APPLICATION OF MINERAL EQUILIBRIA TO CONSTRAIN THE NATURE OF

MANTLE FLUIDS USING MANTLE XENOLITHS

A Dissertation

by

LINDSEY E HUNT

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Chair of Committee,	William Lamb
Committee Members,	Andreas Kronenberg
	Julie Newman
	Debbie Thomas
Head of Department,	Michael Pope

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ABSTRACT

Mantle processes (e.g., melting and deformation) are controlled, in part, by the availability of H_2O. Therefore, determining values of the activity of H_2O (aH_2O) will yield a better understanding of these complex mantle processes. The amount of H_2O contained in the mantle is typically estimated from the H_2O contents of nominally anhydrous mantle minerals (NAMs). Mineral equilibria have also been used to estimate values of aH_2O as well as values of hydrogen (fH_2) and oxygen fugacities (fO_2) in samples from the Earth's mantle. Unlike NAMs, which may be prone to H-loss via diffusion during emplacement on Earth's surface, dehydration equilibria are relatively resistant to re-equilibration and therefore, may be a better approach at constraining the H_2O content of the upper mantle.

Equilibria between co-existing minerals have been used to estimate values of temperature (T), pressure (P), fO_2, fH_2 (where f = fugacity) and aH_2O for twenty amphibole-bearing xenoliths from three different regions, Eastern Australia, Southwestern U.S.A, and South Africa. The xenoliths contain an assemblage of olivine + orthopyroxene + clinopyroxene + amphibole + spinel ± garnet. All of the samples record low values of aH_2O (<0.20), as inferred from amphibole dehydration equilibria at PT conditions that range from 1.1 to 3.0 GPa and 690 to 980˚C, respectively. Values of fH_2 estimated using amphibole dehydrogenation equilibria, and values of fO_2 estimated using oxidation equilibria involving spinel + olivine + orthopyroxene were combined to yield a second estimate of aH_2O; values, which are consistent with the values of aH_2O,

estimated using amphibole equilibria. These low values of aH2O are also consistent with low H2O contents in NAMS that have been measured using FTIR spectroscopy. Furthermore, values of fO_2 have been used to constrain values of the fugacities of other fluid species in the C-O-H system. Calculations based on C-O-H equilibria yield H_2O rich conditions, which are significantly different from values of aH_2O from amphibole equilibria suggesting that the fluid pressure is lower than the lithostatic pressure and that these samples equilibrated in a fluid-absent system.

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CHAPTER I

INTRODUCTION

Volatile species consisting of H, C and O (e.g., H_2O and/or CO_2) can play an important role, in a variety of geologically important processes, occurring in the upper mantle. For example, hydrogen can be contained within hydrous phases, such as amphibole or phlogopite. It can also be structurally bound, likely as OH, within nominally anhydrous minerals (NAMs), such as olivines and pyroxenes. Many NAMs from upper mantle peridotites typically contain around 100 to 300 wt. ppm H_2O, with some values ranging from 40 to 1200 wt. ppm (Bell & Rossman, 1992, Ingrin & Skogby, 2000, Beran & Libowitzky, 2006a, Skogby, 2006, Peslier, 2010). Using NAMs to constrain the H_2O content of the mantle, however, is not always ideal because these minerals can undergo significant diffusion during transport to the surface of the Earth (Ingrin *et al.*, 1995, Kohlstedt & Mackwell, 1998, Ingrin & Skogby, 2000, Demouchy *et al.*, 2006, Peslier & Luhr, 2006) and thus, their H_2O contents may not accurately represent the H_2O content of the mantle.

It is particularly important to quantify the concentration of H in the upper mantle because even trace amounts of H_2O can significantly affect the physical properties of the upper mantle, including electrical conductivity, and rheology (Karato *et al.*, 1986, Bell & Rossman, 1992, Kohlstedt *et al.*, 1995, Mei & Kohlstedt, 2000a,b, Bolfan-Casanova, 2005, Wang *et al.*, 2006, Yoshino *et al.*, 2009, Zhao & Yoshino, 2016). Also, the compositions of melts generated in the mantle are not only a function of pressure and temperature, but also of H_2O activities (Wyllie, 1979, Gaetani & Grove, 1998, Green & Falloon, 1998, Asimow & Langmuir, 2003, Green, 2015). Because H_2O affects physical properties of mantle rocks, the availability of H_2O should influence processes operating in the mantle. For example, the formation of oceanic crust and the evolution of the uppermost mantle at mid-ocean ridges, are likely influenced by the H_2O-contents of upper mantle rocks (Hirth & Kohlstedt, 1996, 2003).

In addition to H-species, carbon-bearing species may also play an important role in the upper mantle. These carbon-bearing species may include graphite, diamond, and CO_2. Recently, Frezotti & Touret (2014) argued that mantle would be largely dominated by fluids CO_2 to a depth of 100 km, and at greater depths, the CO_2 fluids would transition to carbonate melts. The evidence in support of this model is based largely on the presence of CO_2-rich fluid inclusions found in mantle xenoliths, and on petrologic studies on carbonate melts (Roedder, 1965, Andersen & Neumann, 2001, Frezzotti *et al.*, 2010, Frezzotti & Touret, 2014). Fluids rich in CO_2, much like H_2O, may also affect many mantle processes, such as, partial melting and metasomatism (Eggler, 1978, Dasgupta & Hirschmann, 2006, 2010, Dasgupta *et al.*, 2007).

Mineral equilibria provide an approach to ascertain the nature of mantle fluids, and various equilibria have been successfully applied to estimate values of P, T, aH_2O, oxygen fugacity (fO_2), and hydrogen fugacity (fH_2) in samples from the earth's mantle (Nickel & Green, 1985, Wood, 1990, Taylor, 1998, Popp *et al.*, 2006, Lamb & Popp, 2009, Nimis & Grutter, 2010, Miller *et al.*, 2016). Values of oxygen fugacity (fO_2) have been estimated using mineral equilibria based on coexisting olivine, spinel and orthopyroxene (Wood, 1990, Ballhaus *et al.*, 1991, Woodland *et al.*, 1992, Miller *et al.*, 2016). Amphibole dehydrogenation equilibria have been used to estimate values of hydrogen fugacity (fH_2), which can be combined with values of fO_2 from the same sample to estimate aH_2O (Popp & Phillips, 1995, Popp *et al.*, 2006). Amphibole dehydration equilibria have also been used to estimate values of aH_2O (Lamb & Popp, 2009, Bonadiman *et al.*, 2014, Gentili *et al.*, 2015, Kang *et al.*, 2017). Furthermore, combining values aH_2O and fO_2 with calculations of fluid speciation in the C-O-H system has proven to yield particular insight into the nature of fluids in high-grade rocks by determining whether those samples equilibrated in a free fluid system or in a fluid absent one. Lastly, values of aH_2O, estimated using amphibole equilibria, can be compared to the H_2O contents of NAMs that have been measured using Fourier-Transform Infrared (FTIR) Spectroscopy to determine if the H_2O contents of mantle NAMs accurately reflect mantle values.

The goal of this research has been to use mineral equilibria to estimate the fugacities of various fluid species in mantle xenoliths from Eastern Australia, SW U.S.A, and South Africa and, in particular, to determine robust values of aH_2O. Each of the studies, detailed in Chapters 2-4, relies on amphibole-bearing xenoliths that originated below the Moho. Although amphiboles may be a ubiquitous phase in the uppermost mantle (Niida & Green, 1999), mantle amphibole often forms as a result of mantle metasomatism (see O'Reilly & Griffin, 2013, and references therein). They can also form directly from magmas crystallizing deep within the Earth (Best, 1970, Best, 1975, Irving, 1980, Perkins & Anthony, 2011). It has also been suggested that, in some cases, mantle amphiboles form from relatively oxidizing fluids (Dyar *et al.*, 1993) and that amphibole-bearing mantle samples tend to record fO_2 values that are, in general, relatively oxidizing (Bryndzia & Wood, 1990). Quantifying values of aH_2O and fO_2 in amphibole-bearing mantle xenoliths may, therefore, provide insight into the nature of mantle fluids and test the possibility that the presence of amphibole indicates relatively oxidizing and/or H_2O-rich conditions.

CHAPTER II

APPLICATION OF MINERAL EQUILIBRIA TO ESTIMATE FUGACITIES OF H_2O, H_2 AND O_2 IN MANTLE XENOLITHS FROM THE SW U.S.A

Introduction

The mantle may be the largest reservoir of H_2O on earth, and much of the H_2O is likely contained in nominally anhydrous minerals (NAMs) such as olivines and pyroxenes. Although the amount of H_2O stored in NAMs may be relatively small, generally ranging from 40 to 1000 wt. ppm (Ingrin & Skogby, 2000, Beran & Libowitzky, 2006a, Skogby, 2006, Peslier, 2010, Warren & Hauri, 2014), this H_2O can significantly affect the physical properties of the upper mantle, including electrical conductivity and rheology (Karato *et al.*, 1986, Bell & Rossman, 1992, Kohlstedt *et al.*, 1995, Mei & Kohlstedt, 2000a,b, Bolfan-Casanova, 2005, Wang *et al.*, 2006, Yoshino *et al.*, 2009, Zhao & Yoshino, 2016). Also, the compositions of melts generated in the mantle are not only a function of pressure and temperature, but also of H_2O activities (Wyllie, 1979, Gaetani & Grove, 1998, Green & Falloon, 1998, Green, 2015).

Given that trace amounts of H_2O can significantly affect the physical properties of the upper mantle, the determination of values of the activity of H_2O (aH_2O) for samples from the upper mantle should yield additional insight into various mantle processes. While NAMs may be the largest reservoir of H_2O in the mantle, determining values of mantle aH_2O from the H_2O contents of NAMs requires: (1) an accurate description of the relation between aH_2O and NAM H_2O content, and (2) that NAMs have retained their mantle H_2O content during transport and emplacement at the earth's surface.

Early studies quantified the relation between the fugacity of H_2O (fH_2O) and olivine H_2O content as a function of P, T (Mosenfelder *et al.*, 2006), and Fe content (Zhao *et al.*, 2004). More recent work indicates that, in addition to P, T, and Fe content, the H_2O content of olivine is also a function of the Fe, Al, and Ti contents and the oxygen fugacity, (Bai & Kohlstedt, 1993, Zhao *et al.*, 2004, Berry *et al.*, 2005, Demouchy & Mackwell, 2006, Gaetani *et al.*, 2014). These same factors (i.e. P, T, fH_2O, and crystal chemistry) also affect the solubility of H_2O in ortho- and clinopyroxenes (Smyth *et al.*, 1991, Mierdel & Keppler, 2004, Stalder, 2004, Smyth *et al.*, 2007, Bali *et al.*, 2008, Warren & Hauri, 2014). However, the relationship between fugacity of H_2O and pyroxene H_2O content is not well known.

NAMs may also undergo substantial resetting of hydrogen contents during xenolith transport and emplacement on the Earth's surface (Ingrin *et al.*, 1995, Kohlstedt & Mackwell, 1998, Ingrin & Skogby, 2000, Demouchy *et al.*, 2006, Peslier & Luhr, 2006). Thus, this potential H_2O-loss constitutes a major uncertainty in determining the amount of H_2O actually stored in NAMs throughout the mantle. Olivine may be more likely than pyroxenes to undergo resetting during emplacement on Earth's surface (Peslier *et al.*, 2002, Bolfan-Casanova, 2005, Ingrin, 2006, Peslier, 2010, Warren & Hauri, 2014). Thus, pyroxenes may be better indicators of true mantle H_2O contents, yet converting H_2O contents of pyroxenes to values of fH_2O involves significant uncertainties (see previous paragraph).

Mineral equilibria provide another approach to ascertain the nature of mantle fluids, and various equilibria have been successfully applied to estimate values of P, T, aH_2O, oxygen fugacity (fO_2), and hydrogen fugacity (fH_2) in samples from the earth's mantle (Nickel & Green, 1985, Wood, 1990, Taylor, 1998, Popp *et al.*, 2006, Lamb & Popp, 2009, Nimis & Grutter, 2010, Miller *et al.*, 2016). Values of oxygen fugacity (fO_2) have been estimated using mineral equilibria based on coexisting olivine, spinel and orthopyroxene (Wood, 1990, Ballhaus *et al.*, 1991, Woodland *et al.*, 1992). Amphibole dehydrogenation equilibria have been used to estimate values of hydrogen fugacity (fH_2), which can be combined with values of fO_2 from the same sample to estimate aH_2O (Popp & Phillips, 1995, Popp *et al.*, 2006). Amphibole dehydration equilibria have also been used to estimate values of aH_2O (Lamb & Popp, 2009, Bonadiman *et al.*, 2014, Gentili *et al.*, 2015). The goal of this study is to use mineral equilibria to estimate the fugacities of various fluid species in mantle xenoliths from the SW U.S.A and, in particular, to determine robust values of aH_2O. This study relies on amphibole-bearing xenoliths that originated below the Moho. Although amphiboles may be a ubiquitous phase in the uppermost mantle (Niida & Green, 1999), mantle amphibole often forms as a result of mantle metasomatism (see O'Reilly & Griffin, 2013, and references therein). It has been suggested that, in some cases, mantle amphiboles form from relatively oxidizing fluids (Dyar *et al.*, 1993) and that amphibole-bearing mantle samples tend to record fO_2 values that are, in general, relatively oxidizing (Bryndzia & Wood, 1990). Quantifying values of aH_2O and fO_2 in amphibole-bearing mantle xenoliths may, therefore, provide insight into the nature of mantle fluids and test the possibility that the presence of amphibole indicates relatively oxidizing conditions.

Analytical Methods

Electron Microprobe

Chemical characterization of co-existing minerals is required in order to estimate values of P, T, aH_2O, fO_2 and fH_2 from phase equilibria. The minerals in these xenoliths were characterized using a Cameca SX-50 electron microprobe (EMP) located at Texas A&M University. Typical operating conditions typically include an accelerating voltage of 15 kV, and, in the case of anhydrous phases, (e.g., olivine, spinel and pyroxenes) a20nA beam current and a 1μm beam diameter. Amphibole is analyzed using a lower beam current of 10nA and a larger beam diameter of 10 μm in an effort to minimize electron-beam induced diffusion of light elements. Counting times for all phases ranged from 30-60s for major elements and up to 120s for minor elements. Typically, a series of points are analyzed along a traverse from core to rim to quantify the chemical variability within mineral grains. Natural and synthetic mineral standards are used for calibration.

Olivine and spinel analyses have been normalized to three cations, while pyroxenes were normalized to four cations and garnets were normalized to eight cations. Complete characterization of mineral chemistries requires the determination of values of Fe^{3+}/Fe_{Total}, however, conventional EMP analyses cannot differentiate between the two valence states of Fe. In this study, it is assumed that all Fe in olivine is Fe^{2+}, because olivine analyses indicate that this mineral never contains more than trace levels of Fe^{3+} (Brown, 1980). Pyroxene and spinel may each contain significant quantities of Fe^{3+} and the value of Fe^{3+}/Fe_{Total} may be estimated via charge balance. Counting statistics preclude the use of conventional probe analyses to determine values of Fe^{3+}/Fe_{Total} in pyroxenes via charge balance (Canil & O'Neill, 1996). Thus, we have estimated the value of Fe^{3+}/Fe_{Total} for pyroxenes using two methods: (1) charge balance, where $Fe^{3+} = Al^{IV} - Al^{VI} - 2Ti - Cr + Na$ and, (2) assuming that all Fe is Fe^{2+}. This approach permits an examination of the sensitivity of various estimates, for example temperature estimates (described below), to changes in the value of Fe^{3+}/Fe_{Total} in pyroxenes.

While charge balance may not be useful in determining accurate values of Fe^{3+}/Fe_{Total} in pyroxenes (Dyar *et al.*, 1989, Canil & O'Neill, 1996), this approach can be used for spinel given the use of appropriate secondary standards with known values of Fe^{3+}/Fe_{Total} (Wood & Virgo, 1989). For our samples, the value of Fe^{3+}/Fe_{Total} in spinel, as estimated from charge balance, was corrected based on analyses of spinel standards, obtained from B. Wood (Wood & Virgo, 1989, Ionov & Wood, 1992), which have values of Fe^{3+}/Fe_{Total} that have been determined using Mossbauer spectroscopy (see Wood & Virgo, 1989).

Complete characterization of amphibole chemistry requires determination of: (1) the H_2O content, (2) the value of Fe^{3+}/Fe_{Total} (where $Fe_{Total} = Fe^{3+} + Fe^{2+}$), and (3) the fraction of the A-site that is vacant. Because conventional microprobe analyses do not provide this information, normalizing amphibole formulae may require certain assumptions regarding numbers of cations and site occupancies (Spear, 1995, p 103-105).

In this study, the Fe^{3+}/Fe_{Total} of the amphiboles from nine of the samples have been measured using the Fe Lα peak shift method, as described in Lamb *et al.* (2012). The Fe Lα peak was characterized for the amphiboles described in this study, as well as for the amphibole standards originally used by Lamb *et al.* (2012). The original calibration of Lamb *et al.* (2012) differs slightly from the one used in this study, which incorporates these new data acquired on the amphibole standards. This calibration is limited to amphibole compositions with ≥ 5 wt. % FeO (Lamb *et al.*, 2012). Consequently, the Fe^{3+}/Fe_{Total} of the amphibole from samples Ba2-1-1 and TF6 have not been determined using this method as these amphiboles contain insufficient FeO. In these two cases (Ba2-1-1 and TF6) we chose a value of 0 for Fe^{3+}/Fe_{Total} when determining the chemical formula of amphiboles as this choice generates a maximum value of aH_2O when estimated using amphibole dehydration equilibria (as described in subsequent sections of this chapter). The OH contents of all amphiboles were estimated using an empirical relation between the value of Fe^{3+}/Fe_{Total} and the OH content in mantle amphiboles (Popp *et al.*, 1995, King *et al.*, 1999, Lamb & Popp, 2009). Given these values for Fe^{3+}/Fe_{Total} and OH, it is possible to determine the A-site occupancy by requiring the resulting formula to charge balance (Lamb & Popp, 2009).

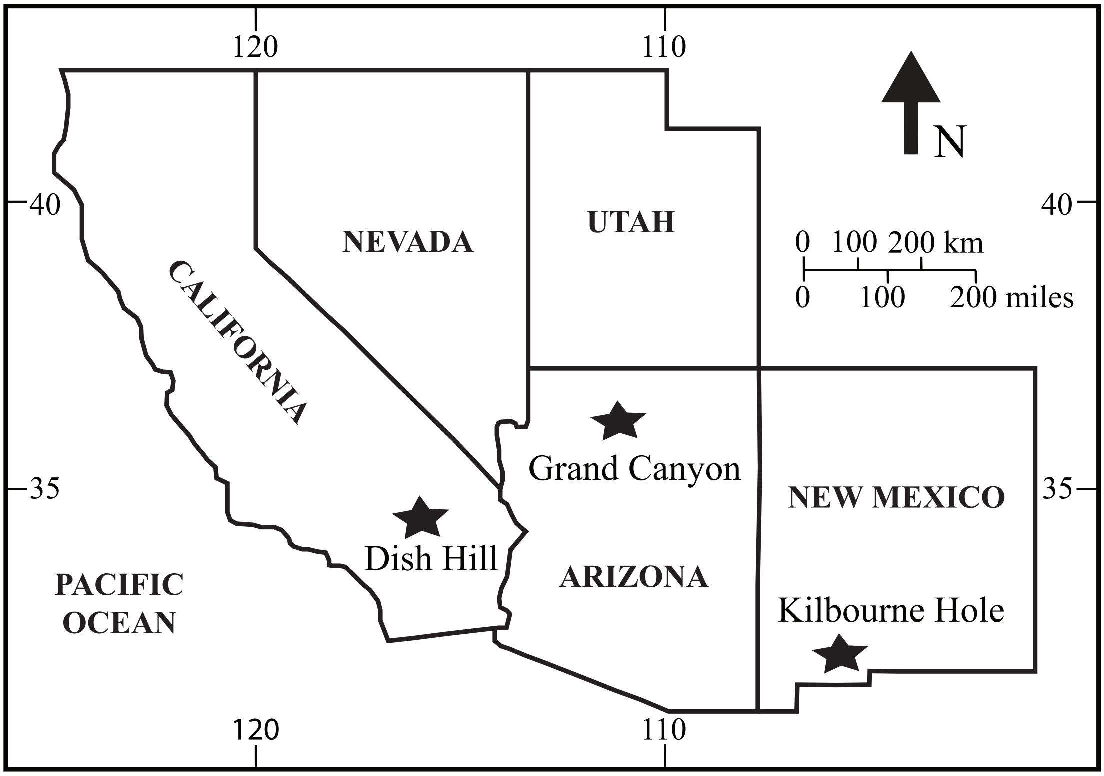


Figure 2.1: Map of Sample Locations from the SW U.S.A**.** Sample locations (denoted by the black-filled stars) for the 11 mantle xenoliths examined in this study: 8 samples are from the Grand Canyon, Arizona. 2 samples are from Dish Hill, California and 1 sample is from Kilbourne Hole, New Mexico.

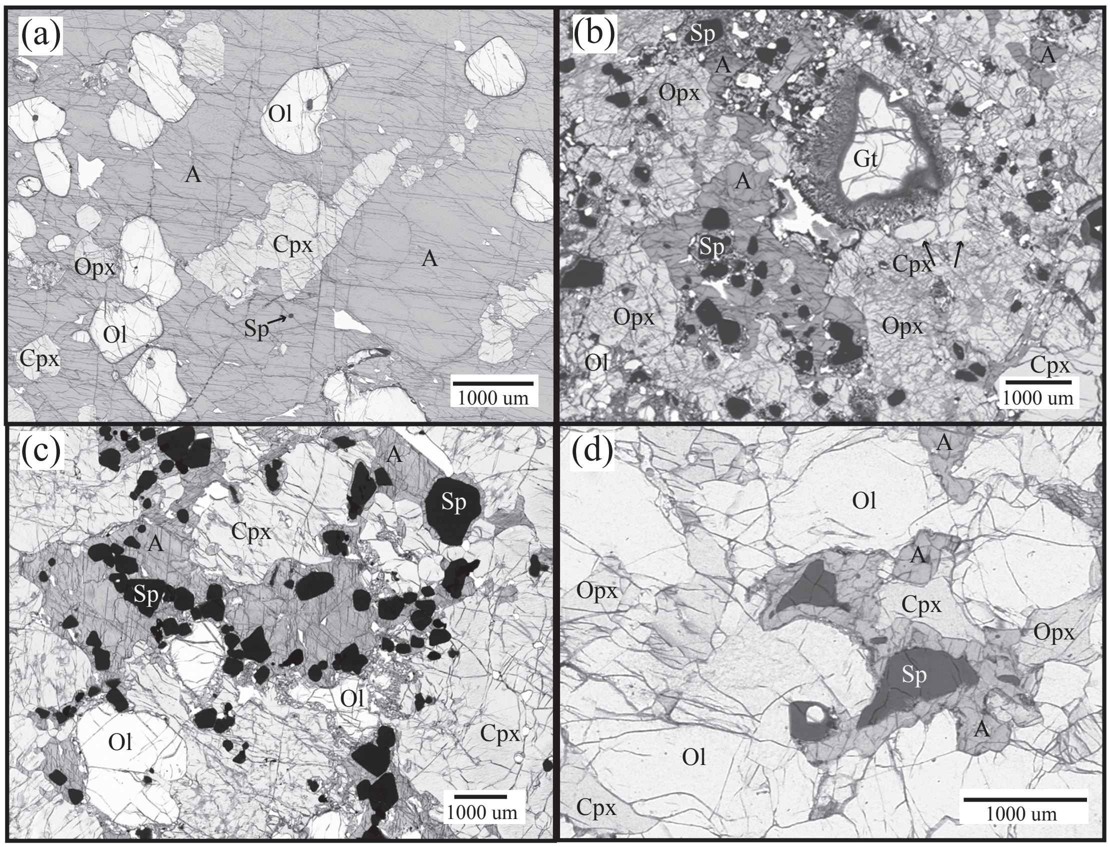


Figure 2.2: Photomicrographs illustrating typical mineralogies and textures observed in SW U.S.A xenoliths. (a) Sample X192 contains abundant amphibole (A) and olivine (Ol) with lesser amounts of orthopyroxene (Opx), clinopyroxene (cpx), and spinel (Sp). (b) Sample X174 is the only garnet-bearing (Gt) sample examined in this study. It is opx-rich with amphibole rimming spinel and occurring as more isolated grains. (c) Sample X229 contains abundant amphibole, cpx and sp. The matrix of the rock contains abundant amphibole and is always rimmed by amphibole. (d) Sample Ba-1-72 is olivine-rich and includes amphibole that occurs rimming spinel and as clusters of individual grains.

Sample Description and Mineralogy

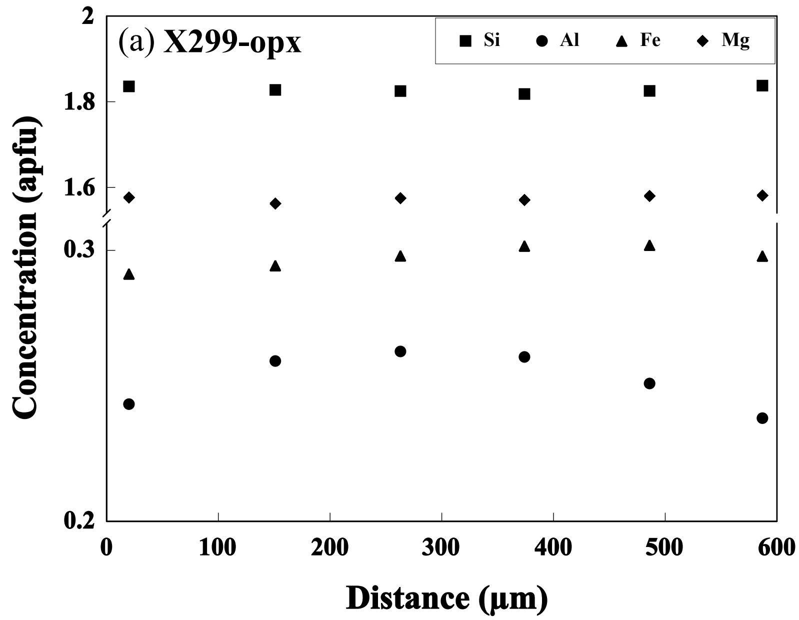
Eleven amphibole-bearing mantle xenoliths from the Southwestern U.S.A have been analyzed as part of this study. Eight samples are from the Grand Canyon. Two samples are from Dish Hill, California and the one remaining sample is from Kilbourne Hole, New Mexico (Figure 2.1). All eleven samples contain co-existing olivine, orthopyroxene, clinopyroxene, amphibole and spinel (Figure 2.2a-d). Sample X174, from the Grand Canyon, also contains garnet.

Grand Canyon

Eight samples from the western Grand Canyon region of northwestern Arizona (X174, X192, X229, X286, X297, X299, X319) were analyzed. These samples were provided by Myron Best, and more detailed information on this location and a description of various xenoliths from this area may be found in Best (1970, 1975). Sample TF6 from Toroweap Valley was provided by J.C.A Riter and information on this location may be found in Riter (1999).

All eight of the Grand Canyon samples are amphibole-rich, with samples X192 and X286 containing as much as 60% amphibole. In these two samples, the amphibole forms the matrix of the rock with the rest of the assemblage (ol, sp, opx, cpx) occurring as inclusions within the amphibole matrix (Figure 2.2a). Amphibole is also a dominant constituent of the matrix in samples X229, X297 and X319; however, these samples contain < 60 % amphibole. Samples X229, X297, and X299 contain approximately 30% amphibole, while samples X174, X319 and TF6 are the least amphibole-rich, containing approximately ≤ 20%. All of these samples typically contain more than 30% olivine and less than 20% spinel. They also contain abundant (≤ 30%) pyroxenes, generally with a higher percentage of clinopyroxene as compared to orthopyroxene. Sample X174 contains abundant orthopyroxene, with only minor amounts of clinopyroxene (Figure 2.2b). Samples X299 and TF6 contain similar amounts of olivine, clinopyroxene and orthopyroxene. In all of the samples, spinel is found both as individual grains and as grains rimmed by amphibole (Figure 2.2b).

The olivines, amphibole, and spinels in all samples are chemically homogeneous (Tables 2.1, 2.2, 2.3, and APPENDIX A, B, C) as are many of the clinopyroxenes and orthopyroxenes (Tables 2.4 and 2.5, and APPENDIX D, E). However, pyroxenes from samples X192, X297, X286 and X299 exhibit small core to rim chemical variations with a broad homogenous core and an Al-depleted, Si-rich rim (Figure 2.3a). Spinels from the Grand Canyon samples are relatively Al-rich, and typically exhibit little if any chemical heterogeneity (Table 2.3). The olivines from these eight samples have Mg# (Mg# =Mg/(Mg+ Fe)) that range from 0.77 to 0.90, and some of these samples, for example, X174, may represent olivine-rich cumulates (Best, 1975). In any sample that may represent cumulates, estimation of values of aH_2O can still provide information concerning the nature of the melts that crystallized the amphiboles and, therefore, may yield insight into mantle melt H_2O contents and metasomatism.



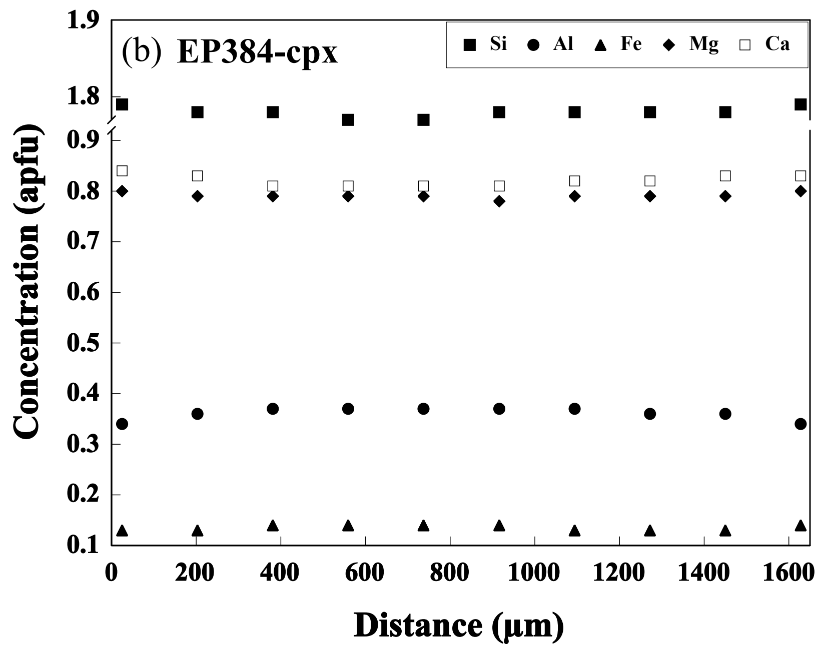


Figure 2.3: Mineral compositions plotted as a function of distance, vertical axes represent locations of grain boundaries. (a) Relative depletion in Al and enrichment in Si is sometimes apparent at grain boundaries as illustrated by this opx grain from sample X299. (b) Similar to the opx in sample X299, cpx from sample EP-3-84 exhibit core to rim variations where the rims are depleted in Al and enriched in both Si and Ca.

Table 2.1: Selected Olivine Analyses (wt. %).

Sample:	X174	X192	X229	X286	X297	X299	X319	Ba-1-72	Ba-2-1-1	EP-3-84	TF6
SiO_2	38.39	39.45	39.97	39.44	39.48	39.71	39.40	40.45	40.81	40.42	40.41
FeO	21.45	15.92	15.62	16.94	16.06	15.38	15.17	11.52	9.33	11.86	9.43
MnO	0.15	0.20	0.20	0.20	0.20	0.20	0.19	0.18	0.14	0.17	0.13
MgO	40.17	44.50	44.78	43.19	44.04	44.52	45.02	47.81	49.21	47.11	49.32
NiO	0.10	0.16	0.13	0.16	0.15	0.14	0.16	0.33	0.38	0.31	0.40
SUM	100.25	100.22	100.70	99.93	99.92	99.95	99.94	100.29	99.88	99.87	99.68

Table 2.2: Selected Amphibole Analyses (wt. %).

Sample:	X174	X192	X229	X286	X297	X299	X319	Ba-1-72	Ba2-1-1	EP-3-84	TF6
SiO_2	40.80	41.42	41.14	41.78	41.48	42.06	41.20	42.83	43.16	41.65	43.38
TiO_2	3.36	3.46	2.63	3.28	2.64	2.08	2.79	1.42	1.77	3.38	0.28
Al_2O_3	15.64	15.63	15.82	14.97	15.31	15.65	15.41	15.56	15.60	15.66	15.29
Cr_2O_3	bdl	0.36	bdl	0.25	0.33	0.32	0.28	1.08	1.10	bdl	1.32
FeO	8.37	6.36	6.94	7.58	6.63	6.70	6.16	5.28	4.34	5.53	4.07
MgO	15.01	15.93	16.10	15.22	16.30	16.42	16.59	17.33	17.92	16.63	18.59
CaO	11.14	11.03	11.69	11.09	11.53	11.47	11.68	10.71	10.56	11.42	11.41
Na_2O	3.31	2.99	2.41	2.71	1.96	2.67	2.71	3.34	3.77	3.30	3.16
K_2O	0.70	1.40	1.08	1.20	1.18	0.56	1.18	0.73	0.05	0.45	0.49
F	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.21	bdl	0.33	bdl
Cl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
H_2O	1.88	1.79	1.77	1.69	1.77	1.85	1.89	1.84	1.91	1.55	2.08
Sum	100.21	100.37	99.58	99.77	99.13	99.78	99.89	100.33	100.18	99.90	100.07
O=F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.14	0.00
O=Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	100.21	100.37	99.58	99.77	99.13	99.78	99.89	100.24	100.18	99.76	100.07

bdl, below detection limit

Table 2.3: Selected Spinel Analyses (wt. %).

Sample:	X174 Average	X192 Average	X229 Average	X286 Rim	X297 Rim	X299 Average	X319 Average	Ba-1-72 Average	Ba2-1-1 Average	EP-3-84 Average	TF6 Average
SiO_2	0.07	0.06	0.06	0.06	bdl	bdl	0.06	0.07	0.08	0.05	0.06
TiO_2	0.58	0.48	0.36	0.37	0.48	0.36	0.45	0.08	0.08	0.16	bdl
Al_2O_3	59.49	58.36	60.91	55.11	55.12	57.93	58.87	53.00	55.80	64.22	49.76
Cr_2O_3	0.15	4.57	0.89	6.81	6.01	3.23	3.48	11.62	10.61	bdl	16.05
FeO	22.41	17.72	18.68	19.52	20.96	19.36	17.71	15.57	11.44	14.10	13.47
MnO	0.08	0.25	0.13	0.21	0.18	0.14	0.22	0.20	0.36	0.11	0.57
MgO	16.65	17.99	18.83	17.74	17.37	18.08	18.60	19.39	20.82	20.65	19.52
NiO	0.16	0.20	0.17	0.23	0.28	0.21	0.22	0.36	0.40	0.25	0.37
ZnO	0.23	0.14	bdl	0.26	bdl	bdl	0.14	0.12	bdl	bdl	bdl
Sum	99.84	99.76	100.02	100.49	100.61	99.30	99.75	100.41	99.61	99.58	99.80
Fe_2O_3	5.84	3.54	6.47	6.69	8.21	6.82	4.60	6.11	2.94	3.56	4.23
FeO	17.16	14.54	12.85	13.51	14.10	13.22	13.57	10.08	8.79	10.90	9.67
Sum	100.58	100.23	100.67	100.90	101.51	99.99	100.34	101.02	99.90	99.94	100.37

bdl, below detection limit

Table 2.4: Selected Clinopyroxene Analyses (wt. %).

Sample:	X174 Average	X192 Average	X229 Average	X286 Average	X297 Rim	X299 Rim	X319 Average1	Ba-1-72 Rim	Ba2-1-1 Average	EP-3-84 Rim	TF6 Average
SiO_2	49.92	49.29	49.27	51.57	50.22	50.18	49.12	51.69	51.33	48.91	52.14
TiO_2	1.09	1.15	1.04	0.74	0.90	0.80	1.13	0.33	0.43	1.25	0.07
Al_2O_3	6.08	7.50	7.66	5.11	5.71	6.60	7.63	6.46	6.87	7.84	4.32
Cr_2O_3	bdl	0.19	bdl	0.14	0.25	0.21	0.18	0.69	0.81	bdl	0.51
FeO	6.12	4.57	3.44	5.64	4.93	4.78	4.94	3.93	3.15	4.21	2.91
MgO	14.86	15.15	14.63	15.26	15.62	15.11	15.45	15.70	15.62	14.69	17.16
CaO	20.74	21.31	21.90	20.95	21.99	21.97	20.46	20.14	20.18	21.20	22.00
Na_2O	0.97	0.78	0.52	0.89	0.53	0.44	0.60	1.44	1.48	0.96	0.67
Sum	99.80	99.95	98.45	100.30	100.15	100.09	99.51	100.39	99.88	99.06	99.78
Fe_2O_3	3.45	2.93	0.27	1.77	2.83	1.33	2.04	2.59	2.21	2.78	2.69
FeO	3.03	1.94	3.19	4.04	2.38	3.58	3.11	1.60	1.17	1.72	0.49
Sum	100.22	100.36	98.48	100.61	100.43	100.23	99.83	100.69	100.14	99.45	100.11

bdl, below detection limit

Table 2.5: Selected Orthopyroxene Analyses (wt. %).

Sample:	X174 Average	X192 Rim	X229 Average	X286 Rim	X297 Rim	X299 Rim	X319 Rim	Ba-1-72 Average	Ba2-1-1 Average	EP-3-84 Average	TF6 Average
SiO_2	52.21	53.26	51.81	53.12	52.34	52.53	52.42	53.30	54.87	54.25	54.69
TiO_2	0.32	0.32	0.26	0.34	0.30	0.22	0.35	0.09	0.11	0.20	0.01
Al_2O_3	5.43	4.94	5.72	4.47	5.48	5.78	5.89	4.69	4.79	4.86	4.26
Cr_2O_3	bdl	bdl	bdl	0.12	0.19	0.15	0.13	0.34	0.38	0.18	0.43
FeO	12.63	11.00	10.62	10.54	10.64	10.18	9.66	7.58	6.18	7.65	6.26
MgO	27.98	29.15	29.52	30.39	29.74	30.32	29.96	32.65	32.48	31.65	32.85
CaO	0.84	0.81	0.74	0.84	0.77	0.74	0.76	0.92	0.81	0.71	0.72
Na_2O	0.06	0.10	0.03	0.05	0.04	bdl	0.03	0.11	0.10	0.06	0.04
Sum	99.48	99.60	98.69	99.87	99.49	99.93	99.21	99.68	99.71	99.54	99.27
Fe_2O_3	1.43	0.73	2.63	2.68	2.42	2.68	1.58	4.39	0.07	0.42	0.00
FeO	11.34	10.35	8.25	8.13	8.46	7.77	8.24	3.63	6.11	7.27	6.26
Sum	99.76	99.88	99.18	100.35	99.95	100.45	99.56	100.12	99.93	99.77	99.46

bdl, below detection limit

Sample X174 contains both garnet and spinel, with a significant amount of spinel (≈ 20%) and lesser amounts of garnet (≈ 5%). The compositions of the garnets in sample X174 are homogenous with little or no core to rim variations in chemical composition (see APPENDIX F for garnet compositions). However, the garnets in this sample are rimmed by kelephyite (Figure 2.2b), which suggests the garnets may not be in equilibrium with the other minerals in this particular sample. Thus, the compositions of this garnet will not be used for the pressure determination of sample X174.

Dish Hill, California

Two samples from Dish Hill, California (Ba-1-72 and Ba2-1-1) and have been provided by the Smithsonian Institute. This location has been described by Wilshire and Trask (1971) and one of the samples in particular, Ba-1-72 has been described by Wilshire et al. (1971, 1980). A portion (1/4) of the thin section from this sample consists solely of amphibole, presumably part of an amphibole-rich vein. The amphibole in the remainder of the Ba-1-72 sample is typically found rimming grains of spinel (Figure 2.2d). The composition of the amphibole in the vein differs slightly from the amphibole found surrounding the spinels, however, all individual amphibole grains are chemically homogenous (Table 2.2). Amphibole in sample Ba2-1-1 occurs as both individual grains and as grains rimming spinel. Unlike many of the Grand Canyon samples, these two samples are not amphibole rich, as both contain less than 10% amphibole. They also contain abundant, compositionally homogeneous olivine (≥ 40%), orthopyroxene (≤ 30%) and Al-rich spinel (≤ 20%) (Tables 2.1, 2.3 and 2.5). The olivine Mg# for samples Ba-1-72 and Ba2-1-1 are 0.88 and 0.90, respectively. Clinopyroxene grains exhibit subtle chemical zonation with a drop in Al content and an increase in Si contents from the core to the rim of a grain (Table 2.4).

Kilbourne Hole, New Mexico

One xenolith, EP-3-84, from Kilbourne Hole, New Mexico has also been analyzed as part of this study (sample provided by the Smithsonian Institute). Information about the sample location and mineralogy of similar spinel-bearing xenoliths found in this location can be found in various publications (e.g., Perkins & Anthony, 2011, and references therein, Satsukawa *et al.*, 2011).

Sample EP-3-84 is clinopyroxene-rich (≈ 40%), with abundant spinel (≈ 30%) and olivine (≈15%) and lesser amounts of orthopyroxene (≈10%) and amphibole (≈ 5%). The olivine, amphibole, orthopyroxene, and spinel are all chemically homogeneous from core-to-rim (Tables 2.1, 2.2, 2.3, and 2.5). The clinopyroxene from this sample exhibits minor chemical zonation with a general decrease in Al content and an increase in Si contents from the core to the rim of a grain (Table 2.4 and Figure 2.3b).

Because amphibole often occurs rimming spinel and, in rare cases, pyroxene grains, this indicates that in most of these samples, the amphibole growth occurred after pyroxene and spinel. We infer, therefore, that the amphiboles are in equilibrium with the rims of chemically zoned pyroxenes and spinels. In these samples, the rim compositions were used when mineral equilibria were applied to estimate P, T, aH_2O, fO_2 and fH_2.

Estimation of Pressure and Temperature

In order to estimate values of aH_2O, fO_2 and fH_2 using mineral equilibria, the pressure (P) and temperature (T) of mineral equilibration must be determined. Pyroxene geothermometry was applied to estimate temperature for all samples, and these T determinations were combined with estimates of the geothermal gradient to determine values of P (as discussed below).

Temperature

Geothermometers based on the compositions of co-existing pyroxenes have been widely applied in mantle rock (e.g., Nimis & Grutter, 2010). However, a number of different versions of the two-pyroxene geothermometer have been formulated (Wells, 1977, Bertrand & Mercier, 1985, Brey & Köhler, 1990, Taylor, 1998) and the accuracy of temperature estimates depends, in part, in choosing the most appropriate geothermometer. Nimis & Grütter (2010) prefer the two pyroxene geothermometer of Taylor (1998) (T98), as compared to other geothermometers that may be applied to mantle peridotites, in part because T98 more accurately reproduces temperatures of experiments designed to yield equilibrium compositions of co-existing pyroxenes. Two other formulations of the pyroxene geothermometer, the enstatite-in-Cpx thermometer of Nimis & Taylor (2000) (NT) and Ca-in-opx thermometer (Brey & Köhler, 1990) as modified by Nimis & Grütter (2010) (BKNG) also agree with T98 within ± 30˚C and ±70˚C respectively, over the temperature range of 900 to 1200˚C (Nimis & Grutter, 2010). Thus, we have compared the results of three geothermometers (T98, NT, BKNG) in an effort to determine if a reliable estimate of the temperature of pyroxene equilibrium had been determined.

In some cases accurate temperature estimates from conventional thermobarometry may require determining values of Fe^{3+}/Fe_{Total} in Fe-bearing minerals, including pyroxenes (Schumacher, 1991, Matjuschkin *et al.*, 2014). The sensitivity of our temperature estimates to differences in Fe^{3+}/Fe_{Total} was evaluated by determining 2-pyx temperatures using two methods, described previously (charge balance and total Fe is Fe^{2+}), to determine values of Fe^{3+}/Fe_{Total} in pyroxenes. The maximum difference in temperature calculated using these methods is 20˚C. This small T difference is similar to other results indicating that the two-pyroxene thermometer, as applied to mantle rocks, is relatively insensitive to uncertainties in Fe^{3+}/Fe_{Total} (Brey & Köhler, 1990, Schumacher, 1991, Canil & O'Neill, 1996, Taylor, 1998). Thus, two-pyroxene temperature estimates used in this chapter are estimated based on stoichiometry.

Pressure

For spinel-bearing peridotites, the determination of pressure is challenging largely because equilibria between the major components of these rocks are generally not pressure sensitive (Köhler & Brey, 1990). For example, Köhler and Brey (1990) developed a geobarometer based on the exchange of Ca- between olivine and clinopyroxene, however, application of this geobarometer is limited by its sensitivity to temperature (O'Reilly *et al.*, 1997, Smith, 1999). Pressures of mineral equilibration were constrained by combining temperature determinations based on two-pyroxene thermometry with a geothermal gradient for this geographic region of the U.S.A. These pressure estimates were compared to minimum and maximum values of P, which is a relatively common approach given the difficulty involved in determining a single value of pressure for spinel-bearing peridotites (Ionov *et al.*, 1993, Riter & Smith, 1996, Lamb & Popp, 2009, Perkins & Anthony, 2011). Minimum pressures for these samples are based on the depth of the Moho (Lamb & Popp, 2009, Perkins & Anthony, 2011) and maximum pressures are based on the transition from spinel-to-garnet (Lamb & Popp, 2009).

The depth of the Moho in the SW USA is approximately 40 km (Lowry & Perez-Gussinye, 2011, Gilbert, 2012). This depth corresponds to a minimum pressure of approximately 1.1 GPa. The maximum pressures estimates, based on the P-T location of the spinel-to-garnet transition (O'Neill, 1981) range from 1.6 to 2.1 GPa, depending on mineral compositions, with an average maximum P estimate of 1.9 GPa (Figure 2.4).

To our knowledge, no geothermal gradient, based on P-T estimates of xenoliths from the SW USA region, has been published. Therefore, we combined a heat flow value for the Grand Canyon of approximately 83 mW/m^2 (Blackwell & Richards, 2004) with the continental heat flow model of Pollack & Sass (1988) to determine a geothermal gradient for this region (Grand Canyon Geothermal Gradient or GCGG). A steady state geotherm may not be directly applicable to regions of active tectonism and/or recent magmatism, such as the Colorado Plateau (Riter & Smith, 1996). However, agreement between the GCGG and the P-T determination from a single garnet-bearing xenolith collected from the Grand Canyon (Best, 1975), supports using a geotherm to estimate P at any given value of T (Figure 2.4). Futhermore, values of aH_2O, fO_2 and fH_2 estimated using mineral equilibria are not strongly P-dependent, such that change the value of P by ± 0.3 GPa has a very small effect, for example, on the estimated value of aH_2O (as discussed in subsequent sections of this chapter).

Taylor's (1998) two-pyroxene thermometer yields temperatures from 880˚C to 960˚C at pressures ranging from 1.4 to 1.6 GPa for the 11 xenoliths included in this study (Table 2.6 and Figure 2.4). The absolute temperature difference between the formulations of T98 and NT generally ranges from 0 to 30˚C, and the difference between T98 and BKNG ranges from 0 to 70˚C with and average difference of 37˚C. These differences are relatively small (see previous discussion, and Nimis & Grutter (2010)) and the agreement between the three formulations of the two-pyroxene thermometer indicates that the co-existing pyroxenes equilibrated at the temperatures given on Table 6. Pressure estimates based on the GCGG are also consistent with minimum and maximum pressure estimates based on depth of the Moho and the spinel-to-garnet transition, respectively (Figure 2.4).

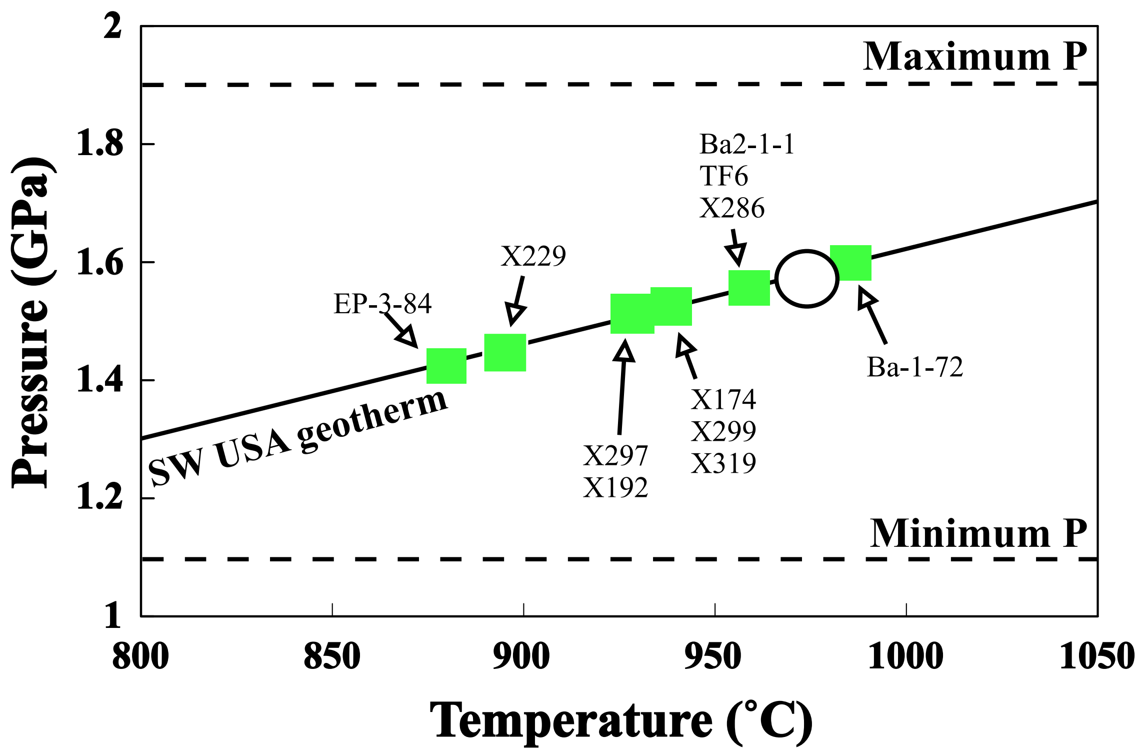


Figure 2.4: P-T estimates for 11 SW U.S.A xenoliths. Temperature estimates, based on Taylor's (1998) two-pyroxene thermometer, were used in combination with geothermal gradients and other constraints to determine pressure estimates for each sample (see text). The minimum pressure is constrained by depth of the Moho (Minimum P = 1.1 GPa), while maximum pressures are based on stability of spinel ± garnet. The maximum pressured depicted in this figure is the average maximum pressure for all of the samples in this study (i.e. Maximum P = 1.9 GPa). The circle represents a P-T determination for a single garnet-bearing xenolith that was also collected by Best (1971) from the Grand Canyon.

Table 2.6: Calculation of equilibration temperature (˚C) and pressure (GPa) of samples from the SW U.S.A.

Sample:	Wells[a]	T98[b]	NT[c]	BKNG[d]	BK[e]	P1	P2
X174	990	940	960	1010	1020	15	11
X192	990	930	960	990	1000	15	
X229	950	900	900	960	980	14	
X286	990	960	970	1000	1010	15	
X297	990	930	950	980	990	15	
X299	980	940	950	970	980	15	
X319	1000	940	960	980	1000	15	
Ba-1-72	1030	980	1000	1030	1040	16	
Ba2-1-1	1000	960	980	990	1000	15	
EP-3-84	960	880	910	950	970	14	
TF6	1000	960	980	960	980	15	

(a) Wells (1977) 2-Px (b) Taylor (1998) 2-Px (c) Nimis & Taylor (2000) -En-in-cpx (d) Nimis & Grutter (2010)- modified B&K Ca-in-opx (e) Brey & Kohler (1990) Ca-in-opx (f) Pressure calculated using geotherm for SWUSA Temperature estimates in **bold** are used for all calculations.

Results: Activities of Fluid Species

Values of aH_2O estimated using Amphibole Dehydration Equilibria

A number of different H_2O-buffering equilibria involving the minerals in our samples can be written. The accuracy of the resulting estimate of aH_2O using any one of these equilibria will depend on various factors, including the accuracy of: (1) the P-T estimates, (2) the characterization of mineral chemistry, (3) the models that describe the activity-composition (a-X) relations in various minerals. Not all activity models may be equally suitable given the mineral chemistry of our samples and the choice of activity model will, to some extant, dictate which H_2O-buffering equilibria will provide the most accurate estimate of aH_2O.

Lamb & Popp (2009) and Popp *et al.* (2006) have applied dehydration equilibria to estimate values of aH_2O in mantle rocks and have considered a number of different H_2O-buffering reactions as well as various models that describe the activity-composition relations in the minerals included in those reactions. For this study, we have adopted their approach and, therefore, estimates of aH_2O are based on the equilibria:

2Pargasite + Enstatite = 2Forsterite +4Diopside + 2Jadeite +2Spinel + H_2O (2.1)

This equilibria was chosen largely because of the Mg-rich nature of olivine, orthopyroxenes, and spinel, and the pargasite-rich amphiboles found in these samples (Lamb & Popp, 2009).

THERMOCALC (Powell *et al.*, 1998) was chosen to estimate values of aH_2O based on equilibria 2.1 (Lamb & Popp, 2009) largely because of the availability of relatively sophisticated models describing the activity-composition (a-X) relations in amphiboles

(Dale *et al.*, 2005). However, other a-X models, consistent with THERMOCALC, may not yet be directly applicable to mantle compositions and/or conditions. The spinel model, (White *et al.*, 2002), for example, may be particularly problematic because it was developed for magnetite and is unsuitable for Cr-bearing mantle spinels (see, for example, the discussion in Lamb & Popp (2009)). Therefore, in addition to the relevant activities of mineral end members obtained using THERMOCALC (Holland & Powell, 1996, 1998, White *et al.*, 2002, Dale *et al.*, 2005, White *et al.*, 2007), Lamb & Popp (2009) also calculated end member activities using activity models that were consistent with the MELTS software package (Ghiorso & Sack, 1995, Asimow & Ghiorso, 1998) as these activity models were developed specifically for common mantle minerals, such as olivine, spinel, and pyroxenes (Sack & Ghiorso, 1989, 1991, 1994 a,b). Lamb & Popp (2009) demonstrated that the choice of activity model, whether developed for MELTS or for THERMOCALC, has little if any effect on the calculated end-member activities for mantle Mg_2SiO_4 in olivine, $Mg_2Si_2O_6$ in orthopyroxene, and $CaMgSi_2O_6$ and $NaAlSi_2O_6$ in clinopyroxene. Because of the Mg-rich nature of many of these minerals, specifically olivine, orthopyroxene and clinopyroxene, the non-ideal activities of these end-members are also almost identical to the ideal activities over this PT range. Given thiscombination of factors, Lamb & Popp (2009) ultimately relied on a combination of activity models to estimate values of aH_2O. The activities of olivine, orthopyroxene, clinopyroxene, and spinel were determined using models consistent with the MELTS software, while the activity of amphibole was determined using models consistent with the THERMOCALC software.

Similar results were obtained for the samples used in this study, with the average difference between end-member activities, as determined using both THERMOCALC and MELTS, for olivine, orthopyroxene and clinopyroxene is relatively small (≈ 0.06). It is, therefore, perhaps not surprising that the choice of activity models has only a small effect on the values of aH_2O estimated using amphibole dehydration equilibria. For example, values of aH_2O for sample EP-3-84 differ by approximately 0.01 (Figure 2.5a), with the greatest difference = 0.04 for sample Ba2-1-1.

Although activity models for amphibole have been developed since the publication of Dale *et al.* (2005), including Diener *et al.* (2007), Diener and Powell (2012), we have applied the amphibole model of Dale *et al.* (2005) for consistency with previous results (e.g., Lamb & Popp, 2009). Furthermore, given the Na-rich amphiboles in all eleven samples, application of these more recent amphibole models should yield little only small changes in values of aH_2O when estimated using equilibrium (2.1). As a test, all three amphibole models (Dale *et al.*, 2005, Diener *et al.*, 2007, Diener & Powell, 2012) were applied to estimate values of aH_2O for all samples, and the resulting difference in aH_2O is less than 0.03.

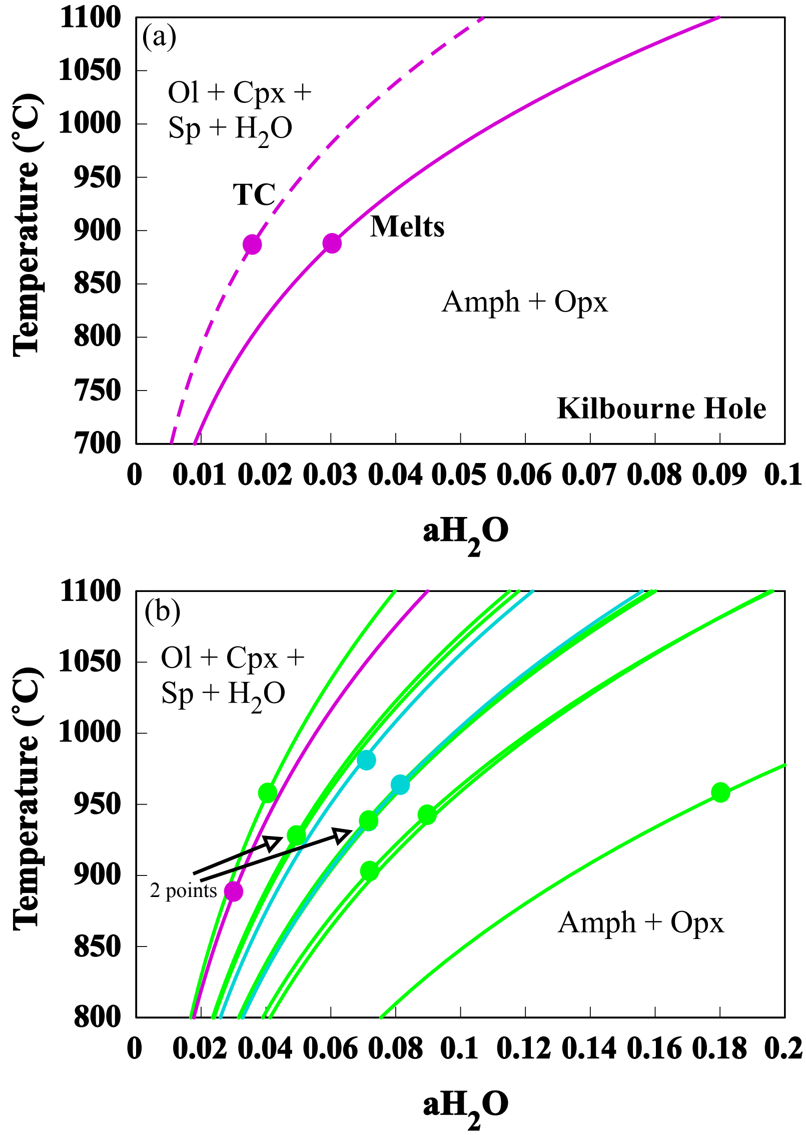


Figure 2.5: The T - aH_2O stabilities of equilibrium (Equation 2.1) at a constant P as indicated by the value in parentheses. Filled circles indicate values of T and aH_2O for each sample. (a) The Kilbourne Hole sample equilibrated at an aH_2O of approximately 0.03 as determined using activity models consistent with MELTS. Activity models consistent with THERMOCALC would reduce the value of aH_2O by only 0.01. (b) The remaining ten samples (Grand Canyon - green, Dish Hill - blue, and Kilbourne Hole - purple) equilibrated at values of aH_2O <0.20.

Application of equilibrium (2.1) yields low values of aH_2O (< 0.20) for all of the mantle xenoliths in this study (Table 2.7 and Figure 2.5b). While the choice in the activity model ultimately does not yield large differences in values of aH_2O, other sources of uncertainty, specifically P and T, have also been considered. An estimated pressure uncertainty of ± 0.4 GPa yields a difference of ± 0.04 in values of aH_2O, while a temperature change of ± 50 ˚C yields a similar change in estimated values of aH_2O = ± 0.04. Therefore, given the combined uncertainties involved in P, T and activity models, the overall uncertainty for values of aH_2O is likely better than ± 0.1.

Table 2.7: Mineral activities and values of aH_2O estimated using amphibole dehydration equilibria.

	Mineral Activities*							aH_2O
	aFo	aDi	aJd	aEn	aSp	aParg	aPy	
X174	0.67	0.66	0.03	0.61	0.66	0.12	0.27	0.07
X192	0.73	0.67	0.03	0.65	0.66	0.10		0.05
X229	0.73	0.81	0.01	0.66	0.70	0.09		0.07
X286	0.71	0.69	0.04	0.67	0.63	0.08		0.04
X297	0.73	0.72	0.02	0.66	0.62	0.06		0.05
X299	0.74	0.70	0.02	0.66	0.67	0.10		0.07
X319	0.74	0.65	0.03	0.66	0.67	0.16		0.09
Ba-1-72	0.79	0.68	0.06	0.75	0.61	0.19		0.07
Ba2-1-1	0.82	0.68	0.07	0.74	0.67	0.34		0.08
EP-3-84	0.79	0.68	0.04	0.71	0.76	0.14		0.03
TF6	0.82	0.77	0.03	0.75	0.60	0.38		0.18

* All mineral activities were calculated using activity models that are consistent with the MELTS software, except for pargasite and pyrope, which were calculated using models that are consistent with the THERMOCALC software (see text for discussion).

Estimations of Oxygen Fugacity (fO_2)

In the upper mantle, values of fO_2 may be affected by several factors, including bulk composition, tectonic setting, and fluids (Wood, 1990, Wood *et al.*, 1990, Woodland *et al.*, 1992, Woodland & Koch, 2003, Frost & McCammon, 2008). Values of fO_2 are typically reported relative to an oxygen buffering equilibria, such as the Fayalite-Magnetite-Quartz (FMQ) buffer, which is based on the equilibria:

$$3\mathrm{Fe_2SiO_4} + \mathrm{O_2} = 2\mathrm{Fe_3O_4} + 3\mathrm{SiO_2} \quad (2.2)$$

and typical values of fO_2 for the uppermost mantle range from FMQ-3 to FMQ+2 (Wood, 1990, Woodland *et al.*, 1992, Woodland & Koch, 2003).

Values of fO_2 have been estimated for mantle xenoliths that contain co-existing spinel, olivine and orthopyroxene, using the equilibria:

$$6\mathrm{Fe_2SiO_4} + \mathrm{O_2} = 3\mathrm{Fe_2Si_2O_6} + 2\mathrm{Fe_3O_4} \quad (2.3)$$

and in this study, we applied the calibration of Wood (1990):

$$\Delta\log fO_2(\mathrm{FMQ}) = 0.35 + \frac{220}{\mathrm{T}} - \frac{0.0369\mathrm{P}}{\mathrm{T}} - 12\log(\mathrm{X_{Fe}^{ol}})$$

$$-\frac{2620\,(\mathrm{X_{Mg}^{ol}})^2}{\mathrm{T}} + 3\log\,(\mathrm{X_{F2}^{M1}X_{Fe}^{M2}})^{\mathrm{opx}} + 2\log\,(\mathrm{a_{Fe_3O_4}^{sp}}) \quad (2.4)$$

For this reaction, the P is in bars, T in in K, $(\mathrm{X_{Fe}^{ol}})$ and $(\mathrm{X_{Mg}^{ol}})$ are the mole fractions of Mg and Fe end-members in olivine, $(\mathrm{X_{Fe}^{M1}X_{Fe}^{M2}})^{\mathrm{opx}}$ are the atomic fraction of Fe in both the M2 and M2 sites in orthopyroxene, and $\mathrm{a_{Fe_3O_4}^{sp}}$ is the activity of Fe_3O_4 in spinel. The estimated values of fO_2 for our samples range from FMQ-0.8 to FMQ+0.6 (Table 2.8 and Figure 2.6).

Table 2.8: Determinations of fO_2, fH_2 and values of aH_2O estimated using a combination of fO_2 and fH_2.

Sample:	$\Delta\log fO_2$ (FMQ)	Fe^{3+}/ Fe Total	$\log fH_2$	aH_2O
X174	-0.48	0.23	1.84	0.10
X192	-0.16	0.42	0.88	0.02
X229	0.41	0.25	1.43	0.12
X286	-0.33	0.36	1.12	0.03
X297	0.39	0.35	1.17	0.07
X299	0.32	0.42	0.76	0.03
X319	-0.12	0.29	1.60	0.10
Ba-1-72	-0.84	0.25	2.03	0.11
Ba2-1-1	0.27	nm	nm	nm
EP-3-84	0.56	0.43	0.68	0.03
TF6	0.47	nm	nm	nm

nm = Values of fH_2 not estimated for samples Ba2-1-1 and TF6 (see text for explanation).

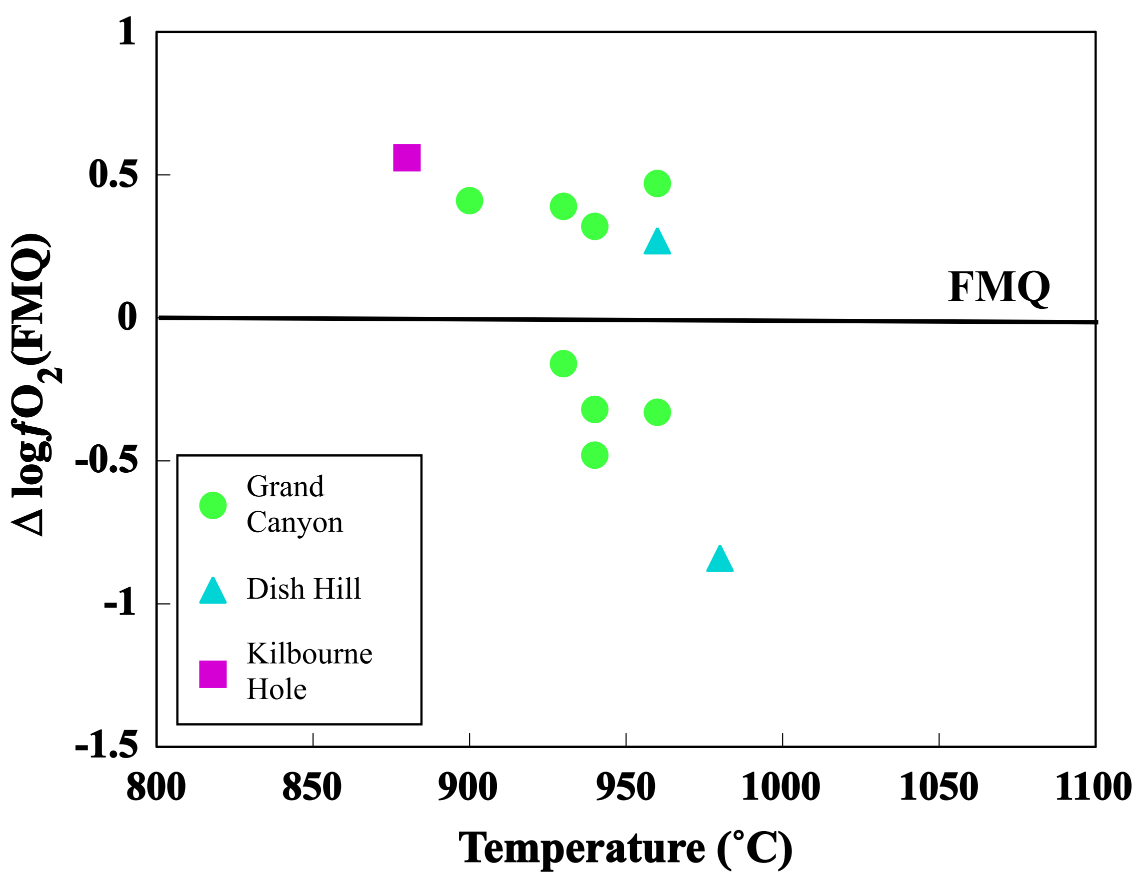


Figure 2.6: Values of fO_2 have been estimated using the oxy-barometer of Wood (1990) and are expressed relative to the FMQ oxygen buffer and as a function of temperature (˚C). The values of $\Delta \log fO_2$ range from 0.8 log units below, to 0.6 log units above FMQ.

Estimations of ƒH₂ using Amphibole Dehydrogenation Equilibria

Values of hydrogen fugacity (fH_2) can be estimated at any given value of P, T, from the chemical composition of a mantle amphibole, including the Fe^{2+} and Fe^{3+} content of amphiboles (Popp & Phillips, 1995, Popp *et al.*, 2006), This approach (Popp & Phillips, 1995, Popp *et al.*, 2006), is based on the Fe-amphibole end-member reaction:

$$Ca_2Fe_5^{2+}Si_8O_{22}(OH)_2 = Ca_2Fe_3^{2+}Fe_2^{3+}Si_8O_{24} + H_2 \quad (2.5)$$

with the equilibrium constant (K) defined as:

$$K = fH_2\ (28.94)\frac{(XFe^{3+})^2(X_{\square})^2}{(XFe^{2+})^2(X_{OH})^2} * \phi = K_x * \phi \quad (2.6)$$

for which

$$\log K_x = 4.23 - \frac{4380}{T} + \{1.37 \times [(Ti + Al_{total}) - 2.49]\} + \left\{\frac{88}{T}[P - 1(kbar)]\right\} \quad (2.7)$$

where □= H-vacancy on the O3 anion position, ϕ is the activity coefficient term and K_x represents the thermodynamic mole fraction term, and T is temperature in K. Values of Fe^{3+}/Fe_{Total} for the amphibole from all the samples, except Ba2-1-1 and TF6 have been estimated using the methods of Lamb *et al.* (2012) (see Analytical Methods section above and Table 2.8).

Values of fH_2 have been determined for nine samples and range from 5 to 107 bars (Table 2.8). Given a value of fH_2 from the dehydrogenation equilibria, and a value of fO_2 from oxybarometry, it is possible to estimate a value of fH_2O using the equilibria $2H_2 + O_2 = 2H_2O$ where the products and reactants are related by the equilibrium constant (K_{H_2O}) as follows:

$$K_{H_2O} = \frac{f_{H_2}(f_{O_2})^{1/2}}{f_{H_2O}} \quad (2.8)$$

For the 9 mantle xenoliths where the Fe^{3+}/Fe_{Total} have been estimated, this method yields low values of aH_2O that are less than to 0.13 (Table 2.8).

Discussion

For any one sample, the value of aH_2O estimated using amphibole dehydration equilibria (Table 2.7) should be equivalent to the value of aH_2O estimated using the combination of amphibole dehydrogenation equilibria and oxybarometry (hereafter referred to as the combined approach). All eleven samples record low values of the aH_2O (<0.20), regardless of which equilibria are used (Tables 2.7 and.2.8 and Figure 2.7). For the nine samples, in which both methods (dehydration equilibria and the combined approach) could be used to estimate values of the aH_2O, the average difference between these two values of aH_2O is 0.03, with the largest difference (0.05) observed in sample X22 (Figure 2.7). Based on these results, the two values of aH_2O for all nine samples agree within uncertainty (± 0.1). This agreement indicates that, these 9 samples from the SW U.S.A, all equilibrated at low values of aH_2O (< 0.20). These low values of aH_2O demonstrate that the presence of amphibole does not require H_2O-rich conditions, a result that agrees with previous studies (Lamb & Popp, 2009, Bonadiman *et al.*, 2014).

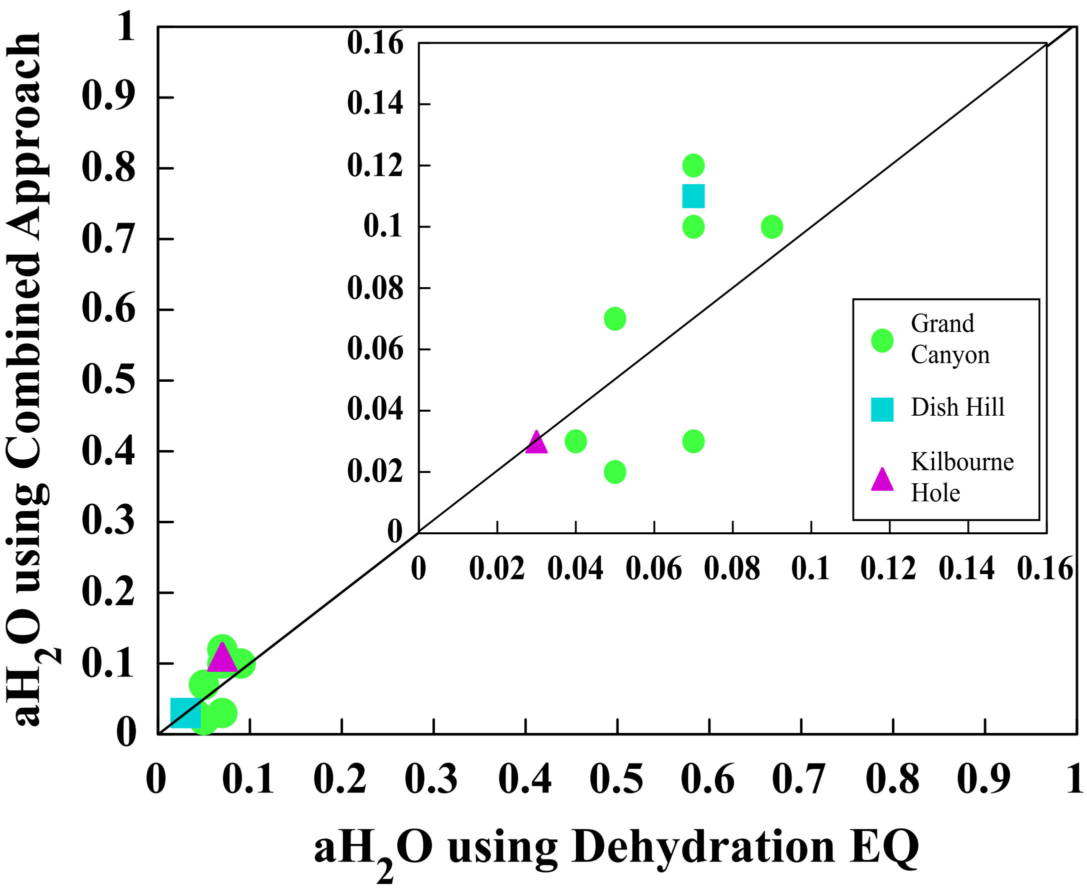


Figure 2.7: A comparison of the values of aH_2O estimated using amphibole dehydration equilibria and the combination of fO_2 and fH_2 (referred to as the combined approach). Both methods yield values of aH_2O that are less than 0.20. In general, most of the samples agree within uncertainty. However, for some samples, particularly X299 and X192, the dehydration equilibria suggest higher values of aH_2O as compared to the combined approach. Therefore, it is possible that samples X299 and X192 may have suffered a limited amount of H-loss during transport.

It has been argued that amphiboles may not be good indicators of mantle fluids due to possible diffusive H-loss during emplacement on Earth's surface (Dyar *et al.*, 1993). However, the comparison of values of aH_2O for any given sample, as determined using dehydration equilibria and the combined approach, can serve as a test of the H-retention of mantle amphiboles. This test is possible largely because values of aH_2O estimated using the combined approach are more sensitive to H-loss from amphibole than those estimated using dehydration equilibria (Lamb & Popp, 2009). This difference in sensitivity is illustrated in Figures 2.8a and 2.8b, which were constructed by estimating values of aH_2O for samples X299 and X192 over a range of amphibole H-contents all greater than the estimated H-content (1.43 and 1.30 atoms per formula unit (apfu) in samples X299 and X192, respectively). Thus, Figures 2.8a and 2.8b plot values of aH_2O as a function of the H-content of the amphibole. Both of these samples record low values of aH_2O using either the combined approach (open square on Figure 2.8) or dehydration equilibria (black circle on Figure 2.8). Adding H to these amphiboles should increase the value of aH_2O for both methods and would better reflect true mantle values if retrograde amphibole H-loss had occurred. In this case increasing the H-content of the amphibole should yield a H-content closer to the equilibrium mantle values and, therefore, should improve the agreement between the estimated using the two approaches (combined vs. dehydration). As expected, adding H to the amphibole formula does increase the estimated value of aH_2O using either method, as illustrated by the two curves in Figures 2.8a and 2.8b. The resulting values of aH_2O, however, begin to diverge significantly once more than approximately 0.15 H apfu is added to the amphibole. Figures 2.8a and

2.8b show that increasing amphibole H-contents produces small changes in aH_2O estimated using dehydration equilibration as compared to much larger increases in values of aH_2O estimated using the combined approach. These results indicate that the amphiboles contained did not suffer loss of H in amounts more than approximately 0.15 H apfu. All other samples from this study yield similar results and, therefore, H-loss from these amphiboles was limited, and the overall agreement between values of aH_2O estimated using both methods indicates that the amphiboles in these samples have retained their mantle H-contents.

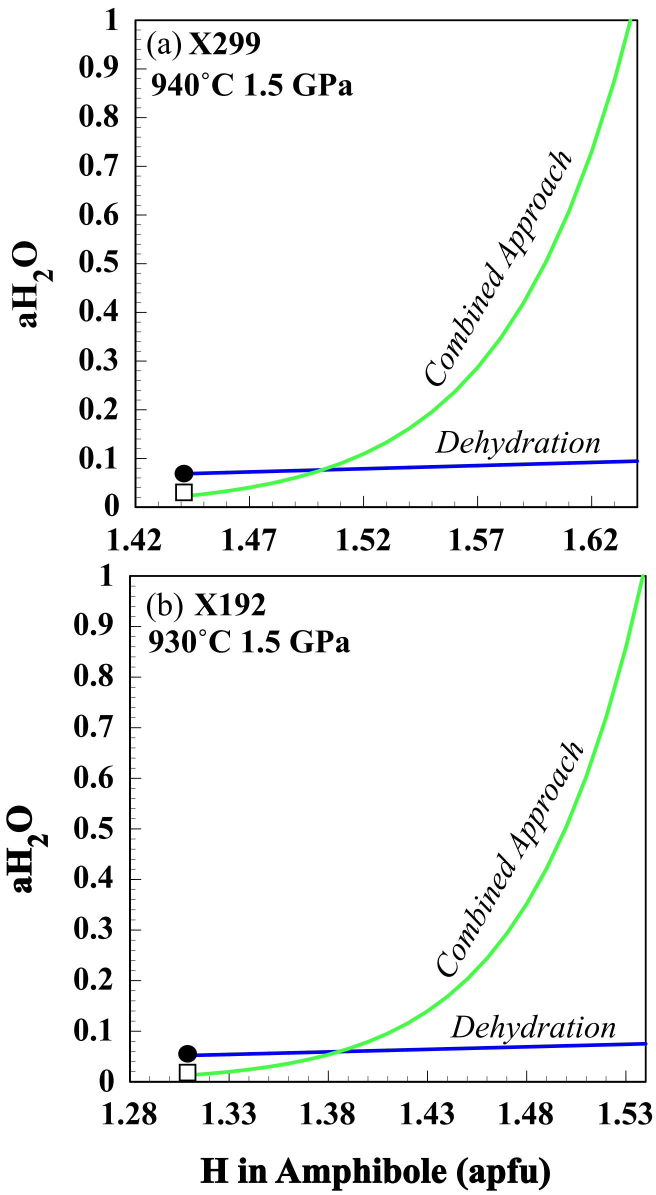


Figure 2.8: Values of aH_2O estimated using amphibole dehydration and dehydrogenation equilibria are plotted as a function of the H-content of the amphibole. Black circles indicate the values of aH_2O and the corresponding hydrogen content of amphiboles for samples (a) X299 and (b) X192. In both (a) and (b), the curve based on the combined approach records a marked change in slope (i.e., values of aH_2O) with increasing amphibole H-content as compared to the curve based on the dehydration reaction. This shows that values of aH_2O estimated using that the combined approach is much more sensitive to small changes in the H-content of the amphibole as compared to the dehydration equilibria. The agreement in these two values of aH_2O, based on the current estimated amphibole H-content, indicates that the amphibole in these two samples may have undergone only very limited H-loss.

Values of mantle aH_2O, fO_2, and the Presence of Oxy-Amphiboles

Bryndzia and Wood (1990) noted that amphibole-bearing samples xenoliths from the sub-continental are relatively oxidized when compared to spinel peridotites that do not contain amphibole but are also sub-continental. In that study, values of $\Delta\log fO_2$ (FMQ) recorded by the amphibole-bearing samples ranged from approximately 0 to +1.5, and while those values fall within the range of samples with no amphibole ($\Delta\log fO_2$ (FMQ) from -1.5 to 2.0), they are distinctly oxidizing on average. However, values of $\Delta\log fO_2$ recorded by the samples in this study range from FMQ-0.8 to FMQ+0.6 (Table 2.8 and Figure 2.6). These values of $\Delta\log fO_2$ fall well within the range typical of the upper mantle (FMQ-3 to FMQ+2) (Wood, 1990, Woodland *et al.*, 1992, Woodland & Koch, 2003) and are not particularly oxidizing.

The absence of any clear correlation between oxygen fugacity and the presence of mantle amphiboles may be surprising because experimental investigations of oxy-amphiboles have demonstrated that, at a given temperature and fluid pressure and when the fluid is dominated by H_2O, the value of Fe^{3+}/Fe_{Total} in an amphibole of a single composition increases with increasing oxygen fugacity (Popp *et al.*, 1995, 2006). This experimental result is predictable because reaction (2.5), and equation (2.6), indicates that production of the oxy-amphibole component in an amphibole is favored by relatively low values of hydrogen fugacity. While consideration of equilibrium (2.8) shows that, for a fixed value of the fugacity of H_2O, low values of hydrogen fugacity will yield elevated values of oxygen fugacity. If mantle amphiboles equilibrated with an H_2O-rich fluid then the presence of amphiboles with a significant oxy-component should, therefore, indicate elevated values of mantle fO_2, particularly amphibole with significant Fe^{3+} contents. We have, therefore, plotted the ferric-ferrous ratios of amphibole vs. the value of oxygen fugacity for our samples, as well as samples described in previous studies (McGuire *et al.*, 1991, Lamb & Popp, 2009, Bonadiman *et al.*, 2014, Gentili *et al.*, 2015). The results, shown in Figure 2.9, indicate that there is no significant correlation between values of $\Delta \log fO_2$ (FMQ) and the Fe^{3+}/Fe_{Total} content of the amphiboles. Furthermore, many of these fO_2 values (Figure 2.9) are relatively reducing (<FMQ). As noted above, reaction (2.5) and equation (2.6) indicate that production of the oxy-amphibole component in an amphibole is favored by relatively low values of hydrogen fugacity. According to equilibrium (2.8) hydrogen fugacity is proportional to the fugacity of H_2O and is inversely proportional to the fugacity of oxygen. Although elevated values of Fe^{3+} in amphiboles are consistent with relatively oxidizing conditions, they are also consistent with low values of the fugacity of H_2O. In other words, elevated values of Fe^{3+} in amphiboles may, in many cases, be indicative of low values of aH_2O rather than elevated values of fO_2.

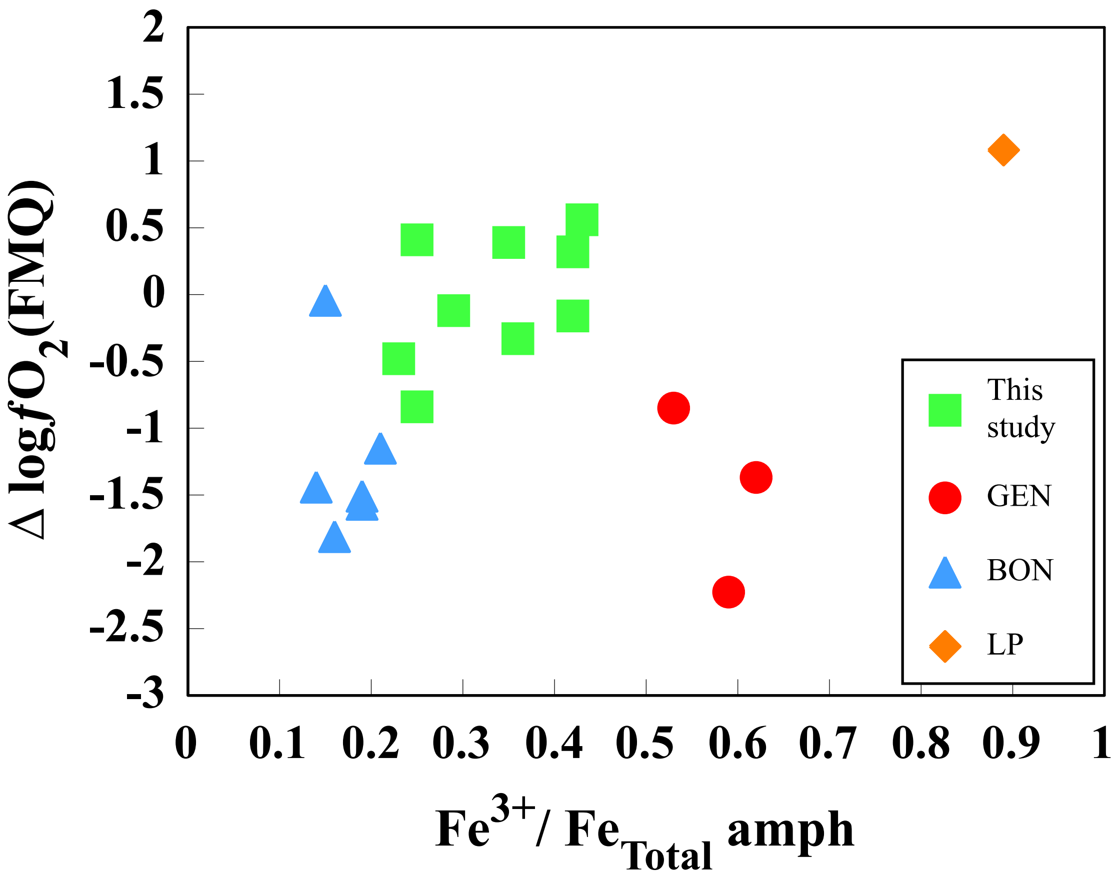


Figure 2.9: This figure illustrates that there is little or no correlation between values of $\Delta \log fO_2$ (FMQ) and the Fe^{3+}/Fe_{Total} content of the amphibole. The ■ represents the samples used in this study. The remaining data points represent data from other publications, which have been recalculated using the same T and fO_2 methods described in this paper. These other studies are: ● Gentili *et al.* (2015), ▲Bonadiman *et al.* (2014), ◆ Lamb & Popp (2009) & McGuire *et al.* (1991).

Conclusions

In summary, all the samples from the SWUSA record low values of aH_2O that are less than 0.20. For samples in which two values of aH_2O could be estimated using the two different approaches, these values agree within uncertainty. This suggests that the amphiboles in these samples have not undergone significant, if any, retrograde H-loss during transport to the Earth's surface and that careful application of amphibole equilibria can reliably estimate values of aH_2O in samples from the earth's mantle.

The low values of aH_2O estimated from amphibole equilibria, show that the presence of amphibole does not require H_2O-rich conditions. In some cases amphibole may be a product of mantle metasomatism. In such cases the addition of various chemical components (e.g., Fe, Ti or alkali elements) may be required to stabilize amphiboles. H_2O might also be added via the metasomatising fluid; however, some or all of this H_2O must have been consumed by minerals in the rock (e.g. amphibole) and could result in equilibration at low values of aH_2O. Amphibole growth may also scavenge any H_2O already present in the rock (e.g., in NAMs) and, therefore, help produce values of aH_2O that are significantly less than 1. In this scenario, amphibole growth could lower the H_2O-contents of NAMs, and this process may have important implications for the rheology of an olivine-rich uppermost mantle. If the formation of amphibole results in H_2O-loss from NAMs then the strength of these NAMs will likely increase (Mei & Kohlstedt, 2000b). Thus, as long as the rheology of the mantle is controlled by olivine and/or other NAMs, the formation of amphibole may actually serve to strengthen mantle rocks.

CHAPTER III

APPLICATION OF C-O-H EQUILIBRIA TO CONSTRAIN THE NATURE OF MANTLE FLUIDS USING XENOLITHS FROM EASTERN AUSTRALIA, SW U.S.A, AND SOUTH AFRICA

Introduction

Volatile species consisting of H, C and O (e.g., H_2O and/or CO_2) can play an important role, in a variety of geologically important processes, occurring in the upper mantle. For example, hydrogen can be contained within hydrous phases, such as amphibole or phlogopite. It can also be structurally bound, likely as OH, within nominally anhydrous minerals (NAMs), such as olivines and pyroxenes. It is important to quantify the H_2O content of the mantle because even small amounts of H_2O can significantly affect the physical properties of the upper mantle, including electrical conductivity, and rheology (Karato *et al.*, 1986, Bell & Rossman, 1992, Kohlstedt *et al.*, 1995, Mei & Kohlstedt, 2000a,b, Bolfan-Casanova, 2005, Wang *et al.*, 2006, Yoshino *et al.*, 2009, Zhao & Yoshino, 2016). Also, the compositions of melts generated in the mantle are not only a function of pressure and temperature, but also of H_2O activities (Wyllie, 1979, Gaetani & Grove, 1998, Green & Falloon, 1998, Asimow & Langmuir, 2003, Green, 2015). Using NAMs to constrain the H_2O content of the mantle, however, is not always ideal because these minerals can undergo significant diffusion during transport to the surface of the Earth (Ingrin *et al.*, 1995, Kohlstedt & Mackwell, 1998, Ingrin & Skogby, 2000, Demouchy *et al.*, 2006, Peslier & Luhr, 2006) and thus, their H_2O contents may not accurately represent the H_2O content of the mantle.

In addition to H-species, carbon-bearing species may also play an important role in the upper mantle. These carbon-bearing species may include graphite, diamond, and CO_2. Recently, Frezotti & Touret (2014) argued that the mantle would be largely dominated by CO_2-rich fluids to a depth of 100 km, and at greater depths, the CO_2 fluids would transition to carbonate melts. The evidence in support of this model is based largely on the presence of CO_2-rich fluid inclusions found in mantle xenoliths, and on petrologic studies on carbonate melts (Roedder, 1965, Andersen & Neumann, 2001, Frezzotti *et al.*, 2010, Frezzotti & Touret, 2014). Fluids rich in CO_2, much like H_2O, may also affect many mantle processes, such as, partial melting and metasomatism (Eggler, 1978, Dasgupta & Hirschmann, 2006, 2010, Dasgupta *et al.*, 2007).

Mineral equilibria can be used to ascertain the nature of mantle fluids. As noted in Chapter 1, mineral equilibria have been successfully applied to estimate values of P, T, aH_2O, oxygen fugacity (fO_2), and hydrogen fugacity (fH_2) in samples from the earth's mantle (Nickel & Green, 1985, Wood, 1990, Taylor, 1998, Popp *et al.*, 2006, Lamb & Popp, 2009, Nimis & Grutter, 2010, Miller *et al.*, 2016). Values of oxygen fugacity (fO_2) have been estimated using mineral equilibria based on coexisting olivine, spinel and orthopyroxene (Wood, 1990, Ballhaus *et al.*, 1991, Woodland *et al.*, 1992, Miller *et al.*, 2016). Amphibole dehydrogenation equilibria have been used to estimate values of hydrogen fugacity (fH_2), which can be combined with values of fO_2 from the same sample to estimate aH_2O (Popp & Phillips, 1995, Popp *et al.*, 2006). Amphibole dehydration equilibria have also been used to estimate values of aH_2O (Lamb & Popp, 2009, Bonadiman *et al.*, 2014, Gentili *et al.*, 2015, Kang *et al.*, 2017). Furthermore, combining values aH_2O and fO_2 with calculations of fluid speciation in the C-O-H system has proven to yield particular insight into the nature of fluids in high-grade rocks.

The goal of this study is to apply mineral equilibria to estimate the fugacities of various fluid species using a suite of amphibole-bearing mantle xenoliths from Eastern Australia, SW U.S.A and South Africa and, in particular, to determine robust values of aH_2O. New values of fO_2 will be estimated using the new oxybarometer formulation of Miller *et al.* (2016). The fO_2 values based on the new formulation can then be combined with values of fH_2 and yield a value of aH_2O. Values of aH_2O estimated using both amphibole dehydration equilibria and by the combined approach (outlined in Ch. 1), as well as values calculated using C-O-H equilibria can then be compared to determine whether the samples in this study, equilibrated in a free fluid system or in a fluid absent one.

Analytical Methods

In order to estimate values of P, T, aH_2O, and fO_2 of the samples in this study, the mineral compositions of co-existing olivine, orthopyroxene, clinopyroxene, spinel, garnet and amphibole were measured using a Cameca SX-50 electron microprobe (EMP) located at Texas A&M University. Operating conditions for the EMP typically included an accelerating voltage of 15 kV, and, in the case of anhydrous phases, (e.g., olivine, spinel and pyroxenes) a 20nA beam current and a 1μm beam diameter. In order to minimize electron-beam induced diffusion of H, F and Cl, the amphibole grains were also analyzed using a lower beam current of 10nA and a larger beam diameter of 10 μm. Counting times for all phases ranged from 30-60s for major elements and up to 120s for minor elements. Core-to-rim traverses were preformed in an effort to quantify any potential chemical variability within mineral grains. In addition to the traverses, several grains of each mineral were also analyzed in each sample to confirm homogeneity among mineral grains. Natural and synthetic mineral standards are used for calibration.

Minerals were normalized to cations (number in parentheses) with the appropriate number of cations denoted in parentheses: olivine (3), pyroxenes (4), spinel (3), and garnet (8). The determination of values of Fe^{3+}/Fe_{Total} for these minerals was accomplished using a variety of methods given that conventional EMP analyses cannot differentiate between the two valence states of Fe. This process is simplest for olivine because olivine analyses indicate that this mineral never contains more than trace levels of Fe^{3+} (Brown, 1980). Thus, for olivine, all Fe is assumed to be Fe^{2+}. Some minerals, however, such as pyroxene and spinel, can contain significant quantities of Fe^{3+} and, therefore, assuming that all Fe is Fe^{2+} would be inherently incomplete. The value of Fe^{3+}/Fe_{Total} for these minerals can be estimated via charge balance. Unfortunately, counting statistics preclude the use of conventional probe analyses to determine values of Fe^{3+}/Fe_{Total} in pyroxenes via charge balance (Canil & O'Neill, 1996). Thus, we have estimated the value of Fe^{3+}/Fe_{Total} for pyroxenes using two methods: (1) charge balance, where $Fe^{3+} = Al^{IV} - Al^{VI} - 2Ti - Cr + Na$ and, (2) assuming that all Fe is Fe^{2+}. This approach permits an examination of the sensitivity of various estimates, for example temperature estimates (described below), to changes in the value of Fe^{3+}/Fe_{Total} in pyroxenes.

While counting statistics limit the ability to determine accurate values of Fe^{3+}/Fe_{Total} via charge balance for pyroxenes (Dyar *et al.*, 1989, Canil & O'Neill, 1996), this approach can be applied for spinel, using secondary standards with known values of Fe^{3+}/Fe_{Total} (Wood & Virgo, 1989). For our samples, the value of Fe^{3+}/Fe_{Total} in spinel, as estimated from charge balance, was corrected based on analyses of secondary spinel standards, obtained from B. Wood (Wood & Virgo, 1989, Ionov & Wood, 1992), which have values of Fe^{3+}/Fe_{Total} that have been previously determined using Mossbauer spectroscopy (see Wood & Virgo, 1989).

Complete characterization of amphibole chemistry requires determination of: (1) the H_2O content, (2) the value of Fe^{3+}/Fe_{Total} (where $Fe_{Total} = Fe^{3+} + Fe^{2+}$), and (3) the fraction of the A-site that is vacant. Because conventional microprobe analyses do not provide this information, normalizing amphibole formulae may require certain assumptions regarding numbers of cations and site occupancies (Spear, 1995, p 103-105).

