TOURMALINE COMPOSITIONS AS INDICATORS OF EMERALD MINERALIZATION AT TSA DA GLISZA, YUKON TERRITORY

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ABSTRACT

Tourmaline, a boron-bearing ring silicate, is ubiquitous at the Tsa da Glisza (formerly Regal Ridge) emerald prospect in the Yukon. It occurs as porphyroblasts in greenschist facies meta-volcanic and ultramafic rocks, as phenocrysts in granite, in aplites and quartz-tourmaline veins that cut the schists, and as granular black masses in highly altered gossan or fault zones. Contact metamorphism and metasomatism of the Devonian-aged greenschist rocks by the Cretaceous-aged granite/aplite/quartz-tourmaline veins appear to be responsible for local emerald mineralization. The quartz-tourmaline veins are particularly important because emeralds form along their selvages, although not all such veins have associated visible emerald mineralization. Tourmaline compositions include solid solutions among Na-Fe schorl, Na-Mg dravite, and Ca-Mg uvite. The major-element compositional variations of the tourmalines correspond well with the bulk-rock chemistry of their respective host rocks. Dravitic tourmalines, with up to 2.12 apfu Y-site Mg, are most common on the property, occurring in country rocks, aplites, and quartz-tourmaline veins. Less commonly, uvites also occur in these same rocks, with up to 0.88 apfu X-site Ca. Schorls, with up to 2.06 apfu Y-site Fe, are limited to granites and aplites and, rarely, with emeralds in country rock. Tourmalines from veins and alteration zones associated with emerald mineralization have subtle differences in major-element compositions, compared with tourmalines from schists and veins with no emerald mineralization. Tourmalines associated with emeralds are slightly more iron-rich dravites compared with tourmalines of schists and alteration zones without emeralds. Analyzed trace elements in tourmalines include Li, Be, Sc, Cr, V, Mn, Ni, Co, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Cd, Mo, Sn, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Yb, Lu, Ta, W, Bi, Pb, Th, and U. Binary plots of major- and trace-element concentrations show that tourmalines associated with emerald occupy restricted ranges of composition, albeit with considerable overlap with tourmalines not associated with emerald. Tourmaline trace-element concentrations that correspond to emerald mineralization include 20 – 40 ppm Co, ~50 ppm Ni, 0.5 ppm La, 0.5 ppm Y, 100 – 200 ppm Li, and 300 – 600 ppm Zn. Trace elements Co, Ni, Zn, Pb, and Sb correlate with increased Fe, and probably enter the Y-site at the expense of Mg. Multivariate statistical analysis, particularly discriminant function analysis using the trace-element concentrations, indicates that tourmaline can act successfully (92-100% correct classification matrix) as a stand-alone indicator of emerald mineralization at Tsa da Glisza.

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A very special thanks to Greg Davison of True North Gems, who has given me the opportunity of working on what is potentially one of the most significant gem finds in Canada, perhaps the world. It was Mr. Davison's suggestion that the tourmalines at Tsa da Glisza could be used to identify, or simply clarify, emerald-mineralized zones.

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I appreciate all the assistance from my 2006 field crew colleagues with True North Gems: Richard Harwood, Larry Gilroy, Dan Coyne, Gary Dyck, and Twila Skinner. From the academic front, I thank the staff of the Dalhousie University Department of Earth Sciences, especially Gordon Brown and Patricia Stoffyn, but also Jiggs Diegor of Memorial University.

CHAPTER 1: INTRODUCTION

1.1 Tourmaline: its structure and composition.

Tourmaline is a cyclosilicate with the composition $XY_3Z_6(BO_3)_3Si_6O_{18}(O,OH,F)_4$ where the X, Y, and Z components represent cations in solid solution. The X site normally contains Na^+ and Ca^{2+} with the possibility of minor K^+. The Y site contains Mg^{2+}, Fe^{2+}, Fe^{3+}, Li^+, Al^{3+}, Mn^{2+}, Ti^{4+}, Cr^{3+}, and/or V^{3+}. The Z site contains predominantly Al^{3+}, but can also contain Mg^{2+},Fe^{3+}, Fe^{2+} and Cr^{3+}. Many other species of tourmaline exist, but dravite, schorl, and uvite are the most important end members for this study and have the following compositions:

- $NaMg_3Al_6(BO_3)_3Si_6O_{18}(O,OH,F)_4$ [*dravite*]
- $NaFe_3Al_6(BO_3)_3Si_6O_{18}(O,OH,F)_4$ [*schorl*]
- $CaMg_4Al_5(BO_3)_3Si_6O_{18}(O,OH,F)_4$ [*uvite*] (Hawthorne and Henry, 1999)

Tourmaline typically forms as brown to black prisms with pseudo-hexagonal and/or trigonal cross sections. In thin section, schorl is typically shades of green, gray, and/or blue; dravite and uvite are both brown to yellow. All three of these species, as well as most species of tourmaline, display strong pleochroism in thin section, and rarely in hand sample. Given that these species are in solid solution with each other, a typical rule of thumb has been that, the deeper the colour, the higher the iron content (Nesse, 2000).

1.2 Previous studies using tourmaline compositions

Tourmaline compositions are potentially helpful indicators in exploration. Dravitic tourmalines are commonly associated with massive sulfide deposits, whereas plutonic rocks typically contain tourmalines of schorlitic compositions. Both schorl and dravite are associated with exhalites (Garda et al. 2003 and references therein).

Several studies have attempted to use tourmaline composition as an indicator of potential ore bodies. In Nova Scotia, Clarke et al. (1989) correlated tourmaline compositions with sulfide mineralization in the South Mountain Batholith and Meguma Group pelites. They identified tourmaline in sulfide mineralized zones in both pelitic rocks and granite as being Al-poor and Mg-rich compared to Al-Fe-rich barren granite.

Yu et al. (2002) used tourmaline as an indicator for locating cassiterite mineralized zones in the Yunlong tin deposit in China. They successfully identified a difference between barren zones and mineralized zones using the compositions of tourmalines in quartz-tourmaline veins, tourmaline-bearing granite, and tourmaline-bearing migmatites.

No studies to date have been carried out using tourmaline as an indicator for any type of gemstone deposit, despite its success as an indicator in exploration, and common abundance in various gemstone deposits.

1.3 Tsa da Glisza

1.3.1 History and geology of Tsa da Glisza

The Tsa da Glisza (the name means "green rock" in native Kaska language) property is located in the Pelly Mountain Range in the southern Yukon Territory. This area is part of the Yukon-Tanana terrane, primarily composed of pre-late Devonian quartz-rich meta-clastic rocks and carbonates, and late Devonian to Mississippian meta-volcanic and meta-plutonic rocks, believed to have been formed in a continental arc setting (Groat et al. 2002). The property lies several kilometres northeast of the Tintina Fault. Although the property was originally explored for base metals, emeralds were discovered there in 1998. True North Gems purchased the property in 2000, and seasonal exploration began in the summer of 2001. The property, then known as Regal Ridge, gained recognition as potentially becoming the first emerald mine in Canada. The name was changed to Tsa da Glisza in 2004. Exploration between 2002 and 2006 included detailed soil and stream sediment sampling, bedrock mapping at 1:10000 scale, trench mapping at 1:50 scale with over 50 trenches excavated, bulk sampling from 2003 to 2005, and diamond drilling from 2002 to 2004. A feasibility study on the viability of a mine at the property is currently underway.

The principal rock types present in the vicinity of the deposit are low-grade, Devonian greenschist-facies ultramafic and mafic schists and meta-plutonic rocks (Fig. 1.1). The ultramafic rocks consist of meta-pyroxenite and meta-peridotite, whereas the mafic rocks are meta-basalts and meta-andesites that have altered to chlorite and biotite schists, some displaying well-defined foliation in a wide range of orientations, although some are massive. A Cretaceous peraluminous granitic pluton intruded the Devonian rocks, creating a weak contact aureole. The granite injected an array of quartz-tourmaline veins and aplite dikes and sills, which extend both continuously and discontinuously for up to hundreds of meters into the greenschists. Contact metamorphism of the country rocks has left a gossan-like mass of jarosite, limonite, phlogopite, talc, and tourmaline. The quartz-tourmaline veins and aplite dikes/sills appear to have transported beryllium and boron into the country rocks (Groat et al. 2002), allowing crystallization of beryl along the boundaries of the veins, near the contacts with the country rock, and tourmaline ubiquitously. The mafic and ultramafic greenschists are the probable sources of chromium, vanadium, and iron required for imparting the unique emerald-green colour to the beryl (Groat et al. 2002).

Emerald mineralization appears to be restricted to the contacts between quartz-tourmaline veins and mafic greenschists (Fig. 1.2), zones of limonite-phlogopite-talc-tourmaline alteration, and mafic schist (i.e., not in the ultramafics). Rarely, emeralds occur in the quartz-tourmaline veins (Fig. 1.3a) and in the aplites (Fig. 1.3b). No emeralds occur in the alteration zones surrounding aplites. The lack of tourmaline in an alteration zone indicates a lack of emeralds; however, the presence of tourmaline does not necessarily indicate the presence of emeralds.

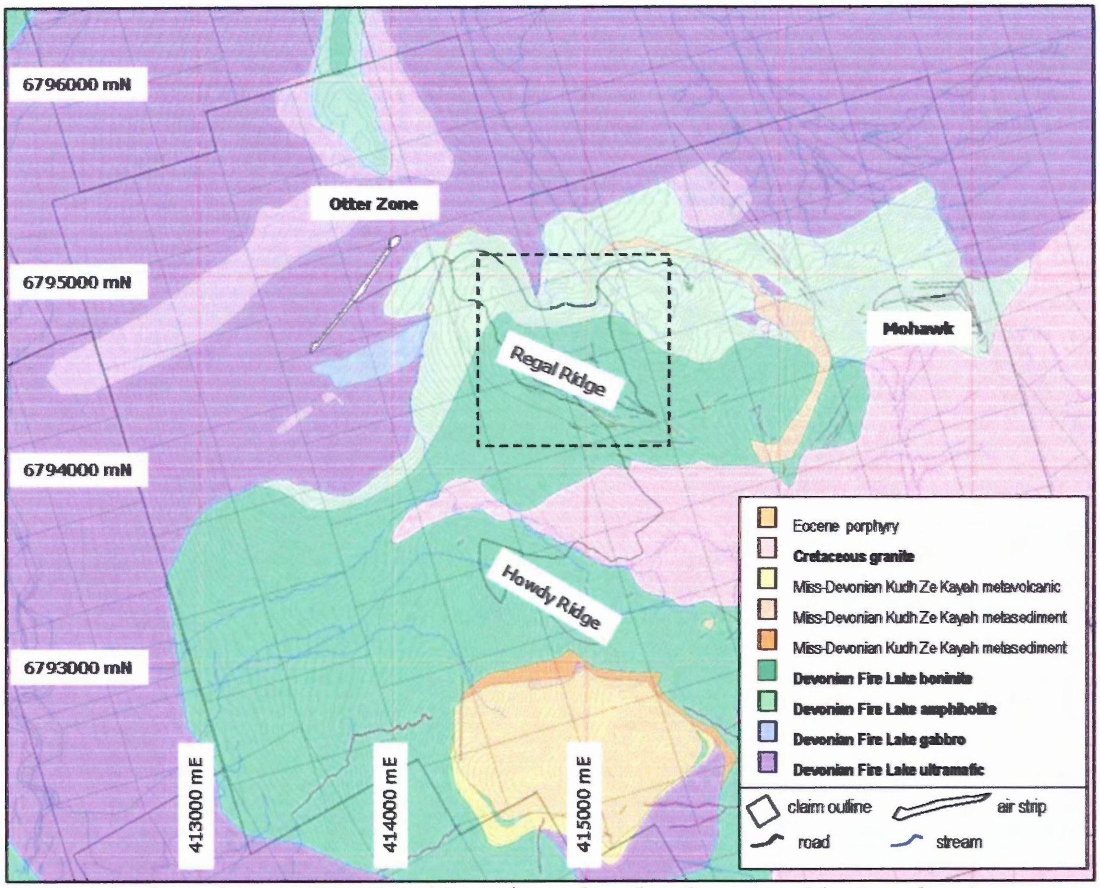

Figure 1.1 Geological map of Tsa da Glisza. The rocks related to emerald mineralization are outlined in bold in the legend. The dashed box indicates the area enlarged in Fig. 1.5. Map courtesy of True North Gems, 2007.

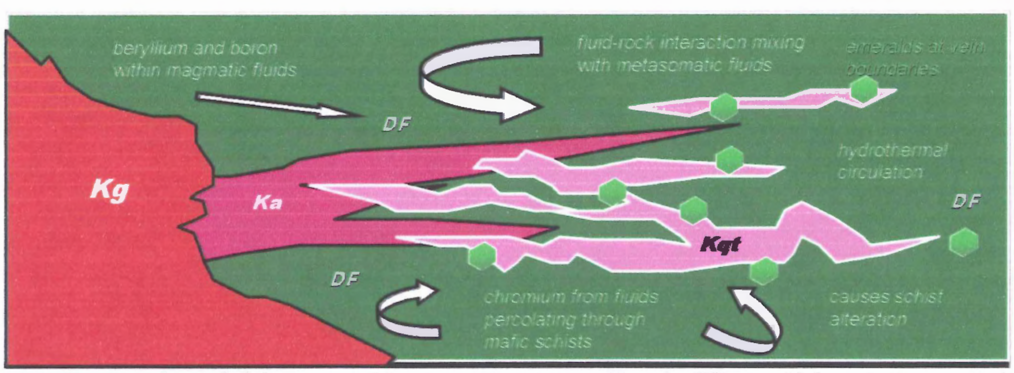

Figure 1.2 Proposed model for emerald mineralization at Tsa da Glisza. Abbreviations: 'Kg' refers to the Cretaceous granite; 'Ka' and 'Kqt' indicate the aplite dikes/sills and quartz-tourmaline veins respectively, injected into the country rocks; 'DF' indicates the Devonian-aged Fire Lake Unit mafic schists. Emeralds form along the selvedges of the quartz-tourmaline veins and DF country rocks, a reaction product of the vein-country rock interaction. Modified from Neufeld et al. 2004.

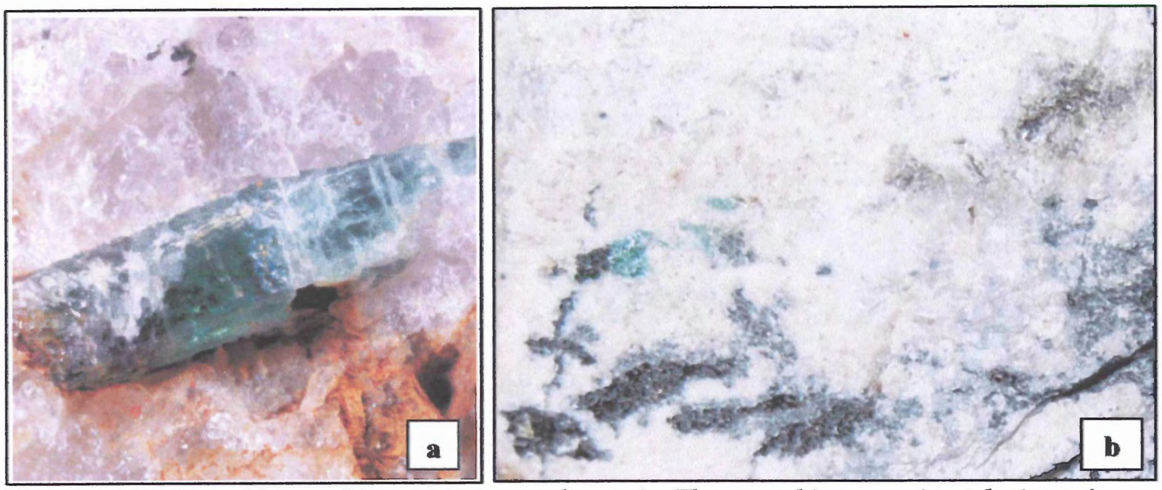

Figure 1.3 (**a**) Emerald crystal in quartz-tourmaline vein. The crystal is approximately 4 mm in length; From Groat et al. 2002. (**b**) Emerald crystal in aplite. The emerald is approximately 1 mm in width. Sample APMT-1.

The emeralds range in size and quality. They are typically 0.5 to 4 centimeters in length, and up to 5 mm wide. They are commonly marked with inclusions of tourmaline, phlogopite, chlorite, and quartz, as well as fluid inclusions. The average chromium content is 3208 ppm (up to a maximum of 7816 ppm), and the average vanadium content is 171 ppm (up to a maximum of 333 ppm).

The Fire Lake Unit mafic schists (DF) consist of four subgroups, DF, DF_1, DF_2, and DF_3 (Fig. 1.4), based on the degree of alteration caused by contact metamorphism. Unit 'DF' is unaltered by contact metamorphism and displays only regional metamorphism to chlorite schist. It ranges from massive to well-foliated. Well-foliated rocks are typically talc-rich. The subscript signifies a qualitative degree of metasomatic alteration. Unit 'DF_1' maintains much of the original schist structure and mineralogy; however, the planar fabric may be better defined, minor phlogopitization or biotitization may have occurred, and tourmaline porphyroblasts are present. The presence of tourmaline porphyroblasts in an otherwise unaltered chlorite schist defines DF_1. The 'DF_2' stage of alteration displays further metasomatic changes, namely moderate to extensive phlogopitization and/or biotitization and tourmalinization. Limonite staining is normally present; however, schistosity and most other features of the protolith DF remain. The 'DF_3' stage of alteration shows extensive tourmalinization, phlogopitization, jarosite, and limonite. All, to nearly all, of the original schist features have been replaced by a granular, almost incohesive, non-foliated, and porous alteration product.

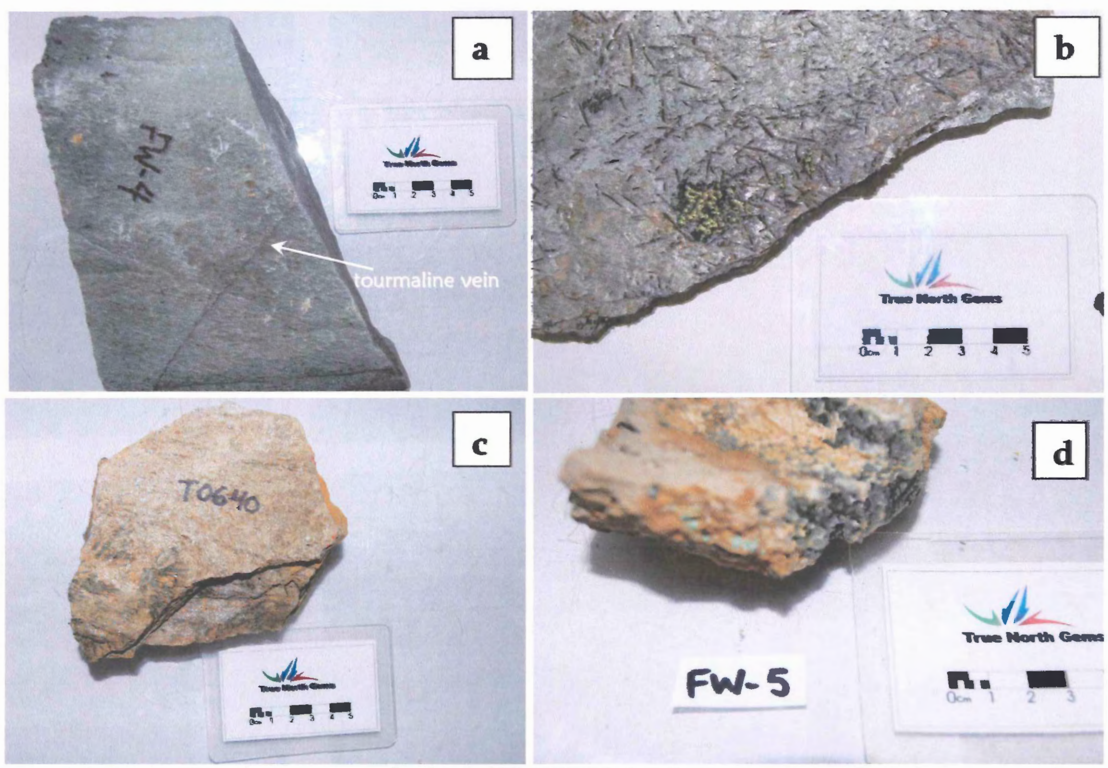

Figure 1.4 Examples of alteration of schists. (a) DF: minimal metasomatic alteration, tourmaline vein present lower right (sample FW-4); **(b)** DF_1: schistosity well-defined, acicular tourmaline porphyroblasts present (sample HR-2); **(c)** DF_2: well-defined foliation, phlogopitization, and tourmalinization (sample T0640); **(d)** DF_3: massive, porous, emerald-bearing (sample FW-5).

A porphyritic felsic dyke of Tertiary age is also present, but it post-dates emerald mineralization, and is, therefore, unlikely to be related to any mineralization on the property. Numerous faults, including thrusts, normal and strike-slip are probably present, but their precise orientations and displacements are still the subject of some debate.

1.3.2 Geographic subdivisions of Tsa da Glisza

Although the geology of Tsa da Glisza is classified by general lithologies, subtle differences in mineralogy and/or physical appearance are present. These variations are prevalent in the Devonian rocks. Because not all rocks of Tsa da Glisza exhibit emerald mineralization, the property has been subdivided into geographic zones. These zones are defined by geology and a geographic landmark, such as a topographic ridge, or in the case of the Otter Zone, the air strip.

1.3.2A Regal Ridge

Regal Ridge (Fig. 1.5) is the original area where emeralds were first discovered in 1998 (Section 1.3.1). The principal rocks on Regal Ridge are DF schists, exhibiting all ranges of alteration. Quartz-tourmaline veins and aplites are also common.

The Southwest Zone, located on the southwestern slope of Regal Ridge, is perhaps the most important area of the property, as there a great deal of exposure of the Southwest Vein, a quartz-tourmaline vein approximately one metre thick that is responsible for emerald mineralization. Past, as well as recent, emerald discoveries in the Southwest Zone have identified some of the largest (up to several centimetres in length) and clearest, richly green emeralds from Tsa da Glisza (Fig. 1.6). The Summit Zone is the area around the summit of Regal Ridge. The area known as Mattscar is located on the north face of Regal Ridge. The Far West Zone is located at the far western edge of Regal Ridge. Significant emerald mineralization has been identified in the Southwest, Summit, Mattscar, and Far West Zones.

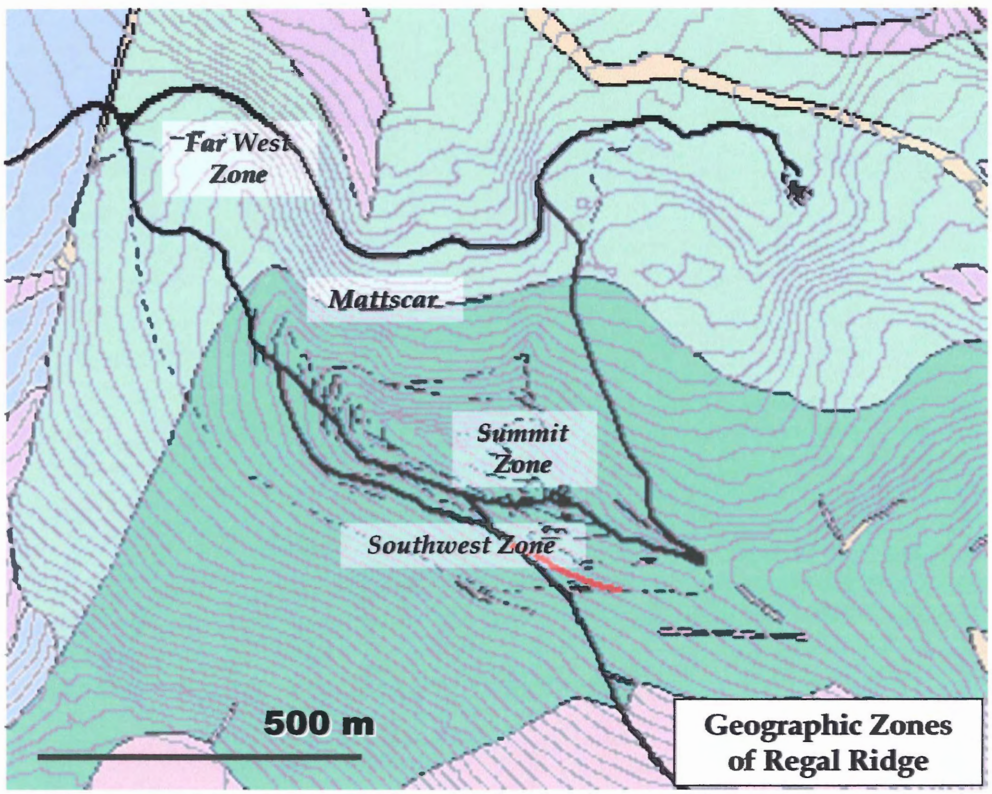

Figure 1.5 The geographic sub-zones of Regal Ridge (main emerald showing at Tsa da Glisza), exclusive to Section 1.3.2A. The map is a blow-up from Figure 1.1. The black lines are roads; the red line located in the Southwest Zone is the 1 m+ Southwest Vein, perhaps the most important quartz-tourmaline vein related to emerald mineralization at Tsa da Glisza.

Figure 1.6 Emeralds in DF_3 from Southwest Zone. Field of view is approximately 13 cm. Discoveries such as these have gained Tsa da Glisza its popularity.

1.3.2B Howdy Ridge

The Shadow Zone is essentially all of Howdy Ridge (Fig. 1.1), the ridge just south of Regal Ridge. The principal rock types are DF, including all stages of alteration. Numerous quartz-tourmaline veins cut the schists (Fig. 1.7). A contact with the granite is also present on the eastern edge of the ridge. Emeralds were identified at Howdy Ridge in 2004, near the geographic apex. Another area of interest, at the very top of the ridge and slightly southeast of the Shadow Zone, has not been given a name. No emeralds have been identified in this "supra-Shadow Zone" area, although the geology is similar to emerald-bearing areas; therefore, it has been an important exploration target. I have identified the samples from this area with the "HR" prefix.

Figure 1.7 Quartz-tourmaline vein cutting DF schists at Howdy Ridge. Sample HRT-3 was taken from the vein pictured (vein is approximately 80 cm thick). Emeralds were discovered here in 2004.

1.3.2C Mohawk

The Mohawk Zone is the area northeast of the Tsa da Glisza base camp, surrounding Mohawk Peak (Fig. 1.1); however, it is not a zone defined by True North Gems. For the purposes of this study, it has been segregated from other samples and given its own designation as a result of its abundance of ultramafic rocks, mafic schists (Fig. 1.8), and granite. The Devonian rocks are cut primarily by aplites, but several small (< 30 cm thick) quartz-tourmaline veins are also present. Emeralds do not occur in this area, but garnet and fuchsite do exist here. Garnet exists as porphyroblasts in DF schists, and also as phenocrysts (or possibly xenocrysts – unconfirmed) in aplites. Fuchsite occurs in quartz-tourmaline veins, near the vein-schist contacts. Garnet and fuchsite do not exist anywhere else at Tsa da Glisza.

Figure 1.8 Steeply dipping DF schists and DUM pyroxenites on Mohawk Peak. The schists in this vicinity do not display the same alteration characterisitcs (namely DF_2 and DF_3) as other emerald-associated schists. The field of view is approximately 6 m wide.

1.3.2D The Otter Zone

The Otter Zone is a large area at the western edge of the property (Fig. 1.1). This area consists mostly of ultramafic rocks (Fig. 1.9), although there are several areas of DF exposure. Aplites and quartz-tourmaline veins are rare in the Otter Zone, but several examples are present. This area was a key exploration target during the 2005 and 2006 seasons, because soil sampling in the Otter Zone identified several high-Be soil anomalies, although no beryl has been found. Nevertheless, several other emerald-producing properties around the world display associations with ultramafic rock (Zacharias et al., 2005); the association at other properties and the high-Be soil anomaly have defined the Otter Zone as a key exploration target at Tsa da Glisza.

Figure 1.9 DUM meta-pyroxenite (grey) and meta-peridotite (brown) in the Otter Zone. High Be-in soil anomalies have made the Otter Zone a key exploration target at Tsa da Glisza, but beryl is not present. A 16-oz rock hammer indicates scale.

1.4 Statement of purpose

Tourmaline is present in all rock units at Tsa da Glisza. This study aims to search for, and define, differences in tourmaline compositions among the various rock types: the Devonian mafic schists and their respective variations in metasomatic alteration, the Devonian ultramafic rocks, the Cretaceous granite and its associated intrusive rocks, including aplites and quartz-tourmaline veins. Also, because not all quartz-tourmaline veins and alteration zones are emerald-related, another objective is to determine if differences between tourmaline from emerald-hosted rocks (vein and other) and non-emerald-hosted rocks exist.

Any resultant interpretation of tourmaline as an indicator mineral applies only to Tsa da Glisza, although it may serve as a model for other tourmaline-bearing emerald deposits, displaying similar geology, i.e. mafic/ultramafic Cr-rich rocks intruded by B-Be-rich peraluminous granite(s) with associated aplites/quartz-tourmaline veins.

1.5 Scope

This study was carried out by collecting tourmaline-bearing rocks at Tsa da Glisza. The samples were analyzed for major-element and trace-element compositions, to identify what, if any, differences exist in the tourmalines of the various host rocks. The precision of the analyses are limited to the reliability of the electron microprobe (major elements) and LAM-ICPMS (trace elements) data. The differences are displayed using scatter-plot point graphs, and various methods of grouping points, including grouping by lithology, by geography, and on an individual sample-by-sample basis. These binary plots, as well as multivariate statistical analysis, test tourmaline as an indicator mineral for emerald mineralization at Tsa da Glisza.

1.6 Claim

I believe that variations exist in tourmalines of different host lithologies at Tsa da Glisza. These differences include both major-element and trace-element compositions, and the compositional differences allow tourmaline to act as an indicator mineral at Tsa da Glisza. Not only do compositional differences exist, but also there are certain areas on the property that favour emerald mineralization and the compositions of tourmalines reflect the probability of emeralds existing in a given area at Tsa da Glisza.

CHAPTER 2: METHODS

2.1 Sample collection

During July and August of 2006, I collected 69 potential tourmaline-bearing samples from the Tsa da Glisza property (Fig. 2.1), including all geographic subdivisions of the property (Table 2.1). These samples belong to three categories:

- field samples (Section 2.1.1) collected during regional mapping and prospecting excursions,
- diamond drill hole samples (Section 2.1.2) collected from drill core from the property, and
- trench samples (Section 2.1.3) collected from selected trenches and bulk sample sites.

2.1.1 Field samples

I chose 44 samples during regional mapping based on geology, mineralogy, grain size, and form of the tourmaline present (Table 2.2). For each sample, I recorded UTM coordinates using a *Garmin e-trex Legend* GPS using the NAD83 coordinate system. Samples collected included 19 mafic schist (DF) samples with varying degrees of contact and regional metamorphism. In addition to the schist samples, five aplite samples, three granite samples, ten quartz-tourmaline vein samples, two emerald-bearing DF_3 samples, one sample of tourmaline sand, and one tourmalinite sample of unknown host lithology were also included. I collected only one tourmaline-bearing ultramafic (DUM) sample; however, I did collect several quartz-tourmaline vein and aplite samples that contain either a contact with the ultramafic rocks, or are near ultramafic country rocks where collected.

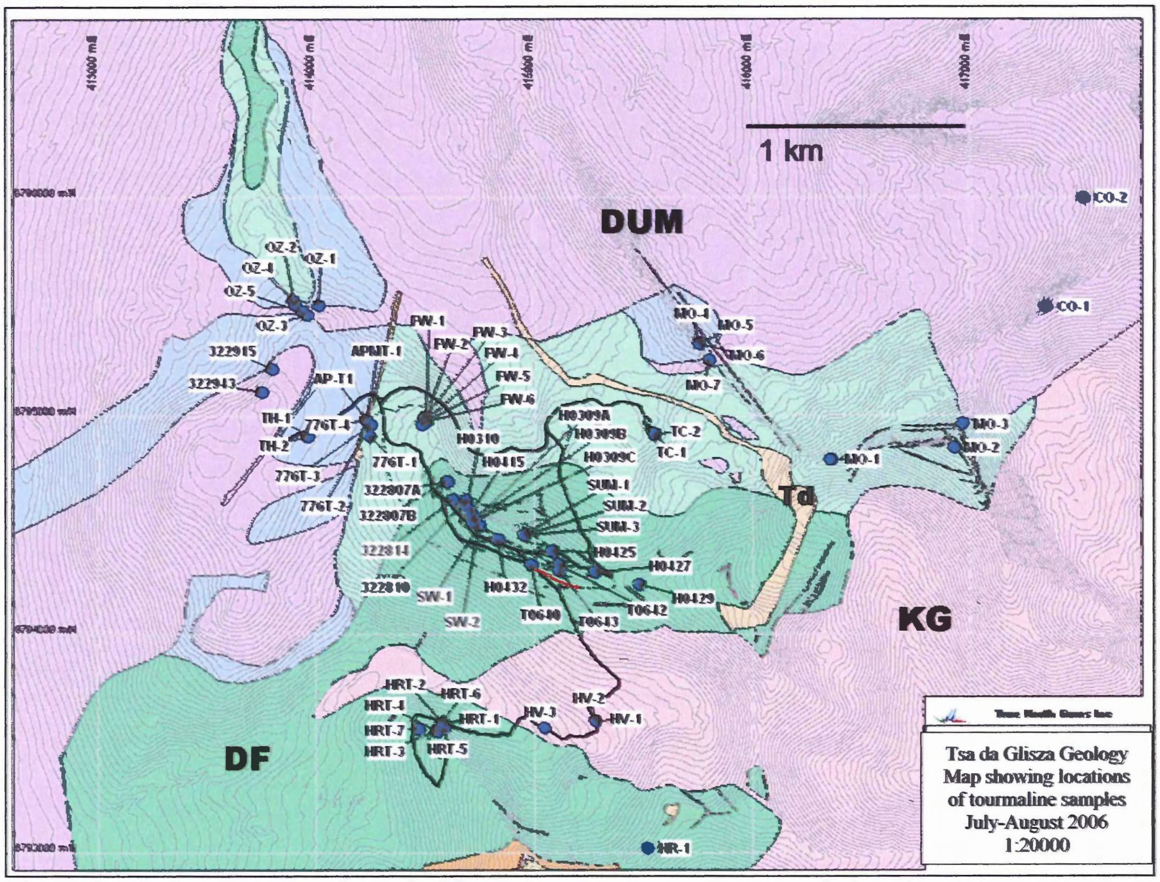

Figure 2.1 Geological map of Tsa da Glisza showing tourmaline sample locations.

Table 2.1 Summary of samples by geographic zone. Samples by geography include surface samples only (i.e., field and trench samples); DDH samples are included in "Others."

Geographic Zone	# of samples	tourmaline-bearing samples	emeralds present?
Summit	3	2	√
Mattscar	5	5	√
Far West	6	5	√
Shadow	7	5	√
Mohawk	7	6	x
Camp	2	1	x
"HR"	4	4	x
Otter	9	6	x
Others	25	14	x
TOTAL	68	48	

Table 2.2 Field samples collected from Tsa da Glisza (**Section 1.3.1** for abbreviations). Samples subsequently discovered to not contain tourmaline have been removed.

Sample ID	UTM East	UTM North	Comments	Lithology
776T-3	414257	6794960	tourmaline porphyroblasts in schist (DF_1)	DF
776T-4	414231	6794979	tourmaline porphyroblasts in schist (DF_2) near aplite contact	DF
FW-2	414503	6794984	fine-grained tourmaline vein or tourmalinization in DF_2	DF
FW-4	414490	6794960	DF_1 w/ tourmaline vein & tourmaline porphyroblasts	DF
FW-5	414509	6794974	DF_3 w/ cavities - emerald bearing	DF
FW-6	414510	6794974	DF_3 w/ cavities - emerald bearing	DF
HR-1	415518	6793020	DF_2 w/ tourmaline porphyroblasts	DF
HR-2	415518	6793020	DF_1 w/ tourmaline porphyroblast	DF
HR-4	415518	6793020	quartz-tourmaline vein	DF
HRT-4	414554	6793559	stratiform tourmaline above upper contact of HRT-3 vein	DF
HRT-6	414582	6793598	DF_2 w/ tourmaline porphyroblasts	DF
MO-1	416370	6794800	tourmaline porphyroblasts in chlorite schist - DF_1/DF_2	DF
MO-3	416965	6794964	tourmaline & talc vein / tourmaline porphyroblasts in chlorite schist - DF_1/DF_2	DF
MO-5	415761	6795330	tourmaline porphyroblasts in biotite-rich chlorite schist - DF_1	DF
SUM-3	414957	6794459	tourmalinized chlorite schist at vein contact - Summit Zone	DF
322915	413805	6795215	tourmaline sand, probably from shear zone - Otter South	DF (?)
322943	413755	6795110	massive porous coarse-grained tourmalinite from Otter South	DF (?)
APMT-1	414231	6794979	identical to AP-T1, but w/ emerald	Ka
AP-T1	414231	6794979	tourmaline phenocrysts in aplite dike	Ka
MO-2	416928	6794855	tourmaline vein within aplite/granite vein	Ka
MO-6	415761	6795330	tourmaline phenocrysts in aplite dike	Ka
TC-2	?	?	tourmaline bearing aplite near base camp	Ka
CO-1	417348	6795499	granite w/ tourmaline phenocrysts	Kg
CO-2	417516	6796000	granite w/ tourmaline phenocrysts	Kg
HV-3	415051	6793575	granite w/ tourmaline phenocrysts	Kg
FW-3	414500	6794984	quartz-tourmaline vein	Kqt
HR-3	415518	6793020	DF_3 w/ heavy tourmalinization and quartz veinlets	Kqt
HRT-1	414582	6793598	visibly pleochroic tourmaline in tourmaline vein	Kqt
HRT-3	414554	6793559	quartz-tourmaline vein near emerald in vein (same vein)	Kqt
MO-7	415804	6795258	quartz-tourmaline vein w/ fuchsite	Kqt
OZ-2	413912	6795506	quartz-tourmaline vein (aplite?) intersecting ultramafics - similar to AP-T1	Kqt
OZ-3	413966	6795464	tourmaline vein w/ minor quartz intersecting ultramafic	Kqt
SUM-1	414957	6794459	quartz-tourmaline vein from Summit Zone	Kqt

2.1.2 Diamond drill-hole samples

Holes were drilled during the 2003 and 2004 field seasons, during True North Gems' Tsa da Glisza drill program. Nine diamond drill hole (DDH) samples were selected based on essentially the same parameters as field samples (Section 2.1.1), collectively in excess of 2.5 m of drill core (Table 2.3). Only four of the nine samples were positively tourmaline-bearing (Section 2.1.4 for rejects). The four positive samples included one schist sample, one sample of aplite, and two samples of unknown lithology, probably DF schists that have undergone extensive metasomatism.

With each sample collected, I recorded the hole identification, as well as the interval and lithology. The core was split in half using a diamond blade tile saw. If the core had been sampled previously and was already halved, the remaining half would be halved again, to ensure True North Gems retains a sample of the original core.

The DDH samples were useful in that they represent samples of the rocks that have not been altered by surface processes, including physical and chemical weathering. Although, weathering is not an issue to the physical or compositional integrity of tourmaline *per se*, the host lithology is susceptible to physical and chemical weathering, particularly DF_3. The DDH samples also provide insight into rocks that are not visible in any surface outcrops, as is the case with samples H0432 and H0425.

Table 2.3 DDH samples collected from Tsa da Glisza (**Section 1.3.1** for abbreviations).

Sample ID	UTM East	UTM North	DDH	From	To	Lithology	Comments
H0309B	414721	6794515	DDH03-09	82.27	82.80	DF	DF_2 w/ moderate tourmalinization, quartz veinlet, limonite and sulfides
H0425	415085	6794384	DDH04-25	54.65	54.76	DF (?)	heavy alteration (DF3?) w/ extensive tourmalinization and moderate quartz veining
H0432	414836	6794438	DDH04-32	50.32	50.70	DF (?)	gypsum needles w/ tourmaline veinlets, minor quartz veinlets, limonite staining
H0429	415482	6794231	DDH04-29	49.83	50.00	Ka	Ka w/ tourmaline veinlets

2.1.3 Trench samples

During regional trench mapping (Fig. 2.2), or regional mapping and prospecting excursions, I collected samples from trenches dug any time between 2002 and 2005, using the same criteria as for field samples (Section 2.1.1). Trench samples also include samples from emerald-bearing bulk samples collected in 2005. Twelve trench samples were collected (Table 2.4), including three schist samples, two quartz-tourmaline vein samples, three emerald-bearing bulk samples, and two highly-altered rocks which were essentially tourmalinites. UTM coordinates were recorded for all samples.

Figure 2.2 Trench face at Tsa da Glisza. Orange slashes indicate metre marks.

Table 2.4 Trench samples collected from Tsa da Glisza (**Section 1.3.1** for abbreviations)

Sample ID	UTM East	UTM North	Lithology	Comments
322807A	414606	6794699	DF	tourmaline porphyroblasts in rusty phlogopite-rich schist - DF_2 near QT vein contact
HRT-7	414473	6793566	DF	DF_1 w/ tourmaline and biotite
OZ-5	413941	6795480	DF	DF_3 - extensive tourmalinization and phlogopotization
T0640	414991	6794317	DF	DF_2 w/ tourmaline layers & porphyroblasts
T0643	415119	6794293	DF	tourmaline in bluish alteration (DF_3)
TH-1	413967	6794907	DF	aplite vein in massive DF
322807	414605	6794700	DF/Kqt	DF_3/quartz-tourmaline vein – emerald-bearing
322810	414688	6794614	DF/Kqt	DF_3/quartz-tourmaline vein – emerald-bearing
322814	414633	6794614	DF/Kqt	DF_3/quartz-tourmaline vein – emerald-bearing
322807B	414605	6794700	Kqt	QT-beryl vein from emerald-bearing bulk sample
T0642	415117	6794318	Kqt	quartz-tourmaline vein intersecting DF/DF_1

2.1.4 Rejected samples

The following samples did not contain tourmaline and were rejected: 776T-1, 776T-2, FW-1, H0309A, H0309C, H0310, H0415, H0427, HRT-2, HRT-5, HV-1, HV-2, MO-4, MOG, OZ-1, OZ-4, SUM-2, and SW-2. The loss in transit of SW-1 and TH-2 reduced the number of samples to 48. Rejected samples (Table 2.5) are not shown in Tables 2.1, 2.2, and 2.3.

2.2 Sample preparation

I submitted 67 samples (all samples including rejects not lost in transit) to Gordon Brown of Dalhousie University who prepared polished thin sections of all samples for tourmaline major-element analysis.

In addition to the thin sections, I crushed pieces of samples using a mini-jaw crusher and a pulverizer. After the rock was crushed, I isolated individual tourmaline grains, set them in labelled zip-lock bags for each sample and gave the bagged grains to Gordon Brown to prepare grain mounts for trace-element analysis.

Table 2.5 The rejected samples, i.e. those that were lost or do not contain tourmaline.

Sample ID	UTM E	UTM N	Lithology	Comments
776T-1	414250	6794907	DF/Kq	quartz vein in DF
776T-2	414257	6794960	DF	talc-chlorite schist
FW-1	414510	6794995	DF	DF_1-DF_2 rusty phlogopite-chlorite schist
H0309A	414721	6794515	DF	DF_1 w/porphyroblasts from DDH03-09, 76.76 - 76.88m
H0309C	414721	6794515	DF	DF_1 w/ porphyroblasts from DDH03-09, 80.59 - 80.78m
H0310	414694	6794589	DF	DF w/ quartz vein; from DDH03-10, 7.38 - 8.10m
H0415	414714	6794553	DF/Kq	DF_1 w/ quartz vein, limonite staining; from DDH04-15, interval N/A
H0427	415282	6794290	Td	Td with possible phenocrysts; from DDH04-27, 41.55 - 41.65m
HRT-2	414582	6793598	DF	DF_2 - DF_3 w/ extensive phlogopitization
HRT-5	414588	6793575	DF	DF_1 chlorite schist w/ wheat-sheaf porphyroblast clusters
HV-1	415280	6793604	Kg	granite with black phenocrysts
HV-2	415280	6793604	Kg	granite with black phenocrysts
MO-4	415761	6795330	DF	DF w/ quartz vein
MOG	416364	6794800	DF	DF_1 w/ garnet porphyroblasts
OZ-1	414014	6795506	DUM	sheared DUM with large, elongate, black porphyroblasts
OZ-4	413900	6795524	Ka	aplite with grey-black crystalline stringers
SUM-2	414957	6794459	DF	DF_1 - DF_2 near quartz-tourmaline vein
SW-1	?	?	DF/Kqt	quartz-tourmaline-emerald vein; LOST IN TRANSIT
SW-2	?	?	DF	silicified DF_3 w/ large emeralds
TH-2	413961	6794908	DF	altered, rusty, massive DF; LOST IN TRANSIT

2.3 Sample Analysis

With the assistance of Patricia Stoffyn of Dalhousie University, I analyzed the tourmaline samples for major-element composition (Section 2.3.1) and trace-element composition (Section 2.3.2) to provide a thorough understanding of the compositions of the tourmalines.

2.3.1 Major element analysis

I used a JEOL 8200 electron microprobe at Dalhousie University with a spot size of 5 µm to measure major-element compositions of the tourmaline grains in each slide (Fig. 2.3). I chose a minimum of five to a maximum of eleven points from various tourmaline crystals on each slide, probing a single grain two to three times in different areas of the crystal. Dr. Stoffyn supervised the probing for major elements on 20 October 2006, 3 November 2006, 8 – 10 December 2006, and 13 – 14 April 2007 (APPENDIX A and B). Elements measured were: Si, Al, B, Na, Ca, Fe (total), Mg, Mn, Cr, V, Ti, K, and F. A kaersutite sample (KK) was used as standard, and all elements were tested using a 20-second count time, except B, which was given 40 seconds.

Figure 2.3 JEOL 8200 electron microprobe at Dalhousie University.

Dr. Stoffyn tabulated the major-element results in an Excel spreadsheet, expressed in terms of weight percent by oxide (wt %). I converted these wt% values to atoms per formula unit (apfu), corrected to 31 oxygens.

2.3.2 Trace element analysis

As a result of time constraints, only selected samples were set into grain mounts to analyze for trace elements, chosen based on lithological variety and ease of obtaining tourmaline grains. The chosen samples included three DF_1, five DF_2, 13 DF_3 (of which three were emerald-bearing), seven aplites (one of which was emerald-bearing), one granite, and nine quartz-tourmaline vein samples (one of which was beryl-bearing). Table 2.6 shows these samples.

On 17 – 18 January 2007, I took the grain mounts to Memorial University in St. John's NL to measure the concentrations of trace elements in the tourmaline grains. Wilfredo [Jiggs] Diegor of Memorial University and I performed the analyses on 38 samples (APPENDIX 3), by Laser Ablation Microprobe Inductively Coupled Plasma Mass Spectroscopy (LAM-ICPMS, Fig. 2.4). Elements measured were Li, Be, B, Al, Sc, Cr, V, Mn, Ni, Co, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Mo, Sn, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Yb, Lu, Ta, W, Bi, Pb, Th, and U. The first two samples, CO-1 and MO-7, were analyzed for K as well. All subsequent samples were analyzed for Cd instead of K. We measured a minimum of five points to a maximum of seven points, with two exceptions: FW-5 did not have enough space on the only exposed crystal to measure five points, so we only analyzed three points, and 776T-3 unfortunately was set too deep in the grain mount to be visible, so no points were measured. A boring diametre of 85 µm was used for a running time of 100 seconds. With a boring rate of approximately 1 µm per second, a hole approximately 85 µm wide by 100 µm deep was left after each analysis.

Mr. Diegor calculated the trace-element contents using the average SiO_2 content from EMP analysis. He then tabulated the results and sent them to me via email.

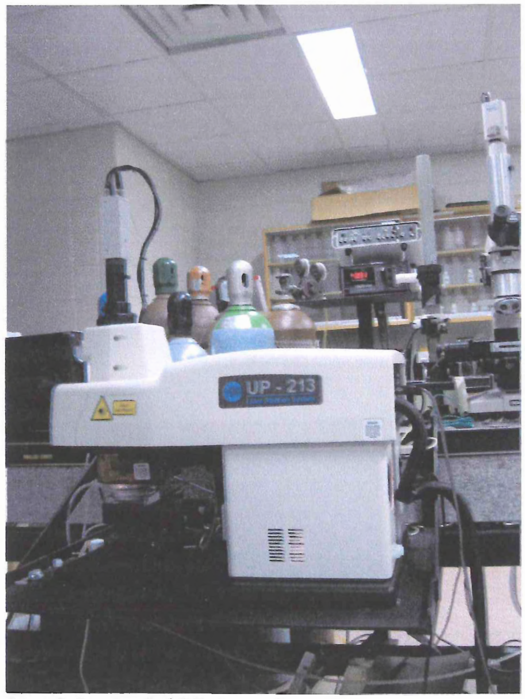

Figure 2.4 LAM-ICPMS unit at Memorial University.

2.4 Data processing

With the assistance of my thesis supervisor, Barrie Clarke, I used multivariate statistics to test tourmalines of Tsa da Glisza as indicators of emerald mineralization. The statistical analyses included calculation of correlation coefficients, cluster analysis, and discriminant function analysis, as detailed below. All of the multivariate plots outlined below were run by Dr. Clarke using SYSTAT software.

2.4.1 Correlation coefficients

Because I analyzed the concentrations of 37 different trace elements in tourmalines, I calculated Pearson and Spearman rank correlation coefficients to determine the correlations of all possible trace-element pairs.

Table 2.6 Samples crushed for tourmaline trace-element analysis at Memorial University. Green checks indicate emerald mineralization. "Narrow" column is restricted to samples that contained visible emerald mineralization. "Expanded" column indicates sample that is near emerald mineralization (within 25 m).

Sample	lithology	Narrow	Expanded
776T-3	DF_1	x	x
776T-4	DF_1	x	x
MO-5	DF_1	x	x
322807A	DF_2	x	√
FW-2	DF_2	x	√
HR-1	DF_2	x	x
HRT-6	DF_2	x	√
T0640	DF_2	x	x
H0309B	DF_3	x	x
H0425	DF_3	x	x
H0432	DF_3	x	x
HR-3	DF_3	x	x
HRT-1	DF_3	x	√
MO-3	DF_3	x	x
OZ-5	DF_3	x	x
T0643	DF_3	x	x
322915	DF_3?	x	x
322943	DF_3?	x	x
322807	E-DF_3	√	√
322810	E-DF_3	√	√
FW-5	E-DF_3	√	√
APMT-1	E-Ka	√	√
AP-T1	Ka	x	√
H0429	Ka	x	x
MO-2	Ka	x	x
MO-6	Ka	x	x
TC-2	Ka	x	x
TH-1	Ka	x	x
CO-1	Kg	x	x
MO-7	Kq	x	x
FW-3	Kqt	x	√
HR-4	Kqt	x	x
HRT-3	Kqt	x	√
OZ-2	Kqt	x	x
OZ-3	Kqt	x	x
SUM-1	Kqt	x	√
T0642	Kqt	x	x
322807B	Kqt-beryl	√	√

The Pearson coefficient is a value between -1.0 and 1.0 (Equation 2.1), where a negative value means there is an anti-correlation, and positive correlation indicates a correlation and zero means no correlation. If the concentrations of two elements are plotted on a simple x-y graph, the correlation is a measure of how well the points defined by those concentrations fit to a line (Fig. 2.5). The Pearson coefficient uses parametric correlations; i.e. the correlation of the actual concentrations of the trace elements. A greater magnitude of the Pearson coefficient (i.e. closer to 1 or -1) corresponds to stronger correlation/anti-correlation. The Pearson coefficient is determined by:

$$r = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

Equation 2.1 Where r is the Pearson coefficient, x and y are the arrays which correlation is being measured; in this case, x and y arrays are two elements being tested for correlation.

