	2.04	2.57	2.40	2.24	2.29	2.28	1.76	2.47
K	0.05	0.08	0.05	0.07	0.09	0.04	0.07	0.05	0.04	0.05	0.08	0.05	0.06
Sr	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.01
Ba	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.05	20.05	20.03	20.05	20.02	20.03	20.00	19.98	20.01	20.01	20.02	20.01	19.99
Ab	53.8	64.3	69.0	67.6	65.5	51.1	64.9	61.2	56.4	58.1	57.3	44.6	62.5
An	44.9	33.7	29.7	30.6	32.3	47.8	33.5	37.5	42.5	40.7	40.8	54.3	36.1
Or	1.3	2.0	1.3	1.7	2.2	1.1	1.6	1.4	1.1	1.2	1.9	1.2	1.5

Table C.2. Feldspar Analysis

Sample K-32

Point	1	2	3	4	10	11	12	16	18	19	20	22	35	36	37
Location	c	i	i	r	c	i	r	i	c	i	r	i	c	i	r
SiO2	58.69	57.19	58.84	59.11	59.80	58.75	58.28	52.50	57.79	58.33	57.53	56.57	56.18	59.13	58.54
Al2O3	25.95	26.61	26.08	25.82	25.29	25.76	25.26	29.12	26.11	25.01	26.06	27.10	27.47	25.56	25.77
FeO	0.14	0.11	0.15	0.15	0.03	0.05	0.14	0.56	0.41	0.34	0.31	0.46	0.12	0.10	0.28
CaO	7.31	8.31	7.62	7.23	6.75	7.40	7.21	11.43	8.09	7.18	7.77	9.19	9.00	7.07	7.34
Na2O	7.20	6.69	7.07	7.24	7.69	7.26	7.14	4.88	6.57	7.12	6.95	6.09	6.16	7.33	7.16
K2O	0.16	0.14	0.17	0.24	0.23	0.19	0.26	0.14	0.25	0.29	0.26	0.19	0.19	0.29	0.30
SrO	0.14	0.17	0.15	0.18	0.22	0.19	0.16	0.14	0.14	0.14	0.14	0.15	0.19	0.15	0.15
BaO	0.00	0.02	0.00	0.03	0.03	0.01	0.03	0.05	0.02	0.05	0.07	0.05	0.04	0.02	0.04
Total	99.58	99.23	100.09	99.99	100.02	99.61	98.49	98.82	99.38	98.46	99.09	99.78	99.35	99.64	99.57
Number of ions on the basis of 32O															
Si	10.53	10.33	10.51	10.57	10.67	10.55	10.58	9.65	10.43	10.60	10.42	10.20	10.16	10.60	10.53
Al	5.49	5.67	5.49	5.44	5.32	5.45	5.40	6.31	5.55	5.36	5.56	5.76	5.86	5.40	5.46
Fe	0.02	0.02	0.02	0.02	0.00	0.01	0.02	0.09	0.06	0.05	0.05	0.07	0.02	0.02	0.04
Ca	1.41	1.61	1.46	1.38	1.29	1.42	1.40	2.25	1.56	1.40	1.51	1.78	1.74	1.36	1.41
Na	2.50	2.34	2.45	2.51	2.66	2.53	2.51	1.74	2.30	2.51	2.44	2.13	2.16	2.55	2.49
K	0.04	0.03	0.04	0.06	0.05	0.04	0.06	0.03	0.06	0.07	0.06	0.04	0.04	0.07	0.07
Sr	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.00	20.02	19.99	20.00	20.02	20.01	20.00	20.08	19.98	20.01	20.05	20.00	20.01	20.01	20.02
Ab	63.4	58.8	62.1	63.6	66.5	63.3	63.2	43.2	58.7	63.1	60.9	53.9	54.7	64.1	62.7
An	35.6	40.4	37.0	35.0	32.3	35.6	35.3	56.0	39.9	35.2	37.6	45.0	44.1	34.2	35.6
Or	0.9	0.8	1.0	1.4	1.3	1.1	1.5	0.8	1.5	1.7	1.5	1.1	1.1	1.7	1.7

Table C.2. Feldspar Analysis
Sample K-41

Point	5	8	9	16	17	25	26
Location	i	i	i	i	i	i	i
SiO2	56.18	55.96	57.44	54.66	58.51	53.07	54.44
Al2O3	26.42	25.74	25.87	27.16	26.08	28.14	28.06
FeO	0.47	0.42	0.46	0.48	0.30	0.40	0.49
CaO	9.36	8.03	8.13	9.56	7.83	10.64	10.78
Na2O	5.87	6.61	6.36	5.79	6.90	5.19	5.00
K2O	0.24	0.61	0.63	0.46	0.19	0.21	0.23
SrO	0.19	0.14	0.13	0.11	0.12	0.12	0.19
BaO	0.05	0.05	0.03	0.03	0.04	0.01	0.04
Total	98.78	97.56	99.06	98.26	99.96	97.78	99.22
Number of ions on the basis of 32O							
Si	10.25	10.33	10.42	10.06	10.48	9.82	9.92
Al	5.68	5.60	5.53	5.89	5.51	6.14	6.03
Fe	0.07	0.07	0.07	0.07	0.05	0.06	0.07
Ca	1.83	1.59	1.58	1.88	1.50	2.11	2.10
Na	2.08	2.37	2.24	2.07	2.40	1.86	1.77
K	0.06	0.14	0.15	0.11	0.04	0.05	0.05
Sr	0.02	0.02	0.01	0.01	0.01	0.01	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	19.98	20.12	20.00	20.09	19.99	20.06	19.97
Ab	52.4	57.7	56.4	50.9	60.8	46.3	45.0
An	46.2	38.7	39.9	46.4	38.1	52.5	53.6
Or	1.4	3.5	3.7	2.7	1.1	1.3	1.4

Table C.2. Feldspar Analysis

Sample K-45(1)

Point	7	8	9	10	15	16	18	19	20	24	25	27	28	29	30	31	34
Location	c	i	r	i	c	i	c	i	r	i	i	i	i	c	i	r	i
SiO2	56.74	54.65	60.02	57.95	58.75	54.89	57.27	56.39	57.26	58.18	57.59	59.55	57.77	53.19	58.66	58.35	58.84
Al2O3	27.21	28.34	24.84	26.43	25.69	28.38	26.70	27.18	26.33	26.41	26.43	25.33	26.31	29.48	26.04	26.13	25.66
FeO	0.34	0.45	0.37	0.24	0.32	0.30	0.32	0.34	0.35	0.32	0.33	0.34	0.39	0.32	0.39	0.35	0.30
CaO	8.98	10.43	6.55	8.16	7.58	10.45	8.65	9.20	8.34	8.18	8.27	7.20	8.22	11.95	7.82	7.84	7.45
Na2O	6.29	5.49	7.50	6.80	7.10	5.59	6.61	6.21	6.56	6.80	6.63	7.24	6.76	4.64	6.87	6.98	7.21
K2O	0.27	0.19	0.37	0.30	0.35	0.19	0.30	0.23	0.24	0.28	0.23	0.36	0.26	0.13	0.29	0.26	0.36
SrO	0.16	0.15	0.13	0.15	0.16	0.13	0.17	0.13	0.21	0.10	0.15	0.16	0.14	0.18	0.16	0.15	0.19
BaO	0.05	0.05	0.05	0.07	0.07	0.04	0.03	0.02	0.03	0.06	0.02	0.09	0.04	0.05	0.08	0.03	0.04
Total	100.02	99.75	99.83	100.09	100.02	99.96	100.05	99.70	99.32	100.32	99.66	100.27	99.88	99.94	100.30	100.09	100.06
Number of ions on the basis of 32O																	
Si	10.21	9.91	10.74	10.39	10.53	9.92	10.30	10.18	10.36	10.41	10.37	10.63	10.39	9.66	10.49	10.45	10.54
Al	5.77	6.05	5.24	5.58	5.43	6.05	5.66	5.78	5.61	5.57	5.61	5.33	5.57	6.31	5.49	5.52	5.42
Fe	0.05	0.07	0.06	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.05	0.05
Ca	1.73	2.03	1.25	1.57	1.46	2.02	1.67	1.78	1.62	1.57	1.60	1.38	1.58	2.32	1.50	1.51	1.43
Na	2.19	1.93	2.60	2.36	2.47	1.96	2.30	2.17	2.30	2.36	2.32	2.51	2.36	1.63	2.38	2.43	2.50
K	0.06	0.04	0.09	0.07	0.08	0.04	0.07	0.05	0.06	0.06	0.05	0.08	0.06	0.03	0.07	0.06	0.08
Sr	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Total	20.03	20.05	19.99	20.03	20.03	20.06	20.06	20.04	20.02	20.02	20.01	20.00	20.03	20.02	19.99	20.03	20.04
Ab	55.0	48.2	66.0	59.1	61.6	48.6	57.1	54.2	57.9	59.1	58.4	63.2	58.9	40.9	60.4	60.8	62.4
An	43.4	50.7	31.8	39.2	36.4	50.3	41.2	44.4	40.7	39.3	40.3	34.7	39.6	58.3	38.0	37.7	35.6
Or	1.5	1.1	2.2	1.7	2.0	1.1	1.7	1.3	1.4	1.6	1.3	2.1	1.5	0.8	1.7	1.5	2.0

Table C.2. Feldspar Analysis
Sample K-46

Point	3	7	8	9	13	15	25	26
Location	i	i	i	i	i	i	i	i
SiO2	57.24	59.18	57.31	58.00	57.24	56.13	52.39	56.84
Al2O3	25.93	25.54	26.35	26.00	26.57	26.58	30.26	26.94
FeO	0.19	0.42	0.39	0.50	0.35	0.37	0.31	0.36
CaO	7.49	7.34	8.53	8.32	8.40	8.61	12.57	9.00
Na2O	7.04	7.18	6.35	6.53	6.40	6.52	4.23	6.33
K2O	0.24	0.30	0.22	0.24	0.26	0.24	0.13	0.23
SrO	0.20	0.22	0.21	0.15	0.16	0.16	0.19	0.18
BaO	0.04	0.04	0.04	0.05	0.04	0.05	0.02	0.01
Total	98.37	100.21	99.39	99.79	99.43	98.66	100.10	99.88
Number of ions on the basis of 32O								
Si	10.43	10.58	10.36	10.43	10.34	10.24	9.51	10.24
Al	5.57	5.38	5.61	5.51	5.65	5.72	6.47	5.72
Fe	0.03	0.06	0.06	0.08	0.05	0.06	0.05	0.05
Ca	1.46	1.40	1.65	1.60	1.63	1.68	2.44	1.74
Na	2.49	2.49	2.23	2.28	2.24	2.31	1.49	2.21
K	0.06	0.07	0.05	0.05	0.06	0.06	0.03	0.05
Sr	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.06	20.01	19.98	19.98	19.99	20.08	20.01	20.03
Ab	62.1	62.8	56.7	57.9	57.1	57.0	37.6	55.3
An	36.5	35.5	42.0	40.7	41.4	41.6	61.7	43.4
Or	1.4	1.7	1.3	1.4	1.5	1.4	0.8	1.3

Table C.2. Feldspar Analysis
Sample K-49

Point	3	9	10	17	18	24	27	28	29
Location	i	i	i	i	i	i	i	i	i
SiO2	57.21	58.60	58.59	54.74	57.03	56.90	58.91	60.52	53.30
Al2O3	25.41	25.65	25.49	27.56	26.18	26.51	25.47	24.37	28.30
FeO	0.45	0.34	0.37	0.32	0.29	0.30	0.46	0.43	0.33
CaO	7.32	7.93	7.48	9.88	8.12	8.65	7.49	6.19	10.83
Na2O	7.05	6.79	7.03	5.79	6.86	6.45	7.02	7.74	5.25
K2O	0.68	0.26	0.33	0.21	0.28	0.22	0.31	0.43	0.12
SrO	0.21	0.19	0.15	0.17	0.19	0.26	0.19	0.09	0.19
BaO	0.05	0.04	0.05	0.04	0.02	0.00	0.03	0.03	0.00
Total	98.38	99.79	99.48	98.71	98.98	99.31	99.86	99.80	98.32
Number of ions on the basis of 32O									
Si	10.46	10.52	10.55	10.01	10.36	10.30	10.57	10.82	9.81
Al	5.48	5.43	5.41	5.94	5.60	5.66	5.38	5.13	6.14
Fe	0.07	0.05	0.06	0.05	0.04	0.05	0.07	0.06	0.05
Ca	1.43	1.53	1.44	1.94	1.58	1.68	1.44	1.19	2.14
Na	2.50	2.36	2.45	2.05	2.42	2.27	2.44	2.68	1.88
K	0.16	0.06	0.08	0.05	0.07	0.05	0.07	0.10	0.03
Sr	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.01	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.13	19.97	20.01	20.06	20.08	20.03	19.99	20.00	20.07
Ab	61.1	59.9	61.8	50.8	59.5	56.7	61.8	67.6	46.4
An	35.0	38.7	36.3	48.0	38.9	42.0	36.4	29.9	52.9
Or	3.9	1.5	1.9	1.2	1.6	1.3	1.8	2.5	0.7

Table C.2. Feldspar Analysis
Sample K-52

Point	2	5	6	11	13	17	18	19	20
Location	i	i	i	i	i	i	i	i	i
SiO2	57.11	57.64	55.39	59.88	57.01	58.32	59.29	56.44	58.10
Al2O3	26.49	25.97	27.55	25.79	26.84	25.74	25.54	27.34	26.36
FeO	0.27	0.44	0.43	0.36	0.42	0.46	0.44	0.36	0.34
CaO	8.35	8.34	9.92	7.25	8.77	7.89	7.32	9.39	8.27
Na2O	6.56	6.53	5.74	7.22	6.42	6.76	7.09	5.95	6.43
K2O	0.29	0.28	0.23	0.46	0.24	0.26	0.29	0.20	0.48
SrO	0.20	0.21	0.20	0.17	0.13	0.16	0.17	0.19	0.16
BaO	0.02	0.02	0.04	0.04	0.07	0.04	0.02	0.00	0.00
Total	99.28	99.43	99.50	101.19	99.89	99.62	100.14	99.87	100.15
Number of ions on the basis of 32O									
Si	10.33	10.41	10.05	10.60	10.27	10.50	10.59	10.17	10.41
Al	5.65	5.53	5.89	5.38	5.70	5.46	5.38	5.81	5.57
Fe	0.04	0.07	0.07	0.05	0.06	0.07	0.06	0.05	0.05
Ca	1.62	1.62	1.93	1.38	1.69	1.52	1.40	1.81	1.59
Na	2.30	2.29	2.02	2.48	2.24	2.36	2.45	2.08	2.23
K	0.07	0.06	0.05	0.10	0.05	0.06	0.07	0.05	0.11
Sr	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Total	20.03	20.00	20.04	20.01	20.03	19.98	19.98	19.99	19.98
Ab	57.7	57.7	50.5	62.6	56.2	59.9	62.6	52.8	56.8
An	40.6	40.7	48.2	34.8	42.4	38.6	35.7	46.1	40.4
Or	1.7	1.6	1.3	2.6	1.4	1.5	1.7	1.2	2.8

Table C.2. Feldspar Analysis
Sample K-56

Point	1	2	8	9	10	12	15	16
Location	i	i	i	i	i	i	i	i
SiO2	57.74	59.61	59.91	56.36	58.76	57.02	55.04	55.94
Al2O3	25.39	25.03	24.42	26.28	25.28	26.60	27.34	26.89
FeO	0.44	0.44	0.36	0.44	0.44	0.27	0.72	0.29
CaO	7.23	7.12	5.79	8.35	7.44	8.52	9.66	9.30
Na2O	7.01	7.18	8.10	6.62	6.91	6.48	5.79	6.06
K2O	0.49	0.50	0.46	0.39	0.55	0.30	0.27	0.23
SrO	0.13	0.14	0.14	0.15	0.17	0.18	0.13	0.24
BaO	0.09	0.09	0.04	0.00	0.07	0.05	0.02	0.04
Total	98.49	100.10	99.22	98.60	99.61	99.41	98.96	98.98
Number of ions on the basis of 32O								
Si	10.52	10.67	10.79	10.29	10.58	10.31	10.05	10.18
Al	5.45	5.28	5.18	5.66	5.36	5.67	5.88	5.77
Fe	0.07	0.07	0.05	0.07	0.07	0.04	0.11	0.04
Ca	1.41	1.36	1.12	1.63	1.44	1.65	1.89	1.81
Na	2.47	2.49	2.83	2.34	2.41	2.27	2.05	2.14
K	0.11	0.11	0.11	0.09	0.13	0.07	0.06	0.05
Sr	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02
Ba	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.05	20.00	20.09	20.10	20.01	20.03	20.06	20.03
Ab	61.9	62.7	69.8	57.6	60.7	56.9	51.2	53.4
An	35.3	34.4	27.6	40.1	36.1	41.3	47.2	45.3
Or	2.8	2.9	2.6	2.2	3.2	1.8	1.6	1.3

Table C.2. Feldspar Analysis
Sample K-62

Point	1	2	3	8	11	12	13	17	18	19	23	27	28	29
Location	c	i	r	i	i	i	i	c	i	r	i	c	i	r
SiO2	54.90	58.77	57.04	57.92	57.38	54.37	59.19	54.27	58.49	57.39	58.82	55.64	56.64	57.89
Al2O3	28.31	25.65	26.63	26.24	26.98	28.99	25.48	28.66	25.96	26.75	25.91	27.63	27.16	26.19
FeO	0.37	0.32	0.42	0.37	0.13	0.18	0.16	0.32	0.40	0.35	0.54	0.35	0.33	0.37
CaO	10.64	7.69	8.85	7.76	8.80	11.14	7.18	10.78	8.03	8.73	7.72	9.66	9.07	7.85
Na2O	5.34	7.01	6.33	6.90	6.52	5.21	7.26	5.40	6.79	6.49	7.16	5.94	6.23	6.97
K2O	0.16	0.30	0.23	0.38	0.20	0.14	0.30	0.17	0.28	0.21	0.31	0.23	0.24	0.28
SrO	0.19	0.18	0.14	0.22	0.20	0.22	0.30	0.20	0.16	0.21	0.15	0.17	0.14	0.12
BaO	0.00	0.05	0.03	0.08	0.04	0.02	0.00	0.00	0.03	0.04	0.04	0.07	0.05	0.03
Total	99.90	99.98	99.68	99.86	100.26	100.27	99.87	99.81	100.13	100.18	100.65	99.68	99.85	99.71
Number of ions on the basis of 32O														
Si	9.93	10.54	10.29	10.42	10.28	9.81	10.60	9.84	10.48	10.30	10.49	10.07	10.21	10.42
Al	6.03	5.42	5.66	5.56	5.70	6.17	5.38	6.12	5.48	5.66	5.45	5.89	5.77	5.55
Fe	0.06	0.05	0.06	0.06	0.02	0.03	0.02	0.05	0.06	0.05	0.08	0.05	0.05	0.06
Ca	2.06	1.48	1.71	1.49	1.69	2.15	1.38	2.09	1.54	1.68	1.47	1.87	1.75	1.51
Na	1.87	2.44	2.21	2.41	2.26	1.82	2.52	1.90	2.36	2.26	2.48	2.08	2.18	2.43
K	0.04	0.07	0.05	0.09	0.05	0.03	0.07	0.04	0.06	0.05	0.07	0.05	0.05	0.06
Sr	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01
Ba	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.01	20.01	20.01	20.05	20.02	20.03	20.00	20.07	20.00	20.02	20.06	20.05	20.02	20.05
Ab	47.2	61.2	55.6	60.4	56.6	45.5	63.6	47.1	59.5	56.7	61.6	52.0	54.6	60.7
An	51.9	37.1	43.0	37.5	42.2	53.7	34.7	51.9	38.9	42.1	36.7	46.7	44.0	37.8
Or	0.9	1.7	1.4	2.2	1.2	0.8	1.7	1.0	1.6	1.2	1.7	1.3	1.4	1.6

