Petrology of the Neoproterozoic Cape Granite Suite hosted W-Mo-REE Riviera endoskarn deposit with special reference to allanite characteristics.

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by

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Thesis presented in partial fulfilment of the requirements for the degree of Master in Earth Sciences at Stellenbosch University.

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March 2015

DECLARATION

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Abstract

The Riviera W-Mo deposit is located near Piketberg in the Western Cape and is hosted by I- and A-type granitoids of the Neoproterozoic to Palaeozoic Cape Granite Suite that intruded the meta-volcano-sedimentary Malmesbury Group. Scheelite and molybdenite are the principal ore minerals and are associated with endoskarn- and vein-type alteration of the granitoids. It is the 6th largest deposit of its kind in the world with a grade of 0.216% tungsten (WO_3) and 0.02% molybdenum (Mo), and a tonnage of 46 Mt. The discovery of rare earth elements in addition to W and Mo in this deposit makes it attractive to the global market as there is currently a demand for tungsten and rare earth elements in the West.

This study comprises a mineralogical and geochemical investigation of a representative suite of drill core samples to identify the various mineral phases, their spatial distribution and textural features. This allowed definition of the relationship between hydrothermal alteration facies and enrichment. In addition this knowledge contributes to unravelling the genesis of this unusual deposit.

Results were obtained by means of optical microscopy, scanning electron microscopy, as well as whole rock geochemical XRF and LA-ICP-MS analyses.

The deposit consist of primary and secondary mineral assemblages; the latter as a result of superimposed skarnification and hydrothermal alteration. Primary minerals include quartz, feldspars (plagioclase and alkali), micas (biotite) and accessory titanite. The process of hydrothermal alteration formed skarn assemblages which include prograde metasomatic minerals like bastnaesite, scheelite, garnet, pyroxene, epidote, titanite, vesuvianite, apatite, and allanite. Other prograde minerals include secondary biotite, white mica, secondary albite and alkali feldspar. A later phase of pervasive hydrothermal alteration of the granite formed retrograde minerals like chlorite, carbonates, amphiboles, sericite (white mica), goethite and clay. Enrichment is mainly in the roof of the Riviera granite cupola.

Three rock types have been identified based on the modal mineralogy, they include firstly and closest to the granite wall rock contact a quartz porphyry monzogranite, followed by a biotite granite to monzogranite and lastly an aphanitic granite to monzogranite at depth in the pluton. Whole rock geochemical data is generally unreliable due to the effect of hydrothermal alteration, although it is speculated that this pluton is largely A-type, metaluminous to peraluminous in composition and subduction-related.

The different hydrothermal alteration types that were identified include argillic and advanced argillic alteration, phyllic and advanced phyllic alteration, and potassic alteration. The spatial relationship between these alteration types appear to be interlayered and follows the contour of the pluton. The

entire pluton has been affected by phyllic alteration and potassic alteration occurs mainly towards the roof of the granite cupola. The other types of alteration occur sporadically.

The vertical distribution of various elements, based on geochemical data, allowed for the identification of a mineralized zone, close to the granite wall-rock contact, and a non-mineralized zone at depth. The mineralized zone constitutes the bulk of the enrichment and is rich in calcic skarn minerals and potassic alteration products. Although altered, the non-mineralized zone reflects the original rock assemblage more clearly with sporadic occurrences of enrichment as skarnified granite patches.

Significant concentrations of allanite, a light rare earth element enriched mineral of the epidote group, were recently discovered in the endoskarn part of the Riviera pluton and could constitute an economically important by-product. Allanite is a complex mineral with poikilitic textures, irregular zonation patterns, metamictization, medium- to coarse grain sizes and no apparent consistent association with other minerals. The two most common types are allanite (Ce) and ferriallanite (Ce).

Chondrite-normalized REE patterns for the whole rock analyses are similar to those of the single grains and suggest that most of the rare earth elements are hosted by allanite. The steep slope of the pattern demonstrates LREE-enrichment and Eu-anomalies vary from slightly negative, neutral to slightly positive. A high ΣLREE content of allanite correlates with a positive Eu-anomaly whereas negative anomalies are associated with low concentrations. This suggests that the partitioning of REE in allanite is redox-sensitive.

Various evolutionary stages gave rise to this complex deposit; from prograde skarn formation to retrograde alteration. The main influence is due to the variability of metasomatizing fluids that evolved from early prograde, high temperature and reduced, to late retrograde, low temperature, and oxidized. A similar study of zoned scheelite from this deposit supports these observations and indicates genetically early scheelite and late stage allanite.

Uittreksel

Die Riviera W-Mo skarn afsetting is naby Piketberg geleë in die Wes-Kaap, en word deur die I- and A-tipe granitoïedes van die Neo-Proterosoïese tot die Paleosoïese Kaapse Graniet Suite gehuisves. Hierdie graniete het die meta-vulkanies-sedimentêre gesteentes van die Malmesbury Groep ingedring. Scheeliet en molibdeniet is the hoof erts minerale en word hoofsaaklik geassosieer met die endoskarn- en aar-tipe fases van die graniete. Die Riviera afsetting is die grootste afsetting van sy soort in die wêreld met ‘n tonnemaat van 46 Mt en ‘n graad van 0.216% WO_3 en 0.02% Mo. Die afsetting is sedert die ontdekking van skaars aardes baie meer aantreklik vir die globale mark omdat daar ‘n groot tekort en aanvraag is vir wolfram en skaars aardes in die Weste.

Hierdie projek beoog om ‘n mineralogiese en geochemiese studie te maak van ‘n verteenwoordige reeks kern monsters. Dit word gedoen om die aantal en verskeie mineraal fases te identifiseer, hul ruimtelike verspreiding af te baken asook hul teksturele eienskappe uit te ken. Dit sal lei tot die definisie van die verhouding tussen die verskeie hidrotermale verandering fasies asook mineralisasie. Benewens sal hierdie inligting bydra tot die begrip van die genese van die afsetting.

Resultate is verkry deur middel van optiese mikroskopie, skandeer elektronmikroskopie, asook geochemiese heelrots XRF en mineraal LA-ICP-MS analises.

Die afsetting bestaan uit primêre en sekondêre minerale samestellings; die laasgenoemde as gevolg van gesuperponeerde skarn-vorming en hidrotermale verandering. Primêre minerale sluit kwarts, veldspate (plagioklaas en alkali), mika (biotiet) en bykomende sfeen in. Die proses van hidrotermale verandering het skarn minerale tot gevolg gehad wat onder andere prograad metasomatiese minerale soos bastnaesiet, scheeliet, granaat, pirokseen, epidoot, sfeen, vesuvianiet, apatiet, en allaniet insluit. Ander prograad minerals sluit biotiet, wit mika, sekondêre albiet en alkali veldspaat in. Die hele graniet is verander deur deurdringende hidrotermale verandering en het retrograad minerale soos chloriet, karbonate, amfibole, serisiet (wit mika), goethiet en klei tot gevolg gehad. Mineralisasie is hoofsaaklik in die dak van die Riviera graniet koepel.

Die gasheer rots bestaan uit drie tipes gesteentes waarvan die klassifikasie gebaseer is op die modale mineralogie. Dit sluit in die eerste plek en die naaste aan die dak van die graniet cupola 'n kwarts porfier monzograniet in, gevolg deur 'n biotiet graniet en monzogranite en laastens 'n afanitiese graniet en monzograniet. Heelrots geochemiesie data is oor die algemeen onbetroubaar as gevolg van die effek van hidrotermal verandering, alhoewel dit voorstel dat die pluton ‘n A-tipe graniet is, met ‘n metalumineuse tot peralumineuse komposisie en subduksie-verwante aard.

Die verskillende tipes hidrotermale verandering wat geïdentifiseer is, sluit argilliese en gevorderde argilliese verandering, fillietiese en gevorderde fillietiese verandering, asook veldspatiese verandering. Die ruimtelike verhouding tussen hierdie verandering tipes blyk asof dit tussengelaagd is, en die lae volg ook die kontoer van die pluton. Die hele pluton is verander deur fillietiese verandering. Veldspatiese verandering kom meestal in die dak van die graniet koepel voor. Die ander vorme van verandering kom sporadies voor.

Die vertikale verspreiding van verskeie elemente (gebaseer op heelrots geochemiese data), het die identifisering van ‘n geminaraliseerde sone, wat naby die kontak van die graniet en wandgesteentes geleë is, en ‘n nie-geminilariseerde sone dieper in die pluton, moontlik gemaak. Die geminaraliseerde sone verteenwoordig die oorgrote meerderheid van die mineralisasie, is ryk in kalsium skarn minerale en produkte van veldspatiese verandering. Die nie-geminilariseerde sone weerspieël die oorspronklike rots duideliker alhoewel dit steeds hidrotermaal verander is, en het sporadiese voorvalle van mineralisasie wat bekend staan as geskarnifiseerde graniet kolle.

Beduidende konsentrasies van allaniet, 'n ligte skaars aarde-verrykte mineraal van die epidoot groep is onlangs in die endoskarn deel van die Riviera Pluton ontdek en kan beskou word as ’n ekonomies belangrike by-produk. Allaniet is 'n komplekse mineraal met poikilitiese teksture, onreëlmatige sonerings patrone, medium tot growwe korrel groottes en geen oënskynlike konsekwente verwantskap met ander minerale in die pluton. Die twee mees algemene tipes is allaniet (Ce) en ferri-allaniet (Ce).

Chondriet genormaliseerde SAE patrone vir die heel rots is soortgelyk aan dié van enkele allaniet korrels en dui dus daarop aan dat die meeste van die skaars aarde elemente in allaniet gehuisves word. Die steil helling van die patroon toon LSAE verryking en die Eu-afwykings wissel van effens negatief, neutraal tot effens positief. 'n Hoë ΣLSAE inhoud van allanitet stem ooreen met 'n positiewe Eu-afwyking, terwyl ‘n negatiewe afwyking geassosieer word met lae konsentrasies. Dit dui daarop dat die verdeling van SAE in allanite redoks sensitief.

Verskeie evolusionêre fases het aanleiding gegee tot hierdie komplekse afsetting, vanaf ‘n prograad skarn-vorming stadium tot retrograad verandering. Die belangrikste invloed is as gevolg die wisselvalligheid van die metasomatiserende vloeistowwe wat ontwikkel het vanaf ‘n vroeë prograad, hoë temperatuur en gereduseerde, tot ‘n laat retrograad, lae temperatuur en geoksideërde vloeistof. 'n Soortgelyke studie van die sonering van scheeliet in hierdie afsetting ondersteun hierdie waarnemings en dui dus op geneties vroeë scheeliet en laat stadium allaniet aan.

Acknowledgements

First and foremost I would like to acknowledge Jesus Christ for completing the work on the cross. Without Him and the knowledge of that, I could not have made it this far.

I would also like to thank my supervisor for always pushing me to be the best I can be, and not letting me settle for less. I am grateful for his guidance. Thank you to Professor Verwoerd for helping me with the editing of my thesis.

Thank you to Madeleine Frasenburg and Dirk Frei at the Central Analytical Facility for helping to analyse my data and for providing a good service, and also to Shawn Kitt for helping me with the Leapfrog software. I would also like to thank Batla Minerals for the geochemical dataset which was completed by an accredited geochemical laboratory.

I thank the National Research Foundation (NRF) for providing funding for my first year of master's and the Mandela Rhodes Foundation for providing finances in my final year. The Mandela Rhodes family have been a great support and benefit to my life and I hereby wish to acknowledge the Foundation and the 2014 cohort as well for their tremendous support.

My parents, family and friends have been a rock in the past two years and I am grateful to them for running the race with me. Specifically I would like to thank Danielle, Signe, Eva, Maré, Tosca, Elné, Leanne and Marina.

Lastly I would like to thank my fiancé, Luke Correia. You are my best friend and my number one fan. I don't have words to express how much your love and support means.

Table of Contents

List of Figures

Chapter 1 – Introduction

Chapter 2 - Geological background

Chapter 3 - Mineral Economics

Chapter 4 - Petrography

Chapter 5 - Geochemistry

Chapter 6 - REE minerals and Geochemistry

Chapter 7 - Discussion and Conclusions

List of Tables

Chapter 1 – Introduction

Chapter 2 - Geological background

Chapter 4 - Petrography

Chapter 6 - REE minerals and Geochemistry

Abbreviations

AAC	-	Anglo American Corporation
A/CNK	-	Al_2O_3/ ($CaO+Na_2O+K_2O$)
AL	-	Alteration Index
All	-	Allanite
AMG	-	Aphanitic granite to monzogranite
An	-	Anorthite
Ap	-	Apatite
Ba	-	Barium
BMG	-	Biotite granite to monzogranite
Bt	-	Biotite
BSE	-	Backscattered electron image
C	-	Carbon
Carb	-	Carbonate
CGS	-	Cape Granite Suite
Chl	-	Chlorite
CL	-	Cathodoluminescence
Com%	-	Compound percent
Cpx	-	Clinopyroxene
Cpy	-	Chalcopyrite
CRM	-	Certified Reference Material
EMP	-	Electron Microprobe
Ep	-	Epidote
Fdsp	-	Feldspar
Fig.	-	Figure
HREE	-	Heavy rare earth elements
IUGS	-	International Union of Geological Sciences
JORC	-	Joint Ore Reserves Committee
K-spar	-	Alkali felspar
K1	-	Alkali feldspar 1
K2	-	Alkali feldspar 2
Kb	-	Kilobar
LA-ICP-MS	-	Laser Ablation Inductively Coupled Plasma Mass Spectrometry
LREE	-	Light rare earth elements (La, Ce, Pr, Nd)
Mo	-	Molybdenum
Ms	-	Muscovite

Mt	-	Million tons
mtu	-	metric ton units
MZ	-	Mineralized Zone
Na	-	Sodium
NMZ	-	Non-mineralized Zone
Opx	-	Orthopyroxene
Plag	-	Plagioclase
Plag1	-	Plagioclase feldspar 1
Plag2	-	Plagioclase feldspar 2
Plag3	-	Plagioclase feldspar 3
PPL	-	Plane polarized light
ppm	-	Parts per million
Py	-	Pyrite
p.y.	-	Per year
QAPF	-	Quartz – Alkali Feldspar – Plagioclase - Feldspathoid
QPMG	-	Quartz porphyry monzogranite
Qtz	-	Quartz
Q-Or-An	-	Quartz-Orthoclase-Anorthite
REE	-	Rare earth elements
REO	-	Rare earth oxides
Riv	-	Riviera
SAE	-	Skaars aarde elemente
SAMREC	-	South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves
Sc	-	Scheelite
SEM	-	Scanning electron microscope
Ser	-	Sericite
Sp	-	Titanite
Sph	-	Sphalerite
T	-	Temperature
TLSAE	-	Totale Ligte skaars aarde elemente
TREE	-	Total rare earth elements
UCEX	-	Union Carbide Exploration Corporation
W	-	Tungsten
Wt%	-	Weight percent
XPL	-	Cross polarized light
XRF	-	X-ray fluorescence
εNd_t	-	Epsilon Neodymium (time)

Chapter 1 – Introduction

1.1 Background

The Riviera Skarn ore deposit is the 6th largest of its kind in the world with a grade of 0.216% tungsten (WO_3) and 0.02% molybdenum (Mo), and has a resource of 46 Mt. The main ore minerals are scheelite and molybdenite (Rozendaal & Boshoff, 2011). The recent discovery of rare earth elements (REE's) as the mineral allanite makes this deposit attractive to the global market as China, being the major producer and consumer not only of REE's but also of tungsten, are withholding exports. This leads to a greater demand in the western world (Chegwidden, 2010). REE's are used nowadays more extensively on a daily basis in a number of applications, making it a more and more attractive and worthwhile commodity to invest in. The latest important end-uses for REE's are in green technologies like wind- and solar-powered energy (Humphries, 2013).

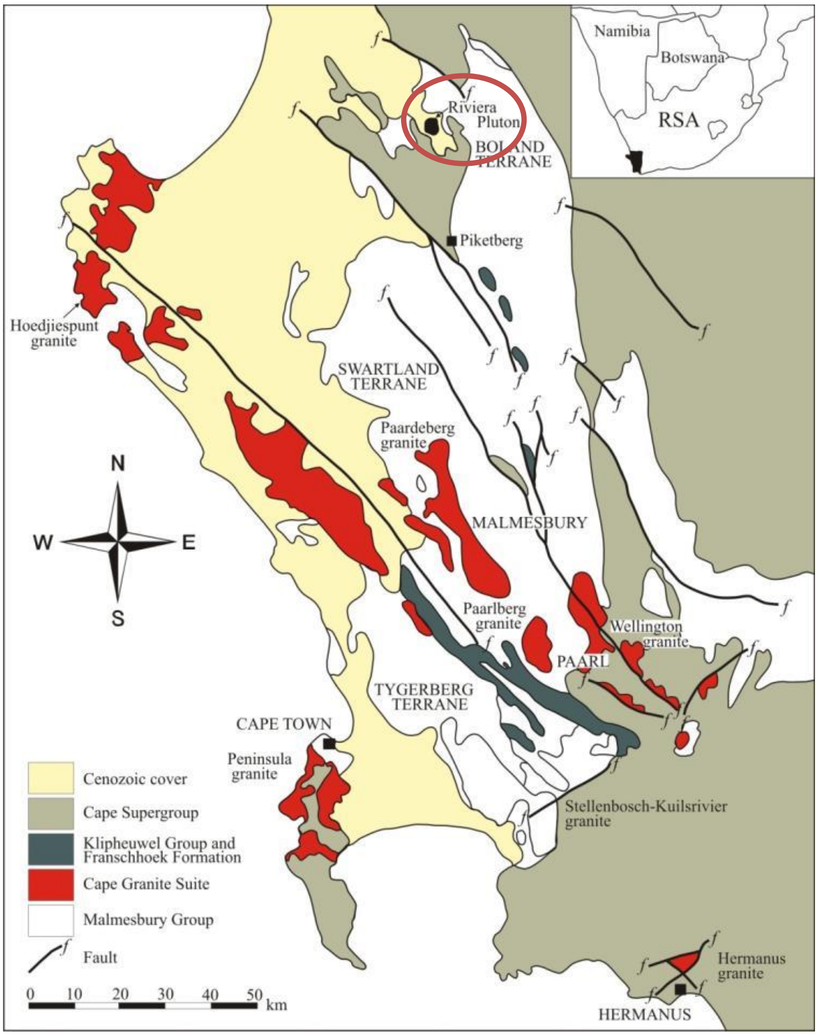


Figure 1.1. The distribution of plutons in the Cape Granite Suite between the Boland, Swartland and Tygerberg terranes. The red circle indicates the position of the Riviera pluton in the Northern parts of the Boland terrane (Rozendaal & Boshoff, 2011).

The W-Mo-REE Riviera skarn deposit (Figure 1.1) is a blind deposit located in the Western Cape north of Piketberg (Rozendaal & Boshoff, 2011). This deposit is associated with the I- and A-type granites of the Cape Granite Suite (CGS), which intruded the Neoproterozoic Malmesbury group between 585±20 and 495±15 Ma in the Boland terrane (Rozendaal et al., 1999).

The Riviera deposit was discovered as a result of stream sediment sampling for tungsten by Union Carbide Exploration Corporation (UCEX) during the 1970's to 1980's (Rozendaal & Scheepers, 1995). In 1975 specifically, a 50 grain scheelite anomaly was detected by ultra-violet lamping. By the end of 1983, feasibility studies were possible due to a joint venture agreement with the Anglo American Corporation (AAC). The ore reserves were calculated at 0.1% WO_3 cut-off, as well as a minimum thickness of 15m, a tabular body with average thickness of 31m was outlined to a depth of 220m below surface (Rozendaal & Boshoff, 2011). Resources grade at 0.216% WO_3 and 0.02% Mo and a tonnage of 46 Mt, with a high grade zone which grades at 0.297% WO_3 and 0.02% Mo of 7 million tons. At that stage, the deposit was not viable, due to the low market price for tungsten (Walker, 1994). Recently and following SAMREC or JORC requirements, the resources have been classified as inferred and are suitable for open-cast mining. Simple geometallurgy will allow recovery of more than 90% tungsten. Due to the change in market price for tungsten in the mid-to late 2000's, renewed interest in the deposit was established and a prospecting license has been awarded to Batla Mining who are re-evaluating the deposit (Rozendaal & Boshoff, 2011).

This project has received much attention from the environmental lobby and has caused some controversy among the local people as this deposit is situated in an area where some vegetation types are restricted to the area (Boucher, 2008). Mining might lead to the extinction of these species and will cause a dramatic change in the area (Hall & Veldhuis, 1985). The flora, being mostly endemic, makes it a typical target for a conservation area. Therefore any mining or road building has been avoided up to now (Boucher, 2008). Mining could also potentially cause pollution of the Krom-Antonie River which drains the area.

REE's were only relatively recently discovered in this deposit by Rozendaal & Scheepers (1995). The principal light rare earth element (LREE) mineral is allanite and is associated with the high grade tungsten part of the deposit (Rozendaal & Boshoff, 2011). A secondary carbonate mineral which has been identified as bastnaesite is located in the high grade zone although it is much less in abundance. Lack of specific knowledge on where these REE's are concentrated as well as economic, environmental and physical factors plays a role in the fact that this deposit is unexploited and mining hasn't commenced.

Allanite is the only mineral of the epidote group that has ever been mined for its LREE, and this has only occurred at Mary Kathleen mine in Australia (Kwak & Abeysinghe, 1987, Gieré and Sorensen, 2004). Allanite with economic concentrations of LREE is found at Hoidas Lake, Saskatchewan, Northern Canada (Hedrick, 2007). But it is not clear whether allanite is being mined or not. Epidote is usually considered a gangue mineral and is also uncommon, although it can be enriched in minor elements such as LREE (Plimer, 1993; Gieré and Sorensen, 2004). Allanite is seen as an accessory mineral in metaluminous to weakly peraluminous felsic rocks as well as hydrothermally altered rocks (Gieré and Sorensen, 2004).

1.2 Previous work

Previous work has been done on this deposit Rozendaal et al (1994, 1995, 2011 and 2012). The structural setting of the Riviera deposit within the Saldania Belt was studied by Rozendaal, et al (1994). On a larger scale Rozendaal and Scheepers (1995) looked at mineral deposits in the Saldania Belt and what metals are associated with which intrusive granite type. An executive summary was provided by Rozendaal and Boshoff (2011) on the Riviera skarn as well as a study of REE's as a by-product. The latest research on this deposit is by Santana and Rozendaal (2012) who specifically studied the minerals associated with REE enrichment as well as the textures of these minerals. The discovery of the deposit was documented by Walker (1994).

Two MSc theses made a significant contribution to the knowledge of two particular aspects namely the relationship between quartz-calcite-vein generations and the W-Mo enrichment in the Riviera deposit (Smit, 1997), and (2) various significant minerals (apatite, allanite, titanite and monazite) and their characteristics in S-, I- A-type Cape Granites (Spicer, 2001). Spicer's thesis provides an important background in terms of the role that REE and trace elements play in explaining granite evolution, specifically that of the Cape Granite Suite.

Two honours studies, one by Pieterse (2013) and the other by Smit (2013), helped respectively in understanding scheelite enrichment and phases in terms of the hydrothermal fluids that played a role in the composition of the deposit, and to understand the mineralogy and chemistry of the wall rocks that surround the Riviera pluton.

Previous studies associated with the Riviera deposit and the CGS have focussed more on the Saldania Belt and its granitic intrusions, as well as the W and Mo enrichment, and very little has been said on the REE's and their distribution and characteristics. This study aims to take this research further through a systematic approach and make it more specific to the REE enrichment and its mineralogy, distribution, textures and associations. New and more advanced technology to determine the mineral chemistry will be used.

1.3 Literature review

This section provides a summary of all the major research done on skarn deposits, endoskarns and tungsten skarns especially. Reference was made to porphyry deposits as the Riviera deposit exhibit porphyry type characteristics. Global deposits of similar association with the Riviera deposit were studied and the main similarities and differences were summarized. Lastly, the importance of REE in the mineral allanite in the Riviera deposit was highlighted by providing a literary summary on the characteristics of allanite. This information will contribute in understanding the genesis of the Riviera deposit and is used to compare the Riviera deposit to similar deposits around the world. Please view the appendices for the detailed literature review.

1.4 Aims and objectives

1. To study the host rocks of the Riviera deposit and the associated hydrothermal alteration.
    - What is the primary and secondary mineralogy, their textural features and their spatial distribution with respect to depth below surface of the pluton? What is the paragenetic sequence?
    - What rock types are present in the Riviera deposit? What is their spatial distribution? What is the composition and classification of the host rock?
    - What hydrothermal alteration types are present and what is their spatial distribution?
    - What are the geochemical charateristics of the host rock and how does it relate to the mineralogy and enrichment in the pluton?
2. REE enrichment
    - What are the REE mineral phases and with what are they associated (e.g alteration types, other economic phases and/or textures)?
    - What are their average grain sizes and morphology?
    - What is the spatial distribution of these minerals?
3. What is the genetic model of the Riviera skarn deposit?
    - What factors/processes played a role in the evolution of the deposit?
    - What was the effect of the hydrothermal fluids in this process?

1.5 Methodology

Diamond drilling (19000m) by Anglo American Corporation (AAC) outlined most of the roof or cupola of the Riviera pluton (Rozendaal, et al., 1994). Samples were collected from 16 representative boreholes from the granite and alteration zones to use in further research on the deposit. Thin section samples from 12 boreholes were selected to study by microscopy under transmitted and reflected light and for investigation by the Scanning Electron Microscope (SEM) (for mineral phase compositions and textures), and Laser Ablation Inductively Coupled Plasma Mass Spectrometer (LA ICP MS) (for trace element studies of allanite). Selected samples were sent away for whole rock major element chemistry by means of x-ray fluorescence (XRF).

Table 1.1 A summary of the boreholes that were sampled, and a breakdown of samples into those that were used for major and minor element geochemistry, as well as for petrographic studies.

		Number of samples		
	Borehole	**Geochemistry**		**Petrography**
		Major and minor	**Only minor/trace**	**Thin-sections**
	A+400	116		6
	AA+400	113		16
	AA+200	-		12
	BB+200	-	124	-
	BB+300	-	162	-
	BB+400	64		10
	BB/CC+350	-	157	-
	CC+200	-	112	-
	CC+400	116	-	8
	D+700	-	-	8
	DD+200	52	-	12
	DD+800	-	-	11
	E-200	38	-	14
	HH+400	-	-	9
	REV27	-	-	17
	REV60	-	-	12
Total	**16**	**499**	**555**	**135**

1.5.1 Petrography

1.5.1.1 Reflected and Transmitted Light Optical Microscopy

Thin-sections (135 in total) from 12 boreholes distributed in such a way as to representatively cover the pluton were studied by a Leitz polarizing microscope fitted for both transmitted and reflected light in order to identify primary and secondary mineral phases and alteration of the minerals, and textures Modal mineralogy determined to infer what the parent host rock was before hydrothermal alteration occurred.

1.5.2 Mineral Chemistry

1.5.2.1 Scanning Electron Microscopy (SEM)

Carbon-coated polished thin-section samples (30) were selected for the SEM. Imaging of the samples, including allanite, carbonate and scheelite grains and analysis of the phase compositions and textures were accomplished using a Zeiss EVO® MA15 Scanning Electron Microscope at the University of Stellenbosch. The SEM was also useful for chemical maps and qualitative mineral chemistry. Quantitative analysis and backscatter images require 15 micrometer thickness (peacock blue colour) of carbon coating, as well as a flat and polished surface. Samples were examined with backscattered electron (BSE) and/or secondary electron images, and phase compositions quantified by EDX analysis using the Zeiss EVO® MA15 detector and Wave Dispersive X-ray Spectrometer and Oxford INCA software was used simultaneously for more quantitative analysis. Beam conditions during the quantitative analyses were 20 kV, with a working distance of 8.5 mm and beam current of approximately – 20nA. The counting time was 10 seconds live-time. Internal Astimex Scientific mineral standards were used for standardization and verification of the analyses. Pure cobalt was used periodically to correct for detector drift.

1.5.3 Whole-rock analyses

An internationally accredited laboratory (ISO/17025-2005), Intertek Genalysis Laboratory Services (South Africa), was used for whole-rock major geochemistry. This laboratory uses checks and balances that are based on international standards (CRM – Certified Reference Materials), therefore the data is reliable, and precision and accuracy is good (refer to appendix).

Major elements and elements like W and REE were analysed using sodium peroxide fusions, and Mo, Cu and S using the four acid approach. Sodium peroxide fusions are used for samples in which the elements (like W and REE) are hosted in minerals that may resist acid digestions. The four acid approach is effective in decomposing almost all mineral species including silicates. Major elements that were analysed include SiO_2, CaO, K_2O, FeO, Al_2O_3, Na_2O, TiO_2, MgO, MnO and P_2O_5. Minor or trace elements include Ag, As, B, Ba, Be, Bi, CO_3, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Ga, Gd, Hf, Ho, In, La, Li, Lu, Mo, Nb, Nd, Ni, Pb, Pr, Rb, Re, S, Sb, Sc, Se, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn and Zr. (CO_3 was analysed by means of acetic acid digestion).

Borehole samples for whole-rock major element geochemistry (499) and 555 for minor elements only were selected on site and couriered to the laboratory. The samples have a continuous length of 1 meter. Samples were crushed into a fine powder (particle size < 75 µm) for major and trace elements analysis. Further operating conditions can be found in the appendix.

1.5.4 Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA ICP MS)

LA ICP MS is a highly sensitive elemental and isotopic analysis method that is performed directly on solid samples. The laser beam focusses on the sample surface to generate fine particles (Laser Ablation). The ablated particles are then transported to the secondary excitation source of the ICP-MS instrument for digestion and ionization of the sampled mass. The excited ions in the plasma torch are subsequently introduced to a mass spectrometer detector for both elemental and isotopic analysis. Thin-section samples (8) containing allanite were selected for LA ICP MS analyses, of which 28 mineral grains of allanite were analysed, and 251 chemical analyses were performed. Mineral selection was based on the grain size and extent of alteration. Trace element concentrations were determined, with special emphasis on REE. The following elements were analysed: Al, P, Ca, Sc, Ti, V, Cr, Mn, Fe, Zn, Ga, Ge, Sr, Zr, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Pb, Th and U. Further operating conditions can be found in the appendix.

1.5.5 Software

Whole-rock data of various borehole intersections were displayed and interpreted using IgPet, Excel, Leapfrog, Micromine and GCDkit software.

Chapter 2 – Geological background

2.1 Regional geological setting

2.1.1 Introduction

The Riviera deposit is located north of Piketberg and regionally forms part of the southernmost extent of the Pan-African Saldanian Orogeny, called the Saldania Belt, which formed a 3 000-km-long chain of geosynclines (Hartnady et al., 1974). This orogeny is equivalent to the Brasiliano orogeny on the South American continent. It is represented as three distinct belts in Southern Africa namely the Damara, Gariep and Saldania belts which are mainly composed of volcano-sedimentary successions that have been subject to low grade metamorphism. The Pan-African and Brasiliano orogeny occurred during the construction of Gondwana. Rifting and the onset of deposition in the Saldania Belt occurred at 750 Ma (Rozendaal et al, 1999).

The Saldania belt is subdivided into three tectonostratigraphic terranes, namely the northeastern Boland, central Swartland and southwestern Tygerberg terranes (Hartnady et al., 1974). These terranes were intruded between 585±20 and 495±15 Ma (Rozendaal et al., 1999) by the syn- to post-tectonic Cape Granite Suite, specifically into the Neoproterozoic lower greenschist-facies meta-volcano-sedimentary Malmesbury Group (Gresse & Scheepers, 1993) which was deposited on the Namaqua-Natal basement (Villaros, 2006). The Cape Granite Suite.was emplaced along two major NW-striking fault zones: the Colenso fault to the south, separating the Tygerberg and Swartland terranes, and the Piketberg-Wellington fault separating the Swartland and Boland terranes (Figure 2.1 and 2.2).

The structural features of the Saldania Belt before the intrusion of the CGS consisted of ductile, dextral strike-slip shearing (before 600 Ma (von Veh, 1983)). During the 560 to 520 Ma period, sinistral strike-slip movement affected the intrusion of the late S-type and early I-type granites. Sinistral shearing continued until after the last intrusions of the CGS (post-orogenic to anorogenic A-type granites) between 520 and 500 Ma (Table 2.1) (Scheepers, 1995). Today, the Paleozoic Table Mountain Group unconformably overlies the Saldanian rocks, and has been affected by open folding of the Permo-Triassic Cape Orogeny (Rozendaal et al., 1994).

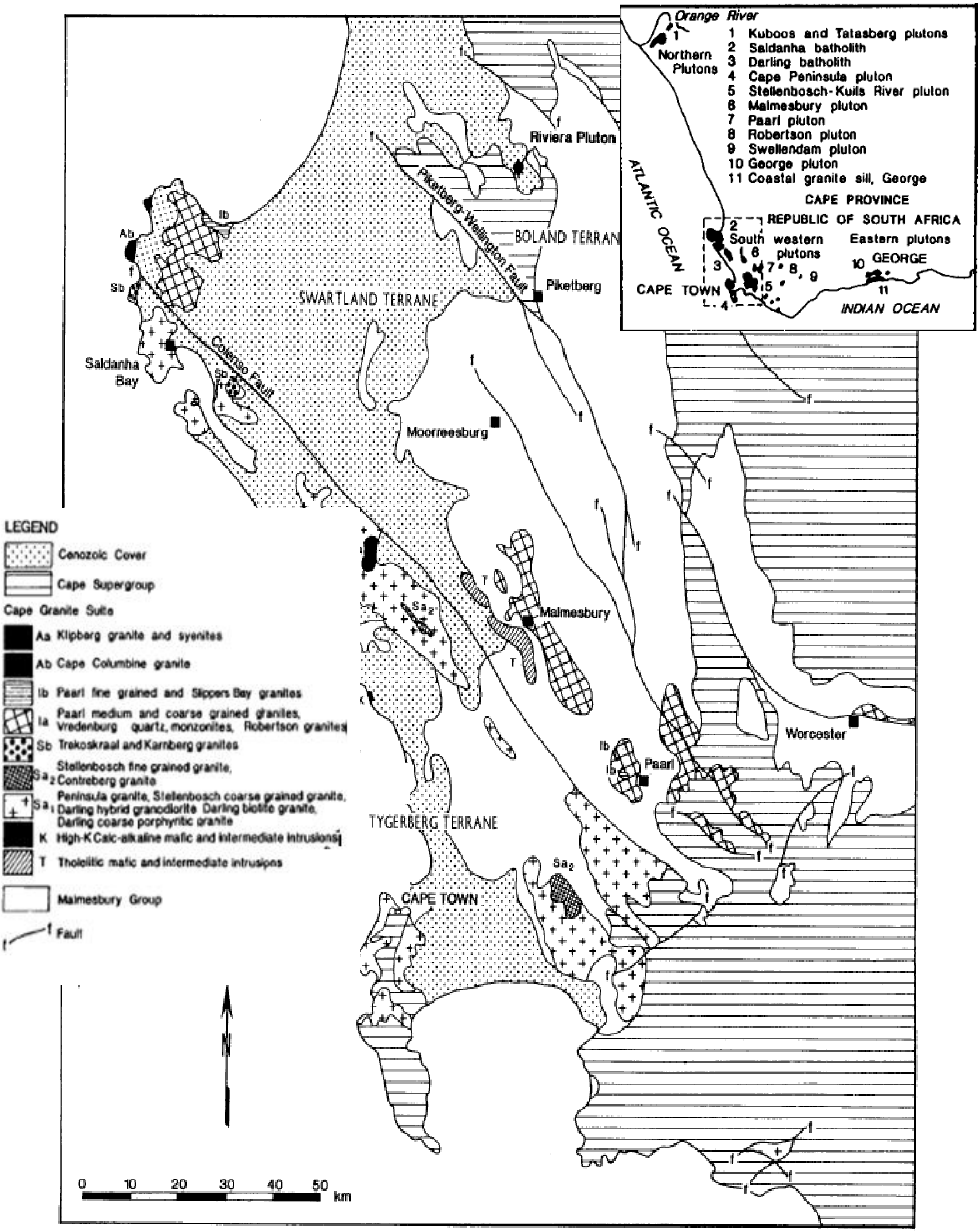


Figure 2.1. A Simplified geological map of the Saldania Belt, Western Cape, South Africa (after Scheepers, 1995).

Table 2.1. The general geological history of part of the Saldania Belt in the Western Cape Province (after Scheepers, 1995).

Age	Rock types	Group	Plutonic phases
320 Ma to 430 Ma	Conglomerate, sandstone, siltstone, shale, quartzite	Table Mountain	
460 Ma	Quartzite, arkose, conglomerate, slate	Klipheuwel	
520-500 Ma	High-K calc-alkaline mafic and intermediate intrusives, A-type granites and highly fractionated I-type granites		Cape Granite Suite - phase III
560-520 Ma	I-type granites and contaminated I-type granites		Cape Granite Suite - phase II
600-540 Ma	Tholeiitic mafic and intermediate intrusives, S-type granites		Cape Granite Suite - phase I
610 Ma to 950 Ma	Metasediments and metavolcanics, greywacke,quartzite, limestone, chlorite-muscovite schists, greenstone, conglomerate, slate	Malmesbury	

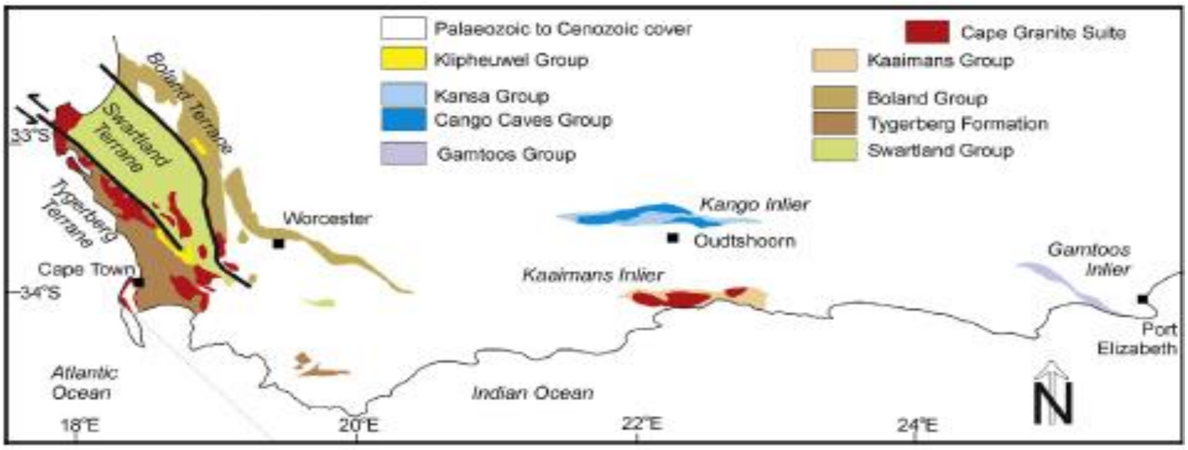
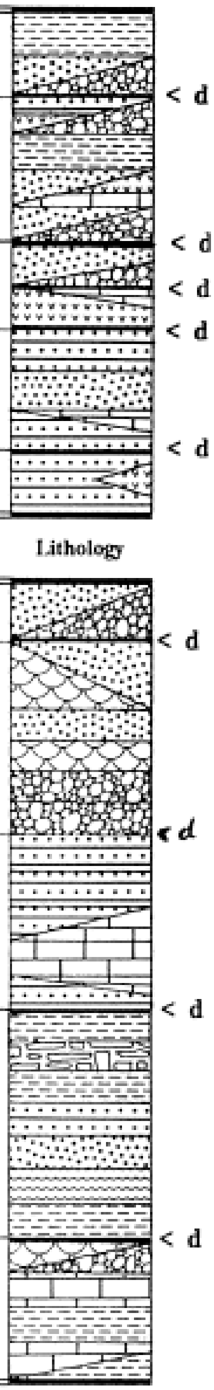


Figure 2.2. The general geology of the western Saldania Belt (modified after Gresse et al., 2006, taken from Frimmel et al., 2013).

Table 2.2. The stratigraphy of the terranes and inliers of the Saldania Belt (after Rozendaal et al., 1999).

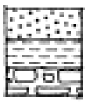
Terrane	Group	Subgroup	Formation	Member
BOLAND	Klipheuwel		Populierbos	
			Magrug	
	Malmesbury	Boland	Brandwacht	
			Porterville	
			Norree	
			Piketberg	
SWARTLAND	Malmesbury		Franschhoek	
			Bridgetown	
		Swartland	Moorreesburg	
			Klipplaat	
			Berg River	
TYGERBERG	Malmesbury		Tygerberg	Bloubergstrand
Inlier	**Group**	**Subgroup**	**Formation**	**Member**
KANGO	Kango		Schoemans Poort	
		Kansa	Schoongezigt/ Gezwinds Kraal	
			Uitvlug	Rooiberg
				Danzers Kloof
			Vaartwell	Andriesberg
				Rietkloof
		Goegamma	Huis River	
			Groenefontein	Brakkerivier
				Nelsrivier
			Matjies River	Kombuis
				Nooitgedagt
KAAIMANS	Kaaimans		Homtini	
			Victoria Bay	
			Soetkraal	
			Skaapkop	(Swart River)
			Sandkraal	
			Saasveld	
			Silver River	
GAMTOOS	Gamtoos		Van Stadens	
			Kaan	
			Kleinrivier	
			Lime Bank	

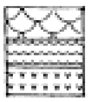
Lithology



() Bed   < d Discontinuous stratigraphy


conglomerate
greywacke
limestone/dolomite


sandstone/quartzite
shale/phyllite
calc-silicate rock


cross-bedded sandstone
schist
volcanic rock

2.1.2 Cape Granite Suite

The Cape Granite Suite in the Western Cape Province of South Africa comprises a series of 3 major phases of magmatism (Table 2.3), which intruded the meta-volcano-sedimentary Malmesbury Group. This suite is composed of a number of Late Precambrian to early Cambrian batholiths and plutons which formed through multiple intrusions (Schoch et al., 1975; Schoch, 1976). Between the youngest and oldest intrusions there is a time gap of 50 million years (Armstrong et al., 1998; Chemale et al., 1999). The suite consists of S-, I- and A-type granites which range in composition from peraluminous, to metaluminous to highly alkaline. Each of the 3 types is further subdivided into two; the S-type into Sa (also Sa_1 and Sa_2) and Sb, the I-types into Ia and Ib and the A-types into Aa and Ab (Table 2.3) (Scheepers, 1995).

The S-types form the first phase of intrusive events, roughly at about 552±4 Ma to 536±4 Ma (Da Silva et al., 2000; Scheepers and Armstrong, 2002), vary in composition from granodioritic to leucogranitic, and are peraluminous to metaluminous in nature (Scheepers, 1995). These granites characteristically contain biotite, cordierite and sometimes garnet (Villaros, et al., 2009). This phase of magmatism is syn-tectonic, contains numerous xenoliths of the Malmesbury Group (Chemale, et al., 2011), and formed in a collisional to post-orogenic setting (Rozendaal, et al., 1999). Only Sa_1 is strictly syn-tectonic, the rest (Sa_2 and Sb) are late tectonic and less deformed (Scheepers, 1995). They are the result of igneous melting with a purely crustal component (Villaros & Stevens, 2006), a partial melt of the Mesoproterozoic meta-sediments of crustal origin (Chemale, et al., 2011). These granites are most likely to contain Sn-W enrichment, are LREE-enriched, exhibit negative Eu-anomalies and well-defined positive slopes (Figure 2.3) (Scheepers, 2000). They are extremely depleted in HREE's and other incompatibles (Zr, Hf and Y) (Scheepers, 2000). S-

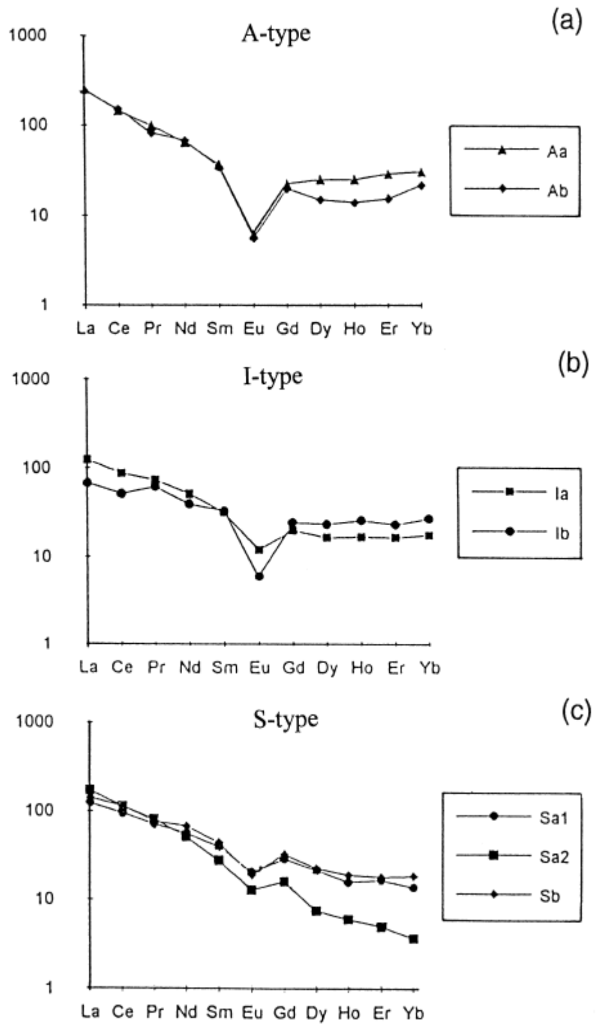


Figure 2.3. Chondrite-normalized REE patterns of the major granitic intrusions (and their subdivisions) in the Cape Granite Suite (after Scheepers & Rozendaal, 1995).

type granites are generally deformed and contain well-developed ductile structures and mylonites in some places. The strike of these plutons is NW-SE, with dominant linear and planar features (Scheepers, 1995).

The second phase of magmatism is represented by the I-type granites which intruded at 539±5 Ma (Da Silva et al., 2000). I-type granites yield older ages hinting towards a stronger juvenile component (εNd_t values between 1.01 to 1.89 Ga). I-type granites consist of monzogranite and granite (Ia) to alkali feldspar granite (Ib). They are metaluminous to slightly peraluminous, and are typically derived from high-K calc-alkaline magma generated by late-orogenic processes (Scheepers, 1995; Chemale et al., 2011). Significant LREE enrichment took place in this phase with enrichment values 200 to 500 times that of chondrite (Scheepers, 1995). These granites are known to host W-Mo-REE enrichment (Scheepers, 2000), exhibit poorly developed negative Eu-anomalies and a horizontal normalized pattern for HREE (Scheepers, 2000). This phase of the Cape Granite Suite gave rise to the first plutonic phase in the Riviera deposit which contains scheelite with minor Mo, REE, Cu-Au and are associated with intermediate intrusives (Scheepers, 2000). Ia intruded into the Malmesbury group whereas Ib intruded into Ia (Scheepers, 1995).

The last phase consists of highly fractionated I-type granites that gave rise to the A-type granites, and is typically high-K calc-alkaline amphibole/biotite quartz syenite to alkali or alkali feldspar granite, emplaced between 536 Ma and 500 Ma (Scheepers, 1995). These plutons have a strong juvenile component, with Nd-values indicating that they formed through plume activity, as well as melting of granulitic crust after generation and segregation of I-type granites (Chemale, et al., 2011). A-type granites host Mo-Cu±Au enrichment that is breccia-related (Scheepers, 2000), are enriched in REE and radioelements (Scheepers, 1995), exhibit large negative Eu-anomalies and a negatively sloping HREE chondrite-normalised pattern (Figure 2.3) (Scheepers, 2000).

Phases two and three formed in extensional environments or in a late- to post-orogenic setting, whereas all three phases show varying degrees of crustal contamination (Chemale, et al., 2011).

The S-type granites occur in the Tygerberg terrane and exhibit decompositional fabrics which indicate the emplacement of the pluton during left-lateral strike-slip movement of the crust (Rozendaal & Scheepers, 1995). I-types occur in the Swartland and Boland terranes, and are composed of medium- to even-grained, locally porphyritic mesocratic granites with rare, almost completely assimiliated metasedimentary mafic xenoliths (Rozendaal & Scheepers, 1995). A-types occur in all three terranes and shows K-Na metasomatism with abundant Th (Rozendaal & Scheepers, 1995). These intrusive events were accompanied by contact metamorphism as well as metasomatism of adjacent sediments (Belcher, 2003).

Table 2.3. Summary of granite-related plutonic events in the Saldania mobile belt and their typical enrichment features (Scheepers, 2000).

Plutonism	Association	Rock type	Examples	Mineralization	No.
Phase III (520–500 Ma)	Aa	Alkali feldspar granite, quartz syenite, syenite	Klipberg granite and quartz syenites	Cu–Mo–Au	13
	Ab	Alkali feldspar granite	Cape Columbine granite	Barren	
Phase II (540–520 Ma)	Ib	Granite, alkali feldspar granite	Paarl fine-grained granite, Slippers Bay Granite	Barren	
	Ia	Monzogranite, granite, alkali feldspar granite	Paarl coarse- and medium-grained granite, Vredenburg quartz monzonite, Greyton pluton, Riviera granite I	W–Mo (REE)	14, 15, 16
Phase I (550–540 Ma)	Sb	Granite	Trekoskraal granite, Karnberg granite, Rondeberg granite, coarse porphyritic Darling granite, Trekoskraal granite	Sn–W	8
	Sa_2	Granite, alkali feldspar granite	Stellenbosch fine-grained granite, Contreberg granite, Olifantskop granite, Cuyperskraal granite, Stellenbosch granite, Schapenberg granite, Haelkraal granite	Sn–W	1, 2, 3, 4, 5, 6, 11, 12
	Sa_1	Granite	Peninsula granite, Stellenbosch and Darling coarse porphyritic granites, Darling hybrid granodiorite, Darling biotite granite, Hoedjiespunt granite, Seeberg granite, Langebaan granite, Langebaan biotite granite	Barren	

2.1.3 Regional Enrichment

Rozendaal and Scheepers (1995) researched the metallogeny of the Saldania Belt in the Western Cape. Four types of mineral deposits were identified. They include tourmalinized and greissenized S-type granites in which quartz or aplite veins occur that host cassiterite and wolframite (±Au, Cu, Mo, Zn, As, Fe-sulphides), as well as stockwork-breccia and vein-style Cu-Mo-Fe-(Au)-sulphide enrichment. The latter is hosted by mafic- to intermediate intrusions of high-K calc-alkaline and I-type affinity. Cu-Mo-Au-sulphides in turn are hosted by hydraulic breccia pipes, stocks and veins which occur in anorogenic A-type alkali feldspar granites and amphibole quartz syenites. Lastly, endo- and exoskarns are found with scheelite being the main ore mineral, as well as minor Cu-Mo-Au-sulphides spatially associated with I-type monzogranite, granite and alkali feldspar granite.

Endo- and exo-granitic vein-type Sn-W deposits occur at Kuilsrivier and Helderberg. Similar small as W-deposits are found in Schapenberg, Somerset-West, Sn-(Au) veins are known in Durbanville, Sn at Vredehoek and Au at Lion’s head. Cu and Cu-Au occurrences associated with intermediate and mafic igneous rocks are found in Boterberg and Mud River, as well as the Yzerfontein-Schaapeiland and Cu-(Mo-Au) associated with alkali granite. The scheelite skarn that is of potential economic importance is the Riviera W-Mo-REE deposit (Figure 2.4), and it has a counterpart in the Robertson W skarn.

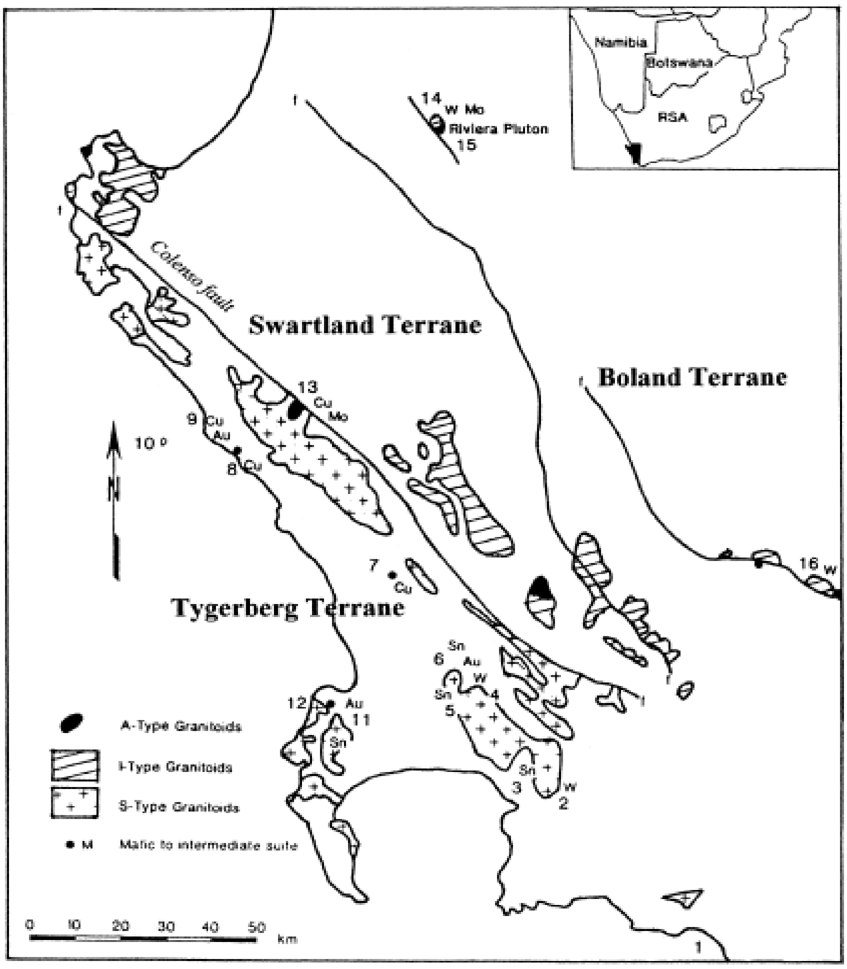


Figure 2.4. The distribution of the granitic intrusions of the CGS and their typical associated enrichment, as well as the subdivision of the various tectono-stratigraphic terranes of the Saldania Belt in the Western Cape (taken from Rozendaal & Scheepers, 1995). Refer to table 4.1.3 for the explanation of the numbers.

2.1.4 Malmesbury Group

The Malmesbury Group forms part of some of the oldest rocks in the Saldania belt and are essentially metasedimentary and metavolcanic in composition (Scheepers, 1995). It is divided into the Tygerberg terrane in the southwest, followed by the central Swartland and Boland terranes towards the northeast (Hartnady et al., 1974). The group is interpreted as a typical greywacke turbidite sequence in the Tygerberg terrane: Mica schists, fine-grained quartzites and quartz schists with limestone and dolomite lenses occur in the Swartland terrane, and coarse-grained quartzites, quartz schists, conglomerate and phyllitic bands characterize the Boland terrane which represents a near-shore environment (Rozendaal & Scheepers, 1995; Hartnady et al., 1974; von Veh, 1983; Haughton, 1932, Beason, 1976, Visser et al., 1981; Dunlevey, 1992). The group as a whole formed in a depositional basin on a passive continental margin that has been ocean-bound to the west (Rozendaal & Scheepers, 1995).

Sub-to lower greenschist facies metamorphism took place throughout Saldania Belt (de Villiers, 1979; Belcher and Kisters, 2003), which resulted in the metasedimentary and metavolcanic rocks associated with the Malmesbury Group.

Structurally the Malmesbury Group is similar to the Swartland Group with NW-SE trending regional scale doubly plunging anticlines (Belcher & Kisters, 2003). The Malmesbury Group exhibits well-developed bedding planes with a bedding-parallel schistosity defined by the preferred alignment of chlorite and muscovite. The bedding was refolded by a subhorizontal shallowly-dipping S1 foliation that resulted in axial planar to isoclinal intrafolial folds (Belcher & Kisters, 2003).

The Malmesbury Group was deposited between 575 and 550 Ma (Armstrong et al., 1998). The age is not precise but inferred. It is bracketed between the end of sedimentation of supracrustals on the Kibaran basement (1.2 to 1.0 Ga ago) and the early Proterozoic post-collisional plutons from the CGS (Da Silva et al., 2000).

2.2 Local Geology

2.2.1 Riviera Pluton

The Riviera pluton forms part of the Cape Granite Suite which intruded the northern part of the Boland terrane (Hartnady et al., 1974) mostly between 585±20 and 495±15 Ma (Da Silva et al., 2000; Rozendaal et al., 1999; Scheepers and Armstrong, 2002; Chemale et al., 2011). The pluton, an I-type monzogranite, granite and alkali feldspar granite, and later A-type granite, which is metaluminous to slightly peraluminous in composition (Rozendaal & Boshoff, 2011) gave rise to the Riviera endoskarn W deposit. Geographically it is situated near the Piketberg Mountains, north of Piketberg in the Western Cape Province of South Africa.

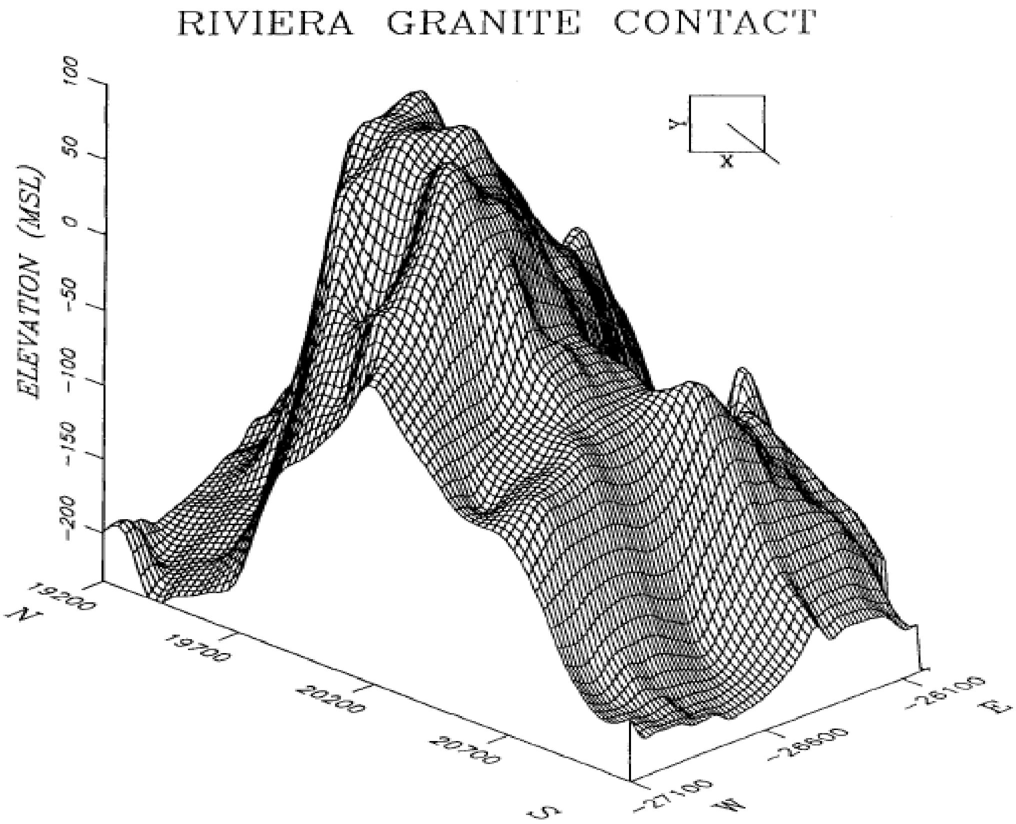


Figure 2.5. A three-dimensional isometric diagram displaying the contact between the Riviera pluton and the Malmesbury Group. The apex of the pluton is exposed at the surface. The current ground-level in the area is approximatel y 100m above mean sea level (Rozendaal & Scheepers, 1995).

The I-type granites of the CGS yield an age of 505±20 Ma using Rb/Sr whole rock data (Walker, 1994) and the A-types were emplaced between 536 Ma and 500 Ma (Chemale, et al., 2011).

Mesozoic high angle northwesterly and northeasterly normal faulting along the western and northern edge of the pluton, traversed the pluton and caused the exhumation of it (Rozendaal et al., 1994).

2.2.2 Wall rocks

The Riviera pluton intruded into a sequence of greenstone-carbonate beds of the Bridgetown Formation in the northern part of the Boland terrane forming a dome-shaped interference structure (Rozendaal et al., 1994) at 539±5 Ma (Da Silva, et al., 2000).

The Boland terrane is mainly composed of regionally metamorphosed greenstone-type metavolcanics and folded and faulted sediments such as lineated and foliated feldspathic quartzites, greywackes, sericite schist, banded iron stone feldspathic grits and conglomerates, and impure marly limestone (Rozendaal, et al., 1999).

The Bridgetown Formation is a series of mafic metavolcanic rocks, enveloped by and interleaved with dolomites and cherts that exhibit sub-horizontal schistosity. Its type locality is a NW-SE-trending elongated body with an extent of 20km by 3km. The northern continuation of the Bridgetown Formation in the Boland terrane also consists of metavolcanic rocks. The Bridgetown Formation shows a strong metamorphic overprint and subsequent intense weathering (Slabber, 1995). The age of the Bridgetown Formation is between 1.0 Ga and 560 Ma (Chemale et al., 2011).

2.2.3 Structural setting

The dome-shaped, periclinal interference structure intruded by the Riviera pluton has a northward-trending whale-back geometry (Figure 2.5) (Rozendaal & Scheepers, 1995). It was later affected by open-folding of the Permo-Triassic Cape Orogeny (Rozendaal et al., 1994).

Structurally the Boland terrane as a whole is simple, comprised of only one phase of near horizontal, upright folds trending north-northwesterly (Rozendaal et al., 1994).

The Riviera pluton is in the core of the Piketberg dome, a large interference structure that resulted from northeasterly trending conjugate kink (monoclinal) folds that overprinted an earlier south-southeasterly trending isoclinal phase. This dome is covered by Table Mountain Group rocks, whereas the southern part has been truncated by the Mesozoic Piketberg-Wellingon Fault, to the south of Piketberg. The Riviera pluton is situated in a horst block between two northwest-striking normal faults which developed as a result of Mesozoic tensional tectonics, and is located on the eastern side of a large open syncline and major fault – the Krom Antonie Lineament. The partial exhumation and discovery of the present position of the Riviera pluton was therefore caused by tensional Mesozoic block faulting, followed by erosion (Rozendaal et al., 1994).

2.2.4 Mineralogy and Enrichment

Potentially economic enrichment is associated with endoskarn, greisen as well as veins. The endoskarn ore is characterised by abundant scheelite (Sch92 – Pow8) and with the best WO_3 grade. Gangue minerals are those typical of Ca-skarns and include coarse-grained grossular garnet, diopside-hedenbergite, calcite, anorthositic plagioclase, epidote, minor vesuvianite, titanite, apatite, zoisite, allanite and fluorite. Most sulphide minerals occur in this zone and include molybdenite, pyrite, pyrrhotite, chalcopyrite and sphalerite (Rozendaal & Boshoff, 2011). The skarn occurs as patches (Figure 2.7) of 1 to 3 meter intersections in the granite host rock.

The greisen-type ore is associated with zones of argillic to advanced argillic alteration zones peripheral to skarn zones. It has a low overall WO_3 grade. Gangue minerals relfect intense metasomatism and include kaolinite, sericite, saussurite, chlorite, secondary quartz, accessory apatite and fluorite. Scheelite is fairly disseminated in this zone and sulphides are seen as accessories (Rozendaal & Boshoff, 2011).

The vein-type ore occurs throughout the pluton. It is of minor importance, and displays erratic nugget-type WO_3 and Mo grade distribution. The veins consist of quartz and quartz-calcite-ankerite. Scheelite is disseminated, with molybdenite being more pronounced. Minor sulphides are associated with this ore, namely pyrrhotite, pyrite, chalcopyrite and sphalerite (Smit, 1997). Mineralized veins extend from the granite into the wall rocks (Rozendaal et al., 1994).

Enrichment in the Riviera pluton is situated in the roof or cupola of the pluton (Figure 2.6) (Rozendaal & Scheepers, 1995). Possible economic concentrations of scheelite are found proximal to wall rock contacts. A halo of sub-economic enrichment also envelops the Riviera pluton in the exoskarn zone; however most of the enrichment is hosted by late tectonic I-type granitoids in the form of endoskarns (Rozendaal & Scheepers, 1995). Enrichment is classified as greisen-type (50%), endoskarn-type (45%) and vein-type ore (5%) totalling 46 Mt, where endoskarn is the most important (Walker, 1994; Rozendaal & Boshoff, 2011).

REE's are mainly associated with allanite, and typically occur in the endoskarn by an enrichment factor of 10. Allanite has a diverse chemistry indicative of several paragenetic phases, has undergone metamictization in some instances, and occurs as medium- to coarse-grained euhedral to irregular anhedral grains. Zoning has been observed as a function of REE which decreases from core to rim. Allanite is mostly associated with the high tungsten grade endoskarn part of the deposit. Apatite, titanite, scheelite and garnet have also been found to contain LREE, but these amounts are negligible (Rozendaal & Boshoff, 2011).

The Riviera deposit is known for its W-Mo-REE-(Cu) enrichment with the main ore minerals being scheelite and molybdenite. A population of 40 endoskarn samples yielded 0.7 % ΣREE. The deposit displays a strong LREE-enrichment with Ce, La and Nd being the major contributors. The endoskarn ore is characterized a weak to positive Eu-anomaly (Rozendaal & Boshoff, 2011). An inferred resource of 20 Mt endoskarn ore at 0.35% ΣREE, would yield 70000 metric tons of in-situ LREE hosted in the high grade zone (Rozendaal & Boshoff, 2011). Economic minerals are hosted by both the Riviera granitoid and the immediate surrounding rocks of Malmesbury group. The ore zone is situated along the eastern edge of whaleback structure (Rozendaal et al., 1994).

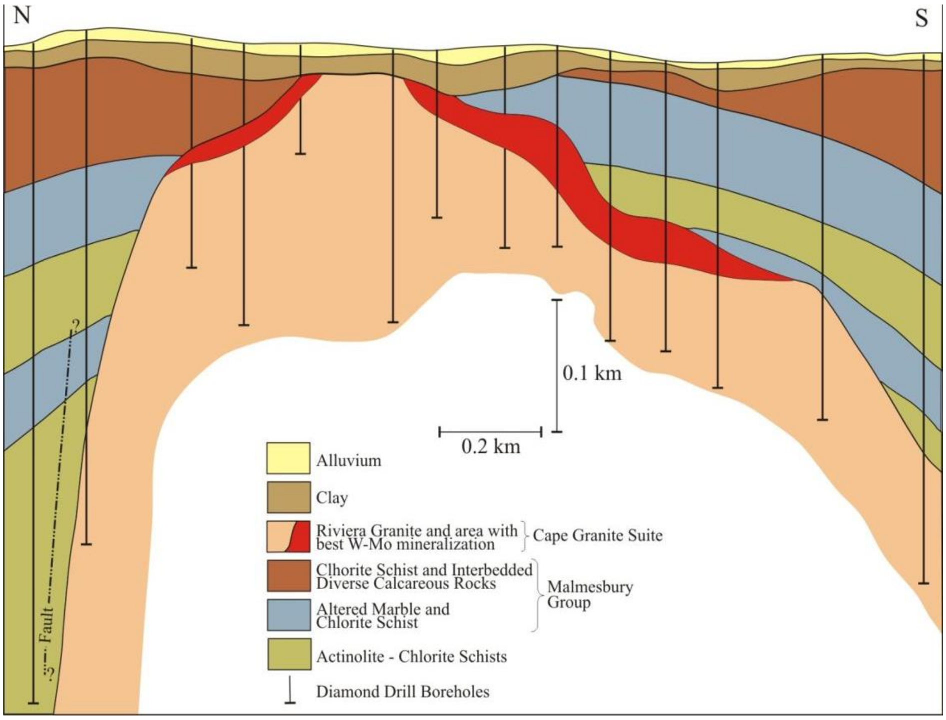


Figure 2.6. Geological north-south cross-section of the Riviera pluton. This diagram displays where the best probable W-Mo enrichment lies that is dominated by endoskarn and skarnified granite (Rozendaal&Boshoff, 2011).

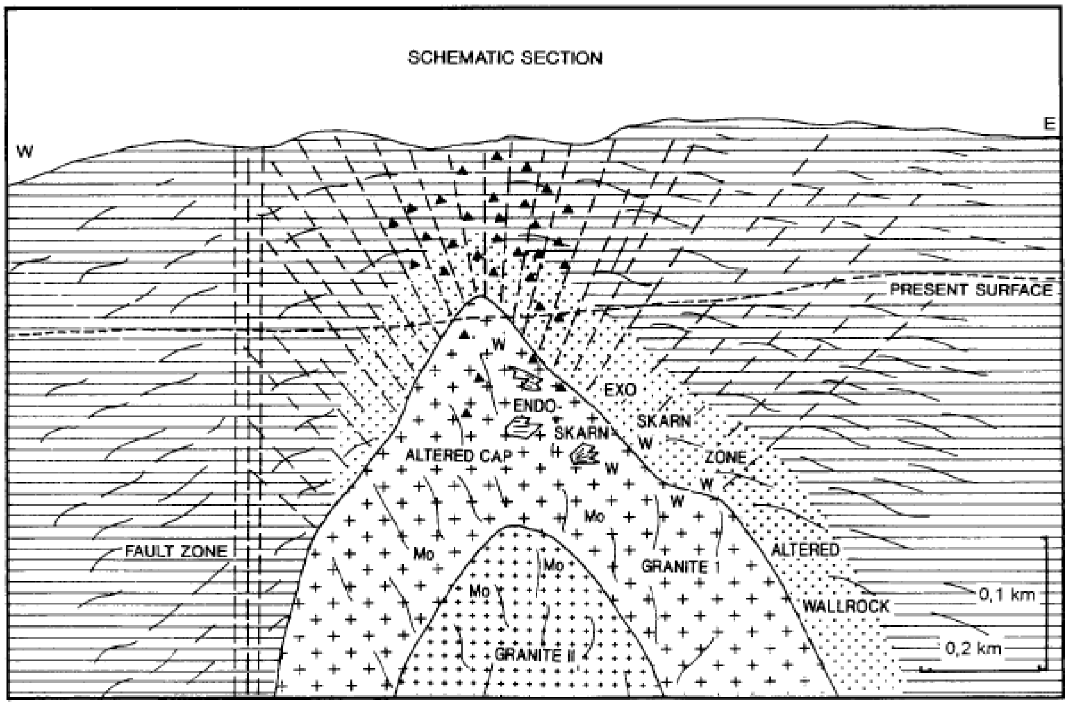


Figure 2.7. A schematic cross-section of the Riviera pluton, showing its enrichment, alteration and granitoid phases I and II (black triangles represent brecciation) (Rozendaal & Scheepers, 1995).

2.2.5 Alteration

The Riviera pluton is characterized by pervasive hydrothermal alteration and metasomatism. The entire roof of the pluton is affected by hydrothermal alteration. Argillic, advanced argillic, phyllic and potassic alteration occur as slightly convex alternating zones, sub-parallel to the roof of the pluton (Figure 2.8). The contact between the pluton and the impermeable metavolcanic wall rocks mark the most pervasive zone of advanced argillic alteration (Rozendaal & Boshoff, 2011).

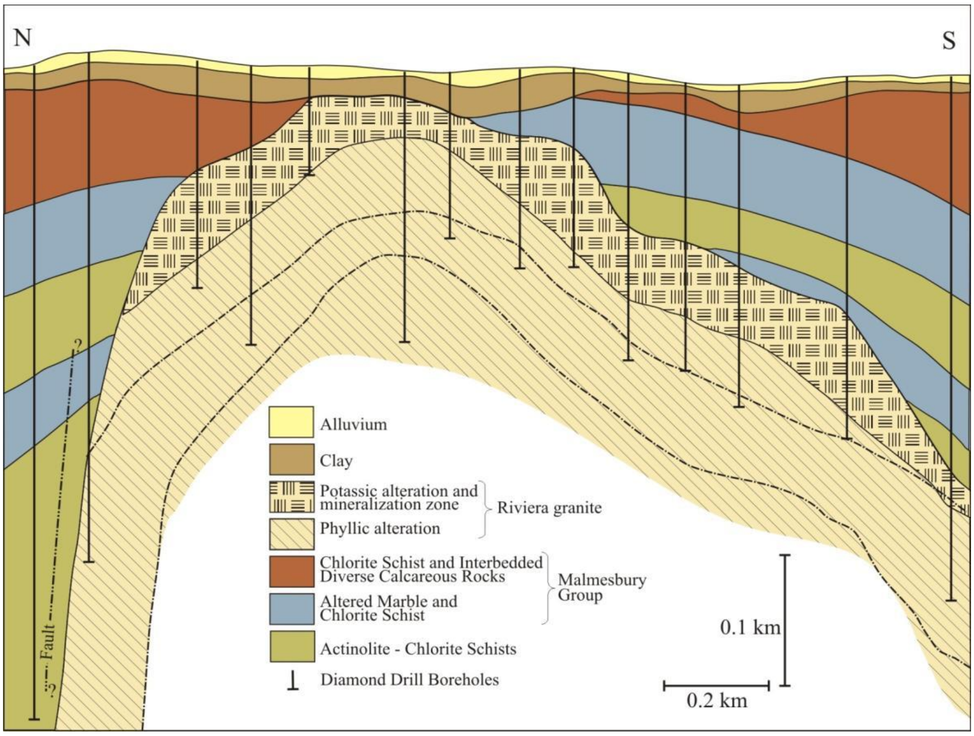


Figure 2.8. Geological north-south cross-section of the Riviera pluton showing the distribution of the major hydrothermal alteration types (Rozendaal&Boshoff, 2011).

The alteration style is very similar to that of base metal porphyry- or greisen-type deposits. Superimposed on the greisen-type alteration are irregular bodies of endoskarn. Endoskarn is most prevalent towards the apex of the granite cupola and occurred as a result of carbonate wall rock xenoliths assimilated by the pluton during intrusion. The xenoliths were subsequently metasomatised. Exoskarns occur in wall rocks as thin zones parallel to their schistoscity. Three late-stage, vertical to sub-vertical quartz and quartz-carbonate vein sets transect the pluton (Rozendaal & Boshoff, 2011).

Chapter 3 – Mineral economics

This chapter explains the importance of W and REE, which is abundant in the Riviera deposit, in the global mineral market today. It explains the current and possible future position of the Riviera deposit with respect to the global market. From the information given in this chapter it is clear that there is scope for further exploration and possibly extraction/mining of the Riviera deposit in the near future.

3.1 Tungsten (W)

3.1.1 Introduction

The unique physical properties of tungsten (W) make it an important mineral for the global market. It is the metal with the highest melting point of all metals (3400°C), has a high density and is also the second hardest material, after diamond (CRU & Roskill, 2011). No real substitute is satisfactory for tungsten in the industry which makes it a strategic metal. Tungsten is commonly used in mature industrial applications (Seddon, 2013) and is considered a strategic or critical metal (Grace, 2014). The variety of uses include: manufacture of hard steel alloys, mill products, chemicals, high speed cutting tools, heavy machinery, speciality steels, jet turbine engines, light bulb filaments and sporting goods (Salazar & McNutt, 2012; Rigby, 2012). Tungsten carbide is also used in electronics and in military applications (Coffin & Thompson, 2008). It is typically priced according to metric ton units (mtu), where a mtu is equal to 10kg, and is sold and traded in the market as ammonium paratungstate (APT) (Coffin & Thompson, 2008).

In the 1990's the market for tungsten was low as there were oversupplies from China which caused a sharp decline in production in the western world. Since the 2000's China started to regulate tungsten production in the country. A sudden increase in the price since 2005 is the result of all the stockpiles being sold that had been built up in the western world in the 90's (Roskill, 2011). The price has been increasing since then and there is currently a demand but no supplies to meet this demand. A drop in the price in 2009 is a result of the global recession; however the price has been rising steadily since then and continues to do so as the market for tungsten has recovered. The leading producers are Russia, Canada, Austria, Bolivia, Portugal and China, which is by far the largest (Jose, 2008).

3.1.2 Current Market

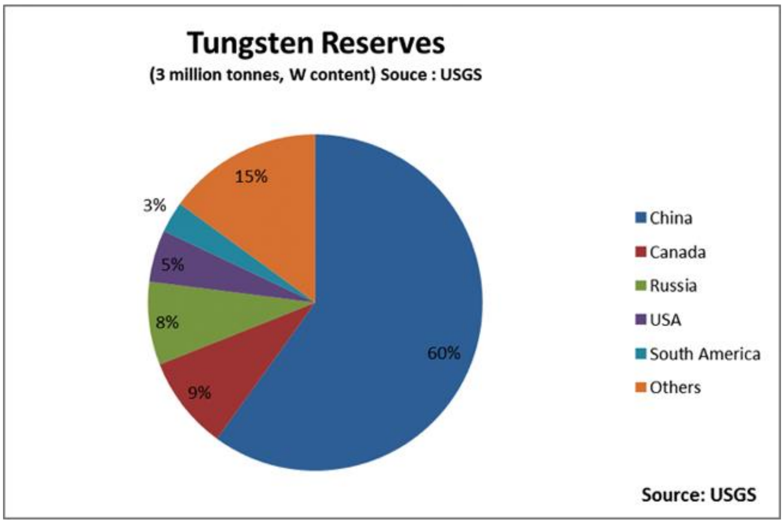
The market for tungsten is a global one, although fairly small in comparison with other commodities. The market at this stage is very strong as the demand for tungsten is robust and there is a shortage in supplies, especially from the western world (Coffin & Thompson, 2008). The market is largely determined by China, being the major producer and consumer of tungsten (GBRM, 2008).

The demand for tungsten is growing rapidly as China is now limiting its tungsten production and exports (Coffin & Thompson, 2008). China is experiencing an increasing domestic demand which led them to limiting the amount of tungsten exports, as well as exploration and mining operations, prohibiting foreign investment, placing quotas on production and exports (Salazar & McNutt, 2012). Another reason for the increase in demand is the sudden global increase in development of national defense, including both civil and war materials (Jose, 2008). The future growth of the tungsten market depends on new discoveries and further exploration, especially in the western world.

3.1.3 Reserves, production and consumption

China accounts for approximately 62% of the global reserves (Figure 3.1) and 83% of global tungsten concentrate production (Sylvester, 2013). The second and third largest producers are Russia at about 5% and Canada at 3.5% (Merriman, 2013). China is the leading consumer at 55% of the global reserves with the U.S and Europe following at 13% and 12% respectively (Sylvester, 2013). Other than China major exporters are Russia, Canada, Bolivia and Portugal (Diniz, 2014). The main importing countries are the U.S and Germany (Seddon, 2013). The global supply for tungsten in 2012 was about 117,000t WO_3 of which 75% was from primary mine supply and the rest from recycling and reuse of tungsten materials (Figure 3.2).

Figure 3.1. Tungsten reserves in the world according to country (Jose, 2008).



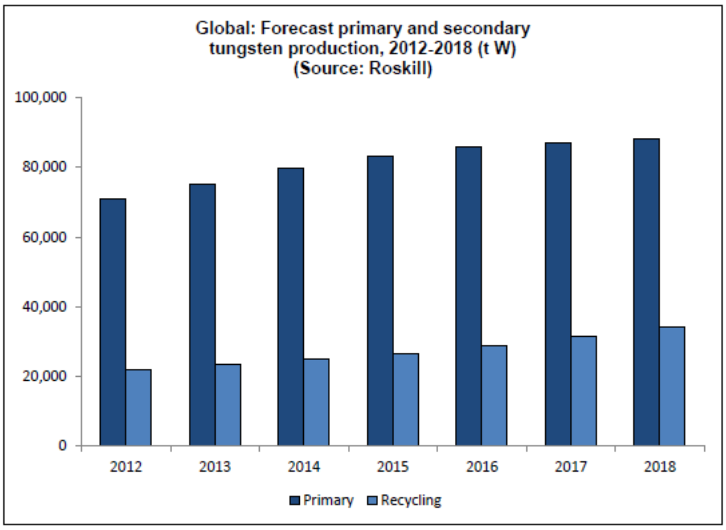


Figure 3.2. Forecast for primary and secondary production of tungsten (Merriman, 2013).

Tungsten consumption is and continues to be driven by tungsten carbide and steel alloy end uses (Merriman, 2013). Overall, consumption has increased since 2009 and is doing so rapidly, whereas production is slightly decreasing due to the shortage of supplies in the western world.

3.1.4 Supply, demand and price

The tungsten market has displayed a steady demand growth at 4-5% per year (Figure 3.3), which translates to 3-5 Kt tungsten per year (Grace, 2014). The demand is predicted to climb even further in the coming years to about 4.5% py (Merriman, 2013). At the rate the demand is rising, the largest reserves outside of China will be exhausted by 2015 (Grace, 2014). As it is now, China will more than likely continue to reduce exports and increase imports of tungsten, therefore, non-Chinese sources of tungsten is imperative (Merriman, 2013). Even though it will still exceed the demand growth of the rest of the world by about 3% p.y. China will persist in driving the demand for tungsten despite the prediction that it will slow down to around 6% py (Merriman, 2013). Globally tungsten demand correlates quite closely with general economic activity and GDP growth, and can therefore fluctuate (Seddon, 2013).

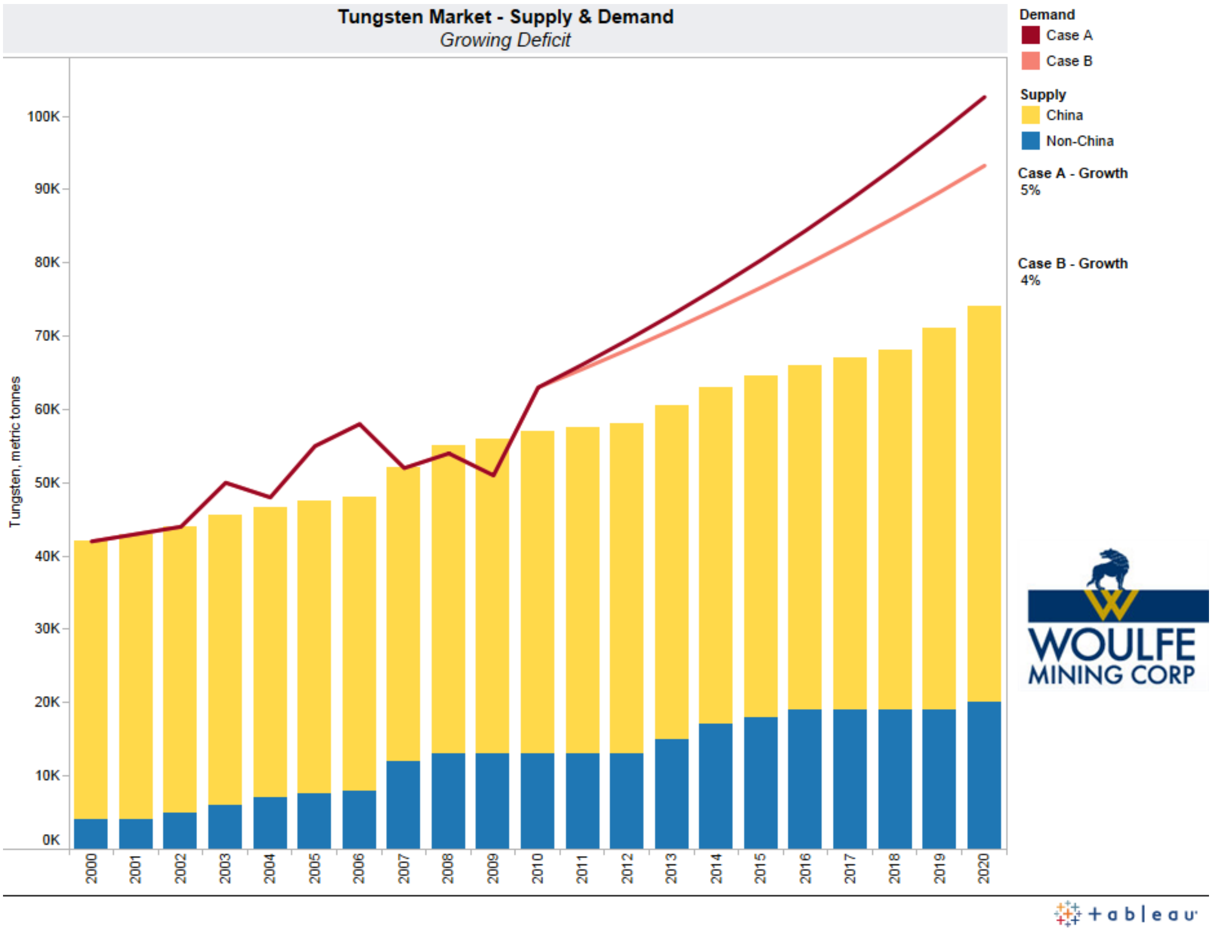


Figure 3.3. The supply and demand curve for tungsten. Case A and B for the demand curve are 5% and 4% respectively. The supply-demand gap is forecasted to increase substantially by 2020. (From http://metalaugmentors.com/).

The supply shortage persists and could lead to much higher prices in the near future. The first new major supply of tungsten will probably enter the market by the second half of 2015 (Grace, 2014). Chinese supplies are unlikely to grow in the years to come (Merriman, 2013), although tungsten recycling is expected to continue to grow at around 8% py over the next few years. This will increase the global production of recycled tungsten from 23% in 2012 to 28% in 2018 (Figure 3.2) (Merriman, 2013).

The price of tungsten today is relatively stable at about US$365 per mtu (= 10 kg) despite the decline in the past 18 months (Figure 3.4) (Diniz, 2014). The price has been growing steadily due to the supply-demand gap, although the market has been quieter of late. It is predicted to rise to the end of 2014 as well as in 2015 (Grace, 2014). Production shortages will result in rising prices up until 2016-2017, after which it may stabilize depending on how many suppliers enter the market (Grace, 2014). Rising production costs and increasing regulations in China are undermining prices. This continues to serve as motivation for expansion and development projects

Figure 3.4. Tungsten prices shown in dollars per 10 kg (Whittaker, 2014).

3.1.5 Outlook

- The long term fundamentals for tungsten appear strong.
- Tungsten demands from developing countries are predicted to show stronger growth (Merriman, 2013).
- Demand continues to climb and will climb to 4.5% py in 2018 (Merriman, 2013).
- New suppliers are only likely to enter the market by the second half of 2015 (Grace, 2014).
- Recycling of secondary tungsten raw materials will outpace primary mine supply of tungsten by 2018 (Merriman, 2013).
- It is predicted that tungsten production will reach 111 602 tonnes in 2015 (Hale, 2011).
- The price will continue to rise to about $478 per metric ton unit (mtu) by 2018 (Grace, 2014).
- The market is becoming more and more dependent on new suppliers to enter the market. New projects are obviously the way forward for the tungsten market to secure future supplies of material.

3.2 Rare Earth Elements (REE)

3.2.1 Introduction

Rare Earth Elements (REE) are a group of seventeen elements which are, in fact not rare, but more abundant than silver. Fifteen (La, Ce, Nd, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) of these elements are part of the lanthanide group in the periodic table (from La^{57} to Lu^{71}), plus scandium and yttrium (Humpries, 2013). They typically have the same physical and chemical properties. They are usually uncommon in mineable concentrations and difficult to separate individually, resulting in high market prices (Chegwidden, 2010).

Low concentrations of REE's are usually found in shales, granites, alkaline rocks and carbonatites (van der Merwe & Jansen, 2010). Concentrations range from 10 to a few 100 ppm's by weight (Hurst, 2010). They are typicaly more abundant in granitic rocks than basic igneous varieties, with their highest concentration in alkaline igneous rocks and carbonatites. Usually however, REE are hosted by bastnaesite and monazite and extracted from heavy mineral sands**.** The uses of the REE depend on each of the elements' unique characteristics (Hurst, 2010). Commercial applications of REE as end-use products include glass, catalysts, metallurgy, ceramics, magnets, lasers, superconductors, data storage, optical fibers, nuclear uses, magnetostrictive alloys, magnetic refrigeration, cement additive, and for paints and coatings. They are critical to high tech applications that define our modern way of life, like cell-phones and laptops. They are becoming especially important in green technologies such as new generation wind-powered turbines, plug-in hybrid vehicles and also as catalysts in oil refineries (Hurst, 2010), as well as automotive and aerospace technologies, certain healthcare applications, energy efficiency and greenhouse gas emission reduction applications (Els, 2014). Heavy Rare Earth Elements (HREE) is more commonly used for high tech applications (Hurst, 2010). They are often referred to as critical and strategic metals (Els, 2014). National security applications are also an important area where REE are vital (Humpries, 2013).

In the late 1940's the majority of the seventeen REE were sourced from placer deposits in India and Brazil (Els, 2014). In the 1950's South Africa produced most of the world's REE's from monazite veins in the Steenkampskraal mine in the Western Cape (Cordier & Gambogi, 2012). From the 1960's to 1980's, REE's were mainly produced in the US, with the Mountain Pass mine in California being the largest REE supplier in the world up until the 1970's (Hurst, 2010).This mine however eventually closed down in 2002 due to China stepping into the REE market by exploiting the major Bayan Obo deposit in Inner Mongolia (Els, 2014).

Individual REE are extracted using both solvent extraction for separation, and ion exchange for purification. By using the latter method up to 99,999% purity can be obtained (van der Merwe & Jansen, 2010). Producing REE is very complicated, much more so than gold, and it is much more costly to extract (Hurst, 2010). The elements are usually separated in the form of oxides. At this point in time China is the world's leader in terms of processing techniques and research (Hurst, 2010).

Although China is doing really well there are also countless problems that they face in their REE industry. Some of them include smuggling, which results in resources being depleted faster, a lack of control and damage to the environment (Hurst, 2010). In 2012 the production quota at REE mines was 134 million tonnes; however statistics showed a 347 million tonnes output (Yang, 2013). Severe environmental damage occurs due to lax mining practices and tailings containing Th that is radioactive. This results in health hazards and rivers being polluted that are vital to the local people. Domestic consumption is also high on the priority list for China as they have a population of some 1.3 billion and a fast growing economy (Hurst, 2010).

3.2.2 Current Market

Currently the market for REE's is quite volatile, as it has always been, because it is nascent but growing nonetheless (Els, 2014). China is still the major producer of REE's worldwide, producing up to 90% of the world's supplies (Figure 3.5), down from 97% in 2008 (van der Merwe & Jansen, 2010). With the fast-growing demand in the west and the reduced exports and related taxes in China not supporting the need in the West, industry is looking for alternative sources. In the short term, investment opportunities are looking good as the need for a supply chain independent of China is evident (Berezowsky, 2014).

According to Chegwidden (2010), there are still significant resources of REE to supply global demand for twenty to forty years. China is the major producer today, with up to 27 Mt of Rare Earth Oxides and about 23% of the world total. At this point in time Canadian exploration companies are targeting REE deposits in their country and globally, specifically to help loosen China's grip on the industry. They plan to produce 20% of the global supply by 2018 as well as lead research and development in the field (Els, 2014).

If the Chinese suddenly decide to lift their highly restrictive quotas and continue trade without restrictions with foreign countries, specifically in the West, the prices would drop so low that it would inhibit small scale, or elementary phase mining operations. Currently, renewable energy must become less expensive as it is competing with oil and gas, to which REE prices are currently a barrier (Hruska, 2012).

All this commotion regarding China's decision to stockpile a resource with such a high global demand should stimulate exploration and discovery of this commodity in other localities in the world. While REE prices have dropped, the timing is exactly right for such exploration activities. With low prices comes a delayed supply of this commodity, until prices rise again as demand for the commodity increases, thus favouring new mining operations. The following three conditions should indicate to investors whether a project is worth investing in (Currie, 2012):

1. favourable REE distribution;
2. a reasonable amount of HREEs;
3. and a joint venture partner to develop expensive projects.

Three main reasons summarize why REEs have become so important:

1. high demand,
2. uncertain supply, and
3. no substitutions (at least not good ones).

The annual demand is expected to be 200 000 tonnes in 2014, from 130 000 in 2010 (Els, 2014). Any new producers at this point will reduce China's market share significantly (Els, 2014). Chinese rare earth production capacity is scattered, thus China has no pricing power over rare earth products (Lina, 2013), and the Chinese market feels pressured because of overcapacity of their domestic markets as well as progress in exploiting rare earth reserves in other countries (Qing, 2013).

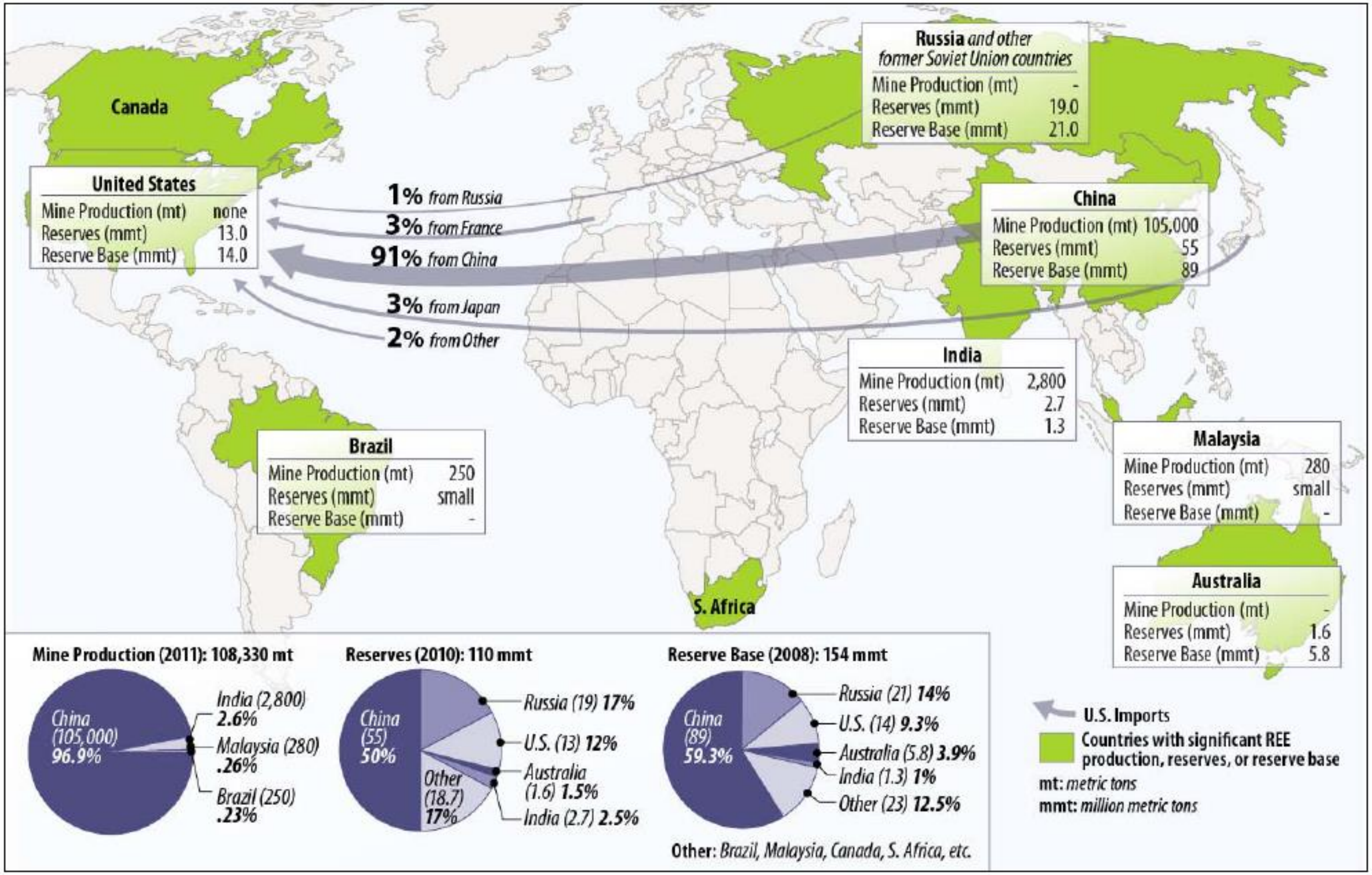
3.2.3 Reserves, production and consumption

The two main REE-bearing minerals are bastnaesite (RE carbonate) and monazite ((Ce, La, Th, Y)-PO_4). Over 90% of the world's economically recoverable REE's are found in primary bastnaesite deposits (Humpries, 2013). Allanite is not of particular importance as it hosts mainly light rare earth elements (LREE). The HREE are what is in demand (Humpries, 2013) and this is hosted by mainly heavy sand minerals such as monazite as monazite has a higher concentration of HREE relative to LREE than other REE minerals (Hurst, 2010).

Monazite heavy sand deposits are the second largest and are located in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand and the U.S. The remaining portion of the resources is made up of apatite, cheralite, eudialyte, loparite, phosphorites, rare-earth-bearing (ion adsorption) clays, secondary monazite, spent uranium solutions and xenotime (Cordier & Gambogi, 2012).

China currently holds 23% of global reserves and produces 95% of the world's REE raw material and 97% REO (Xuequan, 2013). The majority of the HREE still come from China, whereas countries outside of China mostly produce LREE (Figure 3.5) (Humpries, 2013). HREE are however scarcer, thus higher in demand (Humpries, 2013). Russia and Greenland are looking to develop rare earth industries (Qing, 2013). Canada is aiming to supply 20% of global REE by 2018 (Els, 2014).

Other REE reserves and resources occur in Colorado, Idaho, Montana, Missouri, Utah and Wyoming. HREE are also found in Quebec-Labrador (Strange Lake) and Northwest Territories (Thor Lake) in Canada (Humpries, 2013). South Africa, Australia, Brazil, India, Russia, Malaysia and Malawi are other countries that are potential REE suppliers (Humpries, 2013).



Source: U.S. Geological Survey, Mineral Commodity Summaries, 2008-2013. (Figure created by CRS.)

Figure 3.5. Rare Earth Elements – World production, Reserves and U.S Imports (Humphries, 2013).

3.2.4 Price, supply and demand

The price for REE not only depends on the supply and demand thereof, but also on the purity level of individual elements or oxides or chemicals (van der Merwe & Jansen, 2010). The prices for REE are reported mostly in $/kg. HREE are higher in demand than LREE (Figure 3.6). LREE individual prices at 99.999% purity include La at 4.80 $/kg (24/11/2014), Ce at 4.40 $/kg (24/11/2014), Pr at 74 $/kg (08/01/2015) and Nd at 9.2 $/kg (08/01/2015). The HREE prices at 99.999% purity include Sm at 20 $/kg (08/01/2015), Eu at 570 $/kg (08/10/2014), Gd at 32 $/kg (10/10/2014), Tb at 610 $/kg (08/01/2015), Dy at 290 $/kg (10/10/2014). From this it is clear that HREE are more in demand. (La, Ce and Sm prices from mineralprices.com, Pr, Nd, Tb, Dy and Eu from metal-pages.com).

Prices climbed almost 20-fold due to China's monopoly in 2008, but have come down since; some by 70% or more (Els, 2014). They rose again rapidly in 2010 and 2011, but subsequently declined in the first half of 2012. The 2011 price spike was triggered by 40% reduction of Chinese exports in 2010 (Hatch & Lifton, 2013). Price decline continued further in the second quarter of 2013 (Humpries, 2013). The latter decline is as a result of a softer demand due to substitution, high stocks and slow economic recovery. Current prices are similar to what they were in 2007-2009, when many projects emerged. It is predicted that prices are likely to strengthen in 2014, but will decline over the long term (Els, 2014). Prices may remain high again if the global production doesn't catch up (Humpries, 2013).

The sharp drop in profits in 2013 was despite modest revenue growth. Industry revenue in 2013 equalled $12.6 billion, which indicates that it went up by 7,9% (Ningzi, 2014). Profits, however, declined by 28% to less than $1.3 billion (Els, 2014).

The drop in prices is most likely due to illegal mining and selling of REE in China (Els, 2014). It can also be ascribed to Chinese products that are becoming cheaper. The difficulty with this is that the production cost is not decreasing at the same rate as the selling price of the products. Production cost is in fact increasing. REE prices started to increase as a result of China's increasing consumption and the implementation of restrictions on exports (Papp, et al., 2008).

Cost of production is also on the rise because of the generally low grade of REE deposits, increasing capital costs, as well as the environmental and social costs and rising labour cost potential in China (Humpries, 2013).

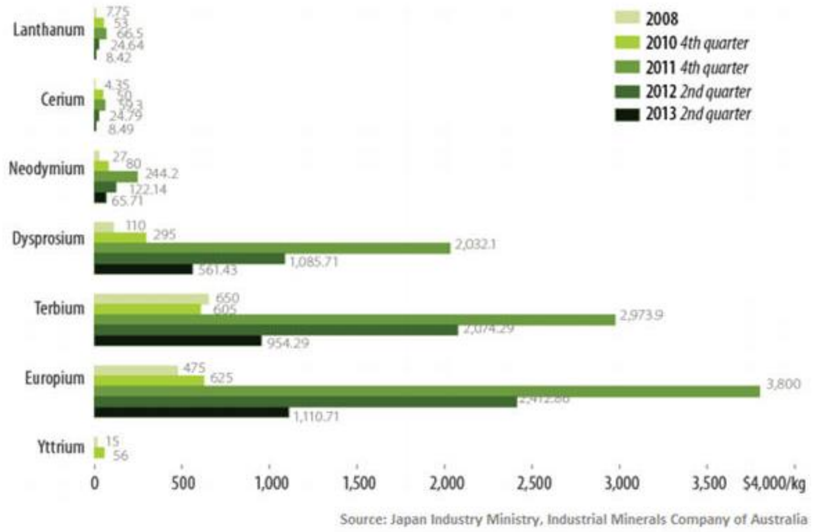


Figure 3.6. Current REE prices and trends. This diagram indicates how the prices have fluctuated since 2008 for various LREE (Els, 2014). This displays the prices for purified individual REE.

The world demand continues to climb (Figure 3.7 and 3.8) (Humpries, 2013) although the demand for Rare Earth Oxides (REO) is lower than predicted, because the amount of REO or REE consumed per-unit basis for many applications has decreased, even though the demand for these technologies is still growing strong (Els, 2014). A surge in the demand is expected, which will give time and reason for global supplies to catch up (Humpries, 2013). The world demand is estimated at 136 000 tonnes per year, compared to global production of 133 600 tonnes in 2010. This production is projected to rise to 210 000 tonnes in 2015, and then 160 000 tonnes by 2016 (Humpries, 2013).

The supply is in a state of surplus in 2014, especially Ce and La (Berezowsky, 2014). Mines in the West may cause excess supply of La, Ce, Pr, but shortfalls mostly of HREE which is mostly in demand (Humpries, 2013). Supplies and prices are also under pressure due to emerging economies which depend largely on materials for new infrastructure projects (Humpries, 2013). Lack of REO separation capacity outside of China causes a major downstream gap in the supply chain (Els, 2014). A diversified global supply will give relief to overexploited Chinese mines (Qing, 2013). It is quite evident that placing the REE supply chain in the global context is unavoidable. It has come to a point where a supply chain outside of China needs to be built up (Humpries, 2013).

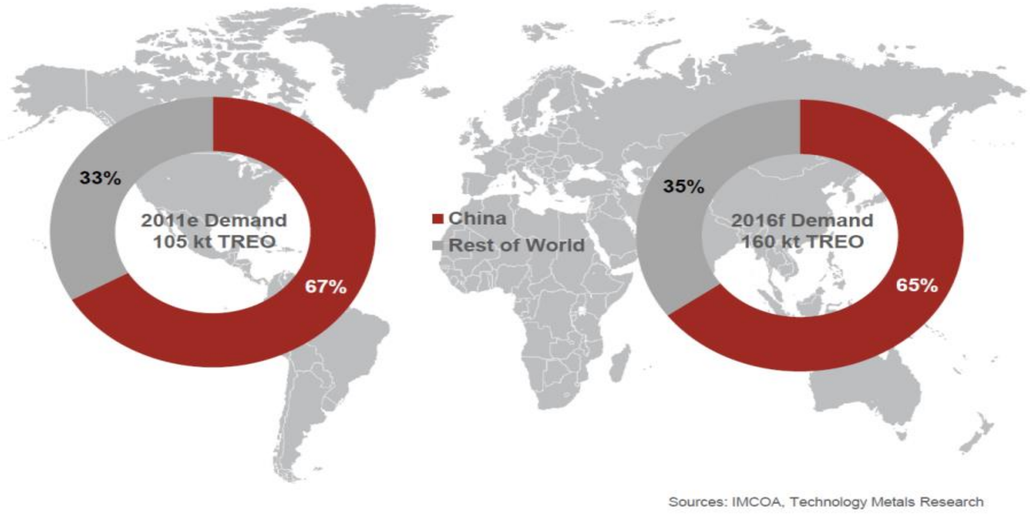


Figure 3.7. The REO demand as it was in 2011 and its forecast in 2016 (Hatch & Lifton, 2013). This shows the demand for rare earth oxides.

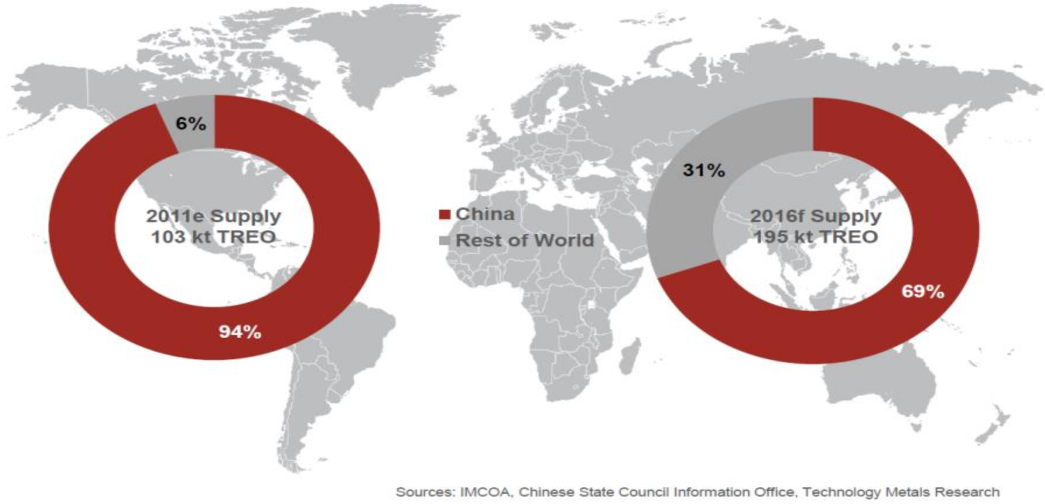
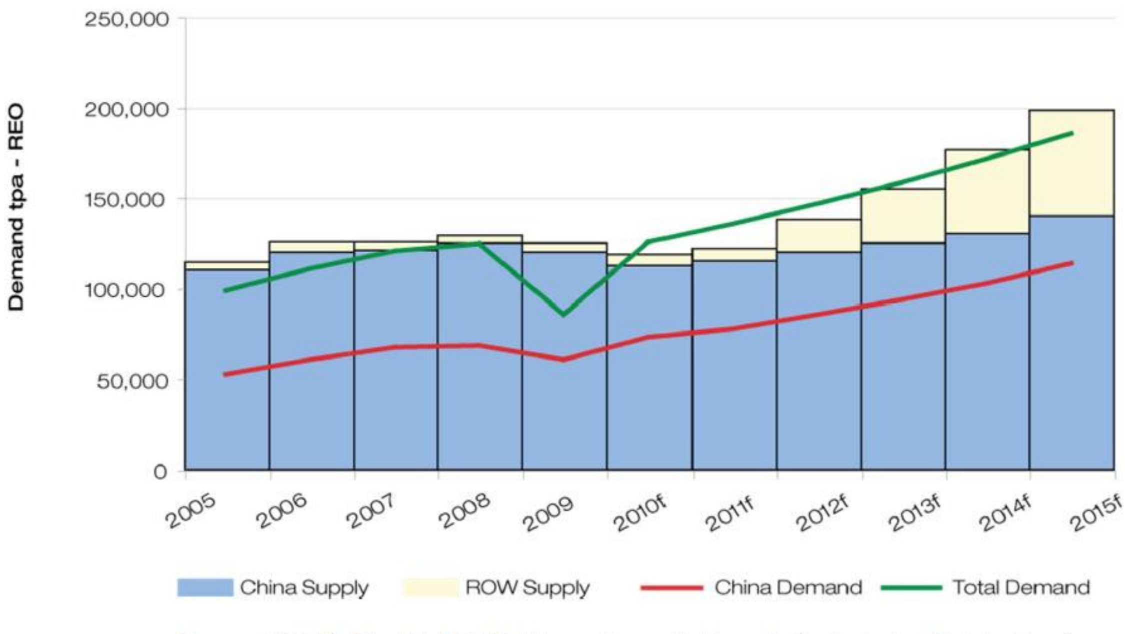


Figure 3.7 continued. The TREO supply as it was in 2011 and its forecast in 2016 (Hatch & Lifton, 2013). This shows the supply for rare earth oxides.



Source: IMCOA, Roskill, CREIC, Discussions with Rare Earths Industry Stakeholders

Figure 3.8. The supply and demand curve for REO in terms of China's supply and demand versus the rest of the world's (ROW) supply and demand.

3.2.5 Outlook

- Despite the restrictions on exports by China, the country will continue to be the world's largest REE producer, at least for the foreseeable future. Even though China will not be able satisfy its own demands, the country will have to continue the export of lower value RE products in order to continue international RE trade relations.
- End-users are busy resorting to substitutes and/or lower amounts in many applications (Els, 2014).
- 40 000 ton annual shortfall in 2015 (Hurst, 2010).
- China's REE industry consolidation will firm up REE in China and elsewhere (Els, 2014).
- It is predicted that prices are likely to strengthen in 2014, but will decline over the long term (Els, 2014).
- Currently the demand continues to climb (Humpries, 2013).
- Demand still remains higher than supply and continues to grow, especially for HREE
- A supply chain outside of China needs to be built up (Humpries, 2013).
- The world demand is estimated at 136 000 tonnes per year, compared to the global production of 133 600 tonnes in 2010. This production is projected to rise to 210 000 tonnes in 2015, and then 160 000 tonnes by 2016 (Humpries, 2013).
- The market will continue to grow.

Future projects need to have robust profit margins that will enable them to endure potential downturns in pricing, as well as timely payback on preproduction capital and prospects of solid revenues from REO's and non-REO products (Els, 2014).

The long term outlook for the industry is an increasingly competitive and diverse group of REE suppliers (Cordier & Gambogi, 2012). However, there is an issue with long term sustainability (Kifle, et al., 2013), as the current state of the market has and will force buyers to look elsewhere and find substitutes for REE. However, for the short term, the market is favourable. Companies already in the industry will also start looking at increasing recycling from waste (Kifle, et al., 2013).

Chapter 4 – Petrography

This section is based on empirical evidence through petrographical and mineral chemistry observations. The major silicate, secondary, accessory and ore minerals of the granite host are discussed in terms of their characteristic features such as textures, alteration products, end-members, and major associations. Skarn minerals found in the granite host are also discussed. From this study the modal mineralogy is then used to classify the host rock. All mineralogical descriptions were made in transmitted light. Ore microscopy was done in reflected light.

Qualitative and quantitative high-, medium- and low-grade zones have been delineated as a guideline to explain the mineralogy and enrichment attributes of the pluton.

All the different types of alteration that have been identified in thin-section studies are discussed in detail in terms of occurrence, as well as texture and mineral chemistry. A comparison is also made with previous literature on what defines the different types of alteration.

Lastly, a paragenetic sequence was derived through observing the textures and alteration features of all the minerals of interest. This aids in the development of a genetic model for the deposit.

General note – where reference is made to depth, it is the depth from the granite-wall rock contact (Figure 4.19). All mineralogy tables are just representative samples. For full results see appendix.

4.1 Mineralogy and mineral chemistry

4.1.1 Silicates

The general silicate mineralogy of the granite host rock is rich in quartz and feldspars, although highly altered, as well as altered sheet silicates. The major silicate minerals, quartz (SiO_2), primary plagioclase feldspar (An_{15-33}), alkali feldspar ($(K, Na)AlSi_3O_8$) and biotite ($(K, Na)(Mg,Mn, Fe)^{+2}{}_3[AlSi_3O_{10}(OH,F)_2$) vary little in this pluton in the sense that they are common throughout the pluton. Variations that are evident are in terms of grain sizes and extent of alteration.

Quartz normally has a range of grain sizes, from porphyritic to cryptocrystalline quartz grains. The latter indicate silicification as a type of alteration in this pluton (see section 4.2). Normally no clear-cut boundary is evident, but a rather irregular or diffusive type of grain boundary. The quartz grains are usually sub-rounded or irregular in shape. Clusters of quartz grains also occur locally. Quartz exhibits undulose extinction throughout the pluton. Towards the roof of the granite cupola the pluton displays a prominent quartz porphyry texture. Micro-quartz veins were also encountered numerous times.

Both alkali and plagioclase feldspar are important mineral phases throughout the pluton in depth. They are always altered; however the degree of alteration varies. Twinning is preserved in the feldspars in most sections, with plagioclase showing albite twins, and alkali feldspar showing cross-hatched or tartan twinning, or Carlsbad twins in some cases. Feldspars usually have a rectangular or sub-rounded, euhedral to subhedral shape. Grain boundaries are usually quite clear-cut, although they can become diffusive depending on the degree of alteration. Grain sizes vary from porphyritic to about 0.2 mm.

Both feldspars alter to small grains of white mica (muscovite – $K_2Al_4[Si_6Al_2O_{20}](OH)_4$) with negligible or no Na). The term white mica will be used from now onwards to refer to any form of secondary muscovite. It appears that plagioclase is always the first feldspar to alter (e.g. Figure 4.1.b), and the extent of alteration is always more than alkali feldspar. In many samples the two feldspars occur next to each other, with plagioclase feldspar in between alkali feldspar (Figure 4.1 and 4.2). A common feature is to find an altered inner plagioclase feldspar core (An_{0-50}), surrounded by a secondary alkali feldspar rim (Figure 4.1.a). This overgrowth of alkali feldspar is in some cases towards the centre of the pluton and forms part of the process of potassic alteration (see section 4.2.3). In other cases, on the periphery of the pluton, overgrowths are also observed; however the rim around the altered inner core of plagioclase is also plagioclase (An_{15-20}), but higher in albite (Figure 4.2.b). Concentric zoning has also been observed in plagioclase feldspar (Figure 4.1.b and c).

Relatively unaltered or secondary alkali feldspar grains are also a common feature in the roof of the pluton. These secondary grains commonly contain no Ba, whereas Ba is present in the original, relatively unaltered alkali feldspar grains by up to 3,8% which has normally been slightly altered by hydrothermal alteration (Table 4.1). There are thus two stages of alkali feldspar formation (Figure 4.1); the first stage which forms part of the original rock composition and is usually altered, and the second stage consisting of relatively unaltered secondary alkali feldspar grains which forms part of the potassic alteration stage. Secondary alkali feldspar exists in two forms; individual fine-grained alkali feldspar grains and rims around altered inner plagioclase feldspar cores.

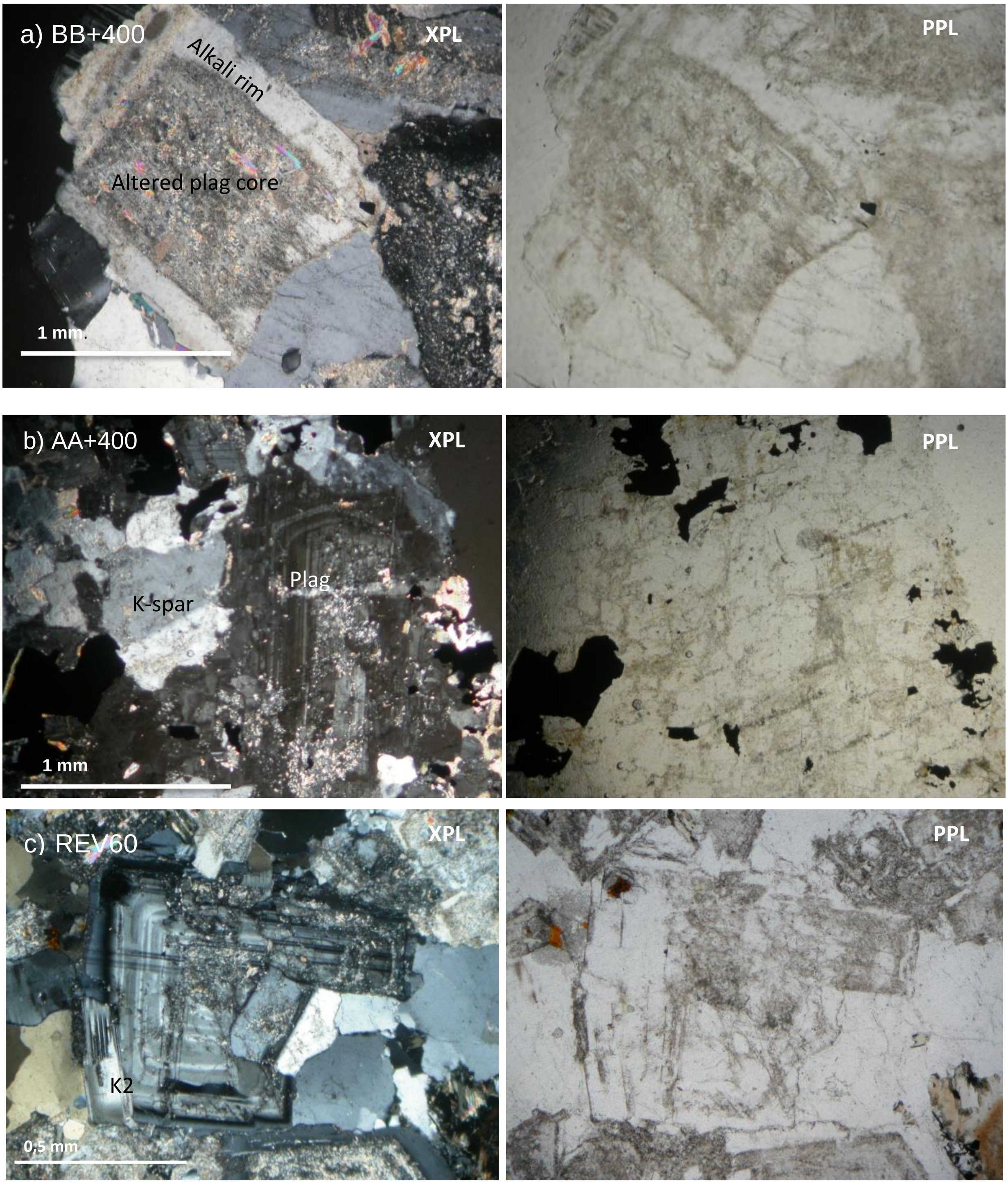


Figure 4.1. Photomicrographs illustrating the common attributes of plagioclase and alkali feldspar in the host rock. a) One form of potassic alteration is characterised by a secondary alkali feldspar rim enclosing an altered inner plagioclase core. b) Twinning in both alkali feldspar (Carlsbad twins to the left) and plagioclase feldspar (albite twins). Also note the concentric zoning in plagioclase feldspar. c) Concentric zoning is still clearly observed in plagioclase feldspar significantly at depth (480 m) in the host rock where more fresh samples are observed. A small grain overgrowth of secondary alkali feldspar is also displayed.

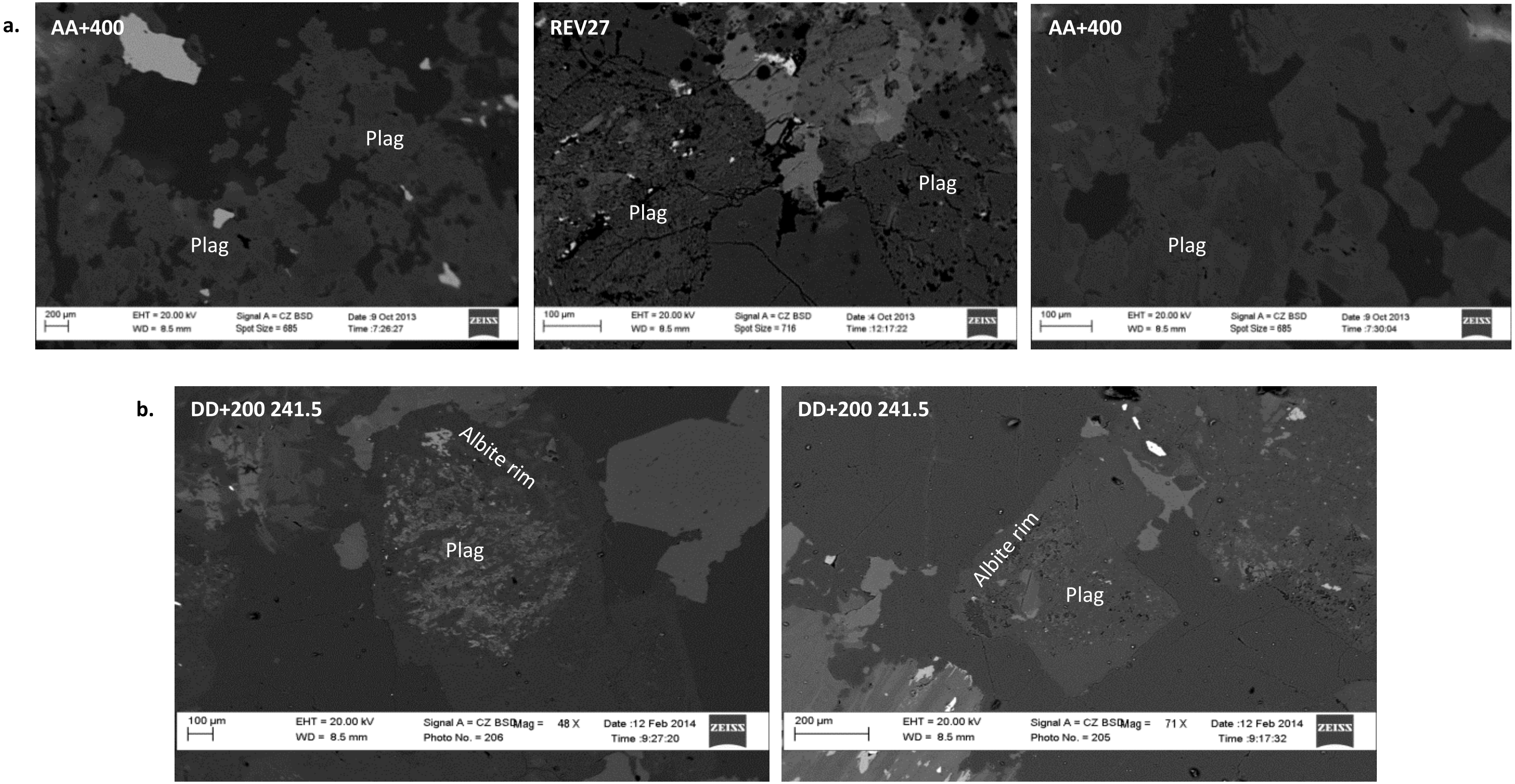


Figure 4.2. BSE images illustrating common attributes of plagioclase feldspar. a) Plagioclase feldspar occurs throughout the host rock. This is typically how plagioclase occurs at low to medium depth (< 137.5 m) below surface. The variability in grey-scale is indicative of varying intensities of base elements like K, Na, and Ca (AA+400 samples). b) Towards the periphery of the pluton, feldspathization in the form of albitization is characterised by an altered inner plagioclase centre, surrounded by a rim of more albitic plagioclase feldspar.

Table 4.1. Representative samples of the major mineral chemistry of the various phases and features of plagioclase and alkali feldspars (wt %). BaO is mostly associated with primary alkali feldspar.

	Na_2O	Al_2O_3	SiO_2	K_2O	CaO	FeO	BaO	Total
Plagioclase feldspar (plag 1)	11.94	19.47	68.83	0.00	0.09	0.14	0.00	100.47
	11.75	19.38	68.01	0.00	0.13	0.00	0.00	99.27
	10.82	20.34	66.34	0.16	1.10	0.00	0.00	98.76
	8.84	23.24	61.94	0.19	4.62	0.18	0.19	99.20
	7.59	24.74	59.46	0.25	6.44	0.00	0.00	98.48
	9.20	21.34	64.79	0.12	3.49	0.16	0.00	99.10
	7.92	25.09	60.12	0.17	6.41	0.00	0.00	99.71
	8.59	24.04	61.67	0.20	5.50	0.00	0.00	100.01
	10.85	20.99	66.58	0.00	1.40	0.00	0.00	99.82
	7.86	25.31	60.02	0.28	7.05	0.18	0.00	100.72
	10.91	19.91	67.78	0.00	0.63	0.00	0.00	99.22
	11.85	19.75	68.18	0.00	0.00	0.00	0.00	99.77
Alkali feldspar (K1)	1.28	19.32	62.91	13.90	0.00	0.00	2.62	100.04
	1.03	19.35	61.80	13.55	0.00	0.00	2.69	98.41
	0.79	18.46	64.83	15.43	0.00	0.00	0.57	100.09
	1.20	19.24	62.68	13.58	0.00	0.00	2.34	99.04
	0.54	18.18	64.32	15.51	0.00	0.00	0.71	99.26
	1.11	18.50	64.38	14.62	0.00	0.00	0.46	99.08
	0.59	18.99	63.29	15.21	0.00	0.00	1.34	99.42
	0.77	18.62	63.52	15.12	0.00	0.00	1.23	99.26
	0.86	18.71	64.18	15.41	0.00	0.00	1.03	100.20
	1.37	18.79	62.01	13.51	0.00	0.00	2.49	98.17
	1.28	18.59	63.44	13.97	0.00	0.00	1.30	98.59
	1.46	19.28	60.95	12.80	0.00	0.00	3.84	98.32
	0.48	18.34	64.70	16.01	0.00	0.00	0.73	100.25
	0.48	18.50	65.30	15.66	0.00	0.00	0.79	100.73
	0.61	18.10	63.53	15.90	0.00	0.00	0.48	98.62
Secondary alkali feldspar (K2)	0.76	18.05	64.59	16.00	0.00	0.00	0.00	99.40
	0.34	18.17	64.97	15.18	0.00	0.00	0.00	98.66
	0.54	18.26	65.21	15.89	0.00	0.00	0.00	99.89
	0.40	18.39	65.08	16.10	0.00	0.00	0.00	99.96
	0.25	18.08	64.68	16.37	0.00	0.00	0.00	99.37
	1.17	18.40	65.24	15.34	0.00	0.00	0.00	100.14
	0.73	18.26	65.30	16.00	0.00	0.00	0.00	100.29
	0.58	18.49	65.30	16.18	0.00	0.00	0.00	100.54
	0.71	18.22	64.58	15.78	0.00	0.00	0.00	99.29
	0.46	18.15	64.73	16.35	0.00	0.00	0.00	99.69
	0.92	18.25	64.72	15.29	0.00	0.00	0.00	99.19
	0.48	18.53	65.14	16.34	0.00	0.00	0.00	100.49
	1.04	18.44	65.34	15.46	0.00	0.00	0.00	100.28
	0.57	18.25	65.59	16.24	0.00	0.00	0.00	100.65

		0.96	18.05	64.53	15.35	0.00	0.00	0.00	98.88
		1.31	18.24	64.11	14.83	0.00	0.00	0.00	98.49
Altered plagioclase feldspar centre (plag2)		8.83	21.15	64.80	0.00	0.00	3.21	0.00	97.98
		9.13	20.59	65.55	0.00	0.00	2.42	0.00	97.70
		8.12	22.13	63.63	0.16	0.00	4.22	0.00	98.26
		9.36	21.03	67.95	0.11	0.00	2.35	0.00	100.81
		9.42	20.46	66.67	0.57	0.00	1.50	0.00	98.62
		9.20	20.11	65.88	0.00	0.00	1.95	0.00	97.14
		9.31	20.46	66.54	0.18	0.00	1.47	0.00	97.96
		8.91	20.57	64.50	0.11	0.00	2.69	0.00	96.77
		7.10	23.76	59.94	0.24	0.00	6.57	0.00	97.61
		8.87	21.94	67.19	0.11	0.00	3.50	0.00	101.62
		10.34	19.19	71.42	0.00	0.00	0.11	0.00	101.06
		9.04	21.62	67.07	0.23	0.00	3.22	0.00	101.19
		9.72	20.44	69.81	0.00	0.00	1.20	0.00	101.18
		9.05	21.34	67.27	0.00	0.00	2.49	0.00	100.16
		9.52	20.43	68.34	0.00	0.00	1.40	0.00	99.69
		9.22	20.86	68.39	0.00	0.00	1.83	0.00	100.30
		9.44	20.49	69.46	0.00	0.00	1.57	0.00	100.96
Rim around plagioclase (plag3)	Albite	9.65	21.68	64.81	0.16	3.67	0.00	0.00	99.96
		9.89	20.77	65.43	0.21	2.79	0.00	0.00	99.09
		9.54	21.67	64.86	0.18	3.64	0.00	0.00	99.88
		10.21	21.36	65.09	0.10	3.38	0.00	0.00	100.13
		9.72	21.31	64.27	0.19	3.75	0.00	0.00	99.23
		10.28	21.19	65.76	0.18	3.03	0.00	0.00	100.44
		9.82	20.96	65.56	0.19	3.16	0.00	0.00	99.68
		8.97	22.17	63.05	0.14	4.65	0.00	0.00	98.98
	Secondary alkali feldspar (K2)	0.85	18.58	61.73	13.30	4.15	0.00	0.00	98.62
		0.62	18.75	59.47	12.39	7.85	0.00	0.00	99.09
		1.05	19.25	61.81	12.92	5.64	0.00	0.00	100.66
		0.81	18.54	61.17	13.12	5.08	0.00	0.00	98.73
		0.95	18.57	62.20	13.15	3.99	0.00	0.00	98.86
		0.71	18.17	61.90	13.87	4.01	0.00	0.00	98.66

Altogether five phases of feldspar have been observed in this pluton. They include primitive plagioclase (plag1) and alkali feldspar (K1), secondary alkali feldspar in the form of rims around altered inner cores of plagioclase (plag2) and small secondary grains (K2) in the matrix, and lastly albitic and potassic rims (plag3) around altered inner plagioclase cores. Plag1 (An_{15-33}) ranges from albite to oligoclase to (Figure 4.3.a), whereas K1 displays slight variations in K_2O, but are slightly more enriched in Na_2O than K2. In terms of Ba, plag1 (Figure 5.1.3.b) contains between 0 and 0.5 wt % Ba. K1 displays a range of Ba concentrations, from 0 to almost 4 wt % Ba, whereas K2 has virtually no Ba (Figure 4.3.b).

More anorthite-rich samples of plag3 (An_{0-50}) (andesine to labradorite) have been observed. The rims around plag2, can either be potassic or albitic (An_{15-20}) in compostion (Figure 4.3.a) and both phases contain no Ba (green crosses).

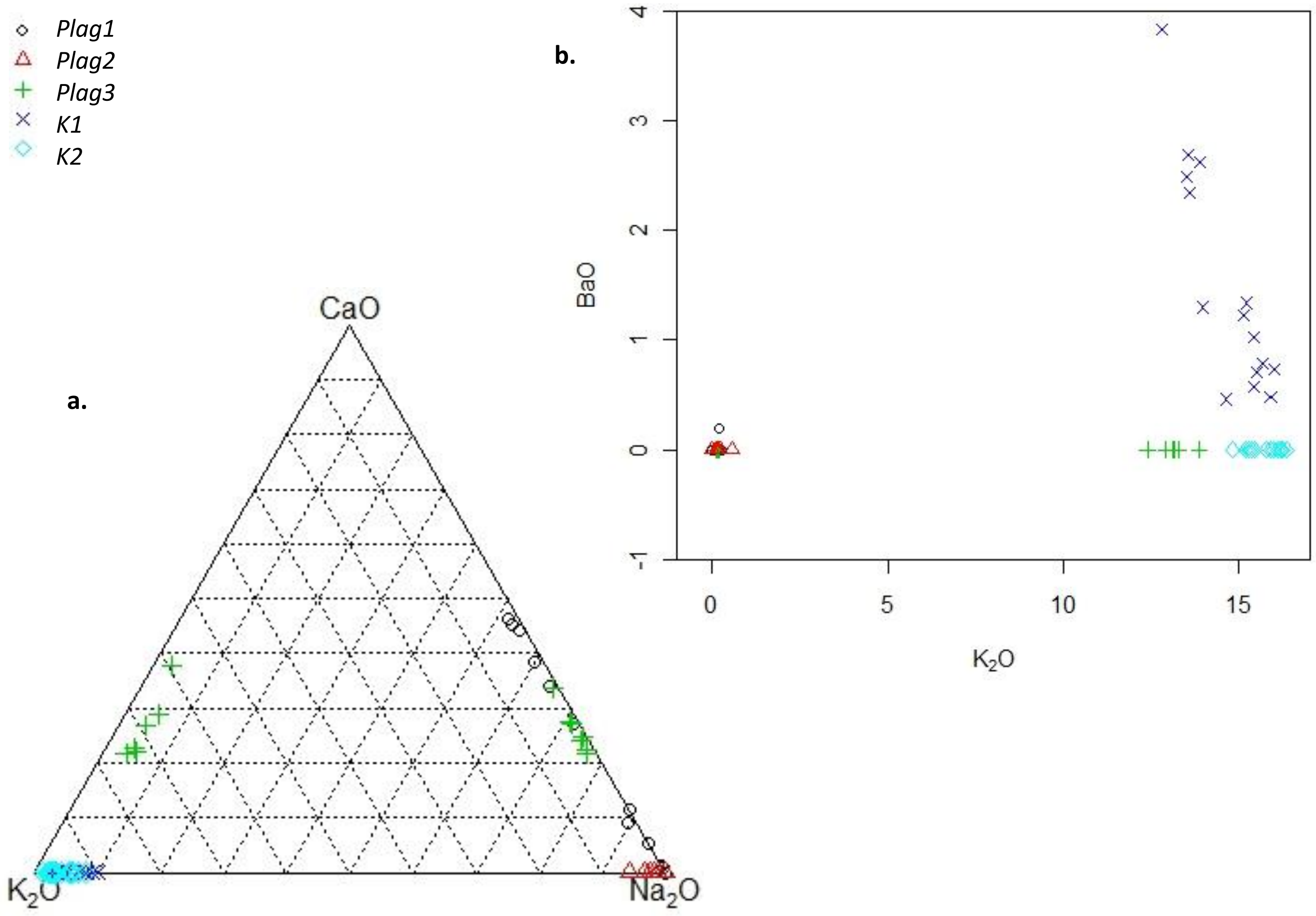


Figure 4.3. These diagrams illustrate the mineral chemistry of all the feldspar phases (n=74). a) A ternary diagram of the feldspar end members display the variable mineral chemistry of the feldspars. Plag 3 describes the rims around plag2 which can either be potassic (cluster of green crosses on the left) or albitic (cluster of green crosses on the right). Plag2 is almost purely albitic. b) Ba is associated mostly with primary alkali feldspar (navy crosses). (Plag1: Primary plagioclase feldspar (open circles), Plag2: altered centre plagioclase (open red triangles), Plag3: rims of alteration around plagioclase (green cross), K1: primary alkali feldspar (navy crosses) and K2: secondary alkali feldspar (open blue squares).

Biotite can either occur as primary (biotite 1) or secondary biotite (biotite 2) (Figure 4.4) whilst the former is more prominent. A distinctive characteristic of biotite is its strong pleochroism and also its cleavage in one direction. The shape of biotite is generally elongated. Biotite has a distinctive red-brown colour, although secondary biotite has a more pronounced red-brown colour under PPL. Primary biotite is usually porphyritic, and also altered to chlorite, white mica and pyrite which is a form of retrograde alteration (refer to ore minerals). Inclusions like apatite are found in biotite (Figure 4.5). At depth, primary biotite is entirely preserved to slightly altered (Figure 4.4.b).

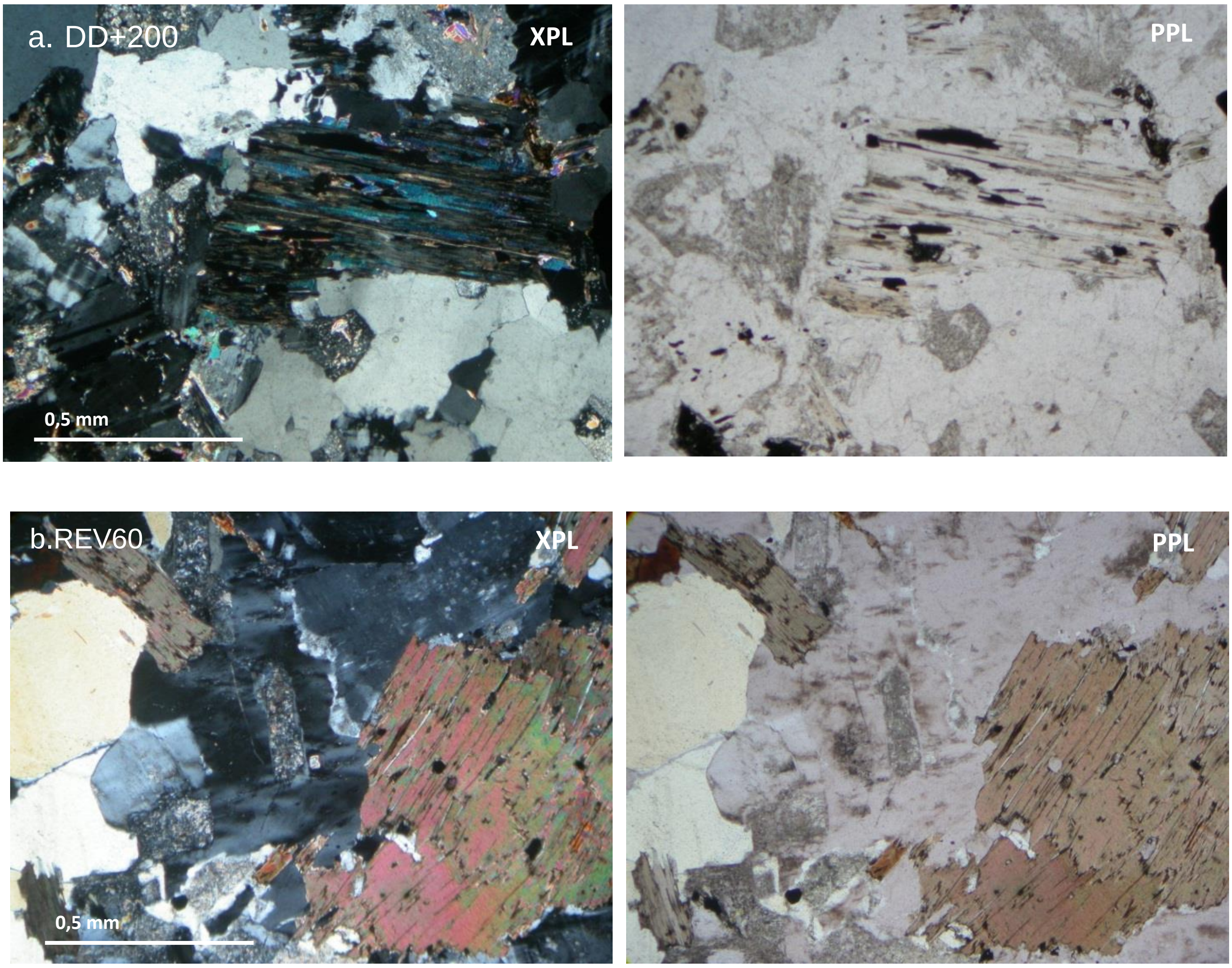


Figure 4.4 Photomicrographs illustrating common attributes of biotite. a) Note the characteristic cleavage in one direction and the alteration into intergrown chlorite, white mica and pyrite. b) Primary biotite in its most primitive form (at a depth of 460.5 m).

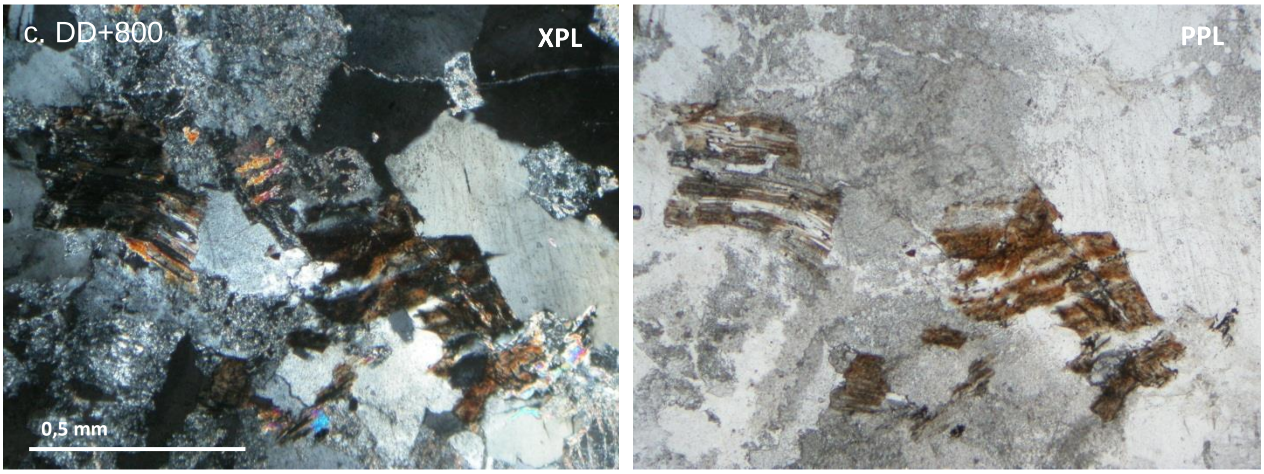


Figure 4.4 continued. c) Secondary biotite (the grain on the right) is not very common in the host rock, but when it occurs it appears in a more intense red-brown colour (under PPL) and does not have a well-defined cleavage in one direction.

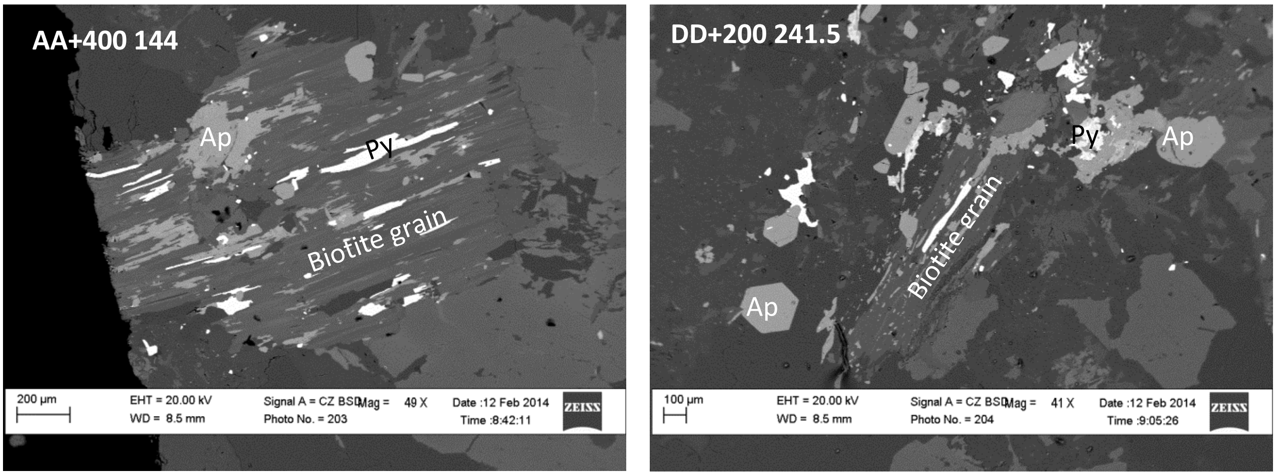


Figure 4.5 These BSE images display the mineral phases that are commonly associated with biotite in the form of intergrowths (white mica, chlorite and pyrite) or inclusions (apatite). White mica and chlorite in these images are the darker thin bands intergrown with primary biotite (slightly lighter bands).

Table 4.2. Representative samples of the major mineral chemistry of primary and secondary biotite (wt %). Primary biotite (biotite 1) has altered to chlorite and muscovite. Primary biotite was not measured due to the effect of hydrothermal alteration. Secondary biotite (Biotite 2) is new biotite grains which form part of the potassic alteration process.

	Na_2O	K_2O	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Total
Biotite 1	0.00	9.80	46.49	0.46	27.69	2.24	0.16	4.95	0.00	91.79
	0.17	10.35	46.45	0.27	28.37	1.96	0.00	4.27	0.00	91.83
	0.30	9.62	43.23	0.46	27.19	1.75	0.00	3.59	3.05	89.18
	0.27	10.21	45.79	0.33	27.86	1.86	0.00	4.50	0.00	90.82
Biotite 2	0.08	9.07	40.64	1.24	12.80	16.14	0.00	14.19	0.00	94.18
	0.07	9.08	40.40	1.21	12.86	17.09	0.01	14.21	0.02	94.94
	0.07	9.25	40.40	1.19	12.64	16.82	0.02	14.37	0.03	94.78

Other silicate phases like epidote, titanite, allanite, white mica and chlorite are seen as secondary minerals and will therefore be discussed in the next section. Allanite will be discussed in detail in chapter 6. White mica will be discussed in section 4.2.2.

4.1.2 Secondary minerals

Secondary minerals include carbonates ((Ca, Mg, Mn, Fe)CO_3), chlorite ($(Mg,Na,Fe,Mn,Al)_{12}[(Si,Al)_8O_{20}](OH)_{16}$), epidote ($Ca_2(Fe,Al)Al_2(SiO_4)(Si_2O_7)O(OH)$), titanite ($CaTiSiO_5$), goethite, secondary biotite ($(K_2(Mg,Fe^{2+})_4(Al,Fe^{3+},Ti)_1[Si_6Al_3O_{20}](OH)_4)$) and white mica (the latter is discussed in section 4.2.2).

Carbonate is usually identified by its extremely high pastel-like birefringence (4th order), and also its characteristic lamellar twinning (Figure 4.6). Secondary carbonates are generally interstitial, and are mostly associated with altered primary plagioclase feldspar. This mineral can also form locally as thin micro-veins, although this is not very common. The occurrence of this mineral is more prominent with lower temperature phyllic alteration although it is pronounced throughout the pluton.

Chlorite is a secondary mineral (Figure 4.4 and 4.6), which forms either by the alteration of primary biotite or directly as a retrograde alteration product. Chlorite exhibits a distinctive anomalous blue interference colour, is green in colour (under PPL) and pleochroic in variations of green. Grains are usually up to 0.5 mm in size. Chlorite decreases with depth, whereas biotite increases with depth, which indicates that the effects of infiltrating water are more pronounced at the top of the pluton. The two main types of chlorite found in this pluton are pycnochlorite and chamosite (Table 4.3).

Epidote is normally a small euhedral rounded to sub-rounded mineral with a high relief (Figure 4.6), is colourless to light green in colour and has bright (2nd order) interference colours. It is relatively fine-grained and occurs sporadically throughout the pluton. Epidote is generally associated with altered plagioclase feldspar and allanite. In the latter case it forms as concentric rims around allanite (see chapter 6).

Titanite has a characteristic diamond shape and a red-brown colour (Figure 4.6). It also has medium to high relief. Grain sizes can be from 0.05 mm to 0.8 mm. Titanite is locally associated with either pyrite or allanite.

Goethite occurs where there is extreme low temperature hydrothermal alteration and is a late stage mineral (Figure 4.6). It appears as small dark brown to red grains all over the matrix.

Secondary biotite is usually much smaller in grain size than primary biotite and also has irregular shapes. Although the distinctive, red-brown colour is evident, the prominent cleavage is not as strongly developed as in primary biotite (Table 4.2).

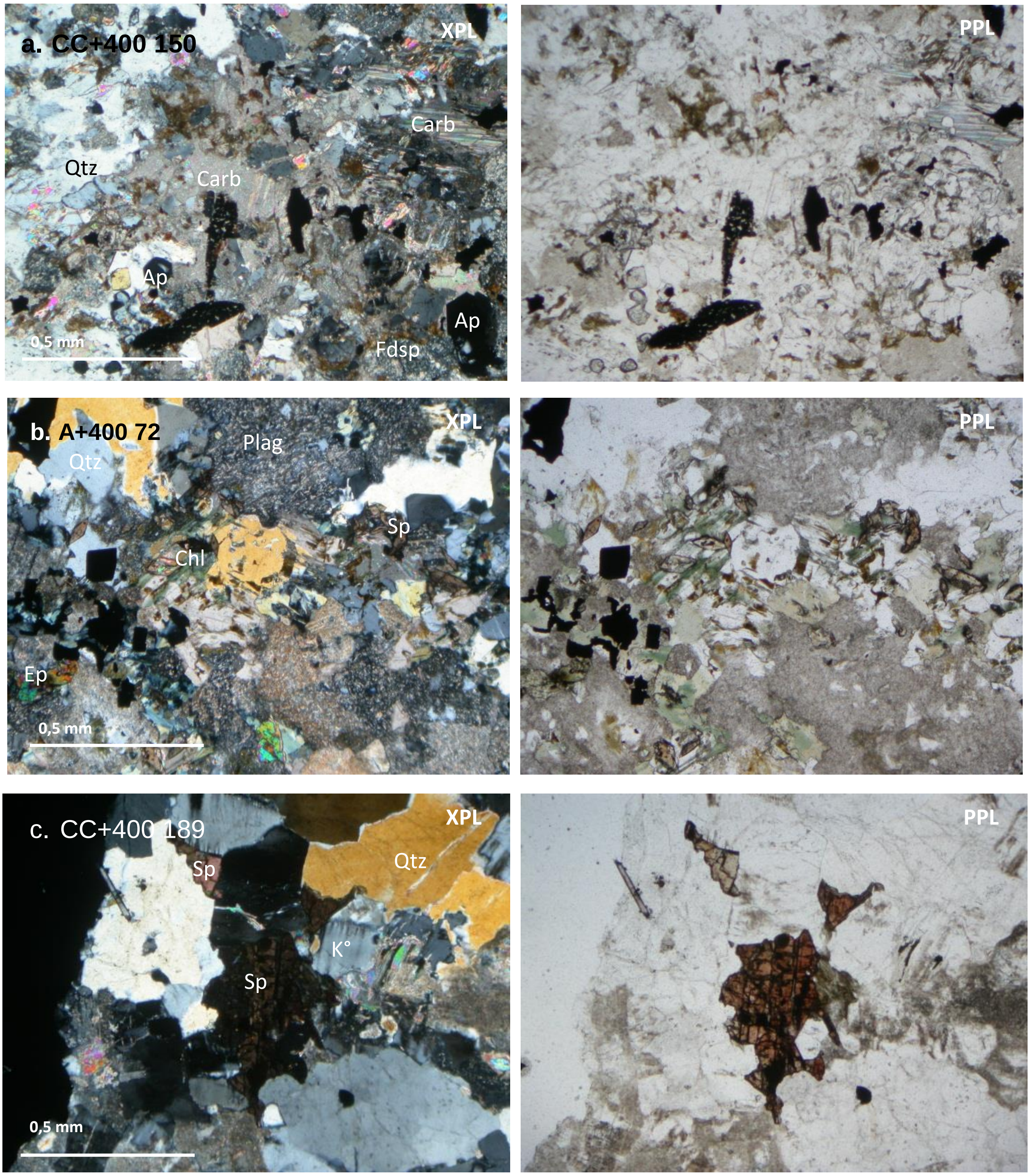


Figure 4.6. Photomicrographs explaining the general aspects of secondary minerals. a) An altered matrix with interstitial carbonate and some euhedral apatite grains in the matrix. b) Altered plagioclase, with some chlorite, epidote and fine-grained titanite (diamond shape) in the matrix. c) Titanite in its distinctive red-brown colour and high relief. Some secondary alkali feldspar is also seen.

Table 4.3. Representative samples of the major mineral chemistry of chlorite, epidote and titanite (wt %). Low total values indicate significant amounts of water in the crystal structure.

Mineral	Variety	F	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	V_2O_5	FeO	Total
Chlorite	Pycnochlorite	0.00	0.00	21.08	20.37	29.03	0.09	0.00	0.00	1.49	0.00	15.77	87.82
		0.00	0.00	21.04	19.50	29.32	0.11	0.00	0.26	1.32	0.00	15.98	87.54
		0.00	0.00	20.56	20.43	28.94	0.00	0.00	0.00	1.48	0.00	16.16	87.57
		0.00	0.00	21.59	17.73	31.04	0.18	0.00	0.34	1.39	0.00	14.63	86.91
		0.00	0.00	20.31	17.72	30.13	0.26	0.00	0.54	1.37	0.00	16.53	86.86
		0.00	0.00	20.01	17.59	29.56	0.37	0.27	0.78	1.31	0.00	15.78	85.65
		0.00	0.00	19.32	18.56	28.02	0.00	0.00	0.17	1.34	0.00	16.71	84.12
		0.00	0.00	18.88	18.86	27.48	0.00	0.00	0.00	1.38	0.00	16.59	83.18
		0.00	0.00	21.55	19.81	28.72	0.00	0.00	0.00	1.35	0.00	14.66	86.09
		0.00	0.00	21.57	19.93	28.76	0.00	0.00	0.00	1.34	0.00	14.18	85.78
		0.00	0.00	21.80	18.28	29.49	0.00	0.00	0.00	1.17	0.00	13.80	84.55
		0.00	0.00	21.09	18.88	28.54	0.00	0.10	0.00	1.19	0.00	14.72	84.51
		0.00	0.00	21.54	18.97	29.58	0.00	0.00	0.00	1.37	0.00	14.51	85.97
	Chamosite	0.00	0.00	16.11	19.21	28.40	0.00	0.00	0.00	0.55	0.00	23.99	88.26
		0.00	0.00	14.71	19.96	27.42	0.00	0.00	0.00	0.76	0.00	25.87	88.72
		0.00	0.00	15.24	19.20	28.24	0.13	0.00	0.00	0.46	0.00	24.79	88.06
		0.00	0.00	15.32	18.54	28.82	0.58	0.17	1.10	0.60	0.00	24.28	89.40
		0.00	0.00	15.26	16.91	28.73	0.20	0.00	1.07	0.64	0.00	23.75	86.55
		0.00	0.00	14.82	19.30	27.31	0.00	0.00	0.00	0.74	0.00	25.71	87.88
		0.00	0.00	14.13	19.23	26.70	0.00	0.00	0.00	0.64	0.00	26.16	86.85
		0.00	0.00	13.43	18.69	27.47	0.10	0.00	0.00	0.75	0.00	27.71	88.14
		0.00	0.00	14.53	19.75	27.14	0.00	0.00	0.20	0.67	0.00	25.74	88.02
		0.00	0.00	14.32	18.93	27.29	0.00	0.00	0.00	0.62	0.00	26.77	87.94
		0.00	0.00	13.24	20.94	25.59	0.00	0.00	0.14	0.81	0.00	26.96	87.68
		0.00	0.00	14.76	17.77	28.93	0.82	0.21	1.30	0.63	0.00	24.23	88.66
		0.00	0.00	14.13	17.39	29.71	1.22	0.60	1.97	0.55	0.00	23.67	89.24
		0.00	0.00	14.26	18.51	28.14	0.40	0.00	0.69	0.69	0.00	26.09	88.78
		0.00	0.23	13.80	19.50	27.01	0.00	0.00	0.00	0.63	0.00	26.75	87.94
		0.00	0.00	14.56	17.86	28.24	0.33	0.00	0.69	0.59	0.00	26.03	88.30
Epidote		0.00	0.00	0.00	26.54	37.91	0.00	21.93	0.00	0.00	0.41	6.85	93.62
		0.00	0.00	0.00	27.74	38.56	0.00	21.88	0.00	0.00	0.75	7.30	96.23
		0.00	0.00	0.00	26.79	38.62	0.00	21.92	0.00	0.00	0.00	7.32	94.65
		0.00	0.00	0.00	27.74	38.57	0.00	21.88	0.00	0.00	0.75	7.30	95.90
		0.00	0.00	0.00	24.91	36.93	0.00	20.99	0.00	0.70	0.00	12.01	95.55
		0.00	0.00	0.00	24.93	35.60	0.00	20.11	0.00	0.50	0.00	11.13	92.43
Titanite		2.44	0.00	0.00	3.40	30.16	0.00	28.78	31.31	0.00	1.80	2.08	99.98
		2.34	0.00	0.00	3.83	30.06	0.00	28.64	30.38	0.00	1.77	1.51	98.53
		2.53	0.00	0.00	3.93	30.14	0.00	28.34	30.24	0.28	2.32	1.54	99.31
		1.65	0.00	0.00	2.12	29.67	0.00	28.79	32.84	0.37	1.46	1.39	98.30
		2.17	0.00	0.00	1.71	29.14	0.00	28.36	32.62	0.33	1.09	1.73	97.14
		2.72	0.00	0.00	2.80	29.39	0.00	28.83	30.29	0.34	0.79	2.53	97.69

	7.92	0.00	0.00	10.29	30.41	0.00	28.58	23.44	0.26	0.00	0.50	101.41
	1.79	0.00	0.00	1.98	30.04	0.00	27.11	34.14	0.00	0.84	1.33	97.25

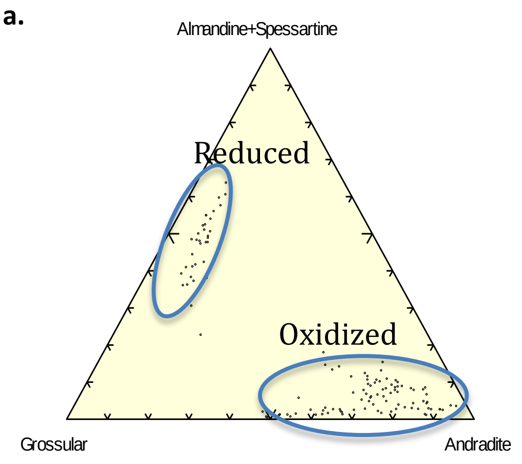
4.1.3 Skarn minerals

Although minerals in this section are grouped as skarn minerals they are also considered to be secondary minerals but forms part of the skarn formation process and are as a result of metasomatism.

Skarn minerals include scheelite ($CaWO_4$), garnet (andradite – $Ca_3(Fe^{3+},Ti)_2Si_3O_{12}$, grossular $Ca_3Al_2Si_3O_{12}$ and almandine/spessartine ($Fe^{2+}{}_3/Mn_3)Al_2Si_3O_{12}$), pyroxene (hed-diop $_{0-54}$) minor amphiboles, allanite ($(Ca,Ce)_3(Fe^{2+},Fe^{3+})Al_2O(SiO_4)(SiO_7)(OH)$), titanite ($CaTiSiO_5$), vesuvianite ($Ca_{10}Mg_2Al_4(SiO_4)_5(Si_2O_7)_2(OH)_4$) and apatite ($Ca_5(PO_4)_3F$). These minerals generally occur close to the granite cupola which is the mineralized zone and constitutes a large part of the endoskarn.

Scheelite is easy to identify with its high relief, bright (2nd order) interference colours and generally sub-rounded shape (Figure 4.9). Variations in colour are from bluish to yellowish and its interference colours are also bright from pink-purple to orange. Shapes vary from sub-rounded subhedral to anhedral in general and are no larger than 1.4 mm. This mineral has also been found away from the granite cupola lower down in the pluton, but in no more than 6 modal %.

Garnet is abundant in the skarn zone, whereas it is only up to 1 to 2 modal % outside the skarn zone. In the skarn zone it has a yellow colour, which indicates an andraditic composition (Figure 4.7). An andraditic composition indicates that oxidation took place due to the presence of Fe^{3+}. Andradite often surrounds an inner more reduced composition (Figure 4.7.b), which indicates that garnet went from initially reduced to oxidized as the fluids evolved. The habit of the garnet in this zone is anhedral and disseminated, and some alteration of these garnets is also evidenced by chlorite (pinitization). Outside this zone garnet is usually colourless and isotropic, subhedral to anhedral and rounded to sub-rounded, and grain sizes no larger than 0.2 mm.



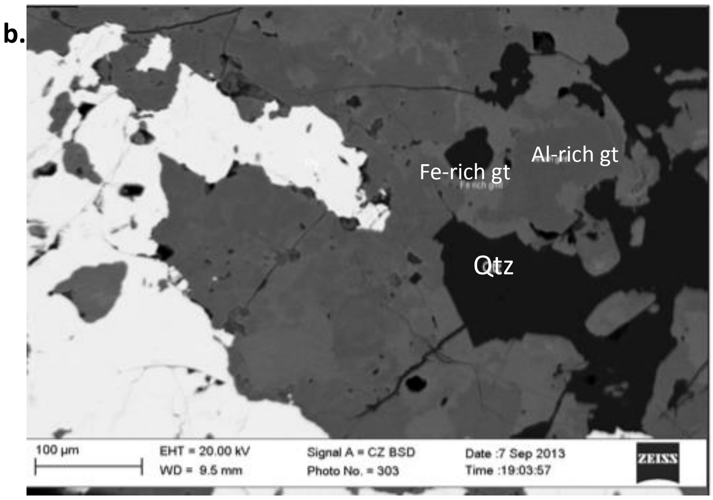


Figure 4.7. Ternary of the major end-members (a) of garnet (n=239). Garnets on the reduced side of the spectrum is found in the centre (darker centre on image b) and is between grossular and almandine/spessartine in composition. Towards the edge of garnet grains, more andraditic samples are found (lighter on image b). These images and data are from Pieterse (2013) and Cousins (pers. comm).

Pyroxene (hedenbergite-diopside $_{0\text{-}54}$, in other words from pure hedenbergite to 54% diopside in composition) is also abundant in the skarn zone and can be up to 10 modal % outside that zone. In the skarn zone it looks like a sea of euhedral rounded to sub-rounded grains. Pyroxene is green in colour, pleochroic in variations of green to green-brown, and has bright (2nd and 3rd order) interference colours, from blue-pink-purple to orange-pink. It has a high relief. Although pyroxene has most of the above-mentioned properties outside the skarn zone, it usually occurs as anhedral clusters or patches sporadically in the matrix. More reduced (hedenbergitic) and more oxidized (diopsidic) samples in the endoskarn (skarn zone) have been observed (Figure 4.8). Pyroxene is also normally altered to amphibole, which is another retrograde alteration product. This mineral is normally present on the edges of pyroxene grains, is brown in colour and has low 1st order interference colours.

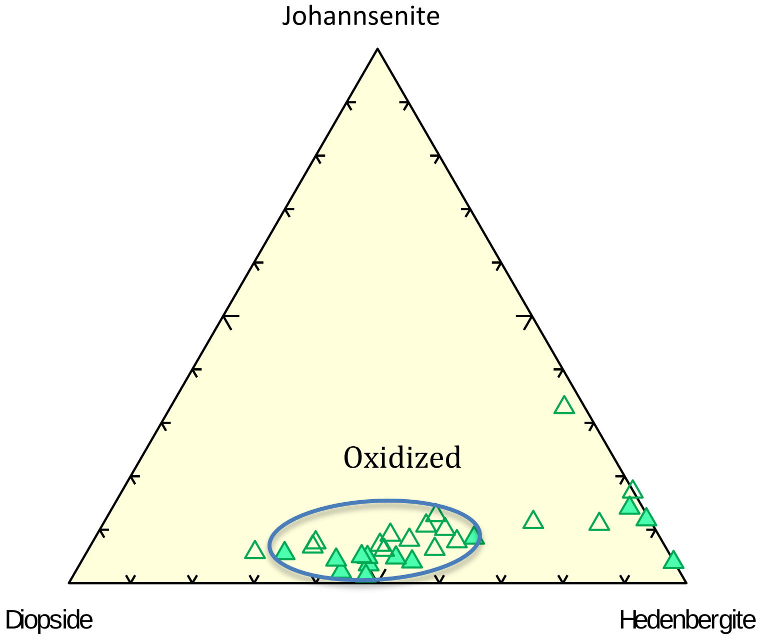


Figure 4.8. Ternary diagram of the major end members of pyroxene (n=29). Clinopyroxene is present in the skarn zone and ranges in composition from the almost pure hedenbergite to more than 50% diopside end member. Data from Pieterse (2013) and Cousins (pers. comm).

Vesuvianite occurs in trace amounts. It is usually a colourless mineral with a medium relief and has low 1st order grey-black interference colours. The mineral is usually euhedral to subhedral and rounded. It often looks like garnet although it is anisotropic. These grains are up to 0.05 mm in size and occur sporadically throughout the pluton.

Apatite is quite prominent in the pluton and occurs all over the matrix (Figure 4.6.a. and 4.10.a). The shape is usually that of small rounded or hexagonal prisms and less commonly anhedral (where it forms part of the matrix). It generally has a low to medium relief with low 1st order dark interference colours. Apatite can also occur in clusters of apatite grains. Although they are usually very small in size, grains of up to 0.2x0.18 mm have been observed. Locally, small apatite grains are associated with the alteration of primary porphyritic biotite (Figure 4.5). Pyrite also has a local association with apatite although it is not often observed. Apatite generally has a smooth texture, although a few exceptional grains have been observed with a rough texture (Figure 4.10.a).

Although epidote, titanite, chlorite and carbonates occur as secondary minerals, they are also associated with the skarn-forming process. Thus they developed both inside and outside the skarn zone. Allanite, being part of the epidote group, is often associated with epidote due to the fact that it is the alteration of epidote that gave rise to allanite (see chapter 6).

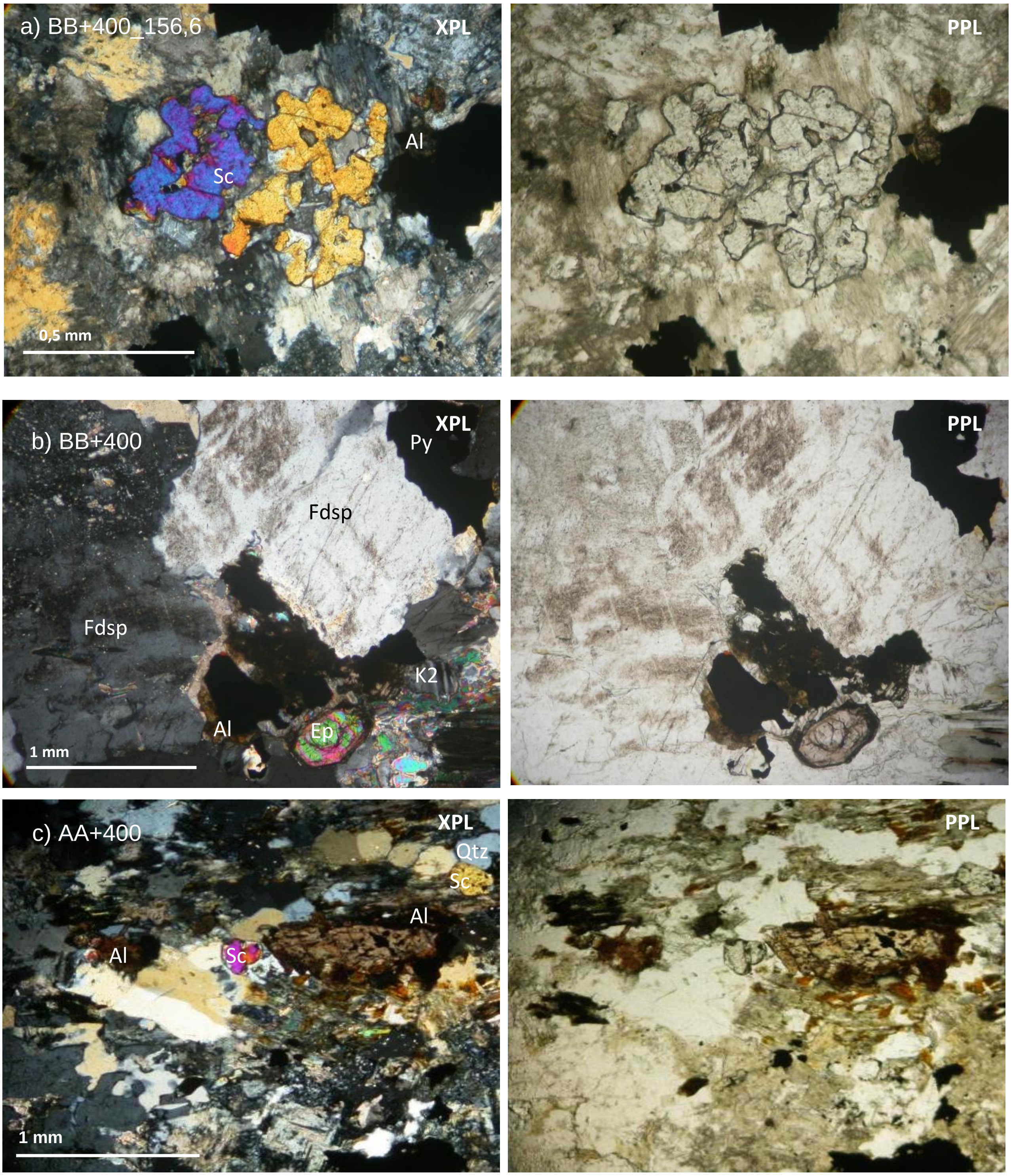


Figure 4.9. Photomicrographs illustrating the general aspects of skarn minerals. a) Scheelite is identified by its high relief and bright interference colours. b) Epidote in close proximity to allanite. Epidote also has a high relief and is light brown to colourless. Pyrite is locally associated with allanite and epidote. Secondary alkali feldspar is marked K2 as previously indicated. c) Fine-grained scheelite occurring with significantly altered allanite.

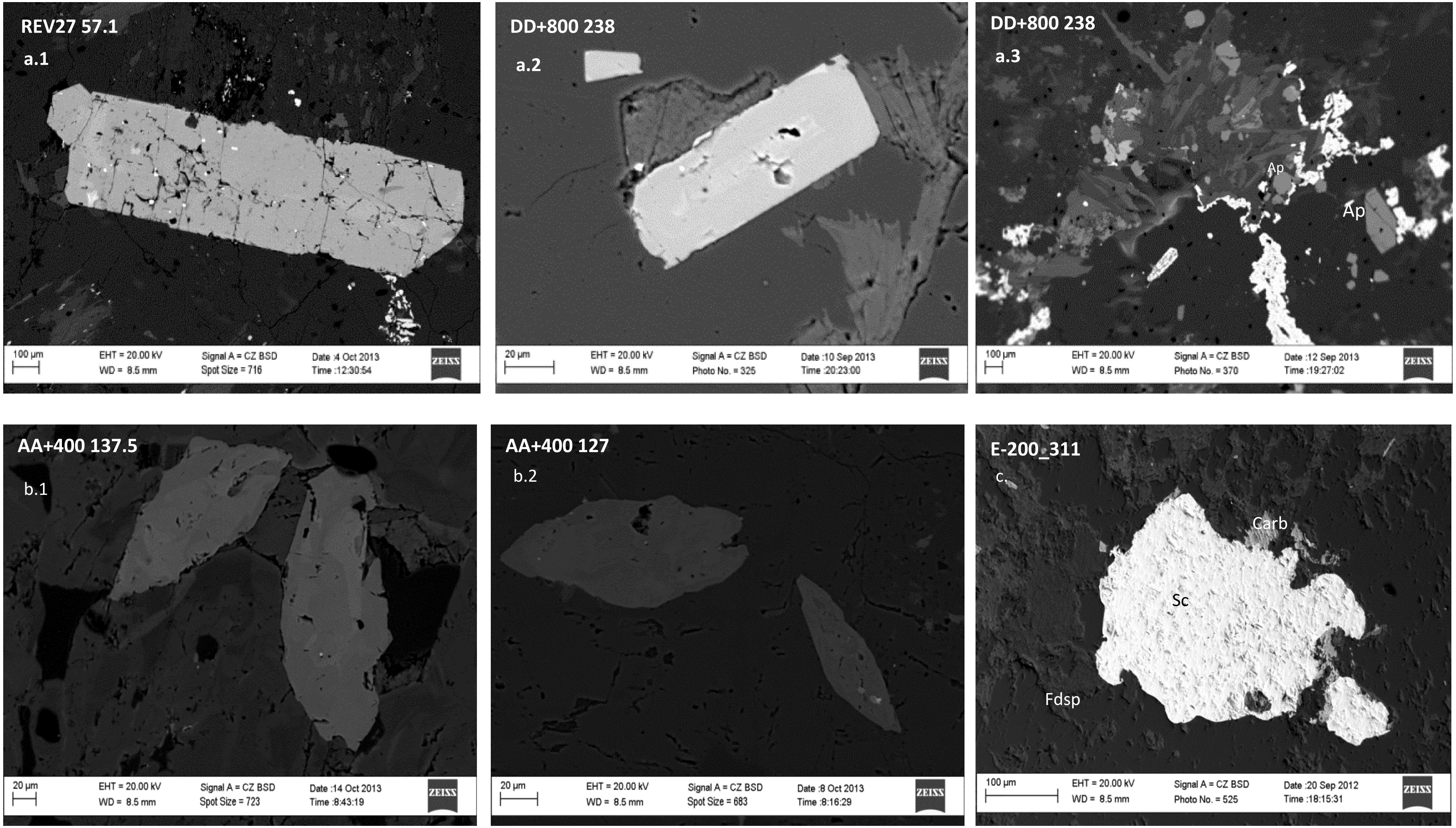


Figure 4.10. BSE images of various skarn minerals. a1, a2 and a3) Apatite is generally euhedral and developed in a range of grain sizes and shapes. b1 and b2) Titanite in its characteristic diamond shape. c) Scheelite with altered plagioclase feldspar surrounding it, as well as some associated bastnaesite (carb).

Table 4.4.a. Representative analyses of the major constituents of pyroxene, and garnet (wt %).

	Na_2O	MgO	Al_2O_3	SiO_2	CaO	TiO_2	Cr_2O_3	MnO	FeO	Fe_2O_3*	Total
Pyroxene	0.00	7.26	0.35	50.89	23.21	0.00	0.00	4.74	12.85	0.00	99.29
	0.39	5.49	0.53	50.75	22.72	0.00	0.00	2.66	17.93	0.00	100.47
	0.32	7.27	1.07	50.16	22.41	0.00	0.00	3.90	14.65	0.00	99.79
	0.22	5.61	0.72	50.76	23.03	0.00	0.00	2.76	17.70	0.00	100.80
	0.00	7.89	0.22	51.09	22.92	0.00	0.00	4.74	11.85	0.00	98.69
	0.19	6.99	0.17	49.71	22.85	0.00	0.00	3.69	13.76	0.00	97.37
	0.00	7.86	0.35	50.09	22.79	0.00	0.00	4.28	11.91	0.00	97.28
	0.50	7.89	0.67	49.86	21.96	0.00	0.00	4.13	12.22	0.00	97.24
	0.00	6.63	1.02	49.76	20.21	0.00	0.00	3.55	17.87	0.00	99.05
	0.00	0.00	5.86	36.95	31.16	0.18	0.00	2.79	21.34	0.00	98.29
	0.00	0.00	3.56	35.88	30.83	0.00	0.19	2.66	24.57	0.00	97.69
	0.00	0.00	2.79	36.11	31.78	0.00	0.00	1.71	25.14	0.00	97.52
	0.00	0.00	2.31	35.68	32.09	0.00	0.00	1.64	25.53	0.00	97.25
	0.00	0.00	1.94	35.92	29.74	0.00	0.00	2.75	27.12	0.00	97.47
Garnet	0.00	0.00	3.05	36.03	32.70	0.00	0.00	0.85	1.00	27.95	101.58
	0.00	0.00	3.17	35.82	32.75	0.23	0.00	1.01	0.89	27.97	101.83
	0.00	0.00	1.66	35.76	31.57	0.00	0.00	1.94	1.35	30.32	102.59
	0.00	0.00	3.54	36.18	32.88	0.21	0.00	1.10	0.58	27.09	101.57
	0.00	0.00	3.13	35.98	33.38	0.18	0.00	0.73	0.39	27.97	101.75
	0.00	0.00	2.50	36.01	32.67	0.00	0.00	0.79	1.06	28.79	101.82
	0.00	0.00	3.31	35.83	33.59	0.75	0.00	0.70	0.18	27.56	101.92

* DROOP method.

Table 4.4.b. Representative analyses of the major constituents of scheelite and apatite (wt %). Note the presence of fluoro-apatite.

	F	Mn	Fe	P	Ca	W	O	Total
Scheelite	0.00	0.00	0.00	0.00	14.15	62.71	22.41	99.27
	0.00	0.00	0.00	0.00	14.34	63.95	22.42	100.71
	0.00	0.00	0.00	0.00	14.52	63.08	22.92	100.53
	0.00	0.00	0.00	0.00	14.40	63.99	22.89	101.28
Apatite	0.00	0.00	0.00	40.80	54.98	1.46	0.00	97.24
	0.00	0.00	0.00	42.56	56.65	1.04	0.00	100.26
	0.00	0.00	0.23	42.08	56.03	1.14	0.00	99.49
	0.00	0.27	0.31	41.68	56.09	1.41	0.00	99.76
	0.00	0.00	0.00	43.17	56.27	1.15	0.00	100.60
	0.00	0.00	0.00	41.99	55.42	0.00	0.00	97.40
	6.43	0.00	0.25	17.21	37.04	0.00	39.08	100.00
	6.91	0.00	0.35	17.38	37.24	0.00	38.13	100.00

4.1.4 Accessory minerals

Minerals that occur in trace amounts are zircon ($ZrSiO_4$) and fluorite (CaF_2). Although in trace amounts, zircon and fluorite are also found sporadically throughout the pluton. Fluorite has mainly been observed in borehole intersection REV60 with very few occurrences in borehole AA+400.

Zircon are considered to be primary in this deposit, has a high relief and bright 3rd order interference colours. It also has a distinctive prismatic shape. Very few zircon grains have been observed.

Fluorite (Figure 4.11) occurs as small crystals or patches where there are clusters of enrichment made up of clinopyroxene and allanite lower down in the pluton, i.e out of the skarn zone. Fluorite formed as part of the mineralizing process. It generally also occurs sporadically in the matrix. Fluorite is isometric and has a triangular euhedral habit. It's normally colourless to purple-lilac in colour. Larger grains of fluorite were seen in borehole REV60, in the periphery of the pluton. Where fluorite was observed it is abundant, but only in very few samples.

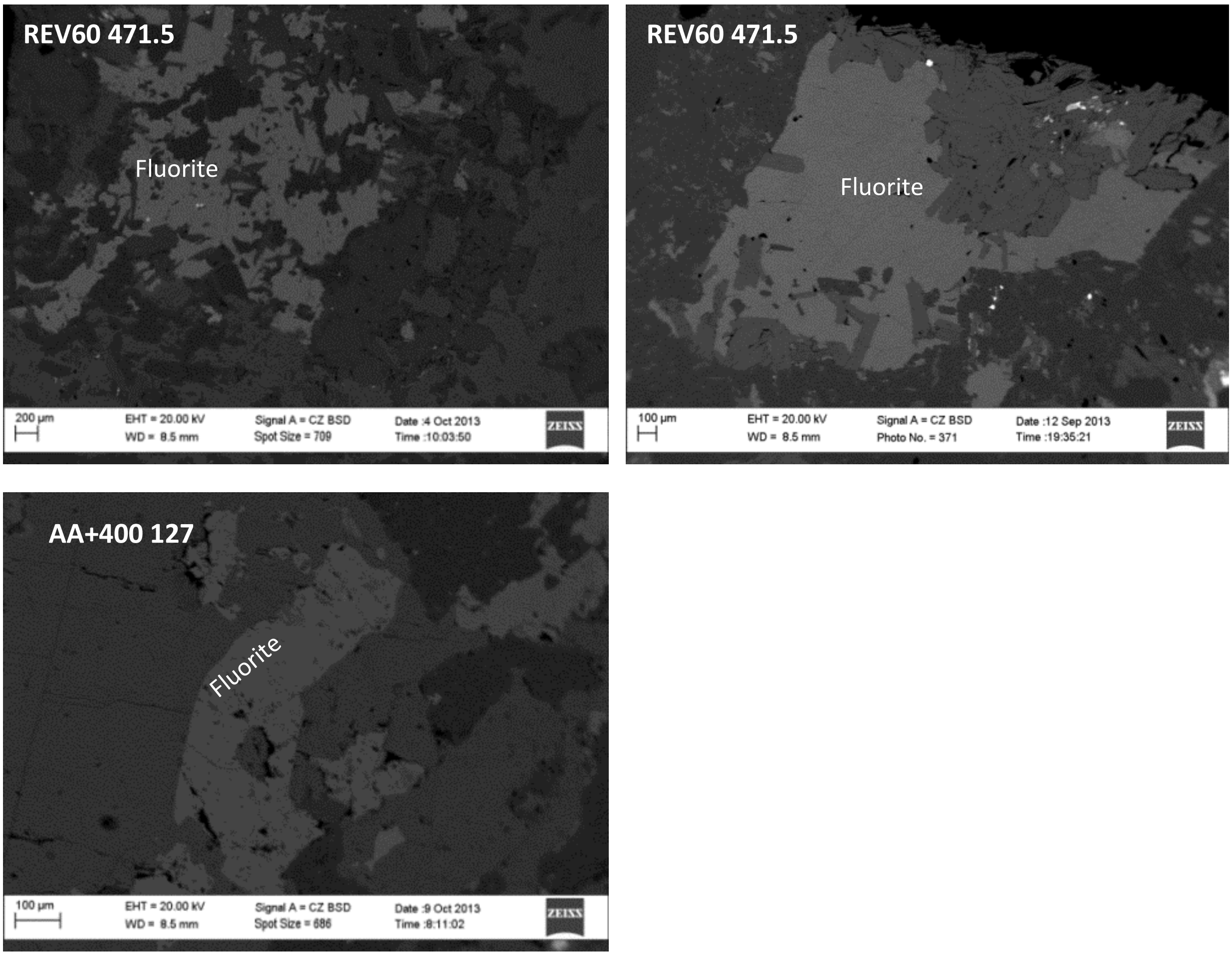


Figure 4.11. BSE images displaying the various occurrences of fluorite. Fluorite is either fine-grained or fairly large subhedral grains. In both cases fluorite is interstitial.

4.1.5 Ore minerals

Ore minerals are also secondary minerals however they will be discussed here. The main ore minerals are pyrite, pyrrhotite, chalcopyrite, molybdenite and sphalerite. Scheelite (section 4.1.3) and allanite are also considered important ore minerals. Allanite will be discussed separately in chapter 6. These minerals are sporadic in all the boreholes examined, but more abundant towards the apex of the cupola and are commonly anhedral.

Pyrite is by far the most abundant ore mineral, is light yellow in colour and isotropic. It is mostly anhedral, either sporadic or associated with the alteration of biotite (Figure 4.12.a). Disseminated pyrite grains with a cubic habit have been observed, thus interpreted as part of the process of pyritization that occurred during metasomatism, as well as retrograde late stage pyrite (Figure 4.13). Some pyrite grains replaced grains such as quartz, which also indicates a late stage development phase. In addition pyrite is also found within altered biotite grains, intergrown with white mica and chlorite as a late-stage replacement along the cleavage planes of biotite. Boundaries are normally clear-cut.

Pyrrhotite is replaced by pyrite in most samples observed. It has a light creamy salmon pink colour and is anisotropic.

Chalcopyrite always occurs with pyrite, has a brighter yellow colour, and is anisotropic. It is common to find pyrite and chalcopyrite intergrown with white mica and chlorite in altered grains of biotite (Figure 4.12.a).

Molybdenite (Figure 4.14.b) is not very prominent and occurs sporadically throughout the pluton. It is silver-grey in colour and is anisotropic. It occurs in both the skarn zone, but also in late-stage quartz veins. Its flaky habit shows the basal cleavage associated with molybdenite. Where it occurs, it has clearly-defined boundaries and euhedral shape which suggests a late-stage development.

Sphalerite can be recognized using transmitted light microscopy as a red-brown isotropic mineral with internal reflections (Figure 4.12.b). In reflected light it is grey and usually euhedral or disseminated. Sphalerite has well-defined boundaries and its euhedral shape means it was probably also one of the products of metasomatism.

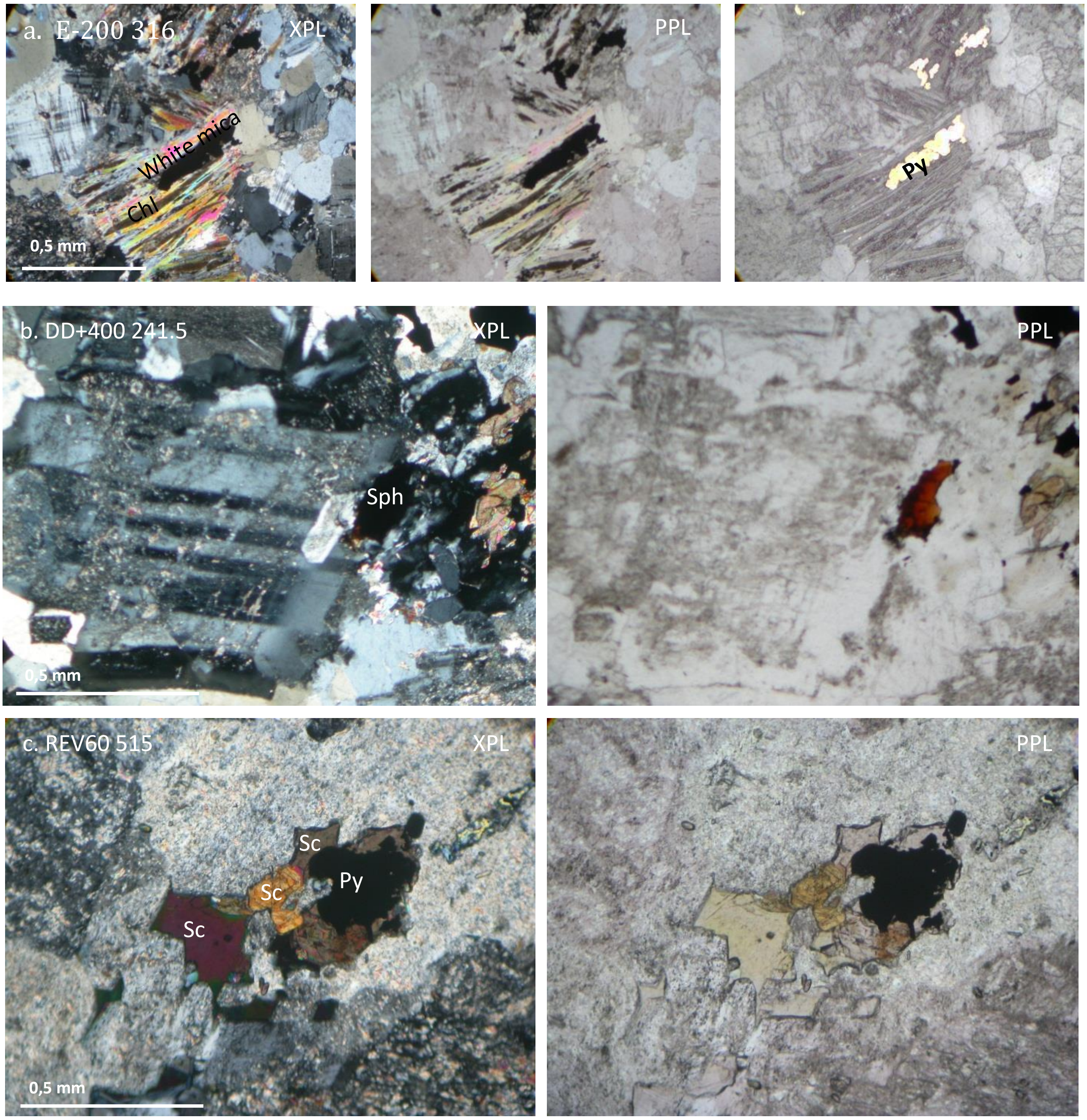


Figure 4.12. Photomicrographs of the various ore minerals. a) Primary biotite alters to white mica, chlorite and pyrite that are intergrown. This is a form of a replacement texture. b) Sphalerite with its distinctive red-brown colour, well-defined boundaries and euhedral shape. c) Pyrite intergrown with scheelite indicates that they crystallized simultaneously in the mineralizing process. This probably happened during the same phase that pyrite replaced biotite.

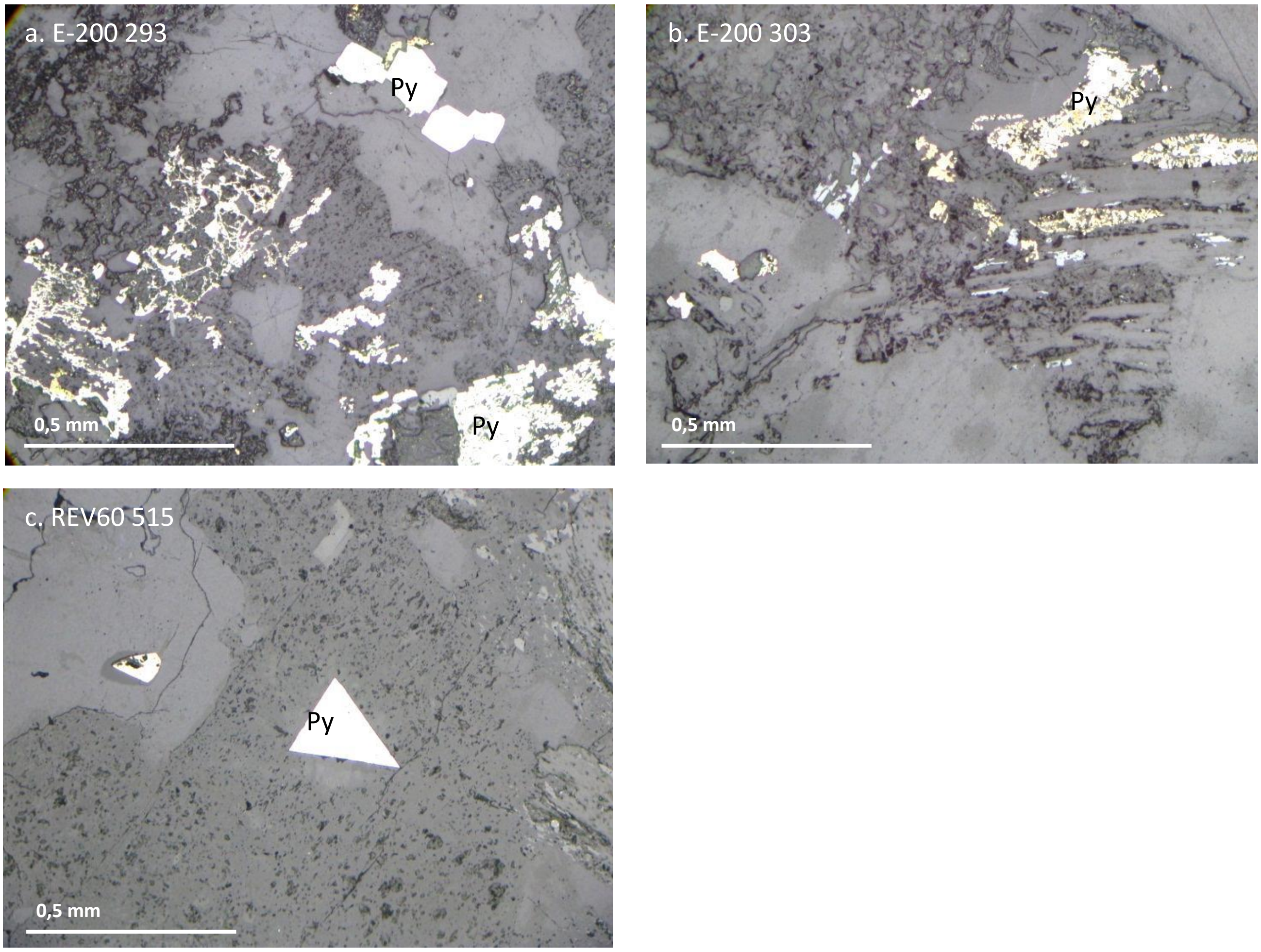


Figure 4.13. Photomicrographs of the various forms in which pyrite occurs (reflected light). Pyrite occurs as either disseminated (a and b) or cubic (c) illustrating that it formed part of the original rock as well as retrograde alteration phases. In (a) two types of pyrite are observed which is a late stage euhedral phase and earlier skeletons of pyrite that formed as a result of the retrogressed pyrrothite. In (c) a typical late stage Euhedral pyrite grain is observed. From these examples one can deduce that all sulphides are secondary.

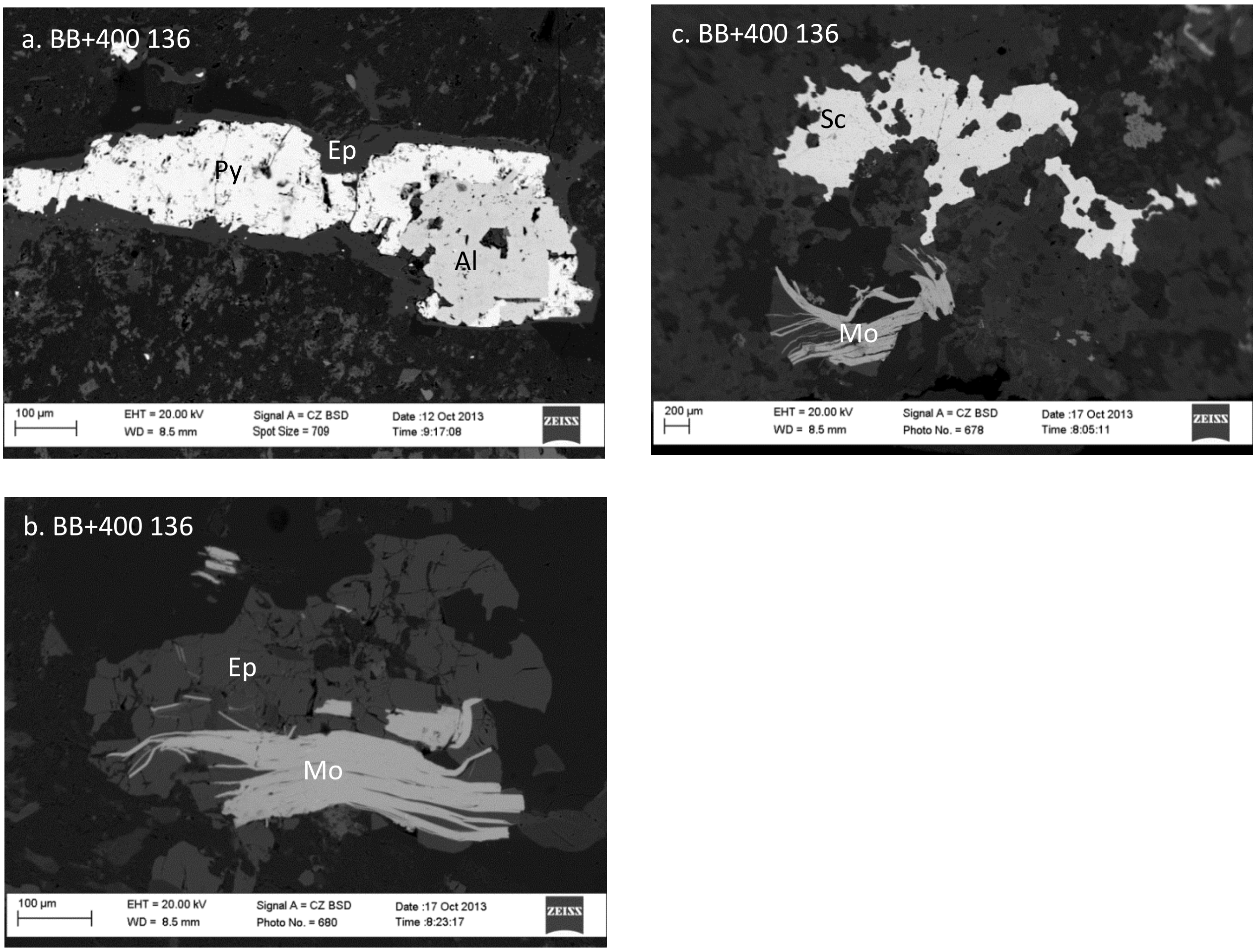


Figure 4.14. BSE images of various ore minerals. a) Pyrite intergrown with allanite surrounded by a rim of epidote. This indicates that allanite and pyrite formed simultaneously and is overgrown by epidote at a later stage. b) Molybdenite in association with epidote which indicates that they formed at the same time. and c) Scheelite with an irregular almost resorbed grain shape coexisting with molybdenite.

4.1.6 Host Rock classification

Based on the mineralogy, the Riviera pluton is clearly pervasively altered through hydrothermal alteration to the extent that the modal mineralogy will be used to classify the pluton instead of the geochemical data, as hydrothermal alteration rendered the geochemical data of limited use as a genetic discriminant. The classification will be based on microscopic identification and modal counts of the primary mineralogy.

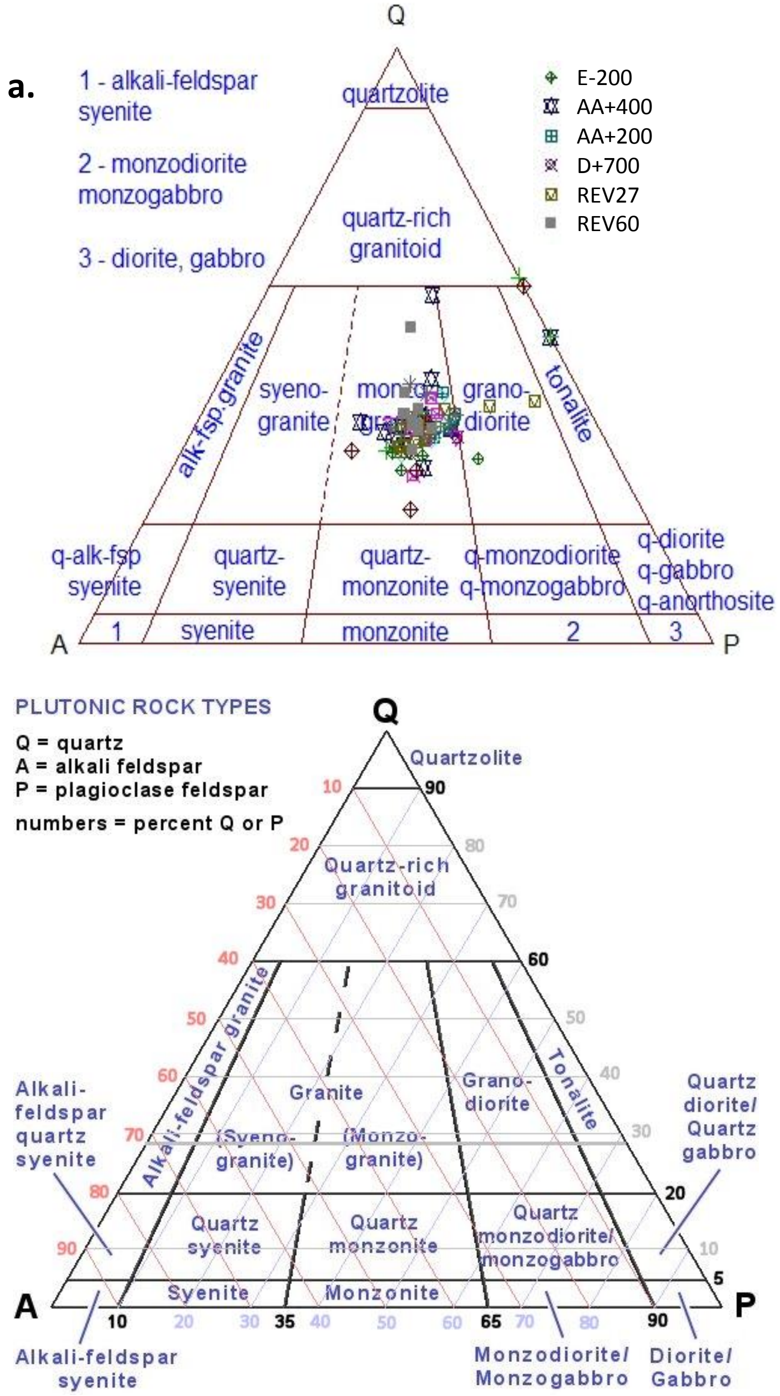


Figure 4.15. This diagram is an IUGS classification diagram, specifically QAP of (Streckeisen, 1974) of a) the modal mineralogy (n=84) showing that this rock is a monzogranite with minor granodiorite and tonalite and b) A newer version of the QAP granite indicating the granite field (based on Streckeisen (1976)). In (b) the host rock is granitic to monzogranitic.

The empirical modal mineralogy and textures enable the pluton to be classified into 3 phases; a quartz porphyry monzogranite (QPMG), a biotite granite to monzogranite (BMG) and an aphanitic granite to monzogranite (AMG). These 3 rock types form the three intrusive phases of the Riviera pluton. The boundaries between the rocks are diffuse due to extensive and pervasive hydrothermal alteration.

The Riviera pluton is derived from a felsic or silica-oversaturated magma, with I and A-type signatures due to the differentiated nature of the pluton (Rozendaal & Scheepers, 1995). Geochemically it is characterized as alkaline to high-K calc-alkaline, with a metaluminous to slightly peraluminous nature (Rozendaal & Boshoff, 2011). The increase of potassium (in the form of alkali feldspar) from the QPMG (the roof of the pluton) towards the AMG (significantly at depth in the pluton) is in accordance with emplacement as part of the last magmatic phases of the CGS dating between 507 and 516 Ma (Chemale et. al., 2011). Figure 4.19 displays the three phases in space.

1. *Quartz porphyry monzogranite (QPMG)*

The first intrusive phase of the Riviera pluton is characterized by large porphyritic quartz grains or 'quartz eyes' (Figure 4.16.a). This zone is found in the roof or cupola of the pluton at relatively shallow levels. The rest of the matrix is relatively finer-grained and consists mostly of large altered plagioclase feldspar (An_{0-33}) (Table 4.1 and Figure 4.1), cryptocrystalline quartz, secondary alkali feldspar (Figure 4.1) and relatively large white mica grains (Figure 4.24). Few sulphides are observed, mostly pyrite when present, and primary biotite is rare. Although it is not continuous, but rather local and sporadic, most of the enrichment is associated with this phase. This phase also contains patches of skarnified granite.

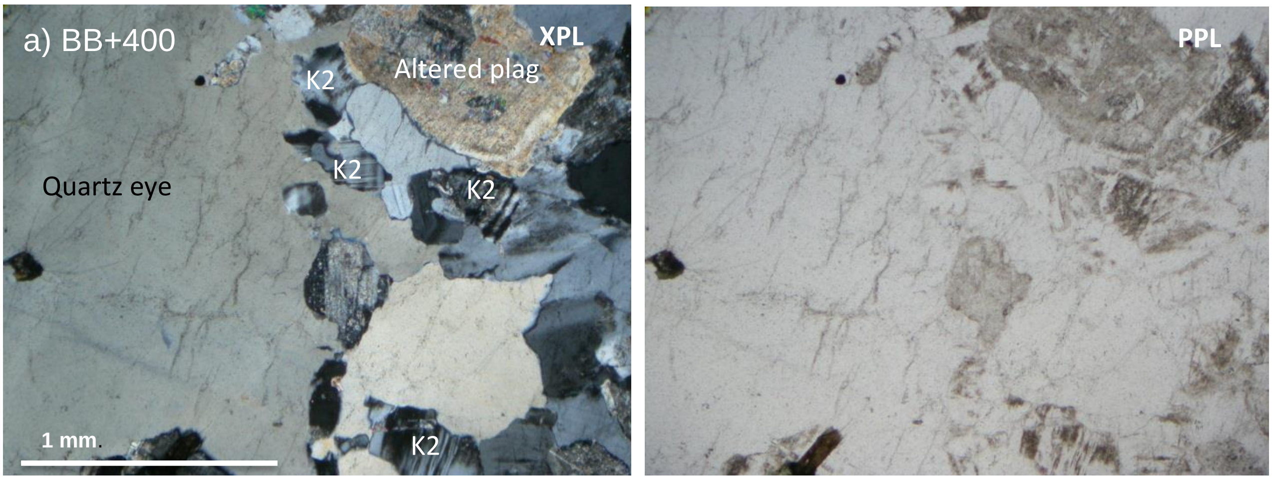


Figure 4.16. Photomicrographs displaying the characteristics of the QPMG. a) The characteristic quartz porphyry or 'quartz eye' texture. Secondary alkali feldspar grains are also observed.

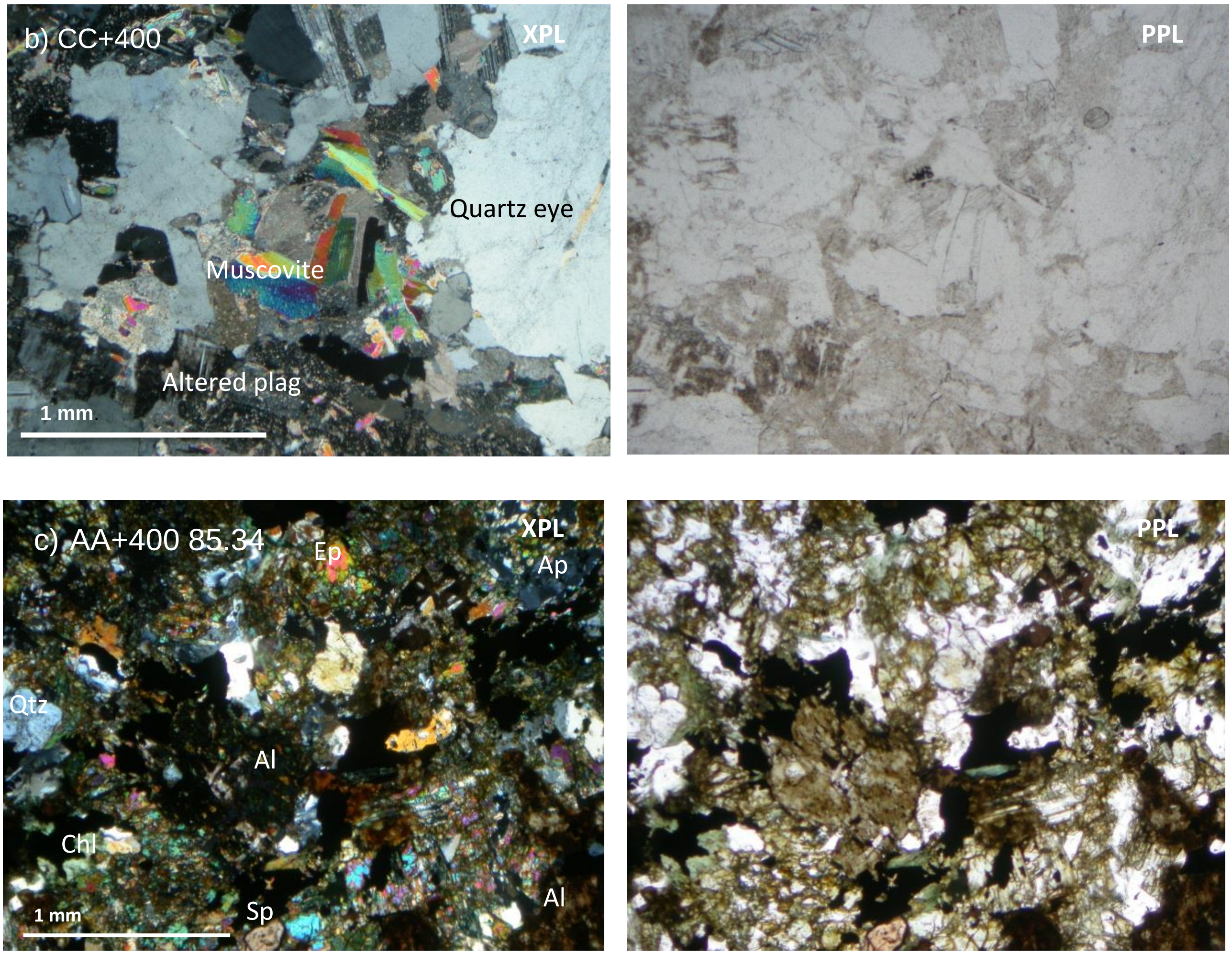


Figure 4.16 continued. Photomicrographs displaying the characteristics of the QPMG. b) Large white mica (secondary muscovite flakes) are found in the QPMG. c) Skarnified granite patches also occurs in this zone.

2. *Biotite granite to monzogranite (BMG)*

This intrusive phase marks the beginning of the footwall as negligible or no enrichment is found or associated with this phase. This phase occurs below the mineralized zone (MZ). The granite is medium-grained with relatively large grains of plagioclase (plag1) (An_{15-33}) (Table 4.1 and Figure 4.1) and alkali feldspar, quartz and primary biotite (Figure 4.17). The quartz content is normally less than the total feldspar content. The alkali feldspar content only exceeds plagioclase locally, but is generally higher compared to QPMG. Concentrically zoned plagioclase feldspar is evident with an altered inner core (plag2) (phyllic alteration), and a late stage albitic rim (plag3) observed as proof of albitization (An_{15-20}) (Figure 4.2). Slightly altered primary biotite is commonly observed in this phase.

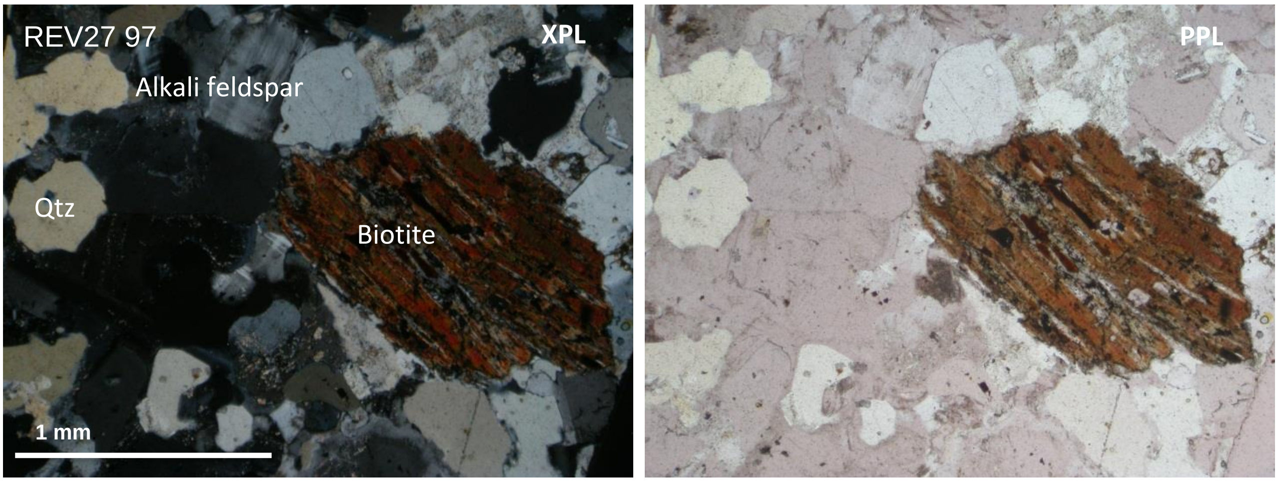


Figure 4.17. A photomicrograph displaying a slightly altered primary biotite grain found in the BMG.

3. Aphanitic granite to monzogranite (AMG)

The last leucocratic phase to intrude is substantially different from other phases. Firstly its overall grain-size is fine-grained (Figure 4.18) compared to the previous two phases and the rock is fairly even-grained. The amount of quartz is usually less than the total feldspar content, with the two feldspars usually being in roughly equal amounts. The amount of alkali feldspar however is higher than that of the first two phases. This phase contains no enrichment and the porphyritic texture is no longer evident.

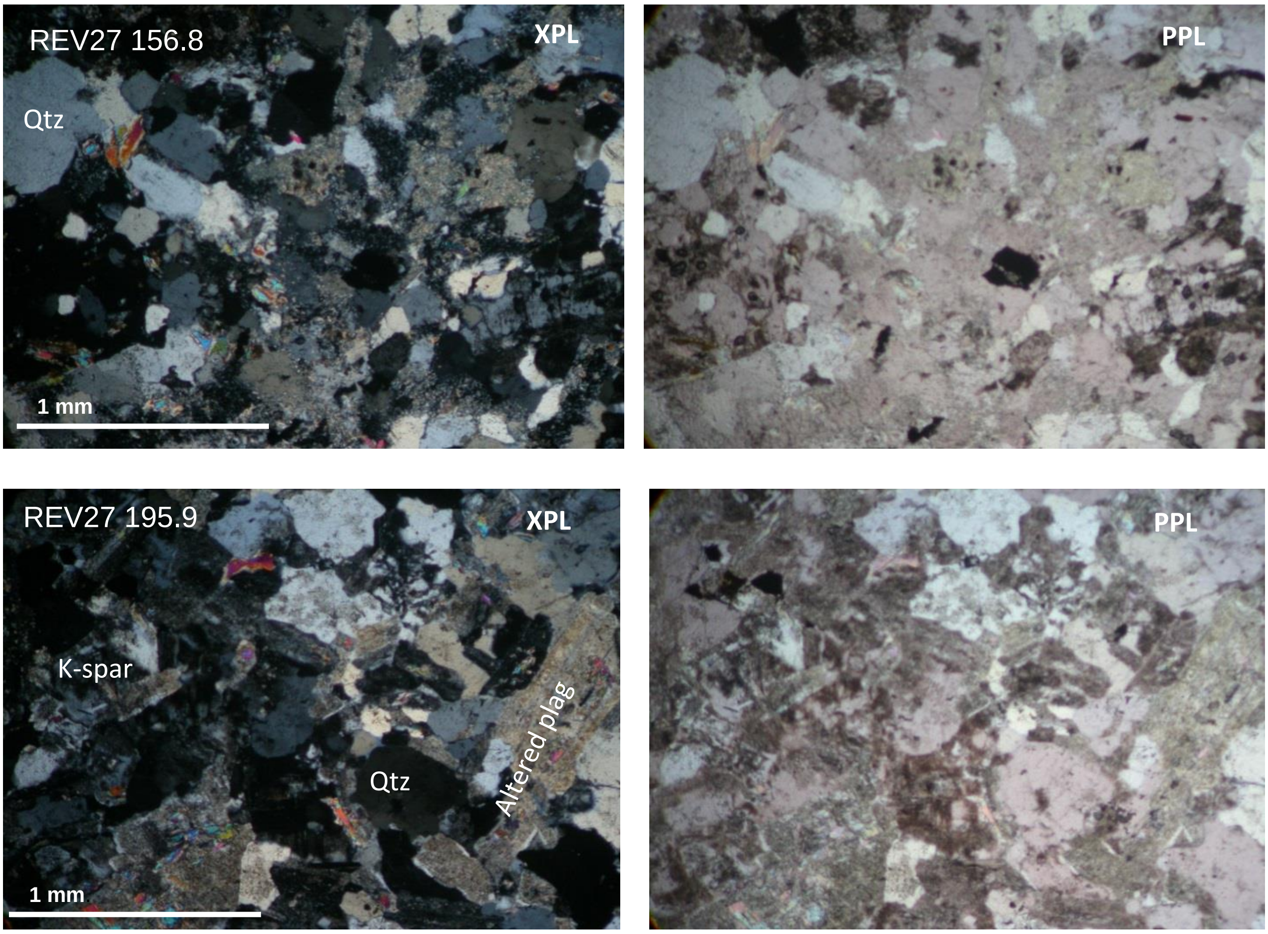


Figure 4.18. Photomicrographs displaying the characteristics of the AMG. Note to finer grain size (compared to the QPMG and the BMG) as there is no quartz porphyry texture in this zone. Alteration is still present, thus the entire pluton is affected by pervasive hydrothermal alteration.

Figure 4.19 displays the spatial distribution of the 3 different plutonic phases discussed above.

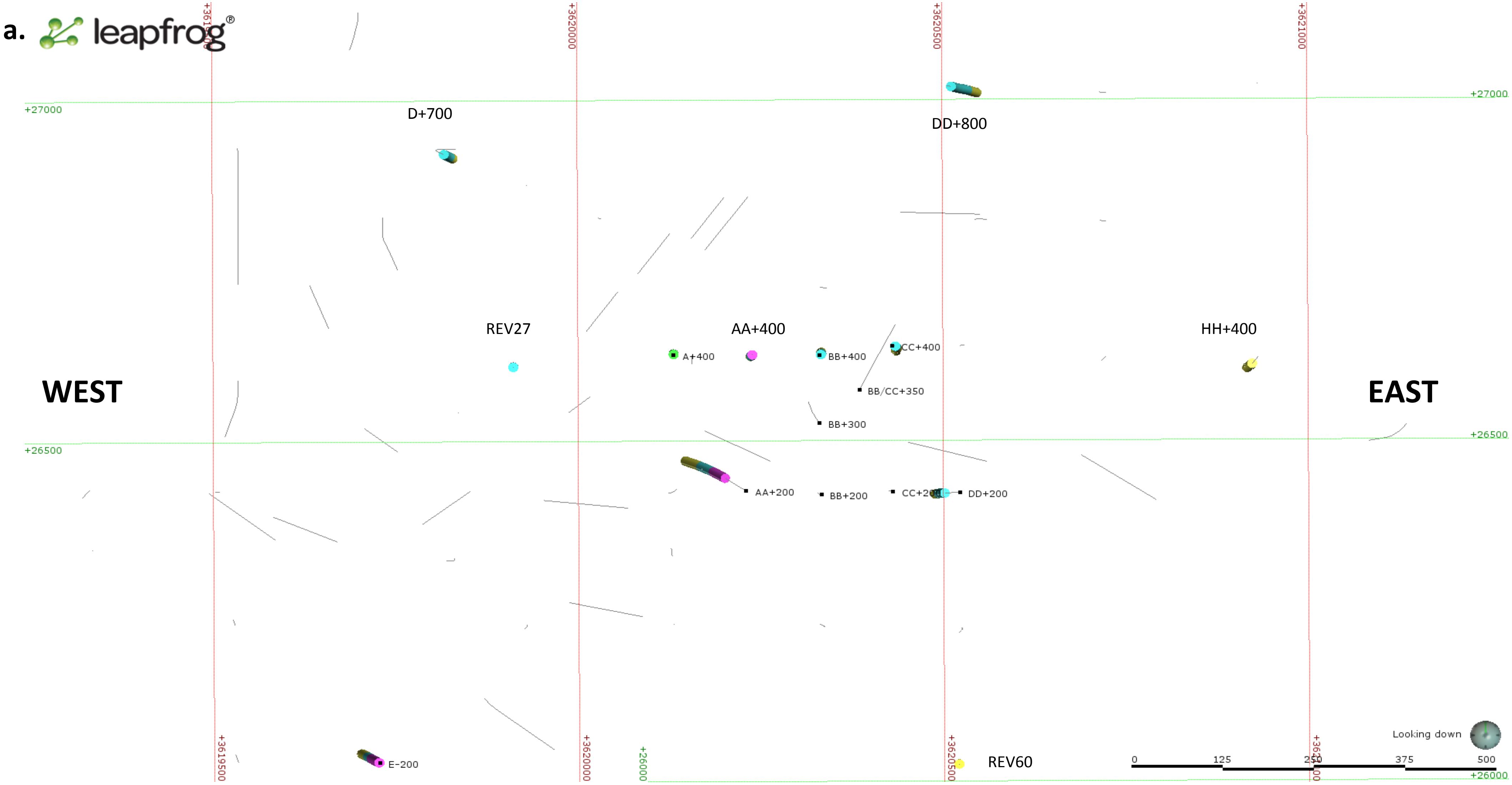


Figure 4.19. This plan view shows the 3 different phases in space relative to each other. This was derived from empirical observations under the optical microscope. a) This first image is in plan view. Note the distribution of the boreholes analysed in thin-section. REV60 is considered to be on the periphery of the pluton. (Black lines represent other borehole intersections).

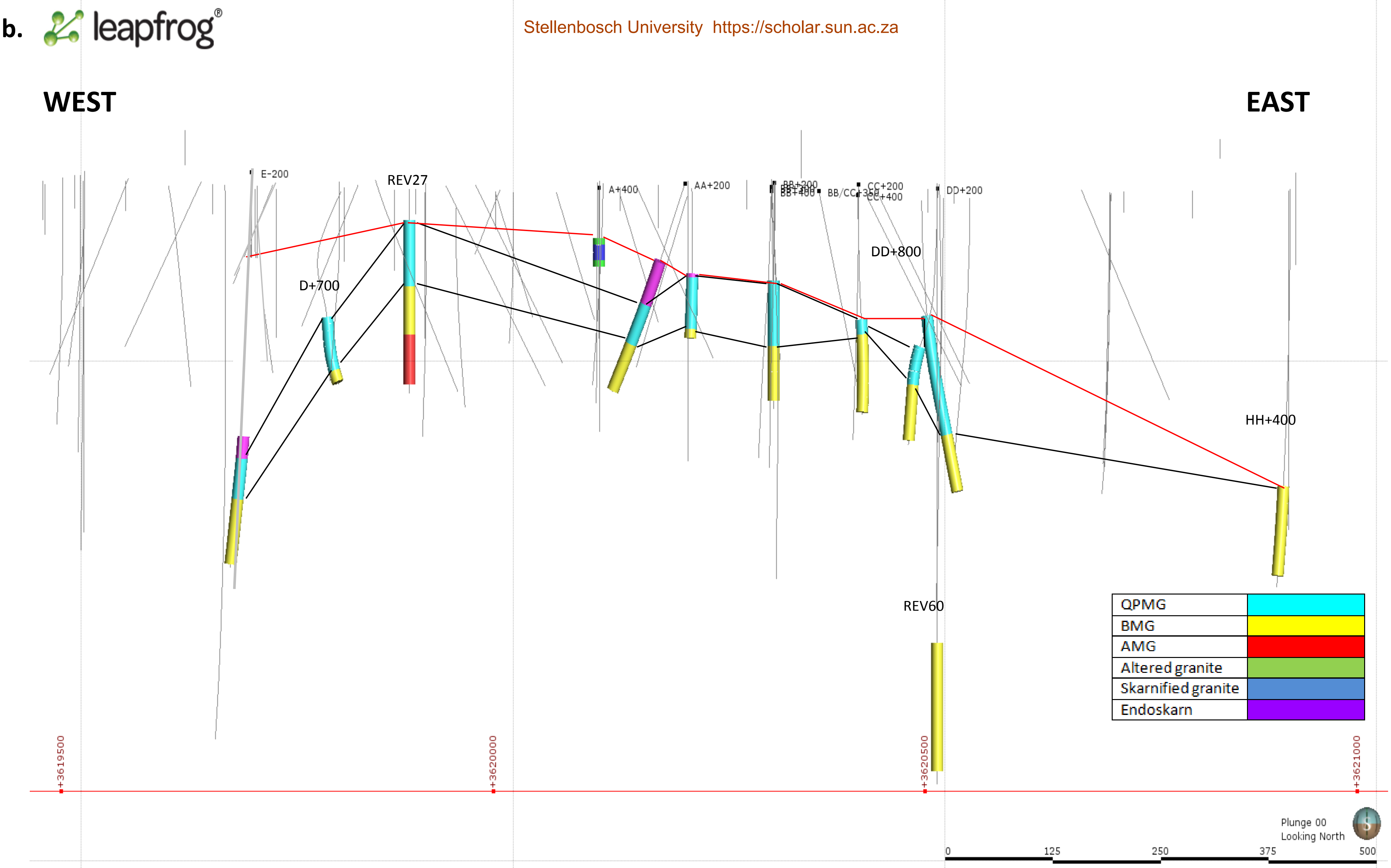


Figure 4.19 continued. b) This east – west section is looking north with a zero degree plunge. The BMG is the deepest phase, except in borehole REV27, where AMG was encountered at depth. In some cases the rock was too pervasively altered to determine its classification and was thus considered to be an altered granite (A+400). The red line displays the granite wall-rock contact.

4.1.7 High-, medium- and low-grade W zones

Although all the boreholes that were examined contain some economic minerals, not all of them are considered part of the high grade zone. Table 4.5 highlights the characteristics and minerals that were used to delineate the high, medium and low grade W zones. This is considered lateral variation in the pluton, not vertical. A table of the average grade per borehole can be found in the appendix. A cut-off grade between the low- and medium and high grade W zones respectively of 0.05% WO_3 was used.

Table 4.5. Table illustrating the basic characteristics of the high-, medium- and low-grade W zones.

	High Grade W zone	**Medium grade W zone**	**Low grade W zone**
Characteristics	• Where economic minerals are not only restricted to the endoskarn zone (top of the granite cupola), but also occur in significant amounts throughout depth in the form of skarnified granite patches. • Higher grade LREE- enrichment in allanite	• Economic minerals are restricted to the endoskarn zone at the top of the granite cupola with a few sporadic occurrences throughout depth.	• Barren Rock. • May contain sporadic amounts of economic minerals (like scheelite and allanite), but in negligible amounts.
Key minerals	• Allanite • Scheelite • Bastnaesite • Sulphides	• Allanite • Scheelite	• Alteration products like clay minerals and extreme sericitization.
Average grade (% WO_3)	Above 0.2%	Between 0.05% and 0.2%	0.05% and under
Borehole example	BB+400	AA+200	E-200

4.2 Hydrothermal alteration

The entire Riviera pluton including all three phases, has been affected by pervasive hydrothermal alteration. Hydrothermal alteration zones and types were delineated and placed into 6 categories; argillic, advanced argillic, phyllic, advanced phyllic, potassic, and skarn according to what was observed in thin-section. Literature that was used in this section was from the following authors: Meyer and Hemley (1967), Lowell and Guilbert (1970), Einaudi et al (1981), Dilles and Einaudi (1992), Evans (1993), and Seedorff et al (2005). For a more detailed photo gallery displaying the different alteration types, please refer to the appendix.

Table 4.6. A summary of the different alteration types found in this pluton and their characteristic features, compared to the literature definition and nomenclature. .

This study				Literature		
Alteration type	**Alteration subtype**	**Defining minerals**	**Other comments from observation**	**Literature nomenclature**	**Literature key minerals**	**Other comments from literature**
Argillic		Clay minerals	• Some twinning in feldspars still observed • Feldspar grain boundaries seen • Intense form of alteration but at a low temperature • Pyrite/pyrrothite	Intermediate argillic	• Kaolin- and montmorrilonite-group minerals • Alteration product of plagioclase • May be accompanied by amorphous clays • Sulphides generally unimportant	• Primary biotite unaffected or altered to chlorite • Potash feldspar not extensively affected
	Advanced argillic	Clay minerals	• Feldspars are indistinguishable • Lowest temperature form of alteration • Pyrite/pyrrothite	Advanced argillic	• Dickite • Kaolinite ($Al_2Si_2O_5(OH)_4$) • Pyrophyllite ($Al_2Si_4O_{10}(OH)_2$) • Sericite and pyrite usually present • Sulphur-rich sulphides of which pyrite is one and most common	• Extreme leaching of bases (alkalis and calcium) from all aluminous phases (feldspars and micas) • If aluminium is significantly mobilized, alteration grades into silicification. • With increasing sericite – it grades outward into sericitization. • This alteration phase is very important in the development of high permeability which is necessary for circulation of enormous quantities of hydrothermal

						fluids and vein growth (Brimhall & Ghiorso, 1983).
Phyllic		• White mica/sericite • Carbonates • Cryptocrystalline quartz • Pyrite/pyrrothite • Chlorite		• Sericitization • Silicification • Carbonatization • Chloritization	• Sericite, quartz and pyrite • Sericite is typically muscovite • Sericitization of granite – feldspars and micas transformed to sericite. • Secondary quartz as a reaction by-product • Primary quartz in the rock is unchanged • Carbonates and anhydrite rare	• One of the most common types of alteration in aluminium-rich rocks (slates, granites, etc). • Sericitization and advanced argillic alteration equivalent • Fluorine-rich environments – topaz together with zunyite and quartz may accompany sericite to form greisen • Sericitization affects feldspars and primary biotite (silica-generating reactions - silicification) • When secondary potash feldspar and/or secondary biotite appears, sericitization grades into potassic alteration • Contact with potassic alteration gradational • Disseminated and veinlet pyrite • Carbonatization usually occurs in the form of ankerite where there is abundant Fe
	Advanced phyllic	• White mica/sericite • Carbonates • Cryptocrystalline quartz • Pyrite/pyrrothite • Chlorite	• Extreme alteration of primary plagioclase • Larger white mica grains (greisenization) • Not necessarily associated with plagioclase • Lower temperature alteration than potassic			
Potassic		• Secondary alkali feldspar • Secondary albite • Secondary biotite	• High temperature alteration	• Potassic • Feldspathization	• Secondary potash feldspar and/or biotite • Minor chlorite • Magnetite and hematite may be present • Sulphides include pyrite, molybdenite and chalcopyrite	• Secondary orthoclase contain more Na than primary orthoclase • Sericite is also present • Secondary minerals replace primary orthoclase, plagioclase and mafic minerals.
Skarn		• Scheelite • Pyroxene • Garnet • Bastnaesite • Allanite	• Most of the enrichment is associated with this type of alteration • It occurs in the roof or cupola of the pluton	• Skarn • Carbonatization	Calc-silicate minerals: • Diopside • Andradite • Wollastonite • Ca-, Mg- and Fe-silicates	• High temperatures involved (650-400 °C) • Variable pressures which is dependent on the depth of composition (one to several kilometres). • Majority of skarns devoid of economic enrichment. • Exoskarn usually contains ore.

		• Epidote • Titanite • Vesuvianite • Molybdenite • Pyrite/pyrrhotite	• This is a reduced calcic skarn • Highest temperature form alteration in this pluton.	
	Skarnified granite	• Scheelite • Allanite • Scattered garnet and pyroxene	• Occurs in sporadic patches outside of the main skarn zone • Usually associated with potassic alteration	

The simplified diagram below (Figure 4.20.a and b) displays the spatial relationship between the various types of hydrothermal alteration as presented in Table 4.6. The contacts or boundaries between the different alteration types are not distinct as the diagram suggests, but rather gradational. Potassic alteration does not usually occur in zones, but are locally associated with phyllic alteration, and mostly occur adjacent to the skarn zone. Phyllic alteration can be found throughout the entire pluton as the diagram indicates (Figure 4.20.b), and is also more common at depth. Argillic, advanced and advanced phyllic alteration occur sporadically throughout depth. Potassic alteration and skarnification (endoskarn) is restricted mainly to the granite wall-rock contact and hosts most of the W and REE enrichment, and all of the Mo enrichment.

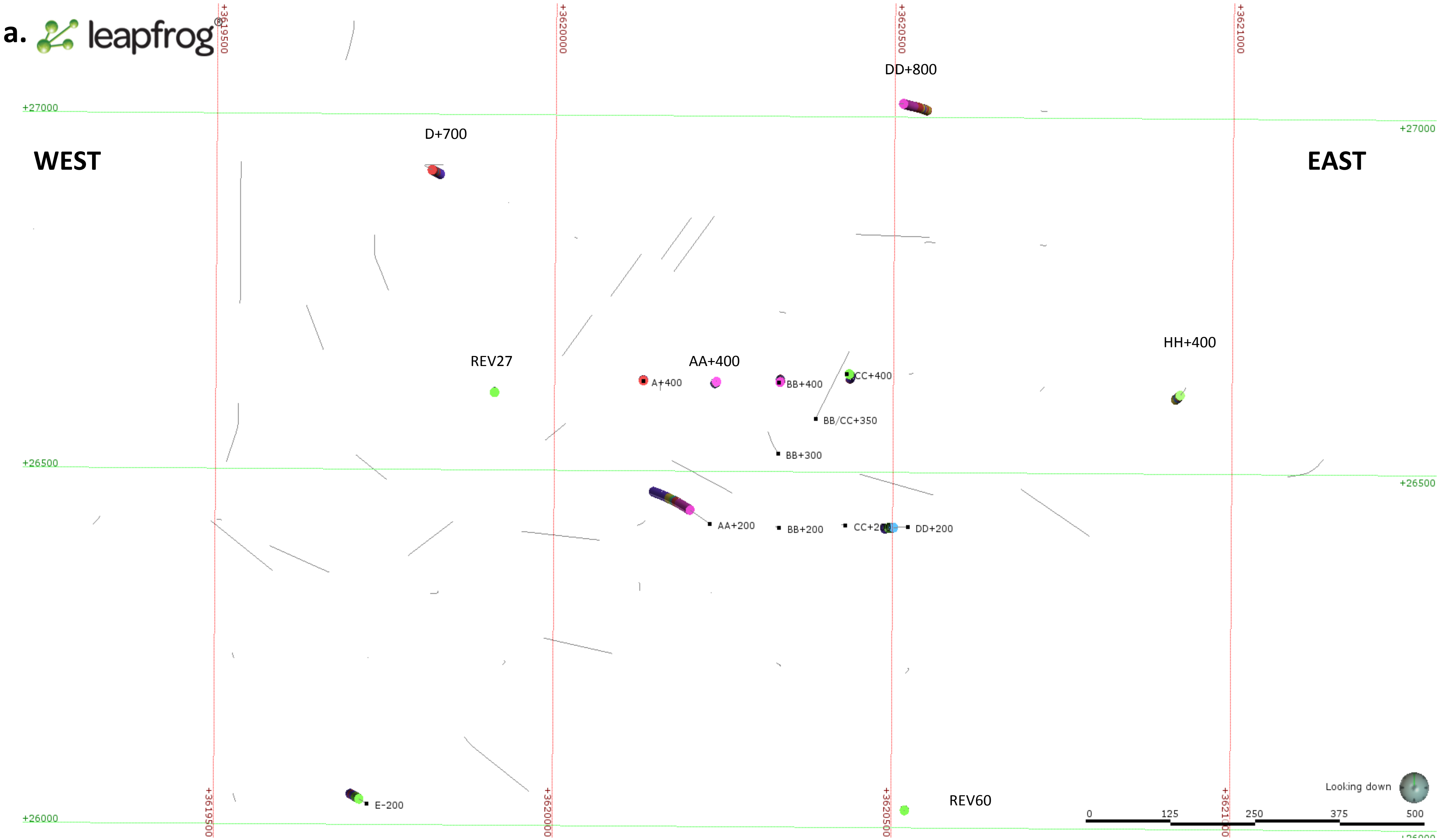


Figure 4.20. This diagram shows the different alteration types in space and relative to each other. This was derived from empirical observations under the optical microscope. a) In plan view.

b.

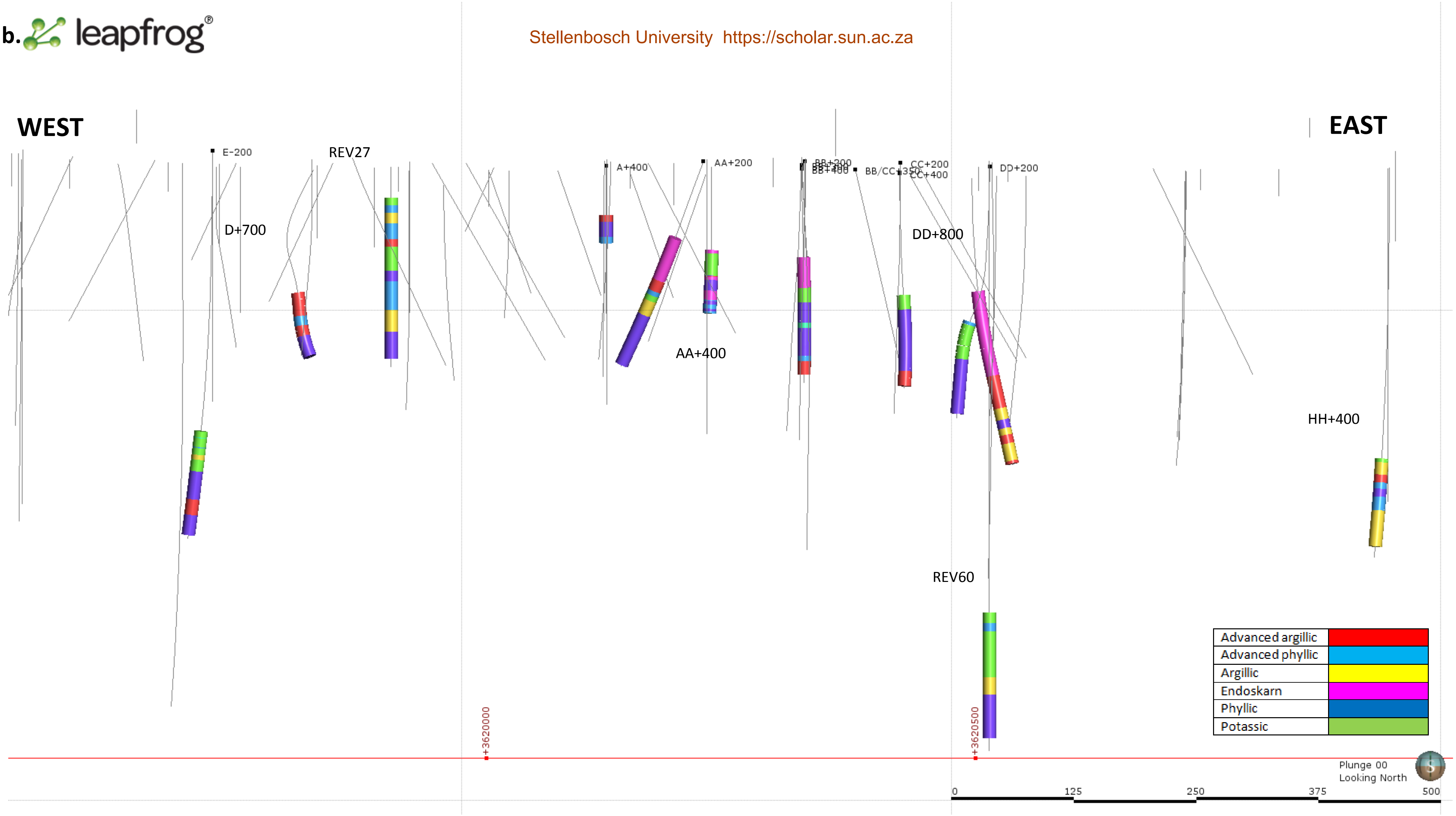


Figure 4.20 continued. b) This E-W section is looking north with a zero degree plunge. Phyllic alteration is the predominant type of alteration in the pluton, although more pronounced towards and in the AMG and BMG. The majority of the phyllic alteration occurs below the endoskarn zone. Phyllic alteration is not associated with W, Mo and REE enrichment. Potassic alteration is mostly found in sporadic patches rather than zones closer to the granite-wall rock contact just below and intermixed with the skarn zone. All the alteration types are interlayered and appears to follow the granite wall-rock contact.

4.2.1 Argillic and Advanced argillic alteration

Argillic and advanced argillic alteration is marked by extreme lower temperature alteration where a sea of highly altered feldspars is the result. This type of alteration occurs sporadically throughout the pluton and is pronounced where it is encountered. Spatially this type of alteration can either occur at the granite wall-rock contact or at depth away from the granite wall-rock contact (Figure 4.20.b). It is also more common in the low grade zone of the pluton, thus no enrichment and negligible amounts of sulphides are associated where this type of alteration is present.

The alteration progressed to such an extent that grain boundaries and twinning of feldspars is no longer identifiable (Figure 4.21.b), which is the case with advanced argillic alteration. In a few cases some twinning or a few grain boundaries are still observed and the alteration is classified as argillic alteration (Figure 4.21.a). The clay mineral kaolinite ($Al_2Si_2O_5(OH)_4$) is the result of this type of alteration (Table 4.7).

Goethite is mostly associated with this type of alteration as amorphous brown spots in the matrix. Carbonates have been observed where this type of alteration occurs, but it is more commonly associated with phyllic alteration. In some cases the quartz porphyry texture is still visible, especially closer to the granite wall-rock contact. Pyroxene is rarely seen and where it developed it is usually disseminated. Sporadic occurrences of individual allanite grains were observed. White mica also occurs, but is usually less than 7 modal %. Disseminated pyrite is also associated with this phase.

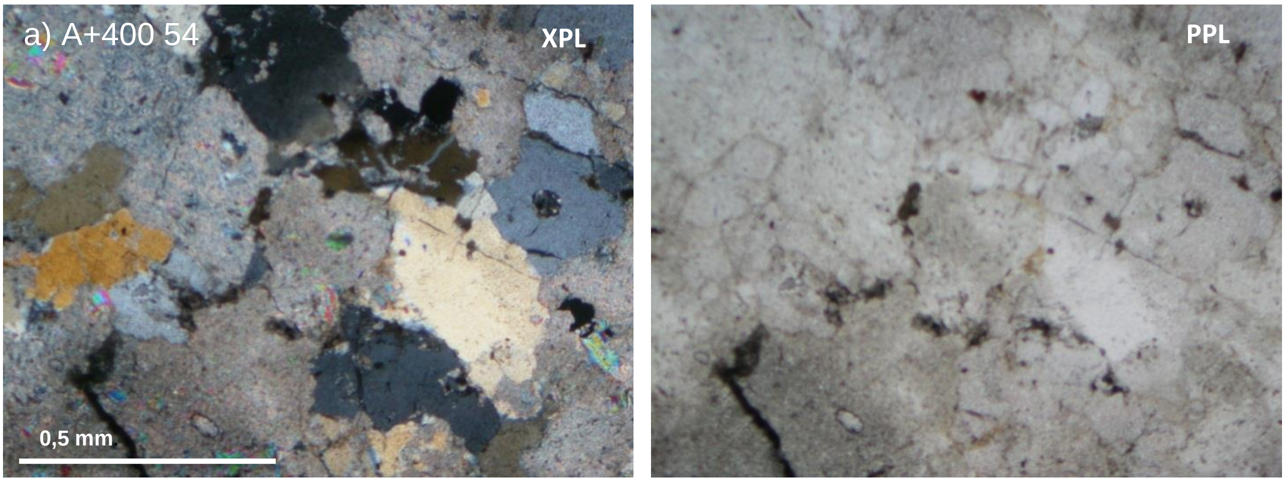


Figure 4.21. These photomicrographs illustrate characteristic examples of argillic and advanced argillic alteration. a) Argillic alteration is characterised by extreme low temperature alteration of feldspars (especially plagioclase), but where grain boundaries are still seen. Sulphides are generally finely disseminated and rare.

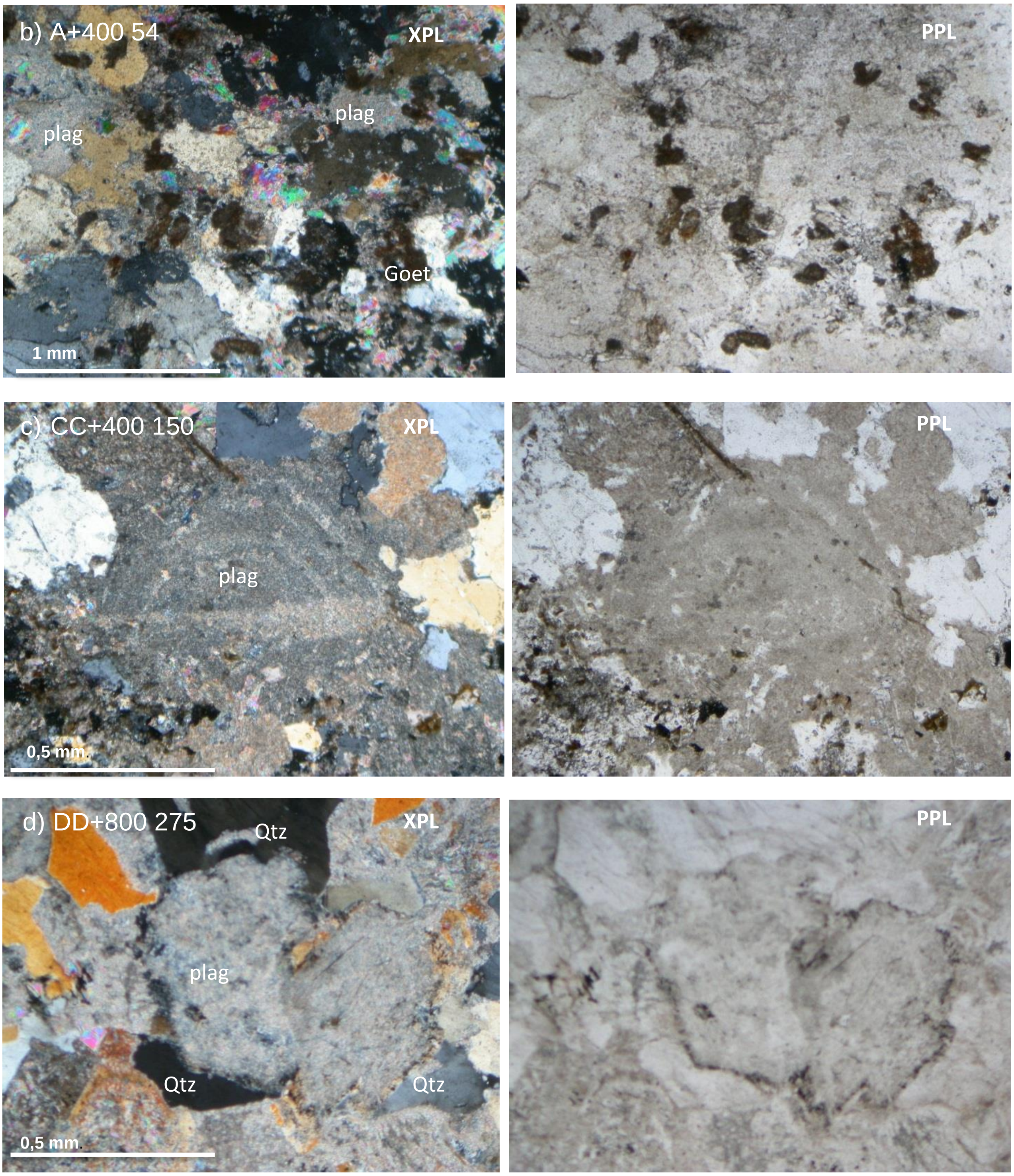


Figure 4.21 continued. b) Advanced argillic alteration is characterized by extreme alteration of feldspars where grain boundaries are not easily identified. This picture also contains goethite (the amorphous brown mineral in the matrix). c) An example of argillic alteration where twinning is still seen. d) Another example of argillic alteration where the grain boundaries are still evident. Some silicification is also observed (indicated by Qtz).

Table 4.7. The typical mineral chemistry of the clay minerals observed in this pluton (wt %). It is speculated that the clay mineral is kaolinite.

	Al_2O_3	SiO_2	Total
Clay minerals	37.55	45.04	82.58
	38.09	46.21	84.30
	37.15	44.87	82.02
	38.71	46.80	85.51
	37.67	45.50	83.18
	37.13	44.63	81.76

4.2.2 Phyllic alteration

Phyllic alteration is developed throughout the pluton and is the commonest of all the types observed (Figure 4.20). This type of alteration denotes the beginning of the alteration of the feldspars. It is marked by the presence of secondary white mica grains (muscovite), cryptocrystalline quartz and carbonates. Advanced phyllic alteration refers to larger white mica grains that are not necessarily associated with the alteration of primary plagioclase but occurs as a secondary product. Some of these larger grains are considered to have developed locally in this deposit as part of the process of greisenization (refer to page 77).

It is common to see phyllic alteration of plagioclase feldspar surrounded by a secondary alkali feldspar rim which is part of potassic alteration. Phyllic alteration is overprinted by potassic alteration. The boundaries between these two alteration types are diffuse.

Generally feldspar alters to sericite (sericitization) and plagioclase feldspar alters to saussurite (saussuritization), in other words white mica (muscovite, Table 4.8). Pyrite is more common with this type of alteration. Pyritization occurs throughout the pluton in the form of pyrrhotite that retrogresses to pyrite.