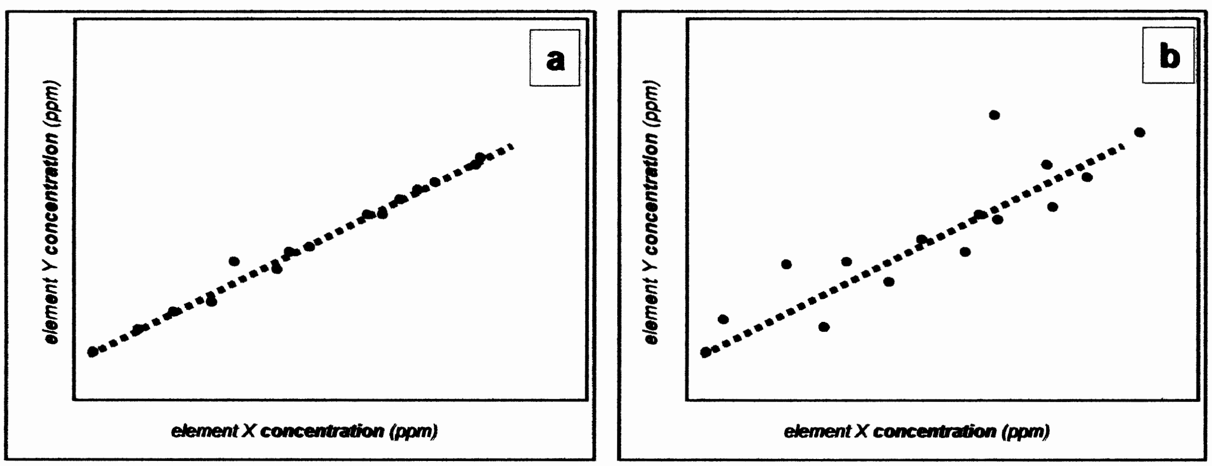

Figure 2.5 Hypothetical binary plots of two elements' concentrations, emphasizing their correlation. In both cases the slope of the line of fit is equal; however, in case **a**, nearly all points lie along the line of fit. Case **a** displays a strong correlation. Because the points in **b** are more scattered and do not lie on the line of fit, the points are not as correlated as in **a**; therefore, **b** has a lower correlation coefficient than **a**.

The problem with the trace elements is that the concentrations of one element can vary by several orders of magnitude across all samples analyzed. Like the Pearson coefficient, the Spearman rank correlation coefficient is also a value between -1.0 and +1.0 (Equation 2.2). The Spearman rank correlation coefficient is defined by:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

Equation 2.2 Spearman rank correlation coefficient; where ρ is the Spearman rank correlation coefficient, d is the distance between ranks, and n is the number of samples. In the example of the trace elements, the n is 37, because there are 37 elements.

Spearman rank ignores the values of the variables and assigns only a rank to that element for that sample, thus it generates non-parametric correlations. Because I analyzed for 37 elements, each element is assigned a rank between 1 and 37 for each sample: 1 representing the lowest concentration of an element in a given sample, and 37 representing the highest concentration of an element in that sample. The Spearman rank correlation coefficient is a value between -1 and +1, assigned to pairs of elements, testing the correlation of the Spearman ranks. Table 2.7 and Figure 2.6 show an example of a comparison between Pearson and Spearman correlation.

Table 2.7 Hypothetical concentrations of two elements in five samples. The Pearson correlation coefficient determines the correlation of the actual concentrations (in ppm). The Spearman rank correlation coefficient determines the correlation of the ranks. In this case, X and Y have a moderate Pearson correlation, but perfect Spearman correlation.

Sample	X (ppm)	Y (ppm)	X Rank	Y Rank	Pearson X-Y	Spearman X-Y
A	5	5	1	1	0.749	1.000
B	15	6	2	2		
C	20	43	3	3		
D	75	100	4	4		
E	400	110	5	5		

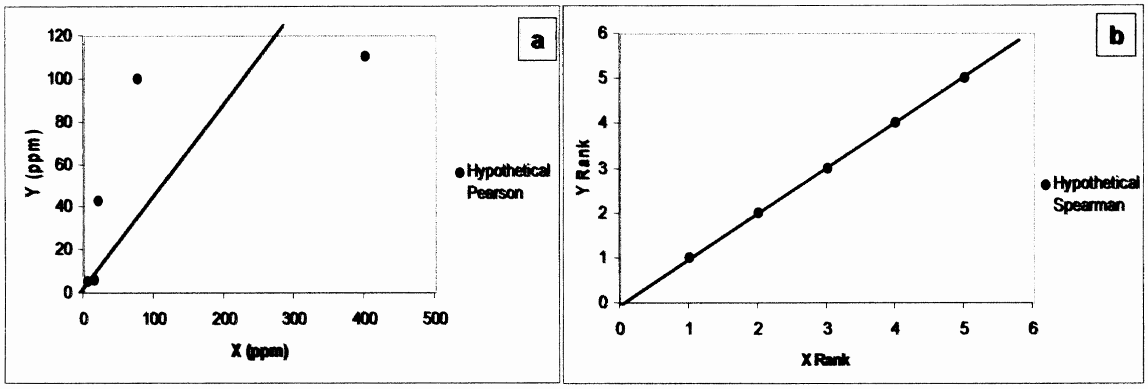

Figure 2.6 Hypothetical binary plot of two elements' concentrations. (**a**) Their actual concentrations are plotted (from Table 2.7), highlighting Pearson correlations. (**b**) The respective ranks of concentrations are plotted, highlighting Spearman correlations. Because the points in **a** do not lie on the line of fit, their correlation is moderate. The Pearson coefficient correlates the values in **a**. However, by non-parametric ranks to the concentrations, as in Table 2.7, by plotting the ranks, the rank points lie along a line, and therefore the ranks are perfectly correlated, resulting in a Spearman coefficient of 1.

2.4.2 Cluster analysis

The human brain is capable of visualizing data in only two and three dimensions, as two- and three-dimensional space are the maximum we can visualize. Mathematics, however, can plot in an infinite number of dimensions, independent of the human brain's ability to visualize. Because many of the concentrations were below the lower limit of detection, we used only 22 trace-element concentrations, resulting in a mutually perpendicular 22-axial plot: one axis for each elemental concentration, and one point for each sample. After plotting all potential functions in hyperspace, cluster analysis determines the appropriate boundaries of clusters of points. The user defines the number of clusters to find, and cluster analysis determines where cluster boundaries exist. We applied cases of 2, 3, and 4 clusters.

2.4.3 Discriminant function analysis

Unlike cluster analysis, which determines the boundaries of natural groupings in hyperspace, discriminant function analysis allows the user to define what the groupings are, and allows the program to identify where the boundary (or boundaries) between them exists (Fig. 2.8). The discriminant function calculates a constant that maximizes the distance between points, and then multiplies each point by that constant. We applied discriminant function analysis using two possible groupings: tourmalines from emerald-bearing rocks ("E") and tourmalines from non-emerald-bearing rocks ("NE"). We performed two discriminant function analyses. The first used a narrow range of the "E" group, limited only to those samples that contained emerald; the second used an expanded range of the "E" group, including tourmalines from emerald-bearing samples, as well as those from rocks near emerald mineralization (± 25 m).

CHAPTER 3: RESULTS

This chapter includes the petrographic descriptions of all tourmaline-bearing lithologies present at Tsa da Glisza, statistical distribution of all elements analyzed, both from EMP and from LAM-ICPMS. End member classification is also included, as determined by EMP.

3.1 Petrographic descriptions of rocks present

Because time was limited over the course of this research, I provide petrographic descriptions of representative samples of Tsa da Glisza, rather than descriptions of each individual sample. Representatives include the Fire Lake Group country rocks (DF_1, DF_2, and DF_3; Section 3.1.1), granite (Section 3.1.2), aplites (Section 3.1.3), and quartz-tourmaline veins (Section 3.1.4). Section 3.1.5 provides descriptions of the anomalous samples that contain tourmaline, but do not belong to the common lithological groups of Tsa da Glisza.

3.1.1 Fire Lake Group schists

Figure 1.4 indicated the differences visible in hand sample of the varying degrees of metasomatic alteration of the country rocks. Increasing tourmaline content is apparent in hand specimen, as noted in Section 1.3.1; however, differences are also evident in thin section, primarily by changes in the volumetric concentration of phlogopite ± biotite, replacing chlorite.

3.1.1A – DF_1 samples

Figure 3.1 provides two representatives of DF_1: samples MO-5 (a) and HR-2 (b). These samples show the range of metasomatism associated within a single subclass of the country rock. The DF_1 samples contain a matrix of moderately to well-foliated chlorite, quartz, tremolite, and plagioclase (Fig. 3.1a). The matrix minerals range between 0.5 and 2 mm in longest dimension. Tourmaline porphyroblasts are present, overprinting the matrix-defined S_1 foliation, evident by the inclusion trails within the tourmaline. The porphyroblasts range in size between 10 and 60 mm in length, and are fractured perpendicular to the long axis. The fractures may be the result of cooling. In some cases, as in HR-2 (Fig. 3.1b), accessory opaque minerals are also present, although the exact composition is unknown; however, based on the abundance of iron-rich minerals in these rocks, the opaques are most likely Fe-, Ti-, and/or Cr-rich, possibly ilmenite, rutile, and/or chromite.

Biotite ± phlogopite is also present in some samples. These minerals are likely the result of metasomatism, evident by their relative abundance surrounding the tourmaline porphyroblasts. The reaction most likely includes the addition of B and K, promoting tourmaline, biotite, and phlogopite crystallization.

3.1.1B DF_2 samples

The DF_2 rocks differ from the DF_1 rocks by increased concentration of tourmaline and mica, indicative of more extensive metasomatism by the addition of B and K. Figure 3.2 shows a representative sample of DF_2 (HR-1). This rock contains a matrix of well-foliated chlorite, phlogopite (± biotite ± muscovite), quartz, and plagioclase, with accessory opaque minerals, and tourmaline porphyroblasts. Similar to the DF_1 samples, the porphyroblasts are superimposed on the matrix-defined foliation; however, the matrix foliation undulates and crenulations are present. The folds and crenulations may be responsible for the increased degree of metasomatism that distinguishes the DF_2 from the DF_1.

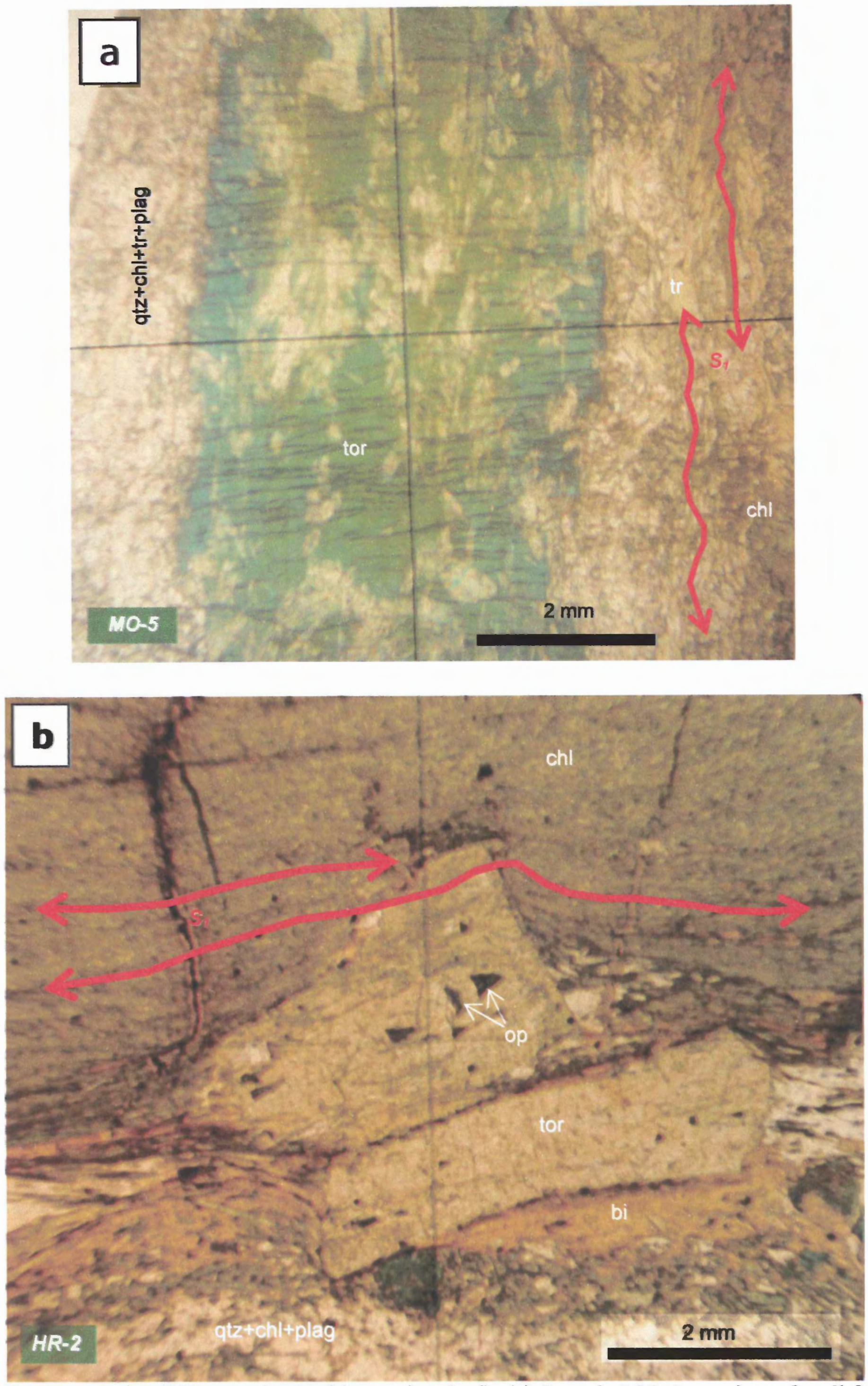

Figure 3.1 Representative DF$_1$ samples in thin section (ppl). (a) Sample MO-5 consists of well foliated chlorite, quartz, tremolite, and plagioclase, with tourmaline porphyroblasts. (b) Sample HR-2 consists of the same assemblage; however, chlorite is also replaced by biotite, and lacks tremolite. In some samples, the chlorite is replaced by phlogopite, instead of biotite, although this replacement texture is not characteristic of DF$_1$. In all cases, inclusion trails within the tourmalines indicate that the growth of porphyroblasts occurred post-S$_1$ foliation. Red lines define the S$_1$ foliation.

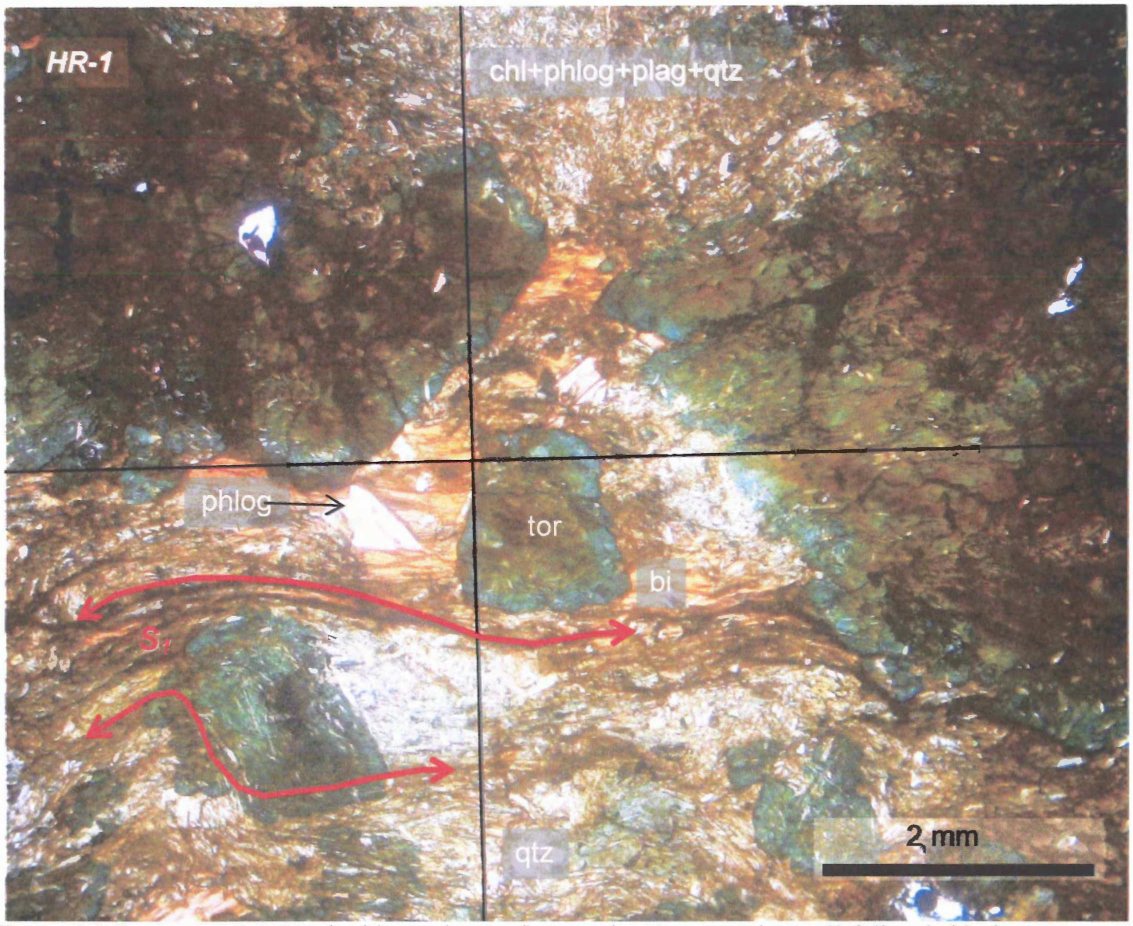

Figure 3.2 Representative DF_2 in thin section (ppl). Sample HR-1 contains well-foliated chlorite, phlogopite, biotite, quartz, and plagioclase, with accessory opaque minerals, and tourmaline porphyroblasts. Like the DF_1 rocks (Fig. 3.1), the porphyroblasts overprint the main S_1 foliation; however, different from the DF_1 rocks is that the S_1 foliation of DF_2 rocks is more folded and crenulations, defined by phlogopite / biotite and quartz / plagioclase, are present. Red lines define the S_1 foliation.

3.1.1C DF_3 samples

The DF_3 rocks display the most influence by metasomatism, evident by near-complete replacement of protolith to non-foliated, slightly porous tourmalinite. Figure 3.3 shows sample SUM-3, a representative DF_3. It contains predominantly tourmaline (50 – 70% by volume); however, lesser amounts of opaque minerals and quartz are also present. Although not present in SUM-3, some DF_3 rocks also contain phlogopite ± muscovite.

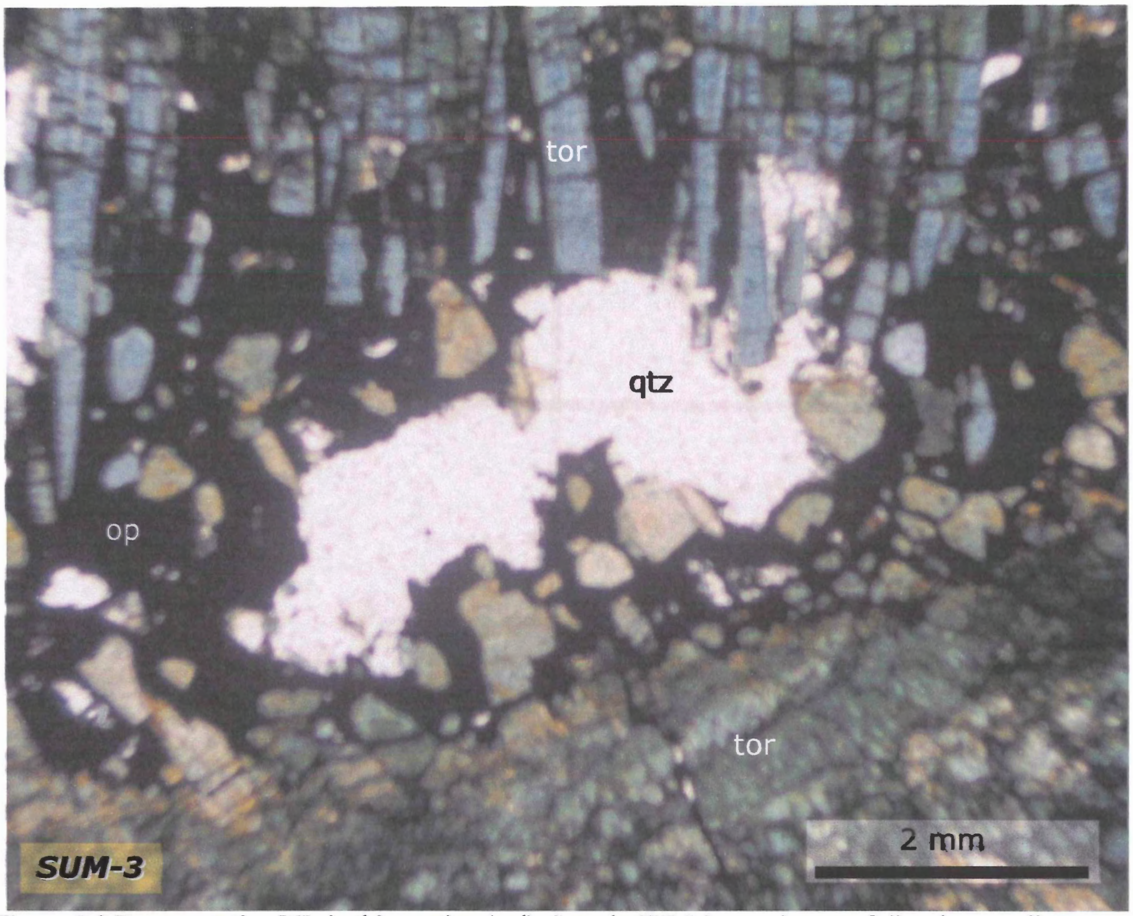

Figure 3.3 Representative DF_3 in thin section (ppl). Sample SUM-3 contains non-foliated tourmaline, opaque minerals, and quartz. Fractures are present and DF_3 rocks are slightly porous. Some samples also contain lower modal abundances of phlogopite ± muscovite.

Samples of DF_3 that contain lower modal abundances of tourmaline and higher modal abundances of quartz rarely also contain beryl, in many cases as emerald. Figure 3.4 shows a representative sample of emerald-bearing DF_3 (sample 322807). The tourmalines in the emerald-bearing DF_3 are present in two forms: coarse-grained, sub-idioblastic tourmaline (several millimetes in size), and fine-grained, idioblastic tourmaline (<1 mm in size). Accessory phlogopite and opaque minerals are also present.

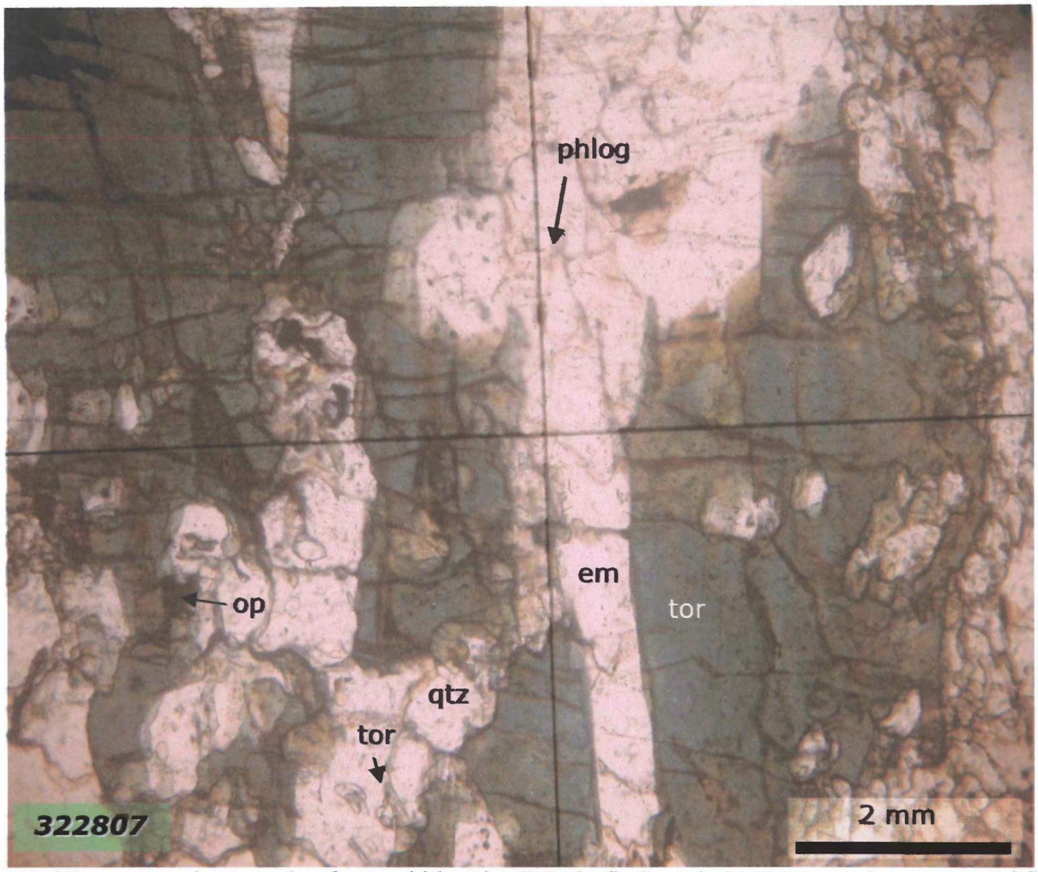

Figure 3.4 Representative sample of emerald-bearing DF_3 (ppl). Sample 322807 contains coarse and fine-grained tourmaline, quartz, and emerald, with accessory phlogopite and opaques.

3.1.2 Granite

The granite at Tsa da Glisza is a coarse-grained, porphyritic granite that contains euhedral to subhedral quartz, plagioclase, K-feldspar (most likely orthoclase), and rarely muscovite ± biotite. Euhedral macrocrysts of tourmaline are also present. The matrix minerals range from 1 mm to 10 mm in size, and the tourmaline macrocrysts reach up to 15 mm wide by 100 mm long. Large tourmalines (i.e. >5 mm cross-sectional width) are typically extensively fractured and contain inclusions of the matrix minerals.

Grain size of the matrix minerals varies in granite samples collected from the northern area of the property (CO-1 and CO-2; CO-1 in Fig. 3.5a). Zones several centimetres across contain medium- to finer-grained minerals ($\leq$ 2 mm) coexist with more extensive zones (size extent unknown) of coarser-grained minerals (> 2 mm, usually < 10 mm). In these samples, tourmaline macrocrysts are present in both grain size groups; however, the tourmalines are smaller in the small grain size assemblage and larger in the large grain size assemblage. Muscovite is rarely present in these samples, typically with the larger grain size group, but no biotite is present in these samples. Myrmekitic and perthitic textures are common in the northern-area of the granite (Fig. 3.5b).

Granites from the southern area (near Howdy Ridge) of the property (HV-1, HV-2, and HV-3, although only HV-3 contained tourmaline in thin section) contain tourmaline macrocrysts, as well as tourmaline veins (veins < 5 mm thick). Both biotite and muscovite are present in the Howdy-region of the granite.

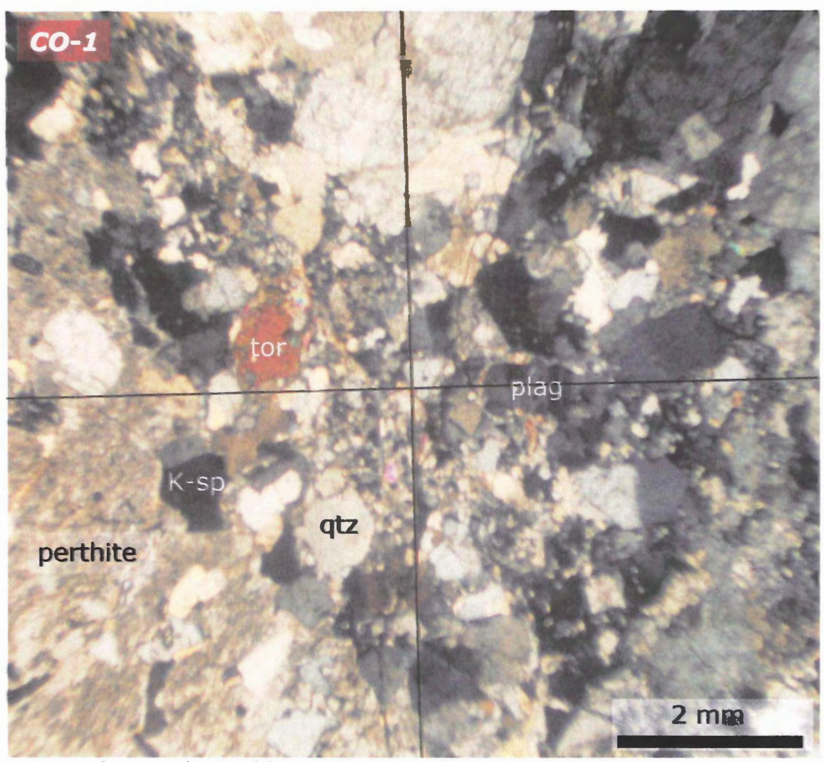

Figure 3.5a Representative granite in thin section (xn). Sample CO-1 contains a matrix of quartz, plagioclase, and K-feldspar (most likely orthoclase), as well as tourmaline macrocrysts. The tourmaline pictured is in cross section, however, the tourmaline in the granites can reach lengths of 10 cm. In addition to the tourmaline macrocrysts, perthitic feldspars are also present as large macrocrysts.

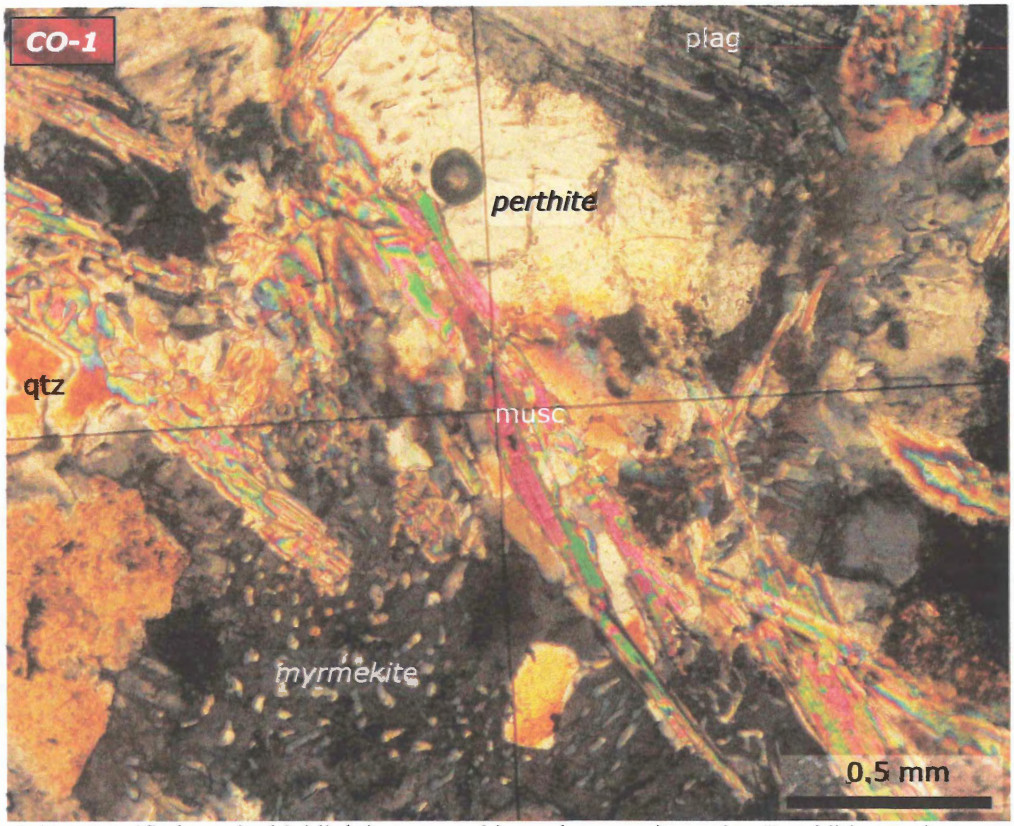

Figure 3.5b Magnified granite highlighting myrmekite and muscovite grains. In addition to the assemblage indicated in Figure 3.5a, muscovite is also present. Where muscovite is present, strong myrmekitic and perthitic textures are associated.

3.1.3 Aplite

Figure 3.6 shows a representative aplite sample (AP-T1) from Tsa da Glisza. It contains a matrix of euhedral to subhedral medium-coarse-grained (1 – 2 mm) quartz, plagioclase (end member not known), and K-feldspar (predominantly microcline, but minor orthoclase is also present), with euhedral tourmaline macrocrysts (up to 2 mm across by 70 mm long). Oscillatory zoning is visible in the tourmaline cross-sections of sample AP-T1 (Fig. 3.6); however, the zoned tourmalines are not characteristic of aplites. Although not pictured, myrmekitic textures are present in some aplites.

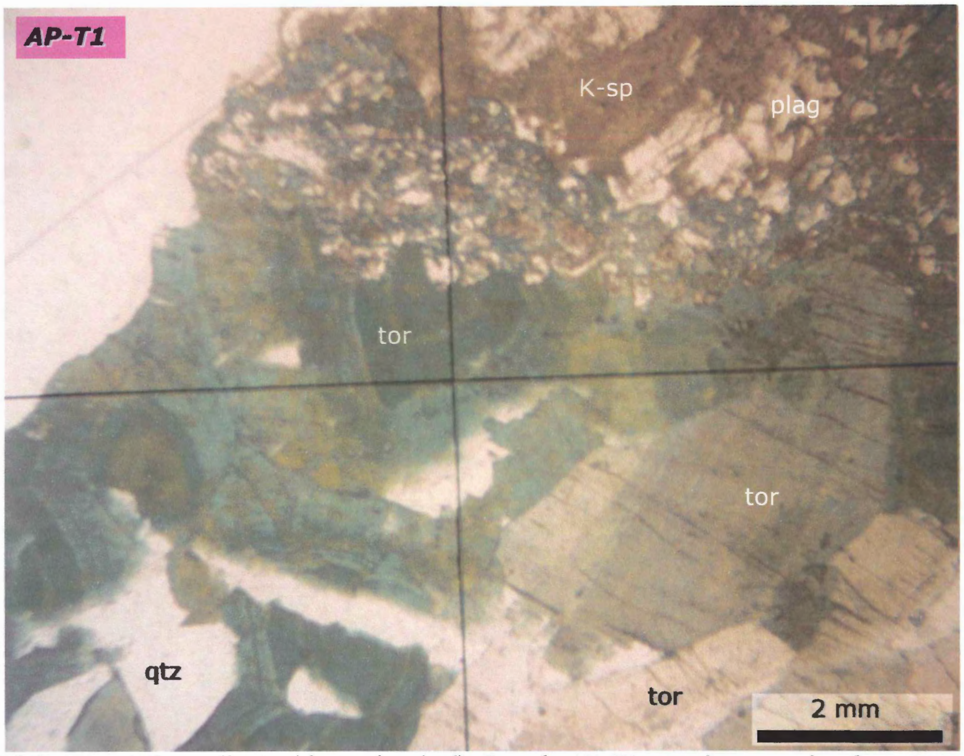

Figure 3.6 Representative aplite in thin section (ppl). Sample AP-T1 contains a matrix of quartz, plagioclase, and K-feldspar, with tourmaline macrocrysts. The tourmalines display oscillatory zoning; however, the zoning in this sample is not common to all aplites.

3.1.4 Quartz-tourmaline veins

The only mineral constituents in the quartz-tourmaline veins are anhedral quartz grains (< 1 mm in size) and euhedral tourmaline grains (vary < 1 mm – 5 mm). Figure 3.7 shows two representative samples of quartz-tourmaline veins in thin section. Sample MO-7 (Fig. 3.7a) contains zoned (brown rims enveloping blue-green cores) tourmalines in a quartz matrix. Major-element analysis indicates that the colour zones correspond to compositional zoning of dravitic rims enveloping schorlitic cores (Section 3.2). Samples MO-7 and 322814 (an emerald-bearing DF_3) are the only samples to positively contain compositionally-zoned tourmalines. Sample OZ-2 (Fig. 3.7b) contains oscillatory-zoned tourmalines in a quartz matrix, although not all tourmalines display zoning. Two sizes of tourmalines are present in OZ-2, including medium-fine-grained tourmalines (1 – 2 mm in length) and coarse-grained tourmalines (>10 mm in length).

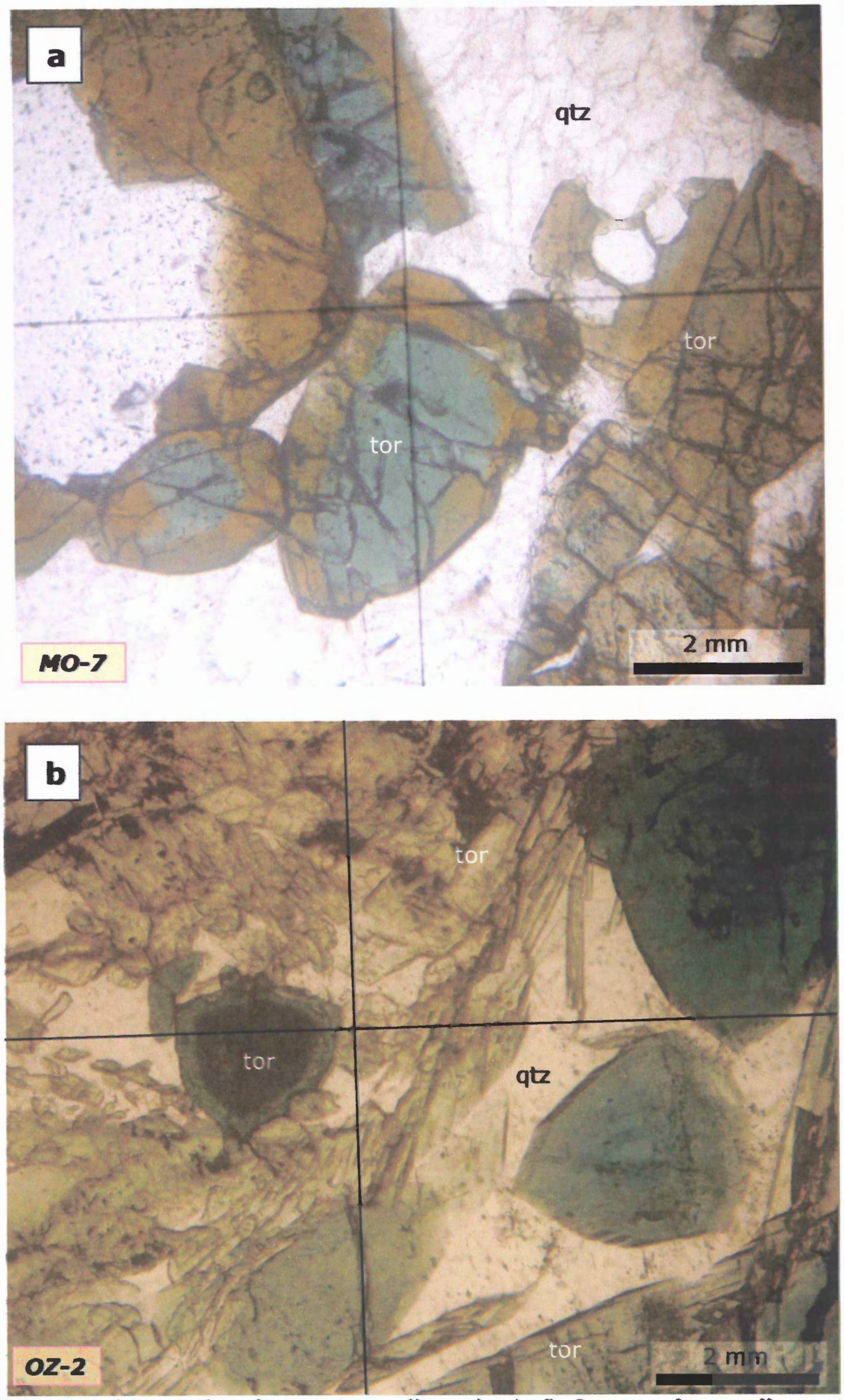

Figure 3.7 Representative samples of quartz-tourmaline veins (ppl). Quartz and tourmaline are the only minerals present in these veins, however, the concentration of tourmaline by volume, the size of the tourmaline grains, and the presence or absence of zoning vary in each sample. Sample MO-7 (a) contains colour-zoned tourmalines, and tourmaline comprises ~10% of the rock by volume. In comparison, sample OZ-2 (b) contains oscillatory-zoned tourmalines, and tourmaline comprises ~60% of the rock by volume, including crystals of variable grain size (length ranging from 1 mm – 10 mm).

3.2 Major-element results

Table 3.1 contains a statistical summary of the EMP analyses. This table shows the minimum, maximum, and average values of each sample, in atoms per formula unit (apfu). Because of inconsistencies in the measured B_2O_3 values, the values shown in Table are corrected to 9.8 weight % B_2O_3. APPENDIXES A includes the measured weight percent of oxide for each analysis. APPENDIX B features the average structural formula of each sample, including X-, Y-, and Z-site occupancies.

Only three species of tourmaline occur at Tsa da Glisza: uvite, dravite and schorl; therefore, only Na, Ca, Mg and Fe contents of a tourmaline grain are required to identify the species. Tourmalines containing more than 1.5 atoms per formula unit (apfu) Fe always contain more than 0.5 apfu Na, so are therefore schorl (above the *schorl-dravite* boundary). Those with more than 1.5 apfu Mg and more than 0.5 apfu Ca are uvite (above the *uvite-dravite* boundary). Dravites contain more than 1.5 Mg and more than 0.5 apfu Na.

The definition of the dravite boundaries is important in this study, given the high degree of solid solution between Na and Ca, and Fe and Mg in these tourmalines. Many of the samples lie near these boundaries and/or lie above and below these boundaries based on multiple points measured in each crystal.

I identified six schorl specimens (322810, CO-1, CO-2, HV-3, H0429, and MO-2), six uvite specimens (322915, 322943, 322807A, FW-6, OZ-3, and TH-1), and the remaining 35 samples were dravitic tourmalines (Fig. 3.8).

Table 3.1 Major-element data in atoms per formula unit. Minimum, maximum, and mean values are indicated and sorted by lithology. Text colour indicates lithology: gray for DF_1, orange for DF_2, brown for DF_3, green for emerald-bearing DF_3, red for granite, pink for aplite, aqua for emerald-bearing aplite, and blue for quartz-tourmaline veins.

	Sample	Si	Ti	B	$Al^{[TOT]}$	Cr	V	Fe	$Mg^{[TOT]}$	Mn	Ca	Na	K	F
min	FW-4 *n=4*	6.20	0.02	2.98	6.79	0.004	0.003	0.78	2.02	0	0.26	0.54	0.002	N/A
max		6.22	0.08	3.02	7.10	0.017	0.009	0.82	2.28	0.002	0.30	0.61	0.004	
mean		6.22	0.05	3.00	6.94	0.011	0.005	0.81	2.16	0.000	0.28	0.57	0.003	
min	HRT-4 *n=3*	6.25	0.10	3.02	6.51	0.029	0.001	0.74	2.34	0.003	0.28	0.56	0.004	N/A
max		6.31	0.11	3.07	6.67	0.039	0.002	0.81	2.36	0.004	0.36	0.64	0.006	
mean		6.29	0.10	3.04	6.58	0.033	0.002	0.78	2.35	0.003	0.31	0.60	0.005	
min	HRT-7 *n=4*	6.29	0.02	2.99	6.64	0.030	0	0.55	2.36	0.000	0.27	0.61	0.004	N/A
max		6.35	0.08	3.00	6.83	0.055	0	0.60	2.45	0.001	0.30	0.64	0.006	
mean		6.33	0.05	2.99	6.74	0.044	0	0.58	2.41	0.000	0.29	0.63	0.005	
min	776T-3 *n=3*	6.22	0.01	2.96	6.77	0.029	0.004	0.60	2.20	0	0.20	0.58	0.003	N/A
max		6.33	0.08	3.01	6.99	0.033	0.010	0.61	2.43	0.005	0.34	0.60	0.011	
mean		6.29	0.03	2.99	6.87	0.031	0.007	0.61	2.32	0.003	0.28	0.59	0.008	
min	776T-4 *n=2*	6.29	0.01	3.04	6.46	0.023	0	0.67	2.59	0.014	0.39	0.54	0.004	0.07
max		6.33	0.01	3.05	6.49	0.042	0.000	0.68	2.63	0.020	0.46	0.64	0.008	0.08
mean		6.31	0.01	3.04	6.48	0.033	0.000	0.68	2.61	0.017	0.43	0.59	0.006	0.07
min	HR-2 *n=3*	6.28	0.03	3.00	6.65	0	0.001	0.64	2.17	0	0.21	0.62	0.000	N/A
max		6.33	0.03	3.01	7.01	0.042	0.008	0.76	2.40	0.003	0.28	0.73	0.003	
mean		6.31	0.03	3.00	6.82	0.019	0.004	0.70	2.27	0.001	0.24	0.69	0.002	
min	MO-1 *n=3*	6.20	0.01	3.00	6.78	0	0	0.77	2.17	0	0.28	0.54	0.004	N/A
max		6.28	0.07	3.02	6.94	0.006	0.003	0.85	2.22	0	0.36	0.57	0.007	
mean		6.25	0.05	3.01	6.87	0.002	0.001	0.80	2.20	0	0.31	0.56	0.005	
min	MO-5 *n=4*	6.43	0.01	2.92	6.87	0.007	0.001	0.45	2.23	0.002	0.24	0.59	0.005	0
max		6.46	0.02	2.94	6.91	0.010	0.004	0.47	2.30	0.008	0.28	0.69	0.007	0
mean		6.45	0.02	2.93	6.90	0.008	0.002	0.46	2.28	0.004	0.26	0.64	0.006	0
min	322807A *n=5*	6.43	0.01	3.01	5.97	0.012	0.002	0.63	2.47	0.001	0.36	0.42	0.003	0.02
max		6.54	0.06	3.03	6.45	0.024	0.006	0.77	2.89	0.003	0.58	0.56	0.006	0.08
mean		6.48	0.03	3.01	6.14	0.018	0.004	0.70	2.77	0.002	0.52	0.47	0.004	0.05
min	FW-2 *n=3*	6.26	0.02	3.02	6.47	0.000	0.004	0.81	2.12	0.007	0.32	0.57	0.008	0.09
max		6.32	0.06	3.06	6.75	0.007	0.014	0.96	2.58	0.016	0.47	0.61	0.022	0.11
mean		6.28	0.04	3.05	6.58	0.002	0.009	0.90	2.30	0.011	0.39	0.59	0.014	0.10
min	HRT-6 *n=6*	6.35	0.03	2.95	6.30	0.016	0.004	0.62	2.33	0.001	0.33	0.50	0.004	0.05
max		6.47	0.09	3.03	6.64	0.085	0.010	0.71	2.78	0.006	0.44	0.57	0.008	0.07
mean		6.40	0.05	2.97	6.51	0.045	0.007	0.67	2.46	0.003	0.39	0.53	0.006	0.05
min	T0640 *n=5*	6.28	0.03	3.01	6.28	0	0	0.64	2.52	0.001	0.31	0.52	0.004	0.04
max		6.36	0.04	3.03	6.58	0.015	0.006	0.76	2.81	0.006	0.50	0.67	0.008	0.06
mean		6.32	0.04	3.02	6.47	0.010	0.002	0.70	2.64	0.004	0.40	0.59	0.005	0.05
min	HRT-1 *n=6*	6.28	0.04	2.99	6.65	0	0.000	0.86	2.09	0.002	0.30	0.56	0.003	0
max		6.39	0.06	3.02	6.77	0	0.001	0.92	2.17	0.005	0.34	0.60	0.005	0.13
mean		6.34	0.05	3.00	6.72	0	0.000	0.89	2.13	0.004	0.32	0.59	0.004	0.04
min	SUM-3 *n=8*	6.13	0.02	3.01	6.49	0	0	0.87	1.93	0	0.21	0.59	0.003	N/A
max		6.35	0.08	3.11	6.76	0.038	0.006	1.78	2.23	0.007	0.33	0.68	0.005	
mean		6.30	0.04	3.04	6.63	0.014	0.002	1.06	2.16	0.002	0.27	0.63	0.004	

	Sample	Si	Ti	B	$Al^{[TOT]}$	Cr	V	Fe	$Mg^{[TOT]}$	Mn	Ca	Na	K	F
min	**322943 *n=5***	6.24	0.01	3.00	6.18	0	0	0.52	2.62	0.002	0.31	0.36	0.001	0.03
max		6.34	0.01	3.06	6.68	0.004	0.003	0.78	2.95	0.005	0.70	0.68	0.005	0.08
mean		6.29	0.01	3.03	6.40	0.001	0.001	0.67	2.81	0.004	0.52	0.50	0.003	0.06
min	**322915 *n=6***	6.29	0.01	3.02	6.19	0	0	0.76	1.71	0	0.17	0.41	0.001	0.08
max		6.33	0.05	3.06	7.07	0	0.002	1.01	2.86	0.006	0.63	0.61	0.006	0.09
mean		6.31	0.02	3.04	6.48	0	0.000	0.82	2.51	0.003	0.46	0.51	0.004	0.09
min	**H0309B *n=7***	6.27	0.02	3.03	6.51	0	0.005	0.93	2.03	0	0.26	0.54	0.003	0
max		6.34	0.07	3.05	6.81	0.020	0.010	1.03	2.28	0.000	0.41	0.64	0.006	0
mean		6.31	0.04	3.04	6.68	0.007	0.007	0.96	2.11	0.000	0.34	0.57	0.004	0
min	**H0425 *n=6***	6.30	0.03	3.00	6.40	0.021	0.001	0.77	2.34	0	0.28	0.59	0.001	0.03
max		6.35	0.06	3.03	6.51	0.076	0.006	0.92	2.58	0	0.36	0.71	0.009	0.03
mean		6.33	0.05	3.01	6.46	0.056	0.004	0.85	2.43	0	0.33	0.66	0.003	0.03
min	**H0432 *n=3***	6.26	0.06	2.99	6.60	0	0.007	0.85	2.27	0	0.36	0.56	0.000	0.02
max		6.31	0.08	3.01	6.68	0.001	0.009	0.89	2.32	0.002	0.37	0.63	0.005	0.05
mean		6.28	0.07	3.00	6.64	0.000	0.008	0.87	2.29	0.001	0.37	0.61	0.003	0.03
min	**HR-3 *n=6***	6.20	0.02	3.00	6.42	0.000	0.000	0.65	2.20	0	0.24	0.52	0.005	0
max		6.33	0.10	3.03	6.96	0.006	0.005	0.88	2.74	0.008	0.45	0.66	0.011	0.02
mean		6.26	0.04	3.01	6.75	0.003	0.003	0.77	2.34	0.004	0.32	0.59	0.008	0.01
min	**MO-3 *n=8***	6.23	0.00	2.99	6.59	0	0	0.62	2.02	0.005	0.22	0.60	0.006	0.05
max		6.32	0.07	3.02	6.94	0.068	0.002	1.02	2.60	0.017	0.40	0.64	0.011	0.10
mean		6.28	0.03	3.00	6.78	0.019	0.000	0.77	2.29	0.010	0.31	0.62	0.008	0.07
min	**OZ-5 *n=4***	6.31	0.01	3.02	6.14	0	0	0.64	2.29	0	0.29	0.36	0.001	0.03
max		6.35	0.02	3.04	6.77	0.030	0.004	0.76	3.02	0.002	0.69	0.61	0.004	0.09
mean		6.33	0.01	3.03	6.36	0.011	0.001	0.69	2.75	0.001	0.53	0.48	0.003	0.06
min	**T0643 *n=5***	6.29	0.05	3.00	6.54	0.004	0.000	0.77	1.91	0	0.22	0.66	0.002	
max		6.46	0.09	3.05	6.95	0.035	0.001	0.95	2.19	0.004	0.31	0.69	0.005	N/A
mean		6.38	0.07	3.02	6.73	0.016	0.001	0.85	2.01	0.001	0.26	0.68	0.004	
min	**322807 *n=3***	6.47	0.02	2.95	6.52	0.051	0.003	0.94	1.76	0.018	0.20	0.57	0.012	0.01
max		6.50	0.06	3.00	6.75	0.144	0.009	0.97	1.98	0.021	0.35	0.68	0.015	0.08
mean		6.49	0.04	2.97	6.61	0.107	0.007	0.95	1.85	0.020	0.27	0.62	0.013	0.06
min	**322810 *n=2***	6.16	0.02	3.01	6.64	0	0.001	0.92	1.85	0.015	0.24	0.59	0.006	0.03
max		6.30	0.03	3.04	6.96	0.014	0.008	1.12	2.22	0.029	0.39	0.73	0.014	0.10
mean		6.23	0.03	3.02	6.80	0.007	0.005	1.02	2.04	0.022	0.31	0.66	0.010	0.06
min	**FW-5 *n=4***	6.41	0.01	2.89	5.97	0.024	0.003	0.81	1.72	0.009	0.18	0.52	0.008	0.05
max		6.62	0.02	2.99	6.88	0.740	0.014	0.90	2.03	0.015	0.39	0.63	0.012	0.08
mean		6.47	0.02	2.96	6.54	0.277	0.009	0.86	1.91	0.012	0.29	0.57	0.011	0.06
min	**CO-1 *n=6***	6.01	0.04	3.06	7.20	0	0	1.92	0.34	0.024	0.02	0.58	0.013	0.01
max		6.25	0.11	3.15	7.45	0	0.002	2.14	0.52	0.050	0.08	0.76	0.019	0.05
mean		6.12	0.09	3.11	7.31	0	0.001	2.06	0.42	0.042	0.06	0.72	0.015	0.04
min	**CO-2 *n=4***	6.35	0.05	3.02	6.93	0	0	1.71	0.60	0.035	0.03	0.62	0.011	
max		6.47	0.15	3.06	7.13	0.001	0	1.82	0.81	0.044	0.09	0.72	0.019	N/A
mean		6.42	0.09	3.03	7.02	0.000	0	1.77	0.68	0.040	0.06	0.68	0.014	
min	**HV-3 *n=2***	6.25	0.13	3.02	6.91	0.001	0.000	1.30	1.17	0.010	0.11	0.74	0.006	
max		6.34	0.16	3.06	6.99	0.002	0.000	1.38	1.35	0.018	0.15	0.78	0.012	N/A
mean		6.29	0.14	3.04	6.95	0.001	0.000	1.34	1.26	0.014	0.13	0.76	0.009	
min	**AP-T1 *n=6***	6.46	0.01	2.93	6.32	0.005	0	0.56	2.06	0.024	0.13	0.65	0.009	0.04
max		6.54	0.04	2.97	6.74	0.026	0.005	0.84	2.65	0.030	0.34	0.83	0.010	0.04
mean		6.50	0.02	2.96	6.59	0.013	0.003	0.75	2.25	0.027	0.20	0.74	0.009	0.05
min	**H0429 *n=7***	6.11	0.07	3.08	7.10	0	0	1.76	0.25	0.048	0.04	0.78	0.014	0.05
max		6.20	0.13	3.12	7.44	0	0.000	2.05	0.84	0.140	0.08	0.84	0.018	0.06
mean		6.15	0.10	3.10	7.23	0	0.000	1.96	0.50	0.086	0.06	0.82	0.015	0.05
min	**MO-2 *n=4***	6.10	0.11	3.06	6.78	0	0	1.45	1.28	0.021	0.10	0.74	0.013	0.05
max		6.26	0.15	3.09	6.99	0	0.004	1.56	1.47	0.030	0.15	0.80	0.017	0.06
mean		6.18	0.13	3.07	6.90	0	0.002	1.51	1.36	0.026	0.13	0.78	0.014	0.06