Table C.2. Feldspar Analysis
Sample K-64

Point	4	5	6	7	8	9	10	13	14	15	16	17	18	25
Location	i	c	i	r	c	i	r	c	i	r	c	i	r	i
SiO2	57.53	54.21	55.23	58.95	57.05	57.30	58.43	55.01	54.05	60.68	59.00	57.54	58.01	59.80
Al2O3	26.39	28.38	27.75	24.92	25.97	26.26	25.67	27.28	28.26	24.06	25.20	26.18	25.76	24.87
FeO	0.47	0.37	0.34	0.31	0.35	0.37	0.36	0.29	0.32	0.33	0.36	0.35	0.33	0.51
CaO	8.41	10.63	9.85	6.98	8.05	8.41	7.49	9.70	10.49	5.98	7.15	8.11	7.71	6.67
Na2O	6.55	5.40	5.70	7.22	6.73	6.55	7.03	5.81	5.41	7.70	7.27	6.74	6.94	7.47
K2O	0.25	0.16	0.16	0.32	0.27	0.25	0.30	0.20	0.17	0.38	0.35	0.25	0.29	0.36
SrO	0.16	0.17	0.14	0.15	0.21	0.16	0.14	0.17	0.22	0.13	0.17	0.18	0.15	0.18
BaO	0.00	0.05	0.07	0.00	0.04	0.03	0.04	0.04	0.01	0.07	0.04	0.06	0.04	0.05
Total	99.75	99.37	99.23	98.85	98.66	99.33	99.46	98.48	98.93	99.32	99.54	99.42	99.23	99.90
Number of ions on the basis of 32O														
Si	10.36	9.87	10.04	10.66	10.39	10.36	10.52	10.07	9.88	10.89	10.61	10.39	10.48	10.71
Al	5.60	6.09	5.94	5.31	5.57	5.60	5.45	5.89	6.09	5.09	5.34	5.57	5.49	5.25
Fe	0.07	0.06	0.05	0.05	0.05	0.06	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.08
Ca	1.62	2.07	1.92	1.35	1.57	1.63	1.45	1.90	2.05	1.15	1.38	1.57	1.49	1.28
Na	2.29	1.91	2.01	2.53	2.37	2.30	2.45	2.06	1.92	2.68	2.54	2.36	2.43	2.59
K	0.06	0.04	0.04	0.07	0.06	0.06	0.07	0.05	0.04	0.09	0.08	0.06	0.07	0.08
Sr	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Total	20.01	20.06	20.01	19.99	20.04	20.02	20.01	20.04	20.05	19.95	20.02	20.03	20.02	20.01
Ab	57.6	47.5	50.7	63.9	59.3	57.7	61.8	51.4	47.8	68.4	63.5	59.2	60.9	65.6
An	40.9	51.6	48.4	34.2	39.2	40.9	36.4	47.4	51.2	29.4	34.5	39.4	37.4	32.4
Or	1.4	0.9	0.9	1.9	1.5	1.4	1.7	1.2	1.0	2.2	2.0	1.4	1.7	2.1

Table C.2. Feldspar Analysis
Sample K-64d

Point	9	10	12	27	29	30	31
Location	i	i	i	c	i	i	i
SiO2	59.04	58.66	59.44	56.52	59.36	58.15	56.24
Al2O3	25.35	25.35	26.10	26.78	24.50	25.38	26.63
FeO	7.24	7.14	7.83	8.72	6.30	7.57	8.85
CaO	0.53	0.51	0.40	0.44	0.52	0.41	0.41
Na2O	0.15	0.15	0.15	0.18	0.13	0.18	0.14
K2O	0.03	0.00	0.03	0.05	0.06	0.09	0.06
SrO	7.30	7.04	6.95	6.36	7.64	7.06	6.22
BaO	0.30	0.30	0.29	0.23	0.37	0.28	0.22
Total	99.95	99.14	101.18	99.29	98.87	99.13	98.77
Number of ions on the basis of 32O							
Si	10.86	10.85	10.79	10.51	11.01	10.80	10.51
Al	5.49	5.53	5.58	5.87	5.35	5.55	5.86
Fe	1.11	1.10	1.19	1.36	0.98	1.18	1.38
Ca	0.10	0.10	0.08	0.09	0.10	0.08	0.08
Na	0.05	0.05	0.05	0.07	0.05	0.07	0.05
K	0.01	0.00	0.01	0.01	0.01	0.02	0.02
Sr	0.78	0.76	0.73	0.69	0.82	0.76	0.67
Ba	0.02	0.02	0.02	0.02	0.03	0.02	0.02
Total	18.43	18.41	18.45	18.60	18.35	18.47	18.59
Ab	32.6	34.1	37.8	40.3	28.3	39.4	34.9
An	63.0	65.9	57.8	53.0	63.5	48.1	55.1
Or	4.4	0.0	4.5	6.7	8.3	12.5	10.0

Table C.2. Feldspar Analysis
Sample K-64l

Point	12	17	20	21	23	26
Location	i	i	i	i	i	i
SiO2	58.43	55.39	55.74	58.91	54.64	57.58
Al2O3	26.27	27.31	28.28	26.87	28.61	27.32
FeO	0.36	0.32	0.39	0.37	0.31	0.31
CaO	7.17	9.84	10.13	8.64	10.76	9.02
Na2O	7.32	5.48	5.44	6.41	5.26	5.85
K2O	0.26	0.19	0.19	0.23	0.13	0.23
SrO	0.12	0.18	0.16	0.17	0.20	0.14
BaO	0.03	0.04	0.02	0.03	0.04	0.01
Total	99.97	98.76	100.34	101.62	99.95	100.44
Number of ions on the basis of 32O						
Si	10.47	10.10	10.01	10.39	9.88	10.28
Al	5.55	5.87	5.99	5.59	6.10	5.75
Fe	0.05	0.05	0.06	0.05	0.05	0.05
Ca	1.38	1.92	1.95	1.63	2.08	1.72
Na	2.54	1.94	1.89	2.19	1.85	2.02
K	0.06	0.04	0.04	0.05	0.03	0.05
Sr	0.01	0.02	0.02	0.02	0.02	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.06	19.95	19.96	19.93	20.01	19.89
Ab	63.9	49.6	48.7	56.5	46.6	53.3
An	34.6	49.2	50.2	42.1	52.7	45.4
Or	1.5	1.1	1.1	1.3	0.7	1.4

Table C.2. Feldspar Analysis

Sample K-65

Point	1	2	3	9	19	21	22	23	24	28	29	30	32	33	34
Location	c	i	r	i	i	c	i	i	r	c	i	r	c	i	r
SiO2	57.77	58.34	54.90	60.29	59.73	55.82	60.19	55.66	52.38	58.02	58.59	53.45	59.42	53.38	56.63
Al2O3	26.11	25.68	27.88	24.78	24.91	27.40	24.86	27.67	29.42	25.93	25.51	28.64	24.80	29.10	26.56
FeO	0.34	0.34	0.38	0.52	0.39	0.29	0.16	0.21	0.54	0.30	0.28	0.42	0.39	0.35	0.29
CaO	8.17	7.70	10.16	6.50	6.76	9.67	6.47	9.74	11.91	8.08	7.32	11.19	6.99	11.49	8.77
Na2O	6.58	7.02	5.60	7.64	7.44	5.98	7.68	5.85	4.47	6.67	7.17	4.98	7.29	4.72	6.30
K2O	0.26	0.29	0.17	0.33	0.35	0.15	0.20	0.12	0.12	0.29	0.28	0.13	0.34	0.14	0.25
SrO	0.19	0.11	0.19	0.15	0.08	0.28	0.15	0.18	0.25	0.19	0.12	0.19	0.15	0.19	0.17
BaO	0.04	0.04	0.00	0.05	0.03	0.07	0.00	0.03	0.01	0.01	0.04	0.03	0.03	0.00	0.01
Total	99.47	99.51	99.29	100.25	99.69	99.65	99.71	99.46	99.09	99.49	99.31	99.02	99.42	99.37	98.98
Number of ions on the basis of 32O															
Si	10.42	10.51	9.99	10.75	10.70	10.11	10.76	10.08	9.60	10.46	10.56	9.78	10.69	9.73	10.28
Al	5.55	5.45	5.98	5.21	5.26	5.85	5.24	5.90	6.36	5.51	5.42	6.18	5.26	6.25	5.68
Fe	0.05	0.05	0.06	0.08	0.06	0.04	0.02	0.03	0.08	0.05	0.04	0.06	0.06	0.05	0.04
Ca	1.58	1.49	1.98	1.24	1.30	1.88	1.24	1.89	2.34	1.56	1.41	2.19	1.35	2.24	1.71
Na	2.30	2.45	1.97	2.64	2.58	2.10	2.66	2.05	1.59	2.33	2.50	1.77	2.54	1.67	2.22
K	0.06	0.07	0.04	0.07	0.08	0.03	0.05	0.03	0.03	0.07	0.06	0.03	0.08	0.03	0.06
Sr	0.02	0.01	0.02	0.02	0.01	0.03	0.02	0.02	0.03	0.02	0.01	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	19.99	20.03	20.03	20.01	20.00	20.04	19.98	20.01	20.02	19.99	20.02	20.03	19.99	20.00	20.01
Ab	58.4	61.2	49.4	66.8	65.2	52.4	67.4	51.7	40.2	58.9	62.9	44.3	64.1	42.3	55.7
An	40.1	37.1	49.6	31.4	32.8	46.8	31.4	47.6	59.2	39.4	35.5	55.0	33.9	56.9	42.8
Or	1.5	1.7	1.0	1.9	2.0	0.8	1.1	0.7	0.7	1.7	1.6	0.7	2.0	0.8	1.4

Table C.2. Feldspar Analysis

Sample K-66

Point	2	6	7	8	11	12	13	19	20	21	23	26	27	28	29	33	34
Location	i	c	i	i	c	i	i	c	i	r	i	c	i	c	i	c	i
SiO2	55.55	56.18	58.94	59.19	58.02	58.21	54.62	54.98	58.56	59.40	54.49	58.53	55.56	55.33	54.99	58.14	56.07
Al2O3	27.81	27.48	25.63	25.53	26.18	25.80	28.27	28.15	26.10	25.22	28.88	26.09	27.89	28.16	28.25	26.14	27.52
FeO	0.35	0.34	0.36	0.30	0.31	0.32	0.33	0.31	0.33	0.29	0.30	0.25	0.30	0.18	0.25	0.30	0.30
CaO	9.89	9.51	7.25	7.30	8.02	7.80	10.46	10.06	7.77	6.97	10.94	7.77	9.77	10.01	10.34	8.03	9.59
Na2O	5.80	5.90	7.27	7.22	6.95	6.86	5.60	5.85	7.09	7.34	5.21	6.95	5.71	5.70	5.43	6.76	5.97
K2O	0.20	0.23	0.33	0.32	0.29	0.31	0.18	0.21	0.32	0.33	0.15	0.32	0.23	0.23	0.19	0.25	0.21
SrO	0.17	0.16	0.13	0.20	0.20	0.18	0.17	0.19	0.18	0.15	0.21	0.21	0.16	0.10	0.22	0.15	0.13
BaO	0.02	0.06	0.06	0.04	0.04	0.03	0.02	0.07	0.00	0.04	0.01	0.11	0.05	0.02	0.04	0.07	0.06
Total	99.79	99.84	99.97	100.09	100.00	99.50	99.65	99.80	100.34	99.73	100.20	100.23	99.66	99.74	99.70	99.84	99.84
Number of ions on the basis of 32O																	
Si	10.04	10.14	10.56	10.59	10.42	10.49	9.91	9.96	10.47	10.65	9.84	10.47	10.05	10.00	9.96	10.44	10.12
Al	5.93	5.84	5.41	5.38	5.54	5.48	6.05	6.01	5.50	5.33	6.14	5.50	5.94	6.00	6.03	5.53	5.85
Fe	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.04	0.04	0.03	0.04	0.04	0.05
Ca	1.92	1.84	1.39	1.40	1.54	1.51	2.03	1.95	1.49	1.34	2.12	1.49	1.89	1.94	2.01	1.54	1.85
Na	2.03	2.06	2.53	2.50	2.42	2.40	1.97	2.05	2.46	2.55	1.82	2.41	2.00	2.00	1.91	2.35	2.09
K	0.05	0.05	0.08	0.07	0.07	0.07	0.04	0.05	0.07	0.08	0.04	0.07	0.05	0.05	0.04	0.06	0.05
Sr	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Total	20.03	20.00	20.04	20.01	20.05	20.01	20.07	20.09	20.05	20.00	20.02	20.02	20.01	20.03	20.00	20.00	20.02
Ab	50.9	52.2	63.3	63.0	60.1	60.3	48.7	50.6	61.1	64.3	45.9	60.7	50.7	50.1	48.2	59.5	52.3
An	48.0	46.5	34.8	35.2	38.3	37.9	50.3	48.2	37.0	33.8	53.3	37.5	48.0	48.6	50.7	39.0	46.5
Or	1.1	1.3	1.9	1.8	1.6	1.8	1.0	1.2	1.8	1.9	0.9	1.8	1.3	1.3	1.1	1.4	1.2

Table C.2. Feldspar Analysis
Sample K-66d

Point	7	8	9	11	12	13	15	16	20	21
Location	i	i	i	i	i	i	i	i	i	r
SiO2	58.59	54.03	57.93	56.05	57.70	54.75	54.49	58.11	55.11	57.69
Al2O3	25.38	28.41	25.84	27.11	25.88	27.95	27.90	25.70	27.80	26.12
FeO	0.36	0.36	0.33	0.27	0.38	0.34	0.39	0.35	0.38	0.35
CaO	7.54	10.70	7.75	9.14	8.04	10.20	10.25	7.59	10.07	8.10
Na2O	7.19	5.31	6.82	6.24	6.77	5.53	5.68	6.97	5.85	6.79
K2O	0.32	0.19	0.29	0.21	0.25	0.18	0.18	0.32	0.18	0.27
SrO	0.16	0.16	0.21	0.16	0.16	0.14	0.19	0.14	0.17	0.17
BaO	0.02	0.04	0.02	0.04	0.03	0.09	0.04	0.01	0.05	0.04
Total	99.56	99.19	99.18	99.21	99.20	99.18	99.11	99.19	99.59	99.54
Number of ions on the basis of 32O										
Si	10.55	9.86	10.47	10.17	10.44	9.97	9.94	10.50	10.00	10.41
Al	5.39	6.11	5.50	5.80	5.52	6.00	6.00	5.47	5.94	5.55
Fe	0.05	0.06	0.05	0.04	0.06	0.05	0.06	0.05	0.06	0.05
Ca	1.45	2.09	1.50	1.78	1.56	1.99	2.00	1.47	1.96	1.57
Na	2.51	1.88	2.39	2.19	2.37	1.95	2.01	2.44	2.06	2.37
K	0.07	0.04	0.07	0.05	0.06	0.04	0.04	0.07	0.04	0.06
Sr	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Total	20.05	20.05	20.00	20.05	20.02	20.03	20.08	20.02	20.08	20.03
Ab	62.2	46.8	60.4	54.6	59.5	49.0	49.6	61.3	50.7	59.3
An	36.0	52.1	38.0	44.2	39.0	49.9	49.4	36.9	48.3	39.1
Or	1.8	1.1	1.7	1.2	1.4	1.0	1.1	1.8	1.0	1.5

Table C.2. Feldspar Analysis
Sample K-66l

Point	9	15	17	18	19
Location	i	i	i	i	i
SiO2	55.79	58.91	57.63	53.50	53.73
Al2O3	27.76	25.92	27.84	29.17	28.18
FeO	0.33	0.34	0.29	0.34	0.33
CaO	9.46	7.49	9.55	11.57	10.48
Na2O	5.88	6.93	4.21	4.88	5.33
K2O	0.20	0.28	0.19	0.14	0.18
SrO	0.15	0.19	0.20	0.15	0.14
BaO	0.07	0.00	0.04	0.04	0.09
Total	99.62	100.07	99.95	99.78	98.47
Number of ions on the basis of 32O					
Si	10.09	10.53	10.29	9.72	9.87
Al	5.91	5.46	5.86	6.25	6.10
Fe	0.05	0.05	0.04	0.05	0.05
Ca	1.83	1.43	1.83	2.25	2.06
Na	2.06	2.40	1.46	1.72	1.90
K	0.05	0.06	0.04	0.03	0.04
Sr	0.02	0.02	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.01
Total	20.01	19.97	19.54	20.03	20.05
Ab	52.3	61.6	43.8	42.9	47.4
An	46.5	36.8	54.9	56.3	51.5
Or	1.1	1.7	1.3	0.8	1.1