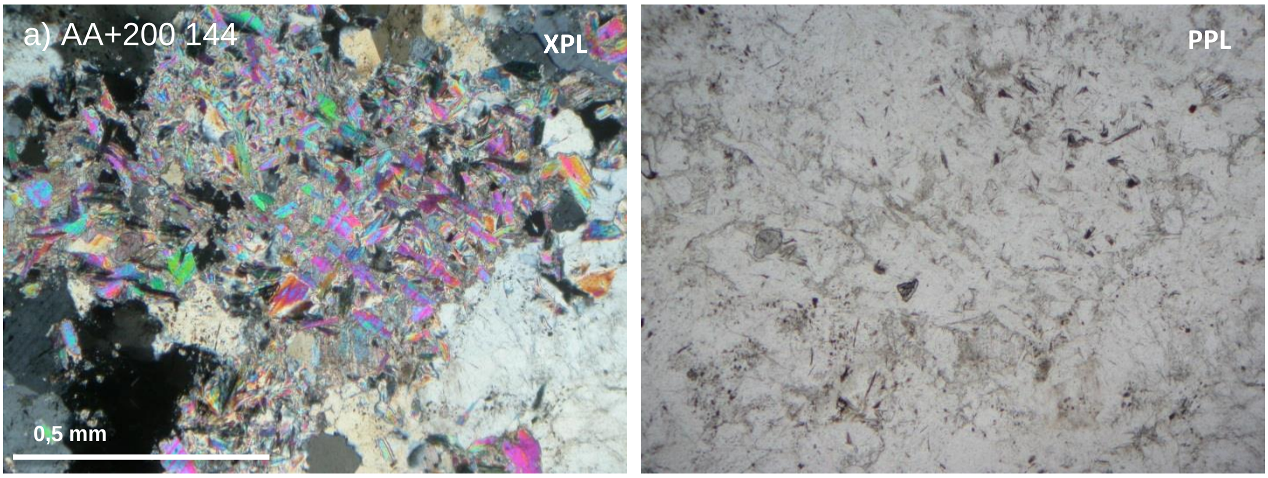


Figure 4.22. Photomicrographs illustrating phyllic alteration. a) Advanced phyllic with abundant fine-grained white micas associated with the alteration of primary plagioclase feldspar.

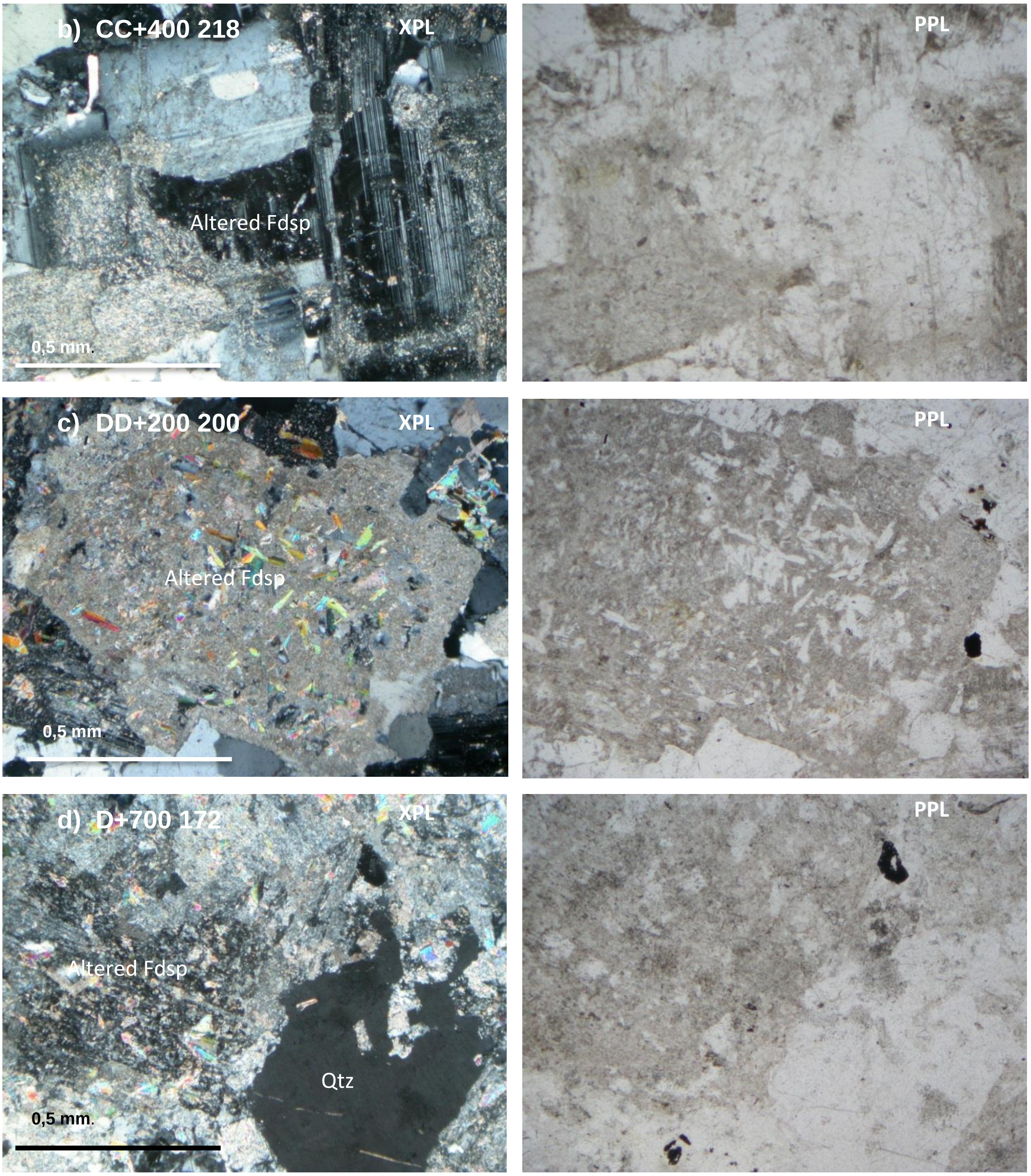


Figure 4.22 continued. b) Phyllic alteration is where alteration of feldspars is seen but to a much lesser extent than advanced phyllic. c) Advanced phyllic can also progress until it borders on argillic alteration. d) Advanced phyllic with some cryptocrystalline quartz (indicated by Qtz).

Sericitization and saussuritization

White micas are mostly associated with the alteration of plagioclase feldspar; in fact the development of white mica seems to occur primarily in the centre of plagioclase grains. This is the process of saussuritization which is evident as small grains within the confines of plagioclase feldspar grain (Figure 4.24.b). Saussurite is essentially a mixture of sericite and other fine-grained minerals such as zoisite, chlorite, and carbonates which are all associated with phyllic alteration. The residual plagioclase is then reconstituted into a more sodium-rich variety (from mindat.org and Deer et al, 1992) which has been observed as plag 3. Alkali feldspar is altered to sericite. Small white mica grains in this deposit are muscovite (Table 4.8). This is the first type of secondary white mica product that has been observed that forms part of the phyllic alteration process. These white mica grains are normally fine- to medium grained.

Greisenization

Relatively large white mica grains that are not associated with the alteration of plagioclase are also observed, although to a much lesser extent. These grains either overprinted feldspar grains or occurred as an alteration product of biotite (Figure 4.24.a). Some of these grains wrap around pre-existing grains of e.g quartz, which testifies to their secondary nature. This is the second type of white mica that has been observed as part of the advanced phyllic alteration process. They are typically larger, contain more F and are not necessarily associated with the alteration of plagioclase feldspar (Table 4.8). This is considered to be the process of greisenization and formed part of the prograde metasomatic phase.

A greisen is defined as a granoblastic aggregate of quartz and muscovite or lepidolite with accessory amounts of topaz, tourmaline and fluorite. It is formed by post-magmatic metasomatic alteration of granite. Greisens are usually associated with tin and tungsten (Best, 1982; Stemprok, 1987). They often develop at the upper contacts of granite intrusions and grade into a zone of feldspathic alteration below (Pollard et al, 1988). The Riviera deposit is not considered to be a greisen as a whole, because tourmaline, topaz and wolframite are not present at all. Minoe fluorite is found in the pluton, but not to the extent that is necessary to consider it as a greisen-type pluton. Fluorite has only been observed in one borehole intersection (REV60). There is significant large white mica grains in this borehole intersection which means that greisenization could have occurred locally, but it is not considered as economically important or significant in the genesis of this deposit. Albitization has been observed as secondary albite rims overprinting altered primary plagioclase feldspar and is locally and spatially associated with the occurrence of these large white micas and fluorite.

Table 4.8. This table illustrates the differences between large white mica grains and smaller white mica grains, which is mainly in their F content. Large white mica grains contain more F and are considered to form as a new generation of white mica that occurred as part of the greisenization phase. The finer grains are alteration products of alkali and plagioclase feldspar. The K in the small white mica grains are believed to have come from solution during the hydrothermal alteration process.

	F	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	TiO_2	MnO	FeO	BaO	Total
White mica large grains	1.82	0.25	2.84	31.23	47.52	10.54	0.29	0.00	0.97	0.00	95.46
	1.62	0.14	2.38	31.99	47.56	10.66	0.16	0.00	0.75	0.00	95.26
	2.25	0.19	4.57	28.70	47.36	10.22	0.37	0.00	1.57	0.00	95.25
	2.28	0.20	4.16	29.60	47.41	10.53	0.32	0.00	1.30	0.00	95.81
	2.40	0.20	5.22	28.41	46.40	10.29	0.52	0.00	1.76	0.00	95.19
	2.38	0.14	2.98	29.75	48.56	10.54	0.20	0.00	1.04	0.00	95.58
	1.96	0.17	3.33	31.04	49.76	10.34	0.38	0.00	0.77	0.00	97.74
	0.00	0.25	0.26	37.38	46.07	9.90	0.13	0.00	0.49	0.00	94.47
	0.00	0.00	1.13	34.97	48.44	10.19	0.22	0.00	0.26	0.00	95.21
	0.45	0.00	1.58	33.63	49.41	10.05	0.26	0.00	0.35	0.00	95.75
	1.04	0.17	3.94	30.79	49.94	10.85	0.48	0.00	0.91	0.00	98.13
	0.80	0.15	2.75	30.68	49.80	10.76	0.51	0.00	0.69	0.00	96.14
	0.74	0.20	3.47	29.94	49.33	10.81	1.06	0.00	1.43	0.00	96.97
	0.00	0.00	1.39	34.23	48.69	10.52	0.21	0.00	0.52	0.00	95.55
	0.00	0.24	2.11	32.17	48.91	10.71	0.41	0.00	0.65	0.00	95.21
	1.72	0.27	2.00	31.83	47.16	9.98	0.35	0.00	0.98	0.00	94.29
	0.94	0.14	1.71	31.98	48.11	9.67	0.16	0.00	1.52	0.22	94.46
	1.95	0.18	3.44	29.31	48.37	10.34	0.34	0.00	1.28	0.33	95.56
	1.73	0.18	3.16	29.48	48.05	10.43	0.36	0.00	1.63	0.34	95.37
	2.01	0.14	2.49	31.11	47.34	10.58	0.38	0.00	0.89	0.59	95.53
	1.48	0.17	2.49	31.14	48.09	10.55	0.26	0.00	0.88	0.68	95.73
White mica small grains	0.00	0.18	1.84	33.33	49.34	10.32	0.20	0.00	0.38	0.00	95.59
	0.00	0.16	1.91	33.42	48.06	10.54	0.16	0.00	0.84	0.00	96.14
	0.00	0.29	2.92	30.32	47.71	10.60	0.53	0.00	1.98	0.00	95.47
	0.00	0.15	2.05	32.46	48.78	11.00	0.27	0.00	0.48	0.00	95.19
	0.00	0.29	2.84	31.82	48.47	10.74	0.26	0.00	0.89	0.00	96.82
	0.00	0.26	2.17	32.59	48.28	10.46	0.15	0.00	0.97	0.00	96.17
	0.00	0.00	1.47	34.14	50.89	9.70	0.20	0.00	0.56	0.00	96.96
	0.00	0.13	1.84	33.35	48.68	10.94	0.20	0.00	0.48	0.00	95.62
	0.00	0.14	2.62	31.97	50.00	11.14	0.16	0.00	1.11	0.00	98.10
	0.00	0.15	2.40	33.17	50.12	10.95	0.21	0.00	0.50	0.00	98.29
	0.00	0.00	2.42	29.64	50.23	8.52	0.15	0.00	2.68	0.27	96.27
	0.00	0.24	2.67	31.15	48.01	10.51	0.00	0.00	0.93	0.33	96.53
	0.00	0.23	3.56	30.33	47.64	10.35	0.00	0.00	1.09	0.46	96.59
	0.00	0.33	0.12	37.93	47.24	10.21	0.00	0.00	0.66	0.29	96.79

0.00	0.31	1.45	33.74	47.59	10.51	0.00	0.00	1.28	0.44	96.72
0.00	0.35	0.49	36.10	46.95	10.32	0.00	0.00	1.46	0.36	96.03
0.00	0.40	0.18	37.49	46.00	10.40	0.54	0.00	0.61	0.00	95.62
0.00	0.21	2.89	31.03	48.05	10.28	0.16	0.00	1.52	0.28	96.82
0.00	0.29	3.69	30.04	47.41	10.50	0.29	0.00	1.74	0.38	96.93
0.00	0.19	2.59	30.95	48.78	10.40	0.00	0.00	1.17	0.00	96.55
0.00	0.46	2.88	30.38	47.78	10.46	0.28	0.31	1.08	0.00	96.08
0.00	0.30	3.16	30.90	48.82	10.60	0.26	0.00	0.86	0.00	97.68
0.00	0.20	2.78	30.26	48.51	10.15	0.14	0.00	0.74	0.00	95.33

Figure 4.23 confirms that white mica in this pluton is mainly muscovite. This is due to its high K_2O content.

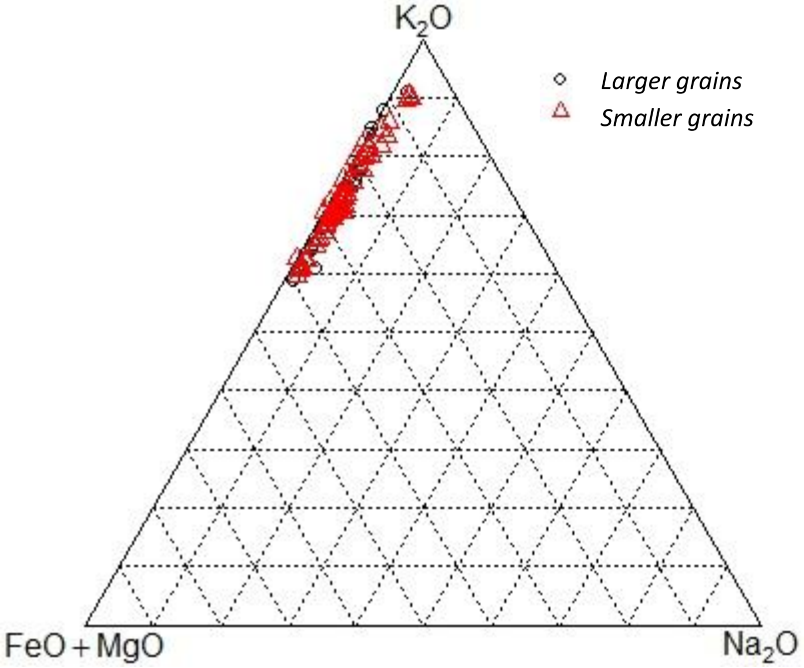


Figure 4.23. Ternary diagram of the white mica in this pluton's end members (n=93). White mica is mainly muscovitic in composition.

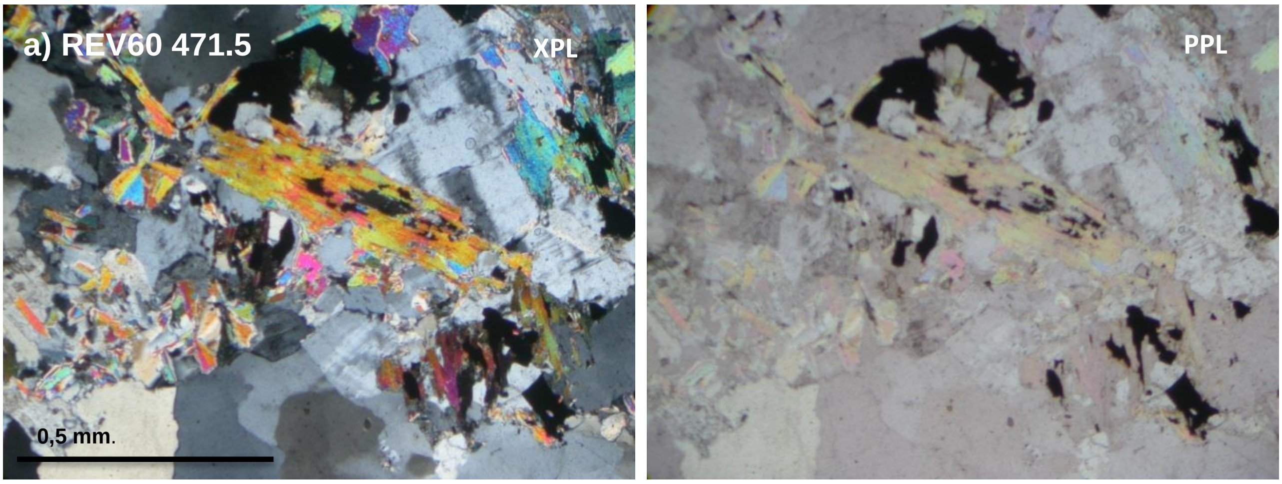


Figure 4.24. Photomicrographs illustrating different forms of white mica. a) Alteration product of primary biotite.

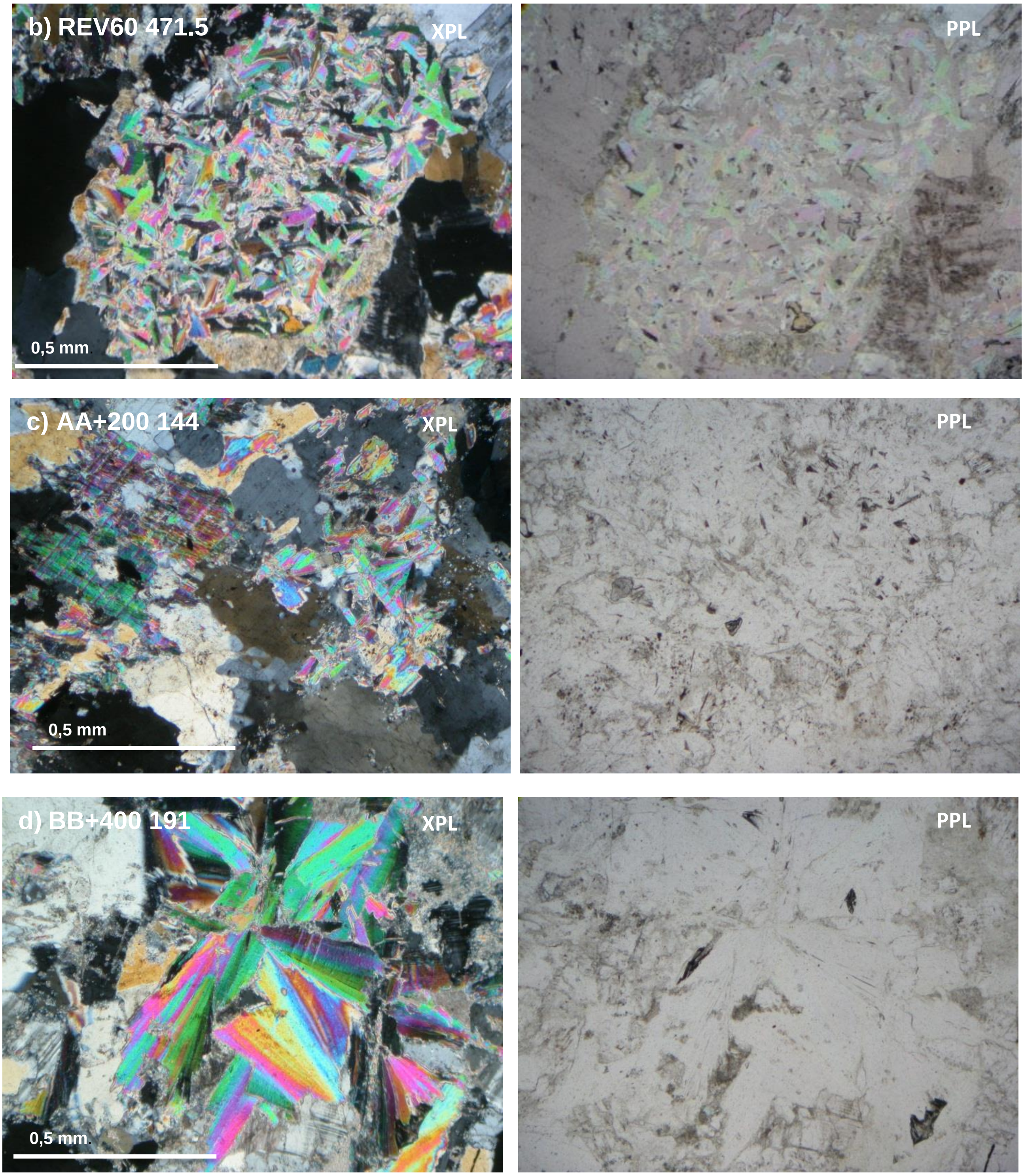


Figure 4.24 continued. b) As an alteration product of primary plagioclase feldspar grains as saussurite. c) Interstitially in the matrix. d) As rosettes which form part of the second generation of white mica and is indicative of greisenization.

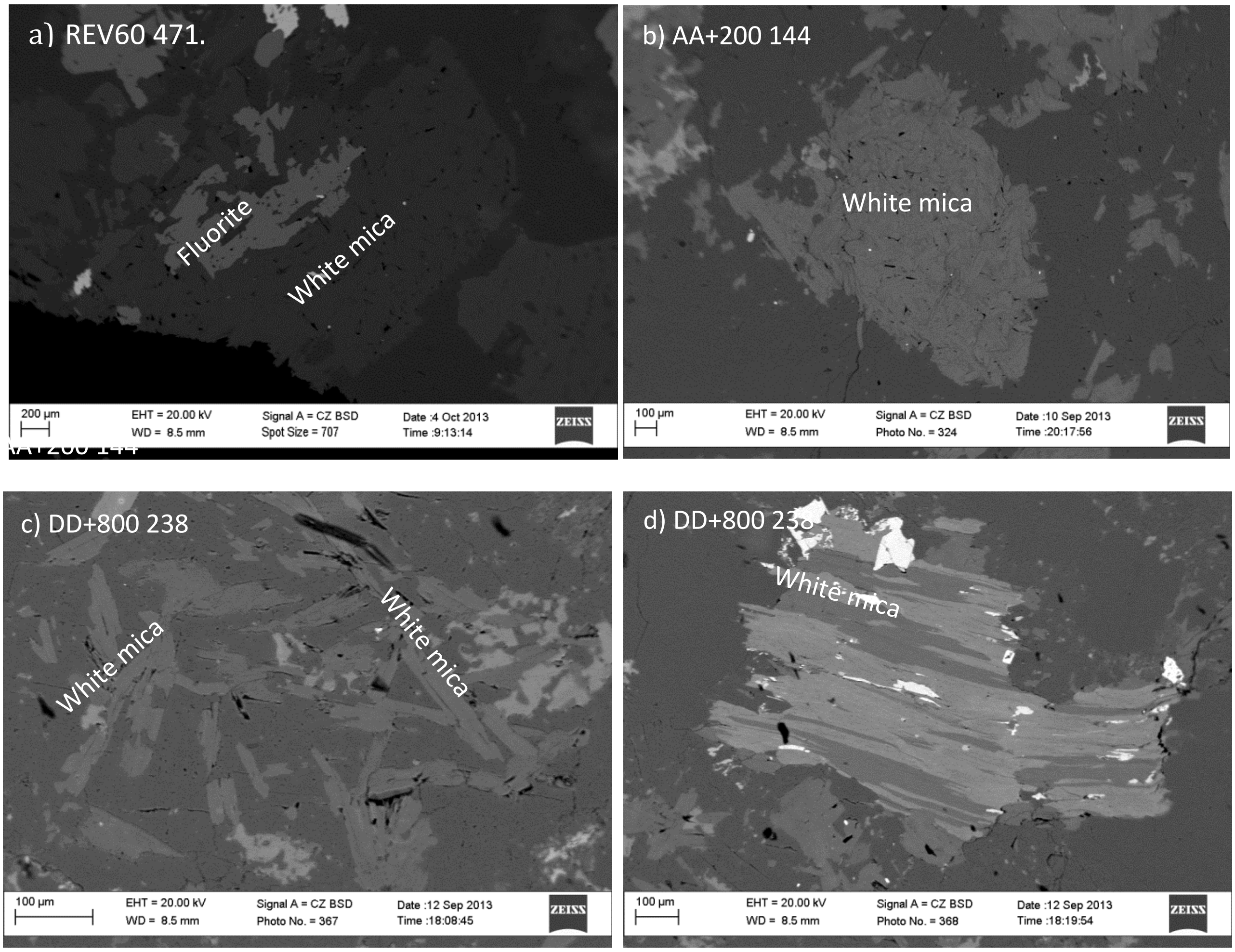


Figure 4.25. BSE images of the different forms of white mica found in the pluton. a) Fluorite (lighter) and white mica occurring together. This is an example of greisenization that occurred locally. b) The extreme alteration of primary plagioclase grains is marked by small white mica grains. c) Larger new white mica grains in the matrix, because of their F contents. d) Alteration of primary biotite to intersheeted with white mica and chlorite.

Silicification

Silicification is recognized as secondary or cryptocrystalline quartz. The porphyritic quartz aggregates are known as 'quartz eyes' due to the fact that they are clearly seen in hand sample and are a primary feature. The smaller cryptocrystalline quartz patches are the result of secondary silica derived from altered plagioclase and potassic feldspar and precipitated close by.

Chloritization

Chloritization is evident in this pluton where secondary chlorite grains are found as an alteration product of biotite and is considered part of the phyllic alteration process (refer to section 4.1.2).

Carbonatization

Secondary carbonate formed as part of the phyllic alteration process and is generally interstitial in nature. Carbonate associated with this type of alteration is considered to be ankerite (refer to section 4.1.2).

4.2.3 Potassic alteration and albitization

Potassic alteration takes place by feldspathization; this is primarily the deposition of secondary alkali feldspar (K-metasomatism) and less importantly the deposition of albitic plagioclase (Na-metasomatism). Secondary biotite (biotite 2) is also associated with this type of alteration (Figure 4.26). These alteration types are all considered to be part of the prograde metasomatic phase.

Secondary alkali feldspar appears in two forms: either as small secondary grains or as zoning around altered plagioclase feldspar. Secondary albite is evident as albitic rims around an altered inner core of primary plagioclase feldspar. Spatially albitization occurs outside of the skarn zone. Secondary biotite is usually much smaller than primary biotite and also has irregular habits and no well-developed cleavage in one direction, although the distinctive red-brown colour is prominent.

Potassic alteration is usually associated with phyllic alteration outside the skarn zone. Potassic alteration overprints phyllic. This is observed as local patches. The intensity of alteration may increase up to where igneous protolith texture is completely destroyed (Figure 4.16.c).

Wherever potassic alteration is encountered, it is never the only form of alteration. It usually occurs with phyllic or advanced phyllic alteration and is no more than 20 to 25% of the alteration in a given section. It is an intense form of alteration that occurs at high temperature where new minerals are formed whereas the other types of alteration almost completely destroy the primary mineralogy.

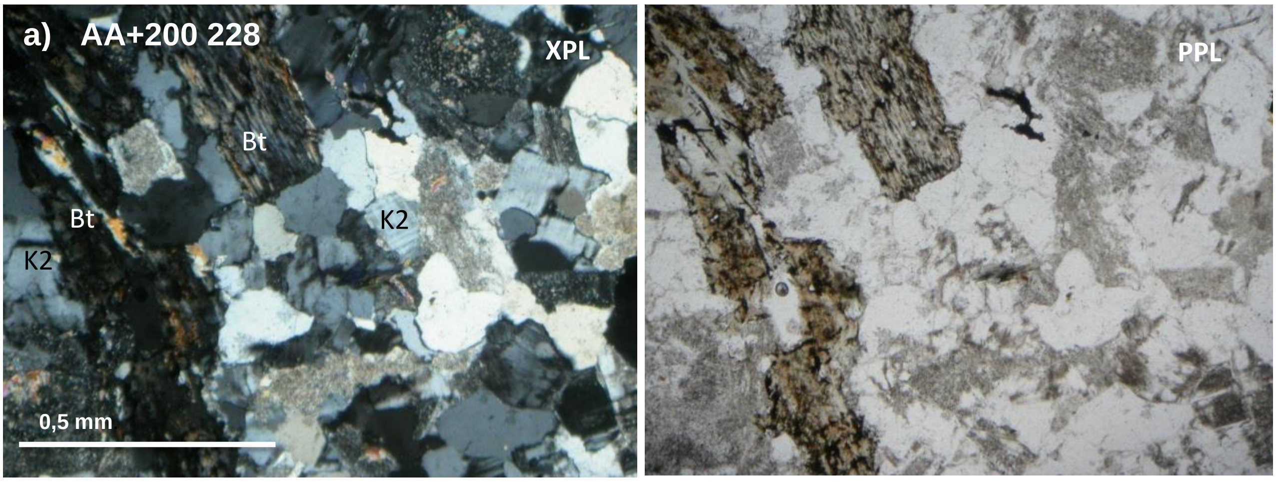


Figure 4.26. Photomicrographs illustrating potassic alteration. a) some phyllic alteration (overprinted by potassic). Note the highly altered primary minerals, overprinted by secondary alkali feldspar.

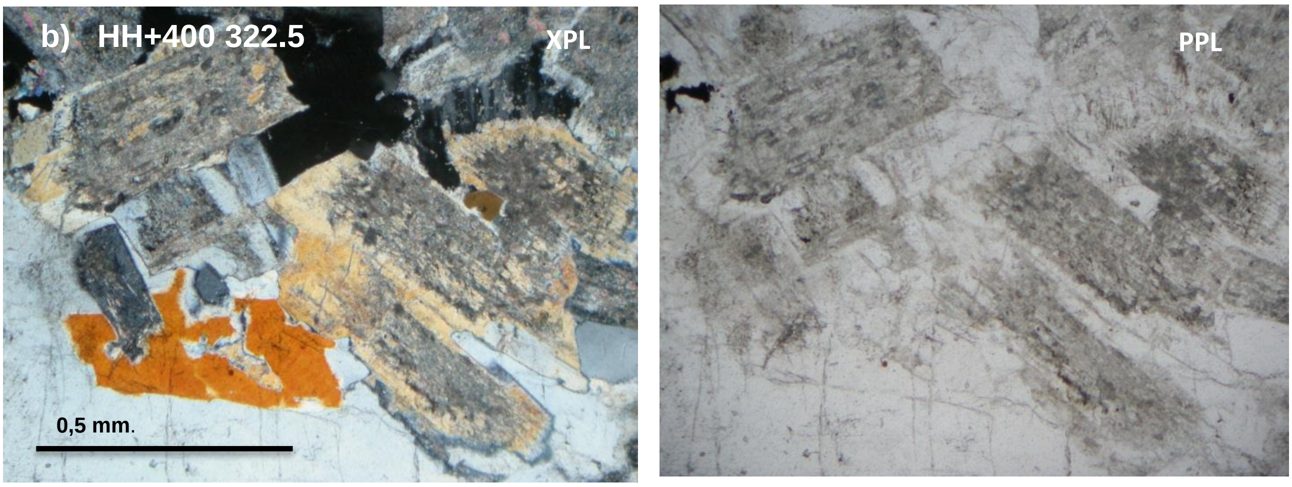


Figure 4.26 continued. c) The selective replacement of plagioclase is displayed in this image. This is an example of albitization and Na metasomatism.

4.2.4 Skarn-type alteration

The skarn zone is best developed towards the apex of the granite cupola, close to the wall rock into which the Riviera pluton intruded. This zone is less well defined, thin and irregular at depth away from the granite wall-rock contact.These zones formed as a result of skarnification or skarn-type alteration. It consists of coarse-grained assemblages of clinopyroxene, garnet, scheelite, allanite, and minor apatite, titanite, pyrite and pyrrhotite (Figure 4.27). Most of the enrichment is also found in this zone, although it is not restricted to it. This zone has the best grade of W enrichment. In the footwal clusters of skarn minerals are found; these rocks are called skarnified granites (Figure 4.16.c). The skarn in this pluton is mainly a calcic skarn and because of the abundance of sulphides it is considered to be a reduced endoskarn.

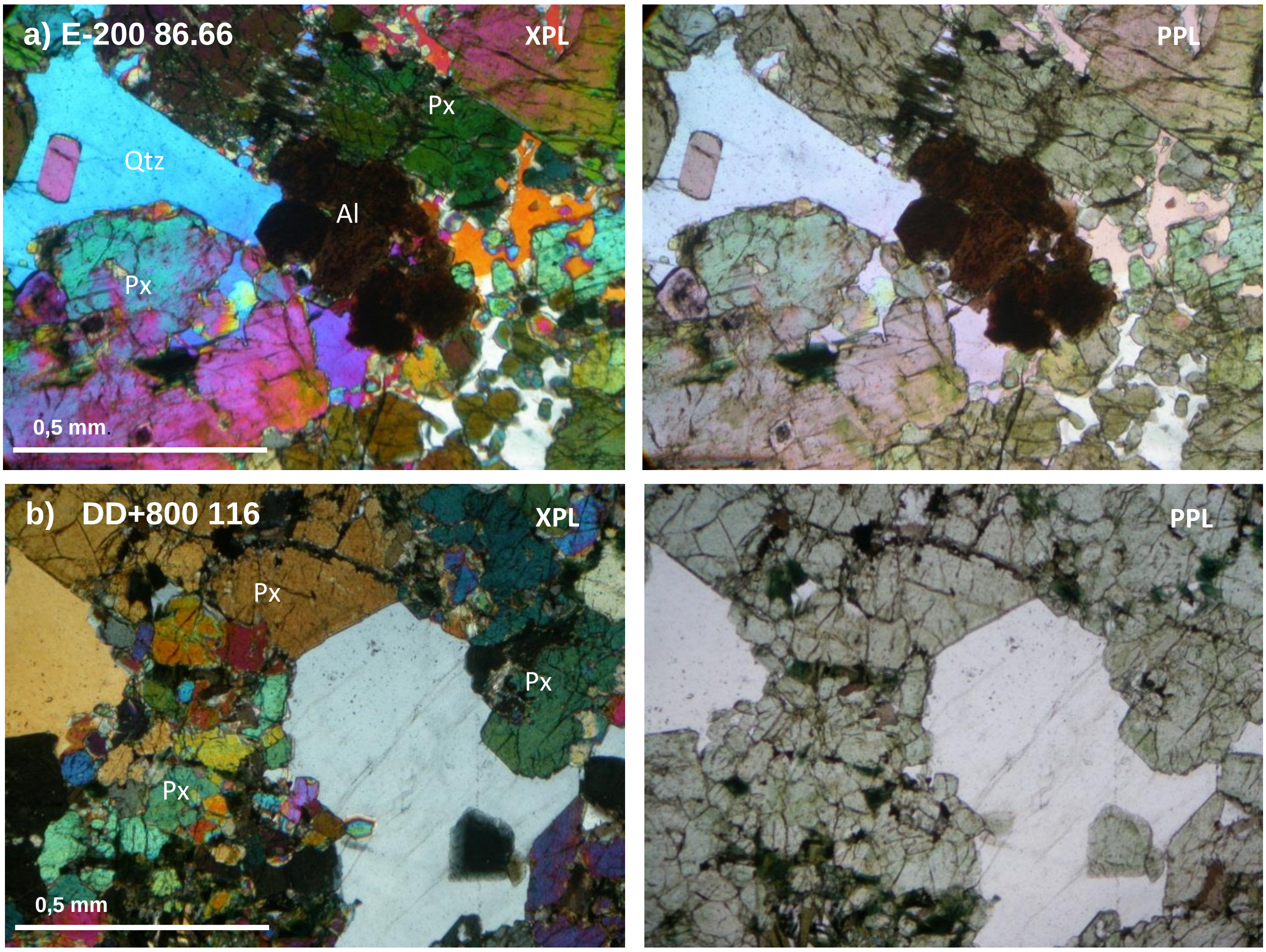


Figure 4.27. Photomicrographs of the skarn zone mineralogy. a) An example of endoskarn. Note the pyroxene and allanite. b) Another example of endoskarn with abundant clinopyroxene.

4.2.5 Paragenetic sequence

The paragenetic sequence (Figure 4.28) was determind by observing the mineralogy, alteration products and their textures. The sequence starts with the minerals that form during crystallization of the pluton namely quartz, feldspars (alkali and plagioclase feldspar), micas (biotite 1) and accessory titanite. The alteration of primary minerals occurred in the form of feldspars that altered to sericite and saussurite as the first fluid phase was introduced. With the prograde skarn development bastnaesite, scheelite, garnet, pyroxene, epidote, titanite, vesuvianite, apatite and allanite formed. Biotite 2, new large muscovite grains, secondary alkali feldspar grains and albite also formed part of the prograde metasomatic phase, but are not skarn related. Lastly, retrograde hydrothermal alteration products include secondary chlorite, carbonates, amphiboles, sericite (white mica), goethite and clay minerals. Retrograde quartz is silicification. Sulphides other than pyrrhotite and pyrite formed lastly in the paragenetic sequence.

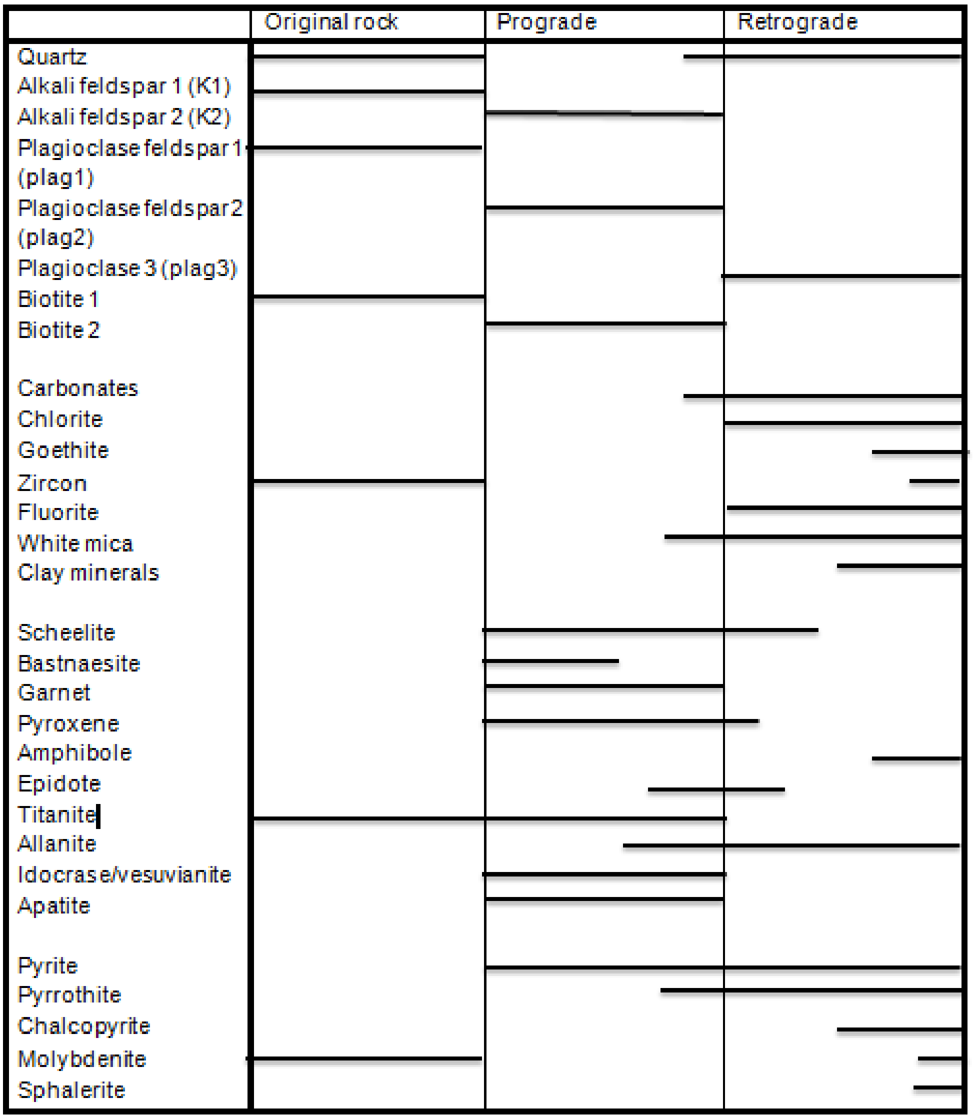


Figure 4.28. This diagram graphically displays a simplified paragenetic sequence that has been observed through textures and mineral assemblages.

4.3 Discussion

Feldspars are very prominent in the Riviera pluton and play an important role in unravelling the history of the deposit in terms of the processes that played a role. Five phases of feldspars have been identified: primary plagioclase that is usually the most altered, plagioclase with an altered inner core surrounded by either unaltered alkali feldspar or albitic rims, and lastly small secondary feldspar grains. Large grains of both plagioclase and alkali feldspar are present, and both display the effects of hydrothermal alteration. Plagioclase is altered to a larger extent and is mostly associated with lower intensity phyllic and argillic alteration in the form of secondary white mica. Plagioclase alters to saussurite and alkali feldspar alters to sericite.

A new generation of alkali feldspar forms as part of potassic alteration which either occurs as single small grains in the matrix or rims around altered primary plagioclase feldspar. Albite also occurs as overgrowths on plagioclase which is Na-metasomatism and part of the potassic alteration process. A new generation of white mica also forms, which is larger and contain more F than the smaller white mica/sericite grains associated with the alteration of primary feldspars, whereas alkali feldspar shows more intense forms of alteration such as albitization and K-metasomatism (secondary alkali feldspar grains). The products of potassic alteration and the new generation of large white mica grains are part of the prograde metasomatic phase. Secondary biotite was also formed through this process.

Secondary minerals that were identified apart from what was mentioned already include carbonates (ankerite), chlorite, epidote, titanite and goethite. Epidote, titanite, chlorite and carbonates (bastnaesite) also form part of the skarn-forming process. Zircon and fluorite have been observed although in accessory amounts.

In terms of skarn minerals, garnet displays compositional zoning, in other words its cores are more reduced and have a grossular composition and the rims with an andraditic composition display an increase in oxygen fugacity during crystallization. In terms of pyroxene more reduced and more oxidized varieties are evident in the skarn zone. Retrograde alteration of pyroxene is evident by the presence of amphibole on the edges of some pyroxene grains in the skarn zone.

Four phases of pyrite were found; a primary disseminated phase, an alteration product of pyrrhotite, associated with the alteration of biotite, and lastly euhedral late stage crystals. The change from pyrrhotite to pyrite also reflects the changing nature of fluids from reduced to oxidized. Sphalerite and molybdenite are relatively unaltered and therefore also considered to be late stage.

Based on modal composition the pluton consists of three closely related rock types: a quartz porphyry monzogranite (QPMG), a biotite granite to monzogranite (BMG) and an aphanitic granite to monzogranite (AMG). More alkali feldspar is found in the AMG than in the QPMG and BMG, which confirms that the pluton evolved to a more differentiated, possible A-type phase.

Alteration types that have been observed include argillic and advanced argillic alteration, phyllic and advanced phyllic alteration that involve mainly sericitization, greisenization, silicification, chloritization and carbonatization, potassic alteration and lastly skarnification. The different alteration phenomena observed varies from extremely low internsity, to extremely high intensity. The low intensity alteration is marked by minerals such as clay minerals, small grains of white mica (sericite), chlorite and carbonates. High intensity alteration minerals are seconday biotite, secondary alkali and plagioclase feldspar (albite), scheelite, garnet, allanite, pyroxene and bastnaesite.

In some cases the alteration is so extensive that the primary rock minerals are unrecognizable. This is the case with both advanced argillic alteration and skarnification. The texture is mostly coarse-grained (except where AMG is encountered), although boundaries between grains, especially feldspars, become diffuse. The boundaries between the different alteration types are either diffuse or gradational, rather than distinct and display a layering effect.

Spatially the different alteration types appear to be interlayered and follow the contour of the pluton. In some cases the first phyllic alteration phase is overprinted by potassic alteration. Argillic alteration also locally grades into silicification. Higher intensity alteration types selectively replace lower intensity alteration types. Potassic alteration does not occur in zones, but is rather sporadic and patchy close to the skarn zone that overprinted mainly phyllic alteration.

Alteration types are associated with one another on various levels. One example is the extreme leaching of K, Na and Ca from aluminous phases (feldspars and micas), leaving behind a concentration of aluminium which results in clay minerals. The elements that were leached precipitate as products of potassic (K) and albitic (Na) alteration and skarn formation (Ca) elsewhere. There also appears to be a link between alteration and enrichment. Most of the enrichment is associated with higher intensity forms of alteration such as skarnification and potassic alteration.

The paragenetic sequence starts with the minerals that form during crystallization of the pluton namely quartz, feldspars (plagioclase and alkali feldpspar), micas (biotite 1) and accessory titanite. The introduction of the first fluid phase just after the pluton intruded caused the alteration of primary minerals that occurred in the form of feldspars that altered to sericite and saussurite. With the prograde skarn formation, bastnaesite, scheelite, garnet, pyroxene, epidote, titanite, vesuvianite, apatite, and allanite formed. During the prograde metasomatic phase minerals such as biotite 2, new large white mica grains, and secondary alkali feldspar and albite formed, but are not skarn-related. Lastly, retrograde hydrothermal alteration products include secondary chlorite, carbonates, amphiboles, sericite (white mica), goethite and clay minerals. Sulphides other than pyrite formed last in the paragenetic sequence.

Chapter 5 - Geochemistry

This chapter is based on major and trace element whole-rock data from borehole intersections A+400, BB+400, CC+400, DD+200, E-200 and AA+200. The extent of hydrothermal alteration rendered the whole-rock data unsuitable for determining the host rock classification. Consequently the whole-rock data were mainly used for determining the effect and extent of hydrothermal alteration on the original host rock.

The whole-rock data were divided into those of the mineralized zone (MZ) and the non-mineralized zone (NMZ). This is based on the vertical distribution and variation of elements. The MZ refers to the zone where the bulk of the enrichment lies, within 160m from the granite-wall rock contact. This zone consists largely of products of higher intensity alteration such as skarnification and potassic alteration. Enrichment is a collective term used in this study to refer to potentially economic minerals, like scheelite, allanite, molybdenite and bastnaesite. The degree of enrichment refers to where there is a significant concentration of economic minerals. The NMZ is the zone that is typically devoid of enrichment and, although hydrothermally altered, it represents the original rock more closely than the MZ.

Within each zone, the element distribution was determined to establish the geochemical characteristics of each zone (vertical distribution plots for each borehole intersection can be viewed in the appendix). To determine which elements correlate with each other, in particular the economic elements with respect to the Alteration Index (AL), correlation matrices were calculated for each zone. Correlation matrices per borehole for the MZ and NMZ can be viewed in the appendix.

The Alteration Index (AL) (see formula below) of Ishikawa et al. (1976) has been used to display not only the spatial distribution and extent of alteration with respect to depth, but also how it relates to elements that normally take part in the alteration process (K_2O, Na_2O, CaO and MgO). It is anticipated that the lower this index, the more skarnification will be present. Other forms of alteration where the index is closer to 100% will likely be present because of pervasive hydrothermal alteration that affected the entire pluton.

$$\mathrm{AL} = \frac{100(K_2\,O + Na_2\,O)}{(K_2\,O + Na_2\,O + MgO + CaO)}$$

Rare earth element characteristics and geochemical REE profiles will be discussed in the next chapter that focusses on allanite (chapter 6).

5.1 Rock classification

Compared to the empirical modal classification (section 4.1.6), the geochemical data clearly reflects the effect of hydrothermal alteration instead of the original composition (Figure 5.1). The geochemical data will therefore be used to characterize and quantify the extent of hydrothermal alteration, as well as potentially economic enrichment. The geochemical data is a reflection of mass transfer processes that occurred due to extensive hydrothermal alteration.

Figure 5.1 display that the data points are scattered on the QAP diagram and in some instances too high in silica to be classified as an intrusive rock. Some quartz veins have been documented which explains samples that are effectively 100% SiO_2. The effects of skarnification and other forms of alteration are evident as the rocks evolved to more alkali- and silica-rich varieties as a result of hydrothermal alteration.

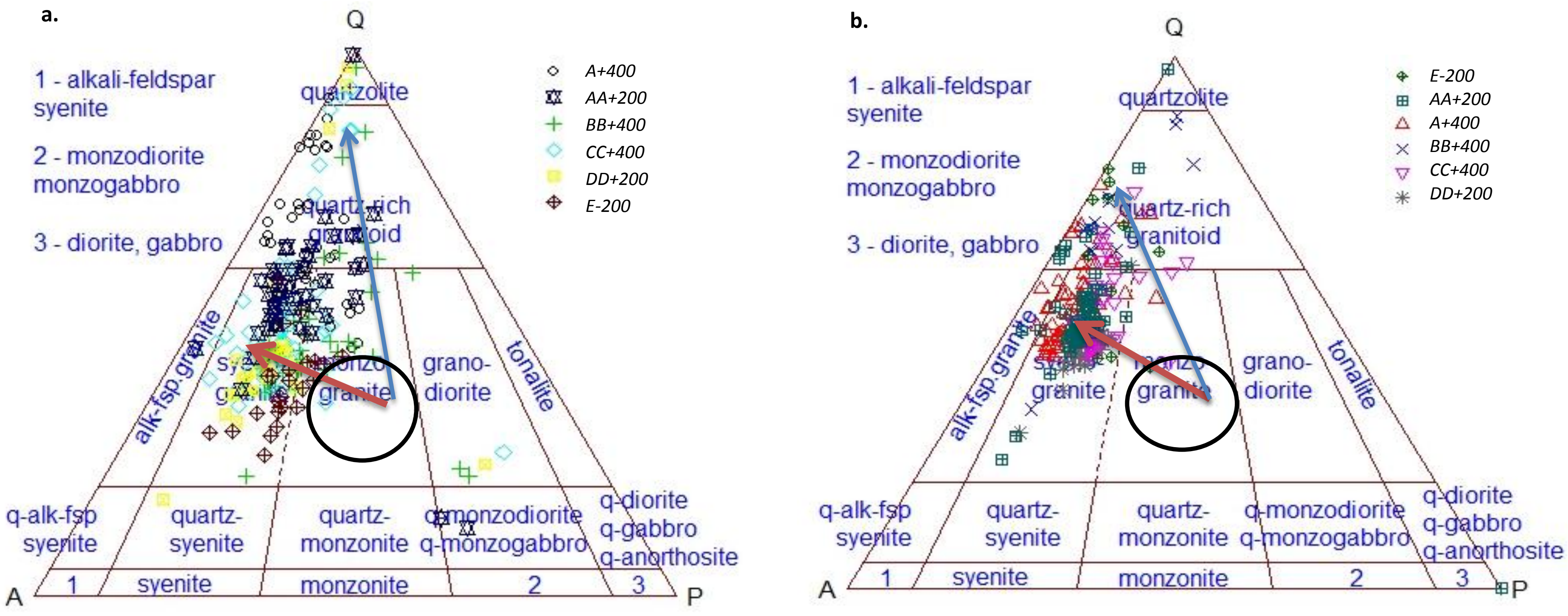


Figure 5.1. IUGS classification diagrams based on CIPW normative calculations of the borehole intersections displayed. QAP diagrams (Streckeisen, 1974) of a) the mineralized zone (MZ) (n=250) and b) the non-mineralized zone (NMZ) (n=247). These diagrams depict the geochemical data of the host rock, which clearly show that the data is not suitable for use in the classification of the host rock. The blue and red arrows illustrate the extent of silicification and potassic alteration respectively.

Some trace elements are deemed incompatible and immobile during pervasive hydrothermal alteration, and are therefore useful as geologic discriminants. Although these types of diagrams are empirical, they help to give an idea of the geological setting that a rock is associated with. Rb, Y, Nb, Ta and Yb (lanthanides) are considered incompatible elements although Rb may be compatible especially if a fluid phase is involved (Pearce et al, 1984; Winter, 2010). According to these diagrams (Figure 5.2), of the MZ, this pluton either intruded during collision, or is a volcanic arc granitoid, or a within-plate granitoid. The Riviera pluton is subduction-related (Scheepers, 1995) and should therefore plot in the syn-COLG field. Yb is part of the REE and Y is strongly REE-related and is therefore enriched in the MZ which renders data related to these elements unsuitable for use as a geologic discriminants. This explains the considerable overlap in the VAG and WPG fields in Figure 5.2. (Other discrimination diagrams can be viewed in the appendix).

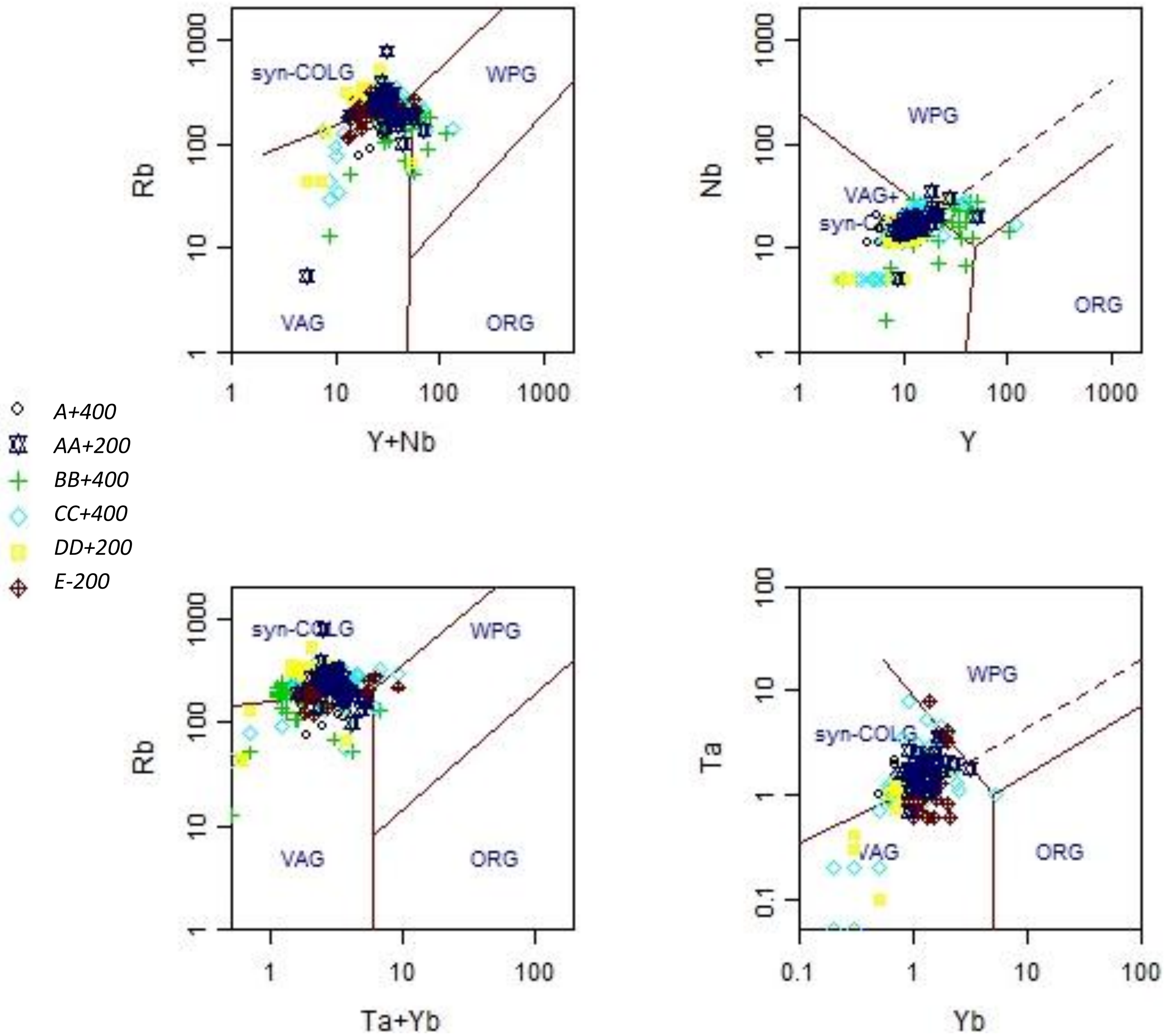


Figure 5.2. Discrimination diagrams (Pearce et al, 1984) showing the data of the MZ. Although the data cluster, they are on the border of three fields (syn-COLG, VAG and WPG). These are three very distinct associations and do not occur together geologically. The Riviera pluton is subduction-related and should plot in the syn-COLG field (Scheepers, 1995). Y and Yb are enriched because of their association with REE in the MZ which renders these diagrams as unsuitable for use as geologic discriminants.

For the NMZ the data is less scattered and clusters in the syn-COLG field with some overlap in the VAG field. This is more accurate and could possibly be used to confirm the subduction-related setting of the Riviera pluton. Thus trace element data from the NMZ are more reliable to use as geologic discriminants compared to data from the MZ, although the effect of hydrothermal alteration is still observed due to the slight shift to the VAG field.

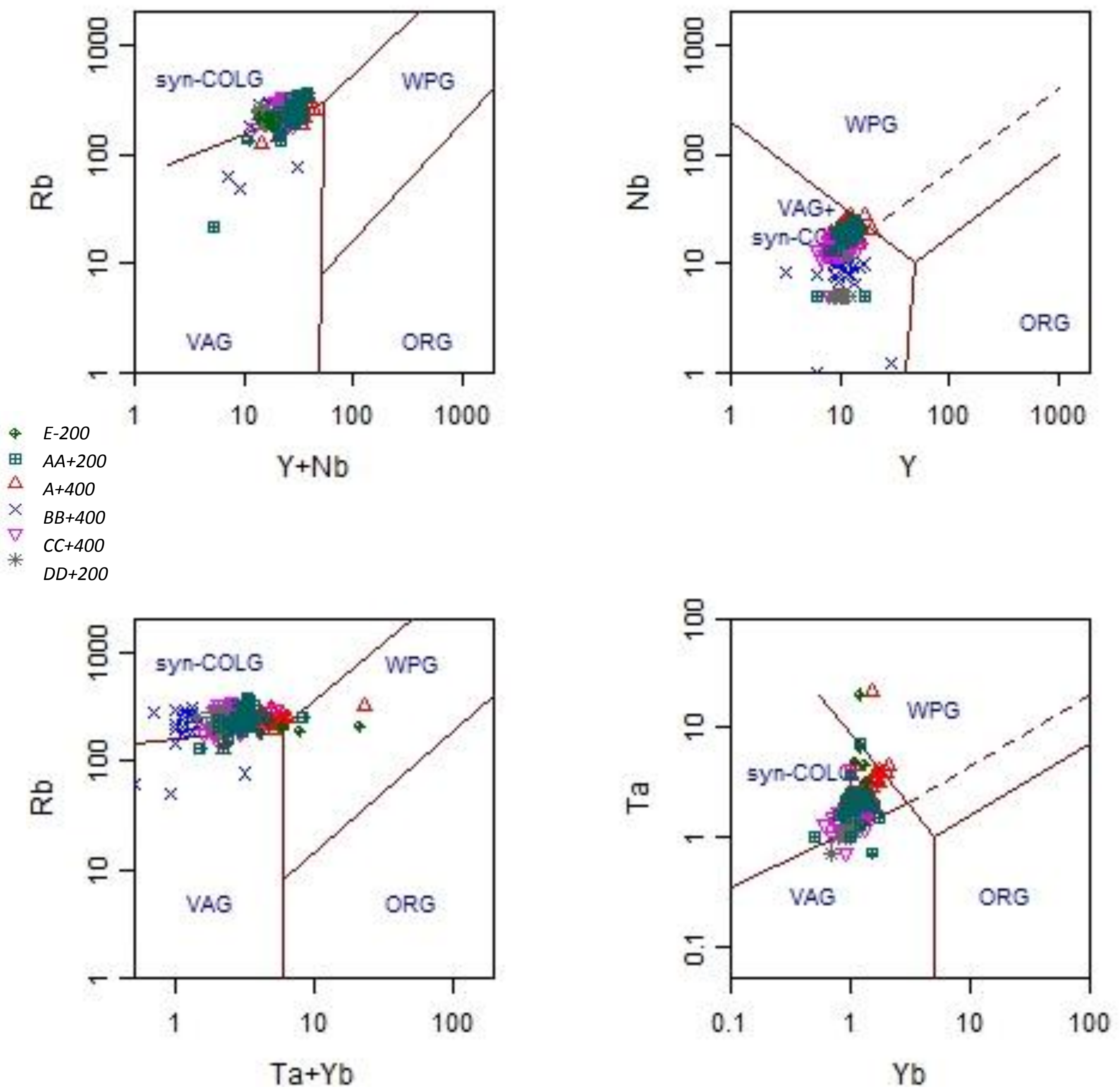


Figure 5.2 continued. These diagrams of the NMZ show that trace element data from the NMZ can be used as a geologic discriminant and confirms that the Riviera pluton is subduction-related. The effect of hydrothermal alteration in the NMZ is however still seen as the overlap in the VAG field. (Syn-COLG – during collision granitoid, VAG – volcanic arc granitoid, WPG – within-plate granitoid and ORG – ocean ridge granitoid).

A-type granitoid discrimination diagrams (Figure 5.3) were used to possibly confirm the late- to post-orogenic nature of the pluton. The major element oxides are not useful in this classification as the data is scattered over all the discriminating fields. This is due to the effect of skarnification and hydrothermal alteration in the MZ. Trace elements like Ce and Y are associated with REE and are enriched in the MZ. This is evident from the diagrams below showing data that is stretched across both the I- and S-type field (bottom left block) and the A-type field to the right. Ga and Al could be used although they are plotted against Ce and Y.

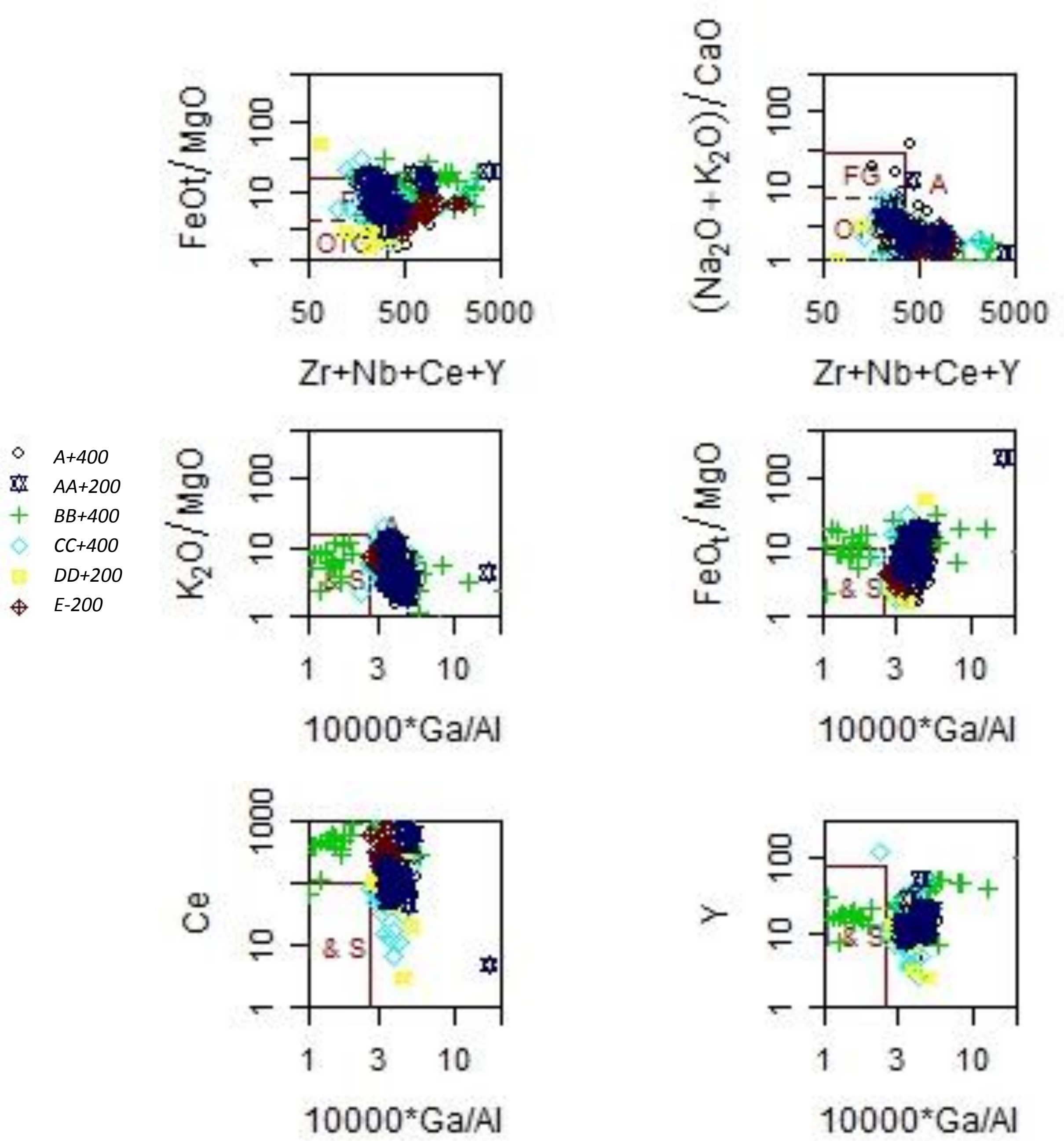


Figure 5.3. Discriminant plots to distinguish A-type granitoids from I- and S-type granitoids (Whalen, 1987). The MZ shows that the major element oxides cannot be used to discriminate between I-, S- and A-type diagrams due to the effect of skarnification and hydrothermal alteration in the MZ. Trace elements such as Ga that were used in the diagrams above can be useful although they are plotted together with Ce and Y which is related to REE in the MZ and are therefore enriched in this zone. (The A-type field is the larger block to the right in each diagram, whereas the I- and S-type field is the small block in the bottom left corner).

Diagrams with Zr, Nb, Ga and Al as variables suggests an A-type nature of the Riviera pluton by showing that most of the data clusters in the A-type field. This is true for all boreholes except BB+400. BB+400 form part of the high grade W zone and mostly consist of potassic alteration and skarnification which displays a less differentiated nature.

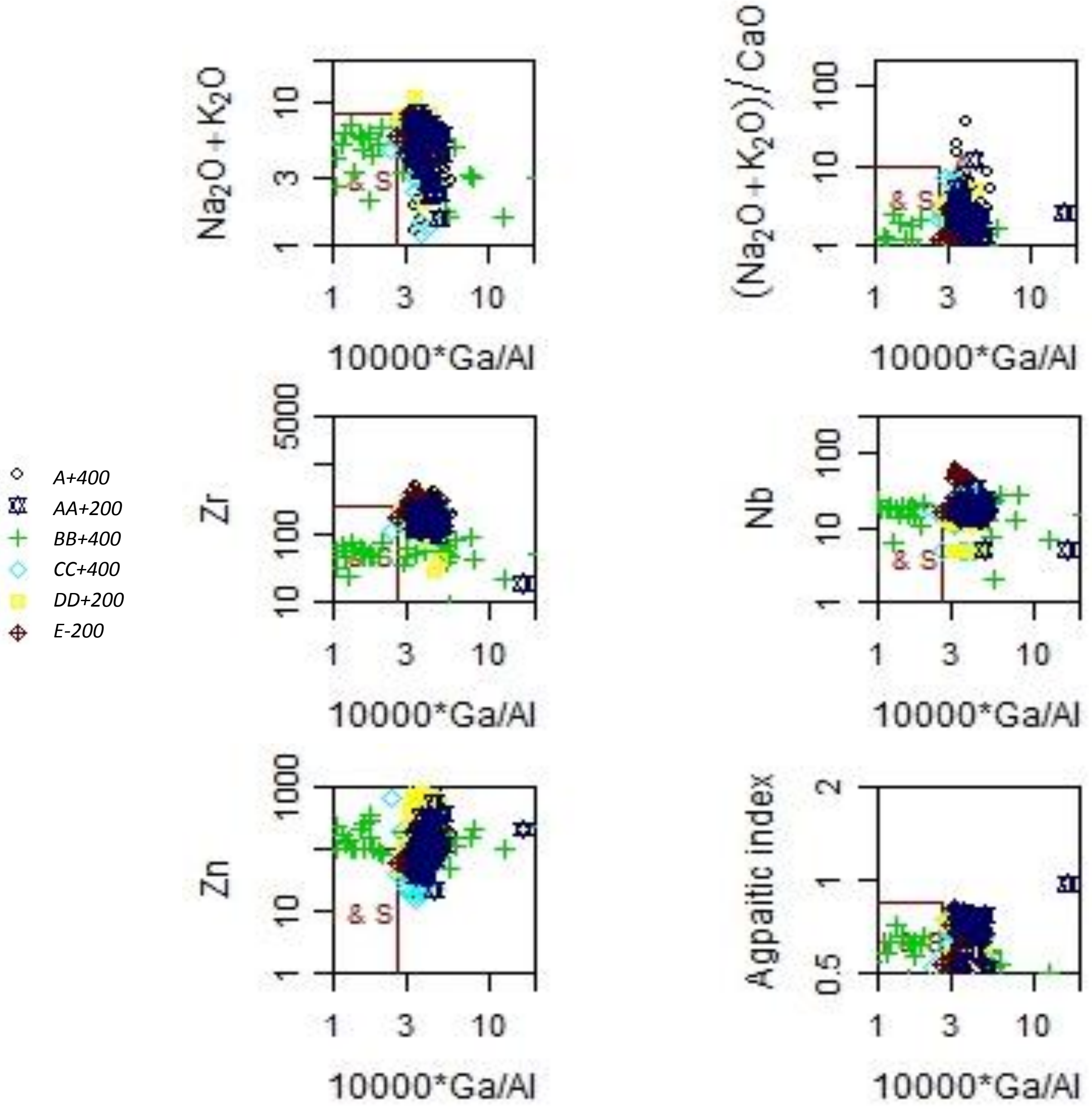


Figure 5.3 continued. Ga, Al, Zr and Nb are useful elements to use to discriminate between I-, S- and A-type granites. Diagrams with these elements suggest a late-orogenic A-type signature of the Riviera pluton. (Agpaitic rocks are peralkaline rocks such as nephelines, syenites and phonolites that contain complex silicates of Zr, Ti and REE, F and other minerals like eudialyte, rinkite (Sorenson, 1997).

For the NMZ, the data is not so scattered, except for some of the major element oxides like FeO, MgO and CaO. The more immobile elements such as Ga, Al, Ce and Y display a late- to post-orogenic A-type signature in the NMZ. Elements like Ce and Y could not be used in the MZ to discriminate between I-, S- and A-type granites, but in the NMZ it is more accurate. This is especially the case in the NMZ as the rock appears to be is more differentiated at depth in the pluton (section 4.1.6). The mineralogy and mineral chemistry indicate that the rock is more alkali-rich in the NMZ.

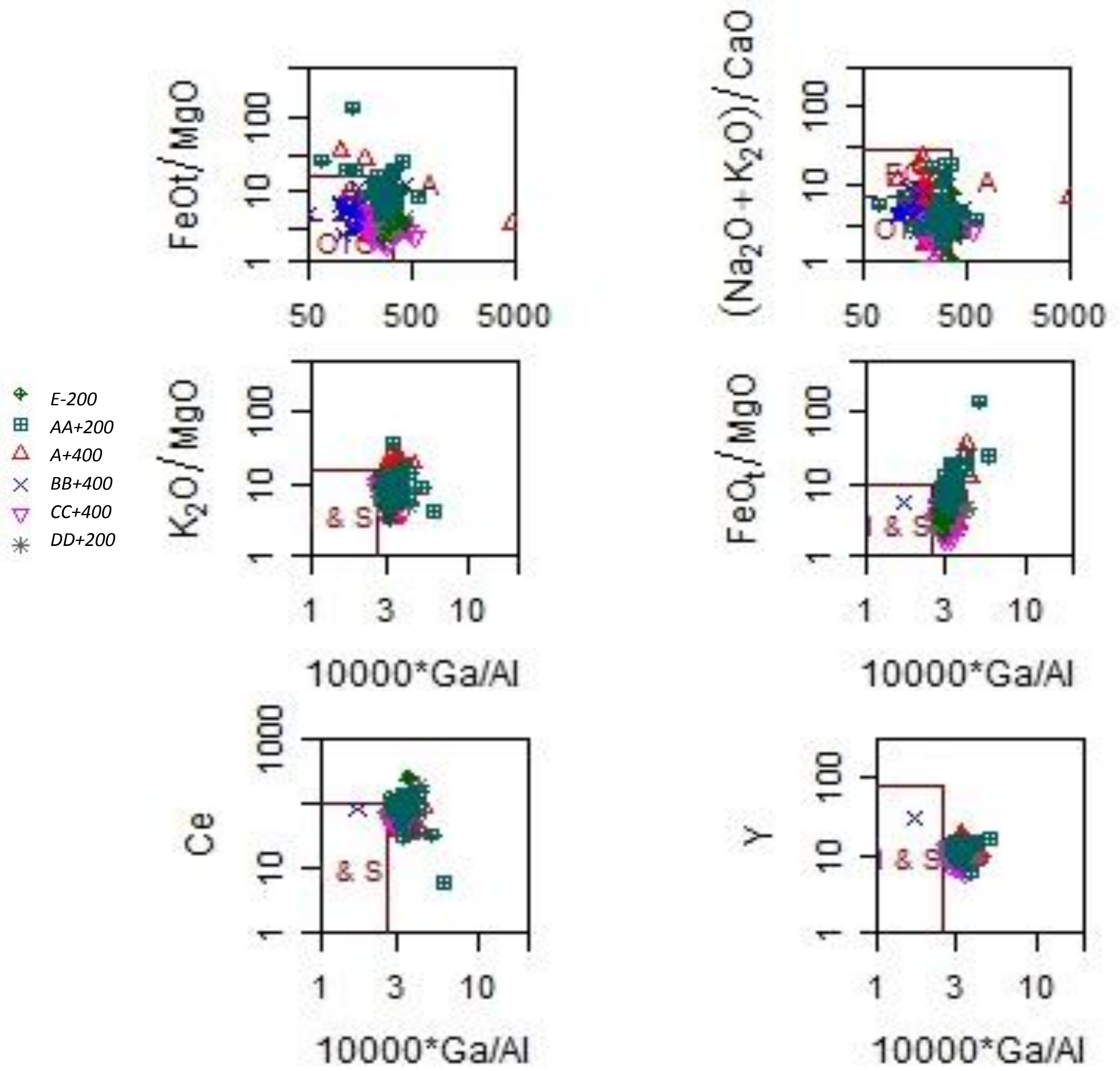


Figure 5.3 continued. The NMZ suggests a differentiated A-type nature that has been observed at depth in the pluton. Major element oxides such as FeO, MgO and CaO at depth are not suitable for discrimination. Ce and Y could not be used in the MZ as discriminants; however in the NMZ they display more accurate and possibly useful results. This is due to more normal concentrations of REE in the NMZ with which Ce and Y are associated.

All of the data below, even major elements such as Na_2O and K_2O display more accurate results. Therefore the pluton is speculated as having a later A-type nature (possibly the last AMG phase) as is illustrated by more pristine data in the NMZ.

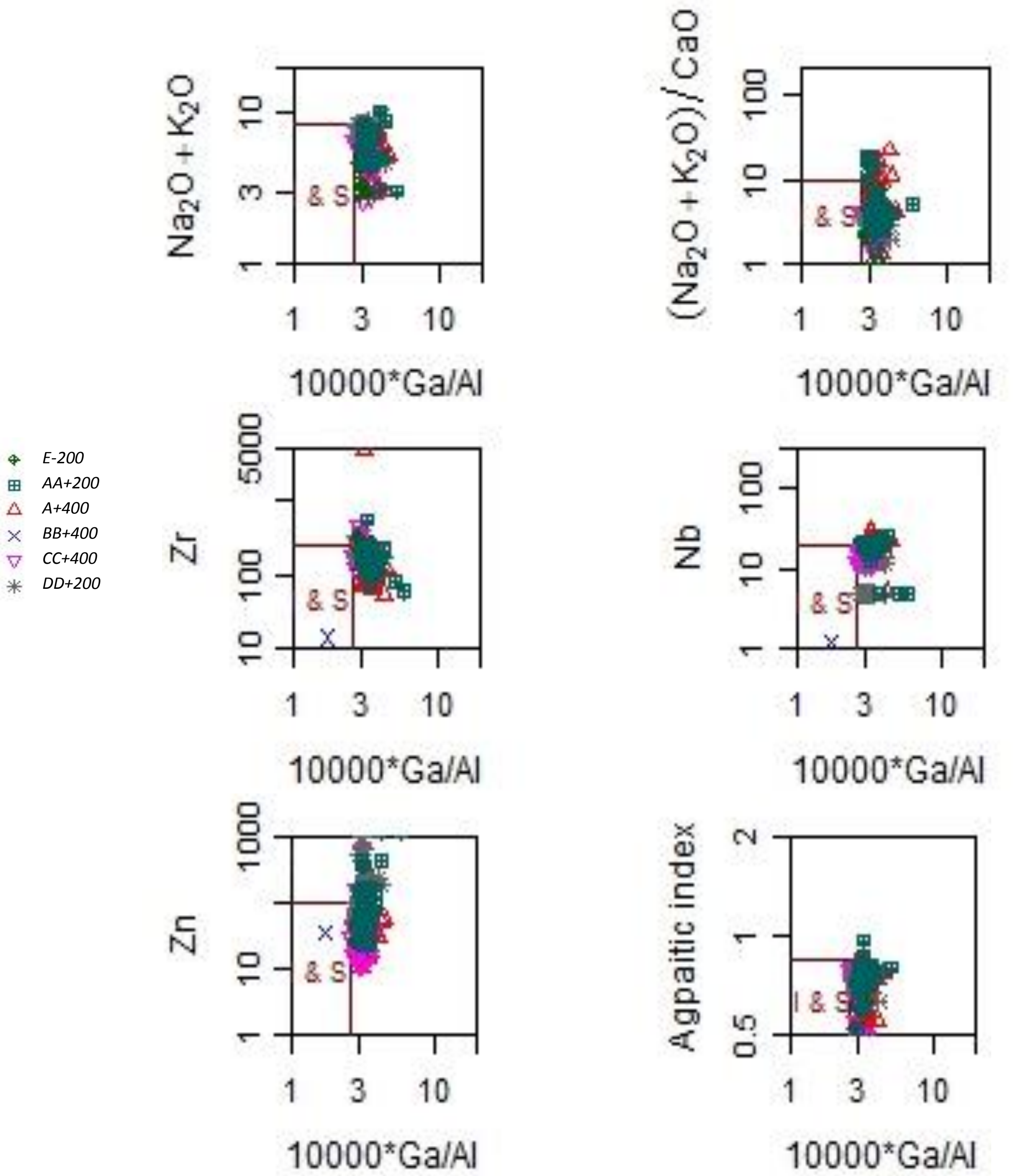


Figure 5.3 continued. The less altered data in the NMZ strongly suggest a late anorogenic A-type nature of the pluton. Major elements such as Na_2O and K_2O are also more useful in the NMZ as geologic discriminants.

5.2 Alteration

The entire Riviera pluton is affected by superimposed pervasive hydrothermal alteration, although the intensity of alteration varies locally. In the Riviera pluton, potassic alteration overprints phyllic alteration (section 4.2.3, Figure 4.1). Where this overprint occurs, enrichment is present in close proximity. Various classification diagrams below (Figure 5.4, 5.5) illustrate the effect and extent of hydrothermal alteration on the host rock.

In Figure 5.4 it is clear the extent of alteration is greater and more widespread in the MZ. Lower temperature alteration prevails in the NMZ such as phyllic and argillic alteration. These types of alteration are associated with the leaching of bases (K and Na) and Ca, and therefore explain the resultant high value of SiO_2 (refer to Figure 5.1). The MZ shows more potassic alteration and silicification than the NMZ, which has been observed mineralogically. Some samples in the MZ display less potassic alteration than the NMZ.

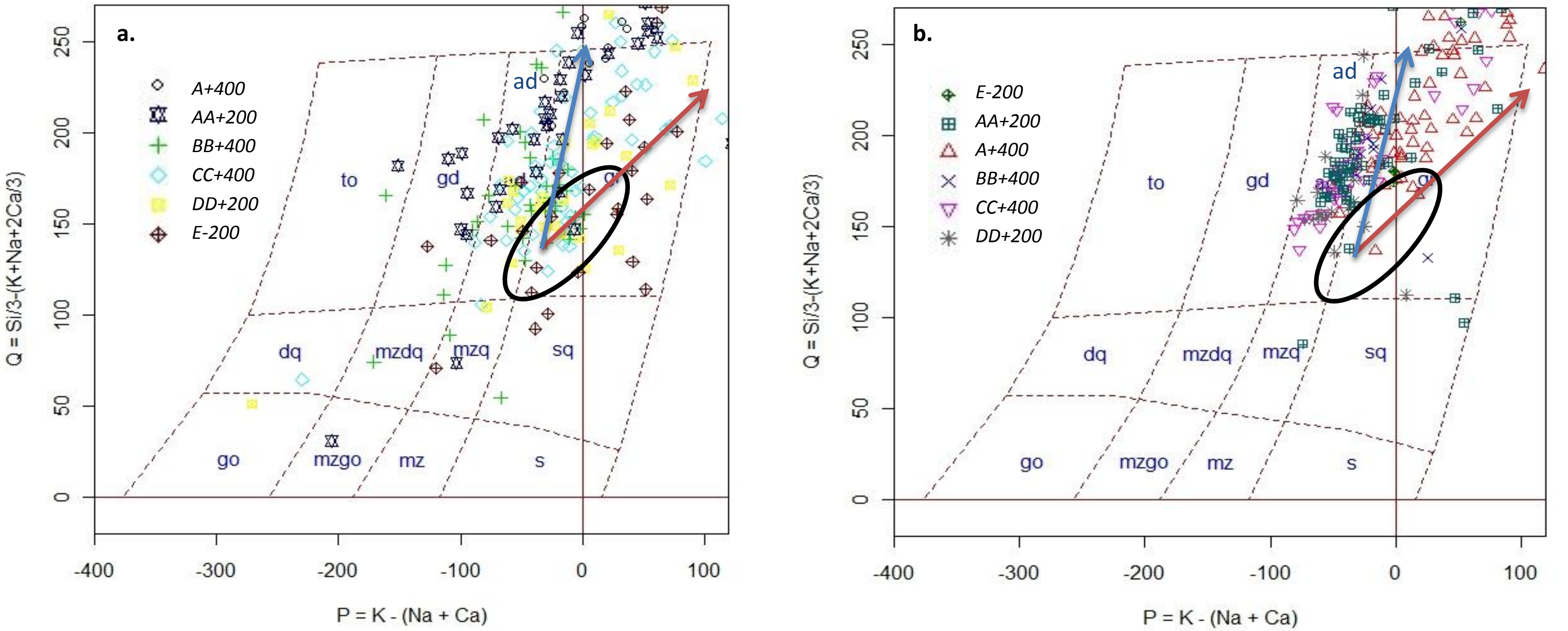


Figure 5.4. De Bon & Le Fort (1983) diagrams of a) the MZ and b) the NMZ. The ellipses indicate where the original host rock would have plotted; in the granite to monzogranite field. Extensive silicification (blue arrow) and potassic alteration (red arrow) altered the original composition of the host rock substantially. (go = gabbro, diorite, anorthosite, mzgo = monzogabbro, monzodiorite, mz = monzonite, s = syenite, dq = quartz diorite, quartz gabbro, quartz anorthosite, mzdq = quartz monzodiorite, quartz monzogabbro, mzq = quartz monzonite, sq = quartz syenite, to = tonalite, trondhjemite, gd = granodiorite, granogabbro, ad = adamellite, gr = granite).

The diagrams below (Figure 5.5) also illustrate the diversity and extent of hydrothermal alteration. Very few MZ samples (compared to the total number) are close to the original composition of the rock (indicated by a black ellipse), although the less altered samples in the NMZ plot in the ellipse. The extent of lower temperature alteration (phyllic, argillic and advanced argillic) is more common in the NMZ. Significant leaching of bases (K and Na) and Ca caused a relative increase in Al_2O_3 leading to a more peraluminous composition in the NMZ. The MZ display a larger extent of potassic alteration than the NMZ. Mineralogically this has been documented by fine-grained secondary alkali feldspar in the MZ, as well as secondary alkali feldspar rims around altered plagioclase grains.

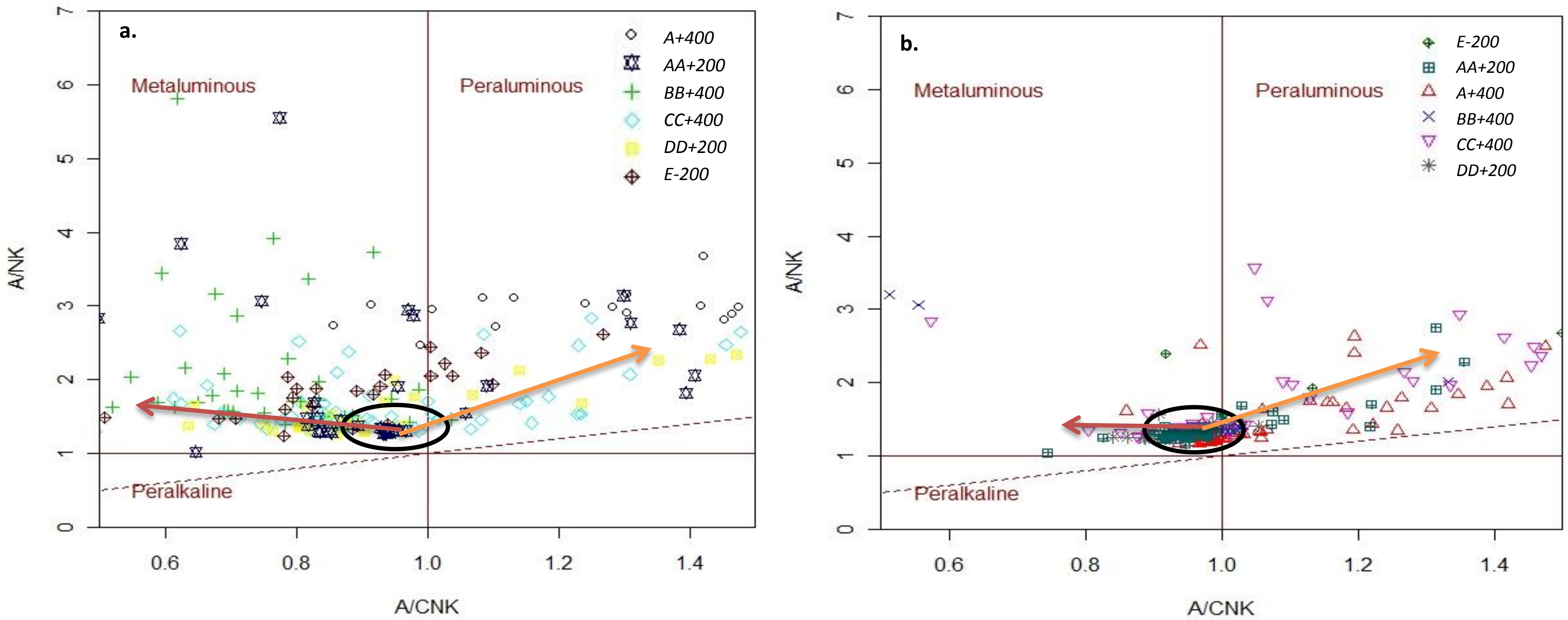


Figure 5.5. Shand's (1943) index of a) the MZ and b) the NMZ. This index is used to discriminate between metaluminous, peraluminous and peralkaline compositions. The original host rock is metaluminous to slightly peraluminous as indicated by the black ellipse (Rozendaal & Boshoff, 2011; Chemale et al, 2011; Scheepers, 1995). The red arrow represents the extent of potassic alteration, whereas the orange arrow represents phyllic, argillic and advanced argillic alteration. The less altered samples in the NMZ are situated within the black circle. A/NK = $Al_2O_3/(Na_2O+K_2O)$, A/CNK = $Al_2O_3/(CaO+Na_2O+K_2O)$.

The following diagram (Figure 5.6) illustrates a clear divergence in the direction of the Al_2O_3 and K_2O end-members from an original monzogranite composition (represented by the black ellipse). This hydrothermal alteration trend towards more clay-rich samples (kaolinite in this case) is the extreme case, but significant sericitization, potassic alteration and albitization also occur. Potassic alteration is evident in samples that display compositions closer to alkali feldspar (indicated by the red dot). A few sericitized samples tend towards the potassic composition indicating that there was an overprint of alteration which has been observed mineralogically. Albitization is also present, although to a lesser extent and is illustrated by samples from borehole intersections CC+400 and AA+200 that plot closer to the CaO and Na_2O end-member. Albitization was recorded in these borehole intersections (section 4.2.3). A few samples are almost completely devoid of any sodic-calcic end-members which illustrates advanced argillic alteration, as is the case in this borehole intersection A+400 (open circles).

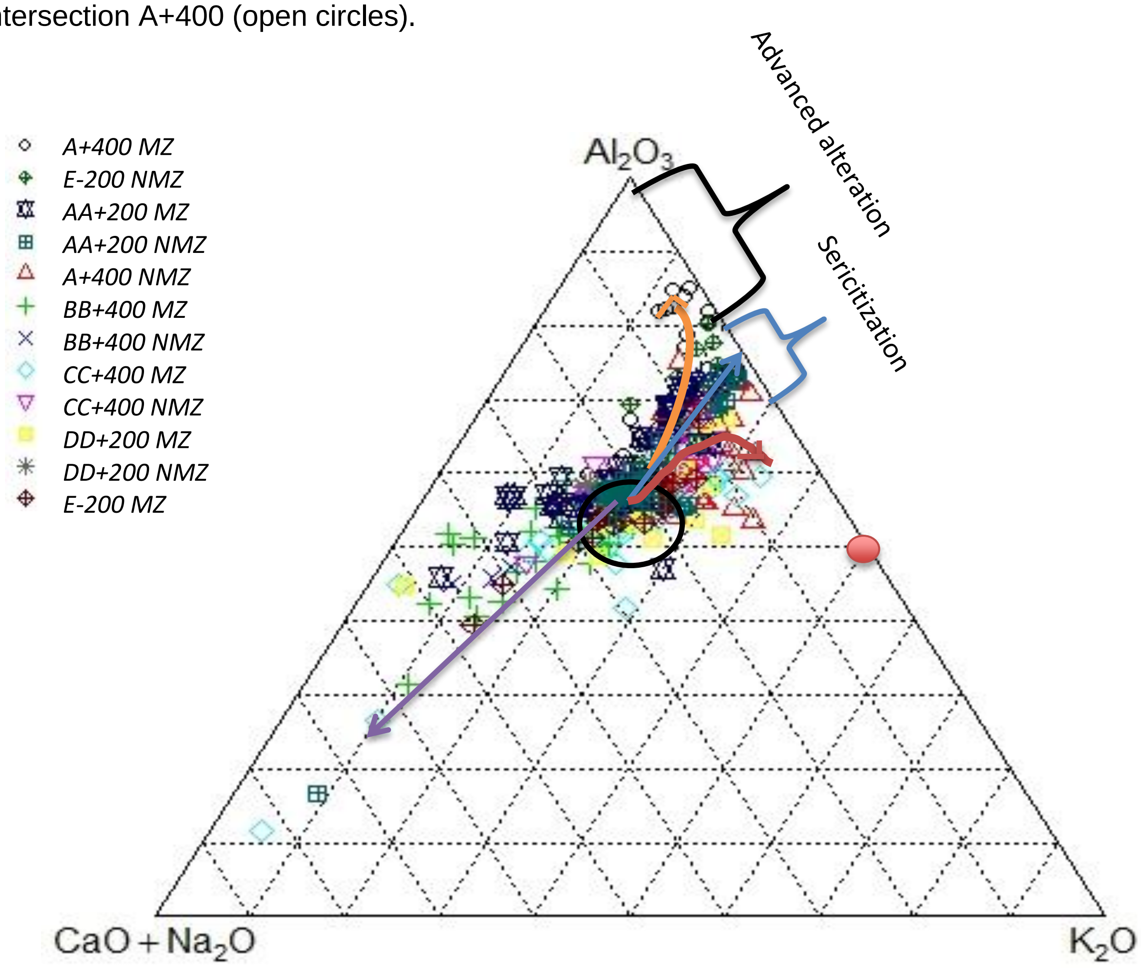


Figure 5.6. Ternary diagram depicting sericitization (blue arrow), advanced argillic alteration (orange arrow), potassic alteration (red arrow) and albitization (purple arrow) plus skarnification (n=497). This diagram represent the data from both the MZ and NMZ (Modified after Nesbitt & Young, 1984;1989). The black ellipse indicates the composition of an average monzogranite, and the red dot indicates the composition of alkali feldspar.

CIPW normative values of the geochemical data have been used to plot the ternary diagram below (Figure 5.7). Significant sericitization has occurred as observed by feldspars and biotite being replaced by sericite or muscovite in this case during the process of hydrothermal alteration. This indicates a loss of calcium and sodium and a gain in potassium, as well as the release of silica. A strong trend of silicification is evident which could be the result of either the deposition of cryptocrystalline quartz and/or the result of the leaching of the basic end-members (CaO, Na_2O and K_2O) and a resultant relative increase in silica. Samples that are 100% quartz are considered to be vein quartz, which has been observed in thin-section.

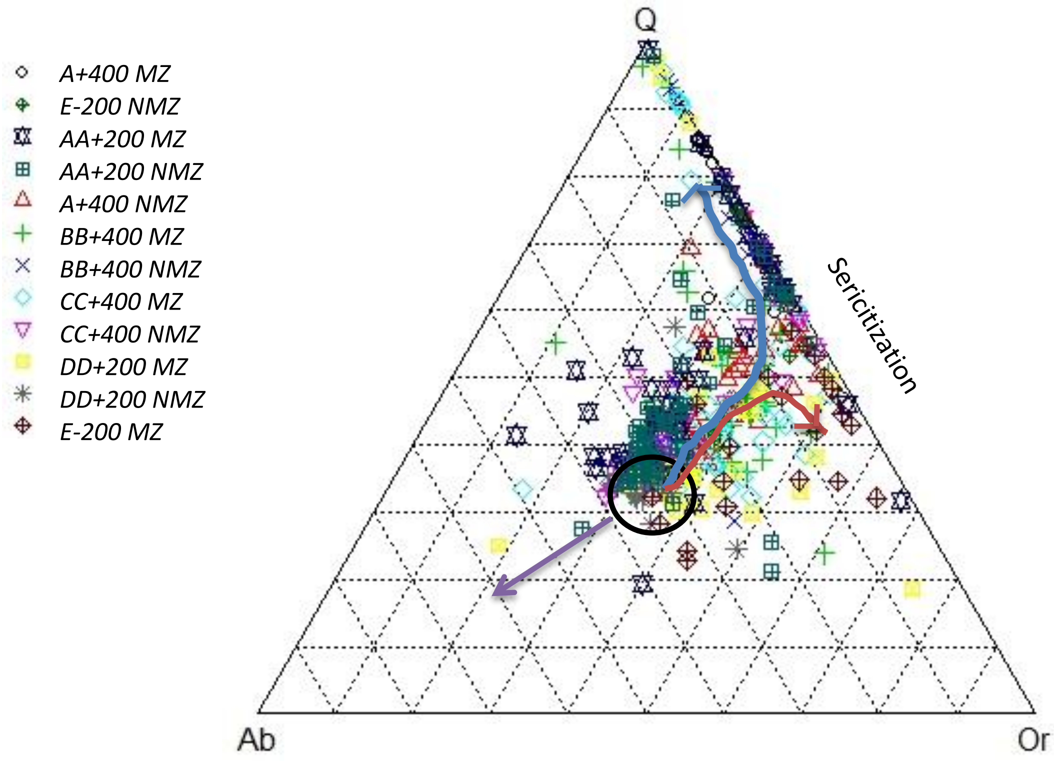


Figure 5.7. Ternary diagram depicting sericitization, potassic alteration (red arrow), silicification (blue arrow) and albitization (purple arrow). This diagram represent the data from the MZ and NMZ (Modified after Nesbitt & Young, 1984;1989). The black ellipse indicates the composition of an average monzogranite. Normative values of quartz, albite and orthoclase were used (n=497).

The Alteration Index for all borehole intersections plotted against depth is shown below (Figure 5.8). The AL of unaltered granite is between the two black lines. The boreholes displaying the highest degree of alteration (>80) are A+400 (MZ and NMZ), BB+400 (NMZ) and E-200 (NMZ). This makes sense as A+400 is characterized by argillic alteration, whereas the AL of the MZ of BB+400 is much lower than the NMZ which illustrates the presence of skarn or skarnified granite closer to the roof of the pluton. The same goes for borehole intersection E-200 with the AL of the MZ being lower than that of the NMZ. The NMZ of BB+400 and E-200 is characterized by alteration from phyllic to advanced argillic in some places. No skarn or skarnified granite samples have been documented in any of the other borehole intersections on this diagram, except AA+200, which displays a similar trend as BB+400 and E-200.

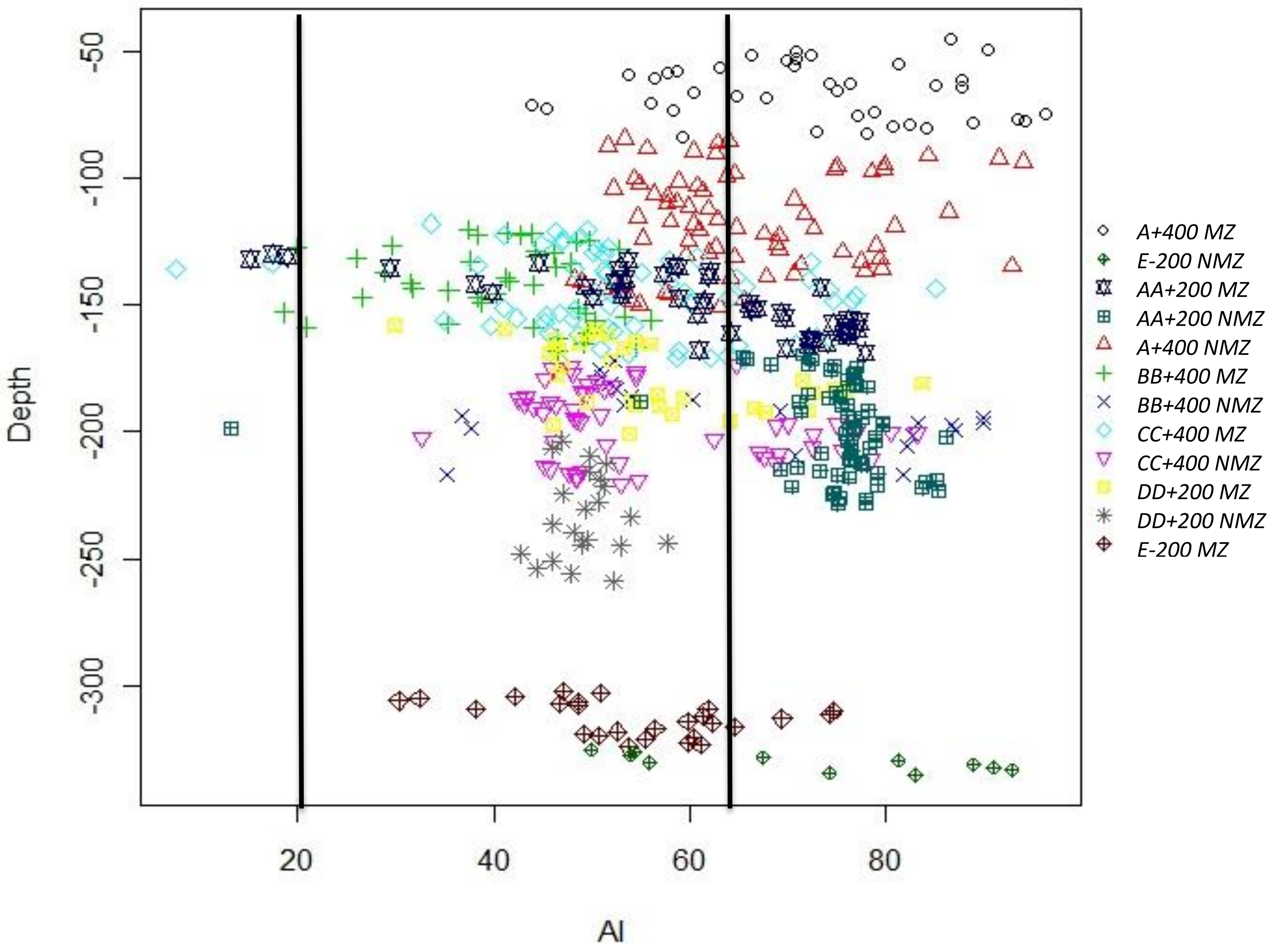


Figure 5.8. Alteration index (AL) plotted against depth in meters below surface (n=497). The boreholes displaying the highest degree of alteration (>80) are A+400 (MZ and NMZ), BB+400 (NMZ) and E-200 (NMZ).

$$AL = \frac{100(K_2O + Na_2O)}{(K_2O + Na_2O + MgO + CaO)}$$

The AL is limited in the sense that it cannot give an accurate estimation of where potassic, phyllic and argillic alteration is situated respectively. The AL however gives an indication of where the skarn zone is situated by showing a lower index (closer to 0%). According to Figure 5.8, the skarn samples are situated within the benchmark area for a typical granite which confirms that data from the MZ cannot be used in classification and discrimination, as well as to determine where more unaltered fresh rock is situated with respect to highly altered rocks.

The Alteration Indices were calculated from major element whole-rock data for borehole intersections E-200, A+400, AA+200, BB+400, CC+400 and DD+200 and are displayed spatially in Figure 5.9. Although the AI varies significantly throughout depth from the granite wall-rock contact, borehole intersections that display extensive lower intensity alteration (e.g. A+400 and AA+200) have higher Alteration Indices (red), whereas borehole intersections with which skarn is associated display lower indices (e.g BB+400). In most cases it seems that the higher the AL, the lower down with respect to depth from the granite wall-rock contact it is. This is true at least for all the enriched borehole intersections. Given the usefulness of the AL in determining where skarn is situated, this diagram confirms that skarn is mostly in the granite cupola of the pluton, with lower intensity forms of alteration (like phyllic alteration) prominent at greater depths.

a.

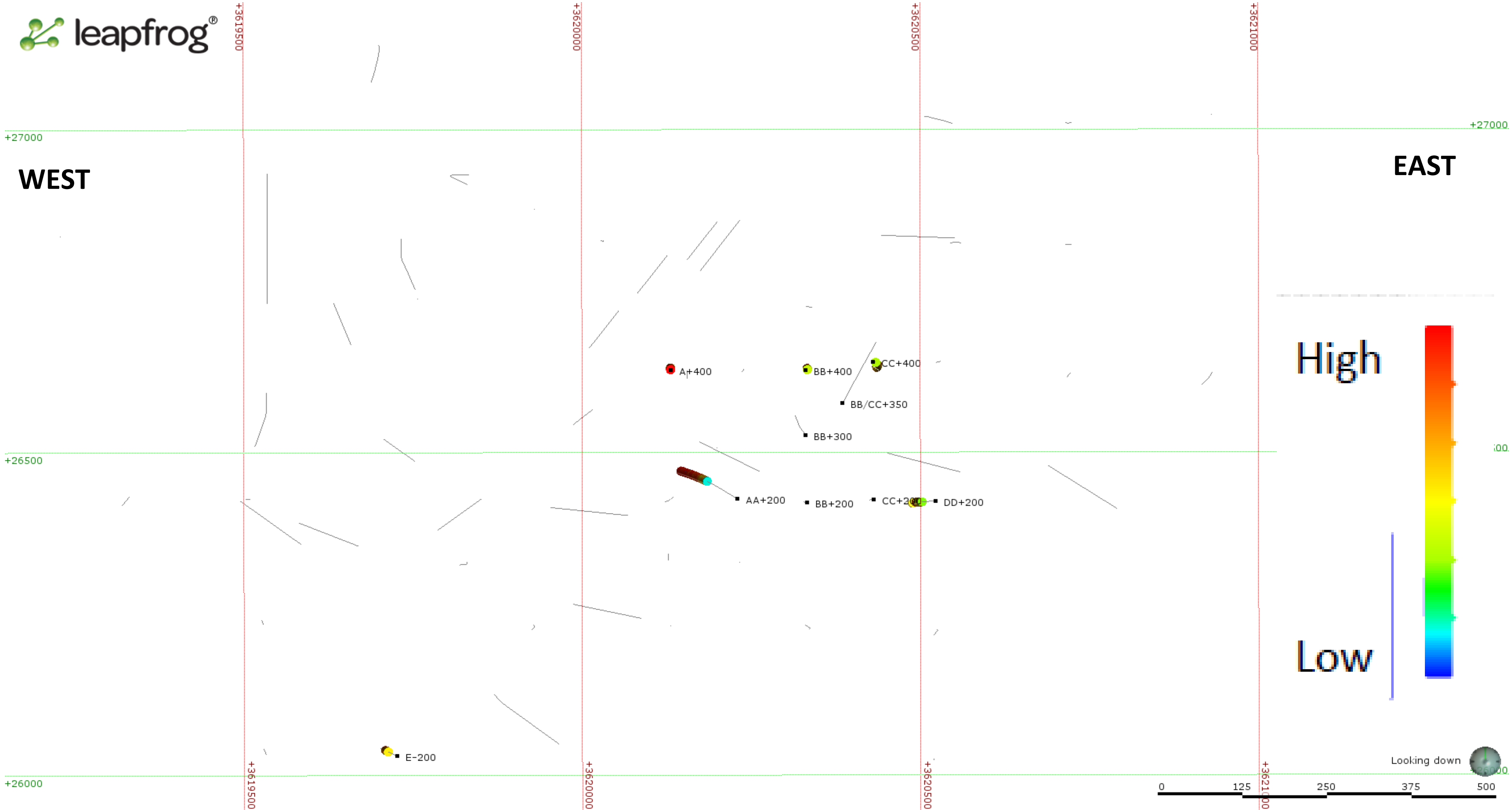


Figure 5.9. These two images display the borehole intersections that were used to calculate the AI as well as the AL down each borehole. Red indicates a high Ai index (>65) whereas blue represents a low index (<30). a) displays the boreholes in plan view.

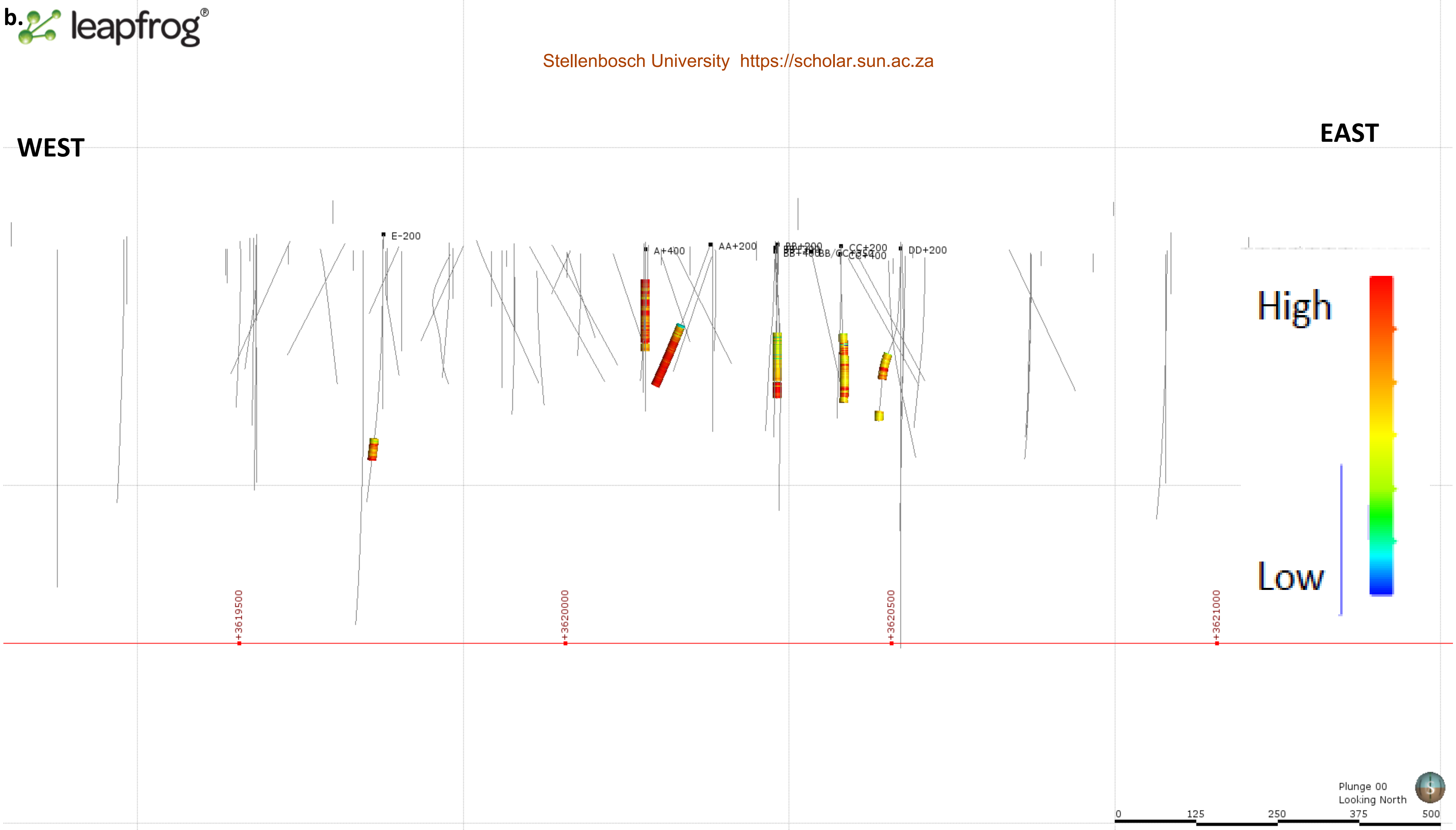


Figure 5.9 continued. b) Looking north with zero plunge. Higher alteration indices are observed mostly at depth from the granite wall-rock contact in the pluton. This illustrates that skarn (yellow-green) is mainly in the cupola of the granite closer to the granite-wall rock contact. A high number is close to 100% and is almost unaltered in terms of skarn.

There appears to be a link between the AL and the degree of enrichment (Figure 5.10). The lower the AL, the greater the chance that enrichment will be present. Enrichment is associated mainly with the skarn zone. Borehole BB+400 (green crosses) is considered part of the high grade W zone and show elevated concentrations of W and LREE at lower alteration indices. This indicates that enrichment is associated with higher intensity alteration (low AL) rather than lower intensity alteration (high AL). A few samples of the various borehole intersections in the MZ displayed below have shown a weak correlation with the AI. Higher values of W and REE are associated with lower AL values and confirm the association of W and REE enrichment with skarn. Mo appears to be independent of this process as no correlation is observed.

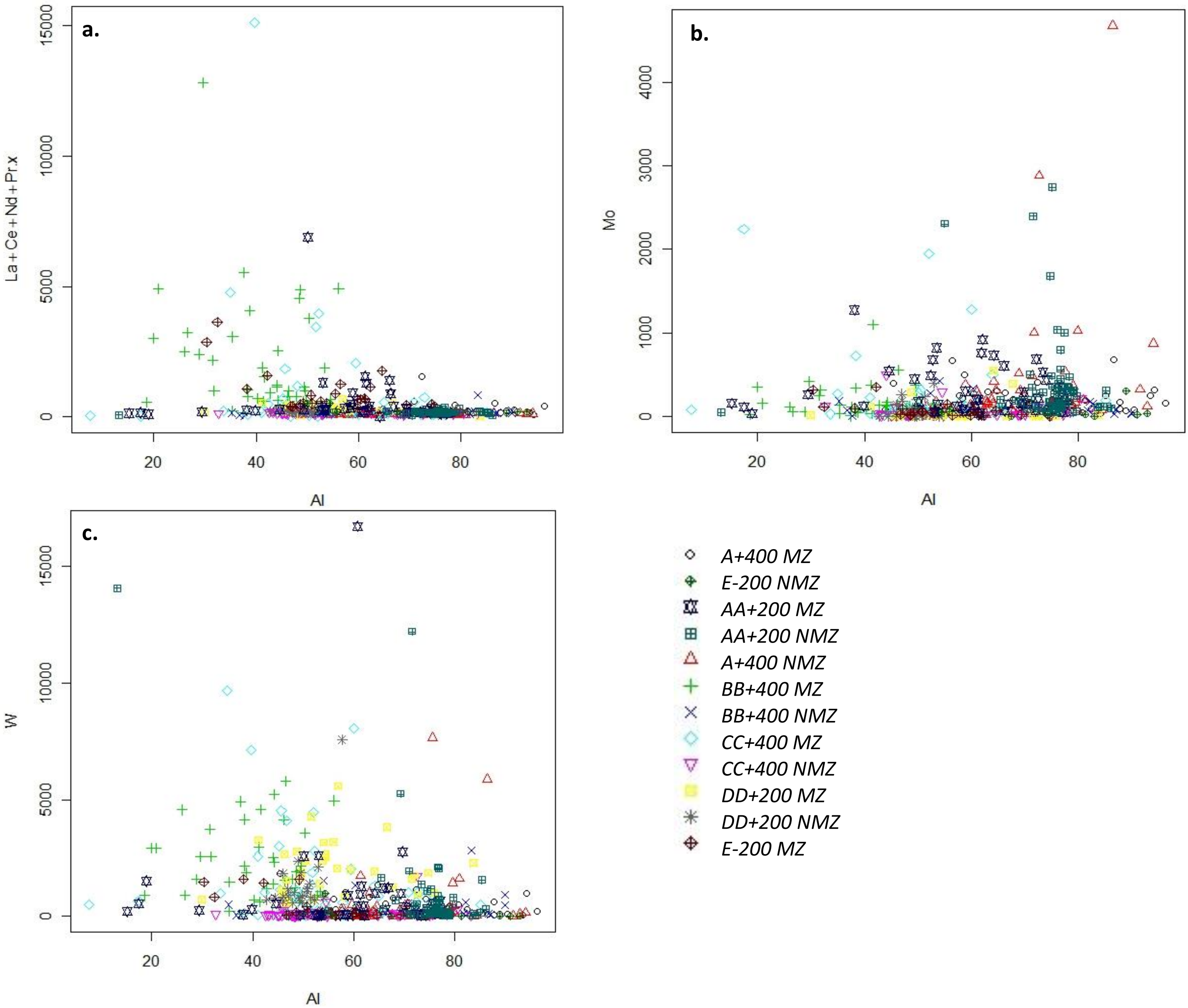


Figure 5.10. Alteration index for all borehole intersections versus a) LREE (ppm), b) Mo (ppm) and c) W (ppm) (n=497). Although there is no strong link to enrichment in general; some borehole intersections (like BB+400 representing the high grade W zone) display elevated W and LREE concentrations the lower the AL is indicating that the significant enrichment is associated skarn. Mo shows no correlation with the AL.

5.3 Vertical distribution of various elements down-the-hole

The vertical distribution diagrams in this section illustrate, as an example, the characteristic trends of some of the major, trace and other elements from the granite wall-rock contact of the boreholes analysed. The profiles of the following elements are displayed: Si, K, Ca, Na, Fe, Mg, Mn, P, Ti, Al, Ba, Sr, Y, Rb, Nb, W, TREE and S. These plots determined where the boundary between the MZ and NMZ is situated within each borehole intersection. A full database of vertical distribution plots can be viewed in the appendix. These trends will also be explained in the MZ and NMZ sections. All average granite (background) values for elements used are from Turekian & Wedepohl (1961).

Si (Figure 5.11.a) remains relatively constant throughout depth and is close to the average Si amount for a typical granite which is 32.3%. In some cases Si is enriched which is due to silicification. The slight increase of Si in the NMZ of E-200 is due to an increase in quartz as this is outside of the skarn zone towards more pristine rock.

a.

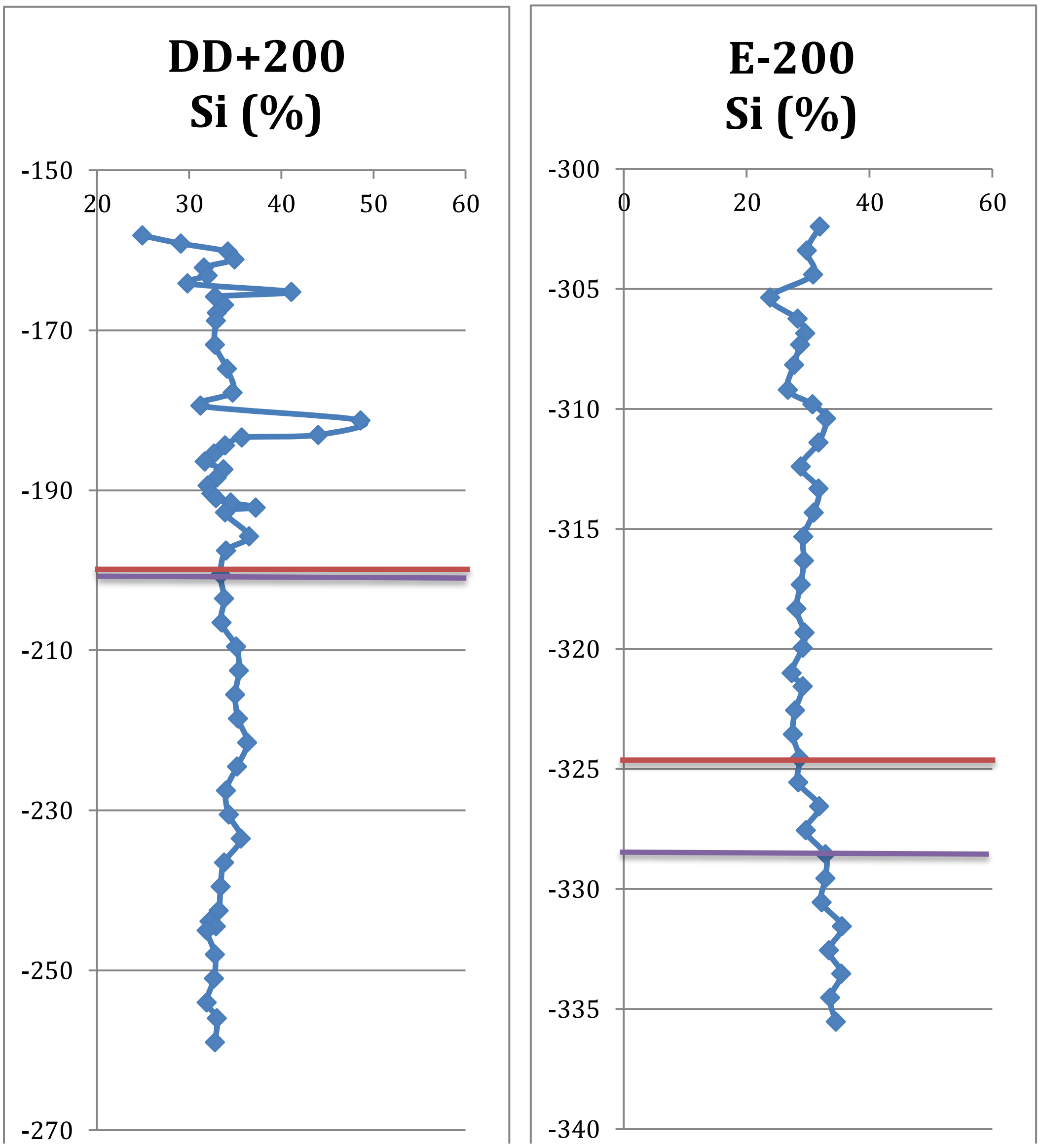


Figure 5.11. Vertical distribution down-the-hole plots from various borehole intersections display the characteristic features of significant elements. a) Si remains relatively constant throughout the depth of the pluton. Silicification could be the cause of some spikes that are enriched in silica. In borehole intersection E-200, the slight increase in Si in the NMZ could be due to an increase in quartz outside of the skarn or MZ. The red line represents the contact between the MZ and the NMZ. The purple line represents the contact between the QPMG and BMG. Only individual elements were used to plot these diagrams as opposed to oxides.

The K concentration down-the-hole in most boreholes is highly variable on a small scale (Figure 5.11.b), but decreases with respect to depth in general. Closer to the granite-wall rock contact, potassic alteration is common which is a significant source of K. In borehole E-200 however, K decreases slightly closer to the granite-wall rock contact. This is due to a lack of potassic alteration products in this borehole, although there is a peak in K that is still evident in the MZ and is a product of K-metasomatism. The average concentration of K in a granite is 3.34 %. Most of the samples below are enriched in K, especially in the MZ which is evidence for K-metasomatism.

b.

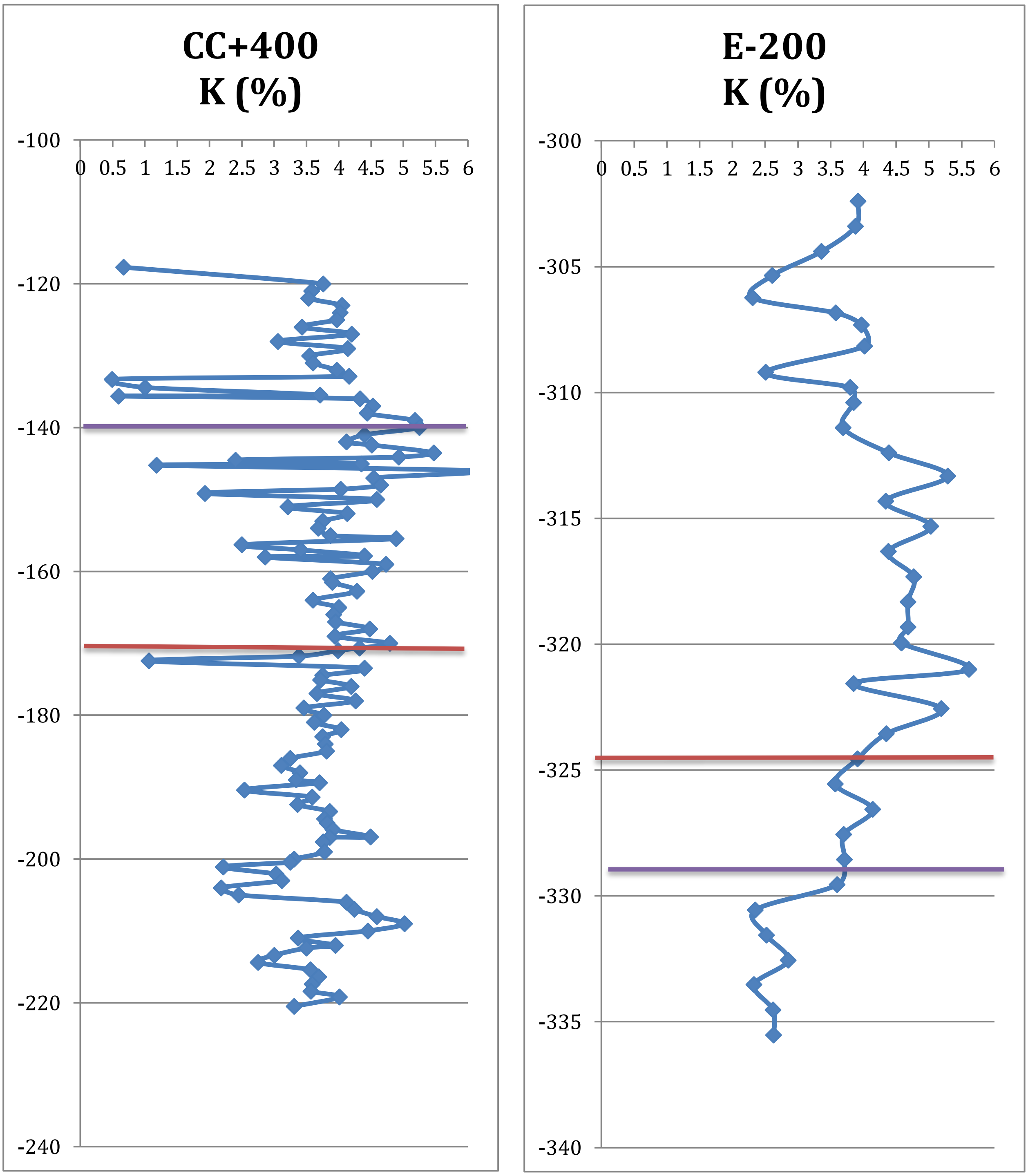


Figure 5.11 continued. b) Although the pattern seems highly irregular, K generally decreases with respect to depth. In the MZ, higher values of K are attributed to potassic alteration (K-metasomatism) which is found mostly close to the granite wall-rock contact. Most of the samples above are above the average value of K in a granite (3.34%), especially in the MZ, which confirms the presence of K-metasomatism. Note that in borehole CC+400 the MZ extends into the BMG.

Ca increases significantly closer to the granite wall-rock contact (Figure 5.11.c) as a result of the increase of skarn minerals and carbonates. This has also been observed mineralogically. The average concentration of Ca in a normal granite is 1.58%. In the MZ, some samples show a concentration of up to 6.5% Ca. This is far above the norm and illustrates that a significant amount of Ca was introduced in the MZ.

Na generally displays an increase with respect to depth (Figure 5.11.d and e), except in borehole E-200. This is due to the extent of alteration of primary plagioclase feldspar closer to the granite-wall rock contact and the effect of albitization. Less altered primary plagioclase feldspar is more albitic (An_{15-33}) than altered plagioclase (An_{0-50}). Albitic rims (An_{15-20}) (effect of Na-metasomatism) are also found outside the skarn zone in the NMZ which is also a contributing factor. All samples for Na plot below the average concentration of Na in granites (2.77%) which illustrates that Na has been significantly mobilized in this pluton and is therefore depleted.

Fe, Mg and Mn all increase in the MZ relative to the NMZ (Figure 5.11.f, g and h). The background values for them are 2.70% (Fe), 0,56% (Mg) and 0,06% (Mn). Fe is significantly enriched in the MZ as a result of secondary biotite which is part of the potassic alteration process. A few samples show enriched Mg, whereas all the other values are below the background value. Mn also displays enriched concentration in the MZ. These elements are all associated with the skarn zone which is in the MZ and therefore explains their enriched concentrations.

P remains relatively constant throughout the MZ and NMZ (Figure 5.11.i), although a slight increase in the MZ is observed. The NMZ seems to be depleted in P relative to the background value of 0.07%. Some P samples in the MZ show enriched concentrations, however most samples in the MZ plot close to the background value.

In terms of Ti (Figure 5.11.j and k), it also increases in the MZ relative to the NMZ. For the most part all samples of Ti plot below the background value (0.23%) except for a few individual samples in the MZ that displays enriched concentrations. Only one borehole intersection (BB+400) displays enriched concentrations of Ti.

Aluminium (Al) remains relatively constant throughout the MZ and NMZ (Figure 5.11.l) and close to the background value of 7.7%. A few samples show Al is depleted, however they are deemed outliers.

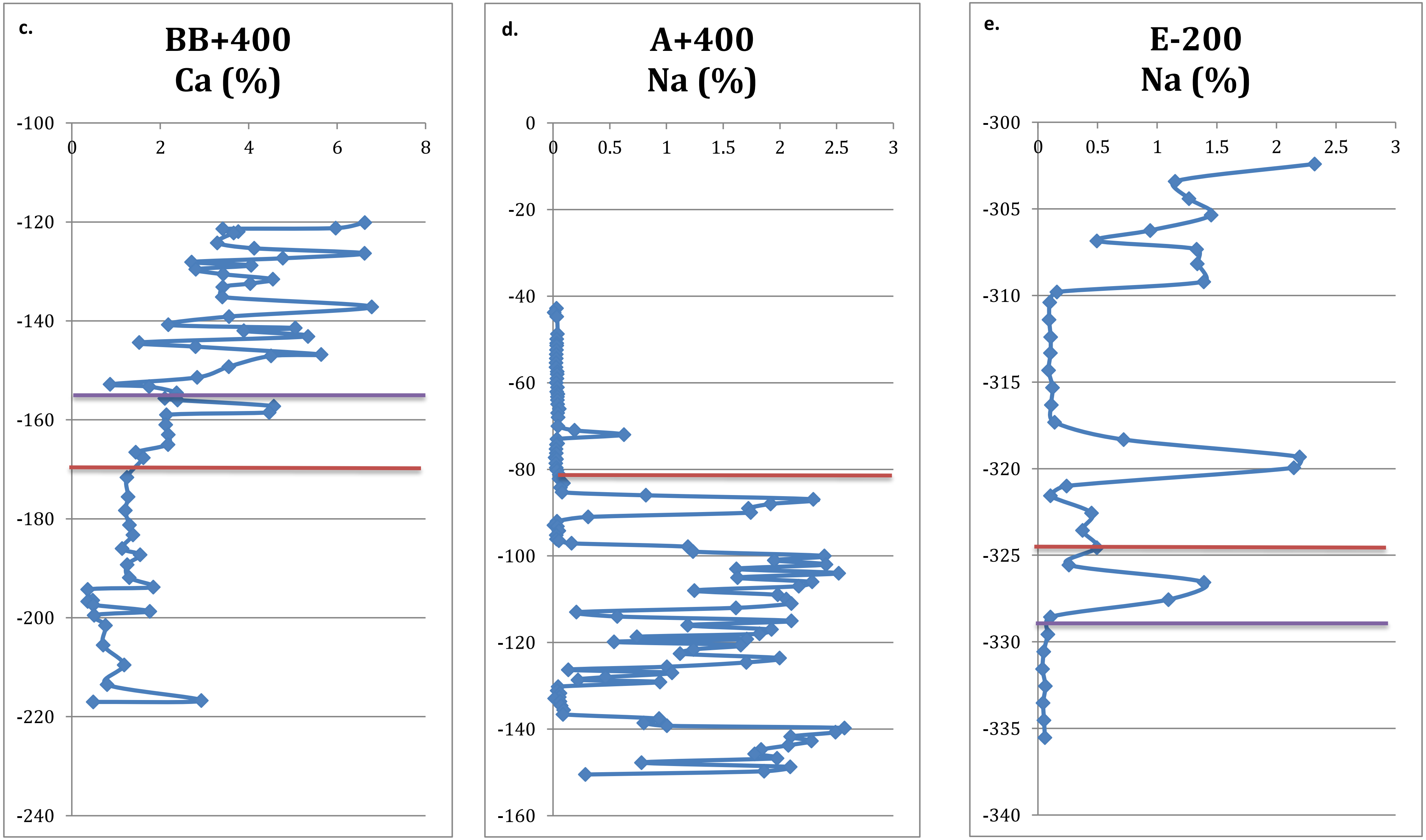


Figure 5.11 continued. c) Ca shows elevated concentrations in all borehole intersections examined mainly as a result of skarn minerals and carboantes in the MZ. Ca is significantly enriched in the MZ. d and e) Na displays lower concentrations closer to the granite-wall rock contact due to the extreme alteration of primary plagioclase feldspar and the presence of albitization at depth in a few boreholes. All Na samples are depleted with respect to the background value of 2.77%, especially in the MZ. (Borehole A+400 is marked with argillic and advanced argillic alteration which made it difficult to determine where the boundary between the QPMG and BMG is situated).

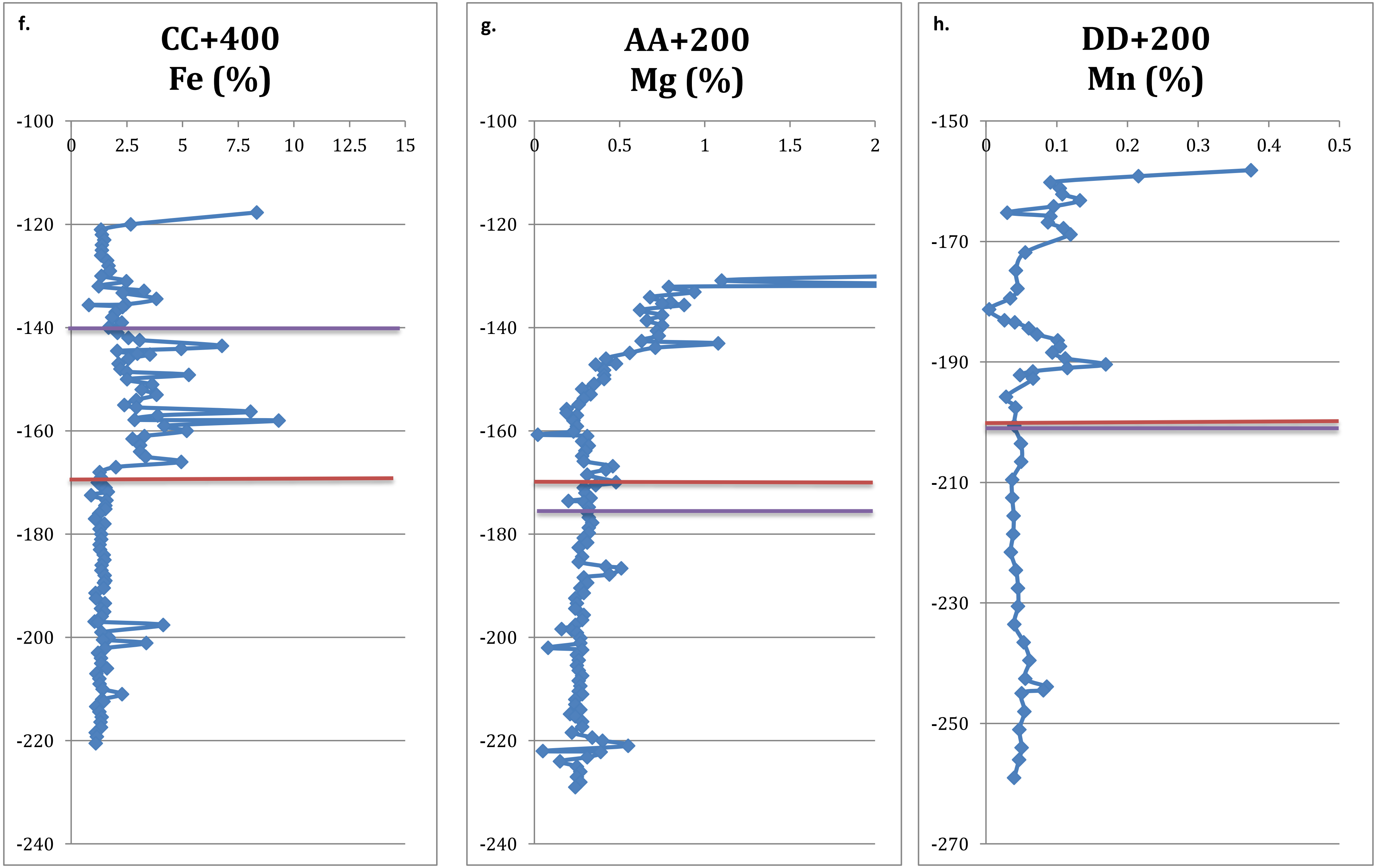


Figure 5.11 continued. f) Fe shows elevated concentrations in the MZ and is enriched in most samples plotted relative to the background value of Fe in granites of 2.70%. g) Mg also display elevated concentrations in the MZ relative to the NMZ. Samples that are closest to the granite wall-rock cupola show enriched concentrations relative to the background value of 0.56%. All other samples towards and in the NMZ are depleted in Mg. h) Enriched concentrations of Mn are also observed in the Mn (background value of 0.06%).

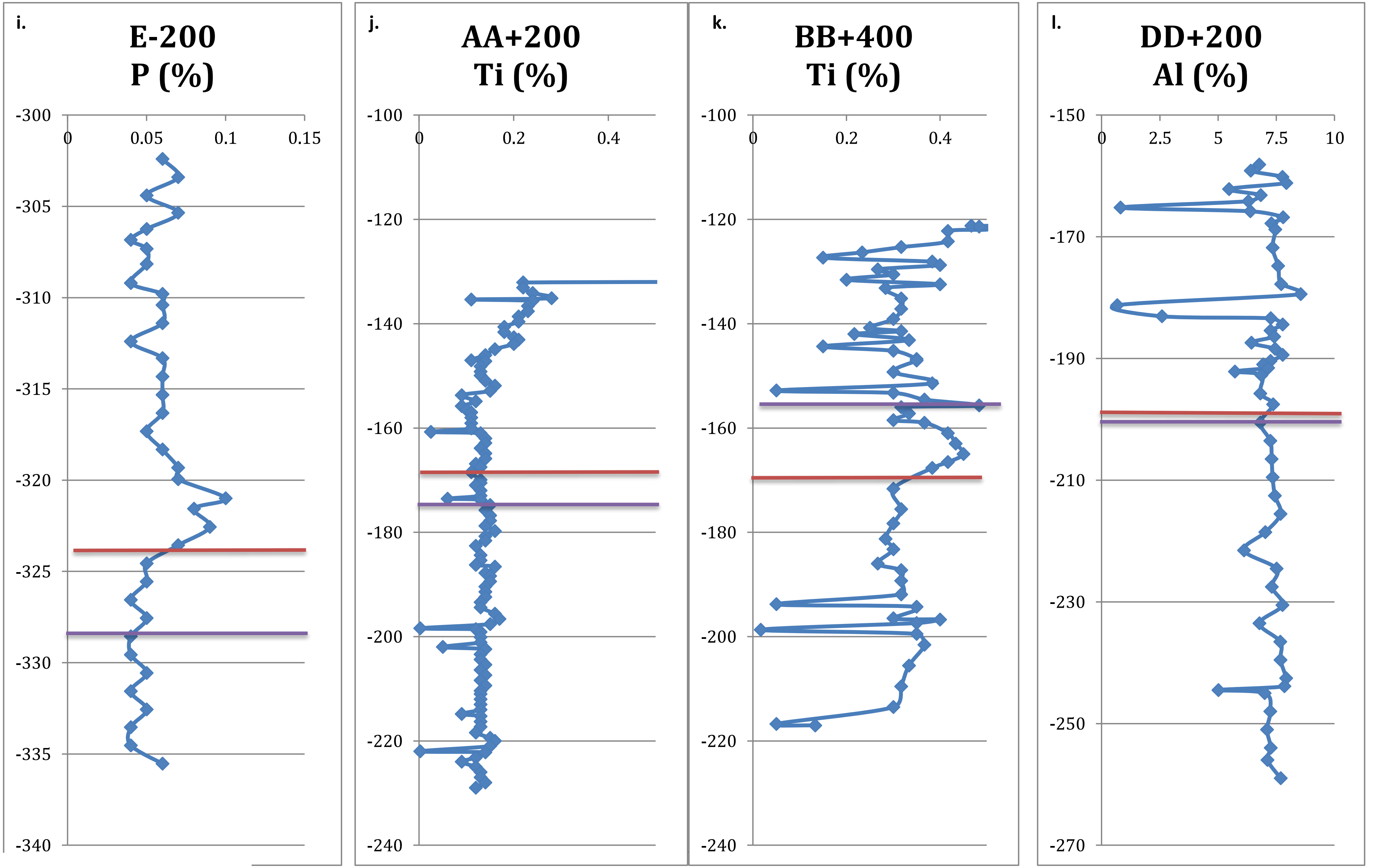


Figure 5.11 continued. i) P remains relatively constant throughout depth from the granite wall-rock contact. A few samples in the MZ show enriched concentrations of P (background value of 0.07%). J and k) Although Ti show elevated concentrations in the MZ with respect to the NMZ, most samples are below the background value of 0,23%. The exception is borehole intersection BB+400, where most samples are above the background. l) Al remain relatively constant with respect to depth and close to the background value of 7.7%, with the exception of a few outliers.

In most borehole intersections Ba displays elevated concentrations close the granite-wall rock contact (Figure 5.11.m and n) and decreases down the borehole. Some boreholes (AA+200 and BB+400) display an increase. Ba is associated mainly with primary alkali feldspar (K1) which is mainly towards and in the BMG and AMG. Ba is also associated with secondary white mica which contain up to 0.7 wt % BaO. The background value for Ba in granitic rocks is 830 ppm. Most of the Ba samples in all boreholes display enriched Ba concentrations which are due to secondary white mica that occurs all over the pluton.

Sr generally decreases with depth (Figure 5.11.o), except in boreholes A+400 and AA+200 where it increases with depth (see appendix). Sr is associated with Ca and therefore will also be associated with skarn minerals carbonates in the MZ. In boreholes A+400 and AA+400, advanced argillic or phyllic alteration is present close to the granite wall-rock contact in these boreholes where there are limited to no skarn minerals with which Sr is associated. The background value for Sr is 300 ppm. Almost all the borehole intersections (except A+400) display enriched Sr values in the MZ and more normal concentrations in the NMZ. This confirms the presence of calcic skarn minerals that are in the MZ close to the roof of the granite cupola.

In all the borehole intersections Y displays a decrease in the NMZ with respect to the MZ (Figure 5.11.p). This is because of Y’s association with REE and therefore allanite which is mainly concentrated in the MZ. The only borehole that shows a slight increase in the NMZ is A+400, although all the Y values are depleted with respect to the background value of 34ppm. For the other borehole intersections, Y values in the MZ are enriched and become depleted towards the NMZ.

Rb displays a lot of small scale variations although in general the trend shows that it either remains relatively constant or decreases slightly towards the NMZ (Figure 5.11.q). Rb is associated with K and will therefore show similar trends which has been observed. In the MZ, enriched concentrations of Rb relative to the background value of 200 ppm are observed. This is due to the abundance of secondary alkali feldspar in the MZ. In the NMZ normal concentrations are observed.

In terms of Nb (Figure 5.11.r) the trend shows a decrease from the MZ to the NMZ. Nb is mostly depleted (background value of 20 ppm), with a few enriched samples in the MZ in borehole intersections BB+400, CC+400 and E-200.

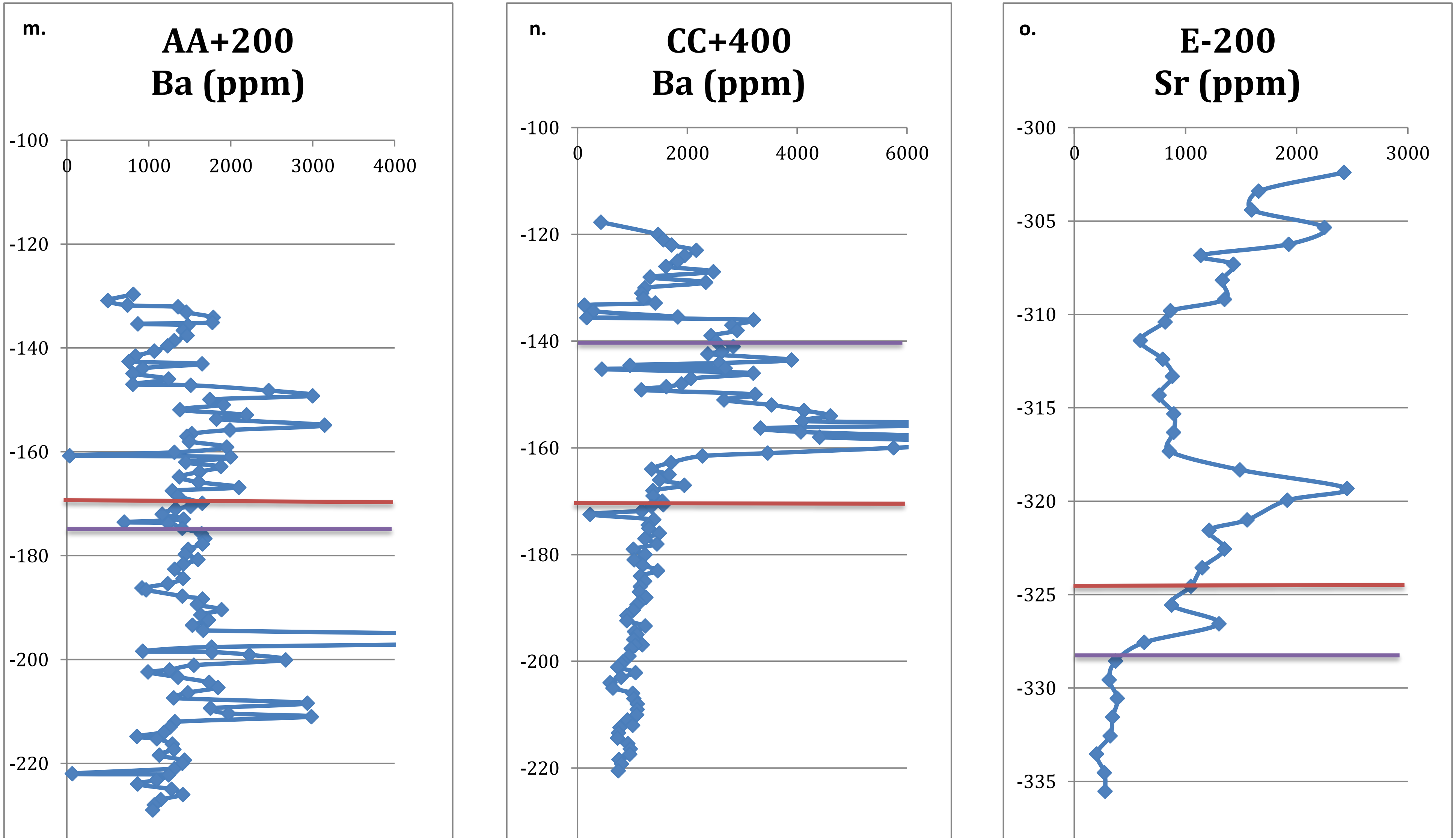


Figure 5.11 continued. m and n) Ba decreases with respect to depth except in borehole AA+200 and BB+400. This is an indication of where enrichment is to be found; where there is negligible or no Ba, enrichment is most likely to be present. o) Sr generally decreases with depth except A+400 and AA+200. This can be explained by less skarn minerals and carbonates in the BMG and AMG.

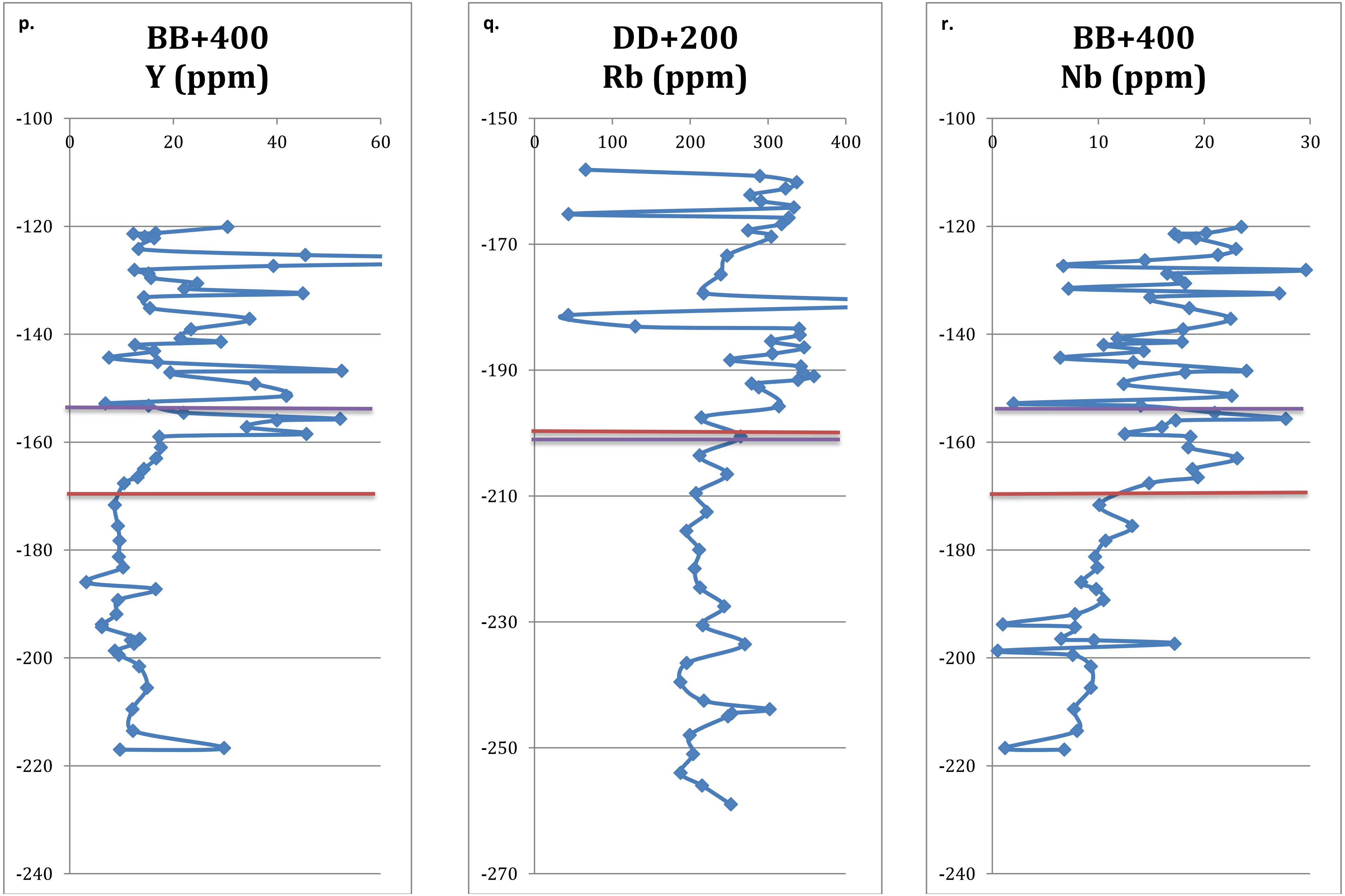


Figure 5.11 continued. p) Y is associated with REE that are mainly hosted by allanite in the MZ. This explains the elevated concentrations of Y in the MZ. q) Rb is associated with K and therefore mainly alkali feldspar and displays a similar trend. Enriched concentrations of Rb are observed in the MZ compared to the 200 ppm background value. r) Although Nb is mostly depleted, it displays an increase in the MZ relative to the NMZ, with a few enriched samples (background value of 20 ppm).

W and REE enrichment is concentrated mainly in the MZ (Figure 5.11.s and t) although smaller local spikes of enrichment may occur in the NMZ. In general W and REE enrichment are not associated spatially (refer to section 5.4.1), although some overlap may occur in some cases. The background value for W is 1.5 ppm which indicates that extremely enriched concentrations of W are associated with the Riviera pluton. REE's background value in a typical granite is 251.3 ppm. Enriched concentrations of REE are observed in the MZ, although local spikes in enrichment can occur in the NMZ.

S concentrations increase in the MZ with respect to the NMZ (Figure 5.11.u) in most cases or remain relatively constant in some borehole intersections (such as A+400). The background value for S in a typical granite is 0.04 % S. S is therefore enriched in the Riviera pluton in both the MZ and the NMZ.

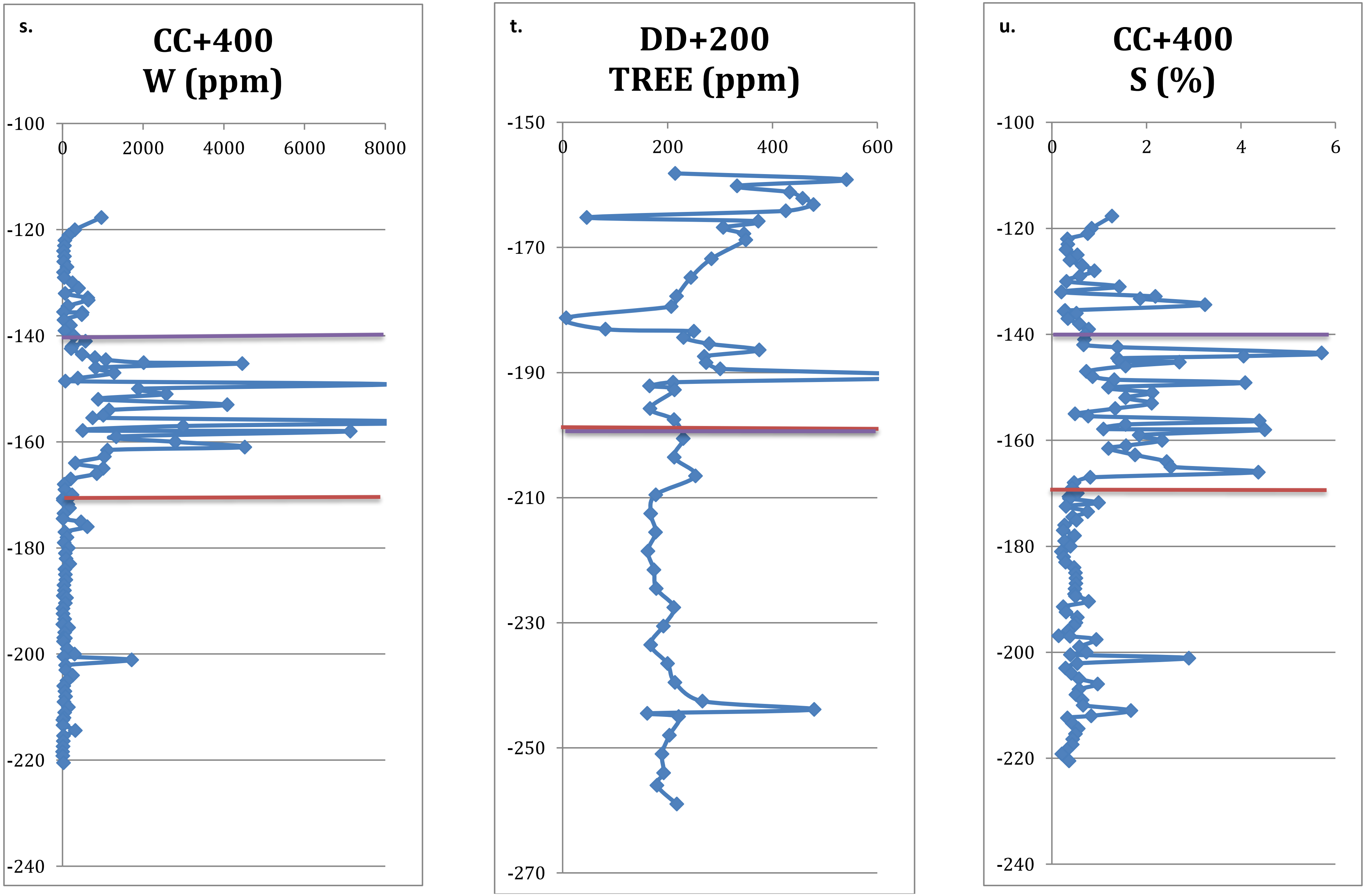


Figure 5.11 continued. s) W is mainly concentrated in the MZ and associated with the skarn. Sporadic occurences of W in the mineral scheelite can occur outside the MZ. W concentrations in the Riviera pluton is far above the background value of 1.5 ppm which indicates a significant deposit of W. t) REE are also mainly concentrated in the MZ in the mineral allanite. W and REE do not correlate well, but some overlap may occur in some boreholes. u) S generally decreases with depth and is enriched with respect to the background value in all borehole intersections.

5.4 Mineralized zone

The mineralized zone (MZ) represents the hydrothermally most altered zone and contains the bulk of enrichment. This zone is located primarily within the QPMG (Figure 4.19), but can extend into the BMG in some borehole intersections. The bulk of the MZ occurs within 160 m of the roof of the granite cupola, although enrichment, especially allanite and scheelite, can occur sporadically as narrow patchy skarnified granite zones throughout the deposit at depth below the MZ.

Mineralogically the MZ contains primary, but altered plagioclase feldspar, more secondary alkali feldspar compared to primary alkali feldspar, as well as quartz phenocrysts and finer-grained cryptocrystalline quartz. Carbonates are more prominent in this zone than in the NMZ. Economic minerals include scheelite, molybdenite, chalcopyrite, allanite and sphalerite. Pyrite and pyrrhotite are always present. Minor concentrations of titanite, chlorite, epidote, albite, fluorite and apatite are apparent.

According to the vertical distribution plots (section 5.3) this zone is characterized by a substantial increase in the economic elements REE (especially LREE including La, Ce, Pr and Nd), W and Cu, whereas Zn, Pb, S and Mo are generally in low concentrations and relatively constant with depth of the deposit. Local spikes in enrichment of these elements that are above the background values for a granite are present. The low sulphur concentration (no more than 5%) is evidence of a reduced nature of the pluton, even though S values are above the background value for a typical granite. Sulphur concentrations increases in the MZ relative to the NMZ of the various borehole intersections.

As far as the major elements are concerned (section 5.3), Si remains relatively constant throughout depth as well as K, although in general K decreases slightly towards the NMZ due to a lack of secondary alkali feldspar in the NMZ. Ca is enriched in the MZ due to the abundance of skarn minerals and carbonates in the MZ. This is also associated with enriched Mn concentrations. The elements Fe, Mg and Ti also show an increase in the MZ which can be attributed to secondary biotite (associated with potassic alteration) and an increase in skarn minerals in the MZ. Most Ti samples are below background values except in the high grade W zone (BB+400). Al remains constant throughout depth and close to the background value of Al for a typical granite. P also remains relatively constant throughout the MZ and NMZ, although a slight increase in the MZ are observed in some borehole intersections.

In all the borehole intersections Na shows a decrease in the MZ relative to the NMZ, except in E-200. Na is most prominent in the original plagioclase feldspar (Table 4.1) in the NMZ as well as in the late-stage albitic rims which is usually found further away from the MZ towards the NMZ (AA+200 and DD+200). In the MZ there are large grains of primary plagioclase feldspars that have been pervasively altered that caused the removal of Na due to its mobile habit. The mobility of Na in the Riviera pluton is indicated by all Na values plotting below the background value for a typical granite.

Correlation matrices of the major and trace elements with the Alteration Index show no correlation between the Alteration Index (AL) and any element in the MZ. For major elements the only significant correlations are SiO_2 with CaO, Al_2O_3 with K_2O and TiO_2 with MgO (Figure 5.12).

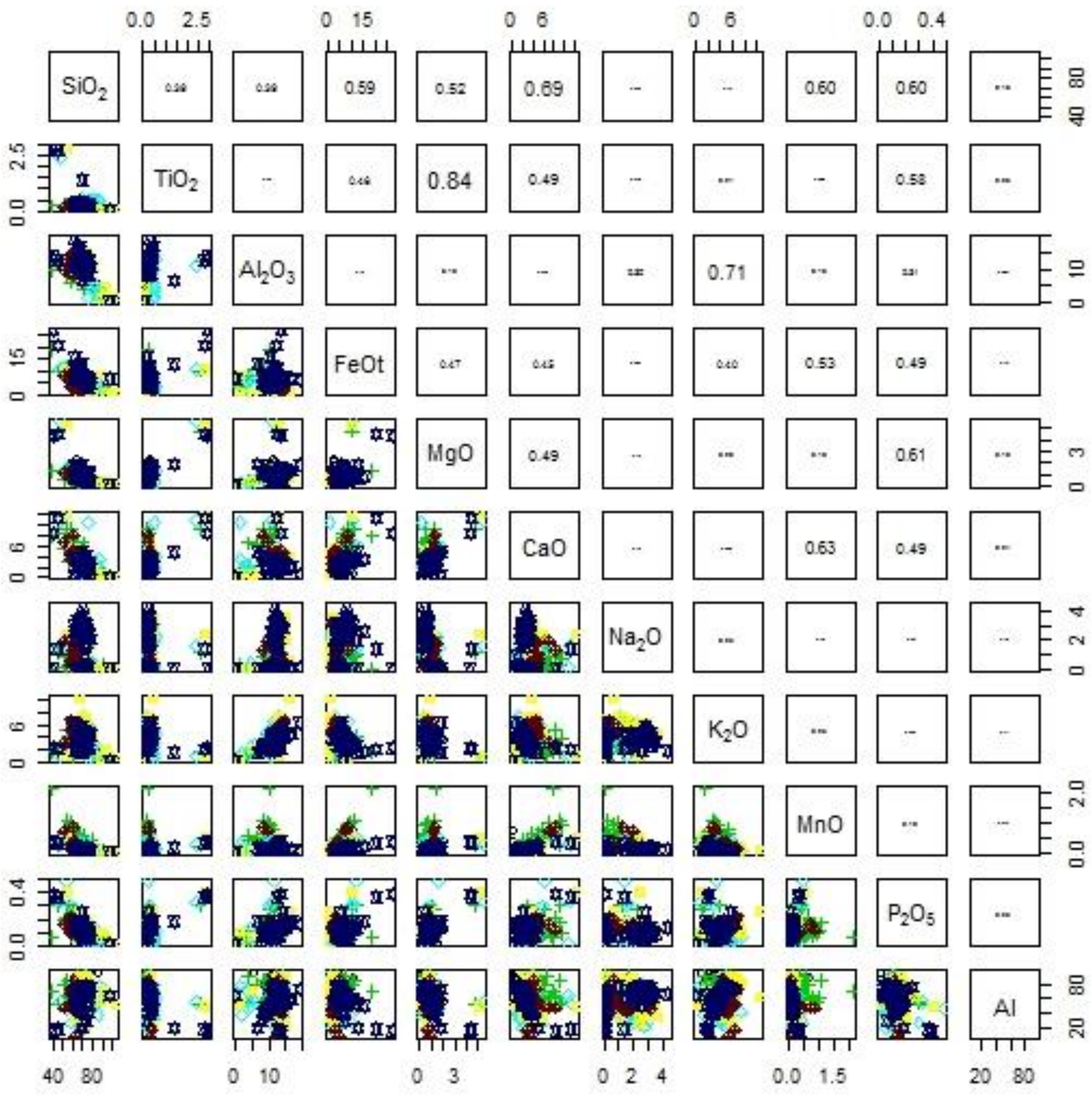


Figure 5.12. A correlation matrix for all the major and trace elements in the MZ. The Alteration Index is also displayed in the matrix. The major elements in the MZ only show three noteworthy correlations: SiO_2 with CaO, Al_2O_3 and K_2O, and TiO2 with MgO.

Trace elements display a very strong correlation between LREE (La and Ce) and both Y and U. Refer to Figure 5.15 for further details. Zr and Hf show a good correlation which is correct according to the periodic table as they are in the same group and indicates that the geochemical analyses is accurate.

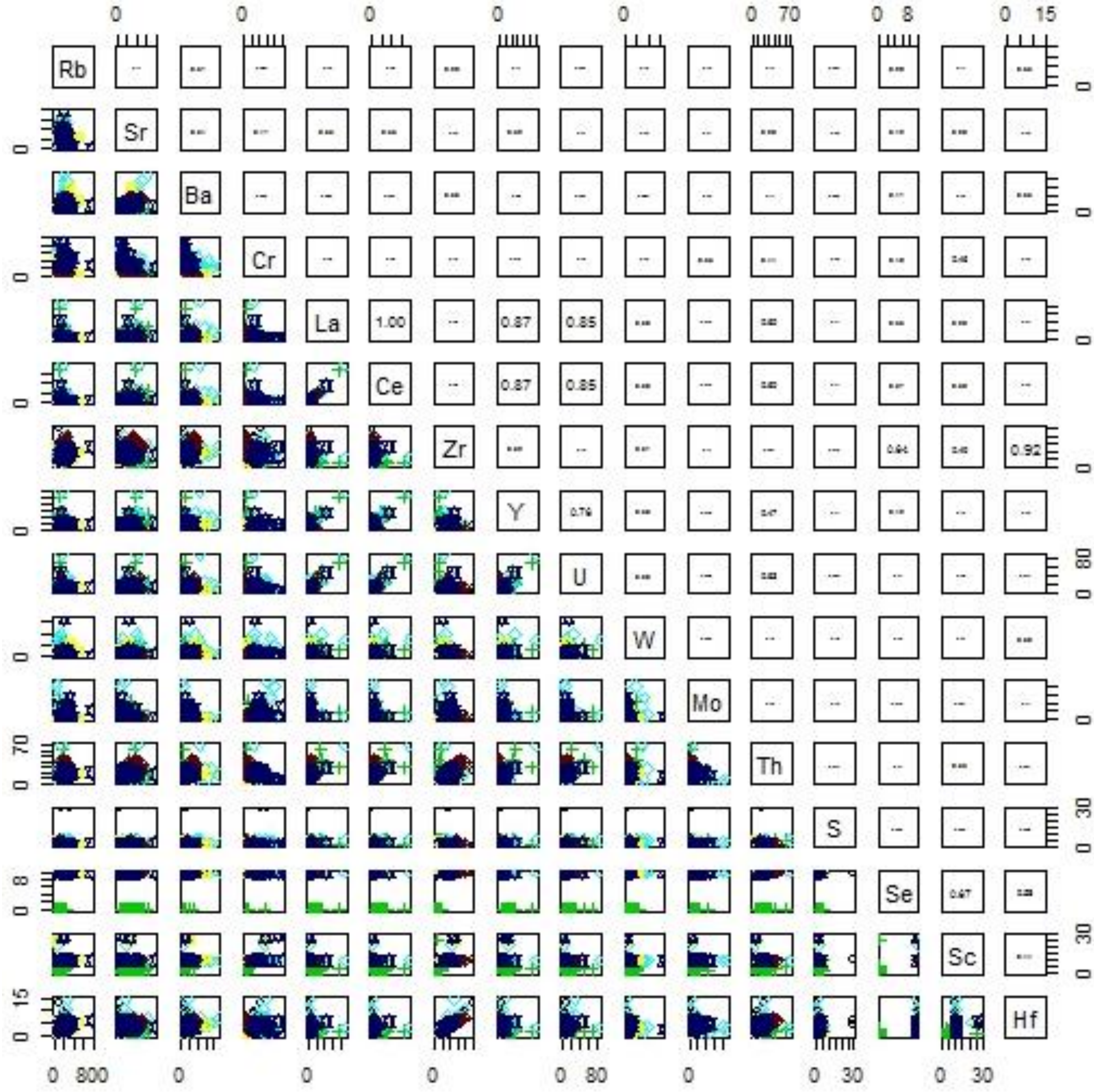


Figure 5.12 continued. The trace elements indicate a correlation between the LREE and Y and U respectively. Zr and Hf, and Se and Sc also display a good correlation.

The negative correlation between CaO and SiO_2 (Figure 5.13) is an indication of the lack of quartz associated with the skarn zone with which CaO is associated. This has been observed by a slight increase in borehole E-200 in the NMZ due to the increase of quartz outside the MZ.

The good correlation between Al_2O_3 and K_2O confirms the association of K with alumina-rich mineral phases like feldspars and micas in the Riviera pluton. The last good correlation between TiO_2 and MgO explains the association of Ti-rich phases like titanite with the MZ as secondary biotite, which is Mg-rich (Table 4.2) is also primarily located in the MZ. Secondary biotite also contains some Ti and is therefore also associated with the MZ.

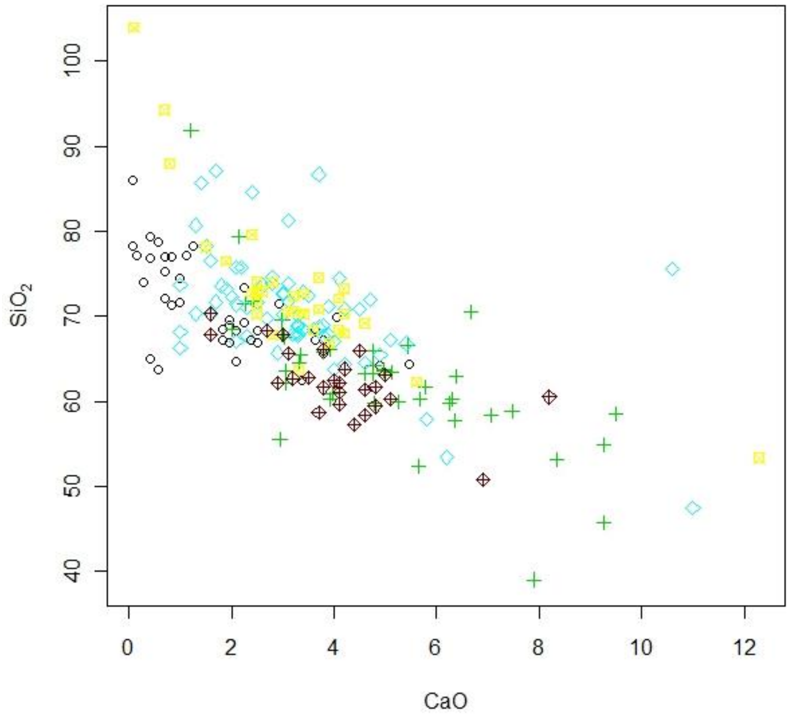


Figure 5.13. The negative correlation observed between SiO_2 (%) and CaO (%) explains the lack of quartz in the skarn zone where there is an abundance of calcic skarn minerals.

Trace elements exhibit a decrease in Ba from the granite-wall rock contact to depth (except in boreholes BB+400 and AA+200), which indicates that Ba is concentrated towards the cupola of pluton in the MZ in most borehole intersections. Ba is associated with primary alkali feldspar and secondary white mica. Primary alkali feldspar is more prominent in the NMZ, which indicates that Ba in the MZ is mostly associated with fine- and coarse-grained secondary white mica (up to 0.7% Ba per grain). Most samples in the MZ indicate enriched concentrations of Ba, with more normal background values towards and in the NMZ.

According to Figure 5.14, BB+400 (high grade W zone) and a few samples from AA+200 (medium grade W zone) display elevated concentrations of Sr relative to Ba, which is attributed to more Ca-minerals, mostly skarn minerals, in this zone. Sr concentrations decrease in general down-the-hole which is an indication of less skarn Ca-minerals at depth.

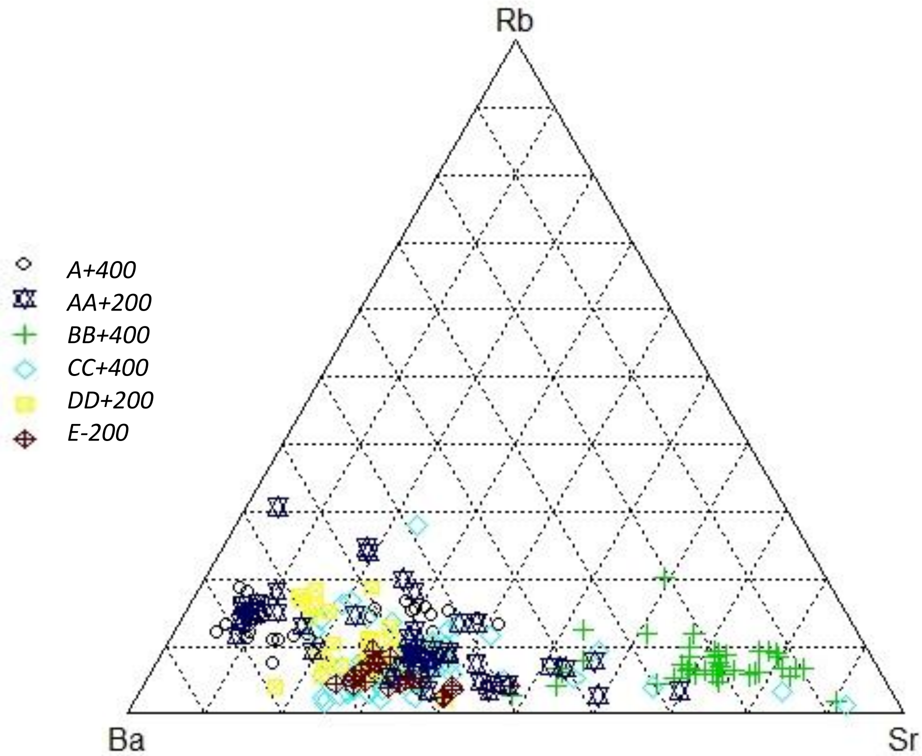


Figure 5.14. Ternary diagram of the distribution of Rb, Ba and Sr in the MZ. The MZ is mostly rich in Ba compared to Sr and Rb, except in the high grade W zone of the deposit (BB+400). The relative increase in Sr in the high grade W zone is due to the presence of abundant skarn minerals in this zone.

A positive correlation between Y and LREE, as well as U and LREE is noticed, which suggests that there is a link between LREE enrichment and U (Figure 5.15); therefore allanite in the MZ is expected to contain significant amounts of U. This was confirmed by the mineral chemistry of allanite (chapter 6). The positive correlation between Y and LREE shows that the data is reliable.

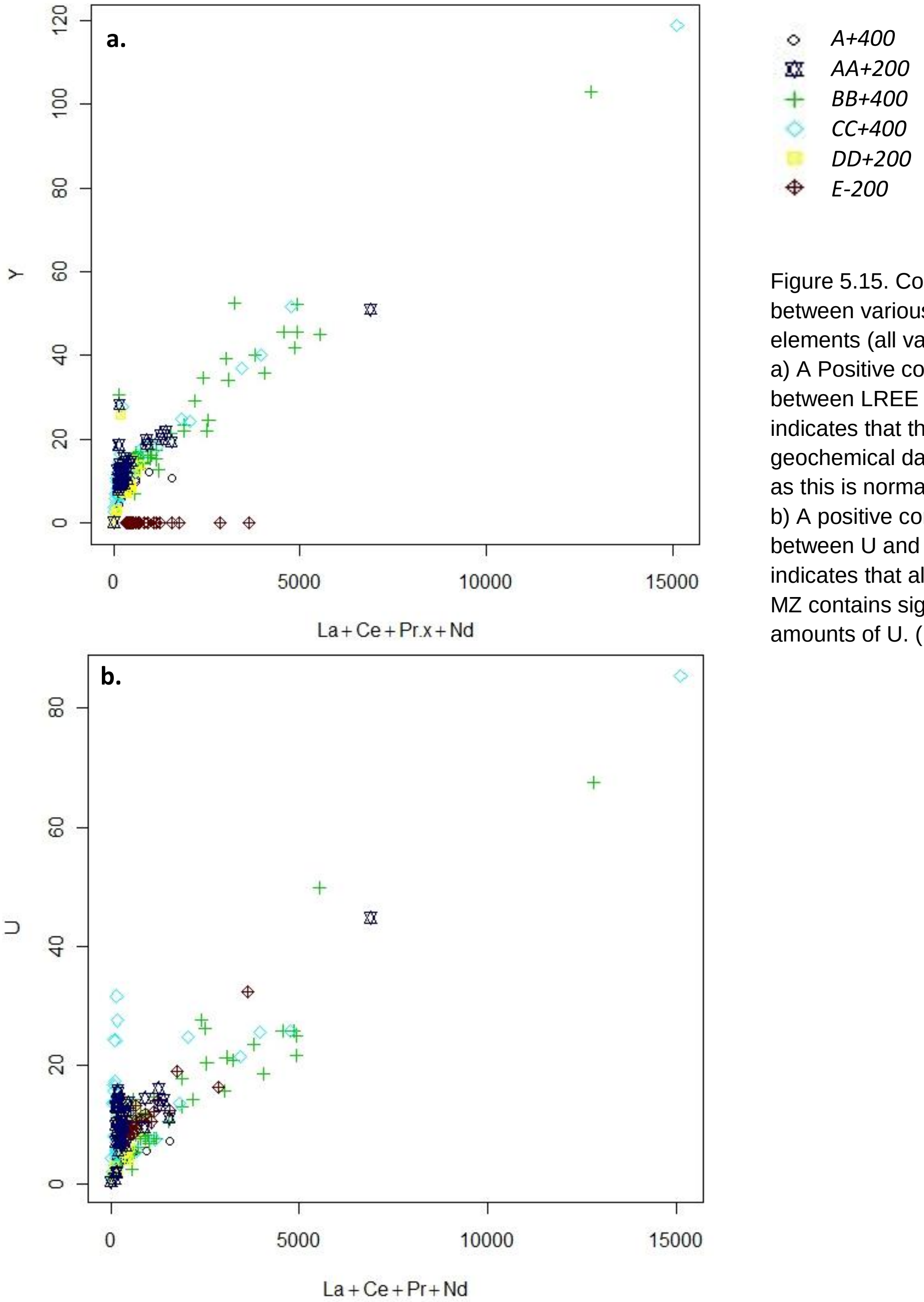
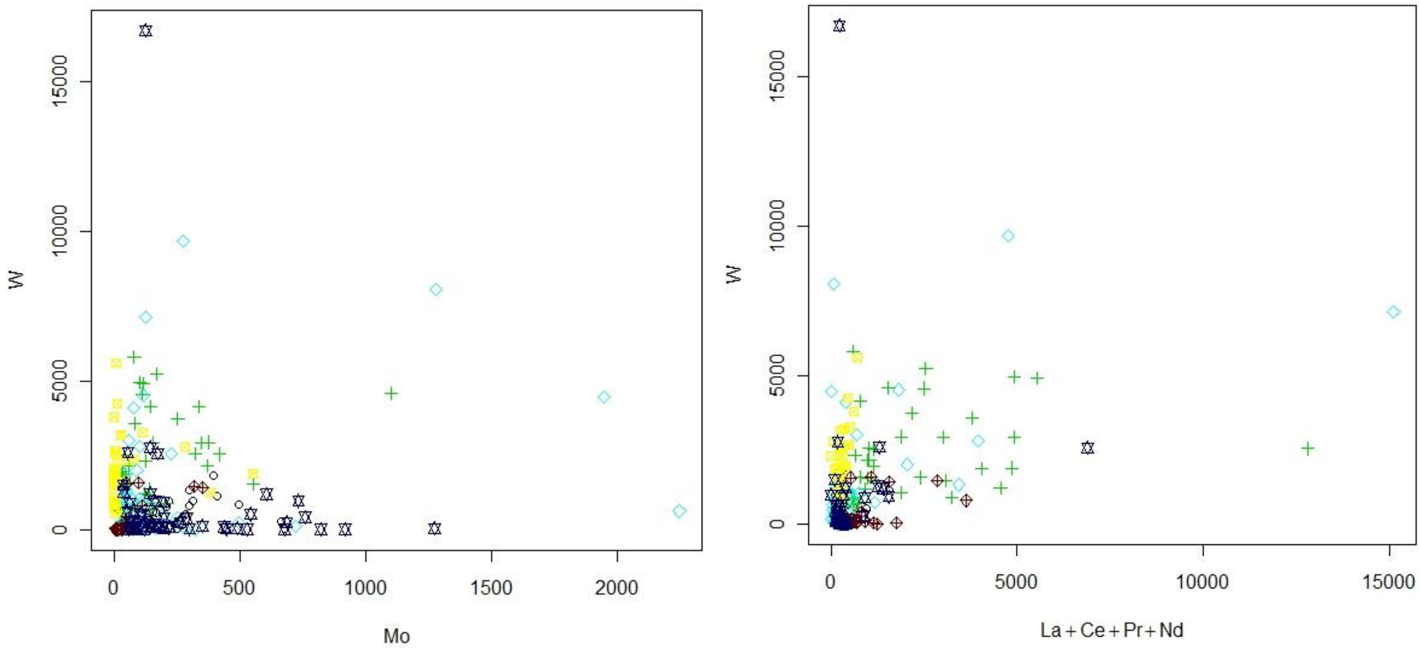


Figure 5.15. Correlation plots between various minor elements (all values in ppm). a) A Positive correlation between LREE and Y indicates that the geochemical data is reliable as this is normally the case. b) A positive correlation between U and LREE indicates that allanite in the MZ contains significant amounts of U. (Pr.x = Pr).

5.4.1 W, Mo and REE enrichment

Apart from the skarn zone in the roof of the granite, enrichment occurs locally where potassic alteration overprints phyllic alteration. This is evident outside the skarn zone as skarnified granite patches. The mineralogy of these small patches of skarn is characterized by clinopyroxene garnet, as well as minor vesuvianite, titanite, calcite, apatite, pyrite, pyrrhotite, chalcopyrite, molybdenite and secondary quartz. In appearance, the composition of the skarnified granite is a closer resemblance of the original granite than the endoskarn.

Weak correlations between the major types of enrichment (W, Mo, LREE) indicate that enrichment in this pluton could not be temporally and spatially related, i.e, it was not accomplished in a single mineralizing event, but rather through multiple episodes (Figure 5.16). Where there is an overlap in enrichment it is observed and interpreted as these skarnified granite patches.



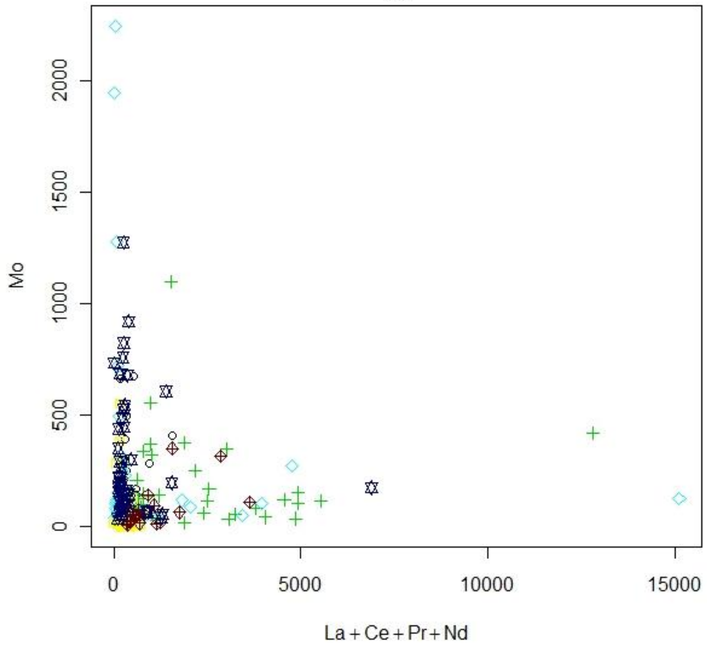


Figure 5.16. Correlation plots between tungsten (W), molybdenum (Mo) and the light rare earth elements (LREE) (all values in ppm). No correlation between the various types of enrichment implies multiple phases of enrichment. A weak correlation between W and the REE indicate that spatially they can be associated where an overlap of alteration occurs in skarnified granite patches.

Down-the-hole plots for borehole intersections E-200 (representing the low grade W zone), AA+200 (representing the medium grade W zone) and BB+400 (representing the high grade W zone) illustrate the relationship between the degree of enrichment (mineralization) and the Alteration Index. There is almost a direct link between the intensity of alteration and the ore grade. The higher intensity alteration types (skarnification and potassic alteration) will more likely contain significant concentrations of economic elements.

The medium grade zone illustrates that as the degree of enrichment increases, the Alteration Index (AL) also increases (Figure 5.17.a). The correlation is evident where there is abundant W and LREE enrichment which supports the correlation between the AL and the W grade. Thus enrichment is not only associated with endoskarn but also with potassic and possibly other forms of alteration. In this zone it is mostly associated with potassic and other lower intensity types of alteration.

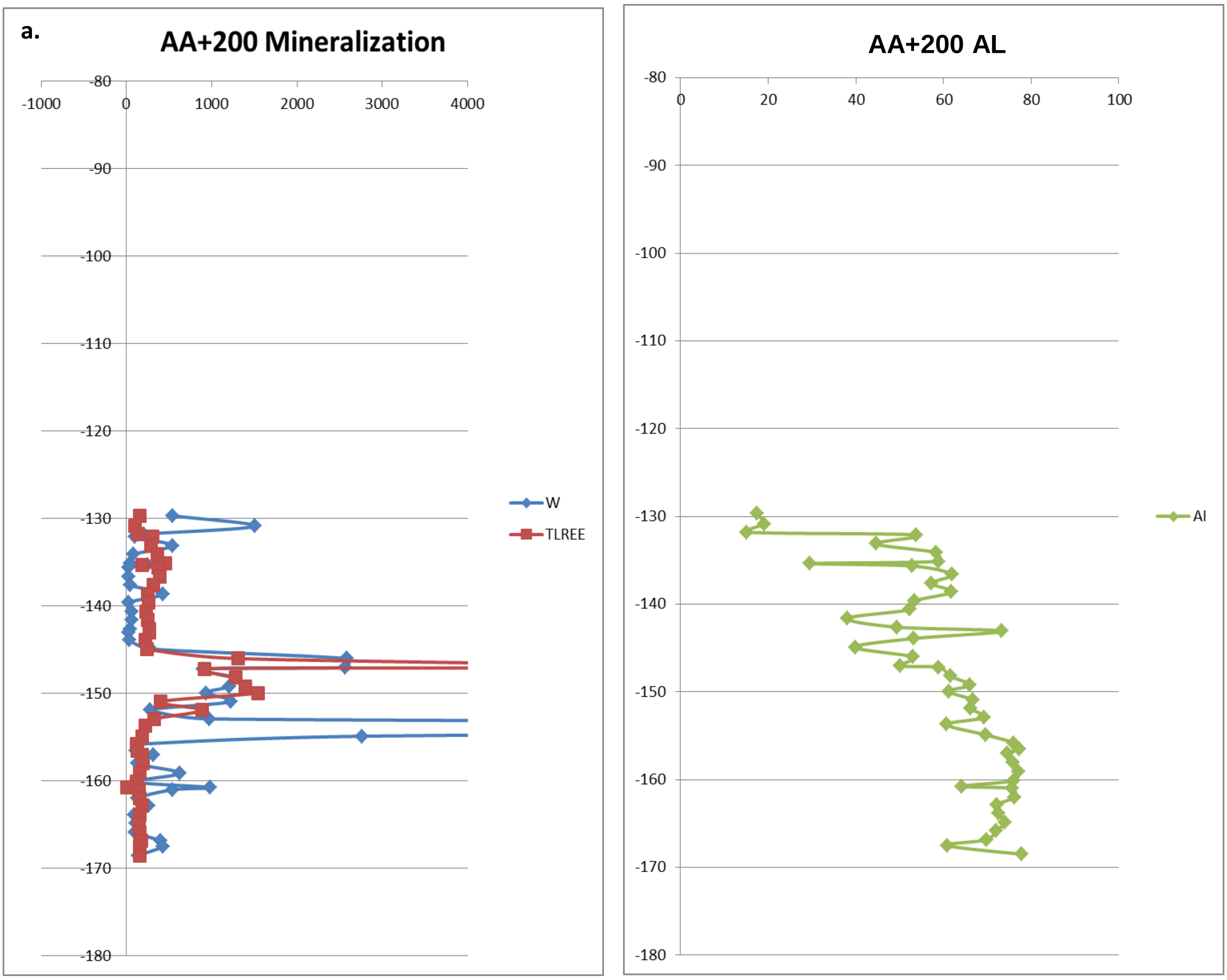
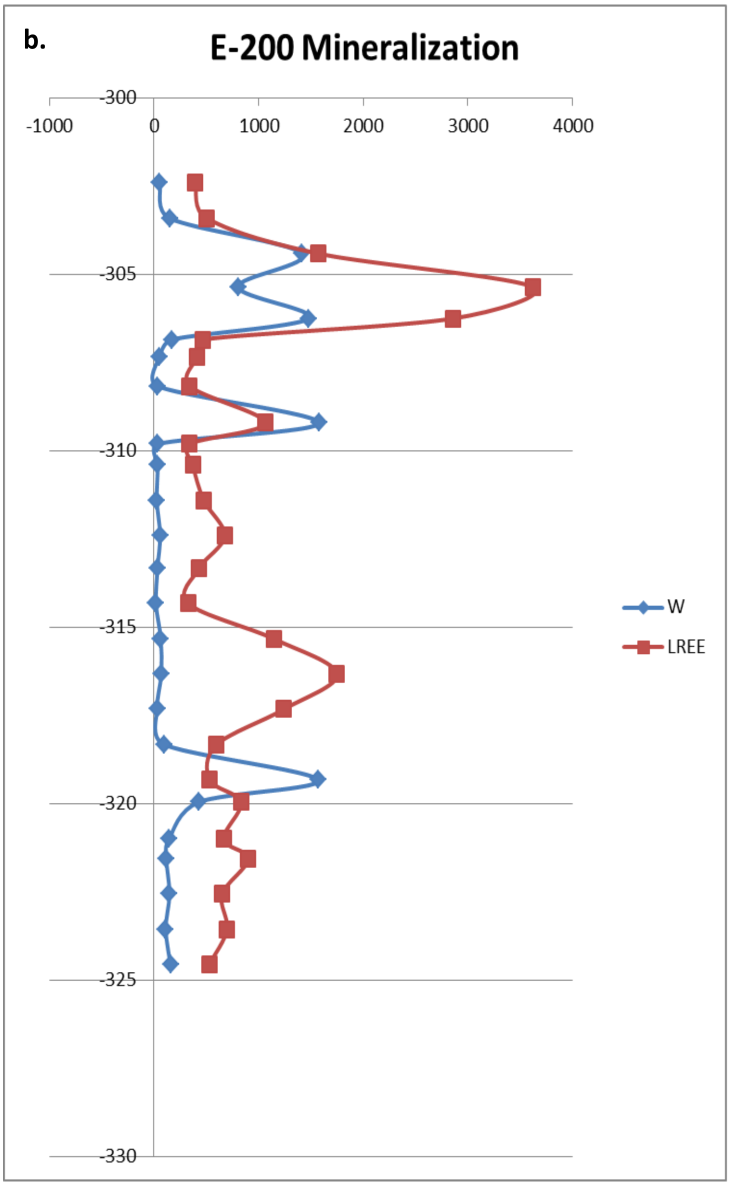


Figure 5.17. Down-the-hole plots of W (ppm) and LREE (ppm) enrichment compared to the Alteration Index (AL) in the MZ. a) AA+200 is between the high grade zone and the periphery of the deposit represents the medium grade zone. As the W and LREE concentration increases, the AL also increase which indicates that enrichment is not only associated with endoskarn.

The low grade W zone displays a trend of the AL decreasing with increasing W and LREE enrichment (Figure 5.17.b). This can be attributed to the fact that enrichment in the low grade W zone is restricted to only the endoskarn zone at the top of the granite cupola, whereas in the higher grade zones enrichment occurs sporadically and is not only associated with endoskarn but also potassic and other lower intensity forms of alteration. This has been observed mineralogically. The low AL is therefore an indication of where the skarn zone is situated.



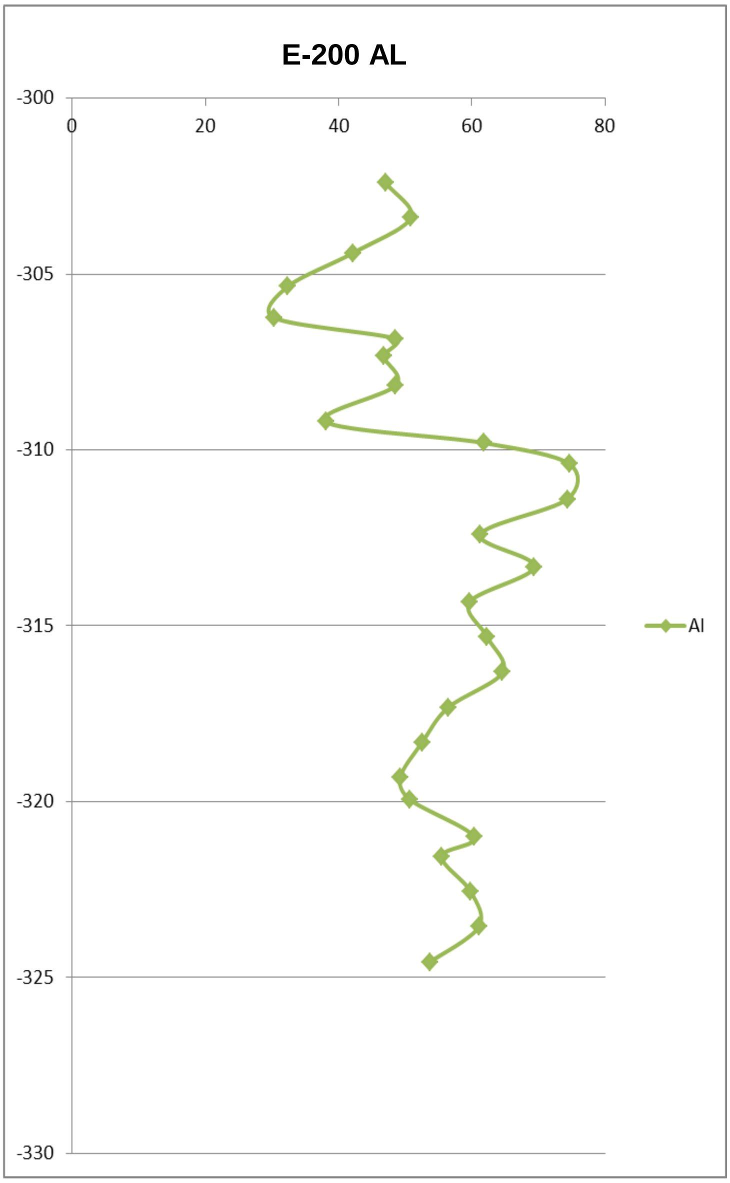


Figure 5.17 continued. b) Borehole intersection E-200 which is on the periphery of the deposit and represents the low grade W zone. This diagram illustrates that enrichment in the low grade W zone is mainly associated and restricted to endoskarn. From the W and LREE trends it is clear that some overlap in enrichment is evident, although W and LREE enrichment are not always associated.

In the high grade W zone, although the trend is sporadic, where there is a spike in W and LREE enrichment, the AI also increases (Figure 5.17.c). The opposite also occurs, where a low concentration of W and LREE enrichment associates with a low AL. This confirms the fact that enrichment in the high – and medium-grade W zones are not only limited to endoskarn but also to potassic and other types of alteration, and occurs sporadically outside the MZ as well.

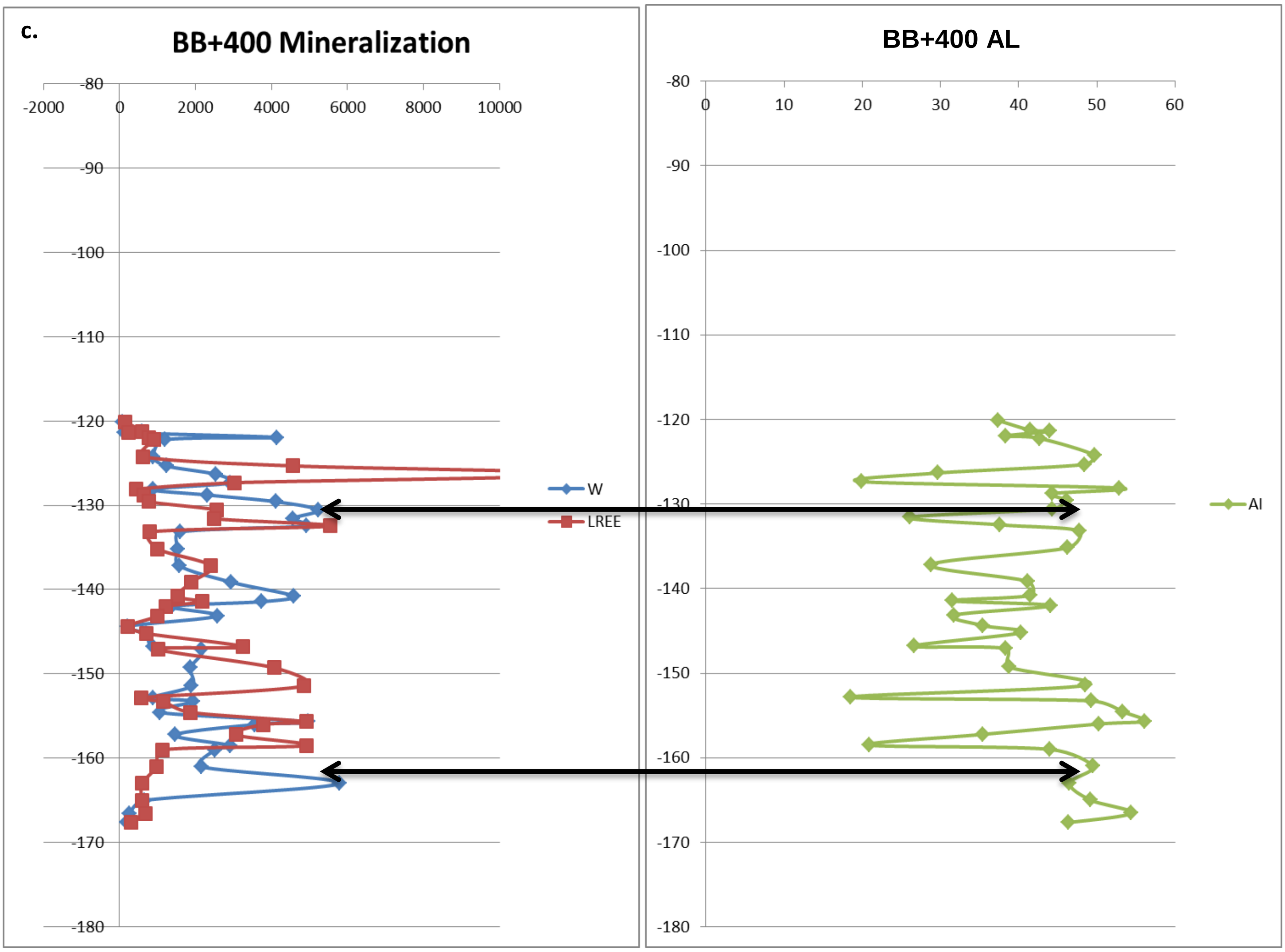


Figure 5.17 continued. c) BB+400 are in the high grade W zone of the deposit. Low AL's are associated with low W values and vice versa which indicates that enrichment in the high grade W zone are not restricted to the skarn zone, but occurs abundantly outside of the skarn zone as well. From the W and LREE trends you can see that some overlap can occur, although they are not spatially and temporally related, but occur as separate mineralizing events.

The spatial distribution of W, LREE and Mo enrichment is displayed visually in Figure 5.18. W enrichment is mainly restricted to the MZ which is within 160m of the granite-wall rock contact, especially to the skarn zone. Some boreholes (BB+300) in the medium grade W zone however, illustrate that sporadic occurrences of enrichment is also found lower down in the pluton and not just in the roof of the pluton. W enrichment is much more concentrated where it occurs than LREE enrichment.

LREE enrichment is rarely associated with W enrichment and occurs much more sporadically than W enrichment, although some overlaps in enrichment have been observed geochemically and mineralogically as skarnified granite patches. Therefore REE enrichment is not only restricted to the skarn zone, but can occur in significant concentrations sporadically throughout the deposit.

a.

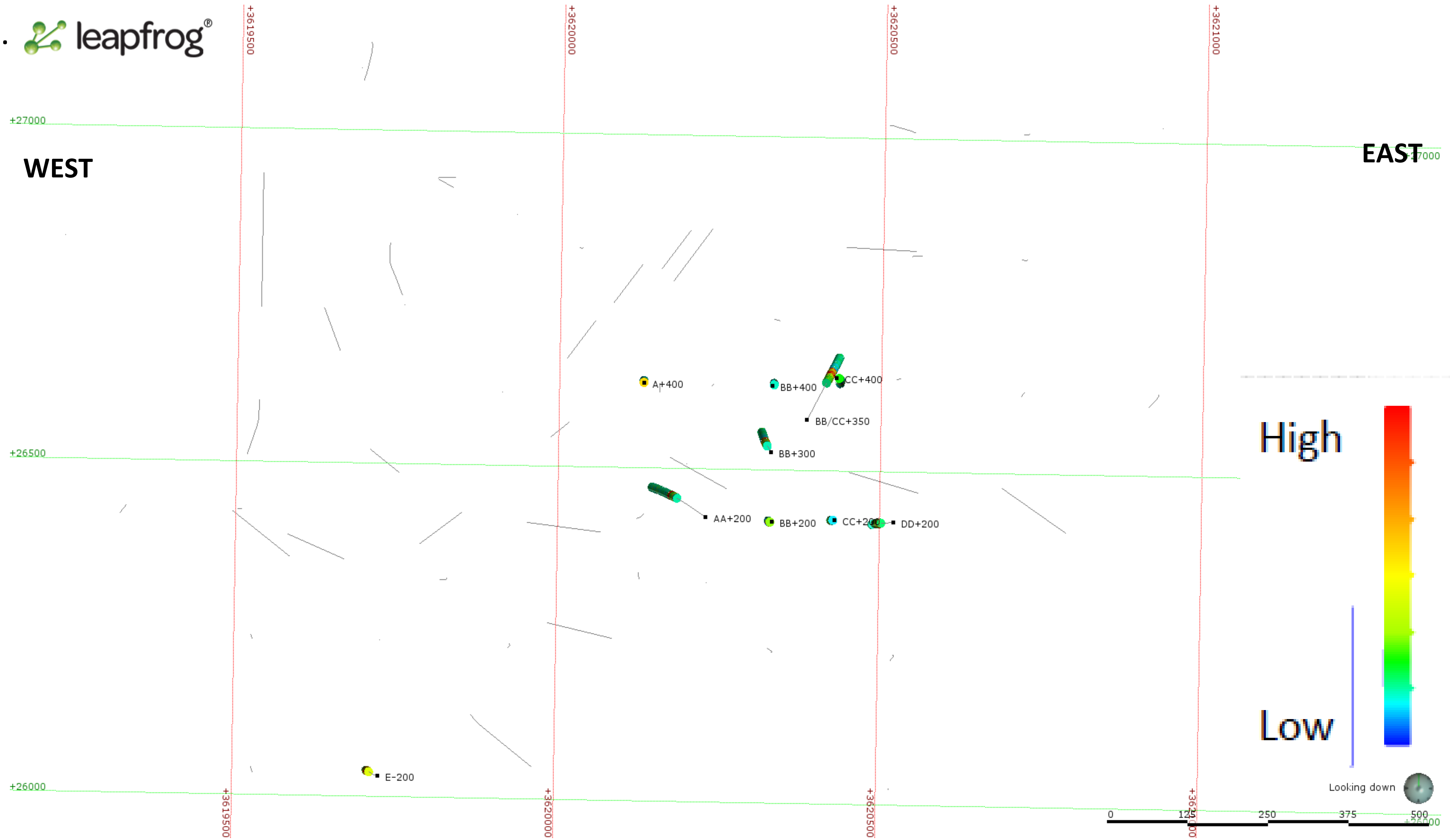


Figure 5.18. This diagram shows the distribution and concentration of W, Mo and LREE (all in ppm) enrichment respectively. This data was obtained through whole-rock analysis. A to C displays W enrichment. a) This first image is in plan view. Note the distribution of the boreholes.

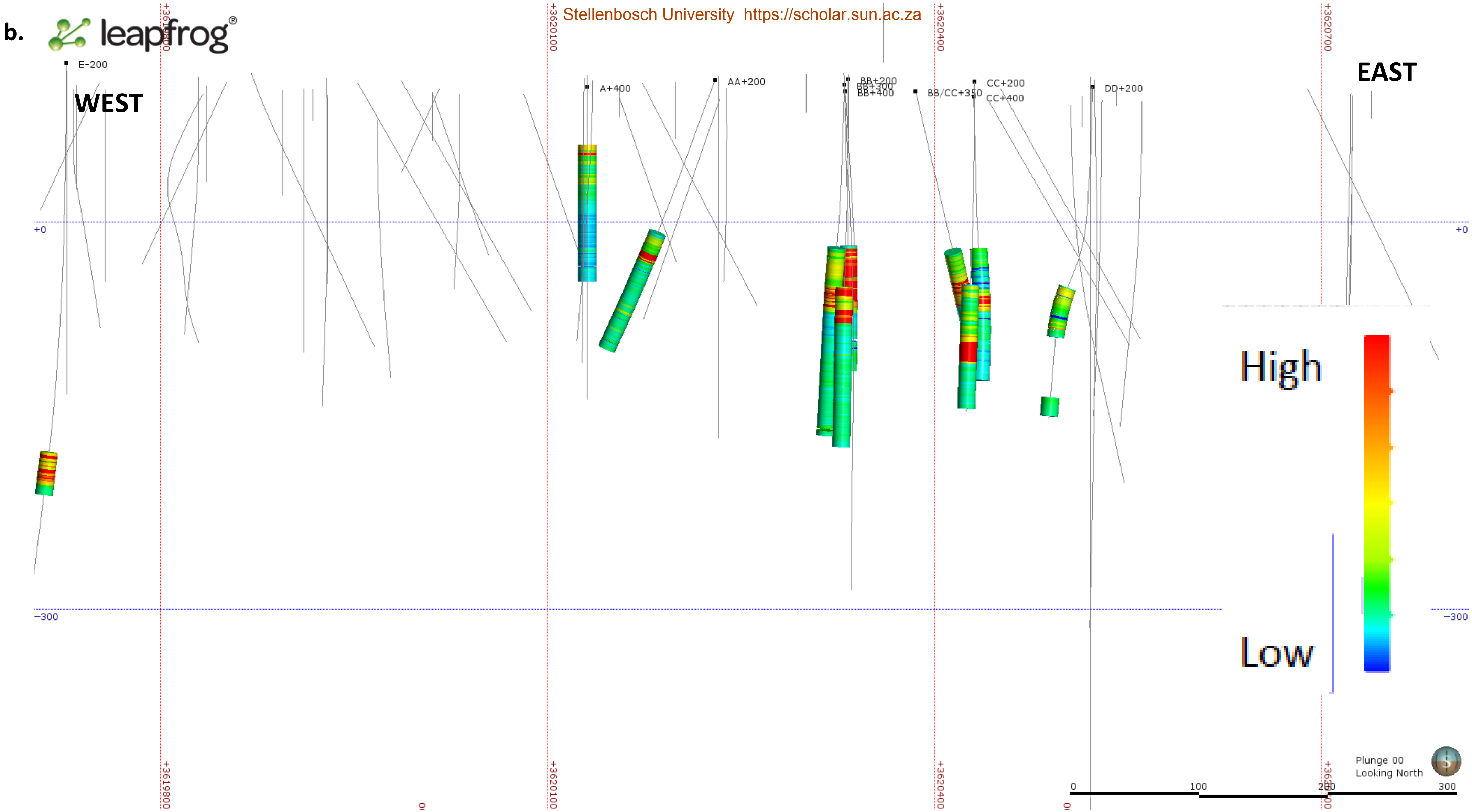


Figure 5.18 continued. b) This image is looking north with a zero degree plunge. Enrichment is mainly in the MZ, within 160m of the granite-wall rock cupola.

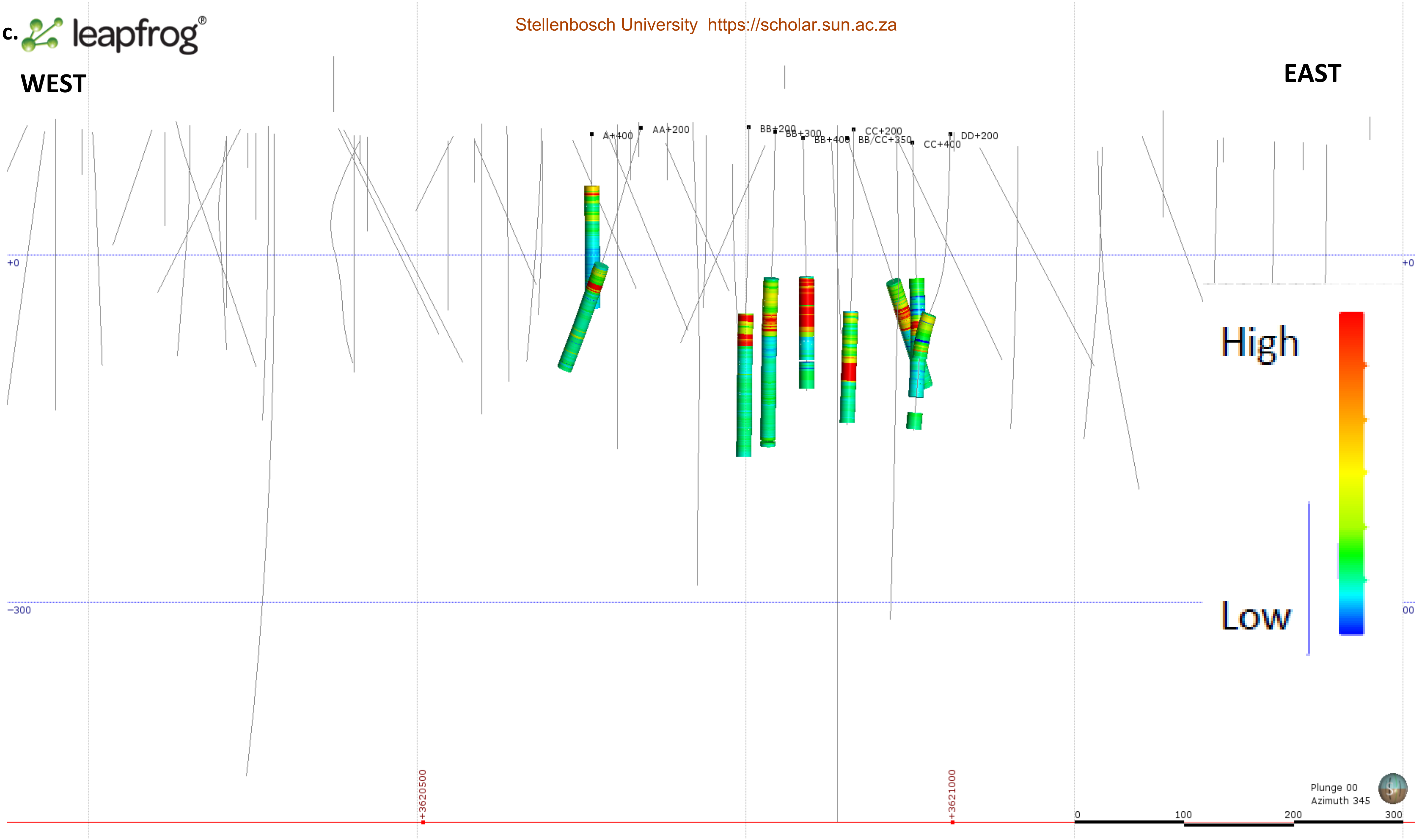


Figure 5.18 continued. c) This image is with an azimuth of 345 with a zero degree plunge. In some boreholes (like BB+300) in the medium grade zone, enrichment is not restricted to the roof of the granite but can also be intense lower down in the deposit.

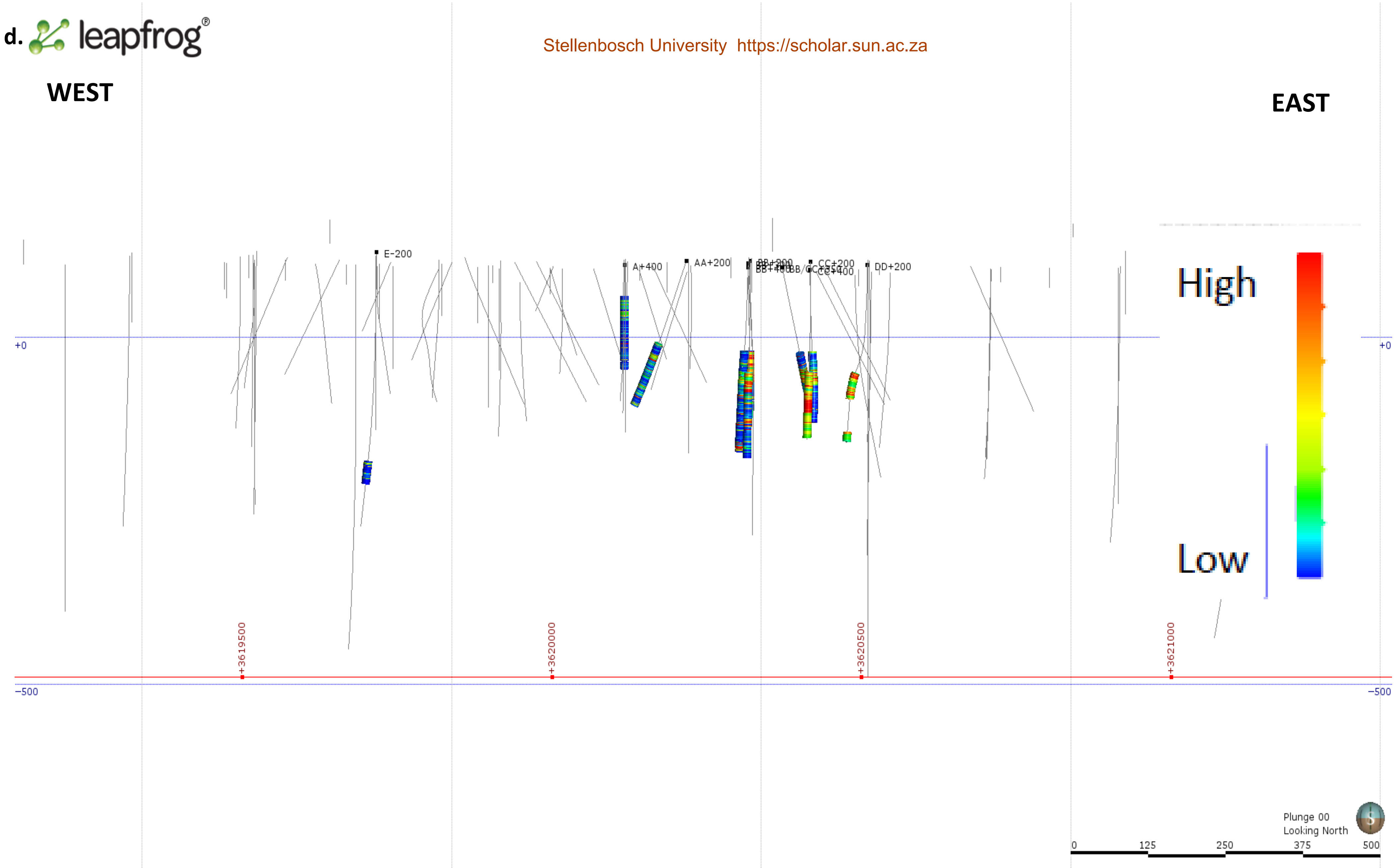


Figure 5.18 continued. d) This image displays LREE enrichment and is looking north with a zero degree plunge. LREE enrichment is rarely associated with W enrichment and occurs much more sporadically than W enrichment.

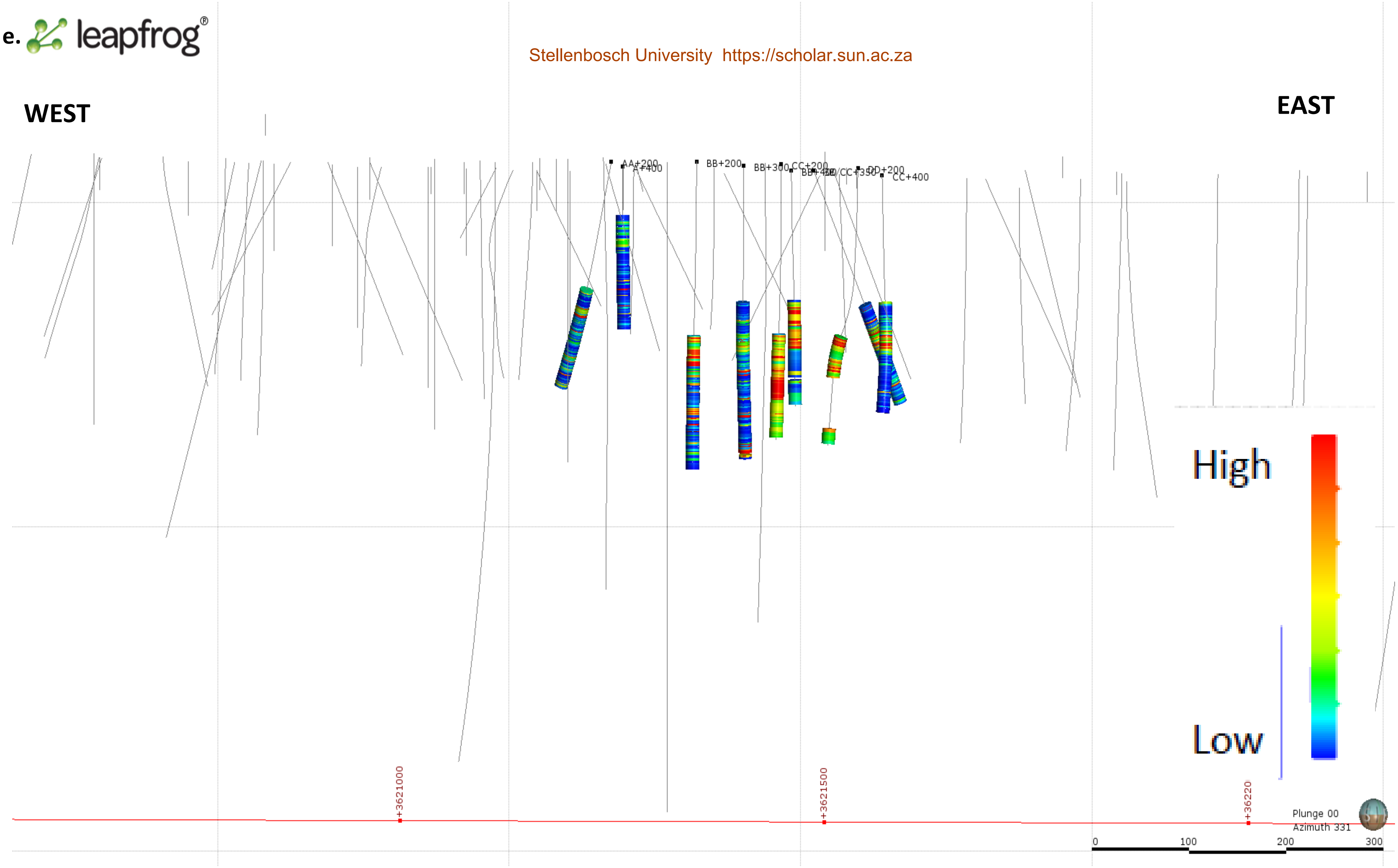


Figure 5.18 continued. e) This image is with an azimuth of 345 with a zero degree plunge.

f.

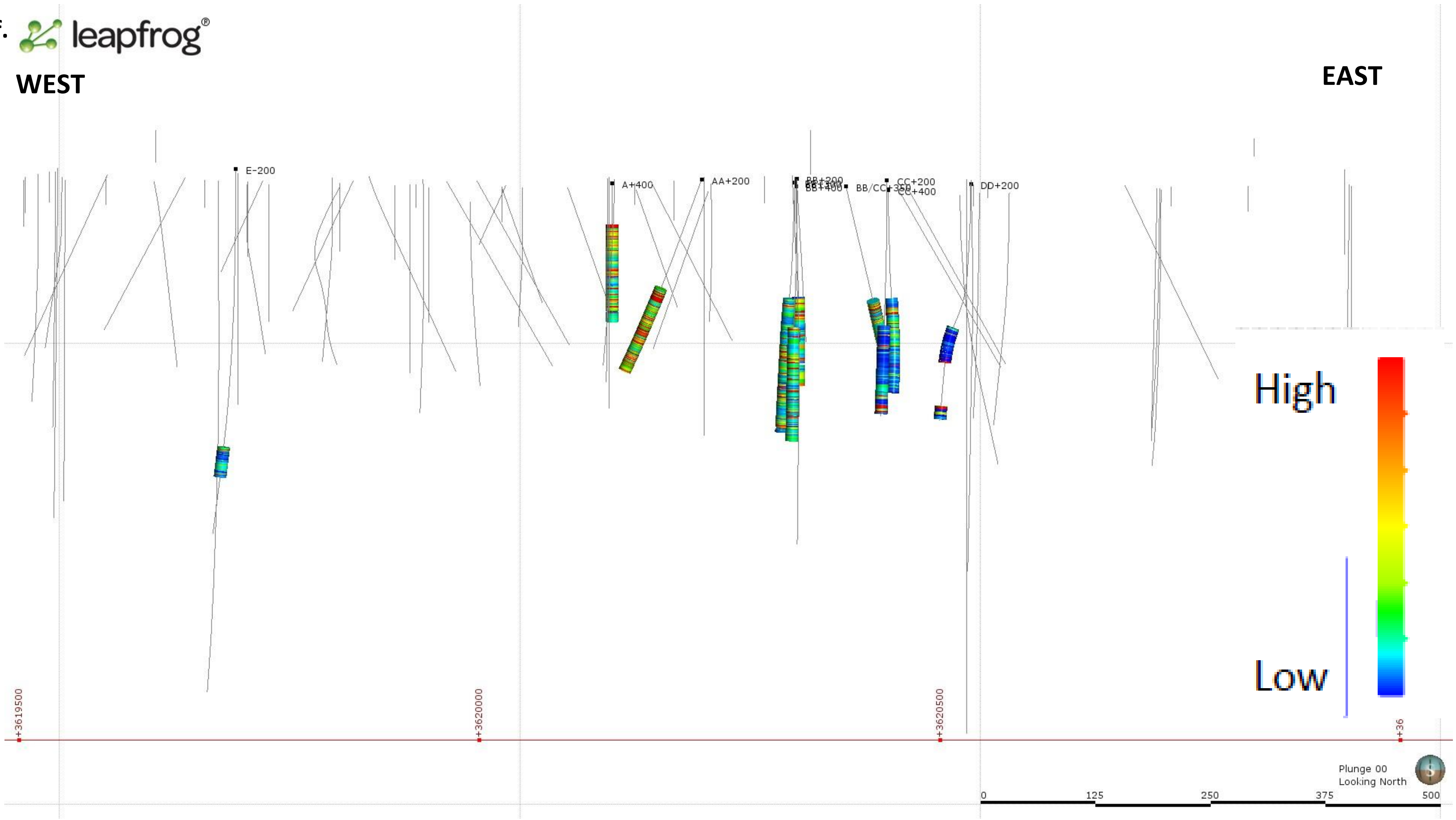


Figure 5.18 continued. f) This image displays Mo enrichment and is looking north with a zero degree plunge. Mo enrichment is far less in abundance and is not restricted to the skarn zone.

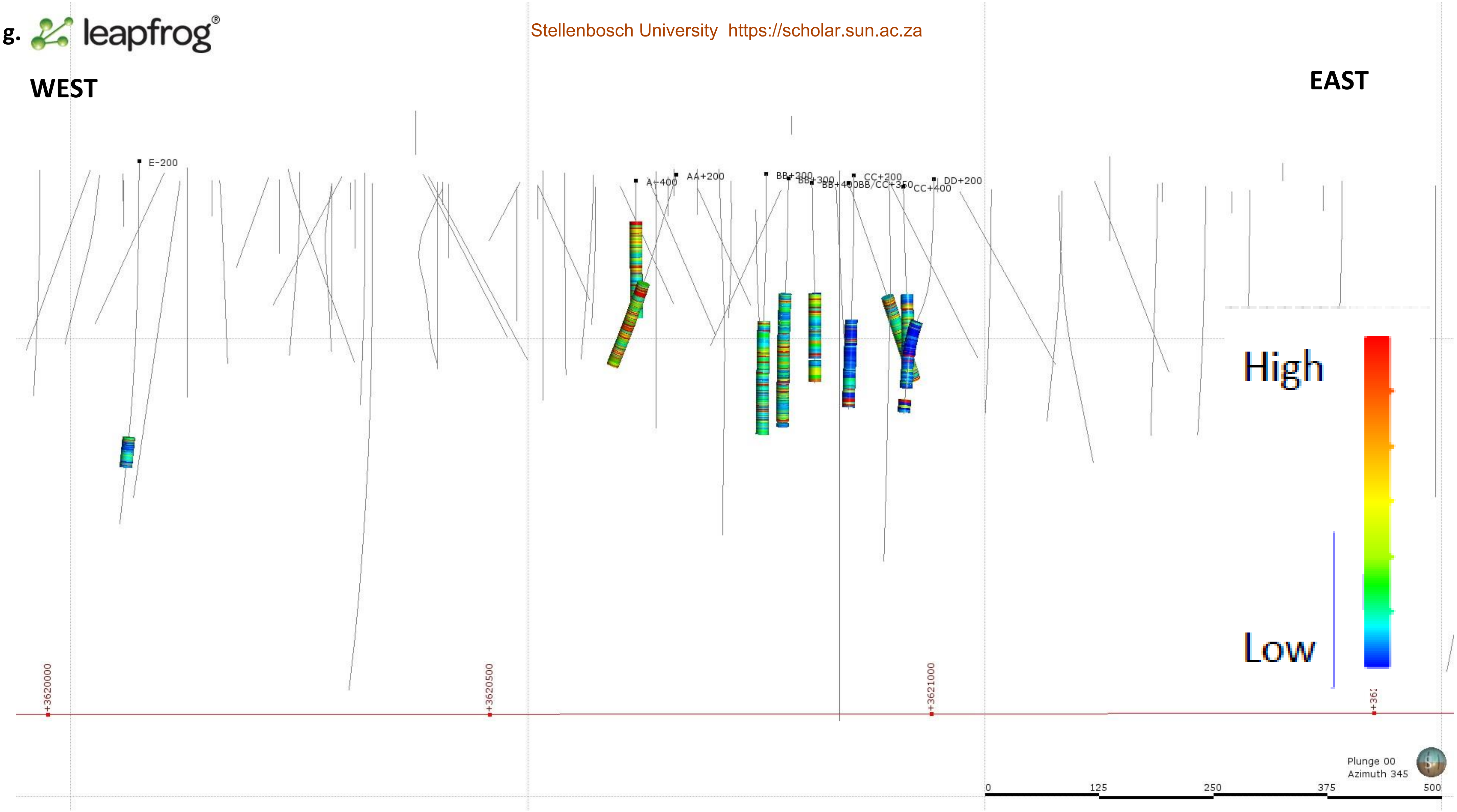


Figure 5.18 continued. g) This image is with an azimuth of 345 with a zero degree plunge.

5.5 Non-mineralized zone

This zone is towards and in the BMG and is characterized by primary quartz, primary but altered plagioclase and primary and slightly altered alkali feldspar. Primary, relatively unaltered biotite is also more prominent in this zone. This zone mainly shows phyllic alteration. Pyrite and pyrrhotite are the prevalent sulphides in this zone. The NMZ although still altered, bears the closest resemblance to the original host rock.

The NMZ shows a significant decrease in enrichment and contains minor to virtually no W, Mo and LREE enrichment (section 5.3). Minor enrichment is attributed to sporadic occurrences of scheelite, allanite and molybdenite, sphalerite and chalcopyrite. The low (no more than 5%), relatively constant S content in the NMZ indicates a reduced nature significantly at depth from the granite-wall rock contact.

An increase in Na in this zone with respect to the MZ is due to primary plagioclase feldspar being less altered than in the MZ, and also the effect of albitization (Na-metasomatism). Si remains relatively constant. K decreases in the NMZ which can be attributed to less secondary alkali feldspar grains. There is a general decrease in Fe, Mg, Mn, Ca and Ti as this is no longer in the skarn zone, whereas P and Al remain relatively constant (section 5.3).

Although Ba decreased in the NMZ, most samples still displays enriched concentrations. This is attributed to primary alkali feldspar and secondary white mica, the latter that occurred as a result of phyllic alteration and is pervasive throughout the entire pluton. Sr also decreases in the NMZ due to less calcic skarn minerals which it is associated with. Y shows depleted concentrations in the NMZ and decreased due to less REE enrichment in this zone. Rb remains relatively constant and displays normal background values in the NMZ. Nb decreases in the NMZ and shows depleted concentrations.

Correlation matrices of the major element oxides and trace elements (Figure 5.19), as well as with the Alteration Index indicate that for the major element oxides there is a significant correlation between TiO_2 and Al_2O_3, and Al_2O_3 and K_2O. There is no correlation with the AL.

A weak correlation between Al_2O_3 and TiO_2 is evident (Figure 5.19). This suggests that minor to no endoskarn or skarnified granite is associated with this zone, although sporadic occurrences of some primary titanite are still present in the NMZ. A good correlation between Al_2O_3 and K_2O illustrates the association of K with alumina-rich phases like feldspars and micas in the NMZ.

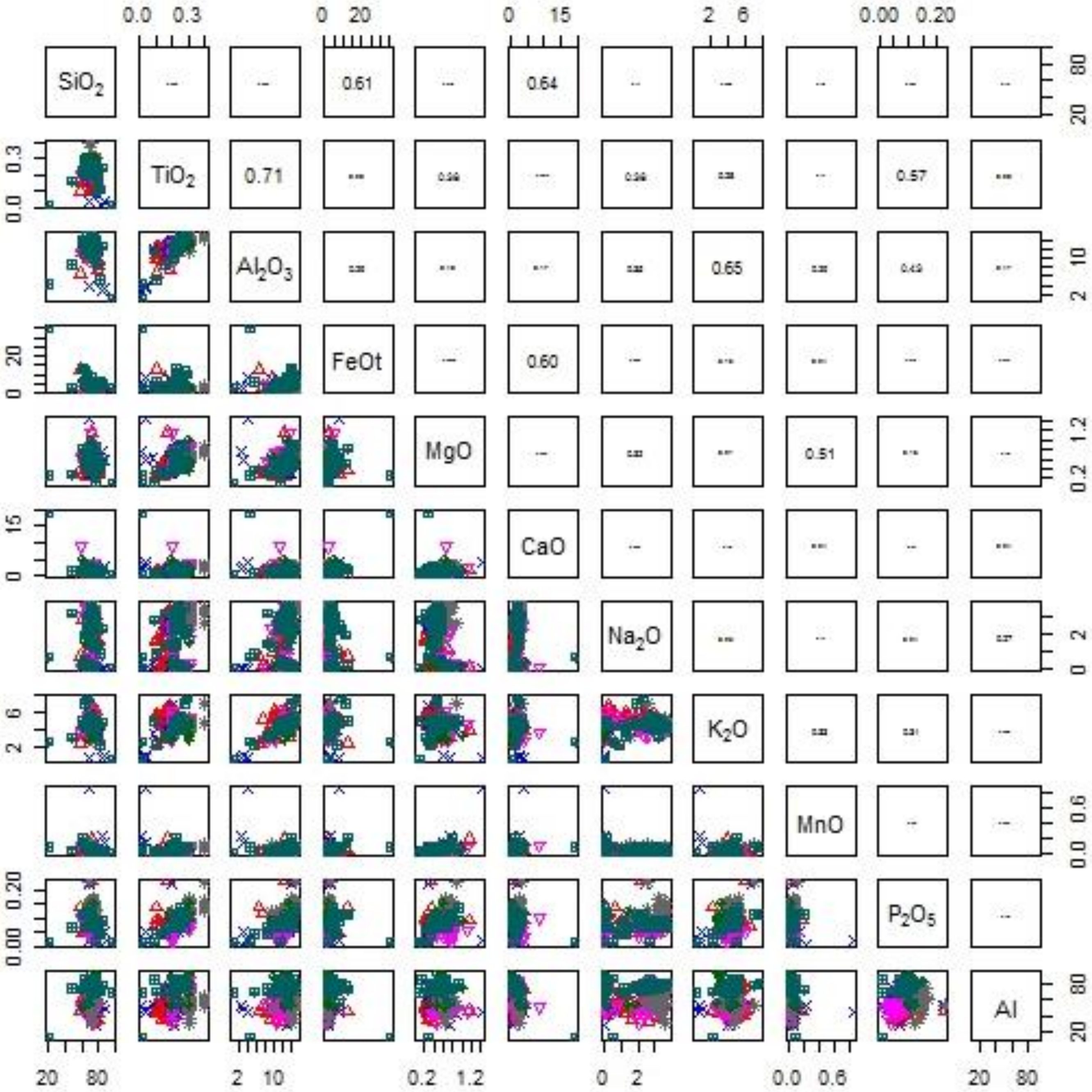


Figure 5.19. A correlation matrix for all the major and trace elements in the NMZ. The Alteration Index is also included in the matrix. The major elements in the NMZ only show two noteworthy correlations; TiO_2 with Al_2O_3, and K_2O with Al_2O_3.

The trace elements Sr and Ba display a positive correlation (Figure 5.21). In this zone there is no correlation between the LREE and Y and U, as is the case in the MZ. A good correlation between Zr and Hf is also seen, which indicates that the geochemical data is reliable (refer to previous section). These observations will be explained below (refer to page 165).

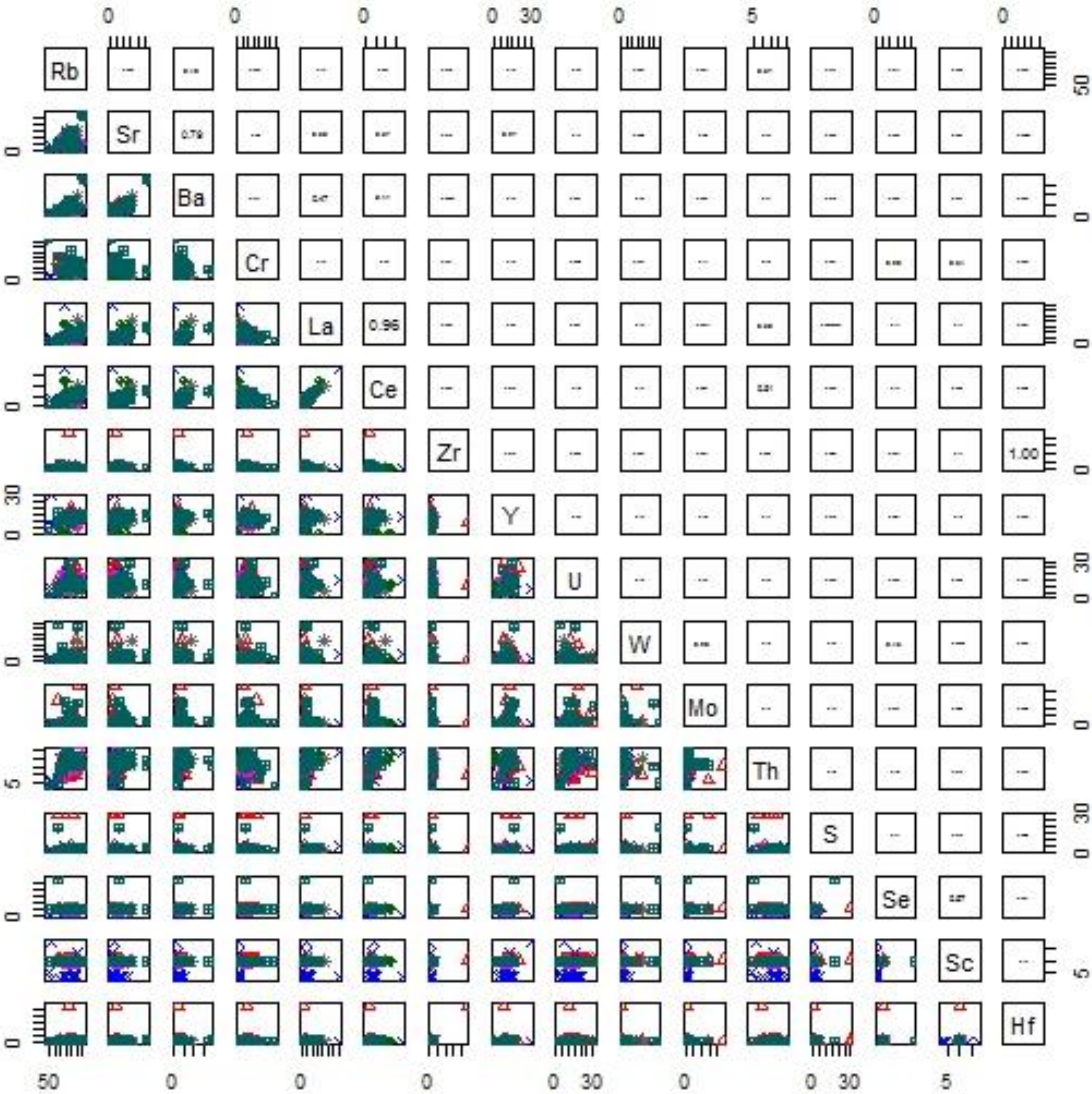


Figure 5.19 continued. The trace elements indicate a correlation between Sr and Ba, and amongst the LREE (La and Ce) as expected. Zr and Hf also displays a good correlation.

P is slightly depleted in the NMZ compared to the MZ (section 5.3), which can be due to slightly less apatite in the NMZ. There is a general decrease in Ba in the NMZ, although Ba values still remain above the background values due to a large amount of secondary white mica. Most of the borehole intersections display lower Sr concentrations compared to the MZ which is linked with less skarn minerals in the NMZ.

According to Figure 5.20 the NMZ is mostly rich in Ba relative to Sr and Rb, which can be attributed to the presence of large primary alkali feldspar grains in the NMZ and secondary white mica as was previously mentioned. The positive correlation between Ba and Sr (Figure 5.21) confirms that the geochemical analysis is reliable as these elements should correlate according to the periodic table.

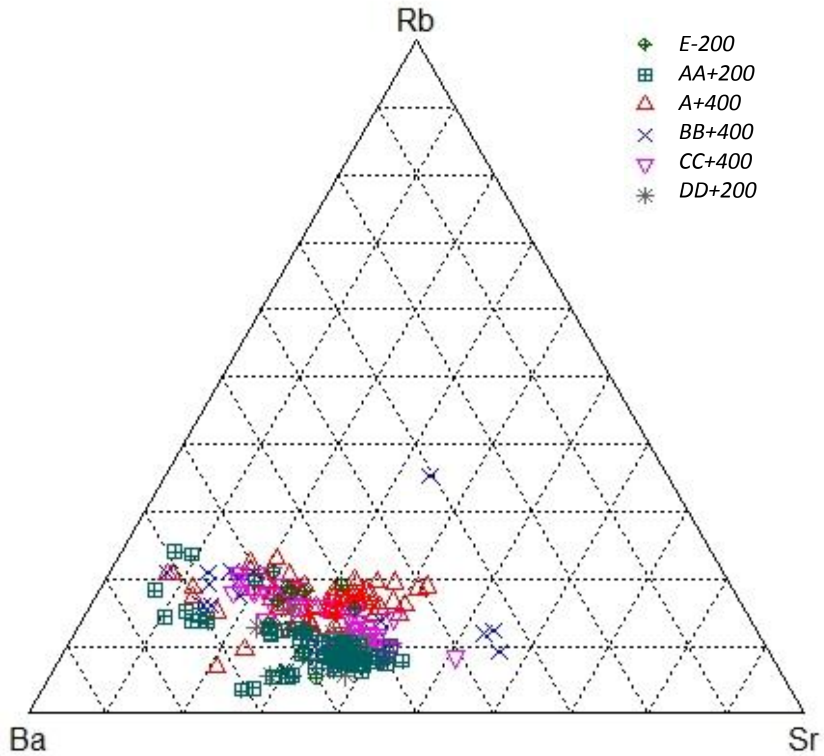


Figure 5.20. Ternary diagram showing the distribution of Rb, Ba and Sr in the NMZ. The NMZ is mostly enriched in Ba compared to Sr and Rb.

A good correlation exists between Y and U and the LREE (Figure 5.21.b) less than 200 ppm LREE after which the correlation breaks down. At low concentrations, detection problems are evident. This is confirmed by depleted Y values in the NMZ (section 5.3).

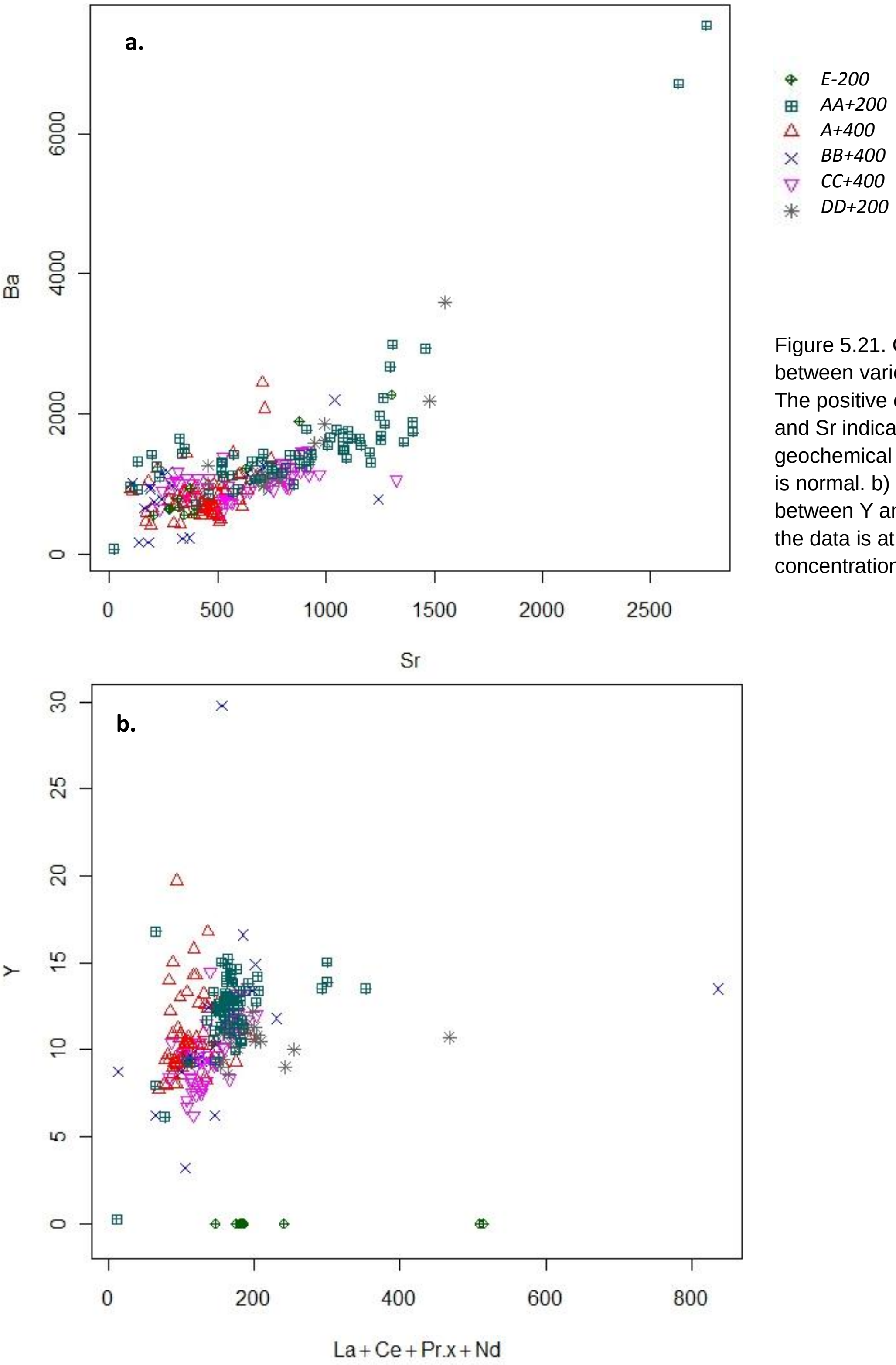


Figure 5.21. Correlation plots between various minor elements. a) The positive correlation between Ba and Sr indicates that the geochemical data is reliable, as this is normal. b) A poor correlation between Y and LREE indicates that the data is at very low concentration levels (Pr.x = Pr).

5.6 Discussion

Geochemical data show that rocks are highly altered therefore the modal classification will be used to classify the rocks. Discrimination diagrams of both the MZ and the NMZ display that the the Riviera pluton is subduction-related, although the effect of hydrothermal alteration is evident as there are overlaps in other fields of the discrimination diagrams. Discrimination diagrams provide a clear distinction between the MZ and NMZ, and indicate that trace elements from the NMZ give more reliable information when it comes to discrimination and classification diagrams. Trace elements like Rb, Ga, Zr and Nb can possibly be used for classification of this pluton. Ce and Y in the NMZ are also reliable and therefore also indicate that REE are not enriched in the NMZ.

A-type discrimination diagrams of the NMZ strongly suggest a late differentiated A-type nature of the pluton, which is possibly the identified late AMG phase. The QPMG and BMG is probably more I-type in nature but due to the effect of hydrothermal alteration on geochemical data, it is simply impossible to determine this using geochemical data.

Potassic, phyllic, argillic and advanced argillic alteration, and silicification are evident. All borehole intersections display a degree of alteration that is more than that of the Alteration Index of a typical granite. The Alteration Index was plotted for the respective boreholes and shows an increase with depth in the pluton. This is in accordance with the fact that skarn occurs mostly in the granite cupola of the pluton, with lower intensity forms of alteration (like phyllic alteration) being more pronounced at depth. The AL is limited in giving an estimation where phyllic, argillic and potassic alteration is distinctly situated, however, it can give a good estimation of where the skarn zone is situated. The lower the index (closer to 0%), the greater the chance of skarn being present and it being situated to the roof of the granite cupola. Significant enrichment is associated with lower alteration indices; thus enrichment is mainly restricted to locations where skarnification took place.

Vertical distribution down-the-hole plots were used to look at each geochemical element throughout the depth of each respective borehole. In comparison with average background values of the various elements of a typical granite, the MZ showed enriched concentrations of elements like K, Ca, Fe, Mg, Mn, Ti, Ba, Sr, Y, Y, Rb, W, REE and S. Na and Nb are depleted in the MZ, and Si, P and Al display normal background concentrations. Elements like K, Ba, W and S display enriched concentrations in the NMZ, whereas Na, P, Ti, Nb and Y are depleted. Si, Al, Sr, Rb and REE display normal background concentrations.

In the MZ lies the bulk of the enrichment, within 160m from the granite wall-rock contact. Calcic skarn minerals, carbonates, sulphides, potassic alteration products and secondary white mica are abundant in this zone. Y and REE show a correlation and are both enriched in this zone. Enriched concentrations of Ba are associated with secondary white mica, Sr with Ca-minerals, and U correlates with REE and indicates that allanite contains a significant amount of U. Weak correlations between W, Mo and REE enrichment indicates that they are not spatially or temporally related. In terms of the genesis of the deposit this implies multiple enrichment events rather than a distinct event. Some overlaps with W and REE enrichment are mineralogically seen as skarnified granite patches.

Enrichment in the MZ is associated with alteration in the sense that in the low grade W zone, enrichment is restricted to endoskarn, whereas with medium- and high W grade zones it is also associated with other types of alteration and occurs sporadically outside the MZ as well. W occurs almost exclusively in the restricted skarn zone (roof of the granite cupola), although sporadic occurences outside of the skarn zone in the medium grade W zone can occur. LREE enrichment occurs sporadically throughout the pluton which implies that it is a late stage phenomenon and is superimposed on previous phases of W enrichment. Mo occurs sporadically throughout the pluton and do not spatially correlate with W and LREE enrichment. There is no disctinct association of Mo with the skarn zone as it is rarely observed in this zone. This was seen geochemically as well. Mo is also less abundant in terms of concentration compared to W and REE enrichment.

The NMZ contains more primary minerals that represent the fresh rock more closely, although the rocks are still significantly altered. A substantial decrease in enrichment is seen. Sporadic occurrences of allanite, scheelite and other ore minerals have been observed in the NMZ. Albitization is more prominent in the NMZ than the MZ which is associated locally with abundant secondary large white mica grains and enriched Ba concentrations.

Chapter 6 - REE minerals and Geochemistry

This chapter describes the main REE-bearing mineral phases through data that have been obtained by ICP MS and also SEM analysis and optical microscopy. The focus of this chapter is on allanite, the most abundant REE-bearing mineral, which was examined in terms of its distinguishing characteristics in the Riviera pluton, its REE, the variability of REE and trace elements across traverses of single grains, and the difference in the REE pattern amongst grains from different borehole intersections. REE are also found in bastnaesite, titanite, scheelite and apatite, although their contributions are insignificant compared to allanite. Special reference was made however to the relationship between allanite and bastnaesite.

ICP MS trace element data were used to determine if any zonation is present in allanite, and to determine the variability in allanite's mineral chemistry. Different allanite phases were distinguished. These phases were examined to see how they relate to the paragenetic sequence.

Based on major and trace whole-rock data from borehole intersections A+400, BB+400, CC+400, DD+200, E-200 and AA+200, as well as trace element data from BB+200, BB+300, BBCC+350 and CC+200 a spider diagram and La-Ce-Nd ternary diagram were created. Chondrite-normalized REE profiles from different borehole intersections (BB+200, BB+300, BBCC+350 and CC+200 additional to the above-mentioned) were also compared to each other from both the MZ and the NMZ. Chondrite values from McDonough W. F. and Sun S.S. (1995) were used.

The Eu-anomaly (Eu/Eu*) was calculated using the following formula (Winter, 2010):

$$\frac{Eu}{Eu}* = \frac{Eu}{\sqrt{(Sm).(Gd)}}$$

6.1 Characteristics of allanite

Allanite, a LREE-enriched member of the epidote group, is the principal host mineral for LREE and occurs mostly within the high grade tungsten endoskarn part of the deposit, towards the apex of the granite cupola. The most common types are ferriallanite and allanite-Ce (Gieré & Sorenson, 2004). The mineral formula of allanite in this pluton is $(RE_{0\cdot 08\text{-}0.21})$ $(Al_{1.72\text{-}2.06})$ $(Fe_{0.99\text{-}1.40})$ $(Ti_{0\text{-}0.04})$ $(Mn_{0.02\text{-}0.15})$ $(Mg_{0.02\text{-}0.12})$ $(Ca_{1.20\text{-}1.76})$ $((SiO_4)_{3.02\text{-}3.16})$.