	Sample	Si	Ti	B	$Al^{[TOT]}$	Cr	V	Fe	$Mg^{[TOT]}$	Mn	Ca	Na	K	F
min	**MO-6** *n=2*	6.46	0.05	2.96	6.67	0.008	0	0.88	1.69	0.021	0.12	0.73	0.009	0.08
max		6.59	0.05	2.98	6.91	0.027	0	0.92	1.81	0.025	0.13	0.76	0.014	0.09
mean		6.52	0.05	2.97	6.79	0.018	0	0.90	1.75	0.023	0.12	0.75	0.011	0.08
min	**TC-2** *n=5*	6.20	0.00	3.00	6.94	0	0.000	0.63	0.69	0.007	0.05	0.51	0.003	0
max		6.29	0.04	3.06	7.59	0.001	0.002	1.51	2.31	0.025	0.20	0.70	0.005	0.06
mean		6.24	0.03	3.03	7.39	0.000	0.001	1.14	1.29	0.018	0.09	0.60	0.003	0.03
min	**TH-1** *n=4*	6.25	0.03	3.02	6.01	0.007	0.006	0.76	2.34	0.003	0.40	0.39	0.005	0
max		6.32	0.05	3.06	6.68	0.026	0.009	0.91	2.81	0.007	0.68	0.58	0.009	0.04
mean		6.29	0.04	3.03	6.48	0.013	0.007	0.81	2.49	0.005	0.49	0.52	0.006	0.03
min	**APMT-1** *n=5*	6.39	0.01	2.93	6.55	0.000	0.001	0.60	1.55	0.029	0.07	0.65	0.007	0.05
max		6.58	0.03	2.96	7.19	0.107	0.005	0.96	2.26	0.044	0.20	0.74	0.012	0.08
mean		6.51	0.01	2.95	6.86	0.044	0.003	0.77	1.86	0.034	0.13	0.72	0.009	0.06
min	**322807B** *n=5*	6.47	0.01	2.91	6.07	0.003	0.003	0.66	2.02	0.005	0.19	0.40	0.007	0.10
max		6.60	0.10	2.97	6.76	0.005	0.011	0.86	2.80	0.009	0.60	0.55	0.010	0.11
mean		6.52	0.05	2.95	6.35	0.004	0.008	0.76	2.43	0.007	0.46	0.47	0.008	0.10
min	**FW-3** *n=3*	6.40	0.05	2.94	6.71	0	0.006	0.83	1.98	0.001	0.29	0.52	0.005	0
max		6.52	0.07	2.97	6.73	0.002	0.008	0.92	2.02	0.005	0.31	0.55	0.008	0
mean		6.46	0.06	2.96	6.72	0.001	0.007	0.87	1.99	0.003	0.30	0.53	0.006	0
min	**HRT-3** *n=3*	6.27	0.03	2.91	6.51	0	0.000	0.85	1.12	0	0.11	0.54	0.004	0
max		6.66	0.04	3.06	7.12	0.005	0.005	1.52	2.24	0.036	0.29	0.63	0.009	0.04
mean		6.45	0.04	3.00	6.73	0.002	0.002	1.08	1.81	0.014	0.22	0.58	0.006	0.01
min	**SUM-1** *n=2*	6.24	0.05	3.03	6.66	0	0	1.02	2.08	0	0.29	0.59	0.002	0
max		6.29	0.08	3.05	6.74	0	0.005	1.04	2.11	0.001	0.29	0.61	0.006	0.01
mean		6.27	0.06	3.04	6.70	0	0.003	1.03	2.10	0.000	0.29	0.60	0.004	0
only good analysis	**HR-4**	6.30	0.07	3.01	6.68	0.008	0.000	0.80	2.19	0.004	0.49	0.46	0.005	0.05
min	**MO-7** *n=7*	6.21	0.03	3.00	6.51	0	0	0.89	0.91	0.019	0.08	0.73	0.012	0.03
max		6.53	0.13	3.08	6.97	0.192	0.003	1.74	1.83	0.038	0.15	0.77	0.017	0.06
mean		6.38	0.08	3.04	6.78	0.106	0.001	1.26	1.42	0.028	0.11	0.76	0.014	0.05
min	**OZ-2** *n=5*	6.33	0.00	3.01	6.20	0	0	0.69	1.85	0.000	0.13	0.44	0.003	0
max		6.37	0.07	3.04	7.05	0.057	0.001	0.96	2.86	0.010	0.60	0.62	0.008	0.04
mean		6.35	0.03	3.02	6.51	0.019	0.000	0.79	2.46	0.006	0.39	0.56	0.006	0.02
min	**OZ-3** *n=2*	6.42	0.01	3.00	6.53	0.000	0.000	0.55	2.28	0	0.29	0.53	0.001	0.04
max		6.44	0.01	3.02	6.65	0.032	0.000	0.67	2.52	0.001	0.48	0.72	0.003	0.08
mean		6.43	0.01	3.01	6.59	0.016	0.000	0.61	2.40	0.000	0.38	0.63	0.002	0.07
min	**T0642** *n=6*	6.26	0.01	2.95	6.80	0	0	0.60	1.98	0.001	0.16	0.65	0	0
max		6.43	0.03	2.98	7.30	0	0	0.72	2.18	0.004	0.22	0.72	0.006	0
mean		6.33	0.02	2.96	7.05	0	0	0.65	2.08	0.002	0.20	0.68	0.002	0

3.3 Trace-element results

Table 3.3 shows the statistical distribution of all elements analyzed for trace concentrations by LAM-ICPMS. APPENDIX C (given in ppm or wt % oxide) contains a complete list of trace-element concentrations.

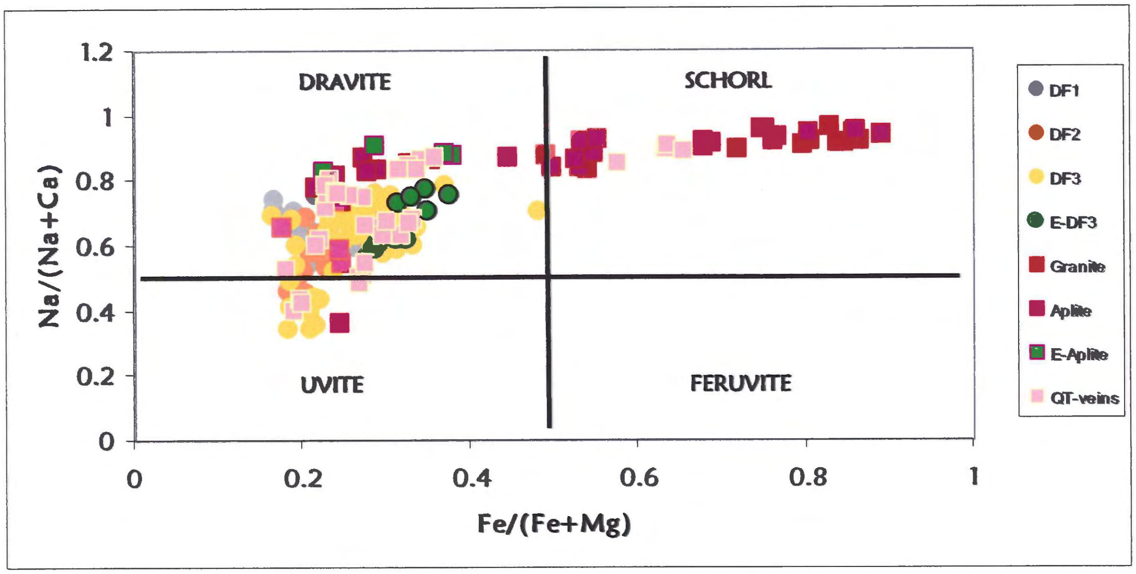

Figure 3.8 A binary plot of end member classification. Samples are organized by lithology and plotted within dravite, schorl, feruvite, and uvite boundaries (defined by Hawthorne & Henry, 1999).

Table 3.2 Minimum, maximum, and mean concentrations of trace elements determined by LAM-ICPMS. Minimum, maximum, and mean (3 – 5 analyses per sample) values are indicated and sorted by lithology. Text colour indicates lithology: gray for DF_1, orange for DF_2, brown for DF_3, green for emerald-bearing DF_3, red for granite, pink for aplite, aqua for emerald-bearing aplite, and blue for quartz-tourmaline veins.

Sample		Li	Be	Sc	V	Cr	MnO	Co	Ni	Cu
776T-4 n=5	min	84.955	28.270	73.355	316.486	1647.837	0.125	39.409	344.091	2.270
	max	186.121	48.107	163.579	403.130	2615.488	0.146	46.160	399.674	4.734
	mean	120.718	37.808	123.336	361.775	2173.931	0.135	42.103	359.497	3.146
MO-5 n=5	min	34.787	13.171	4.666	126.604	372.171	0.022	28.187	177.520	1.911
	max	60.855	22.992	24.536	168.515	546.468	0.109	29.625	201.347	2.956
	mean	41.970	17.799	11.106	147.912	435.959	0.048	29.114	188.227	2.462
322807A n=5	min	32.780	27.628	5.201	244.523	592.820	0.042	17.666	74.766	2.738
	max	55.442	36.407	43.377	324.830	1351.838	0.180	22.987	110.912	9.298
	mean	39.642	31.423	23.957	270.927	928.177	0.105	19.121	90.697	5.062
FW-2 n=5	min	108.806	33.942	53.465	346.251	6.294	0.092	15.416	27.467	59.155
	max	164.607	45.492	96.457	497.861	78.098	0.130	25.064	53.961	178.519
	mean	126.007	39.091	76.147	433.057	37.060	0.110	17.874	40.207	118.475
HR-1 n=5	min	56.564	16.586	15.312	178.543	491.163	0.042	28.509	100.238	1.210
	max	258.692	38.027	83.224	313.109	927.302	0.307	35.515	159.282	2.089
	mean	131.253	28.683	42.164	226.719	620.194	0.147	33.143	118.210	1.680
HRT-6 n=5	min	37.105	16.246	19.565	286.911	186.491	0.045	9.787	34.040	2.963
	max	45.232	30.022	33.674	375.555	294.431	0.186	23.990	49.563	4.573
	mean	41.136	23.875	25.471	339.930	246.346	0.075	18.673	43.352	3.504
T0640 n=7	min	48.704	19.220	15.225	166.391	240.579	0.046	24.368	99.648	2.426
	max	130.558	32.487	98.479	249.513	506.094	0.764	107.660	309.139	56.598
	mean	92.638	25.165	34.884	221.111	388.616	0.157	40.494	153.170	14.454
322915 n=5	min	90.284	27.122	10.878	92.644	7.253	0.072	24.665	28.678	2.004
	max	172.066	56.190	36.684	167.894	190.318	0.118	32.660	121.605	5.179
	mean	132.080	34.172	23.436	141.906	45.756	0.094	29.549	55.295	3.203

Table 3.2 continued

Sample		Li	Be	Sc	V	Cr	MnO	Co	Ni	Cu
322943 n=5	min	60.938	24.278	8.411	210.602	410.716	0.038	23.282	169.314	1.717
	max	89.517	95.581	25.640	375.366	1288.574	0.058	34.984	224.137	3.056
	mean	70.902	50.188	15.800	283.415	737.338	0.049	29.748	192.657	2.354
H0309B n=8	min	36.241	19.074	31.090	475.611	370.844	0.030	33.701	41.651	2.043
	max	85.994	49.240	218.583	841.655	1380.554	0.080	67.526	205.033	6.701
	mean	55.363	28.101	83.725	624.338	865.531	0.046	53.159	114.606	3.542
H0425 n=5	min	26.573	7.213	27.369	62.975	233.388	0.064	20.671	94.162	7.197
	max	77.872	24.816	51.346	320.123	2859.949	0.152	316.068	1307.915	365.631
	mean	61.372	14.419	34.011	248.540	1635.841	0.097	81.645	349.387	93.374
H0432 n=5	min	20.437	20.906	2.404	66.029	10.332	0.027	29.677	83.300	3.663
	max	26.796	27.763	3.763	82.144	1279.555	0.032	32.700	143.722	21.644
	mean	22.052	23.750	3.232	71.263	676.697	0.029	31.657	107.080	12.781
HR-3 n=5	min	27.147	21.443	4.166	152.185	7.431	0.043	21.034	92.398	4.087
	max	77.733	31.309	42.840	269.171	23.671	0.082	51.320	397.995	422.662
	mean	46.845	24.666	15.034	186.969	11.704	0.055	36.994	227.639	125.442
HRT-1 n=5	min	38.084	16.016	7.604	209.720	8.208	0.031	29.966	42.858	2.717
	max	69.075	28.191	22.995	296.649	46.600	0.078	40.321	133.268	8.323
	mean	48.857	21.426	16.636	250.454	17.960	0.050	36.008	83.658	4.370
MO-3 n=5	min	57.888	12.633	17.286	80.467	737.299	0.061	33.598	211.809	1.861
	max	341.694	18.191	58.773	321.910	2082.226	0.328	101.686	400.589	2.741
	mean	179.926	15.905	30.593	145.111	1301.805	0.185	62.254	293.185	2.309
OZ-5 n=5	min	179.999	20.953	8.090	4.390	7.232	0.361	1.552	6.299	2.636
	max	261.337	64.506	15.091	12.191	26.117	0.443	2.751	7.529	6.453
	mean	227.883	44.146	10.999	7.934	11.400	0.413	2.047	6.849	3.938
T0643 n=5	min	76.575	34.747	12.621	243.760	6.405	0.047	13.773	24.963	5.188
	max	110.437	42.474	20.841	382.390	21.495	0.317	27.669	37.413	21.551
	mean	101.490	38.262	17.303	322.645	11.395	0.139	23.760	29.937	11.701
322807 n=5	min	107.180	17.142	10.995	92.535	8.240	0.101	14.230	25.811	2.360
	max	168.687	52.885	25.348	208.550	78.656	0.195	30.976	106.247	6.491
	mean	144.511	34.334	19.796	166.850	40.809	0.151	22.752	58.474	4.161
322810 n=5	min	112.268	27.038	24.453	156.832	674.038	0.092	18.545	31.433	2.343
	max	145.695	44.711	37.577	188.984	2463.529	0.113	21.843	56.351	13.985
	mean	123.580	36.024	32.648	173.581	1582.408	0.104	19.977	46.440	5.167
FW-5 n=3	min	128.054	40.585	43.616	257.323	1523.149	0.127	21.038	59.860	3.166
	max	162.411	71.132	63.644	309.097	8572.470	0.146	25.722	94.077	20.532
	mean	147.514	53.015	52.460	285.376	5073.356	0.139	23.990	82.189	8.997
CO-1 n=5	min	172.077	14.441	3.394	1.354	5.169	0.077	0.811	4.077	2.408
	max	265.965	41.967	8.769	5.156	31.087	0.402	3.948	13.745	26.005
	mean	220.712	31.183	5.750	2.474	13.127	0.261	2.506	6.770	10.961
AP-T1 n=4	min	95.279	25.160	8.699	109.273	58.842	0.236	27.226	66.062	2.668
	max	162.099	39.038	20.090	176.458	5122.011	0.281	30.932	386.845	3.761
	mean	125.246	29.701	12.256	146.325	2264.478	0.257	28.623	226.177	3.144
H0429 n=5	min	18.832	14.567	5.946	144.380	401.581	0.046	31.458	149.511	4.645
	max	36.113	28.733	47.322	244.316	1982.411	0.287	34.872	266.231	33.602
	mean	24.493	20.943	29.384	189.958	1157.169	0.156	33.436	203.541	13.906
MO-2 n=5	min	115.542	20.371	15.168	68.853	18.722	0.211	15.201	16.787	3.926
	max	177.997	51.377	19.247	81.215	164.710	0.230	21.078	21.819	26.448
	mean	140.948	33.448	16.756	74.595	95.221	0.222	19.358	18.981	11.681

Table 3.2 continued

Sample		Li	Be	Sc	V	Cr	MnO	Co	Ni	Cu
MO-6 n=5	min	70.542	19.170	4.174	37.435	25.687	0.029	15.535	87.405	2.498
	max	124.448	25.658	21.650	54.602	233.449	0.199	32.102	181.299	4.247
	mean	87.511	22.968	9.569	44.721	112.818	0.080	25.844	127.678	3.245
TC-2 n=6	min	24.908	3.401	1.685	0.890	4.224	0.053	0.629	2.103	1.008
	max	1235.922	40.493	4.573	5.937	10.487	1.055	2.551	9.164	11.234
	mean	761.151	22.550	3.570	3.449	7.926	0.669	1.761	5.999	6.645
TH-1 n=7	min	11.033	8.265	6.143	72.573	22.285	0.026	26.008	81.987	4.297
	max	104.408	63.975	60.467	247.057	1023.655	0.163	41.604	200.218	30.217
	mean	48.524	30.258	31.124	164.196	411.842	0.100	35.617	144.351	12.640
APMT-1 n=5	min	77.304	28.820	24.693	84.917	845.111	0.157	35.446	251.374	1.949
	max	90.993	40.684	49.584	154.866	1615.281	0.177	41.667	315.092	6.954
	mean	83.972	34.898	35.589	119.844	1179.975	0.169	39.512	274.549	3.447
322807B n=5	min	88.396	38.008	9.173	209.147	25.151	0.051	20.274	78.788	9.677
	max	123.139	81.381	35.199	523.293	528.751	0.096	22.505	146.994	181.587
	mean	99.523	53.483	16.684	388.976	189.909	0.062	21.674	111.665	52.597
FW-3 n=5	min	48.344	15.374	3.270	197.143	7.472	0.035	31.194	35.759	2.409
	max	69.338	30.460	23.697	322.925	39.171	0.047	40.853	145.939	4.867
	mean	55.210	23.691	11.585	251.601	16.536	0.041	36.090	100.122	3.256
HR-4 n=5	min	33.587	22.897	2.824	114.465	6.587	0.046	23.397	51.050	1.933
	max	120.434	137.496	30.847	286.363	688.510	0.158	38.180	196.295	5.288
	mean	72.995	51.573	11.966	172.606	144.631	0.086	29.819	106.944	2.847
HRT-3 n=6	min	22.811	14.139	7.750	111.719	295.917	0.027	12.243	59.373	2.028
	max	94.554	33.728	41.235	271.005	791.257	0.083	30.059	154.606	3.727
	mean	63.275	26.905	23.928	228.008	528.407	0.059	24.196	120.015	2.898
MO-7 n=6	min	220.890	41.338	8.658	22.339	40.121	0.291	13.536	50.838	3.619
	max	264.757	54.749	11.799	32.122	61.621	0.345	15.674	64.277	49.966
	mean	236.213	48.587	10.395	27.738	48.847	0.329	14.425	58.595	17.872
OZ-2 n=5	min	37.188	24.252	6.999	220.107	315.086	0.035	40.235	148.608	2.092
	max	59.237	76.406	36.396	357.506	1995.882	0.045	45.361	199.970	3.035
	mean	48.834	38.633	14.490	302.017	865.849	0.040	42.148	168.009	2.525
OZ-3 n=5	min	53.886	18.438	6.099	118.757	7.537	0.033	32.726	111.619	2.308
	max	68.863	49.248	17.071	207.858	16.013	0.054	75.490	220.852	12.978
	mean	61.020	32.105	9.785	168.939	10.400	0.039	52.793	164.433	6.222
SUM-1 n=5	min	40.902	27.392	16.814	222.497	12.116	0.031	31.903	168.307	2.864
	max	118.090	42.823	47.592	370.134	92.421	0.065	51.390	372.492	53.329
	mean	77.895	34.542	29.696	271.526	45.913	0.048	40.398	261.002	17.693
T0642 n=5	min	46.557	24.705	7.900	272.255	6.432	0.049	36.912	31.159	2.164
	max	70.378	32.252	15.862	325.769	13.529	0.053	43.740	77.082	10.350
	mean	55.670	29.972	11.040	293.801	8.212	0.050	40.933	50.464	4.843

continued

Sample		Zn	As	Rb	Sr	Y	Zr	Nb	Mo	Cd
776T-4 n=5	min	184.389	3.588	0.491	13.123	0.274	0.254	1.100	0.629	1.074
	max	221.327	6.154	47.048	20.777	4.724	0.514	26.980	1.137	1.636
	mean	204.987	5.086	12.479	17.464	1.376	0.399	7.281	0.827	1.239
MO-5 n=5	min	21.142	2.207	0.258	65.188	0.136	0.324	0.066	0.303	0.532
	max	34.302	4.682	1.241	114.719	2.827	1.362	0.174	0.949	1.264
	mean	25.888	3.917	0.723	87.793	1.102	0.622	0.141	0.618	0.757
322807A n=5	min	81.609	3.986	0.148	34.678	0.222	0.326	0.182	0.340	0.644
	max	97.694	6.214	2.344	79.928	6.564	1.896	0.464	0.806	1.858
	mean	90.055	4.814	0.653	50.512	2.414	1.035	0.262	0.572	1.106

Table 3.2 continued

Sample		Zn	As	Rb	Sr	Y	Zr	Nb	Mo	Cd
FW-2 n=5	min	170.198	2.978	0.737	64.114	0.850	0.336	0.204	0.336	0.647
	max	367.377	4.664	1.993	75.820	3.150	0.587	0.367	0.756	0.810
	mean	259.497	3.842	1.312	68.859	1.733	0.432	0.260	0.563	0.749
HR-1 n=5	min	38.630	2.344	2.415	48.868	0.855	0.565	0.124	0.264	0.495
	max	72.749	5.363	23.863	120.269	14.345	2.344	0.239	0.815	1.547
	mean	56.067	4.146	12.510	89.770	5.799	1.248	0.177	0.582	1.224
HRT-6 n=5	min	106.185	3.027	0.211	287.352	0.200	22.566	0.101	0.528	0.585
	max	157.628	5.856	0.424	402.792	2.785	293.834	0.289	1.179	1.142
	mean	119.726	4.282	0.328	350.517	0.898	103.287	0.193	0.815	0.882
T0640 n=7	min	54.472	4.278	0.761	49.188	0.585	0.315	0.102	0.634	0.490
	max	203.222	6.797	24.541	73.288	30.865	7.651	0.308	10.407	1.539
	mean	82.572	5.383	11.084	57.283	5.554	1.674	0.183	2.837	0.988
322915 n=5	min	134.480	3.771	0.240	43.220	0.130	0.218	0.273	0.221	0.212
	max	339.422	6.823	1.098	96.495	0.330	0.490	0.770	1.290	1.059
	mean	223.997	5.119	0.468	69.976	0.237	0.384	0.443	0.728	0.820
322943 n=5	min	30.520	2.420	0.483	1189.762	0.113	0.238	0.118	0.242	0.799
	max	86.957	6.221	263.119	2170.847	0.248	0.628	0.470	1.094	1.131
	mean	60.486	4.656	54.811	1569.495	0.189	0.437	0.226	0.829	0.933
H0309B n=8	min	8.937	3.986	0.231	74.258	0.152	0.324	0.087	0.349	0.186
	max	138.773	5.842	0.522	158.412	1.362	0.979	0.599	1.197	1.447
	mean	46.067	4.699	0.312	106.836	0.617	0.539	0.254	0.689	0.845
H0425 n=5	min	53.567	1.289	7.888	20.234	1.407	0.797	0.064	0.257	0.410
	max	82.367	5.206	53.785	135.588	2.754	70.970	0.122	4.717	1.671
	mean	64.169	3.040	28.202	85.959	1.811	14.987	0.101	1.305	0.968
H0432 n=5	min	40.157	4.724	0.184	148.489	0.116	0.443	0.110	0.460	0.926
	max	44.485	9.026	0.452	232.084	0.279	1.737	0.273	0.740	1.359
	mean	42.758	6.266	0.283	179.031	0.158	1.067	0.218	0.649	1.151
HR-3 n=5	min	70.749	5.216	0.213	244.484	0.151	0.516	0.099	0.605	0.811
	max	266.230	6.050	0.498	361.163	0.236	0.750	1.340	1.066	1.695
	mean	134.311	5.635	0.370	328.255	0.201	0.624	0.560	0.891	1.346
HRT-1 n=5	min	33.231	3.208	0.332	17.354	0.136	0.254	0.084	0.318	0.804
	max	175.517	6.099	131.619	378.934	0.206	0.543	0.328	0.788	1.226
	mean	82.532	4.750	44.110	186.011	0.169	0.436	0.180	0.545	1.012
MO-3 n=5	min	88.892	2.718	0.206	0.431	0.192	0.096	0.094	0.305	0.335
	max	411.296	5.697	1.128	33.495	0.463	4.207	0.195	0.622	1.465
	mean	320.312	4.147	0.527	17.902	0.304	1.090	0.148	0.461	1.032
OZ-5 n=5	min	1151.175	5.033	0.230	10.514	0.107	0.366	0.431	0.352	0.887
	max	1238.346	6.986	0.683	14.264	0.408	0.716	1.017	1.212	5.088
	mean	1211.478	5.934	0.385	12.321	0.225	0.486	0.730	0.797	2.040
T0643 n=5	min	101.068	4.540	0.215	84.375	0.139	0.309	0.158	0.563	0.776
	max	115.764	10.631	9.660	118.957	8.376	0.739	0.259	0.954	1.418
	mean	109.244	6.940	2.861	103.174	2.766	0.438	0.206	0.794	1.061
322807 n=5	min	346.672	5.139	0.208	24.415	0.142	0.299	0.131	0.197	0.583
	max	602.469	7.775	0.335	58.090	0.560	0.623	0.393	0.949	1.394
	mean	489.357	6.317	0.272	44.309	0.344	0.459	0.253	0.610	1.075
322810 n=5	min	151.292	3.099	0.323	55.544	0.147	0.322	0.264	0.229	0.282
	max	339.706	6.751	0.796	64.406	0.301	0.736	0.497	5.358	1.523
	mean	288.256	4.731	0.461	61.451	0.213	0.481	0.339	1.929	0.894

Table 3.2 continued

Sample		Zn	As	Rb	Sr	Y	Zr	Nb	Mo	Cd
FW-5 *n=5*	*min*	368.207	4.639	0.305	57.825	0.206	0.384	0.270	0.543	1.097
	max	445.241	6.177	0.416	71.858	0.881	0.460	0.534	1.092	1.443
	mean	419.433	5.219	0.358	62.733	0.491	0.410	0.374	0.753	1.306
CO-1 *n=5*	*min*	54.831	3.060	0.346	0.873	0.106	0.361	0.847	0.214	0
	max	1385.686	8.120	1430.067	8.534	2.685	21.724	17.905	1.535	0
	mean	836.750	5.501	541.160	4.011	0.822	5.386	6.071	0.873	0
AP-T1 *n=4*	*min*	296.816	4.317	0.270	18.355	0.149	0.277	1.060	0.851	1.072
	max	431.288	7.084	0.338	30.704	0.332	0.819	6.799	1.417	1.508
	mean	342.977	5.803	0.308	22.180	0.244	0.475	2.681	1.053	1.311
H0429 *n=5*	*min*	84.113	4.226	0.314	3.603	0.375	0.410	0.193	0.234	0.510
	max	125.890	5.691	3.065	437.155	5.379	3.817	0.375	0.733	0.973
	mean	102.038	4.812	1.002	228.356	3.358	1.531	0.277	0.516	0.709
MO-2 *n=5*	*min*	594.731	3.175	0.404	47.924	0.182	0.448	0.273	0.410	0.232
	max	648.569	6.741	47.727	51.945	0.413	0.737	0.660	0.862	2.046
	mean	624.353	4.959	15.007	49.919	0.262	0.586	0.432	0.624	1.211
MO-6 *n=5*	*min*	32.792	3.744	0.228	24.562	0.269	0.570	0.151	0.465	0.194
	max	450.563	6.747	45.815	137.441	18.766	499.227	6.367	1.812	1.576
	mean	169.785	5.505	12.887	81.610	4.098	100.579	1.764	1.001	1.005
TC-2 *n=6*	*min*	295.019	1.982	0.388	1.242	0.176	0.486	0.185	0.350	0.269
	max	4937.954	7.656	41.802	4.281	1.222	1.855	4.134	2.304	1.256
	mean	3279.666	4.854	11.587	2.643	0.765	0.905	2.368	0.781	0.775
TH-1 *n=7*	*min*	46.464	1.443	0.157	1.303	0.152	0.336	0.103	0.472	0.461
	max	70.184	6.519	62.417	196.758	6.356	1.948	0.861	0.733	1.468
	mean	56.331	3.675	14.163	77.467	1.472	0.871	0.417	0.588	0.724
APMT-1 *n=5*	*min*	259.856	4.130	0.269	35.526	0.192	0.451	1.089	0.352	1.276
	max	423.269	6.063	0.361	64.216	0.935	24.872	2.981	0.915	2.065
	mean	373.118	4.901	0.310	52.672	0.578	5.840	1.999	0.639	1.511
322807B *n=5*	*min*	80.638	3.755	0.309	82.665	0.266	0.621	0.332	0.486	0.653
	max	125.474	6.995	6.852	189.274	1.728	1.030	0.740	0.974	1.265
	mean	94.700	5.608	1.924	126.707	0.593	0.831	0.479	0.709	0.952
FW-3 *n=5*	*min*	41.902	3.412	0.254	68.102	0.135	0.254	0.107	0.285	0.523
	max	67.728	5.094	1.461	119.850	0.284	2.132	0.165	0.767	1.946
	mean	55.650	3.873	0.716	97.837	0.180	0.957	0.126	0.570	0.991
HR-4 *n=5*	*min*	81.479	3.528	0.308	126.972	0.109	0.241	0.147	0.184	0.354
	max	451.902	4.907	28.746	423.935	0.274	0.421	0.642	0.620	1.218
	mean	218.605	4.228	9.393	286.074	0.170	0.345	0.377	0.368	0.890
HRT-3 *n=6*	*min*	33.777	4.015	0.870	30.411	0.326	0.309	0.097	0.215	0.590
	max	76.854	8.715	21.831	88.020	2.574	0.991	0.300	1.641	2.407
	mean	65.465	5.592	9.094	56.606	1.286	0.567	0.178	0.863	1.067
MO-7 *n=6*	*min*	688.659	2.226	0.280	19.259	0.179	0.372	0.760	0.099	
	max	953.607	11.914	113.518	24.131	1.388	0.781	0.843	1.359	
	mean	793.935	6.607	19.507	20.940	0.764	0.610	0.794	0.707	
OZ-2 *n=5*	*min*	26.809	5.327	0.298	314.502	0.110	0.349	0.179	0.596	0.648
	max	73.851	6.618	0.573	1239.961	0.167	1.167	1.736	0.848	1.744
	mean	40.233	5.885	0.469	829.023	0.141	0.698	0.546	0.705	1.046
OZ-3 *n=5*	*min*	34.014	4.052	0.305	118.180	0.119	0.270	0.179	0.577	0.637
	max	99.755	6.776	0.557	1134.276	0.343	0.538	0.521	0.861	1.818
	mean	59.403	5.218	0.437	683.803	0.193	0.408	0.335	0.649	1.227
SUM-1 *n=5*	*min*	21.887	4.684	0.261	302.339	0.155	0.309	0.218	0.455	0.609
	max	159.716	21.186	0.575	519.930	0.329	0.514	0.447	0.935	1.858
	mean	85.832	9.152	0.386	387.231	0.217	0.424	0.301	0.666	1.144

Table 3.2 continued

Sample		Zn	As	Rb	Sr	Y	Zr	Nb	Mo	Cd
T0642 n=5	min	72.253	4.702	0.205	132.349	0.130	0.293	0.072	0.405	0.280
	max	84.784	7.104	0.357	173.419	0.287	0.425	0.131	1.218	1.744
	mean	78.600	5.934	0.283	157.013	0.176	0.358	0.105	0.695	0.921

continued

Sample		Sn	Sb	Cs	Ba	La	Ce	Pr	Nd	Sm	Eu
776T-4 n=5	min	131.118	0.336	0.188	1.720	0.130	0.254	0.044	0.117	0.121	0.027
	max	242.516	0.693	10.648	19.924	0.303	0.958	0.197	0.893	0.933	0.060
	mean	191.004	0.519	2.892	6.712	0.240	0.585	0.088	0.375	0.306	0.044
MO-5 n=5	min	12.532	0.165	0.046	0.457	0.506	0.417	0.029	0.098	0.010	0.054
	max	16.853	0.299	1.324	1.271	0.766	0.683	0.084	0.403	0.157	0.079
	mean	14.836	0.219	0.492	0.973	0.602	0.597	0.047	0.204	0.095	0.063
322807A n=5	min	43.608	0.107	0.078	0.272	0.380	0.602	0.065	0.218	0.124	0.082
	max	92.096	0.256	1.456	1.546	1.248	1.701	0.224	1.296	0.578	0.203
	mean	64.878	0.193	0.379	0.726	0.812	1.257	0.116	0.488	0.270	0.115
FW-2 n=5	min	76.573	0.233	0.566	1.648	0.158	0.243	0.030	0.140	0.077	0.062
	max	144.351	0.532	1.422	3.813	0.537	0.870	0.132	0.540	0.205	0.131
	mean	113.506	0.343	1.048	2.779	0.362	0.600	0.086	0.313	0.123	0.108
HR-1 n=5	min	10.738	0.181	4.257	2.529	0.476	0.857	0.063	0.190	0.059	0.030
	max	25.105	1.672	24.619	10.263	3.745	5.292	0.379	1.464	0.765	0.314
	mean	19.859	0.583	12.788	5.676	1.409	2.137	0.189	0.740	0.317	0.129
HRT-6 n=5	min	29.226	0.149	0.045	0.664	0.621	1.544	0.167	0.788	0.117	0.345
	max	59.265	14.855	5.748	1.375	3.353	8.771	1.333	6.592	1.733	0.872
	mean	42.987	3.116	1.204	1.107	1.257	3.053	0.426	2.042	0.477	0.560
T0640 n=7	min	39.778	0.137	1.062	1.056	0.164	0.413	0.044	0.188	0.115	0.071
	max	77.300	0.887	43.075	25.188	6.900	18.895	1.865	7.585	2.608	0.416
	mean	56.626	0.347	16.239	4.976	1.565	3.492	0.333	1.345	0.520	0.147
322915 n=5	min	64.344	0.288	0.057	0.329	0.248	0.531	0.062	0.188	0.084	0.086
	max	138.558	0.662	1.284	2.054	0.872	1.800	0.195	0.611	0.190	0.230
	mean	95.881	0.464	0.324	0.733	0.636	1.289	0.137	0.439	0.131	0.143
322943 n=5	min	75.799	0.142	0.039	0.255	0.028	0.020	0.013	0.071	0.077	0.004
	max	177.572	0.382	1.162	24.330	0.048	0.041	0.023	0.142	0.183	0.034
	mean	122.466	0.236	0.285	6.205	0.039	0.031	0.017	0.104	0.118	0.019
H0309B n=8	min	26.780	0.139	0.070	0.435	0.221	0.421	0.045	0.115	0.071	0.071
	max	187.624	0.324	1.712	15.273	1.447	2.444	0.264	1.166	0.258	0.342
	mean	61.989	0.226	0.554	2.722	0.779	1.368	0.142	0.617	0.172	0.201
H0425 n=5	min	17.166	0.130	52.846	2.765	0.144	0.410	0.059	0.258	0.085	0.070
	max	71.242	0.218	263.849	5.442	1.033	1.838	0.144	0.593	0.212	0.126
	mean	40.741	0.171	158.771	4.446	0.535	1.014	0.094	0.415	0.136	0.098
H0432 n=5	min	50.518	0.201	0.179	4.790	0.660	0.879	0.042	0.111	0.074	0.053
	max	126.584	0.303	1.393	7.518	1.666	1.873	0.120	0.334	0.176	0.077
	mean	99.457	0.245	0.530	6.173	1.049	1.202	0.075	0.215	0.111	0.062
HR-3 n=5	min	0.517	0.233	0.040	2.719	0.035	0.038	0.033	0.143	0.070	0.030
	max	81.512	0.733	0.698	39.456	0.514	0.551	0.073	0.236	0.141	0.058
	mean	33.481	0.528	0.298	14.520	0.278	0.234	0.057	0.191	0.115	0.045
HRT-1 n=5	min	0.598	0.162	0.041	0.270	0.032	0.043	0.008	0.067	0.064	0.017
	max	232.526	0.323	8.027	60.073	0.149	0.192	0.030	0.155	0.223	0.055
	mean	89.764	0.242	2.653	19.610	0.104	0.139	0.021	0.118	0.127	0.038
MO-3 n=5	min	0.917	0.093	0.060	0.621	0.059	0.026	0.016	0.075	0.054	0.017
	max	54.880	0.247	1.821	4.207	1.917	3.815	0.413	1.306	0.295	0.144
	mean	28.501	0.158	0.768	1.966	0.747	1.426	0.161	0.488	0.171	0.068

Table 3.2 continued

Sample		Sn	Sb	Cs	Ba	La	Ce	Pr	Nd	Sm	Eu
OZ-5 n=5	min	24.801	0.131	0.033	0.041	5.258	9.492	0.931	2.674	0.354	0.053
	max	30.794	9.254	0.190	0.473	6.681	13.270	1.463	4.009	0.764	0.064
	mean	26.350	2.015	0.074	0.216	6.157	11.873	1.205	3.430	0.536	0.057
T0643 n=5	min	27.007	0.281	0.136	0.757	0.080	0.156	0.027	0.119	0.006	0.108
	max	67.052	0.478	4.880	2.452	0.538	1.163	0.175	0.869	0.433	0.188
	mean	54.641	0.344	1.837	1.177	0.238	0.493	0.077	0.378	0.196	0.146
322807 n=5	min	35.305	0.313	0.046	0.236	0.344	0.592	0.061	0.160	0.114	0.052
	max	83.628	0.672	0.149	0.800	0.531	0.939	0.098	0.365	0.185	0.117
	mean	67.037	0.481	0.096	0.492	0.451	0.822	0.083	0.289	0.134	0.092
322810 n=5	min	78.950	0.198	0.082	0.349	0.325	0.561	0.057	0.215	0.078	0.091
	max	126.293	1.522	8.317	0.987	0.434	0.891	0.107	0.401	0.123	0.110
	mean	104.581	0.492	2.551	0.519	0.378	0.707	0.076	0.271	0.097	0.101
FW-5 n=3	min	107.801	0.721	0.114	0.293	0.290	0.528	0.044	0.176	0.174	0.101
	max	155.827	1.143	0.278	0.806	0.719	1.638	0.176	0.641	0.238	0.114
	mean	127.338	0.920	0.192	0.540	0.511	1.066	0.108	0.348	0.212	0.109
CO-1 n=5	min	20.784	0.355	0.049	0.214	0.056	0.139	0.029	0.084	0.095	0.022
	max	177.080	81.279	63.958	141.524	5.293	9.832	1.092	3.417	0.788	0.113
	mean	70.862	17.201	20.618	34.743	2.309	4.350	0.456	1.377	0.327	0.052
AP-T1 n=4	min	80.980	0.178	0.037	0.799	3.110	7.089	0.825	2.065	0.482	0.023
	max	447.862	0.530	0.064	1.260	4.832	10.484	1.129	2.794	0.828	0.041
	mean	197.253	0.291	0.047	0.970	4.132	9.336	1.020	2.534	0.625	0.032
H0429 n=5	min	9.009	0.098	0.115	6.474	0.320	0.673	0.101	0.402	0.084	0.074
	max	24.459	0.301	3.021	31.014	1.631	1.612	0.171	0.924	0.361	0.140
	mean	18.379	0.190	0.822	13.864	0.925	1.055	0.146	0.589	0.220	0.113
MO-2 n=5	min	33.158	0.189	0.091	0.496	7.325	11.139	1.093	3.212	0.386	0.204
	max	42.652	2.045	2.895	10.320	8.539	13.490	1.464	4.723	0.651	0.248
	mean	38.241	0.620	0.910	3.268	8.055	12.567	1.222	3.696	0.491	0.224
MO-6 n=5	min	23.574	0.222	0.053	1.618	2.386	4.026	0.391	1.289	0.218	0.035
	max	140.895	7.891	3.163	9.542	4.387	6.723	0.573	2.180	0.537	0.087
	mean	55.589	1.895	0.900	4.219	3.092	4.928	0.467	1.543	0.326	0.055
TC-2 n=6	min	5.763	0.320	0.214	0.389	0.257	0.460	0.040	0.106	0.032	0.014
	max	99.863	7.164	4.744	5.486	6.353	13.004	1.273	3.053	0.669	0.053
	mean	71.230	2.111	1.695	1.928	3.799	7.561	0.725	1.753	0.366	0.030
TH-1 n=7	min	3.338	0.084	0.248	3.867	0.045	0.046	0.017	0.051	0.058	0.012
	max	183.075	8.771	7.743	141.132	0.245	0.258	0.055	0.209	0.122	0.072
	mean	61.004	1.561	3.080	32.011	0.132	0.153	0.027	0.110	0.092	0.042
APMT-1 n=5	min	111.490	0.314	0.039	1.177	0.479	0.984	0.106	0.238	0.109	0.031
	max	210.000	0.388	0.449	3.603	0.784	1.838	0.241	0.581	0.237	0.056
	mean	158.411	0.349	0.206	2.262	0.634	1.445	0.176	0.438	0.166	0.047
322807B n=5	min	124.305	0.193	0.076	0.936	0.119	0.241	0.031	0.116	0.071	0.061
	max	191.682	0.328	35.100	2.771	0.521	0.890	0.110	0.484	0.131	0.152
	mean	161.597	0.246	7.271	1.763	0.209	0.405	0.052	0.231	0.108	0.094
FW-3 n=5	min	3.259	0.174	0.034	1.097	0.029	0.073	0.023	0.067	0.079	0.010
	max	165.800	0.337	1.030	4.879	0.282	0.441	0.051	0.122	0.121	0.092
	mean	57.809	0.241	0.413	2.440	0.125	0.206	0.034	0.099	0.090	0.040
HR-4 n=5	min	9.651	0.137	0.136	11.080	0.060	0.101	0.021	0.087	0.040	0.025
	max	51.157	0.309	6.505	320.088	1.143	1.639	0.135	0.280	0.125	0.128
	mean	33.160	0.200	3.289	100.269	0.548	0.726	0.066	0.173	0.085	0.069

Table 3.2 continued

Sample		Sn	Sb	Cs	Ba	La	Ce	Pr	Nd	Sm	Eu
HRT-3 *n=6*	*min*	14.908	0.220	0.639	1.105	0.492	0.716	0.052	0.128	0.084	0.040
	max	50.298	0.748	28.415	2.804	1.635	1.963	0.124	0.492	0.277	0.119
	mean	36.963	0.479	12.312	1.682	0.903	1.203	0.096	0.301	0.140	0.090
MO-7 *n=6*	*min*	21.810	0.291	0.059	0.280	3.920	6.921	0.730	1.759	0.372	0.068
	max	33.781	21.860	7.650	2.369	5.979	13.699	1.311	3.640	0.850	0.110
	mean	25.989	5.637	1.426	0.958	5.298	10.019	1.039	2.756	0.568	0.087
OZ-2 *n=5*	*min*	91.631	0.195	0.039	1.544	0.294	0.278	0.027	0.082	0.062	0.032
	max	214.115	0.395	1.293	6.976	1.311	1.353	0.079	0.275	0.155	0.062
	mean	126.346	0.285	0.304	5.181	0.704	0.740	0.044	0.152	0.090	0.042
OZ-3 *n=5*	*min*	39.743	0.145	0.040	0.282	0.038	0.029	0.007	0.074	0.079	0.025
	max	188.676	0.227	0.134	2.366	0.305	0.239	0.027	0.110	0.232	0.045
	mean	107.631	0.200	0.079	1.606	0.152	0.144	0.018	0.083	0.142	0.038
SUM-1 *n=5*	*min*	74.247	0.217	0.062	0.360	0.118	0.178	0.023	0.066	0.079	0.045
	max	246.255	0.438	0.891	3.478	0.386	0.720	0.074	0.294	0.153	0.100
	mean	149.125	0.285	0.278	1.715	0.232	0.409	0.041	0.140	0.119	0.064
T0642 *n=5*	*min*	3.307	0.241	0.042	2.332	0.049	0.089	0.024	0.069	0.011	0.023
	max	26.148	1.172	0.087	6.252	0.242	0.387	0.046	0.158	0.120	0.077
	mean	15.034	0.495	0.065	4.120	0.153	0.251	0.032	0.122	0.080	0.050

continued

Sample		Yb	Lu	Ta	W	Pb	Bi	Th	U
776T-4 *n=5*	*min*	0.058	0.010	1.430	0.043	27.030	0.022	0.023	0.009
	max	0.402	0.049	9.149	0.431	36.648	0.402	0.231	1.757
	mean	0.151	0.020	3.195	0.125	31.329	0.106	0.086	0.429
MO-5 *n=5*	*min*	0.044	0.010	0.006	0.043	6.548	0.022	0.002	0.001
	max	0.522	0.078	0.015	0.047	8.537	0.146	0.012	0.021
	mean	0.186	0.031	0.010	0.045	7.435	0.075	0.007	0.011
322807A *n=5*	*min*	0.066	0.007	0.044	0.037	6.895	1.250	0.008	0.010
	max	0.601	0.096	0.099	3.212	16.568	6.320	0.058	0.045
	mean	0.269	0.044	0.072	0.768	10.456	3.687	0.022	0.031
FW-2 *n=5*	*min*	0.135	0.033	0.084	64.531	7.532	0.016	0.009	0.168
	max	0.507	0.084	0.421	1043.370	22.887	0.089	0.044	0.807
	mean	0.276	0.049	0.179	317.195	12.681	0.034	0.023	0.476
HR-1 *n=5*	*min*	0.162	0.033	0.012	0.122	5.103	0.022	0.019	0.011
	max	2.068	0.313	0.091	4.122	64.972	0.093	1.192	0.794
	mean	0.880	0.139	0.044	1.597	19.165	0.047	0.275	0.184
HRT-6 *n=5*	*min*	0.072	0.013	0.017	0.036	11.113	0.015	0.019	0.020
	max	0.363	0.142	0.051	0.322	19.033	0.133	0.723	0.322
	mean	0.166	0.056	0.033	0.144	14.681	0.050	0.164	0.108
T0640 *n=7*	*min*	0.062	0.012	0.024	0.061	4.936	0.019	0.009	0.014
	max	2.968	0.405	0.049	69.055	40.946	9.252	0.050	4.115
	mean	0.580	0.081	0.032	10.073	13.124	1.454	0.020	0.721
322915 *n=5*	*min*	0.033	0.007	0.094	0.082	8.731	0.020	0.007	0.004
	max	0.105	0.045	1.128	14.239	15.094	1.266	0.049	0.050
	mean	0.059	0.019	0.479	3.729	11.160	0.334	0.021	0.023
322943 *n=5*	*min*	0.027	0.007	0.062	0.047	13.568	0.023	0.006	0.007
	max	0.083	0.019	0.645	8.292	17.515	0.438	0.017	0.024
	mean	0.051	0.011	0.237	2.927	15.571	0.146	0.011	0.013
H0309B *n=8*	*min*	0.042	0.012	0.007	0.046	8.412	0.012	0.006	0.011
	max	0.875	0.290	0.308	0.388	19.473	0.605	0.077	0.058
	mean	0.222	0.062	0.068	0.114	12.632	0.096	0.024	0.028

Table 3.2 continued

Sample		Yb	Lu	Ta	W	Pb	Bi	Th	U
H0425 n=5	min	0.231	0.033	0.011	0.044	5.546	0.140	0.016	0.011
	max	0.502	0.096	0.062	0.408	9.303	18.671	0.066	0.200
	mean	0.336	0.054	0.030	0.170	6.798	3.891	0.038	0.059
H0432 n=8	min	0.034	0.006	0.010	0.053	6.433	0.009	0.014	0.009
	max	0.091	0.023	0.054	0.112	15.134	0.028	0.035	0.127
	mean	0.067	0.013	0.037	0.077	9.562	0.019	0.020	0.033
HR-3 n=5	min	0.031	0.006	0.017	0.039	8.431	0.022	0.011	0.009
	max	0.083	0.023	2.010	0.094	33.592	0.096	0.027	0.073
	mean	0.063	0.015	0.796	0.063	22.062	0.052	0.016	0.034
HRT-1 n=5	min	0.026	0.001	0.010	0.040	4.621	0.011	0.007	0.010
	max	0.066	0.011	0.109	0.296	8.140	0.026	0.013	0.040
	mean	0.045	0.007	0.048	0.112	6.366	0.018	0.009	0.020
MO-3 n=5	min	0.020	0.007	0.017	0.020	1.361	0.021	0.008	0.015
	max	0.113	0.014	0.129	0.153	12.767	0.385	0.091	0.021
	mean	0.051	0.011	0.073	0.059	8.375	0.095	0.038	0.018
OZ-5 n=5	min	0.030	0.012	0.454	0.049	11.552	0.024	0.009	0.013
	max	0.063	0.022	1.484	0.322	533.357	0.166	0.206	0.029
	mean	0.042	0.017	0.928	0.112	117.024	0.070	0.072	0.018
T0643 n=5	min	0.022	0.009	0.012	0.185	5.991	0.015	0.007	0.007
	max	0.874	0.152	0.035	8.545	10.340	0.047	0.029	0.025
	mean	0.272	0.054	0.018	2.746	8.436	0.031	0.016	0.017
322807 n=5	min	0.023	0.007	0.085	0.055	6.540	0.048	0.007	0.003
	max	0.075	0.018	0.168	0.388	21.860	1.249	0.018	0.032
	mean	0.047	0.011	0.126	0.220	12.086	0.631	0.012	0.017
322810 n=5	min	0.032	0.008	0.119	0.186	9.512	0.157	0.017	0.006
	max	0.070	0.017	0.380	23.477	71.255	3.244	0.165	0.061
	mean	0.047	0.012	0.282	8.373	22.963	0.982	0.062	0.022
FW-5 n=3	min	0.052	0.010	0.093	0.405	32.502	0.121	0.015	0.010
	max	0.124	0.026	0.277	32.718	72.126	9.025	0.221	0.168
	mean	0.090	0.018	0.186	11.445	47.178	3.192	0.086	0.064
CO-1 n=5	min	0.047	0.007	0.205	0.035	20.712	0.020	0.048	0.245
	max	0.472	0.074	2.842	8.667	4975.472	1.614	6.016	16.505
	mean	0.144	0.024	1.011	3.161	1017.590	0.356	1.517	6.060
AP-T1 n=4	min	0.008	0.006	1.646	0.033	14.490	0.022	0.015	0.007
	max	0.078	0.016	26.149	0.073	24.829	0.085	0.090	0.014
	mean	0.047	0.011	8.091	0.053	18.241	0.041	0.042	0.012
H0429 n=5	min	0.045	0.009	0.030	0.032	2.939	0.023	0.010	0.011
	max	0.862	0.135	0.068	0.082	23.409	0.157	0.033	0.064
	mean	0.551	0.081	0.044	0.052	8.876	0.082	0.021	0.035
MO-2 n=5	min	0.038	0.008	0.090	0.037	12.192	0.015	0.014	0.015
	max	0.088	0.017	0.259	0.085	15.552	0.032	0.141	0.091
	mean	0.058	0.012	0.156	0.067	13.803	0.021	0.063	0.035
MO-6 n=5	min	0.059	0.013	0.146	0.059	8.831	0.021	0.022	0.018
	max	4.609	0.736	13.127	0.237	235.094	0.078	4.906	11.277
	mean	0.986	0.160	3.394	0.109	56.362	0.045	1.022	2.297
TC-2 n=6	min	0.038	0.005	0.051	0.019	1.594	0.014	0.040	0.008
	max	0.307	0.053	1.137	0.466	499.002	0.242	0.107	0.471
	mean	0.184	0.028	0.686	0.161	127.220	0.121	0.071	0.121
TH-1 n=7	min	0.054	0.011	0.014	0.026	0.549	0.023	0.009	0.009
	max	1.210	0.203	0.546	0.272	853.476	0.445	0.063	0.034
	mean	0.292	0.053	0.191	0.103	126.224	0.111	0.031	0.020

Table 3.2 continued

Sample		Yb	Lu	Ta	W	Pb	Bi	Th	U
APMT-1 ***n=5***	*min*	0.041	0.005	0.976	0.031	23.615	0.019	0.011	0.011
	max	0.175	0.047	2.270	0.220	27.543	0.052	0.068	0.217
	mean	0.090	0.019	1.610	0.097	25.524	0.027	0.041	0.059
322807B ***n=5***	*min*	0.050	0.008	0.036	32.361	8.677	0.084	0.030	0.019
	max	0.305	0.061	0.112	85.379	13.628	2.042	0.042	0.137
	mean	0.112	0.021	0.059	53.059	11.543	0.980	0.034	0.055
FW-3 ***n=5***	*min*	0.026	0.007	0.015	0.077	4.791	0.016	0.007	0.006
	max	0.129	0.049	0.051	0.455	12.038	0.047	0.030	6.118
	mean	0.064	0.022	0.027	0.296	7.722	0.029	0.017	1.234
HR-4 ***n=5***	*min*	0.026	0.010	0.049	0.023	8.243	0.017	0.015	0.006
	max	0.056	0.013	0.593	0.315	27.179	0.045	0.079	0.040
	mean	0.044	0.011	0.280	0.123	14.575	0.026	0.035	0.015
HRT-3 ***n=6***	*min*	0.036	0.011	0.007	0.034	6.397	0.023	0.006	0.006
	max	0.315	0.053	0.026	0.375	41.069	0.092	0.031	0.098
	mean	0.177	0.028	0.017	0.147	18.096	0.042	0.012	0.039
MO-7 ***n=6***	*min*	0.054	0.006	0.757	0.050	16.484	0.580	0.008	0.006
	max	0.257	0.032	1.179	0.181	1430.163	8.003	0.121	0.112
	mean	0.145	0.018	1.005	0.100	288.977	3.325	0.053	0.056
OZ-2 ***n=5***	*min*	0.027	0.006	0.049	0.067	18.824	0.019	0.007	0.011
	max	0.094	0.013	1.707	0.314	26.657	1.064	0.020	0.019
	mean	0.063	0.009	0.423	0.193	22.433	0.529	0.014	0.016
OZ-3 ***n=5***	*min*	0.014	0.008	0.021	0.049	7.333	0.022	0.012	0.007
	max	0.051	0.018	0.902	1.244	19.929	11.789	0.014	2.802
	mean	0.038	0.012	0.266	0.532	14.722	2.582	0.013	0.571
SUM-1 ***n=5***	*min*	0.041	0.004	0.039	0.142	11.501	0.116	0.008	0.012
	max	0.106	0.034	0.435	3.252	37.213	13.840	0.031	0.031
	mean	0.064	0.016	0.225	1.096	23.925	4.021	0.020	0.019
T0642 ***n=5***	*min*	0.032	0.008	0.011	0.056	7.149	0.024	0.008	0.010
	max	0.093	0.027	0.036	0.295	76.366	0.053	0.064	0.046
	mean	0.058	0.018	0.017	0.190	26.195	0.036	0.030	0.025

CHAPTER 4: DISCUSSION

This chapter contains a discussion of the variations in tourmaline compositions at Tsa da Glisza and their relationships to emerald mineralization. The topics include both major-element (Section 4.1) and trace-element compositions (Section 4.2). The variations in composition occur in all tourmaline sites, displaying extensive solid solution in the X-, Y-, and Z-sites. Section 4.3 uses multivariate statistics to test tourmaline as an indicator for emerald mineralization.