Table C.2. Feldspar Analysis
Sample K-67

Point	2	15	17	19	20	27	33	34	36
Location	i	c	r	i	r	r	i	c	r
SiO2	55.56	52.67	59.13	52.17	57.39	58.41	55.04	58.24	58.72
Al2O3	27.24	29.45	24.73	29.19	25.42	25.55	27.75	25.86	24.99
FeO	0.43	0.25	0.10	0.36	0.31	0.30	0.53	0.34	0.30
CaO	9.74	11.81	6.48	11.76	7.40	7.38	9.90	7.76	6.80
Na2O	5.82	4.75	7.65	4.62	7.06	7.13	5.68	6.95	7.38
K2O	0.21	0.11	0.26	0.12	0.29	0.29	0.19	0.30	0.33
SrO	0.20	0.16	0.16	0.14	0.12	0.17	0.18	0.16	0.12
BaO	0.01	0.01	0.01	0.04	0.05	0.02	0.01	0.02	0.12
Total	99.22	99.19	98.52	98.40	98.04	99.24	99.27	99.63	98.75
Number of ions on the basis of 32O									
Si	10.10	9.63	10.71	9.62	10.49	10.54	10.01	10.48	10.64
Al	5.84	6.35	5.28	6.35	5.48	5.43	5.95	5.48	5.34
Fe	0.07	0.04	0.02	0.05	0.05	0.05	0.08	0.05	0.05
Ca	1.90	2.31	1.26	2.32	1.45	1.43	1.93	1.50	1.32
Na	2.05	1.68	2.68	1.65	2.50	2.49	2.00	2.42	2.59
K	0.05	0.03	0.06	0.03	0.07	0.07	0.04	0.07	0.08
Sr	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total	20.03	20.05	20.02	20.04	20.05	20.02	20.04	20.02	20.03
Ab	51.3	41.9	67.1	41.2	62.3	62.5	50.4	60.8	65.0
An	47.5	57.5	31.4	58.1	36.1	35.8	48.5	37.5	33.1
Or	1.2	0.6	1.5	0.7	1.7	1.7	1.1	1.7	1.9

Table C.2. Feldspar Analysis

Sample K-68

Point	19	20	21	24	25	26	27	28	31	32	33	35	36	37	38	39	40
Location	i	i	r	c	i	i	i	r	c	i	i	c	i	r	c	i	r
SiO2	60.63	56.82	57.92	58.51	58.49	57.06	58.13	55.74	57.99	58.21	57.03	56.66	56.52	58.96	57.25	57.53	58.17
Al2O3	24.22	27.14	25.52	25.61	25.67	25.99	25.71	27.60	25.94	25.61	26.61	26.77	26.55	25.78	26.27	25.71	25.88
FeO	0.10	0.28	0.25	0.35	0.33	0.35	0.35	0.33	0.37	0.33	0.32	0.31	0.30	0.37	0.26	0.30	0.28
CaO	5.66	8.98	7.42	7.80	7.56	7.83	7.68	9.51	7.98	7.62	8.49	8.86	8.64	7.73	8.16	7.61	7.82
Na2O	7.91	6.37	7.15	6.86	7.05	6.83	7.03	6.02	6.73	6.89	6.42	6.38	6.47	7.10	6.63	6.97	6.84
K2O	0.40	0.25	0.28	0.32	0.33	0.33	0.29	0.20	0.27	0.27	0.24	0.26	0.26	0.29	0.28	0.31	0.28
SrO	0.20	0.16	0.19	0.15	0.18	0.15	0.10	0.25	0.15	0.18	0.18	0.17	0.16	0.19	0.12	0.20	0.15
BaO	0.06	0.03	0.05	0.07	0.05	0.07	0.03	0.00	0.01	0.04	0.07	0.03	0.03	0.04	0.02	0.06	0.04
Total	99.17	100.04	98.78	99.66	99.65	98.62	99.33	99.65	99.44	99.15	99.35	99.43	98.94	100.45	98.99	98.68	99.44
Number of ions on the basis of 32O																	
Si	10.88	10.22	10.51	10.52	10.52	10.39	10.49	10.09	10.46	10.52	10.31	10.25	10.27	10.52	10.37	10.46	10.48
Al	5.12	5.75	5.46	5.43	5.44	5.58	5.47	5.89	5.51	5.45	5.67	5.71	5.69	5.42	5.61	5.51	5.49
Fe	0.01	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.04
Ca	1.09	1.73	1.44	1.50	1.46	1.53	1.48	1.84	1.54	1.47	1.65	1.72	1.68	1.48	1.58	1.48	1.51
Na	2.75	2.22	2.52	2.39	2.46	2.41	2.46	2.11	2.35	2.41	2.25	2.24	2.28	2.46	2.33	2.46	2.39
K	0.09	0.06	0.07	0.07	0.08	0.08	0.07	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.06
Sr	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02
Ba	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total	19.98	20.04	20.05	19.99	20.02	20.06	20.04	20.05	20.00	19.99	20.01	20.04	20.05	20.03	20.02	20.05	20.00
Ab	70.0	55.4	62.5	60.3	61.6	60.1	61.3	52.8	59.5	61.1	56.9	55.8	56.7	61.4	58.6	61.3	60.3
An	27.7	43.2	35.9	37.8	36.5	38.0	37.0	46.1	39.0	37.3	41.7	42.8	41.8	37.0	39.8	37.0	38.1
Or	2.3	1.4	1.6	1.8	1.9	1.9	1.7	1.1	1.6	1.6	1.4	1.5	1.5	1.6	1.6	1.8	1.6

Table C.2. Feldspar Analysis

Sample K-69

Point	1	2	3	14	15	16	17	18	19	20	21	22	26	28	29	30
Location	c	i	r	c	i	r	c	r	r	c	i	r	i	c	i	r
SiO2	56.28	57.27	58.20	55.82	57.42	57.36	57.07	59.49	56.91	56.75	51.75	57.93	57.79	55.24	57.65	56.95
Al2O3	27.09	26.21	25.54	27.63	26.56	25.97	26.54	25.20	26.26	26.96	29.57	26.32	26.15	27.82	26.04	26.64
FeO	0.37	0.33	0.31	0.30	0.29	0.39	0.27	0.31	0.34	0.27	0.34	0.34	0.50	0.31	0.32	0.28
CaO	9.36	8.33	7.78	9.72	8.48	8.26	8.52	7.02	8.53	9.06	12.24	8.36	8.18	10.19	8.20	8.88
Na2O	6.03	6.62	6.95	5.80	6.48	6.67	6.62	7.38	6.36	6.33	4.40	6.67	6.69	5.65	6.72	6.32
K2O	0.20	0.23	0.25	0.18	0.25	0.21	0.25	0.33	0.24	0.22	0.11	0.21	0.23	0.21	0.27	0.19
SrO	0.13	0.20	0.14	0.15	0.15	0.13	0.17	0.16	0.11	0.14	0.16	0.16	0.10	0.16	0.20	0.20
BaO	0.06	0.05	0.04	0.00	0.05	0.06	0.01	0.06	0.08	0.05	0.01	0.07	0.04	0.00	0.04	0.04
Total	99.51	99.24	99.21	99.60	99.67	99.05	99.44	99.94	98.83	99.78	98.59	100.07	99.67	99.59	99.44	99.49
Number of ions on the basis of 32O																
Si	10.18	10.37	10.51	10.09	10.34	10.40	10.31	10.65	10.34	10.23	9.54	10.39	10.41	10.01	10.41	10.29
Al	5.78	5.59	5.44	5.89	5.64	5.55	5.65	5.31	5.63	5.73	6.42	5.57	5.55	5.94	5.54	5.67
Fe	0.06	0.05	0.05	0.05	0.04	0.06	0.04	0.05	0.05	0.04	0.05	0.05	0.07	0.05	0.05	0.04
Ca	1.81	1.62	1.51	1.88	1.64	1.60	1.65	1.35	1.66	1.75	2.42	1.61	1.58	1.98	1.59	1.72
Na	2.12	2.32	2.43	2.03	2.26	2.34	2.32	2.56	2.24	2.21	1.57	2.32	2.34	1.99	2.35	2.21
K	0.05	0.05	0.06	0.04	0.06	0.05	0.06	0.07	0.06	0.05	0.03	0.05	0.05	0.05	0.06	0.04
Sr	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Total	20.01	20.03	20.01	20.00	20.00	20.02	20.05	20.01	19.99	20.04	20.05	20.01	20.01	20.03	20.03	20.00
Ab	53.2	58.2	60.9	51.4	57.2	58.6	57.6	64.3	56.6	55.1	39.1	58.4	58.9	49.5	58.8	55.7
An	45.6	40.5	37.7	47.6	41.4	40.1	41.0	33.8	42.0	43.6	60.2	40.4	39.8	49.3	39.7	43.2
Or	1.2	1.3	1.5	1.0	1.4	1.2	1.4	1.9	1.4	1.3	0.7	1.2	1.3	1.2	1.5	1.1

Table C.2. Feldspar Analysis
Sample K-71

Point	1	2	5	13	17	18	19	20
Location	i	c	i	i	i	i	r	c
SiO2	55.27	51.16	54.37	50.11	58.38	57.64	56.48	51.20
Al2O3	27.36	29.54	28.16	29.96	25.53	26.28	26.79	30.57
FeO	0.24	0.56	0.54	0.83	0.37	0.31	0.35	0.70
CaO	9.26	12.00	10.63	13.28	7.71	8.41	9.03	13.39
Na2O	6.09	4.43	5.20	3.79	6.88	6.47	5.91	3.66
K2O	0.22	0.14	0.16	0.13	0.26	0.26	0.23	0.09
SrO	0.19	0.22	0.14	0.20	0.16	0.16	0.26	0.19
BaO	0.05	0.01	0.07	0.01	0.06	0.02	0.01	0.05
Total	98.68	98.05	99.28	98.29	99.35	99.55	99.06	99.85
Number of ions on the basis of 32O								
Si	10.09	9.50	9.91	9.32	10.53	10.39	10.25	9.36
Al	5.89	6.46	6.05	6.57	5.43	5.58	5.73	6.58
Fe	0.04	0.09	0.08	0.13	0.06	0.05	0.05	0.11
Ca	1.81	2.39	2.08	2.65	1.49	1.62	1.76	2.62
Na	2.16	1.60	1.84	1.37	2.41	2.26	2.08	1.30
K	0.05	0.03	0.04	0.03	0.06	0.06	0.05	0.02
Sr	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	20.07	20.08	20.01	20.09	19.99	19.98	19.95	20.01
Ab	53.7	39.7	46.5	33.8	60.8	57.4	53.5	32.9
An	45.1	59.4	52.5	65.4	37.7	41.2	45.2	66.6
Or	1.3	0.8	1.0	0.7	1.5	1.5	1.4	0.5

Table C.2. Feldspar Analysis
Sample K-16 Klycuhevskoi

Point	6	9	10	14	15	18	37
Location	i	i	i	i	i	i	i
SiO2	59.12	57.02	59.33	56.67	58.96	57.67	59.66
Al2O3	24.92	26.76	25.99	26.68	25.88	26.21	25.25
FeO	0.53	0.52	0.49	0.42	0.42	0.52	0.56
CaO	6.80	8.83	7.63	8.69	7.69	8.47	7.06
Na2O	7.51	6.34	7.27	6.40	6.99	6.64	7.31
K2O	0.39	0.20	0.25	0.27	0.33	0.26	0.33
SrO	0.16	0.15	0.19	0.13	0.13	0.11	0.07
BaO	0.04	0.09	0.05	0.07	0.03	0.02	0.04
Total	99.47	99.91	101.19	99.31	100.42	99.91	100.28
Number of ions on the basis of 32O							
Si	10.65	10.27	10.52	10.27	10.52	10.38	10.64
Al	5.29	5.68	5.43	5.70	5.44	5.56	5.31
Fe	0.08	0.08	0.07	0.06	0.06	0.08	0.08
Ca	1.31	1.70	1.45	1.69	1.47	1.63	1.35
Na	2.62	2.21	2.50	2.25	2.42	2.32	2.53
K	0.09	0.05	0.06	0.06	0.08	0.06	0.07
Sr	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Ba	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Total	20.06	20.02	20.05	20.04	20.01	20.03	20.00
Ab	65.2	55.9	62.4	56.2	61.0	57.8	64.0
An	32.6	43.0	36.2	42.2	37.1	40.7	34.1
Or	2.2	1.2	1.4	1.5	1.9	1.5	1.9

Table C.3. Amphibole Analysis
Sample K-1

Point	1	14	18	2	21	22
SiO2	45.16	43.66	44.93	42.26	46.75	46.61
TiO2	1.38	1.25	1.80	1.24	1.63	1.11
Al2O3	10.88	11.21	10.30	12.98	8.33	9.11
FeO	11.04	11.95	13.82	15.65	12.92	13.55
MnO	0.19	0.22	0.32	0.38	0.37	0.40
MgO	15.77	14.51	13.97	11.77	15.07	14.69
CaO	11.47	11.54	10.73	10.64	11.10	11.10
Na2O	2.15	2.16	2.04	2.83	1.85	1.76
K2O	0.46	0.44	0.39	0.54	0.37	0.29
F	0.00	0.00	0.15	1.69	0.00	0.00
Total	98.51	96.95	98.44	99.97	98.37	98.61
TSi	6.50	6.42	6.57	6.29	6.79	6.75
TAl	1.50	1.58	1.43	1.71	1.21	1.25
TFe3	0.00	0.00	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00	8.00	8.00
CAl	0.35	0.36	0.35	0.56	0.22	0.30
CFe3	0.17	0.24	0.04	0.00	0.05	0.17
CTi	0.15	0.14	0.20	0.14	0.18	0.12
CMg	3.38	3.18	3.05	2.61	3.26	3.17
CFe2	0.95	1.08	1.37	1.69	1.30	1.25
CMn	0.00	0.00	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00	0.00	0.00
BFe2	0.21	0.15	0.28	0.26	0.23	0.23
BMn	0.02	0.03	0.04	0.05	0.05	0.05
BCa	1.77	1.82	1.68	1.70	1.73	1.72
BNa	0.00	0.00	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00	0.00	0.00
ANa	0.60	0.62	0.58	0.82	0.52	0.49
AK	0.08	0.08	0.07	0.10	0.07	0.05
Sum_A	0.68	0.70	0.65	0.92	0.59	0.55
Sum_cat	15.68	15.70	15.65	15.92	15.59	15.55

Table C.3. Amphibole Analysis
Sample K-9

Point	1	6	11	20
SiO2	42.94	47.89	45.98	48.59
TiO2	1.55	1.83	1.91	1.40
Al2O3	12.21	7.32	8.63	6.22
FeO	12.99	10.35	11.98	11.47
MnO	0.29	0.26	0.23	0.30
MgO	14.34	17.04	15.80	16.72
CaO	11.27	11.19	11.20	10.95
Na2O	2.33	1.72	1.97	1.45
K2O	0.50	0.30	0.44	0.34
F	0.19	0.20	0.15	0.16
Total	98.59	98.09	98.29	97.61
TSi	6.25	6.90	6.67	7.04
TAl	1.75	1.10	1.33	0.96
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.34	0.14	0.15	0.11
CFe3	0.32	0.03	0.13	0.08
CTi	0.17	0.20	0.21	0.15
CMg	3.11	3.66	3.42	3.61
CFe2	1.06	0.97	1.10	1.05
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.21	0.24	0.23	0.26
BMn	0.04	0.03	0.03	0.04
BCa	1.76	1.73	1.74	1.70
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.66	0.48	0.56	0.41
AK	0.09	0.06	0.08	0.06
Sum_A	0.75	0.54	0.64	0.47
Sum_cat	15.75	15.54	15.64	15.47

Table C.3. Amphibole Analysis
Sample K-12

Point	7	8	13	17
SiO2	44.05	46.25	41.12	45.07
TiO2	2.04	2.07	1.36	2.30
Al2O3	8.94	8.18	14.25	9.56
FeO	11.97	11.33	14.43	12.37
MnO	0.23	0.26	0.23	0.26
MgO	15.22	16.01	12.62	14.97
CaO	11.09	11.10	10.83	11.16
Na2O	2.66	2.06	2.38	2.08
K2O	0.48	0.39	0.38	0.50
F	0.11	0.20	0.10	0.08
Total	96.79	97.86	97.69	98.35
TSi	6.55	6.74	6.07	6.57
TAl	1.45	1.26	1.93	1.43
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.12	0.15	0.55	0.21
CFe3	0.02	0.00	0.33	0.03
CTi	0.23	0.23	0.15	0.25
CMg	3.37	3.48	2.78	3.25
CFe2	1.26	1.14	1.20	1.25
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.20	0.23	0.26	0.23
BMn	0.03	0.03	0.03	0.03
BCa	1.77	1.73	1.71	1.74
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.77	0.58	0.68	0.59
AK	0.09	0.07	0.07	0.09
Sum_A	0.86	0.65	0.75	0.68
Sum_cat	15.86	15.65	15.75	15.68

Table C.3. Amphibole Analysis
Sample K-14

Point	16	18
SiO2	47.69	46.80
TiO2	1.40	1.85
Al2O3	6.96	7.38
FeO	11.87	11.56
MnO	0.33	0.27
MgO	16.33	16.17
CaO	10.84	11.02
Na2O	1.63	1.86
K2O	0.29	0.37
F	0.20	0.11
Total	97.53	97.39
TSi	6.938	6.837
TAl	1.062	1.163
TFe3	0.000	0.000
TTi	0.000	0.000
Sum_T	8.000	8.000
CAl	0.131	0.106
CFe3	0.113	0.055
CTi	0.153	0.204
CMg	3.542	3.521
CFe2	1.061	1.115
CMn	0.000	0.000
CCa	0.000	0.000
Sum_C	5.000	5.000
BMg	0.000	0.000
BFe2	0.270	0.242
BMn	0.040	0.034
BCa	1.690	1.724
BNa	0.000	0.000
Sum_B	2.000	2.000
ACa	0.000	0.000
ANa	0.459	0.527
AK	0.053	0.068
Sum_A	0.512	0.595
Sum_cat	15.512	15.595

Table C.3. Amphibole

Sample K-18	
Point	23
SiO2	44.51
TiO2	1.18
Al2O3	12.48
FeO	11.66
MnO	0.22
MgO	15.35
CaO	11.20
Na2O	2.79
K2O	0.38
F	0.08
Total	99.86
TSi	6.364
TAl	1.636
TFe3	0.000
TTi	0.000
Sum_T	8.000
CAl	0.465
CFe3	0.074
CTi	0.127
CMg	3.272
CFe2	1.062
CMn	0.000
CCa	0.000
Sum_C	5.000
BMg	0.000
BFe2	0.258
BMn	0.027
BCa	1.715
BNa	0.000
Sum_B	2.000
ACa	0.000
ANa	0.774
AK	0.069
Sum_A	0.843
Sum_cat	15.843

Table C.3. Amphibole Analysis
Sample K-21

Point	1	17	25	30
SiO2	45.39	44.79	45.80	47.48
TiO2	2.33	1.21	2.27	1.49
Al2O3	8.88	10.60	8.43	7.30
FeO	12.18	11.46	11.80	11.76
MnO	0.30	0.22	0.26	0.30
MgO	15.34	15.12	15.79	16.45
CaO	11.08	11.30	11.12	10.82
Na2O	2.19	2.18	3.32	2.19
K2O	0.47	0.30	0.38	0.28
F	0.25	0.10	0.18	0.18
Total	98.42	97.27	99.35	98.24
TSi	6.62	6.55	6.67	6.89
TAl	1.38	1.45	1.33	1.11
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.15	0.37	0.12	0.14
CFe3	0.01	0.14	0.00	0.00
CTi	0.26	0.13	0.25	0.16
CMg	3.34	3.30	3.43	3.56
CFe2	1.25	1.06	1.20	1.15
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.23	0.20	0.23	0.28
BMn	0.04	0.03	0.03	0.04
BCa	1.73	1.77	1.74	1.68
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.62	0.62	0.94	0.62
AK	0.09	0.06	0.07	0.05
Sum_A	0.71	0.67	1.01	0.67
Sum_cat	15.71	15.67	16.01	15.67