Allanite is a complex mineral in terms of its textural features such as intergrowths, irregular zonation patterns, replacement and metamictization as well as a non-uniform grain size distribution. The mineral chemistry of allanite is also highly variable and irregular throughout a single grain (Figure 6.8 to 11). The variable mineral chemistry is mainly a function of the LREE and U and Th and will be discussed in detail in the next section.

Allanite has a distinctive light- to dark brown colour (in PPL) and is strongly pleochroic. A poikilitic and/or patchy texture of allanite (Figure 6.1 and 6.2) is common. A wide variety of inclusions are found in allanite ranging from quartz, carbonates (ankerite and bastnaesite), a few rare occurrences of monazite, pure apatite as well as a LREE-enriched apatite, epidote and titanite (Figure 6.6). The presence of radioactive elements such as U and Th makes allanite susceptible to metamictization which has been observed (Figure 6.2.d) (Giere & Sorenson, 2004) as isotropic allanite grains (Figure 6.1.a and c). Allanite very rarely displays concentric zoning (growth zoning) as in Figure 6.2.a, although patchy zoning due to differing concentrations of LREE-enrichment (Figure 6.2.c) is common. Zoning of allanite will be discussed under the mineral chemistry of allanite (section 6.2).

The matrix around allanite grains are normally quartz, epidote, apatite, altered plagioclase feldspar, pyrite, secondary white mica, titanite, carbonates (ankerite), primary altered and secondary alkali feldspar, and chlorite (Figure 6.1). Allanite seems to have no apparent close associates except in some cases bastnaesite, anorthitic plagioclase feldspar, scheelite and pyrite due to the mutual grain boundaries (Figure 6.1 and 6.2).

Allanite usually occurs in close proximity to endoskarn throughout the extent of the deposit, although other random occurrences of allanite are found elsewhere in the skarnified granite zones. On a smaller scale, allanite occurs adjacent to altered plagioclase feldspar in many samples (Figure 6.1. and 6.2).

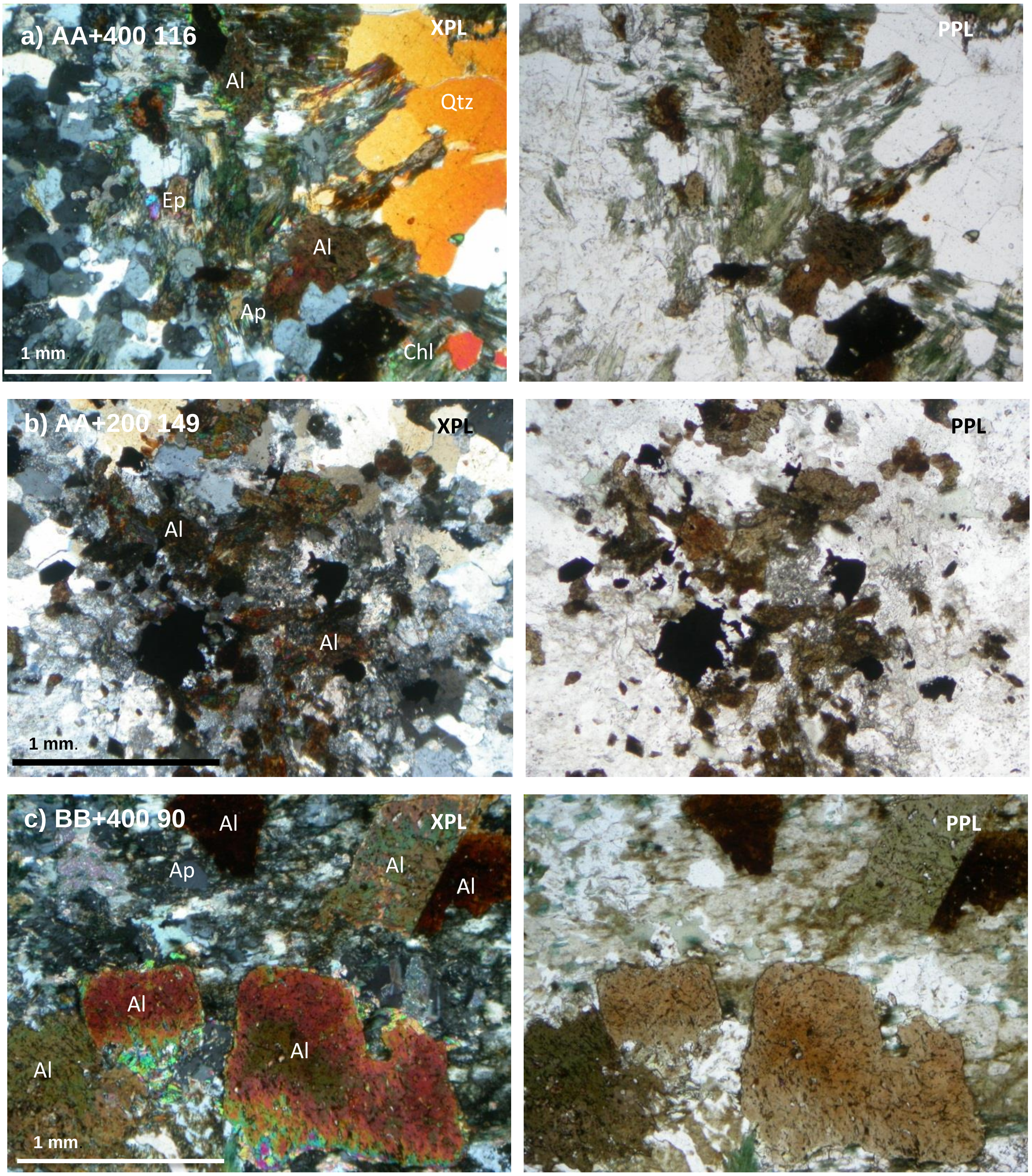


Figure 6.1. Photomicrographs showing the salient features of allanite. a) Subhedral crystals of allanite surrounded by epidote, chlorite, primary and cryptocrystalline quartz and apatite. b) Euhedral to subhedral allanite grains in altered plagioclase feldspar. Note the diffuse boundaries. c) Allanite in the high grade W zone. Note the poikilitic texture and the light to dark brown colour. Zoning is also observed in these grains. Metamict allanite are observed as the isotropic grains in the top half of the image.

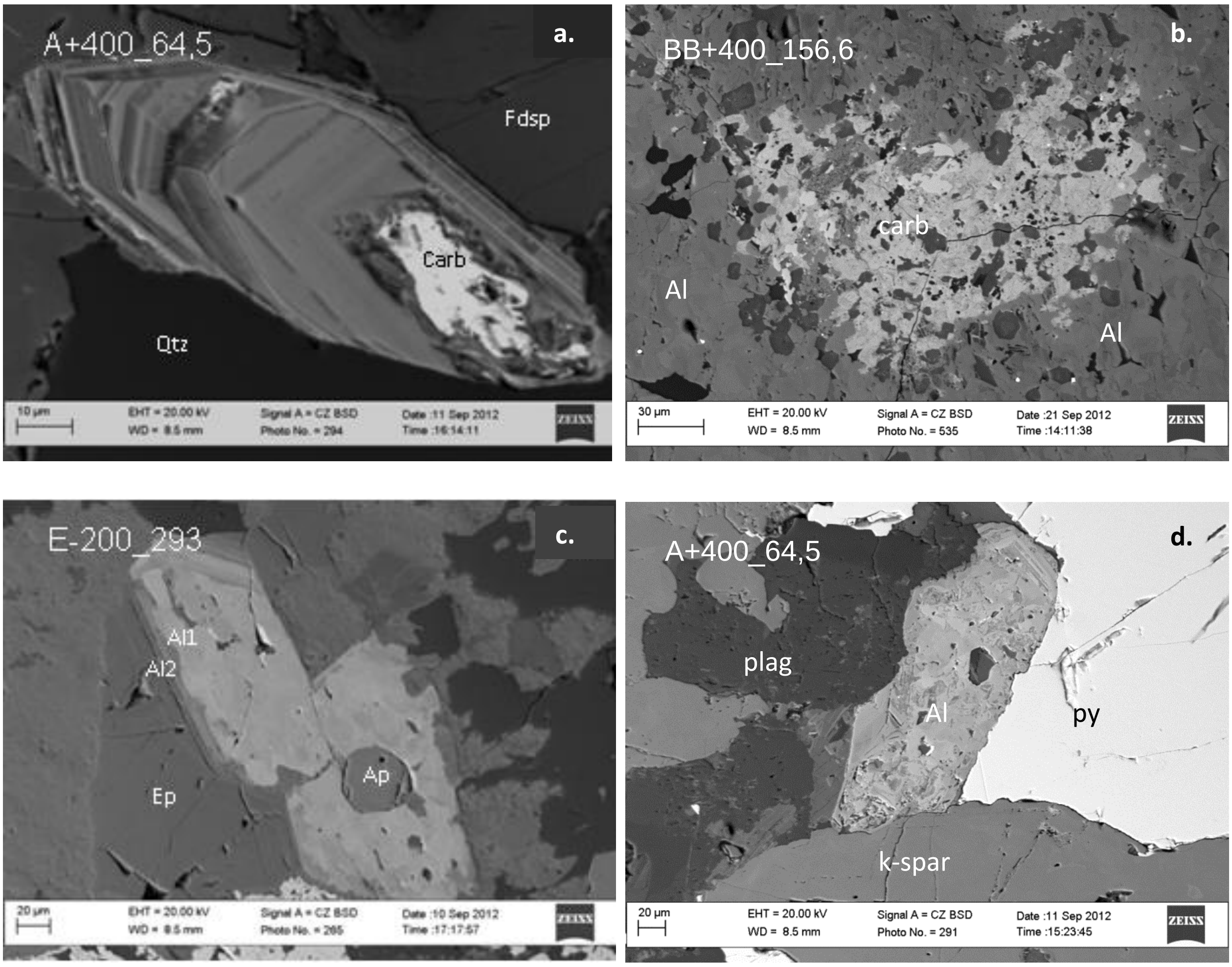


Figure 6.2. BSE images of allanite. a) Allanite displaying concentric zoning. This is in the low grade W zone. b) Bastnaesite surrounded by allanite. This image illustrates the relationship between the two LREE-bearing minerals; bastnaesite is normally in the centre of larger allanite grains with a highly irregular replacement type boundary separating them. Also refer to Figure (a). c) Allanite has varying concentrations of LREE-enrichment. Note the zoning at the top edge of the grain and the irregular patchy zoning within the grain which illustrates two zonation phases; the first one being concentric metasomatic zoning as in (a) and the second one overprinted the first one with the influx of hydrothermal fluids in a patchy-like appearance. The distinct epidote rim surrounding allanite is common. d) Allanite with a metamict texture sharing a mutual grain boundary with pyrite, altered plagioclase feldspar and alkali feldspar.

In terms of grain size allanite varies quite substantially, from a few millimeters to a few hundred microns (Figure 6.3). On average, allanite is typically medium-grained. The shape ranges from mostly anhedral or irregular to subhedral, with few occurrences of euhedral crystals (Figure 6.2.a). Some crystals are also sub-rounded, or even elongated in shape. It is quite easily recognized by not having a distinctive shape, pleochroism, high relief, dark colour, and metamict features. The boundaries are mostly diffuse in thin-section (Figure 6.1.a and Figure 6.1.b); however a few grains have sharp boundaries with a dark rim (BSE images). Dark rims of epidote around these grains are commonly seen (Figure 6.2.a and c).

The grain size distribution of four borehole intersections (A+400, AA+400, BB+400 and E-200) indicates a trend with an estimated long axis to short axis ratio of 2:1. These dimensions are compatible with the monoclinic crystallographic shape of originally euhedral allanite (or epidote) grains. An exception to this trend is in borehole AA+400 where grain shape is generally anhedral and significantly smaller, but more elongate. Synoptic diagrams (Figure 6.3.b) illustrate that the bulk of the grain sizes are between 30 and 150 microns with a significant amount of grains larger than 300 microns. The distribution is right-skewed as there is a natural limit to the size of bigger allanite grains in this deposit. According to the statistics the average grain size is 224 by 129, and the median is 160 by 80 microns (Table 6.1). Due to variability the grain sizes are likely to deviate from the norm as indicated by a large standard deviation. This is also shown by a discontinuous cumulative frequency curve as a result of the inconsistent grain size (Figure 6.3.b).

Table 6.1 - General statistics on the grain size distribution of allanite (n=268).

	Long axis (µm)	**Short axis (µm)**
Min	10	3
Max	1400	900
Average	223.67	129.16
Median	160	80
Standard deviation	211.30	139.40

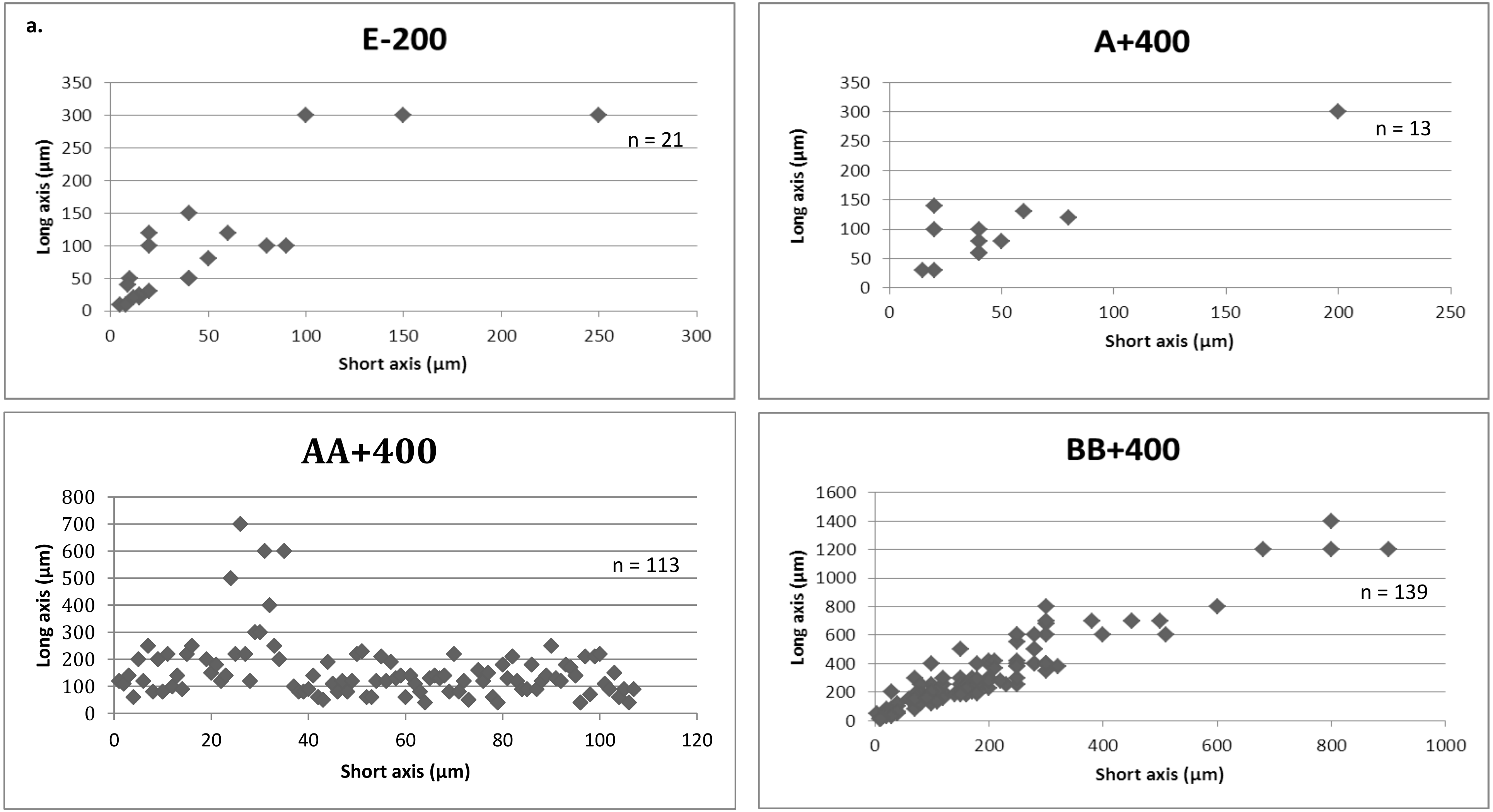
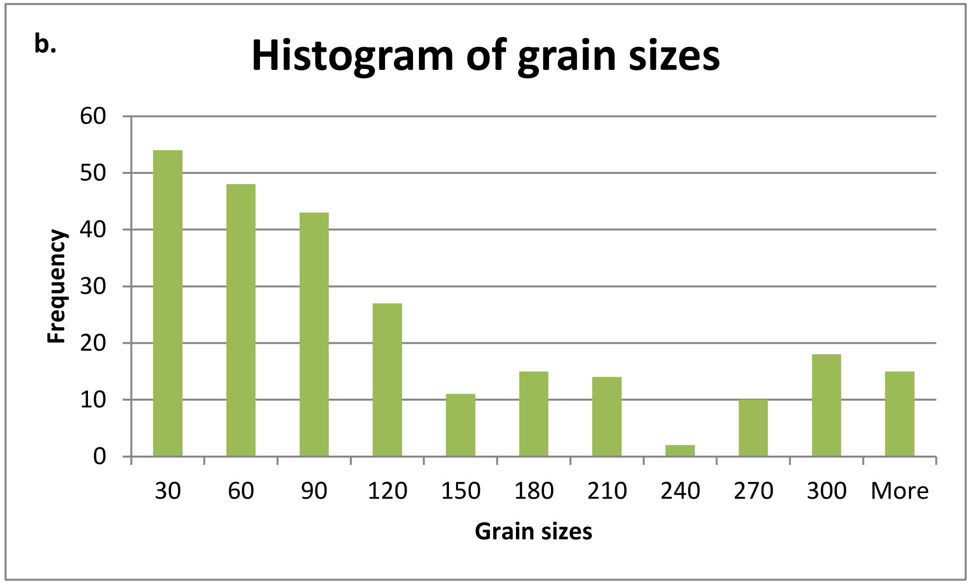


Figure 6.3. Grain size distribution of allanite in borehole intersections, E-200, A+400, AA+400 and BB+400. a) Trends reflected by these four boreholes show a relatively constant ratio of 1:2 (except borehole AA+400).



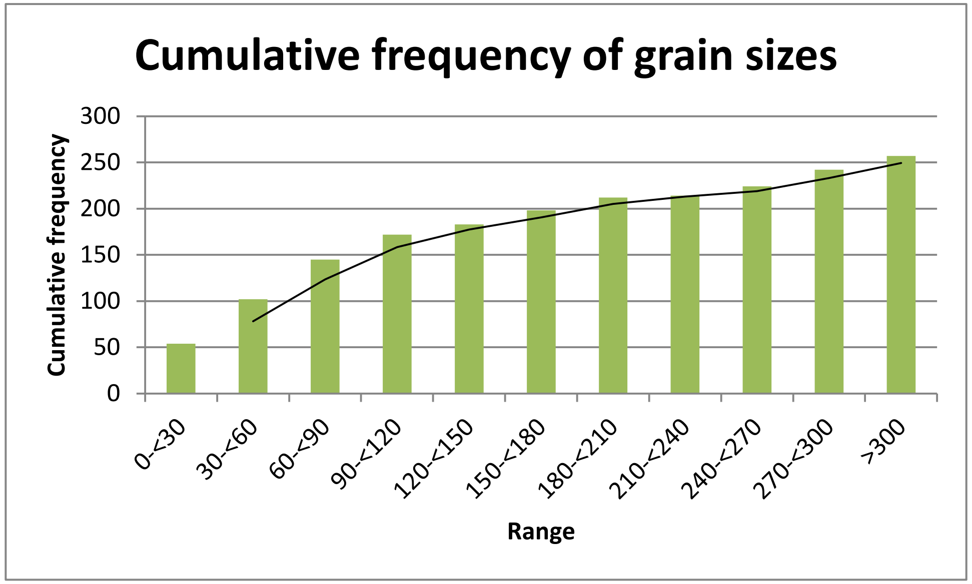


Figure 6.3 continued. b) These synoptic diagrams illustrate that the bulk of the grain sizes are between 30 and 150 microns with a significant amount of grains larger than 300 microns. These diagrams are based on the short axis of allanite.

6.2 Mineral chemistry

In the epidote structure LREE favour the site in the crystal structure which Ca typically occupies in epidote, therefore LREE replace Ca in epidote to form allanite (Gieré & Sorenson, 2004).The diagram below (Figure 6.4) illustrates the relationship between the major elements (FeO, CaO and MgO) and ΣLREE of allanite. Higher concentrations of LREE correlate with relatively higher concentrations of FeO (and MgO) which confirms that LREE replace Ca in the crystal structure of epidote rather than FeO or MgO. Aluminium and iron do not take part in ionic exchange with LREE, therefore they display a relatively constant ratio (Figure 6.4.b), with only the amount of ΣLREE differing within allanite.

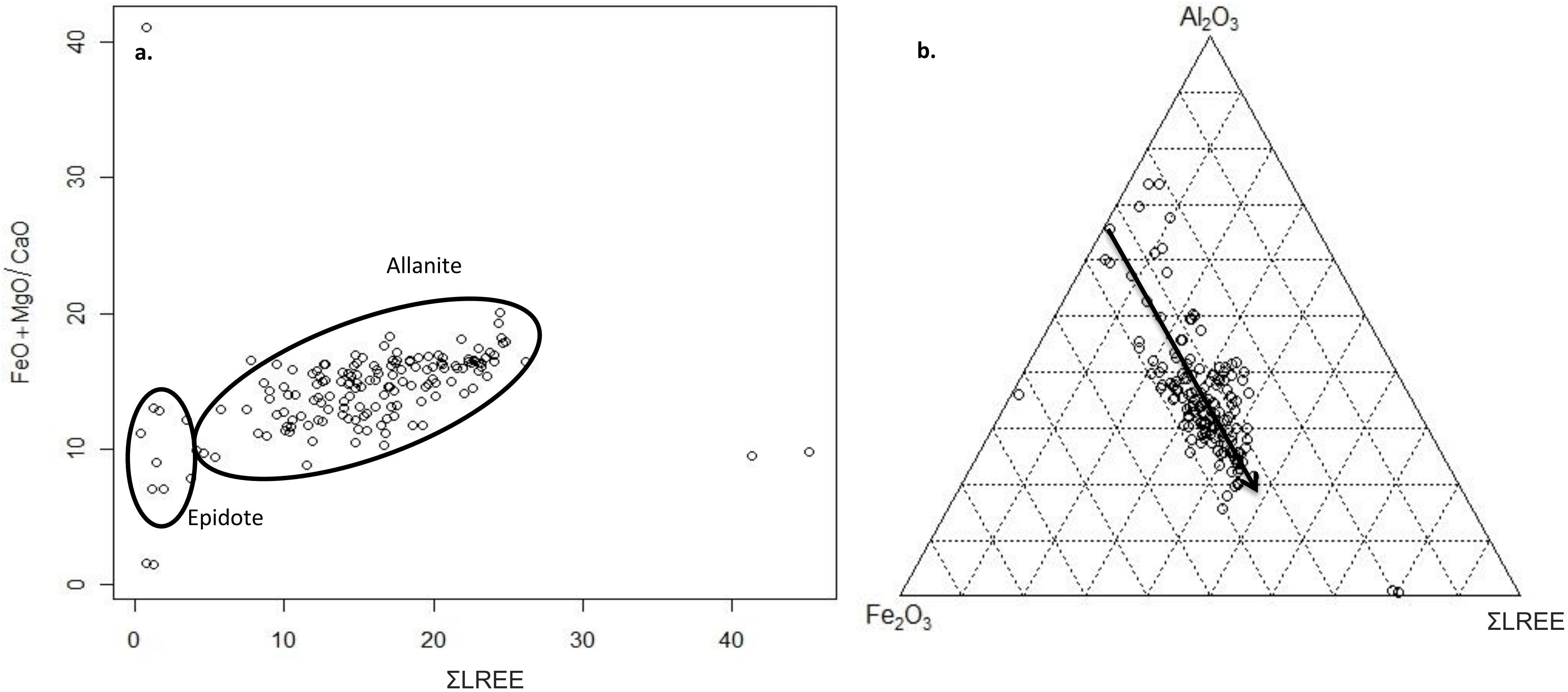
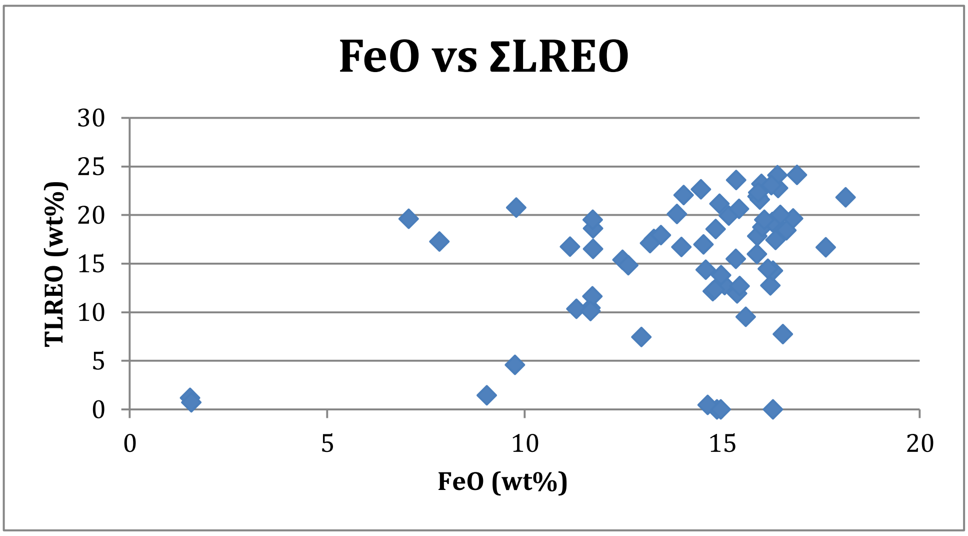


Figure 6.4. These diagrams display some of the mineral chemistry attributes of allanite. a) This diagram illustrates the relationship between the major element oxides (%) associated with allanite and the ΣLREE (ppm). Ca decreases as the ΣLREE increases (n=157). b) The Fe/Al ratio deviates in some cases significantly from the arrow, which suggests that allanite is unstable (or metamict) (Deer et al, 1992). Most of the samples however remain relatively close to the arrow (n=157). (ΣLREE was used, because of the fact that allanite is LREE-enriched.)

Figure 6.5 reflects the absolute relationship between the ΣLREO and FeO, CaO, MgO and MnO respectively. No correlations between FeO, MgO and MnO with ΣLREO suggest that TLREO do not replace FeO, MgO and MnO in the crystal structure of allanite. A strong negative relationship between CaO and ΣLREO indicates that LREO typically replace CaO in the crystal structure of allanite in the Riviera pluton and supports previous findings.



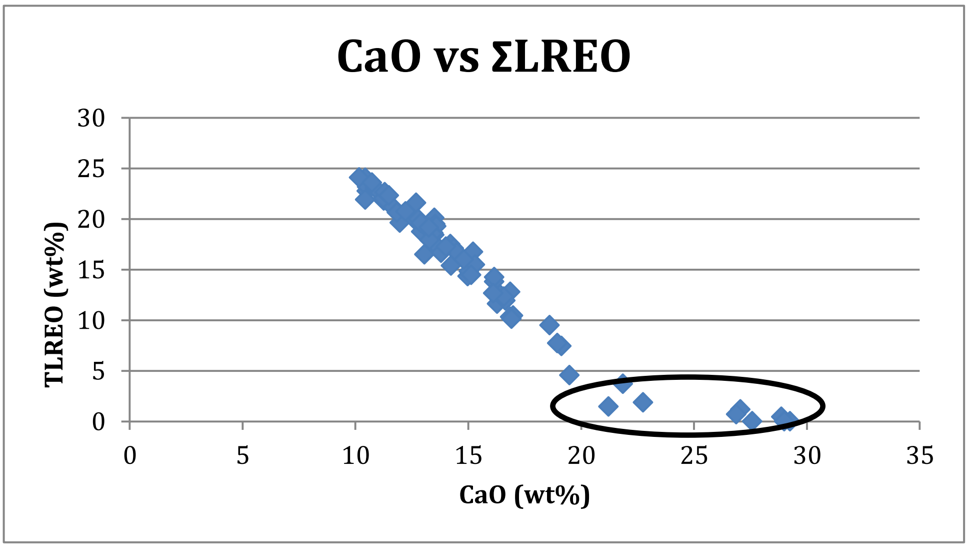
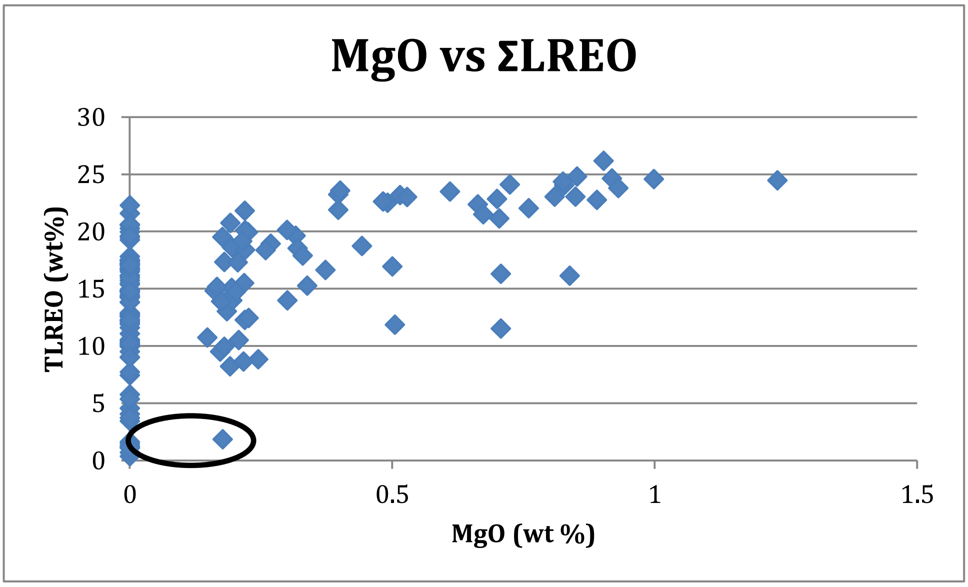


Figure 6.5. The relationship between FeO, CaO, MgO, MnO and the TLREO within allanite suggests that ΣLREO replaces CaO in the crystal structure of allanite (n=70). This is indicated by the strong negative correlation between ΣLREE and CaO. The black ellipse indicates epidote. (This data is based on SEM data).



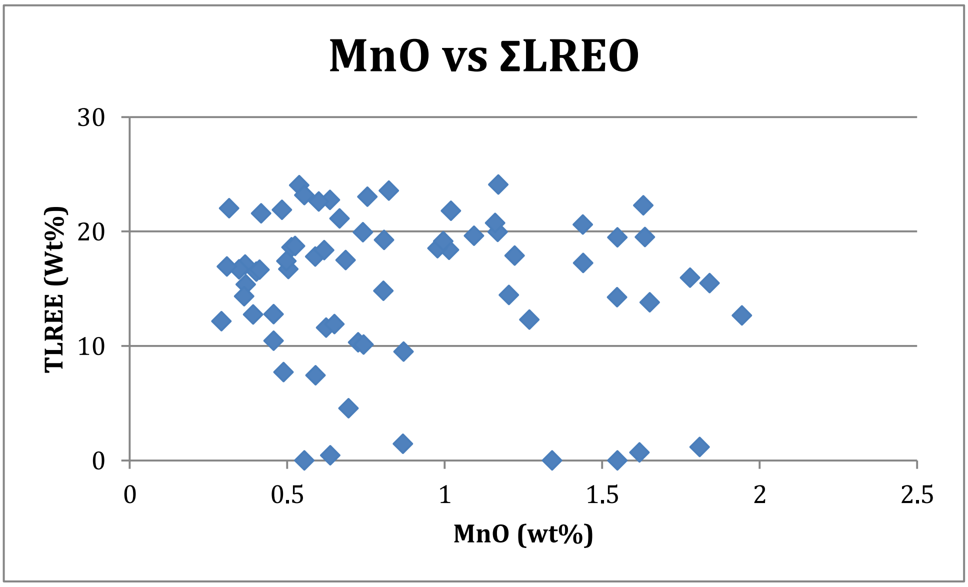


Figure 6.5 continued. ΣLREO was used, because these diagrams were constructed using SEM mineral chemistry data. LREE in allanite are reported as LREO. LREO includes Ce_2O_3, La_2O_3, Pr_2O_3 and Nd_2O_3.

Table 6.2. Chemical composition of allanite (in wt %). These results were obtained using a scanning electron microscope (SEM). Allanite can contain up to 25% REO. Water was not measured; therefore some total values are low. The alteration of allanite causes Fe to become oxidized, and because it is reported in its reduced form (FeO), low analytical totals result (Poitrasson, 2002).

	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	La_2O_3	Ce_2O_3	Pr_2O_3	Nd_2O_3	Total
Allanite	30.71	0.00	14.21	16.24	0.76	0.81	10.86	5.55	12.87	1.94	2.68	96.63
	31.82	0.00	16.76	15.17	0.74	0.23	12.61	5.31	11.23	1.78	1.62	97.25
	34.32	0.00	18.84	14.76	0.29	0.00	16.44	3.48	7.35	0.00	1.33	99.71
	33.58	0.00	17.88	16.22	0.39	0.00	16.31	3.48	7.09	0.74	1.44	100.80
	33.39	0.00	18.90	13.86	0.49	0.22	13.49	4.45	10.49	1.54	3.62	100.44
	34.83	0.00	19.96	14.97	0.46	0.00	16.14	3.29	7.17	0.98	2.38	100.17
	31.01	0.00	16.12	14.93	0.37	0.70	11.66	4.93	11.10	2.46	2.65	96.30
	32.10	0.00	15.95	16.54	0.53	0.26	13.28	4.63	9.36	2.07	2.32	97.04
	34.20	0.00	18.11	16.26	0.65	0.00	18.60	3.06	5.15	0.00	1.27	97.31
	33.42	0.22	17.50	15.60	1.27	0.00	16.63	3.61	6.60	0.00	1.71	96.56
	34.51	0.44	17.82	14.80	1.94	0.00	16.14	4.80	7.82	0.00	1.64	99.92
	32.52	0.34	18.55	12.62	1.20	0.00	15.29	4.97	8.27	0.00	2.25	96.01
	31.35	0.50	15.40	15.88	1.17	0.18	12.98	6.45	10.77	0.00	2.30	96.96
	31.06	0.51	15.14	16.06	1.01	0.00	12.78	6.37	11.19	0.00	2.41	96.54
	31.30	0.56	14.92	16.47	1.34	0.22	13.48	6.08	10.61	0.00	1.73	96.70
	31.23	0.47	16.00	14.63	1.63	0.32	13.41	5.93	10.51	0.00	2.10	96.22
	31.60	0.60	15.92	14.96	1.44	0.33	13.28	5.65	10.36	0.00	1.90	96.03

Table 6.3 Trace element composition of allanite (ppm). These results were obtained using LA ICP MS. When compared to the whole rock data (see appendix), all elements, except Zr and Ba in a few cases display concentrations that are less than the values reported below. Allanite is significantly enriched in REE, Sr, U and Th compared to the whole-rock data.

	Sc	Ga	Ge	Sr	Zr	Ba	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Pb	Th	U
AA+400 137.5	7.76	268.19	239.36	3998.96	13.59	362.91	47342.81	69074.23	5538.58	16062.80	1105.90	273.68	595.72	33.96	101.50	13.98	22.55	2.45	12.94	1.48	31.07	369.59	101.39
	7.09	280.68	217.21	3721.17	11.73	386.67	53449.86	71329.91	5207.49	13812.38	799.06	188.53	477.04	26.04	77.04	10.39	20.48	2.06	10.40	1.02	25.41	242.99	135.82
	10.27	291.96	214.72	4324.30	38.08	384.77	52761.83	70634.19	5208.11	13984.50	799.79	194.27	479.23	24.61	74.33	10.34	21.16	2.00	12.58	1.82	26.44	281.77	137.68
	7.01	263.68	224.72	3505.32	10.39	372.39	52046.73	70466.38	5222.41	14229.29	860.64	218.74	506.89	27.37	85.68	11.44	20.36	2.31	11.89	1.34	26.03	279.66	100.99
	7.93	268.61	226.55	3182.29	11.07	376.64	53235.17	71594.74	5434.21	14906.88	1003.99	258.46	581.65	34.43	121.17	18.19	36.55	4.28	21.27	1.87	29.28	328.74	194.77
AA+400 127	166.21	605.35	202.67	3278.15	21.99	5107.35	22400.32	36147.53	3416.18	11990.94	1282.12	267.45	487.23	31.50	112.56	15.91	35.60	6.05	45.42	6.46	248.75	2644.31	437.73
	145.00	405.85	209.48	3343.71	33.21	1728.41	33145.89	49425.42	4157.60	12811.88	992.15	254.82	445.10	28.59	111.06	16.45	39.74	6.50	57.46	7.82	329.24	3882.99	503.23
	125.29	456.54	273.39	4974.13	13.60	2298.12	54100.98	74741.95	5891.42	16620.88	1080.87	212.94	536.41	32.48	96.04	14.15	31.22	4.11	29.60	8.54	316.49	4406.96	151.81
	115.72	299.78	264.75	3244.64	9.35	545.59	53291.25	75475.16	5955.52	17126.39	1146.94	236.02	575.40	33.43	112.26	15.61	29.57	3.87	19.59	3.09	253.35	3840.76	220.09
	120.68	420.45	275.79	5428.34	20.06	2224.92	42339.88	63867.39	5290.69	16698.81	1309.54	249.14	673.14	48.95	192.02	28.89	64.12	8.00	54.78	7.16	598.18	8317.71	285.50
	31.39	309.80	220.41	2332.09	15.86	512.84	39273.46	55437.91	4469.69	13214.43	1014.88	260.28	543.15	40.23	146.33	21.69	41.96	4.77	25.71	3.14	188.87	2818.70	422.55
BB+400 156.6	6.40	207.58	157.41	6174.92	15.18	205.40	26099.37	39102.97	3227.92	10042.85	685.05	156.83	300.80	14.99	29.49	2.08	2.33	0.20	0.49	<0.125	31.36	238.24	305.93
	8.87	273.44	241.00	3163.28	13.08	324.02	39466.23	61572.34	5362.16	15797.81	1201.15	280.17	584.74	36.15	109.29	13.52	24.68	2.50	16.22	1.87	34.17	358.17	248.72
	9.19	296.68	207.60	2002.11	11.25	301.21	30629.19	48999.02	4224.66	13129.39	1025.62	255.36	531.65	39.96	157.19	22.54	44.68	4.79	31.04	4.25	36.30	306.05	339.29
	8.07	258.24	212.43	3034.47	9.41	281.45	35785.63	54431.43	4569.24	13832.08	1076.19	249.12	531.01	35.80	119.40	15.24	29.16	3.16	16.96	2.18	28.43	292.21	272.94
	19.90	296.04	207.67	2816.19	17.79	296.39	29898.22	47965.14	4157.78	12975.50	1017.67	257.98	502.57	36.17	129.14	17.30	35.51	4.10	25.31	3.51	37.99	383.57	1399.18

AA+400 145.5	1068.75	78.06	250.22	1805.68	4108.16	70.26	7068.66	14180.91	1786.51	7506.78	2720.33	721.25	4273.95	980.77	7401.78	1649.07	4800.66	715.22	4760.05	638.80	63.54	848.74	905.32
	846.32	67.51	275.87	691.16	2134.49	53.58	2872.24	10956.64	1763.08	7910.83	1574.23	858.74	1423.22	253.36	1824.93	413.70	1279.05	211.84	1668.93	247.07	54.78	657.06	1052.85
	631.89	79.02	262.20	772.20	1711.97	59.92	3916.51	12445.13	1856.89	7944.85	1894.38	909.68	2213.14	457.70	3424.39	760.53	2294.45	390.31	2942.26	443.39	75.25	1070.28	1809.47
	805.19	92.71	311.70	1590.87	1998.61	185.90	8382.95	20129.97	2697.98	10110.83	1458.77	504.70	1051.45	165.50	1095.26	240.00	733.63	128.13	945.52	138.07	109.00	1146.42	2083.23
	1038.64	135.69	477.40	4144.34	2062.85	239.24	20525.14	47207.84	6197.39	24183.67	3483.12	660.13	2393.83	352.53	2296.18	496.43	1436.89	226.96	1605.39	222.46	161.55	1468.11	1307.88
BB+400 90	25.08	318.11	343.27	7053.98	11.72	906.39	57961.00	91411.16	7749.58	22874.06	1597.66	384.77	695.11	42.03	152.94	24.28	59.69	7.63	47.94	6.38	30.48	361.43	76.92
	46.13	308.01	318.63	3941.86	9.75	569.30	67638.59	102128.16	8209.87	22951.96	1500.04	375.66	702.30	44.51	156.89	24.33	57.45	7.64	51.96	7.24	27.53	252.36	150.19
	10.26	220.40	283.76	8763.36	17.40	410.11	47180.51	78203.08	6611.89	19570.16	1222.95	263.98	478.79	21.44	51.97	6.04	10.74	1.17	9.26	1.35	41.92	224.86	40.80
	38.87	274.93	314.93	5764.91	13.00	556.73	69194.81	104575.23	8264.18	22646.40	1248.71	235.38	503.23	24.45	64.12	8.76	18.90	2.52	18.48	2.85	35.96	276.87	32.61
	5.99	220.31	169.93	5564.85	13.44	235.96	28584.24	43328.36	3570.85	11124.50	707.82	183.81	297.46	16.62	53.41	7.26	14.04	1.48	7.59	0.63	31.88	213.50	309.12
	6.68	250.26	201.90	4738.59	12.35	366.76	38191.46	57294.77	4787.42	13814.52	905.07	231.27	366.46	20.50	63.60	7.01	12.53	1.17	5.53	0.67	29.67	271.18	255.61
E-200 86.66	91.94	388.42	686.86	12832.87	29.56	471.66	40936.03	35904.24	2879.26	8571.73	707.26	228.83	311.13	21.85	72.83	10.35	15.04	0.95	9.29	0.67	50.43	21.75	300.62
	4.95	293.46	182.67	4163.81	10.95	290.35	46268.26	40815.62	3150.62	9575.73	770.82	284.09	371.43	24.68	83.24	10.59	15.03	0.96	2.27	0.18	1.20	25.94	333.14
	3.34	299.59	164.11	4728.46	10.25	251.32	50318.28	43240.19	3260.10	10010.02	787.78	289.83	384.22	25.44	80.40	10.52	15.19	1.14	3.43	0.10	10.36	25.30	274.20
	4.43	307.40	171.69	3579.58	11.93	252.06	48719.97	42858.51	3267.03	10056.49	763.03	282.94	369.07	24.78	79.63	10.47	14.27	1.14	1.91	0.12	12.00	28.11	250.93
	3.36	319.88	168.72	5994.47	7.07	301.32	64423.96	51694.15	3625.75	10265.34	707.68	285.64	360.49	21.81	69.47	8.50	11.29	0.71	1.20	0.07	6.39	9.36	186.98
	2.75	283.72	139.99	6125.34	4.92	274.84	57693.46	44361.99	3104.35	9035.94	587.34	209.96	273.80	15.18	44.51	4.37	5.95	0.37	0.78	0.06	9.16	15.30	211.95
	2.73	302.61	150.57	5944.30	5.11	281.74	61370.32	48335.13	3428.51	9841.74	669.07	224.29	303.54	16.78	45.14	4.72	6.05	0.25	0.89	0.01	11.04	19.28	199.94

E-200 304	75.95	67.59	216.75	2003.40	7155.40	150.45	924.98	4533.02	1049.38	7743.01	3478.29	833.48	3058.56	410.48	2276.01	423.21	1118.19	145.43	889.69	86.50	19.65	179.25	1610.08
	105.11	150.55	209.82	2141.41	9.37	251.30	27898.39	51007.61	4990.16	15759.16	1462.05	150.49	605.71	44.18	132.90	16.25	27.59	3.10	18.25	2.52	94.31	1418.01	68.80
	226.62	278.49	630.65	1482.70	4.20	812.12	85635.22	161387.45	16174.81	51031.40	5006.04	445.50	2113.63	164.45	545.52	70.38	132.63	14.20	89.38	12.55	247.54	3797.34	90.50
	297.75	252.49	518.48	2242.91	10.43	826.40	67858.37	126525.66	12596.53	40847.73	4122.63	366.81	1823.26	151.64	552.08	73.52	142.82	17.07	118.72	16.44	249.16	4304.64	108.06
	269.15	170.93	367.24	3509.10	7.15	508.69	45932.03	83690.43	8563.51	28723.22	3225.32	301.00	1324.89	98.22	319.18	37.95	66.01	8.18	48.27	7.51	193.48	3507.33	59.30
E-200 293	6.26	292.01	237.43	2141.52	5.80	225.58	28336.92	48038.54	4686.03	15795.20	1374.23	201.44	567.62	36.85	113.93	14.17	24.98	2.60	14.43	2.03	29.70	449.15	311.23
	5.22	208.31	360.94	2378.41	6.28	384.91	47982.70	80508.51	7852.99	26312.96	2336.49	346.64	892.24	57.48	177.42	21.01	37.86	4.58	27.17	3.19	54.95	822.58	161.21
	4.93	254.53	450.43	2920.29	6.23	648.39	61707.01	102673.59	10268.85	34266.83	2982.31	444.38	1174.83	74.00	233.83	28.69	50.82	5.09	28.20	3.43	57.93	1156.87	418.85
	5.40	218.75	223.67	3674.62	10.54	258.71	27551.35	45701.23	4370.74	15010.62	1342.41	233.41	544.99	37.27	121.43	15.70	25.16	2.37	15.20	1.88	41.33	464.74	293.97
	6.24	228.02	404.41	2470.17	5.60	467.06	57754.18	95197.31	9235.44	30754.16	2555.30	365.45	961.61	61.37	185.98	22.02	38.74	4.34	24.12	2.67	67.08	1034.30	256.02
	6.55	213.98	265.85	2200.29	6.53	332.84	43573.15	66895.59	6303.66	20210.82	1671.58	255.86	648.71	42.04	125.10	14.92	27.77	2.88	18.05	2.17	39.01	571.87	111.30

Bastnaesite is also a LREE-bearing phase in the Riviera deposit, although its occurrence is sporadic and negligible. It is usually associated with allanite (Figure 6.2.b) but has a much higher concentration of LREE (Table 6.4). Bastnaesite formed first and due to both bastnaesite and allanite being able to host Ca and LREE, allanite replaced pre-existing bastnaesite (Figure 6.6).

Table 6.4. Chemical composition of bastnaesite (carb) and LREE-enriched apatite (ap) (wt %). These results were obtained using the SEM. Bastnaesite can contain up to 61% REE. Water was not measured therefore some total values appear low.

	F	Al	P	Ca	Fe	Y	La	Ce	Pr	Nd	W	U	O	Total
Carb	6.56	0.00	1.51	8.51	0.00	0.87	11.26	28.38	4.14	7.71	0.97	0.87	14.80	85.58
Carb	8.85	0.14	0.00	3.83	0.00	1.17	12.24	32.77	4.80	9.55	0.89	0.00	12.33	86.57
Carb	8.00	0.14	0.69	5.09	0.00	1.01	10.20	29.86	4.33	8.98	1.04	0.52	12.80	82.64
Carb	6.97	0.21	2.10	5.51	0.26	1.71	9.62	27.99	3.98	8.814	1.27	0.47	14.66	83.55
Carb	7.27	0.15	0.76	5.23	0.00	1.60	9.34	29.11	4.06	10.04	0.96	0.72	12.98	82.21
LREE_Ap	1.20	0.00	10.37	0.97	0.00	0.00	13.11	34.42	5.11	8.71	0.00	0.47	25.06	100.03

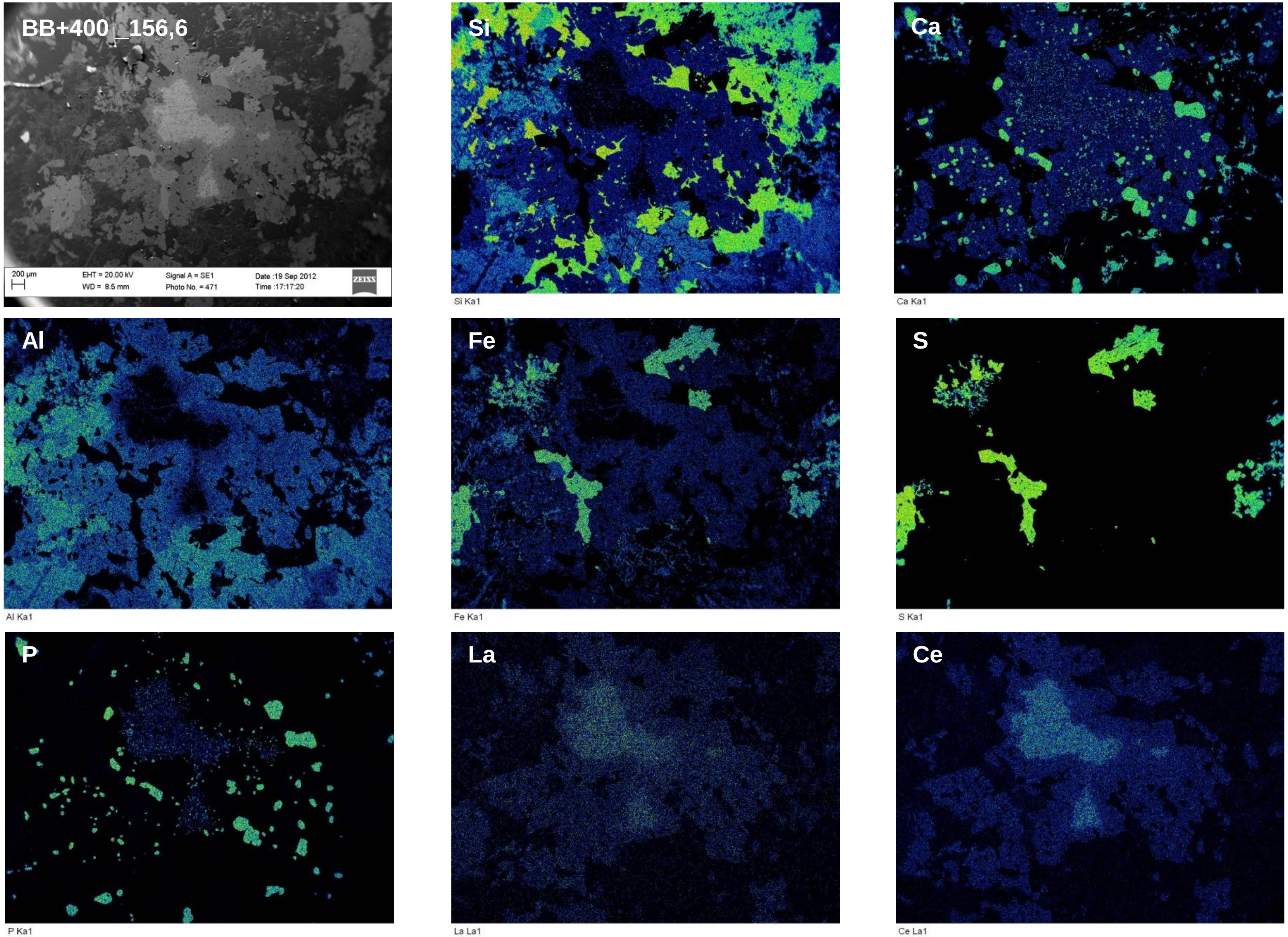


Figure 6.6. Qualitative geochemical maps of bastnaesite and allanite using SEM. These maps show the typical relationship between the two minerals and also their inclusions and neighbouring minerals. Inclusions are normally quartz, epidote and apatite, and neighbouring minerals include pyrite, quartz, feldspars. From this map it is clear that bastnaesite occurred first and was replaced by allanite. This is typical of the high grade W zone. Bright green is where the respective element is most abundant, blue where it is less abundant and black where it does not occur.

Table 6.5. The common REE and trace element characteristics of the high-, medium- and low-grade W zones. This information will be discussed in the following pages.

	E-200	**AA+400**	**BB+400**
Zone	Low grade W zone	Medium grade W zone	High grade W zone
Diagram(s)	Figure 5.3.10	Figure 5.3.8 Figure 5.3.9	Figure 5.3.11 (a) and (b)
Eu-anomaly	Strongly positive More positive in the centre of the grains	Slightly negative to neutral to slightly positive	Slightly positive (more common) to neutral
LREE-enrichment	Most LREE-enriched of all samples analysed	The LREE-enriched pattern is not as steep Of all the samples it is the less LREE-enriched sample	More LREE-enriched than AA+400, less than E-200 More HREE-enrichment in some samples
Zoning	Zoning is defined by the Eu-anomaly being more positive in the middle (more reduced core) towards an oxidized edge Eu-anomaly and TLREE show no relationship	Zoning is defined by the Eu-anomaly: oxidized core (Eu*<1) and a reduced rim (Eu*>1)	(a) Eu* and ΣLREE display opposite trends and U shows the same trend as ΣLREE (b) Eu* and ΣLREE, Th shows the same trend
U/Th	More U than Th Th displays no pattern U roughly displays the same pattern as the ΣLREE	More Th than U Th follows roughly same pattern as ΣLREE U follows opposite trend	Approximately same amounts of U and Th (or more Th than U) U and Th display opposite trends
Trace elements	Sr shows a significant variation that is roughly opposite to the U and TLREE pattern	Sr shows roughly an opposite trend to TLREE Sr can have the same pattern as U	Only Sr shows significant variation which is roughly opposite to ΣLREE pattern
Dominant LREE	3 groups: La-, Ce-, or Nd-enriched	Ce	Ce
Other	Not metamict	Figure 5.3.8 displays a metamict texture (Eu*<1, ΣLREE show opposite trend than Eu*, more Th and same trend as ΣLREE, no U, more variation in all trace elements except Zr)	Not metamict

The trace element distribution of various allanite grains from borehole intersections AA+400, BB+400 and E-200 display a strongly LREE-enriched signature (Figures 6.8 to 6.11). Chondrite-normalized REE patterns for the whole rock analyses (Figure 6.15), although of lower concentration, are similar to those of the single grains displayed below which confirm that most of the REE are hosted by allanite.

Figure 6.7 displays the major LREE content of allanite. Allanite is primarily Ce-dominant, whereas a few analyses show La- or Nd-enrichment. Samples from the high grade W zone (BB+400) are invariably Ce-dominant whereas samples from the lower grade W zones can be La- or Nd-rich as well (E-200 and AA+400). A few samples from borehole intersection E-200 have Ce=Nd with very low La.

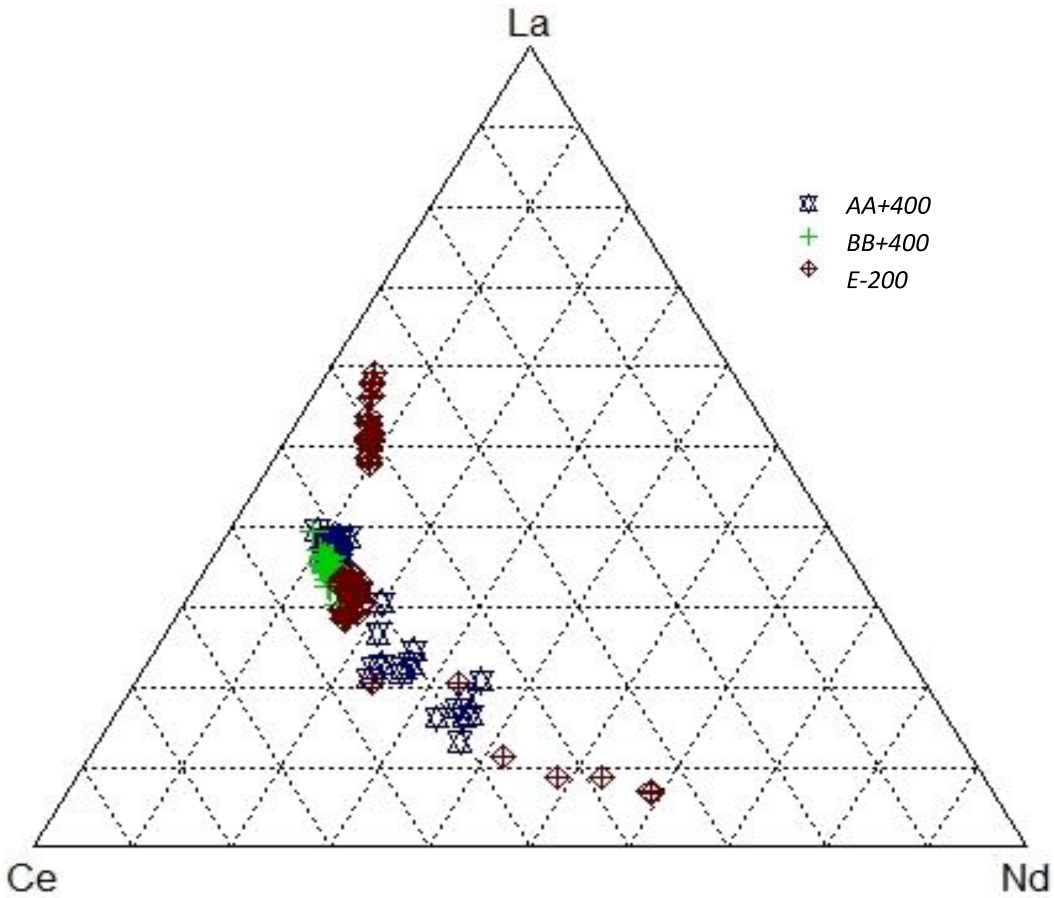


Figure 6.7. Ternary diagram of the major LREE elements (cerium, lanthanum and neodymium). This is based on the mineral chemistry of various allanite grains which are primarily Ce-dominant. A few grains from borehole intersections AA+400 and E-200 display a more La-rich or Nd-rich composition. Samples from E-200 also display Ce=Nd with low La (n=187).

Multiple analyses of traverses across single grains illustrate the irregular mineral chemistry within a single allanite grain (Figures 6.8 to 6.11). LREE profiles across single grains (edge to edge) (Figure 6.9) remain relatively constant, i.e the strong LREE-enriched nature is clear. REE profiles of the single allanite grains differ in the LREE versus HREE enrichment (the steepness of the slope of the profile) and some deviations in the HREE have been observed as well. However the absolute ΣLREE concentration throughout the traverse of a grain varies significantly (Figure 6.9.b). Other trace elements (U, Th, Sc, V, Cr, Zn, Ga, Ge, Sr, Zr and Ba) were also measured along the traverse of single grains with U, Th, Sr and in some cases V and Ba specifically showing considerable variation across a single grain.

Eu anomalies vary from slightly negative, to neutral to slightly positive. A high TLREE content of allanite correlates with a positive Eu-anomaly (Figure 6.10.a) whereas negative anomalies are associated with low concentrations of ΣLREE (Figure 6.8.a). The changing LREE concentrations in allanite reflect the redox condition of the fluids that carried REE (Poitrasson, 2002; Brugger et al, 2006). A later influx of hydrothermal fluids also overprinted previous allanite grains (Poitrasson, 2002) and compromised the amount of ΣLREE (steepness of pattern).

Eu-anomalies have a strong effect on the zonation of allanite, in the sense that the higher this anomaly (Eu*>1) the less LREE are associated with it, except in borehole E-200. Figure 6.10 shows a positive Eu-anomaly and the steepest LREE-enriched pattern of all the samples analysed. This is because a later influx of hydrothermal fluids could have remobilized LREE (Poitrasson, 2002) in the high and medium-grade W zone and deposited it on the periphery of the deposit (E-200). This has been observed by a resorbed allanite contact that has been overprinted by less LREE-enriched allanite and epidote rims (see Figure 6.12), and the steeper REE profile slope. The distinctly positive Eu-anomaly displays an opposite trend to what has been otherwise observed, by showing a relatively reduced core and a more oxidized rim. The strongly positive Eu-anomaly is indicative of a high concentration of ΣLREE and associated U which displays roughly the same pattern through the traverse of a single grain (Figure 6.10.c and d). It has been documented that it is possible for U in its 4+ oxidation state to come with the influx of later hydrothermal fluids (Poitrasson, 2002). The U and ΣLREE patterns can also be roughly opposite which may be attributed to the remnants of the primary signature.

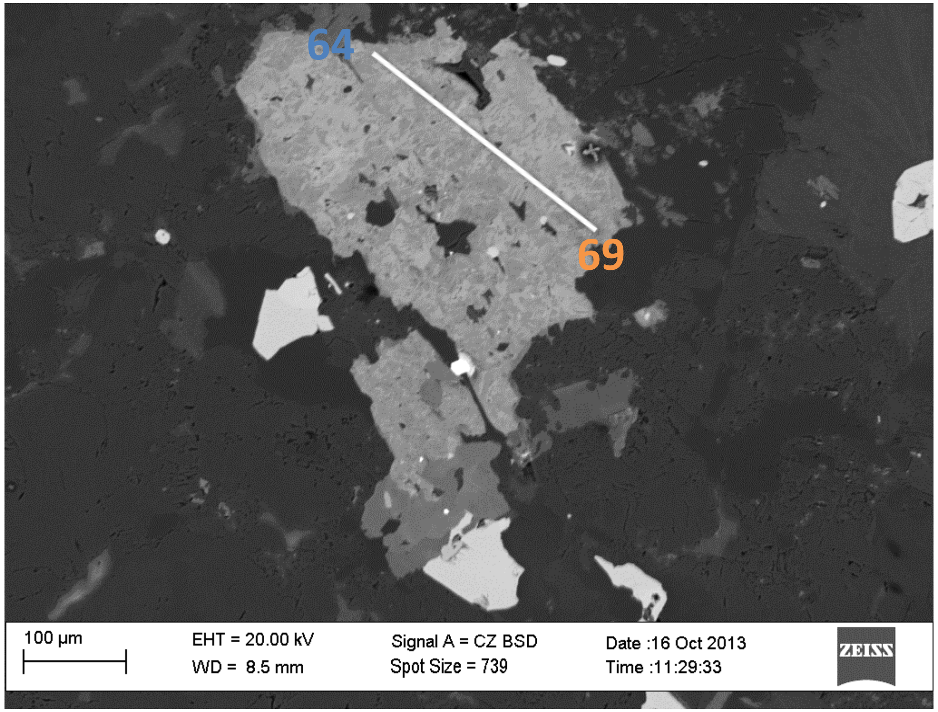
Zoning in allanite (Table 6.5) is mainly caused by differing concentrations of LREE-enrichment. This is evident in the concentric zoning (growth zoning) observed. Concentric zoning marks the first type of zonation which is of prograde metasomatic origin (Figure 6.2.a). Another type of zoning is the irregular patchy type of zonation which is a function of the LREE, U and Th. Lower intensities of LREE-enrichment are evident as dark grey patches in the allanite grains (Figure 6.2.c). Retrograde allanite is observed as the rims of epidote and less LREE-enriched allanite around an altered inner allanite crystal.

Metamict textures have also been observed (Figure 6.2.d and 6.8) which is due to the presence of U and Th that decayed over time and caused radiation damage in prograde metasomatic allanite (Table 6.3). This is evident as grains that are not homogeneous with regards to REE and trace elements. The only grain that shows considerable variation in its trace element distribution is the metamict allanite (Figure 6.8). All the other grains only reflect variations in Sr throughout the traverses of single grains which is related to the distribution of Ca.

Medium grade W zone

Borehole AA+400 marks the medium grade W zone of the deposit. Slightly negative to neutral to slightly positive Eu-anomalies are observed in mineral grains with normalized data. The ΣLREE pattern is the same as the Eu* trend or roughly opposite where the Eu-anomaly is greater than 1 (Figure 6.8.b and c, Figure 6.9.b1 and b2). The grains show an oxidized core and a reduced rim which suggests that allanite started forming at the end of the last scheelite phase when the fluids started becoming oxidized and carried large amounts of REE in them (e.g Haas et al, 1994). The REE pattern is constant in all samples analysed.

Th displays a similar pattern to that of the ΣLREE which indicates that it was in the crystal structure of this particular allanite grain when it formed. The presence of Th rendered allanite in the medium grade W zone susceptible to metamictization which has been observed (Figure 6.8). This could explain the variation in almost all trace elements (Figure 6.8.d) as metamictization compromises the crystal structure and makes trace elements more susceptible to remobilization (Poitrasson, 2002). This metamict sample shows considerable variation in its trace element content compared to other grains, which illustrates the compromised crystal structure and the ability of trace elements to be remobilized more easily in metamict grains.



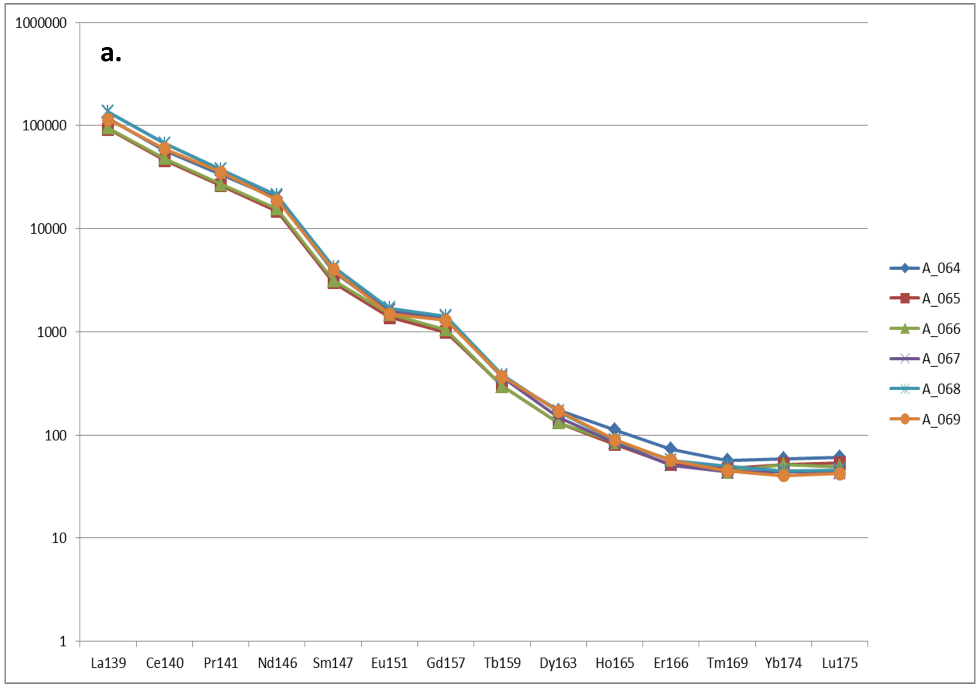


Figure 6.8. Chondrite-normalized REE profile of an allanite grain from borehole intersection AA+400. The LREE-enriched nature of allanite is evident, with just slight variations in the HREE throughout the extent of the grains. The Eu-anomaly is slightly negative. This grain displays a metamict texture and is not homogeneous with respect to REE and trace elements.

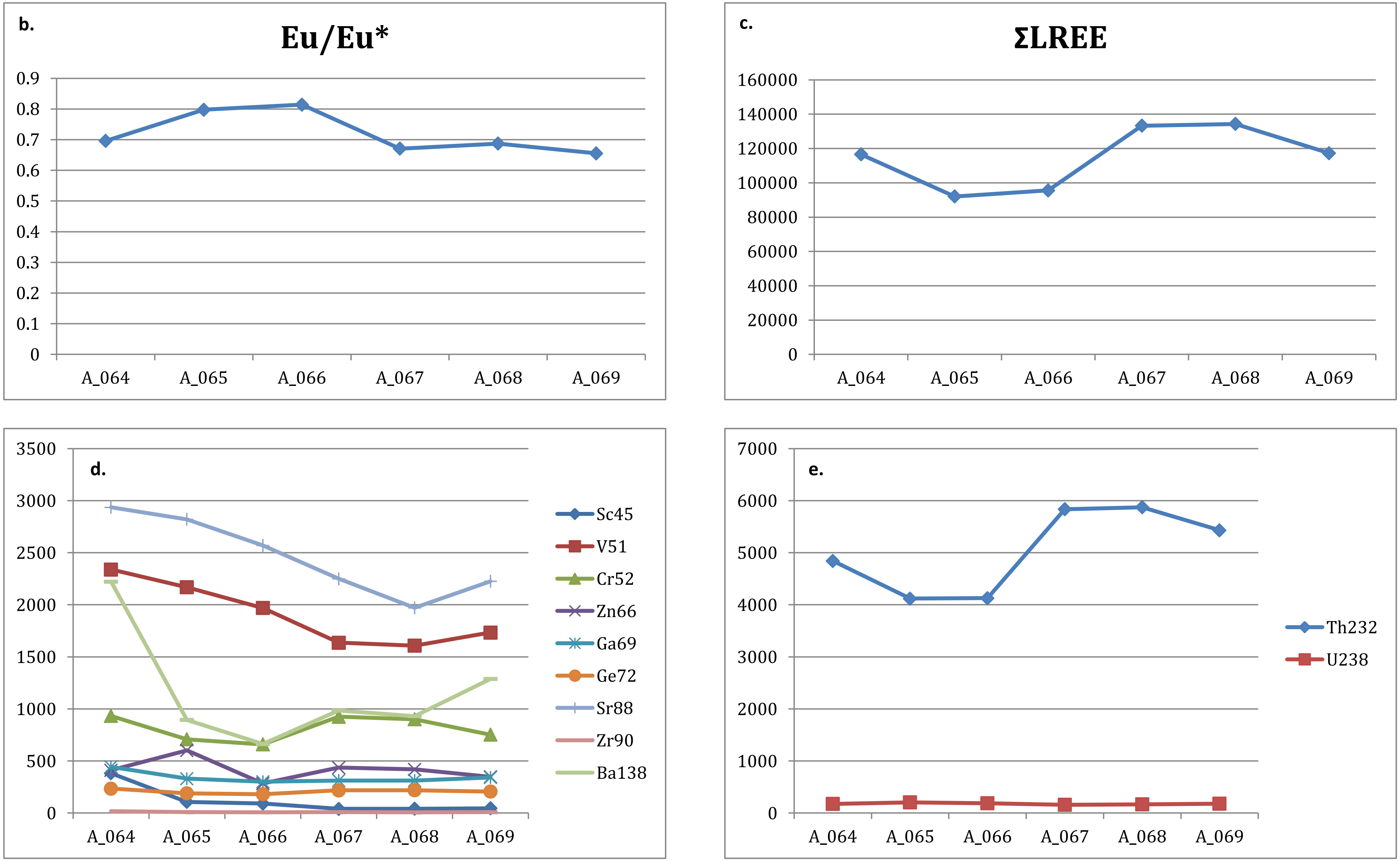
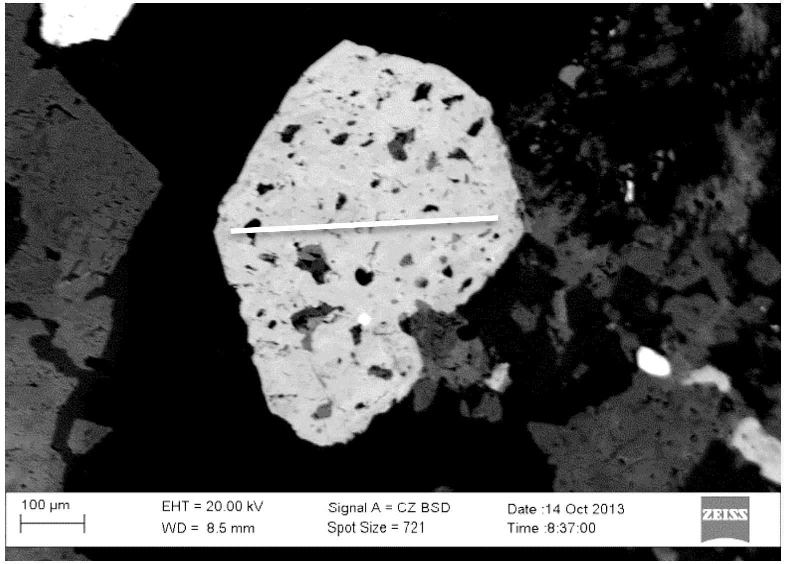
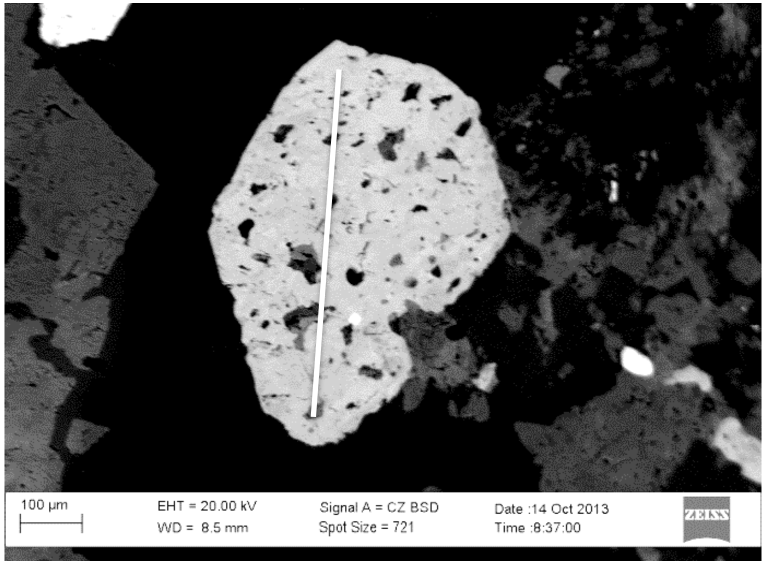
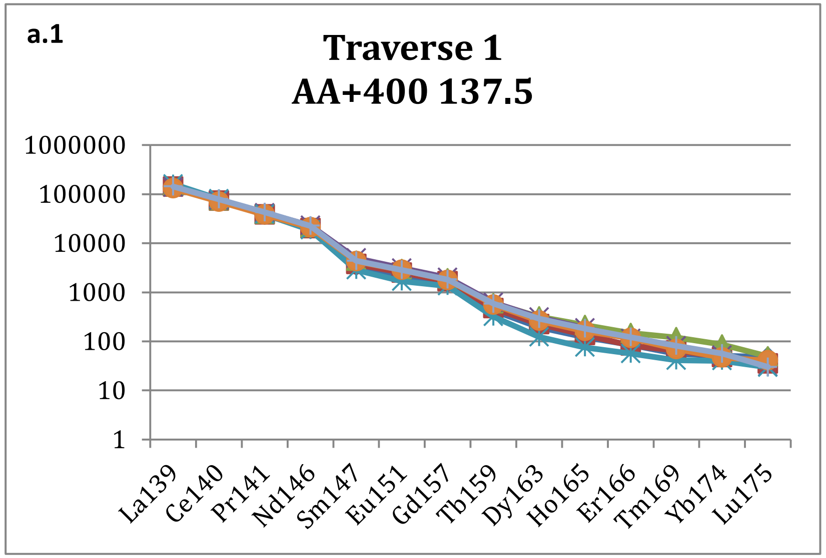


Figure 6.8 continued. b) The Eu-anomaly is entirely below 1 which indicates a reduced nature of the hydrothermal fluid. C) The ΣLREE content does not show a variation from core to rim, although it displays roughly the same pattern as Th (e) and an opposite pattern to the Eu-anomaly (b). d) Significant variation in most of the other trace elements (except Zr) is evident. e) An opposite trend to all the others observed is displayed in this diagram in the sense that Th has a higher absolute concentration than U, and that U shows virtually no trend. (These diagrams were constructed using absolute ppm values, except b).







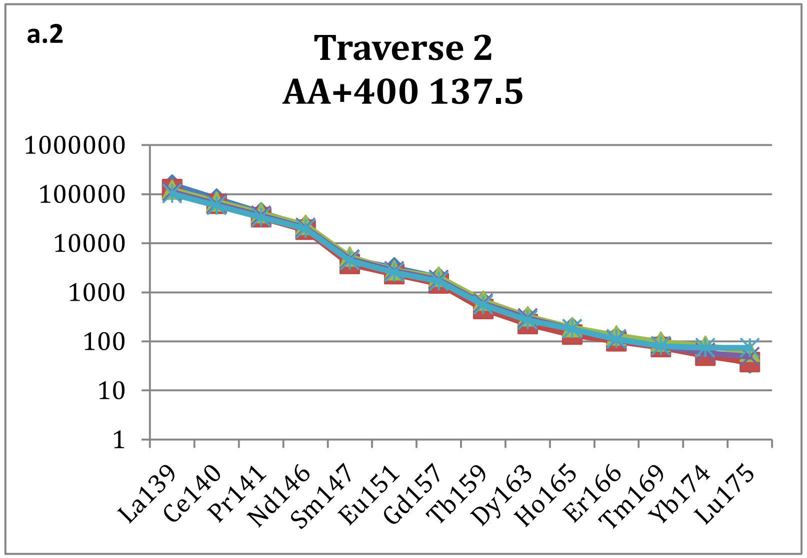


Figure 6.9. Chondrite-normalized REE profiles of a1 and a2) two different traverses (almost perpendicular to each other) of a single allanite grain. This is a sample from borehole AA+400 which is considered the medium-grade W zone. The LREE-enriched signature is evident. Eu-anomalies are neutral to slightly negative (traverse 1) and neutral to slightly positive (traverse 2).

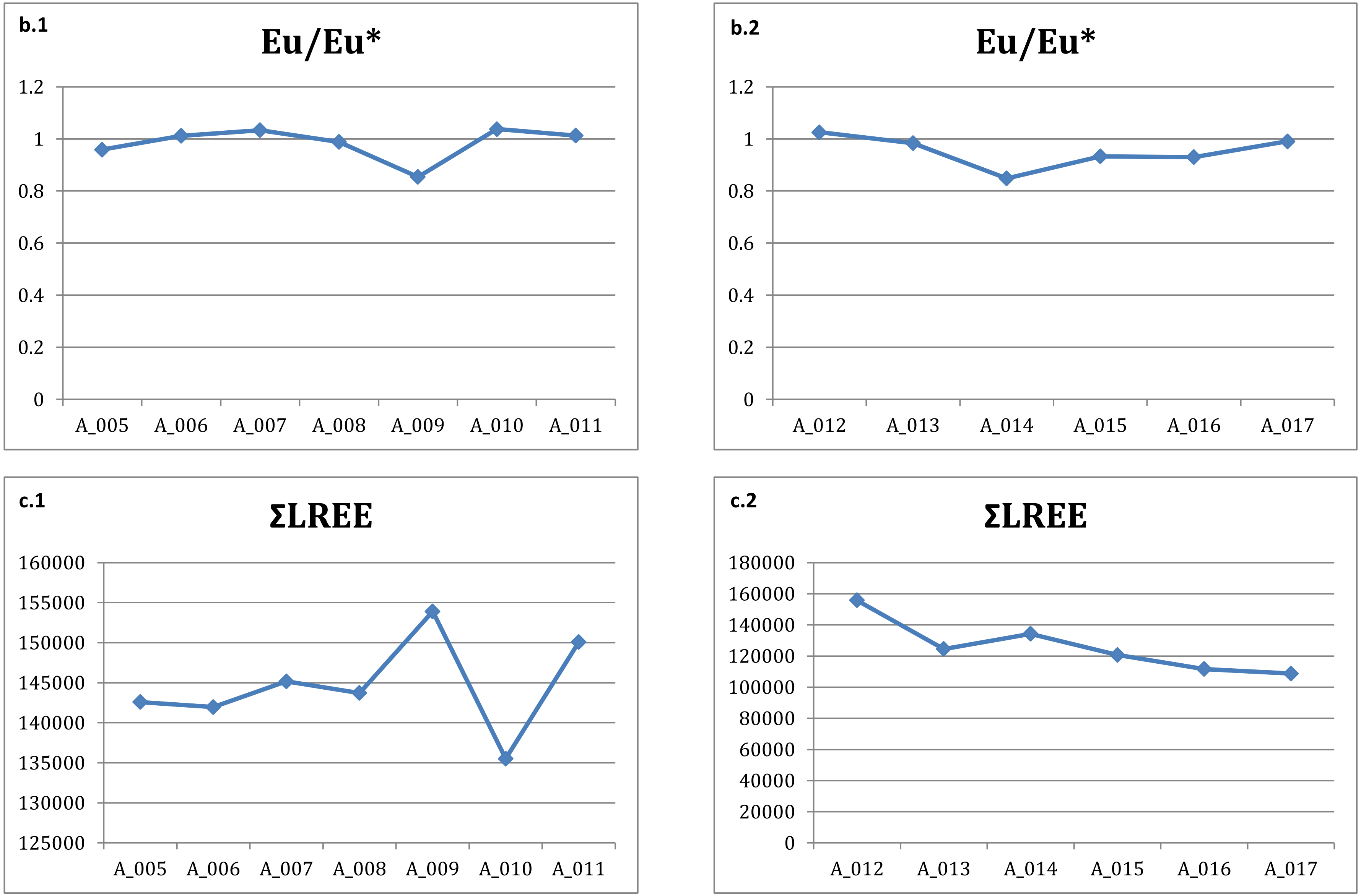


Figure 6.9 continued. b1 and b2) Eu-anomalies of both traverses indicate an oxidized core (Eu/Eu* <1) and a reduced rim (Eu/Eu* >1). c1 and c2) The ΣLREE profile of each traverse is displayed. In contrast to the constant LREE-enriched signature of the chondrite-normalized REE profiles, the absolute ΣLREE content throughout the extent of a grain is inconsistent. (This diagram was constructed using absolute ppm values).

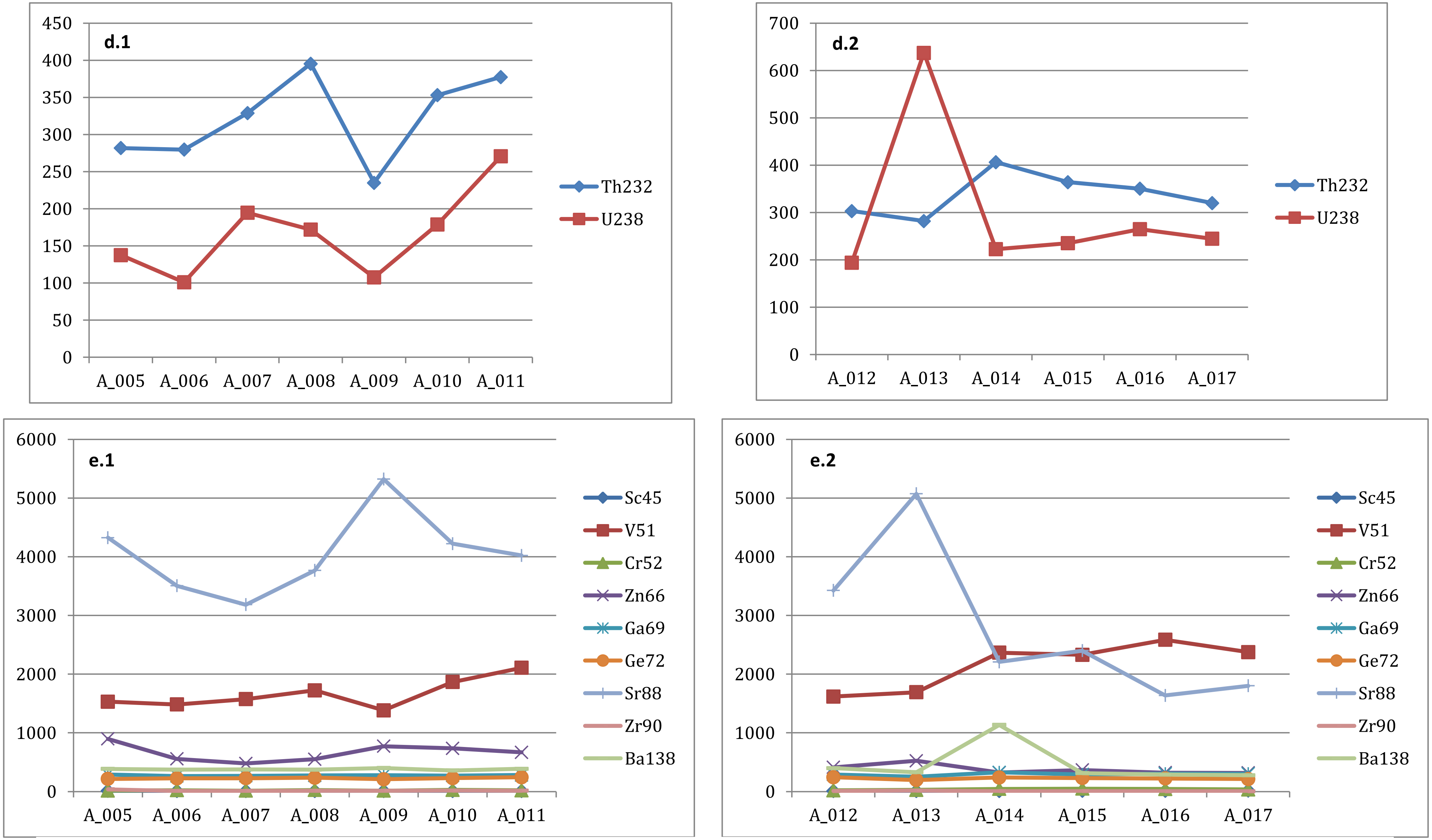


Figure 6.9 continued. d1 and d2) The U and Th contents across the grain also display a variable mineral chemistry. No consistent zonation from core to rim is evident. The sample on the left displays roughly the same pattern, whereas the sample on the right is roughly opposite. e1 and e2) These diagrams display the role of the other measured trace elements in allanite grains. Sr shows the most variability which is related to the distribution of Ca as Sr commonly replaces Ca. (These diagrams were constructed using absolute ppm values).

Low grade W zone

Borehole E-200 represents the low grade W part of the deposit where allanite grains display an overwhelmingly positive Eu-anomaly indicative of reduction. The flow of the hydrothermal fluid is believed to have been up the pluton and along the boundaries with the adjacent wall rocks. Due to the fact that E-200 is on the periphery of the deposit and that the fluids evolved from reduced to oxidized, the fluids that reached the periphery were slightly more oxidized as we can see from core to rim (Figure 6.10.b1 and b2).

The steep slope (steeper than normal) of the REE profile is believed to be as a result of a later influx of hydrothermal fluids that remobilized LREE in the high- and medium-grade W zones and deposited them in the low-grade W zone (E-200). As was mentioned before, the effect of a later hydrothermal fluid is evident by resorbed allanite boundaries that have been overprinted by epidote and less LREE-enriched allanite phases (Figure 6.12.a). When the boundaries were resorbed, REE (especially LREE) partitioned into the fluid phase and reprecipitated in various parts of the deposit. This is also seen in Figure 6.11.a where one half of the allanite grain is more HREE-enriched with respect to the other half of the grain.

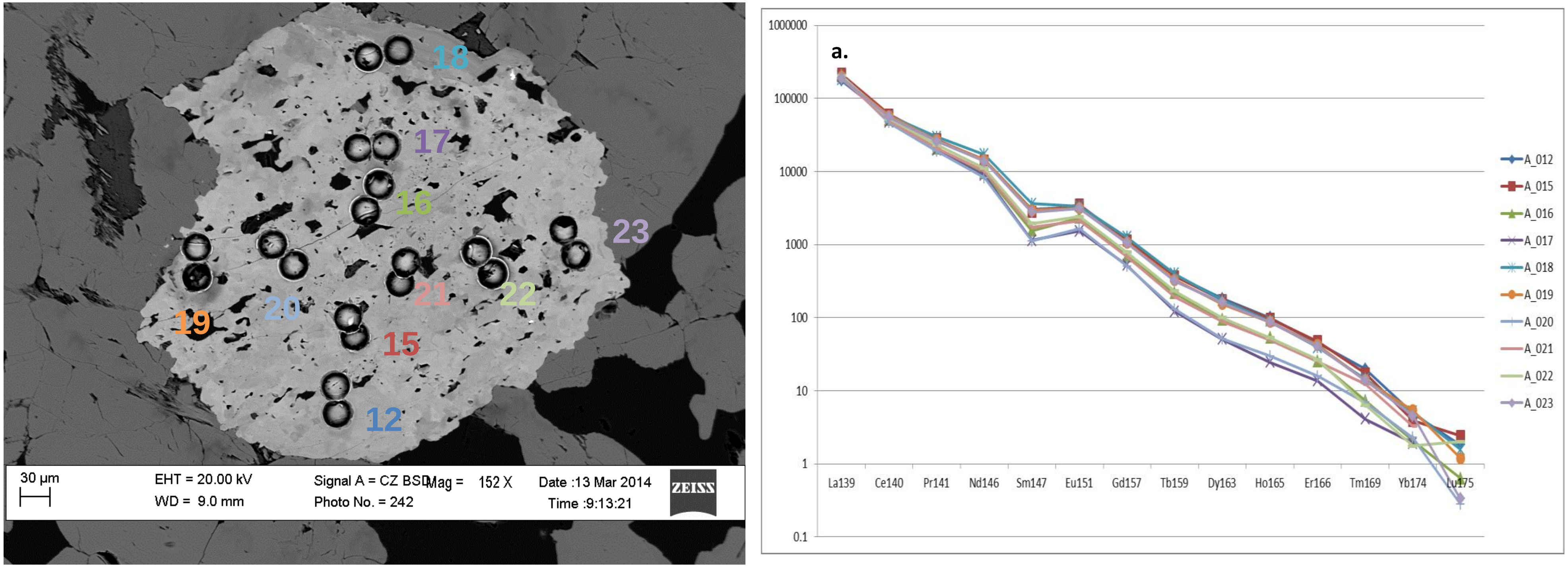


Figure 6.10. a) Chondrite-normalized REE profile of an allanite grain from borehole intersection E-200. The spot analyses were taken on two almost perpendicular traverses. The LREE-enriched nature of allanite is evident, with just slight variations in the HREE throughout the extent of the grains. The steep REE pattern is caused by a secondary addition of LREE that have been remobilized through hydrothermal fluids in the high- and medium-grade W zone and have been redeposited in the low grade W zone (Poitrasson, 2002).

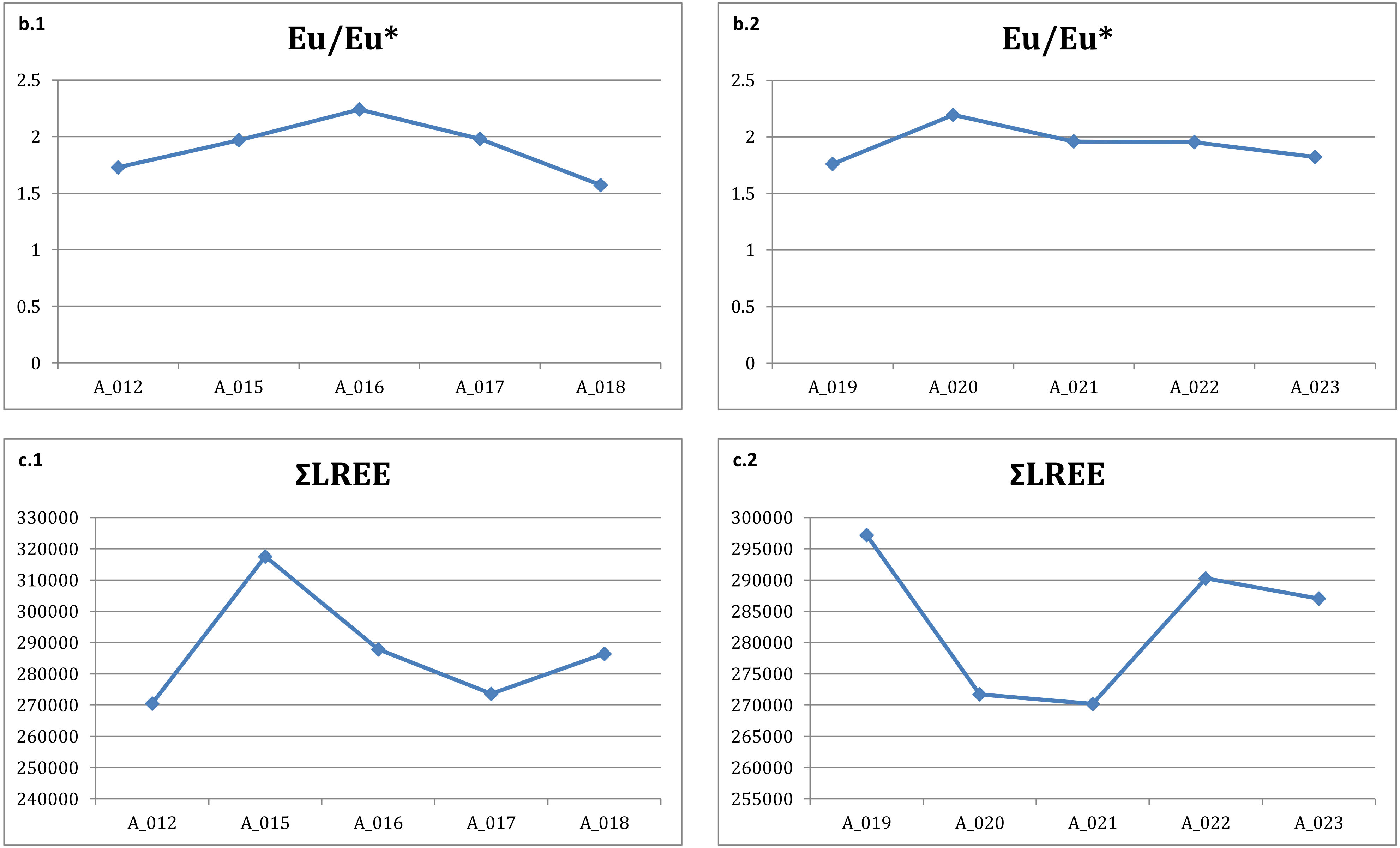


Figure 6.10 continued. b1 and b2) Even though the Eu-anomalies vary from core to rim, they are all greater than one which indicates that this environment is reduced. c1 and c2) The ΣLREE content also varies substantially from core to rim and shows no consistent pattern. (This diagram was constructed using absolute ppm values).

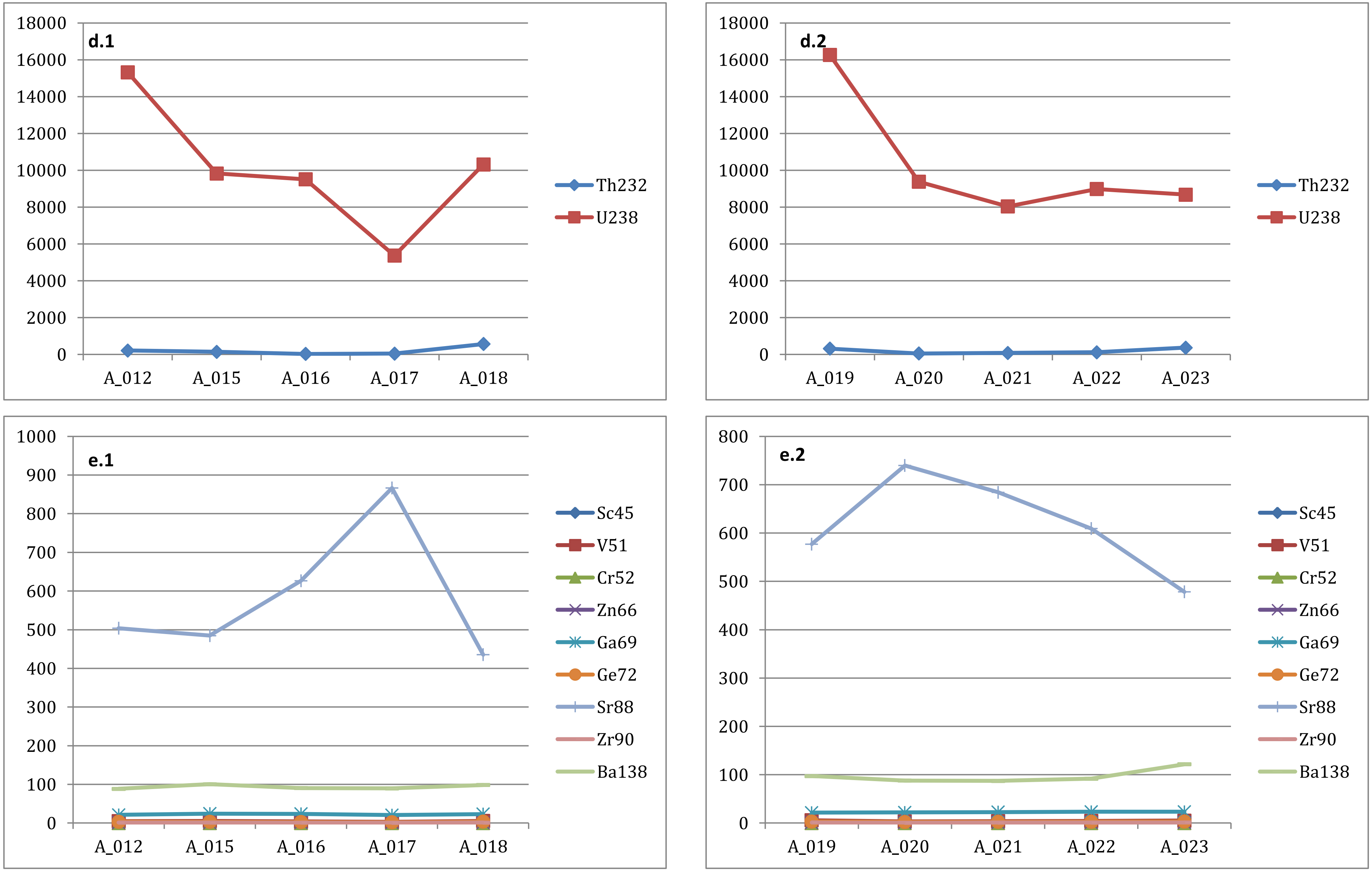


Figure 6.10 continued. d1 and d2) Th does not exhibit a significant trend or high absolute values. U varies substantially and is linked to the ΣLREE diagram in the sense that the two trends seem roughly similar. e1 and e2) Sr displays a significant variation and is linked to the Ca in allanite, Ba and other trace elements are low in concentration and insignificant. (These diagrams were constructed using absolute ppm values).

High grade W zone

BB+400 is considered the high grade W zone which is situated roughly in the centre of the pluton (Figure 4.19.a). The strong LREE-enriched, negatively sloping REE trend is apparent with just slight variations in the HREE. The relative enrichment of HREE relative to LREE in some spots in a grain is due to the remobilization of LREE during the introduction of a second fluid phase, which leached LREE from allanite in the high- and medium-grade W zones and reprecipiated them in the low grade W zone (refer to description of low grade W zone).

Eu-anomalies are slightly positive to neutral. The Eu-anomaly and ΣLREE display opposite trends in one example (Figure 6.11.a2 to a4) with U displaying the same trend as the ΣLREE, and Th showing no association. In the other example (Figure 6.11.b2 to b4) the Eu-anomaly and ΣLREE displays the same trend which is also roughly similar to the Th trend. This inconsistency of trace element trends within allanite grains is indicative of the variable mineral chemistry within allanite.

The only trace element that varies considerably is Sr. In one example (Figure 6.11.b4 and b5) Sr and U display roughly the same trend which is opposite to Th.

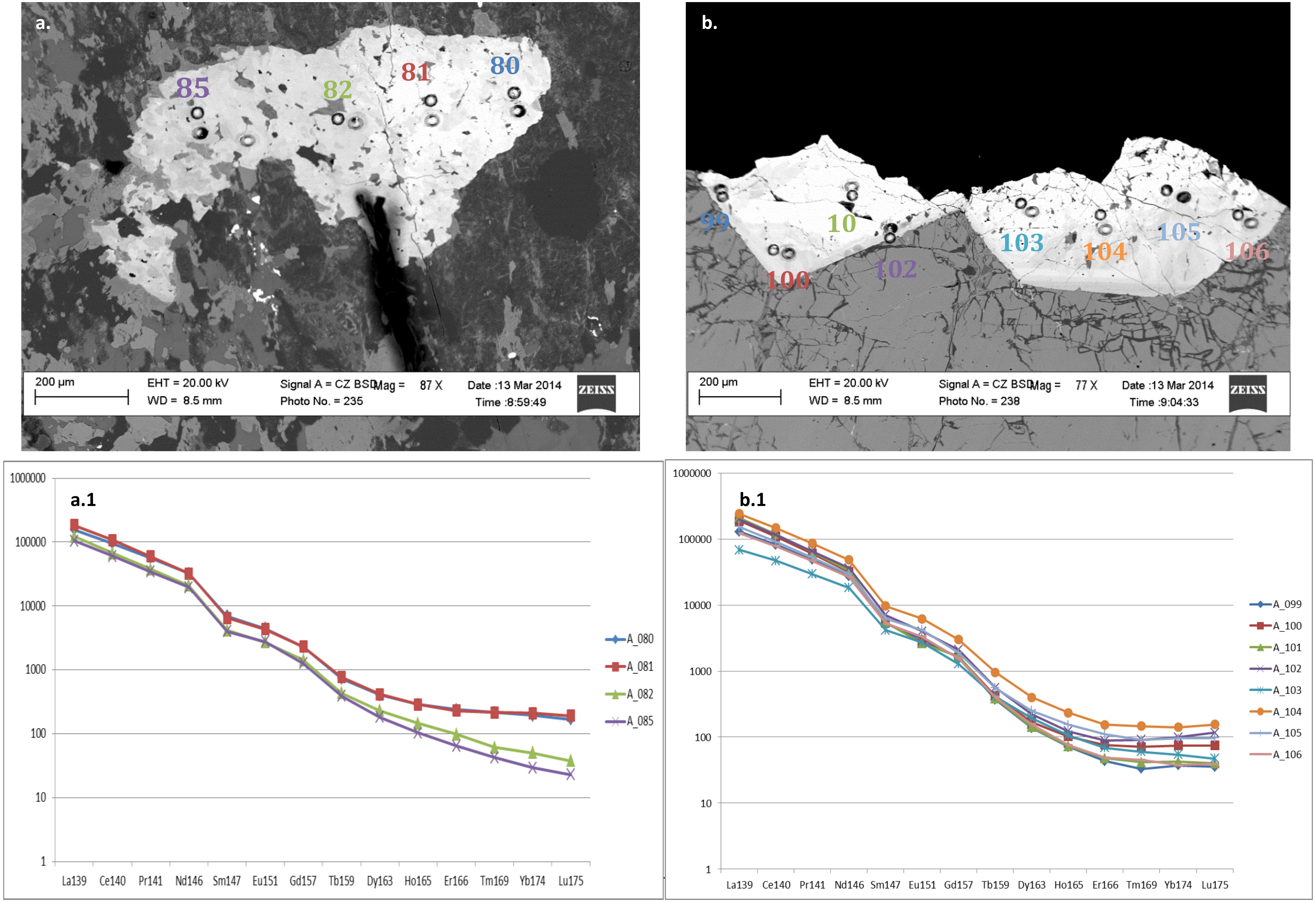


Figure 6.11. Chondrite-normalized REE profiles of two allanite grains from borehole intersection BB+400. The LREE-enriched nature of allanite is evident, with just slight variations in the HREE throughout the extent of the grains. In image (a1) the right side of the grain not only has a relative higher concentration of HREE, but is also brighter than the left side of the grain Eu-anomalies vary from neutral to slightly positive.

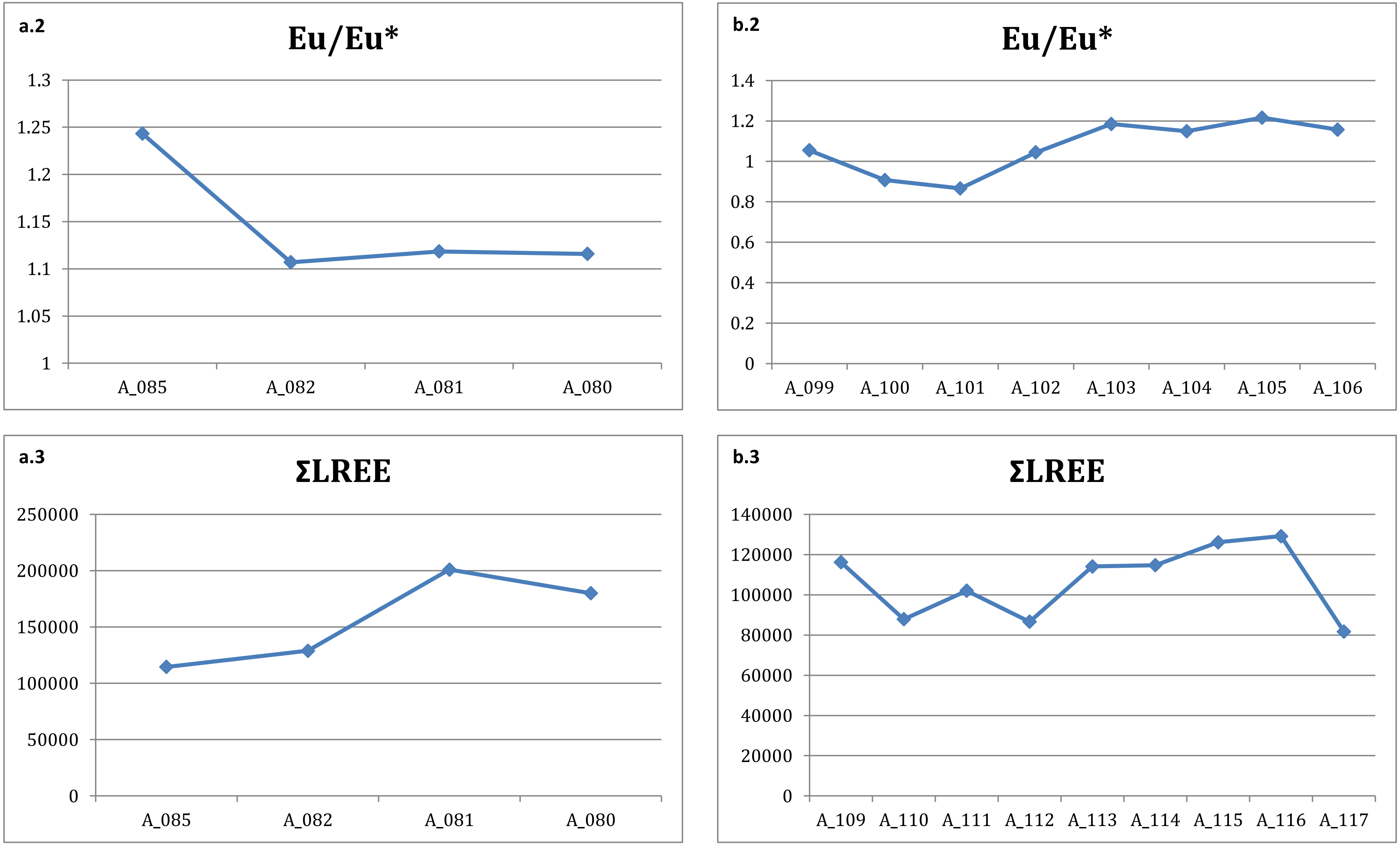


Figure 6.11 continued. The Eu-anomaly of (a.2) is above 1 which indicates a reduced nature. The Eu-anomaly of (b.2) is slightly above and slightly below 1, which illustrates that oxidized and reduced fluids played a role respectively. A high ΣLREE content in (a.3) corresponds to higher Th and lower U and vice versa, which is testament to the influence of later hydrothermal fluids. (ΣLREE diagrams were formulated using absolute ppm values).

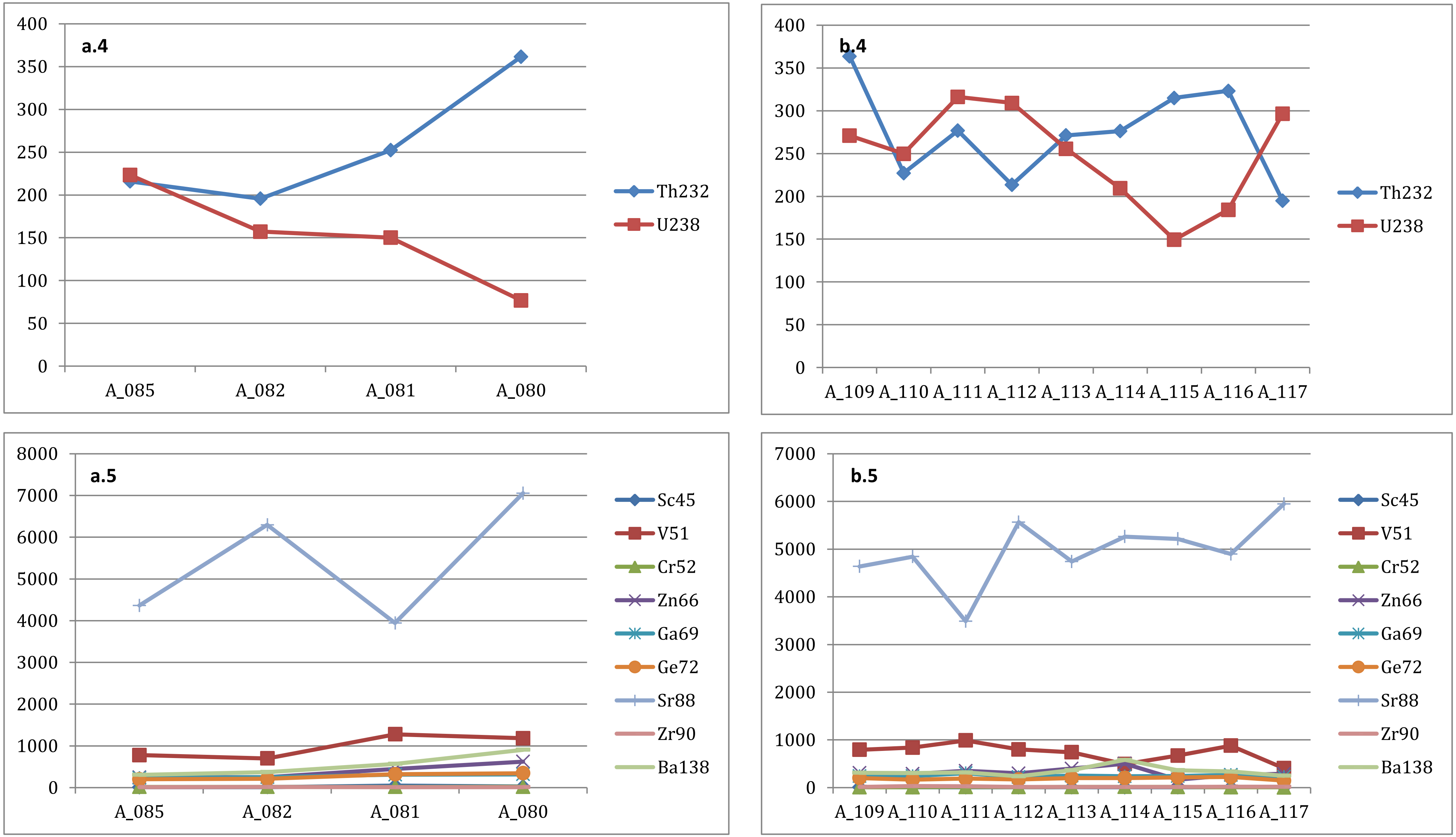
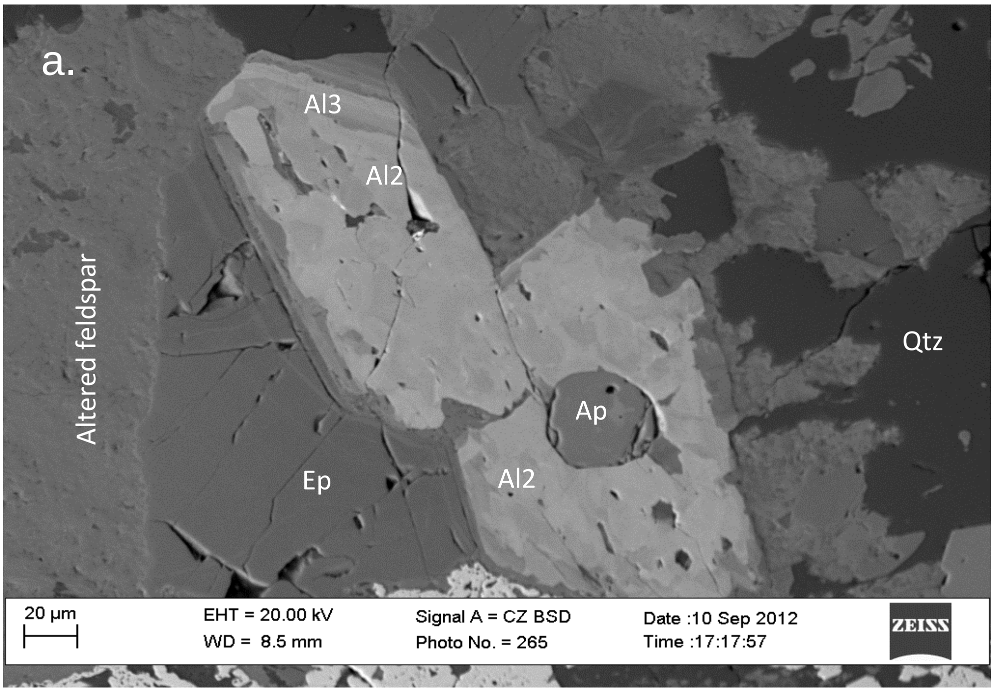


Figure 6.11 continued. Th in (b.4) displays a similar trend to the ΣLREE trend (b.3) with HREE enrichment to the right, and U an opposite trend. This indicates that Th forms part of the original allanite grain. In both (a.5) and (b.5) the only significant variation in the other trace elements is in Sr. (These diagrams were constructed using absolute ppm values).

6.3 Allanite phases

Although concentric zoning is rare in allanite in this pluton, allanite does display a very irregular patchy zonation defined by different levels of LREE concentration. Although zoning is irregular, it is nonetheless distinct (e.g. Figure 6.2). Various phases of LREE concentration are associated with allanite. These phases have been grouped according to weight % LREE. On this basis roughly three allanite phases have been identified; allanite 1 (>20 wt %) – allanite 2 (10-20 wt %) – allanite 3 (2-10 wt%). Allanite paragenesis is: bastnaesite – al1 – al2– al3 and lastly epidote. Table 6.6 (next page) shows representative analyses of LREE within each phase.



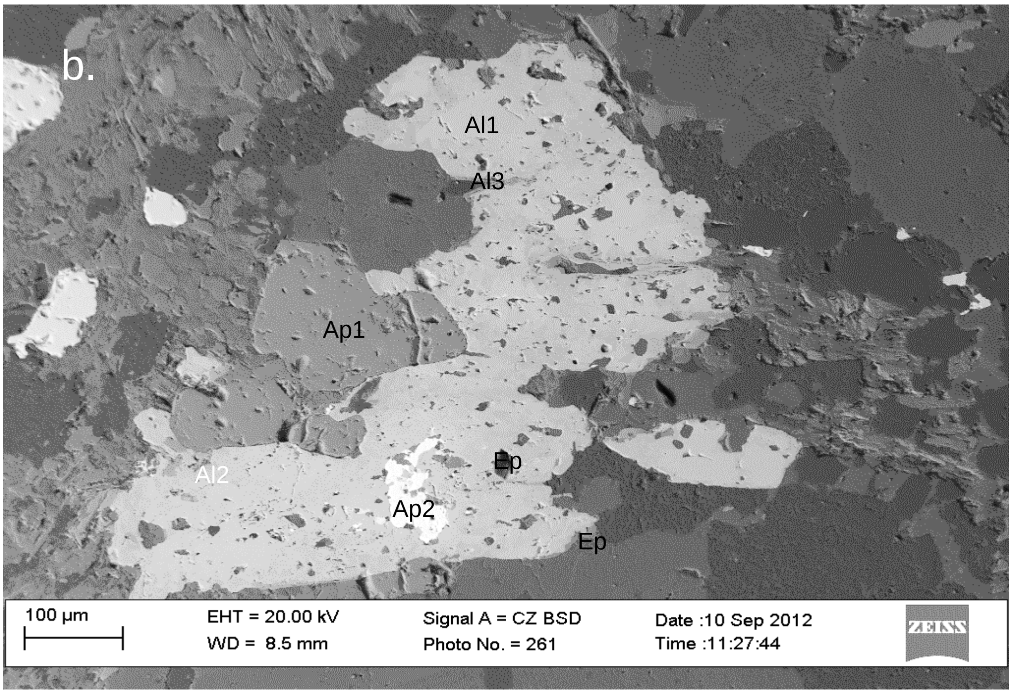


Figure 6.12. These diagrams display the irregular zoning which is common in allanite in this pluton (backscatter images). Note the differing concentrations of LREE concentrations in both diagrams and the epidote rim in (a). Allanite is commonly associated with epidote, apatite and altered feldspar. In diagram (b), LREE-enriched apatite (ap2) has been observed.

Table 6.6. The typical LREE concentrations that are associated with each allanite phase. The first allanite phase (Al1) is above 20 wt% LREE, the second phase (Al2) between 10 and 20 wt % LREE, whereas the last phase (Al3) is between 2 and 10 wt%. Epidote (Ep) formed last.

	La	Ce	Pr	Nd
Ep	0.00	0.97	0.00	0.271
	0.00	0.62	0.00	0.00
	0.00	0.31	0.00	0.00
Al1	3.39	10.85	2.39	3.06
	3.20	11.03	2.70	3.14
	2.99	12.03	2.68	3.34
	4.03	12.40	2.86	3.08
	2.82	10.71	1.98	2.86
	3.18	11.33	2.85	2.97
	3.44	11.27	2.11	2.84
	3.52	11.86	2.451	3.16
Al2	2.97	7.69	1.15	2.45
	3.95	8.00	1.77	1.99
	3.67	8.17	1.38	2.341
	4.20	9.48	2.11	2.271
	3.79	8.96	1.31	3.11
	3.07	6.94	1.30	1.82
	3.57	8.96	1.45	2.02
	2.37	5.37	0.87	1.31
	4.77	9.86	2.11	2.60
Al3	1.29	3.07	0.68	1.561
	1.67	4.73	1.25	1.18
	0.86	1.89	0	1.141
	1.64	4.42	1.25	1.34
	1.80	4.68	0.76	1.33

6.4 Whole rock Rare Earth Elements (REE)

Based on major and trace element whole-rock data from borehole intersections A+400, BB+400, CC+400, DD+200, E-200 and AA+200, as well as trace element data from BB+200, BB+300, BBCC+350 and CC+200, the following results were obtained. The Riviera deposit has has a strongly LREE-enriched geochemical signature (Figure 6.15), with Ce being the dominant LREE (Figure 6.13).

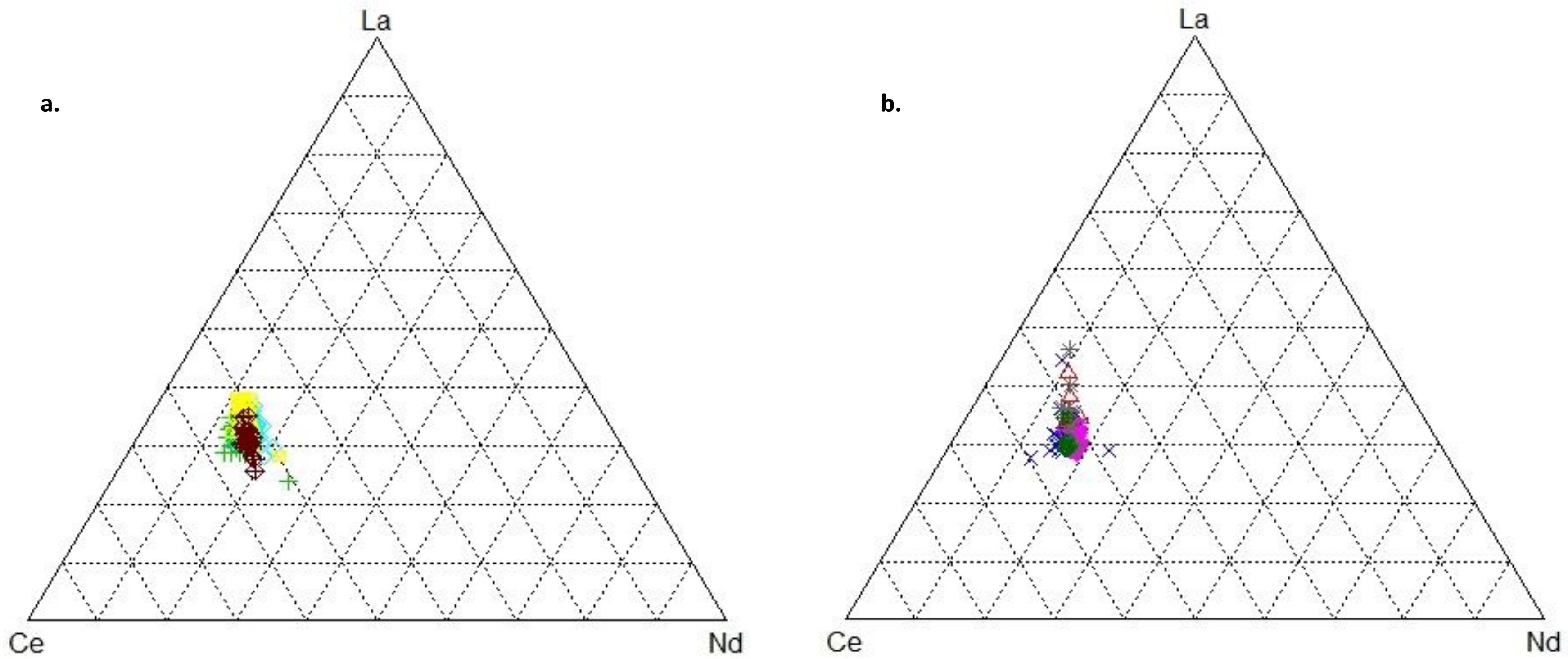


Figure 6.13. Ternary diagram of the major LREE elements (cerium, lanthanum and neodymium) in the Riviera pluton. Both the MZ (n=250) (a) and the NMZ (n=248) (b) display a Ce-dominant nature. The two zones differ slightly, with the NMZ being slightlyt more La-enriched.

Spider diagrams (Figure 6.14) illustrate the LREE-enriched nature of the Riviera deposit with La, Ce and Nd being the most important REE. Troughs in the diagrams indicate the involvement of minerals that are normally associated with the element in question (Winter, 2010).

The MZ and the NMZ display similar trends, with strongly negative Nb and Ta anomalies, a LREE-enriched pattern, a positive spike in U, and a strongly negative Ti anomaly. Nb and Ta are associated with Ti-rich phases like titanite. The fact that Nb, Ta and Ti are displayed for both the MZ and the NMZ confirms the fact that Ti-rich phases like titanite do not only occur in the MZ or skarn zone. A positive spike in U can be as a result of mobilization due to a hydrothermal fluid phase which supposts previous findings (Poitrasson, 2002). A few negative spikes in Th in the MZ is indicative of its presence in allanite which has been observed.

The difference between these two signatures is that the MZ contains samples that have higher relative concentrations of all the elements shown and is more variable than the NMZ. Sr has a pronounced negative anomaly in both the MZ and the NMZ which can be attributed to a significant amount of Ca-rich minerals which are found in both the MZ and the NMZ mineralogically. The Large Ionic Lithophile (LIL) elements such as Sr, K, Rb and Ba can be mobilized by a hydrous fluid phase (Winter, 2010). This is evidenced by some positive spikes in all these elements (K to a much lesser extent). High concentrations of Ba and Rb also indicate that metasomatism took place (Winter, 2010) especially in the MZ.

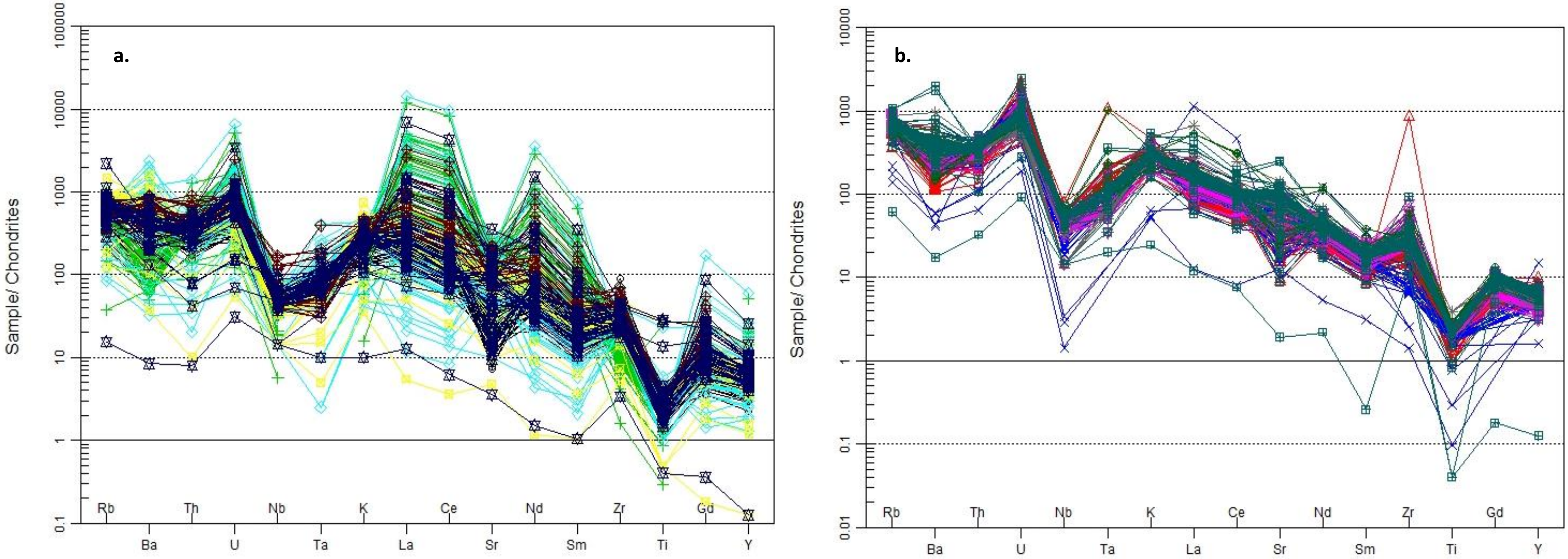


Figure 6.14. Chondrite-normalized spider diagrams (Sun, 1980) of the MZ (a) and the NMZ (b). There is a LREE-enriched trend (negative slope) with cerium, lanthanum and neodynium being the three main contributors. Positive spikes at Rb, Ba, Sr and K (LILE) and U indicate that a hydrous fluid phase was introduced that mobilized these elements and thus also illustrates the effect of hydrothermal alteration. High concentrations of Ba and Rb means metasomatism played a role, in this case K-metasomatism in the form of potassic alteration. Negative spikes in Ti, Nb and Ta are associated with minor Ti-rich phases such as titanite in this deposit. A negative spike in Sr for both the MZ and NMZ are associated with the Ca-rich minerals in the Riviera pluton. Negative spikes for Th in the MZ are attributed to its association with allanite.

The chondrite-normalized REE diagrams below are representative of various borehole intersections (Figure 4.19). All of them display a LREE-enriched negatively sloping trend which is indicative of the LREE-enrichment of the deposit. This is the same pattern for I- and A-type granites of the CGS according to Rozendaal and Scheepers (1995). The pattern for the whole rock closely resembles that of allanite which indicates that REE mainly partitioned into allanite (Figure 6.8 to 6.11 and 6.15).

The amount of REE elements varies quite substantially in some borehole intersections to the extent that the LREE show multiple concentrations between 100 and 10000 whereas the HREE pattern remains almost flat (such as CC+400 and BB+200), which indicates that the slope is variable and therefore the relative LREE to HREE enrichment. This is not related to enrichment as borehole intersections CC+400 and BB+200 are considered medium- and high-grade W zones respectively.

The MZ and NMZ display similar patterns although the NMZ samples are not as LREE-enriched as the MZ, i.e the slopes of the profiles displayed for the NMZ are not as steep as those in the MZ. This confirms that LREE are mainly associated with allanite in the MZ. According to Spicer (2001), the difference between the total ΣREE of the MZ and NMZ or barren zone is the ability to remobilize REE from the prograde metasomatic (in this case) crystallization to the retrograde alteration stage. This ability was higher in the MZ than the NMZ which is reflected by higher overall REE concentrations.

Eu-anomalies are an important indication of the oxidation state of the fluids (Bau, 1991). The anomalies in this pluton vary from slightly negative to neutral. A high ΣREE content correlates with a more neutral Eu-anomaly (BB+200, CC+200, BB+400 and CC+400), whereas a low ΣREE content correlate with a more negative anomaly (BBCC+350 and DD+200).

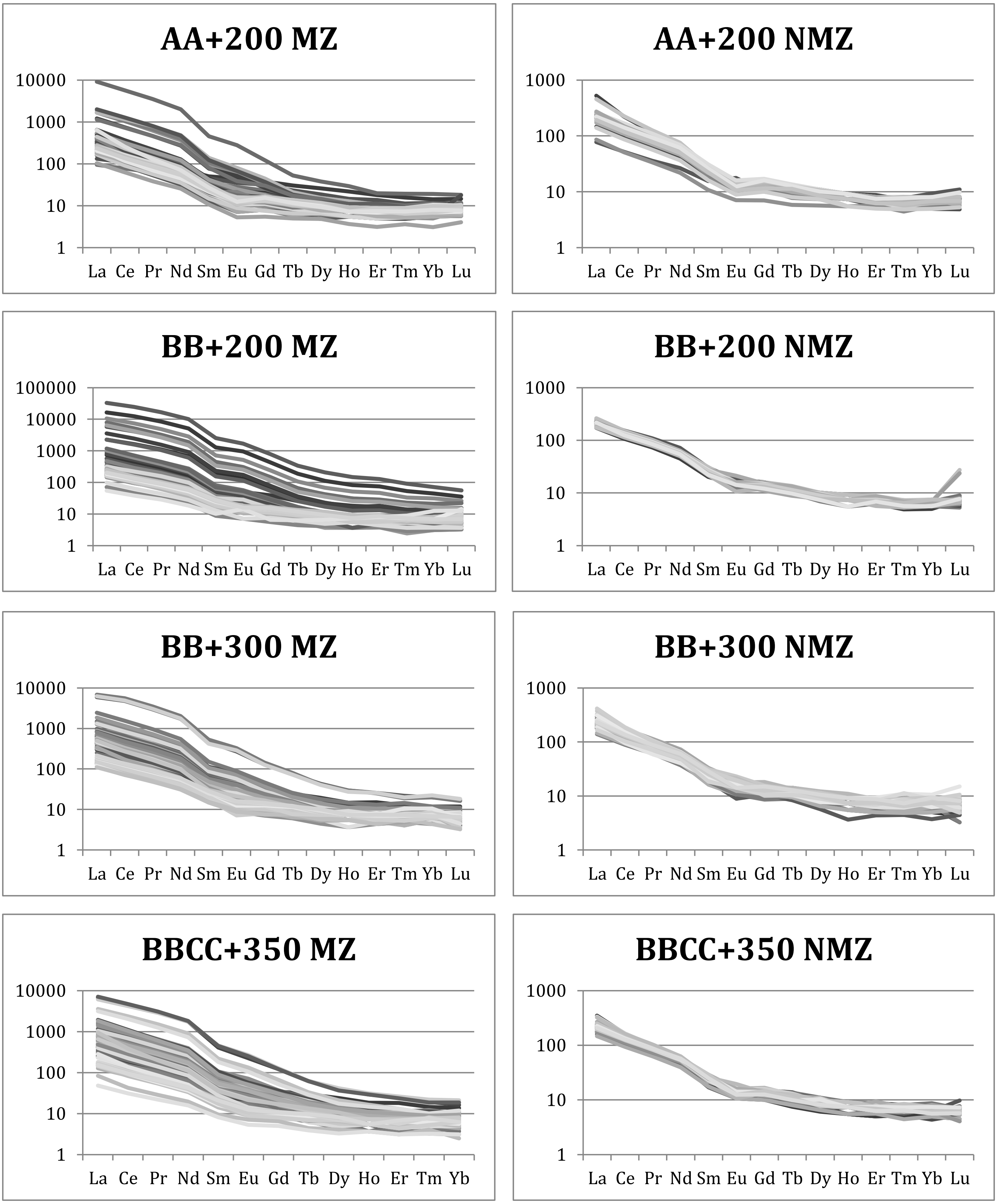


Figure 6.15. Chondrite-normalized REE profiles of various borehole intersections. The diagrams are relatively uniform displaying a strong LREE-enrichment with cerium, lanthanum and neodymium being the three main contributors. Eu-anomalies vary from slightly negative to neutral which is an indication of the redox conditions of the fluid and how it evolved (Bau, 1991). The MZ and NMZ of each borehole intersection were plotted separately.

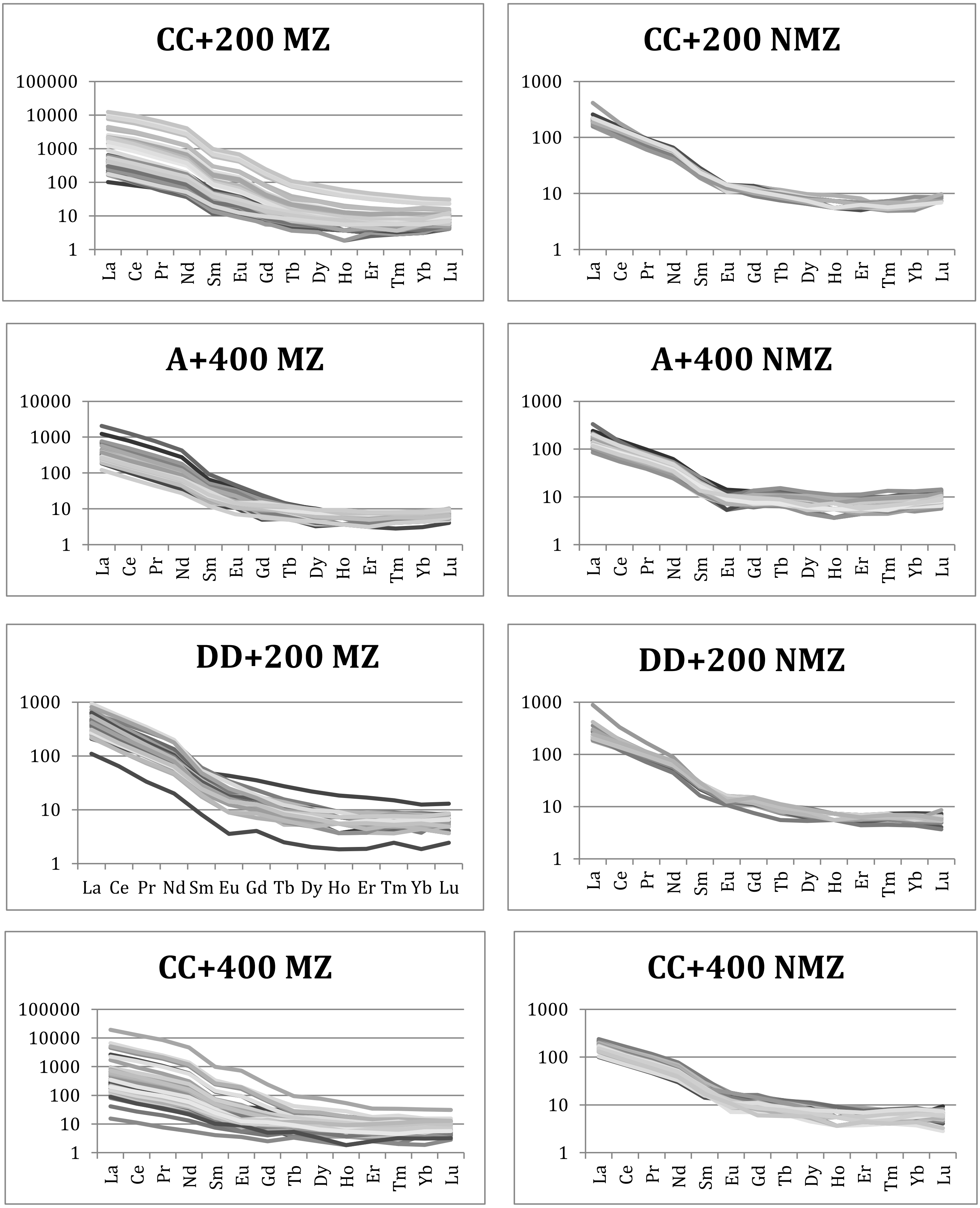


Figure 6.15 continued.

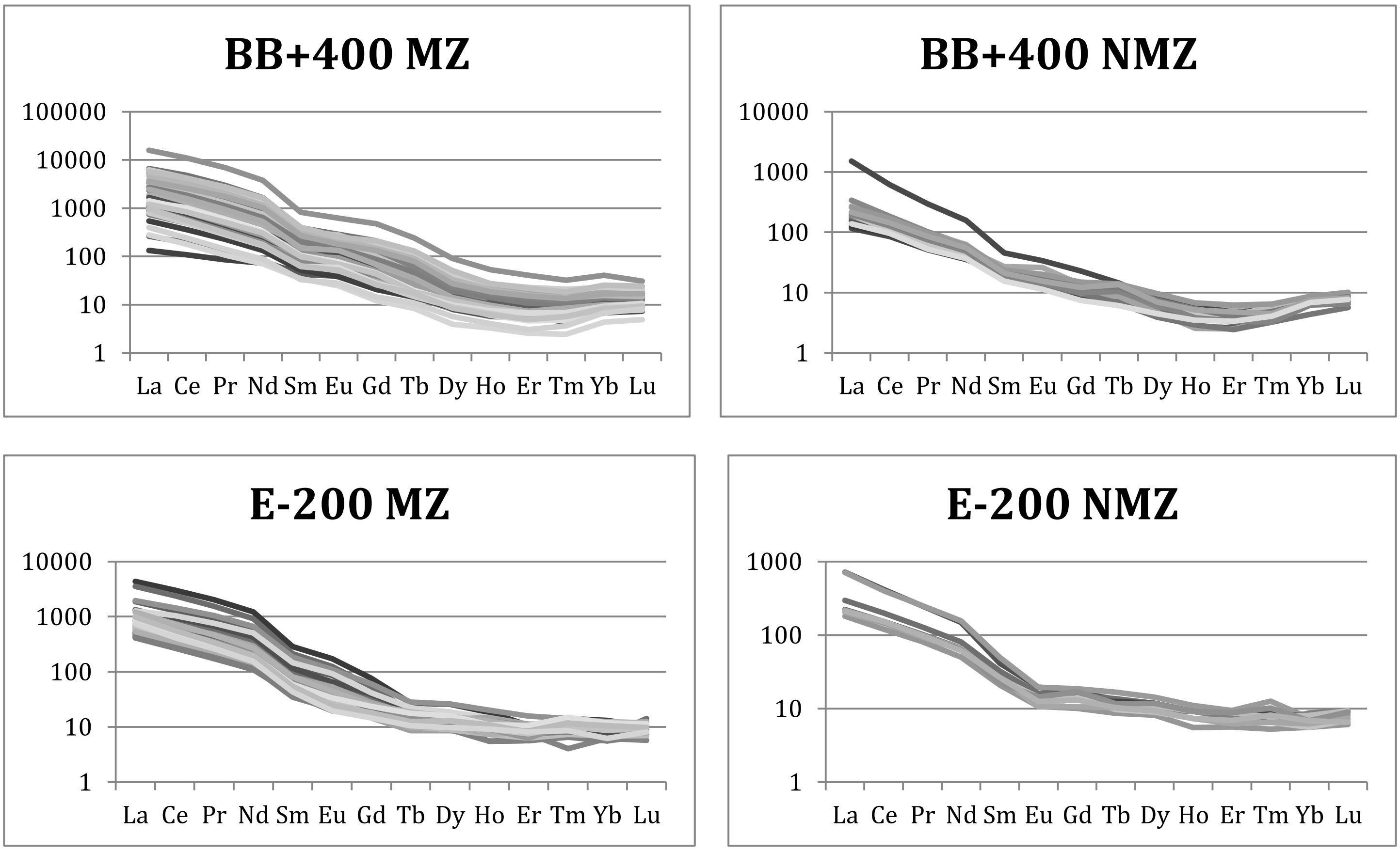


Figure 6.15 continued.

6.5 Discussion

Allanite is a complex mineral in terms of its textural features such as intergrowths, irregular zonation patterns, replacement and metamictization as well as a non-uniform grain size distribution. The most common sub-types in this pluton are ferriallanite and allanite-Ce. The mineral formula of allanite in this pluton, reported with the range of its end-members is $(RE_{0.08-0.21})$ $(Al_{1.72-2.06})$ $(Fe_{0.99-1.40})$ $(Ti_{0-0.04})$ $(Mn_{0.02-0.15})$ $(Mg_{0.02-0.12})$ $(Ca_{1.20-1.76})$ $((SiO_4)_{3.02-3.16})$. LREE replace Ca in the crystal structure of epidote.

Allanite has a poikilitic texture with various inclusions ranging from quartz, a few rare occurrences of monazite, pure apatite as well as a LREE-enriched apatite, epidote and titanite. Mutual grain boundaries between pyrite and allanite indicated that they formed at the same time and confirms allanite's late-stage development. The shape of allanite grains is generally consistent as originally euhedral to subhedral grains, now altered. The long to short axis ratio is normally 2:1. Two zonation types have been observed in allanite which is the prograde metasomatic concentric zoning, and a prograde metasomatic patchy zonation.

The other main LREE-bearing mineral is bastnaesite. Bastnaesite also has a poikilitic texture with inclusions such as apatite, quartz, epidote and titanite. Apatite, epidote and titanite are also skarn minerals, deposited during the skarn development stage. Bastnaesite is also a LREE-bearing phase in this pluton although it is very rare compared to allanite which replaces it.

Chondrite-normalized REE profiles for the whole rock samples are similar to those of the single grains which indicate that most of the rare earth elements are hosted by allanite. The steep slope of the the chondite-normalized REE profiles of single allanite grains indicates that allanite is strongly LREE-enriched. Some patterns are steeper than others; E-200 which is the low grade W part of the deposit and on the periphery of the deposit displays the steepest REE pattern which is attributed to a strong LREE-enrichment relative to the HREE. This is ascribed to a second influx of hydrothermal fluids that remobilized LREE from allanite in the high- and medium- grade W zones and redistributed them on the periphery of the deposit. Resorbed allanite have been observed which has been overprinted by fluids with less LREE associated with them. These rims around pre-existing prograde metasomatic allanite are considered to be retrograde allanite.

REE-profiles remain relatively constant throughout the extent of a grain. On the contrary ΣLREE varies significantly throughout the traverse of a grain which is evidence of allanite's variable mineral chemistry.

The Eu-anomaly is a reflection of the redox state of the fluids (Bau, 1991) and exercised a strong control on the distribution of REE and trace elements such as U and Th. Zoning is mostly defined by the variability of the TLREE content. In the low grade W zone, which experienced a hydrothermal overprint, zoning can also be defined by the distribution of U and Th.

Eu-anomalies in allanite vary from slightly negative, to neutral to slightly positive. A high ΣLREE content of allanite correlates with a positive Eu-anomaly whereas the negative anomalies are associated with lower concentrations in allanite (Wood, 1990b; Haas et al, 1993). The fluids vary from reduced to oxidized. This confirms the late stage that allanite formed with respect to scheelite. As the fluids evolved to more oxidized and scheelite precipitation started to cease (Pieterse, 2013), allanite started to form. This was also seen in thin-section by allanite occurring adjacent to some scheelite grains. Allanite 1 was the first to form, followed by allanite 2, allanite 3 and lastly epidote. As the fluid evolved and the temperature dropped, the ability of the fluids to carry LREE slowly diminished (Banks et al, 1994) and the ΣLREE in allanite became less.

Eu-anomalies for the whole-rock also vary from slightly negative to neutral. A high ΣREE content correlates with a positive Eu-anomaly, whereas a more negative anomaly correlates with a lower amount of ΣREE in the whole-rock. The hydrothermal fluids for the whole-rock thus went from being initially reduced to slightly oxidized.

Hydrothermal alteration either incorporates water into the crystal structure (Ghent, 1972) or the appearance of vacancies (Peterson & McFarlane, 1993). This can explain the low analytical totals and the dark grey to black spots on BSE images observed in allanite.

The presence of radioactive elements such as U and Th makes allanite susceptible to metamictization (isotropic grains in thin-section) which has been observed. This means that the crystal lattices have been destroyed making trace elements more susceptible to remobilization by hydrothermal fluids (Poitrasson, 2002). This is evident in hydrothermally altered allanite where considerable variation in trace elements is observed compared to non-metamict allanite.

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Chapter 7 – Discussion and Conslusions

7.1 Genetic model

The Riviera pluton

The Riviera pluton forms part of the Cape Granite Suite and is a late- to post-orogenic I- and A-type granite, with a metaluminous to slightly peraluminous composition. The age of the pluton is 536±5 Ma. It formed as part of a subduction-related setting. The pluton has been pervasively altered by hydrothermal alteration, to such an extent that no fresh rock samples were found in all the samples studied. Geochemically it was difficult to classify the host rock as hydrothermal alteration rendered the data unsuitable for use in classifying the rock. Thus the modal mineralogy was used to classify the rock. The genesis of the pluton and its associated ore deposit will be explained at the hand of Meinert's (1992) generic model for skarn formation.

This study has shown that the Riviera pluton is made up of 3 phases; the QPMG, followed by a BMG and lastly the AMG.The third phase is substantially different in the sense that it is fine-grained, has undergone lower intensity alteration, and has no mineral enrichment. The QPMG contains the bulk of the enrichment and a higher intensity alteration (skarnification and potassic alteration). This phase also has the characteristic quartz porphyry texture with large altered primary plagioclase feldspars, and shows an A-type signature. The MZ is within the QPMG. The BMG is characterised by primary biotite grains, a lower intensity alteration which mainly consists of phyllic alteration. The NMZ in the BGM to AGM shows more A-type characteristics as the pluton is more differentiated at depth. A-type granites are much richer in alkalis than I- and S-type granites (Scheepers, 1995). The primary Riviera granite in general contains quartz, feldspars, biotite, as well as accessory titanite and some pyrite. The pluton as a whole is considered to be an A-type granite.

Wall rocks

The wall rocks consist of the northern continuation of the Bridgetown Formation which is part of the Malmesbury Group. This Formation consists mainly of metasediments and metavolcanics. The rocks are fine-grained and definitely foliated. They are deeply weathered and have a strong metamorphic overprint. The age of the Bridgetown Formation is between 1.0 Ga and 560 Ma. The Malmesbury Group has undergone regional metamorphism and was subjected to lower greenschist facies conditions. Thus this is a heterogeneous or impure suite of rocks. Smit (2013) showed that there is a significant calcite horizon in the wall rocks of the Bridgetown Formation that could have given rise to this calcic W-skarn at Riviera.

Stages of skarn formation

The first stage in the development of the Riviera skarn deposit was isochemical metamorphism (stage 1) as the pluton intruded the meta-volcano-sedimentary sequence of the Malmesbury Group. Contact metamorphism was also a result of the intrusion. During this stage water was liberated from the pluton and caused minerals such as chlorite and carbonate to form in situ. Phyllic alteration also occurred as the temperature started to increase and caused the alteration of feldspars into small white mica/sericitic grains. Bastnaesite was probably formed at this stage, as LREE are incompatible and would partition into the first fluid phase. This is then precipitated as bastnaesite. Generally chlorite decreases with the depth of the pluton, whereas biotite increases with depth. This is as a result of the breakdown of biotite that resulted in the deposition of chlorite, titanite and epidote through a hydrothermal reaction at 330-340°C. This is also the reason why chlorite and biotite are always associated or at least in close proximity (Eggleton & Banfield, 1985). The quartz porphyry texture close to the granite-wall rock contact within the QPMG indicates rapid crystallization, but without significant brecciation because it probably was not close enough to the surface for volatiles to be rapidly released (Einaudi et al, 1981).

As the pluton became hotter magmatic fluids started permeating the wall rocks to form hornfelses. The intrusion acted as a heat engine and was also responsible for the metasomatizing fluids. Temperatures can reach up to between 500 and 650°C in this stage (Meinert, 1992). This resulted in metasomatism (2nd phase) due to incoming fluids reacting with pre-existing minerals. Fluids evolved and caused changes in pH and Eh conditions that determine which minerals precipitated.

The wall rocks were relatively impermeable and non-porous (thick foliation) as a result of prior metamorphism that caused permeability contrasts, and the fact that there was a higher pressure due to deep emplacement (5 to 25 km) (Meinert, 1992). Deep emplacement can be deduced from little or no brecciation (Einaudi et al, 1981). The pressure at depth allowed time for enrichment due to better diffusion. Deep emplacement also means that the pluton as a whole was reduced. Permeability contrasts are responsible for the patchy texture observed in the allanite grains, i.e the fact that there was no or very little systematic concentric zoning in this mineral. This also explains the fact that the Riviera ore deposit mainly consists of endoskarn; limited hydrothermal fluid circulation caused the fluid to be concentrated on to the roof or cupola of the pluton. Endoskarn occurs where fluid flow is into the pluton or upward along contacts with the country rocks, and forms through infiltration rather than diffusive exchange (Einaudi and Burt, 1982). Where meteoric fluids from above and metasomatizing fluids from below meet, endoskarn forms.

The amount of endoskarn depends on the degree of permeability produced, the direction of the fluid flow and the fluid composition. The direction of the fluid flow in turn depends on the depth of the intrusion, the orientation of permeable areas and the relative orientations of the geological units. After emplacement and crystallization took place in the pluton, high Ca activities evolved in fluids during primary skarn genesis (stage 1) (Kwak and Tan, 1981). These fluids circulated back through fractures into the pluton where primary magmatic minerals reacted with them to form a Ca-rich assemblage. The remaining fluids were exhausted in Ca and now rich in Si, K, Fe, F, amongst other constituents.

The second phase is the higher temperature prograde metasomatic phase, which gave rise to high temperature minerals such as scheelite, titanite, pyroxene and garnet. This is the process of skarnification. Ultimately this is the stage of endoskarn formation, and thus also the first stage of enrichment. Scheelite is the main ore mineral in this stage with no apparent correlation with other minerals. This phase also resulted in the first phases of in situ fluid-assisted dissolution and reprecipitation (Berger, et al., 2008) of bastnaesite into allanite (allanite 1).

Lastly, as the pluton started to cool, a convection cell of circulating meteoric fluids started to develop from above and had a retrograde effect on the pluton pre-existing minerals (stage 3). Although it is still considered prograde metasomatism, it is as the pluton cooled and conditions were not as extreme as stage 2. This stage first caused potassic alteration. This phase was accompanied by a second phase of LREE-enrichment in allanite (allanite 2). In addition, during the breakdown of biotite (stage 1), K was liberated and partitioned into the fluids. This aided in the development of small secondary alkali feldspar grains. This phase of alteration overprinted the initial phyllic alteration that occurred as the pluton intruded and the temperature was before its peak. Mineralogically this is evident by potassic alteration (alkali feldspar rims) overprinting phyllic alteration (altered plagioclase feldspar). The formation of large secondary white mica flakes is also associated with this stage.

As the pluton cooled, sulphides also started to crystallize, mainly pyrite. There are multiple phases of pyrite: pyrite was part of the original rock which is now evident as anhedral disseminated pyrite, it occurs as a retrograde product of pyrrhotite and also in biotite, and formed late in the paragenetic sequence as some of the grains' euhedral shapes are still preserved. Pyrite also has mutual grain boundaries with allanite which means that it formed at the end of the prograde metasomatic stage as well. A few grains of molybdenite and sphalerite of which the shape was also preserved were found, indicating that they probably also crystallized very late in the paragenetic sequence. Sulphides occur sporadically throughout the pluton, with pyrite being the most abundant.

Pervasive hydrothermal alteration was superimposed on the initial metamorphism and metasomatism in the Riviera pluton in the next stage (stage 4). Stage 4 was followed by the development of especially lower intensity phyllic alteration which is evident as extreme alteration of primary plagioclase feldspar (alkali feldspar to a lesser extent) into white mica, silicification and the deposition of carbonates. Common minerals associated with this stage are amphibole, chlorite, interstitial carbonate, epidote and white mica (sericite). This stage also resulted in the last and lowest grade allanite phase (allanite 3).

Another stage (stage 5) followed as the pluton cooled. This stage is characterised by argillic and advanced argillic alteration. This type of alteration gave rise to the depostion of clay minerals. Alteration during this stage probably resulted in the diffuse boundaries and generally sub- to anhedral shape of allanite which had an originally euhedral shape. This stage could also have resulted in the epidote rims around allanite which occur sporadically. Leaching, especially of the bases (K, Na) and Ca, are characteristic of this type of alteration. These elements are precipitated elsewhere as products from several types of alteration.

Enrichment

Enrichment and alteration did not occur all at once, but multiple pulses of fluids played a role in the development of this deposit. Enrichment was thus a discontinuous process over a length of time. This is evidenced by the lack of correlation between the different phases of W, Mo and LREE enrichment that have been distinguished. (Refer to Pearson's correlation matrix in the appendix). W is only associated with Cu in the high grade zone, which indicates that this stage gave rise to W and Cu enrichment. Other observations to support this conslusion are that 3 different phases (sometimes 4 phases) of enrichment for scheelite were recognized (Pieterse, 2013) and 3 different phases of enrichment for allanite. This also explains the complex mineral chemistry of allanite. The fact that potassic alteration overprints phyllic alteration is another supporting observation, as potassic alteration is the higher intensity and overprinted phyllic alteration which is the lower intensity form of alteration. Also, small secondary alkali feldspar grains are superimposed on primary minerals like quartz. This clearly suggests that a later episode of mixed magmatic and hydrothermal fluids was involved, probably as a result of the last anorogenic A-type phase granite intrusion (AMG).

An overlap in enrichment between W and REE has been observed geochemically. Mineralogically this is present as skarnified granite patches. There is thus a weak correlation between W and REE.

W and Cu enrichment took place first, followed by REE enrichment. Molybdenite crystallized mainly in late stage late stage veins and Zn in sphalerite also developed towards the end of the consolidation of the pluton. Towards the end of the deposition of scheelite, allanite started precipitating. The whole rock REE patterns are similar to those of allanite indicating that the bulk of the REE enrichment lies within allanite. The highest concentration of potentially economic minerals is firstly associated with endoskarn or the skarn zone and thereafter with potassic alteration outside of the skarn zone. Sporadic occurrences of economic minerals especially scheelite and allanite occur throughout the pluton.

Hydrothermal fluids

The changing nature of the late- to post-magmatic fluids played a significant role in the evolution of the Riviera deposit. From a mineralogical point of view, it seems that the fluids were initially reduced (no magnetite, but pyrrhotite and abundant pyrite present). Garnet in the endoskarn has an inner grossular and almandine/spessartine composition (with Fe^{2+}) surrounded by andraditic rims (with Fe^{3+}), which is suggests that later oxidizing fluids played a role. Pyroxene also displays more reduced (hedenbergitic) and more oxidized (diopsidic) varieties.

REE play an important role in unravelling the genesis of the Riviera deposit. They are considered incompatible elements that reside in the melt, and their compounds have a low solubility (Henderson, 1996). The mobility of the REE is dependent on pH, Eh and temperature conditions as well as the availability of potential ligands (Bau, 1991; Banks et al, 1994). REE complexes usually form at neutral to alkaline pH conditions (much less at low pH conditions). At high temperature, and near neutral to alkaline pH, Eu^{3+} is stable. REE complexes will form under these conditions which means limited reduction to Eu^{2+} will occur which will result in no negative anomaly developing (Bau, 1991) This was seen especially in borehole E-200 and also in borehole BB+400 which are strongly LREE-enriched with positive Eu-anomalies. At low pH, high temperature conditions, free REE are more stable and the fluid has the ability to carry large amounts of REE (Banks, et al., 1994). Stability of REE complexes increases with increasing temperature, up to 1000°C, and decreases with increasing pressure, up to 5 kbars (Wood, 1990b; Haas et al, 1993). Thus at high temperatures when scheelite formed, the fluid was able to carry large amounts of REE. As the fluids cooled down and started becoming more oxidized, the ability of the fluids to carry REE slowly diminished and REE were then deposited as allanite.

Eu-anomalies are useful in helping to understand the evolution of the fluids as they are strongly temperature dependent. A strong positive anomaly (Eu^{3+} dominant) is found at high temperatures (greater than 250 °C). At intermediate temperatures both valencies occur (Wood, 1990b; Haas et al, 1993). The Eu-anomalies of allanite vary from positive, to neutral to slightly negative. This means that the fluid associated with the deposition of allanite went from initially reduced at high temperature to oxidized at lower temperature.

Eu-anomalies for the whole rock vary from slightly negative to neutral. A high ΣREE content correlates with a more neutral Eu-anomaly, whereas a more positive anomaly correlates with a lower amount of ΣREE. The hydrothermal fluids thus went from being initially reduced to *slightly* oxidized. It is the same with scheelite, which was the first high temperature economic mineral to form during skarn formation. Fluids associated with scheelite were initially reduced and as the fluids became oxidized (Figure 7.2) scheelite stopped forming (Pieterse, 2013). Allanite grains display oxidized cores and more (relatively) reduced rims, because allanite started forming when scheelite ceased to crystallize when the fluids became oxidized. Positive Eu-anomalies in scheelite also indicate that the fluids transporting the metals were initially reduced which are conducive to REE transport and precipitation (Wood, 1990b; Bau, 1991; Haas et al, 1994).

Zoning in allanite is mainly a function of LREE-enrichment. Th and U also played a significant role (especially U) and U came in with a second influx of hydrothermal fluids in some cases. This has been documented before (Poitrasson, 2002). Zoning was first evident as concentric magmatic zoning as well as a patchy zonation. Infiltration metasomatism not only altered the primary zoning through resorption, it also changed REE patterns due to high mineral-liquid partition coefficients (Sorenson & Grossman, 1989; Bau, 1991). This occurs when fluids leach REE from allanite, form complexes and as the temperature decreases, precipitates additional REE in existing allanite. This was observed in E-200 where the REE pattern is the most highly LREE-enriched of all those studied and is overwhelmingly oxidizing with positive Eu-anomalies.

Allanite has a tendency to alter and this makes allanite an impotant provider of REE to hydrothermal fluids as the allanite lattice exercises a weak control on REE exchanges between the mineral and the fluid. During alteration, there is a definite decrease in LREE. The calc-alkaline nature of the rock will produce fluids that are saturated with respect to Ca-bearing minerals and will therefore rather remobilise REE than Ca in allanite (Poitrasson, 2002). Trace elements in metamic allanite are also more vulnerable to remobilization at the introduction of a hydrothermal fluid phase as a result of metamictization which compromises the crystal structure (Poitrasson, 2002).

The composition of RE minerals can be influenced by a number of factors: a decrease in temperature, a decrease in pressure, mixing of fluids, interaction with wall rocks and crystallization of gangue minerals such as apatite and fluorite (Giere, 1996). The mixing of fluids occurs when reduced magmatic fluids from below meet with oxidizing meteoric fluids from above. The change in pH and salinity causes REE complexes to destabilize and/or lowers the solubility of certain RE minerals (Giere, 1996). The alteration of RE minerals can cause the remobilization and re-precipitation of REE which mainly affects the fluoro-carbonates such as bastnaesite in this case.

Apatite and fluorite are important gangue minerals that may play a key role in the composition of RE minerals (Giere, 1990a; Ayers & Watson, 1993). REE have a tendency to form complexes with F^- and PO_4^{3-} that are also hard ligands. When apatite and fluorite precipitates, it initiates the precipitation of RE minerals as well (Giere, 1990a). This is because free REE are not stable unless it is under low pH conditions. The solubility of apatite increases with increasing pressure (Ayers & Watson, 1993). Due to the deep emplacement of the Riviera pluton and the high confining pressure, apatite should have been fairly soluble. The free PO_4^{3-} ligand and high temperature resulted in REE complexes. As the pressure decreased, apatite would have started to precipitate when fluids are neutralized or diluted by CO_2 by coming into contact with the adjacent carbonate wall rocks. This resulted in free REE in unstable conditions and causing them to precipitate as RE minerals (Caruso & Simmons, 1985), such as allanite in this case. Fluorite is not abundant in the Riviera pluton and is thus considered not to have a played a significant role, but apatite may have well done so. The crystallization of calcite is another factor which would have led to a decrease in CO_3^{2-} in the fluid, resulting in the breakdown of REE complexes and the forced precipitation of RE minerals (Caruso & Simmons, 1985).

The changing nature of the fluids resulted in different phases of LREE-enrichment in allanite (3 phases) as indicated by the various REE profiles examined. Partitioning of REE in allanite has been shown to be redox sensitive. As the fluids evolved from initially reduced to oxidized and as the temperature started to lower, the ability of the fluid to carry REE started to diminish. These conditions were favourable for the deposition of allanite, in accordance with late stage enrichment. There was a strong influence of differentiated magmatic fluids rather than meteoric waters due to abundant REE found in this pluton. A rise in pH due to the mixing of magmatic and meteoric fluids resulted in the breakdown of REE-containing complexes and subsequent precipitation of REE minerals such as allanite, titanite and apatite in this case. Skarn formation takes place at a low pH with high acid consumption and thus a low redox potential. Bastnaesite composition is favourable under high pH conditions whereas epidote forms under low pH conditions and allanite as the pH rises (Banks, et al., 1994).

Similar studies of zoned scheelite from this deposit (Pieterse, 2013) support these observations and indicate that changing redox conditions of the fluid controlled sequential precipitation of REE associated with genetically early scheelite and late stage allanite. As was mentioned before, scheelite displays roughly 3 (to four) phases with Mo-rich and REE depleted cores, and Mo-poor and REE-rich rims. This occurred as the fluids evolved from reduced to oxidized (Figure 7.1 and 7.2). This is also a reflection of decreasing temperature. Alteration through a later hydrothermal phase was also observed (Pieterse, 2013).

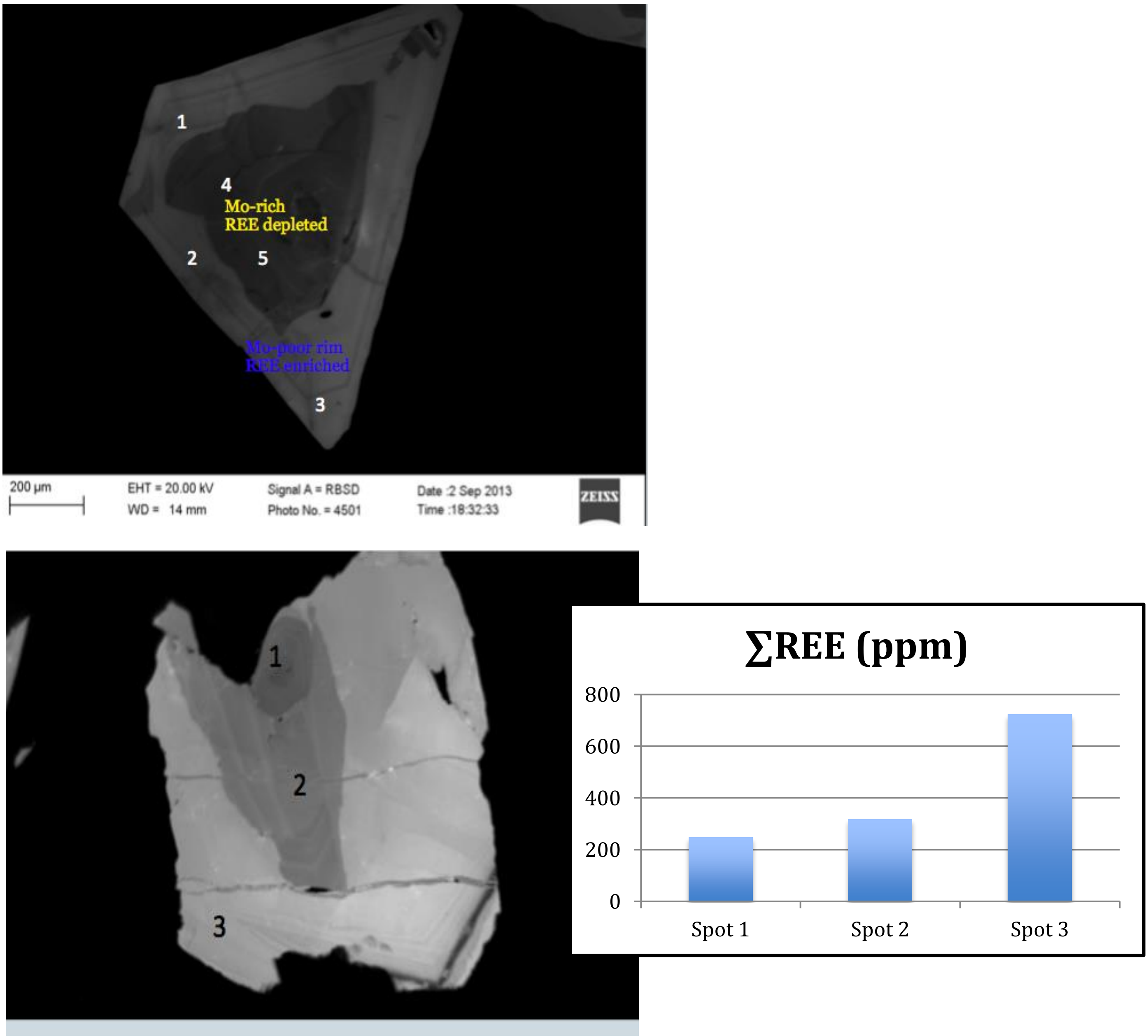

Figure 7.1. Euhedral scheelite crystals from the Riviera deposit with a reduced, REE-depleted and Mo-rich core, and an oxidized, REE-rich and Mo-poor rim.

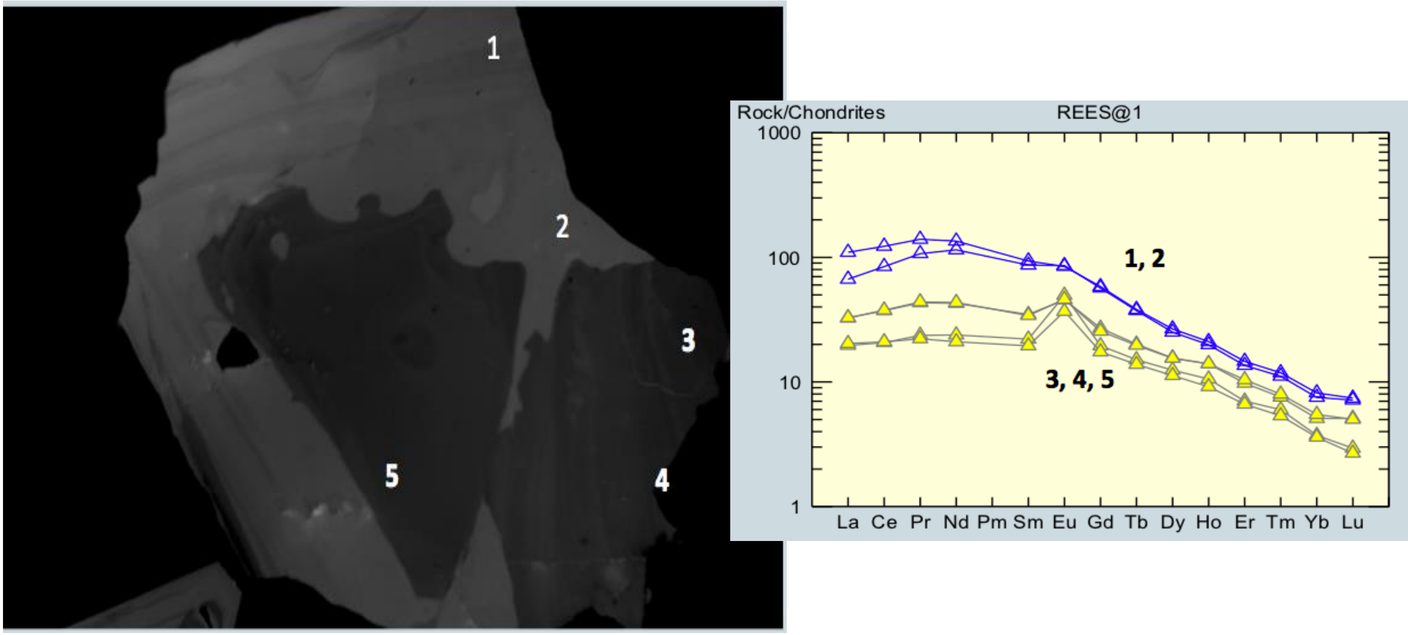

Figure 7.2. REE patterns that are associated with the reduced REE-depleted and Mo-poor part of scheelite (Darker grey on images) display lower overall concentrations of REE and strongly positive Eu-anomalies (Pieterse, 2013).

The large amount of REE in this pluton could not concentrate in plagioclase, garnet or clinopyroxene, or even scheelite as the concentrations are too high. Therefore allanite was a favourable host for the REE (specifically LREE) enrichment (Moore & McStay, 1990).

The fluid that caused the enrichment as it is observed in this pluton was in equilibrium with carbonates, calcic pyroxenes, some amphiboles, and hydrogrossular garnet. This means that the fluid was Ca-rich and Na-poor (Wood, 1990; Taylor et al, 1981) which is also displayed in the whole-rock geochemistry. The fluid evolved from reduced, low pH and Eh and high temperature to oxidized, higher pH and Eh and lower temperature (Figure 7.3).

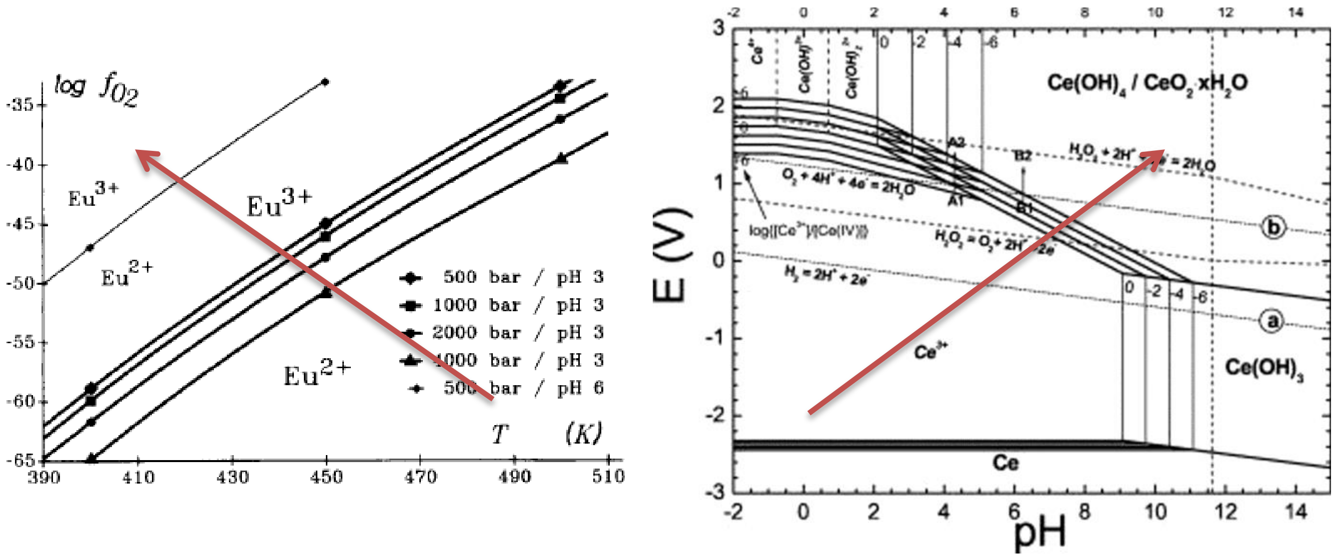

Figure 7.3. Diagrams after (left) Bau (1991) and (right) Yu et al (2005). This typically illustrates the evolution of the fluid (red arrow).

7.2 Global associations

Scheelite skarns have been studied by Newberry and Swanson (1986), who also compared them with Cu-skarn deposits. Scheelite and Cu skarn-associated granitoids are generally similar which can be explained by a similar source of the associated granitic rocks. However, scheelite skarn deposits occur mainly in I-type granites (Kwak, 1978; Einaudi *et al.,* 1981; Einaudi and Burt, 1982), they exhibit variable degrees of crustal contamination, despite a similar source and are more differentiated and crystallized than Cu-skarns, and were formed in deeper plutonic, water-poor environments. The deep plutonic environments lack brecciation, which is also charateristic of porphyry Cu deposits (Einaudi et al, 1981).

Scheelite skarns commonly contain variable amounts of Cu and Mo, (Au very rare), Ag, Sn, Pb, Zn, Co and Ni. They also vary considerably in their carbon content (reducing capacity), as well as in their tungsten content. The bulk of the tungsten in scheelite skarn deposits is of magmatic origin (Kwak, 1978; Dick&Hodgson, 1982). Tungsten is concentrated in exsolved magmatic fluids due to the combined effects of fractional crystallization and magmatic equilibration with a Cl-rich exsolved aqueous phase. Scheelite skarns may be slightly enriched in magnetite and titanite (Newberry & Swanson, 1986).

Plutons that are associated with scheelite skarn deposits range from diorite to granite, but generally consist of the more felsic or differentiated end-members. They are metaluminous to weakly peraluminous (Newberry & Swanson, 1986). The tectonic environments of scheelite skarns are usually continental margin arcs or inner arc environments (Sawkins, 1990; Pirajno, 1992).

Highly carbonaceous wall rocks typically have reduced mineralogies (abundant pyrrhotite and calc-silicate minerals rich in Fe^{2+}). Conversely carbon-poor and/or hematitic wall rocks have oxidized mineralogies with abundant pyrite and minerals poor in Fe^{2+} (Einaudi, et al., 1981).

Scheelite W skarns are mainly endoskarns. Reducing conditions are a prerequisite for the development of endoskarn. The diagnostic assemblage is pyroxene-plagioclase which is typical of most scheelite W skarns (Einaudi and Burt, 1982).

The Riviera deposit conforms in many ways with other scheelite tungsten skarns by displaying a strong link with igneous rocks (Meinert, 1992), an I-type granite association especially the more felsic and differentiated end-members, a deep plutonic emplacement environment, a magmatic origin of the W, an association with Mo, syn- to late orogenic time frame, high Al and Fe contents and low S, scheelite as the most important ore mineral, and reduced calc-silicate and opaque mineralogy (Burt, 1982; Zharikov, 1970; Einaudi, 1977; Shimazaki, 1980; Newberry and Swanson, 1986). Plutons are typically coarse-grained, porphyritic granodiorite to quartz monzonite stocks and batholiths, and there is no indication of forceful emplacement and rapid release of volatiles which is normally indicated by dike swarms, breccia pipes, shatter breccia's, and abundant fractures (Einaudi et al, 1981). Hydrous minerals like biotite, amphiboles and epidote are locally common, particularly close to intrusive and lithologic contacts, and along major hydrothermal channels. Furthermore the Riviera pluton is part of a large batholith, the endoskarn mineralogy consists mainly of pyroxene-plagioclase, and the deposit formed initially under reducing conditions and high temperatures.

Notable differences relate to typical size and grade; the Riviera deposit's tonnage at 46 Mt is substantially larger than the norm, whereas the grade is somewhat lower at 0,216 % WO_3. W-Mo enrichment is closely connected with retrograde alteration, and Mo occurs in quartz-Mo veins. There is also a low F activity in the Riviera pluton.

Globally, deposits most similar to that of the Riviera deposit are King Island in Tasmania (Calver, 2007), Tyrnyauz in Russia (Parasa & Stolyarov, 2012) and Cantung in the Northern Canadian Cordillera (Rasmussen et. al., 2011). They are all similar in the sense that the main element is tungsten and that it is skarn-associated. The main ore mineral for all of them is scheelite and the most common associate is molybdenum as the mineral molybdenite. They were all formed primarily in the Neoproterozoic Period and are subduction-related. The intrusion of felsic rocks/plutons gave rise to these skarn deposits. Cantung is closely comparable with the Riviera deposit in the sense that it is magmatic-hydrothermal and its enrichment is located in the granite cupola or proximal to it. It is also classified as a reduced W skarn. Cantung and Riviera differ however in that WO_3 enrichment is hosted in felsic dykes or aplites in the Cantung deposit, whereas WO_3 enrichment in the Riviera deposit is hosted mainly in the roof of the granite cupola. Not all of these deposits have the same host rocks. King Island is hosted by pelitic and calcareous sedimentary rocks and is classified as an andradite garnet skarn. Tyrnyauz exhibit much the same characteristics as Riviera but with Au as a significant by-product. Only Tyrnyauz has a low grade, high tonnage character like Riviera.

None of the deposits mentioned above identify significantly close to the Riviera deposit in the sense that there is never a REE association with these W skarns. The distribution of REE's and associated rock types in the Riviera deposit was found to be unique compared to deposits in the rest of the world. The Riviera deposit is located in a porphyry-type setting that has been pervasively altered by hydrothermal alteration (Rozendaal & Scheepers, 1992) and a characteristic potential by-product is LREE hosted by the mineral allanite (Rozendaal & Boshoff, 2011).

The relative complexity of this deposit can be ascribed to several reasons. Firstly it is due to the inhomogeneity of the country rocks into which plutons of the Cape Granite suite intruded. Specifically the Malmesbury Group is a metavolcano-sedimentary sequence and is thus a heterogeneous assemblage. The fact that these rocks were first metamorphosed caused permeability contrasts later on when the introduction of magmatic and meteoric fluids commenced. That a later intrusive phase was superimposed is evident through no correlation between the major types of enrichment (W, Mo and REE). This later A-type intrusion has been observed at depth in the AMG.

Another characteristic of this complex deposit is that enrichment commonly occurs closest to the granite-wall rock contact, i.e where the endoskarn is encountered. This is true, particularly for Mo- and W-ores worldwide. Mo enrichment typically accompanies metasomatism by hydrothermal solutions derived from granite porphyry (Liren, Xiuqi, & Shihua, 1991). However this is not the case at Riviera, because it is associated with the vein-type ore.

The Riviera deposit is mainly an endoskarn deposit, as the lack of paucity in the country rocks inhibited the formation of exoskarn (Lowell, 1991). Furthermore the intensity and grade of the hydrothermal alteration is higher and circulation of fluids more extensive towards the granite-wall rock contact or apex of the cupola, relative to deeper down in the deposit where lower grades of hydrothermal alteration prevail.

This review leads one to conclude that some aspects of the Riviera deposit are unique. These are an unusually high amount of LREE-enrichment, a complex internal and external structure of allanite, the association of allanite with bastnaesite (although not always) and that this deposit is a multiphase metasomatic deposit.

Chapter 8 – Summary

The main aim of this investigation was to determine the primary and secondary mineralogy, the textures and distribution of the ore minerals, their geochemistry with special reference to allanite, and the effect that hydrothermal alteration had on the host rock. All this information was then used to construct a genetic model.

- Primary and secondary minerals were identified. Primary minerals include quartz, feldspars, micas and accessory titanite. Prograde metasomatic minerals are bastnaesite, secondary biotite, large secondary white mica, scheelite, garnet, pyroxene, epidote, titanite, vesuvianite, apatite, and allanite. Retrograde minerals are secondary chlorite, ankerite, amphibole, sericite (white mica), goethite and clay.
- Alkali and plagioclase feldspar display 5 distinct phases. Primary plagioclase feldspar is always altered and displays 3 phases; relatively unaltered primary plagioclase feldspar, altered cores of plagioclase feldspar which is usually surrounded by late stage albitic rims or more commonly late stage alkali feldspar rims. The two alkali feldspar phases are primary alkali feldspar which is more common towards the AMG and then small secondary grains or rims of alkali feldspar around altered plagioclase cores. The late stage albitic (Na-metasomatism) and alkali (K-metasomatism) feldspar rims indicate that a later hydrothermal fluid phase played a role.
- The host rock was classified into 3 plutonic phases; a quartz porphyry monzogranite (QPMG), a biotite granite to monzogranite (BMG) and an aphanitic granite to monzogranite (AMG). This is based on the modal mineralogy. The QPMG at the granite wall-rock contact, followed by the BMG and the AMG respectively which is situated at depth away from the granite wall-rock contact. More alkali feldspar is found in the AMG compared to the QPMG and BMG, which confirms that the pluton evolved to more differentiated A-type phases and is confirmed by the whole-rock data.
- The different alteration types observed varies from extremely pervasive, low intensity to extreme high intensity. The lower intensity type of alteration consists of argillic and advanced argillic alteration and is defined by minerals such as clay minerals that occurred as a result of extensive leaching of elements such as K, Na and Ca. Phyllic and advanced phyllic alteration consist mainly of sericitization and saussuritization (small white mica/sericite grains associated with the alteration of feldspars). The entire pluton has been affected by phyllic alteration. Advanced phyllic alteration gave rise to large secondary white mica grains specifically that are not necessarily associated with the alteration of feldspars. Locally this is associated with fluorite and secondary albite (albitization) which is a possible sporadic occurrence of greisen. Other types of alteration that accompanies phyllic alteration

and occurs sporadically in the pluton is greisenization, silicification, chloritization and carbonatization. Potassic alteration consists of minerals such as seconday biotite, secondary alkali and plagioclase (albite) feldspar. Minerals that occurred as a result of skarnification include scheelite, garnet, allanite, clinopyroxene (hed-diop $_{0\text{-}54}$) and bastnaesite.

- The spatial relationship between the different alteration types spatially appears to be interlayered and follows the contour of the pluton. Phyllic alteration is overprinted by potassic alteration particularly in the MZ. Argillic alteration reflecting zones of extreme leaching have been overprinted by secondary quartz (silicification). Higher temperature alteration types selectively overprints lower temperature alteration types. Phyllic alteration occurred first as the alteration of feldspars into sericite and saussurite which was overprinted by potassic alteration and albitization and indicates multi-stage alteration.
- The paragenetic sequence of the mineral phases starts with the minerals that form during crystallization of the pluton namely quartz, feldspars, micas (biotite 1) and accessory titanite. The introduction of the first fluid phase caused the alteration of primary minerals that occurred in the form of feldspars that altered to sericite and saussurite. With the prograde metasomatic skarn development, bastnaesite, scheelite, garnet, pyroxene, epidote, titanite, vesuvianite, apatite, secondary biotite (biotite 2), large secondary white mica, secondary alkali feldspar and albite, and allanite formed. Lastly, retrograde hydrothermal alteration products include secondary chlorite, carbonates, amphiboles, sericite (small white mica grains), goethite and clay minerals. Sulphides other than pyrite formed last in the paragenetic sequence due to euhedral habits observed.
- Geochemical data are not useful for the classification of host rocks as a result of intensive hydrothermal alteration.
- Geochemical data suggest a subduction-related setting of the pluton and the late- to post-orogenic A-type nature of the pluton. The last phase of the pluton, the AMG is believed to be A-type in nature. Trace elements like Ga, Zr, Nb, Ce and Y from the NMZ are more reliable than those of the MZ in giving more accurate immobile representative results in discrimination diagrams.
- Alteration and enrichment are correlated in the sense that the higher temperature alteration gave rise to most of the enrichment. W and REE enrichment is mainly restricted to the roof of the granite cupola, although REE can occur sporadically throughout the pluton. Some overlap of REE with W enrichment is observed as skarnified granite patches outside of the skarn zone. Mo enrichment is low in concentration and is spatially not associated with either W and/or REE enrichment.
- No strong spatial correlation exists between W, Mo and LREE enrichment, indicating that

there were multiple enrichment events.

- This deposit is LREE-enriched with Ce>La>Nd>Pr.
- Allanite is a complex mineral in terms of its textural features such as intergrowths, irregular zonation patterns, replacement and metamictization as well as a non-uniform grain size distribution. The most common types in this pluton are ferriallanite and allanite-Ce.
- Allanite has a poikilitic texture with various inclusions ranging from quartz, a few rare occurrences of monazite, pure apatite as well as a LREE enriched apatite, epidote and titanite. Mutual grain boundaries with pyrite are indicative of allanite's late-stage development.
- Allanite is associated with the high grade tungsten endoskarn-, potassic-ore of the deposit towards the granite-wall rock contact. Sporadic occurrences of allanite have been documented outside of the skarn zone.
- Bastnaesite is the second most important host of REE and is replaced by allanite. Bastnaesite formed first and was replaced by 3 allanite phases and lastly an epidote rim which is characteristic to allanite in this pluton.
- Zoning in allanite grains is in two forms and both are prograde metasomatic. Firstly concentric zoning have been observed, although it is not common in this pluton. A patchy texture with concentric zoning is evident in the rims of some allanite grains. These zones around pre-existing allanite grains are considered to be retrograde and are as a result of later hydrothermal fluid episodes. The patchy texture or zonation of allanite indicates multiple phases of LREE-enrichment through in-situ fluid-assisted dissolution and reprecipitation of LREE from bastnaesite and epidote into allanite.
- The steep slope of the chondrite-normalized REE profiles of single allanite grains indicates that allanite is also strongly LREE-enriched.
- Chondrite-normalized REE patterns for the whole rock analyses are similar to those of the single grains which indicates that most of the rare earth elements are hosted by allanite.
- Allanite is mostly Ce-dominant (especially in the high grade zone); however in the lower grade zones of the deposit some samples indicate slight enrichment of La or Nd. Whole rock data display a Ce-dominant nature.
- Eu-anomalies in allanite vary from slightly negative, to neutral to slightly positive. A high ΣLREE content of allanite correlates with a positive Eu-anomaly whereas the negative anomalies are associated with lower concentrations. This indicates that the hydrothermal or mineralizing fluids vary from reduced to oxidized. This confirms that allanite formed at a late stage with respect to scheelite as scheelite formed under reducing, high temperature conditions. Allanite started crystallizing at the end of scheelite crystallization as the fluids became more oxidized.

- Eu-anomalies of the whole-rock samples vary from slightly negative to neutral. The hydrothermal fluids for the whole-rock thus also went from being initially reduced to slightly oxidized. Mineralogically a reduced nature is observed by the absence magnetite, but pyrrhotite and abundant pyrite. Both garnet and pyroxene display more reduced and more oxidized phases respectively which reflect the changing nature of the fluids.
- In the genetic model of the Riviera deposit, 5 evolutionary stages have been identified; as the pluton intruded, contact metamorphism took place, and the release of hydrothermal fluids caused the alteration of primary minerals (phyllic alteration). Superimposed metasomatism caused pervasive alteration which was firstly prograde skarn formation, followed by potassic alteration, another phase of phyllic alteration (advanced phyllic) and lastly low temperature argillic and advanced argillic alteration.
- A deep emplacement (5 to 25 km) of the Riviera pluton is inferred due to a reduced nature of the pluton and a lack of brecciation despite the quartz porphyry texture.
- The fluid evolved from high temperature, low pH, reduced where free REE (in solution) are more stable giving rise to positive Eu-anomalies, to a lower temperature, oxidized fluid with neutral to alkaline pH and more REE complexes. This conforms to the excepted classic skarn formation by Meinert (1992) where fluids evolve from early prograde and reduced, to late retrograde and oxidized. There was a strong influence of differentiated magmatic fluids due to the large amount of REE associated with this deposit.
- Globally this deposit is similar to scheelite skarn deposits in general. However the REE association with W and Mo appears unique.

The Riviera deposit has been studied extensively in terms of scheelite, allanite and the late stage veins. The next steps that will make a valuable contribution is:

- Fluid inclusion studies to determine the composition, temperature and evolution of the fluid in more detail.
- Sr-isotope research that will aid in the understanding of the evolution of the deposit.
- A study of the wall rocks is necessary in order to determine their influence on the composition of the skarn.

Although this study contributed extensively to the limited mineralogical database, further research of the evolution of hydrothermal fluids is necessary to support findings on the genesis of the deposit. It is anticipated that mining, if it materializes, will bring many more facets to light.

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Appendices

Appendix A – Literature review

A.1. Skarn deposits

Skarn deposits have been studied extensively by a select few authors, such as Einaudi (1981, 1982), Meinert (1981, 1992), Newberry (1981, 1986), Burt (1982) and Kwak (1981, 1987). According to Burt (1982), the first ever published paper on skarn deposits was in 1841. Goldschimdt (1911) was the first person to introduce the term 'skarn' and after that the term stuck. Since 1936, 'skarn' is used for the gangue and ores, where it was previously only used for gangue (Magnussen, 1936).The term skarn is accepted as it is free of any genetic implications (Meinert, 1992). Early scholars referred to skarn deposits as metamorphic or contact deposits (Burt, 1982). Some scholars like Lindgren (1902) maintained that skarn deposits are entirely metasomatic, and that the metals of economic importance were derived from the cooling magma.

According to Kwak (1978), the definition of a skarn deposit is that it is any replacement of a carbonate bearing rock. He went on to define three categories which were 'sensu stricto' skarn (Goldschmidt, 1911), replacement skarn and replacement by greisen solutions such as F-, B- and Li-rich assemblages. Calcic or magnesian minerals may either be abundant, minor or absent. It also includes replacement of non-carbonate rocks such as granites, hornfelses and metavolcanic units. Meinert (1992) stated that skarn deposits can be found in any kind of rock, usually in limestone but otherwise in shales, sandstone, granite, and basalt.

Skarn deposits in general were extensively studied until the 1980's and early 1990's; after that research became much more specific to environments in which skarns are found and individual skarn deposits. Einaudi, Meinert and Newberry (1981), published an extensive paper on skarn deposits, where they looked at their characterisics, tectonic settings and different types. They concluded that a broad correlation is evident between the metal content of skarns and their igneous rock association, as well as tectonic setting (Figure 2). Meinert (1992) found that skarns are found adjacent to plutons, along faults and major shear zones, shallow geothermal systems, sea-floor and lower crustal depths in deeply buried metamorphosed terranes. In short, Fe-rich magnetite skarns are produced by the more mafic igneous rock types in an ocean island arc setting. Minor but economically important metals are Cu, Co and Au. Intermediate to silicic calc-alkaline magmas of continental margins result in W skarns with either Zn, Fe, Cu, Mo or Pb depending on if it's a mesabyssal or hypabyssal environment. Lastly, evolved magmas of continental environments that are either late- or postorogenic result in Sn, W, Mo, Zn, Be, and F skarns (Einaudi et al, 1981). They are all related to magmatic-hydrothermal activity and associated with dioritic to granitic plutonism in orogenic belts (Einaudi and Burt, 1982).

W and Sn skarns are normally at the reduced end of the spectrum (Newberry and Swanson, 1986). Einaudi et al (1981) postulated that skarns are coarse-grained Ca-Fe-Mg-Mn silicates that form as a result of replacement of carbonate-bearing rocks during the processes of both contact metamorphism and metasomatism. These processes include metamorphic recrystallization, bimetasomatic reactions between lithologies that differ, and lastly infiltration metasomatism. Skarns are considered worldwide to be the result of magmatic-hydrothermal systems (Einaudi et al, 1981). What distinguishes skarn deposits from other economic mineral deposits is their gangue mineral assemblage, which is normally a coarse-grained, generally iron-rich mixture of Ca-Mg-Fe-Al silicates. They are formed by metasomatic processes at relatively high temperatures (Einaudi and Burt, 1982).

The most useful method of classifying skarns is to base it on their dominant calc-silicate mineral assemblage. They are either magnesian or calcic, replacing dolomite or limestone respectively. They are further classified based on the dominant metal content. They can be Fe, W, Cu, Zn-Pb, Mo or Sn skarns (Einaudi et al, 1981). Einaudi et al (1981) showed that magnesian skarns with W, Cu and Zn-Pb enrichment are not very common. Subclasses are defined by the second most important metal(s), and they can normally be of any type. The latter will be determined by the magma type, depth of emplacement, reducing capacity, composition of the host rocks, distance of the carbonate rock from the intrusive magma, and lastly the extent to which meteoric water is involved (Einaudi et al, 1981). Again Einaudi and Burt (1982) classified skarns according to the rock types that they replace and the dominant metal. These authors also used the two terms; endoskarn and exoskarn. In general endoskarn is formed by the replacement of intrusive rocks where the skarn-forming fluids are genetically related to the intrusive rock, whereas exoskarn is the replacement of carbonates (Einaudi and Burt, 1982). The majority of skarns are in the form of exoskarns (Ray, 1998).

The age of skarn deposits are generally Mesozoic or younger, although some Paleozoic examples have been identified, which are normally W and Sn skarns (Einaudi et al, 1981). Most deposits of economic importance are relatively young, although ranging from Precambrian to late Tertiary in age (Einaudi and Burt, 1982). Ray et al (1995) studied skarns in British Columbia and found that these occurred in three broad time-periods which relate to three plutonic events. The earliest and most important event was during the Early to Middle Jurassic, followed by the Cretaceous and lastly Eocene-Oligocene.

W and Sn skarns formed in relatively deep environments (5 to 25 km), whereas Cu and Zn-Pb skarns formed in shallow environments and are generally of Tertiary age (Einaudi et al, 1981). According to these authers, W skarns (as well as base metal Cu, Zn-Pb and Mo) generally characterize continental margin orogenic belts. They also established that these skarns are normally affiliated with subduction-related I-type magmas. The granites that intruded to form these skarns are typically coarse-grained granodiorite to quartz monzonite stocks and plutons. These plutons intrude limestone, shale and/or volcanic lithological sequences (Einaudi et al, 1981).

The mineral composition of calcic W skarns and the depth and composition of the host rock result in a continuum between two end-members; the reduced type, which typically formed at greater depths and within carbonate rocks, and the oxidized type which formed at shallower depths and in non-carbonaceous/hematitic host rocks (Einaudi et al, 1981) (Table 2).

Although Meinert (1992) stated that it is the mineralogy that classifies rocks as skarns and also gives an indication of their origin, Einaudi et al (1981) said that it is the evolutionary style of skarn deposits that groups them under one banner. Three major stages of development have been identified which is broadly the same for all skarn deposits. These three stages are: 1. Initial isochemical contact metamorphism, 2. metasomatism, initial ore deposition, initial cooling of the pluton, evolution of the ore-forming fluid, and lastly 3. retrograde alteration and ore deposition which is related to the final cooling phase of the pluton. These stages also result in zoning, which is common in skarn deposits, with the later stages normally overlapping the previous ones (Einaudi et al, 1981).

Calc-silicate hornfelses are normally the result of isochemical metamorphic recrystallization of impure carbonates, whereas relatively pure carbonates result in coarse-grained calc-silicates. The latter is formed by infiltration and diffusion of metasomatic fluids that carry foreign components. Reaction skarn occurs when there is a local exchange of components between two different types of rock. Skarnoid refers to skarn-like rocks of which the origin is complex or uncertain. Skarnoids normally involve metasomatic alteration of impure carbonates, when skarn overprints hornfels or reaction skarn, or when mixed lithologies are homogenized on a large scale (Einaudi and Burt, 1982).

This model is the same one used by Meinert (1992) (Figure 1). He discussed the basic stages of skarn formation and also why there are deviations from the evolutionary model. The causes of deviations from this model include the depth of emplacement, oxidation state, petrochemistry and wall rock composition. He also showed that there are important geochemical and geophysical parameters, and that there are petrologic and tectonic constraints on composition. Meinert (1992) also stressed the fact that skarn deposits can be mapped and are identifiable in the field

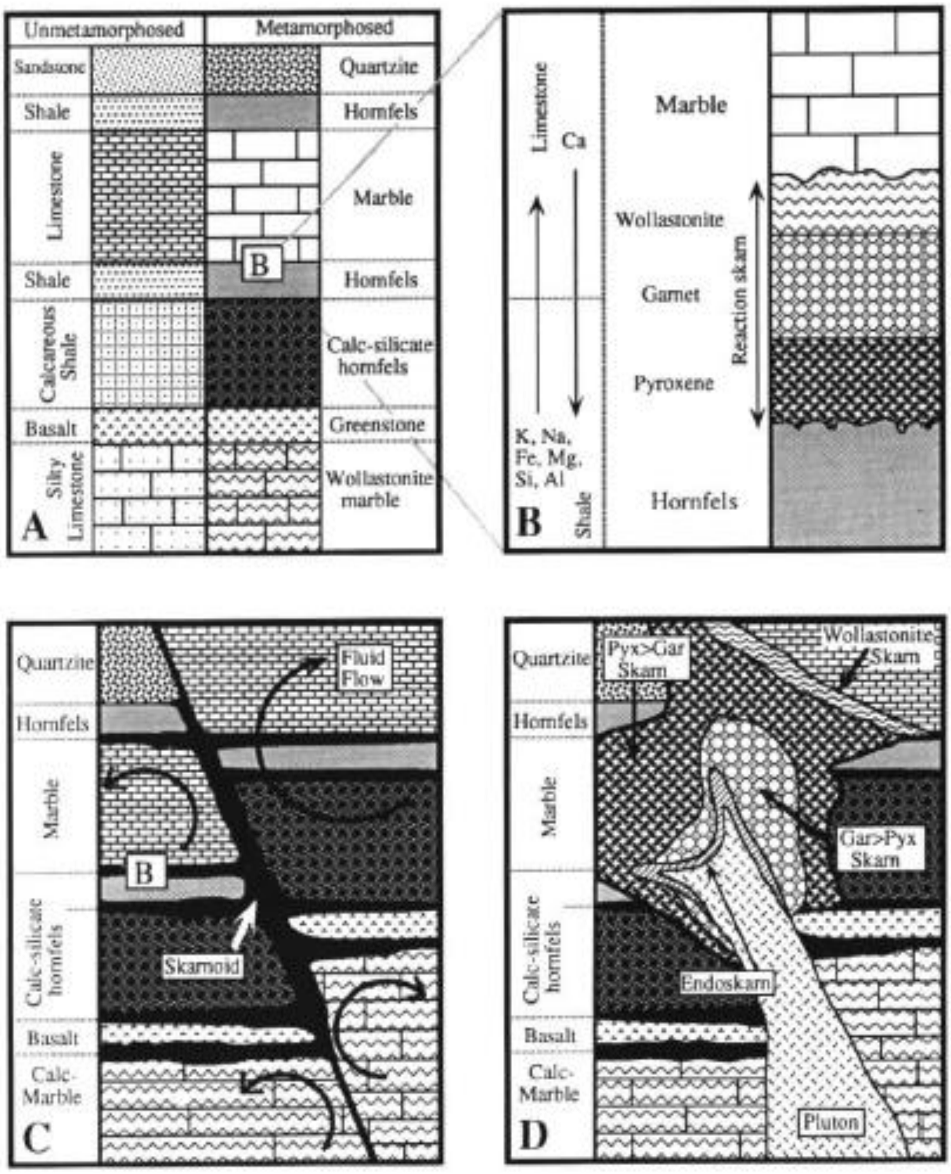


Figure 1. Meinert's (1992) model of the stages of skarn evolution. A) Isochemical metamorphism occurs as the pluton intrudes and involves recrystallization and changes in mineral stability without mass transfer. B) Reaction skarn forms as a result of metamorphism of interlayered lithologies. Mass transfer occurs on a small scale (bimetasomatism). C) Skarnoid results from metamorphism of impure lithologies. Some mass transfer occurs via small-scale fluid movement. D) Fluid-controlled metasomatic skarn is the last stage, is typically coarse grained and hardly reflects the composition or texture of the protolith.

This model is still widely used in terms of determining the genesis of skarn deposits. In terms of the evolution of hydrothermal fluids in skarn systems, from prograde and magmatic to retrograde and meteroric (Meinert, 1992), more recent research (Meinert et al, 2003) challenged this model and concluded that hydrothermal fluids can remain mainly magmatic towards the retrograde stage although they restrict these conclusions to skarn deposits where hydrothermal fluids escaped the igneous pluton and interacted vastly with the wall rocks. Examples of these types of deposits are porphyry Cu deposits (Meinert et al, 2003).

Skarn deposits should not be seen in isolation from other types of minerlization related to granitoid rocks. The image below (Figure 2) shows how the composition of a granite influences the type of deposit that forms. The more differentiated or felsic the granite, the greater the chance of W enrichment.

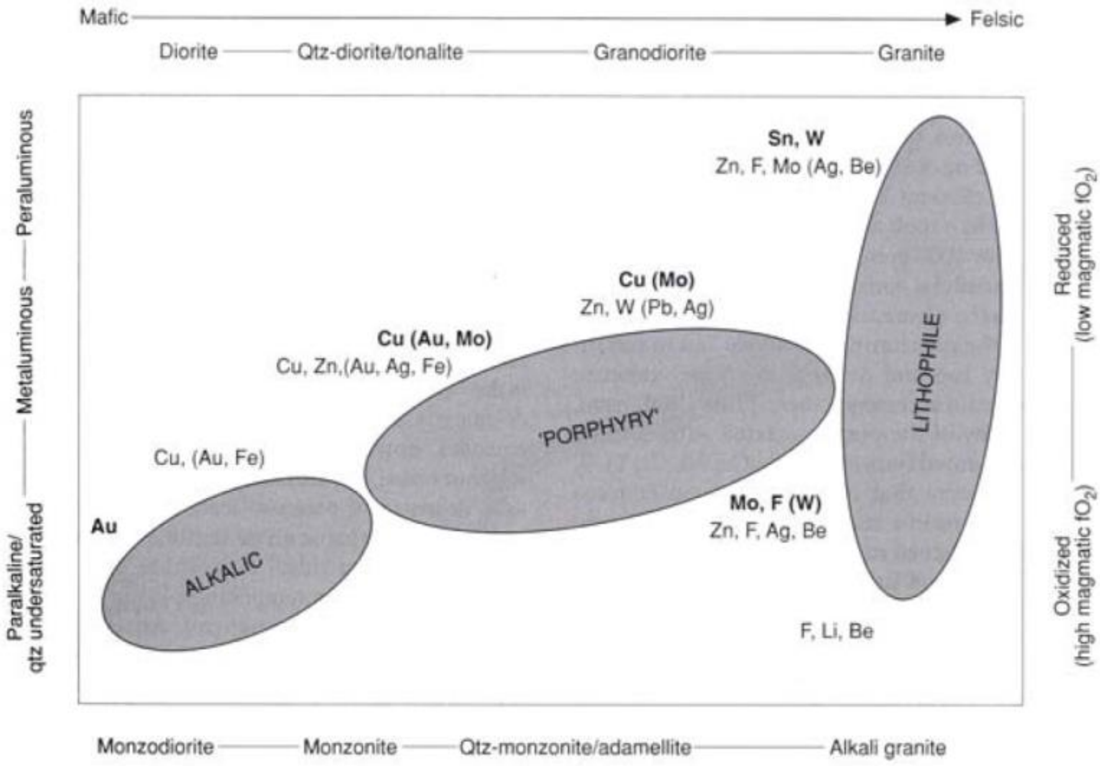


Figure 2. A generalized scheme that links granite compositions and magmatic oxidation state to metal associations and intrusion-related ore deposits (modified after Barton, 1996). Metals in bold reflect the more important associations (Robb, 2005).

A.2 Endoskarns

In the world of skarn deposits, endoskarns are normally the least common type compared to exoskarns (Ray, 1998). Endoskarn replace silicates igneous rock as opposed to carbonate wall rock, i.e they occur in the granite pluton (Kwak, 1987).

Einaudi and Burt (1982) suggested that endoskarns are widespread in districts where metasomatic fluids utilized shale/limestone, volcanic/limestone, or dike/limestone contacts as conduits that were extensively fractured or permeable. Endoskarns also occur in narrow zones at immediate intrusive contacts. Where limestone is absent, endoskarn normally contains ore. They are favoured in areas where fluid flow is generally into the pluton, or upward along contacts with carbonates, and formed through infiltration rather than diffusive exchange. They also display patterns of mineral zoning which reflect the progressive addition of Ca to the protolith rock, and is normally biotite to amphibole to pyroxene to (garnet) towards the limestone or fissures. In addition alkali feldspar disappears with biotite, and plagioclase becomes an important phase throughout the assemblage which is typical of most W-skarns (Einaudi and Burt, 1982).

Kwak (1978) agrees that the term endoskarn is generally applied to cases where the granitic intrusive rock is replaced; minerals generally include clinopyroxene, plagioclase, titanite, quartz, garnet, wollastonite, scapolite and epidote minerals. Endoskarns are normally restricted to W-skarns because of the deep emplacement and generally low F and B (Kwak, 1987). Where endoskarn occurs with exoskarn, ore is generally restricted to exoskarn; however, significant enrichment commonly occurs where only endoskarn is present. In most endoskarns Fe and Ca are added, even when no obvious carbonate units occur. The amount of endoskarn depends on the degree of permeability produced, the direction of the fluid flow and the fluid composition. The direction of the fluid flow in turn depends on the depth of the intrusion, the orientation of permeable areas and the relative orientations of the geological units. A possible model for the composition is that after emplacement and crystallization took place, high Ca activities evolve in fluids during primary skarn genesis (stage 1) (Kwak and Tan, 1981). These fluids are circulated back through fractures into the pluton where primary magmatic minerals react to form a Ca-rich assemblage. The remaining fluids are exhausted in Ca and now rich in Si, K, Fe, F, amongst others, and produces exoskarn.

The lack of endoskarn deposits worldwide is truly reflected in the lack of literature available on this subject. Only two endoskarn deposits were found: the Empire Mine in Idaho USA (Chang & Meinert, 2004), and the Evciler granitoid, Kazdaû in Annakkale, Turkey (Yucel-Ozturk et al, 2005). They will be briefly discussed below.

The Empire Mine in Idaho USA is a Cu-Zn-(Au)-(Ag) skarn deposit associated with a porphyry phase. Ore reserved are estimated at 30,730 tons Cu, 456 tons Zn, 41,159 ounces Au, and

1,293,208 ounces Ag (Wilson et al, 1995). Recent drilling indicates an oxide resource of 18 Mt at 0.49% Cu, 0.19% Zn, 13.5 g Ag/t and 0.48 g Au/t (Chang & Meinert, 2004).

The intrusive rock consists of a quartz monzodiorite, granophyre and granite porphyry. Dikes are also present in the area. The skarn composition and enrichment are associated with the granite porphyry. Wall rocks are argillites and limestones, as well as volcanic rocks (early mafic to intermediate compositions, through silicic, to late silicic and intermediate rocks). Although this deposit is mainly an endoskarn, exoskarn is also evident. Endoskarn is either formed as massive replacements of the intrusive rock, or as calc-silicate veins. The alteration that is evident consists of weakly disseminated diopsidic pyroxene at first replacing the granite porphyry, to clusters of fine grains such as actinolite and titanite, and lastly the carbonate wall rock which has been altered to marble through metamorphism. Retrograde alteration is limited in the endo- and exoskarn, and is evident in minerals such as cryptocrystalline quartz, calcite, chlorite, fluorite and chalcopyrite. Ore minerals include molybdenite, hematite, galena and arsenopyrite. Supergene minerals such as chrysocolla, malachite, azurite, native Cu and limonite are also present. The zonation within endoskarn veins with respect to mineralogy, mineral composition, mineral colour, temperature of fluids and the decrease of fluid temperature from endoskarn to exoskarn, indicate that the fluid originated from the magma (Chang and Meinert, 2004).

The Evciler granitoid in Kazdaû Annakkale, Turkey is a Cu-Au skarn deposit, which mainly consists of endoskarn. The country rocks are amphibole-gneiss, migmatite, marble and amphibolite overlain by ortho-amphibolite. The upper unit consists of sillimanite-gneiss, migmatite, marble, amphibolite and granitic gneiss. Metamorphic rocks comprise mainly grey, dark grey, and brown well-banded quartzo-feldspathic gneisses which include marble, amphibolite and granitic gneiss horizons and lenses. The host rock is typically monzodioritic to granodioritic. It consists mainly of epidote and pyroxene, as well as garnet closer to the contact. Alteration includes epidotization and sericitization. Further away from the host rock into the wall rock, skarn is more disseminated. Normalized REE profiles display a horizontal pattern for the HREE with slightly negative Eu anomalies. Normalized patterns of leucocratic rocks however are LREE-enriched with strong negative Eu anomalies and slightly positively sloping HREE (Figure 3) (Yucel-Ozturk et al, 2005).

The Evciler granitoid has a metaluminous to mildly peraluminous calc-alkaline character. It is also of the volcanic arc type, syn-collisional and display I-type characteristics (Yucel-Ozturk et al, 2005).

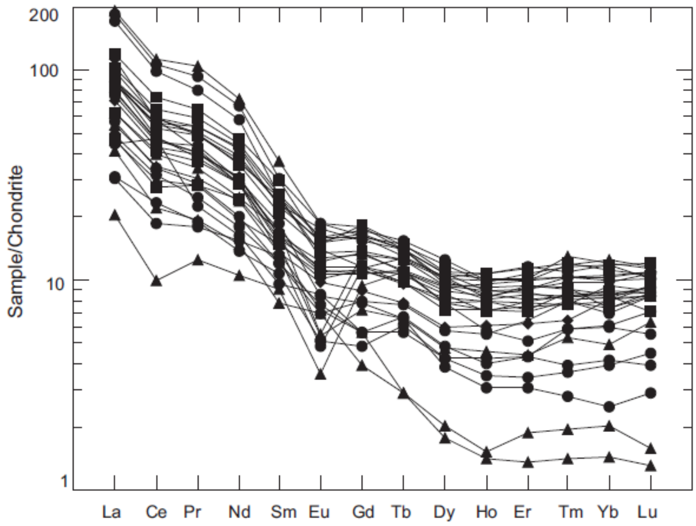


Figure 3. Chondrite-normalized REE patterns for Evciler granitoid (Yucel-Ozturk et al, 2005).

A.3 Tungsten skarns

Scheelite skarns in general have been studied by Newberry and Swanson (1986), who also compared them to Cu-skarn deposits. Scheelite and Cu skarn-associated granitoids are generally similar which can be explained by a similar source of the associated granitic rocks. However, scheelite skarn deposits occur mainly in I-type granites, they exhibit variable degrees of crustal contamination, have a similar source as Cu-skarns but are more differentiated and better crystallized than Cu-skarns: They also originated in deeper plutonic, water-poor environments. Scheelite skarns contain variable amounts of Cu and Mo, (Au very rare), Ag, Sn, Pb, Zn, Co and Ni. They vary considerably in their carbon content (reducing capacity), as well as in their tungsten content, with the bulk of tungsten in scheelite skarn deposits being of magmatic origin (Kwak, 1978; Dick&Hodgson, 1982). Tungsten is concentrated in exsolved magmatic fluids due to the combined effect of fractional crystallization and magmatic equilibration with a Cl-rich exsolved aqueous phase, or slightly elevated concentrations of magnetite and titanite, thus supporting a magmatic origin (Newberry & Swanson, 1986).

Plutons that are associated with scheelite skarn deposits range from diorite to granite, but generally include the more felsic or differentiated end-members. They are metaluminous to weakly peraluminous (Newberry & Swanson, 1986). In terms of wall rocks, highly carbonate-rich wall rocks typically have reduced mineralogies (abundant pyrrhotite and calc-silicate minerals rich in Fe^{2+}). Conversely carbonate-poor and/or hematitic wall rocks have oxidized mineralogies with abundant pyrite and minerals poor in Fe^{2+} (Einaudi, et al., 1981).

According to Einaudi et al (1981), skarns are the largest source of W in the world. The most important W deposits of the western world in the 1980's were those of the northeastern Canadian Cordillera, which were referred to as contact metasomatic deposits at the time (Dick & Hodgson, 1982). The biggest deposit was Mactung, and the largest producer of scheelite concentrate was Cantung.

Einaudi and Burt (1982) gave a general overview of skarn deposits, focussing on terminology, classification, and composition. They formulated, amongst other things, a table summarizing the general characteristics of the different types of skarn deposits. These include Fe, W, Cu, Zn-Pb and Sn-W. The column on W skarns is reproduced below:

Table 1. Diagnostic characteristics of calcic W skarns (Einaudi and Burt, 1982):

Typical size	**Typical grade**	**Metal associated**	**Tectonic setting**	**Associated igneous rocks**	**Cogenetic volcanics in ore zone**	**Pluton morphology**	**Alteration of igneous rocks (endoskarn and other)**	**Exoskarn composition**	**Early minerals**	**Late minerals**	**Ore minerals**
0.1 – 2 m.t	0.7 % WO_3	W, Mo, Cu, (Zn, Bi)	Continental margin, syn- to late orogenic	Quartz diorite to quartz monzonite, rarely alaskite	Absent	Large plutons, batholiths	Endoskarn: local, pyroxene-plagioclase, Other: local quartz-biotite-muscovite-sulfide	High in Al, Fe, low in S	Ferrosalite – hedenbergite, grandite, idocrase, wollastonite	Spessartine – almandine – grandite, biotite, hornblende, plagioclase	Scheelite, molybdenite, chalcopyrite (sphalerite, pyrrhotite, magnetite, pyrite, bismuth)

Einaudi et al (1981) summarized all the important elements of tungsten skarn deposits as follows:

- They occur in Precambrian to Triassic limestone.
- They are associated with calc-alkaline intrusives of Mid-Paleozoic to Late Cretaceous age.
- Metasomatic origin.
- They clearly differ from other skarns in being characterized by reduced calc-silicate and opaque mineralogy (Burt, 1982; Zharikov, 1970; Einaudi, 1977; Shimazaki, 1980; Newberry and Swanson, 1986).
- Plutons are typically coarse-grained, porphyritic granodiorite to quartz monzonite stocks and batholiths.
- There is no indication of forceful emplacement and rapid release of volatiles which is normally indicated by dike swarms, breccia pipes, shatter breccia's, and abundant fractures.
- The tendency to fracture associated with volatile exsolution, decreases rapidly with depth (Burnham, 1979).
- Megascopic alteration of intrusive rocks related to tungsten skarns are limited to narrow zones of endoskarn
- Endoskarn contains clinopyroxene-plagioclase-epidote adjacent to skarn contacts
- They typically occur in argillaceous carbonate rocks and intercalated carbonate-pelite or carbonate-volcanic sequences.
- The host rocks are carbonate-rich and thus impart a low oxidation state to the skarn-forming environment (Dick, 1976; Shimazaki, 1980).
- The occurrence of barren, Fe-poor calc-silicates, beyond Fe-rich scheelite-bearing skarns is characteristic.
- They are generally stratiform and skarn is continuous for hundreds of meters along lithologic contacts but less than 15m thick.
- Pure marble results in medium-grained skarn that is compact and possesses more uniform W grades (Newberry, 1979).
- Skarn mineralogy is expressed as a function of host rock composition (Fonteilles et al, 1978), of intrusive imposed oxidation state (Shimazaki, 1978), and of wall rock imposed oxidation state (Fonteilles et al, 1978; Newberry, 1979).
- Two general varieties of skarn are defined (Newberry, 1979): reduced skarn formed in carbonate-rich host rocks at higher pressures (>1 to 1.3 kb), and oxidized skarn formed in non-carbonate/hematitic host rocks at lesser depths or at lower pressures (<0.5) (Table 2)
- Hydrous minerals (biotite, hornblende, actinolite, and epidote) are locally common, particularly close to intrusive and lithologic contacts, and along major hydrothermal channels.

- High grades of tungsten are associated with retrograde assemblages such as titanite and apatite.
- The abundant release of Ca by the breakdown of pyroxene and garnet during retrograde alteration, allows for the precipitation of W from solution (Newberry, 1980).
- Generally relatively hotter and deeper environment.
- The viability of the deposit depends on tonnage, mining method, geographic location, scheelite grain size, and by-product production.
- Generally early anhydrous skarn contains moderate and relatively consistent grades of fine-grained, high molybdenum scheelite; whereas skarn altered by retrograde fluids contain very high to low grades of medium- to coarse-grained low-molybdenum scheelite (Krauskopf, 1953; Newberry, 1980a).

Table 2. Contrasting characteristics of reduced and oxidized tungsten skarns (Einaudi et al, 1981).

			Reduced skarns	**Oxidized skarns**
Prograde stage	Pyroxene/garnet		10:1 to 2:1	1:1 to 1:10
	Pyroxene composition	Mole % hedenbergite	60 -90	20 – 70
		Mole % johannsenite	5 – 20	0 – 5
	Garnet composition	Mole % andradite	10 – 50	50 – 80
	Late garnet composition	Mole % andradite	0 – 50	80 – 100
		Mole % spessartine	5 – 35	0 – 5
		Mole % almandine	5 – 40	0
Retrograde stage	Typical assemblages		Bt-plag-opaques ± calcite; hbl-opaques-qtz-cc	Ep-chl-cc-qtz; ac-opaques-qtz-cc
	Amphibole	Mole %	0- 80	30 – 60

	composition	ferrotremolite		
		Mole % tremolite	0 – 30	30 – 70
		Mole % ferropargasite	70 – 100	5 – 20
	Diagnostic opaques		Pyrr, mgt (py, native Bi)	Py (mgt, pyrr, bismuthinite)

A.4 Porphyry deposits

Relatively recent research on porphyry deposits were done by Cooke and Walshe (2005), who examined giant porphyry deposits, and Sinclair (2007), who took an in-depth look at the general characteristics of porphyry deposits with a focus on Canadian occurrences. Sillitoe (2010) describes porphyry Cu systems in general. Two deposits in South Africa have been identified and are classified on a global scale as porphyry related deposits (Figure 4). These two deposits are the Riviera deposit and the Boterberg deposit (see Rozendaal & Scheepers, 1995).

Case studies for this review include an article by Soloviev (2010), who investigated the geology, enrichment and fluid inclusion characteristics of the Kensu W skarn and Mo-W-Cu-Au porp

hyry deposit in Kyrgyzstan, Song et al (2012), who examined the Jitoushan and Baizhangyan W-Mo deposits in China, and Noble et al (1984) who focused on a low grade W (scheelite)-Mo porphyry deposit in the South Central Yukon territory.

Porphyry deposits are known to be the most important sources of Cu, supplying about three-quarters of the world's Cu (Sinclair, 2007; Sillitoe, 2010). Primary deposits are also major sources of Mo, Au, Ag, Sn, and by-products that include Re, W, In, Pt, Pd and Se. They are large, low to medium grade deposits although porphyry W-Mo is normally no more than 100 Mt @ 0.1 to 0.3% W (Sinclair, 2007). Silitoe (2010) suggests average grades of 0.5 to 1.5% Cu. What distinguishes W-Mo porphyries from other deposits such as skarns, mantos, mesothermal veins and epithermal precious metal deposits are their large size and the fact that they are generally structurally controlled. They are mainly in the form of stockworks, veins, vein sets, fractures, dike swarms and breccias (Sinclair, 2007; Sillitoe, 2010). Cooke et al (2005) argue that these deposits are normally characterized by low grade Cu, Au and/or Mo enrichment developed within and around a porphyritic intrusive complex.

Geographically they are distributed in a series of extensive, relatively narrow, linear metallogenic provinces or (Sillitoe, 2010), which are predominantly associated with Mesozoic to Cenozoic orogenic belts (Figure 4). In Central Asia and eastern North America the major deposits are in Paleozoic orogens (Sinclair, 2007). The peak periods for the formation of porphyry deposits are Jurassic, Cretaceous, Eocene and Miocene (Sinclair, 2007).

Porphyry Cu is normally in root zones of andesitic stratavolcanoes, in subduction zones, island- and continental arcs: on the contrary porphyry W-Mo is in F-rich granitic rocks. These granites probably intruded during a time of extension related to crustal delamination (Sinclair, 2007). Sillitoe (2010) found that they are widely distributed at convergent plate boundaries. These systems are closely related to igneous plutons that intruded at depths between 5 to 15 km (Sillitoe, 2010).

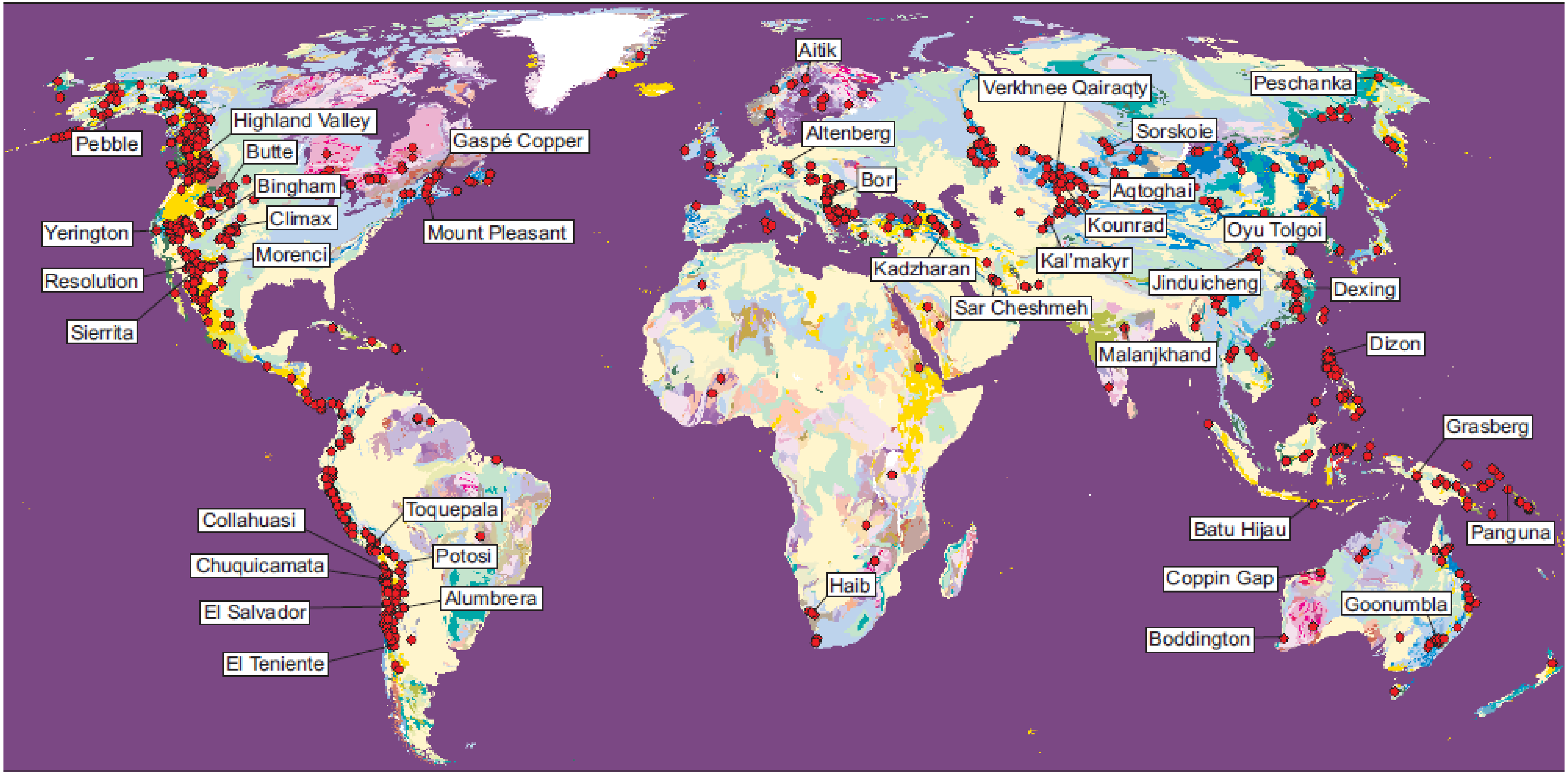


Figure 4. This map displays the occurrences of porphyry deposits worldwide (Kirkham & Dunne, 2000). The two red dots in South Africa are the Riviera and Boterberg deposits. They are considered to be a porphyry associated skarn Cu deposit (Riviera) and a porphyry Cu deposit (Boterberg) respectively.

Some W-Mo deposits are associated with areas of continental thickness that relate to a collisional setting. W-Mo deposits are typically associated with felsic, high silica (72 – 77 wt% SiO_2) granitic plutons that are strongly differentiated and are also generally associated with oxidized magnetite-series plutons (Sinclair, 2007).

According to Cooke et al (2005), tectonic triggers are ephemeral in nature and topographic and thermal anomalies on the down-going slab act as tectonic triggers for porphyry ore emplacement. Compressive tectonic environments, thickened continental crust, and active uplift and erosion are normally associated with their formation.

Although the overall sulphur contents in W, Mo and Sn porphyry deposits are typically low, pyrite remains the dominant sulphide. The principal ore minerals in a W-Mo porphyry deposit are scheelite, wolframite, molybdenite, cassiterite, stannite, bismuthinite and native Bi. Other minerals include: pyrite, arsenopyrite, löllingite, quartz, alkali feldspar, biotite, muscovite, clay minerals, fluorite and topaz. Alteration also forms a characteristic feature of porphyry deposits, and it is normally extensive. It generally consists of an inner potassic zone, an outer propylitic alteration zone, and also zones of phyllic alteration (Sinclair, 2007).

The generally accepted genetic model is the magmatic-hydrothermal model (Figure 5). It is illustrated schematically for a porphyry Cu deposit associated with a stratovolcano below (left) and the orthomagmatic model (right):

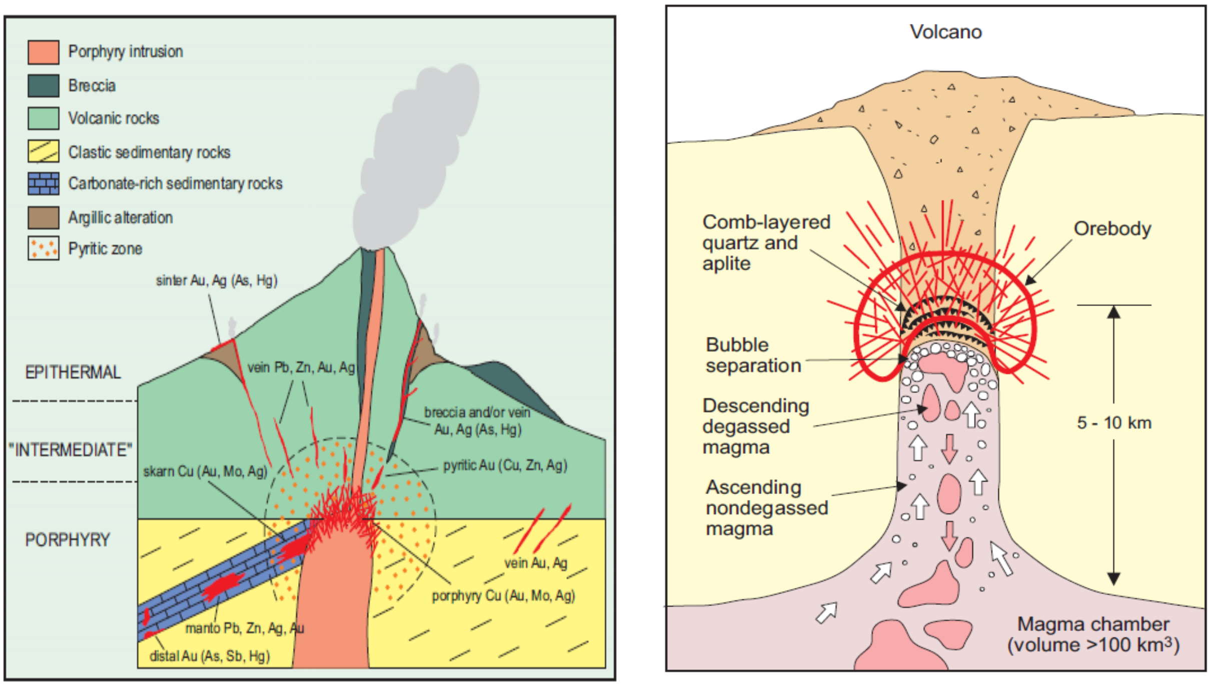


Figure 5. This diagram illustrates the configuration of a Cu system in the root zone of an andesitic stratovolcano (left) and the orthomagmatic model for porphyry Cu deposits (right) (Kirkham and Sinclair, 2000).

For this review three deposits were identified based on their dominant metal association. The first one is the Logtung W-Mo porphyry deposit in the South-central Yukon Territory, Canada (Noble et al, 1984). It consists of 165 Mt of WO_3, at 0.13% WO_3 and 0,053% MoS_2. This deposit is considered a porphyry deposit because the ore occurs in fractures, i.e not a skarn deposit. Multiple felsic intrusions gave rise to four superimposed generations of enrichment in fractures. Host rocks are those typical of the Yukon cataclastic complex, which consists of a tectonic mélange of sheared and tectonically interleaved cataclastic, volcanic, intrusive, and carbonate rocks. The sedimentary rocks in the area are carboniferous sandy dolomites and limestones interbedded with graphitic argillites and phyllites and massive grey quartz. The intrusive suites are a variety of older ultramafic to granodioritic, and younger quartz monzonitic to monzogranitic rocks. These rocks exhibit a seriate to porphyritic texture and are Cretaceous in age. Alteration is evidenced by the following minerals: sericite, calcite, fluorite, epidote, scheelite and biotite being replaced by chlorite. Noble et al (1984) found that tungsten skarn deposits normally contain disseminated or vein-hosted Mo enrichment, and that Mo-porphyry deposits contain accessory/minor scheelite or wolframite. This deposit differs from scheelite skarn deposits in the fact that W-enrichment is temporally related to at least two intrusions whereas many W skarns are related to one. Also, the style of enrichment is fracture-contained, rather than truly disseminated as it is in skarn deposits.

Although the Jitoushan W-Mo deposit of the Yangtze valley in China was mainly studied from a geochronologic and isotopic viewpoint, a few of its characteristics are worth mentioning (Song, et al., 2012). This deposit contains porphyry Mo at depth and the country rocks are made up of sedimentary and low grade metasedimentary rocks. These rocks were intruded by granodiorite, diorite porphyry, granite porphyry and quartz porphyry. The W-Mo enrichment is hosted on the contact between the granodiorite and Cambrian banded limestones. The mineral composition of the diorite porphyry includes quartz, plagioclase feldspar, alkali feldspar, titanite, epidote, biotite, hornblende, apatite, zircon and chloritization of biotite. Alteration is in the form of silicification and chloritization, epidotization, and carbonatization which are developed in the contact zone. The prograde skarn consists of garnet and diopsidic pyroxene, whereas retrograde assemblages consist of tremolite, quartz, fluorite, epidote, calcite, and chlorite. W-Mo enrichment is closely associated with retrograde alteration, and Mo occurs in quartz-Mo veins. Ore minerals are scheelite, molybdenite, pyrite, and minor chalcopyrite, galena, and sphalerite. Scheelite co-exists with garnet, diopside and epidote, and is in the form of euhedral to semi-euhedral granular crystals (0.1 – 3mm, some 8 mm). Fine-grained galena and sphalerite are found closer to the top of the deposit. The types of ore in this deposit include skarn-type ore, disseminated granodiorite-type ore, and quartz vein-type ore. The skarn is both banded and massive. It was concluded that the ore-forming materials were derived from the deep crust (Song, et al., 2012).

Lastly the Baizhangyan deposit in the Middle-Lower Yangtze Valley, in SE-China forms part of a Mo–W–Pb–Zn metallogenic belt (Song, et al., 2012). It has a Re-Os weighted average age of 134.1 ± 2.2 Ma. Orebodies are situated in the contact zone between fine-grained granite and limestone. Four stages of evolution were identified that gave rise to this skarn-porphyry deposit: the skarn stage, consisting of limestone-hosted deposits with minerals such as garnet, diopside, wollastonite, tremolite, vesuvianite and minor epidote and amphibole; the oxide stage, characterized by oxide minerals such as scheelite and minor molybdenite as well as quartz, minor epidote and amphibole; the sulphide stage with molybdenite, pyrite and quartz in extensional fractures and lastly the carbonate stage, made up of quartz and calcite in later tensional fractures. The main intrusive rocks are diorite porphyry, quartz diorite porphyrite, granodiorite, granodiorite porphyry, syenodiorite, granite, monzogranite, granite porphyry, syenite porphyry, quartz porphyry and a few mafic dikes formed in the Mesozoic. Proved and inferred W–Mo reserves reached more than 30,000 tons (about 20,000 tons of W and 10,000 tons of Mo metal) (Song, et al., 2012).

A.5 Global distribution of W deposits

There are many tungsten deposits spread-out worldwide, with many different types of associations linked to them. Figure 6 displays the name, location and association of 72 of the most prominent tungsten deposits in the world.

An extensive table summarizing all the tungsten deposits found in the literature study and available information appears in Table 3. In general these tungsten deposits are post-collisional, subduction-related and originated within the Neoproterozoic to Mesozoic and Tertiary time-periods, mostly within the last 500 Ma. Their host rocks include porphyry monzogranite to granite or monzodiorite to granodiorite, with a peraluminous and reduced nature. They are coarse- to fine-grained. Wall rocks consist of metasediments and metacarbonates, including schists, sandstones, limestones, black and green schist, volcanics and shales. They typically have a low grade, high tonnage assemblage (and vice versa although it is much less common), with the highest WO_3 grade at Cantung mine in the Northwest Territories in Canada, grading at 1.56% WO_3 but at a tonnage of only 6.21 Mt (Rasmussen, et al., 2011). Common associations of tungsten deposits are skarn, greisen, various breccias, and porphyry- and vein-type occurrences. Tungsten deposits are usually classified as exo- or endoskarn, calcsilicate skarn or porphyry type deposits.

The latest literature is biased towards Chinese deposits as China is currently the major producer of this commodity. China has many deposits ranging from VHMS, MVT, SEDEX, skarn, porphyry, Carlin-type, epithermal, orogenic, stratabound and vein-type deposits (Zaw, et al., 2007). However most of them are small compared to the dominant deposits in China. Porphyry deposits are mostly Cu-porphyries and skarn deposits mostly have a Cu-Mo and Au-Cu association, not W. Deposits of interest in this study are the Xingluokeng (Zhang, et al., 2008), Dajishan (Zhang et al, 2007; Ningqiang, 2011), Xingluokeng and Lianhuashan deposits (Zaw, et al., 2007). They are all located in the south of China which is a region rich in mineral resources and with a wide diversity of deposit types (Zaw, et al., 2007). The W deposits are generally classified as porphyry-type and stockwork W-Mo, and are associated with porphyritic rocks, two-mica granites and alkali feldspar granites. These deposits are typically of the low grade high tonnage variety. They date from the Paleozoic to Tertiary, with the younger Tertiary deposits being the most common.

Figure 6. The location and type of major tungsten deposits and districts are illustrated on this map (British Geological Service (2011): Commodity Profile: Tungsten, available from: www.bgs.ac.uk). Only mined deposits are shown on this map. The Riviera deposit has been added (black circle).

Table 3. Similar W deposits around the world.

Deposit	Age	Setting	Host	Wall rocks	Grade/Tonnage		Association	Classification
				South Africa				
Riviera	505 ± 20 Ma	Orogenic belt	I-type granite Endoskarn	Malmesbury group – Greenschist facies metacarbonate rocks	0.2176% WO3 0.020% Mo	46 Mt WO_3 9 Mt Mo	Porphyry type Mo <Au <Ag Zn Pb Cu REE	Endo-granitic ore
				China				
Xingluokeng (Zhang et al, 2008)	156.3±4.8Ma	Orogenic belt	Yanshanian granitic porphyry rocks		0.18%	78 Mt		porphyry-type
Dajishan (Ningqiang, 2011; Zhang et al, 2007; Liu et al, 2011)	151.7P1.6 – intrusion age 144 Ma and 147 Ma – ore-forming ages	Orogenic belt	two-mica granite and muscovite granite. muscovite alkali-feldspar	Devonian clastic rocks Cambrian epimetamorphic			Vein type W-Niobium-Tantalum	

			granite					
Lianhuashan (Sinclair, 2005)	Paleozoic to Tertiary, but Mesozoic and Tertiary examples are more common.	Orogenic belt			0.8% WO_3	40 Mt	Mo Sn Ag Veins and fractures	Stockwork W-Mo
				Canada				
Mactung	Middle- to late cretaceous (87 ±4 my)	Orogenic belt	Relatively pure limestones or marbles, interbedded with argillaceous, commonly graphitic, noncalcereous hornfels (high pelite/carbonate ratio)	Fine-grained sedimentary and metasedimentary strata	0,9 % WO_3	30 Mt	W-Cu-(Zn)	Exoskarn

			Altered limestones/skarns					
Cantung (Rasmussen et al, 2011)	Neoproterozoic and paleozoic margins Cretaceous magmatism 98.2±0.4Ma 96.7±0.6Ma	Orogenic belt	turbiditic sandstone, deep-water limestone, chert, and shale	Argillites Marbles peraluminous, reduced, leucocratic monzogranite to quartz monzonite	1.56% WO_3	4.2 Mt	Cu Zn Bi Au Mo Pb-Ag-Zn veins	Proximal skarn Reduced W skarn
Mar	Cretaceous	Orogenic belt	Lower greenschist facies metasediments		0.36% WO_3	2.17 Mt	Mo Cu	Pyroxene scheelite skarn
				USSR				
Tyrnyauz (Parada & Stolyarov, 2012)		Orogenic belt					W-Mo Scheelite Molybdenite	
Akchatau (Shapovalov & Setkova, 2012)		Orogenic belt					W-Mo greisen	
Vostok-2	Mesozoic	Orogenic	monzodiorit	Sandstone	1.7%	180 kt	W-Au-base	

(Rasskavoz et al, 2012; Soloviev & Krivoschchekov, 2011)		belt	e–granodiorite –granite complex	Siltstone Si-rocks Limestone carbonate–volcanic–terrigenous sequence	WO3	WO3	metals Skarn Greisen Stockwork	
				Brazil				
Rio Grande (www.braziltungsten.com)		Orogenic belt	gneiss and carbonate rocks,				Scheelite	
Bonfim (Neto et al, 2007)	Neo-Proterozoic bt granite; pegmatite	Orogenic belt	quartzite marble, schist	quartzite marble, schist	0.5 – 9% WO_3	>0.3 Mt WO_3 0.5 – 1.5 Mt Au	W-Au	Stratiform; retrograde alteration crosscutting and as impregnation oxidized Exoskarn
				Spain				
Barruecopardo (Antona et al, 1992;	311 – 316 Ma	Orogenic belt	Parallel intragranitic	Metamorphic rocks			Au-W-As Vein type	

Murciego et al, 2009)			bands	Biotite-calc-alkaline affinity rocks				
La Parilla (closed in 1980's – tailings project starting mid 2013)(De la Fuente, 2013)		Orogenic belt			0.1% WO3	Anticipated 28000 mtu W 26 t Sn Per annum	W-Sn	
				Australia				
Mount Carbine (de Roo, 1988)	Devonian	Orogenic belt	Clastic sediments Basic volcanics Quartz-feldspar-muscovite veins		0.1% WO3	28 Mt	W-Sn Vein-type Wolframite Scheelite	Calc-silicate skarn
King Island (Tasmania) (Calver, 2007; Kwak, 1981)	Upper Proterozoic to Cambrian 345 ma	Orogenic belt	Metamorphosed Grassy group: Lower biotite hornfels, lower		0.64 WO_3	14 Mt	W Scheelite Molybdenite (rare)	Endoskarn Stratiform oxidized

		metavolcanics, finely banded hornfels and limestone (bimetasomatism), C lens skarn unit, pyrozene-garnet hornfels, upper biotite hornfels, upper metavolcanic unit. Marl siltstone, conglomerate, basalt, dolomite, limestone				

			Porphyritic granodiorite to quartz monzinite intrusion.					
Thor Mining PLC		Orogenic belt			0.17% MoS_2 and 0.39% WO_3	3253 Kt		
Yanco Glen (Wolf Minerals Ltd)		Orogenic belt			0.216 % WO_3 and 0.022% Sn	82 Mt		
				Mexico				
Naica (Stone, 1959)	Cretaceous	Orogenic belt	Pyrometasomatic- and mesothermal replacement bodies Calc-silicate	Marmorized limestone Shale (+carbonaceous shale) Marble Tertiary volcanic			Base metal sulphides Minor Au and Ag in marmorized limestone and calc-cilicate	Exoskarn No granite intrusion? (pyrometasomatic rather that contact metamorphic –

			skarn	rocks			skarn Cu-Pb-Zn Chalcopyrite	igneous body at depth) Mantos Chimneys
				Japan				
Yaguki (Fujikawa & Matsueda, 1991)	Paleozoic	Orogenic belt	Granodiorite	Metamorphic rocks: black and green schist Limestones: limestone and slate Igneous: ultramafics, gabbroics, granitoids			Cu-Fe-W	Ep-, cpx-, and gt-dominant skarns
				Peru				
San Cristobal (Beuchat et al, 2004; Phillipson & Romberger, 2004; Campbell et al, 1984)	Miocene	Orogenic belt	Veins Carbonate replacement bodies	Monzonite porphyry stocks Phyllites Volcaniclastics (basalts) Carbonate rocks Sediments Limestones	7.32 wt.% Zn, 1.18 wt.% Pb, 0.34 wt.% Cu and 3.83 oz/t Ag	836,000 metric tons	Veins Breccia's Replacement manto's Carbonate replacement ores W-Cu-Pb-Zn	

				Shales Quartzites			Wolframite Sphalerite galena	
Morococha		Orogenic belt	Volcanics	Volcanics Limestones and dolomite Quartz diorite Quartz monzonite porphyry			Cu-Pb-Zn veins Pipe- and manto structures?	
Pasto Bueno (from www.min-eng.com – grade & tonnage)	Tertiary	Orogenic belt	Quartz monzonite stock	Shales Quartzites Limestones	2.04 WO3	223,570 tonnes	Vein type Greisen Vug	
				Czech Republic				
Krasno (Rene and Skoda, 2011; Dolnicek et al, 2012)		Orogenic belt	Altered topaz–albite granite	Gneiss			Sn-W	Greisen
				Portugal				
Panasqueira(Oosterom et al, 1984; Snee et al, 1988)	289_+ 4 Ma	Orogenic belt	Quartz veins in endo-exo contact zone	Porphyritic biotite granite Muscovite-biotite granite	0.25% WO_3 *In the*	4649000 t	Vein-type	

			Metasediments - schists	*year 2000, 332000 t of ore were extracted, which yielded 1269 t of wolframite concentrate (75 % WO3), 12 t of cassiterite concentrate (72 % Sn) and 132 t of chalcopy*		

					rite concentrate (28 % Cu).			
				Austria				
Mittersill Mine (Thalhammer, 1989)	500 Ma (Paleozoic/Mesozoic?)	Orogenic belt	Hornblendites (highest grade) Felsic gneisses Quartz veins (biggest amount)	Scheelite-bearing metvolcanic sequence (hornblendite, cg amphibolites, intercalations of rhyolitic to dacitic gneisses) Metavolcano-sedimentary units: fg amphibolites and gneisses	0.50% WO_3 (up to 15% WO_3)	450 000 t per annum	Scheelite	Stratiform Syngenetic scheelite deposit
				South Korea				
Sangdong	Pre-Cambrian to Triassic	Orogenic belt	Cambrian interbedded pelite/limestone	Intrusive rock: quartz monzonite Interbedded biotite schist,	0.28 % WO_3 0.04% MoS_2	50 Mt	W-Mo (Bi) Wolframite Molybdenite Bismuthinite	Skarn Stratiform

			Tabular calc-silicate horizons (several calcareous beds) Granite porphyry, Pegmatite + dense felsitic rock	sericite schist, quartzite, crystalline limestone, hornfels, hornblende schist Shale Marl Sandstone Phyllite			Tetradymite	
				India				
Degana (Srivastana & Sukhchain, 2005)	Proterozoic	Orogenic belt	high level A-type granite Coarse-grained granite to fine-grained granite porphyry (Degana granite)	Metasediments: phyllites with few quartzite bands (Delhi Supergroup) Silicification Greisenization K-metasomatism			Porphyry Also greisen Vein-type	
				USA				
Burnt Hill		Orogenic			0.147%	2559801		Terrane – VMS

		belt			WO_3	t		deposit
Strawberry mine (Newberry, 1980)	95 ma		Permian to Triassic marl, shale, rhyolite, sandstone, minor limestone	Intrusive rocks: granodiorite and quartz monzonite batholith; pegmatite and aplite dikes	0.9% WO3	>0.5 Mt		Stratiform
				Vietnam				
Nui Phao		Orogenic belt			0.21% WO_3	5570000 0 t		

A.6 Allanite

Allanite, also referred to as orthite, is a mineral that forms part of the epidote group. It is the REE-enriched end-member, and also the most common and most studied REE-epidote *(Gierè & Sorenson, 2004)*. It is a mineral that exhibits considerable compositional variability (Hickling, et al., 1970). Allanite-Ce is the most common type. The extended mineral formula of allanite is (Ca, Sr, Mn^{2+}, Pb^{2+}, U, Th, $REE^{3+})_2$(Al, Fe^{2+}, Fe^{3+}, Mn^{2+}, Mn^{3+}, Mg, Cr^{3+}, V^{3+})(SiO_4)(Si_2O_7)(O,F)(OH), and it has a monoclinic crystal structure (Deer, et al., 1992). The idealized formula for allanite is $CaREEAl_2Fe^{2+}Si_3O_{11}O(OH)$ (Khvostova, 1963). It is related to epidote via the coupled substitution reaction below:

$$REE^{3+} + Fe^{2+} \leftrightarrow Ca^{2+} + Fe^{3+}$$ (Khvostova, 1963)

Allanite is a common accessory phase in igneous, metamorphic and sedimentary rocks. In igneous rocks it occurs in granites, granodiorites, monzonites, syenites and granitic pegmatites (Deer, et al., 1992). Metasomatic allanite is common in geological environments including limestone skarn (Smith, et al., 2002), altered granite (Ward, et al., 1992), and regionally metamorphosed calc-silicate rocks (Sargent, 1964).