4.1 Major-element compositions

The major-element compositions of the tourmalines vary by host lithology, namely tourmalines from country rocks (DF_1, DF_2, and DF_3) and tourmalines from intrusive rocks (granite and aplite samples).

Hawthorne and Henry (1999) classify tourmaline by X-site occupancy. By their definition, the tourmalines of Tsa da Glisza are alkali-group (>50% Na) and calcic-group tourmalines (>50% Ca) (Fig. 4.1). Most samples from Tsa da Glisza are alkali-group tourmalines. Tourmalines from granite contain the highest concentrations of Na and lowest concentrations of Ca; tourmalines from schists contain the lowest Na concentration and highest Ca concentrations (Fig. 4.2). Tourmalines from aplites and quartz-tourmaline veins are highly variable in their X-site cation occupancies; however, the more alkalic tourmalines also contain more vacancies.

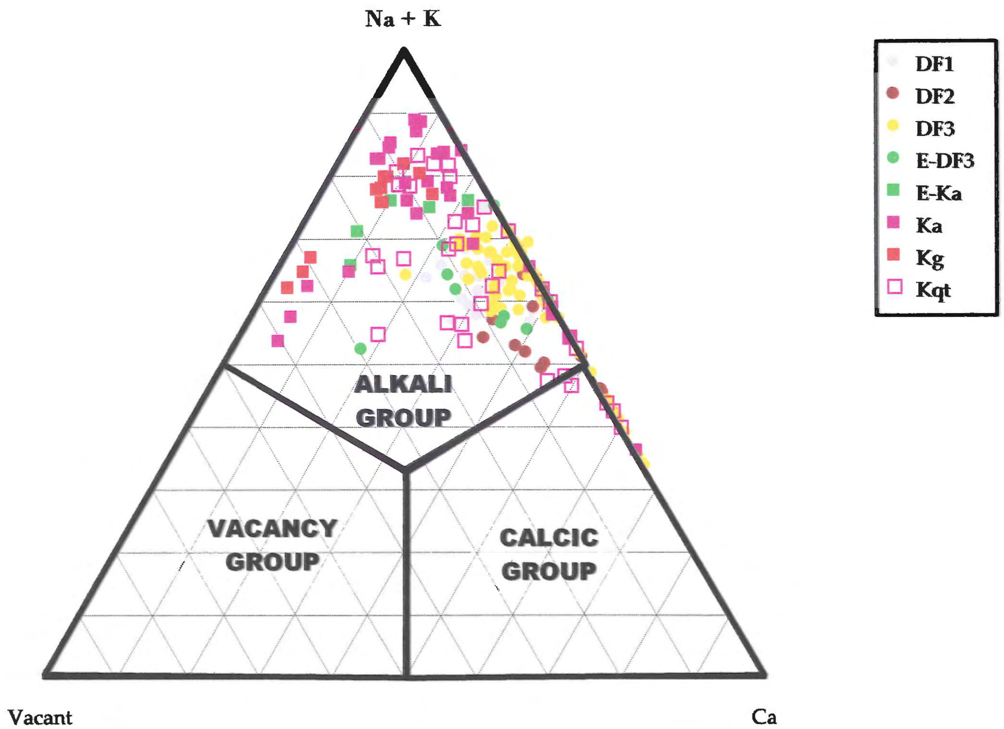

Figure 4.1 Ternary plot of X-site classification of tourmalines (Hawthorne & Henry, 1999). Although some compositions approach the Vacancy Group, the tourmalines from Tsa da Glisza contain a nearly fully occupied X-site, split between Na and Ca; therefore, the tourmalines of Tsa da Glisza are transitional alkali-group and calcic-group tourmalines.

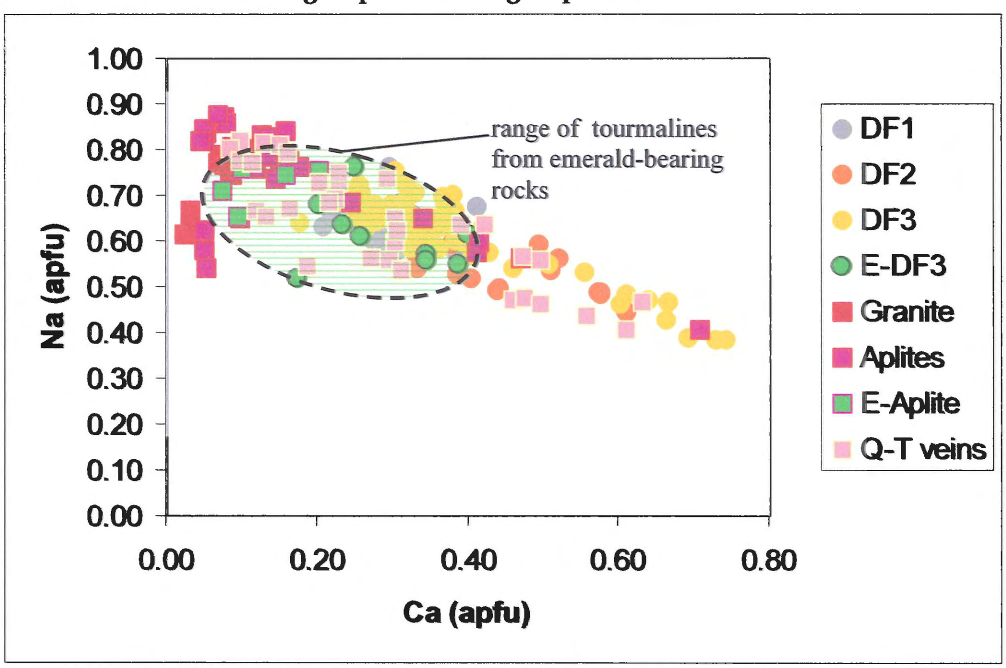

Figure 4.2 Na – Ca concentrations in tourmaline from Tsa da Glisza. The dominant X-site occupants are Na and Ca. All tourmalines analyzed are grouped by lithology. Although considerable overlap does exist, there are slight variations with respect to the degree of alteration of the schists, i.e. DF_1 to DF_3 and a restricted range occupied by tourmalines from emerald-bearing rocks.

Most of the samples still exist on the dravite/schorl side (Na-dominant) of the uvite (Ca-dominant) boundary. Tourmalines from emerald-bearing rocks, including emerald-bearing DF_3 and emerald-bearing aplite, are transitional between tourmalines from granites and tourmalines from schists.

Although Na and Ca are the greatest constituents of the X-site, it is also occupied by minor K. Figure 4.3 shows the Ca-K relationship among tourmalines from country rocks, intrusive rocks, and emerald-bearing rocks. The concentration of K is low, but analytically significant, in all tourmalines from Tsa da Glisza, with generally less than 0.02 apfu; however, distinct differences in K concentrations exist in tourmalines from all lithologies, just as with Na and Ca. The highest K concentrations are present in granite- and aplite-hosted tourmalines, the least K but a relatively broad range of Ca is present in schist-hosted tourmalines, aplite-hosted tourmalines contain greater concentrations of K, and vein-hosted tourmalines have K and Ca concentrations similar to country rocks. Tourmalines from emerald-bearing samples are K-rich compared with those from country rocks, but K-poor in contrast to those from granite/aplite; therefore, the K concentration strongly illustrates the transitional composition of tourmalines from granite to tourmalines from country rock.

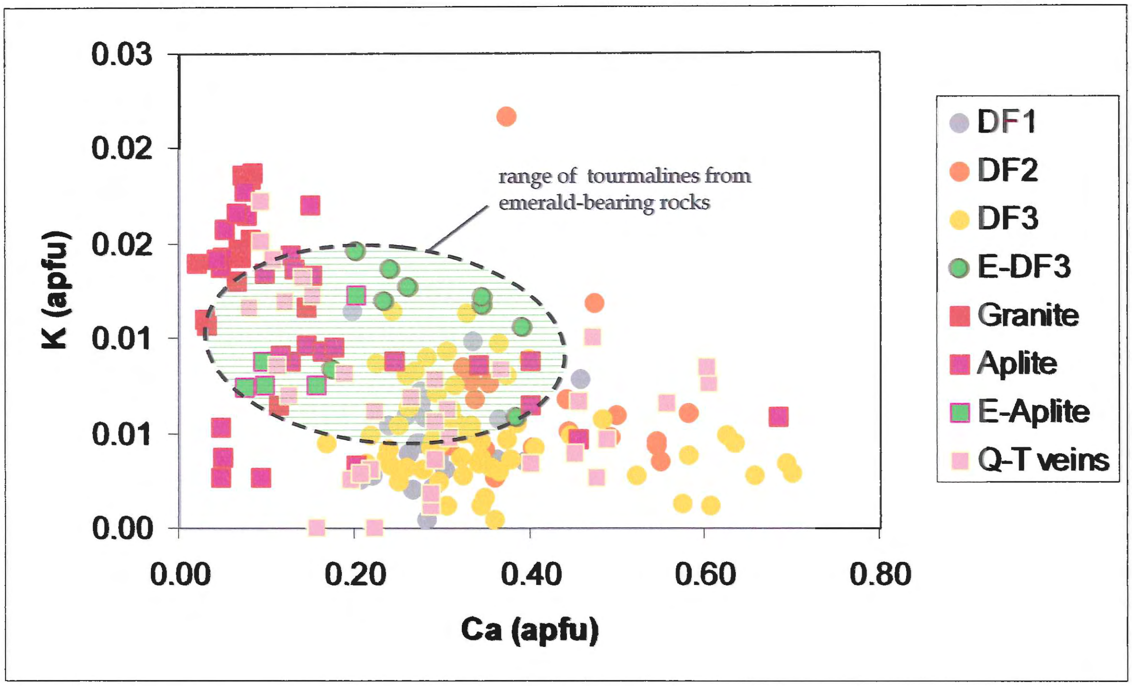

Figure 4.3 K – Ca binary plot showing transitional tourmaline composition. K is the other alkali X-site component. Similar to the Na-Ca plot, K and Ca are inversely proportional. The concentrations vary, although distinctions exist between tourmalines from granite and tourmalines from country-rock. In general, tourmalines from emerald-bearing samples have lower K concentrations than tourmalines from the intrusive rocks, but higher concentrations than those from country rocks; Ca concentrations are lower than those from country rocks, but higher than those from intrusive rocks.

The greatest major-element range exists in the tourmaline Y-site, occupied by Fe, Mg, and minor Al (Fig. 4.4); however, Fe and Mg are the key constituents in the tourmalines of Tsa da Glisza (Fig. 4.5). The Mg and Fe concentrations are inversely correlated. The highest Fe concentrations, and consequently lowest Mg concentrations, exist in tourmalines from the granite. Conversely, tourmalines from the country rocks have the lowest concentrations of Fe, and highest concentrations of Mg. Tourmalines from aplites and quartz-tourmaline veins contain a broad range of Mg-Fe concentrations. Tourmalines from emerald-bearing DF_3 are transitional between the high-Mg schist tourmalines and the high-Fe granite tourmalines.

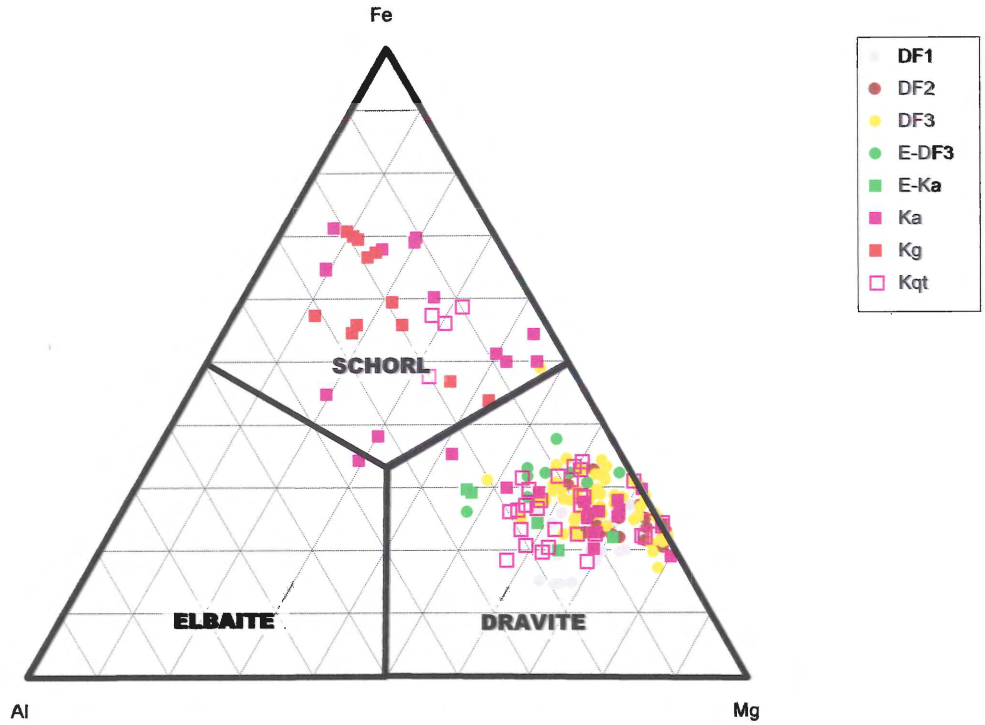

Figure 4.4 Ternary plot of Y-site end members. The Mg and Al concentration indicated is Mg and Al in the Y-site. Elbaite is the typical Al-rich end member, but none of the Tsa da Glisza tourmalines are elbaites, as Li must also be present in the Y-site. Although Li is an important trace element in these tourmalines, it is never a major constituent. The Al-concentration in the Y-site directly correlates with the X-site vacancies.

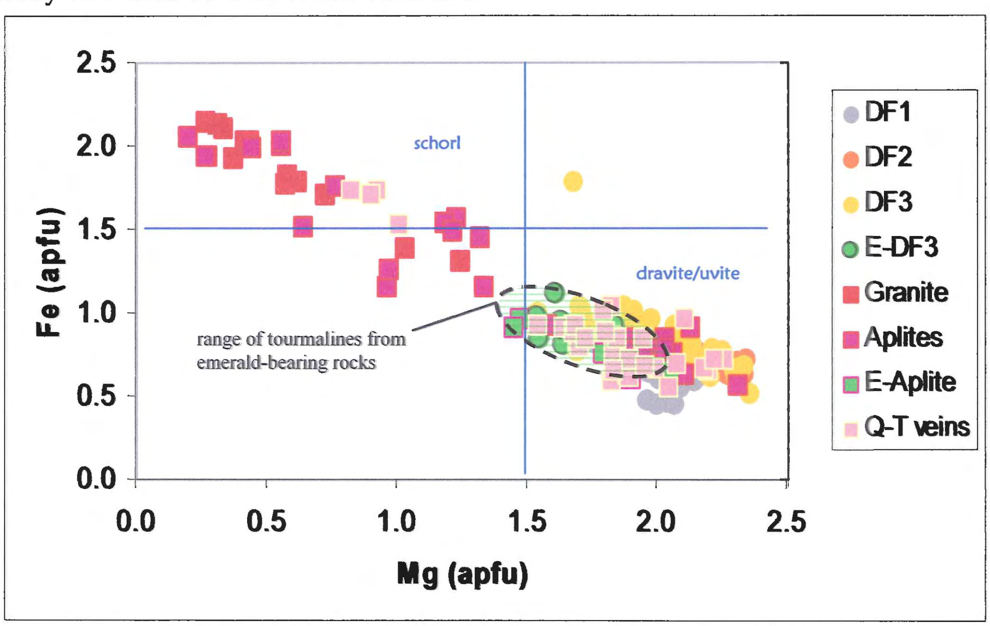

Figure 4.5 Fe – Mg binary plot highlighting transitional range between schorls and dravites / uvites of Tsa da Glisza. The Y-site of all tourmalines analyzed is mostly occupied by Fe and Mg. Although Mg is also in solid solution with Al in the Z-site, the above plot is only the Y-site Mg. Note the distinct separation between schorls (from granites, aplites) and dravites/uvites (from schists).

A distinct separation between tourmalines from country rocks and tourmalines from intrusive rocks is present at the schorl-dravite boundary, as indicated in Figures 4.4 and 4.5; all granite tourmalines, some aplite tourmalines, and some vein tourmalines exist in the schorl range (Fe-dominant). All schists, some aplites, and most vein samples exist in the dravite/uvite range (Mg-dominant).

Although the physical appearance of the schist, and subsequently the form and abundance of tourmaline in the schist, changes considerably with increasing grade of alteration, the major-element composition of the tourmaline changes very little across the DF_{1-3} spectrum (Figs. 4.1 – 4.5). The major-element similarities of tourmalines from DF_{1-3} are problematic, because the difference between DF_1 and DF_3 is related to the influence of the granite on the schist. If that were the case, tourmalines from a DF_3 might be expected to have a major-element composition nearer the granite-hosted tourmaline range, as in the emerald-bearing DF_3 samples; however, the tourmaline compositions from DF3 rocks is not nearer to the composition of granite-hosted tourmalines than are those composition of tourmalines from other country rocks. Tourmalines from schists including DF_1, DF_2, and DF_3, appear to have relatively similar compositions to each other.

Tourmalines from quartz-tourmaline veins display a broad range of compositions from one vein to another; however, they do reflect the composition of their nearest country rock (Fig 4.6). For example, quartz-tourmaline veins that contain Ca-rich dravites are proximal to schist-hosted Ca-rich dravites or uvites. A specific example is sample HR-4, from a quartz-tourmaline vein. The tourmalines in this sample are similar, albeit not identical, to those from samples HR-1, HR-2, and HR-3, which are the proximal DF_2, DF_1, and DF_3, respectively.

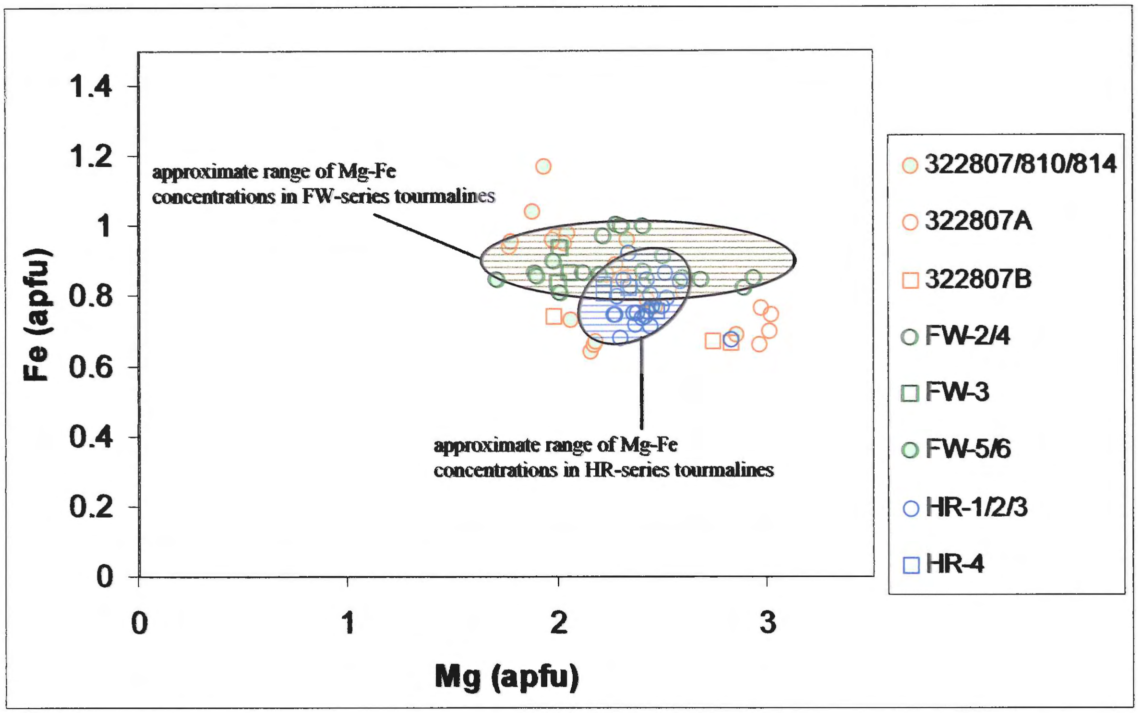

Figure 4.6 Mg to Fe relationship highlighting the similarities of tourmalines of schists and quartz-tourmaline veins using the HR- series and FW- series samples.

Although the DF schists are the main hosts of emerald mineralization, the compositions of the schists are not uniform. As a result of this irregular distribution of bulk composition, not all schists reacted with the quartz-tourmaline veins/metasomatic fluids in the same way, and consequently, not all quartz-tourmaline veins have associated emerald mineralization (Groat et al. 2002). However, the variations in country rock composition are reflected in the composition of the tourmaline from the associated quartz-tourmaline veins (Fig.

4.6); therefore, the tourmalines from the veins can be tested against each other to identify an emerald-related [vein] tourmaline composition (Fig. 4.7). A Y-site Mg:Fe ratio of 2:1 exists for most tourmalines from veins related to emerald mineralization.

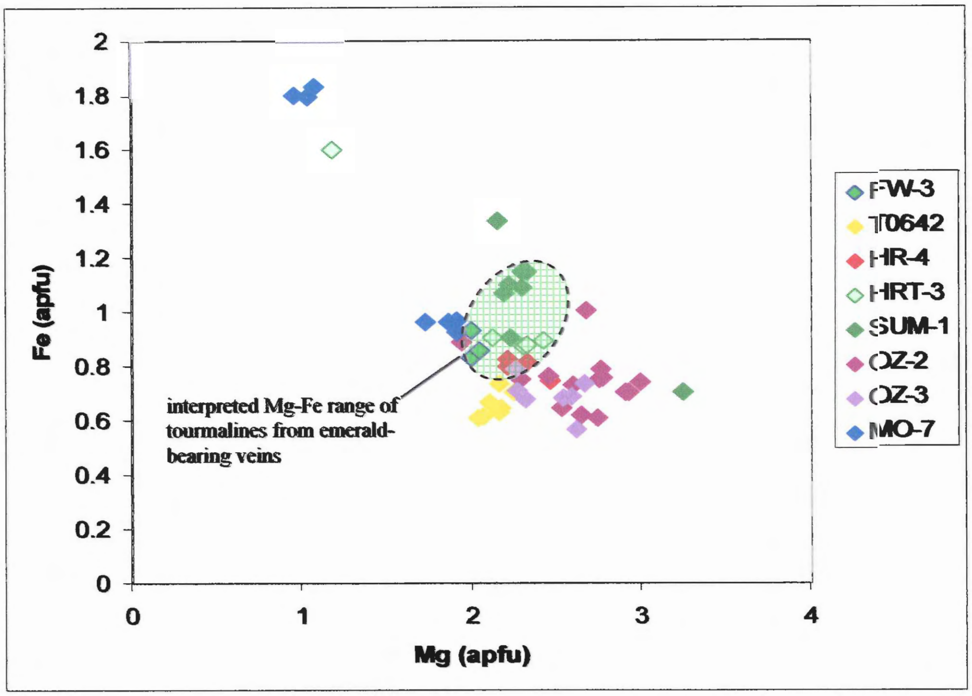

Figure 4.7 Binary plot of Fe – Mg highlighting differences in quartz-tourmaline veins. The green dots represent vein samples related to known emerald mineralization (*FW-3*, *HRT-3*, and *SUM-1*).

The transitional composition of the tourmalines from emerald-bearing DF_3, and, to a lesser extent, those from emerald-bearing aplite, is an example of the interaction between the granite and the country rocks: the mobilization and percolation of Cr and V ions from the country rocks mixing with the B and Be ions from the granite. The aplite dikes, sills, and quartz-tourmaline veins, originating from the granite react with the schists (Section 1.3.1, and Groat et al. 2002), making their tourmalines enriched in Mg, as in sample MO-7 (Fig 4.8).

As opposed to the sills/dikes/veins/ becoming enriched in Mg, possibly all free Fe is initially taken in by the tourmalines, and later Mg is taken in because it is still abundant; however, the situation is most likely the former, because even in the dravitic rims, Fe is still present, albeit at lower concentrations; therefore, it is probable that the sills/dikes/veins began as Fe-rich, and later became Mg-enriched. The enrichment of Mg is evidence of vein contamination by the country rocks.

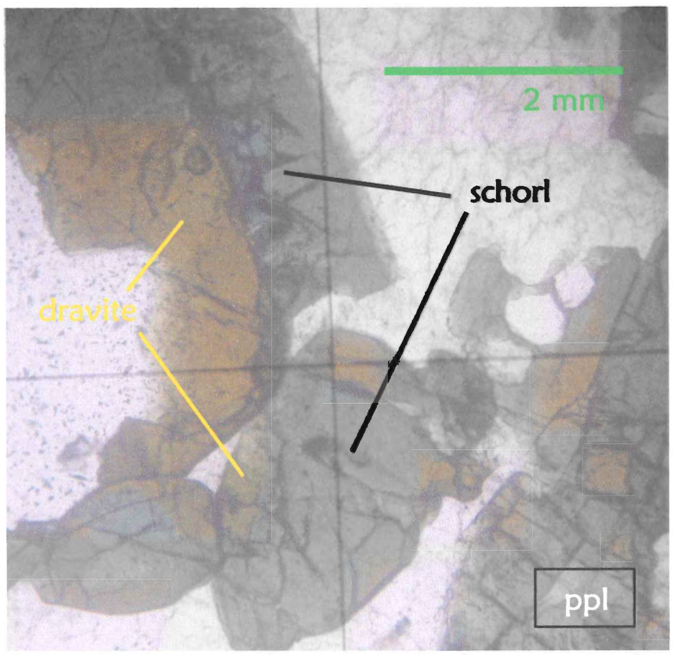

Figure 4.8 Sample MO-7 in thin section, a classic example of compositionally-zoned tourmalines of Tsa da Glisza. This sample is from a quartz-tourmaline vein that contains compositionally-zoned tourmalines. The blue-green centres are schorl and the brown rims are dravite. This compositional zoning of Fe-rich cores, surrounded by Mg-rich rims is an example of the quartz-tourmaline veins becoming enriched in Mg.

The tourmaline Y-site contains the greatest variation in solid solution constituents. Although Fe, Mg, and to a lesser extent, Al are the dominant Y-site end member-defining occupants, minor Mn^{2+}, Ti^{4+}, Cr^{3+}, and V^{3+} occupy this site as well.

The Mn and Ti concentrations display lithologically characteristic concentrations (Fig. 4.9). Granite-hosted tourmalines contain the highest concentrations of Mn and Ti; tourmalines from schists contain negligible Mn and variable concentrations of Ti, although they are never as Ti-rich as those from the granite.

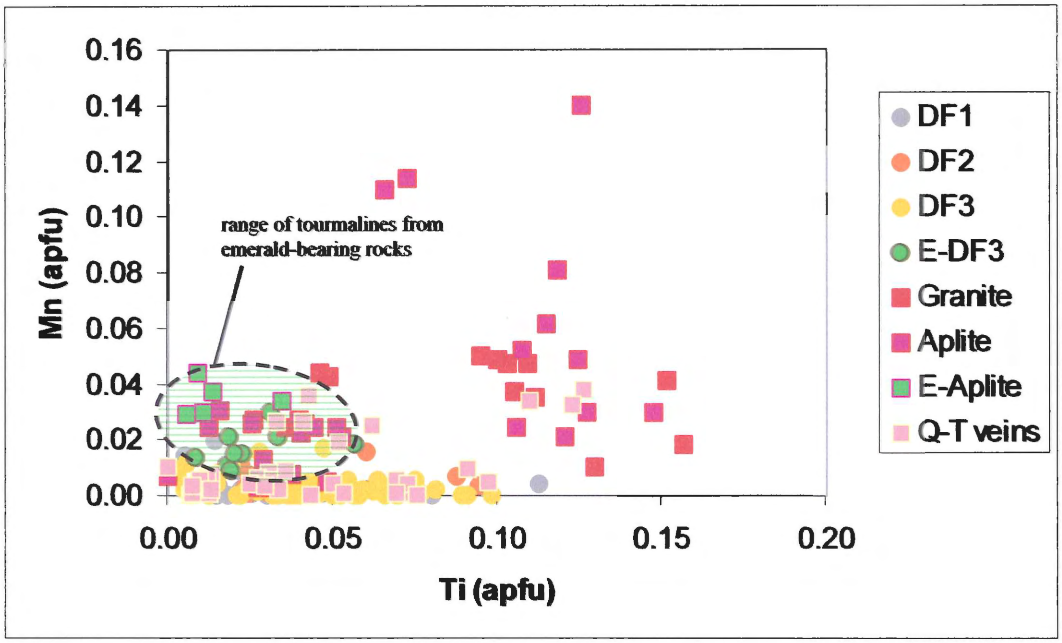

Figure 4.9 Mn and Ti are minor, but important, Y-site constituents. The concentrations of Mn and Ti in tourmalines from granites, aplites, quartz-tourmaline veins and emerald-bearing samples vary, although tourmalines from emerald-bearing rocks are relatively Ti-poor. Tourmalines from schists contain negligible amounts of Mn despite the range in Ti.

Tourmalines from quartz-tourmaline veins and aplites contain variable concentrations of Mn and Ti alike, although similar to those from country rocks. Tourmalines from emerald-bearing rocks have greater Mn concentrations than those from schists, but are Ti-poor.

Although it is also possible that any or all of the Cr^{3+}, V^{3+}, and Fe^{2+} or Fe^{3+} may be present in the Z-site, for the sake of simplicity I have assumed that all of these elements are only present in the Y-site. As the concentrations of Cr^{3+}, $V^{3+}$are so low, it seems an acceptable assumption. I calculated the Fe concentrations only as Fe^{2+}, therefore, the Fe^{3+} concentration is unknown, however, the presence of iron in the Z-site is generally rare and exists only in a few end members (Hawthorne and Henry, 1999).

A compositional distinction between tourmalines from granite and those from country rock also exists in the Z-site, occupied exclusively by Mg and Al (Fig. 4.10). Tourmalines from schists contain the lowest concentrations of Al, with some substitution of Mg for Al, a result of charge balance as Ca substitutes for Na in the X site.

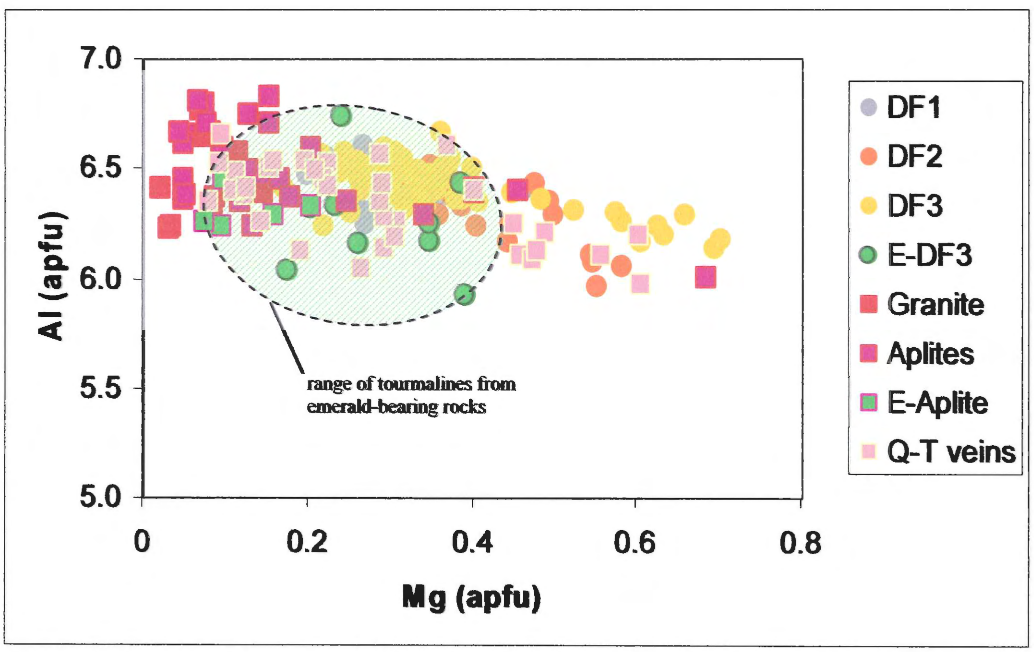

Figure 4.10 The only Z-site occupants are Mg and Al. Decreasing Al with increasing Mg is evident, because of solid solution in the Z-site; Mg in the Z-site is correlated with Ca in the X-site. For every Ca that is present in the X-site, a Mg must be present in the Z-site to remain charge balanced. The Al values can be in excess of 6 apfu, even with Mg in the Z-site, predominantly as a result of O^{2-} for OH^- solid solution in the anion site.

In tourmalines from granites, most aplites, and most quartz-tourmaline veins, the Z-site is exclusively occupied by Al. The lack of Mg in the Z-site is also characteristic of tourmalines from emerald-bearing rocks. Because of substitution of O^{2-} for OH^{-}, the Z-site is in some cases able to accommodate more than six apfu.

As Figures 4.1 – 4.10 indicate, distinct differences exist in major-element compositions of tourmalines from Tsa da Glisza. The variations in major-element composition are present in X-site, with Na and Ca in solid solution, in the Y-site, with Mg and Fe (and to a lesser extent, Mn and Ti) in solid solution, and in the Z-site, with Mg and Al in solid solution. These binary plots of major-element compositions indicate that a specific range in composition of tourmalines is associated with emerald mineralization:

- the X-site ~ $Na_{0.69}K_{0.01}Ca_{0.30}$,
- the Y site ~ $FeMg_2$, allowing some Mn, but Ti-poor, and
- the Z-site less than ~ $Mg_{0.35}$.

The emerald-related range of compositions is similar to that of tourmalines from country rock, but at highest-Fe, highest-Na compositional extent of the country-rock-tourmalines, approaching the compositional range of tourmalines from the granite.

4.2 Trace-element compositions

Unlike the relatively narrow range of the major-element compositions (Section 3.2.1, Section 4.1), the trace-element compositions of tourmalines vary substantially. The tourmalines in all rocks cover a wide range of concentrations of the various trace elements (Table 3.3, APPENDIX C). The use of correlation coefficients simplified the process of interpreting the trace-element concentrations (Table 4.1).

Table 4.1 Comparison of Pearson correlation coefficients with Spearman correlation coefficients (Section 2.4.1). Moderate to strong Pearson correlations (coefficient >0.75) of concentrations above the lower limits of detection (variable with each element) were chosen for binary plots. The last column indicates the binary plots of these elemental pairs.

Element Pair	Pearson Coefficient	Spearman Coefficient	Figure
Co-Ni	0.969	0.745	4.11
La-Nd	0.812	0.860	4.12
Y-Yb	0.951	0.869	4.13
Sb-Pb	0.989	0.736	4.14
Li-Mn	0.789	0.728	4.15
Ce-Zn	0.771	0.541	4.16

Similar to the major-element trends, there are variations in trace-element compositions of the Tsa da Glisza tourmalines from different lithologies. Tables 4.2 and 4.3 show the ranges of selected trace-element concentrations of the tourmalines from the granite compared to the tourmalines from the country rocks. In the cases of Co, Ni, La, Nd, Y, and Yb, tourmalines from the granite samples contain low concentrations of these elements, and tourmalines from schist samples contain comparatively high concentrations of these elements (Table 4.2).

Table 4.2 Co, Ni, La, Nd, Y, and Yb; the trace elements present at relatively higher concentrations in tourmalines from schists.

	Co (ppm)		Ni (ppm)		La (ppm)		Nd (ppm)		Y (ppm)		Yb (ppm)	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
granite-host	0	5	0	10	0	1	0	0.5	0	2.5	0	0.4
schist-host	15	70	40	250	0	1.5	0.1	1.2	0.1	3	0	0.6

Conversely, the tourmalines from the granite contain greater concentrations of Sn, Pb, Sb, Li, and Mn, compared with those from schists (Table 4.3).

Table 4.3 Li, Mn, Sn, Pb, and Sb; the trace elements present at relatively high concentrations in tourmalines from granites.

	Li (ppm)		**Mn** (wt%)		**Sn** (ppm)		**Pb** (ppm)		**Sb** (ppm)	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
granite-host	180	250	0.08	0.40	70	80	20	45	0.5	2
schist-host	0	120	0.02	0.20	0	50	0	25	0	0.5

Figure 4.11 is a binary plot of Co and Ni concentrations in tourmaline samples showing variations in Co-Ni concentrations of variable degrees of country rock alteration. Tourmalines from DF_1 contain the most Ni, less in tourmalines from DF_2, and the least in tourmalines from DF_3; however, the greater the degree of metasomatism, the greater the variation in Ni content. Tourmalines from aplites and quartz-tourmaline veins have varied Co and Ni concentrations, and tourmalines present with emeralds in country rock appear to contain 20 ppm (± 5 ppm) Co and less than 100 ppm Ni. Tourmalines from emerald-bearing aplite have Co concentrations similar to other emerald-bearing rocks, but higher Ni concentration. As Co and Ni are both divalent cations, and are commonly associated with Fe, it is probable that all Co and Ni exist in the tourmaline Y-site.

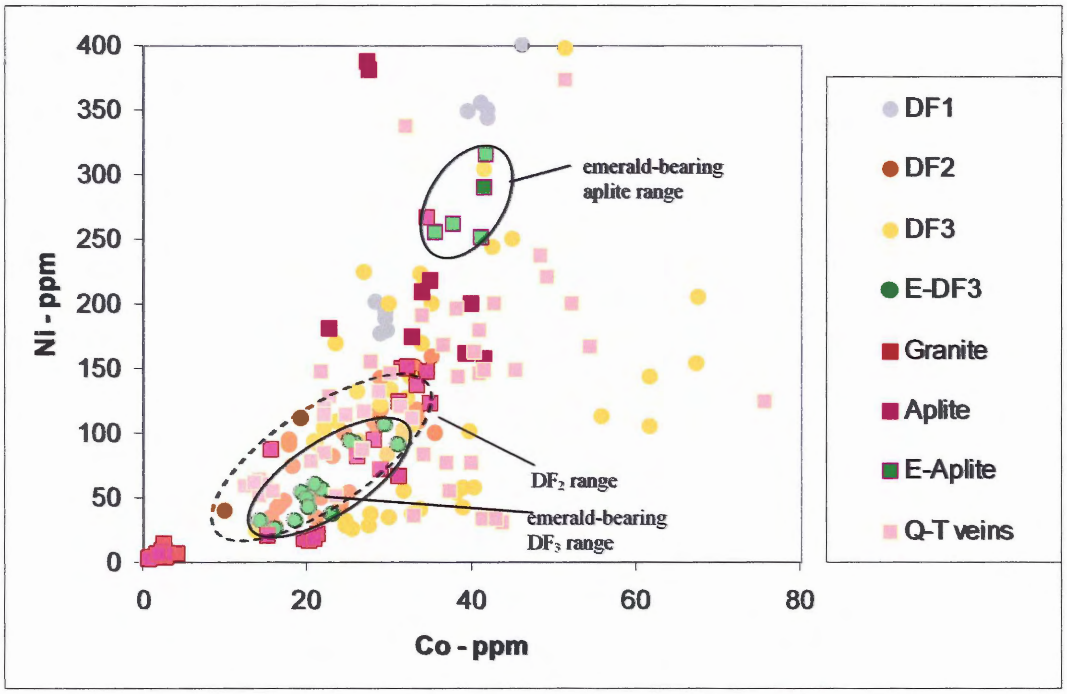

Figure 4.11 Range of Ni – Co concentrations in tourmalines from Tsa da Glisza, shown in a binary plot. Ni and Co are strongly correlated, with a Pearson coefficient of 0.969. Granite tourmalines contain the lowest concentrations, situated near the origin of this plot; emerald-bearing DF_3 tourmalines are restricted between 15 and 35 ppm. The tourmalines from the emerald-bearing aplite are much more Ni-rich, but contain a similar Co concentration as those from other emerald-bearing rocks.

Tourmalines from all lithologies contain a relatively narrow range of La and Nd concentrations, generally less than 2 ppm (Fig. 4.12), although schist-hosted tourmalines contain higher concentrations of both than granite-hosted tourmalines. However, despite the La-Nd variability, quartz-tourmaline vein samples all contain less than 0.5 ppm. Tourmalines from emerald-bearing samples (aplite and DF_3) contain approximately 0.3 to 0.7 ppm of both La and Nd. Both La and Nd are trivalent cations, and therefore, could occupy either the Y- or Z-site; however, as the Y-site commonly displays the most solid solution, it is likely that they La and Nd occupy the Y-site.

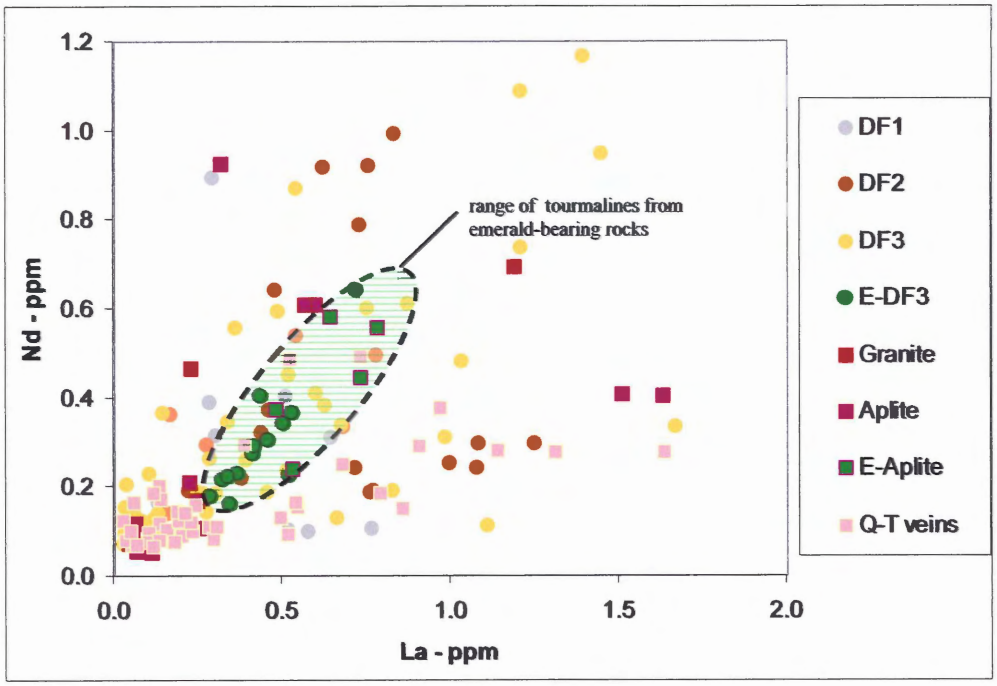

Figure 4.12 Restricted La – Nd range in tourmaline from emerald-bearing rocks. La and Nd are well correlated with a Spearman correlation of 0.959. Tourmalines from aplites, quartz-tourmaline veins, and schists contain a wide range of both La and Nd, within 0 to 2 ppm. Both La and Nd content for emerald-bearing DF_3 samples is approximately 0.5 ppm (± 0.2 ppm).

The Y and Yb concentrations in all tourmalines from Tsa da Glisza are strongly correlated, by Pearson and Spearman correlations. Tourmalines from all lithologies contain minor concentrations of Y and Yb (Fig. 4.13). Aplite- and granite-tourmalines contain 1 ppm Y or less, vein tourmalines contain 2 ppm Y or less. Schist-hosted tourmalines generally contain 2 ppm Y or less, but some contain up to 3 ppm. Tourmalines from emerald-bearing samples (aplite and DF_3) all contain less than 1 ppm Y. Similar to La and Nd, as well as Cr and V (previous section), Y and Yb are both trivalent cations, and likely exist in the tourmaline Y-site.

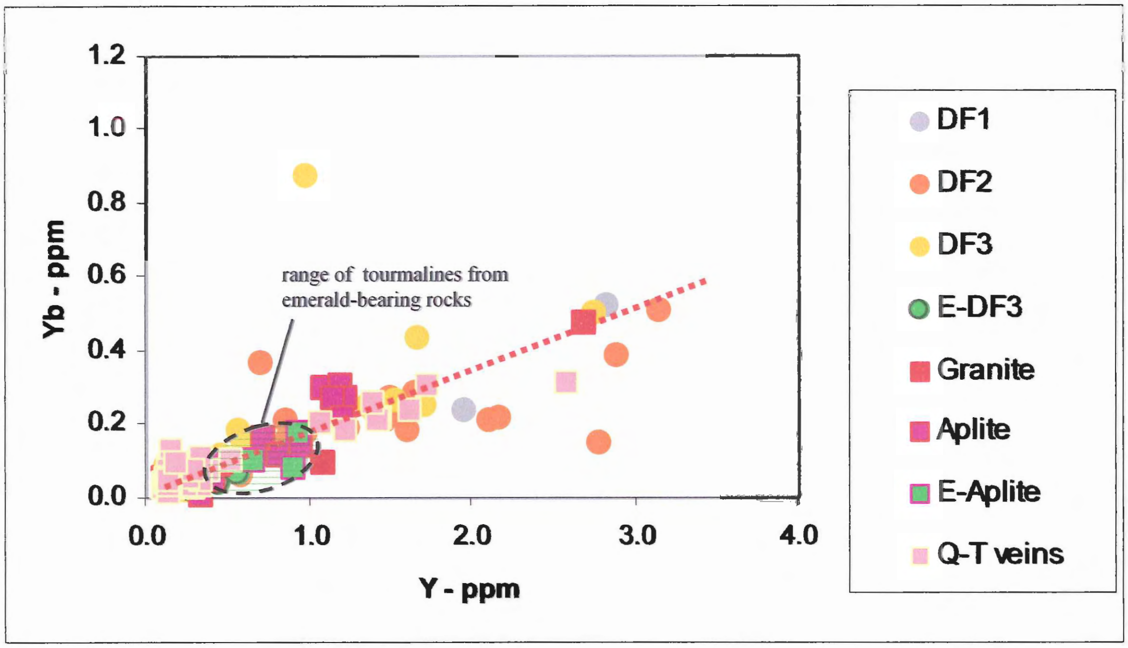

Figure 4.13 Y – Yb plot highlighting a strong linear relationship and narrow range in concentrations. Y and Yb are strongly correlated, with a Pearson coefficient of 0.951 and a Spearman coefficient of 0.869. Tourmalines from emerald-bearing samples contain low concentrations of Y and Yb, compared to most other rocks from Tsa da Glisza.

Tourmalines from DF_2 and DF_3 schists contain similar concentrations of Pb and Sb (Fig. 4.14): generally less than 0.5 ppm Sb and less than 20 ppm Pb. Emerald-bearing samples have higher concentrations of both of these elements: approximately 0.5 ppm Sb and up to 35 ppm Pb. Granite-hosted tourmalines contain the highest concentrations of Sb and Pb, nearly four times the concentration in schist-hosted tourmalines; tourmalines from aplites and quartz-tourmaline veins contain concentrations of Sb and Pb transitional between those from granites and those from schists. This transitional composition is another example of the emerald-bearing tourmalines being similar to the schists, but on the granitic side of the country rock spectrum. Like many of the trace elements featured in this section, Sb and Pb are most likely in the Y-site, based on their large atomic size and their common association with Fe.