In this study, the Fe^{3+}/Fe_{Total} of the amphiboles from nine of the samples have been measured using the Fe Lα peak shift method via the EMP, as described in Lamb *et al.* (2012). For the remaining 11 samples, in which the Fe^{3+}/Fe_{Total} was not measured using the peak-shift method, a value of 0 was chosen for the Fe^{3+}/Fe_{Total}. This decision to assume a value of 0 for amphibole Fe^{3+}/Fe_{Total} was based in large part, because a value of 0 will yield a maximum value of aH_2O when estimated using amphibole dehydration equilibria (as described in subsequent sections of this paper). The OH contents of all amphiboles were estimated using an empirical relation between the value of Fe^{3+}/Fe_{Total} and the OH content in mantle amphiboles (Popp *et al.*, 1995, King *et al.*, 1999, Lamb & Popp, 2009). Given these values for Fe^{3+}/Fe_{Total} and OH, it is possible to determine the A-site occupancy by requiring the resulting formula to charge balance (Lamb & Popp, 2009). Mineral analyses for all samples can be found in the APPENDIX Tables A-F.

Sample Description & Mineralogy

Twenty amphibole-bearing mantle xenoliths from Eastern Australia, Southwestern U.S.A, and South Africa have been analyzed as part of this study. Four samples are from the Bullenmerri and Gnotuk localities in Eastern Australia. Eleven samples are from the Southwestern U.S.A, eight from the Grand Canyon, two are from Dish Hill, California and one is from Kilbourne Hole, New Mexico. The remaining five samples are from South Africa, specifically from the Jagersfontein area. All twenty samples contain co-existing olivine, orthopyroxene, clinopyroxene, and amphibole ± spinel (Figure 3.1a-c). The five xenoliths from South Africa also contain garnet (Figure 3.1d).

In many of these samples, amphibole was found rimming spinel and, in rare cases, pyroxene grains. When this texture is observed, it likely indicates that the growth of amphibole occurred after the growth of spinel, and/or pyroxene. Based on this observation, we assume that for those samples, the amphiboles are in equilibrium with the rims of chemically zoned spinels and/or pyroxenes and therefore, the rim compositions were used when mineral equilibria were applied to estimate P, T, aH_2O,

fO_2 and fH_2. In samples, in which this texture was absent, or when no compositional zoning was observed, the average mineral compositions were used for calculations.

Eastern Australia

Four xenoliths from Eastern Australia have been analyzed as part of this study. These four samples (GN9912, GN9913, BM9912, BM9915) are from the Bullenmerri and Gnotuk mars, which is an area that has been described in detail by Griffin et al. (1984) and O'Reilly & Griffin (1985, 1987, 1988).

The samples from Eastern Australia (referred to as EA in Figures) are olivine-rich (> 60%) and contain varying amounts of pyroxene, amphibole and spinel. Electron microprobe analyses reveal that the chemical compositions of olivine and amphibole from all four Australian samples are relatively homogeneous. Clinopyroxene and orthopyroxene are also largely homogeneous, but sometimes exhibit minor core to rim chemical variation, with a broad homogenous core and an Al-depleted, Si-rich rim (Figure 3.2a). The amphibole grains in these samples typically occur in multi-grain aggregates that often surround grains of spinel or clinopyroxene (Figure 3.2a,b). Spinel grains from the Bullenmerri and Gnotuk mars contain abundant Cr and Al (average Cr # = 0.31, where Cr# = Cr/(Cr+Al)) and typically exhibit chemical zonation with rims relatively enriched in Cr and depleted in Al (Figure 3.2b). The olivine Mg# for the four samples from Eastern Australia range from 0.88 to 0.91 (where Mg# = Mg/(Mg+ Fe)).

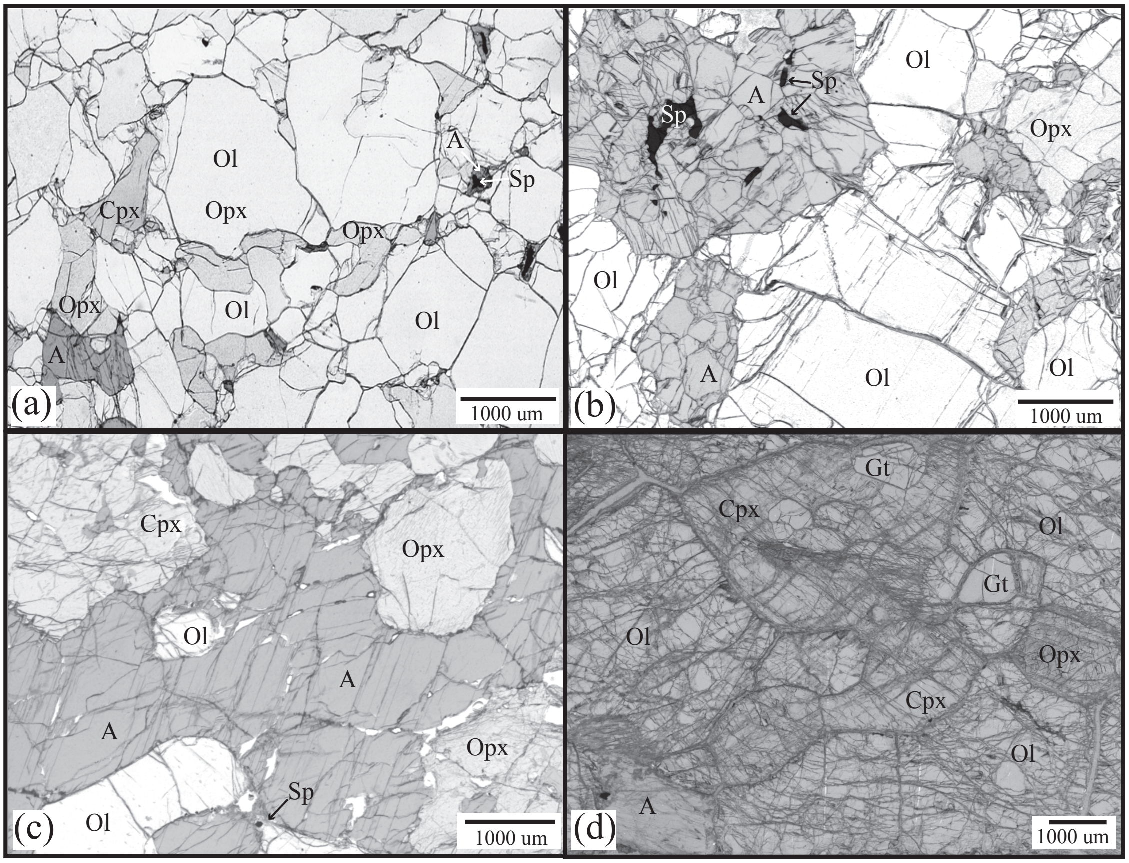


Figure 3.1: Photomicrographs illustrating typical mineralogies and textures observed in xenoliths from Eastern Australia, SW U.S.A, and South Africa. (a) Sample BM9915 contains abundant olivine (Ol) and orthopyroxene (Opx), with lesser amounts of amphibole (A), clinopyroxene (Cpx) and spinel (Sp). The amphibole occurs rimming grains of spinel. (b) Sample GN9912 contains abundant olivine and amphibole. The amphibole occurs both as individual grains and rimming spinel. (c) Sample X286 is amphibole and pyroxene dominated with minor amounts of spinel. (d) Sample JAG 84-524 is an olivine-rich sample that also contains garnet (Gt). It also has equal amounts of orthopyroxene and clinopyroxene with minor amphibole.

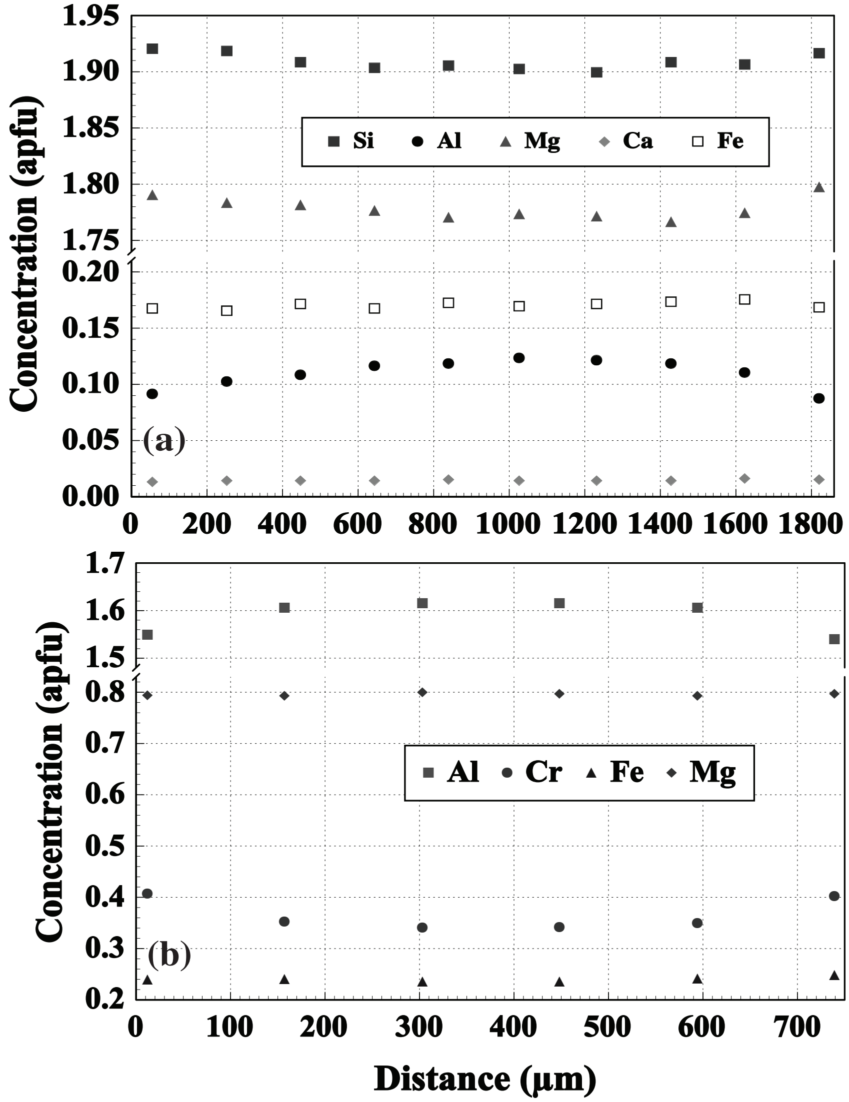


Figure 3.2: Examples of zoning profiles observed in minerals from samples GN9912 and BM9912. Mineral compositions are plotted as a function of distance where vertical axes represent locations of grain boundaries. (a) Relative depletion in Al and enrichment in Si and Mg is sometimes apparent at grain boundaries as illustrated by this opx grain from GN9913. (b) Compositions of a spinel grain from sample BM9912 with rims enriched in Cr and depleted in Al.

Southwestern U.S.A

Eleven xenoliths from the Southwestern U.S.A (referred to as SW U.S.A in Figures and Tables) have been analyzed as part of this study. Eight of these samples are from the western Grand Canyon region of northwestern Arizona (X174, X192, X229, X286, X297, X299, X319). These samples were provided by Myron Best, and more detailed information on this location and a description of various xenoliths from this area may be found in Best (1970, 1975). Sample TF6 from Toroweap Valley was provided by J.C.A Riter and information on this location may be found in Riter (1999). Two samples are from Dish Hill, California (Ba-1-72 and Ba2-1-1) and have been provided by the Smithsonian Institute. This location has been described by Wilshire & Trask (1971) and one of the samples in particular, Ba-1-72 has been described by Wilshire et al. (1971, 1980). The remaining xenolith from the SW U.S.A is sample EP-3-84, which is from Kilbourne Hole, New Mexico (sample provided by the Smithsonian Institute). Information about the sample location and mineralogy of similar spinel-bearing xenoliths found in this location can be found in various publications (e.g., Perkins & Anthony, 2011, Satsukawa *et al.*, 2011, and references therein).

Most of the SW U.S.A xenoliths contain abundant amphibole and olivine, with varying amounts of orthopyroxene, clinopyroxene and spinel. The samples from the Grand Canyon are generally more amphibole-rich (< 60%) compared to the three samples from Dish Hill and Kilbourne Hole (< 10%). Spinel is found both as individual grains and as grains rimmed by amphibole (Figure 3.1b,c). Sample X174 from the Grand Canyon, also contains garnet, which are rimmed by kelephyite. The presence of the kelephyite rims indicates that the garnets may be in disequilibrium with the remaining mineral assemblage, therefore, the compositions of the garnet are not used for the pressure determination of this particular sample.

The chemically compositions of the minerals observed in these samples (i.e. olivine, amphibole, spinel, and pyroxene) from the SW U.S.A are largely homogeneous, with little to no core to rim variation observed. Some of the pyroxenes from the SW U.S.A record minor core to rim variations in Al and Si content, similar to the pyroxenes from Eastern Australia (see Figure 3.2a). The spinels are relatively Al-rich (Average Cr # = 0.06), as compared to the samples from Eastern Australia and South Africa, which contain significantly more Cr than Al. The olivine Mg# for the SW U.S.A. samples range from 0.77 to 0.90, and some of these samples, for example, X174, may represent olivine-rich cumulates (Best, 1975). In any sample that may represent cumulates, estimation of values of aH_2O can still provide information concerning the nature of the melts that crystallized the amphiboles and, therefore, may yield insight into mantle melt H_2O contents and metasomatism.

South Africa

Five xenoliths from South Africa (referred to as SA in Tables) have been analyzed as part of this study. These five xenoliths (JAG 84-524, JAG 84-553, JAG-228, K7269, K7311) are from the Jagersfontein kimberlite pipe and were provided by Steve Haggerty. More detailed information on sample location can be found in various publications (Nixon *et al.*, 1981, Haggerty & Sautter, 1990, Winterburn *et al.*, 1990, Hops *et al.*, 1992.

The five samples from South Africa are olivine-rich (< 50%) with abundant pyroxene and garnet. Three of these samples also contain minor amounts of spinel in addition to the garnet (JAG 84-553, JAG-228, K7269). The chemical compositions of all of the minerals (olivine, pyroxene, amphibole, garnet ± spinel) are homogeneous with no apparent chemical variation observed in any of these five samples. The spinels from South Africa are all Cr-rich (Cr# = 0.69) and the olivine Mg# for these five samples range from 0.91 to 0.93.

Estimation of Pressure and Temperature

Application of mineral equilibria to estimate values of aH_2O and fO_2 requires an estimate of the pressure (P) and temperature (T) of mineral equilibration to be determined for each sample. Pyroxene geothermometry was applied to estimate temperature for all samples, and these T determinations were combined with estimates of the geothermal gradient to determine values of P for the fifteen spinel-bearing xenoliths (as discussed below). In the five garnet-bearing samples from South Africa, garnet-orthopyroxene barometry will be used, in addition to two-pyroxene geothermometry, to constrain pressures.

Temperature

Two-pyroxene geothermometry have been widely applied in mantle rocks (e.g., Nimis & Grutter, 2010). Numerous versions of the two-pyroxene geothermometer have been calibrated for a variety of pyroxene compositions (Wells, 1977, Bertrand & Mercier, 1985, Brey & Köhler, 1990, Taylor, 1998). While numerous versions may be available, geothermometers are often limited to a range of T, P and/or pyroxene compositions (e.g., Nimis & Grutter, 2010). Thus, the accuracy of temperature estimates depends, in part, in choosing the most appropriate geothermometer.

For this study, the two-pyroxene geothermometer of Taylor (1998) (T98) is used to estimate T. The choice of this thermometer was guided by Nimis & Grütter (2010), who favor the TA98 formulation because it more accurately reproduces temperatures of experiments designed to yield equilibrium compositions of co-existing pyroxenes. They suggests that the TA98 is the most ideal mantle geothermometer, as long as T estimates using TA98 are consistent with two other formulations of the pyroxene geothermometer, the enstatite-in-Cpx thermometer of Nimis & Taylor (2000) (NT) and Ca-in-opx thermometer (Brey & Köhler, 1990) as modified by Nimis & Grütter (2010) (BKNG). Over the temperature range of 900 to 1200˚C, temperature estimates based on TA98 should agree with NT and BKNG within ± 30˚C and ±70˚C respectively (Nimis & Grutter, 2010). For temperatures less than 900˚C, the agreement between TA98 and NT remains the same, while the agreement between TA98 and BKNG is expanded to ± 90˚C (Nimis & Grutter, 2010). Thus, we have compared the results of three geothermometers (T98, NT, BKNG) in an effort to determine if a reliable estimate of the temperature of pyroxene equilibrium had been determined.

In some cases accurate temperature estimates from conventional thermobarometry may require determining values of Fe^{3+}/Fe_{Total} in Fe-bearing minerals, including pyroxenes (Schumacher, 1991, Matjuschkin *et al.*, 2014). The sensitivity of our temperature estimates to differences in Fe^{3+}/Fe_{Total} was evaluated by determining 2-pyx temperatures using two methods, described previously (charge balance and total Fe is Fe^{2+}), to determine values of Fe^{3+}/Fe_{Total} in pyroxenes. Ultimately, the choice of whether to use charge balance or to consider all Fe as Fe^{2+} has no impact on our T estimates using either the TA98, or the BKNG formulations. However, the maximum difference in temperature calculated using these two methods with the NT formulation is 20˚C. This small T difference is similar to other results indicating that the two-pyroxene thermometer, as applied to mantle rocks, is relatively insensitive to uncertainties in Fe^{3+}/Fe_{Total} (Brey & Köhler, 1990, Schumacher, 1991, Canil & O'Neill, 1996, Taylor, 1998). Given this small difference in temperature estimations, the temperature estimations used in this paper, will be based off the assumtion that all Fe is Fe^{2+}.

Taylor's (1998) two-pyroxene thermometer yields temperatures from 690˚C to 980˚C for the twenty xenoliths in this study (Table 3.1, Figure 3.3). For the Eastern Australian samples, the temperatures range from 820˚C to 930˚C, while the SW USA samples record slightly higher temperatures that range from 900˚C to 980˚C. The xenoliths from South Africa record the lowest temperatures with temperatures ranging from 690˚C to 790˚C. Temperature estimates based on T98 agree to within ±20˚C with temperatures estimated using NT and to within ±70˚C with temperatures estimated using BKNG. For the lower T samples (i.e. T< 900˚C) from South Africa, the TA98 estimates continue to agree to within ±20˚C with temperatures estimated using NT for all five samples, and to within ±80˚C with temperatures estimated using BKNG for three of the samples. These differences are relatively small (see previous discussion, and Nimis and Grutter (2010)) and the agreement between the three formulations of the two-pyroxene thermometer indicates that the co-existing pyroxenes equilibrated at the temperatures given on Table 3.1. However, the remaining two samples agree to within ±130˚C with temperatures estimated using BKNG. This lack of agreement is not surprising given that these two thermometers (i.e. TA98 and BKNG) have less consistency at T < 900˚C (Nimis & Grutter, 2010) and these two samples have the lowest T estimates at 690 and 720˚C of all the samples in this study.

Pressure

For the five garnet-bearing samples from South Africa, the garnet-orthopyroxene barometer of Nickel and Green (1985) was used to determine pressures, in large part because of its ability to successfully reproduce pressures of mineral equilibration in experiements (Nimis & Grutter, 2010). The garnet-orthopyroxene barometer of Nickel and Green (1985) yields pressures ranging from 2.6 to 3.0 GPa for the South African xenoliths (Table 3.1, Figure 3.3). However, determining pressure estimates for samples that contain spinel instead of garnet, can be particularly challenging because sp-bearing periodites lack a mineral assemblage that is pressure sensitive (Köhler & Brey, 1990). Because fifteen of the samples in this study contain minerals that are relatively insensitive to changes in pressure, the pressures for the sp-bearing peridotites have been constrained by combining two-pyroxene temperature estimates with a geothermal gradient for each respective geographic region, (i.e. Eastern Australia and the SW U.S.A). These pressure estimates for the sp-bearing samples were then compared to minimum and maximum values of P, which is a relatively common approach given the difficulty involved in determining a single value of pressure for spinel-bearing peridotites (Ionov *et al.*, 1993, Riter & Smith, 1996, Lamb & Popp, 2009, Perkins &

Anthony, 2011). Minimum pressures for these samples are based on the depth of the Moho (Lamb & Popp, 2009, Perkins & Anthony, 2011) and maximum pressures are based on the transition from spinel-to-garnet (Lamb & Popp, 2009).

O'Reilly & Griffin (1985) used the garnet-orthopyroxene barometer of Wood (1974) and the garnet-clinopyroxene thermometer of Ellis and Green (1979) to determine P-T condtions for xenoliths collected from Eastern Australia. These P-T estimates define a geothermal gradient for Eastern Austraila, and we have modified this geothermal gradient to be consistent with our choice of the T98 two-pyroxene thermometer (Taylor, 1998). This modified geotherm yields pressures for the four samples from Eastern Austrailia that range from 1.1-1.4 GPa (Table 3.1, Figure 3.3). The depth of the Moho in Eastern Australia is approximately 32 km (Kennett *et al.*, 2011, Salmon *et al.*, 2013). Therefore, the minimum pressure for these samples is approximately 1.0 GPa, while the maximum pressure, based on the P-T location of the spinel-to-garnet transition (O'Neill, 1981) is approximately 1.9 GPa. Thus, pressure constraints estimated using the geotherm are consistent with both the minimum and maximum pressure estimates based on the depth of the Moho and the sp-gt transition, respectively.

Table 3.1: Pressure (Gpa) & Temperature (˚C) Determinations of samples from Eastern Australia, SW U.S.A and South Africa.

Sample:	Wells[a]	T98[b]	NT[c]	BKNG[d]	BK[e]	P1	P2
Eastern Australia							
GN9912	880	**820**	830	740	800	1.1	
GN9913	910	**850**	860	790	840	1.1	
BM9912	960	**920**	930	900	920	1.4	
BM9912	960	**910**	920	860	890	1.3	
SW USA							
X174	960	**940**	940	1010	1020	1.5	1.1
X192	970	**930**	940	990	1000	1.5	
X229	940	**900**	900	960	980	1.4	
X286	970	**960**	960	1000	1010	1.5	
X297	960	**930**	930	980	990	1.5	
X299	960	**940**	940	970	980	1.5	
X319	970	**940**	940	980	1000	1.5	
Ba-1-72	990	**980**	980	1030	1040	1.6	
Ba2-1-1	990	**960**	960	990	1000	1.5	
EP-3-84	940	**880**	890	950	970	1.4	
TF6	980	**960**	960	960	980	1.5	
South Africa							
JAG 84-524	810	**740**	730	750	800		2.7
JAG 84-553	810	**720**	710	860	900		2.8
JAG-228	850	**790**	790	710	780		3.0
K7269	800	**690**	680	820	870		2.7
K7311	810	**720**	700	780	840		2.6

(a) Wells (1977) 2-Px (b) Taylor (1998) 2-Px (c) Nimis & Taylor (2000) -En-in-cpx (d) Nimis & Grutter (2010)- modified B&K Ca-in-opx (e) Brey & Kohler (1990) Ca-in-opx (f) Pressure calculated using geotherm for SWUSA Temperature estimates in **bold** are used for all calculations.

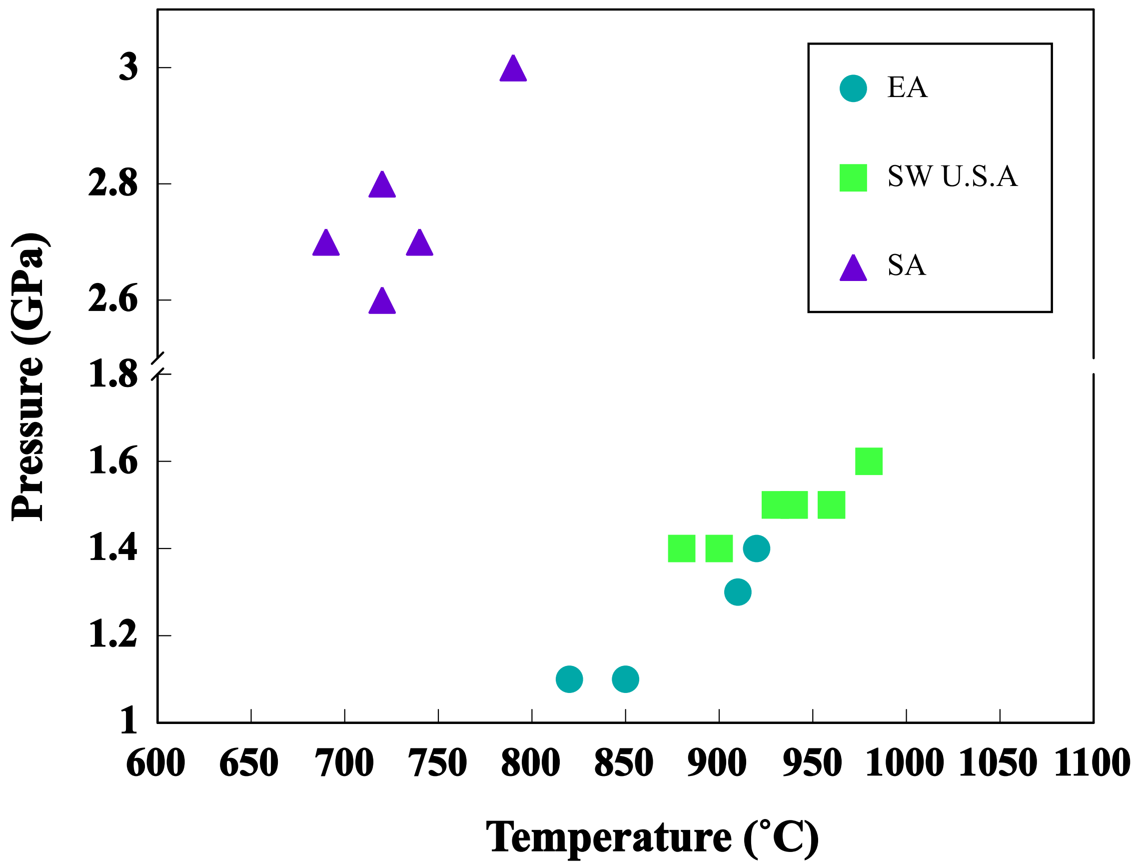


Figure 3.3: P-T estimates for all the samples from Eastern Australia, SW U.S.A and South Africa. Temperature estimates, based on Taylor's (1998) two-pyroxene thermometer, were used in combination with geothermal gradientsother constraints to determine pressure estimates for each sample (see text). For samples containing garnet, the garnet-orthopyroxene geobarometer of Nickel & Green (1985) was used to determine pressure.

The depth of the Moho in the SW USA is approximately 40 km (Lowry & Perez-Gussinye, 2011, Gilbert, 2012), which corresponds to a minimum pressure of approximately 1.1 GPa. The maximum pressures estimates, based on the P-T location of the spinel-to-garnet transition (O'Neill, 1981) range from 1.6 to 2.1 GPa, depending on mineral compositions, with an average maximum P estimate of 1.9 GPa.

In order to determine a geothermal gradient for the SW U.S.A region, we combined a heat flow value for the Grand Canyon of approximately 83 mW/m^2 (Blackwell & Richards, 2004) with the continental heat flow model of Pollack & Sass (1988) (see Chapter 2 for further discussion). Application of the Grand Canyon Geothermal Gradient (GCGG), in combination with two-pyroxene temperature estimates, yields pressures range from 1.4 to 1.6 GPa for the 11 samples from the SW U.S.A (Table 3.1, Figure 3.3). Pressure estimates based on the GCGG are also consistent with minimum and maximum pressure estimates based on depth of the Moho and the spinel-to-garnet transition, respectively.

Results: Activities of Fluid Species

Values of aH_2O estimated using Amphibole Dehydration Equilibria

This study is focused on the application of H_2O-buffering equilibria to estimate values of aH_2O in samples that contain co-existing olivine, orthopyroxene, clinopyroxene, and amphibole ± spinel ±garnet. Based on this assemblage, a number of different H_2O-buffering equilibria can be written. Ultimately, the choice of any one of these H_2O-buffering equilibria depends on various factors, including the accuracy of: (1)

the P-T estimates, (2) the characterization of mineral chemistry, and (3) the models that describe the activity-composition (a-X) relations in various minerals.

For this study, we have adopted the approach outlined by Lamb and Popp (2009) to estimate values of aH_2O based on H_2O-buffering equilibria. This approach has also recently been used by several other authors to estimate values of aH_2O in amphibole-bearing samples (Bonadiman *et al.*, 2014, Gentili *et al.*, 2015, Kang *et al.*, 2017). As described in Lamb and Popp (2009), the following equilibria is used to estimate values of aH_2O in spinel-bearing samples:

$$2\text{Pargasite} + \text{Enstatite} = 2\text{Forsterite} + 4\text{Diopside} + 2\text{Jadeite} + 2\text{Spinel} + H_2O \qquad (2.1)$$

This equilibria was chosen for the sp-bearing samples, in large part due to the Mg-rich nature of olivine, orthopyroxenes, and spinel, and the pargasite-rich amphiboles found in these samples (Lamb & Popp, 2009). However, an additional H_2O-buffering equilibrium is needed to estimate values of aH_2O for the two garnet-bearing xenoliths from South Africa, which do not contain spinel. Therefore, for those samples that contain garnet, but lack spinel, the following equilibria is used to estimate values of aH_2O:

$$2\text{Pargasite} + 5\text{Enstatite} = 4\text{Forsterite} + 4\text{Diopside} + 2\text{Jadeite} + 2\text{Pyrope} + H_2O \qquad (3.1)$$

THERMOCALC (Powell *et al.*, 1998) was chosen to estimate values of aH_2O based on equilibria 2.1 and 3.1 (Lamb & Popp, 2009). This software was ultimately chosen by Lamb and Popp (2009) because of the availability of relatively sophisticated models describing the activity-composition (a-X) relations in amphiboles (Dale *et al.*, 2005, Diener *et al.*, 2007, Diener & Powell, 2012). While these THERMOCALC-based activity models have proven to be suitable for the compositions of many mantle amphiboles, as well as other mantle minerals (i.e. orthopryoxene, clinopyroxene, garnet), other THERMOCALC-based activity models (i.e. spinel) may not be suitable for mantle compositions and/or conditions given many of these activity models (Holland & Powell, 1996, 1998, White *et al.*, 2002, Dale *et al.*, 2005, White *et al.*, 2007) were initially developed for application to crustal rocks rather than those originating from the mantle. However, activity models consistent with the MELTS software package (Sack & Ghiorso, 1989, 1991, 1994a, 1994c, Ghiorso & Sack, 1995, Asimow & Ghiorso, 1998) were developed specifically for the application of mantle minerals and thus, provide another option to calculate end-member activities that can be used to estimate values of aH_2O using the above equilibria (2.1) and (3.1). The approach outlined in Lamb and Popp (2009) suggests the use of a combination of activity models, from both the THERMOCALC and MELTS software packages, given that the choice of activity model, has little if any effect on the calculated end-member activities for mantle Mg_2SiO_4 in olivine, $Mg_2Si_2O_6$ in orthopyroxene, and $CaMgSi_2O_6$ and $NaAlSi_2O_6$ in clinopyroxene. Thus, for this study, the end-member activities of olivine, orthopyroxene, clinopyroxene, and spinel were determined using models consistent with the MELTS software, while the activities of amphibole and garnet were determined using models consistent with the THERMOCALC software.

Application of both equilibrium (2.1) and (3.1) yield low values of aH_2O (< 0.20) for all of the mantle xenoliths in this study (Table 3.2 and Figure 3.4). While the estimated values of aH_2O are not sensitive to the choice in activity model, it is important that other potential sources of uncertainty also be considered. Other potential sources of uncertainty might include, the sensitivity of the estimated values of aH_2O to changes in P and/or T. An estimated pressure uncertainty of ± 0.4 GPa yields a difference of ± 0.04 in values of aH_2O, while a temperature change of ± 50 ˚C yields a similar change in estimated values of aH_2O = ± 0.04. Therefore, given the combined uncertainties involved in P, T and activity models, the overall uncertainty for values of aH_2O for the samples used in this study is likely better than ± 0.1.

Table 3.2: Mineral activities and values of aH_2O estimated using dehydration equilibria for sp-bearing (2.1) and gt-bearing samples (3.1).

				Mineral Activities*				aH_2O	aH_2O
Sample	aFo	aDi	aJd	aEn	aSp	aParg	aPy	E1	E2
Eastern Australia									
GN9912	0.80	0.77	0.10	0.80	0.51	0.24	n/a	0.01	
GN9913	0.82	0.77	0.10	0.83	0.54	0.33	n/a	0.02	
BM9912	0.82	0.77	0.10	0.80	0.60	0.25	n/a	0.03	
BM9915	0.84	0.75	0.08	0.80	0.56	0.30	n/a	0.04	
S.W. USA									
X174	0.67	0.66	0.03	0.61	0.66	0.24	0.27	0.07	
X192	0.73	0.67	0.03	0.65	0.66	0.23	n/a	0.05	
X229	0.73	0.81	0.01	0.66	0.70	0.16	n/a	0.07	
X286	0.71	0.69	0.04	0.67	0.63	0.22	n/a	0.04	
X297	0.73	0.72	0.02	0.66	0.62	0.18	n/a	0.05	
X299	0.74	0.70	0.02	0.66	0.67	0.19	n/a	0.07	
X319	0.74	0.65	0.03	0.66	0.67	0.29	n/a	0.09	
Ba-1-72	0.79	0.68	0.06	0.75	0.61	0.19	n/a	0.07	
Ba2-1-1	0.82	0.68	0.07	0.74	0.67	0.41	n/a	0.08	
EP-3-84	0.79	0.68	0.04	0.71	0.76	0.39	n/a	0.03	
TF6	0.82	0.77	0.03	0.75	0.60	0.39	n/a	0.18	
South Africa									
JAG 84-524	0.84	0.81	0.08	0.85	n/a	0.29	0.48		0.13
JAG 84-553	0.87	0.86	0.06	0.85	0.39	0.30	0.50	0.08	0.15
JAG-228	0.87	0.80	0.10	0.87	0.31	0.35	0.47	0.15	0.23
K7269	0.87	0.87	0.05	0.86	0.42	0.51	0.54	0.12	0.19
K7311	0.85	0.82	0.08	0.85	n/a	0.28	0.47		0.09

*All mineral activities were calculated using activity models that are consistent with the MELTS software, except for pargasite and pyrope, which were calculated using models that are consistent with the THERMOCALC software (see text for discussion).

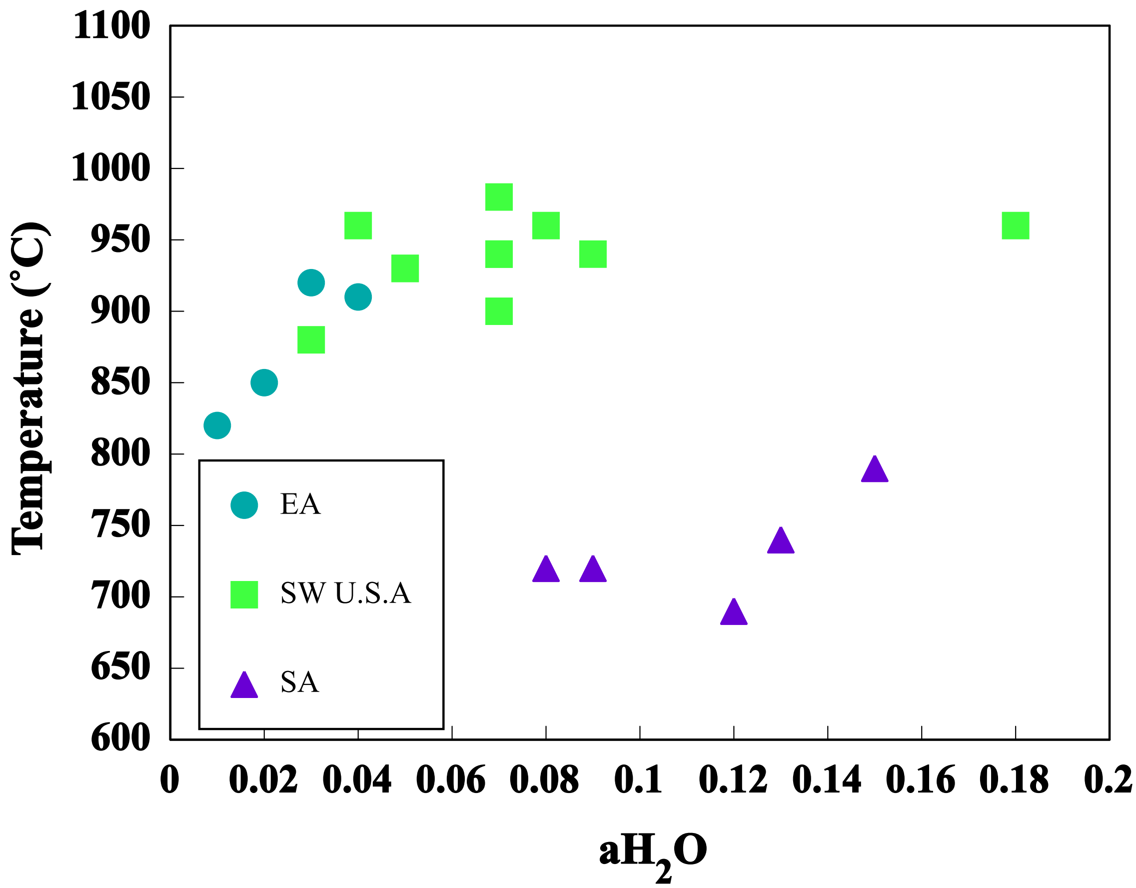


Figure 3.4: Values of aH_2O estimated using amphibole dehydration (Equations 2.1 and 3.1) are plotted as a function of temperature (˚C). All of the samples analyzed in this study equilibrated at values of aH_2O <0.20.

Estimations of Oxygen Fugacity

Mineral equilibria have often been applied to estimate values of oxygen fugacity (fO_2) in samples containing co-existing olivine, spinel and orthopyroxene (Wood, 1990, Ballhaus *et al.*, 1991, Woodland *et al.*, 1992, Miller *et al.*, 2016). In these samples, values of fO_2 are based on the following equilibria:

$$6Fe_2SiO_4 + O_2 = 3Fe_2Si_2O_6 + 2Fe_3O_4 \quad (2.2)$$

Values of fO_2 are also typically reported relative to an oxygen buffering equilibria, such as the Fayalite-Magnetite-Quartz (FMQ) buffer, which is based on the equilibria:

$$3Fe_2SiO_4 + O_2 = 2Fe_3O_4 + 3SiO_2 \quad (2.3)$$

Using oxybarometry, estimates of fO_2 for the uppermost mantle typically range from FMQ-3 to FMQ+2 (Wood, 1990, Woodland *et al.*, 1992, Woodland & Koch, 2003). For this study, we applied the recent calibration of Miller *et al.* (2016).

The estimated values of fO_2 for all of the sp-bearing samples range from FMQ-1 to FMQ+0.7 (Table 3.3 and Figure 3.5). We have also compared these results to values of fO_2 estimated using the formulation of Bryndzia and Wood (1990). The formulation of Bryndzia and Wood (1990) yields values of fO_2 from FMQ-1 to FMQ+1 (Table 3.3). While the two formulations yield very similar estimates of fO_2, values estimated using the Bryndzia and Wood (1990) formulation are generally more reducing by an average of 0.20 log units relative to FMQ, than those estimated using the method of Miller *et al.* (2016). This finding is further supported by Miller *et al.* (2016) who first suggested that their calibration yields more reducing values of fO_2, typically ~ 0.5 log units, when compared to other commonly used oxybarometers.

Discussion

Amphibole-bearing samples yield low values of aH_2O

All twenty-one samples record low values of the aH_2O (<0.20) as estimated using amphibole dehydration equilibria. The four samples from Eastern Australia contain the lowest values of aH_2O (<0.04). The samples from the SW U.S.A and South Africa contain similar values of aH_2O that range from 0.03 to 0.18. These low values of aH_2O demonstrate that the presence of amphibole does not require H_2O-rich conditions, a result that agrees with previous studies (Lamb & Popp, 2009, Bonadiman *et al.*, 2014, Kang *et al.*, 2017).

In samples that contain both spinel and garnet, application of equilibria 2.1 and 3.1, allow two different estimations of aH_2O for the same sample. The two values of aH_2O can permit a test of mineral equilibration because if all minerals are in equilibrium, then application of amphibole dehydration equilibria should yield similar results, within uncertainty, regardless of whether equilibria (2.1) or (3.1) is used. For these three samples, JAG 84-524, JAG-228 and K7269, the two values of aH_2O agree within uncertainty (±0.1), which further suggests that the amphibole from at least these three samples has not undergone significant diffusion.

Table 3.3: Values of fO_2 and estimations of aH_2O based on C-O-H calculations.

Sample:	$\Delta\log fO_2$ (FMQ) Miller	$\Delta\log fO_2$ (FMQ B&W	aH_2O ac= 1	aH_2O aC= 0.1
Eastern Australia				
GN9912	-1.16	-1.26	0.940	0.979
GN9913	-0.19	-0.38		
BM9912	-0.33	-0.28		
BM9915	-0.24	-0.02		
S.W. USA				
X174	-0.19	-0.13		
X192	-0.54	0.00	0.340	0.967
X229	0.31	0.95		
X286	0.08	0.31		
X297	0.44	0.96		
X299	0.51	0.89		
X319	0.10	0.29		
Ba-1-72	0.56	0.91		
Ba2-1-1	0.04	0.30		
EP-3-84	0.65	0.65		
TF6	0.44	0.74		
South Africa				
JAG 84-524	no sp	no sp	no sp	no sp
JAG 84-553	-1.02	-0.93	0.994	0.998
JAG-228	-0.91	-0.77	0.987	0.997
K7269	-0.98	-0.73	0.940	0.998
K7311	no sp	no sp	no sp	no sp

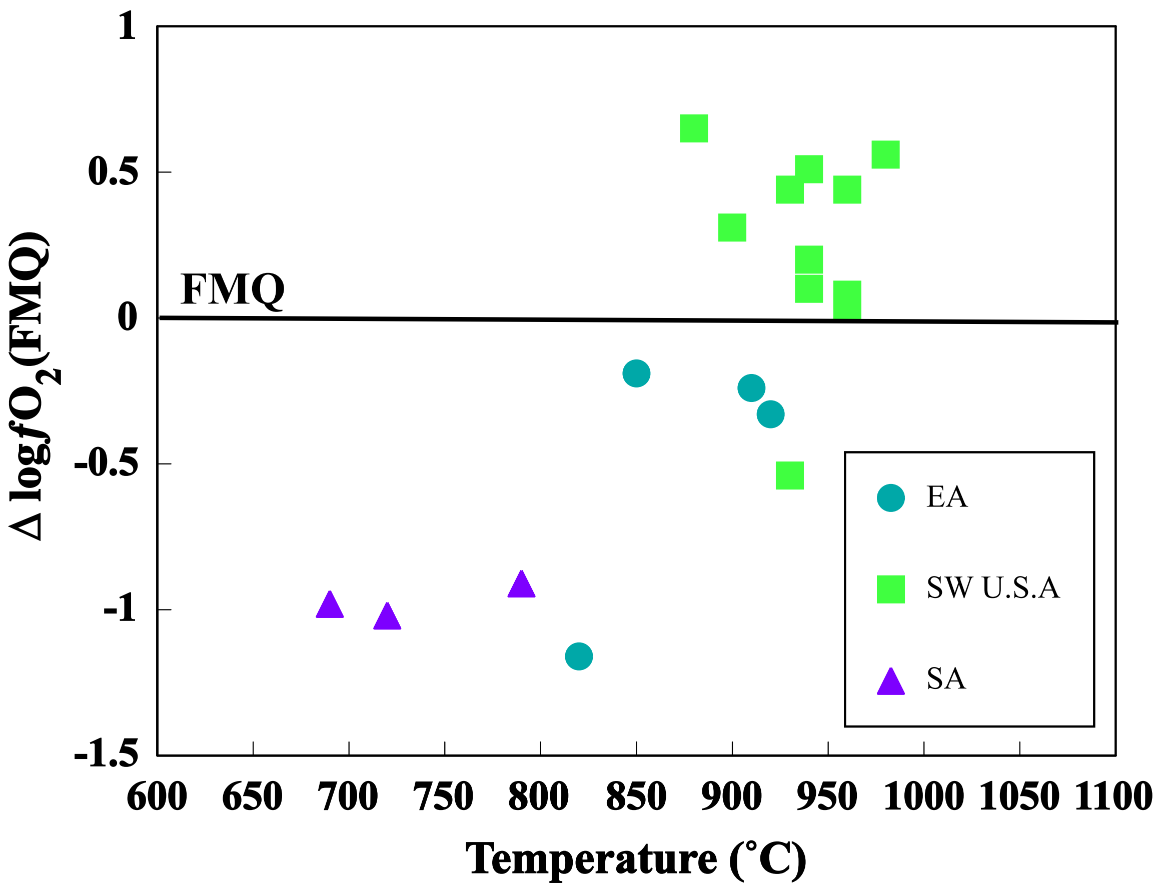


Figure 3.5: Values of fO_2 have been estimated using the oxy-barometer of Miller *et al.* (2016) and are expressed relative to the FMQ oxygen buffer and as a function of temperature (˚C). The values of $\Delta \log fO_2$ range from 1 log unit below, to 0.7 log units above FMQ.

Further Constraints on the Nature of Mantle Fluids: C-O-H Equilibria

This study has applied mineral equilibria to estimate values of aH_2O, fO_2 and fH_2 using mantle xenoliths. Furthermore, given that many of the variables are known, such as P, T, fO_2, (Tables 3.1, and 3.3) and the activity of carbon, they can be used to calculate fluid speciation (H_2O, CO_2, CH_4, H_2, CO, and O_2) in the C-O-H system, which may provide further insight into the nature of mantle fluids (French, 1966, Lamb & Valley, 1984, 1985, Wood *et al.*, 1990, Frost & McCammon, 2008).

In the C-O-H system it is possible to write four independent equilibria that related the fugacities of six fluid species, H_2O, CO_2, CH_4, H_2, CO, and O_2, and the activity of carbon (Ohmoto & Kerrick, 1977)

$$\mathrm{C} + \mathrm{O_2} \leftrightharpoons \mathrm{CO_2} \qquad \mathrm{k_{eq}} = \frac{f\mathrm{CO_2}}{\mathrm{aC} \times f\mathrm{O_2}} \tag{3.2}$$

$$\mathrm{C} + \frac{1}{2}\mathrm{O_2} \leftrightharpoons \mathrm{CO} \qquad \mathrm{k_{eq}} = \frac{f\mathrm{CO}}{\mathrm{aC} \times (f\mathrm{O_2})^{\frac{1}{2}}} \tag{3.3}$$

$$\mathrm{H_2} + \frac{1}{2}\mathrm{O_2} \leftrightharpoons \mathrm{H_2O} \qquad \mathrm{k_{eq}} = \frac{f\mathrm{H_2O}}{f\mathrm{H_2} \times (f\mathrm{O_2})^{\frac{1}{2}}} \tag{3.4}$$

$$\mathrm{CH_4} + 2O_2 \leftrightharpoons \mathrm{CO_2} + 2\mathrm{H_2O} \qquad \mathrm{k_{eq}} = \frac{f\mathrm{H_2O}^{\;2} + f\mathrm{CO_2}}{f\mathrm{CH_4} \times f\mathrm{O_2^2}} \tag{3.5}$$

If a free fluid phase is present along grain boundaries then it is often assumed that the fluid pressure is equivalent to the lithostatic pressure, with value of the lithostatic pressure estimated from the compositions of co-existing minerals. In this case, a fifth equation can be written:

$$\mathrm{P_{Lith}} = \mathrm{P_{Fluid}} = \mathrm{P_{H_2O}} + \mathrm{P_{CO_2}} + \mathrm{P_{CH_4}} + \mathrm{P_{H_2}} + \mathrm{P_{CO}} + \mathrm{P_{O_2}} \tag{3.6}$$

Thus, for a given value of P and T there are five equations and two unknowns. In some cases, values fO_2 have been combined with the presence of graphite (which fixes aC = 1) to fix two of these variables and solve for the remaining three (French, 1966, Lamb & Valley, 1984, 1985, Wood *et al.*, 1990).

Ohmoto and Kerrick (1977) used mineral equilibria to fix the fugacity of a fluid other than O_2 (e.g., H_2O), and then solve for the fugacities of the remaining five using equilibria (3.2) through (3.5). Lamb and Valley (1984) demonstrated that by fixing the fugacities of two fluid species (e.g., H_2O and O_2) in a graphite-bearing rock that it is possible to solve for the fugacities of the remaining four fluid species without using equations (3.6) above. In this case, it is possible to calculate the fluid pressure using equation (3.6) and compare this pressure with the pressure determined from conventional geobarometry. Lamb & Valley (1984, 1985) further demonstrated that, for values of oxygen fugacity that fall within the stability field of graphite (i.e., assuming that aC = 1) will yield the maximum value of the fluid pressure. Furthermore, the assumption that activity of C is equal to 1, will maximize the activities of each of the carbon-bearing fluid species, while yielding a minimum value of H_2O (Lamb & Valley, 1984, 1985). This result is illustrated in Figure 3.6a, where the C-O-H calculations for sample JAG 84-553 were performed assuming that the aC = 1. At these PT conditions, 28 G.Pa and 720˚C respectively, CO_2 dominates under relatively oxidizing conditions, CH_4 under relatively reducing conditions and H_2O under intermediate values of oxygen fugacity. Assuming an aC=1 and this sample's estimated value of fO_2 ($\Delta \log fO_2$ (FMQ) = -0.96), the C-O-H calculations yield a high value of aH_2O (= 0.994) (Figure 3.6a,

Table 3.3). If graphite were present at these PT conditions, along with a free-fluid phase, then this sample would likely have equilibrated under water-rich conditions.

However, this sample does not contain graphite, thus the activity of C would be less than 1. Reducing the activity of carbon expands the range of oxygen fugacity values over which H_2O is the dominant fluid at the expense of carbon-bearing phases, such as CO_2 and CH_4. This is illustrated by performing these calculations at an activity of C of 0.1 (Figure 3.6b). Assuming an aC=0.1 and this sample's estimated value of fO_2 ($\Delta \log fO_2$ (FMQ) = -0.96), the C-O-H calculations yield an even higher value of aH_2O (= 0.998) (Figure 3.6b and Table 3.3).

Thus, as illustrated by Figure 3.6, reducing the activity of carbon results in an increase in aH_2O and therefore, yields a maximum value of the aH_2O, while the assumption that aC=1 yields a minimum value of aH_2O, even in samples with no detectable graphite (e.g. JAG 84-553).

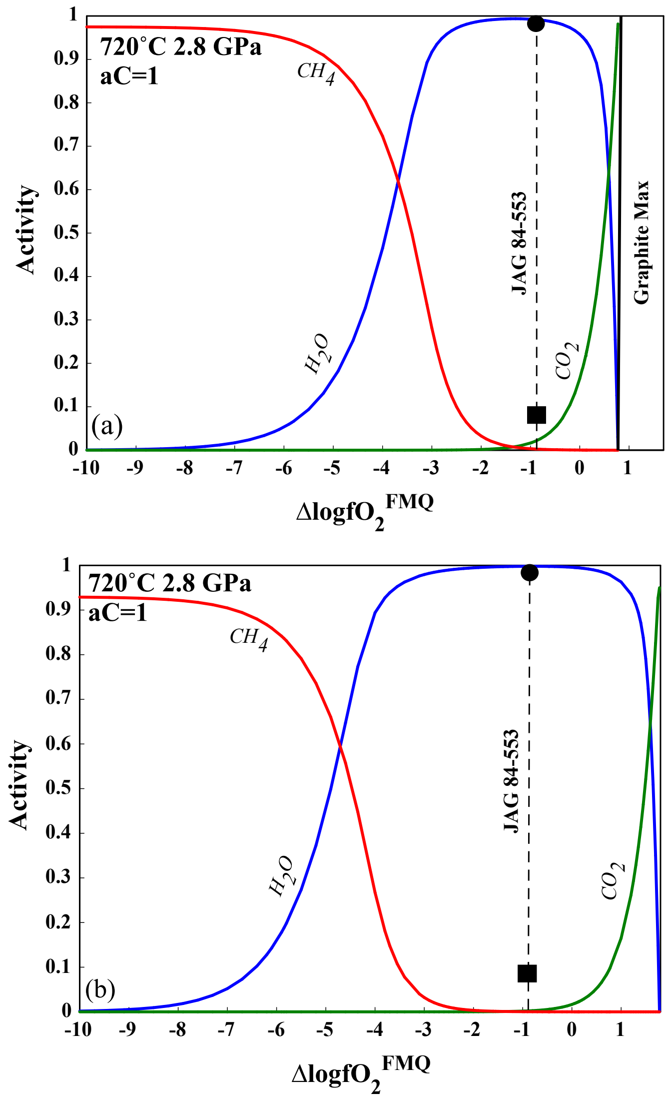


Figure 3.6: Results of fluid speciation using C-O-H calculations. These diagrams illustrate the activities of the dominant fluid species as a function of oxygen fugacity (relative to FMQ) at 720˚C and 2.8 GPa, assuming an activity of C of 1 and 0.1, in (a) and (b) respectively. The solid black line in (a) represents the maximum stability of graphite. The black circle plotted along the dashed line in both (a) and (b) indicates the value of aH_2O as estimated for sample JAG 84-553, which is approximately 1 log unit below FMQ. The black square plotted along the dashed line in both (a) and (b) indicates the value of aH_2O as estimated for sample JAG 84-553 using amphibole dehydration equilibria. (a) Assuming an activity of 1 will yield maximum values for the activities of the carbon-bearing phases and minimum values for the aH_2O. If graphite were present, along with a free-fluid phase, then this sample would have equilibrated under water-rich conditions (aH_2O =0.993). (b) Reducing the activity of C to less than 1, such as 0.1, as shown in this example, will yield maximum values of aH_2O (aH_2O =0.998) and minimum values for aCO_2 and aCH_4.

In cases where mineral equilibria are used to constrain fO_2 and fH_2O, if values of fluid pressure, estimated using calculations of fluid speciation in the C-O-H system, are similar to the pressure estimated from mineral barometry, then the presence of a lithostatically pressured fluid is indicated. However, for sample JAG 84-553 there are two very different estimates for the activity of H_2O; the C-O-H calculations yield a value of 0.99, while amphibole dehydration equilibria yields a value of 0.08. The large difference between these values of aH_2O indicates that the assumption that lithostatic pressure is equal to the fluid pressure and that the only components of this fluid are carbon, oxygen and hydrogen is incorrect. If the calculations are restricted to only the C-O-H system, then the only possible way to satisfy this mathematically would be to have a fluid pressure that is lower than the lithostatic pressure.

However, if $P_{Lith} > P_{Fluid}$ then there are likely two possible scenarios: (1) some non C-O-H fluid (e.g., N_2) was present as a significant constituent of the metamorphic fluid, or (2) the system is a fluid-absent system. In the case of option 2, there would be no grain boundary or free fluid present, and the only fluid present in the sample, would be bound within the NAMs or hydrous minerals, such as amphibole. A fluid absent system is further supported by low values of aH_2O estimated using amphibole equilibria.

Conclusions

In summary, all the samples from Eastern Australia, SW U.S.A and South Africa record low values of aH_2O that are less than 0.20. These low values of aH_2O indicate that the presence of amphibole does not require H_2O-rich conditions. However, if the fluid pressure is equivalent to lithostatic then C-O-H calculations require H_2O-rich fluids. This discrepancy indicates that either a non-COH fluid is present, or that the system is fluid-absent. In the absence of evidence for some exocitc fluid (e.g., N_2) a fluid absent system seems likely, and that the only “fluid” species are trapped within the minerals themselves.

CHAPTER IV

VALUES OF AH_2O ESTIMATED FROM AMPHIBOLE EQUILIBRIA AS COMPARED TO THE H_2O CONTENTS OF NOMINALLY ANHYDROUS MINERALS: A TEST OF H_2O RETENTION

Introduction

Trace amounts of H_2O can significantly affect the physical properties of the upper mantle, including viscosity, conductivity and the rheology (Chopra & Paterson, 1984, Karato *et al.*, 1986, Bell & Rossman, 1992, Kohlstedt *et al.*, 1995, Mei & Kohlstedt, 2000b, Mei & Kohlstedt, 2000a, Bolfan-Casanova, 2005, Yoshino *et al.*, 2009). H_2O also has a profound effect on the melting relations of mantle rocks (Wyllie, 1979, Gaetani & Grove, 1998, Green & Falloon, 1998, Green, 2015). Because H_2O affects physical properties of mantle rocks, the availability of H_2O should influence processes operating in the mantle. For example, the formation of oceanic crust and the evolution of the uppermost mantle at mid-ocean ridges, are likely influenced by the H_2O-contents of upper mantle rocks (Hirth & Kohlstedt, 1996, 2003).

Earth's mantle is an important reservoir of H_2O and many of the estimates of the H_2O contents of mantle rocks are based on the H_2O content that is present in nominally anhydrous minerals (NAMs) such as olivine and pyroxenes. Many NAMs from upper mantle peridotites typically contain around 100 to 300 wt. ppm H_2O, with some values ranging from 40 to 1200 wt. ppm (Bell & Rossman, 1992, Ingrin & Skogby, 2000, Beran & Libowitzky, 2006a, Skogby, 2006, Peslier, 2010). Recent reviews of the H_2O contents in NAMs (Beran & Libowitzky, 2006a, Skogby, 2006, Peslier, 2010) observe that mantle olivines typically contain less than 140 ppm H_2O. However, the H_2O content of mantle olivines can be quite variable (Figure 4.1a) with some values as high as 400 ppm. Mantle pyroxenes contain approximately 40 to 1000 wt. ppm H_2O (Fig 4.1b,c), with clinopyroxene typically containing twice as much H_2O as orthopyroxene.

Kinetic data from diffusion of hydrogen in pyroxene and olivine indicates that substantial resetting of hydrogen contents of NAMs may occur during xenolith entrainment to the Earth's surface (Ingrin *et al.*, 1995, Kohlstedt & Mackwell, 1998, Ingrin & Skogby, 2000, Demouchy *et al.*, 2006, Peslier & Luhr, 2006, Padrón-Navarta *et al.*, 2014). Ultimately, it is not entirely clear if the H_2O content of mantle NAMs now found at Earth's surface accurately reflect mantle H_2O contents, which in turn constitutes a major uncertainty in determining the amount of H_2O actually stored in different tectonic environments throughout the mantle.

Some samples derived from the earth's mantle contain amphibole co-existing with various nominally anhydrous phases. Lamb & Popp (2009) demonstrated that amphibole equilibria can be used to estimate values of the activity of H_2O (aH_2O) in amphibole-bearing mantle samples. These estimates of aH_2O are sufficiently accurate that, when combined with experimentally determined relations between aH_2O and the H_2O content of olivine, they yield useful predictions of the H_2O content of olivine (Lamb & Popp, 2009). In this study, amphibole-bearing mantle samples (xenoliths) are used to evaluate H_2O retention of nominally anhydrous mantle minerals by comparing values of aH_2O, estimated using amphibole equilibria, with the H_2O contents of NAMs that have been measured using Fourier-Transform Infrared (FTIR) Spectroscopy. These measured H_2O contents are also used to estimate partition coefficients for the partitioning of H_2O between coexisting olivine, orthopyroxene and clinopyroxene. If the H_2O contents of NAMs that comprise the xenoliths analyzed in this study have not undergone substantial resetting during emplacement, then the partitioning of H_2O between co-existing NAMs should be consistent with the experimentally determined values. Thus, this paper applies two tests to determine if the H_2O contents of mantle NAMs within our samples accurately reflect mantle values.

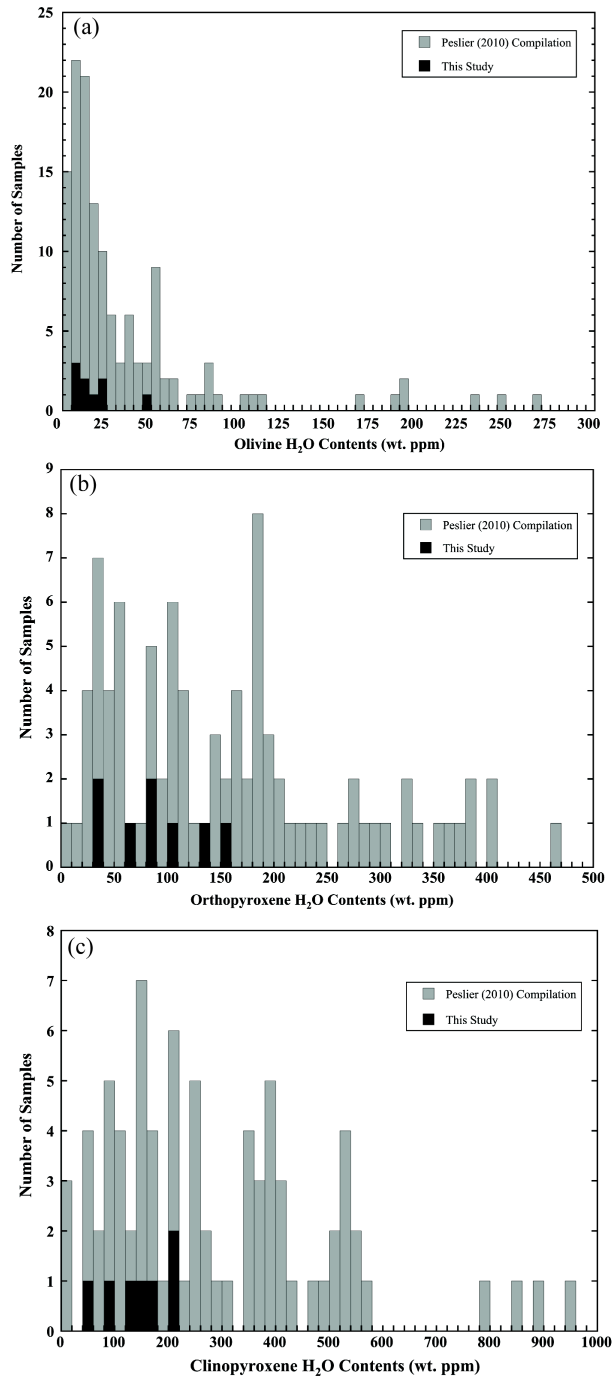


Figure 4.1: H_2O contents of (a) olivine, (b) orthopyroxene, (c) clinopyroxene. Literature data compiled by Peslier (2010) are shown in gray, xenoliths examined in this study are denoted in black. One olivine sample from Peslier (2010), not shown on the figure 3.1a, has an H_2O content of 471 ppm.

Analytical Methods

Electron Microprobe

The samples analyzed in this chapter were characterized in Chapter 2 and Chapter 3 of this text. See the Analytical Methods section in Chapter 2 or 3 for further detail regarding the EMP experimental operating conditions, as well as the normalization procedures used for the minerals in these samples. Also, as mentioned in Chapter 2 and 3, mineral analyses for all samples can be found in the APPENDIX Tables A-F.

FTIR Spectroscopy

The H_2O content of olivine, clinopyroxene and orthopyroxene was determined using a Nicolet Magna 560 FTIR spectrophotometer with NicPlan microscope at Texas A&M University. Doubly-polished thick sections (100-300 μm) were used and each IR spectrum was collected for a total of 512 scans for the wavenumbers 4000-1400 cm^{-1} with a resolution of 4 cm^{-1}. Background subtraction was performed according to the methods in Webber et al. (2010) and involves the removal of free water present, either due to adsorbed water, water found in the epoxy or water as fluid inclusions within the sample, by subtracting a spectra collected from free water.

Early attempts to determine the H_2O contents of NAMs typically relied on an unpolarized light source to quantify the H_2O content of NAMs (Paterson, 1982). Bell *et al.* (2003) demonstrated that the IR absorbance depends on the crystallographic orientation of a given mineral grain and a calibration was developed based on collecting measurements along each of the crystallographic axes. However, the Bell et al. (2003) calibration is impractical for many natural samples with small grain sizes, such as those in the xenoliths studied here. Asimow *et al.* (2006) developed a method that measures the H_2O content of NAMs using polarized IR light of randomly oriented mineral grains. This method requires at least three randomly oriented crystals and the orientation is inferred using the polarized spectra of the grains. Other, more recent, calibrations have shown that the H_2O content of randomly oriented grains can be quantified using unpolarized measurements (Kovács *et al.*, 2008, Sambridge *et al.*, 2008). Implementation of these methods requires measurements of several (e.g., ten or more) randomly oriented grains. Ultimately, the samples examined in this study did not contain a large enough number of grains that were sufficiently free of cracks, inclusions, or alteration to use the methods of Asimow *et al.* (2006), Kovács *et al.* (2008) or Sambridge *et al.* (2008).

Due to our sample limitations, an unpolarized IR light-source was used to quantify the H_2O contents of nominally anhydrous phases. This approach permits direct comparison of our results with many previous measurements of H_2O in NAMs using the Paterson (1982) method (Table 4.1). Mosenfelder et al. (2006) showed that the calibration of Bell et al. (2003), yields measured H_2O contents that are approximately 3.5 times greater than the method of Paterson (1982). We have modified our results using this multiplier to facilitate a direct comparison with Peslier's (2010) recent compilation of the H_2O contents of mantle olivines (Table 4.1).

The Paterson (1982) method was also chosen to estimate the H_2O content of the pyroxenes (Table 4.1), rather than the method of Bell *et al.* (1995). As was the case for olivines, this decision was driven by sample limitations because the Bell *et al.* (1995)

calibration requires measuring the absorbance of polarized IR radiation parallel to three different crystallographic axes. However, given the limited number of suitable grains in our samples we relied upon measurements conducted using unpolarized light on randomly oriented pyroxene grains.

Sample Description & Mineralogy

Nine amphibole-bearing mantle xenoliths from two different continents were used in this study. Four samples are from the Bullenmerri and Gnotuk localities in Eastern Australia. Five samples are from the Southwestern U.S.A, four from Grand Canyon and one is from Dish Hill, California. All nine samples contain co-existing olivine, orthopyroxene, clinopyroxene, amphibole and spinel.

Table 4.1: H_2O contents of NAMs (wt. ppm).

	Th (µm)	n=			Integrated Absorbance (cm^{-1})			H_2O Contents					
								FTIR	FTIR	FTIR	FTIR		
		opx	cpx	ol	opx	cpx	ol^A	opx	cpx	ol^A	ol^B	ol^C	ol^D
Eastern Australia													
GN9912	230	2	0	3	4.47	nm	0.00	87	nm	bdl	bdl	0	1
GN9913	200	5	1	5	1.84	4.94	0.00	36	96	bdl	bdl	1	2
BM9912	220	3	2	2	5.20	8.28	0.28	101	161	5	18	3	4
BM9915	110	4	3	5	5.24	8.08	0.16	66	148	3	11	3	5
S.W. U.S.A													
X229	120	0	4	2	nm	6.09	0.22	nm	121	4	14	12	10
X286	190	2	4	5	1.46	2.73	0.00	30	52	bdl	bdl	13	8
X297	170	1	3	6	6.22	10.56	0.32	130	208	6	21	11	8
X299	230	3	0	3	7.36	nm	0.33	151	nm	6	21	15	12
Ba-1-72	280	1	1	3	4.40	11.88	0.71	82	217	13	46	13	14

Thc, sample thickness; n, number of analyses for each mineral; bdl, concentration below the detection limit; nm, not measured

A- Calculated H_2O content using calibration of Paterson (1982)

B- Calculated H_2O content using calibration of Bell et al. (2003)

C- Predicted H_2O content using Zhao et al. (2004)

D- Predicted H_2O content using Mosenfelder et al. (2006)

Eastern Australia

Four samples are from the Bullenmerri and Gnotuk mars and information on sample location and descriptions on the various types of xenoliths collected from this area can be found in Griffin et al. (1984) and O'Reilly & Griffin (1985, 1987, 1988). Two samples from the Gnotuk Mar (GN9912 and GN9913) and two samples from the Bullenmerri Mar (BM9912, BM9915) were analyzed for this study. See Chapter 3 for a detailed discussion about mineralogy and textures observed in the four samples from Eastern Australia.

Southwestern U.S.A

Five samples were also analyzed from the Southwestern U.S.A (SW U.S.A). Four samples are from the western Grand Canyon region of northwestern Arizona (X229, X286, X297, X299) and were provided by Myron Best. More detailed information on sample location and a description of various xenoliths from this area may be found in Best (1970, 1975). The fifth sample is from Dish Hill, California (Ba-1-72) and has been provided by the Smithsonian Institute. This location has been described by Wilshire & Trask (1971) and this particular sample, Ba-1-72 has been described by Wilshire et al. (1971, 1980). See Chapters 2 and 3 for a detailed discussion about mineralogy and textures observed in the five samples from the SW U.S.A.

Geothermobarometry & P-T of Mineral Equilibration

In order to estimate values of aH_2O using amphibole equilibria, the pressure (P) and temperature (T) of mineral equilibration must be determined. Pyroxene geothermometry was applied to estimate temperature and these T determinations were combined with estimates of the geothermal gradient to determine values of P (see Temperature and Pressure section in Chapter 2).

H_2O Contents of NAMs

The H_2O contents of the NAMs (olivine, orthopyroxene, clinopyroxene) from all nine samples examined in this study were measured using FTIR (Table 4.1). The H_2O content of clinopyroxene from two samples (GN9912 and X299) and orthopyroxene from one sample (X229) were not determined because either: (1) the minerals were not present in the portion of the sample available for FTIR analysis or (2) mineral grains were not suitable for analysis due to the presence of fractures, fluid inclusions, and/or retrograde serpentine. Representative spectra for olivine, orthopyroxene and clinopyroxene from each sample are shown in Figures 4.2, 4.3 and 4.4. The presence of healed inclusions and fractures in most minerals grains, combined with the minimum useful analytical volume of the instrument used in this study, resulted in the inability to acquire IR spectra along a traverse across single grains.

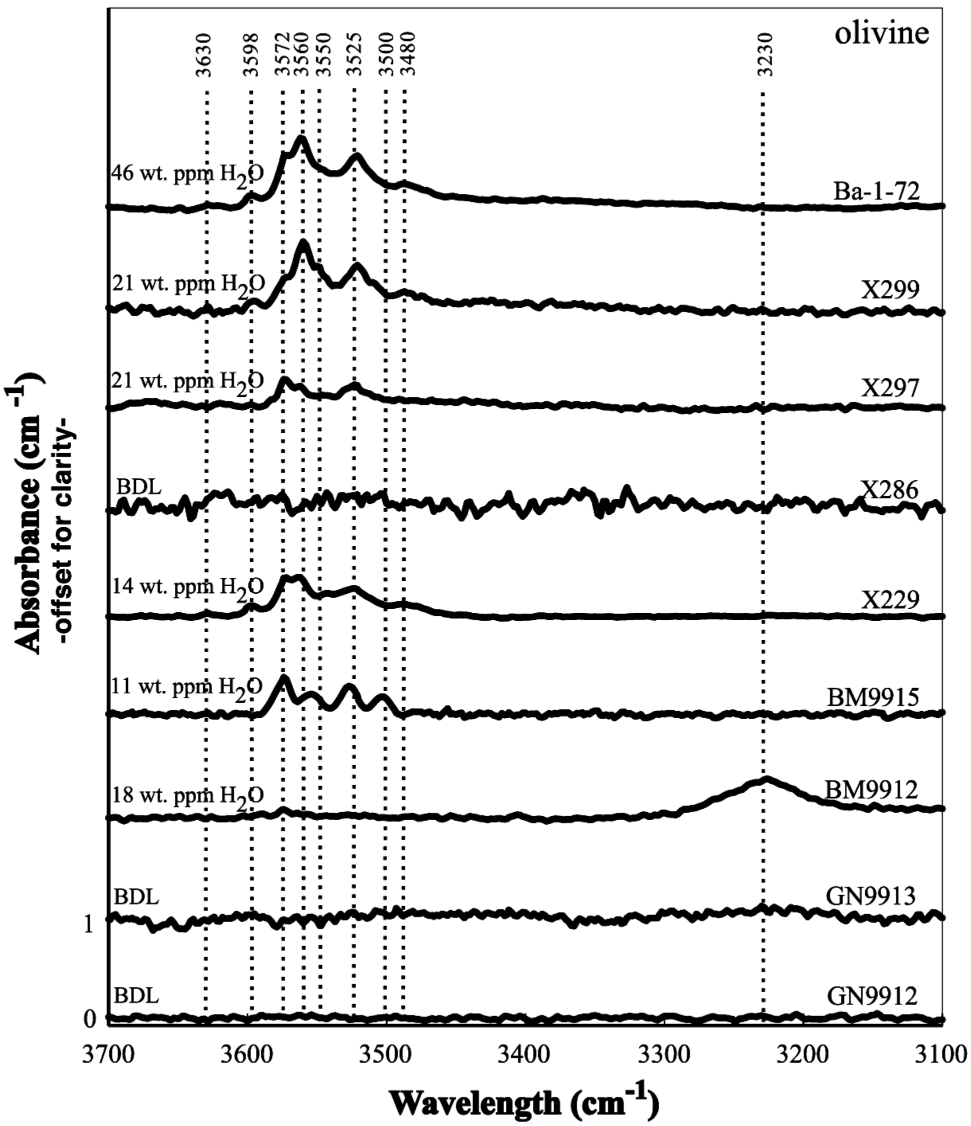


Figure 4.2: Representative non-polarized FTIR spectra of unoriented grains of olivine. The spectra for each sample have been normalized to 1 cm thickness and offset for clarity. Peaks of interest were identified in each spectra and are shown by the thin, black dotted lines. In most samples these peaks, due to OH stretching, occur at 3630, 3598, 3572, 3560, 3550, 3525, 3500 and 3480 cm^{-1}.

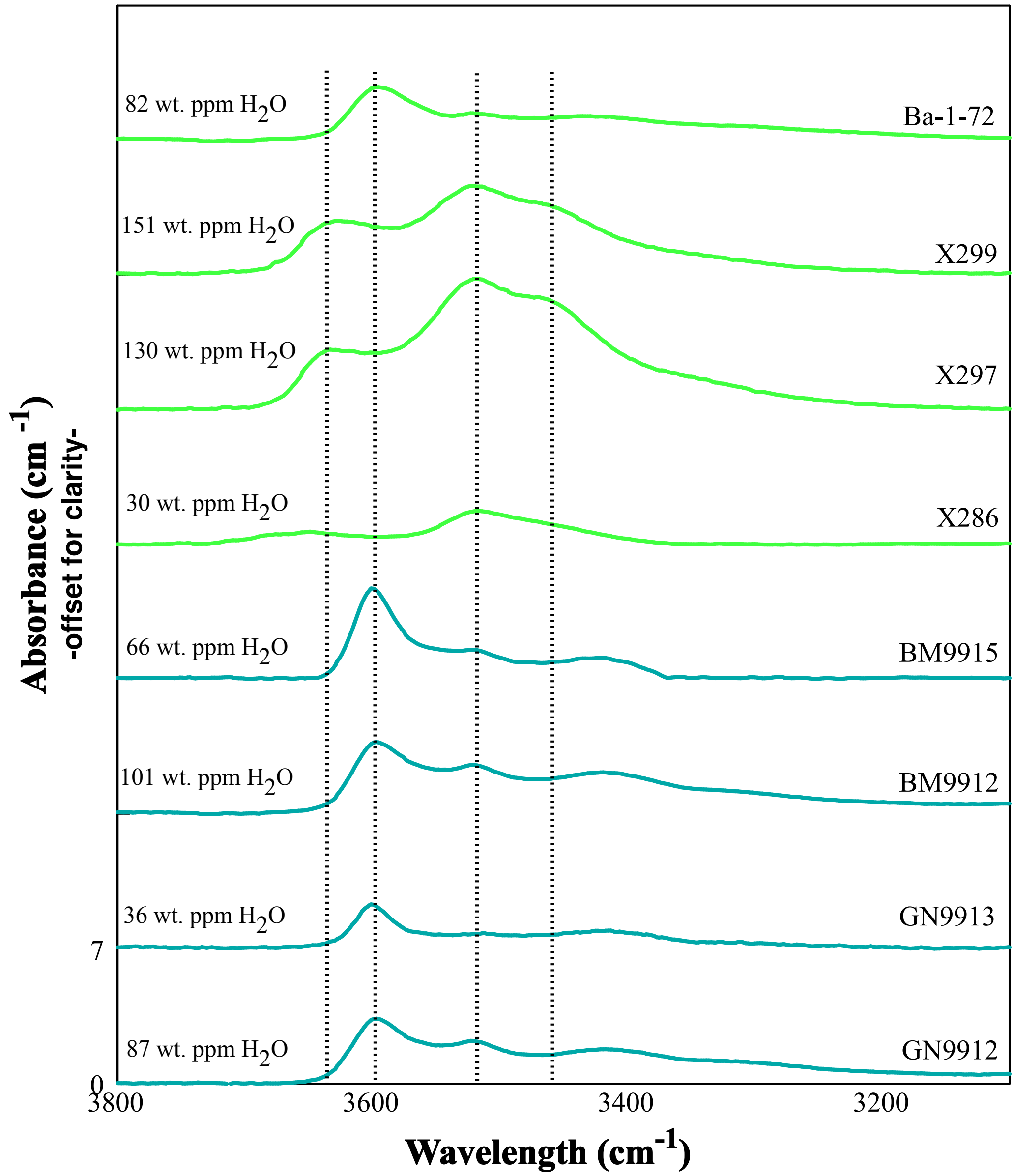


Figure 4.3: Representative non-polarized FTIR spectra of unoriented grains of orthopyroxene. The spectra for each sample have been normalized to 1 cm thickness and offset for clarity. Peaks of interest were identified in each spectra and are shown by the thin, black dotted lines. In most samples these peaks, due to OH stretching, occur at 3600, 3640, 3630, 3520 and 3460 cm^{-1}.

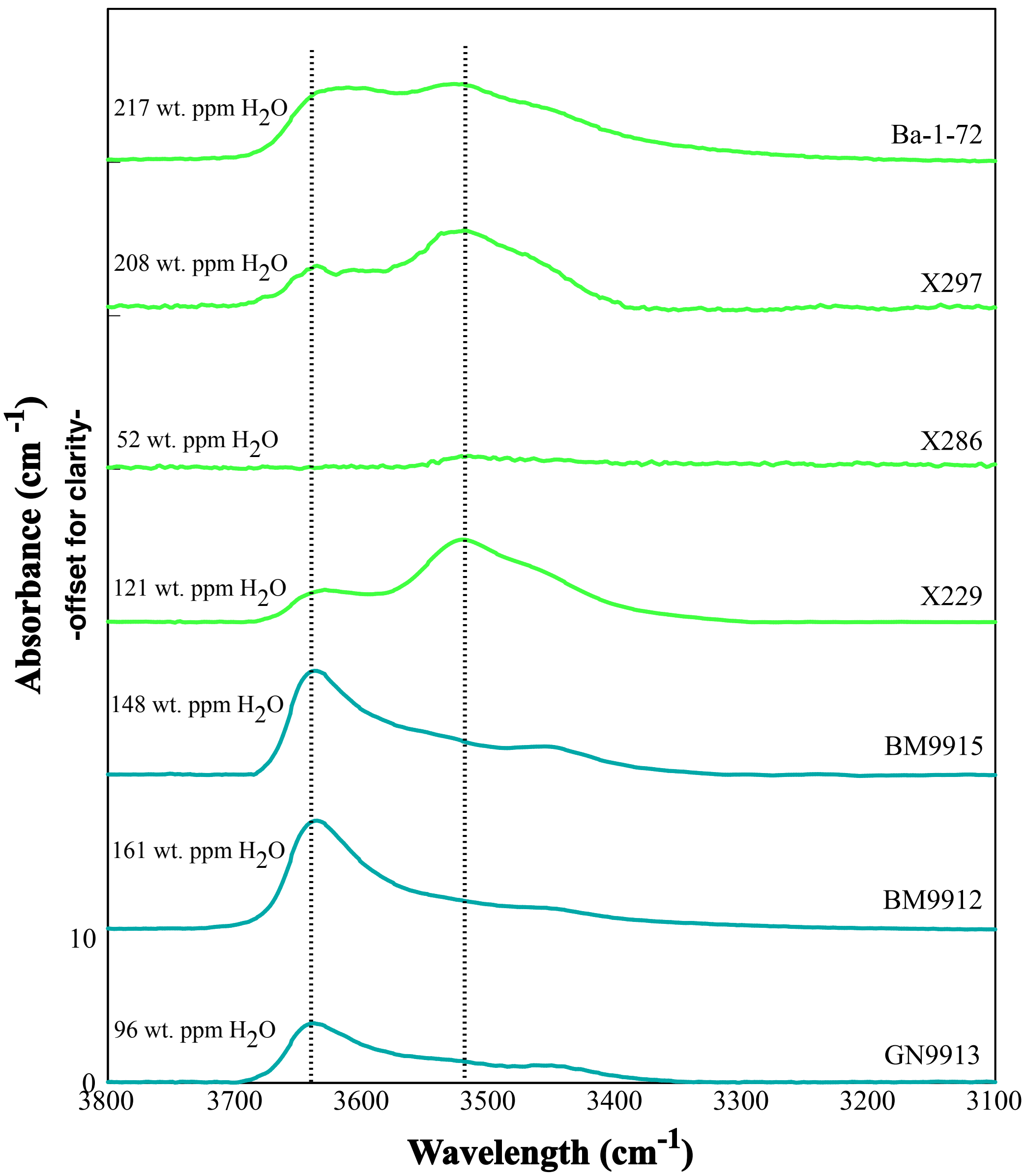


Figure 4.4: Representative non-polarized FTIR spectra of unoriented grains of clinopyroxene. The spectra for each sample have been normalized to 1 cm thickness and offset for clarity. Peaks of interest were identified in each spectra and are shown by the thin, black dotted lines. In most samples these peaks, due to OH stretching, occur at 3600, 3640, 3630, 3520 and 3460 cm^{-1}.

Olivines

A wide variety of OH bands have been identified in natural mantle olivines (Miller *et al.*, 1987). Peaks in the region of 3450 – 3650 cm^{-1} are often classified as high frequency group 1 bands (Bai & Kohlstedt, 1993) and many have been attributed to Si-related OH point defects (Matveev *et al.*, 2001, Lemaire *et al.*, 2004, Walker *et al.*, 2007, Kovács *et al.*, 2010). The IR spectra for olivines in this study include a number of peaks in this region (3450 – 3650 cm^{-1}) indicating that OH-bearing Si-related defects occur in most of our samples that contain detectable amounts of H_2O (Figure 4.2). Two distinctive bands, at 3572 and 3525 cm^{-1}, are also found in this same high frequency region, however they are attributed to Ti-related point defects (Berry *et al.*, 2005, Berry *et al.*, 2007, Walker *et al.*, 2007). These two bands are commonly present in the IR spectra from mantle olivines contained in spinel-bearing xenoliths (Miller *et al.*, 1987, Berry *et al.*, 2007), as well as the xenoliths included in this study (Figure 4.2).

The spectra from three samples (GN9912, GN9913 and X286) contained no detectable peaks and, therefore, H_2O contents for these samples were below the detection level of the instrument (Figure 4.2). The spectra for sample BM9912 showed an additional peak at 3230, which is not seen in any of the other samples. Peaks in this region, from 3100 to 3300 cm^{-1}, are attributed to OH point defects in Mg-vacancies in the M1 and M2 sites in olivine (Lemaire *et al.*, 2004, Berry *et al.*, 2005, Walker *et al.*, 2007, Schmädicke *et al.*, 2013).

These olivine spectra yield H_2O contents of mantle olivines that range from 3 to 13 wt. ppm for five samples, whereas three samples (GN9912, GN9913 and X286) had olivines that recorded values that were below the detection level of the instrument (approximately 2 wt. ppm H_2O). These values are based on the wavelength-specific calibration of Paterson (1982). However, when a correction factor of 3.5 is applied for consistency with the mineral-specific calibration of Bell *et al.* (2003) (see the methods section above), the H_2O contents of those same five olivines range from 9 to 46 wt. ppm with a minimum detection limit of approximately 7 wt. ppm. These corrected olivine H_2O contents will be used for purposes of comparison and discussion from hereafter and in the remaining figures.

Pyroxenes

The FTIR spectra from all of the pyroxenes analyzed have OH bands that occur from 3400 to 3640 cm^{-1} (Figure 4.3 and 4.4). Orthopyroxene spectra generally contain two major peaks at 3600 and 3520 cm^{-1}, and, in some cases, minor peaks at 3630 and 3460 cm^{-1} (Figure 4.3). For clinopyroxene, the two most distinctive peaks are observed at 3640 and 3520 cm^{-1} (Figure 4.4). The H_2O content of the orthopyroxene and clinopyroxene range from 30 to 151 wt. ppm and 52 to 217 wt. ppm respectively (Table 4.1). The measured partition coefficients or D values for $D_{cpx/opx}$, $D_{opx/ol}$, and $D_{cpx/ol}$ in these samples are 2.1 ±0.6, 6.4 ±0.8, and 10.5 ±3.6 respectively.

Values of aH_2O estimated using Amphibole Dehydration Equilibria

A variety of H_2O-buffering equilibria involving the minerals in our samples may be written. However, given that the amphiboles are pargasite-rich, the equilibrium:

2Pargasite + Enstatite = 2Forsterite +4Diopside + 2Jadeite +2Spinel + H_2O (2.1)

$$NaCa_2(Mg_4, Al)Al_2Si_6O_{22}(OH)_2 + Mg_2Si_2O_6 =$$

$$2Mg_2SiO_4 + 4CaMgSi_2O_6 + 2NaAlSi_2O_6 + 2MgAl_2O_4 + 2H_2O$$

may be particularly appropriate to estimate values of aH_2O (Lamb & Popp, 2009).

Application of equilibrium (2.1) yields low values of aH_2O (<0.20) for all samples analyzed in this study (see Table 3.2 in Chapter 3). Values of aH_2O for the samples from Eastern Australia range from 0.01 to 0.04 (Table 3.2) whereas samples from the SW equilibrated at values of aH_2O that range from 0.04 to 0.07 (Table 3.2).

Discussion

The goal of this study is to apply two different methods in an effort to determine if NAMs in mantle xenoliths retain their H_2O contents during their emplacement at the earth's surface. One test involved determining values of H_2O partition coefficients for the three mineral pairs considered here, cpx-opx, opx-ol, and cpx-ol, and comparing these values with values of partition coefficients determined experimentally. If H_2O is not lost during xenolith emplacement, the partitioning of H_2O between coexisting olivine, orthopyroxene, and clinopyroxene, should be consistent with values determined by experiments conducted to simulate mantle P-T-X conditions (Li *et al.*, 2008). Alternatively, retrograde H_2O loss from co-existing minerals should occur at different rates (Peslier *et al.*, 2002, Demouchy *et al.*, 2006, Peslier & Luhr, 2006, Kovács *et al.*, 2012, Padrón-Navarta *et al.*, 2014) such that the distribution of H_2O will not be consistent with the experimentally determined partition coefficients.

The second test (described in a subsequent section) involves comparing values of aH_2O as determined via the application of amphibole equilibria with the H_2O contents of nominally anhydrous minerals. If NAMs record mantle conditions then a positive correlation should exist between NAM H_2O contents and values of aH_2O as recorded by mineral equilibria.

Partitioning of H_2O between co-existing NAMs

The H_2O contents of three different nominally anhydrous minerals, olivine, opx, and cpx, have been determined for samples described in this study. These measurements permit the values of H_2O partition coefficients (D) for three mineral pairs, cpx-opx, opx-ol, and cpx-ol. These values are included in Figures 4.5, 4.6, and 4.7. Also shown on Figures 4.5, 4.6, 4.7 are values of D determined by experimental studies conducted at P-T conditions most relevant to our samples (see below).

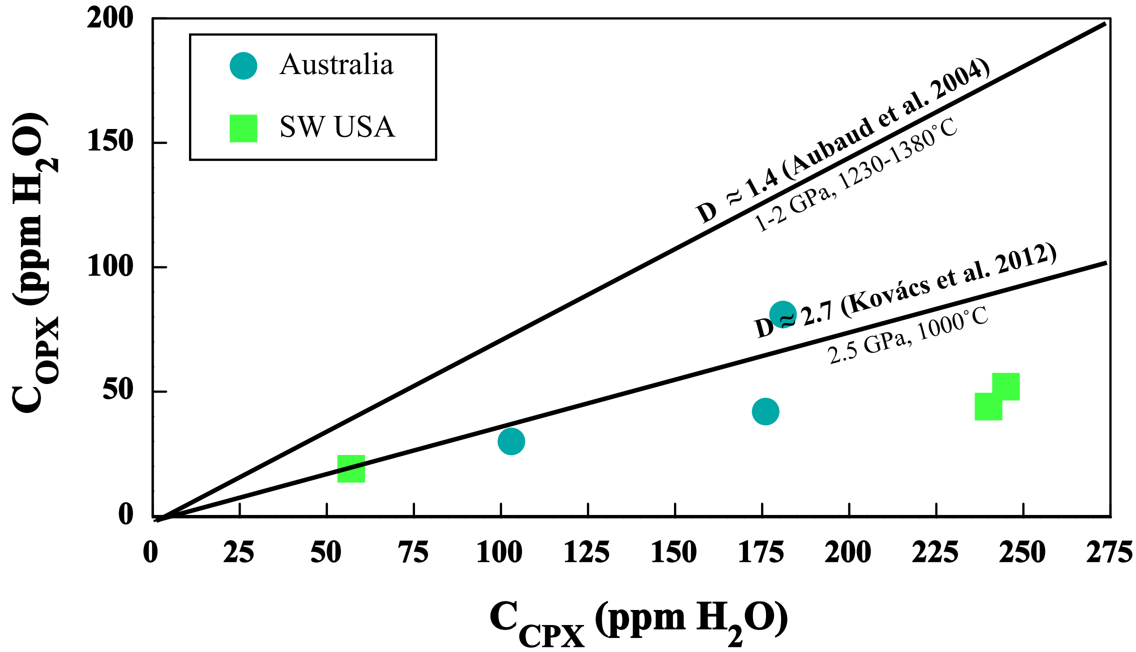


Figure 4.5: H_2O contents of co-existing NAMs illustrate partitioning of H_2O between co-existing orthopyroxene and clinopyroxene. These partition coefficients (D) between cpx/opx can be compared with values from experimental and natural studies. The $D_{cpx/opx}$ for our samples, range from 1.6 to 2.7. This falls within the range of experimentally determined values.

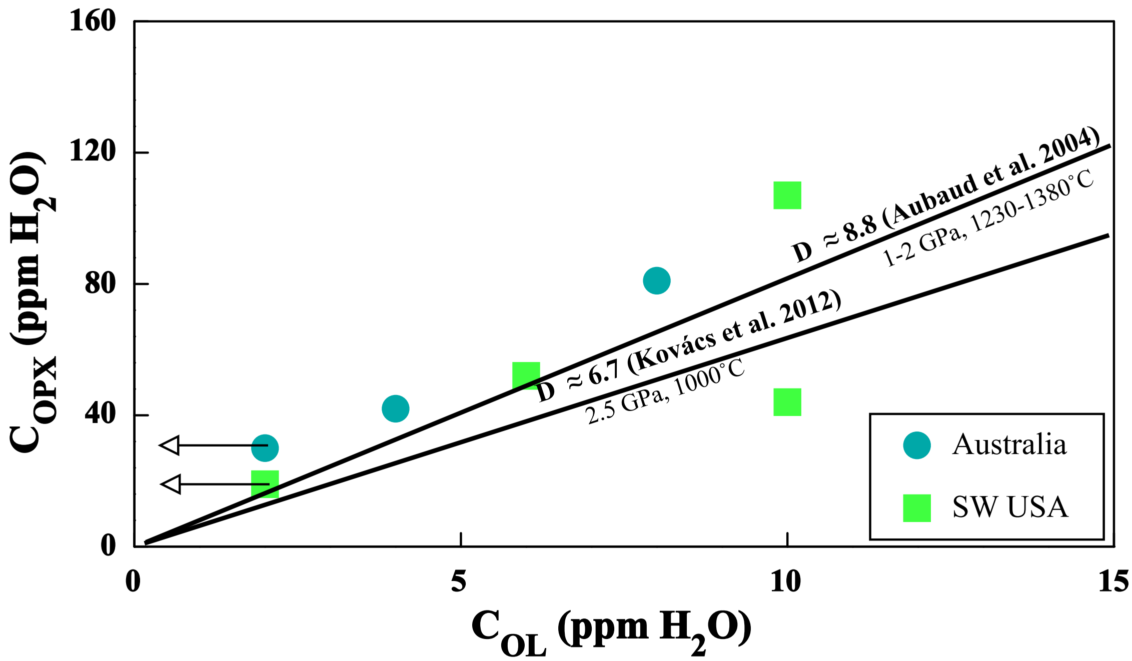


Figure 4.6: H_2O contents of co-existing NAMs illustrate partitioning of H_2O between co-existing orthopyroxene and olivine. These partition coefficients (D) between opx/ol can be compared with values from experimental and natural studies. Values of $D_{opx/ol}$ for the eight opx-bearing samples examined in this study. The H_2O content of olivine from three samples (denoted with arrows) fall below the detection limit. Four of the samples have $D_{opx/ol} \approx 6.9$. Sample Ba-1-72 (DH) does not fall in the range shown in the figure (C_{ol}=46 and C_{opx}= 82) and suggests an even smaller $D_{opx/ol} \approx 2$. These small values of D are generally consistent with experimental values.

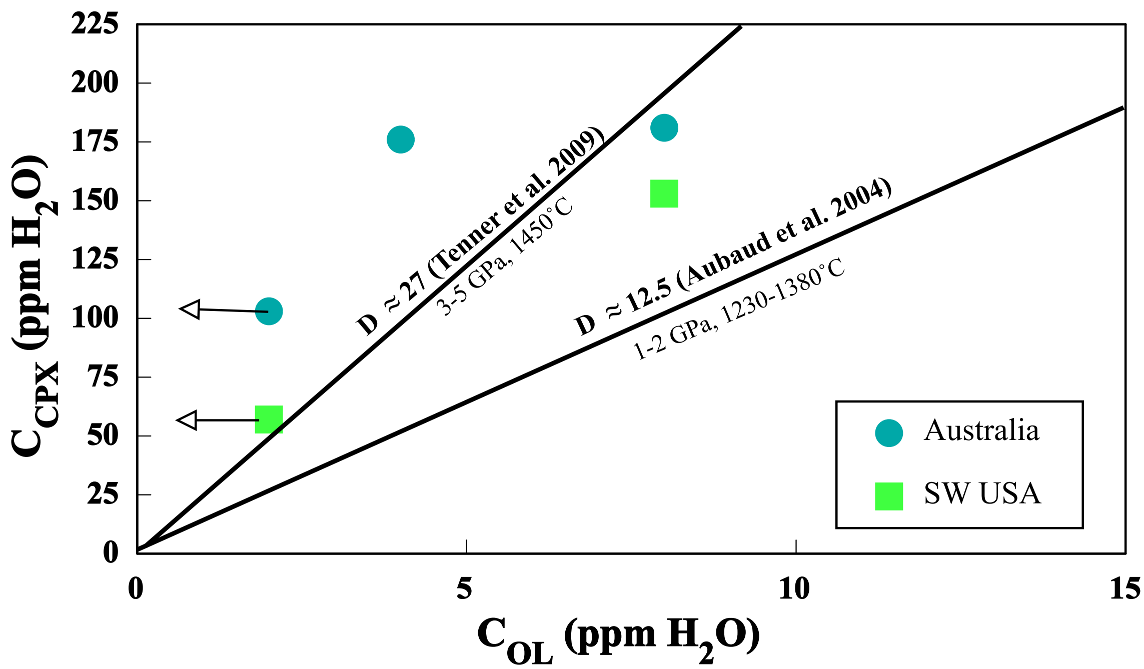


Figure 4.7: H_2O contents of co-existing NAMs illustrate partitioning of H_2O between co-existing clinopyroxene and olivine. These partition coefficients (D) between cpx/ol can be compared with values from experimental and natural studies. Four out of the five of our samples, in which the olivine had detectable levels of H_2O content, have a $D_{cpx/ol}$ of 8.6 to 16.4. Sample Ba-1-72 (DH) does not fall in the range shown in the figure (C_{ol}=46 and C_{cpx}= 217) and has an even smaller value of $D_{cpx/ol} \approx 4.9$. These lower values of $D_{cpx/ol}$ are not consistent with preferential H_2O loss from the olivines.