There are different varieties of allanite, mostly defined by their major cation (Gierè & Sorenson, 2004). They include the following:

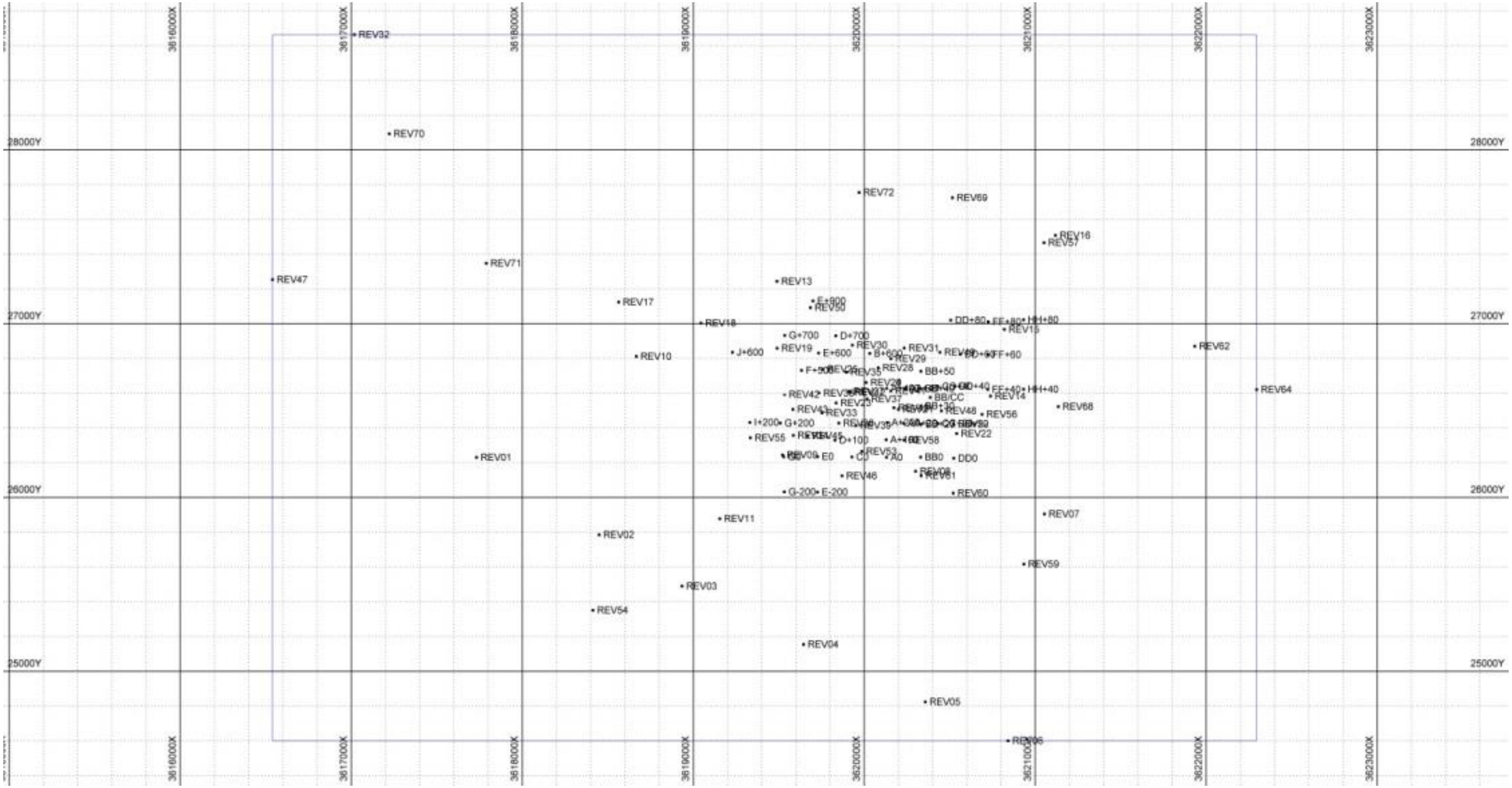
- Dissakisite – Mg-analogue
- Ferriallanite – Fe^{3+} analogue
- Oxyallanite – the oxidized anhydrous form of allanite
- Dollaseite – Mg-analogue that contains F
- Khristovite – Mn-analogue that contains F
- Androsite – Mn-analogue

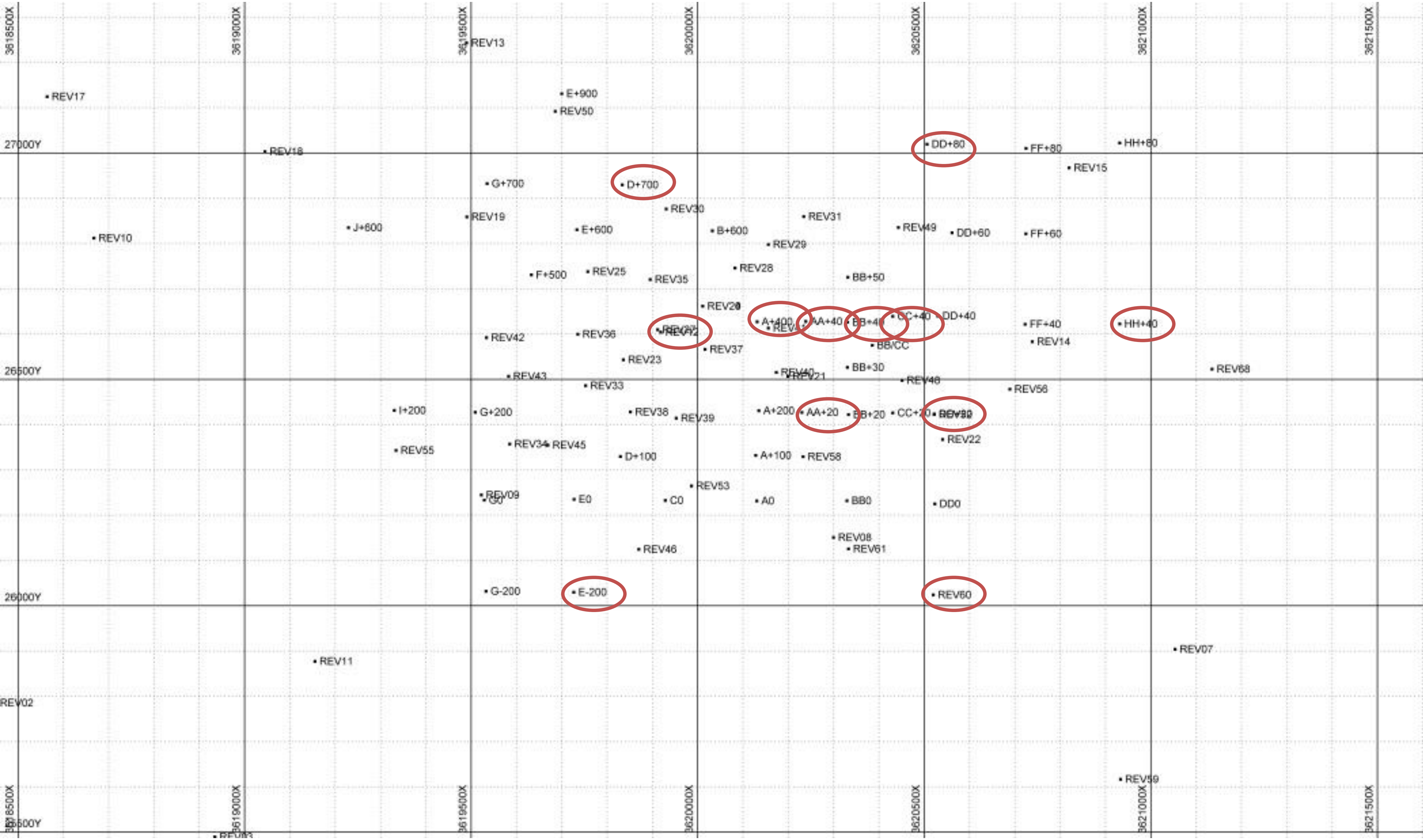
The crystal structure of allanite allows the presence of Th, U, Sr, Pb, alkali elements, Mg and Fe (divalent), vacancies, and Be (Gierè & Sorenson, 2004). The presence of small amounts of Th and U makes allanite suitable for use as a geochronometer. Radioactive isotopes of these elements transform allanite from crystalline to metamict state, either in part or complete. In the metamict state the mineral is more susceptible to alteration. Other substitutions include the halogens, Sc, Zn, Ga, Zr, Sn and Ba (Gierè & Sorenson, 2004).

As the REE-rich end-member of the epidote group, allanite is typically LREE-enriched, fractionating LREE over HREE, and exhibits a pronounced negative Eu anomaly, although positive anomalies also exist. Chondrite-normalized La/Yb values range from 50-300 illustrating that LREE enrichment relative to HREE is variable. Allanite is the richest in La, Ce, Pr and Nd compared to other REE. This is especially the case in granitic rocks (Gierè & Sorenson, 2004). The REE pattern of a given allanite grain is influenced by the crystallization sequences of other REE minerals in the same rock. Fractional crystallization is the reason for strong zonation patterns in igneous allanite (Panto, 1975; Oberli et al., 2004) which often has a dark brown allanite core and an outermost epidote rim, free of any REE, thus REE decreases from core to rim. Allanite can also display pronounced zoning in metamorphic and hydrothermal environments (Sorenson, 1991; Spandler et al., 2003), where zoning is due to the release or consumption of REE during metamorphic reactions that involve other REE-bearing minerals or due to multiple interactions with hydrothermal fluids with variable REE contents (Exley, 1980; Smith et al., 2002). Zoning in these environments ranges from allanite to zoisite to epidote (Gierè & Sorenson, 2004).

Appendix B – Borehole distribution

These diagrams display a plan view of firstly all the borehole intersections that have been drilled before in this project, followed by a zoom in image of the study area of the boreholes studied in thin-section in this study (encircled in red).




3618500X
3619000X
3619500X
3620000X
3620500X
3621000X
3621500X
27000Y
26500Y
26000Y
REV13
REV17
E+900
REV50
REV18
DD+80
FF+80
HH+80
REV15
G+700
D+700
REV30
REV31
REV19
REV10
J+600
E+600
B+600
REV29
REV49
DD+60
FF+60
F+500
REV25
REV35
REV28
BB+50
A+400
AA+40
CC+40
DD+40
FF+40
HH+40
REV42
REV36
REV37
BB/CC
REV14
REV23
BB+30
REV68
REV43
REV33
REV56
I+200
G+200
REV38
REV39
A+200
AA+20
BB+20
REV22
REV55
REV45
D+100
A+100
REV58
REV53
E0
C0
A0
BB0
DD0
REV08
REV61
REV46
G-200
E-200
REV60
REV07
REV11
REV02
REV59

Appendix C – Methodology

C1. XRF

1.1 SAMPLING PREPARATION AND ANALYSIS

Samples for analyses were selected and split on site and couriered to the independent ISO/17025-2005 accredited Intertek Genalysis Laboratory Services (South Africa).

Intertek Genalysis Laboratory Services (South Africa), were chiefly responsible for the sample preparation and SG determination of selected samples by the Archimedis method. Subsequent to the sample preparation, the samples were sent to Intertek Genalysis Laboratory Services in Perth Western Australia, where the analysis were carried out.

Intertek Genalysis Laboratory Services is an accredited laboratory for the requested elements W, Mo, Cu, S and total REE including Sc, Nb, Y, U & Th.

1.1.1 Sample Preparation

At the Genalysis laboratory, Johannesburg, samples were prepared using the following coded procedure:

SD02- Samples received, checked, weighed, and registered.

SP 12 - Sample Dry

- Jaw Crush ~10mm

- Riffle split - Up to 6Kg retain reject

- Pulverise with chrome steel mill better than 75 µ - 300g up to 1.2kg

SP 13 - Sample Dry

- Jaw Crush ~10mm

- Riffle split - Up to 6Kg retain reject

- Pulverise with chrome steel mill better than 75 µ (1.2kg up to 3kg)

1.1.2 Geochemical Analysis

The analysis of tungsten and total rare earth elements which included 14 rare earth elements La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu (LREE's and HREE's) were done using sodium peroxide fusions which offer total dissolution of the sample in nickel crucibles to preclude the presence of unwanted contaminant metals. Sodium peroxide fusions are useful for samples in which the elements of interest are hosted in minerals that may resist acid digestions. These include minerals containing rare earth elements (REE) and tungsten (W).

The elements Mo, Cu and S were dissolved and brought into solution by four acid digestion. This four acid approach will decompose almost all mineral species including silicates and is referred to as "near-total digestions".

Table 1: The range and method used for each element analysed.

Lab Code	Element	Range	Method	Finish
A/4OM	Co	1 -1%	Four-Acid digestion	ICP-OES
A/4OM	Cr	5 -2%	Four-Acid digestion	ICP-OES
A/4OM	Cu	1 -5%	Four-Acid digestion	ICP-OES
A/4OM	Mn	1 -5%	Four-Acid digestion	ICP-OES
A/4OM	Mo	2 -1%	Four-Acid digestion	ICP-OES
A/4OM	Na	20 -10%	Four-Acid digestion	ICP-OES
A/4OM	Ni	1 -5%	Four-Acid digestion	ICP-OES
A/4OM	Zn	1 -5%	Four-Acid digestion	ICP-OES
FP6/OM	Ag	5 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	As	20 -20%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Ba	1 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Be	1 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Bi	0.1 -10%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Cd	1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Ce	0.5 -30%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Cs	0.05 -1%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Dy	0.1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Er	0.1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Eu	0.1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Ga	1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Gd	0.1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS

FP6/OM	Hf	0.1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Ho	0.1 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	In	0.1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	La	0.2 -20%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Li	5 -20%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Lu	0.05 -1%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Nb	10 -30%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Nd	0.1 -20%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Pb	20 -70%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Pr	0.05 -10%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Rb	0.5 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Re	0.1 -1%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Sb	0.5 -10%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Se	20 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Sm	0.1 -10%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Sn	2 -50%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Sr	20 -20%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Ta	0.1 -50%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Tb	0.05 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Te	1 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Th	0.1 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Tl	0.5 -2%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Tm	0.05 -1%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	U	0.1 -60%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	W	1 -50%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Y	0.5 -50%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Yb	0.1 -5%	Sodium Peroxide Fusion Ni crucible	ICP-MS

FP6/OM	Zr	5 -50%	Sodium Peroxide Fusion Ni crucible	ICP-MS
FP6/OM	Al	100 -50%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	B	50 -10%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	Ca	0.1%-70%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	Fe	100 -75%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	K	500 -20%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	Mg	100 -60%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	P	100 -50%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	S	500 -60%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	Sc	20 -5%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	Si	0.1% -30%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	Ti	500 -60%	Sodium Peroxide Fusion Ni crucible	ICP-OES
FP6/OM	V	50 -5%	Sodium Peroxide Fusion Ni crucible	ICP-OES
	CO_3	0.01%-50%	Acetic acid digestion	CS ANALYSER

1.1.3 Internal Genalysis QAQC

Intertek Genalysis Laboratory's Internal Quality Controls are implemented as follows:

- Silica chips (500g – 1kg) are used between samples batches to clean jaw crusher.
- A silica chip (500g – 1kg) flush used in the jaw crushers, is carried out before and after every sample batch and material is labelled and retained for future reference.
- Before and after pulverization, a quartz flush must be ground in each of the bowls selected for the preparation and samples taken from each flush are labelled and stored for future reference.
- All riffle splitting to be performed inside a dust hood to prevent contamination.
- QA checks for grind size are performed to achieve a passing of 85% through 75 micron. QA checks for grind/grain size have been performed on 4% of all samples. (i.e. 1 in every 25)
- High and low-level samples are prepared in the appropriate sections.

Intertek Genalysis Laboratory's certified reference materials and/or in house controls, blanks, splits and replicates are analysed with each batch of samples and the quality control results are reported along with the sample values in the final report.

1.2 Quality Assurance and Quality Control (QA/QC)

AR utilized the services of International Standards Organization (ISO) 17025 accredited laboratories to assay drill hole core samples for the program. These included Intertek Genalysis, South Africa and Intertek Genalysis, Perth, Australia and SGS.

An independent on site quality assurance and quality control program in line with JORC requirements, covering sampling procedures was applied and monitored on a number of levels throughout the program. The onsite QAQC includes the use of certified reference materials (CRM's), coarse blanks, duplicate samples, and SG-calibration. The CRM's are included in a sample batch to verify accuracy of the results. Check samples (duplicates) are included to confirm precision and the repeatability of the analyses.

1.3 Certified Reference Materials (CRMs)

The analytical program was monitored by QA/QC through the routine submission of commercial standard reference materials obtained from accredited reference materials institutions such as WCM Minerals, Canada and Ore Research and Exploration Pty Ltd, Australia.

This was done to achieve optimum accuracy in assessing, verifying, and continuously monitoring the results obtained from the accredited laboratories.

A total of three tungsten Certified reference materials (CRMs) ranging from high to low W-grades were used at a rate of 1:20. The medium grade W-standard also contained certified Mo- values and this was used to monitor the accuracy of the reported Mo values. One rare earth element, with certified values for 14 rare earth elements were used at a rate of 1:20.

Table 2: Certified Reference Materials used in the present study.

Element	CRM	Certified Value	Supplier of CRM
W	W104	0.20%	WCM Minerals
W	W107	0.42%	WCM Minerals
W	W106	2.16%	WCM Minerals
Mo	W107	0.05%	WCM Minerals
Ce	OREAS100a	463 ppm	Ore Research and Exploration Pty Ltd
La	OREAS100a	260 ppm	Ore Research and Exploration Pty Ltd

Nd	OREAS100a	152 ppm	Ore Research and Exploration Pty Ltd
Pr	OREAS100a	47.1 ppm	Ore Research and Exploration Pty Ltd

Each W and Mo-CRM used was carefully and accurately weighed with a digital scale into 20g samples, bagged, sealed, and assigned with a sample number. A record of the preparation and use of the standards were kept electronically.

Each pre-packed 10g REE-CRM used were, bagged, sealed, and assigned with a sample number. A record of the preparation and use of the standards were kept electronically.

The results of the CRMs used in the analytical program are presented below.

1.3.1 Tungsten Certified Reference Materials (CRM's)

Standard W104 (0.2% tungsten) was tested 21 times during analysis and 19 or 95% returned assays within the acceptable 2 standard deviation limit (Fig.1).This is an acceptable result, concerning the Riviera samples because most of the CRM's are within the 0.2 per cent range. The accuracy of the results are therefore acceptable.

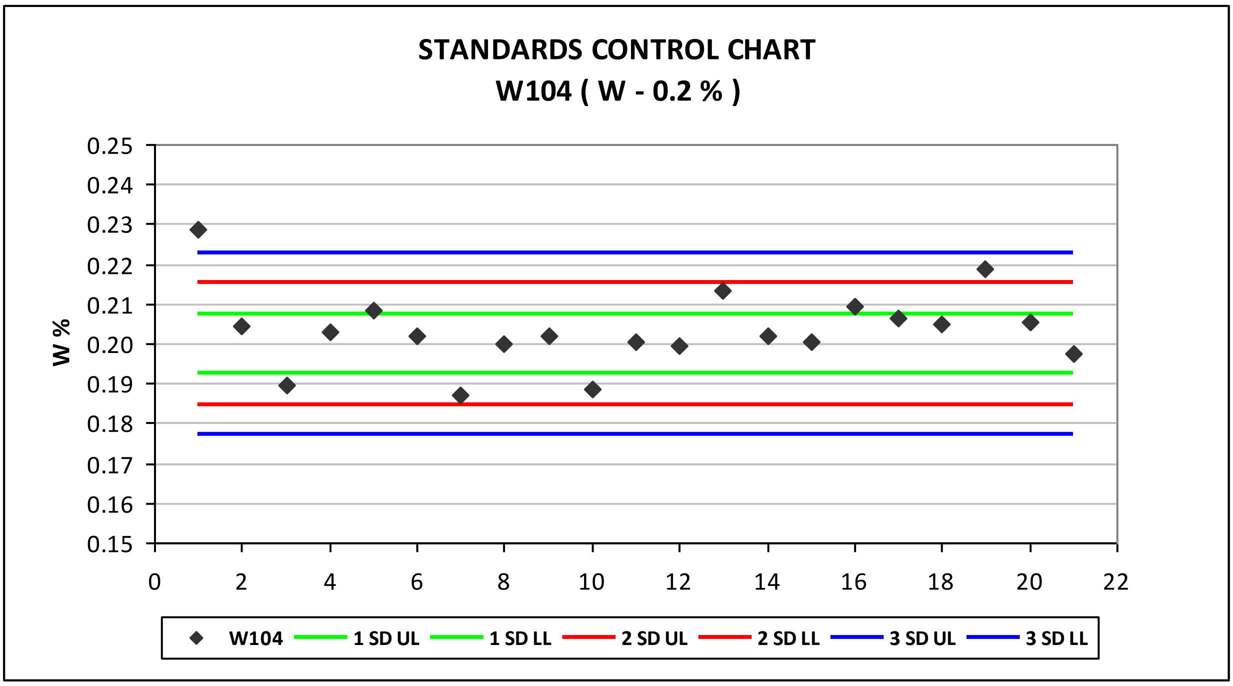


Figure 2: Standards (W104) control chart for a low grade W-CRM within 3 standard deviations (n=21)

Standard W107 (0.42% tungsten) was tested 19 times during analysis and 18 or 95% returned assays within the acceptable 2 standard deviation limit (Fig 2). The 1 assay that fall outside of the 3 standard deviation cut-offs are marginal. The accuracy of the results are acceptable because most of the CRM's are within 1SD of 0.42%.

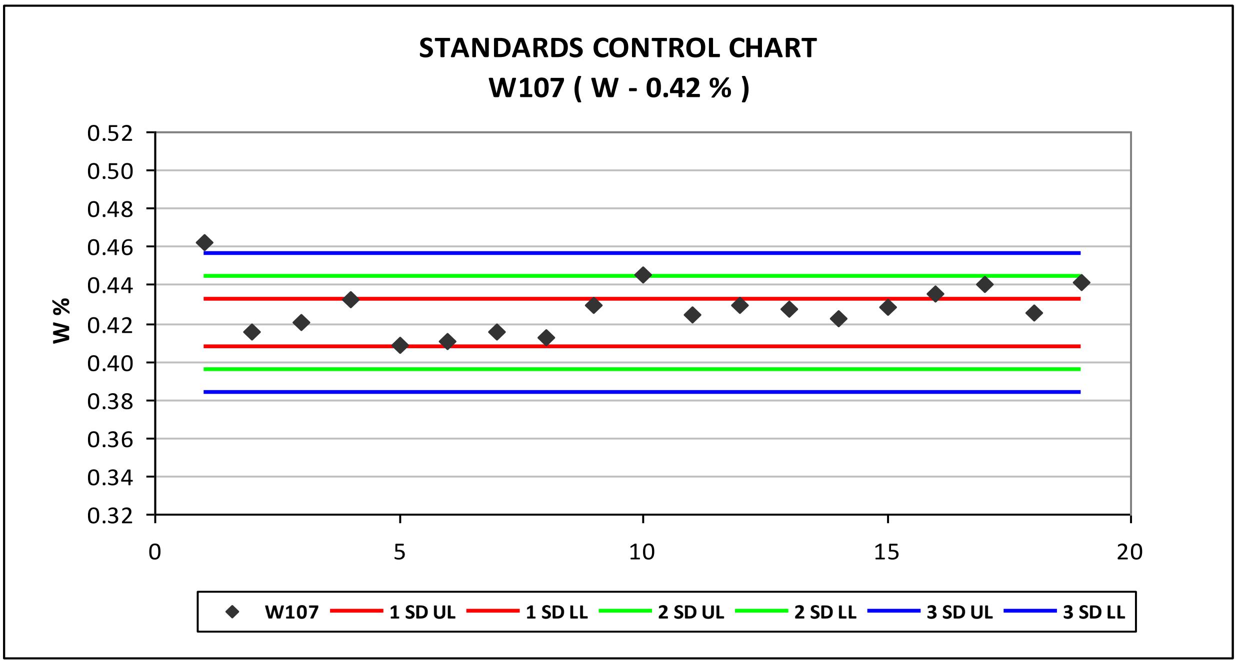


Figure 3: Standards control chart for a medium grade W-CRM within 3 standard deviations (n=19)

Standard W106 (2.16 % tungsten) was tested 16 times during analysis and 13 or 81% returned assays within the acceptable 2 standard deviation limit (Fig 3). The 3 or 18% of assays that fall outside of the 3 standard deviation cut-offs are marginal. The accuracy of the results are acceptable because most of the CRM's are within 2SD of 2.16%.

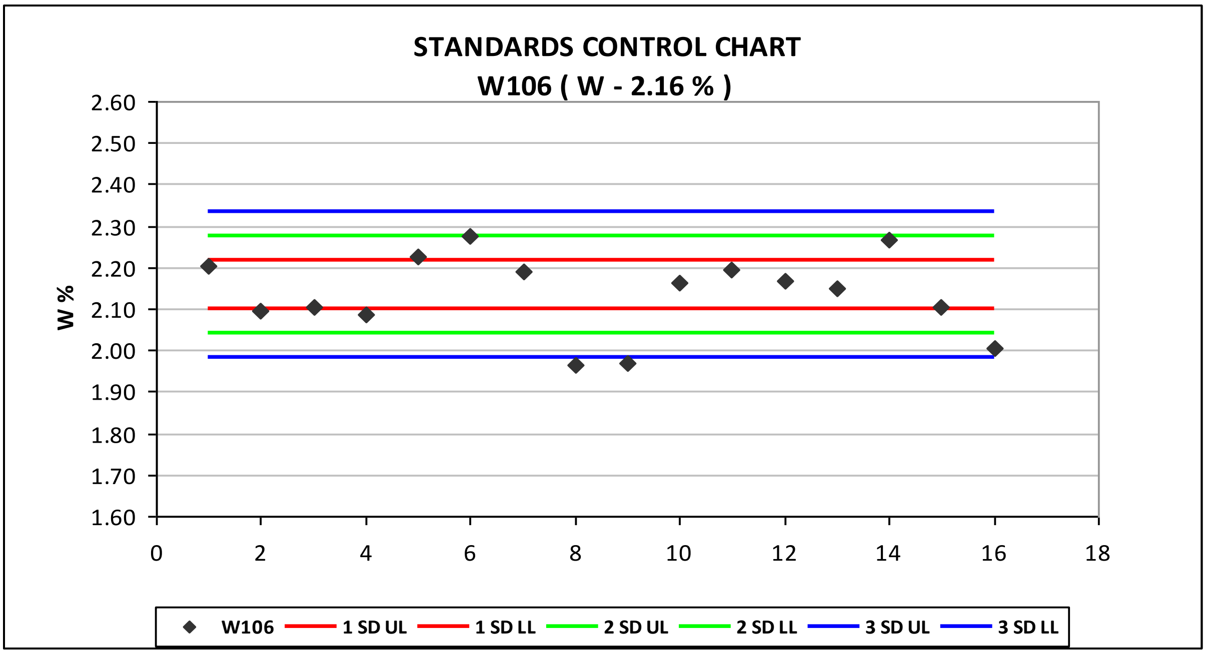


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Figure 4: Standards (W106) control chart for high grade W-CRM within 3 standard deviations (n=16)

1.3.2 Molybdenum Certified Reference Material (CRM)

Standard W107 (0.045% Mo) was tested 12 times during analysis and 12 or 100% returned assays within the acceptable 2 standard deviation limit (Fig 4). All the Mo values are higher than certified values, but the accuracy of the results is acceptable, as most of the CRM's are within 1SD of 0.045%.

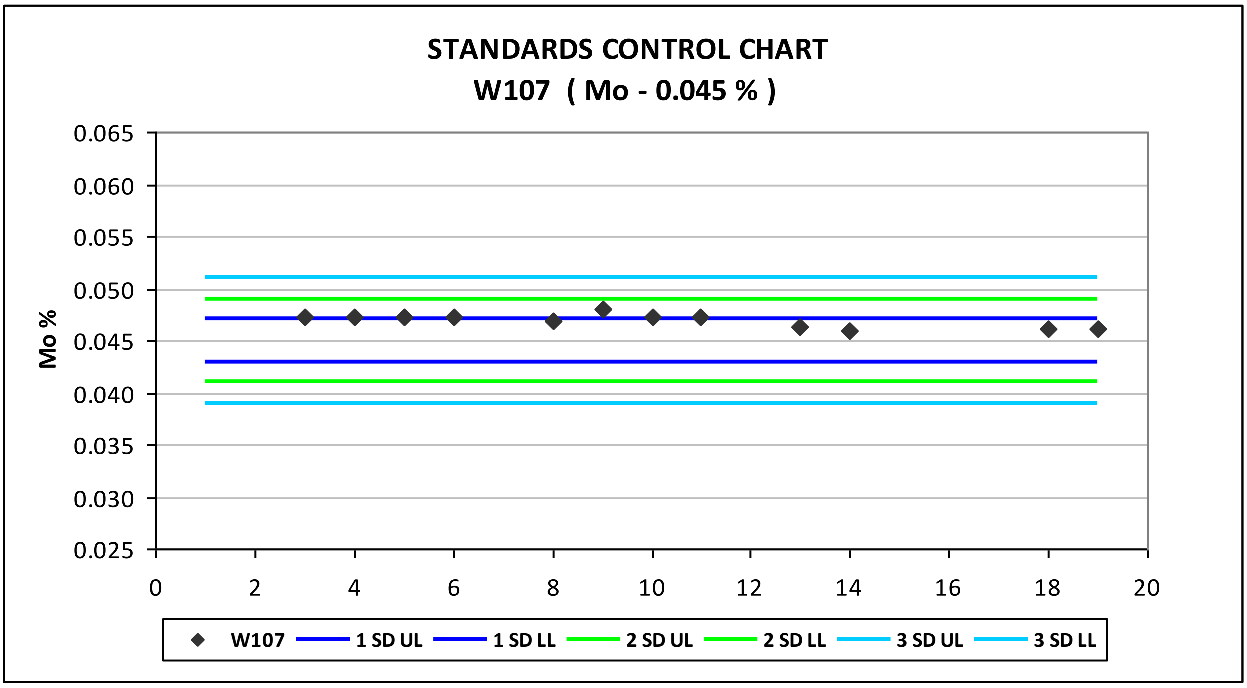


Figure 5: Standards (W107) control chart for Mo - CRM within 3 standard deviations (n=12)

1.3.3 Rare Earth Elements (REE) Certified Reference Materials (CRM's)

Standard Oreas100a (Ce - 463 ppm) was tested 53 times during analysis and 51 or 95% returned assays within the acceptable 2 standard deviation limit (Fig 5). The accuracy for Ce is acceptable, as the majority of CRM's are within 1SD of 463ppm.

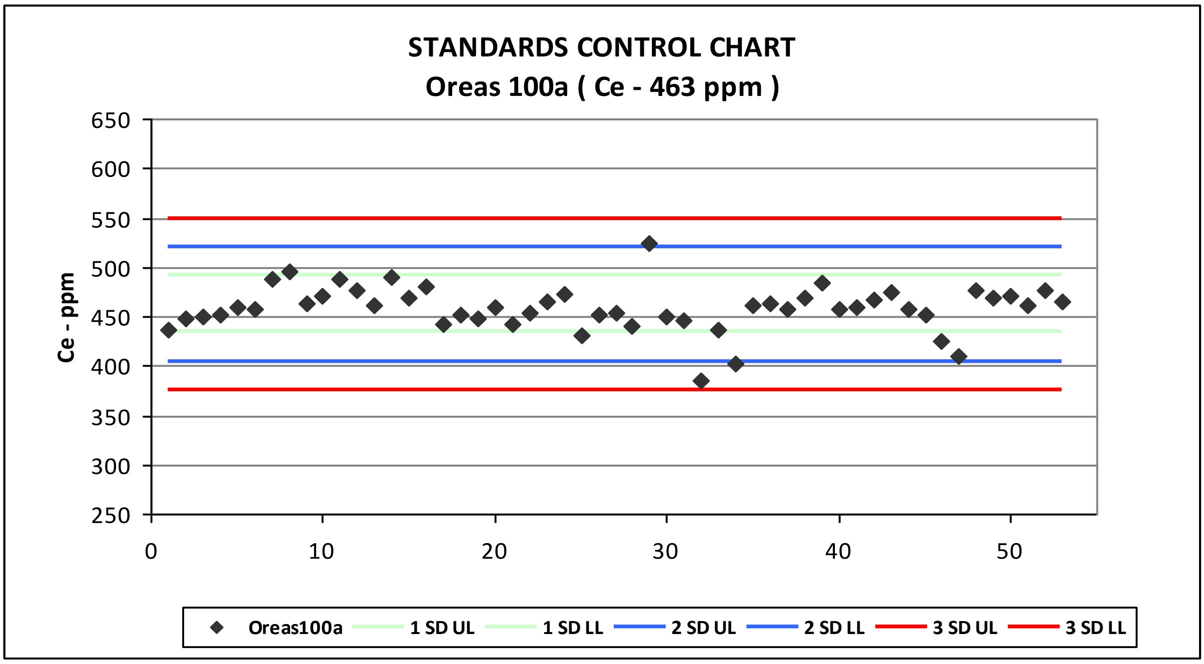


Figure 6: Standards (Oreas 100a) control chart for Ce within 3 standard deviations (n=53)

Standard Oreas100a (La- 260 ppm) was tested 53 times during analysis and 51 or 95% returned assays within the acceptable 2 standard deviation limit (Fig 6). The accuracy for La is acceptable, as the majority of CRM's are within 1SD of 260ppm.

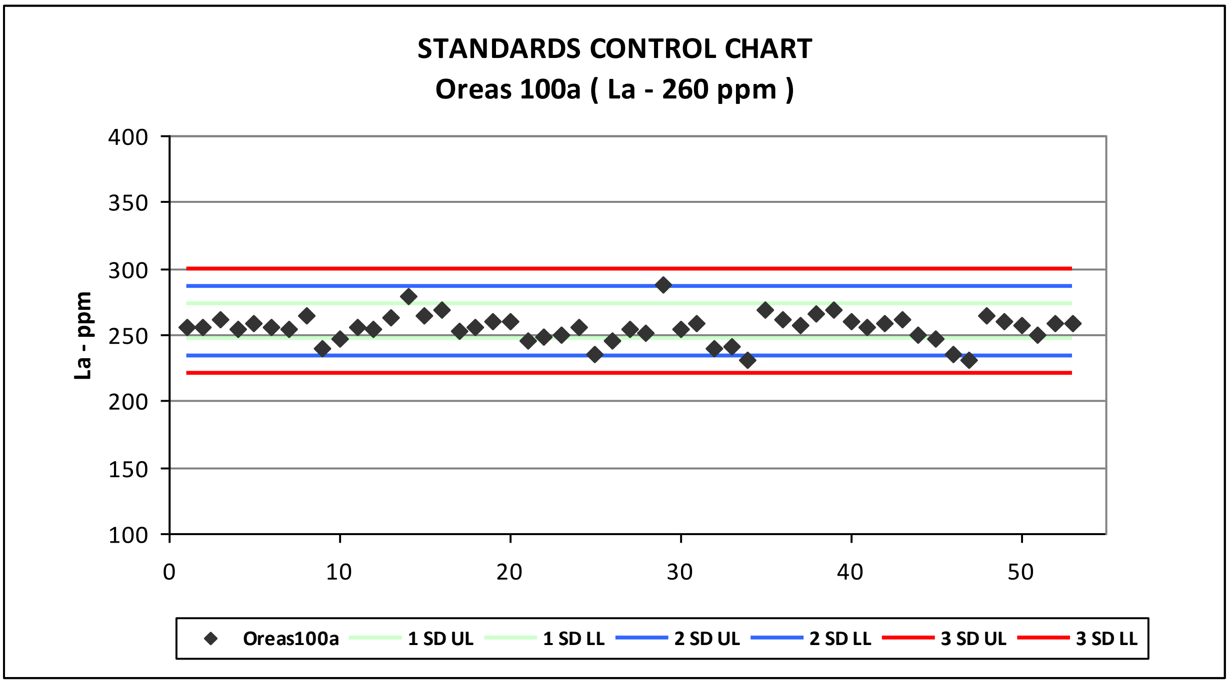


Figure 7: Standards (Oreas 100a) control chart for La within 3 standard deviations (n=53)

Standard Oreas100a (Nd- 152 ppm) was tested 53 times during analysis and 53 or 100% returned assays within the acceptable 2 standard deviation limit (Fig 7). The accuracy for Nd is acceptable, as the majority of CRM's are within 1SD of 152ppm.

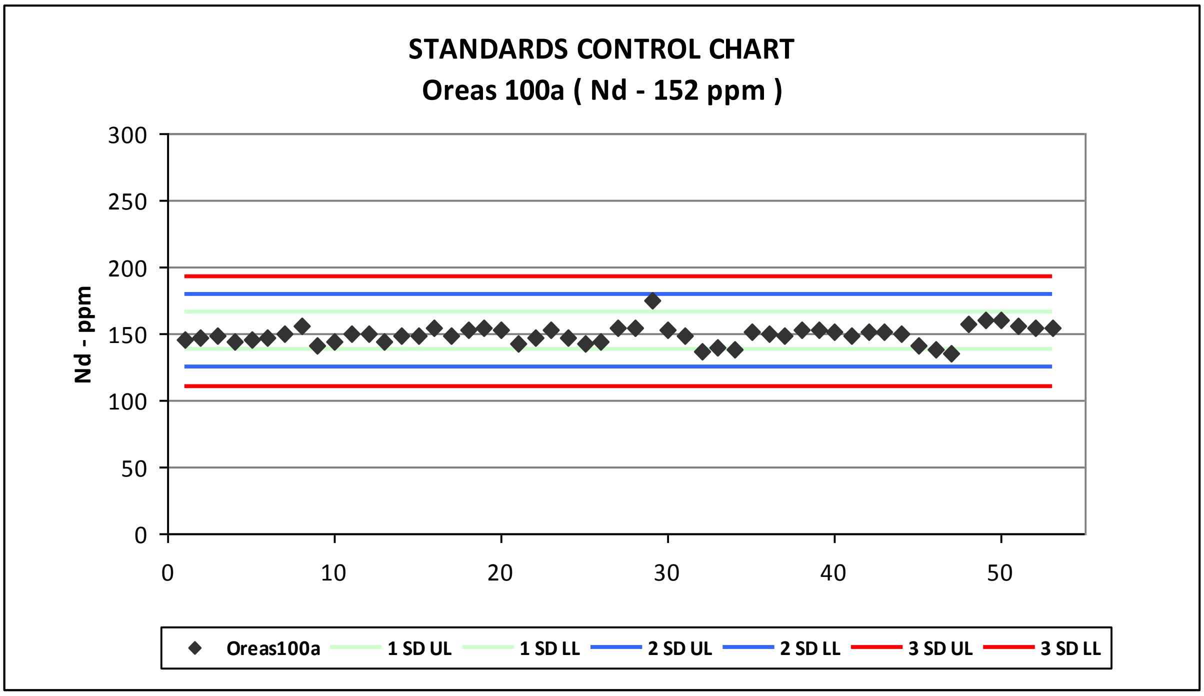


Figure 8: Standards (Oreas 100a) control chart for Nd within 3 standard deviations (n=53)

Standard Oreas100a (Pr- 47.1 ppm) was tested 53 times during analysis and 53 or 100% returned assays within the acceptable 2 standard deviation limit (Fig 8). The accuracy for Pr is acceptable, as the majority of CRM's are within 1SD of 47.1ppm.

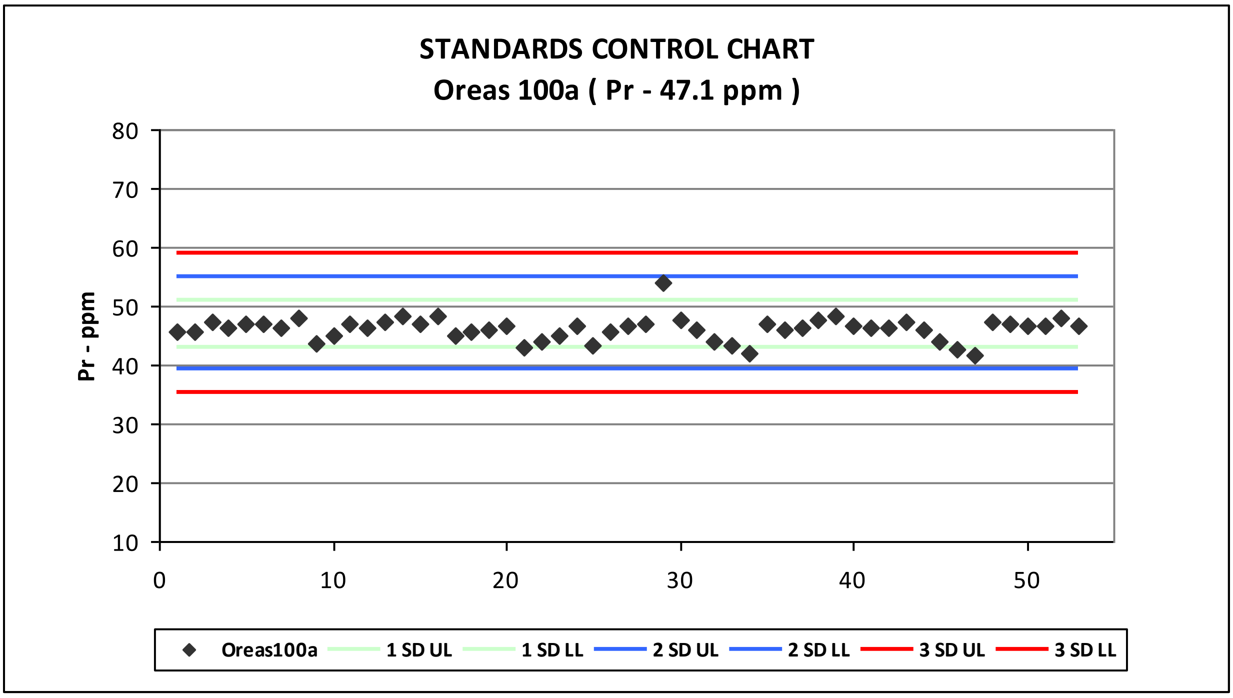


Figure 9: Standards (Oreas 100a) control chart for Pr within 3 standard deviations (n=53)

The certified reference material Oreas 100a selected to monitor the accuracy of results reported for rare earth elements generally falls within range of the expected values for the light rare earths, Ce, La, Pr, and Nd.

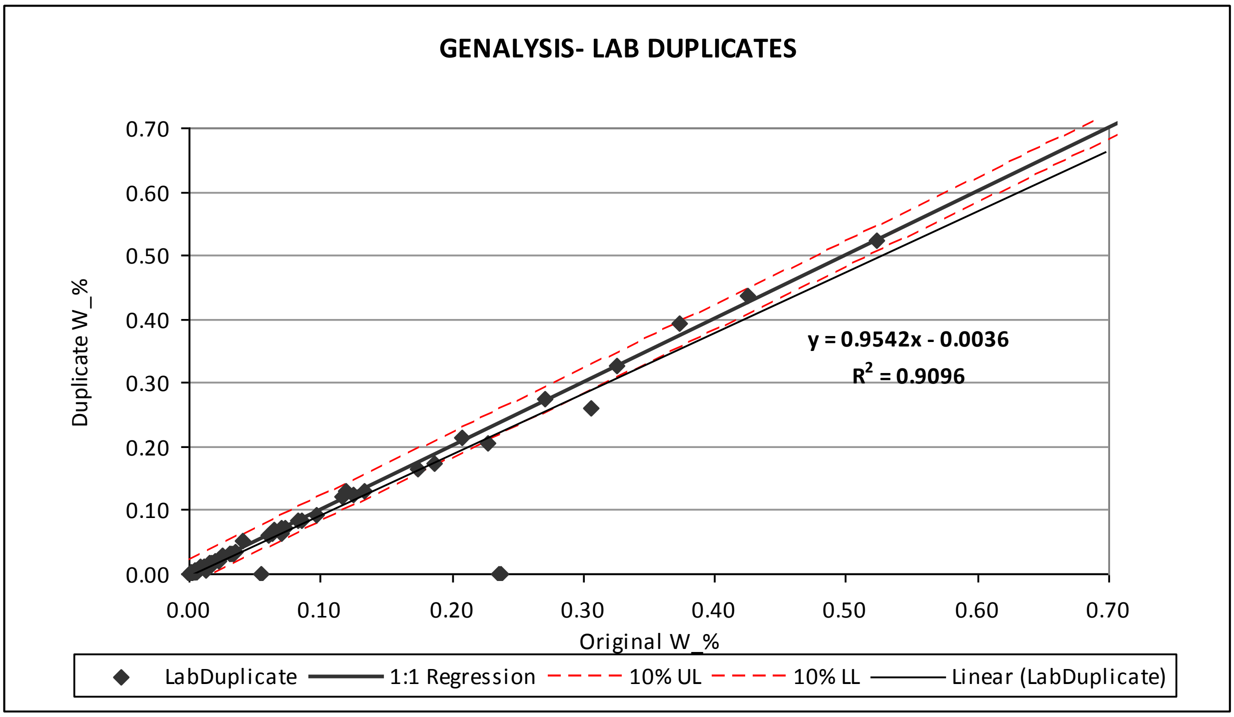


Figure 9: Duplicate samples control chart for all analysed duplicates

A total of 1344 samples were submitted for analysis. The QAQC samples constitute 262 or 19.49 % of the samples of the submitted.

Of the 262 QAQC samples submitted (Table 3), tungsten standards made up 21. 37% or 56 samples, rare earth element standards made up 20.22 % or 53 samples, blanks made up 18.32% or 48 samples, and duplicate samples made up 40.07% or 105 samples.

Table 3: Breakdown of QAQC samples used.

BREAKDOWN OF TOTAL OF 262 QAQC SAMPLES USED		
QAQC	**No of Samples used in QAQC**	**(%) of Samples used in QAQC**
Tungsten Standards	56	21.37
REE Standards	53	20.22
Blanks	48	18.32
Duplicate Samples	105	40.07

QAQC samples were inserted on a per hole basis at a rate of 1 tungsten standard, 1 rare earth element standard, and 1 blank and 2 duplicate samples for every 20 samples.

QAQC samples were inserted routinely every fifth sample, i.e.

- Sample_005 = tungsten standard
- Sample_010 = duplicate sample
- Sample_015 = rare earth element sample
- Sample_020 = duplicate sample
- Sample_025 = blank sample

Tungsten standards W104, W107, and W106 were inserted alternately.

The validation of the standards found that all analysed standards for tungsten, rare earth elements, and molybdenum within the 3 standard deviation limits. The accuracy of these standards from low grade to high grade for tungsten, rare earth elements, and molybdenum, are therefore acceptable.

The external duplicate data pairs that were submitted reported continuous imprecise results and the integrity of these results are in question. A total of 105 duplicate samples pairs were submitted 42% of samples fall outside the 20% upper and lower limits. The precision of the duplicate samples are therefore not be acceptable.

The definite source of the error cannot be pin pointed at this stage and therefore corrective measures will be implemented.

The following actions will be taken to ensure confidence in the preparation, analysis, and results of duplicate samples.

- All current remaining duplicate samples will be considered as contaminated and will be discarded.
- Upon receipt of pulp material from current appointed analytical laboratory (Intertek Genalysis), a fresh set of duplicate samples will be selected and sent to an umpire lab for analysis.
- A new operational procedure for the preparation of duplicates will be drafted which should include a method for homogenising the pulp sample prior to splitting.
- The duplicate that will be re-analysed at an umpire lab will constitute approximately 5-10% of all samples.
- The duplicate samples will be checked within 48 hours of receiving the results from the lab, and any discrepancies will be reported within 24 hours.

C2. LA-ICP-MS

2.1 Instrumental Set-up

A Resonetics 193nm Excimer laser connected to an Agilent 7500ce ICP-MS is used in the analysis of trace elements in bulk rock samples as well as on single mineral grains. Ablation is performed in He gas at a flow rate of 0.35L/min, then mixed with argon (0.9L/min) and Nitrogen (0.004L/min) just before introduction into the ICP plasma. For traces in fusions, 2 spots of 173µm is ablated on each sample using a frequency of 10Hz and 100mJ energy.

2.2 Sample preparation

Fusion disks prepared for XRF analysis by an automatic Claisse M4 Gas Fusion instrument and ultrapure Claisse Flux, using a ratio of 1:10 sample:flux, were coarsely crushed and a chip of sample mounted along with up to 12 other samples in a 2.4cm round resin disk. The mount was mapped, and then polished for analysis.

2.3 Quantification

Trace elements are quantified using NIST 612 for calibration and the % SiO_2 from XRF measurement as internal standard, using standard – sample bracketing. Two replicate measurements are made on each sample. The calibration standard was run every 12 samples. A quality control standard is run in the beginning of the sequence as well as with the calibration standards throughout. BCR-2 or BHVO 2G, both basaltic glass certified reference standards produced by USGS (Dr Steve Wilson, Denver, CO 80225), is used for this purpose. A fusion control standard from certified basaltic reference material (BCR-2, also from USGS) is also analysed in the beginning of a sequence to verify the effective ablation of fused material.

Data was processed using Glitter software, distributed by Access Macquarie Ltd., Macquarie University NSW 2109.

2.4 Detection limits

Traces averages (values in ppm)							
	LA QC standard			Fusion control standard			Detection Limits
	Certified BHVO glass	Average Analysed	*% Deviation*	Certified BCR powder	Average Analysed	*% Deviation*	Instrument DL
Sc	33	32.19	*2.4*	33	36.35	*10.2*	***0.05***
V	308.00	315.85	*2.5*	416.00	411.34	*1.1*	***0.05***
Cr	293	281.36	*4.0*	18	21.14	*17.4*	***0.20***
Co	44	44.63	*1.4*	37	46.65	*26.1*	***0.05***
Ni	116	119.68	*3.2*	18	17.04	*5.3*	***0.10***
Cu	127	126.37	*0.5*	21	27	*28.6*	***0.10***
Zn	102	121.15	*18.8*	127	133.61	*5.2*	***0.20***
Rb	9.2	8.96	*2.6*	46.9	42.58	*9.2*	***0.05***
Sr	396	375.24	*5.2*	340	317.53	*6.6*	***0.05***
Y	26	25.38	*2.4*	37	31.04	*16.1*	***0.05***
Zr	170	116.47	*31.5*	184	168.13	*8.6*	***0.05***
Nb	18.3	18.14	*0.9*	12.6	10.86	*13.8*	***0.05***
Mo	3.8	4.08	*7.4*	250	239.43	*4.2*	***0.20***
Cs	0.10	0.11	*8.1*	1.1	1.073	*2.5*	***0.05***
Ba	131	125.98	*3.8*	677	637.17	*5.9*	***0.20***
La	15.2	16.28	*7.1*	24.9	23.46	*5.8*	***0.05***
Ce	37.6	40.14	*6.8*	52.9	49.42	*6.6*	***0.05***
Pr	5.35	5.64	*5.4*	6.7	6.23	*7.0*	***0.02***
Nd	24.5	23.14	*5.5*	28.7	27.18	*5.3*	***0.10***
Sm	6.1	5.80	*4.9*	6.58	6.07	*7.8*	***0.10***
Eu	2.07	1.96	*5.4*	1.96	1.83	*6.6*	***0.05***
Gd	6.16	5.77	*6.4*	6.75	6.44	*4.6*	***0.10***

Tb	0.92	**0.97**	*5.8*	**1.07**	**0.99**	*7.5*	***0.02***
Dy	**5.28**	**4.95**	*6.3*	**6.41**	**5.76**	*10.1*	***0.05***
Ho	0.98	**1.06**	*8.1*	**1.28**	**1.16**	*9.4*	***0.02***
Er	**2.56**	**2.39**	*6.5*	**3.66**	**3.33**	*9.0*	***0.05***
Tm	0.34	**0.35**	*4.8*	**0.54**	**0.448**	*17.0*	***0.02***
Yb	**2.01**	**1.94**	*3.4*	**3.38**	**3.19**	*5.6*	***0.05***
Lu	**0.279**	**0.30**	*8.2*	**0.503**	**0.469**	*6.8*	***0.02***
Hf	4.32	**4.27**	*1.2*	**4.9**	**4.58**	*6.5*	***0.05***
Ta	1.15	**1.17**	*1.2*	**0.74**	**0.689**	*6.9*	***0.02***
Pb	**1.7**	**1.76**	*3.6*	**11**	**9.55**	*13.2*	***0.05***
Th	1.22	**1.34**	*10.3*	**5.7**	**5.3**	*7.0*	***0.02***
U	**0.403**	**0.47**	*15.5*	**1.69**	**1.49**	*11.8*	***0.02***

Traces replicates (values in ppm)

	LA QC standard			Fusion control standard			Detection Limits
	Certified BHVO glass	**Average Analysed**	*% Deviation*	**Certified BCR powder**	**Average Analysed**	*% Deviation*	**Instrument DL**
Sc	**33**	**32.19**	*2.4*	**33**	**36.35**	*10.2*	***0.05***
V	308.00	**315.85**	*2.5*	416.00	**411.34**	*1.1*	***0.05***
Cr	**293**	**281.36**	*4.0*	**18**	**21.14**	*17.4*	***0.20***
Co	**44**	**44.63**	*1.4*	**37**	**46.65**	*26.1*	***0.05***
Ni	**116**	**119.68**	*3.2*	**18**	**17.04**	*5.3*	***0.10***
Cu	**127**	**126.37**	*0.5*	**21**	**27**	*28.6*	***0.10***
Zn	**102**	**121.15**	*18.8*	**127**	**133.61**	*5.2*	***0.20***
Rb	**9.2**	**8.96**	*2.6*	**46.9**	**42.58**	*9.2*	***0.05***
Sr	**396**	**375.24**	*5.2*	**340**	**317.53**	*6.6*	***0.05***
Y	**26**	**25.38**	*2.4*	**37**	**31.04**	*16.1*	***0.05***
Zr	**170**	**116.47**	*31.5*	**184**	**168.13**	*8.6*	***0.05***
Nb	**18.3**	**18.14**	*0.9*	**12.6**	**10.86**	*13.8*	***0.05***

Mo	**3.8**	**4.08**	*7.4*	**250**	**239.43**	*4.2*	***0.20***
Cs	0.10	**0.11**	*8.1*	**1.1**	**1.073**	*2.5*	***0.05***
Ba	**131**	**125.98**	*3.8*	**677**	**637.17**	*5.9*	***0.20***
La	**15.2**	**16.28**	*7.1*	**24.9**	**23.46**	*5.8*	***0.05***
Ce	**37.6**	**40.14**	*6.8*	**52.9**	**49.42**	*6.6*	***0.05***
Pr	**5.35**	**5.64**	*5.4*	**6.7**	**6.23**	*7.0*	***0.02***
Nd	**24.5**	**23.14**	*5.5*	**28.7**	**27.18**	*5.3*	***0.10***
Sm	**6.1**	**5.80**	*4.9*	**6.58**	**6.07**	*7.8*	***0.10***
Eu	**2.07**	**1.96**	*5.4*	**1.96**	**1.83**	*6.6*	***0.05***
Gd	**6.16**	**5.77**	*6.4*	**6.75**	**6.44**	*4.6*	***0.10***
Tb	0.92	**0.97**	*5.8*	**1.07**	**0.99**	*7.5*	***0.02***
Dy	**5.28**	**4.95**	*6.3*	**6.41**	**5.76**	*10.1*	***0.05***
Ho	0.98	**1.06**	*8.1*	**1.28**	**1.16**	*9.4*	***0.02***
Er	**2.56**	**2.39**	*6.5*	**3.66**	**3.33**	*9.0*	***0.05***
Tm	0.34	**0.35**	*4.8*	**0.54**	**0.448**	*17.0*	***0.02***
Yb	**2.01**	**1.94**	*3.4*	**3.38**	**3.19**	*5.6*	***0.05***
Lu	**0.279**	**0.30**	*8.2*	**0.503**	**0.469**	*6.8*	***0.02***
Hf	4.32	**4.27**	*1.2*	**4.9**	**4.58**	*6.5*	***0.05***
Ta	1.15	**1.17**	*1.2*	**0.74**	**0.689**	*6.9*	***0.02***
Pb	**1.7**	**1.76**	*3.6*	**11**	**9.55**	*13.2*	***0.05***
Th	1.22	**1.34**	*10.3*	**5.7**	**5.3**	*7.0*	***0.02***
U	**0.403**	**0.47**	*15.5*	**1.69**	**1.49**	*11.8*	***0.02***

C3. Borehole detection limits, units and methods

1. A+400

ELEMENTS	UNITS	DETECTION	METHOD
Ag	ppm	5	FP6/MS
Al	%	0.01	FP6/OE
As	ppm	20	FP6/MS
B	ppm	50	FP6/OE
Ba	ppm	1	FP6/MS
Be	ppm	1	FP6/MS
Bi	ppm	0.1	FP6/MS
Ca	%	0.1	FP6/OE
Cd	ppm	1	FP6/MS
Ce	ppm	0.5	FP6/MS
Co	ppm	1	4A/OE
Cr	ppm	5	4A/OE
Cs	ppm	0.05	FP6/MS
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Fe	%	0.01	FP6/OE
Ga	ppm	1	FP6/MS
Gd	ppm	0.1	FP6/MS
Hf	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
In	ppm	0.1	FP6/MS
K	%	0.05	FP6/OE
La	ppm	0.2	FP6/MS
Li	ppm	5	FP6/MS
Lu	ppm	0.05	FP6/MS
Mg	%	0.01	FP6/OE
Mn	ppm	1	4A/OE
Nb	ppm	10	FP6/MS
Nd	ppm	0.1	FP6/MS
Ni	ppm	1	4A/OE
P	%	0.01	FP6/OE
Pb	ppm	20	FP6/MS
Pr	ppm	0.05	FP6/MS
Rb	ppm	0.5	FP6/MS
Re	ppm	0.1	FP6/MS
S	%	0.05	FP6/OE
S	ppm	50	4A/OE
Sb	ppm	0.5	FP6/MS
Sc	ppm	20	FP6/OE
Sc	ppm	1	4A/OE

Se	ppm	20	FP6/MS
Si	%	0.1	FP6/OE
Sm	ppm	0.1	FP6/MS
Sn	ppm	2	FP6/MS
Sr	ppm	20	FP6/MS
Ta	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Te	ppm	1	FP6/MS
Th	ppm	0.1	FP6/MS
Ti	%	0.05	FP6/OE
TIC	%	0.01	C72/CSA
Tl	ppm	0.5	FP6/MS
Tm	ppm	0.05	FP6/MS
U	ppm	0.1	FP6/MS
V	ppm	50	FP6/OE
W	ppm	1	FP6/MS
Yb	ppm	0.1	FP6/MS
Zn	ppm	1	4A/OE
Zr	ppm	5	FP6/MS

2. *AA+200*

ELEMENTS	UNITS	DETECTION	METHOD
Ag	ppm	5	FP6/MS
Al	%	0.01	FP6/OE
As	ppm	20	FP6/MS
B	ppm	50	FP6/OE
Ba	ppm	1	FP6/MS
Be	ppm	1	FP6/MS
Bi	ppm	0.1	FP6/MS
CO3	%	0.05	/CALC
Ca	%	0.1	FP6/OE
Cd	ppm	1	FP6/MS
Ce	ppm	0.5	FP6/MS
Co	ppm	1	4A/OE
Cr	ppm	5	4A/OE
Cs	ppm	0.05	FP6/MS
Cu	ppm	1	4A/OE
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Fe	%	0.01	FP6/OE
Ga	ppm	1	FP6/MS
Gd	ppm	0.1	FP6/MS
Hf	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
In	ppm	0.1	FP6/MS
K	%	0.05	FP6/OE
La	ppm	0.2	FP6/MS
Li	ppm	5	FP6/MS
Lu	ppm	0.05	FP6/MS
Mg	%	0.01	FP6/OE
Mn	ppm	1	4A/OE
Mo	ppm	2	4A/OE
Na	ppm	20	4A/OE
Nb	ppm	10	FP6/MS
Nd	ppm	0.1	FP6/MS
Ni	ppm	1	4A/OE
P	%	0.01	FP6/OE
Pb	ppm	20	FP6/MS
Pr	ppm	0.05	FP6/MS
Rb	ppm	0.5	FP6/MS
Re	ppm	0.1	FP6/MS
S	%	0.05	FP6/OE
S	ppm	50	4A/OE
SG	NONE	0.01	SG/GR

Sb	ppm	0.5	FP6/MS
Sc	ppm	20	FP6/OE
Sc	ppm	1	4A/OE
Se	ppm	20	FP6/MS
Si	%	0.1	FP6/OE
Sm	ppm	0.1	FP6/MS
Sn	ppm	2	FP6/MS
Sr	ppm	20	FP6/MS
Ta	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Te	ppm	1	FP6/MS
Th	ppm	0.1	FP6/MS
Ti	%	0.05	FP6/OE
TIC	%	0.01	C72/CSA
Tl	ppm	0.5	FP6/MS
Tm	ppm	0.05	FP6/MS
U	ppm	0.1	FP6/MS
V	ppm	50	FP6/OE
W	ppm	1	FP6/MS
Y	ppm	0.5	FP6/MS
Yb	ppm	0.1	FP6/MS
Zn	ppm	1	4A/OE
Zr	ppm	5	FP6/MS

3. BB+400

ANA2011-0100 - PROGR	METHOD	LDETECTION	UDETECTION	UNITS
WtRec	WGH79	0.01	0	KG
Moisture	PHY08D	0.1	100	%
Au	FAA303	0.02	50000	PPM
Ag	AAS14E	1	100	PPM
Fe2+	CLA01A	0.1	60	%
SiO2	XRF79V	0.05	100	%
Al2O3	XRF79V	0.05	100	%
CaO	XRF79V	0.01	100	%
MgO	XRF79V	0.05	100	%
Fe	XRF79V	0.01	70	%
FeO	XRF79V	0.01	70	%
K2O	XRF79V	0.01	100	%
MnO	XRF79V	0.01	100	%
Na2O	XRF79V	0.05	100	%
P2O5	XRF79V	0.01	100	%
TiO2	XRF79V	0.01	100	%
Cr2O3	XRF79V	0.01	50	%
V2O5	XRF79V	0.01	100	%
LOI	XRF79V	-50	100	%
As	ICM40B	2	10000	PPM
Ba	ICM40B	5	10000	PPM
Co	ICM40B	0.5	10000	PPM
Cr	ICM40B	1	10000	PPM
Cu	ICM40B	0.5	10000	PPM
Hf	ICM40B	0.5	500	PPM
Mo	ICM40B	0.5	10000	PPM
Nb	ICM40B	0.5	1000	PPM
Ni	ICM40B	0.5	10000	PPM
Pb	ICM40B	3	10000	PPM
Rb	ICM40B	1	1000	PPM
S	ICM40B	0.01	5	%
Sc	ICM40B	0.5	1000	PPM
Sr	ICM40B	0.5	10000	PPM
V	ICM40B	1	10000	PPM
W	ICM40B	0.5	10000	PPM
Zn	ICM40B	1	10000	PPM
Zr	ICM40B	0.5	10000	PPM
CO2	CSA02V	0.04	75	%
Ce	IMS90A	0.1	10000	PPM
Dy	IMS90A	0.05	1000	PPM

Er	IMS90A	0.05	1000	PPM
Eu	IMS90A	0.05	1000	PPM
Gd	IMS90A	0.05	1000	PPM
Ho	IMS90A	0.05	1000	PPM
La	IMS90A	0.1	10000	PPM
Lu	IMS90A	0.05	1000	PPM
Nd	IMS90A	0.1	10000	PPM
Pr	IMS90A	0.05	1000	PPM
Sm	IMS90A	0.1	1000	PPM
Tb	IMS90A	0.05	1000	PPM
Th	IMS90A	0.1	1000	PPM
Tm	IMS90A	0.05	1000	PPM
U	IMS90A	0.05	1000	PPM
Y	IMS90A	0.5	1000	PPM
Yb	IMS90A	0.1	1000	PPM

4. CC+400

ELEMENTS	UNITS	DETECTION	METHOD
Ag	ppm	5	FP6/MS
Al	%	0.01	FP6/OE
Al2O3	%	0.02	/CALC
As	ppm	20	FP6/MS
B	ppm	50	FP6/OE
Ba	ppm	1	FP6/MS
Be	ppm	1	FP6/MS
Bi	ppm	0.1	FP6/MS
CO3	%	0.05	/CALC
Ca	%	0.1	FP6/OE
CaO	%	0.2	/CALC
Cd	ppm	1	FP6/MS
Ce	ppm	0.5	FP6/MS
Co	ppm	1	4A/OE
Cr	ppm	5	4A/OE
Cs	ppm	0.05	FP6/MS
Cu	ppm	1	4A/OE
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Fe	%	0.01	FP6/OE
Fe2O3	%	0.02	/CALC
Ga	ppm	1	FP6/MS
Gd	ppm	0.1	FP6/MS
Hf	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
In	ppm	0.1	FP6/MS
K	%	0.05	FP6/OE
K2O	%	0.1	/CALC
La	ppm	0.2	FP6/MS
Li	ppm	5	FP6/MS
Lu	ppm	0.05	FP6/MS
Mg	%	0.01	FP6/OE
MgO	%	0.02	/CALC
Mn	ppm	1	4A/OE
MnO	ppm	2	/CALC
Mo	ppm	2	4A/OE
Na	ppm	20	4A/OE
Nb	ppm	10	FP6/MS
Nd	ppm	0.1	FP6/MS
Ni	ppm	1	4A/OE
P	%	0.01	FP6/OE

P2O5	%	0.03	/CALC
Pb	ppm	20	FP6/MS
Pr	ppm	0.05	FP6/MS
Rb	ppm	0.5	FP6/MS
Re	ppm	0.1	FP6/MS
S	ppm	50	4A/OE
S	%	0.05	FP6/OE
SG	NONE	0.01	SG/GR
Sb	ppm	0.5	FP6/MS
Sc	ppm	1	4A/OE
Sc	ppm	20	FP6/OE
Se	ppm	20	FP6/MS
Si	%	0.1	FP6/OE
SiO2	%	0.3	/CALC
Sm	ppm	0.1	FP6/MS
Sn	ppm	2	FP6/MS
Sr	ppm	20	FP6/MS
Ta	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Te	ppm	1	FP6/MS
Th	ppm	0.1	FP6/MS
Ti	%	0.05	FP6/OE
TIC	%	0.01	C72/CSA
TiO2	%	0.1	/CALC
Tl	ppm	0.5	FP6/MS
Tm	ppm	0.05	FP6/MS
U	ppm	0.1	FP6/MS
V	ppm	50	FP6/OE
W	ppm	1	FP6/MS
Y	ppm	0.5	FP6/MS
Yb	ppm	0.1	FP6/MS
Zn	ppm	1	4A/OE
Zr	ppm	5	FP6/MS

5. DD+200

ELEMENTS	UNITS	DETECTION	METHOD
Ag	ppm	5	FP6/MS
Al	%	0.01	FP6/OE
Al2O3	%	0.02	/CALC
As	ppm	20	FP6/MS
As-Rp1	ppm	20	FP6/MS

B	ppm	50	FP6/OE
Ba	ppm	1	FP6/MS
Be	ppm	1	FP6/MS
Bi	ppm	0.1	FP6/MS
CO3	%	0.05	/CALC
Ca	%	0.1	FP6/OE
CaO	%	0.2	/CALC
Cd	ppm	1	FP6/MS
Ce	ppm	0.5	FP6/MS
Co	ppm	1	4A/OE
Cr	ppm	5	4A/OE
Cs	ppm	0.05	FP6/MS
Cu	ppm	1	4A/OE
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Fe	%	0.01	FP6/OE
Fe2O3	%	0.02	/CALC
Ga	ppm	1	FP6/MS
Gd	ppm	0.1	FP6/MS
Hf	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
In	ppm	0.1	FP6/MS
K	%	0.05	FP6/OE
K2O	%	0.1	/CALC
La	ppm	0.2	FP6/MS
Li	ppm	5	FP6/MS
Lu	ppm	0.05	FP6/MS
Mg	%	0.01	FP6/OE
MgO	%	0.02	/CALC
Mn	ppm	1	4A/OE
MnO	ppm	2	/CALC
Mo	ppm	2	4A/OE
Na	ppm	20	4A/OE
Na2O	ppm	40	/CALC
Nb	ppm	10	FP6/MS
Nd	ppm	0.1	FP6/MS
Ni	ppm	1	4A/OE
P	%	0.01	FP6/OE
P2O5	%	0.03	/CALC
Pb	ppm	20	FP6/MS
Pr	ppm	0.05	FP6/MS
Rb	ppm	0.5	FP6/MS
Re	ppm	0.1	FP6/MS
S	%	0.05	FP6/OE

S	ppm	50	4A/OE
Sb	ppm	0.5	FP6/MS
Sc	ppm	20	FP6/OE
Sc	ppm	1	4A/OE
Se	ppm	20	FP6/MS
Si	%	0.1	FP6/OE
SiO2	%	0.3	/CALC
Sm	ppm	0.1	FP6/MS
Sn	ppm	2	FP6/MS
Sr	ppm	20	FP6/MS
Ta	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Te	ppm	1	FP6/MS
Th	ppm	0.1	FP6/MS
Ti	%	0.05	FP6/OE
TIC	%	0.01	C72/CSA
TiO2	%	0.1	/CALC
Tl	ppm	0.5	FP6/MS
Tm	ppm	0.05	FP6/MS
U	ppm	0.1	FP6/MS
V	ppm	50	FP6/OE
V2O5	ppm	100	/CALC
W	ppm	1	FP6/MS
Y	ppm	0.5	FP6/MS
Yb	ppm	0.1	FP6/MS
Zn	ppm	1	4A/OE
Zr	ppm	5	FP6/MS

6. E-200

ELEMENTS	UNITS	DETECTION	METHOD
Ag	ppm	5	FP6/MS
Al	%	0.01	FP6/OE
Al2O3	%	0.02	/CALC
As	ppm	20	FP6/MS
B	ppm	50	FP6/OE
Ba	ppm	1	FP6/MS
Be	ppm	1	FP6/MS
Bi	ppm	0.1	FP6/MS
CO3	%	0.05	/CALC
Ca	%	0.1	FP6/OE
CaO	%	0.2	/CALC

Cd	ppm	1	FP6/MS
Ce	ppm	0.5	FP6/MS
Co	ppm	1	4A/OE
Cr	ppm	5	4A/OE
Cs	ppm	0.05	FP6/MS
Cu	ppm	1	4A/OE
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Fe	%	0.01	FP6/OE
Fe2O3	%	0.02	/CALC
Ga	ppm	1	FP6/MS
Gd	ppm	0.1	FP6/MS
Hf	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
In	ppm	0.1	FP6/MS
K	%	0.05	FP6/OE
K2O	%	0.1	/CALC
La	ppm	0.2	FP6/MS
Li	ppm	5	FP6/MS
Lu	ppm	0.05	FP6/MS
Mg	%	0.01	FP6/OE
MgO	%	0.02	/CALC
Mn	ppm	1	4A/OE
MnO	ppm	2	/CALC
Mo	ppm	2	4A/OE
Na	ppm	20	4A/OE
Nb	ppm	10	FP6/MS
Nd	ppm	0.1	FP6/MS
Ni	ppm	1	4A/OE
P	%	0.01	FP6/OE
P2O5	%	0.03	/CALC
Pb	ppm	20	FP6/MS
Pr	ppm	0.05	FP6/MS
Rb	ppm	0.5	FP6/MS
Re	ppm	0.1	FP6/MS
S	%	0.05	FP6/OE
S	ppm	50	4A/OE
SO3	%	0.2	/CALC
SG	NONE	0.01	SG/GR
Sb	ppm	0.5	FP6/MS
Sc	ppm	20	FP6/OE
Sc	ppm	1	4A/OE
Se	ppm	20	FP6/MS
Si	%	0.1	FP6/OE

SiO2	%	0.3	/CALC
Sm	ppm	0.1	FP6/MS
Sn	ppm	2	FP6/MS
Sr	ppm	20	FP6/MS
Ta	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Te	ppm	1	FP6/MS
Th	ppm	0.1	FP6/MS
Ti	%	0.05	FP6/OE
TIC	%	0.01	C72/CSA
TiO2	%	0.1	/CALC
Tl	ppm	0.5	FP6/MS
Tm	ppm	0.05	FP6/MS
U	ppm	0.1	FP6/MS
V	ppm	50	FP6/OE
W	ppm	1	FP6/MS
Yb	ppm	0.1	FP6/MS
Zn	ppm	1	4A/OE
Zr	ppm	5	FP6/MS

7. BB+200

ELEMENTS	UNITS	DETECTION	METHOD
Ce	ppm	0.5	FP6/MS
Cu	ppm	1	4A/OE
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Gd	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
La	ppm	0.2	FP6/MS
Lu	ppm	0.05	FP6/MS
Mo	ppm	2	4A/OE
Nb	ppm	10	FP6/MS
Nd	ppm	0.1	FP6/MS
Pr	ppm	0.05	FP6/MS
S	ppm	50	4A/OE
Sc	ppm	1	4A/OE
Sm	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Th	ppm	0.1	FP6/MS
Tm	ppm	0.05	FP6/MS
U	ppm	0.1	FP6/MS

W	ppm	1	FP6/MS
Yb	ppm	0.1	FP6/MS

8. BB+300

ELEMENTS	UNITS	DETECTION	METHOD
Ce	ppm	0.5	FP6/MS
Cu	ppm	1	4A/OE
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Gd	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
La	ppm	0.2	FP6/MS
Lu	ppm	0.05	FP6/MS
Mo	ppm	2	4A/OE
SG WT-A	g	0.01	SG/GR
SG WT-B	g	0.01	SG/GR
Nb	ppm	10	FP6/MS
Nd	ppm	0.1	FP6/MS
Pr	ppm	0.05	FP6/MS
S	ppm	50	4A/OE
SG	NONE	0.01	SG/GR
Sc	ppm	1	4A/OE
Sm	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Th	ppm	0.1	FP6/MS
Tm	ppm	0.05	FP6/MS
U	ppm	0.1	FP6/MS
W	ppm	1	FP6/MS
Yb	ppm	0.1	FP6/MS

9. BBCC+350

ELEMENTS	UNITS	DETECTION	METHOD
Ce	ppm	0.5	FP6/MS
Cu	ppm	1	4A/OE
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Gd	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
La	ppm	0.2	FP6/MS
Lu	ppm	0.05	FP6/MS
Mo	ppm	2	4A/OE

Mo-Rp1	ppm	20	4AH/OE
Nd	ppm	0.1	FP6/MS
Pr	ppm	0.05	FP6/MS
S	ppm	50	4A/OE
Sc	ppm	1	4A/OE
Sm	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Tm	ppm	0.05	FP6/MS
W	ppm	1	FP6/MS
Yb	ppm	0.1	FP6/MS

10. CC+200

ELEMENTS	UNITS	DETECTION	METHOD
Ce	ppm	0.5	FP6/MS
Cu	ppm	1	4A/OE
Dy	ppm	0.1	FP6/MS
Er	ppm	0.1	FP6/MS
Eu	ppm	0.1	FP6/MS
Gd	ppm	0.1	FP6/MS
Ho	ppm	0.1	FP6/MS
La	ppm	0.2	FP6/MS
Lu	ppm	0.05	FP6/MS
Mo	ppm	2	4A/OE
Nb	ppm	10	FP6/MS
Nd	ppm	0.1	FP6/MS
Pr	ppm	0.05	FP6/MS
S	ppm	50	4A/OE
Sc	ppm	1	4A/OE
Sm	ppm	0.1	FP6/MS
Tb	ppm	0.05	FP6/MS
Th	ppm	0.1	FP6/MS
Tm	ppm	0.05	FP6/MS
U	ppm	0.1	FP6/MS
W	ppm	1	FP6/MS
Yb	ppm	0.1	FP6/MS

Appendix D – Mineralogy

D1. Mineralogy tables

The tables below give a brief description of each thin-section studied in each borehole intersection. The minerals identified, their relative modal percentage and a brief description of a characteristic feature are mentioned. The description of each thin-section is followed by two tables; firstly the type of alteration and estimated rock type for each thin-section, followed by the latter information together with what was observed in hand sample.

1. A+400

A+400 – 50
-Extremely altered
-Matrix almost entirely altered
-Quartz porphyry
-Matrix fine- to small grained

Minerals	Modal %	Description
Quartz	24%	Porphyritic
Diopside	3%	Altered to brown mineral
Goethite	9%	Brown altered material
Plagioclase	49%	Extremely altered to saussirite.
Alkali Feldspar		Extremely altered to sericite.
Calcite	10%	
Allanite	5%	
Opaques	2%	Pyrite – slightly cubic (some), irregular Sphalerite – irregular grains, grey

A+400 – 54
-Extremely altered
-Matrix almost entirely altered
-Quartz porphyry
- Matrix fine- to small grained

Minerals	Modal %	Description
Quartz	25%	Porphyritic.
Goetite	8%	Less than 50. Brown altered mineral Foto 1 – 5x
Plagioclase	44%	Extremely altered to saussirite. Larger muscovite flakes than 50.
Alkali		Extremely altered to sericite.

Feldspar		
Calcite	13%	Patches of calcite. Extremely high birefringence. Moderate relief.
Opaques	4%	Pyrite – irregular, intergrowth texture (<<chalcopyrite) Sphalerite – grey, intergrowth texture
White mica	5	Small- to medium grains
Apatite	1	

A+400 – 57
-Extremely altered
-Matrix almost entirely altered
-Quartz porphyry
- Matrix fine- to small grained

Minerals	**Modal %**	**Description**
Quartz	20%	Porphyritic Undulose extinction.
Calcite	13%	Characteristic calcite twinning. Moderate relief Extremely high birefringence
Plagioclase Alkali feldspar	48%	Feldspars extremely altered – large white mica flakes as product.
Scheelite	1%	Bright interference colours. Small grains. Euhedral High relief. Photo
Opaques	8%	Pyrite – irregular shape, some cubic and subhedral Sphalerite – intergrowth and replacement textures
Goethite	3	
White mica	7	

A+400 – 64.5
-Extremely altered
-Matrix almost entirely altered
-Porphyritic (quartz, feldspar porphyries)
- Matrix fine- to small grained
-5% Potassic (rest is phyllic)

Minerals	**Modal %**	**Description**
Quartz	26%	Porphyritic Undulose extinction Cryptocrystalline quartz
Calcite	13%	Characteristic calcite twinning. Moderate relief. Extremely high birefringence. Associated with plagioclase?

Plagioclase	25%	Some grains show some alteration to saussirite. Albite twinning. Few grains show zoning – not very prominent.
Diopside	6%	Patches of diopside High relief Green mineral Bright interference colours
Chlorite	8%	Anomalous blue interference colour. Interstitial
Garnet	3%	Isotropic High relief Colourless Disseminated
Scheelite	3%	High relief Euhedral grains Bright interference colours. Yellow and blue under PPL
Allanite	4%	Brown under PPL Low order interference colours – some slightly brighter and more colourful High relief
Apatite	4%	Small grains. Low order interference colours
Titanite	2	
Idocrase/vesuvianite	2	
Opaques	4%	Pyrite – some cubic, rest is sub- to anhedral Chalcopyrite – replacement textures Sphalerite

A+400 – 72

-Extremely altered

-Matrix almost entirely altered

-Porphyritic (quartz, feldspar porphyries)

- Matrix fine- to small grained

-6% Potassic (rest is phyllic)

Minerals	**Modal %**	**Description**
Quartz	29%	Porphyritic Some grains fairly small Undulose extinction Cryptocrystalline as well.
Diopside	4%	Very few grains Bright interference colours High relief Green under PPL
Titanite	8%	High relief Distinctive shape Brown mineral

Garnet	4%	Isotropic High relief Colourless under PPL Irregular grains
Apatite	8%	Small grains Also elongated ones
Plagioclase	27%	Albite twins Some grains show some alteration to saussirite.
Calcite	12%	Characteristic calcite twinning. Moderate relief. Extremely high birefringence. Associated with plagioclase that was altered?
Chlorite	9%	Anomalous blue interference colour
Scheelite	2%	High relief Euhedral grains Bright interference colours. Colourless under PPL
Epidote	1	
Zircon	<1	
Opaques	6%	Pyrite – some cubic, rest is subhedral Chalcopyrite – brighter yellow

A+400 – 78.8
-Alteration increases again
- Porphyritic (quartz, feldspar porphyries)
- Matrix small- to medium-grained

Minerals	**Modal %**	**Description**
Quartz	32%	Porphyritic Quartz veins (photo)
White mica	8%	Small- to medium grained Few large white mica flakes – probably an alteration product of feldspars.
Feldspars	42%	Plagioclase extremely altered to saussirite Some K-spar porphyries
Opaques	4%	Pyrite – highly irregular grains Sphalerite – grey, replacement textures
Biotite	3	Remnants Retrograde Altered (photo – altered to white mica)
Goethite	2	Brown spots in matrix

A+400

Depth (m)	**Type of alteration**	**Rock type**
50	Advanced argillic	'Granite'
54	Advanced argillic	'Granite'
57	Advanced argillic	'Granite'

64.5	Phyllic	Skarnified granite
72	Phyllic	Skarnified granite
78.8	Advanced phyllic	‘Granite‘

A+400

Depth (m)	**Type of alteration**	**Rock type**	**Hand samples**
50	Advanced argillic	‘Granite’	Red-brown colour Some greenish minerals Quartz porphyry
54	Advanced argillic	‘Granite’	Red-brown colour (more brown than above) Some greenish minerals Quartz porphyry
57	Advanced argillic	‘Granite’	Red-brown colour Some greenish minerals Quartz porphyry
64.5	Phyllic	Skarnified granite	Dark green-grey colour (red-brown alteration starting)
70,5			Quartz porphyry Brownish colour Some green minerals
72	Phyllic	Skarnified granite	Darker grey colour Greenish minerals (darker and lighter green) Quartz porphyry
78.8	Advanced phyllic	‘Granite‘	Greenish-greyish colour (more green) Some red-brown minerals Quartz porphyry

2. AA +400

AA+400 85.34 -Allanite, chlorite, diopside adjacent or intergrown -photo = 5x		
Minerals	**Modal %**	**Description**
Diopside	26	Disseminated Green Bright interference colours No distinctive shape
Biotite	8	Disseminated primary
Quartz	14	
Chlorite	3	Secondary
Apatite	5	Distinctive shape Small grains
Opaques	18	Sphalerite Pyrite Subhedral to anhedral
Scheelite	3	More yellow, some blue as well (PPL)
Allanite	10	Patchy texture Dissemniated No distinctive grain boundaries
Epidote	4	
Feldspars	7	

AA+400 – 89 -first appearance of zoned plagioclase, although not very prominent -medium-grained (mostly due to alteration minerals) -few porphyry grains of quartz and plagioclase, biotite **-2% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	23%	Also cryptocrystalline
White mica	14%	
Calcite	6%	Associated with altered plagioclase
Plagioclase	26%	Albite twins Zoning Variation in grain sizes – small, unaltered to porphyritic Large white mica flakes associated with plagioclase as alteration product.
Allanite	4%	
Alkali feldspar	15%	Cross-hatched/tartan twinning evident Minor alteration Some grains are secondary Small- and medium grain sizes
Apatite	3%	
Opaques	9%	Pyrite – replacement textures, irregular grains Sphalerite – replacement textures, grey, intergrown Subhedral to anhedral
Zircon	<1	

AA+400 – 94.5 -Zoning more prominent - fairly coarse-grained -porphyritic grains of quartz, feldspars **-2 % Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	24%	Variation in grain sizes: small grains in matrix to porphyritic
Alkali feldspar	23%	Some grains altered to sericite, some secondary Cross-hatched/tartan twinning
Plagioclase	23%	Zoning Albite twins Large white flakes as alteration product
Apatite	3%	
Chlorite	13%	With biotite, muscovite
Calcite	6%	
White mica	4%	
Opaques	4%	Pyrite – exsolution textures, replacement textures, irregular grains, one or two cubic grains Sphalerite – intergrown, anhedral

AA+400 – 111.5 -Not extremely altered -medium- to coarse-grained -porphyry grains of quartz and feldspars **-3% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	27%	Albite twins Altered to saussirite Most grains altered Large white mica flakes associated Weak zoning
Alkali feldspar	21%	Cross-hatched/Tartan twinning Altered to sericite Some secondary
Quartz	20%	Porphyritic
White mica	17%	Large white mica flakes
Calcite	5%	Characteristic calcite twinning Associated with altered plagioclase
Biotite	2%	Very little – patches Altered
Chlorite	1%	
Opaques	4%	Pyrite – slightly cubic habit, replacement textures Sphalerite – intergrowth texture, grey

AA+400 – 112 -silicification		
Minerals	**Modal %**	**Description**
Quartz	31%	Cryptocrystalline quartz Variation in grain sizes Irregular shapes
Apatite	3%	
Calcite	8%	Characteristic calcite twinning Veins and patches Sometimes associated with altered plagioclase
Scheelite	2%	Anhedral/no distinct shape
Chlorite	5%	Secondary
Alkali feldspar	8%	Simple twins
Allanite	11%	
Diopside	8%	Altered Irregular shape

		Colourful birefringence Pleochroic in dark brown to light brown and olive green
Plagioclase	14%	
Garnet	<1	
Biotite	6%	Altered
Opaques	4%	Pyrite – subhedral to anhedral/disseminated Pyrrothite – associated with pyrite Sphalerite – intergrown/disseminated

AA+400 – 112.65		
Minerals	**Modal %**	**Description**
Scheelite	4	
Garnet	2	
Quartz	30	
Opaques	12	Pyrite – some cubic, most subhedral Sphalerite << - intergrown, disseminated
Apatite	4	
Plagioclase (alkali feldspar)	37	Altrered to saussirite
Titanite	3	
Allanite	2	
Calcite	5	
Diopside	3	

AA+400 – 116		
Minerals	**Modal %**	**Description**
Scheelite	2	
Garnet	1	
Quartz	32	
Opaques	5	Pyrite – cubic, subhedral Chalcopyrite – associated with Sphalerite - intergrown
Apatite	3	
Plagioclase (alkali feldspar)	27	Altrered to saussirite
Titanite	1	
Allanite	1	
Calcite	4	
Biotite	7	Some altered to chlorite

White mica	2	
Diopside	15	Some altered to amphibole

AA+400 – 127		
Minerals	**Modal %**	**Description**
Quartz	24%	Variation in grain sizes Cryptocrystalline quartz Porphyritic
Chlorite	5%	
Biotite	1%	

AA+400 – 122 -Not so altered -Zoning		
Minerals	**Modal %**	**Description**
Quartz	27%	Variation in grain sizes Cryptocrystalline quartz
Plagioclase	24%	Not severely altered Albite twins Large white mica flakes Zoning
Alkali feldspar	23%	Altered although not severe Cross-hatched/tartan twinning + sanidine
White mica	8%	Medium- to large grains
Calcite	5%	Associated with altered plagioclase Unusual twinning Anhedral
Opaques	3%	Pyrite – exsolution textures, irregular grains Sphalerite – grey colour, irregular grains <<
Calcite	9%	Associated with altered plagioclase Characteristic calcite twinning
Apatite	6%	
Alkali feldspar	12%	Some grains secondary
Plagioclase	18%	Not severly altered Albite twins
Allanite	5%	
Titanite	5%	
Idocrase	1	
Garnet	2%	Anhedral
Diopside	4%	Altered Pleochroic – brown Dark – high relief

Opaques	5%	Pyrite – slightly cubic habit Chalcopyrite – brighter yellow Molybdenite – needle-shaped grains, anisotropic

AA+400 – 136.38		
Minerals	**Modal %**	**Description**
Epidote	3	
Opaques	15	Sphalerite Pyrite – dominant, few cubic grains Pyrrothite Chalcopyrite Subhedral to anhedral
Quartz	19	
Plagioclase	18	Altered Twinning visible in some grains
White mica	6	
Scheelite	2	
Pyroxene (Diopside)	19	Some altered to amphibole

AA+400 – 137.5 -silicification extreme		
Minerals	**Modal %**	**Description**
Quartz	26%	Variation in grain sizes Irregular shapes Cryptocrystalline quartz Porphyry
Calcite	9%	
Allanite	6%	Associated with altered diopside
Apatite	4%	
White mica		
Scheelite	2%	
Plagioclase	18%	Not severely altered Albite twins
Chlorite	8%	
Diopside	8%	
Alkali feldspar	26%	Cross-hatched/tartan twinning as well as simple twins Not severely altered
Opaques		Pyrite – irregularly shaped grains, exsolution bodies Chalcopyrite – brighter yellow, irregular grain shape Sphalerite

AA+400 – 141

-Not severely altered -medium- to coarse-grained (small grains – alteration products) -porphyry grains of quartz and feldspars **-5% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	27%	
Plagioclase	25%	Zoning Albite twins Altered to saussirite Larger white mica flakes associated with altered plagioclase Variation in grain sizes: porphyritic
Biotite	16%	Altered to chlorite, white mica Not entirely altered
White mica	2	Small- and medium grain sizes
Alkali feldspar	22%	Not severely altered Some are secondary Cross-hatched/tartan twins as well as simple twins
Apatite	22%	
Calcite	4%	
Opaques	2%	Pyrite – irregular intergrowth texture Sphalerite – grey, irregular grains

AA+400 – 145.5		
Minerals	**Modal %**	**Description**
Plagioclase	27	Albite twins Altered Zoning
Calcite	8	
Quartz	29	Porphyritic + smaller grains Cryptocrystalline
Alkali feldspar	20	
Titanite	6	Photo
Allanite	5	
Apatite	2	
Opaques	3	Pyrite – irregular shaped grains, interstitial growth Sphalerite – irregular grains, intergrowth texture Molybdenite – needle-shaped grains, anisotropic Chalcopyrite – needle-shaped

AA+400 – 148 -relatively altered		
Minerals	**Modal %**	**Description**
Quartz	28	
Alkali	27	Twinning (+sanidine)

feldspar		
Plagioclase	29	Rims
Biotite	6	Remnants
White mica	4	Medium grains
Titanite	2	
Opaques	4	Pyrite – exsolution and replacement textures Chalcopyrite - <<, irregular grains

AA+400 – 150
-moderately altered
-zircon

Minerals	Modal %	Description
Quartz	28	
Alkali feldspar	27	Twinning (+sanidine)
Plagioclase	24	Rims Extremely altered
Biotite	6	Remnants
White mica	8	
Opaques		Pyrite – cubic habit Sphalerite – intergrowth texture, irregular grains

AA+400		
Depth (m)	**Type of alteration**	**Rock type**
85.34	Skarn	
86	Skarn?	Skarnified granite
89	Potassic	Altered granite
94.5	Potassic	Altered granite
111.5	Potassic	Altered granite
112	Phyllic	Altered granite
112.65	Advanced argillic	‘Granite’
116	Skarn	
122	Phyllic	Altered granite
127	Advanced Phyllic	Altered granite
136.38	Skarn	
137.5	Advanced Phyllic	Altered granite
141	Phyllic	Altered biotite granite
145.5	Advanced Phyllic	Altered biotite granite
148	Phyllic	Altered biotite granite
150	Advanced Phyllic	Altered biotite granite

AA+400			
Depth (m)	**Type of alteration**	**Rock type**	**Hand samples**
85.34	Skarn		
86	Skarn?	Skarnified granite	Dark colour Dark green minerals
89	Potassic	Altered granite	Green-grey colour Few red-brown minerals Greenish minerals
94.5	Potassic	Altered biotite granite	Green-grey colour Greenish minerals Looks more like normal granite
96.5		Skarn	Dark colour Green minerals and dark brown minerals
111.5	Potassic	Altered biotite granite	Green-grey colour Greenish minerals Looks more like normal granite
112	Advanced phyllic	Altered biotite granite	Dark grey-green colour Green minerals Dark grey minerals
112.65	Advanced argillic	'Granite'	
116	Skarn		
122	Phyllic	Altered biotite granite	Lighter colour Quartz porphyry Few greenish minerals
127	Advanced Phyllic	Altered biotite granite	Dark green-grey colour Quartz porphyry
136.38	Skarn		
137.5	Advanced Phyllic	Altered granite	Skarn Dark colour Green minerals Dark grey to black minerals Pyrite Some quartz
141	Phyllic	Altered biotite granite	Lighter colour Quartz porphyry Few greenish minerals
145.5	Advanced Phyllic	Altered biotite granite	Dark grey-green colour Green minerals Dark grey minerals Quartz porphyry

148	Phyllic	Altered biotite granite	Lighter colour Very few greenish minerals
150	Advanced Phyllic	Altered biotite granite	Lighter colour Few greenish minerals Some red-brown minerals Quartz vein

3. AA200

AA200 85.5 Garnet skarn Retrogression		
Minerals	**Modal %**	**Description**
Quartz		
Pyroxene (diopside)		Distinctive cleavage Brown – altered to amphibole
Calcite		Micro veins
Amphibole		
Scheelite		
Allanite		
Garnet		Peninitization Yellow – andradite Retrograde
Fluorite		
Apatite		
Opaques		Sphalerite Pyrite Pyrrothite Chalcopyrite Subhedral to anhedral grains

AA200 132 -extremely altered -lower T alteration -goethite in matrix due to extreme alteration		
Minerals	**Modal %**	**Description**
Plagioclase Alkali feldspar	46	Matrix of altered feldspars No visible twinning
Quartz	27	Smaller grains relative to other thin-sections Porphyritic
White mica	7	Small- to medium grain sizes
Garnet	1	Euhedral grain(s)
Biotite	3	Remnants of biotite grains altered to chlorite and muscovite
Apatite	2	
Opaques	5	Pyrite

		Sphalerite –grey (intergrown) Irregular/anhedral
Calcite	6	In matrix
Idocrase/vesuvianite	<1	High relief Grey – light brown (PPL)
Goethite	3	

AA200 144 -extremely altered -much lower T alteration		
Minerals	**Modal %**	**Description**
Quartz	26	Porphyritic Small grains as well Cryptocrystalline
White mica	35	Spectrum of grain sizes
Altered feldspars	18	Sea of altered feldspars Some grain boundaries and twinning still visible
Pyroxene (diopside)	1	
Biotite	4	
Epidote	1	
Opaques	7	More sphalerite than pyrite – subhedral, irregular, intergrown Pyrite, few very small cubic grains
Apatite	2	
Calcite	6	In matrix

AA200 149 -moderately altered -not a quartz porphyry -small-to medium grained -a lot of secondary minerals **-3% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Apatite	2	
Garnet	1	Euhedral grain(s)

Calcite	6	
Scheelite - foto	2	
Opaques	6	Pyrite – some cubic, others syb- to anhedral Chalcopyrite – replaces pyrite Sphalerite - subhedral, irregular, intergrown
Biotite	3	Remnants
Chlorite	2	Secondary
Quartz	23	Cryptocrystalline quartz Not porphyritic
Allanite	4	
Titanite	2	More red-brown
White mica	2	
Feldspars	33	Mostly altered Looks like some secondary
Pyroxene (diopside)	8	

AA200 155 -Moderately altered -higher T alteration -medium- to coarse grained -porphyritic texture **-5% Potassic alteration (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	27	Variety of grain sizes Not porphyritic
Biotite	8	Remnants
Alkali feldspar	15	Twinning visible Some grains secondary
Plagioclase	28	Twinning visible Altered - saussirite
Calcite	9	
White mica	3	Large and small flakes – associated with alteration of plagioclase
Opaques	8	Pyrite – some cubic, rest is sub- to anhedral Sphalerite – disseminated, irregular, intergrown
Apatite	2	

AA200 171

-moderately altered -lower T alteration		
Minerals	**Modal %**	**Description**
Biotite	11	Remnants Some primary still visible
Idocrase/vesuvianite	3	Medium relief Colourless Sectored
Plagioclase Alkali feldspar	49	Altered Some cross-hatched/tartan twinning still visible Saussirite Sea of altered feldspars
Quartz	21	
White mica	8	
Opaques	4	Pyrite – sub- to anhedral, poikilitic texture
Calcite	2	

AA200 176 -moderately altered -clusters of alteration -porphyritic texture (quartz, feldspar, biotite porphyries and matrix of smaller alteration product grains) **-11% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Biotite	11	Remnants Some primary still visible
Quartz	26	Not porphyrtitic Cryptocrystalline Fairly even-grained
Alkali feldspar	17	Twinning (also sanidine twins –altered) Some secondary Interstital
Plagioclase	29	Porphyritic Altered – saussirite Twinning visible in a few grains
Opaques	5	Pyrite – some cubic, rest is sub- to anhedral Sphalerite – disseminated, irregular, intergrown
White mica	6	Mostly associated with alteration of plagioclase
Calcite	7	Interstitial Associated with plag
Fluorite	<1	
Apatite	2	

Scheelite	<1	

AA200 149 -moderately altered -not a quartz porphyry -small-to medium grained -a lot of secondary minerals **-3% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Apatite	2	
Garnet	1	Euhedral grain(s)
Calcite	6	
Scheelite - foto	2	
Opaques	6	Pyrite – some cubic, others syb- to anhedral Chalcopyrite – replaces pyrite Sphalerite - subhedral, irregular, intergrown
Biotite	3	Remnants
Chlorite	2	Secondary
Quartz	23	Cryptocrystalline quartz Not porphyritic
Allanite	4	
Titanite	2	More red-brown
White mica	2	
Feldspars	33	Mostly altered Looks like some secondary
Pyroxene (diopside)	8	

AA200 155 -Moderately altered -higher T alteration -medium- to coarse grained -porphyritic texture **-5% Potassic alteration (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	27	Variety of grain sizes Not porphyritic
Biotite	8	Remnants
Alkali feldspar	15	Twinning visible Some grains secondary

Plagioclase	28	Twinning visible Altered - saussirite
Calcite	9	
White mica	3	Large and small flakes – associated with alteration of plagioclase
Opaques	8	Pyrite – some cubic, rest is sub- to anhedral Sphalerite – disseminated, irregular, intergrown
Apatite	2	

AA200 171
-moderately altered
-lower T alteration

Minerals	**Modal %**	**Description**
Biotite	11	Remnants Some primary still visible
Idocrase/vesuvianite	3	Medium relief Colourless Sectored
Plagioclase Alkali feldspar	49	Altered Some cross-hatched/tartan twinning still visible Saussirite Sea of altered feldspars
Quartz	21	
White mica	8	
Opaques	4	Pyrite – sub- to anhedral, poikilitic texture
Calcite	2	

AA200 176
-moderately altered
-clusters of alteration
-porphyritic texture (quartz, feldspar, biotite porphyries and matrix of smaller alteration product grains)
-11% Potassic (rest is advanced phyllic)

Minerals	**Modal %**	**Description**
Biotite	11	Remnants Some primary still visible
Quartz	26	Not porphyrtitic Cryptocrystalline Fairly even-grained

Alkali feldspar	17	Twinning (also sanidine twins –altered) Some secondary Interstital
Plagioclase	29	Porphyritic Altered – saussirite Twinning visible in a few grains
Opaques	5	Pyrite – some cubic, rest is sub- to anhedral Sphalerite – disseminated, irregular, intergrown
White mica	6	Mostly associated with alteration of plagioclase
Calcite	7	Interstitial Associated with plag
Fluorite	<1	
Apatite	2	
Scheelite	<1	

AA200 190
-extremely altered
-higher T alteration
-porphyritic texture (quartz, feldspar, biotite porphyries and matrix of smaller alteration product grains)
-12% Potassic (rest is advanced phyllic)

Minerals	**Modal %**	**Description**
White mica	7	Variety of grain sizes
Calcite	11	
Plagioclase	26	Alteration – saussirite Twinning visible in some grains Rims
Quartz	23	Porphyritic Cryptocrystalline?
Alkali feldspar	15	Twinning Some secondary grains
Biotite	9	Porphyritic Remnants – white mica, chlorite Primary biotite still visible
Opaques	3	Pyrite – some cubic, rest is sub- to anhedral, also replacing biotite Sphalerite – disseminated, irregular, intergrown
Chlorite	1	
Apatite	1	

AA200 200
-extremely altered
-higher T alteration

-porphyritic texture (quartz, feldspar, biotite porphyries and matrix of smaller alteration product grains) **-9% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
White mica	4	
Calcite	9	
Plagioclase	27	Alteration – saussirite Twinning visible in some grains Rims
Quartz	25	Porphyritic Cryptocrystalline
Alkali feldspar	15	Twinning Some secondary grains
Biotite	9	Porphyritic Remnants – white mica, chlorite Primary biotite still visible (less than above)
Opaques	3	Pyrite – some cubic, rest is sub- to anhedral Sphalerite – disseminated, irregular, intergrown
Chlorite	1	
Apatite	1	

AA200 201 -less altered than above -higher T alteration -porphyritic texture (quartz, feldspar, biotite porphyries and matrix of smaller alteration product grains) **-14% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
White mica	5	Larger than above
Calcite	7	
Plagioclase	25	Alteration – saussirite Twinning visible in some grains
Quartz	29	Porphyritic Cryptocrystalline Quartz vein
Alkali feldspar	15	Twinning Some secondary grains Also sanidine twins
Biotite	8	Remnants
Opaques	3	Pyrite – some cubic, rest is sub- to anhedral Sphalerite – disseminated, irregular, intergrown
Chlorite	1	
Apatite	1	

AA200 217 -slightly more altered than above -porphyritic texture (quartz, feldspar, biotite porphyries and matrix of smaller alteration product grains) **-8% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
White mica	8	Larger and smaller flakes
Calcite	9	
Plagioclase	25	Alteration – saussirite Twinning visible in some grains
Quartz	24	Porphyritic Cryptocrystalline
Alkali feldspar	17	Twinning Some secondary grains
Biotite	6	Remnants
Opaques	5	Pyrite – some cubic, rest is sub- to anhedral Sphalerite – disseminated, irregular, intergrown
Goethite	4	Red-brown spots in matrix
Chlorite	1	
Apatite	2	

AA200 228 -more altered than above -coarse-grained -porphyritic texture (quartz, feldspar, biotite porphyries and matrix of smaller alteration product grains) **-9% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
White mica	2	
Calcite	7	
Plagioclase	29	Alteration – saussirite Twinning visible in some grains Rims
Quartz	26	Porphyritic Cryptocrystalline
Alkali feldspar	20	Twinning Some secondary grains
Biotite	9	Porphyritic Remnants – white mica, chlorite Primary biotite still visible Retrogressed
Opaques	6	Pyrite – some cubic, rest is sub- to anhedral

		Sphalerite – disseminated, irregular, intergrown
Apatite	1	

Depth (m)	**Type of alteration**	**Rock type**
85.5	Skarn	
132	Advanced argillic	'Granite'
144	Advanced phyllic	'Granite'
149	Potassic	Altered granite
155	Potassic	Altered granite
171	Argillic	'Granite'
176	Phyllic	Altered biotite granite
190	Phyllic	Altered biotite granite
200	Phyllic	Altered biotite granite
201	Phyllic	Altered biotite granite
217	Phyllic	Altered biotite granite
228	Phyllic	Altered biotite granite

Depth (m)	**Type of alteration**	**Rock type**	**Hand samples**
85.5	Skarn		
132	Advanced argillic	'Granite'	Red-brown-greenish colour Quartz porphyry
144	Advanced phyllic	'Granite'	Greenish-grey colour
149	Potassic*	Altered granite	Darker grey colour Also greenish minerals
155	Potassic*	Altered granite	Lighter grey colour Greenish and red-brown minerals
171	Argillic	'Granite'	Greenish colour Few red-brown minerals
176	Phyllic	Altered biotite granite	Looks more like normal granite Few greenish- and red-brown minerals Quartz porphyry
190	Phyllic	Altered biotite granite	Looks more like normal granite

			Few greenish- and red-brown minerals Quartz porphyry
200	Phyllic	Altered biotite granite	Looks more like normal granite Few greenish- and red-brown minerals Quartz porphyry
201	Phyllic	Altered biotite granite	Grey-greenish colour Much finer grains Quartz veins
217	Phyllic	Altered biotite granite	Looks more like normal granite (greyish colour) Few greenish- and red-brown minerals Quartz porphyry
228	Phyllic	Altered biotite granite	Looks more like normal granite (greenish-greyish colour) Few greenish- and red-brown minerals Quartz porphyry

4. BB+400

BB+400 90		
Minerals	**Modal %**	**Description**
Garnet	10	Anhedral Disseminated
Scheelite	1	Blue
Diopside (pyroxene)	6	
Biotite	14	Some primary still visible Altered to chlorite Fairly large grains relative to others
Chlorite	12	Secondary
Calcite	6	Interstitial
White mica	4	Small- to medium grained
Apatite	16	Small grains in matrix Also clusters
Allanite	3	
Quartz	16	No porphyritic

		Also cryptocrystalline quartz
Plagioclase	10	
Opaques	2	Pyrite – cubic/disseminated >> - random <<Chalcopyrite

BB+400 121.2
-fairly altered
-quartz porphyry
-altered porphyritic texture
-matrix of smaller grains
-15% Potassic (rest is phyllic)

Minerals	Modal %	Description
Quartz	20%	Pophyritic Also smaller grains and cryptocrystalline quartz Undulose extinction
Alkali feldspar	22%	Most grains extremely altered to sericite Cross-hatched/tartan twinning evident Few grains show simple twins Some grains are secondary
Apatite	6%	Small grains Moderate relief Low order interference colours Occurs as single grains in matrix
Calcite	8%	Interstitial Extremely high order interference colours Characteristic calcite twinning evident in some grains
Biotite	13%	(Altered to chlorite: Pleochroic in light green Low order interference colours Moderate relief) Some primary biotite still visible
Plagioclase	20%	Grains altered to saussirite but albite twins still visible in some.
Idocrase/vesuvianite	2	
White mica	2	Small- to medium grained Sometimes associated with altered plagioclase
Opaques	8%	Pyrite - >>, disseminated/random Chalcopyrite – replaced by pyrite

BB+400 136 - extremely altered -quartz porphyry -altered porphyritic texture -matrix of smaller grains **-17% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Calcite	8%	Interstitial Extremely high order interference colours Characteristic calcite twinning evident in some grains
Quartz	26%	Also cryptocrystalline quartz Not porphyritic
Allanite	1	
Garnet	2	Anhedral
Plagioclase	23%	Large grains altered to saussirite but albite twinning still visible in some Some grains are porphyroblastic
Alkali feldspar	18%	Altered to sericite Some secondary grains
Chlorite	7%	Secondary Anomalous blue interference colour Pleochroic in variations of green
Biotite	4	Remnants of primary biotite still visible Altered
Apatite	7%	Small dispersed grains in matrix Moderate relief Colourless Low order interference colours
White mica	1	Small- to medium grained
Idocrase/vesuvianite	1	
Scheelite	1%	
Opaques	4%	Pyrite Chalcopyrite – replaced by pyrite Molybdenite – elongated silver/grey

BB+400 155 -extremely altered -zircon

-quartz porphyry
-altered porphyritic texture
-matrix of smaller grains
-6% Potassic (rest is advanced phyllic)

Minerals	Modal %	Description
Quartz	23%	Porphyritic (larger than above) Small grains as well Undulose extinction Low relief 1st order interference colours Cryptocrystalline quartz
Apatite	6%	Small dispersed grains in matrix Moderate relief Colourless Low order interference colours
Idocrase/vesuvianite	2	Sectored Photo
Calcite	9%	Interstitial Extremely high order interference colours Characteristic calcite twiining evident in some grains
Plagioclase	23%	Grains altered to saussirite but albite twinning still visible in some Some grains are porphyroblastic
Chlorite	10%	Secondary Anomalous blue interference colour Pleochroic in variations of green
Biotite	2	Remnants of primary biotite still visible
Alkali feldspar	17%	Grains show some alteration to sericite Cross-hatched/tartan twinning evident as well as simple twins in a few grains Medium sized grains Some secondary grains
Garnet	2%	High relief Colourless Isotropic Small euherdral grains
White mica	4%	Small- to medium sized flakes of white mica Probably alteration product
Scheelite	<1	More blue (PPL) Pink/purple (XPL)
Opaques	5%	Pyrite – disseminated, random (<<cpy), << cubic (mostly disseminated), also associated with apatite Chalcopyrite << Molybdenite - <<, intergrown Sphalerite

BB+400 156.6
-extremely altered

Minerals	Modal %	Description
Chlorite	6%	Anomalous blue interference colour Pleochroic in variations of green
Biotite	3	Remnants of primary biotite still visible
Garnet	2%	Anhedral
Calcite	8%	
Allanite	13%	Association with diopside
Scheelite	4%	Blue under PPL More yellow under XPL, also pink-purple
Quartz	18%	Small grains
Plagioclase	17%	Altered to saussirite although not severly altered Albite twins Some grains porphyritic
Diopside	8%	High relief Pleochroic in light green to light brown Occurs as medium grained patches Bright interference colours
Titanite	<1%	Accessory
Idocrase/vesuvianite	2	
Apatite	6%	
White mica	2	
Opaques	10%	Pyrite – disseminated, very few cubic Pyrrhotite << <<Chalcopyrite Sphalerite

BB+400 162
-more altered than previous (higher T alteration)
-altered porphyritic texture (quartz and feldspars)
-matrix of smaller grains
-11% Potassic (rest is advanced phyllic)

Minerals	Modal %	Description
Plagioclase	24%	Albite twins Altered to saussirite Some porphyroblastic
Alkali feldspar	16%	Some altered to sericite Some are secondary
White mica	7%	Large white mica flakes – alteration product of feldspars Also smaller flakes
Quartz	23%	Porphyritic

Apatite	5%	
Chlorite	7%	Secondary Anomalous blue interference colour
Calcite	4%	
Allanite	6%	
Titanite	3%	
Opaques	5%	Pyrite - <<cpy altered to pyrite, disseminated, <cubic, inclusions Chalcopyrite Molybdenite – associated with sphalerite Sphalerite Pyrrothite Replacement textures

BB+400 181 -Zoning in feldspars prominent -Moderately altered -Overall coarse-grained -Shapes not so irregular due to alteration that is not so extensive -porphyritic texture **12% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Alkali feldspar	23%	Porphyritic Some secondary grains
White mica	8%	Variety of grain sizes
Quartz	22%	Porphyritic
Biotite	12%	Porphyritic Remnants – altered to white mica, chlorite Some primary still visible
Plagioclase	24%	Porphyritic Albite twins Some grains are porphyroblastic Zoning prominent – altered center (rims)
Apatite	4%	
Titanite	2	
Epidote	1	
Opaques	4%	Pyrite – replacement textures, irregular grain shape Molybdenite – grey, replacement textures (biotite) Chalcopyrite - << Molybdenite <

BB+400 191
-Irregular grains
-more altered than above (lower T alteration)

Minerals	**Modal %**	**Description**
Alkali feldspar	13%	Cross-hatched/tartan twinning Altered – some only with minor alterations
White mica	26%	Variety of grain sizes More prominent than previous slide
Quartz	24%	Porphyritic
Plagioclase	21%	Albite twins Most grains highly altered
Calcite	5%	Interstitial
Diopside	<1%	Blob of diopside
Scheelite	<1%	A single euhedral grain
Apatite	3%	
Biotite	4%	Remnants
Opaques	4%	Pyrite – cubic << Chalcopyrite Molybdenite – irregular grain shape, intergrowth texture

BB+400 196
-extremely altered

Minerals	**Modal %**	**Description**
Quartz	23%	Porphyritic
Plagioclase Alkali feldspar	51%	Extremely altered to saussirite Extremely altered to sericite Sea of altered feldspars
White mica	15%	Variety of grain sizes Large white mica flakes in matrix
Apatite	3%	
Goethite	2%	Brown spots in matrix
Diopside	2%	
Opaques	4%	Pyrite – highly irregular grains Chalcopyrite << Molybdenite – replacement textures Sphalerite

BB+400 210
-extremely altered (more than above)

Minerals	**Modal %**	**Description**
Quartz	24%	Variation in grain sizes: from porphyritic to small grains in matrix.

Plagioclase	53%	
Alkali feldspar		
Goethite	2%	Brown spots in matrix
White mica	15%	Variety of grain sizes
Opaques	5%	Pyrite – irregular grains, exsolution textures <<Chalcopyrite Molybdenite – highly irregular grains

BB+400		
Depth (m)	**Type of alteration**	**Rock type**
90	Skarnified granite	
121.2	Potassic*	Altered granite
136	Phyllic	Altered granite
155	Phyllic	Altered biotite granite
156.6	Skarnified granite	
162	Phyllic	Altered biotite granite
181	Phyllic	Altered biotite granite
191	Advanced phyllic	Altered biotite granite
196	Advanced argillic	‘Granite’
210	Advanced argillic	‘Granite’

BB+400			
Depth (m)	**Type of alteration**	**Rock type**	**Hand samples**
90	Skarn	Skarnified granite	Very dark Fine-grained Quartz porphyry Skarn
121.2	Potassic	Altered granite	Grey-green colour Greenish minerals Quartz porphyry
136	Phyllic	Altered granite	Grey-green colour Greenish minerals Quartz porphyry
155	Phyllic	Altered biotite granite	Grey-green colour Greenish minerals Quartz porphyry
156.6	Skarnified granite		Very dark Fine-grained Skarn
162	Phyllic	Altered biotite granite	Grey colour Looks more like normal granite Few green minerals
181	Phyllic	Altered biotite granite	Lighter colour Quartz porphyry Few greenish minerals
191	Advanced phyllic	Altered biotite granite	Green colour (white mica? Altered feldspars?)) Quartz porphyry
196	Advanced argillic	‘Granite’	Green colour (white mica? Altered feldspars?) Quartz porphyry Few red-brown

			minerals
210	Advanced argillic	'Granite'	Green colour – more green than above (white mica? Altered feldspars?) Quartz porphyry

5. CC+400

C400 125 -moderately altered - coarser grained		
Minerals	**Modal %**	**Description**
Plagioclase	28	Albite twinning Alteration – saussirite Relatively large rectangular/sub-rounded grains Altered plag with rims around
Alkali feldspar	16	Cross-hatched/tartan twinning Some grains secondary Some altered – sericite Carlsbad twins - sanidine
Apatite	2	Large grains
Calcite	3	Clusters of chlorite – medium grained
Chlorite	7	Secondary
Biotite	11	Coarse-grained Remnants of biotite grains altered to chlorite and muscovite
White mica	4	Variety of grain sizes (mostly medium grained)
Quartz	27	Porphyritic Large grains and smaller grains Irregular shapes Diffusive boundaries
Opaques	3	Pyrite – most cubic, others subhedral Sphalerite – intergrown/irregular/disseminated

C400 140 -extremely altered -higher T alteration -Quartz porphyry		
Minerals	**Modal %**	**Description**
Quartz	23	Porphyritic and small grains

		Sub-rounded to irregular shapes
Alkali feldspar	20	Mostly altered to sericite Sanidine (Carlsbad twins) Some secondary grains (potassic alteration – 10%)
Calcite	11	Interstitial Calcite micro veins
Biotite	14	Some primary biotite still visible Remnants of biotite grains replaced by chlorite, muscovite
Plagioclase	21	Fairly large grains Altered to saussirite
Goethite	2	Red-brown spots in matrix Retrogressed
Apatite	2	Large grains (+small)
Opaques	2	Very few grains Fine grain sizes Pyrite Sphalerite
White mica	5	

C400 150 -extremely altered -lower T alteration -clusters of alteration (photo x2) -finer grained		
Minerals	**Modal %**	**Description**
Quartz	25	Cryptocrystalline quartz
Opaques	7	Pyrite – some cubic, others sub- to anhedral Chalcopyrite – associated with pyrite, darker yellow Sphalerite – intergrown, small grains
Calcite	8	
White mica	7	Medium grain sizes (mostly)
Allanite	1	Photo
Scheelite	1	Photo (+apatite) More yellow (PPL)
Plagioclase	28	Severely altered Zoned (photo)
Alkali feldspar	20	Altered to sericite Some secondary grains (borderline)
Fluorite	1	

C400 173 -extremely altered -Overall medium grained -lower T alteration to one side, higher T to other side		
Minerals	**Modal %**	**Description**
One side: Plagioclase Alkali feldspar Other side:	34	Matrix altered Cannot distinguish between grains Some albite twins visible under alteration (saussirite) Some secondary alkali feldspar grains
Quartz	23	Porphyritic
Calcite	13	
Biotite	10	Porphyritic Remnants of biotite grains altered to chlorite and muscovite
Opaques	6	Pyrite – blocky (on top of other grains – late stage), rest is subhedral Sphalerite – intergrown/irregular
White mica	11	Small- to medium grain sizes In plagioclase grains (center) Photo
Apatite	3	Medium sized grains as well

C400 189 -extremely altered (higher T alteration)		
Minerals	**Modal %**	**Description**
Plagioclase	29	Alteration – saussirite Some albite twins visible under alteration Large altered grains and smaller grains Saussiritic alteration in some grains extensive – larger white mica flakes Zoned (photo)
Calcite	8	
Quartz	24	
Alkali feldspar	16	Some new grains (interstitial – some) Cross-hatched/tartan twins Medium grained
Biotite	13	Remnants of biotite grains altered to chlorite and muscovite
Titanite	1	
White mica	4	
Apatite	2	
Opaques	3	Pyrite – mostly subhedral, also interstitial in biotite (alteration product)

C400 203
-extremely altered
-Lower T
-more opaques
-fine-grained
-Quartz porphyry

Minerals	**Modal %**	**Description**
Quartz	24	Porphyry
Plagioclase Alkali feldspar	44	Matrix altered feldspars
White mica	8	
Opaques	7	Pyrite – mostly subhedral, some cubic, also interstitial in biotite (alteration product) Sphalerite - <<, intergrown/irregular/disseminated
Calcite	9	
Apatite	3	
Biotite	5	Remnants of biotite grains altered to chlorite and muscovite

C400 210
-extremely altered
-lower T alteration

Minerals	**Modal %**	**Description**
Quartz	24	Porphyritic and small grains Sub-rounded to irregular shapes
Plagioclase Alkali feldspar	46	Matrix altered feldspars No grain shapes/twinning visible
White mica	16	Variety of grain sizes
Calcite	10	Micro veins
Idocrase/vesuvianite	1	
Opaques	2	Pyrite – subhedral to anhedral
Apatite	2	
Zircon	<1	Micro

C400 218
-moderately altered
-higher T alteration

Minerals	**Modal %**	**Description**

Quartz	24	
Plagioclase	20	Albite twinning Alteration mostly in center of grains – saussirite Zoned (photo)
Alkali feldspar	21	Cross-hatched/tartan twins Some secondary grains (some interstitial or on top of other grains)
Biotite	14	Remnants of biotite grains altered to chlorite and muscovite
Apatite	2	
Scheelite	<1	
Titanite	<1	
Opaques	8	Pyrite – subhedral to anhedral
Zircon	<1	Micro

Depth (m)	**Type of alteration**	**Rock type**
125	Potassic	Altered granite/quartz monzonite
140	Phyllic	Altered biotite granite
150	Phyllic	Altered biotite granite
173	Phyllic	Altered biotite granite
189	Phyllic	Altered biotite granite
203	Advanced argillic	Altered biotite granite
210	Advanced argillic	Altered biotite granite
218	Phyllic	Altered biotite granite

Depth (m)	Type of alteration	Rock type	Hand samples
125	Potassic	Altered granite	Looks like normal granite Greenish minerals
140	Phyllic	Altered biotite granite	Red-brown colour Few greenish minerals Quartz porphyry
150	Phyllic	Altered biotite granite	Dark grey colour Few greenish minerals Very few red-brown minerals
173	Phyllic	Altered biotite granite	Dark green colour Quartz porphyry
189	Phyllic	Altered biotite granite	Green-grey colour
203	Advanced argillic	Altered biotite granite	Looks like normal granite Greenish minerals Quartz porphyry
210	Advanced argillic	Altered biotite granite	Green colour Quartz porphyry Green-brown minerals
218	Phyllic	Altered biotite granite	Grey colour Looks like normal granite Quartz porphyry

6. D+700

D700 133 -extremely altered		
Minerals	**Modal %**	**Description**
Calcite	7	Characteristic twinning
Biotite	9	Disseminated Sometimes associated with calcite
Quartz	24	Porphyry + smaller grains
Plagioclase Alkali feldspar	40	Extremely sericitized/saussiritized No twinning visible
Apatite	1	Small grains in matrix
White mica	<1	Medium grained
Opaques	2	Pyrite Sphalerite Anhedral, disseminated
Garnet	<1	
Goethite	5	Brown spots in matrix

D700 147 -extremely altered		
Minerals	**Modal %**	**Description**
Calcite	5	
Biotite	2	
Quartz	45	
Plagioclase Alkali feldspar	28	
Apatite	6	
White mica	3	
Opaques	9	Pyrite – disseminated, anhedral Chalcopyrite – small grains in matrix, disseminated Sphalerite - disseminated, anhedral
Scheelite	<1	Bluish under PPL
Epidote	2	
Garnet	<1	
Goethite		

D700 157 -moderately altered		
Minerals	**Modal %**	**Description**

Biotite	11	Porphyry Some altered to chlorite, muscovite Distinctive pleochroism Disseminated Some primary biotite still visible
Alkali feldspar	18	Porphyritic Cross-hatched/tartan twinning Some sericite
Apatite	1	
Plagioclase	33	Saussirite Large extremely altered grain with alkali feldspar rim
Idocrase/vesuvianite	<1	
Quartz	27	Porphyry
Secondary white mica flakes	4	
Opaques	5	Pyrite – subhedral, mostly anhedral/disseminated Chalcopyrite Sphalerite

D700 167
-extremely altered
-more oxides
-no porphyry texture
-**compare white mica in altered biotite with those in matrix**

Minerals	**Modal %**	**Description**
Opaques	12	Pyrite – cubic (euhedral) to anhedral/disseminated Sphalerite – anhedral/disseminated
Quartz	25	Porphyry and small grains Cryptocrystalline quartz
Plagioclase Alkali feldspar	43	Matrix sericitized/saussiritized Mostly saussirite No distinctive twinning observed
Apatite	3	
white mica	6	Few large flakes Also small and medium grains
Biotite	3	Disseminated Altered to white mica as well
Goethite	5	Brown spots in matrix
Calcite	3	
Zircon	<1	

D700 172
-extremely altered
-zircon

Minerals	Modal %	Description
Opaques	8	Pyrite Chalcopyrite Sphalerite Anhedral/disseminated
Quartz	27	Porphyry and small grains
Plagioclase Alkali feldspar	41	Matrix sericitized/saussiritized Mostly saussirite Some twinning observed
Biotite	12	Grains altered to chlorite Characteristic elongated twinning Also patches with distinctive pleochroism Secondary
Calcite	5	Distinctive twinning
Apatite	3	
White mica	4	Spectrum of grain sizes

D700 178 -moderately altered -porphyritic texture **-3% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Biotite	6	Some altered to chlorite, muscovite Distinctive pleochroism Characteristic cleavage
Alkali feldspar	23	Cross-hatched/tartan twinning Some sericite Some secondary grains (unaltered)
Apatite	5	
Plagioclase	26	Saussirite Large extremely altered grain with alkali feldspar rim Albite twins
Quartz	23	Porphyry
White mica	8	
Titanite	4	
Opaques	5	Pyrite – subhedral and disseminated

D700 188 -moderately altered -quartz porphyry -porphyritic texture **-5% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Oxides	8	Pyrite Sphalerite Disseminated/anhedral
Quartz	26	Porphyry and small grains
Plagioclase	29	Saussirite – some Some extremely altered grains have alkali feldspar rims around it Twinning
Alkali feldspar	24	Sericite – some Some secondary unaltered grains Twinning
Biotite	5	Grains of biotite altered to chlorite Cleavage
Calcite	5	
White mica	3	

D700 200 -moderately altered -quartz porphyry -porphyritic texture **-5% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Opaques	6	Pyrite Chalcopyrite Sphalerite - intergrown Subhedral to anhedral
Quartz	21	Porphyry and small grains
Plagioclase	25	Some saussiritized Twinning
Alkali feldspar	23	Twinning Some secondary
Biotite	13	Some altered to chlorite, muscovite Distinctive pleochroism Characteristic cleavage
Titanite	4	
Apatite	3	
Calcite	3	Characteristic twinning
White mica	2	Small grains

Depth (m)	Type of alteration	Rock type
133	Advanced argillic	‘Granite’
147	Advanced argillic	‘Granite’
157	Advanced phyllic	Altered granite
167	Advanced argillic	‘Granite’
172	Advanced phyllic (bordering argillic)	‘Granite’
178	Phyllic	Altered granite
188	Phyllic	Altered granite
200	Phyllic	Altered biotite granite

Depth (m)	Type of alteration	Rock type	Hand samples
133	Advanced argillic	‘Granite’	Red-brown-green colour Quartz porphyry
147	Advanced argillic	‘Granite’	Dark red-brown Quartz veins
157	Advanced phyllic	Altered granite	Green-grey colour Red-brown mineral
167	Advanced argillic	‘Granite’	Red-brown colour Few greenish minerals Quartz porphyry
172	Advanced phyllic (bordering argillic)	‘Granite’	Green-grey colour Few orange-brown minerals
178	Phyllic	Altered granite	Looks more like normal granite Quartz porphyry Few greenish minerals
188	Phyllic	Altered granite	Looks more like normal granite Quartz porphyry Few greenish minerals
200	Phyllic	Altered biotite granite	Looks more like normal granite Quartz porphyry Few greenish minerals

7. DD+200

D200 160.9
-extremely altered
-small- to medium grain sizes (matrix)
Quartz porphyry

Minerals	**Modal %**	**Description**
Quartz	25	Porphyritic Cryptocrystalline
White mica	9	Small to medium grain size
Calcite	7	
Alkali feldspar	21	
Plagioclase	24	
Opaques	5	Pyrite <<Sphalerite – red/brown (photo) <<<chalcopyrite Disseminated/irregular/anhedral grains
Biotite	6	Retrograde
Scheelite	<1	More yellow (photo)
Apatite	2	
Idocrase/vesuvianite	1	

D200 164.5
-extremely altered
-small- to medium grain sizes (matrix)
-Quartz porphyry
-5% potassic alteration (rest is advanced phyllic)

Minerals	**Modal %**	**Description**
Opaques	6	Pyrite (few cubic) <<Sphalerite – red/brown (photo) <<<chalcopyrite Disseminated/irregular/anhedral grains
Apatite	2	
Epidote	1	
Calcite	10	
Alkali feldspar	18	Twinning Some grains secondary (small grains in matrix) Some grains slightly altered
Zircon	<1	
White mica	11	Small to medium grain size
Quartz	22	Porphyry Also cryptocrystalline

Plagioclase	24	Altered – saussirite
Biotite	5	Remnants (white mica, chl) Primary biotite still visible
Idocrase/vesuvianite	1	Medium relief Black under XPL
Fluorite	<1	
Scheelite	1	Blue and yellow (yellow has lower order interference colours and blue vice versa)

D200 175
-moderately altered
-brown mineral in matrix? Associated with biotite
-Quartz porphyry
-Coarser grained than above
-7% potassic alteration (rest is advanced phyllic)

Minerals	**Modal %**	**Description**
Alkali feldspar	25	Some grains altered Some secondary (small grains in matrix)
Plagioclase	29	Altered – saussirite Rims
Biotite	10	Remnant
Quartz	21	Porphyry + smaller grains
Calcite	4	+Micro veins
Zircon	<1	
Epidote	3	Yellow
Opaques	5	Pyrite (most cubic/euhedral) <<Sphalerite – red/brown (photo) <<<chalcopyrite Disseminated/irregular/anhedral grains
Goethite		Brown mineral in matrix
Apatite	2	

D200 186.7 -extremely altered -Quartz porphyry -Small- to medium grains in the matrix **-5% Potassic alteration (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	26	Porphyry
Alkali feldspar	15	Some secondary Twinning
Plagioclase	22	Severely altered Larger white mica flakes to centre of some plag grains Twinning sometimes visible Coarse grains
White mica	15	Small to large grains
Scheelite	2	Meer kleurvol (xPL) Meer groen (PPL)
Idocrase/vesuvianite	1	
Fluorite	<1	
Calcite	7	
Biotite	4	Remnants – completely altered (mostly white mica and brown mineral)
Opaques	4	Pyrite (some cubic/euhedral) <<Sphalerite – red/brown (photo) Disseminated/irregular/anhedral grains
Epidote	3	Yellow-brown?
Apatite	2	
Zircon	<1	

D200 194 -extremely altered (lower T) -fine- to medium grained matrix -Quartz porphyry **-2% Potassic (rest is advanced phyllic/bordering argillic)**		
Minerals	**Modal %**	**Description**
goethite	5	Tiny grains scattered throughout matrix Yellow-brown
Calcite	8	
Quartz	26	Porphyry
Plagioclase Alkali feldspar	29	Severely altered Sea of altered feldspars
Apatite	2	
White mica	14	Fairly large grains

		+smaller grains
Opaques	4	Pyrite (mostly cubic/euhedral) Sphalerite (disseminated/intergrown/anhedral)
Biotite	8	Remnants – completely altered
Idocrase/vesuvianite	1	

D200 200 -moderately altered -Quartz porphyry -Coarser-grained than above		
Minerals	**Modal %**	**Description**
Plagioclase	29	Altered – large white mica's in plag grain Twinning visible Well-defined boundaries Zoning
Quartz	30	Porphyry
Opaques	4	Pyrite (some cubic, euhedral to subhedral) Sphalerite (disseminated/intergrown/anhedral)
Biotite	8	Some primary still visible Remnants – altered to chlorite and muscovite
Alkali feldspar	19	Twinning Some grains secondary
Calcite	3	
Apatite	2	
Epidote	2	
White mica	4	Small- to medium-grained sizes Mostly associated with plagioclase

D200 211.5 -moderately altered -Quartz porphyry -relatively coarse-grained **-10% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	26	Altered – large (smaller than above) white mica's in plag grain Twinning visible Well-defined boundaries

		Zoned
Quartz	28	
Opaques	3	Pyrite (some cubic, rest subhedral to anhedral/disseminated) Sphalerite (disseminated/intergrown/anhedral)
Biotite	7	Some primary still visible Remnants – altered to chlorite and muscovite Not completely altered
Alkali feldspar	19	Twinning Some grains secondary
Calcite	3	
Apatite	1	
Epidote	1	
White mica	5	Mostly associated with plagioclase Larger grains than above Small- to medium-grained sizes
Titanite	2	
Garnet	<1	Euhedral High relief Isotropic

D200 223 -moderately altered -porphyritic texture (quartz and feldspars porphyritic) **-15% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Alkali feldspar	26	Twinning Large grains – porphyritic Some grains altered Some grains secondary
Quartz	25	
Opaques	4	Pyrite (few cubic, mostly subhedral) Sphalerite (disseminated/intergrown/anhedral) <<Chalcopyrite (subhedral)
White mica	4	Small- to medium grain sizes
Epidote	2	
Apatite	2	
Calcite	4	
Idocrase/vesuvianite	1	
Biotite	9	Remnants
Plagioclase	25	Altered – large white mica flakes
Zircon	<1	

D200 230
-extremely altered
- porphyritic texture (quartz and feldspars porphyritic)
-relatively coarse-grained
-15% Potassic alteration (rest is advanced phyllic)

Minerals	**Modal %**	**Description**
Quartz	27	
Calcite	15	Micro veins
Plagioclase	29	Altered – large white mica grains in centre, also calcite sometimes Twinning visible
Alkali feldspar	17	Secondary grains
White mica	3	Small- to medium grain sizes
Opaques	3	Pyrite (few cubic, mostly subhedral) Sphalerite (disseminated/intergrown/anhedral) <<Chalcopyrite (subhedral)
Apatite	2	
Biotite	5	

D200 241.5
-moderately altered
-relatively coarse-grained
- porphyritic texture (quartz and feldspars porphyritic)
-16% Potassic alteration (rest is phyllic alteration)

Minerals	**Modal %**	**Description**
Zircon	<1	
Quartz	26	Porphyry
Calcite	11	Micro veins
Plagioclase	28	Altered Twinning visible Zoned
Alkali feldspar	19	Secondary grains
White mica	3	Small- to medium grain sizes
Titanite	3	Brown colour Pleochroic
Opaques	3	Pyrite (few cubic, mostly subhedral) Sphalerite (disseminated/intergrown/anhedral)
Apatite	2	
Biotite	5	

D200 244

-moderately altered -relatively coarse-grained - porphyritic texture (quartz and feldspars porphyritic) **-10% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	25	Porphyry
Calcite	5	Micro veins
Plagioclase	27	Altered – in centre Twinning visible Zoned
Alkali feldspar	21	Secondary grains Large grains – porphyritic
White mica	6	Small- to medium grain sizes
Opaques	4	Pyrite (few cubic, mostly subhedral to anhedral) Sphalerite (disseminated/intergrown/anhedral, 1 or 2euhedral)
Apatite	1	
Biotite	11	

D200 256 -moderately altered -relatively coarse-grained - porphyritic texture (quartz and feldspars porphyritic, some biotite grains as well) **-10% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	27	
Calcite	3	
Plagioclase	29	Altered Twinning visible Zoned
Alkali feldspar	21	Some grains secondary
White mica	3	Mostly small-grained
Opaques	3	Pyrite <<Sphalerite – red/brown Disseminated/irregular/anhedral grains
Titanite	1	
Apatite	1	
Biotite	12	Some primary still visible (some grains almost completely primary)

Depth (m)	**Type of alteration**	**Rock type**
160.9	Advanced Phyllic	Altered granite
164.5	Potassic*	Altered granite
175	Potassic*	Altered granite
186.7	Potassic*	Altered granite
194	Potassic*	Altered granite
200	Phyllic	Altered granite
211.5	Phyllic	Altered biotite granite
223	Phyllic	Altered biotite granite
230	Phyllic	Altered biotite granite
241.5	Phyllic	Altered biotite granite
244	Phyllic	Altered biotite granite
256	Phyllic	Altered biotite granite

Depth (m)	**Type of alteration**	**Rock type**	**Hand samples**
160.9	Advanced Phyllic	Altered granite	Dark grey Quartz porphyry Few green minerals
164.5	Potassic*	Altered granite	Dark grey Quartz porphyry Few green minerals
175	Potassic*	Altered granite	Dark grey Quartz porphyry Few green minerals Red-brown minerals
186.7	Potassic*	Altered granite	Dark grey-green Quartz porphyry Few green minerals Red-brown minerals
194	Potassic*	Altered granite	Lighter grey-green colour Red-brown minerals More altered (more green minerals) Quartz porphyry
200	Phyllic	Altered biotite granite	Looks more like normal granite Very few green minerals Quartz porphyry
211.5	Phyllic	Altered biotite granite	Looks more like normal granite Very few green minerals Quartz porphyry
223	Phyllic	Altered biotite granite	Looks more like normal granite Very few green minerals Quartz porphyry Few red-brown minerals
230	Phyllic	Altered biotite granite	Looks more like normal granite Very few green minerals Quartz porphyry
241.5	Phyllic	Altered biotite granite	Looks more like normal granite Very few green minerals Quartz porphyry
244	Phyllic	Altered biotite granite	Looks more like normal granite Very few green minerals

			Quartz porphyry
256	Potassic*	Altered granite	Looks more like normal granite Quartz porphyry

8. DD+800

DD800 116.00 -Feldspars		
Minerals	**Modal %**	**Description**
Pyroxene (diopside)	55	Bright interference colours and lower order interference colours Green to green-brown Some grey under PPL
Amphibole	8	Brown under PPl Lower order interference colours
Epidote	3	High relief Euhedral Colourless to light green High order interference colours
Chlorite	5	
Biotite	5	Some primary Altered to secondary minerals
Quartz	20	
Apatite	2	
Calcite	2	

DD800 204 -extremely altered		
Minerals	**Modal %**	**Description**
Quartz	28%	Porphyry and small grains Diffuse boundaries Not rounded
Plagioclase Alkali feldspar	48%	Matrix almost entirely sericitized
Pyroxene	8	Disseminated pieces in matrix
Calcite	3	
Opaque's	4	Sphalerite – small spots in matrix
White mica	2	Small to medium grained flakes
Goethite	4	Matrix Brown spots
Garnet	<1	Euhedral grain
Apatite	2	

DD800 220 -extremely altered		
Minerals	**Modal %**	**Description**

Quartz	27	Porphyry and small grains Diffuse boundaries Not rounded
Apatite	2	
White mica	33	Large flakes (larger than above) + medium grained Some grains wrap around pre-existing grains (eg quartz)
Plagioclase Alkali feldspar	26	No clearly defined grains Twinning and grain boundaries not visible/could not be defined.
Calcite	11	
Goethite	3	Spots in matrix (brown and red-brown)
Scheelite	<1	
Opaques	1	Pyrite Sphalerite Very small grains
Garnet	<1	

DD800 238 -extremely altered		
Minerals	**Modal %**	**Description**
Quartz	25	Porphyritic and smaller grains (spectrum)
Apatite	2	
White mica	29	Large and small flakes
Plagioclase Alkali feldspar	27	Sea of altered feldspars Some twinning (albite) still visible
Calcite	7	Calcite grain sizes up to half FOV (X5)
Biotite	5	Remnants – altered to chlorite and white mica Some primary still visible
Opaques	3	Pyrite – some cubic Sphalerite

DD800 250 -Slightly altered		
Minerals	**Modal %**	**Description**
Quartz	25	Porphyry and small grains Diffuse boundaries Not rounded
White mica	15	Large flakes
Biotite	13	Remnants of large biotite flakes, replaced by chlorite and white mica Characteristic twinning Also grains with foxy brown-red colour
Plagioclase	17	Grain boundaries identified Saussiritized (some grains more than others)

Alkali feldspar	15	Cross-hatched/tartan twinnig Carlsbad twins (sanidine)
Calcite	4	
Allanite	4	
Titanite	2	
Garnet	<1	
Apatite	2	
Opaques	3	Pyrite – subhedral to anhedral and alteration product of biotite Sphalerite (foto3) – intergrown, small grains, disseminated

DD800 259 -extremely altered		
Minerals	**Modal %**	**Description**
Quartz	25	Porphyry and small grains Diffuse boundaries Not rounded
Alkali feldspar Plagioclase	44	Matrix altered feldspars Very small amounts of twinning visible (albite)
Biotite	17	Altered to chlorite Remnants of primary biotite still visible Secondary as well
Chlorite	1	Secondary
Apatite	2	
Opaques	5	Pyrite – some cubic, rest sub- to anhedral Sphalerite – intergrown, disseminated, small grains
Allanite	4	Grains with diffuse boundaries Euhedral to subhedral
Chlorite	3	

DD800 266 -extremely altered		
Minerals	**Modal %**	**Description**
Quartz	33	Porphyry and small grains Diffuse boundaries Not rounded
Alkali feldspar Plagioclase	42	Matrix altered feldspars
Calcite	4	
White mica	11	Some grains wrap around pre-existing grains (eg quartz)
Opaques	3	Pyrite – some cubic, rest sub- to anhedral Sphalerite – intergrown, disseminated, small grains, associated with altered biotite

Goethite	2	Brown spots in the matrix
Garnet	<1	Euhedral
Apatite	3	
Biotite	4	Remnants Deformed
Pyroxene	4	Remnants in matrix Moderate relief Greenish colour

DD800 275 -extremely altered		
Minerals	**Modal %**	**Description**
Plagioclase Alkali feldspar	42	Albite twinning Alteration – saussirite (in center) K-spar – completely altered – no new grains/twinning visible
Quartz	25	Porphyry and small grains Diffuse boundaries Not rounded
Garnet	<1	
Pyroxene	7	Euhedral grains Moderate relief Grey Birefringant in low order colours Cleavage visible although characteristic cleavage slightly distorted
Biotite	15	Remnant of biotite grains altered to chlorite
Allanite	4	Fairly large grain
Opaques	2	Sphalerite – very small grains in matrix
Apatite	2	

DD800 286 -extremely altered		
Minerals	**Modal %**	**Description**
Plagioclase Alkali feldspar	41	Matrix altered feldspars Shape and twinning sometimes still visible
Quartz	24	Porphyry and small grains Diffuse boundaries Not rounded
Idocrase/scapolite	5	Euhedral grains Moderate relief Grey Birefringant in low order colours Cleavage visible although characteristic cleavage slightly

		distorted
Biotite	14	Remnant of biotite grains altered to chlorite, muscovite Characteristic cleavage Some primary biotite still visible
White mica	3	Small grains
Calcite	4	
Apatite	3	
Sphene	1	
Opaques	5	Pyrite – subhedral to anhedral and alteration product of biotite Sphalerite– intergrown, small grains, disseminated, also alteration product of biotite

DD800 293 -extremely altered		
Minerals	**Modal %**	**Description**
Plagioclase Alkali feldspar	37	Matrix altered feldspars
Quartz	21	Porphyry and small grains Diffuse boundaries Not rounded
White mica	11	Medium grained
Apatite	2	
Golden-brown spots in matrix	3	
Biotite	15	Porphyritic Remnants of biotite Some primary still visible
Idocrase/scapolite	7	Euhedral grains Moderate relief Grey Birefringant in low order colours Cleavage visible although characteristic cleavage slightly distorted
Epidote	2	
Opaques	2	Pyrite – subhedral to anhedral and alteration product of biotite Sphalerite– intergrown, small grains, disseminated,

DD800 296 -moderately altered		
Minerals	**Modal %**	**Description**
Quartz	24	Porphyry and small grains (mostly small) Diffuse boundaries

		Not rounded
Biotite	14	Porphyritic Remnant of biotite grains altered to chlorite, muscovite Characteristic cleavage Some primary still visible
Plagioclase Alkali feldspar	50	Matrix altered feldspars No visible twinning/grains
Apatite	2	
Opaques	2	Pyrite – subhedral to anhedral and alteration product of biotite Sphalerite– intergrown, small grains, disseminated
Idocrase/scapolite	8	Euhedral grains Moderate relief Grey Birefringant in low order colours Cleavage visible although characteristic cleavage slightly distorted

Depth (m)	**Type of alteration**	**Rock type**
116	Skarn	
204	Advanced argillic	'Granite'
220	Advanced argillic	'Granite'
238	Argillic	Altered biotite granite
250	Phyllic	Altered biotite granite
259	Argillic	Altered biotite granite
266	Advanced argillic	Altered biotite granite
275	Argillic	Altered biotite granite
286	Argillic	Altered biotite granite
293	Advanced argillic	Altered biotite granite
296	Advanced argillic	Altered biotite granite

Depth (m)	**Type of alteration**	**Rock type**	**Hand samples**
116	Skarn		
204	Advanced argillic	'Granite'	Brown-grey colour Quartz porphyry Few greenish minerals
220	Advanced argillic	'Granite'	Light grey-green colour Few red-brown minerals Quartz porphyry

			Quartz vein Altered matrix
238	Argillic	Altered biotite granite	Looks like normal granite Light grey Green minerals
250	Phyllic	Altered biotite granite	Looks like normal granite Light grey Few green minerals
259	Argillic	Altered biotite granite	Looks like normal granite Light grey Green minerals
266	Advanced argillic	Altered biotite granite	Darker green-grey Quartz porphyry
275	Argillic	Altered biotite granite	Looks like normal granite Light grey Green minerals Quartz porphyry
286	Argillic	Altered biotite granite	Looks like normal granite Light grey Green minerals Quartz porphyry
293	Advanced argillic	Altered biotite granite	Looks like normal granite Light grey Green minerals Quartz porphyry Matrix fairly altered
296	Advanced argillic	Altered biotite granite	Looks like normal granite Light grey Green minerals Quartz porphyry Matrix fairly altered Red-brown minerals as well

9. E-200

E-200 86.66 -skarn		
Minerals	**Modal %**	**Description**
Pyroxene (diopside)	65	High relief Green to colourless under PPl Pleochroic Bright interference colours
Quartz	31	Plagioclase?

Opaques	1	Pyrite - disseminated
Allanite	3	Poikilitic texture
Epidote	2	

E-200 287
-Extreme hydrothermal alteration
- Porphyritic texture
-fairly coarse-grained
-15% Potassic alteration (rest is phyllic)

Minerals	**Modal %**		**Description**
Alkali feldspar		20	Tartan/cross-hatched twinning. Altered to sericite. Some grains are secondary. Also sanidine twins
Titanite		5	High relief, brown. Pleochroic halo's. Distinctive shape (diamond). Sometimes associated with diopside
Quartz		18	Porphyritic
Biotite		10	Altered to chlorite.
Apatite		4	Small grains in matrix. Moderate relief, low interference colours.
Epidote		2	
Diopside		8	Patches of diopside. High relief. Green under PPL .Bright interference colours. Undergoes alteration to dark brown mineral.
Calcite		4	Characteristic calcite deformation twins. Extremely high interference colours. Some calcite veins. Associated with feldspar – plag
Plagioclase		24	Porphyritic. Altered to saussirite. Zoning. Rims of alkali feldspar
Amphibole		1	Retrograde alteration product
Zircon		<1%	High relief. Distinctive shape. Bright interference colours
Opaques	Pyrite	4	Cubic and disseminated (mostly) Abundant
	<Chalcopyrite		Disseminated
	<Sphalerite		Cubic

E-200 293
-skarnified granite
-Diopside and opaques looks like it overprinted the original granite

Minerals		**Modal %**	**Description**
Pyroxene (Diopside)		20	Altered. Patches of diopside – very few euhedral grains. High relief. Green under PPl. Bright interference colours. Overprints quartz
Biotite		10	Altered to chlorite Commonly found in close association with diopside.
Titanite		3	High relief, brown. Pleochroic halo's. Distinctive shape (diamond?). Associated with diopside
Calcite		11	Interstitial
Plagioclase		10	Altered to saussirite.
Scheelite		7	Round grains. Bright interference colours. High relief.
Allanite		6	Extremely high relief. Brown mineral.
Amphibole		3	
Apatite		9	Small grains in matrix. Moderate relief, low interference colours. Also larger grains (secondary?)
Quartz		15	Porphyritic. Grains of calcite, diopside, feldspars inside? Cryptocrystalline quartz as well
Garnet		2%	Euhedral. Isotropic. High relief. Colourless under PPL?
Opaques	Pyrite	8	Disseminated (mostly) + blocky Inclusions of gangue Abundant
	Sphalerite		
	Pyrrhotite		Associated with pyrite
	Chalcopyrite		Retrograde alteration product

E-200 294
-extremely altered
-mostly medium grained (fine- and small-grained minerals in matrix due to alteration)
-Porphyritic texture
-20% Potassic (rest is phyllic)

Minerals	**Modal %**	**Description**
Plagioclase	29	Zoning
Alkali feldspar	26	Alkali feldspar rims around plagioclase. Cross-hatched/tartan twinning. Some grains have simple twins (sanidine). Some grains secondary

Rutile	<1%	accessory
Pyroxene (Diopside)	5	Altered. Patches of diopside – very few euhedral grains. High relief. Green under PPL. Bright interference colours.
Chlorite	8	Anomalous blue interference colour. Probably alteration product of biotite.
Titanite	5	Associated with chlorite.
Allanite	2	
Epidote	2	
Amphibole	1	Retrograde alteration product
Quartz	16	Porphyritic. Undulose extinction.
Zircon	<1%	Accessory
Apatite	2%	Small grains in matrix. Moderate relief, low interference colours.
Fluorite	<1	
Opaques	2	Pyrite – disseminated

E-200 303
-extremely altered
-Quartz porphyry
-bordering argillic

Minerals	**Modal %**	**Description**
Biotite	3	Remnants – altered to white mica Pyrite also alteration product
Plagioclase Alkali Feldspar	50	Extensive sericitization – large white mica flakes. Makes up most of matrix Plagioclase - Zoning Some twinning still visible
Calcite	5	
Apatite	5	
White mica	7	Small-to medium grained
Quartz	22	Porphyritic
Opaques	4	Pyrite – disseminated(mostly)/cubic, inclusions (most abundant) Molybdenite – white, anisotropic, high relief, disseminated, elongated (photo) Sphalerite

E-200 304
-mostly medium-grained (smaller grains due to alteration)
-porphyritic texture
-not quartz porphyry

-25% Potassic alteration (rest is phyllic)		
Minerals	**Modal %**	**Description**
Chlorite	3	Secondary/replacement
Calcite	6	
Alkali feldspar	18	Some grains secondary.
Titanite	5	
Pyroxene (Diopside)	6	Allanite and opaques associated with diopside?
Quartz	25	Porphyritic
Plagioclase	24	Zoning
Apatite	2	
Allanite	3	
Opaques	4	
Fluorite	<1	
Zircon	<1	Pyrite – disseminated(mostly)/cubic, inclusions (most abundant) Molybdenite – white, anisotropic, high relief, disseminated, elongated Sphalerite Pyrrothite

E-200 311 -Severely altered (lower T) -quartz porphyry -matrix = altered		
Minerals	**Modal %**	**Description**
Quartz	21	Porphyritic. Undulose extinction.
Calcite	15	Sporadic Interstitial
Goethite	2	
White mica	9	Mostly small grains Alteration product of feldspars.
Scheelite	1	Small grains.
Garnet	1	
Epidote	1	
Apatite	6	
Alkali feldspar	40	Extreme sericitization. Some twinning still visible
Plagioclase		Altered to saussirite. Some grain boundaries still visible
Zircon	<1%	
Opaques	4	Pyrite – chalcopyrite replacement textures, disseminated Sphalerite

E-200 316 -Potassic alteration. - Unusual feature: few altered minerals in large piece of K-spar? - feldspar with zoning in large porphyritic grain of k-spar (upper right corner with name on right hand side) -porphyritic texture -coarse grained (smaller grains due to alteration)		
Minerals	**Modal %**	**Description**
Alkali feldspar	29	Zoning Some grains secondary Some porphyritic.
Quartz	23	Porphyritic
Calcite	6	Calcite interstitial.
Plagioclase	19	Albite twins
Biotite	6	
White mica	12	
Opaques	5	Pyrite – disseminated (mostly), cubic Sphalerite – disseminated Chalcopyrite – small amount, retrograde

E-200 328 -quartz porphyry -mostly medium grained -moderately altered **-9% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	24	Saussiritization. Zoning/alteration in center of grain
Alkali feldspar	25	Some grains are secondary. Altered to sericite. Some grains show simple twins. Also cross-hatched/tartan twins.
Chlorite	3	Alteration product of biotite Secondary
Biotite	5	Most biotite altered to chlorite.
Quartz	23	Porphyritic.
Calcite	4	
Allanite	<1	
Apatite	2	
Opaques	5	Pyrite and chalcopyrite (retrograde) (<<) – disseminated Sphalerite – mostly associated with pyrite Both inclusions in altered biotite grains

E-200 341 **-extremely altered** **-**quartz porphyry -mostly medium grained **-7% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Biotite	19	Remnants Interlayered with white mica, biotite.
Alkali feldspar	25	Zoning OR cyclic twinning (upper right corner with the label on the right hand side). Some grains are secondary. Tartan/cross-hatched twinning. Also sanidine twins.
Plagioclase	26	Altered Twinning visible in some grains
Pyroxene (Diopside)	3	
Quartz	21	
Calcite	4	Veins.
White mica	6	
Opaques	6	Pyrite – blocky/disseminated, sometimes associated with biotite grain mineral Sphalerite – irregular/disseminated

E-200 357
-Extremely altered (lower T)
- Matrix almost entirely sericitized
-Quartz porphyry

Minerals	**Modal %**	**Description**
Quartz	23%	Porphyritic Undulose extinction
Alkali feldspar	60%	
Plagioclase		
White mica	2%	Alteration product of feldspars
Biotite	6%	Interlayered with dark mineral which occurs as biotite alters to chlorite, white mica and Fe is released.
Calcite	5	
Goethite	<1%	Accessory mineral
Opaques	3%	Molybdenite (>>) – intergrowth texture Pyrite – cubic, disseminated, small grains

E-200 373
-moderately altered (higher T alteration)
-Quartz porphyry
-3% Potassic alteration (rest is phyllic)

Minerals	**Modal %**	**Description**
Quartz	22%	Porphyritic
White mica	5%	
Calcite	4%	Calcite veins.
Biotite	15%	Grains of interlayered secondary chlorite, primary biotite, secondary muscovite and a dark mineral (release of Fe as biotite alters to chlorite). These grains mostly consist of chlorite.
Plagioclase	25%	Some grains altered to saussirite.
Alkali feldspar	22%	Cross-hatched/Tartan twinning. Some grains show simple twins (sanidine). Some grains are secondary. Some grains altered to sericite.
Apatite	3%	
Opaques	4%	Pyrite (>>) – cubic/blocky >>, disseminated, associated with altered biotite grains, inclusions of gangue Sphalerite – intergrowth textures, sometimes associated with pyrite and altered biotite grains

E-200 386 **-extremely altered (higher T alteration)** -Quartz porphyry **-2% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Biotite	17%	Red-brown colour under PPL. Pleochroic in light-brown to deep red-brown –some still primary i.e not altered. Interlayered with chlorite as it alters to it.
Chlorite	8%	Anomalously blue interference colours.
Quartz	23%	Porphyritic Undulose extinction
Plagioclase	28%	Cyclic twinning or zoning Albite twinning. Rims Slightly altered to saussirite
Alkali feldspar	22%	Grain show cross-hatched/tartan twinning. One or two grains show simple twins with cyclic zoning? Some grains are secondary. Some grains are porphyritic
Opaques	2%	Pyrite – overprints other minerals, disseminated, intergrowth textures Sphalerite – intergrowth Both associated with biotite…

E-200 394 -moderately altered -porphyritic texture -fairly coarse-grained (smaller grains due to alteration) **-3% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Alkali feldspar	16	Grains show cross-hatched/tartan twinning. Few grains altered to sericite. Some grains are secondary.
Quartz	23	
Chlorite	3%	Anomalous blue interference colour. Secondary
Calcite	6%	Interstitial
Biotite	15%	Primary biotite which is altered to chlorite.
White mica	2%	Few large elongated grains of muscovite.
Plagioclase	35%	Altered to saussirite. Zoning around inner core where it is altered.
Opaques	<1%	Pyrite – cubic, disseminated

Depth (m)	**Type of alteration**	**Rock type**
86.66	Skarn	
287	Potassic	Quartz monzogranite
293	Skarnified granite	
294	Potassic	Quartz monzogranite
303	Advanced phyllic	‘Granite’
304	Potassic	Altered granite
311	Argillic	‘Granite’
316	Potassic	Altered granite
328	Phyllic	Altered biotite granite
341	Phyllic	Altered biotite granite
357	Advanced argillic	Altered biotite granite
373	Phyllic	Altered biotite granite
386	Phyllic	Altered biotite granite
394	Phyllic	Altered biotite granite

Depth (m)	Type of alteration	Rock type	Hand sample
86.66	Skarn		
287	Potassic	Quartz monzogranite	Darker grey Quartz porphyry
293	Skarnified granite		Very dark
294	Potassic	Quartz monzogranite	Darker grey Quartz porphyry
303	Advanced phyllic	'Granite'	Red-brown colour Few greenish minerals
304	Potassic	Altered granite	Darker grey Quartz porphyry
311	Argillic	'Granite'	Red-brown colour Also substantial amount of greenish minerals
316	Potassic	Altered granite	Red-brown colour Also greenish minerals (more altered than below)
328	Phyllic	Altered biotite granite	Not quartz porphyry Greyish colour Secondary alkali feldspar More greener minerals than below
341	Phyllic	Altered biotite granite	Not quartz porphyry Greyish colour Secondary alkali feldspar
357	Advanced argillic	Altered biotite granite	Quartz porphyry Reddish-brownish-greenish colour (more red-brown)
373	Phyllic	Altered biotite granite	Not quartz porphyry Greenish colour Secondary alkali feldspar
386	Phyllic	Altered biotite granite	Not quartz porphyry Greyish colour Secondary alkali feldspar
394	Phyllic	Altered biotite granite	Not quartz porphyry Greenish colour Secondary alkali feldspar

10. HH+400

HH400 298 -moderately altered -higher T alteration + lower T alteration -strong argillic overprint?		
Minerals	**Modal %**	**Description**
Quartz	21	Porphyritic Large and small grains Sub-rounded to irregular shapes Boundaries not distinct
Biotite	10	Remnants of biotite grains altered to chlorite, muscovite Characteristic elongated shape
Alkali feldspar	19	Cross-hatched tartan twinning Some secondary grains Alteration- sericite
Calcite	8	+micro veins
Opaques	5	Pyrite – cubic and disseminated, subrounded euhedral to anhedral Sphalerite Molybdenite
Epidote	2	Small grains in matrix High relief Rounded to subrounded
Plagioclase	20	Grains almost entirely altered to saussirite Altered to medium-sized grains of white mica
White mica	7	Small- to medium grains (some large grains)
Chlorite	3	
Garnet	1	Euhedral grain(s)
Titanite	1	
Apatite	1	

HH400 302 -moderately altered		
Minerals	**Modal %**	**Description**
Quartz	25	Large and small grains Sub-rounded to irregular shapes Boundaries not distinct Also cryptocrystalline quartz
Opaques	4	Pyrite – cubic and disseminated, subhedral to anhedral Sphalerite Chalcopyrite
Biotite	8	Remnants of biotite grains altered to chlorite, muscovite

		Characteristic elongated shape
Garnet	1	Euhedral grain(s)
Idocrase/scapolite	3	Euhedral
Titanite?	2	
Plagioclase	26	Severely altered to saussirite Large grains Also some smaller grains
Chlorite	5	
White mica	3	Small to medium grains
Calcite	4	
Goethite	2	Golden-brown spots in the matrix
Alkali feldspar	14	
Epidote	2	Small grains in matrix High relief Rounded to subrounded
Apatite	1	

HH400 314.5 -extremely altered		
Minerals	**Modal %**	**Description**
Plagioclase Alkali feldspar	51	Severely altered to saussirite Large grains Also some smaller grains Matrix of altered feldspars
Biotite	13	Porphyritic Remnants of biotite grains altered to chlorite, muscovite Characteristic elongated shape
Quartz	21	Porphyritic Large and small grains Sub-rounded to irregular shapes Boundaries not distinct
White mica	5	Small to medium grains
Calcite	3	
Opaques	4	Sphalerite Pyrite All disseminated/anhedral
Goethite	1	
Epidote	1	
Apatite	2	
Scheelite	1	

HH400 315 -extremely altered -low T alteration

Minerals	**Modal %**	**Description**
Plagioclase Alkali feldspar	45	Matrix of altered feldspars
Calcite	8	+micro veins
Quartz	24	Porphyritic Large and small grains Sub-rounded to irregular shapes Boundaries not distinct
White mica	6	Large to small grains
Opaques	4	Pyrite – cubic (euhedral) Sphalerite
Apatite	2	
Epidote	1	
Biotite	6	Remnants of biotite grains altered to chlorite, muscovite Characteristic elongated/rectangular shape
Chlorite	4	

HH400 322.5 -moderately altered		
Minerals	**Modal %**	**Description**
Plag	21	Twinning visible Grains altered Rims
Biotite	13	Remnants of biotite grains altered to chlorite, muscovite Characteristic elongated shape
Alkali feldspar	15	Twinning
Calcite	5	Also associated with altered feldspar
Opaques	4	Pyrite – subhedral to anhedral Sphalerite – anhedral/disseminated
White mica	3	
Titanite	1	
Apatite	2	
Quartz	26	Porphyritic Large and small grains Sub-rounded to irregular shapes Boundaries not distinct Rims around

HH400 329 -moderately altered (less than above) Higher T alteration -fairly coarse-grained -quartz porphyries **-9% Potassic (rest is phyllic)**

Minerals	Modal %	Description
Plag	21	Twinning visible Grains altered Rims
Biotite	11	Remnants of biotite grains altered to chlorite, muscovite Characteristic elongated shape
Alkali feldspar	18	Twinning Some grains secondary
Calcite	4	
Opaques	3	Pyrite – anhedral/disseminated
Epidote	1	
Titanite	1	
White mica	4	Small- and medium grains
Apatite	3	
Quartz	30	Porphyritic Large and small grains Sub-rounded to irregular shapes Boundaries not distinct Rims around

HH400 337 -moderately altered (slightly less than above) -higher T alteration		
Minerals	**Modal %**	**Description**
Plag	21	Twinning visible Grains altered Rims Alteration normally in the center
Biotite	14	Remnants of biotite grains altered to chlorite, muscovite Characteristic elongated shape Bigger and more distinct grains than above
Alkali feldspar	20	Twinning Most grains secondary
Calcite	5	
Opaques	4	Pyrite – anhedral/disseminated Sphalerite - anhedral/disseminated
Titanite	3	High relief Brown
White mica	5	Secondary
Scheelite	<1	
Apatite	2	
Quartz	24	Porphyritic Large and small grains Sub-rounded to irregular shapes Boundaries not distinct

		Rims around

HH400 351 -moderately altered (more than above) -lower T alteration		
Minerals	**Modal %**	**Description**
Quartz	21	Porphyritic Large and small grains Sub-rounded to irregular shapes Boundaries not distinct Rims around
Plag Alkali feldspar	45	Twinning visible in some Grains severely altered
Biotite	13	Porphyritic Remnants of biotite grains altered to chlorite, muscovite Characteristic elongated shape Some primary biotite still visible
Opaques	4	Pyrite – anhedral/disseminated Sphalerite - anhedral/disseminated
Apatite	2	
White mica	6	

HH400 388 -moderately altered -higher T alteration -fairly coarse-grained -quartz porphyries **-2% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Alkali feldspar	20	Larger secondary grains
Plag	19	Twinning visible Alteration Rims
Quartz	22	Porphyritic Large and small grains Sub-rounded to irregular shapes Boundaries not distinct Also cryptocrystalline quartz
Biotite	15	Porphyritic Remnants of biotite grains altered to chlorite, muscovite Characteristic elongated shape Some primary biotite still visible
White mica	4	
Opaques	1	Pyrite – cubic and disseminated

Depth (m)	Type of alteration	Rock type
298	Potassic (argillic overprint)	Altered biotite granite
302	Argillic	Altered biotite granite
314.5	Advanced argillic	'Granite'
315	Advanced argillic	'Granite'
322.5	**Advanced phyllic**	Altered biotite granite
329	Phyllic	Altered biotite granite
337	**Advanced phyllic**	Altered biotite granite
351	Argillic	'Granite'
388	Phyllic	Altered biotite granite

Depth (m)	Type of alteration	Rock type	Hand samples
298	Potassic (argillic overprint)	Altered biotite granite	Light grey-green Quartz porphyry
302	Argillic	Altered biotite granite	Darker grey-green Quartz porphyry
314.5	Advanced argillic	'Granite'	Light grey-green Abundant green minerals
315	Advanced argillic	'Granite'	Dark grey-green Dark green minerals (+lighter)
322.5	**Advanced phyllic**	Altered biotite granite	Light grey Few greenish minerals Few red-brown minerals
329	Phyllic	Altered biotite granite	Light grey Few greenish minerals Few brown minerals
337	**Advanced phyllic**	Altered biotite granite	Looks more like normal granite Few greenish minerals
351	Argillic	'Granite'	Light grey-green Quartz porphyry
388	Phyllic	Altered biotite granite	Looks more like normal granite Few greenish minerals

11. REV27

REV27 31 -moderately to severely altered -goethite -porhyritic, but very altered **-20% Potassic, rest is phyllic**		
Minerals	**Modal %**	**Description**
Plagioclase	29	Altered
Calcite	4	
Epidote	2	
Quartz	28	Also cryptocrystalline
Biotite	6	
White mica	1	
Opaques	5	Sphalerite Pyrite – cubic and disseminated Chalcopyrite Pyrrhotite
Apatite	2	
Alkali feldspar	21	Some secondary

REV27 39.1 -moderately to severely altered (lower T) -altered texture -porphyritic grains		
Minerals	**Modal %**	**Description**
Plagioclase	35	Twinning visible Altered to saussirite – large white mica flakes (as well as small one's)
Calcite	9	Sometimes associated with alteration of plag.
Quartz	31	Porphyry
Biotite	3	Remnants
White mica	6	Mostly associated with plag
Opaques	4	Pyrite - disseminated Sphalerite – intergrown and/or disseminated Chalcopyrite
Alkali feldspar	12	
Zircon	<1	

REV27 46.8 -moderately altered to severely altered (lower T) -porphyritic, altered texture

Minerals	Modal %	Description
Plagioclase Alkali feldspar	46	Twinning visible of plag Plag altered to saussirite – large white mica flakes (as well as small one's) Can't identify alkali feldspar Altered matrix of feldspars
Calcite	10	Sometimes associated with alteration of plag.
Quartz	29	Porphyry
Biotite	4	Remnants
White mica	6	Mostly associated with plag
Opaques	5	Pyrite - disseminated Sphalerite – intergrown and/or disseminated Chalcopyrite

REV27 57.1 - moderately altered to severely altered (lower T) - potassic but with strong phyllic overprint		
Minerals	**Modal %**	**Description**
Plagioclase	39	Twinning visible of plag Plag altered to saussirite – large white mica flakes (as well as small one's) (Probably altered alkali feldspar as well)
Calcite	5	Randomly in matrix
Quartz	31	Porphyry
Biotite	6	Remnants – entirely altered
White mica	5	
Opaques	5	Pyrite - disseminated Sphalerite – intergrown and/or disseminated Chalcopyrite Molybdenite
Epidote	2	Associated with altered biotite
Alkali feldspar	6	
Apatite	2	

REV27 67.5 -extremely altered -porphyritic, altered texture		
Minerals	**Modal %**	**Description**
Plagioclase	55	

Alkali feldspar		
Quartz	26	Porphyry
Calcite	8	
Idocrase	<1	Colourless Medium relief Low order interference colours (actually only black) Subhedral shape
Scheelite	<1	More yellow
White mica	9	
Apatite	2	
Epidote	<1	
Opaques	5	Molybdenite Pyrrhotite Pyrite Sphalerite

REV27 73.7
-extremely altered
-altered matrix
-porphyritic, altered texture

Minerals	**Modal %**	**Description**
Quartz	33	Porphyritic
Epidote	2	
Plagioclase Alkali feldspar	44	Entirely altered
Opaques	7	Pyrite Chalcopyrite Sphalerite All disseminated
Biotite	8	
Apatite	1	
White mica	5	

REV27 81.1
-moderately altered
-medium- to coarse-grained (fine grained alteration products)
-porphyritic texture
-10% Potassic (rest is phyllic)

Minerals	**Modal %**	**Description**
Plagioclase	29	Twinning visible Altered
Quartz	31	Porphyry
Alkali feldspar	23	Secondary grains Older grains slightly altered Twinning
White mica	7	
Idocrase	2	High relief Colourless Low order birefringence Fine-grained
Apatite	2	
Opaques	<1	Pyrite Chalcopyrite Small spots in matrix

REV27 97
-moderately altered
-porphyritic, altered texture
-medium- to coarse-grained
-15% Potassic (rest is phyllic)

Minerals	**Modal %**	**Description**
Plagioclase	27	Twinning visible Altered Some grains porphyritic
Quartz	31	A lot of smaller grains Few grains porphyritic
Alkali feldspar	24	Secondary grains Older grains slightly altered Twinning (also sanidine – Carlsbad twins)
White mica	3	
Biotite	6	Remnants – altered to chlorite and white mica Some relatively unaltered/primary
Apatite	1	
Opaques	4	Pyrite Chalcopyrite Sphalerite All disseminated
Allanite?	<1	
Epidote?	1	
Calcite	3	
Zircon	<1	

REV27 106.1 -moderately to extremely altered (higher T) -altered porphyritic texture **-5% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	25	Twinning visible Altered Some grains porphyritic Rims
Quartz	26	Porphyritic Smaller grains as well
Alkali feldspar	15	Secondary grains Older grains slightly altered Twinning (also sanidine – Carlsbad twins)
White mica	3	
Biotite	6	Remnants – altered to chlorite and muscovite Some relatively unaltered
Apatite	1	
Opaques	10	Pyrite Chalcopyrite Sphalerite >> (red-brown) All disseminated
Epidote	2	
Calcite	8	Looks slightly different

REV27 116.8 -moderately to extremely altered (lower T)		
Minerals	**Modal %**	**Description**
Plagioclase	33	Twinning visible Altered Some grains porphyritic Matrix = sea of altered plag (+alkali)
Quartz	30	Porphyritic Smaller grains as well
Alkali feldspar	25	Older grains altered Twinning
Biotite	3	Remnants
Opaques	4	Pyrite Chalcopyrite Sphalerite All disseminated
White mica	4	

Apatite	1	

REV27 132.9 -extremely altered (lower T) -strong phyllic overprint		
Minerals	**Modal %**	**Description**
Plagioclase	27	Twinning visible Altered Some grains porphyritic Matrix = sea of altered plag (+alkali)
Quartz	30	Porphyritic Smaller grains as well Cryptocrystalline quartz
Alkali feldspar	26	Older grains altered Twinning Large grains
Biotite	2	Remnants
Opaques	3	Pyrite Sphalerite
White mica	4	
Apatite	1	
Calcite	8	Associated with altered plag

REV27 146.1 -extremely altered		
Minerals	**Modal %**	**Description**
Plagioclase Alkali feldspar	55	Altered Sea of altered feldspars Some alkali feldspar twinning still visible
Quartz	30	Smaller grains
Opaques	3	Pyrite Sphalerite Chalcopyrite All disseminated
White mica	3	
Calcite	9	Cluster of calcite grains

REV27 158.8 -extremely altered		
Minerals	**Modal %**	**Description**
Plagioclase Alkali feldspar	55	Altered Sea of altered feldspars

		Some alkali feldspar twinning still visible
Quartz	31	Smaller grains
Opaques	3	Pyrite Sphalerite Chalcopyrite All disseminated
White mica	3	
Calcite	8	

REV27 167.8 -moderately altered -relatively even-grained -altered texture **-4% Potassic (rest is advanced phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	30	Twinning Altered (less than above) Large white mica flakes in plag – associated with alteration Rims
Quartz	29	
Opaques	3	Pyrite Sphalerite Chalcopyrite All disseminated (anhedral)
White mica	5	
Calcite	4	
Alkali feldspar	29	Twinning Some grains secondary (also sanidine – Carlsbad twins) Some slightly altered Larger grains as well

REV27 172.2 -slightly to moderately altered (higher T) -relatively even-grained -altered texture **-11% Potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	29	Twinning Altered (less than above) Large white mica flakes in plag – associated with alteration Rims Larger grains as well

Quartz	28	Smaller grains Cryprocrystalline quartz
Opaques	2	Pyrite Sphalerite All disseminated (anhedral)
Calcite	4	
Alkali feldspar	27	Twinning Some grains secondary Some slightly altered Larger grains as well
Biotite	10	Relatively unaltered/primary

REV27 180.8 -slightly to moderately altered -small- to medium-grained -altered texture **-8% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	29	Twinning Altered (less than above) Large white mica flakes in plag – associated with alteration Rims Larger grains as well
Quartz	27	Smaller grains Cryprocrystalline quartz
Opaques	2	Pyrite Sphalerite All disseminated (anhedral)
Calcite	2	
Alkali feldspar	28	Twinning Some grains secondary Some slightly altered Larger grains as well
Biotite	10	Relatively unaltered/primary Some slightly altered to chlorite
Chlorite	2	

REV27 195.9 -moderately altered (more than above) -quartz porphyry -altered texture -**7% Potassic (rest is phyllic)**

Minerals	Modal %	Description
Plagioclase	29	Twinning Altered (less than above) Large white mica flakes in plag – associated with alteration Rims Larger grains as well
Quartz	27	Smaller grains Cryprocrystalline quartz
Opaques	4	Pyrite Sphalerite Chalcopyrite Anhedral/disseminated
Calcite	6	
Alkali feldspar	24	Twinning Some grains secondary Some slightly altered Larger grains as well
Biotite	4	Relatively unaltered Some slightly altered to chlorite and muscovite
White mica	3	

Depth (m)	Type of alteration	Rock type
31	Potassic	Altered granite
39.1	Advanced phyllic	‘Granite’
46.8	Argillic	‘Granite’
57.1	Advanced phyllic	‘Granite’
67.5	Advanced phyllic	‘Granite’
73.7	Advanced argillic	‘Granite’
81.1	Potassic	‘Granite’
97	Potassic	Altered biotite granite
106.1	Phyllic	Altered biotite granite
116.8	Advanced phyllic	Altered biotite granite
132.9	Advanced phyllic	Altered biotite granite
146.1	Argillic	Aphanitic granite
156.8	Argillic	Aphanitic granite
167.8	Phyllic	Aphanitic granite
172.2	Phyllic	Aphanitic granite
180.8	Phyllic	Aphanitic granite
195.9	Phyllic	Aphanitic granite

Depth (m)	Type of alteration	Rock type	Hand samples
31	Potassic	Altered granite	Dark Red-brown Quartz porphyry
39.1	Advanced phyllic	'Granite'	Light grey-green colour Few red-brown minerals Greenish minerals
46.8	Argillic	'Granite'	Light green-grey Altered matrix Quartz porphyry
57.1	Advanced phyllic	'Granite'	Light green colour Red-brown alteration Quartz porphyry Greenish minerals
67.5	Advanced phyllic	'Granite'	Light green colour Altered matrix
73.7	Advanced argillic	'Granite'	Darker green-grey Red-brown alteration Quartz porphyry
81.1	Potassic	'Granite'	Light grey-green Quartz porphyry Secondary alkali feldspar Greenish minerals
97	Potassic	Altered biotite granite	Light grey-green Quartz porphyry Secondary alkali feldspar Greenish minerals
106.1	Phyllic	Altered biotite granite	Light grey Red-brown minerals/alteration Secondary alkali feldspar Greenish minerals
116.8	Advanced phyllic	Altered biotite granite	Light green colour Altered matrix
132.9	Advanced phyllic	Altered biotite granite	Light green colour Altered matrix Few red-brown minerals
146.1	Argillic	Aphanitic granite	Light green-grey Finer grained Quartz veins
156.8	Argillic	Aphanitic granite	Light green-grey Finer grained Few red-brown minerals
167.8	Phyllic	Aphanitic granite	Light green-grey

			Greenish minerals Relatively finer grained
172.2	Phyllic	Aphanitic granite	Darker grey colour Relatively finer grained Feldspar porphyry
180.8	Phyllic	Aphanitic granite	Light grey Relatively finer grained Quartz porphyry
195.9	Phyllic	Aphanitic granite	Light grey Relatively finer grained Quartz porphyry

12. REV60

REV60 460.5 -slightly altered -coarse grained -not a quartz porphyry **-5% Potassic alteration**		
Minerals	**Modal %**	**Description**
Quartz	30	Porphyritic Sub-rounded to irregular shapes
Plagioclase	25	Alteration – saussirite Zoning around alteration or alteration in centre of grain Albite twins visible Porphyritic
Alkali feldspar	23	Cross-hatched/tartan twinning Grains can be fairly large Secondary grains Porphyritic
Biotite	13	Coarse- to medium sized grains Grains still relatively primary Some porphyritic
Opaques	3	Pyrite – blocky Sphalerite
Epidote	3	Small grains
Calcite	1	Micro-veins
Apatite	1	
Titanite	2	

REV60 471.5 -moderately altered -fairly coarse-grained -not a quartz porphyry -Largely phyllic alteration **-2% Potassic alteration**		
Minerals	**Modal %**	**Description**
Quartz	18	Porphyritic
Plagioclase	17	Albite twinning
Alkali feldspar	14	Cross-hatched/tartan twinning
White mica	30	Associated with plagioclase Large and medium grain sizes
Apatite	3	
Epidote	3	
Opaques	4	Pyrite – blocky Chalcopyrite << Sphalerite
Biotite	8	Remnants Some grains mostly replaced by muscovite
Scheelite	2	More blue (PPL)
Calcite	1	
Fluorite	<1	

REV60 480 -moderately altered -Porphyritic texture -fairly coarse-grained **-7% potassic (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	24	Altered – saussirite Zoning Twinning visible in some grains
Alkali feldspar	19	Twinning visible Some grains secondary
Biotite	6	Remnants Some grains relatively primary/unaltered
Quartz	28	Porphyritic
White mica	10	
Calcite	2	
Epidote	2	
Opaques	4	Pyrite – blocky Sphalerite
Apatite	3	
Scheelite	1	Single grain(s)

REV60 500 -moderately altered (more altered than above) -porphyry texture Fairly coarse grained **-2% Potassic alteration (rest is phyllic)**		
Minerals	**Modal %**	**Description**
Plagioclase	25	Zoning Altered
Alkali feldspar	20	Some secondary grains
Quartz	26	
Epidote	2	
Biotite	10	Remnants Some almost entirely replaced by chlorite
Calcite	2	
Titanite	1	
Chlorite	2	Secondary
Opaques	4	Pyrite-blocky
Apatite	2	
Pyroxene (diopside?)	6	Green colour under PPL High relief

REV60 515 -moderately altered -Medium- to coarse-grained -not a quartz porphyry -Porphyritic texture **-5% Potassic (rest is advanved phyllic)**		
Minerals	**Modal %**	**Description**
Biotite	8	Remnants Some almost entirely replaced by chlorite Characteristic shape
Plagioclase	29	Twinning visible Altered – saussirite Zoning
Alkali feldspar	25	Twinning visible Some grains relatively coarse-grained Some secondary grains
Quartz	26	
Calcite	1	
Scheelite	1	
Epidote	2	
Titanite	1	

Pyroxene (diopside?)	2	High relief Colourful birefringence Green under PPL
Opaques	4	Pyrite – blocky and disseminated (photo x10) Less sphalerite
Apatite	2	
Allanite	1	Photo (x10 magnification) Zoning
Garnet	1	Single grain(s) Euhedral grain

REV60 518 -moderately to extremely altered -Medium- to coarse-grained -not a quartz porphyry -Porphyritic texture **-5% Potassic (rest is advanved phyllic)**		
Minerals	**Modal %**	**Description**
Quartz	22	Porphyritic + smaller grains Cryptocrystalline Clusters of quartz grains
Biotite	10	Remnants Some primary biotite still visible Characteristic shape
Calcite	2	
Plagioclase	23	Twinning visible Alteration Zoning
White mica	6	Small- to medium- grain sizes
Alkali feldspar	16	Twinning Some grains secondary
Epidote	2	Associated with altered biotite (photo)
Opaques	4	Mostly pyrite – blocky and disseminated Sphalerite
Scheelite	<1	More blue
Apatite	1	
Allanite	1	photo

REV60 527 -extremely altered (lower T) -Quartz porphyry

-medium- to coarse grained (with fine grains in matrix due to alteration)		
Minerals	**Modal %**	**Description**
Calcite	6	+micro-veins
Alkali feldspar	20	Altered Twinning and some grain boundaries still visible
White mica	13	Small- to medium grained Mostly associated with altered plagioclase
Plagioclase	25	Altered Some grain boundaries still visible
Opaques	2	Mostly pyrite – blocky and disseminated (subrounded) Sphalerite
Biotite	7	Remnants – altered to white mica Very few primary biotite still visible
Apatite	2	
Quartz	25	Porphyry

REV60 544.5 -moderately altered -medium- to coarse grained (with fine grains in matrix due to alteration) -porphyritic texture -not a quartz porphyry **-3% Potassic (rest is advanved phyllic)**		
Minerals	**Modal %**	**Description**
Calcite	6	+Micro veins
Alkali feldspar	23	Twinning Some grains secondary
White mica	7	Small- to medium grained
Plagioclase	27	Alteration within grains Twinning Zoning
Opaques	2	Sphalerite – subrounded to disseminated (very small grains to medium grained) Pyrite – blocky, disseminated and subrounded (>>pyrite)
Biotite	4	Remnants Some primary biotite still visible
Apatite	1	
Idocrase	<1	Medium relief Low order interference colours Euhedral shape Inclusions photo
Quartz	29	Porphyritic Clusters of quartz grains
Zircon	<1	

REV60 564
-extremely altered
-medium- to coarse-grained (fine-to small grains in matrix due to alteration)
-Not a quartz porphyry
-3% Potassic (rest is advanved phyllic)

Minerals	Modal %	Description
Biotite	7	Remnants Some primary biotite still visible
Plagioclase	21	Altered – saussirite Twinning visible in some grains
Alkali feldspar	19	Twinning visible in some grains Some secondary grains
Quartz	29	
Allanite	1	
Calcite	4	
White mica	10	Small- to medium grained Associated with plag
Epidote	2	
Apatite	2	
Opaques	3	Pyrite – blocky, disseminated and subrounded <<Sphalerite
Scheelite	1	
Idocrase	1	Medium relief Low order interference colours Euhedral shape Inclusions
Zircon	<1	

REV60 575.9
-moderately altered
-medium- to coarse-grained (fine-to small grains in matrix due to alteration)
-Not a quartz porphyry
-7% Potassic (rest is advanved phyllic)

Minerals	Modal %	Description
Biotite	10	Remnants
Quartz	30	Porphyritic
Alkali feldspar	23	Porphyritic Twinning Some grains relatively new/secondary
Plagioclase	27	Porphyritic Grains altered – saussirite Zoning

Calcite	4	Also associated with altered biotite grains (in those grains) +micro-veins
Epidote	4	
Opaques	3	Pyrite – blocky, disseminated and subrounded <<Sphalerite
Apatite	1	
Titanite	1	

REV60 589
-moderately altered
-coarse-grained
-not quartz porphyry
-porphyritic texture
-8% Potassic (rest is phyllic)

Minerals	Modal %	Description
Plagioclase	22	Severely altered – saussirite Albite twins visible in some Alteration in centre in some grains
Alkali feldspar	18	Twinning Some grains relatively new/secondary
Quartz	45	
Biotite	9	Remnants Most primary biotite still visible Altered to chlorite
Calcite	3	
Opaques	3	Pyrite – blocky, mostly disseminated
Apatite	1	

REV60 603
-moderately altered
-coarse-grained
-not quartz porphyry
-porphyritic texture
-8% Potassic (rest is advanced phyllic)

Minerals	Modal %	Description
Plagioclase	20	Severely altered – saussirite Albite twins visible in some Alteration in centre in some grains Zoning
Alkali feldspar	18	Twinning Some grains relatively new/secondary
Quartz	42	
White mica	5	Small- to medium grained Associated with plag

Biotite	9	
Calcite	3	
Opaques	3	Pyrite – blocky, disseminated (mostly) and subrounded <<Sphalerite
Apatite	1	

Depth (m)	Type of alteration	Rock type
460.5	Potassic	Altered biotite granite
471.5	Advanced phyllic	Altered biotite granite
480	Potassic	Altered biotite granite
500	Potassic	Altered biotite granite
515	Potassic	Altered biotite granite
518	Potassic	Altered biotite granite
527	Argillic	Altered biotite granite
544.5	Phyllic	Altered biotite granite
564	Phyllic	Altered biotite granite
575.9	Phyllic	Altered biotite granite
589	Phyllic	Altered biotite granite
603	Phyllic	Altered biotite granite

Depth (m)	Type of alteration	Rock type	Hand samples
460.5	Potassic	Altered biotite granite	Looks like normal granite Quartz porphyry
471.5	Advanced phyllic	Altered biotite granite	Light grey colour Greenish minerals Few red-brown minerals Quartz porphyry
480	Potassic	Altered biotite granite	Looks like normal granite Quartz porphyry
500	Potassic	Altered biotite granite	Looks like normal granite Quartz porphyry Few greenish minerals
515	Potassic	Altered biotite granite	Looks like normal granite Quartz porphyry Few greenish minerals
518	Potassic	Altered biotite granite	Light grey colour Looks like normal granite Quartz porphyry Few greenish minerals Few red-brown minerals
527	Argillic	Altered biotite granite	Light green-grey colour

			Greenish minerals Quartz porphyry
544.5	Phyllic	Altered biotite granite	Looks like normal granite Quartz porphyry Few greenish minerals
564	Phyllic	Altered biotite granite	Looks like normal granite (more light-grey) Quartz porphyry Few greenish minerals
575.9	Phyllic	Altered biotite granite	Looks like normal granite Quartz porphyry Few greenish and red-brown minerals
589	Phyllic	Altered biotite granite	Looks like normal granite Quartz porphyry Few greenish minerals
603	Phyllic	Altered biotite granite	Looks like normal granite Quartz porphyry Few greenish and red-brown minerals

Appendix E – Alteration index

1. Argillic alteration

1. Defining minerals:

- Clay minerals
- Goethite

2. Distinguishing features:

- Alteration of feldspars
- Some twinning in feldspars still observed
- Feldspar grain boundaries seen
- Pyrite/pyrrothite also observed

3. Spatial distribution:

- Can either occur at the granite wall-rock contact or at depth away from the granite wall-rock contact
- Common in the low grade zone of the pluton

A+400 54

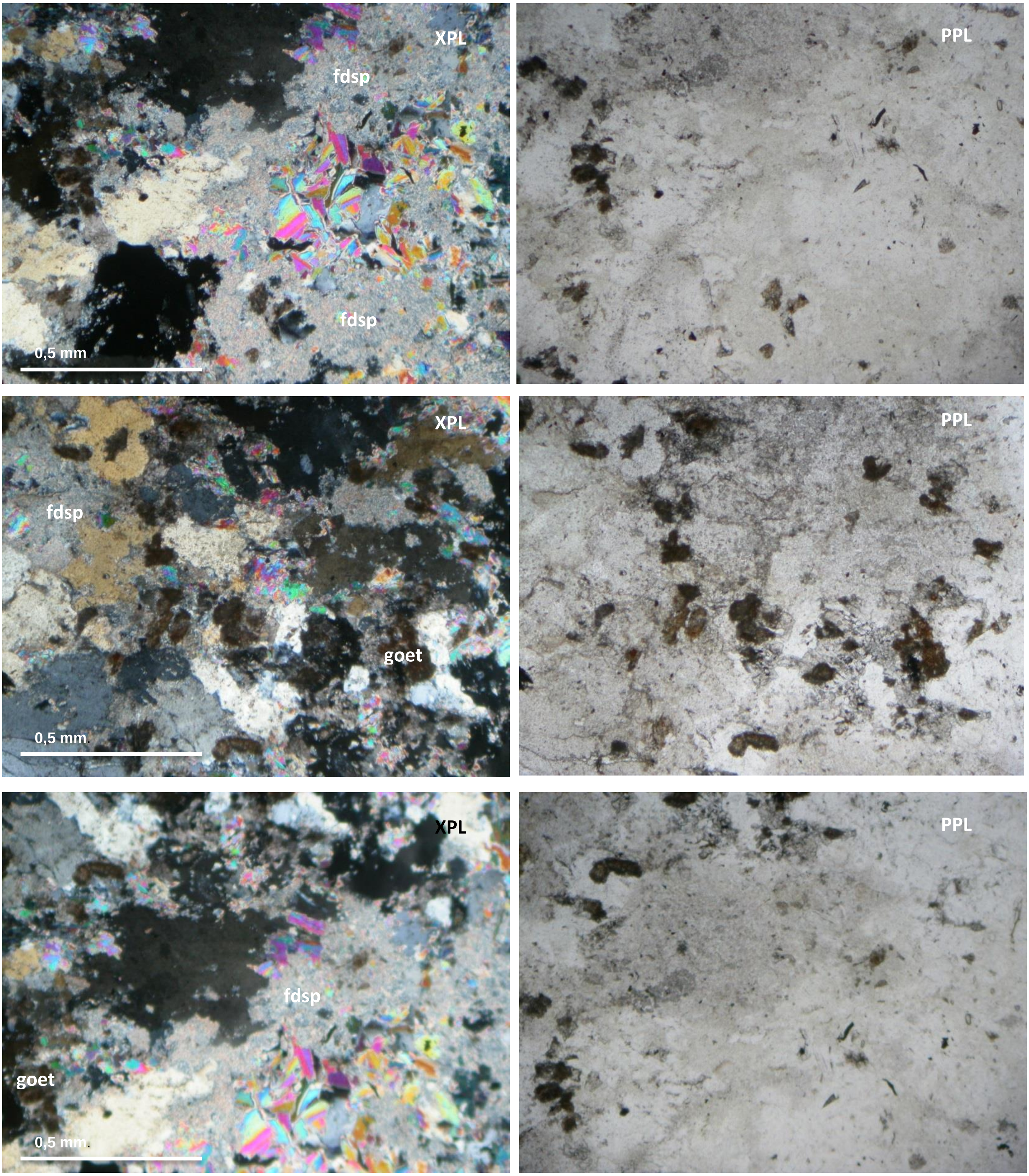


Figure 1. Examples of argillic alteration in A+400 54. Note the alteration of feldspars (Fdsp) and the presence of goethite (goet).

A+400 64.5

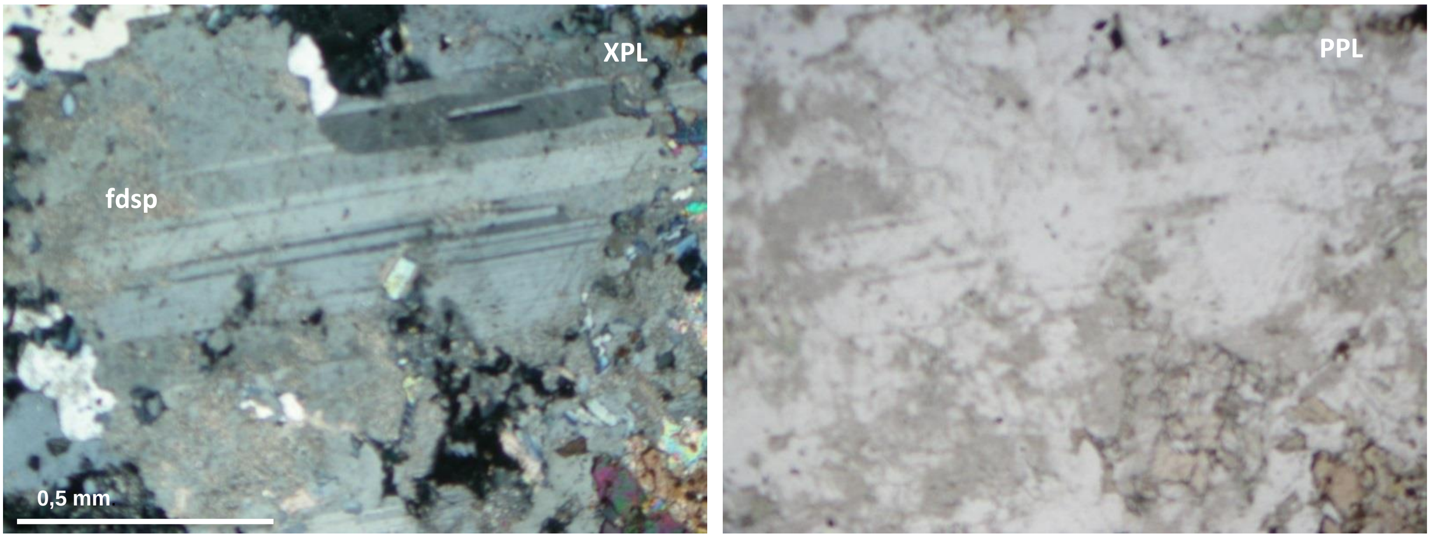


Figure 2. Example of argillic alteration in A+400 64.5. Note the alteration of feldspars (fdsp).

AA+400 111.5

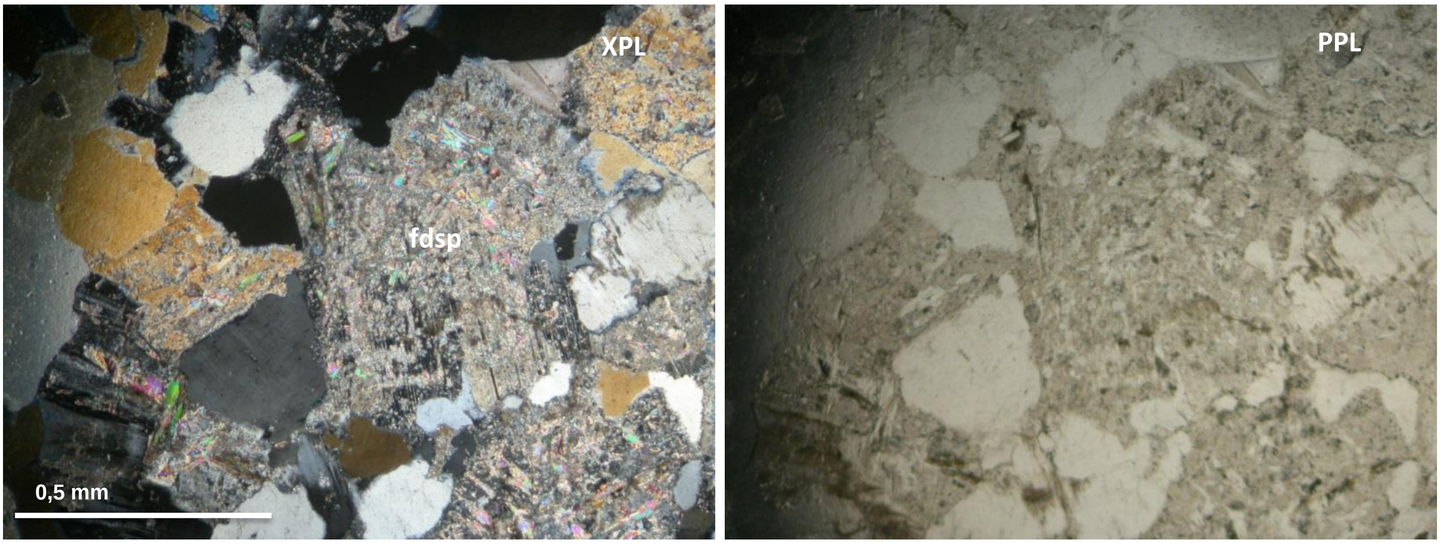


Figure 3. Example of argillic alteration in AA+400 111.5. Note the alteration of feldspars (Fdsp)

BB+400 210

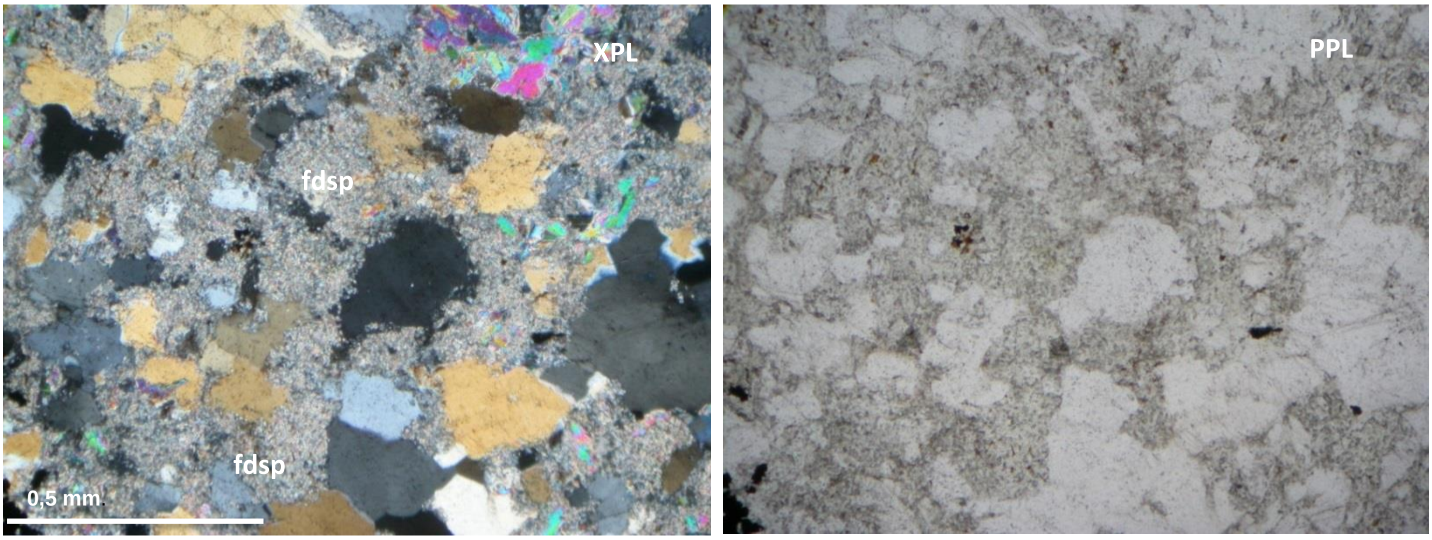


Figure 4. Example of argillic alteration in BB+300 210. Note the alteration of feldspar (fdsp).

2. Advanced argillic alteration

1. Defining minerals:

- Clay minerals
- Goethite

2. Distinguishing features:

- Extreme alteration of feldspars; leaching of K, Na and Ca
- Feldspars are indistinguishable
- Pyrite/pyrrothite also observed

3. Spatial distribution:

- Can either occur at the granite wall-rock contact or at depth away from the granite wall-rock contact
- Common in the low grade zone of the pluton

A+400 50

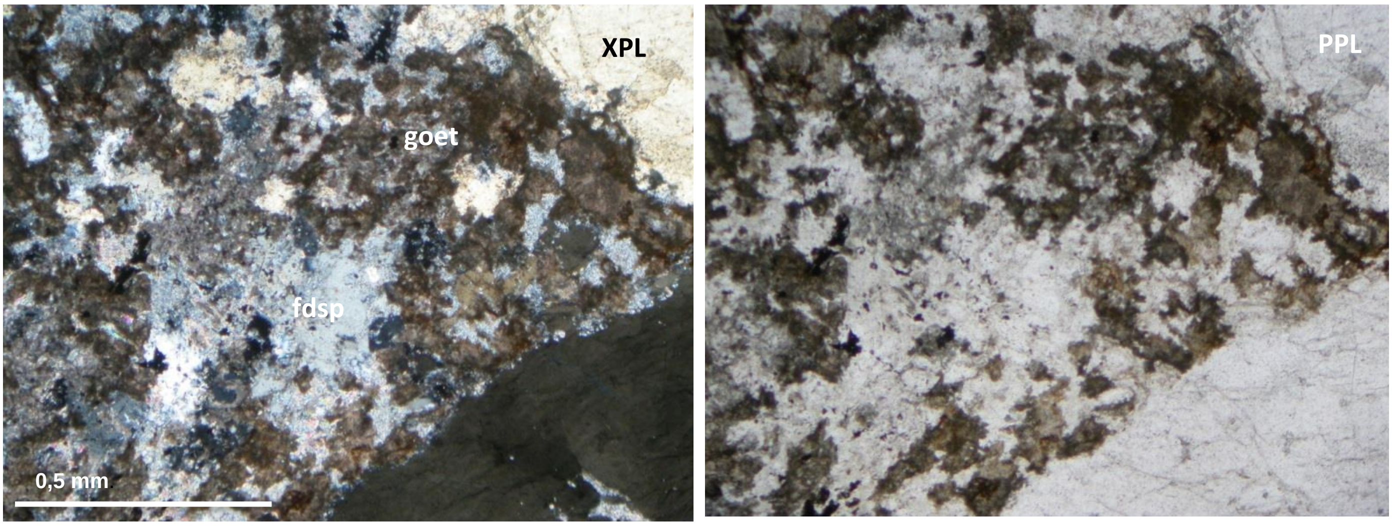


Figure 5. Example of advanced argillic alteration in A+400 50. Note the extreme alteration of the feldspars (fdsp) and the presence of goethite (goet).

CC+400 150

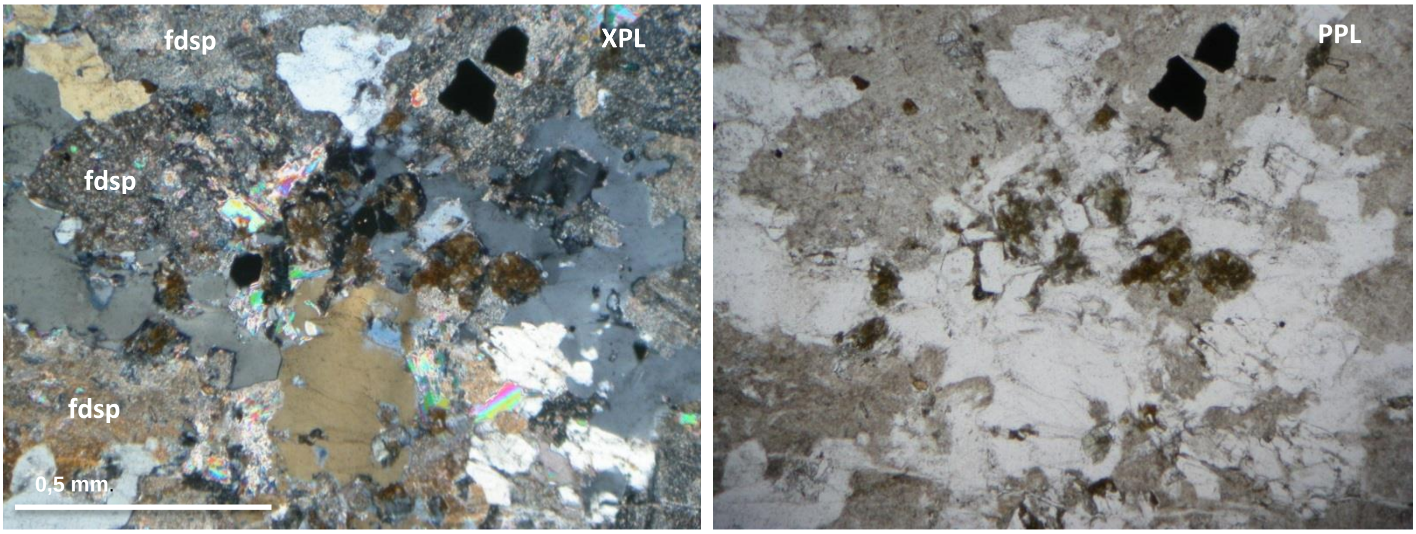


Figure 6. Example of advanced argillic alteration in CC+400 150. Note the extreme alteration of feldspars (fdsp).

D700 133

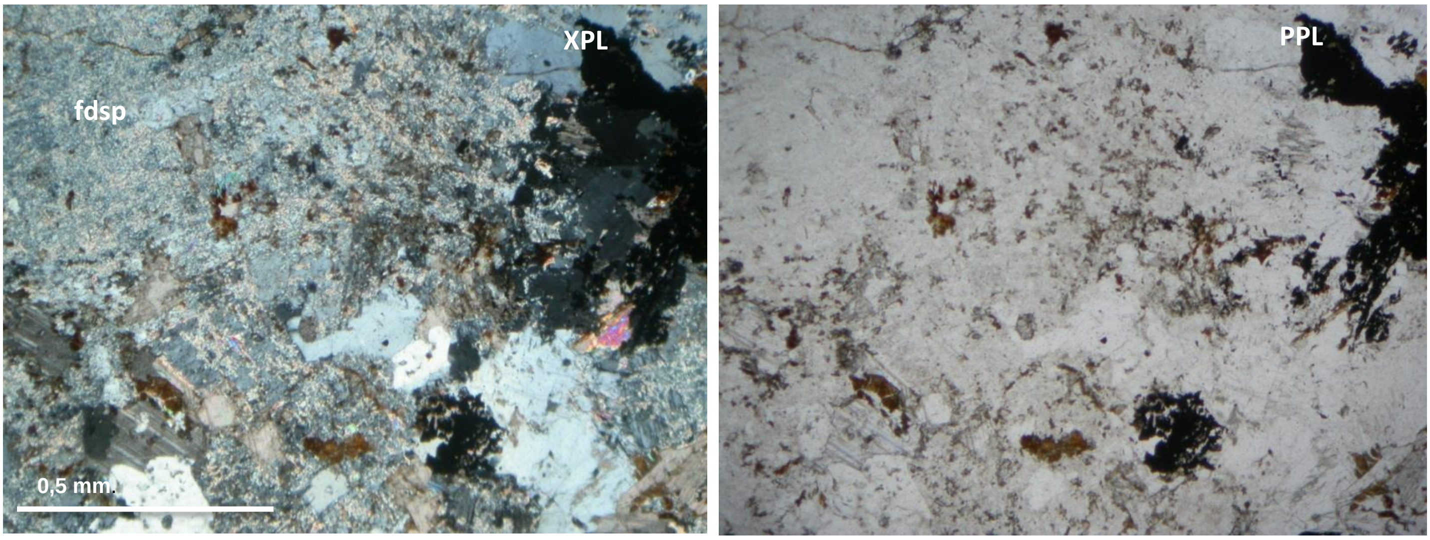


Figure 7. Example of advanced argillic alteration in D+700 133. Note the extreme leaching of feldspars (fdsp).

DD+800 275

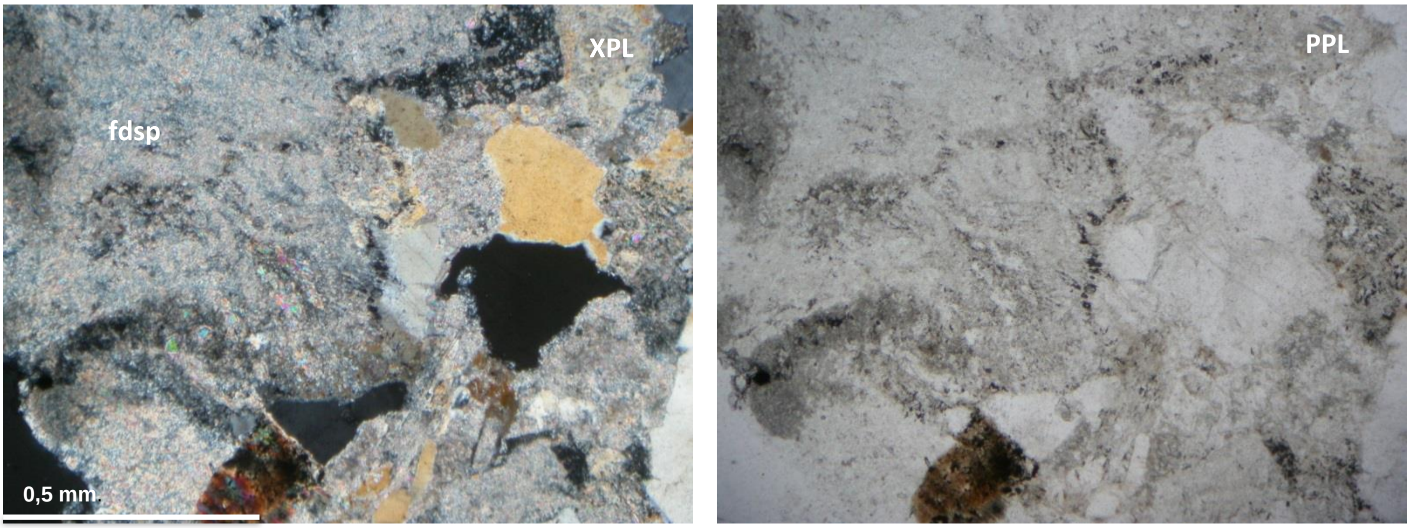


Figure 8. Example of advanced argillic alteration in DD+800 275. Note the extreme leaching of feldspars (fdsp).

3. Phyllic alteration

1. Defining minerals:

- White mica
- Carbonates
- Cryptocrystalline quartz
- Pyrite/pyrrothite
- Chlorite

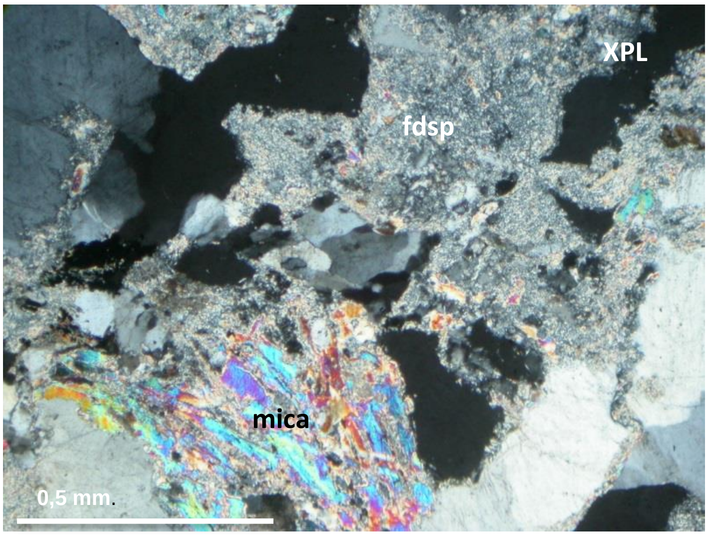
2. Distinguishing features:

- Alteration of feldspars into sericite (alkali feldspar) and saussurite (plagioclase feldspar)
- Most pervasive alteration

3. Spatial distribution:

- Developed throughout the pluton

BB+400 196



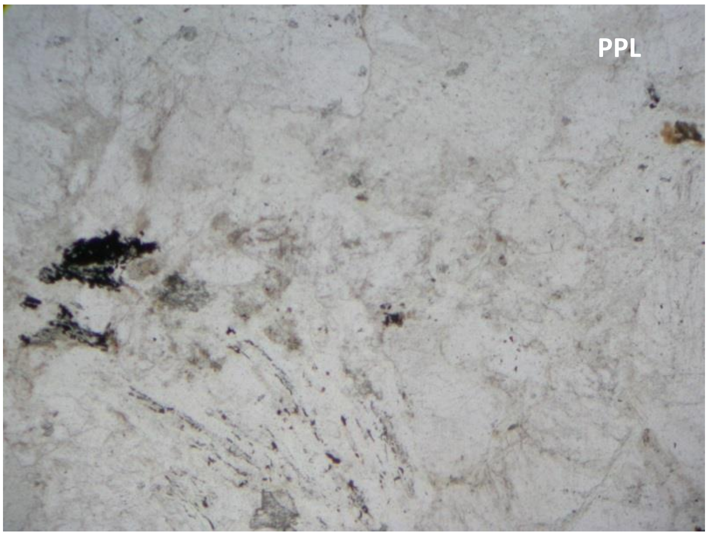
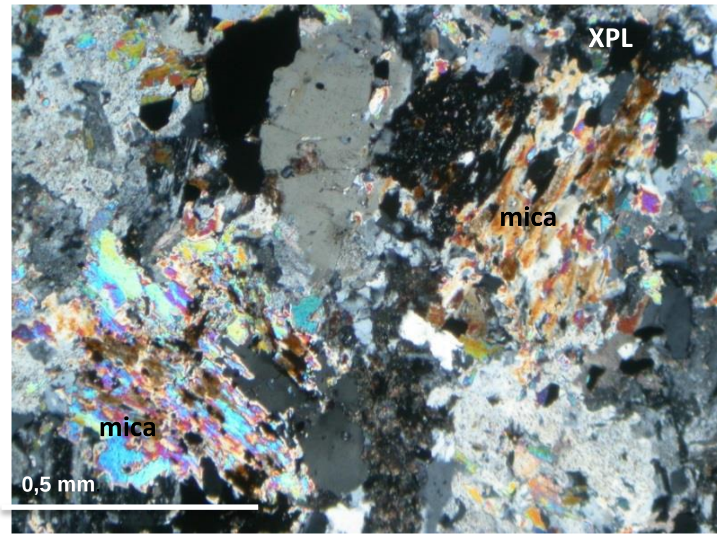


Figure 9. Example of phyllic alteration in BB+400 196. Note the alteration of feldspars (fdsp) and the presence of white mica (mica).

DD+200 164.5



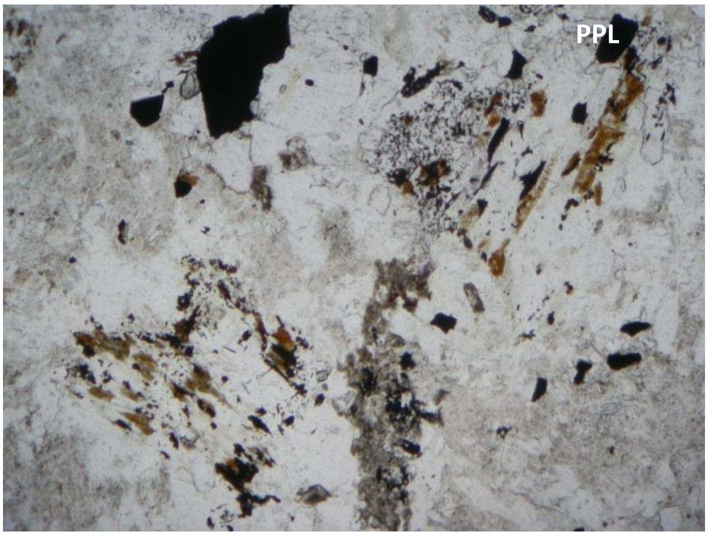


Figure 10. Example of phyllic alteration in DD+200 164.5. Note the alteration of feldspars (fdsp) and the presence of white mica (mica).

DD+200 186.7

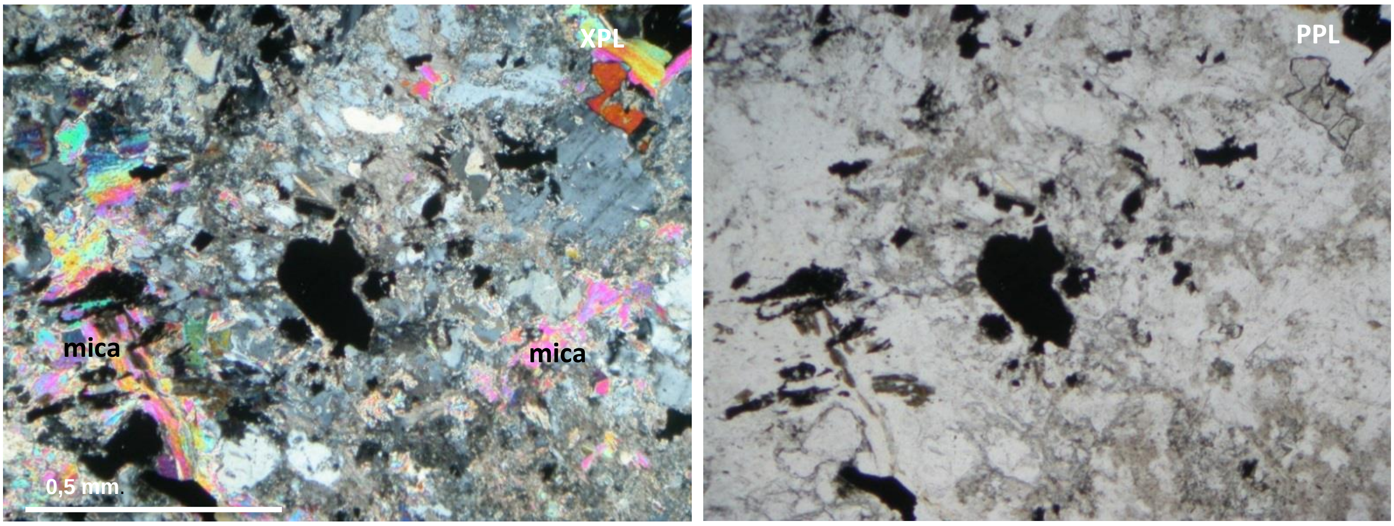


Figure 11. Example of phyllic alteration in DD+200 186.7.

DD+200 194

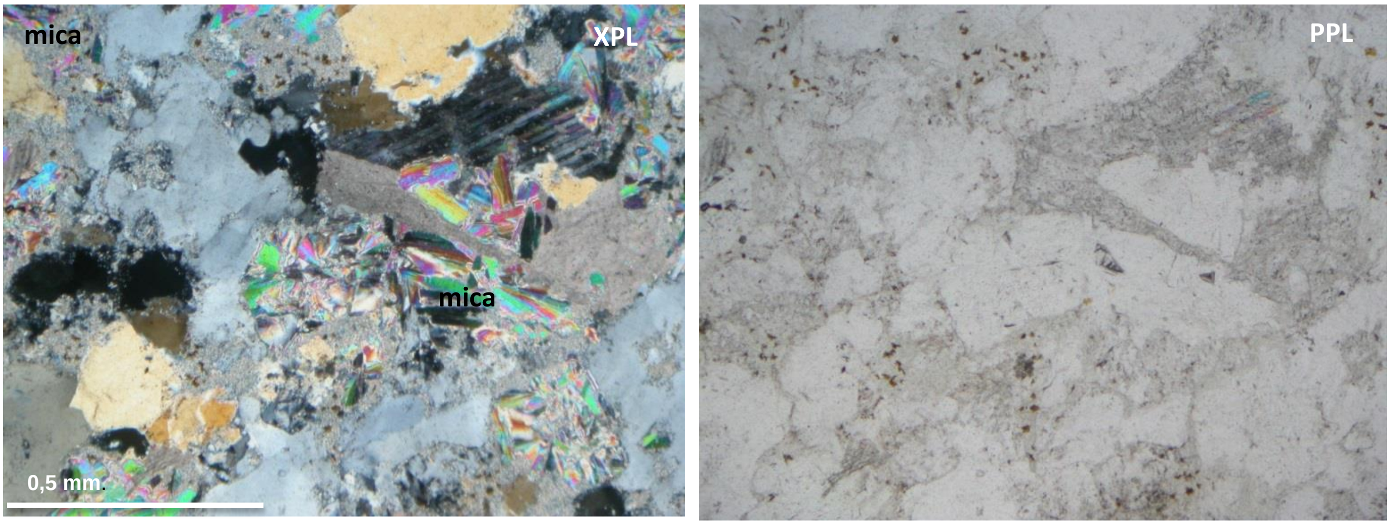


Figure 12. Example of phyllic alteration in DD+200 194.

DD+200 130

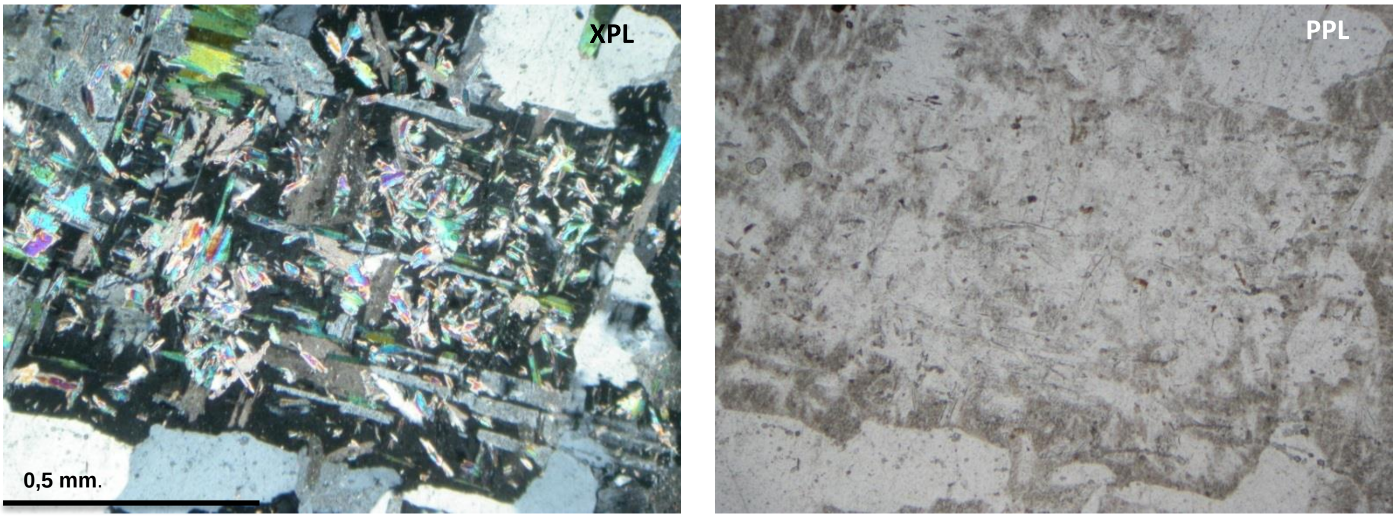


Figure 13. Example of phyllic alteration in DD+200 130. Feldspar altering to sericite/saussurite is typical of phyllic alteration.

4. Advanced phyllic alteration

1. Defining minerals:

- White mica
- Carbonates
- Cryptocrystalline quartz
- Pyrite/pyrrothite
- Chlorite

2. Distinguishing features:

- Extreme alteration of primary plagioclase
- Larger white mica grains (greisenization) associated locally with fluorite
- Not necessarily associated with plagioclase

3. Spatial distribution:

- Developed throughout the pluton

AA+400 145.5

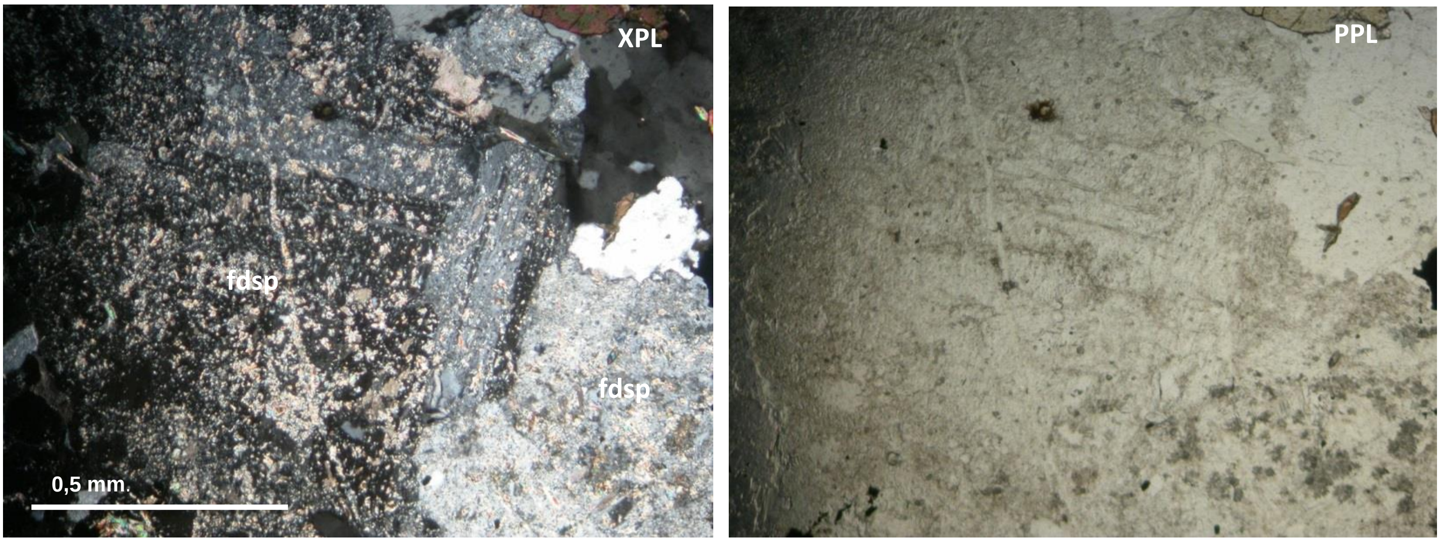


Figure 14. Example of advanced phyllic alteration in AA+400 145.5.

AA+200 144

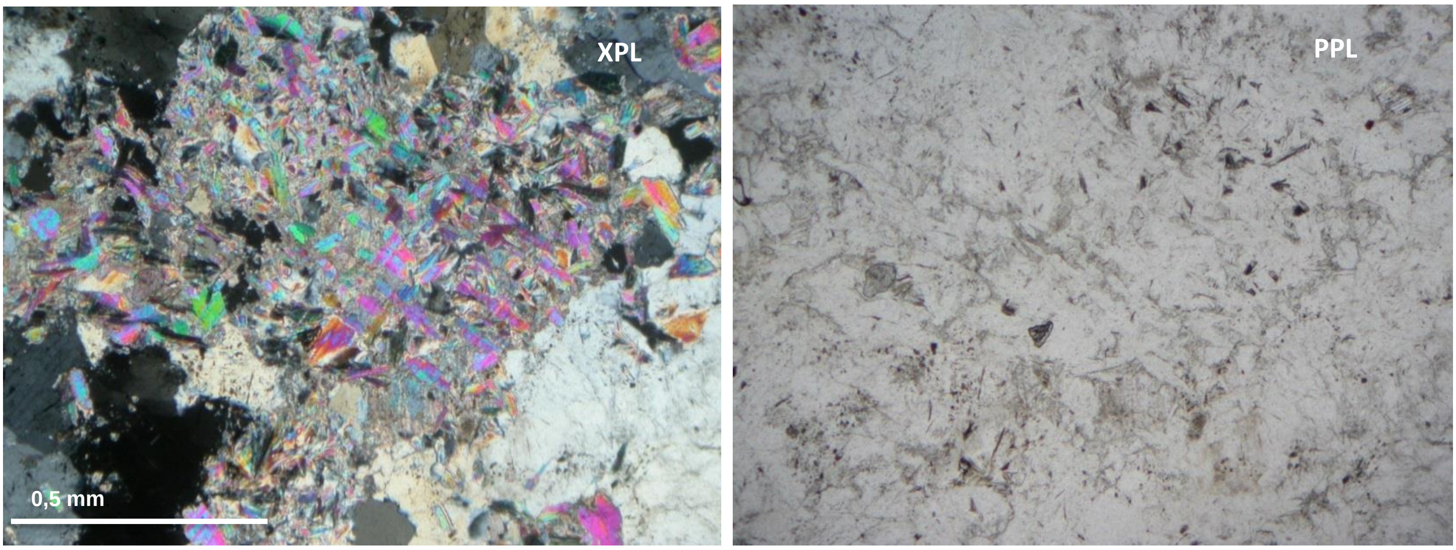


Figure 15. Example of advanced phyllic alteration in AA+200 144.

5. Potassic alteration

1. Defining minerals:

- Secondary alkali feldspar (potassic alteration)
- Secondary albite (albitization)
- Secondary biotite

2. Distinguishing features:

- High intensity alteration
- Alkali feldspar rims around an inner altered plagioclase feldspar core
- Small secondary alkali feldspar grains
- Overprints phyllic alteration

3. Spatial distribution:

- Closer to the granite wall rock contact
- Also occurs outside of the skarn zone where it is associated with phyllic alteration

REV60 589

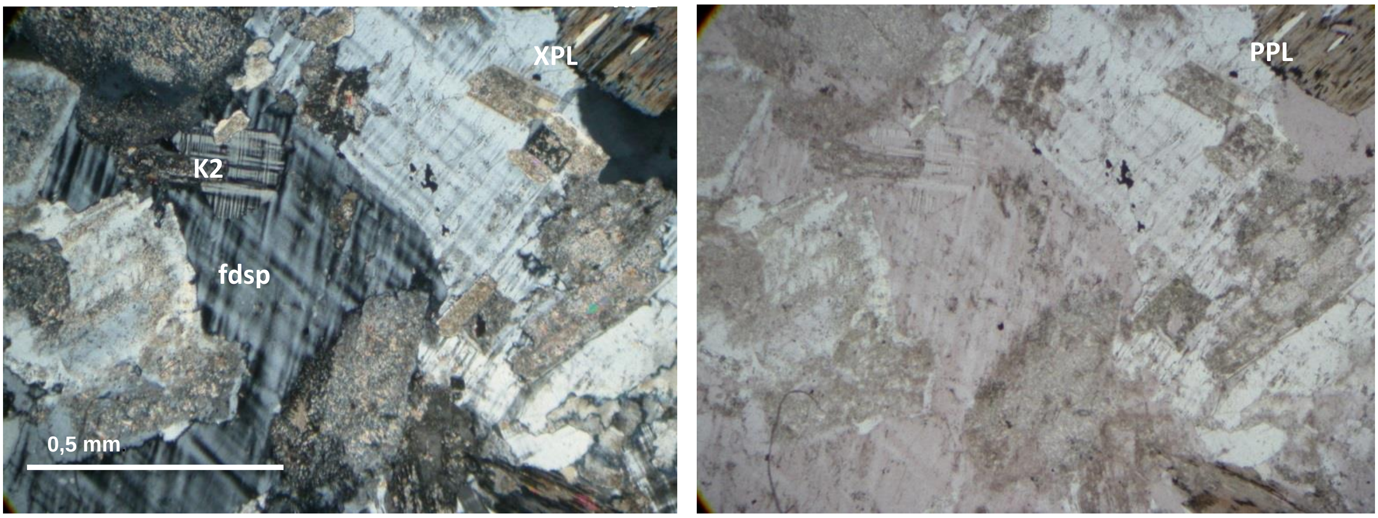


Figure 16. Example of potassic alteration in REV60 589. Note the secondary alkali feldspar grain (K2) overprinting the larger, primary alkali feldspar grain.

AA+400 94.5

Figure 17. Example of potassic alteration in AA+400 94.5. Note the rim of albite around the altered inner plagioclase core.

AA+400 122

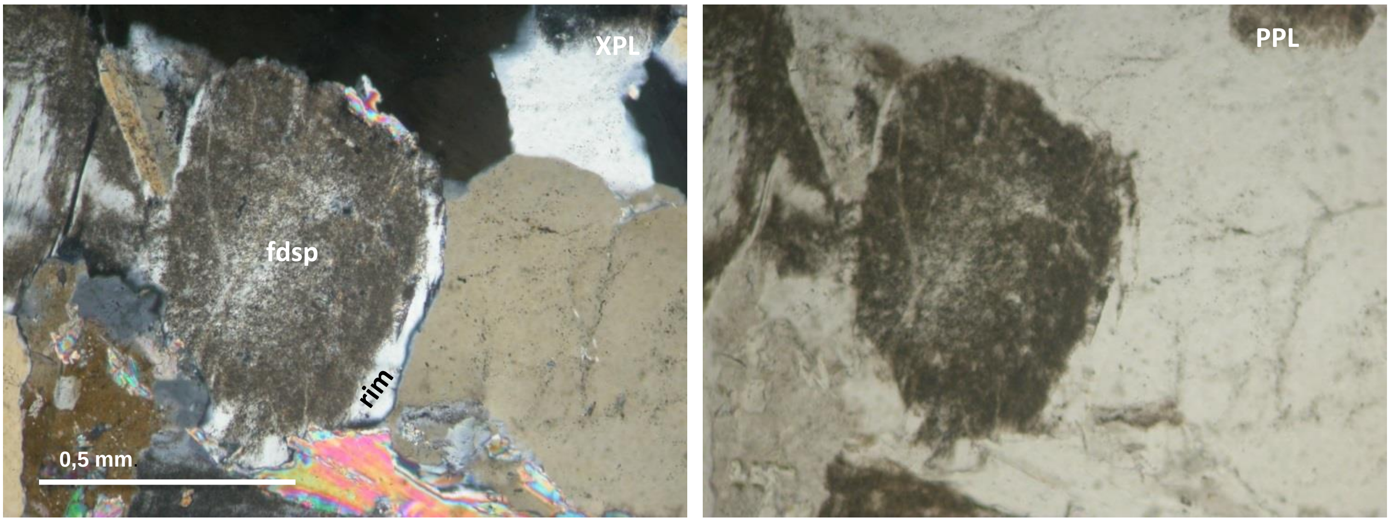


Figure 18. Example of potassic alteration in AA+200 122. Note the rim of albite around the altered inner plagioclase core.

AA+200 228

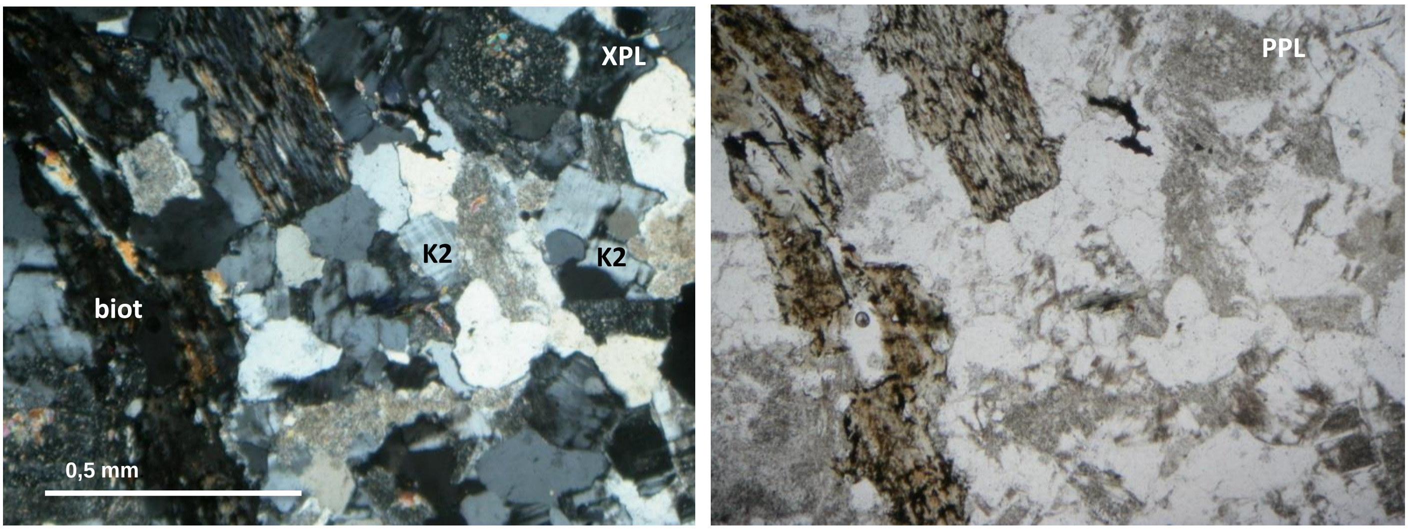


Figure 19. Example of potassic alteration in AA+200 228. Note the secondary biotite (biot) and small secondary alkali feldspar grains (K2).

BB+400 121.1

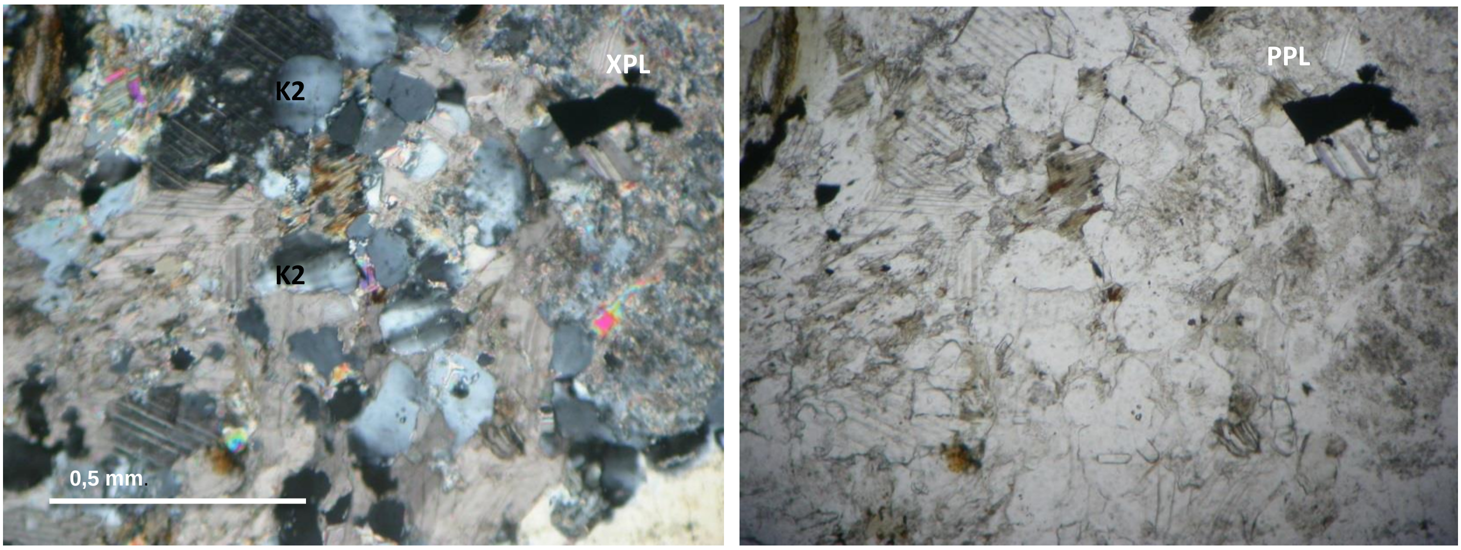


Figure 20. Example of potassic alteration in BB+400 121.1. Note the small secondary alkali feldspar grains (K2).

E-200 328

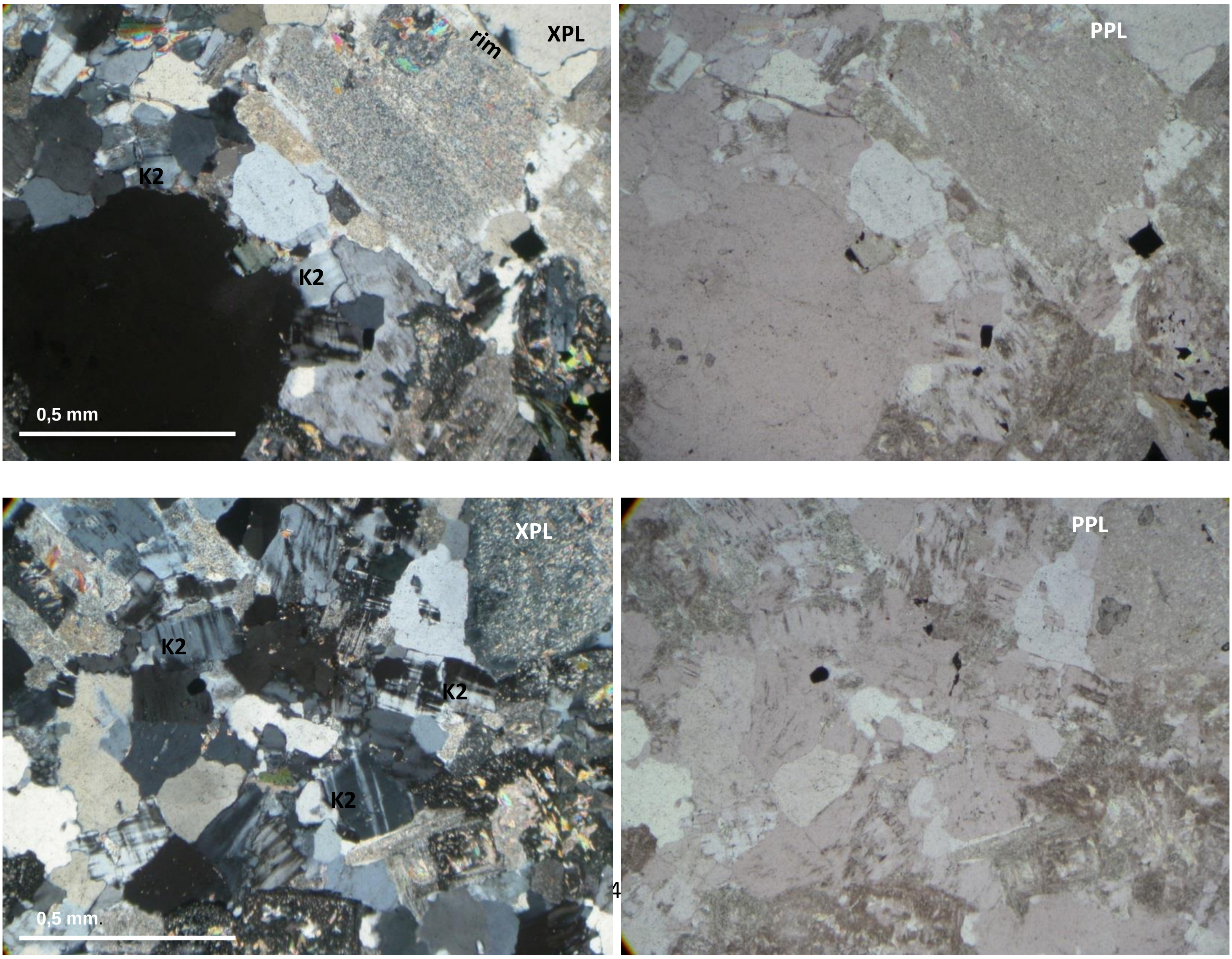


Figure 21. Examples of potassic alteration in E-200 328.

6. Skarn alteration

1. Defining minerals:

- Scheelite
- Pyroxene
- Garnet
- Bastnaesite
- Allanite
- Epidote
- Titanite
- Vesuvianite
- Molybdenite
- Pyrite/pyrrothite

2. Distinguishing features:

- Most of the enrichment is associated with this type of alteration
- Coarse-grained assemblages of clinopyroxene, garnet, allanite, scheelite, etc.

3. Spatial distribution:

- In the roof of the granite cupola

E-200 86.66

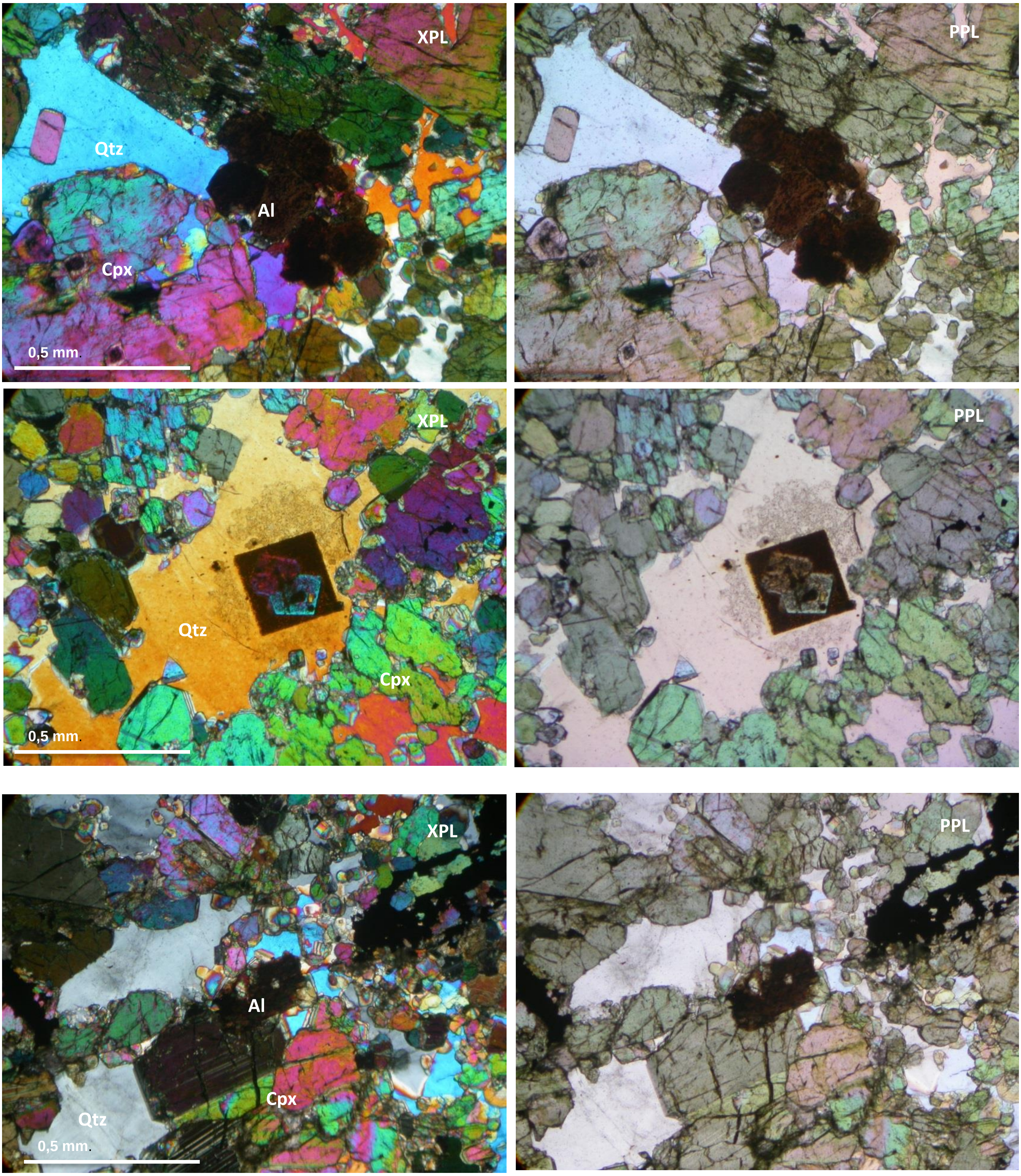


Figure 22. Examples of skarn in E-200 86.66. Note the presence of allanite (Al), clinopyroxene (Cpx) and quartz (Qtz).

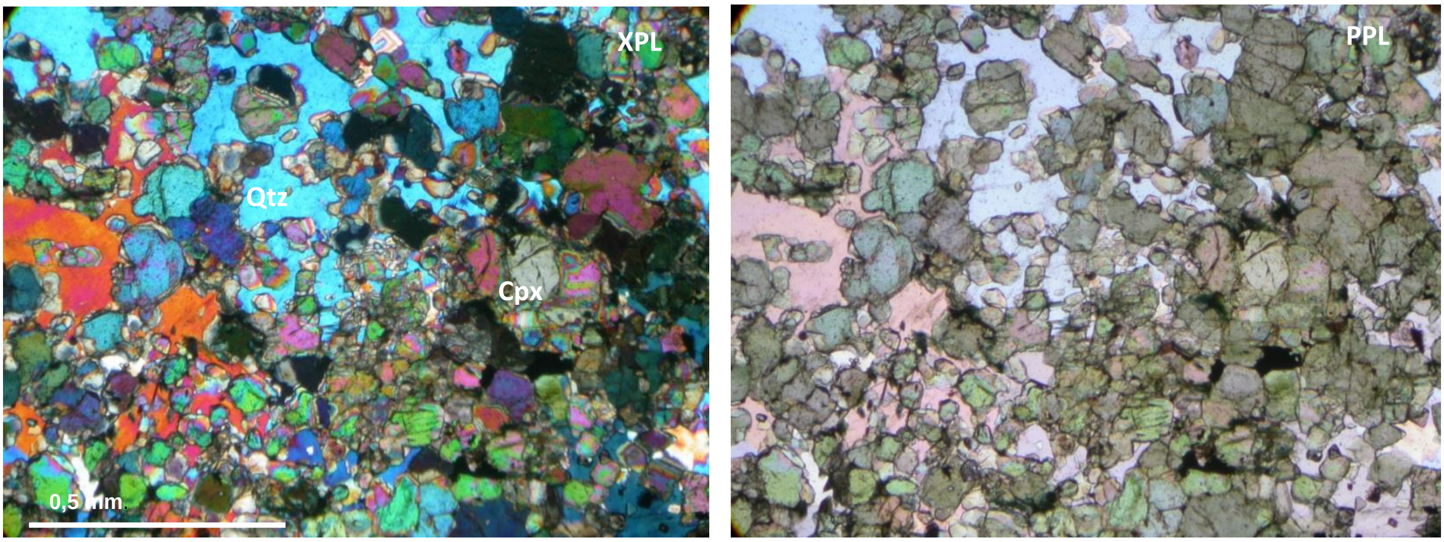


Figure 22 continued. Example of skarn in E-200 86.66.

7. Skarnified granite

1. Defining minerals:

- Scheelite
- Allanite
- Scattered garnet and pyroxene

2. Distinguishing features:

- Occurs in sporadic patches
- Usually associated with potassic alteration

3. Spatial distribution

- Outside of the main skarn zone

AA+400 85.34

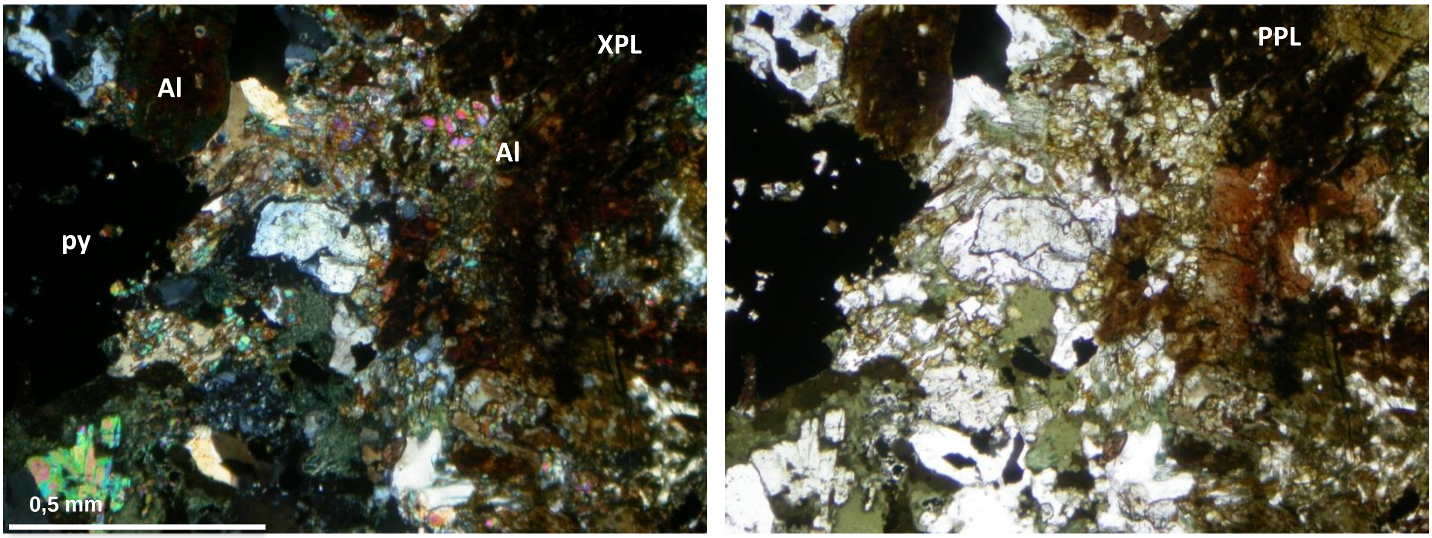


Figure 23. Example of skarnified granite in AA+400 85.34.

AA+400 136.38

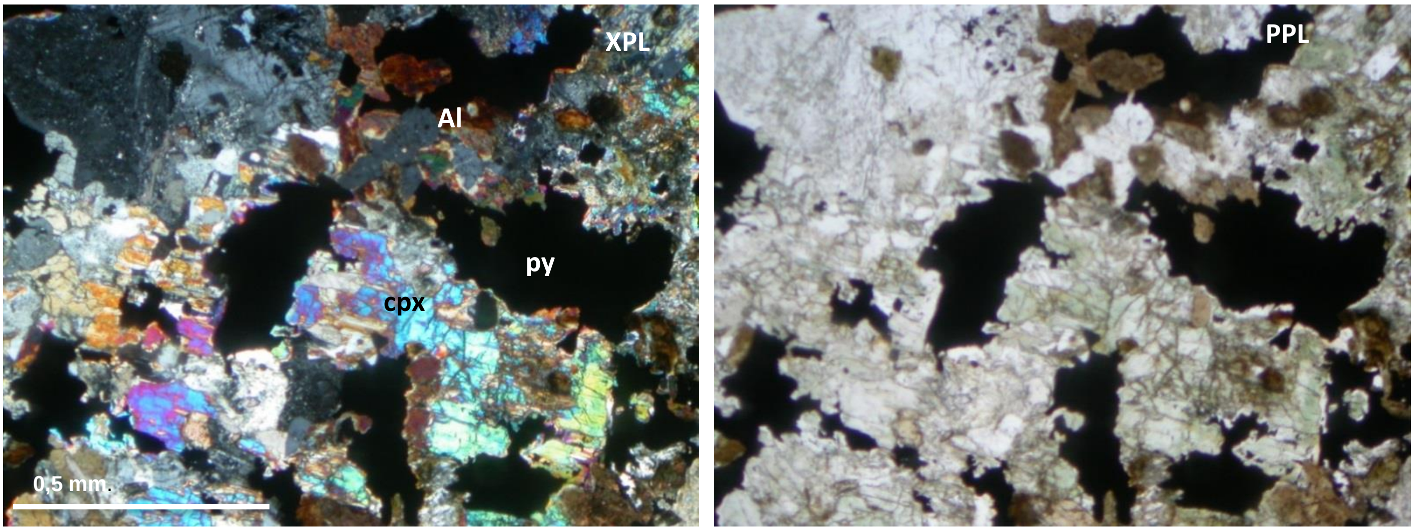


Figure 24. Example of skarnified granite in AA+400 136.38.