Table C.3. Amphibole Analysis
Sample K-26

Point	1	5	7	22
SiO2	45.92	43.48	44.82	50.35
TiO2	1.74	1.88	1.10	1.00
Al2O3	7.73	11.70	10.37	6.07
FeO	11.63	13.96	13.73	10.96
MnO	0.32	0.31	0.40	0.44
MgO	15.50	13.36	14.41	17.54
CaO	10.88	10.71	9.94	10.28
Na2O	1.64	2.27	1.82	1.27
K2O	0.31	0.30	0.27	0.16
F	0.11	0.48	0.07	0.18
Total	95.78	98.46	96.92	98.25
TSi	6.81	6.39	6.60	7.20
TAl	1.19	1.61	1.40	0.80
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.17	0.42	0.40	0.22
CFe3	0.10	0.07	0.18	0.00
CTi	0.20	0.21	0.12	0.11
CMg	3.43	2.93	3.16	3.74
CFe2	1.11	1.38	1.13	0.94
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.23	0.27	0.38	0.37
BMn	0.04	0.04	0.05	0.05
BCa	1.73	1.69	1.57	1.58
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.47	0.65	0.52	0.35
AK	0.06	0.06	0.05	0.03
Sum_A	0.53	0.70	0.57	0.38
Sum_cat	15.53	15.70	15.57	15.38

Table C.3. Amphibole Analysis
Sample K-27

Point	1	2	10	12	17	18
SiO2	50.28	42.63	44.93	41.96	44.12	45.94
TiO2	1.25	1.85	1.31	1.66	1.70	2.14
Al2O3	5.36	12.25	9.41	12.69	10.86	8.44
FeO	10.98	13.58	13.48	13.15	10.60	11.93
MnO	0.29	0.31	0.37	0.20	0.14	0.28
MgO	17.65	13.77	14.46	13.78	16.21	15.62
CaO	10.61	11.20	10.89	11.22	11.14	11.02
Na2O	1.32	2.40	1.80	2.42	2.34	1.98
K2O	0.20	0.35	0.41	0.33	0.50	0.39
F	0.10	0.16	0.19	0.00	0.56	0.16
Total	98.03	98.49	97.24	97.42	98.18	97.89
TSi	7.21	6.23	6.62	6.18	6.41	6.70
TAl	0.79	1.77	1.38	1.82	1.59	1.30
TFe3	0.00	0.00	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00	8.00	8.00
CAl	0.11	0.34	0.25	0.38	0.27	0.15
CFe3	0.01	0.27	0.25	0.33	0.20	0.04
CTi	0.13	0.20	0.15	0.18	0.19	0.24
CMg	3.77	3.00	3.18	3.02	3.51	3.40
CFe2	0.97	1.18	1.18	1.09	0.84	1.17
CMn	0.00	0.00	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00	0.00	0.00
BFe2	0.34	0.21	0.24	0.20	0.25	0.24
BMn	0.04	0.04	0.05	0.03	0.02	0.04
BCa	1.63	1.75	1.72	1.77	1.73	1.72
BNa	0.00	0.00	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00	0.00	0.00
ANa	0.37	0.68	0.51	0.69	0.66	0.56
AK	0.04	0.07	0.08	0.06	0.09	0.07
Sum_A	0.41	0.75	0.59	0.75	0.75	0.63
Sum_cat	15.41	15.75	15.59	15.75	15.75	15.63

Table C.3. Amphibole Analysis
Sample K-32

Point	15	21	31	9
SiO2	45.46	39.61	44.33	46.13
TiO2	2.50	2.34	2.98	1.63
Al2O3	8.82	8.78	10.01	7.70
FeO	11.91	12.35	12.24	11.96
MnO	0.25	0.34	0.24	0.38
MgO	15.36	13.58	14.71	16.01
CaO	11.10	14.82	10.96	10.66
Na2O	1.85	1.71	1.93	1.44
K2O	0.48	0.39	0.47	0.29
F	0.08	0.07	0.08	0.17
Total	97.79	93.98	97.94	96.36
TSi	6.64	6.04	6.49	6.78
TAl	1.36	1.58	1.51	1.22
TFe3	0.00	0.39	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.16	0.00	0.22	0.11
CFe3	0.04	0.85	0.01	0.28
CTi	0.27	0.27	0.33	0.18
CMg	3.34	3.08	3.21	3.51
CFe2	1.19	0.34	1.24	0.92
CMn	0.00	0.04	0.00	0.00
CCa	0.00	0.42	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.23	0.00	0.25	0.27
BMn	0.03	0.00	0.03	0.05
BCa	1.74	2.00	1.72	1.68
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.52	0.50	0.55	0.41
AK	0.09	0.08	0.09	0.06
Sum_A	0.61	0.58	0.64	0.47
Sum_cat	15.61	15.58	15.64	15.47

Table C.3. Amphibole
Sample K-41

Point	14
SiO2	46.66
TiO2	1.64
Al2O3	7.94
FeO	12.39
MnO	0.35
MgO	15.25
CaO	11.08
Na2O	1.76
K2O	0.41
F	0.13
Total	97.61
TSi	6.83
TAl	1.17
TFe3	0.00
TTi	0.00
Sum_T	8.00
CAl	0.20
CFe3	0.04
CTi	0.18
CMg	3.33
CFe2	1.26
CMn	0.00
CCa	0.00
Sum_C	5.00
BMg	0.00
BFe2	0.22
BMn	0.04
BCa	1.74
BNa	0.00
Sum_B	2.00
ACa	0.00
ANa	0.50
AK	0.08
Sum_A	0.57
Sum_cat	15.57

Table C.3. Amphibole Analysis
Sample K-45(1)

Point	2	13	21	22
SiO2	45.31	47.93	44.41	48.13
TiO2	2.22	1.95	1.42	1.73
Al2O3	9.10	7.24	10.97	7.21
FeO	12.23	11.24	12.64	10.87
MnO	0.24	0.29	0.28	0.26
MgO	15.38	16.26	14.73	17.05
CaO	11.02	11.18	11.22	11.12
Na2O	2.05	1.77	2.09	1.64
K2O	0.44	0.34	0.49	0.32
F	0.17	0.17	0.09	0.21
Total	98.15	98.37	98.34	98.54
TSi	6.61	6.93	6.46	6.90
TAl	1.39	1.07	1.54	1.10
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.17	0.16	0.33	0.12
CFe3	0.08	0.00	0.22	0.08
CTi	0.24	0.21	0.16	0.19
CMg	3.34	3.50	3.19	3.65
CFe2	1.17	1.13	1.10	0.96
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.25	0.23	0.22	0.26
BMn	0.03	0.04	0.03	0.03
BCa	1.72	1.73	1.75	1.71
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.58	0.50	0.59	0.46
AK	0.08	0.06	0.09	0.06
Sum_A	0.66	0.56	0.68	0.52
Sum_cat	15.66	15.56	15.68	15.52

Table C.3. Amphibole Analysis
Sample K-46

Point	1	2	20	24
SiO2	46.60	47.90	47.26	47.97
TiO2	1.98	1.30	1.88	1.58
Al2O3	8.75	7.66	8.06	7.59
FeO	12.38	12.53	11.74	11.31
MnO	0.30	0.34	0.30	0.35
MgO	15.01	15.70	15.48	16.23
CaO	10.91	10.75	11.05	10.92
Na2O	1.93	1.57	1.75	1.64
K2O	0.38	0.36	0.33	0.28
F	0.11	0.15	0.17	0.11
Total	98.33	98.26	98.01	97.98
TSi	6.78	6.94	6.87	6.94
TAl	1.22	1.06	1.13	1.07
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.28	0.24	0.25	0.23
CFe3	0.00	0.03	0.00	0.00
CTi	0.22	0.14	0.21	0.17
CMg	3.26	3.39	3.36	3.50
CFe2	1.25	1.20	1.19	1.10
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.26	0.29	0.24	0.27
BMn	0.04	0.04	0.04	0.04
BCa	1.70	1.67	1.72	1.69
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.54	0.44	0.49	0.46
AK	0.07	0.07	0.06	0.05
Sum_A	0.61	0.51	0.55	0.51
Sum_cat	15.61	15.51	15.55	15.51

Table 49. Amphibole Analysis
Sample K-49

Point	1	2	7	14	15
SiO2	43.11	42.98	41.19	48.84	46.00
TiO2	1.75	1.77	1.96	1.50	2.25
Al2O3	12.55	12.54	13.60	6.82	8.59
FeO	11.26	11.17	14.66	11.48	12.03
MnO	0.17	0.15	0.25	0.29	0.26
MgO	15.42	14.99	11.76	16.55	15.36
CaO	11.06	11.28	11.44	11.17	10.92
Na2O	2.44	2.46	2.30	1.52	2.06
K2O	0.50	0.50	0.68	0.26	0.47
F	0.00	0.15	0.07	0.10	0.24
Total	98.25	97.98	97.92	98.51	98.19
TSi	6.24	6.26	6.12	7.01	6.72
TAl	1.76	1.74	1.88	0.99	1.28
TFe3	0.00	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00	8.00
CAl	0.38	0.41	0.50	0.17	0.20
CFe3	0.22	0.15	0.15	0.03	0.00
CTi	0.19	0.19	0.22	0.16	0.25
CMg	3.33	3.26	2.61	3.54	3.35
CFe2	0.88	0.99	1.53	1.10	1.21
CMn	0.00	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00	0.00
BFe2	0.26	0.22	0.15	0.25	0.26
BMn	0.02	0.02	0.03	0.04	0.03
BCa	1.72	1.76	1.82	1.72	1.71
BNa	0.00	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00	0.00
ANa	0.69	0.69	0.66	0.42	0.58
AK	0.09	0.09	0.13	0.05	0.09
Sum_A	0.78	0.79	0.79	0.47	0.67
Sum_cat	15.78	15.79	15.79	15.47	15.67

Table C.3. Amphibole Analysis
Sample K-52

Point	1	3	16
SiO2	43.77	45.29	43.17
TiO2	1.31	2.28	1.51
Al2O3	12.15	9.18	12.31
FeO	13.75	12.42	13.36
MnO	0.27	0.30	0.23
MgO	13.07	14.69	14.63
CaO	10.63	10.93	10.54
Na2O	2.78	2.14	2.81
K2O	0.44	0.44	0.32
F	0.09	0.22	0.12
Total	98.23	97.90	98.99
TSi	6.46	6.66	6.27
TAl	1.54	1.34	1.73
TFe3	0.00	0.00	0.00
TTi	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00
CAl	0.57	0.25	0.38
CFe3	0.00	0.00	0.18
CTi	0.15	0.25	0.17
CMg	2.87	3.22	3.17
CFe2	1.41	1.29	1.12
CMn	0.00	0.00	0.00
CCa	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00
BMg	0.00	0.00	0.00
BFe2	0.29	0.24	0.33
BMn	0.03	0.04	0.03
BCa	1.68	1.72	1.64
BNa	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00
ACa	0.00	0.00	0.00
ANa	0.80	0.61	0.79
AK	0.08	0.08	0.06
Sum_A	0.88	0.69	0.85
Sum_cat	15.88	15.69	15.85

Table C.3. Amphibole

Sample K-56	
Point	20
SiO2	44.83
TiO2	1.36
Al2O3	11.79
FeO	8.78
MnO	0.11
MgO	17.33
CaO	10.80
Na2O	2.46
K2O	0.63
F	0.10
Total	98.19
TSi	6.43
TAl	1.57
TFe3	0.00
TTi	0.00
Sum_T	8.00
CAl	0.42
CFe3	0.06
CTi	0.15
CMg	3.71
CFe2	0.67
CMn	0.00
CCa	0.00
Sum_C	5.00
BMg	0.00
BFe2	0.33
BMn	0.01
BCa	1.66
BNa	0.00
Sum_B	2.00
ACa	0.00
ANa	0.69
AK	0.11
Sum_A	0.80
Sum_cat	15.80

Table C.3. Amphibole Analysis
Sample K-62

Point	7	14	15	22
SiO2	47.26	42.97	45.80	47.97
TiO2	1.35	1.53	2.28	1.89
Al2O3	7.34	12.40	8.52	7.14
FeO	13.66	12.95	10.75	10.54
MnO	0.41	0.23	0.20	0.23
MgO	15.09	14.30	16.50	17.14
CaO	11.00	10.92	11.53	11.24
Na2O	1.43	2.45	2.02	1.81
K2O	0.63	0.44	0.37	0.34
F	0.00	0.00	0.24	0.21
Total	98.16	98.19	98.19	98.50
TSi	6.89	6.27	6.63	6.89
TAl	1.11	1.73	1.37	1.11
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.14	0.40	0.08	0.10
CFe3	0.15	0.21	0.16	0.03
CTi	0.15	0.17	0.25	0.20
CMg	3.28	3.11	3.56	3.67
CFe2	1.28	1.10	0.95	0.99
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.23	0.27	0.19	0.24
BMn	0.05	0.03	0.02	0.03
BCa	1.72	1.71	1.79	1.73
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.41	0.69	0.57	0.51
AK	0.12	0.08	0.07	0.06
Sum_A	0.52	0.78	0.63	0.57
Sum_cat	15.52	15.78	15.63	15.57

Table C.3. Amphibole Analysis
Sample K-64

Point	1	24	30	36
SiO2	48.81	46.14	44.05	44.71
TiO2	1.48	2.05	2.73	1.36
Al2O3	6.19	8.37	9.28	10.56
FeO	10.97	11.34	11.88	12.05
MnO	0.27	0.27	0.25	0.20
MgO	17.02	15.95	15.05	15.16
CaO	11.16	11.03	11.23	11.07
Na2O	1.49	1.90	2.14	2.11
K2O	0.31	0.40	0.50	0.32
F	0.22	0.09	0.09	0.10
Total	97.91	97.53	97.19	97.63
TSi	7.04	6.73	6.50	6.52
TAl	0.96	1.27	1.50	1.48
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.10	0.17	0.11	0.33
CFe3	0.06	0.04	0.08	0.20
CTi	0.16	0.23	0.30	0.15
CMg	3.66	3.47	3.31	3.30
CFe2	1.02	1.10	1.20	1.03
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.24	0.24	0.19	0.25
BMn	0.03	0.03	0.03	0.03
BCa	1.73	1.72	1.78	1.73
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.42	0.54	0.61	0.60
AK	0.06	0.08	0.09	0.06
Sum_A	0.48	0.61	0.71	0.66
Sum_cat	15.48	15.61	15.71	15.66

Table C.3. Amphibole Analysis
Sample K-64d

Point	3	4	7	8	16	17	18
SiO2	49.18	44.98	50.82	48.20	45.90	48.70	44.86
TiO2	0.92	1.52	0.72	1.48	1.72	1.17	1.57
Al2O3	5.76	9.17	4.75	7.16	8.08	5.92	8.99
FeO	10.86	12.75	10.32	11.32	12.10	10.72	12.39
MnO	0.31	0.27	0.26	0.30	0.30	0.29	0.24
MgO	17.40	14.91	18.12	16.82	15.52	17.24	15.09
CaO	11.16	11.22	11.10	11.16	11.24	11.00	11.11
Na2O	1.42	2.04	1.13	1.75	1.88	1.52	2.00
K2O	0.23	0.58	0.23	0.33	0.37	0.24	0.45
F	0.13	0.15	0.17	0.17	0.77	0.14	0.21
Total	97.35	97.58	97.60	98.69	97.86	96.94	96.90
TSi	7.10	6.61	7.28	6.92	6.73	7.07	6.62
TAl	0.90	1.39	0.72	1.08	1.27	0.93	1.38
TFe3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00	8.00	8.00	8.00
CAl	0.08	0.20	0.08	0.13	0.13	0.09	0.19
CFe3	0.18	0.17	0.13	0.09	0.16	0.11	0.18
CTi	0.10	0.17	0.08	0.16	0.19	0.13	0.17
CMg	3.75	3.27	3.87	3.60	3.39	3.73	3.32
CFe2	0.89	1.20	0.85	1.03	1.13	0.94	1.13
CMn	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BFe2	0.24	0.20	0.27	0.25	0.20	0.25	0.21
BMn	0.04	0.03	0.03	0.04	0.04	0.04	0.03
BCa	1.73	1.77	1.70	1.72	1.77	1.71	1.76
BNa	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ANa	0.40	0.58	0.31	0.49	0.54	0.43	0.57
AK	0.04	0.11	0.04	0.06	0.07	0.04	0.09
Sum_A	0.44	0.69	0.36	0.55	0.60	0.47	0.66
Sum_cat	15.44	15.69	15.36	15.55	15.60	15.47	15.66

Table C.3. Amphibole Analysis
Sample K-64l

Point	5	7	8	10
SiO2	47.22	46.18	47.14	48.26
TiO2	1.44	1.83	2.02	1.93
Al2O3	6.56	7.58	8.52	8.81
FeO	10.92	11.84	11.27	12.07
MnO	0.30	0.25	0.28	0.30
MgO	17.57	16.31	16.52	16.94
CaO	11.43	10.80	11.00	11.19
Na2O	1.67	1.85	2.10	2.11
K2O	0.29	0.42	0.31	0.38
F	0.13	0.32	0.18	0.00
Total	97.52	97.38	99.34	102.00
TSi	6.82	6.76	6.75	6.72
TAl	1.12	1.24	1.25	1.28
TFe3	0.06	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.00	0.07	0.19	0.17
CFe3	0.35	0.17	0.00	0.07
CTi	0.16	0.20	0.22	0.20
CMg	3.78	3.56	3.53	3.52
CFe2	0.71	1.01	1.07	1.04
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.20	0.28	0.28	0.30
BMn	0.04	0.03	0.03	0.04
BCa	1.77	1.69	1.69	1.67
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.47	0.53	0.58	0.57
AK	0.05	0.08	0.06	0.07
Sum_A	0.52	0.60	0.64	0.64
Sum_cat	15.52	15.60	15.64	15.64