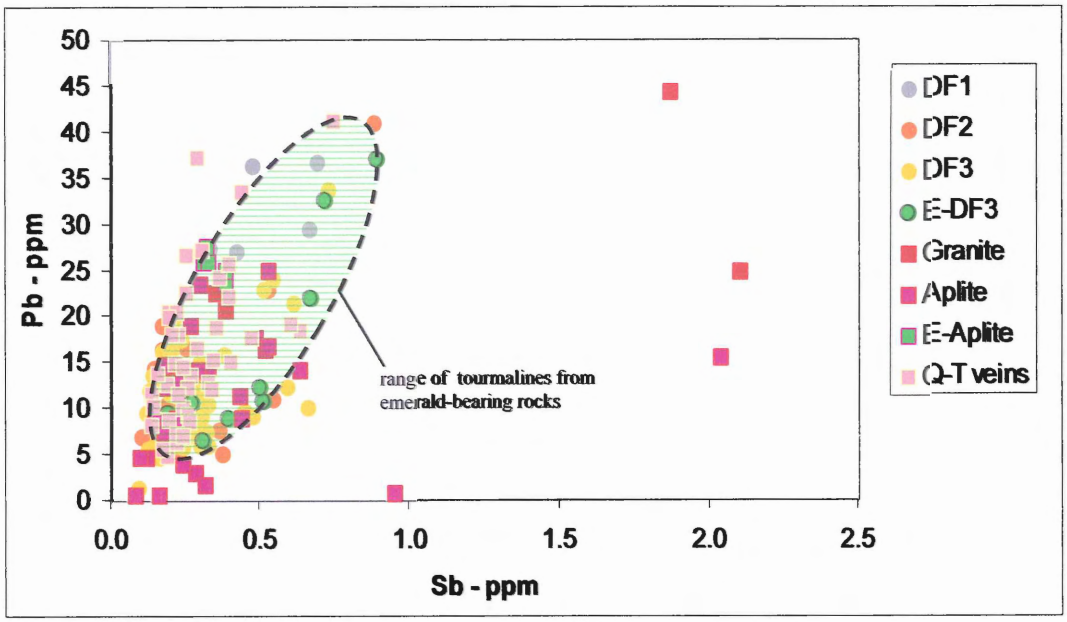

Figure 4.14 Sb – Pb plot highlighting concentrations higher than those found in non-emerald-nearing country rocks. Sb and Pb have a Pearson correlation 0.989. Note high concentration of both these elements in tourmalines from the granite, compared with the low concentrations in tourmalines in the schists. Tourmalines related to emeralds in DF_3 samples and aplites are both transitional between granite-tourmalines and schist-tourmalines.

Because LAM-ICPMS is more sensitive than EMP, the Mn concentrations are clearer in the LAM-ICPMS results, shown with Li in Figure 4.15. Granite-hosted tourmalines contain the highest concentrations of Li and Mn; schist-hosted tourmalines and vein tourmalines contain the lowest concentrations. Aplite-hosted tourmalines and those from tourmalines of emerald-bearing samples contain Li and Mn concentrations comparable to those from schist samples but slightly higher (up to 100 ppm more Li and 0.1 wt% MnO). The DF_2 schist tourmalines contain Li and Mn concentrations similar to tourmalines from emerald-bearing samples. Both Li and Mn are commonly present in the Y-site.

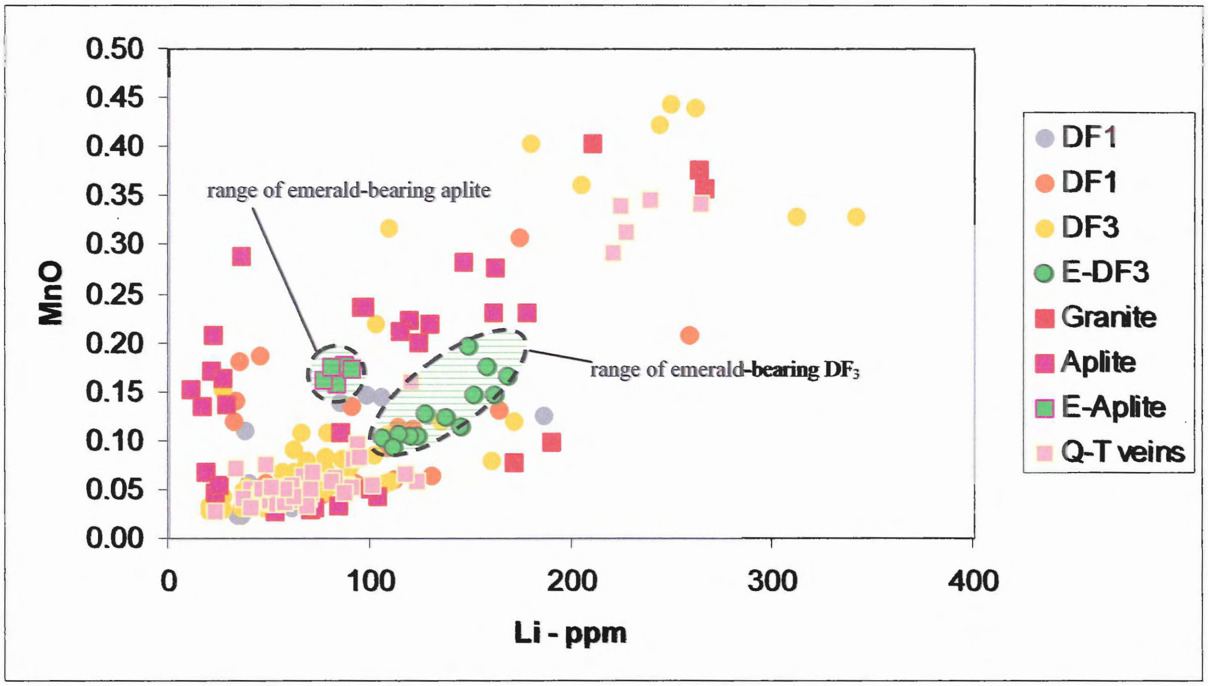

Figure 4.15 Binary plot of Li – Mn highlighting transitional tourmaline composition. Li and Mn are moderately correlated with Pearson coefficient of 0.789 and a Spearman coefficient of 0.728. Many of the tourmalines from schist samples as well as quartz-tourmaline vein samples contain low concentrations of Mn and Li, relative to those from the granite, and from emerald mineralized samples. Compared with other schists, tourmalines from DF_2 samples display similar influence from the granite as those from emerald-bearing samples, particularly higher Mn concentrations.

One of the best indicators of emerald mineralization is the Zn concentrations of tourmalines at Tsa da Glisza. Figure 4.16 shows Zn plotted with Ce. The Ce concentrations vary in tourmalines from all lithologies. The Zn concentrations are relatively constant in tourmalines from most rocks at Tsa da Glisza, less than 200 ppm, but those that are emerald-bearing also have anomalously high Zn in the tourmalines, ranging between 300 and 600 ppm.

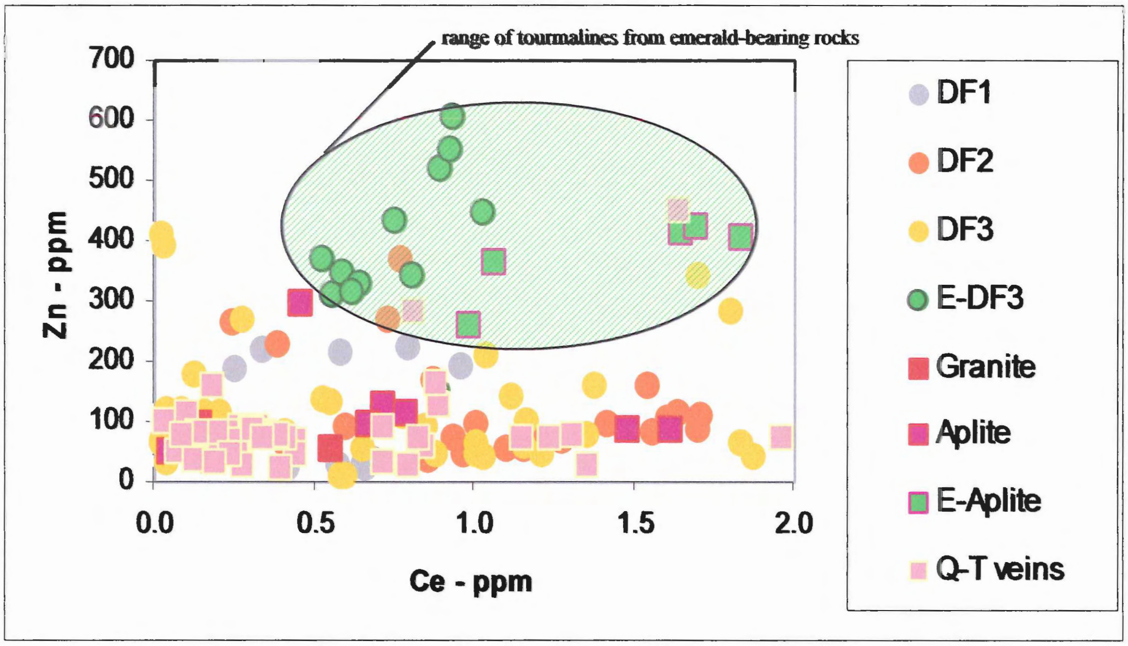

Figure 4.16 Ce and Zn, highlighting comparatively high Zn concentrations in tourmalines from emerald-bearing rocks. Although Ce and Zn are moderately correlated, Zn concentrations are relatively constant in most rocks at Tsa da Glisza, with 100 ppm or less; however, emerald-bearing rocks contain 300 – 600 ppm Zn, and 0.5 – 1.5 ppm Ce.

Like the major-element compositions, the trace-element compositions in tourmalines vary by lithology. Many of the siderophile metals, such as Pb, Sb, Ni, Co, and Zn, have characteristic lithologically-related concentrations in the tourmalines, including those that contain emeralds. Certain rare-earth elements, namely La, Nd, Y, Yb, and Ce, are present at characteristically low concentrations in tourmalines from emerald-bearing rocks. As a result, the tourmalines from rocks that contain emeralds occupy narrow ranges of binary trace-element plots, just as they do with the major elements. In some cases (Figs. 4.11, 4.12, 4.16), the trace-element concentrations is restrictive with respect to emerald mineralization, and not transitional between tourmalines from country rocks and tourmalines from granite.

In both major- and trace-element compositions, the tourmalines from emerald-bearing rocks have compositions predominantly within the range of tourmalines from country rocks, although approaching the granite-tourmaline range. As a result, Fe and Al in the Y-site are at higher concentrations at the expense of Mg. Related to the major-element, relatively higher, Fe-Al concentrations, the tourmaline trace elements characteristic of emerald mineralization also occupy the Y-site. However, because many of the trace elements measured are trivalent cations, such as La^{3+}, Nd^{3+}, Y^{3+}, Yb^{3+}, Sb^{3+}, and Ce^{3+}, it is possible that many occupy the Z-site, replacing Al^{3+} and/or Mg^{2+}, although it is not as likely. Also possible, but even less likely, is that those elements may replace B^{3+}.

4.3 Multivariate statistical analysis

Although the binary and ternary plots in Figs. 4.1 – 4.16 are simple to interpret, they are limited. A multi-dimensional approach is not necessary with the major-element concentrations, because there is less variation and it is easily interpreted in two-dimensional space; however, the trace-element concentrations vary significantly and the range of concentrations in tourmalines from emerald-bearing samples is not as narrow as in the major-element composition. Therefore, I used multivariate statistics to plot trace-element concentrations in hyperspace. Because many of the elements analyzed were determined to be at concentrations below the lower limit of detection, only 22 of the trace-element concentrations were used for the multivariate approach. The 22 elemental concentrations included Li, Be, Sc, V, Cr, MnO, Co, Ni, Zn, Sr, Nb, Sn, Cs, Ba, La, Ce, Eu, Ta, W, Pb, Bi, and U. This 22-element plot results in a 22-dimensional plot, with each axis mutually perpendicular. I applied cluster analysis and discriminant function analysis to test tourmaline as a stand-alone indicator for emerald mineralization at Tsa da Glisza.

4.3.1 Cluster analysis

The cluster analysis did not prove to be successful. I examined cases of two, three, and four clusters (Table 4.4). None of the potential clusters displayed any correlation of samples within that cluster. The cases of two and three clusters identified essentially the same clusters, but splitting one cluster into two in the three-cluster scenario. The four-cluster scenario identified different clusters than the two- and three-cluster scenarios, but still did not identify emerald-relating groups.

4.3.2 Discriminant function analysis

For discriminant function analysis (DFA), I classified the trace-element concentrations into two groupings: tourmalines with emerald (E) and tourmalines not with emerald (NE). The DFA identified the discriminant function between these two groupings (Table 4.5). Based on a sample proximity to the plane, the groupings are placed in a classification matrix. This matrix classifies each sample as affirmatively belonging to the group defined by the user.

Table 4.4 Results of cluster analysis, including 2-, 3-, and 4-cluster possibilities. Results appear to be biased to one cluster, but there are no apparent correlations within clusters.

Sample	Lithology	2 Clusters	3 Cluster	4 Clusters
MO-5	DF_1	1	1	1
776T-4	DF_1	2	2	2
FW-2	DF_2	1	1	1
HR-1	DF_2	1	1	1
HRT-6	DF_2	1	1	1
T0640	DF_2	1	1	1
322807A	DF_2	1	1	2
322915	DF_3	1	1	1
H0432	DF_3	1	1	1
HR-3	DF_3	1	1	1
HRT-1	DF_3	1	1	1
T0643	DF_3	1	1	1
OZ-5	DF_3	1	3	1
322943	DF_3	1	1	2
H0309B	DF_3	1	1	2
MO-3	DF_3	1	1	2
H0425	DF_3	2	2	2
322807	E-DF	1	1	1
322807B	E-DF	1	1	1
322810	E-DF	2	2	2
FW-5	E-DF	2	2	4
CO-1	Kg	1	1	1
MO-2	Ka	1	1	1
MO-6	Ka	1	1	1
TH-1	Ka	1	1	1
H0429	Ka	1	1	2
AP-T1	Ka	2	2	2
TC-2	Ka	1	3	3
APMT-1	E-Ka	1	1	2
FW-3	Kqt	1	1	1
HR-4	Kqt	1	1	1
HRT-3	Kqt	1	1	1
MO-7	Kqt	1	1	1
OZ-3	Kqt	1	1	1
SUM-1	Kqt	1	1	1
T0642	Kqt	1	1	1
OZ-2	Kqt	1	1	2

In the narrow case, DFA classified all five emerald-bearing samples as belonging to the emerald group and all 32 non-emerald-bearing samples as belonging to the no-emerald group (Table 4.6), determining these groupings as 100% effective.

In the second possible case, which expands the emerald-bearing cluster from five to 13, DFA classified 12 of the 13 emerald-bearing samples in the emerald group, and 22 of the 24 non-emerald-bearing samples in the no-emerald group (Table 4.7), determining these groupings as 92% effective.

Table 4.5 Canonical discriminant functions of each element for narrow and expanded DFA.

	Discriminant Function	
	Narrow	**Expanded**
Li	0.016	0.008
Be	-0.207	0.018
Sc	-0.001	0.003
V	0.005	-0.002
Cr	-0.000	-0.000
MnO	-0.108	9.506
Co	0.004	0.093
Ni	-0.008	-0.007
Zn	-0.005	-0.003
Sr	0.005	0.003
Nb	1.064	0.692
Sn	-0.016	-0.022
Cs	-0.006	0.001
Ba	0.055	0.002
La	-0.628	1.687
Ce	0.778	-0.892
Eu	-5.625	-1.985
Ta	-0.114	0.002
W	0.010	-0.002
Pb	0.007	0.006
Bi	0.488	-0.373
U	-1.056	-0.087
Constant	5.170	-2.883

Table 4.6 Classification matrix of narrow discriminant function analysis. The classification is 100% effective, because emerald-bearing samples affirmatively lie within the boundaries of the emerald-bearing cluster, and all non-emerald-bearing samples lie within the boundaries of the non-emerald-bearing cluster.

	emerald	no emerald	% correct
emerald	5	0	100
no emerald	0	32	100
TOTAL	5	32	100

Table 4.7 Classification matrix of expanded discriminant function analysis. The classification is 92% effective.

	emerald	no emerald	% correct
emerald	12	1	92
no emerald	2	22	92
TOTAL	14	23	92

I cannot explain the misclassification of samples in the expanded case. The misclassified case of the "emerald" for a "non-emerald" class refers to sample FW-3, which is a quartz-tourmaline vein sample responsible for emerald mineralization. Other quartz-tourmaline vein samples linked to emerald mineralization, such as HRT-3 and SUM-1 were classified correctly. The two misclassified "non-emerald" for "emerald" refer to samples 322915 and H0432. It is simply possible that these samples are near emerald mineralization that has not been discovered. This is certainly possible with H0432, because it is a DDH sample that was drilled in the vicinity of emerald mineralization. The misclassification of these two samples may also indicate that the tourmalines were once present with emerald mineralization, but are no longer, whether erosion has occurred, or subsequent transport of the emeralds [or tourmaline] by later metasomatic fluids.

Figure 4.17 provides a simplified possible reason why discriminant function serves as an excellent data-processing method for defining tourmaline as an indicator for emerald mineralization. Because there is such a variety in the host lithologies of the tourmalines, natural clusters are easily defined (from Table

4.4); however, the natural clusters are not the separator segregating tourmalines from emerald-bearing rocks from non-emerald-bearing rocks.

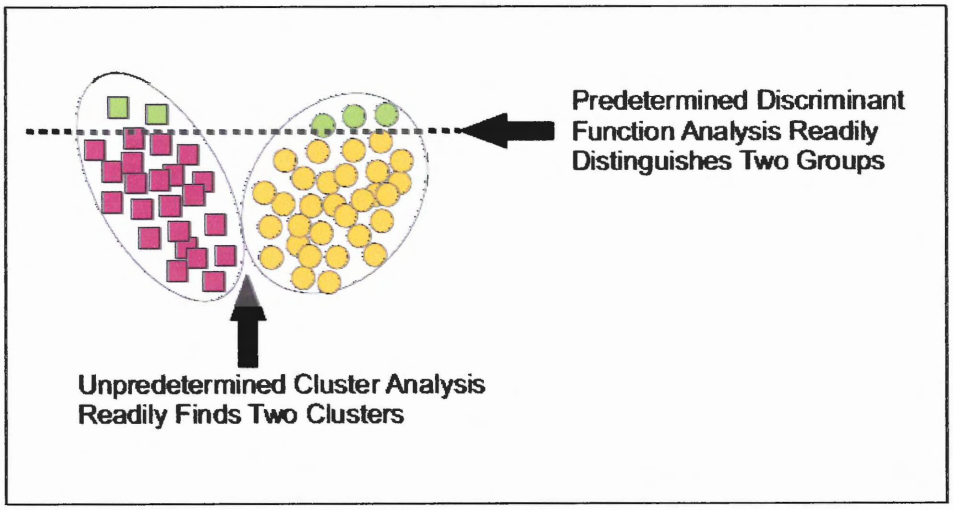

Figure 4.17 A simplified example of the benefit of discriminant function analysis to cluster analysis. Cluster analysis finds the natural groupings; however, discriminant function analysis finds the boundary between set groupings. In our case, the set groupings are tourmalines from emerald-bearing rocks and tourmalines not from emerald-bearing rocks. Image used courtesy of Barrie Clarke.

Although they are not clustered in hyperspace, discriminant function analysis indicates that the distinction between tourmalines from rocks that contain emeralds and tourmalines from rocks that do not contain emeralds is strong. Not only can discriminant function be applied to tourmalines from rocks that contain emeralds, but it also applies in the case of tourmalines from rocks that are near emerald mineralization. An important unknown factor testing the effectiveness of the expanded function is the minimum distance to emerald mineralization. I have assumed 25 m, although this value may be expanded, or slightly reduced.

CHAPTER 5: CONCLUSIONS

The following are the most important conclusions concerning emerald mineralization at Tsa da Glisza:

- Tourmaline is ubiquitous in the area, but emerald occurs principally at contacts with quartz-tourmaline veins in highly metasomatized schists, raising the possibility that tourmaline may act as an indicator mineral.
- Tourmaline compositions are primarily alkali (dravite and shorl), with minor calcic (uvite).
- Tourmaline compositions in the country rocks tend to be dravite, whereas those in granite-related rocks tend to be schorl.
- Bivariate plots of Ca-Na, Mg-Fe, and Mg-Al show that tourmaline associated with emerald tends to occupy approximately the middle of the compositional range of $(Na_{0.7}Ca_{0.3})(FeMg_2)(Mg_{0.3}Al_{5.7})(BO_3)_3Si_6O_{18}(O,OH,F)_4$, but with compositional overlap with non-emerald associated tourmalines.
- Of these, moderate to strong Pearson and Spearman correlations exist for: Ni-Co, La-Nd, Y-Yb, Sb-Pb, Li-Mn, and Ce-Zn.
- For many of the trace elements, elements such as Ni, Co, Pb, and Zn enter the Y-site in the T structure, although others such as Y, Yb, La, Ce, and Sb may also enter the Z-site or boron-site.
- Multivariate cluster analysis was not successful in defining the emerald-related tourmalines from non-emerald-related tourmalines.

- Discriminant function analysis was highly successful, both with the narrow (100%) and expanded (92% success) populations, in distinguishing between those tourmalines that are associated with emerald and those tourmalines that are not.
- Trace-element concentrations in tourmalines at Tsa da Glisza strongly suggest that tourmaline is an indicator mineral for emerald mineralization at this deposit.

Since exploration began at Tsa da Glisza, the identification of emerald-hosted zones has been done by physical appearance. The identification of quartz-tourmaline veins has always been the driving factor in identification of emeralds on the property. The presence of DF1, DF2, and DF3 alteration assemblages in the contact zones has always been a supporting observation to indicate probable emerald presence. Nevertheless, emeralds are not always present in these areas; therefore, the need for a more precise method of identifying emerald mineralization exists. This research has proved that there are major- and trace-element compositional differences in tourmalines, not only by lithology, but within lithology as well. Not only do the differences exist but the use of discriminant function with the trace-element concentration provides a high degree of accuracy of identifying nearby emerald mineralization, even when not directly visible.

Future Research

In many respects, the current work is *preliminary*, and needs further research in the following areas:

- increased rigour of the multivariate statistics, including transforming those variables with non-normal distributions, using a combination of major and trace elements, and using stepwise DFA to eliminate the non-significant elements to increase the ratio of samples to variables;
- addition of boron isotopic compositions ($^{11}B/^{10}B$ ratios) to the mix of variables to test for their contribution to the discriminating power of tourmalines, and to better understand the chemical evolution of the system that produced the emeralds at Tsa da Glisza.

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APPENDIX A: MAJOR-ELEMENT CONCENTRATIONS, WT% OXIDE

This section includes the weight percent oxide concentration of each element measured by EMP, as well as the combined total. Those analyses that, were not of tourmaline, or did not add up to total greater than 95%, are not included. There was apparently error in the B_2O_3 results, therefore, totals greater than 95%, based on assume B_2O_3 concentrations of up to 10% were included.

The analyses were done under two different analytical files: the first file analyzing the tourmalines for Si, Ti, B, Al, Cr, V, Fe, Mn, Mg, Ca, Na, and K (Part 1). The second file reanalyzed for Si, Ti, Al, Fe, Mg, Ca, Na, K, F, and fixed 9.8 wt% B_2O_3 (Part 2).

Part 1

The results from Part 1 were gathered on 20 October, 3 November, and 8 – 10 December, 2006.

Sample	Lithology	SIO2	TIO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
776T-3 1	DF1	34.9487	0.598	6.5236	32.6786	0.2319	0.0388	4.0756	0	8.8081	1.585	1.6684	0.0133	**91.17**
776T-3 2	DF1	35.7125	0.0735	6.7161	32.4912	0.2067	0.0315	4.0634	0.0366	9.2103	1.7723	1.7641	0.0433	**92.122**
776T-3 3	DF1	36.125	0.0827	6.4208	33.8485	0.2361	0.0678	4.1492	0.024	8.4266	1.0525	1.7602	0.0511	**92.245**
776T-3 avg	***DF1***	***35.595***	***0.251***	***6.5535***	***33.006***	***0.225***	***0.046***	***4.0961***	***0.02***	***8.815***	***1.47***	***1.731***	***0.036***	***91.845***
776T-4 1	DF1	35.0902	0.0395	6.627	30.4027	0.2935	0	4.4317	0.0922	9.6396	2.0351	1.8291	0.0153	**90.496**
776T-4 2	DF1	35.0414	0.1053	7.3007	30.6661	0.164	0.0024	4.5539	0.1299	9.8194	2.3859	1.5582	0.0343	**91.762**
776T-4 avg	***DF1***	***35.066***	***0.072***	***6.9639***	***30.534***	***0.229***	***0.001***	***4.4928***	***0.111***	***9.7295***	***2.211***	***1.694***	***0.025***	***91.129***
FW-4 1	DF1	35.1706	0.1355	6.3507	34.0838	0.0262	0.0219	5.5338	0	7.6489	1.3838	1.5799	0.0171	**91.952**
FW-4 2	DF1	35.2782	0.2914	6.0332	33.7382	0.1066	0.0342	5.4902	0	7.9106	1.5362	1.5994	0.0094	**92.028**
FW-4 3	DF1	34.7601	0.4898	6.1222	32.5403	0.1213	0.0312	5.2531	0.0127	8.5607	1.3946	1.7535	0.009	**91.049**
FW-4 4	DF1	35.068	0.5786	6.0883	32.4477	0.0493	0.0612	5.5214	0	8.6072	1.5575	1.7261	0.0163	**91.722**
FW-4 avg	***DF1***	***35.069***	***0.374***	***6.1486***	***33.203***	***0.076***	***0.037***	***5.4496***	***0.003***	***8.1819***	***1.468***	***1.665***	***0.013***	***91.688***
HR-2 1	DF1	35.5518	0.2257	6.3249	32.5526	0.301	0.0591	4.7777	0	8.4648	1.1584	2.0671	0.0121	**91.495**
HR-2 2	DF1	35.7344	0.193	6.6267	31.8229	0.1031	0.0087	5.1047	0.0043	9.0727	1.4873	2.112	0.0017	**92.272**
HR-2 3	DF1	35.2585	0.1922	6.2718	33.4013	0	0.0204	4.3123	0.02	8.1877	1.0821	1.8076	0.0113	**90.565**
HR-2 avg	***DF1***	***35.515***	***0.204***	***6.4078***	***32.592***	***0.135***	***0.029***	***4.7316***	***0.008***	***8.5751***	***1.243***	***1.996***	***0.008***	***91.444***
HRT-4 1	DF1	34.4739	0.7103	7.865	31.2089	0.2105	0.0084	4.8844	0.0225	8.6594	1.4451	1.6989	0.0252	**91.213**
HRT-4 2	DF1	35.2885	0.8354	7.1655	31.1295	0.2074	0.0158	5.3918	0.0267	8.7775	1.4429	1.8412	0.0196	**92.142**
HRT-4 3	DF1	35.1533	0.7142	6.8504	30.7699	0.2718	0.0156	5.3547	0.0168	8.8272	1.8933	1.602	0.0247	**91.494**
HRT-4 avg	***DF1***	***34.972***	***0.753***	***7.2936***	***31.036***	***0.23***	***0.013***	***5.2103***	***0.022***	***8.7547***	***1.594***	***1.714***	***0.023***	***91.616***

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
HRT-7 1	DF1	35.9287	0.3504	5.0801	32.0724	0.3911	0	4.0221	0.0056	9.299	1.6126	1.7882	0.0266	**90.577**
HRT-7 2	DF1	35.9148	0.5793	5.6887	31.8702	0.2156	0	4.0524	0.0014	9.2769	1.5389	1.8678	0.021	**91.027**
HRT-7 3	DF1	35.5113	0.399	6.1303	32.7254	0.2726	0	3.7515	0.0028	8.9873	1.5231	1.7924	0.0185	**91.114**
HRT-7 4	DF1	35.8384	0.1838	7.5581	32.7273	0.3821	0	3.7457	0.0028	8.9515	1.4307	1.8778	0.0197	**92.718**
HRT-7 avg	***DF1***	***35.798***	***0.378***	***6.1143***	***32.349***	***0.315***	***0***	***3.8929***	***0.003***	***9.1287***	***1.526***	***1.832***	***0.021***	***91.359***
MO-1 1	DF1	35.4646	0.1109	6.613	33.2338	0.0414	0.0181	5.1747	0	8.2053	1.4503	1.6394	0.0291	**91.981**
MO-1 2	DF1	34.7236	0.3715	5.8802	32.6854	0	0.0032	5.3262	0	8.3425	1.894	1.5458	0.0158	**90.788**
MO-1 3	DF1	35.1229	0.5533	5.9809	32.2496	0	0	5.698	0	8.2697	1.5225	1.659	0.0175	**91.073**
MO-1 avg	***DF1***	***35.104***	***0.345***	***6.158***	***32.723***	***0.014***	***0.007***	***5.3996***	***0***	***8.2725***	***1.622***	***1.615***	***0.021***	***91.281***
MO-5 1	DF1	37.0395	0.1697	9.0423	33.7705	0.0708	0.0128	3.106	0.0118	8.7961	1.481	1.8667	0.0322	**95.4**
MO-5 2	DF1	37.4032	0.0788	10.2003	33.7493	0.0646	0.0267	3.1473	0.0355	8.9446	1.2981	2.0495	0.0243	**97.022**
MO-5 3	DF1	37.1565	0.1171	9.5717	33.8894	0.0565	0.0236	3.1498	0.0207	8.8956	1.3954	1.8966	0.0269	**96.2**
MO-5 4	DF1	37.4735	0.1764	8.7927	33.9707	0.0494	0.0045	3.2635	0.0548	8.6748	1.4575	1.7691	0.0283	**95.715**
MO-5 avg	***DF1***	***37.268***	***0.136***	***9.4018***	***33.845***	***0.06***	***0.017***	***3.1667***	***0.031***	***8.8278***	***1.408***	***1.895***	***0.028***	***96.084***
322807A 1	DF2	35.999	0.0945	6.4321	30.6669	0.0829	0.0256	5.1765	0.0207	9.271	1.877	1.6216	0.0117	**91.28**
322807A 2	DF2	36.3613	0.1735	6.5045	29.3205	0.1453	0.0438	4.2211	0.0178	10.6262	2.856	1.3474	0.0198	**91.637**
322807A 3	DF2	36.0449	0.4466	6.1579	28.7742	0.1195	0.0127	4.8175	0.0148	10.5335	2.843	1.3126	0.0189	**91.096**
322807A 4	DF2	36.5499	0.1819	6.7065	28.9151	0.1695	0.0245	4.4757	0.0044	10.8301	3.0504	1.2276	0.0265	**92.162**
322807A 5	DF2	36.7307	0.1753	6.9241	28.4488	0.1057	0.0192	4.7973	0.0133	10.8862	2.884	1.355	0.0153	**92.355**
322807A avg	***DF2***	***36.337***	***0.214***	***6.545***	***29.225***	***0.125***	***0.025***	***4.6976***	***0.014***	***10.429***	***2.702***	***1.373***	***0.018***	***91.706***
FW-2 1	DF2	34.7073	0.1648	6.9119	31.6822	0.05	0.0276	6.131	0.0697	7.8684	1.6773	1.7402	0.0364	**91.067**
FW-2 2	DF2	35.0608	0.1817	7.0295	30.7333	0.0008	0.096	5.43	0.0484	9.6723	2.4741	1.6308	0.0519	**92.41**
FW-2 3	DF2	34.9687	0.4425	7.2762	30.6757	0.0011	0.0595	6.376	0.1024	8.1372	1.9288	1.6919	0.0937	**91.754**
FW-2 avg	***DF2***	***34.912***	***0.263***	***7.0725***	***31.03***	***0.017***	***0.061***	***5.979***	***0.074***	***8.5593***	***2.027***	***1.688***	***0.061***	***91.743***
HRT-6 1	DF2	36.6594	0.1971	10.072	31.7551	0.1126	0.0698	4.5822	0.0252	9.7106	2.0612	1.5613	0.0256	**96.832**
HRT-6 2	DF2	35.6977	0.3672	10.6882	29.8964	0.1177	0.0541	4.1771	0.0059	10.4155	2.3217	1.4363	0.022	**95.2**
HRT-6 3	DF2	36.1359	0.6614	10.4321	31.676	0.307	0.0497	4.5833	0.0429	9.135	1.782	1.5938	0.0299	**96.429**
HRT-6 4	DF2	36.1234	0.7141	9.8088	32.0705	0.3202	0.033	4.6185	0.0237	8.8928	1.7652	1.6621	0.0344	**96.067**
HRT-6 5	DF2	37.1113	0.2845	10.1286	31.3393	0.4742	0.0288	4.8409	0.0222	9.2722	2.3677	1.4799	0.0304	**97.38**
HRT-6 6	DF2	36.6717	0.2264	10.0378	31.892	0.6163	0.0674	4.6618	0.0089	8.9833	2.1575	1.5322	0.0189	**96.874**
HRT-6 avg	***DF2***	***36.4***	***0.408***	***10.195***	***31.438***	***0.325***	***0.05***	***4.5773***	***0.021***	***9.4016***	***2.076***	***1.544***	***0.027***	***96.464***

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
T0640 1	DF2	35.7897	0.2708	6.5835	31.407	0.0967	0	4.3305	0.0098	9.5395	1.6162	1.9345	0.0192	**91.598**
T0640 2	DF2	35.5893	0.2893	6.8496	29.9097	0	0	4.73	0.0225	10.5632	2.608	1.546	0.026	**92.134**
T0640 3	DF2	35.4397	0.1901	7.3455	31.2033	0.0731	0.0258	5.0765	0.0365	9.4854	1.8455	1.8045	0.0333	**92.559**
T0640 4	DF2	35.307	0.2466	6.57	31.2909	0.0921	0.0017	4.7347	0.028	9.5945	1.8235	1.7873	0.0179	**91.494**
T0640 5	DF2	35.0879	0.3254	7.5599	30.0966	0.1039	0.0412	4.638	0.0196	10.4439	2.5662	1.4901	0.0208	**92.394**
T0640 avg	***DF2***	***35.443***	***0.264***	***6.9817***	***30.782***	***0.073***	***0.014***	***4.7019***	***0.023***	***9.9253***	***2.092***	***1.712***	***0.023***	***92.036***
322915 1	DF3	35.3558	0.0917	6.5464	33.5479	0	0	6.7279	0	6.4235	0.8823	1.7565	0.0195	**91.352**
322915 2	DF3	35.0275	0.1106	6.5389	30.1298	0	0.0008	5.0789	0.0266	10.1479	2.9819	1.2635	0.0055	**91.312**
322915 3	DF3	34.8078	0.3388	6.6558	29.4147	0	0	5.02	0.0056	10.3519	2.9991	1.317	0.0165	**90.927**
322915 4	DF3	34.9671	0.3012	6.9277	29.1779	0	0.0137	5.0172	0.0154	10.6403	3.2799	1.1726	0.0191	**91.532**
322915 5	DF3	35.3984	0.0456	6.445	30.4039	0	0	5.4156	0.0154	9.8233	2.5182	1.4948	0.025	**91.585**
322915 6	DF3	35.2016	0.1092	6.3961	31.1204	0	0	5.5533	0.0405	8.8806	1.7322	1.7509	0.0234	**90.808**
322915 avg	***DF3***	***35.126***	***0.166***	***6.585***	***30.632***	***0***	***0.002***	***5.4688***	***0.017***	***9.3779***	***2.399***	***1.459***	***0.018***	***91.253***
322943 1	DF3	35.4799	0.0651	5.8845	31.3908	0	0.001	4.0213	0.0285	9.8287	1.6297	1.917	0.0234	**90.27**
322943 2	DF3	35.6056	0.06	6.8463	31.9631	0.0289	0	3.4996	0.0143	10.0722	1.6123	1.9924	0.0052	**91.7**
322943 3	DF3	35.3288	0.1057	5.8061	29.6251	0	0	4.4843	0.03	11.0313	3.2649	1.2606	0.0212	**90.958**
322943 4	DF3	34.5145	0.0631	6.1622	28.9621	0	0.0128	5.1012	0.0214	10.9241	3.6106	1.0313	0.0125	**90.416**
322943 5	DF3	34.7823	0.0611	6.4488	29.7402	0	0.0201	5.2217	0.0271	10.7117	3.4156	1.0525	0.0121	**91.493**
322943 avg	***DF3***	***35.142***	***0.071***	***6.2296***	***30.336***	***0.006***	***0.007***	***4.4656***	***0.024***	***10.514***	***2.707***	***1.451***	***0.015***	***90.967***
H0309B 1	DF3	35.4014	0.2824	5.6045	32.0506	0.1418	0.0488	6.2169	0	7.6241	1.3726	1.7339	0.0276	**90.505**
H0309B 2	DF3	35.2335	0.1595	6.7168	32.2998	0	0.0443	6.255	0	7.6428	1.4478	1.8309	0.0136	**91.644**
H0309B 3	DF3	34.9714	0.5105	6.6228	31.0496	0	0.0681	6.8508	0	7.7424	1.9587	1.6241	0.0157	**91.414**
H0309B 4	DF3	35.0688	0.5192	5.9565	31.702	0.0541	0.0342	6.222	0	7.7933	1.774	1.583	0.0149	**90.722**
H0309B 5	DF3	35.1542	0.292	6.3933	30.9882	0.0144	0.0696	6.6333	0	8.1927	1.9987	1.5554	0.0238	**91.316**
H0309B 6	DF3	34.9342	0.2494	6.3889	32.0611	0.1135	0.0433	6.3083	0	7.7488	1.5698	1.6527	0.0229	**91.093**
H0309B 7	DF3	35.219	0.2978	6.4332	30.714	0.0281	0.0552	6.4006	0.0028	8.5097	2.1046	1.5651	0.0182	**91.348**
H0309B avg	***DF3***	***35.14***	***0.33***	***6.3023***	***31.552***	***0.05***	***0.052***	***6.4124***	***4E-04***	***7.8934***	***1.747***	***1.649***	***0.02***	***91.149***
H0425 1	DF3	35.7711	0.271	5.5905	31.1387	0.4823	0.0094	5.5606	0	9.1478	1.5646	1.9835	0.0107	**91.53**
H0425 2	DF3	35.5333	0.4196	5.5413	30.4162	0.1512	0.0298	5.1442	0	9.7018	1.859	1.8953	0.0141	**90.706**
H0425 3	DF3	35.592	0.3734	5.8533	31.0593	0.3222	0.0256	6.0902	0	9.1897	1.8326	1.872	0.0068	**92.217**
H0425 4	DF3	35.3997	0.4249	5.6861	30.3672	0.4751	0.0434	6.1368	0	9.0395	1.802	1.8869	0.0162	**91.278**

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
H0425 5	DF3	35.4329	0.3891	5.5327	30.7378	0.5368	0.0334	5.5864	0	8.7754	1.7959	1.7055	0.0051	**90.531**
H0425 6	DF3	35.5916	0.2352	5.4651	30.8373	0.4214	0.0074	5.7573	0	9.0181	1.4809	2.0395	0.0392	**90.893**
H0425 avg	***DF3***	***35.512***	***0.312***	***5.4989***	***30.788***	***0.479***	***0.02***	***5.6719***	***0***	***8.8968***	***1.638***	***1.873***	***0.022***	***90.712***
H0432 1	DF3	35.3991	0.4709	6.7971	32.0478	0.0053	0.0476	5.953	0.0085	8.6026	1.8962	1.8167	0.0017	**93.047**
H0432 2	DF3	35.2141	0.607	6.3638	31.6599	0	0.0654	5.9609	0.0114	8.5487	1.9618	1.6353	0.0203	**92.049**
H0432 3	DF3	35.5483	0.4937	6.3771	31.5433	0	0.0476	5.7039	0	8.7852	1.9185	1.8375	0.013	**92.268**
H0432 avg	***DF3***	***35.387***	***0.524***	***6.5127***	***31.75***	***0.002***	***0.054***	***5.8726***	***0.007***	***8.6455***	***1.926***	***1.763***	***0.012***	***92.455***
HR-3 1	DF3	34.8376	0.4436	7.9534	32.9503	0.0207	0.0233	5.2069	0.014	8.3635	1.6042	1.7132	0.0409	**93.172**
HR-3 2	DF3	35.1748	0.1148	7.9957	32.4025	0.0122	0.0247	5.2793	0.0519	8.9758	1.9643	1.7011	0.0354	**93.733**
HR-3 3	DF3	35.5076	0.2179	7.7359	30.5538	0.0392	0.0019	4.3869	0.0492	10.3101	2.3368	1.5093	0.0213	**92.67**
HR-3 4	DF3	35.2572	0.1734	8.2834	31.9404	0.0015	0.0208	5.5145	0.0098	8.485	1.3999	1.8954	0.0362	**93.018**
HR-3 5	DF3	35.0787	0.7299	6.8121	31.7507	0.028	0.0184	5.8979	0	8.3814	1.6059	1.6349	0.0217	**91.96**
HR-3 6	DF3	34.9343	0.2856	7.7067	33.0919	0.0094	0.0334	4.8517	0.0351	8.2827	1.2815	1.8238	0.05	**92.386**
HR-3 avg	***DF3***	***35.132***	***0.328***	***7.7479***	***32.115***	***0.019***	***0.02***	***5.1895***	***0.027***	***8.7998***	***1.699***	***1.713***	***0.034***	***92.823***
HRT-1 1	DF3	35.5352	0.3528	7.7707	32.47	0	0.0009	6.0963	0.0237	8.2509	1.6989	1.7476	0.0164	**93.963**
HRT-1 2	DF3	35.9439	0.3207	7.9604	32.4144	0	0.0015	5.7998	0.0296	8.1258	1.7166	1.7551	0.0222	**94.09**
HRT-1 3	DF3	35.8669	0.4089	7.22	32.3469	0	0.0017	5.786	0.034	8.2027	1.5615	1.7487	0.0204	**93.198**
HRT-1 4	DF3	36.2269	0.4783	7.951	31.9827	0	0.0032	6.2347	0.0355	7.9591	1.6699	1.65	0.0244	**94.216**
HRT-1 5	DF3	35.5348	0.3429	7.6704	32.203	0	0.0037	6.1003	0.0148	7.9023	1.6991	1.6511	0.012	**93.135**
HRT-1 6	DF3	35.6475	0.4108	8.0712	31.7193	0	0.0017	6.0194	0.0207	7.9689	1.7969	1.7129	0.0199	**93.389**
HRT-1 avg	***DF3***	***35.793***	***0.386***	***7.774***	***32.189***	***0***	***0.002***	***6.0061***	***0.026***	***8.0683***	***1.69***	***1.711***	***0.019***	***93.665***
MO-3 1	DF3	35.2122	0.0409	6.3413	31.3657	0.0497	0.0118	5.0331	0.0747	9.3645	1.8994	1.771	0.0424	**91.207**
MO-3 2	DF3	35.482	0.0868	6.465	31.5407	0.4843	0.0014	4.1739	0.0352	9.8572	2.0967	1.7397	0.039	**92.002**
MO-3 3	DF3	35.2028	0.0204	6.4454	32.2284	0.0758	0.0061	5.2508	0.0492	8.6573	1.6209	1.7898	0.0274	**91.374**
MO-3 4	DF3	35.6074	0.2081	6.0502	33.2352	0.2295	0	4.672	0.1042	8.1231	1.1846	1.8789	0.0382	**91.332**
MO-3 5	DF3	35.5709	0.0899	6.2275	31.9292	0.1846	0.0058	4.8832	0.0423	9.0033	1.7238	1.734	0.0498	**91.444**
MO-3 6	DF3	35.2051	0.1459	6.2224	33.307	0.0599	0	5.0914	0.0733	8.3679	1.5467	1.8751	0.0313	**91.926**
MO-3 7	DF3	35.3822	0.5625	6.9971	32.789	0	0	5.2731	0.038	8.2929	1.3635	1.8151	0.0355	**92.549**
MO-3 8	DF3	35.0121	0.354	6.5892	32.6147	0	0	6.8464	0.1111	7.6079	1.6484	1.7301	0.0329	**92.547**
MO-3 avg	***DF3***	***35.334***	***0.189***	***6.4173***	***32.376***	***0.135***	***0.003***	***5.153***	***0.066***	***8.6593***	***1.636***	***1.792***	***0.037***	***91.798***

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
OZ-5 1	DF3	35.4918	0.0516	5.8471	32.0683	0.0456	0	4.6452	0.0112	8.5841	1.5002	1.7506	0.0187	90.015
OZ-5 2	DF3	35.5044	0.0396	5.9149	30.1259	0	0	4.3044	0.0126	10.6566	2.7321	1.4398	0.0119	90.742
OZ-5 3	DF3	35.2288	0.1612	6.2911	29.131	0.209	0.0301	5.0664	0	10.5886	3.1431	1.2715	0.0051	91.126
OZ-5 4	DF3	35.0823	0.0517	6.537	28.9758	0.0686	0	4.5193	0.014	11.2774	3.5953	1.0401	0.0148	91.176
OZ-5 avg	DF3	35.327	0.076	6.1475	30.075	0.081	0.008	4.6338	0.009	10.277	2.743	1.376	0.013	90.765
SUM-3 1	DF3	35.1664	0.2044	6.0581	31.5529	0.2595	0	6.3376	0.0071	8.3469	1.5614	1.826	0.0194	91.34
SUM-3 2	DF3	35.2774	0.5705	5.8528	30.7969	0.2654	0.0368	6.7414	0.0028	8.2151	1.5105	1.7695	0.0199	91.059
SUM-3 3	DF3	35.6436	0.1556	6.2587	31.8962	0.0561	0	6.4645	0.0014	8.2357	1.1265	1.8926	0.0148	91.746
SUM-3 4	DF3	35.4405	0.3748	5.9736	31.2189	0.1639	0.0143	6.484	0.0071	8.1161	1.3582	1.8426	0.0139	91.008
SUM-3 5	DF3	35.2495	0.2268	5.584	31.8969	0.0275	0.0142	5.7723	0.0256	8.2395	1.2462	1.8421	0.0178	90.142
SUM-3 6	DF3	33.2989	0.266	5.4215	29.9482	0	0.0412	11.5628	0.0439	7.0291	1.2665	1.6533	0.0228	90.554
SUM-3 7	DF3	35.5574	0.1659	5.8269	32.2421	0.0213	0	5.9607	0	8.2323	1.2707	1.9663	0.0143	91.258
SUM-3 8	DF3	35.1569	0.4795	5.1394	31.2535	0.0127	0.016	6.92	0.0171	8.2379	1.7322	1.7336	0.0216	90.721
SUM-3 avg	DF3	35.099	0.305	5.7644	31.351	0.101	0.015	7.0304	0.013	8.0816	1.384	1.816	0.018	90.978
T0643 1	DF3	35.328	0.3858	7.9324	33.1281	0.0292	0.0042	5.6442	0.0148	7.3499	1.2471	1.9737	0.0164	93.054
T0643 2	DF3	35.6892	0.6763	8.2137	31.5035	0.2447	0.0046	6.3527	0	7.5556	1.525	1.9114	0.0208	93.698
T0643 3	DF3	35.2609	0.6581	8.3907	30.7922	0.1009	0.0028	5.5893	0	8.1541	1.6216	1.9344	0.0217	92.527
T0643 4	DF3	36.2359	0.4328	8.1389	32.1001	0.1025	0.0039	5.682	0	7.448	1.3237	1.9934	0.0107	93.472
T0643 5	DF3	36.3689	0.3384	8.2917	32.5008	0.0938	0.0038	5.1544	0.0296	7.2256	1.1517	1.9754	0.0213	93.156
T0643 avg	DF3	35.777	0.498	8.1935	32.005	0.114	0.004	5.6845	0.009	7.5466	1.374	1.958	0.018	93.181
322807 1	E-DF3	36.9245	0.4304	9.8446	31.4649	0.3654	0.0639	6.4944	0.1211	7.5587	1.8428	1.6671	0.0523	96.83
322807 2	E-DF3	37.128	0.1446	9.532	32.8773	1.0425	0.0247	6.4348	0.1417	6.7838	1.0882	1.9995	0.0656	97.263
322807 3	E-DF3	36.6522	0.2501	10.8355	31.412	0.9094	0.0579	6.539	0.1373	6.8121	1.3803	1.8004	0.0558	96.842
322807 avg	E-DF3	36.902	0.275	10.071	31.918	0.772	0.049	6.4894	0.133	7.0515	1.437	1.822	0.058	96.978
322810 1	E-DF3	34.2932	0.23	7.0501	32.8948	0	0.0055	7.4404	0.1933	6.9155	1.2499	2.094	0.0593	92.426
322810 2	E-DF3	35.4401	0.1681	6.9131	31.6521	0.1013	0.0578	6.177	0.0983	8.3898	2.0204	1.7058	0.0255	92.749
322810 avg	E-DF3	34.867	0.199	6.9816	32.273	0.051	0.032	6.8087	0.146	7.6527	1.635	1.9	0.042	92.588
FW-5 1	E-DF3	36.7202	0.1371	9.6275	33.0685	0.5841	0.0546	5.9014	0.0723	7.2246	1.2499	1.8615	0.0532	96.555
FW-5 2	E-DF3	36.303	0.1446	10.4628	28.6217	5.2839	0.1016	5.4963	0.0603	7.699	2.061	1.6148	0.0468	97.896
FW-5 3	E-DF3	36.4365	0.1553	10.063	31.2693	1.8885	0.0194	6.1173	0.0973	7.5631	1.8411	1.6411	0.054	97.146
FW-5 4	E-DF3	38.7526	0.0643	10.2727	34.1563	0.1748	0.0699	5.9527	0.0945	6.7536	0.962	1.5763	0.0383	98.868

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
CO-1 1	Kg	33.4904	0.7235	6.9414	33.4595	0	0.0111	13.8656	0.3104	1.4082	0.3689	2.0541	0.0793	92.712
CO-1 2	Kg	33.4218	0.79	7.2396	33.3822	0	0.015	13.1623	0.3035	1.7743	0.3326	2.0738	0.0552	92.55
CO-1 3	Kg	32.5869	0.6802	6.7248	33.8183	0	0.0148	13.8516	0.3187	1.2185	0.3414	2.0869	0.0619	91.704
CO-1 4	Kg	34.5459	0.2638	6.088	34.9016	0	0.0074	12.6622	0.159	1.4509	0.1103	1.6425	0.0601	91.892
CO-1 5	Kg	32.2762	0.7339	6.7752	33.5238	0	0.0061	13.4918	0.298	1.4585	0.3591	2.078	0.0598	91.06
CO-1 6	Kg	33.3314	0.7594	6.5156	33.19	0	0	13.1769	0.2382	1.8824	0.4153	2.1414	0.0781	91.729
CO-1 avg	*Kg*	*33.275*	*0.658*	*6.7141*	*33.713*	*0*	*0.009*	*13.368*	*0.271*	*1.5321*	*0.321*	*2.013*	*0.066*	*91.941*
CO-2 1	Kg	36.242	0.3627	8.0701	33.6171	0	0	12.1851	0.2817	2.2782	0.1576	1.8017	0.0483	95.045
CO-2 2	Kg	36.0058	0.3402	7.9404	33.7693	0.0068	0	11.7884	0.2875	2.2481	0.166	1.8565	0.0465	94.456
CO-2 3	Kg	35.1037	1.1147	7.672	32.6267	0	0	11.8136	0.2669	2.618	0.4401	2.0498	0.081	93.787
CO-2 4	Kg	35.9835	0.8296	7.6466	32.8966	0	0	11.4209	0.2289	3.0385	0.4332	2.0861	0.0667	94.631
CO-2 avg	*Kg*	*35.834*	*0.662*	*7.8323*	*33.227*	*0.002*	*0*	*11.802*	*0.266*	*2.5457*	*0.299*	*1.949*	*0.061*	*94.479*
HV-3 1	Kg	35.4818	1.1659	7.3872	32.8176	0.0158	0.0027	9.2294	0.118	4.4085	0.7602	2.1207	0.0509	93.559
HV-3 2	Kg	34.5589	0.9538	7.8667	32.8312	0.0043	0.0018	8.6319	0.0648	5.026	0.5842	2.2204	0.0278	92.772
HV-3	*Kg*	*35.02*	*1.06*	*7.627*	*32.824*	*0.01*	*0.002*	*8.9307*	*0.091*	*4.7173*	*0.672*	*2.171*	*0.039*	*93.165*
AP-T1 1	Ka	37.4006	0.0972	10.216	32.8275	0.0329	0.0377	5.3892	0.1893	8.0748	0.6843	2.4735	0.0393	97.462
AP-T1 2	Ka	36.8995	0.1971	10.538	32.692	0.0929	0.0088	5.7636	0.1831	7.9063	0.7807	2.1865	0.0432	97.292
AP-T1 3	Ka	37.2368	0.121	9.7366	31.9287	0.0836	0.0256	5.7464	0.2039	8.3961	0.8779	2.2856	0.0414	96.684
AP-T1 4	Ka	37.7195	0.0972	9.9825	32.6006	0.0811	0.0362	4.7345	0.1656	8.4755	0.9546	2.2711	0.0428	97.161
AP-T1 5	Ka	37.2027	0.3131	9.7466	30.6075	0.1883	0.0091	3.8274	0.1718	10.1368	1.8146	1.9109	0.0384	95.967
AP-T1 6	Ka	36.971	0.3013	9.9123	31.46	0.0991	0	5.1648	0.1789	8.8064	1.3105	2.0139	0.0392	96.258
AP-T1	*Ka*	*37.238*	*0.188*	*10.022*	*32.019*	*0.096*	*0.02*	*5.1043*	*0.182*	*8.6327*	*1.07*	*2.19*	*0.041*	*96.804*
H0429 1	Ka	33.2973	0.83	7.2675	32.9916	0	0	13.0511	0.3938	2.3148	0.3785	2.3528	0.0758	92.953
H0429 2	Ka	33.3139	0.9056	7.9108	33.3841	0	0	13.2638	0.8968	0.9082	0.2628	2.2619	0.067	93.175
H0429 3	Ka	33.9621	0.8607	7.7493	33.2051	0	0.0006	13.0654	0.521	1.806	0.2543	2.3082	0.061	93.794
H0429 4	Ka	33.7391	0.7808	7.9872	32.9207	0	0	11.5074	0.3347	3.0814	0.3927	2.3484	0.0703	93.163
H0429 5	Ka	33.2185	0.8993	7.6138	32.887	0	0	13.1842	0.3092	2.2629	0.3337	2.3711	0.0706	93.15
H0429 6	Ka	33.9127	0.4816	7.3985	34.3796	0	0	12.7117	0.7093	1.1743	0.2466	2.2268	0.0588	93.3
H0429 7	Ka	33.4538	0.5265	7.0871	34.4877	0	0	12.6167	0.7321	1.1449	0.2152	2.2019	0.0606	92.527
H0429 avg	*Ka*	*33.557*	*0.755*	*7.5735*	*33.465*	*0*	*9E-05*	*12.771*	*0.557*	*1.8132*	*0.298*	*2.296*	*0.066*	*93.152*