8. Other

DD+200 175

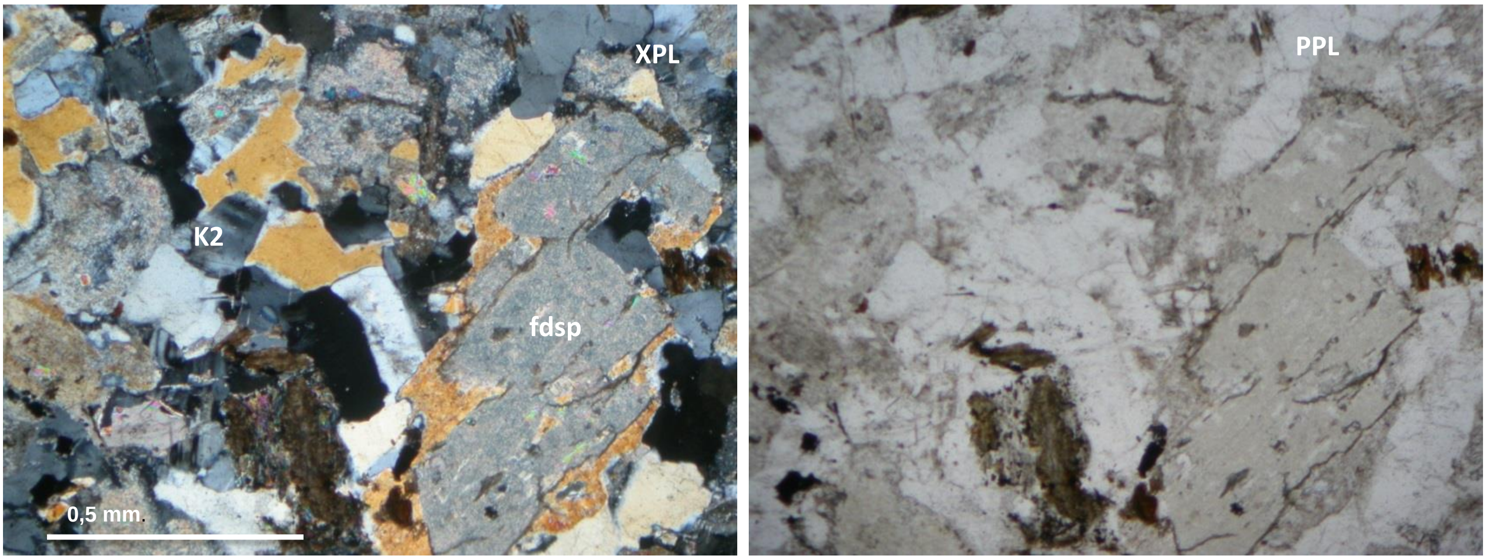


Figure 25. Argillic and phyllic with potassic overprint in DD+200 175.

DD+200 244

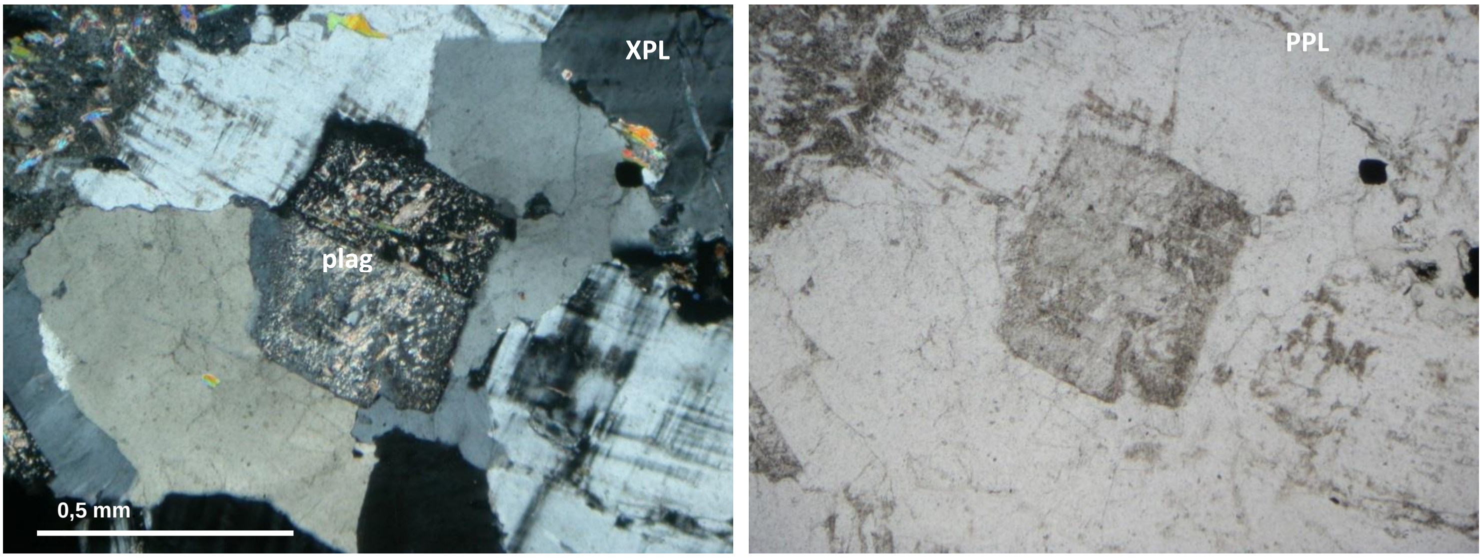


Figure 26. Plagioclase feldspar (plag) is always the first feldspar to alter.

Appendix F – Mineral chemistry

F1. Mineral chemistry tables

These tables are raw SEM data for the various minerals that were examined which include feldspars, biotite (primary and secondary), chlorite, scheelite, pyroxene, apatite, garnet, fluorite, kaolinite, white mica, molybdenite and carbonates. Results are reported in weight percent. Samples used to analyse the different minerals are indicated in each mineral section.

1. Feldspars

Samples: AA+400 127, 137.5, 145.5, BB+400 136, 191, CC+400 150, DD+200 241.5, DD+800 238, REV27 57.1 and REV60 471.5.

	Na_2O	Al_2O_3	SiO_2	K_2O	CaO	FeO	BaO	Total
Plagioclase	11.94	19.47	68.83	0.00	0.09	0.14	0.00	100.47
	11.75	19.38	68.01	0.00	0.13	0.00	0.00	99.27
	10.82	20.34	66.34	0.16	1.10	0.00	0.00	98.76
	8.84	23.24	61.94	0.19	4.62	0.18	0.19	99.20
	7.59	24.74	59.46	0.25	6.44	0.00	0.00	98.48
	11.85	20.74	70.12	0.00	0.57	0.00	0.00	103.28
	9.69	23.46	65.18	0.22	3.90	0.00	0.00	102.45
	10.22	23.01	65.93	0.21	3.70	0.26	0.00	103.33
	9.20	21.34	64.79	0.12	3.49	0.16	0.00	99.10
	7.92	25.09	60.12	0.17	6.41	0.00	0.00	99.71
	8.59	24.04	61.67	0.20	5.50	0.00	0.00	100.01
	10.85	20.99	66.58	0.00	1.40	0.00	0.00	99.82
	7.86	25.31	60.02	0.28	7.05	0.18	0.00	100.72
	9.85	23.14	64.94	0.12	3.73	0.00	0.00	101.78
	9.35	23.24	63.56	0.00	4.11	0.18	0.22	100.67
	1.53	19.24	62.99	13.58	0.20	0.00	2.32	99.86
	7.45	26.79	59.87	4.68	0.25	0.71	0.00	99.76
	11.29	20.09	67.29	0.15	0.99	0.00	0.00	99.81
	12.02	19.52	68.73	0.00	0.00	0.00	0.00	100.27
	11.20	20.77	66.49	0.64	0.31	0.26	0.00	99.40
	11.73	19.67	68.27	0.00	0.42	0.00	0.00	100.09
	11.28	20.29	66.90	0.35	0.59	0.23	0.00	99.63
	11.71	20.16	68.62	0.24	0.35	0.00	0.00	101.07
	12.50	20.05	70.69	0.00	0.00	0.00	0.00	103.24
	12.02	19.90	68.35	0.18	0.13	0.00	0.00	100.58
	11.67	19.94	68.33	0.36	0.00	0.00	0.23	100.53
	11.99	19.47	68.95	0.00	0.18	0.00	0.00	100.59
	12.05	20.29	69.04	0.12	0.16	0.00	0.00	101.67
	9.70	21.07	64.41	1.86	0.29	0.36	0.36	98.06
	11.61	20.63	68.08	0.36	0.38	0.00	0.00	101.06

	11.65	19.60	67.06	0.28	0.21	0.22	0.00	99.03
	1.20	17.65	63.03	14.84	0.19	0.00	0.00	96.91
	1.31	18.24	64.11	14.83	0.00	0.00	0.00	98.49
	11.49	19.78	69.03	0.00		0.00	0.00	100.30
	10.91	19.91	67.78	0.00	0.63	0.00	0.00	99.22
	11.06	19.85	68.25	0.00	0.49	0.00	0.00	99.66
	11.08	19.67	68.95	0.00	0	0.00	0.00	99.70
	11.85	19.75	68.18	0.00	0	0.00	0.00	99.77
Alkali feldspar	1.28	19.32	62.91	13.90	0	0	2.62	100.04
	1.03	19.35	61.80	13.55	0	0	2.69	98.41
	0.79	18.46	64.83	15.43	0	0	0.57	100.09
	1.20	19.24	62.68	13.58	0	0	2.34	99.04
	0.54	18.18	64.32	15.51	0	0	0.71	99.26
	1.31	19.00	62.54	13.70	0	0	1.72	98.28
	1.10	19.12	61.56	13.83	0	0	2.55	98.16
	0.94	18.49	63.08	14.45	0	0	1.25	98.22
	0.95	18.52	62.99	14.42	0	0	1.70	98.58
	1.11	18.50	64.38	14.62	0	0	0.46	99.08
	0.59	18.99	63.29	15.21	0	0	1.34	99.42
	0.77	18.62	63.52	15.12	0	0	1.23	99.26
	0.86	18.71	64.18	15.41	0	0	1.03	100.20
	1.25	19.44	61.74	13.53	0	0	2.52	98.48
	1.45	18.72	62.96	13.68	0	0	1.45	98.26
	1.51	19.51	61.88	13.09	0	0	2.47	98.46
	1.28	18.90	62.35	13.79	0	0	1.93	98.24
	1.59	19.55	61.69	13.13	0	0	2.58	98.54
	1.48	19.12	61.43	13.08	0	0	2.92	98.03
	1.37	18.79	62.01	13.51	0	0	2.49	98.17
	1.28	18.59	63.44	13.97	0	0	1.30	98.59
	1.44	19.11	61.64	13.25	0	0	2.88	98.03
	1.46	19.28	60.95	12.80	0	0	3.84	98.32
	1.13	19.20	61.78	13.88	0	0	2.31	98.30
	0.32	18.13	64.58	16.35	0	0	0.29	99.67
	0.69	18.53	65.33	15.73	0	0	0.58	100.86
	0.55	18.53	64.73	15.61	0	0	0.67	100.09
	0.70	18.42	64.58	15.82	0	0	0.39	99.90
	0.33	18.32	64.73	16.53	0	0	0.60	100.50
	0.48	18.34	64.70	16.01	0	0	0.73	100.25
	0.48	18.50	65.30	15.66	0	0	0.79	100.73
	0.61	18.10	63.53	15.90	0	0	0.48	98.62
Secondary alkali feldspar	0.76	18.05	64.59	16.00	0	0	0	99.40
	0.34	18.17	64.97	15.18	0	0	0	98.66
	0.31	18.04	64.10	16.11	0	0	0	98.56
	0.32	18.38	64.98	15.78	0	0	0	99.45
	0.54	18.26	65.21	15.89	0	0	0	99.89
	0.40	18.39	65.08	16.10	0	0	0	99.96

	0.25	18.08	64.68	16.37	0	0	0	99.37
	0.40	18.26	64.47	16.22	0	0	0	99.34
	0.53	18.19	65.64	16.01	0	0	0	100.37
	1.17	18.40	65.24	15.34	0	0	0	100.14
	0.98	18.31	65.06	15.50	0	0	0	99.85
	0.91	18.34	65.51	15.79	0	0	0	100.54
	0.64	18.42	65.32	16.12	0	0	0	100.50
	0.53	18.53	65.62	16.30	0	0	0	100.98
	0.56	18.48	65.14	16.19	0	0	0	100.37
	0.83	18.58	65.83	15.89	0	0	0	101.12
	0.73	18.26	65.30	16.00	0	0	0	100.29
	0.41	18.29	64.98	16.46	0	0	0	100.14
	0.60	18.40	65.81	16.14	0	0	0	100.95
	0.61	18.51	65.28	16.10	0	0	0	100.50
	0.58	18.49	65.30	16.18	0	0	0	100.54
	0.71	18.22	64.58	15.78	0	0	0	99.29
	0.46	18.15	64.73	16.35	0	0	0	99.69
	0.48	18.00	64.32	16.06	0	0	0	98.85
	0.92	18.25	64.72	15.29	0	0	0	99.19
	0.48	18.53	65.14	16.34	0	0	0	100.49
	0.71	18.43	65.59	15.88	0	0	0	100.61
	1.04	18.44	65.34	15.46	0	0	0	100.28
	0.57	18.25	65.59	16.24	0	0	0	100.65
	0.96	18.05	64.53	15.35	0	0	0	98.88
	1.31	18.24	64.11	14.83	0	0	0	98.49
Rim around plagioclase	9.65	21.68	64.81	0.16	3.67	0	0	99.96
	9.28	21.87	63.94	0.14	4.31	0	0	99.55
	9.74	21.22	64.51	0.19	3.57	0	0	99.22
	9.40	21.46	64.75	0.27	3.57	0	0	99.45
	9.11	22.20	63.58	0.17	4.45	0	0	99.51
	9.44	21.16	63.65	0.16	3.46	0	0	97.86
	10.61	19.75	66.50	0.00	1.69	0	0	98.55
	9.61	21.02	63.78	0.09	3.25	0	0	97.76
	9.77	20.52	64.22	0.16	2.80	0	0	97.47
	8.93	21.73	62.81	0.28	4.12	0	0	97.87
	9.74	22.47	65.48	0.18	4.13	0	0	102.00
	9.71	21.48	66.13	0.43	3.49	0	0	101.24
	9.81	21.89	66.03	0.13	4.05	0	0	101.91
	9.89	20.77	65.43	0.21	2.79	0	0	99.09
	10.40	21.47	67.64	0.28	2.88	0	0	102.66
	10.29	20.93	66.69	0.17	2.98	0	0	101.06
	9.96	21.92	65.74	0.17	3.49	0	0	101.28
	9.77	21.90	65.28	0.19	3.87	0	0	101.01
	9.54	21.67	64.86	0.18	3.64	0	0	99.88
	10.21	21.36	65.09	0.10	3.38	0	0	100.13
	9.72	21.31	64.27	0.19	3.75	0	0	99.23

	10.28	21.19	65.76	0.18	3.03	0	0	100.44
	9.88	21.05	66.33	0.35	2.92	0	0	100.53
	9.87	21.34	65.80	0.23	3.11	0	0	100.37
	10.31	20.87	65.95	0.13	2.60	0	0	99.87
	9.82	20.96	65.56	0.19	3.16	0	0	99.68
	8.97	22.17	63.05	0.14	4.65	0	0	98.98
	10.32	20.74	65.69	0.12	2.44	0	0	99.32
	10.41	21.82	68.11	0.13	3.01	0	0	103.49
	0.85	18.53	61.99	13.63	3.87	0	0	98.87
	0.85	18.58	61.73	13.30	4.15	0	0	98.62
	0.62	18.75	59.47	12.39	7.85	0	0	99.09
	1.05	19.25	61.81	12.92	5.64	0	0	100.66
	0.81	18.54	61.17	13.12	5.08	0	0	98.73
	0.95	18.57	62.20	13.15	3.99	0	0	98.86
	0.71	18.17	61.90	13.87	4.01	0	0	98.66
Altered plagioclase feldspar centre	8.83	21.15	64.80	0.00	0.00	3.21	0	97.98
	8.20	22.08	63.94	0.00	0.00	4.12	0	98.34
	8.41	21.41	63.60	0.24	0.00	4.15	0	97.81
	9.13	20.59	65.55	0.00	0.00	2.42	0	97.70
	8.12	22.13	63.63	0.16	0.00	4.22	0	98.26
	8.09	21.00	63.22	0.12	0.00	3.58	0	96.01
	8.32	20.89	63.36	0.20	0.00	3.26	0	96.04
	8.86	20.15	64.95	0.11	0.00	2.26	0	96.33
	9.15	19.05	65.83	0.00	0.00	1.17	0	95.20
	9.23	19.32	65.88	0.27	0.00	0.92	0	95.62
	9.36	21.03	67.95	0.11	0.00	2.35	0	100.81
	1.35	0.00	105.21	0.00	0.00	0.00	0	106.56
	8.49	22.59	65.61	0.13	0.00	4.18	0	101.00
	9.42	20.46	66.67	0.57	0.00	1.50	0	98.62
	9.20	20.11	65.88	0.00	0.00	1.95	0	97.14
	9.31	20.46	66.54	0.18	0.00	1.47	0	97.96
	8.91	20.57	64.50	0.11	0.00	2.69	0	96.77
	7.10	23.76	59.94	0.24	0.00	6.57	0	97.61
	8.87	21.94	67.19	0.11	0.00	3.50	0	101.62
	10.34	19.19	71.42	0.00	0.00	0.11	0	101.06
	9.04	21.62	67.07	0.23	0.00	3.22	0	101.19
	9.72	20.44	69.81	0.00	0.00	1.20	0	101.18
	9.05	21.34	67.27	0.00	0.00	2.49	0	100.16
	9.52	20.43	68.34	0.00	0.00	1.40	0	99.69
	9.22	20.86	68.39	0.00	0.00	1.83	0	100.30
	9.44	20.49	69.46	0.00	0.00	1.57	0	100.96
	1.80	18.06	63.08	14.16	2.16	0.00	0	99.25
	2.35	18.03	64.18	13.73	1.65	0.00	0	99.95
	2.16	18.04	64.29	14.37	1.62	0.00	0	100.48
	2.13	18.22	64.69	14.59	1.35	0.00	0	100.97
	2.08	18.19	63.72	14.20	1.78	0.00	0	99.97

	2.05	18.42	64.13	14.39	1.40	0.00	0	100.38
	2.08	17.82	64.22	14.28	1.37	0.00	0	99.77

2. Chlorite

There was some difficulty analysing primary biotite data. Primary biotite in this pluton is mostly altered to chlorite and muscovite.

Samples: DD+200 144, 241.5, and AA+400 144.

	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	FeO	Total
Pycnochlorite	0.00	21.08	20.37	29.03	0.09	0.00	0.00	1.49	15.77	87.82
	0.00	21.04	19.50	29.32	0.11	0.00	0.26	1.32	15.98	87.54
	0.00	20.56	20.43	28.94	0.00	0.00	0.00	1.48	16.16	87.57
	0.00	21.59	17.73	31.04	0.18	0.00	0.34	1.39	14.63	86.91
	0.00	20.31	17.72	30.13	0.26	0.00	0.54	1.37	16.53	86.86
	0.00	20.01	17.59	29.56	0.37	0.27	0.78	1.31	15.78	85.65
	0.00	19.32	18.56	28.02	0.00	0.00	0.17	1.34	16.71	84.12
	0.00	18.88	18.86	27.48	0.00	0.00	0.00	1.38	16.59	83.18
	0.00	21.55	19.81	28.72	0.00	0.00	0.00	1.35	14.66	86.09
	0.00	21.57	19.93	28.76	0.00	0.00	0.00	1.34	14.18	85.78
	0.00	21.80	18.28	29.49	0.00	0.00	0.00	1.17	13.80	84.55
	0.00	21.09	18.88	28.54	0.00	0.10	0.00	1.19	14.72	84.51
	0.00	21.54	18.97	29.58	0.00	0.00	0.00	1.37	14.51	85.97
Chamosite	0.00	16.11	19.21	28.40	0.00	0.00	0.00	0.55	23.99	88.26
	0.00	14.71	19.96	27.42	0.00	0.00	0.00	0.76	25.87	88.72
	0.00	15.24	19.20	28.24	0.13	0.00	0.00	0.46	24.79	88.06
	0.00	15.32	18.54	28.82	0.58	0.17	1.10	0.60	24.28	89.40
	0.00	15.26	16.91	28.73	0.20	0.00	1.07	0.64	23.75	86.55
	0.00	14.82	19.30	27.31	0.00	0.00	0.00	0.74	25.71	87.88
	0.00	14.13	19.23	26.70	0.00	0.00	0.00	0.64	26.16	86.85
	0.00	13.43	18.69	27.47	0.10	0.00	0.00	0.75	27.71	88.14
	0.00	14.53	19.75	27.14	0.00	0.00	0.20	0.67	25.74	88.02
	0.00	14.32	18.93	27.29	0.00	0.00	0.00	0.62	26.77	87.94
	0.00	13.24	20.94	25.59	0.00	0.00	0.14	0.81	26.96	87.68
	0.00	14.76	17.77	28.93	0.82	0.21	1.30	0.63	24.23	88.66
	0.00	14.13	17.39	29.71	1.22	0.60	1.97	0.55	23.67	89.24
	0.00	14.26	18.51	28.14	0.40	0.00	0.69	0.69	26.09	88.78
	0.23	13.80	19.50	27.01	0.00	0.00	0.00	0.63	26.75	87.94
	0.00	14.56	17.86	28.24	0.33	0.00	0.69	0.59	26.03	88.30
	0.00	13.76	19.72	26.92	0.15	0.00	0.00	0.78	26.69	88.03
	0.00	13.69	17.72	28.63	0.18	0.28	1.24	0.61	26.37	88.72
	0.00	13.58	20.11	26.56	0.00	0.00	0.00	0.59	27.48	88.32
	0.00	12.50	17.05	30.22	1.15	1.00	2.49	0.77	25.13	90.31
	0.00	14.48	18.64	27.51	0.00	0.00	0.00	0.74	26.13	87.50
	0.00	14.79	16.84	29.05	0.27	0.00	1.73	0.61	24.82	88.10
	0.00	13.23	20.66	26.09	0.00	0.00	0.00	0.82	28.19	88.99

3. Scheelite

Samples: BB+400 90, 136 and CC+400 150.

Scheelite				
	Ca	**W**	**O**	**Total**
1	14.46	62.74	22.51	99.71
2	14.15	62.71	22.41	99.27
3	14.34	63.95	22.42	100.71
4	14.52	63.08	22.92	100.53
5	14.40	63.99	22.89	101.28
6	14.64	63.83	22.81	101.28
7	14.55	65.09	23.35	102.99
8	14.19	63.89	22.35	100.43
9	14.32	62.42	22.31	99.05
10	14.00	63.02	22.04	99.05
11	14.16	63.89	22.33	100.38
12	14.41	63.76	22.40	100.57

4. Pyroxene

Samples: AA+200 85.5 and E-200 86.66.

Pyroxene										
	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**CaO**	**TiO_2**	**Cr_2O_3**	**MnO**	**FeO**	**Total**
1	0	7.26	0.35	50.89	23.21	0	0	4.74	12.85	99.29
2	0.25	7.45	0.20	52.42	23.82	0	0	4.56	13.34	102.04
3	0	6.12	1.45	48.06	20.13	0	0	3.85	17.45	97.06
4	0.39	5.49	0.53	50.75	22.72	0	0	2.66	17.93	100.47
5	0.32	7.27	1.07	50.16	22.41	0	0	3.90	14.65	99.79
6	0.22	5.61	0.72	50.76	23.03	0	0	2.76	17.70	100.80
7	0	7.89	0.22	51.09	22.92	0	0	4.74	11.85	98.69
8	0.19	6.99	0.17	49.71	22.85	0	0	3.69	13.76	97.37
9	0	7.86	0.35	50.09	22.79	0	0	4.28	11.91	97.28
10	0.50	7.89	0.67	49.86	21.96	0	0	4.13	12.22	97.24
11	0.22	7.72	0.21	50.58	22.14	0	0	4.45	12.39	97.71
12	0	6.63	1.02	49.76	20.21	0	0	3.55	17.87	99.05
13	0	7.50	3.83	45.45	15.29	0	0	4.04	20.50	96.61

14	0	0	2.22	36.42	30.05	0	0	3.73	26.29	98.71
15	0	0	5.86	36.95	31.16	0.18	0	2.79	21.34	98.29
16	0	0	4.62	36.49	31.46	0	0	2.33	22.75	97.66
17	0	0	3.85	36.87	30.94	0	0	2.07	24.99	98.72
18	0	0	4.24	36.42	31.51	0	0	2.25	23.48	97.89
19	0	0	1.84	36.18	30.06	0	0	3.40	27.24	98.73
20	0	0	3.07	36.44	31.51	0	0	2.30	25.22	98.55
21	0	0	3.56	35.88	30.83	0	0.19	2.66	24.57	97.69
22	0	0	2.79	36.11	31.78	0	0	1.71	25.14	97.52
23	0	0	2.83	36.38	30.90	0	0	2.17	25.46	97.73
24	0	0	3.72	36.32	31.33	0	0	2.08	23.74	97.20
25	0	0	2.96	36.09	30.60	0	0	2.26	25.19	97.10
26	0	0	2.31	35.68	32.09	0	0	1.64	25.53	97.25
27	0	0	1.94	35.92	29.74	0	0	2.75	27.12	97.47

5. Fluorite

Samples: AA+400 127, 145.5, CC+400 150 and REV60 471.5.

	Fluorite		
	Ca	**F**	**Total**
1	48.51	45.98	94.49
2	49.10	46.55	95.65
3	51.14	48.48	99.61
4	51.97	49.27	101.25
5	51.56	48.88	100.44

6. Molybdenite

Sample: BB+400 136

Molybdenite			
	S	Mo	Total
1	39.40	60.90	100.30
2	39.88	61.60	101.49
3	39.67	59.02	98.69
4	40.04	61.72	101.75
5	40.40	61.61	102.02

7. Apatite

Samples: AA+400 127, 145.5, CC+400 150, DD+800 238, REV60 471.5, E-200 86.66 and DD+200 144.

Apatite						
	P	Ca	Mn	Fe	W	Total
1	40.80	54.98	0.00	0.00	1.46	97.24
2	42.56	56.65	0.00	0.00	1.04	100.26
3	42.08	56.03	0.00	0.23	1.14	99.49
4	41.68	56.09	0.27	0.31	1.41	99.76
5	43.17	56.27	0.00	0.00	1.15	100.60
6	43.03	56.02	0.00	0.00	0.76	99.81
7	45.06	59.11	0.52	0.00	0.97	105.67
8	44.87	58.37	0.00	0.00	1.12	104.37
9	43.00	56.94	0.00	0.00	1.08	101.02
10	42.02	55.93	0.00	0.00	0.85	98.80
11	43.57	56.37	0.00	0.00	0.93	100.86
12	43.38	56.53	0.57	0.00	0.74	101.22
13	41.06	56.08	0.00	0.00	1.07	98.22
14	43.04	56.43	0.41	0.00	1.08	100.97
15	43.44	56.83	0.00	0.00	0.97	101.25
16	43.45	57.03	0.00	0.00	0.00	100.47
17	43.42	57.74	0.00	0.00	0.00	101.16
18	40.68	54.86	0.00	0.00	0.00	95.53
19	42.91	56.39	0.00	0.00	0.00	99.31

20	42.75	55.72	0.00	0.00	0.00	98.46
21	43.12	55.94	0.00	0.00	0.00	99.07
22	42.87	56.55	0.00	0.00	0.00	99.42
23	41.99	55.42	0.00	0.00	0.00	97.40

Fluoro-apatite

	O	F	P	Ca	Fe	Total
1	38.52	7.19	17.25	36.74	0.31	100.00
2	39.08	6.43	17.21	37.04	0.25	100.00
3	38.13	6.91	17.38	37.24	0.35	100.00
4	40.24	4.56	17.57	37.63	0.00	100.00

8. Clay minerals

Sample: A+400 78.8.

	Na_2O	Al_2O_3	SiO_2	FeO	Total
1	0.139879	38.79976	46.58744	0	85.52708
2	0	37.76374	45.35678	0.31183	83.43235
3	0	37.54852	45.03464	0	82.58316
4	0	38.08719	46.21071	0	84.29791
5	0	37.15244	44.86988	0	82.02232
6	0	38.7064	46.80241	0	85.5088
7	0	38.3231	46.4518	0	84.7749
8	0	38.69015	46.95579	0.142528	85.78846
9	0	37.67427	45.50365	0	83.17793
10	0	37.12923	44.62852	0	81.75775

9. White mica

Samples: A+400 78.8, AA+200 144, BB+400 191, DD+800 238, REV27 57.1 and REV60 471.5.

White mica – larger flakes										
	F	**Na_2O**	**MgO**	**Al_2O_3**	**SiO_2**	**K_2O**	**TiO_2**	**FeO**	**BaO**	**Total**
1	1.82	0.25	2.84	31.23	47.52	10.54	0.29	0.97	0.00	95.46
2	2.35	0.23	4.40	29.23	48.15	10.39	0.57	1.19	0.00	96.51
3	1.62	0.14	2.38	31.99	47.56	10.66	0.16	0.75	0.00	95.26
4	2.25	0.19	4.57	28.70	47.36	10.22	0.37	1.57	0.00	95.25
5	2.28	0.20	4.16	29.60	47.41	10.53	0.32	1.30	0.00	95.81
6	2.40	0.20	5.22	28.41	46.40	10.29	0.52	1.76	0.00	95.19
7	2.38	0.14	2.98	29.75	48.56	10.54	0.20	1.04	0.00	95.58
8	1.96	0.17	3.33	31.04	49.76	10.34	0.38	0.77	0.00	97.74
9	0.00	0.25	0.26	37.38	46.07	9.90	0.13	0.49	0.00	94.47
10	0.00	0.00	1.13	34.97	48.44	10.19	0.22	0.26	0.00	95.21
11	0.45	0.00	1.58	33.63	49.41	10.05	0.26	0.35	0.00	95.75
12	0.00	0.28	2.35	32.92	48.74	10.69	0.29	0.75	0.00	96.02
13	0.76	0.00	2.26	32.53	49.05	10.87	0.26	0.60	0.00	96.32
14	0.00	0.14	1.86	33.99	49.25	10.68	0.24	0.52	0.00	96.68
15	1.04	0.23	4.64	29.93	49.12	10.58	0.39	1.04	0.00	96.97
16	1.04	0.17	3.94	30.79	49.94	10.85	0.48	0.91	0.00	98.13
17	0.80	0.15	2.75	30.68	49.80	10.76	0.51	0.69	0.00	96.14
18	0.74	0.20	3.47	29.94	49.33	10.81	1.06	1.43	0.00	96.97
19	0.00	0.00	1.39	34.23	48.69	10.52	0.21	0.52	0.00	95.55
20	0.00	0.24	2.11	32.17	48.91	10.71	0.41	0.65	0.00	95.21
21	1.72	0.27	2.00	31.83	47.16	9.98	0.35	0.98	0.00	94.29
22	0.94	0.14	1.71	31.98	48.11	9.67	0.16	1.52	0.22	94.46
23	1.95	0.18	3.44	29.31	48.37	10.34	0.34	1.28	0.33	95.56
24	1.82	0.19	4.02	29.65	47.26	10.43	0.40	1.54	0.37	95.70
25	1.98	0.44	2.90	24.55	42.72	7.56	16.53	1.48	0.00	98.17
26	1.73	0.18	3.16	29.48	48.05	10.43	0.36	1.63	0.34	95.37
27	2.01	0.14	2.49	31.11	47.34	10.58	0.38	0.89	0.59	95.53
28	1.48	0.17	2.49	31.14	48.09	10.55	0.26	0.88	0.68	95.73

White mica – smaller grains										
	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	TiO_2	MnO	FeO	BaO	Total
1	0.18	1.84	33.33	49.34	10.32	0.20	0.00	0.38	0.00	95.59
2	0.16	1.91	33.42	48.06	10.54	0.16	0.00	0.84	0.00	96.14
3	0.17	2.90	30.44	48.09	10.45	0.41	0.00	1.39	0.00	95.08
4	0.31	3.17	31.55	47.65	10.65	0.32	0.00	1.23	0.00	95.98
5	0.00	2.32	31.45	49.07	10.89	0.31	0.00	0.49	0.00	95.41
6	0.29	2.92	30.32	47.71	10.60	0.53	0.00	1.98	0.00	95.47
7	0.18	2.00	34.02	47.98	10.83	0.14	0.00	0.61	0.00	96.91
8	0.16	1.98	32.75	48.23	10.77	0.50	0.00	0.76	0.00	96.17
9	0.15	2.05	32.46	48.78	11.00	0.27	0.00	0.48	0.00	95.19
10	0.29	2.84	31.82	48.47	10.74	0.26	0.00	0.89	0.00	96.82
11	0.26	2.17	32.59	48.28	10.46	0.15	0.00	0.97	0.00	96.17
12	0.16	2.21	32.47	48.47	10.36	0.42	0.00	1.10	0.00	95.18
13	0.00	2.80	31.63	48.90	10.64	0.15	0.00	0.55	0.00	96.05
14	0.00	2.39	30.69	51.38	9.08	0.17	0.00	1.40	0.00	95.12
15	0.00	2.28	31.24	50.42	10.04	0.19	0.00	1.55	0.00	95.71
16	0.00	1.47	34.14	50.89	9.70	0.20	0.00	0.56	0.00	96.96
17	0.13	1.84	33.35	48.68	10.94	0.20	0.00	0.48	0.00	95.62
18	0.30	4.74	31.21	49.04	11.03	0.38	0.00	1.70	0.00	100.28
19	0.28	2.78	31.93	49.69	10.91	0.17	0.00	1.36	0.00	98.01
20	0.14	2.62	31.97	50.00	11.14	0.16	0.00	1.11	0.00	98.10
21	0.16	1.95	32.22	48.49	10.77	0.62	0.00	0.79	0.00	95.01
22	0.15	2.40	33.17	50.12	10.95	0.21	0.00	0.50	0.00	98.29
23	0.00	2.42	29.64	50.23	8.52	0.15	0.00	2.68	0.27	96.27
24	0.24	2.67	31.15	48.01	10.51	0.00	0.00	0.93	0.33	96.53
25	0.24	2.76	30.39	48.06	10.36	0.18	0.00	1.06	0.29	95.77
26	0.26	2.52	30.93	47.44	10.38	0.00	0.00	0.96	0.53	95.52
27	0.24	4.66	28.98	47.03	10.44	0.30	0.00	1.86	0.35	97.27
28	0.14	2.63	31.11	48.51	10.50	0.15	0.00	0.91	0.00	96.65
29	0.23	3.56	30.33	47.64	10.35	0.00	0.00	1.09	0.46	96.59
30	0.23	2.58	30.89	47.70	10.54	0.42	0.00	1.13	0.40	96.23
31	0.14	1.19	33.32	49.21	9.30	0.00	0.00	0.76	0.21	95.57
32	0.33	0.12	37.93	47.24	10.21	0.00	0.00	0.66	0.29	96.79
33	0.30	1.30	33.83	47.60	10.22	0.00	0.00	0.96	0.37	95.69
34	0.32	0.17	36.99	46.09	10.56	0.00	0.00	0.76	0.37	96.26
35	0.25	0.43	36.05	46.13	10.28	0.00	0.00	1.00	0.00	95.30
36	0.37	0.34	36.42	45.97	10.44	0.00	0.00	1.35	0.39	95.27
37	0.32	0.20	37.38	45.65	10.53	0.00	0.00	0.60	0.34	95.02
38	0.31	1.45	33.74	47.59	10.51	0.00	0.00	1.28	0.44	96.72
39	0.35	0.49	36.10	46.95	10.32	0.00	0.00	1.46	0.36	96.03
40	0.40	0.18	37.49	46.00	10.40	0.54	0.00	0.61	0.00	95.62
41	0.21	2.89	31.03	48.05	10.28	0.16	0.00	1.52	0.28	96.82
42	0.22	4.41	29.64	47.43	9.93	0.32	0.00	1.77	0.45	96.53
43	0.23	2.50	30.93	48.68	9.88	0.27	0.00	1.45	0.00	96.33

44	0.19	3.08	30.03	48.72	9.38	0.16	0.00	1.63	0.00	95.11
45	0.23	4.39	29.01	47.70	10.26	0.38	0.00	1.96	0.00	97.00
46	0.22	2.74	30.76	48.49	9.96	0.21	0.00	1.39	0.32	96.27
47	0.26	2.63	30.88	48.24	10.19	0.25	0.00	1.38	0.00	96.07
48	0.23	4.17	29.35	47.00	10.10	0.36	0.00	2.19	0.39	96.65
49	0.27	2.35	31.23	47.87	10.25	0.00	0.00	1.44	0.53	96.03
50	0.29	3.69	30.04	47.41	10.50	0.29	0.00	1.74	0.38	96.93
51	0.24	2.73	30.94	47.65	10.53	0.00	0.00	1.55	0.46	96.06
52	0.25	4.09	29.79	46.66	10.40	0.36	0.00	1.99	0.41	96.70
53	0.19	2.59	30.95	48.78	10.40	0.00	0.00	1.17	0.00	96.55
54	0.46	2.88	30.38	47.78	10.46	0.28	0.31	1.08	0.00	96.08
55	0.25	2.03	32.52	47.40	10.41	0.00	0.00	1.46	0.53	96.56
56	0.21	3.20	30.05	47.60	10.24	0.46	0.00	1.31	0.30	95.61
57	0.24	4.40	29.43	47.30	10.37	0.58	0.00	1.97	0.24	97.70
58	0.30	2.63	30.99	47.49	10.49	0.23	0.21	1.41	0.00	96.47
59	0.26	3.89	29.63	47.70	10.43	0.40	0.38	1.18	0.00	96.66
60	0.30	3.16	30.90	48.82	10.60	0.26	0.00	0.86	0.00	97.68
61	0.40	3.11	31.18	49.26	10.57	0.17	0.00	0.68	0.00	97.44
62	0.16	0.78	36.02	48.01	9.24	0.00	0.00	0.74	0.42	96.45
63	0.26	4.31	29.76	47.10	9.71	0.36	0.00	2.00	0.27	96.61
64	0.20	2.35	31.02	48.05	9.66	0.34	0.00	1.26	0.00	95.18
65	0.20	2.78	30.26	48.51	10.15	0.14	0.00	0.74	0.00	95.33

10. Carbonates

Samples: AA+200 144 and AA+400 145.5.

	Mg	Ca	Mn	Fe	O	Total
Carbonates	6.17	22.56	2.19	11.08	16.88	58.90
	7.10	22.30	1.50	8.99	16.59	56.49
	6.71	22.32	1.60	9.66	16.55	56.84
	7.70	23.01	1.27	7.04	16.64	55.67
	6.30	22.37	1.81	9.94	16.45	56.87
	0.00	37.80	6.19	0.42	17.01	61.42
	0.00	37.77	3.70	0.00	16.15	57.62
	0.00	39.06	2.47	0.00	16.31	57.84

11. *Skarn minerals (Cousins, pers. comm.)*

Sample	Skarn type	Sample	Slide	Depth	Analysis	SiO2	TiO2	ZrO2	AL2O3	Cr2O3	Fe2O3	V2O3	Y2O3	FeO	MnO	MgO	CaO	Na2O	Total	Si	Ti	Zr	Al	Cr	Fe 3+	V	Y
A1	Garnet endoskarn	LEC 11. S8	94348	-142.58	G1	36.03	0.00	0.00	3.05	0.00	27.95	0.00	0.00	1.00	0.85	0.00	32.70	0.00	101.58	2.97	0.00	0.00	0.30	0.00	1.73	0.00	0.00
A2	Garnet endoskarn	LEC 11. S8	94348	-142.58	G2	35.82	0.23	0.00	3.17	0.00	27.97	0.00	0.00	0.89	1.01	0.00	32.75	0.00	101.83	2.95	0.01	0.00	0.31	0.00	1.73	0.00	0.00
A3	Garnet endoskarn	LEC 11. S8	94348	-142.58	G6	35.76	0.00	0.00	1.66	0.00	30.32	0.00	0.00	1.35	1.94	0.00	31.57	0.00	102.59	2.95	0.00	0.00	0.16	0.00	1.88	0.00	0.00
A4	Garnet endoskarn	LEC 11. S8	94348	-142.58	G7	36.18	0.21	0.00	3.54	0.00	27.09	0.00	0.00	0.58	1.10	0.00	32.88	0.00	101.57	2.97	0.01	0.00	0.34	0.00	1.67	0.00	0.00
A5	Garnet endoskarn	LEC 11. S8	94348	-142.58	G8	35.98	0.18	0.00	3.13	0.00	27.97	0.00	0.00	0.39	0.73	0.00	33.38	0.00	101.75	2.96	0.01	0.00	0.30	0.00	1.73	0.00	0.00
A6	Garnet endoskarn	LEC 11. S8	94348	-142.58	G9	36.01	0.00	0.00	2.50	0.00	28.79	0.00	0.00	1.06	0.79	0.00	32.67	0.00	101.82	2.97	0.00	0.00	0.24	0.00	1.79	0.00	0.00
A7	Garnet endoskarn	LEC 11. S8	94348	-142.58	G10	35.83	0.75	0.00	3.31	0.00	27.56	0.00	0.00	0.18	0.70	0.00	33.59	0.00	101.92	2.93	0.05	0.00	0.32	0.00	1.70	0.00	0.00
B1	Pyroxene endoskarn	LEC 10. S2	94324	-141.65	G1 A	36.95	0.20	0.00	19.39	0.00	3.34	0.00	0.00	7.65	14.43	0.07	17.68	0.00	99.70	2.96	0.01	0.00	1.83	0.00	0.20	0.00	0.00
B2	Pyroxene endoskarn	LEC 10. S2	94324	-141.65	G2 A	37.30	0.26	0.00	19.13	0.00	3.62	0.00	0.00	6.99	14.18	0.07	18.48	0.00	100.02	2.97	0.02	0.00	1.80	0.00	0.22	0.00	0.00
B3	Pyroxene endoskarn	LEC 10. S2	94324	-141.65	G3 A	36.88	0.34	0.00	19.94	0.00	2.28	0.00	0.00	8.31	15.88	0.10	15.87	0.00	99.61	2.96	0.02	0.00	1.88	0.00	0.14	0.00	0.00
B4	Pyroxene endoskarn	LEC 10. S2	94324	-141.65	G4 B	36.64	0.37	0.00	19.87	0.00	2.68	0.00	0.00	8.23	16.65	0.11	15.41	0.00	99.95	2.94	0.02	0.00	1.88	0.00	0.16	0.00	0.00
B5	Pyroxene endoskarn	LEC 10. S2	94324	-141.65	G5 C	36.91	0.25	0.00	19.80	0.00	3.07	0.00	0.00	6.90	14.54	0.08	18.41	0.00	99.95	2.94	0.02	0.00	1.86	0.00	0.18	0.00	0.00
B6	Pyroxene endoskarn	LEC 10. S2	94324	-141.65	G6 C	36.89	0.25	0.00	19.39	0.00	3.61	0.00	0.00	6.60	14.00	0.06	19.02	0.00	99.83	2.94	0.02	0.00	1.82	0.00	0.22	0.00	0.00
B7	Pyroxene endoskarn	LEC 10. S2	94324	-141.65	G7 D	36.94	0.31	0.00	19.35	0.00	3.41	0.00	0.00	7.27	14.51	0.08	17.95	0.00	99.82	2.95	0.02	0.00	1.82	0.00	0.21	0.00	0.00
B8	Pyroxene endoskarn	LEC 10. S2	94324	-141.65	G8 D	37.07	0.30	0.00	19.24	0.00	3.32	0.00	0.00	7.51	14.83	0.07	17.40	0.00	99.74	2.97	0.02	0.00	1.82	0.00	0.20	0.00	0.00
B9	Pyroxene endoskarn	LEC 10. S3	94325	-142.17	G1 A	36.84	0.25	0.00	19.14	0.00	3.44	0.00	0.00	5.32	15.73	0.08	18.26	0.00	99.05	2.96	0.02	0.00	1.81	0.00	0.21	0.00	0.00

B10	Pyroxene endoskarn	LEC 10.S3	94325	-142.17	G2 A	36.92	0.00	0.00	19.72	0.00	2.89	0.00	0.00	6.56	15.12	0.08	17.95	0.00	99.23	2.96	0.00	0.00	1.86	0.00	0.17	0.00	0.00
B11	Pyroxene endoskarn	LEC 10.S3	94325	-142.17	G3 B	36.86	0.27	0.00	19.34	0.00	3.03	0.00	0.00	6.90	15.29	0.09	17.31	0.00	99.09	2.97	0.02	0.00	1.83	0.00	0.18	0.00	0.00
B12	Pyroxene endoskarn	LEC 10.S3	94325	-142.17	G4 B	36.93	0.28	0.00	19.26	0.00	2.75	0.00	0.00	7.11	15.04	0.09	17.11	0.00	98.56	2.98	0.02	0.00	1.83	0.00	0.17	0.00	0.00
B13	Pyroxene endoskarn	LEC 10.S3	94325	-142.17	G5 C	37.14	0.24	0.00	19.94	0.00	0.00	0.00	0.00	8.34	18.18	0.10	15.20	0.00	99.14	3.00	0.01	0.00	1.90	0.00	0.00	0.00	0.00
B14	Pyroxene endoskarn	LEC 10.S3	94325	-142.17	G6 C	37.00	0.22	0.00	19.70	0.00	2.28	0.00	0.00	6.23	17.71	0.12	15.80	0.00	99.06	2.98	0.01	0.00	1.87	0.00	0.14	0.00	0.00
B15	Pyroxene endoskarn	LEC 10.S3	94325	-142.17	G7 D	36.92	0.29	0.00	19.37	0.00	2.59	0.00	0.00	6.26	14.67	0.11	18.05	0.00	98.26	2.98	0.02	0.00	1.84	0.00	0.16	0.00	0.00
B16	Pyroxene endoskarn	LEC 10.S3	94325	-142.17	G8 D	36.83	0.17	0.00	19.63	0.00	2.45	0.00	0.00	5.82	16.13	0.09	17.38	0.00	98.49	2.97	0.01	0.00	1.87	0.00	0.15	0.00	0.00
B17	Pyroxene endoskarn	LEC 11.S4	94344	-138.33	G1 A	36.69	0.00	0.00	20.59	0.00	0.00	0.00	0.00	9.78	21.37	0.09	10.63	0.00	99.14	2.98	0.00	0.00	1.97	0.00	0.00	0.00	0.00
B18	Pyroxene endoskarn	LEC 11.S4	94344	-138.33	G2 A	36.74	0.00	0.00	19.94	0.00	0.00	0.00	0.00	9.56	20.20	0.07	11.94	0.00	98.44	3.00	0.00	0.00	1.92	0.00	0.00	0.00	0.00
B19	Pyroxene endoskarn	LEC 11.S4	94344	-138.33	G3 A	37.13	0.00	0.00	20.46	0.00	0.00	0.00	0.00	9.43	19.91	0.07	13.27	0.00	100.26	2.98	0.00	0.00	1.94	0.00	0.00	0.00	0.00
B20	Pyroxene endoskarn	LEC 11.S4	94344	-138.33	G4 B	36.17	0.39	0.00	19.39	0.00	2.39	0.00	0.00	7.78	19.54	0.10	12.66	0.00	98.43	2.96	0.02	0.00	1.87	0.00	0.15	0.00	0.00
B21	Pyroxene endoskarn	LEC 11.S4	94344	-138.33	G5 B	36.37	0.00	0.00	19.55	0.00	2.87	0.00	0.00	6.29	20.64	0.08	13.43	0.00	99.23	2.95	0.00	0.00	1.87	0.00	0.18	0.00	0.00
B22	Pyroxene endoskarn	LEC 11.S12	94352	-163.69	G1 A	37.12	0.27	0.00	19.64	0.00	2.48	0.00	0.00	7.75	15.10	0.08	16.85	0.00	99.28	2.98	0.02	0.00	1.86	0.00	0.15	0.00	0.00
B23	Pyroxene endoskarn	LEC 11.S12	94352	-163.69	G2 A	36.84	0.36	0.00	19.75	0.00	2.59	0.00	0.00	7.99	15.12	0.10	16.71	0.00	99.48	2.95	0.02	0.00	1.87	0.00	0.16	0.00	0.00
B24	Pyroxene endoskarn	LEC 11.S12	94352	-163.69	G3 B	36.98	0.32	0.00	20.01	0.00	2.48	0.00	0.00	6.94	16.48	0.07	16.74	0.00	100.02	2.95	0.02	0.00	1.88	0.00	0.15	0.00	0.00
B25	Pyroxene endoskarn	LEC 11.S12	94352	-163.69	G4 B	37.16	0.26	0.00	20.25	0.00	2.39	0.00	0.00	8.20	14.18	0.10	17.75	0.00	100.27	2.95	0.02	0.00	1.89	0.00	0.14	0.00	0.00
B26	Pyroxene endoskarn	LEC 11.S12	94352	-163.69	G5 C	37.03	0.32	0.00	20.10	0.00	0.00	0.00	0.00	9.40	15.69	0.10	16.18	0.00	98.81	2.99	0.02	0.00	1.91	0.00	0.00	0.00	0.00
B27	Pyroxene endoskarn	LEC 11.S12	94352	-163.69	G6 C	36.81	0.31	0.00	20.09	0.00	0.00	0.00	0.00	9.49	15.59	0.10	16.28	0.00	98.67	2.98	0.02	0.00	1.92	0.00	0.00	0.00	0.00

C1	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G1 A	35.66	0.76	0.00	8.95	0.00	19.15	0.00	0.00	0.34	2.92	0.00	31.92	0.00	99.70	2.91	0.05	0.00	0.86	0.00	1.18	0.00	0.00
C2	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G2 A	35.32	0.45	0.00	6.36	0.00	23.34	0.00	0.00	0.18	2.20	0.00	32.48	0.00	100.33	2.91	0.03	0.00	0.62	0.00	1.45	0.00	0.00
C3	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G3 B	35.23	1.11	0.00	4.76	0.00	25.18	0.00	0.00	0.39	1.29	0.06	32.68	0.00	100.71	2.91	0.07	0.00	0.46	0.00	1.56	0.00	0.00
C4	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G4 B	35.35	0.96	0.00	4.95	0.00	24.71	0.00	0.00	0.49	1.36	0.06	32.45	0.00	100.32	2.92	0.06	0.00	0.48	0.00	1.54	0.00	0.00
C5	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G5 C	35.54	0.35	0.00	6.70	0.00	22.60	0.00	0.00	0.48	2.58	0.00	31.87	0.00	100.13	2.93	0.02	0.00	0.65	0.00	1.40	0.00	0.00
C6	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G6 C	35.67	0.17	0.00	6.47	0.00	23.19	0.00	0.00	0.15	2.74	0.00	32.15	0.00	100.53	2.93	0.01	0.00	0.63	0.00	1.43	0.00	0.00
C7	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G7 D	35.28	0.51	0.00	3.92	0.00	26.11	0.00	0.00	1.86	2.15	0.00	30.54	0.00	100.36	2.94	0.03	0.00	0.39	0.00	1.64	0.00	0.00
C8	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G8 D	35.75	1.21	0.00	6.35	0.00	22.46	0.00	0.00	0.99	1.54	0.00	32.18	0.00	100.49	2.93	0.07	0.00	0.61	0.00	1.38	0.00	0.00
C9	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G9 E	35.03	0.75	0.00	3.37	0.00	26.24	0.00	0.00	0.25	2.42	0.00	31.09	0.00	99.15	2.95	0.05	0.00	0.34	0.00	1.66	0.00	0.00
C10	Pyroxene-garnet endoskarn	LEC 2. S4	95048	-135.54	G10 E	34.89	1.27	0.00	4.76	0.00	24.56	0.00	0.00	0.51	2.93	0.06	30.83	0.00	99.80	2.91	0.08	0.00	0.47	0.00	1.54	0.00	0.00
C11	Pyroxene-garnet endoskarn	LEC 2. S5	94282	-135.6	G1 A	35.74	0.19	0.00	6.05	0.00	22.35	0.00	0.00	2.52	2.96	0.06	29.13	0.00	98.99	2.99	0.01	0.00	0.60	0.00	1.41	0.00	0.00
C12	Pyroxene-garnet endoskarn	LEC 2. S5	94282	-135.6	G2 A	35.77	0.10	0.00	5.56	0.00	23.27	0.00	0.00	2.68	3.48	0.00	28.75	0.00	99.60	2.99	0.01	0.00	0.55	0.00	1.46	0.00	0.00
C13	Pyroxene-garnet endoskarn	LEC 2. S5	94282	-135.6	G3 A	36.04	0.13	0.00	6.20	0.00	22.29	0.00	0.00	2.82	3.66	0.07	28.52	0.00	99.73	2.99	0.01	0.00	0.61	0.00	1.39	0.00	0.00
C14	Pyroxene-garnet endoskarn	LEC 2. S5	94282	-135.6	G4 B	35.36	0.71	0.00	4.86	0.00	23.63	0.00	0.00	2.00	1.78	0.00	30.19	0.00	98.53	2.98	0.05	0.00	0.48	0.00	1.50	0.00	0.00
C15	Pyroxene-garnet endoskarn	LEC 2. S5	94282	-135.6	G5 B	35.23	0.47	0.00	3.52	0.00	25.98	0.00	0.00	1.37	1.91	0.00	30.61	0.00	99.09	2.97	0.03	0.00	0.35	0.00	1.65	0.00	0.00
C16	Pyroxene-garnet endoskarn	LEC 2. S5	94282	-135.6	G6 B	35.31	0.43	0.00	3.85	0.00	25.29	0.00	0.00	1.40	1.81	0.08	30.47	0.00	98.63	2.98	0.03	0.00	0.38	0.00	1.61	0.00	0.00
C17	Pyroxene-garnet endoskarn	LEC 2. S5	94282	-135.6	G7D B	34.00	0.53	0.00	5.10	0.00	22.97	0.00	0.00	0.00	1.59	0.06	32.14	0.00	96.37	2.92	0.03	0.00	0.52	0.00	1.49	0.00	0.00
C18	Pyroxene-garnet endoskarn	LEC 2. S5	94282	-135.6	G8 B	35.65	0.13	0.00	4.52	0.00	24.88	0.00	0.00	0.52	0.50	0.00	32.75	0.00	98.95	2.98	0.01	0.00	0.45	0.00	1.57	0.00	0.00

C19	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G9 B	35.57	0.19	0.00	3.37	0.00	26.04	0.00	0.00	1.12	0.78	0.00	31.63	0.00	98.69	3.00	0.01	0.00	0.34	0.00	1.65	0.00	0.00
C20	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G10 C	35.87	0.40	0.00	5.49	0.00	23.06	0.00	0.00	1.87	1.07	0.00	31.21	0.00	98.98	2.99	0.03	0.00	0.54	0.00	1.45	0.00	0.00
C21	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G11 C	35.45	0.00	0.00	3.64	0.00	26.21	0.00	0.00	1.13	0.46	0.00	32.15	0.00	99.05	2.98	0.00	0.00	0.36	0.00	1.66	0.00	0.00
C22	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G12 C	35.72	0.00	0.00	6.84	0.00	23.32	0.00	0.00	3.46	0.54	0.00	31.72	0.00	101.60	2.91	0.00	0.00	0.66	0.00	1.43	0.00	0.00
C23	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G13 D	35.88	0.43	0.00	5.97	0.00	22.75	0.00	0.00	1.20	1.21	0.00	31.91	0.00	99.35	2.97	0.03	0.00	0.58	0.00	1.42	0.00	0.00
C24	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G14 D	35.78	0.00	0.00	4.61	0.00	24.81	0.00	0.00	1.08	1.04	0.00	31.94	0.00	99.25	2.99	0.00	0.00	0.45	0.00	1.56	0.00	0.00
C25	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G15 D	36.07	0.36	0.00	6.16	0.00	22.20	0.00	0.00	0.93	1.32	0.05	31.85	0.00	98.94	2.99	0.02	0.00	0.60	0.00	1.39	0.00	0.00
C26	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G16 E	35.38	0.00	0.00	1.59	0.00	28.74	0.00	0.00	0.79	0.68	0.00	31.52	0.00	98.69	3.01	0.00	0.00	0.16	0.00	1.84	0.00	0.00
C27	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G17 E	35.73	0.00	0.00	4.90	0.00	24.14	0.00	0.00	1.21	0.91	0.00	31.78	0.00	98.67	2.99	0.00	0.00	0.48	0.00	1.52	0.00	0.00
C28	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G18 F	35.10	0.00	0.00	2.84	0.00	26.89	0.00	0.00	1.15	0.89	0.00	31.32	0.00	98.19	2.99	0.00	0.00	0.29	0.00	1.72	0.00	0.00
C29	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G19 F	35.58	0.00	0.00	2.11	0.00	28.04	0.00	0.00	0.28	0.73	0.00	31.84	0.00	98.58	3.02	0.00	0.00	0.21	0.00	1.79	0.00	0.00
C30	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G20 F	35.64	0.00	0.00	2.83	0.00	27.05	0.00	0.00	0.87	0.85	0.00	31.60	0.00	98.83	3.01	0.00	0.00	0.28	0.00	1.72	0.00	0.00
C31	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G21 F	34.81	0.00	0.00	2.23	0.00	28.17	0.00	0.00	0.71	0.90	0.00	31.74	0.00	98.56	2.97	0.00	0.00	0.22	0.00	1.81	0.00	0.00
C32	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G22 G	35.45	0.19	0.00	4.72	0.00	23.90	0.00	0.00	1.21	3.01	0.00	29.74	0.00	98.23	3.00	0.01	0.00	0.47	0.00	1.52	0.00	0.00
C33	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G23 G	35.27	0.00	0.00	9.48	0.00	18.71	0.00	0.00	2.44	0.45	0.00	32.12	0.00	98.47	2.91	0.00	0.00	0.92	0.00	1.16	0.00	0.00
C34	Pyroxene-garnet endoskarn	LEC 2.S5	94282	-135.6	G24 G	36.18	0.41	0.00	6.66	0.00	21.16	0.00	0.00	0.89	2.29	0.00	30.96	0.00	98.55	3.00	0.03	0.00	0.65	0.00	1.32	0.00	0.00
D1	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G1 A	38.30	0.38	0.00	2.75	0.00	27.28	0.00	0.00	0.00	1.30	0.06	29.52	0.00	99.59	3.16	0.02	0.00	0.27	0.00	1.69	0.00	0.00
D2	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G2 A	34.90	0.56	0.00	4.20	0.00	25.91	0.00	0.00	1.36	1.90	0.07	31.07	0.00	99.97	2.92	0.04	0.00	0.41	0.00	1.63	0.00	0.00

D3	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G3 A	35.37	0.66	0.00	5.78	0.00	23.68	0.00	0.00	0.18	1.62	0.00	32.65	0.00	99.94	2.92	0.04	0.00	0.56	0.00	1.47	0.00	0.00
D4	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G4 B	35.66	0.69	0.00	7.78	0.00	21.10	0.00	0.00	0.51	0.77	0.11	33.39	0.00	100.00	2.91	0.04	0.00	0.75	0.00	1.30	0.00	0.00
D5	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G5 B	35.99	1.19	0.00	7.96	0.00	20.70	0.00	0.00	0.83	0.74	0.05	33.44	0.00	100.90	2.91	0.07	0.00	0.76	0.00	1.26	0.00	0.00
D6	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G6 B	35.72	0.76	0.00	7.87	0.00	20.99	0.00	0.00	0.96	0.60	0.05	33.32	0.00	100.27	2.91	0.05	0.00	0.76	0.00	1.29	0.00	0.00
D7	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G7 B	35.58	1.17	0.00	5.85	0.00	23.22	0.00	0.00	0.61	0.83	0.00	32.94	0.00	100.19	2.92	0.07	0.00	0.57	0.00	1.44	0.00	0.00
D8	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G8 C	36.48	0.51	0.00	8.65	0.00	20.03	0.00	0.00	0.47	0.78	0.00	34.01	0.00	100.92	2.94	0.03	0.00	0.82	0.00	1.21	0.00	0.00
D9	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G9 C	36.45	0.73	0.00	10.40	0.00	17.41	0.00	0.00	1.33	1.82	0.00	32.65	0.00	100.78	2.92	0.04	0.00	0.98	0.00	1.05	0.00	0.00
D10	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G10 C	36.42	0.62	0.00	9.15	0.00	19.50	0.00	0.00	0.29	1.08	0.00	34.08	0.00	101.13	2.92	0.04	0.00	0.87	0.00	1.18	0.00	0.00
D11	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G11 D	36.22	0.00	0.00	5.46	0.00	24.59	0.00	0.00	1.02	0.49	0.00	33.30	0.00	101.08	2.96	0.00	0.00	0.53	0.00	1.51	0.00	0.00
D12	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G12 D	36.08	1.07	0.00	7.90	0.00	20.85	0.00	0.00	0.62	0.77	0.06	33.60	0.00	100.94	2.92	0.06	0.00	0.75	0.00	1.27	0.00	0.00
D13	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G13 D	36.41	0.00	0.00	6.29	0.00	23.24	0.00	0.00	1.43	0.39	0.00	33.09	0.00	100.84	2.97	0.00	0.00	0.60	0.00	1.43	0.00	0.00
D14	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G14 E	35.75	0.82	0.00	5.32	0.00	23.89	0.00	0.00	0.70	2.17	0.06	31.60	0.00	100.31	2.95	0.05	0.00	0.52	0.00	1.48	0.00	0.00
D15	Garnet-pyroxene endoskarn	LEC 9.S14	94319	-141.98	G15 E	35.89	0.81	0.00	5.07	0.00	24.51	0.00	0.00	0.85	2.16	0.08	31.65	0.00	101.01	2.95	0.05	0.00	0.49	0.00	1.51	0.00	0.00
D16	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G1 A	36.30	0.00	0.00	6.95	0.00	22.36	0.00	0.00	1.05	0.84	0.00	33.08	0.00	100.57	2.96	0.00	0.00	0.67	0.00	1.37	0.00	0.00
D17	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G2 A	36.32	0.00	0.00	8.09	0.00	20.45	0.00	0.00	0.63	0.77	0.00	33.39	0.00	99.65	2.97	0.00	0.00	0.78	0.00	1.26	0.00	0.00
D18	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G3 A	36.59	0.08	0.00	8.04	0.00	20.77	0.00	0.00	1.08	0.84	0.00	33.26	0.00	100.66	2.96	0.00	0.00	0.77	0.00	1.27	0.00	0.00
D19	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G4 B	35.88	0.85	0.00	9.59	0.00	17.03	0.00	0.00	1.46	6.18	0.00	27.87	0.00	98.86	2.96	0.05	0.00	0.93	0.00	1.06	0.00	0.00
D20	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G5 C	36.15	0.12	0.00	8.80	0.00	19.19	0.00	0.00	1.74	4.90	0.00	29.09	0.06	100.04	2.96	0.01	0.00	0.85	0.00	1.18	0.00	0.00

D21	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G6 C	35.81	0.87	0.00	9.13	0.00	17.65	0.00	0.00	1.42	4.81	0.00	28.90	0.00	98.60	2.96	0.05	0.00	0.89	0.00	1.10	0.00	0.00
D22	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G7 C	36.05	0.13	0.00	8.95	0.00	18.74	0.00	0.00	1.64	4.57	0.00	29.30	0.00	99.38	2.96	0.01	0.00	0.87	0.00	1.16	0.00	0.00
D23	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G8 D	36.12	0.00	0.00	6.73	0.00	22.17	0.00	0.00	1.22	3.71	0.00	30.28	0.00	100.24	2.97	0.00	0.00	0.65	0.00	1.37	0.00	0.00
D24	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G9 D	36.04	0.29	0.00	7.62	0.00	20.48	0.00	0.00	1.19	3.86	0.00	30.04	0.00	99.52	2.97	0.02	0.00	0.74	0.00	1.27	0.00	0.00
D25	Garnet-pyroxene endoskarn	LEC 10.S15	94333	-182.95	G10 D	35.96	0.42	0.00	6.82	0.00	21.65	0.00	0.00	1.37	3.64	0.00	30.03	0.00	99.88	2.97	0.03	0.00	0.66	0.00	1.34	0.00	0.00
D26	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G1 A	35.99	0.32	0.00	7.03	0.00	21.37	0.00	0.00	2.09	3.26	0.05	29.72	0.00	99.83	2.97	0.02	0.00	0.68	0.00	1.33	0.00	0.00
D27	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G2 A	36.00	0.23	0.00	7.11	0.00	21.33	0.00	0.00	1.69	3.15	0.00	30.22	0.00	99.72	2.97	0.01	0.00	0.69	0.00	1.32	0.00	0.00
D28	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G3 A	36.04	0.16	0.00	6.83	0.00	21.90	0.00	0.00	1.82	3.12	0.00	30.22	0.00	100.09	2.97	0.01	0.00	0.66	0.00	1.36	0.00	0.00
D29	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G4 B	36.00	0.29	0.00	6.70	0.00	22.09	0.00	0.00	1.56	2.81	0.00	30.68	0.00	100.11	2.96	0.02	0.00	0.65	0.00	1.37	0.00	0.00
D30	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G5 B	35.30	0.75	0.00	5.90	0.00	23.10	0.00	0.00	1.21	2.62	0.00	30.82	0.00	99.69	2.93	0.05	0.00	0.58	0.00	1.44	0.00	0.00
D31	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G6 B	35.54	0.76	0.00	6.07	0.00	22.83	0.00	0.00	1.33	2.41	0.00	30.98	0.00	99.92	2.94	0.05	0.00	0.59	0.00	1.42	0.00	0.00
D32	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G7 C	35.35	0.42	0.00	5.45	0.00	24.03	0.00	0.00	0.82	3.57	0.00	30.45	0.00	100.09	2.94	0.03	0.00	0.53	0.00	1.50	0.00	0.00
D33	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G8 C	35.47	0.54	0.00	5.55	0.00	23.55	0.00	0.00	1.57	2.59	0.00	30.50	0.00	99.77	2.95	0.03	0.00	0.54	0.00	1.47	0.00	0.00
D34	Garnet-pyroxene endoskarn	LEC 11.S2	94343	-137.35	G9 C	35.50	0.31	0.00	6.55	0.00	22.24	0.00	0.00	1.61	3.34	0.07	29.90	0.00	99.52	2.95	0.02	0.00	0.64	0.00	1.39	0.00	0.00
D35	Garnet-pyroxene endoskarn	LEC 14.S7	94362	-176.47	G1 A	37.18	0.00	0.00	10.40	0.00	17.73	0.00	0.00	0.61	0.73	0.00	34.32	0.00	100.97	2.96	0.00	0.00	0.98	0.00	1.06	0.00	0.00
D36	Garnet-pyroxene endoskarn	LEC 14.S7	94362	-176.47	G2 A	37.29	0.00	0.00	10.80	0.00	17.16	0.00	0.00	0.71	0.61	0.00	34.42	0.00	100.98	2.96	0.00	0.00	1.01	0.00	1.03	0.00	0.00
D37	Garnet-pyroxene endoskarn	LEC 14.S7	94362	-176.47	G3 A	36.82	0.00	0.00	10.09	0.00	18.19	0.00	0.00	0.96	0.72	0.00	33.91	0.00	100.69	2.95	0.00	0.00	0.95	0.00	1.10	0.00	0.00
D38	Garnet-pyroxene endoskarn	LEC 14.S7	94362	-176.47	G4 B	37.18	0.09	0.00	10.94	0.00	17.06	0.00	0.00	0.68	0.69	0.00	34.45	0.00	101.07	2.95	0.01	0.00	1.02	0.00	1.02	0.00	0.00

D39	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G5 B	36.79	0.51	0.00	8.38	0.00	19.92	0.00	0.00	0.51	0.93	0.00	33.63	0.00	100.67	2.97	0.03	0.00	0.80	0.00	1.21	0.00	0.00
D40	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G6 B	36.59	0.47	0.00	8.31	0.00	20.05	0.00	0.00	0.61	0.93	0.00	33.48	0.00	100.44	2.96	0.03	0.00	0.79	0.00	1.22	0.00	0.00
D41	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G7 C	36.83	0.23	0.00	11.50	0.00	16.04	0.00	0.00	0.74	0.43	0.00	34.42	0.00	100.19	2.94	0.01	0.00	1.08	0.00	0.96	0.00	0.00
D42	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G8 C	37.11	0.26	0.00	11.88	0.00	15.52	0.00	0.00	0.89	0.79	0.00	34.19	0.00	100.65	2.95	0.02	0.00	1.11	0.00	0.93	0.00	0.00
D43	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G9 C	37.15	0.41	0.00	11.72	0.00	16.02	0.00	0.00	0.75	0.45	0.00	34.78	0.00	101.27	2.93	0.02	0.00	1.09	0.00	0.95	0.00	0.00
D44	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G10 D	37.00	0.24	0.00	11.08	0.00	17.09	0.00	0.00	0.18	0.49	0.00	35.12	0.00	101.19	2.93	0.01	0.00	1.03	0.00	1.02	0.00	0.00
D45	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G11 D	36.38	0.33	0.00	9.33	0.00	18.91	0.00	0.00	0.72	1.16	0.00	33.38	0.00	100.22	2.94	0.02	0.00	0.89	0.00	1.15	0.00	0.00
D46	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G12 D	36.88	0.20	0.00	10.24	0.00	17.87	0.00	0.00	0.48	0.64	0.00	34.37	0.00	100.67	2.95	0.01	0.00	0.96	0.00	1.07	0.00	0.00
D47	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G13 D	36.69	0.19	0.00	11.17	0.00	16.52	0.00	0.00	0.47	0.50	0.00	34.49	0.00	100.02	2.94	0.01	0.00	1.06	0.00	1.00	0.00	0.00
D48	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G14 E	35.73	1.34	0.00	6.69	0.00	22.09	0.00	0.00	1.11	2.92	0.07	31.04	0.00	100.99	2.92	0.08	0.00	0.64	0.00	1.36	0.00	0.00
D49	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G15 E	35.43	1.08	0.00	6.67	0.00	22.60	0.00	0.00	1.23	3.19	0.07	30.86	0.00	101.12	2.90	0.07	0.00	0.64	0.00	1.39	0.00	0.00
D50	Garnet-pyroxene endoskarn	LEC 14. S7	94362	-176.47	G16 E	35.69	1.18	0.00	7.14	0.00	21.29	0.00	0.00	1.37	2.68	0.00	30.99	0.00	100.33	2.92	0.07	0.00	0.69	0.00	1.31	0.00	0.00
E1	(Garnet)-pyroxene endoskarn	LEC 9. S11	94316	-137.78	G1 A	36.97	0.30	0.00	18.46	0.00	4.16	0.00	0.00	8.08	10.49	0.00	20.20	0.00	98.66	2.98	0.02	0.00	1.75	0.00	0.25	0.00	0.00
E2	(Garnet)-pyroxene endoskarn	LEC 9. S11	94316	-137.78	G2 A	36.72	0.43	0.00	16.62	0.09	7.02	0.00	0.00	3.30	6.72	0.00	26.89	0.00	97.80	2.96	0.03	0.00	1.58	0.01	0.43	0.00	0.00
E3	(Garnet)-pyroxene endoskarn	LEC 9. S11	94316	-137.78	G3 B	36.49	0.28	0.00	18.38	0.00	5.02	0.00	0.00	7.93	9.50	0.00	21.38	0.00	98.97	2.94	0.02	0.00	1.74	0.00	0.30	0.00	0.00
E4	(Garnet)-pyroxene endoskarn	LEC 9. S11	94316	-137.78	G4 B	36.86	0.33	0.00	18.30	0.00	5.06	0.00	0.00	6.03	7.92	0.00	24.21	0.00	98.70	2.95	0.02	0.00	1.73	0.00	0.30	0.00	0.00
E5	(Garnet)-pyroxene endoskarn	LEC 9. S11	94316	-137.78	G5 C	35.30	0.59	0.00	5.26	0.00	23.55	0.00	0.00	1.51	2.87	0.00	29.99	0.00	99.06	2.96	0.04	0.00	0.52	0.00	1.49	0.00	0.00
E6	(Garnet)-pyroxene endoskarn	LEC 9. S11	94316	-137.78	G6 C	35.25	0.65	0.00	5.36	0.00	23.84	0.00	0.00	1.10	2.56	0.00	30.84	0.00	99.60	2.94	0.04	0.00	0.53	0.00	1.50	0.00	0.00

E7	(Garnet)-pyroxene endoskarn	LEC 9.S11	94316	-137.78	G7 D	35.56	0.67	0.00	5.94	0.00	22.95	0.00	0.00	2.27	2.47	0.00	30.12	0.00	99.99	2.95	0.04	0.00	0.58	0.00	1.43	0.00	0.00
E8	(Garnet)-pyroxene endoskarn	LEC 9.S11	94316	-137.78	G8 D	35.30	1.18	0.00	6.30	0.00	22.15	0.00	0.00	1.32	2.81	0.08	30.39	0.00	99.52	2.93	0.07	0.00	0.62	0.00	1.38	0.00	0.00
E9	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G1 A	36.76	0.30	0.00	20.47	0.00	2.16	0.00	0.00	7.84	14.11	0.13	17.98	0.00	99.75	2.93	0.02	0.00	1.92	0.00	0.13	0.00	0.00
E10	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G2 A	37.28	0.21	0.00	19.95	0.00	3.03	0.00	0.00	7.05	13.54	0.10	19.31	0.00	100.47	2.95	0.01	0.00	1.86	0.00	0.18	0.00	0.00
E11	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G3 B	36.83	0.33	0.00	20.03	0.00	0.00	0.00	0.00	10.31	17.94	0.11	13.92	0.00	99.46	2.98	0.02	0.00	1.91	0.00	0.00	0.00	0.00
E12	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G4 B	35.58	0.37	0.00	19.60	0.00	2.31	0.00	0.00	6.71	19.41	0.09	13.55	0.00	97.62	2.93	0.02	0.00	1.90	0.00	0.14	0.00	0.00
E13	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G5 C	35.75	0.33	0.00	19.90	0.00	2.90	0.00	0.00	6.97	18.65	0.11	14.49	0.17	99.26	2.90	0.02	0.00	1.90	0.00	0.18	0.00	0.00
E14	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G6 C	36.25	0.36	0.00	19.82	0.00	2.49	0.00	0.00	7.96	18.27	0.12	14.01	0.00	99.28	2.93	0.02	0.00	1.89	0.00	0.15	0.00	0.00
E15	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G7 D	35.98	0.00	0.00	20.28	0.00	2.92	0.00	0.00	7.66	15.13	0.15	17.21	0.00	99.32	2.90	0.00	0.00	1.93	0.00	0.18	0.00	0.00
E16	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G8 D	36.33	0.23	0.00	20.37	0.00	2.53	0.00	0.00	7.20	15.16	0.11	17.64	0.00	99.55	2.91	0.01	0.00	1.92	0.00	0.15	0.00	0.00
E17	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G9 E	36.22	0.23	0.00	19.88	0.00	3.37	0.00	0.00	5.72	14.77	0.06	19.17	0.00	99.43	2.90	0.01	0.00	1.88	0.00	0.20	0.00	0.00
E18	(Garnet)-pyroxene endoskarn	LEC 9.S12	94317	-141.21	G10 E	36.17	0.20	0.00	19.60	0.00	3.36	0.00	0.00	5.88	13.79	0.06	19.51	0.00	98.57	2.92	0.01	0.00	1.87	0.00	0.20	0.00	0.00

continued

Sample	Fe2+	Mn	Mg	Ca	Na	Total	Tet-Al	Tet-Fe	Pyrope	Almandine	Grossular	Spessartine	Uvarovite	Andradite	Knoringite	Schorlorrite	Yttrogarnet	Yamatoite	Goldmanite	Kimzeyite	FerricKimzeyite	Khoharite	Skiagite	Calderite	Name
A1	0.07	0.06	0.00	2.89	0.00	0.00	0.03	0.00	0.00	2.32	9.65	0.45	0.00	87.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
A2	0.06	0.07	0.00	2.89	0.00	0.00	0.05	0.00	0.00	0.10	9.09	2.38	0.00	87.73	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
A3	0.09	0.14	0.00	2.79	0.00	0.00	0.05	0.00	0.00	0.80	0.00	3.47	0.00	94.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	Spessartine-Andradite
A4	0.04	0.08	0.00	2.89	0.00	0.00	0.03	0.00	0.00	0.00	12.21	2.57	0.00	84.57	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
A5	0.03	0.05	0.00	2.94	0.00	0.00	0.04	0.00	0.00	0.00	11.05	0.96	0.00	87.42	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
A6	0.07	0.06	0.00	2.89	0.00	0.00	0.03	0.00	0.00	2.46	6.97	0.00	0.00	90.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
A7	0.01	0.05	0.00	2.95	0.00	0.00	0.07	0.00	0.00	0.00	11.08	1.12	0.00	85.47	0.00	2.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
B1	0.51	0.98	0.01	1.52	0.00	0.00	0.04	0.00	0.00	15.98	40.30	32.95	0.00	10.17	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B2	0.47	0.96	0.01	1.58	0.00	0.00	0.03	0.00	0.00	15.16	41.11	32.03	0.00	10.91	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B3	0.56	1.08	0.01	1.36	0.00	0.00	0.04	0.00	0.00	17.99	37.82	36.22	0.00	6.94	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B4	0.55	1.13	0.01	1.32	0.00	0.00	0.06	0.00	0.00	17.06	35.42	38.20	0.00	8.19	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
B5	0.46	0.98	0.01	1.57	0.00	0.00	0.06	0.00	0.00	13.63	43.07	33.21	0.00	9.33	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B6	0.44	0.95	0.01	1.63	0.00	0.00	0.06	0.00	0.00	0.00	49.70	36.77	0.00	12.65	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B7	0.49	0.98	0.01	1.54	0.00	0.00	0.05	0.00	0.00	15.21	40.42	33.06	0.00	10.36	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B8	0.50	1.00	0.01	1.49	0.00	0.00	0.03	0.00	0.00	16.35	39.02	33.67	0.00	10.05	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B9	0.36	1.07	0.01	1.57	0.00	0.00	0.04	0.00	0.00	11.18	41.58	35.98	0.00	10.49	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B10	0.44	1.03	0.01	1.54	0.00	0.00	0.04	0.00	0.00	13.21	43.26	34.69	0.00	8.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B11	0.46	1.04	0.01	1.49	0.00	0.00	0.03	0.00	0.00	0.00	47.02	41.12	0.00	10.88	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B12	0.48	1.03	0.01	1.48	0.00	0.00	0.02	0.00	0.34	16.00	40.16	34.29	0.00	8.36	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B13	0.56	1.24	0.01	1.31	0.00	0.00	0.02	0.00	0.00	9.58	45.72	43.95	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B14	0.42	1.21	0.01	1.36	0.00	0.00	0.02	0.00	0.05	14.03	37.95	40.37	0.00	6.94	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
B15	0.42	1.00	0.01	1.56	0.00	0.00	0.02	0.00	0.38	14.10	43.32	33.45	0.00	7.87	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B16	0.39	1.10	0.01	1.50	0.00	0.00	0.03	0.00	0.00	12.65	42.38	36.97	0.00	7.49	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B17	0.66	1.47	0.01	0.93	0.00	0.00	0.02	0.00	0.00	17.84	31.72	50.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
B18	0.65	1.40	0.01	1.05	0.00	0.00	0.01	0.00	0.00	14.57	36.55	48.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine

B19	0.63	1.35	0.01	1.14	0.00	0.00	0.03	0.00	0.00	12.18	40.17	47.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
B20	0.53	1.35	0.01	1.11	0.00	0.00	0.04	0.00	0.00	17.42	28.59	45.38	0.00	7.39	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
B21	0.43	1.42	0.01	1.17	0.00	0.00	0.05	0.00	0.00	12.39	30.63	48.06	0.00	8.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
B22	0.52	1.03	0.01	1.45	0.00	0.00	0.02	0.00	0.00	17.36	40.07	34.27	0.00	7.50	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B23	0.54	1.03	0.01	1.44	0.00	0.00	0.05	0.00	0.00	17.24	39.25	34.51	0.00	7.88	0.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B24	0.46	1.11	0.01	1.43	0.00	0.00	0.05	0.00	0.00	0.00	46.33	43.77	0.00	8.76	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B25	0.54	0.95	0.01	1.51	0.00	0.00	0.05	0.00	0.00	0.00	51.69	38.70	0.00	8.68	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B26	0.63	1.07	0.01	1.40	0.00	0.00	0.02	0.00	0.00	13.26	48.09	37.64	0.00	0.00	0.00	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
B27	0.64	1.07	0.01	1.41	0.00	0.00	0.04	0.00	0.00	12.55	48.79	37.68	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
C1	0.02	0.20	0.00	2.79	0.00	0.00	0.09	0.00	0.00	0.00	34.29	0.00	0.00	63.19	0.00	2.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C2	0.01	0.15	0.00	2.87	0.00	0.00	0.09	0.00	0.00	0.00	22.83	0.00	0.00	75.71	0.00	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C3	0.03	0.09	0.01	2.89	0.00	0.00	0.09	0.00	0.00	0.00	14.81	2.91	0.00	78.80	0.00	3.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C4	0.03	0.10	0.01	2.87	0.00	0.00	0.08	0.00	0.00	0.41	16.04	3.20	0.00	77.35	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C5	0.03	0.18	0.00	2.81	0.00	0.00	0.07	0.00	0.00	0.00	23.03	4.62	0.00	71.26	0.00	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C6	0.01	0.19	0.00	2.83	0.00	0.00	0.07	0.00	0.00	0.00	22.58	3.76	0.00	73.14	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C7	0.13	0.15	0.00	2.73	0.00	0.00	0.06	0.00	0.00	3.13	7.53	5.10	0.00	82.64	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C8	0.07	0.11	0.00	2.82	0.00	0.00	0.07	0.00	0.00	2.18	21.33	3.57	0.00	69.30	0.00	3.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C9	0.02	0.17	0.00	2.81	0.00	0.00	0.05	0.00	0.00	0.59	8.05	5.77	0.00	83.24	0.00	2.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C10	0.04	0.21	0.01	2.76	0.00	0.00	0.09	0.00	0.00	0.91	10.81	6.92	0.00	77.37	0.00	3.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C11	0.18	0.21	0.01	2.61	0.00	0.00	0.01	0.00	0.00	5.88	16.09	6.99	0.00	70.44	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C12	0.19	0.25	0.00	2.57	0.00	0.00	0.01	0.00	0.00	0.00	13.13	8.72	0.00	77.82	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C13	0.20	0.26	0.01	2.54	0.00	0.00	0.01	0.00	0.26	6.52	14.60	8.59	0.00	69.66	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C14	0.14	0.13	0.00	2.72	0.00	0.00	0.02	0.00	0.00	4.73	14.84	3.58	0.00	75.62	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C15	0.10	0.14	0.00	2.77	0.00	0.00	0.03	0.00	0.00	3.18	8.32	4.55	0.00	82.50	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C16	0.10	0.13	0.01	2.76	0.00	0.00	0.02	0.00	0.01	3.30	10.72	4.33	0.00	80.74	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C17	0.00	0.12	0.01	2.96	0.00	0.00	0.08	0.00	0.00	0.00	22.41	0.00	0.00	75.84	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C18	0.04	0.04	0.00	2.93	0.00	0.00	0.02	0.00	0.00	1.22	19.19	0.61	0.00	78.58	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite

C19	0.08	0.06	0.00	2.86	0.00	0.00	0.00	0.00	0.00	2.65	12.73	1.48	0.00	83.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C20	0.13	0.08	0.00	2.79	0.00	0.00	0.01	0.00	0.00	4.38	20.20	2.04	0.00	72.84	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C21	0.08	0.03	0.00	2.90	0.00	0.00	0.02	0.00	0.00	2.67	13.72	0.15	0.00	83.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C22	0.24	0.04	0.00	2.77	0.00	0.00	0.09	0.00	0.00	0.00	22.56	0.00	0.00	77.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C23	0.08	0.09	0.00	2.83	0.00	0.00	0.03	0.00	0.00	2.73	22.17	2.84	0.00	70.91	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C24	0.08	0.07	0.00	2.86	0.00	0.00	0.01	0.00	0.00	2.57	17.69	0.00	0.00	79.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C25	0.06	0.09	0.01	2.83	0.00	0.00	0.01	0.00	0.00	1.95	24.77	3.11	0.00	69.70	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C26	0.06	0.05	0.00	2.87	0.00	0.00	0.00	0.00	0.00	1.89	3.81	1.64	0.00	92.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C27	0.08	0.06	0.00	2.85	0.00	0.00	0.01	0.00	0.00	2.84	19.06	1.85	0.00	76.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C28	0.08	0.06	0.00	2.86	0.00	0.00	0.01	0.00	0.00	2.75	9.11	1.66	0.00	86.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C29	0.02	0.05	0.00	2.89	0.00	0.00	0.00	0.00	0.00	0.68	7.03	1.78	0.00	90.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C30	0.06	0.06	0.00	2.86	0.00	0.00	0.00	0.00	0.00	2.06	9.44	2.03	0.00	86.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C31	0.05	0.06	0.00	2.90	0.00	0.00	0.03	0.00	0.00	0.11	6.38	2.19	0.00	91.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C32	0.09	0.22	0.00	2.69	0.00	0.00	0.00	0.00	0.00	2.57	13.67	7.22	0.00	76.38	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C33	0.17	0.03	0.00	2.84	0.00	0.00	0.09	0.00	0.00	0.00	38.64	0.00	0.00	61.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
C34	0.06	0.16	0.00	2.75	0.00	0.00	0.00	0.00	0.00	1.54	26.02	5.45	0.00	66.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D1	0.00	0.09	0.01	2.61	0.00	0.00	0.00	0.00	0.28	0.00	2.56	3.35	0.00	93.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Andradite
D2	0.10	0.13	0.01	2.78	0.00	0.00	0.08	0.00	0.00	0.00	9.75	4.60	0.00	83.83	0.00	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D3	0.01	0.11	0.00	2.89	0.00	0.00	0.08	0.00	0.00	0.00	21.48	0.00	0.00	76.41	0.00	2.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D4	0.04	0.05	0.01	2.92	0.00	0.00	0.09	0.00	0.00	0.00	30.88	1.11	0.00	65.86	0.00	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D5	0.06	0.05	0.01	2.90	0.00	0.00	0.09	0.00	0.00	1.90	30.43	0.00	0.00	63.98	0.00	3.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D6	0.07	0.04	0.01	2.91	0.00	0.00	0.09	0.00	0.00	1.65	30.69	0.00	0.00	65.29	0.00	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D7	0.04	0.06	0.00	2.90	0.00	0.00	0.08	0.00	0.00	0.00	21.59	1.95	0.00	72.81	0.00	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D8	0.03	0.05	0.00	2.93	0.00	0.00	0.06	0.00	0.00	0.00	35.96	1.15	0.00	61.32	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D9	0.09	0.12	0.00	2.80	0.00	0.00	0.08	0.00	0.00	1.29	39.22	4.16	0.00	53.12	0.00	2.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D10	0.02	0.07	0.00	2.93	0.00	0.00	0.08	0.00	0.00	0.00	37.44	0.99	0.00	59.68	0.00	1.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D11	0.07	0.03	0.00	2.92	0.00	0.00	0.04	0.00	0.00	1.50	21.85	0.00	0.00	76.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite

D12	0.04	0.05	0.01	2.91	0.00	0.00	0.08	0.00	0.00	0.63	30.51	1.77	0.00	63.83	0.00	3.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D13	0.10	0.03	0.00	2.89	0.00	0.00	0.03	0.00	0.00	2.63	25.31	0.00	0.00	72.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D14	0.05	0.15	0.01	2.79	0.00	0.00	0.05	0.00	0.24	1.61	16.40	5.06	0.00	74.15	0.00	2.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D15	0.06	0.15	0.01	2.78	0.00	0.00	0.05	0.00	0.11	1.94	14.65	5.02	0.00	75.79	0.00	2.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D16	0.07	0.06	0.00	2.89	0.00	0.00	0.04	0.00	0.00	2.34	28.14	0.00	0.00	69.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D17	0.04	0.05	0.00	2.92	0.00	0.00	0.03	0.00	0.00	0.00	34.95	1.48	0.00	63.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D18	0.07	0.06	0.00	2.89	0.00	0.00	0.04	0.00	0.00	2.48	33.12	0.00	0.00	64.16	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D19	0.10	0.43	0.00	2.46	0.00	0.00	0.04	0.00	0.00	3.00	27.31	14.47	0.00	53.15	0.00	2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D20	0.12	0.34	0.00	2.55	0.01	0.00	0.04	0.00	0.00	2.56	25.85	11.44	0.00	59.76	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D21	0.10	0.34	0.00	2.56	0.00	0.00	0.04	0.00	0.00	2.87	28.54	11.29	0.00	55.23	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D22	0.11	0.32	0.00	2.58	0.00	0.00	0.04	0.00	0.00	2.42	27.95	10.72	0.00	58.51	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D23	0.08	0.26	0.00	2.67	0.00	0.00	0.03	0.00	0.00	0.00	20.83	8.83	0.00	70.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D24	0.08	0.27	0.00	2.65	0.00	0.00	0.03	0.00	0.00	2.21	24.12	9.01	0.00	63.76	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D25	0.09	0.25	0.00	2.65	0.00	0.00	0.03	0.00	0.00	2.77	20.04	8.51	0.00	67.38	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D26	0.14	0.23	0.01	2.63	0.00	0.00	0.03	0.00	0.00	4.51	20.30	7.61	0.00	66.57	0.00	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D27	0.12	0.22	0.00	2.67	0.00	0.00	0.03	0.00	0.00	0.00	22.96	7.62	0.00	68.69	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D28	0.13	0.22	0.00	2.67	0.00	0.00	0.03	0.00	0.00	3.14	20.68	7.31	0.00	68.38	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D29	0.11	0.20	0.00	2.71	0.00	0.00	0.04	0.00	0.00	2.67	21.02	6.56	0.00	68.85	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D30	0.08	0.18	0.00	2.74	0.00	0.00	0.07	0.00	0.00	1.75	17.01	6.18	0.00	72.69	0.00	2.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D31	0.09	0.17	0.00	2.75	0.00	0.00	0.06	0.00	0.00	0.00	18.63	5.80	0.00	73.14	0.00	2.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D32	0.06	0.25	0.00	2.71	0.00	0.00	0.06	0.00	0.00	0.06	14.08	8.48	0.00	76.07	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D33	0.11	0.18	0.00	2.72	0.00	0.00	0.05	0.00	0.00	2.81	15.27	6.12	0.00	74.08	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D34	0.11	0.23	0.01	2.66	0.00	0.00	0.05	0.00	0.00	2.43	18.42	7.91	0.00	70.25	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D35	0.04	0.05	0.00	2.93	0.00	0.00	0.04	0.00	0.00	0.00	45.11	1.07	0.00	53.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D36	0.05	0.04	0.00	2.93	0.00	0.00	0.04	0.00	0.00	1.09	46.98	0.00	0.00	51.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D37	0.06	0.05	0.00	2.91	0.00	0.00	0.05	0.00	0.00	1.31	42.93	0.00	0.00	55.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D38	0.04	0.05	0.00	2.93	0.00	0.00	0.05	0.00	0.00	0.00	47.16	0.89	0.00	51.70	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite

D39	0.03	0.06	0.00	2.90	0.00	0.00	0.04	0.00	0.00	0.00	35.25	2.13	0.00	61.06	0.00	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D40	0.04	0.06	0.00	2.90	0.00	0.00	0.04	0.00	0.00	0.74	34.42	2.13	0.00	61.28	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D41	0.05	0.03	0.00	2.94	0.00	0.00	0.06	0.00	0.00	0.32	50.04	0.00	0.00	48.93	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Andradite-Grossular
D42	0.06	0.05	0.00	2.91	0.00	0.00	0.05	0.00	0.00	1.82	50.41	0.00	0.00	46.97	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Andradite-Grossular
D43	0.05	0.03	0.00	2.94	0.00	0.00	0.07	0.00	0.00	0.50	49.99	0.00	0.00	48.29	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Andradite-Grossular
D44	0.01	0.03	0.00	2.98	0.00	0.00	0.07	0.00	0.00	0.00	47.41	0.00	0.00	51.88	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D45	0.05	0.08	0.00	2.89	0.00	0.00	0.06	0.00	0.00	0.00	38.38	2.34	0.00	58.26	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D46	0.03	0.04	0.00	2.94	0.00	0.00	0.05	0.00	0.00	0.00	44.38	0.53	0.00	54.47	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D47	0.03	0.03	0.00	2.96	0.00	0.00	0.06	0.00	0.00	0.00	48.80	0.00	0.00	50.62	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D48	0.08	0.20	0.01	2.71	0.00	0.00	0.08	0.00	0.25	2.52	18.51	6.72	0.00	67.88	0.00	4.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D49	0.08	0.22	0.01	2.70	0.00	0.00	0.10	0.00	0.00	0.00	17.70	7.55	0.00	71.35	0.00	3.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
D50	0.09	0.19	0.00	2.72	0.00	0.00	0.08	0.00	0.00	0.00	22.11	6.39	0.00	67.74	0.00	3.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
E1	0.54	0.72	0.00	1.74	0.00	0.00	0.02	0.00	0.00	17.93	44.64	23.89	0.00	12.62	0.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
E2	0.22	0.46	0.00	2.32	0.00	0.00	0.04	0.00	0.00	6.86	54.77	15.37	0.30	21.39	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Andradite-Grossular
E3	0.53	0.65	0.00	1.84	0.00	0.00	0.06	0.00	0.00	15.66	46.12	21.92	0.00	15.44	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
E4	0.40	0.54	0.00	2.08	0.00	0.00	0.05	0.00	0.00	12.03	53.50	18.08	0.00	15.40	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
E5	0.11	0.20	0.00	2.69	0.00	0.00	0.04	0.00	0.00	3.31	13.66	6.80	0.00	74.36	0.00	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
E6	0.08	0.18	0.00	2.75	0.00	0.00	0.06	0.00	0.00	1.45	15.12	6.07	0.00	75.33	0.00	2.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
E7	0.16	0.17	0.00	2.67	0.00	0.00	0.05	0.00	0.00	4.70	15.57	5.81	0.00	71.82	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
E8	0.09	0.20	0.01	2.70	0.00	0.00	0.07	0.00	0.27	3.05	17.30	6.58	0.00	69.19	0.00	3.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Andradite
E9	0.52	0.95	0.02	1.54	0.00	0.00	0.07	0.00	0.00	15.58	44.59	32.32	0.00	6.60	0.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
E10	0.47	0.91	0.01	1.64	0.00	0.00	0.05	0.00	0.00	0.00	52.96	35.67	0.00	10.65	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
E11	0.70	1.23	0.01	1.21	0.00	0.00	0.04	0.00	0.00	13.74	41.67	43.53	0.00	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
E12	0.46	1.35	0.01	1.20	0.00	0.00	0.07	0.00	0.00	0.00	37.11	53.11	0.00	8.42	0.00	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
E13	0.47	1.28	0.01	1.26	0.03	0.00	0.10	0.00	0.00	12.99	33.00	43.89	0.00	9.09	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
E14	0.54	1.25	0.01	1.22	0.00	0.00	0.07	0.00	0.00	16.50	32.30	42.39	0.00	7.70	0.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Grossular-Spessartine
E15	0.52	1.03	0.02	1.49	0.00	0.00	0.10	0.00	0.00	0.00	48.47	41.00	0.00	10.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular

E16	0.48	1.03	0.01	1.51	0.00	0.00	0.09	0.00	0.00	0.00	49.74	40.46	0.00	8.98	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
E17	0.38	1.00	0.01	1.65	0.00	0.00	0.10	0.00	0.00	0.00	49.86	37.85	0.00	11.51	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular
E18	0.40	0.94	0.01	1.69	0.00	0.00	0.08	0.00	0.00	0.00	51.84	35.84	0.00	11.63	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Spessartine-Grossular

Appendix G – Average grade per borehole (whole-rock data)

The weighted average grade for WO_3 and REE were calculated using the whole-rock data of the respective boreholes. This was done to create an idea of in which borehole intersection/cross-sectional area most of the mineralization lies. This was supported by what was observed in thin-section and through the vertical distribution plots.

A cut-off grade of 0.05% WO_3 was used to delineate between the low and the medium and high grade zones respectively. The high grade zone is above 0.2% WO_3, thus the medium grade zone is between 0.05% and 0.2% WO_3. REE was calculated but not cut-off based. Green indicates the low grade zone, whereas orange indicates the medium grade zone and lastly red indicates the high grade zone.

Boreholes			**Average grade WO_3 (%)**	**Average grade REE (%)**
	MZ / NMZ	**Length of section (meters)**		
A+400	MZ	From 44.71 to 83.2m	0.05	0.03
	NMZ	From 84.2 to 150.5m	0.04	0.01
AA+200	MZ	From 129.67 to 195.62m	0.14	0.04
	NMZ	From 196.6 to 229m	0.09	0.02
BB+200	MZ	From 161 to 249.98m	0.17	0.11
	NMZ	From 250 to 285m	0.04	0.02
BB+300	MZ	From 126.84 to 199m	0.08	0.14
	NMZ	From 200 to 273.6m	0.06	0.05
BB+400	MZ	From 120.12 to 167.66m	0.31	0.21
	NMZ	From 171.65 to 217.03m	0.05	0.02
BBCC+350	MZ	From 139.36 to 199.7m	0.17	0.18
	NMZ	From 200.7 to 239.9m	0.05	0.06
CC+200	MZ	From 157.33 to 221.35m	0.43	0.33
	NMZ	From 224.35 to 253.63m	0.16	0.06
CC+400	MZ	From 117.7 to 171.79m	0.17	0.08
	NMZ	From 173.45 to 220.51m	0.02	0.02
DD+200	MZ	From 158.15 to 200.54m	0.26	0.03
	NMZ	From 203.54 to 259m	0.17	0.02
E-200	MZ	From 302.4 to 324.56m	0.04	0.09
	NMZ	From 325.56 to 335.53m	0.02	0.03

Appendix H - Geochemical data per borehole

H1. Geochemistry tables

The data displayed in this appendix is the whole rock major, minor and trace elements for each borehole displayed. Boreholes BB+200, BB+300, BBCC+350 and CC+200 have only been analysed for trace elements. Major and minor elements (SiO_2, Al_2O_3, CaO, FeO, Fe_2O_3, K_2O, MgO, MnO, Na_2O, P_2O_5 and TiO_2) are reported in weight percent, and trace (Ag, As, B, Ba, Be, Bi, Cd, Ce, Co, Cr, Cs, Dy, Er, Eu, Ga, Gd, Hf, Ho, In, La, Li, Nb, Nd, Ni, Pr, Rb, Re, Sb, Sc, Se, Sm, Sr, Ta, Tb, Te, Th, Tl, Tm, U, V, Y, Yb, Zr) and ore (Cu, Pb, Zn, W, Mo, Sn) elements are reported in parts per million (ppm). Refer to appendix C for the units, detection limits and methods that were used for each element in each borehole intersection.

1. *A+400*

Sample	A400_003	A400_004	A400_006	A400_007	A400_008	A400_009	A400_011	A400_012	A400_013	A400_014	A400_016	A400_017	A400_018	A400_019
Depth	-44.71	-48.75	-49.88	-50.85	-51.40	-52.40	-53.40	-54.40	-55.40	-56.40	-57.40	-58.00	-59.00	-60.00
SiO2	63.75	65.03	64.60	67.17	68.45	69.52	68.88	71.66	68.24	68.24	62.46	69.95	64.18	67.17
Al2O3	9.84	11.07	11.28	9.69	11.62	11.34	10.37	10.83	12.41	10.18	10.85	12.24	11.66	10.47
FeO	7.93	4.39	4.18	4.01	2.94	2.88	3.29	3.05	2.79	3.21	4.63	2.26	2.35	2.46
Fe2O3	3.78	2.09	1.99	1.91	1.40	1.37	1.57	1.45	1.33	1.53	2.20	1.08	1.12	1.17
K2O	2.83	3.43	3.53	2.93	3.52	3.45	3.16	3.32	3.69	2.93	3.14	3.55	3.49	3.20
MgO	1.09	0.99	1.67	1.82	1.34	1.43	1.46	1.09	1.43	1.43	1.67	2.04	2.24	1.74
MnO	0.69	0.35	0.29	0.30	0.19	0.20	0.23	0.16	0.16	0.18	0.24	0.28	0.33	0.29
Na2O	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.04
P2O5	0.18	0.11	0.11	0.09	0.11	0.09	0.09	0.09	0.09	0.05	0.02	0.11	0.11	0.09
TiO2	0.42	0.30	0.30	0.25	0.25	0.27	0.25	0.27	0.30	0.27	0.27	0.33	0.32	0.30
Ag	2.50	2.50	2.50	9.00	2.50	5.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Al	5.21	5.86	5.97	5.13	6.15	6.00	5.49	5.73	6.57	5.39	5.74	6.48	6.17	5.54
As	31.00	10.00	23.00	10.00	10.00	10.00	10.00	30.00	35.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	961.00	1281.00	1271.00	1208.00	1434.00	1346.00	1180.00	1267.00	1430.00	1323.00	1440.00	1572.00	1533.00	1396.00
Be	20.00	20.00	19.00	18.00	16.00	16.00	15.00	18.00	19.00	16.00	19.00	23.00	21.00	18.00
Bi	8.50	26.10	27.50	91.20	8.90	44.80	12.60	17.30	7.20	14.30	20.70	2.60	3.00	5.90
Ca	0.40	0.30	1.50	1.70	1.30	1.40	1.40	0.70	1.50	1.80	2.40	2.90	3.50	2.70
CaO	0.56	0.42	2.10	2.38	1.82	1.96	1.96	0.98	2.10	2.52	3.36	4.06	4.90	3.78
Cd	4.00	6.00	2.00	7.00	3.00	2.00	3.00	2.00	1.00	1.00	1.00	0.05	0.05	2.00
Ce	256.90	133.70	298.00	491.10	791.40	300.80	111.30	108.00	106.30	117.30	160.40	160.00	139.90	84.70
Co	11.00	8.00	6.00	5.00	4.00	4.00	4.00	6.00	4.00	4.00	3.00	2.00	2.00	3.00
Cr	324.00	159.00	121.00	318.00	126.00	198.00	222.00	135.00	234.00	130.00	201.00	117.00	216.00	155.00
Cs	17.48	20.95	20.87	19.07	19.42	18.47	16.61	17.80	19.31	16.31	17.15	22.00	19.67	15.49
Cu	435.00	281.00	272.00	666.00	265.00	198.00	209.00	213.00	183.00	198.00	204.00	160.00	130.00	145.00
Dy	2.50	1.70	2.00	2.40	2.30	2.10	1.80	1.50	1.60	1.50	1.80	1.80	1.80	1.40

Er	1.20	0.90	1.10	1.20	1.00	0.90	0.80	0.70	0.80	0.70	0.80	0.90	0.80	0.70
Eu	1.70	1.10	1.70	2.20	2.60	1.90	1.20	1.00	1.20	1.10	1.40	1.50	1.50	1.10
Fe	8.81	4.87	4.64	4.45	3.26	3.20	3.65	3.39	3.10	3.56	5.14	2.51	2.61	2.73
Ga	30.00	32.00	30.00	27.00	26.00	26.00	25.00	28.00	29.00	24.00	23.00	28.00	25.00	22.00
Gd	3.70	2.50	3.00	4.00	4.80	3.60	2.50	2.30	2.80	2.30	2.80	2.90	2.50	1.80
Hf	4.90	4.70	5.90	3.50	4.10	4.50	8.20	5.00	6.00	9.20	6.60	8.50	6.60	4.90
Ho	0.40	0.30	0.40	0.40	0.40	0.40	0.30	0.30	0.30	0.30	0.30	0.40	0.30	0.20
In	0.70	0.40	0.40	0.60	0.30	0.30	0.20	0.20	0.30	0.20	0.20	0.20	0.20	0.20
K	2.35	2.85	2.93	2.43	2.92	2.86	2.62	2.76	3.06	2.43	2.61	2.95	2.90	2.66
La	162.30	79.70	177.60	294.00	489.80	181.50	64.90	63.80	60.30	73.60	105.50	98.10	88.80	60.70
Li	61.00	71.00	60.00	90.00	46.00	50.00	61.00	50.00	47.00	38.00	31.00	32.00	30.00	28.00
Lu	0.18	0.14	0.19	0.23	0.18	0.13	0.15	0.15	0.16	0.15	0.14	0.25	0.16	0.21
Mg	0.66	0.60	1.01	1.10	0.81	0.86	0.88	0.66	0.86	0.86	1.01	1.23	1.35	1.05
Mn	0.54	0.27	0.23	0.23	0.15	0.16	0.18	0.13	0.13	0.14	0.19	0.21	0.25	0.23
Mo	676.00	82.00	145.00	286.00	410.00	169.00	268.00	190.00	133.00	299.00	494.00	253.00	81.00	666.00
Na	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03
Nb	17.00	16.00	19.00	15.00	16.00	15.00	15.00	16.00	18.00	15.00	14.00	17.00	15.00	13.00
Nd	69.30	40.70	79.60	125.40	195.00	82.60	34.90	33.40	36.10	36.20	49.50	50.00	40.70	23.10
Ni	21.00	13.00	8.00	8.00	3.00	5.00	6.00	5.00	5.00	1.00	3.00	0.50	4.00	0.50
P	0.08	0.05	0.05	0.04	0.05	0.04	0.04	0.04	0.04	0.02	0.01	0.05	0.05	0.04
Pb	68.00	95.00	65.00	228.00	58.00	169.00	58.00	29.00	10.00	28.00	24.00	10.00	10.00	62.00
Pr	23.90	13.39	27.95	44.45	71.50	28.44	11.19	10.81	11.15	11.91	16.24	16.26	13.54	7.63
Rb	231.70	318.30	286.20	259.60	263.80	244.20	227.00	235.20	266.90	212.90	208.50	242.20	225.50	205.10
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	1.71	0.84	0.88	0.96	1.24	0.57	0.74	1.03	0.86	1.82	3.61	0.24	0.25	0.44
SO3	4.28	2.10	2.20	2.40	3.10	1.43	1.85	2.58	2.15	4.55	9.03	0.60	0.63	1.10
Sb	0.90	0.60	0.03	0.50	0.03	0.03	0.60	0.70	0.03	0.90	1.30	0.03	0.03	0.70
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	29.80	30.40	30.20	31.40	32.00	32.50	32.20	33.50	31.90	31.90	29.20	32.70	30.00	31.40

Sm	6.60	4.70	7.20	9.70	13.90	7.60	4.50	4.00	4.40	4.10	5.60	5.40	4.40	2.90
Sn	33.00	25.00	38.00	23.00	26.00	31.00	20.00	20.00	34.00	24.00	24.00	25.00	21.00	27.00
Sr	81.00	86.00	147.00	133.00	177.00	155.00	160.00	152.00	167.00	146.00	178.00	194.00	266.00	263.00
Ta	1.20	1.10	1.20	0.90	1.00	1.10	1.10	1.10	1.10	1.10	1.50	1.10	1.20	2.10
Tb	0.46	0.34	0.42	0.49	0.48	0.43	0.37	0.32	0.37	0.31	0.40	0.39	0.34	0.25
Te	0.50	1.00	1.00	4.00	0.50	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	14.30	11.20	11.30	9.60	12.40	14.20	13.60	14.30	7.70	9.20	8.60	15.10	18.50	16.40
Ti	0.25	0.18	0.18	0.15	0.15	0.16	0.15	0.16	0.18	0.16	0.16	0.20	0.19	0.18
Tl	1.80	2.30	2.20	2.00	2.20	1.70	1.60	1.70	1.80	1.50	1.50	1.70	1.60	1.40
Tm	0.18	0.12	0.14	0.18	0.15	0.13	0.12	0.10	0.13	0.11	0.13	0.15	0.13	0.11
U	6.20	4.50	5.40	5.50	7.30	5.10	5.00	5.10	4.00	3.90	3.90	4.70	4.90	5.30
V	133.00	78.00	85.00	123.00	67.00	25.00	56.00	63.00	67.00	25.00	58.00	54.00	74.00	25.00
W	72.00	70.00	217.00	551.00	1158.00	592.00	194.00	26.00	435.00	836.00	871.00	240.00	123.00	281.00
Y	13.40	8.90	10.50	12.20	10.60	9.80	9.50	7.40	8.50	8.40	9.40	10.40	10.10	8.10
Yb	1.10	0.90	1.10	1.30	1.10	0.90	0.90	0.80	0.80	0.80	0.80	0.90	0.80	0.70
Zn	182.00	217.00	95.00	214.00	84.00	77.00	106.00	60.00	54.00	53.00	44.00	91.00	75.00	70.00
Zr	185.00	174.00	223.00	127.00	152.00	165.00	324.00	189.00	224.00	386.00	267.00	363.00	273.00	173.00
Al	86.65	90.34	70.84	66.23	72.29	70.90	69.80	81.28	70.53	63.01	58.57	57.66	53.69	56.43

continued

Sample	A400_021	A400_022	A400_023	A400_024	A400_026	A400_027	A400_028	A400_029	A400_031	A400_032	A400_033	A400_034	A400_036	A400_037	A400_038	A400_039
Depth	-61.05	-62.06	-62.60	-63.26	-64.00	-64.93	-66.00	-67.00	-68.00	-70.00	-71.00	-72.00	-73.00	-74.00	-74.28	-75.28
SiO2	75.30	78.29	66.96	71.23	72.09	67.17	67.17	66.96	73.37	68.45	64.39	65.67	69.31	77.22	78.29	77.01
Al2O3	13.04	8.65	12.75	12.98	13.21	14.15	12.26	12.28	12.21	13.87	12.36	11.32	9.41	10.96	11.62	12.07
FeO	1.97	1.81	2.04	1.59	2.27	1.83	2.41	2.69	2.28	2.49	2.72	3.53	4.13	3.49	1.83	1.63
Fe2O3	0.94	0.86	0.97	0.76	1.08	0.87	1.15	1.28	1.09	1.18	1.30	1.68	1.97	1.66	0.87	0.78
K2O	4.36	3.11	4.18	4.14	4.26	4.37	4.05	3.70	3.91	4.13	3.78	2.95	2.29	3.31	2.45	1.86
MgO	1.03	1.11	1.61	0.96	1.06	1.26	1.62	1.04	0.93	0.56	0.66	0.90	0.91	1.06	0.51	0.61
MnO	0.09	0.10	0.16	0.16	0.21	0.16	0.23	0.18	0.13	0.16	0.27	0.21	0.20	0.20	0.10	0.12
Na2O	0.05	0.04	0.06	0.05	0.05	0.06	0.08	0.06	0.06	0.06	0.26	0.84	0.05	0.05	0.04	0.04
P2O5	0.11	0.07	0.11	0.09	0.11	0.11	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.07	0.07	0.05
TiO2	0.33	0.23	0.33	0.35	0.35	0.35	0.32	0.32	0.32	0.33	0.32	0.30	0.25	0.22	0.20	0.20
Ag	2.50	7.00	2.50	2.50	2.50	2.50	2.50	6.00	2.50	2.50	2.50	9.00	2.50	2.50	2.50	2.50
Al	6.90	4.58	6.75	6.87	6.99	7.49	6.49	6.50	6.46	7.34	6.54	5.99	4.98	5.80	6.15	6.39
As	959.00	322.00	229.00	10.00	10.00	10.00	132.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	38.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	1604.00	1113.00	1704.00	1764.00	1742.00	1865.00	1519.00	1550.00	1652.00	2259.00	2277.00	1884.00	1184.00	1379.00	691.00	436.00
Be	20.00	14.00	18.00	20.00	19.00	18.00	17.00	18.00	17.00	24.00	25.00	26.00	20.00	17.00	11.00	9.00
Bi	5.20	20.20	10.80	8.70	7.40	1.80	6.90	21.30	15.30	21.00	6.00	50.80	24.10	10.50	6.60	1.20
Ca	0.50	0.90	1.40	0.60	0.50	1.30	2.60	1.80	1.60	2.60	3.90	2.70	1.60	0.80	0.05	0.50
CaO	0.70	1.26	1.96	0.84	0.70	1.82	3.64	2.52	2.24	3.64	5.46	3.78	2.24	1.12	0.07	0.70
Cd	2.00	15.00	6.00	4.00	3.00	1.00	2.00	4.00	10.00	5.00	2.00	5.00	2.00	2.00	1.00	0.05
Ce	83.50	63.10	73.60	97.10	84.40	72.00	102.70	148.80	117.40	153.10	147.00	148.20	138.10	228.90	203.30	78.70
Co	4.00	3.00	3.00	2.00	3.00	4.00	3.00	4.00	4.00	5.00	4.00	5.00	5.00	3.00	4.00	3.00
Cr	298.00	186.00	262.00	148.00	134.00	272.00	141.00	337.00	160.00	225.00	147.00	319.00	144.00	283.00	138.00	31.00
Cs	22.97	15.20	21.41	16.54	16.68	14.86	13.95	14.37	16.81	17.39	14.61	11.88	9.60	14.52	10.54	6.52
Cu	211.00	160.00	155.00	164.00	170.00	75.00	114.00	269.00	170.00	338.00	232.00	362.00	311.00	123.00	138.00	166.00
Dy	1.20	0.80	1.30	0.90	1.00	1.10	1.30	1.40	1.40	1.30	1.50	1.40	1.40	1.50	1.80	1.90

Er	0.60	0.50	0.70	0.60	0.60	0.60	0.60	0.60	0.70	0.60	0.80	0.70	0.70	0.60	1.10	1.20
Eu	0.80	0.60	0.80	0.70	0.80	0.90	1.10	1.40	1.40	1.50	1.60	1.40	1.30	1.70	1.30	0.70
Fe	2.19	2.01	2.26	1.77	2.52	2.03	2.68	2.99	2.53	2.76	3.02	3.92	4.59	3.87	2.03	1.81
Ga	29.00	19.00	28.00	29.00	29.00	27.00	27.00	30.00	30.00	32.00	29.00	29.00	25.00	31.00	24.00	22.00
Gd	1.50	1.00	1.50	1.10	1.20	1.40	1.60	1.90	2.20	2.10	2.10	2.00	2.10	2.70	2.40	1.90
Hf	5.80	3.50	7.90	5.40	5.20	6.30	4.90	4.50	5.40	4.90	4.90	5.70	4.90	3.90	4.60	6.40
Ho	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40
In	0.20	0.60	0.30	0.30	0.30	0.20	0.30	0.30	0.60	0.60	0.40	0.40	0.30	0.30	0.10	0.05
K	3.62	2.58	3.47	3.44	3.54	3.63	3.36	3.07	3.25	3.43	3.14	2.45	1.90	2.75	2.03	1.54
La	57.10	44.00	48.40	64.80	56.60	45.80	63.00	89.90	70.20	100.30	98.70	94.10	89.00	146.30	136.00	49.50
Li	60.00	72.00	94.00	52.00	68.00	40.00	45.00	49.00	65.00	39.00	39.00	48.00	34.00	56.00	54.00	58.00
Lu	0.13	0.10	0.15	0.15	0.13	0.12	0.15	0.12	0.14	0.12	0.13	0.13	0.13	0.14	0.18	0.20
Mg	0.62	0.67	0.97	0.58	0.64	0.76	0.98	0.63	0.56	0.34	0.40	0.54	0.55	0.64	0.31	0.37
Mn	0.07	0.08	0.12	0.12	0.16	0.12	0.17	0.14	0.10	0.12	0.21	0.16	0.15	0.16	0.07	0.09
Mo	166.00	155.00	124.00	248.00	96.00	203.00	268.00	301.00	208.00	88.00	79.00	393.00	215.00	137.00	160.00	49.00
Na	0.04	0.03	0.04	0.04	0.04	0.04	0.06	0.04	0.05	0.04	0.19	0.62	0.04	0.04	0.03	0.03
Nb	15.00	11.00	13.00	20.00	17.00	15.00	13.00	13.00	13.00	15.00	13.00	16.00	14.00	15.00	21.00	20.00
Nd	22.90	16.00	20.40	23.50	21.80	20.00	29.80	42.10	38.80	46.70	43.50	44.70	39.50	63.70	53.70	23.00
Ni	7.00	4.00	5.00	3.00	3.00	6.00	2.00	5.00	4.00	7.00	4.00	6.00	7.00	2.00	8.00	4.00
P	0.05	0.03	0.05	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.02
Pb	33.00	194.00	102.00	102.00	74.00	10.00	47.00	189.00	87.00	132.00	30.00	237.00	100.00	37.00	34.00	26.00
Pr	7.48	5.59	6.74	8.74	7.82	6.79	10.22	14.52	12.02	15.44	14.25	15.00	13.45	21.76	18.38	7.49
Rb	344.30	254.30	344.20	259.90	288.80	266.80	243.40	230.10	263.80	220.30	222.60	183.40	143.30	229.00	164.40	120.30
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	30.00	1.05	0.87	0.14	0.43	0.14	0.39	0.56	0.38	0.55	1.14	1.68	2.02	1.34	0.85	0.77
SO3	75.00	2.63	2.18	0.35	1.08	0.35	0.98	1.40	0.95	1.38	2.85	4.20	5.05	3.35	2.13	1.93
Sb	0.70	0.03	0.03	0.03	0.03	0.03	0.50	0.03	0.03	0.03	0.03	0.50	0.70	1.60	1.10	0.03
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	35.20	36.60	31.30	33.30	33.70	31.40	31.40	31.30	34.30	32.00	30.10	30.70	32.40	36.10	36.60	36.00

Sm	2.50	1.80	2.70	2.10	2.30	2.20	2.80	4.30	4.40	4.70	4.30	4.80	4.00	6.20	5.60	3.00
Sn	19.00	13.00	16.00	23.00	20.00	19.00	15.00	15.00	19.00	21.00	19.00	20.00	21.00	18.00	9.00	7.00
Sr	128.00	137.00	155.00	117.00	133.00	233.00	605.00	428.00	357.00	438.00	960.00	856.00	348.00	335.00	274.00	227.00
Ta	1.30	1.00	1.30	1.50	1.30	1.50	1.10	1.00	1.10	1.90	1.20	1.20	0.90	1.10	2.30	2.50
Tb	0.24	0.19	0.25	0.18	0.22	0.23	0.24	0.31	0.30	0.28	0.30	0.31	0.31	0.30	0.37	0.36
Te	0.50	1.00	1.00	0.50	0.50	0.50	0.50	1.00	2.00	1.00	0.50	3.00	0.50	0.50	0.50	0.50
Th	16.90	11.20	19.70	18.70	16.40	19.00	14.00	13.00	14.10	15.30	14.00	11.80	11.30	10.90	18.70	20.00
Ti	0.20	0.14	0.20	0.21	0.21	0.21	0.19	0.19	0.19	0.20	0.19	0.18	0.15	0.13	0.12	0.12
Tl	2.40	1.70	2.20	1.90	2.00	2.00	1.80	1.70	1.80	1.80	1.80	1.60	1.10	1.60	1.10	0.80
Tm	0.10	0.07	0.11	0.10	0.12	0.11	0.10	0.10	0.11	0.10	0.14	0.12	0.11	0.11	0.16	0.19
U	5.10	3.20	4.40	4.60	4.20	5.30	5.00	4.20	3.40	4.20	4.50	5.60	3.90	4.80	9.40	10.10
V	74.00	25.00	72.00	72.00	70.00	72.00	61.00	84.00	74.00	93.00	81.00	85.00	108.00	75.00	56.00	25.00
W	632.00	623.00	736.00	222.00	42.00	13.00	432.00	1360.00	771.00	746.00	785.00	1840.00	1002.00	431.00	214.00	34.00
Y	6.00	4.50	7.20	5.70	6.40	6.20	6.70	7.70	8.00	7.60	9.20	8.10	8.30	8.40	10.40	11.50
Yb	0.70	0.50	0.80	0.70	0.70	0.70	0.80	0.70	0.70	0.70	0.80	0.80	0.80	0.80	1.10	1.30
Zn	72.00	512.00	228.00	158.00	119.00	56.00	92.00	155.00	337.00	574.00	120.00	166.00	74.00	89.00	39.00	19.00
Zr	209.00	125.00	306.00	190.00	189.00	223.00	178.00	169.00	193.00	171.00	181.00	220.00	202.00	131.00	161.00	230.00
Al	87.75	76.41	74.15	85.13	87.63	75.03	60.44	64.82	67.80	55.95	43.76	45.43	58.33	78.84	96.36	77.03

continued

Sample	A400_041	A400_042	A400_043	A400_044	A400_046	A400_047	A400_048	A400_049	A400_051	A400_052	A400_053	A400_054	A400_056	A400_057	A400_058	A400_059
Depth	-76.28	-77.30	-77.63	-78.60	-79.60	-80.20	-81.20	-82.20	-83.20	-84.20	-85.30	-86.00	-86.92	-88.00	-89.00	-90.00
SiO2	77.22	85.99	74.02	78.72	79.36	76.80	77.01	74.44	71.45	72.73	70.38	74.44	74.23	74.02	73.16	74.23
Al2O3	12.47	5.54	12.57	10.34	9.22	13.30	12.43	14.32	12.60	10.83	11.47	11.55	13.76	12.40	12.00	12.04
FeO	2.25	2.51	1.76	1.52	1.28	1.54	1.49	1.15	1.30	1.15	1.84	1.34	1.07	1.34	1.14	0.96
Fe2O3	1.07	1.20	0.84	0.72	0.61	0.73	0.71	0.55	0.62	0.55	0.87	0.64	0.51	0.64	0.54	0.46
K2O	2.02	1.25	2.06	2.17	1.48	1.89	1.84	3.22	3.81	3.84	4.24	4.87	4.75	4.93	5.48	5.94
MgO	0.50	0.28	0.51	0.60	0.43	0.56	0.61	0.51	0.65	0.58	0.68	0.55	0.50	0.43	0.40	0.35
MnO	0.17	0.08	0.09	0.06	0.04	0.06	0.06	0.03	0.04	0.05	0.07	0.04	0.03	0.03	0.03	0.03
Na2O	0.04	0.03	0.04	0.03	0.04	0.05	0.07	0.07	0.12	0.09	0.11	1.10	3.09	2.59	2.32	2.35
P2O5	0.02	0.02	0.07	0.07	0.07	0.11	0.09	0.11	0.11	0.09	0.11	0.09	0.11	0.09	0.09	0.07
TiO2	0.22	0.12	0.23	0.18	0.17	0.23	0.22	0.25	0.23	0.20	0.23	0.18	0.25	0.22	0.17	0.17
Ag	2.50	5.00	2.50	10.00	6.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Al	6.60	2.93	6.65	5.47	4.88	7.04	6.58	7.58	6.67	5.73	6.07	6.11	7.28	6.56	6.35	6.37
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	471.00	253.00	479.00	481.00	325.00	393.00	365.00	654.00	838.00	920.00	983.00	1000.00	1070.00	825.00	858.00	643.00
Be	8.00	4.00	9.00	8.00	7.00	8.00	7.00	9.00	8.00	8.00	8.00	11.00	9.00	8.00	8.00	9.00
Bi	5.20	196.10	40.80	282.90	10.10	5.70	2.70	6.30	5.40	7.40	7.60	7.30	1.30	2.10	2.40	8.10
Ca	0.10	0.05	0.20	0.40	0.30	0.30	0.60	0.70	2.10	2.70	1.90	1.50	1.30	1.20	1.10	1.00
CaO	0.14	0.07	0.28	0.56	0.42	0.42	0.84	0.98	2.94	3.78	2.66	2.10	1.82	1.68	1.54	1.40
Cd	4.00	2.00	1.00	7.00	3.00	1.00	1.00	1.00	1.00	8.00	0.05	0.05	0.05	0.05	9.00	0.05
Ce	83.60	44.20	104.30	82.80	73.10	91.50	92.40	104.90	100.80	77.80	87.20	69.70	92.80	62.00	75.10	54.30
Co	5.00	7.00	4.00	4.00	4.00	4.00	4.00	3.00	2.00	4.00	4.00	3.00	2.00	3.00	3.00	3.00
Cr	220.00	215.00	257.00	165.00	173.00	228.00	107.00	158.00	136.00	113.00	291.00	102.00	137.00	131.00	209.00	130.00
Cs	7.98	4.09	7.77	7.26	5.12	6.58	6.12	7.88	7.60	8.24	9.07	8.80	9.45	8.93	8.69	8.45
Cu	159.00	300.00	148.00	160.00	107.00	133.00	150.00	127.00	130.00	127.00	126.00	97.00	69.00	117.00	261.00	70.00
Dy	1.90	1.10	2.10	1.70	1.50	1.90	2.40	2.30	2.30	1.60	1.60	1.60	2.10	1.90	2.30	1.90

Er	1.20	0.50	1.20	1.00	0.80	1.10	1.20	1.30	1.30	0.90	1.00	0.90	1.20	1.00	1.20	1.00
Eu	0.70	0.40	0.90	0.60	0.60	0.80	0.80	0.80	0.80	0.70	0.80	0.70	0.80	0.60	0.60	0.50
Fe	2.50	2.79	1.95	1.69	1.42	1.71	1.65	1.28	1.44	1.28	2.04	1.49	1.19	1.49	1.27	1.07
Ga	23.00	10.00	24.00	21.00	18.00	24.00	22.00	25.00	21.00	20.00	20.00	20.00	22.00	21.00	22.00	21.00
Gd	2.10	1.20	2.60	1.80	2.00	2.30	2.30	3.00	2.50	2.00	2.00	1.80	2.60	2.00	2.70	2.00
Hf	4.80	2.50	4.50	3.60	4.60	13.00	6.20	4.80	3.90	4.00	4.20	4.60	5.00	4.20	4.20	3.50
Ho	0.40	0.20	0.40	0.40	0.30	0.40	0.40	0.50	0.50	0.30	0.30	0.30	0.40	0.30	0.50	0.40
In	0.10	0.05	0.05	0.10	0.10	0.05	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.20	0.05
K	1.68	1.04	1.71	1.80	1.23	1.57	1.53	2.67	3.16	3.19	3.52	4.04	3.94	4.09	4.55	4.93
La	55.30	28.90	68.90	54.50	45.80	57.20	58.70	66.90	63.00	50.80	54.50	44.30	56.90	35.60	43.70	32.10
Li	71.00	41.00	68.00	55.00	47.00	63.00	62.00	55.00	45.00	48.00	39.00	42.00	33.00	36.00	39.00	28.00
Lu	0.25	0.14	0.24	0.17	0.16	0.22	0.21	0.23	0.24	0.18	0.21	0.17	0.27	0.20	0.23	0.26
Mg	0.30	0.17	0.31	0.36	0.26	0.34	0.37	0.31	0.39	0.35	0.41	0.33	0.30	0.26	0.24	0.21
Mn	0.13	0.06	0.07	0.04	0.03	0.05	0.05	0.02	0.03	0.04	0.06	0.03	0.03	0.03	0.02	0.02
Mo	251.00	313.00	70.00	93.00	43.00	33.00	100.00	42.00	30.00	170.00	148.00	150.00	118.00	46.00	68.00	25.00
Na	0.03	0.02	0.03	0.02	0.03	0.03	0.05	0.05	0.09	0.07	0.08	0.82	2.29	1.92	1.72	1.74
Nb	20.00	11.00	22.00	17.00	14.00	18.00	19.00	21.00	19.00	15.00	17.00	18.00	18.00	21.00	16.00	19.00
Nd	23.30	12.60	29.00	22.80	20.50	27.30	27.80	31.70	29.30	22.10	25.00	20.30	28.40	19.50	24.50	17.60
Ni	7.00	5.00	7.00	5.00	6.00	6.00	4.00	5.00	4.00	3.00	6.00	6.00	5.00	6.00	6.00	5.00
P	0.01	0.01	0.03	0.03	0.03	0.05	0.04	0.05	0.05	0.04	0.05	0.04	0.05	0.04	0.04	0.03
Pb	35.00	114.00	58.00	255.00	62.00	53.00	42.00	48.00	57.00	44.00	41.00	53.00	50.00	49.00	48.00	51.00
Pr	7.75	4.09	9.73	7.76	6.88	8.75	9.12	10.03	9.59	7.24	8.37	6.68	9.11	6.22	7.66	5.60
Rb	142.70	75.50	140.70	136.10	89.20	117.40	110.60	168.00	187.20	191.70	201.40	225.90	220.90	232.30	244.20	234.50
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	30.00	1.64	0.81	0.73	0.45	0.34	0.59	0.66	0.74	0.57	0.63	0.65	0.37	0.66	0.55	0.39
SO3	75.00	4.10	2.03	1.83	1.13	0.85	1.48	1.65	1.85	1.43	1.58	1.63	0.93	1.65	1.38	0.98
Sb	0.50	1.20	0.90	0.90	0.03	0.03	0.03	0.50	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	36.10	40.20	34.60	36.80	37.10	35.90	36.00	34.80	33.40	34.00	32.90	34.80	34.70	34.60	34.20	34.70

Sm	3.20	1.80	4.00	2.80	2.90	3.40	3.80	4.60	3.70	2.80	3.30	2.80	3.80	3.00	3.80	2.60
Sn	10.00	9.00	8.00	7.00	7.00	6.00	6.00	7.00	6.00	6.00	8.00	9.00	6.00	6.00	6.00	5.00
Sr	232.00	202.00	432.00	255.00	194.00	224.00	242.00	261.00	514.00	634.00	455.00	512.00	727.00	499.00	507.00	434.00
Ta	2.50	1.20	2.30	2.00	1.60	2.10	2.30	2.40	2.10	1.60	1.80	4.40	2.50	2.60	2.10	2.70
Tb	0.31	0.18	0.40	0.32	0.30	0.33	0.40	0.42	0.43	0.32	0.34	0.31	0.42	0.36	0.47	0.33
Te	0.50	9.00	1.00	4.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	18.20	9.10	21.20	16.60	14.90	21.50	21.10	23.00	19.20	11.30	11.60	12.00	19.60	18.10	21.30	18.70
Ti	0.13	0.07	0.14	0.11	0.10	0.14	0.13	0.15	0.14	0.12	0.14	0.11	0.15	0.13	0.10	0.10
Tl	0.90	0.60	0.90	1.00	0.60	0.80	0.70	1.20	1.40	1.30	1.50	1.70	1.60	1.60	1.60	1.50
Tm	0.19	0.10	0.20	0.17	0.14	0.19	0.18	0.20	0.20	0.15	0.14	0.16	0.17	0.19	0.18	0.19
U	12.70	6.00	11.50	11.60	8.30	9.40	13.00	13.20	12.70	7.70	5.40	9.30	8.40	14.60	16.80	20.80
V	68.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	61.00	987.00	75.00	301.00	484.00	20.00	20.00	29.00	12.00	40.00	17.00	169.00	39.00	80.00	26.00	298.00
Y	11.30	6.00	11.30	9.30	7.90	10.50	11.90	12.70	12.20	9.20	9.30	9.40	11.10	10.30	12.70	10.70
Yb	1.20	0.70	1.40	1.20	0.90	1.20	1.20	1.30	1.30	1.00	1.00	1.10	1.10	1.20	1.40	1.30
Zn	142.00	35.00	44.00	214.00	104.00	44.00	50.00	32.00	33.00	225.00	26.00	31.00	25.00	27.00	311.00	32.00
Zr	157.00	97.00	149.00	115.00	157.00	502.00	230.00	166.00	132.00	137.00	150.00	197.00	183.00	134.00	115.00	108.00
Al	93.41	94.13	88.90	82.35	80.66	84.06	72.91	78.02	59.26	53.36	64.01	62.83	51.63	55.68	60.35	62.64

continued

Sample	A400_061	A400_062	A400_064	A400_066	A400_067	A400_068	A400_069	A400_071	A400_072	A400_073	A400_074	A400_076	A400_077	A400_078	A400_079
Depth	-91.00	-92.00	-93.17	-94.20	-95.20	-96.10	-96.50	-97.10	-97.88	-99.00	-100.00	-101.00	-102.00	-103.00	-104.00
SiO2	72.73	77.44	76.15	73.80	71.66	71.88	76.37	72.95	77.22	80.00	74.87	70.81	74.02	75.51	74.44
Al2O3	13.42	12.60	12.04	12.91	13.38	12.24	12.83	12.07	10.32	9.16	13.08	12.64	12.96	11.60	13.04
FeO	1.04	1.05	1.55	1.27	1.80	1.80	0.94	1.24	1.54	1.70	0.87	1.81	0.88	0.98	0.98
Fe2O3	0.50	0.50	0.74	0.60	0.86	0.86	0.45	0.59	0.73	0.81	0.42	0.86	0.42	0.47	0.47
K2O	5.40	4.38	4.66	5.22	3.14	3.93	4.18	5.90	4.63	4.37	5.18	5.40	5.13	5.20	4.88
MgO	0.60	0.63	0.55	0.60	0.76	1.16	0.51	0.53	0.35	0.27	0.33	0.38	0.35	0.35	0.36
MnO	0.03	0.02	0.01	0.03	0.06	0.19	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03
Na2O	0.42	0.05	0.05	0.07	0.04	0.04	0.07	0.22	1.60	1.66	3.23	2.63	3.25	2.18	3.40
P2O5	0.09	0.11	0.09	0.07	0.07	0.09	0.07	0.09	0.05	0.05	0.05	0.07	0.07	0.07	0.07
TiO2	0.20	0.18	0.17	0.15	0.18	0.17	0.17	0.22	0.15	0.13	0.18	0.17	0.17	0.15	0.18
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	33.00	2.50	2.50	2.50
Al	7.10	6.67	6.37	6.83	7.08	6.48	6.79	6.39	5.46	4.85	6.92	6.69	6.86	6.14	6.90
As	10.00	10.00	46.00	10.00	30.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	1032.00	900.00	930.00	1211.00	461.00	599.00	583.00	775.00	736.00	652.00	469.00	663.00	504.00	726.00	573.00
Be	15.00	16.00	13.00	13.00	11.00	13.00	10.00	6.00	6.00	8.00	6.00	18.00	7.00	7.00	7.00
Bi	2.90	5.10	7.20	6.40	6.80	4.30	3.40	1.40	3.40	5.80	0.80	525.20	1.50	11.40	1.00
Ca	0.50	0.30	0.20	1.00	0.90	1.20	0.80	1.10	0.80	0.70	1.00	1.00	0.90	1.00	1.00
CaO	0.70	0.42	0.28	1.40	1.26	1.68	1.12	1.54	1.12	0.98	1.40	1.40	1.26	1.40	1.40
Cd	1.00	1.00	3.00	2.00	1.00	1.00	0.05	0.05	0.05	3.00	0.05	4.00	0.05	0.05	0.05
Ce	64.50	67.20	60.30	60.10	64.90	65.60	60.40	67.70	50.20	39.50	50.00	43.80	44.10	54.30	60.10
Co	3.00	3.00	4.00	3.00	3.00	3.00	3.00	4.00	4.00	5.00	3.00	7.00	3.00	3.00	3.00
Cr	226.00	131.00	112.00	175.00	116.00	373.00	133.00	206.00	220.00	168.00	103.00	133.00	85.00	134.00	121.00
Cs	13.72	15.18	11.62	12.27	11.24	15.50	11.88	7.77	6.75	5.81	7.14	8.32	7.27	7.83	7.09
Cu	65.00	71.00	178.00	85.00	229.00	76.00	86.00	94.00	150.00	176.00	64.00	120.00	64.00	74.00	60.00
Dy	1.80	1.50	1.60	2.20	2.30	2.50	2.30	2.70	1.70	1.30	1.50	1.50	1.90	1.60	1.80

Er	1.00	0.90	0.90	1.20	1.30	1.30	1.50	1.60	0.90	0.90	0.90	0.90	1.10	0.90	1.00
Eu	0.50	0.50	0.50	0.60	0.60	0.70	0.60	0.60	0.40	0.30	0.60	0.40	0.50	0.50	0.60
Fe	1.16	1.17	1.72	1.41	2.00	2.00	1.04	1.38	1.71	1.89	0.97	2.01	0.98	1.09	1.09
Ga	23.00	23.00	22.00	25.00	24.00	22.00	22.00	21.00	18.00	17.00	22.00	22.00	22.00	20.00	21.00
Gd	2.00	1.80	1.80	2.00	2.30	2.40	2.20	2.60	1.50	1.30	1.90	1.50	1.80	1.60	2.00
Hf	3.80	3.70	3.10	3.30	3.70	3.20	3.70	4.20	3.10	2.60	3.20	2.90	4.50	3.60	4.60
Ho	0.40	0.30	0.30	0.40	0.40	0.40	0.50	0.60	0.30	0.30	0.30	0.30	0.40	0.30	0.30
In	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
K	4.48	3.64	3.87	4.33	2.61	3.26	3.47	4.90	3.84	3.63	4.30	4.48	4.26	4.32	4.05
La	37.50	39.80	37.30	39.80	39.20	40.40	34.70	41.00	31.40	24.60	29.80	25.50	25.90	31.20	34.80
Li	39.00	45.00	46.00	51.00	51.00	45.00	42.00	31.00	30.00	27.00	22.00	34.00	23.00	34.00	26.00
Lu	0.22	0.18	0.18	0.26	0.26	0.27	0.30	0.33	0.21	0.17	0.20	0.19	0.25	0.21	0.22
Mg	0.36	0.38	0.33	0.36	0.46	0.70	0.31	0.32	0.21	0.16	0.20	0.23	0.21	0.21	0.22
Mn	0.02	0.02	0.01	0.03	0.05	0.14	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Mo	75.00	325.00	872.00	1024.00	123.00	152.00	74.00	146.00	313.00	208.00	21.00	384.00	39.00	120.00	47.00
Na	0.31	0.03	0.04	0.05	0.03	0.03	0.05	0.16	1.19	1.23	2.39	1.95	2.41	1.62	2.52
Nb	22.00	19.00	18.00	19.00	21.00	19.00	22.00	27.00	17.00	14.00	17.00	17.00	18.00	15.00	17.00
Nd	20.50	21.10	18.20	18.40	20.60	20.80	19.20	21.50	15.70	12.00	17.90	14.30	14.50	17.40	20.00
Ni	7.00	3.00	2.00	0.50	3.00	9.00	4.00	5.00	6.00	6.00	3.00	4.00	4.00	4.00	4.00
P	0.04	0.05	0.04	0.03	0.03	0.04	0.03	0.04	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Pb	44.00	28.00	32.00	44.00	57.00	37.00	47.00	68.00	39.00	53.00	50.00	1247.00	56.00	64.00	50.00
Pr	6.50	6.87	5.97	5.94	6.53	6.59	5.95	7.00	5.07	3.98	5.49	4.44	4.59	5.53	6.27
Rb	277.30	263.00	267.70	298.50	187.20	216.20	215.40	255.10	205.70	200.50	226.20	254.90	230.20	244.30	212.40
Re	0.05	0.05	0.05	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.05	0.05
S	30.00	0.51	1.18	0.87	1.25	0.17	0.44	0.46	0.79	0.98	0.35	1.59	0.35	0.50	0.39
SO3	75.00	1.28	2.95	2.18	3.13	0.43	1.10	1.15	1.98	2.45	0.88	3.98	0.88	1.25	0.98
Sb	0.60	0.70	0.03	0.03	0.03	0.03	0.50	0.03	0.03	0.03	0.03	1.20	0.03	0.03	0.03
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	34.00	36.20	35.60	34.50	33.50	33.60	35.70	34.10	36.10	37.40	35.00	33.10	34.60	35.30	34.80

Sm	3.00	3.00	2.70	2.70	3.30	2.90	2.80	3.20	2.10	1.70	2.60	2.00	2.10	2.60	3.20
Sn	5.00	5.00	8.00	7.00	5.00	6.00	5.00	5.00	4.00	4.00	4.00	5.00	4.00	6.00	5.00
Sr	179.00	105.00	99.00	220.00	168.00	356.00	170.00	270.00	385.00	427.00	504.00	481.00	511.00	423.00	497.00
SrO	211.68	124.17	117.08	260.17	198.68	421.00	201.04	319.30	455.30	504.97	596.03	568.83	604.30	500.24	587.75
Ta	2.90	2.60	2.50	3.30	3.50	2.80	3.30	3.90	2.30	2.10	2.20	2.30	2.80	1.80	2.00
Tb	0.31	0.28	0.31	0.38	0.40	0.45	0.41	0.48	0.32	0.23	0.29	0.27	0.31	0.27	0.35
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	11.00	0.50	0.50	0.50
Th	18.90	19.10	15.90	16.30	17.30	15.70	18.10	19.70	14.20	12.60	18.40	13.50	15.00	16.20	20.50
Ti	0.12	0.11	0.10	0.09	0.11	0.10	0.10	0.13	0.09	0.08	0.11	0.10	0.10	0.09	0.11
Tl	2.00	1.90	1.90	2.00	1.30	1.60	1.40	1.90	1.50	1.40	1.40	1.70	1.50	1.70	1.40
Tm	0.17	0.16	0.15	0.22	0.21	0.23	0.23	0.25	0.16	0.13	0.14	0.16	0.20	0.16	0.16
U	18.40	16.50	18.40	26.70	19.70	13.60	24.10	21.90	15.20	15.40	17.90	14.40	17.40	18.60	16.50
V	25.00	25.00	25.00	25.00	25.00	58.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	54.00	17.00	164.00	185.00	32.00	16.00	440.00	21.00	427.00	217.00	39.00	76.00	16.00	207.00	11.00
Y	10.20	8.20	8.10	12.70	13.20	12.60	14.30	16.80	9.60	7.90	9.40	9.00	10.90	9.50	10.70
Yb	1.30	1.00	1.00	1.50	1.60	1.50	1.60	2.00	1.20	1.00	1.20	1.00	1.40	1.20	1.30
Zn	65.00	24.00	76.00	60.00	28.00	35.00	24.00	63.00	63.00	90.00	18.00	47.00	20.00	27.00	18.00
Zr	104.00	106.00	91.00	87.00	102.00	95.00	99.00	114.00	78.00	67.00	91.00	86.00	135.00	117.00	147.00
Al	84.30	91.51	94.00	79.85	75.07	74.72	79.80	78.53	64.62	63.71	54.37	58.91	54.88	60.81	52.24

continued

Sample	A400_081	A400_082	A400_083	A400_084	A400_086	A400_087	A400_088	A400_089	A400_091	A400_092	A400_093	A400_094	A400_096	A400_097	A400_098	A400_099
Depth	-105.00	-106.00	-107.00	-108.00	-109.00	-110.00	-111.00	-112.00	-113.00	-114.00	-115.00	-116.00	-117.00	-118.00	-118.70	-119.22
SiO2	73.37	72.73	73.16	75.51	73.16	73.80	73.16	64.82	71.66	74.23	60.75	80.22	76.80	74.87	66.74	72.73
Al2O3	12.21	12.96	13.11	12.77	12.53	13.13	12.96	11.02	13.11	11.77	11.19	9.69	12.87	13.23	9.66	12.74
FeO	0.97	0.78	0.74	0.95	0.83	0.80	0.78	0.60	1.30	1.07	0.76	1.16	0.84	1.02	5.43	1.68
Fe2O3	0.46	0.37	0.35	0.45	0.39	0.38	0.37	0.29	0.62	0.51	0.36	0.55	0.40	0.48	2.59	0.80
K2O	6.00	5.42	5.61	5.70	5.44	5.32	5.36	5.11	6.70	5.44	4.49	4.57	5.40	5.48	5.11	5.19
MgO	0.35	0.35	0.30	0.36	0.32	0.35	0.33	0.25	0.38	0.38	0.28	0.28	0.32	0.38	0.30	0.33
MnO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.02	0.02
Na2O	2.19	3.08	2.92	1.68	2.67	2.77	2.83	2.17	0.28	0.76	2.83	1.60	2.60	2.45	1.00	2.30
P2O5	0.23	0.07	0.07	0.09	0.07	0.07	0.07	0.05	0.07	0.07	0.05	0.09	0.07	0.07	0.05	0.07
TiO2	0.17	0.17	0.17	0.18	0.17	0.20	0.18	0.15	0.18	0.15	0.15	0.12	0.17	0.17	0.15	0.17
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Al	6.46	6.86	6.94	6.76	6.63	6.95	6.86	5.83	6.94	6.23	5.92	5.13	6.81	7.00	5.11	6.74
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	34.00	10.00	10.00	10.00	10.00	10.00	68.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	105.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	1144.00	626.00	547.00	740.00	567.00	544.00	693.00	800.00	1433.00	890.00	601.00	881.00	688.00	810.00	913.00	832.00
Be	8.00	6.00	8.00	9.00	6.00	6.00	6.00	6.00	9.00	8.00	5.00	11.00	8.00	13.00	7.00	9.00
Bi	23.70	1.30	4.70	62.60	5.00	1.30	1.00	1.20	29.30	6.00	0.60	11.60	1.10	0.90	18.40	11.90
Ca	1.30	1.00	1.00	0.60	1.00	1.00	0.70	0.80	0.60	1.10	0.80	0.90	1.10	1.00	0.20	0.50
CaO	1.82	1.40	1.40	0.84	1.40	1.40	0.98	1.12	0.84	1.54	1.12	1.26	1.54	1.40	0.28	0.70
Cd	4.00	1.00	0.05	2.00	0.05	0.05	0.05	0.05	3.00	1.00	0.05	0.05	0.05	0.05	1.00	0.05
Ce	57.10	46.50	45.10	47.30	46.00	49.40	46.80	38.30	65.70	47.80	44.80	41.90	48.70	49.20	43.10	48.70
Co	3.00	3.00	3.00	3.00	2.00	2.00	2.00	2.00	1.00	3.00	3.00	4.00	2.00	3.00	12.00	6.00
Cr	120.00	87.00	124.00	102.00	113.00	132.00	110.00	169.00	129.00	184.00	91.00	238.00	121.00	186.00	175.00	251.00
Cs	7.68	7.20	6.88	8.18	7.38	8.08	8.34	7.18	11.20	9.25	6.46	6.28	6.83	8.83	8.39	9.14
Cu	103.00	70.00	63.00	74.00	55.00	48.00	54.00	62.00	104.00	78.00	70.00	135.00	67.00	81.00	737.00	159.00
Dy	2.50	1.50	1.50	1.60	1.60	1.50	1.40	1.20	2.20	1.90	1.30	2.00	2.10	1.80	1.80	1.40

Er	1.50	0.90	0.90	1.00	1.00	0.80	0.80	0.90	1.10	1.00	0.70	1.10	1.40	1.10	1.00	0.80
Eu	0.60	0.50	0.60	0.50	0.50	0.50	0.50	0.40	0.50	0.50	0.40	0.30	0.50	0.60	0.40	0.50
Fe	1.08	0.87	0.82	1.06	0.92	0.89	0.87	0.67	1.44	1.19	0.84	1.29	0.93	1.13	6.03	1.86
Ga	21.00	21.00	22.00	21.00	21.00	22.00	21.00	18.00	23.00	20.00	18.00	16.00	21.00	22.00	21.00	21.00
Gd	2.60	1.40	1.40	1.80	1.70	1.50	1.40	1.40	2.00	1.80	1.20	1.70	1.80	1.70	1.40	1.60
Hf	3.20	3.60	3.50	3.60	3.60	3.90	3.50	110.60	4.40	3.70	2.50	2.80	3.50	5.20	3.40	4.70
Ho	0.50	0.30	0.30	0.30	0.30	0.30	0.20	0.30	0.40	0.40	0.20	0.40	0.40	0.30	0.30	0.30
In	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05
K	4.98	4.50	4.66	4.73	4.52	4.42	4.45	4.24	5.56	4.52	3.73	3.79	4.48	4.55	4.24	4.31
La	35.30	27.60	25.60	27.10	25.70	28.10	26.80	22.30	43.60	29.10	27.10	26.00	29.30	28.50	29.20	30.40
Li	31.00	26.00	24.00	35.00	25.00	27.00	31.00	22.00	35.00	31.00	26.00	31.00	27.00	33.00	39.00	35.00
Lu	0.27	0.17	0.20	0.18	0.20	0.20	0.19	0.16	0.25	0.23	0.15	0.26	0.31	0.22	0.18	0.20
Mg	0.21	0.21	0.18	0.22	0.19	0.21	0.20	0.15	0.23	0.23	0.17	0.17	0.19	0.23	0.18	0.20
Mn	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Mo	243.00	57.00	49.00	37.00	28.00	22.00	58.00	123.00	4680.00	1003.00	56.00	86.00	45.00	49.00	202.00	57.00
Na	1.63	2.29	2.17	1.25	1.98	2.06	2.10	1.61	0.21	0.57	2.10	1.19	1.93	1.82	0.74	1.71
Nb	16.00	17.00	17.00	17.00	18.00	18.00	16.00	15.00	28.00	17.00	14.00	14.00	19.00	18.00	16.00	17.00
Nd	19.30	15.20	14.90	15.30	15.60	16.40	15.30	12.70	21.00	15.70	14.20	13.10	15.90	15.90	12.70	15.20
Ni	4.00	5.00	5.00	3.00	5.00	4.00	4.00	4.00	0.50	4.00	3.00	7.00	3.00	5.00	6.00	7.00
P	0.10	0.03	0.03	0.04	0.03	0.03	0.03	0.02	0.03	0.03	0.02	0.04	0.03	0.03	0.02	0.03
Pb	90.00	43.00	51.00	103.00	54.00	49.00	50.00	40.00	84.00	67.00	36.00	59.00	46.00	35.00	65.00	51.00
Pr	5.99	4.79	4.67	4.96	4.74	5.05	4.71	3.98	6.56	4.94	4.54	4.22	4.83	5.02	4.14	4.95
Rb	265.90	235.70	246.30	256.90	227.20	235.40	249.40	225.60	318.20	251.30	201.60	198.20	228.40	247.90	251.00	249.70
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.30	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	30.00	0.23	0.29	0.45	0.28	0.31	0.29	0.24	1.26	0.74	0.19	0.59	0.27	0.46	4.98	0.83
SO3	75.00	0.58	0.73	1.13	0.70	0.78	0.73	0.60	3.15	1.85	0.48	1.48	0.68	1.15	12.45	2.08
Sb	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	4.50	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	34.30	34.00	34.20	35.30	34.20	34.50	34.20	30.30	33.50	34.70	28.40	37.50	35.90	35.00	31.20	34.00

Sm	3.00	2.30	2.30	2.30	2.10	2.40	2.00	2.10	3.20	2.60	2.20	2.30	2.40	2.40	1.70	2.40
Sn	5.00	4.00	4.00	5.00	3.00	4.00	4.00	5.00	5.00	4.00	3.00	5.00	5.00	5.00	6.00	7.00
Sr	602.00	471.00	477.00	354.00	388.00	424.00	469.00	433.00	354.00	341.00	420.00	350.00	444.00	346.00	391.00	315.00
Ta	1.90	2.10	2.70	3.10	2.50	2.20	2.00	2.20	21.50	2.70	1.90	2.20	3.10	2.30	2.10	2.20
Tb	0.42	0.27	0.27	0.29	0.31	0.31	0.23	0.25	0.38	0.34	0.26	0.37	0.37	0.33	0.26	0.27
Te	0.50	0.50	0.50	2.00	0.50	0.50	0.50	0.50	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	14.50	13.50	14.70	13.80	15.20	15.80	12.50	9.70	15.60	15.00	11.70	12.00	15.50	16.20	11.40	15.00
Ti	0.10	0.10	0.10	0.11	0.10	0.12	0.11	0.09	0.11	0.09	0.09	0.07	0.10	0.10	0.09	0.10
Tl	1.80	1.60	1.70	1.80	1.60	1.60	1.60	1.60	2.40	1.90	1.30	1.60	1.70	1.70	1.60	1.70
Tm	0.25	0.16	0.15	0.15	0.15	0.15	0.14	0.14	0.22	0.17	0.15	0.18	0.22	0.19	0.15	0.13
U	12.10	17.70	14.70	11.30	15.20	16.10	10.30	10.40	18.60	17.60	8.00	18.10	22.30	18.80	29.30	9.70
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	1740.00	17.00	18.00	506.00	17.00	22.00	15.00	27.00	5876.00	71.00	13.00	115.00	22.00	9.00	1619.00	22.00
Y	15.80	9.20	9.30	9.40	9.50	9.20	8.00	8.00	12.40	10.70	8.00	12.20	13.00	10.90	8.60	8.50
Yb	1.60	1.20	1.30	1.10	1.10	1.10	1.00	0.90	1.50	1.40	0.90	1.50	1.60	1.30	1.30	1.00
Zn	123.00	33.00	25.00	59.00	13.00	28.00	11.00	15.00	29.00	23.00	25.00	17.00	18.00	13.00	33.00	21.00
Zr	96.00	107.00	110.00	113.00	116.00	128.00	110.00	4784.00	139.00	122.00	80.00	75.00	112.00	167.00	112.00	170.00
Al	61.26	56.29	57.78	70.65	58.60	57.63	59.88	61.92	86.37	71.67	54.71	62.89	58.00	60.35	80.88	64.77

continued

Sample	A400_101	A400_102	A400_103	A400_104	A400_106	A400_107	A400_108	A400_109	A400_111	A400_112	A400_113	A400_114	A400_116	A400_117	A400_118	A400_119
Depth	-119.85	-120.60	-121.60	-122.60	-123.60	-124.60	-125.60	-126.30	-127.00	-128.00	-128.64	-129.15	-130.20	-131.10	-131.70	-132.60
SiO2	57.97	71.88	71.23	75.30	70.38	69.10	70.59	78.29	68.03	68.67	76.15	71.45	80.00	77.65	74.23	75.08
Al2O3	6.69	11.11	10.94	9.94	12.60	12.32	11.41	7.60	11.36	12.92	10.15	12.70	8.35	10.30	13.26	12.53
FeO	8.81	1.45	1.13	1.18	2.01	2.08	1.70	2.36	1.31	1.22	0.72	0.92	1.40	1.03	1.04	1.17
Fe2O3	4.19	0.69	0.54	0.56	0.96	0.99	0.81	1.12	0.63	0.58	0.34	0.44	0.66	0.49	0.50	0.56
K2O	2.30	4.96	5.61	5.32	4.79	5.54	6.02	5.13	5.02	5.87	6.14	4.87	2.84	2.94	5.20	4.14
MgO	0.36	0.28	0.22	0.23	0.41	0.40	0.36	0.27	0.40	0.53	0.38	0.40	0.35	0.46	0.50	0.43
MnO	0.03	0.02	0.02	0.02	0.04	0.04	0.04	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.02
Na2O	0.72	2.23	1.67	1.51	2.69	2.30	1.35	0.18	1.41	0.62	0.30	1.27	0.06	0.05	0.08	0.07
P2O5	0.14	0.07	0.09	0.09	0.07	0.07	0.07	0.11	0.07	0.09	0.07	0.09	0.07	0.07	0.07	0.07
TiO2	0.10	0.13	0.10	0.10	0.20	0.20	0.18	0.18	0.18	0.22	0.15	0.20	0.15	0.17	0.20	0.20
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Al	3.54	5.88	5.79	5.26	6.67	6.52	6.04	4.02	6.01	6.84	5.37	6.72	4.42	5.45	7.02	6.63
As	10.00	10.00	10.00	10.00	39.00	22.00	10.00	21.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	62.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	410.00	767.00	766.00	1003.00	700.00	1360.00	2078.00	2442.00	1121.00	1093.00	1455.00	672.00	429.00	441.00	721.00	661.00
Be	10.00	11.00	8.00	8.00	11.00	10.00	8.00	7.00	9.00	11.00	15.00	7.00	8.00	7.00	10.00	9.00
Bi	12.10	9.90	13.40	8.20	7.30	6.40	24.80	10.20	2.60	3.80	9.00	3.70	81.60	42.90	5.00	15.10
Ca	0.20	0.80	0.80	0.70	1.10	1.20	1.10	0.90	1.30	1.60	1.30	1.40	1.50	1.30	1.00	0.90
CaO	0.28	1.12	1.12	0.98	1.54	1.68	1.54	1.26	1.82	2.24	1.82	1.96	2.10	1.82	1.40	1.26
Cd	3.00	1.00	3.00	2.00	0.05	1.00	2.00	2.00	0.05	7.00	2.00	5.00	1.00	2.00	1.00	4.00
Ce	38.30	56.90	45.60	37.20	51.50	63.00	64.60	87.60	56.00	54.00	33.80	50.40	64.10	42.00	52.40	55.30
Co	12.00	4.00	4.00	4.00	5.00	6.00	5.00	7.00	4.00	3.00	2.00	3.00	4.00	4.00	3.00	4.00
Cr	350.00	122.00	252.00	141.00	165.00	125.00	203.00	163.00	146.00	242.00	143.00	150.00	135.00	294.00	148.00	261.00
Cs	6.55	7.29	6.91	6.29	10.75	9.77	9.93	6.92	10.52	13.51	9.61	10.03	7.75	9.29	12.92	10.97
Cu	1450.00	189.00	135.00	93.00	143.00	227.00	175.00	244.00	121.00	75.00	66.00	66.00	124.00	73.00	80.00	131.00
Dy	1.60	2.40	3.10	1.50	1.50	1.70	1.60	1.80	1.50	1.60	1.10	1.70	1.50	1.70	1.70	1.60

Er	0.80	1.40	1.80	0.90	0.90	1.10	1.00	1.10	0.90	0.90	0.70	0.90	0.70	0.90	0.90	1.00
Eu	0.50	0.50	0.40	0.40	0.50	0.50	0.40	0.50	0.50	0.60	0.40	0.60	0.50	0.50	0.50	0.50
Fe	9.78	1.61	1.25	1.31	2.23	2.31	1.89	2.62	1.46	1.35	0.80	1.02	1.55	1.14	1.16	1.30
Ga	15.00	20.00	19.00	18.00	23.00	24.00	23.00	18.00	21.00	23.00	20.00	21.00	16.00	18.00	23.00	22.00
Gd	1.60	2.10	2.70	1.30	1.70	2.10	1.80	2.00	1.50	1.60	1.30	1.50	1.70	1.60	1.80	1.50
Hf	1.60	3.80	4.10	3.30	5.10	4.40	4.60	3.40	4.50	5.30	5.80	6.60	4.80	3.60	3.90	4.00
Ho	0.30	0.40	0.60	0.30	0.30	0.40	0.30	0.40	0.30	0.30	0.20	0.30	0.30	0.30	0.30	0.30
In	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.10	0.05	0.05	0.05	0.10
K	1.91	4.12	4.66	4.42	3.98	4.60	5.00	4.26	4.17	4.87	5.10	4.04	2.36	2.44	4.32	3.44
La	27.00	35.70	26.60	25.70	29.80	41.90	50.70	78.80	38.70	33.00	20.20	29.30	43.60	23.50	30.90	32.20
Li	50.00	31.00	25.00	27.00	39.00	46.00	45.00	33.00	49.00	43.00	38.00	50.00	49.00	49.00	39.00	48.00
Lu	0.34	0.29	0.35	0.19	0.24	0.21	0.22	0.19	0.17	0.18	0.14	0.18	0.16	0.17	0.22	0.25
Mg	0.22	0.17	0.13	0.14	0.25	0.24	0.22	0.16	0.24	0.32	0.23	0.24	0.21	0.28	0.30	0.26
Mn	0.02	0.02	0.02	0.01	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
Mo	2884.00	295.00	75.00	98.00	88.00	145.00	520.00	366.00	182.00	311.00	200.00	36.00	95.00	87.00	166.00	537.00
Na	0.54	1.65	1.24	1.12	2.00	1.71	1.00	0.14	1.05	0.46	0.22	0.94	0.04	0.04	0.06	0.05
Nb	5.00	20.00	20.00	11.00	18.00	20.00	19.00	23.00	17.00	17.00	14.00	14.00	12.00	12.00	17.00	18.00
Nd	12.90	18.60	16.30	11.30	16.70	19.40	17.50	20.20	16.70	17.60	11.20	16.40	19.10	14.00	17.70	18.90
Ni	0.50	4.00	9.00	4.00	4.00	4.00	3.00	5.00	4.00	6.00	1.00	4.00	4.00	8.00	3.00	6.00
P	0.06	0.03	0.04	0.04	0.03	0.03	0.03	0.05	0.03	0.04	0.03	0.04	0.03	0.03	0.03	0.03
Pb	71.00	61.00	63.00	46.00	49.00	42.00	71.00	44.00	39.00	47.00	42.00	54.00	123.00	81.00	34.00	58.00
Pr	3.95	5.89	4.99	3.62	5.26	6.22	5.91	7.11	5.35	5.42	3.60	5.17	6.30	4.39	5.43	5.69
Rb	124.40	229.80	250.10	231.10	235.00	277.00	295.20	235.20	244.40	293.60	297.20	237.70	147.40	181.20	264.10	230.40
Re	0.20	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.05	0.05	0.05	0.05
S	30.00	0.77	0.55	0.76	1.35	1.35	1.00	1.62	0.70	0.58	0.26	0.34	0.80	0.44	0.24	0.55
SO3	75.00	1.93	1.38	1.90	3.38	3.38	2.50	4.05	1.75	1.45	0.65	0.85	2.00	1.10	0.60	1.38
Sb	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.80	0.03	0.03	0.03	0.03	0.60	0.03	0.03	0.03
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	27.10	33.60	33.30	35.20	32.90	32.30	33.00	36.60	31.80	32.10	35.60	33.40	37.40	36.30	34.70	35.10

Sm	2.40	3.10	3.00	1.60	2.50	2.70	2.50	2.60	2.30	2.40	1.70	2.30	2.60	2.20	2.70	2.90
Sn	5.00	5.00	4.00	4.00	6.00	7.00	8.00	7.00	6.00	5.00	5.00	6.00	6.00	6.00	6.00	6.00
Sr	192.00	471.00	489.00	481.00	478.00	744.00	715.00	706.00	595.00	524.00	569.00	488.00	328.00	295.00	303.00	196.00
Ta	1.20	4.10	4.40	2.10	2.10	2.10	2.00	2.50	2.20	2.20	1.60	1.60	1.30	1.10	1.70	1.90
Tb	0.29	0.39	0.55	0.26	0.27	0.34	0.29	0.34	0.28	0.29	0.24	0.27	0.27	0.27	0.32	0.30
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	2.00	1.00	0.50	0.50
Th	6.60	15.80	15.20	8.30	17.40	16.00	13.50	9.20	14.90	15.60	10.10	10.80	10.40	11.00	14.00	12.90
Ti	0.06	0.08	0.06	0.06	0.12	0.12	0.11	0.11	0.11	0.13	0.09	0.12	0.09	0.10	0.12	0.12
Tl	0.90	1.50	1.70	1.60	1.70	1.90	2.00	1.70	1.70	1.80	2.00	1.70	1.00	1.10	1.80	1.60
Tm	0.14	0.23	0.33	0.15	0.17	0.18	0.15	0.16	0.16	0.14	0.14	0.13	0.11	0.12	0.14	0.15
U	14.20	20.70	24.80	14.00	18.40	18.50	14.70	9.80	14.70	15.10	11.10	10.70	6.80	5.30	7.70	6.40
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	54.00	63.00	61.00	70.00	131.00	81.00	199.00	393.00	96.00	256.00	7661.00	134.00	502.00	87.00	105.00	178.00
Y	9.70	14.30	19.70	9.40	10.10	11.00	10.10	10.80	9.60	9.60	7.70	9.00	8.40	9.40	9.50	9.80
Yb	1.00	1.70	2.10	1.10	1.20	1.20	1.10	1.00	1.20	1.00	0.80	0.90	0.90	1.00	1.10	1.10
Zn	56.00	43.00	88.00	48.00	46.00	32.00	38.00	58.00	18.00	203.00	43.00	154.00	18.00	32.00	54.00	148.00
Zr	53.00	109.00	113.00	99.00	163.00	139.00	144.00	121.00	148.00	185.00	211.00	248.00	184.00	126.00	139.00	127.00
Al	72.65	61.02	67.65	69.05	55.17	59.89	68.82	78.92	62.64	69.09	75.52	61.97	59.65	64.55	79.36	77.43

continued

Sample	A400_122	A400_123	A400_124	A400_126	A400_127	A400_128	A400_129	A400_131	A400_132	A400_133	A400_134	A400_136	A400_137	A400_138	A400_139	A400_141	A400_142	A400_143	A400_144
Depth	-133.62	-134.60	-135.60	-136.60	-137.60	-138.60	-139.25	-139.75	-140.75	-141.75	-142.75	-143.75	-144.75	-145.75	-146.75	-147.75	-148.75	-149.75	-150.50
SiO2	74.87	76.15	72.95	74.44	75.51	73.37	76.15	71.88	66.74	75.30	77.01	74.23	74.66	72.52	73.59	73.37	74.66	75.08	73.59
Al2O3	11.90	12.89	12.36	12.66	12.91	12.83	11.36	13.40	12.98	12.60	13.34	12.75	12.89	12.53	11.81	12.36	12.77	12.53	10.30
FeO	1.36	1.15	0.89	0.76	1.12	1.13	1.31	1.13	0.99	1.26	1.22	1.22	1.46	1.76	1.22	1.13	1.05	1.22	1.33
Fe2O3	0.65	0.55	0.42	0.36	0.53	0.54	0.62	0.54	0.47	0.60	0.58	0.58	0.69	0.84	0.58	0.54	0.50	0.58	0.63
K2O	4.28	4.46	5.67	5.48	5.32	4.81	4.28	4.44	4.16	4.40	4.75	4.52	5.30	5.32	4.48	5.00	4.85	4.77	5.31
MgO	0.45	0.41	0.25	0.35	0.41	0.43	0.40	0.46	0.41	0.41	0.41	0.46	0.50	0.46	0.40	0.71	0.45	0.50	0.61
MnO	0.04	0.02	0.02	0.03	0.02	0.03	0.00	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.04
Na2O	0.08	0.10	0.13	0.12	1.26	1.08	1.35	3.46	3.36	2.82	3.07	2.80	2.47	2.40	2.66	1.05	2.82	2.51	0.38
P2O5	0.07	0.09	0.07	0.07	0.09	0.07	0.05	0.07	0.07	0.09	0.07	0.09	0.09	0.07	0.07	0.07	0.07	0.07	0.07
TiO2	0.18	0.18	0.10	0.12	0.22	0.20	0.17	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.20	0.20	0.20	0.20	0.17
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Al	6.30	6.82	6.54	6.70	6.83	6.79	6.01	7.09	6.87	6.67	7.06	6.75	6.82	6.63	6.25	6.54	6.76	6.63	5.45
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	682.00	674.00	990.00	956.00	916.00	759.00	708.00	536.00	596.00	745.00	681.00	770.00	920.00	1009.00	715.00	826.00	682.00	728.00	1106.00
Be	7.00	7.00	7.00	9.00	8.00	9.00	8.00	7.00	7.00	7.00	8.00	9.00	9.00	9.00	7.00	11.00	9.00	9.00	10.00
Bi	3.50	2.30	4.70	3.60	4.20	4.30	18.60	15.50	10.80	13.90	2.70	3.50	8.40	4.10	11.30	5.10	3.50	4.20	28.30
Ca	1.30	0.20	1.00	1.10	0.80	1.00	0.90	1.30	1.00	1.00	1.10	1.40	1.30	1.30	1.20	1.40	1.20	1.30	2.20
CaO	1.82	0.28	1.40	1.54	1.12	1.40	1.26	1.82	1.40	1.40	1.54	1.96	1.82	1.82	1.68	1.96	1.68	1.82	3.08
Cd	0.05	0.05	3.00	0.05	0.05	0.05	7.00	0.05	0.05	3.00	0.05	1.00	3.00	4.00	4.00	0.05	1.00	3.00	0.05
Ce	50.60	53.70	42.80	40.70	51.60	51.20	45.90	49.80	56.90	72.50	54.40	53.00	52.30	71.40	49.10	53.80	52.70	50.80	46.80
Co	4.00	5.00	6.00	4.00	5.00	5.00	6.00	5.00	5.00	6.00	5.00	5.00	5.00	9.00	6.00	7.00	4.00	6.00	7.00
Cr	109.00	163.00	84.00	81.00	125.00	117.00	259.00	87.00	97.00	90.00	161.00	108.00	108.00	190.00	119.00	162.00	93.00	191.00	141.00
Cs	9.50	9.57	10.97	10.39	12.32	12.27	9.87	7.27	6.68	8.48	7.69	8.99	9.06	8.71	8.30	11.90	8.28	8.71	10.53
Cu	102.00	77.00	92.00	47.00	71.00	65.00	126.00	41.00	39.00	83.00	76.00	109.00	175.00	241.00	89.00	71.00	63.00	78.00	72.00
Dy	1.50	2.10	2.60	2.30	1.60	1.50	1.60	1.50	1.60	1.50	1.60	1.40	1.60	1.60	1.30	1.60	1.70	1.50	1.60

Er	1.00	1.20	1.40	1.40	1.00	0.90	0.90	0.90	0.90	0.80	1.00	0.80	1.00	1.00	0.80	0.90	1.00	0.90	0.90
Eu	0.50	0.60	0.50	0.50	0.40	0.40	0.40	0.60	0.60	0.60	0.50	0.50	0.60	0.60	0.50	0.50	0.50	0.50	0.60
Fe	1.51	1.28	0.99	0.84	1.24	1.26	1.45	1.25	1.10	1.40	1.36	1.36	1.62	1.95	1.35	1.25	1.17	1.36	1.48
Ga	21.00	22.00	24.00	21.00	23.00	21.00	21.00	23.00	22.00	22.00	23.00	23.00	24.00	24.00	21.00	23.00	22.00	23.00	19.00
Gd	1.80	2.00	2.20	1.90	1.70	1.40	1.40	1.40	1.70	2.00	1.80	1.70	1.50	1.80	1.70	1.90	1.80	1.50	1.90
Hf	5.10	3.60	3.40	3.20	4.60	3.60	3.80	5.00	4.20	4.60	4.80	5.30	5.10	4.90	5.40	4.60	5.00	4.30	3.90
Ho	0.30	0.40	0.50	0.40	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40
In	0.05	0.05	0.05	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.05	0.05	0.05	0.05
K	3.55	3.70	4.71	4.55	4.42	3.99	3.55	3.69	3.45	3.65	3.94	3.75	4.40	4.42	3.72	4.15	4.03	3.96	4.41
La	29.50	31.20	26.40	25.10	30.00	29.30	27.20	28.20	32.20	44.50	31.50	32.40	31.60	47.70	27.80	29.70	29.60	28.60	27.60
Li	57.00	59.00	38.00	43.00	40.00	38.00	38.00	27.00	28.00	37.00	33.00	52.00	54.00	45.00	44.00	51.00	43.00	45.00	48.00
Lu	0.20	0.22	0.27	0.29	0.20	0.17	0.21	0.20	0.19	0.19	0.19	0.16	0.21	0.20	0.26	0.19	0.23	0.20	0.21
Mg	0.27	0.25	0.15	0.21	0.25	0.26	0.24	0.28	0.25	0.25	0.25	0.28	0.30	0.28	0.24	0.43	0.27	0.30	0.37
Mn	0.03	0.02	0.02	0.02	0.02	0.02	0.00	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03
Mo	488.00	123.00	217.00	83.00	94.00	60.00	415.00	29.00	42.00	84.00	103.00	48.00	74.00	122.00	68.00	50.00	74.00	64.00	169.00
Na	0.06	0.07	0.09	0.09	0.93	0.80	1.00	2.57	2.49	2.09	2.28	2.08	1.84	1.78	1.98	0.78	2.09	1.86	0.29
Nb	14.00	20.00	15.00	19.00	19.00	16.00	17.00	16.00	16.00	18.00	18.00	16.00	17.00	18.00	17.00	17.00	18.00	17.00	17.00
Nd	16.40	17.60	14.50	13.60	17.10	16.50	15.30	16.40	18.60	23.10	18.00	17.20	16.80	21.90	16.70	17.80	17.70	17.20	15.90
Ni	1.00	4.00	2.00	3.00	4.00	4.00	6.00	3.00	1.00	4.00	5.00	4.00	2.00	5.00	5.00	5.00	4.00	6.00	5.00
P	0.03	0.04	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.04	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
Pb	47.00	47.00	64.00	47.00	60.00	28.00	117.00	66.00	69.00	73.00	52.00	39.00	39.00	51.00	65.00	29.00	44.00	51.00	97.00
Pr	5.05	5.47	4.53	4.26	5.33	5.13	4.61	5.13	5.88	7.38	5.62	5.37	5.41	6.91	5.11	5.67	5.48	5.35	4.99
Rb	213.60	223.60	283.10	248.80	270.30	247.50	223.30	199.70	199.90	223.00	220.20	236.10	263.00	258.60	228.40	271.70	233.00	238.60	265.60
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	0.66	0.50	0.49	0.32	0.66	0.51	0.63	0.28	0.27	0.60	0.45	0.65	0.63	0.69	0.51	30.00	0.40	0.50	0.78
SO3	1.65	1.25	1.23	0.80	1.65	1.28	1.58	0.70	0.68	1.50	1.13	1.63	1.58	1.73	1.28	75.00	1.00	1.25	1.95
Sb	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.50	0.50	0.03	0.03	0.03	0.03	0.03	0.03
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	35.00	35.60	34.10	34.80	35.30	34.30	35.60	33.60	31.20	35.20	36.00	34.70	34.90	33.90	34.40	34.30	34.90	35.10	34.40

Sm	2.60	2.80	2.70	2.60	2.40	2.10	2.10	2.40	2.60	3.00	2.40	2.30	2.60	2.80	2.30	2.50	2.50	2.50	2.00
Sn	7.00	6.00	5.00	5.00	5.00	3.00	4.00	3.00	3.00	5.00	4.00	6.00	6.00	7.00	4.00	5.00	4.00	5.00	6.00
Sr	304.00	612.00	526.00	393.00	276.00	272.00	336.00	503.00	477.00	430.00	467.00	600.00	537.00	641.00	479.00	379.00	426.00	431.00	677.00
Ta	1.40	2.20	3.10	3.80	2.20	1.60	2.30	1.80	1.60	1.80	2.00	1.60	1.80	1.80	1.90	1.90	1.90	1.80	1.70
Tb	0.28	0.37	0.39	0.37	0.27	0.26	0.26	0.27	0.28	0.32	0.32	0.25	0.31	0.28	0.28	0.31	0.30	0.27	0.32
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	13.50	14.40	13.20	13.10	17.70	15.70	14.90	15.90	16.70	17.40	17.40	16.30	15.90	17.80	14.80	17.10	16.40	16.30	13.90
Ti	0.11	0.11	0.06	0.07	0.13	0.12	0.10	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.10
Tl	1.40	1.40	1.80	1.60	1.90	1.70	1.60	1.30	1.40	1.50	1.50	1.50	1.70	1.70	1.50	1.70	1.50	1.60	1.70
Tm	0.15	0.21	0.24	0.23	0.17	0.14	0.15	0.13	0.14	0.14	0.15	0.15	0.14	0.14	0.15	0.16	0.15	0.13	0.16
U	10.50	11.90	15.20	15.20	17.70	15.30	19.30	17.60	12.60	15.20	16.10	11.60	14.00	16.80	13.30	14.40	14.80	14.10	12.80
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	99.00	100.00	1426.00	17.00	20.00	13.00	253.00	49.00	30.00	202.00	55.00	70.00	299.00	323.00	29.00	148.00	28.00	74.00	1029.00
Y	9.00	13.30	15.00	14.00	10.30	9.40	9.10	9.80	10.30	10.10	10.40	9.30	10.50	10.60	9.40	10.50	10.40	10.10	11.20
Yb	1.10	1.40	1.70	1.60	1.10	1.00	1.10	1.10	1.10	1.00	1.10	1.00	1.20	1.30	1.20	1.10	1.10	1.20	1.20
Zn	44.00	23.00	50.00	25.00	19.00	25.00	19.00	23.00	37.00	93.00	24.00	36.00	88.00	148.00	137.00	24.00	34.00	108.00	15.00
Zr	177.00	118.00	94.00	90.00	135.00	114.00	105.00	177.00	127.00	146.00	146.00	186.00	174.00	163.00	171.00	157.00	161.00	133.00	124.00
Al	71.31	92.85	79.52	77.88	70.69	67.87	64.16	48.17	49.00	53.26	52.81	51.16	57.45	57.86	52.91	65.49	54.10	54.90	63.11

2. AA+200

Sample	AA200_001	AA200_002	AA200_003	AA200_004	AA200_006	AA200_007	AA200_008	AA200_009	AA200_011	AA200_012	AA200_013	AA200_014	AA200_016	AA200_017	AA200_018	AA200_019
SiO2	45.35	69.74	40.00	69.10	66.31	66.96	67.81	73.59	66.53	70.16	68.67	72.52	69.31	67.38	72.95	75.73
Al2O3	12.43	6.63	13.76	13.53	13.53	15.21	16.85	7.78	15.00	13.98	14.32	13.83	13.08	12.06	9.58	8.86
FeO	10.27	6.30	13.53	2.95	3.50	3.31	3.47	3.67	3.32	3.80	3.09	2.95	4.01	3.42	3.56	2.64
Fe2O3	11.41	7.01	15.04	3.27	3.89	3.67	3.86	4.07	3.69	4.22	3.43	3.27	4.46	3.80	3.96	2.93
CaO	11.33	4.90	8.40	2.10	3.36	1.96	1.96	4.34	2.38	1.40	1.82	1.40	2.10	1.96	3.64	1.96
MnO	0.33	0.18	0.36	0.12	0.21	0.12	0.12	0.21	0.14	0.13	0.12	0.09	0.12	0.11	0.13	0.08
MgO	4.46	1.82	4.33	1.31	1.56	1.13	1.33	1.24	1.46	1.03	1.24	1.09	1.24	1.19	1.21	1.04
Na2O	1.39	0.04	0.03	0.05	0.05	0.06	0.06	0.04	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.06
K2O	1.95	1.54	2.24	3.90	3.90	4.26	4.64	2.29	4.23	3.90	4.05	3.99	3.78	3.42	2.94	2.87
TiO2	2.77	1.40	2.95	0.37	0.37	0.40	0.47	0.18	0.40	0.38	0.38	0.35	0.35	0.30	0.30	0.33
P2O5	0.37	0.18	0.39	0.11	0.14	0.14	0.18	0.07	0.16	0.16	0.14	0.14	0.14	0.11	0.11	0.11
Ag	2.50	25.00	13.00	2.50	2.50	2.50	2.50	2.50	5.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	73.00	10.00	10.00	27.00	38.00	27.00	25.00	10.00	10.00	10.00	29.00	44.00	136.00	105.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	810.00	499.00	741.00	1356.00	1455.00	1787.00	1774.00	865.00	1477.00	1419.00	1467.00	1309.00	1230.00	1065.00	836.00	758.00
Be	12.00	7.00	12.00	15.00	14.00	14.00	14.00	9.00	13.00	12.00	12.00	14.00	12.00	12.00	10.00	10.00
Bi	14.20	198.20	32.50	3.20	3.80	15.20	4.00	29.50	7.60	9.90	5.10	8.40	9.30	5.10	4.50	3.40
Cd	7.00	45.00	5.00	1.00	2.00	2.00	3.00	170.00	7.00	4.00	2.00	6.00	5.00	4.00	3.00	5.00
Ce	70.40	47.60	66.90	146.50	137.40	176.50	225.30	90.60	181.00	190.50	153.50	120.40	129.70	112.20	123.20	130.60
Co	48.00	22.00	61.00	6.00	6.00	8.00	7.00	6.00	6.00	8.00	6.00	6.00	7.00	6.00	5.00	5.00
Cr	273.00	330.00	440.00	198.00	147.00	212.00	202.00	343.00	232.00	184.00	202.00	190.00	186.00	150.00	183.00	178.00
Cs	19.88	15.33	18.43	29.22	27.58	30.49	34.10	17.33	32.00	30.34	29.23	29.13	28.13	23.80	20.25	21.85
Cu	188.00	460.00	357.00	221.00	322.00	366.00	313.00	211.00	357.00	345.00	244.00	249.00	327.00	425.00	346.00	83.00
Dy	6.40	3.00	4.60	2.40	1.90	2.20	3.00	1.60	2.80	2.70	3.00	2.30	2.20	2.10	2.50	2.70

Er	2.90	1.30	2.20	1.10	1.00	1.10	1.50	0.80	1.30	1.40	1.40	1.20	1.10	1.20	1.20	1.30
Eu	2.50	1.60	2.00	1.00	1.20	1.00	1.30	0.90	1.40	1.20	1.20	0.90	1.00	0.90	1.10	0.90
Ga	24.00	17.00	31.00	25.00	27.00	26.00	30.00	20.00	29.00	27.00	26.00	26.00	26.00	25.00	22.00	20.00
Gd	7.60	4.60	6.30	3.10	3.00	3.00	3.90	2.20	3.80	4.00	3.70	2.90	2.80	2.70	3.30	2.90
Hf	5.60	3.00	6.00	4.90	4.40	5.30	6.00	2.30	5.50	5.50	5.20	4.40	5.20	4.20	4.70	4.60
Ho	1.20	0.50	0.80	0.40	0.30	0.40	0.50	0.30	0.50	0.50	0.50	0.40	0.40	0.40	0.50	0.50
In	0.30	1.30	0.20	0.05	0.20	0.20	0.30	4.70	0.30	0.20	0.10	0.20	0.20	0.20	0.10	0.20
La	38.40	22.50	31.30	99.80	94.80	120.10	154.60	63.50	123.20	126.90	98.20	77.80	83.40	75.40	81.60	91.70
Li	154.00	105.00	307.00	48.00	49.00	36.00	45.00	67.00	61.00	49.00	53.00	55.00	57.00	56.00	72.00	80.00
Lu	0.36	0.20	0.28	0.16	0.16	0.18	0.29	0.14	0.25	0.20	0.22	0.17	0.19	0.16	0.18	0.20
Mo	112.00	37.00	157.00	143.00	545.00	90.00	301.00	263.00	679.00	920.00	119.00	760.00	824.00	490.00	1275.00	446.00
Nb	30.00	17.00	35.00	14.00	14.00	16.00	18.00	5.00	17.00	16.00	17.00	15.00	17.00	15.00	15.00	17.00
Nd	34.30	25.40	34.20	42.00	38.10	46.00	58.20	24.40	47.80	54.00	45.70	35.40	37.50	33.00	37.00	36.10
Ni	231.00	113.00	240.00	12.00	7.00	10.00	8.00	12.00	7.00	8.00	10.00	7.00	8.00	8.00	7.00	9.00
Pb	104.00	944.00	414.00	28.00	39.00	109.00	63.00	174.00	98.00	65.00	45.00	94.00	110.00	50.00	34.00	24.00
Pr	8.48	5.92	8.31	13.76	12.46	16.15	20.19	8.18	16.37	17.83	14.94	11.58	12.29	10.70	11.82	11.99
Rb	177.10	139.80	197.40	280.80	269.30	260.00	308.50	188.60	293.40	267.20	290.50	273.70	269.30	271.40	306.80	329.70
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.20	0.05	0.10	0.10	0.05	0.20	0.10
S	1.33	1.36	0.34	0.74	0.56	0.90	0.85	1.04	0.71	1.38	1.16	1.08	1.88	1.50	1.86	1.36
Sb	0.25	0.70	0.70	0.25	0.80	1.30	1.00	0.70	0.70	1.00	0.25	0.25	0.50	0.25	0.25	0.25
Sc	27.00	10.00	29.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	7.50	5.20	6.80	5.00	4.50	5.10	6.30	3.00	5.50	6.70	6.00	4.60	4.60	4.40	5.00	4.60
Sn	16.00	16.00	18.00	17.00	24.00	24.00	29.00	19.00	27.00	26.00	18.00	15.00	21.00	17.00	20.00	20.00
Sr	1273.00	399.00	533.00	219.00	329.00	185.00	182.00	474.00	189.00	143.00	159.00	116.00	142.00	152.00	395.00	250.00
Ta	2.00	1.20	2.10	1.30	1.10	1.20	1.30	0.70	1.20	1.30	1.50	1.20	1.20	1.50	1.20	1.90
Tb	1.10	0.59	0.84	0.37	0.38	0.35	0.50	0.31	0.46	0.46	0.48	0.43	0.36	0.36	0.38	0.42
Te	0.50	6.00	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	3.80	2.10	4.00	20.00	20.60	23.30	26.50	10.90	21.40	20.60	21.60	19.20	19.80	15.90	14.50	14.20
Tl	1.40	1.20	1.70	2.00	2.00	2.20	2.40	1.50	2.20	2.30	2.30	2.10	2.60	2.00	2.10	2.00

Tm	0.39	0.16	0.28	0.19	0.14	0.16	0.22	0.12	0.20	0.18	0.20	0.18	0.17	0.17	0.19	0.18
U	2.00	0.90	1.90	9.90	7.90	9.50	13.70	5.50	13.30	12.30	12.20	8.00	10.00	7.30	7.40	8.80
V	293.00	160.00	317.00	57.00	61.00	65.00	72.00	65.00	63.00	59.00	65.00	55.00	59.00	25.00	51.00	57.00
W	541.00	1503.00	204.00	99.00	540.00	77.00	43.00	254.00	26.00	27.00	41.00	430.00	26.00	60.00	61.00	42.00
Y	28.30	12.70	18.60	11.30	9.40	10.60	14.80	9.00	14.70	14.10	14.80	11.70	11.80	12.10	12.90	13.70
Yb	2.30	1.10	1.90	1.10	0.90	1.00	1.40	0.90	1.50	1.30	1.50	1.10	1.20	1.10	1.20	1.30
Zn	339.00	1291.00	304.00	46.00	76.00	75.00	90.00	4864.00	215.00	122.00	55.00	166.00	148.00	132.00	78.00	164.00
Zr	233.00	125.00	253.00	186.00	175.00	213.00	243.00	124.00	213.00	210.00	205.00	175.00	202.00	173.00	198.00	194.00
Al	17.45	19.00	15.15	53.70	44.57	58.35	58.86	29.42	52.77	62.02	57.28	61.85	53.45	52.38	38.08	49.35

continued

Sample	AA200_021	AA200_022	AA200_023	AA200_024	AA200_026	AA200_027	AA200_028	AA200_029	AA200_031	AA200_032	AA200_033	AA200_034	AA200_036	AA200_037	AA200_038	AA200_039
SiO2	61.18	75.51	76.37	63.32	62.68	62.89	65.03	66.74	68.45	69.10	70.59	68.67	69.74	77.22	77.87	74.23
Al2O3	19.25	10.94	8.31	11.22	10.35	12.13	12.24	11.81	11.53	12.30	11.64	11.85	11.09	12.98	10.39	11.07
FeO	3.07	1.60	2.10	6.15	7.77	5.39	4.98	4.37	4.73	3.85	4.14	3.69	4.30	3.51	2.47	2.68
Fe2O3	3.42	1.77	2.33	6.83	8.64	5.99	5.53	4.86	5.26	4.27	4.60	4.10	4.78	3.90	2.75	2.97
CaO	0.56	2.10	3.08	3.22	3.50	3.64	3.36	2.80	2.94	2.80	2.66	2.52	3.22	2.80	1.68	1.68
MnO	0.03	0.09	0.09	0.14	0.21	0.17	0.20	0.17	0.14	0.11	0.11	0.08	0.07	0.07	0.04	0.03
MgO	1.79	1.18	0.93	0.70	0.80	0.60	0.68	0.68	0.68	0.58	0.46	0.55	0.48	0.43	0.32	0.32
Na2O	0.09	0.11	0.05	1.97	2.60	2.97	3.31	3.07	3.14	3.53	4.37	3.17	2.27	2.50	2.03	2.47
K2O	6.38	3.61	2.60	2.46	1.72	3.10	3.16	3.70	2.58	3.26	1.75	3.76	3.46	4.90	4.31	4.35
TiO2	0.35	0.33	0.27	0.23	0.18	0.23	0.22	0.22	0.22	0.23	0.27	0.25	0.15	0.20	0.15	0.17
P2O5	0.16	0.14	0.09	0.14	0.18	0.11	0.11	0.11	0.09	0.09	0.14	0.14	0.05	0.07	0.05	0.05
Ag	2.50	7.00	8.00	24.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	188.00	45.00	34.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	54.00	92.00	25.00	25.00	25.00	25.00

Ba	1648.00	925.00	805.00	1241.00	804.00	1511.00	2462.00	2999.00	1744.00	1910.00	1378.00	2190.00	1825.00	3144.00	1990.00	1522.00
Be	19.00	10.00	12.00	38.00	44.00	46.00	32.00	29.00	31.00	47.00	33.00	21.00	45.00	21.00	9.00	10.00
Bi	2.30	1.30	83.10	16.90	10.70	24.60	7.50	7.50	6.60	9.30	5.60	8.70	13.10	6.20	2.80	4.40
Cd	0.50	2.00	3.00	12.00	4.00	8.00	3.00	6.00	3.00	21.00	3.00	8.00	13.00	11.00	3.00	3.00
Ce	132.30	108.40	114.90	640.60	3480.70	457.90	641.60	710.00	784.20	193.60	442.90	152.00	93.50	80.30	55.10	59.30
Co	5.00	3.00	2.00	12.00	9.00	9.00	10.00	10.00	11.00	9.00	11.00	8.00	7.00	6.00	7.00	6.00
Cr	141.00	243.00	157.00	108.00	126.00	102.00	104.00	164.00	112.00	106.00	124.00	147.00	139.00	117.00	197.00	178.00
Cs	49.66	24.20	22.61	10.75	9.11	10.67	6.90	6.67	7.49	8.01	5.84	7.54	8.46	9.53	7.06	7.27
Cu	32.00	29.00	100.00	654.00	689.00	527.00	481.00	456.00	486.00	439.00	481.00	397.00	454.00	316.00	236.00	226.00
Dy	2.70	2.30	1.50	3.80	9.40	3.20	3.80	3.80	3.50	2.50	3.60	2.40	2.40	1.60	1.20	1.60
Er	1.30	1.30	0.80	1.70	3.20	1.70	1.80	1.70	1.50	1.30	1.70	1.20	1.30	1.00	0.80	0.90
Eu	1.10	0.90	1.00	3.30	15.70	2.90	3.80	4.50	3.80	1.40	2.20	1.00	1.20	0.70	0.40	0.40
Ga	45.00	24.00	20.00	31.00	24.00	29.00	31.00	27.00	27.00	29.00	31.00	26.00	28.00	29.00	19.00	21.00
Gd	3.40	2.70	2.50	6.40	24.30	5.30	7.10	8.90	7.40	3.60	6.00	3.20	2.40	1.80	1.60	1.60
Hf	6.30	4.90	3.80	3.70	5.90	3.80	3.80	3.30	2.60	3.10	4.00	3.70	2.80	3.90	3.20	3.10
Ho	0.50	0.50	0.30	0.70	1.60	0.60	0.60	0.70	0.60	0.50	0.60	0.40	0.40	0.30	0.30	0.30
In	0.10	0.05	0.10	0.50	0.70	0.40	0.30	0.30	0.30	0.70	0.20	0.20	0.40	0.40	0.10	0.05
La	82.10	66.20	78.20	444.80	2168.50	286.00	395.50	392.70	473.30	128.90	270.40	113.80	95.60	73.30	41.50	42.30
Li	182.00	86.00	75.00	57.00	75.00	72.00	48.00	39.00	53.00	49.00	36.00	42.00	59.00	54.00	38.00	38.00
Lu	0.20	0.22	0.14	0.25	0.45	0.25	0.25	0.25	0.27	0.22	0.29	0.19	0.17	0.17	0.15	0.15
Mo	528.00	58.00	124.00	56.00	175.00	63.00	41.00	607.00	197.00	145.00	68.00	163.00	125.00	146.00	351.00	224.00
Nb	15.00	15.00	13.00	21.00	20.00	22.00	20.00	21.00	20.00	20.00	24.00	20.00	16.00	19.00	15.00	15.00
Nd	41.20	33.60	32.70	164.70	912.40	124.40	180.90	221.40	216.60	55.50	126.90	40.80	21.90	20.20	14.60	17.50
Ni	7.00	9.00	5.00	5.00	7.00	6.00	5.00	5.00	5.00	5.00	6.00	6.00	5.00	6.00	6.00	7.00
Pb	10.00	57.00	185.00	41.00	42.00	65.00	20.00	32.00	23.00	64.00	28.00	75.00	117.00	59.00	41.00	48.00
Pr	13.29	10.69	10.87	57.53	325.61	42.79	61.56	72.96	74.34	18.24	42.77	13.93	7.46	7.03	4.95	5.56
Rb	774.00	389.80	270.70	181.30	134.30	190.00	163.90	173.30	151.60	171.30	99.10	195.20	215.10	273.20	222.10	226.10
Re	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.05	0.05	0.05	0.20	0.05	0.05	0.05
S	1.95	0.54	0.89	3.26	3.19	2.44	1.81	1.69	1.88	1.52	1.61	1.49	1.90	1.48	0.95	0.97
Sb	0.25	0.25	0.25	0.25	0.25	0.50	0.25	0.25	0.25	0.25	0.25	0.25	0.60	0.25	0.25	0.25

Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	5.40	4.20	3.70	14.30	67.20	11.40	15.80	20.50	18.20	6.20	11.90	4.70	3.10	2.60	2.00	2.30
Sn	36.00	22.00	16.00	24.00	35.00	20.00	22.00	20.00	19.00	17.00	19.00	14.00	18.00	13.00	7.00	7.00
Sr	103.00	311.00	418.00	999.00	1067.00	3883.00	2146.00	1869.00	1681.00	1737.00	2154.00	1810.00	1134.00	1540.00	1049.00	818.00
Ta	1.10	1.10	2.70	1.90	1.80	2.10	1.70	1.70	3.60	2.50	2.50	2.00	1.90	2.10	1.80	1.70
Tb	0.44	0.35	0.33	0.63	1.92	0.57	0.63	0.76	0.67	0.39	0.63	0.38	0.39	0.29	0.21	0.22
Te	0.50	0.50	2.00	0.50	1.00	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	19.90	18.00	13.50	19.50	28.70	16.40	20.00	19.80	22.70	10.90	14.30	15.90	13.20	16.10	13.70	14.10
Tl	4.50	2.50	1.70	1.40	1.10	1.40	1.10	1.30	1.00	1.10	0.70	1.30	1.50	1.70	1.40	1.50
Tm	0.21	0.18	0.15	0.23	0.48	0.25	0.25	0.23	0.25	0.18	0.25	0.20	0.17	0.15	0.12	0.14
U	11.80	10.40	6.90	13.30	44.80	14.40	16.10	14.10	11.10	6.50	9.50	9.60	14.40	15.80	13.00	13.10
V	73.00	61.00	25.00	84.00	204.00	68.00	73.00	54.00	62.00	25.00	25.00	52.00	79.00	72.00	25.00	25.00
W	28.00	34.00	289.00	2589.00	2568.00	899.00	1283.00	1205.00	931.00	1222.00	276.00	972.00	16715.00	2761.00	143.00	110.00
Y	15.70	12.60	9.40	20.10	51.00	18.80	21.10	21.80	19.40	14.10	19.90	13.30	11.70	10.30	7.80	8.60
Yb	1.40	1.30	0.90	1.60	3.10	1.60	1.80	1.50	1.60	1.10	1.60	1.20	1.20	1.20	0.90	0.90
Zn	23.00	38.00	70.00	382.00	134.00	257.00	124.00	173.00	102.00	562.00	121.00	216.00	335.00	259.00	72.00	81.00
Zr	252.00	191.00	147.00	136.00	254.00	150.00	147.00	117.00	114.00	133.00	160.00	150.00	98.00	143.00	120.00	114.00
Al	73.37	53.17	39.80	53.06	50.15	58.89	61.56	66.06	61.24	66.79	66.21	69.33	60.75	69.63	76.08	77.36

continued

Sample	AA200_041	AA200_042	AA200_043	AA200_044	AA200_046	AA200_047	AA200_048	AA200_049	AA200_051	AA200_052	AA200_053	AA200_054	AA200_056	AA200_057	AA200_058	AA200_059
SiO2	73.59	73.80	70.59	75.30	97.55	69.74	72.30	72.52	74.87	72.52	73.59	74.44	72.73	73.16	61.39	71.02
Al2O3	11.87	12.43	13.36	11.83	0.23	14.30	12.81	12.28	11.07	11.75	12.04	11.38	12.87	12.26	14.04	11.98
FeO	2.15	2.30	3.11	2.68	3.34	2.91	1.92	2.32	1.90	1.79	2.38	2.66	1.67	1.69	6.33	2.07
Fe2O3	2.39	2.56	3.46	2.97	3.72	3.23	2.13	2.57	2.12	1.99	2.64	2.96	1.86	1.87	7.03	2.30
CaO	1.96	1.96	1.96	1.82	0.07	2.24	1.96	2.24	1.96	1.96	1.96	1.40	2.80	1.12	1.26	1.96
MnO	0.04	0.04	0.05	0.04	0.01	0.05	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.04	0.19	0.06
MgO	0.41	0.38	0.41	0.38	0.03	0.51	0.46	0.53	0.50	0.46	0.48	0.76	0.70	0.51	0.80	0.60
Na2O	2.68	3.01	2.87	2.74	0.04	2.80	3.13	2.42	2.26	2.62	1.79	0.23	1.44	0.91	0.11	0.10
K2O	4.28	4.36	5.11	4.26	0.14	5.79	4.63	4.77	4.23	4.26	4.49	4.76	4.01	4.85	5.06	4.72
TiO2	0.18	0.18	0.18	0.18	0.04	0.22	0.23	0.23	0.22	0.23	0.23	0.20	0.22	0.18	0.22	0.22
P2O5	0.05	0.07	0.11	0.09	0.01	0.25	0.07	0.09	0.09	0.07	0.09	0.09	0.09	0.07	0.11	0.09
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	29.00	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	75.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	62.00	25.00
Ba	1463.00	1493.00	1950.00	1313.00	32.00	1998.00	1449.00	1878.00	1617.00	1371.00	1608.00	2098.00	1284.00	1352.00	1651.00	1507.00
Be	13.00	11.00	18.00	13.00	0.50	20.00	11.00	12.00	9.00	9.00	9.00	10.00	48.00	9.00	11.00	12.00
Bi	24.70	16.20	7.80	4.00	18.20	9.30	6.40	9.00	17.40	20.90	5.40	34.20	5.40	4.50	443.80	7.40
Cd	4.00	5.00	7.00	1.00	8.00	8.00	3.00	3.00	3.00	2.00	2.00	3.00	2.00	3.00	48.00	2.00
Ce	85.10	87.40	70.10	55.80	5.00	69.40	78.40	86.80	76.50	69.40	75.60	84.30	78.10	79.30	80.00	98.70
Co	6.00	5.00	5.00	7.00	10.00	6.00	5.00	5.00	5.00	4.00	5.00	6.00	4.00	3.00	15.00	7.00
Cr	132.00	162.00	120.00	181.00	498.00	118.00	147.00	129.00	157.00	126.00	187.00	255.00	175.00	240.00	150.00	301.00
Cs	8.62	9.55	8.52	11.20	0.28	10.09	9.04	10.41	10.31	10.29	13.41	20.62	20.00	17.70	32.69	25.63
Cu	189.00	204.00	339.00	217.00	325.00	243.00	146.00	198.00	158.00	162.00	198.00	276.00	105.00	100.00	628.00	198.00
Dy	1.50	1.80	1.80	1.60	0.10	3.00	2.30	2.50	1.90	1.90	1.80	2.30	2.60	2.30	2.70	2.60
Er	0.90	1.00	0.90	0.80	0.05	1.80	1.20	1.20	0.90	0.90	0.80	1.10	1.40	1.20	1.50	1.40

Eu	0.60	0.60	0.60	0.50	0.05	0.70	0.70	0.70	0.60	0.70	0.60	0.70	0.80	0.60	1.00	0.90
Ga	22.00	24.00	27.00	23.00	2.00	27.00	22.00	23.00	20.00	21.00	22.00	22.00	23.00	22.00	31.00	24.00
Gd	2.00	2.10	2.00	1.50	0.10	2.90	2.50	2.70	2.50	2.40	2.20	2.40	3.00	2.80	3.00	3.20
Hf	3.60	3.80	3.70	3.20	0.40	4.10	4.10	3.70	3.50	3.20	4.90	3.10	3.90	3.50	4.30	4.10
Ho	0.30	0.30	0.30	0.30	0.05	0.60	0.40	0.50	0.30	0.30	0.30	0.40	0.50	0.40	0.50	0.50
In	0.10	0.20	0.20	0.05	0.20	0.20	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.20	0.05
La	71.70	72.70	59.10	39.80	4.00	52.20	50.10	58.90	52.20	45.60	52.80	65.50	49.20	49.50	52.30	67.20
Li	48.00	46.00	46.00	63.00	7.00	60.00	49.00	57.00	47.00	48.00	46.00	60.00	51.00	51.00	70.00	60.00
Lu	0.18	0.19	0.16	0.16	0.03	0.25	0.25	0.19	0.44	0.19	0.16	0.14	0.20	0.18	0.24	0.20
Mo	81.00	109.00	52.00	173.00	733.00	108.00	179.00	686.00	217.00	438.00	68.00	291.00	200.00	200.00	2400.00	203.00
Nb	16.00	16.00	16.00	16.00	5.00	17.00	20.00	20.00	16.00	16.00	17.00	18.00	20.00	17.00	20.00	19.00
Nd	21.20	22.40	18.10	16.20	0.90	20.40	24.00	26.10	22.30	20.60	21.70	21.80	23.80	24.20	24.50	29.50
Ni	6.00	7.00	6.00	7.00	11.00	7.00	8.00	5.00	6.00	4.00	8.00	7.00	6.00	7.00	0.50	11.00
Pb	124.00	88.00	61.00	45.00	38.00	61.00	49.00	66.00	66.00	81.00	57.00	111.00	41.00	70.00	957.00	69.00
Pr	7.35	7.58	6.09	5.31	0.33	6.43	7.62	8.58	7.23	6.80	7.01	7.48	7.55	7.70	7.88	9.37
Rb	246.00	235.30	265.70	210.80	5.40	299.10	245.70	267.40	229.60	233.00	246.20	271.60	250.10	311.90	316.40	301.70
Re	0.05	0.05	0.05	0.05	0.10	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.05	0.30	0.05
S	0.88	0.91	1.42	0.94	1.32	1.28	0.61	0.91	0.68	0.70	0.87	1.04	0.44	0.79	3.18	0.61
Sb	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.60	0.25	0.25	0.25	0.25	0.25	1.40	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	2.80	3.10	2.60	2.20	0.20	3.20	3.40	3.50	3.20	3.10	2.90	3.00	3.90	3.40	3.80	4.00
Sn	8.00	8.00	12.00	9.00	1.00	12.00	9.00	11.00	10.00	17.00	12.00	10.00	8.00	9.00	15.00	14.00
Sr	808.00	977.00	1197.00	900.00	39.00	1120.00	901.00	1123.00	901.00	940.00	883.00	568.00	679.00	472.00	324.00	345.00
Ta	1.60	1.80	1.40	1.70	0.20	1.60	2.10	1.90	1.50	1.60	1.80	1.70	2.10	2.00	1.80	1.90
Tb	0.25	0.26	0.30	0.24	0.03	0.46	0.38	0.36	0.32	0.30	0.30	0.33	0.46	0.38	0.50	0.44
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.50	9.00	0.50
Th	15.50	17.20	13.40	11.70	0.40	15.20	16.10	17.00	16.20	15.20	13.00	13.30	18.70	18.10	15.10	17.20
Tl	1.50	1.60	1.70	1.40	0.25	2.00	1.60	1.80	1.70	1.60	1.90	2.00	1.80	2.00	2.50	2.20

Tm	0.16	0.15	0.13	0.14	0.03	0.23	0.19	0.19	0.15	0.13	0.13	0.15	0.18	0.19	0.21	0.19
U	13.60	15.50	10.30	9.90	0.40	12.80	13.90	13.10	9.10	7.10	7.40	9.20	14.00	12.80	15.30	10.70
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	52.00
W	311.00	130.00	627.00	113.00	986.00	539.00	126.00	262.00	89.00	107.00	99.00	403.00	428.00	136.00	12187.00	1652.00
Y	9.40	9.80	10.60	9.30	0.25	18.70	12.60	12.90	10.80	9.50	10.20	11.70	14.20	12.40	15.20	14.20
Yb	1.00	1.10	1.00	1.00	0.05	1.60	1.30	1.20	0.90	0.80	0.90	1.00	1.20	1.20	1.50	1.30
Zn	100.00	156.00	195.00	37.00	217.00	199.00	71.00	67.00	52.00	37.00	60.00	73.00	51.00	75.00	1211.00	68.00
Zr	130.00	141.00	135.00	115.00	19.00	150.00	146.00	144.00	130.00	118.00	212.00	118.00	150.00	127.00	167.00	150.00
AI	74.57	75.89	77.07	76.11	64.23	75.74	76.20	72.18	72.54	73.98	72.03	69.78	60.94	77.93	71.55	65.36

continued

Sample	AA200_061	AA200_062	AA200_063	AA200_064	AA200_066	AA200_067	AA200_068	AA200_069	AA200_071	AA200_072	AA200_073	AA200_074	AA200_076	AA200_077	AA200_078	AA200_079
SiO2	74.87	71.23	72.73	82.79	72.95	74.02	71.88	70.81	71.23	73.59	71.45	72.52	84.50	70.81	74.44	72.09
Al2O3	10.18	11.77	12.17	5.40	11.32	13.34	12.79	13.08	13.36	12.45	13.36	11.41	12.32	12.30	12.77	12.36
FeO	1.76	1.66	1.97	3.19	1.76	1.83	1.99	1.93	1.93	1.99	1.74	2.48	2.59	1.45	1.70	1.61
Fe2O3	1.96	1.84	2.19	3.55	1.96	2.03	2.22	2.14	2.14	2.22	1.93	2.76	2.87	1.62	1.89	1.79
CaO	2.10	2.10	2.10	1.12	1.82	1.82	2.10	1.82	1.82	1.68	1.96	1.68	1.54	1.68	1.96	2.24
MnO	0.04	0.05	0.04	0.03	0.04	0.04	0.06	0.05	0.05	0.05	0.05	0.06	0.03	0.04	0.04	0.05
MgO	0.48	0.50	0.55	0.33	0.48	0.53	0.51	0.53	0.56	0.53	0.53	0.48	0.51	0.43	0.46	0.43
Na2O	1.29	2.61	2.28	0.87	2.64	3.30	3.00	3.28	3.29	2.97	3.55	3.05	2.22	2.54	2.60	2.53
K2O	3.65	4.20	4.55	2.24	4.14	4.59	4.59	4.51	4.57	4.28	4.36	4.04	4.64	4.99	4.65	4.34
TiO2	0.20	0.22	0.22	0.10	0.22	0.25	0.23	0.25	0.25	0.23	0.27	0.23	0.23	0.20	0.22	0.22
P2O5	0.07	0.07	0.07	0.05	0.07	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.07	0.09	0.09
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	1327.00	1161.00	1424.00	699.00	1238.00	1409.00	1644.00	1683.00	1654.00	1480.00	1445.00	1600.00	1421.00	1314.00	1416.00	1231.00
Be	8.00	11.00	11.00	8.00	10.00	8.00	13.00	10.00	198.00	39.00	11.00	17.00	13.00	10.00	12.00	9.00
Bi	7.40	7.00	5.50	8.30	29.70	4.10	6.00	3.70	8.40	3.20	2.50	6.30	7.50	3.00	3.90	1.90
Cd	3.00	4.00	2.00	3.00	3.00	1.00	1.00	1.00	5.00	2.00	0.50	3.00	6.00	2.00	2.00	0.50
Ce	99.80	71.50	83.40	38.40	79.10	79.90	88.60	84.70	90.90	82.60	77.60	76.20	76.10	74.30	73.80	75.30
Co	3.00	5.00	4.00	8.00	5.00	4.00	3.00	4.00	4.00	5.00	3.00	7.00	6.00	3.00	3.00	4.00
Cr	173.00	177.00	232.00	386.00	230.00	163.00	135.00	118.00	144.00	147.00	74.00	192.00	235.00	171.00	110.00	141.00
Cs	15.02	9.13	20.70	5.89	7.71	7.66	7.53	6.92	8.02	7.46	7.84	7.09	8.93	9.64	10.08	11.02
Cu	152.00	114.00	150.00	182.00	122.00	85.00	141.00	123.00	117.00	142.00	130.00	230.00	195.00	116.00	140.00	124.00
Dy	2.50	2.50	2.50	1.20	2.40	2.60	2.40	2.40	2.10	2.20	2.30	2.20	2.30	2.40	2.40	2.40
Er	1.10	1.20	1.40	0.50	1.30	1.20	1.20	1.20	1.10	0.90	1.10	1.00	1.20	1.20	1.10	1.20
Eu	0.70	0.70	0.80	0.30	0.70	0.80	0.70	0.80	0.80	0.80	0.80	0.70	0.70	0.70	0.70	0.70
Ga	18.00	21.00	22.00	11.00	19.00	21.00	22.00	22.00	23.00	22.00	23.00	21.00	22.00	21.00	22.00	21.00
Gd	3.30	2.70	3.10	1.10	2.60	2.90	2.90	3.00	2.90	2.70	2.90	2.60	2.90	2.60	2.70	2.70
Hf	5.30	6.50	4.10	2.30	4.20	4.00	3.80	4.70	4.10	3.90	4.00	3.90	3.80	5.70	4.50	4.20
Ho	0.40	0.50	0.50	0.20	0.40	0.50	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.50	0.40	0.40
In	0.05	0.10	0.05	0.10	0.05	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.20	0.05	0.05	0.05
La	62.70	43.00	52.00	24.50	49.70	47.10	57.40	52.80	58.00	48.00	47.20	48.00	46.00	45.60	48.50	45.70
Li	45.00	48.00	59.00	34.00	44.00	39.00	37.00	34.00	44.00	38.00	41.00	41.00	58.00	50.00	49.00	40.00
Lu	0.16	0.19	0.26	0.10	0.19	0.20	0.20	0.20	0.15	0.14	0.14	0.19	0.18	0.19	0.16	0.18
Mo	118.00	98.00	278.00	188.00	1677.00	285.00	98.00	94.00	451.00	794.00	123.00	560.00	345.00	342.00	479.00	114.00
Nb	17.00	18.00	20.00	5.00	19.00	19.00	19.00	19.00	17.00	17.00	19.00	20.00	19.00	19.00	19.00	18.00
Nd	30.40	22.90	25.90	11.80	24.80	26.10	27.10	26.70	27.90	27.10	25.80	23.70	24.30	24.10	23.60	23.60
Ni	8.00	9.00	10.00	12.00	1.00	6.00	8.00	7.00	6.00	4.00	5.00	7.00	6.00	7.00	4.00	8.00
Pb	66.00	97.00	75.00	43.00	120.00	57.00	51.00	47.00	72.00	45.00	39.00	56.00	84.00	49.00	51.00	33.00
Pr	9.75	7.39	8.07	3.57	7.70	8.11	8.67	8.37	8.85	8.25	7.77	7.51	7.69	7.39	7.50	7.38
Rb	228.20	232.40	257.80	131.70	214.50	230.90	238.20	230.10	245.40	226.20	235.90	219.00	264.20	281.70	252.20	243.40
Re	0.05	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.10	0.05	0.10	0.05	0.05	0.05	0.05

S	0.57	0.52	0.67	1.00	0.70	0.46	0.70	0.58	0.59	0.74	0.60	0.98	1.13	0.56	0.65	0.50
Sb	0.25	0.25	0.80	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	4.40	3.80	4.00	1.60	3.50	3.80	3.80	3.60	3.90	3.90	3.90	3.50	3.60	3.30	3.30	3.60
Sn	10.00	11.00	11.00	5.00	7.00	10.00	10.00	9.00	10.00	9.00	10.00	13.00	11.00	8.00	9.00	8.00
Sr	705.00	795.00	933.00	402.00	749.00	878.00	1121.00	1255.00	1100.00	1085.00	1201.00	1078.00	709.00	657.00	931.00	814.00
Ta	1.80	1.90	2.40	1.00	1.90	2.00	2.00	1.90	1.70	1.50	1.80	2.00	2.00	2.30	2.20	2.10
Tb	0.45	0.41	0.44	0.18	0.44	0.48	0.40	0.42	0.37	0.36	0.41	0.38	0.41	0.36	0.39	0.40
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	16.50	16.00	17.10	7.60	16.20	17.20	17.50	17.40	17.60	16.80	17.90	15.90	17.20	17.80	17.20	17.50
Tl	1.50	1.50	1.70	0.90	1.40	1.50	1.50	1.50	1.60	1.40	1.60	1.50	1.80	1.90	1.70	1.70
Tm	0.18	0.18	0.19	0.09	0.18	0.21	0.19	0.16	0.15	0.13	0.16	0.16	0.17	0.17	0.17	0.17
U	10.00	16.20	15.50	6.70	11.80	11.20	10.80	10.80	9.90	12.60	11.10	13.20	12.40	14.00	12.00	11.50
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	319.00	501.00	441.00	683.00	220.00	99.00	263.00	114.00	855.00	160.00	61.00	708.00	691.00	290.00	141.00	57.00
Y	12.70	13.30	13.90	6.10	12.60	13.20	12.80	12.60	11.20	10.90	12.30	11.30	12.20	12.30	12.50	12.60
Yb	1.10	1.20	1.40	0.50	1.10	1.20	1.20	1.10	1.00	0.90	1.00	1.10	1.10	1.10	1.20	1.20
Zn	77.00	112.00	80.00	94.00	48.00	33.00	33.00	38.00	158.00	39.00	35.00	79.00	133.00	59.00	71.00	24.00
Zr	217.00	256.00	159.00	99.00	166.00	157.00	150.00	183.00	152.00	149.00	151.00	153.00	145.00	246.00	174.00	164.00
Al	65.71	72.40	72.10	68.22	74.67	77.05	74.39	76.82	76.72	76.64	76.05	76.64	76.97	78.11	74.95	71.99

continued

Sample	AA200_081	AA200_082	AA200_083	AA200_084	AA200_086	AA200_087	AA200_088	AA200_089	AA200_091	AA200_092	AA200_093	AA200_094	AA200_096	AA200_097	AA200_098	AA200_099
SiO2	76.58	75.94	65.89	70.38	72.73	74.66	72.73	68.88	73.80	74.02	63.11	65.03	72.30	19.68	74.23	72.09
Al2O3	12.30	14.13	13.45	12.58	13.11	11.39	12.92	13.23	11.70	11.66	13.79	15.21	13.28	4.46	11.07	12.60

FeO	1.66	2.01	3.86	1.94	1.89	2.08	1.84	2.68	2.08	2.33	5.79	4.45	1.97	17.83	2.87	2.19
Fe2O3	1.84	2.23	4.29	2.16	2.10	2.32	2.04	2.97	2.32	2.59	6.43	4.95	2.19	19.82	3.19	2.43
CaO	0.70	0.70	2.94	2.38	1.96	1.82	1.68	2.94	1.82	1.68	2.24	2.10	1.68	19.31	1.68	1.96
MnO	0.04	0.05	0.09	0.07	0.05	0.05	0.04	0.03	0.04	0.04	0.09	0.08	0.04	0.09	0.04	0.04
MgO	0.70	0.85	0.73	0.48	0.51	0.45	0.48	0.40	0.41	0.40	0.48	0.46	0.40	0.27	0.36	0.41
Na2O	0.09	0.06	0.11	3.01	3.26	2.68	3.10	3.01	2.61	2.65	1.94	2.27	3.06	0.59	2.31	2.87
K2O	4.16	4.37	4.36	4.05	4.59	4.29	4.66	5.30	4.47	4.51	7.07	7.79	5.05	2.37	4.48	4.73
TiO2	0.20	0.27	0.23	0.25	0.25	0.23	0.23	0.23	0.22	0.22	0.27	0.28	0.25	0.00	0.20	0.22
P2O5	0.07	0.09	0.11	0.09	0.09	0.09	0.09	0.09	0.09	0.07	0.11	0.11	0.09	0.01	0.07	0.07
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	8.00	2.50	2.50	2.50	2.50	1249.00	14.00	2.50
As	30.00	39.00	33.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	264.00	10.00	10.00
B	25.00	25.00	52.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	917.00	965.00	1410.00	1654.00	1590.00	1885.00	1633.00	1727.00	1533.00	1665.00	7535.00	6702.00	1766.00	926.00	1768.00	2228.00
Be	10.00	14.00	16.00	15.00	12.00	12.00	9.00	13.00	19.00	11.00	23.00	17.00	11.00	617.00	20.00	13.00
Bi	8.30	3.10	5.10	1.70	3.50	3.10	6.00	9.90	18.50	12.30	23.10	13.90	3.90	9170.40	47.40	12.70
Cd	0.50	3.00	5.00	1.00	1.00	1.00	1.00	0.50	4.00	5.00	15.00	6.00	1.00	1791.00	6.00	3.00
Ce	71.00	78.20	71.50	90.90	82.70	143.30	80.70	79.50	78.80	83.70	156.60	135.30	83.10	31.90	81.10	84.20
Co	3.00	6.00	8.00	4.00	4.00	7.00	5.00	5.00	5.00	7.00	10.00	8.00	4.00	50.00	6.00	5.00
Cr	289.00	171.00	242.00	121.00	162.00	266.00	154.00	168.00	183.00	208.00	119.00	141.00	221.00	147.00	531.00	202.00
Cs	22.78	26.62	23.37	9.68	7.89	7.33	7.54	8.23	7.80	7.99	9.50	9.29	7.65	8.08	8.13	8.22
Cu	58.00	164.00	297.00	148.00	132.00	165.00	116.00	107.00	150.00	198.00	588.00	414.00	119.00	425.00	382.00	165.00
Dy	1.90	2.30	2.70	2.30	2.60	2.90	2.60	2.60	2.40	2.30	2.30	2.70	2.50	2.10	2.10	2.40
Er	0.90	1.10	1.40	1.20	1.40	1.40	1.30	1.40	1.10	1.20	1.20	1.40	1.30	1.30	1.00	1.30
Eu	0.70	0.60	0.70	0.70	0.70	0.80	0.80	0.90	0.70	0.70	0.70	0.70	0.80	1.00	0.60	0.60
Ga	22.00	24.00	24.00	24.00	23.00	20.00	22.00	22.00	20.00	21.00	31.00	31.00	22.00	12.00	21.00	23.00
Gd	2.50	2.70	2.70	3.10	2.90	3.30	2.80	2.90	2.90	2.60	3.10	3.10	2.80	2.00	2.50	2.80
Hf	4.00	4.70	4.20	4.30	4.10	3.70	4.10	4.20	4.10	4.60	5.40	4.50	5.10	2.20	3.70	3.80
Ho	0.40	0.40	0.50	0.40	0.50	0.50	0.50	0.40	0.40	0.40	0.40	0.50	0.40	0.40	0.40	0.40

In	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.50	0.30	0.05	51.00	0.20	0.05
La	43.50	48.20	56.30	61.90	51.90	105.60	49.00	49.00	48.60	56.10	152.70	124.00	53.80	18.40	61.00	57.10
Li	58.00	66.00	54.00	41.00	36.00	36.00	38.00	38.00	42.00	43.00	43.00	40.00	33.00	29.00	45.00	43.00
Lu	0.15	0.17	0.25	0.19	0.20	0.24	0.18	0.21	0.18	0.20	0.19	0.19	0.19	0.27	0.16	0.19
Mo	56.00	62.00	2301.00	193.00	298.00	269.00	163.00	342.00	1040.00	157.00	106.00	244.00	65.00	45.00	111.00	132.00
Nb	17.00	19.00	19.00	19.00	20.00	19.00	19.00	18.00	17.00	18.00	25.00	25.00	20.00	5.00	17.00	18.00
Nd	22.90	24.80	20.30	27.00	25.60	38.20	24.70	25.40	24.80	24.70	32.40	30.20	25.80	12.10	23.70	24.50
Ni	10.00	10.00	1.00	6.00	7.00	7.00	8.00	7.00	4.00	9.00	6.00	7.00	9.00	4.00	19.00	7.00
Pb	43.00	65.00	72.00	31.00	55.00	45.00	51.00	68.00	102.00	69.00	151.00	78.00	74.00	39206.00	366.00	85.00
Pr	7.00	7.70	6.46	8.67	8.14	12.89	7.78	7.90	7.60	7.90	11.95	10.90	8.14	3.34	7.55	7.84
Rb	319.30	337.00	264.30	217.40	240.90	224.20	244.90	273.50	239.30	244.90	352.00	369.90	251.60	131.80	250.50	252.10
Re	0.05	0.05	0.30	0.05	0.05	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.20	0.05	0.05
S	0.52	0.58	2.17	0.63	0.61	0.74	0.59	0.86	0.77	0.85	2.61	1.90	0.65	17.69	0.88	0.82
Sb	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.70	9.90	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	57.00	10.00	10.00
Sm	3.40	3.30	3.20	3.80	3.80	4.60	3.80	3.50	3.60	3.40	4.00	4.10	3.70	2.30	3.20	3.40
Sn	9.00	12.00	13.00	13.00	11.00	11.00	9.00	7.00	8.00	9.00	19.00	17.00	11.00	12.00	10.00	9.00
Sr	127.00	97.00	572.00	1156.00	1358.00	1399.00	1251.00	1078.00	1005.00	1018.00	2757.00	2628.00	1048.00	592.00	911.00	1263.00
Ta	1.80	2.10	1.50	1.80	2.10	1.90	1.80	1.90	1.80	1.70	2.10	2.10	7.10	0.70	1.70	1.90
Tb	0.37	0.37	0.43	0.46	0.48	0.50	0.44	0.42	0.43	0.40	0.42	0.47	0.42	0.32	0.36	0.41
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	2.00	0.50	0.50	312.00	2.00	0.50
Th	16.00	18.40	17.70	18.40	18.10	24.20	17.80	18.40	16.40	15.80	15.10	18.20	18.70	5.20	15.80	19.60
Tl	2.00	2.20	1.90	1.50	1.50	1.40	1.60	1.80	1.50	1.60	2.30	2.30	1.50	5.30	1.60	1.60
Tm	0.15	0.17	0.22	0.17	0.19	0.22	0.19	0.19	0.18	0.16	0.18	0.18	0.15	0.19	0.16	0.17
U	10.00	11.80	31.90	12.90	16.70	26.80	11.90	13.00	10.20	11.00	11.80	12.00	12.30	3.60	13.80	12.70
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	58.00	25.00	51.00	25.00	25.00	25.00
W	54.00	19.00	214.00	80.00	155.00	595.00	81.00	51.00	299.00	189.00	2049.00	808.00	513.00	14066.00	608.00	359.00

Y	10.50	12.00	15.00	13.40	14.30	15.00	13.80	14.20	13.10	12.30	13.50	13.90	12.80	16.80	11.00	12.80
Yb	1.00	1.20	1.70	1.20	1.40	1.60	1.30	1.30	1.10	1.10	1.30	1.20	1.20	1.50	1.10	1.10
Zn	21.00	93.00	132.00	27.00	47.00	41.00	38.00	24.00	97.00	146.00	456.00	164.00	33.00	44873.00	181.00	75.00
Zr	161.00	166.00	167.00	169.00	161.00	142.00	163.00	158.00	162.00	201.00	219.00	168.00	204.00	84.00	132.00	149.00
Al	75.24	74.14	54.91	71.16	76.05	75.46	78.22	71.35	76.01	77.50	76.82	79.70	79.61	13.15	76.88	76.22

continued

Sample	AA200_101	AA200_102	AA200_103	AA200_104	AA200_106	AA200_107	AA200_108	AA200_109	AA200_111	AA200_112	AA200_113	AA200_114	AA200_116	AA200_117	AA200_118	AA200_119
SiO2	67.17	71.66	75.30	71.23	71.66	72.30	72.52	71.45	71.88	70.59	72.30	72.30	70.38	73.80	73.37	71.66
Al2O3	11.98	13.13	11.34	13.17	12.83	12.58	12.55	12.47	12.85	12.96	13.70	12.06	12.87	12.81	13.60	13.26
FeO	2.65	2.19	1.26	1.70	1.70	2.19	2.47	2.06	1.92	2.19	2.16	2.05	3.92	1.94	1.85	2.07
Fe2O3	2.95	2.43	1.40	1.89	1.89	2.43	2.75	2.29	2.13	2.43	2.40	2.27	4.36	2.16	2.06	2.30
CaO	1.82	1.96	1.12	1.68	1.68	1.96	1.96	1.68	1.96	2.38	2.10	1.82	1.82	1.82	1.82	2.24
MnO	0.06	0.05	0.02	0.04	0.03	0.04	0.04	0.04	0.05	0.07	0.05	0.05	0.07	0.04	0.04	0.04
MgO	0.45	0.45	0.13	0.46	0.41	0.43	0.41	0.43	0.46	0.43	0.45	0.43	0.46	0.40	0.40	0.45
Na2O	2.95	3.26	2.72	3.75	3.37	3.04	3.17	3.35	3.51	3.01	3.31	3.06	2.56	3.12	3.05	2.09
K2O	4.47	4.31	5.05	4.28	4.46	4.58	4.49	4.24	4.38	4.71	4.93	4.13	4.83	4.44	4.59	4.46
TiO2	0.22	0.22	0.08	0.23	0.22	0.22	0.23	0.22	0.23	0.22	0.23	0.22	0.22	0.22	0.22	0.22
P2O5	0.07	0.07	0.01	0.07	0.09	0.09	0.09	0.07	0.07	0.07	0.09	0.09	0.09	0.09	0.07	0.09
Ag	2.50	2.50	6.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	2669.00	1548.00	1252.00	988.00	1356.00	1733.00	1843.00	1475.00	1304.00	2934.00	1752.00	1972.00	2982.00	1317.00	1258.00	1186.00
Be	13.00	12.00	7.00	7.00	10.00	13.00	14.00	12.00	11.00	17.00	15.00	12.00	14.00	19.00	9.00	10.00
Bi	4.60	9.50	3.40	2.10	6.30	5.70	13.40	4.60	4.30	23.30	13.70	5.10	9.60	3.50	4.30	179.30

Cd	1.00	3.00	1.00	0.50	3.00	2.00	3.00	2.00	5.00	81.00	1.00	1.00	0.50	1.00	0.50	6.00
Ce	83.40	86.20	31.20	85.90	80.30	75.80	82.90	77.50	82.00	85.80	84.30	79.00	138.40	73.30	81.10	79.60
Co	11.00	5.00	4.00	4.00	3.00	5.00	7.00	5.00	5.00	5.00	5.00	5.00	7.00	4.00	4.00	5.00
Cr	246.00	186.00	212.00	152.00	205.00	139.00	259.00	200.00	173.00	188.00	155.00	287.00	164.00	232.00	146.00	298.00
Cs	9.14	8.31	4.58	6.72	7.36	8.22	7.83	7.85	7.24	9.43	8.53	7.53	8.66	8.22	8.65	11.14
Cu	229.00	173.00	89.00	73.00	128.00	186.00	207.00	163.00	126.00	204.00	142.00	150.00	338.00	167.00	130.00	123.00
Dy	2.20	2.20	1.40	2.10	2.40	2.00	2.30	2.40	2.40	2.50	2.50	2.50	2.50	2.40	2.40	2.40
Er	1.20	1.10	0.90	1.10	1.10	1.00	1.20	1.20	1.30	1.30	1.30	1.20	1.20	1.20	1.20	1.10
Eu	0.60	0.70	0.40	0.80	0.80	0.70	0.70	0.70	0.80	0.80	0.70	0.70	0.80	0.70	0.70	0.70
Ga	23.00	23.00	20.00	22.00	21.00	23.00	24.00	22.00	22.00	24.00	23.00	21.00	24.00	21.00	22.00	21.00
Gd	2.50	3.00	1.40	3.10	2.90	2.60	2.80	2.70	2.90	2.70	2.70	2.60	3.10	2.50	2.90	2.80
Hf	3.40	3.90	2.60	4.10	4.00	3.60	3.80	5.30	4.10	3.50	4.40	4.20	4.10	4.20	4.10	3.80
Ho	0.40	0.40	0.30	0.40	0.40	0.40	0.40	0.40	0.50	0.40	0.50	0.40	0.50	0.40	0.40	0.40
In	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.20	2.30	0.05	0.05	0.05	0.05	0.05	0.10
La	63.80	55.50	20.30	49.50	49.50	53.20	56.90	51.30	51.40	61.70	53.60	50.10	108.00	44.60	49.10	49.00
Li	30.00	41.00	13.00	31.00	36.00	43.00	38.00	33.00	30.00	41.00	35.00	31.00	46.00	33.00	35.00	38.00
Lu	0.19	0.18	0.16	0.20	0.19	0.15	0.17	0.19	0.18	0.18	0.18	0.15	0.19	0.19	0.20	0.17
Mo	97.00	49.00	99.00	47.00	316.00	150.00	98.00	469.00	54.00	285.00	185.00	386.00	245.00	1002.00	176.00	498.00
Nb	18.00	15.00	13.00	15.00	16.00	17.00	19.00	18.00	19.00	18.00	19.00	21.00	21.00	18.00	18.00	17.00
Nd	24.00	26.30	10.00	28.70	26.70	23.40	24.40	23.80	25.50	24.20	24.90	24.80	34.70	22.80	24.70	24.90
Ni	9.00	9.00	10.00	7.00	8.00	8.00	10.00	6.00	8.00	7.00	9.00	9.00	8.00	4.00	7.00	8.00
Pb	45.00	93.00	53.00	82.00	57.00	63.00	82.00	43.00	43.00	79.00	74.00	50.00	53.00	44.00	44.00	229.00
Pr	7.74	8.43	3.12	8.72	8.25	7.45	7.76	7.63	8.02	7.94	8.10	7.72	11.75	7.27	7.89	7.62
Rb	226.60	234.50	238.00	206.70	227.60	250.20	238.30	220.10	208.00	259.10	241.60	214.80	248.60	226.40	228.10	240.40
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.05
S	1.04	0.73	0.38	0.38	0.52	0.82	0.90	0.70	0.57	0.90	0.74	0.65	1.79	0.76	0.79	1.19
Sb	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

Sm	3.50	4.00	1.60	4.00	3.90	3.40	3.30	3.60	3.70	3.50	3.60	3.60	4.20	3.40	3.40	3.50
Sn	10.00	11.00	5.00	8.00	8.00	10.00	10.00	8.00	8.00	10.00	7.00	10.00	14.00	7.00	8.00	8.00
Sr	1297.00	1162.00	909.00	850.00	1095.00	1402.00	1271.00	1076.00	1207.00	1461.00	1100.00	1246.00	1307.00	923.00	751.00	515.00
Ta	1.70	1.00	1.80	1.00	1.30	3.50	1.90	1.90	2.30	2.00	2.10	2.10	2.00	2.10	2.30	2.20
Tb	0.39	0.34	0.21	0.39	0.40	0.35	0.38	0.44	0.47	0.41	0.39	0.44	0.44	0.42	0.38	0.38
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	2.00
Th	16.70	23.40	18.90	25.10	20.60	17.20	17.70	18.20	18.90	17.60	18.60	17.30	18.40	17.20	18.50	17.20
Tl	1.50	1.50	1.50	1.30	1.40	1.60	1.60	1.40	1.30	1.60	1.60	1.40	1.60	1.40	1.60	1.70
Tm	0.17	0.17	0.14	0.16	0.17	0.14	0.17	0.16	0.18	0.20	0.18	0.16	0.16	0.17	0.16	0.17
U	11.60	11.10	22.00	10.70	12.90	9.50	13.40	12.10	13.10	11.20	13.60	12.90	11.40	11.30	12.10	11.80
V	52.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	2081.00	146.00	291.00	37.00	71.00	343.00	466.00	124.00	368.00	1374.00	495.00	314.00	273.00	104.00	42.00	1918.00
Y	12.40	11.50	7.90	11.60	12.40	11.20	13.00	12.70	14.60	13.40	13.80	12.80	13.50	12.50	13.00	11.90
Yb	1.10	1.00	1.00	1.00	1.20	1.00	1.30	1.20	1.20	1.20	1.30	1.20	1.10	1.20	1.30	1.20
Zn	43.00	78.00	30.00	27.00	85.00	53.00	40.00	44.00	143.00	2439.00	29.00	28.00	27.00	27.00	28.00	150.00
Zr	132.00	150.00	67.00	152.00	149.00	135.00	150.00	222.00	162.00	129.00	174.00	170.00	158.00	162.00	152.00	143.00
Al	76.60	75.87	86.12	78.92	78.90	76.12	76.36	78.25	76.52	73.32	76.38	76.17	76.39	77.33	77.51	70.91

continued

Sample	AA200_121	AA200_122	AA200_123	AA200_124	AA200_126	AA200_127	AA200_128	AA200_129	AA200_131	AA200_132	AA200_133	AA200_134	AA200_136	AA200_137	AA200_138	AA200_139	AA200_141
SiO2	79.36	72.52	75.94	72.95	69.74	71.66	74.66	71.23	97.12	67.81	63.75	48.99	72.73	71.88	72.52	71.45	73.16
Al2O3	8.73	13.02	12.51	13.42	12.41	14.27	14.27	15.36	0.96	13.32	11.26	8.73	11.68	12.40	13.13	13.04	11.09
FeO	1.39	1.66	1.72	1.71	1.44	1.90	2.03	2.12	1.00	2.24	2.24	1.03	2.17	1.92	1.62	1.61	2.59
Fe2O3	1.54	1.84	1.92	1.90	1.60	2.12	2.26	2.36	1.12	2.49	2.49	1.14	2.42	2.13	1.80	1.79	2.87
CaO	1.68	1.68	1.54	1.68	1.68	0.84	0.28	0.42	0.07	0.28	0.28	1.82	1.96	1.96	1.82	1.82	1.82
MnO	0.03	0.04	0.03	0.03	0.04	0.02	0.01	0.01	0.00	0.04	0.08	0.04	0.05	0.05	0.05	0.04	0.04

MgO	0.35	0.40	0.46	0.46	0.36	0.56	0.66	0.91	0.08	0.65	0.51	0.25	0.41	0.45	0.41	0.45	0.40
Na2O	1.33	1.21	3.05	1.71	2.19	2.67	0.13	0.07	0.01	0.21	0.51	3.20	2.94	3.16	3.41	3.54	2.72
K2O	3.23	4.49	4.57	4.75	4.36	5.36	4.87	4.99	0.35	4.54	4.10	2.90	3.99	4.16	4.46	4.47	3.95
TiO2	0.15	0.22	0.22	0.22	0.20	0.25	0.27	0.25	0.00	0.23	0.20	0.15	0.20	0.22	0.22	0.23	0.20
P2O5	0.05	0.09	0.09	0.07	0.07	0.09	0.07	0.14	0.01	0.11	0.07	0.07	0.09	0.09	0.09	0.09	0.09
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	855.00	1097.00	1284.00	1305.00	1127.00	1436.00	1408.00	1313.00	66.00	1242.00	1095.00	864.00	1278.00	1413.00	1144.00	1066.00	1048.00
Be	6.00	10.00	11.00	11.00	9.00	10.00	11.00	18.00	1.00	10.00	8.00	7.00	15.00	11.00	9.00	7.00	8.00
Bi	8.70	1.90	10.70	7.40	3.10	3.70	3.20	10.00	4.00	6.90	5.70	3.80	11.90	3.40	1.60	1.00	84.30
Cd	1.00	1.00	0.50	4.00	2.00	1.00	1.00	2.00	34.00	1.00	68.00	2.00	12.00	6.00	1.00	0.50	15.00
Ce	55.70	81.10	85.90	72.00	71.80	90.90	90.40	89.30	6.10	102.80	66.90	53.20	84.80	91.50	80.80	86.20	72.50
Co	6.00	5.00	4.00	4.00	4.00	4.00	6.00	5.00	5.00	5.00	5.00	4.00	5.00	4.00	4.00	3.00	6.00
Cr	410.00	158.00	111.00	221.00	137.00	281.00	276.00	261.00	713.00	272.00	334.00	138.00	143.00	236.00	158.00	158.00	173.00
Cs	7.73	9.20	10.78	12.10	10.02	11.64	11.21	17.05	1.21	11.31	9.34	5.60	8.74	8.52	7.98	6.86	6.51
Cu	65.00	146.00	137.00	127.00	125.00	146.00	122.00	96.00	12.00	131.00	136.00	110.00	163.00	148.00	108.00	99.00	155.00
Dy	2.00	2.40	2.10	1.80	2.10	2.30	2.00	2.10	0.05	2.70	2.00	1.80	2.50	2.30	2.60	2.50	2.10
Er	0.90	1.20	0.90	0.90	1.10	1.20	1.10	1.10	0.05	1.30	1.20	0.80	1.30	1.30	1.20	1.20	1.00
Eu	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.05	0.90	0.70	0.50	0.70	0.70	0.70	0.70	0.60
Ga	15.00	21.00	21.00	22.00	20.00	22.00	22.00	26.00	3.00	21.00	19.00	15.00	20.00	21.00	21.00	21.00	18.00
Gd	2.20	2.70	2.40	2.20	2.70	2.70	2.10	2.70	0.05	3.40	2.60	2.00	2.70	3.00	3.00	3.20	2.30
Hf	2.80	4.30	3.90	3.80	3.60	4.20	5.10	4.80	1.20	4.20	3.40	11.40	3.30	3.60	4.10	3.90	3.40
Ho	0.40	0.50	0.30	0.30	0.40	0.40	0.40	0.40	0.05	0.50	0.40	0.30	0.40	0.50	0.50	0.50	0.40
In	0.05	0.05	0.05	0.10	0.05	0.05	0.05	0.05	0.20	0.05	1.80	0.05	0.40	0.20	0.05	0.05	0.30
La	34.60	48.70	54.00	45.40	45.00	57.30	57.20	58.90	3.80	61.80	41.00	33.00	61.50	65.00	49.20	52.60	45.50
Li	34.00	36.00	45.00	47.00	40.00	46.00	51.00	74.00	12.00	49.00	45.00	25.00	35.00	43.00	31.00	32.00	32.00
Lu	0.12	0.19	0.17	0.16	0.15	0.17	0.14	0.18	0.03	0.20	0.14	0.13	0.16	0.17	0.20	0.24	0.17

Mo	170.00	66.00	287.00	354.00	103.00	312.00	113.00	312.00	90.00	103.00	113.00	173.00	172.00	119.00	356.00	249.00	2741.00
Nb	13.00	18.00	19.00	18.00	17.00	19.00	21.00	21.00	5.00	19.00	15.00	13.00	16.00	18.00	19.00	18.00	17.00
Nd	17.80	25.90	26.00	22.40	22.40	26.80	26.30	24.30	1.30	31.60	21.10	16.70	24.40	26.70	25.40	28.00	22.60
Ni	12.00	4.00	9.00	5.00	2.00	18.00	11.00	11.00	18.00	11.00	9.00	8.00	7.00	10.00	8.00	7.00	0.50
Pb	32.00	36.00	45.00	67.00	41.00	48.00	30.00	47.00	10.00	49.00	53.00	36.00	68.00	47.00	43.00	53.00	194.00
Pr	5.56	7.95	8.33	6.91	7.10	8.97	8.65	8.35	0.47	10.26	6.55	5.27	8.10	8.70	7.93	8.69	7.18
Rb	174.00	230.40	247.90	265.10	228.30	273.40	268.10	323.20	21.40	261.90	228.40	154.40	199.40	211.70	223.20	204.30	188.00
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.50
S	0.53	0.60	0.98	0.85	0.70	0.78	0.79	0.77	0.14	0.67	0.72	0.81	0.72	0.59	0.40	0.33	1.46
Sb	0.25	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	2.70	3.50	3.40	2.90	3.30	3.50	3.10	3.30	0.05	4.60	3.20	2.40	3.50	3.90	3.90	3.90	3.30
Sn	6.00	7.00	9.00	7.00	7.00	8.00	8.00	9.00	1.00	8.00	7.00	5.00	9.00	10.00	7.00	5.00	7.00
Sr	457.00	521.00	520.00	519.00	569.00	336.00	194.00	127.00	21.00	219.00	230.00	571.00	877.00	834.00	750.00	697.00	652.00
Ta	1.60	2.20	2.00	2.10	2.20	2.30	2.50	2.60	0.40	2.20	1.90	1.60	1.90	2.10	2.00	2.10	1.90
Tb	0.33	0.44	0.34	0.28	0.34	0.40	0.31	0.36	0.00	0.49	0.38	0.29	0.42	0.42	0.46	0.46	0.41
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	2.00
Th	11.40	18.80	18.00	18.10	16.80	19.60	21.40	21.30	1.60	20.40	16.20	12.40	16.60	17.80	19.50	19.70	16.40
Tl	1.20	1.60	1.60	1.80	1.50	1.80	1.70	2.10	0.25	1.80	1.70	1.10	1.40	1.40	1.40	1.30	1.30
Tm	0.13	0.19	0.14	0.11	0.14	0.16	0.17	0.16	0.03	0.20	0.17	0.12	0.16	0.19	0.20	0.19	0.15
U	9.00	12.80	11.80	11.80	11.50	11.40	9.80	8.20	1.20	14.20	14.10	10.10	14.10	12.60	12.40	12.40	10.70
V	51.00	25.00	25.00	25.00	25.00	25.00	58.00	25.00	54.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	5239.00	39.00	61.00	59.00	233.00	155.00	32.00	131.00	107.00	99.00	1546.00	219.00	1086.00	1168.00	184.00	166.00	79.00
Y	9.20	13.10	9.90	9.30	11.10	11.70	10.40	10.60	0.25	13.40	11.70	9.30	12.50	13.80	14.90	14.60	12.10
Yb	0.80	1.10	0.90	0.90	1.00	1.10	1.00	1.10	0.05	1.20	1.20	0.80	1.00	1.30	1.30	1.30	1.10
Zn	26.00	352.00	127.00	177.00	82.00	65.00	42.00	44.00	1124.00	35.00	1971.00	81.00	350.00	166.00	39.00	29.00	428.00
Zr	103.00	160.00	139.00	135.00	130.00	160.00	215.00	181.00	59.00	163.00	132.00	523.00	122.00	137.00	155.00	141.00	122.00
Al	69.22	73.30	79.17	75.06	76.23	85.12	84.12	79.14	70.34	83.68	85.29	74.71	74.49	75.24	77.88	77.93	75.06

3. *BB+400*

Sample	BB400_01	BB400_02	BB400_03	BB400_04	BB400_05	BB400_06	BB400_07	BB400_08	BB400_09	BB400_10	BB400_11	BB400_12	BB400_13	BB400_14	BB400_15	BB400_16	BB400_17	BB400_18	BB400_19	BB400_20
SiO_2	45.70	53.10	65.90	60.00	63.40	63.30	61.70	54.90	70.50	65.80	60.20	60.20	59.80	57.70	52.30	64.20	63.30	58.50	63.60	63.50
Al_2O_3	12.10	11.60	12.90	11.50	11.90	12.20	11.10	8.40	3.80	12.30	11.90	10.90	10.90	6.17	9.67	10.60	10.80	10.30	9.75	8.04
CaO	9.27	8.35	4.77	5.26	5.12	4.60	5.77	9.26	6.67	3.79	5.67	3.92	4.79	6.36	5.64	4.77	4.76	9.49	4.97	3.05
MgO	4.74	1.32	0.54	0.61	0.55	0.49	0.73	1.18	0.40	0.49	0.52	0.49	0.50	0.63	0.54	0.41	0.43	0.44	0.53	0.44
FeO	7.07	4.74	1.75	4.77	3.21	3.34	4.66	7.70	5.36	2.68	4.37	6.34	5.24	7.42	7.07	4.08	4.74	5.83	5.27	8.12
Fe_2O_3	3.37	2.26	0.83	2.27	1.53	1.59	2.22	3.67	2.55	1.28	2.08	3.02	2.50	3.53	3.37	1.94	2.26	2.78	2.51	3.87
K_2O	1.49	5.24	4.49	3.24	4.49	5.33	5.23	2.82	1.33	5.62	4.67	3.97	4.08	1.64	2.93	4.80	4.64	3.68	3.61	2.38
MnO	0.24	0.63	0.26	0.32	0.46	0.45	0.78	1.07	0.58	0.39	0.40	0.31	0.44	0.50	0.64	0.48	0.56	0.93	0.64	0.45
Na_2O	1.16	0.91	1.65	0.93	1.66	1.29	0.57	0.22	0.28	1.66	0.86	1.28	0.97	0.08	0.12	0.92	1.12	0.70	0.96	0.92
P_2O_5	0.30	0.21	0.09	0.11	0.08	0.08	0.07	0.17	0.11	0.10	0.15	0.16	0.11	0.09	0.20	0.08	0.09	0.10	0.11	0.08
TiO_2	2.58	0.28	0.29	0.30	0.25	0.25	0.19	0.14	0.09	0.23	0.24	0.16	0.18	0.12	0.24	0.17	0.19	0.19	0.18	0.15
Cr_2O_3	0.07	0.01	0.01	0.08	0.03	0.02	0.02	0.03	0.03	0.13	0.01	0.12	0.06	0.01	0.01	0.11	0.01	0.01	0.01	0.01
V_2O_5	0.05	0.02	0.02	0.02	0.02	0.02	0.03	0.05	0.04	0.02	0.03	0.01	0.03	0.01	0.04	0.02	0.02	0.03	0.03	0.02
LOI	9.25	6.51	4.25	5.42	2.23	2.09	2.15	2.29	3.18	2.51	3.37	4.79	4.12	7.39	9.26	1.83	2.25	2.42	2.14	6.02
Au	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ag	0.50	0.50	0.50	1.50	0.50	3.40	0.50	0.50	0.50	0.50	4.20	8.00	0.50	4.40	1.40	3.50	2.60	0.50	0.50	1.00
As	36.00	16.00	4.00	10.00	5.00	12.00	13.00	23.00	9.00	8.00	1.00	1.00	8.00	10.00	13.00	4.00	22.00	15.00	3.00	4.00
Ba	912.00	372.00	2800.00	230.00	604.00	559.00	888.00	841.00	244.00	2230.00	314.00	460.00	514.00	243.00	222.00	714.00	553.00	825.00	566.00	428.00
Co	50.90	6.60	3.00	7.80	4.60	4.20	4.70	7.30	7.10	3.50	4.80	7.60	7.00	12.30	7.90	5.60	5.40	4.40	5.70	10.80
Cr	263.00	26.00	14.00	24.00	18.00	19.00	16.00	24.00	20.00	17.00	19.00	27.00	18.00	24.00	24.00	18.00	19.00	21.00	27.00	32.00
Cu	82.90	222.00	106.00	686.00	258.00	230.00	245.00	552.00	275.00	207.00	385.00	898.00	528.00	1550.00	1100.00	407.00	560.00	311.00	586.00	822.00