Partition coefficients that describe the relative concentrations of H_2O in co-existing clinopyroxene (cpx) and orthopyroxene (opx) ($D_{cpx/opx}$) for our samples range from 1.6 to 2.7 (Figure 4.5). These values fall within the range of $D_{cpx/opx}$ from 1.3 to 2.8 that were measured for natural samples reported in the literature (Bell & Rossman, 1992, Peslier *et al.*, 2002, Grant *et al.*, 2007a). Experimentally determined the partition coefficients for co-existing pyroxenes range from 1.4 to 3.5 (Aubaud *et al.*, 2004, Hauri *et al.*, 2006, Tenner *et al.*, 2009, Kovács *et al.*, 2012). These experiments were conducted at pressures ranging from 1 to 4.5 GPa and temperatures of 1000 to 1440˚C. It is, therefore, likely that the range in the values of D (1.4 to 3.5) reflect, at least to some extent, the effect of P-T on the value of the partition coefficient. Of the four experimental studies mentioned above, the temperature conditions (1000˚C) employed by Kovács *et al.* (2012) are most similar to the temperature of mineral equilibration recorded by our samples (820˚C to 1000˚C, Table 4.1). Conversely, pressures of mineral equilibration for our samples ranged from 1.1 to 1.6 GPa, which fall within the range of the experiments performed by Aubaud *et al.* (2004). This indicates that the best estimate of the $D_{cpx/opx}$ for our samples lies in the range of 1.4 to 2.7. This range includes the average value for our xenoliths of 2.1 ±0.6, a result consistent with little or no H_2O loss for our pyroxenes. However, determining a single value for the partition coefficient that is directly applicable to any given sample is not possible without additional experimental data. Given this uncertainty, some H_2O loss from these pyroxenes cannot be ruled out. In the extreme case, if the value of D most appropriate for our sample is ≈ 2.7 then cpx grains from certain samples could have suffered loss of approximately 25 to 100 ppm

H_2O (Figure 4.5). Alternatively, if the D value most appropriate for our sample is ≈ 1.4 then approximately 10 to 40 wt. ppm H_2O may have best lost from the opx in certain samples (Figure 4.5). A more likely scenario is both pyroxenes may have suffered some limited loss of H_2O during the transport and emplacement of the xenoliths on the surface of the earth (Figure 3.5).

The $D_{opx/ol}$ of the eight opx-bearing samples examined in this study range from <4 to 12.4 (Figure 4.6). Three of these eight samples have olivines with H_2O contents that are below the detection limit, and, therefore, those values of $D_{opx/ol}$ are poorly constrained. Experimentally determined partition coefficients between orthopyroxene (opx) and olivine ($D_{opx/ol}$) range from 4.7 to 24 (Aubaud *et al.*, 2004, Hauri *et al.*, 2006, Grant *et al.*, 2007b, Kovács *et al.*, 2012). The two experimental studies performed at P-T conditions that most closely match the P-T of mineral equilibration in for our samples are Aubaud et al. (2004) and Kovács *et al.* (2012), and these studies yield $D_{opx/ol}$ of 8.8 and 6.7, respectively (Figure 4.6).

The average value of $D_{opx/ol}$ recorded by natural spinel-bearing peridotites, as reported in the literature, is approximately 41, while samples that contain garnet typically yield a D of approximately 12 (Bell & Rossman, 1992, Grant *et al.*, 2007a). These values of D, recorded in a number of natural samples, are large compared to the experimentally determined values, and natural samples record a wide range in D values (Bell & Rossman, 1992, Grant *et al.*, 2007a). Variations in D could, to some extent, reflect mantle conditions if the samples have different chemical compositions and they equilibrated at various temperature and pressures. However, variations in the value of D could also reflect partial loss of H_2O, particularly if these two phases suffered differential H-loss. For example, the relatively large values of $D_{opx/ol}$ recorded in various natural samples may be one line of evidence that would be consistent with the preferential loss of H_2O from olivine during transport to Earth's surface (Peslier & Luhr, 2006, Li *et al.*, 2008, Schmädicke *et al.*, 2013, Warren & Hauri, 2014). In contrast to many values reported in the literature, our samples preserve relatively small values of D, a result inconsistent with significant H_2O loss from olivine.

The $D_{cpx/ol}$ values for four out of the five of our samples, in which the olivine had detectable levels of H_2O content, range 9.2 to 14.1 (Figure 4.7 and Table 4.1). Sample Ba-1-72 has an even smaller value of D of 4.9. Experiments that examined the partitioning of H_2O between clinopyroxene (cpx) and olivine ($D_{cpx/ol}$) yield a $D_{cpx/ol}$ of approximately 12.5 at 1-2 GPa, 1230-1380˚C (Aubaud et al., 2004, Figure 4.7) and 27 at 3 GPa and 1450˚C, respectively (Aubaud *et al.*, 2004, Tenner *et al.*, 2009). Natural samples often yield much larger values of $D_{cpx/ol}$ and also exhibit significant differences between spinel and garnet peridotites, averaging approximately 88 and 22 respectively (Grant *et al.*, 2007a). These relatively large values of D are consistent with preferential loss of H_2O from olivine relative to cpx. However, the samples examined in this study record relatively low values of D that are inconsistent with significant H_2O loss from olivine.

This comparison, between the values of various partition coefficients measured in our samples with those determined experimentally, is generally consistent with little or no H_2O loss from the pyroxenes and olivine contained in our samples. However, the accuracy of this comparison is limited by the availability of relevant experimental data. Thus, additional experimental data are required before it is possible to assign an accurate value for the partitioning of H_2O between nominally anhydrous mantle phases at any given value of the P and T. Partitioning of H_2O between NAMs may also be affected by the chemical compositions of individual minerals. Many authors have found that the H_2O content of pyroxene is positively correlated with the Al_2O_3 content (Rauch & Keppler, 2002, Mierdel & Keppler, 2004, Stalder, 2004, Mierdel *et al.*, 2007). Additionally, the solubility of H_2O in olivine may vary as a function of Fe-content, silica activity and/or trace elements concentrations, such as Ti (Bai & Kohlstedt, 1993, Zhao *et al.*, 2004, Berry *et al.*, 2005, Demouchy & Mackwell, 2006). If mineral chemistry affects the solubility of H_2O in NAMs it is likely that mineral chemistry will also affect partitioning of H_2O between NAMs. At this time, a full description of the distribution of H_2O between co-existing NAMs as a function of P, T, and crystal chemistry is lacking. Consequently, while the comparison between experimentally determined and natural values of D (e.g., Figures 4.5, 4.6, 4.7) is useful, it is not a definitive indicator of negligible retrograde H_2O loss from NAMs.

Comparing Values of aH_2O with NAM H_2O Contents

Another test of mantle NAM H_2O retention applied in this study is the comparison between values of aH_2O estimated from amphibole equilibria and NAM H_2O content. Of the nine xenoliths examined in this study, the four from Eastern Australia record the lowest aH_2O values estimated using amphibole equilibria. They also record some of the lowest olivine H_2O contents (Table 4.1). The five samples from the

SW U.S.A record higher aH_2O values and three of these samples record the highest olivine H_2O contents (Tables 4.1). This general agreement, between these two sets of values, suggests that low H_2O contents in the olivines from mantle xenoliths may (at least in some cases) reflect mantle conditions, rather than H_2O-loss during ascent. Most importantly, perhaps is that values of aH_2O are all < 0.20 and olivine H_2O contents (≤ 46 ppm) are on the lower end of the range of measured olivine H_2O contents as shown on Figure 4.1a (Beran & Libowitzky, 2006a, Skogby, 2006, Peslier, 2010). This is also true for the pyroxenes, as opx and cpx H_2O contents for our samples range from 30 to 151 wt. ppm and 52 to 217 wt. ppm respectively, while values reported in the literature usually range from 40 to 1000 wt. ppm H_2O (Fig 4.1b,c). Thus, all the samples analyzed in this study record low values of aH_2O (< 0.2) and values of NAM H_2O contents are on the low end of the range of values recorded by mantle NAMs (Figure 4.1). This result suggests mantle NAMs in these samples accurately reflect mantle H_2O contents. However, this comparison is qualitative and, therefore, at least some limited H_2O-loss from mantle NAMs is still possible.

A more quantitative comparison is possible between values of aH_2O, as estimated from amphibole equilibria and olivine H_2O contents using the experimental studies of Zhao *et al.* (2004) and Mosenfelder *et al.* (2006), which permit estimation of olivine H_2O contents for any given value of fH_2O (where fugacity and activity are related via the equation $aH_2O=fH_2O/f^oH_2O$; where f^oH_2O is the fugacity of pure H_2O at the P-T conditions of interest). The values of aH_2O estimated in this study, in combination with P and T estimates and the calibrations of either Zhao *et al.* (2004) or

Mosenfelder *et al.* (2006), yield olivine H_2O contents that are less than 15 wt. ppm for all samples (Table 4.1, Figure 4.8). For the purposes of the following discussion, we have chosen the calibration of Mosenfelder *et al.* (2006), when comparing the predicted vs. measured H_2O contents. However, using the calibration of Zhao et al. (2004) would only make minor differences in the values of olivine H_2O contents estimated from values of aH_2O (Figure 4.8), as compared to the calibration of Mosenfelder et al. (2006), and would not change the conclusions of this study. Also, because Mosenfelder *et al.* (2006) and Zhao et al. (2004), predict the H_2O content of the olivine using the Bell *et al.* (2003) calibration, a correction factor of 3.5 (see previous FTIR discussion) has been applied to the measured H_2O contents in order to maintain consistency between the current study and previous experimental investigations (Aubaud *et al.*, 2004, Kovács *et al.*, 2012).

Values of aH_2O estimated for samples from Eastern Australia range from 0.01 to 0.04. An estimated temperature uncertainty of ± 50 ˚C, combined with a pressure uncertainty of ± 0.2 GPa, yields an uncertainty in aH_2O of ± 0.02. These values of aH_2O, when combined with the experimental study of Mosenfelder *et al.* (2006), yield olivine H_2O contents of 1 to 5 ppm (Table 4.1). These predicted values are slightly lower than the measured olivine H_2O contents, which range from < 2 to 10 ppm (Table 4.1, Figure 4.9). This observation is not consistent with H_2O loss from these olivines that contain detectable amounts of H_2O.

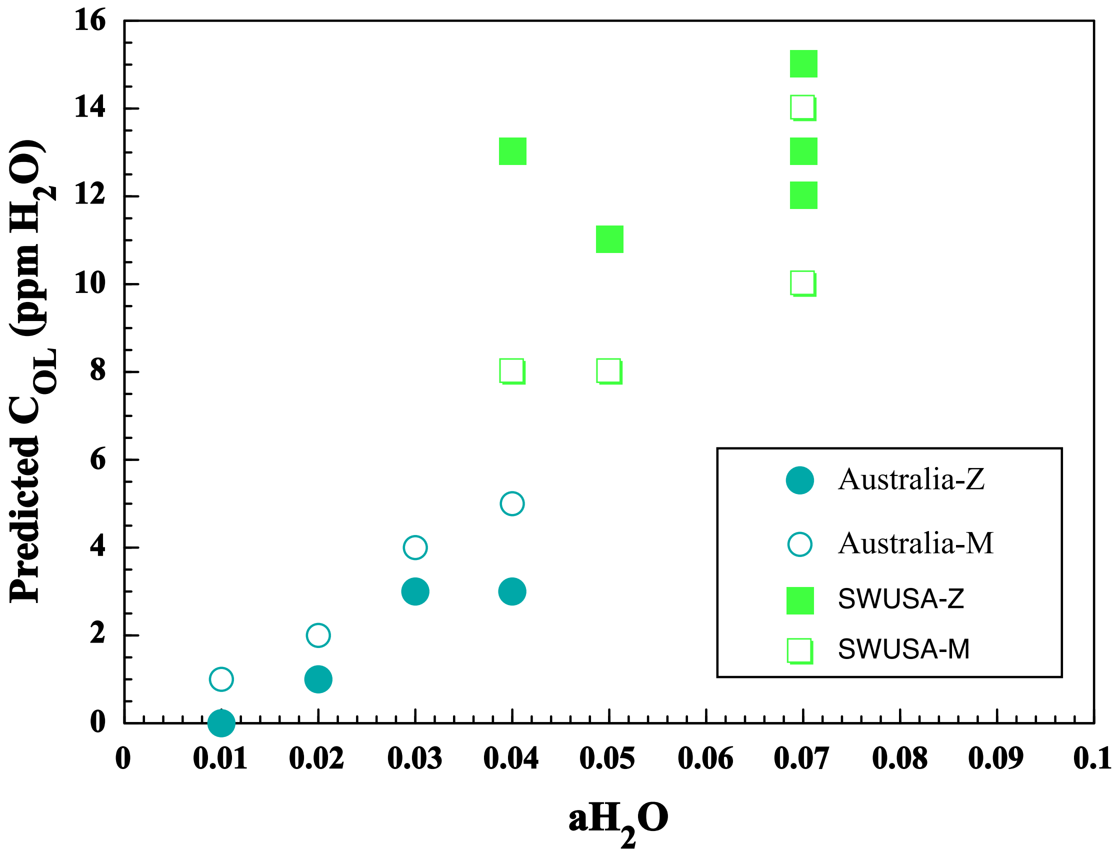


Figure 4.8: Olivine H_2O contents can be predicted based on P-T-fH_2O using the two experimentally determined relations of Zhao et al. (2004) and Mosenfelder et al. (2006). The calibration of Zhao et al. (2004), depicted by filled symbols, predicts olivine H_2O contents for the Eastern Australia (circles) and SW U.S.A (squares) from 0 to 1 wt. ppm for the samples analyzed in this study. The calibration of Mosenfelder et al. (2006), depicted by open symbols, predicts olivine H_2O contents from 1 to 14 wt. ppm.

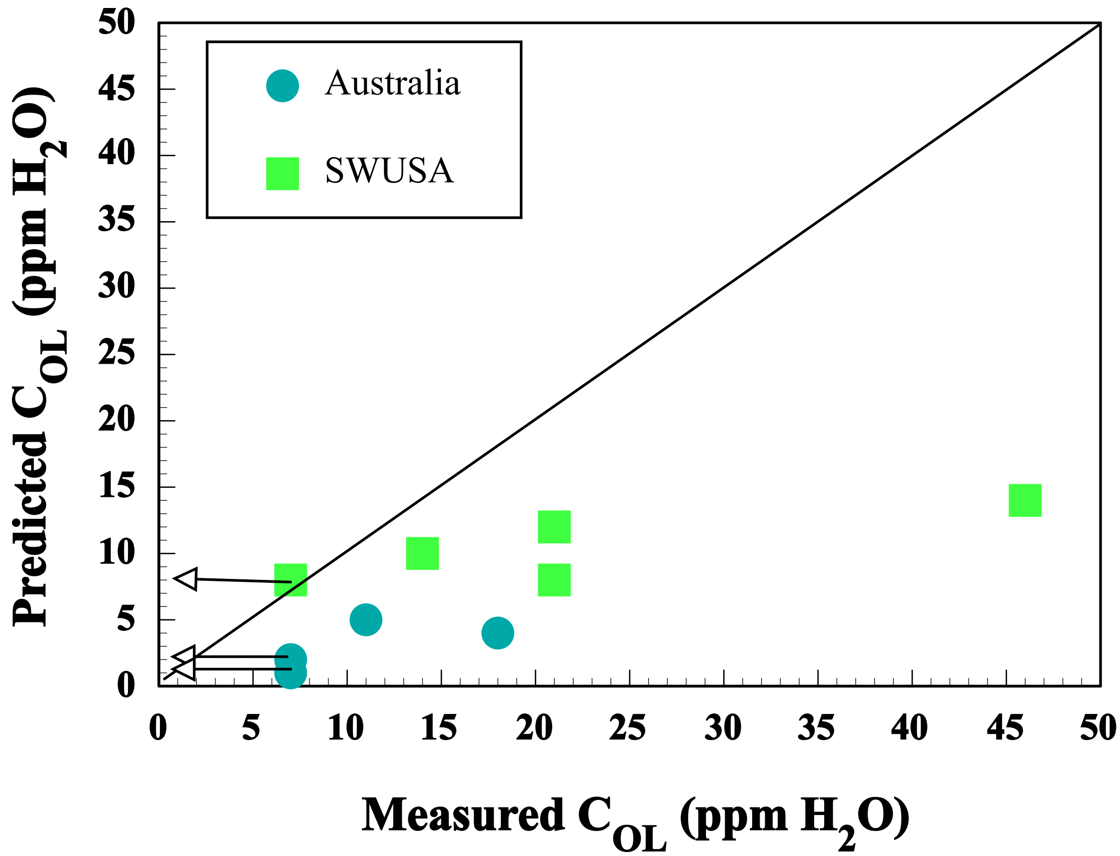


Figure 4.9: A comparison of the predicted and the measured olivine H_2O contents. Three samples have H_2O contents that are below the detection limit are denoted by arrows. The predicted and measured olivine H_2O contents agree within uncertainty.

Values of aH_2O estimated for samples from the SW U.S.A range from 0.04 to 0.07, which, when combined with the experimental study of Mosenfelder *et al.* (2006), yield predicted olivine H_2O contents of 8 to 14 ppm (Table 4.1). Given T and P uncertainties of ± 50 ˚C and ±0.2 GPa, respectively, the uncertainty in aH_2O for these samples is approximately ± 0.08 to ± 0.10. This uncertainty in aH_2O translates to uncertainties in predicted olivine H_2O contents of ± 14 to ± 20 ppm. Measured olivine H_2O contents in all the SW U.S.A samples agree, within uncertainty, with predicted values (Figure 4.9). However, given the uncertainties in the measured and the predicted values of olivine H_2O contents, some H_2O loss during xenolith emplacement can't be ruled out. Our results suggest that this H_2O-loss, if it occurred, was limited to approximately 15 ppm (Figure 4.9).

Conclusions

The H_2O contents of nominally anhydrous phases examined in this study are relatively low. For example, the olivines in our xenoliths contain less than 25 wt. ppm H_2O (with olivines from one sample containing 46 wt. ppm H_2O). Whereas mantle olivines record a range of H_2O contents that are quite variable, with a number of values in excess of 100 wt. ppm (Figure 4.1a). In some cases, mantle olivines may have suffered the diffusive loss of hydrogen during xenolith transport to the surface of the earth (Bell & Rossman, 1992, Ingrin & Skogby, 2000, Beran & Libowitzky, 2006b, Skogby, 2006, Peslier, 2010). Our comparison between olivine H_2O contents estimated from values of aH_2O and the H_2O contents of olivine measured in the same samples indicates that, while some H_2O loss from olivines may have occurred, the amounts involved are limited. Thus, our results indicate that some of these low values of NAM H_2O content may approximately reflect mantle conditions and therefore the uppermost mantle is, to some extent, heterogeneous with respect to its H_2O content.

CHAPTER V

CONCLUSIONS

In summary, all the samples from Eastern Australia, SW U.S.A and South Africa record low values of aH_2O that are less than 0.20. For samples in which two values of aH_2O could be estimated using the two different approaches, these values agree within uncertainty. This suggests that the amphiboles, at least in those samples, have not undergone significant, if any, retrograde H-loss during transport to the Earth's surface and that careful application of amphibole equilibria can reliably estimate values of aH_2O in samples from the earth's mantle. Calculations based on C-O-H equilibria yield H_2O rich conditions, which are significantly different than values of aH_2O from amphibole equilibria suggesting that the fluid pressure is lower than the lithostatic pressure and that these samples equilibrated in a fluid-absent system.

The H_2O contents of nominally anhydrous phases examined in these samples are relatively low. For example, the olivines in our xenoliths contain less than 25 wt. ppm H_2O (with olivines from one sample containing 46 wt. ppm H_2O). Whereas mantle olivines record a range of H_2O contents that are quite variable, with a number of values in excess of 100 wt. ppm (Figure 4.1a). In some cases, mantle olivines may have suffered the diffusive loss of hydrogen during xenolith transport to the surface of the earth (Bell & Rossman, 1992, Ingrin & Skogby, 2000, Beran & Libowitzky, 2006b, Skogby, 2006, Peslier, 2010). Our comparison between olivine H_2O contents estimated from values of aH_2O and the H_2O contents of olivine measured in the same samples indicates that, while some H_2O loss from olivines may have occurred, the amounts involved are limited. Thus, our results indicate that some of these low values of NAM H_2O content may approximately reflect mantle conditions and therefore the uppermost mantle is, to some extent, heterogeneous with respect to its H_2O content.

The low values of aH_2O estimated from amphibole equilibria, show that the presence of amphibole does not require H_2O-rich conditions. In some cases amphibole may be a product of mantle metasomatism. In such cases the addition of various chemical components (e.g., Fe, Ti or alkali elements) may be required to stabilize amphiboles. H_2O might also be added via the metasomatising fluid; however, some or all of this H_2O must have been consumed by minerals in the rock (e.g. amphibole) and could result in equilibration at low values of aH_2O. Amphibole growth may also scavenge any H_2O already present in the rock (e.g., in NAMs) and, therefore, help produce values of aH_2O that are significantly less than 1. In this scenario, amphibole growth could lower the H_2O-contents of NAMs, and this process may have important implications for the rheology of an olivine-rich uppermost mantle. If the formation of amphibole results in H_2O-loss from NAMs then the strength of these NAMs will likely increase (Mei & Kohlstedt, 2000b). Thus, as long as the rheology of the mantle is controlled by olivine and/or other NAMs, the formation of amphibole may actually serve to strengthen mantle rocks.

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APPENDIX A

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
GN9912 grain-E1	40.49	10.97	0.19	47.91	0.36	99.92	1.00	0.23	0.00	1.76	0.01
GN9912 grain-E2	40.62	11.16	0.18	47.86	0.41	100.23	1.00	0.23	0.00	1.76	0.01
GN9912 grain-E3	40.59	10.80	0.16	47.33	0.40	99.27	1.01	0.22	0.00	1.75	0.01
GN9912 grain-E4	40.35	10.98	0.21	47.65	0.37	99.55	1.00	0.23	0.00	1.76	0.01
GN9912 grain-E5	40.33	10.94	0.22	48.02	0.35	99.90	1.00	0.23	0.00	1.77	0.01
GN9912 grain-E AVG	40.47	10.97	0.19	47.75	0.38	99.77	1.00	0.23	0.00	1.76	0.01
GN9912 grain-G1	40.90	10.82	0.15	48.00	0.31	100.17	1.01	0.22	0.00	1.76	0.01
GN9912 grain-G2	40.52	10.87	0.23	47.95	0.41	99.97	1.00	0.22	0.00	1.76	0.01
GN9912 grain-G3	40.46	11.02	0.17	47.89	0.40	99.94	1.00	0.23	0.00	1.76	0.01
GN9912 grain-G4	40.73	11.11	0.17	48.40	0.40	100.81	1.00	0.23	0.00	1.76	0.01
GN9912 grain-G5	40.64	11.19	0.17	48.10	0.38	100.47	1.00	0.23	0.00	1.76	0.01
GN9912 grain-G6	40.49	10.64	0.19	48.26	0.38	99.95	1.00	0.22	0.00	1.77	0.01
GN9912 grain-G7	40.62	10.98	0.15	48.01	0.39	100.15	1.00	0.23	0.00	1.76	0.01
GN9912 grain-G8	40.50	11.02	0.17	47.92	0.36	99.96	1.00	0.23	0.00	1.76	0.01
GN9912 grain-G9	40.52	10.96	0.17	48.16	0.36	100.17	1.00	0.23	0.00	1.77	0.01
GN9912 grain-G10	40.55	11.07	0.17	48.17	0.34	100.30	1.00	0.23	0.00	1.77	0.01
GN9912 grain-G AVG	40.59	10.97	0.17	48.08	0.37	100.19	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H1	40.58	11.10	0.18	48.19	0.33	100.37	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H2	40.71	11.38	0.17	48.20	0.42	100.88	1.00	0.23	0.00	1.76	0.01

bdl, concentration below detection lim

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
GN9912 grain-H3	40.61	11.18	0.15	48.16	0.35	100.44	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H4	40.25	11.15	0.17	47.67	0.35	99.59	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H5	40.52	11.23	0.19	48.04	0.38	100.35	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H6	40.70	11.36	0.17	48.31	0.36	100.89	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H7	40.64	11.10	0.18	48.33	0.34	100.59	1.00	0.23	0.00	1.77	0.01
GN9912 grain-H8	40.53	11.17	0.18	47.94	0.40	100.23	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H9	40.66	10.97	0.19	47.93	0.43	100.17	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H10	40.79	11.07	0.18	48.00	0.37	100.41	1.00	0.23	0.00	1.76	0.01
GN9912 grain-H AVG	40.60	11.17	0.17	48.08	0.37	100.39	1.00	0.23	0.00	1.76	0.01
GN9912 ALL AVG	40.56	11.04	0.18	47.97	0.37	100.12	1.00	0.23	0.00	1.76	0.01
GN9913 grain-C1	40.59	9.63	0.14	49.30	0.37	100.06	0.99	0.20	0.00	1.80	0.01
GN9913 grain-C2	40.69	9.42	0.14	49.04	0.41	99.69	1.00	0.19	0.00	1.80	0.01
GN9913 grain-C3	40.48	9.65	0.13	49.36	0.37	99.99	0.99	0.20	0.00	1.80	0.01
GN9913 grain-C4	40.62	9.47	0.11	48.92	0.33	99.44	1.00	0.19	0.00	1.80	0.01
GN9913 grain-C5	40.87	8.27	0.16	49.80	0.33	99.56	1.00	0.17	0.00	1.82	0.01
GN9913 grain-C AVG	40.65	9.29	0.14	49.28	0.36	99.72	1.00	0.19	0.00	1.80	0.01
GN9913 grain-H1	40.53	9.47	0.11	48.85	0.40	99.38	1.00	0.20	0.00	1.79	0.01
GN9913 grain-H2	40.72	9.55	0.13	49.00	0.38	99.81	1.00	0.20	0.00	1.79	0.01
GN9913 grain-H3	40.43	9.58	0.13	49.08	0.35	99.58	0.99	0.20	0.00	1.80	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
GN9913 grain-H4	40.52	9.44	0.14	48.53	0.38	99.03	1.00	0.20	0.00	1.79	0.01
GN9913 grain-H5	40.58	9.35	0.12	48.95	0.32	99.33	1.00	0.19	0.00	1.80	0.01
GN9913 grain-H AVG	40.56	9.48	0.12	48.88	0.37	99.41	1.00	0.20	0.00	1.80	0.01
GN9913 grain-J1	40.68	9.47	0.14	48.99	0.40	99.68	1.00	0.19	0.00	1.79	0.01
GN9913 grain-J2	40.88	9.48	0.15	48.82	0.39	99.72	1.00	0.19	0.00	1.79	0.01
GN9913 grain-J3	40.59	9.41	0.13	48.83	0.36	99.33	1.00	0.19	0.00	1.80	0.01
GN9913 grain-J4	40.73	9.55	0.16	48.99	0.41	99.83	1.00	0.20	0.00	1.79	0.01
GN9913 grain-J5	40.83	9.63	0.10	49.18	0.41	100.15	1.00	0.20	0.00	1.79	0.01
GN9913 grain-J AVG	40.74	9.51	0.14	48.96	0.39	99.74	1.00	0.20	0.00	1.79	0.01
GN9913 grain-M1	40.78	9.27	0.18	49.48	0.42	100.12	1.00	0.19	0.00	1.80	0.01
GN9913 grain-M2	40.88	9.40	0.14	49.13	0.30	99.85	1.00	0.19	0.00	1.80	0.01
GN9913 grain-M3	40.64	9.38	0.13	49.00	0.37	99.52	1.00	0.19	0.00	1.80	0.01
GN9913 grain-M4	40.80	9.33	0.14	49.08	0.33	99.68	1.00	0.19	0.00	1.80	0.01
GN9913 grain-M5	40.94	9.37	0.16	49.55	0.41	100.47	1.00	0.19	0.00	1.80	0.01
GN9913 grain-M6	40.61	9.47	0.13	49.25	0.44	99.93	0.99	0.19	0.00	1.80	0.01
GN9913 grain-M7	40.91	9.46	0.11	49.33	0.35	100.16	1.00	0.19	0.00	1.80	0.01
GN9913 grain-M8	40.63	9.40	0.15	49.45	0.44	100.07	0.99	0.19	0.00	1.80	0.01
GN9913 grain-M9	40.55	9.49	0.13	49.27	0.43	99.90	0.99	0.19	0.00	1.80	0.01
GN9913 grain-M10	40.45	9.32	0.11	49.33	0.37	99.60	0.99	0.19	0.00	1.81	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
GN9913 grain-M AVG	40.72	9.39	0.14	49.29	0.38	99.92	1.00	0.19	0.00	1.80	0.01
GN9913 ALL AVG	40.67	9.41	0.13	49.10	0.38	99.69	1.00	0.19	0.00	1.80	0.01
BM9912 grain-D1	41.22	8.85	0.13	49.77	0.45	100.46	1.00	0.18	0.00	1.80	0.01
BM9912 grain-D2	41.00	8.92	0.11	49.69	0.40	100.15	1.00	0.18	0.00	1.81	0.01
BM9912 grain-D3	41.01	8.75	0.15	49.62	0.39	99.96	1.00	0.18	0.00	1.81	0.01
BM9912 grain-D4	41.02	8.86	0.12	49.66	0.39	100.09	1.00	0.18	0.00	1.81	0.01
BM9912 grain-D5	41.35	8.90	0.13	49.96	0.36	100.75	1.00	0.18	0.00	1.81	0.01
BM9912 grain-D6	41.15	8.68	0.09	49.89	0.38	100.23	1.00	0.18	0.00	1.81	0.01
BM9912 grain-D AVG	41.12	8.83	0.12	49.76	0.39	100.23	1.00	0.18	0.00	1.81	0.01
BM9912 grain-F1	41.16	8.72	0.10	49.79	0.35	100.18	1.00	0.18	0.00	1.81	0.01
BM9912 grain-F2	41.03	8.96	0.12	49.60	0.38	100.15	1.00	0.18	0.00	1.80	0.01
BM9912 grain-F3	41.14	8.79	0.13	49.74	0.39	100.24	1.00	0.18	0.00	1.81	0.01
BM9912 grain-F4	40.90	8.91	0.13	49.96	0.37	100.31	1.00	0.18	0.00	1.81	0.01
BM9912 grain-F5	41.14	9.05	0.15	50.13	0.42	100.96	1.00	0.18	0.00	1.81	0.01
BM9912 grain-F AVG	41.07	8.88	0.13	49.84	0.38	100.31	1.00	0.18	0.00	1.81	0.01
BM9912 grain-H1	41.29	9.03	0.10	49.65	0.44	100.55	1.00	0.18	0.00	1.80	0.01
BM9912 grain-H2	40.82	8.59	0.14	49.07	0.37	99.04	1.01	0.18	0.00	1.80	0.01
BM9912 grain-H3	41.13	8.79	0.11	49.75	0.45	100.27	1.00	0.18	0.00	1.81	0.01
BM9912 grain-H4	40.78	8.98	0.15	49.61	0.37	99.92	1.00	0.18	0.00	1.81	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
BM9912 grain-H5	41.16	8.71	0.13	49.71	0.40	100.15	1.00	0.18	0.00	1.81	0.01
BM9912 grain-H6	40.64	8.69	0.15	49.40	0.37	99.33	1.00	0.18	0.00	1.81	0.01
BM9912 grain-H AVG	40.97	8.80	0.13	49.53	0.40	99.83	1.00	0.18	0.00	1.81	0.01
BM9912 grain-I1	41.16	8.71	0.10	49.70	0.38	100.12	1.00	0.18	0.00	1.81	0.01
BM9912 grain-I2	41.23	8.82	0.13	49.65	0.42	100.29	1.00	0.18	0.00	1.80	0.01
BM9912 grain-I3	41.24	8.78	0.13	49.88	0.38	100.46	1.00	0.18	0.00	1.81	0.01
BM9912 grain-I4	41.25	8.98	0.11	49.84	0.35	100.57	1.00	0.18	0.00	1.81	0.01
BM9912 grain-I5	41.19	8.79	0.11	49.87	0.40	100.39	1.00	0.18	0.00	1.81	0.01
BM9912 grain-I6	41.28	8.97	0.13	49.86	0.43	100.72	1.00	0.18	0.00	1.80	0.01
BM9912 grain-I AVG	41.22	8.84	0.12	49.80	0.39	100.37	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J1	41.14	8.91	0.12	50.03	0.37	100.63	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J2	40.95	8.65	0.12	49.65	0.38	99.79	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J3	41.13	8.61	0.16	49.72	0.42	100.03	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J4	41.10	8.93	0.10	49.74	0.44	100.37	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J5	40.85	8.73	0.12	49.60	0.47	99.77	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J6	41.05	8.72	0.15	49.63	0.43	100.03	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J7	40.90	8.85	0.13	49.86	0.37	100.11	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J8	41.01	8.87	0.13	49.45	0.40	99.89	1.00	0.18	0.00	1.80	0.01
BM9912 grain-J9	41.04	8.95	0.13	49.61	0.43	100.20	1.00	0.18	0.00	1.80	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
BM9912 grain-J10	40.95	8.74	0.15	49.61	0.41	99.91	1.00	0.18	0.00	1.81	0.01
BM9912 grain-J AVG	41.01	8.80	0.13	49.69	0.41	100.04	1.00	0.18	0.00	1.81	0.01
BM9912 ALL AVG	41.08	8.83	0.13	49.73	0.40	100.16	1.00	0.18	0.00	1.81	0.01
BM9915 grain-A1	41.02	8.40	0.12	50.53	0.41	100.47	0.99	0.17	0.00	1.82	0.01
BM9915 grain-A2	40.97	8.50	0.13	50.54	0.40	100.54	0.99	0.17	0.00	1.82	0.01
BM9915 grain-A3	40.76	8.41	0.12	50.66	0.41	100.36	0.99	0.17	0.00	1.83	0.01
BM9915 grain-A4	41.16	8.44	0.11	50.64	0.41	100.75	0.99	0.17	0.00	1.82	0.01
BM9915 grain-A5	41.01	8.64	0.12	50.69	0.46	100.92	0.99	0.17	0.00	1.82	0.01
BM9915 grain-A AVG	40.98	8.48	0.12	50.61	0.42	100.61	0.99	0.17	0.00	1.83	0.01
BM9915 grain-B1	40.98	8.67	0.11	50.63	0.36	100.75	0.99	0.18	0.00	1.82	0.01
BM9915 grain-B2	40.92	8.39	0.12	50.72	0.38	100.52	0.99	0.17	0.00	1.83	0.01
BM9915 grain-B3	40.95	8.33	0.11	50.82	0.42	100.62	0.99	0.17	0.00	1.83	0.01
BM9915 grain-B4	41.02	8.52	0.14	50.66	0.39	100.73	0.99	0.17	0.00	1.83	0.01
BM9915 grain-B5	41.02	8.58	0.12	50.79	0.41	100.93	0.99	0.17	0.00	1.83	0.01
BM9915 grain-B AVG	40.98	8.50	0.12	50.72	0.39	100.71	0.99	0.17	0.00	1.83	0.01
BM9915 grain-D1	40.84	8.52	0.11	50.45	0.40	100.31	0.99	0.17	0.00	1.82	0.01
BM9915 grain-D2	40.84	8.42	0.13	50.44	0.40	100.22	0.99	0.17	0.00	1.83	0.01
BM9915 grain-D3	41.00	8.53	0.11	50.64	0.35	100.63	0.99	0.17	0.00	1.83	0.01
BM9915 grain-D4	41.02	8.51	0.12	50.77	0.40	100.82	0.99	0.17	0.00	1.83	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
BM9915 grain-D4	40.90	8.50	0.13	50.74	0.41	100.68	0.99	0.17	0.00	1.83	0.01
BM9915 grain-D AVG	40.92	8.50	0.12	50.61	0.39	100.53	0.99	0.17	0.00	1.83	0.01
BM9915 grain-E1	40.96	8.80	0.10	50.58	0.40	100.85	0.99	0.18	0.00	1.82	0.01
BM9915 grain-E2	41.15	8.75	0.12	50.74	0.41	101.17	0.99	0.18	0.00	1.82	0.01
BM9915 grain-E3	40.96	8.68	0.14	50.76	0.39	100.93	0.99	0.18	0.00	1.83	0.01
BM9915 grain-E4	40.94	8.58	0.13	50.70	0.43	100.78	0.99	0.17	0.00	1.83	0.01
BM9915 grain-E AVG	41.00	8.70	0.12	50.70	0.41	100.93	0.99	0.18	0.00	1.82	0.01
BM9915 ALL AVG	40.97	8.54	0.12	50.66	0.40	100.70	0.99	0.17	0.00	1.83	0.01
X174 grain-A1	38.52	20.88	0.21	40.28	0.00	99.88	0.99	0.45	0.00	1.55	0.00
X174 grain-A2	38.37	21.66	0.14	40.06	0.10	100.33	0.99	0.47	0.00	1.54	0.00
X174 grain-A3	38.42	21.57	0.13	40.05	0.10	100.27	0.99	0.47	0.00	1.54	0.00
X174 grain-A4	38.43	21.70	0.15	40.14	0.15	100.57	0.99	0.47	0.00	1.54	0.00
X174 grain-A5	38.31	21.55	0.21	40.00	0.00	100.06	0.99	0.47	0.00	1.54	0.00
X174 grain-A AVG	38.41	21.47	0.17	40.10	0.07	100.22	0.99	0.46	0.00	1.54	0.00
X174 grain-B1	38.33	21.46	0.13	40.09	0.12	100.13	0.99	0.46	0.00	1.54	0.00
X174 grain-B2	38.16	21.52	0.13	39.85	0.10	99.76	0.99	0.47	0.00	1.54	0.00
X174 grain-B3	38.34	21.62	0.12	40.18	0.10	100.36	0.99	0.47	0.00	1.54	0.00
X174 grain-B4	38.48	21.59	0.12	40.09	0.10	100.37	0.99	0.47	0.00	1.54	0.00
X174 grain-B5	38.14	21.44	0.14	40.06	0.09	99.87	0.99	0.46	0.00	1.55	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
X174 grain-B AVG	38.29	21.53	0.13	40.05	0.10	100.10	0.99	0.46	0.00	1.54	0.00
X174 grain-C1	38.04	21.43	0.16	40.11	0.10	99.83	0.98	0.46	0.00	1.55	0.00
X174 grain-C2	38.48	21.66	0.14	40.15	0.08	100.50	0.99	0.47	0.00	1.54	0.00
X174 grain-C3	38.33	21.44	0.15	40.15	0.12	100.18	0.99	0.46	0.00	1.54	0.00
X174 grain-C4	38.44	21.39	0.13	40.18	0.11	100.25	0.99	0.46	0.00	1.54	0.00
X174 grain-C5	38.55	21.31	0.15	40.04	0.11	100.15	0.99	0.46	0.00	1.54	0.00
X174 grain-C AVG	38.37	21.44	0.14	40.13	0.10	100.18	0.99	0.46	0.00	1.54	0.00
X174 grain-D1	38.49	21.24	0.15	40.48	0.13	100.47	0.99	0.46	0.00	1.55	0.00
X174 grain-D2	38.35	21.44	0.14	40.31	0.14	100.37	0.99	0.46	0.00	1.55	0.00
X174 grain-D3	38.57	21.44	0.16	40.47	0.11	100.74	0.99	0.46	0.00	1.55	0.00
X174 grain-D4	38.44	21.53	0.15	40.34	0.11	100.58	0.99	0.46	0.00	1.54	0.00
X174 grain-D5	38.67	21.07	0.14	40.34	0.11	100.33	0.99	0.45	0.00	1.55	0.00
X174 grain-D AVG	38.50	21.34	0.15	40.39	0.12	100.50	0.99	0.46	0.00	1.55	0.00
X174 ALL AVG	38.39	21.45	0.15	40.17	0.10	100.25	0.99	0.46	0.00	1.54	0.00
X192 grain-A1	39.55	15.67	0.20	44.70	0.19	100.31	0.99	0.33	0.00	1.67	0.00
X192 grain-A2	39.62	15.79	0.20	44.68	0.18	100.47	0.99	0.33	0.00	1.67	0.00
X192 grain-A3	39.58	15.86	0.17	44.54	0.16	100.32	0.99	0.33	0.00	1.67	0.00
X192 grain-A4	39.62	15.91	0.22	44.81	0.16	100.72	0.99	0.33	0.00	1.67	0.00
X192 grain-A5	39.68	16.02	0.20	44.45	0.17	100.52	1.00	0.34	0.00	1.66	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
X192 grain-A AVG	39.61	15.85	0.20	44.63	0.17	100.47	0.99	0.33	0.00	1.67	0.00
X192 grain-B1	40.21	15.68	0.21	44.22	0.19	100.51	1.01	0.33	0.00	1.65	0.00
X192 grain-B2	39.50	15.57	0.22	44.74	0.19	100.21	0.99	0.33	0.00	1.67	0.00
X192 grain-B3	39.41	15.47	0.19	44.99	0.14	100.19	0.99	0.32	0.00	1.68	0.00
X192 grain-B4	39.35	15.67	0.21	44.83	0.20	100.26	0.99	0.33	0.00	1.68	0.00
X192 grain-B5	39.19	15.23	0.20	44.87	0.18	99.67	0.99	0.32	0.00	1.68	0.00
X192 grain-B AVG	39.53	15.53	0.20	44.73	0.18	100.17	0.99	0.33	0.00	1.67	0.00
X192 grain-C1	38.51	16.44	0.19	43.53	0.13	98.81	0.98	0.35	0.00	1.66	0.00
X192 grain-C2	39.09	16.87	0.21	43.53	0.13	99.83	0.99	0.36	0.00	1.64	0.00
X192 grain-C3	39.15	16.86	0.19	43.61	0.15	99.96	0.99	0.36	0.00	1.65	0.00
X192 grain-C4	39.33	16.92	0.20	43.61	0.16	100.21	0.99	0.36	0.00	1.64	0.00
X192 grain-C5	39.56	16.68	0.21	43.62	0.16	100.22	1.00	0.35	0.00	1.64	0.00
X192 grain-C AVG	39.13	16.75	0.20	43.58	0.15	99.80	0.99	0.36	0.00	1.65	0.00
X192 grain-D1	39.58	15.43	0.18	44.95	0.16	100.29	0.99	0.32	0.00	1.68	0.00
X192 grain-D2	39.64	15.72	0.21	45.18	0.15	100.90	0.99	0.33	0.00	1.68	0.00
X192 grain-D3	39.61	15.55	0.19	45.21	0.13	100.70	0.99	0.32	0.00	1.68	0.00
X192 grain-D4	39.41	15.57	0.18	45.04	0.15	100.34	0.99	0.33	0.00	1.68	0.00
X192 grain-D5	39.35	15.39	0.19	44.91	0.13	99.97	0.99	0.32	0.00	1.68	0.00
X192 grain-D AVG	39.52	15.53	0.19	45.06	0.14	100.44	0.99	0.32	0.00	1.68	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
X192 ALL AVG	39.45	15.92	0.20	44.50	0.16	100.22	0.99	0.33	0.00	1.67	0.00
X229 grain-C1	39.89	15.47	0.21	44.63	0.12	100.32	1.00	0.32	0.00	1.67	0.00
X229 grain-C2	39.84	16.03	0.20	44.71	0.11	100.89	0.99	0.33	0.00	1.66	0.00
X229 grain-C3	40.01	16.01	0.21	44.66	0.15	101.03	1.00	0.33	0.00	1.66	0.00
X229 grain-C4	40.32	12.53	0.16	47.09	0.10	100.20	1.00	0.26	0.00	1.73	0.00
X229 grain-C AVG	40.01	15.01	0.19	45.27	0.12	100.61	1.00	0.31	0.00	1.68	0.00
X229 grain-E1	40.15	15.16	0.20	45.10	0.12	100.74	1.00	0.32	0.00	1.68	0.00
X229 grain-E2	39.91	15.88	0.20	44.51	0.12	100.62	1.00	0.33	0.00	1.66	0.00
X229 grain-E3	39.90	15.95	0.21	44.75	0.13	100.95	1.00	0.33	0.00	1.66	0.00
X229 grain-E4	39.93	15.90	0.23	44.67	0.15	100.88	1.00	0.33	0.00	1.66	0.00
X229 grain-E5	39.88	15.64	0.18	45.06	0.11	100.86	0.99	0.33	0.00	1.67	0.00
X229 grain-E AVG	39.95	15.71	0.20	44.82	0.13	100.81	1.00	0.33	0.00	1.67	0.00
X229 grain-G1	39.88	16.23	0.21	44.13	0.15	100.61	1.00	0.34	0.00	1.65	0.00
X229 grain-G2	40.05	16.08	0.20	44.34	0.15	100.81	1.00	0.34	0.00	1.65	0.00
X229 grain-G3	39.91	16.13	0.21	44.29	0.13	100.66	1.00	0.34	0.00	1.65	0.00
X229 grain-G AVG	39.94	16.15	0.21	44.25	0.14	100.69	1.00	0.34	0.00	1.65	0.00
X229 ALL AVG	39.97	15.62	0.20	44.78	0.13	100.70	1.00	0.33	0.00	1.67	0.00
X286 grain-B1	39.40	16.56	0.20	43.00	0.21	99.37	1.00	0.35	0.00	1.63	0.00
X286 grain-B2	39.35	17.05	0.16	43.21	0.20	99.97	1.00	0.36	0.00	1.63	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
X286 grain-B3	39.52	16.97	0.20	43.29	0.15	100.13	1.00	0.36	0.00	1.63	0.00
X286 grain-B4	39.42	16.92	0.20	43.37	0.11	100.03	1.00	0.36	0.00	1.64	0.00
X286 grain-B5	39.46	16.83	0.19	43.29	0.21	99.98	1.00	0.36	0.00	1.63	0.00
X286 grain-B AVG	39.43	16.86	0.19	43.23	0.18	99.89	1.00	0.36	0.00	1.63	0.00
X286 grain-E1	39.41	17.03	0.21	43.04	0.17	99.87	1.00	0.36	0.00	1.63	0.00
X286 grain-E2	39.33	17.00	0.20	43.17	0.18	99.88	1.00	0.36	0.00	1.63	0.00
X286 grain-E3	39.42	16.87	0.19	43.31	0.11	99.90	1.00	0.36	0.00	1.64	0.00
X286 grain-E4	39.41	16.96	0.22	43.28	0.19	100.06	1.00	0.36	0.00	1.63	0.00
X286 grain-E5	39.34	16.89	0.20	43.17	0.15	99.76	1.00	0.36	0.00	1.63	0.00
X286 grain-E6	39.49	17.06	0.21	43.20	0.18	100.13	1.00	0.36	0.00	1.63	0.00
X286 grain-E AVG	39.40	16.97	0.21	43.19	0.16	99.93	1.00	0.36	0.00	1.63	0.00
X286 grain-F1	39.44	17.21	0.20	43.20	0.15	100.21	1.00	0.36	0.00	1.63	0.00
X286 grain-F2	39.51	16.96	0.20	43.00	0.14	99.81	1.00	0.36	0.00	1.63	0.00
X286 grain-F3	39.55	16.80	0.18	43.21	0.15	99.89	1.00	0.36	0.00	1.63	0.00
X286 grain-F AVG	39.50	16.99	0.20	43.13	0.15	99.97	1.00	0.36	0.00	1.63	0.00
X286 ALL AVG	39.44	16.94	0.20	43.19	0.16	99.93	1.00	0.36	0.00	1.63	0.00
X297 grain-A1	39.55	16.05	0.19	44.16	0.18	100.12	1.00	0.34	0.00	1.66	0.00
X297 grain-A2	39.50	16.15	0.21	44.09	0.15	100.10	1.00	0.34	0.00	1.66	0.00
X297 grain-A3	39.56	16.21	0.22	43.81	0.14	99.93	1.00	0.34	0.00	1.65	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
X297 grain-A AVG	39.53	16.14	0.21	44.02	0.16	100.05	1.00	0.34	0.00	1.65	0.00
X297 grain-E1	39.36	16.38	0.21	43.74	0.19	99.89	1.00	0.35	0.00	1.65	0.00
X297 grain-E2	39.50	16.58	0.22	43.76	0.14	100.20	1.00	0.35	0.00	1.65	0.00
X297 grain-E3	39.52	16.39	0.19	43.65	0.13	99.89	1.00	0.35	0.00	1.65	0.00
X297 grain-E4	39.48	16.68	0.19	43.55	0.15	100.04	1.00	0.35	0.00	1.64	0.00
X297 grain-E5	39.34	16.45	0.20	43.50	0.13	99.62	1.00	0.35	0.00	1.64	0.00
X297 grain-E6	39.23	16.39	0.23	43.71	0.17	99.73	0.99	0.35	0.00	1.65	0.00
X297 grain-E7	39.06	16.31	0.18	43.60	0.16	99.30	0.99	0.35	0.00	1.65	0.00
X297 grain-E8	40.04	13.80	0.13	46.07	0.14	100.18	1.00	0.29	0.00	1.71	0.00
X297 grain-E AVG	39.44	16.12	0.19	43.95	0.15	99.85	1.00	0.34	0.00	1.65	0.00
X297 grain-G1	39.63	15.80	0.19	44.00	0.17	99.79	1.00	0.33	0.00	1.66	0.00
X297 grain-G2	39.49	16.13	0.22	44.05	0.15	100.05	1.00	0.34	0.00	1.65	0.00
X297 grain-G3	39.66	16.03	0.17	44.22	0.14	100.22	1.00	0.34	0.00	1.66	0.00
X297 grain-G4	39.39	16.03	0.20	44.22	0.14	99.97	0.99	0.34	0.00	1.66	0.00
X297 grain-G5	39.40	16.04	0.22	44.19	0.11	99.96	0.99	0.34	0.00	1.66	0.00
X297 grain-G AVG	39.51	16.00	0.20	44.14	0.14	100.00	1.00	0.34	0.00	1.66	0.00
X297 ALL AVG	39.48	16.06	0.20	44.04	0.15	99.92	1.00	0.34	0.00	1.66	0.00
X299 grain-A1	39.68	15.90	0.23	44.51	0.16	100.48	0.99	0.33	0.00	1.66	0.00
X299 grain-A2	39.68	15.77	0.21	44.22	0.13	100.07	1.00	0.33	0.00	1.66	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
X299 grain-A3	39.60	15.70	0.20	44.19	0.13	99.88	1.00	0.33	0.00	1.66	0.00
X299 grain-A4	39.73	15.50	0.20	44.60	0.18	100.32	1.00	0.33	0.00	1.67	0.00
X299 grain-A5	39.56	15.81	0.21	44.30	0.15	100.11	1.00	0.33	0.00	1.66	0.00
X299 grain-A AVG	39.65	15.74	0.21	44.36	0.15	100.11	1.00	0.33	0.00	1.66	0.00
X299 grain-B1	39.74	15.64	0.20	44.35	0.13	100.11	1.00	0.33	0.00	1.66	0.00
X299 grain-B2	39.61	15.53	0.20	44.27	0.15	99.84	1.00	0.33	0.00	1.66	0.00
X299 grain-B3	39.63	15.59	0.17	44.29	0.14	99.87	1.00	0.33	0.00	1.66	0.00
X299 grain-B4	39.62	15.62	0.22	44.38	0.17	100.04	1.00	0.33	0.00	1.66	0.00
X299 grain-B5	39.70	15.35	0.20	44.30	0.12	99.72	1.00	0.32	0.00	1.67	0.00
X299 grain-B AVG	39.66	15.55	0.20	44.32	0.14	99.86	1.00	0.33	0.00	1.66	0.00
X299 grain-C1	40.13	13.36	0.17	46.25	0.14	100.19	1.00	0.28	0.00	1.71	0.00
X299 grain-C2	39.72	15.37	0.21	44.64	0.16	100.16	1.00	0.32	0.00	1.67	0.00
X299 grain-C3	39.54	15.43	0.20	44.30	0.11	99.63	1.00	0.33	0.00	1.67	0.00
X299 grain-C4	39.74	15.29	0.17	44.74	0.11	100.15	1.00	0.32	0.00	1.67	0.00
X299 grain-C AVG	39.78	14.86	0.19	44.99	0.13	99.95	1.00	0.31	0.00	1.68	0.00
X299 grain-D1	39.75	15.45	0.21	44.47	0.17	100.15	1.00	0.32	0.00	1.67	0.00
X299 grain-D2	39.82	15.50	0.20	44.33	0.14	100.10	1.00	0.33	0.00	1.66	0.00
X299 grain-D3	39.67	15.21	0.18	44.46	0.11	99.70	1.00	0.32	0.00	1.67	0.00
X299 grain-D AVG	39.75	15.39	0.20	44.42	0.14	99.90	1.00	0.32	0.00	1.67	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
X299 ALL AVG	39.71	15.38	0.20	44.52	0.14	99.95	1.00	0.32	0.00	1.67	0.00
X319 grain-A1	39.68	12.70	0.13	46.49	0.14	99.15	0.99	0.27	0.00	1.74	0.00
X319 grain-A2	39.50	15.21	0.17	44.74	0.15	99.78	0.99	0.32	0.00	1.68	0.00
X319 grain-A3	39.37	15.38	0.19	44.86	0.18	99.97	0.99	0.32	0.00	1.68	0.00
X319 grain-A4	39.39	15.37	0.19	44.98	0.15	100.08	0.99	0.32	0.00	1.68	0.00
X319 grain-A5	39.30	15.44	0.21	44.86	0.15	99.96	0.99	0.32	0.00	1.68	0.00
X319 grain-A6	39.20	15.39	0.18	44.91	0.17	99.84	0.99	0.32	0.00	1.68	0.00
X319 grain-A7	39.15	15.41	0.20	45.11	0.17	100.04	0.98	0.32	0.00	1.69	0.00
X319 grain-A8	39.41	15.31	0.18	44.81	0.20	99.90	0.99	0.32	0.00	1.68	0.00
X319 grain-A9	39.39	15.41	0.19	44.89	0.20	100.08	0.99	0.32	0.00	1.68	0.00
X319 grain-A10	39.55	15.52	0.21	44.98	0.18	100.43	0.99	0.32	0.00	1.68	0.00
X319 grain-A AVG	39.39	15.11	0.18	45.06	0.17	99.92	0.99	0.32	0.00	1.69	0.00
X319 grain-B1	39.11	14.84	0.19	44.93	0.10	99.16	0.99	0.31	0.00	1.69	0.00
X319 grain-B2	39.30	15.21	0.19	44.76	0.18	99.63	0.99	0.32	0.00	1.68	0.00
X319 grain-B3	39.44	15.28	0.17	44.78	0.16	99.82	0.99	0.32	0.00	1.68	0.00
X319 grain-B4	39.14	15.10	0.21	44.91	0.17	99.53	0.99	0.32	0.00	1.69	0.00
X319 grain-B5	39.36	15.14	0.19	45.04	0.18	99.91	0.99	0.32	0.00	1.69	0.00
X319 grain-B6	39.09	15.38	0.18	44.78	0.15	99.57	0.99	0.32	0.00	1.68	0.00
X319 grain-B7	39.33	15.24	0.18	44.89	0.16	99.79	0.99	0.32	0.00	1.68	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
X319 grain-B8	39.41	15.41	0.21	44.94	0.14	100.12	0.99	0.32	0.00	1.68	0.00
X319 grain-B9	39.38	15.30	0.19	44.85	0.17	99.90	0.99	0.32	0.00	1.68	0.00
X319 grain-B10	39.46	15.29	0.18	44.97	0.17	100.07	0.99	0.32	0.00	1.68	0.00
X319 grain-B AVG	39.30	15.22	0.19	44.88	0.16	99.75	0.99	0.32	0.00	1.68	0.00
X319 grain-C1	39.39	15.22	0.20	45.19	0.14	100.14	0.99	0.32	0.00	1.69	0.00
X319 grain-C2	39.60	15.18	0.19	44.92	0.13	100.02	0.99	0.32	0.00	1.68	0.00
X319 grain-C3	39.42	15.25	0.17	45.11	0.15	100.10	0.99	0.32	0.00	1.69	0.00
X319 grain-C4	39.60	15.34	0.19	45.14	0.14	100.42	0.99	0.32	0.00	1.68	0.00
X319 grain-C5	39.56	14.10	0.16	45.65	0.17	99.64	0.99	0.30	0.00	1.71	0.00
X319 grain-C AVG	39.51	15.02	0.18	45.20	0.14	100.06	0.99	0.31	0.00	1.69	0.00
X319 grain-D1	39.64	15.26	0.18	44.84	0.16	100.07	1.00	0.32	0.00	1.68	0.00
X319 grain-D2	39.22	15.23	0.19	44.97	0.16	99.77	0.99	0.32	0.00	1.69	0.00
X319 grain-D3	39.40	15.41	0.21	45.05	0.22	100.29	0.99	0.32	0.00	1.68	0.00
X319 grain-D4	39.41	15.37	0.21	45.01	0.17	100.16	0.99	0.32	0.00	1.68	0.00
X319 grain-D5	39.39	15.37	0.17	44.75	0.18	99.86	0.99	0.32	0.00	1.68	0.00
X319 grain-D AVG	39.41	15.33	0.19	44.92	0.18	100.03	0.99	0.32	0.00	1.68	0.00
X319 ALL AVG	39.40	15.17	0.19	45.02	0.16	99.94	0.99	0.32	0.00	1.69	0.00
Ba-1-72 grain-A1	40.49	11.42	0.17	48.00	0.30	100.51	0.99	0.23	0.00	1.76	0.01
Ba-1-72 grain-A2	40.43	11.43	0.16	48.01	0.37	100.50	0.99	0.23	0.00	1.76	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
Ba-1-72 grain-A3	40.37	11.44	0.16	48.19	0.37	100.64	0.99	0.23	0.00	1.76	0.01
Ba-1-72 grain-A AVG	40.43	11.43	0.16	48.07	0.34	100.43	0.99	0.23	0.00	1.76	0.01
Ba-1-72 grain-B1	40.42	11.55	0.19	47.67	0.29	100.22	1.00	0.24	0.00	1.75	0.01
Ba-1-72 grain-B2	40.35	11.81	0.18	47.74	0.34	100.53	0.99	0.24	0.00	1.75	0.01
Ba-1-72 grain-B3	40.36	11.65	0.18	47.70	0.30	100.32	0.99	0.24	0.00	1.75	0.01
Ba-1-72 grain-B AVG	40.38	11.67	0.18	47.70	0.31	100.24	0.99	0.24	0.00	1.75	0.01
Ba-1-72 grain-C1	40.58	11.52	0.19	47.78	0.29	100.50	1.00	0.24	0.00	1.75	0.01
Ba-1-72 grain-C2	40.34	11.61	0.16	47.73	0.41	100.37	0.99	0.24	0.00	1.75	0.01
Ba-1-72 grain-C3	40.61	11.35	0.17	47.60	0.39	100.24	1.00	0.23	0.00	1.75	0.01
Ba-1-72 grain-C4	40.65	11.29	0.19	47.48	0.33	100.04	1.00	0.23	0.00	1.75	0.01
Ba-1-72 grain-C5	40.49	11.56	0.16	47.57	0.34	100.24	1.00	0.24	0.00	1.75	0.01
Ba-1-72 grain-C6	40.49	11.25	0.22	47.71	0.31	100.12	1.00	0.23	0.00	1.76	0.01
Ba-1-72 grain-C7	40.67	11.63	0.18	47.72	0.38	100.72	1.00	0.24	0.00	1.75	0.01
Ba-1-72 grain-C AVG	40.55	11.46	0.18	47.66	0.35	100.19	1.00	0.24	0.00	1.75	0.01
Ba-1-72 ALL AVG	40.45	11.52	0.18	47.81	0.33	100.29	1.00	0.24	0.00	1.75	0.01
Ba-2-1-1 grain-A1	41.01	9.33	0.13	49.14	0.37	99.98	1.01	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-A2	40.53	9.30	0.15	48.77	0.39	99.14	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-A3	40.89	9.36	0.16	49.21	0.34	99.96	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-A4	40.80	9.44	0.14	49.35	0.40	100.12	1.00	0.19	0.00	1.80	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
Ba-2-1-1 grain-A5	40.94	9.23	0.14	49.25	0.37	99.93	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-A AVG	40.83	9.33	0.14	49.14	0.37	99.82	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-B1	40.67	9.23	0.12	49.13	0.34	99.50	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-B2	40.83	9.27	0.13	49.15	0.34	99.72	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-B3	40.76	9.25	0.13	49.22	0.39	99.75	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-B4	40.90	9.45	0.16	49.17	0.39	100.06	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-B5	40.76	9.48	0.16	49.29	0.37	100.04	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-B AVG	40.78	9.34	0.14	49.19	0.37	99.81	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-C1	40.69	9.52	0.12	49.39	0.39	100.12	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-C2	40.85	9.29	0.13	49.31	0.39	99.97	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-C3	40.98	9.30	0.13	49.44	0.43	100.28	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-C4	40.69	9.43	0.15	49.46	0.40	100.13	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-C5	40.82	9.41	0.14	49.36	0.37	100.09	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-C AVG	40.81	9.39	0.13	49.39	0.40	100.12	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-D1	40.94	9.33	0.17	49.05	0.36	99.85	1.00	0.19	0.00	1.79	0.01
Ba-2-1-1 grain-D2	40.88	9.36	0.16	49.43	0.38	100.21	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-D3	40.80	9.22	0.14	48.88	0.38	99.42	1.01	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-D4	40.75	9.22	0.12	49.03	0.38	99.50	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 grain-D5	40.81	9.21	0.16	49.21	0.42	99.80	1.00	0.19	0.00	1.80	0.01

bdl, concentration below the detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
Ba-2-1-1 grain-D AVG	40.83	9.27	0.15	49.12	0.38	99.76	1.00	0.19	0.00	1.80	0.01
Ba-2-1-1 ALL AVG	40.81	9.33	0.14	49.21	0.38	99.88	1.00	0.19	0.00	1.80	0.01
EP-3-84 grain-A1	40.44	11.78	0.19	47.11	0.31	99.83	1.00	0.24	0.00	1.74	0.00
EP-3-84 grain-A2	40.31	11.81	0.16	46.89	0.34	99.51	1.00	0.25	0.00	1.74	0.01
EP-3-84 grain-A3	40.38	11.99	0.18	47.22	0.34	100.11	1.00	0.25	0.00	1.74	0.01
EP-3-84 grain-A4	40.47	11.91	0.18	47.05	0.29	99.89	1.00	0.25	0.00	1.74	0.00
EP-3-84 grain-A5	40.54	11.97	0.16	47.08	0.30	100.04	1.00	0.25	0.00	1.74	0.00
EP-3-84 grain-A AVG	40.43	11.89	0.17	47.07	0.31	99.88	1.00	0.25	0.00	1.74	0.00
EP-3-84 grain-B1	40.54	11.84	0.17	47.09	0.30	99.95	1.01	0.25	0.00	1.74	0.00
EP-3-84 grain-B2	40.53	11.99	0.18	47.14	0.28	100.12	1.00	0.25	0.00	1.74	0.00
EP-3-84 grain-B3	40.18	11.91	0.16	47.00	0.31	99.56	1.00	0.25	0.00	1.74	0.00
EP-3-84 grain-B4	40.47	11.83	0.16	47.09	0.34	99.90	1.00	0.25	0.00	1.74	0.01
EP-3-84 grain-B5	40.50	11.95	0.15	47.21	0.31	100.12	1.00	0.25	0.00	1.74	0.00
EP-3-84 grain-B AVG	40.45	11.91	0.17	47.10	0.31	99.93	1.00	0.25	0.00	1.74	0.00
EP-3-84 grain-C1	40.57	11.73	0.16	47.10	0.29	99.85	1.01	0.24	0.00	1.74	0.00
EP-3-84 grain-C2	40.40	11.82	0.15	47.14	0.28	99.78	1.00	0.25	0.00	1.74	0.00
EP-3-84 grain-C3	40.27	11.79	0.19	47.14	0.29	99.68	1.00	0.24	0.00	1.75	0.00
EP-3-84 grain-C4	40.30	11.82	0.19	47.17	0.33	99.80	1.00	0.25	0.00	1.75	0.00
EP-3-84 grain-C5	40.44	11.76	0.17	47.17	0.29	99.84	1.00	0.24	0.00	1.74	0.00

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
EP-3-84 grain-C AVG	40.40	11.78	0.17	47.14	0.30	99.79	1.00	0.24	0.00	1.74	0.00
EP-3-84 ALL AVG	40.42	11.86	0.17	47.11	0.31	99.87	1.00	0.25	0.00	1.74	0.00
TF6 grain-A1	40.47	9.36	0.14	49.35	0.42	99.72	0.99	0.19	0.00	1.81	0.01
TF6 grain-A2	40.48	9.43	0.13	49.38	0.44	99.86	0.99	0.19	0.00	1.80	0.01
TF6 grain-A3	40.58	9.48	0.11	49.43	0.41	100.02	0.99	0.19	0.00	1.80	0.01
TF6 grain-A4	40.11	9.46	0.16	49.18	0.42	99.32	0.99	0.20	0.00	1.81	0.01
TF6 grain-A5	40.13	9.53	0.12	49.32	0.43	99.53	0.99	0.20	0.00	1.81	0.01
TF6 grain-A AVG	40.35	9.45	0.13	49.33	0.42	99.69	0.99	0.19	0.00	1.81	0.01
TF6 grain-B1	40.36	9.45	0.14	49.69	0.37	100.02	0.99	0.19	0.00	1.81	0.01
TF6 grain-B2	40.42	9.47	0.13	49.22	0.39	99.62	0.99	0.19	0.00	1.80	0.01
TF6 grain-B3	40.49	9.44	0.12	49.33	0.42	99.80	0.99	0.19	0.00	1.80	0.01
TF6 grain-B4	40.42	9.37	0.15	49.50	0.38	99.83	0.99	0.19	0.00	1.81	0.01
TF6 grain-B5	40.20	9.36	0.14	49.46	0.39	99.55	0.99	0.19	0.00	1.81	0.01
TF6 grain-B AVG	40.38	9.42	0.14	49.44	0.39	99.76	0.99	0.19	0.00	1.81	0.01
TF6 grain-C1	40.49	9.40	0.13	49.06	0.39	99.47	1.00	0.19	0.00	1.80	0.01
TF6 grain-C2	40.53	9.39	0.15	49.20	0.36	99.63	1.00	0.19	0.00	1.80	0.01
TF6 grain-C3	40.41	9.38	0.10	49.08	0.40	99.36	1.00	0.19	0.00	1.80	0.01
TF6 grain-C4	40.66	9.41	0.13	49.45	0.43	100.08	0.99	0.19	0.00	1.80	0.01
TF6 grain-C5	40.37	9.45	0.12	49.43	0.35	99.71	0.99	0.19	0.00	1.81	0.01

bdl, concentration below the detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
TF6 grain-C AVG	40.49	9.40	0.12	49.24	0.39	99.65	0.99	0.19	0.00	1.80	0.01
TF6 grain-D1	40.32	9.49	0.11	49.29	0.40	99.61	0.99	0.20	0.00	1.81	0.01
TF6 grain-D2	40.62	9.41	0.14	49.49	0.41	100.07	0.99	0.19	0.00	1.80	0.01
TF6 grain-D3	40.42	9.41	0.13	49.15	0.41	99.51	0.99	0.19	0.00	1.80	0.01
TF6 grain-D4	40.34	9.52	0.13	49.16	0.37	99.53	0.99	0.20	0.00	1.80	0.01
TF6 grain-D5	40.31	9.32	0.13	49.23	0.43	99.42	0.99	0.19	0.00	1.81	0.01
TF6 grain-D AVG	40.40	9.43	0.13	49.26	0.40	99.63	0.99	0.19	0.00	1.80	0.01
TF6 ALL AVG	40.41	9.43	0.13	49.32	0.40	99.68	0.99	0.19	0.00	1.81	0.01
JAG 84-524 grain-A1	40.92	8.43	0.10	50.38	0.41	100.25	0.99	0.17	0.00	1.83	0.01
JAG 84-524 grain-A2	40.93	8.46	0.09	50.20	0.40	100.08	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-A3	40.76	8.20	0.07	49.17	0.39	98.60	1.01	0.17	0.00	1.81	0.01
JAG 84-524 grain-A4	40.55	8.33	0.10	49.84	0.42	99.22	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-A5	40.80	8.36	0.08	50.17	0.43	99.84	1.00	0.17	0.00	1.83	0.01
JAG 84-524 grain-A AVG	40.79	8.36	0.09	49.95	0.41	99.60	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-B1	40.73	8.40	0.09	50.27	0.40	99.89	0.99	0.17	0.00	1.83	0.01
JAG 84-524 grain-B2	40.74	8.36	0.09	50.15	0.40	99.74	1.00	0.17	0.00	1.83	0.01
JAG 84-524 grain-B3	40.83	8.35	0.10	50.18	0.43	99.88	1.00	0.17	0.00	1.83	0.01
JAG 84-524 grain-B4	40.73	8.23	0.11	50.12	0.42	99.60	1.00	0.17	0.00	1.83	0.01
JAG 84-524 grain-B AVG	40.76	8.33	0.10	50.18	0.41	99.78	1.00	0.17	0.00	1.83	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
JAG 84-524 grain-C1	40.77	8.29	0.07	50.41	0.39	99.92	0.99	0.17	0.00	1.83	0.01
JAG 84-524 grain-C2	40.89	8.31	0.09	50.31	0.39	100.00	1.00	0.17	0.00	1.83	0.01
JAG 84-524 grain-C3	40.54	8.40	0.09	50.07	0.38	99.48	0.99	0.17	0.00	1.83	0.01
JAG 84-524 grain-C4	40.76	8.36	0.12	50.42	0.40	100.06	0.99	0.17	0.00	1.83	0.01
JAG 84-524 grain-C5	40.82	8.45	0.09	50.43	0.39	100.18	0.99	0.17	0.00	1.83	0.01
JAG 84-524 grain-C AVG	40.76	8.36	0.09	50.33	0.39	99.93	0.99	0.17	0.00	1.83	0.01
JAG 84-524 grain-D1	40.63	8.42	0.10	49.90	0.38	99.43	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-D2	40.70	8.38	0.13	50.10	0.39	99.69	0.99	0.17	0.00	1.83	0.01
JAG 84-524 grain-D3	40.87	8.43	0.10	50.21	0.41	100.02	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-D4	40.95	8.33	0.09	50.09	0.43	99.89	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-D5	40.89	8.39	0.11	49.76	0.39	99.54	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-D AVG	40.81	8.39	0.10	50.01	0.40	99.71	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-E1	41.28	8.39	0.09	49.93	0.43	100.12	1.01	0.17	0.00	1.81	0.01
JAG 84-524 grain-E2	41.25	8.44	0.13	50.64	0.40	100.86	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-E3	41.22	8.40	0.10	50.28	0.40	100.40	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-E4	40.98	8.45	0.09	49.97	0.42	99.91	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-E5	41.02	8.48	0.11	50.26	0.41	100.28	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-E6	41.27	8.35	0.09	50.14	0.47	100.32	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-E AVG	41.17	8.42	0.10	50.20	0.42	100.32	1.00	0.17	0.00	1.82	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
JAG 84-524 grain-F1	41.21	8.38	0.10	49.76	0.41	99.86	1.01	0.17	0.00	1.81	0.01
JAG 84-524 grain-F2	40.83	8.43	0.10	49.91	0.40	99.67	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-F3	40.87	8.43	0.08	49.80	0.41	99.59	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-F4	41.09	8.39	0.10	50.15	0.44	100.17	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-F5	40.71	8.45	0.10	49.95	0.40	99.61	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-F6	41.15	8.34	0.11	49.99	0.40	99.99	1.00	0.17	0.00	1.82	0.01
JAG 84-524 grain-F7	40.74	8.59	0.09	49.86	0.41	99.69	1.00	0.18	0.00	1.82	0.01
JAG 84-524 grain-F AVG	40.94	8.43	0.10	49.92	0.41	99.80	1.00	0.17	0.00	1.82	0.01
JAG 84-524 ALL AVG	40.87	8.38	0.10	50.10	0.41	99.85	1.00	0.17	0.00	1.82	0.01
JAG 84-553 grain-A1	41.05	6.85	0.08	51.49	0.36	99.82	0.99	0.14	0.00	1.86	0.01
JAG 84-553 grain-A2	41.26	6.85	0.08	51.65	0.41	100.25	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-A3	41.28	6.89	0.08	51.51	0.41	100.17	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-A4	41.33	6.87	0.09	51.57	0.40	100.26	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-A5	41.33	6.87	0.09	51.51	0.39	100.19	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-A AVG	41.25	6.86	0.09	51.55	0.40	100.14	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-B1	41.36	6.88	0.07	51.62	0.35	100.29	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-B2	41.26	7.00	0.08	51.48	0.42	100.23	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-B3	41.24	6.88	0.07	51.43	0.37	99.98	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-B4	41.30	6.78	0.11	51.54	0.38	100.11	1.00	0.14	0.00	1.86	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
JAG 84-553 grain-B5	40.95	6.86	0.08	51.14	0.34	99.36	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-B AVG	41.22	6.88	0.08	51.44	0.37	100.00	1.00	0.14	0.00	1.86	0.01
JAG 84-553 grain-C1	41.44	7.02	0.08	51.34	0.39	100.26	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-C2	41.49	6.98	0.07	51.52	0.43	100.48	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-C3	41.50	7.04	0.07	51.47	0.39	100.48	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-C4	41.28	7.07	0.09	51.55	0.40	100.39	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-C5	41.41	6.99	0.10	51.39	0.39	100.29	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-C AVG	41.43	7.02	0.08	51.45	0.40	100.38	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-D1	41.36	6.85	0.06	51.34	0.36	99.97	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-D2	41.27	6.95	0.09	51.39	0.36	100.05	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-D3	41.31	6.94	0.09	51.38	0.38	100.09	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-D4	41.35	6.93	0.07	51.41	0.40	100.16	1.00	0.14	0.00	1.85	0.01
JAG 84-553 grain-D AVG	41.21	7.33	0.08	51.09	0.37	100.08	1.00	0.15	0.00	1.85	0.01
JAG 84-553 ALL AVG	41.28	7.02	0.08	51.38	0.39	100.15	1.00	0.14	0.00	1.85	0.01
JAG-228 grain-A1	41.81	6.63	0.09	52.37	0.41	101.31	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-A2	41.48	6.61	0.10	52.27	0.43	100.88	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-A3	41.57	6.53	0.07	52.31	0.43	100.91	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-A4	41.70	6.55	0.07	52.21	0.44	100.97	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-A5	41.50	6.65	0.10	52.26	0.46	100.96	0.99	0.13	0.00	1.86	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
JAG-228 grain-A6	41.85	6.70	0.09	52.35	0.44	101.42	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-A7	41.52	6.69	0.08	52.46	0.42	101.16	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-A8	41.74	6.58	0.10	52.47	0.40	101.28	1.00	0.13	0.00	1.87	0.01
JAG-228 grain-A9	41.63	6.62	0.10	52.39	0.44	101.18	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-A10	41.24	6.61	0.08	52.45	0.42	100.80	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-A AVG	41.60	6.61	0.09	52.35	0.43	101.09	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-B1	41.41	6.54	0.09	52.69	0.42	101.15	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-B2	41.66	6.60	0.09	52.31	0.46	101.12	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-B3	41.54	6.60	0.08	52.26	0.46	100.94	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-B4	41.34	6.51	0.08	52.30	0.43	100.65	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-B5	41.72	6.58	0.07	52.08	0.43	100.88	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-B6	41.66	6.56	0.07	52.23	0.46	100.97	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-B7	41.39	6.50	0.07	52.28	0.42	100.66	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-B8	41.39	6.58	0.10	52.23	0.42	100.72	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-B9	41.97	6.60	0.10	52.35	0.41	101.43	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-B AVG	41.56	6.56	0.08	52.30	0.43	100.95	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-C1	41.25	6.64	0.10	52.23	0.45	100.67	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-C2	41.33	6.62	0.09	52.24	0.41	100.68	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-C3	41.61	6.58	0.09	52.55	0.41	101.24	0.99	0.13	0.00	1.87	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
JAG-228 grain-C4	41.74	6.59	0.08	52.53	0.43	101.37	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-C5	41.72	6.62	0.08	52.36	0.38	101.15	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-C6	41.61	6.64	0.10	52.36	0.45	101.16	0.99	0.13	0.00	1.86	0.01
JAG-228 grain-C7	41.48	6.53	0.10	52.45	0.46	101.02	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-C8	41.44	6.55	0.09	52.08	0.42	100.59	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-C9	41.57	6.61	0.10	52.22	0.44	100.93	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-C10	41.88	6.66	0.08	52.51	0.43	101.56	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-C AVG	41.56	6.60	0.09	52.35	0.43	101.04	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-D1	41.55	6.48	0.06	52.05	0.46	100.60	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-D2	41.38	6.57	0.07	52.33	0.42	100.77	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-D3	41.25	6.52	0.08	52.51	0.44	100.81	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-D4	41.34	6.64	0.09	52.31	0.43	100.81	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-D5	41.58	6.56	0.09	52.42	0.45	101.10	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-D6	41.39	6.55	0.12	52.60	0.47	101.13	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-D7	41.82	6.53	0.09	52.36	0.51	101.31	1.00	0.13	0.00	1.86	0.01
JAG-228 grain-D8	41.07	6.55	0.08	52.35	0.42	100.47	0.99	0.13	0.00	1.87	0.01
JAG-228 grain-D9	41.28	6.49	0.08	52.60	0.43	100.89	0.99	0.13	0.00	1.88	0.01
JAG-228 grain-D10	41.25	6.52	0.09	52.69	0.51	101.05	0.98	0.13	0.00	1.88	0.01
JAG-228 grain-D AVG	41.39	6.54	0.08	52.42	0.45	100.89	0.99	0.13	0.00	1.87	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
JAG-228 ALL AVG	41.53	6.58	0.09	52.36	0.44	100.99	0.99	0.13	0.00	1.87	0.01
K7269 grain-A1	40.86	7.16	0.08	51.52	0.46	100.08	0.99	0.14	0.00	1.86	0.01
K7269 grain-A2	41.04	7.18	0.07	51.92	0.46	100.68	0.99	0.14	0.00	1.86	0.01
K7269 grain-A3	40.71	7.16	0.09	51.58	0.53	100.06	0.98	0.14	0.00	1.86	0.01
K7269 grain-A4	41.44	7.05	0.09	51.99	0.38	100.95	0.99	0.14	0.00	1.86	0.01
K7269 grain-A5	41.52	7.14	0.06	52.01	0.45	101.19	0.99	0.14	0.00	1.86	0.01
K7269 grain-A AVG	41.12	7.14	0.08	51.80	0.46	100.59	0.99	0.14	0.00	1.86	0.01
K7269 grain-B1	41.91	6.96	0.07	52.99	0.44	102.36	0.99	0.14	0.00	1.87	0.01
K7269 grain-B2	40.93	7.15	0.07	51.94	0.40	100.49	0.99	0.14	0.00	1.86	0.01
K7269 grain-B3	41.80	0.55	0.09	49.86	0.44	92.72	1.07	0.01	0.00	1.91	0.01
K7269 grain-B4	41.47	7.13	0.08	51.64	0.44	100.76	1.00	0.14	0.00	1.85	0.01
K7269 grain-B5	41.51	7.12	0.07	51.91	0.43	101.03	0.99	0.14	0.00	1.85	0.01
K7269 grain-B AVG	41.52	5.78	0.08	51.67	0.43	99.47	1.01	0.12	0.00	1.87	0.01
K7269 grain-C1	40.99	7.02	0.07	51.61	0.44	100.13	0.99	0.14	0.00	1.86	0.01
K7269 grain-C2	41.14	7.06	0.06	51.78	0.43	100.47	0.99	0.14	0.00	1.86	0.01
K7269 grain-C3	41.17	7.08	0.09	51.77	0.43	100.55	0.99	0.14	0.00	1.86	0.01
K7269 grain-C4	41.23	7.10	0.09	51.80	0.45	100.66	0.99	0.14	0.00	1.86	0.01
K7269 grain-C5	41.35	7.11	0.07	51.65	0.44	100.61	1.00	0.14	0.00	1.85	0.01
K7269 grain-C AVG	41.18	7.07	0.08	51.72	0.44	100.48	0.99	0.14	0.00	1.86	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
K7269 grain-D1	41.00	7.11	0.07	51.53	0.44	100.16	0.99	0.14	0.00	1.86	0.01
K7269 grain-D2	40.71	7.13	0.05	51.63	0.39	99.90	0.99	0.14	0.00	1.86	0.01
K7269 grain-D3	40.94	7.06	0.08	51.93	0.43	100.43	0.99	0.14	0.00	1.86	0.01
K7269 grain-D4	40.91	7.09	0.09	51.46	0.44	99.99	0.99	0.14	0.00	1.86	0.01
K7269 grain-D5	41.62	7.05	0.08	51.65	0.43	100.82	1.00	0.14	0.00	1.85	0.01
K7269 grain-D AVG	41.04	7.09	0.07	51.64	0.42	100.26	0.99	0.14	0.00	1.86	0.01
K7269 ALL AVG	41.21	6.77	0.08	51.71	0.44	100.20	0.99	0.14	0.00	1.86	0.01
K7311 grain-A1	40.51	8.23	0.06	51.41	0.42	100.63	0.98	0.17	0.00	1.85	0.01
K7311 grain-A2	41.72	8.20	0.10	51.05	0.41	101.47	1.00	0.16	0.00	1.83	0.01
K7311 grain-A3	41.45	8.16	0.09	51.24	0.37	101.30	1.00	0.16	0.00	1.83	0.01
K7311 grain-A4	41.41	8.22	0.09	51.08	0.43	101.23	1.00	0.17	0.00	1.83	0.01
K7311 grain-A AVG	41.27	8.20	0.08	51.19	0.41	101.16	0.99	0.16	0.00	1.84	0.01
K7311 grain-B1	41.44	8.26	0.08	50.78	0.42	100.98	1.00	0.17	0.00	1.83	0.01
K7311 grain-B2	41.22	8.31	0.08	50.88	0.38	100.87	0.99	0.17	0.00	1.83	0.01
K7311 grain-B3	41.60	8.18	0.08	51.24	0.42	101.52	1.00	0.16	0.00	1.83	0.01
K7311 grain-B4	41.40	8.52	0.09	50.02	0.39	100.41	1.01	0.17	0.00	1.81	0.01
K7311 grain-B AVG	41.41	8.32	0.08	50.73	0.40	100.94	1.00	0.17	0.00	1.83	0.01
K7311 grain-C1	41.49	8.13	0.09	49.98	0.44	100.13	1.01	0.17	0.00	1.82	0.01
K7311 grain-C2	41.37	8.23	0.09	50.97	0.47	101.12	1.00	0.17	0.00	1.83	0.01

bdl, concentration below detection limit

OLIVINE COMPOSITIONS

Sample	SiO_2	FeO	MnO	MgO	NiO	SUM	Si	Fe	Mn	Mg	Ni
K7311 grain-C3	41.45	8.39	0.10	51.01	0.44	101.39	1.00	0.17	0.00	1.83	0.01
K7311 grain-C4	41.24	8.15	0.09	51.22	0.44	101.15	0.99	0.16	0.00	1.84	0.01
K7311 grain-C5	40.75	8.05	0.09	52.09	0.34	101.32	0.97	0.16	0.00	1.86	0.00
K7311 grain-C AVG	41.26	8.19	0.09	51.05	0.43	101.02	0.99	0.16	0.00	1.83	0.01
K7311 grain-D1	41.56	8.05	0.12	51.59	0.42	101.73	0.99	0.16	0.00	1.84	0.01
K7311 grain-D2	41.38	8.06	0.08	51.42	0.46	101.40	0.99	0.16	0.00	1.84	0.01
K7311 grain-D3	41.45	7.97	0.08	50.75	0.43	100.67	1.00	0.16	0.00	1.83	0.01
K7311 grain-D4	41.63	8.03	0.06	51.19	0.43	101.34	1.00	0.16	0.00	1.83	0.01
K7311 grain-D5	41.92	8.11	0.09	51.26	0.45	101.82	1.00	0.16	0.00	1.83	0.01
K7311 grain-D AVG	41.59	8.04	0.08	51.24	0.44	101.39	1.00	0.16	0.00	1.83	0.01
K7311 grain-E1	40.60	8.27	0.10	50.81	0.42	100.19	0.99	0.17	0.00	1.84	0.01
K7311 grain-E2	40.76	8.37	0.11	50.90	0.45	100.59	0.99	0.17	0.00	1.84	0.01
K7311 grain-E3	40.58	8.21	0.10	50.71	0.39	99.98	0.99	0.17	0.00	1.84	0.01
K7311 grain-E4	40.55	8.21	0.10	50.53	0.44	99.82	0.99	0.17	0.00	1.84	0.01
K7311 grain-E5	40.75	8.35	0.11	50.53	0.46	100.19	0.99	0.17	0.00	1.83	0.01
K7311 grain-E6	40.61	8.25	0.08	50.68	0.38	100.01	0.99	0.17	0.00	1.84	0.01
K7311 grain-E7	40.81	8.13	0.08	50.78	0.39	100.19	0.99	0.16	0.00	1.84	0.01
K7311 grain-E AVG	40.67	8.26	0.09	50.71	0.42	100.14	0.99	0.17	0.00	1.84	0.01
K7311 ALL AVG	41.24	8.20	0.09	50.98	0.42	100.93	0.99	0.17	0.00	1.83	0.01

bdl, concentration below detection limit

APPENDIX B

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
GN9912 grain-A1	44.80	0.66	13.76	1.22	3.89	18.14	10.92	3.63	0.61	bdl	0.06	2.06	99.75	0.00	0.01	99.73
GN9912 grain-A2	44.64	0.58	13.60	1.15	3.68	18.15	10.89	3.65	0.62	bdl	0.06	2.05	99.08	0.00	0.01	99.06
GN9912 grain-A AVG	44.72	0.62	13.68	1.18	3.78	18.14	10.91	3.64	0.61	bdl	0.06	2.06	99.41	0.00	0.01	99.40
GN9912 grain-B1	43.92	0.55	14.69	1.59	3.83	17.69	10.62	3.74	0.64	bdl	0.06	2.05	99.38	0.00	0.01	99.36
GN9912 grain-B2	44.08	0.54	14.61	1.66	3.86	17.70	10.61	3.76	0.65	bdl	0.06	2.02	99.55	0.00	0.01	99.54
GN9912 grain-B3	44.00	0.55	14.65	1.63	3.84	17.69	10.62	3.75	0.65	bdl	0.06	2.04	99.46	0.00	0.01	99.45
GN9912 grain-B4	44.31	0.52	14.72	1.44	3.82	17.77	10.61	3.59	0.62	bdl	0.06	2.05	99.51	0.00	0.01	99.49
GN9912 grain-B5	44.24	0.53	14.77	1.47	3.84	17.73	10.52	3.74	0.65	bdl	0.07	2.04	99.61	0.00	0.01	99.59
GN9912 grain-B6	44.28	0.52	14.74	1.45	3.83	17.75	10.57	3.67	0.64	bdl	0.06	2.05	99.56	0.00	0.01	99.54
GN9912 grain-B7	43.79	0.52	14.79	1.60	3.81	17.89	10.56	3.67	0.65	bdl	0.07	2.04	99.39	0.00	0.02	99.37
GN9912 grain-B8	43.97	0.52	14.93	1.49	3.67	18.18	10.70	3.78	0.59	bdl	0.06	2.04	99.93	0.00	0.01	99.92
GN9912 grain-B AVG	43.88	0.52	14.86	1.55	3.74	18.04	10.63	3.73	0.62	bdl	0.07	2.04	99.66	0.00	0.01	99.65
GN9912 AVG	44.22	0.55	14.48	1.45	3.80	17.91	10.68	3.70	0.63	bdl	0.06	2.04	99.52	0.00	0.01	99.51
GN9913 grain-A1	43.89	0.45	14.97	1.69	3.44	17.86	10.59	3.84	0.52	bdl	0.08	2.04	99.36	0.00	0.02	99.34
GN9913 grain-A2	43.76	0.48	14.73	1.72	3.37	17.78	10.67	3.83	0.48	bdl	0.07	2.02	98.89	0.00	0.01	98.87
GN9913 grain-A AVG	43.83	0.46	14.85	1.70	3.41	17.82	10.63	3.83	0.50	bdl	0.07	2.03	99.12	0.00	0.02	99.11
GN9913 grain-D1	44.38	0.44	14.03	1.53	3.24	17.96	10.65	3.66	0.65	bdl	0.07	2.04	98.64	0.00	0.01	98.63
GN9913 grain-D2	43.76	0.46	14.59	1.76	3.53	17.86	10.58	3.82	0.68	bdl	0.05	2.06	99.14	0.00	0.01	99.13
GN9913 grain-D AVG	44.07	0.45	14.31	1.64	3.38	17.91	10.62	3.74	0.67	bdl	0.06	2.05	98.89	0.00	0.01	98.88
GN9913 grain-I1	43.78	0.52	14.05	1.76	3.34	17.97	10.91	3.59	0.93	bdl	0.07	2.03	98.94	0.00	0.02	98.93
GN9913 grain-I2	43.79	0.54	14.28	1.79	3.39	17.94	10.80	3.54	1.00	bdl	0.07	2.03	99.18	0.00	0.02	99.16

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
GN9913 grain-I AVG	43.78	0.53	14.16	1.78	3.37	17.96	10.85	3.57	0.96	bdl	0.07	2.03	99.06	0.00	0.02	99.05
GN9913 grain-F1	44.32	0.49	14.00	1.55	3.31	18.15	10.74	3.80	0.57	bdl	0.06	2.04	99.03	0.00	0.01	99.01
GN9913 grain-F2	44.36	0.51	13.84	1.70	3.38	18.15	10.63	3.71	0.59	bdl	0.07	2.04	98.98	0.00	0.02	98.96
GN9913 grain-F AVG	44.34	0.50	13.92	1.63	3.35	18.15	10.69	3.76	0.58	bdl	0.07	2.04	99.00	0.00	0.01	98.99
GN9913 AVG	44.77	0.48	13.46	1.51	3.18	18.53	10.55	3.58	0.61	bdl	0.07	2.05	98.79	0.00	0.02	98.78
BM9912 grain-A1	43.52	1.31	14.96	1.44	3.44	17.73	10.35	3.74	0.32	bdl	0.08	2.04	98.91	0.00	0.02	98.90
BM9912 grain-A2	43.68	1.37	15.35	1.49	3.39	17.63	10.23	3.68	0.41	bdl	0.08	2.03	99.33	0.00	0.02	99.31
BM9912 grain-A AVG	43.60	1.34	15.15	1.46	3.42	17.68	10.29	3.71	0.36	bdl	0.08	2.03	99.12	0.00	0.02	99.11
BM9912 grain-H1	43.49	1.44	15.05	1.39	3.51	17.65	10.59	3.57	0.71	bdl	0.08	2.06	99.54	0.00	0.02	99.52
BM9912 grain-H2	43.19	1.41	14.86	1.50	3.55	17.89	10.56	3.60	0.73	bdl	0.06	2.04	99.38	0.00	0.01	99.37
BM9912 grain-H3	43.34	1.42	14.95	1.44	3.53	17.77	10.58	3.59	0.72	bdl	0.07	2.05	99.46	0.00	0.02	99.44
BM9912 grain-H4	43.22	1.45	15.05	1.46	3.47	17.96	10.71	3.54	0.69	bdl	0.06	2.04	99.65	0.00	0.01	99.64
BM9912 grain-H5	43.37	1.49	15.03	1.43	3.50	18.10	10.65	3.63	0.72	bdl	0.06	2.06	100.0	0.00	0.01	100.0
BM9912 grain-H AVG	43.30	1.47	15.04	1.45	3.49	18.03	10.68	3.59	0.71	bdl	0.06	2.05	99.85	0.00	0.01	99.83
BM9912 AVG	43.41	1.41	15.05	1.45	3.48	17.83	10.51	3.63	0.60	bdl	0.07	1.93	99.43	0.00	0.02	99.42
BM9915 grain-G1	43.98	1.07	13.11	2.37	3.38	18.68	10.34	3.75	0.90	bdl	0.07	2.06	99.70	0.00	0.02	99.68
BM9915 grain-G2	44.73	1.19	13.29	2.04	3.29	18.67	9.98	3.84	0.97	bdl	0.08	2.02	100.1	0.00	0.02	100.1
BM9915 grain-G3	44.49	1.27	13.47	2.19	3.20	18.64	10.05	3.78	0.92	bdl	0.07	2.04	100.1	0.00	0.02	100.1
BM9915 grain-G4	44.24	1.24	13.56	2.21	3.38	18.57	10.14	3.74	0.99	bdl	0.06	2.06	100.2	0.00	0.01	100.2
BM9915 grain-G5	44.28	1.32	13.72	2.17	3.40	18.41	10.01	3.84	0.98	bdl	0.08	2.06	100.3	0.00	0.02	100.2
BM9915 grain-G6	44.04	1.35	13.73	2.00	3.23	18.46	9.97	3.71	0.97	bdl	0.08	2.01	99.56	0.00	0.02	99.54

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
BM9915 grain-G7	44.00	1.35	13.68	2.17	3.06	18.47	10.22	3.71	0.96	bdl	0.06	2.03	99.69	0.00	0.01	99.68
BM9915 grain-G8	44.39	1.39	13.70	2.06	3.27	18.51	10.26	3.76	0.92	bdl	0.06	2.05	100.4	0.00	0.01	100.3
BM9915 grain-G9	44.34	1.35	13.66	1.99	3.28	18.53	10.10	3.78	0.94	bdl	0.06	2.04	100.1	0.00	0.01	100.1
BM9915 grain-G10	44.03	1.30	13.64	2.05	3.31	18.37	10.06	3.88	1.00	bdl	0.07	2.06	99.77	0.00	0.02	99.76
BM9915 grain-G11	43.93	1.30	13.61	2.02	3.18	18.46	10.02	3.75	0.99	bdl	0.07	2.02	99.34	0.00	0.02	99.32
BM9915 grain-G12	43.88	1.27	13.70	2.05	3.20	18.57	10.28	4.04	0.96	bdl	0.07	2.05	100.1	0.00	0.02	100.1
BM9915 grain-G13	44.14	1.24	13.63	2.10	3.31	18.54	10.25	3.79	0.98	bdl	0.08	2.04	100.1	0.00	0.02	100.1
BM9915 grain-G14	44.04	1.22	13.46	2.07	3.36	18.41	10.21	3.87	0.95	bdl	0.07	2.03	99.69	0.00	0.01	99.68
BM9915 grain-G15	44.44	1.18	13.33	2.11	3.43	18.71	10.21	3.87	0.91	bdl	0.07	2.03	100.3	0.00	0.02	100.3
BM9915 grain-G AVG	44.20	1.27	13.55	2.10	3.29	18.53	10.14	3.81	0.96	bdl	0.07	2.04	99.95	0.00	0.02	99.94
BM9915 grain-F1	43.82	1.25	13.56	2.25	3.30	18.63	10.13	3.81	0.90	bdl	0.07	2.04	99.76	0.00	0.02	99.74
BM9915 grain-F2	44.17	1.28	13.70	2.07	3.15	18.51	10.09	3.83	0.95	bdl	0.07	2.02	99.81	0.00	0.02	99.80
BM9915 grain-F3	44.39	1.27	13.61	2.28	3.36	18.49	10.32	3.91	0.92	bdl	0.07	2.04	100.7	0.00	0.02	100.6
BM9915 grain-F4	44.32	1.25	13.74	2.25	3.19	18.47	10.23	3.82	0.94	bdl	0.06	2.04	100.3	0.00	0.01	100.3
BM9915 grain-F5	44.40	1.26	13.60	2.11	3.27	18.57	10.07	3.86	0.93	bdl	0.07	2.07	100.2	0.00	0.01	100.2
BM9915 grain-F6	43.83	1.39	13.63	2.08	3.19	18.46	10.40	3.77	0.93	bdl	0.09	2.04	99.80	0.00	0.02	99.78
BM9915 grain-F7	44.26	1.37	13.48	2.01	3.18	18.66	9.99	3.82	0.91	bdl	0.07	2.06	99.81	0.00	0.02	99.79
BM9915 grain-F8	44.15	1.27	13.59	2.17	3.09	18.58	10.25	3.82	0.92	bdl	0.08	2.03	99.94	0.00	0.02	99.92
BM9915 grain-F9	44.26	1.34	13.53	2.18	3.26	18.62	10.17	3.89	0.93	bdl	0.05	2.06	100.3	0.00	0.01	100.3
BM9915 grain-F10	44.32	1.30	13.55	2.15	3.28	18.39	10.18	3.79	0.89	bdl	0.05	2.06	99.96	0.00	0.01	99.95
BM9915 grain-F11	44.52	1.26	13.47	2.12	3.27	18.58	10.09	3.72	0.95	bdl	0.07	2.07	100.1	0.00	0.02	100.1