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
MO-2 1	Ka	34.1681	1.0798	6.7343	31.6883	0	0.0183	10.2637	0.1944	5.0807	0.7773	2.2772	0.0732	92.355
MO-2 2	Ka	34.6754	0.9364	6.3183	32.2843	0	0	10.1968	0.1927	4.7361	0.5038	2.1041	0.0579	92.006
MO-2 3	Ka	34.0723	0.7774	6.3492	32.7724	0	0.0253	9.7846	0.1569	4.9596	0.653	2.2315	0.0619	91.844
MO-2 4	Ka	33.4448	0.8758	6.8024	32.322	0	0.0006	9.514	0.1359	5.3967	0.7769	2.262	0.0572	91.588
MO-2 avg	*Ka*	*34.09*	*0.917*	*6.5511*	*32.267*	*0*	*0.011*	*9.9398*	*0.17*	*5.0433*	*0.678*	*2.219*	*0.063*	*91.948*
MO-6 1	Ka	36.746	0.4007	7.4955	33.3329	0.0603	0	6.2719	0.1402	6.4567	0.6156	2.1388	0.0406	93.699
MO-6 2	Ka	37.6307	0.3898	8.1891	32.3544	0.195	0	6.0137	0.1653	6.9329	0.7012	2.2474	0.0609	94.88
MO-6 avg	*Ka*	*37.188*	*0.395*	*7.8423*	*32.844*	*0.128*	*0*	*6.1428*	*0.153*	*6.6948*	*0.658*	*2.193*	*0.051*	*94.29*
TC-2 1	Ka	35.0272	0.2169	7.5058	34.8736	0	0.0034	7.7153	0.0836	5.3754	0.4933	1.8174	0.0117	93.124
TC-2 2	Ka	35.5359	0	6.1176	33.252	0	0.0102	4.2707	0.0455	8.7409	1.0713	2.0376	0.0143	91.096
TC-2 3	Ka	34.798	0.1903	6.7256	35.8904	0	0.0144	7.6877	0.1672	3.7631	0.2467	1.5807	0.0113	91.075
TC-2 4	Ka	34.6827	0.2975	7.4875	35.5109	0	0.0117	8.3789	0.1474	3.8025	0.2534	1.7285	0.0229	92.324
TC-2 5	Ka	34.2871	0.3241	6.9839	35.5944	0.0063	0.0065	9.9924	0.157	2.5567	0.2574	1.4674	0.016	91.649
TC-2 avg	*Ka*	*34.866*	*0.206*	*6.9641*	*35.024*	*0.001*	*0.009*	*7.609*	*0.12*	*4.8477*	*0.464*	*1.726*	*0.015*	*91.854*
TH-1 1	Ka	34.954	0.2455	7.5742	31.6263	0.0477	0.0443	5.166	0.0199	8.8614	2.376	1.5573	0.0203	92.493
TH-1 2	Ka	35.3183	0.2038	7.9285	31.7574	0.0621	0.0459	5.0722	0.0185	8.8081	2.0949	1.6193	0.0285	92.958
TH-1 3	Ka	34.9822	0.3546	7.4779	28.2153	0.1854	0.0592	6.0217	0.0327	10.429	3.532	1.1124	0.025	92.428
TH-1 4	Ka	35.0948	0.2754	7.5231	30.924	0.0779	0.0383	5.2053	0.0484	9.0769	2.0852	1.6576	0.0381	92.045
TH-1 avg	*Ka*	*35.087*	*0.27*	*7.6259*	*30.631*	*0.093*	*0.047*	*5.3663*	*0.03*	*9.2939*	*2.522*	*1.487*	*0.028*	*92.481*
APMT-1 1	E-Ka	37.8163	0.2643	9.1064	32.0432	0.2633	0.0169	4.5211	0.2277	8.7229	1.0878	2.2123	0.0552	96.337
APMT-1 2	E-Ka	37.2412	0.1055	9.7323	33.9938	0.0016	0.0092	6.5353	0.2509	5.9934	0.5048	1.9197	0.0392	96.327
APMT-1 3	E-Ka	37.7708	0.0435	9.65	33.0584	0.7786	0.026	5.1765	0.1964	7.1898	0.401	2.0943	0.0331	96.419
APMT-1 4	E-Ka	36.4926	0.0707	8.6745	34.8478	0.0649	0.0325	6.1772	0.2935	5.9236	0.5196	2.1924	0.0335	95.323
APMT-1 5	E-Ka	37.494	0.0808	9.5837	32.9605	0.4978	0.0342	4.1149	0.1981	7.8947	0.8416	2.1984	0.0335	95.932
APMT-1 avg	*E-Ka*	*37.363*	*0.113*	*9.3494*	*33.381*	*0.321*	*0.024*	*5.305*	*0.233*	*7.1449*	*0.671*	*2.123*	*0.039*	*96.068*
322807B 1	Kqt	37.405	0.2313	9.2094	29.4078	0.019	0.0207	4.502	0.0548	10.7281	3.2225	1.1804	0.0339	96.015
322807B 2	Kqt	38.4057	0.1005	11.0193	33.3735	0.0308	0.0685	5.2496	0.0518	7.8686	1.0298	1.6601	0.0371	98.895
322807B 3	Kqt	36.8861	0.206	9.8021	29.9865	0.0318	0.0381	4.558	0.0415	10.4552	2.9594	1.2719	0.029	96.266
322807B 4	Kqt	36.9567	0.6901	9.5873	30.8619	0.035	0.075	5.8466	0.0621	8.7713	2.435	1.3785	0.0299	96.73
322807B 5	Kqt	37.0262	0.7369	9.1762	30.7071	0.0383	0.0696	5.7499	0.0326	8.8643	2.517	1.3874	0.0449	96.351
322807B avg	*Kqt*	*37.336*	*0.393*	*9.7589*	*30.867*	*0.031*	*0.054*	*5.1812*	*0.049*	*9.3375*	*2.433*	*1.376*	*0.035*	*96.851*

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
FW-3 1	Kqt	37.4891	0.3808	8.9261	32.7724	0	0.0426	5.678	0.0266	7.6464	1.5637	1.6369	0.0352	**96.198**
FW-3 2	Kqt	36.4687	0.5262	8.9847	32.5028	0.0108	0.0599	6.288	0.0369	7.5807	1.6361	1.5524	0.0211	**95.668**
FW-3 3	Kqt	36.7733	0.5383	8.4525	32.4916	0.0144	0.0456	5.7847	0.0044	7.7177	1.6274	1.5392	0.0277	**95.017**
FW-3 avg	***Kqt***	***36.91***	***0.482***	***8.7878***	***32.589***	***0.008***	***0.049***	***5.9169***	***0.023***	***7.6483***	***1.609***	***1.576***	***0.028***	**95.628**
HR-4 1	Kqt	35.4885	0.544	8.816	31.8947	0.0559	0.0034	5.3578	0.0267	8.2594	2.5652	1.3245	0.0204	**94.357**
HRT-3 1	Kqt	34.6108	0.3148	6.3259	33.3424	0	0.0002	10.0394	0.2324	4.1518	0.5738	1.8007	0.0368	**91.429**
HRT-3 2	Kqt	35.9454	0.3227	6.9694	31.1697	0.038	0.0017	5.6768	0	8.3897	1.5227	1.6443	0.0158	**91.696**
HRT-3 3	Kqt	38.7055	0.2476	7.5537	32.1126	0.0009	0.0391	6.1442	0.0385	8.0319	1.4297	1.6309	0.0311	**95.966**
HRT-3 avg	***Kqt***	***36.421***	***0.295***	***6.9497***	***32.208***	***0.013***	***0.014***	***7.2868***	***0.09***	***6.8578***	***1.175***	***1.692***	***0.028***	**93.03**
MO-7 core 1	Kqt	34.163	0.9233	6.2138	32.448	0	0	11.418	0.2443	3.7335	0.4795	2.1954	0.074	**91.893**
MO-7 core 2	Kqt	35.6042	0.8074	6.1362	31.7513	0	0	11.2354	0.2194	3.6205	0.4107	2.1515	0.0503	**91.987**
MO-7 core 3	Kqt	34.5735	0.8992	6.8677	32.594	0	0	11.3706	0.209	3.3711	0.4753	2.1002	0.065	**92.526**
MO-7 core avg	***Kqt***	***34.78***	***0.877***	***6.4059***	***32.264***	***0***	***0***	***11.341***	***0.224***	***3.575***	***0.455***	***2.149***	***0.063***	**92.135**
MO-7 rim 1	Kqt	36.4281	0.3063	5.8062	31.9782	1.3525	0	6.1641	0.173	6.6528	0.6393	2.2213	0.0528	**91.775**
MO-7 rim 2	Kqt	36.5969	0.3839	6.4771	30.9401	1.3198	0.0136	5.9349	0.1226	6.8499	0.7431	2.2168	0.0581	**91.657**
MO-7 rim 3	Kqt	36.0212	0.2461	6.5342	32.7059	1.2281	0	6.2053	0.1728	6.216	0.5669	2.1293	0.0621	**92.088**
MO-7 rim 4	Kqt	35.0368	0.4566	6.7793	31.4854	1.3489	0.0239	6.1487	0.1627	6.8234	0.7897	2.1566	0.0531	**91.265**
MO-7 rim avg	***Kqt***	***36.021***	***0.348***	***6.3992***	***31.777***	***1.312***	***0.009***	***6.1133***	***0.158***	***6.6355***	***0.685***	***2.181***	***0.057***	**91.696**
MO-7 bulk avg	***Kqt***	***35.489***	***0.575***	***6.4021***	***31.986***	***0.75***	***0.005***	***8.3539***	***0.186***	***5.3239***	***0.586***	***2.167***	***0.059***	**91.884**
OZ-2 1	Kqt	35.7359	0.2661	6.5472	29.5464	0.0194	0	4.794	0.0578	10.7693	3.1514	1.279	0.0372	**92.204**
OZ-2 2	Kqt	35.8156	0	6.2345	33.6587	0.2275	0	5.7157	0.0648	6.9716	0.6589	1.7923	0.0309	**91.171**
OZ-2 3	Kqt	35.5495	0.0898	5.7084	31.5534	0.0227	0.0065	4.6549	0.038	9.1901	1.9213	1.7207	0.0368	**90.492**
OZ-2 4	Kqt	35.7325	0.0715	6.3391	30.4513	0.4025	0	4.8059	0.0367	9.8414	2.0948	1.737	0.015	**91.528**
OZ-2 5	Kqt	35.1705	0.5133	6.6264	29.5171	0	0	6.407	0.0028	9.5233	2.3356	1.537	0.0171	**91.65**
OZ-2 avg	***Kqt***	***35.601***	***0.188***	***6.2911***	***30.945***	***0.134***	***0.001***	***5.2755***	***0.04***	***9.2591***	***2.032***	***1.613***	***0.027***	**91.409**
OZ-3 1	Kqt	36.2533	0.0531	7.0851	31.1823	0.0023	0.0005	3.7029	0	9.5312	2.5057	1.5482	0.0116	**91.876**
OZ-3 2	Kqt	36.005	0.0561	8.525	31.6496	0.2256	0.0018	4.4946	0.0059	8.5682	1.4995	2.083	0.0049	**93.119**
OZ-3 avg	***Kqt***	***36.129***	***0.055***	***7.8051***	***31.416***	***0.114***	***0.001***	***4.0988***	***0.003***	***9.0497***	***2.003***	***1.816***	***0.008***	**92.498**
SUM-1 1	Kqt	34.8499	0.395	6.1222	31.9195	0	0	6.9538	0.0043	7.8905	1.4915	1.7666	0.0078	**91.401**
SUM-1 2	Kqt	34.8927	0.5584	6.4331	31.3023	0	0.0375	6.7414	0	7.7467	1.5042	1.6853	0.0242	**90.926**
SUM-1 avg	***Kqt***	***34.871***	***0.477***	***6.2777***	***31.611***	***0***	***0.019***	***6.8476***	***0.002***	***7.8186***	***1.498***	***1.726***	***0.016***	**91.164**

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	Na2O	K2O	TOTAL
T0642 1	Kqt	35.6538	0.0558	7.4968	35.2565	0	0	4.0525	0.0236	7.5461	0.8363	1.9036	0	**92.825**
T0642 2	Kqt	35.7427	0.19	7.6308	34.0055	0	0	4.2793	0.0265	8.0244	1.1819	2.0539	0	**93.135**
T0642 3	Kqt	36.0196	0.0956	7.3488	34.4189	0	0	4.2062	0.0044	8.0035	1.0473	2.065	0.0115	**93.221**
T0642 4	Kqt	36.3482	0.2542	7.8215	33.4901	0	0	4.9137	0.0133	8.0624	1.1614	1.9758	0.0137	**94.054**
T0642 5	Kqt	36.9171	0.2264	7.4247	33.1199	0	0	4.6932	0.0206	8.3815	1.1926	2.1384	0.0274	**94.142**
T0642 6	Kqt	36.1935	0.098	7.3092	34.7045	0	0	4.4519	0.0118	7.8319	1.114	1.9483	0.0129	**93.676**
T0642 avg	***Kqt***	***36.146***	***0.153***	***7.5053***	***34.166***	***0***	***0***	***4.4328***	***0.017***	***7.975***	***1.089***	***2.014***	***0.011***	***93.509***

Part 2

The results from Part 2 were gathered on 13 and 14 April, 2007.

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	FeO	MgO	CaO	Na2O	K2O	F	Total
776T-4 1	DF1	34.8792	0.0311	9.8	30.9922	4.5853	9.5151	1.9463	1.858	0.0072	0.6588	93.9959
776T-4 2	DF1	35.1891	0.0368	9.8	31.0441	4.603	9.1112	1.6199	2.0721	0.0108	0.5768	93.821
776T-4 3	DF1	35.4213	0.0142	9.8	29.8922	4.6344	9.6216	1.9853	1.8989	0.0078	0.5897	93.6172
776T-4 avg	***DF1***	***35.1632***	***0.02737***	***9.8***	***30.6428***	***4.60757***	***9.41597***	***1.8505***	***1.943***	***0.0086***	***0.60843***	***93.8114***
MO-5 1	DF1	36.3574	0.0613	9.8	33.7307	3.3155	9.064	0.7739	1.938	0	0	95.0409
MO-5 2	DF1	35.4865	0.1695	9.8	33.0523	3.245	9.16	1.3736	1.9025	0	0	94.1894
MO-5 3	DF1	35.3251	0.187	9.8	33.5037	3.3646	8.9787	1.4363	1.9199	0	0	94.5154
MO-5 4	DF1	35.1607	0.1111	9.8	33.4263	3.2165	9.1963	1.3539	2.0844	0	0	94.3493
MO-5 avg	***DF1***	***35.5824***	***0.13223***	***9.8***	***33.4283***	***3.2854***	***9.09975***	***1.23443***	***1.9612***	***0***	***0***	***94.5238***
322807A 1	DF2	35.7745	0.1577	9.8	31.6007	5.0619	9.0492	1.8752	1.7675	0	0.213	95.2101
322807A 2	DF2	35.1095	0.2689	9.8	30.9575	4.9662	9.5952	2.5191	1.4424	0	0.3842	94.8813
322807A 3	DF2	35.503	0.2808	9.8	30.3224	4.83	10.3957	2.78	1.3327	0	0.5885	95.5854
322807A 4	DF2	35.7941	0.3016	9.8	29.4932	4.3726	11.0448	3.1651	1.2121	0.0049	0.7188	95.6046
322807A avg	***DF2***	***35.5453***	***0.25225***	***9.8***	***30.5935***	***4.80768***	***10.0212***	***2.58485***	***1.43868***	***0.00123***	***0.47613***	***95.3204***
FW-2 1	DF2	35.2886	0.1545	9.8	30.2104	4.9256	9.5917	2.3335	1.627	0.0098	0.7759	94.3904
FW-2 2	DF2	35.3559	0.2099	9.8	30.1007	5.26	10.1966	2.7952	1.365	0.0068	0.9737	95.6538
FW-2 avg	***DF2***	***35.3223***	***0.1822***	***9.8***	***30.1556***	***5.0928***	***9.89415***	***2.56435***	***1.496***	***0.0083***	***0.8748***	***95.0221***

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	FeO	MgO	CaO	Na2O	K2O	F	Total
HR-1 1	DF2	35.5424	0.5684	9.8	31.3443	4.8793	8.7775	1.4123	2.0748	0	0	94.3991
HR-1 2	DF2	35.7266	0.2716	9.8	32.0126	4.5485	8.584	1.4052	1.9871	0.0009	0	94.3366
HR-1 3	DF2	35.3048	0.099	9.8	31.007	4.8938	8.379	1.5009	1.9132	0	0.0009	92.8983
HR-1 4	DF2	35.1045	0.147	9.8	30.8858	5.086	7.9982	1.6771	1.7261	0	0.0087	92.4298
HR-1 avg	***DF2***	***35.4196***	***0.2715***	***9.8***	***31.3124***	***4.8519***	***8.43468***	***1.49888***	***1.9253***	***0.00023***	***0.0024***	***93.516***
HRT-6 1	DF2	35.5499	0.1446	9.8	29.0917	4.1941	10.2813	2.4156	1.6037	0.0006	0.4234	93.3267
HRT-6 2	DF2	36.0882	0.1134	9.8	30.4219	4.2719	10.3732	2.4812	1.4552	0.0069	0.4762	95.2877
HRT-6 3	DF2	35.9904	0.2269	9.8	28.7614	4.3106	10.394	2.5495	1.5298	0	0.4447	93.8202
HRT-6 4	DF2	35.6636	0.1929	9.8	28.4839	4.0205	10.3654	2.3916	1.4809	0.0039	0.5684	92.7318
HRT-6 avg	***DF2***	***35.823***	***0.16945***	***9.8***	***29.1897***	***4.19928***	***10.3535***	***2.45948***	***1.5174***	***0.00285***	***0.47818***	***93.7916***
T0640 1	DF2	35.6485	0.2635	9.8	31.4169	4.6256	9.6417	1.7475	2.0473	0	0.3626	95.401
T0640 2	DF2	35.6134	0.3118	9.8	31.0749	4.4616	9.8744	1.9413	1.9664	0.0011	0.4753	95.3202
T0640 3	DF2	36.0206	0.2382	9.8	31.7244	4.2854	9.7789	1.8097	1.9271	0	0.4696	95.8563
T0640 4	DF2	36.0468	0.2778	9.8	31.3391	4.4659	10.0133	1.9442	1.9357	0	0.5303	96.1299
T0640 avg	***DF2***	***35.8323***	***0.27283***	***9.8***	***31.3888***	***4.45963***	***9.82708***	***1.86068***	***1.96913***	***0.00028***	***0.45945***	***95.6769***
322915 1	DF3	35.0947	0.1439	9.8	32.2676	6.9496	7.453	1.8017	1.7002	0.0005	0.8052	95.6775
322915 2	DF3	34.6929	0.0734	9.8	31.5842	6.4859	8.03	1.965	1.7972	0.015	0.6972	94.8472
322915 3	DF3	35.2912	0.2594	9.8	31.6078	7.0761	7.5795	2.0353	1.6536	0.0098	0.7793	95.764
322915 avg	***DF3***	***35.0263***	***0.1589***	***9.8***	***31.8199***	***6.8372***	***7.6875***	***1.934***	***1.717***	***0.00843***	***0.76057***	***95.4296***
322943 core 1	DF3	35.7725	0	9.8	31.9707	2.4192	11.3388	2.9412	1.3787	0.0026	0.627	95.9868
322943 core 2	DF3	36.1571	0.0376	9.8	32.2065	3.4097	9.696	1.3544	1.9411	0.0034	0.3537	94.8107
322943 core 3	DF3	36.2894	0	9.8	32.7358	3.7306	9.3768	1.1969	1.9935	0	0.2709	95.2799
322943 core avg	***DF3***	***36.073***	***0.01253***	***9.8***	***32.3043***	***3.1865***	***10.1372***	***1.83083***	***1.7711***	***0.002***	***0.4172***	***95.3591***
322943 rim 1	DF3	35.53	0	9.8	30.244	4.2121	11.1209	3.4153	1.1482	0	0.5909	95.8127
322943 rim 2	DF3	35.5414	0.0695	9.8	29.0685	5.0752	11.3096	3.7954	0.9189	0	0.6925	95.9795
322943 rim 3	DF3	35.2909	0.0376	9.8	30.2587	5.2082	10.614	3.4608	1.0477	0.0042	0.5293	96.0286
322943 rim avg	***DF3***	***35.4541***	***0.0357***	***9.8***	***29.8571***	***4.83183***	***11.0148***	***3.55717***	***1.03827***	***0.0014***	***0.60423***	***95.9403***
322943 avg		***35.7636***	***0.02412***	***9.8***	***31.0807***	***4.00917***	***10.576***	***2.694***	***1.40468***	***0.0017***	***0.51072***	***95.6497***
H0309B 1	DF3	35.2575	0.1272	9.8	32.0675	5.8809	7.8609	1.654	1.7768	0	0.0295	94.442
H0309B 2	DF3	34.8164	0.4461	9.8	31.2908	6.1909	7.7325	1.745	1.6757	0	0.0019	93.6986
H0309B avg	***DF3***	***35.037***	***0.28665***	***9.8***	***31.6792***	***6.0359***	***7.7967***	***1.6995***	***1.72625***	***0***	***0.0157***	***94.0703***

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	FeO	MgO	CaO	Na2O	K2O	F	Total
H0425 5	DF3	35.7197	0.2797	9.8	30.6195	5.1296	9.6949	1.6584	1.9857	0	0.2292	95.0203
H0425 6	DF3	36.8985	0.1983	9.8	30.5847	4.9195	9.5758	1.6632	2.0269	0	0.2838	95.8313
H0425 7	DF3	35.3727	0.23	9.8	30.8653	5.5235	9.1497	1.5133	2.0911	0	0.2336	94.6809
H0425 avg	***DF3***	***35.997***	***0.236***	***9.8***	***30.6898***	***5.19087***	***9.47347***	***1.61163***	***2.03457***	***0***	***0.24887***	***95.1775***
H0432 1	DF3	35.568	0.6796	9.8	31.0148	5.6506	8.6464	1.9164	1.7446	0	0.2381	95.1582
H0432 2	DF3	35.4605	0.6183	9.8	30.8138	5.5142	9.27	2.1803	1.6939	0	0.4555	95.6148
H0432 3	DF3	33.7238	0.498	9.8	32.2364	5.9944	8.1339	1.911	1.7551	0	0.1588	94.1446
H0432 4	DF3	35.7283	0.5043	9.8	31.7946	5.6925	8.4604	1.8404	1.8096	0	0.3049	95.8067
H0432 avg	***DF3***	***35.1202***	***0.57505***	***9.8***	***31.4649***	***5.71293***	***8.62768***	***1.96203***	***1.7508***	***0***	***0.28933***	***95.1811***
HR-3 1	DF3	35.3577	0.3268	9.8	32.0897	5.2213	8.2329	1.378	1.9356	0.0017	0.0801	94.3902
HR-3 2	DF3	35.1028	0.3241	9.8	32.6345	4.6341	8.5314	1.2441	2.0166	0	0	94.2877
HR-3 3	DF3	35.3851	0.3855	9.8	32.2821	4.6524	8.635	1.4012	1.9691	0	0.1446	94.5942
HR-3 4	DF3	35.5414	0.3064	9.8	32.6841	4.7432	8.3959	1.1316	1.9455	0	0.0232	94.5616
HR-3 avg	***DF3***	***35.3468***	***0.3357***	***9.8***	***32.4226***	***4.81275***	***8.4488***	***1.28873***	***1.9667***	***0.00043***	***0.06198***	***94.4584***
HRT-1 1	DF3	35.0656	0.4323	9.8	32.2322	6.1829	8.586	1.6526	1.5652	0.0007	0.0778	95.5626
HRT-1 2	DF3	34.5534	0.3057	9.8	32.2992	5.7612	8.6982	1.5982	1.602	0	0.1401	94.6991
HRT-1 3	DF3	34.4458	0.3054	9.8	33.0259	6.0132	7.5112	1.4544	1.3423	0.2318	1.1711	94.8081
HRT-1 5	DF3	35.2187	0.5012	9.8	32.4462	6.3272	8.3747	1.7347	1.5904	0.0046	0	95.9978
HRT-1 6	DF3	35.6864	0.4033	9.8	32.5794	6.3721	8.3973	1.7228	1.6228	0	0	96.5842
HRT-1 avg	***DF3***	***34.994***	***0.38958***	***9.8***	***32.5166***	***6.13132***	***8.31348***	***1.63254***	***1.54454***	***0.04742***	***0.2778***	***95.5304***
MO-3 1	DF3	35.9232	0.2913	9.8	32.8411	4.794	8.9243	1.5528	1.8185	0.0004	0.561	96.2705
MO-3 2	DF3	35.075	0.2839	9.8	34.2285	7.1703	6.3465	1.0999	1.7898	0.0227	0.4713	96.0896
MO-3 3	DF3	35.6479	0.0668	9.8	32.8501	5.6672	8.3026	1.3166	1.7957	0.0059	0.8923	95.9695
MO-3 4	DF3	35.2624	0.3114	9.8	31.1852	5.3519	9.4416	2.1861	1.6213	0.0104	0.6781	95.563
MO-3 avg	***DF3***	***35.4771***	***0.23835***	***9.8***	***32.7762***	***5.74585***	***8.25375***	***1.53885***	***1.75633***	***0.00985***	***0.65068***	***95.9732***
OZ-5 1	DF3	35.3609	0.1274	9.8	29.6352	4.8922	10.5691	3.0692	1.2491	0	0.228	94.8352
OZ-5 2	DF3	35.5978	0.055	9.8	30.2207	4.247	10.7951	2.4478	1.6449	0.0033	0.4383	95.0655
OZ-5 3	DF3	35.7862	0.0058	9.8	31.7652	4.6166	9.0703	1.7193	1.7116	0.0018	0.5511	94.796
OZ-5 4	DF3	35.8175	0.0203	9.8	29.6939	4.6065	10.6564	2.7334	1.4541	0.0077	0.8377	95.2749
OZ-5 avg	***DF3***	***35.6406***	***0.05213***	***9.8***	***30.3288***	***4.59058***	***10.2727***	***2.49243***	***1.51493***	***0.0032***	***0.51378***	***94.9929***

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	FeO	MgO	CaO	Na2O	K2O	F	Total
322807 1	E-DF3	34.126	0.1696	9.8	33.268	6.9585	7.2427	1.1435	1.9706	0.0177	0.6931	95.098
322807 2	E-DF3	34.5327	0.1898	9.8	32.4925	6.7632	6.8708	1.3313	1.8786	0.0431	0.6372	94.271
322807 3	E-DF3	35.1962	0.0316	9.8	34.965	7.1887	5.298	0.3348	1.6308	0.0093	0.1064	94.5161
322807 4	E-DF3	34.8774	0.1957	9.8	31.8768	6.4952	6.4944	1.1181	1.8159	0.0167	0.5127	92.9871
322807 avg	***E-DF3***	***34.6831***	***0.14668***	***9.8***	***33.1506***	***6.8514***	***6.47648***	***0.98193***	***1.82398***	***0.0217***	***0.48735***	***94.2181***
322810 1	E-DF3	34.0923	0.0493	9.8	33.0276	7.2798	5.9296	0.7228	1.833	0.0087	0.4408	92.9984
322810 2	E-DF3	32.8692	0.2468	9.8	30.1234	6.7264	8.0962	2.0968	1.6752	0.015	0.8292	92.1292
322810 3	E-DF3	34.84	0.0551	9.8	33.6748	6.8976	5.9643	0.5398	1.9205	0.0031	0.2992	93.8685
322810 4	E-DF3	34.9815	0.1277	9.8	32.374	6.8074	7.3657	1.4295	2.0066	0.0166	0.6492	95.285
322810 avg	***E-DF3***	***34.1958***	***0.11973***	***9.8***	***32.3***	***6.9278***	***6.83895***	***1.19723***	***1.85883***	***0.01085***	***0.5546***	***93.5703***
FW-5 1	E-DF3	35.469	0.0679	9.8	31.9743	5.6016	7.5562	1.285	1.9137	0.0142	0.439	93.9362
FW-5 2	E-DF3	35.1189	0.1076	9.8	30.3871	5.6529	8.1953	1.8415	1.719	0.0123	0.5093	93.1296
FW-5 3	E-DF3	34.3856	0.2693	9.8	27.8907	5.3374	8.9462	2.8715	1.2931	0.0021	0.6366	91.1646
FW-5 4	E-DF3	34.9569	0.0932	9.8	31.9749	6.0069	7.2765	1.1255	2.017	0.0218	0.4956	93.5597
FW-5 avg	***E-DF3***	***34.9826***	***0.1345***	***9.8***	***30.5568***	***5.6497***	***7.99355***	***1.78088***	***1.7357***	***0.0126***	***0.52013***	***92.9475***
CO-1 1	Kg	33.897	0.7177	9.8	33.2127	13.2285	1.8334	0.3772	2.004	0.0455	0.3764	95.334
CO-1 2	Kg	33.5732	0.7063	9.8	33.6449	13.0736	1.5554	0.2772	1.9461	0.039	0.379	94.8352
CO-1 3	Kg	33.5242	0.6385	9.8	33.7529	12.96	1.5997	0.3776	1.9556	0.0412	0.4185	94.8921
CO-1 5	Kg	34.3102	0.216	9.8	34.2731	12.1649	1.4243	0.0861	1.6329	0.0347	0.1256	94.015
CO-1 avg	***Kg***	***33.8262***	***0.56963***	***9.8***	***33.7209***	***12.8568***	***1.6032***	***0.27953***	***1.88465***	***0.0401***	***0.32488***	***94.7691***
AP-T1 2	Ka	35.8454	0.3167	9.8	31.488	6.1659	8.449	1.0615	2.1625	0.0024	0.4329	95.5421
AP-T1 3	Ka	36.0072	0.1017	9.8	33.3112	5.7178	7.6035	0.5862	2.3551	0.0031	0.3897	95.7115
AP-T1 4	Ka	35.8073	0.1453	9.8	32.172	5.7475	8.4223	0.7738	2.4127	0.0081	0.4436	95.5459
AP-T1 avg	***Ka***	***35.8866***	***0.1879***	***9.8***	***32.3237***	***5.87707***	***8.15827***	***0.80717***	***2.3101***	***0.00453***	***0.42207***	***95.5998***
H0429 1	Ka	33.7515	0.7556	9.8	32.7336	13.5272	2.394	0.3426	2.4448	0.0472	0.4293	96.0451
H0429 2	Ka	33.8376	0.7838	9.8	32.6898	13.2123	2.4832	0.3338	2.3947	0.054	0.4148	95.8294
H0429 3	Ka	34.1348	0.8215	9.8	30.8219	12.1731	3.3541	0.4504	2.3144	0.0523	0.4511	94.1838
H0429 4	Ka	34.3429	0.992	9.8	31.7479	13.3206	2.0931	0.3698	2.3668	0.0554	0.4787	95.3657
H0429 avg	***Ka***	***34.0167***	***0.83823***	***9.8***	***31.9983***	***13.0583***	***2.5811***	***0.37415***	***2.38018***	***0.05223***	***0.44348***	***95.356***

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	FeO	MgO	CaO	Na2O	K2O	F	Total
MO-2 1	Ka	34.7631	0.8238	9.8	31.9271	9.2016	5.1571	0.7412	2.2106	0.0485	0.4741	94.9476
MO-2 2	Ka	34.5799	1.2644	9.8	31.5095	9.7623	5.014	0.7339	2.2146	0.0552	0.4627	95.2018
MO-2 3	Ka	35.0773	0.9094	9.8	32.3501	9.0434	5.1478	0.7148	2.1384	0.231	0.5168	95.7115
MO-2 avg	***Ka***	***34.8068***	***0.9992***	***9.8***	***31.9289***	***9.33577***	***5.1063***	***0.72997***	***2.18787***	***0.11157***	***0.48453***	***95.287***
MO-6 1	Ka	35.2926	0.4147	9.8	33.4439	6.1612	7.2245	0.9504	2.3289	0.0184	0.8237	96.1116
MO-6 2	Ka	35.281	0.2934	9.8	33.1386	6.3825	7.5197	1.0513	2.2878	0.0287	0.7491	96.2168
MO-6 3	Ka	35.2195	0.406	9.8	33.4389	6.458	7.26	0.8025	2.428	0.0265	0.7128	96.2522
MO-6 4	Ka	35.6159	0.4518	9.8	32.8019	6.1581	7.4735	0.7647	2.4618	0.0246	0.7335	95.9771
MO-6 avg	***Ka***	***35.3523***	***0.39148***	***9.8***	***33.2058***	***6.28995***	***7.36943***	***0.89223***	***2.37663***	***0.02455***	***0.75478***	***96.1394***
TC-2 1	Ka	33.9275	0.2496	9.8	35.3537	8.7351	3.1967	2.3289	1.5334	0.0015	0.1097	95.19
TC-2 2	Ka	35.4497	0.1544	9.8	36.8661	9.2873	2.9211	0.1652	1.3212	0	0.0266	95.9805
TC-2 3	Ka	34.2448	0.2513	9.8	33.2512	9.8164	3.514	0.2588	2.3408	0.0365	0.5102	93.8093
TC-2 4	Ka	34.5801	0.2514	9.8	33.2956	9.5055	3.3475	0.2067	2.2559	0.0273	0.454	93.5329
TC-2 avg	***Ka***	***34.5505***	***0.22668***	***9.8***	***34.6917***	***9.33608***	***3.24483***	***0.7399***	***1.86283***	***0.01633***	***0.27513***	***94.6282***
TH-1 1	Ka	34.0615	0.385	9.8	33.3464	5.7252	7.9323	1.799	1.778	0.0027	0	94.8302
TH-1 2	Ka	33.9645	0.2014	9.8	32.5554	5.0246	8.7253	1.924	1.7999	0	0.3704	94.2096
TH-1 3	Ka	35.3271	0.1719	9.8	32.5212	5.9531	8.177	1.4156	1.8184	0.0059	0.3963	95.4197
TH-1 avg	***Ka***	***34.451***	***0.25277***	***9.8***	***32.8077***	***5.56763***	***8.2782***	***1.71287***	***1.79877***	***0.00287***	***0.25557***	***94.8198***
APMT-1 2	E-Ka	35.6789	0.0706	9.8	34.1886	5.5905	7.1535	0.6515	2.3692	0.0008	0.4493	95.7638
APMT-1 3	E-Ka	35.8352	0.1384	9.8	33.028	5.522	8.0456	0.9498	2.3294	0.0044	0.4577	95.9179
APMT-1 4	E-Ka	35.4932	0.153	9.8	31.8068	4.5275	9.2076	1.6575	2.0935	0	0.7251	95.159
APMT-1 avg	***E-Ka***	***35.6691***	***0.12067***	***9.8***	***33.0078***	***5.21333***	***8.13557***	***1.08627***	***2.26403***	***0.00173***	***0.54403***	***95.6136***
322807B 1	Kqt	35.772	0.1736	9.8	29.695	4.7781	10.8342	3.0907	1.3115	0.005	1.0192	96.0502
322807B 2	Kqt	35.7214	0.1534	9.8	29.6308	4.465	10.9246	2.9711	1.3513	0.0031	0.8641	95.5211
322807B 3	Kqt	35.6863	0.1765	9.8	29.0638	4.7313	10.8841	3.2391	1.2507	0	0.9334	95.3723
322807B 4	Kqt	35.1455	0.3781	9.8	30.2013	5.7996	9.5431	2.831	1.3685	0.008	0.8501	95.5674
322807B avg	***Kqt***	***35.5813***	***0.2204***	***9.8***	***29.6477***	***4.9435***	***10.5465***	***3.03298***	***1.3205***	***0.00403***	***0.9167***	***95.6278***
FW-3 1	Kqt	35.0211	0.1696	9.8	32.7932	5.6625	8.0648	1.3143	1.881	0	0	94.7066
FW-3 2	Kqt	35.5608	0.116	9.8	32.7994	5.521	8.0798	1.0769	1.7713	0	0	94.7253
FW-3 3	Kqt	35.1207	0.2603	9.8	32.8443	5.926	7.9476	1.5132	1.6995	0	0	95.1117
FW-3 4	Kqt	35.072	0.3308	9.8	32.6996	6.1142	7.9975	1.8182	1.6511	0.0061	0	95.4896
FW-3 avg	***Kqt***	***35.1937***	***0.21918***	***9.8***	***32.7841***	***5.80593***	***8.02243***	***1.43065***	***1.75073***	***0.00153***	***0***	***95.0083***

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	FeO	MgO	CaO	Na2O	K2O	F	Total
HR-4 1	Kqt	35.3726	0.4389	9.8	30.6145	5.4404	9.3549	2.7022	1.3596	0.0033	0.4932	95.372
HR-4 2	Kqt	35.3736	0.4619	9.8	30.5095	5.7479	9.3139	2.8099	1.2882	0	0.4578	95.57
HR-4 3	Kqt	34.7358	0.8332	9.8	29.8729	6.001	8.7452	2.5357	1.3425	0	0.4067	94.1019
HR-4 4	Kqt	35.7931	0.263	9.8	31.0824	5.0956	9.6793	1.9514	1.8884	0.0017	0.4928	95.8403
HR-4 avg	***Kqt***	***35.3188***	***0.49925***	***9.8***	***30.5198***	***5.57123***	***9.27333***	***2.4998***	***1.46968***	***0.00125***	***0.46263***	***95.2211***
HRT-3 1	Kqt	35.2892	0.1427	9.8	33.0211	5.3197	8.5252	1.3191	1.8258	0.0007	0.0092	95.2489
HRT-3 2	Kqt	34.8276	0.2855	9.8	31.8817	5.5941	8.6431	1.6418	1.71	0	0.3623	94.5937
HRT-3 3	Kqt	35.0365	0.3955	9.8	31.3095	6.3373	8.2557	1.616	1.7065	0	0	94.4571
HRT-3 4	Kqt	34.9209	0.4883	9.8	31.6372	6.7283	8.325	1.7517	1.5924	0	0	95.2439
HRT-3 avg	***Kqt***	***35.0186***	***0.328***	***9.8***	***31.9624***	***5.99485***	***8.43725***	***1.58215***	***1.70868***	***0.00018***	***0.09288***	***94.8859***
MO-7 core 2	Kqt	34.927	0.851	9.8	32.4669	10.9833	3.5604	0.4398	2.2954	0.0383	0.5011	95.6523
MO-7 core 3	Kqt	35.0519	0.2121	9.8	34.0755	11.1765	2.9113	0.1709	1.9159	0.0328	0.2193	95.474
MO-7 core avg	***Kqt***	***34.9895***	***0.53155***	***9.8***	***33.2712***	***11.0799***	***3.23585***	***0.30535***	***2.10565***	***0.03555***	***0.3602***	***95.5632***
MO-7 rim 1	Kqt	35.4988	0.4143	9.8	31.9839	6.1867	6.86	0.6717	2.3137	0.0334	0.4708	94.0352
MO-7 rim 2	Kqt	35.1699	0.585	9.8	31.7932	7.2755	6.5168	0.7937	2.3671	0.0357	0.4676	94.6077
MO-7 rim 3	Kqt	35.1804	0.5536	9.8	33.2526	7.6249	6.2248	0.5448	2.2703	0.0358	0.4872	95.7694
MO-7 rim 4	Kqt	35.3338	0.4821	9.8	31.3389	5.9963	7.0956	0.7714	2.3302	0.0338	0.48	93.4601
MO-7 rim avg	***Kqt***	***35.2957***	***0.50875***	***9.8***	***32.0922***	***6.77085***	***6.6743***	***0.6954***	***2.32033***	***0.03468***	***0.4764***	***94.4681***
MO-7 avg	***Kqt***	***35.1809***	***0.5173***	***9.8***	***32.5343***	***8.38674***	***5.38488***	***0.54913***	***2.23982***	***0.035***	***0.43283***	***94.8787***
OZ-2 1	Kqt	34.9507	0.3085	9.8	30.4641	5.6384	9.0894	1.5555	1.9995	0	0	93.8062
OZ-2 2	Kqt	35.5576	0.9698	9.8	28.951	6.7662	9.8012	1.979	1.7983	0	0.265	95.7766
OZ-2 3	Kqt	35.5408	0.2573	9.8	30.2169	4.8466	10.4847	2.5082	1.5131	0	0.3178	95.3517
OZ-2 avg	***Kqt***	***35.3497***	***0.51187***	***9.8***	***29.8773***	***5.7504***	***9.79177***	***2.01423***	***1.7703***	***0***	***0.19427***	***94.9782***
OZ-3 1	Kqt	35.9161	0.0348	9.8	30.5872	4.0066	11.3756	2.8573	1.3954	0	0.7098	96.384
OZ-3 2	Kqt	36.308	0.0377	9.8	31.0714	4.0733	10.8307	2.6348	1.584	0.002	0.6959	96.7449
OZ-3 3	Kqt	35.8876	0.1129	9.8	29.8522	4.8931	11.0626	3.5371	1.033	0	0.6128	96.5333
OZ-3 4	Kqt	35.2063	0.2345	9.8	30.3401	4.8101	10.2585	3.1268	1.2226	0	0.3777	95.2177
OZ-3 avg	***Kqt***	***35.8295***	***0.10498***	***9.8***	***30.4627***	***4.44578***	***10.8819***	***3.039***	***1.30875***	***0.0005***	***0.59905***	***96.22***
SUM-1 1	Kqt	35.0743	0.4042	9.8	31.5707	6.8799	8.0701	1.4887	1.8023	0	0.0849	95.1395
SUM-1 2	Kqt	35.2235	0.5779	9.8	31.3488	7.1947	7.8426	1.4449	1.7749	0	0	95.2074

Sample	Lithology	SiO2	TiO2	B2O3	Al2O3	FeO	MgO	CaO	Na2O	K2O	F	Total
SUM-1 3	Kqt	35.2743	0.9685	9.8	30.2881	7.8641	8.0921	1.7197	1.7292	0.0018	0.0381	95.76
SUM-1 4	Kqt	34.7442	0.3925	9.8	32.1038	6.2858	7.8781	1.365	1.6471	0	0	94.2166
SUM-1 avg	***Kqt***	***35.0093***	***0.6805***	***9.8***	***31.196***	***7.07495***	***7.9851***	***1.54235***	***1.68815***	***0.0009***	***0.01905***	***94.9883***
T0642 1	Kqt	35.7986	0.0933	9.8	33.7499	4.2753	8.5588	1.1348	2.0696	0	0.0064	95.484
T0642 2	Kqt	35.8922	0.1108	9.8	33.8358	4.4252	8.5392	1.1923	1.9527	0	0.01	95.7541
T0642 3	Kqt	35.3013	0.1983	9.8	33.4172	4.4115	8.5781	1.1565	1.9801	0	0.0135	94.8509
T0642 4	Kqt	35.5835	0.3294	9.8	33.3114	4.5636	8.4085	1.3106	1.8739	0	0.0046	95.1837
T0642 avg	***Kqt***	***35.6439***	***0.18295***	***9.8***	***33.5786***	***4.4189***	***8.52115***	***1.19855***	***1.96908***	***0***	***0.00863***	***95.3182***

APPENDIX B: MAJOR-ELEMENT COMPOSITIONS, AVERAGE STRUCTURAL FORMULAE (APFU)

This section includes the calculated structural formulae, based on the average concentrations of each sample (included in APPENDIX A). Because the boron results were unreliable, the formulae included in this section have been corrected to 9.8 weight percent B_2O_3. Because Mg and Al are present in both the Y-site and the Z-site, they have been calculated to indicate the individual Y-site and Z-site concentrations.

Sample	Lithology	*X-site*			*Y-site*							*Z-site*		B	Si
		Na	K	Ca	Fe	Mg[Y]	Mn	Al[Y]	Ti	Cr	V	Al[Z]	Mg[Z]		
776T-3	DF1	0.59	0.01	0.28	0.61	2.04	0.00	0.40	0.03	0.03	0.01	6.47	0.28	2.99	6.29
776T-4	DF1	0.59	0.01	0.43	0.68	1.90	0.02	0.38	0.01	0.03	0.00	5.29	0.71	3.04	6.31
FW-4	DF1	0.57	0.00	0.28	0.81	1.88	0.00	0.39	0.05	0.01	0.01	6.55	0.28	3.00	6.22
HR-2	DF1	0.69	0.00	0.24	0.70	2.03	0.00	0.29	0.03	0.02	0.00	6.54	0.24	3.00	6.31
HRT-4	DF1	0.60	0.01	0.31	0.78	1.91	0.00	0.26	0.10	0.03	0.00	5.30	0.44	3.04	6.29
HRT-7	DF1	0.63	0.00	0.29	0.58	2.12	0.00	0.29	0.05	0.04	0	6.45	0.29	2.99	6.33
MO-1	DF1	0.56	0.00	0.31	0.80	1.89	0	0.39	0.05	0.00	0.00	6.48	0.31	3.01	6.25
MO-5	DF1	0.64	0.01	0.26	0.46	2.01	0.00	0.60	0.02	0.01	0.00	6.30	0.26	2.93	6.45
322807A	DF2	0.47	0.00	0.52	0.70	1.78	0.00	0.47	0.03	0.02	0.00	4.54	0.99	3.01	6.48
FW-2	DF2	0.59	0.01	0.39	0.90	1.71	0.01	0.35	0.04	0.00	0.01	5.06	0.59	3.05	6.28
HRT-6	DF2	0.53	0.01	0.39	0.67	1.94	0.00	0.36	0.05	0.05	0.01	5.11	0.53	2.97	6.40
T0640	DF2	0.59	0.01	0.40	0.70	1.90	0.00	0.35	0.04	0.01	0.00	5.26	0.74	3.02	6.32
322915	DF3	0.51	0.00	0.46	0.82	1.72	0.00	0.46	0.02	0	0.00	4.74	0.79	3.04	6.31
322943	DF3	0.50	0.00	0.52	0.67	1.81	0.00	0.51	0.01	0.00	0.00	5.01	0.99	3.03	6.29
H0309B	DF3	0.57	0.00	0.34	0.96	1.70	0.00	0.36	0.04	0.01	0.01	5.23	0.41	3.04	6.31
H0425	DF3	0.66	0.00	0.33	0.85	1.82	0	0.23	0.05	0.06	0.00	5.16	0.61	3.01	6.33
H0432	DF3	0.61	0.00	0.37	0.87	1.76	0.00	0.31	0.07	0.00	0.01	5.16	0.52	3.00	6.28
HR-3	DF3	0.59	0.01	0.32	0.77	1.90	0.00	0.35	0.04	0.00	0.00	5.21	0.44	3.01	6.26
HRT-1	DF3	0.59	0.00	0.32	0.89	1.79	0.00	0.36	0.05	0	0.00	5.30	0.34	3.00	6.34
MO-3	DF3	0.62	0.01	0.31	0.77	1.92	0.01	0.33	0.03	0.02	0.00	5.30	0.37	3.00	6.28
OZ-5	DF3	0.48	0.00	0.53	0.69	1.78	0.00	0.50	0.01	0.01	0.00	4.54	0.97	3.03	6.33
SUM-3	DF3	0.63	0.00	0.27	1.05	1.68	0.00	0.31	0.04	0.01	0.00	5.21	0.48	3.04	6.30
T0643	DF3	0.68	0.00	0.26	0.85	1.74	0.00	0.39	0.07	0.02	0.00	6.34	0.27	3.02	6.38

Sample	Lithology	X-site			Y-site							Z-site		B	Si
		Na	K	Ca	Fe	Mg[Y]	Mn	Al[Y]	Ti	Cr	V	Al[Z]	Mg[Z]		
322807	E-DF3	0.62	0.01	0.27	0.95	1.58	0.02	0.41	0.04	0.11	0.01	6.20	0.27	2.97	6.49
322810	E-DF3	0.66	0.01	0.31	1.02	1.67	0.02	0.29	0.03	0.01	0.00	5.34	0.37	3.02	6.23
FW-5	E-DF3	0.57	0.01	0.29	0.86	1.62	0.01	0.36	0.02	0.27	0.01	6.18	0.29	2.96	6.47
APMT-1	E-Ka	0.72	0.01	0.13	0.77	1.73	0.03	0.58	0.01	0.04	0.00	6.28	0.13	2.95	6.51
AP-T1	Ka	0.74	0.01	0.20	0.75	2.05	0.03	0.21	0.02	0.01	0.00	6.38	0.20	2.95	6.50
H0429	Ka	0.82	0.02	0.06	1.96	0.44	0.09	0.61	0.10	0	0.00	6.61	0.06	3.10	6.15
MO-2	Ka	0.78	0.01	0.13	1.51	1.23	0.03	0.21	0.13	0	0.00	6.69	0.13	3.07	6.18
MO-6	Ka	0.75	0.01	0.12	0.90	1.63	0.02	0.52	0.05	0.02	0	6.27	0.12	2.97	6.53
TC-2	Ka	0.60	0.00	0.09	1.14	1.20	0.02	0.94	0.03	0.00	0.00	6.45	0.09	3.03	6.24
TH-1	Ka	0.52	0.01	0.48	0.81	1.71	0.00	0.43	0.04	0.01	0.01	4.80	0.78	3.03	6.29
CO-1	Kg	0.72	0.02	0.06	2.06	0.36	0.04	0.70	0.09	0	0.00	6.61	0.06	3.11	6.12
CO-2	Kg	0.68	0.01	0.06	1.77	0.62	0.04	0.77	0.09	0.00	0	6.25	0.06	3.03	6.42
HV-3	Kg	0.76	0.01	0.13	1.34	1.13	0.01	0.48	0.14	0.00	0.00	6.47	0.13	3.04	6.29
322807B	Kqt	0.47	0.01	0.46	0.76	1.79	0.01	0.46	0.05	0.00	0.01	4.90	0.64	2.95	6.52
FW-3	Kqt	0.53	0.01	0.30	0.87	1.69	0.00	0.53	0.06	0.00	0.01	6.19	0.30	2.96	6.46
HRT-3	Kqt	0.55	0.01	0.29	1.01	1.62	0.01	0.48	0.05	0.00	0.00	6.24	0.29	3.00	6.42
MO-7 core	Kqt	0.76	0.01	0.09	1.72	0.88	0.03	0.42	0.12	0	0	6.47	0.09	3.07	6.31
MO-7 rim	Kqt	0.75	0.01	0.13	0.91	1.63	0.02	0.32	0.05	0.19	0.00	6.36	0.13	3.02	6.43
MO-7	Kqt	0.76	0.01	0.11	1.31	1.26	0.03	0.37	0.08	0.09	0.00	6.42	0.11	3.04	6.37
OZ-2	Kqt	0.56	0.01	0.39	0.79	1.82	0.01	0.39	0.03	0.02	0.00	4.97	0.64	3.02	6.35
OZ-3	Kqt	0.63	0.00	0.38	0.61	2.01	0.00	0.36	0.01	0.02	0.00	5.25	0.39	3.01	6.43
SUM-1	Kqt	0.60	0.00	0.29	1.03	1.68	0.00	0.33	0.06	0	0.00	5.26	0.41	3.04	6.27
T0642	Kqt	0.68	0.00	0.20	0.65	1.88	0.00	0.56	0.02	0	0	6.49	0.20	2.96	6.33

APPENDIX C: TRACE ELEMENT CONCENTRATIONS

This section includes the measured concentrations of elements analyzed by LAM-ICPMS. The average values are given in Section 3.3).