Hf	1.20	1.60	1.40	2.30	1.70	1.50	1.70	1.90	1.00	1.70	1.80	2.40	2.50	1.70	2.00	2.10	1.70	2.00	2.10	2.10
Mo	7.00	35.30	73.40	336.00	135.00	210.00	122.00	418.00	349.00	151.00	125.00	145.00	171.00	114.00	117.00	96.60	554.00	61.60	374.00	1100.00
Nb	23.50	20.20	17.20	17.60	19.20	23.00	21.30	14.40	6.70	29.60	16.50	17.50	18.20	7.20	27.10	14.90	18.60	22.50	18.00	11.80
Ni	187.00	20.00	13.20	13.90	11.70	11.50	11.70	19.20	14.00	9.60	9.30	10.40	9.90	12.80	13.30	7.90	9.30	17.10	11.80	8.00
Pb	5.00	18.00	13.00	33.00	17.00	107.00	20.00	24.00	11.00	16.00	85.00	226.00	22.00	84.00	23.00	108.00	61.00	16.00	16.00	14.00
Rb	140.00	209.00	234.00	226.00	203.00	219.00	194.00	128.00	69.00	214.00	202.00	211.00	181.00	104.00	150.00	193.00	189.00	160.00	152.00	108.00
S	0.43	1.08	0.47	3.44	0.90	0.97	0.84	1.86	2.34	0.64	1.58	3.60	2.61	3.92	4.22	1.79	2.08	1.28	2.13	5.00
Sc	26.00	4.40	4.00	3.50	4.60	4.70	3.50	3.20	2.60	4.00	3.30	3.30	3.40	3.80	4.20	3.30	3.80	4.00	3.30	2.40
Sr	1180.00	2480.00	1670.00	656.00	2740.00	2810.00	3040.00	1890.00	884.00	2790.00	2470.00	1710.00	1860.00	869.00	1220.00	2460.00	2220.00	2090.00	1890.00	1270.00
V	225.00	107.00	43.00	85.00	105.00	96.00	145.00	258.00	167.00	69.00	93.00	80.00	151.00	101.00	227.00	98.00	95.00	155.00	143.00	93.00
W	90.90	599.00	115.00	4150.00	1190.00	886.00	1230.00	2540.00	2920.00	883.00	2310.00	4120.00	5230.00	4560.00	4920.00	1590.00	1540.00	1570.00	2940.00	4590.00
Zn	103.00	160.00	95.00	235.00	129.00	433.00	147.00	235.00	99.00	76.00	91.00	183.00	152.00	131.00	212.00	100.00	295.00	95.00	159.00	187.00
Zr	30.90	50.30	48.30	57.50	46.80	49.10	49.20	49.30	21.60	58.60	45.60	69.70	59.30	40.20	42.10	52.40	46.70	53.60	46.30	36.60
CO2	6.70	6.57	3.59	3.94	3.03	2.59	2.71	3.22	3.82	2.54	3.31	2.55	4.10	6.85	6.59	3.19	2.68	2.96	2.33	1.96
Ce	66.60	302.00	118.00	392.00	472.00	311.00	2340.00	6690.00	1560.00	220.00	324.00	397.00	1320.00	1290.00	2930.00	423.00	518.00	1260.00	973.00	812.00
Dy	5.87	5.59	3.67	3.21	3.46	1.96	8.97	22.30	8.30	2.07	2.32	2.40	5.83	5.65	10.10	2.28	2.85	5.42	3.63	3.18
Er	2.78	2.06	1.62	1.48	1.59	0.86	2.74	6.55	2.49	0.93	1.20	0.98	1.50	1.26	2.66	0.86	1.08	2.00	1.35	1.14
Eu	2.70	5.15	2.18	3.10	3.35	2.30	15.10	35.00	9.27	2.14	5.02	4.53	8.86	7.45	16.10	6.11	6.30	11.20	7.81	6.06
Gd	6.59	10.40	4.26	6.42	7.68	4.51	31.30	94.20	25.40	4.08	5.75	6.55	17.30	17.30	41.70	8.75	9.98	20.90	15.50	12.20
Ho	0.91	0.75	0.63	0.63	0.64	0.31	1.16	2.92	1.03	0.32	0.44	0.43	0.61	0.54	1.24	0.32	0.43	0.87	0.56	0.49
La	31.60	175.00	62.20	248.00	268.00	203.00	1440.00	3750.00	869.00	129.00	200.00	237.00	798.00	783.00	1580.00	216.00	286.00	679.00	557.00	437.00
Lu	0.36	0.25	0.23	0.23	0.26	0.23	0.43	0.76	0.43	0.22	0.25	0.26	0.31	0.26	0.40	0.19	0.23	0.35	0.24	0.24
Nd	33.30	90.10	36.50	99.50	123.00	68.30	558.00	1730.00	439.00	61.00	86.70	101.00	311.00	309.00	752.00	111.00	138.00	343.00	265.00	205.00
Pr	7.86	29.70	11.60	35.00	42.90	25.90	216.00	639.00	154.00	21.00	29.80	36.00	117.00	115.00	277.00	38.60	48.10	120.00	94.40	73.40
Sm	7.00	14.90	6.30	10.80	12.00	7.60	48.40	122.00	35.00	7.60	10.90	11.70	23.30	23.30	58.00	17.30	19.10	36.20	25.70	22.90
Tb	0.98	1.41	0.71	1.04	1.05	0.51	3.49	8.62	2.73	0.51	0.72	0.83	1.79	1.80	3.75	1.04	1.05	2.20	1.48	1.07

Th	6.80	14.10	18.70	21.20	19.50	16.30	19.10	28.70	16.40	12.60	23.90	23.50	29.60	25.50	42.00	16.30	16.70	28.60	23.00	21.40
Tm	0.35	0.25	0.16	0.14	0.17	0.14	0.36	0.79	0.36	0.13	0.17	0.16	0.23	0.19	0.37	0.11	0.13	0.31	0.20	0.18
U	1.57	5.19	4.84	12.00	7.57	5.44	25.80	67.60	15.70	5.40	8.22	8.02	20.30	26.20	49.90	7.70	8.27	27.60	17.80	10.60
Y	30.50	16.60	12.30	14.50	16.30	13.30	45.50	103.00	39.30	12.50	15.20	15.70	24.60	22.10	45.00	14.30	15.50	34.70	23.40	21.40
Yb	2.50	1.80	1.20	1.20	1.30	1.10	3.00	6.60	3.00	1.20	1.40	1.40	1.40	1.60	2.70	1.10	1.20	2.40	1.70	1.50
Al	37.39	41.47	43.93	38.35	42.64	49.70	48.46	29.67	19.93	52.85	44.28	46.17	44.29	26.06	37.59	47.80	46.30	28.79	41.11	41.53

continued

Sample	BB400_21	BB400_22	BB400_23	BB400_24	BB400_25	BB400_26	BB400_27	BB400_28	BB400_29	BB400_30	BB400_31	BB400_32	BB400_33	BB400_34	BB400_35	BB400_36	BB400_37	BB400_38	BB400_39	BB400_40
SiO2	58.40	66.50	58.90	79.40	66.10	39.00	60.30	63.70	60.90	91.90	71.80	64.50	55.50	65.40	63.00	59.80	69.60	67.80	62.10	67.60
Al2O3	9.65	9.77	11.70	3.68	8.65	9.92	11.80	9.76	11.70	1.23	9.17	12.60	11.20	11.60	10.50	10.10	11.60	12.50	13.10	12.30
CaO	7.07	5.44	7.47	2.13	3.91	7.89	6.30	4.96	3.96	1.21	2.44	3.31	2.94	3.34	6.39	6.24	2.99	2.97	3.05	3.04
MgO	0.62	0.36	0.57	0.35	0.63	1.33	0.67	0.66	0.68	0.10	0.45	0.61	0.98	0.60	0.76	1.24	0.57	0.53	0.58	0.56
FeO	6.84	3.95	4.28	4.36	5.17	13.16	3.77	4.26	4.98	2.11	3.55	3.27	8.40	3.87	3.02	5.45	2.98	2.96	3.30	2.78
Fe2O3	3.26	1.88	2.04	2.08	2.46	6.27	1.79	2.03	2.37	1.00	1.69	1.56	4.00	1.84	1.44	2.59	1.42	1.41	1.57	1.32
K2O	3.04	4.49	3.03	0.83	2.05	1.54	3.82	2.54	4.30	0.23	3.07	5.14	4.04	4.53	3.54	0.99	3.58	4.71	4.38	4.54
MnO	1.00	0.47	0.56	0.40	0.63	2.12	0.57	0.38	0.41	0.11	0.21	0.30	0.40	0.28	0.39	0.47	0.12	0.10	0.12	0.10
Na2O	0.89	0.71	0.26	0.03	0.06	0.03	0.93	0.09	1.32	0.24	1.18	1.72	0.99	1.73	1.46	2.20	2.30	2.37	2.65	2.22
P2O5	0.11	0.07	0.08	0.03	0.10	0.06	0.10	0.15	0.18	0.06	0.10	0.10	0.30	0.15	0.13	0.27	0.10	0.11	0.11	0.10
TiO2	0.19	0.13	0.20	0.09	0.18	0.21	0.21	0.18	0.23	0.03	0.18	0.22	0.29	0.19	0.20	0.18	0.22	0.25	0.26	0.27
Cr2O3	0.01	0.01	0.01	0.01	0.01	0.01	0.13	0.01	0.01	0.01	0.32	0.02	0.11	0.21	0.01	0.02	0.09	0.03	0.04	0.04
V2O5	0.04	0.02	0.02	0.01	0.03	0.07	0.02	0.02	0.03	0.01	0.01	0.02	0.04	0.01	0.01	0.03	0.01	0.01	0.01	0.01
LOI	3.35	2.25	6.58	4.09	5.55	12.25	5.58	5.44	3.57	0.66	3.05	2.39	6.25	1.96	3.78	3.03	1.64	1.34	1.97	1.39
Au	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Ag	0.50	0.50	1.80	2.30	5.10	0.50	3.90	3.50	0.50	0.50	2.70	0.50	0.50	0.50	5.70	0.50	2.60	2.80	1.60	3.20
As	14.00	8.00	17.00	15.00	45.00	48.00	6.00	13.00	11.00	3.00	243.00	13.00	16.00	5.00	14.00	8.00	2.00	8.00	1.00	4.00
Ba	191.00	380.00	387.00	306.00	289.00	237.00	267.00	492.00	724.00	246.00	478.00	774.00	480.00	280.00	378.00	218.00	579.00	520.00	797.00	307.00

Co	6.00	3.80	6.20	4.70	4.40	7.80	4.00	5.50	6.70	3.20	4.50	4.30	11.90	6.40	5.70	7.60	5.00	4.80	5.90	4.70
Cr	24.00	19.00	19.00	23.00	26.00	40.00	16.00	17.00	20.00	16.00	14.00	16.00	27.00	16.00	14.00	18.00	15.00	18.00	22.00	16.00
Cu	620.00	270.00	413.00	278.00	407.00	268.00	348.00	632.00	444.00	238.00	491.00	456.00	1020.00	582.00	365.00	585.00	373.00	406.00	457.00	383.00
Hf	2.40	1.50	2.00	0.60	1.30	1.80	1.80	1.50	1.90	0.03	1.40	1.70	2.90	3.00	1.90	2.90	2.00	2.00	2.70	1.70
Mo	253.00	140.00	321.00	133.00	90.20	53.40	59.20	42.30	36.10	25.90	27.90	16.50	104.00	83.70	34.70	154.00	38.10	370.00	80.20	26.90
Nb	17.90	10.50	14.30	6.40	13.30	24.00	18.20	12.40	22.60	2.00	14.00	21.00	27.70	17.30	16.00	12.50	18.70	18.50	23.10	18.90
Ni	12.80	10.80	15.00	7.80	11.90	15.50	10.90	10.00	9.00	6.30	5.40	7.60	10.40	7.40	13.10	12.10	7.40	8.70	7.70	7.50
Pb	15.00	21.00	37.00	74.00	143.00	16.00	97.00	133.00	17.00	11.00	51.00	29.00	22.00	18.00	155.00	13.00	68.00	70.00	51.00	72.00
Rb	132.00	178.00	169.00	51.00	126.00	88.00	192.00	175.00	187.00	13.00	137.00	220.00	179.00	209.00	216.00	52.00	211.00	249.00	222.00	227.00
S	2.39	1.05	1.96	2.15	1.87	2.22	1.46	2.03	2.18	0.82	1.88	1.32	4.45	1.68	1.26	2.14	1.15	1.24	1.59	1.13
Sc	4.10	2.80	3.90	1.70	4.70	4.70	3.60	3.70	4.30	0.60	3.40	4.00	5.70	3.20	4.00	2.60	3.10	4.00	6.00	3.90
Sr	1680.00	2640.00	1150.00	387.00	652.00	1140.00	1800.00	740.00	2040.00	241.00	1300.00	2470.00	1730.00	1860.00	1210.00	2550.00	1690.00	1890.00	2280.00	1900.00
V	195.00	107.00	101.00	79.00	131.00	361.00	102.00	120.00	155.00	37.00	58.00	75.00	216.00	98.00	95.00	172.00	51.00	48.00	52.00	42.00
W	3730.00	1380.00	2570.00	215.00	694.00	891.00	2150.00	1870.00	1890.00	879.00	1940.00	1060.00	4960.00	3560.00	1460.00	2910.00	2520.00	2150.00	5780.00	653.00
Zn	155.00	97.00	105.00	143.00	359.00	155.00	276.00	204.00	153.00	51.00	108.00	88.00	119.00	104.00	73.00	165.00	216.00	105.00	113.00	88.00
Zr	50.00	48.40	53.50	23.60	46.40	45.90	58.30	55.70	69.60	9.10	45.60	71.50	83.70	93.20	72.10	86.60	63.40	74.00	73.40	63.50
CO2	3.06	2.74	6.48	3.09	4.82	11.80	5.61	5.17	3.01	0.77	1.99	2.45	1.85	2.25	4.28	2.85	1.45	1.32	1.46	1.46
Ce	1130.00	618.00	510.00	110.00	357.00	1660.00	544.00	2090.00	2540.00	294.00	627.00	965.00	2550.00	1950.00	1580.00	2560.00	588.00	510.00	299.00	298.00
Dy	4.68	1.97	2.34	0.97	2.44	8.37	2.84	5.81	7.52	0.97	2.32	3.47	10.40	8.09	6.75	12.50	2.84	2.96	2.43	2.20
Er	1.72	0.85	0.89	0.41	0.87	3.25	1.11	2.17	2.84	0.44	0.74	1.17	3.67	2.53	2.40	3.48	1.06	1.09	1.07	0.79
Eu	8.34	6.15	4.75	1.39	3.50	15.60	5.28	10.30	14.10	1.32	4.36	7.48	14.70	12.60	10.00	14.20	4.24	3.90	3.30	2.88
Gd	17.20	9.98	8.54	2.42	7.81	29.70	9.75	26.40	33.50	3.70	8.59	13.50	36.30	29.30	26.60	41.70	9.04	8.74	5.53	5.28
Ho	0.76	0.32	0.33	0.18	0.37	1.43	0.42	0.92	1.14	0.14	0.33	0.53	1.49	1.12	1.02	1.50	0.43	0.46	0.41	0.36
La	645.00	395.00	326.00	66.20	228.00	939.00	307.00	1290.00	1450.00	177.00	315.00	581.00	1480.00	1120.00	854.00	1350.00	337.00	286.00	194.00	188.00
Lu	0.32	0.18	0.23	0.12	0.24	0.51	0.25	0.36	0.43	0.09	0.19	0.25	0.53	0.36	0.42	0.60	0.26	0.25	0.26	0.22
Nd	292.00	146.00	123.00	32.20	88.40	477.00	126.00	494.00	632.00	68.10	150.00	239.00	655.00	528.00	469.00	745.00	151.00	139.00	75.60	77.40
Pr	104.00	53.70	43.80	9.84	31.40	165.00	46.50	189.00	237.00	24.90	55.20	87.20	241.00	190.00	162.00	258.00	53.60	47.60	26.20	26.80

Sm	29.60	19.70	19.00	5.10	10.90	48.20	15.30	39.30	53.00	7.90	15.60	22.20	52.70	44.10	39.90	59.90	15.50	14.90	9.30	9.40
Tb	1.70	0.76	0.95	0.30	0.84	2.83	0.96	2.19	3.29	0.35	0.67	1.26	4.23	3.29	2.88	4.68	0.71	0.66	0.61	0.53
Th	30.20	16.50	16.50	4.50	8.20	25.70	18.00	29.50	32.50	7.10	19.80	23.80	63.40	33.60	32.50	31.70	27.60	27.00	19.10	20.40
Tm	0.25	0.11	0.14	0.06	0.15	0.44	0.18	0.28	0.35	0.03	0.12	0.21	0.52	0.34	0.33	0.45	0.16	0.16	0.17	0.14
U	14.20	7.65	6.78	3.36	6.14	20.80	7.21	18.60	25.80	2.54	7.54	13.00	21.70	23.40	21.30	25.00	14.60	11.60	14.20	11.20
Y	29.20	12.60	16.30	7.60	17.00	52.50	19.40	35.80	41.80	6.90	15.20	22.00	52.20	40.00	34.20	45.70	17.30	17.60	16.70	14.30
Yb	2.30	1.10	1.30	0.70	1.30	3.90	1.50	2.30	2.90	0.50	1.20	1.60	3.70	2.50	2.70	4.10	1.50	1.50	1.50	1.40
Al	31.50	44.09	31.77	35.38	40.30	26.61	38.31	38.79	48.54	18.54	49.30	53.34	56.09	50.29	35.39	20.90	43.96	49.53	46.53	49.23

continued

Sample	BB400_41	BB400_42	BB400_43	BB400_44	BB400_45	BB400_46	BB400_47	BB400_48	BB400_49	BB400_50	BB400_51	BB400_52	BB400_53	BB400_54	BB400_55	BB400_56	BB400_57	BB400_58	BB400_59
SiO2	68.50	71.50	74.40	71.90	72.20	73.00	71.50	72.50	68.00	73.00	73.60	85.90	75.40	71.10	74.50	76.50	85.00	75.60	72.30
Al2O3	13.10	12.70	12.20	13.50	13.00	12.80	12.90	11.00	14.10	13.20	13.10	3.17	13.20	9.59	13.00	12.50	2.73	12.80	13.40
CaO	2.02	2.26	1.74	1.78	1.69	1.82	1.93	1.59	2.16	1.75	1.81	2.57	0.50	0.66	0.50	0.67	2.46	0.70	1.06
MgO	0.50	0.43	0.29	0.32	0.28	0.28	0.28	0.33	0.28	0.29	0.57	0.59	0.80	0.60	0.74	0.72	0.75	0.76	0.89
FeO	3.01	2.05	1.31	1.36	1.04	0.97	1.09	1.37	2.02	0.99	1.12	1.94	1.54	4.87	1.97	1.28	2.16	1.65	2.15
Fe2O3	1.43	0.98	0.62	0.65	0.49	0.46	0.52	0.65	0.96	0.47	0.53	0.92	0.73	2.32	0.94	0.61	1.03	0.79	1.02
K2O	4.72	3.97	4.44	4.70	4.53	4.59	4.60	3.99	6.66	4.84	5.02	0.92	4.27	3.03	4.15	3.99	0.75	4.13	4.29
MnO	0.08	0.06	0.05	0.05	0.03	0.03	0.03	0.04	0.05	0.04	0.04	0.15	0.06	0.06	0.06	0.05	0.23	0.05	0.09
Na2O	2.35	2.82	2.58	3.09	2.93	2.71	2.50	2.10	2.40	2.76	0.67	0.03	0.07	0.07	0.05	0.05	0.03	0.03	0.03
P2O5	0.09	0.08	0.05	0.06	0.05	0.05	0.06	0.05	0.22	0.06	0.06	0.05	0.05	0.11	0.05	0.07	0.01	0.07	0.09
TiO2	0.25	0.23	0.18	0.19	0.18	0.17	0.18	0.16	0.19	0.19	0.19	0.03	0.21	0.18	0.24	0.21	0.01	0.21	0.22
Cr2O3	0.02	0.05	0.06	0.01	0.01	0.01	0.01	0.09	0.09	0.09	0.09	0.13	0.46	0.01	0.02	0.01	0.02	0.04	0.11
V2O5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01

LOI	2.14	1.24	1.18	1.18	1.19	1.42	1.98	1.90	1.31	1.30	2.57	2.46	2.95	5.46	3.47	2.81	2.94	2.81	3.32
Au	0.01	0.01	0.06	0.03	0.01	0.01	0.01	0.03	0.01	0.06	0.03	0.03	0.03	0.03	0.02	0.01	0.02	0.01	0.04
Ag	0.50	1.40	1.00	0.50	0.50	0.50	0.50	1.30	0.50	0.50	1.90	1.40	1.80	2.60	3.00	2.40	0.50	1.20	3.00
As	10.00	3.00	3.00	1.00	2.00	5.00	5.00	4.00	4.00	5.00	28.00	24.00	32.00	115.00	37.00	53.00	33.00	86.00	50.00
Ba	434.00	878.00	1210.00	1150.00	915.00	1050.00	1150.00	1260.00	779.00	1130.00	2200.00	228.00	1170.00	160.00	782.00	964.00	169.00	1010.00	1140.00
Co	6.20	4.80	3.10	2.90	2.30	2.20	2.40	3.50	5.10	2.30	2.70	1.50	2.30	6.20	4.10	1.50	1.50	2.70	7.70
Cr	19.00	13.00	11.00	7.00	7.00	8.00	8.00	8.00	13.00	10.00	15.00	17.00	12.00	19.00	13.00	9.00	24.00	11.00	17.00
Cu	390.00	283.00	208.00	133.00	97.40	96.90	105.00	201.00	259.00	90.30	215.00	12.90	225.00	558.00	260.00	126.00	14.50	109.00	201.00
Hf	1.80	1.20	1.20	1.40	1.30	1.10	1.20	1.30	1.50	1.30	1.40	0.03	1.30	1.60	1.40	2.90	0.03	1.50	1.60
Mo	33.40	63.80	279.00	96.50	66.90	35.30	41.80	427.00	337.00	27.80	63.70	77.10	37.20	120.00	35.50	33.50	10.40	79.20	158.00
Nb	19.40	14.80	10.10	13.20	10.70	9.70	9.90	8.40	9.80	10.50	7.80	1.00	7.80	6.50	9.60	17.20	0.50	7.60	9.30
Ni	6.40	6.20	5.10	5.50	4.80	5.70	6.90	6.10	6.40	5.40	6.60	8.60	3.80	5.40	6.10	27.00	8.50	5.70	7.80
Pb	18.00	45.00	45.00	38.00	33.00	37.00	33.00	36.00	46.00	41.00	82.00	58.00	53.00	81.00	92.00	67.00	6.00	32.00	71.00
Rb	206.00	187.00	197.00	203.00	178.00	210.00	205.00	182.00	282.00	146.00	217.00	61.00	276.00	185.00	271.00	305.00	49.00	295.00	266.00
S	1.58	0.83	0.60	0.48	0.40	0.48	0.48	0.77	1.02	0.46	0.87	0.82	1.00	4.93	1.33	0.67	0.68	1.04	1.17
Sc	4.80	4.10	3.00	3.60	3.10	2.80	3.00	2.90	3.40	2.70	3.10	2.20	3.90	2.90	3.60	13.50	4.60	3.70	3.80
Sr	1710.00	1290.00	706.00	800.00	734.00	667.00	639.00	711.00	1240.00	698.00	1040.00	370.00	267.00	179.00	241.00	185.00	137.00	105.00	240.00
V	40.00	25.00	17.00	18.00	16.00	17.00	16.00	20.00	24.00	17.00	32.00	10.00	32.00	93.00	39.00	23.00	14.00	22.00	27.00
W	262.00	194.00	208.00	165.00	141.00	119.00	102.00	1520.00	1320.00	97.00	161.00	45.70	911.00	2810.00	470.00	119.00	59.50	76.20	149.00
Zn	57.00	71.00	49.00	54.00	43.00	44.00	50.00	112.00	117.00	37.00	94.00	85.00	127.00	443.00	262.00	67.00	26.00	106.00	137.00
Zr	62.00	44.00	35.00	41.70	36.50	38.30	42.30	35.20	41.90	43.30	80.90	14.30	44.10	39.70	47.70	41.50	7.90	51.30	57.50
CO2	1.21	1.24	1.06	1.09	1.06	1.29	1.63	1.26	1.37	1.15	1.45	2.88	0.60	0.70	0.55	0.80	3.78	0.56	1.35
Ce	337.00	148.00	52.40	58.60	64.10	56.60	79.20	59.90	89.00	65.10	72.30	30.70	75.90	378.00	113.00	65.30	6.60	78.30	98.90
Dy	2.07	1.40	1.53	1.10	1.21	1.04	1.22	0.80	2.25	1.09	1.16	0.69	0.97	1.90	1.45	1.70	1.15	1.58	1.82
Er	0.80	0.49	0.53	0.54	0.55	0.55	0.51	0.28	0.95	0.42	0.40	0.30	0.39	0.76	0.71	0.68	0.65	0.54	0.69
Eu	2.94	1.57	0.81	0.89	0.86	0.82	0.98	0.37	1.47	0.93	0.92	0.45	0.73	1.91	0.90	0.93	0.34	0.81	1.04
Gd	5.11	2.86	2.37	1.59	1.88	1.54	1.92	0.94	2.69	1.88	1.93	1.28	1.95	4.54	2.06	1.99	0.84	1.98	2.77

Ho	0.34	0.22	0.22	0.22	0.22	0.22	0.22	0.12	0.32	0.15	0.14	0.12	0.16	0.32	0.25	0.25	0.22	0.21	0.29
La	229.00	94.70	27.50	33.10	37.20	30.00	40.80	27.90	64.40	37.10	44.00	20.80	44.40	359.00	80.40	46.80	4.00	46.80	61.50
Lu	0.23	0.20	0.19	0.19	0.22	0.22	0.20	0.03	0.22	0.18	0.19	0.11	0.14	0.23	0.23	0.21	0.16	0.16	0.22
Nd	80.40	40.00	16.20	17.90	20.40	16.60	21.10	12.90	24.30	20.00	22.10	10.60	19.40	71.80	28.30	19.70	3.20	22.20	28.90
Pr	28.80	13.00	4.75	5.33	5.81	4.83	6.26	4.57	7.38	5.89	6.57	2.68	6.26	27.30	9.44	5.84	0.69	6.98	8.88
Sm	9.10	4.90	2.90	3.10	3.40	3.00	3.50	1.70	4.00	3.30	3.70	2.00	2.80	6.70	2.90	2.30	0.60	2.60	3.20
Tb	0.62	0.39	0.38	0.24	0.24	0.24	0.30	0.16	0.49	0.28	0.31	0.18	0.24	0.52	0.39	0.39	0.17	0.38	0.50
Th	24.00	20.60	16.30	17.40	21.20	16.50	20.20	10.20	19.00	19.80	21.20	5.40	17.80	23.40	20.70	17.10	3.20	16.70	18.60
Tm	0.14	0.09	0.10	0.09	0.11	0.11	0.11	0.03	0.16	0.08	0.09	0.03	0.08	0.13	0.13	0.13	0.10	0.08	0.14
U	10.30	11.00	17.00	15.70	15.70	21.60	18.60	5.13	13.00	13.80	12.90	3.62	8.70	14.90	13.70	15.30	2.46	12.50	11.40
Y	13.10	10.50	8.70	9.30	9.60	9.50	10.30	3.20	16.60	9.30	9.00	6.20	6.20	13.50	11.80	12.40	8.70	9.50	13.40
Yb	1.30	1.10	1.00	1.10	1.10	1.20	1.10	0.30	1.30	1.00	1.00	0.50	0.70	1.30	1.20	1.30	0.90	1.00	1.30
AI	54.43	46.41	52.27	50.76	51.01	51.81	52.42	53.93	60.35	53.22	69.27	36.78	89.89	83.26	89.89	86.74	37.64	87.09	82.68

continued					
Sample	BB400_60	BB400_61	BB400_62	BB400_63	BB400_64
SiO2	70.80	74.10	74.80	67.50	80.50
Al2O3	13.30	12.30	11.60	4.01	11.90
CaO	0.99	1.65	1.11	4.09	0.67
MgO	0.77	0.73	0.69	1.44	0.62
FeO	2.28	1.45	1.49	5.79	1.05
Fe2O3	1.09	0.69	0.71	2.76	0.50
K2O	4.21	3.85	3.67	0.79	3.47
MnO	0.06	0.08	0.06	0.84	0.05
Na2O	0.10	0.24	0.17	0.03	0.24

P2O5	0.09	0.06	0.06	0.02	0.05
TiO2	0.20	0.19	0.18	0.03	0.08
Cr2O3	0.01	0.01	0.01	0.01	0.01
V2O5	0.01	0.01	0.01	0.01	0.01
LOI	3.37	2.75	2.69	8.81	2.55
Au	0.01	0.02	0.01	0.01	0.01
Ag	1.80	1.20	0.50	0.50	0.50
As	29.00	21.00	18.00	30.00	18.00
Ba	652.00	980.00	928.00	225.00	748.00
Co	5.70	3.30	3.50	1.60	1.40
Cr	15.00	12.00	11.00	27.00	7.00
Cu	252.00	119.00	159.00	16.40	124.00
Hf	1.70	1.60	1.70	0.03	1.30
Mo	172.00	103.00	316.00	182.00	70.00
Nb	9.30	7.70	8.00	1.20	6.80
Ni	7.00	6.10	6.10	13.10	3.80
Pb	71.00	44.00	37.00	29.00	29.00
Rb	218.00	269.00	267.00	76.00	237.00
S	1.60	0.76	0.83	0.42	0.43
Sc	3.30	3.80	3.20	18.00	2.20
Sr	161.00	286.00	189.00	337.00	205.00
V	26.00	20.00	19.00	29.00	11.00
W	594.00	567.00	302.00	494.00	120.00
Zn	92.00	61.00	83.00	38.00	51.00
Zr	64.00	58.90	56.70	14.20	37.10
CO2	1.21	1.07	1.27	8.76	0.73
Ce	104.00	87.40	88.20	81.40	58.90
Dy	2.36	1.85	1.73	5.11	1.10
Er	1.00	0.64	0.77	2.79	0.54

Eu	1.13	0.91	0.87	1.17	0.64
Gd	2.99	2.47	2.42	3.66	1.48
Ho	0.37	0.29	0.28	1.04	0.19
La	61.10	51.00	51.10	44.40	32.90
Lu	0.25	0.21	0.20	0.45	0.19
Nd	27.80	25.50	25.40	22.80	16.70
Pr	8.96	7.76	7.92	7.17	4.89
Sm	3.50	3.10	3.10	3.70	2.30
Tb	0.50	0.44	0.49	0.62	0.22
Th	21.40	18.40	20.60	5.60	10.80
Tm	0.16	0.12	0.11	0.42	0.10
U	15.40	10.60	11.90	7.21	15.10
Y	14.90	12.10	12.20	29.80	9.70
Yb	1.40	1.10	1.20	3.10	1.10
AI	82.04	70.79	77.31	35.15	81.80

4. CC+400

Sample	CC400_001	CC400_002	CC400_003	CC400_004	CC400_006	CC400_007	CC400_008	CC400_009	CC400_011	CC400_012	CC400_013	CC400_014	CC400_016	CC400_017	CC400_018	CC400_019
SiO2	47.40	68.90	72.90	70.80	73.90	72.70	71.80	74.60	73.80	73.60	71.20	72.00	68.90	74.40	71.00	86.70
Na2O	1.57	2.19	2.25	2.54	2.70	3.15	3.16	3.04	2.61	1.66	1.76	0.21	0.05	0.05	0.06	0.01
CaO	11.00	3.80	3.40	4.20	3.10	3.00	3.10	2.80	2.80	2.60	3.90	4.70	3.30	4.10	2.30	3.70
MgO	5.55	1.37	0.56	0.50	0.61	0.65	0.73	0.66	0.69	0.66	0.70	0.86	0.89	0.90	1.18	0.18
MnO	0.26	0.10	0.07	0.11	0.08	0.08	0.08	0.08	0.08	0.07	0.11	0.13	0.11	0.13	0.08	0.10
FeO	7.50	2.40	1.21	1.24	1.33	1.24	1.24	1.22	1.45	1.50	1.57	1.22	2.23	1.11	2.94	2.08
Fe2O3	3.57	1.15	0.57	0.59	0.63	0.59	0.59	0.58	0.69	0.72	0.75	0.58	1.06	0.53	1.40	0.99
K2O	0.80	4.50	4.30	4.20	4.90	4.80	4.80	4.10	5.10	3.70	5.00	4.30	4.30	4.80	5.00	0.60
Al2O3	10.95	13.22	12.06	12.20	13.79	13.73	13.79	12.69	13.14	11.47	12.94	11.92	13.42	13.82	14.63	1.55
P2O5	0.33	0.11	0.06	0.07	0.09	0.09	0.09	0.08	0.09	0.08	0.09	0.08	0.10	0.10	0.11	0.02
TiO2	2.40	0.60	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.50
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	25.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	424.00	1466.00	1565.00	1714.00	2161.00	1950.00	1823.00	1605.00	2473.00	1322.00	2333.00	1227.00	1167.00	1200.00	1416.00	124.00
Be	13.00	10.00	11.00	12.00	10.00	9.00	12.00	9.00	8.00	7.00	11.00	12.00	14.00	15.00	17.00	3.00
Bi	9.30	10.10	8.10	7.10	4.60	3.30	4.80	30.20	9.80	2.00	16.60	8.70	18.90	3.80	16.90	15.50
CO3	7.19	3.00	3.45	4.25	2.35	2.65	2.65	2.80	2.35	2.55	4.15	4.85	3.40	4.05	2.15	4.00
Cd	2.00	1.00	1.00	0.50	1.00	0.50	1.00	7.00	1.00	1.00	0.50	1.00	2.00	1.00	1.00	2.00
Ce	110.60	116.90	106.60	82.20	104.10	104.20	101.80	87.30	130.40	87.30	126.90	104.70	100.40	99.70	123.70	13.30
Co	41.00	10.00	4.00	4.00	4.00	3.00	4.00	4.00	4.00	4.00	5.00	5.00	9.00	1.00	6.00	7.00
Cr	259.00	156.00	139.00	134.00	128.00	156.00	82.00	151.00	168.00	208.00	74.00	164.00	162.00	160.00	197.00	293.00
Cs	7.66	13.20	12.05	10.44	9.81	9.13	9.72	8.22	10.64	15.99	15.12	25.09	27.19	26.00	30.23	3.06
Cu	297.00	194.00	175.00	171.00	147.00	135.00	140.00	127.00	157.00	180.00	206.00	181.00	295.00	169.00	331.00	271.00

Dy	5.60	2.20	1.40	1.40	1.90	2.00	2.40	2.10	2.00	1.80	2.10	1.80	2.30	1.90	2.00	0.50
Er	2.40	1.00	0.70	0.70	1.10	1.20	1.20	1.10	1.00	0.80	1.00	1.00	1.40	0.90	0.80	0.20
Eu	2.20	1.00	0.90	0.80	0.80	0.80	0.90	0.80	0.90	0.70	1.00	1.00	1.00	1.00	1.10	0.20
Ga	20.00	21.00	21.00	20.00	21.00	20.00	20.00	18.00	20.00	16.00	20.00	20.00	21.00	22.00	24.00	3.00
Gd	6.70	3.20	2.10	2.00	3.20	2.70	3.00	2.90	2.40	2.60	2.60	2.80	3.20	2.60	2.80	0.40
Hf	5.70	4.80	4.70	4.80	5.50	6.00	6.10	4.60	5.00	4.90	4.90	4.20	4.50	6.60	5.50	2.70
Ho	1.00	0.40	0.30	0.30	0.40	0.40	0.40	0.30	0.40	0.30	0.30	0.30	0.40	0.40	0.30	0.05
In	0.40	0.10	0.10	0.05	0.05	0.05	0.10	0.40	0.10	0.05	0.20	0.10	0.20	0.10	0.20	0.05
La	65.40	76.40	76.60	57.10	66.80	67.00	64.20	55.10	91.40	58.30	89.90	68.60	64.40	62.30	83.60	8.60
Li	129.00	66.00	49.00	50.00	39.00	38.00	40.00	38.00	42.00	38.00	32.00	55.00	54.00	53.00	100.00	29.00
Lu	0.30	0.14	0.10	0.13	0.18	0.14	0.14	0.14	0.12	0.15	0.15	0.13	0.19	0.15	0.15	0.03
Mo	30.00	33.00	24.00	35.00	22.00	20.00	13.00	19.00	21.00	323.00	278.00	73.00	251.00	165.00	127.00	2246.00
Nb	27.00	16.00	12.00	12.00	13.00	14.00	13.00	13.00	13.00	5.00	13.00	12.00	16.00	14.00	16.00	5.00
Nd	45.30	36.00	27.60	23.80	30.90	31.50	32.00	28.20	37.00	26.50	35.80	31.40	31.50	30.80	36.60	3.70
Ni	163.00	34.00	5.00	5.00	6.00	5.00	3.00	6.00	7.00	4.00	2.00	4.00	7.00	3.00	7.00	0.50
Pb	25.00	49.00	69.00	54.00	66.00	47.00	49.00	88.00	79.00	35.00	43.00	49.00	51.00	21.00	88.00	36.00
Pr	11.65	11.00	9.41	7.51	9.49	9.83	9.93	8.41	11.55	8.11	11.57	9.85	9.74	9.62	11.37	1.21
Rb	55.60	264.30	261.90	241.70	240.60	236.50	239.50	214.80	256.40	215.00	247.50	297.40	280.60	311.00	377.70	29.60
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.20
S	1.27	0.84	0.76	0.33	0.34	0.30	0.54	0.38	0.64	0.90	0.59	0.31	1.43	0.20	2.19	1.87
Sb	0.50	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.50	0.25	0.25	0.70
Sc	22.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	22.10	32.20	34.10	33.10	34.50	34.00	33.60	34.90	34.50	34.40	33.30	33.70	32.20	34.80	33.20	40.50
Sm	7.40	4.10	3.10	3.00	4.20	3.90	4.10	3.70	4.40	3.30	4.30	4.00	4.50	4.30	4.40	0.50
Sn	25.00	12.00	15.00	14.00	14.00	11.00	10.00	10.00	17.00	11.00	20.00	17.00	20.00	15.00	19.00	3.00
Sr	920.00	904.00	985.00	1110.00	1154.00	1133.00	1078.00	920.00	1290.00	716.00	1448.00	1061.00	783.00	850.00	461.00	736.00
Ta	1.30	1.30	1.20	1.10	1.20	1.20	1.30	1.30	1.10	0.70	1.10	0.90	1.20	1.20	1.10	0.05
Tb	0.96	0.39	0.29	0.22	0.33	0.34	0.37	0.34	0.35	0.24	0.28	0.36	0.32	0.40	0.27	0.03

Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00
Th	3.20	18.50	18.20	16.20	18.20	17.30	16.10	16.40	17.20	13.00	16.30	14.70	17.50	17.90	16.90	1.70
Ti	1.45	0.38	0.14	0.13	0.19	0.18	0.19	0.17	0.19	0.16	0.18	0.16	0.18	0.20	0.20	0.03
TIC	1.44	0.60	0.69	0.85	0.47	0.53	0.53	0.56	0.47	0.51	0.83	0.97	0.68	0.81	0.43	0.80
Tl	0.60	2.00	2.00	1.90	1.90	1.70	1.80	1.60	1.90	1.50	1.70	1.90	2.50	2.20	3.00	0.90
Tm	0.31	0.14	0.11	0.09	0.15	0.15	0.16	0.17	0.16	0.18	0.13	0.11	0.18	0.15	0.13	0.03
U	3.20	10.80	12.60	10.80	11.20	8.70	10.20	11.60	6.40	7.50	6.80	9.00	13.00	12.20	8.80	2.10
V	279.00	73.00	25.00	25.00	25.00	25.00	25.00	51.00	25.00	25.00	25.00	25.00	52.00	61.00	58.00	25.00
W	967.00	309.00	161.00	60.00	48.00	27.00	50.00	31.00	114.00	27.00	45.00	250.00	398.00	65.00	627.00	642.00
Y	27.80	13.00	9.30	9.40	11.80	12.00	12.90	12.30	11.50	10.00	11.20	12.00	13.70	12.40	10.70	3.60
Yb	2.40	1.20	0.70	0.80	1.00	1.20	1.20	1.00	0.90	0.80	0.90	1.00	1.50	1.10	1.10	0.20
Zn	247.00	88.00	50.00	40.00	69.00	46.00	62.00	203.00	63.00	39.00	40.00	54.00	63.00	61.00	50.00	26.00
Zr	232.00	176.00	157.00	166.00	187.00	198.00	237.00	159.00	180.00	163.00	175.00	165.00	168.00	248.00	184.00	124.00
Al	33.56	49.50	46.26	41.07	48.72	47.00	46.92	44.89	51.68	50.56	50.16	51.23	60.79	57.86	72.40	17.36

continued

Sample	CC400_021	CC400_022	CC400_023	CC400_024	CC400_026	CC400_027	CC400_028	CC400_029	CC400_031	CC400_032	CC400_033	CC400_034	CC400_036	CC400_037	CC400_038	CC400_039
SiO2	84.60	65.50	75.60	64.50	70.20	68.50	69.70	70.20	71.70	68.50	67.10	66.30	68.10	81.30	72.40	85.70
Na2O	0.02	0.82	0.09	1.19	2.14	2.03	0.98	1.01	1.84	1.70	1.13	0.25	1.20	0.12	0.48	0.03
CaO	2.40	4.90	10.60	4.60	3.00	3.60	2.70	1.60	2.50	3.40	2.10	1.00	1.00	3.10	3.50	1.40
MgO	0.30	0.81	0.18	0.87	0.78	0.67	0.57	0.46	0.64	0.70	0.77	0.48	0.41	0.36	0.63	0.15
MnO	0.09	0.16	0.30	0.18	0.13	0.13	0.07	0.05	0.09	0.15	0.08	0.05	0.03	0.04	0.13	0.04
FeO	3.44	2.21	0.71	2.07	1.79	1.66	2.04	1.50	1.87	2.31	2.76	6.10	4.45	1.86	2.67	3.18
Fe2O3	1.64	1.05	0.34	0.99	0.85	0.79	0.97	0.72	0.89	1.10	1.32	2.90	2.12	0.88	1.27	1.51
K2O	1.20	4.50	0.70	5.20	5.50	5.30	6.20	6.30	5.30	5.00	5.40	6.60	5.90	2.90	5.20	1.40
Al2O3	3.54	13.04	1.49	12.85	13.66	13.16	12.49	12.32	13.39	11.83	13.66	11.57	11.80	5.61	10.76	2.03
P2O5	0.05	0.10	0.02	0.12	0.10	0.10	0.07	0.05	0.12	0.10	0.11	0.14	0.08	0.06	0.11	0.04
TiO2	0.50	0.30	0.50	0.30	0.30	0.30	0.20	0.10	0.30	0.30	0.40	0.30	0.20	0.50	0.10	0.50
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	287.00	1826.00	166.00	3204.00	2810.00	2908.00	2429.00	2520.00	2838.00	2621.00	2372.00	3898.00	2584.00	953.00	2686.00	441.00
Be	4.00	13.00	35.00	18.00	14.00	17.00	12.00	11.00	28.00	18.00	19.00	22.00	15.00	6.00	17.00	2.00
Bi	22.40	23.00	7.00	22.60	21.60	8.80	6.10	14.50	26.30	5.90	5.30	19.40	6.30	5.00	10.00	4.70
CO3	2.55	5.00	12.14	4.80	2.65	3.35	2.60	1.25	1.95	2.50	1.80	0.40	0.30	3.00	3.10	1.25
Cd	0.50	0.50	2.00	0.50	2.00	1.00	1.00	0.50	4.00	2.00	2.00	2.00	2.00	0.50	1.00	2.00
Ce	45.40	97.00	16.70	73.40	77.00	84.50	48.20	33.10	73.10	67.70	65.70	75.50	47.70	16.60	1060.40	6.80
Co	10.00	4.00	2.00	5.00	4.00	4.00	5.00	4.00	5.00	5.00	5.00	12.00	10.00	5.00	4.00	9.00
Cr	366.00	193.00	238.00	199.00	152.00	148.00	161.00	92.00	127.00	190.00	222.00	259.00	207.00	216.00	183.00	394.00
Cs	6.63	17.50	3.34	12.37	12.12	13.18	11.83	9.81	11.23	9.53	12.83	11.90	9.75	5.51	8.24	1.70
Cu	435.00	195.00	223.00	241.00	175.00	213.00	214.00	202.00	277.00	271.00	307.00	788.00	644.00	247.00	167.00	627.00
Dy	0.80	1.90	0.70	1.40	1.20	1.50	1.30	1.10	1.00	0.90	1.30	1.30	1.00	1.20	3.60	0.60

Er	0.50	0.80	0.40	0.60	0.60	0.60	0.70	0.80	0.60	0.50	0.60	0.80	0.80	0.70	1.70	0.40
Eu	0.50	1.00	0.50	0.80	0.80	0.80	0.50	0.30	0.80	0.80	0.90	0.70	0.50	0.30	5.30	0.20
Ga	7.00	21.00	3.00	23.00	21.00	21.00	22.00	21.00	25.00	21.00	23.00	20.00	18.00	10.00	18.00	4.00
Gd	1.00	2.20	0.60	1.60	1.60	1.60	1.40	1.20	1.30	1.40	1.40	1.70	1.30	0.80	6.50	0.50
Hf	2.10	6.20	1.80	5.70	5.80	5.40	4.40	4.40	5.30	5.60	5.90	4.60	4.10	4.90	3.50	3.70
Ho	0.20	0.30	0.10	0.30	0.20	0.30	0.20	0.30	0.20	0.20	0.20	0.30	0.20	0.20	0.60	0.10
In	0.10	0.20	0.10	0.20	0.20	0.20	0.05	0.05	0.30	0.10	0.20	0.20	0.10	0.05	0.40	0.10
La	30.10	65.70	12.50	54.00	52.00	57.20	32.80	23.00	50.80	47.10	46.30	46.80	29.60	9.80	624.20	3.70
Li	37.00	74.00	31.00	57.00	96.00	94.00	228.00	59.00	68.00	110.00	78.00	55.00	29.00	34.00	46.00	48.00
Lu	0.03	0.17	0.03	0.10	0.09	0.12	0.11	0.13	0.10	0.10	0.11	0.11	0.12	0.13	0.25	0.07
Mo	721.00	71.00	83.00	44.00	22.00	31.00	67.00	79.00	48.00	63.00	95.00	195.00	151.00	104.00	90.00	1946.00
Nb	5.00	13.00	5.00	12.00	12.00	16.00	17.00	13.00	14.00	12.00	13.00	16.00	14.00	5.00	13.00	5.00
Nd	12.80	28.10	4.80	19.50	22.70	25.60	13.90	10.20	21.00	20.00	18.70	23.70	15.50	6.00	267.50	2.60
Ni	6.00	5.00	5.00	8.00	4.00	4.00	5.00	3.00	4.00	4.00	6.00	8.00	8.00	6.00	6.00	3.00
Pb	49.00	49.00	10.00	38.00	55.00	54.00	67.00	56.00	113.00	49.00	53.00	61.00	75.00	30.00	34.00	23.00
Pr	4.09	9.02	1.50	6.62	7.26	7.83	4.55	3.09	6.79	6.34	6.04	7.33	5.05	1.84	98.45	0.71
Rb	77.70	235.50	33.10	252.40	261.60	259.70	286.80	274.30	253.20	226.20	283.70	297.10	263.80	129.00	226.40	43.50
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.20
S	3.24	0.28	0.26	0.52	0.34	0.58	0.78	0.71	0.69	0.67	1.39	5.71	4.06	1.39	1.43	2.70
Sb	0.70	0.90	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	39.60	30.60	35.30	30.20	32.80	32.00	32.60	32.80	33.50	32.00	31.40	31.00	31.90	38.00	33.90	40.00
Sm	1.60	3.20	0.70	2.20	2.70	2.90	2.20	1.60	2.10	2.20	2.40	3.10	1.60	1.10	20.00	0.60
Sn	8.00	21.00	5.00	26.00	16.00	23.00	18.00	12.00	22.00	20.00	20.00	19.00	11.00	4.00	13.00	2.00
Sr	466.00	1152.00	2258.00	1649.00	1272.00	1450.00	1246.00	1035.00	1286.00	1371.00	952.00	1219.00	910.00	1320.00	1297.00	416.00
Ta	0.20	1.10	0.05	0.90	1.10	1.40	8.10	3.60	1.20	0.80	1.20	1.10	2.20	1.70	3.30	0.20
Tb	0.13	0.26	0.11	0.22	0.21	0.22	0.22	0.16	0.13	0.14	0.18	0.21	0.19	0.19	0.70	0.12
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.50	0.50	0.50	0.50	0.50	1.00

Th	4.80	19.30	2.20	16.90	19.30	16.70	13.70	12.30	16.90	15.90	20.00	13.30	12.00	5.10	17.30	1.00
Ti	0.05	0.20	0.03	0.19	0.21	0.20	0.10	0.09	0.21	0.18	0.21	0.18	0.11	0.03	0.07	0.03
TIC	0.51	1.00	2.43	0.96	0.53	0.67	0.52	0.25	0.39	0.50	0.36	0.08	0.06	0.60	0.62	0.25
Tl	1.20	1.70	0.25	1.70	1.80	2.00	2.20	2.10	1.90	1.70	2.10	2.20	2.10	0.90	1.50	0.25
Tm	0.03	0.11	0.03	0.10	0.06	0.09	0.09	0.09	0.08	0.05	0.10	0.12	0.14	0.12	0.27	0.05
U	3.10	5.40	0.80	5.70	5.80	5.10	13.70	15.70	4.90	4.40	5.60	7.00	17.20	13.60	24.70	4.40
V	25.00	62.00	25.00	64.00	60.00	61.00	25.00	25.00	57.00	51.00	66.00	25.00	25.00	25.00	71.00	25.00
W	137.00	26.00	488.00	477.00	39.00	197.00	62.00	286.00	571.00	239.00	216.00	489.00	805.00	1073.00	2011.00	4459.00
Y	5.30	9.60	5.90	7.50	7.10	7.60	8.30	7.40	7.10	6.50	7.20	9.00	8.10	6.90	24.20	3.90
Yb	0.50	0.90	0.30	0.60	0.60	0.70	0.90	0.80	0.60	0.70	0.60	0.80	1.00	0.90	1.70	0.30
Zn	22.00	36.00	65.00	49.00	100.00	83.00	36.00	48.00	144.00	76.00	61.00	62.00	56.00	16.00	53.00	20.00
Zr	99.00	225.00	79.00	202.00	210.00	210.00	149.00	133.00	196.00	220.00	216.00	169.00	131.00	186.00	104.00	161.00
Al	38.28	48.16	7.60	51.19	54.99	51.46	64.81	72.12	57.80	52.79	65.64	85.01	74.16	50.27	59.41	51.97

continued

Sample	CC400_041	CC400_042	CC400_043	CC400_044	CC400_046	CC400_047	CC400_048	CC400_049	CC400_051	CC400_052	CC400_053	CC400_054	CC400_056	CC400_057	CC400_058	CC400_059
SiO2	70.30	70.00	73.70	78.30	80.70	67.70	67.70	68.00	67.90	68.70	67.20	66.80	57.90	70.90	67.90	53.40
Na2O	1.03	0.19	0.86	0.28	0.45	1.93	3.08	2.72	1.86	2.34	2.21	1.78	1.51	1.27	1.73	1.38
CaO	1.30	3.30	1.00	1.50	1.30	3.80	3.30	3.30	3.90	3.70	5.10	5.40	5.80	4.50	3.20	6.20
MgO	0.34	0.72	0.46	0.45	0.33	0.64	0.54	0.62	0.56	0.60	0.66	0.74	0.91	0.66	0.56	1.57
MnO	0.04	0.07	0.05	0.04	0.06	0.12	0.11	0.12	0.16	0.22	0.30	0.38	0.48	0.29	0.22	0.48
FeO	2.31	1.92	1.99	2.25	4.75	2.26	3.28	2.85	3.45	2.63	2.14	2.64	7.25	3.49	2.57	8.39
Fe2O3	1.10	0.91	0.95	1.07	2.26	1.08	1.56	1.36	1.64	1.25	1.02	1.26	3.45	1.66	1.22	4.00
K2O	7.40	5.50	5.60	4.80	2.30	5.50	3.90	5.00	4.50	4.40	4.70	5.90	3.00	4.10	5.30	3.40
Al2O3	12.86	11.17	11.42	9.65	4.73	13.64	13.42	13.02	11.91	12.79	12.84	12.91	9.98	10.09	12.43	11.44
P2O5	0.06	0.07	0.06	0.05	0.14	0.12	0.13	0.10	0.13	0.11	0.10	0.10	0.30	0.10	0.08	0.49
TiO2	0.10	0.10	0.10	0.50	0.50	0.40	0.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.20	0.20
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	3199.00	2062.00	1891.00	1617.00	1160.00	3235.00	2668.00	3531.00	4124.00	4607.00	4097.00	9150.00	3330.00	4067.00	6517.00	4408.00
Be	13.00	14.00	13.00	9.00	11.00	29.00	37.00	35.00	34.00	30.00	23.00	22.00	81.00	22.00	25.00	57.00
Bi	8.10	5.50	6.60	3.30	22.90	8.40	6.10	5.30	7.90	4.50	2.20	2.00	58.30	80.40	5.30	49.00
CO3	1.00	2.15	0.85	1.10	0.75	2.75	2.65	2.60	2.65	3.35	5.15	5.00	3.55	4.15	2.95	4.20
Cd	0.50	2.00	0.50	0.50	2.00	2.00	4.00	4.00	3.00	3.00	2.00	0.50	13.00	59.00	0.50	22.00
Ce	44.30	56.20	51.00	31.70	31.50	126.30	147.60	124.00	187.30	167.70	249.20	580.60	2352.50	341.10	237.90	7690.80
Co	6.00	4.00	5.00	4.00	9.00	6.00	5.00	5.00	6.00	3.00	4.00	7.00	8.00	5.00	7.00	5.00
Cr	176.00	221.00	261.00	316.00	343.00	131.00	116.00	90.00	151.00	143.00	135.00	125.00	121.00	235.00	196.00	120.00
Cs	9.14	9.11	9.64	6.82	3.39	12.79	9.16	8.29	9.41	9.17	8.81	7.04	11.55	7.87	11.38	8.08
Cu	259.00	288.00	288.00	280.00	603.00	237.00	404.00	370.00	417.00	335.00	202.00	170.00	628.00	354.00	256.00	743.00
Dy	1.70	2.00	1.50	1.70	0.80	1.60	1.70	1.90	2.00	2.00	2.20	2.90	8.40	2.30	2.10	18.80

Er	1.10	1.20	0.90	1.00	0.40	0.70	0.90	0.90	1.00	1.00	1.20	1.30	2.80	1.20	1.10	5.50
Eu	0.40	0.50	0.40	0.30	0.50	1.20	1.50	1.10	1.70	1.50	1.80	2.60	11.20	2.20	1.80	40.90
Ga	23.00	21.00	21.00	16.00	11.00	29.00	32.00	28.00	31.00	30.00	29.00	28.00	25.00	25.00	29.00	14.00
Gd	1.70	1.90	1.70	1.60	1.00	2.10	2.80	2.30	2.90	2.80	3.60	4.10	17.50	4.10	3.20	47.80
Hf	5.10	5.00	4.50	3.20	2.20	4.90	5.50	5.60	5.90	7.00	5.80	7.40	3.60	4.60	4.10	3.30
Ho	0.30	0.40	0.30	0.30	0.10	0.30	0.30	0.30	0.40	0.30	0.50	0.50	1.50	0.40	0.40	2.90
In	0.05	0.20	0.05	0.05	0.10	0.20	0.30	0.20	0.30	0.30	0.40	0.50	1.80	2.90	0.20	3.10
La	28.10	40.50	34.20	19.40	21.00	84.30	97.70	79.10	130.10	110.20	157.10	405.70	1545.40	222.00	140.90	4550.50
Li	38.00	56.00	71.00	47.00	39.00	55.00	45.00	43.00	45.00	46.00	62.00	55.00	80.00	48.00	40.00	460.00
Lu	0.19	0.20	0.19	0.20	0.08	0.11	0.18	0.11	0.13	0.16	0.13	0.19	0.38	0.14	0.20	0.76
Mo	123.00	48.00	44.00	110.00	1280.00	41.00	228.00	109.00	78.00	36.00	28.00	37.00	273.00	58.00	40.00	127.00
Nb	18.00	13.00	15.00	11.00	5.00	16.00	21.00	17.00	19.00	16.00	17.00	19.00	22.00	19.00	18.00	17.00
Nd	13.60	16.00	17.30	10.80	9.80	35.50	44.50	37.00	57.50	49.60	69.50	140.70	635.80	93.10	65.50	2107.40
Ni	5.00	5.00	6.00	6.00	4.00	5.00	2.00	3.00	3.00	4.00	3.00	12.00	2.00	4.00	6.00	3.00
Pb	77.00	55.00	62.00	51.00	10.00	43.00	53.00	53.00	68.00	38.00	23.00	35.00	108.00	139.00	22.00	39.00
Pr	4.56	5.36	5.13	3.34	3.26	12.22	14.96	12.53	18.62	16.69	24.68	52.83	229.21	32.31	22.97	779.56
Rb	314.50	247.00	254.30	204.20	91.30	290.70	204.00	230.70	210.30	207.80	216.00	210.60	135.20	180.30	212.60	139.60
Re	0.05	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.05	0.10
S	1.56	0.73	0.86	1.32	4.09	1.20	2.12	1.56	2.11	1.34	0.49	0.77	4.39	1.56	1.09	4.51
Sb	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	32.90	32.70	34.40	36.60	37.70	31.60	31.60	31.80	31.70	32.10	31.40	31.20	27.00	33.10	31.70	25.00
Sm	2.20	2.30	2.40	1.80	1.50	4.10	5.50	4.30	5.80	5.50	7.00	10.80	48.50	8.40	6.40	144.80
Sn	11.00	10.00	11.00	7.00	8.00	23.00	27.00	27.00	32.00	26.00	32.00	41.00	56.00	28.00	24.00	55.00
Sr	1405.00	934.00	848.00	707.00	577.00	1567.00	1557.00	1918.00	1631.00	1779.00	1951.00	3065.00	1931.00	1800.00	2135.00	2098.00
Ta	5.30	2.90	3.00	2.60	0.70	1.20	1.10	1.20	0.90	0.90	1.00	1.00	1.10	0.80	1.00	1.00
Tb	0.31	0.35	0.27	0.30	0.19	0.28	0.33	0.35	0.35	0.36	0.38	0.48	1.51	0.48	0.44	3.38
Te	0.50	0.50	0.50	0.50	2.00	0.50	0.50	0.50	1.00	0.50	0.50	0.50	2.00	3.00	0.50	2.00

Th	13.40	13.30	14.10	11.70	6.20	18.90	15.10	15.80	9.80	13.20	13.50	14.00	25.20	11.40	10.70	70.20
Ti	0.08	0.06	0.07	0.03	0.05	0.23	0.27	0.19	0.19	0.19	0.20	0.20	0.19	0.17	0.14	0.10
TIC	0.20	0.43	0.17	0.22	0.15	0.55	0.53	0.52	0.53	0.67	1.03	1.00	0.71	0.83	0.59	0.84
Tl	2.20	1.60	1.70	1.50	0.80	1.90	1.40	1.60	1.50	1.40	1.50	1.40	1.00	1.30	1.60	1.00
Tm	0.20	0.15	0.13	0.16	0.08	0.12	0.14	0.15	0.13	0.17	0.17	0.21	0.48	0.19	0.17	0.84
U	24.20	16.50	13.50	16.70	8.10	4.60	8.00	6.70	4.30	4.70	5.50	7.50	25.70	5.60	4.50	85.40
V	25.00	25.00	25.00	25.00	25.00	72.00	70.00	61.00	99.00	94.00	82.00	98.00	185.00	85.00	63.00	368.00
W	823.00	1282.00	382.00	72.00	8055.00	1883.00	2573.00	888.00	4082.00	1152.00	1009.00	746.00	9673.00	2990.00	502.00	7133.00
Y	10.60	12.10	10.40	9.90	5.00	8.90	10.00	10.50	11.70	10.80	12.50	18.10	51.60	15.70	13.90	118.80
Yb	1.30	1.40	1.10	1.20	0.50	0.70	0.80	1.00	1.00	0.90	1.00	1.50	2.50	1.20	1.10	5.20
Zn	19.00	60.00	32.00	20.00	24.00	78.00	164.00	153.00	122.00	102.00	75.00	86.00	458.00	1712.00	54.00	673.00
Zr	135.00	178.00	139.00	111.00	86.00	198.00	219.00	207.00	220.00	262.00	230.00	276.00	148.00	174.00	156.00	109.00
Al	76.88	64.07	76.54	74.66	60.03	51.73	41.03	48.26	46.76	45.29	42.29	48.05	34.85	45.22	54.29	39.59

continued

Sample	CC400_061	CC400_062	CC400_063	CC400_064	CC400_066	CC400_067	CC400_068	CC400_069	CC400_071	CC400_072	CC400_073	CC400_074	CC400_076	CC400_077	CC400_078	CC400_079
SiO2	67.10	63.70	64.40	68.80	75.80	71.70	67.70	65.70	72.60	73.20	75.80	76.50	72.30	71.40	73.60	87.10
Na2O	2.03	1.67	2.25	2.32	0.07	0.05	0.06	0.11	2.24	2.19	2.35	1.92	1.55	1.80	0.72	0.03
CaO	4.00	4.00	4.20	3.30	2.20	1.70	2.30	2.90	3.00	1.90	2.10	1.60	2.00	2.10	1.80	1.70
MgO	0.73	0.79	0.72	0.63	0.87	0.79	0.91	0.88	0.62	0.46	0.48	0.43	0.61	0.72	0.68	0.21
MnO	0.26	0.31	0.23	0.17	0.09	0.07	0.07	0.08	0.08	0.04	0.05	0.04	0.05	0.04	0.04	0.02
FeO	3.76	4.67	2.96	2.48	2.78	2.78	3.01	4.45	1.80	1.14	1.21	1.07	1.22	1.39	1.48	0.80
Fe2O3	1.79	2.23	1.41	1.18	1.33	1.33	1.43	2.12	0.86	0.54	0.57	0.51	0.58	0.66	0.70	0.38
K2O	5.70	5.40	4.70	4.70	5.20	4.30	4.80	4.70	4.80	5.40	4.70	5.80	5.20	4.80	4.10	1.30
Al2O3	12.67	12.31	12.53	13.14	14.17	12.65	13.99	12.97	13.01	12.65	12.18	12.20	12.02	13.65	11.64	3.65
P2O5	0.16	0.18	0.14	0.09	0.09	0.09	0.13	0.11	0.09	0.06	0.04	0.03	0.05	0.07	0.07	0.02
TiO2	0.20	0.30	0.30	0.20	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.30	0.20	0.50
Ag	2.50	6.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	12.00	2.50	2.50	2.50	2.50	5.00
As	10.00	10.00	10.00	10.00	23.00	76.00	68.00	149.00	10.00	10.00	10.00	10.00	10.00	10.00	24.00	10.00
B	25.00	25.00	25.00	25.00	25.00	57.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	7506.00	5758.00	3461.00	2274.00	1701.00	1347.00	1670.00	1491.00	1945.00	1372.00	1373.00	1543.00	1558.00	1344.00	1171.00	227.00
Be	31.00	31.00	30.00	22.00	28.00	13.00	24.00	19.00	13.00	7.00	8.00	8.00	7.00	7.00	12.00	8.00
Bi	12.40	5.70	2.90	5.80	13.00	11.30	15.00	24.00	23.60	5.70	2.40	3.70	3.80	2.40	4.80	13.70
CO3	2.55	3.30	3.85	3.20	1.60	1.15	2.20	2.50	2.70	1.45	1.65	1.30	1.50	1.75	1.60	0.45
Cd	4.00	2.00	2.00	2.00	3.00	2.00	2.00	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Ce	1719.40	1993.40	947.70	223.20	375.00	243.30	272.70	275.70	123.90	61.90	58.90	73.00	78.90	81.80	80.20	11.10
Co	3.00	5.00	4.00	3.00	3.00	3.00	6.00	5.00	4.00	2.00	2.00	4.00	3.00	4.00	4.00	2.00
Cr	93.00	108.00	99.00	166.00	109.00	110.00	218.00	178.00	155.00	175.00	236.00	228.00	270.00	248.00	273.00	363.00
Cs	7.91	8.57	9.83	12.05	20.85	23.43	24.21	24.66	11.69	9.95	9.94	9.81	9.76	10.30	15.32	6.00
Cu	447.00	577.00	313.00	240.00	281.00	328.00	417.00	377.00	204.00	97.00	93.00	95.00	93.00	82.00	146.00	14.00
Dy	5.60	6.10	4.00	2.40	3.20	2.50	2.50	2.20	2.50	1.60	2.10	2.50	2.60	2.00	1.60	0.30

Er	2.30	2.30	1.70	1.20	1.40	1.20	1.10	0.80	1.20	0.80	1.10	1.40	1.60	1.00	0.80	0.30
Eu	9.50	10.70	5.30	1.80	2.30	1.50	1.70	1.50	0.80	0.60	0.60	0.60	0.70	0.80	0.70	0.20
Ga	27.00	26.00	28.00	30.00	28.00	28.00	32.00	31.00	24.00	20.00	22.00	21.00	21.00	22.00	19.00	8.00
Gd	12.30	13.40	7.60	3.40	4.60	3.40	3.70	3.30	3.00	1.80	2.00	2.80	2.20	2.60	2.30	0.50
Hf	4.90	5.30	5.10	3.40	3.10	5.90	3.90	4.90	4.20	4.80	4.40	8.20	14.60	10.70	7.50	2.50
Ho	0.90	1.00	0.70	0.40	0.60	0.40	0.40	0.40	0.40	0.30	0.30	0.50	0.50	0.30	0.30	0.05
In	0.80	0.90	0.50	0.20	0.30	0.20	0.20	0.30	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
La	1074.20	1212.30	531.20	128.20	214.90	144.10	187.30	176.10	82.70	37.10	35.70	46.50	51.20	46.20	47.40	6.50
Li	115.00	75.00	105.00	55.00	136.00	120.00	185.00	212.00	75.00	50.00	80.00	77.00	608.00	107.00	145.00	269.00
Lu	0.30	0.32	0.27	0.21	0.26	0.22	0.18	0.23	0.18	0.16	0.20	0.23	0.32	0.17	0.14	0.03
Mo	50.00	103.00	118.00	33.00	33.00	53.00	71.00	86.00	81.00	128.00	96.00	496.00	35.00	30.00	57.00	38.00
Na	1.50	1.24	1.67	1.72	0.05	0.04	0.04	0.08	1.66	1.63	1.75	1.43	1.15	1.33	0.53	0.02
Nb	27.00	28.00	28.00	27.00	26.00	24.00	24.00	21.00	18.00	15.00	24.00	26.00	20.00	18.00	13.00	5.00
Nd	477.90	544.20	255.40	68.00	112.20	73.20	73.00	71.90	39.30	20.50	19.40	23.00	24.80	27.60	26.40	3.30
Ni	2.00	3.00	2.00	4.00	4.00	5.00	6.00	5.00	5.00	4.00	5.00	3.00	6.00	7.00	6.00	9.00
Pb	64.00	34.00	10.00	54.00	74.00	55.00	63.00	63.00	101.00	46.00	42.00	53.00	35.00	53.00	67.00	160.00
Pr	176.92	197.85	90.79	22.47	37.54	24.35	26.36	24.77	12.33	6.57	6.35	7.56	7.96	8.40	8.69	1.09
Rb	237.30	223.70	222.80	241.00	294.60	337.60	344.90	341.60	258.10	267.80	257.70	282.70	263.80	250.20	271.60	131.20
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	1.85	2.33	1.57	1.20	1.76	2.43	2.52	4.37	0.81	0.47	0.43	0.54	0.36	0.37	0.99	0.30
Sb	0.60	0.25	0.25	0.25	0.50	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	31.40	29.80	30.10	32.20	35.40	33.50	31.70	30.70	33.90	34.20	35.40	35.70	33.80	33.40	34.40	40.70
Sm	36.00	38.80	21.20	6.90	10.30	7.00	7.00	7.40	4.80	2.40	3.00	3.70	3.60	3.80	3.60	0.40
Sn	32.00	36.00	27.00	21.00	21.00	24.00	27.00	24.00	15.00	10.00	10.00	8.00	9.00	10.00	10.00	7.00
Sr	2438.00	2122.00	2036.00	1602.00	440.00	410.00	442.00	569.00	1342.00	845.00	919.00	862.00	818.00	715.00	540.00	109.00
Ta	1.90	1.70	1.70	2.30	2.90	2.10	1.90	1.90	1.60	1.30	2.40	4.60	3.90	2.30	1.00	0.20
Tb	0.88	1.01	0.64	0.40	0.60	0.46	0.44	0.36	0.46	0.31	0.34	0.35	0.43	0.30	0.33	0.06

Te	1.00	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	0.50	0.50	1.00
Th	27.10	26.40	18.70	17.50	15.40	18.40	24.40	20.50	17.70	17.80	20.40	20.60	21.30	18.50	18.10	2.50
Ti	0.15	0.16	0.15	0.15	0.15	0.16	0.18	0.16	0.15	0.14	0.12	0.13	0.14	0.17	0.14	0.03
TIC	0.51	0.66	0.77	0.64	0.32	0.23	0.44	0.50	0.54	0.29	0.33	0.26	0.30	0.35	0.32	0.09
Tl	1.70	1.50	1.50	1.80	2.50	2.50	2.60	2.30	1.80	1.90	1.70	2.10	1.70	1.70	1.70	0.80
Tm	0.33	0.36	0.30	0.20	0.19	0.19	0.21	0.17	0.18	0.12	0.15	0.22	0.27	0.16	0.11	0.03
U	21.40	25.50	13.50	9.90	10.90	9.70	10.80	13.40	10.10	12.30	24.10	31.60	27.50	11.50	7.60	1.20
V	111.00	130.00	89.00	66.00	61.00	25.00	58.00	56.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	1329.00	2794.00	4518.00	1112.00	1041.00	320.00	1012.00	851.00	207.00	43.00	64.00	240.00	24.00	21.00	137.00	176.00
Y	36.90	40.10	24.90	14.80	18.00	13.40	13.60	11.80	13.20	9.10	11.70	14.40	16.40	11.70	8.70	2.60
Yb	2.10	2.20	1.60	1.40	1.60	1.30	1.30	1.00	1.30	0.90	1.30	1.70	2.00	1.20	0.90	0.20
Zn	187.00	102.00	94.00	99.00	117.00	95.00	88.00	62.00	44.00	25.00	25.00	21.00	33.00	39.00	43.00	29.00
Zr	170.00	190.00	192.00	127.00	109.00	210.00	118.00	170.00	142.00	169.00	113.00	158.00	261.00	383.00	313.00	123.00
Al	51.62	52.20	45.65	48.66	72.82	74.36	70.79	64.97	50.85	58.89	53.76	63.87	62.06	58.62	65.48	46.65

continued

Sample	CC400_081	CC400_082	CC400_083	CC400_084	CC400_086	CC400_087	CC400_088	CC400_089	CC400_091	CC400_092	CC400_093	CC400_094	CC400_096	CC400_097	CC400_098	CC400_099
SiO2	73.30	71.60	70.70	69.90	72.10	71.60	68.40	72.10	70.80	71.20	72.20	73.80	72.80	68.10	64.40	70.70
Na2O	1.65	3.25	2.55	2.50	2.09	2.27	3.19	2.68	2.64	2.69	2.29	3.11	3.07	3.43	3.54	3.25
CaO	1.60	2.30	3.40	2.20	3.50	2.50	2.50	2.20	2.50	2.40	2.70	2.30	2.30	2.50	2.30	2.30
MgO	0.65	0.58	0.54	0.64	0.78	0.60	0.50	0.49	0.64	0.63	0.76	0.58	0.63	0.63	0.62	0.58
MnO	0.04	0.05	0.08	0.06	0.07	0.05	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.04	0.05
FeO	1.42	1.38	1.38	1.13	0.96	1.34	1.14	1.22	1.22	1.14	1.16	1.31	1.34	1.23	1.22	1.35
Fe2O3	0.68	0.66	0.66	0.54	0.46	0.64	0.54	0.58	0.58	0.54	0.55	0.63	0.64	0.59	0.58	0.64
K2O	5.30	4.50	4.50	5.00	4.40	5.10	4.20	4.50	4.40	4.90	4.50	4.60	4.60	3.90	3.70	4.10
Al2O3	13.45	13.76	12.26	13.61	12.99	12.92	12.78	13.23	13.06	13.29	13.26	13.86	13.90	12.91	12.29	13.08
P2O5	0.08	0.08	0.08	0.08	0.06	0.08	0.09	0.08	0.09	0.08	0.09	0.09	0.09	0.09	0.09	0.09
TiO2	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Ag	2.50	2.50	5.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	1386.00	1289.00	1297.00	1488.00	1226.00	1444.00	1014.00	1230.00	1027.00	1188.00	1460.00	1144.00	1220.00	1142.00	1127.00	1245.00
Be	8.00	6.00	7.00	8.00	6.00	6.00	4.00	8.00	7.00	6.00	8.00	6.00	70.00	7.00	7.00	9.00
Bi	5.50	2.30	77.50	21.40	17.10	8.10	7.10	2.40	4.70	4.50	33.20	18.10	9.70	4.40	6.10	7.70
CO3	1.15	1.60	2.55	1.85	3.40	2.10	1.95	1.60	1.90	1.80	2.10	1.75	1.60	1.30	1.35	1.50
Cd	17.00	0.50	2.00	0.50	0.50	1.00	0.50	0.50	0.50	0.50	1.00	4.00	0.50	0.50	2.00	1.00
Ce	87.80	86.60	77.30	84.30	77.60	96.00	89.40	82.10	83.10	86.70	83.90	95.00	90.60	88.70	86.10	89.20
Co	2.00	2.00	3.00	3.00	2.00	4.00	3.00	3.00	2.00	3.00	4.00	3.00	3.00	3.00	2.00	2.00
Cr	114.00	140.00	187.00	205.00	164.00	168.00	124.00	202.00	189.00	163.00	156.00	147.00	139.00	146.00	153.00	196.00
Cs	14.23	8.59	10.05	11.59	11.08	9.66	8.06	10.09	9.76	10.05	9.98	9.91	10.74	8.68	7.46	8.60
Cu	160.00	107.00	133.00	116.00	85.00	111.00	88.00	111.00	114.00	121.00	114.00	91.00	74.00	98.00	98.00	117.00
Dy	2.30	2.30	2.30	2.10	2.10	2.20	2.30	2.30	2.20	2.20	2.20	2.80	1.90	2.70	2.70	2.20

Er	1.00	1.00	1.10	1.10	1.20	1.00	1.10	1.00	1.00	0.90	1.00	1.40	1.10	1.30	1.20	1.10
Eu	0.80	1.00	0.80	1.00	1.00	0.70	0.90	0.90	0.70	0.90	0.70	0.90	1.00	1.00	0.80	0.90
Ga	22.00	21.00	21.00	22.00	21.00	21.00	19.00	21.00	20.00	21.00	20.00	21.00	21.00	21.00	20.00	21.00
Gd	3.00	2.70	2.70	2.60	2.80	3.00	2.80	2.90	2.70	2.60	2.60	3.10	2.80	2.80	2.90	2.70
Hf	6.60	6.70	6.20	6.10	5.50	4.90	5.50	5.10	8.90	5.50	11.70	6.70	5.40	6.20	4.70	6.20
Ho	0.30	0.40	0.40	0.30	0.40	0.40	0.40	0.40	0.40	0.30	0.40	0.50	0.40	0.50	0.50	0.40
In	0.70	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05
La	50.80	48.40	43.80	49.60	43.00	53.10	50.60	45.10	46.20	48.00	47.00	53.30	51.00	51.30	48.10	50.70
Li	86.00	134.00	127.00	96.00	222.00	193.00	107.00	133.00	106.00	70.00	115.00	73.00	68.00	88.00	39.00	61.00
Lu	0.17	0.20	0.17	0.23	0.15	0.17	0.19	0.18	0.15	0.12	0.17	0.20	0.18	0.15	0.17	0.16
Mo	15.00	18.00	25.00	65.00	26.00	293.00	29.00	70.00	32.00	30.00	33.00	29.00	14.00	28.00	40.00	20.00
Nb	17.00	17.00	16.00	15.00	15.00	16.00	14.00	16.00	15.00	15.00	16.00	17.00	15.00	16.00	15.00	16.00
Nd	31.30	30.10	26.40	28.80	26.40	31.30	30.30	29.10	28.00	30.40	28.50	32.80	30.20	31.60	31.20	31.20
Ni	17.00	6.00	6.00	6.00	5.00	4.00	4.00	7.00	6.00	6.00	7.00	4.00	5.00	5.00	4.00	6.00
Pb	64.00	53.00	161.00	80.00	73.00	38.00	49.00	42.00	52.00	54.00	80.00	65.00	65.00	52.00	61.00	57.00
Pr	9.59	9.11	8.15	9.03	8.34	10.08	9.22	8.53	8.75	9.44	8.69	10.04	9.53	9.72	9.43	9.73
Rb	307.10	231.80	264.10	277.70	260.60	271.20	208.20	231.90	226.70	246.40	234.40	231.90	250.00	194.40	179.50	210.90
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	0.76	0.44	0.52	0.27	0.24	0.48	0.27	0.39	0.20	0.25	0.29	0.47	0.50	0.51	0.51	0.49
Sb	0.25	0.25	0.25	0.25	1.40	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	34.30	33.50	33.10	32.70	33.70	33.50	32.00	33.70	33.10	33.30	33.70	34.50	34.00	31.80	30.10	33.10
Sm	4.20	4.50	3.70	3.90	3.80	4.20	4.80	4.10	3.90	4.00	4.20	4.50	4.40	4.90	4.80	4.30
Sn	16.00	13.00	14.00	13.00	12.00	13.00	10.00	11.00	10.00	12.00	14.00	11.00	11.00	11.00	11.00	12.00
Sr	525.00	814.00	800.00	914.00	918.00	897.00	732.00	787.00	812.00	882.00	886.00	846.00	786.00	968.00	920.00	834.00
Ta	1.40	1.70	1.40	1.40	1.50	1.30	1.20	1.50	1.40	1.40	1.40	1.80	1.30	1.60	1.50	1.40
Tb	0.43	0.37	0.35	0.39	0.37	0.45	0.45	0.42	0.39	0.38	0.37	0.44	0.38	0.40	0.45	0.37
Te	0.50	0.50	2.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	1.00	1.00	0.50	0.50	0.50	0.50

Th	24.40	16.70	17.70	16.00	20.00	19.60	19.20	19.80	18.10	20.70	17.80	21.40	19.10	18.40	18.50	18.70
Ti	0.19	0.19	0.17	0.17	0.17	0.17	0.18	0.19	0.18	0.18	0.19	0.20	0.21	0.18	0.18	0.19
TIC	0.23	0.32	0.51	0.37	0.68	0.42	0.39	0.32	0.38	0.36	0.42	0.35	0.32	0.26	0.27	0.30
Tl	2.20	1.70	1.70	2.00	1.60	1.90	1.50	1.60	1.50	1.70	1.60	1.60	1.90	1.30	1.30	1.50
Tm	0.13	0.14	0.18	0.18	0.17	0.16	0.19	0.18	0.14	0.16	0.16	0.19	0.17	0.18	0.20	0.15
U	10.60	9.40	9.20	9.50	10.70	9.10	8.60	9.60	9.50	9.10	7.90	10.00	9.70	9.80	9.60	10.00
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	41.00	16.00	464.00	616.00	60.00	111.00	46.00	147.00	75.00	89.00	181.00	63.00	75.00	86.00	39.00	49.00
Y	12.10	11.90	11.40	11.30	12.40	11.70	13.40	12.10	11.70	10.90	11.10	13.60	11.70	13.40	13.20	11.30
Yb	1.10	1.10	1.20	1.00	1.10	1.10	1.30	1.10	1.10	0.90	1.20	1.20	1.00	1.40	1.40	1.20
Zn	657.00	32.00	40.00	37.00	30.00	39.00	26.00	32.00	25.00	29.00	62.00	168.00	43.00	40.00	77.00	55.00
Zr	247.00	235.00	226.00	237.00	214.00	186.00	195.00	190.00	365.00	202.00	439.00	269.00	205.00	234.00	204.00	254.00
Al	64.69	47.80	45.87	54.54	48.11	54.42	45.22	50.55	49.53	52.06	51.31	48.90	49.35	43.31	42.54	45.75

continued

Sample	CC400_101	CC400_102	CC400_103	CC400_104	CC400_106	CC400_107	CC400_108	CC400_109	CC400_111	CC400_112	CC400_113	CC400_114	CC400_116	CC400_117	CC400_118	CC400_119
SiO2	69.50	69.50	69.30	71.90	69.60	72.10	71.30	70.20	71.20	73.80	72.90	70.60	77.10	74.60	75.00	77.40
Na2O	3.66	3.39	2.38	3.15	3.68	2.86	3.22	3.03	2.94	0.08	0.24	0.15	0.06	0.06	0.05	0.03
CaO	2.50	2.60	2.20	1.90	2.00	2.30	2.40	2.50	2.50	2.00	2.10	2.40	1.50	1.10	0.90	1.20
MgO	0.67	0.67	0.50	0.38	0.55	0.63	0.63	0.58	0.50	0.81	0.86	1.13	0.68	0.78	0.78	0.57
MnO	0.05	0.05	0.05	0.03	0.03	0.04	0.04	0.04	0.05	0.03	0.04	0.08	0.03	0.03	0.03	0.02
FeO	1.38	1.32	1.31	0.98	1.00	1.36	1.21	1.33	1.23	0.95	1.08	3.72	1.22	1.52	1.29	3.03
Fe2O3	0.66	0.63	0.63	0.47	0.48	0.65	0.57	0.63	0.59	0.45	0.51	1.77	0.58	0.72	0.61	1.45
K2O	4.00	4.50	3.10	4.30	4.10	4.70	4.60	4.60	4.70	5.40	4.60	4.50	4.60	4.00	3.90	2.70
Al2O3	13.84	13.31	9.59	12.27	13.27	13.68	13.70	13.72	13.86	14.12	13.41	13.42	11.36	11.80	11.97	8.53
P2O5	0.09	0.09	0.07	0.06	0.07	0.07	0.08	0.09	0.08	0.08	0.07	0.06	0.07	0.04	0.02	0.05
TiO2	0.30	0.30	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.20
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	5.00	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	22.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	1127.00	1081.00	1016.00	899.00	898.00	1231.00	1039.00	1081.00	1022.00	1177.00	1049.00	978.00	939.00	837.00	796.00	732.00
Be	7.00	7.00	5.00	5.00	6.00	8.00	6.00	8.00	7.00	13.00	12.00	9.00	9.00	11.00	12.00	9.00
Bi	1.60	1.60	16.40	5.80	1.40	9.80	1.80	13.30	3.30	3.60	7.70	60.40	119.20	11.10	5.10	30.80
CO3	1.60	1.80	1.50	0.80	0.35	2.15	1.55	1.35	2.15	1.55	1.20	1.05	0.80	0.45	0.50	0.30
Cd	0.50	0.50	10.00	0.50	0.50	1.00	0.50	0.50	0.50	0.50	3.00	0.50	4.00	2.00	0.50	0.50
Ce	101.50	85.90	63.20	59.60	71.20	80.60	81.70	79.20	77.60	82.50	74.20	41.70	57.00	63.10	62.10	51.60
Co	3.00	2.00	3.00	2.00	2.00	4.00	2.00	3.00	3.00	2.00	2.00	3.00	3.00	3.00	4.00	8.00
Cr	156.00	135.00	166.00	161.00	73.00	147.00	98.00	132.00	169.00	131.00	198.00	253.00	170.00	239.00	261.00	280.00
Cs	8.73	9.88	7.02	7.57	7.85	9.89	10.34	10.29	8.62	20.90	21.37	14.74	16.45	18.93	26.99	14.33
Cu	85.00	98.00	154.00	53.00	51.00	107.00	86.00	95.00	102.00	111.00	107.00	54.00	90.00	118.00	142.00	374.00
Dy	2.50	2.20	1.50	1.60	1.70	2.10	1.80	1.80	1.70	1.50	1.70	1.30	1.40	1.50	1.50	1.40

Er	1.10	1.00	0.80	1.00	0.90	1.00	1.00	0.90	0.90	0.70	0.80	0.90	0.70	0.70	0.70	0.70
Eu	0.90	0.90	0.60	0.70	0.70	0.90	0.80	0.80	0.80	0.70	0.80	0.70	0.50	0.60	0.50	0.40
Ga	22.00	22.00	16.00	18.00	20.00	22.00	22.00	24.00	21.00	25.00	23.00	27.00	20.00	20.00	21.00	15.00
Gd	3.20	2.30	1.60	1.70	2.30	2.40	2.40	2.70	2.60	2.30	2.20	1.70	1.80	1.80	1.90	1.60
Hf	7.70	5.30	3.30	4.40	4.40	5.30	5.00	5.00	5.30	4.80	5.50	4.40	6.20	5.30	4.90	3.40
Ho	0.40	0.40	0.30	0.30	0.30	0.30	0.40	0.30	0.30	0.20	0.30	0.30	0.30	0.30	0.20	0.20
In	0.05	0.05	0.50	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.05	0.20	0.05	0.05	0.10
La	56.20	49.30	36.60	33.40	40.80	49.00	48.10	45.40	44.40	47.10	42.50	23.80	32.10	38.20	36.70	34.30
Li	92.00	278.00	55.00	152.00	74.00	134.00	66.00	46.00	48.00	79.00	112.00	301.00	66.00	81.00	65.00	71.00
Lu	0.14	0.17	0.10	0.16	0.17	0.16	0.17	0.15	0.14	0.14	0.12	0.16	0.16	0.15	0.11	0.14
Mo	12.00	16.00	496.00	19.00	7.00	21.00	9.00	38.00	21.00	21.00	18.00	22.00	23.00	221.00	40.00	112.00
Nb	15.00	15.00	5.00	12.00	14.00	17.00	16.00	15.00	15.00	15.00	16.00	14.00	13.00	16.00	16.00	11.00
Nd	35.10	31.30	22.20	21.10	25.20	27.40	28.20	27.30	26.40	28.00	24.40	13.60	19.50	21.40	20.50	16.90
Ni	5.00	5.00	3.00	6.00	3.00	6.00	3.00	6.00	6.00	5.00	7.00	6.00	6.00	7.00	8.00	7.00
Pb	67.00	41.00	54.00	51.00	44.00	55.00	51.00	59.00	62.00	41.00	42.00	94.00	182.00	56.00	36.00	134.00
Pr	10.80	9.40	6.81	6.48	7.74	8.20	8.54	8.28	8.13	8.69	7.92	4.34	5.86	6.63	6.42	5.50
Rb	205.50	219.10	177.30	197.20	183.20	244.40	233.80	230.40	241.10	329.70	337.10	288.10	269.40	276.10	264.80	201.50
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	0.48	0.50	0.78	0.24	0.30	0.54	0.51	0.47	0.35	0.14	0.38	0.94	0.58	0.73	0.39	2.90
Sb	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	32.50	32.50	32.40	33.60	32.50	33.70	33.30	32.80	33.30	34.50	34.10	33.00	36.00	34.90	35.10	36.20
Sm	5.20	4.30	3.10	2.90	3.30	3.50	3.70	3.20	3.60	3.70	3.30	2.10	2.70	2.80	2.80	2.90
Sn	10.00	11.00	9.00	7.00	6.00	12.00	12.00	10.00	9.00	11.00	12.00	13.00	12.00	11.00	9.00	10.00
Sr	845.00	784.00	748.00	625.00	646.00	851.00	732.00	804.00	821.00	317.00	308.00	549.00	451.00	382.00	321.00	338.00
Ta	1.20	1.20	0.70	1.30	1.30	1.50	1.30	1.10	1.10	1.20	1.50	1.30	1.20	1.50	1.70	1.00
Tb	0.41	0.40	0.29	0.30	0.30	0.33	0.35	0.31	0.33	0.30	0.29	0.23	0.25	0.24	0.23	0.21
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	2.00	2.00	0.50	0.50	1.00

Th	19.90	19.80	12.90	15.20	19.00	18.30	17.10	18.40	18.00	19.20	20.00	14.10	14.20	14.90	14.60	9.60
Ti	0.19	0.19	0.13	0.12	0.16	0.17	0.17	0.18	0.17	0.18	0.17	0.13	0.13	0.14	0.14	0.10
TIC	0.32	0.36	0.30	0.16	0.07	0.43	0.31	0.27	0.43	0.31	0.24	0.21	0.16	0.09	0.10	0.06
Tl	1.40	1.50	1.30	1.30	1.20	1.70	1.70	1.70	1.70	2.30	2.10	2.00	1.90	1.90	1.70	1.50
Tm	0.16	0.14	0.10	0.16	0.13	0.17	0.17	0.12	0.15	0.10	0.12	0.12	0.13	0.12	0.14	0.11
U	12.80	10.60	6.90	8.50	11.30	11.00	7.20	10.30	13.50	9.80	11.00	9.90	10.00	10.30	12.30	9.00
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	52.00	25.00	25.00	25.00	25.00
W	23.00	103.00	72.00	15.00	13.00	56.00	12.00	155.00	55.00	33.00	73.00	29.00	121.00	302.00	40.00	1716.00
Y	12.00	11.30	7.80	9.00	9.10	11.20	10.50	10.10	10.20	8.30	9.20	8.40	7.50	8.00	7.70	6.70
Yb	1.20	1.10	0.90	1.00	0.90	1.10	0.90	1.10	1.10	0.80	1.00	0.80	0.80	0.90	0.80	0.70
Zn	42.00	23.00	344.00	19.00	25.00	51.00	28.00	47.00	32.00	25.00	107.00	37.00	139.00	43.00	23.00	15.00
Zr	297.00	222.00	147.00	152.00	151.00	212.00	183.00	205.00	202.00	195.00	223.00	184.00	249.00	204.00	193.00	119.00
Al	43.11	46.31	44.02	48.11	45.03	50.83	48.21	48.35	48.86	74.92	69.98	68.81	77.16	80.52	83.16	72.59

continued

Sample	CC400_121	CC400_122	CC400_123	CC400_124	CC400_126	CC400_127	CC400_128	CC400_129	CC400_131	CC400_132	CC400_133	CC400_134	CC400_136	CC400_137	CC400_138	CC400_139	CC400_141	CC400_142	CC400_143	CC400_144
SiO2	59.60	72.70	73.70	72.00	72.30	74.40	68.70	73.20	67.90	74.50	75.80	74.60	63.90	70.30	69.10	70.70	71.70	72.00	70.40	73.20
Na2O	0.07	0.05	0.04	0.04	0.06	0.07	0.69	0.09	0.09	0.04	0.80	2.29	3.11	2.62	3.05	3.21	3.25	3.25	2.45	2.05
CaO	8.70	2.70	3.80	3.50	2.10	1.80	2.30	2.90	2.80	1.30	1.70	1.80	1.80	1.80	1.90	2.20	1.80	1.80	1.90	1.90
MgO	0.66	0.78	0.69	0.75	0.69	0.69	0.59	0.67	0.61	0.80	0.69	0.37	0.44	0.42	0.45	0.52	0.45	0.44	0.47	0.45
MnO	0.11	0.05	0.07	0.09	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03
FeO	1.37	1.08	1.21	1.22	1.44	1.02	1.13	1.14	1.27	2.05	1.25	1.31	1.01	1.13	1.23	1.19	1.21	0.99	1.04	0.99
Fe2O3	0.65	0.51	0.57	0.58	0.69	0.48	0.54	0.54	0.60	0.98	0.60	0.62	0.48	0.54	0.59	0.57	0.57	0.47	0.49	0.47
K2O	3.60	3.80	2.60	3.00	5.00	5.10	5.50	6.00	5.40	4.10	4.80	4.20	3.60	3.30	4.30	4.40	4.30	4.30	4.80	4.00
Al2O3	11.37	12.28	10.26	10.32	11.84	11.42	12.73	13.16	12.07	11.83	12.82	11.81	11.53	10.66	12.68	13.11	13.07	13.43	13.12	10.69
P2O5	0.10	0.04	0.03	0.03	0.04	0.04	0.06	0.05	0.04	0.04	0.05	0.04	0.06	0.05	0.05	0.06	0.06	0.05	0.06	0.04
TiO2	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	26.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	1057.00	792.00	592.00	644.00	1002.00	1026.00	1085.00	1088.00	1076.00	908.00	1002.00	772.00	744.00	729.00	915.00	957.00	949.00	755.00	800.00	738.00
Be	11.00	10.00	8.00	9.00	64.00	68.00	8.00	9.00	10.00	10.00	10.00	5.00	5.00	7.00	5.00	6.00	6.00	6.00	7.00	6.00
Bi	3.30	2.70	3.30	19.70	20.40	24.20	3.50	37.80	5.40	13.50	9.30	40.60	1.40	4.30	3.10	5.50	1.20	0.50	1.00	3.80
CO3	9.69	3.25	3.30	3.40	1.70	0.45	1.80	2.70	3.15	0.30	0.75	1.00	0.75	0.50	0.85	1.10	0.60	0.50	1.20	0.60
Cd	0.50	0.50	0.50	3.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.50	0.50	0.50	0.50	0.50
Ce	68.20	68.10	49.70	42.70	64.80	55.20	59.20	70.40	54.70	57.60	60.10	56.70	62.30	61.40	67.20	67.00	60.60	65.90	63.80	53.30
Co	3.00	4.00	3.00	4.00	4.00	2.00	3.00	4.00	4.00	4.00	3.00	3.00	4.00	4.00	3.00	3.00	4.00	4.00	3.00	4.00
Cr	168.00	152.00	161.00	183.00	147.00	84.00	134.00	116.00	184.00	173.00	81.00	140.00	117.00	80.00	110.00	124.00	132.00	154.00	125.00	139.00
Cs	14.00	17.15	11.76	15.89	24.32	28.47	21.02	26.82	22.60	25.94	19.60	8.60	6.71	7.18	7.16	7.72	8.27	8.99	10.20	8.07
Cu	117.00	98.00	87.00	65.00	135.00	116.00	87.00	80.00	97.00	63.00	60.00	56.00	70.00	101.00	76.00	66.00	66.00	33.00	40.00	64.00
Dy	2.00	1.70	1.60	1.60	1.80	1.30	1.80	1.60	1.50	1.10	1.40	1.50	1.50	1.30	1.60	1.80	2.00	1.90	1.60	1.40

Er	1.10	0.90	0.90	0.90	0.70	0.80	0.90	0.90	0.90	0.60	0.70	0.90	0.80	0.70	0.80	0.90	0.90	1.10	0.70	0.70
Eu	1.00	0.60	0.60	0.70	0.60	0.50	0.50	0.70	0.50	0.40	0.50	0.50	0.60	0.60	0.60	0.60	0.70	0.60	0.60	0.60
Ga	19.00	20.00	16.00	18.00	19.00	21.00	19.00	20.00	20.00	22.00	21.00	17.00	16.00	16.00	20.00	20.00	20.00	19.00	20.00	17.00
Gd	2.80	2.00	1.70	1.50	1.80	1.70	1.80	2.00	1.80	1.40	1.70	1.90	2.20	1.60	2.00	2.00	1.80	2.20	1.70	1.20
Hf	5.30	4.50	3.90	4.00	3.80	4.20	4.00	4.70	3.80	4.50	4.50	3.60	4.00	4.80	4.00	6.50	6.30	6.50	7.10	7.20
Ho	0.40	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.20	0.30	0.30	0.30	0.20	0.40	0.30	0.30	0.40	0.30	0.20
In	0.05	0.05	0.05	0.20	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
La	41.20	41.40	30.40	24.50	41.50	34.30	37.00	43.30	34.70	34.30	35.10	32.60	37.40	40.20	41.20	39.40	38.00	38.30	36.00	31.10
Li	70.00	65.00	64.00	69.00	62.00	67.00	52.00	57.00	59.00	73.00	65.00	29.00	29.00	34.00	30.00	39.00	33.00	25.00	32.00	31.00
Lu	0.19	0.15	0.16	0.15	0.12	0.15	0.14	0.17	0.13	0.07	0.13	0.13	0.12	0.13	0.17	0.16	0.14	0.18	0.15	0.08
Mo	130.00	18.00	23.00	25.00	52.00	29.00	17.00	14.00	31.00	58.00	21.00	17.00	27.00	111.00	14.00	14.00	24.00	14.00	12.00	19.00
Na	0.05	0.04	0.03	0.03	0.05	0.06	0.51	0.07	0.07	0.03	0.59	1.70	2.31	1.94	2.27	2.38	2.41	2.41	1.82	1.52
Nb	14.00	13.00	12.00	12.00	14.00	14.00	15.00	15.00	18.00	13.00	13.00	14.00	12.00	12.00	15.00	16.00	16.00	17.00	16.00	12.00
Nd	23.30	20.60	17.30	14.80	21.60	18.10	20.10	23.50	18.70	19.10	19.80	18.80	20.40	19.80	21.60	22.80	20.50	23.50	22.60	17.50
Ni	4.00	5.00	5.00	6.00	6.00	2.00	5.00	4.00	6.00	6.00	3.00	6.00	5.00	2.00	5.00	5.00	4.00	4.00	5.00	4.00
Pb	32.00	43.00	36.00	54.00	71.00	73.00	57.00	109.00	58.00	46.00	50.00	106.00	45.00	46.00	53.00	67.00	53.00	66.00	55.00	46.00
Pr	7.05	6.73	5.15	4.48	6.57	5.94	6.30	7.45	5.72	5.84	6.10	5.68	6.57	6.32	7.06	7.15	6.51	7.19	6.71	5.45
Rb	218.00	240.90	183.20	230.80	296.80	325.50	305.30	319.90	302.70	301.80	298.90	208.50	175.70	171.90	191.10	194.10	191.00	183.80	223.90	188.50
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	0.54	0.29	0.41	0.57	0.97	0.57	0.51	0.64	0.66	1.67	0.83	0.33	0.43	0.56	0.50	0.44	0.43	0.32	0.21	0.36
Sb	0.80	0.25	0.25	0.25	0.25	0.60	0.25	0.25	0.25	0.70	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Si	27.90	34.00	34.40	33.60	33.80	34.80	32.10	34.20	31.80	34.80	35.40	34.90	29.90	32.90	32.30	33.00	33.50	33.60	32.90	34.20
Sm	3.30	2.50	2.60	2.30	3.10	2.80	2.80	3.20	2.40	2.60	3.00	2.40	2.70	2.70	2.70	3.40	2.90	3.30	3.30	2.50
Sn	8.00	8.00	6.00	7.00	8.00	10.00	7.00	7.00	12.00	9.00	7.00	4.00	5.00	6.00	6.00	7.00	6.00	4.00	4.00	5.00
Sr	1324.00	544.00	519.00	232.00	321.00	283.00	458.00	356.00	406.00	243.00	382.00	538.00	561.00	566.00	756.00	817.00	827.00	525.00	531.00	549.00
Ta	1.50	1.30	1.20	1.20	1.40	1.40	1.50	1.40	4.20	1.30	1.30	1.50	1.00	1.00	1.40	1.40	1.80	2.60	2.00	1.50

Tb	0.40	0.25	0.30	0.29	0.26	0.26	0.28	0.34	0.25	0.23	0.22	0.24	0.32	0.25	0.26	0.32	0.30	0.30	0.28	0.21
Te	0.50	0.50	0.50	1.00	1.00	2.00	0.50	1.00	0.50	0.50	0.50	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	17.80	17.20	15.20	14.00	16.80	13.30	16.60	18.90	20.50	15.80	17.50	16.40	15.40	15.70	16.70	17.30	17.00	20.00	16.30	13.10
Ti	0.14	0.12	0.10	0.10	0.12	0.12	0.13	0.14	0.13	0.12	0.13	0.12	0.12	0.12	0.13	0.15	0.14	0.14	0.14	0.11
TIC	1.94	0.65	0.66	0.68	0.34	0.09	0.36	0.54	0.63	0.06	0.15	0.20	0.15	0.10	0.17	0.22	0.12	0.10	0.24	0.12
Tl	1.50	1.50	1.10	1.30	2.20	2.20	2.00	2.20	2.00	1.90	2.20	1.40	1.20	1.30	1.20	1.20	1.30	1.20	1.50	1.30
Tm	0.19	0.13	0.13	0.13	0.15	0.13	0.14	0.13	0.11	0.10	0.10	0.14	0.11	0.10	0.14	0.13	0.16	0.19	0.12	0.10
U	10.40	11.20	10.50	11.50	13.00	17.10	13.00	13.20	13.30	12.20	14.70	12.70	19.50	9.40	14.20	13.70	17.60	14.20	12.70	11.30
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	79.00	82.00	252.00	114.00	34.00	64.00	79.00	36.00	148.00	54.00	41.00	12.00	16.00	319.00	26.00	19.00	18.00	7.00	12.00	29.00
Y	14.50	9.00	9.80	10.40	8.20	8.30	9.60	9.30	8.10	6.20	7.40	8.40	9.30	7.50	9.00	9.70	10.40	11.50	9.30	7.10
Yb	1.30	1.00	1.00	1.00	1.00	1.00	0.90	1.10	1.00	0.60	0.90	0.90	0.90	0.90	1.00	0.90	1.10	1.30	1.00	0.70
Zn	30.00	24.00	12.00	105.00	23.00	39.00	35.00	23.00	31.00	16.00	12.00	16.00	31.00	74.00	30.00	24.00	34.00	43.00	19.00	19.00
Zr	211.00	164.00	144.00	147.00	135.00	150.00	143.00	169.00	130.00	156.00	162.00	124.00	182.00	183.00	159.00	276.00	231.00	285.00	333.00	333.00
Al	32.70	62.49	46.16	51.47	72.45	75.55	67.04	69.03	67.53	78.48	68.70	52.75	45.12	45.71	48.95	47.64	48.46	48.40	54.76	52.98

5. DD+200

Sample	DD200_001	DD200_002	DD200_003	DD200_004	DD200_006	DD200_007	DD200_008	DD200_009	DD200_011	DD200_012	DD200_013	DD200_014	DD200_016	DD200_017	DD200_018	DD200_019
SiO2	53.30	62.20	73.20	74.60	67.70	68.40	63.70	88.00	70.20	72.40	70.70	70.30	70.20	72.90	74.10	66.80
Al2O3	12.79	12.10	14.67	14.98	10.33	12.90	11.90	1.53	12.05	14.71	13.77	14.10	13.86	14.33	14.56	16.16
CaO	12.30	5.60	4.20	3.70	2.80	3.60	3.30	0.80	3.40	3.20	3.70	4.20	2.50	2.60	2.50	3.90
FeO	7.52	2.31	1.91	1.87	2.45	1.74	2.75	5.30	2.86	1.37	1.43	1.47	1.40	1.30	1.33	1.19
Fe2O3	3.58	1.10	0.91	0.89	1.17	0.83	1.31	2.52	1.36	0.65	0.68	0.70	0.66	0.62	0.63	0.57
K2O	1.10	4.60	6.10	5.60	4.30	4.70	5.40	0.70	5.30	6.10	5.10	5.40	5.30	4.60	4.50	10.60
MgO	5.14	0.96	0.64	0.69	0.52	0.66	0.67	0.16	0.74	0.76	0.63	0.66	0.70	0.69	0.68	0.77
MnO	0.48	0.28	0.12	0.13	0.14	0.17	0.12	0.04	0.12	0.11	0.14	0.15	0.07	0.05	0.06	0.04
Na2O	2.33	2.37	2.41	2.67	1.75	2.65	1.79	0.10	1.35	2.80	2.88	3.02	3.06	3.36	3.47	0.63
P2O5	0.41	0.20	0.16	0.18	0.17	0.13	0.15	0.09	0.15	0.16	0.16	0.14	0.14	0.13	0.11	0.26
V2O5	560.00	138.00	101.00	50.00	50.00	108.00	50.00	50.00	118.00	106.00	50.00	50.00	102.00	50.00	50.00	140.00
TiO2	2.80	0.30	0.40	0.30	0.30	0.30	0.30	0.05	0.30	0.30	0.30	0.30	0.30	0.30	0.40	0.40
Ag	2.50	7.00	2.50	2.50	2.50	2.50	2.50	2.50	5.00	2.50	2.50	5.00	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	52.00	203.00	10.00	10.00	10.00	10.00	10.00	10.00	40.00
B	25.00	164.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	2011.00	4000.00	2727.00	2512.00	2788.00	3214.00	4528.00	396.00	3041.00	6132.00	2373.00	2561.00	2158.00	1518.00	1234.00	2922.00
Be	34.00	56.00	39.00	45.00	35.00	50.00	38.00	7.00	79.00	21.00	24.00	29.00	10.00	9.00	11.00	25.00
Bi	2.70	31.00	11.50	13.50	6.70	10.00	8.80	25.80	17.90	4.30	59.30	39.70	5.40	2.20	5.30	10.20
CO3	2.35	3.63	2.04	2.38	2.04	2.89	2.36	0.38	1.63	2.32	3.04	2.96	1.91	1.44	1.95	1.46
Cd	1.00	22.00	17.00	23.00	7.00	17.00	24.00	18.00	23.00	6.00	16.00	8.00	2.00	1.00	3.00	33.00
Ce	87.60	258.60	158.70	207.00	220.50	227.10	197.50	20.50	173.10	141.80	159.30	161.80	130.50	114.90	102.10	96.10
Co	69.00	104.00	103.00	100.00	176.00	110.00	129.00	318.00	107.00	90.00	107.00	86.00	98.00	98.00	83.00	77.00
Cr	261.00	20.00	8.00	8.00	9.00	10.00	9.00	2.50	8.00	9.00	9.00	8.00	5.00	6.00	6.00	7.00
Cs	7.40	16.51	14.61	15.18	12.48	12.79	14.74	2.59	19.12	14.57	12.39	12.75	10.87	11.58	12.07	20.84
Cu	230.00	277.00	225.00	217.00	385.00	216.00	359.00	441.00	376.00	202.00	173.00	140.00	112.00	98.00	113.00	100.00

Dy	5.40	3.00	1.50	1.50	1.60	1.60	1.70	0.30	2.40	2.60	2.70	2.30	2.60	2.50	2.20	1.70
Er	2.70	1.30	0.70	0.70	0.70	0.80	0.90	0.20	1.10	1.40	1.30	1.00	1.40	1.00	1.10	0.90
Eu	2.40	1.90	0.90	1.00	1.30	1.00	0.90	0.20	1.00	0.90	1.00	1.20	1.00	1.00	0.90	0.80
Ga	25.00	29.00	30.00	31.00	24.00	29.00	28.00	4.00	28.00	27.00	25.00	24.00	23.00	21.00	22.00	29.00
Gd	7.00	4.60	2.40	2.20	2.90	2.60	2.70	0.50	2.90	3.50	3.20	3.10	3.50	3.20	2.60	2.30
Hf	6.40	5.00	4.90	6.20	3.80	4.20	5.00	0.40	3.80	4.70	4.60	5.10	4.50	5.40	5.00	5.10
Ho	1.00	0.50	0.20	0.20	0.30	0.30	0.30	0.05	0.40	0.50	0.50	0.40	0.50	0.40	0.40	0.30
In	0.30	0.90	0.60	0.90	0.40	0.70	0.90	0.60	0.90	0.30	0.60	0.30	0.05	0.05	0.10	1.10
La	49.20	148.90	103.20	148.50	141.70	170.40	151.30	15.80	129.40	91.50	111.20	114.40	84.90	66.30	58.50	59.40
Li	64.00	77.00	65.00	81.00	67.00	69.00	76.00	15.00	74.00	71.00	58.00	68.00	53.00	66.00	58.00	72.00
Lu	0.32	0.20	0.10	0.12	0.09	0.12	0.12	0.03	0.17	0.21	0.17	0.16	0.19	0.16	0.14	0.15
Mo	13.00	113.00	56.00	1.00	14.00	3.00	9.00	284.00	26.00	1.00	2.00	1.00	3.00	29.00	4.00	16.00
Nb	28.00	15.00	12.00	12.00	11.00	12.00	11.00	5.00	11.00	13.00	13.00	12.00	14.00	14.00	13.00	17.00
Nd	38.40	84.60	44.80	48.30	60.90	49.60	47.10	5.50	41.60	42.30	44.30	43.70	39.20	36.80	33.20	30.30
Ni	182.00	13.00	5.00	4.00	3.00	5.00	1.00	4.00	5.00	5.00	6.00	6.00	5.00	3.00	7.00	3.00
Pb	0.00	331.00	149.00	165.00	79.00	92.00	97.00	33.00	150.00	59.00	184.00	190.00	83.00	52.00	85.00	93.00
Pr	9.71	26.49	14.81	17.63	20.77	18.74	16.49	1.82	14.81	13.89	14.63	14.71	12.63	11.76	10.31	9.56
Rb	65.60	289.60	337.10	322.60	277.40	290.90	333.30	43.70	326.70	317.40	274.40	304.30	247.40	239.30	217.20	518.20
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	1.34	1.32	1.19	1.12	1.76	1.15	2.00	4.43	2.43	0.74	0.92	0.90	0.81	0.73	0.67	1.19
Sb	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	26.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	7.40	9.00	4.20	4.70	5.80	4.90	4.90	0.70	4.60	5.50	5.40	5.00	5.30	4.90	4.30	3.80
Sn	42.00	53.00	35.00	32.00	29.00	31.00	29.00	5.00	40.00	18.00	21.00	16.00	8.00	7.00	7.00	14.00
Sr	1382.00	1663.00	1230.00	1104.00	1194.00	1464.00	1405.00	169.00	930.00	1323.00	1093.00	1091.00	885.00	786.00	744.00	1174.00
Ta	1.70	1.20	1.20	1.10	1.00	1.10	1.00	0.30	1.00	1.20	1.20	1.00	1.30	1.10	1.00	1.00
Tb	0.99	0.56	0.30	0.29	0.33	0.30	0.30	0.08	0.39	0.45	0.42	0.35	0.50	0.43	0.34	0.32
Te	0.50	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.50	0.50	0.50

Th	3.80	17.20	14.70	22.60	16.60	18.80	16.30	2.10	15.30	17.70	18.90	17.20	20.00	24.50	19.10	18.40
Ti	1.68	0.21	0.22	0.21	0.17	0.19	0.18	0.03	0.17	0.21	0.20	0.20	0.20	0.21	0.21	0.21
TIC	0.47	0.73	0.41	0.48	0.41	0.58	0.47	0.08	0.33	0.46	0.61	0.59	0.38	0.29	0.39	0.29
Tl	0.70	2.20	2.60	2.40	2.10	2.10	2.60	0.25	2.60	2.30	2.20	2.30	1.80	1.70	1.60	3.90
Tm	0.37	0.21	0.11	0.15	0.10	0.13	0.13	0.03	0.18	0.22	0.20	0.20	0.21	0.17	0.14	0.18
U	2.20	6.10	5.30	4.50	5.50	3.90	5.20	1.90	8.80	11.10	14.00	11.30	10.10	10.00	7.60	14.00
V	314.00	78.00	56.00	52.00	25.00	61.00	25.00	25.00	66.00	60.00	25.00	50.00	57.00	25.00	25.00	79.00
W	695.00	3263.00	2317.00	1904.00	4250.00	2662.00	2667.00	2789.00	3195.00	1382.00	1513.00	1096.00	714.00	650.00	570.00	1619.00
Y	25.90	15.20	7.10	7.90	8.30	8.70	9.70	2.40	12.70	14.40	14.00	12.50	15.20	12.50	10.70	10.00
Yb	2.00	1.40	0.70	0.70	0.70	0.80	0.90	0.30	1.20	1.30	1.20	1.00	1.30	1.00	1.00	1.00
Zn	182.00	662.00	518.00	683.00	220.00	544.00	683.00	554.00	656.00	202.00	474.00	238.00	73.00	50.00	115.00	988.00
Zr	274.00	198.00	211.00	265.00	167.00	184.00	202.00	41.00	152.00	189.00	183.00	214.00	186.00	236.00	202.00	203.00
Al	29.89	41.08	50.50	49.68	51.46	46.15	54.39	48.79	56.00	53.32	46.56	45.64	51.92	47.03	46.44	71.50

continued

Sample	DD200_021	DD200_022	DD200_023	DD200_024	DD200_026	DD200_027	DD200_028	DD200_029	DD200_031	DD200_032	DD200_033	DD200_034	DD200_036	DD200_037	DD200_038	DD200_039
SiO2	103.90	94.20	76.40	72.60	70.10	67.90	72.00	70.60	68.40	69.20	70.40	73.90	79.60	72.60	78.10	72.80
Al2O3	1.27	4.89	13.72	14.68	13.70	14.01	12.15	14.08	14.67	13.71	13.09	13.52	10.80	12.96	12.87	13.91
CaO	0.10	0.70	1.90	2.40	3.40	4.20	4.10	3.20	4.10	4.60	3.10	2.80	2.40	3.40	1.50	2.50
FeO	0.29	0.61	1.47	1.25	2.18	1.87	1.81	1.64	1.58	1.17	1.22	1.17	1.11	1.12	0.83	1.31
Fe2O3	0.14	0.29	0.70	0.60	1.04	0.89	0.86	0.78	0.75	0.56	0.58	0.56	0.53	0.53	0.39	0.63
K2O	0.50	1.90	5.30	5.80	5.30	5.90	5.30	5.10	6.60	7.20	7.30	6.80	4.60	5.50	4.70	4.60
MgO	0.10	0.33	0.91	0.93	0.78	0.86	0.76	0.64	0.69	0.55	0.57	0.69	0.62	0.70	0.81	0.57
MnO	0.01	0.03	0.05	0.08	0.09	0.13	0.14	0.12	0.14	0.22	0.15	0.09	0.06	0.09	0.04	0.05
Na2O	0.02	0.05	0.08	0.13	1.26	0.44	1.04	2.68	2.01	1.27	0.86	0.11	0.08	1.05	1.58	3.57
P2O5	0.02	0.06	0.16	0.16	0.13	0.17	0.11	0.15	0.12	0.18	0.10	0.19	0.08	0.13	0.13	0.09
V2O5	50.00	50.00	113.00	50.00	50.00	121.00	50.00	50.00	102.00	143.00	109.00	50.00	50.00	50.00	50.00	50.00
TiO2	0.05	0.05	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.30	0.20	0.20	0.20	0.30
Ag	2.50	2.50	5.00	2.50	6.00	2.50	2.50	2.50	5.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	30.00	57.00	10.00	22.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	31.00	34.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	139.00	469.00	1350.00	1426.00	1783.00	2308.00	2150.00	2232.00	2749.00	3307.00	2979.00	1631.00	1194.00	1337.00	1371.00	1265.00
Be	2.00	6.00	18.00	20.00	32.00	48.00	37.00	37.00	42.00	74.00	49.00	23.00	17.00	22.00	16.00	13.00
Bi	14.00	14.80	17.50	4.70	36.10	11.40	11.90	5.60	21.00	7.50	9.90	4.80	4.50	4.20	60.20	7.00
CO3	0.20	0.29	1.82	2.65	2.85	3.56	3.13	2.48	2.74	3.02	2.34	2.77	2.46	3.47	1.00	1.79
Cd	59.00	47.00	19.00	6.00	17.00	27.00	18.00	18.00	37.00	40.00	43.00	11.00	15.00	8.00	15.00	8.00
Ce	2.90	39.30	115.50	107.80	130.50	179.00	126.30	128.50	141.90	345.50	308.70	99.00	76.50	99.40	77.40	98.60
Co	411.00	224.00	100.00	91.00	121.00	115.00	156.00	136.00	88.00	101.00	131.00	125.00	174.00	108.00	131.00	101.00
Cr	2.50	7.00	7.00	7.00	8.00	8.00	8.00	9.00	9.00	7.00	8.00	8.00	2.50	2.50	8.00	7.00
Cs	2.83	11.64	33.47	37.71	23.60	26.39	18.87	17.42	19.63	23.55	18.89	26.79	22.35	21.38	17.00	9.61
Cu	7.00	146.00	248.00	141.00	241.00	237.00	224.00	232.00	208.00	119.00	156.00	140.00	112.00	98.00	136.00	145.00
Dy	0.05	0.50	1.90	1.80	1.40	1.30	1.20	1.80	1.50	2.40	2.00	2.00	1.30	1.60	1.20	1.80

Er	0.05	0.30	0.90	0.90	0.60	0.60	0.60	1.00	0.80	1.10	1.10	1.20	0.80	0.80	0.70	1.00
Eu	0.05	0.20	0.80	0.80	0.80	0.90	0.70	0.90	0.90	1.80	1.40	0.70	0.50	0.70	0.50	0.80
Ga	3.00	10.00	26.00	24.00	26.00	28.00	25.00	26.00	29.00	31.00	27.00	23.00	18.00	21.00	25.00	23.00
Gd	0.05	0.80	2.40	2.50	2.30	2.00	2.00	2.60	2.30	3.70	3.30	2.50	1.40	1.90	1.70	2.50
Hf	0.20	1.40	3.80	4.20	4.30	4.00	3.70	5.10	3.70	2.50	3.00	4.10	2.80	3.70	3.10	4.10
Ho	0.05	0.10	0.30	0.30	0.20	0.20	0.20	0.40	0.30	0.50	0.40	0.40	0.30	0.30	0.30	0.30
In	1.10	1.00	0.80	0.30	0.70	1.00	0.70	0.80	1.40	1.70	1.60	0.50	0.50	0.30	0.60	0.30
La	1.70	26.10	81.30	68.30	92.10	130.80	93.10	86.00	98.70	222.00	192.30	61.00	53.40	68.90	51.50	65.10
Li	23.00	39.00	80.00	94.00	81.00	76.00	91.00	56.00	83.00	62.00	69.00	70.00	70.00	70.00	103.00	61.00
Lu	0.03	0.06	0.16	0.12	0.19	0.12	0.14	0.16	0.13	0.18	0.20	0.21	0.13	0.13	0.09	0.16
Mo	13.00	10.00	10.00	1.00	1.00	1.00	27.00	1.00	9.00	7.00	1.00	1.00	385.00	1.00	553.00	1.00
Nb	5.00	5.00	12.00	11.00	18.00	11.00	11.00	16.00	13.00	14.00	16.00	15.00	13.00	17.00	5.00	5.00
Nd	0.70	9.20	31.10	32.30	34.40	40.40	30.40	34.90	36.20	90.50	80.60	29.10	20.70	26.10	22.00	27.60
Ni	2.00	3.00	5.00	4.00	6.00	5.00	4.00	4.00	4.00	3.00	3.00	5.00	1.00	3.00	0.50	2.00
Pb	86.00	123.00	194.00	60.00	248.00	139.00	136.00	78.00	178.00	93.00	123.00	79.00	83.00	91.00	169.00	77.00
Pr	0.25	3.08	10.36	10.30	11.95	14.71	10.91	11.80	12.62	31.98	28.56	9.40	6.75	8.88	7.16	9.21
Rb	43.50	129.60	340.00	340.90	303.90	346.30	305.70	251.40	342.30	345.20	359.10	338.60	279.00	288.30	314.10	214.40
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	0.39	0.57	1.36	0.54	1.87	1.09	1.18	1.02	1.14	0.66	0.81	0.84	1.05	0.89	0.33	0.56
Sb	0.25	0.25	0.25	0.25	0.60	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	0.20	1.20	4.00	4.00	3.70	3.80	3.40	3.90	4.00	7.90	7.10	3.50	2.60	3.10	2.80	3.60
Sn	1.00	6.00	17.00	11.00	22.00	26.00	27.00	24.00	26.00	33.00	21.00	12.00	10.00	9.00	16.00	10.00
Sr	52.00	106.00	264.00	293.00	742.00	721.00	882.00	1180.00	1182.00	1147.00	846.00	385.00	288.00	615.00	380.00	845.00
Ta	0.10	0.40	1.10	0.70	1.00	0.70	0.70	1.90	0.90	1.30	1.60	1.50	1.20	1.60	1.10	1.20
Tb	0.03	0.09	0.30	0.33	0.24	0.19	0.21	0.31	0.24	0.44	0.36	0.32	0.22	0.27	0.23	0.31
Te	0.50	0.50	0.50	0.50	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.50
Th	0.50	4.60	14.10	20.50	17.90	22.90	17.60	17.40	15.30	16.60	19.50	18.30	14.60	18.40	15.70	18.70

Ti	0.03	0.05	0.17	0.20	0.18	0.19	0.16	0.19	0.16	0.11	0.11	0.16	0.11	0.15	0.14	0.18
TIC	0.04	0.06	0.36	0.53	0.57	0.71	0.63	0.50	0.55	0.60	0.47	0.55	0.49	0.70	0.20	0.36
Tl	0.25	0.90	2.30	2.30	2.20	2.60	2.10	2.00	2.50	2.60	2.90	2.60	2.10	2.10	2.00	1.50
Tm	0.03	0.06	0.16	0.14	0.12	0.09	0.14	0.17	0.13	0.18	0.21	0.19	0.12	0.13	0.13	0.15
U	0.70	3.00	10.40	7.60	9.70	10.50	7.40	11.90	7.60	9.00	13.20	14.00	10.20	12.20	10.20	9.80
V	25.00	25.00	63.00	55.00	50.00	68.00	55.00	55.00	57.00	80.00	61.00	51.00	25.00	25.00	25.00	25.00
W	2273.00	1835.00	1006.00	910.00	2059.00	1986.00	3134.00	1651.00	2547.00	5560.00	3805.00	1720.00	1238.00	850.00	1905.00	949.00
Y	0.25	3.10	10.20	9.70	7.70	7.10	7.60	10.50	9.10	13.70	12.40	12.50	8.40	9.30	7.50	10.40
Yb	0.50	0.30	0.90	0.90	0.60	0.70	0.70	1.20	0.80	1.10	1.20	1.20	0.80	0.90	0.70	1.00
Zn	2042.00	1171.00	593.00	196.00	516.00	792.00	522.00	608.00	1110.00	1174.00	1290.00	342.00	458.00	238.00	419.00	245.00
Zr	29.00	78.00	157.00	181.00	181.00	159.00	159.00	219.00	163.00	98.00	111.00	152.00	111.00	147.00	132.00	172.00
Al	83.73	74.76	75.84	72.69	56.62	59.28	54.11	49.39	54.38	56.89	66.52	71.99	67.79	58.22	64.11	46.00

continued

Sample	DD200_041	DD200_042	DD200_043	DD200_044	DD200_046	DD200_047	DD200_048	DD200_049	DD200_051	DD200_052	DD200_053	DD200_054	DD200_056	DD200_057	DD200_058	DD200_059	DD200_061	DD200_062	DD200_063	DD200_064	DD200_066	DD200_067	DD200_068
SiO2	71.40	72.20	71.60	75.10	75.70	75.00	75.60	77.60	75.30	72.80	73.40	76.20	72.40	71.50	71.10	68.90	70.50	68.20	70.30	69.90	68.30	70.70	70.20
Al2O3	12.87	13.69	13.78	13.87	14.05	14.51	13.28	11.54	14.19	13.82	14.66	12.82	14.48	14.51	14.96	14.83	9.46	13.23	13.68	13.42	13.71	13.46	14.54
CaO	2.50	2.50	2.60	2.30	2.30	2.30	2.30	2.30	2.30	2.50	2.30	2.20	2.90	2.40	2.60	3.20	2.40	2.20	2.40	2.20	2.20	2.40	1.90
FeO	2.22	1.39	1.28	1.29	1.07	1.20	1.17	1.46	1.31	1.27	1.37	1.24	1.30	1.91	1.95	2.58	2.03	1.71	1.31	1.31	1.29	1.14	1.26
Fe2O3	1.06	0.66	0.61	0.61	0.51	0.57	0.56	0.69	0.62	0.60	0.65	0.59	0.62	0.91	0.93	1.23	0.97	0.81	0.63	0.62	0.61	0.54	0.60
K2O	5.50	4.70	4.60	4.90	5.30	5.00	5.10	4.60	4.40	5.20	5.00	4.90	4.70	4.70	5.30	7.00	3.20	5.10	3.80	4.00	3.90	4.20	4.80
MgO	0.55	0.65	0.57	0.62	0.57	0.64	0.58	0.52	0.63	0.64	0.73	0.68	0.76	0.78	0.74	0.87	0.61	0.65	0.68	0.72	0.73	0.65	0.70
MnO	0.05	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.07	0.08	0.07	0.11	0.11	0.07	0.07	0.06	0.07	0.06	0.05
Na2O	2.70	3.55	3.49	3.27	3.24	3.41	3.20	2.58	3.36	3.20	3.59	2.56	3.51	3.51	3.56	2.58	1.57	2.91	3.60	3.34	3.60	2.88	3.13
P2O5	0.14	0.12	0.12	0.15	0.12	0.14	0.11	0.13	0.16	0.17	0.15	0.13	0.14	0.16	0.13	0.23	0.12	0.11	0.15	0.15	0.13	0.11	0.13
V2O5	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
TiO2	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40	0.40	0.30	0.40	0.20	0.30	0.30	0.30	0.30	0.30	0.40
Ag	8.00	2.50	2.50	2.50	2.50	5.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	48.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	22.00	10.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	1485.00	1380.00	1581.00	1077.00	1063.00	1037.00	1043.00	1135.00	964.00	1114.00	1106.00	1013.00	979.00	1615.00	2188.00	3597.00	1262.00	1856.00	1037.00	1139.00	1165.00	1065.00	1261.00
Be	20.00	19.00	27.00	13.00	9.00	9.00	9.00	21.00	11.00	20.00	16.00	10.00	8.00	13.00	19.00	37.00	26.00	18.00	9.00	12.00	8.00	13.00	10.00
Bi	123.10	13.00	21.40	14.60	12.60	5.20	70.30	18.70	8.30	10.50	15.10	79.50	1.80	5.60	4.40	17.40	13.30	6.10	2.40	4.20	3.60	1.80	5.90
CO3	1.71	1.73	2.03	0.88	0.95	0.70	1.13	1.49	1.90	2.08	1.03	1.63	2.17	0.93	0.53	1.72	2.44	1.05	1.63	1.13	0.86	2.05	1.50
Cd	24.00	9.00	24.00	3.00	2.00	1.00	19.00	8.00	3.00	1.00	2.00	36.00	0.50	1.00	2.00	8.00	6.00	3.00	2.00	2.00	1.00	1.00	1.00
Ce	106.60	97.90	118.10	82.70	78.70	81.90	76.20	80.00	82.80	98.70	88.80	78.70	92.70	96.70	116.40	202.60	73.60	100.10	95.70	89.10	90.20	83.40	102.20
Co	115.00	92.00	89.00	96.00	107.00	88.00	125.00	103.00	108.00	113.00	96.00	112.00	88.00	96.00	108.00	88.00	112.00	91.00	91.00	102.00	122.00	80.00	86.00

Cr	8.00	9.00	8.00	7.00	7.00	8.00	8.00	9.00	8.00	10.00	8.00	9.00	8.00	10.00	11.00	13.00	10.00	9.00	10.00	11.00	9.00	9.00	11.00
Cs	11.14	8.69	10.17	8.67	10.28	12.15	9.75	8.49	10.00	10.75	9.99	12.78	9.94	9.60	9.20	11.33	13.24	10.06	10.28	12.44	14.39	11.66	12.05
Cu	209.00	171.00	161.00	119.00	92.00	79.00	122.00	195.00	124.00	136.00	124.00	110.00	83.00	200.00	282.00	399.00	349.00	215.00	110.00	125.00	87.00	126.00	124.00
Dy	1.70	1.80	1.50	1.80	1.80	2.00	1.70	1.50	2.00	2.30	2.20	1.60	2.00	1.80	1.80	1.90	1.30	1.80	2.00	1.70	2.00	2.00	2.20
Er	0.90	1.00	0.80	1.00	1.00	1.00	0.90	0.80	1.10	1.10	1.10	0.90	1.00	1.00	0.90	0.90	0.70	0.90	1.00	1.00	1.10	1.00	1.00
Eu	0.80	0.70	0.80	0.70	0.70	0.80	0.60	0.70	0.80	0.90	0.90	0.70	0.90	0.90	0.90	0.90	0.60	0.80	0.80	0.80	0.90	0.80	0.70
Ga	22.00	23.00	24.00	21.00	21.00	21.00	21.00	20.00	22.00	22.00	23.00	21.00	22.00	23.00	26.00	32.00	21.00	24.00	21.00	21.00	21.00	20.00	22.00
Gd	2.50	2.60	2.10	2.30	2.20	2.50	2.10	2.20	2.60	3.00	2.80	2.30	3.00	2.60	2.50	2.30	1.50	2.30	2.90	2.30	2.60	2.60	3.00
Hf	6.70	4.90	4.20	5.20	4.30	4.30	4.00	3.70	4.30	4.70	4.80	4.40	4.70	4.60	4.70	5.10	4.20	5.20	5.80	4.70	4.70	5.10	5.50
Ho	0.30	0.40	0.30	0.40	0.40	0.40	0.30	0.30	0.40	0.40	0.40	0.30	0.40	0.40	0.40	0.30	0.30	0.30	0.40	0.30	0.40	0.30	0.40
In	0.80	0.30	0.80	0.05	0.05	0.05	0.60	0.30	0.05	0.05	0.05	1.10	0.05	0.05	0.05	0.40	0.30	0.20	0.05	0.05	0.05	0.05	0.05
La	73.10	64.50	84.30	49.50	44.60	46.50	43.10	51.50	47.70	56.50	51.30	44.80	53.00	66.70	98.30	209.50	52.80	71.30	53.80	51.10	50.80	47.60	57.50
Li	69.00	58.00	66.00	49.00	49.00	46.00	52.00	50.00	62.00	76.00	60.00	99.00	60.00	60.00	58.00	76.00	99.00	63.00	60.00	61.00	66.00	99.00	82.00
Lu	0.12	0.18	0.13	0.15	0.14	0.13	0.13	0.10	0.13	0.17	0.18	0.12	0.16	0.12	0.13	0.13	0.09	0.21	0.13	0.16	0.16	0.13	0.14
Mo	80.00	266.00	37.00	89.00	45.00	1.00	20.00	233.00	185.00	13.00	3.00	1.00	4.00	18.00	9.00	81.00	107.00	398.00	6.00	138.00	1.00	32.00	19.00
Nb	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	11.00	5.00	5.00	5.00	5.00	12.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Nd	29.00	29.00	29.90	25.70	25.40	28.20	24.90	24.50	27.30	33.00	29.30	25.70	31.70	29.00	29.70	40.40	20.30	28.80	31.40	28.70	29.40	27.80	34.20
Ni	3.00	1.00	2.00	3.00	3.00	3.00	2.00	0.50	2.00	3.00	2.00	4.00	3.00	3.00	2.00	3.00	2.00	1.00	2.00	2.00	4.00	2.00	3.00
Pb	346.00	104.00	58.00	57.00	51.00	48.00	131.00	48.00	46.00	42.00	62.00	168.00	40.00	49.00	56.00	65.00	36.00	46.00	36.00	38.00	39.00	30.00	37.00
Pr	9.78	9.31	10.29	8.31	8.03	8.49	7.71	7.88	8.40	10.00	9.10	8.01	9.41	9.43	10.26	15.34	6.58	9.29	9.59	9.06	9.17	8.64	10.47
Rb	264.90	212.20	247.40	207.50	221.30	195.10	211.50	205.70	212.60	243.70	216.00	270.30	195.50	187.30	217.70	302.30	253.60	248.60	199.50	203.80	187.60	215.20	252.20
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	1.70	0.66	0.66	0.56	0.42	0.44	0.52	0.72	0.54	0.56	0.58	0.61	0.46	0.84	0.94	1.22	1.32	0.81	0.48	0.47	0.43	0.37	0.33
Sb	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

Sm	3.60	3.90	3.60	3.20	3.60	3.90	3.50	3.20	3.80	4.20	4.10	3.40	4.00	3.70	3.60	4.10	2.40	4.00	4.30	3.80	4.20	3.90	4.30
Sn	13.00	11.00	13.00	9.00	6.00	6.00	7.00	13.00	9.00	13.00	11.00	16.00	9.00	15.00	20.00	35.00	25.00	22.00	8.00	9.00	8.00	10.00	7.00
Sr	707.00	927.00	947.00	723.00	699.00	667.00	689.00	795.00	710.00	677.00	787.00	456.00	711.00	995.00	1478.00	1551.00	454.00	993.00	780.00	730.00	706.00	712.00	657.00
Ta	1.20	1.10	1.10	1.30	1.40	1.30	1.10	1.00	1.30	1.30	1.30	1.00	1.10	1.10	1.20	1.20	0.70	1.00	1.10	1.10	1.10	1.00	1.50
Tb	0.30	0.34	0.27	0.30	0.30	0.35	0.28	0.29	0.35	0.37	0.34	0.30	0.36	0.34	0.31	0.28	0.20	0.32	0.34	0.29	0.37	0.35	0.40
Te	2.00	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.50	0.50	0.50	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	18.80	18.30	16.90	17.90	16.50	17.90	16.00	15.50	18.10	19.20	18.50	16.70	18.30	17.00	16.40	20.20	12.60	18.30	20.00	18.00	17.70	17.90	21.60
Ti	0.16	0.18	0.16	0.17	0.16	0.19	0.17	0.15	0.19	0.19	0.21	0.18	0.21	0.22	0.21	0.22	0.13	0.18	0.20	0.20	0.20	0.20	0.22
TIC	0.34	0.35	0.41	0.18	0.19	0.14	0.23	0.30	0.38	0.42	0.21	0.33	0.43	0.19	0.11	0.34	0.49	0.21	0.33	0.23	0.17	0.41	0.30
Tl	2.00	1.70	1.80	1.60	1.70	1.40	1.60	1.50	1.50	1.80	1.50	1.70	1.40	1.40	1.60	2.30	1.80	1.90	1.50	1.50	1.40	1.50	1.90
Tm	0.13	0.17	0.13	0.16	0.14	0.17	0.13	0.14	0.16	0.16	0.18	0.14	0.17	0.15	0.16	0.16	0.11	0.15	0.17	0.15	0.18	0.15	0.17
U	12.50	10.70	7.40	8.70	8.60	9.70	6.90	7.70	9.50	9.20	8.80	7.20	8.30	6.90	7.40	5.90	6.10	7.70	7.20	7.70	9.60	8.20	9.70
V	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	2371.00	1168.00	1840.00	849.00	797.00	581.00	1165.00	1391.00	883.00	1075.00	765.00	812.00	657.00	1012.00	1848.00	7570.00	2358.00	2099.00	711.00	826.00	783.00	571.00	694.00
Y	9.30	11.30	9.00	11.00	10.90	11.20	9.40	8.60	11.50	12.20	12.00	9.40	11.40	10.50	10.00	10.70	9.00	10.50	11.10	10.10	11.30	10.40	10.80
Yb	0.90	1.10	0.90	1.10	1.00	0.90	0.90	0.80	1.00	1.20	1.20	0.80	1.10	1.00	0.90	1.00	0.70	0.90	1.10	0.90	0.90	1.00	1.10
Zn	692.00	273.00	704.00	103.00	80.00	53.00	540.00	239.00	98.00	57.00	73.00	1067.00	29.00	51.00	60.00	248.00	190.00	101.00	91.00	66.00	69.00	61.00	57.00
Zr	283.00	206.00	179.00	219.00	167.00	178.00	176.00	161.00	181.00	197.00	202.00	188.00	199.00	205.00	201.00	205.00	178.00	234.00	242.00	200.00	207.00	210.00	228.00
Al	53.76	46.93	45.93	49.79	51.44	49.67	50.81	51.21	47.04	50.62	49.31	53.95	45.99	48.13	49.49	57.64	48.95	52.93	42.73	45.99	44.39	47.86	52.21

6. *E-200*

Sample	E200_002	E200_003	E200_004	E200_006	E200_007	E200_008	E200_009	E200_011	E200_012	E200_013	E200_014	E200_016	E200_017	E200_018	E200_019	E200_021	E200_022	E200_023	E200_024
SiO2	68.30	63.80	66.00	50.80	60.50	63.10	61.40	59.40	57.20	65.60	70.30	67.90	61.60	67.90	66.10	62.40	62.70	61.70	60.20
Al2O3	14.24	12.59	10.44	9.72	8.01	11.67	12.93	11.96	11.90	13.91	13.09	13.81	13.22	13.87	13.79	13.13	12.26	12.18	13.45
CaO	2.70	4.20	4.50	6.90	8.20	5.00	4.60	4.80	4.40	3.10	1.60	1.60	3.80	3.00	3.80	4.00	3.20	4.80	5.10
FeO	1.16	2.06	3.08	5.40	6.10	2.72	2.26	3.42	6.11	1.82	1.46	1.96	2.42	2.11	1.60	2.58	3.43	2.31	2.14
Fe2O3	0.55	0.98	1.47	2.57	2.90	1.30	1.08	1.63	2.91	0.87	0.69	0.94	1.15	1.00	0.76	1.23	1.63	1.10	1.02
K2O	4.70	4.70	4.00	3.10	2.80	4.30	4.80	4.80	3.00	4.60	4.60	4.40	5.30	6.40	5.20	6.10	5.30	5.70	5.60
MgO	0.48	1.24	0.52	1.14	1.31	1.05	0.81	1.44	0.86	0.76	0.51	0.60	0.94	0.72	0.61	0.79	0.82	0.77	1.11
MnO	0.07	0.18	0.25	0.74	0.86	0.35	0.26	0.38	0.28	0.15	0.12	0.09	0.17	0.16	0.11	0.17	0.16	0.20	0.19
Na2O	3.13	1.55	1.71	1.96	1.27	0.67	1.79	1.80	1.87	0.21	0.13	0.13	0.14	0.14	0.12	0.16	0.15	0.19	0.97
P2O5	0.13	0.15	0.11	0.16	0.12	0.09	0.12	0.12	0.10	0.14	0.13	0.13	0.10	0.14	0.14	0.13	0.13	0.12	0.14
TiO2	0.40	0.40	0.30	0.20	0.20	0.30	0.30	0.30	0.30	0.40	0.30	0.40	0.30	0.40	0.40	0.30	0.30	0.30	0.30
Ag	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	41.00	10.00	10.00	10.00	10.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	2836.00	3350.00	2684.00	3303.00	2859.00	2885.00	2712.00	2242.00	1397.00	2242.00	1339.00	1363.00	1766.00	2080.00	1597.00	2110.00	2215.00	1893.00	2749.00
Be	7.00	7.00	10.00	22.00	23.00	11.00	7.00	11.00	16.00	6.00	5.00	3.00	8.00	8.00	6.00	8.00	10.00	6.00	9.00
Bi	0.40	1.30	3.90	1.10	5.10	0.70	1.10	1.50	7.90	7.20	1.60	0.90	1.70	2.40	0.60	0.80	5.40	2.00	2.80
CO3	2.20	6.20	4.55	6.05	5.80	6.25	5.50	6.79	4.45	3.65	1.55	1.75	5.90	2.95	4.20	5.00	3.30	6.00	18.39
Cd	0.50	0.50	0.50	1.00	4.00	0.50	0.50	2.00	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.50
Ce	196.30	253.90	792.50	1854.90	1468.20	236.90	208.20	170.90	535.60	166.80	191.60	234.00	338.70	217.00	164.80	581.30	888.20	638.60	298.70
Co	3.00	4.00	5.00	6.00	6.00	3.00	4.00	3.00	11.00	3.00	2.00	5.00	5.00	3.00	4.00	3.00	5.00	4.00	3.00
Cr	11.00	14.00	10.00	10.00	9.00	9.00	7.00	7.00	8.00	15.00	9.00	9.00	9.00	11.00	11.00	8.00	9.00	9.00	11.00
Cs	9.87	10.01	7.61	14.37	10.11	9.77	8.61	8.22	7.76	7.23	5.67	5.37	5.92	14.77	6.67	5.95	6.15	6.66	7.03
Cu	44.00	84.00	263.00	192.00	224.00	87.00	95.00	233.00	1235.0	75.00	112.00	122.00	159.00	105.00	86.00	99.00	242.00	72.00	104.00

									0										
Dy	2.50	2.30	3.50	6.30	4.60	2.10	2.80	2.40	3.10	2.50	2.20	2.20	2.70	2.60	2.50	4.20	6.40	4.60	3.10
Er	1.00	1.20	1.20	1.70	1.10	0.90	1.20	1.10	1.20	0.90	0.90	1.00	1.30	1.30	1.20	1.40	2.50	1.60	1.00
Eu	1.30	1.50	4.80	9.70	7.00	1.50	1.70	1.10	3.20	1.10	1.20	1.60	2.10	1.30	1.30	3.70	6.20	5.20	2.30
Ga	23.00	23.00	20.00	25.00	20.00	21.00	24.00	21.00	31.00	24.00	21.00	22.00	20.00	24.00	23.00	21.00	22.00	17.00	22.00
Gd	3.10	3.80	7.50	15.10	10.70	2.90	3.70	3.50	6.00	3.70	3.30	3.60	4.40	3.30	3.60	7.70	12.10	8.30	4.80
Hf	6.00	4.90	4.90	3.90	3.70	3.80	6.20	5.20	6.10	5.60	6.70	5.20	4.60	6.10	6.60	4.80	4.90	4.50	4.80
Ho	0.50	0.50	0.60	1.00	0.60	0.40	0.50	0.50	0.60	0.30	0.30	0.40	0.60	0.40	0.50	0.70	1.10	0.80	0.50
In	0.20	0.30	0.40	1.30	1.70	0.40	0.30	0.30	0.70	0.20	0.20	0.20	0.30	0.30	0.10	0.40	0.40	0.20	0.30
La	116.10	152.60	443.90	1023.1 0	833.10	137.90	124.20	98.30	314.70	103.80	106.70	141.50	197.90	126.00	96.90	304.40	458.60	299.80	173.30
Li	17.00	37.00	70.00	34.00	35.00	101.00	89.00	20.00	20.00	47.00	167.00	59.00	33.00	41.00	41.00	33.00	34.00	31.00	22.00
Lu	0.18	0.14	0.18	0.25	0.24	0.22	0.22	0.28	0.35	0.21	0.17	0.17	0.20	0.19	0.20	0.23	0.27	0.28	0.21
Mo	92.00	55.00	351.00	110.00	317.00	29.00	25.00	10.00	96.00	13.00	7.00	28.00	15.00	29.00	10.00	14.00	64.00	17.00	48.00
Nb	17.00	16.00	14.00	18.00	13.00	13.00	16.00	16.00	14.00	16.00	16.00	18.00	17.00	22.00	21.00	17.00	17.00	16.00	26.00
Nd	58.50	72.40	249.70	554.60	419.20	69.90	61.60	54.50	159.60	50.30	53.30	75.50	102.70	66.80	49.80	195.00	305.10	230.70	95.40
Ni	7.00	8.00	4.00	4.00	3.00	2.00	9.00	3.00	4.00	4.00	2.00	4.00	3.00	3.00	2.00	2.00	4.00	4.00	3.00
Pb	10.00	10.00	10.00	10.00	10.00	10.00	10.00	25.00	23.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Pr	19.26	24.62	83.33	188.46	142.50	23.50	20.21	16.89	53.05	16.34	17.88	24.53	34.74	21.46	16.10	62.43	97.18	70.28	31.53
Rb	194.50	202.30	167.70	136.30	116.40	178.60	196.70	197.20	121.40	186.30	182.30	163.30	205.60	308.60	214.60	232.80	209.90	215.60	220.40
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	0.20	0.36	1.28	0.98	1.27	0.66	0.64	0.75	4.52	0.15	0.40	0.82	0.64	0.60	0.35	0.68	1.02	0.49	0.54
Sb	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.60	0.80	2.50	5.00	1.30	1.20	0.90	1.20	1.80	0.25	0.25
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	6.20	7.50	20.10	42.30	31.50	6.40	6.90	5.70	14.20	5.90	5.10	7.30	9.40	6.80	5.90	17.10	27.30	21.60	9.30
Sn	11.00	16.00	28.00	42.00	37.00	17.00	13.00	11.00	29.00	11.00	10.00	10.00	14.00	15.00	13.00	14.00	13.00	11.00	26.00
Sr	2427.0 0	1659.0 0	1596.0 0	2252.0 0	1930.0 0	1137.0 0	1432.0 0	1332.0 0	1352.0 0	865.00	817.00	594.00	796.00	883.00	763.00	895.00	894.00	855.00	1489.0 0
Ta	0.90	0.80	0.60	0.60	0.60	0.60	0.90	1.00	0.70	0.90	0.80	1.00	0.80	1.20	1.10	0.90	0.80	0.90	7.80

Tb	0.38	0.37	0.70	0.98	0.68	0.31	0.43	0.41	0.57	0.40	0.36	0.36	0.46	0.35	0.40	0.74	1.01	0.80	0.55
Te	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	20.90	20.50	20.50	16.70	16.10	15.10	21.20	19.50	13.30	19.70	18.80	18.60	19.90	23.80	28.00	24.00	26.20	20.90	20.40
Ti	0.22	0.23	0.16	0.15	0.12	0.16	0.21	0.20	0.17	0.24	0.20	0.24	0.20	0.23	0.25	0.21	0.18	0.18	0.21
TIC	0.44	1.24	0.91	1.21	1.16	1.25	1.10	1.36	0.89	0.73	0.31	0.35	1.18	0.59	0.84	1.00	0.66	1.20	3.68
Tl	0.90	0.90	0.90	0.60	0.60	0.80	1.00	1.00	0.70	0.90	0.90	1.30	1.00	1.50	1.10	1.10	1.20	1.10	1.10
Tm	0.16	0.10	0.22	0.35	0.23	0.17	0.18	0.18	0.22	0.19	0.16	0.18	0.23	0.20	0.20	0.26	0.35	0.33	0.27
U	8.70	8.50	12.30	32.30	16.30	9.70	10.70	6.90	10.40	6.70	8.70	7.90	9.20	8.90	9.00	12.10	19.00	14.00	8.50
V	25.00	57.00	80.00	119.00	103.00	54.00	25.00	25.00	213.00	25.00	25.00	52.00	54.00	52.00	25.00	51.00	75.00	25.00	25.00
W	53.00	150.00	1414.0 0	802.00	1478.0 0	173.00	56.00	33.00	1576.0 0	35.00	36.00	26.00	57.00	33.00	18.00	64.00	68.00	29.00	98.00
Yb	1.10	1.00	1.30	2.10	1.50	1.00	1.10	1.10	1.10	0.90	0.90	1.10	1.10	1.20	1.20	1.20	2.00	1.60	1.40
Zn	66.00	87.00	96.00	213.00	345.00	85.00	83.00	101.00	148.00	86.00	56.00	82.00	79.00	80.00	47.00	71.00	123.00	62.00	63.00
Zr	268.00	223.00	216.00	178.00	172.00	151.00	282.00	236.00	295.00	273.00	290.00	233.00	212.00	254.00	298.00	216.00	227.00	180.00	235.00
Al	47.05	50.80	42.13	32.37	30.27	48.56	46.73	48.59	38.09	61.80	74.66	74.33	61.28	69.39	59.71	62.33	64.62	56.47	52.51

continued

Sample	E200_026	E200_027	E200_028	E200_029	E200_031	E200_032	E200_033	E200_034	E200_036	E200_037	E200_038	E200_039	E200_041	E200_042	E200_043	E200_044	E200_046	E200_047
SiO2	62.80	62.20	58.30	62.20	59.70	58.70	61.10	60.90	68.10	63.20	70.10	70.10	68.90	76.00	71.40	75.60	71.80	73.80
Al2O3	13.51	14.16	14.51	12.72	14.00	13.26	12.76	12.48	13.26	14.03	13.65	13.81	12.51	10.17	13.19	12.46	12.72	13.24
CaO	3.50	2.90	4.60	4.10	4.10	3.70	4.10	4.60	2.60	2.80	2.20	1.00	2.70	0.40	0.30	0.20	1.40	0.70
FeO	2.50	3.24	2.48	3.31	2.82	3.36	3.58	3.83	2.18	1.49	0.93	1.16	1.79	1.77	0.92	1.40	1.39	1.23
Fe2O3	1.19	1.54	1.18	1.58	1.34	1.60	1.70	1.82	1.04	0.71	0.44	0.55	0.85	0.84	0.44	0.67	0.66	0.59
K2O	5.60	5.50	6.80	4.60	6.30	5.20	4.70	4.30	5.00	4.50	4.50	4.30	2.80	3.00	3.40	2.80	3.20	3.20
MgO	0.66	0.47	0.69	0.68	0.71	1.39	0.82	0.63	0.33	0.49	0.35	0.50	0.70	0.63	0.45	0.55	1.01	0.59
MnO	0.18	0.15	0.16	0.17	0.15	0.15	0.09	0.10	0.05	0.05	0.04	0.04	0.08	0.02	0.02	0.03	0.05	0.03
Na2O	2.96	2.89	0.32	0.14	0.61	0.51	0.67	0.35	1.88	1.48	0.14	0.11	0.07	0.05	0.08	0.06	0.07	0.08
P2O5	0.16	0.17	0.22	0.19	0.20	0.15	0.11	0.11	0.10	0.12	0.10	0.10	0.10	0.09	0.11	0.09	0.09	0.15
TiO2	0.30	0.30	0.40	0.30	0.30	0.20	0.20	0.20	0.30	0.30	0.30	0.30	0.20	0.20	0.30	0.30	0.30	0.30
Ag	2.50	2.50	2.50	2.50	2.50	2.50	16.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
As	10.00	10.00	10.00	10.00	10.00	10.00	10.00	60.00	10.00	10.00	10.00	10.00	10.00	109.00	10.00	10.00	79.00	10.00
B	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ba	3432.00	2710.00	3078.00	2132.00	3478.00	3309.00	2469.00	1894.00	2275.00	1215.00	936.00	785.00	567.00	558.00	666.00	554.00	646.00	639.00
Be	11.00	14.00	9.00	11.00	8.00	12.00	12.00	12.00	11.00	9.00	7.00	6.00	9.00	8.00	6.00	5.00	6.00	6.00
Bi	5.30	3.20	16.80	8.30	1.70	4.80	56.10	9.50	1.80	1.20	0.40	11.50	1.00	41.90	2.90	1.80	8.20	1.40
CO3	3.50	3.35	4.70	4.45	4.80	4.80	4.90	5.00	12.79	2.75	2.20	0.95	2.95	0.10	0.20	0.20	2.35	0.20
Cd	0.50	1.00	5.00	2.00	0.50	1.00	10.00	1.00	0.50	0.50	0.50	1.00	0.50	0.50	0.50	0.50	0.50	2.00
Ce	264.70	417.30	328.10	450.40	325.10	342.70	255.50	253.90	246.00	122.00	94.00	91.60	93.80	73.40	91.20	89.20	90.70	92.80
Co	3.00	7.00	4.00	7.00	5.00	9.00	15.00	18.00	8.00	4.00	3.00	2.00	3.00	4.00	3.00	2.00	2.00	3.00
Cr	11.00	7.00	5.00	2.50	6.00	5.00	2.50	2.50	9.00	11.00	8.00	9.00	6.00	6.00	8.00	7.00	7.00	9.00
Cs	12.15	7.61	7.16	7.14	7.17	6.03	6.89	8.80	8.77	9.71	8.00	10.53	9.88	22.95	11.91	12.75	13.41	11.61
Cu	115.00	267.00	151.00	229.00	205.00	293.00	435.00	468.00	227.00	75.00	33.00	55.00	78.00	57.00	72.00	65.00	61.00	82.00
Dy	3.20	3.40	3.60	3.80	3.90	3.20	2.40	2.90	3.50	2.90	2.90	2.30	2.70	2.00	2.20	2.30	2.90	2.30
Er	1.20	1.80	1.70	1.60	1.70	1.30	1.30	1.40	1.50	1.40	1.30	1.20	1.40	0.90	1.00	1.00	1.40	1.10

Eu	1.60	3.00	2.30	2.50	1.90	1.40	1.10	1.10	1.10	0.90	0.70	0.70	0.80	0.60	0.60	0.60	0.80	0.70
Ga	22.00	24.00	25.00	25.00	28.00	26.00	25.00	24.00	25.00	21.00	20.00	21.00	21.00	19.00	20.00	19.00	21.00	22.00
Gd	3.40	5.50	4.90	5.00	4.70	3.60	2.90	3.30	3.70	3.00	2.60	2.90	2.70	2.00	2.80	2.10	3.40	2.60
Hf	5.10	6.40	7.40	5.90	6.50	4.20	3.40	2.80	3.20	4.70	6.50	8.00	5.30	5.80	4.90	4.50	4.00	4.40
Ho	0.50	0.80	0.70	0.70	0.60	0.60	0.50	0.50	0.60	0.50	0.50	0.50	0.50	0.30	0.40	0.40	0.50	0.40
In	0.30	0.30	0.50	0.30	0.30	0.30	0.50	0.20	0.05	0.10	0.05	0.10	0.05	0.05	0.05	0.05	0.05	0.05
La	164.40	234.70	206.70	283.90	204.60	232.30	176.20	169.80	168.40	70.30	52.50	51.60	50.70	42.80	50.80	48.40	50.70	50.30
Li	22.00	21.00	25.00	60.00	30.00	26.00	46.00	157.00	66.00	118.00	141.00	281.00	434.00	106.00	385.00	163.00	176.00	168.00
Lu	0.24	0.31	0.24	0.29	0.28	0.24	0.20	0.16	0.20	0.22	0.23	0.23	0.23	0.15	0.17	0.18	0.22	0.16
Mo	49.00	57.00	75.00	143.00	55.00	51.00	52.00	122.00	49.00	42.00	3.00	25.00	59.00	302.00	20.00	38.00	29.00	4.00
Nb	45.00	60.00	56.00	45.00	41.00	25.00	20.00	20.00	24.00	19.00	21.00	19.00	18.00	14.00	18.00	17.00	16.00	18.00
Nd	75.30	133.90	96.80	121.90	89.40	89.40	70.30	67.80	71.50	36.70	29.40	30.20	29.80	22.80	29.00	28.80	29.20	28.10
Ni	2.00	2.00	2.00	1.00	2.00	2.00	2.00	3.00	5.00	3.00	3.00	2.00	4.00	5.00	2.00	2.00	2.00	4.00
Pb	10.00	10.00	93.00	10.00	10.00	10.00	442.00	10.00	10.00	10.00	10.00	30.00	10.00	150.00	35.00	21.00	79.00	10.00
Pr	25.87	43.83	32.67	42.98	30.34	31.54	24.25	23.00	23.28	11.87	9.40	9.43	9.07	7.55	9.17	8.72	9.10	9.11
Rb	213.40	205.50	270.20	187.40	248.50	201.30	177.60	181.70	204.50	183.30	198.70	221.90	176.50	213.80	219.30	201.70	213.20	201.10
Re	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
S	0.67	1.57	0.99	1.78	1.01	1.37	2.34	2.40	1.07	0.47	0.14	0.31	0.68	1.38	0.38	0.63	0.30	0.57
Sb	0.25	0.25	0.25	2.00	0.90	0.25	0.50	0.80	0.25	0.25	0.25	0.25	1.10	2.90	0.25	1.00	1.10	0.50
Sc	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Se	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sm	7.90	11.90	10.10	11.90	8.70	8.10	6.40	6.10	7.30	4.80	3.90	3.70	3.80	3.10	3.90	3.90	3.30	3.90
Sn	14.00	14.00	18.00	20.00	19.00	13.00	13.00	14.00	16.00	10.00	6.00	8.00	10.00	12.00	8.00	10.00	9.00	13.00
Sr	2455.00	1916.00	1555.00	1213.00	1352.00	1150.00	1049.00	876.00	1301.00	630.00	372.00	314.00	388.00	345.00	322.00	201.00	271.00	278.00
Ta	2.50	3.80	4.10	3.20	3.50	1.30	1.40	1.30	20.20	6.60	4.50	3.20	2.80	1.80	2.20	1.80	1.80	4.80
Tb	0.42	0.61	0.55	0.67	0.64	0.45	0.38	0.48	0.60	0.49	0.45	0.39	0.42	0.31	0.35	0.37	0.42	0.37
Te	0.50	0.50	0.50	0.50	0.50	0.50	2.00	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Th	34.00	45.20	39.20	38.80	33.00	32.30	25.30	22.30	17.80	19.90	20.00	20.40	18.00	16.80	18.90	17.90	18.10	17.80
Ti	0.20	0.19	0.22	0.19	0.20	0.14	0.14	0.15	0.16	0.20	0.16	0.17	0.15	0.12	0.16	0.15	0.16	0.16

TIC	0.70	0.67	0.94	0.89	0.96	0.96	0.98	1.00	2.56	0.55	0.44	0.19	0.59	0.02	0.04	0.04	0.47	0.04
Tl	1.10	1.10	1.40	1.50	1.50	1.10	1.40	1.30	1.40	1.00	0.90	1.00	0.90	1.20	1.10	1.10	1.20	1.10
Tm	0.25	0.29	0.31	0.30	0.37	0.29	0.21	0.24	0.31	0.16	0.20	0.16	0.19	0.13	0.16	0.16	0.25	0.20
U	9.10	10.70	10.60	11.70	13.20	10.30	12.40	10.60	10.10	11.10	11.60	10.70	10.70	8.80	9.00	8.90	9.50	8.80
V	25.00	56.00	58.00	66.00	76.00	63.00	25.00	51.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
W	1566.00	428.00	143.00	117.00	147.00	111.00	158.00	92.00	967.00	70.00	22.00	12.00	20.00	17.00	7.00	14.00	12.00	22.00
Yb	1.40	1.70	2.00	2.00	1.90	1.70	1.00	1.30	1.20	1.20	1.30	1.40	1.30	0.90	0.90	1.00	1.10	1.10
Zn	84.00	101.00	192.00	126.00	74.00	90.00	282.00	45.00	26.00	39.00	28.00	52.00	33.00	30.00	26.00	25.00	26.00	69.00
Zr	257.00	341.00	390.00	310.00	327.00	188.00	130.00	107.00	160.00	216.00	313.00	349.00	214.00	271.00	210.00	203.00	169.00	196.00
AI	49.22	50.75	60.33	55.45	59.84	61.05	53.66	49.90	54.34	53.86	67.44	81.20	55.85	88.92	90.96	92.83	74.15	82.97

7. BB+200

SAMPLE	Ce	Cu	Dy	Er	Eu	Gd	Ho	La	Lu	Mo	Nb	Nd	Pr	S	Sc	Sm	Tb	Th	Tm	U	W	Yb
BB+200_001	139.50	198.00	5.40	2.70	2.80	7.80	1.00	79.90	0.33	44.00	34.00	53.10	15.63	12904.00	37.00	8.70	0.92	3.70	0.34	2.10	343.00	2.10
BB+200_002	396.50	449.00	2.60	1.40	3.20	6.10	0.50	214.90	0.19	236.00	13.00	124.70	41.45	14058.00	4.00	12.00	0.61	8.20	0.18	5.70	1143.00	1.10
BB+200_003	2534.10	283.00	10.00	4.30	15.80	28.90	1.70	1368.50	0.38	389.00	35.00	738.50	253.38	14253.00	8.00	61.50	2.37	23.40	0.51	27.00	2845.00	2.60
BB+200_004	994.60	357.00	4.30	2.30	7.30	12.40	0.80	531.10	0.23	100.00	20.00	306.10	102.19	13022.00	5.00	26.70	1.05	19.20	0.28	14.30	1585.00	1.70
BB+200_006	15080.50	274.00	50.90	20.50	95.40	157.00	8.00	7838.20	1.38	192.00	16.00	4576.60	1552.77	15483.00	7.00	377.30	12.27	122.00	2.24	137.90	1397.00	11.50
BB+200_007	4525.90	549.00	16.60	7.40	28.80	47.80	2.80	2521.30	0.64	86.00	17.00	1291.50	448.35	28120.00	7.00	105.00	3.85	45.50	0.82	50.90	2454.00	5.00
BB+200_008	1490.00	264.00	5.60	2.90	9.70	15.60	0.90	843.20	0.32	44.00	25.00	413.80	143.48	12257.00	5.00	34.40	1.29	16.90	0.34	15.10	1084.00	2.20
BB+200_009	207.00	280.00	1.60	0.80	1.90	3.20	0.30	135.70	0.14	29.00	23.00	59.30	20.37	9354.00	4.00	5.80	0.31	9.30	0.12	10.80	747.00	0.90
BB+200_011	204.50	259.00	1.60	0.80	2.00	3.00	0.30	134.50	0.14	36.00	20.00	60.40	20.13	10205.00	3.00	5.50	0.34	8.90	0.13	7.10	492.00	0.70
BB+200_012	279.60	302.00	2.40	1.40	2.40	4.30	0.40	173.70	0.20	31.00	24.00	78.50	27.18	9477.00	5.00	7.80	0.48	17.80	0.17	5.40	493.00	1.20
BB+200_013	158.10	531.00	1.40	0.80	1.40	2.60	0.20	101.00	0.15	1267.00	17.00	48.60	16.34	40321.00	3.00	5.00	0.29	10.30	0.11	3.80	818.00	0.80
BB+200_014	112.80	273.00	0.90	0.60	1.00	1.90	0.20	72.90	0.08	50.00	13.00	33.80	11.35	28057.00	3.00	3.40	0.21	5.20	0.06	2.60	912.00	0.50
BB+200_016	170.00	377.00	2.10	1.20	1.80	3.70	0.40	108.60	0.19	42.00	23.00	54.30	17.74	13025.00	5.00	6.20	0.46	11.10	0.14	4.30	1461.00	1.00
BB+200_017	176.10	296.00	2.10	1.00	1.60	3.40	0.40	112.20	0.19	96.00	28.00	54.80	18.29	8459.00	6.00	5.50	0.40	7.80	0.14	4.30	2690.00	1.00
BB+200_018	968.40	276.00	4.20	2.10	6.40	10.80	0.70	536.10	0.22	52.00	24.00	278.30	97.07	11124.00	5.00	23.10	0.93	13.90	0.26	16.50	1556.00	1.60
BB+200_019	7614.20	360.00	27.50	12.00	54.20	85.30	4.50	3904.10	0.87	64.00	12.00	2324.60	776.51	20270.00	5.00	189.50	6.84	49.50	1.31	122.70	3860.00	7.20
BB+200_021	3147.00	442.00	10.40	4.60	17.30	29.20	1.70	1865.60	0.54	40.00	35.00	864.30	299.16	19864.00	7.00	65.60	2.30	41.30	0.56	61.40	3060.00	3.40
BB+200_022	2579.10	333.00	8.70	3.90	14.30	22.90	1.40	1512.20	0.37	43.00	31.00	680.70	244.63	18620.00	5.00	50.30	1.84	29.70	0.48	24.70	2084.00	2.60
BB+200_023	320.70	293.00	2.10	1.00	2.10	4.30	0.40	190.00	0.17	38.00	23.00	89.90	31.47	14299.00	4.00	8.00	0.41	15.40	0.15	6.30	514.00	0.90
BB+200_024	373.20	363.00	2.40	1.30	2.60	5.30	0.40	241.20	0.13	39.00	22.00	99.50	35.36	16487.00	4.00	9.40	0.53	20.00	0.15	7.20	1662.00	0.90
BB+200_026	437.60	405.00	2.80	1.20	3.00	5.60	0.50	277.50	0.15	52.00	19.00	117.50	41.30	16103.00	6.00	10.40	0.58	12.70	0.16	5.70	4044.00	0.90
BB+200_027	84.00	235.00	1.80	1.00	0.70	2.20	0.30	53.40	0.13	291.00	22.00	24.90	8.30	8163.00	3.00	3.20	0.31	15.00	0.13	7.40	285.00	1.00

BB+200_028	105.90	136.00	2.30	1.40	0.90	3.00	0.40	65.20	0.18	90.00	24.00	32.40	10.54	5875.00	4.00	4.10	0.41	16.80	0.15	7.60	122.00	1.20
BB+200_029	90.30	119.00	2.30	1.10	0.90	3.40	0.40	54.90	0.18	190.00	21.00	30.00	9.55	6363.00	4.00	4.30	0.44	17.80	0.16	8.20	133.00	1.20
BB+200_031	64.10	153.00	1.80	1.10	0.80	2.30	0.30	38.90	0.16	81.00	19.00	20.70	6.69	6580.00	4.00	3.00	0.30	15.50	0.17	7.10	771.00	0.90
BB+200_032	72.50	102.00	1.70	0.90	0.80	2.50	0.30	44.60	0.15	169.00	20.00	24.20	7.54	5408.00	4.00	3.30	0.34	14.90	0.12	6.80	133.00	0.80
BB+200_033	80.50	191.00	2.00	1.10	0.90	2.60	0.40	55.00	0.18	152.00	27.00	25.80	8.10	7819.00	5.00	3.30	0.29	19.50	0.15	16.90	2264.00	1.10
BB+200_034	86.10	280.00	1.90	1.10	0.80	2.30	0.40	59.00	0.21	503.00	25.00	24.90	8.36	13799.00	4.00	3.20	0.33	18.70	0.16	17.70	699.00	1.10
BB+200_036	71.10	244.00	2.00	1.10	0.80	2.40	0.40	47.80	0.16	107.00	24.00	21.90	7.05	11229.00	4.00	3.10	0.31	13.70	0.15	9.90	519.00	1.20
BB+200_037	71.20	185.00	2.00	1.10	0.80	2.50	0.40	45.20	0.18	110.00	24.00	22.70	7.18	7281.00	4.00	3.10	0.36	15.00	0.19	11.20	496.00	1.10
BB+200_038	80.50	253.00	2.00	1.20	0.80	2.40	0.40	60.20	0.19	199.00	28.00	23.70	7.92	13907.00	4.00	3.50	0.33	17.50	0.17	11.30	2220.00	1.10
BB+200_039	68.40	192.00	1.40	0.80	0.70	2.20	0.30	46.90	0.17	695.00	26.00	20.90	6.75	9583.00	4.00	3.00	0.27	18.40	0.12	13.30	966.00	0.90
BB+200_041	67.00	107.00	1.60	1.00	0.80	2.20	0.30	41.80	0.14	81.00	20.00	22.00	7.01	4375.00	3.00	2.90	0.28	17.10	0.14	11.70	79.00	1.00
BB+200_042	63.90	91.00	1.60	1.00	0.70	2.10	0.30	38.40	0.15	59.00	19.00	20.90	6.69	3727.00	4.00	2.60	0.29	13.20	0.15	10.30	146.00	0.90
BB+200_043	28.10	34.00	1.00	0.60	0.40	1.10	0.20	16.90	0.08	45.00	5.00	9.70	2.93	1881.00	1.00	1.30	0.16	5.50	0.07	4.40	133.00	0.50
BB+200_044	64.50	104.00	1.90	1.30	0.80	2.10	0.40	45.10	0.18	102.00	19.00	19.40	6.30	4012.00	3.00	2.40	0.30	12.40	0.16	9.10	540.00	1.10
BB+200_046	63.50	106.00	1.50	0.80	0.70	1.80	0.20	39.80	0.14	74.00	18.00	20.40	6.42	4779.00	4.00	2.90	0.26	14.60	0.11	10.10	171.00	0.70
BB+200_047	72.30	175.00	1.60	1.00	0.70	2.10	0.40	53.50	0.17	103.00	21.00	20.30	6.82	7522.00	4.00	2.70	0.33	14.90	0.16	15.90	601.00	1.00
BB+200_048	97.20	228.00	1.60	1.10	0.80	2.00	0.30	83.30	0.20	72.00	27.00	23.80	8.71	15682.00	5.00	2.70	0.31	12.70	0.17	26.80	767.00	1.10
BB+200_049	62.50	548.00	1.70	0.90	0.70	1.80	0.30	50.60	0.14	1298.00	15.00	17.00	5.79	11447.00	3.00	2.40	0.28	10.90	0.13	20.20	2003.00	0.90
BB+200_051	64.20	60.00	1.50	0.90	0.60	2.00	0.30	39.10	0.10	77.00	18.00	20.50	6.49	2055.00	3.00	2.90	0.28	13.60	0.11	8.90	33.00	0.90
BB+200_052	70.50	105.00	1.80	1.00	0.80	2.30	0.30	42.60	0.16	94.00	20.00	23.10	7.47	6589.00	3.00	3.30	0.32	15.70	0.15	8.40	61.00	1.00
BB+200_053	72.00	110.00	1.70	1.00	0.80	2.30	0.30	42.20	0.16	41.00	21.00	24.00	7.52	11216.00	5.00	3.30	0.32	15.50	0.14	10.20	166.00	1.00
BB+200_054	65.10	80.00	1.50	1.00	0.70	2.30	0.30	38.50	0.16	70.00	20.00	21.50	6.69	2620.00	4.00	2.80	0.30	15.60	0.14	12.20	27.00	1.00
BB+200_056	68.40	99.00	1.80	1.10	0.80	2.60	0.30	40.50	0.20	71.00	20.00	22.20	7.06	5306.00	4.00	3.00	0.36	17.00	0.16	13.30	155.00	1.20
BB+200_057	58.40	107.00	1.70	0.90	0.60	2.20	0.30	35.60	0.15	142.00	18.00	20.10	6.30	5096.00	4.00	2.80	0.26	14.60	0.12	10.20	174.00	0.90
BB+200_058	58.00	89.00	1.60	0.90	0.70	1.90	0.30	34.40	0.16	77.00	273.00	19.10	6.17	3625.00	4.00	2.70	0.29	13.30	0.10	9.50	270.00	0.90
BB+200_060	135.80	211.00	1.70	0.80	1.60	3.00	0.30	75.60	0.11	20.00	30.00	45.20	14.74	9972.00	5.00	4.70	0.33	15.10	0.13	3.30	2159.00	0.70
BB+200_061	72.40	72.00	2.00	1.00	0.80	2.10	0.40	43.30	0.15	127.00	30.00	22.50	7.43	4445.00	4.00	2.80	0.32	13.90	0.15	11.70	114.00	0.80
BB+200_062	67.00	65.00	2.00	1.00	0.70	2.10	0.40	39.70	0.12	62.00	33.00	20.30	6.83	3446.00	4.00	2.50	0.30	11.80	0.15	10.70	90.00	0.90
BB+200_063	76.40	63.00	2.20	1.10	0.80	2.50	0.40	45.00	0.19	51.00	31.00	23.40	7.79	3771.00	5.00	3.30	0.36	13.80	0.18	9.30	22.00	1.00

BB+200_064	86.00	146.00	2.50	1.20	0.90	2.80	0.40	58.00	0.17	679.00	27.00	25.80	8.64	7611.00	4.00	3.60	0.41	16.00	0.18	11.20	185.00	1.10
BB+200_066	85.80	101.00	2.20	1.30	0.90	3.00	0.40	50.80	0.22	103.00	27.00	28.10	9.00	5383.00	4.00	3.60	0.41	19.00	0.16	10.60	126.00	1.30
BB+200_067	81.70	107.00	2.50	1.30	0.90	2.90	0.50	49.50	0.20	88.00	25.00	26.60	8.55	5199.00	4.00	3.90	0.42	19.10	0.17	10.30	111.00	1.20
BB+200_068	81.60	157.00	2.20	1.20	0.80	2.90	0.50	54.10	0.20	170.00	24.00	25.20	8.07	7493.00	4.00	3.70	0.40	16.50	0.16	10.50	152.00	1.10
BB+200_069	94.00	147.00	2.20	1.10	0.80	3.10	0.40	62.20	0.26	55.00	24.00	28.20	9.36	7172.00	4.00	3.80	0.41	17.20	0.17	8.80	224.00	1.10
BB+200_071	88.80	108.00	2.50	1.40	1.00	3.20	0.50	54.70	0.19	67.00	24.00	29.20	9.23	5647.00	4.00	3.90	0.46	21.30	0.18	11.00	221.00	1.30
BB+200_072	90.50	137.00	2.50	1.30	0.90	3.10	0.40	58.70	0.19	56.00	25.00	28.20	9.12	6707.00	4.00	4.00	0.44	19.50	0.17	10.60	184.00	1.20
BB+200_073	87.50	74.00	2.30	1.30	0.90	3.20	0.50	52.20	0.19	16.00	25.00	28.50	9.04	4621.00	4.00	3.90	0.42	19.50	0.18	11.20	31.00	1.30
BB+200_074	85.10	97.00	2.30	1.30	0.80	3.00	0.40	50.90	0.18	27.00	24.00	27.80	8.81	5285.00	4.00	3.90	0.42	19.70	0.18	10.30	389.00	1.10
BB+200_076	80.10	96.00	2.20	1.20	0.90	2.80	0.40	47.60	0.21	66.00	23.00	26.00	8.26	5554.00	4.00	3.60	0.37	17.60	0.16	9.50	342.00	1.10
BB+200_077	88.30	90.00	2.30	1.20	1.00	3.20	0.40	53.30	0.18	19.00	24.00	28.20	9.19	5028.00	4.00	3.90	0.43	19.40	0.15	11.50	37.00	1.20
BB+200_078	86.20	200.00	2.20	1.30	0.80	2.50	0.40	62.70	0.16	55.00	26.00	25.20	8.42	8212.00	4.00	3.40	0.38	17.40	0.15	11.60	1293.00	1.20
BB+200_079	69.40	238.00	1.70	1.10	0.70	2.20	0.40	54.00	0.16	277.00	25.00	19.80	6.52	9327.00	5.00	2.90	0.30	10.40	0.16	10.00	2156.00	1.00
BB+200_081	60.70	281.00	1.50	1.10	0.60	2.00	0.30	47.90	0.20	909.00	22.00	16.60	5.69	10565.00	4.00	2.30	0.26	10.90	0.14	13.20	1866.00	0.90
BB+200_082	77.40	463.00	2.00	1.20	0.80	2.50	0.40	59.80	0.20	30.00	27.00	22.80	7.43	18691.00	5.00	2.90	0.36	13.90	0.16	9.30	3391.00	1.10
BB+200_083	82.30	207.00	1.80	1.00	0.70	2.30	0.40	65.00	0.17	99.00	24.00	23.10	7.83	9628.00	3.00	3.00	0.29	12.60	0.15	8.70	1931.00	1.10
BB+200_084	71.80	305.00	1.80	1.10	0.80	2.30	0.40	55.40	0.16	70.00	24.00	20.80	6.86	12139.00	5.00	2.80	0.33	13.10	0.14	8.20	4224.00	1.00
BB+200_086	80.90	280.00	2.10	1.10	0.70	2.60	0.40	59.20	0.16	53.00	28.00	22.90	7.71	10793.00	5.00	3.30	0.35	17.20	0.16	14.30	1454.00	1.10
BB+200_087	91.30	117.00	2.30	1.20	0.90	3.10	0.40	57.10	0.19	58.00	27.00	29.50	9.37	6339.00	4.00	4.40	0.41	18.10	0.17	14.90	88.00	1.30
BB+200_088	87.40	84.00	2.20	1.10	0.90	2.90	0.40	52.90	0.19	14.00	24.00	28.10	9.00	3312.00	4.00	4.10	0.38	17.40	0.18	10.80	110.00	1.10
BB+200_089	90.30	198.00	2.50	1.30	0.90	2.80	0.50	57.80	0.24	104.00	23.00	28.60	9.16	9199.00	5.00	3.70	0.41	18.90	0.19	13.10	3719.00	1.30
BB+200_091	72.10	643.00	2.20	1.30	0.80	2.30	0.40	46.10	0.23	147.00	21.00	21.60	7.25	12935.00	4.00	3.10	0.35	16.80	0.18	14.30	1260.00	1.30
BB+200_092	82.00	111.00	2.00	1.10	0.90	2.80	0.40	48.00	0.15	22.00	23.00	26.00	8.37	4667.00	4.00	3.70	0.39	15.60	0.15	10.00	271.00	1.10
BB+200_093	83.40	97.00	2.00	1.10	0.80	2.80	0.40	51.20	0.16	35.00	22.00	26.10	8.43	3956.00	4.00	3.60	0.39	14.70	0.14	10.90	75.00	1.10
BB+200_094	82.20	77.00	2.10	1.00	0.70	2.70	0.40	52.90	0.14	272.00	23.00	26.30	8.32	5878.00	3.00	3.40	0.34	15.70	0.14	10.40	140.00	0.90
BB+200_096	84.30	122.00	2.40	1.20	0.90	3.20	0.40	50.20	0.16	26.00	26.00	27.30	8.81	6723.00	5.00	4.00	0.46	17.90	0.15	10.90	45.00	1.20
BB+200_097	83.70	129.00	2.50	1.30	0.90	3.20	0.40	52.90	0.18	44.00	22.00	26.80	8.42	5873.00	5.00	3.80	0.42	17.60	0.16	10.10	2989.00	1.10
BB+200_098	88.50	112.00	2.30	1.20	0.80	3.10	0.50	58.00	0.18	31.00	23.00	27.20	8.84	4112.00	4.00	3.80	0.45	18.00	0.18	10.40	132.00	1.20
BB+200_099	39.10	1177.00	1.20	0.70	0.40	1.50	0.30	23.40	0.09	54.00	10.00	12.70	4.08	4537.00	2.00	1.90	0.22	8.60	0.09	4.70	372.00	0.60

BB+200_101	62.20	88.00	1.90	0.90	0.70	2.20	0.30	37.20	0.14	90.00	17.00	19.80	6.54	3174.00	4.00	2.70	0.32	12.70	0.16	7.70	83.00	0.90
BB+200_102	89.80	503.00	2.90	1.40	1.00	3.30	0.50	55.50	0.20	26.00	26.00	29.90	9.42	5499.00	4.00	4.40	0.48	19.20	0.19	11.90	332.00	1.30
BB+200_103	68.10	93.00	2.00	1.20	0.80	2.70	0.40	38.70	0.23	47.00	19.00	22.30	7.08	6405.00	3.00	3.40	0.37	14.80	0.17	8.70	105.00	1.00
BB+200_104	75.10	69.00	2.20	1.30	0.90	2.80	0.40	43.60	0.35	96.00	21.00	24.00	7.64	4125.00	4.00	3.60	0.43	15.80	0.18	9.70	28.00	1.10
BB+200_106	80.10	79.00	2.20	1.30	0.90	2.80	0.40	48.30	0.19	171.00	21.00	26.50	8.31	4689.00	4.00	3.80	0.36	16.70	0.19	9.90	226.00	1.00
BB+200_107	23.40	14.00	1.60	1.30	0.80	1.30	0.40	12.90	0.32	1.00	11.00	8.50	2.67	692.00	3.00	1.50	0.23	2.20	0.22	0.70	38753.00	2.00
BB+200_108	83.00	110.00	2.30	1.40	0.90	3.10	0.40	47.60	0.17	53.00	23.00	27.70	8.61	5071.00	4.00	4.10	0.43	18.70	0.18	10.80	300.00	1.10
BB+200_109	84.70	59.00	2.40	1.30	0.90	3.10	0.50	48.90	0.17	36.00	22.00	26.90	8.82	3949.00	4.00	4.00	0.43	18.00	0.17	10.00	68.00	1.20
BB+200_111	92.20	95.00	2.50	1.30	1.00	3.20	0.50	54.10	0.17	182.00	22.00	29.40	9.43	5778.00	4.00	4.00	0.45	19.40	0.18	9.50	130.00	1.10
BB+200_112	94.40	75.00	2.20	1.30	1.00	3.20	0.40	55.80	0.18	59.00	23.00	32.70	10.09	3727.00	4.00	4.50	0.44	18.60	0.15	11.70	139.00	1.00
BB+200_113	78.40	186.00	2.10	1.10	0.80	2.50	0.40	49.50	0.15	494.00	21.00	24.60	7.78	9652.00	3.00	3.50	0.41	15.70	0.14	9.90	726.00	1.00
BB+200_114	90.70	74.00	2.50	1.30	0.90	3.10	0.50	54.20	0.21	73.00	23.00	29.20	9.54	4895.00	4.00	4.40	0.42	17.30	0.16	10.00	82.00	1.10
BB+200_116	81.00	100.00	2.20	1.30	0.90	2.80	0.40	47.30	0.22	23.00	23.00	26.90	8.59	5954.00	4.00	4.00	0.43	15.90	0.16	9.00	91.00	1.10
BB+200_117	88.00	89.00	2.40	1.30	0.90	3.00	0.50	54.60	0.16	59.00	24.00	28.10	8.95	5185.00	4.00	4.30	0.43	15.80	0.15	9.10	194.00	1.10
BB+200_118	83.10	89.00	2.30	1.30	0.90	2.70	0.40	51.90	0.17	645.00	23.00	26.50	8.77	5411.00	4.00	3.60	0.42	17.00	0.16	11.50	56.00	1.10
BB+200_119	87.80	120.00	2.40	1.20	0.90	3.00	0.40	54.80	0.15	39.00	22.00	27.70	9.05	5168.00	3.00	3.70	0.39	18.50	0.15	11.20	185.00	1.20
BB+200_121	65.80	63.00	1.90	1.00	0.80	2.40	0.40	40.90	0.18	586.00	22.00	20.60	6.80	891.00	3.00	3.00	0.35	14.70	0.12	7.80	229.00	0.80
BB+200_122	86.80	242.00	2.20	1.00	0.80	2.60	0.40	58.00	0.13	137.00	24.00	26.40	8.64	10984.00	5.00	3.70	0.39	14.60	0.16	8.30	1801.00	0.90
BB+200_123	90.10	153.00	2.20	1.10	0.90	3.10	0.40	57.90	0.16	43.00	24.00	28.30	9.20	7198.00	4.00	3.90	0.42	16.00	0.16	10.70	442.00	1.00
BB+200_124	85.50	115.00	2.30	1.10	0.90	2.90	0.40	53.70	0.17	51.00	23.00	27.80	8.80	5795.00	4.00	4.10	0.43	17.00	0.17	7.90	223.00	1.10
BB+200_126	83.80	91.00	2.20	1.30	0.80	3.00	0.40	51.10	0.16	59.00	26.00	27.30	8.60	3792.00	4.00	4.00	0.44	16.90	0.15	10.00	61.00	1.00
BB+200_127	84.00	66.00	2.30	1.00	0.90	2.80	0.40	53.30	0.22	25.00	26.00	26.80	8.56	2305.00	4.00	3.80	0.42	15.30	0.16	11.20	87.00	1.10
BB+200_128	84.10	92.00	2.10	1.20	0.80	3.20	0.40	53.00	0.14	147.00	26.00	26.40	8.77	4792.00	4.00	3.80	0.43	14.60	0.15	9.10	68.00	1.00
BB+200_129	76.10	91.00	2.10	1.20	0.80	2.70	0.40	45.20	0.17	28.00	24.00	24.70	7.87	6004.00	4.00	3.50	0.44	13.50	0.16	9.70	330.00	1.00
BB+200_131	86.70	106.00	2.30	1.30	0.90	3.00	0.50	57.00	0.17	134.00	26.00	27.50	8.74	5286.00	4.00	3.70	0.46	17.90	0.18	10.80	357.00	1.20
BB+200_132	81.30	53.00	2.20	1.10	0.90	3.00	0.40	47.80	0.19	11.00	24.00	26.40	8.64	3166.00	4.00	3.90	0.41	17.50	0.14	10.90	52.00	1.10
BB+200_133	91.80	109.00	2.20	1.20	0.90	2.90	0.40	60.10	0.15	26.00	25.00	28.30	9.30	5833.00	5.00	3.50	0.43	15.80	0.15	9.40	984.00	1.00
BB+200_134	77.50	166.00	1.70	1.00	0.70	2.50	0.30	50.60	0.15	207.00	20.00	23.50	7.76	7791.00	4.00	3.30	0.36	14.10	0.13	7.00	724.00	0.90
BB+200_136	86.50	99.00	2.10	1.10	0.90	2.70	0.40	52.50	0.17	96.00	25.00	27.90	8.85	5688.00	4.00	3.80	0.44	19.40	0.15	10.00	496.00	1.10

BB+200_137	80.10	75.00	2.10	1.00	0.80	2.80	0.40	50.00	0.20	40.00	22.00	26.70	8.30	4118.00	4.00	3.70	0.41	15.50	0.15	10.90	66.00	1.00
BB+200_138	83.70	80.00	2.10	1.20	0.80	2.80	0.40	52.10	0.19	48.00	23.00	26.60	8.83	3279.00	4.00	3.90	0.39	17.20	0.15	10.10	61.00	1.00
BB+200_139	81.10	110.00	2.10	1.10	0.80	2.80	0.40	48.50	0.15	76.00	22.00	26.40	8.27	6500.00	3.00	3.80	0.37	17.30	0.16	11.50	155.00	1.00
BB+200_141	93.20	148.00	2.50	1.40	0.90	3.20	0.50	62.30	0.67	46.00	23.00	28.80	9.48	5716.00	4.00	4.60	0.49	17.10	0.18	11.60	609.00	1.10
BB+200_142	81.60	150.00	2.20	1.10	0.80	3.00	0.40	52.40	0.58	193.00	22.00	25.80	8.42	7514.00	5.00	4.10	0.40	15.80	0.16	9.40	636.00	1.10
BB+200_143	85.70	51.00	2.20	1.20	0.90	3.10	0.40	50.40	0.16	28.00	24.00	27.70	8.83	1772.00	4.00	4.10	0.44	16.20	0.16	10.10	30.00	1.00
BB+200_144	81.60	54.00	2.40	1.40	1.20	3.00	0.40	47.80	0.16	38.00	22.00	26.60	8.45	1858.00	4.00	4.10	0.48	15.30	0.17	9.70	17.00	1.10
BB+200_146	84.30	67.00	2.40	1.20	0.90	3.00	0.40	49.50	0.16	88.00	24.00	27.60	8.72	2140.00	4.00	4.10	0.42	17.10	0.16	10.00	26.00	1.10
BB+200_147	77.20	99.00	2.30	1.10	0.90	2.90	0.40	47.30	0.17	58.00	24.00	25.60	8.03	3794.00	4.00	3.50	0.44	16.00	0.17	8.60	126.00	1.10
BB+200_148	78.20	100.00	2.20	1.20	0.80	2.90	0.40	47.20	0.17	117.00	23.00	25.40	8.25	5001.00	3.00	3.90	0.41	17.40	0.15	10.20	68.00	1.00
BB+200_149	71.50	96.00	1.80	0.90	0.60	2.40	0.40	43.00	0.16	90.00	22.00	23.50	7.37	6145.00	3.00	3.20	0.34	16.00	0.13	9.20	47.00	0.90
BB+200_151	5.00	6.00	0.10	0.05	0.05	0.20	0.05	3.30	0.03	18.00	5.00	2.20	0.62	94.00	0.50	0.20	0.03	0.90	0.03	0.20	13.00	0.05
BB+200_152	69.40	87.00	1.90	1.10	0.80	2.20	0.30	41.50	0.18	49.00	23.00	23.60	7.30	3649.00	4.00	3.40	0.32	18.20	0.15	10.90	31.00	1.10
BB+200_153	70.80	75.00	1.90	1.10	0.80	2.60	0.40	41.40	0.18	88.00	22.00	22.90	7.36	3651.00	4.00	3.30	0.36	18.60	0.16	13.30	16.00	1.20
BB+200_154	76.30	97.00	1.80	1.10	0.80	2.40	0.30	51.40	0.19	102.00	23.00	24.60	7.87	4081.00	4.00	3.30	0.35	17.70	0.14	12.00	49.00	0.90

8. BB+300

SAMPLE	Ce	Cu	Dy	Er	Eu	Gd	Ho	La	Lu	Mo	Nb	Nd	Pr	S	Sc	Sm	Tb	Th	Tm	U	W	Yb
BB+300_001	69.10	272.00	4.80	2.40	1.80	6.10	0.80	33.30	0.29	53.00	33.00	34.30	8.65	14645.00	33.00	7.40	0.88	4.30	0.31	4.40	176.00	1.90
BB+300_002	100.40	261.00	1.50	0.90	1.10	2.80	0.30	59.60	0.13	157.00	11.00	32.90	10.63	6743.00	4.00	3.90	0.29	15.60	0.11	5.50	102.00	1.00
BB+300_003	111.80	232.00	1.90	1.00	1.00	2.80	0.40	74.90	0.16	29.00	15.00	31.40	10.96	7278.00	5.00	4.00	0.32	17.80	0.13	9.20	388.00	1.00
BB+300_004	147.70	238.00	2.00	1.10	1.20	3.30	0.40	100.50	0.15	66.00	16.00	40.60	13.39	9735.00	5.00	4.70	0.42	18.30	0.19	10.50	26.00	1.20
BB+300_006	160.70	190.00	2.50	1.40	1.50	3.20	0.50	104.80	0.18	25.00	15.00	46.50	15.49	621.00	5.00	5.90	0.52	22.10	0.22	11.20	29.00	1.30
BB+300_007	154.50	166.00	2.10	1.00	1.30	3.40	0.30	104.80	0.16	31.00	13.00	43.80	14.57	2671.00	4.00	5.20	0.44	17.60	0.14	9.10	17.00	1.10
BB+300_008	120.30	284.00	2.20	1.00	0.90	2.90	0.40	78.10	0.11	189.00	15.00	35.00	11.68	24139.00	4.00	4.50	0.44	20.50	0.14	18.20	83.00	1.20
BB+300_009	114.30	255.00	1.90	1.10	0.80	2.50	0.40	70.50	0.16	381.00	13.00	34.50	11.29	14004.00	4.00	4.40	0.40	19.40	0.16	10.20	45.00	0.90
BB+300_011	175.10	270.00	1.90	0.90	1.30	2.90	0.30	122.10	0.13	268.00	14.00	45.30	16.43	11329.00	5.00	5.20	0.39	19.90	0.13	8.10	60.00	0.80
BB+300_012	133.40	409.00	2.00	1.10	1.10	2.80	0.40	99.40	0.14	229.00	14.00	36.40	12.20	14134.00	3.00	4.20	0.40	11.20	0.13	6.50	76.00	0.90
BB+300_013	187.10	177.00	2.00	1.00	1.30	3.10	0.30	131.80	0.11	62.00	13.00	51.20	17.30	8845.00	4.00	5.80	0.35	17.70	0.10	7.20	38.00	0.90
BB+300_014	150.20	176.00	2.60	1.30	1.50	3.20	0.50	95.00	0.16	48.00	15.00	44.40	15.52	7720.00	5.00	5.00	0.51	16.90	0.18	7.40	216.00	1.10
BB+300_016	162.00	187.00	2.70	1.20	1.60	3.80	0.50	106.30	0.18	59.00	12.00	46.80	15.43	7028.00	5.00	5.40	0.55	18.10	0.15	6.40	70.00	1.20
BB+300_017	230.50	308.00	1.70	1.00	1.80	3.50	0.30	166.40	0.13	36.00	12.00	59.30	21.08	12682.00	4.00	6.20	0.48	16.80	0.13	5.50	232.00	0.80
BB+300_018	205.20	283.00	1.70	0.80	1.50	2.90	0.30	155.30	0.09	60.00	11.00	51.30	18.62	11701.00	3.00	5.30	0.39	17.50	0.11	4.30	204.00	0.80
BB+300_019	210.00	235.00	2.60	1.30	1.60	4.10	0.40	149.80	0.12	65.00	11.00	56.40	20.05	10255.00	3.00	6.30	0.58	24.90	0.17	6.30	104.00	1.00
BB+300_021	199.10	321.00	2.30	1.10	1.50	3.50	0.40	137.70	0.12	115.00	11.00	53.30	19.02	13453.00	3.00	5.90	0.47	23.80	0.17	7.60	193.00	1.10
BB+300_022	245.80	677.00	2.70	1.30	2.40	4.40	0.50	148.90	0.14	60.00	17.00	80.00	26.36	26754.00	5.00	8.70	0.57	14.80	0.19	6.50	1986.00	1.20
BB+300_023	177.10	408.00	2.30	1.10	1.70	3.60	0.40	116.70	0.18	114.00	12.00	53.10	17.78	16566.00	4.00	5.70	0.47	13.80	0.15	5.60	1842.00	1.10
BB+300_024	201.10	272.00	2.60	1.30	1.90	3.80	0.50	131.70	0.17	92.00	12.00	57.40	20.17	11402.00	3.00	6.60	0.50	18.80	0.17	5.30	667.00	1.00
BB+300_026	159.50	191.00	1.80	0.90	1.60	3.00	0.30	101.50	0.10	105.00	11.00	49.00	16.86	5560.00	3.00	5.00	0.37	12.40	0.12	3.20	698.00	0.80
BB+300_027	224.80	206.00	2.20	1.00	1.70	3.60	0.40	153.80	0.15	27.00	11.00	62.00	21.58	6129.00	3.00	6.50	0.49	20.80	0.11	6.70	84.00	0.90
BB+300_028	198.80	194.00	2.40	1.30	1.50	3.40	0.40	140.00	0.15	36.00	13.00	57.60	18.48	7488.00	5.00	6.50	0.53	19.70	0.16	5.50	701.00	0.90
BB+300_029	153.80	133.00	2.30	1.20	1.20	3.30	0.40	96.50	0.15	24.00	12.00	45.30	15.02	6873.00	5.00	5.60	0.46	21.60	0.15	8.30	51.00	1.00
BB+300_031	174.70	177.00	3.00	1.40	1.50	3.80	0.50	110.60	0.21	41.00	16.00	50.60	17.01	8188.00	5.00	6.20	0.51	19.10	0.18	9.50	98.00	1.30

BB+300_032	142.20	163.00	2.40	1.20	1.20	3.50	0.40	90.20	0.14	25.00	13.00	42.60	14.31	5504.00	5.00	5.50	0.51	21.70	0.14	8.40	105.00	1.00
BB+300_033	131.70	136.00	2.50	1.20	1.10	3.30	0.40	79.80	0.17	36.00	12.00	40.20	13.34	6408.00	5.00	5.10	0.50	19.80	0.12	10.40	76.00	1.00
BB+300_034	120.10	119.00	2.40	1.10	1.20	3.00	0.50	71.90	0.10	22.00	13.00	36.60	12.45	6417.00	4.00	5.00	0.40	15.70	0.14	6.30	165.00	1.00
BB+300_036	130.40	133.00	2.60	1.20	1.40	3.60	0.50	80.60	0.19	24.00	14.00	38.80	13.24	7224.00	5.00	5.20	0.51	18.00	0.15	7.20	90.00	1.30
BB+300_037	123.00	109.00	2.60	1.10	1.20	3.20	0.40	76.30	0.16	35.00	12.00	38.00	12.06	5568.00	4.00	4.80	0.46	19.70	0.14	7.30	21.00	0.90
BB+300_038	130.70	180.00	2.80	1.30	1.40	3.20	0.50	83.60	0.20	66.00	20.00	38.60	13.19	7924.00	5.00	4.60	0.53	21.90	0.20	15.10	297.00	1.20
BB+300_039	167.20	351.00	2.20	1.20	1.50	3.10	0.40	101.90	0.20	150.00	19.00	47.40	16.28	16870.00	5.00	5.50	0.42	17.90	0.18	16.50	994.00	1.00
BB+300_041	319.40	341.00	2.40	1.30	2.30	4.20	0.50	194.90	0.15	92.00	18.00	90.60	32.31	15159.00	4.00	9.40	0.60	18.30	0.16	11.50	726.00	1.30
BB+300_042	74.20	542.00	0.50	0.20	0.40	0.80	X	47.60	X	40.00	X	20.10	7.27	22889.00	X	1.90	0.09	2.60	X	1.30	1036.00	0.20
BB+300_043	495.40	377.00	2.90	1.10	3.30	5.30	0.50	305.00	0.21	57.00	16.00	136.60	48.69	16978.00	4.00	11.80	0.63	17.10	0.17	14.10	1335.00	1.40
BB+300_044	247.10	331.00	2.00	1.10	1.90	3.30	0.40	166.90	0.18	104.00	19.00	66.80	23.66	14632.00	4.00	5.80	0.42	19.40	0.19	9.90	609.00	1.40
BB+300_046	366.90	243.00	3.50	1.80	3.60	5.30	0.60	206.90	0.22	26.00	26.00	108.20	37.68	10596.00	4.00	11.20	0.80	24.20	0.26	13.30	420.00	1.60
BB+300_047	2913.90	1006.00	10.60	4.10	15.20	25.50	1.60	1397.70	0.42	296.00	17.00	793.10	275.18	34900.00	13.00	68.30	2.66	30.20	0.54	39.70	4535.00	3.20
BB+300_048	383.30	402.00	3.40	1.70	3.10	5.70	0.60	225.80	0.24	158.00	28.00	108.20	38.23	16753.00	5.00	10.40	0.69	25.40	0.27	8.40	74.00	1.70
BB+300_049	3392.90	574.00	10.20	4.00	18.30	28.40	1.60	1605.70	0.40	107.00	27.00	920.90	321.70	24515.00	4.00	78.20	2.88	45.00	0.47	40.60	2815.00	3.20
BB+300_051	627.80	366.00	4.40	1.80	4.50	7.30	0.70	351.40	0.23	51.00	28.00	181.60	63.38	14439.00	4.00	16.70	0.93	26.70	0.26	15.50	425.00	1.70
BB+300_052	266.50	366.00	2.80	1.70	2.30	4.20	0.60	166.30	0.25	23.00	26.00	70.70	25.20	15767.00	4.00	7.60	0.56	24.90	0.23	8.80	198.00	1.80
BB+300_053	2995.70	817.00	9.90	4.10	16.10	25.20	1.50	1476.20	0.45	68.00	27.00	799.50	280.77	33502.00	4.00	62.00	2.62	31.50	0.49	36.40	3261.00	3.60
BB+300_054	388.90	367.00	3.10	1.50	2.80	4.90	0.60	232.70	0.16	25.00	22.00	107.50	36.90	16756.00	5.00	10.40	0.61	22.50	0.21	10.60	876.00	1.50
BB+300_056	334.30	343.00	3.10	1.40	2.50	4.60	0.50	208.10	0.20	33.00	25.00	93.80	32.81	14542.00	5.00	9.00	0.69	25.60	0.20	11.00	811.00	1.70
BB+300_057	575.30	380.00	3.40	1.90	3.80	6.80	0.60	341.40	0.21	36.00	25.00	160.20	56.09	17147.00	4.00	14.40	0.91	24.80	0.22	15.50	1176.00	1.40
BB+300_058	312.30	439.00	2.70	1.30	2.40	5.40	0.50	197.50	0.17	37.00	23.00	88.80	30.94	25034.00	4.00	9.00	0.56	25.90	0.20	12.80	763.00	1.30
BB+300_059	206.90	602.00	2.30	1.20	1.70	3.40	0.40	135.70	0.11	104.00	16.00	57.60	19.28	38659.00	4.00	6.00	0.48	21.20	0.18	11.70	2141.00	1.20
BB+300_061	508.80	498.00	2.80	1.40	3.20	5.60	0.50	310.30	0.15	79.00	15.00	145.40	49.92	25554.00	4.00	13.00	0.63	18.90	0.24	9.80	1251.00	1.20
BB+300_062	287.60	406.00	2.40	1.10	2.30	4.80	0.50	189.00	0.12	53.00	18.00	82.80	28.32	18319.00	4.00	8.40	0.57	19.60	0.16	7.90	1254.00	1.00
BB+300_063	201.70	496.00	2.30	1.00	1.80	3.30	0.40	137.10	0.16	368.00	19.00	58.00	19.43	19520.00	3.00	5.60	0.50	20.20	0.19	8.60	516.00	1.00
BB+300_064	706.50	440.00	3.50	1.70	4.10	7.50	0.60	436.00	0.17	50.00	22.00	191.70	66.92	19749.00	5.00	15.80	0.74	26.90	0.26	13.40	1401.00	1.50
BB+300_066	950.00	433.00	4.40	2.10	5.00	9.20	0.80	579.70	0.27	40.00	19.00	251.50	88.87	21031.00	5.00	22.20	0.93	20.70	0.36	14.90	1442.00	1.90
BB+300_067	182.20	332.00	2.30	1.30	1.70	3.80	0.50	112.60	0.13	46.00	17.00	54.30	18.10	14181.00	5.00	7.20	0.54	18.40	0.20	15.20	821.00	1.30

BB+300_068	167.80	395.00	2.00	1.20	1.40	3.00	0.50	108.30	0.18	31.00	16.00	45.40	16.15	13560.00	4.00	4.50	0.37	15.70	0.18	8.30	322.00	1.30
BB+300_069	167.30	329.00	1.70	0.80	1.10	2.40	0.30	123.30	0.11	44.00	16.00	44.40	15.21	14029.00	3.00	5.10	0.39	15.70	0.15	9.00	563.00	1.10
BB+300_071	167.70	308.00	1.90	1.10	1.20	3.30	0.40	118.40	0.15	39.00	18.00	44.40	15.49	10237.00	5.00	4.50	0.42	16.70	0.19	7.70	166.00	1.00
BB+300_072	104.40	203.00	1.80	1.10	0.80	2.10	0.40	80.20	0.15	71.00	18.00	27.30	9.26	17593.00	5.00	3.50	0.35	16.70	0.19	11.90	98.00	1.30
BB+300_073	48.90	142.00	1.10	0.70	0.50	1.40	0.20	31.90	0.13	730.00	15.00	14.60	5.01	6771.00	4.00	2.30	0.22	16.30	0.12	12.20	216.00	0.70
BB+300_074	60.60	188.00	1.30	0.80	0.60	1.80	0.30	38.90	0.13	140.00	13.00	18.20	6.15	7688.00	4.00	2.40	0.26	16.80	0.10	7.80	293.00	0.90
BB+300_076	58.10	133.00	1.40	0.80	0.60	1.60	0.20	36.40	0.09	62.00	14.00	19.00	5.99	5274.00	4.00	2.80	0.26	16.00	0.13	9.60	259.00	0.90
BB+300_077	47.90	182.00	1.30	0.70	0.50	1.50	0.30	30.20	0.12	77.00	11.00	14.70	4.74	11434.00	4.00	2.20	0.25	14.20	0.12	10.50	652.00	1.00
BB+300_078	55.80	142.00	1.40	0.90	0.40	1.60	0.30	33.90	0.13	307.00	13.00	17.00	5.77	6915.00	3.00	2.60	0.27	16.50	0.14	12.50	89.00	1.00
BB+300_079	58.30	105.00	1.50	0.90	0.50	1.70	0.30	35.90	0.13	203.00	16.00	18.10	5.72	3990.00	3.00	3.00	0.23	15.40	0.13	9.10	83.00	1.00
BB+300_081	64.10	105.00	2.00	1.10	0.60	2.30	0.30	39.40	0.15	64.00	15.00	20.50	6.45	5451.00	4.00	3.00	0.32	18.20	0.18	13.30	623.00	1.10
BB+300_082	21.80	177.00	0.40	0.20	0.20	0.40	X	14.60	X	355.00	X	6.50	1.96	5336.00	X	1.00	0.08	3.90	X	4.70	369.00	0.10
BB+300_083	71.30	146.00	1.80	1.10	0.80	2.30	0.30	44.90	0.15	710.00	11.00	22.60	7.22	27076.00	3.00	3.80	0.34	16.60	0.17	19.10	349.00	1.30
BB+300_084	61.60	100.00	2.10	1.10	0.70	2.10	0.40	36.60	0.21	777.00	14.00	19.20	6.15	8604.00	3.00	2.30	0.34	16.80	0.19	14.70	152.00	1.30
BB+300_086	66.40	192.00	1.90	1.10	0.70	2.00	0.40	44.70	0.15	183.00	17.00	20.00	6.46	15774.00	4.00	2.70	0.34	17.00	0.15	12.40	555.00	1.40
BB+300_087	54.50	119.00	1.80	1.10	0.60	1.80	0.40	35.40	0.13	114.00	17.00	17.10	5.22	4338.00	4.00	2.50	0.35	16.30	0.17	9.40	153.00	1.40
BB+300_088	43.80	69.00	1.40	1.10	0.50	2.00	0.30	26.30	0.13	202.00	16.00	14.20	4.55	3209.00	3.00	2.20	0.28	14.20	0.18	9.00	166.00	1.20
BB+300_089	44.00	100.00	1.80	0.90	0.50	1.80	0.40	26.60	0.08	247.00	15.00	15.90	4.58	3579.00	3.00	2.60	0.28	11.00	0.17	6.90	359.00	1.20
BB+300_091	63.80	57.00	1.80	1.00	0.60	2.00	0.30	37.10	0.14	136.00	15.00	21.30	6.93	2561.00	4.00	3.30	0.38	18.20	0.17	13.00	72.00	1.00
BB+300_092	50.40	241.00	2.20	1.20	0.80	2.20	0.40	30.50	0.15	491.00	X	16.50	5.61	13948.00	4.00	3.00	0.35	15.00	0.26	12.40	1832.00	1.70
BB+300_093	56.40	185.00	1.80	1.10	0.60	2.30	0.30	35.80	0.15	345.00	11.00	17.90	5.49	18715.00	5.00	2.70	0.33	15.20	0.14	13.10	3243.00	1.10
BB+300_094	10.90	221.00	0.40	0.10	0.10	0.40	X	6.70	X	97.00	X	3.60	1.19	6364.00	X	0.40	0.06	2.40	X	2.10	319.00	0.20
BB+300_096	69.60	111.00	1.80	0.90	0.70	2.10	0.30	42.50	0.20	81.00	16.00	21.70	6.89	4327.00	4.00	2.90	0.31	16.20	0.17	12.50	308.00	1.00
BB+300_097	67.70	112.00	1.70	1.00	0.70	2.00	0.30	40.70	0.09	43.00	14.00	21.00	7.18	4839.00	4.00	3.20	0.31	16.50	0.13	11.50	140.00	1.20
BB+300_098	44.60	196.00	1.50	0.70	0.50	1.50	0.30	26.00	0.08	430.00	X	14.60	4.46	13024.00	3.00	2.30	0.27	10.50	0.14	9.00	2790.00	0.70
BB+300_099	60.40	88.00	1.80	0.90	0.70	2.40	0.40	35.30	0.14	250.00	14.00	18.70	6.01	5212.00	3.00	3.00	0.28	14.40	0.13	9.30	39.00	1.00
BB+300_101	75.90	76.00	2.10	1.30	0.70	2.50	0.40	44.40	0.17	61.00	17.00	24.60	7.58	4991.00	4.00	3.90	0.41	17.60	0.17	12.60	32.00	1.30
BB+300_102	78.10	76.00	2.10	1.00	0.80	2.70	0.40	45.50	0.15	77.00	16.00	25.80	8.06	5322.00	4.00	3.90	0.44	19.40	0.18	11.20	36.00	1.30
BB+300_103	82.90	76.00	2.30	1.10	0.90	2.80	0.40	49.10	0.11	80.00	16.00	25.50	8.52	3998.00	4.00	3.70	0.44	18.40	0.17	10.30	121.00	1.20

BB+300_104	82.70	88.00	2.50	1.20	0.90	2.90	0.40	50.80	0.16	81.00	16.00	26.90	8.68	4358.00	4.00	4.20	0.43	18.70	0.18	10.10	71.00	1.10
BB+300_106	76.00	152.00	2.10	1.00	0.80	2.60	0.40	48.00	0.13	76.00	18.00	24.00	7.95	6747.00	4.00	3.30	0.44	17.10	0.16	10.90	915.00	1.10
BB+300_107	71.10	130.00	1.90	0.90	0.70	2.60	0.30	42.10	0.12	270.00	16.00	23.70	7.17	4417.00	3.00	3.80	0.40	17.40	0.12	9.50	69.00	0.90
BB+300_108	72.00	208.00	1.70	0.90	0.70	2.50	0.40	42.70	0.08	117.00	15.00	23.60	7.31	5276.00	4.00	3.20	0.38	16.70	0.11	9.20	105.00	1.00
BB+300_109	67.90	143.00	1.80	0.80	0.80	2.30	0.30	41.50	0.11	187.00	13.00	22.20	6.70	4631.00	3.00	3.20	0.32	15.90	0.12	9.50	355.00	0.80
BB+300_111	69.20	149.00	1.90	0.90	0.70	2.20	0.40	42.70	0.11	105.00	16.00	21.90	7.11	6784.00	4.00	3.20	0.35	16.70	0.11	11.00	575.00	1.00
BB+300_112	72.90	122.00	2.10	1.00	0.70	2.30	0.30	43.60	0.12	44.00	16.00	22.50	7.23	7323.00	4.00	3.90	0.35	17.10	0.15	12.50	77.00	1.00
BB+300_113	74.00	101.00	2.00	0.90	0.50	2.40	0.30	42.70	0.12	86.00	16.00	22.90	7.45	3268.00	4.00	4.10	0.32	13.10	0.14	7.40	256.00	0.90
BB+300_114	54.50	78.00	1.90	1.00	0.60	1.70	0.40	33.20	0.08	87.00	15.00	16.90	5.61	2389.00	3.00	2.70	0.32	12.90	0.13	7.60	30.00	1.10
BB+300_116	77.90	252.00	2.00	0.90	0.90	2.20	0.40	62.40	0.15	409.00	13.00	22.90	7.14	14176.00	3.00	3.30	0.45	16.50	0.15	7.80	334.00	0.90
BB+300_117	75.00	100.00	2.20	1.20	0.80	2.90	0.40	45.90	0.17	238.00	15.00	25.20	7.30	5774.00	3.00	3.70	0.46	17.20	0.18	11.50	148.00	1.20
BB+300_118	84.70	98.00	2.50	1.20	0.90	2.60	0.50	51.10	0.16	38.00	17.00	27.90	8.55	5328.00	3.00	4.00	0.48	19.00	0.23	10.40	137.00	1.10
BB+300_119	77.90	84.00	2.30	1.30	0.80	3.00	0.50	46.60	0.17	31.00	17.00	26.20	7.96	4584.00	4.00	3.70	0.50	18.10	0.23	9.80	93.00	1.30
BB+300_121	83.60	119.00	2.50	1.10	0.90	2.90	0.50	51.30	0.19	23.00	18.00	27.10	8.57	6014.00	4.00	3.90	0.49	19.00	0.15	9.50	37.00	1.30
BB+300_122	81.60	78.00	2.40	1.20	0.80	2.90	0.40	48.20	0.12	89.00	17.00	27.10	8.42	4059.00	4.00	4.10	0.42	18.90	0.17	11.70	104.00	1.30
BB+300_123	82.10	93.00	2.40	1.20	0.80	3.00	0.40	49.10	0.19	56.00	16.00	27.00	8.17	2689.00	4.00	4.00	0.43	18.60	0.19	11.50	187.00	1.10
BB+300_124	81.90	174.00	2.30	1.20	0.80	2.90	0.40	55.50	0.15	105.00	15.00	26.30	7.82	8876.00	4.00	3.80	0.44	16.70	0.15	9.30	347.00	1.10
BB+300_126	95.40	268.00	2.70	1.30	1.10	3.10	0.50	71.10	0.18	27.00	17.00	27.10	8.99	15213.00	5.00	4.50	0.40	18.70	0.23	13.80	3200.00	1.40
BB+300_127	95.00	176.00	2.20	1.20	0.80	3.00	0.50	66.40	0.13	104.00	13.00	27.90	8.87	7222.00	4.00	4.10	0.46	16.70	0.18	11.20	937.00	1.10
BB+300_128	72.20	96.00	2.00	1.00	0.80	2.70	0.50	43.30	0.16	14.00	15.00	23.20	7.64	4461.00	4.00	3.80	0.37	16.90	0.15	10.20	27.00	0.90
BB+300_129	87.00	77.00	2.50	1.10	0.90	2.90	0.40	53.00	0.18	25.00	16.00	28.70	8.75	3957.00	3.00	4.60	0.46	19.50	0.18	10.00	18.00	1.00
BB+300_131	82.00	76.00	2.40	1.20	0.80	2.80	0.40	49.20	0.17	158.00	17.00	27.20	8.26	4565.00	4.00	3.90	0.43	18.80	0.16	10.90	17.00	1.00
BB+300_132	81.20	102.00	2.50	1.20	0.90	2.80	0.40	51.50	0.21	194.00	17.00	26.50	8.25	5517.00	3.00	4.00	0.49	19.80	0.17	13.00	109.00	1.20
BB+300_133	94.60	82.00	2.60	1.20	1.00	3.20	0.50	54.50	0.20	677.00	17.00	30.90	9.57	8110.00	3.00	4.60	0.44	19.40	0.21	9.50	127.00	1.00
BB+300_134	98.00	131.00	2.80	1.40	1.00	3.60	0.50	59.00	0.20	24.00	17.00	32.80	9.99	5595.00	4.00	4.70	0.49	22.00	0.21	11.30	81.00	1.40
BB+300_136	74.40	86.00	2.30	1.20	0.80	2.70	0.40	45.20	0.15	1406.00	14.00	26.30	7.61	8248.00	3.00	3.50	0.47	16.50	0.17	8.90	291.00	1.00
BB+300_137	87.00	82.00	2.60	1.30	0.80	2.80	0.50	51.50	0.17	51.00	16.00	28.90	8.78	6384.00	4.00	4.20	0.45	19.80	0.23	13.70	79.00	1.30
BB+300_138	79.10	106.00	2.40	1.10	0.70	2.80	0.40	50.20	0.15	1609.00	15.00	26.70	8.06	7274.00	3.00	4.10	0.39	16.70	0.19	11.40	64.00	1.20
BB+300_139	94.10	101.00	2.50	1.30	0.90	2.80	0.40	64.60	0.16	43.00	16.00	27.80	9.35	6546.00	4.00	3.80	0.42	18.10	0.16	13.90	85.00	1.20

BB+300_141	70.80	100.00	2.20	0.90	0.80	2.50	0.40	45.10	0.17	35.00	17.00	24.80	6.99	5925.00	3.00	3.50	0.38	16.40	0.14	10.40	128.00	0.90
BB+300_142	91.10	95.00	2.20	1.10	0.70	2.60	0.30	57.50	0.16	116.00	15.00	27.80	9.00	5853.00	3.00	3.70	0.42	19.50	0.19	10.40	65.00	1.10
BB+300_143	76.70	100.00	1.40	0.70	0.50	2.10	0.20	69.90	0.11	55.00	17.00	21.20	6.66	3925.00	4.00	2.80	0.30	10.70	0.11	8.20	1863.00	0.60
BB+300_144	106.50	440.00	2.70	1.30	1.10	3.10	0.40	71.60	0.20	1009.00	17.00	33.10	10.52	34175.00	5.00	4.90	0.42	20.00	0.19	12.30	62.00	1.40
BB+300_146	47.00	8.00	0.90	0.40	0.40	1.10	0.20	32.30	0.07	46.00	X	13.00	4.52	3299.00	2.00	1.60	0.17	8.80	X	6.10	243.00	0.30
BB+300_147	101.40	95.00	1.90	0.90	0.80	3.00	0.30	68.80	0.17	114.00	18.00	30.60	9.84	8207.00	4.00	4.30	0.41	20.10	0.15	19.20	494.00	1.00
BB+300_148	74.60	65.00	2.40	1.00	0.70	2.70	0.40	50.00	0.14	191.00	17.00	23.10	7.47	9463.00	7.00	3.30	0.44	16.90	0.18	13.00	3826.00	1.30
BB+300_149	97.30	149.00	2.60	1.40	0.90	2.80	0.40	69.00	0.23	1116.00	17.00	29.50	9.30	22438.00	8.00	4.50	0.48	18.10	0.20	18.80	9367.00	1.40
BB+300_151	86.40	70.00	2.20	1.00	0.80	2.80	0.40	53.70	0.17	23.00	17.00	26.90	8.65	5499.00	4.00	4.10	0.42	19.70	0.17	11.50	136.00	1.20
BB+300_152	90.90	84.00	2.40	1.20	1.00	2.90	0.50	59.20	0.19	117.00	17.00	29.50	8.99	4577.00	4.00	4.30	0.46	19.70	0.17	11.90	279.00	1.20
BB+300_153	57.00	80.00	1.60	0.80	0.60	2.10	0.30	34.80	0.14	264.00	12.00	18.80	5.83	4178.00	4.00	2.40	0.34	13.00	0.12	7.60	81.00	0.80
BB+300_154	78.50	90.00	2.10	1.10	0.80	2.70	0.40	48.00	0.14	165.00	15.00	26.20	7.96	4616.00	3.00	3.80	0.48	17.40	0.18	10.90	37.00	1.10
BB+300_156	78.10	94.00	2.90	1.20	0.90	2.70	0.40	47.60	0.20	46.00	18.00	27.20	8.09	5128.00	4.00	4.00	0.51	18.40	0.14	11.00	20.00	1.20
BB+300_157	81.40	138.00	2.40	1.10	0.80	3.00	0.40	52.70	0.22	198.00	17.00	26.30	7.92	6355.00	3.00	4.50	0.47	17.80	0.20	11.40	235.00	1.20
BB+300_158	82.40	102.00	2.20	1.00	0.60	2.60	0.40	56.70	0.23	28.00	17.00	26.50	8.16	7222.00	4.00	4.60	0.43	17.20	0.19	13.80	498.00	1.00
BB+300_159	74.60	90.00	1.70	1.00	0.60	1.80	0.40	44.50	0.17	103.00	14.00	22.30	7.40	6318.00	4.00	2.70	0.35	16.30	0.14	9.70	1314.00	1.10
BB+300_161	79.40	79.00	3.00	1.40	0.80	3.00	0.60	50.00	0.18	156.00	17.00	24.80	7.63	4259.00	3.00	4.10	0.51	18.60	0.16	12.60	54.00	1.40
BB+300_162	82.50	102.00	2.30	1.00	0.70	2.80	0.40	53.70	0.17	25.00	16.00	25.80	8.24	5254.00	4.00	4.00	0.44	18.50	0.16	11.30	89.00	1.00
BB+300_163	77.10	69.00	2.30	1.30	0.90	2.90	0.40	47.70	0.19	76.00	16.00	27.00	7.93	4088.00	4.00	4.00	0.47	18.80	0.18	11.90	22.00	1.20
BB+300_164	81.40	73.00	2.30	1.10	0.90	2.80	0.50	52.80	0.17	79.00	17.00	25.90	8.18	4113.00	4.00	4.30	0.45	18.90	0.16	12.60	99.00	1.20
BB+300_166	83.70	65.00	2.50	1.20	0.80	2.70	0.40	53.30	0.15	37.00	16.00	26.60	8.37	3741.00	3.00	3.50	0.44	24.10	0.22	11.70	48.00	1.10
BB+300_167	84.80	61.00	2.60	1.40	0.90	3.00	0.50	49.60	0.18	24.00	16.00	28.10	8.51	3966.00	4.00	4.30	0.46	19.60	0.21	12.70	38.00	1.20
BB+300_168	83.10	63.00	2.80	1.30	0.80	2.90	0.40	50.90	0.18	43.00	16.00	27.70	8.66	3757.00	4.00	4.20	0.44	19.90	0.15	10.10	35.00	1.30
BB+300_169	79.80	80.00	2.60	1.30	0.80	2.70	0.40	47.90	0.21	28.00	16.00	27.30	8.04	4871.00	4.00	3.60	0.39	20.00	0.20	11.30	96.00	1.10
BB+300_171	83.90	72.00	2.50	1.30	0.80	2.80	0.50	51.00	0.21	49.00	17.00	28.20	8.33	4551.00	4.00	4.30	0.43	19.90	0.17	9.80	136.00	1.40
BB+300_172	80.40	92.00	2.60	1.40	0.80	3.00	0.50	49.90	0.18	34.00	15.00	27.60	8.11	4658.00	4.00	3.90	0.48	18.10	0.21	11.70	122.00	1.20
BB+300_173	88.00	96.00	2.40	1.20	0.90	3.00	0.40	54.60	0.17	36.00	18.00	29.70	8.77	5215.00	4.00	4.30	0.44	18.40	0.18	11.40	158.00	1.30
BB+300_174	79.30	112.00	2.30	1.20	0.70	2.90	0.40	50.80	0.20	37.00	16.00	24.90	7.88	6128.00	4.00	3.90	0.42	17.40	0.20	10.60	292.00	1.10
BB+300_176	75.70	85.00	2.40	1.10	0.80	2.70	0.50	46.50	0.18	76.00	15.00	26.30	7.53	4879.00	4.00	4.50	0.47	17.50	0.18	10.40	28.00	1.20

BB+300_177	79.30	65.00	2.50	1.30	0.90	2.90	0.50	47.50	0.21	74.00	16.00	27.20	7.99	4202.00	4.00	4.60	0.47	18.90	0.18	13.80	14.00	1.10
BB+300_178	86.00	97.00	2.40	1.30	0.80	2.50	0.40	57.40	0.20	256.00	15.00	27.40	8.57	5239.00	3.00	4.00	0.42	18.70	0.16	11.80	84.00	1.20
BB+300_179	79.90	70.00	2.50	1.30	0.90	3.00	0.40	48.90	0.18	37.00	16.00	26.00	7.57	3823.00	4.00	3.60	0.44	19.30	0.20	11.60	16.00	1.30
BB+300_181	83.50	170.00	2.30	1.10	0.80	2.80	0.40	61.00	0.20	28.00	15.00	25.80	8.04	8432.00	4.00	3.70	0.45	20.00	0.18	9.80	609.00	1.10
BB+300_182	69.80	171.00	2.10	1.10	0.70	2.40	0.40	47.80	0.17	149.00	17.00	22.50	6.89	7331.00	5.00	3.60	0.40	16.60	0.15	9.00	4321.00	1.20
BB+300_183	76.90	81.00	2.50	1.40	0.80	2.50	0.50	47.60	0.17	46.00	18.00	24.60	7.98	5521.00	3.00	4.00	0.45	17.70	0.20	11.10	239.00	1.40
BB+300_184	76.50	330.00	2.50	1.10	0.90	2.70	0.40	54.80	0.19	208.00	20.00	22.50	7.19	13204.00	6.00	3.40	0.45	19.20	0.21	14.20	4100.00	1.20
BB+300_186	68.80	116.00	1.60	1.00	0.70	2.20	0.30	46.40	0.16	156.00	15.00	21.50	6.58	3732.00	4.00	3.10	0.34	15.20	0.13	10.50	290.00	1.00
BB+300_187	77.90	95.00	2.20	1.10	0.80	2.50	0.40	50.30	0.15	73.00	19.00	25.20	7.62	3443.00	4.00	3.60	0.37	19.60	0.17	12.00	219.00	1.10
BB+300_188	58.40	259.00	2.60	1.50	0.90	2.50	0.50	44.30	0.37	142.00	23.00	18.40	5.46	11664.00	5.00	3.20	0.44	28.40	0.27	14.70	2138.00	1.70
BB+300_189	91.20	377.00	2.30	1.20	1.00	2.50	0.40	76.40	0.23	564.00	20.00	23.20	7.96	16491.00	5.00	3.10	0.43	22.10	0.20	11.90	4803.00	1.30
BB+300_191	114.60	482.00	2.80	1.30	1.10	2.80	0.50	96.70	0.22	327.00	28.00	30.10	9.86	18452.00	5.00	4.50	0.46	35.00	0.28	24.00	6694.00	1.40
BB+300_192	105.00	424.00	2.80	1.30	1.30	3.10	0.50	88.40	0.21	290.00	20.00	27.90	9.38	4064.00	5.00	4.60	0.47	44.30	0.22	18.10	3439.00	1.50
BB+300_193	90.90	421.00	2.10	1.20	1.20	2.60	0.40	75.50	0.16	26.00	19.00	24.40	7.74	12798.00	4.00	3.70	0.36	32.10	0.19	15.70	1412.00	1.00
BB+300_194	93.70	666.00	1.90	1.00	1.00	2.00	0.40	78.10	0.14	339.00	20.00	25.70	8.21	17664.00	5.00	3.00	0.37	26.80	0.18	17.00	3351.00	1.10
BB+300_196	92.90	193.00	1.90	1.20	0.90	2.20	0.40	73.60	0.18	42.00	20.00	24.60	8.50	10989.00	4.00	3.30	0.38	18.90	0.21	15.60	1580.00	1.00
BB+300_197	113.20	481.00	2.30	1.30	1.10	2.70	0.50	98.50	0.26	178.00	19.00	29.00	9.57	21181.00	5.00	4.30	0.43	18.10	0.17	13.90	9907.00	1.40
BB+300_198	84.10	157.00	2.30	1.00	0.80	2.50	0.40	60.40	0.15	24.00	19.00	24.80	7.72	8371.00	4.00	3.70	0.43	16.20	0.15	10.60	1536.00	1.20
BB+300_199	63.20	80.00	2.20	1.10	0.80	2.10	0.40	39.60	0.12	31.00	18.00	22.20	6.54	4187.00	4.00	2.70	0.38	13.00	0.21	10.50	45.00	1.20
BB+300_201	81.00	106.00	2.40	1.20	0.80	2.50	0.40	52.80	0.18	23.00	19.00	25.70	7.88	5104.00	4.00	3.70	0.47	16.50	0.16	11.10	62.00	1.20
BB+300_202	82.80	92.00	2.60	1.40	0.80	3.00	0.50	55.40	0.20	26.00	17.00	27.30	8.13	4857.00	4.00	4.20	0.46	17.50	0.18	13.60	43.00	1.50

9. BBCC+350

SAMPLE	Ce	Cu	Dy	Er	Eu	Gd	Ho	La	Lu	Mo	Nd	Pr	S	Sc	Sm	Tb	Tm	W	Yb
BB/CC+350_001	79.20	131.00	5.90	2.90	2.20	6.90	1.00	39.60	0.32	49.00	37.90	9.68	8253.00	29.00	7.50	1.07	0.36	160.00	2.20
BB/CC+350_002	106.50	302.00	1.80	0.90	0.90	2.10	0.30	78.00	0.19	302.00	28.80	9.56	14419.00	4.00	3.40	0.30	0.11	94.00	0.60
BB/CC+350_003	80.00	253.00	1.50	0.80	0.90	1.90	0.30	61.80	0.09	371.00	19.90	6.74	9382.00	3.00	2.50	0.26	0.14	2815.00	0.80
BB/CC+350_004	136.60	214.00	1.80	0.90	1.10	2.80	0.30	94.20	0.16	118.00	38.00	12.93	5865.00	4.00	4.60	0.36	0.14	147.00	0.90
BB/CC+350_006	143.00	203.00	1.80	0.70	0.90	2.70	0.30	102.10	0.17	136.00	40.80	13.43	7887.00	4.00	4.50	0.31	0.14	89.00	0.90
BB/CC+350_007	79.70	200.00	1.50	0.50	0.90	1.90	0.30	57.60	0.09	10000.00	23.40	7.39	30595.00	0.50	3.10	0.25	0.10	7536.00	0.70
BB/CC+350_008	152.20	348.00	1.50	1.00	1.00	2.50	0.30	115.40	0.15	354.00	41.30	13.50	17977.00	4.00	4.40	0.30	0.15	312.00	0.70
BB/CC+350_009	114.90	285.00	1.40	0.80	0.80	2.00	0.20	85.00	0.09	144.00	30.80	10.49	7749.00	4.00	3.50	0.26	0.11	83.00	0.70
BB/CC+350_011	131.30	298.00	1.40	0.70	1.00	2.40	0.30	78.30	0.12	170.00	33.60	11.14	18044.00	5.00	3.70	0.28	0.12	70.00	0.80
BB/CC+350_012	134.50	172.00	2.40	1.40	1.40	4.00	0.50	96.50	0.33	390.00	37.30	12.36	19768.00	3.00	5.00	0.53	0.18	45.00	0.90
BB/CC+350_013	134.20	199.00	1.90	1.00	1.10	3.10	0.30	85.00	0.13	28.00	40.80	13.47	8086.00	5.00	5.20	0.38	0.14	37.00	1.10
BB/CC+350_014	113.50	198.00	1.80	0.80	1.10	2.80	0.30	71.30	0.17	101.00	34.80	11.10	12463.00	4.00	4.70	0.32	0.14	30.00	0.70
BB/CC+350_016	141.10	233.00	1.60	0.80	1.10	2.40	0.30	97.70	0.10	265.00	38.00	13.09	8865.00	4.00	3.90	0.31	0.11	56.00	0.80
BB/CC+350_017	137.20	281.00	1.80	0.80	1.30	2.30	0.30	99.60	0.10	396.00	37.60	12.57	11797.00	3.00	4.40	0.33	0.13	135.00	0.80
BB/CC+350_018	149.50	243.00	1.70	0.90	1.30	2.90	0.30	104.10	0.14	43.00	41.30	14.17	7538.00	4.00	4.60	0.27	0.12	259.00	0.90
BB/CC+350_019	114.20	174.00	2.10	1.00	1.20	3.00	0.30	69.40	0.11	43.00	36.20	11.78	6661.00	4.00	4.40	0.33	0.16	23.00	1.00
BB/CC+350_021	121.30	156.00	1.90	1.00	1.20	3.00	0.40	74.40	0.15	24.00	39.30	11.91	5354.00	3.00	4.70	0.41	0.14	49.00	1.00
BB/CC+350_022	34.30	50.00	0.80	0.40	0.50	1.00	0.20	21.90	0.03	159.00	11.60	3.55	943.00	2.00	1.70	0.15	0.05	4924.00	0.30
BB/CC+350_023	175.40	189.00	2.10	1.20	1.60	4.00	0.40	119.60	0.16	45.00	51.80	16.63	8045.00	5.00	6.00	0.45	0.17	1464.00	1.00
BB/CC+350_024	78.70	314.00	1.10	0.60	0.80	1.70	0.30	59.40	0.16	837.00	22.90	7.38	13046.00	3.00	2.60	0.23	0.10	5649.00	0.70
BB/CC+350_026	159.90	256.00	2.50	1.30	1.50	2.90	0.50	110.30	0.21	140.00	46.30	15.92	8105.00	4.00	5.80	0.47	0.18	59.00	1.20
BB/CC+350_027	244.50	286.00	2.70	1.20	1.70	3.80	0.40	162.80	0.15	55.00	74.70	24.04	5908.00	4.00	7.30	0.51	0.16	202.00	1.10
BB/CC+350_028	165.90	251.00	2.50	1.20	1.60	3.50	0.50	112.90	0.20	87.00	51.50	16.57	6045.00	5.00	6.40	0.48	0.20	181.00	1.20
BB/CC+350_029	91.50	493.00	1.40	0.80	1.00	2.10	0.30	62.30	0.08	205.00	30.20	9.60	16705.00	3.00	2.90	0.24	0.10	1501.00	0.70

BB/CC+350_031	158.30	303.00	2.10	1.10	1.60	3.40	0.50	103.00	0.17	23.00	50.00	15.69	11963.00	4.00	5.60	0.45	0.18	136.00	0.90
BB/CC+350_032	211.20	220.00	2.00	1.00	2.00	4.00	0.50	154.20	0.13	201.00	63.40	20.55	8092.00	4.00	6.60	0.48	0.17	230.00	1.00
BB/CC+350_033	200.90	258.00	2.00	1.00	1.90	3.60	0.40	145.40	0.11	300.00	55.80	18.36	9312.00	5.00	5.90	0.38	0.16	1705.00	1.10
BB/CC+350_034	153.10	483.00	1.60	0.80	1.60	2.50	0.20	122.80	0.10	163.00	40.00	13.87	22650.00	4.00	4.70	0.31	0.13	587.00	0.70
BB/CC+350_036	2765.20	581.00	9.70	4.00	12.60	24.30	1.60	1603.30	0.39	188.00	802.00	272.41	38427.00	6.00	60.80	2.22	0.48	4458.00	2.60
BB/CC+350_037	91.10	44.00	1.20	0.60	0.90	1.80	0.20	55.00	0.08	19.00	27.10	9.35	6470.00	1.00	3.30	0.26	0.08	35.00	0.50
BB/CC+350_038	1452.50	528.00	5.20	2.10	7.50	13.20	0.90	842.80	0.21	70.00	409.60	139.38	31956.00	4.00	32.50	1.19	0.25	668.00	1.70
BB/CC+350_039	497.50	400.00	3.10	1.60	2.80	5.70	0.60	279.00	0.22	59.00	137.50	45.67	16809.00	4.00	12.10	0.67	0.22	875.00	1.50
BB/CC+350_041	259.70	368.00	1.90	0.90	1.80	3.40	0.40	180.10	0.13	78.00	71.20	24.15	15496.00	3.00	6.60	0.42	0.13	4247.00	0.70
BB/CC+350_042	600.20	929.00	3.40	1.60	3.70	6.50	0.60	366.80	0.21	117.00	166.40	55.98	21191.00	4.00	14.10	0.73	0.23	2202.00	1.60
BB/CC+350_043	219.30	358.00	2.70	1.50	1.80	4.00	0.50	139.30	0.18	40.00	64.50	21.21	15299.00	4.00	6.90	0.47	0.18	796.00	1.50
BB/CC+350_044	659.20	530.00	3.90	1.80	4.00	7.40	0.70	400.30	0.28	58.00	181.00	60.28	22709.00	5.00	15.60	0.83	0.30	4781.00	1.60
BB/CC+350_046	2559.60	545.00	10.20	4.20	15.10	25.60	1.70	1441.40	0.44	39.00	795.50	263.74	22832.00	5.00	67.40	2.25	0.54	2411.00	3.40
BB/CC+350_047	2884.30	1073.00	9.00	3.80	14.20	24.10	1.60	1690.50	0.53	61.00	829.60	284.21	41639.00	6.00	66.50	2.23	0.46	7202.00	3.00
BB/CC+350_048	313.70	375.00	2.90	1.40	2.40	4.60	0.50	224.00	0.18	73.00	85.60	29.56	13777.00	4.00	8.20	0.53	0.18	743.00	1.30
BB/CC+350_049	37.40	31.00	0.40	0.20	0.20	0.50	0.05	21.50	0.03	3.00	11.40	3.82	752.00	0.50	1.10	0.06	0.03	178.00	0.10
BB/CC+350_051	383.10	596.00	3.60	1.90	2.70	5.60	0.70	247.30	0.25	52.00	103.70	35.02	20925.00	5.00	10.50	0.70	0.23	1211.00	1.70
BB/CC+350_052	674.80	1284.00	3.90	1.80	3.20	7.20	0.70	455.60	0.22	128.00	172.20	58.37	40241.00	6.00	15.50	0.80	0.28	6263.00	1.70
BB/CC+350_053	301.80	616.00	3.00	1.40	2.30	4.50	0.50	216.30	0.22	53.00	85.60	28.95	18122.00	4.00	8.70	0.60	0.24	1174.00	1.40
BB/CC+350_054	419.10	561.00	3.40	1.50	2.70	6.10	0.60	247.30	0.20	139.00	119.40	39.05	22131.00	4.00	12.20	0.73	0.25	1648.00	1.50
BB/CC+350_056	279.10	367.00	2.80	1.60	2.00	4.30	0.50	185.50	0.20	44.00	79.50	26.69	15862.00	4.00	8.20	0.49	0.22	858.00	1.40
BB/CC+350_057	191.10	412.00	2.40	1.40	1.60	3.90	0.50	129.50	0.13	127.00	53.10	18.04	17372.00	4.00	6.40	0.44	0.22	378.00	1.30
BB/CC+350_058	544.70	366.00	3.70	1.70	2.90	6.20	0.60	329.10	0.46	67.00	144.00	49.08	14626.00	5.00	11.80	0.69	0.22	1381.00	1.50
BB/CC+350_059	227.60	486.00	2.80	1.40	1.80	4.10	0.50	150.90	0.21	54.00	64.40	21.41	18389.00	5.00	6.70	0.55	0.21	1530.00	1.40
BB/CC+350_061	263.80	427.00	2.80	1.50	2.00	4.60	0.50	176.00	0.19	76.00	73.70	25.17	16417.00	5.00	7.80	0.57	0.22	2710.00	1.60
BB/CC+350_062	31.10	21.00	0.10	0.05	0.10	0.30	0.05	20.30	0.03	58.00	8.90	2.93	3399.00	0.50	0.60	0.03	0.03	80.00	0.05
BB/CC+350_063	137.70	535.00	1.20	0.70	0.80	2.20	0.30	95.10	0.15	89.00	38.80	12.89	4134.00	3.00	4.10	0.22	0.12	109.00	0.80
BB/CC+350_064	304.80	643.00	2.40	1.20	2.00	4.20	0.40	195.00	0.15	451.00	82.90	29.22	25574.00	5.00	7.70	0.46	0.18	4185.00	1.20
BB/CC+350_066	276.50	522.00	3.00	1.70	2.10	4.50	0.60	184.90	0.25	196.00	76.70	26.27	18362.00	6.00	7.40	0.57	0.22	2088.00	1.70

BB/CC+350_067	278.30	403.00	2.80	1.40	2.20	4.40	0.50	172.70	0.17	57.00	80.10	27.28	16964.00	4.00	8.80	0.52	0.21	1337.00	1.30
BB/CC+350_068	174.00	504.00	2.60	1.40	1.50	3.50	0.40	113.80	0.25	160.00	52.10	16.94	20830.00	6.00	6.00	0.50	0.22	255.00	1.40
BB/CC+350_069	280.30	605.00	2.70	1.30	2.00	4.30	0.50	185.10	0.35	1286.00	79.40	27.22	33086.00	5.00	8.00	0.50	0.20	2332.00	1.30
BB/CC+350_071	1247.80	498.00	4.30	2.10	5.90	10.40	0.80	749.90	0.25	80.00	330.80	116.34	19796.00	6.00	27.00	1.04	0.25	1855.00	1.90
BB/CC+350_072	642.80	436.00	3.20	1.60	2.80	6.00	0.60	433.60	0.21	142.00	159.60	55.94	19904.00	6.00	13.10	0.64	0.22	1666.00	1.50
BB/CC+350_073	211.60	335.00	2.00	1.20	1.30	3.30	0.40	154.50	0.21	85.00	55.00	18.94	14290.00	4.00	5.60	0.43	0.19	715.00	1.30
BB/CC+350_074	51.80	89.00	1.60	0.80	0.60	1.70	0.30	30.20	0.16	98.00	17.50	5.38	4666.00	3.00	2.60	0.24	0.16	70.00	1.00
BB/CC+350_076	53.50	113.00	1.60	0.90	0.50	1.80	0.30	35.00	0.17	87.00	17.40	5.25	5962.00	3.00	2.60	0.24	0.15	129.00	1.00
BB/CC+350_077	54.00	126.00	1.50	0.90	0.60	1.90	0.30	35.00	0.16	106.00	17.50	5.51	6068.00	3.00	2.70	0.26	0.16	177.00	0.90
BB/CC+350_078	71.80	296.00	1.70	0.90	0.70	2.20	0.30	55.20	0.15	105.00	20.20	6.63	27258.00	4.00	2.70	0.30	0.17	622.00	1.10
BB/CC+350_079	53.30	112.00	1.50	0.90	0.60	1.70	0.30	34.70	0.18	40.00	17.60	5.35	6297.00	4.00	2.60	0.28	0.14	154.00	1.00
BB/CC+350_081	54.70	286.00	1.50	0.90	0.50	1.50	0.30	38.20	0.17	499.00	16.30	5.36	11511.00	3.00	2.50	0.25	0.16	706.00	0.90
BB/CC+350_082	26.20	896.00	1.00	0.50	0.40	1.30	0.20	19.90	0.06	107.00	9.00	2.65	40710.00	2.00	1.40	0.16	0.10	11817.00	0.40
BB/CC+350_083	63.60	231.00	1.60	1.00	0.70	1.90	0.40	42.60	0.20	25.00	19.20	6.34	13384.00	4.00	2.70	0.29	0.17	348.00	1.20
BB/CC+350_084	67.30	166.00	1.60	0.90	0.70	2.20	0.30	41.80	0.18	98.00	21.00	6.91	9031.00	3.00	3.30	0.31	0.15	178.00	0.90
BB/CC+350_086	9.80	390.00	0.40	0.20	0.20	0.40	0.05	6.10	0.03	100.00	3.60	1.07	36937.00	0.50	0.70	0.08	0.03	6669.00	0.05
BB/CC+350_087	84.90	769.00	1.50	0.90	0.70	1.90	0.30	67.10	0.14	756.00	23.10	7.86	31508.00	3.00	2.60	0.32	0.15	573.00	0.90
BB/CC+350_088	236.60	1964.00	2.60	1.20	1.20	3.40	0.40	224.60	0.16	649.00	50.30	18.44	82155.00	5.00	5.20	0.48	0.19	3226.00	1.20
BB/CC+350_089	64.50	254.00	1.40	0.80	0.60	1.90	0.30	42.00	0.13	126.00	20.20	6.46	10598.00	3.00	2.60	0.29	0.15	159.00	1.10
BB/CC+350_091	58.70	148.00	1.40	1.00	0.60	2.00	0.30	37.70	0.11	214.00	18.70	5.89	6997.00	3.00	2.80	0.28	0.16	103.00	1.00
BB/CC+350_092	50.80	166.00	1.60	0.80	0.50	1.70	0.30	33.90	0.15	98.00	15.30	5.00	7113.00	3.00	2.10	0.25	0.15	143.00	0.80
BB/CC+350_093	61.50	145.00	1.70	1.10	0.70	2.10	0.40	39.40	0.16	191.00	19.20	5.99	6718.00	3.00	2.90	0.29	0.14	49.00	1.10
BB/CC+350_094	56.70	207.00	1.80	1.00	0.60	1.80	0.30	37.90	0.18	154.00	16.60	5.30	8216.00	3.00	2.40	0.28	0.15	434.00	0.90
BB/CC+350_096	58.00	335.00	1.70	0.70	0.50	1.60	0.30	38.10	0.13	82.00	18.10	5.74	19866.00	3.00	2.60	0.25	0.13	1217.00	1.00
BB/CC+350_097	19.00	353.00	0.80	0.50	0.30	1.00	0.20	11.40	0.05	502.00	7.20	2.03	16161.00	1.00	1.20	0.14	0.08	13228.00	0.50
BB/CC+350_098	57.30	116.00	1.70	0.90	0.60	2.10	0.40	34.40	0.18	42.00	19.00	5.86	5598.00	4.00	2.80	0.35	0.20	123.00	1.10
BB/CC+350_099	57.70	138.00	1.90	1.10	0.60	2.20	0.40	36.50	0.18	58.00	18.50	5.80	6568.00	4.00	2.60	0.35	0.19	219.00	1.20
BB/CC+350_101	58.40	113.00	2.00	1.10	0.70	2.10	0.30	36.40	0.17	32.00	19.20	5.95	5195.00	3.00	3.10	0.35	0.19	87.00	1.00
BB/CC+350_102	65.30	190.00	1.70	1.00	0.70	2.10	0.40	42.50	0.16	601.00	20.90	6.34	6520.00	3.00	2.80	0.31	0.16	235.00	1.00

BB/CC+350_103	61.20	171.00	1.80	1.00	0.60	2.20	0.30	37.50	0.16	313.00	21.40	6.44	6656.00	3.00	3.00	0.33	0.14	147.00	1.10
BB/CC+350_104	84.40	281.00	2.20	1.00	0.80	2.40	0.40	58.60	0.24	111.00	25.00	8.29	12150.00	4.00	3.30	0.35	0.15	86.00	1.00
BB/CC+350_106	98.60	338.00	1.80	0.80	0.80	2.10	0.30	82.50	0.14	229.00	26.50	8.74	14444.00	3.00	3.10	0.34	0.15	423.00	0.80
BB/CC+350_107	64.20	241.00	1.60	0.90	0.60	2.10	0.30	44.20	0.10	827.00	20.50	6.32	10015.00	3.00	2.50	0.34	0.13	306.00	1.00
BB/CC+350_108	76.00	217.00	1.80	1.10	0.70	2.40	0.40	47.60	0.13	145.00	24.70	7.72	7699.00	4.00	3.50	0.34	0.16	100.00	1.00
BB/CC+350_109	69.60	444.00	1.60	0.80	0.70	2.20	0.30	48.40	0.13	226.00	21.60	6.68	22464.00	4.00	3.10	0.30	0.13	463.00	0.70
BB/CC+350_111	68.50	364.00	1.80	0.90	0.70	2.40	0.40	42.90	0.14	63.00	21.10	7.00	31803.00	4.00	3.50	0.34	0.16	314.00	1.00
BB/CC+350_112	82.40	183.00	1.70	0.90	0.70	2.20	0.30	53.90	0.15	73.00	24.70	8.02	9870.00	4.00	3.40	0.28	0.14	24.00	0.90
BB/CC+350_113	73.90	159.00	1.50	0.80	0.60	2.00	0.30	50.30	0.11	210.00	21.50	7.24	16195.00	3.00	2.60	0.27	0.13	20.00	0.80
BB/CC+350_114	46.80	285.00	0.70	0.40	0.40	1.10	0.10	31.50	0.03	153.00	14.40	4.50	10140.00	2.00	1.90	0.13	0.05	12.00	0.40
BB/CC+350_116	63.20	271.00	2.60	1.00	0.80	3.00	0.40	40.00	0.18	126.00	21.50	6.47	13032.00	3.00	3.40	0.46	0.14	18.00	1.10
BB/CC+350_117	57.30	129.00	1.60	0.90	0.60	2.00	0.30	34.80	0.11	81.00	18.10	5.78	5849.00	3.00	2.60	0.29	0.11	183.00	0.80
BB/CC+350_118	77.90	222.00	2.40	1.20	0.90	3.00	0.50	51.50	0.18	1164.00	24.30	7.68	8475.00	4.00	3.90	0.50	0.17	266.00	1.10
BB/CC+350_119	71.10	205.00	2.20	1.10	0.70	3.00	0.40	45.30	0.17	189.00	22.50	7.25	7257.00	4.00	3.60	0.43	0.19	351.00	1.20
BB/CC+350_121	67.50	180.00	2.00	1.10	0.70	2.70	0.40	41.60	0.18	110.00	22.80	6.75	9355.00	3.00	3.50	0.40	0.17	222.00	1.10
BB/CC+350_122	67.90	133.00	2.00	1.00	0.70	2.50	0.40	42.00	0.14	71.00	22.10	6.88	6494.00	3.00	3.50	0.38	0.17	161.00	1.00
BB/CC+350_123	82.70	211.00	2.30	1.20	0.80	2.80	0.40	56.00	0.19	142.00	25.10	7.80	10840.00	4.00	3.90	0.38	0.17	484.00	0.90
BB/CC+350_124	76.30	158.00	2.30	1.40	0.90	2.60	0.50	53.70	0.16	56.00	23.60	7.71	6822.00	4.00	3.20	0.46	0.17	621.00	1.20
BB/CC+350_126	79.90	189.00	2.30	1.30	0.90	2.90	0.50	57.40	0.15	58.00	24.10	7.84	7121.00	4.00	3.70	0.46	0.18	515.00	1.10
BB/CC+350_127	88.30	178.00	2.30	1.10	0.70	3.10	0.40	63.50	0.16	47.00	26.50	8.69	6684.00	4.00	4.10	0.40	0.16	421.00	1.00
BB/CC+350_128	82.20	118.00	2.70	1.40	0.80	2.90	0.50	53.90	0.17	45.00	25.70	8.36	6189.00	4.00	3.80	0.49	0.20	814.00	1.40
BB/CC+350_129	78.80	124.00	2.70	1.40	0.80	2.90	0.40	50.20	0.18	81.00	25.60	8.09	6311.00	3.00	3.90	0.45	0.20	110.00	1.20
BB/CC+350_131	81.40	206.00	2.30	1.00	0.80	2.30	0.40	57.50	0.18	170.00	25.00	7.80	9060.00	4.00	3.50	0.38	0.16	1153.00	1.10
BB/CC+350_132	101.10	236.00	2.40	1.20	0.90	3.10	0.40	79.40	0.15	74.00	28.50	9.18	12578.00	5.00	3.90	0.41	0.15	3129.00	1.10
BB/CC+350_133	80.50	137.00	2.20	1.10	0.70	2.70	0.40	50.40	0.16	73.00	25.40	8.00	7533.00	3.00	3.90	0.37	0.18	159.00	1.00
BB/CC+350_134	72.70	160.00	2.20	1.20	0.60	2.70	0.40	44.30	0.17	303.00	23.30	7.52	7750.00	3.00	3.60	0.39	0.16	250.00	1.10
BB/CC+350_136	77.10	135.00	2.40	1.10	0.80	2.60	0.50	47.10	0.15	57.00	24.60	7.67	6376.00	3.00	3.60	0.42	0.15	121.00	1.00
BB/CC+350_137	79.80	227.00	2.40	1.30	0.80	2.70	0.40	53.30	0.17	126.00	24.20	7.97	7093.00	3.00	3.40	0.44	0.14	78.00	1.10
BB/CC+350_138	78.50	139.00	2.30	1.20	0.80	2.80	0.40	47.70	0.16	203.00	26.10	7.86	7510.00	4.00	3.90	0.43	0.18	346.00	1.10

BB/CC+350_139	72.50	111.00	2.50	1.00	0.80	2.90	0.40	44.30	0.14	273.00	24.50	7.40	5641.00	3.00	3.70	0.39	0.15	209.00	1.10
BB/CC+350_141	78.50	131.00	2.50	1.30	0.80	2.60	0.40	47.90	0.10	35.00	25.00	7.92	6089.00	3.00	3.60	0.43	0.16	150.00	1.00
BB/CC+350_142	84.40	171.00	2.40	1.10	0.80	3.20	0.50	53.80	0.16	49.00	27.20	8.68	7299.00	4.00	4.00	0.43	0.15	151.00	1.10
BB/CC+350_143	81.50	160.00	2.70	1.30	0.80	3.00	0.40	52.90	0.17	250.00	26.30	8.27	7224.00	3.00	4.20	0.43	0.16	212.00	1.30
BB/CC+350_144	67.90	109.00	2.10	1.10	0.80	2.50	0.40	41.30	0.17	431.00	22.40	6.73	10991.00	3.00	3.40	0.36	0.17	452.00	1.00
BB/CC+350_146	77.50	169.00	2.40	1.10	0.80	2.40	0.40	50.00	0.13	51.00	23.80	7.66	9491.00	3.00	3.20	0.40	0.18	90.00	1.10
BB/CC+350_147	76.00	147.00	2.60	1.00	0.70	3.00	0.40	51.50	0.17	92.00	24.50	7.69	6814.00	3.00	3.40	0.36	0.17	133.00	1.10
BB/CC+350_148	82.20	137.00	2.30	1.20	0.90	3.30	0.40	53.00	0.17	60.00	26.70	8.23	5487.00	3.00	4.30	0.45	0.18	137.00	1.10
BB/CC+350_149	80.50	126.00	2.30	1.30	0.90	3.20	0.50	50.30	0.18	20.00	26.20	8.25	6340.00	3.00	3.70	0.47	0.20	12.00	1.10
BB/CC+350_151	98.10	105.00	2.40	1.20	1.10	2.70	0.50	76.30	0.15	53.00	28.60	9.50	4846.00	3.00	3.80	0.45	0.16	940.00	1.10
BB/CC+350_152	81.40	191.00	2.50	1.50	0.90	2.90	0.40	52.80	0.16	523.00	25.00	8.07	9869.00	4.00	3.60	0.39	0.18	803.00	1.10
BB/CC+350_153	3.60	813.00	0.20	0.05	0.05	0.10	0.05	1.90	0.03	683.00	1.40	0.33	35192.00	7.00	0.20	0.03	0.03	4.00	0.05
BB/CC+350_154	84.90	307.00	2.40	1.20	0.80	2.60	0.50	59.40	0.16	147.00	25.60	8.24	11608.00	4.00	3.80	0.45	0.21	378.00	1.20
BB/CC+350_156	82.10	226.00	2.50	1.20	0.80	2.80	0.40	53.60	0.18	455.00	25.10	8.08	9433.00	4.00	4.00	0.36	0.18	279.00	1.20
BB/CC+350_157	75.90	150.00	1.90	1.10	0.70	2.90	0.40	46.00	0.15	250.00	26.10	7.86	7888.00	3.00	4.30	0.39	0.15	109.00	1.00
BB/CC+350_158	78.20	246.00	2.00	1.00	0.70	2.50	0.40	49.30	0.14	208.00	25.90	7.97	14292.00	3.00	3.70	0.36	0.16	314.00	0.90

10. CC+200

Sample	Ce	Cu	Dy	Er	Eu	Gd	Ho	La	Lu	Mo	Nb	Nd	Pr	S	Sc	Sm	Tb	Th	Tm	U	W	Yb
CC+200_001	49.20	279.00	4.00	1.80	1.50	5.00	0.70	23.90	0.28	11.00	28.00	26.00	5.94	18405.00	33.00	5.50	0.75	2.00	0.23	1.90	259.00	1.40
CC+200_002	150.80	291.00	2.00	0.90	1.60	3.00	0.30	74.40	0.19	27.00	16.00	55.90	16.62	11475.00	6.00	6.30	0.41	13.20	0.13	6.80	1829.00	0.80
CC+200_003	263.20	259.00	2.30	1.00	2.10	4.10	0.40	152.90	0.22	16.00	17.00	84.90	26.01	11436.00	4.00	8.50	0.49	10.90	0.15	6.50	2403.00	1.00
CC+200_004	151.10	264.00	1.80	1.00	1.40	2.70	0.30	77.80	0.19	27.00	17.00	50.80	15.66	11487.00	5.00	5.50	0.37	16.70	0.13	4.30	1109.00	0.90
CC+200_006	117.10	251.00	1.50	0.70	1.00	2.20	0.30	70.10	0.17	12.00	14.00	36.80	11.65	10338.00	6.00	3.90	0.31	17.70	0.11	4.60	1236.00	0.80
CC+200_007	72.00	253.00	1.20	0.70	0.80	1.60	0.20	46.20	0.15	153.00	13.00	20.70	6.52	9664.00	5.00	2.20	0.18	14.20	0.13	5.50	1385.00	0.70
CC+200_008	195.00	422.00	2.40	1.20	1.60	3.50	0.40	105.60	0.23	29.00	15.00	64.40	19.96	16710.00	5.00	6.80	0.45	15.70	0.15	8.90	2780.00	1.10
CC+200_009	184.90	298.00	1.90	0.90	1.40	2.80	0.30	115.40	0.21	17.00	18.00	53.20	16.63	12550.00	8.00	5.60	0.36	27.80	0.12	8.50	1214.00	1.00
CC+200_011	150.20	222.00	1.70	0.80	1.00	2.50	0.20	99.00	0.16	10.00	16.00	43.30	13.89	8729.00	6.00	4.60	0.31	23.20	0.13	6.60	1168.00	0.80
CC+200_012	159.30	185.00	1.80	0.90	1.10	2.70	0.30	100.30	0.18	4.00	16.00	43.10	13.77	9284.00	4.00	4.60	0.36	22.40	0.14	7.00	671.00	1.00
CC+200_013	106.30	261.00	1.50	0.90	0.80	2.10	0.30	69.70	0.19	231.00	13.00	31.20	9.93	12213.00	4.00	3.80	0.27	18.40	0.13	5.60	1842.00	0.70
CC+200_014	58.80	209.00	1.00	0.50	0.60	1.10	0.20	38.80	0.17	5.00	11.00	17.60	5.44	8423.00	3.00	2.00	0.18	13.50	0.07	3.40	906.00	0.50
CC+200_016	94.60	221.00	1.00	0.50	0.80	1.50	0.20	70.50	0.11	6.00	13.00	25.50	8.06	10089.00	3.00	2.70	0.19	21.80	0.07	5.90	1228.00	0.60
CC+200_017	108.40	331.00	1.20	0.60	0.90	1.80	0.20	86.60	0.10	6.00	12.00	28.90	9.30	14221.00	3.00	3.00	0.21	19.90	0.09	4.60	1563.00	0.50
CC+200_018	60.90	152.00	0.80	0.40	0.60	1.20	0.10	43.90	0.10	11.00	10.00	16.60	5.28	10157.00	4.00	1.70	0.14	13.50	0.07	3.40	2405.00	0.50
CC+200_019	7.40	31.00	0.30	0.20	0.20	0.20	0.05	4.70	0.03	1.00	5.00	2.30	0.67	1789.00	3.00	0.40	0.03	2.20	0.03	0.70	4504.00	0.10
CC+200_021	74.40	233.00	1.00	0.50	0.70	1.50	0.20	52.80	0.12	8.00	14.00	20.00	6.55	10620.00	4.00	2.40	0.19	20.30	0.07	5.20	1161.00	0.50
CC+200_022	119.20	231.00	1.30	0.70	1.00	1.80	0.20	87.30	0.11	4.00	14.00	30.80	10.24	9253.00	9.00	3.60	0.26	18.70	0.11	5.60	1000.00	0.70
CC+200_023	86.90	286.00	1.10	0.60	0.80	1.40	0.20	71.80	0.11	6.00	14.00	21.90	7.15	11938.00	7.00	2.20	0.18	15.30	0.09	4.70	1788.00	0.70
CC+200_024	86.00	240.00	1.00	0.50	0.70	1.30	0.20	64.80	0.14	8.00	12.00	21.40	7.08	9638.00	5.00	2.40	0.17	16.00	0.09	4.20	1281.00	0.50
CC+200_026	89.00	206.00	0.80	0.50	0.50	1.20	0.10	78.40	0.14	5.00	10.00	20.00	6.94	7472.00	5.00	2.00	0.13	13.30	0.07	3.60	1291.00	0.50
CC+200_027	97.50	178.00	1.20	0.60	1.30	1.50	0.20	72.50	0.13	15.00	11.00	25.60	8.31	8249.00	5.00	2.80	0.24	13.20	0.09	3.40	1655.00	0.70
CC+200_028	119.90	418.00	1.60	0.80	1.10	2.10	0.30	97.70	0.16	33.00	15.00	32.90	10.86	20860.00	12.00	3.70	0.32	14.70	0.12	5.40	6950.00	0.90
CC+200_029	153.70	261.00	1.70	0.90	1.10	2.40	0.30	108.20	0.17	412.00	15.00	42.80	14.10	14381.00	6.00	4.90	0.32	19.60	0.12	16.70	4291.00	0.80

CC+200_031	125.60	335.00	1.70	0.90	1.00	2.30	0.30	75.50	0.17	7.00	17.00	38.40	11.78	13038.00	5.00	4.50	0.30	22.50	0.12	9.10	1562.00	1.00
CC+200_032	114.00	197.00	1.40	0.70	0.80	1.90	0.20	75.70	0.15	180.00	14.00	32.90	10.43	5121.00	4.00	3.60	0.26	20.30	0.10	6.10	1744.00	0.70
CC+200_033	128.90	214.00	1.60	0.70	1.00	2.10	0.30	84.60	0.15	12.00	10.00	37.40	12.04	5573.00	4.00	4.10	0.25	17.40	0.11	5.70	1650.00	0.70
CC+200_034	157.10	199.00	1.70	0.80	1.00	2.70	0.30	103.40	0.18	129.00	14.00	42.10	14.01	16259.00	4.00	4.80	0.30	22.70	0.10	7.40	998.00	0.80
CC+200_036	162.60	153.00	2.50	1.30	1.20	3.30	0.50	95.50	0.20	12.00	16.00	51.60	15.72	5954.00	5.00	6.30	0.49	26.90	0.18	12.40	588.00	1.30
CC+200_037	166.30	141.00	2.10	1.00	1.30	3.40	0.40	102.30	0.27	3.00	13.00	49.70	16.13	5974.00	4.00	5.90	0.39	25.40	0.14	9.60	522.00	1.00
CC+200_038	152.50	200.00	1.40	0.70	1.00	2.30	0.30	101.00	0.18	1.00	15.00	39.60	13.23	8452.00	6.00	4.00	0.26	16.50	0.10	4.90	561.00	0.70
CC+200_039	110.10	179.00	1.20	0.60	0.90	2.00	0.20	71.40	0.13	6.00	10.00	31.50	10.30	9039.00	5.00	3.40	0.24	16.70	0.10	4.60	1232.00	0.60
CC+200_041	68.30	168.00	1.50	0.70	0.70	1.70	0.30	45.60	0.13	51.00	13.00	21.40	6.46	9359.00	3.00	2.60	0.26	13.40	0.11	5.20	1198.00	0.80
CC+200_042	70.00	169.00	1.50	0.80	0.70	1.90	0.30	46.30	0.16	47.00	13.00	21.50	6.71	9626.00	3.00	2.60	0.25	13.70	0.11	5.90	1240.00	0.80
CC+200_043	109.50	221.00	1.30	0.60	1.00	1.60	0.20	74.40	0.13	8.00	14.00	31.00	10.13	10510.00	4.00	3.50	0.23	17.30	0.08	4.90	1772.00	0.60
CC+200_044	153.00	210.00	1.70	0.80	1.60	2.70	0.30	88.30	0.14	9.00	13.00	47.60	14.67	10119.00	5.00	5.00	0.34	19.80	0.10	5.60	1986.00	0.80
CC+200_046	143.00	244.00	1.20	0.60	1.30	1.90	0.20	80.70	0.13	19.00	13.00	45.60	14.49	11426.00	6.00	4.30	0.27	12.20	0.11	3.40	3761.00	0.70
CC+200_047	125.30	203.00	1.40	0.70	1.30	2.20	0.30	65.10	0.11	9.00	12.00	43.80	13.79	9361.00	4.00	4.30	0.24	13.40	0.10	3.30	2350.00	0.70
CC+200_048	133.30	191.00	1.50	0.80	1.40	2.40	0.30	71.60	0.13	7.00	16.00	46.40	14.06	9055.00	5.00	4.80	0.26	13.20	0.09	3.30	1909.00	0.70
CC+200_049	98.20	208.00	1.20	0.60	1.00	1.60	0.20	58.00	0.10	6.00	12.00	30.60	9.58	8707.00	5.00	3.40	0.20	15.70	0.11	3.90	990.00	0.60
CC+200_051	126.00	206.00	1.20	0.60	1.10	1.70	0.20	71.60	0.13	8.00	12.00	38.20	12.45	9838.00	5.00	3.70	0.21	14.10	0.10	3.70	2179.00	0.60
CC+200_052	200.50	181.00	1.30	0.70	1.50	2.30	0.20	122.50	0.12	7.00	16.00	57.20	19.26	9612.00	4.00	5.10	0.25	8.00	0.09	3.50	1828.00	0.80
CC+200_053	329.00	216.00	1.60	0.70	1.90	2.60	0.30	211.60	0.21	11.00	19.00	86.70	29.99	9650.00	5.00	6.70	0.31	13.60	0.13	5.20	1941.00	0.90
CC+200_054	207.60	184.00	1.60	0.80	1.60	2.60	0.30	120.50	0.17	12.00	18.00	64.20	20.78	9635.00	6.00	5.90	0.30	8.90	0.12	4.60	2812.00	0.80
CC+200_056	218.80	169.00	1.50	0.70	1.60	2.60	0.30	136.70	0.16	18.00	17.00	61.80	20.08	8789.00	4.00	5.70	0.25	8.60	0.09	4.60	2287.00	0.90
CC+200_057	234.00	178.00	1.90	0.90	1.70	2.90	0.30	138.40	0.22	14.00	19.00	67.60	22.40	11203.00	6.00	6.10	0.34	11.30	0.13	5.00	5313.00	1.00
CC+200_058	255.50	175.00	1.90	1.00	2.00	3.00	0.30	143.30	0.16	15.00	25.00	78.60	25.54	9855.00	6.00	7.10	0.35	7.10	0.16	4.40	5594.00	0.90
CC+200_059	605.80	168.00	2.50	1.20	3.60	4.90	0.40	330.40	0.34	6.00	25.00	179.70	59.26	7083.00	4.00	14.30	0.44	14.20	0.17	7.60	2760.00	1.30
CC+200_061	1210.20	195.00	4.70	1.80	8.00	9.90	0.70	597.80	0.31	19.00	22.00	370.80	120.60	11267.00	5.00	30.60	0.89	15.90	0.26	17.40	6989.00	1.70
CC+200_062	915.20	178.00	3.70	1.60	6.20	7.90	0.60	459.20	0.23	26.00	20.00	286.90	89.97	11095.00	5.00	22.80	0.70	11.80	0.22	12.00	6513.00	1.50
CC+200_063	985.50	179.00	4.30	1.90	7.10	9.50	0.70	493.60	0.30	26.00	25.00	311.60	100.81	7227.00	5.00	26.00	0.81	10.40	0.29	13.00	6901.00	1.70
CC+200_064	1770.30	166.00	6.80	2.70	11.80	16.40	1.10	898.40	0.36	21.00	25.00	547.90	178.75	7615.00	5.00	44.00	1.38	13.20	0.38	26.90	3638.00	2.50
CC+200_066	1015.90	151.00	4.20	1.80	6.90	8.50	0.70	520.20	0.27	16.00	26.00	304.10	99.87	7515.00	5.00	24.80	0.79	12.00	0.29	16.40	4123.00	1.80

CC+200_067	3457.70	238.00	12.50	5.00	23.00	29.30	2.10	1807.70	0.57	20.00	24.00	1092.80	353.35	9943.00	5.00	87.20	2.68	19.80	0.65	48.80	4618.00	3.70
CC+200_068	4563.80	301.00	15.80	5.60	29.50	40.50	2.50	2349.30	0.67	22.00	25.00	1430.10	459.03	11979.00	6.00	112.60	3.34	24.10	0.82	55.40	4896.00	4.50
CC+200_069	1957.50	516.00	6.50	2.60	11.30	15.20	1.00	1042.50	0.39	22.00	27.00	575.10	188.16	18435.00	6.00	44.40	1.14	14.80	0.37	33.60	9028.00	2.80
CC+200_071	4073.10	399.00	13.80	5.10	25.80	34.60	2.10	2076.00	0.56	30.00	17.00	1230.80	402.08	16426.00	6.00	99.20	2.81	17.10	0.65	45.60	10016.00	3.70
CC+200_072	5827.60	730.00	20.00	7.40	37.70	48.90	3.20	2925.40	0.75	62.00	15.00	1830.30	592.75	35705.00	7.00	144.90	3.85	18.30	0.96	81.20	23657.00	5.30
CC+200_073	933.80	216.00	3.00	1.30	4.40	5.90	0.50	509.90	0.25	10.00	25.00	237.50	82.20	14757.00	5.00	16.70	0.54	25.80	0.20	16.00	2615.00	1.50
CC+200_074	833.90	257.00	2.50	1.20	3.70	4.50	0.40	501.70	0.23	10.00	19.00	201.20	72.45	12073.00	5.00	13.80	0.44	17.40	0.19	8.70	3949.00	1.20
CC+200_076	508.20	365.00	2.70	1.30	2.90	4.80	0.40	291.50	0.21	44.00	17.00	142.30	46.52	26420.00	5.00	12.00	0.56	19.20	0.21	6.60	6883.00	1.30
CC+200_077	722.30	319.00	2.80	1.30	3.70	5.60	0.50	422.40	0.30	18.00	20.00	184.60	63.93	14466.00	6.00	14.70	0.55	15.00	0.19	13.40	6205.00	1.30
CC+200_078	649.70	438.00	2.40	1.00	3.10	5.10	0.40	376.50	0.17	24.00	14.00	169.40	58.02	19778.00	6.00	12.90	0.44	14.50	0.16	8.60	4068.00	0.90
CC+200_079	219.10	359.00	2.20	1.00	1.70	3.50	0.40	125.80	0.18	13.00	14.00	65.60	21.09	19848.00	4.00	6.70	0.45	13.60	0.14	7.00	2314.00	1.00
CC+200_081	167.30	428.00	2.00	0.90	1.30	2.80	0.40	98.60	0.14	27.00	15.00	51.50	15.96	16445.00	6.00	5.50	0.37	15.90	0.14	13.00	3729.00	1.00
CC+200_082	70.70	113.00	1.60	0.90	0.70	1.90	0.30	41.80	0.17	12.00	14.00	23.20	6.94	6415.00	4.00	2.90	0.29	16.70	0.14	10.90	894.00	0.90
CC+200_083	95.60	151.00	2.00	1.10	0.70	2.40	0.40	61.00	0.21	84.00	16.00	28.60	8.89	7244.00	4.00	3.80	0.38	17.10	0.16	12.80	1216.00	1.10
CC+200_084	77.10	131.00	2.10	1.10	0.80	2.20	0.40	47.40	0.20	62.00	16.00	24.40	7.40	5867.00	4.00	3.50	0.37	16.00	0.16	11.20	1330.00	1.20
CC+200_086	82.10	155.00	1.90	1.00	0.70	2.30	0.40	52.20	0.18	58.00	16.00	26.10	7.72	11160.00	4.00	3.40	0.35	17.10	0.15	9.90	1258.00	1.00
CC+200_087	83.90	164.00	2.10	1.00	0.70	2.40	0.40	51.20	0.20	25.00	17.00	25.90	7.99	8654.00	4.00	3.40	0.38	17.20	0.14	10.70	1027.00	1.10
CC+200_088	86.30	154.00	2.00	1.00	0.80	2.60	0.30	51.90	0.18	100.00	18.00	27.90	8.42	5108.00	4.00	4.00	0.38	19.50	0.14	9.80	1151.00	1.00
CC+200_089	110.10	416.00	1.90	1.00	0.80	2.30	0.40	97.80	0.22	43.00	34.00	26.60	8.69	22095.00	3.00	3.20	0.30	16.10	0.17	10.80	2825.00	1.00
CC+200_091	77.90	119.00	2.10	1.10	0.80	2.40	0.40	46.00	0.21	41.00	18.00	26.00	7.85	7086.00	4.00	3.80	0.36	17.70	0.18	11.70	1452.00	1.10
CC+200_092	59.10	194.00	1.60	0.90	0.60	2.00	0.30	37.20	0.18	376.00	16.00	19.60	5.79	13047.00	3.00	2.80	0.28	13.50	0.12	10.40	1665.00	0.80
CC+200_093	73.50	121.00	1.90	1.10	0.70	2.70	0.40	41.70	0.22	57.00	17.00	25.10	7.39	4077.00	4.00	3.70	0.41	18.10	0.16	10.80	839.00	1.10
CC+200_094	81.20	103.00	1.80	1.00	0.80	2.20	0.30	46.10	0.21	219.00	16.00	27.10	7.98	8468.00	4.00	4.00	0.34	19.10	0.16	9.00	978.00	1.00
CC+200_096	67.50	122.00	1.60	0.90	0.70	1.80	0.30	38.20	0.21	240.00	15.00	22.00	6.51	11080.00	4.00	3.00	0.27	17.20	0.14	10.10	1281.00	1.00
CC+200_097	80.80	69.00	1.90	1.10	0.80	2.30	0.40	43.90	0.23	28.00	17.00	26.10	8.09	5105.00	4.00	3.70	0.35	19.00	0.18	10.10	797.00	1.20
CC+200_098	83.10	82.00	1.90	1.00	0.80	2.40	0.30	45.70	0.18	7.00	17.00	27.40	8.43	19604.00	5.00	3.60	0.31	17.00	0.18	11.70	1085.00	1.20
CC+200_099	1.30	118.00	0.05	0.05	0.05	0.05	0.05	0.60	0.03	1.00	5.00	0.30	0.11	1588.00	1.00	0.05	0.03	0.20	0.03	0.20	2173.00	0.05
CC+200_101	78.60	236.00	2.40	1.30	0.80	2.60	0.50	44.40	0.21	10.00	15.00	26.50	7.97	8411.00	4.00	3.60	0.42	17.00	0.13	11.00	640.00	1.20
CC+200_102	84.30	105.00	2.00	1.00	0.80	2.60	0.40	45.30	0.22	5.00	17.00	29.40	8.52	9933.00	5.00	4.20	0.38	17.40	0.17	12.10	854.00	1.00

CC+200_103	88.30	102.00	2.00	0.80	0.80	2.70	0.30	48.90	0.18	29.00	18.00	30.00	8.79	2759.00	5.00	4.20	0.35	17.80	0.15	9.40	835.00	1.00
CC+200_104	78.30	128.00	1.70	0.90	0.80	2.30	0.30	43.40	0.24	561.00	15.00	25.50	7.74	5685.00	4.00	3.50	0.33	35.10	0.13	7.60	1268.00	0.80
CC+200_106	80.10	183.00	2.10	1.10	0.60	2.30	0.40	47.20	0.21	55.00	18.00	25.40	7.61	7376.00	4.00	3.40	0.38	17.70	0.17	10.00	926.00	1.20
CC+200_107	60.20	370.00	2.00	1.10	0.70	2.00	0.40	39.80	0.18	215.00	14.00	18.60	5.63	24975.00	3.00	2.90	0.31	11.70	0.17	18.70	840.00	1.00
CC+200_108	84.50	227.00	1.90	0.90	0.80	2.50	0.30	49.20	0.18	430.00	16.00	26.20	8.19	15908.00	5.00	3.80	0.35	15.60	0.13	9.00	848.00	0.90
CC+200_109	83.10	135.00	1.70	0.90	0.80	2.00	0.30	48.60	0.20	719.00	15.00	26.90	7.94	5103.00	4.00	3.60	0.30	17.60	0.15	9.30	897.00	1.00
CC+200_111	85.90	126.00	2.00	1.00	0.80	2.20	0.40	48.70	0.21	28.00	16.00	28.00	8.43	7747.00	5.00	3.60	0.35	18.70	0.18	9.60	768.00	1.40
CC+200_112	78.60	102.00	1.90	1.00	0.80	2.20	0.40	45.00	0.24	19.00	16.00	26.50	7.68	2142.00	4.00	3.60	0.33	17.20	0.17	10.40	801.00	1.10
CC+200_113	86.90	138.00	1.80	1.00	0.80	2.20	0.30	52.00	0.17	77.00	15.00	27.20	8.50	8265.00	4.00	3.50	0.33	18.10	0.14	9.30	1180.00	1.00

Appendix I – Discrimination diagrams

Geochemical data have been altered substantially through the process of hydrothermal alteration and is therefore rendered not useful in classifying the granite host rock. Data is scattered over many fields and therefore do not contribute as no meaningful conclusions can be drawn, except that the data has been altered. Discrimination diagrams of Batchelor and Bowden (1985), Frost et al (2001), Sylvester (1989), Schandl and Gorton (2002) and Maniar and Piccoli (1989) for both the MZ and the NMZ have been added to illustrate the effect of hydrothermal alteration on geochemical data. For the NMZ, the data is less scattered and can be used to speculate the history of the pluton.