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
BM9915 grain-F12	44.10	1.32	13.61	2.09	3.26	18.66	10.09	3.76	0.90	bdl	0.09	2.03	99.91	0.00	0.02	99.89
BM9915 grain-F13	44.07	1.33	13.44	2.27	3.07	18.60	10.12	3.87	0.89	bdl	0.08	2.04	99.76	0.00	0.02	99.74
BM9915 grain-F14	44.51	1.30	13.34	2.24	3.12	18.47	10.10	3.82	0.94	bdl	0.08	2.03	99.94	0.00	0.02	99.92
BM9915 grain-F15	44.30	1.31	13.46	2.29	3.15	18.60	10.16	3.76	0.93	bdl	0.08	2.04	100.1	0.00	0.02	100.1
BM9915 grain-F AVG	44.23	1.30	13.55	2.17	3.21	18.55	10.16	3.82	0.92	bdl	0.07	2.04	100.0	0.00	0.02	100.0
BM9915 grain-B1	43.92	1.08	13.04	2.27	3.48	18.33	10.25	3.68	0.94	bdl	0.06	2.03	99.08	0.00	0.01	99.06
BM9915 grain-B2	44.26	1.16	13.22	2.20	3.58	18.48	10.13	3.83	0.95	bdl	0.07	2.04	99.90	0.00	0.02	99.89
BM9915 grain-B3	43.92	1.16	13.34	2.25	3.54	18.38	10.03	3.82	0.99	bdl	0.07	2.01	99.50	0.00	0.02	99.49
BM9915 grain-B4	43.88	1.19	13.40	2.25	3.50	18.50	10.00	3.71	1.04	bdl	0.06	2.03	99.56	0.00	0.01	99.55
BM9915 grain-B5	44.06	1.18	13.53	2.12	3.19	18.15	10.05	3.79	0.99	bdl	0.07	2.00	99.12	0.00	0.02	99.11
BM9915 grain-B6	44.07	1.23	13.58	2.20	3.49	18.34	9.99	3.64	1.02	bdl	0.07	2.02	99.64	0.00	0.02	99.62
BM9915 grain-B7	44.47	1.26	13.58	2.11	3.51	18.38	9.93	3.78	1.01	bdl	0.08	2.06	100.2	0.00	0.02	100.1
BM9915 grain-B8	44.09	1.28	13.75	2.16	3.44	18.21	10.02	3.77	1.02	bdl	0.07	2.06	99.85	0.00	0.02	99.83
BM9915 grain-B9	44.20	1.29	13.56	2.18	3.48	18.27	10.05	3.73	1.00	bdl	0.07	2.03	99.86	0.00	0.02	99.84
BM9915 grain-B10	44.20	1.24	13.53	1.98	3.38	18.23	10.07	3.79	0.99	bdl	0.08	2.01	99.49	0.00	0.02	99.47
BM9915 grain-B11	43.98	1.22	13.57	2.08	3.44	18.30	10.07	3.79	0.97	bdl	0.07	2.02	99.51	0.00	0.02	99.49
BM9915 grain-B12	44.31	1.22	13.54	2.15	3.45	18.49	9.98	3.84	1.02	bdl	0.07	2.05	100.1	0.00	0.02	100.1
BM9915 grain-B13	44.68	1.24	13.33	2.17	3.36	18.52	10.00	3.73	0.99	bdl	0.07	2.02	100.1	0.00	0.02	100.1
BM9915 grain-B14	44.60	1.19	13.01	2.02	3.40	18.66	10.00	3.82	0.95	bdl	0.08	2.01	99.74	0.00	0.02	99.72
BM9915 grain-B15	44.69	1.12	12.86	2.13	3.19	18.52	10.19	3.84	0.95	bdl	0.08	2.04	99.62	0.00	0.02	99.60
BM9915 grain-B AVG	44.22	1.20	13.39	2.15	3.43	18.38	10.05	3.77	0.99	bdl	0.07	2.03	99.68	0.00	0.02	99.67

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
BM9915 grain-A1	43.88	1.00	12.98	2.50	3.15	18.80	10.33	3.77	0.93	bdl	0.06	2.01	99.40	0.00	0.01	99.39
BM9915 grain-A2	44.26	1.02	13.04	2.37	3.11	18.77	10.32	3.79	0.98	bdl	0.10	2.03	99.80	0.00	0.02	99.77
BM9915 grain-A3	43.85	1.02	13.23	2.51	3.09	18.60	10.34	3.78	0.96	bdl	0.06	2.03	99.46	0.00	0.01	99.45
BM9915 grain-A4	44.01	0.99	13.13	2.63	2.97	18.57	10.39	3.71	0.98	bdl	0.08	2.03	99.48	0.00	0.02	99.47
BM9915 grain-A5	44.05	1.01	13.14	2.73	3.08	18.57	10.29	3.82	0.95	bdl	0.07	2.01	99.73	0.00	0.02	99.71
BM9915 grain-A6	44.43	1.04	13.16	2.62	3.01	18.35	10.36	3.84	0.96	bdl	0.07	2.03	99.87	0.00	0.02	99.85
BM9915 grain-A7	43.82	0.98	13.26	2.71	2.90	18.60	10.37	3.57	0.96	bdl	0.08	2.06	99.31	0.00	0.02	99.29
BM9915 grain-A8	43.78	0.99	13.14	2.77	3.02	18.53	10.31	3.84	0.99	bdl	0.07	2.06	99.49	0.00	0.02	99.48
BM9915 grain-A9	44.30	1.01	13.16	2.92	3.09	18.53	10.27	3.74	0.93	bdl	0.07	2.03	100.0	0.00	0.02	100.0
BM9915 grain-A10	44.12	0.99	13.01	2.55	3.08	18.65	10.25	3.84	0.96	bdl	0.06	2.03	99.54	0.00	0.01	99.52
BM9915 grain-A11	44.46	1.02	13.11	2.48	2.97	18.67	10.27	3.85	0.97	bdl	0.07	2.01	99.86	0.00	0.01	99.85
BM9915 grain-A12	44.39	1.03	13.11	2.50	3.13	18.66	10.24	3.81	0.96	bdl	0.06	2.03	99.92	0.00	0.01	99.90
BM9915 grain-A13	44.42	0.97	13.11	2.57	3.15	18.69	10.22	3.88	0.92	bdl	0.10	2.03	100.1	0.00	0.02	100.0
BM9915 grain-A14	44.59	0.98	13.14	2.43	3.07	18.71	10.35	3.78	0.93	0.22	0.06	2.00	100.3	0.09	0.01	100.2
BM9915 grain-A15	44.29	1.03	13.06	2.45	3.12	18.71	10.20	3.76	1.00	bdl	0.08	2.03	99.71	0.00	0.02	99.70
BM9915 grain-A AVG	44.18	1.01	13.12	2.58	3.06	18.63	10.30	3.79	0.96	bdl	0.07	2.03	99.71	0.00	0.02	99.70
BM9915 AVG	44.21	1.19	13.40	2.25	3.25	18.52	10.16	3.79	0.96	bdl	0.07	1.96	99.76	0.00	0.02	99.74
X174 grain-A1	40.72	3.34	15.72	0.00	8.28	14.96	11.23	3.29	0.70	bdl	bdl	2.03	100.3	0.00	0.00	100.3
X174 grain-A2	40.74	3.36	15.59	0.00	8.30	15.10	11.17	3.46	0.70	bdl	bdl	1.99	100.4	0.00	0.00	100.4
X174 grain-A3	40.98	3.38	15.81	0.00	8.37	15.06	11.15	3.39	0.71	bdl	bdl	2.06	100.9	0.00	0.00	100.9
X174 grain-A4	40.97	3.48	15.67	0.02	8.57	15.03	11.05	3.44	0.75	bdl	bdl	2.04	101.0	0.00	0.00	101.0

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X174 grain-A5	41.09	3.20	15.67	0.04	8.19	14.92	10.72	3.32	0.74	bdl	bdl	2.00	99.88	0.00	0.00	99.88
X174 grain-A6	40.96	3.28	15.78	0.03	8.32	14.96	10.78	3.20	0.66	bdl	bdl	1.99	99.97	0.00	0.00	99.97
X174 grain-A7	40.64	3.35	15.85	0.03	8.24	14.97	11.24	3.38	0.80	bdl	bdl	2.01	100.5	0.00	0.00	100.5
X174 grain-A8	40.73	3.40	15.86	0.00	8.49	15.03	11.38	3.37	0.71	bdl	bdl	2.05	101.0	0.00	0.00	101.0
X174 grain-A9	40.79	3.45	15.71	0.00	8.47	15.00	11.35	3.29	0.76	bdl	bdl	2.01	100.8	0.00	0.00	100.8
X174 grain-A AVG	40.85	3.36	15.74	0.02	8.36	15.00	11.12	3.35	0.72	bdl	bdl	2.02	100.5	0.00	0.00	100.5
X174 grain-B1	40.49	3.48	15.73	0.02	8.48	15.00	11.26	3.24	0.78	bdl	bdl	2.00	100.5	0.00	0.00	100.5
X174 grain-B2	40.83	3.47	15.89	0.00	8.46	14.97	11.10	3.31	0.81	bdl	bdl	2.06	100.9	0.00	0.00	100.9
X174 grain-B3	40.70	3.49	15.66	0.03	8.24	14.94	11.20	3.20	0.78	bdl	bdl	2.00	100.2	0.00	0.00	100.2
X174 grain-B4	40.50	3.43	15.68	0.03	8.36	14.89	11.13	3.24	0.87	bdl	bdl	2.03	100.2	0.00	0.00	100.2
X174 grain-B5	40.38	3.42	15.66	0.01	8.21	14.99	11.31	3.11	0.89	bdl	bdl	2.01	99.98	0.00	0.00	99.98
X174 grain-B6	40.87	3.47	15.76	0.02	8.20	15.07	11.22	3.24	0.78	bdl	bdl	2.01	100.6	0.00	0.00	100.6
X174 grain-B7	40.83	3.38	15.64	0.00	8.40	15.14	11.18	3.28	0.76	bdl	bdl	1.99	100.6	0.00	0.00	100.6
X174 grain-B8	40.83	3.41	15.69	0.01	8.34	15.10	11.02	3.18	0.71	bdl	bdl	2.04	100.3	0.00	0.00	100.3
X174 grain-B9	40.79	3.38	15.59	0.03	8.24	15.09	11.25	3.30	0.72	bdl	bdl	1.98	100.4	0.00	0.00	100.4
X174 grain-B10	40.90	3.37	15.51	0.04	8.44	15.08	11.25	3.34	0.68	bdl	bdl	2.01	100.6	0.00	0.00	100.6
X174 grain-B AVG	40.71	3.43	15.68	0.02	8.34	15.03	11.19	3.24	0.78	bdl	bdl	2.01	100.4	0.00	0.00	100.4
X174 grain-C1	41.04	3.37	15.62	0.07	8.53	14.98	11.13	3.33	0.63	bdl	bdl	2.04	100.7	0.00	0.00	100.7
X174 grain-C2	40.84	3.30	15.65	0.01	8.47	15.08	11.13	3.37	0.66	bdl	bdl	2.02	100.5	0.00	0.00	100.5
X174 grain-C3	40.93	3.35	15.65	0.03	8.30	15.08	11.04	3.30	0.64	bdl	bdl	2.03	100.3	0.00	0.00	100.3
X174 grain-C4	40.95	3.29	15.51	0.00	8.36	14.87	11.01	3.37	0.62	bdl	bdl	2.01	99.99	0.00	0.00	99.99

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X174 grain-C5	40.85	3.36	15.52	0.04	8.56	15.07	11.05	3.49	0.59	bdl	bdl	2.07	100.6	0.00	0.00	100.6
X174 grain-C6	40.86	3.35	15.57	0.01	8.41	14.90	11.16	3.43	0.58	bdl	bdl	1.97	100.2	0.00	0.00	100.2
X174 grain-C7	40.94	3.36	15.53	0.00	8.25	14.85	10.98	3.35	0.63	bdl	bdl	1.98	99.86	0.00	0.00	99.86
X174 grain-C8	40.70	3.40	15.49	0.05	8.35	15.05	11.00	3.28	0.62	bdl	bdl	1.99	99.93	0.00	0.00	99.93
X174 grain-C9	40.85	3.46	15.53	0.00	8.40	14.93	11.08	3.42	0.63	bdl	bdl	2.02	100.3	0.00	0.00	100.3
X174 grain-C10	40.74	3.35	15.64	0.02	8.64	15.04	11.00	3.36	0.65	bdl	bdl	2.02	100.5	0.00	0.00	100.5
X174 grain-C AVG	40.87	3.36	15.57	0.02	8.43	14.98	11.06	3.37	0.62	bdl	bdl	2.01	100.3	0.00	0.00	100.3
X174 grain-D1	40.63	3.28	15.41	0.03	8.31	15.02	11.34	3.29	0.68	bdl	bdl	1.99	99.97	0.00	0.00	99.97
X174 grain-D2	40.83	3.30	15.50	0.00	8.36	15.09	11.10	3.33	0.67	bdl	bdl	1.99	100.2	0.00	0.00	100.2
X174 grain-D3	40.75	3.29	15.52	0.00	8.51	15.14	11.22	3.32	0.65	bdl	bdl	2.01	100.4	0.00	0.00	100.4
X174 grain-D4	40.98	3.22	15.83	0.00	8.24	14.76	11.09	3.31	0.67	bdl	bdl	1.99	100.1	0.00	0.00	100.1
X174 grain-D5	40.86	3.24	15.55	0.05	8.28	14.85	11.32	3.36	0.71	bdl	bdl	1.98	100.2	0.00	0.00	100.2
X174 grain-D6	40.41	3.30	15.70	0.04	8.36	15.06	10.91	3.39	0.71	bdl	bdl	2.05	99.92	0.00	0.00	99.92
X174 grain-D7	40.94	3.27	15.62	0.02	8.37	15.12	11.24	3.20	0.74	bdl	bdl	1.99	100.5	0.00	0.00	100.5
X174 grain-D8	40.97	3.28	15.60	0.02	8.38	15.07	11.34	3.26	0.68	bdl	bdl	2.00	100.6	0.00	0.00	100.6
X174 grain-D9	40.64	3.35	15.43	0.00	8.27	14.89	11.22	3.41	0.66	bdl	bdl	1.98	99.84	0.00	0.00	99.84
X174 grain-D10	40.68	3.33	15.48	0.00	8.49	15.07	11.18	3.09	0.67	bdl	bdl	2.02	100.0	0.00	0.00	100.0
X174 grain-D AVG	40.77	3.29	15.56	0.02	8.36	15.01	11.20	3.29	0.68	bdl	bdl	2.00	100.2	0.00	0.00	100.2
X174 ALL AVG	40.80	3.36	15.64	0.02	8.37	15.01	11.14	3.31	0.70	bdl	bdl	2.01	100.4	0.00	0.00	100.4
X192 grain-A1	42.04	3.33	15.85	0.42	6.36	16.23	11.17	2.99	1.39	bdl	bdl	2.04	101.8	0.00	0.00	101.8
X192 grain-A2	41.27	3.44	15.70	0.33	6.20	15.95	10.96	3.04	1.45	bdl	bdl	2.01	100.4	0.00	0.00	100.4

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X192 grain-A3	40.95	3.44	15.71	0.38	6.41	15.88	10.70	2.94	1.39	bdl	bdl	2.00	99.80	0.00	0.00	99.80
X192 grain-A4	41.32	3.46	15.68	0.41	6.15	16.14	10.92	3.11	1.39	bdl	bdl	2.03	100.6	0.00	0.00	100.6
X192 grain-A5	41.50	3.56	15.65	0.40	6.15	15.92	11.00	2.86	1.40	bdl	bdl	2.00	100.4	0.00	0.00	100.4
X192 grain-A6	40.85	3.52	15.57	0.36	6.36	16.20	11.02	2.78	1.44	bdl	bdl	1.98	100.1	0.00	0.00	100.1
X192 grain-A7	41.41	3.41	15.65	0.37	6.33	15.98	11.16	2.87	1.41	bdl	bdl	2.06	100.7	0.00	0.00	100.7
X192 grain-A8	41.14	3.41	15.65	0.39	6.18	16.27	11.06	2.75	1.41	bdl	bdl	2.04	100.3	0.00	0.00	100.3
X192 grain-A9	41.30	3.38	15.72	0.37	6.05	16.21	11.09	3.01	1.33	bdl	bdl	1.97	100.4	0.00	0.00	100.4
X192 grain-A10	41.45	3.35	15.65	0.50	5.88	16.10	11.11	2.80	1.41	bdl	bdl	2.03	100.3	0.00	0.00	100.3
X192 grain-A AVG	41.32	3.43	15.68	0.39	6.21	16.09	11.02	2.92	1.40	bdl	bdl	2.01	100.5	0.00	0.00	100.5
X192 grain-B1	41.79	3.26	15.78	0.37	5.98	16.36	11.07	3.02	1.45	bdl	bdl	2.00	101.1	0.00	0.00	101.1
X192 grain-B2	41.35	3.50	15.79	0.40	6.43	16.17	10.91	2.98	1.46	bdl	bdl	2.02	101.0	0.00	0.00	101.0
X192 grain-B3	41.35	3.46	15.73	0.41	6.37	15.95	11.16	3.08	1.38	bdl	bdl	2.05	101.0	0.00	0.00	101.0
X192 grain-B4	41.37	3.43	15.44	0.38	6.25	16.12	10.98	2.84	1.34	bdl	bdl	2.03	100.2	0.00	0.00	100.2
X192 grain-B5	41.35	3.42	15.59	0.40	6.27	15.99	10.97	3.02	1.36	bdl	bdl	2.02	100.4	0.00	0.00	100.4
X192 grain-B6	41.38	3.55	15.52	0.41	6.20	16.24	11.09	2.88	1.41	bdl	bdl	2.07	100.7	0.00	0.00	100.7
X192 grain-B7	41.19	3.61	15.71	0.41	6.44	16.02	10.94	2.81	1.44	bdl	bdl	2.04	100.6	0.00	0.00	100.6
X192 grain-B8	41.30	3.40	15.94	0.41	6.21	16.13	10.99	2.91	1.48	bdl	bdl	2.06	100.8	0.00	0.00	100.8
X192 grain-B9	41.68	3.24	15.41	0.37	5.85	16.18	11.50	2.94	1.31	bdl	bdl	2.02	100.5	0.00	0.00	100.5
X192 grain-B10	41.40	3.41	15.64	0.33	6.06	16.20	11.33	2.90	1.41	bdl	bdl	2.04	100.7	0.00	0.00	100.7
X192 grain-B AVG	41.42	3.43	15.66	0.39	6.21	16.13	11.09	2.94	1.40	bdl	bdl	2.03	100.7	0.00	0.00	100.7
X192 grain-C1	41.01	3.43	15.59	0.45	6.44	15.98	11.05	2.93	1.34	bdl	bdl	2.00	100.2	0.00	0.00	100.2

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X192 grain-C2	41.25	3.45	15.68	0.30	6.67	16.09	11.09	2.85	1.41	bdl	bdl	2.03	100.8	0.00	0.00	100.8
X192 grain-C3	41.31	3.52	15.75	0.44	6.42	15.99	11.08	2.82	1.41	bdl	bdl	1.99	100.7	0.00	0.00	100.7
X192 grain-C4	41.47	3.47	15.58	0.36	6.46	16.03	11.13	2.99	1.48	bdl	bdl	2.03	101.0	0.00	0.00	101.0
X192 grain-C5	41.48	3.51	15.78	0.42	6.58	16.02	10.95	2.75	1.49	bdl	bdl	2.07	101.0	0.00	0.00	101.0
X192 grain-C6	41.54	3.53	15.72	0.33	6.36	16.05	10.97	2.84	1.40	bdl	bdl	2.01	100.7	0.00	0.00	100.7
X192 grain-C7	41.11	3.42	15.59	0.34	6.15	16.01	11.29	2.87	1.39	bdl	bdl	2.09	100.2	0.00	0.00	100.2
X192 grain-C8	41.37	3.53	15.79	0.43	6.22	16.10	11.16	2.76	1.41	bdl	bdl	2.04	100.8	0.00	0.00	100.8
X192 grain-C9	41.72	3.39	15.63	0.42	6.22	16.08	11.05	2.70	1.46	bdl	bdl	2.01	100.7	0.00	0.00	100.7
X192 grain-C10	41.36	3.50	15.66	0.36	6.17	16.01	11.05	2.94	1.45	bdl	bdl	2.01	100.5	0.00	0.00	100.5
X192 grain-C AVG	41.36	3.47	15.68	0.38	6.37	16.03	11.08	2.84	1.42	bdl	bdl	2.03	100.7	0.00	0.00	100.7
X192 grain-D1	42.35	3.33	14.75	0.12	7.31	15.63	9.77	3.70	1.11	bdl	bdl	1.99	100.0	0.00	0.00	100.0
X192 grain-D2	41.58	3.65	15.29	0.13	6.92	15.11	10.86	3.28	1.37	bdl	bdl	2.01	100.2	0.00	0.00	100.2
X192 grain-D3	41.62	3.64	15.55	0.19	6.79	15.19	11.03	3.29	1.40	bdl	bdl	2.04	100.7	0.00	0.00	100.7
X192 grain-D4	41.41	3.80	15.28	0.20	6.93	15.33	10.95	3.33	1.41	bdl	bdl	2.03	100.7	0.00	0.00	100.7
X192 grain-D5	41.63	3.59	15.66	0.24	6.69	15.31	10.89	3.33	1.41	bdl	bdl	2.05	100.8	0.00	0.00	100.8
X192 grain-D6	41.72	3.37	15.56	0.19	6.71	15.34	11.05	3.14	1.50	bdl	bdl	1.99	100.6	0.00	0.00	100.6
X192 grain-D7	41.54	3.37	15.78	0.34	6.50	15.34	11.12	3.12	1.48	bdl	bdl	2.01	100.6	0.00	0.00	100.6
X192 grain-D8	41.25	3.44	15.81	0.43	6.30	15.56	11.33	3.24	1.39	bdl	bdl	2.00	100.7	0.00	0.00	100.7
X192 grain-D9	41.44	3.44	15.75	0.45	6.27	15.90	11.14	3.18	1.40	bdl	bdl	2.00	101.0	0.00	0.00	101.0
X192 grain-D10	41.41	3.28	15.63	0.38	6.23	16.06	11.06	3.08	1.43	bdl	bdl	2.05	100.6	0.00	0.00	100.6
X192 grain-D AVG	41.59	3.49	15.50	0.27	6.67	15.48	10.92	3.27	1.39	bdl	bdl	2.02	100.6	0.00	0.00	100.6

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X192 ALL AVG	41.42	3.46	15.63	0.36	6.36	15.93	11.03	2.99	1.40	bdl	bdl	2.02	100.6	0.00	0.00	100.6
X229 grain-B1	40.89	2.34	15.73	bdl	7.00	16.25	11.66	2.58	0.90	bdl	bdl	1.99	99.35	0.00	0.00	99.35
X229 grain-B2	40.86	2.45	15.98	0.10	7.10	16.20	11.65	2.51	0.88	bdl	bdl	2.00	99.73	0.00	0.00	99.73
X229 grain-B3	41.31	2.45	15.84	0.10	6.67	16.36	11.69	2.61	0.92	bdl	bdl	2.01	99.94	0.00	0.00	99.94
X229 grain-B4	41.42	2.46	15.73	bdl	7.07	16.43	11.64	2.58	0.88	bdl	bdl	2.02	100.2	0.00	0.00	100.2
X229 grain-B5	41.06	2.54	16.10	0.12	7.00	16.06	11.57	2.33	1.16	0.20	bdl	1.98	100.1	0.00	0.00	100.1
X229 grain-B6	41.10	2.55	15.84	bdl	7.02	16.10	11.73	2.41	1.13	bdl	bdl	2.04	99.92	0.00	0.00	99.92
X229 grain-B7	40.92	2.63	15.90	0.12	6.94	15.95	11.79	2.30	1.28	bdl	bdl	2.00	99.81	0.00	0.00	99.81
X229 grain-B8	41.25	2.63	15.80	0.16	6.68	15.95	11.64	2.22	1.24	bdl	bdl	2.03	99.59	0.00	0.00	99.59
X229 grain-B9	41.04	2.61	16.05	bdl	6.86	16.09	11.77	2.28	1.12	0.21	bdl	1.98	100.0	0.01	0.45	100.5
X229 grain-B10	41.16	2.52	16.04	0.11	6.81	16.22	11.79	2.43	1.03	bdl	bdl	2.01	100.1	0.00	0.00	100.1
X229 grain-B11	40.86	2.59	15.87	0.11	6.90	15.96	11.80	2.42	1.14	bdl	bdl	2.01	99.64	0.00	0.00	99.64
X229 grain-B12	41.06	2.45	15.92	0.12	6.89	16.17	11.62	2.44	1.07	bdl	bdl	2.01	99.74	0.00	0.00	99.74
X229 grain-B13	41.53	2.34	15.75	0.11	6.97	16.15	11.81	2.45	0.86	bdl	bdl	2.04	100.0	0.00	0.00	100.0
X229 grain-B14	41.35	2.42	16.02	bdl	7.02	16.21	11.82	2.54	0.96	bdl	bdl	2.03	100.4	0.00	0.00	100.4
X229 grain-B AVG	41.13	2.50	15.90	0.11	6.92	16.15	11.71	2.44	1.04	bdl	bdl	2.01	99.91	0.00	0.00	99.91
X229 grain-E1	40.98	2.74	15.65	bdl	6.85	16.12	11.79	2.37	0.96	bdl	bdl	1.99	99.45	0.00	0.00	99.45
X229 grain-E2	41.26	2.93	15.64	bdl	6.85	16.03	11.67	2.30	1.29	bdl	bdl	2.04	99.99	0.00	0.00	99.99
X229 grain-E3	40.83	2.96	15.57	bdl	7.09	16.05	11.57	2.35	1.25	bdl	bdl	2.02	99.69	0.00	0.00	99.69
X229 grain-E4	41.10	3.01	15.66	bdl	7.00	16.01	11.55	2.33	1.27	0.19	bdl	1.99	100.1	0.00	0.00	100.1
X229 grain-E5	40.97	2.96	15.68	bdl	6.88	16.04	11.48	2.29	1.26	bdl	bdl	2.07	99.64	0.00	0.00	99.64

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X229 grain-E6	40.92	2.83	15.73	bdl	6.91	15.92	11.66	2.31	1.16	bdl	bdl	2.01	99.45	0.00	0.00	99.45
X229 grain-E7	41.30	2.73	15.74	bdl	6.94	15.88	11.73	2.29	1.16	0.19	bdl	1.99	99.95	0.00	0.45	100.4
X229 grain-E8	40.92	2.80	15.73	0.11	6.89	15.95	11.80	2.31	1.17	bdl	bdl	2.04	99.70	0.00	0.00	99.70
X229 grain-E9	41.17	2.66	15.83	bdl	6.97	15.98	11.70	2.51	1.20	bdl	bdl	2.01	100.0	0.00	0.00	100.0
X229 grain-E10	41.10	2.69	15.77	bdl	6.99	15.88	11.78	2.37	1.12	bdl	bdl	1.99	99.69	0.00	0.00	99.69
X229 grain-E11	41.26	2.60	15.87	0.12	7.07	16.08	11.83	2.32	1.02	bdl	bdl	2.02	100.2	0.00	0.00	100.2
X229 grain-E12	41.65	2.61	15.73	bdl	6.93	16.27	11.61	2.38	0.93	bdl	bdl	2.04	100.1	0.00	0.00	100.1
X229 grain-E13	41.15	2.57	15.87	bdl	6.94	16.31	11.54	2.65	0.96	bdl	bdl	2.03	100.0	0.00	0.00	100.0
X229 grain-E14	41.51	2.56	15.88	0.10	7.02	16.11	11.52	2.47	0.91	bdl	bdl	2.01	100.1	0.00	0.00	100.1
X229 grain-E AVG	41.15	2.76	15.74	bdl	6.95	16.04	11.66	2.38	1.12	bdl	bdl	2.02	99.82	0.00	0.00	99.82
X229 ALL AVG	41.14	2.63	15.82	bdl	6.94	16.10	11.69	2.41	1.08	bdl	bdl	1.77	99.58	0.00	0.00	99.58
X286 grain-A1	42.33	2.98	14.73	0.26	7.57	15.60	11.19	2.85	0.96	bdl	bdl	2.02	100.5	0.00	0.00	100.5
X286 grain-A2	41.44	3.07	15.19	0.37	6.65	15.73	11.48	2.37	1.24	bdl	bdl	2.00	99.54	0.00	0.00	99.54
X286 grain-A3	41.89	3.03	14.96	0.32	7.11	15.67	11.34	2.61	1.10	bdl	bdl	2.01	100.0	0.00	0.00	100.0
X286 grain-A4	41.35	3.79	15.15	0.23	8.33	14.82	10.64	2.86	1.37	bdl	bdl	2.04	100.6	0.00	0.00	100.6
X286 grain-A5	41.77	3.50	14.96	0.21	8.23	14.54	10.72	2.61	1.36	bdl	bdl	1.99	99.89	0.00	0.00	99.89
X286 grain-A6	41.66	3.56	14.98	0.14	8.09	14.87	10.80	2.83	1.32	bdl	bdl	2.06	100.3	0.00	0.00	100.3
X286 grain-A7	41.85	3.55	14.98	0.12	7.85	14.77	10.96	2.79	1.30	bdl	bdl	2.01	100.2	0.00	0.00	100.2
X286 grain-A8	41.69	3.33	14.84	0.19	7.76	14.88	11.09	2.97	1.10	bdl	bdl	2.01	99.86	0.00	0.00	99.86
X286 grain-A AVG	41.67	3.54	14.98	0.18	8.05	14.78	10.84	2.81	1.29	bdl	bdl	2.02	100.2	0.00	0.00	100.2
X286 ALL AVG	41.78	3.28	14.97	0.25	7.58	15.22	11.09	2.71	1.20	bdl	bdl	1.69	99.77	0.00	0.00	99.77

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X297 grain-A1	41.22	2.90	15.21	0.32	6.64	16.20	11.54	0.12	1.15	bdl	bdl	1.99	97.29	0.00	0.00	97.29
X297 grain-A2	41.49	2.62	15.26	0.30	6.50	16.35	11.63	2.22	1.31	bdl	bdl	2.00	99.68	0.00	0.00	99.68
X297 grain-A3	41.36	2.76	15.24	0.31	6.57	16.28	11.59	1.17	1.23	bdl	bdl	2.00	98.49	0.00	0.00	98.49
X297 grain-A4	41.85	2.52	15.50	0.33	6.90	16.12	11.57	2.31	1.21	bdl	bdl	2.03	100.3	0.00	0.00	100.3
X297 grain-A5	41.49	2.51	15.18	0.28	6.75	16.33	11.29	2.25	1.21	bdl	bdl	2.00	99.29	0.00	0.00	99.29
X297 grain-A6	41.86	2.46	15.36	0.34	6.69	16.20	11.50	2.23	1.33	bdl	bdl	2.03	100.0	0.00	0.00	100.0
X297 grain-A7	41.34	2.55	15.35	0.38	6.49	16.33	11.35	2.34	1.23	bdl	bdl	1.98	99.34	0.00	0.00	99.34
X297 grain-A8	41.86	2.18	15.49	0.42	6.87	16.56	11.52	2.66	0.46	bdl	bdl	2.00	100.0	0.00	0.00	100.0
X297 grain-A AVG	41.68	2.44	15.38	0.35	6.74	16.31	11.45	2.36	1.09	bdl	bdl	2.01	99.79	0.00	0.00	99.79
X297 grain-J1	41.38	2.74	15.28	0.29	6.43	16.28	11.47	2.25	1.07	bdl	bdl	2.04	99.23	0.00	0.00	99.23
X297 grain-J2	41.19	2.81	15.34	0.38	6.84	16.28	11.65	2.39	1.07	bdl	bdl	2.00	99.93	0.00	0.00	99.93
X297 grain-J3	41.37	2.87	15.43	0.35	6.63	16.21	11.48	2.37	1.07	bdl	bdl	2.01	99.79	0.00	0.00	99.79
X297 grain-J4	41.09	2.85	15.32	0.37	6.44	16.31	11.70	2.27	1.16	bdl	bdl	1.99	99.49	0.00	0.00	99.49
X297 grain-J5	41.08	2.86	15.43	0.37	6.62	16.01	11.61	2.26	1.17	bdl	bdl	1.99	99.40	0.00	0.00	99.40
X297 grain-J6	41.51	2.85	15.55	0.33	6.60	16.14	11.63	2.38	1.18	bdl	bdl	2.04	100.2	0.00	0.00	100.2
X297 grain-J7	41.36	2.77	15.52	0.29	6.81	16.28	11.52	2.55	1.19	0.20	bdl	1.99	100.5	0.08	0.00	100.4
X297 grain-J8	41.15	2.79	15.47	0.41	6.69	16.24	11.56	2.38	1.20	bdl	bdl	2.04	99.91	0.00	0.00	99.91
X297 grain-J9	41.26	2.74	15.32	0.31	6.65	16.41	11.40	2.41	1.26	0.21	bdl	1.98	99.94	0.09	0.00	99.85
X297 grain-J10	41.37	2.70	15.36	0.34	6.67	16.43	11.56	2.25	1.27	bdl	bdl	2.03	99.98	0.00	0.00	99.98
X297 grain-J11	41.34	2.59	15.31	0.39	6.45	16.34	11.62	2.50	1.27	bdl	bdl	2.00	99.81	0.00	0.00	99.81
X297 grain-J12	41.28	2.59	15.01	0.37	6.59	16.40	11.41	2.36	1.27	bdl	bdl	2.01	99.28	0.00	0.00	99.28

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X297 grain-J13	41.57	2.59	15.15	0.37	6.78	16.43	11.70	2.32	1.34	bdl	bdl	2.00	100.3	0.00	0.00	100.3
X297 grain-J14	41.55	2.63	15.20	0.39	6.62	16.53	11.67	2.32	1.32	bdl	bdl	2.02	100.2	0.00	0.00	100.2
X297 grain-J15	41.49	2.62	15.28	0.31	6.49	16.36	11.55	2.34	1.31	bdl	bdl	2.00	99.74	0.00	0.00	99.74
X297 grain-J16	41.69	2.61	15.14	0.31	6.41	16.41	11.51	2.28	1.31	bdl	bdl	2.04	99.70	0.00	0.00	99.70
X297 grain-J17	41.78	2.57	15.14	0.31	6.71	16.32	11.29	2.32	1.28	0.20	bdl	1.99	99.89	0.09	0.00	99.80
X297 grain-J18	41.55	2.60	15.26	0.33	6.47	16.56	11.55	2.50	1.24	0.24	bdl	1.97	100.3	0.00	0.44	100.7
X297 grain-J19	41.42	2.63	15.34	0.39	6.40	16.38	11.50	2.44	1.30	0.21	bdl	1.98	99.98	0.09	0.00	99.89
X297 grain-J AVG	41.39	2.71	15.31	0.35	6.59	16.33	11.54	2.36	1.22	bdl	bdl	2.01	99.81	0.00	0.00	99.81
X297 ALL AVG	41.48	2.64	15.31	0.33	6.63	16.30	11.53	1.96	1.18	bdl	bdl	1.77	99.13	0.00	0.00	99.13
X299 grain-A AVG	41.87	1.94	15.76	0.46	6.85	16.39	11.33	2.75	0.37	bdl	bdl	2.04	99.76	0.00	0.00	99.76
X299 grain-B AVG	42.24	2.20	15.61	0.27	6.70	16.33	11.61	2.53	0.69	bdl	bdl	2.04	100.2	0.00	0.00	100.2
X299 grain-C AVG	42.07	2.10	15.57	0.24	6.55	16.55	11.46	2.74	0.61	bdl	bdl	2.03	99.92	0.00	0.00	99.92
X299 ALL AVG	42.06	2.08	15.65	0.32	6.70	16.42	11.47	2.67	0.56	bdl	bdl	1.85	99.78	0.00	0.00	99.78
X319 grain-A1	41.23	2.73	15.60	0.23	6.11	16.36	11.71	2.63	1.21	bdl	bdl	2.03	99.86	0.00	0.00	99.86
X319 grain-A2	41.08	2.78	15.67	0.20	6.26	16.68	11.57	2.71	1.18	bdl	bdl	2.06	100.2	0.00	0.00	100.2
X319 grain-A3	41.53	2.80	15.61	0.25	6.10	16.44	11.75	2.69	1.12	bdl	bdl	2.03	100.3	0.00	0.00	100.3
X319 grain-A4	41.37	2.82	15.43	0.27	6.28	16.28	11.83	2.64	1.23	bdl	bdl	2.03	100.2	0.00	0.00	100.2
X319 grain-A5	41.46	2.70	15.55	0.28	6.13	16.62	11.69	2.66	1.18	bdl	bdl	2.05	100.3	0.00	0.00	100.3
X319 grain-A6	41.74	2.71	15.40	0.31	6.16	16.69	11.74	2.76	1.16	bdl	bdl	2.05	100.7	0.00	0.00	100.7
X319 grain-A7	41.68	2.70	15.04	0.24	6.02	16.76	11.70	2.71	1.08	bdl	bdl	2.04	99.97	0.00	0.00	99.97
X319 grain-A8	41.57	2.64	15.19	0.23	6.50	16.58	11.68	2.83	1.15	bdl	bdl	2.03	100.4	0.00	0.00	100.4

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X319 grain-A9	41.12	2.70	15.66	0.34	6.08	16.49	11.66	2.72	1.21	bdl	bdl	2.04	100.0	0.00	0.00	100.0
X319 grain-A10	41.51	2.66	15.27	0.32	6.27	16.89	11.73	2.89	1.07	bdl	bdl	2.09	100.7	0.00	0.00	100.7
X319 grain-A AVG	41.43	2.72	15.44	0.27	6.19	16.58	11.71	2.72	1.16	bdl	bdl	2.05	100.3	0.00	0.00	100.3
X319 grain-B1	41.24	2.71	15.39	0.22	6.21	16.64	11.62	2.84	1.06	bdl	bdl	2.02	99.94	0.00	0.00	99.94
X319 grain-B2	41.55	2.69	15.29	0.32	6.05	16.85	11.80	2.83	1.06	bdl	bdl	2.06	100.5	0.00	0.00	100.5
X319 grain-B3	41.38	2.76	15.40	0.29	6.12	16.64	11.65	2.90	1.08	bdl	bdl	2.04	100.3	0.00	0.00	100.3
X319 grain-B4	41.34	2.58	15.55	0.32	6.20	16.50	11.43	2.68	1.02	bdl	bdl	2.02	99.63	0.00	0.00	99.63
X319 grain-B5	40.94	2.63	15.34	0.29	6.19	16.72	11.67	2.72	1.08	bdl	bdl	2.05	99.63	0.00	0.00	99.63
X319 grain-B6	40.91	2.56	15.33	0.24	5.83	16.81	11.71	2.81	1.06	bdl	bdl	2.06	99.31	0.00	0.00	99.31
X319 grain-B7	41.18	2.71	15.46	0.23	6.32	16.67	11.62	2.88	0.98	bdl	bdl	2.03	100.1	0.00	0.00	100.1
X319 grain-B8	40.94	2.62	15.54	0.30	6.23	16.60	11.68	2.85	1.02	bdl	bdl	2.03	99.79	0.00	0.00	99.79
X319 grain-B9	40.82	2.53	15.11	0.24	6.19	16.47	11.41	2.76	0.90	bdl	bdl	2.03	98.46	0.00	0.00	98.46
X319 grain-B AVG	41.14	2.64	15.38	0.27	6.15	16.66	11.62	2.81	1.03	bdl	bdl	2.04	99.73	0.00	0.00	99.73
X319 grain-C1	41.08	2.80	15.50	0.22	6.16	16.80	11.64	2.73	1.20	bdl	bdl	2.05	100.2	0.00	0.00	100.2
X319 grain-C2	41.30	2.82	15.55	0.31	5.92	16.44	11.62	2.62	1.24	bdl	bdl	2.00	99.81	0.00	0.00	99.81
X319 grain-C3	41.30	2.88	15.38	0.29	6.03	16.54	11.70	2.67	1.25	bdl	bdl	2.01	100.0	0.00	0.00	100.0
X319 grain-C4	41.00	2.89	15.43	0.35	6.25	16.47	11.65	2.73	1.34	bdl	bdl	2.04	100.1	0.00	0.00	100.1
X319 grain-C5	41.14	2.81	15.44	0.33	6.17	16.38	11.71	2.73	1.22	bdl	bdl	2.01	99.94	0.00	0.00	99.94
X319 grain-C6	40.88	2.99	15.38	0.29	5.90	16.47	11.71	2.75	1.27	bdl	bdl	2.01	99.63	0.00	0.00	99.63
X319 grain-C7	41.25	2.97	15.31	0.26	6.11	16.50	11.82	2.66	1.21	bdl	bdl	2.02	100.1	0.00	0.00	100.1
X319 grain-C8	41.06	2.94	15.37	0.26	6.30	16.55	11.82	2.63	1.22	bdl	bdl	2.00	100.1	0.00	0.00	100.1

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
X319 grain-C9	40.79	2.97	15.25	0.29	6.29	16.32	11.69	2.80	1.32	bdl	bdl	2.01	99.73	0.00	0.00	99.73
X319 grain-C10	40.97	3.04	15.28	0.29	6.12	16.79	11.60	2.47	1.35	bdl	bdl	1.98	99.88	0.00	0.00	99.88
X319 grain-C AVG	41.08	2.91	15.39	0.29	6.13	16.52	11.70	2.68	1.26	bdl	bdl	2.01	99.96	0.00	0.00	99.96
X319 grain-D1	41.41	2.84	15.30	0.24	6.10	16.80	11.84	2.70	1.14	bdl	bdl	2.01	100.4	0.00	0.00	100.4
X319 grain-D2	40.95	2.85	15.57	0.31	6.45	16.49	11.76	2.55	1.40	bdl	bdl	2.02	100.4	0.00	0.00	100.4
X319 grain-D3	40.83	2.87	15.57	0.31	6.15	16.61	11.65	2.67	1.43	bdl	bdl	2.01	100.1	0.00	0.00	100.1
X319 grain-D4	41.12	2.89	15.47	0.32	6.26	16.44	11.44	2.40	1.41	bdl	bdl	2.01	99.75	0.00	0.00	99.75
X319 grain-D5	41.17	2.99	15.41	0.30	6.26	16.40	11.57	2.59	1.42	bdl	bdl	2.03	100.1	0.00	0.00	100.1
X319 grain-D6	41.03	2.79	15.33	0.26	6.10	16.58	11.87	2.79	1.30	bdl	bdl	2.02	100.0	0.00	0.00	100.0
X319 grain-D7	40.90	2.83	15.54	0.33	6.02	16.56	11.78	2.55	1.35	bdl	bdl	2.00	99.85	0.00	0.00	99.85
X319 grain-D8	41.11	2.88	15.50	0.23	6.15	16.72	11.86	2.78	1.18	bdl	bdl	2.03	100.4	0.00	0.00	100.4
X319 grain-D9	41.62	2.87	15.30	0.21	6.24	16.70	11.64	2.77	1.19	bdl	bdl	2.05	100.6	0.00	0.00	100.6
X319 grain-D10	41.25	2.82	15.19	0.31	6.16	16.70	11.71	2.70	1.12	bdl	bdl	2.03	99.98	0.00	0.00	99.98
X319 grain-D AVG	41.14	2.86	15.42	0.28	6.19	16.60	11.71	2.65	1.29	bdl	bdl	2.02	100.2	0.00	0.00	100.2
X319 ALL AVG	41.20	2.79	15.41	0.28	6.16	16.59	11.68	2.71	1.18	bdl	bdl	2.03	100.0	0.00	0.00	100.0
Ba-1-72 grain-A1	42.74	1.20	15.33	1.21	5.28	17.35	10.59	3.24	0.95	0.23	bdl	1.99	100.1	0.10	0.00	100.0
Ba-1-72 grain-A2	42.81	1.15	15.63	1.33	5.39	17.17	10.60	3.22	0.98	0.22	bdl	2.00	100.5	0.09	0.00	100.4
Ba-1-72 grain-A3	42.75	1.10	15.64	1.27	5.52	17.12	10.71	3.31	0.94	0.27	bdl	1.98	100.6	0.11	0.00	100.5
Ba-1-72 grain-A4	42.68	1.13	15.62	1.15	5.40	17.43	10.67	3.18	0.87	0.29	bdl	1.97	100.4	0.12	0.00	100.3
Ba-1-72 grain-A5	43.05	1.18	15.40	1.20	5.30	17.33	10.77	3.16	0.92	0.23	bdl	2.00	100.5	0.10	0.00	100.4
Ba-1-72 grain-A AVG	42.81	1.15	15.52	1.23	5.37	17.28	10.67	3.22	0.93	0.25	bdl	1.99	100.4	0.10	0.00	100.3

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
Ba-1-72 grain-B1	42.75	1.47	15.69	0.94	5.28	17.35	10.81	3.33	0.64	0.20	bdl	2.02	100.5	0.08	0.00	100.4
Ba-1-72 grain-B2	42.63	1.42	15.65	1.02	5.26	17.12	10.74	3.34	0.61	0.25	bdl	1.98	100.0	0.10	0.00	99.92
Ba-1-72 grain-B3	42.73	1.40	15.59	1.07	5.30	17.18	10.70	3.40	0.65	bdl	bdl	2.05	100.0	0.00	0.00	100.0
Ba-1-72 grain-B4	42.75	1.42	15.66	1.14	5.29	17.48	10.81	3.44	0.66	0.23	bdl	2.01	100.9	0.10	0.00	100.8
Ba-1-72 grain-B5	43.08	1.43	15.56	1.07	5.14	17.55	10.75	3.45	0.62	bdl	bdl	2.04	100.7	0.00	0.00	100.7
Ba-1-72 grain-B AVG	42.79	1.43	15.63	1.05	5.25	17.34	10.76	3.39	0.64	0.19	bdl	2.02	100.5	0.08	0.00	100.4
Ba-1-72 grain-C1	42.82	1.69	15.56	0.88	5.41	17.22	10.69	3.39	0.58	bdl	bdl	2.07	100.3	0.00	0.00	100.3
Ba-1-72 grain-C2	42.87	1.70	15.34	0.95	5.26	17.44	10.69	3.37	0.63	0.22	bdl	1.81	100.3	0.09	0.00	100.2
Ba-1-72 grain-C3	43.11	1.62	15.46	1.00	5.02	17.27	10.59	3.42	0.60	bdl	bdl	2.04	100.1	0.00	0.00	100.1
Ba-1-72 grain-C4	42.90	1.70	15.57	0.88	5.21	17.33	10.72	3.45	0.62	bdl	bdl	2.03	100.4	0.00	0.00	100.4
Ba-1-72 grain-C5	43.01	1.71	15.55	0.94	5.33	17.35	10.81	3.31	0.63	bdl	bdl	2.03	100.7	0.00	0.00	100.7
Ba-1-72 grain-C6	42.97	1.62	15.53	0.98	5.17	17.39	10.75	3.37	0.61	bdl	bdl	2.04	100.4	0.00	0.00	100.4
Ba-1-72 grain-C7	43.04	1.69	15.57	1.03	5.14	17.43	10.67	3.43	0.61	0.28	bdl	1.99	100.8	0.12	0.00	100.7
Ba-1-72 grain-C8	42.73	1.71	15.55	0.96	5.17	17.35	10.59	3.46	0.65	0.21	bdl	2.01	100.4	0.09	0.00	100.3
Ba-1-72 grain-C9	42.84	1.67	15.56	1.06	5.21	17.36	10.62	3.40	0.60	0.19	bdl	2.02	100.5	0.08	0.00	100.5
Ba-1-72 grain-C10	43.01	1.68	15.52	0.99	5.10	17.41	10.85	3.46	0.60	0.20	bdl	2.02	100.8	0.09	0.00	100.8
Ba-1-72 grain-C11	42.67	1.64	15.69	0.87	5.30	17.44	10.68	3.38	0.64	0.22	bdl	2.01	100.5	0.09	0.00	100.4
Ba-1-72 grain-C AVG	42.90	1.68	15.53	0.96	5.21	17.36	10.70	3.40	0.61	0.19	bdl	2.01	100.6	0.08	0.00	100.5
Ba-1-72 ALL AVG	42.83	1.42	15.56	1.08	5.28	17.33	10.71	3.34	0.73	0.21	bdl	1.84	100.3	0.09	0.00	100.2
Ba2-1-1 grain-A1	43.55	1.67	15.49	1.10	4.33	17.72	10.59	3.76	0.06	bdl	bdl	2.10	100.4	0.00	0.00	100.4
Ba2-1-1 grain-A2	43.43	1.65	15.66	1.03	4.38	17.99	10.38	3.75	0.06	bdl	bdl	2.11	100.4	0.00	0.00	100.4

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
Ba2-1-1 grain-A3	43.69	1.66	15.61	1.08	4.33	17.90	10.73	3.85	0.07	bdl	bdl	2.12	101.0	0.00	0.00	101.0
Ba2-1-1 grain-A4	43.24	1.71	15.56	1.14	4.40	17.86	10.58	3.85	0.05	bdl	bdl	2.11	100.5	0.00	0.00	100.5
Ba2-1-1 grain-A5	43.54	1.73	15.46	1.14	4.24	17.87	10.51	3.79	0.06	bdl	bdl	2.11	100.5	0.00	0.00	100.5
Ba2-1-1 grain-A6	43.61	1.73	15.64	1.05	4.24	17.87	10.72	3.76	0.07	bdl	bdl	2.12	100.8	0.00	0.00	100.8
Ba2-1-1 grain-A7	43.40	1.74	15.70	1.14	4.35	17.79	10.78	3.80	0.06	bdl	bdl	2.12	100.9	0.00	0.00	100.9
Ba2-1-1 grain-A8	42.94	1.68	15.56	1.06	4.36	17.88	10.66	3.89	0.06	bdl	bdl	2.10	100.2	0.00	0.00	100.2
Ba2-1-1 grain-A9	43.38	1.76	15.56	1.11	4.10	17.84	10.59	3.80	0.06	bdl	bdl	2.10	100.3	0.00	0.00	100.3
Ba2-1-1 grain-A10	43.51	1.68	15.52	1.09	4.45	17.86	10.44	3.57	0.10	bdl	bdl	2.08	100.3	0.00	0.00	100.3
Ba2-1-1 grain-A AVG	43.43	1.70	15.58	1.09	4.32	17.86	10.60	3.78	0.06	bdl	bdl	2.11	100.5	0.00	0.00	100.5
Ba2-1-1 grain-B1	43.52	1.74	15.67	1.11	4.48	17.85	10.55	3.50	0.05	bdl	bdl	2.11	100.6	0.00	0.00	100.6
Ba2-1-1 grain-B2	43.29	1.76	15.69	1.05	4.59	17.97	10.48	3.83	0.05	bdl	bdl	2.07	100.8	0.00	0.00	100.8
Ba2-1-1 grain-B3	43.06	1.68	15.61	1.06	4.28	17.93	10.66	3.83	0.04	bdl	bdl	2.12	100.3	0.00	0.00	100.3
Ba2-1-1 grain-B4	43.50	1.70	15.63	1.11	4.37	17.91	10.60	3.70	0.05	bdl	bdl	2.09	100.6	0.00	0.00	100.6
Ba2-1-1 grain-B5	43.30	1.75	15.61	1.07	4.32	18.07	10.52	3.77	0.05	bdl	bdl	2.11	100.6	0.00	0.00	100.6
Ba2-1-1 grain-B6	43.13	1.78	15.77	1.02	4.39	17.88	10.62	3.85	0.03	bdl	bdl	2.11	100.6	0.00	0.00	100.6
Ba2-1-1 grain-B7	42.98	1.76	15.79	1.06	4.41	17.93	10.45	3.74	0.07	bdl	bdl	2.09	100.3	0.00	0.00	100.3
Ba2-1-1 grain-B8	43.16	1.73	15.73	1.12	4.35	17.88	10.53	3.70	0.04	bdl	bdl	2.13	100.4	0.00	0.00	100.4
Ba2-1-1 grain-B9	43.20	1.69	15.81	1.19	4.34	17.87	10.68	3.78	0.03	bdl	bdl	2.13	100.7	0.00	0.00	100.7
Ba2-1-1 grain-B10	43.28	1.73	15.58	1.10	4.24	17.99	10.61	3.96	0.03	bdl	bdl	2.13	100.6	0.00	0.00	100.6
Ba2-1-1 grain-B AVG	43.24	1.73	15.69	1.09	4.38	17.93	10.57	3.77	0.04	bdl	bdl	2.11	100.5	0.00	0.00	100.5
Ba2-1-1 grain-C1	42.77	1.76	15.61	1.06	4.35	17.94	10.38	3.77	0.05	bdl	bdl	2.11	99.80	0.00	0.00	99.80

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
Ba2-1-1 grain-C2	42.62	1.75	15.57	1.15	4.41	17.96	10.54	3.75	0.05	bdl	bdl	2.10	99.91	0.00	0.00	99.91
Ba2-1-1 grain-C3	43.00	1.71	15.56	1.03	4.36	17.86	10.49	3.80	0.05	bdl	bdl	2.10	99.96	0.00	0.00	99.96
Ba2-1-1 grain-C4	43.29	1.85	15.51	1.15	4.32	17.75	10.61	3.78	0.04	bdl	bdl	2.13	100.4	0.00	0.00	100.4
Ba2-1-1 grain-C5	43.50	1.76	15.43	1.15	4.29	17.92	10.58	3.76	0.05	bdl	bdl	2.08	100.5	0.00	0.00	100.5
EP-3-84 grain-A1	41.62	3.15	15.56	0.02	5.22	16.80	11.59	3.38	0.34	0.34	bdl	1.93	99.96	0.14	0.00	99.81
EP-3-84 grain-A2	41.76	3.36	15.80	0.01	5.42	16.58	11.53	3.51	0.37	0.33	bdl	1.95	100.6	0.14	0.00	100.5
EP-3-84 grain-A3	41.71	3.31	15.80	0.00	5.45	16.56	11.39	3.40	0.35	0.31	bdl	1.96	100.2	0.13	0.00	100.1
EP-3-84 grain-A4	41.54	3.22	15.79	0.03	5.34	16.67	11.54	3.41	0.48	0.32	bdl	1.94	100.3	0.13	0.00	100.1
EP-3-84 grain-A5	41.64	3.27	15.86	0.00	5.70	16.47	11.46	3.33	0.47	bdl	bdl	1.99	100.2	0.00	0.00	100.2
EP-3-84 grain-A6	41.57	3.29	15.77	0.04	5.33	16.57	11.29	3.36	0.43	0.33	bdl	1.94	99.92	0.14	0.00	99.78
EP-3-84 grain-A7	41.87	3.32	15.69	0.00	5.47	16.62	11.63	3.37	0.47	0.36	bdl	1.94	100.7	0.15	0.00	100.6
EP-3-84 grain-A8	41.82	3.21	15.84	0.00	5.44	16.72	11.40	3.42	0.41	0.35	bdl	1.94	100.5	0.15	0.00	100.4
EP-3-84 grain-A9	41.75	3.31	15.79	0.05	5.30	16.65	11.30	3.31	0.35	0.38	bdl	1.92	100.1	0.16	0.00	99.95
EP-3-84 grain-A10	41.79	3.26	15.85	0.01	5.40	16.62	11.53	3.33	0.38	0.27	bdl	1.98	100.4	0.11	0.00	100.3
EP-3-84 grain-A AVG	41.71	3.27	15.77	0.02	5.41	16.63	11.46	3.38	0.41	0.30	bdl	1.95	100.3	0.13	0.00	100.2
EP-3-84 grain-B1	41.99	3.39	15.44	0.00	5.45	16.69	11.49	3.27	0.42	0.32	bdl	1.95	100.4	0.14	0.00	100.3
EP-3-84 grain-B2	41.54	3.48	15.65	0.02	5.73	16.66	11.38	3.29	0.47	0.40	bdl	1.91	100.5	0.17	0.00	100.4
EP-3-84 grain-B3	41.65	3.52	15.58	0.00	5.66	16.61	11.26	3.35	0.55	0.38	bdl	1.92	100.5	0.16	0.00	100.3
EP-3-84 grain-B4	41.87	3.57	15.66	0.00	5.66	16.61	11.30	3.28	0.51	0.31	bdl	1.97	100.7	0.13	0.00	100.6
EP-3-84 grain-B5	41.52	3.49	15.71	0.04	5.61	16.72	11.20	3.33	0.49	0.33	bdl	1.94	100.4	0.14	0.00	100.2
EP-3-84 grain-B6	41.62	3.37	15.70	0.02	5.62	16.46	11.42	3.30	0.44	0.35	bdl	1.94	100.2	0.15	0.00	100.1

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
EP-3-84 grain-B7	41.96	3.38	15.78	0.01	5.66	16.80	11.17	3.38	0.41	0.36	bdl	1.93	100.8	0.15	0.00	100.7
EP-3-84 grain-B8	41.66	3.29	15.85	0.00	5.65	16.52	11.53	3.28	0.40	0.39	bdl	1.91	100.5	0.16	0.00	100.3
EP-3-84 grain-B9	41.78	3.40	15.74	0.01	5.59	16.52	11.10	3.34	0.48	0.32	bdl	1.95	100.2	0.13	0.00	100.1
EP-3-84 grain-B10	41.59	3.28	15.41	0.00	5.49	16.90	11.25	3.40	0.38	0.31	bdl	1.95	99.96	0.13	0.00	99.83
EP-3-84 grain-B AVG	41.72	3.42	15.65	0.01	5.61	16.65	11.31	3.32	0.45	0.35	bdl	1.94	100.4	0.15	0.00	100.3
EP-3-84 grain-C1	41.52	3.33	15.48	0.01	5.56	16.65	11.48	3.15	0.45	0.32	bdl	1.94	99.88	0.14	0.00	99.74
EP-3-84 grain-C2	41.55	3.49	15.53	0.00	5.59	16.51	11.57	3.37	0.48	0.34	bdl	1.94	100.4	0.14	0.00	100.2
EP-3-84 grain-C3	41.10	3.92	15.54	0.01	5.45	16.74	11.59	2.98	0.43	0.44	bdl	1.88	100.1	0.18	0.00	99.90
EP-3-84 grain-C4	41.67	3.43	15.68	0.00	5.51	16.76	11.40	3.31	0.47	0.30	bdl	1.96	100.5	0.13	0.00	100.4
EP-3-84 grain-C5	41.56	3.41	15.52	0.01	5.63	16.68	11.47	3.07	0.51	0.32	bdl	1.95	100.1	0.13	0.00	99.98
EP-3-84 grain-C6	41.66	3.42	15.63	0.00	5.66	16.54	11.38	3.00	0.53	0.25	bdl	1.98	100.0	0.10	0.00	99.94
EP-3-84 grain-C7	41.64	3.28	15.64	0.01	5.72	16.67	11.47	3.28	0.51	0.42	bdl	1.90	100.5	0.18	0.00	100.4
EP-3-84 grain-C8	41.27	3.46	15.60	0.01	5.72	16.59	11.45	3.26	0.58	0.36	bdl	1.92	100.2	0.15	0.00	100.1
EP-3-84 grain-C9	41.45	3.39	15.50	0.00	5.58	16.43	11.53	3.16	0.59	0.38	bdl	1.91	99.91	0.16	0.00	99.75
EP-3-84 grain-C10	41.75	3.45	15.53	0.01	5.35	16.62	11.40	3.37	0.49	0.36	bdl	1.92	100.3	0.15	0.00	100.1
EP-3-84 grain-C AVG	41.52	3.46	15.56	0.01	5.58	16.62	11.47	3.19	0.50	0.35	bdl	1.93	100.2	0.15	0.00	100.0
EP-3-84 ALL AVG	41.65	3.38	15.66	0.01	5.53	16.63	11.42	3.30	0.45	0.33	bdl	1.94	100.3	0.14	0.00	100.2
TF6 grain-A1	43.21	0.25	15.24	1.50	4.15	18.56	11.59	3.17	0.45	bdl	bdl	2.11	100.2	0.00	0.00	100.2
TF6 grain-A2	43.29	0.23	14.97	1.43	4.15	18.69	11.30	3.23	0.43	bdl	bdl	2.11	99.82	0.00	0.00	99.82
TF6 grain-A3	43.77	0.28	15.19	1.21	4.26	18.90	11.34	3.13	0.44	bdl	bdl	2.13	100.6	0.00	0.00	100.6
TF6 grain-A4	43.77	0.28	14.90	1.26	4.20	18.65	11.25	3.16	0.41	bdl	bdl	2.10	99.97	0.00	0.00	99.97

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
TF6 grain-A5	43.65	0.29	15.01	1.32	4.20	18.91	11.30	3.26	0.38	bdl	bdl	2.13	100.4	0.00	0.00	100.4
TF6 grain-A6	43.37	0.26	14.84	1.31	4.14	18.91	11.34	3.17	0.44	bdl	bdl	2.12	99.90	0.00	0.00	99.90
TF6 grain-A7	43.69	0.29	15.11	1.26	4.11	18.78	11.26	3.32	0.46	bdl	bdl	2.12	100.4	0.00	0.00	100.4
TF6 grain-A8	43.38	0.31	15.06	1.27	4.06	18.77	11.46	3.26	0.47	bdl	bdl	2.12	100.1	0.00	0.00	100.1
TF6 grain-A9	43.52	0.25	15.30	1.22	3.82	18.79	11.41	3.20	0.46	bdl	bdl	2.12	100.1	0.00	0.00	100.1
TF6 grain-A10	43.35	0.27	15.24	1.30	3.92	18.67	11.42	3.01	0.52	bdl	bdl	2.10	99.79	0.00	0.00	99.79
TF6 grain-A AVG	43.50	0.27	15.08	1.31	4.10	18.76	11.37	3.19	0.45	bdl	bdl	2.12	100.1	0.00	0.00	100.1
TF6 grain-B1	43.54	0.30	15.47	1.35	4.03	18.63	11.29	3.11	0.49	bdl	bdl	2.08	100.3	0.00	0.00	100.3
TF6 grain-B2	43.11	0.32	15.39	1.27	4.07	18.78	11.42	3.14	0.45	bdl	bdl	2.12	100.1	0.00	0.00	100.1
TF6 grain-B3	43.59	0.28	15.23	1.39	4.07	18.62	11.51	3.18	0.48	bdl	bdl	2.13	100.5	0.00	0.00	100.5
TF6 grain-B4	43.33	0.25	15.49	1.31	4.08	18.44	11.55	3.23	0.45	bdl	bdl	2.11	100.3	0.00	0.00	100.3
TF6 grain-B5	43.43	0.28	15.26	1.27	3.93	18.35	11.52	3.06	0.55	bdl	bdl	2.11	99.75	0.00	0.00	99.75
TF6 grain-B6	43.45	0.29	15.36	1.31	4.15	18.75	11.40	3.24	0.49	bdl	bdl	2.13	100.6	0.00	0.00	100.6
TF6 grain-B7	43.29	0.25	15.16	1.32	4.11	18.59	11.47	3.30	0.51	bdl	bdl	2.09	100.1	0.00	0.00	100.1
TF6 grain-B8	43.30	0.30	15.30	1.33	4.00	18.44	11.34	3.01	0.50	bdl	bdl	2.08	99.59	0.00	0.00	99.59
TF6 grain-B9	43.48	0.26	15.24	1.22	4.11	18.59	11.46	3.02	0.48	bdl	bdl	2.12	99.97	0.00	0.00	99.97
TF6 grain-B10	43.03	0.25	15.41	1.26	4.09	18.58	11.49	3.14	0.49	bdl	bdl	2.11	99.84	0.00	0.00	99.84
TF6 grain-B AVG	43.35	0.28	15.33	1.30	4.06	18.58	11.45	3.14	0.49	bdl	bdl	2.11	100.1	0.00	0.00	100.1
TF6 grain-C1	43.47	0.27	15.39	1.39	3.98	18.49	11.49	3.21	0.53	bdl	bdl	2.12	100.3	0.00	0.00	100.3
TF6 grain-C2	43.23	0.28	15.35	1.32	4.02	18.55	11.24	3.20	0.54	bdl	bdl	2.10	99.82	0.00	0.00	99.82
TF6 grain-C3	43.24	0.28	15.31	1.41	3.98	18.48	11.46	3.18	0.50	bdl	bdl	2.11	99.95	0.00	0.00	99.95

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
TF6 grain-C4	43.26	0.26	15.45	1.29	4.02	18.45	11.31	3.14	0.53	bdl	bdl	2.08	99.80	0.00	0.00	99.80
TF6 grain-C5	43.53	0.31	15.46	1.37	4.16	18.55	11.24	3.09	0.51	bdl	bdl	2.10	100.3	0.00	0.00	100.3
TF6 grain-C6	43.39	0.24	15.38	1.29	4.24	18.58	11.57	3.10	0.50	bdl	bdl	2.09	100.4	0.00	0.00	100.4
TF6 grain-C7	43.41	0.31	15.28	1.40	4.29	18.75	11.37	3.01	0.53	bdl	bdl	2.11	100.5	0.00	0.00	100.5
TF6 grain-C8	43.12	0.32	15.32	1.37	4.02	18.59	11.33	3.17	0.52	bdl	bdl	2.11	99.86	0.00	0.00	99.86
TF6 grain-C9	43.39	0.32	15.30	1.21	4.21	18.54	11.41	3.04	0.51	bdl	bdl	2.12	100.0	0.00	0.00	100.0
TF6 grain-C10	43.39	0.29	15.48	1.33	4.00	18.50	11.23	3.08	0.53	bdl	bdl	2.12	99.93	0.00	0.00	99.93
TF6 grain-C AVG	43.34	0.29	15.37	1.34	4.09	18.55	11.36	3.12	0.52	bdl	bdl	2.11	100.1	0.00	0.00	100.1
TF6 grain-D1	43.49	0.33	15.43	1.20	4.09	18.58	11.56	3.13	0.53	bdl	bdl	2.12	100.5	0.00	0.00	100.5
TF6 grain-D2	43.20	0.30	15.40	1.32	4.12	18.38	11.65	3.11	0.55	bdl	bdl	2.09	100.1	0.00	0.00	100.1
TF6 grain-D3	43.32	0.28	15.28	1.39	4.01	18.58	11.36	3.11	0.50	bdl	bdl	2.11	99.95	0.00	0.00	99.95
TF6 grain-D4	43.37	0.26	15.47	1.36	4.03	18.55	11.42	3.26	0.47	bdl	bdl	2.11	100.3	0.00	0.00	100.3
TF6 grain-D5	43.36	0.32	15.46	1.40	3.98	18.51	11.38	3.28	0.54	bdl	bdl	2.12	100.3	0.00	0.00	100.3
TF6 grain-D6	43.52	0.32	15.30	1.32	4.11	18.58	11.23	3.13	0.51	bdl	bdl	2.10	100.1	0.00	0.00	100.1
TF6 grain-D7	43.26	0.25	15.44	1.40	4.10	18.40	11.43	3.13	0.50	bdl	bdl	2.11	100.0	0.00	0.00	100.0
TF6 grain-D8	42.75	0.27	15.26	1.34	3.81	18.44	11.59	3.04	0.50	bdl	bdl	2.10	99.09	0.00	0.00	99.09
TF6 grain-D9	43.40	0.32	15.35	1.39	4.06	18.45	11.36	3.09	0.52	bdl	bdl	2.09	100.0	0.00	0.00	100.0
TF6 grain-D AVG	43.29	0.29	15.38	1.34	4.03	18.52	11.44	3.14	0.51	bdl	bdl	2.11	100.0	0.00	0.00	100.0
TF6 ALL AVG	43.38	0.28	15.29	1.32	4.07	18.59	11.41	3.16	0.49	bdl	bdl	2.11	100.1	0.00	0.00	100.1
JAG 84-524 grain-A1	46.03	0.14	10.36	2.13	2.70	20.06	10.29	3.50	1.24	bdl	bdl	1.99	98.45	0.00	0.00	98.45
JAG 84-524 grain-A2	46.03	0.16	10.79	2.11	2.81	19.67	10.19	3.83	1.25	0.30	bdl	1.94	99.09	0.12	0.00	98.96

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
JAG 84-524 grain-A3	46.22	0.15	10.35	2.10	2.92	20.03	10.37	3.57	1.20	bdl	bdl	2.02	98.93	0.00	0.00	98.93
JAG 84-524 grain-A4	46.26	0.18	10.52	2.21	2.74	19.94	10.21	3.71	1.21	0.30	0.11	1.93	99.32	0.13	0.02	99.16
JAG 84-524 grain-A5	45.96	0.14	10.41	2.24	2.96	19.77	10.21	3.62	1.18	bdl	0.10	1.99	98.57	0.00	0.02	98.54
JAG 84-524 grain-A6	46.32	0.14	10.62	2.23	2.84	20.05	10.16	3.74	1.27	bdl	bdl	2.03	99.40	0.00	0.00	99.40
JAG 84-524 grain-A7	46.02	0.00	10.39	2.12	2.83	19.82	10.26	3.66	1.15	bdl	bdl	1.98	98.23	0.00	0.00	98.23
JAG 84-524 grain-A8	45.83	0.14	10.53	2.11	2.88	19.71	10.16	3.68	1.25	bdl	0.08	2.04	98.40	0.00	0.02	98.38
JAG 84-524 grain-A9	46.03	0.14	10.34	2.29	2.73	19.99	10.27	3.65	1.34	bdl	bdl	2.02	98.82	0.00	0.00	98.82
JAG 84-524 grain-A10	46.01	0.14	10.62	2.20	2.73	19.86	10.20	3.63	1.26	bdl	bdl	2.00	98.64	0.00	0.00	98.64
JAG 84-524 grain-A11	45.58	0.15	10.53	2.01	2.92	19.84	10.26	3.88	1.30	bdl	bdl	1.99	98.45	0.00	0.00	98.45
JAG 84-524 grain-A12	45.59	0.16	10.66	2.17	2.78	19.74	10.19	3.85	1.28	bdl	0.09	1.97	98.48	0.00	0.02	98.46
JAG 84-524 grain-A13	45.62	0.17	10.46	2.17	2.78	19.78	10.18	3.63	1.22	0.24	bdl	1.96	98.21	0.10	0.00	98.11
JAG 84-524 grain-A14	45.84	0.13	10.35	2.08	2.86	20.01	10.05	3.67	1.27	bdl	bdl	1.98	98.23	0.00	0.00	98.23
JAG 84-524 grain-A15	45.91	0.00	10.43	2.08	2.76	20.03	10.40	3.68	1.24	bdl	0.08	2.00	98.60	0.00	0.02	98.58
JAG 84-524 grain-A16	45.95	0.16	10.23	2.03	2.97	19.98	10.07	3.68	1.29	bdl	0.08	1.98	98.41	0.00	0.02	98.39
JAG 84-524 grain-A AVG	45.95	0.13	10.47	2.14	2.83	19.89	10.22	3.69	1.25	bdl	bdl	1.99	98.55	0.00	0.00	98.55
JAG 84-524 grain-B1	46.10	0.16	10.35	1.97	3.05	20.23	10.01	3.63	1.27	bdl	0.08	2.00	98.84	0.00	0.02	98.82
JAG 84-524 grain-B2	46.29	0.17	10.64	1.97	2.72	20.04	10.30	3.57	1.25	bdl	bdl	2.01	98.95	0.00	0.00	98.95
JAG 84-524 grain-B3	46.03	0.14	10.58	2.08	2.96	19.97	10.24	3.66	1.24	bdl	bdl	2.01	98.90	0.00	0.00	98.90
JAG 84-524 grain-B4	46.31	0.14	10.46	2.07	2.90	20.10	10.34	3.76	1.25	bdl	bdl	2.00	99.31	0.00	0.00	99.31
JAG 84-524 grain-B5	46.14	0.17	10.59	2.21	2.76	19.96	10.27	3.62	1.21	bdl	0.08	2.02	99.02	0.00	0.02	99.00
JAG 84-524 grain-B6	45.25	0.14	10.04	2.10	2.87	19.67	11.34	3.64	1.17	bdl	bdl	1.98	98.18	0.00	0.00	98.18

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
JAG 84-524 grain-B7	46.13	0.12	10.58	2.16	2.73	19.73	10.40	3.54	1.23	bdl	bdl	2.00	98.62	0.00	0.00	98.62
JAG 84-524 grain-B8	45.97	0.12	10.48	1.87	3.10	19.99	10.16	3.58	1.21	bdl	bdl	1.97	98.45	0.00	0.00	98.45
JAG 84-524 grain-B9	46.58	0.17	10.45	2.13	3.00	19.96	10.35	3.83	1.20	bdl	0.09	2.02	99.77	0.00	0.02	99.75
JAG 84-524 grain-B10	46.35	0.15	10.61	2.04	2.79	20.16	10.40	3.59	1.20	bdl	bdl	2.05	99.33	0.00	0.00	99.33
JAG 84-524 grain-B11	46.16	0.15	10.35	2.21	2.88	19.78	10.23	3.61	1.28	0.28	bdl	1.94	98.87	0.12	0.00	98.75
JAG 84-524 grain-B12	46.67	0.13	10.46	1.98	2.69	19.92	10.40	3.73	1.24	bdl	bdl	2.02	99.24	0.00	0.00	99.24
JAG 84-524 grain-B13	46.46	0.16	10.49	2.07	2.88	20.05	10.36	3.88	1.20	bdl	0.08	2.02	99.66	0.00	0.02	99.64
JAG 84-524 grain-B14	46.52	0.14	10.55	1.88	2.79	19.97	10.32	3.56	1.22	bdl	bdl	2.02	98.97	0.00	0.00	98.97
JAG 84-524 grain-B15	46.60	0.12	10.45	1.97	2.81	20.13	10.14	3.65	1.23	0.25	bdl	1.98	99.33	0.10	0.00	99.22
JAG 84-524 grain-B16	46.97	0.16	10.54	1.93	2.86	19.96	10.25	3.76	1.19	bdl	bdl	2.02	99.64	0.00	0.00	99.64
JAG 84-524 grain-B17	46.40	0.19	10.47	1.86	2.81	20.16	10.20	3.69	1.21	bdl	bdl	2.00	98.98	0.00	0.00	98.98
JAG 84-524 grain-B18	46.68	0.18	10.61	1.80	2.99	20.10	10.40	3.57	1.21	bdl	bdl	2.00	99.53	0.00	0.00	99.53
JAG 84-524 grain-B19	46.67	0.15	10.42	1.97	2.89	20.02	9.91	3.61	1.16	bdl	0.10	1.98	98.86	0.00	0.02	98.84
JAG 84-524 grain-B AVG	46.33	0.15	10.48	2.01	2.87	19.99	10.32	3.66	1.22	bdl	bdl	2.00	99.03	0.00	0.00	99.03
JAG 84-524 grain-C1	46.25	0.16	10.51	2.02	2.83	20.00	10.36	3.51	1.24	bdl	bdl	1.99	98.88	0.00	0.00	98.88
JAG 84-524 grain-C2	45.95	0.14	10.38	2.02	2.84	19.94	10.24	3.57	1.26	0.26	bdl	1.96	98.55	0.11	0.00	98.44
JAG 84-524 grain-C3	46.10	0.17	10.35	2.04	2.84	19.89	10.01	3.54	1.26	bdl	0.08	1.96	98.23	0.00	0.02	98.21
JAG 84-524 grain-C4	45.83	0.11	10.49	2.20	2.93	20.09	10.12	3.55	1.14	bdl	0.09	1.99	98.54	0.00	0.02	98.52
JAG 84-524 grain-C5	46.49	0.13	10.44	2.17	3.02	20.15	10.21	3.67	1.21	bdl	0.09	2.00	99.58	0.00	0.02	99.56
JAG 84-524 grain-C6	46.32	0.14	10.38	2.18	2.77	19.89	10.03	3.60	1.25	0.27	bdl	1.95	98.78	0.11	0.00	98.66
JAG 84-524 grain-C7	45.05	0.17	9.94	2.16	2.72	19.75	9.55	5.00	1.13	bdl	1.17	1.67	98.29	0.00	0.26	98.02

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
JAG 84-524 grain-C8	46.57	0.16	10.50	2.20	2.86	20.04	10.30	3.87	1.19	bdl	0.10	2.01	99.80	0.00	0.02	99.78
JAG 84-524 grain-C9	46.36	0.18	10.49	2.05	2.89	19.93	10.13	3.72	1.19	0.24	0.09	1.97	99.24	0.10	0.02	99.11
JAG 84-524 grain-C10	46.40	0.13	10.37	2.27	2.70	19.97	10.27	3.77	1.20	bdl	bdl	2.01	99.09	0.00	0.00	99.09
JAG 84-524 grain-C11	46.67	0.17	10.53	2.13	2.74	20.05	10.10	3.68	1.18	bdl	bdl	2.00	99.24	0.00	0.00	99.24
JAG 84-524 grain-C12	46.61	0.16	10.55	2.23	3.02	20.12	10.04	3.63	1.20	0.32	0.09	1.95	99.90	0.13	0.02	99.75
JAG 84-524 grain-C13	46.79	0.11	10.53	2.20	2.76	20.25	10.27	3.74	1.27	bdl	bdl	2.02	99.94	0.00	0.00	99.94
JAG 84-524 grain-C14	46.28	0.16	10.34	2.10	2.80	19.96	10.05	3.65	1.19	0.26	0.11	1.95	98.84	0.11	0.03	98.70
JAG 84-524 grain-C15	46.64	0.14	10.34	2.05	2.69	20.41	10.15	3.64	1.23	bdl	bdl	2.05	99.34	0.00	0.00	99.34
JAG 84-524 grain-C16	46.87	0.15	10.64	2.09	2.92	20.34	10.18	3.65	1.25	0.24	bdl	2.00	100.3	0.10	0.00	100.2
JAG 84-524 grain-C AVG	46.28	0.15	10.42	2.12	2.83	20.02	10.12	3.78	1.21	bdl	0.11	1.97	99.06	0.00	0.03	99.03
JAG 84-524 grain-D1	46.02	0.15	10.55	2.08	2.87	19.99	10.27	3.43	1.25	bdl	bdl	1.98	98.59	0.00	0.00	98.59
JAG 84-524 grain-D2	45.97	0.13	10.54	2.11	2.80	19.94	10.34	3.59	1.20	bdl	0.09	2.01	98.71	0.00	0.02	98.69
JAG 84-524 grain-D3	46.07	0.15	10.51	2.15	2.86	20.05	10.27	3.62	1.20	bdl	bdl	1.98	98.84	0.00	0.00	98.84
JAG 84-524 grain-D4	46.28	0.16	10.57	2.03	2.81	19.93	10.25	3.65	1.17	bdl	bdl	2.01	98.86	0.00	0.00	98.86
JAG 84-524 grain-D5	45.69	0.15	10.57	2.05	2.79	20.29	10.24	3.61	1.23	bdl	bdl	2.00	98.61	0.00	0.00	98.61
JAG 84-524 grain-D AVG	46.01	0.15	10.55	2.08	2.83	20.04	10.27	3.58	1.21	bdl	bdl	2.00	98.70	0.00	0.00	98.70
JAG 84-524 grain-E1	46.26	0.18	9.96	2.08	2.93	20.11	10.18	3.48	1.27	bdl	bdl	1.98	98.44	0.00	0.00	98.44
JAG 84-524 grain-E2	45.98	0.15	10.53	2.03	2.75	20.00	10.29	3.61	1.25	bdl	bdl	1.97	98.57	0.00	0.00	98.57
JAG 84-524 grain-E3	46.24	0.15	10.53	2.04	2.84	19.90	10.21	3.55	1.21	bdl	bdl	2.00	98.67	0.00	0.00	98.67
JAG 84-524 grain-E4	45.98	0.14	10.29	1.93	2.90	19.94	10.09	3.64	1.24	bdl	bdl	1.96	98.10	0.00	0.00	98.10
JAG 84-524 grain-E5	46.20	0.15	10.52	2.01	2.80	20.00	10.18	3.54	1.21	bdl	bdl	2.01	98.62	0.00	0.00	98.62

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
JAG 84-524 grain-E6	46.20	0.16	10.50	2.02	2.80	19.95	10.22	3.57	1.26	bdl	bdl	2.02	98.70	0.00	0.00	98.70
JAG 84-524 grain-E AVG	46.14	0.16	10.39	2.02	2.84	19.98	10.19	3.57	1.24	bdl	bdl	1.99	98.52	0.00	0.00	98.52
JAG 84-524 ALL AVG	46.14	0.15	10.46	2.08	2.84	19.99	10.22	3.65	1.23	bdl	bdl	1.99	98.75	0.00	0.00	98.75
JAG 84-553 grain-A1	45.83	0.10	11.62	2.11	2.01	20.29	10.90	3.70	0.67	bdl	0.14	2.05	99.42	0.00	0.03	99.39
JAG 84-553 grain-A2	45.84	bdl	11.62	2.14	2.01	20.34	10.93	3.77	0.61	bdl	0.11	2.04	99.42	0.00	0.03	99.40
JAG 84-553 grain-A3	45.96	0.10	11.68	1.97	2.23	20.28	11.26	3.71	0.59	bdl	0.13	2.09	100.0	0.00	0.03	99.98
JAG 84-553 grain-A4	46.05	bdl	11.77	2.28	2.16	20.34	10.64	3.90	0.50	bdl	bdl	2.08	99.72	0.00	0.00	99.72
JAG 84-553 grain-A5	45.96	bdl	11.55	2.02	2.00	20.24	10.96	3.87	0.56	bdl	0.10	2.05	99.29	0.00	0.02	99.27
JAG 84-553 grain-A6	45.99	bdl	11.50	2.23	1.99	20.22	11.05	3.74	0.70	bdl	0.11	2.08	99.61	0.00	0.03	99.58
JAG 84-553 grain-A7	46.15	bdl	11.56	2.11	2.03	20.50	11.01	3.91	0.69	bdl	0.12	2.04	100.1	0.00	0.03	100.1
JAG 84-553 grain-A8	45.59	bdl	11.62	2.22	2.13	20.30	11.18	3.80	0.75	bdl	0.10	2.04	99.74	0.00	0.02	99.72
JAG 84-553 grain-A9	45.98	0.10	11.50	2.03	2.10	20.49	10.97	3.77	0.72	bdl	0.08	2.10	99.85	0.00	0.02	99.83
JAG 84-553 grain-A10	46.07	bdl	11.72	2.09	2.09	20.25	11.00	3.77	0.68	bdl	0.12	2.04	99.83	0.00	0.03	99.80
JAG 84-553 grain-A AVG	45.94	bdl	11.61	2.12	2.08	20.32	10.99	3.79	0.65	bdl	0.10	2.06	99.70	0.00	0.02	99.68
JAG 84-553 grain-B1	46.01	bdl	11.64	2.39	2.12	20.37	10.83	3.79	0.74	bdl	0.10	2.07	100.1	0.00	0.02	100.0
JAG 84-553 grain-B2	46.04	bdl	11.59	2.05	1.95	20.26	11.14	3.70	0.84	bdl	0.12	2.05	99.74	0.00	0.03	99.72
JAG 84-553 grain-B3	46.09	bdl	11.71	2.21	2.10	20.36	10.99	3.62	0.94	bdl	0.09	2.10	100.2	0.00	0.02	100.2
JAG 84-553 grain-B4	45.89	bdl	11.66	2.12	2.01	20.51	11.19	3.70	0.73	bdl	0.09	2.06	99.95	0.00	0.02	99.93
JAG 84-553 grain-B5	46.07	bdl	11.71	2.14	2.07	20.49	10.85	3.88	0.74	bdl	0.10	2.08	100.1	0.00	0.02	100.1
JAG 84-553 grain-B6	45.89	bdl	11.69	2.06	2.09	20.36	11.13	3.76	0.71	bdl	bdl	2.06	99.74	0.00	0.00	99.74
JAG 84-553 grain-B7	46.12	0.10	11.49	2.30	2.09	20.33	11.01	3.64	0.75	bdl	0.10	2.04	99.98	0.00	0.02	99.95

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
JAG 84-553 grain-B8	46.04	0.11	11.84	2.24	2.09	20.35	11.07	3.65	0.71	bdl	0.10	2.10	100.3	0.00	0.02	100.3
JAG 84-553 grain-B9	45.97	bdl	11.50	2.24	1.94	20.23	11.11	3.81	0.71	bdl	0.11	2.08	99.71	0.00	0.03	99.68
JAG 84-553 grain-B AVG	46.01	bdl	11.65	2.19	2.05	20.36	11.04	3.73	0.76	bdl	0.09	2.07	99.98	0.00	0.02	99.96
JAG 84-553 grain-C1	45.89	0.11	11.76	2.04	2.19	20.34	11.15	3.79	0.71	bdl	0.10	2.09	100.2	0.00	0.02	100.1
JAG 84-553 grain-C2	45.47	0.11	11.74	2.07	2.02	20.33	10.92	3.90	0.66	bdl	0.11	2.02	99.34	0.00	0.03	99.31
JAG 84-553 grain-C3	45.97	bdl	11.84	2.21	2.11	20.42	11.03	3.80	0.62	bdl	0.10	2.06	100.2	0.00	0.02	100.1
JAG 84-553 grain-C4	46.14	bdl	11.78	2.08	2.03	20.36	11.18	3.74	0.64	bdl	0.09	2.07	100.1	0.00	0.02	100.1
JAG 84-553 grain-C5	45.96	bdl	11.71	2.20	2.14	20.54	10.92	3.89	0.52	bdl	0.13	2.06	100.1	0.00	0.03	100.0
JAG 84-553 grain-C6	46.06	0.10	11.74	2.08	2.03	20.59	11.06	3.92	0.52	bdl	0.11	2.08	100.3	0.00	0.02	100.3
JAG 84-553 grain-C7	45.91	0.09	11.63	2.08	2.18	20.33	10.98	3.95	0.47	bdl	0.12	2.07	99.81	0.00	0.03	99.79
JAG 84-553 grain-C8	45.94	bdl	11.69	1.97	2.11	20.46	10.83	3.65	0.56	bdl	0.12	2.05	99.38	0.00	0.03	99.36
JAG 84-553 grain-C9	46.14	bdl	11.81	2.16	2.17	20.45	10.98	3.67	0.68	bdl	0.10	2.10	100.3	0.00	0.02	100.2
JAG 84-553 grain-C10	45.63	0.11	11.64	2.07	2.03	20.20	11.08	3.68	0.82	bdl	0.12	2.03	99.40	0.00	0.03	99.37
JAG 84-553 grain-C AVG	45.91	0.05	11.73	2.10	2.10	20.40	11.01	3.80	0.62	bdl	0.11	2.06	99.90	0.00	0.02	99.87
JAG 84-553 ALL AVG	45.96	0.04	11.67	2.14	2.08	20.36	11.01	3.77	0.68	bdl	0.10	2.07	99.86	0.00	0.02	99.84
JAG-228 grain-A1	46.96	bdl	10.98	2.25	2.01	20.41	10.42	3.96	1.13	bdl	0.09	2.09	100.3	0.00	0.02	100.3
JAG-228 grain-A2	46.98	bdl	11.13	2.19	1.99	20.60	10.22	3.82	1.20	bdl	0.10	2.08	100.3	0.00	0.02	100.3
JAG-228 grain-A3	46.59	bdl	11.07	2.27	2.15	20.83	10.18	3.61	1.15	bdl	bdl	2.07	99.93	0.00	0.00	99.93
JAG-228 grain-A4	46.99	bdl	11.05	2.30	1.99	20.42	10.27	3.78	1.16	bdl	0.10	2.08	100.1	0.00	0.02	100.1
JAG-228 grain-A5	46.70	bdl	11.12	2.25	1.95	20.51	10.22	3.94	1.14	bdl	0.10	2.04	99.96	0.00	0.02	99.94
JAG-228 grain-A6	47.04	bdl	11.24	2.23	2.05	20.59	10.24	3.81	1.17	bdl	0.09	2.05	100.5	0.00	0.02	100.5

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
JAG-228 grain-A7	46.82	bdl	11.17	2.26	1.92	20.50	10.38	3.84	1.20	bdl	bdl	2.04	100.1	0.00	0.00	100.1
JAG-228 grain-A8	47.11	bdl	11.29	2.26	1.95	20.36	10.19	3.75	1.21	bdl	0.09	2.08	100.3	0.00	0.02	100.3
JAG-228 grain-A9	47.03	bdl	11.10	2.17	1.99	20.44	10.39	3.82	1.16	bdl	0.10	2.07	100.3	0.00	0.02	100.2
JAG-228 grain-A10	46.73	bdl	11.48	2.14	2.31	20.66	10.15	3.78	1.07	bdl	0.10	2.08	100.5	0.00	0.02	100.5
JAG-228 grain-A AVG	46.89	bdl	11.16	2.23	2.03	20.53	10.27	3.81	1.16	bdl	0.08	2.07	100.2	0.00	0.02	100.2
JAG-228 grain-B1	47.18	bdl	11.12	2.14	2.05	20.61	10.42	3.97	1.10	bdl	0.10	2.04	100.7	0.00	0.02	100.7
JAG-228 grain-B2	46.75	bdl	11.36	2.24	2.04	20.49	10.23	3.77	1.14	bdl	0.08	2.08	100.2	0.00	0.02	100.2
JAG-228 grain-B3	47.05	bdl	11.14	2.39	1.98	20.59	10.21	3.87	1.16	bdl	0.09	2.04	100.5	0.00	0.02	100.5
JAG-228 grain-B4	46.99	bdl	11.20	2.30	2.12	20.74	10.27	3.76	1.16	bdl	bdl	2.09	100.6	0.00	0.00	100.6
JAG-228 grain-B5	46.91	bdl	11.13	2.08	1.94	20.67	10.45	3.76	1.15	bdl	0.08	2.08	100.3	0.00	0.02	100.2
JAG-228 grain-B6	46.89	bdl	11.08	2.17	2.05	20.73	10.39	3.84	1.08	bdl	0.10	2.07	100.4	0.00	0.02	100.4
JAG-228 grain-B7	46.58	bdl	11.14	2.28	2.08	20.48	10.34	3.96	1.15	bdl	0.12	2.03	100.2	0.00	0.03	100.1
JAG-228 grain-B8	46.93	bdl	10.94	2.18	2.07	20.45	10.47	3.70	1.27	bdl	bdl	2.05	100.1	0.00	0.00	100.1
JAG-228 grain-B9	46.86	bdl	11.02	2.16	2.01	20.50	10.44	3.81	1.17	bdl	0.09	2.05	100.1	0.00	0.02	100.1
JAG-228 grain-B10	47.05	bdl	11.10	2.28	2.00	20.58	10.22	3.78	1.12	bdl	0.09	2.07	100.3	0.00	0.02	100.3
JAG-228 grain-B AVG	46.92	bdl	11.12	2.22	2.03	20.58	10.35	3.82	1.15	bdl	0.08	2.06	100.3	0.00	0.02	100.3
JAG-228 grain-C1	46.76	bdl	11.24	2.27	2.07	20.59	10.24	3.86	1.09	bdl	0.12	2.08	100.3	0.00	0.03	100.3
JAG-228 grain-C2	46.89	bdl	11.21	2.25	2.03	20.73	10.17	3.67	1.18	bdl	0.13	2.00	100.3	0.00	0.03	100.2
JAG-228 grain-C3	47.08	bdl	11.16	2.16	2.04	20.53	10.35	3.76	1.12	bdl	0.09	2.08	100.4	0.00	0.02	100.3
JAG-228 grain-C4	46.84	bdl	11.19	2.28	2.15	20.47	10.29	3.91	1.16	bdl	0.11	2.05	100.4	0.00	0.02	100.4
JAG-228 grain-C5	47.00	bdl	11.09	2.27	2.09	20.46	10.25	3.88	1.09	bdl	0.10	2.03	100.3	0.00	0.02	100.2

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
JAG-228 grain-C6	47.18	bdl	10.98	2.31	2.09	20.41	10.43	3.70	1.25	bdl	0.10	2.05	100.5	0.00	0.02	100.5
JAG-228 grain-C7	46.79	bdl	11.19	2.20	2.14	20.51	10.27	3.90	1.17	bdl	0.10	2.02	100.3	0.00	0.02	100.3
JAG-228 grain-C8	46.48	bdl	11.14	2.14	2.20	21.10	10.01	3.73	1.22	bdl	0.10	2.05	100.2	0.00	0.02	100.1
JAG-228 grain-C9	47.16	bdl	11.08	2.17	2.01	20.62	10.20	3.98	1.23	bdl	0.12	2.03	100.6	0.00	0.03	100.6
JAG-228 grain-C10	46.78	bdl	11.15	2.28	2.11	20.50	10.45	3.81	1.15	bdl	0.10	2.07	100.4	0.00	0.02	100.4
JAG-228 grain-C AVG	46.90	bdl	11.14	2.23	2.09	20.59	10.27	3.82	1.17	bdl	0.11	2.05	100.4	0.00	0.02	100.3
JAG-228 grain-D1	46.62	bdl	11.00	2.19	2.14	20.54	10.31	3.71	1.04	bdl	0.11	2.05	99.70	0.00	0.02	99.68
JAG-228 grain-D2	46.95	bdl	11.10	2.25	2.06	20.58	10.40	3.80	1.07	bdl	0.13	2.04	100.4	0.00	0.03	100.3
JAG-228 grain-D3	47.19	bdl	11.13	2.08	2.09	20.56	10.36	3.74	1.14	bdl	0.09	2.05	100.4	0.00	0.02	100.4
JAG-228 grain-D4	46.98	bdl	10.99	2.16	2.01	20.61	10.36	3.81	1.15	bdl	0.09	2.04	100.2	0.00	0.02	100.2
JAG-228 grain-D5	46.93	bdl	11.19	2.17	2.00	20.57	10.44	3.82	1.16	bdl	0.10	2.09	100.5	0.00	0.02	100.4
JAG-228 grain-D6	46.99	bdl	11.10	2.22	2.10	20.61	10.18	3.77	1.16	bdl	0.12	2.06	100.3	0.00	0.03	100.3
JAG-228 grain-D7	47.14	bdl	11.31	2.29	2.04	20.58	10.34	3.85	1.19	bdl	0.10	2.12	101.0	0.00	0.02	100.9
JAG-228 grain-D8	47.03	bdl	11.06	2.23	2.00	20.79	10.48	3.70	1.16	bdl	0.09	2.06	100.6	0.00	0.02	100.6
JAG-228 grain-D9	46.76	bdl	11.08	2.23	1.99	20.56	10.38	3.97	1.15	bdl	0.11	2.05	100.3	0.00	0.02	100.2
JAG-228 grain-D10	47.27	bdl	10.85	2.26	2.00	20.83	10.27	3.88	1.17	bdl	0.08	2.08	100.7	0.00	0.02	100.6
JAG-228 grain-D AVG	46.99	bdl	11.08	2.21	2.04	20.62	10.35	3.80	1.14	bdl	0.10	2.06	100.4	0.00	0.02	100.4
JAG-228 ALL AVG	46.92	bdl	11.13	2.22	2.05	20.58	10.31	3.81	1.15	bdl	0.09	2.06	100.3	0.00	0.02	100.3
K7269 grain-A1	45.19	bdl	11.76	2.17	2.20	20.30	11.03	3.78	0.51	bdl	bdl	2.10	99.03	0.00	0.00	99.03
K7269 grain-A2	45.48	bdl	11.72	2.07	2.14	20.33	11.10	3.81	0.51	bdl	bdl	2.09	99.24	0.00	0.00	99.24
K7269 grain-A3	45.32	bdl	11.86	2.20	2.18	20.13	11.27	3.70	0.45	bdl	0.10	2.07	99.28	0.00	0.02	99.25