Element	Li	Be	B	Al_2O_3	SiO_2	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As	Rb	Sr
Isotopic Mass	7	9	10	27	29	45	51	52	55	59	60	63	66	75	85	88
measurement	ppm	ppm	ppm	wt%	wt%	ppm	ppm	ppm	wt%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
322807 1	149.608	27.880	13955.556	31.431	36.902	24.162	208.550	36.476	0.195	30.976	90.576	4.408	602.469	<6.850	<0.335	49.838
322807 3	158.591	43.706	11909.160	29.514	36.902	25.348	202.617	48.415	0.174	29.389	106.247	4.272	518.064	<5.821	<0.255	58.090
322807 4	107.180	<17.142	5508.921	15.605	36.902	10.995	92.535	8.240	0.101	14.230	32.202	<2.360	346.672	<6.002	<0.237	24.415
322807 5	138.488	30.057	6720.689	19.000	36.902	16.678	134.474	32.256	0.123	16.107	25.811	3.272	429.704	<5.139	<0.208	36.417
322807 6	168.687	52.885	9116.973	25.862	36.902	21.795	196.076	78.656	0.164	23.055	37.533	6.491	549.876	<7.775	<0.323	52.783
322807A 1	41.646	33.249	9594.573	28.503	36.337	6.542	324.830	956.337	0.042	18.040	74.766	2.871	84.999	<5.268	<0.230	79.928
322807A 2	55.442	28.043	8782.214	29.471	36.337	5.201	250.594	1119.077	0.044	22.987	81.650	<2.738	81.609	<6.214	<0.276	57.168
322807A 3	32.780	36.407	5383.398	18.217	36.337	43.377	278.773	1351.838	0.119	17.800	94.503	<3.085	93.811	<4.453	<0.265	45.503
322807A 4	33.398	27.628	5006.169	15.218	36.337	35.916	255.914	592.820	0.140	17.666	91.652	9.298	92.160	<4.150	0.148	34.678
322807A 5	34.944	31.787	5248.866	15.431	36.337	28.749	244.523	620.814	0.180	19.111	110.912	7.320	97.694	<3.986	2.344	35.283
322807B 1	88.396	51.986	47138.561	29.066	37.336	12.595	453.200	155.638	0.053	22.505	127.782	23.018	89.847	<6.184	<0.409	189.274
322807B 2	123.139	81.381	33881.298	30.198	37.336	14.944	523.293	92.087	0.057	21.573	146.994	9.677	90.391	<6.027	1.710	116.550
322807B 3	93.616	39.896	21374.914	24.071	37.336	35.199	404.040	528.751	0.096	22.001	84.978	181.587	125.474	<3.755	6.852	82.665
322807B 4	91.155	38.008	18451.046	24.936	37.336	9.173	209.147	25.151	0.051	20.274	78.788	26.325	80.638	<5.079	0.341	111.081
322807B 5	101.307	56.145	16722.248	27.698	37.336	11.511	355.199	147.916	0.054	22.016	119.782	22.375	87.151	<6.995	<0.309	133.964
322810 1	145.695	<27.038	13988.730	26.991	31.465	37.577	188.984	2131.513	0.113	21.843	56.351	<2.824	329.377	<6.751	<0.385	64.406
322810 2	124.342	39.848	11729.080	25.925	31.465	35.351	182.999	1841.459	0.104	19.357	54.300	<2.472	308.891	<5.414	<0.375	62.457
322810 3	120.198	44.711	10747.675	25.645	31.465	36.368	180.358	2463.529	0.103	19.991	48.204	<2.343	312.016	<3.919	<0.323	63.157
322810 4	115.398	35.678	9060.372	24.699	31.465	24.453	158.731	801.502	0.106	20.148	41.911	4.209	339.706	<4.470	0.424	55.544
322810 5	112.268	32.843	7722.921	23.164	31.465	29.492	156.832	674.038	0.092	18.545	31.433	13.985	151.292	<3.099	0.796	61.692
322915 1	135.641	29.241	10704.315	31.704	34.984	10.878	139.408	<9.437	0.118	32.660	36.885	<2.710	279.546	<6.823	<0.384	73.998
322915 2	102.266	27.456	10142.744	28.473	34.984	19.970	92.644	190.318	0.085	28.809	121.605	<2.004	208.360	<3.771	<0.240	43.220
322915 3	172.066	56.190	9867.129	28.885	34.984	36.684	143.041	<10.996	0.118	29.891	34.630	<3.070	339.422	<5.587	<0.281	81.280
322915 4	90.284	27.122	9724.906	29.663	34.984	13.646	167.894	<10.777	0.072	31.722	54.678	<3.051	158.175	<5.038	0.339	96.495
322915 5	160.141	30.849	9378.595	29.608	34.984	36.001	166.543	<7.253	0.079	24.665	28.678	5.179	134.480	<4.377	1.098	54.885

Element	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La
Isotopic Mass	89	90	93	95	111	118	121	133	137	139
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
322807 1	0.290	<0.623	0.310	<0.833	<0.583	82.756	0.513	<0.046	<0.706	0.461
322807 3	0.447	<0.447	0.269	<0.592	<1.394	77.523	0.672	0.128	0.380	0.531
322807 4	<0.142	<0.299	<0.131	<0.949	<1.044	35.305	<0.313	0.060	<0.236	0.344
322807 5	0.282	<0.521	<0.159	<0.479	<1.109	55.974	0.399	0.149	<0.338	0.414
322807 6	0.560	<0.406	0.393	0.197	<1.247	83.628	0.505	0.097	0.800	0.503
322807A 1	<0.222	<0.547	<0.206	<0.806	<1.858	92.096	<0.256	<0.081	0.574	1.248
322807A 2	<0.224	0.326	0.248	<0.551	<1.060	54.429	<0.177	<0.078	<0.272	1.082
322807A 3	2.170	1.106	0.208	<0.742	<1.313	61.452	<0.231	<0.089	0.384	0.679
322807A 4	2.891	1.896	0.182	<0.421	<0.657	43.608	<0.193	0.192	0.855	0.380
322807A 5	6.564	1.299	0.464	<0.340	<0.644	72.805	<0.107	1.456	1.546	0.671
322807B 1	0.266	0.861	0.435	<0.974	<1.016	151.894	0.193	0.076	1.639	0.135
322807B 2	0.379	0.993	0.740	<0.486	<0.936	191.682	0.328	0.856	2.771	0.133
322807B 3	1.728	1.030	0.332	0.777	<1.265	187.261	0.245	35.100	1.691	0.521
322807B 4	0.271	0.621	0.470	<0.514	<0.891	124.305	0.194	0.209	0.936	0.138
322807B 5	0.320	0.648	0.419	<0.793	<0.653	152.842	0.270	0.115	1.780	0.119
322810 1	<0.292	<0.421	0.276	<0.566	<1.089	126.293	<0.209	0.082	0.520	0.369
322810 2	<0.160	<0.484	0.284	<1.268	<0.856	115.517	<0.198	0.388	0.349	0.325
322810 3	0.162	<0.322	0.372	0.229	0.282	107.648	0.277	0.295	0.363	0.342
322810 4	<0.147	0.443	0.264	2.222	<1.523	78.950	0.255	3.675	0.376	0.420
322810 5	0.301	0.736	0.497	5.358	<0.721	94.499	1.522	8.317	0.987	0.434
322915 1	<0.246	<0.465	0.429	<1.290	<1.059	64.344	0.448	0.057	0.341	0.872
322915 2	0.130	<0.316	0.770	<0.950	0.212	138.558	0.326	0.100	0.538	0.516
322915 3	<0.194	<0.490	0.329	0.221	<1.039	113.517	0.594	<0.074	<0.329	0.870
322915 4	<0.286	<0.429	0.416	<0.735	<1.022	80.548	0.662	0.105	<0.402	0.674
322915 5	0.330	<0.218	<0.273	<0.444	<0.770	82.340	0.288	1.284	2.054	0.248

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Element	Ce	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Isotopic Mass	140	141	146	147	153	172	175	181	182	208	209	232	238
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
322807 1	0.939	0.098	0.304	<0.124	0.101	0.023	<0.012	0.143	0.206	10.735	0.433	<0.015	<0.019
322807 3	0.898	0.073	0.365	<0.185	0.117	0.042	<0.011	0.168	0.228	21.860	0.532	0.014	0.023
322807 4	0.592	0.061	0.160	<0.130	0.052	<0.028	<0.008	0.085	0.055	6.540	0.048	<0.007	0.003
322807 5	0.756	0.091	0.273	<0.114	0.081	<0.075	<0.007	0.086	0.222	8.952	0.891	0.007	0.010
322807 6	0.926	0.094	0.342	0.118	0.109	0.067	<0.018	0.149	0.388	12.344	1.249	0.018	0.032
322807A 1	1.701	0.101	0.298	<0.165	0.113	<0.066	<0.012	0.076	<0.148	16.568	3.071	<0.010	<0.020
322807A 2	1.557	0.114	0.297	<0.259	0.087	<0.077	<0.007	0.099	3.212	9.492	1.250	<0.008	<0.010
322807A 3	1.008	0.065	0.333	<0.225	<0.088	0.218	<0.053	<0.059	<0.170	8.945	1.776	<0.058	<0.045
322807A 4	0.602	0.076	0.218	<0.124	0.082	0.385	0.052	0.044	0.272	10.379	6.320	0.019	0.039
322807A 5	1.419	0.224	1.296	0.578	0.203	0.601	0.096	0.084	0.037	6.895	6.019	0.014	0.042
322807B 1	0.325	0.044	0.201	<0.131	0.095	<0.065	0.015	0.036	49.881	12.564	0.819	0.034	0.019
322807B 2	0.264	0.031	0.116	<0.071	0.090	0.076	0.010	0.112	32.361	12.811	0.567	0.030	0.137
322807B 3	0.890	0.110	0.484	0.116	0.152	0.305	0.061	0.055	37.939	10.034	0.084	0.042	0.072
322807B 4	0.241	0.035	0.172	<0.105	0.061	0.050	0.008	0.045	85.379	8.677	2.042	0.034	0.024
322807B 5	0.303	0.038	0.183	<0.118	0.072	0.063	0.014	0.046	59.732	13.628	1.389	0.033	0.024
322810 1	0.648	0.058	0.229	<0.083	0.105	<0.070	<0.011	0.380	<0.220	13.741	0.159	0.035	<0.013
322810 2	0.561	0.067	0.215	<0.111	0.103	<0.039	<0.012	0.315	0.186	9.512	0.209	0.017	<0.006
322810 3	0.624	0.057	0.221	0.090	0.091	0.039	0.008	0.314	0.946	10.662	0.157	0.028	<0.012
322810 4	0.810	0.091	0.290	<0.123	0.098	<0.032	<0.012	0.119	8.883	9.645	1.144	0.067	0.020
322810 5	0.891	0.107	0.401	0.078	0.110	<0.057	0.017	0.285	23.477	71.255	3.244	0.165	0.061
322915 1	1.800	0.188	0.610	0.144	0.123	<0.037	<0.015	0.355	<0.082	9.682	0.020	<0.015	<0.019
322915 2	1.037	0.120	0.450	<0.150	0.133	0.033	0.007	1.128	1.908	15.094	0.115	0.007	<0.014
322915 3	1.700	0.195	0.611	<0.085	0.230	<0.087	<0.013	0.298	0.510	12.252	0.082	<0.016	0.004
322915 4	1.378	0.120	0.336	<0.084	0.144	0.035	<0.013	0.520	1.907	10.045	0.188	<0.016	<0.027
322915 5	0.531	<0.062	<0.188	<0.190	<0.086	<0.105	<0.045	0.094	14.239	8.731	1.266	<0.049	<0.050

Element	Li	Be	B	Al_2O_3	SiO_2	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As	Rb	Sr
Isotopic Mass	7	9	10	27	29	45	51	52	55	59	60	63	66	75	85	88
measurement	ppm	ppm	ppm	wt%	wt%	ppm	ppm	ppm	wt%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
322943 1	69.000	24.278	9245.957	28.286	34.928	17.512	237.929	1288.574	0.048	34.984	199.656	<2.532	66.383	<4.609	<0.483	1245.899
322943 2	89.517	76.535	9963.481	28.802	34.928	25.640	261.362	1059.713	0.058	33.813	169.815	<2.466	86.957	<4.923	0.731	1445.800
322943 3	64.351	<25.934	10046.838	27.926	34.928	15.088	375.366	416.854	0.047	26.814	224.137	<2.000	61.383	<5.108	0.881	1795.170
322943 4	60.938	95.581	7205.185	23.954	34.928	8.411	210.602	410.716	0.038	23.282	169.314	<1.717	30.520	<2.420	263.119	1189.762
322943 5	70.703	28.612	11219.460	30.674	34.928	12.349	331.818	510.834	0.055	29.846	200.365	<3.056	57.188	<6.221	8.842	2170.847
776T-4 1	105.473	48.107	35881.234	26.301	34.439	144.314	330.131	2531.916	0.143	41.941	349.809	<2.270	213.229	<6.092	0.491	20.777
776T-4 2	186.121	39.359	30114.130	24.543	34.439	73.355	316.486	1647.837	0.125	41.837	344.091	4.734	188.852	<3.676	47.048	19.969
776T-4 3	97.935	39.542	31253.007	26.014	34.439	163.579	382.671	2615.488	0.146	41.166	355.472	<2.390	221.327	<5.921	11.304	19.394
776T-4 4	84.955	33.761	28014.394	26.384	34.439	134.585	376.456	1853.019	0.137	39.409	348.440	2.738	217.140	<6.154	2.213	14.054
776T-4 5	129.107	28.270	######	25.664	34.439	100.846	403.130	2221.393	0.125	46.160	399.674	3.600	184.389	<3.588	1.340	13.123
APMT-1 1	83.413	31.684	66191.461	29.193	37.363	24.693	84.917	845.111	0.157	37.740	261.503	6.954	259.856	<4.601	0.355	54.762
APMT-1 2	77.304	37.438	######	28.908	37.363	33.010	96.296	1037.861	0.161	35.446	255.594	<2.159	365.075	<4.130	<0.361	64.216
APMT-1 3	87.141	40.684	51988.534	30.199	37.363	42.873	145.702	1170.632	0.177	41.208	251.374	3.392	415.029	<5.104	<0.283	35.526
APMT-1 4	90.993	35.862	48031.103	29.313	37.363	27.783	117.438	1615.281	0.173	41.667	315.092	<1.949	423.269	<6.063	<0.269	60.401
APMT-1 5	81.010	28.820	42813.019	28.731	37.363	49.584	154.866	1230.988	0.174	41.497	289.181	2.781	402.359	<4.609	<0.282	48.453
AP-T1 1	95.279	<26.352	24614.683	31.664	37.238	9.371	109.273	3809.469	0.236	27.452	380.557	<3.244	296.816	<7.084	<0.291	18.355
AP-T1 2	97.294	25.160	######	31.626	37.238	20.090	143.694	5122.011	0.236	27.226	386.845	<2.903	314.140	<4.317	<0.333	19.037
AP-T1 3	146.313	39.038	21580.193	33.825	37.238	10.865	155.876	67.590	0.281	28.884	71.244	<3.761	329.665	<7.023	<0.338	20.623
AP-T1 4	162.099	28.255	19743.354	32.498	37.238	8.699	176.458	58.842	0.275	30.932	66.062	<2.668	431.288	<4.787	<0.270	30.704
CO-1 1	190.712	<41.967	1415.672	24.433	32.879	<8.769	<5.156	31.087	0.098	<2.409	<13.745	12.839	54.831	8.120	1238.101	1.415
CO-1 2	211.027	35.132	17825.589	29.833	32.879	5.679	<2.193	<8.562	0.402	2.563	<4.198	7.142	1385.686	<5.005	<0.683	2.593
CO-1 3	265.965	35.835	17318.958	29.099	32.879	5.941	<1.974	<11.120	0.356	3.948	<6.255	6.413	1299.843	<5.470	<0.346	8.534
CO-1 4	263.780	28.539	15367.470	29.265	32.879	4.965	<1.694	<9.695	0.375	2.799	5.576	26.005	1347.326	<5.850	36.605	6.643
CO-1 5	172.077	<14.441	432.459	22.604	32.879	3.394	<1.354	<5.169	0.077	<0.811	<4.077	2.408	96.066	<3.060	1430.067	0.873

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Element	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La
Isotopic Mass	89	90	93	95	111	118	121	133	137	139
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
322943 1	<0.170	<0.628	0.245	<0.906	<1.131	109.073	<0.213	0.039	<0.407	<0.045
322943 2	<0.113	<0.402	0.470	<0.925	<0.859	143.021	<0.382	<0.063	<0.358	<0.048
322943 3	<0.235	<0.497	<0.157	<1.094	<0.799	177.572	0.205	0.089	<0.255	<0.028
322943 4	0.248	<0.238	<0.118	<0.242	<0.892	75.799	0.142	1.162	24.330	0.032
322943 5	<0.179	<0.420	<0.139	<0.978	<0.984	106.863	<0.240	0.072	5.675	0.041
776T-4 1	0.339	<0.494	1.717	<0.842	<1.074	188.984	0.336	0.188	1.720	0.303
776T-4 2	4.724	<0.514	26.980	<0.872	<1.207	131.118	0.476	10.648	19.924	0.291
776T-4 3	<0.274	<0.356	1.100	<0.656	<1.636	242.516	0.668	1.921	7.175	0.283
776T-4 4	0.630	<0.254	1.725	<1.137	<1.198	219.782	0.423	1.041	2.429	0.195
776T-4 5	0.915	<0.376	4.884	<0.629	<1.078	172.619	0.693	0.663	2.312	0.130
APMT-1 1	0.903	0.774	1.767	<0.915	<1.276	111.490	0.386	0.449	3.603	0.479
APMT-1 2	<0.201	1.695	1.089	<0.643	<1.381	210.000	0.324	<0.039	1.177	0.530
APMT-1 3	0.935	24.872	2.981	<0.594	<1.336	145.162	0.314	0.265	2.180	0.731
APMT-1 4	0.192	<0.451	1.411	<0.352	<1.495	117.224	0.331	0.070	1.429	0.644
APMT-1 5	0.660	1.407	2.746	<0.693	<2.065	208.178	0.388	0.209	2.921	0.784
AP-T1 1	<0.149	<0.450	1.060	<1.049	<1.072	172.249	0.269	<0.045	1.008	3.110
AP-T1 2	0.204	0.819	6.799	<0.851	<1.420	447.862	0.530	<0.037	1.260	4.233
AP-T1 3	<0.332	<0.356	1.330	<1.417	<1.243	87.919	0.178	<0.064	0.812	4.354
AP-T1 4	0.292	0.277	1.535	<0.893	<1.508	80.980	<0.186	<0.040	0.799	4.832
CO-1 1	1.082	21.724	9.526	<1.535		107.043	81.279	37.820	141.524	0.230
CO-1 2	0.120	0.513	0.896	<1.008		23.440	0.387	<0.052	<0.234	1.193
CO-1 3	<0.106	<0.363	0.847	0.214		20.784	1.877	<0.049	<0.214	4.771
CO-1 4	2.685	3.968	1.180	<1.195		25.962	<0.355	1.213	7.460	5.293
CO-1 5	<0.117	0.361	17.905	<0.412		177.080	2.106	63.958	24.281	0.056

Element	Ce	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Isotopic Mass	140	141	146	147	153	172	175	181	182	208	209	232	238
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
322943 1	<0.020	<0.016	<0.142	<0.174	<0.020	<0.083	<0.019	0.165	<0.153	14.611	<0.033	<0.017	<0.013
322943 2	<0.032	<0.014	<0.108	<0.183	0.004	<0.067	<0.007	0.645	<0.047	15.748	<0.025	<0.017	<0.024
322943 3	0.027	<0.013	<0.071	<0.077	<0.024	<0.045	<0.010	0.252	<0.061	16.412	0.023	<0.008	<0.011
322943 4	0.041	<0.021	<0.096	<0.079	<0.015	<0.027	0.007	0.064	8.292	13.568	0.438	<0.006	<0.010
322943 5	0.037	<0.023	<0.102	<0.078	<0.034	0.033	<0.014	0.062	6.083	17.515	0.210	<0.008	<0.007
776T-4 1	0.582	0.066	0.312	0.138	0.040	0.058	0.015	1.430	<0.044	27.305	<0.027	0.023	<0.009
776T-4 2	0.958	0.197	0.893	0.933	0.060	0.402	0.049	9.149	0.431	36.274	0.402	0.231	1.757
776T-4 3	0.795	0.080	0.388	0.139	0.050	<0.069	<0.013	1.797	<0.053	29.387	<0.027	0.107	<0.026
776T-4 4	0.338	0.044	0.117	0.121	0.041	0.122	0.010	1.575	<0.043	27.030	0.022	0.026	0.061
776T-4 5	0.254	0.057	0.164	<0.199	0.027	0.103	0.014	2.023	0.057	36.648	0.052	0.045	0.292
APMT-1 1	0.984	0.136	0.371	0.158	0.056	0.079	0.019	1.244	0.080	23.615	0.052	0.058	0.024
APMT-1 2	1.063	0.106	0.238	0.109	0.054	<0.054	<0.008	1.716	<0.031	27.543	<0.021	<0.012	0.011
APMT-1 3	1.646	0.241	0.442	0.205	0.031	0.175	0.047	1.844	0.115	25.758	0.022	0.054	0.217
APMT-1 4	1.695	0.168	0.581	0.124	0.052	<0.041	0.005	0.976	0.038	25.830	<0.021	<0.011	0.013
APMT-1 5	1.838	0.228	0.557	0.237	0.042	0.100	0.017	2.270	0.220	24.876	<0.019	0.068	0.028
AP-T1 1	7.089	0.825	2.065	0.482	<0.041	<0.043	<0.006	1.646	<0.054	19.021	0.022	0.015	<0.007
AP-T1 2	10.484	1.107	2.794	0.828	<0.030	<0.078	<0.007	26.149	<0.033	24.829	0.085	0.045	<0.014
AP-T1 3	9.741	1.021	2.600	0.558	0.023	0.008	<0.016	2.230	<0.073	14.490	<0.032	0.016	<0.013
AP-T1 4	10.030	1.129	2.676	0.633	<0.033	<0.059	<0.013	2.339	<0.053	14.626	<0.025	0.090	<0.013
CO-1 1	0.548	0.111	0.464	<0.201	<0.067	<0.095	<0.020	1.400	6.924	4975.472	1.614	6.016	16.505
CO-1 2	2.248	0.216	0.693	<0.126	<0.023	<0.052	<0.010	0.342	<0.035	20.712	<0.024	0.063	0.320
CO-1 3	8.984	0.832	2.228	0.425	<0.034	<0.052	<0.009	0.205	<0.045	44.351	0.079	0.048	0.245
CO-1 4	9.832	1.092	3.417	0.788	0.113	0.472	0.074	0.264	0.135	22.539	0.045	1.343	12.127
CO-1 5	0.139	<0.029	0.084	<0.095	<0.022	<0.047	<0.007	2.842	8.667	24.876	0.020	0.114	1.103

Element	Li	Be	B	Al_2O_3	SiO_2	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As	Rb	Sr
Isotopic Mass	7	9	10	27	29	45	51	52	55	59	60	63	66	75	85	88
measurement	ppm	ppm	ppm	wt%	wt%	ppm	ppm	ppm	wt%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
FW-2 1	120.396	35.385	<-2160.332	27.975	34.500	82.734	443.931	78.098	0.106	16.487	43.744	178.519	170.198	<4.664	1.430	70.601
FW-2 2	108.806	40.077	<-3124.688	27.564	34.500	61.035	389.441	77.087	0.092	15.416	34.105	76.683	225.802	<2.978	1.993	64.114
FW-2 3	121.650	45.492	<-2991.055	28.068	34.500	87.047	487.802	12.258	0.110	16.286	41.760	175.924	268.323	<3.439	0.737	75.820
FW-2 4	114.575	40.555	######	28.166	34.500	96.457	497.861	<6.294	0.112	16.120	27.467	59.155	265.785	<4.118	1.045	65.639
FW-2 5	164.607	33.942	######	28.933	34.500	53.465	346.251	11.563	0.130	25.064	53.961	102.096	367.377	<4.013	1.353	68.122
FW-3 1	51.558	29.448	39139.583	29.428	36.910	13.409	277.819	14.939	0.043	38.239	143.787	<2.409	51.137	<5.094	0.720	119.850
FW-3 2	48.524	17.666	######	23.378	36.910	11.297	249.678	39.171	0.035	31.194	120.299	4.867	41.902	<3.844	1.461	92.922
FW-3 3	69.338	30.460	######	25.548	36.910	3.270	197.143	<8.469	0.039	32.843	35.759	3.242	66.136	<3.412	0.425	68.102
FW-3 4	48.344	<15.374	28412.666	30.700	36.910	23.697	322.925	12.628	0.047	40.853	145.939	<2.500	51.346	<3.413	<0.254	112.528
FW-3 5	58.286	25.506	23218.226	26.480	36.910	6.251	210.439	<7.472	0.041	37.322	54.827	<3.260	67.728	<3.604	0.717	95.781
FW-5 1	152.079	47.330	<-2641.606	31.293	37.053	63.644	289.709	8572.470	0.145	25.722	92.630	20.532	445.241	<6.177	<0.416	57.825
FW-5 2	162.411	40.585	<-3157.696	31.865	37.053	50.122	257.323	5124.450	0.146	25.210	94.077	<3.292	444.850	<4.840	<0.354	58.516
FW-5 3	128.054	71.132	<-4222.458	30.261	37.053	43.616	309.097	1523.149	0.127	21.038	59.860	<3.166	368.207	<4.639	<0.305	71.858
H0309B 1	40.460	19.074	42751.727	28.107	35.060	31.090	559.250	797.936	0.030	38.116	54.304	<2.927	11.130	<5.842	<0.522	87.539
H0309B 2	36.241	27.822	######	29.182	35.060	32.655	501.695	978.516	0.031	33.701	41.651	<6.068	8.937	<4.247	0.386	98.161
H0309B 3	47.305	<23.300	30155.612	28.301	35.060	64.960	556.367	1031.453	0.031	67.526	205.033	<2.531	19.227	<5.544	<0.286	92.381
H0309B 4	44.808	21.540	26724.415	29.503	35.060	75.150	599.284	370.844	0.034	67.210	153.333	<3.222	13.415	<4.019	<0.231	117.079
H0309B 5	42.747	21.223	21188.888	26.185	35.060	71.176	475.611	625.264	0.038	61.573	143.887	<2.043	27.531	<4.281	0.301	93.672
H0309B 6	83.119	49.240	######	28.669	35.060	128.323	829.464	1380.554	0.054	39.723	101.380	6.701	75.424	<4.886	<0.250	74.258
H0309B 7	62.226	38.256	######	27.660	35.060	218.583	841.655	834.073	0.067	61.611	104.983	<2.217	74.101	<3.986	0.274	158.412
H0309B 8	85.994	24.356	######	28.616	35.060	47.865	631.378	905.611	0.080	55.812	112.274	<2.631	138.773	<4.783	<0.248	133.189
H0425 1	26.573	<7.213	######	2.714	32.495	31.198	62.975	233.388	0.152	316.068	1307.915	365.631	82.367	<1.289	7.888	20.234
H0425 2	73.967	12.819	<-3142.300	22.132	32.495	29.356	308.272	1467.785	0.064	21.939	104.128	14.058	53.567	<5.206	29.989	103.677
H0425 3	77.872	<13.711	<-2370.513	18.409	32.495	30.784	275.815	2859.949	0.069	20.671	94.162	7.197	58.881	<2.897	53.785	85.214
H0425 4	62.599	24.816	<-3370.412	23.099	32.495	27.369	320.123	2087.341	0.091	26.053	131.640	24.774	62.038	<3.790	19.823	135.588
H0425 5	65.852	<13.538	<-2127.842	16.641	32.495	51.346	275.517	1530.745	0.108	23.490	109.092	55.209	63.994	<2.017	29.526	85.080

Element	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La
Isotopic Mass	89	90	93	95	111	118	121	133	137	139
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
FW-2 1	3.150	0.587	0.367	<0.575	<0.806	114.433	0.532	1.212	3.813	0.537
FW-2 2	1.463	0.386	0.234	<0.460	<0.690	112.286	<0.365	1.343	3.155	0.222
FW-2 3	1.548	<0.454	0.247	<0.756	<0.810	119.884	0.233	0.566	1.960	0.458
FW-2 4	0.850	<0.336	0.247	<0.336	<0.647	144.351	0.301	0.696	1.648	0.158
FW-2 5	1.653	<0.395	0.204	<0.688	<0.792	76.573	0.284	1.422	3.318	0.434
FW-3 1	0.169	0.999	0.107	<0.767	<0.613	8.682	<0.242	0.466	2.882	0.056
FW-3 2	0.284	1.042	0.165	<0.285	<0.863	13.663	0.259	1.030	4.879	0.101
FW-3 3	0.135	<0.254	<0.109	<0.472	<0.523	97.643	<0.193	0.300	1.097	0.156
FW-3 4	0.153	2.132	<0.108	<0.650	<1.010	3.259	0.174	<0.034	2.055	0.029
FW-3 5	<0.161	<0.356	0.142	<0.678	<1.946	165.800	0.337	0.234	1.287	0.282
FW-5 1	0.881	0.384	0.534	<1.092	<1.097	155.827	0.721	<0.278	0.806	0.719
FW-5 2	0.385	<0.460	0.317	<0.543	<1.378	118.386	1.143	0.185	<0.523	0.523
FW-5 3	<0.206	<0.386	0.270	<0.623	<1.443	107.801	0.897	0.114	0.293	0.290
H0309B 1	0.414	<0.979	<0.219	<1.197	<1.297	32.914	<0.285	0.750	<1.371	0.283
H0309B 2	0.569	<0.395	<0.144	<0.839	0.186	28.829	0.139	0.768	<15.273	0.337
H0309B 3	<0.152	<0.537	<0.087	0.349	<0.599	46.254	0.224	0.231	0.604	1.208
H0309B 4	<0.219	<0.415	<0.272	<0.551	<0.906	54.016	<0.324	<0.074	0.580	1.393
H0309B 5	0.591	<0.324	<0.106	<0.444	<0.927	70.836	0.177	1.712	0.435	1.447
H0309B 6	0.650	<0.401	0.478	<0.711	<1.173	187.624	0.212	0.150	0.665	0.748
H0309B 7	0.978	0.894	0.125	<0.679	0.228	26.780	0.229	0.677	1.410	0.221
H0309B 8	1.362	<0.366	0.599	<0.739	<1.447	48.655	0.220	0.070	1.442	0.596
H0425 1	1.710	0.832	0.100	<0.257	<0.410	17.166	0.197	52.846	5.442	0.144
H0425 2	1.658	70.970	<0.122	<4.717	<1.281	29.630	0.155	192.512	2.765	0.393
H0425 3	1.407	0.797	<0.118	<0.495	<0.713	54.365	<0.155	263.849	4.337	0.623
H0425 4	1.526	1.478	<0.101	<0.664	<0.766	71.242	0.218	92.506	4.702	1.033
H0425 5	2.754	0.860	<0.064	<0.390	<1.671	31.301	0.130	192.143	4.985	0.484

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Element	Ce	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Isotopic Mass	**140**	**141**	**146**	**147**	**153**	**172**	**175**	**181**	**182**	**208**	**209**	**232**	**238**
measurement	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
FW-2 1	0.870	0.132	0.540	0.205	0.122	0.507	0.084	0.421	1043.370	22.887	0.089	0.023	0.775
FW-2 2	0.386	0.064	0.192	<0.077	0.110	0.207	0.053	0.100	84.621	7.532	0.021	<0.009	0.300
FW-2 3	0.729	0.112	0.371	<0.125	0.131	0.249	0.036	0.177	278.687	11.322	0.024	0.044	0.807
FW-2 4	0.243	<0.030	0.140	<0.106	0.062	0.135	0.037	0.084	64.531	9.130	<0.019	<0.020	0.168
FW-2 5	0.773	0.094	0.321	<0.102	0.119	0.283	0.033	0.113	114.766	12.534	<0.016	<0.020	0.332
FW-3 1	0.089	<0.029	<0.067	<0.121	<0.016	0.081	0.034	0.022	0.142	6.799	<0.020	0.007	<6.118
FW-3 2	0.164	<0.023	<0.094	0.080	0.036	0.026	0.007	0.031	0.364	9.341	0.047	0.030	0.019
FW-3 3	0.264	0.034	0.102	<0.085	0.045	<0.055	<0.014	0.015	0.444	4.791	<0.016	0.016	0.006
FW-3 4	0.073	<0.033	<0.122	<0.084	0.010	0.129	0.049	0.051	0.077	5.640	<0.018	<0.013	<0.009
FW-3 5	0.441	0.051	0.110	<0.079	0.092	0.029	<0.007	0.016	0.455	12.038	0.043	0.016	0.020
FW-5 1	1.638	0.176	0.641	0.174	0.114	0.124	0.026	0.277	32.718	32.502	9.025	0.221	0.168
FW-5 2	1.033	0.105	0.226	<0.238	0.101	0.094	0.019	0.188	0.405	72.126	0.121	<0.015	<0.010
FW-5 3	0.528	0.044	<0.176	<0.225	0.113	0.052	<0.010	0.093	1.211	36.904	0.430	0.021	0.014
H0309B 1	0.595	0.074	0.261	<0.143	0.147	0.106	0.022	<0.019	<0.099	8.412	<0.021	<0.032	<0.029
H0309B 2	0.580	0.067	0.345	0.071	0.179	0.181	0.032	<0.014	<0.058	8.432	0.035	<0.015	0.016
H0309B 3	2.095	0.239	1.088	0.177	0.275	<0.047	<0.012	<0.011	<0.059	11.314	<0.605	<0.011	<0.011
H0309B 4	2.444	0.264	1.166	0.222	0.277	<0.042	<0.015	<0.029	<0.052	11.552	<0.034	<0.007	<0.016
H0309B 5	2.332	0.217	0.949	0.143	0.342	0.146	0.031	0.007	0.046	16.232	<0.017	<0.006	0.058
H0309B 6	1.356	0.144	0.599	0.214	0.211	0.127	0.033	0.088	0.101	19.473	<0.027	0.012	<0.018
H0309B 7	0.421	0.045	0.115	<0.258	0.071	0.875	0.290	0.069	0.109	13.132	<0.012	0.033	0.036
H0309B 8	1.122	0.085	0.410	<0.150	0.108	0.250	0.060	0.308	0.388	12.512	<0.017	0.077	0.038
H0425 1	0.410	0.059	0.364	0.179	0.074	0.249	0.039	0.022	0.408	6.973	18.671	0.066	0.048
H0425 2	0.655	0.081	0.258	<0.103	0.123	0.432	0.096	0.013	<0.044	6.182	0.140	0.026	0.200
H0425 3	1.161	0.079	0.381	<0.101	0.070	0.231	0.033	0.042	0.070	9.303	0.232	0.016	0.018
H0425 4	1.838	0.144	0.481	<0.085	0.097	0.266	0.037	0.062	0.098	5.988	0.143	0.036	0.011
H0425 5	1.005	0.107	0.593	0.212	0.126	0.502	0.066	0.011	0.230	5.546	0.266	0.046	0.019

Element	Li	Be	B	Al_2O_3	SiO_2	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As	Rb	Sr
Isotopic Mass	7	9	10	27	29	45	51	52	55	59	60	63	66	75	85	88
measurement	ppm	ppm	ppm	wt%	wt%	ppm	ppm	ppm	wt%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
H0429 1	22.657	21.359	5036.613	11.699	33.557	41.467	187.243	401.581	0.207	32.585	174.835	10.381	115.064	<4.548	0.476	131.087
H0429 2	<23.529	23.382	14590.097	28.447	33.557	5.946	192.124	1982.411	0.046	34.872	218.438	14.707	88.071	<5.691	0.347	393.337
H0429 3	<18.832	28.733	12942.463	26.501	33.557	7.178	181.724	1078.078	0.067	34.416	266.231	4.645	84.113	<4.286	<0.314	437.155
H0429 4	36.113	16.674	<58.732	4.145	33.557	45.009	144.380	646.042	0.287	31.458	149.511	33.602	125.890	<4.226	3.065	3.603
H0429 5	21.336	14.567	6362.011	17.155	33.557	47.322	244.316	1677.734	0.170	33.849	208.687	6.197	97.054	<5.310	0.810	176.598
H0432 1	<20.437	27.110	12573.561	29.434	34.416	<3.337	69.862	932.551	0.028	32.700	106.160	13.037	44.082	<6.053	<0.452	169.207
H0432 2	<21.020	21.138	11600.737	28.885	34.416	2.987	82.144	1279.555	0.028	31.728	103.191	17.875	44.113	<5.955	<0.305	187.388
H0432 3	<21.137	20.906	11179.930	28.501	34.416	3.763	71.479	837.668	0.027	31.659	99.028	3.663	44.485	<5.573	0.184	157.987
H0432 4	<26.796	<21.835	10651.304	30.130	34.416	<3.669	66.801	323.381	0.029	32.522	143.722	21.644	40.157	<9.026	<0.213	232.084
H0432 5	<20.868	27.763	9672.478	28.573	34.416	<2.404	66.029	10.332	0.032	29.677	83.300	7.688	40.953	<4.724	<0.260	148.489
HR-1 1	91.144	34.511	######	28.369	35.285	29.044	220.530	601.336	0.134	33.262	117.666	<2.089	52.084	<5.363	7.793	114.025
HR-1 2	75.769	30.104	19804.234	28.594	35.285	15.312	185.402	494.701	0.045	35.515	100.238	<2.026	46.798	<5.072	2.415	88.039
HR-1 3	56.564	24.188	14483.091	23.009	35.285	26.041	178.543	491.163	0.042	28.509	105.046	<1.210	38.630	<3.053	4.846	77.646
HR-1 4	258.692	16.586	4149.318	14.817	35.285	57.198	236.010	586.470	0.206	33.445	108.820	<1.725	72.749	<2.344	23.863	48.868
HR-1 5	174.099	38.027	10858.580	21.758	35.285	83.224	313.109	927.302	0.307	34.985	159.282	<1.352	70.074	<4.896	23.632	120.269
HR-3 1	77.733	31.309	17022.392	27.922	35.112	42.840	269.171	10.733	0.082	21.034	92.398	74.332	266.230	<6.050	<0.498	244.484
HR-3 2	38.613	21.443	14774.790	28.366	35.112	11.426	185.015	<7.776	0.051	26.221	93.818	4.087	133.036	<5.823	<0.213	361.163
HR-3 3	54.061	21.480	11876.132	26.059	35.112	8.338	164.521	23.671	0.048	51.320	397.995	422.662	116.478	<5.646	<0.367	353.216
HR-3 4	27.147	21.503	11725.640	29.023	35.112	8.400	163.950	<7.431	0.043	41.446	303.373	11.130	70.749	<5.440	<0.316	354.270
HR-3 5	36.674	27.592	10402.254	26.892	35.112	4.166	152.185	<8.908	0.049	44.949	250.612	114.998	85.063	<5.216	<0.456	328.144
HR-4 1	120.434	137.496	######	27.687	35.353	30.847	171.748	<10.361	0.158	34.134	83.947	<2.623	451.902	<3.911	28.746	126.972
HR-4 2	48.617	40.010	22146.657	25.624	35.353	16.332	160.492	688.510	0.075	38.180	196.295	<2.039	165.217	<4.907	16.687	332.523
HR-4 3	70.775	29.091	16508.558	20.547	35.353	2.824	129.963	<6.587	0.046	23.397	51.050	<2.350	81.479	<4.089	0.585	297.037
HR-4 4	33.587	28.370	######	27.149	35.353	4.030	286.363	<7.104	0.071	26.574	86.827	1.933	113.018	<3.528	0.308	423.935
HR-4 5	91.561	22.897	14556.411	22.195	35.353	5.795	114.465	10.594	0.080	26.809	116.602	5.288	281.408	<4.704	0.639	249.901

Element	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La
Isotopic Mass	89	90	93	95	111	118	121	133	137	139
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
H0429 1	5.379	1.614	0.322	<0.398	<0.715	21.979	<0.122	0.384	9.375	0.599
H0429 2	0.375	0.798	0.266	<0.733	<0.779	24.459	0.301	0.115	6.474	1.512
H0429 3	0.715	0.410	0.193	<0.541	<0.570	16.049	0.146	0.131	7.068	1.631
H0429 4	5.058	3.817	0.375	<0.234	<0.510	20.400	<0.284	3.021	31.014	0.320
H0429 5	5.262	1.018	0.230	<0.672	<0.973	9.009	<0.098	0.459	15.389	0.564
H0432 1	<0.132	<0.443	0.273	<0.740	<1.163	91.946	<0.248	0.336	4.790	0.825
H0432 2	<0.133	1.088	0.191	<0.726	<1.303	102.918	<0.201	0.392	6.580	1.110
H0432 3	0.116	1.737	0.270	<0.460	<1.003	126.584	<0.250	0.179	4.864	0.660
H0432 4	<0.129	<0.613	0.110	<0.721	<0.926	50.518	0.303	0.350	7.114	1.666
H0432 5	0.279	1.454	0.248	<0.597	<1.359	125.320	0.224	1.393	7.518	0.984
HR-1 1	5.633	2.344	<0.222	<0.621	<1.547	20.303	<0.181	7.795	4.109	3.745
HR-1 2	0.873	1.364	0.148	<0.815	<1.345	25.105	1.672	4.257	2.529	0.767
HR-1 3	0.855	0.565	<0.150	<0.264	<0.495	22.678	0.547	6.407	2.785	0.716
HR-1 4	7.292	1.134	<0.124	<0.559	<1.219	10.738	0.285	24.619	8.694	0.476
HR-1 5	14.345	0.832	0.239	<0.651	<1.516	20.473	0.230	20.862	10.263	1.342
HR-3 1	<0.186	<0.750	1.015	<1.066	<0.811	81.512	0.512	0.108	4.816	0.264
HR-3 2	<0.236	<0.554	1.340	<0.865	<1.695	76.191	0.548	<0.040	2.719	0.514
HR-3 3	0.151	0.516	<0.201	<0.605	<1.601	2.626	0.613	0.698	39.456	0.272
HR-3 4	<0.204	0.666	<0.146	<0.975	<1.260	0.517	<0.233	<0.076	9.129	0.035
HR-3 5	0.230	0.636	0.099	<0.944	<1.361	6.561	0.733	0.568	16.482	0.303
HR-4 1	<0.148	<0.399	0.642	<0.404	<0.964	47.843	0.309	2.018	320.088	1.143
HR-4 2	<0.109	<0.336	0.406	0.184	0.354	51.157	0.137	1.824	115.366	0.790
HR-4 3	0.274	0.328	0.434	<0.381	<0.748	27.548	0.259	5.962	31.186	0.203
HR-4 4	<0.137	<0.421	0.256	<0.620	<1.218	9.651	<0.158	0.136	23.624	0.060
HR-4 5	<0.182	<0.241	0.147	<0.252	<1.164	29.602	0.138	6.505	11.080	0.546

Element	Ce	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Isotopic Mass	**140**	**141**	**146**	**147**	**153**	**172**	**175**	**181**	**182**	**208**	**209**	**232**	**238**
measurement	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
H0429 1	0.791	0.126	0.608	0.264	0.129	0.833	0.126	0.045	0.082	4.698	0.134	0.020	0.064
H0429 2	1.483	0.161	0.407	<0.084	0.074	<0.045	0.009	0.068	<0.066	23.409	0.023	0.022	0.030
H0429 3	1.612	0.169	0.402	<0.149	0.094	0.163	0.017	0.041	<0.036	8.757	0.027	0.019	<0.011
H0429 4	0.716	0.171	0.924	0.361	0.127	0.854	0.135	0.030	0.043	2.939	0.157	0.033	0.054
H0429 5	0.673	0.101	0.606	0.243	0.140	0.862	0.119	0.035	<0.032	4.576	0.068	<0.010	0.017
H0432 1	1.012	0.047	<0.192	<0.074	0.053	0.034	<0.012	0.036	<0.053	6.433	<0.014	<0.018	<0.011
H0432 2	1.214	0.078	<0.111	<0.117	0.072	<0.066	<0.009	0.054	0.091	7.771	0.019	0.035	0.011
H0432 3	0.879	0.042	<0.131	<0.089	0.053	0.058	0.015	0.051	0.112	11.100	<0.028	0.016	<0.127
H0432 4	1.873	0.120	0.334	<0.100	0.077	<0.088	0.006	<0.010	0.063	15.134	0.026	<0.014	<0.009
H0432 5	1.032	0.090	0.310	<0.176	0.054	0.091	0.023	0.032	<0.064	7.371	0.009	0.016	<0.009
HR-1 1	5.292	0.379	1.165	0.280	0.135	0.903	0.134	0.023	0.268	6.865	0.039	1.192	0.057
HR-1 2	0.968	0.063	0.190	<0.173	0.030	0.162	0.033	0.091	0.122	64.972	0.053	0.041	<0.011
HR-1 3	0.857	0.070	0.242	0.059	0.034	0.210	0.036	0.049	0.401	11.058	0.093	0.019	<0.794
HR-1 4	0.941	0.146	0.640	0.308	0.131	1.057	0.182	0.012	3.073	7.827	0.022	0.022	0.021
HR-1 5	2.627	0.288	1.464	0.765	0.314	2.068	0.313	0.048	4.122	5.103	0.030	0.102	0.039
HR-3 1	0.278	0.069	<0.183	<0.139	<0.058	<0.083	<0.021	1.889	0.094	22.869	0.033	<0.027	0.034
HR-3 2	0.551	0.073	0.236	<0.120	0.043	<0.077	<0.006	2.010	<0.058	24.062	<0.028	<0.014	<0.021
HR-3 3	0.087	0.033	0.143	<0.141	<0.047	<0.078	<0.010	<0.026	0.039	21.358	0.096	0.013	0.034
HR-3 4	<0.038	<0.040	<0.206	<0.104	<0.030	<0.031	<0.023	0.017	<0.068	8.431	<0.022	<0.013	<0.009
HR-3 5	0.214	0.068	0.185	<0.070	<0.048	0.045	<0.017	0.041	<0.057	33.592	0.080	0.011	0.073
HR-4 1	1.639	0.135	0.280	0.070	0.128	0.026	<0.010	0.593	<0.023	27.179	0.020	<0.015	<0.012
HR-4 2	0.884	0.072	0.184	0.040	0.095	<0.040	<0.013	0.485	0.055	11.464	<0.017	0.017	0.008
HR-4 3	0.197	0.022	<0.087	<0.125	0.035	0.055	0.011	0.154	0.315	12.264	0.045	0.079	0.040
HR-4 4	0.101	<0.021	<0.163	<0.106	<0.025	<0.045	<0.013	0.049	0.161	13.727	0.030	0.029	0.006
HR-4 5	0.810	0.078	0.152	0.082	0.062	<0.056	0.010	0.122	0.061	8.243	0.020	0.032	0.009

Element	Li	Be	B	Al_2O_3	SiO_2	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As	Rb	Sr
Isotopic Mass	7	9	10	27	29	45	51	52	55	59	60	63	66	75	85	88
measurement	ppm	ppm	ppm	wt%	wt%	ppm	ppm	ppm	wt%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
HRT-1 1	56.349	<28.191	16272.739	32.436	35.375	17.374	235.769	<10.852	0.067	40.321	58.199	8.323	119.867	<4.691	3.217	17.354
HRT-1 2	40.885	22.337	17002.644	31.581	35.375	7.604	275.049	<8.208	0.038	38.823	57.528	<2.936	44.695	<6.099	<0.332	378.934
HRT-1 3	38.084	18.254	15156.553	27.656	35.375	22.995	296.649	15.726	0.034	32.051	126.436	<2.717	39.349	<5.096	84.861	262.374
HRT-1 4	39.892	22.331	14313.227	26.937	35.375	19.667	235.082	46.600	0.031	29.966	133.268	<3.771	33.231	<3.208	131.619	242.535
HRT-1 5	69.075	<16.016	17584.570	30.740	35.375	15.539	209.720	<8.412	0.078	38.880	42.858	4.104	175.517	<4.655	<0.522	28.859
HRT-3 1	41.139	31.137	8371.036	28.455	35.112	17.359	267.773	646.518	0.050	28.707	131.578	<3.243	73.800	<8.715	1.097	88.020
HRT-3 2	67.149	33.728	7602.268	26.941	35.112	23.278	271.005	791.257	0.063	30.059	146.387	<2.865	72.983	<5.092	5.830	63.324
HRT-3 4	82.261	27.922	5268.522	20.278	35.112	25.959	222.504	716.646	0.061	21.949	114.586	<2.314	60.669	<4.099	14.036	44.137
HRT-3 5	94.554	<25.816	5202.733	21.002	35.112	41.235	245.742	295.917	0.083	24.605	113.559	3.212	74.709	<4.968	21.831	49.197
HRT-3 6	22.811	<14.139	2926.405	12.264	35.112	7.750	111.719	346.299	0.027	12.243	59.373	<2.028	33.777	<4.015	0.870	30.411
HRT-3 7	71.734	28.686	6077.880	25.985	35.112	27.987	249.309	373.807	0.066	27.616	154.606	<3.727	76.854	<6.661	10.901	64.548
HRT-6 1	42.053	30.022	106110.044	28.741	36.400	33.674	375.555	238.353	0.050	21.472	49.563	<4.573	112.705	<5.856	<0.391	402.792
HRT-6 2	45.232	16.246	######	24.532	36.400	19.565	286.911	244.652	0.186	9.787	40.381	<3.030	157.628	<3.164	<0.211	287.352
HRT-6 3	37.105	<19.889	61026.415	27.582	36.400	20.955	338.507	294.431	0.045	17.151	47.730	<3.495	112.990	<5.595	<0.295	328.412
HRT-6 4	41.740	29.157	######	29.031	36.400	29.444	361.626	267.803	0.049	23.990	45.045	<3.459	109.124	<3.027	<0.319	401.504
HRT-6 5	39.550	<24.061	######	29.373	36.400	23.714	337.051	186.491	0.047	20.963	34.040	<2.963	106.185	<3.767	<0.424	332.527
MO-2 1	161.623	43.294	18530.703	30.994	33.638	19.247	81.215	164.710	0.230	21.078	21.819	<4.440	648.569	<5.245	<0.404	51.945
MO-2 2	177.997	51.377	18644.633	30.445	33.638	18.699	68.853	149.398	0.229	19.602	17.681	26.448	644.447	<3.175	47.727	47.924
MO-2 3	119.710	27.339	19553.008	30.527	33.638	15.442	76.568	69.496	0.223	20.111	16.787	3.926	609.401	<6.741	1.495	50.357
MO-2 4	129.869	20.371	######	30.432	33.638	15.225	74.972	73.778	0.219	20.799	18.445	4.038	624.617	<4.816	4.999	48.974
MO-2 5	115.542	24.857	######	31.069	33.638	15.168	71.369	18.722	0.211	15.201	20.171	19.556	594.731	<4.820	20.409	50.393
MO-3 1	57.888	16.696	15229.306	28.738	35.334	58.773	321.910	1166.124	0.061	42.546	243.408	<2.525	88.892	<5.697	<0.250	23.125
MO-3 2	108.875	18.191	14000.300	28.673	35.334	27.521	95.050	1297.536	0.105	33.598	223.046	<2.350	362.589	<3.916	<0.206	31.964
MO-3 3	79.123	17.748	14061.355	29.831	35.334	30.184	80.467	737.299	0.107	33.924	211.809	<2.741	349.047	<5.181	<0.287	33.495
MO-3 4	312.052	<12.633	38.610	23.616	35.334	17.286	104.233	1225.842	0.327	101.686	400.589	2.069	411.296	<2.718	1.128	0.495
MO-3 5	341.694	<14.259	<44.909	23.624	35.334	19.203	123.895	2082.226	0.328	99.515	387.071	<1.861	389.735	<3.222	0.765	0.431