I1. MZ

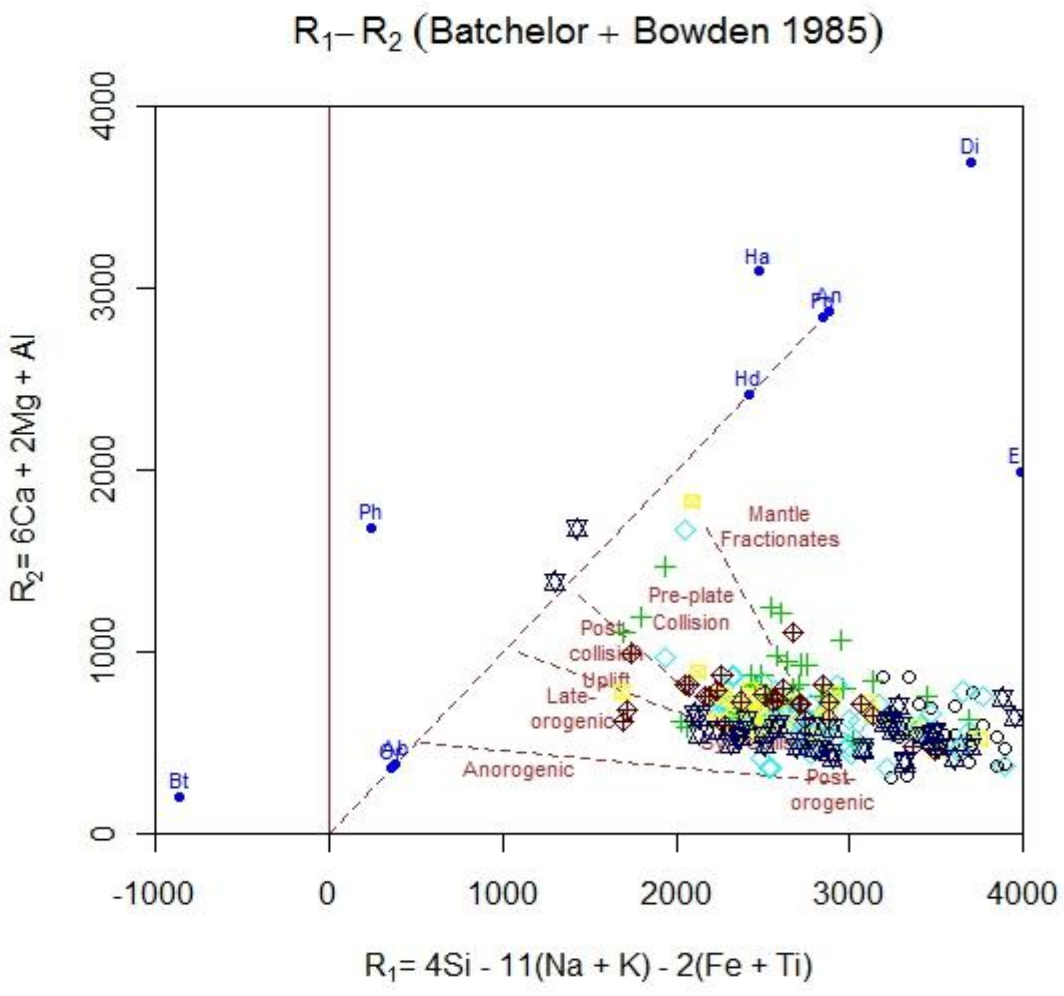


Figure 1. R1-R2 diagram of Batchelor and Bowden (1985) for the MZ. The data is scattered across all fields and are therefore not useful.

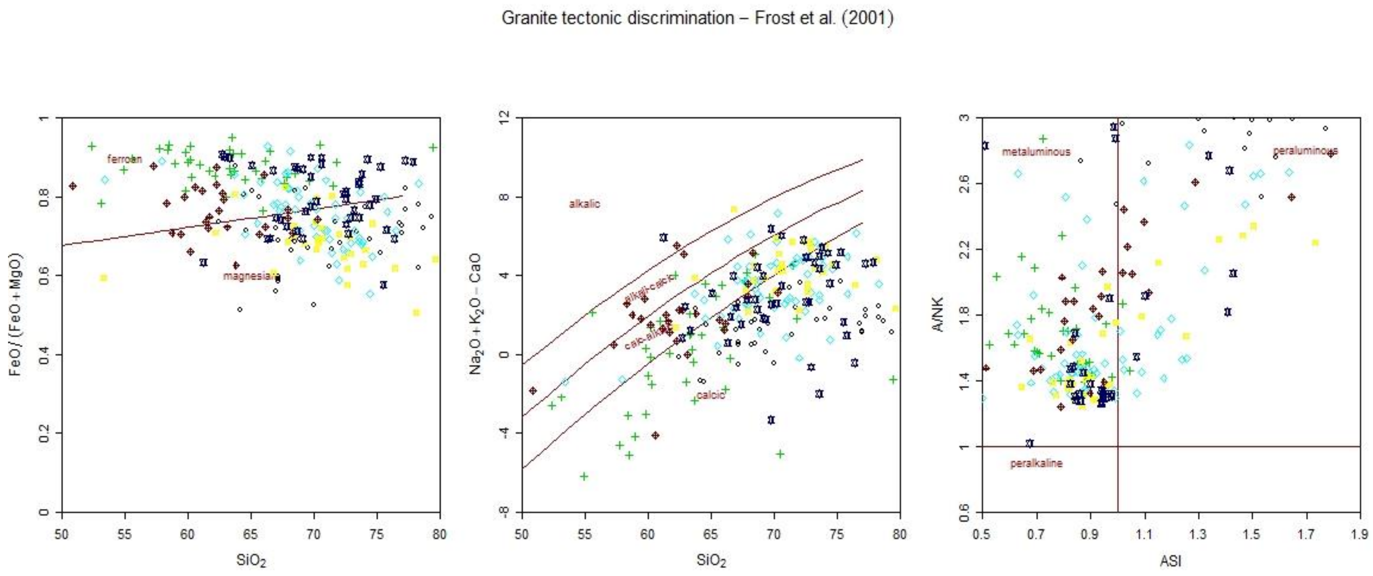


Figure 2. Discrimination diagrams of Frost et al (2001) for the MZ. The data is too scattered to contribute.

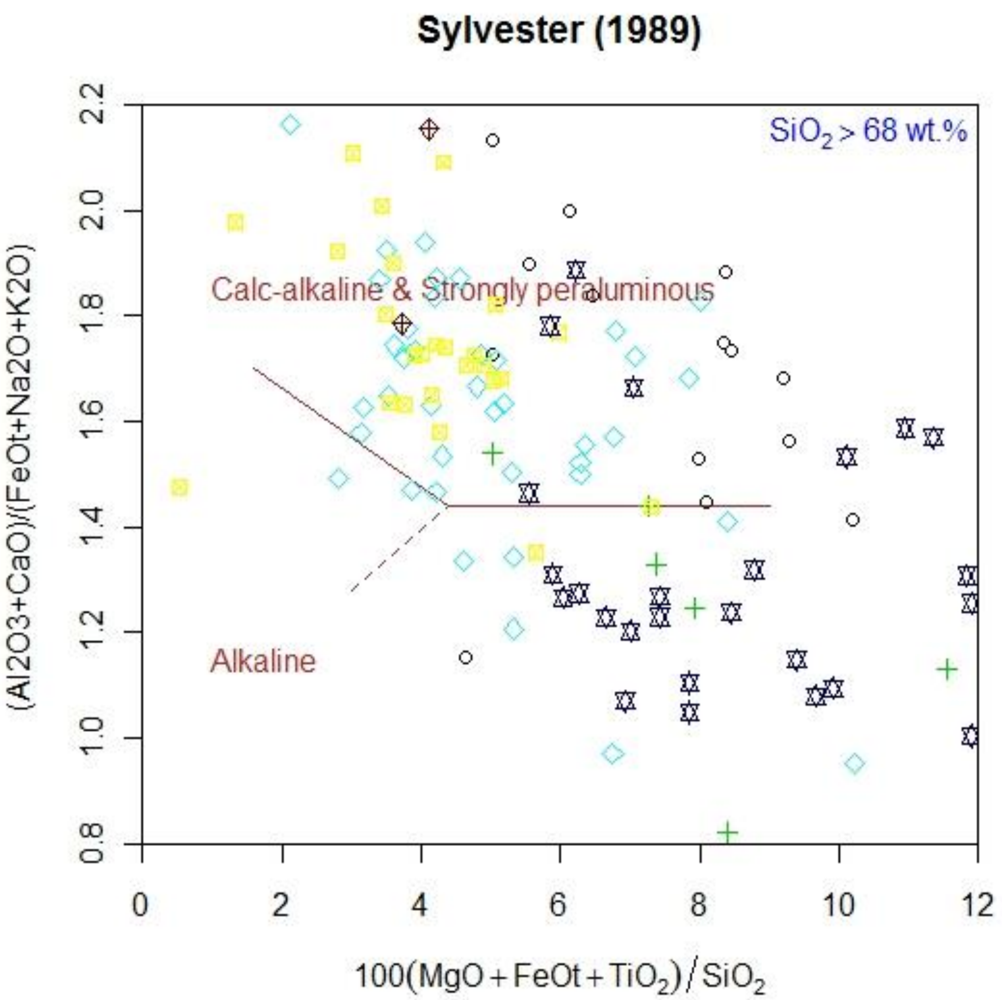


Figure 3. Discrimination diagrams of Sylvester (1989) for the MZ. The data is too scattered to contribute.

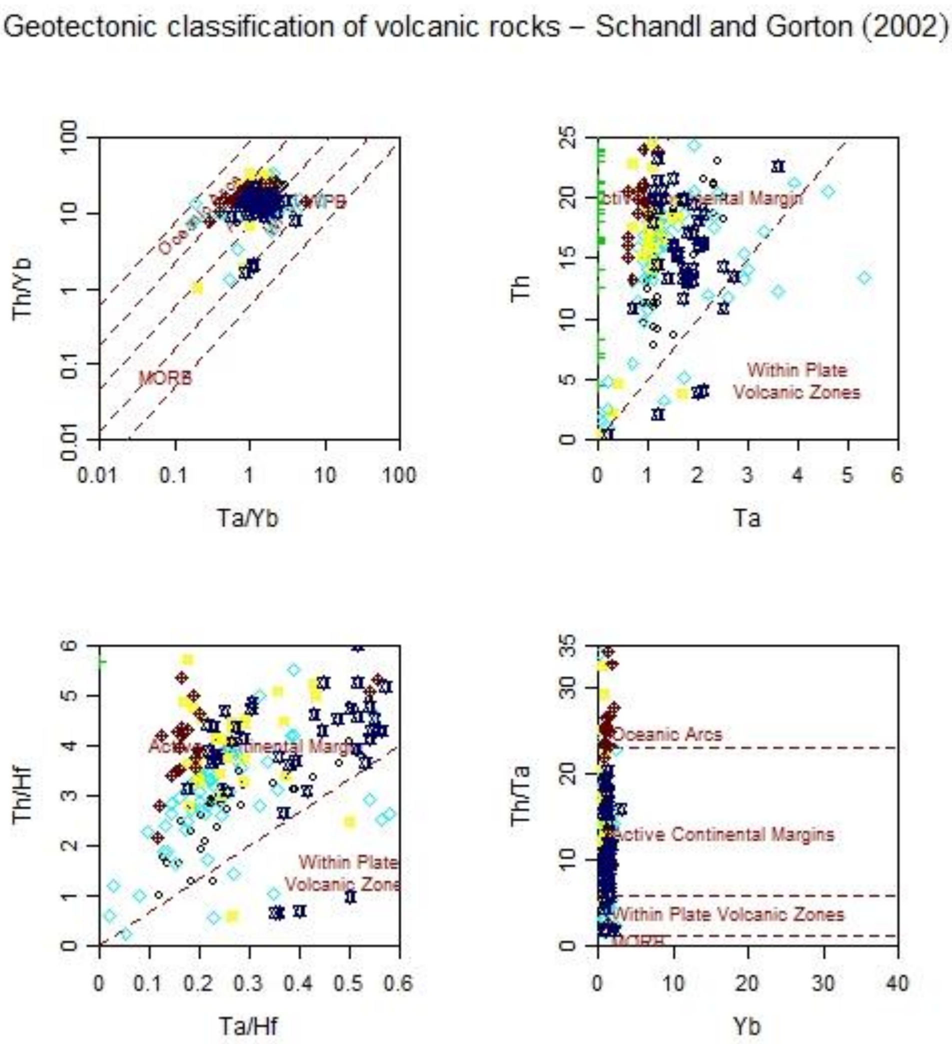


Figure 4. Discrimination diagrams of Schandl and Gorton (2002) for the MZ. The data is too scattered to contribute. From this diagram it can be deduced that trace elements like Yb can be used in this study as a geologic discriminant.

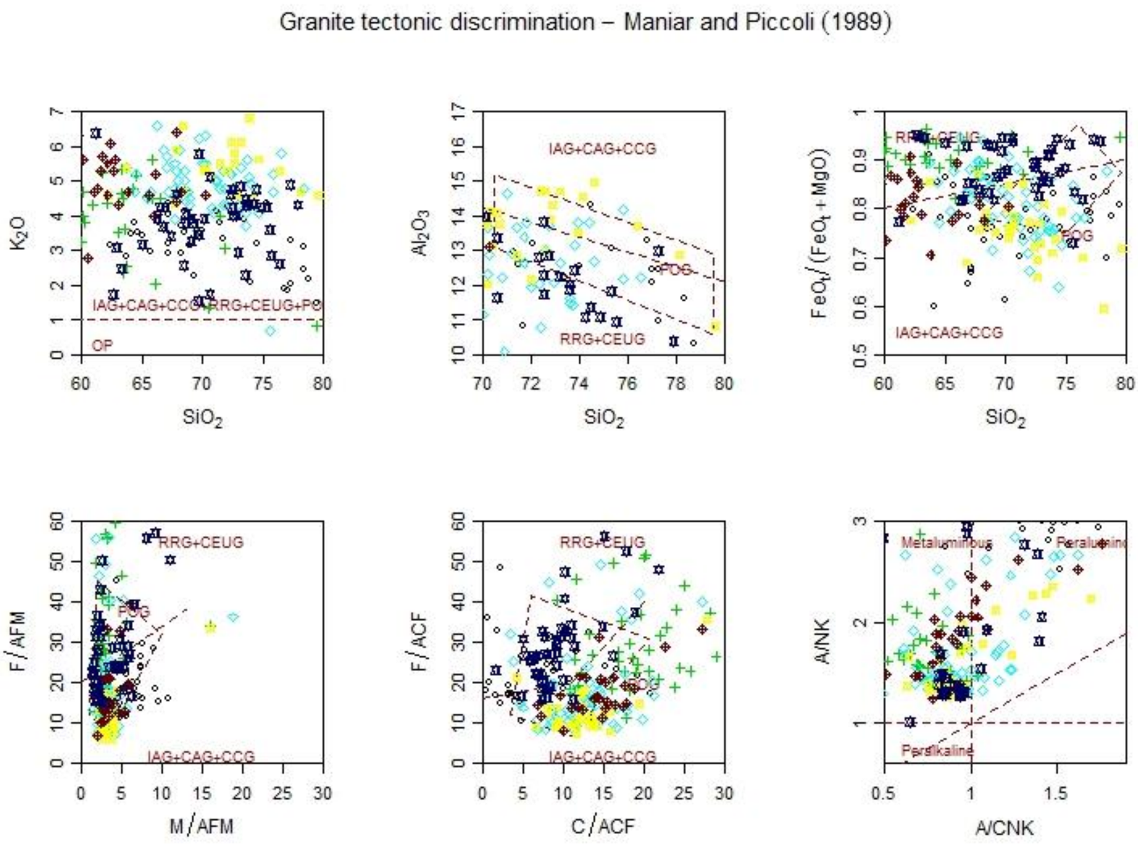


Figure 5. Discrimination diagrams of Maniar and Piccoli (1989) for the MZ. The data is scattered over most fields and therefore do not contribute.

I2. NMZ

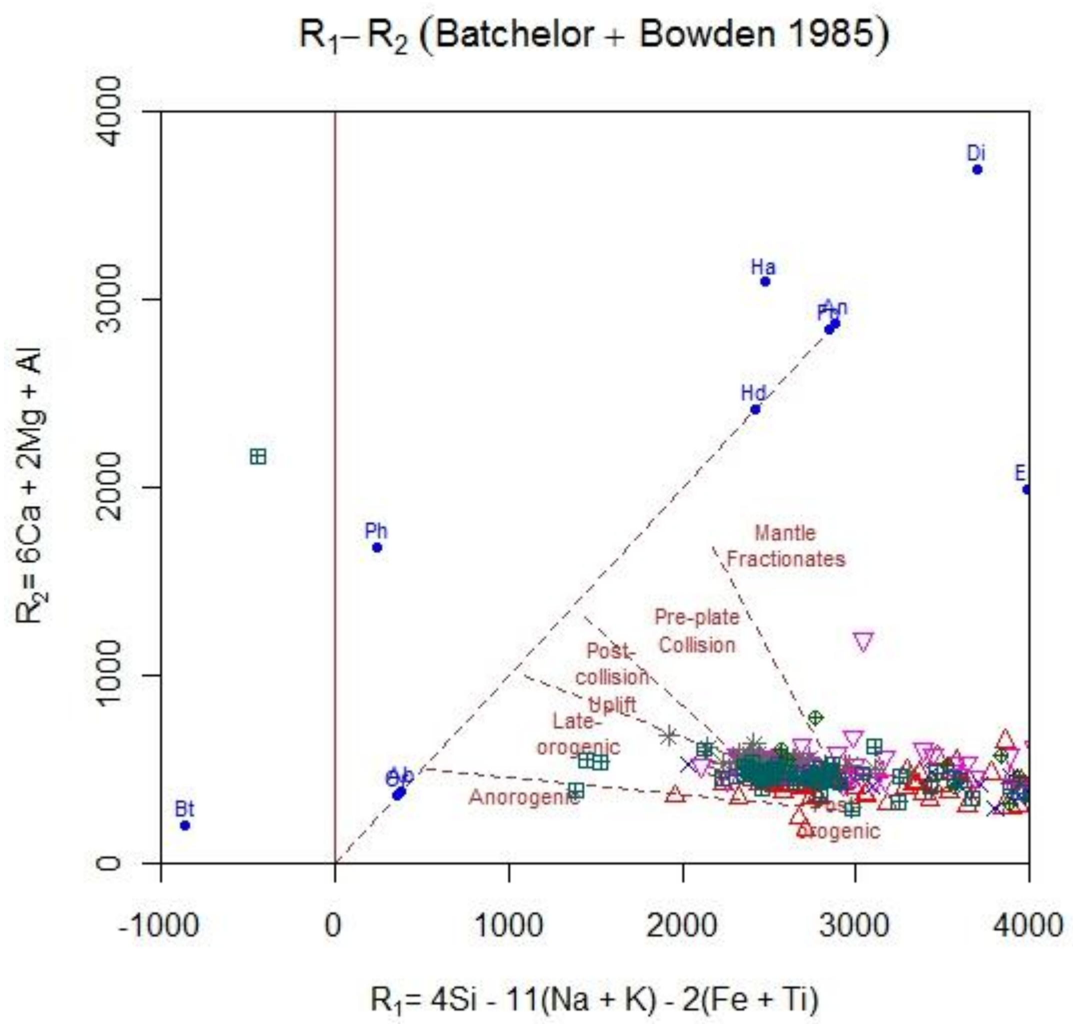


Figure 6. R1-R2 diagram of Batchelor and Bowden (1985) for the NMZ. This suggests a late to post-orogenic pluton which is the case with Riviera.

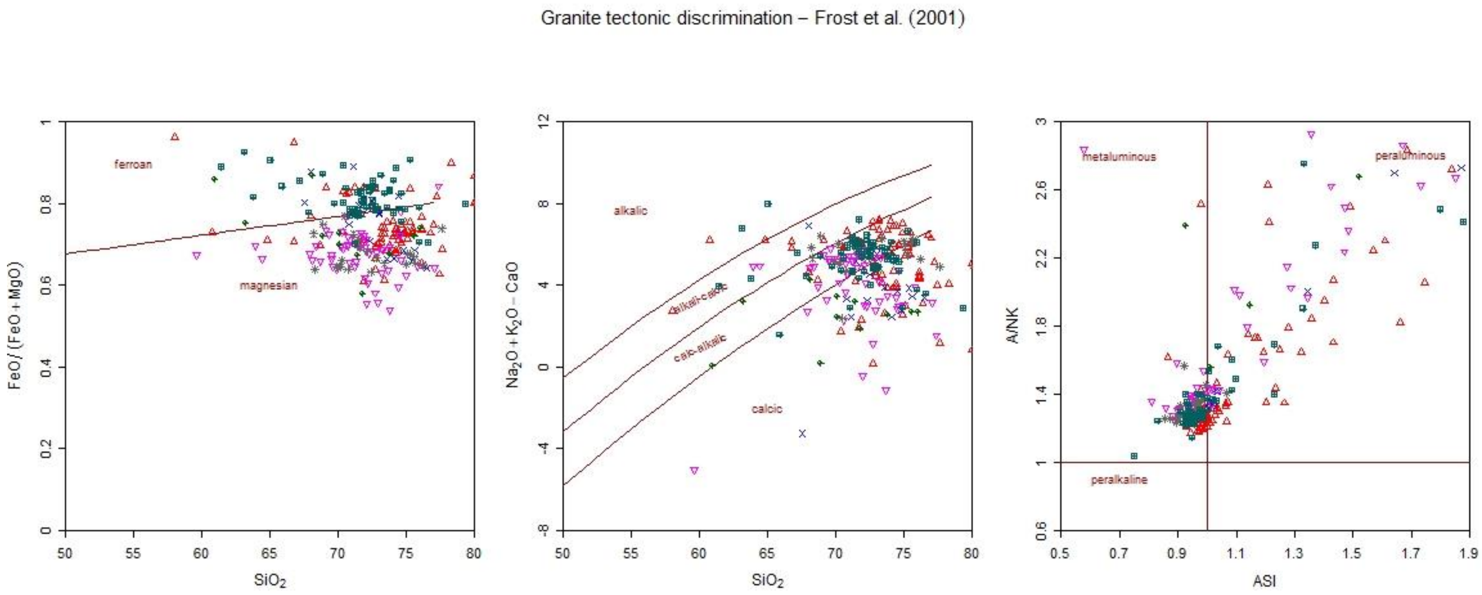


Figure 7. Discrimination diagrams of Frost et al (2001) for the NMZ. The data is scattered over more than one field. However a slightly metaluminous to peraluminous composition of the pluton is suggested which is the case with the Riviera.

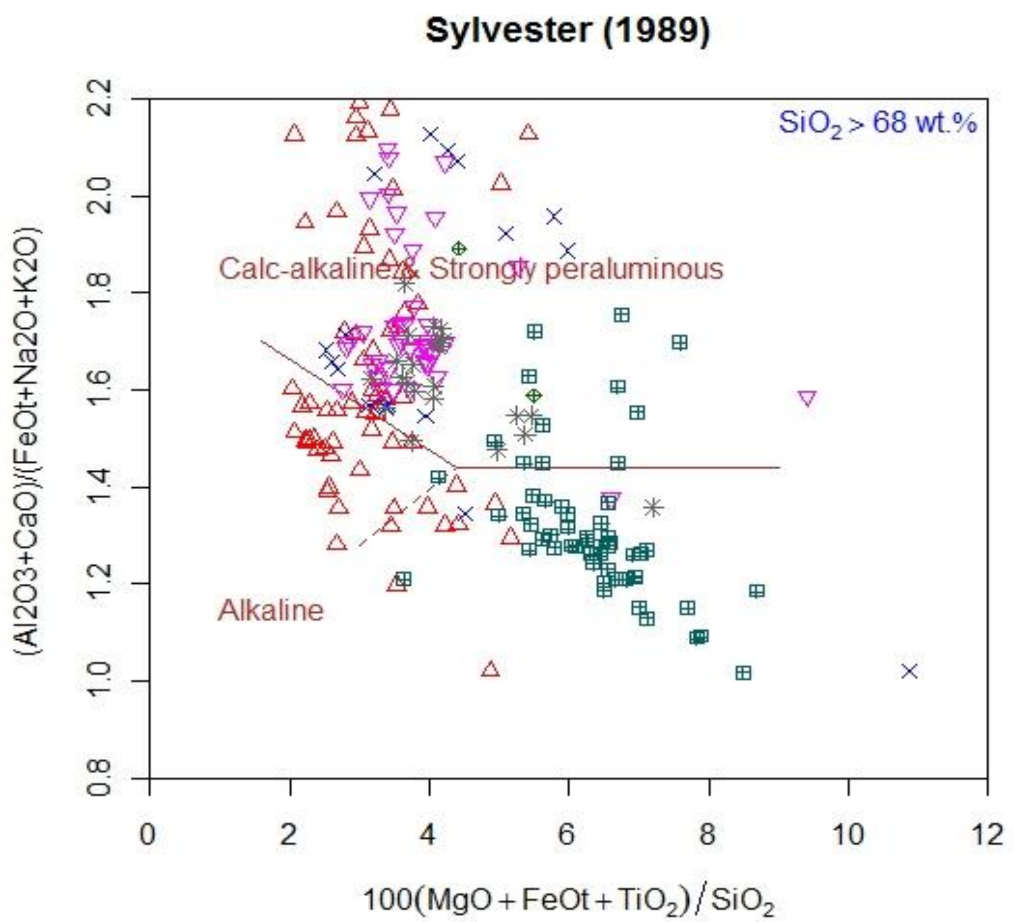


Figure 8. Discrimination diagrams of Sylvester (1989) for the NMZ. Data is scattered over more than one field and therefore do not contribute.

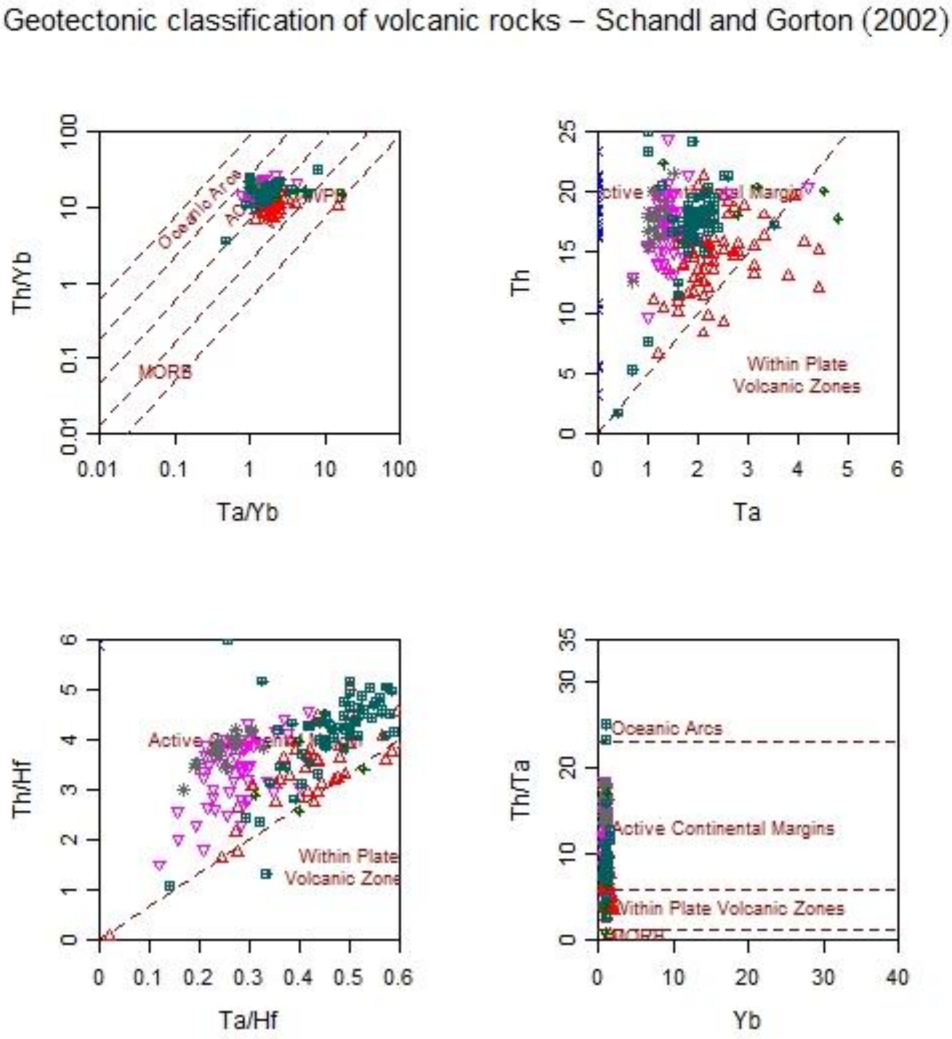


Figure 9. Discrimination diagrams of Schandl and Gorton (2002) for the NMZ. Although the data is less scattered than the MZ, the results are not; the Riviera is not part of an active continental margin setting. From this diagram it is also clear that trace elements like Yb can be used in this study as a geologic discriminant.

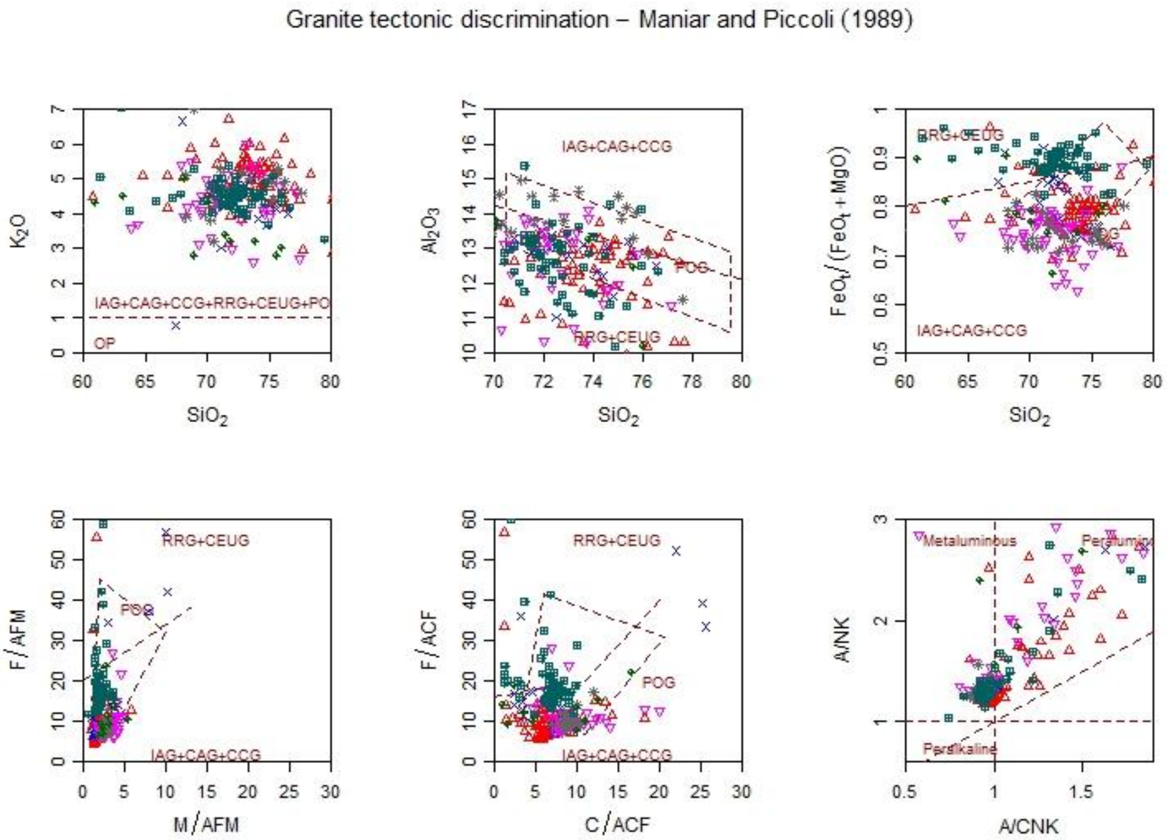


Figure 10. Discrimination diagrams of Maniar and Piccoli (1989) for the NMZ. The data is too scattered to make a meaningful contribution.

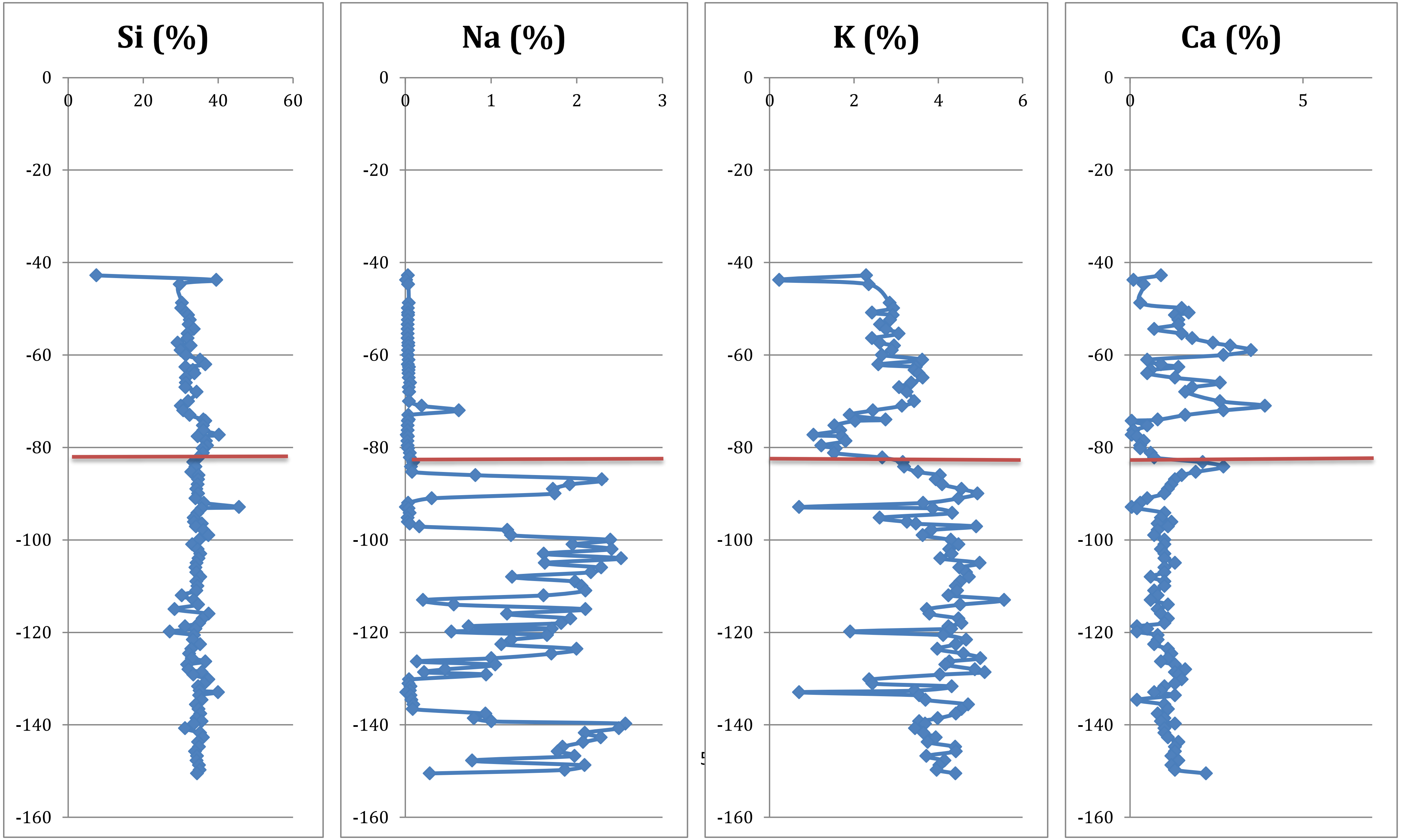
Appendix J – Vertical distribution plots

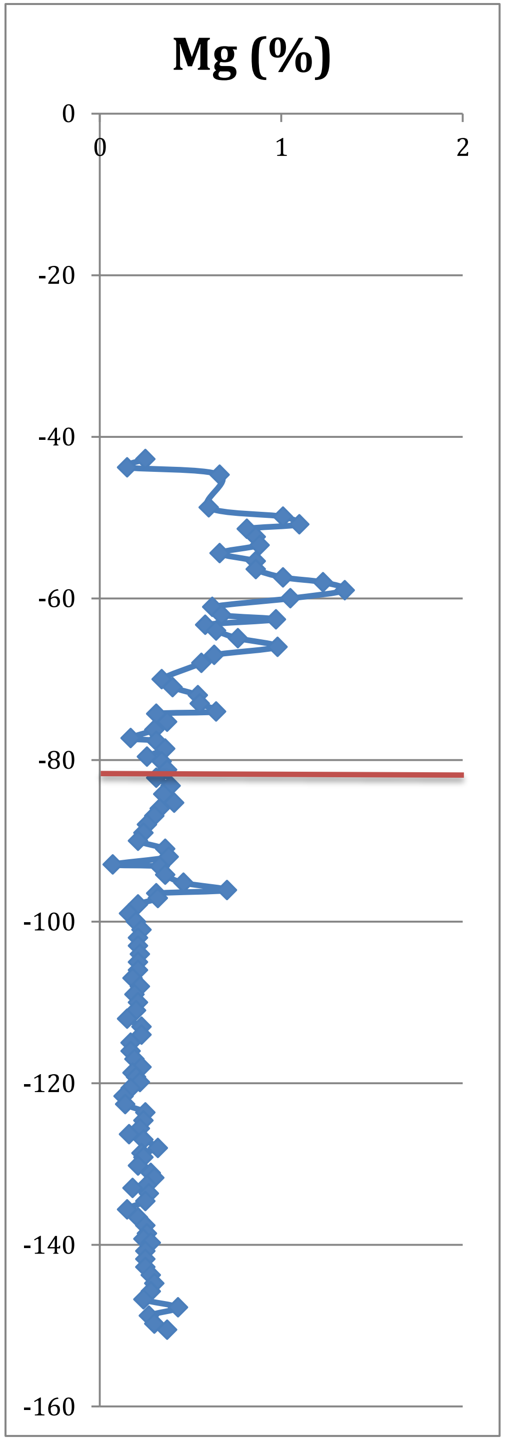
These vertical distribution or down-the-hole plots are based on geochemical data (appendix H) and displays the major, minor, trace and ore (W, LREE, Mo, Pb, Zn, Cu) elements individually versus depth (meters) for each borehole intersection. This was done to get an idea of the spatial position of the mineralization and helped in defining the mineralized and the non-mineralized zone. The MZ were defined by where the abundance of mainly W and REE mineralization is situated. The mineralized zone is where W is greater than 0,05%. The NMZ is thus the zone that is typically devoid of significant amounts of mineralization.

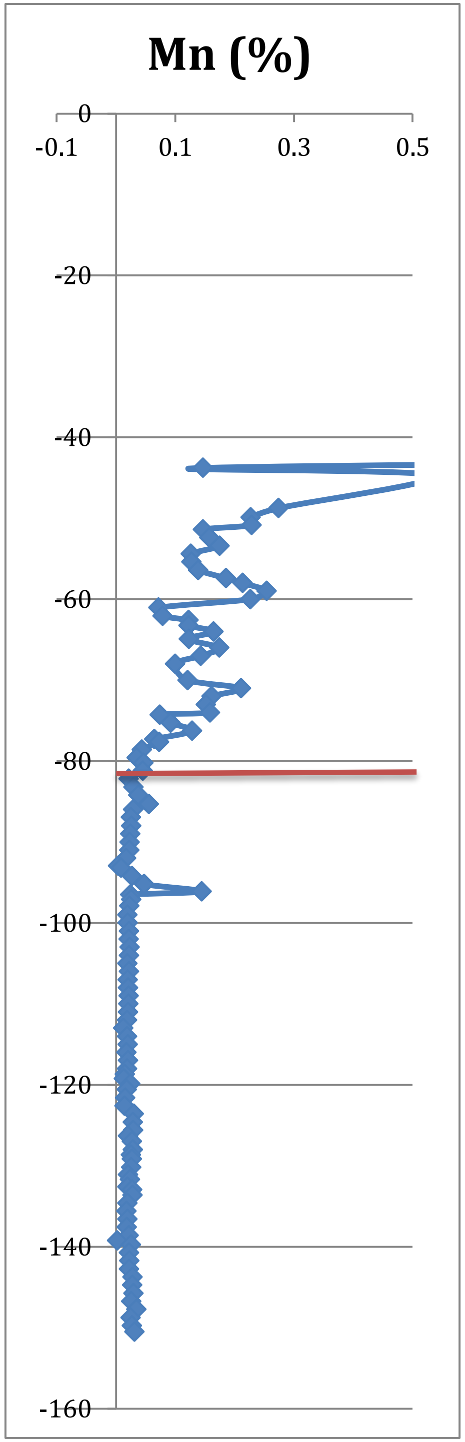
The vertical distribution plots also helped in defining the relationship between all the elements and contributed to the interpretation of the alteration.

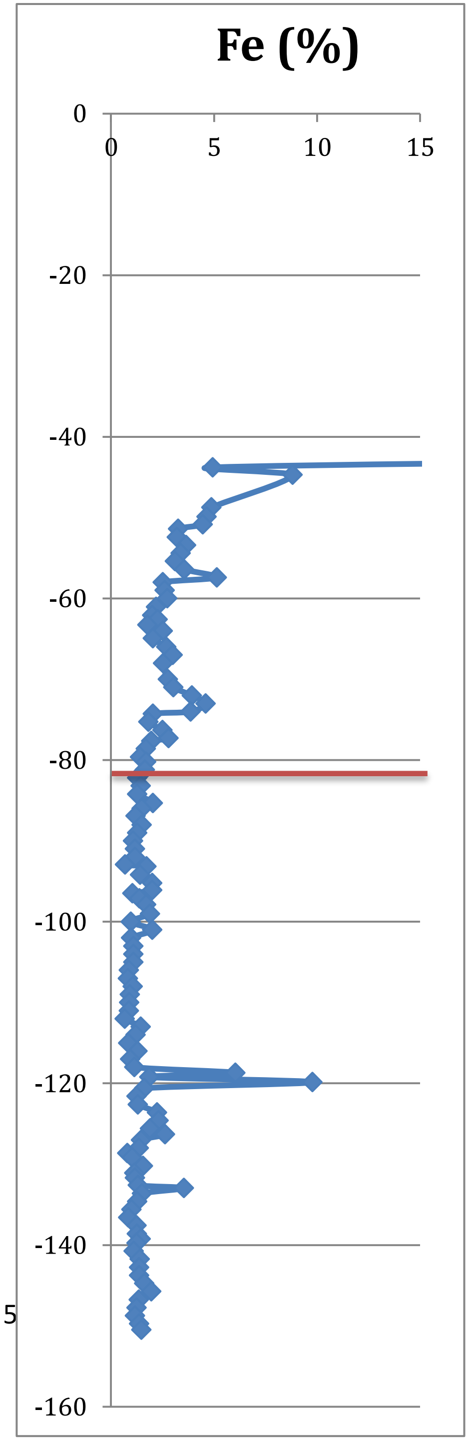
The units in which the various elements are plotted are indicated in brackets. The red line displays the defined contact between the mineralized zone and the non-mineralized zone.

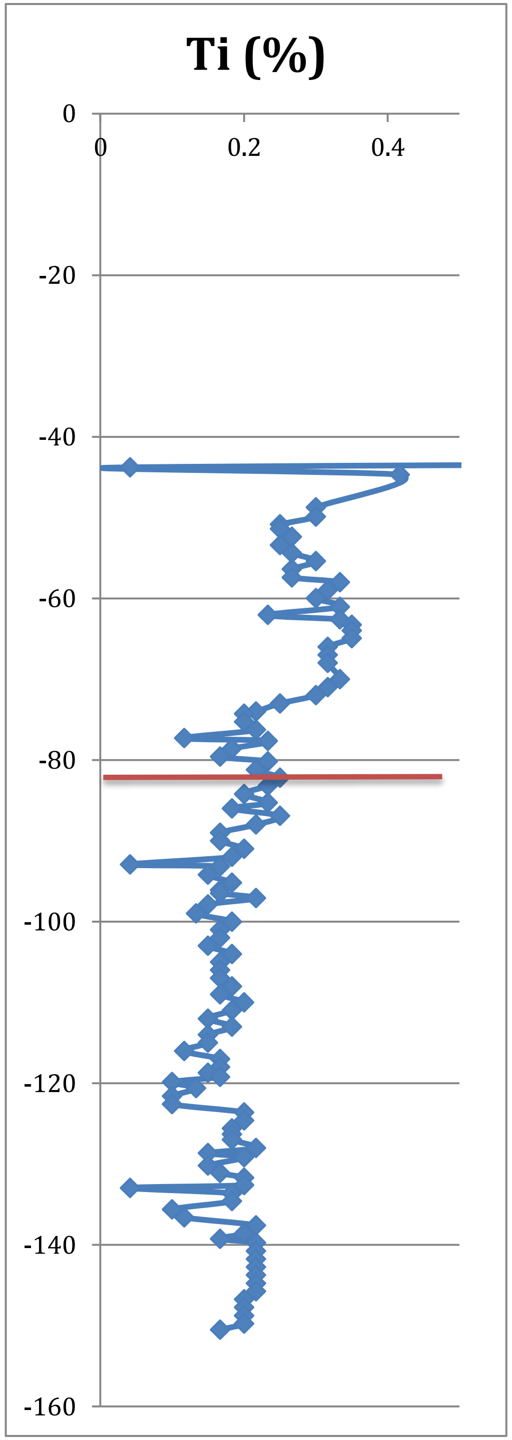
1. A+400

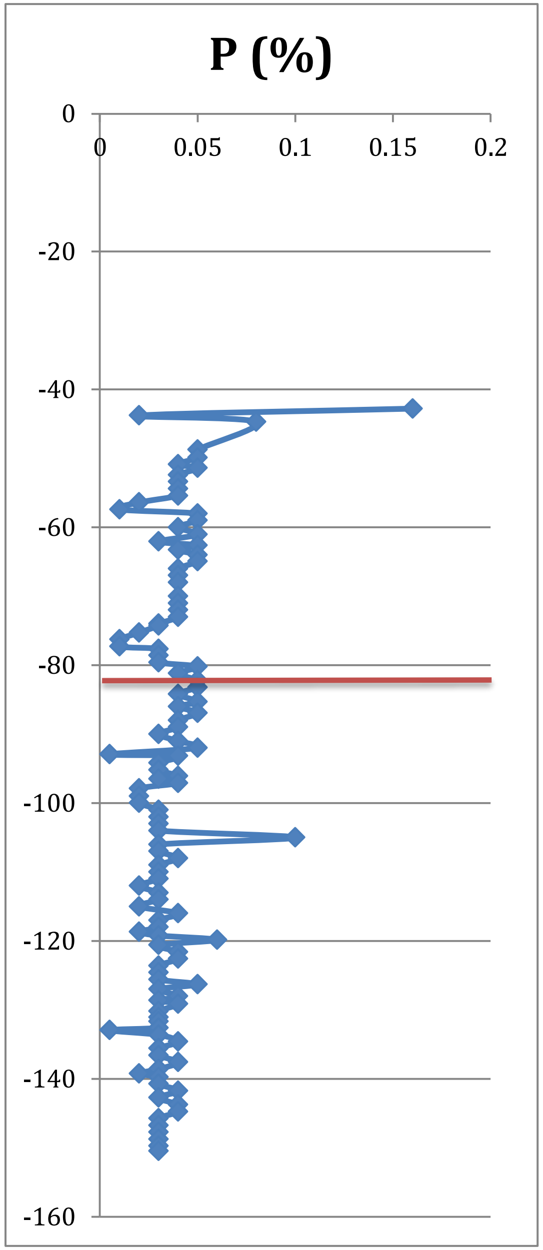


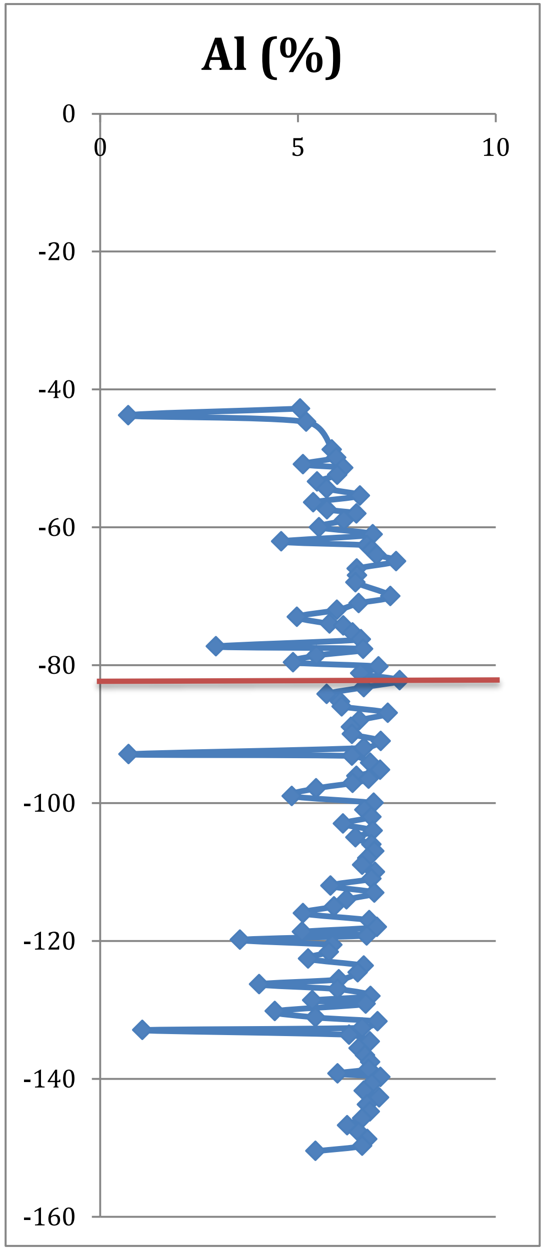

Mg (%)
0
1
2
0
-20
-40
-60
-80
-100
-120
-140
-160

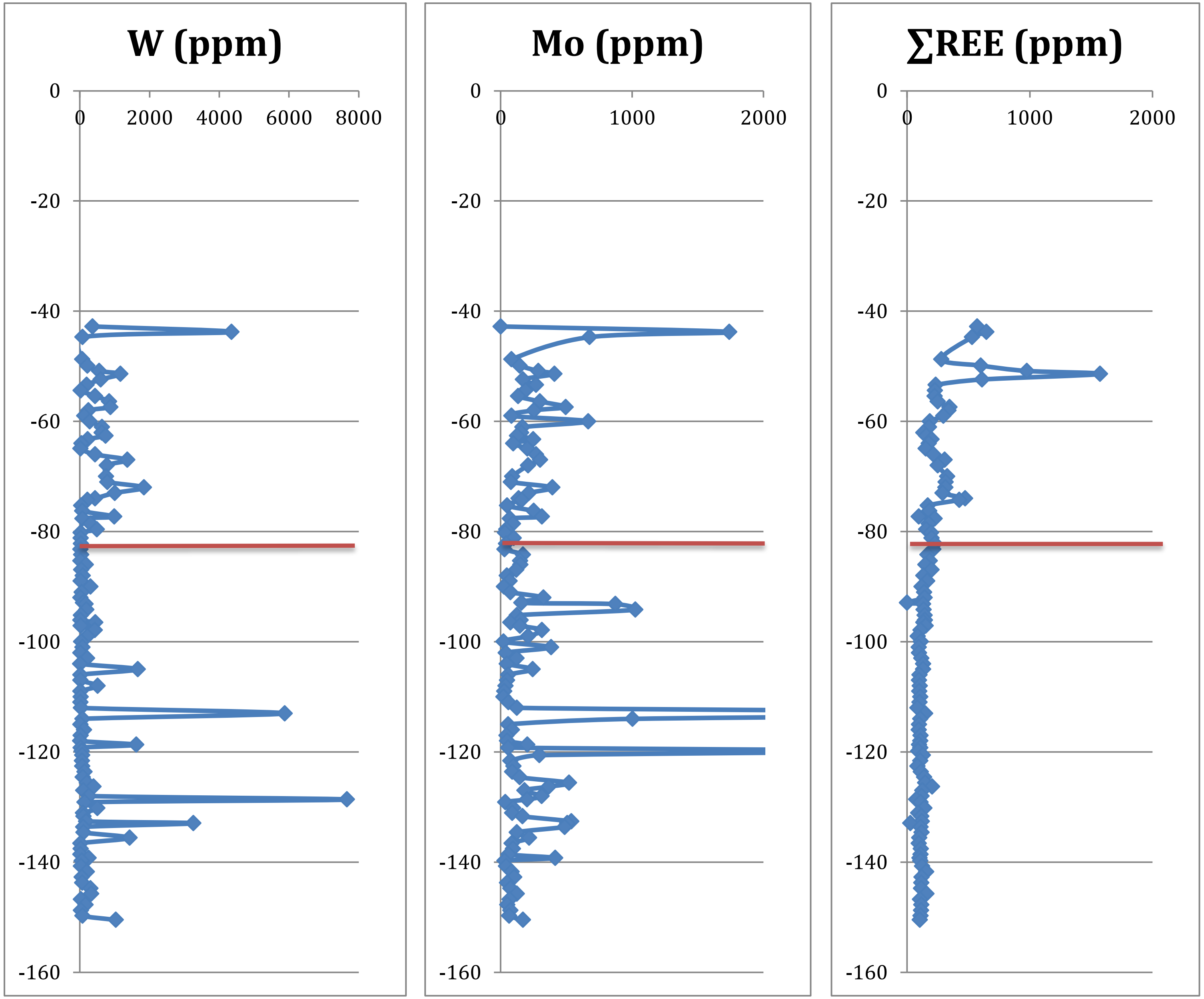

Mn (%)
-0.1
0.1
0.3
0.5
0
-20
-40
-60
-80
-100
-120
-140
-160

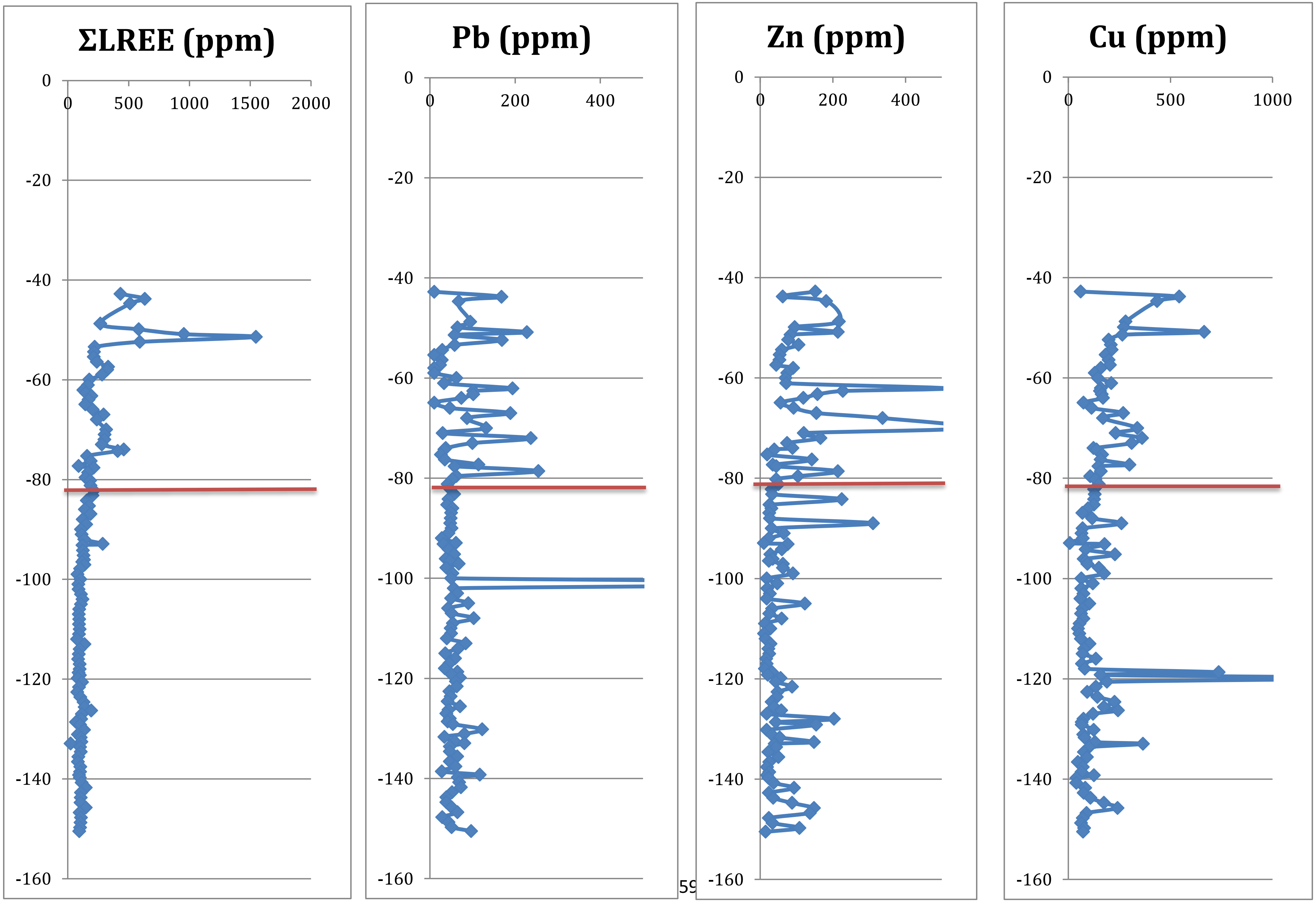

Fe (%)
0
5
10
15
0
-20
-40
-60
-80
-100
-120
-140
-160


Ti (%)
0
0.2
0.4
0
-20
-40
-60
-80
-100
-120
-140
-160

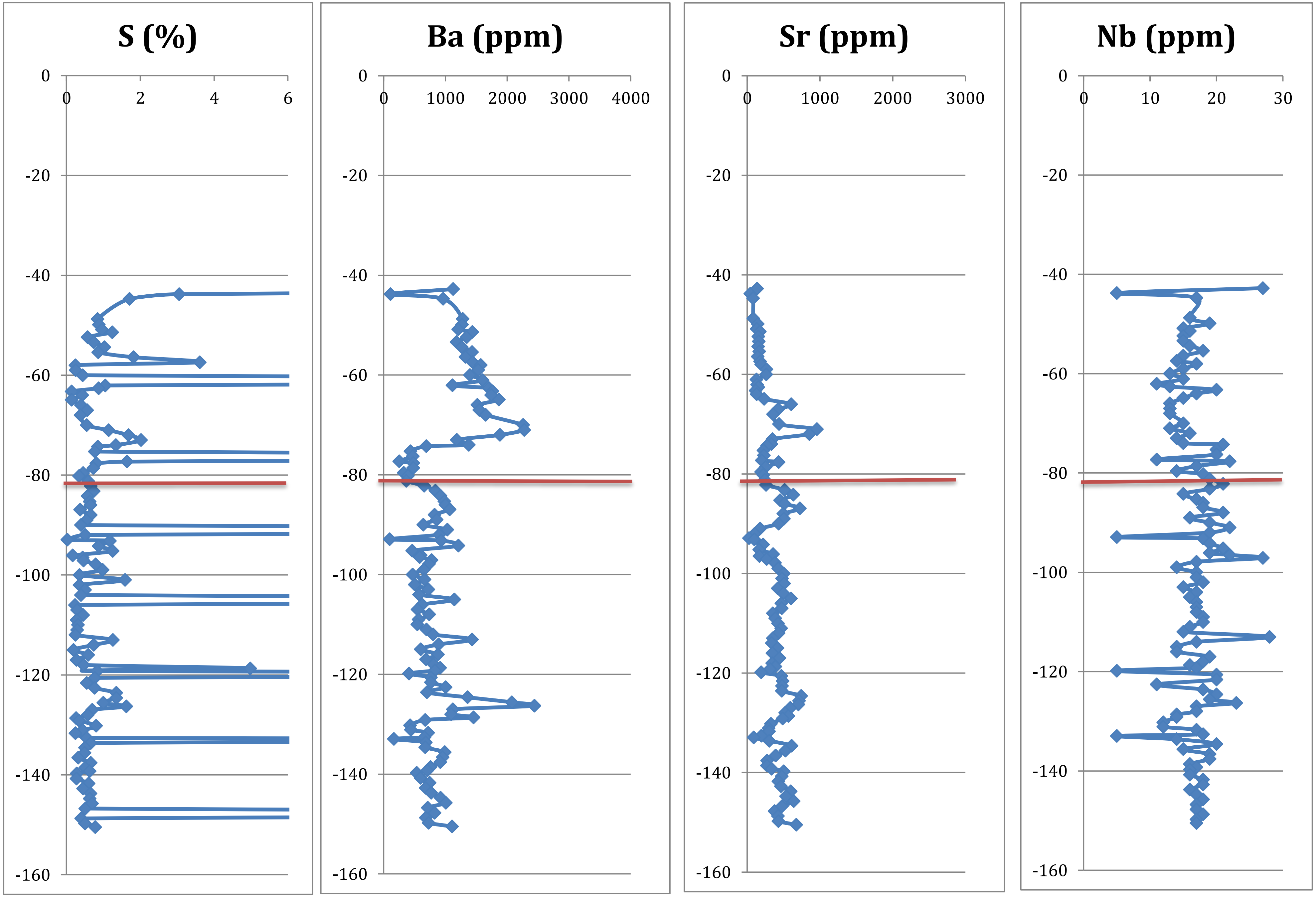

P (%)
0
0.05
0.1
0.15
0.2
0
-20
-40
-60
-80
-100
-120
-140
-160

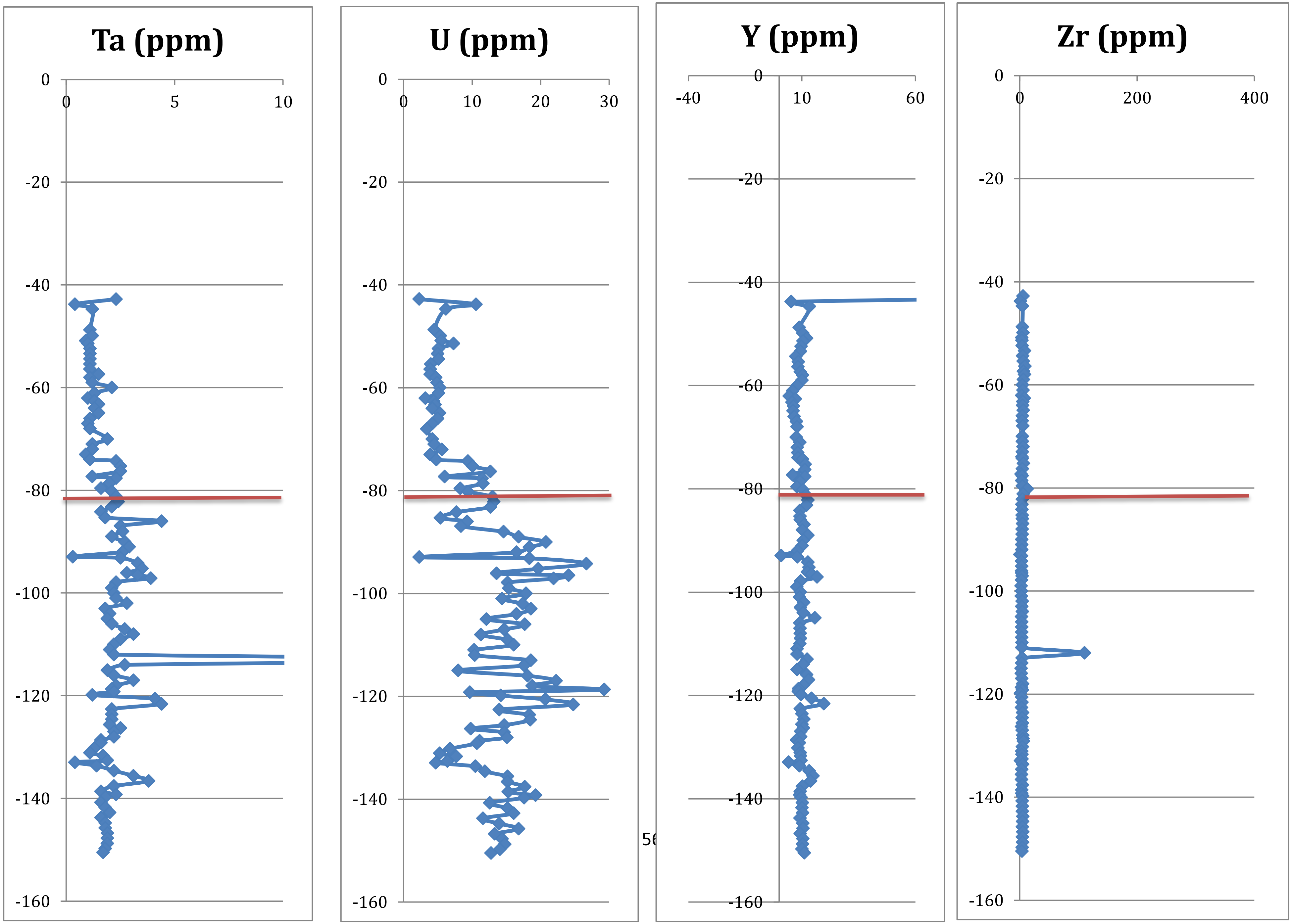

Al (%)
0
5
10
0
-20
-40
-60
-80
-100
-120
-140
-160

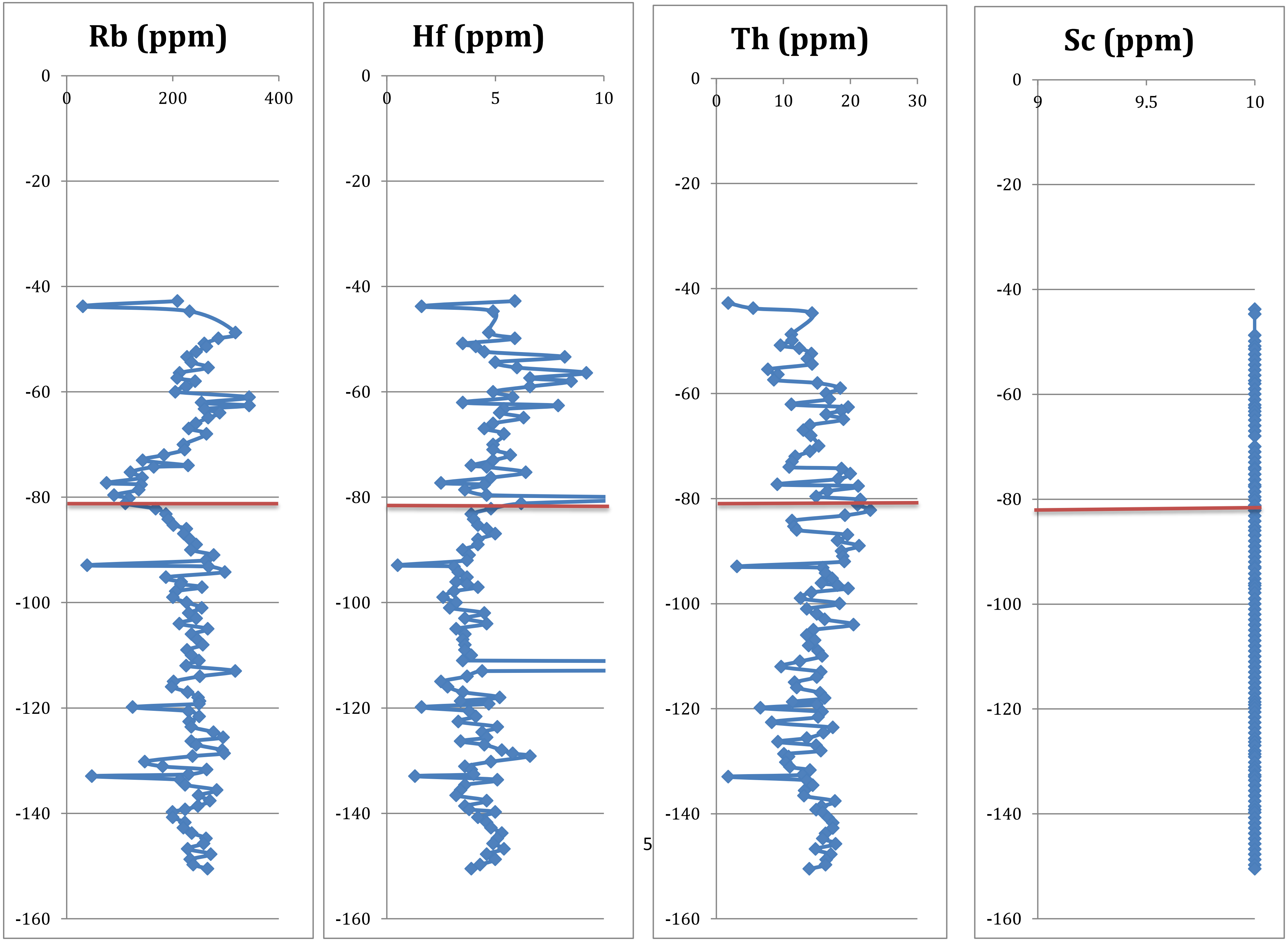

W (ppm)
Mo (ppm)
∑REE (ppm)
0
2000
4000
6000
8000
1000
-20
-40
-60
-80
-100
-120
-140
-160



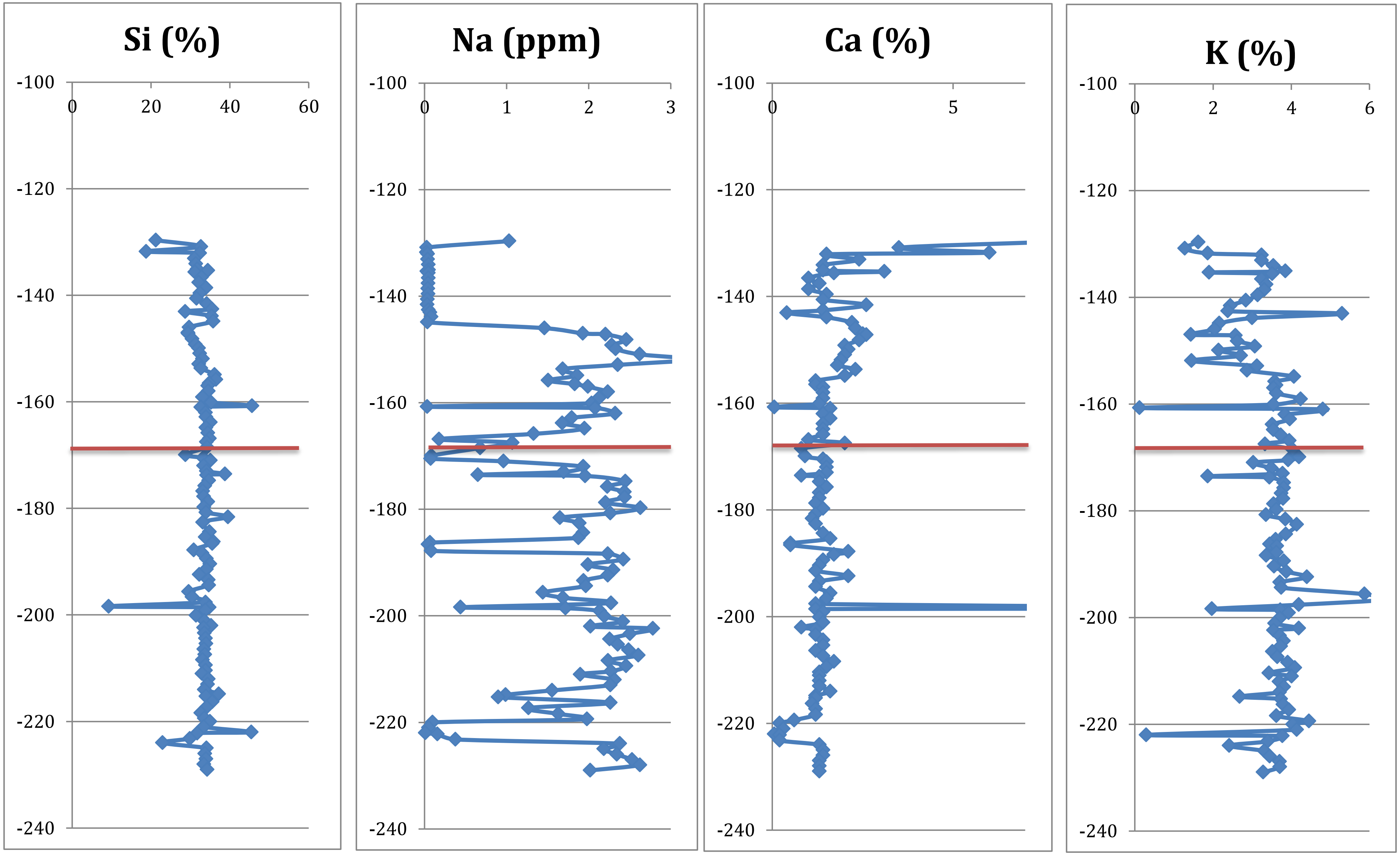
ΣLREE (ppm)
0
500
1000
1500
2000
Pb (ppm)
0
200
400
Zn (ppm)
0
200
400
Cu (ppm)
0
500
1000
0
-20
-40
-60
-80
-100
-120
-140
-160

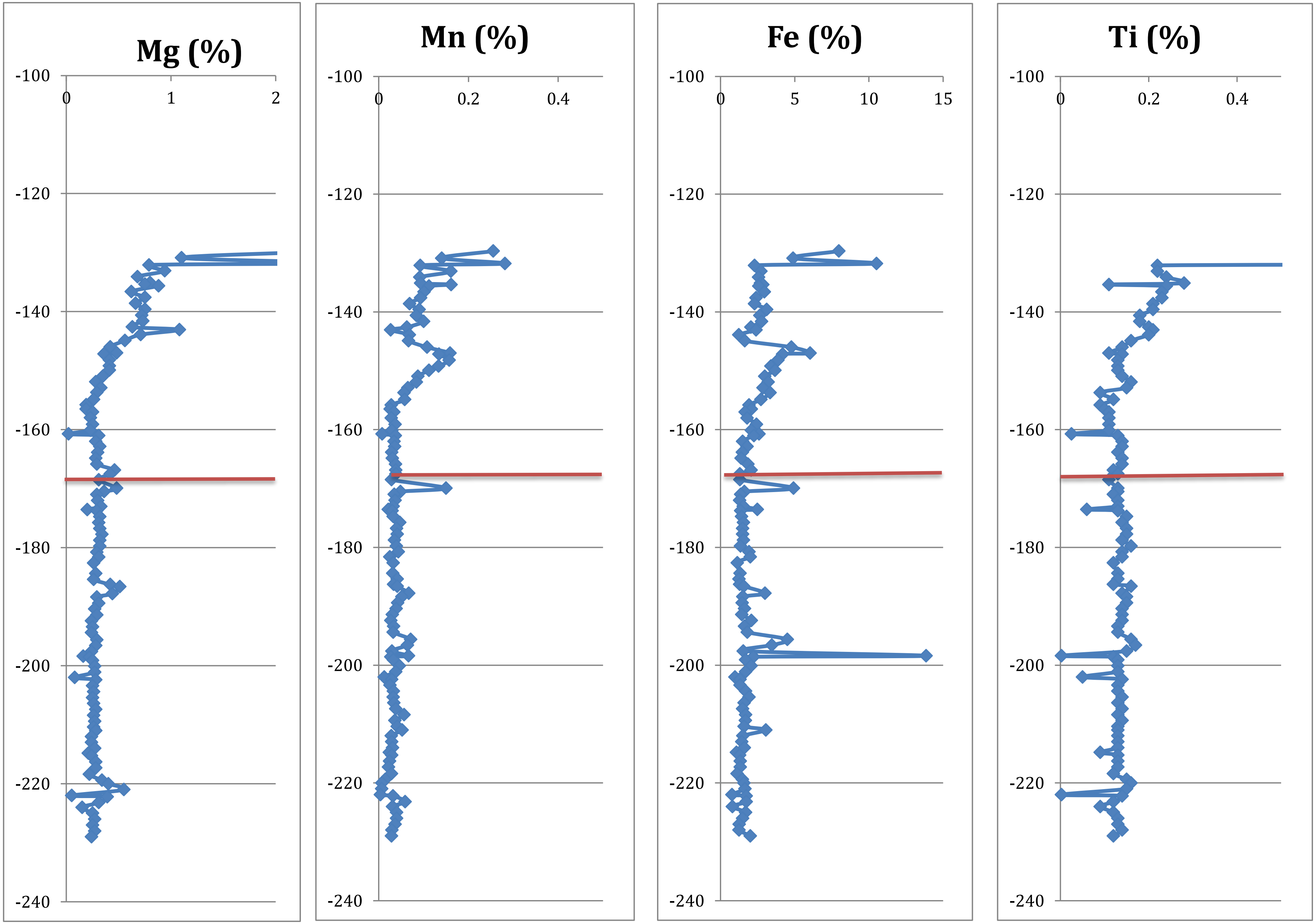

S (%)
0
2
4
6
0
-20
-40
-60
-80
-100
-120
-140
-160
Ba (ppm)
0
1000
2000
3000
4000
Sr (ppm)
0
1000
2000
3000
Nb (ppm)
0
10
20
30

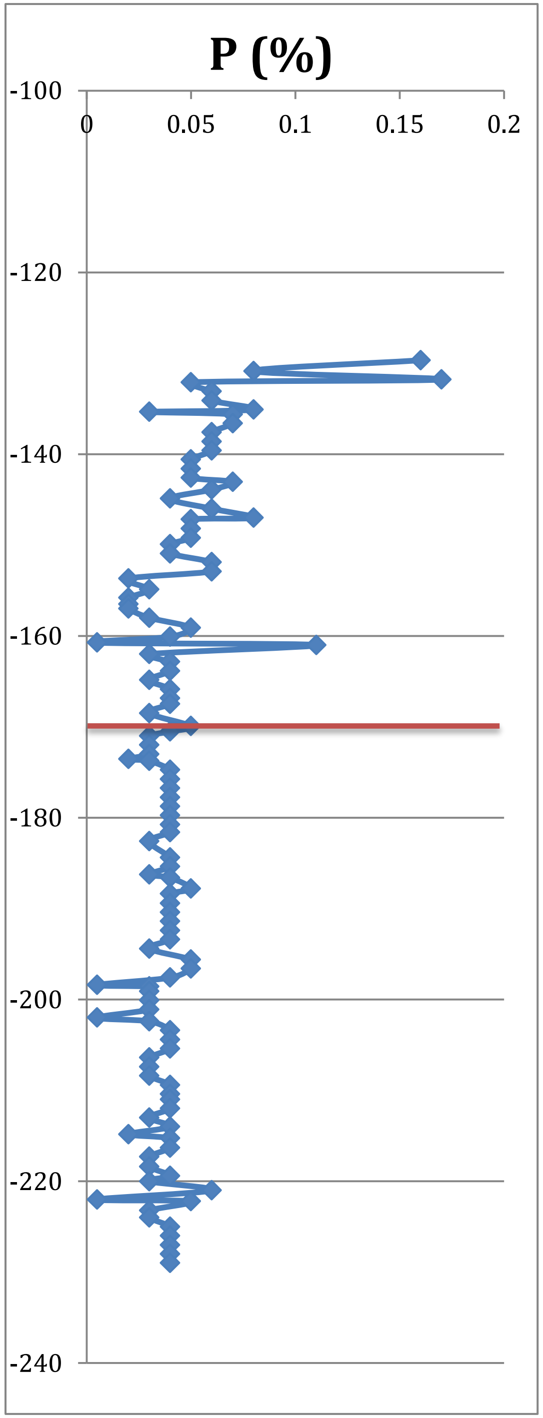

Ta (ppm)
0 5 10
0 -20 -40 -60 -80 -100 -120 -140 -160
U (ppm)
0 10 20 30
0 -20 -40 -60 -80 -100 -120 -140 -160
Y (ppm)
-40 10 60
0 -20 -40 -60 -80 -100 -120 -140 -160
Zr (ppm)
0 200 400
0 -20 -40 -60 -80 -100 -120 -140 -160

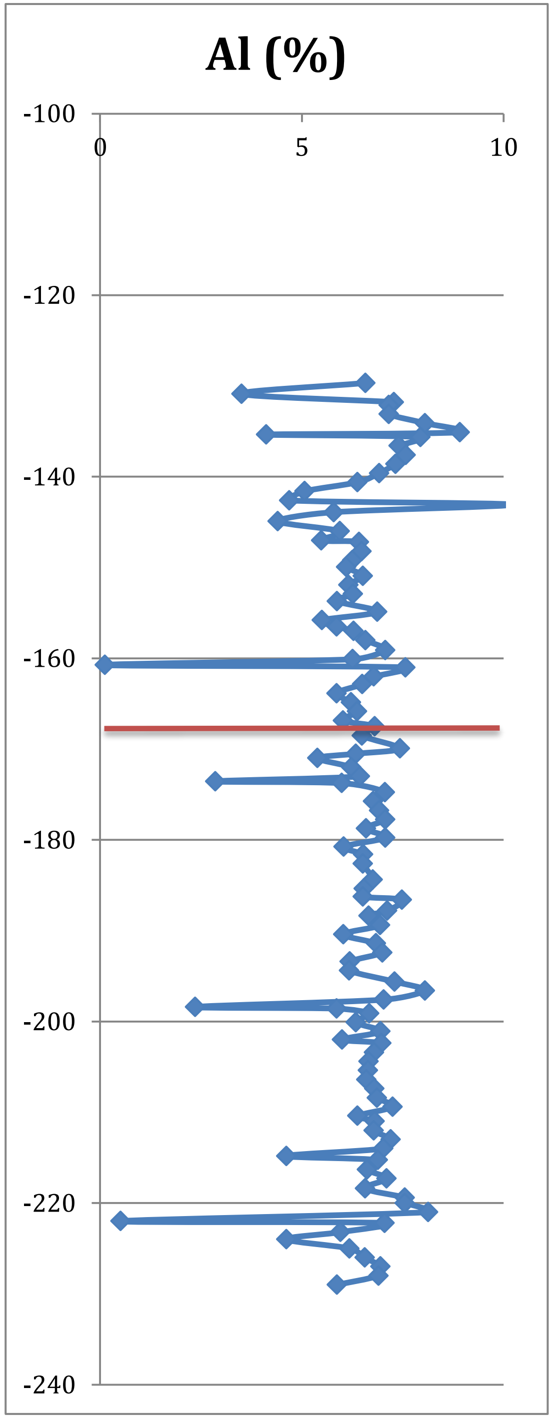

Rb (ppm)
0
200
400
Hf (ppm)
0
5
10
Th (ppm)
0
10
20
30
Sc (ppm)
9
9.5
10
0
-20
-40
-60
-80
-100
-120
-140
-160

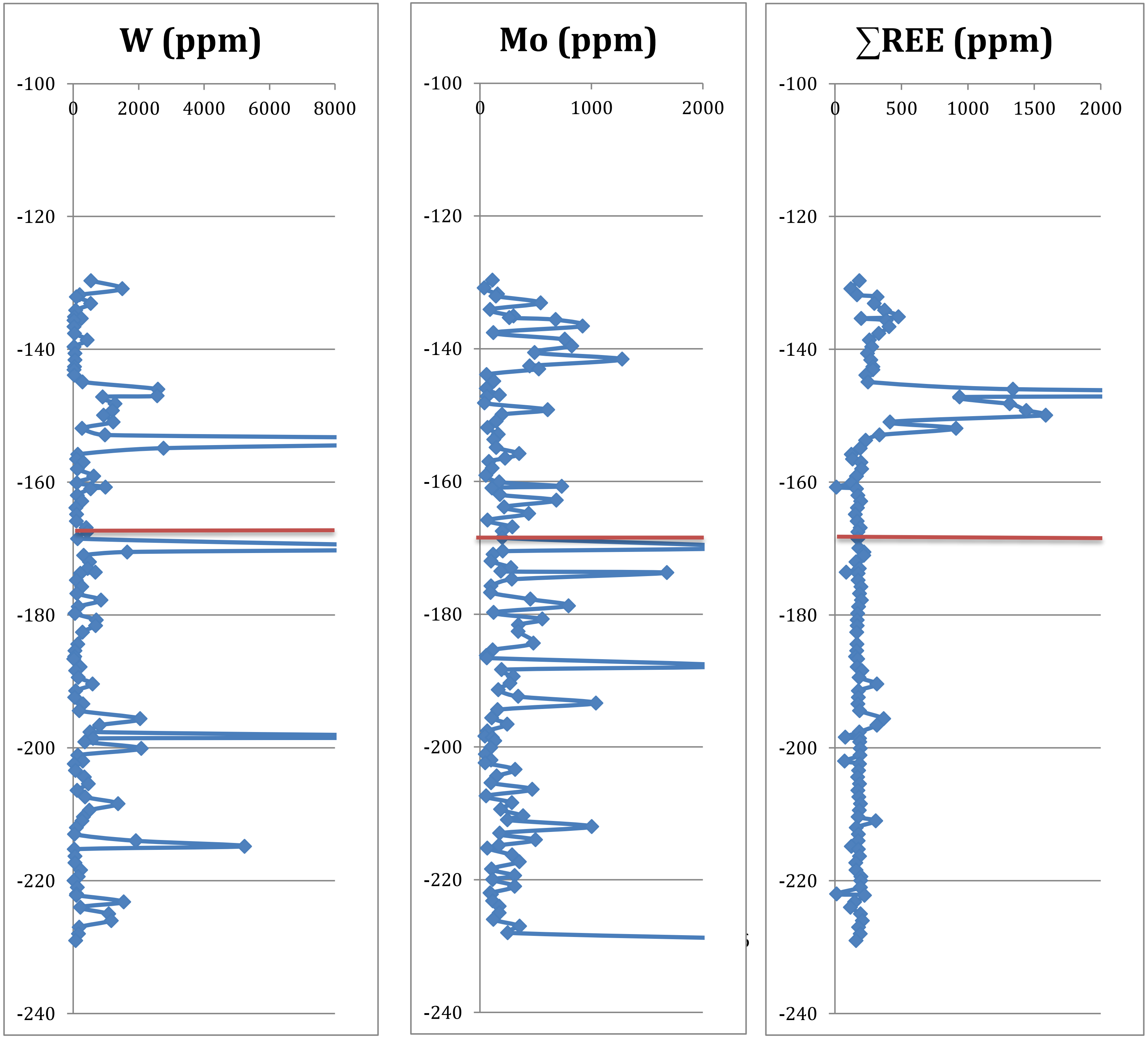
2. AA+200

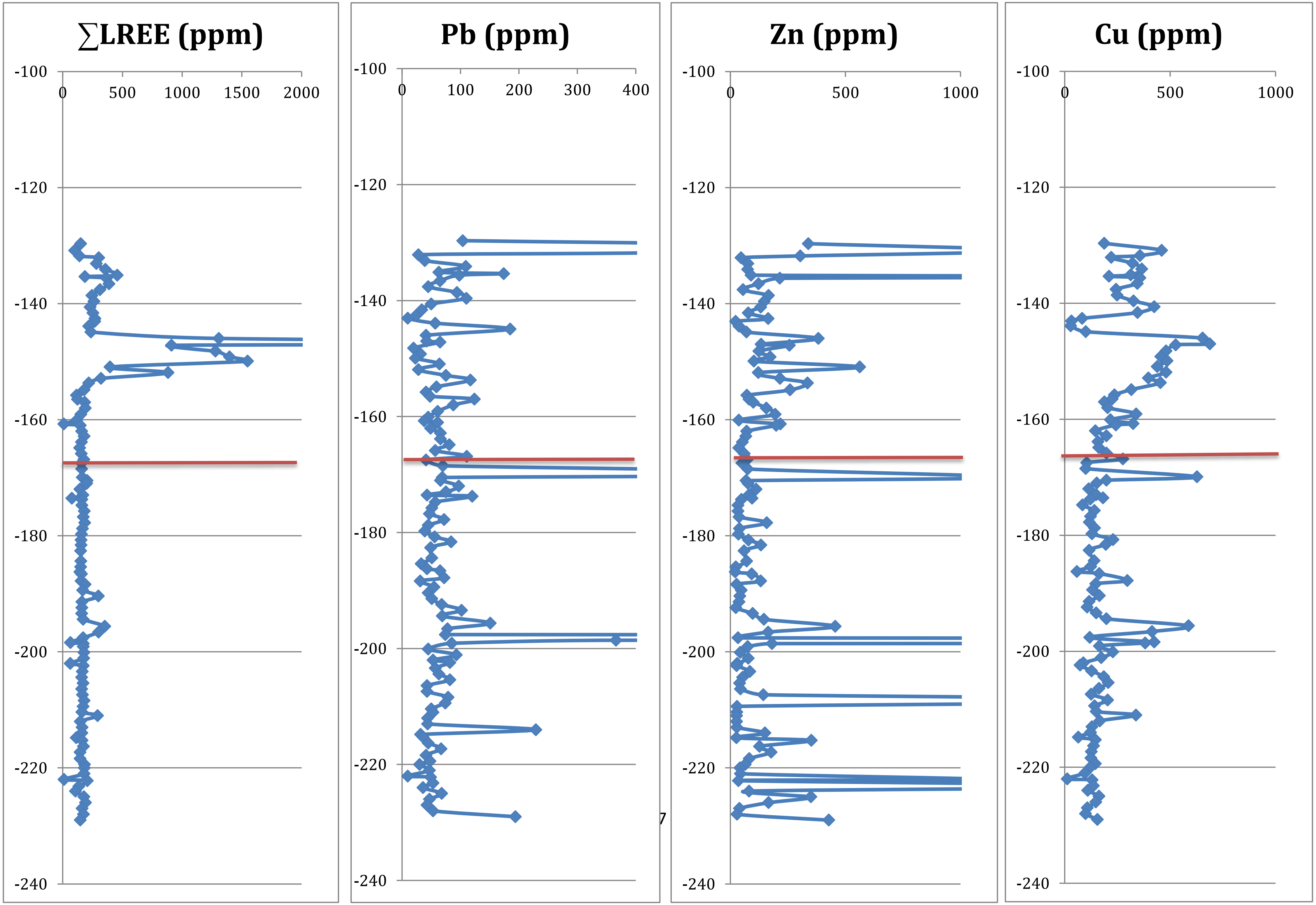


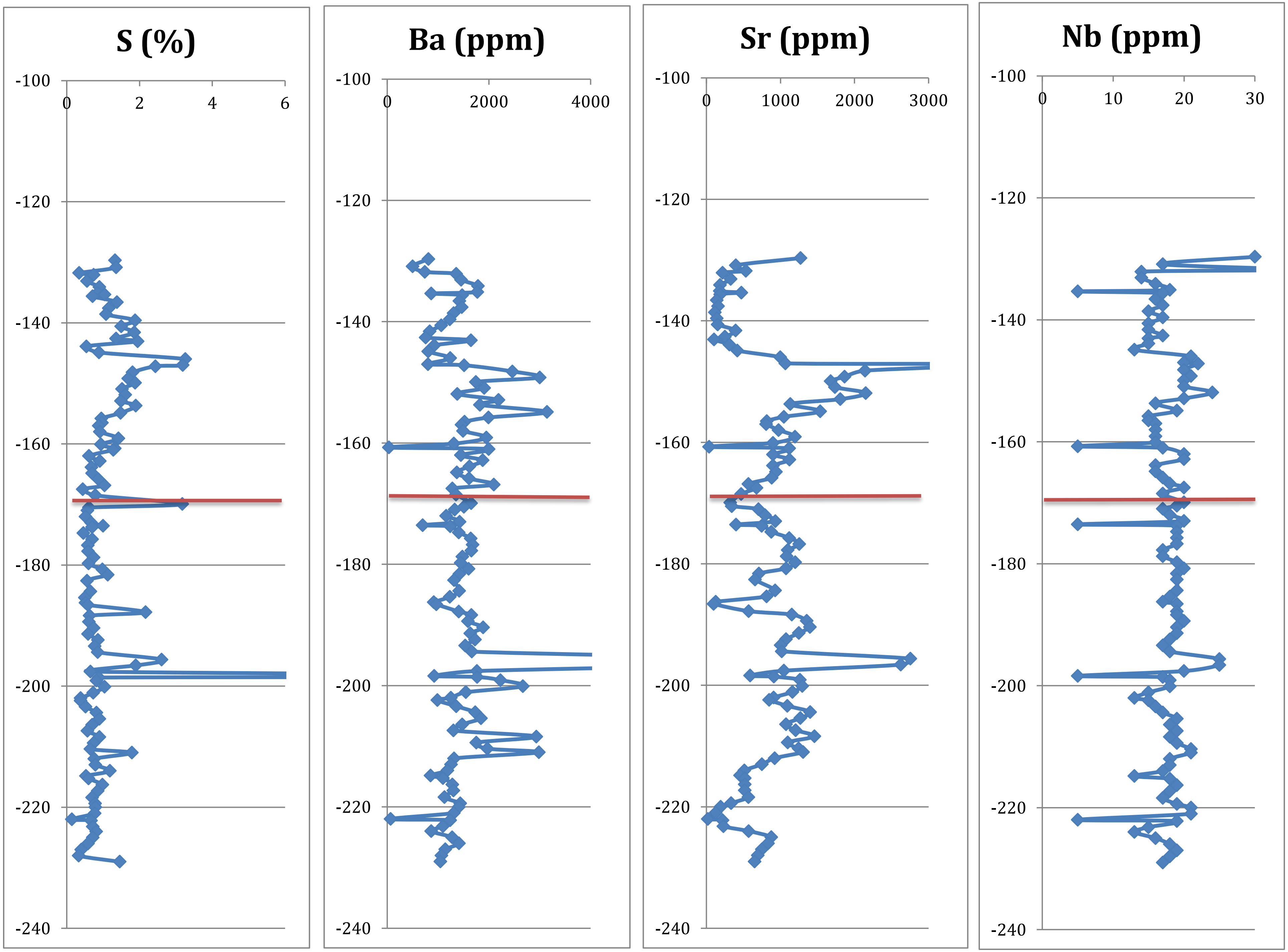

Mg (%)
Mn (%)
Fe (%)
Ti (%)
0
1
2
0.2
0.4
5
10
15
-100
-120
-140
-160
-180
-200
-220
-240


P (%)
0
0.05
0.1
0.15
0.2
-100
-120
-140
-160
-180
-200
-220
-240

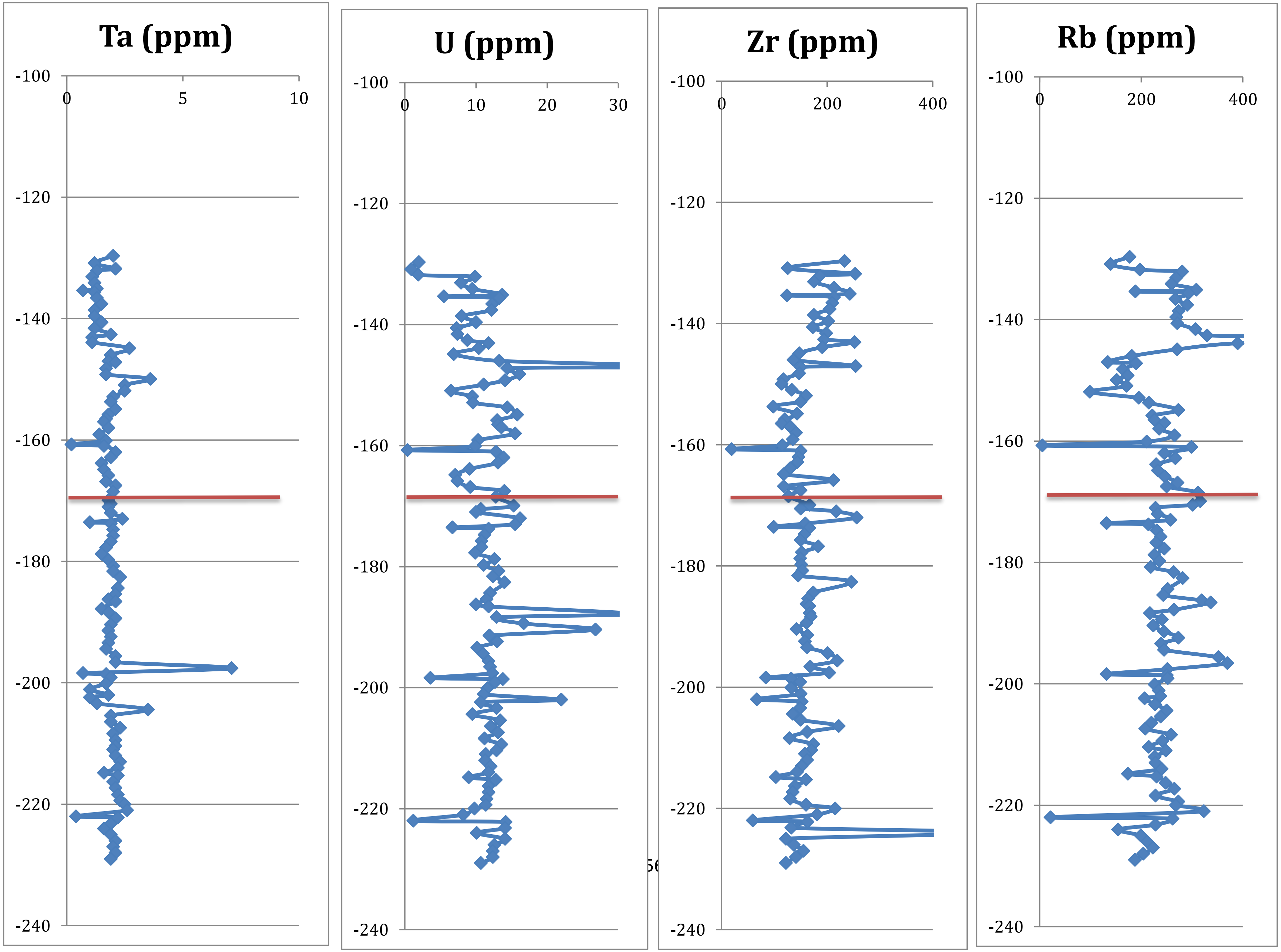

Al (%)
0
5
10
-100
-120
-140
-160
-180
-200
-220
-240

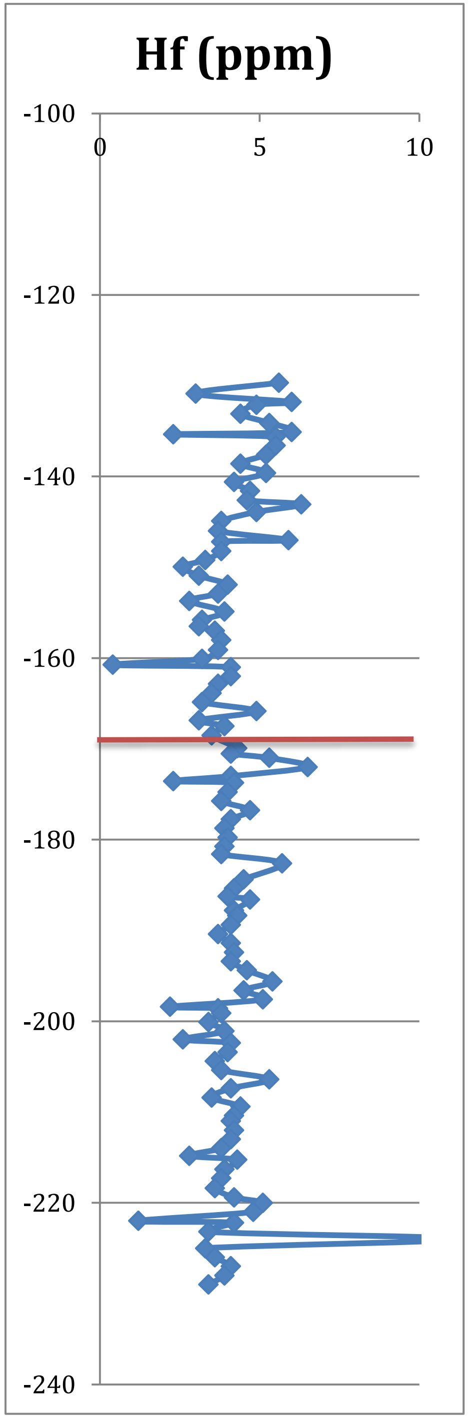

W (ppm)
Mo (ppm)
∑REE (ppm)
0
2000
4000
6000
8000
1000
500
1500
-100
-120
-140
-160
-180
-200
-220
-240

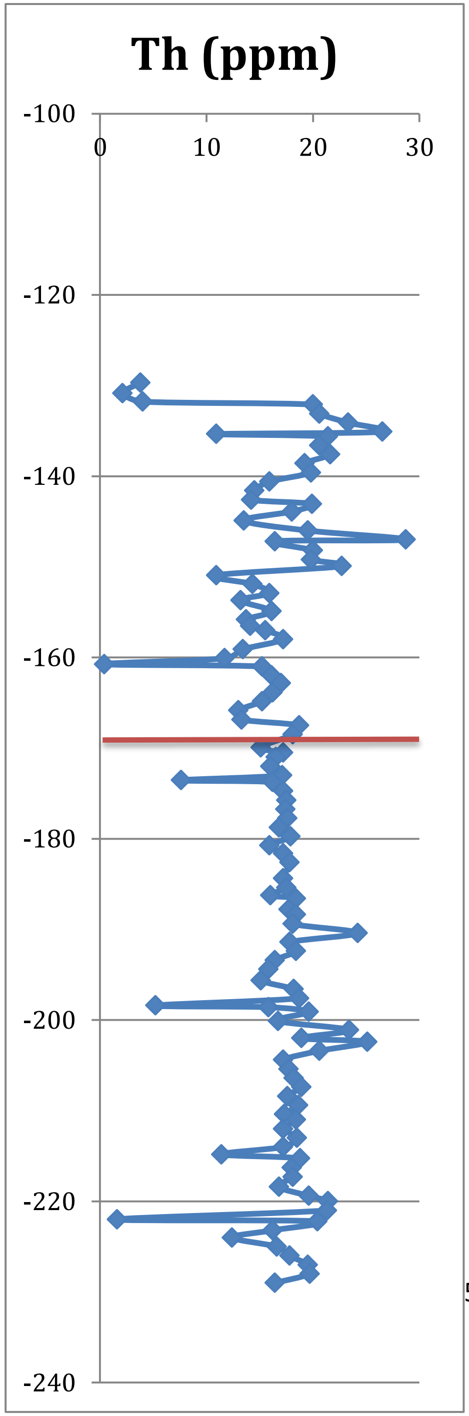

∑LREE (ppm)
0 500 1000 1500 2000
-100 -120 -140 -160 -180 -200 -220 -240
Pb (ppm)
0 100 200 300 400
-100 -120 -140 -160 -180 -200 -220 -240
Zn (ppm)
0 500 1000
-100 -120 -140 -160 -180 -200 -220 -240
Cu (ppm)
0 500 1000
-100 -120 -140 -160 -180 -200 -220 -240

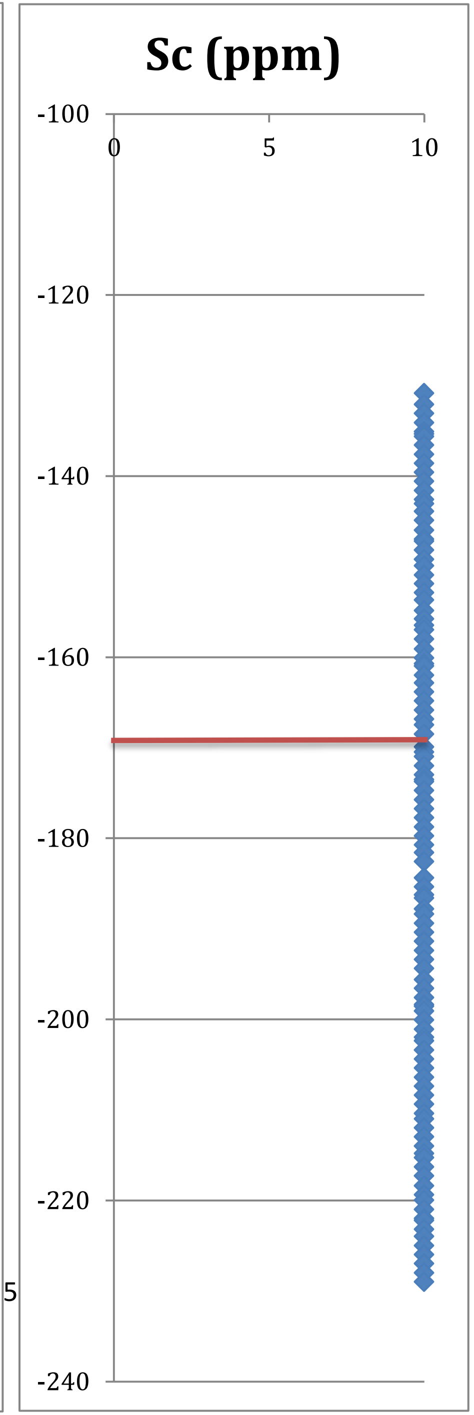


S (%)
-100
-120
-140
-160
-180
-200
-220
-240
0
2
4
6
Ba (ppm)
-100
-120
-140
-160
-180
-200
-220
-240
0
2000
4000
Sr (ppm)
-100
-120
-140
-160
-180
-200
-220
-240
0
1000
2000
3000
Nb (ppm)
-100
-120
-140
-160
-180
-200
-220
-240
0
10
20
30


Ta (ppm)
U (ppm)
Zr (ppm)
Rb (ppm)
0
5
10
20
30
200
400
-100
-120
-140
-160
-180
-200
-220
-240

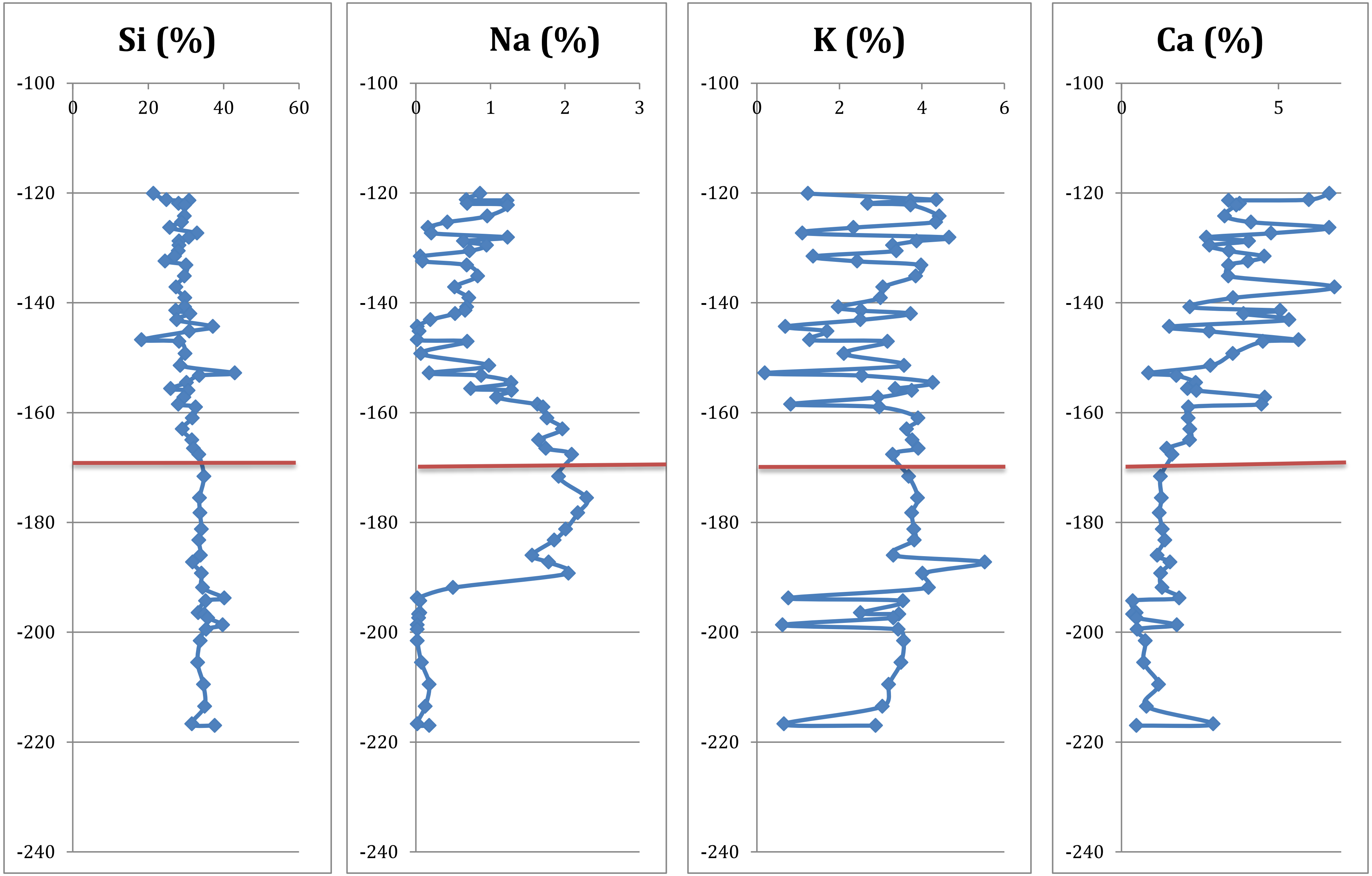

Hf (ppm)
0
5
10
-100
-120
-140
-160
-180
-200
-220
-240

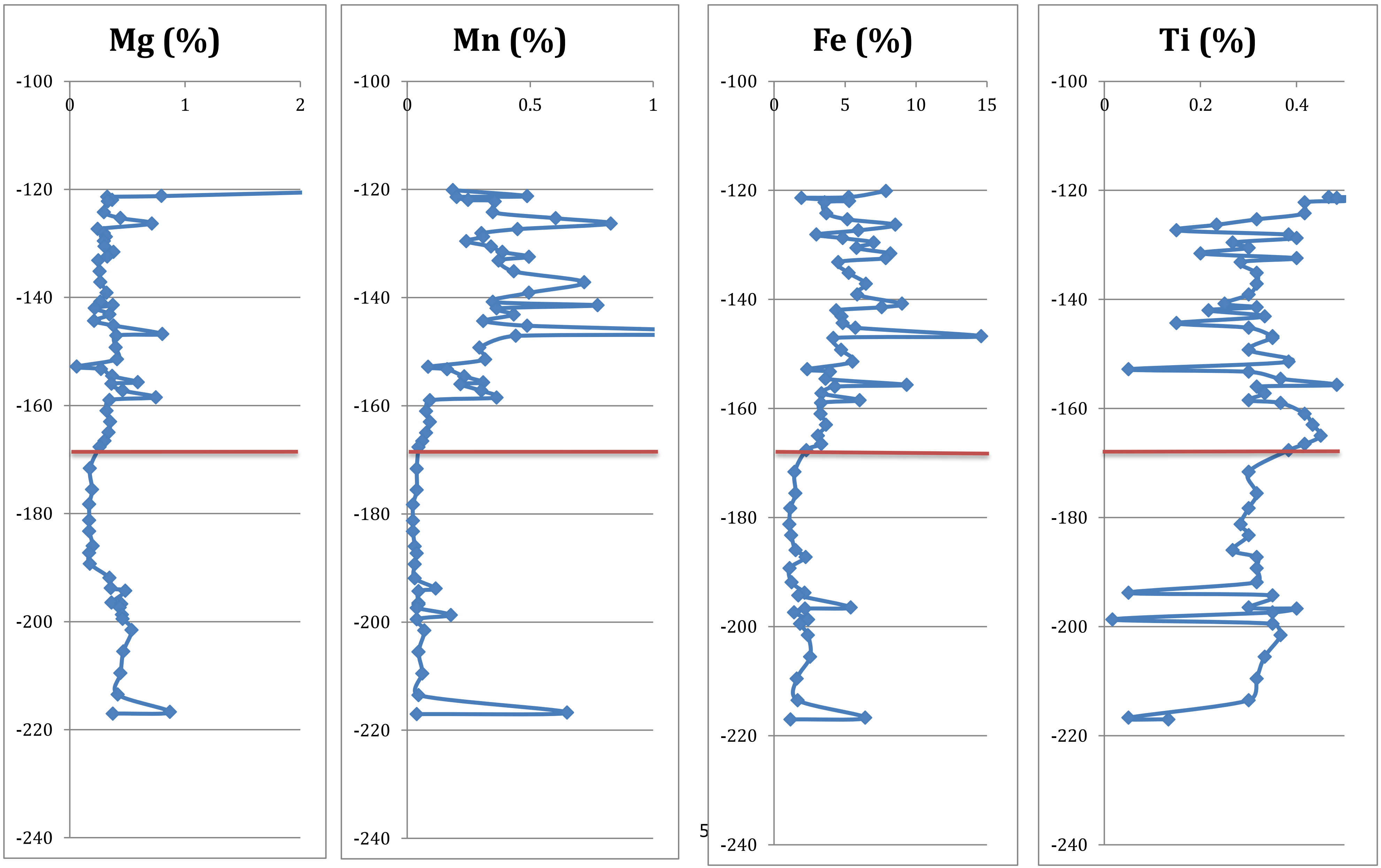

Th (ppm)
0
10
20
30
-100
-120
-140
-160
-180
-200
-220
-240

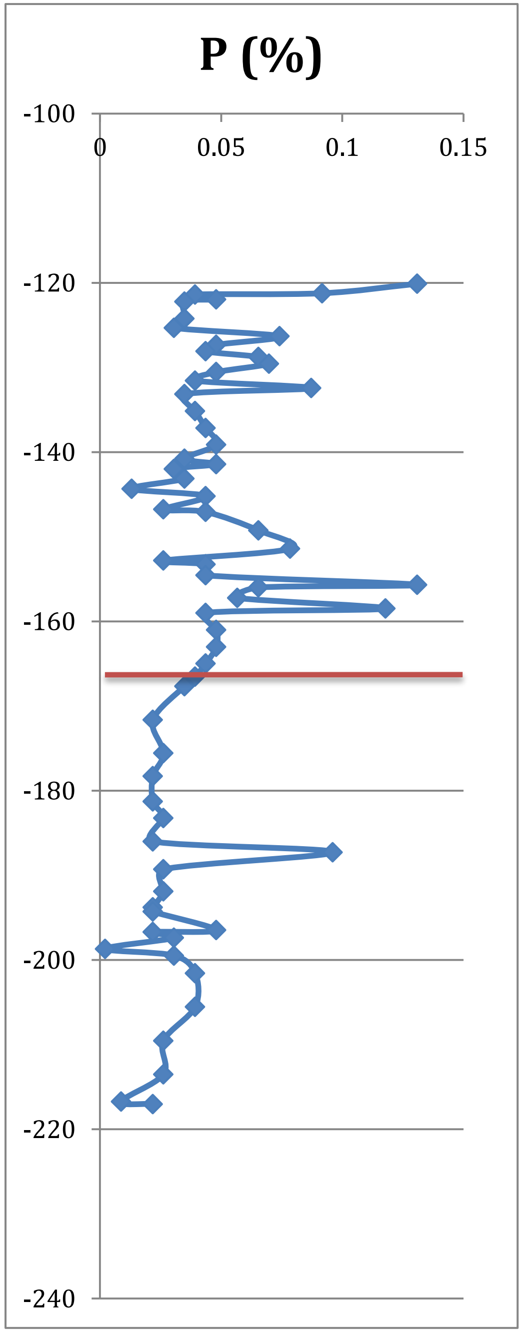

Sc (ppm)
0
5
10
-100
-120
-140
-160
-180
-200
-220
-240

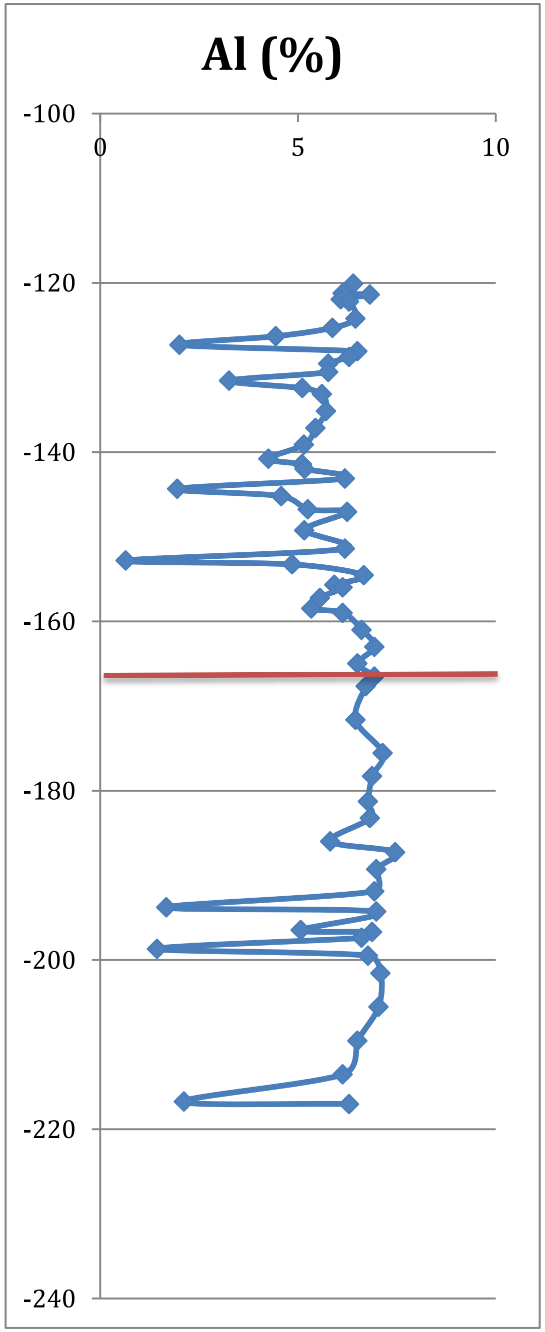
5

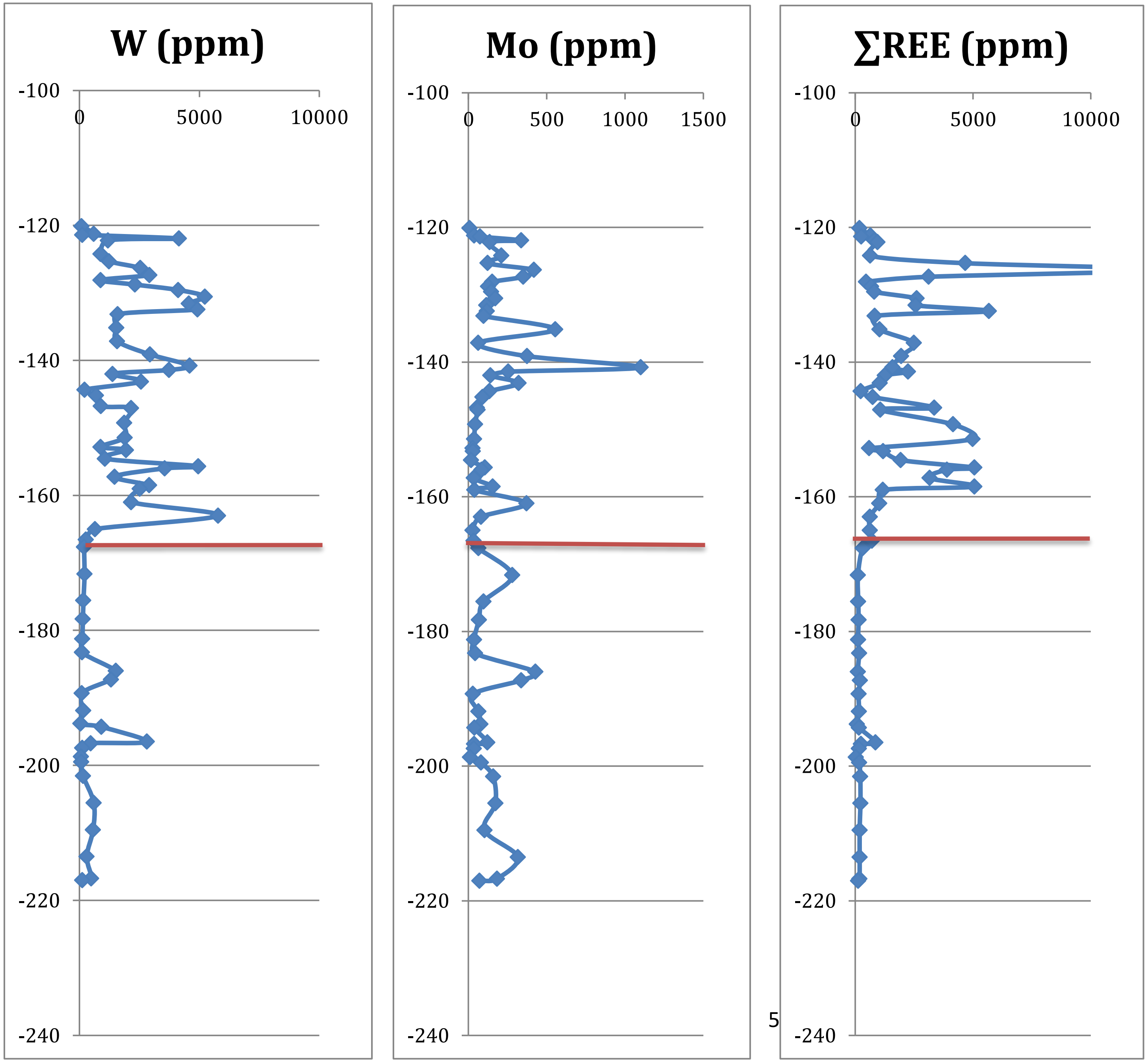
3. BB+400

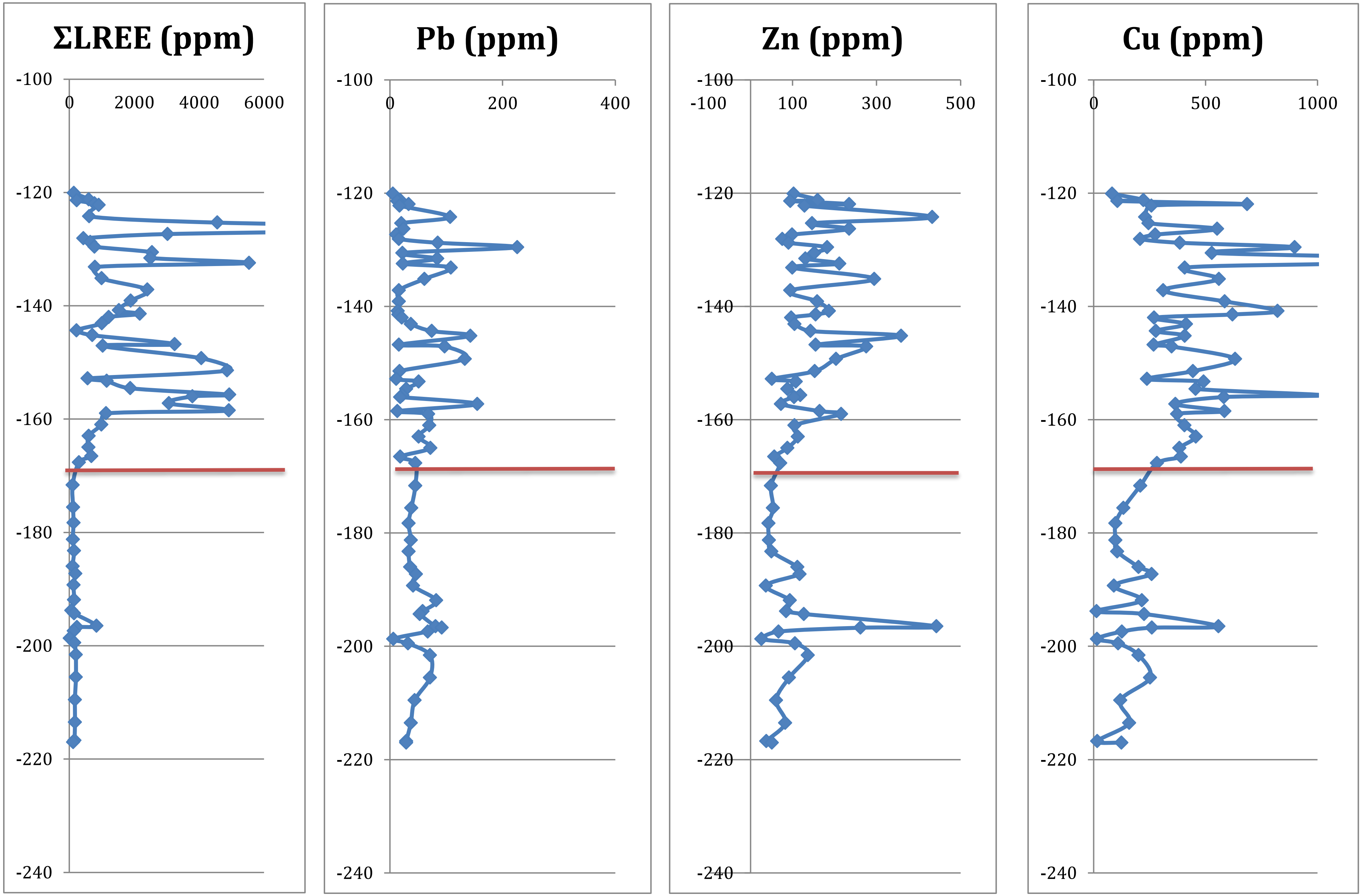


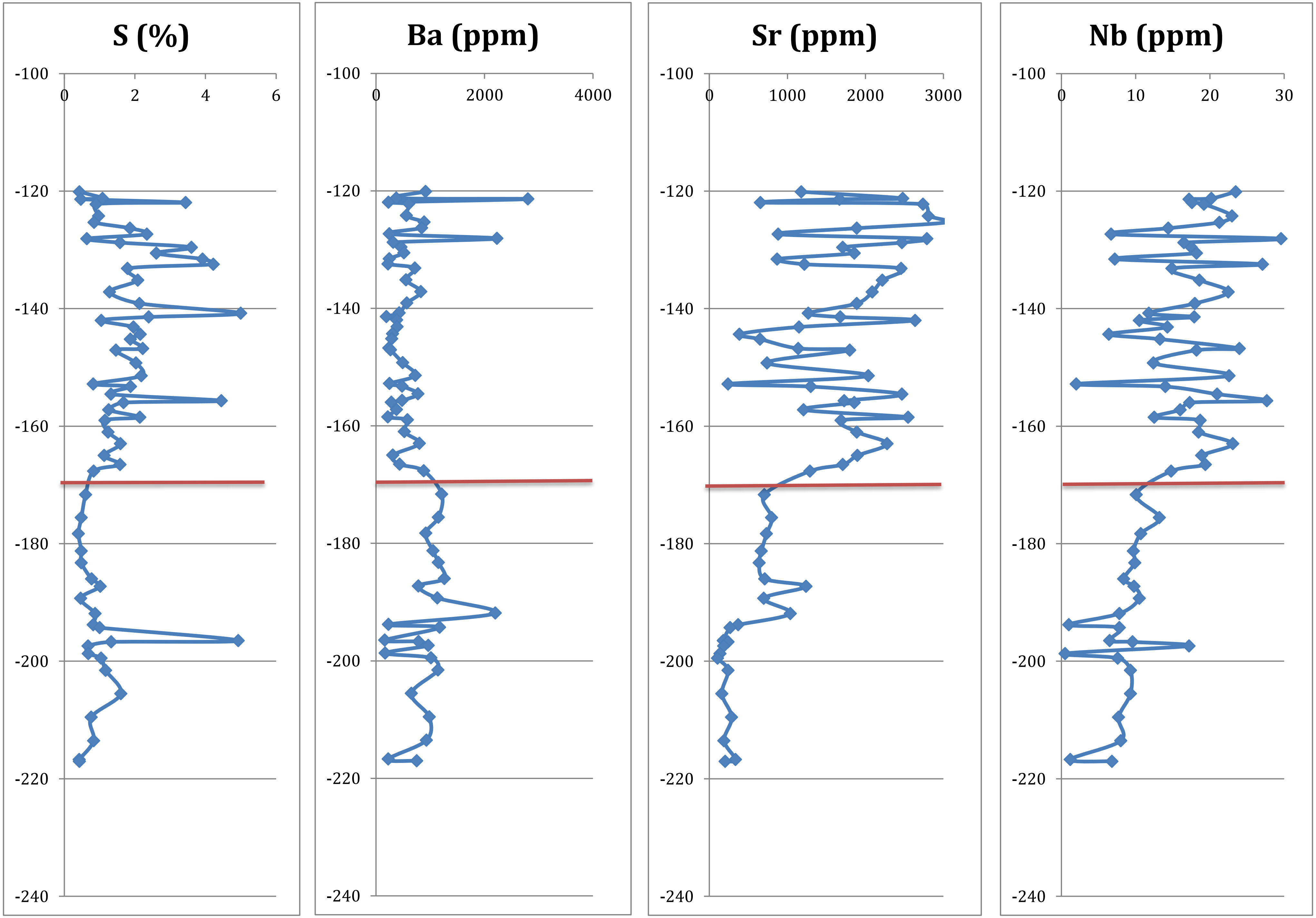

Mg (%)
0
1
2
Mn (%)
0
0.5
1
Fe (%)
0
5
10
15
Ti (%)
0
0.2
0.4
-100
-120
-140
-160
-180
-200
-220
-240

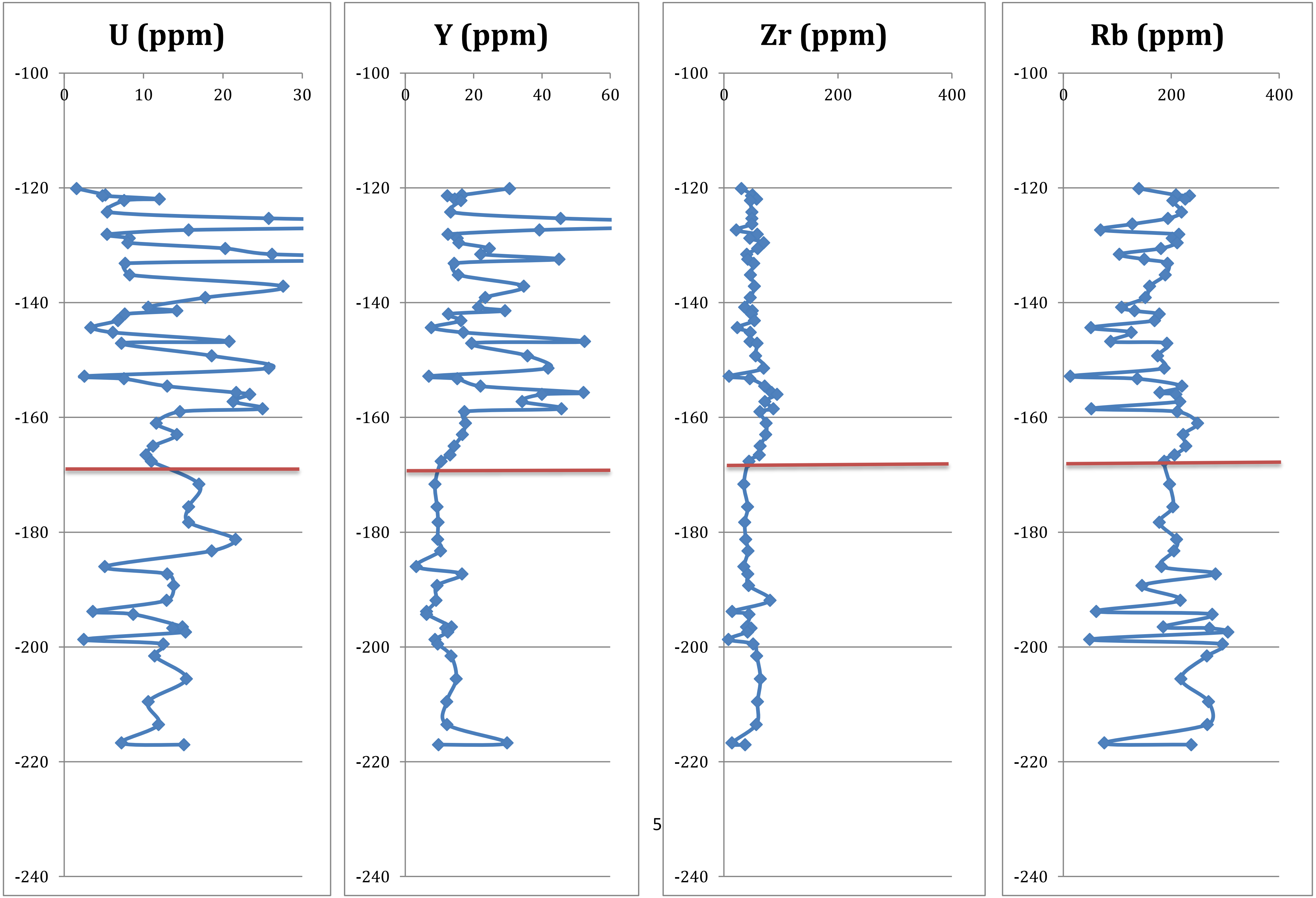

P (%)
0
0.05
0.1
0.15
-100
-120
-140
-160
-180
-200
-220
-240

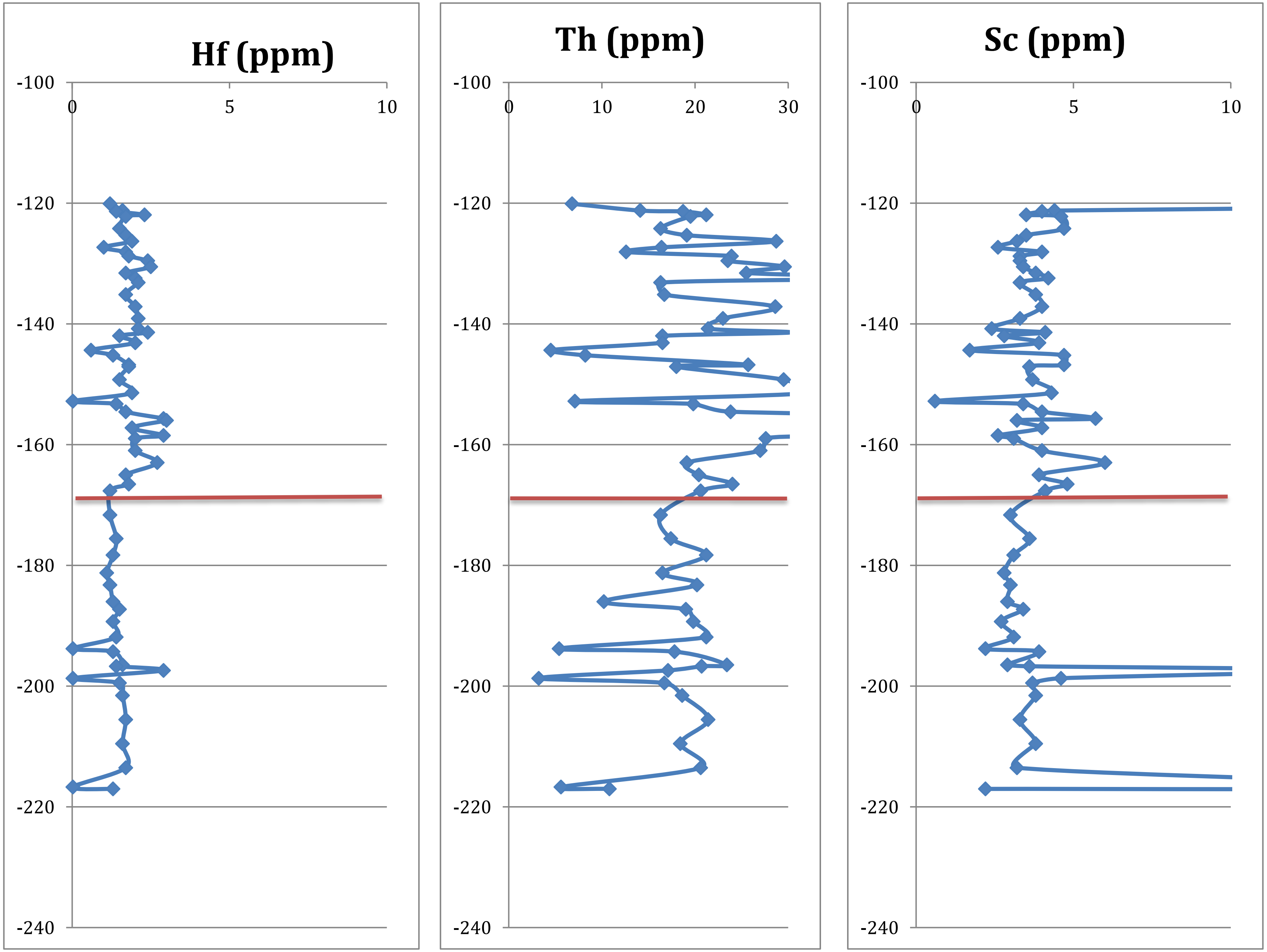

Al (%)
0
5
10
-100
-120
-140
-160
-180
-200
-220
-240


W (ppm)
0
5000
10000
-100
-120
-140
-160
-180
-200
-220
-240
Mo (ppm)
0
500
1000
1500
-100
-120
-140
-160
-180
-200
-220
-240
∑REE (ppm)
0
5000
10000
-100
-120
-140
-160
-180
-200
-220
-240

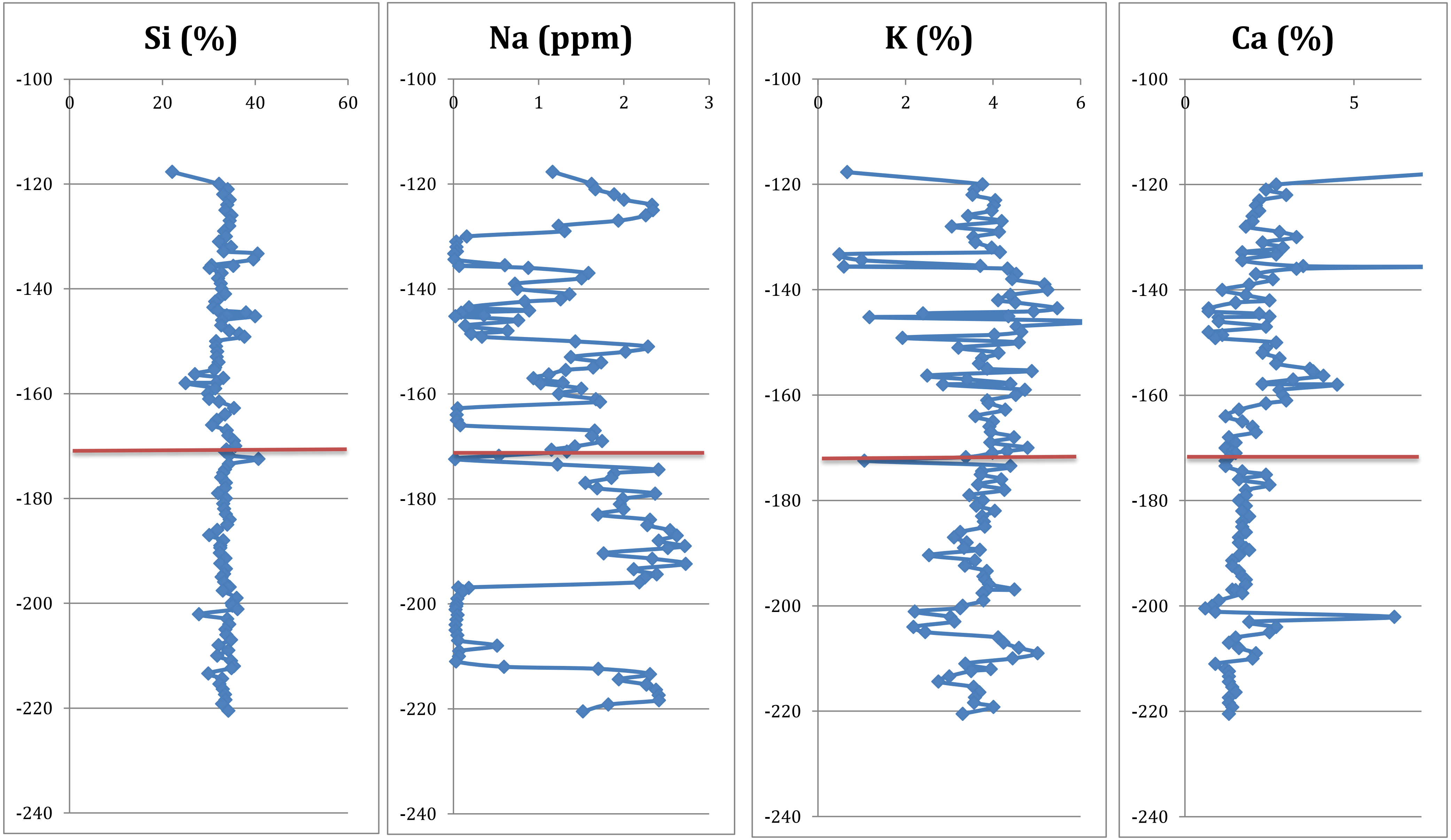

ΣLREE (ppm)
0 2000 4000 6000
Pb (ppm)
0 200 400
Zn (ppm)
-100 100 300 500
Cu (ppm)
0 500 1000
-100 -120 -140 -160 -180 -200 -220 -240

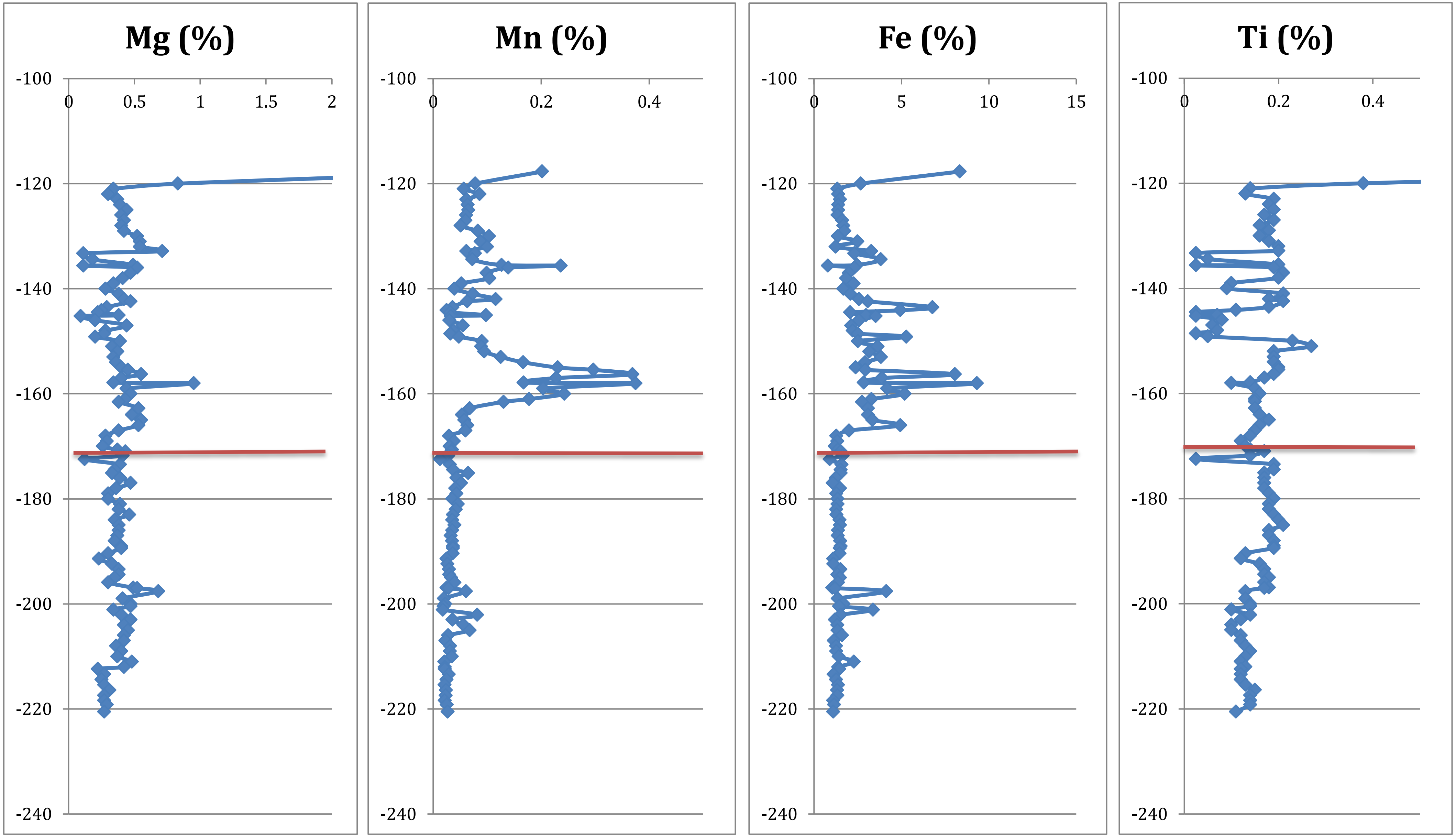

S (%)
0
2
4
6
Ba (ppm)
0
2000
4000
Sr (ppm)
0
1000
2000
3000
Nb (ppm)
0
10
20
30
-100
-120
-140
-160
-180
-200
-220
-240

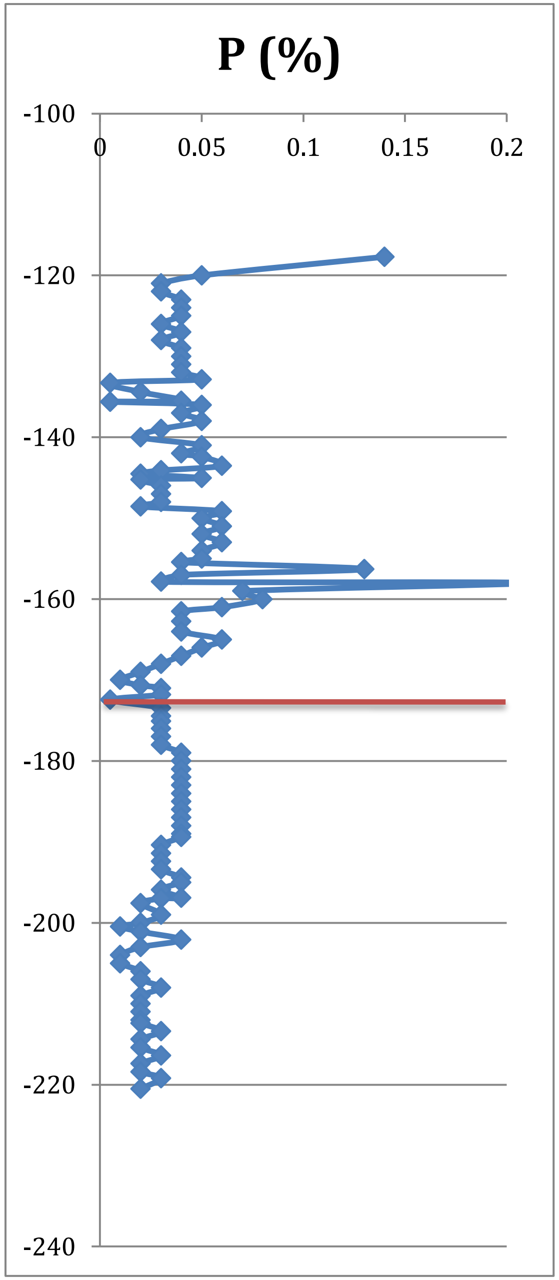

U (ppm)
Y (ppm)
Zr (ppm)
Rb (ppm)
-100
-120
-140
-160
-180
-200
-220
-240
0
10
20
30
40
60
200
400

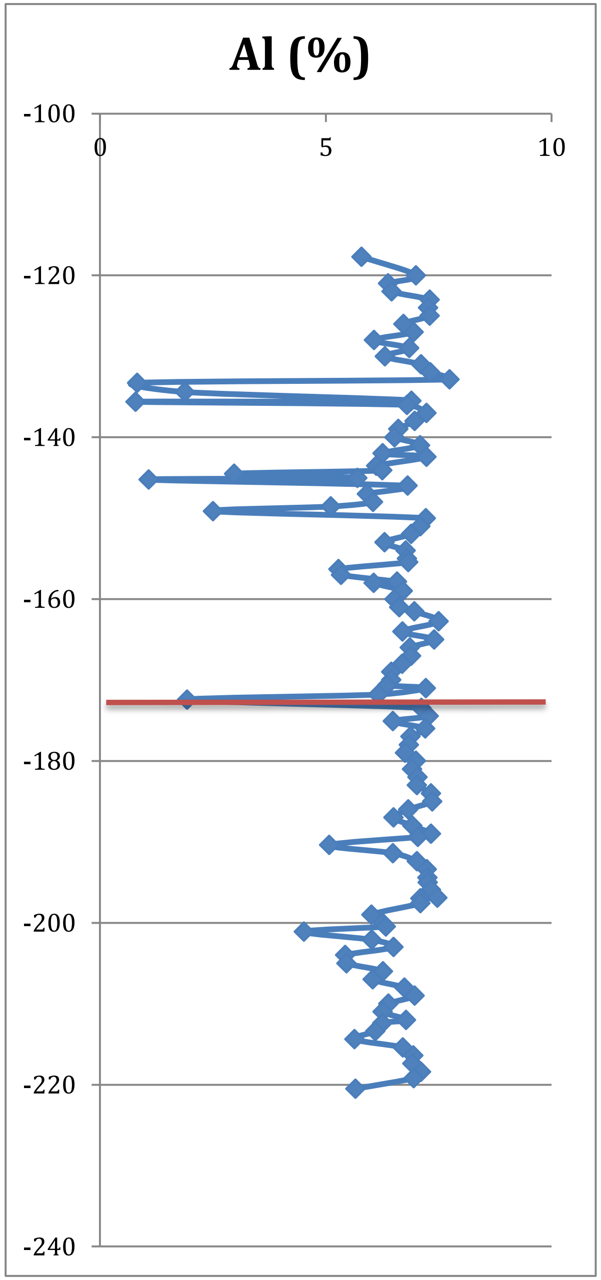

Hf (ppm)
Th (ppm)
Sc (ppm)
0
5
10
0
10
20
30
0
5
10
-100
-120
-140
-160
-180
-200
-220
-240

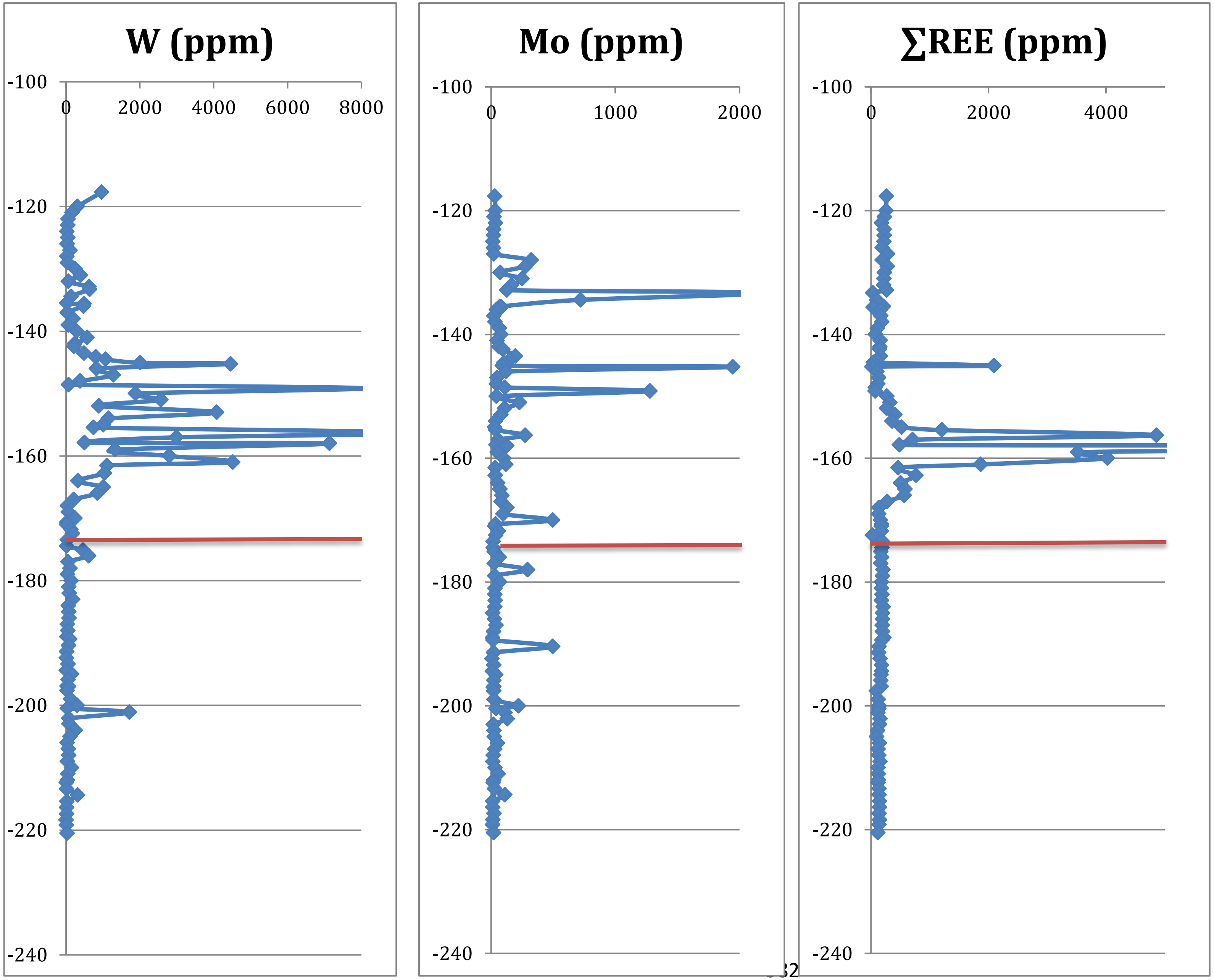
4. CC+400

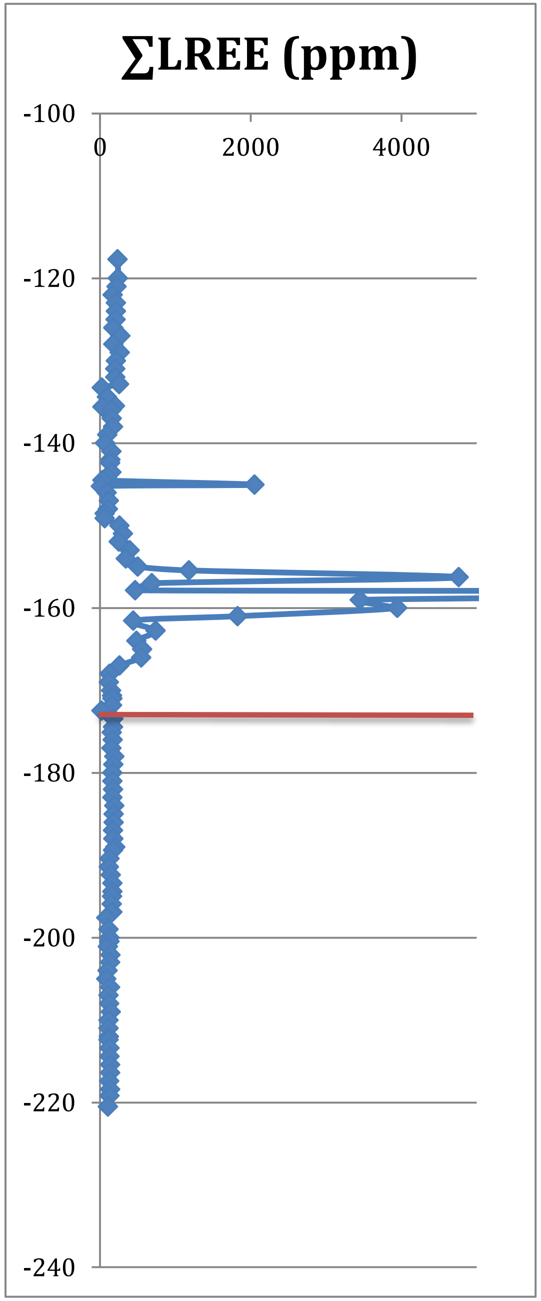

Si (%)
0
20
40
60
-100
-120
-140
-160
-180
-200
-220
-240
Na (ppm)
0
1
2
3
K (%)
0
2
4
6
Ca (%)
0
5

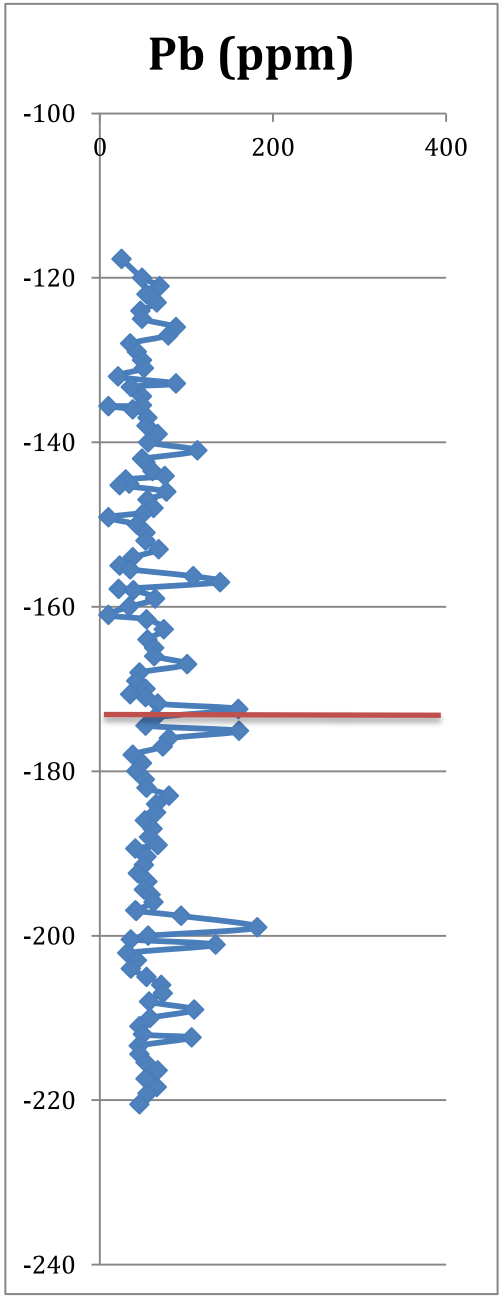

Mg (%)
0
0.5
1
1.5
2
-100
-120
-140
-160
-180
-200
-220
-240
Mn (%)
0
0.2
0.4
-100
-120
-140
-160
-180
-200
-220
-240
Fe (%)
0
5
10
15
-100
-120
-140
-160
-180
-200
-220
-240
Ti (%)
0
0.2
0.4
-100
-120
-140
-160
-180
-200
-220
-240

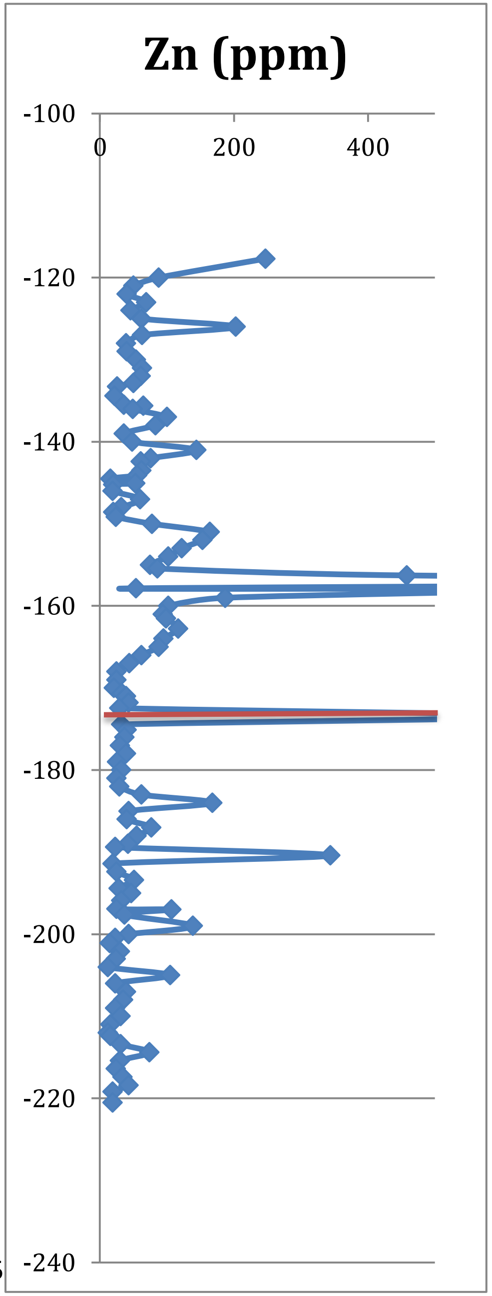

P (%)
-100
-120
-140
-160
-180
-200
-220
-240
0
0.05
0.1
0.15
0.2

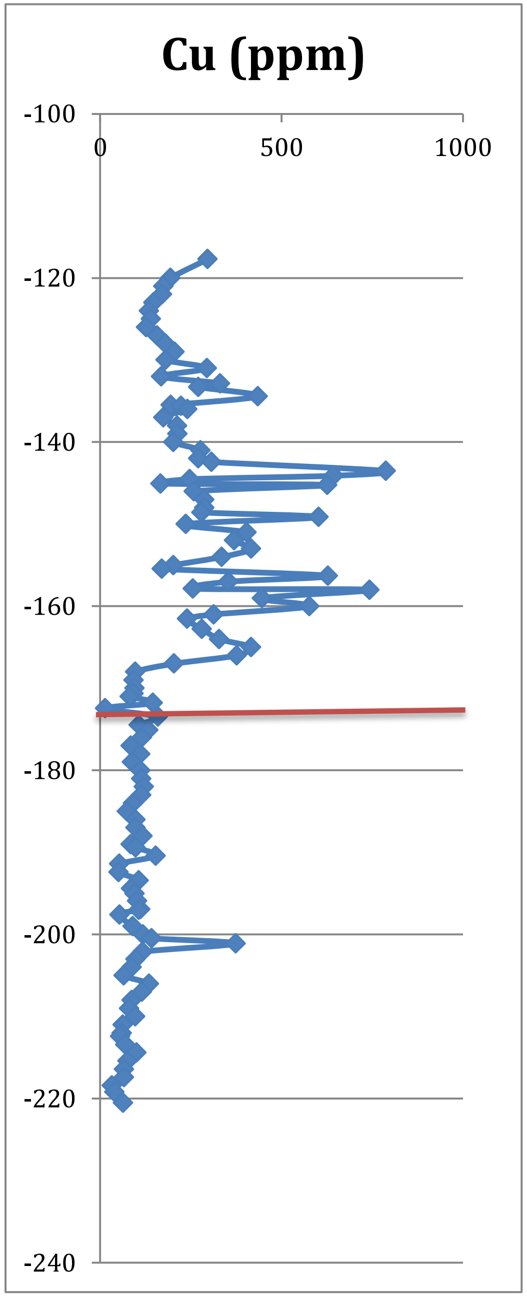

Al (%)
-100
-120
-140
-160
-180
-200
-220
-240
0
5
10

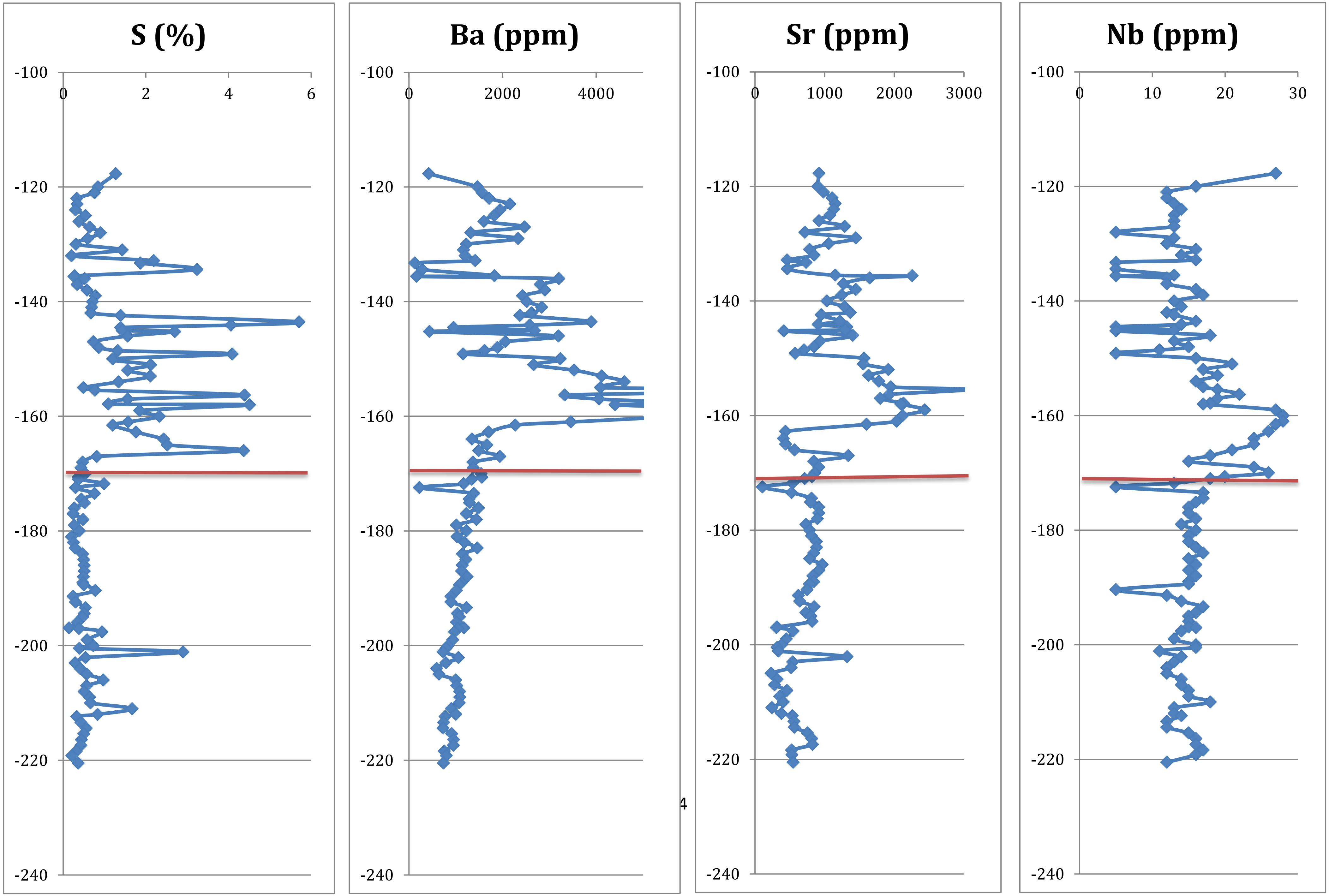

W (ppm)
0
2000
4000
6000
8000
-100
-120
-140
-160
-180
-200
-220
-240
Mo (ppm)
0
1000
2000
-100
-120
-140
-160
-180
-200
-220
-240
∑REE (ppm)
0
2000
4000
-100
-120
-140
-160
-180
-200
-220
-240

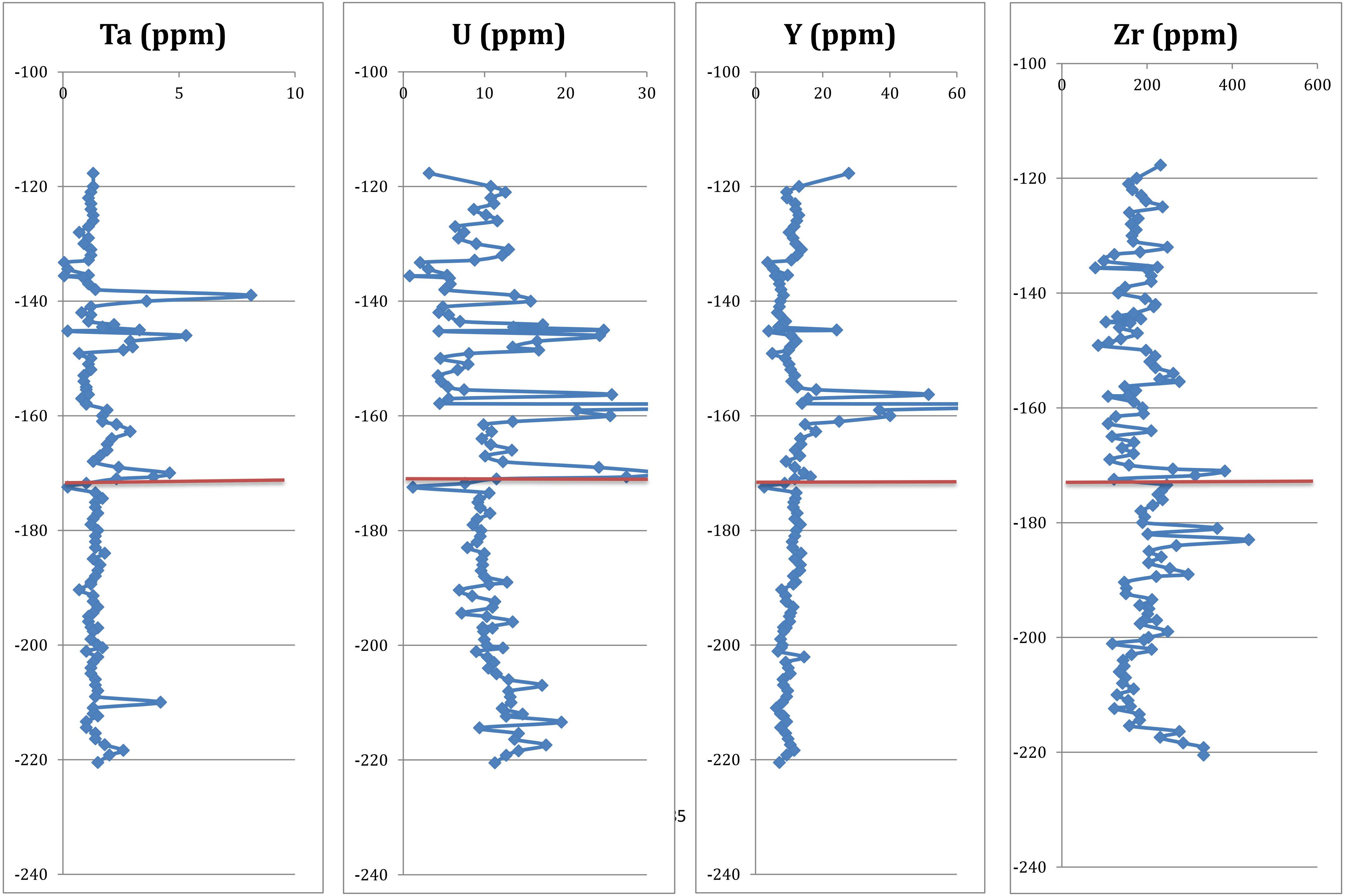

∑LREE (ppm)
0
2000
4000
-100
-120
-140
-160
-180
-200
-220
-240

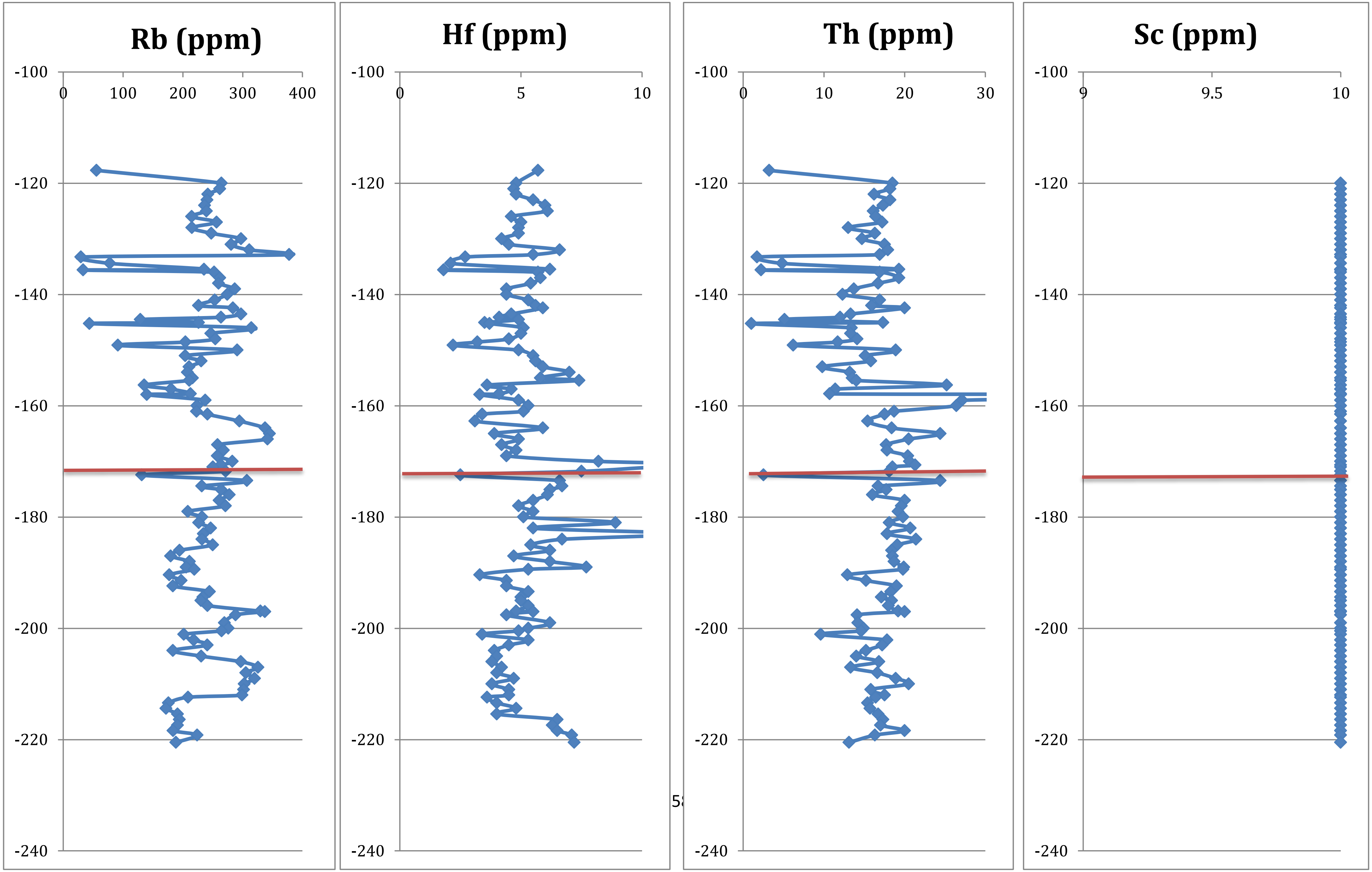

Pb (ppm)
0
200
400
-100
-120
-140
-160
-180
-200
-220
-240


Zn (ppm)
0
200
400
-100
-120
-140
-160
-180
-200
-220
-240

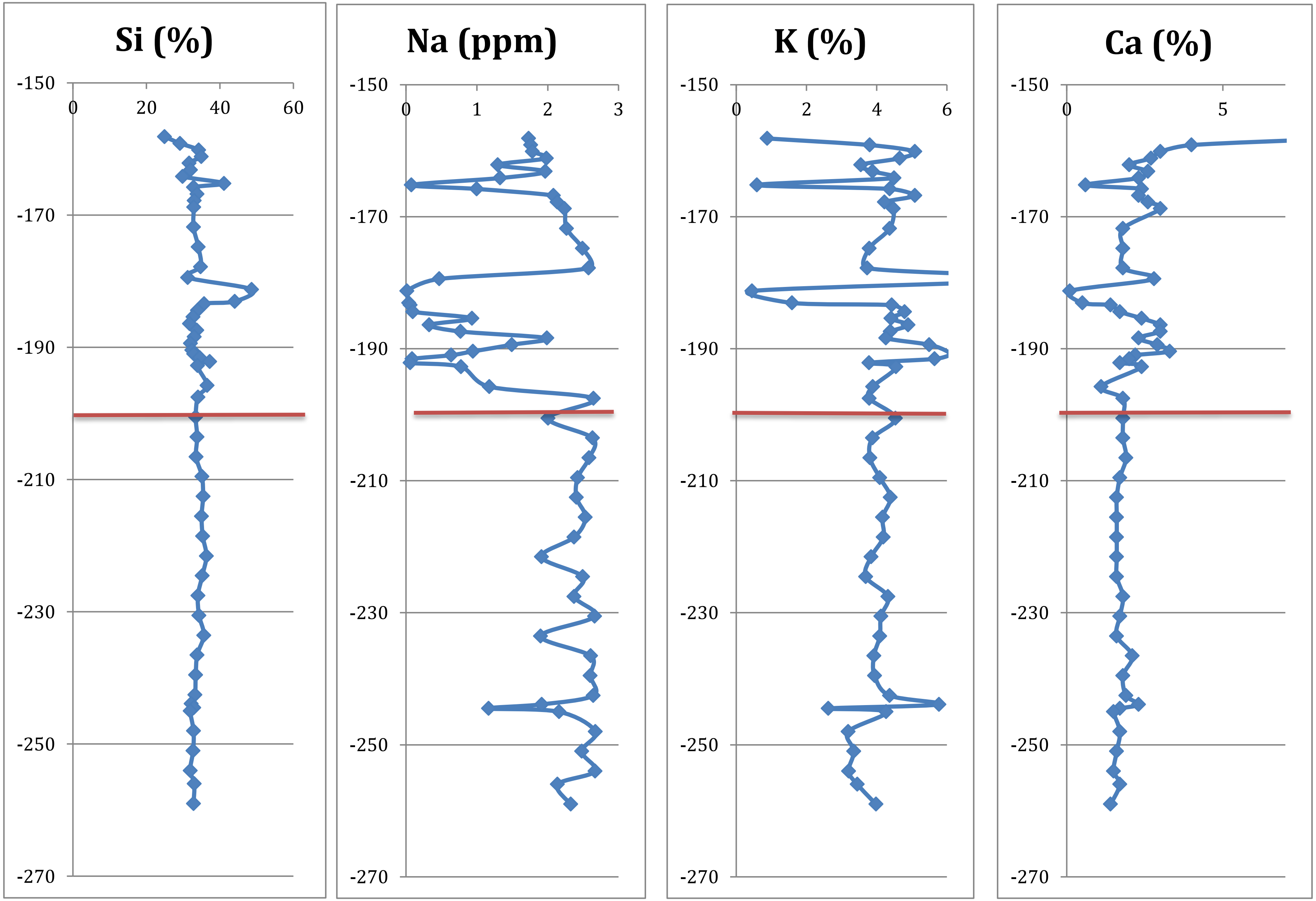

Cu (ppm)
0
500
1000
-100
-120
-140
-160
-180
-200
-220
-240

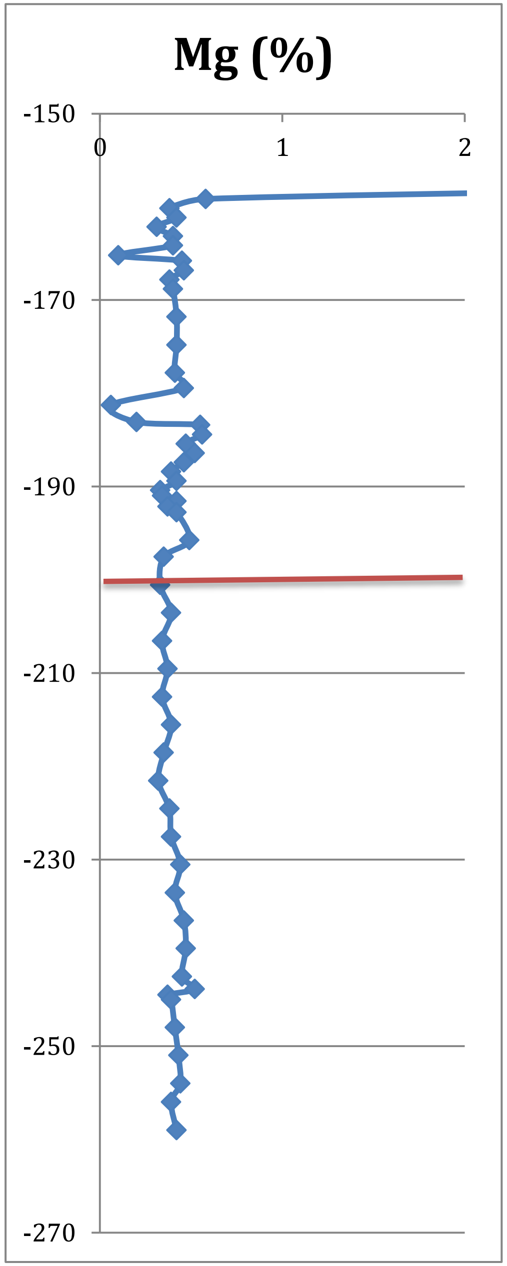

S (%)
Ba (ppm)
Sr (ppm)
Nb (ppm)
-100
-120
-140
-160
-180
-200
-220
-240
0
2
4
6
2000
4000
1000
3000
10
20
30

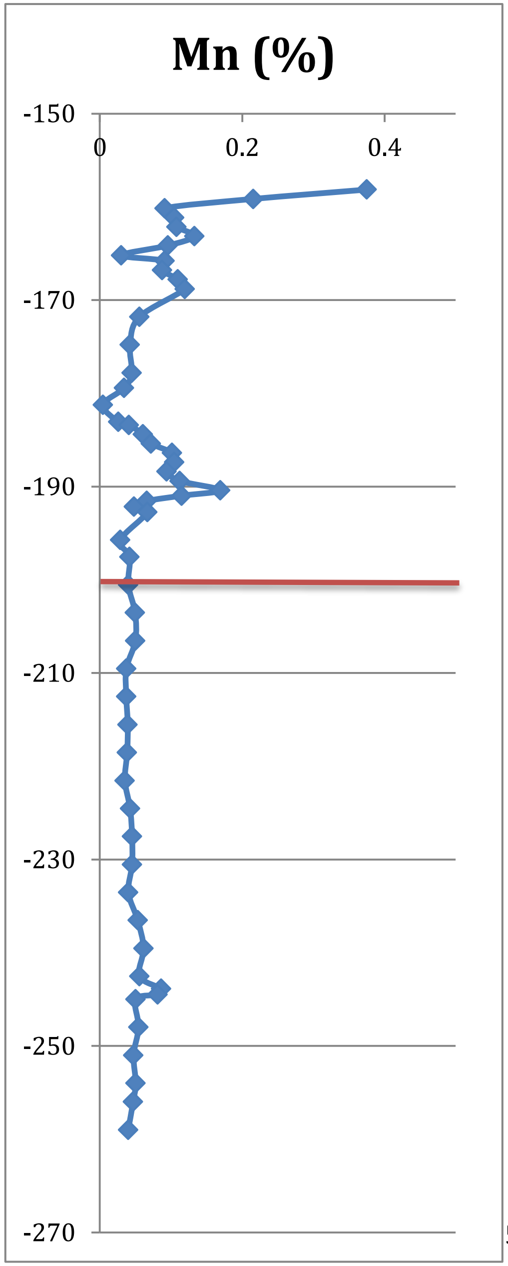

Ta (ppm)
0
5
10
U (ppm)
0
10
20
30
Y (ppm)
0
20
40
60
Zr (ppm)
0
200
400
600
-100
-120
-140
-160
-180
-200
-220
-240

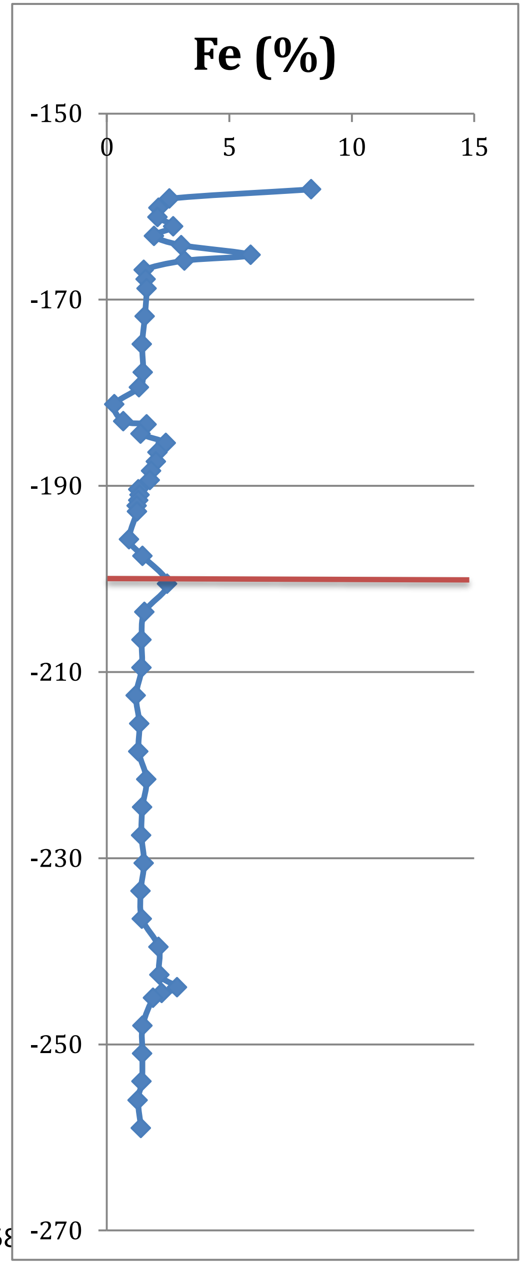

Rb (ppm)
0 100 200 300 400
-100 -120 -140 -160 -180 -200 -220 -240
Hf (ppm)
0 5 10
-100 -120 -140 -160 -180 -200 -220 -240
Th (ppm)
0 10 20 30
-100 -120 -140 -160 -180 -200 -220 -240
Sc (ppm)
9 9.5 10
-100 -120 -140 -160 -180 -200 -220 -240

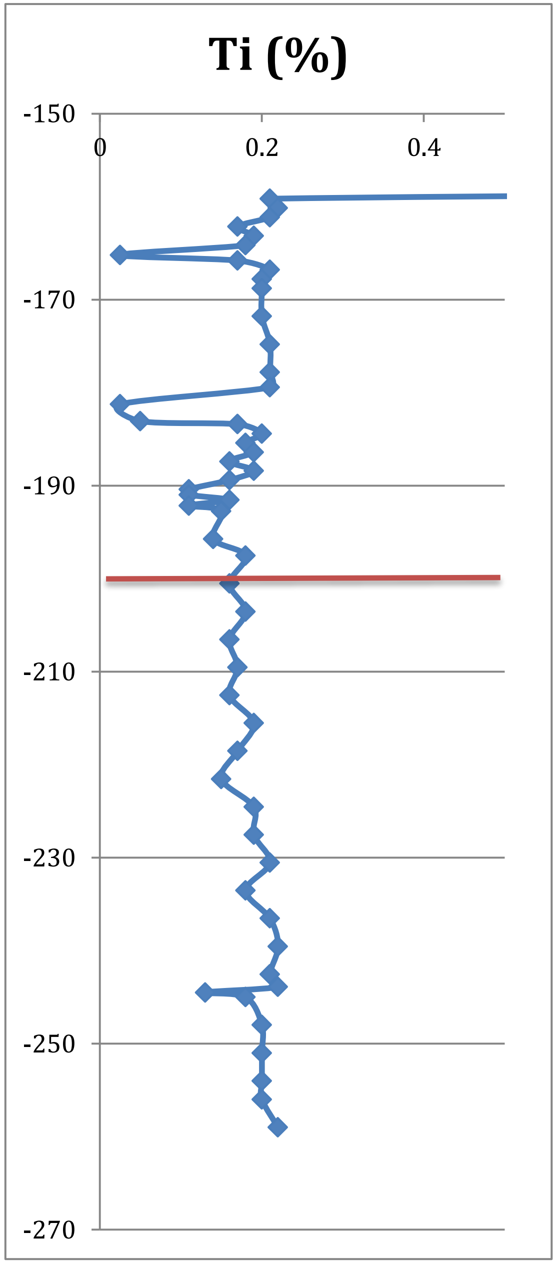
5. DD+200

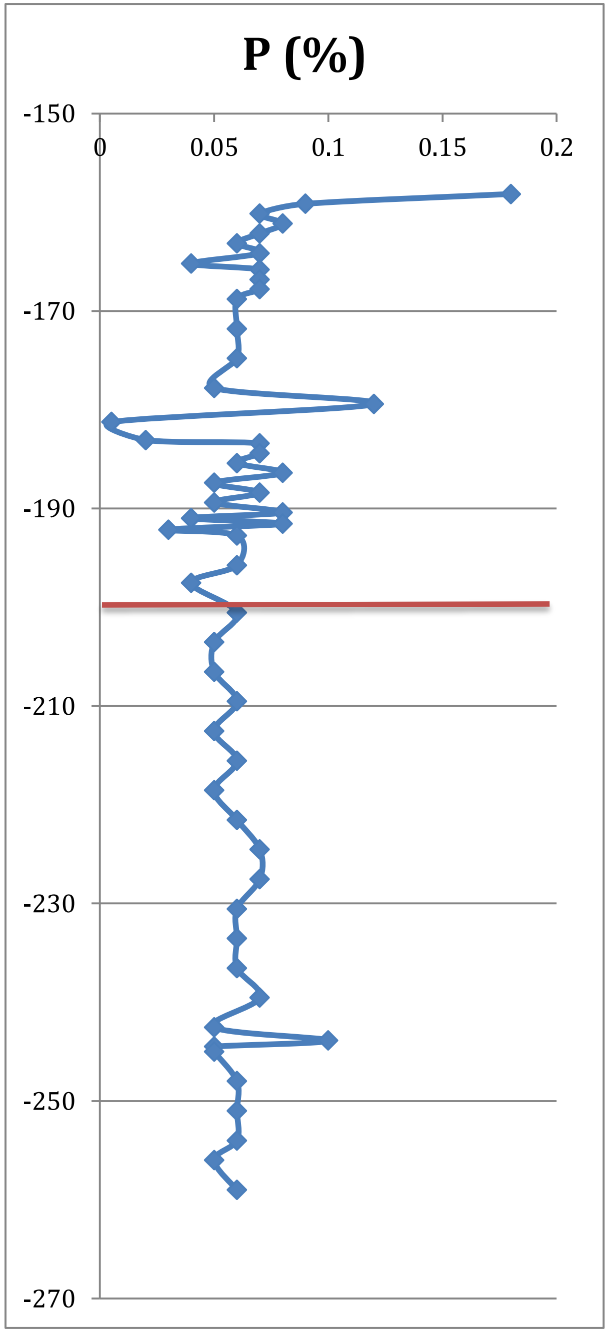

Si (%)
0 20 40 60
-150 -170 -190 -210 -230 -250 -270
Na (ppm)
0 1 2 3
-150 -170 -190 -210 -230 -250 -270
K (%)
0 2 4 6
-150 -170 -190 -210 -230 -250 -270
Ca (%)
0 5
-150 -170 -190 -210 -230 -250 -270

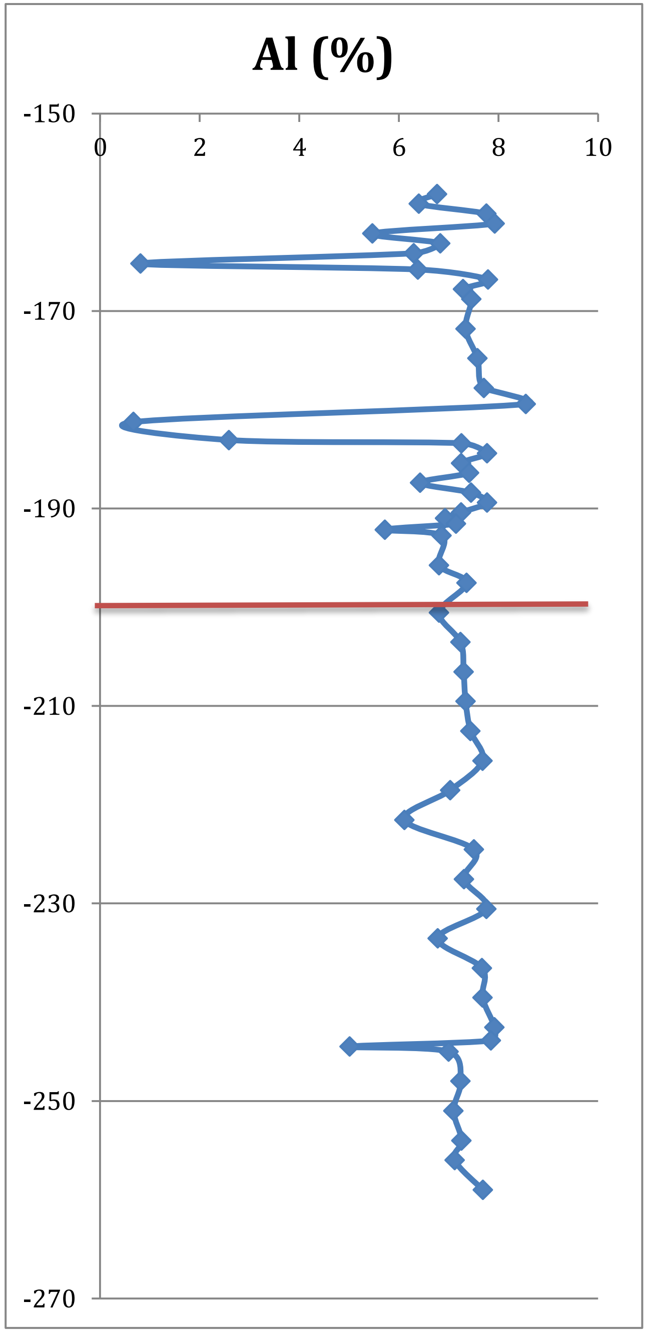

Mg (%)
-150
-170
-190
-210
-230
-250
-270
0
1
2

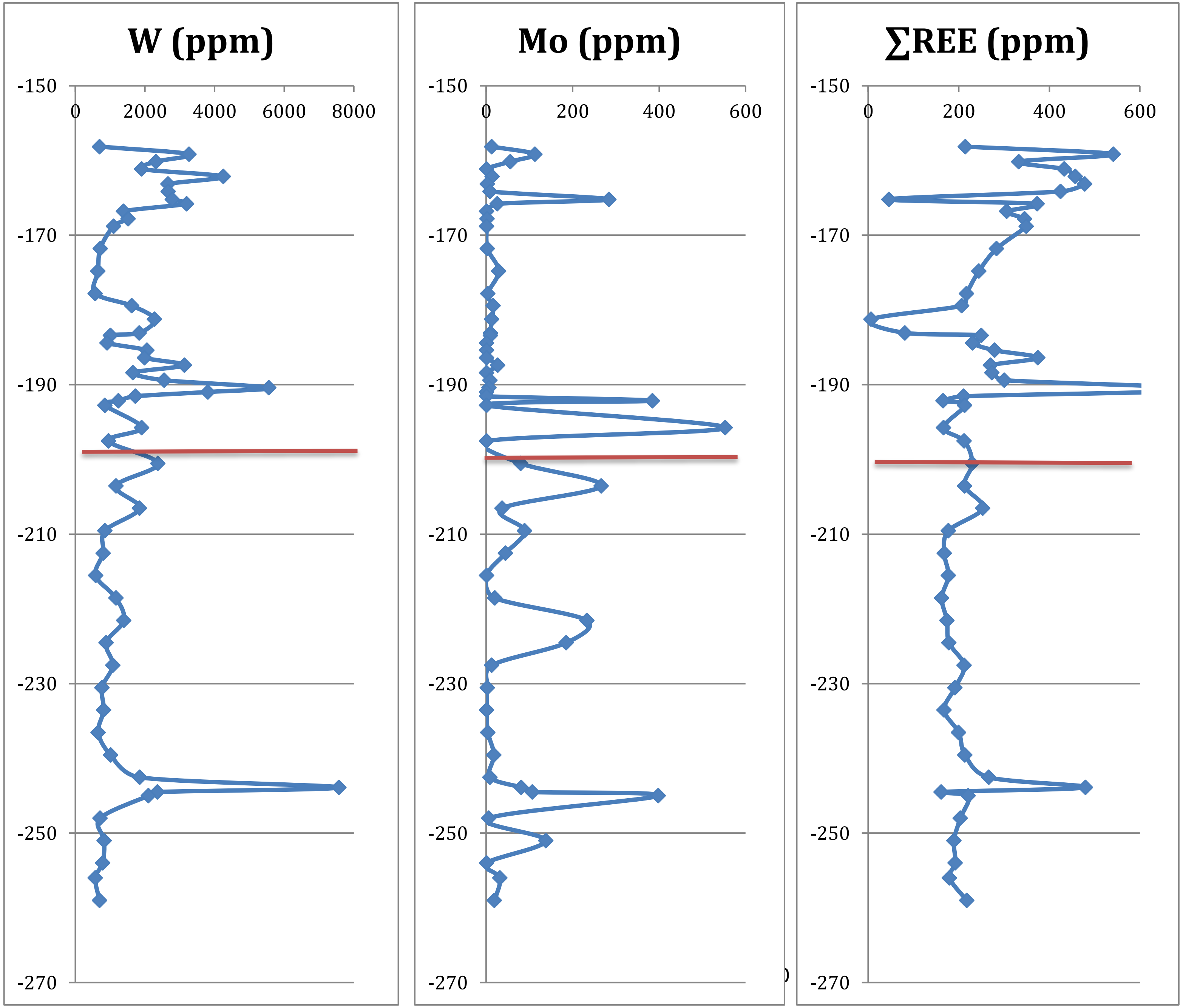

Mn (%)
-150
-170
-190
-210
-230
-250
-270
0
0.2
0.4

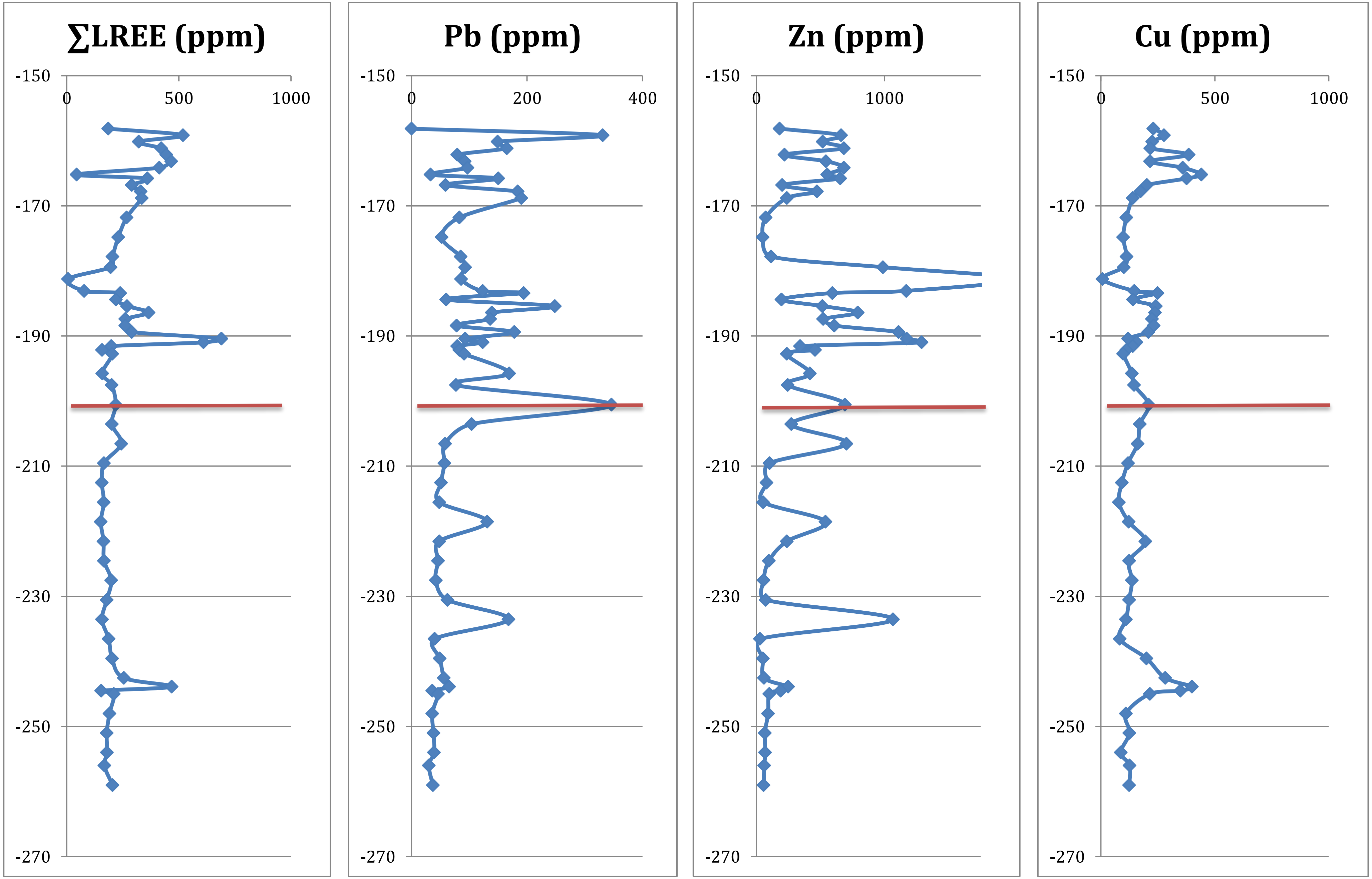

Fe (%)
-150
-170
-190
-210
-230
-250
-270
0
5
10
15


Ti (%)
-150
-170
-190
-210
-230
-250
-270
0
0.2
0.4

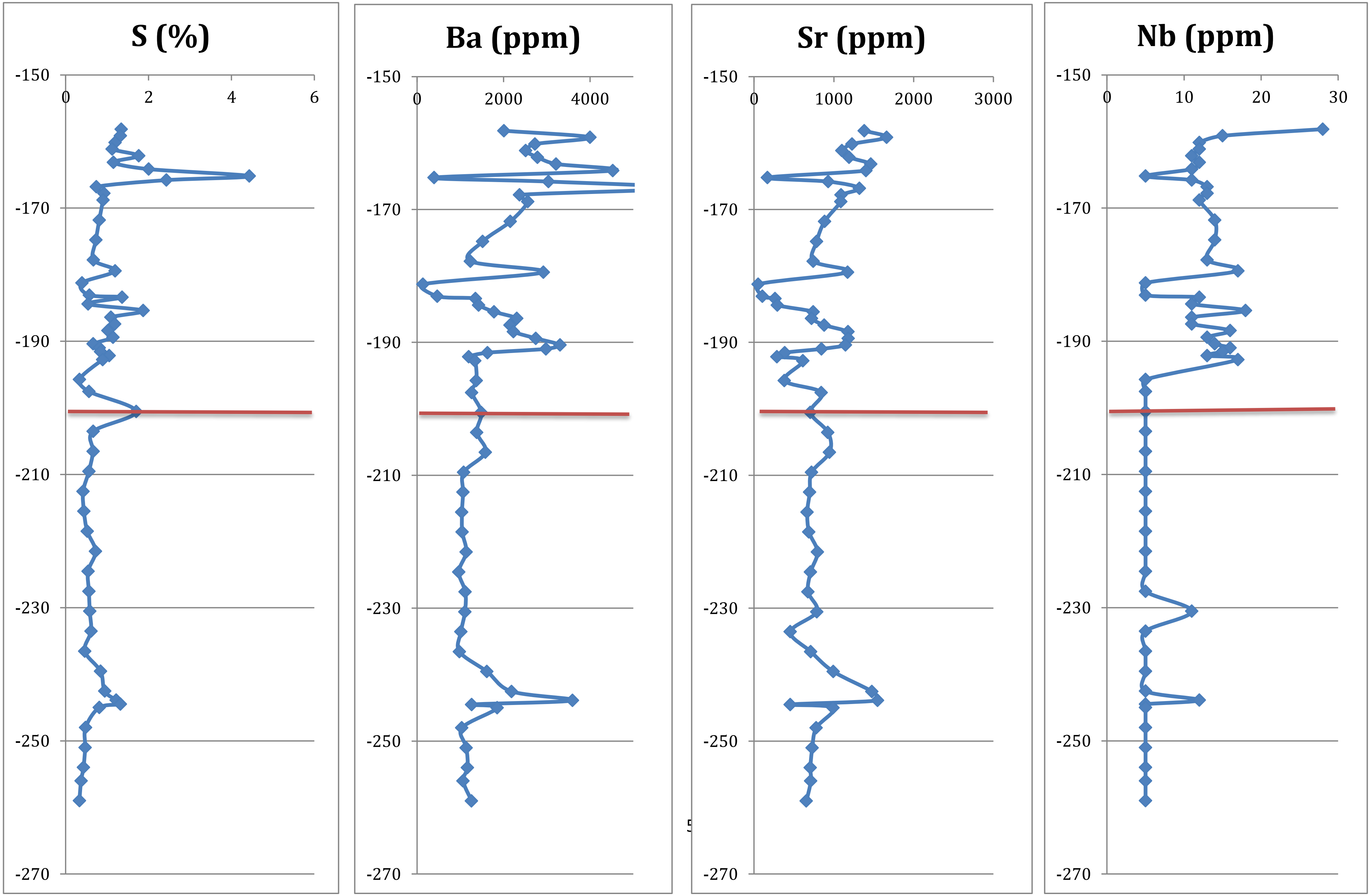

P (%)
0
0.05
0.1
0.15
0.2
-150
-170
-190
-210
-230
-250
-270

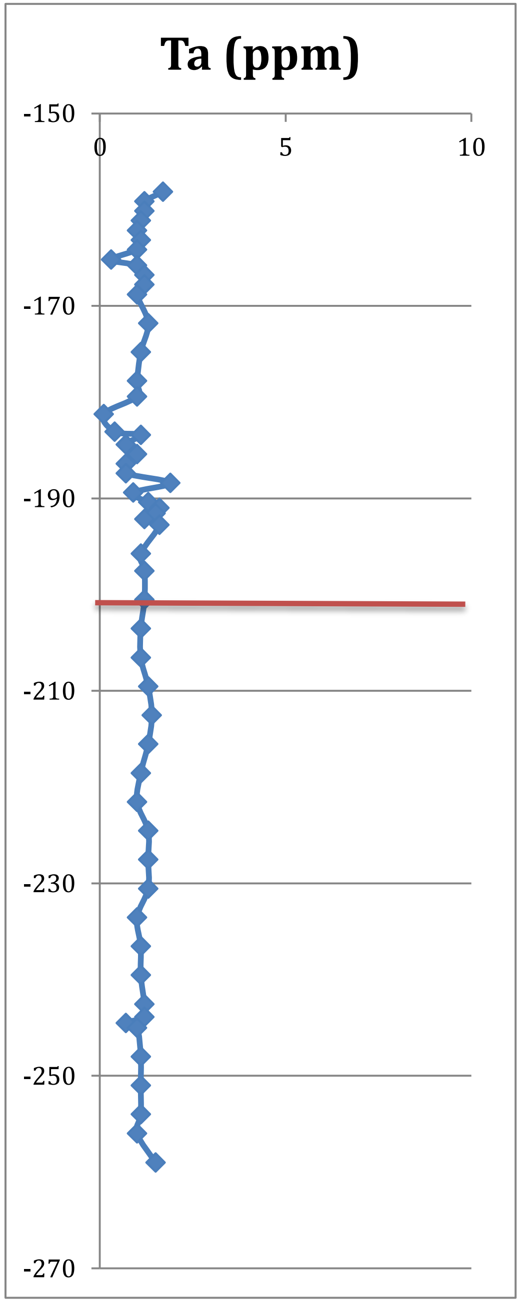

Al (%)
0
2
4
6
8
10
-150
-170
-190
-210
-230
-250
-270

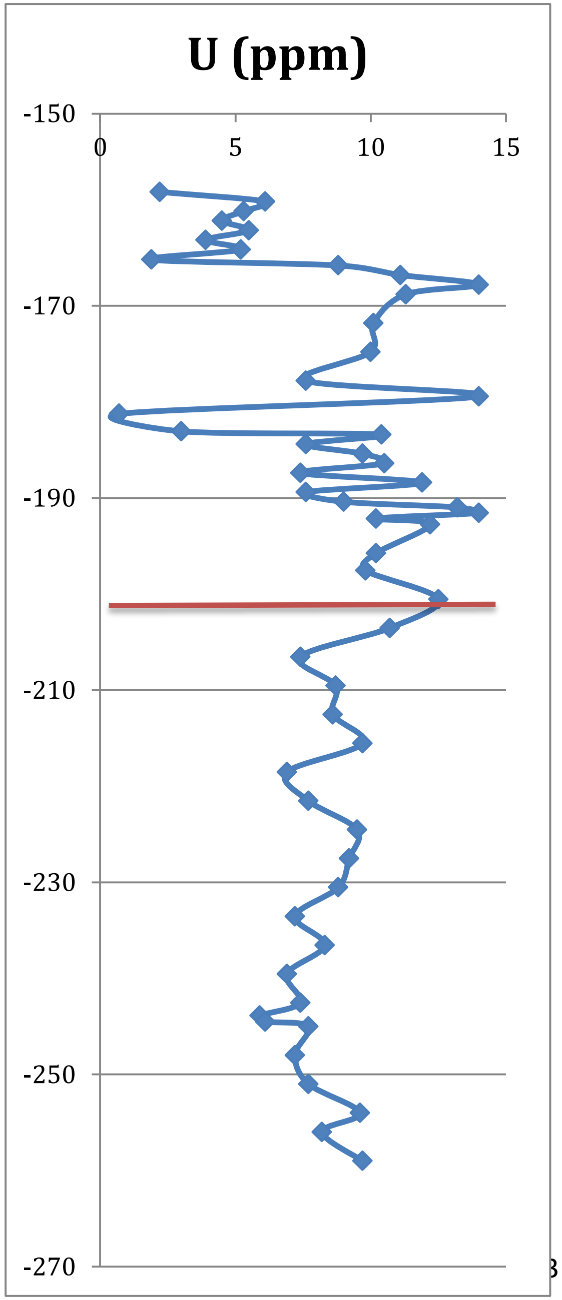

W (ppm)
0
2000
4000
6000
8000
-150
-170
-190
-210
-230
-250
-270
Mo (ppm)
0
200
400
600
-150
-170
-190
-210
-230
-250
-270
∑REE (ppm)
0
200
400
600
-150
-170
-190
-210
-230
-250
-270

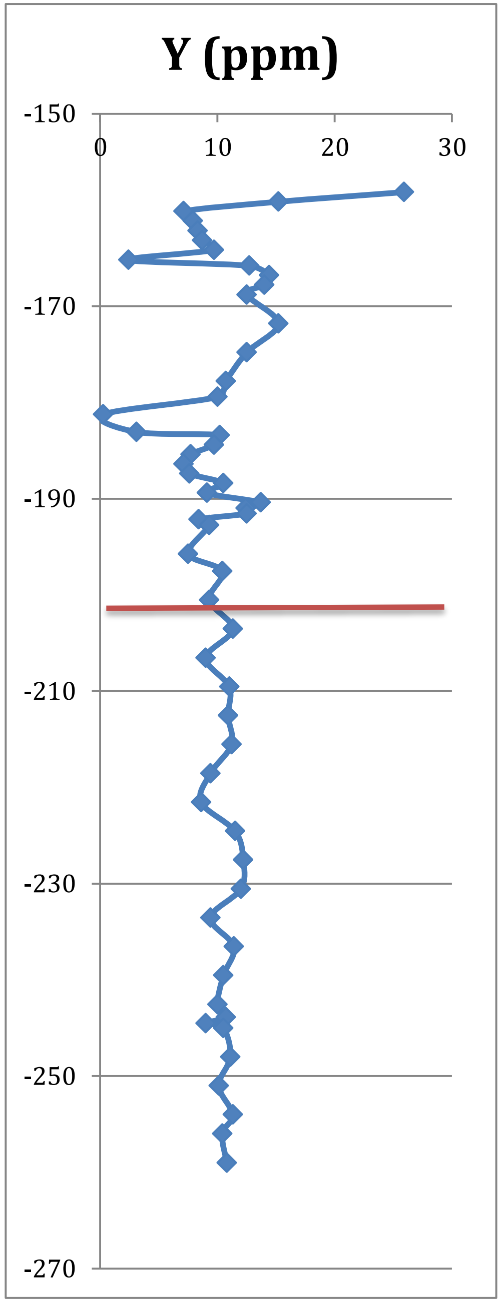


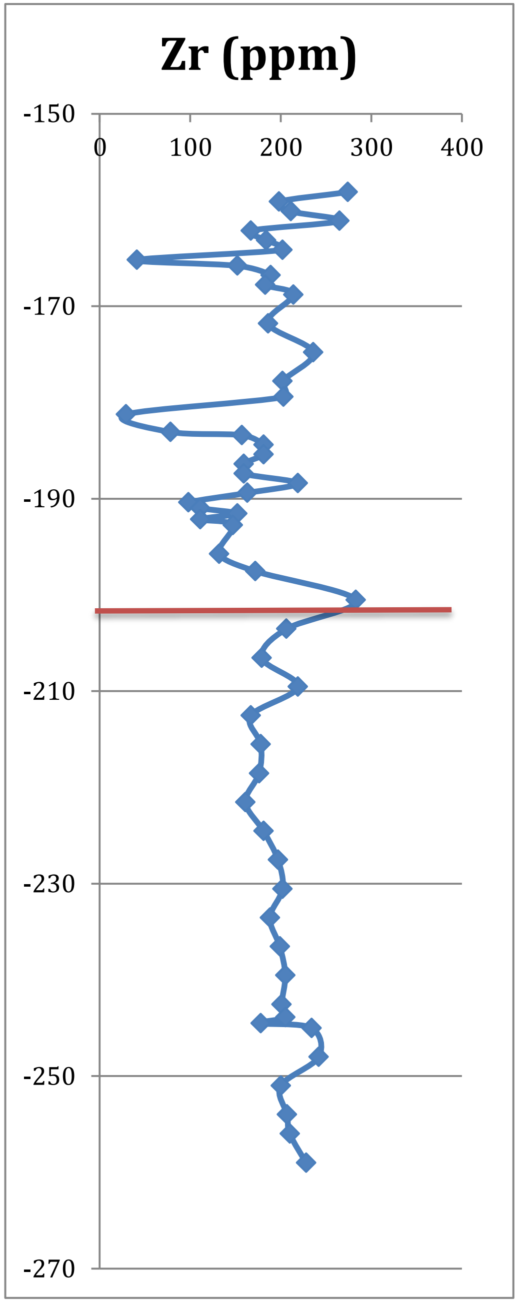
ΣLREE (ppm)
Pb (ppm)
Zn (ppm)
Cu (ppm)
-150
-170
-190
-210
-230
-250
-270
0
500
1000
200
400

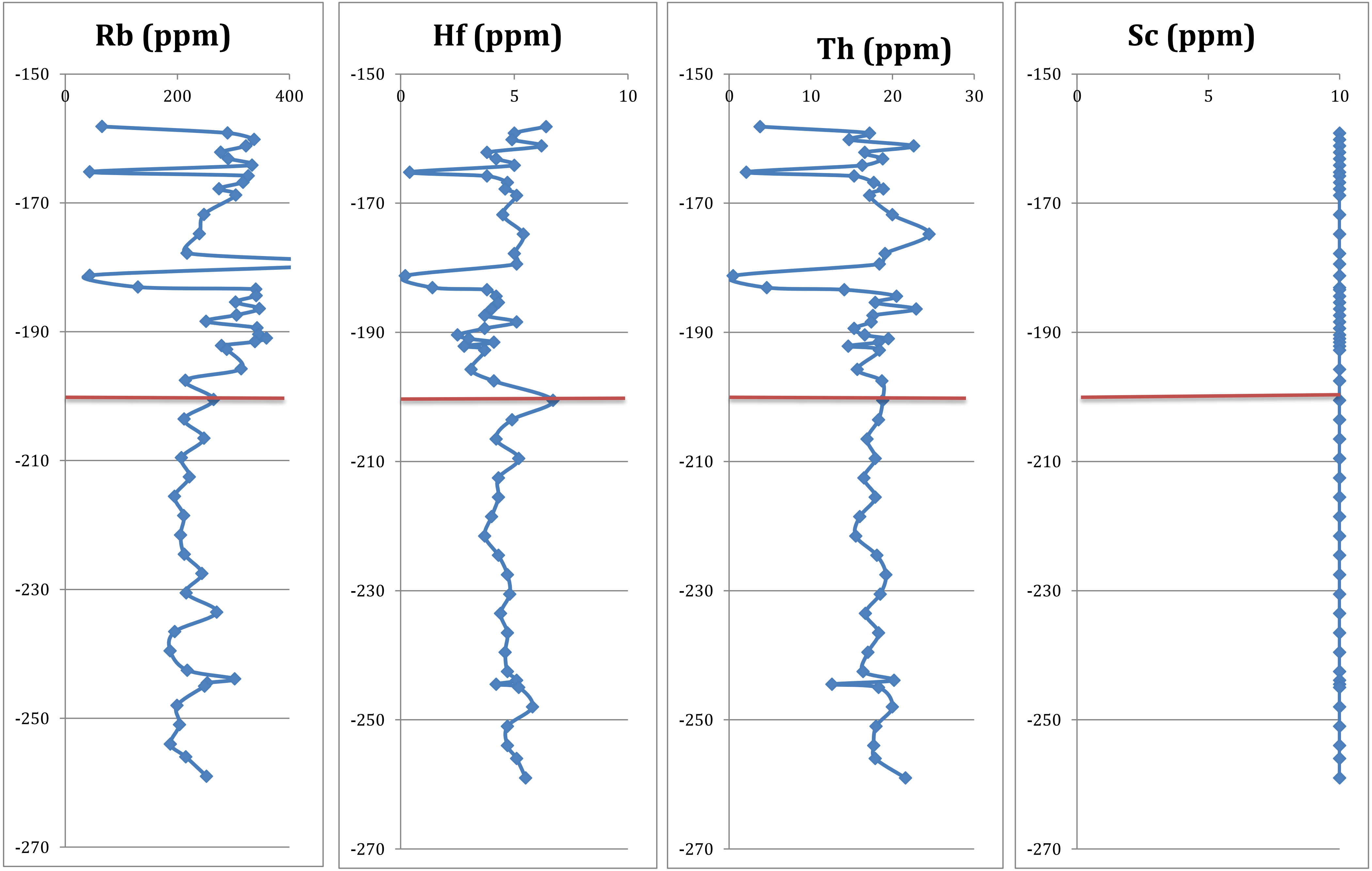

S (%)
0
2
4
6
Ba (ppm)
0
2000
4000
Sr (ppm)
0
1000
2000
3000
Nb (ppm)
0
10
20
30
-150
-170
-190
-210
-230
-250
-270


Ta (ppm)
0
5
10
-150
-170
-190
-210
-230
-250
-270

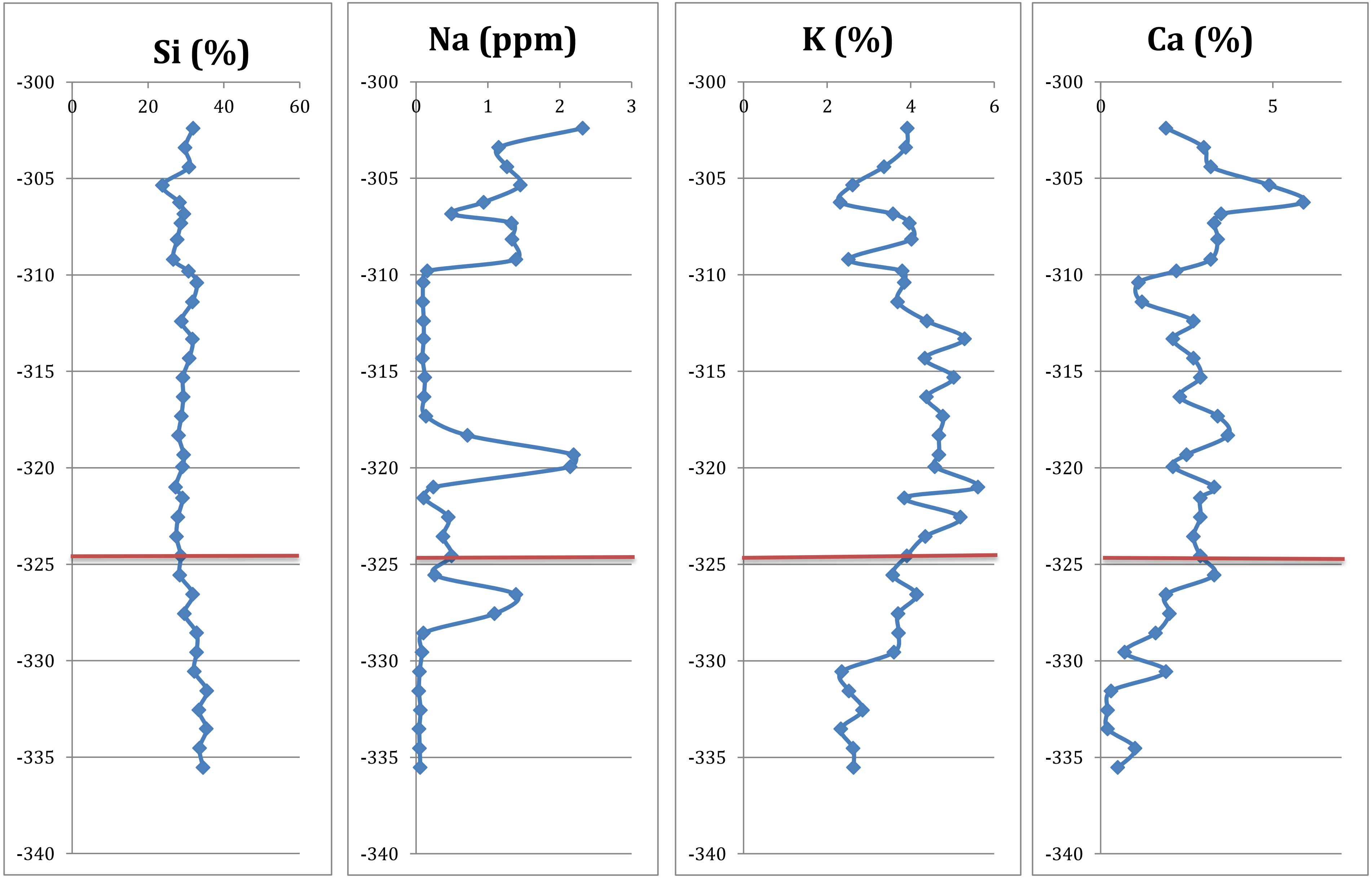

U (ppm)
0
5
10
15
-150
-170
-190
-210
-230
-250
-270

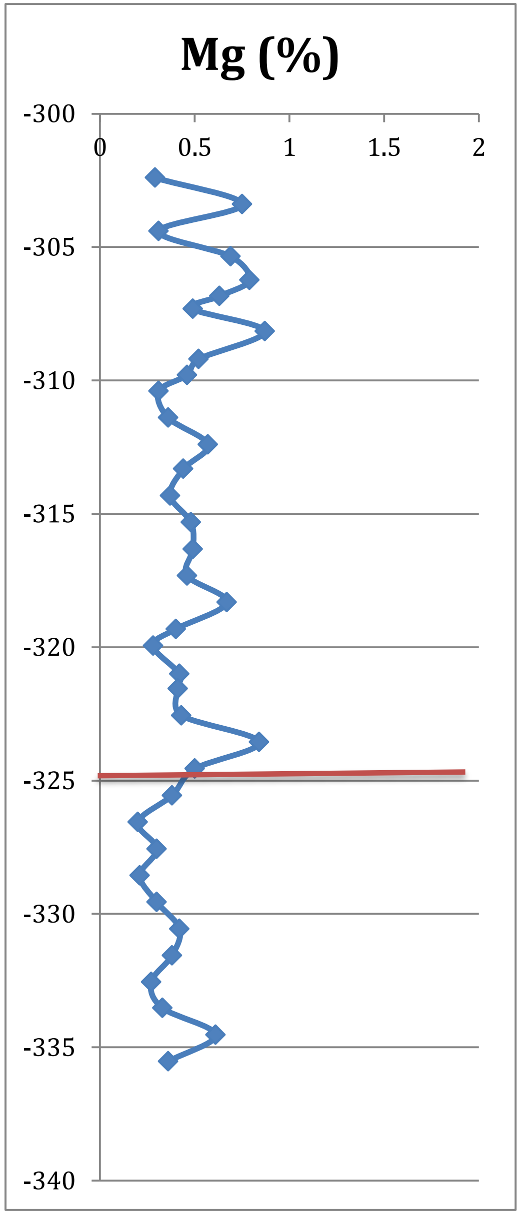

Y (ppm)
0
10
20
30
-150
-170
-190
-210
-230
-250
-270

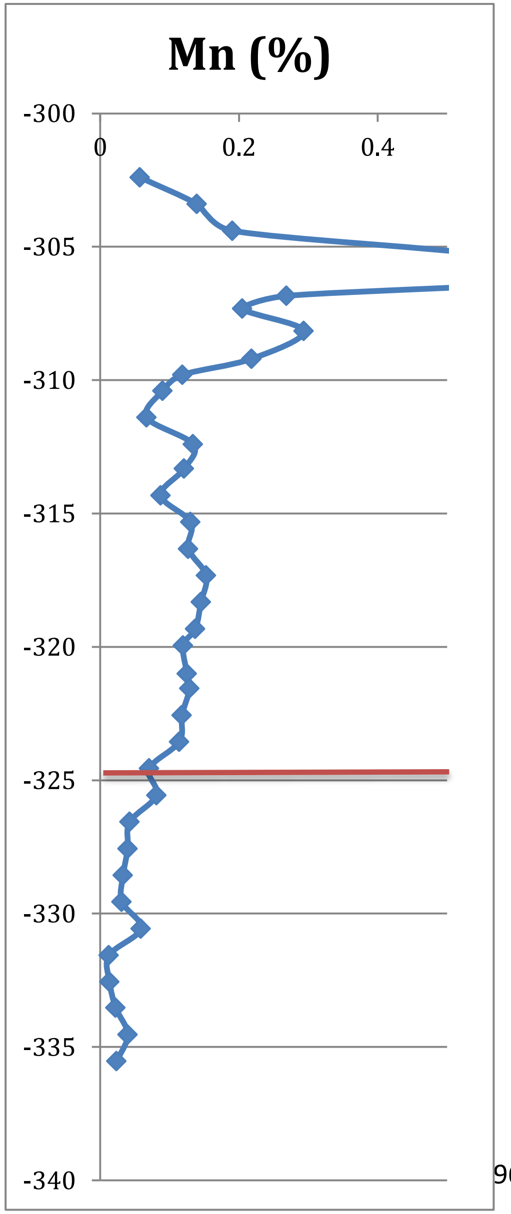

Zr (ppm)
0
100
200
300
400
-150
-170
-190
-210
-230
-250
-270

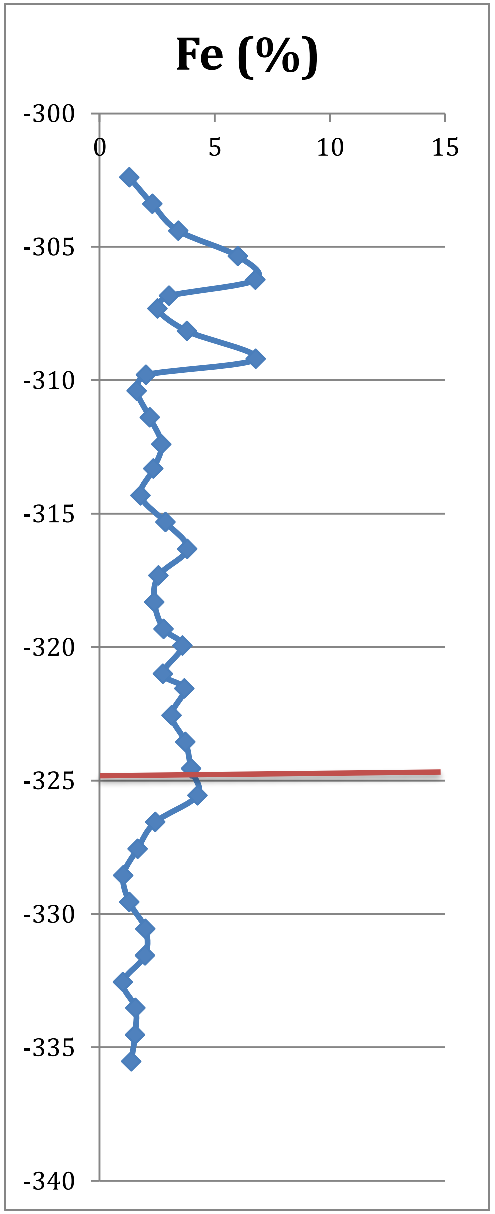

Rb (ppm)
0
200
400
Hf (ppm)
0
5
10
Th (ppm)
0
10
20
30
Sc (ppm)
0
5
10
-150
-170
-190
-210
-230
-250
-270