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
K7269 grain-A4	45.82	bdl	11.71	2.26	2.07	20.15	11.25	3.72	0.50	bdl	0.11	2.10	99.68	0.00	0.03	99.66
K7269 grain-A5	45.50	bdl	11.87	2.06	2.09	20.47	11.22	3.71	0.48	bdl	0.08	2.10	99.58	0.00	0.02	99.56
K7269 grain-A6	45.74	bdl	11.76	2.17	2.11	20.41	11.16	3.94	0.47	bdl	bdl	2.06	99.81	0.00	0.00	99.81
K7269 grain-A7	45.90	bdl	12.02	2.23	2.23	20.45	11.21	3.73	0.47	bdl	0.09	2.12	100.4	0.00	0.02	100.4
K7269 grain-A8	45.37	bdl	11.68	2.17	2.17	20.63	11.29	3.79	0.46	bdl	bdl	2.10	99.65	0.00	0.00	99.65
K7269 grain-A9	45.45	bdl	11.83	2.15	2.23	20.51	11.38	3.91	0.47	bdl	0.11	2.10	100.1	0.00	0.02	100.1
K7269 grain-A10	45.62	bdl	11.76	2.21	2.17	20.58	11.19	3.81	0.52	bdl	bdl	2.09	99.95	0.00	0.00	99.95
K7269 grain-A AVG	45.54	bdl	11.79	2.17	2.16	20.40	11.21	3.79	0.48	bdl	0.05	2.09	99.68	0.00	0.01	99.67
K7269 grain-B1	46.07	bdl	11.52	2.13	2.23	20.70	11.17	3.86	0.47	bdl	0.09	2.11	100.4	0.00	0.02	100.3
K7269 grain-B2	45.64	bdl	11.80	2.17	2.05	20.45	11.22	3.87	0.47	bdl	bdl	2.09	99.76	0.00	0.00	99.76
K7269 grain-B3	45.77	bdl	11.71	2.10	2.16	20.37	11.06	3.92	0.50	bdl	bdl	2.10	99.69	0.00	0.00	99.69
K7269 grain-B4	45.91	bdl	11.65	2.05	2.16	20.32	11.44	3.80	0.52	bdl	bdl	2.11	99.96	0.00	0.00	99.96
K7269 grain-B5	45.66	bdl	11.69	2.15	2.09	20.34	11.19	3.79	0.51	bdl	bdl	2.10	99.53	0.00	0.00	99.53
K7269 grain-B6	46.19	bdl	11.81	2.28	2.14	20.27	11.27	3.79	0.52	bdl	bdl	2.11	100.4	0.00	0.00	100.4
K7269 grain-B7	45.87	bdl	11.78	2.20	2.11	20.58	11.10	3.70	0.48	bdl	0.09	2.11	100.0	0.00	0.02	100.0
K7269 grain-B8	45.49	bdl	11.72	1.98	2.13	20.28	11.30	3.90	0.53	bdl	bdl	2.08	99.40	0.00	0.00	99.40
K7269 grain-B9	45.70	bdl	11.70	2.13	2.02	20.42	11.26	3.76	0.52	bdl	bdl	2.05	99.54	0.00	0.00	99.54
K7269 grain-B10	45.49	bdl	11.69	1.97	2.23	20.60	11.34	3.87	0.54	bdl	0.10	2.08	99.89	0.00	0.02	99.87
K7269 grain-B AVG	45.78	bdl	11.71	2.11	2.13	20.43	11.24	3.82	0.51	bdl	0.03	2.09	99.85	0.00	0.01	99.84
K7269 grain-C1	45.95	bdl	11.76	2.21	2.09	20.53	11.18	3.90	0.45	bdl	0.08	2.09	100.2	0.00	0.02	100.2
K7269 grain-C2	46.16	bdl	11.92	2.21	2.07	20.39	11.29	3.86	0.45	bdl	bdl	2.11	100.5	0.00	0.00	100.5

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
K7269 grain-C3	46.14	bdl	11.75	2.09	2.13	20.53	11.29	3.75	0.51	bdl	0.11	2.09	100.4	0.00	0.02	100.4
K7269 grain-C4	46.15	bdl	11.85	2.12	2.05	20.15	11.35	3.72	0.42	bdl	0.10	2.11	100.0	0.00	0.02	99.98
K7269 grain-C5	46.27	bdl	11.80	2.15	2.08	20.25	11.24	3.87	0.45	bdl	0.11	2.09	100.3	0.00	0.02	100.3
K7269 grain-C6	46.11	bdl	11.86	2.18	2.11	20.41	11.25	3.78	0.48	bdl	bdl	2.10	100.3	0.00	0.00	100.3
K7269 grain-C7	46.34	bdl	11.78	2.20	2.08	20.24	11.22	3.84	0.48	bdl	0.09	2.11	100.4	0.00	0.02	100.4
K7269 grain-C8	46.36	bdl	11.87	2.20	2.13	20.41	11.26	3.85	0.44	bdl	0.09	2.13	100.7	0.00	0.02	100.7
K7269 grain-C9	46.32	bdl	11.75	2.10	2.21	20.12	11.11	4.06	0.48	bdl	0.10	2.11	100.4	0.00	0.02	100.3
K7269 grain-C10	46.29	bdl	11.80	2.15	2.15	20.52	11.10	4.05	0.48	bdl	0.09	2.09	100.7	0.00	0.02	100.7
K7269 grain-C AVG	46.21	bdl	11.81	2.16	2.11	20.36	11.23	3.87	0.46	bdl	0.08	2.10	100.4	0.00	0.02	100.4
K7269 ALL AVG	45.91	bdl	11.79	2.15	2.12	20.39	11.22	3.82	0.48	bdl	0.06	2.10	100.0	0.00	0.01	100.0
K7311 grain-A1	45.21	0.32	13.03	2.28	2.69	19.75	9.84	3.53	1.63	bdl	0.09	2.03	100.4	0.00	0.02	100.4
K7311 grain-A2	44.03	0.46	14.16	2.40	3.09	19.06	9.79	3.55	1.85	bdl	bdl	2.06	100.4	0.00	0.00	100.4
K7311 grain-A3	44.64	0.41	12.22	2.17	3.04	19.20	11.28	3.40	1.20	bdl	bdl	2.00	99.55	0.00	0.00	99.55
K7311 grain-A4	44.21	0.54	13.85	2.07	3.16	18.89	9.60	3.46	1.85	bdl	bdl	2.03	99.64	0.00	0.00	99.64
K7311 grain-A5	43.25	0.60	13.14	2.30	3.23	18.95	11.56	3.09	1.45	bdl	bdl	2.00	99.57	0.00	0.00	99.57
K7311 grain-A AVG	44.27	0.46	13.28	2.24	3.04	19.17	10.41	3.40	1.60	bdl	bdl	2.02	99.90	0.00	0.00	99.92
K7311 grain-B1	44.02	0.51	14.12	2.39	2.77	19.12	9.58	3.43	1.99	bdl	bdl	2.01	99.95	0.00	0.00	99.95
K7311 grain-B2	45.90	0.22	11.50	2.31	2.68	20.01	10.06	3.76	1.06	bdl	0.09	2.05	99.65	0.00	0.02	99.63
K7311 grain-B3	46.56	0.18	11.15	2.14	2.55	20.30	10.33	3.95	0.83	bdl	0.11	2.06	100.2	0.00	0.02	100.1
K7311 grain-B4	46.55	0.21	11.27	2.28	2.41	20.26	10.22	4.04	0.91	bdl	0.09	2.03	100.3	0.00	0.02	100.2
K7311 grain-B5	43.87	0.52	14.75	2.11	2.71	18.95	9.52	3.50	1.94	bdl	bdl	2.01	99.86	0.00	0.00	99.86

bdl, concentration below detection limit

AMPHIBOLE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	K_2O	F	Cl	H_2O	Sum	O=F	O=Cl	Sum
K7311 grain-B6	44.81	0.51	13.32	2.21	2.97	19.27	9.95	3.68	1.76	bdl	bdl	2.03	100.5	0.00	0.00	100.5
K7311 grain-B7	46.14	0.22	11.00	2.18	2.49	20.38	10.29	3.88	0.93	bdl	0.13	1.96	99.57	0.00	0.03	99.54
K7311 grain-B8	44.42	0.62	13.85	2.25	2.82	19.13	9.74	3.56	1.95	bdl	bdl	2.05	100.4	0.00	0.00	100.4
K7311 grain-B AVG	45.28	0.37	12.62	2.23	2.67	19.68	9.96	3.72	1.42	bdl	0.05	2.02	100.0	0.00	0.01	100.0
K7311 grain-C1	45.91	0.19	10.77	2.14	2.62	19.91	10.43	3.79	0.93	bdl	0.10	1.98	98.78	0.00	0.02	98.76
K7311 grain-C2	46.19	0.24	11.25	2.34	2.77	19.72	10.40	3.71	1.09	bdl	0.10	2.02	99.83	0.00	0.02	99.81
K7311 grain-C3	43.14	0.65	14.58	2.79	2.87	18.38	10.06	3.03	2.14	bdl	bdl	2.02	99.66	0.00	0.00	99.66
K7311 grain-C4	44.82	0.33	12.36	2.17	3.10	19.26	10.05	3.53	1.40	bdl	0.08	2.03	99.13	0.00	0.02	99.11
K7311 grain-C5	43.64	0.58	14.71	2.51	2.88	18.60	9.58	3.20	2.08	bdl	bdl	2.04	99.82	0.00	0.00	99.82
K7311 grain-C6	43.24	0.52	13.09	2.42	3.27	18.46	11.52	3.06	1.42	bdl	bdl	2.02	99.00	0.00	0.00	99.00
K7311 grain-C7	45.07	0.39	12.39	1.95	2.89	19.31	10.21	3.49	1.51	bdl	bdl	2.02	99.23	0.00	0.00	99.23
K7311 grain-C8	45.50	0.21	11.81	2.29	2.63	19.79	10.22	3.65	1.29	bdl	0.08	2.01	99.48	0.00	0.02	99.46
K7311 grain-C9	43.88	0.55	14.43	2.58	2.82	18.69	9.57	3.35	2.01	bdl	bdl	2.05	99.93	0.00	0.00	99.93
K7311 grain-C10	44.65	0.58	12.79	2.18	2.98	19.10	10.20	3.40	1.53	bdl	bdl	2.00	99.41	0.00	0.00	99.41
K7311 grain-C11	43.85	1.08	14.77	1.82	3.29	18.44	9.86	3.01	2.04	bdl	bdl	2.04	100.2	0.00	0.00	100.2
K7311 grain-C12	44.09	0.92	13.68	1.93	3.65	18.48	9.86	3.40	1.69	bdl	bdl	2.01	99.71	0.00	0.00	99.71
K7311 grain-C13	39.18	1.45	17.23	1.36	3.32	23.56	0.04	1.20	8.96	bdl	bdl	1.95	98.23	0.00	0.00	98.23
K7311 grain-C AVG	44.09	0.59	13.37	2.19	3.01	19.36	9.38	3.22	2.16	bdl	bdl	2.01	99.39	0.00	0.01	99.41
K7311 ALL AVG	44.55	0.48	13.09	2.22	2.91	19.40	9.92	3.45	1.73	bdl	bdl	2.02	99.76	0.00	0.01	99.79

bdl, concentration below detection limit

APPENDIX C

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
GN9912 grain-E1	bdl	bdl	41.14	26.35	15.84	0.38	15.92	bdl	0.37	100.00	1.53	14.47	100.15
GN9912 grain-E2	bdl	bdl	40.99	26.28	15.41	0.37	16.00	0.25	0.30	99.61	1.62	13.96	99.77
GN9912 grain-E3	bdl	bdl	40.78	26.46	15.61	0.37	15.83	bdl	0.34	99.40	1.30	14.44	99.53
GN9912 grain-E4	bdl	bdl	40.58	26.64	15.53	0.32	15.84	0.22	bdl	99.12	1.16	14.48	99.24
GN9912 grain-E5	bdl	bdl	40.67	26.27	15.48	0.32	15.87	bdl	bdl	98.60	1.07	14.52	98.71
GN9912 grain-E6	bdl	bdl	40.60	26.70	15.33	0.38	15.95	0.20	0.49	99.64	1.66	13.84	99.80
GN9912 grain-E7	bdl	bdl	40.82	26.76	16.03	0.37	15.98	0.00	0.34	100.30	1.82	14.39	100.49
GN9912 grain-E8	bdl	bdl	40.81	26.89	15.75	0.38	15.93	0.27	0.34	100.36	1.68	14.24	100.53
GN9912 grain-E9	bdl	bdl	40.71	26.70	15.57	0.37	15.86	0.26	bdl	99.46	1.21	14.48	99.58
GN9912 grain-E AVG	bdl	bdl	40.79	26.56	15.62	0.36	15.91	0.20	0.36	99.80	1.45	14.31	99.94
GN9912 grain-F1	bdl	bdl	42.96	24.63	15.35	0.36	16.36	0.24	0.34	100.24	1.60	13.91	100.40
GN9912 grain-F2	bdl	bdl	44.07	23.94	14.98	0.35	16.69	0.24	0.32	100.59	1.30	13.81	100.72
GN9912 grain-F3	bdl	bdl	43.39	24.87	15.12	0.36	16.46	0.24	bdl	100.44	0.81	14.39	100.52
GN9912 grain-F AVG	bdl	bdl	43.47	24.48	15.15	0.36	16.50	0.24	0.33	100.53	1.24	14.04	100.65
GN9912 ALL AVG Core	bdl	bdl	40.99	26.28	15.41	0.37	16.00	0.25	0.30	99.61	2.61	13.07	99.87
GN9912 ALL AVG Rim	**bdl**	**bdl**	**40.32**	**27.12**	**15.78**	**0.39**	**15.70**	**0.21**	**0.42**	**99.94**	**1.54**	**14.39**	**100.09**
GN9913 grain-D1	bdl	bdl	43.77	23.40	13.00	0.21	17.52	0.29	bdl	98.18	2.09	11.12	98.39
GN9913 grain-D2	bdl	bdl	43.75	23.00	13.30	0.30	17.64	0.27	bdl	98.26	2.67	10.90	98.52
GN9913 grain-D3	bdl	bdl	44.26	23.02	13.11	0.33	17.80	0.17	0.32	99.01	2.63	10.75	99.27
GN9913 grain-D4	bdl	bdl	44.21	23.14	12.83	0.25	17.89	0.39	bdl	98.71	2.41	10.66	98.95
GN9913 grain-D5	bdl	bdl	44.09	22.88	13.00	0.38	17.80	0.24	bdl	98.40	2.57	10.69	98.65

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
GN9913 grain-D6	bdl	bdl	44.17	23.60	13.05	0.29	17.85	bdl	bdl	98.96	2.13	11.13	99.18
GN9913 grain-D7	bdl	bdl	44.22	23.60	12.88	0.24	17.94	0.26	bdl	99.15	2.25	10.85	99.37
GN9913 grain-D8	bdl	bdl	44.00	23.31	13.13	0.26	17.90	0.18	bdl	98.78	2.56	10.83	99.04
GN9913 grain-D9	bdl	bdl	43.83	23.73	12.72	0.30	17.80	bdl	bdl	98.39	1.96	10.96	98.58
GN9913 grain-D10	bdl	bdl	43.26	23.83	12.56	0.29	18.15	0.23	bdl	98.32	2.73	10.11	98.60
GN9913 grain-D AVG	bdl	bdl	43.96	23.35	12.96	0.29	17.83	0.25	0.32	98.95	2.40	10.80	99.19
GN9913 grain-L1	bdl	bdl	39.31	28.40	13.09	0.32	17.25	0.17	bdl	98.55	2.42	10.91	98.79
GN9913 grain-L2	bdl	bdl	41.37	26.38	13.40	0.35	17.17	0.24	0.31	99.23	2.40	11.24	99.47
GN9913 grain-L3	bdl	bdl	40.95	26.42	13.53	0.40	17.14	0.19	bdl	98.63	2.48	11.30	98.88
GN9913 grain-L4	bdl	bdl	41.00	26.33	13.76	0.30	16.97	0.21	bdl	98.57	2.36	11.64	98.81
GN9913 grain-L5	bdl	bdl	41.24	26.37	13.70	0.35	17.12	0.32	0.35	99.44	2.72	11.25	99.71
GN9913 grain-L6	bdl	bdl	41.08	26.43	13.76	0.33	17.10	0.20	bdl	98.90	2.46	11.54	99.15
GN9913 grain-L7	bdl	bdl	38.12	29.31	13.92	0.37	16.66	0.20	bdl	98.57	2.57	11.61	98.83
GN9913 grain-L8	bdl	bdl	38.56	28.83	13.80	0.39	16.88	0.23	bdl	98.68	2.73	11.34	98.95
GN9913 grain-L9	bdl	bdl	40.38	26.70	13.70	0.35	16.89	0.29	0.32	98.62	2.69	11.27	98.89
GN9913 grain-L10	bdl	bdl	38.68	28.71	13.31	0.37	17.03	bdl	bdl	98.09	2.38	11.17	98.33
GN9913 grain-L AVG	bdl	bdl	40.07	27.39	13.60	0.35	17.02	0.23	0.33	98.98	2.52	11.33	99.23
GN9913 ALL AVG Core	bdl	bdl	44.09	22.88	13.00	0.38	17.80	0.24	bdl	98.40	2.57	10.69	98.65
GN9913 ALL AVG Rim	bdl	bdl	43.26	23.83	12.56	0.29	18.15	0.23	bdl	98.32	2.21	10.58	98.54
BM9912 grain-D1	0.05	0.10	47.98	20.19	11.45	0.24	19.71	0.20	bdl	99.93	2.60	9.11	100.19
BM9912 grain-D2	bdl	0.07	48.95	19.13	11.42	0.28	19.72	0.30	bdl	99.87	2.58	9.10	100.13

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
BM9912 grain-D3	bdl	0.12	48.97	18.95	11.39	0.25	19.52	0.24	bdl	99.44	2.22	9.39	99.66
BM9912 grain-D4	0.05	bdl	48.86	18.93	11.29	0.22	19.54	0.34	bdl	99.23	2.35	9.17	99.47
BM9912 grain-D5	0.05	0.08	48.74	18.99	10.95	0.27	19.62	0.33	bdl	99.03	2.16	9.00	99.25
BM9912 grain-D AVG	bdl	0.09	48.70	19.24	11.30	0.25	19.62	0.28	bdl	99.49	2.39	9.16	99.73
BM9912 grain-E1	bdl	bdl	48.62	19.52	11.55	0.24	19.35	0.26	bdl	99.53	2.27	9.51	99.76
BM9912 grain-E2	bdl	bdl	48.48	19.77	11.38	0.23	19.64	0.26	bdl	99.76	2.49	9.14	100.01
BM9912 grain-E3	0.05	bdl	47.81	20.15	11.30	0.30	19.66	0.29	bdl	99.56	2.65	8.91	99.82
BM9912 grain-E4	bdl	0.07	47.89	19.76	11.64	0.26	19.38	0.24	bdl	99.25	2.56	9.34	99.51
BM9912 grain-E5	bdl	0.08	48.14	19.55	11.56	0.26	19.48	0.26	bdl	99.34	2.60	9.22	99.60
BM9912 grain-E AVG	bdl	0.08	48.19	19.75	11.49	0.26	19.50	0.26	bdl	99.52	2.52	9.22	99.77
BM9912 grain-F1	0.05	bdl	51.33	16.66	11.17	0.22	20.07	0.26	bdl	99.77	1.95	9.41	99.96
BM9912 grain-F2	bdl	0.07	51.22	16.56	10.82	0.23	20.02	0.25	bdl	99.17	1.66	9.33	99.33
BM9912 grain-F3	0.04	bdl	51.33	16.45	10.75	0.23	19.93	0.37	bdl	99.10	1.53	9.38	99.25
BM9912 grain-F4	bdl	bdl	49.79	18.56	10.84	0.22	20.22	0.18	bdl	99.81	2.25	8.81	100.04
BM9912 grain-F AVG	bdl	0.07	50.92	17.06	10.90	0.22	20.06	0.27	bdl	99.49	1.85	9.23	99.67
BM9912 grain-A1	bdl	bdl	48.54	19.00	10.58	0.25	19.67	0.29	bdl	98.32	1.80	8.95	98.50
BM9912 grain-A2	0.05	bdl	51.39	16.80	10.82	0.18	20.05	0.30	bdl	99.59	1.44	9.52	99.73
BM9912 grain-A3	bdl	bdl	51.77	16.26	10.62	0.24	20.26	0.36	bdl	99.50	1.91	8.90	99.69
BM9912 grain-A4	0.05	0.09	51.78	16.29	10.60	0.24	20.17	0.30	bdl	99.52	1.34	9.40	99.65
BM9912 grain-A5	0.06	0.09	51.58	16.72	10.91	0.19	20.13	0.28	bdl	99.95	1.36	9.68	100.09
BM9912 grain-A6	bdl	0.07	49.10	19.08	11.12	0.27	20.08	0.33	bdl	100.05	2.61	8.77	100.31

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
BM9912 grain-A AVG	0.05	0.08	50.69	17.36	10.77	0.23	20.06	0.31	bdl	99.56	1.74	9.20	99.73
BM9912 grain-J1	bdl	0.08	50.56	16.85	10.35	0.16	19.90	0.35	bdl	98.25	1.33	9.16	98.38
BM9912 grain-J2	bdl	0.09	50.98	17.05	10.92	0.20	20.01	0.31	bdl	99.56	1.65	9.43	99.73
BM9912 grain-J3	bdl	0.09	50.54	17.08	10.38	0.21	20.22	0.29	bdl	98.80	1.86	8.70	98.98
BM9912 grain-J AVG	bdl	0.09	50.69	16.99	10.55	0.19	20.04	0.32	bdl	98.87	1.61	9.10	99.03
BM9912 ALL AVG Core	bdl	bdl	51.77	16.26	10.62	0.24	20.26	0.36	bdl	99.50	2.33	8.52	99.73
BM9912 ALL AVG Rim	bdl	bdl	48.54	19.00	10.58	0.25	19.67	0.29	bdl	98.32	2.17	8.80	98.72
BM9915 grain-A1	0.04	0.18	26.69	41.74	14.47	0.54	16.05	0.20	bdl	99.92	3.17	11.61	100.24
BM9915 grain-A2	bdl	0.19	27.41	41.80	14.59	0.57	15.76	0.14	0.25	100.70	2.41	12.42	100.94
BM9915 grain-A3	bdl	0.16	27.52	41.56	14.58	0.52	15.80	0.15	bdl	100.29	2.32	12.50	100.53
BM9915 grain-A4	bdl	0.18	27.42	41.26	14.75	0.53	15.88	0.18	bdl	100.21	2.89	12.15	100.49
BM9915 grain-A5	bdl	0.18	27.23	41.52	14.48	0.56	15.95	0.17	bdl	100.09	2.76	11.99	100.36
BM9915 grain-A AVG	bdl	0.18	27.25	41.57	14.58	0.54	15.89	0.17	bdl	100.18	2.71	12.14	100.46
BM9915 grain-G1	bdl	0.13	28.87	40.13	14.87	0.50	15.87	0.18	bdl	100.55	2.51	12.61	100.80
BM9915 grain-G2	bdl	0.15	30.32	38.28	14.86	0.54	16.21	0.20	bdl	100.55	3.00	12.16	100.85
BM9915 grain-G3	bdl	0.13	28.99	40.10	14.98	0.54	15.96	0.20	bdl	100.89	2.76	12.50	101.17
BM9915 grain-G4	bdl	0.15	28.99	39.94	14.92	0.56	15.94	0.16	bdl	100.66	2.68	12.50	100.93
BM9915 grain-G5	bdl	0.14	29.09	39.53	14.88	0.52	15.96	0.14	bdl	100.26	2.79	12.37	100.54
BM9915 grain-G6	bdl	0.14	28.31	40.89	14.89	0.53	15.93	0.18	bdl	100.87	2.68	12.48	101.14
BM9915 grain-G7	bdl	0.17	27.67	40.99	15.21	0.57	15.75	0.19	bdl	100.54	3.07	12.44	100.85
BM9915 grain-G8	bdl	0.12	27.46	41.61	15.10	0.58	15.60	0.14	bdl	100.60	2.57	12.79	100.86

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
BM9915 grain-G AVG	bdl	0.14	27.46	41.61	15.10	0.58	15.60	0.14	bdl	100.62	2.57	12.79	100.88
BM9915 grain-B1	bdl	0.15	27.26	41.69	15.18	0.55	15.48	0.20	bdl	100.51	2.50	12.93	100.76
BM9915 grain-B2	bdl	0.16	27.54	41.10	15.01	0.55	15.63	0.17	0.28	100.43	2.98	12.32	100.73
BM9915 grain-B3	bdl	0.13	27.34	41.34	15.30	0.54	15.74	0.14	bdl	100.53	3.20	12.42	100.85
BM9915 grain-B4	bdl	0.15	27.15	41.29	15.35	0.55	15.56	0.15	bdl	100.20	3.04	12.62	100.50
BM9915 grain-B5	bdl	0.13	27.21	41.51	15.11	0.55	15.49	0.16	bdl	100.17	2.55	12.81	100.42
BM9915 grain-B AVG	bdl	0.14	27.30	41.39	15.19	0.55	15.58	0.16	bdl	100.31	2.85	12.62	100.60
BM9915 grain-C1	bdl	0.18	27.40	41.34	14.61	0.54	15.78	0.23	bdl	100.09	2.57	12.30	100.35
BM9915 grain-C2	bdl	0.17	28.18	40.58	14.62	0.52	15.95	0.18	bdl	100.20	2.63	12.25	100.46
BM9915 grain-C3	bdl	0.14	28.54	40.44	14.73	0.49	15.99	0.23	bdl	100.55	2.69	12.30	100.82
BM9915 grain-C4	bdl	0.16	28.12	40.89	14.50	0.52	16.00	0.18	bdl	100.36	2.54	12.21	100.61
BM9915 grain-C5	bdl	0.15	28.22	40.68	14.48	0.52	16.02	bdl	bdl	100.05	2.42	12.30	100.29
BM9915 grain-C AVG	bdl	0.16	28.09	40.78	14.59	0.52	15.95	0.20	bdl	100.29	2.57	12.28	100.55
BM9915 ALL AVG	bdl	0.16	27.53	41.34	14.86	0.55	15.75	0.17	bdl	100.35	2.68	12.46	100.62
X174 grain-A1	0.04	0.62	59.35	bdl	22.40	0.06	17.02	0.18	0.22	99.90	6.51	16.54	100.71
X174 grain-A2	0.08	0.56	59.71	bdl	22.27	0.09	16.83	0.18	0.31	100.02	6.03	16.84	100.74
X174 grain-A3	0.08	0.60	59.53	bdl	22.32	0.08	16.90	0.17	bdl	99.68	5.98	16.95	100.42
X174 grain-A4	0.05	0.62	59.43	0.05	22.37	0.10	16.90	0.15	0.27	99.95	6.26	16.74	100.74
X174 grain-A5	0.07	0.60	59.65	bdl	22.53	0.11	16.83	0.14	0.19	100.13	6.10	17.04	100.92
X174 grain-A6	0.08	0.62	59.66	0.05	22.40	0.05	16.85	0.10	0.24	100.04	5.91	17.08	100.78
X174 grain-A7	0.08	0.62	59.50	0.05	22.34	0.08	16.85	0.13	bdl	99.63	5.85	17.08	100.36

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X174 grain-A8	0.08	0.61	59.71	bdl	22.32	0.05	16.80	0.16	0.15	99.89	5.76	17.14	100.67
X174 grain-A9	0.07	0.64	59.69	bdl	22.21	0.06	16.84	0.13	bdl	99.64	5.60	17.18	100.38
X174 grain-A10	0.06	0.58	59.84	bdl	22.23	bdl	16.88	0.16	0.17	99.92	5.85	16.97	100.69
X174 grain-A AVG	0.07	0.61	59.61	bdl	22.34	0.07	16.87	0.15	0.15	99.87	5.99	16.95	100.63
X174 grain-B1	0.09	0.62	59.10	0.18	22.45	0.12	16.73	0.15	0.31	99.73	6.23	16.85	100.55
X174 grain-B2	0.07	0.58	58.85	0.20	22.57	bdl	16.60	0.14	0.29	99.32	6.22	16.97	100.14
X174 grain-B3	0.05	0.61	59.29	0.20	22.69	0.05	16.54	0.12	0.31	99.85	5.95	17.33	100.62
X174 grain-B4	0.07	0.57	59.39	0.18	22.59	0.11	16.55	0.18	0.31	99.95	5.99	17.20	100.69
X174 grain-B5	0.06	0.59	59.13	0.22	22.72	0.06	16.65	0.20	0.28	99.91	6.32	17.04	100.74
X174 grain-B6	0.07	0.59	59.09	0.20	22.74	0.10	16.57	0.16	0.25	99.76	6.19	17.17	100.52
X174 grain-B7	0.06	0.58	59.41	0.17	22.65	0.06	16.45	0.19	0.27	99.84	5.79	17.44	100.59
X174 grain-B8	0.20	0.60	59.17	0.20	22.43	0.06	16.42	0.13	0.32	99.52	5.43	17.54	100.21
X174 grain-B9	0.08	0.60	59.32	0.18	22.91	0.07	16.48	0.15	0.32	100.11	6.05	17.47	100.86
X174 grain-B10	0.10	0.58	59.31	0.19	22.29	0.08	16.37	0.16	0.22	99.29	5.36	17.47	99.98
X174 grain-B AVG	0.08	0.59	59.20	0.19	22.60	0.07	16.54	0.16	0.29	99.73	5.95	17.25	100.49
X174 grain-C1	0.07	0.60	59.70	0.18	22.84	0.10	16.51	0.15	0.00	100.15	5.67	17.74	100.92
X174 grain-C2	0.07	0.58	59.74	0.22	22.34	0.11	16.63	0.20	0.19	100.08	5.64	17.27	100.75
X174 grain-C3	0.05	0.54	59.52	0.18	22.54	0.13	16.70	0.15	0.24	100.05	6.11	17.04	100.82
X174 grain-C4	0.06	0.57	59.93	0.21	22.59	0.09	16.73	0.23	0.17	100.58	5.88	17.30	101.30
X174 grain-C5	bdl	0.53	59.74	0.18	22.29	0.11	16.74	0.18	0.19	99.95	5.94	16.94	100.71
X174 grain-C6	0.08	0.60	59.69	0.17	22.35	0.08	16.65	0.20	0.14	99.96	5.60	17.31	100.64

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X174 grain-C7	0.08	0.54	59.83	0.18	22.50	0.11	16.66	0.17	0.21	100.28	5.76	17.32	101.01
X174 grain-C8	0.07	0.56	59.61	0.19	22.46	0.12	16.52	0.22	0.19	99.93	5.67	17.35	100.66
X174 grain-C9	0.06	0.58	59.63	0.20	22.53	0.07	16.62	0.18	0.27	100.14	5.84	17.27	100.88
X174 grain-C10	0.07	0.57	59.66	0.15	22.52	0.08	16.47	0.20	0.19	99.91	5.55	17.53	100.65
X174 grain-C AVG	0.06	0.57	59.71	0.19	22.50	0.10	16.62	0.19	0.18	100.10	5.77	17.31	100.84
X174 grain-D1	0.06	0.55	59.31	0.23	21.96	0.10	16.45	0.18	0.26	99.09	5.37	17.13	99.83
X174 grain-D2	0.06	0.60	59.67	0.22	22.37	0.08	16.62	0.16	0.32	100.09	5.69	17.25	100.82
X174 grain-D3	0.06	0.59	59.34	0.24	22.48	0.06	16.67	0.21	0.26	99.90	6.01	17.07	100.69
X174 grain-D4	0.05	0.57	59.54	0.22	22.53	0.06	16.63	0.17	0.24	100.01	5.89	17.23	100.77
X174 grain-D5	0.06	0.57	59.50	0.22	22.26	0.09	16.68	0.18	0.23	99.79	5.78	17.06	100.52
X174 grain-D6	0.07	0.58	59.44	0.27	22.34	0.06	16.67	0.14	0.35	99.92	5.85	17.07	100.67
X174 grain-D7	0.08	0.52	59.36	0.22	22.15	0.09	16.69	0.15	0.33	99.58	5.89	16.85	100.33
X174 grain-D8	0.07	0.58	59.55	0.22	22.13	0.05	16.66	0.13	0.30	99.69	5.57	17.12	100.45
X174 grain-D9	0.06	0.57	59.11	0.21	21.90	0.09	16.47	0.14	0.25	98.78	5.41	17.04	99.54
X174 grain-D10	0.07	0.56	59.76	0.25	21.91	0.09	16.35	0.21	0.37	99.56	4.99	17.41	100.23
X174 grain-D AVG	0.06	0.57	59.46	0.23	22.20	0.08	16.59	0.16	0.29	99.64	5.65	17.12	100.39
X174 ALL AVG	0.07	0.58	59.49	0.15	22.41	0.08	16.65	0.16	0.23	99.84	5.84	17.16	100.58
X192 grain-A1	0.08	0.52	58.01	4.79	17.54	0.26	17.98	0.18	0.24	99.59	3.53	14.36	100.08
X192 grain-A2	0.06	0.52	57.78	4.76	17.72	0.29	18.01	0.21	bdl	99.35	3.72	14.37	99.84
X192 grain-A3	0.05	0.49	58.13	4.88	17.87	0.28	18.00	0.21	0.17	100.08	3.72	14.52	100.59
X192 grain-A4	0.05	0.52	58.04	4.80	18.05	0.24	18.10	0.20	bdl	99.99	3.88	14.56	100.50

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X192 grain-A5	0.05	0.55	57.82	4.81	17.76	0.28	18.02	0.16	bdl	99.45	3.64	14.48	99.92
X192 grain-A6	0.04	0.47	57.73	4.75	17.92	0.27	18.13	0.24	0.17	99.72	4.29	14.06	100.29
X192 grain-A7	0.05	0.52	57.84	4.76	17.93	0.27	18.11	0.20	0.17	99.84	4.09	14.25	100.34
X192 grain-A8	0.04	0.48	57.91	4.79	17.71	0.24	17.95	0.24	0.16	99.51	3.69	14.39	100.04
X192 grain-A9	0.04	0.54	58.03	4.78	17.60	0.25	17.95	0.26	bdl	99.46	3.38	14.56	99.94
X192 grain-A10	0.06	0.56	57.88	4.71	17.44	0.23	17.80	0.16	0.24	99.07	3.15	14.60	99.56
X192 grain-A AVG	0.05	0.51	57.92	4.78	17.75	0.26	18.00	0.21	0.12	99.61	3.71	14.42	100.11
X192 grain-B1	0.07	0.48	58.27	4.57	17.61	0.26	17.63	0.15	0.15	99.18	2.91	14.99	99.60
X192 grain-B2	0.06	0.50	58.38	4.54	18.10	0.25	17.87	0.20	0.20	100.10	3.65	14.81	100.57
X192 grain-B3	0.06	0.50	58.32	4.67	18.00	0.25	17.85	0.18	0.18	100.01	3.49	14.85	100.49
X192 grain-B4	0.05	0.46	58.39	4.69	18.05	0.28	17.87	0.21	0.21	100.20	3.68	14.75	100.68
X192 grain-B5	0.04	0.48	58.38	4.68	18.12	0.24	17.95	0.21	0.21	100.30	3.81	14.70	100.82
X192 grain-B6	0.06	0.49	58.23	4.64	18.24	0.25	17.99	0.25	0.15	100.30	4.00	14.64	100.81
X192 grain-B7	0.04	0.46	58.01	4.71	17.87	0.32	17.92	0.22	bdl	99.55	3.73	14.51	100.01
X192 grain-B8	0.06	0.48	57.97	4.65	17.98	0.28	17.89	0.20	0.23	99.72	3.89	14.48	100.21
X192 grain-B9	0.06	0.51	58.23	4.63	17.82	0.23	17.75	0.19	bdl	99.42	3.13	15.01	99.87
X192 grain-B10	0.07	0.53	57.66	4.66	17.79	0.24	17.47	0.18	bdl	98.61	2.96	15.12	99.03
X192 grain-B AVG	0.06	0.49	58.18	4.64	17.96	0.26	17.82	0.20	0.13	99.74	3.53	14.79	100.21
X192 grain-C1	0.06	0.43	58.90	4.22	17.35	0.24	17.89	0.22	0.19	99.50	3.03	14.62	99.94
X192 grain-C2	0.05	0.45	58.48	4.30	17.34	0.22	17.99	0.15	0.19	99.16	3.32	14.36	99.61
X192 grain-C3	0.06	0.45	58.92	4.26	17.41	0.22	18.04	0.18	0.18	99.72	3.21	14.52	100.15

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X192 grain-C4	0.06	0.45	58.84	4.30	17.56	0.27	18.12	0.18	0.24	100.00	3.52	14.39	100.51
X192 grain-C5	0.06	0.42	59.43	4.34	17.38	0.21	18.29	0.19	0.21	100.52	3.29	14.41	100.93
X192 grain-C6	0.05	0.45	58.75	4.28	17.47	0.25	18.18	0.24	0.00	99.65	3.52	14.30	100.13
X192 grain-C7	0.04	0.51	59.08	4.20	17.51	0.22	18.26	0.18	0.22	100.22	3.50	14.36	100.70
X192 grain-C8	0.06	0.45	59.15	4.36	17.39	0.25	18.20	0.20	0.17	100.23	3.28	14.44	100.66
X192 grain-C9	0.06	0.43	59.18	4.17	17.58	0.23	18.29	0.22	0.20	100.36	3.66	14.29	100.83
X192 grain-C AVG	0.06	0.45	58.97	4.27	17.44	0.23	18.14	0.19	0.18	99.93	3.37	14.41	100.38
X192 grain-D1	0.06	0.56	58.51	4.56	17.46	0.23	17.86	0.19	0.20	99.63	3.01	14.75	100.13
X192 grain-D2	0.06	0.56	58.52	4.62	17.72	0.24	17.86	0.22	bdl	99.81	3.05	14.97	100.25
X192 grain-D3	0.05	0.54	58.62	4.56	17.78	0.24	17.81	0.21	0.15	99.95	3.13	14.96	100.42
X192 grain-D4	0.06	0.56	59.18	4.68	17.81	0.25	17.70	0.20	0.15	100.59	2.52	15.54	100.99
X192 grain-D5	0.06	0.52	59.00	4.70	17.63	0.25	17.67	0.21	0.24	100.28	2.64	15.26	100.70
X192 grain-D6	0.05	0.54	58.85	4.62	17.36	0.22	17.65	0.23	0.19	99.72	2.41	15.20	100.05
X192 grain-D7	0.05	0.55	58.90	4.62	17.63	0.25	17.56	0.19	bdl	99.75	2.30	15.56	100.08
X192 grain-D8	0.06	0.54	58.72	4.61	17.79	0.27	17.63	0.27	0.18	100.07	2.82	15.25	100.53
X192 grain-D9	0.06	0.52	58.91	4.60	17.63	0.25	17.52	0.15	bdl	99.65	2.25	15.61	100.08
X192 grain-D10	0.06	0.57	58.92	4.62	17.45	0.26	17.32	0.22	bdl	99.42	1.77	15.86	99.71
X192 grain-D AVG	0.06	0.54	58.81	4.62	17.63	0.25	17.66	0.21	0.11	99.89	2.59	15.30	100.29
X192 ALL AVG	0.06	0.48	58.36	4.57	17.72	0.25	17.99	0.20	0.14	99.76	3.54	14.54	100.23
X299 grain-A1	bdl	0.39	57.09	4.14	20.54	0.19	17.86	0.20	bdl	100.42	7.66	13.65	101.19
X299 grain-A2	bdl	0.38	56.90	3.97	20.30	0.13	17.91	0.24	bdl	99.82	8.27	12.86	100.65

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X299 grain-A3	bdl	0.35	57.43	3.91	19.77	0.14	17.83	0.25	bdl	99.67	6.95	13.51	100.37
X299 grain-A4	0.04	0.29	58.03	3.16	19.72	0.11	17.92	0.21	bdl	99.48	6.92	13.49	100.18
X299 grain-A AVG	bdl	0.35	57.36	3.80	20.08	0.14	17.88	0.23	bdl	99.84	7.45	13.38	100.58
X299 grain-B1	bdl	0.43	57.66	3.15	19.57	0.15	18.19	0.22	bdl	99.37	7.43	12.89	100.11
X299 grain-B2	bdl	0.42	57.89	3.13	19.51	0.14	18.09	0.26	bdl	99.43	6.85	13.34	100.12
X299 grain-B3	bdl	0.42	57.78	3.14	19.54	0.14	18.14	0.24	bdl	99.40	7.14	13.12	100.11
X299 grain-B4	0.04	0.28	58.39	2.97	18.37	0.19	17.90	bdl	bdl	98.15	5.33	13.58	98.68
X299 grain-B5	bdl	0.32	58.74	2.97	18.87	0.20	18.20	bdl	bdl	99.30	6.16	13.32	99.92
X299 grain-B6	0.04	0.34	58.36	3.02	18.99	0.11	18.15	bdl	bdl	99.02	6.18	13.43	99.64
X299 grain-B7	0.05	0.30	58.25	2.97	18.79	0.15	18.18	0.19	bdl	98.89	6.48	12.96	99.54
X299 grain-B8	bdl	0.32	58.36	3.10	18.96	0.11	17.99	bdl	bdl	98.84	5.82	13.72	99.42
X299 grain-B9	bdl	0.30	58.19	2.98	19.46	0.15	18.21	0.22	bdl	99.51	7.31	12.88	100.25
X299 grain-B AVG	bdl	0.31	58.38	3.00	18.91	0.15	18.11	0.21	bdl	99.06	6.21	13.32	99.69
X299 grain-C1	bdl	0.36	58.40	3.07	18.93	0.15	18.19	0.24	bdl	99.33	6.54	13.05	99.99
X299 grain-C2	0.05	0.35	58.25	3.12	19.34	0.09	18.18	0.20	bdl	99.59	6.78	13.24	100.27
X299 grain-C3	0.06	0.32	58.37	3.15	18.97	0.19	18.10	0.21	bdl	99.34	6.32	13.28	99.98
X299 grain-C4	bdl	0.32	58.36	3.03	19.17	0.15	18.29	0.18	bdl	99.49	7.02	12.86	100.20
X299 grain-C5	0.05	0.31	58.13	3.09	18.84	0.13	18.19	0.18	bdl	98.91	6.53	12.96	99.56
X299 grain-C6	0.06	0.29	58.04	3.08	18.47	0.14	17.96	0.18	bdl	98.21	5.84	13.21	98.80
X299 grain-C AVG	bdl	0.32	58.26	3.09	18.95	0.14	18.15	0.20	bdl	99.11	6.50	13.10	99.76
X299 grain-D1	0.05	0.37	57.88	3.17	19.25	0.11	17.99	0.17	bdl	98.99	6.52	13.38	99.64

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X299 grain-D2	bdl	0.39	57.89	3.06	19.38	0.14	18.22	bdl	bdl	99.08	7.07	13.02	99.79
X299 grain-D AVG	bdl	0.38	57.88	3.11	19.31	0.12	18.11	0.17	bdl	99.09	6.80	13.20	99.78
X299 ALL AVG	bdl	0.36	57.93	3.23	19.36	0.14	18.08	0.21	bdl	99.30	6.82	13.22	99.99
X319 grain-A1	0.06	0.51	58.61	3.46	17.04	0.19	18.70	0.16	bdl	98.73	4.17	13.29	99.30
X319 grain-A2	0.06	0.46	58.79	3.52	17.75	0.25	18.71	0.20	bdl	99.73	4.70	13.52	100.35
X319 grain-A3	0.04	0.44	59.00	3.45	17.60	0.26	18.78	0.26	0.22	100.06	4.91	13.19	100.66
X319 grain-A4	0.05	0.49	59.07	3.45	17.56	0.23	18.78	0.25	0.16	100.04	4.62	13.40	100.65
X319 grain-A5	0.06	0.44	59.27	3.43	17.32	0.18	18.67	0.29	0.18	99.85	4.24	13.50	100.43
X319 grain-A6	0.07	0.45	58.61	3.46	17.40	0.21	18.73	0.23	0.20	99.36	4.74	13.13	99.94
X319 grain-A7	0.06	0.46	59.31	3.42	17.67	0.21	18.68	0.20	0.20	100.21	4.45	13.66	100.79
X319 grain-A8	0.06	0.47	59.18	3.48	17.47	0.21	18.61	0.19	bdl	99.65	4.09	13.78	100.18
X319 grain-A9	0.06	0.41	58.82	3.51	17.37	0.23	18.79	0.26	bdl	99.45	4.63	13.20	100.02
X319 grain-A10	0.06	0.43	59.08	3.42	17.32	0.22	18.70	0.24	0.17	99.63	4.45	13.31	100.20
X319 grain-A AVG	0.06	0.46	58.97	3.46	17.45	0.22	18.71	0.23	0.11	99.67	4.50	13.40	100.25
X319 grain-B1	0.06	0.49	58.74	3.60	17.94	0.25	18.49	0.21	0.18	99.95	4.60	13.81	100.54
X319 grain-B2	0.07	0.44	58.82	3.56	17.85	0.26	18.58	0.22	0.17	99.98	4.73	13.59	100.55
X319 grain-B3	0.05	0.44	58.74	3.49	18.10	0.21	18.45	0.20	0.17	99.85	4.75	13.82	100.47
X319 grain-B4	0.06	0.44	58.97	3.53	18.04	0.23	18.45	0.23	0.27	100.20	4.67	13.84	100.77
X319 grain-B5	0.06	0.47	58.94	3.43	18.10	0.23	18.44	0.23	0.16	100.05	4.62	13.94	100.65
X319 grain-B6	0.07	0.42	58.92	3.48	17.93	0.22	18.48	0.26	0.16	99.95	4.62	13.78	100.56
X319 grain-B7	0.05	0.44	58.42	3.43	17.83	0.19	18.56	0.19	0.17	99.27	4.90	13.41	99.90

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X319 grain-B8	0.06	0.44	58.85	3.51	17.93	0.20	18.47	0.17	0.00	99.62	4.43	13.95	100.21
X319 grain-B9	0.04	0.41	58.45	3.52	18.01	0.24	18.51	0.20	0.19	99.58	5.05	13.47	100.20
X319 grain-B AVG	0.06	0.44	58.76	3.50	17.97	0.23	18.49	0.21	0.16	99.83	4.71	13.73	100.43
X319 ALL AVG	0.06	0.45	58.87	3.48	17.71	0.22	18.60	0.22	0.14	99.75	4.60	13.57	100.34
Ba-1-72 grain-A1	0.04	0.10	51.69	12.78	16.11	0.17	18.78	0.38	0.15	100.20	5.86	10.84	100.78
Ba-1-72 grain-A2	0.07	0.06	51.77	12.95	15.98	0.23	19.18	0.39	0.13	100.76	6.45	10.18	101.40
Ba-1-72 grain-A3	bdl	0.06	51.56	12.82	15.68	0.21	19.09	0.35	0.04	99.81	6.24	10.06	100.43
Ba-1-72 grain-A AVG	0.06	0.07	51.67	12.85	15.92	0.20	19.02	0.38	0.11	100.27	6.18	10.36	100.89
Ba-1-72 grain-B1	0.08	0.07	54.32	10.52	15.03	0.19	19.73	0.35	0.18	100.47	5.80	9.81	101.05
Ba-1-72 grain-B2	0.07	0.08	54.46	10.49	15.36	0.18	19.79	0.36	0.20	100.98	6.15	9.82	101.60
Ba-1-72 grain-B3	0.08	0.12	54.46	10.32	15.44	0.17	19.83	0.33	0.04	100.78	6.11	9.95	101.39
Ba-1-72 grain-B4	0.09	0.08	54.26	10.52	15.19	0.21	19.75	0.43	0.08	100.61	6.02	9.78	101.21
Ba-1-72 grain-B5	0.07	0.07	54.13	10.15	15.08	0.20	19.71	0.22	0.22	99.85	6.07	9.62	100.46
Ba-1-72 grain-B AVG	0.08	0.08	54.33	10.40	15.22	0.19	19.76	0.34	0.14	100.54	6.03	9.79	101.14
Ba-1-72 ALL AVG	0.07	0.08	53.00	11.62	15.57	0.20	19.39	0.36	0.12	100.41	6.11	10.08	101.02
Ba2-1-1 grain-A1	0.09	0.08	55.30	10.52	11.31	0.39	20.98	0.39	bdl	99.06	3.43	8.23	99.41
Ba2-1-1 grain-A2	0.11	0.08	55.52	10.66	11.52	0.35	20.87	0.35	bdl	99.45	3.10	8.73	99.76
Ba2-1-1 grain-A3	0.11	0.05	55.74	10.48	11.68	0.39	20.93	0.37	bdl	99.74	3.38	8.64	100.08
Ba2-1-1 grain-A4	0.08	0.07	55.91	10.63	11.43	0.35	20.90	0.40	bdl	99.77	2.99	8.74	100.07
Ba2-1-1 grain-A5	0.04	0.08	55.50	10.74	11.58	0.33	20.79	0.34	bdl	99.40	3.14	8.75	99.71
Ba2-1-1 grain-A6	0.06	0.09	55.79	10.61	11.36	0.39	20.98	0.40	0.16	99.83	3.30	8.39	100.16

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
Ba2-1-1 grain-A7	0.10	0.04	54.88	10.67	11.54	0.33	20.51	0.43	bdl	98.48	3.09	8.75	98.79
Ba2-1-1 grain-A8	0.06	0.08	55.53	11.12	11.62	0.40	20.85	0.43	0.18	100.27	3.33	8.62	100.61
Ba2-1-1 grain-A9	0.09	0.09	55.38	11.01	11.45	0.35	20.71	0.41	bdl	99.47	2.85	8.88	99.76
Ba2-1-1 grain-A AVG	0.08	0.07	55.51	10.71	11.50	0.36	20.83	0.39	0.04	99.50	3.18	8.64	99.82
Ba2-1-1 grain-B1	0.07	0.07	55.54	10.60	11.31	0.34	20.76	0.38	bdl	99.07	2.90	8.70	99.36
Ba2-1-1 grain-B2	0.09	0.09	55.54	10.73	11.50	0.37	20.77	0.35	bdl	99.44	2.97	8.83	99.74
Ba2-1-1 grain-B3	0.08	0.07	55.71	10.68	11.71	0.36	20.87	0.38	bdl	99.86	3.25	8.79	100.18
Ba2-1-1 grain-B4	0.15	0.11	55.80	10.60	11.41	0.38	20.86	0.48	bdl	99.77	2.89	8.81	100.06
Ba2-1-1 grain-B5	0.10	0.08	55.89	10.52	11.58	0.35	20.79	0.39	bdl	99.70	2.94	8.93	99.99
Ba2-1-1 grain-B6	0.08	0.04	55.88	10.58	11.56	0.35	20.90	0.44	bdl	99.83	3.20	8.67	100.15
Ba2-1-1 grain-B7	0.09	0.07	55.89	10.50	11.36	0.34	20.76	0.36	bdl	99.37	2.72	8.91	99.64
Ba2-1-1 grain-B8	0.08	0.10	55.92	10.62	11.45	0.37	20.84	0.34	bdl	99.71	2.84	8.89	99.99
Ba2-1-1 grain-B9	0.11	0.10	55.66	10.58	11.66	0.36	20.84	0.42	bdl	99.73	3.18	8.80	100.05
Ba2-1-1 grain-B10	0.10	0.12	55.76	10.64	11.60	0.40	20.73	0.36	bdl	99.70	2.83	9.05	99.99
Ba2-1-1 grain-B AVG	0.10	0.08	55.76	10.60	11.51	0.36	20.81	0.39	bdl	99.62	2.97	8.84	99.91
Ba2-1-1 grain-C1	0.07	0.07	56.27	10.52	11.34	0.35	20.57	0.39	bdl	99.58	2.23	9.33	99.80
Ba2-1-1 grain-C2	0.09	0.11	56.03	10.72	11.49	0.37	20.81	0.38	bdl	99.99	2.71	9.05	100.26
Ba2-1-1 grain-C3	0.06	0.10	55.88	10.58	11.55	0.38	20.87	0.36	bdl	99.78	3.07	8.79	100.09
Ba2-1-1 grain-C4	0.09	0.06	55.74	10.47	11.47	0.35	20.90	0.35	bdl	99.43	3.16	8.63	99.75
Ba2-1-1 grain-C5	0.10	0.08	55.87	10.65	11.58	0.33	20.85	0.43	bdl	99.90	3.00	8.88	100.20
Ba2-1-1 grain-C6	0.08	0.08	55.83	10.59	11.52	0.38	20.88	0.40	bdl	99.75	3.11	8.73	100.06

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
Ba2-1-1 grain-C7	0.09	0.08	55.85	10.68	11.38	0.39	20.84	0.39	bdl	99.71	2.88	8.79	99.99
Ba2-1-1 grain-C8	0.08	0.07	55.80	10.68	11.36	0.37	20.73	0.42	bdl	99.51	2.76	8.88	99.78
Ba2-1-1 grain-C9	0.09	0.07	56.03	10.84	11.32	0.37	20.65	0.39	bdl	99.76	2.37	9.19	99.99
Ba2-1-1 grain-C10	0.09	0.09	56.10	10.60	11.16	0.37	20.17	0.40	bdl	98.98	1.53	9.79	99.13
Ba2-1-1 grain-C AVG	0.08	0.08	55.94	10.63	11.42	0.37	20.73	0.39	bdl	99.64	2.68	9.00	99.91
Ba2-1-1 grain-D1	0.07	0.08	56.09	10.52	10.76	0.33	21.05	0.41	bdl	99.33	2.64	8.39	99.59
Ba2-1-1 grain-D2	0.06	0.11	56.09	10.56	11.45	0.36	20.77	0.40	bdl	99.80	2.71	9.01	100.08
Ba2-1-1 grain-D3	0.08	0.10	56.04	10.48	11.42	0.36	20.92	0.39	bdl	99.78	2.96	8.76	100.08
Ba2-1-1 grain-D4	0.07	0.09	56.08	10.48	11.51	0.36	20.88	0.42	bdl	99.89	2.99	8.81	100.19
Ba2-1-1 grain-D5	0.08	0.10	55.96	10.46	11.57	0.36	20.97	0.41	bdl	99.89	3.23	8.67	100.22
Ba2-1-1 grain-D6	0.08	0.07	56.11	10.49	11.27	0.36	21.01	0.39	bdl	99.79	2.97	8.60	100.09
Ba2-1-1 grain-D7	0.07	0.09	55.86	10.44	11.25	0.36	20.96	0.50	bdl	99.52	3.12	8.44	99.83
Ba2-1-1 grain-D8	0.07	0.12	55.89	10.51	11.43	0.41	20.87	0.39	bdl	99.67	3.00	8.73	99.97
Ba2-1-1 grain-D9	0.08	0.10	55.94	10.46	11.44	0.33	20.87	0.39	bdl	99.62	2.93	8.81	99.91
Ba2-1-1 grain-D10	0.09	0.10	55.88	10.43	11.20	0.33	20.92	0.45	bdl	99.39	2.91	8.59	99.68
Ba2-1-1 grain-D AVG	0.08	0.10	55.99	10.48	11.33	0.36	20.92	0.41	bdl	99.67	2.94	8.68	99.96
Ba2-1-1 ALL AVG	0.08	0.08	55.80	10.61	11.44	0.36	20.82	0.40	bdl	99.61	2.94	8.79	99.90
EP-3-84 grain-A1	0.07	0.00	64.11	bdl	13.74	0.06	20.68	0.28	0.21	99.15	3.72	10.40	99.52
EP-3-84 grain-A2	0.04	0.16	64.48	bdl	13.76	0.10	20.67	0.31	bdl	99.52	3.21	10.87	99.84
EP-3-84 grain-A3	0.05	0.18	64.40	bdl	13.67	0.11	20.75	0.36	bdl	99.52	3.32	10.68	99.85
EP-3-84 grain-A4	0.05	0.17	64.21	bdl	13.68	0.09	20.64	0.32	bdl	99.16	3.23	10.78	99.49

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
EP-3-84 grain-A5	0.05	0.16	64.37	bdl	13.89	0.07	20.63	0.28	0.15	99.60	3.36	10.86	99.94
EP-3-84 grain-A6	0.06	0.18	64.28	bdl	13.91	0.09	20.69	0.30	bdl	99.51	3.37	10.87	99.84
EP-3-84 grain-A7	0.07	0.16	64.37	bdl	13.62	0.12	20.62	0.31	bdl	99.27	3.05	10.88	99.57
EP-3-84 grain-A8	0.05	0.15	64.33	bdl	13.71	0.07	20.60	0.24	bdl	99.15	3.06	10.95	99.46
EP-3-84 grain-A9	0.07	0.16	64.31	bdl	13.65	0.09	20.62	0.27	0.16	99.32	3.18	10.79	99.64
EP-3-84 grain-A10	0.06	0.19	64.46	bdl	13.64	0.12	20.74	0.34	bdl	99.55	3.18	10.78	99.87
EP-3-84 grain-A AVG	0.06	0.15	64.33	bdl	13.73	0.09	20.66	0.30	0.05	99.37	3.27	10.79	99.70
EP-3-84 grain-B1	0.07	0.20	64.15	bdl	14.46	0.11	20.31	0.18	bdl	99.48	3.17	11.60	99.80
EP-3-84 grain-B2	0.06	0.16	64.23	bdl	14.44	0.11	20.30	0.22	bdl	99.51	3.20	11.55	99.83
EP-3-84 grain-B3	0.04	0.15	64.18	bdl	14.15	0.08	20.26	0.19	bdl	99.05	2.97	11.48	99.35
EP-3-84 grain-B4	0.04	0.18	64.18	bdl	14.18	0.14	20.34	0.18	bdl	99.24	3.11	11.38	99.56
EP-3-84 grain-B5	0.06	0.15	64.10	bdl	13.95	0.11	20.36	0.24	bdl	98.97	3.02	11.24	99.27
EP-3-84 grain-B6	0.06	0.16	64.18	bdl	14.08	0.11	20.39	0.20	bdl	99.17	3.08	11.30	99.48
EP-3-84 grain-B7	0.05	0.16	64.36	bdl	13.97	0.10	20.50	0.22	bdl	99.36	3.08	11.19	99.67
EP-3-84 grain-B8	0.05	0.13	64.15	bdl	14.07	0.09	20.50	0.25	bdl	99.24	3.34	11.06	99.57
EP-3-84 grain-B9	0.05	0.18	64.29	bdl	13.88	0.12	20.54	0.27	bdl	99.32	3.14	11.05	99.64
EP-3-84 grain-B AVG	0.05	0.16	64.20	bdl	14.13	0.11	20.39	0.22	bdl	99.26	3.12	11.32	99.57
EP-3-84 grain-C1	0.06	0.17	64.25	bdl	13.73	0.11	20.56	0.22	bdl	99.11	3.02	11.01	99.41
EP-3-84 grain-C2	0.06	0.15	64.48	bdl	14.09	0.10	20.61	0.21	bdl	99.69	3.26	11.15	100.02
EP-3-84 grain-C3	0.07	0.17	64.84	bdl	14.04	0.08	20.68	0.25	bdl	100.12	3.08	11.27	100.43
EP-3-84 grain-C4	0.06	0.14	64.39	bdl	13.97	0.10	20.55	0.26	bdl	99.47	3.19	11.10	99.79

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
EP-3-84 grain-C5	0.05	0.14	64.39	bdl	13.95	0.12	20.62	0.28	bdl	99.53	3.33	10.95	99.87
EP-3-84 grain-C6	0.07	0.17	64.50	bdl	13.98	0.10	20.54	0.29	bdl	99.66	3.09	11.20	99.97
EP-3-84 grain-C7	0.05	0.19	64.45	bdl	13.95	0.12	20.51	0.23	bdl	99.49	3.01	11.24	99.79
EP-3-84 grain-C8	0.05	0.15	64.32	bdl	13.90	0.11	20.52	0.25	bdl	99.31	3.13	11.09	99.62
EP-3-84 grain-C9	0.05	0.18	64.43	bdl	13.87	0.10	20.50	0.20	bdl	99.33	2.91	11.25	99.62
EP-3-84 grain-C10	0.07	0.15	64.31	bdl	13.83	0.13	20.42	0.19	bdl	99.09	2.86	11.26	99.38
EP-3-84 grain-C AVG	0.06	0.16	64.44	bdl	13.93	0.11	20.55	0.24	bdl	99.48	3.09	11.15	99.79
EP-3-84 grain-D1	0.04	0.20	63.78	bdl	14.98	0.11	20.60	0.14	bdl	99.85	4.25	11.15	100.27
EP-3-84 grain-D2	0.04	0.17	64.04	bdl	15.33	0.12	20.61	0.18	0.16	100.65	4.59	11.19	101.11
EP-3-84 grain-D3	0.05	0.17	63.94	bdl	15.56	0.09	20.51	0.15	bdl	100.48	4.50	11.51	100.93
EP-3-84 grain-D4	0.03	0.18	63.92	bdl	14.88	0.09	20.46	bdl	bdl	99.55	3.80	11.46	99.94
EP-3-84 grain-D5	0.05	0.22	63.78	bdl	15.07	0.09	20.52	0.19	bdl	99.92	4.20	11.30	100.34
EP-3-84 grain-D6	0.05	0.17	63.90	bdl	14.96	0.15	20.52	0.23	0.17	100.15	4.32	11.07	100.58
EP-3-84 grain-D7	0.05	0.20	63.87	bdl	15.03	0.08	20.59	0.29	bdl	100.12	4.30	11.15	100.55
EP-3-84 grain-D8	0.05	0.12	64.03	bdl	15.05	0.13	20.49	0.20	bdl	100.06	4.17	11.29	100.48
EP-3-84 grain-D9	0.04	0.15	63.79	bdl	14.90	0.15	20.42	0.18	0.17	99.80	4.19	11.12	100.22
EP-3-84 grain-D10	0.04	0.16	63.72	bdl	15.18	0.10	20.52	0.20	0.14	100.06	4.57	11.07	100.52
EP-3-84 grain-D11	0.05	0.13	63.88	bdl	15.44	0.09	20.61	0.22	bdl	100.42	4.71	11.20	100.90
EP-3-84 grain-D12	0.04	0.17	63.45	bdl	15.35	0.12	20.61	0.26	bdl	99.99	4.92	10.92	100.49
EP-3-84 grain-D13	0.03	0.18	63.79	bdl	15.07	0.13	20.50	0.13	bdl	99.83	4.22	11.27	100.25
EP-3-84 grain-D14	0.05	0.14	63.70	bdl	15.00	0.14	20.45	0.25	bdl	99.73	4.29	11.14	100.15

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
EP-3-84 grain-D15	0.03	0.16	63.77	bdl	15.25	0.18	20.64	0.17	0.23	100.43	4.87	10.87	100.92
EP-3-84 grain-D16	0.03	0.20	63.80	bdl	14.78	0.13	20.53	0.19	bdl	99.65	4.09	11.10	100.06
EP-3-84 grain-D17	0.04	0.19	63.76	bdl	15.01	0.09	20.39	0.23	0.20	99.91	4.21	11.22	100.33
EP-3-84 grain-D AVG	0.04	0.17	63.82	bdl	15.11	0.12	20.53	0.19	0.06	100.03	4.37	11.18	100.47
EP-3-84 grain-E1	0.03	0.18	64.52	bdl	13.70	0.10	21.30	0.28	0.16	100.27	4.21	9.91	100.69
EP-3-84 grain-E2	0.04	0.17	64.46	bdl	13.72	0.10	21.15	0.38	bdl	100.01	3.97	10.15	100.41
EP-3-84 grain-E3	0.06	0.11	64.34	bdl	13.72	0.10	21.16	0.27	0.20	99.96	4.18	9.96	100.38
EP-3-84 grain-E4	0.02	0.20	64.26	bdl	13.18	0.12	20.84	0.30	bdl	98.92	3.14	10.35	99.24
EP-3-84 grain-E5	0.03	0.16	64.29	bdl	13.76	0.09	21.13	0.26	bdl	99.73	4.00	10.16	100.13
EP-3-84 grain-E6	0.05	0.13	64.23	bdl	13.57	0.16	21.16	0.31	bdl	99.60	4.05	9.92	100.00
EP-3-84 grain-E7	0.04	0.19	64.38	bdl	13.94	0.08	21.08	0.24	bdl	99.93	3.92	10.41	100.33
EP-3-84 grain-E8	0.04	0.14	64.14	bdl	13.58	0.07	21.09	0.34	0.28	99.69	4.17	9.82	100.10
EP-3-84 grain-E9	0.03	0.17	64.34	bdl	13.61	0.10	21.17	0.30	bdl	99.72	3.95	10.06	100.12
EP-3-84 grain-E10	0.05	0.15	64.16	bdl	13.51	0.08	21.16	0.28	0.24	99.63	4.09	9.82	100.04
EP-3-84 grain-E AVG	0.04	0.16	64.31	bdl	13.63	0.10	21.12	0.30	0.09	99.75	3.97	10.06	100.14
EP-3-84 ALL AVG	0.05	0.16	64.22	bdl	14.10	0.11	20.65	0.25	bdl	99.58	3.56	10.90	99.94
TF6 grain-A1	0.07	0.05	50.16	15.75	13.80	0.58	19.63	0.38	0.13	100.54	4.56	9.70	101.05
TF6 grain-A2	0.07	0.05	50.07	15.80	13.50	0.56	19.61	0.40	0.08	100.13	4.27	9.66	100.65
TF6 grain-A3	0.06	0.05	49.98	15.95	13.58	0.60	19.61	0.39	0.13	100.35	4.40	9.62	100.91
TF6 grain-A4	0.07	bdl	49.94	15.98	13.55	0.54	19.57	0.40	0.07	100.12	4.30	9.69	100.65
TF6 grain-A5	0.05	bdl	49.76	15.84	13.47	0.56	19.57	0.33	0.18	99.75	4.48	9.44	100.30

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
TF6 grain-A6	0.06	bdl	50.10	16.22	13.45	0.55	19.56	0.32	0.16	100.40	4.06	9.79	100.87
TF6 grain-A7	0.07	bdl	49.95	16.12	13.62	0.57	19.56	0.39	0.08	100.35	4.31	9.75	100.84
TF6 grain-A8	0.07	0.05	49.88	15.89	13.37	0.61	19.58	0.44	0.22	100.10	4.36	9.44	100.64
TF6 grain-A9	0.07	bdl	49.85	15.80	13.38	0.56	19.67	0.36	0.06	99.74	4.43	9.39	100.25
TF6 grain-A10	0.10	bdl	49.97	15.68	13.25	0.57	19.39	0.41	0.08	99.49	3.87	9.77	99.93
TF6 grain-A AVG	0.07	bdl	49.97	15.90	13.50	0.57	19.57	0.38	0.12	100.07	4.30	9.62	100.61
TF6 grain-B1	0.06	bdl	49.29	16.14	13.41	0.62	19.35	0.31	bdl	99.17	4.17	9.66	99.59
TF6 grain-B2	0.06	bdl	49.27	16.23	13.44	0.58	19.49	0.45	0.17	99.69	4.57	9.33	100.24
TF6 grain-B3	0.06	0.04	49.55	16.39	13.76	0.57	19.51	0.41	bdl	100.29	4.39	9.81	100.83
TF6 grain-B4	0.07	0.05	49.49	16.24	13.65	0.60	19.48	0.30	bdl	99.88	4.24	9.84	100.43
TF6 grain-B5	0.06	bdl	49.41	16.38	13.44	0.57	19.50	0.38	0.14	99.87	4.37	9.51	100.40
TF6 grain-B6	0.06	0.07	49.55	16.30	13.63	0.57	19.42	0.35	0.16	100.11	4.21	9.83	100.61
TF6 grain-B7	0.06	bdl	49.47	16.33	13.56	0.55	19.45	0.38	bdl	99.79	4.23	9.75	100.29
TF6 grain-B8	0.06	bdl	49.71	16.30	13.35	0.60	19.52	0.31	0.15	100.00	4.12	9.64	100.53
TF6 grain-B9	0.06	bdl	49.60	16.32	13.31	0.54	19.51	0.38	bdl	99.72	4.05	9.66	100.20
TF6 grain-B10	0.06	0.05	49.73	16.18	13.53	0.57	19.62	0.38	bdl	100.11	4.33	9.63	100.62
TF6 grain-B AVG	0.06	bdl	49.51	16.28	13.51	0.58	19.48	0.36	bdl	99.78	4.27	9.67	100.38
TF6 grain-C1	0.06	bdl	49.86	15.74	13.31	0.57	19.47	0.42	0.15	99.58	4.28	9.45	100.01
TF6 grain-C2	0.05	bdl	49.84	16.06	13.55	0.57	19.57	0.35	bdl	99.99	4.34	9.65	100.42
TF6 grain-C3	0.08	bdl	49.84	16.20	13.46	0.55	19.55	0.38	0.19	100.24	4.26	9.63	100.73
TF6 grain-C4	0.06	0.05	49.64	16.16	13.58	0.57	19.55	0.35	bdl	99.96	4.27	9.74	100.46

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
TF6 grain-C5	0.05	0.06	49.63	16.13	13.53	0.52	19.47	0.35	bdl	99.75	4.08	9.86	100.33
TF6 grain-C6	0.06	bdl	49.67	16.28	13.50	0.56	19.50	0.35	bdl	99.92	4.14	9.77	100.43
TF6 grain-C7	0.07	bdl	49.68	16.33	13.58	0.58	19.56	0.38	bdl	100.17	4.30	9.71	100.68
TF6 grain-C8	0.08	bdl	49.82	16.18	13.42	0.55	19.53	0.36	bdl	99.94	4.05	9.77	100.43
TF6 grain-C9	0.05	bdl	50.02	15.97	13.32	0.53	19.58	0.33	bdl	99.80	4.01	9.71	100.29
TF6 grain-C10	0.08	bdl	50.00	15.86	13.47	0.58	19.56	0.40	bdl	99.93	4.21	9.69	100.45
TF6 grain-C AVG	0.06	bdl	49.80	16.09	13.47	0.56	19.53	0.37	bdl	99.89	4.19	9.70	100.42
TF6 grain-D1	0.07	bdl	49.90	15.75	13.37	0.55	19.56	0.38	bdl	99.59	4.22	9.57	100.08
TF6 grain-D2	0.04	0.05	49.81	15.98	13.40	0.53	19.56	0.39	bdl	99.76	4.22	9.60	100.18
TF6 grain-D3	0.05	0.06	49.71	16.00	13.38	0.60	19.52	0.29	bdl	99.61	4.08	9.70	100.11
TF6 grain-D4	0.06	bdl	49.65	16.12	13.58	0.58	19.55	0.40	bdl	99.93	4.44	9.58	100.43
TF6 grain-D5	0.06	0.06	49.51	16.15	13.61	0.57	19.48	0.32	bdl	99.76	4.24	9.80	100.29
TF6 grain-D6	0.06	bdl	49.54	16.19	13.48	0.54	19.43	0.39	bdl	99.62	4.20	9.70	100.04
TF6 grain-D7	0.05	0.06	49.73	16.11	13.37	0.61	19.36	0.33	bdl	99.62	3.86	9.89	100.00
TF6 grain-D8	0.07	bdl	49.84	16.02	13.30	0.54	19.48	0.33	bdl	99.58	3.91	9.79	100.11
TF6 grain-D9	0.08	0.00	49.66	15.67	12.92	0.56	19.52	0.32	bdl	98.73	3.91	9.40	99.23
TF6 grain-D10	0.07	bdl	50.21	15.48	13.52	0.51	19.58	0.40	bdl	99.76	4.27	9.68	100.27
TF6 grain-D AVG	0.06	bdl	49.76	15.95	13.39	0.56	19.50	0.36	bdl	99.59	4.13	9.67	100.08
TF6 ALL AVG	0.06	bdl	49.76	16.05	13.47	0.57	19.52	0.37	bdl	99.80	4.23	9.67	100.37
X297 grain-C1	0.04	0.48	55.12	6.01	20.96	0.18	17.37	0.28	bdl	100.45	7.61	14.12	101.21
X297 grain-C2	bdl	0.52	54.61	6.13	21.55	0.14	17.18	0.21	bdl	100.34	7.90	14.44	101.13

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X297 grain-C3	0.05	0.57	54.63	6.13	21.97	0.21	17.12	0.24	bdl	100.90	8.18	14.61	101.72
X297 grain-C4	0.07	0.55	54.65	5.99	21.49	0.15	17.38	0.20	bdl	100.47	8.16	14.15	101.29
X297 grain-C AVG	0.05	0.53	54.75	6.06	21.49	0.17	17.26	0.23	bdl	100.55	7.96	14.33	101.35
X297 grain-D1	bdl	0.51	55.55	5.28	21.04	0.22	17.58	0.22	bdl	100.40	8.15	13.71	101.22
X297 grain-D2	bdl	0.47	55.76	5.47	20.61	0.19	17.37	0.25	bdl	100.13	7.09	14.23	100.84
X297 grain-D3	0.05	0.51	55.62	5.46	21.17	0.13	17.62	bdl	bdl	100.56	7.68	14.26	101.33
X297 grain-D4	0.05	0.51	55.73	5.30	20.90	0.17	17.57	0.27	bdl	100.49	7.62	14.04	101.26
X297 grain-D AVG	0.05	0.50	55.66	5.38	20.93	0.18	17.54	0.25	bdl	100.48	7.64	14.06	101.25
X297 ALL AVG Core	0.05	0.57	54.63	6.13	21.97	0.21	17.12	0.24	bdl	100.90	7.71	15.03	101.67
X297 ALL AVG Rim	bdl	0.48	55.12	6.01	20.96	0.18	17.37	0.28	bdl	100.41	8.21	14.10	101.76
X229 grain-A1	0.07	0.38	61.33	1.04	18.49	0.13	18.51	0.20	bdl	100.16	5.18	13.83	100.68
X229 grain-A2	0.06	0.38	60.88	0.95	18.71	0.12	18.85	0.21	bdl	100.16	6.46	12.89	100.81
X229 grain-A3	0.05	0.38	60.98	0.86	18.31	0.15	18.92	0.15	bdl	99.80	6.20	12.73	100.42
X229 grain-A4	bdl	0.38	60.99	0.85	18.38	0.13	18.89	0.18	bdl	99.79	6.21	12.79	100.41
X229 grain-A5	bdl	0.37	60.61	0.84	18.47	0.15	18.95	0.10	bdl	99.48	6.86	12.30	100.16
X229 grain-A AVG	0.06	0.38	60.96	0.91	18.47	0.14	18.82	0.17	bdl	99.90	6.18	12.91	100.52
X229 grain-B1	0.06	0.37	60.62	0.84	18.93	0.09	18.85	0.17	bdl	99.94	6.88	12.74	100.62
X229 grain-B2	bdl	0.37	60.81	0.89	18.98	0.11	18.83	0.18	bdl	100.17	6.82	12.84	100.85
X229 grain-B3	bdl	0.31	60.87	0.87	18.99	0.14	18.90	0.17	bdl	100.23	7.21	12.50	100.96
X229 grain-B4	0.05	0.33	60.95	0.83	19.03	0.13	18.86	0.18	bdl	100.36	6.88	12.84	101.05
X229 grain-B5	0.05	0.35	61.02	0.90	18.51	0.12	18.76	0.16	bdl	99.86	6.03	13.08	100.47

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
X229 grain-B AVG	0.06	0.35	60.85	0.86	18.89	0.12	18.84	0.17	bdl	100.13	6.76	12.80	100.81
X229 ALL AVG	0.06	0.36	60.91	0.89	18.68	0.13	18.83	0.17	bdl	100.02	6.47	12.85	100.67
JAG 84-553 grain-A1	bdl	0.11	15.96	53.14	15.93	1.63	12.85	0.09	0.27	99.97	2.22	13.93	100.19
JAG 84-553 grain-A2	bdl	0.11	16.30	53.32	15.98	1.54	12.65	0.11	0.27	100.27	1.60	14.54	100.43
JAG 84-553 grain-A3	bdl	0.08	16.59	53.23	16.19	1.56	12.42	bdl	0.27	100.34	1.24	15.08	100.46
JAG 84-553 grain-A4	bdl	0.08	16.70	52.90	16.45	1.61	12.39	bdl	0.22	100.35	1.47	15.13	100.50
JAG 84-553 grain-A5	bdl	0.13	16.61	53.16	16.58	1.55	12.36	bdl	0.24	100.63	1.35	15.36	100.76
JAG 84-553 grain-A6	bdl	0.09	16.37	53.46	16.75	1.53	12.31	bdl	0.22	100.73	1.45	15.44	100.87
JAG 84-553 grain-A7	bdl	0.09	16.42	53.33	16.74	1.53	12.35	0.09	0.23	100.77	1.60	15.30	100.93
JAG 84-553 grain-A8	bdl	0.09	16.59	53.59	16.49	1.49	12.35	bdl	0.20	100.79	1.08	15.51	100.90
JAG 84-553 grain-A9	bdl	0.08	16.65	53.46	16.50	1.51	12.48	bdl	0.26	100.94	1.39	15.25	101.08
JAG 84-553 grain-A10	bdl	0.10	16.61	53.58	16.01	1.52	12.77	0.08	bdl	100.66	1.26	14.87	100.78
JAG 84-553 grain-A AVG	bdl	0.10	16.48	53.32	16.36	1.55	12.49	0.04	0.22	100.54	1.47	15.04	100.69
JAG 84-553 grain-B1	bdl	0.11	16.31	53.27	16.48	1.58	12.65	0.11	0.15	100.65	1.94	14.74	100.84
JAG 84-553 grain-B2	bdl	0.13	16.43	53.09	16.68	1.65	12.39	0.05	0.16	100.58	1.68	15.16	100.75
JAG 84-553 grain-B3	bdl	0.09	16.56	52.70	16.64	1.57	12.39	0.10	0.25	100.30	1.82	15.00	100.49
JAG 84-553 grain-B4	bdl	0.08	16.71	52.90	16.80	1.56	12.43	bdl	0.30	100.76	1.81	15.18	100.94
JAG 84-553 grain-B5	bdl	0.11	16.84	52.87	16.58	1.51	12.45	bdl	bdl	100.37	1.28	15.43	100.50
JAG 84-553 grain-B6	bdl	0.09	16.81	52.71	16.80	1.54	12.45	bdl	0.29	100.69	1.83	15.16	100.88
JAG 84-553 grain-B7	bdl	0.08	16.66	52.98	16.69	1.56	12.45	0.11	0.26	100.78	1.80	15.07	100.96
JAG 84-553 grain-B8	bdl	0.09	16.61	53.02	16.46	1.53	12.52	0.14	0.21	100.58	1.71	14.92	100.75

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
JAG 84-553 grain-B9	bdl	0.16	16.57	53.29	16.32	1.50	12.66	bdl	0.24	100.74	1.50	14.97	100.89
JAG 84-553 grain-B AVG	bdl	0.10	16.52	52.98	16.55	1.56	12.56	0.05	0.20	100.54	1.84	14.90	100.72
JAG 84-553 grain-C1	bdl	0.07	16.17	52.69	15.80	1.59	12.79	0.00	0.33	99.44	2.06	13.95	99.65
JAG 84-553 grain-C2	bdl	0.10	16.33	52.92	16.20	1.54	12.48	bdl	bdl	99.57	1.36	14.98	99.70
JAG 84-553 grain-C3	bdl	0.09	16.61	52.29	16.58	1.55	12.49	bdl	0.20	99.80	1.93	14.84	99.99
JAG 84-553 grain-C4	bdl	0.09	16.85	52.30	16.36	1.58	12.50	bdl	0.24	99.91	1.67	14.85	100.08
JAG 84-553 grain-C5	bdl	0.04	16.80	52.47	16.45	1.59	12.47	bdl	0.17	99.98	1.70	14.92	100.15
JAG 84-553 grain-C6	bdl	0.09	16.67	53.02	16.60	1.53	12.46	bdl	0.16	100.52	1.53	15.23	100.67
JAG 84-553 grain-C7	bdl	0.09	16.40	52.96	16.32	1.58	12.42	0.08	0.23	100.07	1.60	14.88	100.23
JAG 84-553 grain-C8	bdl	0.08	16.39	52.95	16.54	1.48	12.44	bdl	0.32	100.19	1.73	14.98	100.36
JAG 84-553 grain-C9	bdl	0.06	16.13	52.73	16.48	1.49	12.43	bdl	0.16	99.49	1.85	14.82	99.68
JAG 84-553 grain-C10	bdl	0.09	16.14	52.78	16.40	1.62	12.40	0.11	0.23	99.77	1.93	14.67	99.96
JAG 84-553 grain-C AVG	bdl	0.08	16.45	52.71	16.37	1.55	12.49	0.02	0.20	99.87	1.74	14.81	100.05
JAG 84-553 grain-D1	bdl	0.09	16.17	52.56	16.17	1.64	12.64	bdl	0.22	99.49	2.10	14.28	99.70
JAG 84-553 grain-D2	bdl	0.08	16.95	52.33	16.28	1.52	12.47	bdl	0.00	99.64	1.28	15.13	99.76
JAG 84-553 grain-D3	bdl	0.05	17.14	52.18	16.21	1.45	12.55	0.10	0.31	99.98	1.60	14.77	100.14
JAG 84-553 grain-D4	bdl	0.07	16.31	52.93	16.40	1.56	12.32	0.10	0.25	99.93	1.62	14.93	100.10
JAG 84-553 grain-D5	bdl	0.09	16.38	52.90	16.21	1.55	12.37	0.11	0.17	99.78	1.43	14.93	99.93
JAG 84-553 grain-D6	bdl	0.08	16.27	53.06	16.22	1.58	12.41	bdl	bdl	99.62	1.31	15.04	99.76
JAG 84-553 grain-D7	bdl	0.07	16.18	53.53	16.44	1.58	12.39	bdl	0.31	100.50	1.56	15.03	100.66
JAG 84-553 grain-D8	bdl	0.08	16.36	52.94	16.13	1.51	12.48	bdl	0.30	99.80	1.51	14.77	99.95

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
JAG 84-553 grain-D9	bdl	0.07	16.44	52.82	16.25	1.58	12.45	0.08	0.17	99.86	1.59	14.81	100.02
JAG 84-553 grain-D10	bdl	0.08	16.22	52.96	16.00	1.55	12.70	bdl	0.21	99.70	1.78	14.39	99.88
JAG 84-553 grain-D AVG	bdl	0.08	16.44	52.82	16.23	1.55	12.48	0.04	0.19	99.83	1.58	14.81	99.99
JAG 84-553 ALL AVG	bdl	0.10	16.29	53.09	16.22	1.56	12.66	0.05	0.19	100.17	1.82	14.58	100.35
K7269 grain-A1	bdl	bdl	16.14	53.75	16.01	1.75	12.51	bdl	bdl	100.16	1.29	14.85	100.53
K7269 grain-A2	bdl	bdl	16.28	53.81	16.03	1.84	12.28	bdl	0.16	100.39	1.04	15.09	100.74
K7269 grain-A3	bdl	bdl	16.25	53.60	16.80	1.79	12.33	bdl	bdl	100.77	1.65	15.32	101.17
K7269 grain-A4	bdl	bdl	16.32	53.69	16.66	1.81	12.25	bdl	0.21	100.92	1.49	15.31	101.34
K7269 grain-A5	bdl	bdl	16.49	53.81	16.78	1.80	12.28	bdl	bdl	101.16	1.34	15.58	101.52
K7269 grain-A6	bdl	bdl	16.40	53.66	16.66	1.85	12.31	bdl	0.16	101.04	1.60	15.22	101.36
K7269 grain-A7	bdl	bdl	16.34	53.89	16.82	1.73	12.32	bdl	0.24	101.33	1.57	15.40	101.81
K7269 grain-A8	bdl	bdl	16.41	53.57	16.54	1.81	12.35	bdl	0.22	100.89	1.59	15.11	101.25
K7269 grain-A9	bdl	bdl	16.36	53.72	16.80	1.84	12.52	bdl	0.28	101.52	2.08	14.92	101.94
K7269 grain-A10	bdl	bdl	16.74	53.64	16.32	1.80	12.91	bdl	0.17	101.57	1.98	14.54	102.04
K7269 grain-A AVG	bdl	bdl	16.37	53.71	16.54	1.80	12.40	bdl	0.14	100.98	1.56	15.13	101.37
K7269 grain-B1	bdl	bdl	16.11	52.70	16.26	1.83	12.68	bdl	0.19	99.77	2.39	14.12	100.23
K7269 grain-B2	bdl	bdl	16.23	53.71	16.49	1.87	12.40	bdl	0.22	100.93	1.70	14.95	101.35
K7269 grain-B3	bdl	bdl	16.47	53.05	16.66	1.71	12.39	bdl	bdl	100.29	1.64	15.18	100.74
K7269 grain-B4	bdl	bdl	16.60	53.18	16.44	1.74	12.40	bdl	0.23	100.59	1.58	15.02	100.99
K7269 grain-B5	bdl	bdl	16.16	53.17	16.44	1.86	12.48	bdl	0.14	100.25	2.00	14.64	100.69
K7269 grain-B6	bdl	bdl	16.46	53.02	16.47	1.82	12.56	bdl	bdl	100.34	1.89	14.77	100.75

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
K7269 grain-B7	bdl	bdl	16.34	53.75	16.52	1.76	12.54	bdl	0.31	101.22	1.86	14.85	101.61
K7269 grain-B8	bdl	bdl	16.42	53.61	16.77	1.83	12.53	bdl	0.25	101.41	2.03	14.94	101.86
K7269 grain-B9	bdl	bdl	16.41	53.74	16.75	1.70	12.59	bdl	0.20	101.39	1.90	15.04	101.88
K7269 grain-B10	bdl	bdl	16.66	53.61	16.40	1.85	12.86	bdl	0.24	101.61	2.15	14.46	102.02
K7269 grain-B AVG	bdl	bdl	16.39	53.35	16.52	1.80	12.54	bdl	0.18	100.78	1.91	14.80	101.21
K7269 grain-C1	bdl	bdl	16.93	53.59	16.15	1.73	12.75	bdl	0.28	101.43	1.54	14.76	101.82
K7269 grain-C2	bdl	bdl	17.03	53.04	16.49	1.72	12.63	bdl	0.22	101.13	1.73	14.94	101.55
K7269 grain-C3	bdl	bdl	17.09	53.43	16.48	1.75	12.64	bdl	0.25	101.64	1.61	15.03	102.02
K7269 grain-C4	bdl	bdl	17.23	53.05	16.31	1.67	12.67	bdl	0.27	101.21	1.52	14.94	101.62
K7269 grain-C5	bdl	bdl	17.21	53.14	16.32	1.73	12.66	bdl	0.25	101.30	1.52	14.95	101.71
K7269 grain-C6	bdl	bdl	17.27	53.14	16.50	1.66	12.71	bdl	0.16	101.44	1.60	15.07	101.79
K7269 grain-C7	bdl	bdl	16.99	52.86	16.48	1.82	12.76	bdl	0.30	101.19	2.15	14.54	101.66
K7269 grain-C8	bdl	bdl	16.77	53.27	16.75	1.74	12.71	bdl	0.25	101.47	2.14	14.82	101.93
K7269 grain-C9	bdl	bdl	16.58	53.06	16.26	1.71	12.67	bdl	0.26	100.53	1.90	14.54	100.95
K7269 grain-C10	bdl	bdl	16.19	53.07	16.49	1.80	12.82	bdl	0.17	100.54	2.55	14.19	101.01
K7269 grain-C AVG	bdl	bdl	16.93	53.16	16.42	1.73	12.70	bdl	0.24	101.19	1.83	14.78	101.61
K7269 ALL AVG	bdl	bdl	16.56	53.41	16.49	1.78	12.55	bdl	0.19	100.98	1.77	14.90	101.40
JAG-228 grain-A1	bdl	bdl	14.83	55.64	15.72	1.66	12.73	0.08	bdl	100.66	1.56	14.31	101.02
JAG-228 grain-A2	bdl	0.06	14.66	56.20	15.71	1.70	12.80	0.09	0.23	101.45	1.64	14.23	101.82
JAG-228 grain-A3	bdl	0.04	14.54	56.24	15.31	1.71	12.87	bdl	bdl	100.72	1.31	14.13	101.03
JAG-228 grain-A4	bdl	bdl	14.60	56.41	15.71	1.67	12.85	0.11	0.19	101.53	1.71	14.17	101.94

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
JAG-228 grain-A5	bdl	0.04	14.61	56.19	15.92	1.67	12.90	bdl	0.15	101.48	1.86	14.24	101.83
JAG-228 grain-A6	bdl	0.06	14.65	56.26	15.75	1.69	12.94	0.10	0.19	101.63	1.83	14.10	101.98
JAG-228 grain-A7	bdl	bdl	14.52	56.49	15.63	1.72	12.98	0.11	0.17	101.62	1.91	13.91	101.98
JAG-228 grain-A8	bdl	0.06	14.62	56.28	15.45	1.68	12.94	bdl	0.18	101.21	1.51	14.09	101.59
JAG-228 grain-A9	bdl	bdl	14.59	56.17	15.46	1.69	13.04	0.10	bdl	101.06	1.79	13.85	101.42
JAG-228 grain-A10	bdl	bdl	14.90	55.58	15.70	1.70	13.31	bdl	0.25	101.43	2.47	13.48	101.97
JAG-228 grain-A AVG	bdl	0.03	14.65	56.15	15.64	1.69	12.94	0.06	0.14	101.28	1.76	14.05	101.66
JAG-228 grain-B1	bdl	0.04	15.25	55.89	15.47	1.67	13.11	0.14	0.17	101.75	1.73	13.92	102.04
JAG-228 grain-B2	bdl	bdl	15.10	56.00	15.79	1.63	13.06	0.08	0.15	101.80	1.86	14.11	102.21
JAG-228 grain-B3	bdl	bdl	14.99	55.99	15.69	1.63	13.09	bdl	bdl	101.38	1.74	14.12	101.74
JAG-228 grain-B4	bdl	bdl	15.05	55.91	15.61	1.61	13.15	0.14	0.24	101.72	2.05	13.77	102.07
JAG-228 grain-B5	bdl	bdl	15.00	55.72	15.81	1.64	13.11	0.09	0.15	101.51	2.12	13.90	101.95
JAG-228 grain-B6	bdl	bdl	15.01	55.63	15.69	1.62	13.03	bdl	bdl	101.03	1.70	14.17	101.41
JAG-228 grain-B7	bdl	bdl	15.00	55.84	15.93	1.60	13.09	0.12	bdl	101.58	2.04	14.09	101.95
JAG-228 grain-B8	bdl	0.05	15.01	55.65	15.76	1.58	13.08	bdl	bdl	101.13	1.79	14.15	101.47
JAG-228 grain-B9	bdl	bdl	15.04	55.91	15.58	1.61	13.11	bdl	bdl	101.24	1.65	14.10	101.63
JAG-228 grain-B10	bdl	bdl	15.02	55.35	15.71	1.69	13.06	bdl	0.21	101.04	2.15	13.78	101.45
JAG-228 grain-B AVG	bdl	0.01	15.05	55.79	15.70	1.63	13.09	0.06	0.09	101.42	1.88	14.01	101.79
JAG-228 grain-C1	bdl	0.09	14.87	55.55	15.97	1.68	12.90	bdl	bdl	101.05	1.84	14.31	101.37
JAG-228 grain-C2	bdl	0.05	14.96	55.60	15.57	1.65	12.95	bdl	0.15	100.92	1.66	14.08	101.30
JAG-228 grain-C3	bdl	bdl	15.07	55.56	15.49	1.62	12.98	0.11	bdl	100.84	1.63	14.03	101.21

bdl, concentration below detection limit

SPINEL COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	NiO	ZnO	Sum	Fe_2O_3	FeO	Sum
JAG-228 grain-C4	bdl	bdl	15.15	55.43	15.62	1.68	13.04	0.11	bdl	101.03	1.87	13.94	101.42
JAG-228 grain-C5	bdl	bdl	15.10	55.02	15.94	1.67	12.99	0.08	bdl	100.80	2.20	13.96	101.20
JAG-228 grain-C6	bdl	0.04	15.21	55.26	15.90	1.70	13.00	0.11	0.20	101.42	2.15	13.97	101.80
JAG-228 grain-C7	bdl	0.05	15.13	55.53	15.48	1.60	12.98	0.10	0.16	101.02	1.61	14.03	101.38
JAG-228 grain-C8	bdl	0.06	14.93	55.43	15.60	1.70	13.00	bdl	0.21	100.92	1.91	13.88	101.30
JAG-228 grain-C9	bdl	0.07	15.06	55.37	15.54	1.67	13.16	0.10	0.21	101.17	2.07	13.67	101.55
JAG-228 grain-C AVG	bdl	0.04	15.05	55.41	15.68	1.66	13.00	0.07	0.10	101.02	1.88	13.99	101.39
JAG-228 grain-D1	bdl	0.06	15.11	55.26	15.71	1.59	12.97	0.09	0.24	101.03	1.91	13.98	101.40
JAG-228 grain-D2	bdl	bdl	15.00	55.42	15.82	1.71	13.03	0.09	bdl	101.07	2.12	13.91	101.41
JAG-228 grain-D3	bdl	0.05	15.04	55.53	15.92	1.74	12.99	0.10	bdl	101.37	2.02	14.10	101.70
JAG-228 grain-D4	bdl	0.05	15.06	55.38	15.75	1.65	13.05	bdl	0.25	101.18	2.05	13.90	101.55
JAG-228 grain-D5	bdl	0.06	15.11	55.07	15.54	1.66	12.98	bdl	bdl	100.43	1.71	14.00	100.75
JAG-228 grain-D6	bdl	bdl	15.06	55.55	15.80	1.62	13.02	bdl	0.16	101.21	1.95	14.04	101.61
JAG-228 grain-D7	bdl	bdl	15.09	55.35	15.69	1.66	13.00	0.09	0.20	101.06	2.03	13.86	101.46
JAG-228 grain-D8	bdl	0.06	14.96	55.49	15.88	1.76	12.95	bdl	0.24	101.34	2.09	14.00	101.71
JAG-228 grain-D9	bdl	0.04	14.92	55.39	15.83	1.63	12.96	0.10	0.16	101.03	2.06	13.97	101.41
JAG-228 grain-D10	bdl	0.05	14.72	55.22	15.73	1.65	12.94	bdl	bdl	100.30	1.94	13.99	100.69
JAG-228 grain-D AVG	bdl	0.04	15.01	55.37	15.76	1.67	12.99	0.05	0.13	101.00	1.99	13.98	101.37
JAG 228 ALL AVG	0.00	0.03	14.94	55.68	15.70	1.66	13.00	0.06	0.11	101.18	1.88	14.01	101.55

bdl, concentration below detection limit

APPENDIX D

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
GN9912 grain-A1	54.24	0.06	4.64	0.82	2.28	15.45	20.60	1.95	100.05	0.35	1.96	100.08
GN9912 grain-A2	54.76	0.08	3.93	0.74	2.39	15.75	21.03	1.79	100.46	0.17	2.23	100.48
GN9912 grain-A3	54.54	bdl	4.92	0.69	2.39	15.19	20.54	2.06	100.34	0.16	2.24	100.35
GN9912 grain-A4	54.63	bdl	4.76	0.71	2.39	15.45	20.65	2.05	100.64	0.62	1.84	100.71
GN9912 grain-A5	54.62	bdl	4.43	0.82	2.34	15.55	20.89	1.87	100.52	0.20	2.16	100.54
GN9912 grain-A6	54.49	bdl	4.72	0.65	2.35	15.31	20.57	2.05	100.15	0.41	1.98	100.19
GN9912 grain-A7	54.51	0.07	4.83	0.72	2.49	15.37	20.47	1.97	100.45	0.02	2.47	100.45
GN9912 grain-A8	54.43	0.06	4.68	0.68	2.47	15.35	20.64	1.94	100.26	0.14	2.34	100.27
GN9912 grain-A AVG	54.53	0.07	4.61	0.73	2.39	15.43	20.67	1.96	100.39	0.26	2.15	100.42
GN9912 grain-B1	54.34	0.09	4.59	0.93	2.41	16.14	20.29	1.81	100.60	0.69	1.79	100.67
GN9912 grain-B2	54.58	bdl	4.82	0.88	2.42	15.47	20.61	2.03	100.80	0.58	1.90	100.85
GN9912 grain-B3	54.55	bdl	5.02	0.75	2.44	15.31	20.64	2.02	100.72	0.35	2.13	100.76
GN9912 grain-B4	54.70	0.07	4.99	0.87	2.44	15.38	20.47	2.03	100.96	0.06	2.39	100.96
GN9912 grain-B5	54.51	bdl	4.98	0.88	2.31	15.29	20.78	1.98	100.73	0.23	2.11	100.76
GN9912 grain-B6	54.92	bdl	3.55	0.92	2.43	16.02	21.44	1.55	100.84	0.00	2.43	100.84
GN9912 grain-B AVG	54.60	0.08	4.66	0.87	2.41	15.60	20.71	1.90	100.83	0.32	2.12	100.86
GN9912 grain-C1	54.95	bdl	3.86	0.89	2.24	15.75	21.12	1.82	100.64	0.13	2.12	100.65
GN9912 grain-C2	54.78	bdl	4.94	0.97	2.27	15.37	20.56	2.06	100.94	0.07	2.20	100.95
GN9912 grain-C3	54.49	0.06	5.08	0.84	2.45	15.33	20.47	2.09	100.82	0.54	1.96	100.87
GN9912 grain-C4	54.60	bdl	4.27	1.00	2.40	15.68	20.82	1.84	100.60	0.31	2.13	100.63
GN9912 grain-C5	54.68	bdl	4.81	0.92	2.48	15.39	20.68	2.04	100.98	0.51	2.01	101.03