Element	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La
Isotopic Mass	89	90	93	95	111	118	121	133	137	139
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
HRT-1 1	<0.168	<0.488	0.189	0.318	<1.009	211.074	0.302	0.214	<0.270	0.032
HRT-1 2	<0.136	<0.254	<0.161	<0.606	<1.093	<0.598	<0.245	<0.041	3.816	0.131
HRT-1 3	<0.181	<0.394	<0.136	<0.333	<0.804	2.686	0.178	4.881	33.535	0.149
HRT-1 4	<0.152	<0.499	<0.084	<0.682	<1.226	1.934	<0.162	8.027	60.073	0.092
HRT-1 5	<0.206	<0.543	0.328	<0.788	<0.926	232.526	0.323	0.104	0.354	0.118
HRT-3 1	<0.335	<0.991	<0.300	<1.641	<0.698	40.675	0.267	1.626	<1.991	1.635
HRT-3 2	1.622	0.383	<0.257	<1.226	<0.976	41.671	<0.220	9.478	1.596	0.906
HRT-3 4	1.435	<0.494	<0.147	<0.749	<0.872	26.299	<0.637	16.462	1.238	0.678
HRT-3 5	2.574	0.826	<0.143	0.215	<0.590	50.298	0.602	28.415	2.804	0.731
HRT-3 6	0.326	<0.309	<0.097	<0.495	<0.857	14.908	0.748	0.639	1.105	0.492
HRT-3 7	1.423	<0.396	0.125	<0.853	<2.407	47.927	0.402	17.253	1.360	0.973
HRT-6 1	0.700	293.834	0.289	<1.056	<0.953	43.390	<0.177	<0.049	1.228	0.753
HRT-6 2	0.578	107.140	0.200	<0.778	<1.142	47.044	<14.855	<5.748	0.664	0.621
HRT-6 3	2.785	69.257	0.165	<0.528	<0.585	59.265	<0.174	<0.045	1.314	3.353
HRT-6 4	<0.200	23.636	<0.212	<1.179	<1.139	36.009	0.149	0.103	1.375	0.834
HRT-6 5	0.227	22.566	<0.101	<0.533	<0.590	29.226	<0.227	0.075	0.955	0.727
MO-2 1	0.238	<0.737	0.440	<0.862	<1.735	33.158	<0.330	<0.092	0.496	7.961
MO-2 2	0.413	0.538	0.660	<0.617	<2.046	38.980	0.240	2.895	10.320	8.539
MO-2 3	0.295	<0.679	0.410	<0.410	<1.405	38.296	2.045	<0.091	0.598	8.094
MO-2 4	0.184	<0.448	0.377	<0.762	<0.636	38.118	<0.296	0.267	2.147	8.357
MO-2 5	0.182	<0.530	0.273	<0.467	0.232	42.652	<0.189	1.204	2.780	7.325
MO-3 1	<0.192	4.207	0.107	<0.507	<1.377	54.880	<0.122	<0.078	<0.743	0.452
MO-3 2	0.356	<0.397	<0.166	0.305	<1.465	45.076	<0.247	0.060	0.621	1.917
MO-3 3	0.463	<0.394	0.195	<0.622	<1.127	40.636	0.182	0.096	0.739	1.210
MO-3 4	0.250	<0.096	0.178	<0.389	<0.857	0.998	0.148	1.821	3.518	0.059
MO-3 5	0.259	<0.358	<0.094	<0.482	<0.335	0.917	0.093	1.783	4.207	0.097

Element	Ce	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Isotopic Mass	**140**	**141**	**146**	**147**	**153**	**172**	**175**	**181**	**182**	**208**	**209**	**232**	**238**
measurement	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
HRT-1 1	<0.043	0.008	<0.155	<0.190	0.051	<0.058	<0.009	0.089	<0.040	5.977	0.026	0.008	0.024
HRT-1 2	0.168	0.030	<0.139	<0.069	0.017	<0.029	0.001	<0.011	<0.072	5.689	<0.014	<0.007	<0.016
HRT-1 3	0.192	<0.022	<0.102	<0.090	0.030	<0.046	<0.011	0.019	<0.081	8.140	0.011	<0.009	0.040
HRT-1 4	0.167	<0.023	0.067	<0.223	<0.034	0.026	0.007	<0.010	<0.070	4.621	<0.017	<0.013	<0.010
HRT-1 5	0.124	0.020	0.125	<0.064	0.055	<0.066	<0.008	0.109	0.296	7.403	0.023	0.008	<0.011
HRT-3 1	1.963	0.116	0.278	<0.122	0.119	<0.036	<0.016	0.017	<0.069	8.462	<0.025	<0.031	<0.014
HRT-3 2	1.235	0.084	0.288	<0.277	0.104	0.237	0.036	0.020	0.086	6.397	<0.024	<0.009	0.026
HRT-3 4	0.845	0.083	0.247	<0.089	0.080	0.216	0.029	0.011	0.109	18.473	0.092	<0.007	0.028
HRT-3 5	1.151	0.124	0.492	0.171	0.107	0.315	0.053	0.026	0.375	19.207	0.058	0.012	0.098
HRT-3 6	0.716	0.052	0.128	<0.084	0.040	0.048	<0.011	0.007	0.034	41.069	<0.023	<0.007	<0.006
HRT-3 7	1.307	0.115	0.375	0.096	0.088	0.209	0.021	0.019	0.206	14.970	0.027	0.006	0.064
HRT-6 1	1.636	0.204	0.922	<0.153	0.537	0.363	0.142	0.028	0.059	16.388	<0.015	0.031	0.117
HRT-6 2	1.544	0.202	0.917	0.157	0.345	0.172	0.065	<0.051	<0.036	12.531	0.017	0.019	0.041
HRT-6 3	8.771	1.333	6.592	1.733	0.872	0.151	0.043	0.045	<0.050	19.033	0.022	0.723	0.322
HRT-6 4	1.707	0.224	0.991	<0.223	0.597	<0.072	0.013	0.025	0.322	14.339	0.133	0.021	0.020
HRT-6 5	1.605	0.167	0.788	<0.117	0.451	0.072	0.017	0.017	0.253	11.113	0.061	0.027	0.037
MO-2 1	12.618	1.093	3.400	0.456	0.204	<0.058	<0.012	0.172	<0.068	13.892	<0.032	<0.014	<0.015
MO-2 2	13.490	1.464	4.723	0.651	0.248	<0.050	0.008	0.259	<0.067	13.194	0.015	0.141	0.091
MO-2 3	12.852	1.300	3.437	0.440	0.230	<0.057	<0.017	0.138	0.085	15.552	0.017	0.100	0.030
MO-2 4	12.733	1.141	3.709	0.523	0.212	<0.088	<0.013	0.119	<0.078	14.182	<0.021	0.038	0.019
MO-2 5	11.139	1.114	3.212	0.386	0.226	<0.038	<0.008	0.090	<0.037	12.192	<0.018	<0.023	0.020
MO-3 1	0.853	0.098	0.186	<0.176	0.059	<0.050	<0.012	0.129	<0.042	9.488	0.022	<0.017	0.021
MO-3 2	3.815	0.413	1.306	0.295	0.098	0.048	<0.013	0.072	<0.041	12.325	<0.026	0.008	0.018
MO-3 3	2.404	0.260	0.735	0.224	0.144	0.113	0.014	0.089	0.153	12.767	<0.021	0.017	0.017
MO-3 4	0.026	<0.016	<0.138	<0.054	<0.017	<0.023	<0.007	0.056	<0.039	5.931	<0.022	0.059	0.015
MO-3 5	0.029	<0.020	<0.075	<0.104	<0.021	<0.020	<0.007	0.017	<0.020	1.361	0.385	0.091	0.020

Element	Li	Be	B	Al_2O_3	SiO_2	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As	Rb	Sr
Isotopic Mass	7	9	10	27	29	45	51	52	55	59	60	63	66	75	85	88
measurement	ppm	ppm	ppm	wt%	wt%	ppm	ppm	ppm	wt%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
MO-5 1	38.463	<22.992	7328.316	20.410	37.268	24.536	163.070	379.173	0.109	29.625	179.441	<2.079	34.302	<4.682	1.226	65.188
MO-5 2	60.855	<14.656	12143.571	31.781	37.268	7.213	126.604	380.688	0.031	29.517	188.963	<2.693	21.343	<2.207	0.525	83.518
MO-5 3	39.957	<13.171	9921.251	27.702	37.268	12.990	150.401	546.468	0.055	29.349	193.867	<1.911	27.296	<3.921	1.241	70.124
MO-5 4	34.787	<19.444	11644.812	32.214	37.268	4.666	130.971	372.171	0.022	28.187	201.347	<2.956	21.142	<4.465	<0.366	105.418
MO-5 5	35.787	<18.731	11562.622	33.432	37.268	6.126	168.515	501.297	0.023	28.890	177.520	<2.672	25.360	<4.308	<0.258	114.719
MO-6 1	124.448	<25.142	12458.604	31.699	37.188	21.650	54.602	25.687	0.199	22.619	181.299	<3.002	450.563	<5.960	45.815	32.261
MO-6 2	70.542	<25.658	14388.305	35.595	37.188	<5.223	42.454	233.449	0.029	31.030	123.873	<3.535	40.018	<6.747	<0.796	137.441
MO-6 3	84.357	23.843	14015.125	31.844	37.188	5.464	37.435	104.804	0.033	32.102	150.788	<4.247	32.792	<5.675	<0.228	102.249
MO-6 4	85.450	<21.025	9436.809	20.907	37.188	11.333	39.025	46.393	0.107	15.535	87.405	<2.942	289.835	<5.401	17.297	24.562
MO-6 5	72.761	<19.170	15577.781	30.931	37.188	4.174	50.086	153.757	0.030	27.935	95.027	<2.498	35.718	<3.744	<0.297	111.535
MO-7 1	227.300	49.737	12956.511	26.771	35.489	11.799	32.122	61.621	0.313	14.008	64.277	15.472	791.366	<9.619	113.518	19.259
MO-7 2	239.711	53.498	11852.726	29.568	35.489	10.015	24.939	54.266	0.345	14.264	59.986	20.329	688.659	<5.345	1.417	24.131
MO-7 3	224.740	46.216	12030.184	28.979	35.489	8.658	22.339	48.035	0.339	14.908	59.847	12.834	856.151	<11.914	<0.464	21.479
MO-7 4	239.877	54.749	11725.092	29.297	35.489	11.193	29.131	46.319	0.344	14.158	50.838	3.619	774.440	<5.545	0.280	20.805
MO-7 5	220.890	41.338	9065.199	27.712	35.489	9.937	32.033	40.121	0.291	13.536	61.764	49.966	699.390	<2.226	1.017	19.303
MO-7 6	264.757	45.981	10778.425	29.736	35.489	10.767	25.865	42.719	0.341	15.674	54.856	5.010	953.607	<4.991	<0.345	20.666
OZ-2 1	45.202	<24.252	11495.389	26.681	35.207	10.138	344.423	315.086	0.045	40.901	179.169	<2.363	44.182	<5.764	0.573	857.140
OZ-2 2	52.824	30.345	12060.706	28.019	35.207	6.999	239.696	1995.882	0.035	42.669	199.970	<2.092	26.809	<5.974	0.427	564.667
OZ-2 3	59.237	28.253	12871.066	28.188	35.207	36.396	220.107	933.419	0.043	45.361	148.608	<2.497	73.851	<5.327	<0.298	314.502
OZ-2 4	49.720	33.908	13437.511	27.974	35.207	10.028	357.506	711.092	0.038	41.571	149.176	<2.640	27.465	<6.618	0.535	1239.961
OZ-2 5	37.188	76.406	14012.467	25.963	35.207	8.888	348.352	373.767	0.040	40.235	163.122	<3.035	28.859	<5.743	0.514	1168.846
OZ-3 1	53.886	49.248	11054.911	28.088	35.574	10.781	207.858	<7.537	0.035	49.232	220.852	12.978	46.184	<6.014	0.481	942.845
OZ-3 2	64.135	38.318	11150.900	28.290	35.574	6.099	168.409	<8.911	0.038	52.194	199.409	5.122	38.055	<4.857	<0.393	1134.276
OZ-3 3	57.393	26.827	11849.631	28.959	35.574	7.224	200.367	<7.864	0.036	54.325	166.275	<3.226	34.014	<6.776	<0.557	844.847
OZ-3 4	60.825	27.695	12201.263	32.302	35.574	17.071	149.305	<11.675	0.054	75.490	124.009	<2.308	99.755	<4.389	<0.305	118.180
OZ-3 5	68.863	18.438	8037.332	18.437	35.574	7.753	118.757	16.013	0.033	32.726	111.619	7.475	79.008	<4.052	0.451	378.867

Element	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La
Isotopic Mass	89	90	93	95	111	118	121	133	137	139
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
MO-5 1	2.827	1.362	<0.146	<0.303	<0.717	16.853	0.181	0.535	1.271	0.506
MO-5 2	0.414	<0.456	<0.066	<0.646	<1.264	13.526	<0.240	0.484	1.162	0.518
MO-5 3	1.960	0.324	<0.174	<0.446	<0.620	16.726	<0.165	1.324	1.259	0.641
MO-5 4	<0.136	<0.439	<0.148	<0.745	<0.532	12.532	0.299	0.071	0.457	0.576
MO-5 5	<0.174	<0.527	<0.173	<0.949	<0.654	14.541	<0.209	<0.046	0.714	0.766
MO-6 1	0.812	0.614	<0.151	<1.207	<1.576	40.635	7.891	3.163	9.542	3.102
MO-6 2	<0.269	<0.570	1.191	<1.812	0.194	38.590	<0.434	<0.078	1.804	4.387
MO-6 3	18.766	499.227	6.367	0.465	<1.398	140.895	0.485	<0.089	2.071	2.552
MO-6 4	0.328	0.815	0.206	<0.935	<0.908	23.574	<0.222	1.118	6.058	2.386
MO-6 5	0.315	1.667	0.906	<0.584	<0.950	34.250	0.440	<0.053	1.618	3.031
MO-7 1	1.221	<0.781	0.843	0.099		33.781	<0.368	7.650	2.369	5.979
MO-7 2	1.065	0.749	0.770	<1.140		24.969	0.395	0.231	1.269	5.814
MO-7 3	0.518	<0.583	0.806	<1.359		23.801	21.860	0.094	<0.333	3.920
MO-7 4	0.179	<0.525	0.760	<0.557		27.168	0.291	0.076	0.360	5.504
MO-7 5	1.388	0.647	0.777	<0.353		21.810	8.533	0.447	1.137	4.882
MO-7 6	<0.215	<0.372	0.806	<0.731		24.407	2.374	<0.059	<0.280	5.685
OZ-2 1	<0.145	0.762	0.260	<0.655	<0.907	111.829	0.255	0.065	6.976	0.519
OZ-2 2	<0.110	1.167	<0.179	<0.596	<1.272	105.777	0.195	0.081	4.095	0.294
OZ-2 3	<0.146	<0.349	0.273	<0.848	<0.648	91.631	0.355	<0.042	1.544	0.537
OZ-2 4	<0.167	0.819	1.736	<0.666	<0.658	214.115	0.395	<0.039	6.937	0.860
OZ-2 5	<0.139	<0.390	0.281	<0.758	<1.744	108.378	0.223	<1.293	6.354	1.311
OZ-3 1	0.119	<0.538	0.290	<0.613	<1.242	122.707	0.196	0.134	2.366	0.305
OZ-3 2	<0.249	<0.341	0.362	<0.578	<1.612	105.378	<0.227	0.062	2.265	0.105
OZ-3 3	<0.132	<0.499	<0.179	<0.577	<0.824	39.743	<0.209	0.046	1.975	0.178
OZ-3 4	<0.343	<0.392	0.521	<0.861	<1.818	188.676	0.222	<0.040	<0.282	<0.038
OZ-3 5	<0.124	<0.270	0.322	<0.615	<0.637	81.652	<0.145	0.110	1.141	0.135

Element	Ce	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Isotopic Mass	140	141	146	147	153	172	175	181	182	208	209	232	238
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
MO-5 1	0.683	0.084	0.403	0.092	0.079	0.522	0.078	<0.012	<0.043	6.548	0.146	0.010	0.019
MO-5 2	0.417	0.029	<0.103	<0.090	0.054	0.082	0.010	<0.006	<0.047	6.813	0.066	<0.006	<0.008
MO-5 3	0.571	0.056	0.311	0.123	0.072	0.235	0.040	<0.008	<0.045	6.793	0.118	<0.006	0.021
MO-5 4	0.660	0.032	<0.098	0.010	0.054	<0.044	<0.014	<0.015	<0.044	8.482	<0.022	<0.012	<0.007
MO-5 5	0.655	0.033	<0.104	<0.157	0.054	<0.047	<0.011	<0.009	<0.047	8.537	<0.022	0.002	0.001
MO-6 1	5.478	0.563	1.485	0.281	0.087	0.115	0.019	0.164	0.237	235.094	0.078	0.058	0.047
MO-6 2	6.723	0.573	2.180	0.366	<0.052	0.060	0.016	2.215	0.059	11.270	<0.033	0.058	<0.018
MO-6 3	4.026	0.415	1.371	0.537	0.057	4.609	0.736	13.127	0.089	17.621	0.068	4.906	11.277
MO-6 4	4.137	0.391	1.289	0.229	0.042	<0.059	<0.013	0.146	<0.087	8.992	<0.021	0.022	0.042
MO-6 5	4.279	0.391	1.390	0.218	0.035	0.085	0.015	1.319	0.073	8.831	0.026	0.064	0.102
MO-7 1	13.699	1.248	3.517	0.850	0.075	0.184	0.019	0.873	0.108	24.213	3.528	0.045	0.050
MO-7 2	10.413	1.311	3.640	0.742	0.110	0.206	0.025	0.966	0.062	22.035	3.509	0.100	0.061
MO-7 3	6.921	0.730	1.759	0.394	0.091	0.102	0.013	1.110	0.181	1430.163	0.580	0.033	0.029
MO-7 4	9.767	0.941	2.530	0.455	0.068	<0.066	<0.006	1.179	0.050	16.484	8.003	0.008	0.080
MO-7 5	8.566	0.999	2.470	0.597	0.095	0.257	0.032	0.757	0.122	136.245	1.961	0.121	0.112
MO-7 6	10.746	1.004	2.618	0.372	0.084	<0.054	<0.011	1.144	0.078	104.723	2.372	<0.011	0.006
OZ-2 1	0.441	0.027	<0.091	<0.096	0.032	<0.089	<0.006	0.132	0.256	26.657	0.853	0.020	<0.019
OZ-2 2	0.278	<0.027	<0.082	<0.062	0.037	<0.027	<0.010	0.049	0.108	20.488	0.103	0.009	<0.018
OZ-2 3	0.827	0.044	<0.163	<0.069	<0.046	<0.094	<0.011	0.051	0.220	18.824	0.605	0.013	<0.016
OZ-2 4	0.799	0.043	0.149	<0.070	0.034	<0.030	<0.006	1.707	0.314	25.693	1.064	0.019	<0.015
OZ-2 5	1.353	0.079	0.275	<0.155	0.062	<0.075	<0.013	0.174	<0.067	20.504	<0.019	<0.007	<0.011
OZ-3 1	0.239	<0.017	<0.110	<0.097	0.045	<0.041	<0.009	0.103	1.244	19.929	0.030	0.012	0.014
OZ-3 2	0.129	<0.023	<0.074	<0.185	0.032	<0.033	<0.012	0.076	0.762	18.006	<0.030	0.014	0.015
OZ-3 3	0.190	<0.027	<0.074	<0.079	<0.025	0.014	<0.014	0.021	0.088	18.116	<0.022	<0.013	<0.007
OZ-3 4	0.029	0.007	<0.079	<0.232	<0.042	<0.050	<0.018	0.902	<0.049	7.333	<11.789	<0.014	<2.802
OZ-3 5	0.132	<0.017	<0.080	<0.118	0.044	<0.051	<0.008	0.228	0.518	10.226	1.041	0.012	<0.015

Element	Li	Be	B	Al_2O_3	SiO_2	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As	Rb	Sr
Isotopic Mass	7	9	10	27	29	45	51	52	55	59	60	63	66	75	85	88
measurement	ppm	ppm	ppm	wt%	wt%	ppm	ppm	ppm	wt%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
OZ-5 1	261.337	49.598	15682.595	29.985	34.887	11.756	9.229	<8.689	0.438	2.243	<6.574	2.636	1214.661	<5.033	<0.230	10.514
OZ-5 2	249.299	64.506	16565.519	29.966	34.887	15.091	5.018	<7.232	0.443	1.912	<6.299	6.453	1238.346	<6.180	<0.420	12.088
OZ-5 3	204.950	20.953	19706.775	30.832	34.887	9.446	12.191	<7.690	0.361	2.751	<6.565	3.941	1151.175	<6.191	0.683	12.578
OZ-5 4	179.999	32.027	18559.794	30.621	34.887	8.090	8.843	<7.274	0.402	1.776	<7.529	3.143	1218.185	<5.282	<0.277	14.264
OZ-5 5	243.827	53.647	17190.159	29.317	34.887	10.611	4.390	<26.117	0.421	<1.552	<7.277	3.520	1235.024	<6.986	<0.316	12.160
SUM-1 1	40.902	<29.476	14554.115	26.728	34.721	47.592	280.890	57.274	0.031	31.903	336.599	2.948	21.887	<4.760	<0.382	519.930
SUM-1 2	62.301	42.823	11801.528	25.442	34.721	29.053	237.711	45.072	0.041	33.854	190.622	17.298	72.273	8.336	0.349	433.449
SUM-1 3	118.090	42.395	12623.160	26.647	34.721	24.789	246.397	92.421	0.065	51.390	372.492	2.864	159.716	<4.684	<0.364	313.975
SUM-1 4	81.072	30.622	11742.461	26.547	34.721	30.231	370.134	12.116	0.058	48.415	236.991	12.024	91.477	<6.794	0.261	366.460
SUM-1 5	87.110	27.392	10472.403	24.975	34.721	16.814	222.497	22.681	0.046	36.430	168.307	53.329	83.809	21.186	0.575	302.339
T0640 1	77.428	28.662	8537.784	26.419	35.070	20.340	216.572	438.093	0.059	28.806	142.916	<3.729	66.276	<5.597	7.846	52.112
T0640 2	48.704	24.173	9031.770	27.287	35.070	20.587	226.593	362.840	0.055	28.827	117.726	<2.426	66.595	<6.125	0.761	67.419
T0640 3	130.558	<19.220	8643.247	25.851	35.070	25.502	237.402	468.219	0.064	32.773	142.734	9.987	63.164	<5.342	21.153	50.019
T0640 4	112.444	26.159	9684.022	27.882	35.070	34.610	247.406	506.094	0.059	33.068	150.672	4.689	68.150	<4.278	7.282	54.985
T0640 5	93.247	21.391	7250.550	21.617	35.070	15.225	166.391	240.579	0.055	24.368	99.648	20.315	54.472	<4.571	7.805	49.188
T0640 6	121.655	32.487	6855.128	19.875	35.070	98.479	249.513	330.309	0.764	107.660	309.139	56.598	203.222	<4.971	24.541	53.969
T0640 7	64.432	24.065	9172.124	26.580	35.070	29.446	203.899	374.179	0.046	27.956	109.351	<3.435	56.124	<6.797	8.201	73.288
T0642 1	70.378	30.094	9416.874	29.368	36.005	7.900	298.941	<6.432	0.049	43.740	31.159	<2.424	80.219	<4.702	<0.283	132.349
T0642 2	46.557	24.705	9763.965	29.991	36.005	15.862	272.255	<6.785	0.049	36.912	77.082	4.426	77.788	<5.553	<0.334	161.194
T0642 3	52.615	32.200	10346.563	30.150	36.005	9.914	325.769	<13.529	0.053	41.287	33.832	4.853	84.784	<7.104	0.205	172.524
T0642 4	57.536	32.252	10850.262	30.346	36.005	10.890	282.867	<6.734	0.049	42.822	33.728	<2.164	77.954	<5.377	<0.357	145.579
T0642 5	51.264	30.612	11559.239	30.564	36.005	10.633	289.174	<7.578	0.051	39.903	76.521	10.350	72.253	<6.933	<0.238	173.419
T0643 1	109.830	<40.616	10032.014	28.667	35.611	20.841	243.760	21.495	0.317	27.669	37.413	9.189	101.068	<6.994	9.660	89.104
T0643 2	102.651	35.060	6636.474	19.816	35.611	12.621	279.294	<7.539	0.219	13.773	24.963	10.850	111.118	<5.001	3.469	84.375
T0643 3	76.575	34.747	9252.895	27.087	35.611	19.322	361.362	<7.139	0.047	27.330	28.611	<21.551	103.102	<10.631	<0.359	118.957
T0643 4	110.437	42.474	9008.891	27.774	35.611	15.548	382.390	<6.405	0.057	25.411	26.281	11.727	115.167	<4.540	<0.215	110.200
T0643 5	107.959	<38.415	8835.000	27.838	35.611	18.185	346.418	<14.398	0.055	24.616	32.415	<5.188	115.764	<7.536	<0.601	113.234

Element	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La
Isotopic Mass	89	90	93	95	111	118	121	133	137	139
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
OZ-5 1	<0.207	<0.474	0.680	<0.760	<5.088	24.801	<0.199	<0.044	<0.264	6.681
OZ-5 2	0.205	0.716	0.901	<0.500	<1.522	24.883	<0.131	<0.057	0.075	6.213
OZ-5 3	0.408	<0.436	0.431	<0.352	<0.887	26.314	9.254	0.190	<0.473	5.258
OZ-5 4	<0.107	<0.366	0.620	<1.212	<1.230	30.794	0.189	<0.033	0.041	6.041
OZ-5 5	<0.196	0.439	1.017	<1.159	<1.475	24.957	<0.302	<0.045	<0.226	6.593
SUM-1 1	<0.178	<0.458	0.232	<0.935	<1.858	246.255	0.289	0.095	1.338	0.192
SUM-1 2	<0.160	<0.357	0.218	<0.455	<0.609	154.499	0.438	0.248	0.924	0.234
SUM-1 3	<0.263	<0.483	0.219	<0.529	<1.522	132.754	0.217	0.062	<0.360	0.118
SUM-1 4	0.155	<0.309	0.387	<0.907	<0.871	137.869	0.253	0.095	3.478	0.386
SUM-1 5	0.329	0.514	0.447	0.506	<0.861	74.247	0.230	0.891	2.478	0.229
T0640 1	1.497	7.651	<0.151	<0.771	<0.839	44.954	<0.378	9.494	2.558	1.079
T0640 2	0.978	<0.722	<0.102	<0.634	<0.490	39.778	<0.236	1.062	1.664	0.999
T0640 3	1.610	<0.691	<0.308	<1.792	<1.519	70.083	0.246	25.854	<1.211	0.274
T0640 4	1.238	<0.424	<0.127	<3.772	<0.855	67.521	0.277	7.874	1.056	0.164
T0640 5	2.104	<0.315	<0.220	1.260	<0.768	54.446	0.887	14.511	1.624	0.776
T0640 6	30.865	1.487	0.205	10.407	0.909	77.300	<0.271	43.075	25.188	6.900
T0640 7	0.585	0.424	<0.167	<1.226	<1.539	42.302	<0.137	11.800	1.528	0.760
T0642 1	<0.145	<0.293	<0.072	0.405	0.280	9.652	<0.241	<0.057	2.476	0.068
T0642 2	0.287	0.425	0.122	<0.546	<0.865	26.148	0.474	0.070	5.640	0.242
T0642 3	0.130	<0.334	<0.131	<0.705	<1.744	17.321	0.242	0.071	3.900	0.191
T0642 4	<0.130	<0.407	<0.104	<0.600	<0.810	3.307	0.346	<0.042	2.332	0.049
T0642 5	0.187	<0.332	<0.095	<1.218	<0.906	18.743	1.172	0.087	6.252	0.213
T0643 1	8.376	<0.326	<0.227	<0.891	<1.418	27.007	0.328	3.592	0.880	0.538
T0643 2	4.879	<0.418	<0.164	<0.954	<1.201	61.195	0.306	4.880	2.452	0.359
T0643 3	<0.144	<0.396	<0.158	<0.633	<0.979	57.057	0.281	0.301	0.943	0.080
T0643 4	<0.139	<0.309	<0.221	<0.563	<0.929	67.052	0.327	0.136	0.757	0.110
T0643 5	<0.290	<0.739	<0.259	<0.929	0.776	60.895	<0.478	0.277	0.854	0.104

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Element	Ce	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Isotopic Mass	**140**	**141**	**146**	**147**	**153**	**172**	**175**	**181**	**182**	**208**	**209**	**232**	**238**
measurement	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
OZ-5 1	13.270	1.463	4.009	0.585	0.064	<0.034	<0.017	0.936	<0.065	11.552	<0.033	<0.011	<0.017
OZ-5 2	12.407	1.234	3.689	0.764	0.053	<0.031	<0.015	1.212	<0.068	11.811	0.077	0.206	0.029
OZ-5 3	9.492	0.931	2.674	0.354	0.054	0.050	<0.022	0.454	0.322	533.357	0.166	0.068	<0.015
OZ-5 4	11.425	1.093	2.996	0.471	0.061	<0.030	<0.017	0.554	<0.049	16.484	<0.024	<0.009	<0.016
OZ-5 5	12.772	1.304	3.783	0.507	0.055	<0.063	<0.012	1.484	<0.054	11.917	0.049	0.065	<0.013
SUM-1 1	0.394	0.035	0.121	<0.129	0.046	<0.065	<0.015	0.039	0.267	37.213	0.409	0.008	0.012
SUM-1 2	0.407	0.032	0.099	<0.115	0.045	<0.041	<0.014	0.136	0.813	33.464	1.506	0.016	<0.012
SUM-1 3	0.178	<0.023	0.066	<0.153	0.100	<0.057	0.004	0.272	0.142	14.907	0.116	<0.016	<0.014
SUM-1 4	0.720	0.074	0.294	<0.118	0.055	<0.050	<0.013	0.435	1.005	22.541	4.233	0.030	0.031
SUM-1 5	0.348	0.040	0.121	<0.079	0.076	0.106	0.034	0.240	3.252	11.501	13.840	0.031	0.023
T0640 1	1.275	0.081	0.241	0.116	0.075	0.270	0.044	0.036	0.088	4.936	0.035	<0.011	0.040
T0640 2	1.174	0.079	0.253	<0.192	0.121	0.176	0.026	0.030	0.061	6.016	<9.252	<0.014	0.014
T0640 3	0.413	0.055	0.292	<0.238	0.110	0.183	0.031	0.024	0.286	9.737	0.112	<0.026	0.120
T0640 4	0.426	0.044	0.362	<0.115	0.071	0.188	0.019	<0.026	0.225	11.259	0.061	0.009	0.070
T0640 5	1.160	0.147	0.495	0.126	0.127	0.212	0.032	0.034	0.595	40.946	0.496	<0.016	0.667
T0640 6	18.895	1.865	7.585	2.608	0.416	2.968	0.405	0.049	69.055	10.340	0.202	0.050	4.115
T0640 7	1.103	0.060	0.188	<0.248	0.112	<0.062	<0.012	0.026	0.200	8.637	0.019	<0.013	0.024
T0642 1	0.136	0.025	<0.069	<0.073	<0.029	<0.032	<0.026	<0.013	0.056	7.149	0.036	0.017	<0.015
T0642 2	0.387	0.046	0.158	<0.112	0.077	0.073	0.027	0.036	0.295	17.587	0.036	0.064	0.046
T0642 3	0.307	<0.024	0.144	<0.086	0.074	<0.045	0.012	0.011	0.205	14.581	0.029	0.028	0.028
T0642 4	0.089	<0.026	<0.099	<0.120	0.023	<0.045	<0.008	0.011	0.137	15.292	0.024	0.008	<0.010
T0642 5	0.338	0.037	<0.140	0.011	0.045	<0.093	<0.015	0.015	0.259	76.366	0.053	0.033	0.026
T0643 1	1.163	0.175	0.869	0.433	0.187	0.874	0.152	<0.015	8.545	5.991	<0.046	<0.018	0.024
T0643 2	0.778	0.123	0.554	<0.187	0.188	0.367	0.052	<0.016	4.227	9.173	0.047	0.007	0.020
T0643 3	0.156	<0.029	<0.123	0.006	0.130	<0.047	<0.018	0.014	0.185	7.580	<0.015	<0.015	<0.007
T0643 4	0.205	<0.032	<0.119	<0.137	0.108	0.022	<0.009	0.012	0.576	10.340	<0.020	<0.011	0.009
T0643 5	0.161	<0.027	<0.227	<0.218	0.116	<0.048	<0.040	<0.035	0.199	9.096	<0.025	<0.029	<0.025

Element	Li	Be	B	Al_2O_3	SiO_2	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As	Rb	Sr
Isotopic Mass	7	9	10	27	29	45	51	52	55	59	60	63	66	75	85	88
measurement	ppm	ppm	ppm	wt%	wt%	ppm	ppm	ppm	wt%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
TC-2 1	803.418	19.106	18565.305	28.907	34.648	<3.732	<3.787	<8.636	0.804	<1.768	<6.993	7.537	3937.325	<7.656	7.754	3.340
TC-2 2	813.481	40.493	12828.857	23.140	34.648	<3.048	5.937	<6.855	0.631	1.646	<5.782	6.773	2967.982	<4.487	41.802	4.281
TC-2 3	541.317	22.805	14791.307	29.880	34.648	<4.573	<4.143	<10.487	0.617	<2.159	<9.164	11.234	4937.954	<4.484	11.662	<1.242
TC-2 4	24.908	<3.401	1118.896	2.690	34.648	<1.685	<0.890	<4.224	0.053	<0.629	<2.103	<1.008	295.019	<1.982	0.388	1.331
TC-2 6	1147.858	27.848	11679.877	31.038	34.648	4.144	4.137	<8.388	0.855	2.551	6.131	5.941	3529.098	<4.531	7.252	3.421
TC-2 7	1235.922	<21.645	11573.580	32.396	34.648	<4.239	<1.800	<8.963	1.055	1.813	<5.819	7.376	4010.617	<5.981	0.662	2.243
TH-1 1	26.963	<11.939	<87.322	5.652	35.087	60.467	223.427	375.721	0.163	39.247	161.270	30.217	59.292	<2.821	1.078	4.428
TH-1 2	<11.033	<9.102	<50.486	2.341	35.087	37.380	117.919	200.997	0.150	34.858	123.612	8.606	52.155	<3.882	<0.157	1.312
TH-1 3	16.295	<8.256	<43.625	1.652	35.087	37.516	135.161	451.698	0.135	34.438	147.718	6.170	48.768	<3.501	7.159	1.303
TH-1 4	104.408	63.975	9774.758	30.247	35.087	9.634	226.207	1023.655	0.043	41.604	158.223	4.297	66.232	<6.519	<0.300	196.758
TH-1 5	52.483	57.194	6182.558	22.755	35.087	6.143	72.573	22.285	0.026	26.008	81.987	4.592	46.464	<3.390	62.417	175.708
TH-1 6	28.404	<8.265	<41.214	2.078	35.087	40.364	127.030	394.812	0.135	33.322	137.427	15.472	51.220	<1.443	27.394	1.554
TH-1 7	100.081	31.074	9192.807	30.148	35.087	26.368	247.057	413.728	0.049	39.844	200.218	19.128	70.184	<4.167	0.633	161.209

Element	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La
Isotopic Mass	89	90	93	95	111	118	121	133	137	139
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
TC-2 1	1.090	0.640	2.825	0.571	0.269	85.996	7.164	0.899	1.529	4.853
TC-2 2	1.189	1.021	4.134	<0.372	<0.705	66.899	0.633	4.744	5.486	3.314
TC-2 3	<0.448	<1.855	2.438	<2.304	<1.256	99.863	3.047	2.645	<2.208	3.217
TC-2 4	0.176	0.820	0.185	<0.453	<0.510	5.763	0.320	0.696	0.492	0.257
TC-2 6	1.222	0.606	2.958	<0.350	<1.053	83.833	0.985	0.973	1.463	4.800
TC-2 7	0.464	<0.486	1.669	<0.633	<0.857	85.027	0.520	0.214	<0.389	6.353
TH-1 1	6.356	1.948	0.376	<0.560	<0.551	23.133	0.244	1.156	25.803	0.245
TH-1 2	1.147	0.693	<0.103	<0.472	<0.461	3.338	0.952	0.285	4.625	0.045
TH-1 3	0.940	0.509	<0.151	<0.547	<0.560	5.065	<0.166	1.606	10.976	<0.065
TH-1 4	0.312	0.835	0.861	<0.603	<1.468	183.075	0.530	0.248	3.867	0.169
TH-1 5	<0.152	<0.336	0.253	0.733	<0.599	59.861	<0.180	7.743	141.132	0.068
TH-1 6	1.213	0.980	0.321	<0.548	<0.654	5.677	0.084	6.593	20.335	0.110
TH-1 7	0.185	0.798	0.856	<0.653	<0.776	146.877	8.771	3.931	17.339	0.223

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Element	Ce	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Isotopic Mass	140	141	146	147	153	172	175	181	182	208	209	232	238
measurement	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
TC-2 1	9.866	0.967	2.317	0.417	<0.021	0.300	0.045	0.704	0.466	499.002	0.242	0.100	0.044
TC-2 2	6.867	0.699	1.764	0.407	<0.015	0.307	0.053	1.137	0.121	14.168	0.113	0.092	0.064
TC-2 3	5.475	0.504	0.973	<0.256	<0.053	<0.089	<0.023	0.679	0.096	168.764	0.121	<0.047	0.032
TC-2 4	0.460	0.040	0.106	<0.032	<0.014	0.038	0.005	0.051	<0.019	1.594	<0.014	0.040	0.471
TC-2 6	9.696	0.864	2.305	0.416	<0.038	0.272	0.031	0.875	0.192	63.399	0.137	0.107	0.105
TC-2 7	13.004	1.273	3.053	0.669	<0.040	0.096	<0.014	0.669	<0.069	16.394	0.099	0.042	<0.008
TH-1 1	0.241	0.038	0.167	0.122	0.047	1.210	0.203	0.037	<0.026	3.969	0.144	0.020	0.011
TH-1 2	0.046	<0.022	<0.071	<0.097	<0.020	0.274	0.048	0.014	0.073	0.822	0.051	0.011	0.030
TH-1 3	<0.067	<0.055	<0.115	<0.099	<0.053	0.143	<0.036	<0.048	<0.091	0.549	<0.037	<0.040	<0.034
TH-1 4	0.231	<0.023	<0.102	<0.107	0.072	0.089	0.019	0.546	0.117	16.781	<0.024	0.057	<0.015
TH-1 5	0.127	<0.017	<0.055	<0.058	0.026	<0.054	<0.011	0.173	0.040	7.359	<0.023	0.017	<0.009
TH-1 6	0.098	<0.018	0.051	<0.073	0.012	0.220	0.043	0.019	0.100	0.609	0.056	0.009	0.024
TH-1 7	0.258	0.018	<0.209	<0.091	0.066	<0.054	0.012	0.500	0.272	853.476	0.445	0.063	0.018

APPENDIX D: PEARSON COEFFICIENTS OF TRACE ELEMENTS

This section includes the calculated Pearson correlation coefficients of the trace element concentrations (APPENDIX C). Because many elements analyzed were only at concentration near or below the lower limit of detection, many of those elements have strong correlations; however, those that were always at concentration near or below the lower limit of detection are not useful elements for this study, despite their strong correlations.

	Li	Be	B	Al_2O_3	Sc	V	Cr	MnO	Co	Ni	Cu	Zn	As
Li	1	0.591	0.437	0.347	0.435	0.179	0.408	0.789	0.415	0.399	0.448	0.804	0.317
Be		1	0.743	0.404	0.711	0.619	0.634	0.498	0.714	0.703	0.741	0.584	0.451
B			1	0.252	0.835	0.756	0.725	0.406	0.884	0.842	0.803	0.499	0.347
Al_2O_3				1	0.223	0.321	0.248	0.196	0.217	0.199	0.176	0.348	0.476
Sc					1	0.817	0.744	0.254	0.796	0.789	0.733	0.130	0.298
V						1	0.602	-0.038	0.683	0.637	0.610	-0.085	0.316
Cr							1	0.244	0.738	0.766	0.648	0.188	0.302
MnO								1	0.245	0.242	0.286	0.854	0.214
Co									1	0.969	0.864	0.439	0.363
Ni										1	0.860	0.418	0.370
Cu											1	0.470	0.364
Zn												1	0.362
As													1

	Rb	Sr	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La	Ce
Li	0.454	0.214	0.407	0.391	0.469	0.389	0.493	0.371	0.484	0.435	0.486	0.589	0.623
Be	0.643	0.630	0.586	0.669	0.634	0.560	0.529	0.693	0.702	0.672	0.867	0.405	0.451
B	0.721	0.638	0.623	0.732	0.717	0.620	0.439	0.668	0.776	0.809	0.820	0.333	0.379
Al_2O_3	0.187	0.269	0.084	0.255	0.219	0.230	0.406	0.371	0.229	0.135	0.237	0.346	0.333
Sc	0.626	0.523	0.662	0.642	0.650	0.616	0.399	0.692	0.676	0.738	0.741	0.215	0.273
V	0.489	0.578	0.492	0.552	0.494	0.491	0.322	0.601	0.537	0.621	0.605	-0.027	0.025
Cr	0.717	0.625	0.529	0.600	0.756	0.552	0.398	0.753	0.752	0.742	0.688	0.249	0.288
MnO	0.262	0.087	0.416	0.236	0.320	0.374	0.278	0.224	0.317	0.273	0.297	0.691	0.745
Co	0.711	0.669	0.746	0.713	0.715	0.747	0.427	0.674	0.765	0.827	0.827	0.278	0.333

	Rb	Sr	Y	Zr	Nb	Mo	Cd	Sn	Sb	Cs	Ba	La	Ce
Ni	0.690	0.668	0.742	0.701	0.720	0.728	0.449	0.706	0.744	0.803	0.813	0.255	0.318
Cu	0.674	0.595	0.760	0.718	0.655	0.705	0.443	0.628	0.733	0.780	0.843	0.316	0.378
Zn	0.510	0.331	0.404	0.403	0.539	0.462	0.540	0.395	0.569	0.448	0.498	0.741	0.771
As	0.333	0.359	0.342	0.397	0.316	0.417	0.371	0.393	0.420	0.313	0.397	0.321	0.356
Rb	1	0.672	0.540	0.621	0.902	0.553	0.427	0.676	0.924	0.746	0.762	0.307	0.336
Sr		1	0.438	0.567	0.657	0.476	0.333	0.636	0.699	0.603	0.638	0.176	0.197
Y			1	0.718	0.566	0.744	0.373	0.489	0.584	0.651	0.673	0.377	0.469
Zr				1	0.637	0.562	0.464	0.591	0.696	0.707	0.760	0.343	0.400
Nb					1	0.540	0.409	0.729	0.858	0.710	0.720	0.327	0.358
Mo						1	0.374	0.517	0.603	0.674	0.621	0.360	0.443
Cd							1	0.457	0.453	0.437	0.462	0.393	0.427
Sn								1	0.683	0.618	0.654	0.199	0.256
Sb									1	0.765	0.814	0.347	0.376
Cs										1	0.802	0.296	0.341
Ba											1	0.321	0.368
La												1	0.978
Ce													1

	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Li	0.653	0.624	0.568	0.420	0.384	0.362	0.440	0.418	0.456	0.431	0.459	0.451
Be	0.544	0.667	0.682	0.713	0.569	0.549	0.651	0.657	0.660	0.687	0.666	0.609
B	0.484	0.652	0.684	0.765	0.627	0.633	0.737	0.739	0.740	0.802	0.749	0.692
Al_2O_3	0.336	0.313	0.265	0.271	0.120	0.137	0.265	0.222	0.214	0.147	0.235	0.219
Sc	0.382	0.571	0.651	0.725	0.648	0.657	0.659	0.698	0.642	0.691	0.649	0.604
V	0.141	0.363	0.462	0.676	0.484	0.510	0.512	0.596	0.507	0.559	0.509	0.463
Cr	0.374	0.525	0.580	0.626	0.516	0.493	0.818	0.751	0.749	0.699	0.728	0.688
MnO	0.724	0.623	0.564	0.283	0.354	0.322	0.313	0.274	0.301	0.274	0.277	0.287
Co	0.443	0.633	0.714	0.742	0.666	0.637	0.741	0.736	0.733	0.888	0.742	0.689
Ni	0.432	0.616	0.713	0.704	0.657	0.619	0.754	0.707	0.710	0.849	0.720	0.664
Cu	0.495	0.672	0.735	0.754	0.674	0.638	0.677	0.741	0.685	0.799	0.699	0.647
Zn	0.766	0.715	0.620	0.447	0.346	0.320	0.565	0.546	0.563	0.478	0.530	0.547

	Pr	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
As	0.388	0.432	0.443	0.402	0.311	0.308	0.340	0.322	0.398	0.460	0.392	0.357
Rb	0.414	0.555	0.584	0.627	0.526	0.504	0.814	0.815	0.926	0.683	0.888	0.870
Sr	0.278	0.434	0.477	0.558	0.435	0.424	0.677	0.699	0.697	0.585	0.669	0.637
Y	0.548	0.699	0.821	0.703	0.951	0.914	0.594	0.569	0.544	0.580	0.656	0.633
Zr	0.520	0.688	0.721	0.815	0.807	0.829	0.697	0.619	0.631	0.650	0.779	0.692
Nb	0.435	0.563	0.626	0.604	0.560	0.535	0.904	0.817	0.864	0.670	0.851	0.839
Mo	0.508	0.644	0.724	0.636	0.632	0.601	0.553	0.562	0.575	0.580	0.576	0.583
Cd	0.490	0.521	0.507	0.462	0.368	0.357	0.420	0.352	0.408	0.376	0.441	0.398
Sn	0.345	0.483	0.551	0.570	0.488	0.462	0.795	0.688	0.671	0.624	0.673	0.637
Sb	0.468	0.625	0.650	0.707	0.570	0.555	0.836	0.844	0.989	0.732	0.944	0.909
Cs	0.444	0.623	0.663	0.729	0.637	0.613	0.709	0.715	0.731	0.771	0.738	0.689
Ba	0.488	0.674	0.713	0.787	0.656	0.631	0.722	0.716	0.765	0.756	0.780	0.719
La	0.938	0.812	0.646	0.402	0.332	0.307	0.381	0.300	0.327	0.300	0.345	0.333
Ce	0.978	0.873	0.741	0.466	0.395	0.369	0.417	0.323	0.348	0.336	0.368	0.359
Pr	1	0.944	0.837	0.600	0.478	0.457	0.492	0.402	0.425	0.433	0.456	0.434

	Nd	Sm	Eu	Yb	Lu	Ta	W	Pb	Bi	Th	U
Nd	1	0.949	0.805	0.631	0.612	0.611	0.556	0.569	0.591	0.611	0.573
Sm		1	0.832	0.730	0.708	0.651	0.588	0.589	0.632	0.644	0.615
Eu			1	0.660	0.664	0.621	0.650	0.639	0.683	0.675	0.605
Yb				1	0.985	0.617	0.555	0.527	0.563	0.701	0.653
Lu					1	0.595	0.535	0.507	0.541	0.687	0.636
Ta						1	0.831	0.839	0.696	0.853	0.823
W							1	0.853	0.693	0.812	0.801
Pb								1	0.704	0.941	0.918
Bi									1	0.706	0.662
Th										1	0.961
U											1

APPENDIX E: SPEARMAN RANK CORRELATION COEFFICIENTS

This section includes the calculated Spearman correlation coefficients of the trace element concentrations (APPENDIX C). Plot selection was predominantly based on Pearson correlation, however, I also considered elemental pairs that displayed strong Spearman correlations, and were generally at concentrations above the lower limit of detection.

	Be	Sc	V	Cr	MnO	Co	Ni	Zn	Sr	Y	Nb	Sn	Sb
Be	1.000												
Sc	0.077	1.000											
V	0.160	0.527	1.000										
Cr	-0.018	0.564	0.168	1.000									
MnO	0.142	0.119	-0.463	0.055	1.000								
Co	-0.337	0.287	0.289	0.278	-0.474	1.000							
Ni	-0.255	0.295	0.140	0.540	-0.271	**0.745**	1.000						
Zn	0.297	-0.055	-0.453	-0.135	0.805	-0.583	-0.416	1.000					
Sr	-0.067	-0.066	0.491	-0.087	-0.799	0.429	0.263	-0.677	1.000				
Y	-0.176	0.421	0.043	0.188	0.454	-0.215	0.045	0.087	-0.365	1.000			
Nb	0.425	-0.196	-0.357	-0.031	0.343	-0.238	-0.037	0.528	-0.308	-0.097	1.000		
Sn	0.408	0.178	0.242	0.246	-0.135	0.037	0.136	0.078	0.015	-0.238	0.430	1.000	
Sb	0.235	-0.037	-0.231	-0.278	0.385	-0.467	-0.487	0.445	-0.384	0.194	0.471	-0.088	1.000
Cs	-0.115	0.194	-0.054	0.060	0.216	-0.084	-0.041	-0.015	-0.246	0.502	-0.103	-0.195	0.023
Ba	-0.160	-0.094	-0.031	-0.063	-0.145	0.364	0.285	-0.257	0.309	-0.046	0.061	-0.070	-0.161
La	-0.206	-0.179	-0.553	0.112	0.573	-0.411	-0.228	0.414	-0.514	0.315	0.257	-0.305	0.398
Ce	-0.135	-0.054	-0.531	0.138	0.669	-0.415	-0.265	0.541	-0.624	0.329	0.290	-0.214	0.464
Nd	-0.116	0.034	-0.423	0.106	0.802	-0.513	-0.280	0.643	-0.654	0.525	0.273	-0.221	0.442
Eu	-0.066	0.446	0.154	0.135	0.248	-0.237	-0.360	0.132	-0.143	0.465	-0.312	-0.307	0.129
Yb	-0.261	0.319	0.142	0.173	0.158	-0.094	0.088	-0.194	-0.109	**0.869**	-0.177	-0.213	0.160
Ta	0.390	-0.153	-0.421	0.041	0.339	-0.152	0.065	0.558	-0.321	-0.172	0.914	0.422	0.364
W	0.442	0.271	0.417	-0.116	-0.006	-0.191	-0.337	0.049	0.009	0.074	-0.097	0.413	-0.007
Pb	0.454	-0.119	-0.268	-0.109	0.324	-0.249	-0.124	0.407	-0.294	0.020	0.641	0.128	**0.736**
Bi	0.300	0.104	0.021	0.203	0.092	-0.054	0.173	0.110	-0.129	0.140	0.115	0.227	-0.074
U	-0.058	0.301	0.076	0.020	0.418	-0.244	-0.120	0.382	-0.369	0.592	0.204	-0.002	0.458
Li	0.394	0.019	-0.368	-0.132	**0.728**	-0.431	-0.373	0.764	-0.698	n/a	0.370	0.094	n/a

	Cs	Ba	La	Ce	Nd	Eu	Yb	Ta	W	Pb	Bi	U	Li
Cs	1.000												
Ba	0.401	1.000											
La	0.082	-0.192	1.000										
Ce	0.074	-0.276	**0.959**	1.000									
Nd	0.162	-0.260	**0.860**	**0.908**	1.000								
Eu	0.277	-0.278	0.344	0.396	0.445	1.000							
Yb	0.495	0.159	0.218	0.187	0.311	0.355	1.000						
Ta	-0.153	0.050	0.226	0.277	0.239	-0.382	-0.279	1.000					
W	0.164	-0.147	-0.323	-0.226	-0.118	0.246	0.025	-0.057	1.000				
Pb	-0.106	0.004	0.234	0.267	0.216	-0.293	0.009	0.657	0.004	1.000			
Bi	0.000	-0.280	-0.104	-0.080	0.004	0.021	0.066	0.193	0.381	0.187	1.000		
U	0.456	0.103	0.283	0.346	0.472	0.273	0.566	0.149	0.177	0.371	0.122	1.000	
Li	0.152	-0.271	0.339	0.485	n/a	0.151	n/a	0.433	0.314	0.407	0.206	0.244	1.000

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