Table C.3. Amphibole Analysis
Sample K-65

Point	6	7	18	20	25	26
SiO2	43.40	42.13	46.10	41.79	40.82	43.82
TiO2	2.19	1.63	2.08	1.92	1.85	1.43
Al2O3	10.85	11.86	8.01	12.68	13.87	10.69
FeO	12.09	13.46	12.01	14.38	14.52	9.39
MnO	0.20	0.25	0.28	0.21	0.19	0.16
MgO	14.66	13.78	15.62	12.89	12.55	17.32
CaO	11.11	11.21	11.10	10.35	10.59	10.43
Na2O	2.35	2.37	1.81	2.66	2.70	2.66
K2O	0.49	0.35	0.39	0.40	0.50	0.46
F	0.00	0.05	0.00	0.00	0.00	0.22
Total	97.33	97.09	97.39	97.28	97.57	96.57
TSi	6.39	6.24	6.74	6.23	6.07	6.42
TAl	1.61	1.76	1.26	1.77	1.93	1.58
TFe3	0.00	0.00	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00	8.00	8.00
CAl	0.27	0.30	0.12	0.45	0.50	0.26
CFe3	0.09	0.35	0.09	0.05	0.15	0.17
CTi	0.24	0.18	0.23	0.22	0.21	0.16
CMg	3.22	3.04	3.41	2.86	2.78	3.78
CFe2	1.18	1.13	1.15	1.42	1.37	0.63
CMn	0.00	0.00	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00	0.00	0.00
BFe2	0.22	0.19	0.23	0.32	0.29	0.35
BMn	0.03	0.03	0.04	0.03	0.02	0.02
BCa	1.75	1.78	1.74	1.65	1.69	1.64
BNa	0.00	0.00	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00	0.00	0.00
ANa	0.67	0.68	0.51	0.77	0.78	0.76
AK	0.09	0.07	0.07	0.08	0.10	0.09
Sum_A	0.76	0.75	0.59	0.84	0.87	0.84
Sum_cat	15.76	15.75	15.59	15.84	15.87	15.84

Table C.3. Amphibole Analysis
Sample K-66

Point	1	24	32	35
SiO2	41.70	45.08	46.39	47.77
TiO2	2.17	2.05	2.02	1.73
Al2O3	13.59	10.27	8.36	7.43
FeO	11.13	12.18	12.19	11.76
MnO	0.13	0.24	0.25	0.32
MgO	14.95	15.21	15.54	16.31
CaO	11.65	10.88	11.18	11.12
Na2O	2.35	2.25	1.90	1.67
K2O	0.81	0.38	0.41	0.32
F	0.11	0.12	0.11	0.03
Total	98.58	98.65	98.34	98.46
TSi	6.04	6.54	6.74	6.88
TAl	1.96	1.46	1.26	1.12
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.36	0.29	0.17	0.14
CFe3	0.32	0.02	0.05	0.08
CTi	0.24	0.22	0.22	0.19
CMg	3.23	3.29	3.36	3.50
CFe2	0.86	1.18	1.20	1.09
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.18	0.28	0.23	0.25
BMn	0.02	0.03	0.03	0.04
BCa	1.81	1.69	1.74	1.72
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.66	0.63	0.53	0.47
AK	0.15	0.07	0.08	0.06
Sum_A	0.81	0.70	0.61	0.53
Sum_cat	15.81	15.70	15.61	15.53

Table C.3. Amphibole Analysis
Sample K-66d

Point	14	17	18	19
SiO2	46.97	44.11	45.84	43.13
TiO2	1.87	2.14	1.82	2.39
Al2O3	7.67	9.62	8.87	10.70
FeO	11.18	12.14	12.20	12.90
MnO	0.29	0.30	0.35	0.30
MgO	16.05	14.93	15.40	14.12
CaO	11.28	11.16	11.06	11.11
Na2O	1.70	2.04	1.87	2.15
K2O	0.33	0.48	0.33	0.53
F	0.09	0.08	0.23	0.13
Total	97.42	96.98	97.98	97.46
TSi	6.84	6.51	6.68	6.37
TAl	1.16	1.49	1.32	1.63
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.16	0.18	0.20	0.23
CFe3	0.06	0.16	0.13	0.15
CTi	0.21	0.24	0.20	0.27
CMg	3.48	3.28	3.35	3.11
CFe2	1.10	1.14	1.12	1.24
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.21	0.20	0.23	0.20
BMn	0.04	0.04	0.04	0.04
BCa	1.76	1.76	1.73	1.76
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.48	0.58	0.53	0.62
AK	0.06	0.09	0.06	0.10
Sum_A	0.54	0.67	0.59	0.71
Sum_cat	15.54	15.67	15.59	15.71

Table C.3. Amphibole Analysis
Sample K-66l

Point	7	11	21
SiO2	46.19	47.02	44.41
TiO2	1.29	1.67	2.29
Al2O3	7.84	7.06	9.61
FeO	11.56	10.85	12.60
MnO	0.31	0.26	0.30
MgO	16.25	16.95	14.69
CaO	10.85	11.16	10.97
Na2O	1.72	1.67	2.13
K2O	0.31	0.34	0.45
F	0.15	0.16	0.43
Total	96.47	97.14	97.88
TSi	6.78	6.84	6.54
TAl	1.22	1.16	1.46
TFe3	0.00	0.00	0.00
TTi	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00
CAl	0.14	0.05	0.20
CFe3	0.25	0.21	0.06
CTi	0.14	0.18	0.25
CMg	3.56	3.68	3.22
CFe2	0.91	0.88	1.26
CMn	0.00	0.00	0.00
CCa	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00
BMg	0.00	0.00	0.00
BFe2	0.26	0.23	0.23
BMn	0.04	0.03	0.04
BCa	1.71	1.74	1.73
BNa	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00
ACa	0.00	0.00	0.00
ANa	0.49	0.47	0.61
AK	0.06	0.06	0.09
Sum_A	0.55	0.53	0.69
Sum_cat	15.55	15.53	15.69

Table C.3. Amphibole Analysis
Sample K-67

Point	1	6	23	31
SiO2	45.00	43.70	41.93	43.97
TiO2	2.28	2.24	1.45	1.63
Al2O3	8.96	10.33	12.27	11.18
FeO	12.21	13.47	11.23	10.26
MnO	0.27	0.26	0.16	0.16
MgO	14.95	13.94	15.03	16.15
CaO	11.08	11.04	11.06	11.20
Na2O	2.11	2.13	2.28	2.18
K2O	0.45	0.47	0.51	0.54
F	0.17	0.14	0.15	0.00
Total	97.48	97.72	96.07	97.26
TSi	6.63	6.45	6.21	6.39
TAl	1.38	1.55	1.79	1.61
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.18	0.25	0.35	0.31
CFe3	0.01	0.11	0.36	0.23
CTi	0.25	0.25	0.16	0.18
CMg	3.28	3.07	3.32	3.50
CFe2	1.28	1.33	0.81	0.78
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.22	0.22	0.22	0.24
BMn	0.03	0.03	0.02	0.02
BCa	1.75	1.75	1.76	1.75
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.60	0.61	0.65	0.61
AK	0.08	0.09	0.10	0.10
Sum_A	0.69	0.70	0.75	0.71
Sum_cat	15.69	15.70	15.75	15.71

Table C.3. Amphibole Analysis
Sample K-68

Point	1	10	22	29
SiO2	47.47	46.65	44.69	47.58
TiO2	1.57	1.69	2.18	1.58
Al2O3	7.64	7.73	9.09	7.61
FeO	11.89	11.90	12.04	12.14
MnO	0.27	0.32	0.26	0.32
MgO	16.12	15.83	15.47	15.98
CaO	11.13	11.12	10.96	10.76
Na2O	1.67	1.69	2.07	1.76
K2O	0.38	0.36	0.41	0.34
F	0.14	0.17	0.09	0.13
Total	98.27	97.46	97.24	98.19
TSi	6.86	6.81	6.57	6.90
TAl	1.14	1.19	1.44	1.10
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.16	0.14	0.14	0.20
CFe3	0.10	0.13	0.15	0.01
CTi	0.17	0.19	0.24	0.17
CMg	3.47	3.45	3.39	3.45
CFe2	1.10	1.10	1.09	1.17
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.24	0.22	0.24	0.29
BMn	0.03	0.04	0.03	0.04
BCa	1.72	1.74	1.72	1.67
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.47	0.48	0.59	0.50
AK	0.07	0.07	0.08	0.06
Sum_A	0.54	0.55	0.67	0.56
Sum_cat	15.54	15.55	15.67	15.56

Table C.3. Amphibole Analysis
Sample K-69

Point	11	12	23	36
SiO2	45.49	46.70	44.72	45.98
TiO2	2.11	1.73	1.93	2.02
Al2O3	8.19	7.52	9.76	8.80
FeO	11.56	11.71	12.82	11.93
MnO	0.23	0.31	0.30	0.23
MgO	16.11	16.19	14.82	15.69
CaO	11.09	11.09	10.92	11.04
Na2O	1.86	1.71	2.06	1.96
K2O	0.39	0.30	0.40	0.45
F	0.14	0.17	0.10	0.24
Total	97.16	97.43	97.83	98.32
TSi	6.66	6.81	6.55	6.68
TAl	1.34	1.19	1.45	1.32
TFe3	0.00	0.00	0.00	0.00
TTi	0.00	0.00	0.00	0.00
Sum_T	8.00	8.00	8.00	8.00
CAl	0.07	0.10	0.23	0.19
CFe3	0.21	0.18	0.14	0.06
CTi	0.23	0.19	0.21	0.22
CMg	3.52	3.52	3.24	3.40
CFe2	0.97	1.02	1.18	1.14
CMn	0.00	0.00	0.00	0.00
CCa	0.00	0.00	0.00	0.00
Sum_C	5.00	5.00	5.00	5.00
BMg	0.00	0.00	0.00	0.00
BFe2	0.23	0.23	0.25	0.25
BMn	0.03	0.04	0.04	0.03
BCa	1.74	1.73	1.71	1.72
BNa	0.00	0.00	0.00	0.00
Sum_B	2.00	2.00	2.00	2.00
ACa	0.00	0.00	0.00	0.00
ANa	0.53	0.48	0.58	0.55
AK	0.07	0.06	0.07	0.08
Sum_A	0.60	0.54	0.66	0.64
Sum_cat	15.60	15.54	15.66	15.64

Table C.3. Amphibole Analysis
Sample K-71

Point	12	16
SiO2	42.71	44.53
TiO2	2.72	2.49
Al2O3	11.15	10.28
FeO	10.55	11.08
MnO	0.20	0.29
MgO	15.76	15.67
CaO	11.58	11.23
Na2O	2.59	2.46
K2O	0.41	0.42
F	0.23	0.18
Total	97.88	98.62
TSi	6.23	6.46
TAl	1.77	1.54
TFe3	0.00	0.00
TTi	0.00	0.00
Sum_T	8.00	8.00
CAl	0.15	0.22
CFe3	0.21	0.01
CTi	0.30	0.27
CMg	3.43	3.39
CFe2	0.91	1.11
CMn	0.00	0.00
CCa	0.00	0.00
Sum_C	5.00	5.00
BMg	0.00	0.00
BFe2	0.17	0.22
BMn	0.03	0.04
BCa	1.81	1.75
BNa	0.00	0.00
Sum_B	2.00	2.00
ACa	0.00	0.00
ANa	0.73	0.69
AK	0.08	0.08
Sum_A	0.81	0.77
Sum_cat	15.81	15.77

Table C.4. Magnetite Analysis
Sample K-1

Point	6	7a	9a	12a	3b	8b
SiO2	0.07	0.13	0.06	0.06	0.19	0.05
TiO2	4.98	7.25	5.20	4.84	14.90	31.54
Al2O3	1.87	1.77	1.88	1.94	0.82	0.30
Cr2O3	0.37	0.51	0.37	0.37	0.18	0.17
Fe2O3	58.32	51.56	56.58	57.15	67.34	38.63
FeO	33.06	35.53	33.55	32.28	10.73	26.23
MnO	0.52	0.36	0.42	0.54	0.33	0.27
MgO	1.74	1.02	1.30	1.75	1.68	1.21
CaO	0.02	0.06	0.04	0.02	0.08	0.04
Total	100.95	98.19	99.38	98.95	97.11	99.03

Table C.4. Magnetite Analysis
Sample K-9

Point	25	26	27	28	24b	29b	30b
SiO2	0.05	0.11	0.04	0.05	0.02	0.02	0.03
TiO2	5.01	4.98	5.06	5.03	27.38	28.08	24.90
Al2O3	1.53	1.46	1.46	1.48	0.37	0.43	0.36
Cr2O3	0.57	0.46	0.42	0.58	0.04	0.29	0.23
Fe2O3	58.46	57.22	58.18	58.26	47.79	46.02	51.39
FeO	33.03	32.38	32.96	33.06	22.15	22.91	20.54
MnO	0.47	0.48	0.47	0.47	0.22	0.07	0.11
MgO	1.76	1.72	1.72	1.70	1.41	1.51	1.18
CaO	0.01	0.07	0.04	0.02	0.13	0.13	0.24
Total	100.89	98.89	100.36	100.64	99.98	100.93	99.96

Table C.4. Magnetite Analysis
Sample K-12

Point	3	1a	8a	10a	2b	9b
SiO2	0.10	0.08	0.12	0.09	0.09	0.19
TiO2	0.64	2.49	2.12	0.77	10.80	22.55
Al2O3	0.48	7.97	0.49	1.19	0.60	0.99
Cr2O3	0.31	0.46	0.21	0.57	0.04	0.14
Fe2O3	65.71	55.16	62.96	65.43	76.41	52.81
FeO	30.11	29.99	31.36	29.97	6.90	17.13
MnO	0.04	0.26	0.06	0.18	0.45	0.12
MgO	0.59	2.74	0.65	1.00	1.57	2.13
CaO	0.51	0.03	0.12	0.00	0.08	0.07
Total	98.48	99.18	98.09	99.20	97.26	97.26

Table C.4. Magnetite Analysis

Sample K-14

Point	11	12	17	29	4a	5a	6a	11a	15a	16a	1b	2b	3b	7b	8b	12b	13b
SiO2	0.18	0.07	0.08	0.07	0.09	0.08	0.08	0.07	0.09	0.09	0.04	0.06	0.07	0.09	0.07	0.81	0.13
TiO2	13.15	5.41	6.72	5.40	5.23	4.74	6.06	6.21	4.94	4.91	28.55	28.19	28.08	28.64	28.95	25.07	25.65
Al2O3	2.22	1.60	3.28	1.76	1.79	1.86	1.67	0.55	1.71	1.68	0.33	0.34	0.31	0.31	0.35	0.37	0.46
Cr2O3	0.13	0.27	0.82	0.61	0.41	0.62	0.20	0.54	0.56	0.76	0.28	0.23	0.27	0.21	0.26	0.33	0.22
Fe2O3	41.69	57.47	52.45	56.86	56.56	57.42	55.28	55.70	57.12	57.36	44.75	45.35	44.74	44.31	43.44	49.71	49.49
FeO	37.92	33.27	34.08	33.37	32.85	32.39	33.48	33.79	32.50	32.69	23.22	22.82	22.99	23.11	23.36	19.16	20.16
MnO	0.42	0.43	0.52	0.41	0.46	0.50	0.46	0.28	0.45	0.49	0.28	0.23	0.22	0.25	0.22	0.12	0.13
MgO	3.19	1.76	2.12	1.71	1.68	1.72	1.74	1.57	1.73	1.69	1.42	1.48	1.34	1.52	1.58	2.06	1.80
CaO	0.07	0.01	0.11	0.03	0.04	0.01	0.02	0.02	0.05	0.01	0.04	0.04	0.06	0.02	0.03	0.08	0.05
Total	98.97	100.27	100.17	100.23	99.11	99.33	99.00	98.72	99.14	99.66	100.44	100.43	99.51	99.54	99.40	99.23	99.36

Table C.4. Magnetite Analysis
Sample K-18

Point	4a	5a	9a	10a	12a	19a	20a	1b	2b	3b
SiO2	0.10	0.11	0.37	0.10	0.12	0.09	0.09	0.06	0.14	0.06
TiO2	5.15	6.70	7.73	9.04	6.69	9.04	5.60	30.36	23.93	28.53
Al2O3	1.83	1.41	1.30	1.30	1.68	0.95	1.06	0.28	0.61	0.37
Cr2O3	0.37	0.56	0.36	0.37	0.58	0.43	0.58	0.16	0.19	0.18
Fe2O3	56.48	54.11	51.38	49.93	54.15	50.19	56.90	40.52	51.20	43.48
FeO	32.07	33.92	34.52	35.89	33.57	36.12	33.27	25.12	20.28	24.11
MnO	0.44	0.23	0.22	0.33	0.26	0.35	0.31	0.20	0.15	0.10
MgO	2.04	1.96	1.88	2.02	2.25	1.82	1.75	1.26	0.90	1.01
CaO	0.05	0.05	0.13	0.03	0.02	0.04	0.01	0.05	0.06	0.04
Total	98.52	99.04	97.90	99.00	99.32	99.02	99.56	98.94	98.46	99.07

Point	6b	7b	8b	11b	13	14b	16b	17b	18b	21b
SiO2	0.04	0.07	0.03	0.07	0.08	0.06	0.11	0.12	0.12	0.08
TiO2	28.01	27.55	28.03	30.41	30.21	30.87	37.16	20.36	34.61	18.34
Al2O3	0.31	0.23	0.36	0.42	0.26	0.29	0.34	0.95	0.40	0.51
Cr2O3	0.14	0.17	0.23	0.18	0.04	0.06	0.11	0.19	0.11	0.16
Fe2O3	45.91	45.96	45.16	41.46	41.03	40.97	29.27	61.41	32.94	62.44
FeO	22.51	22.10	22.67	24.73	23.76	24.32	29.57	15.93	27.36	13.65
MnO	0.18	0.09	0.06	0.16	0.20	0.23	0.42	0.35	0.43	0.11
MgO	1.56	1.59	1.59	1.59	1.92	1.93	2.08	1.57	2.05	1.78
CaO	0.02	0.03	0.05	0.07	0.10	0.10	0.05	0.07	0.07	0.07
Total	99.85	98.79	99.36	99.86	98.15	99.45	99.70	101.93	98.85	97.82

Table C.4. Magnetite Analysis
Sample K-21

Point	3a	11a	29a	31a	6b	7b	10b	12b
SiO2	0.06	0.06	0.09	0.04	0.04	0.04	0.00	0.15
TiO2	6.75	5.27	5.79	5.00	28.09	28.12	26.81	18.32
Al2O3	1.83	1.83	1.82	1.82	0.38	0.40	0.38	0.93
Cr2O3	0.44	0.49	0.49	0.38	0.23	0.23	0.18	0.29
Fe2O3	54.34	57.33	55.63	56.89	46.00	46.62	47.58	62.69
FeO	33.72	32.43	33.09	33.01	22.70	22.59	21.43	14.06
MnO	0.44	0.45	0.41	0.41	0.18	0.12	0.19	0.23
MgO	2.20	2.19	1.93	1.47	1.55	1.66	1.59	1.66
CaO	0.05	0.23	0.21	0.14	0.04	0.00	0.25	0.32
Total	99.85	100.27	99.46	99.16	100.71	100.79	99.43	100.00