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
GN9912 grain-C AVG	54.70	0.06	4.59	0.92	2.37	15.50	20.73	1.97	100.85	0.31	2.09	100.88
GN9912 grain-D1	54.77	0.06	4.68	0.89	2.44	15.64	20.70	1.95	101.12	0.43	2.05	101.16
GN9912 grain-D2	54.77	bdl	4.74	0.87	2.33	15.63	20.78	1.87	100.98	0.00	2.33	100.98
GN9912 grain-D3	54.50	bdl	4.88	0.84	2.39	15.49	20.52	2.02	100.64	0.53	1.91	100.70
GN9912 grain-D4	55.37	bdl	3.40	0.87	2.41	16.21	21.32	1.64	101.22	0.02	2.40	101.22
GN9912 grain-D AVG	54.85	0.06	4.43	0.86	2.39	15.74	20.83	1.87	101.04	0.25	2.17	101.06
GN9912 ALL AVG Core	54.58	bdl	4.82	0.88	2.42	15.47	20.61	2.03	100.80	0.58	1.90	100.85
GN9912 ALL AVG Rim	54.92	bdl	3.55	0.92	2.43	16.02	21.44	1.55	100.84	0.00	2.43	100.84
GN9913 grain-A1	54.80	bdl	2.90	1.11	2.18	16.41	21.07	1.57	100.03	0.19	2.01	100.05
GN9913 grain-A2	54.34	0.06	4.42	1.21	2.15	15.73	20.71	1.88	100.49	0.42	1.77	100.53
GN9913 grain-A3	54.00	0.06	4.59	1.17	2.07	15.52	20.57	1.92	99.89	0.56	1.56	99.94
GN9913 grain-A4	53.74	bdl	4.70	1.15	2.25	15.53	20.40	2.01	99.79	2.32	0.16	100.02
GN9913 grain-A5	54.20	0.08	4.48	1.08	2.06	15.58	20.63	1.86	99.96	0.02	2.04	99.96
GN9913 grain-A6	53.73	bdl	4.24	1.17	2.07	15.72	20.82	1.78	99.53	0.84	1.31	99.61
GN9913 grain-A7	54.23	0.07	4.51	1.14	2.08	15.67	20.48	1.90	100.08	0.16	1.93	100.09
GN9913 grain-A AVG	54.15	0.07	4.26	1.15	2.12	15.74	20.67	1.84	99.99	0.64	1.54	100.06
GN9913 grain-B1	54.07	0.06	4.71	1.07	2.22	15.46	20.34	1.92	99.84	0.03	2.19	99.84
GN9913 grain-B2	54.06	bdl	4.71	1.00	2.09	15.52	20.35	1.90	99.62	0.00	2.09	99.62
GN9913 grain-B3	53.79	bdl	4.66	1.17	2.10	15.43	20.32	1.96	99.43	0.44	1.70	99.47
GN9913 grain-B4	53.76	0.07	4.61	1.07	2.21	15.41	20.39	1.88	99.41	0.22	2.01	99.43
GN9913 grain-B AVG	53.92	0.06	4.67	1.08	2.15	15.46	20.35	1.92	99.60	0.17	2.00	99.62

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
GN9913 grain-C1	54.01	bdl	4.19	1.13	2.15	15.71	20.71	1.82	99.73	0.63	1.58	99.80
GN9913 grain-C2	54.00	bdl	4.69	1.14	2.08	15.48	20.52	1.88	99.79	0.10	1.99	99.80
GN9913 grain-C3	53.94	bdl	4.85	1.23	2.25	15.46	20.46	1.89	100.08	0.33	1.95	100.12
GN9913 grain-C4	53.98	0.07	4.88	1.09	2.15	15.41	20.46	1.98	100.03	0.46	1.74	100.07
GN9913 grain-C5	53.87	0.08	4.85	1.19	2.08	15.56	20.18	1.90	99.71	0.16	1.94	99.72
GN9913 grain-C AVG	53.96	0.08	4.69	1.15	2.14	15.52	20.47	1.90	99.91	0.34	1.84	99.95
GN9913 ALL AVG Core	54.20	0.08	4.48	1.08	2.06	15.58	20.63	1.86	99.96	0.02	2.04	99.96
GN9913 ALL AVG Rim	54.80	bdl	2.90	1.11	2.18	16.41	21.07	1.57	100.03	0.19	2.01	100.05
BM9912 grain-A1	53.67	0.29	5.78	1.05	2.32	15.77	20.31	1.74	100.93	0.08	2.25	100.93
BM9912 grain-A2	54.00	0.25	5.54	0.86	2.44	15.82	20.18	1.80	100.89	0.05	2.39	100.89
BM9912 grain-A3	54.09	0.25	5.40	0.91	2.38	15.97	20.26	1.84	101.10	0.46	1.96	101.14
BM9912 grain-A4	54.12	0.27	5.71	0.87	2.32	15.99	20.07	1.84	101.17	0.09	2.24	101.17
BM9912 grain-A5	53.82	0.23	5.97	0.94	2.32	15.74	20.05	1.91	100.98	0.40	1.96	101.02
BM9912 grain-A AVG	53.94	0.26	5.68	0.93	2.35	15.86	20.17	1.82	101.01	0.22	2.16	101.03
BM9912 grain-B1	53.95	0.18	5.78	0.99	2.45	15.73	19.84	1.91	100.83	0.09	2.37	100.84
BM9912 grain-B2	53.82	0.26	5.54	0.77	2.30	15.73	20.08	1.95	100.45	0.57	1.79	100.50
BM9912 grain-B3	54.16	0.18	5.45	0.70	2.34	15.82	20.11	1.89	100.64	0.15	2.21	100.66
BM9912 grain-B4	53.92	0.21	5.79	0.81	2.47	15.79	19.99	1.97	100.96	0.78	1.76	101.04
BM9912 grain-B AVG	53.96	0.21	5.64	0.82	2.39	15.77	20.00	1.93	100.72	0.40	2.03	100.76
BM9912 grain-C1	54.15	0.22	5.87	1.22	2.37	15.69	20.12	1.90	101.55	0.00	2.37	101.55
BM9912 grain-C2	54.04	0.29	5.46	1.01	2.34	15.95	20.23	1.86	101.17	0.45	1.93	101.21

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
BM9912 grain-C3	53.51	0.34	5.54	1.05	2.16	15.74	20.68	1.70	100.73	0.34	1.85	100.76
BM9912 grain-C4	53.41	0.32	5.69	1.06	2.28	15.62	21.00	1.78	101.17	1.26	1.14	101.30
BM9912 grain-C5	53.75	0.33	5.65	0.99	2.20	15.64	20.79	1.71	101.04	0.04	2.16	101.05
BM9912 grain-C6	53.27	0.31	5.66	1.10	2.21	15.36	21.06	1.66	100.63	0.32	1.93	100.66
BM9912 grain-C AVG	53.69	0.30	5.65	1.07	2.26	15.67	20.64	1.77	101.05	0.40	1.90	101.09
BM9912 grain-D1	53.69	0.30	5.47	0.92	2.34	15.87	20.17	1.78	100.55	0.30	2.07	100.58
BM9912 grain-D2	53.67	0.28	5.39	0.94	2.36	15.95	20.39	1.66	100.63	0.17	2.20	100.65
BM9912 grain-D3	53.71	0.29	5.41	1.06	2.23	15.93	20.55	1.71	100.89	0.43	1.84	100.93
BM9912 grain-D4	53.46	0.29	5.53	1.05	2.16	15.97	20.39	1.71	100.56	0.53	1.68	100.61
BM9912 grain-D AVG	53.63	0.29	5.45	1.00	2.27	15.93	20.37	1.71	100.66	0.36	1.95	100.69
BM9912 grain-E1	53.54	0.27	5.81	0.88	2.40	15.57	20.29	1.78	100.53	0.18	2.24	100.54
BM9912 grain-E2	53.80	0.26	5.04	0.82	2.34	16.03	20.96	1.51	100.76	0.24	2.12	100.79
BM9912 grain-E3	53.67	0.26	5.42	0.85	2.37	15.80	20.63	1.65	100.64	0.21	2.18	100.67
BM9912 grain-E4	53.74	0.24	5.53	0.76	2.26	15.95	20.42	1.73	100.64	0.47	1.83	100.68
BM9912 grain-E5	53.62	0.29	5.36	0.89	2.16	15.97	20.54	1.61	100.44	0.04	2.13	100.45
BM9912 grain-E6	53.05	0.28	5.26	0.89	2.21	15.87	20.59	1.56	99.69	0.46	1.80	99.74
BM9912 grain-E7	53.13	0.29	5.27	0.95	2.31	15.90	20.67	1.50	100.03	0.34	2.00	100.07
BM9912 grain-E AVG	53.39	0.28	5.35	0.87	2.24	15.92	20.56	1.60	100.20	0.33	1.94	100.23
BM9912 grain-F1	53.75	0.27	5.17	0.77	2.36	16.03	20.75	1.58	100.67	0.37	2.03	100.71
BM9912 grain-F2	53.81	0.29	5.18	0.75	2.18	15.91	20.85	1.64	100.58	0.27	1.93	100.61
BM9912 grain-F3	53.97	0.24	5.29	0.87	2.42	16.06	20.57	1.63	101.04	0.24	2.20	101.07

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
BM9912 grain-F4	53.84	0.27	5.78	0.90	2.33	15.87	20.21	1.87	101.06	0.61	1.78	101.12
BM9912 grain-F AVG	53.84	0.27	5.35	0.82	2.32	15.97	20.59	1.68	100.84	0.37	1.98	100.88
BM9912 ALL AVG Core	54.09	0.25	5.40	0.91	2.38	15.97	20.26	1.84	101.10	0.46	1.96	101.14
BM9912 ALL AVG Rim	53.82	0.23	5.97	0.94	2.32	15.74	20.05	1.91	100.98	0.40	1.96	101.02
BM9915 grain-A1	53.88	0.15	3.78	1.18	2.31	16.84	19.96	1.88	99.97	2.29	0.25	100.21
BM9915 grain-A2	54.10	0.19	3.64	1.28	2.26	16.83	20.08	1.84	100.21	1.94	0.51	100.41
BM9915 grain-A3	53.68	0.20	3.55	1.22	2.18	16.64	20.23	1.84	99.53	2.30	0.11	99.77
BM9915 grain-A4	53.70	0.23	3.52	1.32	2.20	16.74	20.17	1.81	99.69	2.15	0.27	99.91
BM9915 grain-A5	53.88	0.17	3.51	1.33	2.31	16.86	20.07	1.87	99.99	2.46	0.09	100.24
BM9915 grain-A6	53.82	0.17	3.50	1.33	2.30	16.86	20.05	1.85	99.89	2.48	0.07	100.14
BM9915 grain-A AVG	53.84	0.19	3.58	1.28	2.26	16.79	20.09	1.85	99.88	2.27	0.22	100.11
BM9915 grain-B1	53.87	0.14	4.12	1.08	2.30	16.52	19.94	1.97	99.94	2.27	0.26	100.17
BM9915 grain-B2	53.86	0.16	3.73	1.12	2.31	16.73	20.00	1.81	99.71	1.93	0.57	99.91
BM9915 grain-B3	53.91	0.18	3.44	1.21	2.33	16.78	19.98	1.76	99.59	1.65	0.84	99.76
BM9915 grain-B4	54.17	0.19	3.60	1.07	2.39	16.83	20.06	1.83	100.13	1.92	0.67	100.33
BM9915 grain-B5	53.67	0.17	3.81	1.36	2.21	16.56	20.18	1.83	99.78	1.99	0.42	99.99
BM9915 grain-B6	53.14	0.15	4.10	1.42	2.26	16.32	19.85	1.95	99.19	2.44	0.07	99.44
BM9915 grain-B7	53.36	0.18	3.79	1.23	2.18	16.40	19.96	1.94	99.03	2.34	0.07	99.27
BM9915 grain-B8	53.75	0.15	3.69	1.12	2.29	16.69	20.23	1.85	99.76	2.46	0.08	100.01
BM9915 grain-B AVG	53.72	0.16	3.78	1.20	2.28	16.60	20.02	1.87	99.64	2.13	0.37	99.86
BM9915 grain-C1	53.58	0.13	4.02	1.28	2.68	16.34	19.66	2.02	99.70	2.71	0.25	99.97

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
BM9915 grain-C2	53.79	0.13	3.99	1.29	2.71	16.27	19.77	2.04	100.00	2.42	0.53	100.25
BM9915 grain-C3	53.61	0.15	3.97	1.33	2.74	16.29	19.43	2.01	99.52	2.03	0.91	99.73
BM9915 grain-C4	53.83	0.17	4.01	1.32	2.71	16.49	19.39	2.15	100.06	2.78	0.21	100.34
BM9915 grain-C5	53.66	0.15	4.15	1.47	2.68	16.41	19.52	2.12	100.16	2.84	0.13	100.45
BM9915 grain-C6	53.65	0.18	4.06	1.28	2.66	16.45	19.21	2.13	99.62	2.57	0.35	99.88
BM9915 grain-C7	53.99	0.14	3.98	1.23	2.68	16.48	19.25	2.17	99.92	2.49	0.45	100.17
BM9915 grain-C8	53.75	0.17	4.08	1.33	2.75	16.53	19.32	2.16	100.08	2.95	0.10	100.37
BM9915 grain-C9	53.98	0.15	4.07	1.26	2.77	16.46	19.21	2.10	100.00	2.01	0.96	100.20
BM9915 grain-C AVG	53.76	0.15	4.04	1.31	2.71	16.41	19.42	2.10	99.89	2.53	0.43	100.15
BM9915 ALL AVG	53.77	0.17	3.80	1.26	2.42	16.60	19.84	1.94	99.81	2.31	0.34	100.04
X174 grain-A1	48.92	1.27	7.13	bdl	6.16	14.21	21.08	0.89	99.66	3.41	3.10	100.09
X174 grain-A2	49.22	1.17	6.51	bdl	6.04	14.54	20.95	0.90	99.33	3.52	2.88	99.77
X174 grain-A3	48.92	1.21	6.81	bdl	6.22	14.45	20.91	0.92	99.44	3.85	2.76	99.83
X174 grain-A4	48.76	1.31	7.13	bdl	6.08	14.21	21.23	0.97	99.69	4.03	2.46	100.10
X174 grain-A5	49.03	1.32	7.14	bdl	6.20	14.17	21.22	0.96	100.05	3.80	2.79	100.54
X174 grain-A6	48.52	1.35	7.37	bdl	6.20	14.02	20.97	0.87	99.30	3.29	3.25	99.72
X174 grain-A7	49.01	1.30	7.22	bdl	6.19	14.07	21.12	0.95	99.85	3.39	3.14	100.27
X174 grain-A8	48.58	1.32	7.46	bdl	6.03	14.07	20.96	0.97	99.39	3.65	2.75	99.85
X174 grain-A9	48.37	1.29	7.29	bdl	5.93	14.10	21.08	0.98	99.04	4.14	2.21	99.56
X174 grain-A10	49.41	1.19	6.79	bdl	6.05	14.36	21.00	0.97	99.76	3.29	3.09	100.19
X174 grain-A AVG	48.87	1.27	7.08	bdl	6.11	14.22	21.05	0.94	99.55	3.64	2.84	99.99

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X174 grain-B1	48.75	1.32	7.10	bdl	6.12	14.24	21.04	1.00	99.57	4.06	2.47	99.98
X174 grain-B2	49.00	1.28	7.22	bdl	6.18	14.20	21.20	0.94	100.02	3.73	2.83	100.48
X174 grain-B3	49.04	1.28	7.10	bdl	6.18	14.26	21.09	0.95	99.89	3.58	2.97	100.26
X174 grain-B4	48.59	1.38	7.44	bdl	6.04	14.12	21.10	0.94	99.61	3.74	2.68	100.09
X174 grain-B5	48.57	1.41	7.67	bdl	6.06	14.02	21.21	0.95	99.90	3.68	2.75	100.27
X174 grain-B6	48.24	1.60	8.30	bdl	6.13	13.71	21.14	1.00	100.11	3.61	2.88	100.56
X174 grain-B7	48.24	1.42	7.89	bdl	5.96	13.88	21.23	0.92	99.55	3.66	2.67	100.00
X174 grain-B8	48.77	1.37	7.44	bdl	6.05	14.01	21.10	0.94	99.66	3.26	3.12	100.08
X174 grain-B9	48.81	1.30	7.29	bdl	5.97	14.01	21.12	0.94	99.44	3.14	3.15	99.76
X174 grain-B10	47.92	1.62	9.65	bdl	7.98	15.78	15.99	0.93	99.86	2.59	5.65	100.29
X174 grain-B AVG	48.59	1.40	7.71	bdl	6.27	14.22	20.62	0.95	99.76	3.50	3.12	100.18
X174 grain-C1	48.60	1.35	7.50	bdl	6.31	14.22	20.99	0.90	99.85	3.76	2.93	100.23
X174 grain-C2	48.82	1.38	7.56	bdl	5.99	13.98	21.31	0.92	99.95	3.17	3.14	100.27
X174 grain-C3	48.64	1.35	7.43	bdl	6.08	14.01	21.21	0.92	99.63	3.61	2.84	100.12
X174 grain-C4	48.73	1.33	7.42	bdl	6.03	14.06	21.13	0.91	99.60	3.22	3.13	99.93
X174 grain-C5	48.47	1.38	7.73	bdl	5.91	13.91	21.41	0.92	99.71	3.53	2.74	100.07
X174 grain-C6	48.50	1.46	7.93	bdl	5.88	13.86	21.38	0.89	99.89	3.12	3.07	100.21
X174 grain-C7	48.65	1.43	7.81	bdl	6.08	13.94	21.42	0.91	100.23	3.49	2.95	100.59
X174 grain-C8	48.91	1.31	7.48	bdl	6.00	14.11	21.41	0.90	100.10	3.42	2.92	100.45
X174 grain-C9	48.99	1.28	7.23	bdl	5.86	14.31	21.30	0.94	99.91	3.79	2.45	100.40
X174 grain-C10	48.83	1.28	7.35	bdl	6.01	14.14	21.33	0.92	99.86	3.74	2.65	100.33

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X174 grain-C AVG	48.71	1.35	7.54	bdl	6.01	14.05	21.29	0.91	99.87	3.48	2.88	100.26
X174 grain-D1	49.97	1.10	6.06	bdl	6.14	14.81	20.76	1.01	99.85	3.41	3.08	100.20
X174 grain-D2	50.00	1.09	6.08	bdl	6.11	14.84	20.71	0.93	99.76	3.06	3.36	100.16
X174 grain-D3	49.89	1.08	6.00	bdl	6.11	14.88	20.75	0.95	99.65	3.43	3.03	100.10
X174 grain-D4	49.92	1.11	6.09	bdl	6.03	14.98	20.70	0.93	99.76	3.29	3.08	100.18
X174 grain-D5	49.81	1.09	6.11	bdl	6.29	14.82	20.68	1.00	99.80	3.79	2.89	100.28
X174 grain-D6	49.94	1.12	6.16	bdl	6.13	14.83	20.74	0.98	99.90	3.38	3.09	100.33
X174 grain-D7	49.86	1.07	6.08	bdl	6.10	14.87	20.78	0.97	99.72	3.62	2.85	100.18
X174 grain-D8	50.03	1.05	5.95	bdl	6.16	14.96	20.76	0.99	99.90	3.72	2.82	100.39
X174 grain-D9	49.80	1.09	6.11	bdl	6.11	14.88	20.70	1.03	99.73	3.80	2.69	100.12
X174 grain-D10	50.00	1.10	6.19	bdl	6.06	14.77	20.85	0.92	99.89	2.99	3.37	100.27
X174 grain-D AVG	49.92	1.09	6.08	bdl	6.12	14.86	20.74	0.97	99.80	3.45	3.03	100.22
X174 ALL AVG	49.92	1.09	6.08	0.00	6.12	14.86	20.74	0.97	99.80	0.00	6.12	99.80
X192 grain-A1	49.80	1.19	6.54	0.22	4.32	15.28	21.85	0.77	99.97	2.78	1.82	100.26
X192 grain-A2	49.47	0.96	7.83	0.08	4.58	14.84	21.81	0.78	100.33	2.96	1.92	100.74
X192 grain-A3	49.33	1.12	7.38	0.33	5.47	17.23	18.31	0.71	99.88	3.38	2.43	100.32
X192 grain-A4	49.07	1.11	7.48	0.14	4.48	14.87	21.60	0.82	99.55	3.21	1.59	99.98
X192 grain-A5	49.11	1.14	8.11	0.26	4.54	14.54	21.50	0.84	100.04	2.57	2.23	100.45
X192 grain-A6	49.06	0.90	8.24	0.12	4.78	14.74	21.43	0.78	100.05	3.08	2.01	100.50
X192 grain-A7	49.48	1.22	6.87	0.26	4.46	15.27	21.43	0.74	99.73	2.69	2.05	100.14
X192 grain-A8	49.83	1.28	6.68	0.22	4.43	15.30	21.76	0.71	100.21	2.53	2.15	100.60

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X192 grain-A9	48.95	1.17	8.25	bdl	4.43	14.66	21.59	0.88	99.93	3.13	1.62	100.35
X192 grain-A10	48.77	1.45	7.66	0.31	4.24	14.78	21.79	0.79	99.78	2.98	1.56	100.25
X192 grain-A AVG	49.29	1.15	7.50	0.19	4.57	15.15	21.31	0.78	99.95	2.93	1.94	100.36
X192 grain-B1	50.73	0.94	5.40	0.14	4.42	15.55	21.64	0.94	99.76	3.20	1.54	100.22
X192 grain-B2	49.66	1.11	7.30	0.09	4.28	14.83	21.52	0.99	99.78	2.94	1.64	100.22
X192 grain-B3	49.38	1.10	7.70	bdl	4.39	14.70	21.61	1.00	99.89	3.35	1.39	100.33
X192 grain-B4	49.05	1.13	8.12	bdl	4.45	14.54	21.63	1.05	99.97	3.76	1.07	100.46
X192 grain-B5	49.33	1.03	7.87	bdl	4.43	14.58	21.46	0.96	99.74	2.88	1.84	100.18
X192 grain-B6	49.28	1.15	7.95	0.09	4.52	14.63	21.42	0.97	100.01	3.03	1.80	100.46
X192 grain-B7	49.28	1.12	7.55	0.34	4.38	14.69	21.45	1.02	99.84	3.28	1.43	100.30
X192 grain-B8	49.29	1.20	7.43	0.36	4.33	14.78	21.40	1.06	99.85	3.51	1.18	100.34
X192 grain-B9	49.91	1.13	6.70	0.28	4.11	14.98	21.48	1.03	99.61	2.80	1.59	100.00
X192 grain-B10	50.21	1.23	6.47	0.32	4.24	15.07	21.41	1.03	99.97	2.52	1.98	100.32
X192 grain-B AVG	49.61	1.11	7.25	0.17	4.36	14.83	21.50	1.00	99.84	3.13	1.55	100.28
X192 grain-C1	48.56	1.41	7.28	0.28	4.39	15.13	21.64	0.94	99.63	4.70	0.16	100.20
X192 grain-C2	49.18	1.28	7.35	0.33	4.54	14.93	21.57	0.87	100.06	3.18	1.69	100.38
X192 grain-C3	50.45	0.76	7.87	bdl	6.81	20.80	13.15	0.57	100.40	2.79	4.30	100.84
X192 grain-C4	49.75	1.04	7.68	0.14	5.64	17.89	17.65	0.72	100.52	3.42	2.57	100.86
X192 grain-C5	49.25	1.26	7.44	0.18	4.57	14.99	21.54	0.82	100.06	3.10	1.78	100.52
X192 grain-C6	49.22	1.32	7.51	0.27	4.72	14.91	21.73	0.84	100.51	3.49	1.58	101.01
X192 grain-C7	48.78	1.40	8.09	0.26	4.65	14.61	21.51	0.86	100.16	3.10	1.87	100.58

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X192 grain-C8	49.19	1.18	7.41	0.26	4.65	15.20	21.22	0.79	99.89	3.14	1.83	100.31
X192 grain-C9	49.03	1.04	7.95	0.19	4.63	14.67	21.57	0.75	99.83	2.77	2.14	100.26
X192 grain-C10	50.05	1.25	6.56	0.18	4.40	15.48	21.81	0.76	100.49	2.87	1.82	100.88
X192 grain-C AVG	49.34	1.19	7.51	0.21	4.90	15.86	20.34	0.79	100.15	3.26	1.97	100.58
X192 grain-D1	49.54	1.20	6.46	0.21	4.42	15.37	21.90	0.75	99.86	3.50	1.28	100.33
X192 grain-D2	49.48	1.12	7.62	0.28	5.23	16.86	18.89	0.70	100.18	2.96	2.57	100.59
X192 grain-D3	49.31	1.25	7.34	0.25	4.35	14.93	21.72	0.77	99.93	2.63	1.99	100.28
X192 grain-D4	49.22	1.13	7.84	0.28	4.81	15.89	20.26	0.71	100.14	2.92	2.18	100.55
X192 grain-D5	48.81	1.32	7.71	0.36	4.78	15.26	20.97	0.72	99.93	3.06	2.03	100.35
X192 grain-D6	49.05	1.21	7.88	0.35	4.60	15.08	21.39	0.75	100.30	3.05	1.86	100.71
X192 grain-D7	49.26	1.27	7.62	0.33	4.55	14.89	21.72	0.75	100.38	2.72	2.10	100.75
X192 grain-D8	49.00	1.28	7.74	0.28	4.50	14.81	21.63	0.78	100.01	2.88	1.91	100.42
X192 grain-D9	49.06	1.24	7.89	0.31	4.56	14.76	21.67	0.77	100.24	2.81	2.03	100.64
X192 grain-D AVG	49.19	1.22	7.57	0.29	4.64	15.32	21.13	0.74	100.11	2.95	1.99	100.51
X192 ALL AVG	49.36	1.17	7.46	0.22	4.62	15.29	21.07	0.83	100.01	3.07	1.86	100.43
X229 grain-B1	49.95	1.02	7.14	bdl	3.76	14.92	22.19	0.46	99.61	0.47	3.33	99.66
X229 grain-B2	49.20	1.03	7.68	bdl	3.70	14.51	22.12	0.46	98.90	0.47	3.28	98.95
X229 grain-B3	49.14	1.02	7.81	bdl	3.77	14.62	21.95	0.48	98.97	0.71	3.13	99.04
X229 grain-B4	48.81	1.05	7.79	bdl	3.67	14.55	21.94	0.51	98.42	0.87	2.89	98.51
X229 grain-B5	49.23	1.02	7.64	bdl	3.74	14.56	21.95	0.44	98.70	0.12	3.63	98.71
X229 grain-B6	49.42	0.98	7.46	bdl	3.64	14.68	21.86	0.44	98.61	-0.01	3.66	98.61

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X229 grain-B7	48.86	1.03	7.71	bdl	3.65	14.29	21.71	0.53	97.93	0.18	3.49	97.94
X229 grain-B8	49.64	1.02	7.79	bdl	3.84	14.63	21.75	0.49	99.30	-0.13	3.95	99.29
X229 grain-B9	49.06	1.03	7.69	bdl	3.44	14.55	21.88	0.48	98.25	0.20	3.26	98.27
X229 grain-B10	49.32	1.01	7.72	bdl	3.66	14.57	21.80	0.53	98.73	0.29	3.40	98.76
X229 grain-B11	48.95	1.02	7.73	bdl	3.69	14.59	21.79	0.48	98.35	0.55	3.20	98.41
X229 grain-B12	49.15	1.03	7.78	bdl	3.67	14.47	22.04	0.47	98.77	0.31	3.39	98.80
X229 grain-B13	48.85	1.09	7.84	bdl	3.63	14.51	21.97	0.49	98.52	0.69	3.00	98.59
X229 grain-B14	49.47	1.01	7.76	bdl	3.74	14.63	22.03	0.48	99.23	0.35	3.43	99.26
X229 grain-B15	49.18	1.03	7.87	bdl	3.64	14.59	22.03	0.45	98.97	0.41	3.27	99.01
X229 grain-B16	49.18	1.05	7.78	bdl	3.72	14.57	21.96	0.46	98.84	0.35	3.40	98.88
X229 grain-B17	49.30	1.05	7.66	bdl	3.57	14.63	22.02	0.47	98.85	0.29	3.31	98.88
X229 grain-B18	49.07	1.06	7.78	bdl	3.56	14.62	22.07	0.46	98.70	0.52	3.09	98.76
X229 grain-B19	49.24	1.15	7.55	bdl	3.56	14.71	22.23	0.48	99.03	0.73	2.90	99.10
X229 grain-B20	48.23	1.82	9.12	bdl	2.80	14.77	22.13	0.58	99.59	1.05	1.85	99.70
X229 grain-B AVG	49.16	1.08	7.76	bdl	3.62	14.60	21.97	0.48	98.67	0.42	3.24	98.72
X229 grain-H1	49.34	0.96	7.82	bdl	3.40	14.40	21.91	0.59	98.53	0.13	3.27	98.55
X229 grain-H2	49.39	0.93	7.49	bdl	3.32	14.78	21.49	0.57	98.06	0.00	3.32	98.06
X229 grain-H3	49.41	1.00	7.54	bdl	3.27	14.67	21.89	0.55	98.46	0.20	3.09	98.48
X229 grain-H4	49.34	1.16	7.37	bdl	3.03	14.81	21.98	0.52	98.36	0.14	2.90	98.37
X229 grain-H AVG	49.37	1.01	7.55	bdl	3.25	14.67	21.82	0.56	98.23	0.12	3.15	98.24
X229 ALL AVG	49.27	1.04	7.66	bdl	3.44	14.63	21.90	0.52	98.45	0.27	3.19	98.48

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X286 grain-A1	51.57	0.74	5.11	0.14	5.64	15.26	20.95	0.89	100.43	1.77	4.04	100.61
X286 grain-A2	50.03	1.07	7.16	0.17	5.65	14.22	20.89	0.93	100.27	1.61	4.20	100.43
X286 grain-A3	50.45	0.92	6.36	0.12	5.46	14.69	20.82	0.82	99.78	1.22	4.37	99.90
X286 grain-A4	50.10	1.05	6.97	0.40	5.34	14.54	20.97	0.87	100.31	1.55	3.94	100.47
X286 grain-A5	50.27	0.94	6.94	0.18	5.28	14.66	21.05	0.82	100.31	1.55	3.88	100.46
X286 grain-A6	50.02	0.86	7.13	0.45	5.26	14.44	21.07	0.78	100.14	1.28	4.11	100.26
X286 grain-A7	49.51	0.86	7.51	0.61	5.32	14.37	20.91	0.81	100.08	1.86	3.65	100.27
X286 grain-A8	49.82	0.82	7.49	0.54	5.31	14.23	21.11	0.74	100.13	1.02	4.39	100.23
X286 grain-A9	49.67	0.80	7.51	0.62	5.37	14.41	21.09	0.81	100.42	2.07	3.51	100.63
X286 grain-A10	50.49	1.00	6.34	0.17	5.19	15.06	21.19	0.67	100.22	1.25	4.06	100.35
X286 grain-A AVG	50.19	0.91	6.85	0.34	5.38	14.59	21.00	0.81	100.08	1.52	4.01	100.23
X286 grain-C1	50.09	0.90	7.50	0.51	4.88	14.43	21.26	0.89	100.60	1.55	3.48	100.75
X286 grain-C2	50.05	0.87	7.35	0.61	4.99	14.40	21.02	0.85	100.26	1.16	3.94	100.37
X286 grain-C3	49.69	0.87	7.26	0.59	5.03	14.43	21.08	0.89	99.96	2.00	3.23	100.16
X286 grain-C4	50.24	0.97	6.82	0.58	5.09	14.59	21.17	0.89	100.44	1.65	3.61	100.60
X286 grain-C5	50.35	1.04	6.51	0.31	5.00	14.82	21.33	0.80	100.36	1.66	3.50	100.53
X286 grain-C6	51.29	0.89	5.34	0.18	4.81	15.30	21.48	0.76	100.15	1.24	3.70	100.28
X286 grain-C AVG	50.28	0.92	6.80	0.46	4.97	14.66	21.22	0.85	100.16	1.54	3.58	100.32
X286 grain-G1	50.18	1.20	6.41	0.23	4.82	15.04	21.51	0.69	100.12	1.50	3.47	100.27
X286 grain-G2	49.75	1.22	7.31	0.26	5.00	14.72	21.33	0.68	100.38	1.40	3.75	100.52
X286 grain-G3	49.72	1.22	7.20	0.25	4.94	14.66	21.52	0.63	100.26	1.26	3.81	100.38

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X286 grain-G4	49.70	1.20	7.14	0.15	4.74	14.72	21.72	0.67	100.14	1.67	3.24	100.30
X286 grain-G5	50.12	1.15	6.86	0.25	4.91	15.03	21.55	0.65	100.55	1.53	3.53	100.70
X286 grain-G6	50.08	1.05	6.58	0.43	4.71	14.95	21.47	0.62	100.02	1.15	3.67	100.13
X286 grain-G7	49.92	0.97	7.02	0.51	5.24	15.65	19.80	0.63	99.86	1.10	4.25	99.97
X286 grain-G8	49.81	0.92	7.38	0.68	4.60	14.69	21.21	0.69	100.05	0.94	3.75	100.15
X286 grain-G9	49.60	1.11	7.49	0.48	4.59	14.68	21.47	0.63	100.16	1.09	3.61	100.27
X286 grain-G10	50.18	1.18	6.33	0.34	4.69	15.21	21.62	0.59	100.19	1.36	3.46	100.33
X286 grain-G AVG	49.90	1.12	6.97	0.36	4.82	14.94	21.32	0.65	100.08	1.30	3.60	100.15
X286 ALL AVG Core	49.51	0.86	7.51	0.61	5.32	14.37	20.91	0.81	99.90	1.86	3.65	100.09
X286 ALL AVG Rim	51.57	0.74	5.11	0.14	5.64	15.26	20.95	0.89	100.30	1.63	4.17	100.46
X297 grain-A1	50.03	1.03	5.91	0.17	4.87	15.32	21.94	0.43	99.83	1.86	3.19	100.01
X297 grain-A2	50.02	0.98	6.44	0.26	5.01	15.40	21.87	0.52	100.68	2.66	2.62	100.95
X297 grain-A3	49.92	0.98	6.46	0.29	4.92	15.28	21.90	0.50	100.37	2.30	2.86	100.61
X297 grain-A4	49.93	0.88	6.36	0.29	4.85	15.38	21.69	0.51	99.89	2.15	2.91	100.10
X297 grain-A5	49.78	0.96	6.39	0.20	4.75	15.22	21.92	0.47	99.69	1.96	2.99	99.89
X297 grain-A6	50.13	0.98	5.75	0.30	4.72	15.63	21.86	0.43	99.80	1.94	2.97	99.99
X297 grain-A AVG	49.97	0.97	6.22	0.25	4.85	15.37	21.86	0.48	99.97	2.15	2.92	100.18
X297 grain-C1	50.22	0.90	5.71	0.25	4.93	15.62	21.99	0.53	100.15	2.83	2.38	100.43
X297 grain-C2	49.58	0.99	6.65	0.28	5.05	15.04	21.78	0.48	99.85	2.03	3.23	100.05
X297 grain-C3	49.22	0.96	7.02	0.31	4.87	15.05	21.74	0.54	99.71	2.59	2.54	99.97
X297 grain-C4	49.41	0.94	7.15	0.31	5.15	14.92	21.67	0.52	100.22	2.41	2.98	100.46

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X297 grain-C5	49.52	0.94	7.00	0.33	4.98	14.92	21.45	0.51	99.65	1.53	3.61	99.80
X297 grain-C6	49.74	1.03	6.21	0.37	4.95	15.22	21.92	0.51	99.95	2.37	2.82	100.19
X297 grain-C AVG	49.62	0.96	6.62	0.31	4.99	15.13	21.76	0.52	99.90	2.29	2.93	100.13
X297 grain-B1	50.15	0.97	5.92	0.23	5.03	15.42	21.61	0.51	100.00	2.12	3.12	100.21
X297 grain-B2	50.37	0.89	6.23	0.23	5.22	15.53	21.31	0.51	100.45	1.89	3.52	100.64
X297 grain-B3	50.17	1.00	6.19	0.23	4.96	15.54	21.42	0.49	99.99	1.65	3.47	100.15
X297 grain-B AVG	50.23	0.95	6.11	0.23	5.07	15.50	21.44	0.50	100.04	1.89	3.37	100.23
X297 ALL AVG Core	49.41	0.94	7.15	0.31	5.15	14.92	21.67	0.52	100.07	2.41	2.98	100.31
X297 ALL AVG Rim	50.22	0.90	5.71	0.25	4.93	15.62	21.99	0.53	100.15	2.83	2.38	100.43
X299 grain-A1	50.18	0.80	6.60	0.21	4.78	15.11	21.97	0.44	100.09	1.33	3.58	100.23
X299 grain-A2	49.75	0.92	7.23	0.14	4.70	14.79	21.91	0.49	99.94	1.21	3.62	100.06
X299 grain-A3	49.97	0.94	7.22	0.24	4.89	14.77	21.75	0.50	100.27	0.89	4.09	100.36
X299 grain-A4	49.75	0.88	7.13	0.16	4.75	14.79	21.74	0.49	99.69	1.06	3.79	99.80
X299 grain-A5	49.54	0.90	7.42	0.23	4.99	14.66	21.89	0.53	100.14	1.72	3.44	100.31
X299 grain-A6	49.60	0.98	7.49	0.20	5.00	14.82	21.67	0.49	100.24	1.40	3.73	100.38
X299 grain-A7	49.85	0.98	7.37	0.22	5.10	14.72	21.97	0.50	100.71	1.48	3.76	100.86
X299 grain-A8	50.25	0.90	6.81	0.24	4.94	14.95	22.00	0.48	100.57	1.23	3.84	100.69
X299 grain-A1 AVG	49.86	0.91	7.16	0.20	4.89	14.83	21.86	0.49	100.21	1.29	3.73	100.34
X299 grain-D1	49.75	0.83	7.26	0.20	4.77	14.58	21.65	0.49	99.52	0.58	4.24	99.58
X299 grain-D2	49.88	0.86	7.29	0.19	5.03	14.76	21.55	0.54	100.09	1.14	4.00	100.21
X299 grain-D3	49.53	0.85	7.42	0.27	4.99	14.54	21.50	0.51	99.61	0.91	4.17	99.70

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X299 grain-D4	49.89	0.82	7.36	0.21	4.99	14.80	21.53	0.51	100.10	1.01	4.08	100.20
X299 grain-D5	49.80	0.84	7.39	0.15	5.29	14.82	21.68	0.56	100.53	1.94	3.54	100.72
X299 grain-D6	50.04	0.80	7.40	0.27	5.00	14.67	21.66	0.53	100.37	0.87	4.22	100.45
X299 grain-D7	49.79	0.87	7.50	0.27	4.94	14.62	21.51	0.55	100.04	0.87	4.16	100.12
X299 grain-D8	49.97	0.92	7.48	0.23	4.98	14.67	21.70	0.51	100.46	0.79	4.27	100.54
X299 grain-D AVG	49.83	0.85	7.39	0.22	5.00	14.68	21.60	0.52	100.09	1.01	4.08	100.19
X299 grain-B1	50.22	0.84	6.83	0.15	4.65	15.04	21.85	0.43	100.01	0.70	4.02	100.08
X299 grain-B2	49.68	0.96	7.27	0.24	4.72	14.77	21.82	0.46	99.91	0.96	3.85	100.00
X299 grain-B3	49.74	0.95	7.26	0.18	4.70	14.67	21.89	0.49	99.87	0.94	3.86	99.96
X299 grain-B4	50.04	bld	7.12	0.17	4.84	14.88	21.88	0.46	99.39	1.87	3.15	99.57
X299 grain-B5	50.09	0.87	7.18	0.29	4.77	14.72	21.86	0.54	100.33	0.93	3.93	100.42
X299 grain-B6	50.12	0.94	7.11	0.24	4.82	14.77	21.80	0.51	100.31	0.75	4.15	100.38
X299 grain-B7	50.22	0.90	6.56	0.22	4.58	15.07	21.90	0.51	99.95	1.14	3.56	100.06
X299 grain-B8	50.61	0.87	6.24	0.19	4.29	15.14	21.90	0.49	99.73	0.33	4.00	99.76
X299 grain-B AVG	50.09	0.90	6.95	0.21	4.67	14.88	21.86	0.49	100.05	0.95	3.81	100.14
X299 grain-C1	49.52	0.95	7.49	0.17	4.62	14.49	21.75	0.56	99.55	0.93	3.79	99.64
X299 grain-C2	49.64	0.95	7.69	0.23	4.73	14.48	21.29	0.65	99.64	0.67	4.12	99.70
X299 grain-C3	49.43	0.88	7.61	0.27	4.92	14.49	21.41	0.61	99.60	1.25	3.79	99.73
X299 grain-C4	49.83	0.85	7.30	0.24	4.73	14.56	21.48	0.59	99.58	0.66	4.13	99.65
X299 grain-C5	49.76	0.93	7.62	0.26	4.69	14.52	21.42	0.61	99.81	0.58	4.16	99.86
X299 grain-C6	49.88	0.86	7.00	0.21	4.67	14.82	21.61	0.58	99.61	1.11	3.67	99.73

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X299 grain-C AVG	49.68	0.90	7.45	0.23	4.72	14.56	21.49	0.60	99.63	0.87	3.94	99.72
X299 ALL AVG Core	49.54	0.90	7.42	0.23	4.99	14.66	21.89	0.53	100.14	1.72	3.44	100.31
X299 ALL AVG Rim	50.18	0.80	6.60	0.21	4.78	15.11	21.97	0.44	100.09	1.33	3.58	100.23
X319 grain-A1	49.70	1.06	6.43	0.13	4.57	15.19	21.93	0.50	99.50	2.02	2.76	99.84
X319 grain-A2	48.98	1.14	7.70	0.17	4.86	14.68	21.63	0.63	99.78	2.47	2.64	100.17
X319 grain-A3	48.71	1.05	7.25	0.19	4.74	14.84	21.74	0.60	99.13	3.04	2.01	99.52
X319 grain-A4	49.37	1.01	6.86	0.17	4.76	15.21	21.55	0.67	99.60	3.11	1.96	100.06
X319 grain-A5	49.35	1.11	7.42	0.22	4.94	14.78	21.55	0.64	100.02	2.18	2.98	100.34
X319 grain-A6	49.27	1.05	7.17	0.15	4.99	14.96	21.65	0.64	99.87	2.93	2.35	100.29
X319 grain-A7	48.75	1.07	7.44	0.15	4.70	14.79	21.76	0.58	99.23	2.82	2.17	99.66
X319 grain-A8	48.74	1.06	7.77	0.13	4.92	14.69	21.61	0.69	99.60	3.21	2.04	100.05
X319 grain-A9	48.90	1.02	7.44	0.17	4.86	14.88	21.72	0.63	99.62	3.16	2.02	100.03
X319 grain-A10	49.91	1.09	5.98	0.18	4.49	15.59	22.23	0.51	99.98	2.87	1.92	100.39
X319 grain-A AVG	49.17	1.07	7.14	0.16	4.78	14.96	21.74	0.61	99.63	2.78	2.28	100.04
X319 grain-B1	45.66	2.77	9.59	0.91	3.50	14.13	22.42	0.47	99.45	2.78	1.01	99.73
X319 grain-B2	50.25	2.43	23.32	0.00	5.46	3.23	8.95	2.80	96.43	- 29.55	32.01	93.50
X319 grain-B3	49.66	1.07	6.09	0.17	4.53	15.41	22.05	0.51	99.48	2.65	2.15	99.87
X319 grain-B4	49.74	1.18	6.65	0.19	4.56	15.30	21.91	0.52	100.04	2.08	2.69	100.33
X319 grain-B5	48.99	1.14	6.69	0.18	4.70	15.18	21.90	0.58	99.36	3.32	1.71	99.81
X319 grain-B6	49.34	1.16	6.88	0.20	4.59	15.14	21.76	0.60	99.66	2.53	2.31	100.00
X319 grain-B7	49.31	1.15	6.95	0.15	4.57	15.10	21.91	0.52	99.66	2.32	2.48	100.02

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X319 grain-B8	49.07	1.23	7.19	0.20	4.54	14.94	21.86	0.54	99.56	2.26	2.50	99.91
X319 grain-B9	48.94	1.21	7.20	0.21	4.59	14.96	21.88	0.56	99.54	2.69	2.17	99.93
X319 grain-B10	49.78	1.07	6.47	0.19	4.49	15.29	22.06	0.48	99.83	2.13	2.58	100.19
X319 grain-B11	49.65	1.08	6.49	0.13	4.47	15.25	21.86	0.55	99.47	2.19	2.50	99.79
X319 grain-B12	48.92	1.17	7.56	0.22	4.60	14.87	22.04	0.58	99.97	2.92	1.97	100.39
X319 grain-B13	48.97	1.17	7.65	0.15	4.73	14.83	21.66	0.59	99.75	2.41	2.56	100.13
X319 grain-B14	48.77	1.19	7.80	0.15	4.71	14.75	21.76	0.60	99.74	2.57	2.40	100.00
X319 grain-B15	48.98	1.18	7.67	0.21	4.80	14.89	21.77	0.59	100.09	2.79	2.30	100.53
X319 grain-B16	48.93	1.13	7.61	0.17	4.78	14.79	21.82	0.59	99.82	2.74	2.32	100.23
X319 grain-B17	48.25	1.15	7.60	0.21	4.70	14.81	21.66	0.61	98.98	3.44	1.61	99.48
X319 grain-B18	48.88	1.14	7.48	0.21	4.81	14.90	21.65	0.63	99.70	2.99	2.12	100.12
X319 grain-B19	51.58	0.63	6.59	0.15	8.07	24.24	8.69	0.26	100.20	1.71	6.53	100.54
X319 grain-B20	49.03	1.16	7.45	0.17	4.92	15.43	20.90	0.56	99.61	2.44	2.73	99.94
X319 grain-B21	48.25	0.93	7.34	0.17	5.08	15.95	19.47	0.52	97.71	2.74	2.62	98.11
X319 grain-B22	48.75	1.10	7.60	0.21	4.89	15.13	21.22	0.57	99.47	2.84	2.34	99.90
X319 grain-B23	48.68	1.12	7.61	0.17	4.70	14.73	21.56	0.62	99.17	2.61	2.35	99.56
X319 grain-B24	48.60	1.13	7.77	0.13	4.72	14.75	21.57	0.61	99.27	2.71	2.29	99.63
X319 grain-B25	48.97	1.06	7.74	0.20	5.28	15.97	20.06	0.60	99.87	3.13	2.46	100.30
X319 grain-B26	49.56	0.95	7.41	0.15	5.51	17.50	17.91	0.47	99.45	2.02	3.69	99.77
X319 grain-B27	48.66	1.13	7.72	0.19	4.80	14.87	21.62	0.61	99.60	3.07	2.04	100.03
X319 grain-B28	48.73	1.15	7.59	0.18	4.72	14.76	21.97	0.59	99.69	3.08	1.95	100.16

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X319 grain-B29	48.75	1.17	7.54	0.16	4.75	14.94	21.84	0.55	99.70	3.01	2.05	100.14
X319 grain-B30	49.43	1.11	6.34	0.18	4.46	15.31	21.89	0.54	99.27	2.46	2.25	99.52
X319 grain-B31	49.43	1.09	6.25	0.19	4.55	15.30	22.01	0.50	99.33	2.66	2.16	99.73
X319 grain-B32	49.14	1.10	7.08	0.12	4.59	15.06	21.77	0.60	99.46	2.71	2.16	99.83
X319 grain-B33	49.00	1.07	7.19	0.13	4.66	15.05	21.69	0.58	99.37	2.83	2.11	99.78
X319 grain-B34	50.18	0.87	6.97	0.18	5.98	19.00	16.16	0.43	99.76	2.09	4.09	100.12
X319 grain-B35	49.09	0.91	7.36	0.15	6.10	17.92	17.93	0.50	99.96	4.40	2.14	100.57
X319 grain-B36	49.86	0.80	7.33	0.15	6.25	19.18	15.63	0.43	99.64	2.52	3.99	100.05
X319 grain-B37	50.63	0.66	7.04	0.13	7.27	21.64	12.01	0.35	99.74	2.10	5.38	100.13
X319 grain-B38	48.50	1.11	7.85	0.16	4.77	14.81	21.71	0.63	99.55	3.37	1.74	100.01
X319 grain-B39	48.78	1.02	7.61	0.17	4.87	14.82	21.75	0.58	99.61	3.05	2.12	100.05
X319 grain-B40	48.65	1.06	7.87	0.16	4.71	14.74	21.51	0.60	99.29	2.57	2.40	99.65
X319 grain-B41	48.91	1.03	7.39	0.20	4.66	14.91	21.62	0.65	99.36	2.93	2.02	99.78
X319 grain-B42	48.71	1.06	7.80	0.19	4.73	14.65	21.73	0.63	99.50	2.76	2.25	99.87
X319 grain-B43	49.57	0.98	7.62	0.17	5.44	17.01	18.57	0.51	99.86	2.12	3.54	100.23
X319 grain-B44	49.49	0.95	7.62	0.15	5.39	16.97	18.47	0.54	99.58	2.16	3.45	99.94
X319 grain-B45	48.64	1.08	7.88	0.12	4.79	14.64	21.83	0.56	99.54	2.71	2.36	99.93
X319 grain-B46	48.67	1.09	7.73	0.14	4.77	14.74	21.65	0.65	99.44	3.07	2.01	99.88
X319 grain-B47	49.21	1.00	7.22	0.16	4.82	15.02	21.57	0.59	99.58	2.62	2.46	100.00
X319 grain-B48	49.38	1.05	6.99	0.13	4.71	15.20	21.68	0.58	99.71	2.63	2.34	100.09
X319 grain-B49	49.22	1.03	6.77	0.19	4.63	15.20	21.96	0.58	99.56	3.18	1.77	99.98

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X319 grain-B50	49.79	1.08	6.44	0.15	4.49	15.50	21.97	0.49	99.91	2.39	2.34	100.26
X319 grain-B AVG	49.12	1.13	7.63	0.18	4.94	15.45	20.46	0.60	99.51	2.04	3.11	99.83
X319 grain-C1	49.60	1.16	6.30	0.16	4.42	15.44	22.06	0.52	99.66	2.67	2.02	100.06
X319 grain-C2	48.94	1.18	6.89	0.16	4.39	15.06	22.19	0.52	99.33	2.91	1.78	99.73
X319 grain-C3	48.99	1.20	6.95	0.17	4.61	15.08	21.94	0.51	99.46	2.74	2.15	99.87
X319 grain-C4	49.06	1.14	6.94	0.21	4.47	15.09	21.94	0.51	99.35	2.55	2.17	99.74
X319 grain-C5	48.96	1.18	7.33	0.18	4.54	14.87	21.75	0.52	99.33	2.06	2.69	99.66
X319 grain-C6	48.62	1.23	7.43	0.20	4.59	15.01	21.84	0.55	99.47	3.05	1.85	99.89
X319 grain-C7	48.81	1.12	6.99	0.12	4.63	15.09	22.07	0.53	99.35	3.28	1.69	99.77
X319 grain-C8	49.08	1.09	6.73	0.13	4.54	15.15	22.21	0.51	99.45	3.13	1.73	99.86
X319 grain-C9	48.87	1.29	7.17	0.17	4.49	15.02	21.95	0.55	99.51	2.69	2.07	99.89
X319 grain-C10	44.59	2.92	10.18	0.85	3.52	13.62	22.77	0.46	98.91	3.50	0.37	99.26
X319 grain-C AVG	48.55	1.35	7.29	0.23	4.42	14.94	22.07	0.52	99.38	2.86	1.85	99.77
X319 grain-D1	49.46	1.07	6.22	0.16	4.46	15.48	22.09	0.50	99.44	2.97	1.80	99.83
X319 grain-D2	48.76	1.16	7.19	0.22	4.67	15.03	21.99	0.54	99.56	3.27	1.73	100.04
X319 grain-D3	48.83	0.99	7.46	0.18	4.76	14.88	21.67	0.51	99.28	2.53	2.48	99.68
X319 grain-D4	48.88	1.05	7.49	0.17	4.64	14.88	21.84	0.51	99.45	2.46	2.42	99.79
X319 grain-D5	48.29	1.04	7.79	0.02	4.77	14.84	21.97	0.56	99.27	3.80	1.35	99.77
X319 grain-D6	48.60	1.02	7.74	0.17	4.75	14.74	21.91	0.54	99.47	2.97	2.08	99.86
X319 grain-D7	48.47	1.03	7.82	0.17	4.73	14.68	21.66	0.58	99.12	2.85	2.17	99.54
X319 grain-D8	48.71	1.16	7.78	0.09	4.83	14.79	21.83	0.59	99.78	3.03	2.11	100.18

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X319 grain-D9	48.69	1.24	7.48	0.10	4.79	15.07	21.67	0.55	99.58	3.04	2.06	100.00
X319 grain-D10	49.47	1.10	6.17	0.15	4.61	15.44	22.09	0.57	99.60	3.40	1.55	100.07
X319 grain-D AVG	48.82	1.09	7.31	0.14	4.70	14.98	21.87	0.55	99.45	3.03	1.97	99.88
X319 ALL AVG	48.91	1.16	7.35	0.18	4.71	15.08	21.53	0.57	99.49	2.55	2.42	99.75
Ba-1-72 grain-A1	51.83	0.20	6.05	0.71	4.18	15.85	19.92	1.46	100.35	3.06	1.42	100.65
Ba-1-72 grain-A2	51.67	0.22	6.00	0.85	4.00	15.91	20.02	1.39	100.18	2.91	1.38	100.47
Ba-1-72 grain-A3	51.75	0.21	6.02	0.78	4.09	15.88	19.97	1.42	100.12	2.99	1.40	100.41
Ba-1-72 grain-A4	51.68	0.19	5.98	0.64	4.19	15.89	20.14	1.34	100.18	2.99	1.50	100.48
Ba-1-72 grain-A5	50.84	0.45	7.29	0.79	4.27	15.22	19.72	1.49	100.29	2.91	1.66	100.58
Ba-1-72 grain-A6	51.47	0.24	6.22	0.60	3.91	15.78	19.98	1.42	99.84	3.01	1.20	100.14
Ba-1-72 grain-A7	51.33	0.29	6.50	0.67	4.12	15.63	19.95	1.42	99.91	2.97	1.45	100.21
Ba-1-72 grain-A8	51.40	0.32	6.47	0.69	3.83	15.80	20.02	1.40	100.15	2.91	1.22	100.44
Ba-1-72 grain-A9	50.77	0.56	7.41	0.77	4.02	15.23	19.97	1.48	100.32	2.78	1.52	100.59
Ba-1-72 grain-A10	50.86	0.34	6.82	0.67	3.94	15.53	20.31	1.41	99.96	3.57	0.72	100.32
Ba-1-72 grain-A AVG	51.01	0.41	6.90	0.71	3.93	15.52	20.10	1.43	100.00	3.09	1.15	100.31
Ba-1-72 grain-B1	51.37	0.25	6.46	0.70	4.00	15.73	20.04	1.40	100.05	2.97	1.33	100.34
Ba-1-72 grain-B2	50.72	0.40	7.14	0.72	3.94	15.47	20.07	1.39	100.03	3.15	1.10	100.35
Ba-1-72 grain-B3	51.31	0.27	6.57	0.54	4.04	15.77	20.16	1.34	100.16	3.05	1.29	100.46
Ba-1-72 grain-B AVG	51.13	0.31	6.73	0.65	3.99	15.66	20.09	1.38	99.93	3.06	1.24	100.24
Ba-1-72 grain-C1	51.69	0.33	6.46	0.69	3.93	15.70	20.14	1.44	100.43	2.59	1.60	100.69
Ba-1-72 grain-C2	51.32	0.32	6.75	0.69	3.75	15.51	20.08	1.35	99.87	2.03	1.92	100.07

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
Ba-1-72 grain-C3	51.12	0.34	6.83	0.67	4.02	15.50	20.18	1.40	100.30	3.10	1.22	100.61
Ba-1-72 grain-C4	51.03	0.45	7.16	0.74	3.93	15.34	20.11	1.42	100.36	2.63	1.57	100.62
Ba-1-72 grain-C5	50.78	0.53	7.27	0.82	3.99	15.31	20.08	1.39	100.30	2.64	1.61	100.57
Ba-1-72 grain-C6	50.97	0.53	7.28	0.87	4.16	15.28	20.25	1.47	101.07	3.36	1.14	101.41
Ba-1-72 grain-C7	50.99	0.48	7.29	0.71	3.82	15.25	19.99	1.43	100.09	2.24	1.80	100.32
Ba-1-72 grain-C8	51.07	0.47	7.21	0.81	3.77	15.23	20.10	1.37	100.16	1.84	2.11	100.34
Ba-1-72 grain-C9	51.44	0.36	6.57	0.74	4.17	15.66	20.33	1.45	100.86	3.56	0.97	101.21
Ba-1-72 grain-C AVG	51.16	0.42	6.98	0.75	3.95	15.42	20.14	1.41	100.22	2.67	1.55	100.49
Ba-1-72 ALL AVG Core	50.97	0.53	7.28	0.87	4.16	15.28	20.25	1.47	100.82	3.36	1.14	101.15
Ba-1-72 ALL AVG Rim	51.69	0.33	6.46	0.69	3.93	15.70	20.14	1.44	100.39	2.59	1.60	100.65
Ba2-1-1 grain-A1	51.50	0.34	6.19	0.71	3.31	15.91	20.28	1.36	99.60	2.32	1.22	99.95
Ba2-1-1 grain-A2	51.30	0.41	6.78	0.79	3.14	15.70	20.28	1.47	99.88	2.58	0.81	100.31
Ba2-1-1 grain-A3	51.14	0.42	6.99	0.76	3.13	15.63	20.33	1.54	99.94	3.01	0.42	100.39
Ba2-1-1 grain-A4	51.15	0.43	6.88	0.77	3.22	15.58	20.36	1.39	99.78	2.22	1.23	100.14
Ba2-1-1 grain-A5	51.08	0.41	6.91	0.83	3.18	15.62	20.38	1.45	99.85	2.66	0.78	100.24
Ba2-1-1 grain-A6	51.19	0.40	6.85	0.86	3.07	15.58	20.40	1.49	99.83	2.56	0.77	100.20
Ba2-1-1 grain-A7	51.32	0.40	6.74	0.87	3.20	15.63	20.33	1.45	99.93	2.31	1.12	100.26
Ba2-1-1 grain-A8	51.17	0.41	6.84	0.81	3.15	15.74	20.24	1.44	99.80	2.51	0.90	100.16
Ba2-1-1 grain-A9	50.89	0.39	6.77	0.86	3.09	15.64	20.44	1.41	99.48	2.78	0.59	99.82
Ba2-1-1 grain-A10	51.70	0.33	6.33	0.65	3.21	16.02	20.25	1.37	99.85	2.15	1.28	100.19
Ba2-1-1 grain-A AVG	51.24	0.39	6.73	0.79	3.17	15.70	20.33	1.44	99.79	2.51	0.91	100.07

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
Ba2-1-1 grain-B1	51.70	0.32	6.37	0.77	3.30	15.82	20.25	1.44	99.96	2.22	1.30	100.36
Ba2-1-1 grain-B2	51.32	0.46	7.14	0.85	3.09	15.47	20.13	1.47	99.93	1.75	1.52	100.21
Ba2-1-1 grain-B3	51.33	0.48	7.10	0.88	3.13	15.50	19.96	1.47	99.83	1.57	1.71	100.10
Ba2-1-1 grain-B4	51.03	0.45	7.08	0.85	3.09	15.46	20.21	1.46	99.63	2.12	1.19	99.91
Ba2-1-1 grain-B5	51.34	0.45	7.09	0.82	3.13	15.59	20.27	1.49	100.17	2.35	1.02	100.55
Ba2-1-1 grain-B6	51.13	0.45	6.85	0.78	3.12	15.70	20.22	1.48	99.73	2.58	0.80	100.09
Ba2-1-1 grain-B7	51.19	0.49	6.92	0.82	3.22	15.64	20.21	1.52	100.02	2.68	0.82	100.41
Ba2-1-1 grain-B8	51.48	0.43	6.81	0.73	3.07	15.55	19.97	1.51	99.54	1.58	1.65	99.85
Ba2-1-1 grain-B9	51.20	0.47	7.18	0.92	3.14	15.33	20.01	1.51	99.76	1.61	1.70	100.03
Ba2-1-1 grain-B10	51.66	0.51	7.26	0.92	3.21	15.57	20.16	1.59	100.88	2.25	1.19	101.24
Ba2-1-1 grain-B11	50.86	0.46	7.05	0.92	3.09	15.43	20.20	1.46	99.47	2.24	1.07	99.84
Ba2-1-1 grain-B12	51.36	0.47	7.11	0.90	3.03	15.34	20.18	1.52	99.91	1.61	1.59	100.22
Ba2-1-1 grain-B13	51.68	0.37	6.52	0.83	3.22	15.75	20.43	1.42	100.21	2.12	1.31	100.51
Ba2-1-1 grain-B AVG	51.29	0.43	6.86	0.83	3.14	15.55	20.19	1.48	99.75	2.08	1.27	99.98
Ba2-1-1 ALL AVG	51.33	0.43	6.87	0.81	3.15	15.62	20.18	1.48	99.88	2.21	1.17	100.14
EP-3-84 grain-A1	49.18	1.14	7.61	bdl	3.98	14.99	21.29	0.94	99.13	2.87	1.40	99.58
EP-3-84 grain-A2	49.07	1.19	8.05	bdl	4.24	14.81	21.12	1.01	99.48	3.01	1.54	99.88
EP-3-84 grain-A3	49.16	1.19	8.19	bdl	4.25	14.84	21.00	0.96	99.58	2.57	1.94	100.01
EP-3-84 grain-A4	48.89	1.23	8.27	bdl	4.35	14.78	20.81	0.95	99.27	2.54	2.07	99.70
EP-3-84 grain-A5	48.78	1.24	8.42	bdl	4.14	14.76	20.87	0.97	99.17	2.62	1.78	99.56

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
EP-3-84 grain-A6	48.72	1.26	8.61	bdl	4.17	14.68	20.95	0.99	99.37	2.77	1.68	99.83
EP-3-84 grain-A7	48.83	1.27	8.53	bdl	4.18	14.71	20.71	1.02	99.23	2.44	1.98	99.61
EP-3-84 grain-A8	48.79	1.24	8.42	bdl	3.95	14.67	20.73	0.98	98.78	2.08	2.08	99.18
EP-3-84 grain-A9	49.08	1.25	7.98	bdl	4.04	14.86	21.19	0.94	99.34	2.58	1.72	99.80
EP-3-84 grain-A10	49.43	1.13	7.38	bdl	3.96	14.95	21.58	0.82	99.24	2.31	1.88	99.65
EP-3-84 grain-A AVG	48.99	1.21	8.14	bdl	4.13	14.80	21.03	0.96	99.26	2.58	1.81	99.63
EP-3-84 grain-B1	48.86	1.26	7.87	bdl	4.18	14.73	21.35	0.98	99.23	3.16	1.34	99.65
EP-3-84 grain-B2	48.54	1.33	8.36	bdl	4.19	14.57	21.06	1.03	99.08	3.12	1.39	99.59
EP-3-84 grain-B3	48.67	1.34	8.49	bdl	4.44	14.58	20.63	1.02	99.15	2.51	2.18	99.55
EP-3-84 grain-B4	48.75	1.33	8.59	bdl	4.49	14.73	20.68	1.05	99.61	3.03	1.77	100.02
EP-3-84 grain-B5	48.53	1.32	8.67	bdl	4.46	14.57	20.73	1.07	99.36	3.19	1.60	99.83
EP-3-84 grain-B6	48.50	1.27	8.60	bdl	4.41	14.48	20.74	1.02	99.02	2.76	1.93	99.44
EP-3-84 grain-B7	48.57	1.27	8.52	bdl	4.33	14.48	20.84	1.07	99.07	3.00	1.63	99.58
EP-3-84 grain-B8	48.59	1.29	8.41	bdl	4.39	14.47	20.84	1.01	99.02	2.73	1.94	99.50
EP-3-84 grain-B9	48.66	1.31	8.31	bdl	4.39	14.36	21.14	0.99	99.16	2.70	1.96	99.63
EP-3-84 grain-B10	48.84	1.27	7.92	bdl	4.52	14.72	21.31	0.95	99.52	3.33	1.52	99.98
EP-3-84 grain-B AVG	48.65	1.30	8.37	bdl	4.38	14.57	20.93	1.02	99.22	2.95	1.73	99.63
EP-3-84 grain-C1	49.13	1.21	7.72	bdl	4.11	14.83	21.47	0.92	99.38	2.85	1.55	99.82
EP-3-84 grain-C2	48.72	1.28	8.21	bdl	4.15	14.60	21.26	0.97	99.19	2.91	1.53	99.71
EP-3-84 grain-C3	48.79	1.32	8.44	bdl	4.17	14.57	21.24	0.95	99.47	2.55	1.88	99.86

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
EP-3-84 grain-C4	48.61	1.29	8.62	bdl	4.35	14.51	20.89	1.05	99.31	2.94	1.71	99.71
EP-3-84 grain-C5	48.68	1.30	8.71	bdl	4.27	14.53	21.00	1.04	99.54	2.95	1.62	100.02
EP-3-84 grain-C6	48.57	1.29	8.72	bdl	4.36	14.39	20.83	1.05	99.20	2.70	1.94	99.60
EP-3-84 grain-C7	48.66	1.28	8.68	bdl	4.39	14.48	20.81	1.01	99.30	2.57	2.08	99.72
EP-3-84 grain-C8	48.53	1.32	8.66	bdl	4.28	14.47	20.85	1.06	99.16	2.90	1.68	99.63
EP-3-84 grain-C9	48.59	1.30	8.44	bdl	4.22	14.39	21.09	0.97	99.01	2.51	1.96	99.40
EP-3-84 grain-C10	48.93	1.25	7.97	bdl	4.36	14.59	21.32	0.92	99.34	2.71	1.92	99.80
EP-3-84 grain-C AVG	48.79	1.27	8.31	bdl	4.26	14.64	21.01	0.99	99.26	2.76	1.77	99.65
EP-3-84 ALL AVG Core	48.67	1.28	8.56	bdl	4.30	14.58	20.82	1.02	99.23	2.75	1.83	99.62
EP-3-84 ALL AVG Rim	48.91	1.25	7.84	0.00	4.21	14.69	21.20	0.96	99.06	2.66	1.82	99.33
TF6 grain-A1	52.33	0.09	4.52	0.53	2.90	16.96	22.09	0.65	100.06	2.09	1.02	100.36
TF6 grain-A2	52.52	0.06	4.24	0.47	2.91	17.11	22.06	0.64	100.01	1.98	1.13	100.21
TF6 grain-A3	52.23	0.06	4.21	0.45	2.97	17.11	21.88	0.64	99.55	2.27	0.93	99.86
TF6 grain-A4	52.26	0.08	4.09	0.48	2.89	17.27	22.01	0.68	99.75	2.74	0.43	100.03
TF6 grain-A5	52.25	0.06	4.10	0.39	2.94	17.29	22.02	0.67	99.72	2.95	0.29	100.10
TF6 grain-A6	52.45	0.06	4.03	0.35	2.93	17.31	21.91	0.61	99.64	2.25	0.90	99.98
TF6 grain-A7	52.56	0.04	4.02	0.35	2.86	17.39	22.16	0.65	100.03	2.74	0.39	100.39
TF6 grain-A8	52.51	0.06	4.05	0.47	2.80	17.25	21.98	0.68	99.79	2.31	0.72	100.10
TF6 grain-A9	52.30	0.06	4.33	0.50	2.92	17.02	21.83	0.73	99.68	2.22	0.92	99.91
TF6 grain-A10	51.79	0.06	4.45	0.58	2.89	16.99	21.99	0.61	99.36	2.54	0.61	99.70

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
TF6 grain-A AVG	52.32	0.06	4.20	0.46	2.90	17.17	21.99	0.66	99.76	2.41	0.74	100.06
TF6 grain-B1	51.90	0.07	4.96	0.65	2.93	16.77	21.91	0.70	99.88	2.24	0.92	100.11
TF6 grain-B2	51.64	0.11	4.99	0.71	3.01	16.80	21.95	0.70	99.91	2.77	0.53	100.19
TF6 grain-B3	51.76	0.09	4.92	0.66	2.88	16.74	21.99	0.78	99.80	2.79	0.37	100.08
TF6 grain-B4	51.44	0.07	5.02	0.66	3.03	16.80	21.84	0.76	99.61	3.21	0.15	99.94
TF6 grain-B5	51.55	0.09	5.17	0.63	2.99	16.81	21.98	0.76	99.98	3.26	0.07	100.31
TF6 grain-B6	51.42	0.09	5.22	0.69	2.92	16.67	21.77	0.71	99.49	2.61	0.57	99.83
TF6 grain-B7	51.52	0.09	5.19	0.72	2.95	16.65	21.97	0.72	99.81	2.79	0.44	100.18
TF6 grain-B8	51.71	0.08	5.18	0.63	2.97	16.69	21.90	0.75	99.91	2.63	0.61	100.17
TF6 grain-B9	51.10	0.09	5.10	0.68	2.88	16.77	22.10	0.74	99.45	3.70	-0.44	99.82
TF6 grain-B10	51.86	0.05	4.68	0.73	2.95	16.74	22.35	0.65	100.02	2.77	0.46	100.41
TF6 grain-B AVG	51.59	0.08	5.04	0.67	2.95	16.74	21.98	0.73	99.79	2.88	0.37	100.10
TF6 grain-C1	52.74	0.05	3.71	0.52	2.87	17.47	22.09	0.67	100.12	2.69	0.46	100.51
TF6 grain-C2	52.83	0.08	3.46	0.40	2.74	17.73	22.14	0.63	100.00	2.67	0.34	100.27
TF6 grain-C3	52.38	0.06	3.56	0.44	2.79	17.57	22.09	0.60	99.48	2.88	0.19	99.87
TF6 grain-C4	52.63	0.07	3.64	0.39	2.87	17.61	22.04	0.59	99.83	2.56	0.57	100.18
TF6 grain-C5	52.62	0.06	3.82	0.58	2.89	17.35	22.16	0.63	100.11	2.49	0.65	100.44
TF6 grain-C6	52.53	0.06	3.56	0.47	2.75	17.55	22.08	0.59	99.58	2.46	0.54	99.83
TF6 grain-C7	52.58	bdl	3.49	0.47	2.78	17.65	22.00	0.56	99.57	2.38	0.64	99.81
TF6 grain-C8	52.77	0.09	3.56	0.37	2.92	17.68	22.01	0.61	100.00	2.51	0.66	100.25

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
TF6 grain-C9	52.44	0.06	3.81	0.39	2.86	17.45	22.00	0.69	99.70	2.98	0.18	100.08
TF6 grain-C10	52.18	0.09	4.57	0.56	2.96	17.09	21.97	0.73	100.15	2.89	0.37	100.54
TF6 grain-C AVG	52.57	0.06	3.72	0.46	2.84	17.51	22.06	0.63	99.85	2.65	0.46	100.18
TF6 grain-D1	52.05	0.07	4.72	0.63	3.01	16.82	22.03	0.72	100.04	2.61	0.66	100.39
TF6 grain-D2	51.57	0.07	4.51	0.59	2.92	17.01	21.79	0.67	99.13	2.91	0.31	99.51
TF6 grain-D3	52.13	0.08	4.37	0.50	2.93	17.20	21.98	0.68	99.88	2.78	0.43	100.16
TF6 grain-D4	51.86	0.06	4.21	0.42	2.94	17.44	21.92	0.65	99.51	3.41	-0.12	99.86
TF6 grain-D5	52.69	0.08	4.02	0.44	2.92	17.42	21.91	0.66	100.15	2.38	0.78	100.51
TF6 grain-D6	52.14	0.05	3.94	0.28	2.96	17.61	21.99	0.62	99.59	3.50	-0.19	100.07
TF6 grain-D7	52.10	0.06	4.10	0.31	2.97	17.47	21.86	0.63	99.50	3.11	0.18	99.91
TF6 grain-D8	52.28	0.06	4.24	0.37	2.88	17.27	21.91	0.61	99.63	2.30	0.81	99.94
TF6 grain-D9	52.14	0.07	4.41	0.40	2.98	17.05	21.94	0.67	99.66	2.44	0.79	99.91
TF6 grain-D10	51.95	0.08	4.65	0.67	3.07	16.87	22.27	0.65	100.21	2.90	0.46	100.61
TF6 grain-D AVG	52.09	0.07	4.32	0.46	2.96	17.22	21.96	0.66	99.73	2.84	0.41	100.09
TF6 ALL AVG	52.14	0.07	4.32	0.51	2.91	17.16	22.00	0.67	99.78	2.69	0.49	100.11
JAG 84-524 grain-A1	53.54	bdl	2.23	1.60	1.96	15.95	21.32	1.74	98.33	1.94	0.22	98.52
JAG 84-524 grain-A2	54.45	bdl	2.17	1.84	1.95	16.10	21.30	1.77	99.56	1.11	0.95	99.67
JAG 84-524 grain-A3	54.12	bdl	2.24	1.94	1.83	16.06	21.18	1.84	99.22	1.50	0.49	99.44
JAG 84-524 grain-A4	54.37	bdl	2.26	1.95	1.84	16.14	21.34	1.90	99.79	1.96	0.08	99.99
JAG 84-524 grain-A5	54.41	bdl	2.32	1.86	1.84	16.03	21.42	1.90	99.77	1.78	0.25	99.95

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-A6	54.23	bdl	2.25	1.84	1.89	16.05	21.25	1.88	99.39	1.75	0.32	99.61
JAG 84-524 grain-A7	54.04	bdl	2.20	1.83	1.85	16.09	21.32	1.77	99.09	1.57	0.44	99.25
JAG 84-524 grain-A8	54.20	bdl	2.20	1.85	1.88	16.15	21.43	1.90	99.62	0.00	1.88	99.67
JAG 84-524 grain-A9	54.39	bdl	2.17	1.68	1.97	16.24	21.37	1.75	99.59	1.55	0.58	99.74
JAG 84-524 grain-A10	54.67	bdl	2.21	1.55	1.91	16.35	21.38	1.77	99.84	1.40	0.66	99.98
JAG 84-524 grain-A AVG	54.24	bdl	2.23	1.79	1.89	16.11	21.33	1.82	99.42	1.69	0.38	99.61
JAG 84-524 grain-B1	53.78	bdl	2.20	1.71	1.94	16.05	21.37	1.73	98.78	1.85	0.28	98.97
JAG 84-524 grain-B2	54.16	bdl	2.18	1.72	1.95	16.17	21.53	1.75	99.46	1.90	0.24	99.65
JAG 84-524 grain-B3	53.85	bdl	2.16	1.80	1.95	16.10	21.45	1.82	99.12	0.00	1.95	99.16
JAG 84-524 grain-B4	53.94	bdl	2.14	1.70	1.87	16.27	21.38	1.76	99.04	0.00	1.87	99.04
JAG 84-524 grain-B5	53.90	bdl	2.12	1.63	1.91	16.18	21.54	1.86	99.15	0.00	1.91	99.20
JAG 84-524 grain-B6	53.74	bdl	2.18	1.65	1.90	16.02	21.37	1.88	98.73	0.00	1.90	98.80
JAG 84-524 grain-B7	53.86	bdl	2.22	1.93	1.88	15.94	21.22	1.78	98.83	1.51	0.53	98.98
JAG 84-524 grain-B8	54.01	bdl	2.26	1.92	1.86	15.93	21.32	1.87	99.17	1.85	0.20	99.36
JAG 84-524 grain-B9	54.05	bdl	2.22	1.85	1.77	16.00	21.39	1.89	99.16	0.00	1.77	99.16
JAG 84-524 grain-B10	53.73	bdl	2.23	1.59	1.93	16.35	21.30	1.87	98.99	0.00	1.93	98.99
JAG 84-524 grain-B AVG	53.90	bdl	2.19	1.75	1.89	16.10	21.39	1.82	99.04	0.00	1.89	99.06
JAG 84-524 grain-C1	53.20	bdl	2.20	1.66	1.96	16.12	21.30	1.81	98.24	0.00	1.96	98.29
JAG 84-524 grain-C2	53.90	bdl	2.22	1.75	1.85	16.25	21.33	1.79	99.08	0.00	1.85	99.08
JAG 84-524 grain-C3	54.00	bdl	2.22	1.88	1.99	16.17	21.44	1.82	99.53	0.00	1.99	99.53

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-C4	53.96	bdl	2.26	1.91	1.82	15.99	21.39	1.90	99.22	0.00	1.82	99.22
JAG 84-524 grain-C5	53.15	bdl	2.30	2.04	2.07	16.10	21.47	1.76	98.89	0.00	2.07	98.94
JAG 84-524 grain-C6	54.09	bdl	2.25	1.89	1.90	16.06	21.29	1.82	99.29	1.69	0.39	99.52
JAG 84-524 grain-C7	53.97	bdl	2.33	1.98	1.87	16.13	21.15	1.88	99.29	0.00	1.87	99.29
JAG 84-524 grain-C8	54.09	bdl	2.23	1.95	1.89	16.08	21.32	1.87	99.43	2.10	0.00	99.64
JAG 84-524 grain-C9	54.12	bdl	2.21	1.80	1.90	16.24	21.50	1.90	99.66	0.00	1.90	99.66
JAG 84-524 grain-C10	54.42	bdl	2.27	1.59	2.00	16.66	21.34	1.80	100.09	0.00	2.00	100.14
JAG 84-524 grain-C AVG	53.89	bdl	2.25	1.84	1.92	16.18	21.35	1.84	99.27	0.00	1.92	99.29
JAG 84-524 grain-D1	53.36	bdl	2.20	1.64	1.84	16.11	21.33	1.73	98.21	0.00	1.84	98.41
JAG 84-524 grain-D2	53.92	bdl	2.20	1.81	1.86	16.14	21.33	1.79	99.04	1.96	0.10	99.35
JAG 84-524 grain-D3	53.49	bdl	2.24	1.97	1.83	16.14	21.23	1.87	98.77	0.00	1.83	98.88
JAG 84-524 grain-D4	54.08	bdl	2.24	1.83	1.94	16.04	21.34	1.82	99.29	1.79	0.34	99.60
JAG 84-524 grain-D5	53.65	bdl	2.18	1.88	1.93	16.14	21.39	1.82	99.01	0.00	1.93	99.15
JAG 84-524 grain-D6	54.24	bdl	2.19	1.91	1.93	15.97	21.35	1.81	99.40	1.38	0.69	99.67
JAG 84-524 grain-D7	53.93	bdl	2.14	1.84	1.90	16.14	21.35	1.84	99.14	0.00	1.90	99.23
JAG 84-524 grain-D8	53.82	bdl	2.15	1.72	1.88	16.08	21.30	1.80	98.74	1.94	0.13	99.02
JAG 84-524 grain-D9	53.87	bdl	2.17	1.69	1.92	16.21	21.34	1.90	99.09	0.00	1.92	99.24
JAG 84-524 grain-D10	54.15	bdl	2.21	1.55	2.07	16.73	21.10	1.67	99.47	2.07	0.20	99.81
JAG 84-524 grain-D AVG	53.85	bdl	2.19	1.78	1.91	16.17	21.31	1.80	99.01	0.00	1.91	99.06
JAG 84-524 grain-E1	53.99	bdl	2.21	1.68	2.15	16.34	21.42	1.75	99.54	0.00	2.15	99.80

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-E2	54.36	bdl	2.18	1.69	1.92	16.31	21.36	1.69	99.51	1.28	0.77	99.82
JAG 84-524 grain-E3	54.14	bdl	2.27	1.74	1.92	16.18	21.47	1.75	99.47	1.83	0.27	99.83
JAG 84-524 grain-E4	54.04	bdl	2.19	1.70	2.03	16.06	21.15	1.74	98.91	1.34	0.82	99.16
JAG 84-524 grain-E5	54.25	bdl	2.16	1.71	1.90	16.17	21.22	1.70	99.11	1.03	0.98	99.40
JAG 84-524 grain-E6	54.17	bdl	2.25	1.87	2.01	16.27	21.21	1.73	99.51	1.60	0.58	99.76
JAG 84-524 grain-E7	54.31	bdl	2.28	1.91	1.92	16.06	21.42	1.76	99.66	1.29	0.76	99.99
JAG 84-524 grain-E8	54.16	bdl	2.25	1.68	2.04	16.35	21.32	1.83	99.63	0.00	2.04	99.75
JAG 84-524 grain-E9	54.17	bdl	2.16	1.68	2.07	16.25	21.48	1.80	99.61	0.00	2.07	99.65
JAG 84-524 grain-E AVG	54.18	bdl	2.22	1.74	2.00	16.22	21.34	1.75	99.44	1.75	0.42	99.63
JAG 84-524 grain-F1	54.20	bdl	2.25	1.48	2.05	16.39	21.22	1.73	99.32	1.85	0.38	99.63
JAG 84-524 grain-F2	54.28	bdl	2.30	1.70	1.89	16.16	21.33	1.81	99.47	1.68	0.38	99.66
JAG 84-524 grain-F3	54.44	bdl	2.28	1.76	1.94	16.36	21.38	1.83	99.99	2.05	0.10	100.33
JAG 84-524 grain-F4	54.14	bdl	2.30	2.01	1.99	16.01	21.25	1.87	99.57	1.88	0.30	99.91
JAG 84-524 grain-F5	54.11	bdl	2.21	1.78	1.75	16.18	21.25	1.82	99.10	1.67	0.25	99.42
JAG 84-524 grain-F AVG	54.23	bdl	2.27	1.75	1.92	16.22	21.29	1.81	99.49	1.83	0.28	99.70
JAG 84-524 grain-G1	54.60	bdl	2.34	1.93	1.97	15.97	21.40	1.81	100.02	1.07	1.01	100.28
JAG 84-524 grain-G2	54.54	bdl	2.29	1.82	1.98	16.02	21.33	1.92	99.90	1.67	0.48	100.13
JAG 84-524 grain-G3	54.46	bdl	2.34	1.84	1.97	16.01	21.22	1.78	99.62	0.92	1.14	99.79
JAG 84-524 grain-G4	54.65	bdl	2.28	1.86	1.92	16.08	21.41	1.84	100.04	1.33	0.72	100.33
JAG 84-524 grain-G AVG	54.56	bdl	2.31	1.86	1.96	16.02	21.34	1.84	99.90	1.25	0.84	100.04

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-H1	54.49	bdl	2.29	1.67	1.94	16.19	21.54	1.68	99.80	1.09	0.96	100.03
JAG 84-524 grain-H2	54.68	bdl	2.19	1.64	1.93	16.12	21.39	1.70	99.65	0.58	1.41	99.81
JAG 84-524 grain-H3	54.52	bdl	2.19	1.82	1.89	16.14	21.57	1.81	99.94	1.59	0.47	100.26
JAG 84-524 grain-H4	54.65	bdl	2.19	1.95	1.96	16.24	21.53	1.92	100.44	2.28	-0.09	100.74
JAG 84-524 grain-H5	54.56	bdl	2.19	1.87	1.76	16.30	21.45	1.65	99.78	0.79	1.05	99.95
JAG 84-524 grain-H6	54.67	bdl	2.24	1.55	2.01	16.24	21.65	1.73	100.09	1.50	0.66	100.28
JAG 84-524 grain-H AVG	54.60	bdl	2.22	1.75	1.92	16.21	21.52	1.75	99.95	1.30	0.74	100.11
JAG 84-524 ALL AVG	54.18	bdl	2.23	1.78	1.93	16.15	21.36	1.80	99.44	1.83	0.29	99.65
JAG 84-553 grain-A1	54.36	bdl	1.67	1.26	1.14	17.05	22.76	1.07	99.29	0.70	0.51	99.36
JAG 84-553 grain-A2	54.64	bdl	1.68	1.20	1.22	17.14	22.89	1.18	99.95	1.36	0.00	100.09
JAG 84-553 grain-A3	54.84	bdl	1.64	1.26	1.24	16.98	22.75	1.23	99.94	0.87	0.45	100.02
JAG 84-553 grain-A4	54.72	bdl	1.69	1.18	1.21	17.12	22.83	1.20	99.94	1.24	0.10	100.07
JAG 84-553 grain-A5	54.88	bdl	1.64	1.26	1.23	17.06	22.79	1.18	100.04	0.77	0.54	100.12
JAG 84-553 grain-A6	54.72	bdl	1.60	1.31	1.29	17.09	22.62	1.18	99.81	0.86	0.52	99.90
JAG 84-553 grain-A7	54.87	bdl	1.67	1.23	1.23	17.07	22.80	1.19	100.04	0.83	0.48	100.12
JAG 84-553 grain-A8	54.69	bdl	1.60	1.48	1.20	16.90	22.72	1.20	99.78	0.66	0.60	99.85
JAG 84-553 grain-A9	54.77	bdl	1.62	1.33	1.12	17.08	22.79	1.15	99.86	0.66	0.53	99.93
JAG 84-553 grain-A10	54.98	bdl	1.74	1.15	1.27	17.16	22.63	1.16	100.10	0.55	0.77	100.15
JAG 84-553 grain-A AVG	54.75	bdl	1.66	1.27	1.21	17.06	22.76	1.17	99.87	0.85	0.45	99.96
JAG-228 grain-A1	54.98	bdl	2.43	1.88	1.17	16.44	21.50	1.80	100.20	0.68	0.56	100.27

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG-228 grain-A2	55.11	bdl	2.45	1.77	1.28	16.49	21.48	1.78	100.37	0.61	0.72	100.43
JAG-228 grain-A3	55.00	bdl	2.47	1.86	1.27	16.54	21.41	1.80	100.34	0.86	0.49	100.42
JAG-228 grain-A4	54.88	bdl	2.49	1.83	1.34	16.53	21.46	1.83	100.35	1.27	0.19	100.47
JAG-228 grain-A5	55.22	bdl	2.43	1.77	1.26	16.51	21.46	1.76	100.42	0.37	0.93	100.46
JAG-228 grain-A6	55.01	bdl	2.45	1.91	1.35	16.59	21.43	1.77	100.51	0.91	0.53	100.60
JAG-228 grain-A7	55.25	bdl	2.43	1.79	1.26	16.60	21.58	1.78	100.69	0.78	0.56	100.77
JAG-228 grain-A8	54.92	bdl	2.40	1.87	1.34	16.57	21.53	1.76	100.38	1.05	0.40	100.49
JAG-228 grain-A9	55.13	bdl	2.36	1.87	1.21	16.56	21.47	1.76	100.36	0.50	0.76	100.41
JAG-228 grain-A10	54.85	bdl	2.34	1.82	1.25	16.63	21.50	1.72	100.11	0.89	0.45	100.20
JAG-228 grain-A11	55.10	bdl	2.34	1.80	1.30	16.72	21.59	1.78	100.63	1.25	0.18	100.76
JAG-228 grain-A12	55.21	bdl	2.34	1.63	1.36	16.69	21.50	1.70	100.43	0.57	0.85	100.49
JAG-228 grain-A13	55.02	bdl	2.26	1.75	1.29	16.66	21.53	1.68	100.19	0.64	0.72	100.25
JAG-228 grain-A14	55.07	bdl	2.29	1.74	1.31	16.67	21.61	1.76	100.46	1.15	0.28	100.57
JAG-228 grain-A15	55.02	bdl	2.30	1.77	1.33	16.73	21.60	1.76	100.50	1.34	0.12	100.64
JAG-228 grain-A16	55.34	bdl	2.31	1.86	1.27	16.66	21.49	1.67	100.58	0.04	1.23	100.58
JAG-228 grain-A17	55.27	bdl	2.33	1.77	1.29	16.67	21.48	1.75	100.56	0.61	0.75	100.62
JAG-228 grain-A18	55.17	bdl	2.37	1.74	1.36	16.70	21.49	1.70	100.54	0.66	0.77	100.61
JAG-228 grain-A19	55.43	bdl	2.41	1.74	1.37	16.62	21.49	1.81	100.87	0.74	0.71	100.94
JAG-228 grain-A20	55.18	bdl	2.45	1.79	1.35	16.67	21.55	1.79	100.77	1.10	0.35	100.89
JAG-228 grain-A AVG	55.11	bdl	2.38	1.80	1.30	16.61	21.51	1.76	100.46	0.80	0.58	100.54

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7269 grain-A1	54.57	bdl	1.62	1.12	1.15	17.38	23.13	1.12	100.07	0.00	1.15	100.07
K7269 grain-A2	54.39	bdl	1.63	1.08	1.24	17.48	23.20	1.16	100.18	0.00	1.24	100.18
K7269 grain-A3	54.37	bdl	1.62	1.23	1.14	17.61	23.11	1.10	100.19	0.00	1.14	100.19
K7269 grain-A4	54.86	bdl	1.63	1.02	1.19	17.48	23.24	1.09	100.49	0.00	1.19	100.49
K7269 grain-A5	54.57	bdl	1.65	0.98	1.24	17.62	23.42	1.06	100.53	0.00	1.24	100.53
K7269 grain-A6	54.57	bdl	1.59	1.03	1.16	17.62	23.26	1.10	100.32	0.00	1.16	100.32
K7269 grain-A7	54.58	bdl	1.57	1.07	1.17	17.64	23.25	1.04	100.32	0.00	1.17	100.32
K7269 grain-A8	54.43	bdl	1.60	1.12	1.19	17.58	23.11	1.12	100.15	0.00	1.19	100.15
K7269 grain-A9	54.78	bdl	1.63	1.08	1.13	17.65	23.29	1.07	100.63	0.00	1.13	100.63
K7269 grain-A10	54.67	bdl	1.64	1.04	1.23	17.62	23.21	1.07	100.47	0.00	1.23	100.47
K7269 grain-A AVG	54.58	bdl	1.62	1.08	1.18	17.57	23.22	1.09	100.33	0.00	1.18	100.33
K7269 grain-B1	54.13	bdl	1.59	1.01	1.22	17.77	23.20	1.06	99.98	0.00	1.22	99.98
K7269 grain-B2	54.50	bdl	1.61	0.98	1.23	17.63	23.27	1.03	100.25	0.00	1.23	100.25
K7269 grain-B3	54.77	bdl	1.59	1.04	1.30	17.54	23.13	1.07	100.44	0.00	1.30	100.44
K7269 grain-B4	54.78	bdl	1.63	1.07	1.18	17.60	23.31	1.11	100.69	0.00	1.18	100.69
K7269 grain-B5	54.72	bdl	1.59	1.19	1.22	17.44	23.34	1.03	100.53	0.00	1.22	100.53
K7269 grain-B6	54.55	bdl	1.56	1.09	1.22	17.67	23.30	1.06	100.44	0.00	1.22	100.44
K7269 grain-B7	54.65	bdl	1.60	1.01	1.31	17.73	23.07	1.06	100.42	0.00	1.31	100.42
K7269 grain-B8	54.88	bdl	1.60	1.00	1.30	17.61	23.31	1.09	100.77	0.00	1.30	100.77
K7269 grain-B9	54.59	bdl	1.62	1.08	1.21	17.57	23.20	1.05	100.33	0.00	1.21	100.33

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7269 grain-B10	54.43	bdl	1.56	1.32	1.22	17.46	23.15	1.15	100.28	0.00	1.22	100.28
K7269 grain-B AVG	54.60	bdl	1.59	1.08	1.24	17.60	23.23	1.07	100.41	0.00	1.24	100.41
K7269 grain-C1	55.46	bdl	1.61	1.12	1.24	17.28	23.21	1.11	101.02	0.69	0.62	101.09
K7269 grain-C2	55.06	bdl	1.59	1.08	1.32	17.41	23.30	1.11	100.87	0.00	1.32	100.87
K7269 grain-C3	55.08	bdl	1.59	1.02	1.18	17.49	23.05	1.05	100.45	0.97	0.30	100.55
K7269 grain-C4	54.80	bdl	1.62	1.03	1.13	17.61	23.06	1.08	100.33	0.00	1.13	100.33
K7269 grain-C5	54.75	bdl	1.61	1.01	1.25	17.64	23.20	1.03	100.50	0.00	1.25	100.50
K7269 grain-C6	54.61	bdl	1.62	1.11	1.21	17.70	23.22	1.10	100.56	0.00	1.21	100.56
K7269 grain-C7	54.69	bdl	1.61	0.95	1.29	17.59	23.17	1.10	100.40	0.00	1.29	100.40
K7269 grain-C8	54.49	bdl	1.56	1.02	1.28	17.77	23.08	1.05	100.26	0.00	1.28	100.26
K7269 grain-C9	54.77	bdl	1.57	0.86	1.31	17.66	23.34	1.11	100.63	0.00	1.31	100.63
K7269 grain-C10	54.17	bdl	1.58	1.06	1.25	17.87	23.05	1.02	100.00	0.00	1.25	100.00
K7269 grain-C AVG	54.79	bdl	1.60	1.03	1.25	17.60	23.17	1.08	100.50	0.00	1.25	100.50
K7269 grain-D1	55.02	bdl	1.51	1.24	1.22	17.47	23.33	1.08	100.88	0.00	1.22	100.88
K7269 grain-D2	54.66	bdl	1.62	0.91	1.29	17.65	23.41	1.08	100.61	0.00	1.29	100.61
K7269 grain-D3	55.08	bdl	1.61	1.07	1.25	17.55	23.18	1.10	100.85	0.00	1.25	100.85
K7269 grain-D4	55.08	bdl	1.63	1.19	1.27	17.37	23.24	1.09	100.87	0.00	1.27	100.87
K7269 grain-D5	54.32	bdl	1.53	0.92	1.30	18.10	22.85	0.99	100.01	0.00	1.30	100.01
K7269 grain-D6	54.50	bdl	1.60	1.01	1.14	17.64	23.20	1.10	100.19	0.00	1.14	100.19
K7269 grain-D7	54.53	bdl	1.58	1.08	1.33	17.79	23.21	1.08	100.59	0.00	1.33	100.59