Table C.4. Magnetite Analysis
Sample K-26

Point	3a	7a	9a	10a	11a	13a	1b	2b	4b	5b	8b	12b
SiO2	0.10	0.10	0.09	0.15	0.10	0.09	0.07	0.03	0.04	0.05	0.06	0.08
TiO2	4.78	4.77	5.21	4.76	5.03	4.96	32.54	32.91	34.06	25.24	27.83	33.33
Al2O3	1.68	1.76	1.72	1.81	1.69	1.69	0.27	0.27	0.24	0.82	0.33	0.27
Cr2O3	1.01	0.24	0.37	0.01	0.04	0.08	0.08	0.07	0.03	0.13	0.01	0.03
Fe2O3	56.77	57.98	56.75	58.17	57.74	57.58	37.43	37.21	35.46	50.59	46.73	36.52
FeO	32.79	32.88	33.10	32.78	32.97	33.11	25.91	26.19	26.72	17.61	23.01	26.20
MnO	0.48	0.41	0.45	0.47	0.49	0.46	0.39	0.41	0.55	0.14	0.23	0.41
MgO	1.42	1.53	1.53	1.54	1.56	1.38	1.79	1.80	1.98	3.14	1.13	2.00
CaO	0.04	0.08	0.03	0.02	0.03	0.06	0.05	0.02	0.03	0.13	0.03	0.03
Total	99.06	99.76	99.25	99.72	99.65	99.40	99.10	99.45	99.50	98.82	99.78	99.02

Table C.4. Magnetite Analysis
Sample K-27

Point	4	20	31	32	36
SiO2	0.06	0.04	0.04	0.02	0.01
TiO2	5.17	5.44	5.48	5.49	5.23
Al2O3	1.32	1.79	1.76	1.95	1.67
Cr2O3	0.29	0.45	0.19	0.36	0.20
Fe2O3	58.19	57.61	57.46	57.44	56.77
FeO	33.38	33.81	33.70	33.92	33.40
MnO	0.39	0.49	0.43	0.49	0.00
MgO	1.55	1.61	1.62	1.60	1.57
CaO	0.13	0.08	0.03	0.04	0.01
Total	100.49	101.33	100.71	101.31	98.87

Table C.4. Magnetite Analysis
Sample K-31

Point	14	25	26	36
SiO2	0.05	0.04	0.04	0.07
TiO2	4.77	6.14	6.16	5.04
Al2O3	1.69	1.61	2.03	1.48
Cr2O3	0.72	0.13	0.15	0.69
Fe2O3	57.28	55.82	55.04	56.53
FeO	32.79	34.19	34.17	32.57
MnO	0.36	0.52	0.49	0.49
MgO	1.53	1.48	1.50	1.57
CaO	0.08	0.04	0.11	0.25
Total	99.26	99.96	99.68	98.69

Table C.4. Magnetite Analysis
Sample K-32

Point	26	32	33	34
SiO2	0.54	0.04	0.06	0.09
TiO2	3.59	7.69	5.02	4.49
Al2O3	1.70	1.85	1.65	1.69
Cr2O3	0.90	0.17	0.17	0.18
Fe2O3	59.53	52.70	58.01	58.94
FeO	32.55	35.68	33.72	33.34
MnO	0.35	0.38	0.43	0.40
MgO	1.10	1.60	1.25	1.19
CaO	0.12	0.11	0.06	0.07
Total	100.37	100.23	100.36	100.39

Table C.4. Magnetite Analysis
Sample K-41

Point	15	5a	6a	9a	10a	12a	3b	4b	7b	8b	11b
SiO2	0.02	0.15	0.10	0.07	0.10	0.10	0.07	0.60	0.07	0.08	0.06
TiO2	2.92	6.79	7.67	6.37	6.39	5.87	28.96	27.40	28.45	29.81	29.38
Al2O3	1.19	2.02	1.75	1.74	1.74	1.73	0.36	0.54	0.34	0.15	0.33
Cr2O3	0.17	0.47	0.18	0.32	0.31	0.30	0.14	0.18	0.16	0.11	0.11
Fe2O3	60.54	53.00	52.43	54.62	54.60	55.68	43.72	43.58	44.63	42.04	43.34
FeO	32.34	33.45	34.70	33.66	33.74	33.17	23.15	22.08	22.99	23.78	23.39
MnO	0.11	0.41	0.44	0.43	0.33	0.38	0.20	0.16	0.14	0.25	0.25
MgO	0.53	2.15	1.99	1.86	1.89	1.92	1.69	1.61	1.55	1.64	1.72
CaO	0.01	0.17	0.03	0.04	0.02	0.10	0.07	0.06	0.05	0.08	0.05
Total	97.83	98.61	99.28	99.10	99.12	99.24	99.02	97.31	99.20	98.77	99.46

Table C.4. Magnetite Analysis
Sample K-45(1)

Point	5	6	14	23
SiO2	0.06	0.07	0.06	0.05
TiO2	4.93	5.02	5.39	4.93
Al2O3	1.75	1.76	1.52	1.72
Cr2O3	0.54	0.56	0.47	0.48
Fe2O3	58.22	58.06	57.29	58.68
FeO	33.03	33.40	33.62	33.05
MnO	0.45	0.45	0.34	0.48
MgO	1.72	1.57	1.57	1.77
CaO	0.03	0.03	0.10	0.01
Total	100.73	100.93	100.36	101.16

Table C.4. Magnetite Analysis
Sample K-46

Point	2	1b	6b	12b	14b
SiO2	0.11	0.10	0.05	0.27	0.25
TiO2	5.56	16.28	28.33	26.63	26.43
Al2O3	1.86	1.23	0.39	0.44	0.37
Cr2O3	0.36	0.27	0.14	0.56	0.51
Fe2O3	54.74	65.01	44.60	46.26	46.55
FeO	34.78	13.13	22.80	21.72	21.62
MnO	0.27	0.18	0.22	0.24	0.16
MgO	0.59	1.30	1.57	1.44	1.39
CaO	0.04	0.06	0.06	0.16	0.18
Total	98.32	99.01	98.97	100.24	99.82

Table C.4. Magnetite Analysis
Sample K-49

Point	5	21	26
SiO2	0.09	0.06	0.09
TiO2	5.58	2.14	4.00
Al2O3	1.24	1.98	1.92
Cr2O3	0.47	0.57	1.00
Fe2O3	54.44	62.37	58.72
FeO	34.39	30.98	32.14
MnO	0.19	0.15	0.45
MgO	0.59	1.37	1.59
CaO	0.04	0.01	0.03
Total	97.02	99.63	99.95

Table C.4. Magnetite Analysis
Sample K-52

Point	8	9	11	12	2b	3b	4b	6b	10b
SiO2	0.10	0.08	0.09	0.11	0.09	0.06	0.08	1.62	0.04
TiO2	6.26	6.79	5.68	7.06	14.20	43.74	13.78	7.17	29.31
Al2O3	1.13	1.02	1.42	1.73	1.58	0.12	1.28	0.25	0.22
Cr2O3	0.51	0.19	0.53	0.25	0.10	0.04	0.32	0.19	0.07
Fe2O3	54.69	54.61	56.21	53.79	72.11	16.42	70.13	84.74	43.40
FeO	33.91	34.13	32.66	33.99	9.51	35.27	10.84	2.74	23.59
MnO	0.42	0.43	0.42	0.48	0.60	0.50	0.18	0.57	0.23
MgO	1.44	1.70	2.06	2.11	2.13	2.06	1.36	1.90	1.53
CaO	0.00	0.02	0.01	0.03	0.03	0.05	0.08	0.07	0.01
Total	98.45	98.96	99.10	99.55	101.09	99.02	99.63	99.92	99.10

Table C.4. Magnetite Analysis
Sample K-56

Point	2	8	5b	7b
SiO2	0.10	0.11	0.07	0.05
TiO2	9.23	8.93	25.36	36.05
Al2O3	2.55	0.97	0.32	0.25
Cr2O3	0.13	0.34	0.31	0.02
Fe2O3	49.52	50.21	49.98	31.32
FeO	34.28	35.94	19.98	27.61
MnO	0.35	0.31	0.13	0.34
MgO	3.42	1.82	1.72	2.61
CaO	0.05	0.03	0.08	0.07
Total	99.63	98.64	100.03	98.96

Table C.4. Magnetite Analysis
Sample K-62

Point	9	30	34	35
SiO2	0.03	0.05	0.05	0.08
TiO2	5.99	4.96	5.28	4.89
Al2O3	1.55	1.64	1.60	1.66
Cr2O3	0.22	0.68	0.52	0.54
Fe2O3	56.62	58.55	57.52	58.29
FeO	34.64	33.18	33.36	33.04
MnO	0.40	0.55	0.49	0.48
MgO	1.34	1.68	1.62	1.64
CaO	0.07	0.02	0.11	0.03
Total	100.84	101.30	100.54	100.65

Table C.4. Magnetite Analysis
Sample K-64

Point	1	2	3	4
SiO2	0.08	0.05	0.07	0.07
TiO2	4.92	4.57	5.21	5.15
Al2O3	1.70	1.83	1.53	1.53
Cr2O3	0.55	0.59	0.61	0.46
Fe2O3	56.61	56.99	56.68	57.39
FeO	32.25	32.15	32.62	32.75
MnO	0.37	0.33	0.37	0.39
MgO	1.77	1.65	1.82	1.81
CaO	0.19	0.11	0.20	0.04
Total	98.44	98.26	99.10	99.58

Table C.4. Magnetite Analysis
Sample K-64d

Point	1	2	14	15
SiO2	0.07	0.07	0.05	1.17
TiO2	4.44	4.95	4.64	4.56
Al2O3	1.56	1.56	1.50	1.83
Cr2O3	0.06	0.44	0.10	0.17
Fe2O3	58.97	57.72	59.01	57.87
FeO	32.19	32.53	32.72	31.96
MnO	0.32	0.47	0.35	0.35
MgO	1.76	1.77	1.64	1.84
CaO	0.06	0.10	0.01	0.05
Total	99.43	99.61	100.01	99.79

Table C.4. Magnetite Analysis
Sample K-64l

Point	1	2	3	4	2a	3a	4a	8a	9a	11a	1b	5b	6b	7b
SiO2	0.06	0.07	0.07	0.09	0.06	0.06	0.09	0.11	0.06	0.06	0.13	0.08	0.07	0.19
TiO2	5.03	4.84	5.05	4.87	5.01	5.04	4.83	5.08	5.10	4.87	25.22	26.86	26.79	23.77
Al2O3	1.56	1.60	1.45	1.60	1.56	1.61	1.54	1.53	1.56	1.55	0.37	0.34	0.35	0.42
Cr2O3	0.46	0.46	0.46	0.44	0.55	0.54	0.49	0.50	0.48	0.51	0.21	0.33	0.21	0.27
Fe2O3	58.43	57.96	58.30	57.97	57.68	57.78	57.89	57.30	57.59	57.97	48.50	47.81	47.90	49.37
FeO	33.15	32.46	32.97	32.57	32.63	32.81	32.56	32.60	32.85	32.53	20.53	21.87	21.69	19.39
MnO	0.35	0.43	0.46	0.33	0.42	0.46	0.42	0.46	0.38	0.47	0.00	0.15	0.14	0.18
MgO	1.77	1.81	1.75	1.84	1.83	1.78	1.72	1.79	1.77	1.78	1.41	1.42	1.46	1.25
CaO	0.02	0.03	0.04	0.05	0.00	0.01	0.01	0.03	0.04	0.01	0.04	0.12	0.07	1.35
Total	100.82	99.65	100.55	99.76	99.75	100.09	99.54	99.41	99.83	99.76	97.81	100.43	100.10	97.89

Table C.4. Magnetite Analysis
Sample K-65

Point	10	12	15	16
SiO2	0.08	0.46	0.07	0.01
TiO2	4.14	7.44	6.10	28.97
Al2O3	3.22	1.93	1.64	0.41
Cr2O3	0.61	0.04	0.07	0.04
Fe2O3	56.56	53.30	56.08	12.07
FeO	31.87	34.81	33.43	54.73
MnO	0.34	0.53	0.71	0.35
MgO	1.81	1.90	1.81	1.55
CaO	0.30	0.10	0.03	0.05
Total	98.94	100.50	99.94	98.17

Table C.4. Magnetite Analysis
Sample K-66

Point	3	17
SiO2	0.08	0.04
TiO2	4.88	5.32
Al2O3	1.82	1.76
Cr2O3	0.70	0.35
Fe2O3	57.32	57.52
FeO	33.07	33.34
MnO	0.35	0.43
MgO	1.54	1.73
CaO	0.12	0.04
Total	99.88	100.54

Table C.4. Magnetite Analysis
Sample K-66d

Point	2a	5a	6a	9a	12a	13a	3b	4b	7b	8b	10b	11b
SiO2	0.10	0.09	0.08	0.05	0.09	0.09	0.04	0.03	0.07	0.07	0.06	0.11
TiO2	5.21	5.21	5.00	5.09	5.30	5.36	27.48	27.45	27.34	26.82	27.11	26.91
Al2O3	1.78	1.78	1.75	1.79	1.72	1.76	0.35	0.34	0.37	0.35	0.37	0.38
Cr2O3	0.04	0.00	0.05	0.07	0.07	0.06	0.06	0.06	0.09	0.07	0.08	0.03
Fe2O3	56.96	57.68	57.66	58.71	57.26	56.70	46.47	46.59	46.48	46.81	47.21	46.39
FeO	32.83	33.15	32.90	33.58	33.12	33.21	22.28	22.34	22.19	21.83	22.02	21.66
MnO	0.44	0.47	0.43	0.38	0.45	0.39	0.17	0.21	0.17	0.18	0.20	0.27
MgO	1.68	1.66	1.61	1.62	1.66	1.58	1.42	1.35	1.41	1.34	1.38	1.43
CaO	0.07	0.02	0.04	0.02	0.03	0.00	0.05	0.04	0.11	0.31	0.06	0.15
Total	99.11	100.06	99.52	101.30	99.71	99.15	98.57	99.14	98.68	98.30	99.16	98.03

Table C.4. Magnetite Analysis
Sample K-66l

Point	1	2	3	22	4a	5a	6a	7a	8a	9a	1b	2b	3b
SiO2	0.07	0.07	0.06	0.21	0.08	0.11	0.12	0.09	0.12	0.13	0.08	0.06	0.08
TiO2	4.28	4.99	5.23	4.72	5.00	4.88	5.11	4.80	4.95	4.84	26.56	26.41	27.03
Al2O3	1.74	1.80	1.81	1.70	1.84	1.81	1.74	1.76	1.77	1.82	0.40	0.37	0.50
Cr2O3	0.52	0.55	0.51	0.36	0.48	0.47	0.36	0.46	0.35	0.39	0.24	0.21	0.17
Fe2O3	59.70	58.19	57.42	57.27	57.80	57.44	57.45	57.70	56.83	57.52	48.22	48.10	46.78
FeO	32.77	33.22	33.25	32.33	33.04	32.63	32.95	32.66	32.54	32.56	21.92	21.68	21.90
MnO	0.40	0.42	0.44	0.46	0.45	0.50	0.42	0.37	0.41	0.51	0.11	0.15	0.22
MgO	1.60	1.70	1.72	1.59	1.70	1.67	1.71	1.69	1.65	1.66	1.26	1.27	1.47
CaO	0.01	0.03	0.01	0.19	0.01	0.03	0.05	0.01	0.03	0.02	0.15	0.19	0.27
Total	101.10	100.96	100.44	98.84	100.40	99.53	99.92	99.55	98.65	99.44	100.17	99.74	99.46

Table C.4. Magnetite Analysis
Sample K-67

Point	3	11	13	24
SiO2	0.07	0.04	0.08	0.04
TiO2	4.82	4.96	5.03	5.09
Al2O3	2.31	1.69	1.58	1.75
Cr2O3	0.59	0.48	0.31	0.50
Fe2O3	57.16	58.10	58.05	57.75
FeO	32.91	33.02	32.91	32.85
MnO	0.35	0.54	0.47	0.55
MgO	1.70	1.63	1.71	1.80
CaO	0.05	0.02	0.01	0.03
Total	99.95	100.47	100.16	100.35

Table C.4. Magnetite Analysis
Sample K-68

Point	2	3	5
SiO2	0.07	0.05	0.05
TiO2	4.99	5.13	5.06
Al2O3	1.89	1.90	1.94
Cr2O3	0.40	0.90	0.36
Fe2O3	57.12	56.64	57.46
FeO	32.57	32.85	32.93
MnO	0.53	0.45	0.43
MgO	1.73	1.78	1.76
CaO	0.04	0.02	0.03
Total	99.31	99.72	100.00

Table C.4. Magnetite Analysis
Sample K-69

Point	6	8	9
SiO2	0.07	0.05	0.05
TiO2	5.02	5.03	4.87
Al2O3	1.80	1.83	1.82
Cr2O3	0.35	0.46	0.41
Fe2O3	57.23	57.15	57.81
FeO	32.72	32.81	32.72
MnO	0.40	0.44	0.40
MgO	1.73	1.68	1.76
CaO	0.04	0.02	0.02
Total	99.36	99.45	99.85

Table C.4. Magnetite Analysis
Sample K-71

Point	1a	2a	3a	4a	5a	6a
SiO2	0.12	0.12	0.08	0.10	0.09	0.10
TiO2	4.74	4.77	4.62	4.47	4.49	4.69
Al2O3	2.93	2.86	2.95	2.82	2.87	2.91
Cr2O3	0.28	0.20	0.22	0.45	0.29	0.11
Fe2O3	57.10	56.91	57.21	57.52	57.92	57.07
FeO	31.38	31.43	31.07	31.27	31.41	31.11
MnO	0.43	0.46	0.44	0.48	0.39	0.42
MgO	2.58	2.47	2.65	2.45	2.51	2.62
CaO	0.05	0.03	0.07	0.05	0.00	0.05
Total	99.62	99.24	99.30	99.58	99.96	99.09

Table C.4. Magnetite Analysis
Sample K-16 Klyuchevskoi

Point	22	30	33	29	34	1a	14a	15a	16a	2b	3b	4b
SiO2	0.23	0.08	0.11	0.06	0.20	0.20	0.11	0.15	0.12	0.07	0.08	0.08
TiO2	4.77	16.27	5.14	27.95	15.86	6.86	5.34	10.67	5.85	29.10	29.16	29.31
Al2O3	7.06	1.02	1.82	0.31	2.23	1.57	2.06	1.79	1.37	0.31	0.30	0.38
Cr2O3	0.19	0.30	0.47	0.10	0.15	0.33	0.19	0.26	0.10	0.13	0.15	0.14
Fe2O3	50.83	34.97	56.84	45.06	61.89	53.12	55.61	45.35	56.50	44.19	43.99	43.44
FeO	30.94	42.42	31.97	22.52	13.98	34.15	33.37	37.16	33.19	23.46	23.43	23.77
MnO	0.37	0.34	0.35	0.14	0.05	0.36	0.40	0.56	0.44	0.17	0.24	0.17
MgO	2.91	1.73	2.24	1.54	1.05	1.67	1.34	1.82	1.86	1.58	1.59	1.54
CaO	0.09	0.05	0.03	0.04	0.06	0.05	0.09	0.11	0.04	0.02	0.06	0.09
Total	97.38	97.18	98.97	98.48	96.70	98.30	98.51	97.86	99.47	99.60	99.75	99.66

Table C.5. Ilmenite Analysis
Sample K-12

Point	2	7
SiO2	0.11	0.13
TiO2	44.91	46.94
Al2O3	0.07	0.05
Cr2O3	0.06	0.11
Fe2O3	14.38	11.80
FeO	31.98	33.73
MnO	1.22	1.39
MgO	4.06	4.02
CaO	0.10	0.09
V2O3		0.21
Total	97.41	98.47

Table C.6. Pyroxene Analysis
Sample K-14

Point	5	30
SiO2	52.74	53.23
TiO2	0.15	0.10
Al2O3	2.46	0.47
FeO	15.09	17.97
MnO	0.56	1.30
MgO	27.55	25.98
CaO	1.34	0.74
Na2O	0.02	0.00
K2O	0.01	0.00
Total	99.91	99.79
TSi	1.89	1.94
TAl	0.10	0.02
TFe3	0.00	0.04
M1Al	0.00	0.00
M1Ti	0.00	0.00
M1Fe3	0.10	0.05
M1Fe2	0.00	0.00
M1Mg	0.90	0.95
M2Mg	0.58	0.47
M2Fe2	0.35	0.46
M2Mn	0.02	0.04
M2Ca	0.05	0.03
M2Na	0.00	0.00
M2K	0.00	0.00
Sum_cat	4.00	4.00
WO	2.58	1.43
EN	73.88	69.59
FS	23.54	28.99
WEF	99.86	99.98
JD	0.00	0.00
AE	0.14	0.02

Table C.6. Pyroxene Analysis
Sample K-18

Point	7	8	18	19
SiO2	54.07	55.19	52.64	55.65
TiO2	0.16	0.24	0.27	0.11
Al2O3	2.12	2.57	2.49	0.32
FeO	11.56	14.68	5.93	15.65
MnO	0.28	0.41	0.24	0.80
MgO	30.46	28.59	16.98	27.68
CaO	1.13	1.40	20.75	0.95
Na2O	0.04	0.02	0.33	0.02
K2O	0.01	0.02	0.00	0.00
Total	99.84	103.12	99.62	101.18
TSi	1.91	1.92	1.93	1.98
TAl	0.09	0.08	0.07	0.01
TFe3	0.00	0.00	0.00	0.00
M1Al	0.00	0.02	0.04	0.00
M1Ti	0.00	0.01	0.01	0.00
M1Fe3	0.09	0.05	0.04	0.01
M1Fe2	0.00	0.00	0.00	0.00
M1Mg	0.91	0.92	0.91	0.99
M2Mg	0.69	0.56	0.01	0.49
M2Fe2	0.25	0.38	0.14	0.45
M2Mn	0.01	0.01	0.01	0.02
M2Ca	0.04	0.05	0.82	0.04
M2Na	0.00	0.00	0.02	0.00
M2K	0.00	0.00	0.00	0.00
Sum_cat	4.00	4.00	4.00	4.00
WO	2.15	2.63	42.19	1.82
EN	80.32	75.11	48.02	73.62
FS	17.53	22.26	9.79	24.56
WEF	99.69	99.89	97.59	99.85
JD	0.00	0.03	1.14	0.00
AE	0.31	0.08	1.27	0.15

Table C.6. Pyroxene Analysis
Sample K-26

Point	19	20
SiO2	50.13	51.73
TiO2	0.79	0.37
Al2O3	4.15	3.23
FeO	8.02	6.09
MnO	0.27	0.19
MgO	14.62	16.35
CaO	20.83	21.30
Na2O	0.45	0.36
K2O	0.00	0.01
Total	99.26	99.62
TSi	1.87	1.90
TAl	0.14	0.10
TFe3	0.00	0.00
M1Al	0.05	0.04
M1Ti	0.02	0.01
M1Fe3	0.08	0.07
M1Fe2	0.04	0.00
M1Mg	0.81	0.88
M2Mg	0.00	0.01
M2Fe2	0.13	0.12
M2Mn	0.01	0.01
M2Ca	0.83	0.84
M2Na	0.03	0.03
M2K	0.00	0.00
Sum_cat	4.00	4.00
WO	43.72	43.52
EN	42.69	46.48
FS	13.59	10.00
WEF	96.58	97.34
JD	1.30	0.97
AE	2.13	1.69

Table C.6. Pyroxene Analysis
Sample K-41

Point	10	13	23
SiO2	51.37	54.95	50.83
TiO2	0.30	0.11	0.49
Al2O3	1.46	0.30	3.38
FeO	7.58	16.60	6.11
MnO	0.30	0.77	0.20
MgO	15.63	27.03	17.19
CaO	21.43	0.98	19.87
Na2O	0.44	0.02	0.38
K2O	0.03	0.00	0.01
Total	98.53	100.75	98.45
TSi	1.92	1.98	1.88
TAl	0.06	0.01	0.12
TFe3	0.02	0.01	0.00
M1Al	0.00	0.00	0.03
M1Ti	0.01	0.00	0.01
M1Fe3	0.10	0.02	0.09
M1Fe2	0.02	0.00	0.00
M1Mg	0.87	0.98	0.87
M2Mg	0.00	0.47	0.08
M2Fe2	0.10	0.47	0.10
M2Mn	0.01	0.02	0.01
M2Ca	0.86	0.04	0.79
M2Na	0.03	0.00	0.03
M2K	0.00	0.00	0.00
Sum_cat	4.00	4.00	4.00
WO	43.44	1.87	40.79
EN	44.10	72.12	49.12
FS	12.46	26.01	10.10
WEF	96.70	99.84	97.16
JD	0.00	0.00	0.67
AE	3.30	0.16	2.17

Table C.6. Pyroxene A

Sample K-52	
Point	21
SiO2	54.42
TiO2	0.17
Al2O3	1.03
FeO	17.17
MnO	0.87
MgO	26.35
CaO	0.96
Na2O	0.04
K2O	0.00
Total	101.01
TSi	1.96
TAl	0.04
TFe3	0.00
M1Al	0.00
M1Ti	0.01
M1Fe3	0.04
M1Fe2	0.00
M1Mg	0.96
M2Mg	0.45
M2Fe2	0.48
M2Mn	0.03
M2Ca	0.04
M2Na	0.00
M2K	0.00
Sum_cat	4.00
WO	1.86
EN	70.91
FS	27.24
WEF	99.74
JD	0.00
AE	0.26

Table C.6. Pyroxene Analysis
Sample K-56

Point	4	17	21
SiO2	53.07	49.90	53.05
TiO2	0.37	0.42	0.27
Al2O3	1.38	3.73	0.92
FeO	6.50	6.95	7.01
MnO	0.31	0.22	0.42
MgO	16.25	16.62	16.25
CaO	21.63	20.03	20.85
Na2O	0.47	0.30	0.34
K2O	0.01	0.01	0.00
Total	99.97	98.17	99.11
TSi	1.95	1.86	1.97
TAl	0.05	0.14	0.03
TFe3	0.00	0.00	0.00
M1Al	0.01	0.02	0.01
M1Ti	0.01	0.01	0.01
M1Fe3	0.06	0.12	0.03
M1Fe2	0.04	0.00	0.05
M1Mg	0.89	0.85	0.90
M2Mg	0.00	0.07	0.00
M2Fe2	0.11	0.10	0.13
M2Mn	0.01	0.01	0.01
M2Ca	0.85	0.80	0.83
M2Na	0.03	0.02	0.03
M2K	0.00	0.00	0.00
Sum_cat	4.00	4.00	4.00
WO	43.65	41.09	42.32
EN	45.63	47.43	45.89
FS	10.73	11.48	11.78
WEF	96.62	97.68	97.50
JD	0.39	0.35	0.55
AE	2.99	1.97	1.95

Table C.6. Pyroxene A

Sample K-66l	
Point	4
SiO2	53.40
TiO2	0.11
Al2O3	0.50
FeO	18.33
MnO	0.91
MgO	26.10
CaO	0.75
Na2O	0.02
K2O	0.00
Total	100.13
TSi	1.94
TAl	0.02
TFe3	0.04
M1Al	0.00
M1Ti	0.00
M1Fe3	0.05
M1Fe2	0.00
M1Mg	0.94
M2Mg	0.47
M2Fe2	0.47
M2Mn	0.03
M2Ca	0.03
M2Na	0.00
M2K	0.00
Sum_cat	4.00
WO	1.45
EN	69.71
FS	28.84
WEF	99.83
JD	0.00
AE	0.17

Table C.6. Pyroxene Analysis
Sample K-71

Point	7	8
SiO2	54.14	52.57
TiO2	0.23	0.36
Al2O3	1.77	2.10
FeO	14.54	7.28
MnO	0.61	0.41
MgO	27.79	15.94
CaO	1.27	20.95
Na2O	0.02	0.38
K2O	0.01	0.02
Total	100.39	100.01
TSi	1.94	1.93
TAl	0.07	0.07
TFe3	0.00	0.00
M1Al	0.01	0.03
M1Ti	0.01	0.01
M1Fe3	0.05	0.05
M1Fe2	0.00	0.04
M1Mg	0.94	0.87
M2Mg	0.54	0.00
M2Fe2	0.39	0.13
M2Mn	0.02	0.01
M2Ca	0.05	0.83
M2Na	0.00	0.03
M2K	0.00	0.00
Sum_cat	4.00	4.00
WO	2.45	42.65
EN	74.70	45.13
FS	22.85	12.22
WEF	99.83	97.18
JD	0.03	0.94
AE	0.14	1.88

Table C.6. Pyroxene Analysis
Sample K-16 Klyuchevskoi

Point	3	12	35	38
SiO2	53.71	52.10	53.73	52.43
TiO2	0.24	0.30	0.36	0.21
Al2O3	0.75	1.46	1.39	0.66
FeO	7.05	6.83	17.47	6.76
MnO	0.42	0.28	0.42	0.47
MgO	16.20	15.71	25.44	16.16
CaO	22.05	22.09	1.99	21.50
Na2O	0.36	0.46	0.04	0.36
K2O	0.00	0.03	0.00	0.00
Total	100.78	99.25	100.83	98.55
TSi	1.96	1.93	1.94	1.96
TAl	0.03	0.06	0.06	0.03
TFe3	0.01	0.01	0.00	0.02
M1Al	0.00	0.00	0.00	0.00
M1Ti	0.01	0.01	0.01	0.01
M1Fe3	0.05	0.09	0.04	0.06
M1Fe2	0.06	0.04	0.00	0.04
M1Mg	0.88	0.87	0.95	0.90
M2Mg	0.00	0.00	0.42	0.00
M2Fe2	0.10	0.08	0.49	0.10
M2Mn	0.01	0.01	0.01	0.02
M2Ca	0.86	0.88	0.08	0.86
M2Na	0.03	0.03	0.00	0.03
M2K	0.00	0.00	0.00	0.00
Sum_cat	4.00	4.00	4.00	4.00
WO	43.73	44.62	3.88	43.32
EN	44.70	44.17	68.91	45.30
FS	11.57	11.22	27.20	11.38
WEF	97.39	96.58	99.71	97.38
JD	0.00	0.00	0.00	0.00
AE	2.61	3.42	0.29	2.63

Table C.7. Electron microprobe settings

Glass microprobe calibration settings
Beam current: 10keV
Beam size: 5-25µm

Major element	Line	Analyzing Crystal	Standard	Detection Limit (wt.%)
Na	Ka	TAP	Albite	0.041
F	Ka	TAP	Fluorophlogopite	0.22
Mg	Ka	TAP	Orthoclase	0.037
Al	Ka	TAP	Orthoclase	0.038
Si	Ka	TAP	Diopside	0.041
P	Ka	LLIF	Magnetite	0.072
S	Ka	PET	Pyrite	0.028
Cl	Ka	PET	Scapolite	0.027
K	Ka	PET	Orthoclase	0.049
Ca	Ka	PET	Beeson apatite	0.055
Ti	Ka	PET	Ilmenite	0.078
Mn	Ka	PET	MnO	0.106
Fe	Ka	LLIF	Magnetite	0.101

Amphibole microprobe calibration settings
Beam current: 20keV
Beam size: 15µm

Major element	Line	Analyzing Crystal	Standard	Detection Limit (wt.%)
Na	Ka	TAP	Albite	0.023
F	Ka	TAP	Phlogopite	0.141
Mg	Ka	TAP	Forsterite	0.018
Al	Ka	TAP	Anorthite	0.017
Si	Ka	TAP	Orthoclase	0.019
K	Ka	PET	Orthoclase	0.026
Ca	Ka	PET	Beeson apatite	0.026
Ti	Ka	PET	Ilmenite	0.035
Mn	Ka	LLIF	MnO	0.056
Fe	Ka	LLIF	Magnetite	0.048

Pyroxene microprobe calibration settings
Beam current: 20keV
Beam size: 15µm

Major element	Line	Analyzing Crystal	Standard	Detection Limit (wt.%)
Na	Ka	TAP	Albite	0.023
Mg	Ka	TAP	Diopside	0.019
Al	Ka	TAP	Al2O3	0.017
Si	Ka	TAP	Orthoclase	0.019
K	Ka	PET	Orthoclase	0.026
Ca	Ka	PET	eeson apati	0.028
Ti	Ka	PET	Ilmenite	0.037
Cr	Ka	LLIF	Cr2O3	0.049
Mn	Ka	LLIF	MnO	0.051
Fe	Ka	LLIF	Magnetite	0.058
Ni	Ka	LLIF	Ni	0.02

Magnetite microprobe calibration settings
Beam current: 20keV
Beam size: 15µm

Major element	Line	Analyzing Crystal	Standard	Detection Limit (wt.%)
Mg	Ka	TAP	Diopside	0.025
Al	Ka	TAP	Orthoclase	0.022
Ca	Ka	PET	Diopside	0.027
Ti	Ka	PET	Ilmenite	0.038
Cr	Ka	LLIF	Cr2O3	0.046
Mn	Ka	LLIF	MnO	0.055
Fe	Ka	LLIF	Magnetite	0.067

Ilmnenite microprobe calibration settings
Beam current: 20keV
Beam size: 15µm

Major element	Line	Analyzing Crystal	Standard	Detection Limit (wt.%)
Mg	Ka	TAP	Diopside	0.023
Al	Ka	TAP	Al2O3	0.019
Ca	Ka	PET	Diopside	0.027
Ti	Ka	PET	Ilmenite	0.041
Cr	Ka	LLIF	Cr2O3	0.049
Mn	Ka	PET	MnO	0.055
Fe	Ka	LLIF	Magnetite	0.063

Feldspar microprobe calibration settings
Beam current: 20keV
Beam size: 15µm

Major element	Line	Analyzing Crystal	Standard	Detection Limit (wt.%)
Na	Ka	TAP	Albite	0.021
Al	Ka	TAP	Phlogopite	0.008
Si	Ka	TAP	Diopside	0.021
K	Ka	TAP	Orthoclase	0.024
Ca	Ka	TAP	Orthoclase	0.023
Fe	Ka	PET	eeson apati	0.05

APPENDIX D

X-RAY FLUORESCENCE ANALYSES

Major and trace elements of bulk samples were measured by X-ray fluorescence at New Mexico Institute of Mining and Technology. Fused glass discs were used to determine major elements and pressed powder pellets were used to determine trace elements. New Mexico Rhyolite, an in-house standard, was prepared in triplicate along with duplicate and triplicate rock powders to ensure instrumental accuracy and consistency in sample preparation.

Table D.1. Whole Rock Major and Trace Element Analysis

Sample	00K69	00K71	90119/1	00K63	00K68	00K70	00K6	00K7	00K66	96025/4	00K8	00K67
Age ybp	38	148	148	250	250	500	950	950	950	950	1100	1100
SiO2	60.59	54.87	56.48	60.43	60.29	60.29	60.16	59.52	60.61	59.83	59.90	60.41
TiO2	0.54	0.71	0.64	0.55	0.55	0.56	0.57	0.60	0.55	0.57	0.55	0.54
Al2O3	16.59	16.84	16.72	16.41	16.48	16.59	16.46	16.76	16.67	16.66	16.51	16.39
Fe2O3	5.19	7.32	6.74	5.37	5.33	5.41	5.63	5.78	5.29	5.47	5.40	5.29
MnO	0.10	0.13	0.12	0.10	0.10	0.10	0.11	0.11	0.10	0.11	0.11	0.10
MgO	3.73	5.52	5.17	3.74	3.75	3.84	4.05	3.95	3.58	3.74	3.82	3.77
CaO	5.97	7.95	7.13	5.97	5.99	6.08	6.14	6.25	5.89	5.99	6.10	5.91
Na2O	4.59	3.96	3.84	4.45	4.52	4.50	4.33	4.36	4.52	4.40	4.41	4.51
K2O	1.29	1.16	1.17	1.37	1.35	1.34	1.30	1.26	1.33	1.34	1.34	1.39
P2O5	0.17	0.20	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.19	0.18	0.18
L.O.I.	0.47	0.68	0.83	0.86	1.12	0.85	1.27	1.17	1.04	1.22	1.39	0.92
Total	99.22	99.35	99.03	99.42	99.65	99.76	100.21	99.94	99.77	99.51	99.72	99.42
S	265	191	80	120	130	60	299	540	247	426	375	514
Cl	538	350	491	526	595	496	574	650	469	492	671	353
V	116	131	144	106	111	116	111	103	110	130	98	106
Cr	117	178	161	91	111	114	141	118	93	107	111	111
Ni	29	41	43	28	26	29	36	30	25	31	29	30
Cu	37	46	58	21	34	29	35	28	36	28	33	27
Zn	54	67	65	52	52	50	60	57	53	59	54	51
Ga	18	19	18	18	18	18	18	19	17	17	19	17
As	7	5	5	7	7	7	6	6	7	6	6	7
Rb	21	16	19	25	23	22	21	20	22	22	22	23
Sr	556	636	523	569	569	563	549	568	585	559	590	580
Y	13	17	14	13	12	13	14	14	13	14	14	14
Zr	111	99	99	113	109	111	111	104	107	107	109	110
Nb	2	1	2	2	2	2	2	2	2	2	2	1
Mo	1	1	1	2	1	1	1	1	1	1	1	1
Ba	408	387	411	500	452	468	428	430	451	422	473	465
Pb	6	7	6	8	8	7	6	7	6	8	8	9
Th	1	<1	1	<1	2	1	0	0	0	2	0	4
U	1	<1	0	1	1	1	1	0	0	0	2	2