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7269 grain-D8	54.38	bdl	1.60	0.99	1.28	17.71	23.24	1.09	100.29	0.00	1.28	100.29
K7269 grain-D9	54.49	bdl	1.60	0.95	1.26	17.79	23.10	1.08	100.27	0.00	1.26	100.27
K7269 grain-D10	54.71	bdl	1.60	0.93	1.25	17.85	23.34	1.12	100.80	0.00	1.25	100.80
K7269 grain-D AVG	54.68	bdl	1.59	1.03	1.26	17.69	23.21	1.08	100.54	0.00	1.26	100.54
K7269 ALL AVG	54.66	bdl	1.60	1.05	1.23	17.62	23.21	1.08	100.45	0.00	1.23	100.45
K7311 grain-A1	54.62	0.05	2.33	1.64	1.59	16.56	21.63	1.82	100.24	0.00	1.59	100.24
K7311 grain-A2	54.73	0.05	2.30	1.64	1.57	16.54	21.61	1.77	100.19	1.59	0.14	100.35
K7311 grain-A3	54.30	0.05	2.27	1.60	1.60	16.44	21.76	1.73	99.74	0.00	1.60	99.74
K7311 grain-A4	54.38	0.00	2.22	1.71	1.55	16.43	21.78	1.69	99.76	0.00	1.55	99.76
K7311 grain-A5	54.69	0.07	2.31	1.72	1.69	16.47	21.78	1.69	100.40	1.46	0.38	100.55
K7311 grain-A6	54.48	0.06	2.25	1.57	1.59	16.54	21.58	1.70	99.77	1.56	0.19	99.92
K7311 grain-A7	54.91	0.00	2.26	1.63	1.54	16.43	21.58	1.79	100.14	1.26	0.41	100.27
K7311 grain-A8	54.56	0.04	2.30	1.71	1.55	16.44	21.69	1.74	100.04	1.60	0.11	100.20
K7311 grain-A9	54.66	0.05	2.35	1.66	1.65	16.38	21.62	1.73	100.10	1.31	0.48	100.24
K7311 grain-A10	54.09	0.00	2.28	1.60	1.56	16.35	21.79	1.74	99.41	0.00	1.56	99.41
K7311 grain-A AVG	54.54	0.04	2.29	1.65	1.59	16.46	21.68	1.74	99.98	1.69	0.07	100.15
K7311 grain-B1	54.71	0.07	2.34	1.60	1.66	16.54	21.65	1.81	100.37	0.00	1.66	100.37
K7311 grain-B2	54.82	0.04	2.29	1.66	1.56	16.43	21.62	1.77	100.19	1.33	0.37	100.32
K7311 grain-B3	54.59	0.04	2.32	1.58	1.61	16.51	21.61	1.73	99.99	1.58	0.19	100.15
K7311 grain-B4	55.06	0.05	2.31	1.63	1.56	16.76	21.59	1.75	100.72	1.49	0.23	100.87

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-B5	54.74	0.01	2.31	1.62	1.59	16.44	21.69	1.75	100.14	1.50	0.24	100.30
K7311 grain-B6	52.75	0.07	2.39	1.69	2.12	18.44	20.06	1.58	99.10	0.00	2.12	99.10
K7311 grain-B7	54.84	0.05	2.32	1.68	1.57	16.44	21.68	1.75	100.33	1.27	0.42	100.46
K7311 grain-B8	54.58	0.00	2.31	1.53	1.56	16.57	21.65	1.75	99.96	0.00	1.56	99.96
K7311 grain-B AVG	54.43	0.10	2.17	1.61	1.83	16.87	21.50	1.63	100.14	2.03	0.01	100.34
K7311 grain-C1	54.63	0.05	2.33	1.61	1.56	16.70	21.71	1.80	100.39	0.00	1.56	100.39
K7311 grain-C2	54.92	bdl	2.21	1.66	1.53	16.39	21.77	1.71	100.18	1.00	0.63	100.28
K7311 grain-C3	54.71	0.04	2.26	1.60	1.62	16.48	21.60	1.74	100.04	1.42	0.34	100.18
K7311 grain-C4	54.78	bdl	2.24	1.66	1.60	16.48	21.67	1.69	100.12	1.18	0.53	100.24
K7311 grain-C5	54.53	bdl	2.22	1.59	1.58	16.68	21.69	1.74	100.03	0.00	1.58	100.03
K7311 grain-C6	54.48	bdl	2.24	1.65	1.61	16.66	21.62	1.75	100.01	0.00	1.61	100.01
K7311 grain-C7	54.83	bdl	2.22	1.59	1.57	16.59	21.59	1.71	100.10	1.30	0.40	100.23
K7311 grain-C8	54.76	bdl	2.23	1.58	1.60	16.44	21.73	1.76	100.09	1.58	0.18	100.25
K7311 grain-C9	55.05	bdl	2.28	1.61	1.56	16.40	21.51	1.76	100.17	0.76	0.87	100.25
K7311 grain-C10	54.77	bdl	2.32	1.55	1.60	16.30	21.63	1.77	99.93	1.21	0.51	100.05
K7311 grain-C AVG	54.75	bdl	2.26	1.61	1.58	16.51	21.65	1.74	100.11	1.52	0.22	100.26
K7311 grain-D1	53.83	0.06	1.52	1.91	1.85	16.96	22.65	1.20	99.99	0.00	1.85	99.99
K7311 grain-D2	53.86	0.05	1.34	1.81	1.71	17.20	23.09	0.91	99.97	0.00	1.71	99.97
K7311 grain-D3	54.47	bdl	2.26	1.54	1.51	16.30	21.78	1.71	99.56	1.40	0.25	99.70
K7311 grain-D4	54.68	0.04	2.24	1.64	1.57	16.50	21.83	1.80	100.30	0.00	1.57	100.30

bdl, concentration below detection limit

CLINOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-D5	54.58	bdl	2.25	1.70	1.57	16.50	21.86	1.73	100.20	0.00	1.57	100.20
K7311 grain-D6	54.58	bdl	2.26	1.59	1.54	16.50	21.84	1.80	100.11	0.00	1.54	100.11
K7311 grain-D7	54.83	0.05	2.28	1.69	1.61	16.56	21.75	1.71	100.48	1.44	0.32	100.62
K7311 grain-D8	54.27	0.06	1.29	1.80	1.68	17.22	23.19	0.93	100.44	1.59	0.25	100.60
K7311 grain-D9	54.75	0.04	2.29	1.68	1.59	16.46	21.95	1.72	100.47	1.69	0.07	100.65
K7311 grain-D10	54.81	bdl	2.32	1.63	1.65	16.58	21.81	1.77	100.56	0.00	1.65	100.56
K7311 grain-D AVG	54.46	bdl	2.01	1.70	1.63	16.68	22.17	1.53	100.21	0.00	1.63	100.21
K7311 ALL AVG	54.55	0.04	2.18	1.64	1.66	16.63	21.75	1.66	100.11	1.78	0.06	100.29

bdl, concentration below detection limit

APPENDIX E

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
GN9912 grain-B1	55.90	bdl	1.94	0.17	6.83	33.97	0.30	0.05	99.16	1.63	5.37	99.32
GN9912 grain-B2	56.12	bdl	2.01	0.20	7.28	34.02	0.37	0.05	100.03	1.97	5.50	100.23
GN9912 grain-B3	55.83	bdl	2.04	0.22	7.04	33.87	0.37	0.08	99.45	1.89	5.34	99.64
GN9912 grain-B4	55.93	bdl	2.10	0.22	6.92	33.87	0.38	0.08	99.49	1.61	5.48	99.65
GN9912 grain-B5	55.96	bdl	2.11	0.26	6.88	33.93	0.33	bdl	99.47	1.10	5.89	99.58
GN9912 grain-B6	55.88	bdl	1.99	0.19	6.88	34.02	0.33	0.05	99.34	1.76	5.29	99.52
GN9912 grain-B7	55.83	bdl	2.01	0.21	6.99	33.92	0.35	0.09	99.40	1.90	5.28	99.59
GN9912 grain-B8	55.87	bdl	2.00	0.18	7.02	33.97	0.39	bdl	99.43	1.71	5.48	99.60
GN9912 grain-B9	55.87	bdl	1.94	0.16	7.01	34.04	0.38	0.08	99.48	2.13	5.09	99.69
GN9912 grain-B10	56.06	bdl	1.91	0.20	6.92	33.99	0.36	0.08	99.51	1.66	5.42	99.68
GN9912 grain-B AVG	55.92	bdl	2.00	0.20	6.98	33.96	0.36	0.07	99.49	1.74	5.42	99.66
GN9912 grain-C1	55.78	bdl	1.89	0.22	6.96	34.27	0.33	0.05	99.50	2.47	4.74	99.74
GN9912 grain-C2	55.44	bdl	2.26	0.21	7.31	34.21	0.31	0.07	99.80	3.27	4.37	100.13
GN9912 grain-C3	55.23	bdl	2.23	0.22	6.98	33.80	0.30	0.07	98.83	2.34	4.87	99.06
GN9912 grain-C4	56.14	bdl	2.20	0.28	6.94	34.19	0.31	0.05	100.11	1.69	5.42	100.28
GN9912 grain-C5	55.64	bdl	2.46	0.28	7.06	33.81	0.34	0.04	99.62	1.79	5.45	99.80
GN9912 grain-C6	54.40	bdl	2.11	0.29	6.94	33.47	0.33	0.07	97.60	2.77	4.45	97.88
GN9912 grain-C7	55.33	bdl	2.45	0.30	7.16	33.98	0.30	0.05	99.58	2.71	4.73	99.85
GN9912 grain-C8	55.37	bdl	2.27	0.37	6.91	34.07	0.31	0.04	99.35	2.52	4.64	99.60
GN9912 grain-C9	55.77	bdl	2.31	0.32	7.15	34.18	0.34	0.05	100.11	2.55	4.85	100.36

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
GN9912 grain-C AVG	55.45	bdl	2.24	0.28	7.04	34.00	0.32	0.05	99.39	2.46	4.84	99.63
GN9912 grain-G1	56.02	bdl	2.19	0.28	6.77	34.40	0.33	0.07	100.06	2.20	4.79	100.28
GN9912 grain-G2	55.96	bdl	2.27	0.27	6.65	34.26	0.29	0.07	99.77	1.93	4.91	99.97
GN9912 grain-G3	55.93	bdl	2.24	0.21	7.12	34.28	0.30	0.07	100.14	2.43	4.93	100.39
GN9912 grain-G4	55.67	bdl	2.45	0.20	6.91	34.28	0.32	0.09	99.93	2.82	4.38	100.21
GN9912 grain-G5	55.77	bdl	2.28	0.19	6.79	34.30	0.32	0.06	99.72	2.37	4.65	99.95
GN9912 grain-G6	55.77	bdl	2.13	0.21	6.85	34.32	0.29	0.07	99.63	2.43	4.66	99.88
GN9912 grain-G7	56.03	bdl	2.19	0.18	6.79	34.22	0.31	0.10	99.80	2.06	4.93	100.01
GN9912 grain-G8	55.81	bdl	2.27	0.23	6.99	34.25	0.35	0.06	99.95	2.42	4.81	100.20
GN9912 grain-G9	55.50	bdl	2.71	0.26	6.82	33.93	0.69	0.19	100.10	3.22	3.92	100.43
GN9912 grain-G10	55.77	bdl	2.25	0.20	6.82	34.32	0.27	0.05	99.70	2.36	4.70	99.93
GN9912 grain-G AVG	55.82	bdl	2.30	0.22	6.85	34.26	0.35	0.08	99.88	2.43	4.67	100.12
GN9912 ALL AVG Core	55.33	bdl	2.45	0.30	7.16	33.98	0.30	0.05	99.58	2.71	4.73	99.85
GN9912 ALL AVG Rim	55.78	bdl	1.89	0.22	6.96	34.27	0.33	0.05	99.50	2.47	4.74	99.74
GN9913 grain-B1	56.26	bdl	1.99	0.23	6.04	34.71	0.39	0.05	99.66	1.63	4.57	99.83
GN9913 grain-B2	55.62	bdl	2.26	0.29	6.14	34.78	0.38	0.05	99.52	2.75	3.67	99.80
GN9913 grain-B3	55.27	bdl	2.33	0.35	5.99	34.63	0.40	0.08	99.05	3.01	3.27	99.35
GN9913 grain-B4	55.47	bdl	2.39	0.39	5.90	34.59	0.42	bdl	99.15	2.14	3.97	99.37
GN9913 grain-B AVG	55.65	bdl	2.24	0.31	6.02	34.68	0.40	0.06	99.36	2.38	3.87	99.60
GN9913 grain-H1	55.50	bdl	2.09	0.35	5.94	34.85	0.39	0.04	99.17	2.86	3.37	99.45

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
GN9913 grain-H2	55.91	bdl	2.00	0.29	5.79	34.67	0.38	0.08	99.11	1.94	4.04	99.30
GN9913 grain-H3	55.67	bdl	2.10	0.35	6.04	34.74	0.36	0.07	99.33	2.53	3.77	99.58
GN9913 grain-H4	55.37	bdl	2.08	0.29	5.95	34.58	0.37	0.06	98.70	2.54	3.66	98.96
GN9913 grain-H5	55.81	bdl	1.96	0.19	5.94	34.75	0.39	0.09	99.13	2.45	3.73	99.37
GN9913 grain-H6	55.02	bdl	2.06	0.30	5.75	34.53	0.40	0.04	98.10	2.64	3.37	98.36
GN9913 grain-H7	55.53	bdl	1.93	0.29	5.72	34.56	0.40	0.07	98.49	2.12	3.81	98.70
GN9913 grain-H8	55.50	bdl	1.94	0.27	5.99	34.74	0.39	0.06	98.90	2.79	3.48	99.18
GN9913 grain-H9	55.97	bdl	1.99	0.34	5.96	34.90	0.41	0.08	99.66	2.56	3.65	99.92
GN9913 grain-H10	55.41	bdl	2.05	0.42	5.83	34.92	0.43	0.05	99.11	3.06	3.07	99.41
GN9913 grain-H AVG	55.57	bdl	2.02	0.31	5.89	34.72	0.39	0.07	98.97	2.55	3.60	99.22
GN9913 grain-C1	55.61	bdl	2.16	0.42	5.98	34.54	0.43	0.07	99.21	2.27	3.94	99.43
GN9913 grain-C2	55.69	bdl	1.93	0.32	5.96	34.82	0.39	0.07	99.18	2.78	3.46	99.46
GN9913 grain-C3	54.95	bdl	2.42	0.41	5.73	34.66	0.41	0.08	98.66	3.20	2.85	98.98
GN9913 grain-C4	55.39	bdl	2.37	0.39	5.79	34.39	0.39	0.05	98.76	1.96	4.02	98.95
GN9913 grain-C5	55.36	bdl	2.37	0.37	6.01	34.46	0.37	bdl	98.93	2.06	4.15	99.14
GN9913 grain-C6	55.69	bdl	2.37	0.37	6.07	34.44	0.37	0.06	99.36	1.90	4.36	99.55
GN9913 grain-C7	55.19	bdl	2.32	0.33	5.88	34.59	0.42	0.05	98.78	2.82	3.35	99.06
GN9913 grain-C8	55.20	bdl	2.28	0.36	6.00	34.54	0.43	0.08	98.89	2.90	3.39	99.18
GN9913 grain-C9	55.31	bdl	2.44	0.38	5.96	34.61	0.36	0.08	99.14	2.81	3.43	99.42
GN9913 grain-C10	55.75	bdl	1.59	0.20	5.86	34.83	0.39	0.09	98.71	2.59	3.53	98.97

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
GN9913 grain-C AVG	55.41	bdl	2.22	0.36	5.92	34.59	0.39	0.07	98.97	2.53	3.65	99.22
GN9913 grain-A1	55.73	bdl	2.25	0.31	5.81	34.84	0.35	0.09	99.38	2.53	3.54	99.63
GN9913 grain-A2	55.35	bdl	2.50	0.31	5.70	34.52	0.38	0.08	98.84	2.27	3.66	99.07
GN9913 grain-A3	55.12	bdl	2.65	0.37	5.90	34.50	0.37	0.07	98.98	2.68	3.48	99.25
GN9913 grain-A4	54.85	bdl	2.85	0.41	5.74	34.33	0.37	0.10	98.65	2.77	3.25	98.92
GN9913 grain-A5	55.19	bdl	2.91	0.40	5.96	34.38	0.40	0.07	99.31	2.46	3.75	99.55
GN9913 grain-A6	55.02	bdl	3.01	0.42	5.86	34.41	0.39	0.06	99.16	2.58	3.53	99.42
GN9913 grain-A7	54.89	bdl	2.98	0.45	5.90	34.35	0.39	0.12	99.07	2.98	3.22	99.37
GN9913 grain-A8	55.05	bdl	2.90	0.41	5.99	34.18	0.39	0.07	98.98	2.26	3.95	99.21
GN9913 grain-A9	55.09	bdl	2.71	0.41	6.03	34.39	0.43	0.06	99.13	2.68	3.62	99.40
GN9913 grain-A10	55.55	bdl	2.14	0.27	5.84	34.94	0.41	0.07	99.22	3.03	3.11	99.52
GN9913 grain-A AVG	55.18	bdl	2.69	0.38	5.87	34.49	0.39	0.08	99.07	2.62	3.51	99.33
GN9913 ALL AVG Core	55.02	bdl	3.01	0.42	5.86	34.41	0.39	0.06	99.16	2.58	3.53	99.42
GN9913 ALL AVG Rim	55.55	bdl	2.14	0.27	5.84	34.94	0.41	0.07	99.22	3.03	3.11	99.52
BM9912 grain-A1	55.23	bdl	3.67	0.42	5.31	34.38	0.64	0.08	99.73	2.11	3.41	99.94
BM9912 grain-A2	55.53	bdl	3.65	0.41	5.34	34.43	0.67	0.14	100.16	2.43	3.15	100.40
BM9912 grain-A3	55.64	0.08	3.65	0.42	5.51	34.36	0.65	0.09	100.40	1.68	4.01	100.57
BM9912 grain-A4	55.73	0.06	3.57	0.47	5.56	34.27	0.65	0.11	100.41	1.59	4.13	100.57
BM9912 grain-A5	55.48	bdl	3.57	0.45	5.59	34.51	0.67	0.10	100.37	2.32	3.50	100.60
BM9912 grain-A6	55.54	bdl	3.58	0.38	5.68	34.53	0.63	0.10	100.43	2.48	3.45	100.68

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
BM9912 grain-A7	55.22	0.06	3.70	0.35	5.72	34.52	0.58	0.14	100.29	2.87	3.14	100.57
BM9912 grain-A8	55.45	bdl	3.68	0.40	5.49	34.44	0.60	0.09	100.14	2.15	3.55	100.36
BM9912 grain-A AVG	55.48	0.07	3.63	0.41	5.52	34.43	0.64	0.11	100.28	2.20	3.54	100.50
BM9912 grain-B1	55.46	0.06	3.71	0.40	5.43	34.28	0.61	0.08	100.02	1.63	3.96	100.18
BM9912 grain-B2	55.66	0.08	3.46	0.29	5.53	34.60	0.61	0.11	100.32	2.23	3.52	100.55
BM9912 grain-B3	55.59	0.06	3.43	0.35	5.67	34.66	0.63	0.11	100.51	2.66	3.28	100.77
BM9912 grain-B4	55.40	0.08	3.52	0.35	5.69	34.44	0.64	0.07	100.18	2.24	3.68	100.40
BM9912 grain-B5	55.67	0.07	3.63	0.35	5.57	34.40	0.57	0.10	100.35	1.72	4.02	100.52
BM9912 grain-B6	55.49	0.08	3.59	0.33	5.55	34.28	0.60	0.06	99.98	1.65	4.06	100.14
BM9912 grain-B7	55.86	0.07	3.57	0.35	5.57	34.62	0.57	0.09	100.69	1.86	3.89	100.88
BM9912 grain-B8	55.41	bdl	3.68	0.36	5.60	34.42	0.62	0.10	100.18	2.46	3.38	100.43
BM9912 grain-A AVG	55.57	0.07	3.57	0.35	5.57	34.46	0.61	0.09	100.29	2.06	3.72	100.49
BM9912 grain-C1	55.41	bdl	3.52	0.45	5.53	34.23	0.63	0.07	99.84	1.71	3.99	100.01
BM9912 grain-C2	55.67	0.08	3.47	0.40	5.59	34.39	0.64	0.10	100.33	1.85	3.92	100.52
BM9912 grain-C3	55.45	0.06	3.48	0.27	5.66	34.39	0.67	0.11	100.09	2.37	3.53	100.32
BM9912 grain-C4	55.46	bdl	3.50	0.40	5.42	34.46	0.62	0.11	99.98	2.20	3.44	100.20
BM9912 grain-C5	55.26	0.07	3.53	0.32	5.44	34.35	0.67	0.10	99.74	2.20	3.45	99.96
BM9912 grain-C6	55.38	bdl	3.67	0.34	5.57	34.51	0.63	0.08	100.17	2.62	3.21	100.44
BM9912 grain-C7	55.28	bdl	3.66	0.35	5.67	34.37	0.61	0.08	100.04	2.39	3.52	100.27
BM9912 grain-C8	55.57	0.06	3.37	0.28	5.71	34.48	0.59	0.11	100.17	2.30	3.64	100.40

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
BM9912 grain-C AVG	55.44	0.07	3.52	0.35	5.57	34.40	0.63	0.09	100.08	2.21	3.59	100.30
BM9912 grain-D1	55.02	bdl	3.60	0.47	5.48	34.21	0.63	0.11	99.52	2.33	3.38	99.75
BM9912 grain-D2	55.18	bdl	3.46	0.34	5.46	34.34	0.66	0.11	99.55	2.34	3.36	99.78
BM9912 grain-D3	55.42	0.06	3.45	0.38	5.51	34.55	0.61	0.11	100.09	2.46	3.29	100.34
BM9912 grain-D4	55.64	bdl	3.57	0.34	5.56	34.43	0.65	0.12	100.29	2.28	3.50	100.52
BM9912 grain-D5	55.42	bdl	3.38	0.46	5.30	34.55	0.62	0.07	99.80	2.06	3.44	100.00
BM9912 grain-D AVG	55.34	0.06	3.49	0.40	5.46	34.41	0.63	0.10	99.90	2.29	3.40	100.13
BM9912 grain-E1	55.20	0.06	3.59	0.36	5.58	34.45	0.62	0.07	99.93	2.39	3.43	100.17
BM9912 grain-E2	55.52	0.06	3.59	0.31	5.59	34.33	0.59	0.09	100.08	1.88	3.89	100.27
BM9912 grain-E3	55.48	0.06	3.56	0.37	5.51	34.48	0.56	0.11	100.13	2.15	3.58	100.34
BM9912 grain-E4	55.23	bdl	3.58	0.38	5.71	34.42	0.61	0.13	100.06	2.81	3.18	100.34
BM9912 grain-E5	55.18	bdl	3.52	0.30	5.42	34.56	0.57	0.11	99.67	2.78	2.92	99.95
BM9912 grain-E6	55.01	0.06	3.51	0.34	5.38	34.99	0.59	0.12	100.00	3.76	1.99	100.37
BM9912 grain-E AVG	55.27	0.06	3.56	0.34	5.53	34.54	0.59	0.11	100.00	2.63	3.17	100.26
BM9912 grain-F1	55.38	bdl	3.71	0.46	5.59	34.26	0.68	bdl	100.09	1.64	4.11	100.25
BM9912 grain-F2	55.28	0.08	3.75	0.42	5.51	34.48	0.61	0.11	100.25	2.47	3.29	100.49
BM9912 grain-F3	55.21	bdl	3.81	0.41	5.56	34.30	0.66	0.08	100.03	2.28	3.51	100.26
BM9912 grain-F4	55.36	0.09	3.75	0.30	5.55	34.34	0.60	0.06	100.04	1.93	3.81	100.24
BM9912 grain-F5	55.31	0.08	3.68	0.44	5.58	34.37	0.63	0.11	100.19	2.28	3.52	100.42
BM9912 grain-F AVG	55.31	0.08	3.74	0.40	5.55	34.35	0.64	0.09	100.17	2.12	3.65	100.38

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
BM9912 ALL AVG Core	55.38	bdl	3.67	0.34	5.57	34.51	0.63	0.08	100.17	2.62	3.21	100.44
BM9912 ALL AVG Rim	55.57	0.06	3.37	0.28	5.71	34.48	0.59	0.11	100.17	2.30	3.64	100.40
BM9915 grain-B1	56.95	0.06	2.07	0.44	5.75	34.44	0.59	0.11	100.42	0.50	5.30	100.47
BM9915 grain-B2	56.88	0.09	2.10	0.36	5.78	34.18	0.57	0.11	100.06	0.15	5.65	100.08
BM9915 grain-B3	56.80	0.06	2.20	0.40	5.88	34.49	0.52	0.11	100.45	0.92	5.05	100.55
BM9915 grain-B4	56.65	bdl	2.25	0.40	5.85	34.36	0.49	0.09	100.08	0.65	5.27	100.15
BM9915 grain-B5	56.56	0.06	2.26	0.46	5.73	34.10	0.48	0.12	99.77	0.22	5.54	99.79
BM9915 grain-B6	56.85	0.07	2.23	0.45	5.81	34.45	0.51	0.11	100.50	0.69	5.19	100.57
BM9915 grain-B7	56.71	bdl	2.26	0.44	5.82	34.32	0.51	0.13	100.18	0.67	5.22	100.25
BM9915 grain-B8	56.87	0.05	2.25	0.45	5.86	34.35	0.51	0.14	100.48	0.61	5.31	100.54
BM9915 grain-B9	56.85	0.06	2.17	0.45	5.66	34.34	0.49	0.11	100.13	0.22	5.47	100.15
BM9915 grain-B10	56.65	0.06	2.16	0.39	5.88	34.27	0.54	0.13	100.10	0.80	5.16	100.18
BM9915 grain-B AVG	56.78	0.06	2.19	0.42	5.80	34.33	0.52	0.12	100.23	0.54	5.32	100.28
BM9915 grain-D1	57.30	0.07	2.14	0.37	5.34	34.75	0.60	0.10	100.66	0.15	5.20	100.67
BM9915 grain-D2	57.22	0.06	2.05	0.41	5.38	34.79	0.62	0.10	100.63	0.49	4.93	100.68
BM9915 grain-D3	57.17	0.05	2.20	0.36	5.25	34.70	0.61	0.11	100.45	0.16	5.10	100.46
BM9915 grain-D4	57.39	0.05	2.19	0.40	5.42	34.85	0.60	0.10	101.00	0.37	5.08	101.03
BM9915 grain-D5	57.14	0.07	2.16	0.41	5.20	34.65	0.63	0.12	100.36	0.12	5.09	100.37
BM9915 grain-D6	57.12	0.05	2.14	0.44	5.37	34.80	0.61	0.12	100.65	0.68	4.76	100.72
BM9915 grain-D7	57.24	0.07	2.11	0.37	5.36	34.65	0.62	0.11	100.52	0.15	5.22	100.54

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
BM9915 grain-D8	57.22	0.07	2.14	0.43	5.41	34.85	0.61	0.11	100.84	0.64	4.83	100.90
BM9915 grain-D AVG	57.22	0.06	2.14	0.40	5.34	34.75	0.61	0.11	100.64	0.35	5.03	100.67
BM9915 grain-A1	57.29	bdl	2.16	0.42	5.52	34.83	0.56	0.09	100.86	0.58	5.00	100.92
BM9915 grain-A2	57.13	0.05	2.19	0.42	5.37	34.59	0.61	0.10	100.45	0.16	5.23	100.47
BM9915 grain-A3	57.14	0.06	2.18	0.40	5.33	34.65	0.65	0.10	100.50	0.25	5.10	100.53
BM9915 grain-A4	57.03	0.08	2.14	0.42	5.29	34.65	0.63	0.09	100.33	0.29	5.03	100.36
BM9915 grain-A5	57.10	0.06	2.14	0.31	5.37	34.65	0.60	0.12	100.36	0.43	4.98	100.40
BM9915 grain-A6	57.19	0.07	2.16	0.41	5.34	34.72	0.60	0.10	100.59	0.23	5.13	100.61
BM9915 grain-A7	57.12	0.05	2.12	0.46	5.35	34.67	0.61	0.12	100.49	0.41	4.98	100.53
BM9915 grain-A8	57.23	0.06	2.19	0.45	5.34	34.74	0.54	0.09	100.64	0.11	5.24	100.65
BM9915 grain-A9	57.24	0.06	2.10	0.44	5.37	34.77	0.58	0.11	100.66	0.38	5.03	100.70
BM9915 grain-A AVG	57.16	0.06	2.15	0.41	5.36	34.70	0.60	0.10	100.55	0.32	5.08	100.58
BM9915 grain-C1	57.28	0.05	2.13	0.46	5.42	34.61	0.62	0.11	100.68	0.20	5.23	100.70
BM9915 grain-C2	57.29	0.05	2.20	0.46	5.44	34.76	0.50	0.13	100.82	0.35	5.13	100.86
BM9915 grain-C3	57.12	0.05	2.29	0.43	5.30	34.69	0.50	0.11	100.49	0.20	5.12	100.51
BM9915 grain-C4	57.15	0.06	2.22	0.45	5.35	34.65	0.47	0.12	100.47	0.13	5.23	100.48
BM9915 grain-C5	57.09	0.07	2.25	0.44	5.45	34.79	0.55	0.09	100.74	0.58	4.93	100.80
BM9915 grain-C6	57.31	0.07	2.23	0.51	5.43	34.66	0.55	0.11	100.87	0.04	5.40	100.87
BM9915 grain-C7	57.25	0.06	2.20	0.46	5.38	34.60	0.59	0.12	100.67	0.03	5.36	100.67
BM9915 grain-C AVG	57.21	0.06	2.22	0.46	5.40	34.68	0.54	0.11	100.68	0.22	5.20	100.70

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
BM9915 ALL AVG	57.09	0.06	2.18	0.42	5.48	34.62	0.57	0.11	100.52	0.36	5.16	100.56
X174 grain-A1	52.03	0.33	4.92	bdl	12.34	28.81	0.87	0.07	99.37	3.11	9.55	99.85
X174 grain-A2	52.30	0.33	5.57	bdl	12.76	27.96	0.83	0.08	99.82	1.50	11.41	100.10
X174 grain-A3	52.44	0.33	5.37	bdl	12.43	27.91	0.90	0.05	99.44	0.80	11.71	99.66
X174 grain-A4	52.08	0.34	5.47	bdl	12.46	27.86	0.86	0.04	99.11	1.06	11.50	99.36
X174 grain-A5	52.04	0.34	5.77	bdl	12.56	27.93	0.86	0.07	99.57	1.51	11.21	99.85
X174 grain-A6	51.87	0.35	6.06	bdl	12.66	27.78	0.77	0.07	99.55	1.41	11.39	99.82
X174 grain-A7	52.39	0.30	5.53	bdl	12.60	28.02	0.75	0.07	99.66	1.19	11.53	99.95
X174 grain-A8	52.00	0.32	5.70	bdl	12.92	27.78	0.83	0.04	99.58	1.54	11.53	99.91
X174 grain-A9	52.28	0.29	5.31	bdl	12.73	27.75	0.87	0.07	99.30	1.11	11.73	99.55
X174 grain-A10	52.67	0.30	4.65	bdl	12.79	27.97	0.92	0.05	99.35	1.04	11.85	99.59
X174 grain-A AVG	52.21	0.32	5.43	bdl	12.63	27.98	0.84	0.06	99.48	1.43	11.34	99.76
X174 grain-B1	52.85	0.30	4.57	bdl	13.04	28.40	0.89	0.08	100.14	2.06	11.19	100.49
X174 grain-B2	52.46	0.30	5.38	bdl	12.75	28.03	0.83	0.08	99.83	1.42	11.47	100.09
X174 grain-B3	52.29	0.31	5.29	bdl	12.87	28.00	0.91	0.05	99.71	1.63	11.40	99.98
X174 grain-B4	52.35	0.31	5.33	bdl	12.97	28.03	0.86	0.07	99.91	1.80	11.35	100.25
X174 grain-B5	52.30	0.32	5.55	bdl	12.41	27.63	0.89	0.06	99.17	0.47	11.99	99.39
X174 grain-B6	52.43	0.33	5.48	bdl	12.73	27.83	0.87	bdl	99.69	0.78	12.03	99.90
X174 grain-B7	52.27	0.31	5.33	bdl	12.72	27.80	0.90	0.07	99.40	1.25	11.60	99.67
X174 grain-B8	52.25	0.32	5.43	bdl	12.81	28.08	0.88	0.07	99.83	1.86	11.14	100.12

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X174 grain-B9	52.04	0.34	5.38	bdl	12.84	27.78	0.88	0.08	99.33	1.66	11.35	99.64
X174 grain-B10	52.34	0.31	4.69	bdl	12.62	28.03	0.92	0.07	98.98	1.51	11.26	99.26
X174 grain-B AVG	52.36	0.32	5.24	bdl	12.78	27.96	0.88	0.06	99.60	1.44	11.48	99.88
X174 grain-C1	52.34	0.33	4.81	bdl	12.68	28.02	0.93	0.08	99.17	1.56	11.27	99.46
X174 grain-C2	52.05	0.36	5.21	bdl	12.79	27.73	0.87	0.10	99.11	1.60	11.36	99.44
X174 grain-C3	52.37	0.31	5.26	bdl	12.84	27.78	0.87	0.08	99.52	1.21	11.76	99.77
X174 grain-C4	52.13	0.32	5.47	bdl	12.93	27.64	0.85	0.05	99.38	1.15	11.90	99.64
X174 grain-C5	51.94	0.31	5.40	bdl	12.64	27.69	0.91	0.06	98.94	1.33	11.44	99.23
X174 grain-C6	52.10	0.30	5.38	bdl	12.74	27.71	0.85	0.07	99.16	1.24	11.63	99.41
X174 grain-C7	52.63	0.34	4.81	bdl	12.75	28.11	0.88	0.07	99.59	1.34	11.54	99.85
X174 grain-C8	52.34	0.33	5.31	bdl	12.93	27.71	0.87	0.05	99.53	0.99	12.04	99.74
X174 grain-C9	52.16	0.33	5.34	bdl	13.05	27.90	0.87	0.06	99.71	1.81	11.42	99.99
X174 grain-C10	52.42	0.40	4.96	bdl	12.79	27.49	1.15	0.08	99.30	0.80	12.08	99.51
X174 grain-C AVG	52.25	0.33	5.19	bdl	12.81	27.78	0.90	0.07	99.34	1.30	11.64	99.60
X174 grain-D1	52.94	0.32	4.56	bdl	12.88	28.25	0.89	0.06	99.89	1.29	11.72	100.13
X174 grain-D2	52.00	0.34	5.69	bdl	12.81	27.85	0.85	0.06	99.58	1.62	11.36	99.89
X174 grain-D3	52.57	0.37	5.40	bdl	12.92	27.89	0.90	0.05	100.10	1.11	11.92	100.38
X174 grain-D4	52.41	0.34	5.44	bdl	12.84	27.80	0.86	0.04	99.74	0.99	11.96	100.00
X174 grain-D5	52.38	0.39	5.53	bdl	12.96	27.80	0.85	0.06	99.96	1.18	11.90	100.22
X174 grain-D6	52.17	0.36	5.54	bdl	12.88	27.78	0.90	0.05	99.69	1.37	11.65	99.98

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X174 grain-D7	52.09	0.37	5.80	bdl	12.67	27.53	1.22	0.08	99.76	1.33	11.47	100.06
X174 grain-D8	52.18	0.40	5.58	bdl	12.84	27.62	1.14	0.15	99.91	1.79	11.23	100.23
X174 grain-D9	52.56	0.29	5.49	bdl	13.08	27.87	0.88	0.07	100.24	1.40	11.82	100.52
X174 grain-D10	52.62	0.31	5.07	bdl	12.64	27.98	0.88	0.07	99.56	1.06	11.69	99.85
X174 grain-D AVG	52.39	0.35	5.41	bdl	12.85	27.84	0.94	0.07	99.84	1.31	11.67	100.13
X174 ALL AVG	52.30	0.33	5.32	bdl	12.77	27.89	0.89	0.07	99.56	1.37	11.53	99.84
X192 grain-A1	53.78	0.28	2.97	bdl	11.69	29.16	0.67	0.06	98.60	0.50	11.24	98.86
X192 grain-A2	52.54	0.35	5.09	bdl	11.70	28.34	0.83	0.11	98.96	0.96	10.84	99.28
X192 grain-A3	52.84	0.36	5.16	bdl	11.64	28.76	0.81	0.09	99.67	1.18	10.59	99.97
X192 grain-A4	53.00	0.31	4.86	bdl	11.12	28.96	0.75	0.08	99.18	0.70	10.49	99.46
X192 grain-A5	54.54	0.21	3.68	bdl	10.74	30.00	0.59	0.11	99.86	0.25	10.51	100.06
X192 grain-A6	53.17	0.29	5.38	bdl	10.86	29.37	0.66	0.12	99.93	1.05	9.91	100.21
X192 grain-A7	53.06	0.39	5.67	bdl	10.45	28.96	1.29	0.14	99.95	0.83	9.70	100.24
X192 grain-A8	53.16	0.34	5.74	bdl	10.55	29.41	0.68	0.09	100.06	0.64	9.97	100.32
X192 grain-A9	52.92	0.39	5.81	bdl	10.59	28.84	1.12	0.11	99.76	0.58	10.07	100.03
X192 grain-A10	53.64	0.31	5.01	bdl	10.66	29.66	0.72	0.06	100.05	0.58	10.13	100.33
X192 grain-A AVG	53.26	0.32	4.94	bdl	11.00	29.15	0.81	0.10	99.60	0.73	10.35	99.88
X192 grain-B1	53.13	0.32	4.08	bdl	11.73	28.85	0.73	0.08	98.94	0.93	10.90	99.22
X192 grain-B2	52.35	0.40	5.23	bdl	10.93	27.85	2.17	0.18	99.22	1.61	9.48	99.60
X192 grain-B3	52.63	0.37	4.97	bdl	10.72	28.45	1.37	0.11	98.62	0.71	10.09	98.90

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X192 grain-B4	51.71	0.51	5.71	bdl	10.78	26.46	3.93	0.28	99.38	2.40	8.62	99.80
X192 grain-B5	53.39	0.24	4.38	bdl	11.60	28.73	0.63	0.24	99.21	1.00	10.71	99.52
X192 grain-B6	52.38	0.36	5.79	bdl	11.31	28.47	0.81	0.10	99.22	0.84	10.56	99.45
X192 grain-B7	52.59	0.39	5.73	bdl	11.05	28.32	1.16	0.13	99.35	0.60	10.51	99.58
X192 grain-B8	52.98	0.37	5.39	bdl	11.05	28.77	0.98	0.10	99.73	0.68	10.43	100.06
X192 grain-B9	52.88	0.35	5.14	bdl	10.94	28.84	0.86	0.06	99.07	0.42	10.56	99.29
X192 grain-B10	54.01	0.28	3.36	bdl	11.25	29.53	0.63	0.06	99.11	0.39	10.90	99.37
X192 grain-B AVG	52.81	0.36	4.98	bdl	11.14	28.43	1.32	0.13	99.18	0.96	10.28	99.48
X192 grain-C1	53.98	0.29	3.57	bdl	10.21	30.51	0.76	0.03	99.35	1.18	9.15	99.63
X192 grain-C2	53.38	0.33	4.32	bdl	10.18	30.10	0.82	0.06	99.18	1.32	9.00	99.48
X192 grain-C3	52.90	0.36	5.45	bdl	10.25	29.87	0.77	0.08	99.67	1.62	8.79	100.02
X192 grain-C4	52.49	0.39	5.97	bdl	10.31	29.32	0.97	0.09	99.63	1.48	8.99	99.99
X192 grain-C5	52.43	0.39	6.02	bdl	10.12	29.49	0.79	0.10	99.33	1.42	8.84	99.63
X192 grain-C6	52.05	0.47	6.30	bdl	9.68	28.31	2.32	0.19	99.41	1.68	8.16	99.77
X192 grain-C7	52.47	0.36	5.94	bdl	10.12	29.44	0.87	0.08	99.29	1.34	8.92	99.62
X192 grain-C8	52.55	0.42	5.83	bdl	10.07	29.29	1.22	0.09	99.47	1.40	8.81	99.80
X192 grain-C9	52.76	0.37	5.22	bdl	10.06	29.69	0.78	0.05	98.93	1.13	9.04	99.25
X192 grain-C10	54.06	0.29	3.84	bdl	10.30	30.56	0.75	0.04	99.83	1.31	9.12	100.13
X192 grain-C AVG	52.91	0.37	5.25	bdl	10.13	29.66	1.00	0.08	99.41	1.39	8.88	99.73
X192 grain-D1	52.78	0.37	4.62	0.09	10.78	29.19	0.78	0.06	98.66	0.95	9.93	98.96

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X192 grain-D2	52.18	0.40	5.84	0.08	10.81	28.94	0.84	0.06	99.16	1.32	9.62	99.46
X192 grain-D3	52.08	0.41	6.24	0.14	10.55	28.54	1.39	0.10	99.44	1.35	9.34	99.79
X192 grain-D4	52.41	0.36	5.25	0.09	10.39	29.38	0.80	0.08	98.75	1.53	9.01	99.14
X192 grain-D5	52.68	0.36	5.22	0.08	10.47	29.23	0.96	0.08	99.09	1.15	9.43	99.40
X192 grain-D6	52.36	0.37	5.72	0.11	10.51	29.43	0.82	0.05	99.35	1.65	9.03	99.71
X192 grain-D7	53.14	0.32	4.85	0.10	10.49	29.78	0.77	0.08	99.52	1.42	9.22	99.83
X192 grain-D8	53.11	0.37	5.01	0.00	10.35	29.79	0.75	0.07	99.44	1.22	9.25	99.75
X192 grain-D9	52.83	0.34	5.32	0.11	10.11	29.84	0.77	0.06	99.38	1.44	8.82	99.72
X192 grain-D10	54.02	0.24	3.63	0.00	10.34	30.38	0.71	0.06	99.38	1.17	9.29	99.70
X192 grain-D AVG	52.76	0.35	5.17	0.08	10.48	29.45	0.86	0.07	99.22	1.32	9.29	99.55
X192 ALL AVG	52.93	0.35	5.08	bdl	10.69	29.17	1.00	0.09	99.35	1.10	9.70	99.66
X192 AVG Core	52.74	0.36	5.41	bdl	10.65	28.99	1.10	0.11	99.42	1.19	9.59	99.73
X192 AVG Rim	53.20	0.33	4.56	bdl	10.77	29.39	0.87	0.07	99.22	0.99	9.88	99.52
X229 grain-A1	52.11	0.27	5.54	0.03	10.44	29.57	0.74	0.02	98.71	2.16	8.50	98.93
X229 grain-A2	51.71	0.28	5.95	0.05	10.83	29.52	0.75	0.03	99.12	2.96	8.18	99.42
X229 grain-A3	51.50	0.26	5.97	0.00	10.62	29.36	0.76	0.05	98.51	2.94	7.98	98.81
X229 grain-A4	51.83	0.27	5.71	0.02	10.52	29.45	0.73	0.04	98.57	2.47	8.30	98.82
X229 grain-A5	51.88	0.24	5.41	0.03	10.71	29.72	0.75	0.03	98.76	3.01	8.01	99.06
X229 grain-A AVG	51.81	0.26	5.72	0.03	10.62	29.52	0.74	0.03	98.73	2.71	8.19	99.01
X229 grain-B1	51.14	0.22	6.30	0.03	10.64	29.00	0.72	0.05	98.10	2.71	8.21	98.37

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X229 grain-B2	51.18	0.29	6.75	0.05	10.91	29.04	0.70	0.05	98.97	2.77	8.42	99.25
X229 grain-B3	51.52	0.25	6.34	0.00	10.79	29.23	0.70	0.03	98.85	2.62	8.43	99.12
X229 grain-B4	51.61	0.25	6.48	0.05	10.84	29.23	0.73	0.03	99.23	2.66	8.45	99.50
X229 grain-B5	51.04	0.23	6.75	0.03	10.74	29.04	0.71	0.01	98.54	2.76	8.26	98.82
X229 grain-B AVG	51.30	0.25	6.52	0.03	10.78	29.11	0.71	0.03	98.74	2.70	8.35	99.01
X229 ALL AVG	51.55	0.25	6.12	0.03	10.70	29.32	0.73	0.03	98.73	2.63	8.25	98.91
X286 grain-A1	53.29	0.32	3.71	0.13	10.23	30.45	0.75	0.03	98.91	2.03	8.40	99.11
X286 grain-A2	53.12	0.33	3.95	0.17	10.39	30.48	0.76	0.03	99.21	2.52	8.11	99.46
X286 grain-A3	52.91	0.35	4.05	0.11	10.12	30.24	0.77	0.03	98.56	1.95	8.36	98.75
X286 grain-A4	53.52	0.34	4.03	0.11	10.16	30.53	0.76	0.06	99.51	1.84	8.50	99.69
X286 grain-A AVG	53.21	0.33	3.94	0.13	10.22	30.42	0.76	0.04	99.05	2.09	8.34	99.26
X286 grain-B1	53.38	0.31	3.71	0.06	10.19	30.50	0.75	0.00	98.91	1.84	8.53	99.10
X286 grain-B2	53.63	0.31	3.67	0.10	10.57	30.58	0.73	0.04	99.62	2.18	8.60	99.84
X286 grain-B3	53.41	0.28	3.73	0.13	10.55	30.53	0.72	0.05	99.39	2.50	8.30	99.65
X286 grain-B AVG	53.48	0.30	3.70	0.10	10.44	30.54	0.73	0.03	99.31	2.17	8.48	99.53
X286 grain-C1	52.87	0.29	3.82	0.10	10.77	30.44	0.73	0.04	99.07	3.14	7.94	99.38
X286 grain-C2	53.54	0.27	3.88	0.14	10.48	30.59	0.71	0.05	99.67	2.31	8.41	99.90
X286 grain-C3	53.48	0.28	3.91	0.14	10.15	30.43	0.74	0.05	99.17	1.76	8.56	99.35
X286 grain-C4	53.30	0.28	3.87	0.13	10.47	30.49	0.73	0.05	99.30	2.40	8.30	99.54
X286 grain-C5	53.57	0.29	3.88	0.12	10.27	30.43	0.73	0.03	99.30	1.57	8.86	99.46

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X286 grain-C6	53.63	0.31	4.05	0.05	10.29	30.40	0.74	0.04	99.49	1.55	8.89	99.65
X286 grain-C7	53.61	0.28	3.99	0.13	10.33	30.59	0.73	0.04	99.70	2.00	8.54	99.89
X286 grain-C8	53.66	0.26	3.94	0.16	10.48	30.34	0.72	0.02	99.57	1.53	9.11	99.73
X286 grain-C9	53.66	0.31	3.92	0.13	10.15	30.50	0.79	0.03	99.48	1.57	8.73	99.64
X286 grain-C AVG	53.63	0.29	3.95	0.12	10.30	30.45	0.74	0.03	99.51	1.64	8.82	99.67
X286 grain-D1	53.70	0.31	3.77	0.06	10.32	30.59	0.79	0.05	99.58	2.02	8.50	99.78
X286 grain-D2	53.34	0.35	4.13	0.08	10.45	30.25	0.77	0.00	99.36	1.60	9.00	99.52
X286 grain-D3	53.45	0.34	4.26	0.05	10.57	30.29	0.84	0.02	99.80	1.82	8.93	99.98
X286 grain-D4	53.67	0.29	4.15	0.12	10.64	30.40	0.78	0.00	100.06	1.74	9.08	100.23
X286 grain-D AVG	53.54	0.32	4.08	0.08	10.49	30.38	0.79	0.02	99.70	1.80	8.88	99.88
X286 grain-E1	53.12	0.34	4.47	0.12	10.54	30.39	0.84	0.05	99.87	2.68	8.13	100.14
X286 grain-E2	53.14	0.39	4.66	0.14	10.52	30.08	0.94	0.04	99.89	1.97	8.74	100.09
X286 grain-E3	53.06	0.38	4.82	0.15	10.59	30.03	0.89	0.01	99.96	1.91	8.87	100.15
X286 grain-E4	53.14	0.38	4.90	0.11	10.54	29.96	0.83	0.04	99.91	1.70	9.01	100.08
X286 grain-E5	52.90	0.34	4.88	0.12	10.61	30.14	0.87	0.02	99.87	2.37	8.47	100.11
X286 grain-E6	53.33	0.31	4.27	0.15	10.62	30.48	0.72	0.03	99.90	2.44	8.43	100.15
X286 grain-E7	53.08	0.35	4.67	0.08	10.42	30.21	0.83	0.02	99.65	2.05	8.57	99.86
X286 grain-E AVG	53.11	0.36	4.66	0.12	10.55	30.19	0.85	0.03	99.86	2.16	8.60	100.08
X286 grain-F1	53.50	0.31	3.91	0.12	10.65	30.32	0.76	0.03	99.60	1.91	8.93	99.79
X286 grain-F2	53.08	0.31	4.38	0.11	10.67	30.32	0.69	0.02	99.58	2.38	8.52	99.82

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X286 grain-F3	53.04	0.31	4.22	0.14	10.78	30.33	0.73	0.05	99.58	2.69	8.35	99.85
X286 grain-F4	53.40	0.29	4.19	0.13	10.91	30.30	0.74	0.01	99.97	2.23	8.90	100.19
X286 grain-F5	53.39	0.30	3.90	0.11	10.77	30.48	0.71	0.06	99.71	2.66	8.38	99.98
X286 grain-F AVG	53.28	0.30	4.12	0.12	10.76	30.35	0.73	0.03	99.69	2.38	8.62	99.92
X286 ALL AVG Core	52.90	0.34	4.88	0.12	10.61	30.14	0.87	0.02	99.87	2.37	8.47	100.11
X286 ALL AVG Rim	53.12	0.34	4.47	0.12	10.54	30.39	0.84	0.05	99.87	2.68	8.13	100.14
X297 grain-A1	52.34	0.30	5.48	0.19	10.64	29.74	0.77	0.04	99.49	2.42	8.46	99.73
X297 grain-A2	51.72	0.31	5.85	0.15	10.71	29.58	0.75	0.03	99.09	2.95	8.06	99.38
X297 grain-A3	51.59	0.40	6.26	0.18	10.43	29.34	1.48	0.06	99.74	3.41	7.36	100.08
X297 grain-A4	51.80	0.35	6.20	0.15	10.69	29.76	0.75	0.04	99.73	3.13	7.87	100.05
X297 grain-A5	51.74	0.34	6.39	0.17	10.45	29.80	0.76	0.05	99.70	3.19	7.59	100.02
X297 grain-A6	51.66	0.33	5.86	0.18	10.38	29.88	0.76	0.04	99.08	3.20	7.50	99.40
X297 grain-A AVG	51.81	0.34	6.01	0.17	10.55	29.68	0.88	0.04	99.47	3.05	7.81	99.78
X297 grain-B1	52.22	0.29	4.67	0.12	10.23	30.12	0.78	0.03	98.45	2.89	7.63	98.74
X297 grain-B2	52.17	0.28	5.17	0.13	10.86	30.08	0.86	0.03	99.59	3.66	7.57	99.95
X297 grain-B3	52.30	0.31	5.17	0.12	10.99	30.01	0.87	0.01	99.77	3.30	8.02	100.10
X297 grain-B4	52.14	0.35	5.37	0.13	10.28	29.72	1.08	0.05	99.10	2.70	7.85	99.37
X297 grain-B5	52.45	0.31	5.60	0.19	10.74	30.38	0.82	0.04	100.52	3.72	7.39	100.89
X297 grain-B AVG	52.26	0.31	5.19	0.14	10.62	30.06	0.88	0.03	99.49	3.25	7.69	99.81
X297 grain-C1	52.36	0.34	4.97	0.11	10.19	30.37	0.95	0.01	99.31	3.23	7.29	99.63

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X297 grain-C2	52.59	0.30	5.56	0.12	10.27	30.28	0.81	0.05	99.97	2.88	7.68	100.26
X297 grain-C3	52.36	0.35	5.64	0.19	10.21	30.26	0.83	0.02	99.85	2.92	7.58	100.14
X297 grain-C4	52.31	0.37	5.87	0.18	10.23	30.20	0.90	0.03	100.09	2.92	7.60	100.38
X297 grain-C AVG	52.40	0.34	5.51	0.15	10.22	30.28	0.87	0.03	99.80	2.99	7.54	100.10
X297 ALL AVG Core	51.74	0.34	6.39	0.17	10.45	29.80	0.76	0.05	99.70	3.19	7.59	100.02
X297 ALL AVG Rim	52.34	0.30	5.48	0.19	10.64	29.74	0.77	0.04	99.49	2.42	8.46	99.73
X299 grain A1	52.23	0.30	5.87	0.14	10.01	30.08	0.77	0.06	99.46	2.62	7.66	99.72
X299 grain A2	51.90	0.30	6.25	0.15	10.12	29.76	0.85	0.05	99.37	2.60	7.78	99.63
X299 grain A3	51.68	0.28	6.31	bdl	9.86	29.92	0.84	bdl	98.89	2.73	7.40	99.16
X299 grain A4	51.66	0.29	6.28	0.15	10.25	29.94	0.76	0.05	99.36	3.28	7.29	99.69
X299 grain A5	51.92	0.21	6.06	0.12	10.27	30.15	0.67	bdl	99.40	3.17	7.42	99.71
X299 grain A6	52.53	0.22	5.78	0.15	10.18	30.32	0.74	bdl	99.93	2.68	7.77	100.20
X299 grain A AVG	51.99	0.27	6.09	0.14	10.12	30.03	0.77	0.05	99.45	2.85	7.55	99.73
X299 grain B1	52.02	0.18	5.84	0.17	10.23	30.18	0.81	bdl	99.43	3.25	7.30	99.75
X299 grain B2	52.50	0.22	5.45	bdl	10.03	30.18	0.80	bdl	99.18	2.29	7.98	99.41
X299 grain B3	52.11	0.24	6.17	0.14	10.31	29.99	0.76	0.05	99.77	2.91	7.69	100.06
X299 grain B4	51.64	0.20	6.40	0.12	10.40	29.78	0.73	bdl	99.27	2.99	7.70	99.57
X299 grain B5	52.71	0.18	5.16	0.16	10.08	30.41	0.73	bdl	99.42	2.48	7.85	99.67
X299 grain B AVG	52.20	0.21	5.80	0.15	10.21	30.11	0.76	0.05	99.48	2.78	7.70	99.76
X299 grain C1	52.24	0.21	5.67	bdl	9.74	30.18	0.72	0.04	98.80	2.46	7.52	99.05

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X299 grain C2	51.83	0.23	6.13	bdl	9.94	30.09	0.70	bdl	98.91	2.72	7.49	99.18
X299 grain C3	52.04	0.22	5.90	bdl	9.84	30.14	0.71	0.04	98.87	2.59	7.51	99.13
X299 grain C4	52.28	0.21	5.52	0.16	9.80	30.14	0.78	0.07	98.95	2.55	7.50	99.21
X299 grain C5	51.81	0.27	5.91	bdl	10.05	29.71	0.82	bdl	98.56	2.26	8.01	98.79
X299 grain C6	51.95	0.27	6.11	0.16	9.95	29.71	0.89	bdl	99.04	2.08	8.07	99.24
X299 grain C7	51.80	0.26	6.14	bdl	10.04	29.82	0.86	0.04	98.96	2.82	7.51	99.24
X299 grain C8	52.23	0.33	6.15	0.17	10.17	29.87	0.85	bdl	99.78	2.20	8.19	100.00
X299 grain C9	51.74	0.28	6.15	bdl	10.21	29.92	0.85	0.05	99.20	3.25	7.28	99.52
X299 grain C10	51.94	0.30	6.04	0.14	9.87	29.85	1.45	bdl	99.58	3.08	7.10	99.89
X299 grain C11	52.00	0.26	6.15	0.17	9.68	30.18	0.78	bdl	99.20	2.56	7.38	99.46
X299 grain C AVG	51.97	0.27	6.02	0.16	9.97	29.90	0.91	0.05	99.25	2.60	7.63	99.51
X299 grain D1	52.49	0.24	5.91	bdl	9.91	30.40	0.70	bdl	99.66	2.46	7.70	99.90
X299 grain D2	52.17	0.26	5.70	0.19	10.12	30.10	0.75	bdl	99.29	2.54	7.84	99.54
X299 grain D3	52.01	0.28	5.78	bdl	9.88	30.16	0.78	bdl	98.89	2.65	7.49	99.16
X299 grain D4	52.14	0.25	5.80	bdl	9.98	30.20	0.81	bdl	99.19	2.69	7.56	99.46
X299 grain D5	51.93	0.25	6.06	bdl	9.89	29.90	0.84	0.06	98.95	2.74	7.42	99.22
X299 grain D6	51.76	0.29	6.00	0.16	9.59	29.81	0.82	0.06	98.47	2.30	7.52	98.70
X299 grain D7	52.00	0.24	5.92	bdl	9.93	29.94	0.82	0.05	98.90	2.65	7.55	99.16
X299 grain D8	52.08	0.26	5.59	0.19	9.88	30.12	0.77	bdl	98.88	2.47	7.65	99.13
X299 grain D AVG	52.07	0.26	5.85	0.18	9.90	30.08	0.79	0.05	99.17	2.56	7.59	99.43

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X299 AVG Core	51.66	0.29	6.28	0.15	10.25	29.94	0.76	0.05	99.36	3.28	7.29	99.69
X299 AVG Rim	52.53	0.22	5.78	0.15	10.18	30.32	0.74	0.00	99.93	2.41	8.02	100.18
X319 grain-A1	52.13	0.34	5.97	0.14	9.68	30.29	0.78	0.03	99.35	2.70	7.24	99.81
X319 grain-A2	52.50	0.43	6.52	0.17	9.57	29.73	0.84	0.05	99.80	1.00	8.67	100.08
X319 grain-A3	52.44	0.40	6.47	0.13	9.89	29.71	0.81	bdl	99.85	1.20	8.81	100.15
X319 grain-A4	52.25	0.39	6.32	0.13	9.74	29.77	0.75	0.04	99.39	1.51	8.39	99.76
X319 grain-A5	52.35	0.35	6.31	0.10	9.74	29.77	0.78	0.03	99.43	1.37	8.50	99.75
X319 grain-A6	52.41	0.36	6.38	0.16	9.85	29.63	0.77	bdl	99.57	0.99	8.95	99.86
X319 grain-A7	53.00	0.32	4.72	0.09	9.67	30.21	0.77	0.03	98.81	1.34	8.46	99.16
X319 grain-A AVG	52.44	0.37	6.10	0.13	9.73	29.87	0.79	0.03	99.46	1.44	8.43	99.79
X319 grain-B1	52.83	0.31	5.90	0.10	9.84	30.04	0.74	0.06	99.81	1.47	8.52	100.13
X319 grain-B2	52.05	0.31	5.94	0.14	9.54	29.86	0.75	0.03	98.61	1.74	7.97	99.02
X319 grain-B3	52.42	0.35	6.22	0.12	9.85	29.79	0.77	0.05	99.57	1.50	8.50	99.90
X319 grain-B4	52.35	0.40	6.23	0.12	9.75	29.44	0.87	0.05	99.22	0.93	8.91	99.51
X319 grain-B5	52.05	0.37	6.33	0.16	9.69	29.51	0.78	bdl	98.91	1.17	8.64	99.26
X319 grain-B6	52.23	0.34	6.11	0.17	9.68	29.68	0.83	0.03	99.07	1.41	8.42	99.43
X319 grain-B7	51.89	0.38	6.26	0.16	9.58	29.54	0.80	0.05	98.66	1.41	8.31	98.97
X319 grain-B8	52.26	0.39	6.04	0.11	9.89	29.84	0.75	0.03	99.30	1.70	8.37	99.66
X319 grain-B9	52.49	0.35	5.58	0.14	9.47	29.90	0.76	0.03	98.72	1.07	8.51	99.00
X319 grain-B AVG	52.29	0.35	6.07	0.13	9.70	29.73	0.79	0.04	99.10	1.38	8.46	99.43

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
X319 grain-C1	52.34	0.35	6.12	0.12	9.70	29.68	0.76	0.04	99.11	1.19	8.63	99.44
X319 grain-C2	52.41	0.32	6.09	0.11	9.73	29.86	0.73	0.04	99.28	1.45	8.43	99.63
X319 grain-C3	52.05	0.35	6.26	0.17	9.77	29.65	0.75	0.03	99.03	1.52	8.40	99.37
X319 AVG Core	52.10	0.37	6.31	0.14	9.69	29.65	0.80	0.04	99.11	1.45	8.39	99.45
X319 AVG Rim	52.42	0.35	5.89	0.13	9.66	29.96	0.76	0.03	99.21	1.35	8.45	99.35
Ba-1-72 grain-A1	53.14	0.08	4.28	0.39	8.23	32.58	0.94	0.10	99.74	5.19	3.56	100.25
Ba-1-72 grain-A2	53.17	0.15	4.94	0.35	8.17	32.33	0.88	0.10	100.07	4.50	4.12	100.52
Ba-1-72 grain-A3	53.62	0.07	4.36	0.35	7.73	32.63	0.96	0.09	99.80	4.16	3.99	100.22
Ba-1-72 grain-A4	52.67	0.10	4.59	0.32	8.01	32.51	0.93	0.12	99.23	5.37	3.18	99.77
Ba-1-72 grain-A5	53.30	0.07	4.57	0.29	7.93	32.68	0.93	0.13	99.90	4.97	3.46	100.39
Ba-1-72 grain-A AVG	53.18	0.09	4.55	0.34	8.01	32.54	0.93	0.11	99.75	4.84	3.66	100.23
Ba-1-72 grain-B1	53.26	0.07	4.70	0.40	7.33	32.65	0.92	0.13	99.46	4.19	3.56	99.88
Ba-1-72 grain-B2	53.26	0.09	4.72	0.40	7.50	32.70	0.92	0.08	99.68	4.27	3.66	100.10
Ba-1-72 grain-B3	52.91	0.06	4.73	0.29	7.38	32.65	0.93	0.07	99.02	4.49	3.34	99.46
Ba-1-72 grain-B4	53.14	0.07	4.72	0.36	7.41	32.67	0.93	0.09	99.38	4.32	3.52	99.82
Ba-1-72 grain-B5	53.71	0.08	4.78	0.31	7.46	32.84	0.89	0.10	100.15	4.00	3.86	100.55
Ba-1-72 grain-B6	53.63	0.08	4.83	0.30	7.25	32.54	0.90	0.16	99.68	3.59	4.01	100.04
Ba-1-72 grain-B7	53.45	0.07	4.95	0.31	7.16	32.80	0.91	0.11	99.75	3.99	3.57	100.15
Ba-1-72 grain-B8	53.37	0.06	4.90	0.33	7.46	32.87	0.90	0.10	99.99	4.49	3.42	100.44
Ba-1-72 grain-B AVG	53.54	0.07	4.87	0.31	7.33	32.76	0.90	0.12	99.89	4.02	3.71	100.29

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
Ba-1-72 grain-C1	53.38	0.11	4.66	0.34	7.45	32.77	0.96	0.15	99.82	4.57	3.34	100.27
Ba-1-72 grain-C2	53.20	0.14	4.54	0.32	7.73	32.56	0.91	0.12	99.51	4.38	3.79	99.95
Ba-1-72 grain-C3	53.43	0.11	4.65	0.33	7.58	32.54	0.96	0.15	99.74	4.25	3.76	100.17
Ba-1-72 grain-C AVG	53.34	0.12	4.62	0.33	7.59	32.62	0.94	0.14	99.69	4.40	3.63	100.13
Ba-1-72 ALL AVG	53.30	0.09	4.69	0.34	7.58	32.65	0.92	0.11	99.68	4.10	3.90	100.09
Ba2-1-1 grain-A1	55.20	0.09	4.60	0.31	5.90	32.46	0.83	0.14	99.53	0.00	5.90	99.83
Ba2-1-1 grain-A2	54.97	0.14	4.76	0.38	6.06	32.43	0.80	0.10	99.64	0.00	6.06	99.76
Ba2-1-1 grain-A3	54.69	0.12	4.93	0.42	6.16	32.56	0.80	0.10	99.78	0.00	6.16	100.00
Ba2-1-1 grain-A4	54.70	0.12	4.88	0.41	6.07	32.22	0.78	0.10	99.27	0.00	6.07	99.48
Ba2-1-1 grain-A5	55.11	0.14	4.96	0.40	6.24	32.31	0.81	0.09	100.07	0.00	6.24	100.30
Ba2-1-1 grain-A6	54.80	0.14	4.90	0.45	6.34	32.34	0.82	0.09	99.88	0.00	6.34	100.04
Ba2-1-1 grain-A7	54.77	0.10	4.93	0.42	6.09	32.40	0.82	0.12	99.65	0.00	6.09	99.92
Ba2-1-1 grain-A8	54.76	0.13	5.00	0.43	6.22	32.46	0.82	0.10	99.92	0.00	6.22	100.16
Ba2-1-1 grain-A9	54.69	0.12	4.95	0.46	6.20	32.48	0.82	0.08	99.81	0.00	6.20	99.97
Ba2-1-1 grain-A10	54.92	0.08	4.56	0.34	6.24	32.70	0.80	0.10	99.73	0.00	6.24	99.88
Ba2-1-1 grain-A AVG	54.86	0.12	4.85	0.40	6.15	32.44	0.81	0.10	99.73	0.00	6.15	99.93
Ba2-1-1 grain-B1	54.23	0.08	4.47	0.35	6.13	32.27	0.80	0.09	98.41	0.42	5.75	98.67
Ba2-1-1 grain-B2	54.75	0.09	4.50	0.30	6.16	32.71	0.83	0.08	99.44	0.74	5.49	99.79
Ba2-1-1 grain-B3	55.22	0.08	4.60	0.38	6.28	32.55	0.81	0.10	100.03	0.00	6.28	100.18
Ba2-1-1 grain-B4	54.73	0.12	4.60	0.34	6.43	32.67	0.80	0.10	99.78	0.99	5.53	100.18

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
Ba2-1-1 grain-B5	54.91	0.10	4.87	0.45	6.22	32.42	0.78	0.07	99.80	0.00	6.22	99.90
Ba2-1-1 grain-B6	54.59	0.11	4.83	0.41	6.03	32.46	0.79	0.10	99.31	0.10	5.94	99.43
Ba2-1-1 grain-B7	54.76	0.12	4.68	0.35	6.22	32.54	0.81	0.09	99.56	0.21	6.03	99.70
Ba2-1-1 grain-B8	54.52	0.12	4.84	0.45	6.02	32.50	0.79	0.11	99.34	0.36	5.70	99.50
Ba2-1-1 grain-B9	55.05	0.09	4.83	0.40	6.25	32.54	0.81	0.12	100.09	0.06	6.20	100.22
Ba2-1-1 grain-B10	55.42	0.08	4.65	0.34	6.22	32.83	0.79	0.09	100.42	0.11	6.12	100.72
Ba2-1-1 grain-B AVG	54.82	0.10	4.69	0.38	6.20	32.55	0.80	0.09	99.62	0.24	5.98	99.82
Ba2-1-1 grain-C1	55.11	0.08	4.63	0.31	6.03	32.51	0.82	0.08	99.57	0.00	6.03	99.77
Ba2-1-1 grain-C2	54.84	0.09	4.60	0.33	6.12	32.32	0.79	0.10	99.18	0.00	6.12	99.29
Ba2-1-1 grain-C3	54.61	0.08	4.78	0.35	6.26	32.51	0.78	0.07	99.43	0.48	5.82	99.75
Ba2-1-1 grain-C4	54.81	0.11	4.94	0.39	6.04	32.47	0.82	0.09	99.66	0.00	6.04	99.81
Ba2-1-1 grain-C5	54.71	0.12	4.80	0.39	6.25	32.28	0.81	0.11	99.47	0.00	6.25	99.57
Ba2-1-1 grain-C6	54.59	0.11	4.86	0.37	6.24	32.54	0.80	0.10	99.59	0.68	5.63	99.92
Ba2-1-1 grain-C7	54.58	0.15	4.91	0.43	6.15	32.33	0.81	0.10	99.45	0.15	6.02	99.73
Ba2-1-1 grain-C8	54.78	0.14	4.84	0.42	6.04	32.47	0.80	0.06	99.54	0.00	6.04	99.83
Ba2-1-1 grain-C9	55.07	0.10	4.77	0.38	6.20	32.50	0.79	0.09	99.90	0.00	6.20	100.18
Ba2-1-1 grain-C10	55.37	0.08	4.59	0.36	6.21	32.57	0.81	0.10	100.09	0.00	6.21	100.35
Ba2-1-1 grain-C AVG	54.85	0.11	4.77	0.37	6.15	32.45	0.80	0.09	99.59	0.00	6.15	99.81
Ba2-1-1 grain-D1	55.37	0.10	4.64	0.37	6.31	32.71	0.79	0.09	100.38	0.00	6.31	100.51
Ba2-1-1 grain-D2	55.05	0.11	4.89	0.38	6.17	32.30	0.82	0.11	99.81	0.00	6.17	100.06

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
Ba2-1-1 grain-D3	54.97	0.11	5.01	0.38	6.25	32.47	0.82	0.14	100.15	0.00	6.25	100.38
Ba2-1-1 grain-D4	54.78	0.12	5.04	0.38	6.23	32.22	0.84	0.16	99.77	0.20	6.05	100.10
Ba2-1-1 grain-D5	54.77	0.14	5.07	0.41	6.13	32.36	0.86	0.11	99.85	0.06	6.08	100.09
Ba2-1-1 grain-D6	54.92	0.12	4.96	0.39	6.27	32.44	0.82	0.11	100.01	0.00	6.27	100.13
Ba2-1-1 grain-D7	54.67	0.13	4.90	0.39	6.42	32.49	0.79	0.09	99.87	0.56	5.91	100.17
Ba2-1-1 grain-D8	54.80	0.09	4.80	0.39	6.15	32.55	0.80	0.11	99.68	0.39	5.80	99.97
Ba2-1-1 grain-D9	55.02	0.09	4.72	0.37	6.01	32.55	0.81	0.09	99.66	0.00	6.01	99.91
Ba2-1-1 grain-D10	55.19	0.10	4.58	0.36	6.18	32.72	0.79	0.10	100.01	0.17	6.03	100.27
Ba2-1-1 grain-D AVG	54.95	0.11	4.86	0.38	6.21	32.48	0.81	0.11	99.92	0.09	6.13	100.15
Ba2-1-1 ALL AVG	54.87	0.11	4.79	0.38	6.18	32.48	0.81	0.10	99.71	0.07	6.11	99.93
EP-3-84 grain-A1	54.40	0.22	4.74	0.20	7.32	31.66	0.75	0.04	99.32	0.00	7.32	99.46
EP-3-84 grain-A2	54.46	0.18	4.89	0.17	7.56	31.56	0.73	0.05	99.60	0.00	7.56	99.84
EP-3-84 grain-A3	54.18	0.19	4.97	0.16	7.63	31.70	0.72	0.04	99.60	0.62	7.07	99.91
EP-3-84 grain-A4	54.40	0.24	5.02	0.17	7.59	31.64	0.70	0.04	99.79	0.00	7.59	99.97
EP-3-84 grain-A5	54.20	0.20	4.97	0.20	7.78	31.54	0.70	0.04	99.63	0.28	7.53	99.83
EP-3-84 grain-A6	54.53	0.22	4.99	0.16	7.79	31.57	0.73	0.06	100.05	0.05	7.74	100.23
EP-3-84 grain-A7	54.23	0.20	4.92	0.17	7.81	31.64	0.68	0.05	99.70	0.54	7.32	99.96
EP-3-84 grain-A8	54.14	0.21	4.90	0.14	7.59	31.67	0.69	0.05	99.40	0.60	7.06	99.74
EP-3-84 grain-A9	54.25	0.17	4.86	0.17	7.73	31.67	0.71	0.09	99.65	0.72	7.08	99.88
EP-3-84 grain-A10	54.35	0.20	4.73	0.16	7.66	31.83	0.70	0.04	99.67	0.52	7.19	99.86

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
EP-3-84 grain-A AVG	54.31	0.20	4.90	0.17	7.65	31.65	0.71	0.05	99.64	0.31	7.37	99.86
EP-3-84 grain-B1	54.68	0.20	4.62	0.20	7.80	31.72	0.73	0.05	100.00	0.08	7.72	100.14
EP-3-84 grain-B2	54.37	0.20	4.75	0.19	7.64	31.66	0.71	0.06	99.59	0.26	7.41	99.76
EP-3-84 grain-B3	54.23	0.19	4.78	0.19	7.58	31.61	0.69	0.03	99.31	0.25	7.36	99.62
EP-3-84 grain-B4	54.05	0.21	4.89	0.14	7.60	31.68	0.67	0.06	99.29	0.79	6.90	99.68
EP-3-84 grain-B5	53.92	0.20	4.96	0.15	7.61	31.70	0.69	0.08	99.31	0.96	6.75	99.56
EP-3-84 grain-B6	53.98	0.17	4.99	0.19	7.65	31.61	0.69	0.07	99.35	0.82	6.91	99.65
EP-3-84 grain-B7	53.97	0.19	4.96	0.21	7.68	31.52	0.75	0.07	99.33	0.66	7.09	99.53
EP-3-84 grain-B8	54.14	0.20	4.83	0.23	7.48	31.60	0.72	0.07	99.27	0.36	7.16	99.48
EP-3-84 grain-B9	54.20	0.22	4.81	0.17	7.74	31.58	0.70	0.07	99.47	0.43	7.35	99.65
EP-3-84 grain-B10	54.23	0.18	4.68	0.14	7.75	31.82	0.71	0.04	99.54	0.81	7.02	99.77
EP-3-84 grain-B AVG	54.18	0.20	4.82	0.18	7.65	31.65	0.71	0.06	99.45	0.54	7.17	99.68
EP-3-84 ALL AVG	54.25	0.20	4.86	0.18	7.65	31.65	0.71	0.06	99.54	0.21	7.46	99.57
TF6 grain-A1	54.29	bdl	4.30	0.44	6.18	32.80	0.66	0.04	98.70	1.00	5.28	98.94
TF6 grain-A2	54.59	bdl	4.43	0.38	6.30	32.72	0.77	0.04	99.24	0.93	5.46	99.63
TF6 grain-A3	54.46	bdl	4.41	0.50	6.35	32.76	0.78	bdl	99.29	0.84	5.59	99.55
TF6 grain-A4	54.35	bdl	4.30	0.43	6.17	32.70	0.80	0.04	98.79	0.87	5.39	99.00
TF6 grain-A5	54.89	bdl	4.24	0.39	6.25	32.82	0.75	0.07	99.39	0.56	5.75	99.56
TF6 grain-A6	54.52	bdl	4.26	0.42	6.10	32.68	0.78	0.04	98.79	0.70	5.47	99.16
TF6 grain-A7	54.86	bdl	4.17	0.41	6.18	32.89	0.76	0.03	99.30	0.53	5.70	99.50

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
TF6 grain-A8	54.83	bdl	4.17	0.39	6.32	32.95	0.74	0.00	99.45	0.67	5.72	99.75
TF6 grain-A9	54.68	bdl	4.26	0.46	6.24	32.84	0.72	0.06	99.26	0.96	5.38	99.64
TF6 grain-A10	54.85	bdl	4.31	0.34	6.18	32.81	0.65	0.03	99.16	0.17	6.03	99.28
TF6 grain-A AVG	54.63	bdl	4.28	0.41	6.23	32.80	0.74	0.03	99.14	0.72	5.58	99.40
TF6 grain-B1	54.77	0.04	4.46	0.49	6.22	32.77	0.71	0.04	99.49	0.37	5.89	99.65
TF6 grain-B2	54.56	0.04	4.52	0.43	6.37	32.90	0.70	0.06	99.57	1.14	5.34	99.80
TF6 grain-B3	54.59	bdl	4.48	0.43	6.35	32.68	0.76	0.04	99.33	0.72	5.71	99.54
TF6 grain-B4	54.80	bdl	4.32	0.43	6.21	32.85	0.79	0.06	99.45	0.94	5.36	99.87
TF6 grain-B5	54.71	bdl	4.32	0.37	6.18	32.90	0.75	0.05	99.28	0.98	5.31	99.67
TF6 grain-B6	54.74	bdl	4.25	0.46	6.18	32.90	0.77	0.05	99.34	0.79	5.47	99.55
TF6 grain-B7	54.60	bdl	4.28	0.45	6.40	32.89	0.71	0.05	99.40	1.10	5.41	99.65
TF6 grain-B8	54.77	bdl	4.19	0.47	6.19	32.91	0.77	0.05	99.34	0.80	5.47	99.54
TF6 grain-B9	54.56	bdl	4.32	0.47	6.17	32.85	0.73	0.05	99.20	1.00	5.27	99.55
TF6 grain-B10	54.86	bdl	4.43	0.50	6.20	32.98	0.65	0.05	99.67	0.79	5.49	100.01
TF6 grain-B AVG	54.70	bdl	4.36	0.45	6.25	32.86	0.73	0.05	99.41	0.86	5.47	99.68
TF6 grain-C1	54.57	bdl	4.39	0.49	6.25	32.89	0.63	0.05	99.26	0.99	5.36	99.60
TF6 grain-C2	54.72	0.04	4.29	0.46	6.22	32.86	0.62	0.05	99.27	0.67	5.63	99.58
TF6 grain-C3	54.82	bdl	4.14	0.47	6.32	32.96	0.69	0.04	99.47	0.87	5.54	99.77
TF6 grain-C4	54.53	bdl	4.13	0.47	6.41	32.93	0.70	0.05	99.21	1.45	5.10	99.64
TF6 grain-C5	54.57	bdl	4.06	0.48	6.23	32.81	0.70	0.04	98.89	0.87	5.45	99.21

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
TF6 grain-C6	54.90	bdl	3.95	0.40	6.30	32.91	0.71	bdl	99.18	0.41	5.93	99.34
TF6 grain-C7	54.88	bdl	3.98	0.39	6.25	32.99	0.68	bdl	99.20	0.56	5.74	99.49
TF6 grain-C8	55.01	bdl	4.05	0.47	6.17	33.02	0.72	0.03	99.49	0.61	5.62	99.79
TF6 grain-C9	54.81	0.04	4.11	0.37	6.41	32.99	0.68	0.03	99.42	1.02	5.50	99.78
TF6 grain-C10	54.77	bdl	4.32	0.43	6.24	33.03	0.62	0.06	99.46	0.90	5.43	99.67
TF6 grain-C AVG	54.76	bdl	4.14	0.44	6.28	32.94	0.68	0.03	99.28	0.83	5.53	99.59
TF6 grain-D1	54.46	bdl	4.28	0.44	6.30	32.80	0.70	bdl	98.98	0.76	5.62	99.19
TF6 grain-D2	54.82	bdl	4.17	0.39	6.23	32.94	0.73	0.05	99.35	0.85	5.47	99.66
TF6 grain-D3	54.91	bdl	4.10	0.35	6.36	32.84	0.75	0.04	99.35	0.62	5.80	99.57
TF6 grain-D4	54.84	0.06	4.12	0.32	6.29	32.81	0.76	0.05	99.24	0.55	5.79	99.43
TF6 grain-D5	54.76	bdl	4.17	0.36	6.23	32.75	0.78	0.03	99.08	0.41	5.86	99.23
TF6 grain-D6	54.82	bdl	4.17	0.46	6.17	32.88	0.76	0.03	99.30	0.56	5.67	99.50
TF6 grain-D7	54.71	0.04	4.28	0.38	6.37	32.86	0.78	bdl	99.42	0.87	5.59	99.80
TF6 grain-D8	54.66	0.05	4.31	0.40	6.31	32.74	0.73	0.04	99.24	0.60	5.77	99.43
TF6 grain-D9	54.46	bdl	4.48	0.51	6.31	32.64	0.77	0.04	99.20	0.76	5.62	99.41
TF6 grain-D10	54.49	bdl	4.48	0.47	6.28	32.80	0.73	0.04	99.27	1.10	5.28	99.68
TF6 grain-D AVG	54.69	bdl	4.26	0.41	6.28	32.81	0.75	0.03	99.24	0.71	5.65	99.49
TF6 ALL AVG	54.69	0.00	4.26	0.43	6.26	32.85	0.72	0.04	99.25	0.58	5.74	99.31
JAG 84-524 grain-A1	56.69	bdl	0.53	0.31	4.89	35.40	0.42	0.14	98.37	0.86	4.12	98.70
JAG 84-524 grain-A2	57.18	bdl	0.72	0.19	5.19	35.14	0.20	0.05	98.65	0.07	5.12	98.79

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-A3	57.66	bdl	0.75	0.30	5.31	35.16	0.19	0.03	99.40	0.00	5.31	99.68
JAG 84-524 grain-A4	57.84	bdl	0.75	0.24	5.22	35.13	0.22	0.07	99.47	0.00	5.22	99.71
JAG 84-524 grain-A5	57.60	bdl	0.72	0.27	5.15	35.01	0.24	0.05	99.05	0.00	5.15	99.27
JAG 84-524 grain-A6	57.78	bdl	0.69	0.20	5.26	35.13	0.25	0.09	99.39	0.00	5.26	99.64
JAG 84-524 grain-A7	57.42	bdl	0.68	0.18	5.22	35.20	0.20	0.06	98.95	0.00	5.22	99.07
JAG 84-524 grain-A8	57.60	bdl	0.67	0.25	5.24	35.11	0.23	0.06	99.17	0.00	5.24	99.27
JAG 84-524 grain-A9	57.67	bdl	0.71	0.19	5.45	35.14	0.21	0.07	99.45	0.01	5.44	99.71
JAG 84-524 grain-A10	58.19	bdl	0.75	0.18	5.12	35.25	0.21	0.07	99.77	0.00	5.12	99.85
JAG 84-524 grain-A AVG	57.56	bdl	0.70	0.23	5.20	35.17	0.24	0.07	99.17	0.00	5.20	99.36
JAG 84-524 grain-B1	57.33	bdl	0.73	0.25	5.36	34.76	0.22	0.05	98.70	0.00	5.36	98.85
JAG 84-524 grain-B2	57.51	bdl	0.73	0.25	5.22	35.25	0.20	0.08	99.24	0.07	5.16	99.39
JAG 84-524 grain-B3	57.69	bdl	0.71	0.28	5.26	35.15	0.22	0.07	99.37	0.00	5.26	99.63
JAG 84-524 grain-B4	57.69	bdl	0.72	0.24	5.38	35.31	0.18	0.07	99.58	0.00	5.38	99.68
JAG 84-524 grain-B5	57.48	bdl	0.70	0.29	5.18	35.16	0.19	0.07	99.06	0.00	5.18	99.16
JAG 84-524 grain-B6	57.89	bdl	0.68	0.23	5.20	35.29	0.20	0.04	99.53	0.00	5.20	99.66
JAG 84-524 grain-B7	58.07	bdl	0.72	0.23	5.27	35.22	0.18	0.04	99.73	0.00	5.27	99.86
JAG 84-524 grain-B8	57.67	bdl	0.67	0.22	5.22	35.33	0.21	0.07	99.39	0.00	5.22	99.50
JAG 84-524 grain-B9	57.19	bdl	0.83	0.23	5.47	35.60	0.22	0.12	99.65	1.09	4.48	99.98
JAG 84-524 grain-B10	57.16	bdl	0.72	0.22	5.37	36.39	0.20	0.07	100.13	1.15	4.34	100.37
JAG 84-524 grain-B AVG	57.57	bdl	0.72	0.24	5.29	35.34	0.20	0.07	99.44	0.20	5.11	99.61

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-C1	57.00	bdl	0.73	0.23	5.33	34.78	0.22	0.07	98.36	0.00	5.33	98.50
JAG 84-524 grain-C2	57.47	bdl	0.70	0.27	5.26	35.01	0.20	0.06	98.97	0.00	5.26	99.06
JAG 84-524 grain-C3	57.79	bdl	0.78	0.26	5.42	35.24	0.20	0.03	99.71	0.00	5.42	99.89
JAG 84-524 grain-C4	57.39	bdl	0.75	0.30	5.23	35.42	0.20	0.06	99.35	0.58	4.71	99.65
JAG 84-524 grain-C5	57.63	bdl	0.75	0.31	5.22	35.31	0.20	0.05	99.47	0.00	5.22	99.75
JAG 84-524 grain-C6	57.73	bdl	0.71	0.27	5.13	35.22	0.21	0.03	99.30	0.00	5.13	99.55
JAG 84-524 grain-C7	57.92	bdl	0.74	0.23	5.34	35.27	0.22	0.09	99.80	0.00	5.34	99.91
JAG 84-524 grain-C8	57.74	bdl	0.70	0.26	5.26	35.27	0.21	0.04	99.47	0.00	5.26	99.58
JAG 84-524 grain-C9	57.69	bdl	0.73	0.25	5.34	35.38	0.20	0.08	99.65	0.20	5.15	99.81
JAG 84-524 grain-C10	57.41	bdl	0.74	0.24	5.27	35.87	0.20	0.07	99.81	1.41	4.01	100.06
JAG 84-524 grain-C AVG	57.58	bdl	0.73	0.26	5.28	35.28	0.20	0.06	99.39	0.01	5.27	99.56
JAG 84-524 grain-D1	58.20	bdl	0.73	0.18	5.40	35.34	0.18	0.07	100.09	0.00	5.40	100.22
JAG 84-524 grain-D2	57.77	bdl	0.70	0.00	5.37	35.23	0.18	0.06	99.31	0.00	5.37	99.43
JAG 84-524 grain-D3	57.75	bdl	0.74	0.25	5.35	35.22	0.18	0.03	99.52	0.00	5.35	99.76
JAG 84-524 grain-D4	57.54	bdl	0.71	0.27	5.29	35.20	0.16	0.06	99.24	0.00	5.30	99.51
JAG 84-524 grain-D5	57.54	bdl	0.72	0.26	5.20	35.19	0.19	0.04	99.14	0.00	5.20	99.23
JAG 84-524 grain-D6	57.73	bdl	0.70	0.26	5.20	35.15	0.19	0.05	99.28	0.00	5.20	99.49
JAG 84-524 grain-D7	57.66	bdl	0.69	0.26	5.21	35.13	0.19	0.10	99.22	0.00	5.21	99.35
JAG 84-524 grain-D8	57.61	bdl	0.69	0.29	5.44	35.14	0.20	0.08	99.46	-0.06	5.49	99.58
JAG 84-524 grain-D9	57.57	bdl	0.71	0.26	5.31	35.05	0.18	0.05	99.13	0.00	5.31	99.41

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-D10	57.33	bdl	0.74	0.24	5.31	35.73	0.20	0.08	99.62	1.40	4.05	99.97
JAG 84-524 grain-D AVG	57.67	bdl	0.71	0.23	5.31	35.24	0.18	0.06	99.40	-0.14	5.44	99.57
JAG 84-524 grain-E1	56.84	bdl	0.72	0.23	5.16	36.15	0.17	0.05	99.32	1.08	4.19	99.64
JAG 84-524 grain-E2	56.84	bdl	0.71	0.22	5.34	36.11	0.20	0.06	99.48	1.14	4.32	99.84
JAG 84-524 grain-E3	56.89	bdl	0.73	0.21	5.42	36.07	0.22	0.05	99.59	1.09	4.44	99.82
JAG 84-524 grain-E4	56.92	bdl	0.73	0.29	5.30	36.09	0.20	0.05	99.58	1.01	4.39	99.87
JAG 84-524 grain-E5	57.15	bdl	0.71	0.24	5.33	36.16	0.22	0.03	99.84	1.05	4.39	100.14
JAG 84-524 grain-E6	56.85	bdl	0.75	0.23	5.39	36.22	0.21	0.06	99.71	1.07	4.43	100.05
JAG 84-524 grain-E7	56.90	bdl	0.72	0.22	5.34	36.04	0.21	0.06	99.49	1.12	4.33	99.71
JAG 84-524 grain-E AVG	56.91	bdl	0.72	0.23	5.33	36.12	0.20	0.05	99.57	1.08	4.36	99.86
JAG 84-524 grain-F1	56.88	bdl	0.71	0.23	5.22	35.99	0.21	0.05	99.29	1.10	4.23	99.58
JAG 84-524 grain-F2	56.96	bdl	0.70	0.19	5.30	36.11	0.23	0.05	99.54	1.16	4.26	99.87
JAG 84-524 grain-F3	56.99	bdl	0.71	0.22	5.21	36.08	0.20	0.06	99.47	1.14	4.19	99.82
JAG 84-524 grain-F4	57.04	bdl	0.74	0.26	5.34	36.35	0.21	0.04	99.98	1.01	4.43	100.34
JAG 84-524 grain-F5	56.75	bdl	0.69	0.27	5.30	36.14	0.21	0.06	99.42	1.11	4.30	99.63
JAG 84-524 grain-F6	56.93	bdl	0.73	0.18	5.36	36.17	0.22	0.07	99.66	1.18	4.30	100.01
JAG 84-524 grain-F7	56.99	bdl	0.71	0.27	5.33	36.28	0.22	0.04	99.84	1.04	4.39	100.21
JAG 84-524 grain-F8	57.01	bdl	0.77	0.23	5.35	36.33	0.21	0.05	99.95	1.02	4.43	100.24
JAG 84-524 grain-F9	56.94	bdl	0.73	0.21	5.37	36.21	0.20	0.04	99.70	1.07	4.41	100.04
JAG 84-524 grain-F10	57.17	bdl	0.75	0.20	5.34	36.01	0.22	0.05	99.74	1.07	4.38	99.98

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-F11	56.87	bdl	0.71	0.22	5.41	36.36	0.20	0.07	99.84	1.17	4.36	100.17
JAG 84-524 grain-F12	56.59	bdl	0.72	0.19	5.25	35.63	0.21	0.06	98.65	1.13	4.23	98.94
JAG 84-524 grain-F AVG	56.93	bdl	0.72	0.22	5.32	36.14	0.21	0.05	99.59	1.10	4.33	99.90
JAG 84-524 grain-G1	56.88	bdl	0.73	0.17	5.40	36.12	0.20	0.03	99.53	1.08	4.43	99.84
JAG 84-524 grain-G2	56.81	bdl	0.85	0.25	4.91	36.18	0.48	0.09	99.57	0.97	4.04	99.90
JAG 84-524 grain-G3	57.17	bdl	0.73	0.26	5.28	36.15	0.19	0.05	99.83	1.05	4.34	100.14
JAG 84-524 grain-G4	56.44	bdl	0.80	0.30	5.12	35.33	0.99	0.12	99.10	1.06	4.17	99.40
JAG 84-524 grain-G5	56.96	bdl	0.70	0.20	5.30	36.17	0.22	0.06	99.61	1.18	4.24	99.92
JAG 84-524 grain-G6	56.69	bdl	0.76	0.29	5.16	35.51	0.81	0.12	99.34	1.14	4.14	99.71
JAG 84-524 grain-G7	56.64	bdl	0.70	0.21	5.27	36.03	0.21	0.04	99.10	1.10	4.28	99.45
JAG 84-524 grain-G8	56.87	bdl	0.73	0.22	5.27	36.14	0.22	0.05	99.50	1.08	4.30	99.87
JAG 84-524 grain-G9	56.73	bdl	0.72	0.22	5.22	35.88	0.23	0.09	99.09	1.19	4.15	99.40
JAG 84-524 grain-G AVG	56.80	bdl	0.75	0.24	5.21	35.95	0.39	0.07	99.41	1.09	4.23	99.74
JAG 84-524 grain-H1	56.74	bdl	0.70	0.23	5.32	35.78	0.20	0.05	99.02	1.11	4.33	99.37
JAG 84-524 grain-H2	56.86	bdl	0.72	0.21	5.19	35.96	0.20	0.04	99.18	1.07	4.22	99.51
JAG 84-524 grain-H3	56.75	bdl	0.73	0.20	5.33	36.01	0.20	0.05	99.27	1.10	4.34	99.59
JAG 84-524 grain-H4	56.93	bdl	0.72	0.23	5.22	36.02	0.21	0.04	99.37	1.06	4.27	99.64
JAG 84-524 grain-H5	56.90	bdl	0.72	0.29	5.29	36.04	0.22	0.08	99.54	1.10	4.30	99.87
JAG 84-524 grain-H6	56.95	bdl	0.71	0.23	5.56	36.04	0.21	0.06	99.76	1.13	4.54	100.10
JAG 84-524 grain-H7	57.08	bdl	0.69	0.21	5.35	36.12	0.22	0.05	99.72	1.16	4.31	100.04

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-H8	56.77	bdl	0.73	0.25	5.30	35.96	0.18	0.07	99.26	1.10	4.32	99.59
JAG 84-524 grain-H9	56.74	bdl	0.73	0.28	5.30	36.00	0.20	0.07	99.32	1.06	4.34	99.58
JAG 84-524 grain-H10	56.69	bdl	0.77	0.30	5.26	35.96	0.19	0.08	99.25	1.01	4.36	99.58
JAG 84-524 grain-H11	56.89	bdl	0.72	0.20	5.23	35.95	0.19	0.07	99.25	1.16	4.18	99.57
JAG 84-524 grain-H AVG	56.85	bdl	0.72	0.24	5.30	35.99	0.20	0.06	99.36	1.10	4.32	99.68
JAG 84-524 ALL AVG	57.23	bdl	0.72	0.24	5.28	35.65	0.23	0.06	99.42	1.29	4.12	99.73
JAG 84-553 grain-A1	57.69	bdl	0.68	0.14	4.55	36.17	0.19	0.04	99.46	0.67	3.95	99.64
JAG 84-553 grain-A2	57.95	bdl	0.68	0.18	4.40	36.14	0.24	0.06	99.65	0.20	4.22	99.76
JAG 84-553 grain-A3	57.65	bdl	0.67	0.19	4.54	36.37	0.16	0.06	99.63	1.26	3.40	99.97
JAG 84-553 grain-A4	57.46	bdl	0.73	0.20	4.35	35.81	0.71	0.07	99.33	1.06	3.40	99.68
JAG 84-553 grain-A5	57.56	bdl	0.78	0.29	4.10	35.38	1.34	0.10	99.56	0.73	3.45	99.76
JAG 84-553 grain-A6	57.82	bdl	0.68	0.20	4.35	36.45	0.15	0.03	99.69	0.83	3.61	99.99
JAG 84-553 grain-A7	57.61	bdl	0.70	0.17	4.52	36.36	0.16	0.00	99.52	0.96	3.65	99.84
JAG 84-553 grain-A8	57.91	bdl	0.69	0.19	4.43	36.34	0.17	0.03	99.75	0.36	4.11	99.79
JAG 84-553 grain-A9	57.94	bdl	0.72	0.16	4.44	36.38	0.18	0.03	99.85	0.60	3.90	100.10
JAG 84-553 grain-A10	57.76	bdl	0.70	0.18	4.44	36.11	0.17	0.00	99.36	0.00	4.44	99.36
JAG 84-553 grain-A AVG	57.74	bdl	0.70	0.19	4.41	36.15	0.35	0.04	99.58	0.66	3.82	99.79
JAG 84-553 grain-B1	57.65	bdl	0.70	0.19	4.53	36.30	0.19	0.04	99.59	1.01	3.62	99.89
JAG 84-553 grain-B2	57.50	bdl	0.69	0.19	4.49	36.19	0.19	0.04	99.29	0.76	3.81	99.37
JAG 84-553 grain-B3	57.50	bdl	0.67	0.27	4.44	36.35	0.18	0.04	99.45	1.11	3.45	99.65