Table D.1. Whole Rock Major and Trace Element Analysis

Sample	00K45(1)	00K45(2)	00K9	00K64	97049/1	90116/9	00K50	00K65-1	00K65-2	97049/3	00K51	00K62-1
Age ybp	1400	1400	1450	1450	1450	1500	1600	1600	1600	1600	1750	2200
SiO2	60.45	60.47	59.61	60.15	59.41	58.67	57.65	59.58	59.23	59.11	60.71	60.99
TiO2	0.53	0.54	0.53	0.54	0.55	0.53	0.66	0.58	0.56	0.59	0.50	0.52
Al2O3	16.41	16.44	16.36	16.34	16.23	16.80	16.42	16.40	16.21	16.11	16.67	16.28
Fe2O3	5.16	5.24	5.25	5.29	5.51	5.22	6.23	5.53	5.40	5.85	4.80	5.03
MnO	0.10	0.10	0.10	0.10	0.11	0.10	0.12	0.10	0.10	0.11	0.09	0.10
MgO	3.73	3.76	3.79	3.83	4.22	3.80	4.67	4.00	3.99	4.63	3.19	3.77
CaO	5.91	5.95	5.93	5.91	5.91	5.79	6.54	6.13	6.04	6.35	5.47	5.70
Na2O	4.50	4.46	4.45	4.50	4.40	4.37	4.35	4.46	4.48	4.31	4.66	4.47
K2O	1.34	1.30	1.31	1.35	1.30	1.28	1.22	1.32	1.33	1.31	1.30	1.39
P2O5	0.17	0.17	0.18	0.17	0.18	0.17	0.21	0.18	0.17	0.19	0.17	0.17
L.O.I.	1.03	2.05	1.31	1.19	1.37	4.46	1.44	1.14	1.67	0.91	2.09	1.58
Total	99.33	100.48	98.82	99.38	99.19	101.19	99.51	99.43	99.19	99.47	99.65	100.00
S	227	264	531	275	86		410	2521	3391	213	99	282
Cl	785	848	947	691	550		878	670	1341	801	569	536
V	86	81	96	108	130		129	117	126	130	98	108
Cr	114	116	122	114	153		136	132	123	173	94	127
Ni	30	29	32	29	47		45	33	30	40	25	33
Cu	27	30	30	36	28		47	21	24	44	25	30
Zn	52	50	53	50	58		60	54	53	56	52	51
Ga	18	18	18	18	18		19	18	17	17	19	18
As	7	8	6	7	7		5	6	7	6	6	6
Rb	23	23	22	23	22		20	22	22	22	21	23
Sr	558	549	555	561	542		539	554	538	540	568	565
Y	13	13	13	13	13		16	14	14	14	12	13
Zr	113	114	110	109	111		123	118	110	111	119	108
Nb	2	2	2	1	2		2	2	2	2	2	1
Mo	1	1	2	1	1		1	1	2	1	1	1
Ba	444	472	444	466	417		399	424	441	429	431	456
Pb	7	7	7	7	6		7	8	6	7	6	7
Th			1	0			1	1	0	2		
U	2	1	1	1	1		1	1	1	2	2	1

Table D.1. Whole Rock Major and Trace Element Analysis

Sample	00K62-2	00K62(2)	00K53	00K54	00K55	97048/5	00K15	00K57	00K20A1	00K20A2	00K20B	00K22
Age ybp	2200	2200	2400	2550	2800	3100	3600	3600	3700	3700	3700	3700
SiO2	60.91	57.47	61.13	59.04	59.72	56.37	51.43	51.72	56.28	56.15	55.96	55.96
TiO2	0.53	0.49	0.52	0.56	0.54	0.68	0.83	0.77	0.60	0.60	0.61	0.60
Al2O3	16.26	15.35	16.58	16.42	16.30	15.47	13.69	13.51	14.94	14.93	14.88	14.93
Fe2O3	5.03	4.70	5.04	5.54	5.27	6.97	9.43	8.68	6.97	6.99	7.04	7.03
MnO	0.10	0.09	0.10	0.10	0.10	0.13	0.16	0.15	0.12	0.12	0.12	0.12
MgO	3.78	3.50	3.45	4.09	3.85	7.26	10.58	10.61	8.36	8.42	8.50	8.50
CaO	5.72	5.36	5.69	6.12	5.83	7.07	8.36	8.14	7.19	7.22	7.21	7.22
Na2O	4.45	4.30	4.34	4.22	4.30	3.88	2.71	2.75	3.71	3.70	3.67	3.67
K2O	1.39	1.32	1.34	1.31	1.34	1.14	1.70	1.90	1.07	1.06	1.07	1.06
P2O5	0.17	0.16	0.15	0.18	0.18	0.19	0.36	0.39	0.16	0.16	0.16	0.16
L.O.I.	1.61	6.77	2.09	1.92	1.85	0.58	0.78	0.83	0.24	0.14	0.13	0.23
Total	99.95	99.51	100.42	99.52	99.27	99.74	100.03	99.45	99.66	99.50	99.36	99.50
S	276	142	246	203	278	216	588	645	239		105	199
Cl	508	526	500	643	519	352	224	232	247		227	292
V	105	110	99	120	106	173	261	246	159	162	158	165
Cr	129	108	105	130	123	416	591	626	520	508	506	508
Ni	37	28	29	32	33	115	157	167	148	148	148	146
Cu	32	26	20	22	28	49	54	44	65	60	66	63
Zn	53	49	50	54	55	65	77	75	65	63	64	64
Ga	18	17	18	19	19	18	16	16	17	17	17	16
As	5	6	7	6	6	4	2	2	4	3	3	3
Rb	23	24	23	23	23	18	38	41	16	16	16	16
Sr	561	565	558	544	537	475	482	519	463	459	455	459
Y	13	12	12	13	13	15	21	20	15	14	15	14
Zr	110	111	109	113	115	100	93	99	89	90	89	89
Nb	2	2	2	2	2	2	2	2	2	2	2	2
Mo	1	1	1	0	1	1	1	0	0	0	1	0
Ba	451	478	490	422	447	365	467	496	345	352	351	341
Pb	8	8	7	8	7	7	7	8	6	5	5	5
Th		0		1	0	2	1	0	0	1	1	0
U	1	1	1	2	1	1	1	1	2	1	1	1

Table D.1. Whole Rock Major and Trace Element Analysis

Sample	00K23	00K17	00K19-1	00K19-2	00K21-1	00K21-2	00K47	00K58	00K48	00K25	00K27	00K28
Age ybp	3700	3750	3800	3800	3800	3800	3800	3800	3900	4100	4500	4700
SiO2	61.31	57.32	60.24	60.21	60.49	60.52	59.35	57.11	59.91	57.86	56.46	60.18
TiO2	0.53	0.58	0.52	0.53	0.52	0.52	0.57	0.62	0.51	0.66	0.66	0.53
Al2O3	16.36	15.58	16.40	16.48	16.23	16.29	16.41	15.73	16.41	16.03	15.25	16.56
Fe2O3	5.15	6.38	4.97	5.15	5.03	5.12	5.60	6.23	5.00	6.14	6.89	5.02
MnO	0.10	0.12	0.09	0.10	0.09	0.10	0.11	0.11	0.10	0.11	0.13	0.09
MgO	3.87	6.78	3.60	3.85	3.78	3.85	4.11	5.62	3.68	4.94	6.72	3.30
CaO	5.86	6.76	5.65	5.69	5.76	5.82	6.07	6.52	5.67	6.52	7.40	5.78
Na2O	4.53	3.91	4.55	4.45	4.50	4.47	4.40	4.02	4.45	4.09	3.67	4.50
K2O	1.31	1.12	1.39	1.38	1.35	1.35	1.30	1.40	1.35	1.33	1.19	1.36
P2O5	0.16	0.16	0.13	0.17	0.16	0.17	0.18	0.20	0.17	0.23	0.18	0.17
L.O.I.	1.29	1.14	1.56	1.57	1.50	1.55	1.53	1.41	2.20	1.77	1.28	1.74
Total	100.47	99.84	99.10	99.58	99.42	99.76	99.63	98.98	99.45	99.69	99.82	99.24
S	395	343	695	118	161	177	274	235	467	469	371	144
Cl	541	389	562	466	541	573	570	527	577	461	695	559
V	90	135	87	89	92	90	104	127	96	133	134	81
Cr	131	358	110	133	123	128	130	254	117	195	370	85
Ni	33	106	28	32	34	37	34	61	32	62	66	22
Cu	42	60	30	30	48	53	20	48	39	28	14	30
Zn	52	57	51	53	51	51	56	61	53	65	58	52
Ga	18	18	18	18	18	18	18	18	18	18	17	18
As	6	5	6	6	6	6	6	5	6	6	6	8
Rb	22	17	24	25	22	22	22	23	22	21	21	23
Sr	548	508	563	541	576	574	542	552	586	574	499	565
Y	13	14	13	13	13	13	15	14	13	15	14	12
Zr	108	96	112	111	109	111	116	109	108	114	95	111
Nb	2	2	2	2	2	2	2	1	2	2	2	2
Mo	1	0	1	1	1	1	1	0	1	0	1	1
Ba	441	386	458	466	456	461	421	473	434	401	374	456
Pb	7	6	8	7	8	7	8	8	8	7	7	7
Th	1		2	2	1	0	0			1	1	0
U	1	2	0	1	1	1	2	1	0	1	0	2

Table D.1. Whole Rock Major and Trace Element Analysis

Sample	00K59	00K29	00K30	00K35	00K31-1	00K31-2	00K31-3	00K38	96030/1	97058/2	00K32	00K39
Age ybp	4700	4800	5600	6900	7500	7500	7500	7600	7600	7600	7700	7700
SiO2	60.26	60.44	61.16	60.25	61.60	62.05	61.13	60.40	54.31	52.65	62.55	62.09
TiO2	0.54	0.55	0.53	0.51	0.51	0.52	0.53	0.56	0.75	0.72	0.48	0.46
Al2O3	16.80	16.59	16.69	16.69	16.68	16.67	16.70	16.30	15.15	15.21	16.67	16.75
Fe2O3	5.05	5.29	4.90	4.73	4.65	4.69	4.86	5.29	7.65	8.13	4.49	4.40
MnO	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.10	0.13	0.14	0.09	0.09
MgO	3.24	3.63	3.18	3.15	2.80	2.81	3.00	3.52	8.15	9.25	2.35	2.27
CaO	5.73	6.00	5.72	5.40	5.36	5.37	5.58	4.72	7.03	7.77	5.12	5.05
Na2O	4.57	4.38	4.55	4.68	4.69	4.69	4.61	3.96	3.38	3.14	4.40	4.47
K2O	1.30	1.35	1.36	1.30	1.42	1.43	1.43	1.44	1.06	0.90	1.46	1.44
P2O5	0.19	0.18	0.18	0.17	0.17	0.17	0.17	0.16	0.17	0.17	0.18	0.17
L.O.I.	1.87	1.77	1.89	2.05	1.35	1.43	1.38	3.26	1.44	1.17	2.02	2.13
Total	99.64	100.27	100.25	99.02	99.33	99.92	99.48	99.72	99.21	99.25	99.80	99.32
S	186	378	484	1367	214	212	210	1003	82	82	274	635
Cl	614	507	475	635	486	452	510	105	237	272	316	400
V	104	97	106	86	69	75	72	122	207	233	70	57
Cr	84	113	85	88	65	72	73	100	503	563	52	47
Ni	24	30	25	24	18	21	20	29	168	173	15	13
Cu	19	29	33	27	27	26	27	50	51	70	15	16
Zn	53	55	58	51	49	51	51	58	73	74	54	50
Ga	18	17	18	18	19	18	18	18	18	16	18	18
As	8	7	6	5	7	7	6	11	4	4	6	7
Rb	22	22	22	22	28	25	25	25	20	16	30	30
Sr	576	563	586	583	573	569	568	471	467	393	544	551
Y	13	12	13	13	12	12	13	14	16	16	12	11
Zr	113	108	112	106	117	122	118	129	100	91	119	118
Nb	2	2	2	1	2	2	2	2	3	3	2	2
Mo	1	1	1	1	1	1	1	1	0	0	1	1
Ba	400	438	404	393	465	451	455	510	416	328	456	476
Pb	6	7	9	7	7	8	8	9	7	6	7	6
Th			1		0	1	1		4	3		
U	0	2	0	1	1	2	2	2	1	1	1	1

Table D.1. Whole Rock Major and Trace Element Analysis

Sample	00K40	00K60	00K61	00K33	00K34	00K43	00K44
Age ybp	7900	8100	8300	8500	8600	8700	8900
SiO2	60.64	58.60	57.41	59.12	59.81	57.81	58.80
TiO2	0.54	0.59	0.61	0.61	0.63	0.67	0.63
Al2O3	16.84	17.03	17.20	16.84	16.63	16.45	16.43
Fe2O3	5.17	5.56	5.74	5.68	5.83	6.24	6.01
MnO	0.10	0.11	0.11	0.11	0.12	0.12	0.11
MgO	2.89	3.49	3.70	3.41	3.55	4.37	3.91
CaO	5.66	5.99	6.08	6.03	6.13	6.60	6.23
Na2O	4.31	4.27	4.08	4.24	4.12	4.07	4.20
K2O	1.39	1.29	1.27	1.47	1.53	1.38	1.43
P2O5	0.20	0.14	0.20	0.21	0.21	0.18	0.20
L.O.I.	2.17	2.27	2.97	1.74	1.83	1.92	1.78
Total	99.91	99.34	99.37	99.45	100.39	99.81	99.73
S	682	596	475	460	216	1789	1200
Cl	463	582	682	534	636	425	547
V	89	127	111	103	102	132	122
Cr	67	82	93	69	69	112	104
Ni	20	23	25	19	18	27	27
Cu	16	20	27	31	43	49	41
Zn	56	54	55	57	56	60	59
Ga	18	18	18	19	18	18	19
As	6	6	6	7	6	5	6
Rb	25	22	23	26	27	23	25
Sr	554	578	567	546	545	615	528
Y	13	15	16	15	16	16	17
Zr	120	115	122	129	126	114	122
Nb	2	2	1	2	2	2	2
Mo	1	1	1	2	2	1	2
Ba	429	438	443	465	513	447	443
Pb	7	8	8	8	9	10	8
Th	0		0		2	1	1
U	1	2	1	2	1	2	0

Table D.2. Analytical precision of XRF analyses

Sample	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	SUM
00K19-1	60.74	0.52	16.31	5.02	0.094	3.62	5.70	4.57	1.39	0.17	99.68
00K19-1 dup	60.61	0.52	16.33	5.01	0.094	3.60	5.68	4.56	1.38	0.17	99.50
Average	60.67	0.52	16.32	5.01	0.09	3.61	5.69	4.56	1.39	0.17	99.59
Std dev	0.09	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	
00K27	56.63	0.65	15.28	6.82	0.126	6.62	7.40	3.67	1.19	0.18	99.84
00K27 dup	56.40	0.66	15.23	6.92	0.127	6.76	7.39	3.67	1.19	0.18	99.80
00K27 trip	56.35	0.66	15.24	6.92	0.128	6.79	7.41	3.67	1.17	0.18	99.80
Average	56.37	0.66	15.23	6.92	0.13	6.77	7.40	3.67	1.18	0.18	99.80
Std dev	0.04	0.00	0.01	0.00	0.00	0.02	0.01	0.00	0.01	0.00	
00K33	59.08	0.61	16.83	5.66	0.114	3.40	6.02	4.24	1.47	0.21	99.37
00K33 dup	59.16	0.61	16.85	5.69	0.115	3.42	6.03	4.23	1.47	0.21	99.52
Average	59.12	0.61	16.84	5.68	0.11	3.41	6.03	4.24	1.47	0.21	99.45
Std dev	0.06	0.00	0.01	0.02	0.00	0.01	0.01	0.01	0.00	0.00	
00K35	60.35	0.50	16.65	4.73	0.090	3.14	5.40	4.67	1.29	0.17	99.05
00K35dup	60.15	0.51	16.74	4.74	0.089	3.16	5.39	4.69	1.31	0.17	99.00
Average	60.25	0.51	16.69	4.73	0.09	3.15	5.40	4.68	1.30	0.17	99.02
Std dev	0.14	0.00	0.06	0.01	0.00	0.01	0.01	0.01	0.01	0.00	
00K40	60.60	0.54	16.84	5.17	0.104	2.89	5.65	4.31	1.38	0.20	99.85
00K40 dup	60.69	0.54	16.84	5.18	0.104	2.89	5.66	4.31	1.39	0.20	99.97
Average	60.64	0.54	16.84	5.17	0.10	2.89	5.66	4.31	1.39	0.20	99.91
Std dev	0.06	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.00	
00K59	60.18	0.54	16.77	5.06	0.096	3.23	5.72	4.57	1.31	0.19	99.50
00K59 dup	60.28	0.54	16.77	5.05	0.096	3.24	5.72	4.56	1.30	0.18	99.66
00K59 trip	60.33	0.55	16.85	5.06	0.096	3.24	5.73	4.58	1.30	0.19	99.76
Average	60.31	0.54	16.81	5.05	0.10	3.24	5.73	4.57	1.30	0.19	99.71
Std dev	0.04	0.00	0.06	0.01	0.00	0.00	0.01	0.01	0.00	0.00	
00K65-1	59.53	0.58	16.38	5.52	0.104	3.99	6.11	4.45	1.32	0.18	99.32
00K65-1 dup	59.66	0.59	16.38	5.54	0.104	4.01	6.13	4.46	1.31	0.18	99.51
00K65-1 trip	59.57	0.58	16.43	5.53	0.103	3.99	6.14	4.46	1.32	0.18	99.45
Average	59.61	0.58	16.41	5.54	0.10	4.00	6.13	4.46	1.32	0.18	99.48
Std dev	0.06	0.00	0.04	0.01	0.00	0.01	0.01	0.00	0.01	0.00	
00K68	60.41	0.55	16.48	5.33	0.102	3.75	6.00	4.52	1.35	0.18	99.79
00K68 dup	60.16	0.55	16.47	5.32	0.102	3.76	5.98	4.52	1.35	0.18	99.51
Average	60.29	0.55	16.48	5.33	0.10	3.75	5.99	4.52	1.35	0.18	99.65
Std dev	0.18	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	
00K69	60.50	0.53	16.58	5.18	0.098	3.73	5.96	4.59	1.29	0.17	99.10
00K69 dup	60.68	0.54	16.60	5.21	0.099	3.74	5.97	4.59	1.28	0.17	99.34
Average	60.59	0.54	16.59	5.19	0.10	3.73	5.97	4.59	1.29	0.17	99.22
Std dev	0.13	0.00	0.01	0.02	0.00	0.01	0.01	0.00	0.01	0.00	