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-553 grain-B4	57.96	bdl	0.66	0.19	4.53	36.24	0.14	0.03	99.75	0.27	4.29	99.87
JAG 84-553 grain-B5	57.99	bdl	0.69	0.13	4.47	36.33	0.17	0.03	99.81	0.54	3.98	100.13
JAG 84-553 grain-B6	57.34	bdl	0.68	0.17	4.33	36.36	0.18	0.03	99.09	1.19	3.26	99.34
JAG 84-553 grain-B7	58.01	bdl	0.71	0.20	4.33	36.37	0.16	0.04	99.83	0.33	4.03	99.97
JAG 84-553 grain-B8	58.12	bdl	0.70	0.22	4.40	36.35	0.16	0.05	100.00	0.30	4.13	100.16
JAG 84-553 grain-B9	58.09	bdl	0.70	0.22	4.40	36.57	0.17	0.04	100.18	0.67	3.79	100.34
JAG 84-553 grain-B AVG	57.79	bdl	0.69	0.20	4.44	36.34	0.17	0.04	99.67	0.69	3.82	99.86
JAG 84-553 grain-C1	57.92	bdl	0.69	0.20	4.36	36.16	0.16	0.03	99.52	0.09	4.28	99.73
JAG 84-553 grain-C2	57.89	bdl	0.73	0.26	4.19	35.71	0.74	0.05	99.57	0.00	4.19	99.57
JAG 84-553 grain-C3	58.04	bdl	0.66	0.20	4.34	36.07	0.20	0.06	99.57	0.00	4.34	99.78
JAG 84-553 grain-C4	58.03	bdl	0.68	0.24	4.32	36.20	0.20	0.04	99.72	0.03	4.30	99.82
JAG 84-553 grain-C5	58.00	bdl	0.68	0.23	4.45	36.20	0.19	0.00	99.74	0.01	4.44	99.88
JAG 84-553 grain-C6	57.22	bdl	0.84	0.36	4.04	34.64	2.28	0.16	99.53	1.25	2.91	99.77
JAG 84-553 grain-C7	57.88	bdl	0.69	0.23	4.38	36.25	0.20	0.04	99.67	0.38	4.04	99.82
JAG 84-553 grain-C8	57.90	bdl	0.70	0.21	4.59	36.22	0.19	0.04	99.84	0.49	4.16	99.97
JAG 84-553 grain-C9	57.85	bdl	0.66	0.19	4.39	36.27	0.18	0.02	99.55	0.32	4.10	99.68
JAG 84-553 grain-C10	58.13	bdl	0.64	0.19	4.40	36.22	0.16	0.03	99.77	0.03	4.37	100.02
JAG 84-553 grain-C11	57.73	bdl	0.70	0.27	4.34	36.16	0.19	0.04	99.43	0.37	4.01	99.61
JAG 84-553 grain-C12	57.52	bdl	0.66	0.25	4.41	36.02	0.25	0.05	99.16	0.55	3.92	99.30
JAG 84-553 grain-C13	57.65	bdl	0.65	0.24	4.58	36.13	0.17	0.00	99.42	0.41	4.20	99.56

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-553 grain-C14	57.61	bdl	0.73	0.26	4.40	35.75	0.87	0.04	99.66	0.61	3.86	99.72
JAG 84-553 grain-C15	57.60	bdl	0.72	0.29	4.39	35.53	1.13	0.08	99.73	0.86	3.62	99.94
JAG 84-553 grain-C16	57.77	bdl	0.71	0.24	4.48	36.11	0.37	0.07	99.74	0.61	3.93	99.80
JAG 84-553 grain-C17	58.14	bdl	0.67	0.23	4.35	36.33	0.19	0.04	99.93	0.24	4.13	100.18
JAG 84-553 grain-C18	57.73	bdl	0.77	0.30	4.11	34.86	1.94	0.10	99.81	0.41	3.74	100.03
JAG 84-553 grain-C19	57.49	bdl	0.74	0.20	4.47	35.41	0.85	0.07	99.22	0.36	4.14	99.35
JAG 84-553 grain-C20	57.97	bdl	0.72	0.19	4.48	36.21	0.15	0.04	99.76	0.22	4.29	99.90
JAG 84-553 grain-C21	57.96	bdl	0.67	0.17	4.62	36.31	0.16	0.03	99.91	0.63	4.05	100.19
JAG 84-553 grain-C22	57.49	bdl	0.82	0.36	4.10	34.42	2.62	0.15	99.96	1.09	3.12	100.29
JAG 84-553 grain-C23	57.65	bdl	0.72	0.21	4.42	35.68	0.81	0.07	99.56	0.60	3.89	99.70
JAG 84-553 grain-C24	57.87	bdl	0.68	0.18	4.31	35.68	0.40	0.06	99.18	0.00	4.31	99.28
JAG 84-553 grain-C25	58.00	bdl	0.69	0.15	4.64	36.20	0.20	0.06	99.93	0.52	4.17	100.10
JAG 84-553 grain-C26	57.83	bdl	0.69	0.21	4.36	36.33	0.18	0.03	99.64	0.57	3.85	99.84
JAG 84-553 grain-C27	57.67	bdl	0.73	0.18	4.35	36.06	0.25	0.04	99.28	0.34	4.05	99.43
JAG 84-553 grain-C28	57.84	bdl	0.72	0.19	4.47	36.32	0.18	0.06	99.78	0.74	3.81	99.98
JAG 84-553 grain-C29	57.71	bdl	0.74	0.22	4.45	35.83	0.61	0.07	99.63	0.75	3.78	99.96
JAG 84-553 grain-C30	57.70	bdl	0.71	0.19	4.43	36.07	0.20	0.03	99.33	0.29	4.17	99.48
JAG 84-553 grain-C31	57.87	bdl	0.72	0.23	4.42	36.20	0.15	0.02	99.62	0.04	4.38	99.63
JAG 84-553 grain-C32	57.47	bdl	0.74	0.32	4.13	34.89	1.63	0.11	99.30	0.44	3.73	99.54
JAG 84-553 grain-C33	56.72	bdl	0.93	0.47	3.50	31.09	6.55	0.31	99.57	1.13	2.48	99.78

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG 84-553 grain-C34	57.79	bdl	0.68	0.21	4.43	36.19	0.17	0.04	99.50	0.41	4.07	99.66
JAG 84-553 grain-C35	57.53	bdl	0.74	0.28	4.43	35.28	1.43	0.10	99.79	0.93	3.59	99.88
JAG 84-553 grain-C36	57.78	bdl	0.66	0.23	4.38	36.03	0.22	0.04	99.33	0.24	4.17	99.60
JAG 84-553 grain-C37	57.76	bdl	0.65	0.18	4.44	36.19	0.18	0.02	99.42	0.21	4.25	99.44
JAG 84-553 grain-C38	57.93	bdl	0.69	0.20	4.34	36.29	0.16	0.04	99.65	0.30	4.07	99.79
JAG 84-553 grain-C39	57.79	bdl	0.72	0.17	4.53	36.00	0.27	0.06	99.54	0.33	4.23	99.65
JAG 84-553 grain-C40	57.56	bdl	0.73	0.19	4.34	36.23	0.17	0.07	99.28	0.91	3.52	99.56
JAG 84-553 grain-C41	57.86	bdl	0.68	0.18	4.54	36.45	0.17	0.04	99.90	1.02	3.62	100.22
JAG 84-553 grain-C42	57.86	bdl	0.73	0.25	4.47	35.41	1.08	0.09	99.88	0.50	4.02	100.17
JAG 84-553 grain-C43	57.72	bdl	0.68	0.21	4.38	36.02	0.45	0.06	99.52	0.71	3.74	99.81
JAG 84-553 grain-C44	57.99	bdl	0.69	0.19	4.33	36.09	0.20	0.04	99.53	0.00	4.33	99.65
JAG 84-553 grain-C45	57.92	bdl	0.70	0.25	4.45	36.01	0.29	0.04	99.65	0.03	4.42	99.75
JAG 84-553 grain-C46	57.87	bdl	0.71	0.26	4.31	35.61	0.78	0.06	99.60	0.01	4.30	99.74
JAG 84-553 grain-C47	57.90	bdl	0.68	0.22	4.44	36.15	0.25	0.07	99.70	0.44	4.04	99.86
JAG 84-553 grain-C48	58.04	bdl	0.74	0.27	4.37	35.78	0.65	0.09	99.93	0.07	4.30	100.03
JAG 84-553 grain-C49	58.11	bdl	0.72	0.17	4.51	36.41	0.15	0.05	100.11	0.37	4.17	100.15
JAG 84-553 grain-C50	57.77	bdl	0.69	0.19	4.39	36.25	0.18	0.00	99.48	0.43	4.00	99.74
JAG 84-553 grain-C AVG	57.78	bdl	0.71	0.23	4.37	35.84	0.63	0.06	99.62	0.41	4.01	99.79
JAG 84-553 ALL AVG	57.77	bdl	0.70	0.21	4.41	36.11	0.38	0.05	99.62	0.59	3.88	99.81
JAG-228 grain-A1	58.50	bdl	0.75	0.26	4.16	36.54	0.20	0.05	100.46	0.00	4.16	100.55

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG-228 grain-A2	58.58	bdl	0.76	0.27	4.15	36.63	0.18	0.04	100.60	0.00	4.15	100.69
JAG-228 grain-A3	58.74	bdl	0.81	0.28	4.19	36.71	0.19	0.03	100.95	0.00	4.19	101.06
JAG-228 grain-A4	58.29	bdl	0.82	0.31	4.20	36.46	0.20	0.06	100.35	0.14	4.07	100.44
JAG-228 grain-A5	58.20	bdl	0.84	0.31	4.14	36.75	0.18	0.04	100.47	0.67	3.54	100.64
JAG-228 grain-A6	58.73	bdl	0.85	0.28	4.03	36.52	0.19	0.06	100.65	0.00	4.03	100.77
JAG-228 grain-A7	58.24	bdl	0.84	0.24	4.18	36.73	0.18	0.05	100.46	0.61	3.63	100.60
JAG-228 grain-A8	58.78	bdl	0.77	0.27	4.05	36.75	0.16	0.07	100.84	0.00	4.05	100.92
JAG-228 grain-A9	58.57	bdl	0.74	0.25	4.10	36.67	0.16	0.05	100.53	0.00	4.10	100.61
JAG-228 grain-A10	57.96	bdl	0.72	0.23	4.09	37.01	0.20	0.04	100.25	1.46	2.78	100.50
JAG-228 grain-A AVG	58.46	bdl	0.79	0.27	4.13	36.68	0.19	0.05	100.56	0.18	3.97	100.67
JAG-228 grain-B1	58.78	bdl	0.75	0.24	4.19	36.91	0.19	0.03	101.09	0.22	3.98	101.22
JAG-228 grain-B2	58.64	bdl	0.73	0.27	4.11	36.89	0.16	0.08	100.87	0.45	3.70	101.01
JAG-228 grain-B3	59.04	bdl	0.73	0.22	4.06	36.70	0.19	0.06	101.00	0.00	4.06	101.10
JAG-228 grain-B4	58.92	bdl	0.77	0.25	4.06	36.80	0.20	0.05	101.04	0.00	4.06	101.13
JAG-228 grain-B5	58.94	bdl	0.77	0.25	4.14	36.83	0.18	0.07	101.19	0.00	4.14	101.28
JAG-228 grain-B6	58.56	bdl	0.78	0.26	3.96	36.75	0.19	0.05	100.55	0.02	3.95	100.65
JAG-228 grain-B7	58.48	bdl	0.82	0.25	4.24	36.72	0.19	0.03	100.73	0.19	4.07	100.75
JAG-228 grain-B8	58.55	bdl	0.81	0.29	4.15	36.74	0.19	0.03	100.76	0.13	4.03	100.87
JAG-228 grain-B9	58.38	bdl	0.84	0.31	4.16	36.75	0.19	0.06	100.68	0.51	3.70	100.80
JAG-228 grain-B10	58.54	bdl	0.89	0.30	4.02	36.62	0.16	0.02	100.56	0.00	4.02	100.68

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG-228 grain-B11	58.30	bdl	0.87	0.29	4.14	36.77	0.18	0.05	100.59	0.46	3.73	100.64
JAG-228 grain-B12	58.69	bdl	0.87	0.31	4.23	36.54	0.20	0.06	100.91	0.00	4.23	101.04
JAG-228 grain-B13	58.49	bdl	0.89	0.32	4.18	36.88	0.18	0.07	101.01	0.70	3.56	101.18
JAG-228 grain-B14	58.75	bdl	0.88	0.34	4.17	36.64	0.20	0.05	101.03	0.00	4.17	101.13
JAG-228 grain-B15	58.48	bdl	0.87	0.34	4.12	36.55	0.17	0.07	100.60	0.00	4.11	100.70
JAG-228 grain-B16	58.74	bdl	0.85	0.25	4.23	36.62	0.19	0.07	100.96	0.00	4.23	101.06
JAG-228 grain-B17	58.49	bdl	0.85	0.26	4.26	36.62	0.16	0.07	100.70	0.23	4.05	100.82
JAG-228 grain-B18	58.72	bdl	0.83	0.25	4.15	36.73	0.18	0.07	100.92	0.08	4.08	101.05
JAG-228 grain-B19	58.85	bdl	0.78	0.24	4.14	36.68	0.19	0.05	100.92	0.00	4.14	101.06
JAG-228 grain-B20	57.84	bdl	0.74	0.23	4.25	37.01	0.18	0.07	100.31	1.92	2.53	100.63
JAG-228 grain-B AVG	58.61	bdl	0.81	0.27	4.15	36.74	0.18	0.06	100.82	0.15	4.01	100.93
JAG-228 grain-C1	58.11	bdl	0.78	0.30	4.11	36.88	0.17	0.04	100.39	0.98	3.24	100.59
JAG-228 grain-C2	58.89	bdl	0.82	0.27	3.98	36.79	0.16	0.04	100.95	0.00	3.98	101.08
JAG-228 grain-C3	58.48	bdl	0.81	0.27	4.16	36.96	0.18	0.05	100.91	0.66	3.57	100.98
JAG-228 grain-C4	58.65	bdl	0.81	0.28	4.21	36.77	0.19	0.05	100.96	0.21	4.03	101.06
JAG-228 grain-C5	58.62	bdl	0.80	0.23	4.18	36.89	0.19	0.05	100.96	0.46	3.77	101.10
JAG-228 grain-C6	58.81	bdl	0.78	0.23	4.07	36.77	0.16	0.04	100.87	0.00	4.07	100.98
JAG-228 grain-C7	58.54	bdl	0.73	0.26	4.28	36.81	0.21	0.05	100.87	0.60	3.74	101.08
JAG-228 grain-C8	59.24	bdl	0.75	0.21	4.11	36.69	0.17	0.04	101.22	0.00	4.11	101.30
JAG-228 grain-C9	58.39	bdl	0.76	0.26	4.17	36.79	0.16	0.04	100.58	0.49	3.73	100.72

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
JAG-228 grain-C10	59.17	bdl	0.76	0.25	4.03	37.28	0.17	0.03	101.68	0.28	3.78	101.86
JAG-228 grain-C AVG	58.69	bdl	0.78	0.25	4.13	36.86	0.18	0.04	100.94	0.22	3.94	101.06
JAG-228 grain-D1	58.41	bdl	0.72	0.21	4.14	36.65	0.17	0.08	100.39	0.38	3.80	100.55
JAG-228 grain-D2	58.18	bdl	0.79	0.25	4.16	36.71	0.21	0.04	100.34	0.66	3.57	100.51
JAG-228 grain-D3	58.43	bdl	0.81	0.20	3.97	36.71	0.18	0.06	100.35	0.14	3.84	100.44
JAG-228 grain-D4	58.04	bdl	0.85	0.21	4.06	36.53	0.18	0.05	99.93	0.40	3.70	100.08
JAG-228 grain-D5	58.69	bdl	0.86	0.21	4.20	36.61	0.17	0.07	100.81	0.00	4.20	100.90
JAG-228 grain-D6	58.71	bdl	0.89	0.26	4.11	36.44	0.18	0.05	100.63	0.00	4.11	100.73
JAG-228 grain-D7	58.74	bdl	0.87	0.24	4.30	36.64	0.18	0.06	101.02	0.00	4.31	101.15
JAG-228 grain-D8	58.70	bdl	0.85	0.30	4.09	36.71	0.17	0.06	100.87	0.00	4.09	100.96
JAG-228 grain-D9	58.52	bdl	0.79	0.27	4.11	36.90	0.18	0.05	100.82	0.58	3.58	101.01
JAG-228 grain-D10	57.64	bdl	0.74	0.19	4.19	36.89	0.16	0.06	99.87	1.81	2.57	100.18
JAG-228 grain-D AVG	58.41	bdl	0.82	0.23	4.13	36.68	0.18	0.06	100.50	0.31	3.85	100.64
JAG 228 ALL AVG	58.54	bdl	0.80	0.26	4.13	36.74	0.18	0.05	100.70	0.22	3.94	100.82
K7269 grain-A1	58.14	bdl	0.69	0.15	4.47	36.11	0.16	0.03	99.75	0.00	4.47	99.96
K7269 grain-A2	58.55	bdl	0.69	0.18	4.57	36.54	0.17	0.03	100.74	0.32	4.29	101.01
K7269 grain-A3	58.17	bdl	0.68	0.17	4.41	36.25	0.18	0.02	99.88	0.00	4.41	100.09
K7269 grain-A4	58.28	bdl	0.72	0.19	4.46	36.11	0.19	0.03	99.98	0.00	4.46	99.98
K7269 grain-A5	58.40	bdl	0.72	0.22	4.58	36.47	0.18	0.03	100.59	0.24	4.36	100.69
K7269 grain-A6	58.44	bdl	0.67	0.15	4.41	36.35	0.16	bdl	100.19	0.00	4.41	100.42

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7269 grain-A7	58.46	bdl	0.70	0.24	4.48	36.47	0.16	0.03	100.53	0.18	4.32	100.77
K7269 grain-A8	58.74	bdl	0.69	0.18	4.57	36.67	0.17	0.04	101.04	0.34	4.27	101.30
K7269 grain-A9	58.48	bdl	0.71	0.18	4.53	36.32	0.17	0.03	100.41	0.00	4.53	100.64
K7269 grain-A AVG	58.30	bdl	0.72	0.20	4.49	36.13	0.46	0.05	100.35	0.17	4.34	100.53
K7269 grain-B1	59.06	bdl	0.70	0.18	4.50	36.72	0.16	bdl	101.31	0.00	4.50	101.31
K7269 grain-B2	58.11	bdl	0.68	0.15	4.42	36.32	0.20	0.04	99.92	0.23	4.21	100.04
K7269 grain-B3	58.22	bdl	0.71	0.15	4.45	36.44	0.18	bdl	100.16	0.15	4.32	100.28
K7269 grain-B4	58.16	bdl	0.74	0.19	4.55	36.19	0.39	0.04	100.25	0.20	4.37	100.27
K7269 grain-B5	57.78	bdl	0.65	0.18	4.43	36.56	0.16	bdl	99.75	0.91	3.62	99.94
K7269 grain-B6	58.01	bdl	0.54	0.12	5.27	36.01	0.21	bdl	100.16	0.68	4.66	100.48
K7269 grain-B7	58.03	bdl	0.79	0.24	4.26	34.87	1.96	0.12	100.26	0.21	4.07	100.36
K7269 grain-B8	58.11	bdl	0.71	0.22	4.47	36.44	0.17	bdl	100.12	0.31	4.19	100.28
K7269 grain-B9	58.01	bdl	0.75	0.28	4.33	35.20	1.64	0.06	100.27	0.27	4.09	100.44
K7269 grain-B10	58.11	bdl	0.69	0.19	4.43	36.11	0.17	bdl	99.70	0.00	4.43	99.78
K7269 grain-B AVG	58.16	bdl	0.70	0.19	4.51	36.08	0.52	0.03	100.19	0.20	4.33	100.31
K7269 grain-C1	57.33	bdl	0.70	0.15	4.56	36.83	0.16	0.03	99.75	1.17	3.52	100.00
K7269 grain-C2	58.41	bdl	0.69	0.19	4.51	36.55	0.17	0.03	100.54	0.27	4.27	100.65
K7269 grain-C3	58.29	bdl	0.68	0.17	4.35	36.47	0.18	0.03	100.16	0.11	4.25	100.26
K7269 grain-C4	58.07	bdl	0.66	0.22	4.68	36.60	0.21	bdl	100.44	1.07	3.72	100.74
K7269 grain-C5	57.89	bdl	0.67	0.24	4.45	36.53	0.18	bdl	99.97	0.71	3.81	100.09

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7269 grain-C6	57.90	bdl	0.69	0.16	4.46	36.54	0.16	bdl	99.91	0.77	3.77	100.10
K7269 grain-C7	58.32	bdl	0.68	0.21	4.55	36.46	0.15	bdl	100.37	0.13	4.43	100.50
K7269 grain-C8	58.50	bdl	0.66	0.25	4.61	36.59	0.21	bdl	100.81	0.38	4.26	101.06
K7269 grain-C9	57.86	bdl	0.67	0.18	4.52	36.49	0.17	0.02	99.90	0.89	3.72	100.10
K7269 grain-C10	58.31	bdl	0.69	0.16	4.58	36.51	0.15	0.03	100.43	0.42	4.20	100.58
K7269 grain-C AVG	58.09	bdl	0.68	0.19	4.53	36.56	0.17	bdl	100.23	0.71	3.89	100.42
K7269 grain-D1	57.91	bdl	0.70	0.15	4.57	36.63	0.16	bdl	100.12	1.15	3.54	100.45
K7269 grain-D2	58.20	bdl	0.68	0.19	4.49	36.73	0.18	bdl	100.46	0.77	3.79	100.65
K7269 grain-D3	58.20	bdl	0.67	0.21	4.41	36.41	0.16	bdl	100.07	0.03	4.38	100.17
K7269 grain-D4	58.31	bdl	0.68	0.20	4.55	36.52	0.15	bdl	100.41	0.27	4.31	100.56
K7269 grain-D5	58.32	bdl	0.70	0.17	4.54	36.45	0.17	0.03	100.36	0.24	4.32	100.49
K7269 grain-D6	58.03	bdl	0.68	0.18	4.48	36.53	0.17	bdl	100.06	0.60	3.94	100.25
K7269 grain-D7	58.04	bdl	0.68	0.17	4.51	36.58	0.20	bdl	100.18	0.78	3.81	100.39
K7269 grain-D8	58.41	bdl	0.69	0.19	4.47	36.39	0.16	0.04	100.34	0.06	4.42	100.53
K7269 grain-D9	58.13	bdl	0.67	0.20	4.62	36.57	0.18	bdl	100.36	0.70	3.99	100.54
K7269 grain-D10	57.97	bdl	0.69	0.19	4.37	36.20	0.18	bdl	99.59	0.00	4.37	99.79
K7269 grain-D AVG	58.15	bdl	0.68	0.18	4.50	36.50	0.17	bdl	100.20	0.46	4.09	100.38
K7269 ALL AVG	58.18	bdl	0.69	0.19	4.51	36.32	0.33	bdl	100.24	0.00	4.51	100.37
K7311 grain-A1	59.29	bdl	0.74	0.20	5.08	35.05	0.34	0.08	100.78	0.00	5.08	100.97
K7311 grain-A2	58.20	bdl	0.75	0.20	5.09	35.67	0.21	0.05	100.17	0.00	5.09	100.28

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-A3	58.13	bdl	0.78	0.23	5.02	35.53	0.41	0.07	100.16	0.00	5.02	100.42
K7311 grain-A4	57.69	bdl	0.73	0.28	5.15	36.12	0.23	0.03	100.22	1.31	3.97	100.57
K7311 grain-A5	58.58	bdl	0.76	0.20	5.10	35.88	0.31	0.06	100.88	0.00	5.10	100.97
K7311 grain-A6	58.59	bdl	0.73	0.19	5.24	35.78	0.19	0.06	100.78	0.00	5.24	100.78
K7311 grain-A7	58.22	bdl	0.70	0.19	5.15	35.85	0.19	0.05	100.36	0.02	5.13	100.46
K7311 grain-A8	57.66	bdl	0.70	0.23	5.18	35.58	0.45	0.07	99.87	0.75	4.51	100.04
K7311 grain-A9	58.56	bdl	0.69	0.21	5.29	35.46	0.19	0.05	100.45	0.00	5.29	100.55
K7311 grain-A10	57.58	bdl	0.70	0.21	5.19	36.15	0.19	0.04	100.06	1.12	4.18	100.29
K7311 grain-A AVG	58.25	bdl	0.73	0.21	5.15	35.71	0.27	0.06	100.37	0.00	5.15	100.50
K7311 grain-B1	57.97	bdl	0.68	0.18	5.33	34.86	0.17	0.05	99.23	0.00	5.33	99.34
K7311 grain-B2	57.89	bdl	0.72	0.26	5.18	36.04	0.20	0.06	100.33	0.94	4.33	100.55
K7311 grain-B3	57.79	bdl	0.90	0.26	5.05	35.39	0.73	0.12	100.25	0.68	4.44	100.41
K7311 grain-B4	57.76	bdl	1.05	0.42	4.80	34.47	1.65	0.18	100.32	0.24	4.58	100.45
K7311 grain-B5	58.20	bdl	0.83	0.29	5.26	35.86	0.18	0.06	100.67	0.21	5.07	100.79
K7311 grain-B6	58.02	bdl	0.83	0.25	5.05	36.16	0.19	0.05	100.54	0.79	4.34	100.72
K7311 grain-B7	58.09	bdl	0.76	0.27	5.01	36.52	0.17	0.02	100.85	1.24	3.90	101.10
K7311 grain-B AVG	57.96	bdl	0.82	0.27	5.10	35.61	0.47	0.08	100.31	0.38	4.76	100.46
K7311 grain-C1	57.56	bdl	0.70	0.23	5.04	35.95	0.18	0.03	99.70	0.74	4.37	99.77
K7311 grain-C2	57.57	bdl	0.73	0.25	5.09	35.90	0.18	0.04	99.77	0.81	4.36	99.93
K7311 grain-C3	57.97	bdl	0.73	0.30	5.02	35.75	0.20	0.05	100.01	0.00	5.02	100.11

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-C4	58.01	bdl	0.75	0.29	4.95	35.89	0.17	0.05	100.10	0.20	4.76	100.31
K7311 grain-C5	58.12	bdl	0.76	0.22	5.15	35.90	0.20	0.07	100.40	0.22	4.95	100.42
K7311 grain-C6	58.35	bdl	0.75	0.30	4.98	35.62	0.18	0.03	100.21	0.00	4.98	100.33
K7311 grain-C7	58.21	bdl	0.74	0.25	4.90	35.92	0.20	0.04	100.26	0.00	4.90	100.46
K7311 grain-C8	58.05	bdl	0.75	0.23	5.07	35.77	0.15	0.03	100.05	0.00	5.07	100.25
K7311 grain-C9	57.71	bdl	0.70	0.21	5.03	35.95	0.16	0.03	99.77	0.59	4.50	99.93
K7311 grain-C10	58.72	bdl	0.72	0.18	5.14	35.56	0.20	0.06	100.57	0.00	5.14	100.66
K7311 grain-C AVG	58.03	bdl	0.73	0.24	5.04	35.82	0.18	0.04	100.08	0.04	5.00	100.19
K7311 grain-D1	57.56	bdl	0.70	0.23	5.04	35.95	0.18	0.03	99.70	0.74	4.37	99.77
K7311 grain-D2	57.57	bdl	0.73	0.25	5.09	35.90	0.18	0.04	99.77	0.81	4.36	99.93
K7311 grain-D3	57.97	bdl	0.73	0.30	5.02	35.75	0.20	0.05	100.01	0.00	5.02	100.11
K7311 grain-D4	58.01	bdl	0.75	0.29	4.95	35.89	0.17	0.05	100.10	0.20	4.76	100.31
K7311 grain-D5	58.12	bdl	0.76	0.22	5.15	35.90	0.20	0.07	100.40	0.22	4.95	100.42
K7311 grain-D6	58.35	bdl	0.75	0.30	4.98	35.62	0.18	0.03	100.21	0.00	4.98	100.33
K7311 grain-D7	58.21	bdl	0.74	0.25	4.90	35.92	0.20	0.04	100.26	0.00	4.90	100.46
K7311 grain-D8	58.05	bdl	0.75	0.23	5.07	35.77	0.15	0.03	100.05	0.00	5.07	100.25
K7311 grain-D9	57.71	bdl	0.70	0.21	5.03	35.95	0.16	0.03	99.77	0.59	4.50	99.93
K7311 grain-D10	58.72	bdl	0.72	0.18	5.14	35.56	0.20	0.06	100.57	0.00	5.14	100.66
K7311 grain-D11	58.03	bdl	0.73	0.24	5.04	35.82	0.18	0.04	100.08	0.04	5.00	100.19
K7311 grain-D12	58.17	bdl	0.75	0.26	4.99	35.83	0.19	0.05	100.24	0.00	4.99	100.37

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-D13	57.93	bdl	0.72	0.23	5.07	35.81	0.18	0.04	99.98	0.15	4.93	100.09
K7311 grain-D14	57.22	bdl	0.69	0.23	5.22	35.99	0.18	0.05	99.57	0.00	5.22	99.69
K7311 grain-D15	56.99	bdl	0.70	0.22	5.01	37.06	0.19	0.02	100.19	1.08	4.04	100.50
K7311 grain-D16	56.81	bdl	0.77	0.25	5.07	36.91	0.20	0.05	100.05	1.01	4.16	100.29
K7311 grain-D17	56.94	bdl	0.78	0.20	5.27	36.94	0.21	0.06	100.38	1.07	4.31	100.62
K7311 grain-D18	57.30	bdl	0.76	0.22	5.06	37.12	0.19	0.04	100.70	1.04	4.13	101.01
K7311 grain-D19	56.58	bdl	0.94	0.34	4.84	34.94	1.81	0.18	99.64	1.73	3.29	99.90
K7311 grain-D20	56.70	bdl	0.85	0.29	5.13	36.79	0.19	0.03	99.98	0.78	4.43	100.27
K7311 grain-D21	56.58	bdl	0.82	0.26	5.18	36.90	0.21	0.05	99.99	0.92	4.35	100.18
K7311 grain-D22	56.28	bdl	0.79	0.27	5.23	36.79	0.19	0.03	99.57	0.89	4.43	99.78
K7311 grain-D23	56.69	bdl	0.78	0.26	5.20	37.17	0.21	0.06	100.37	1.01	4.30	100.58
K7311 grain-D24	57.10	bdl	0.76	0.30	5.17	37.39	0.18	0.06	100.95	1.01	4.26	101.25
K7311 grain-D25	57.44	bdl	0.69	0.21	5.24	35.91	0.19	0.06	99.73	1.17	4.19	99.97
K7311 grain-D26	57.37	bdl	0.79	0.27	5.18	35.74	0.18	0.04	99.56	1.02	4.26	99.91
K7311 grain-D27	57.18	bdl	0.83	0.27	5.33	35.69	0.18	0.05	99.54	1.29	4.17	99.78
K7311 grain-D28	57.22	bdl	0.85	0.32	5.21	35.86	0.20	0.02	99.69	1.33	4.02	99.96
K7311 grain-D29	57.30	bdl	0.76	0.00	5.21	35.79	0.19	0.06	99.31	1.28	4.06	99.57
K7311 grain-D30	57.04	bdl	0.84	0.30	5.15	35.24	0.94	0.12	99.62	1.00	4.25	99.83
K7311 grain-D31	57.82	bdl	0.75	0.27	5.12	35.13	0.66	0.10	99.85	0.01	5.12	99.94
K7311 grain-D32	57.23	bdl	0.70	0.19	5.31	35.60	0.19	0.08	99.29	1.15	4.27	99.48

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-D33	57.39	bdl	0.67	0.18	5.23	35.84	0.19	0.03	99.52	1.14	4.20	99.76
K7311 grain-D34	57.07	bdl	0.69	0.24	5.23	35.89	0.20	0.05	99.36	1.11	4.24	99.48
K7311 grain-D35	56.54	bdl	0.72	0.20	5.35	35.92	0.22	0.05	98.99	1.12	4.34	99.33
K7311 grain-D36	56.92	bdl	0.70	0.15	5.19	36.87	0.20	0.03	100.06	1.15	4.15	100.33
K7311 grain-D37	57.12	bdl	0.72	0.20	5.32	37.17	0.20	0.05	100.78	1.15	4.29	101.01
K7311 grain-D38	56.34	bdl	0.74	0.22	5.31	37.00	0.19	0.05	99.86	1.08	4.34	100.07
K7311 grain-D39	56.73	bdl	0.76	0.29	5.23	36.82	0.20	0.02	100.04	0.90	4.41	100.27
K7311 grain-D40	56.79	bdl	0.77	0.21	5.16	36.91	0.19	0.03	100.05	1.02	4.25	100.33
K7311 grain-D41	56.63	bdl	0.77	0.22	5.28	36.97	0.18	0.05	100.09	1.04	4.34	100.41
K7311 grain-D42	56.54	bdl	0.78	0.21	5.36	36.80	0.19	0.05	99.93	1.04	4.42	100.25
K7311 grain-D43	56.62	bdl	0.81	0.24	5.24	37.08	0.19	0.06	100.23	0.99	4.35	100.56
K7311 grain-D44	56.78	bdl	0.80	0.28	5.11	36.72	0.19	0.05	99.92	0.92	4.28	100.17
K7311 grain-D45	56.80	bdl	0.82	0.23	5.18	36.57	0.20	0.05	99.84	0.94	4.34	100.16
K7311 grain-D46	56.64	bdl	0.81	0.27	5.29	36.87	0.21	0.04	100.12	0.92	4.46	100.46
K7311 grain-D47	56.68	bdl	0.78	0.28	5.30	36.63	0.19	0.04	99.89	0.94	4.45	100.20
K7311 grain-D48	56.85	bdl	0.77	0.22	5.25	37.01	0.19	0.04	100.33	1.02	4.33	100.66
K7311 grain-D49	56.47	bdl	0.73	0.24	5.32	36.72	0.17	0.03	99.68	1.03	4.39	100.00
K7311 grain-D50	57.12	bdl	0.78	0.26	5.32	36.50	0.18	0.07	100.21	1.04	4.38	100.49
K7311 grain-D51	56.72	bdl	0.71	0.20	5.30	36.52	0.18	0.04	99.67	1.12	4.29	99.83
K7311 grain-D52	56.39	bdl	0.72	0.21	5.22	36.70	0.17	0.04	99.44	1.08	4.25	99.72

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-D53	56.46	bdl	0.72	0.24	5.31	36.74	0.19	0.06	99.72	1.10	4.32	100.00
K7311 grain-D54	56.58	bdl	0.74	0.26	5.23	37.23	0.18	0.03	100.25	1.00	4.33	100.61
K7311 grain-D55	57.18	bdl	0.72	0.19	5.21	36.20	0.20	0.04	99.74	1.12	4.20	100.06
K7311 grain-D56	56.65	bdl	0.70	0.20	5.24	37.02	0.20	0.05	100.05	1.16	4.19	100.36
K7311 grain-D57	56.47	bdl	0.73	0.23	5.21	36.80	0.19	0.05	99.66	1.07	4.24	99.94
K7311 grain-D58	56.70	bdl	0.79	0.27	5.24	37.19	0.18	0.05	100.43	0.97	4.37	100.82
K7311 grain-D59	56.48	bdl	0.76	0.26	5.17	36.58	0.35	0.02	99.62	0.93	4.34	99.89
K7311 grain-D60	56.65	bdl	0.84	0.23	5.33	36.31	0.41	0.07	99.84	0.96	4.46	100.06
K7311 grain-D61	56.51	bdl	0.88	0.28	5.14	36.37	0.37	0.03	99.59	1.52	3.77	99.89
K7311 grain-D62	56.20	bdl	0.86	0.26	5.52	36.45	0.43	0.08	99.80	0.92	4.70	100.10
K7311 grain-D63	56.62	bdl	0.86	0.33	5.27	36.96	0.29	0.06	100.38	0.81	4.54	100.67
K7311 grain-D64	56.35	bdl	0.86	0.29	5.41	36.75	0.21	0.03	99.90	0.78	4.71	100.12
K7311 grain-D65	56.53	bdl	0.89	0.36	5.27	36.39	0.66	0.11	100.21	1.64	3.80	100.57
K7311 grain-D66	56.49	bdl	0.86	0.30	5.17	36.25	0.45	0.08	99.61	0.88	4.38	99.94
K7311 grain-D67	56.56	bdl	0.87	0.30	5.19	36.34	0.62	0.09	99.97	0.90	4.38	100.25
K7311 grain-D68	56.54	bdl	0.86	0.33	5.16	36.50	0.42	0.08	99.88	0.86	4.38	100.22
K7311 grain-D69	56.68	bdl	0.81	0.33	5.13	36.76	0.36	0.04	100.10	0.85	4.37	100.39
K7311 grain-D70	56.96	bdl	0.81	0.27	5.19	36.50	0.46	0.05	100.24	0.93	4.35	100.52
K7311 grain-D71	56.60	bdl	0.74	0.22	5.19	36.51	0.39	0.06	99.71	1.10	4.21	99.89
K7311 grain-D72	56.76	bdl	0.71	0.22	5.18	37.40	0.17	0.03	100.46	1.09	4.20	100.77

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-D73	56.44	bdl	0.73	0.29	5.24	36.70	0.19	0.05	99.64	1.02	4.33	99.94
K7311 grain-D74	56.77	bdl	0.75	0.30	5.18	36.64	0.18	0.05	99.87	0.98	4.30	100.20
K7311 grain-D75	57.09	bdl	0.74	0.21	5.17	36.44	0.29	0.05	99.98	2.94	2.53	100.45
K7311 grain-D76	56.74	bdl	0.80	0.29	5.27	36.54	0.35	0.06	100.05	0.94	4.42	100.38
K7311 grain-D77	56.84	bdl	0.75	0.22	5.20	36.67	0.28	0.06	100.01	1.08	4.23	100.31
K7311 grain-D78	56.81	bdl	0.85	0.26	5.06	36.09	1.02	0.11	100.21	1.03	4.13	100.50
K7311 grain-D79	56.89	bdl	0.82	0.27	5.22	36.51	0.61	0.08	100.39	0.99	4.33	100.55
K7311 grain-D80	56.29	bdl	0.96	0.37	4.93	35.27	1.69	0.19	99.70	1.70	3.40	100.06
K7311 grain-D81	56.47	bdl	0.94	0.35	5.15	35.84	1.30	0.17	100.21	1.73	3.60	100.51
K7311 grain-D82	56.54	bdl	0.98	0.34	5.07	35.60	1.46	0.15	100.13	1.60	3.63	100.53
K7311 grain-D83	56.45	bdl	0.94	0.33	5.21	36.24	0.70	0.10	99.98	1.55	3.81	100.29
K7311 grain-D84	56.86	bdl	0.90	0.30	5.16	36.43	0.69	0.08	100.42	1.62	3.70	100.74
K7311 grain-D85	56.56	bdl	0.86	0.27	5.18	36.40	0.44	0.06	99.77	0.85	4.41	99.90
K7311 grain-D86	57.05	bdl	0.88	0.30	5.11	36.79	0.34	0.08	100.55	1.65	3.63	100.88
K7311 grain-D87	56.45	bdl	0.87	0.37	5.23	36.24	0.62	0.10	99.87	0.84	4.48	100.03
K7311 grain-D88	56.70	bdl	0.83	0.28	5.20	36.66	0.18	0.06	99.92	0.89	4.40	100.21
K7311 grain-D89	56.70	bdl	0.82	0.27	5.10	36.53	0.38	0.07	99.87	0.94	4.26	100.16
K7311 grain-D90	56.72	bdl	0.81	0.35	5.26	36.68	0.46	0.07	100.36	0.89	4.46	100.50
K7311 grain-D91	56.84	bdl	0.81	0.29	5.35	36.72	0.37	0.05	100.43	0.92	4.53	100.64
K7311 grain-D92	56.48	bdl	0.72	0.23	5.38	36.33	0.18	0.04	99.37	1.08	4.42	99.67

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-D93	56.83	bdl	0.71	0.23	5.34	36.78	0.18	0.05	100.12	1.11	4.35	100.46
K7311 grain-D94	56.67	bdl	0.73	0.22	5.42	36.80	0.18	0.05	100.07	1.10	4.43	100.35
K7311 grain-D95	56.56	bdl	0.76	0.23	5.24	36.79	0.19	0.07	99.84	1.10	4.25	100.13
K7311 grain-D96	56.92	bdl	0.77	0.26	5.25	36.71	0.21	0.06	100.23	0.95	4.40	100.43
K7311 grain-D97	56.87	bdl	0.80	0.28	5.24	37.06	0.21	0.07	100.53	0.98	4.36	100.86
K7311 grain-D98	56.40	bdl	0.90	0.34	5.33	36.34	0.75	0.13	100.30	1.45	4.02	100.66
K7311 grain-D99	56.82	bdl	0.76	0.25	5.35	36.19	0.20	0.03	99.61	0.96	4.48	99.77
K7311 grain-D100	57.40	bdl	0.77	0.40	5.23	36.99	0.19	0.05	101.02	0.86	4.46	101.16
K7311 grain-D101	56.34	bdl	0.83	0.30	5.35	36.50	0.45	0.07	99.83	0.90	4.54	100.10
K7311 grain-D102	56.52	bdl	0.86	0.32	5.05	36.11	0.63	0.09	99.59	0.87	4.27	99.88
K7311 grain-D103	56.83	bdl	0.89	0.31	5.17	35.95	1.07	0.11	100.32	1.69	3.65	100.56
K7311 grain-D104	56.85	bdl	0.85	0.29	5.23	36.84	0.20	0.04	100.30	0.82	4.49	100.64
K7311 grain-D105	56.83	bdl	0.85	0.24	5.15	36.61	0.19	0.04	99.90	0.88	4.36	100.15
K7311 grain-D106	57.00	bdl	0.87	0.24	5.21	36.74	0.26	0.05	100.36	0.87	4.42	100.70
K7311 grain-D107	56.78	bdl	0.86	0.29	5.20	36.82	0.18	0.04	100.17	0.80	4.48	100.47
K7311 grain-D108	56.81	bdl	0.86	0.33	5.33	36.72	0.33	0.08	100.45	0.87	4.54	100.73
K7311 grain-D109	56.80	bdl	0.83	0.31	5.40	37.07	0.19	0.04	100.64	0.85	4.64	100.90
K7311 grain-D110	56.21	bdl	0.79	0.26	5.39	36.87	0.20	0.05	99.77	0.96	4.53	100.02
K7311 grain-D111	56.62	bdl	0.79	0.28	5.27	36.55	0.20	0.04	99.75	0.92	4.45	99.97
K7311 grain-D112	57.10	bdl	0.76	0.27	5.12	37.02	0.17	0.03	100.46	0.96	4.26	100.73

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-D113	56.79	bdl	0.71	0.24	5.22	36.87	0.19	0.05	100.08	1.10	4.23	100.29
K7311 grain-D114	56.89	bdl	0.76	0.28	5.24	36.70	0.20	0.07	100.14	1.05	4.30	100.48
K7311 grain-D115	56.66	bdl	0.74	0.26	5.29	36.61	0.20	0.06	99.82	1.04	4.36	100.08
K7311 grain-D116	56.72	bdl	0.81	0.24	5.25	36.80	0.36	0.07	100.25	1.02	4.33	100.55
K7311 grain-D117	56.95	bdl	0.80	0.19	5.23	36.84	0.49	0.10	100.58	1.17	4.18	100.88
K7311 grain-D118	56.93	bdl	0.78	0.24	5.33	36.06	0.37	0.05	99.78	0.98	4.45	100.11
K7311 grain-D119	56.77	bdl	0.75	0.24	5.26	36.15	0.19	0.04	99.40	1.00	4.36	99.74
K7311 grain-D120	56.77	bdl	0.77	0.24	5.25	36.99	0.19	0.02	100.24	0.94	4.41	100.55
K7311 grain-D AVG	56.69	bdl	0.82	0.25	5.18	36.46	0.47	0.07	99.94	0.96	4.31	100.28
K7311 grain-E1	56.92	bdl	0.81	0.24	5.21	36.59	0.25	0.05	100.08	0.95	4.36	100.32
K7311 grain-E2	56.91	bdl	0.86	0.28	5.37	36.62	0.20	0.06	100.30	0.86	4.60	100.58
K7311 grain-E3	56.61	bdl	0.86	0.28	5.17	36.95	0.19	0.03	100.08	0.79	4.46	100.39
K7311 grain-E4	56.38	bdl	0.84	0.26	5.28	36.64	0.18	0.04	99.62	0.84	4.53	99.85
K7311 grain-E5	56.86	bdl	0.82	0.22	5.23	36.69	0.20	0.04	100.05	0.92	4.40	100.34
K7311 grain-E6	57.00	bdl	0.85	0.25	5.23	36.85	0.19	0.02	100.39	0.81	4.50	100.66
K7311 grain-E7	56.72	bdl	0.85	0.30	5.14	36.47	0.56	0.07	100.10	0.88	4.35	100.46
K7311 grain-E8	56.50	bdl	0.87	0.28	5.29	36.88	0.19	0.03	100.04	0.78	4.59	100.34
K7311 grain-E9	56.71	bdl	0.76	0.25	5.33	36.82	0.19	0.05	100.10	1.01	4.43	100.38
K7311 grain-E10	56.67	bdl	0.75	0.29	5.26	36.38	0.31	0.07	99.74	1.02	4.35	100.08
K7311 grain-E11	56.74	bdl	0.75	0.22	5.35	37.02	0.18	0.05	100.31	1.09	4.37	100.60

bdl, concentration below detection limit

ORTHOPYROXENE COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	Sum	Fe_2O_3	FeO	Sum
K7311 grain-E12	56.76	bdl	0.80	0.26	5.23	36.55	0.34	0.06	100.00	0.97	4.36	100.27
K7311 grain-E13	57.48	bdl	0.70	0.19	4.92	36.55	0.19	0.04	100.07	1.15	3.88	100.40
K7311 grain-E14	57.74	bdl	0.70	0.15	4.85	36.93	0.19	0.03	100.57	1.19	3.78	100.92
K7311 grain-E15	57.66	bdl	0.67	0.17	4.91	37.06	0.18	0.04	100.69	1.22	3.81	100.95
K7311 grain-E AVG	57.49	bdl	0.68	0.20	4.93	36.80	0.19	0.04	100.33	1.16	3.89	100.62
K7311 ALL AVG	57.70	bdl	0.75	0.24	5.09	36.10	0.29	0.05	100.22	1.34	3.89	100.49

bdl, concentration below detection limit

APPENDIX F

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
X174 grain-A1	40.42	0.22	23.10	bdl	14.75	0.40	14.77	6.08	bdl	99.74	0.83	14.00	99.83
X174 grain-A2	40.59	0.25	23.44	bdl	14.66	0.38	15.38	6.09	bdl	100.79	1.66	13.16	100.96
X174 grain-A3	40.82	0.25	23.64	bdl	14.47	0.37	15.40	6.13	bdl	101.08	1.23	13.36	101.20
X174 grain-A4	40.54	0.27	23.44	bdl	14.58	0.36	15.33	6.27	bdl	100.78	1.76	13.00	100.96
X174 grain-A5	40.45	0.32	23.43	bdl	14.25	0.36	15.22	6.39	bdl	100.42	1.42	12.97	100.56
X174 grain-A6	40.63	0.30	23.55	bdl	14.35	0.41	15.21	6.36	bdl	100.81	1.30	13.18	100.94
X174 grain-A7	40.58	0.29	23.49	bdl	14.62	0.39	15.15	6.37	bdl	100.90	1.57	13.21	101.06
X174 grain-A8	40.56	0.31	23.49	bdl	14.93	0.37	15.12	6.35	bdl	101.12	1.79	13.33	101.30
X174 grain-A9	40.63	0.27	23.44	bdl	14.71	0.38	15.06	6.20	bdl	100.69	1.19	13.64	100.81
X174 grain-A10	40.74	0.26	23.15	bdl	15.01	0.32	14.76	6.14	bdl	100.38	0.61	14.46	100.44
X174 grain-A AVG	40.60	0.27	23.42	bdl	14.63	0.37	15.14	6.24	bdl	100.67	1.34	13.43	100.80
X174 grain-B1	40.62	0.28	23.25	bdl	14.70	0.38	14.73	6.39	bdl	100.35	0.80	13.98	100.43
X174 grain-B2	40.83	0.27	23.40	bdl	14.79	0.35	14.88	6.28	bdl	100.80	0.73	14.14	100.87
X174 grain-B3	40.50	0.27	23.33	bdl	14.86	0.31	14.94	6.30	bdl	100.51	1.32	13.67	100.64
X174 grain-B4	40.76	0.26	23.36	bdl	15.04	0.36	14.95	6.22	bdl	100.94	1.17	13.99	101.06
X174 grain-B5	40.59	0.27	23.50	bdl	15.08	0.34	14.92	6.21	bdl	100.92	1.33	13.89	101.06
X174 grain-B6	40.56	0.26	23.37	bdl	15.05	0.30	14.98	6.25	bdl	100.77	1.46	13.74	100.92
X174 grain-B7	40.81	0.26	23.45	bdl	15.09	0.33	14.93	6.45	bdl	101.32	1.40	13.83	101.46
X174 grain-B8	40.49	0.23	23.42	bdl	15.18	0.33	14.86	6.29	bdl	100.79	1.60	13.74	100.95
X174 grain-B9	40.58	0.25	23.52	bdl	14.84	0.38	14.89	6.45	bdl	100.91	1.42	13.57	101.05
X174 grain-B AVG	40.64	0.26	23.40	bdl	14.96	0.34	14.90	6.32	bdl	100.81	1.25	13.84	100.94

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
X174 grain-C1	41.05	0.31	22.65	bdl	14.97	0.39	15.27	5.71	bdl	100.34	0.59	14.43	100.40
X174 grain-C2	41.02	0.26	23.28	bdl	14.53	0.35	14.95	5.82	bdl	100.21	0.00	14.53	100.21
X174 grain-C3	40.82	0.26	23.55	bdl	14.80	0.36	15.14	6.11	bdl	101.04	1.04	13.87	101.15
X174 grain-C4	40.61	0.25	23.18	bdl	14.44	0.37	14.80	6.14	bdl	99.78	0.30	14.17	99.81
X174 grain-C5	40.79	0.25	23.17	bdl	14.27	0.34	14.87	6.21	bdl	99.91	0.09	14.19	99.92
X174 grain-C6	40.74	0.24	23.09	bdl	14.50	0.38	14.95	6.02	bdl	99.92	0.36	14.17	99.96
X174 grain-C7	40.63	0.23	23.06	bdl	14.40	0.35	15.06	5.92	bdl	99.65	0.42	14.02	99.69
X174 grain-C8	40.69	0.22	23.35	bdl	14.28	0.35	14.66	6.18	bdl	99.72	0.00	14.28	99.72
X174 grain-C9	40.56	0.23	23.13	bdl	14.35	0.32	14.74	6.27	bdl	99.60	0.31	14.08	99.63
X174 grain-C AVG	40.77	0.25	23.16	bdl	14.50	0.36	14.94	6.04	bdl	100.02	0.29	14.25	100.05
X174 grain-D1	40.55	0.33	23.32	bdl	14.06	0.34	14.82	6.10	bdl	99.52	0.00	14.06	99.52
X174 grain-D2	40.32	0.31	23.02	bdl	14.26	0.28	15.10	6.27	bdl	99.55	1.11	13.26	99.66
X174 grain-D3	40.54	0.30	23.19	bdl	14.39	0.34	15.06	5.89	bdl	99.70	0.44	14.00	99.75
X174 grain-D4	40.69	0.30	23.27	bdl	14.27	0.33	15.17	5.89	bdl	99.92	0.29	14.01	99.95
X174 grain-D5	40.49	0.38	23.44	bdl	14.45	0.28	15.55	6.10	bdl	100.69	1.70	12.92	100.86
X174 grain-D6	40.41	0.35	23.10	bdl	14.09	0.32	15.14	6.04	bdl	99.45	0.55	13.59	99.50
X174 grain-D7	40.43	0.34	23.18	bdl	14.35	0.32	15.12	6.08	bdl	99.82	0.86	13.58	99.91
X174 grain-D AVG	40.38	0.34	23.19	bdl	14.44	0.32	15.21	5.99	bdl	99.86	1.07	13.47	99.96
X174 ALL AVG	40.62	0.28	23.30	bdl	14.59	0.35	15.03	6.16	bdl	100.33	0.89	13.79	100.42
JAG 84-524 grain-A1	41.40	bdl	22.22	2.87	9.43	0.60	18.74	5.08	bdl	100.34	0.50	8.98	100.39
JAG 84-524 grain-A2	41.56	bdl	22.29	2.72	9.37	0.55	18.78	4.98	bdl	100.25	0.10	9.28	100.26

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-A3	41.65	bdl	22.12	2.68	9.47	0.56	18.80	5.06	bdl	100.34	0.26	9.24	100.37
JAG 84-524 grain-A4	41.60	bdl	22.36	2.74	9.07	0.65	19.16	4.98	bdl	100.56	0.58	8.55	100.62
JAG 84-524 grain-A5	41.64	bdl	22.22	2.62	8.99	0.65	19.19	5.05	bdl	100.35	0.58	8.47	100.40
JAG 84-524 grain-A6	41.77	bdl	22.19	2.62	9.06	0.68	19.13	5.08	bdl	100.53	0.44	8.67	100.57
JAG 84-524 grain-A7	41.59	bdl	22.16	2.80	8.93	0.67	19.14	5.05	bdl	100.34	0.51	8.47	100.39
JAG 84-524 grain-A8	41.63	bdl	22.34	2.92	9.13	0.60	19.05	4.97	bdl	100.64	0.32	8.84	100.67
JAG 84-524 grain-A9	41.43	bdl	22.36	2.75	8.93	0.58	19.19	5.09	bdl	100.34	0.80	8.21	100.42
JAG 84-524 grain-A AVG	41.59	bdl	22.25	2.75	9.15	0.62	19.02	5.04	bdl	100.41	0.45	8.75	100.45
JAG 84-524 grain-B1	41.50	bdl	22.19	2.74	8.88	0.66	19.02	5.12	bdl	100.11	0.42	8.50	100.15
JAG 84-524 grain-B2	41.42	bdl	22.32	2.83	8.99	0.70	19.14	5.05	bdl	100.44	0.85	8.23	100.53
JAG 84-524 grain-B3	41.70	bdl	22.30	2.72	9.04	0.62	19.20	5.01	bdl	100.59	0.50	8.59	100.64
JAG 84-524 grain-B4	41.54	bdl	22.20	2.82	9.07	0.64	19.15	5.08	bdl	100.50	0.79	8.36	100.58
JAG 84-524 grain-B5	41.60	bdl	22.13	2.81	8.96	0.63	19.25	5.08	bdl	100.45	0.73	8.29	100.52
JAG 84-524 grain-B6	41.50	bdl	22.08	2.65	8.77	0.62	19.17	5.06	bdl	99.85	0.49	8.33	99.90
JAG 84-524 grain-B7	41.53	bdl	22.31	2.77	9.08	0.64	19.19	5.02	bdl	100.53	0.78	8.38	100.61
JAG 84-524 grain-B8	41.65	bdl	22.28	2.82	9.00	0.61	19.17	5.02	bdl	100.54	0.45	8.59	100.59
JAG 84-524 grain-B9	41.40	bdl	22.38	2.67	9.01	0.63	19.13	5.08	bdl	100.30	0.83	8.26	100.38
JAG 84-524 grain-B10	41.41	bdl	22.13	2.68	8.84	0.63	18.85	5.29	bdl	99.82	0.38	8.50	99.86
JAG 84-524 grain-B AVG	41.52	bdl	22.23	2.75	8.96	0.64	19.13	5.08	bdl	100.31	0.62	8.40	100.38
JAG 84-524 grain-C1	41.31	bdl	22.17	2.60	8.94	0.64	19.02	5.09	bdl	99.77	0.69	8.32	99.84
JAG 84-524 grain-C2	41.56	bdl	22.24	2.64	9.17	0.64	19.03	5.16	bdl	100.44	0.72	8.52	100.51

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-C3	41.35	bdl	21.78	2.74	9.11	0.66	19.21	4.83	bdl	99.68	0.86	8.34	99.77
JAG 84-524 grain-C4	41.41	bdl	22.20	2.83	9.16	0.64	19.03	5.07	bdl	100.33	0.79	8.45	100.41
JAG 84-524 grain-C5	41.48	bdl	21.93	3.00	9.22	0.64	18.87	5.15	bdl	100.29	0.56	8.71	100.34
JAG 84-524 grain-C6	41.38	bdl	22.04	3.04	9.34	0.67	18.87	5.09	bdl	100.41	0.77	8.65	100.49
JAG 84-524 grain-C7	41.39	bdl	22.06	2.88	9.31	0.65	18.95	5.22	bdl	100.46	1.06	8.35	100.57
JAG 84-524 grain-C8	41.56	bdl	22.20	2.85	9.24	0.69	19.01	5.14	bdl	100.69	0.80	8.52	100.77
JAG 84-524 grain-C9	41.65	bdl	22.36	2.81	9.06	0.62	19.22	4.98	bdl	100.69	0.57	8.54	100.75
JAG 84-524 grain-C AVG	41.45	bdl	22.11	2.82	9.17	0.65	19.02	5.08	bdl	100.31	0.76	8.49	100.38
JAG 84-524 grain-D1	41.43	bdl	22.27	2.70	9.09	0.60	19.11	5.14	bdl	100.34	0.88	8.29	100.42
JAG 84-524 grain-D2	41.74	bdl	22.41	2.70	8.96	0.63	19.10	5.17	bdl	100.70	0.39	8.60	100.74
JAG 84-524 grain-D3	41.62	bdl	22.28	2.92	9.06	0.65	19.20	5.03	bdl	100.76	0.69	8.44	100.83
JAG 84-524 grain-D4	41.40	bdl	22.25	2.89	8.88	0.66	19.03	5.11	bdl	100.21	0.56	8.38	100.26
JAG 84-524 grain-D5	41.54	bdl	22.08	2.80	8.95	0.63	19.20	5.11	bdl	100.32	0.78	8.25	100.40
JAG 84-524 grain-D6	41.50	bdl	22.43	2.78	9.17	0.63	19.23	5.21	bdl	100.94	1.25	8.05	101.07
JAG 84-524 grain-D7	41.47	bdl	22.40	2.77	8.95	0.64	19.19	5.02	bdl	100.45	0.72	8.29	100.52
JAG 84-524 grain-D8	41.16	bdl	21.75	2.94	9.05	0.63	19.16	4.78	bdl	99.47	0.83	8.30	99.55
JAG 84-524 grain-D9	41.62	bdl	22.22	2.85	9.13	0.67	19.16	5.02	bdl	100.66	0.70	8.50	100.73
JAG 84-524 grain-D10	41.70	bdl	22.42	2.67	9.10	0.65	19.31	5.03	bdl	100.89	0.85	8.34	100.97
JAG 84-524 grain-D AVG	41.52	bdl	22.25	2.80	9.03	0.64	19.17	5.06	bdl	100.47	0.76	8.34	100.55
JAG 84-524 grain-E1	41.06	bdl	21.93	2.99	9.27	0.53	18.69	5.00	bdl	99.47	0.48	8.84	99.52
JAG 84-524 grain-E2	41.00	bdl	22.34	2.70	9.30	0.56	18.93	4.93	bdl	99.76	1.00	8.40	99.86

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-E3	41.03	bdl	22.03	2.80	9.28	0.59	18.86	4.98	bdl	99.57	0.91	8.46	99.66
JAG 84-524 grain-E4	41.33	bdl	22.15	2.74	9.30	0.54	18.79	5.09	bdl	99.94	0.49	8.86	99.99
JAG 84-524 grain-E5	41.28	bdl	22.20	2.74	9.41	0.52	18.84	5.00	bdl	99.99	0.63	8.84	100.05
JAG 84-524 grain-E6	41.14	bdl	22.16	2.89	9.32	0.55	18.85	5.06	bdl	99.97	0.85	8.55	100.06
JAG 84-524 grain-E7	41.03	bdl	22.21	2.69	9.37	0.55	18.86	4.94	bdl	99.65	0.90	8.56	99.74
JAG 84-524 grain-E8	41.31	bdl	22.33	2.73	9.32	0.57	18.90	5.01	bdl	100.17	0.68	8.71	100.24
JAG 84-524 grain-E9	41.29	bdl	22.25	2.70	9.35	0.57	18.89	4.93	bdl	99.98	0.60	8.81	100.04
JAG 84-524 grain-E10	41.32	bdl	22.26	2.74	9.23	0.56	18.89	5.08	bdl	100.08	0.63	8.66	100.14
JAG 84-524 grain-E11	41.69	bdl	22.23	2.68	9.32	0.55	18.86	5.12	bdl	100.45	0.23	9.11	100.47
JAG 84-524 grain-E12	41.32	bdl	22.18	2.73	9.29	0.60	18.90	5.06	bdl	100.08	0.74	8.63	100.15
JAG 84-524 grain-E AVG	41.23	bdl	22.19	2.76	9.31	0.56	18.86	5.02	bdl	99.93	0.68	8.70	99.99
JAG 84-524 grain-F1	41.40	bdl	22.32	2.69	9.22	0.56	18.87	5.06	bdl	100.12	0.45	8.82	100.16
JAG 84-524 grain-F2	41.26	bdl	22.22	2.64	9.35	0.55	18.92	4.98	bdl	99.92	0.75	8.67	100.00
JAG 84-524 grain-F3	41.11	bdl	22.09	2.71	9.35	0.57	18.94	4.99	bdl	99.76	1.03	8.42	99.86
JAG 84-524 grain-F4	41.37	bdl	22.21	2.80	9.34	0.55	18.85	5.09	bdl	100.21	0.61	8.79	100.27
JAG 84-524 grain-F5	41.44	bdl	22.35	2.71	9.25	0.55	18.81	5.01	bdl	100.12	0.23	9.05	100.14
JAG 84-524 grain-F6	41.38	bdl	22.21	2.73	9.65	0.57	18.82	4.99	bdl	100.35	0.77	8.96	100.43
JAG 84-524 grain-F7	41.44	bdl	22.10	2.81	9.69	0.58	18.63	5.14	bdl	100.39	0.58	9.17	100.45
JAG 84-524 grain-F8	41.37	bdl	21.95	3.24	9.75	0.56	18.54	5.13	bdl	100.54	0.52	9.28	100.59
JAG 84-524 grain-F9	41.51	bdl	21.93	3.04	9.65	0.54	18.62	5.16	bdl	100.45	0.40	9.29	100.49
JAG 84-524 grain-F10	41.65	bdl	22.06	2.85	9.59	0.57	18.63	5.08	bdl	100.43	0.09	9.51	100.44

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG 84-524 grain-F AVG	41.39	bdl	22.14	2.82	9.48	0.56	18.76	5.06	bdl	100.23	0.54	9.00	100.28
JAG 84-524 ALL AVG	41.45	bdl	22.20	2.78	9.19	0.61	18.99	5.06	bdl	100.28	0.64	8.61	100.34
JAG 84-553 grain-A1	41.91	bdl	22.62	2.28	7.85	0.60	19.75	5.01	bdl	100.01	0.00	7.85	100.01
JAG 84-553 grain-A2	41.83	bdl	22.32	2.69	8.12	0.55	19.68	5.10	bdl	100.28	0.30	7.84	100.31
JAG 84-553 grain-A3	41.84	bdl	22.38	2.58	8.36	0.60	19.80	4.85	bdl	100.41	0.51	7.90	100.46
JAG 84-553 grain-A4	41.75	bdl	22.38	2.63	8.22	0.58	19.77	4.83	bdl	100.17	0.35	7.91	100.20
JAG 84-553 grain-A5	41.96	bdl	22.29	2.71	8.04	0.62	19.70	4.83	bdl	100.15	0.00	8.04	100.15
JAG 84-553 grain-A6	42.01	bdl	22.37	2.64	8.26	0.63	19.84	4.65	bdl	100.40	0.00	8.26	100.40
JAG 84-553 grain-A7	41.76	bdl	22.33	2.79	8.17	0.60	19.79	4.84	bdl	100.27	0.35	7.86	100.30
JAG 84-553 grain-A8	42.02	bdl	22.27	2.85	8.05	0.60	19.78	4.76	bdl	100.32	0.00	8.05	100.32
JAG 84-553 grain-A9	41.76	bdl	22.48	2.67	8.21	0.63	19.60	4.95	bdl	100.30	0.22	8.01	100.32
JAG 84-553 grain-A10	41.92	bdl	22.32	2.95	7.89	0.62	19.60	5.10	bdl	100.40	0.00	7.89	100.40
JAG 84-553 grain-A AVG	41.88	bdl	22.38	2.68	8.12	0.60	19.73	4.89	bdl	100.27	0.10	8.03	100.28
JAG 84-553 grain-B1	41.86	bdl	22.32	2.70	7.80	0.57	19.64	5.18	bdl	100.07	0.00	7.80	100.07
JAG 84-553 grain-B2	41.93	bdl	22.46	2.48	8.15	0.52	19.61	5.21	bdl	100.36	0.19	7.98	100.38
JAG 84-553 grain-B3	41.83	bdl	22.24	2.61	7.91	0.57	19.43	5.34	bdl	99.92	0.00	7.91	99.92
JAG 84-553 grain-B4	41.80	bdl	22.53	2.29	8.31	0.58	19.12	5.13	bdl	99.75	0.00	8.31	99.75
JAG 84-553 grain-B5	42.01	bdl	22.62	2.39	8.06	0.55	19.65	5.21	bdl	100.50	0.10	7.98	100.50
JAG 84-553 grain-B6	41.95	bdl	22.44	2.40	8.18	0.55	19.57	5.14	bdl	100.22	0.05	8.14	100.23
JAG 84-553 grain-B7	41.92	bdl	22.47	2.64	8.17	0.57	19.57	5.21	bdl	100.55	0.22	7.97	100.57
JAG 84-553 grain-B8	41.89	bdl	22.44	2.51	8.23	0.60	19.62	5.25	bdl	100.53	0.50	7.78	100.58

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG 84-553 grain-B9	42.01	bdl	22.45	2.61	8.17	0.59	19.63	5.05	bdl	100.51	0.00	8.17	100.51
JAG 84-553 grain-B10	42.20	bdl	22.37	2.68	8.16	0.58	19.51	5.12	bdl	100.62	0.00	8.16	100.62
JAG 84-553 grain-B AVG	41.94	bdl	22.43	2.53	8.11	0.57	19.54	5.18	bdl	100.30	0.01	8.11	100.30
JAG 84-553 grain-C1	41.90	bdl	22.66	2.21	8.19	0.59	19.68	5.07	bdl	100.30	0.30	7.92	100.33
JAG 84-553 grain-C2	41.77	bdl	22.24	2.72	7.98	0.63	19.45	5.11	bdl	99.90	0.00	7.98	99.90
JAG 84-553 grain-C3	41.67	bdl	22.34	2.50	8.23	0.63	19.55	5.09	bdl	100.01	0.47	7.81	100.05
JAG 84-553 grain-C4	41.95	bdl	22.44	2.57	8.34	0.60	19.54	5.11	bdl	100.55	0.18	8.18	100.57
JAG 84-553 grain-C5	41.79	bdl	22.38	2.41	8.24	0.60	19.61	5.08	bdl	100.11	0.37	7.90	100.15
JAG 84-553 grain-C6	41.86	bdl	22.13	2.65	8.02	0.61	19.50	5.09	bdl	99.86	0.00	8.02	99.86
JAG 84-553 grain-C7	41.93	bdl	22.30	2.43	8.16	0.62	19.59	5.06	bdl	100.08	0.05	8.11	100.08
JAG 84-553 grain-C8	41.86	bdl	22.25	2.66	8.28	0.58	19.66	4.99	bdl	100.29	0.29	8.02	100.32
JAG 84-553 grain-C9	42.07	bdl	22.49	2.54	7.90	0.57	19.74	5.00	bdl	100.30	0.00	7.90	100.30
JAG 84-553 grain-C10	41.84	bdl	22.53	1.99	8.08	0.58	19.88	4.97	bdl	99.86	0.48	7.65	99.90
JAG 84-553 grain-C AVG	41.86	bdl	22.38	2.47	8.14	0.60	19.62	5.06	bdl	100.13	0.16	8.00	100.14
JAG 84-553 grain-D1	41.40	bdl	22.08	2.63	8.04	0.61	19.48	5.01	bdl	99.25	0.32	7.75	99.28
JAG 84-553 grain-D2	41.68	bdl	22.34	2.62	8.07	0.58	19.62	4.94	bdl	99.84	0.13	7.96	99.85
JAG 84-553 grain-D3	41.80	bdl	22.41	2.51	8.30	0.61	19.68	4.76	bdl	100.08	0.13	8.18	100.09
JAG 84-553 grain-D4	41.85	bdl	22.37	2.48	8.10	0.62	19.67	4.82	bdl	99.92	0.00	8.10	99.92
JAG 84-553 grain-D5	41.78	bdl	22.34	2.68	8.47	0.62	19.59	4.98	bdl	100.46	0.50	8.03	100.51
JAG 84-553 grain-D6	41.53	bdl	22.23	2.59	8.08	0.62	19.55	4.90	bdl	99.49	0.19	7.91	99.51
JAG 84-553 grain-D7	41.95	bdl	22.36	2.62	8.06	0.59	19.57	5.23	bdl	100.38	0.09	7.98	100.39

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG 84-553 grain-D8	41.78	bdl	22.22	2.66	8.27	0.60	19.50	5.14	bdl	100.17	0.30	8.01	100.20
JAG 84-553 grain-D9	41.88	bdl	22.39	2.22	7.84	0.60	19.63	5.22	bdl	99.77	0.04	7.80	99.78
JAG 84-553 grain-D10	42.02	bdl	22.56	2.50	8.08	0.53	19.61	5.28	bdl	100.58	0.09	8.00	100.59
JAG 84-553 grain-D AVG	41.77	bdl	22.33	2.55	8.13	0.60	19.59	5.03	bdl	99.99	0.17	7.98	100.01
JAG 84-553 ALL AVG	41.86	bdl	22.38	2.56	8.13	0.59	19.62	5.04	bdl	100.17	0.11	8.03	100.18
JAG-228 grain-A1	41.75	bdl	22.30	2.80	7.41	0.55	20.55	4.73	bdl	100.08	0.80	6.68	100.16
JAG-228 grain-A2	42.22	bdl	22.47	2.79	7.49	0.56	20.39	4.84	bdl	100.76	0.13	7.37	100.77
JAG-228 grain-A3	42.45	bdl	22.43	2.95	7.43	0.61	20.41	4.76	bdl	101.04	0.00	7.43	101.04
JAG-228 grain-A4	42.53	bdl	22.65	2.69	7.36	0.62	20.57	4.78	bdl	101.20	0.00	7.36	101.20
JAG-228 grain-A5	42.57	bdl	22.42	2.89	7.40	0.53	20.35	4.88	bdl	101.04	0.00	7.40	101.04
JAG-228 grain-A6	42.59	bdl	22.60	2.89	7.56	0.58	20.46	4.86	bdl	101.54	0.00	7.56	101.54
JAG-228 grain-A7	42.45	bdl	22.37	2.86	7.47	0.57	20.41	4.83	bdl	100.95	0.00	7.47	100.95
JAG-228 grain-A8	42.44	bdl	22.36	2.86	7.42	0.59	20.44	4.86	bdl	100.96	0.00	7.42	100.96
JAG-228 grain-A9	42.47	bdl	22.82	2.76	7.48	0.56	20.52	4.77	bdl	101.39	0.00	7.48	101.39
JAG-228 grain-A AVG	42.39	bdl	22.49	2.83	7.45	0.57	20.45	4.81	bdl	100.99	0.00	7.45	100.99
JAG-228 grain-B1	41.40	bdl	22.20	2.66	7.41	0.53	20.20	4.76	bdl	99.15	0.61	6.85	99.21
JAG-228 grain-B2	42.27	bdl	22.32	2.99	7.35	0.55	20.40	4.91	bdl	100.79	0.01	7.34	100.79
JAG-228 grain-B3	42.20	bdl	22.68	2.80	7.30	0.58	20.47	4.85	bdl	100.87	0.14	7.17	100.89
JAG-228 grain-B4	42.20	bdl	22.60	3.06	7.34	0.62	20.46	4.94	bdl	101.21	0.34	7.03	101.24
JAG-228 grain-B5	42.30	bdl	22.54	3.14	7.26	0.58	20.30	4.82	bdl	100.93	0.00	7.26	100.93
JAG-228 grain-B6	42.11	bdl	22.49	2.93	7.48	0.60	20.43	4.98	bdl	101.02	0.60	6.95	101.08

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG 84-553 grain-D8	41.78	bdl	22.22	2.66	8.27	0.60	19.50	5.14	bdl	100.17	0.30	8.01	100.20
JAG 84-553 grain-D9	41.88	bdl	22.39	2.22	7.84	0.60	19.63	5.22	bdl	99.77	0.04	7.80	99.78
JAG 84-553 grain-D10	42.02	bdl	22.56	2.50	8.08	0.53	19.61	5.28	bdl	100.58	0.09	8.00	100.59
JAG 84-553 grain-D AVG	41.77	bdl	22.33	2.55	8.13	0.60	19.59	5.03	bdl	99.99	0.17	7.98	100.01
JAG 84-553 ALL AVG	41.86	bdl	22.38	2.56	8.13	0.59	19.62	5.04	bdl	100.17	0.11	8.03	100.18
JAG-228 grain-A1	41.75	bdl	22.30	2.80	7.41	0.55	20.55	4.73	bdl	100.08	0.80	6.68	100.16
JAG-228 grain-A2	42.22	bdl	22.47	2.79	7.49	0.56	20.39	4.84	bdl	100.76	0.13	7.37	100.77
JAG-228 grain-A3	42.45	bdl	22.43	2.95	7.43	0.61	20.41	4.76	bdl	101.04	0.00	7.43	101.04
JAG-228 grain-A4	42.53	bdl	22.65	2.69	7.36	0.62	20.57	4.78	bdl	101.20	0.00	7.36	101.20
JAG-228 grain-A5	42.57	bdl	22.42	2.89	7.40	0.53	20.35	4.88	bdl	101.04	0.00	7.40	101.04
JAG-228 grain-A6	42.59	bdl	22.60	2.89	7.56	0.58	20.46	4.86	bdl	101.54	0.00	7.56	101.54
JAG-228 grain-A7	42.45	bdl	22.37	2.86	7.47	0.57	20.41	4.83	bdl	100.95	0.00	7.47	100.95
JAG-228 grain-A8	42.44	bdl	22.36	2.86	7.42	0.59	20.44	4.86	bdl	100.96	0.00	7.42	100.96
JAG-228 grain-A9	42.47	bdl	22.82	2.76	7.48	0.56	20.52	4.77	bdl	101.39	0.00	7.48	101.39
JAG-228 grain-A AVG	42.39	bdl	22.49	2.83	7.45	0.57	20.45	4.81	bdl	100.99	0.00	7.45	100.99
JAG-228 grain-B1	41.40	bdl	22.20	2.66	7.41	0.53	20.20	4.76	bdl	99.15	0.61	6.85	99.21
JAG-228 grain-B2	42.27	bdl	22.32	2.99	7.35	0.55	20.40	4.91	bdl	100.79	0.01	7.34	100.79
JAG-228 grain-B3	42.20	bdl	22.68	2.80	7.30	0.58	20.47	4.85	bdl	100.87	0.14	7.17	100.89
JAG-228 grain-B4	42.20	bdl	22.60	3.06	7.34	0.62	20.46	4.94	bdl	101.21	0.34	7.03	101.24
JAG-228 grain-B5	42.30	bdl	22.54	3.14	7.26	0.58	20.30	4.82	bdl	100.93	0.00	7.26	100.93
JAG-228 grain-B6	42.11	bdl	22.49	2.93	7.48	0.60	20.43	4.98	bdl	101.02	0.60	6.95	101.08

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG-228 grain-B7	42.38	bdl	22.41	2.93	7.51	0.57	20.36	4.93	bdl	101.07	0.02	7.50	101.07
JAG-228 grain-B8	41.97	bdl	22.38	3.10	7.35	0.58	20.46	5.00	bdl	100.84	0.70	6.72	100.91
JAG-228 grain-B9	42.16	bdl	22.32	3.05	7.31	0.59	20.27	4.95	bdl	100.66	0.00	7.31	100.66
JAG-228 grain-B10	42.36	bdl	22.45	3.01	7.44	0.61	20.37	4.93	bdl	101.16	0.04	7.40	101.16
JAG-228 grain-B11	42.35	bdl	22.49	3.05	7.43	0.58	20.32	4.98	bdl	101.21	0.00	7.43	101.21
JAG-228 grain-B12	42.57	bdl	22.75	2.89	7.37	0.54	20.43	4.82	bdl	101.37	0.00	7.37	101.37
JAG-228 grain-B13	42.23	bdl	22.56	2.93	7.35	0.57	20.34	4.89	bdl	100.86	0.00	7.35	100.86
JAG-228 grain-B14	42.16	bdl	22.59	2.74	7.53	0.64	20.52	4.79	bdl	100.97	0.54	7.05	101.02
JAG-228 grain-B15	42.24	bdl	22.53	3.02	7.46	0.58	20.38	4.89	bdl	101.10	0.15	7.33	101.11
JAG-228 grain-B16	42.09	bdl	22.79	2.84	7.35	0.60	20.59	4.81	bdl	101.07	0.54	6.86	101.12
JAG-228 grain-B17	42.07	bdl	22.46	3.00	7.46	0.58	20.44	4.87	bdl	100.89	0.47	7.04	100.93
JAG-228 grain-B18	41.90	bdl	22.49	2.81	7.47	0.60	20.39	4.83	bdl	100.50	0.58	6.95	100.55
JAG-228 grain-B19	42.17	bdl	22.65	2.99	7.33	0.59	20.45	4.76	bdl	100.94	0.07	7.27	100.95
JAG-228 grain-B AVG	42.16	bdl	22.53	2.92	7.41	0.59	20.43	4.88	bdl	100.91	0.28	7.15	100.94
JAG-228 grain-D1	42.14	bdl	22.72	2.75	7.43	0.59	20.57	4.71	bdl	100.91	0.37	7.10	100.95
JAG-228 grain-D2	42.44	bdl	22.68	2.80	7.30	0.60	20.65	4.76	bdl	101.24	0.10	7.21	101.25
JAG-228 grain-D3	42.44	bdl	22.60	2.76	7.43	0.57	20.62	4.78	bdl	101.21	0.16	7.29	101.22
JAG-228 grain-D4	42.48	bdl	22.66	2.81	7.31	0.60	20.65	4.80	bdl	101.30	0.09	7.22	101.31
JAG-228 grain-D5	42.16	bdl	22.69	2.56	7.33	0.54	20.64	4.62	bdl	100.54	0.19	7.15	100.56
JAG-228 grain-D6	42.53	bdl	22.67	2.63	7.57	0.60	20.56	4.73	bdl	101.29	0.04	7.54	101.29
JAG-228 grain-D7	42.17	bdl	22.61	2.59	7.46	0.59	20.60	4.79	bdl	100.80	0.52	6.98	100.85

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
JAG-228 grain-D8	42.24	bdl	22.53	2.89	7.58	0.56	20.56	4.74	bdl	101.10	0.40	7.22	101.14
JAG-228 grain-D9	42.30	bdl	22.48	2.72	7.37	0.59	20.54	4.94	bdl	100.94	0.37	7.04	100.97
JAG-228 grain-D10	41.88	bdl	22.52	2.70	7.25	0.59	20.63	4.92	bdl	100.47	0.93	6.41	100.56
JAG-228 grain-D AVG	42.28	bdl	22.62	2.72	7.40	0.58	20.60	4.78	bdl	100.98	0.32	7.12	101.01
JAG-228 ALL AVG	42.25	bdl	22.56	2.82	7.41	0.58	20.49	4.82	bdl	100.94	0.22	7.22	100.96
K7311 grain-A1	40.88	bdl	22.10	2.48	9.44	0.56	19.14	5.04	bdl	99.65	1.91	7.72	99.84
K7311 grain-A2	41.69	bdl	22.49	2.46	8.94	0.58	19.18	5.05	bdl	100.39	0.36	8.62	100.42
K7311 grain-A3	41.69	bdl	22.55	2.52	8.99	0.53	19.42	5.01	bdl	100.72	0.80	8.27	100.80
K7311 grain-A4	41.80	bdl	22.60	2.34	9.06	0.50	19.49	4.91	bdl	100.70	0.68	8.45	100.77
K7311 grain-A5	41.78	0.06	22.49	2.32	8.94	0.53	19.26	5.12	bdl	100.49	0.38	8.60	100.53
K7311 grain-A6	41.49	bdl	22.37	2.41	8.99	0.54	19.27	5.08	bdl	100.19	0.83	8.24	100.28
K7311 grain-A7	41.75	0.00	22.63	2.47	8.96	0.51	19.28	4.99	bdl	100.58	0.35	8.65	100.62
K7311 grain-A8	41.62	0.06	22.36	2.51	9.05	0.59	19.33	5.00	bdl	100.51	0.77	8.36	100.59
K7311 grain-A9	41.80	0.06	22.23	2.51	9.26	0.57	19.17	5.00	bdl	100.61	0.42	8.88	100.65
K7311 grain-A AVG	41.61	0.03	22.43	2.45	9.07	0.55	19.28	5.02	bdl	100.43	0.72	8.42	100.50
K7311 grain-B1	41.45	bdl	22.29	2.56	8.87	0.54	18.88	5.08	bdl	99.67	0.01	8.86	99.67
K7311 grain-B2	41.64	bdl	22.30	2.67	8.81	0.60	19.27	5.04	bdl	100.33	0.47	8.38	100.38
K7311 grain-B3	41.93	bdl	22.43	2.64	8.94	0.57	19.33	5.07	bdl	100.92	0.38	8.60	100.96
K7311 grain-B4	41.97	bdl	22.66	2.41	8.99	0.58	19.38	4.96	bdl	100.96	0.33	8.69	100.99
K7311 grain-B5	41.41	bdl	22.46	2.58	9.15	0.59	19.03	5.01	bdl	100.23	0.65	8.57	100.30
K7311 grain-B6	41.72	bdl	22.45	2.52	8.85	0.54	19.32	5.02	bdl	100.42	0.41	8.48	100.46

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
K7311 grain-B7	41.74	bdl	22.54	2.45	8.97	0.62	19.41	4.94	bdl	100.67	0.68	8.36	100.74
K7311 grain-B8	41.92	bdl	22.64	2.55	8.86	0.59	19.46	5.06	bdl	101.06	0.56	8.35	101.12
K7311 grain-B9	42.03	bdl	22.69	2.34	8.92	0.57	19.42	4.91	bdl	100.90	0.16	8.78	100.91
K7311 grain-B AVG	41.76	bdl	22.50	2.52	8.93	0.58	19.28	5.01	bdl	100.57	0.41	8.56	100.61
K7311 grain-C1	41.24	bdl	22.27	2.52	8.82	0.55	19.49	5.01	bdl	99.90	1.35	7.60	100.03
K7311 grain-C2	41.55	bdl	22.51	2.59	8.98	0.56	19.32	5.05	bdl	100.55	0.86	8.21	100.64
K7311 grain-C3	41.46	bdl	22.37	2.65	8.84	0.53	19.22	5.01	bdl	100.06	0.53	8.36	100.12
K7311 grain-C4	41.72	bdl	22.41	2.44	8.86	0.58	19.24	5.03	bdl	100.27	0.32	8.57	100.31
K7311 grain-C5	41.62	bdl	22.43	2.55	8.86	0.57	19.26	4.88	bdl	100.17	0.29	8.60	100.20
K7311 grain-C6	41.47	bdl	22.43	2.63	9.04	0.61	19.10	5.00	bdl	100.28	0.57	8.53	100.33
K7311 grain-C7	41.30	bdl	22.33	2.58	8.97	0.55	19.06	5.01	bdl	99.80	0.60	8.43	99.86
K7311 grain-C8	41.56	bdl	22.50	2.54	8.71	0.59	19.22	5.03	bdl	100.16	0.35	8.39	100.19
K7311 grain-C9	41.78	bdl	22.57	2.56	9.01	0.58	19.26	5.08	bdl	100.82	0.51	8.54	100.87
K7311 grain-C10	41.88	bdl	22.63	2.58	8.94	0.56	19.17	5.03	bdl	100.77	0.05	8.89	100.78
K7311 grain-C AVG	41.56	bdl	22.44	2.56	8.90	0.57	19.23	5.01	bdl	100.28	0.54	8.41	100.33
K7311 grain-D1	42.22	bdl	22.50	2.42	9.40	0.50	19.27	5.05	bdl	101.36	0.27	9.15	101.38
K7311 grain-D2	42.04	bdl	22.24	2.41	9.34	0.51	19.34	4.99	bdl	100.87	0.53	8.87	100.93
K7311 grain-D3	42.27	bdl	22.35	2.46	9.53	0.52	19.28	4.95	bdl	101.35	0.24	9.32	101.37
K7311 grain-D4	42.14	bdl	22.30	2.35	9.45	0.51	19.09	5.03	bdl	100.93	0.00	9.45	100.93
K7311 grain-D5	41.91	bdl	22.41	2.27	9.51	0.51	19.22	5.03	bdl	100.85	0.68	8.90	100.92
K7311 grain-D6	42.17	bdl	22.35	2.29	9.26	0.50	19.28	4.97	bdl	100.82	0.08	9.19	100.83

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
K7311 grain-D7	42.20	0.09	22.56	2.27	9.35	0.46	19.19	5.08	bdl	101.19	0.00	9.35	101.19
K7311 grain-D8	42.18	0.06	22.35	2.32	9.43	0.47	19.19	5.04	bdl	101.02	0.09	9.34	101.03
K7311 grain-D9	42.06	0.08	22.37	2.33	9.08	0.48	19.30	5.07	bdl	100.76	0.11	8.98	100.77
K7311 grain-D10	42.13	0.06	22.26	2.31	9.30	0.51	19.29	5.08	bdl	100.94	0.29	9.03	100.97
K7311 grain-D11	41.98	0.07	22.35	2.14	9.25	0.48	19.23	5.04	bdl	100.52	0.24	9.03	100.54
K7311 grain-D12	41.90	bdl	22.46	2.29	9.47	0.45	19.34	4.94	bdl	100.84	0.69	8.85	100.91
K7311 grain-D13	42.01	bdl	22.26	2.30	9.41	0.45	19.28	4.98	bdl	100.70	0.43	9.03	100.74
K7311 grain-D14	42.03	bdl	22.34	2.22	9.26	0.47	19.30	4.99	bdl	100.62	0.31	8.98	100.65
K7311 grain-D15	41.78	bdl	22.31	2.17	9.41	0.47	19.12	4.98	bdl	100.24	0.44	9.01	100.29
K7311 grain-D16	41.84	bdl	22.30	2.30	9.33	0.48	19.15	5.01	bdl	100.41	0.38	8.99	100.45
K7311 grain-D17	42.15	0.05	22.28	2.15	9.25	0.50	19.17	4.96	bdl	100.51	0.00	9.25	100.51
K7311 grain-D18	41.89	bdl	22.11	2.22	9.17	0.51	19.11	4.96	bdl	99.95	0.00	9.16	99.95
K7311 grain-D19	41.94	bdl	22.34	2.21	9.24	0.47	19.24	4.94	bdl	100.38	0.20	9.06	100.40
K7311 grain-D20	42.25	bdl	22.24	2.28	9.23	0.52	19.25	4.98	bdl	100.75	0.00	9.23	100.75
K7311 grain-D AVG	42.05	bdl	22.33	2.29	9.33	0.49	19.23	5.00	bdl	100.75	0.24	9.12	100.77
K7311 grain-E1	41.82	bdl	22.35	2.25	9.18	0.49	19.15	4.99	bdl	100.22	0.21	8.99	100.24
K7311 grain-E2	42.01	bdl	22.27	2.28	9.27	0.49	19.36	4.92	bdl	100.60	0.37	8.93	100.63
K7311 grain-E3	41.48	bdl	22.16	2.26	8.81	0.49	18.97	4.75	bdl	98.93	0.00	8.81	98.93
K7311 grain-E4	41.58	bdl	21.98	2.10	8.63	0.46	18.99	4.81	bdl	98.55	0.00	8.63	98.55
K7311 grain-E5	41.33	bdl	22.05	2.19	8.61	0.49	18.95	4.85	bdl	98.48	0.00	8.61	98.48
K7311 grain-E6	41.36	bdl	22.04	2.25	8.63	0.47	19.05	4.80	bdl	98.59	0.00	8.63	98.59

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
K7311 grain-E7	41.43	bdl	22.17	2.06	8.83	0.48	19.05	4.84	bdl	98.86	0.00	8.83	98.86
K7311 grain-E8	41.31	bdl	22.09	2.15	8.78	0.50	19.06	4.80	bdl	98.69	0.02	8.77	98.69
K7311 grain-E9	41.62	bdl	22.18	2.17	8.84	0.46	19.10	4.78	bdl	99.13	0.00	8.84	99.13
K7311 grain-E10	41.62	bdl	22.10	2.12	8.90	0.49	19.05	4.77	bdl	99.05	0.00	8.90	99.05
K7311 grain-E11	41.46	bdl	22.12	2.23	8.93	0.49	19.15	4.83	bdl	99.20	0.18	8.76	99.22
K7311 grain-E12	41.28	bdl	22.06	2.09	8.68	0.50	19.00	4.78	bdl	98.38	0.00	8.68	98.38
K7311 grain-E13	41.73	bdl	22.18	2.05	8.56	0.51	19.00	4.79	bdl	98.82	0.00	8.56	98.82
K7311 grain-E14	41.74	bdl	22.33	2.07	8.61	0.50	19.00	4.83	bdl	99.08	0.00	8.61	99.08
K7311 grain-E15	41.55	bdl	22.27	2.23	8.68	0.52	19.03	4.80	bdl	99.09	0.00	8.68	99.09
K7311 grain-E16	41.53	0.06	22.10	2.10	8.72	0.51	19.05	4.73	bdl	98.80	0.00	8.72	98.80
K7311 grain-E17	41.43	bdl	22.14	2.11	8.82	0.49	19.04	4.87	bdl	98.90	0.00	8.82	98.90
K7311 grain-E AVG	41.53	bdl	22.14	2.16	8.78	0.49	19.06	4.81	bdl	98.97	0.00	8.78	98.97
K7311 ALL AVG	41.70	bdl	22.37	2.40	9.01	0.53	19.22	4.97	0.00	100.21	0.00	9.01	100.21
K7269 grain-A1	41.65	bdl	22.49	2.21	8.29	0.58	20.58	4.88	bdl	100.66	2.23	6.28	100.89
K7269 grain-A2	41.65	bdl	22.23	2.77	8.13	0.61	20.04	5.07	bdl	100.49	1.30	6.97	100.62
K7269 grain-A3	41.71	bdl	21.98	3.04	8.27	0.60	20.06	5.27	bdl	100.93	1.68	6.76	101.10
K7269 grain-A4	41.76	bdl	22.06	2.98	8.09	0.60	19.82	5.30	bdl	100.61	0.99	7.20	100.71
K7269 grain-A5	41.87	bdl	22.11	2.80	8.43	0.59	19.90	5.15	bdl	100.84	1.14	7.40	100.96
K7269 grain-A6	41.99	bdl	22.39	2.73	8.35	0.60	19.96	5.18	bdl	101.19	1.07	7.39	101.29
K7269 grain-A7	42.06	bdl	22.52	2.53	8.26	0.54	19.92	5.22	bdl	101.06	0.79	7.55	101.14
K7269 grain-A8	42.28	bdl	22.85	2.17	8.27	0.51	19.83	5.19	bdl	101.11	0.25	8.04	101.13

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
K7269 grain-A9	42.22	bdl	23.02	2.20	8.28	0.54	19.99	5.26	bdl	101.49	0.79	7.57	101.57
K7269 grain-A10	42.50	bdl	23.14	2.23	8.24	0.55	19.52	5.17	bdl	101.34	-0.68	8.86	101.27
K7269 grain-A AVG	41.97	bdl	22.48	2.56	8.26	0.57	19.96	5.17	bdl	100.97	0.96	7.40	101.07
K7269 grain-B1	41.01	bdl	21.96	3.03	8.17	0.58	19.81	5.53	bdl	100.08	2.34	6.06	100.32
K7269 grain-B2	41.37	bdl	22.02	2.80	8.31	0.56	19.80	5.32	bdl	100.17	1.70	6.78	100.34
K7269 grain-B3	41.51	bdl	22.24	2.86	8.24	0.58	19.82	5.33	bdl	100.58	1.49	6.90	100.72
K7269 grain-B4	41.66	bdl	22.25	2.79	8.20	0.53	19.75	5.35	bdl	100.52	1.09	7.22	100.63
K7269 grain-B5	41.64	bdl	22.47	2.54	8.07	0.62	19.86	5.31	bdl	100.49	1.22	6.97	100.62
K7269 grain-B6	42.06	bdl	22.59	2.42	8.23	0.58	19.88	5.14	bdl	100.89	0.60	7.69	100.95
K7269 grain-B7	41.79	bdl	22.66	2.19	8.05	0.55	19.78	5.31	bdl	100.31	0.78	7.35	100.39
K7269 grain-B8	41.92	bdl	22.83	2.08	8.15	0.54	19.87	5.17	bdl	100.57	0.68	7.53	100.64
K7269 grain-B9	42.56	bdl	23.11	2.15	8.31	0.53	19.99	5.18	bdl	101.83	0.23	8.10	101.85
K7269 grain-B10	42.65	bdl	23.11	2.17	8.13	0.54	19.94	5.14	bdl	101.68	-0.19	8.31	101.66
K7269 grain-B AVG	41.82	bdl	22.52	2.50	8.19	0.56	19.85	5.28	bdl	100.71	0.99	7.29	100.81
K7269 grain-C1	41.62	bdl	22.35	2.83	8.21	0.57	19.43	5.36	bdl	100.36	0.57	7.69	100.42
K7269 grain-C2	41.86	bdl	22.68	2.45	8.31	0.54	19.81	5.19	bdl	100.85	0.86	7.54	100.94
K7269 grain-C3	41.66	bdl	22.83	2.10	8.14	0.53	19.86	5.13	bdl	100.25	0.94	7.29	100.34
K7269 grain-C4	41.94	bdl	22.92	2.11	8.14	0.53	19.98	5.16	bdl	100.79	0.84	7.38	100.87
K7269 grain-C5	41.73	bdl	22.59	2.70	8.28	0.59	19.90	5.19	bdl	100.98	1.24	7.17	101.10
K7269 grain-C6	41.95	bdl	22.93	2.23	8.14	0.56	19.83	5.23	bdl	100.86	0.66	7.55	100.92
K7269 grain-C7	41.95	bdl	22.60	2.60	8.24	0.57	19.79	5.29	bdl	101.05	0.79	7.54	101.13

bdl, concentration below detection limit

GARNET COMPOSITIONS

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	NiO	Sum	Fe_2O_3	FeO	Sum
K7269 grain-C8	41.96	bdl	22.83	2.16	8.31	0.55	20.13	5.12	bdl	101.06	1.26	7.18	101.19
K7269 grain-C9	41.75	bdl	22.76	2.13	8.07	0.58	20.02	5.17	bdl	100.47	1.15	7.03	100.59
K7269 grain-C10	41.47	bdl	22.77	2.23	7.99	0.55	20.42	5.08	bdl	100.52	2.08	6.12	100.72
K7269 grain-C AVG	41.79	bdl	22.73	2.35	8.18	0.56	19.92	5.19	bdl	100.72	1.04	7.25	100.82
K7269 grain-D1	41.85	bdl	22.66	2.20	8.07	0.57	19.88	5.28	bdl	100.51	0.91	7.26	100.60
K7269 grain-D2	42.07	bdl	22.70	2.42	8.25	0.59	19.83	5.39	bdl	101.25	0.90	7.45	101.34
K7269 grain-D3	42.12	bdl	22.67	2.34	8.15	0.59	19.83	5.33	bdl	101.03	0.63	7.59	101.09
K7269 grain-D4	41.85	bdl	22.69	2.36	8.16	0.58	19.85	5.30	bdl	100.78	0.98	7.27	100.88
K7269 grain-D5	42.02	bdl	22.78	2.62	8.26	0.60	19.98	5.22	bdl	101.47	1.03	7.33	101.57
K7269 grain-D6	42.09	bdl	22.60	2.65	8.42	0.61	20.09	5.24	bdl	101.69	1.35	7.20	101.83
K7269 grain-D7	41.72	bdl	22.61	2.53	8.25	0.56	20.03	5.26	bdl	100.96	1.53	6.87	101.11
K7269 grain-D8	41.98	bdl	22.52	2.70	8.29	0.57	20.00	5.31	bdl	101.37	1.25	7.16	101.50
K7269 grain-D9	41.94	bdl	22.39	2.75	8.31	0.63	20.05	5.30	bdl	101.37	1.48	6.98	101.52
K7269 grain-D10	42.01	bdl	22.64	2.77	8.16	0.57	20.26	5.17	bdl	101.58	1.37	6.93	101.72
K7269 grain-D AVG	41.96	bdl	22.63	2.53	8.23	0.59	19.98	5.28	bdl	101.20	1.14	7.20	101.32
K7269 ALL AVG	41.88	bdl	22.59	2.49	8.22	0.57	19.93	5.23	bdl	100.90	1.03	7.29	101.00

bdl, concentration below detection limit