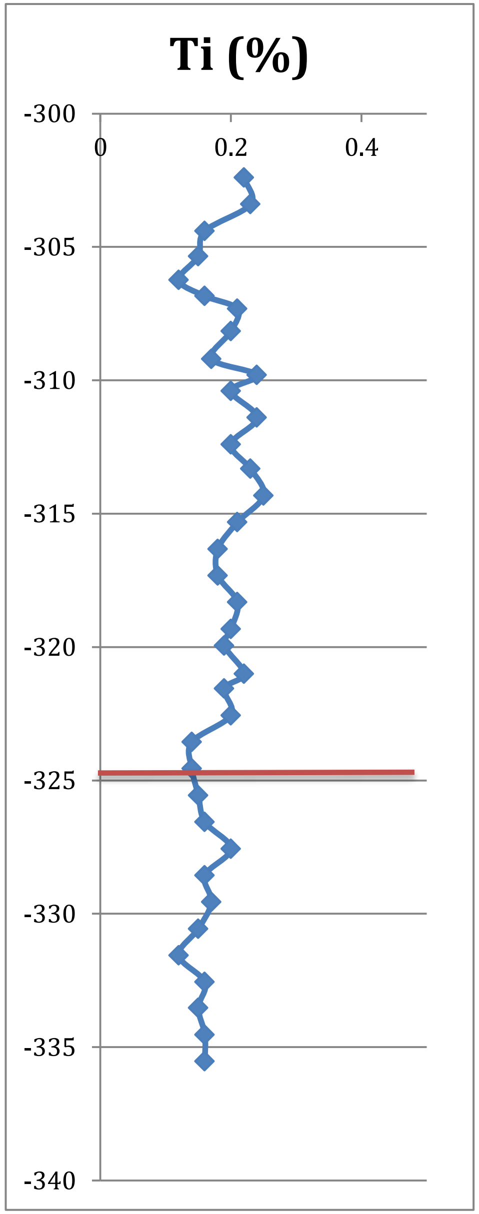
6. E-200

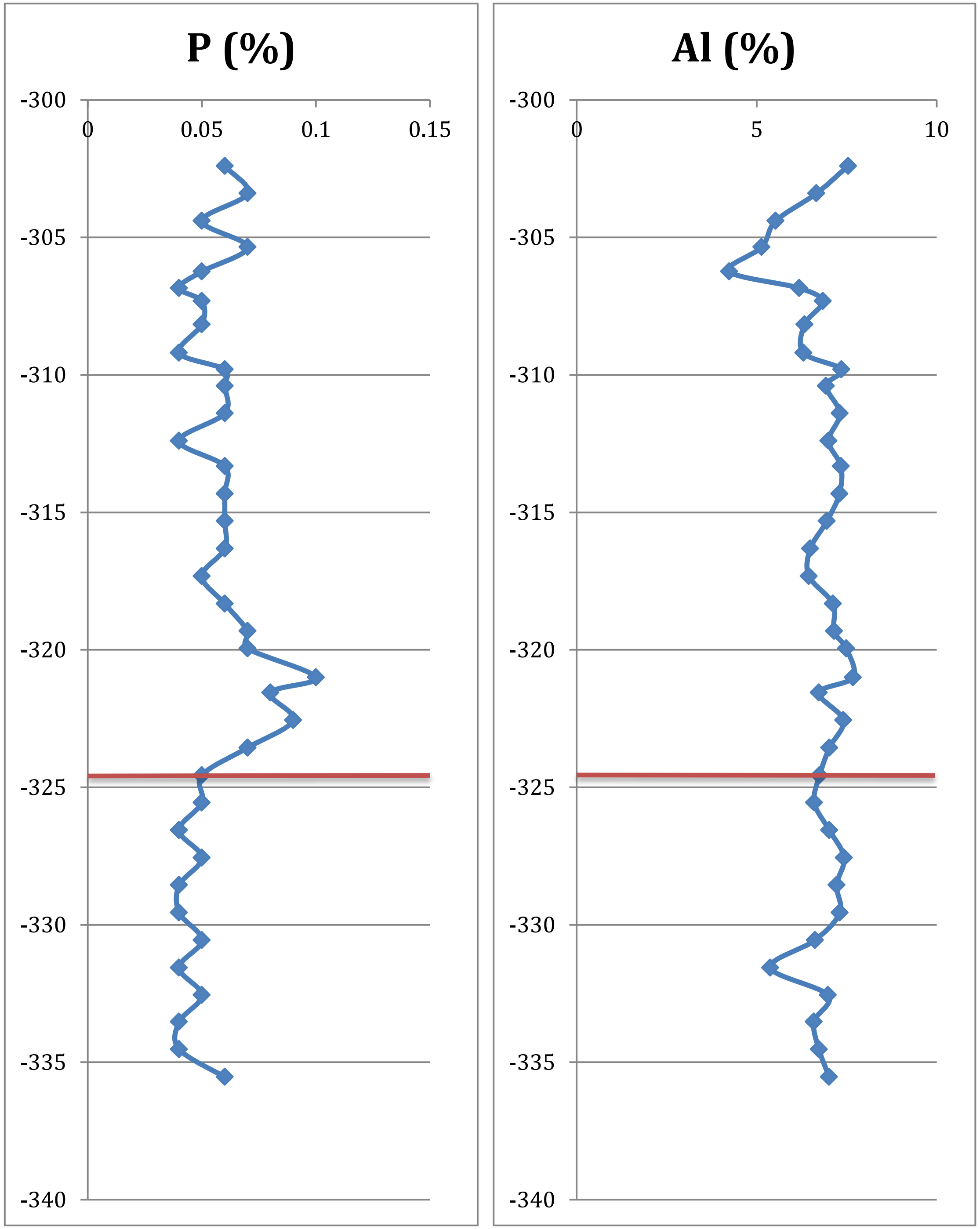

Si (%)
Na (ppm)
K (%)
Ca (%)
-300
-305
-310
-315
-320
-325
-330
-335
-340
0
20
40
60
1
2
3
4
6
5

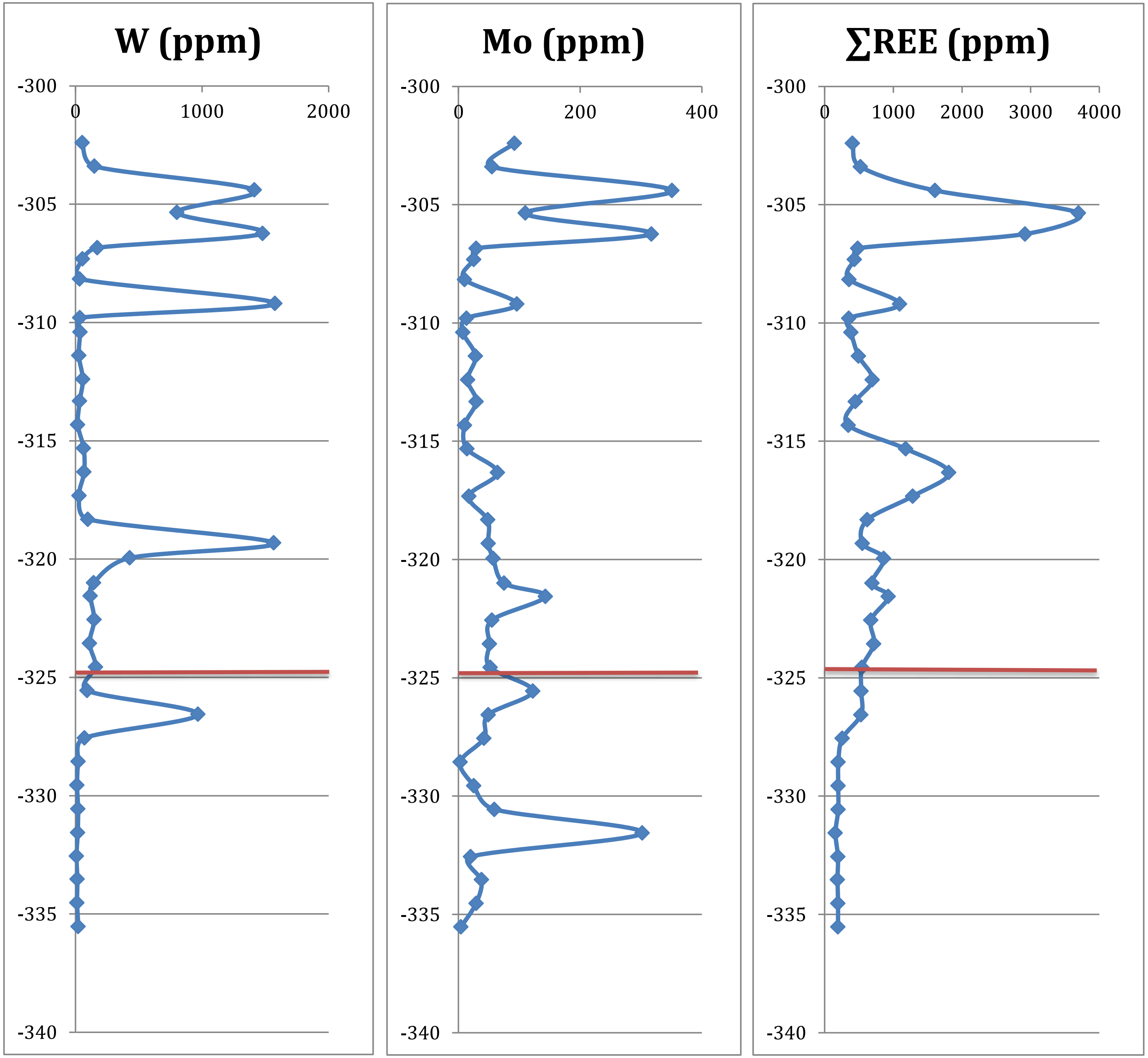

Mg (%)
0 0.5 1 1.5 2
-300 -305 -310 -315 -320 -325 -330 -335 -340

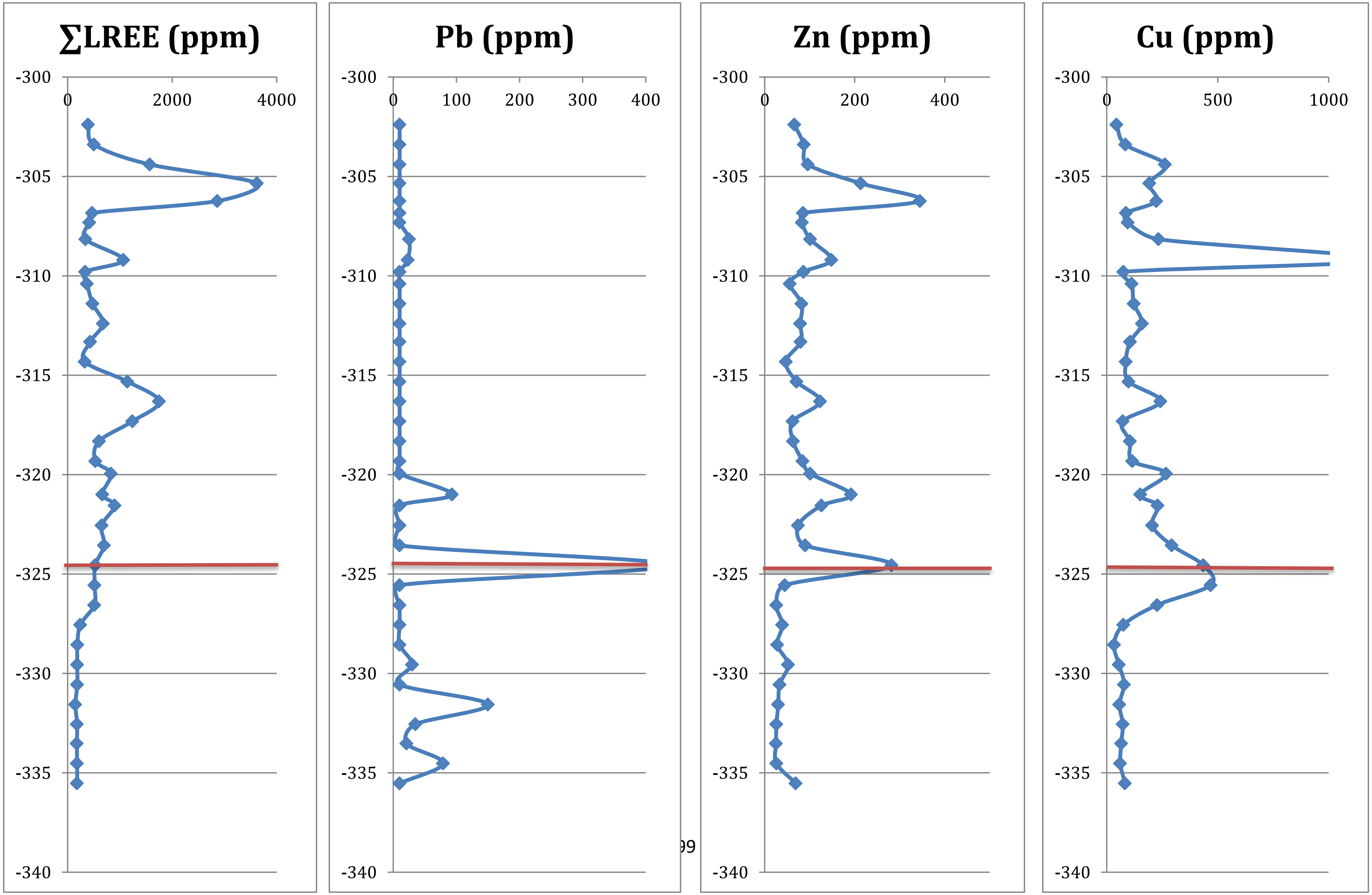

Mn (%)
0 0.2 0.4
-300 -305 -310 -315 -320 -325 -330 -335 -340

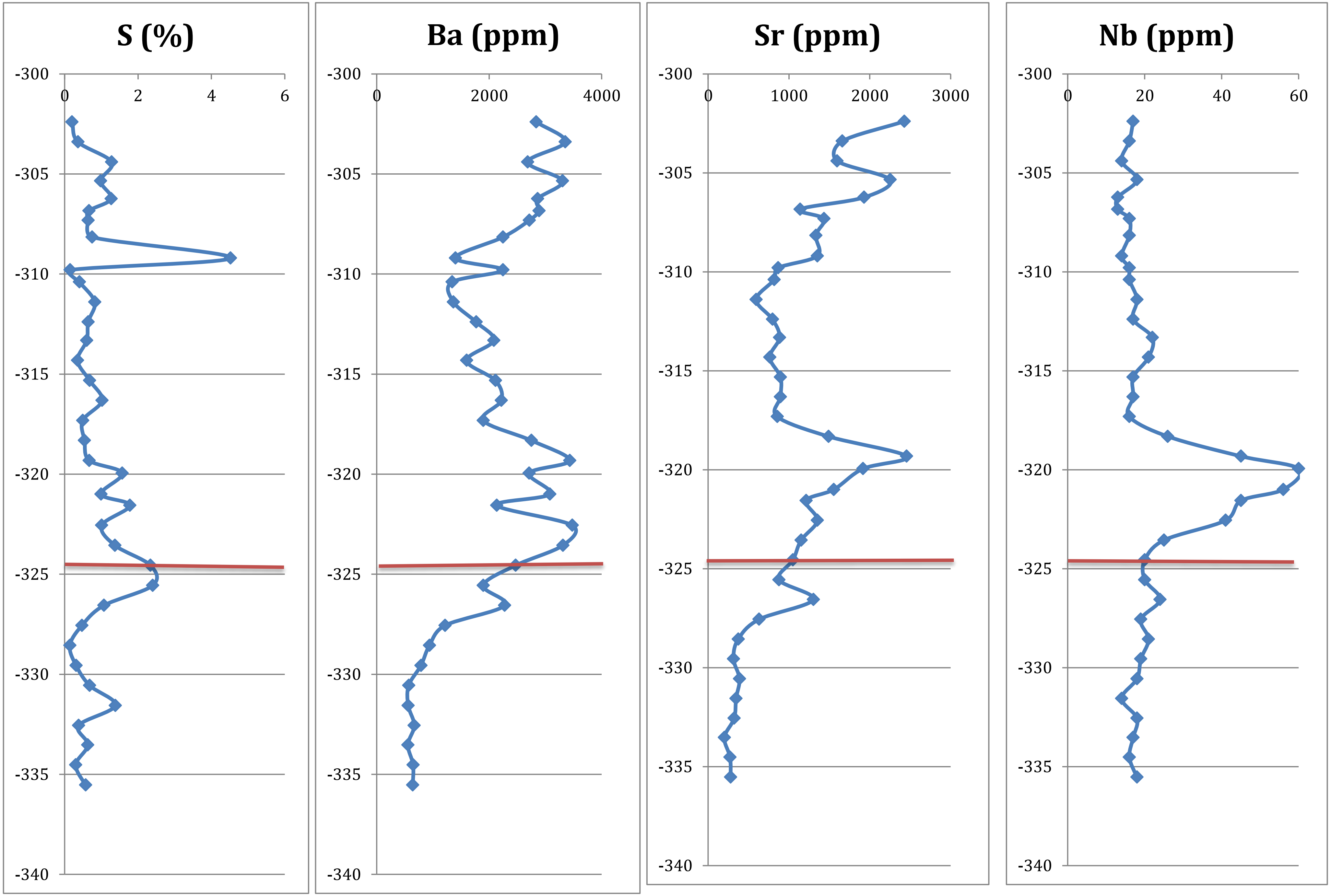

Fe (%)
0 5 10 15
-300 -305 -310 -315 -320 -325 -330 -335 -340

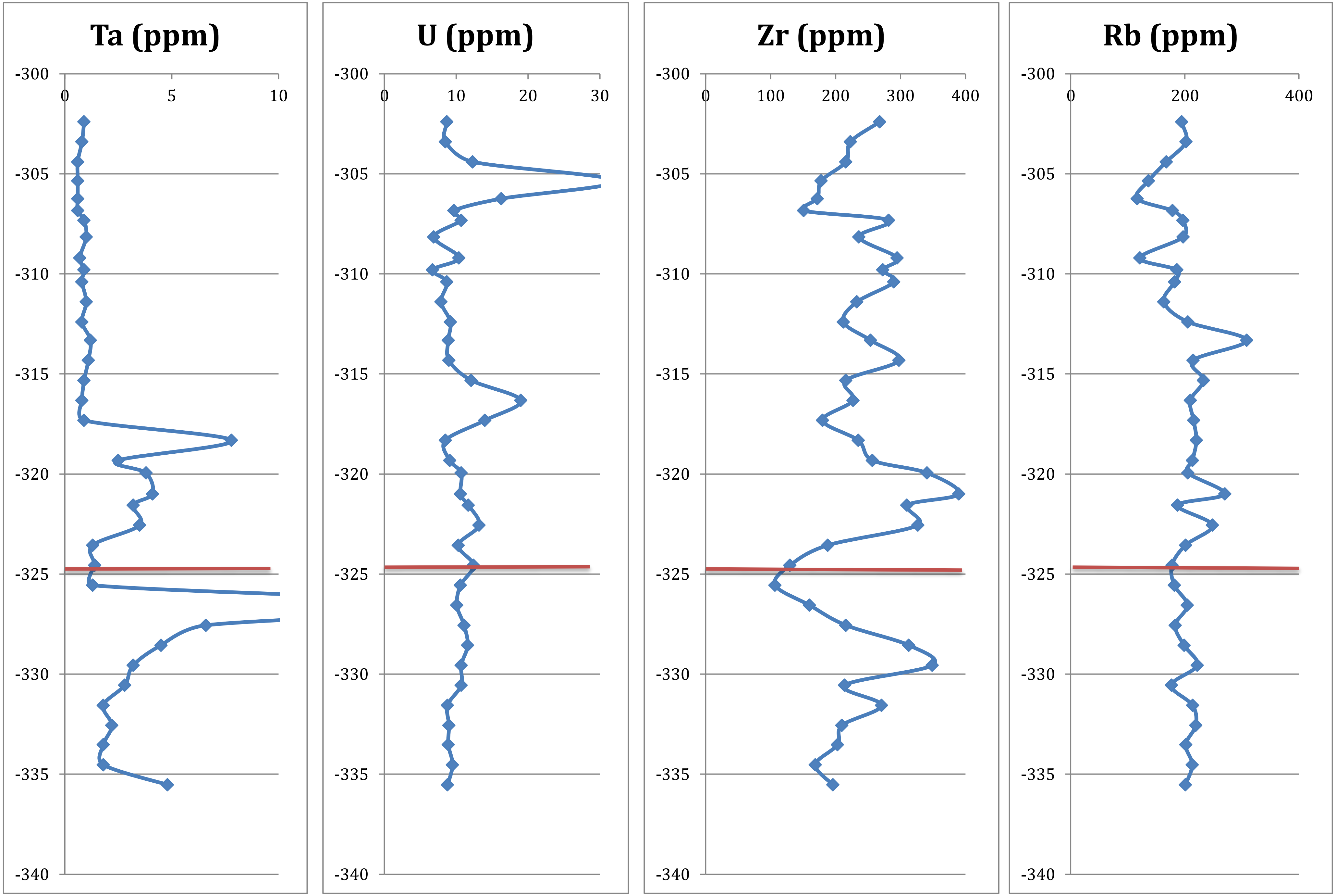

Ti (%)
0 0.2 0.4
-300 -305 -310 -315 -320 -325 -330 -335 -340

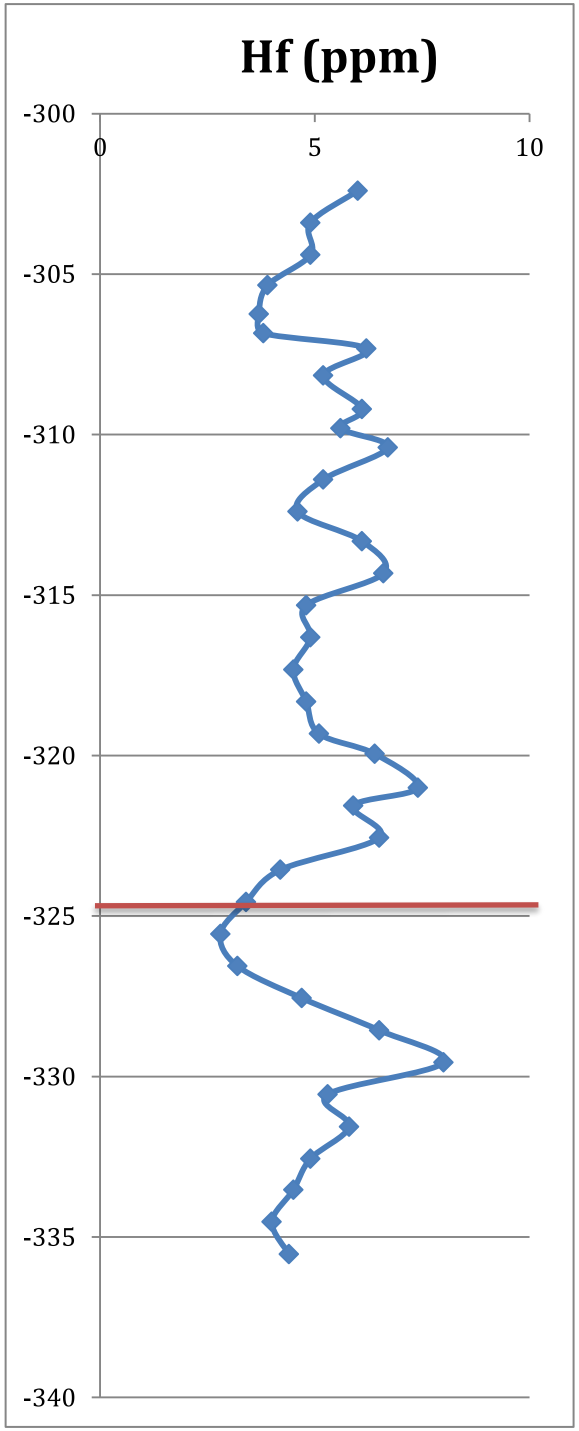

P (%)
0
0.05
0.1
0.15
-300
-305
-310
-315
-320
-325
-330
-335
-340
Al (%)
0
5
10
-300
-305
-310
-315
-320
-325
-330
-335
-340

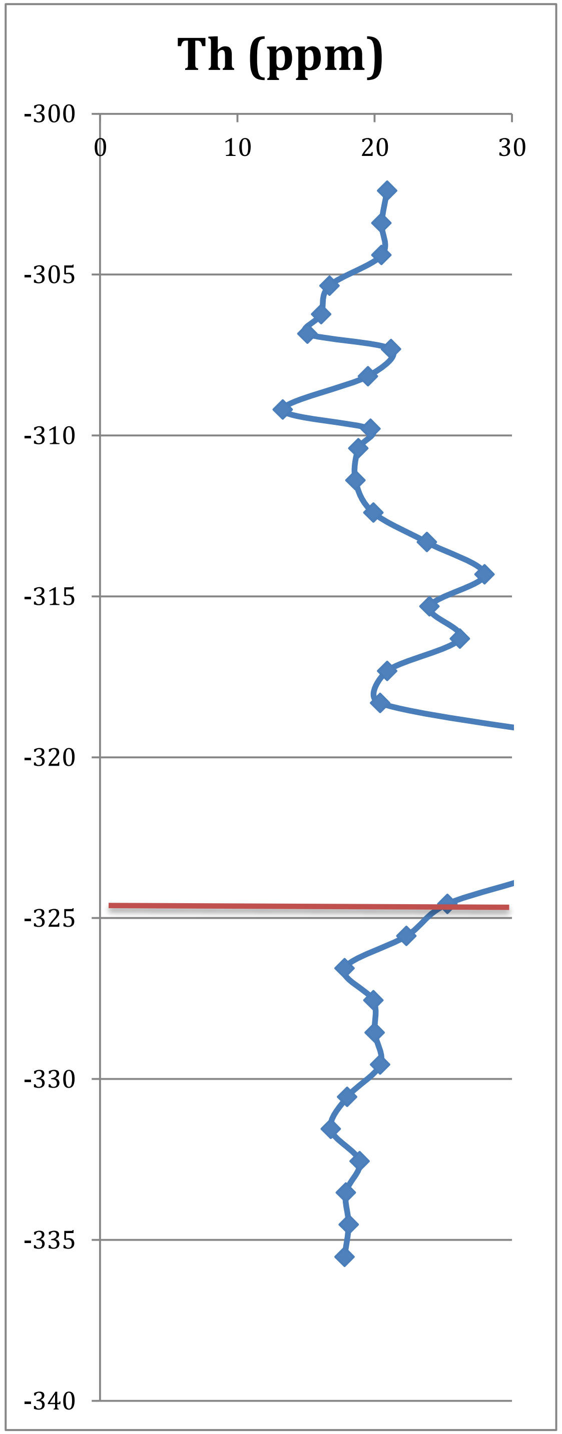

W (ppm)
Mo (ppm)
∑REE (ppm)
-300
-305
-310
-315
-320
-325
-330
-335
-340
0
1000
2000
200
400
3000
4000

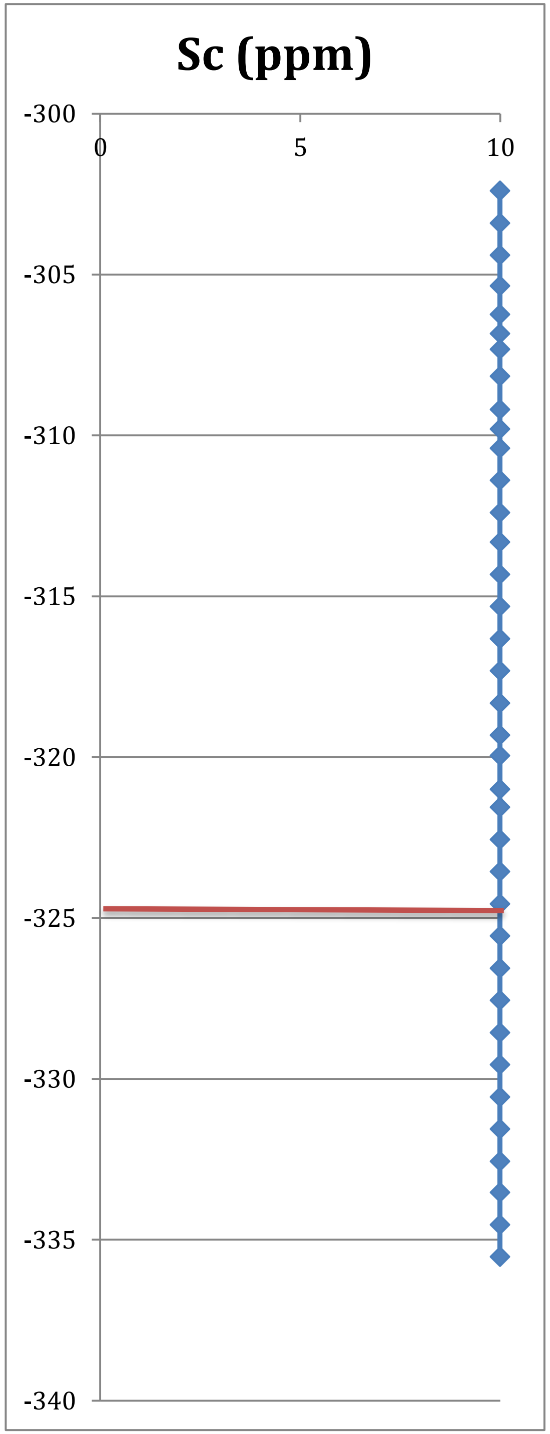

∑LREE (ppm)
Pb (ppm)
Zn (ppm)
Cu (ppm)
-300
-305
-310
-315
-320
-325
-330
-335
-340
0
2000
4000
0
100
200
300
400
0
200
400
0
500
1000


S (%)
-300
-305
-310
-315
-320
-325
-330
-335
-340
0
2
4
6
Ba (ppm)
0
2000
4000
Sr (ppm)
0
1000
2000
3000
Nb (ppm)
0
20
40
60


Ta (ppm)
0
5
10
U (ppm)
0
10
20
30
Zr (ppm)
0
100
200
300
400
Rb (ppm)
0
200
400
-300
-305
-310
-315
-320
-325
-330
-335
-340


Hf (ppm)
0
5
10
-300
-305
-310
-315
-320
-325
-330
-335
-340


Th (ppm)
0
10
20
30
-300
-305
-310
-315
-320
-325
-330
-335
-340


Sc (ppm)
0
5
10
-300
-305
-310
-315
-320
-325
-330
-335
-340

Appendix K - Correlation matrices

Correlation matrices for both the mineralized (MZ) and the non-mineralized (NMZ) zones respectively for 6 borehole intersections were calculated using GCDkit software. Additionally, the correlation coefficients and –plots were also calculated for all the data in one dataset (point 7). All these matrices are displayed in this appendix section. AI in the diagrams is the Alteration Index and is expressed by:

$$AI = \frac{100(K2O + Na2O)}{(K2O + Na2O + MgO + CaO)}$$

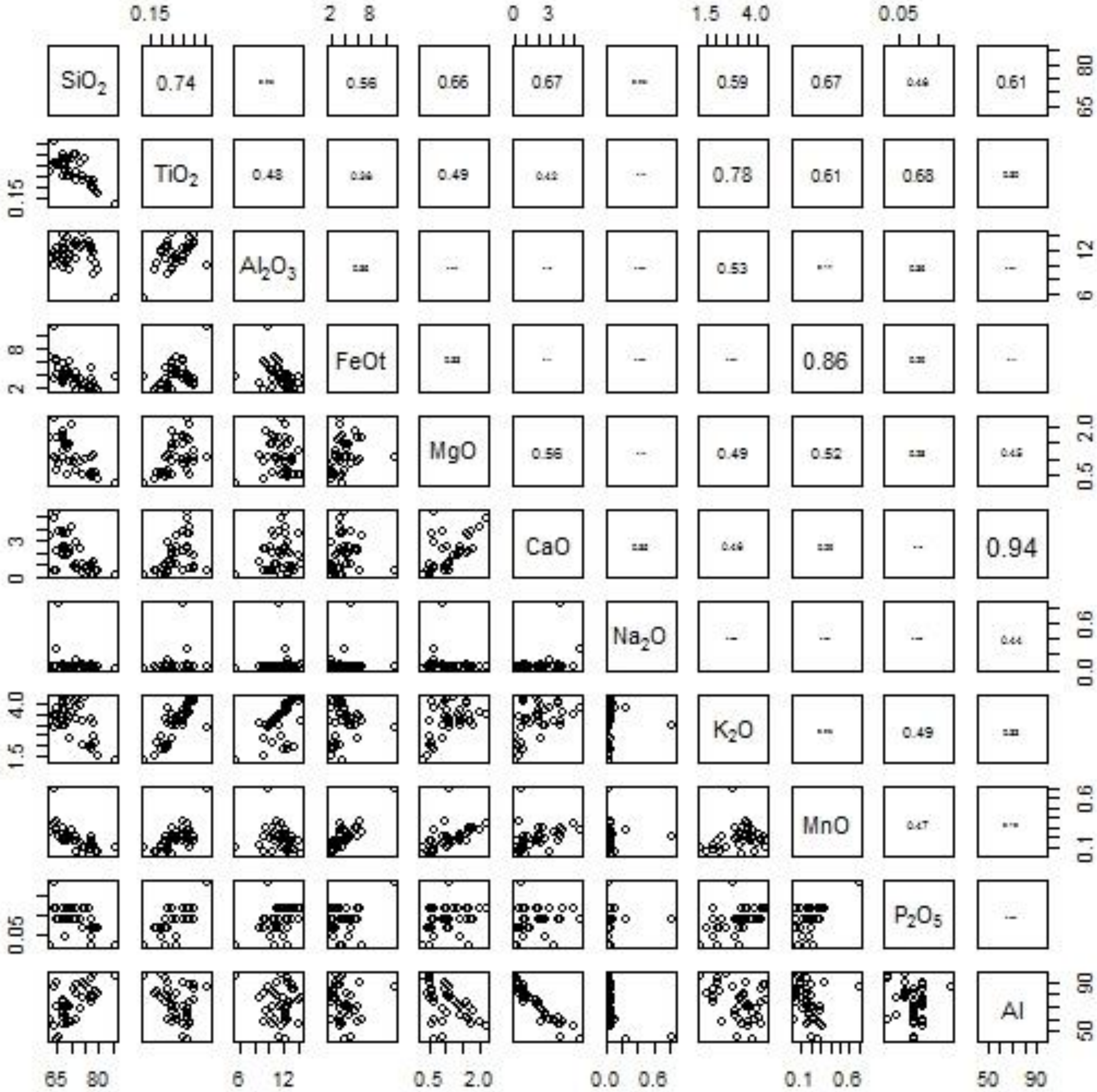
As explained in the thesis, the MZ refers to the zone where the bulk of the mineralization lies and is closest to the granite wall-rock contact (within 160m of it). This zone consists largely of products of higher grades of alteration such as skarnification and potassic alteration. Mineralization refers to where potentially economic minerals, like scheelite, allanite, molybdenite and bastnaesite, are situated. The NMZ is the zone that is devoid of any significant amounts of mineralization and represents the original rock more closely than the MZ.

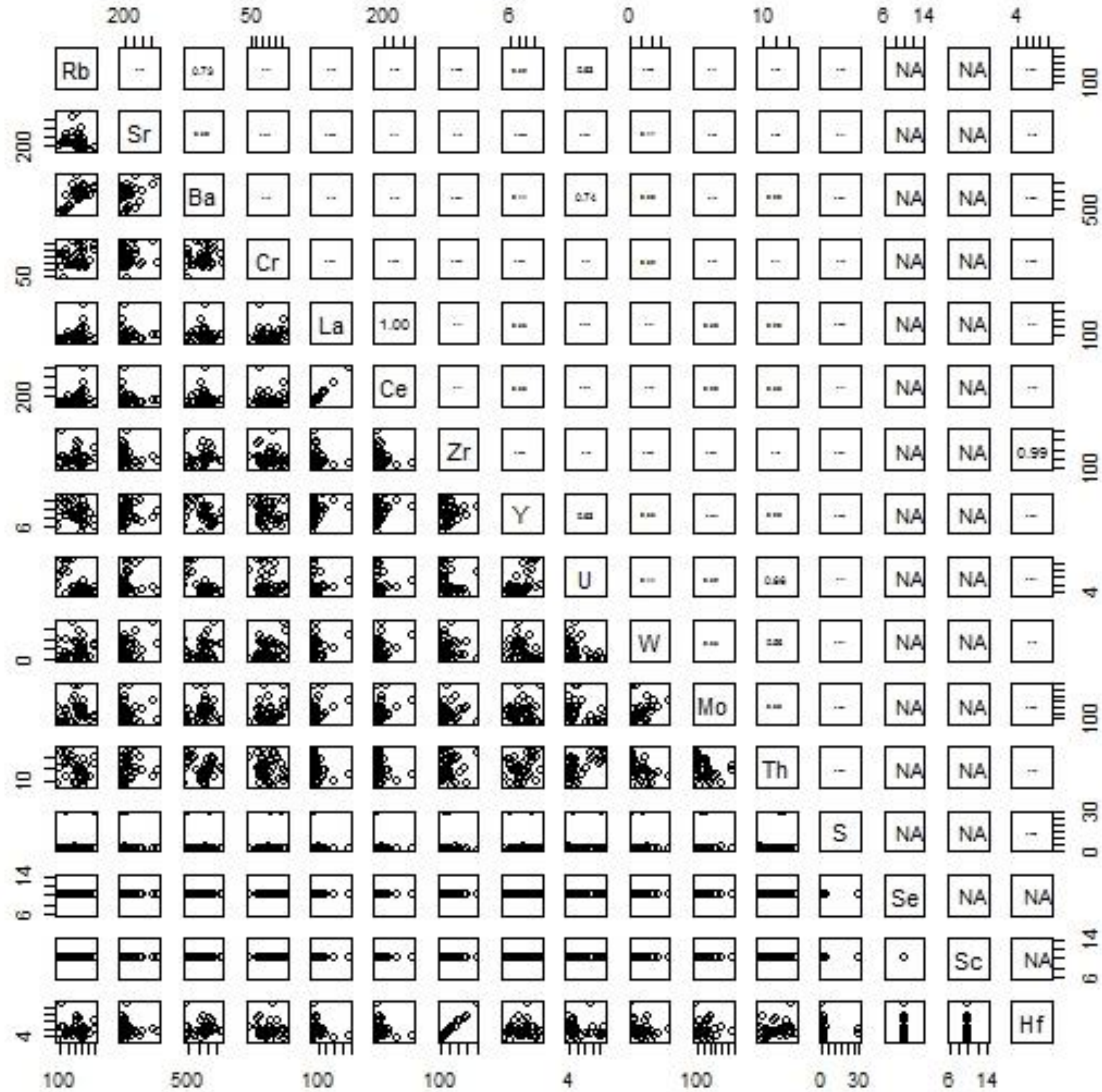
Three separate correlation plots for both the MZ and the NMZ from each of the respective boreholes were made. The first plot is between all the major elements including SiO_2, TiO_2, Al_2O_3, FeO, MgO, CaO, Na_2O, K_2O, MnO, P_2O_5 and AI (Alteration Index). The trace elements that were used to calculate and plot the correlation coefficients include Rb, Sr, Ba, Cr, La, Ce, Zr, Y, U, W, Mo, Th, Se, Sc, Hf and S. Lastly a mixture between major and trace elements were calculated and plotted. They include: SiO_2, TiO_2, Al_2O_3, FeO, MgO, CaO, Na_2O, K_2O, MnO, P_2O_5, W, Ce, Sr, Ba, Th, and S.

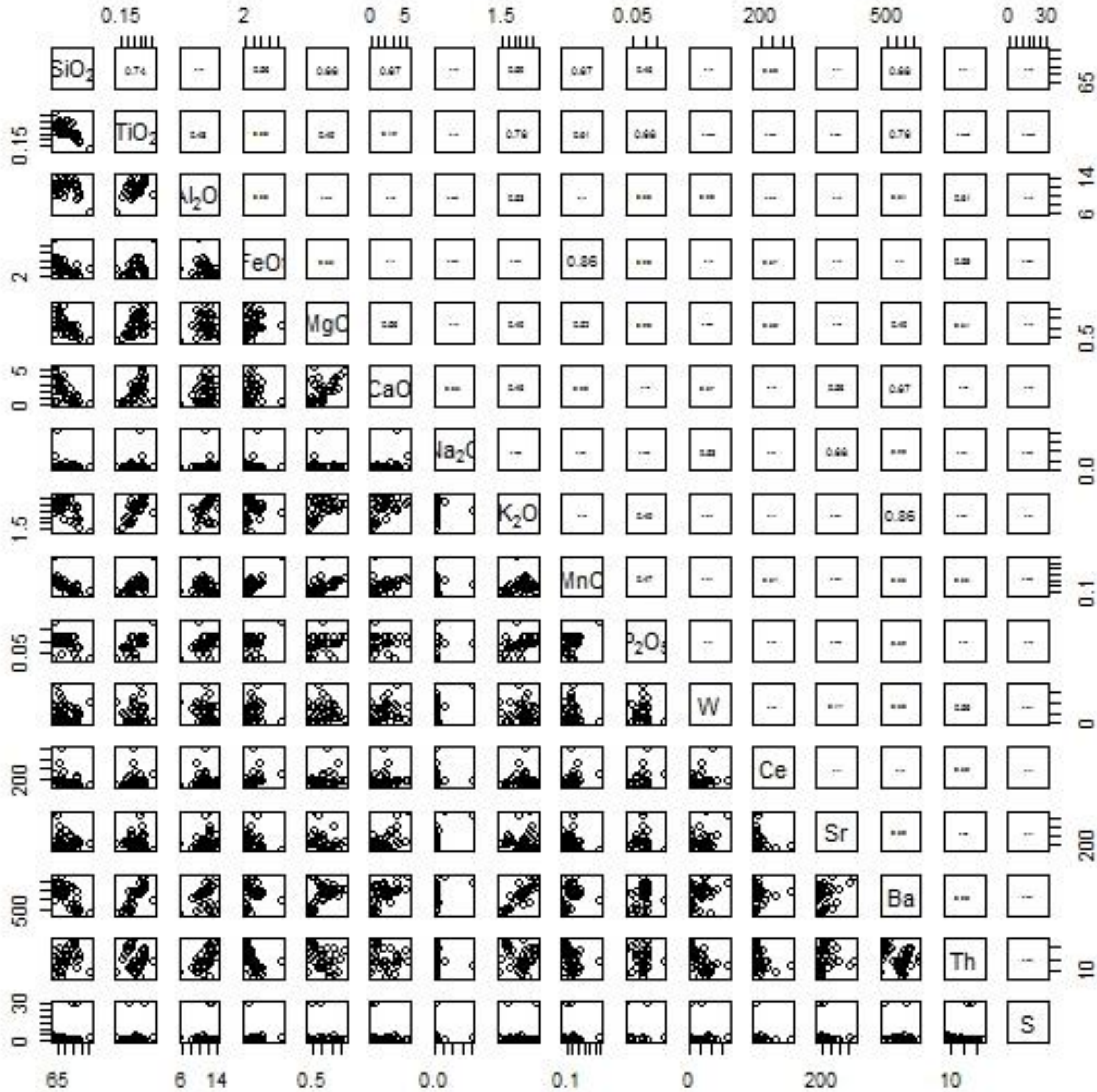
All the datasets have been interpreted and the results have been discussed in the geochemistry section in the thesis (chapter 5).

1. A+400

1.1 MZ

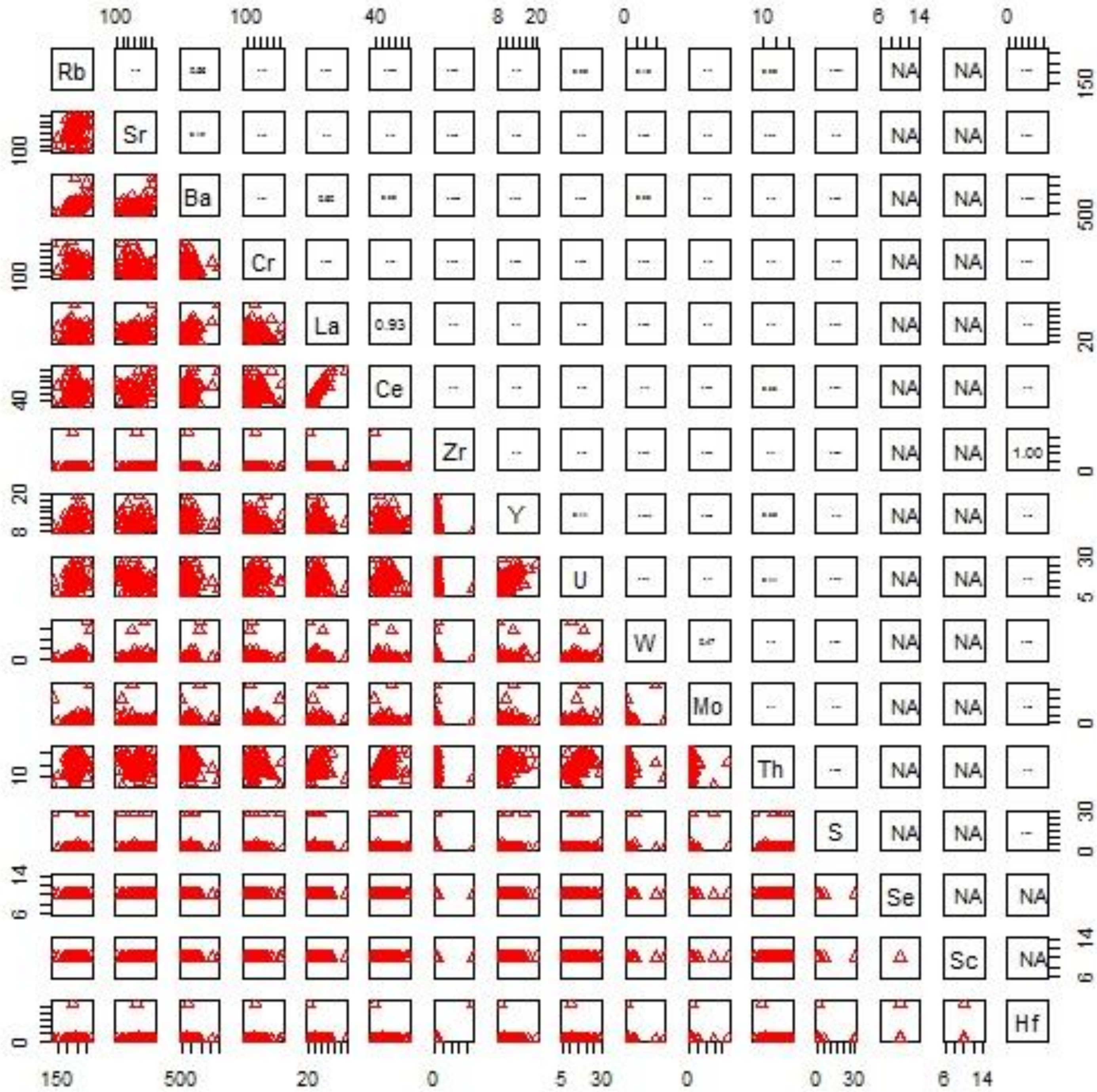

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
AI
0.74
0.56
0.66
0.67
0.59
0.67
0.61
0.48
0.49
0.78
0.61
0.68
0.53
0.86
0.56
0.49
0.52
0.94
0.49


Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf
1.00
0.99
NA


SiO2
TiO2
Al2O
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S
0.15
2
0 5
1.5
0.05
200
500
0 30
65
6 14
0.5
0.0
0.1
0
10
0.74
0.79
0.86
0.86

1.2 NMZ

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.49
0.54
0.55
0.77
0.49
0.81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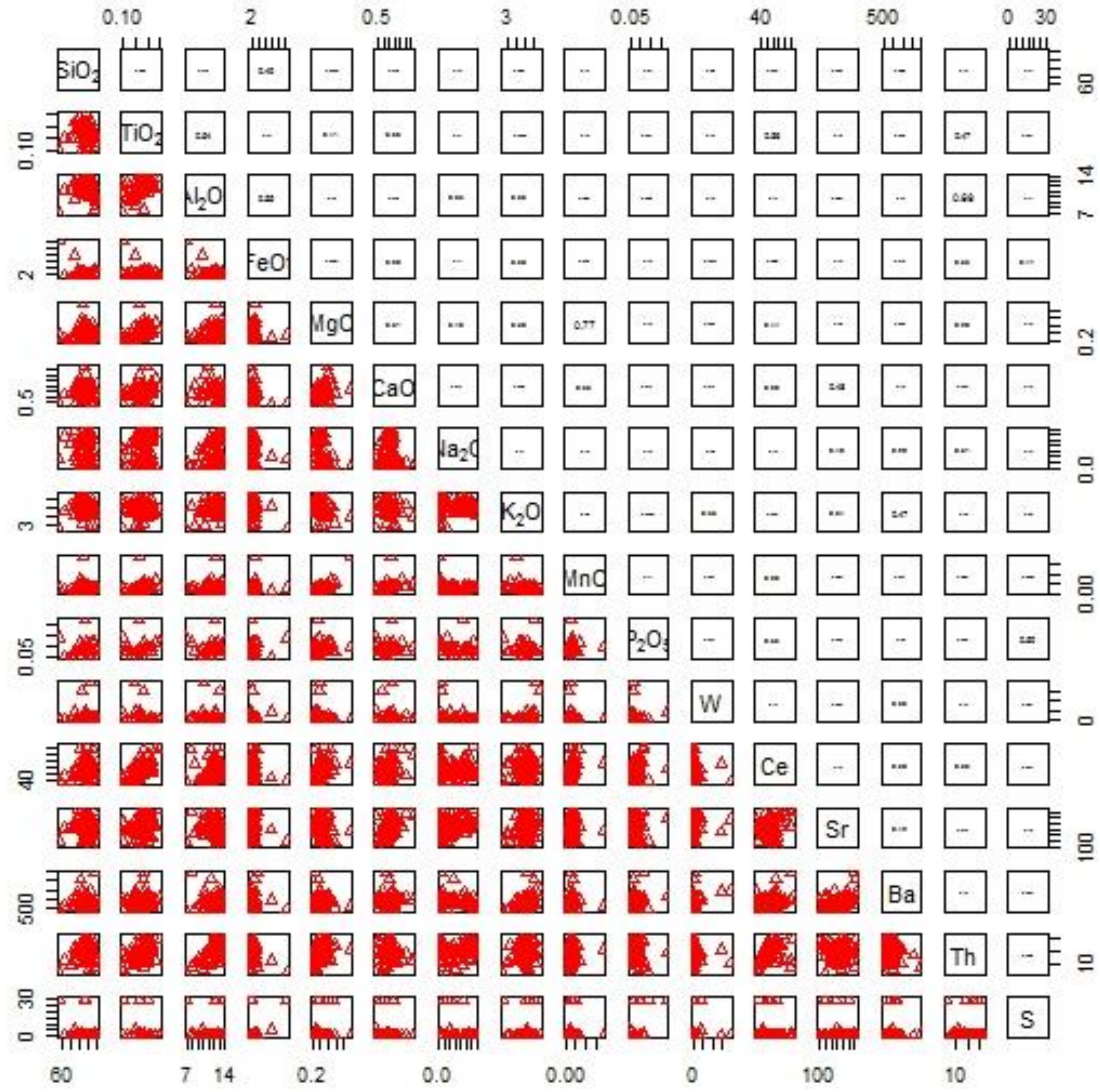
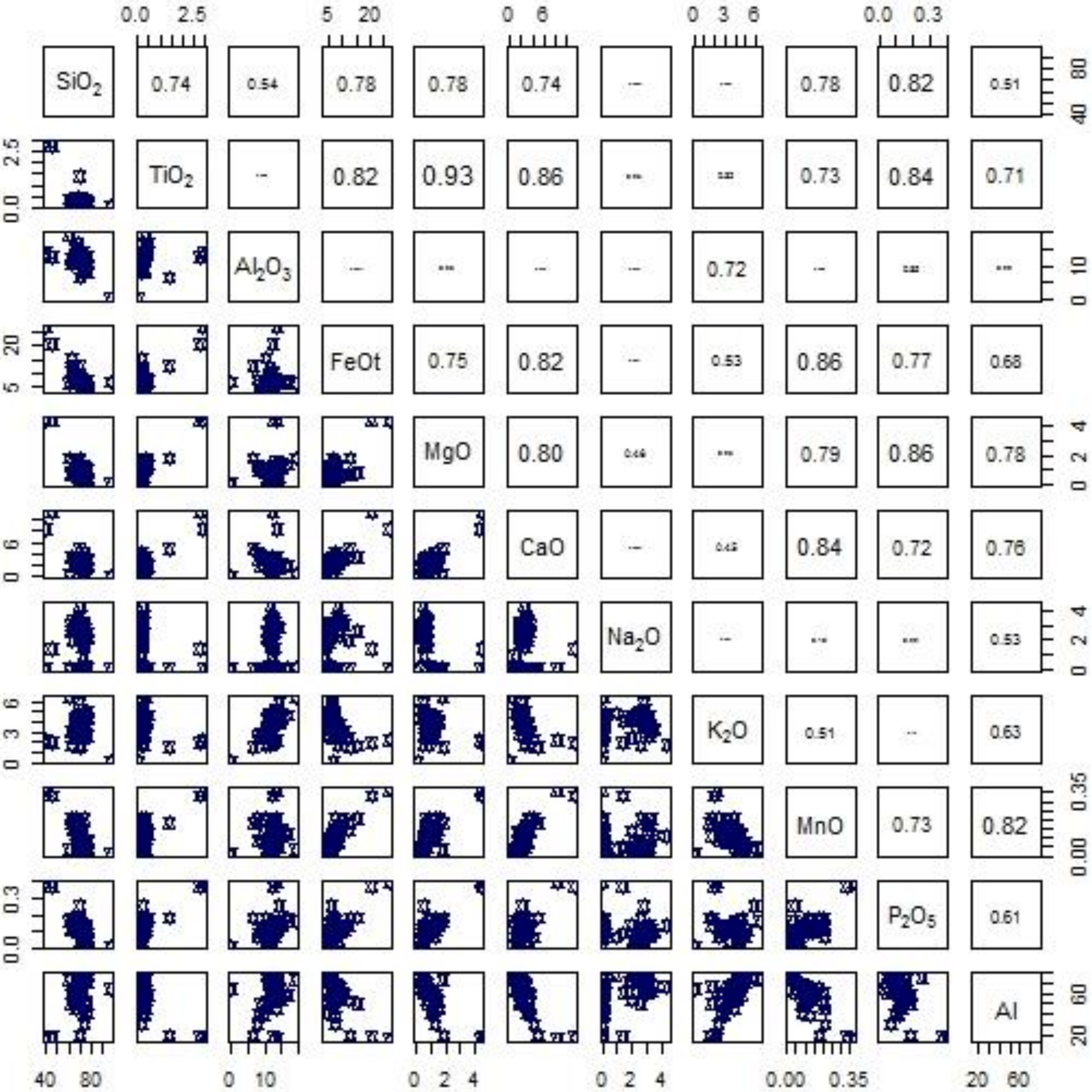
Sr
Ba
Cr
La
0.93
Ce
Zr
1.00
Y
U
W
Mo
Th
S
Se
Sc
Hf
NA

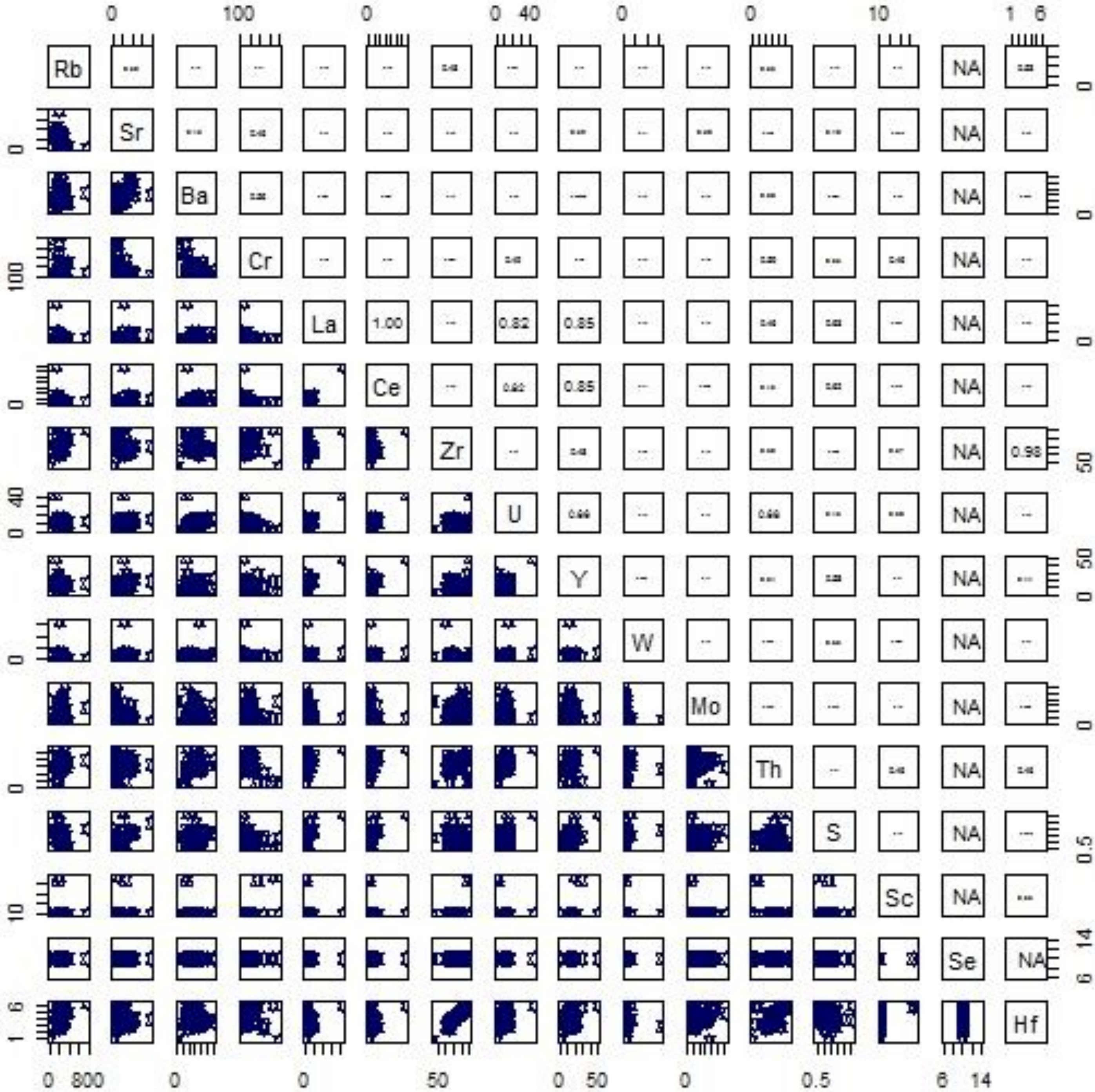

SiO2
TiO2
Al2O
FeO
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S

2. AA+200

2.1 MZ



SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.74
0.54
0.78
0.78
0.74
0.78
0.82
0.51
0.82
0.93
0.86
0.73
0.84
0.71
0.72
0.75
0.82
0.53
0.86
0.77
0.68
0.80
0.79
0.86
0.78
0.84
0.72
0.76
0.53
0.51
0.63
0.73
0.82
0.61


Rb
Sr
Ba
Cr
La
Ce
Zr
U
Y
W
Mo
Th
S
Sc
Se
Hf
NA
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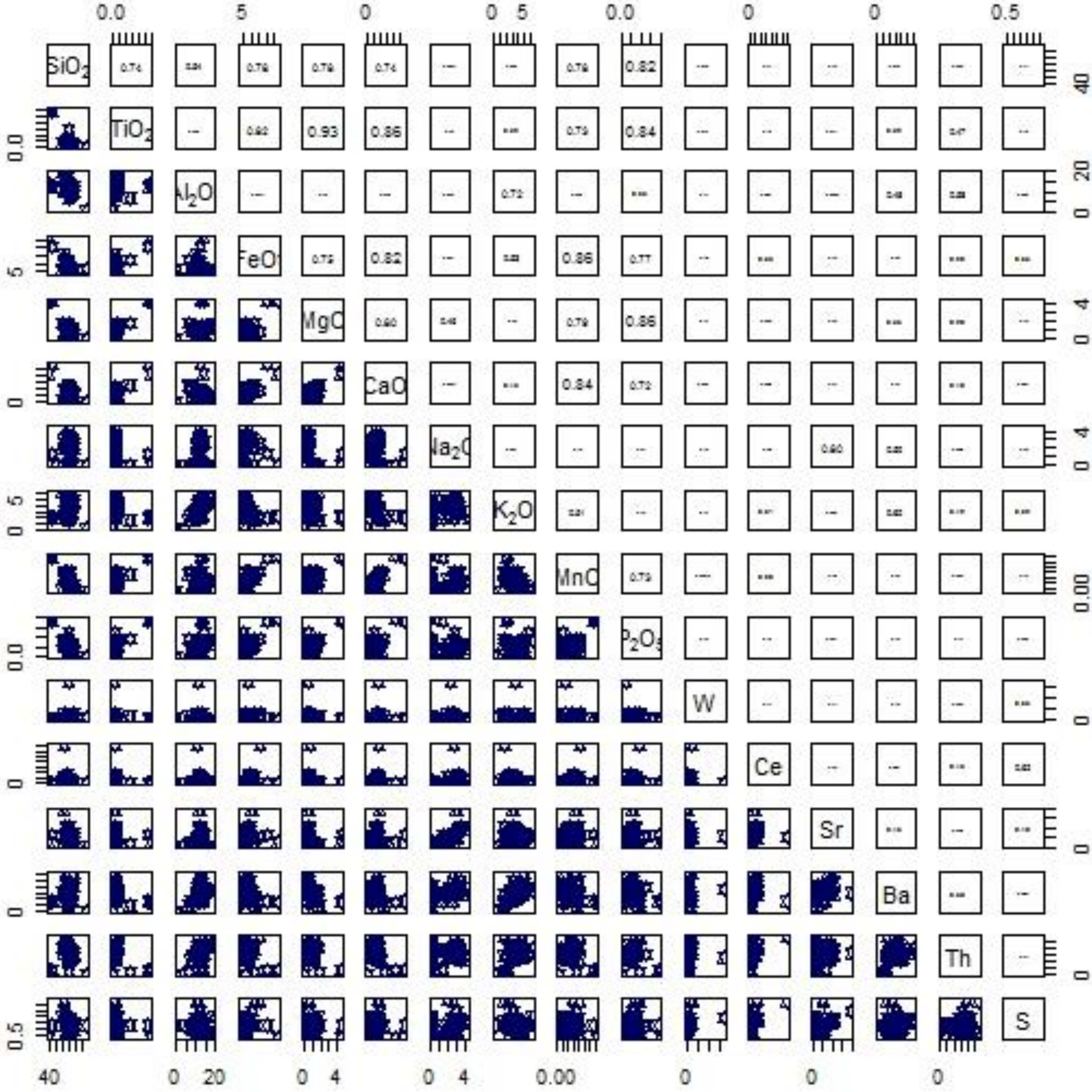
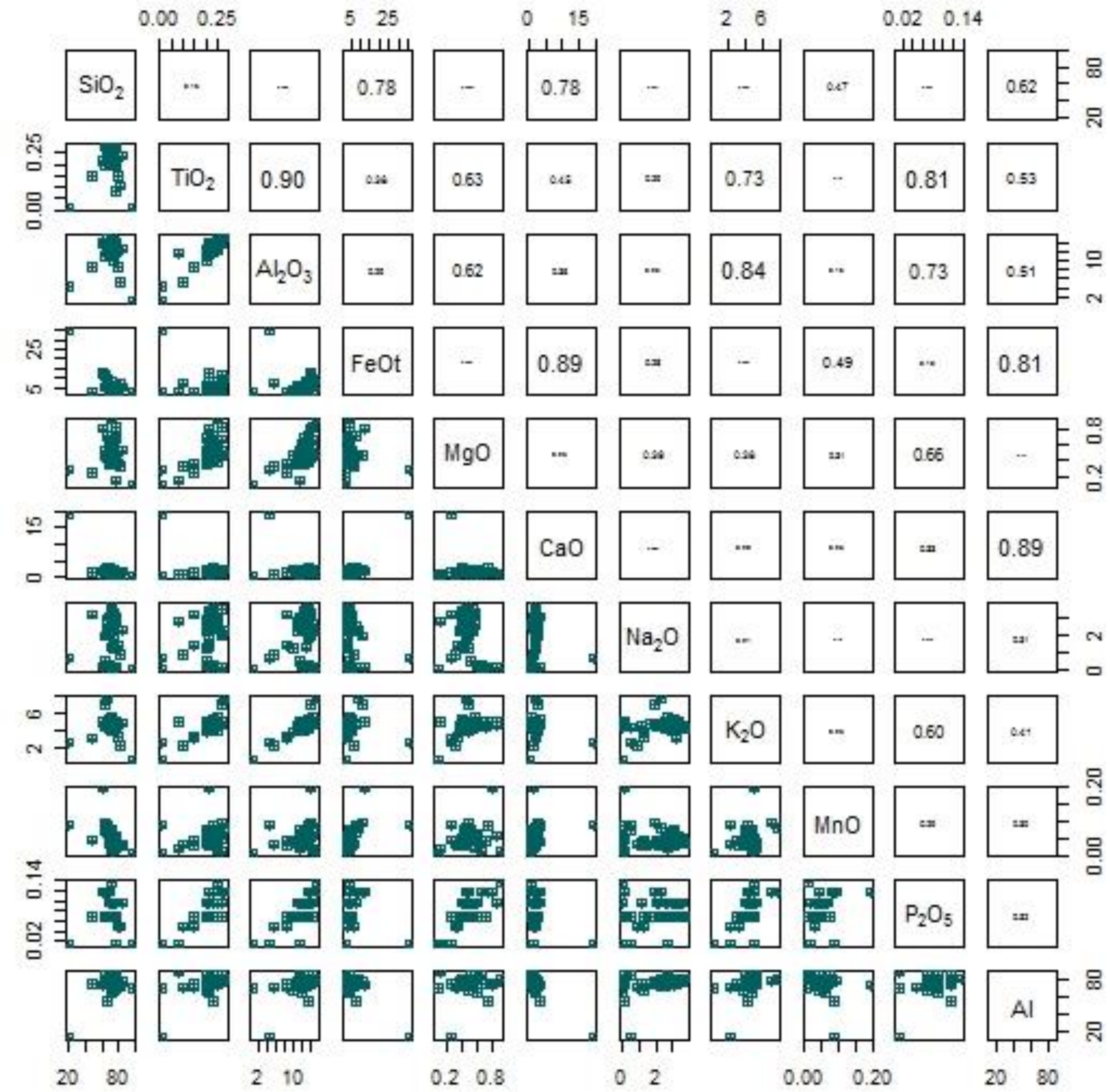
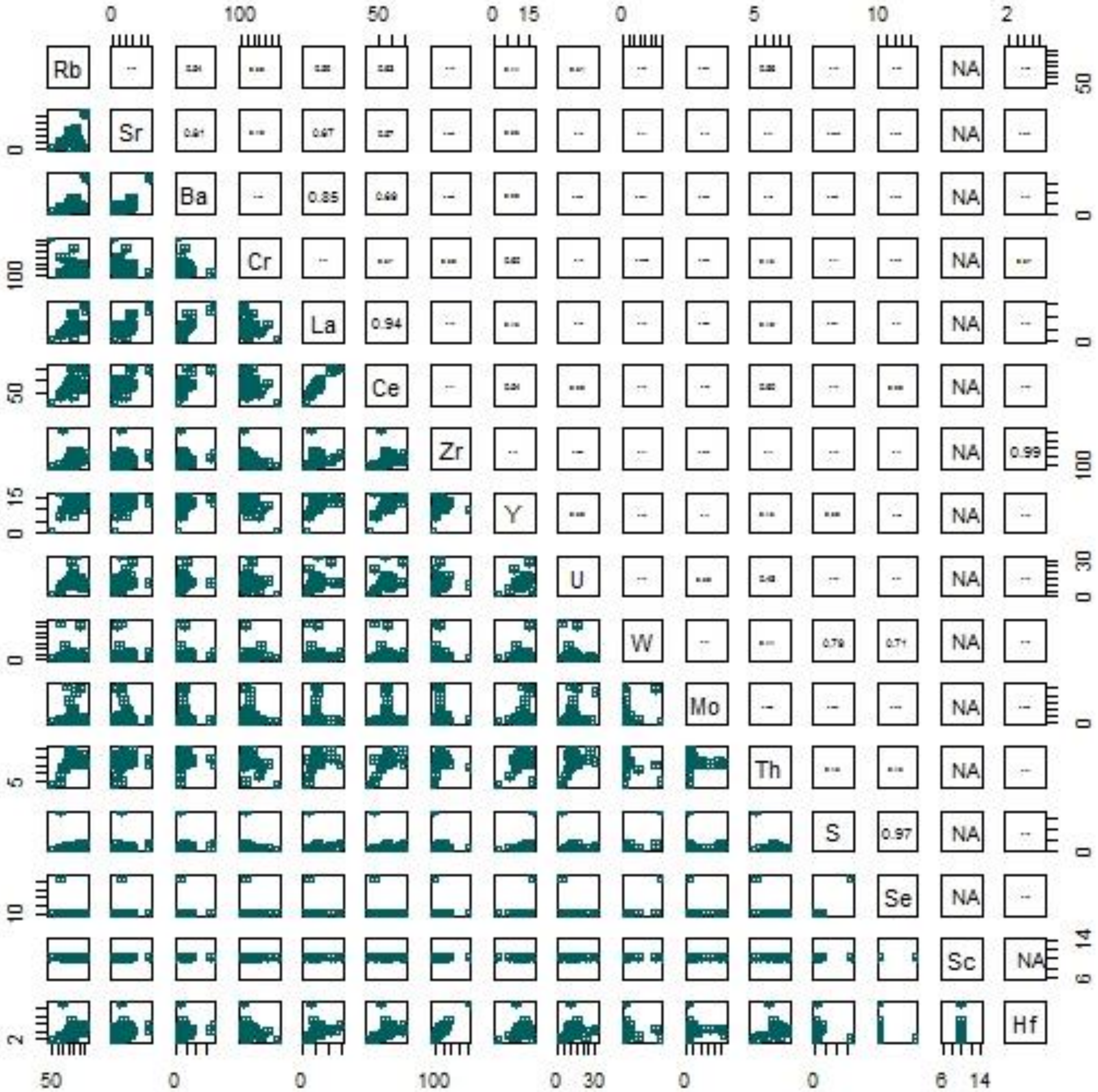
0.82
0.85
0.98

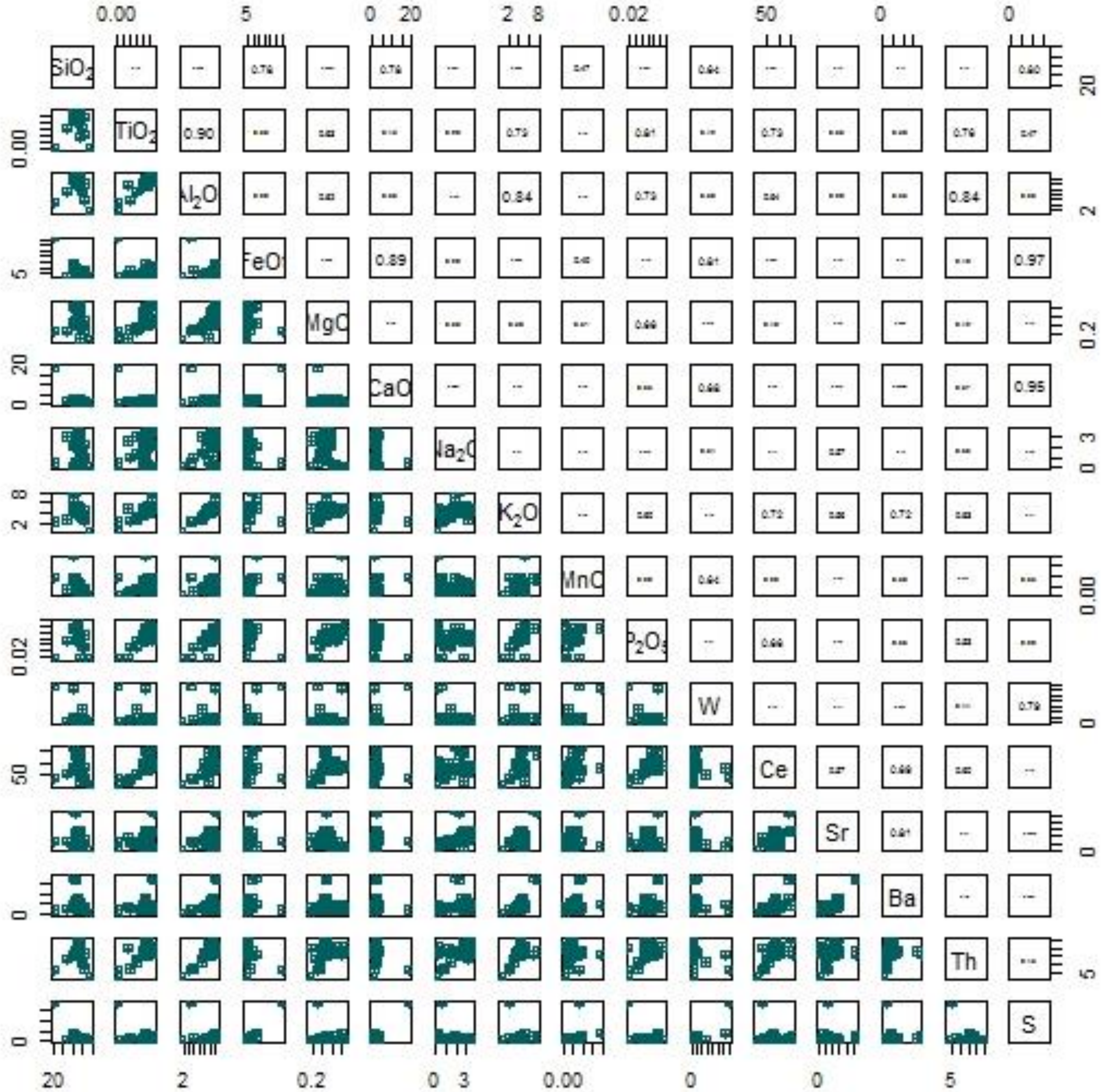

SiO2
TiO2
Al2O
FeO
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S

2.2 NMZ



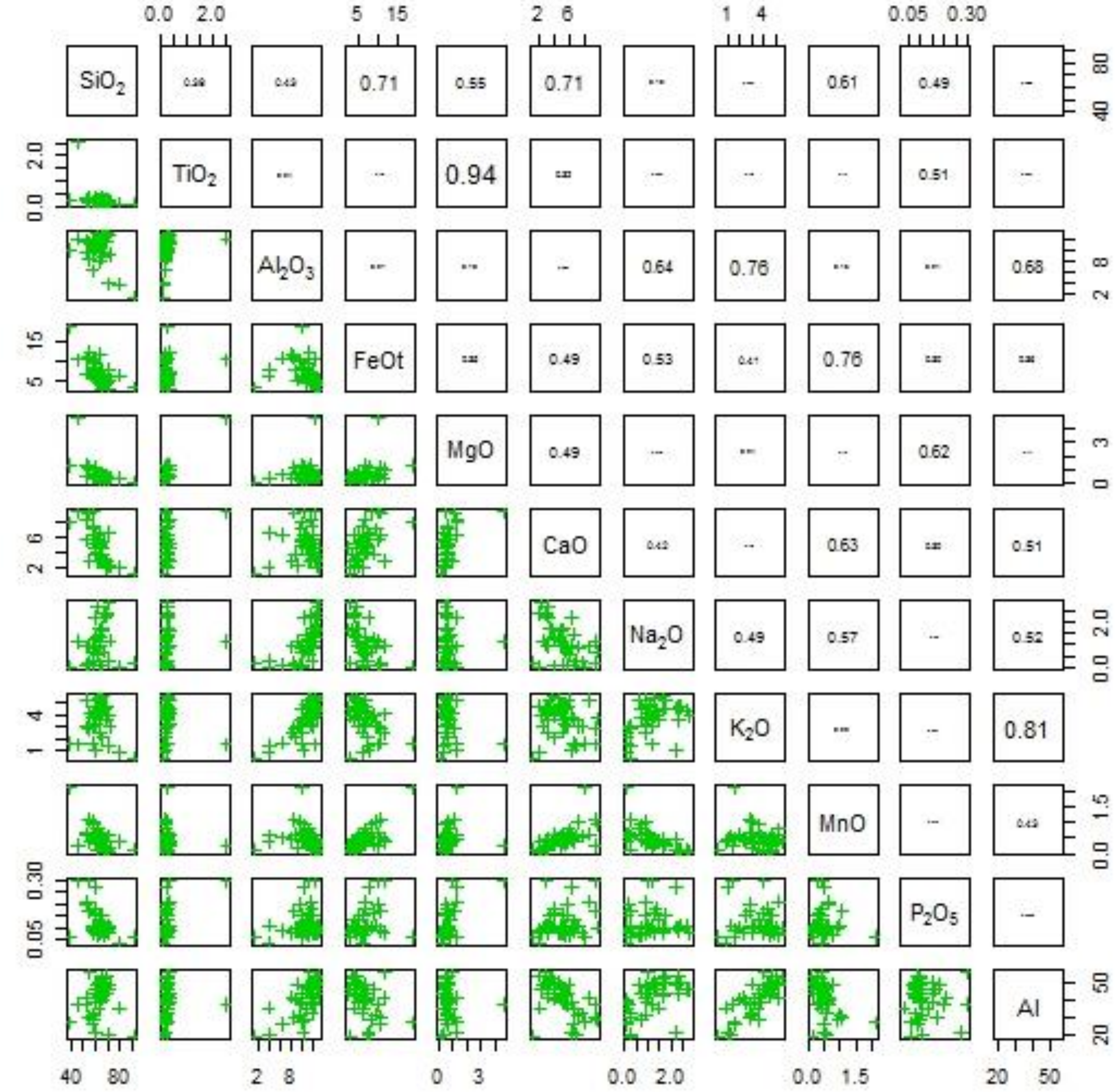
SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
AI
0.78
0.78
0.62
0.90
0.63
0.73
0.81
0.53
0.62
0.84
0.73
0.51
0.89
0.49
0.81
0.66
0.89
0.60
0.00 0.25
5 25
0 15
2 6
0.02 0.14
20 80
2 10
0.2 0.8
0 2
0.00 0.20

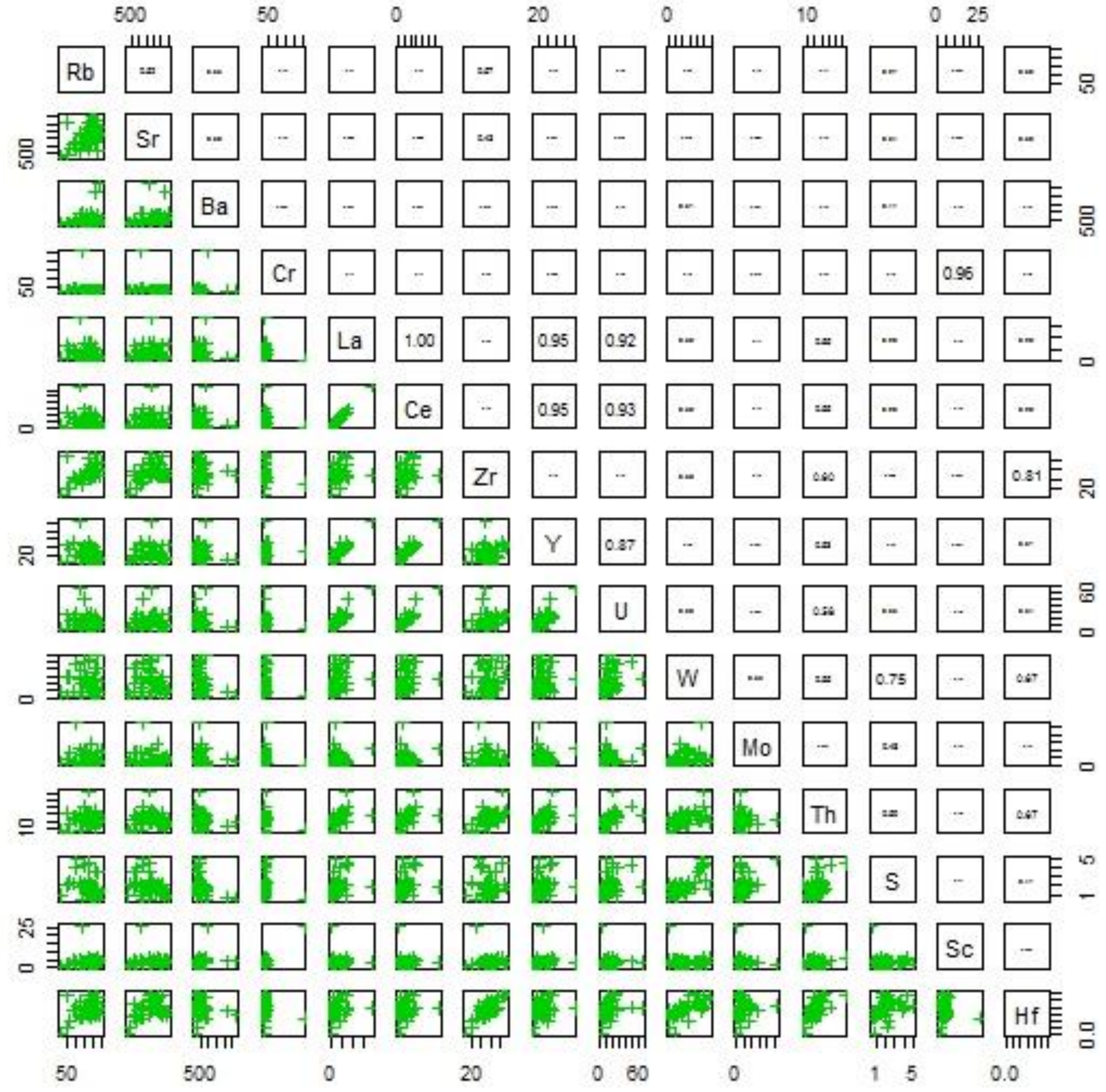

Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf
0.85
0.94
0.99
0.79
0.71
0.97
NA

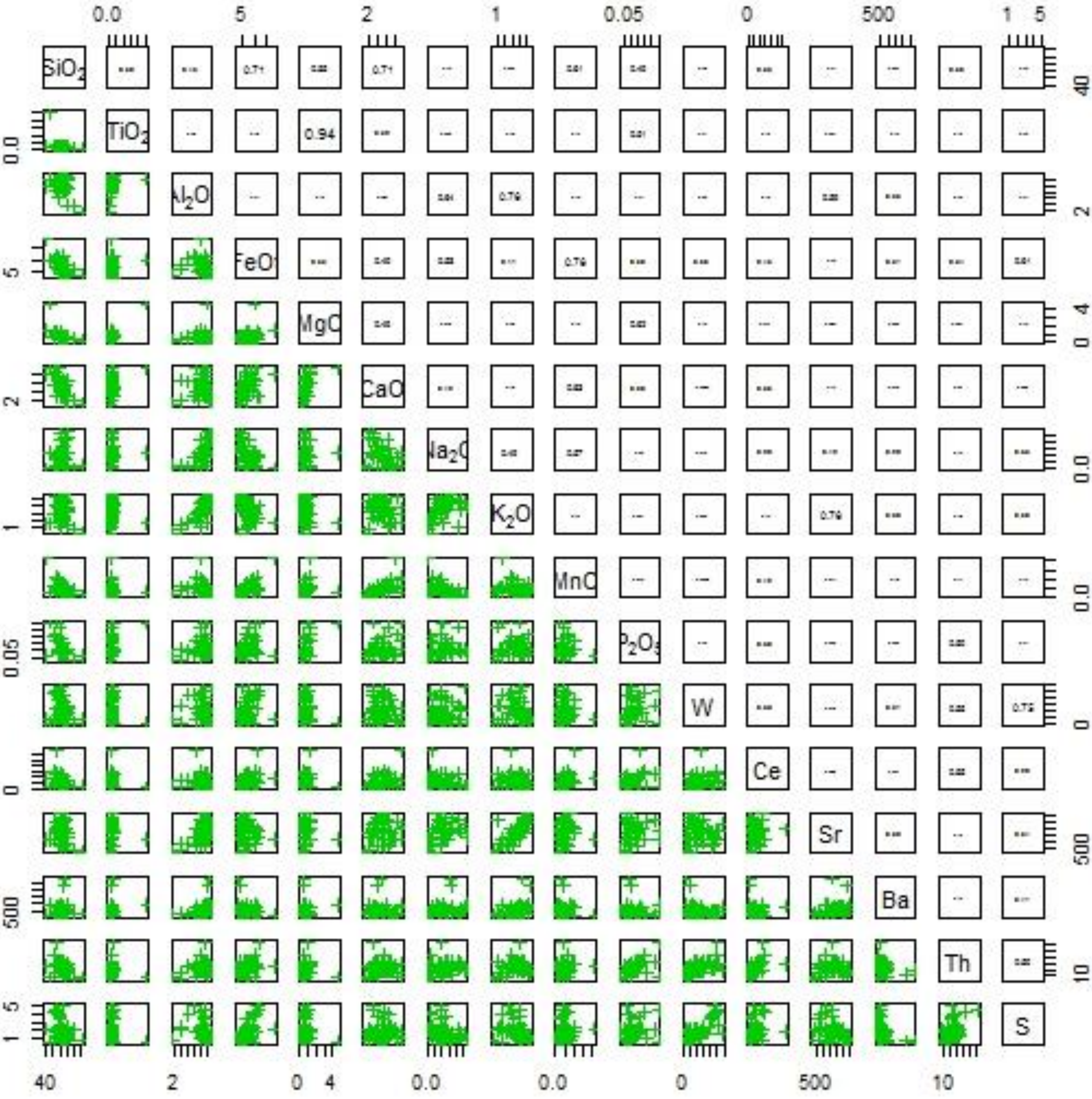

SiO2
TiO2
Al2O
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S
0.90
0.84
0.89
0.97
0.95

3. BB+400

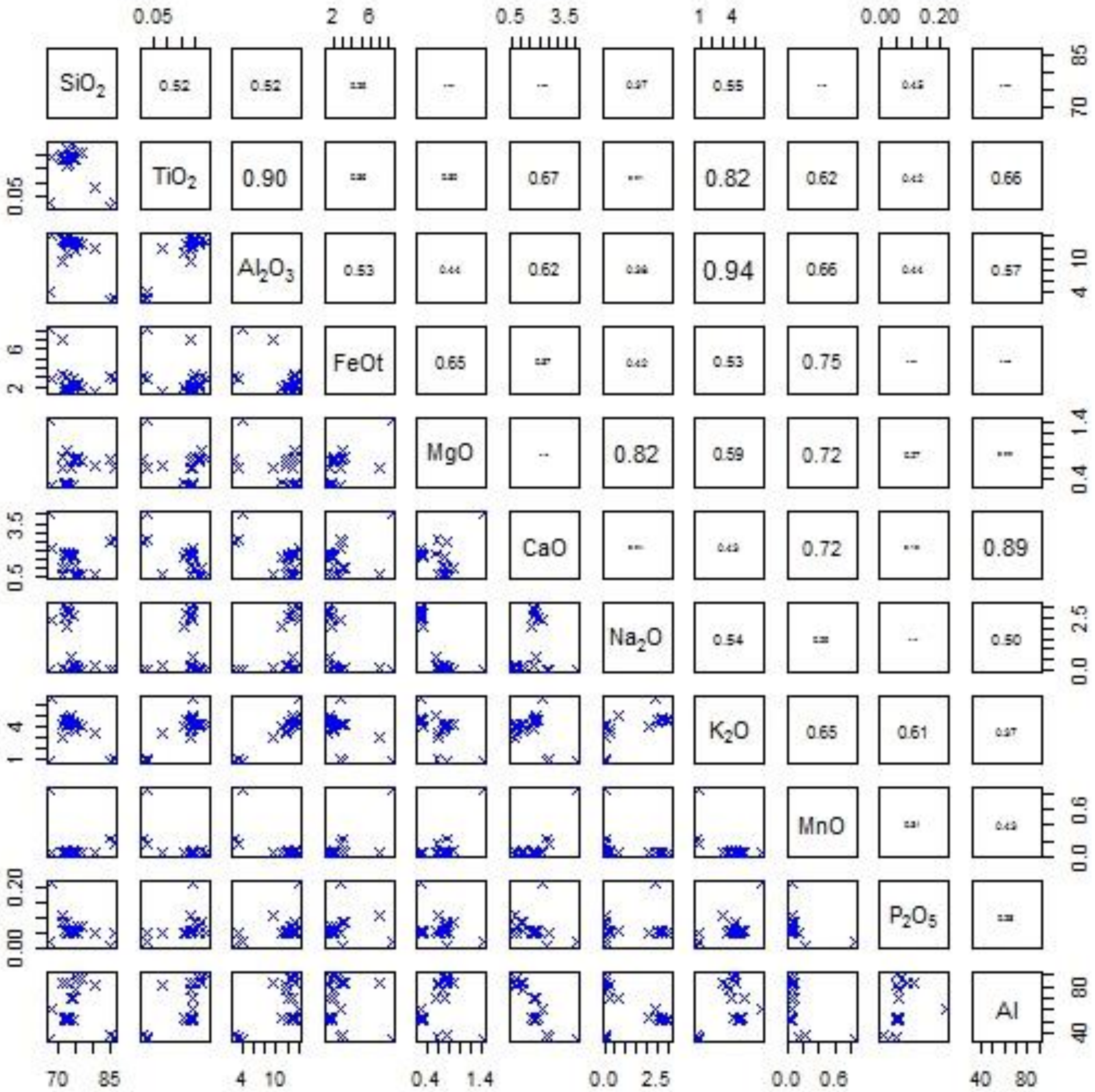
3.1 MZ

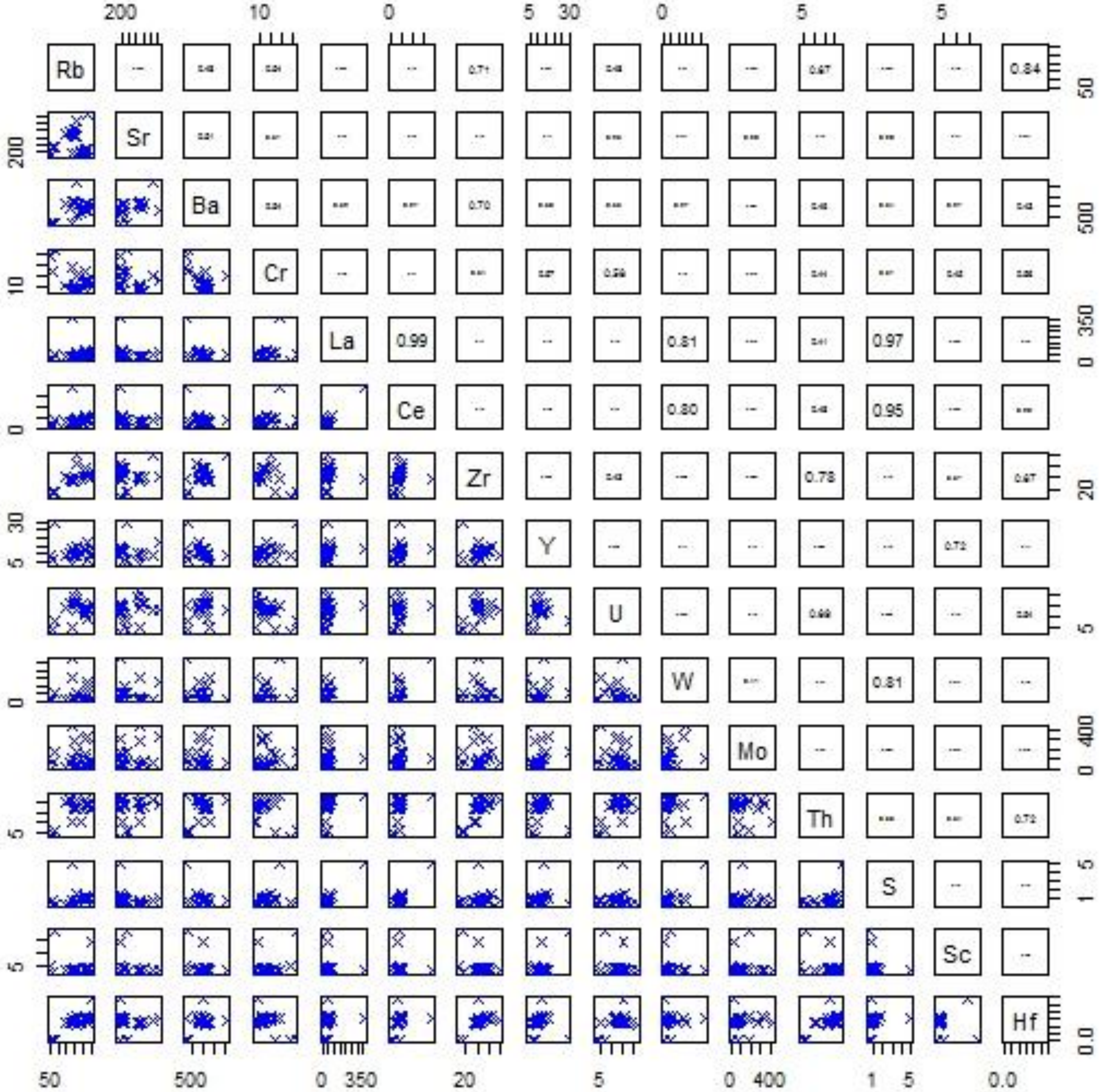

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.71
0.55
0.71
0.61
0.49
0.94
0.51
0.64
0.76
0.68
0.49
0.53
0.76
0.49
0.62
0.63
0.51
0.49
0.57
0.52
0.81

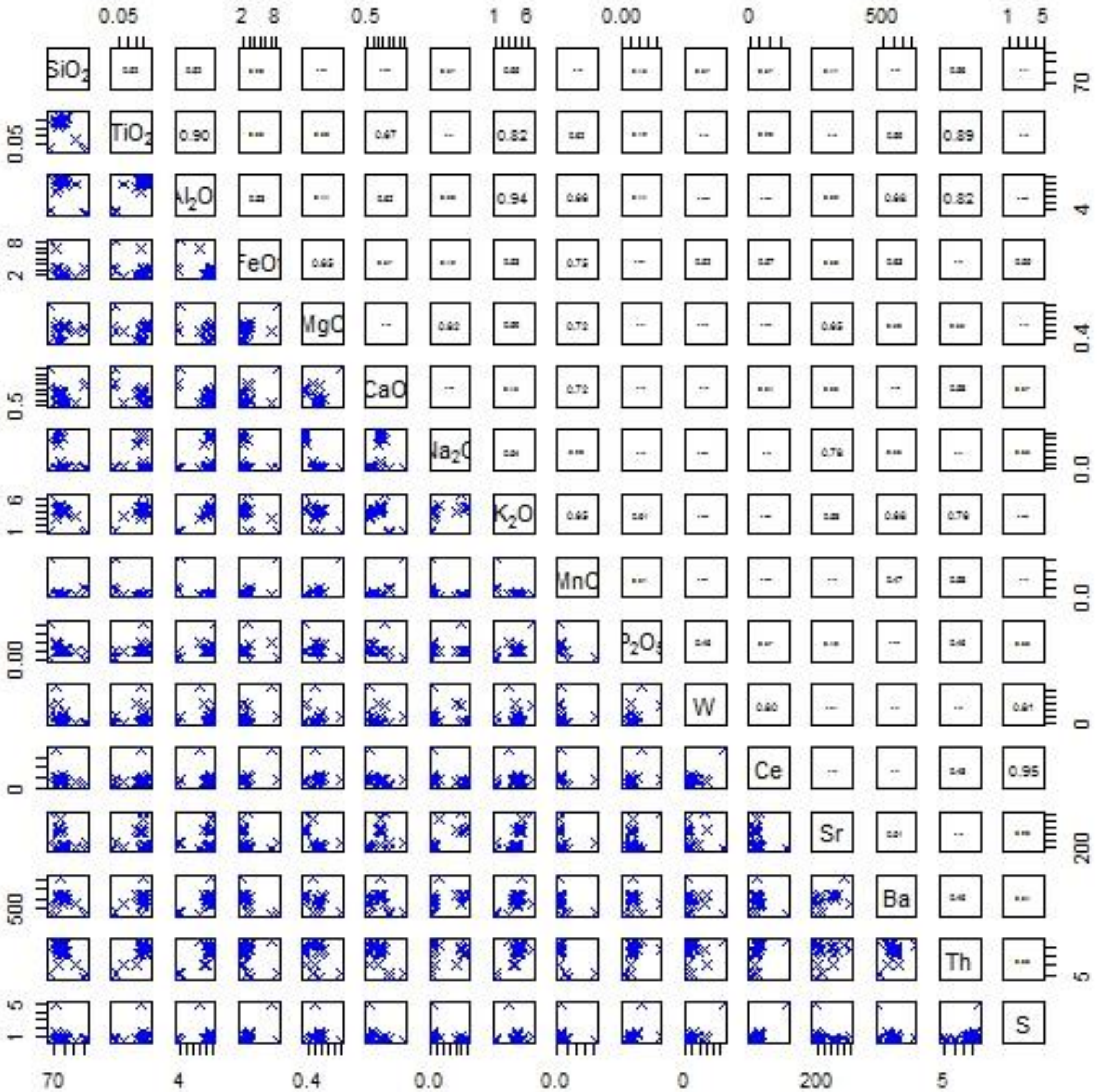

Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Sc
Hf
1.00
0.95
0.92
0.95
0.93
0.81
0.87
0.75
0.96


SiO2
TiO2
Al2O
FeO
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S
0.71
0.71
0.94
0.79
0.79
0.79
0.73

3.2 NMZ

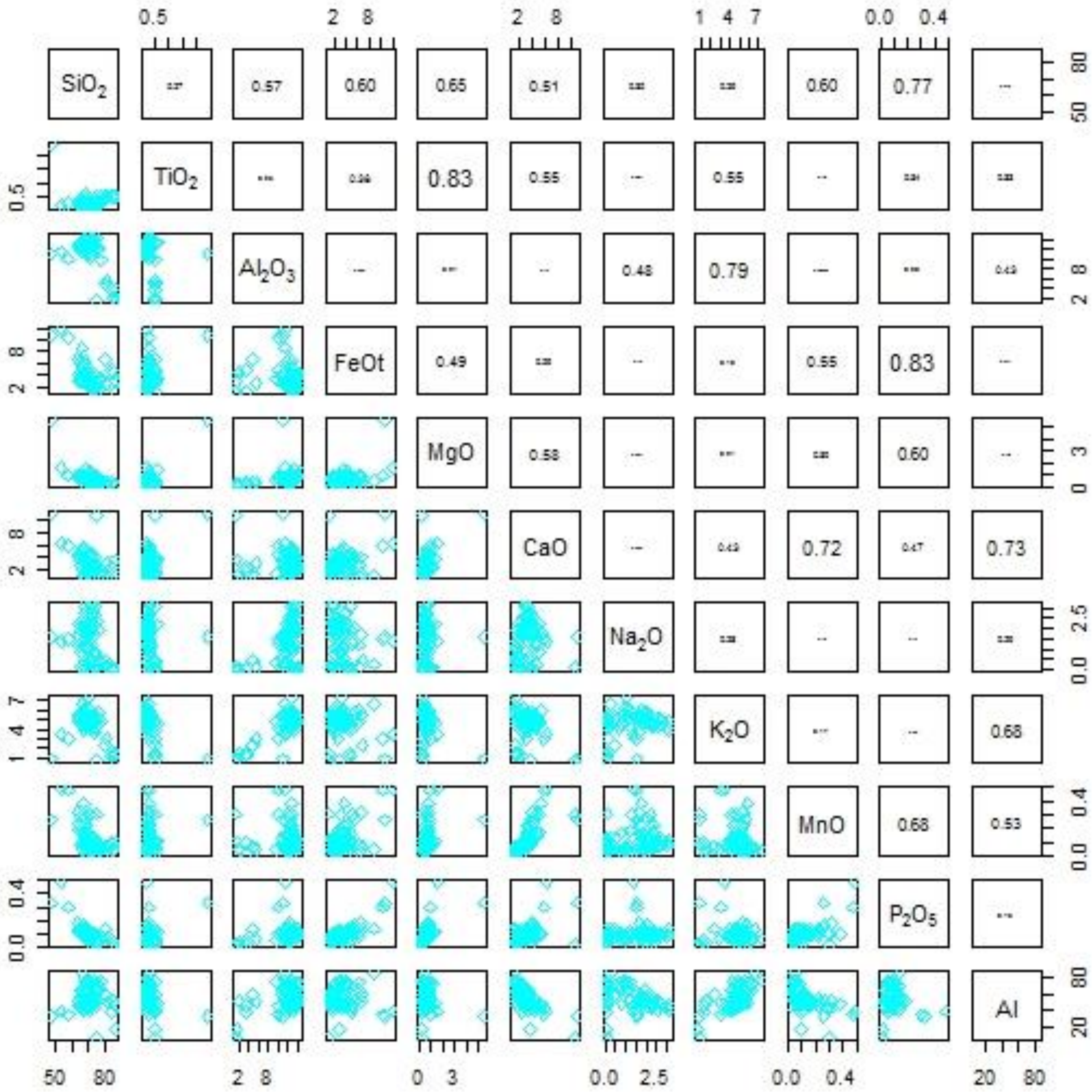

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.90
0.82
0.94
0.82
0.89
0.75
0.72
0.72


Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Sc
Hf
0.71
0.67
0.84
0.70
0.99
0.81
0.97
0.80
0.95
0.78
0.72
0.81

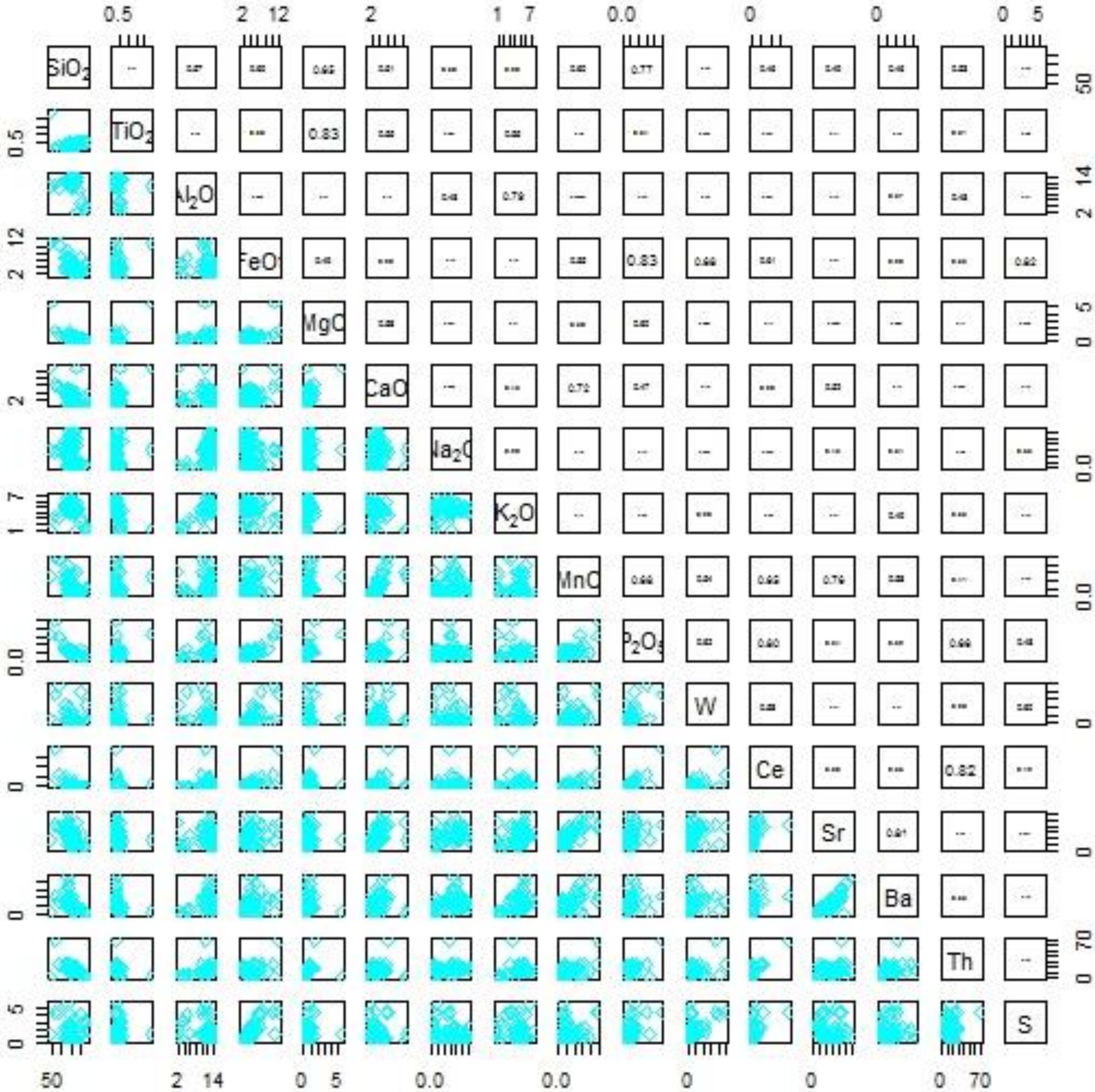

SiO2
TiO2
Al2O
FeO
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S

4. CC+400

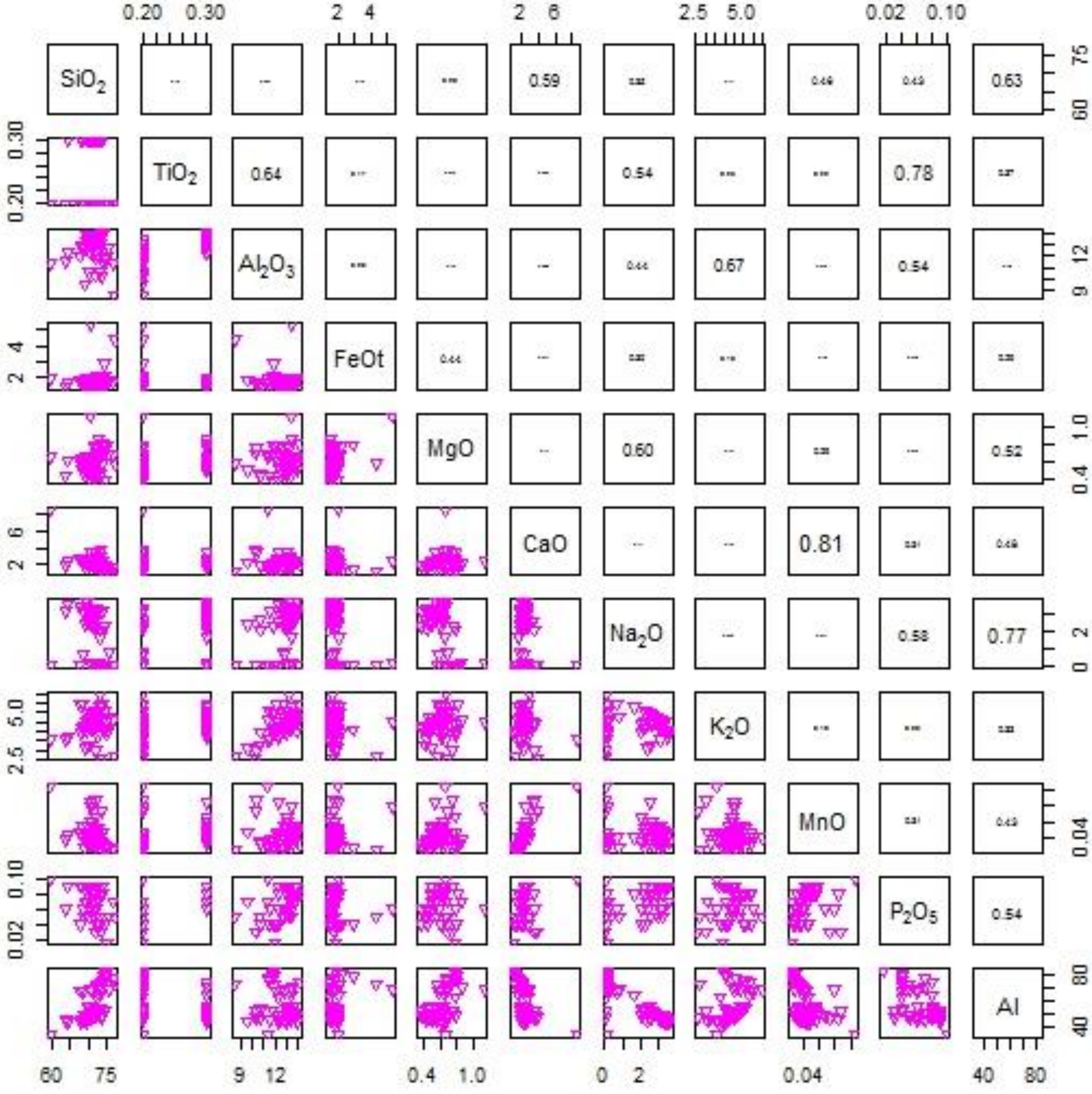
4.1 MZ

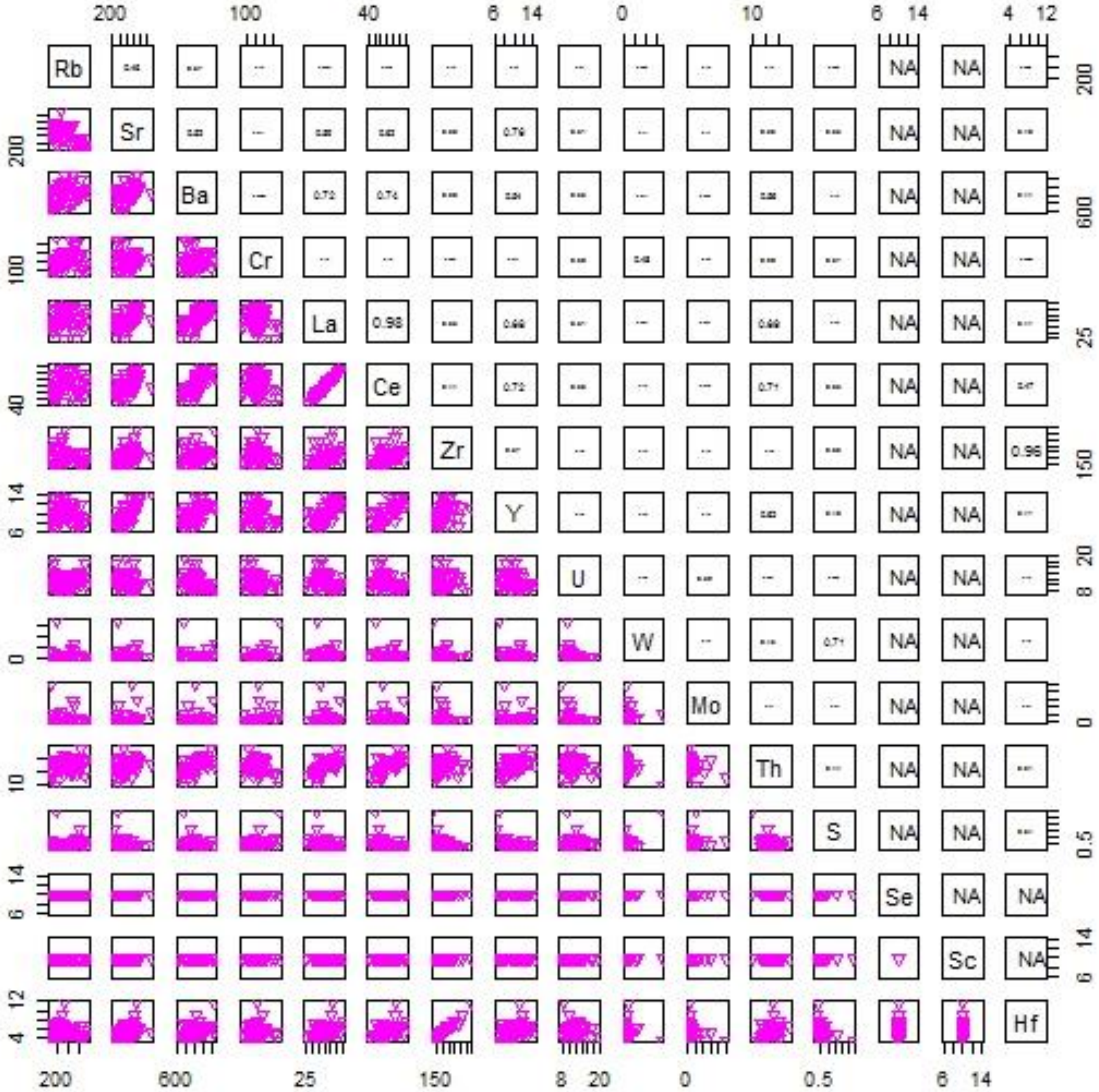

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.57
0.60
0.65
0.51
0.60
0.77
0.83
0.55
0.55
0.48
0.79
0.49
0.55
0.83
0.58
0.60
0.72
0.73
0.68
0.68
0.53

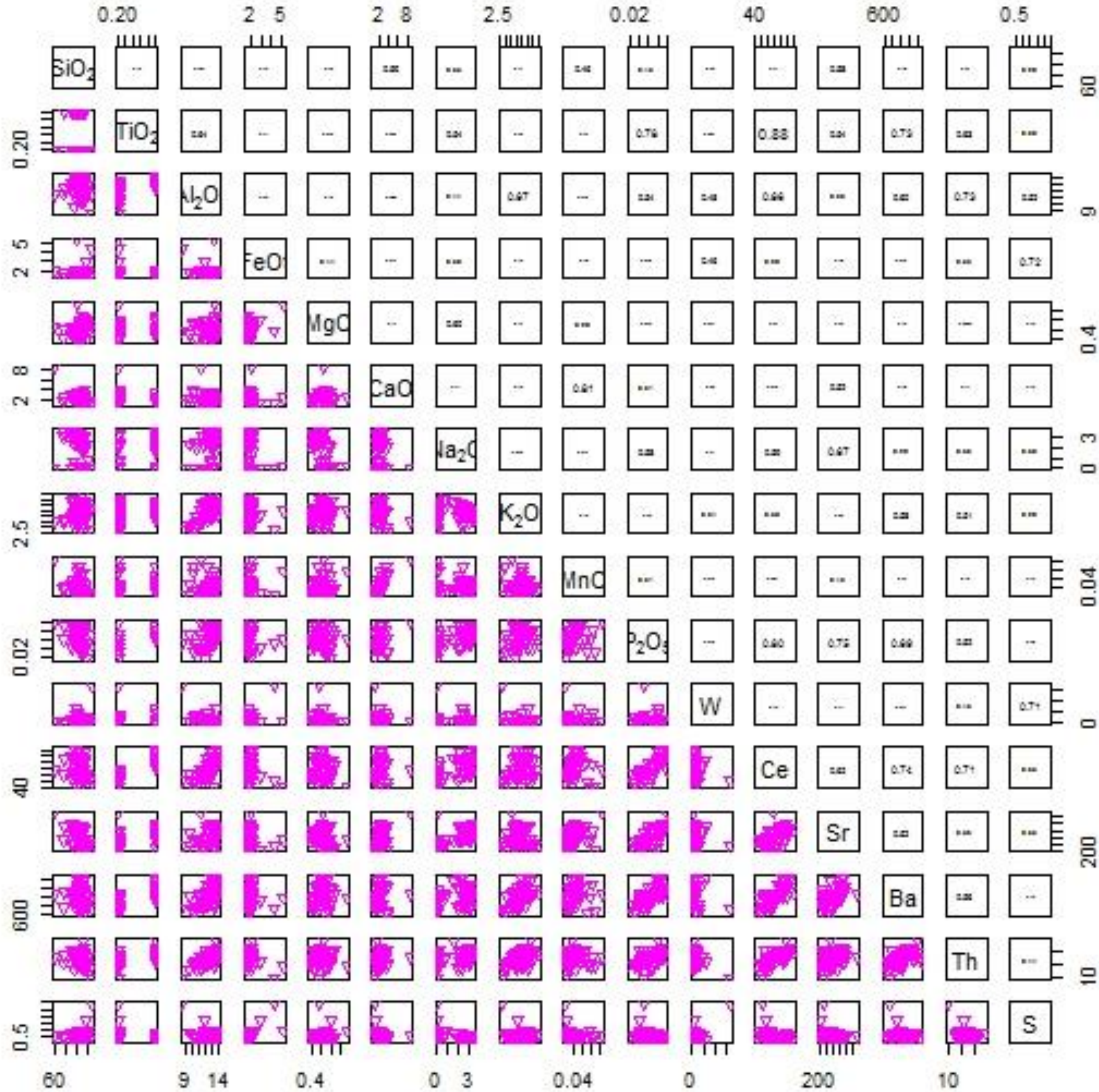

Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf
NA
1.00
0.98
0.84
0.85
0.82


SiO2
TiO2
Al2O
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S

4.2 NMZ

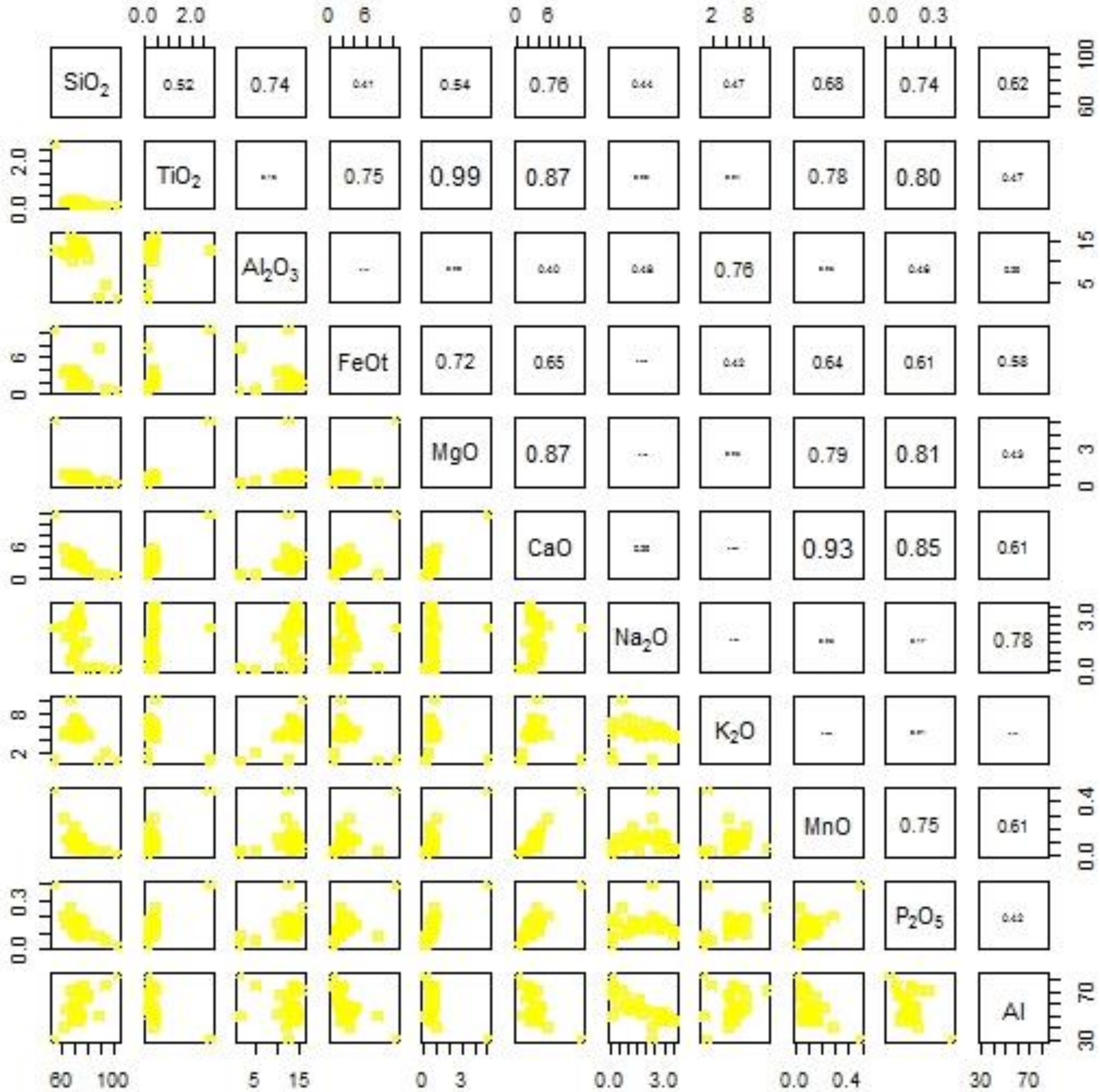

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.59
0.63
0.64
0.54
0.78
0.67
0.54
0.60
0.52
0.81
0.58
0.77
0.54


Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf
NA
0.98
0.96
0.79
0.72
0.74
0.71
200
100
40
6
14
0
10
12
4
600
25
150
8
20
0.5


0.20
2 5
2 8
2.5
0.02
40
600
0.5
SiO2
TiO2
Al2O
FeO
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S
60
9
0.4
0 3
0.04
0
200
10
9 14

5. DD+200

5.1 MZ

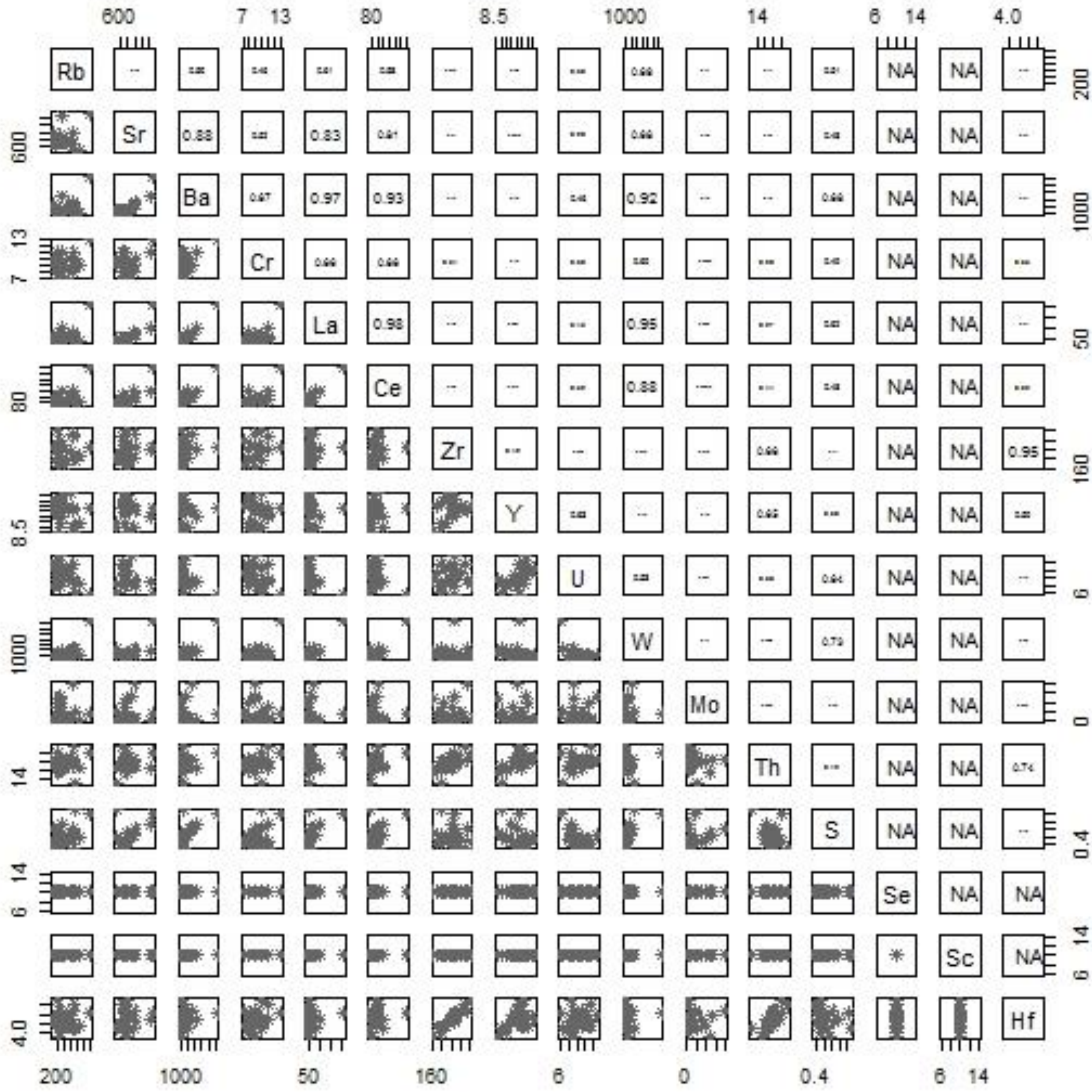

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.74
0.54
0.76
0.68
0.74
0.62
0.75
0.99
0.87
0.78
0.80
0.76
0.72
0.65
0.64
0.61
0.58
0.87
0.79
0.81
0.93
0.85
0.61
0.78
0.75
0.61

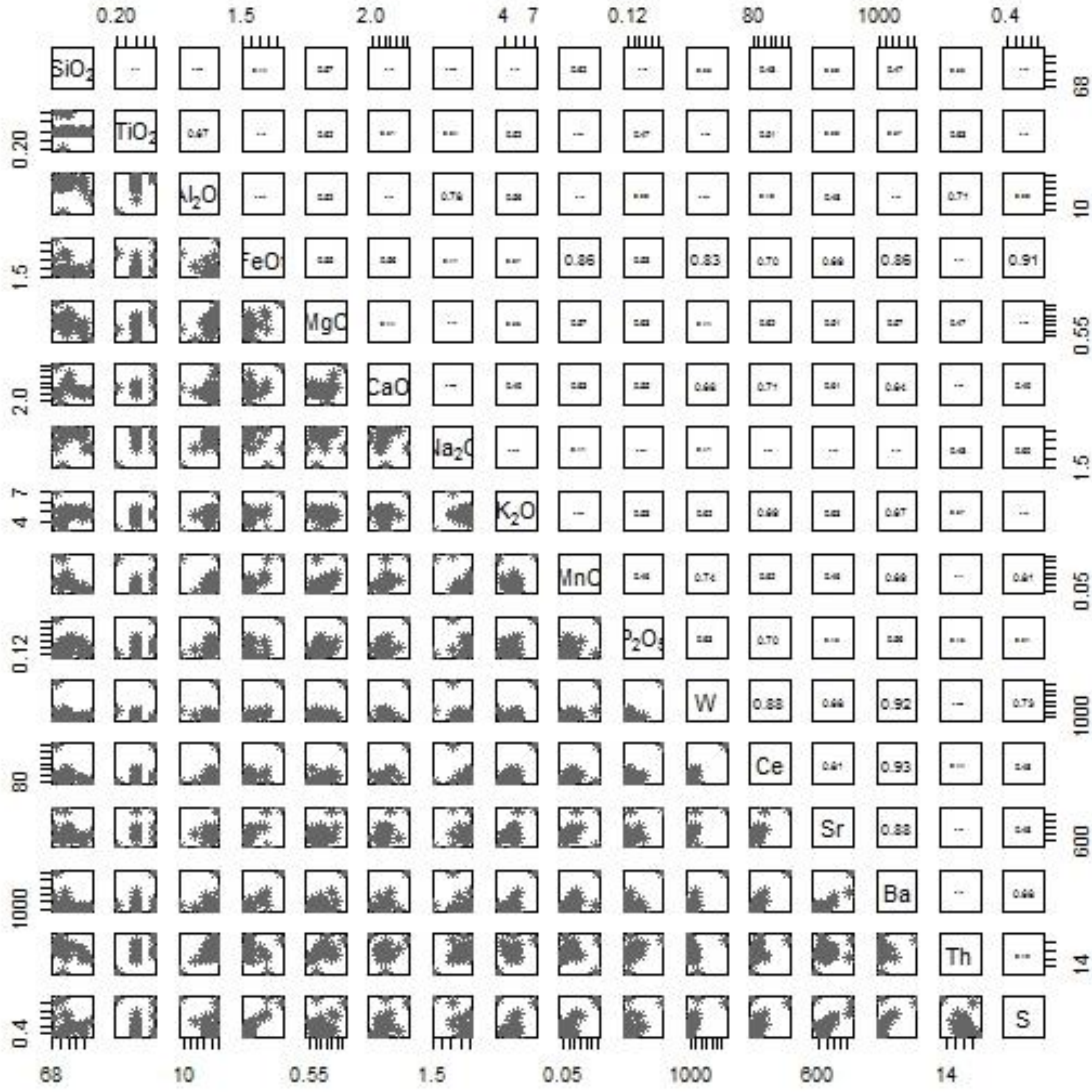
Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf
0.72
NA
1.00
0.98
0.99


SiO2
TiO2
Al2O
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S

5.2 NMZ

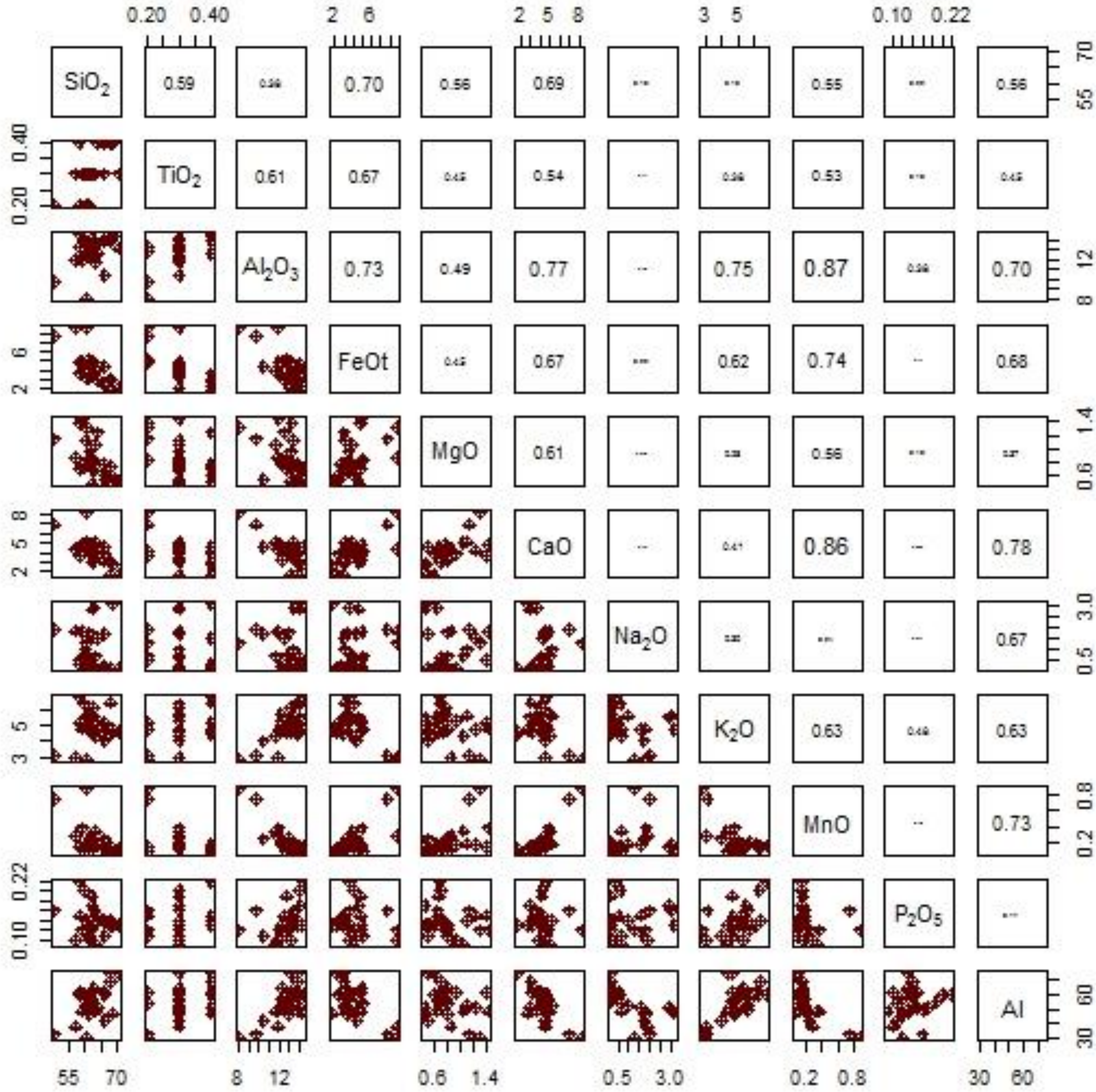

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.67
0.44
0.57
0.62
0.62
0.52
0.47
0.52
0.78
0.56
0.55
0.56
0.86
0.53
0.63
0.57
0.49
0.63
0.55
0.51
0.53
0.75

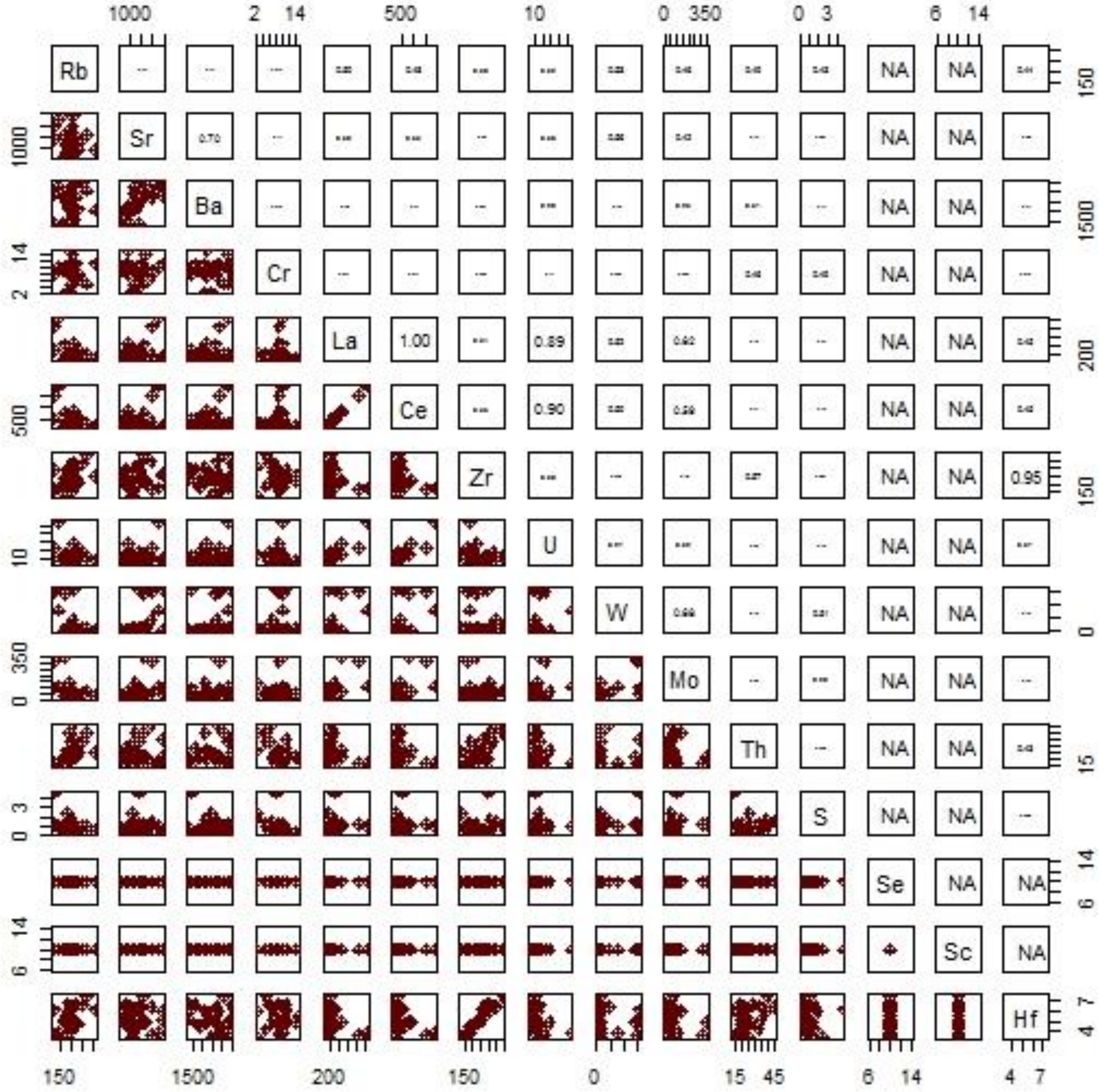

Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf


SiO2
TiO2
Al2O
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S
0.20
1.5
2.0
4 7
0.12
80
1000
0.4
68
10
0.55
1.5
0.05
1000
600
14
0.86
0.83
0.70
0.86
0.91
0.88
0.92
0.93
0.88

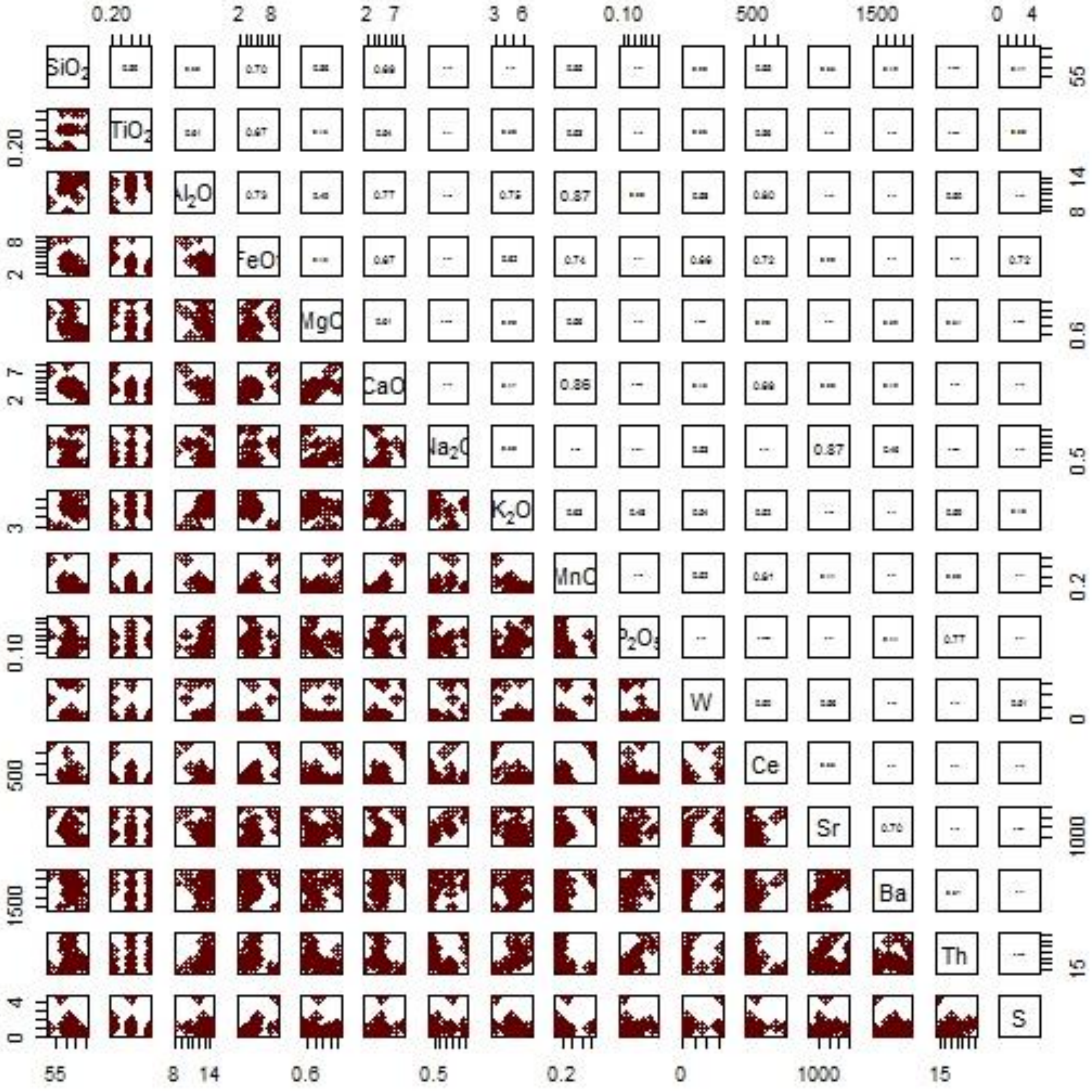
6. E-200

6.1 MZ

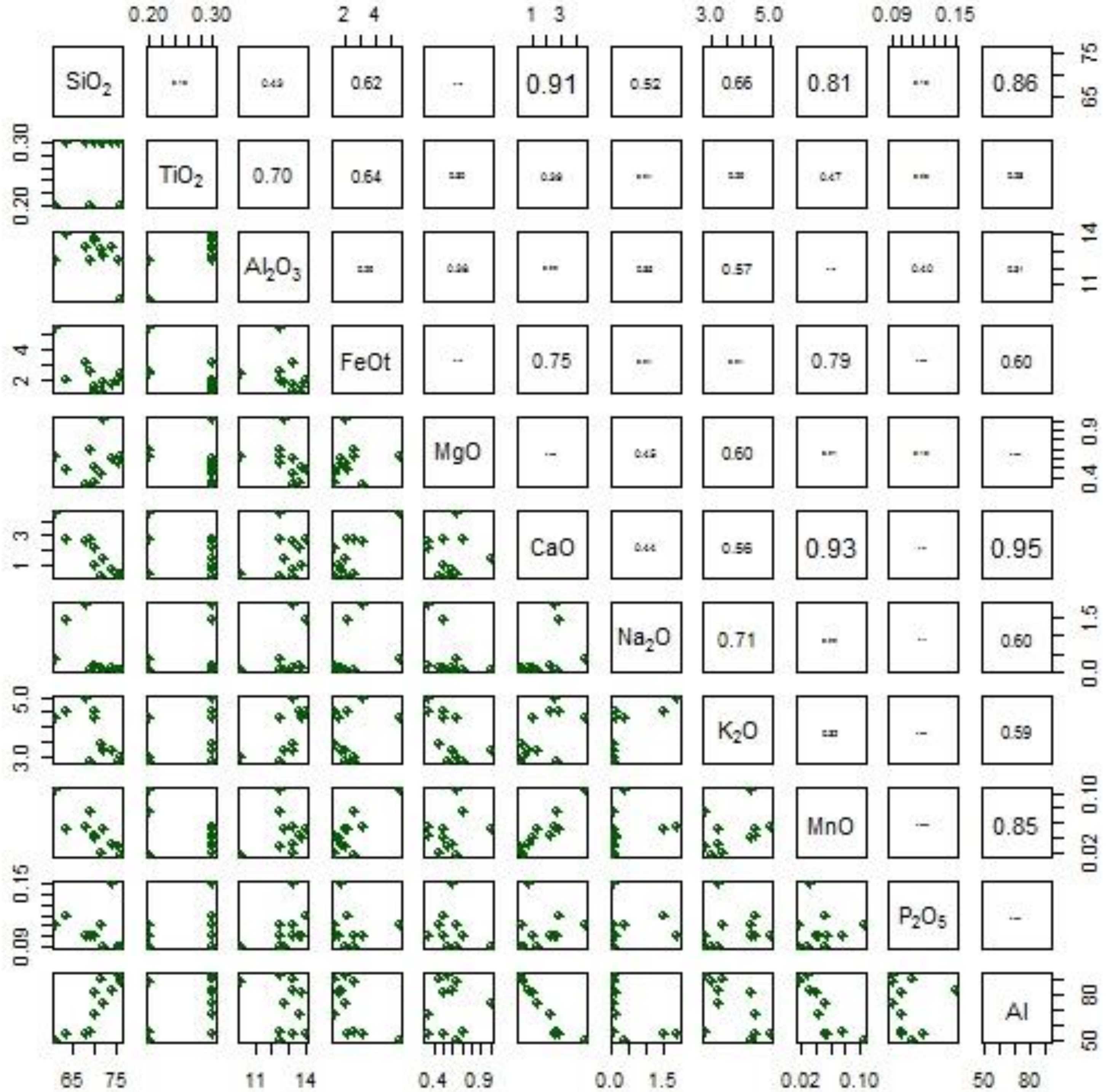

SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.59
0.70
0.56
0.69
0.55
0.56
0.61
0.67
0.54
0.53
0.73
0.49
0.77
0.75
0.87
0.70
0.67
0.62
0.74
0.68
0.61
0.56
0.86
0.78
0.67
0.63
0.63
0.73



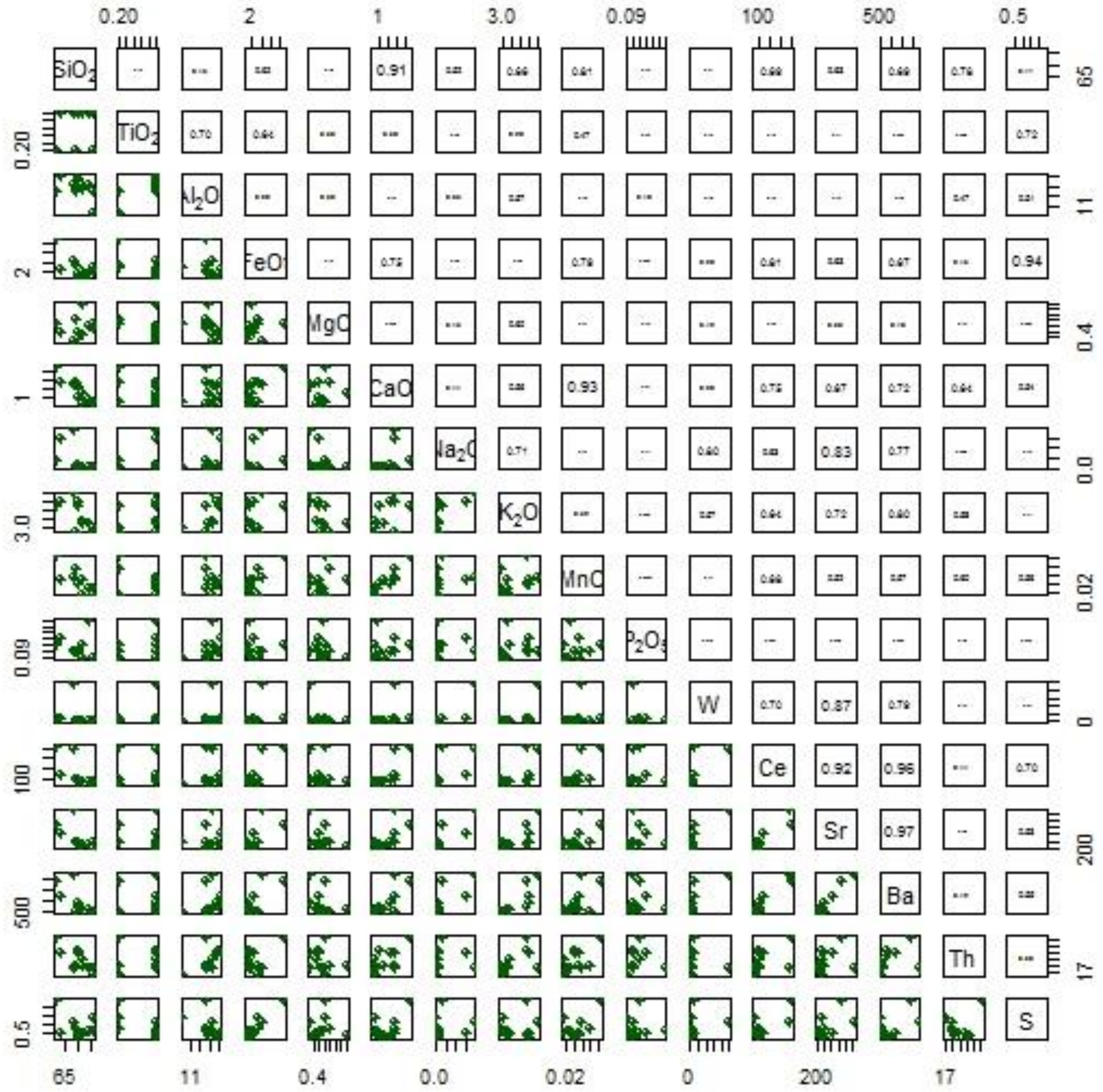
Rb
Sr
Ba
Cr
La
Ce
Zr
U
W
Mo
Th
S
Se
Sc
Hf
0.70
1.00
0.89
0.90
0.95
NA
1000
2 14
500
10
0 350
0 3
6 14
150
1500
200
0
15
4 7
15 45


SiO2
TiO2
Al2O
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S

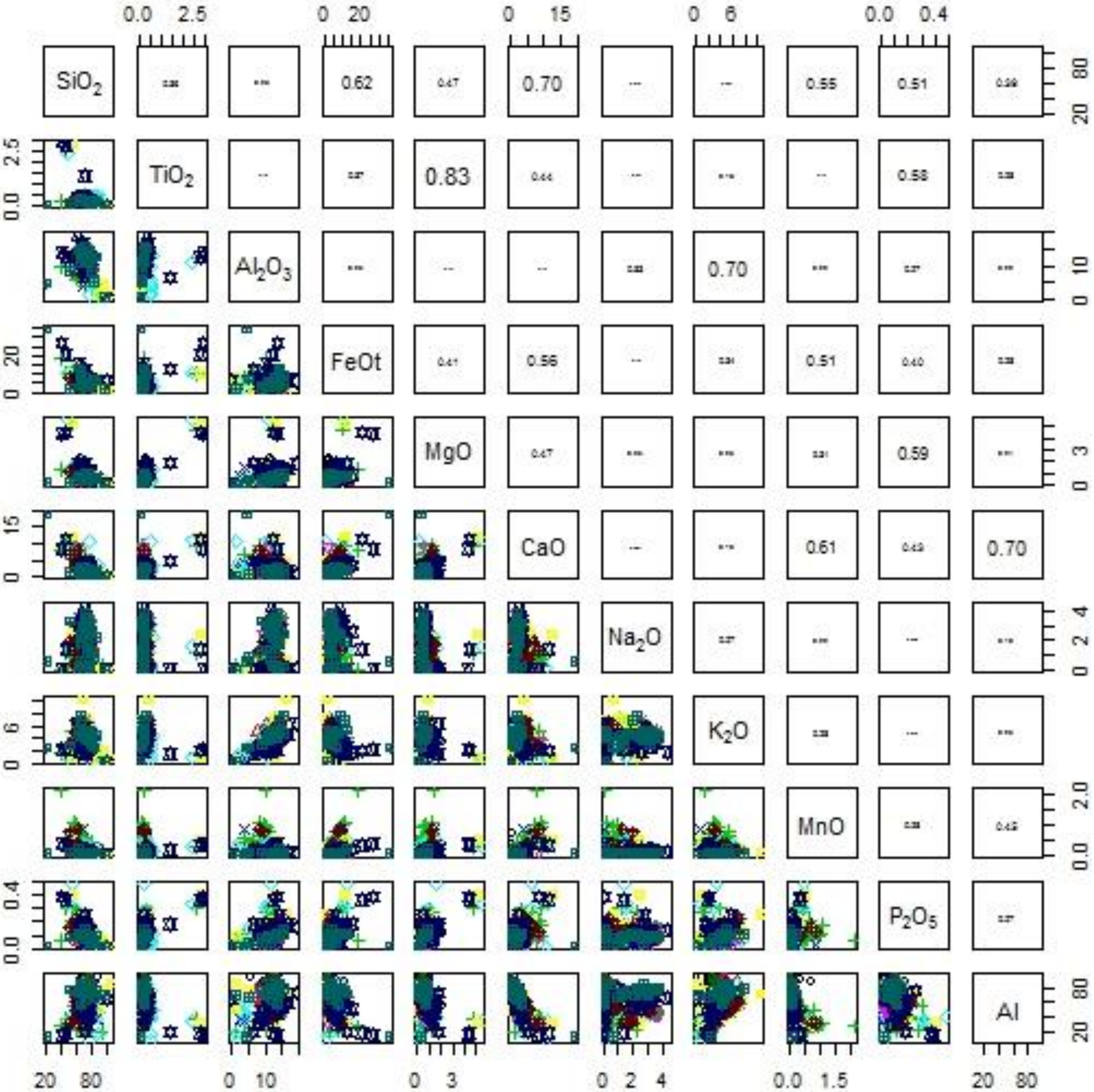
6.2 NMZ


SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.62
0.91
0.52
0.66
0.81
0.86
0.70
0.64
0.57
0.75
0.79
0.60
0.60
0.56
0.93
0.95
0.71
0.60
0.59
0.85


Rb
Sr
Ba
Cr
La
Ce
Zr
U
W
Mo
Th
S
Se
Sc
Hf
0.97
0.93
0.92
0.87
0.96
0.96
0.79
1.00
0.98
NA
200
4
100
9.0
0 300
0.5
6 14
180
500
40
0
17
3 7

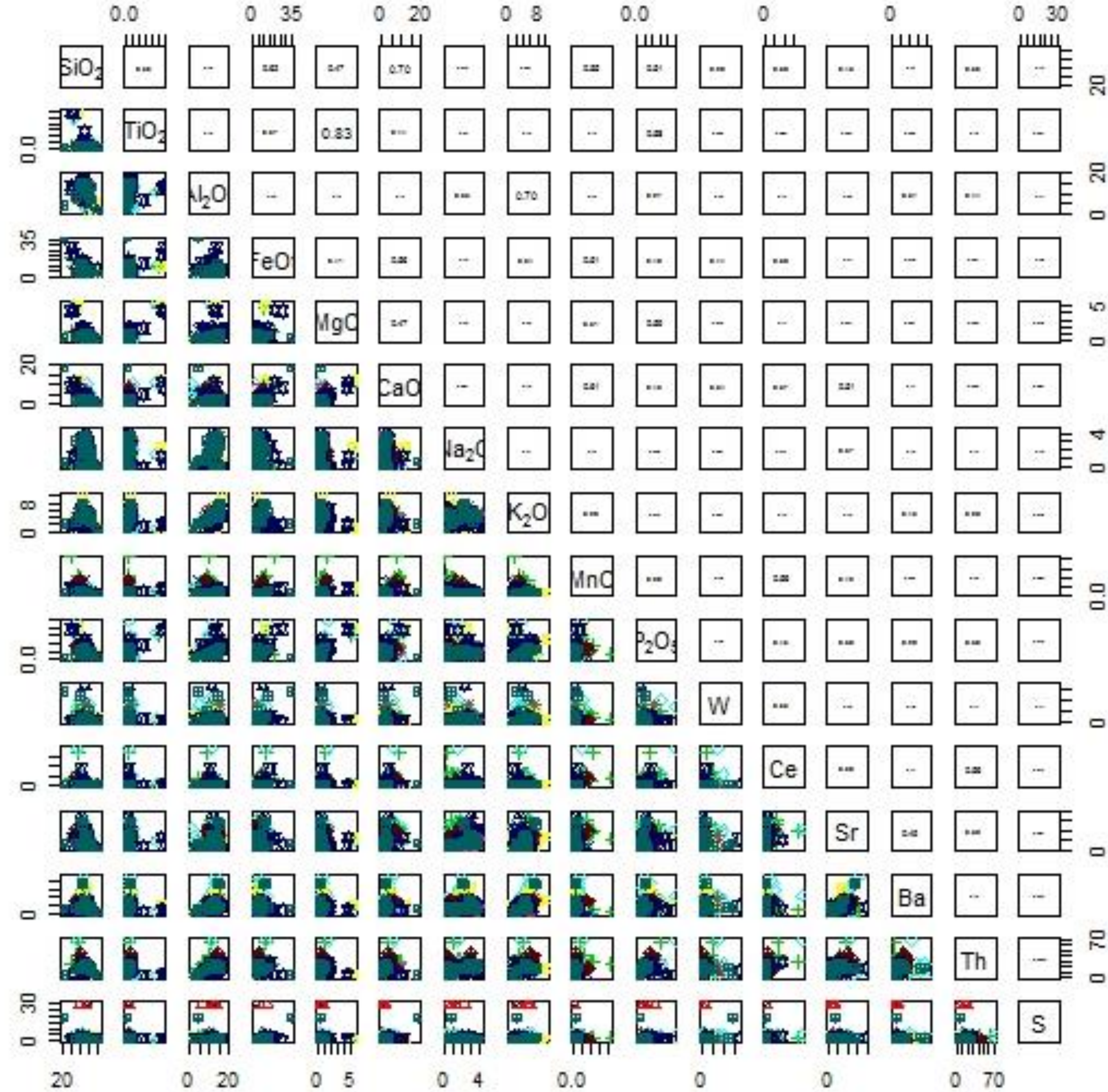

SiO2
TiO2
Al2O
FeO
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S
0.91
0.93
0.83
0.87
0.92
0.96
0.97
0.94
0.20
2
1
3.0
0.09
100
500
0.5
65
11
0.4
0.0
0.02
0
200
17

7. All



SiO2
TiO2
Al2O3
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
Al
0.62
0.47
0.70
0.55
0.51
0.83
0.44
0.58
0.70
0.41
0.56
0.51
0.40
0.47
0.59
0.61
0.70


Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf
1.00
0.84
0.84
0.99


SiO2
TiO2
Al2O
FeO
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S

Appendix L – Mineralized and non-mineralized zone

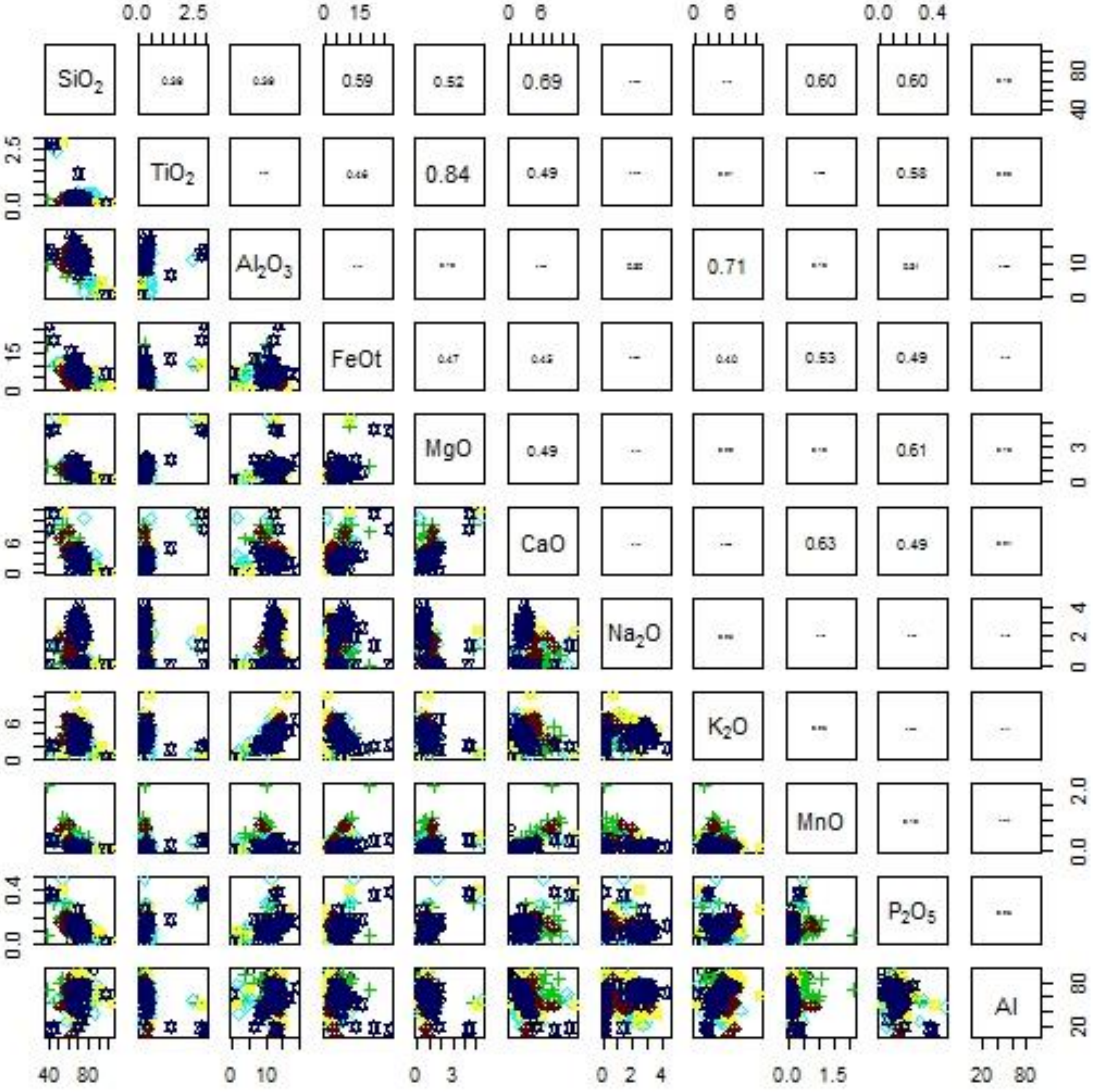
The data in appendix J is based on the vertical distribution plots (appendix I). Trends for each borehole in the major, minor, trace and ore minerals were documented and summarized below. The mineralized (MZ) and non-mineralized zone (NMZ) was determined from this data. (If an element is reported in brackets it indicates that hardly any significant variation has been identified although overall it seems to be an ingoing or outgoing element). Additionally a major and trace element correlation matrix was calculated for all the samples from all the borehole intersections for the both the mineralized zone and the non-mineralized zone.

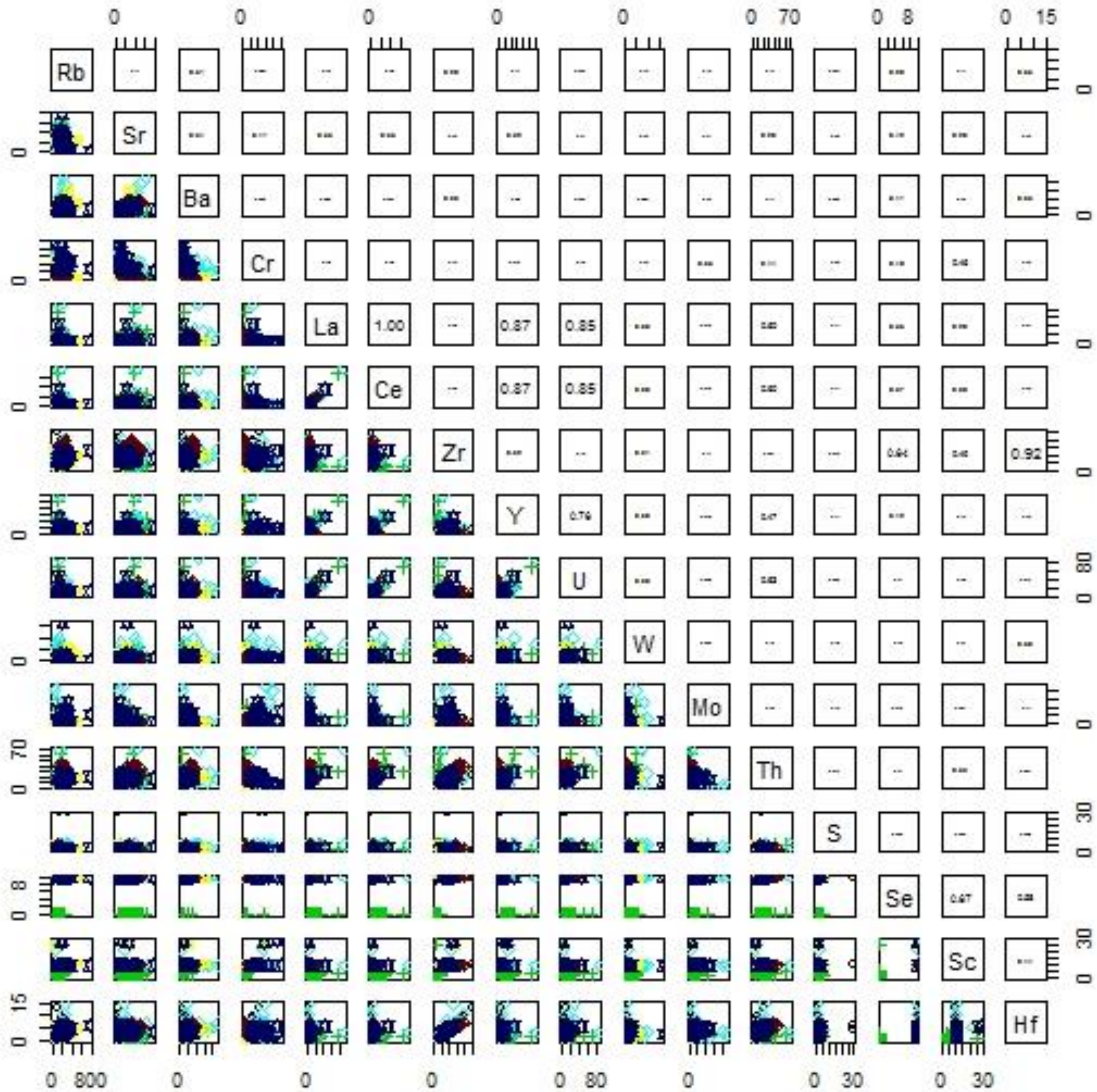
L1. Mineralized zone

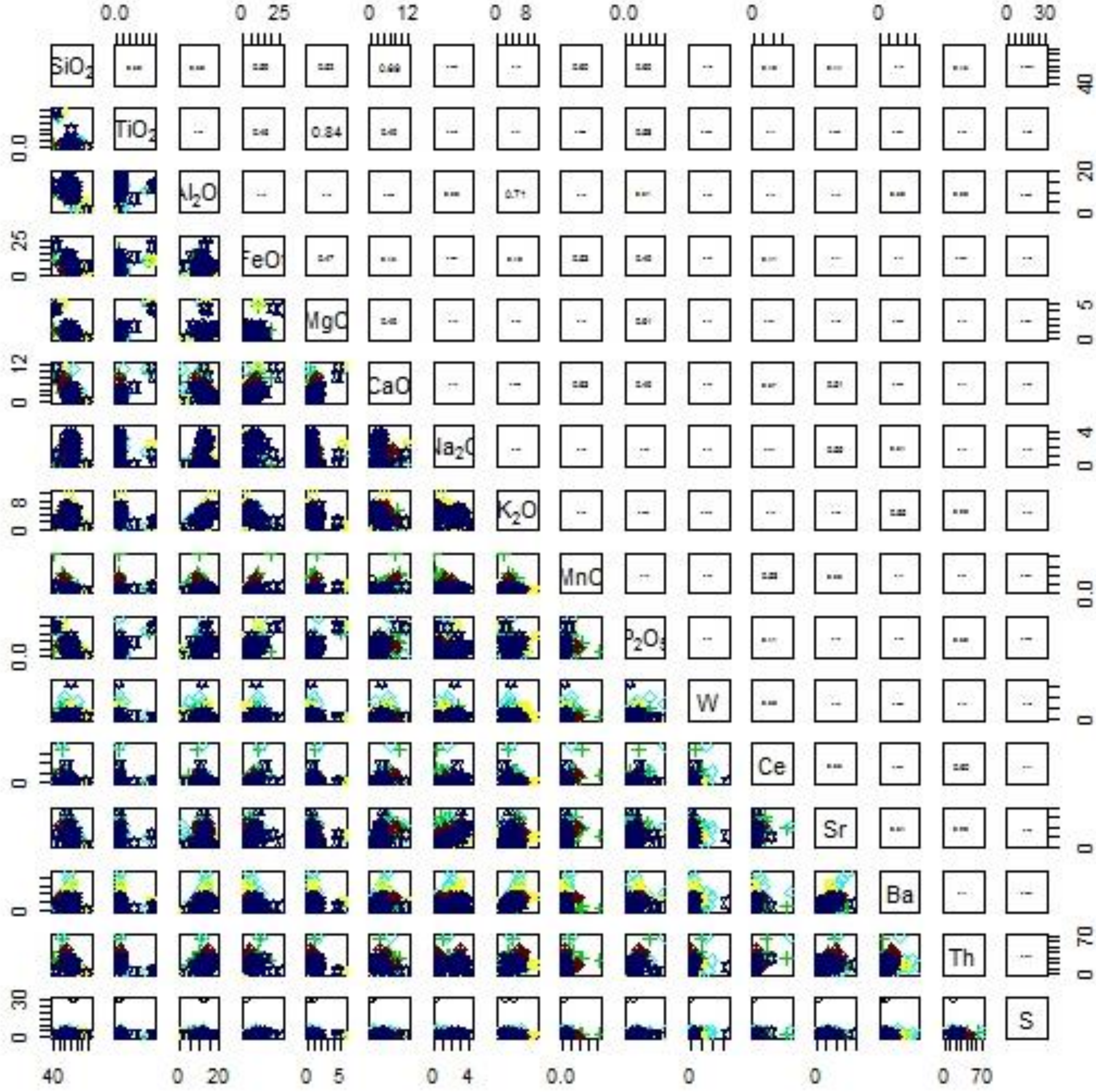
Section	Zone	Element type	Enriched	Depleted
		A+400		
42,78 to 83,2 m	Mineralized	Ore elements	∑LREE, ∑REE, W, (Mo), Cu, Zn, (S)	(Pb)
		Major	Fe, Mg, Mn, Ca, Ti	K, (Si), Na
		Minor	Ba, (P)	
		Trace	(Zr), (Hf)	(Rb), Sr, Ta, (Th), U, (Y)
		BB+400		
120.12 – 167.66 m	Mineralized	Ore elements	∑LREE, ∑REE, W, (Mo), Cu, (Zn), S	(Pb)
		Major	Ca, (Mg), Fe, Mn, (Ti)	(K), Na, (Si)
		Minor	(P)	Ba
		Trace	(Sc), Sr, Nb, (Y), (Hf), (Zr)	(Rb), (U)
		CC+400		
117.7 – 172.45 m	Mineralized	Ore elements	(Mo), S, Cu, W, ∑LREE, (Pb), (Zn), ∑REE	
		Major	(Ca), (K), Fe, Mn, (Mg), Ti	Na, (Si)

		Minor	Ba, (P)	
		Trace	(Hf), (Nb), (Rb), Sr	(Ta), (U), (Th)
		DD+200		
158,15 – 200,54 m	Mineralized	Ore elements	(Mo), S, W, ∑LREE, ∑REE, Cu, Pb, Zn	
		Major	Ca, (Fe), (Mg), Mn, (Ti)	(K), Na, (Si)
		Minor	Ba, (P)	
		Trace	Nb, Rb, U, (Th), Sr, (Y)	Hf, (Ta), (Zr)
		E-200		
302.4 – 324.56 m	Mineralized	Ore elements	Cu, W, Mo, Zn, ∑LREE, ∑REE, S	Pb
		Major	Ca, K, Na, Fe, Mn, Mg, Ti	(Si)
		Minor	Ba, P	
		Trace	(Hf), Sr, (U), (Th), (Zr)	(Rb), (Nb), Ta

1.1 MZ correlation matrices




Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf
1.00
0.87
0.85
0.92
0.79
0.94
0.92

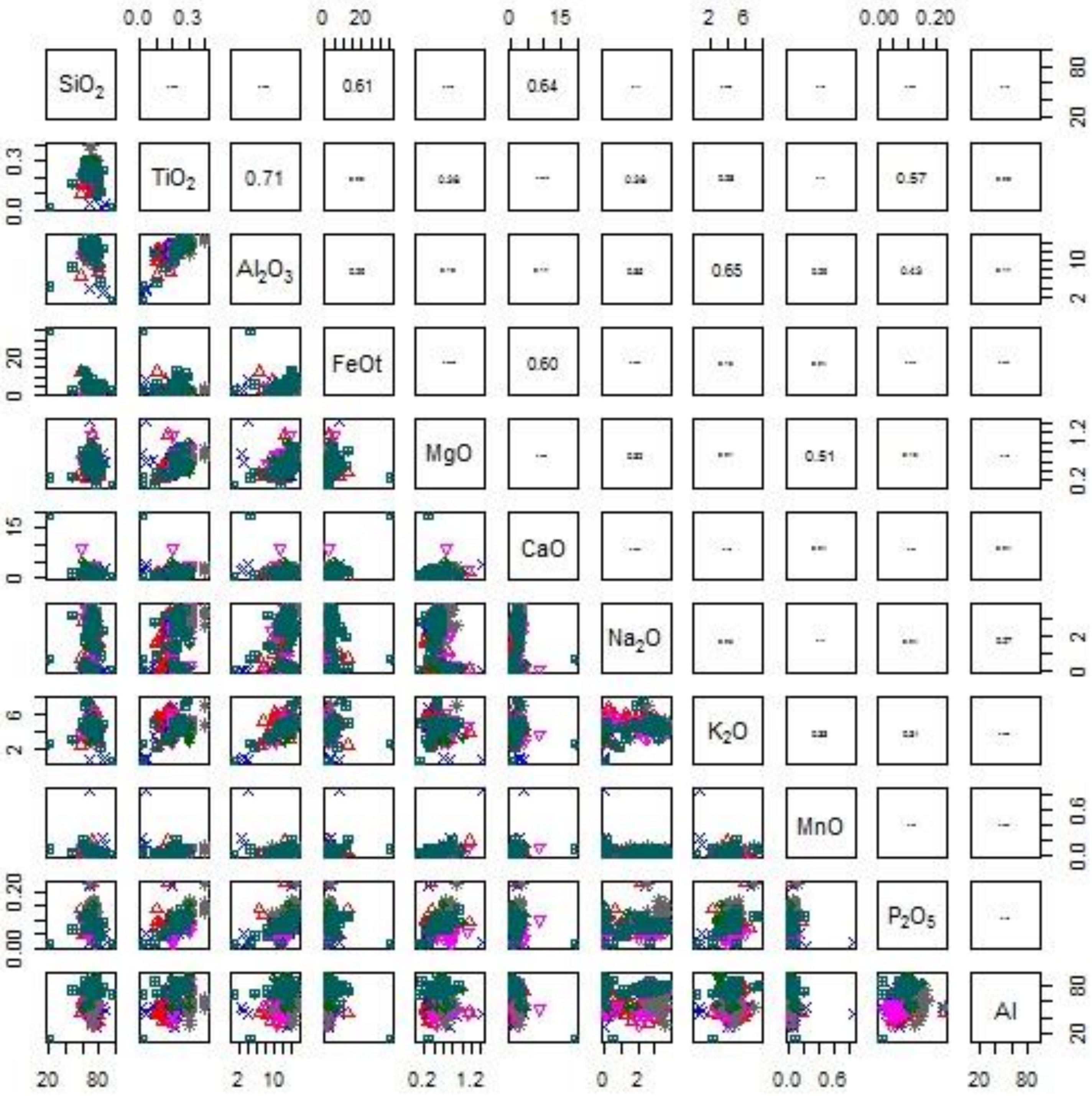

SiO2
TiO2
Al2O
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Sr
Ba
Th
S

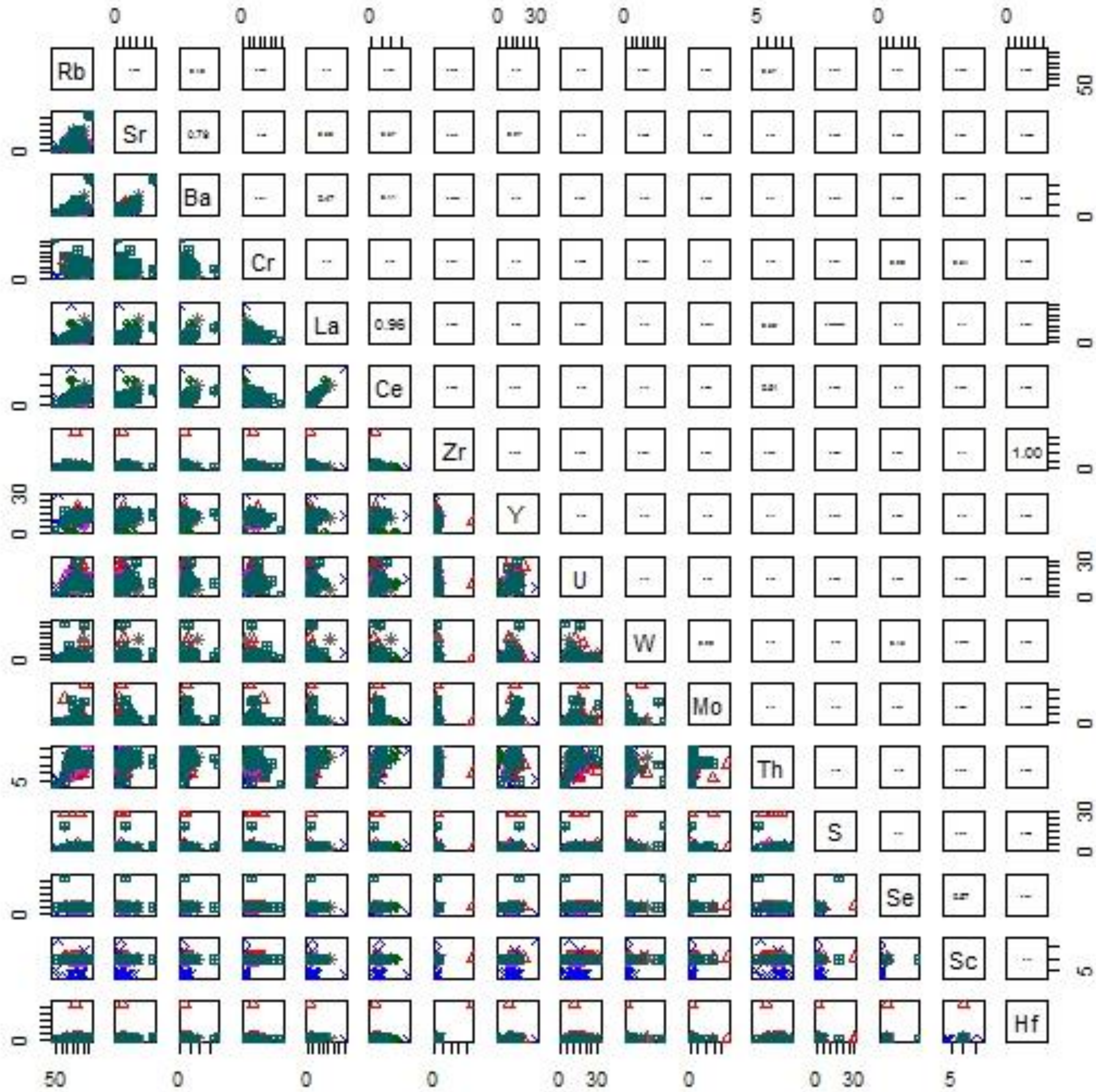
L2. Non-mineralized zone

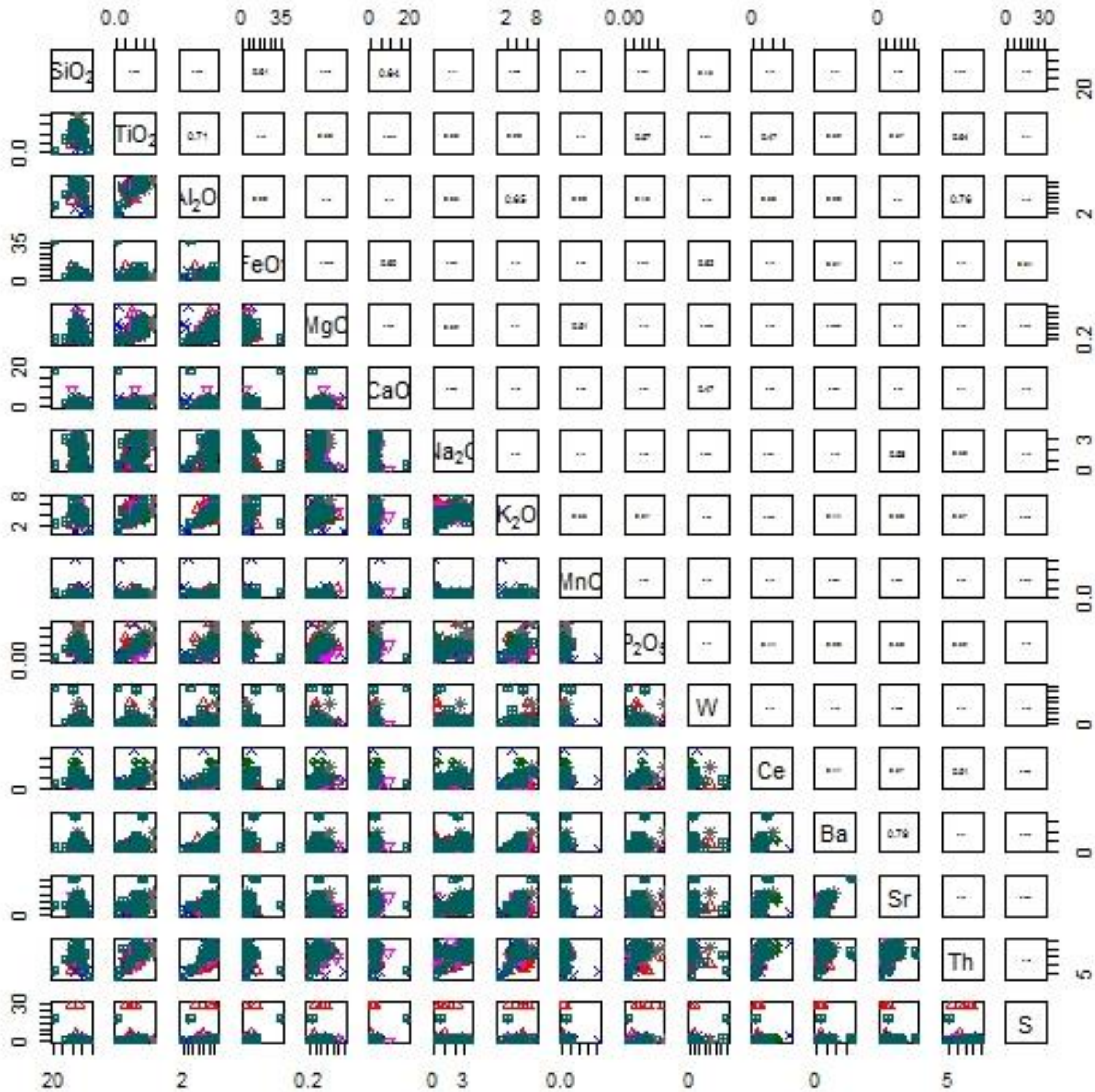
Section	Zone	Element type	Enriched	Depleted
		A+400		
42,78 to 83,2 m	Mineralized	Ore elements	∑LREE, ∑REE, W, (Mo), Cu, Zn, (S)	(Pb)
		Major	Fe, Mg, Mn, Ca, Ti	K, (Si), Na
		Minor	Ba, (P)	
		Trace	(Zr), (Hf)	(Rb), Sr, Ta, (Th), U, (Y)
		BB+400		
120.12 – 167.66 m	Mineralized	Ore elements	∑LREE, ∑REE, W, (Mo), Cu, (Zn), S	(Pb)
		Major	Ca, (Mg), Fe, Mn, (Ti)	(K), Na, (Si)
		Minor	(P)	Ba
		Trace	(Sc), Sr, Nb, (Y), (Hf), (Zr)	(Rb), (U)
		CC+400		
117.7 – 172.45 m	Mineralized	Ore elements	(Mo), S, Cu, W, ∑LREE, (Pb), (Zn), ∑REE	
		Major	(Ca), (K), Fe, Mn, (Mg), Ti	Na, (Si)
		Minor	Ba, (P)	
		Trace	(Hf), (Nb), (Rb), Sr	(Ta), (U), (Th)
		DD+200		
158,15 – 200,54 m	Mineralized	Ore elements	(Mo), S, W, ∑LREE, ∑REE, Cu, Pb, Zn	
		Major	Ca, (Fe), (Mg), Mn, (Ti)	(K), Na, (Si)
		Minor	Ba, (P)	
		Trace	Nb, Rb, U, (Th), Sr, (Y)	Hf, (Ta), (Zr)
		E-200		

302.4 – 324.56 m	Mineralized	Ore elements	Cu, W, Mo, Zn, ∑LREE, ∑REE, S	Pb
		Major	Ca, K, Na, Fe, Mn, Mg, Ti	(Si)
		Minor	Ba, P	
		Trace	(Hf), Sr, (U), (Th), (Zr)	(Rb), (Nb), Ta

2.1 NMZ Correlation matrices




Rb
Sr
Ba
Cr
La
Ce
Zr
Y
U
W
Mo
Th
S
Se
Sc
Hf
0.79
0.96
1.00


SiO2
TiO2
Al2O
FeOt
MgO
CaO
Na2O
K2O
MnO
P2O5
W
Ce
Ba
Sr
Th
S

Appendix M – Allanite SEM/LA ICP MS data

In this section of the appendix you will find the major, minor and trace element data of allanite. The scanning electron microscope (SEM) was used ro analyse major and minor elements. Samples used in the SEM are from A+400 (50, 64.5), AA+400 (112, 127, 137.5, 145.5), BB+400 (90, 156.6) and E-200 (293, 304, 311). Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) was performed on allanite grains from samples found in AA+400 (127, 137.5, 145.5), BB+400 (90, 156.6) and E-200 (86.66, 293, 304). Not all the samples used in the SEM could be used for trace element analyses in the LA-ICP-MS, because the spot size for the LA-ICP-MS is 30 microns. Some allanite grains found in the other thin-sections were smaller than 30 microns. LA ICP MS allanite data was standardised on aluminium (Al).

The methodology (chapter 1 in thesis) and appendix C can be viewed for operating conditions and further details.

1. SEM

Elements are reported in weight percent. Samples include A+400 50 and 64.5, AA+400 112, 127, 137.5 and 145.5, BB+400 90 and 156.6, and E-200 293, 304 and 311.

	F	MgO	Al_2O_3	SiO_2	CaO	ScO	V_2O_5	TiO_2	MnO	FeO	Nb_2O_5	La_2O_3	Ce_2O_3	Pr_2O_3	Nd_2O_3	Total
1	0.00	0.89	13.32	30.90	10.49	0.00	0.00	0.00	0.64	16.41	0.00	5.28	12.72	2.02	2.74	95.41
2	0.00	0.83	13.25	30.27	10.43	0.00	0.00	0.00	0.54	16.40	0.00	5.08	13.48	2.70	2.80	95.77
3	0.00	0.51	14.08	30.59	10.51	0.00	0.00	0.00	0.55	15.99	0.00	5.25	12.86	2.26	2.81	95.42
4	0.00	0.40	13.39	30.14	10.42	0.00	0.00	0.00	0.48	15.89	0.00	5.10	12.43	1.80	2.57	92.64
5	0.00	0.72	12.72	30.03	10.16	0.00	0.00	0.00	1.17	16.89	0.00	5.82	13.24	2.50	2.53	95.79
6	0.00	0.18	14.03	29.73	10.88	0.00	0.00	0.00	0.61	14.30	0.00	4.03	9.73	1.49	2.09	87.08
7	0.00	0.22	12.70	30.43	11.25	0.00	0.00	0.00	1.02	18.12	0.00	5.13	12.12	1.74	2.81	95.55
8	0.00	0.00	24.91	36.93	21.00	0.00	0.00	0.00	0.70	12.01	0.00	0.00	0.00	0.00	0.00	95.55
9	0.00	0.32	15.11	30.76	11.96	0.00	0.00	0.00	1.09	16.79	0.00	5.03	10.79	1.49	2.32	95.67
10	0.00	0.40	13.27	30.00	10.30	0.00	0.00	0.00	0.62	16.33	0.00	5.51	12.94	2.13	2.66	94.16
11	0.00	0.00	22.37	34.51	18.08	0.00	0.00	0.00	0.76	12.91	0.00	1.42	3.14	0.62	0.59	94.41
12	0.00	0.00	20.30	33.04	16.52	0.00	0.00	0.00	0.80	12.76	0.00	2.46	5.31	0.91	1.28	93.38
13	0.00	0.00	15.65	31.07	13.11	0.00	0.00	0.00	0.47	16.11	0.00	4.77	9.38	1.15	1.89	93.59
14	0.00	0.27	14.08	30.75	12.16	0.00	0.00	0.00	0.81	16.75	0.00	4.75	10.66	1.46	2.07	93.75
15	0.00	0.70	12.89	29.85	10.46	0.00	0.00	0.00	0.82	16.35	0.00	5.46	12.67	2.16	2.56	93.92
16	0.00	0.00	22.62	34.26	18.22	0.00	0.00	0.00	0.60	12.11	0.00	0.90	1.93	0.00	0.61	91.26
17	0.00	0.81	14.21	30.71	10.86	0.00	0.00	0.00	0.75	16.24	0.00	5.55	12.87	1.94	2.68	96.63
18	0.00	0.00	18.80	32.09	14.20	0.00	0.00	0.00	0.68	13.27	0.00	4.91	9.47	1.34	1.80	96.56
19	0.00	0.49	13.87	30.69	10.48	0.00	0.00	0.00	0.45	16.26	0.00	4.90	12.66	2.28	2.69	94.76
20	0.00	0.40	14.65	30.22	10.73	0.00	0.00	0.00	0.82	15.35	0.00	5.74	12.92	2.06	2.87	95.74
21	0.00	0.00	18.35	30.48	17.36	0.00	0.00	0.00	0.88	12.43	0.00	2.80	6.36	0.85	1.08	90.58
22	0.00	0.23	16.76	31.82	12.61	0.00	0.00	0.00	0.74	15.16	0.00	5.31	11.23	1.78	1.62	97.25
23	0.00	0.00	16.67	32.14	13.33	0.00	0.00	0.00	0.59	15.89	0.00	4.56	9.59	1.32	2.34	96.42

24	0.00	0.00	23.27	34.77	18.51	0.00	0.00	0.00	0.91	12.79	0.00	0.50	1.13	0.00	0.00	91.89
25	0.00	0.19	20.02	32.23	13.45	0.00	0.00	0.00	0.51	11.73	0.00	4.93	10.35	1.35	1.99	96.76
26	0.00	0.00	23.61	35.72	18.76	0.00	0.00	0.00	1.00	12.98	0.00	0.50	0.76	0.00	0.00	93.34
27	0.00	0.00	20.99	34.14	15.20	0.00	0.00	0.00	0.50	11.15	0.00	4.42	9.22	1.08	2.02	102.01
28	0.00	0.00	21.73	36.03	19.12	0.00	0.00	0.00	0.59	12.96	0.00	2.02	4.40	0.00	1.04	101.10
29	0.00	0.00	18.84	34.32	16.44	0.00	0.00	0.00	0.29	14.76	0.00	3.48	7.35	0.00	1.33	99.71
30	0.00	0.00	17.88	33.58	16.30	0.00	0.00	0.00	0.39	16.22	0.00	3.48	7.09	0.74	1.44	100.80
31	0.00	0.00	18.70	33.93	16.86	0.00	0.00	0.00	0.46	15.06	0.00	3.23	7.00	1.05	1.50	101.80
32	0.00	0.00	15.65	31.94	12.68	0.00	0.00	0.00	0.42	15.95	0.00	5.28	12.04	1.88	2.40	101.37
33	0.00	0.00	26.40	37.74	21.20	0.00	0.68	0.00	0.87	9.04	0.00	0.00	1.13	0.00	0.32	97.38
34	0.00	0.00	19.93	34.06	14.35	0.00	0.00	0.00	0.37	13.17	0.00	4.12	9.02	1.12	2.85	98.99
35	0.00	0.00	19.36	33.18	13.05	0.00	0.58	0.00	0.40	11.73	0.00	3.70	8.63	1.69	2.49	94.80
36	0.00	0.00	19.61	33.47	14.48	0.00	0.00	0.00	0.35	13.97	0.00	3.48	9.01	1.35	2.85	98.56
37	0.00	0.00	25.31	36.64	19.47	0.00	0.00	0.00	0.69	9.75	0.00	1.01	2.22	0.00	1.33	96.42
38	0.00	9.35	21.13	28.58	1.18	0.00	0.00	0.00	1.65	33.13	0.00	0.00	0.73	0.00	0.00	95.75
39	0.00	0.22	18.90	33.39	13.49	0.00	0.00	0.00	0.49	13.85	0.00	4.45	10.49	1.54	3.62	100.44
40	0.00	0.00	19.96	34.83	16.14	0.00	0.00	0.00	0.46	14.97	0.00	3.28	7.17	0.97	2.38	100.17
41	0.00	0.00	20.75	36.18	18.93	0.00	0.00	0.00	0.32	16.53	0.00	1.51	3.59	0.80	1.82	100.43
42	0.00	0.00	23.64	35.21	16.97	0.00	0.00	0.00	0.67	11.66	0.00	2.27	5.56	1.02	1.60	98.61
43	0.00	0.76	16.16	30.84	11.24	0.00	0.00	0.00	0.31	14.02	0.00	5.34	11.61	2.16	2.93	95.36
44	0.00	0.70	16.12	31.01	11.66	0.00	0.00	0.00	0.37	14.93	0.00	4.92	11.10	2.46	2.65	96.30
45	0.00	0.50	17.36	31.64	13.72	0.00	0.00	0.00	0.62	14.52	0.00	5.03	8.78	1.29	1.84	95.32
46	0.00	0.85	12.08	29.94	10.22	0.00	0.00	0.00	0.46	17.32	0.00	3.97	12.70	2.80	3.57	93.91
47	0.00	0.00	20.34	32.67	14.22	0.00	0.00	0.00	0.72	12.47	0.00	3.60	8.13	1.52	2.13	95.80
48	0.00	0.61	12.96	30.02	10.35	0.00	0.00	0.00	0.50	16.70	0.00	3.76	12.92	3.16	3.66	94.63
49	0.00	0.00	22.39	33.85	16.27	0.00	0.00	0.00	0.62	11.71	0.00	2.78	6.29	1.02	1.53	96.47
50	0.00	0.92	11.16	29.54	9.40	0.00	0.00	0.00	0.44	17.69	0.00	3.50	14.09	3.13	3.90	93.78
51	0.00	0.83	9.90	29.32	9.43	0.00	0.00	0.00	0.57	19.21	0.00	3.53	13.71	3.10	4.02	93.62
52	0.00	0.00	22.91	34.51	16.86	0.00	0.00	0.00	0.74	11.31	0.00	1.96	5.54	1.46	1.38	96.66

53	0.00	0.90	12.04	29.24	9.22	0.00	0.00	0.00	0.52	16.38	0.00	4.73	14.52	3.34	3.60	94.49
54	0.00	0.85	11.17	30.01	9.29	0.00	0.00	0.00	0.64	17.83	0.00	3.91	13.74	3.27	3.89	94.99
55	0.00	0.66	13.59	30.73	10.72	0.00	0.00	0.00	0.30	16.35	0.00	3.36	12.31	3.19	3.52	94.72
56	0.00	0.00	24.45	34.78	19.68	0.00	0.00	0.00	0.38	11.20	0.00	0.00	0.36	0.00	0.00	90.85
57	0.00	0.00	25.40	36.41	20.55	0.00	0.00	0.00	0.60	11.05	0.00	0.00	0.00	0.00	0.00	94.01
58	0.00	0.67	13.59	30.14	10.43	0.00	0.00	0.00	0.40	16.11	0.00	3.31	12.54	2.32	3.34	92.86
59	0.00	1.23	8.70	29.22	9.05	0.00	0.00	0.00	0.53	19.90	0.00	3.61	13.71	3.55	3.60	93.50
60	0.00	0.93	12.11	29.65	9.88	0.00	0.00	0.00	0.74	17.00	0.00	3.73	13.27	3.33	3.46	94.12
61	0.00	0.26	15.95	32.10	13.28	0.00	0.00	0.00	0.52	16.54	0.00	4.63	9.36	2.07	2.32	97.04
62	0.00	0.00	22.52	34.46	16.91	0.00	0.00	0.00	0.60	11.67	0.00	1.93	5.18	1.46	1.56	96.27
63	0.00	0.44	15.79	31.18	12.91	0.00	0.00	0.00	0.50	16.02	0.00	4.19	10.50	1.70	2.36	95.98
64	0.00	0.00	22.17	33.40	16.81	0.00	0.00	0.00	0.60	11.36	0.00	2.11	5.48	0.89	1.55	94.36
65	0.00	0.53	13.67	30.00	10.38	0.00	0.00	0.00	0.33	15.69	0.00	4.03	13.20	2.46	3.32	94.19
66	0.00	0.48	15.10	30.75	11.29	0.00	0.00	0.00	0.41	14.46	0.00	5.59	11.55	2.46	3.03	95.13
67	0.00	1.00	10.85	29.81	9.38	0.00	0.00	0.00	0.65	18.07	0.00	4.13	13.89	2.87	3.69	94.93
68	0.00	0.00	18.66	32.79	15.86	0.00	0.00	0.24	0.90	12.96	0.00	4.06	6.87	0.00	1.97	94.31
69	0.00	0.00	14.62	31.19	13.55	0.00	0.00	0.32	1.81	16.35	0.00	5.38	9.96	0.00	2.08	95.26
70	0.00	0.00	14.14	31.12	13.78	0.00	0.00	0.44	1.62	17.62	0.00	5.34	9.21	0.00	2.11	95.38
71	0.00	0.00	15.41	31.78	14.89	0.00	0.00	0.22	1.15	16.14	0.00	4.60	8.52	0.00	1.56	94.28
72	0.00	0.00	14.73	30.94	13.66	0.00	0.00	0.57	1.06	16.35	0.00	5.59	9.78	0.00	2.07	94.76
73	0.00	0.00	12.95	30.85	13.27	0.00	0.00	0.58	1.34	18.27	0.00	5.14	9.69	0.00	2.24	94.33
74	0.00	0.00	23.91	35.38	20.50	0.00	0.00	0.00	0.71	9.88	0.00	1.29	2.15	0.00	0.64	94.45
75	1.99	0.00	1.79	29.29	27.05	0.00	0.00	32.41	0.55	1.53	1.65	0.53	0.66	0.00	0.00	97.45
76	0.00	0.00	1.89	28.84	27.24	0.00	0.00	33.26	0.00	1.60	0.60	0.00	0.00	0.00	0.51	93.93
77	1.54	0.00	2.03	28.98	26.86	0.00	0.00	32.39	0.36	1.56	1.13	0.00	0.71	0.00	0.00	95.55
78	2.38	0.00	2.94	29.13	27.57	0.00	0.00	31.05	0.36	1.92	0.60	0.00	0.00	0.00	0.00	95.95
79	0.00	0.00	17.32	32.62	15.31	0.00	0.00	0.26	1.87	13.65	0.00	3.71	6.82	0.00	1.45	93.01
80	0.00	0.00	16.65	32.35	14.97	0.00	0.00	0.46	1.55	14.87	0.00	4.57	8.05	0.00	1.72	95.19
81	0.00	0.00	14.24	30.95	13.11	0.00	0.00	0.44	0.82	16.56	0.00	5.32	9.93	0.00	2.26	93.65

82	0.00	0.00	15.00	30.99	13.76	0.00	0.00	0.51	0.93	15.88	0.00	5.01	9.07	0.00	2.09	93.24
83	0.00	0.00	16.11	32.00	15.42	0.00	0.00	0.34	1.06	14.97	0.00	3.87	7.08	0.00	1.62	92.46
84	0.00	0.00	16.13	32.05	15.83	0.00	0.00	0.42	1.38	15.79	0.00	4.01	6.61	0.00	1.53	93.75
85	0.00	0.00	15.61	31.15	14.09	0.00	0.00	0.44	1.22	15.07	0.00	4.95	8.65	0.00	2.16	93.33
86	0.00	0.00	16.64	32.70	16.72	0.00	0.00	0.25	0.81	15.88	0.00	3.32	6.09	0.00	1.14	93.54
87	0.00	0.00	14.72	31.20	14.42	0.00	0.00	0.33	1.16	16.94	0.00	4.41	8.58	0.00	1.75	93.51
88	0.00	0.00	16.71	32.06	13.53	0.00	0.00	0.47	0.81	14.58	0.00	6.24	10.99	0.00	2.27	97.66
89	0.00	0.00	18.34	32.12	13.57	0.00	0.00	0.47	0.87	11.72	0.00	6.18	10.47	0.00	2.62	96.36
90	0.00	0.00	18.11	34.20	18.59	0.00	0.00	0.00	0.65	16.26	0.00	3.06	5.15	0.00	1.29	97.31
91	0.00	0.00	17.50	33.42	16.63	0.00	0.00	0.22	1.27	15.60	0.00	3.61	6.60	0.00	1.71	96.56
92	0.00	0.00	17.19	32.29	16.57	0.00	0.00	0.25	1.55	15.37	0.00	3.84	6.97	0.00	1.50	95.54
93	0.00	0.00	17.82	34.51	16.14	0.00	0.00	0.44	1.94	14.80	0.00	4.79	7.82	0.00	1.64	99.92
94	0.00	0.00	16.96	33.03	16.10	0.00	0.00	0.22	0.81	16.29	0.00	4.10	7.15	0.00	1.43	96.08
95	0.00	0.00	15.89	31.54	14.45	0.00	0.00	0.45	2.20	14.86	0.00	4.61	8.35	0.00	1.90	94.26
96	0.00	0.00	16.05	31.69	15.05	0.00	0.00	0.44	1.51	15.59	0.00	4.82	8.05	0.00	1.44	94.65
97	0.00	0.00	15.72	32.00	15.02	0.00	0.00	0.36	1.84	15.44	0.00	5.04	8.27	0.00	1.50	95.19
98	0.00	0.00	15.28	32.96	12.23	0.00	0.00	0.64	2.06	12.07	0.00	4.03	7.14	0.00	1.40	87.81
99	0.00	0.00	14.59	32.43	11.76	0.00	0.00	0.51	2.22	12.11	0.00	3.57	6.92	0.00	1.75	85.87
100	0.00	0.00	15.01	30.17	12.15	0.00	0.00	0.53	1.88	13.17	0.00	5.60	9.24	0.00	1.30	89.04
101	0.00	0.00	18.13	31.81	14.88	0.00	0.00	0.00	0.93	12.24	0.00	4.64	7.86	0.00	1.74	92.24
102	0.00	0.00	13.71	30.85	13.60	0.00	0.00	0.41	1.70	17.12	0.00	5.73	9.75	0.00	2.05	94.91
103	0.00	0.00	14.45	30.75	13.30	0.00	0.00	0.53	1.43	16.49	0.00	5.43	9.70	0.00	2.10	94.18
104	0.00	0.00	13.37	29.89	11.83	0.00	0.00	0.52	1.29	16.34	0.00	6.76	11.80	0.00	2.00	93.80
105	0.00	0.00	13.30	30.12	12.07	0.00	0.00	0.69	1.40	16.74	0.00	6.64	11.62	0.00	2.34	94.92
106	0.00	0.00	13.65	30.44	11.79	0.00	0.00	0.67	1.12	16.92	0.00	6.87	11.27	0.00	2.15	94.87
107	0.00	0.00	18.05	32.42	14.32	0.00	0.00	0.44	0.98	12.16	0.00	4.39	7.94	0.00	2.44	93.15
108	0.00	0.00	18.36	32.18	14.96	0.00	0.00	0.32	2.02	11.43	0.00	4.41	8.01	0.00	2.50	94.20
109	0.00	0.00	18.55	32.52	15.29	0.00	0.00	0.34	1.20	12.62	0.00	4.97	8.27	0.00	2.24	96.01
110	0.00	0.00	16.63	32.71	15.13	0.00	0.00	0.31	1.78	15.35	0.00	4.73	8.22	0.00	1.51	96.36

111	0.00	0.00	15.83	32.03	14.80	0.00	0.00	0.34	1.64	16.15	0.00	5.15	8.72	0.00	2.11	96.76
112	0.00	0.00	15.00	29.11	10.62	0.00	0.00	0.53	0.66	12.50	0.00	1.17	11.13	0.00	1.55	82.28
113	0.00	0.18	14.57	30.07	11.58	0.00	0.00	0.55	0.93	13.87	0.00	1.17	9.83	0.00	2.03	84.77
114	0.00	0.19	14.55	30.03	11.22	0.00	0.00	0.64	1.08	13.92	0.00	1.17	10.81	0.00	2.41	86.02
115	0.00	0.00	16.70	31.61	15.07	0.00	0.00	0.00	0.94	13.69	0.00	1.17	6.37	0.00	1.46	87.01
116	0.00	0.17	17.35	31.68	14.68	0.00	0.00	0.22	1.49	12.49	0.00	1.17	6.91	0.00	1.44	87.60
117	0.00	0.00	15.86	31.49	14.00	0.00	0.00	0.42	1.58	14.04	0.00	1.17	7.33	0.00	1.72	87.62
118	0.00	0.00	16.72	31.97	15.15	0.00	0.00	0.33	1.38	14.29	0.00	1.17	6.23	0.00	1.63	88.85
119	0.00	0.15	15.85	30.78	14.11	0.00	0.00	0.43	0.80	14.00	0.00	1.17	7.94	0.00	1.65	86.87
120	0.00	0.18	15.84	31.34	14.19	0.00	0.00	0.37	0.85	14.62	0.00	1.17	7.20	0.00	1.55	87.30
121	0.00	0.24	17.66	37.15	12.15	0.00	0.00	0.30	0.76	10.95	0.00	1.17	6.49	0.00	1.19	88.06
122	0.00	0.21	17.01	30.88	13.80	0.00	0.00	0.36	1.34	12.13	0.00	1.17	7.69	0.00	1.66	86.26
123	0.00	0.19	15.86	34.39	11.15	0.00	0.00	0.48	0.89	11.12	0.00	1.17	5.98	0.00	1.08	82.32
124	0.00	0.22	15.68	29.82	11.75	0.00	0.00	0.42	1.29	11.34	0.00	4.74	8.93	0.00	1.83	86.02
125	0.00	0.00	15.93	29.72	11.83	0.00	0.00	0.35	0.66	12.28	0.00	5.47	9.54	0.00	1.84	87.62
126	0.00	0.19	15.64	30.03	13.01	0.00	0.00	0.43	1.21	13.11	0.00	4.91	8.76	0.00	1.41	88.70
127	0.00	0.22	15.58	31.19	13.89	0.00	0.00	0.33	1.56	13.77	0.00	3.96	7.05	0.00	1.26	88.82
128	0.00	0.23	15.61	31.02	13.91	0.00	0.00	0.29	1.44	13.41	0.00	4.01	7.07	0.00	1.35	88.35
129	0.00	0.00	13.86	30.22	12.93	0.00	0.00	0.37	1.31	14.45	0.00	5.00	8.32	0.00	1.42	87.88
130	0.00	0.00	21.81	34.03	17.66	0.00	0.00	0.00	1.69	9.42	0.00	1.72	2.96	0.00	0.69	89.99
131	0.00	0.20	15.37	30.07	13.34	0.00	0.00	0.35	1.55	13.46	0.00	4.50	7.80	0.00	1.70	88.34
132	0.00	0.20	18.63	31.52	13.60	0.00	0.00	0.34	1.07	10.47	0.00	5.14	8.17	0.00	1.43	90.57
133	0.00	0.30	15.14	34.45	12.46	0.00	0.00	0.39	1.22	13.05	0.00	4.66	7.74	0.00	1.58	90.99
134	0.00	0.18	15.40	31.34	12.98	0.00	0.00	0.49	1.17	15.88	0.00	6.45	10.77	0.00	2.29	96.96
135	0.00	0.00	15.14	31.06	12.78	0.00	0.00	0.51	1.01	16.06	0.00	6.37	11.19	0.00	2.41	96.54
136	0.00	0.22	14.92	31.29	13.48	0.00	0.00	0.56	1.34	16.47	0.00	6.08	10.61	0.00	1.73	96.70
137	0.00	0.00	4.67	29.81	29.24	0.00	0.00	30.86	0.00	0.97	0.00	0.00	0.00	0.00	0.00	95.55
138	0.00	0.00	3.17	29.64	28.87	0.00	0.00	31.75	0.00	1.84	0.00	0.00	0.00	0.00	0.44	95.71
139	0.00	0.00	3.34	29.59	28.99	0.00	0.00	30.97	0.00	2.46	0.00	0.00	0.00	0.00	0.00	95.36

140	0.00	0.00	14.18	30.32	11.48	0.00	0.00	0.59	0.64	16.62	0.00	8.02	12.65	0.00	1.63	96.12
141	0.00	0.00	14.52	30.40	11.82	0.00	0.00	0.73	1.55	16.28	0.00	6.44	11.75	0.00	2.44	95.94
142	0.00	0.32	16.00	31.23	13.41	0.00	0.00	0.46	1.63	14.63	0.00	5.93	10.51	0.00	2.10	96.22
143	0.00	0.00	0.46	18.74	2.51	0.00	0.00	17.66	3.37	9.49	0.00	13.04	23.93	0.00	4.39	93.60
144	0.00	0.16	15.66	31.92	14.97	0.00	0.00	0.00	0.88	16.29	0.00	4.68	8.76	0.00	1.39	94.71
145	0.00	0.33	15.91	31.60	13.28	0.00	0.00	0.60	1.44	14.96	0.00	5.65	10.36	0.00	1.90	96.03
146	0.00	0.19	14.29	30.11	12.22	0.00	0.00	0.71	0.98	15.91	0.00	6.63	11.63	0.00	2.48	95.16
147	0.00	0.00	15.74	31.84	14.00	0.00	0.00	0.58	1.22	15.42	0.00	5.54	9.56	0.00	2.14	96.05
148	0.00	0.37	18.76	31.73	14.17	0.00	0.00	0.00	2.09	10.23	0.00	5.20	9.39	0.00	2.04	93.99
149	0.00	0.00	16.11	31.37	13.91	0.00	0.00	0.42	1.47	14.54	0.00	5.19	9.64	0.00	2.20	94.87
150	0.00	0.00	15.33	30.97	12.89	0.00	0.00	0.69	1.16	14.83	0.00	6.46	11.05	0.00	2.10	95.47
151	0.00	0.21	16.85	30.92	13.24	0.00	0.00	0.51	1.44	13.45	0.00	6.06	10.62	0.00	2.46	95.78
152	0.00	0.00	0.33	18.30	1.76	0.00	0.00	16.68	4.01	9.78	0.00	14.40	25.71	0.00	5.09	96.07
153	0.00	0.30	14.11	30.02	11.87	0.00	0.00	0.99	1.05	14.89	0.00	6.17	11.27	0.00	2.70	93.37
154	0.00	0.17	15.76	31.42	14.92	0.00	0.00	0.44	1.67	15.62	0.00	4.32	7.93	0.00	1.66	93.92
155	0.00	0.21	17.19	31.81	13.89	0.00	0.00	0.33	1.21	12.44	0.00	5.34	9.60	0.00	2.35	94.37
156	0.00	0.17	16.15	31.09	14.41	0.00	0.00	0.45	1.92	14.59	0.00	4.91	8.54	0.00	1.72	93.94
157	0.00	0.71	15.02	31.47	13.67	0.00	0.00	0.00	0.85	15.54	0.00	5.73	10.59	0.00	0.00	93.58
158	0.00	0.34	14.59	31.51	13.57	0.00	0.00	0.00	0.50	16.70	0.00	5.53	9.73	0.00	0.00	92.47
159	0.00	0.84	14.76	31.17	12.95	0.25	0.00	0.00	0.80	15.02	0.00	5.56	10.58	0.00	0.00	91.92
160	0.00	0.22	18.26	33.93	17.68	0.00	0.00	0.00	0.00	14.85	0.00	3.06	5.59	0.00	0.00	93.58
161	0.00	0.71	14.67	33.62	9.88	0.00	0.00	0.00	1.29	8.75	0.00	3.46	8.08	0.00	0.00	80.45
162	0.00	0.50	14.60	33.55	10.24	0.00	0.00	0.00	0.86	10.55	0.00	3.64	8.21	0.00	0.00	82.15
163	0.00	0.00	25.94	36.83	21.85	0.24	0.00	0.00	1.00	7.83	0.00	1.42	2.30	0.00	0.00	97.40
164	0.00	0.18	27.25	37.58	22.74	0.25	0.00	0.00	1.19	7.06	0.00	0.63	1.23	0.00	0.00	98.10
165	0.00	0.00	25.14	36.21	22.74	0.54	0.00	0.00	1.42	7.11	0.00	0.44	0.66	0.00	0.00	94.27

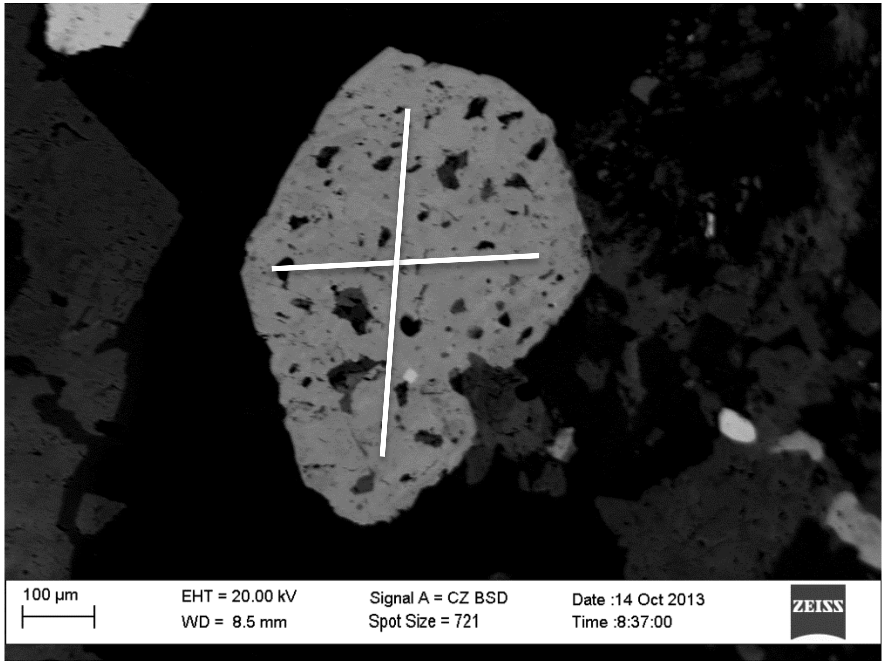
2. LA-ICP-MS

All ICP MS data are reported in parts per million (ppm).

2.1 AA+400

									AA+400 137.5								
Sample	**A_005**	**A_006**	**A_007**	**A_008**	**A_009**	**A_010**	**A_011**	**A_012**	**A_013**	**A_014**	**A_017**	**A_018**	**A_019**	**A_020**	**A_021**	**A_022**	**A_023**
Al	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56
P	41.09	41.07	47.58	41.02	44.09	42.28	43.97	38.51	42.60	41.88	40.76	46.79	45.34	43.85	43.56	59.51	41.65
Ca	96353.66	94286.97	96430.76	95067.30	89283.32	90789.04	87831.94	93874.08	102472.30	88807.76	131759.80	83743.56	84477.41	82893.55	83220.99	96466.91	111557.80
Sc	7.76	7.09	10.27	7.01	7.93	6.76	7.96	8.85	6.66	6.84	7.34	9.13	10.74	12.52	13.98	98.42	11.58
Ti	3346.78	3792.25	3568.88	3933.55	3649.06	3406.46	4250.01	2815.30	4014.60	4298.02	2880.24	3735.51	2541.95	1817.95	1506.88	1638.11	20584.64
V	1929.14	1828.73	1530.02	1483.84	1573.89	1723.94	1382.46	1866.04	2108.51	1617.48	1692.17	2364.66	2328.75	2584.60	2375.14	1392.14	1652.11
Cr	28.56	12.43	16.73	21.42	14.12	26.17	15.38	28.20	21.13	21.28	27.06	45.72	48.65	42.53	35.63	32.94	17.13
Mn	4561.54	6071.67	4725.17	5086.53	4195.51	3488.14	4123.18	4553.21	5442.54	3276.26	5904.42	4647.51	3966.18	4807.54	5084.78	4987.16	5956.24
Fe	76776.10	78768.52	80254.00	78063.87	76478.50	74937.77	76805.37	71284.39	82574.34	75918.63	81187.99	68948.25	62235.07	52702.00	54000.21	686234.90	77193.45
Zn	614.47	668.57	896.87	555.32	478.58	550.04	771.09	735.56	667.43	412.50	524.02	324.08	366.27	321.98	318.01	468.62	574.67
Ga	268.19	280.68	291.96	263.68	268.61	274.97	276.91	272.54	281.06	290.13	251.06	326.28	290.85	303.68	301.55	257.60	277.09
Ge	239.36	217.21	214.72	224.72	226.55	236.36	209.72	228.96	243.53	244.63	196.78	240.84	231.15	223.87	214.06	190.16	329.42
Sr	3998.96	3721.17	4324.30	3505.32	3182.29	3765.91	5321.37	4222.96	4021.74	3425.74	5073.05	2208.88	2399.05	1636.93	1801.70	5619.58	3708.54
Zr	13.59	11.73	38.08	10.39	11.07	11.92	15.17	16.92	15.27	9.85	16.79	7.60	7.71	5.40	6.15	25.26	245.14
Ba	362.91	386.67	384.77	372.39	376.64	372.38	400.11	359.40	388.02	399.73	328.02	1134.60	313.60	289.56	277.95	408.47	497.14
La	47342.81	53449.86	52761.83	52046.73	53235.17	50378.70	58875.92	48114.52	52715.01	57183.45	46293.43	44871.27	40698.64	37267.39	36353.09	32822.62	57242.84
Ce	69074.23	71329.91	70634.19	70466.38	71594.74	71378.02	76468.84	67189.70	75414.96	76953.12	60450.16	67133.39	60246.91	55838.80	54400.72	49265.03	86846.50

Pr	5538.58	5207.49	5208.11	5222.41	5434.21	5670.21	5300.70	5239.47	5856.04	5776.60	4562.08	5547.27	4996.92	4608.71	4449.41	4136.12	7292.80
Nd	16062.80	13812.38	13984.50	14229.29	14906.88	16297.46	13266.72	14966.73	16107.00	15896.70	13200.85	16721.87	14746.83	13940.06	13568.51	12734.65	21510.94
Sm	1105.90	799.06	799.79	860.64	1003.99	1143.62	658.06	985.34	1009.08	1098.22	859.89	1218.94	1085.42	1020.38	957.34	849.08	1656.19
Eu	273.68	188.53	194.27	218.74	258.46	269.91	145.58	248.29	248.22	275.00	202.20	242.58	235.95	220.52	220.06	215.13	361.21
Gd	595.72	477.04	479.23	506.89	581.65	608.59	411.95	542.69	555.51	611.17	458.70	625.97	549.89	514.03	481.02	432.26	800.50
Tb	33.96	26.04	24.61	27.37	34.43	35.80	18.50	32.36	34.00	36.84	26.23	38.83	34.28	31.87	30.01	25.81	47.90
Dy	101.50	77.04	74.33	85.68	121.17	118.15	46.72	99.78	110.63	116.36	85.33	122.86	113.12	103.12	93.97	89.59	166.88
Ho	13.98	10.39	10.34	11.44	18.19	15.96	6.45	13.86	15.58	16.20	11.50	16.35	15.08	15.09	13.49	12.01	26.98
Er	22.55	20.48	21.16	20.36	36.55	28.34	14.08	29.16	30.31	30.29	24.81	32.60	26.76	27.88	27.54	22.97	57.05
Tm	2.45	2.06	2.00	2.31	4.28	2.87	1.47	2.47	2.89	3.24	2.68	3.48	2.81	2.86	2.95	2.98	6.68
Yb	12.94	10.40	12.58	11.89	21.27	12.84	9.95	11.56	13.97	14.10	12.62	20.01	14.46	18.28	20.30	19.74	46.43
Lu	1.48	1.02	1.82	1.34	1.87	1.16	1.13	1.56	1.14	1.35	1.42	2.32	1.84	2.81	2.96	3.16	5.77
Pb	31.07	25.41	26.44	26.03	29.28	31.38	26.31	32.10	32.77	22.86	27.44	182.92	30.23	26.10	26.58	113.72	48.22
Th	369.59	242.99	281.77	279.66	328.74	395.40	234.92	353.02	377.40	303.01	281.87	406.33	364.06	350.29	320.01	318.61	766.48
U	101.39	135.82	137.68	100.99	194.77	171.92	107.64	178.81	270.73	194.17	637.30	222.65	235.27	264.76	244.59	214.94	1011.28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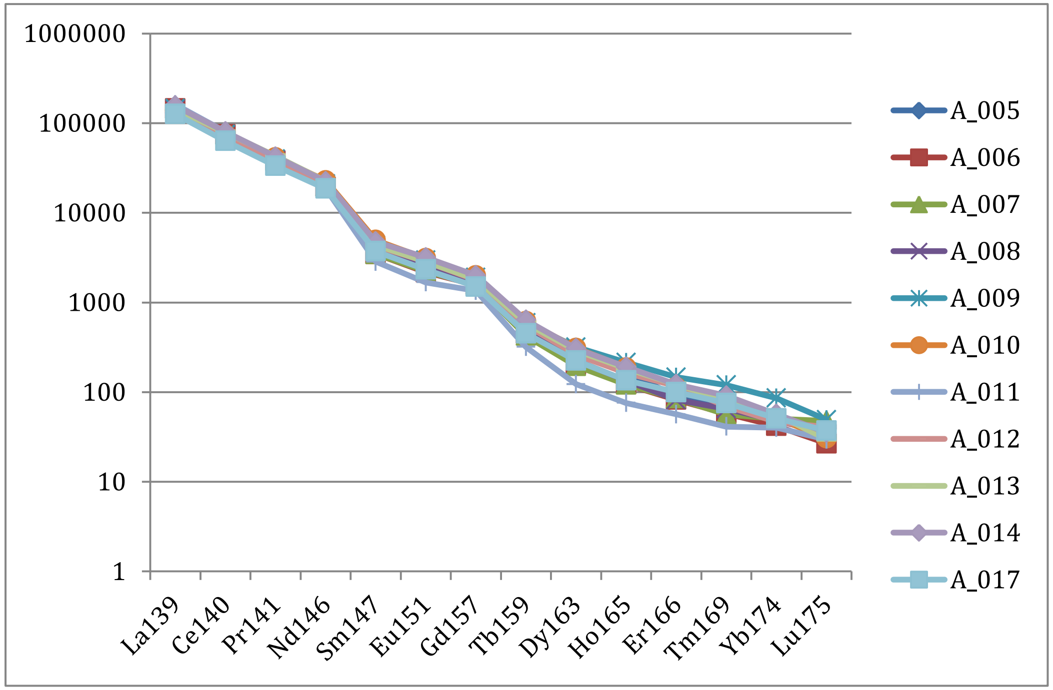
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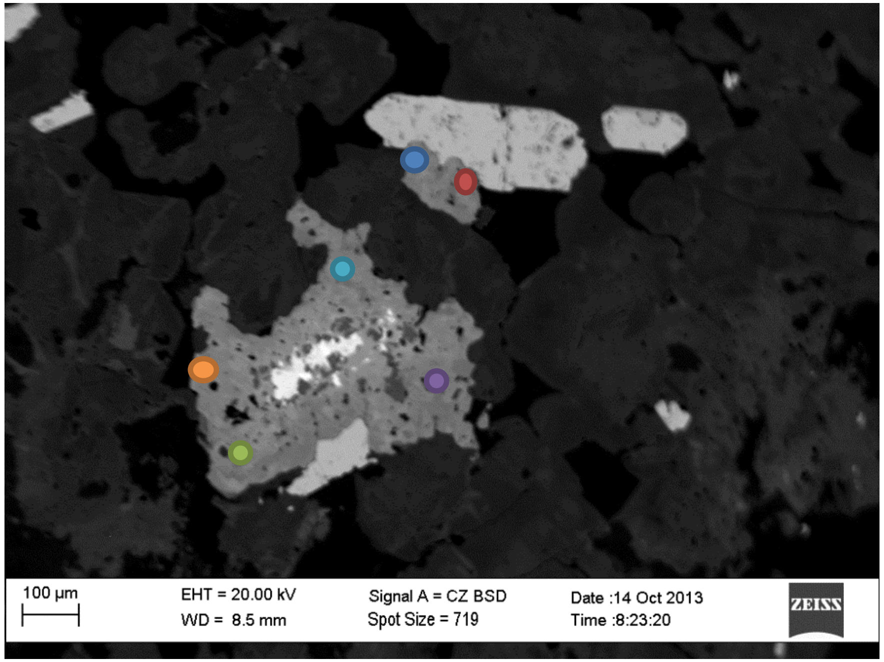
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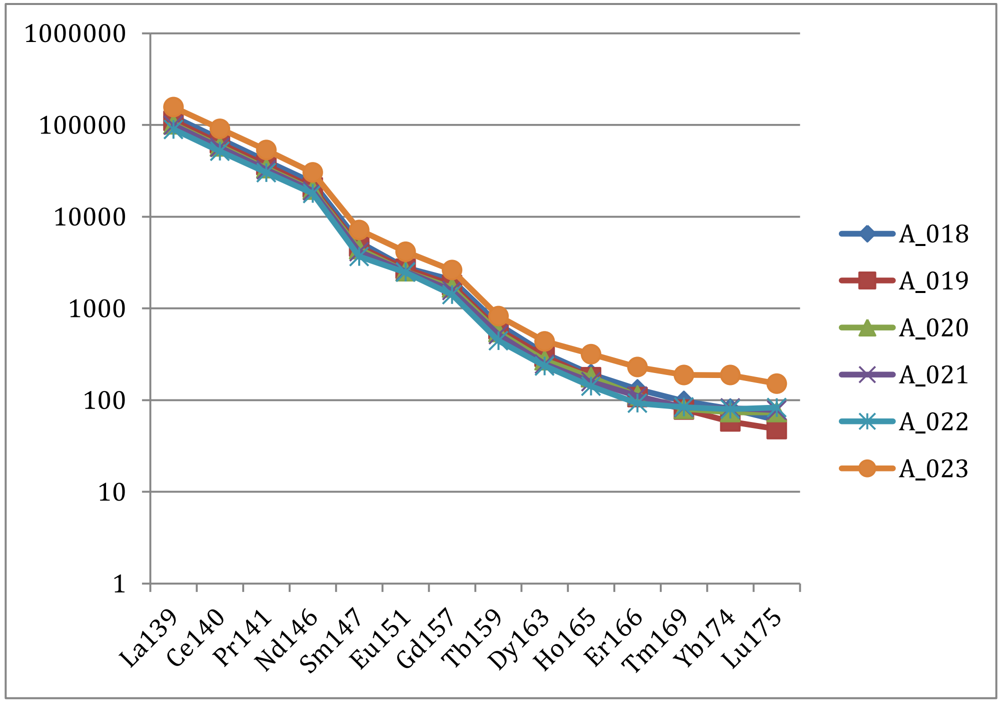
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Lu175
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A_019
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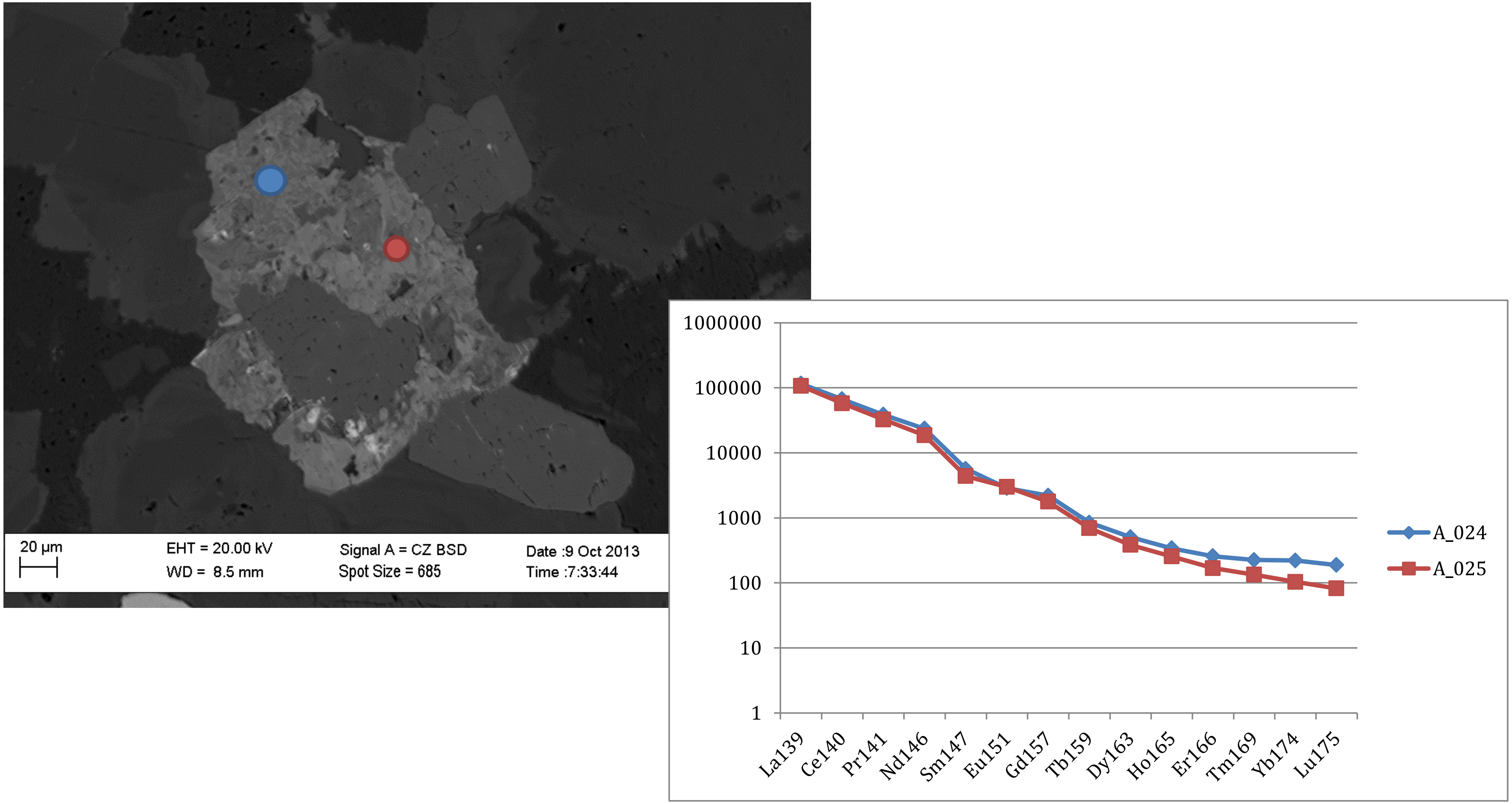
A_021
A_022
A_023

AA+400 127						
Sample	**A_024**	**A_025**	**A_026**	**A_027**	**A_030**	**A_031**
Al	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56
P	183.92	252.33	2730.08	44.67	40020.74	42.44
Ca	75850.45	87829.85	200837.30	93579.59	196052.98	84423.47
Sc	166.21	145.00	125.29	115.72	120.68	31.39
Ti	1500.60	2303.67	3499.99	3300.65	2948.17	2295.93
V	2432.17	2112.42	2747.07	3224.63	2985.36	4245.57
Cr	307.21	193.64	175.97	158.68	144.24	130.11
Mn	6220.23	8126.20	10846.93	5695.85	5879.75	4511.21
Fe	46168.57	65764.55	89115.16	83845.20	67505.22	65699.48
Zn	204.23	316.35	436.07	386.57	354.35	287.99
Ga	605.35	405.85	456.54	299.78	420.45	309.80
Ge	202.67	209.48	273.39	264.75	275.79	220.41
Sr	3278.15	3343.71	4974.13	3244.64	5428.34	2332.09
Zr	21.99	33.21	13.60	9.35	20.06	15.86
Ba	5107.35	1728.41	2298.12	545.59	2224.92	512.84
La	22400.32	33145.89	54100.98	53291.25	42339.88	39273.46
Ce	36147.53	49425.42	74741.95	75475.16	63867.39	55437.91
Pr	3416.18	4157.60	5891.42	5955.52	5290.69	4469.69
Nd	11990.94	12811.88	16620.88	17126.39	16698.81	13214.43
Sm	1282.12	992.15	1080.87	1146.94	1309.54	1014.88
Eu	267.45	254.82	212.94	236.02	249.14	260.28
Gd	487.23	445.10	536.41	575.40	673.14	543.15
Tb	31.50	28.59	32.48	33.43	48.95	40.23
Dy	112.56	111.06	96.04	112.26	192.02	146.33
Ho	15.91	16.45	14.15	15.61	28.89	21.69
Er	35.60	39.74	31.22	29.57	64.12	41.96

Tm	6.05	6.50	4.11	3.87	8.00	4.77
Yb	45.42	57.46	29.60	19.59	54.78	25.71
Lu	6.46	7.82	8.54	3.09	7.16	3.14
Pb	248.75	329.24	316.49	253.35	598.18	188.87
Th	2644.31	3882.99	4406.96	3840.76	8317.71	2818.70
U	437.73	503.23	151.81	220.09	285.50	422.55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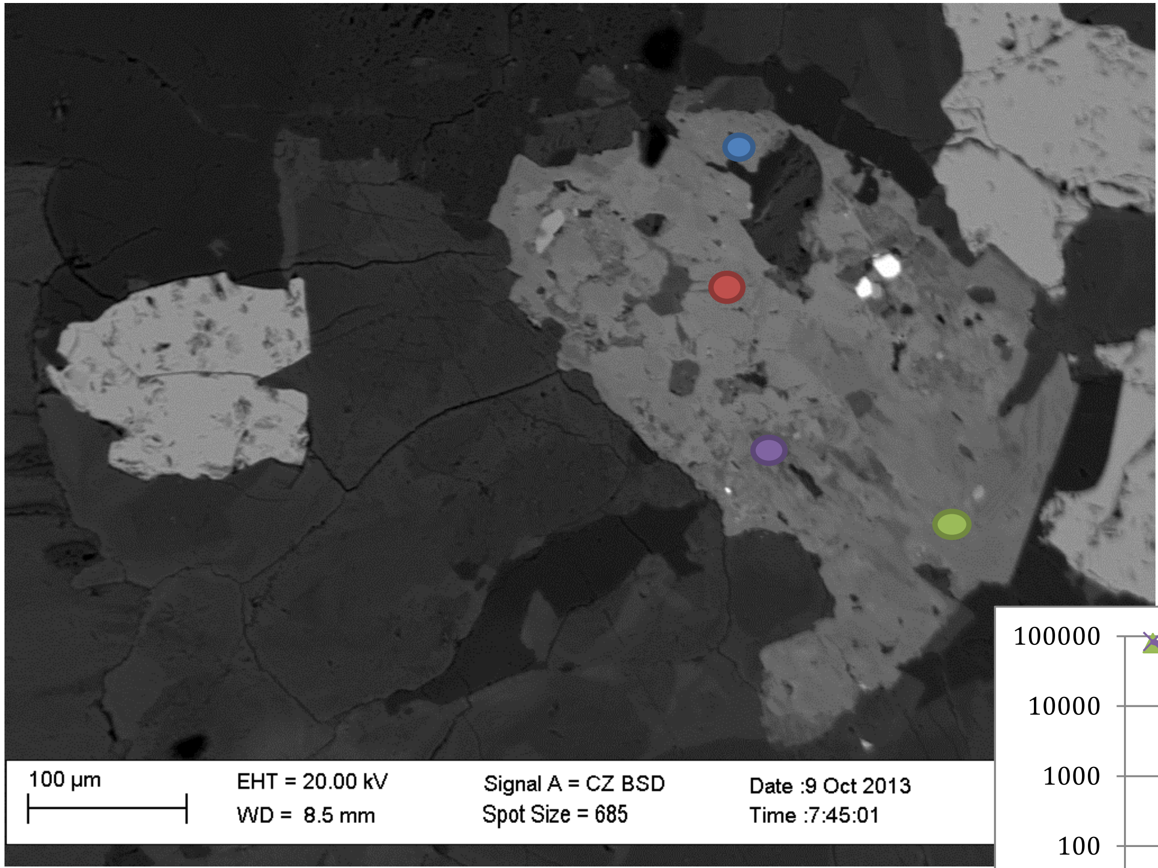
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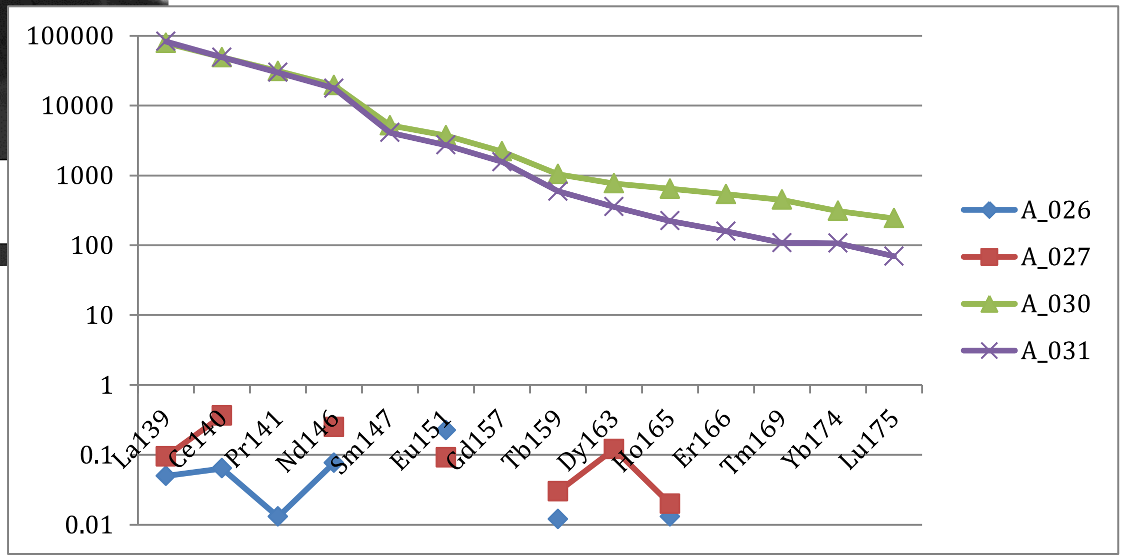
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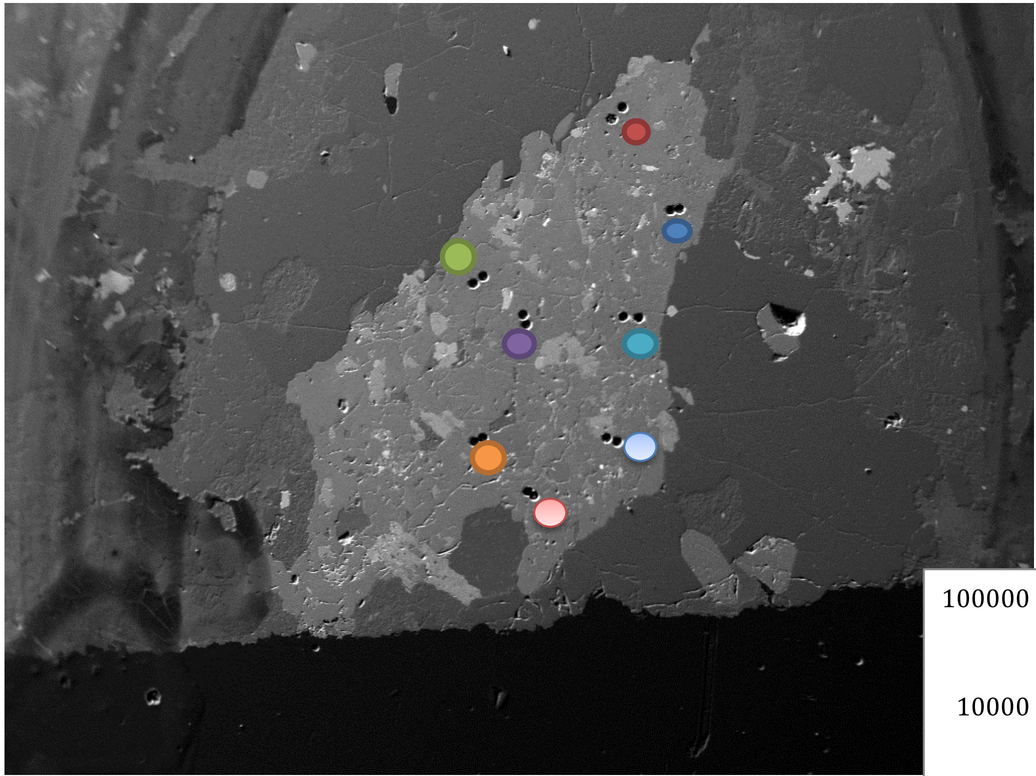
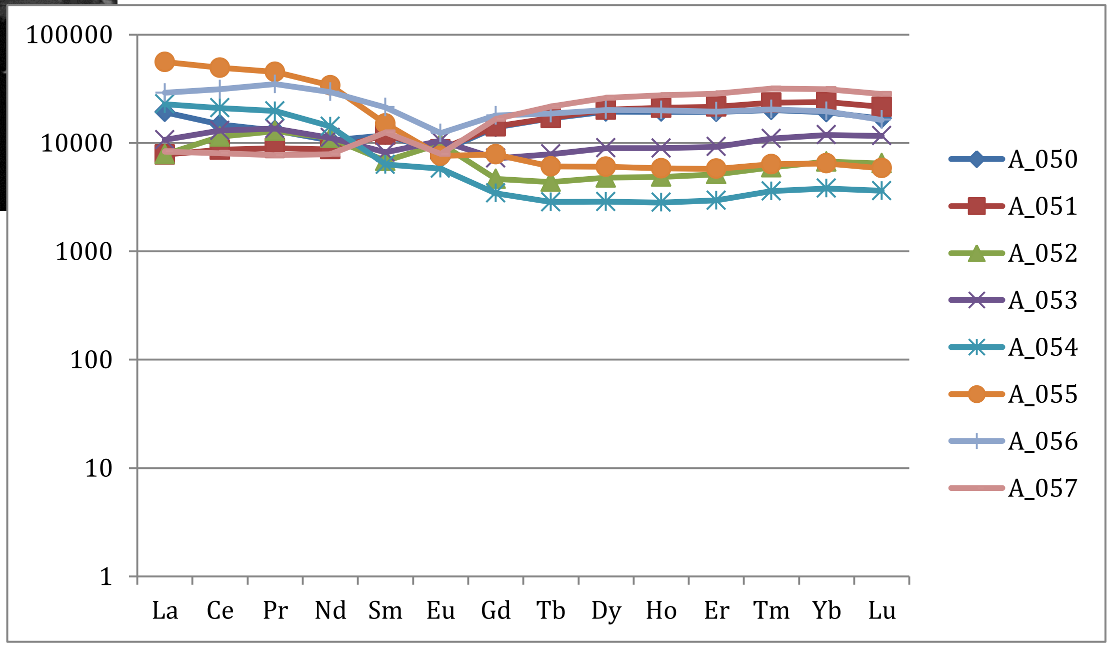
A_026
A_027
A_030
A_031

	AA+400 145.5																									
Sample	**A_050**	**A_051**	**A_052**	**A_053**	**A_054**	**A_055**	**A_056**	**A_057**	**A_058**	**A_061**	**A_062**	**A_063**	**A_064**	**A_065**	**A_066**	**A_067**	**A_068**	**A_069**	**A_070**	**A_073**	**A_074**	**A_075**	**A_076**	**A_077**	**A_078**	**A_079**
Al	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56
P	787.42	637.92	1422.85	1275.82	230.24	271.82	846.80	1063.31	38.06	39.14	39749.13	923.69	293.41	32.05	37.1	38.15	37.79	31.48	925.58	153.15	566.91	1380.10	757.00	1693.66	8148.32	1120.21
Ca	1345136.38	1090471.50	1315130.75	1192968.63	1409612.75	1709116.00	1476389.63	811088.81	79240.84	83320.47	182908.69	80421.38	189190.67	85252.85	87236.88	84213.80	88117.80	75528.05	1398400.13	982208.31	1448629.13	995468.13	1536734.13	1372224.63	1590636.75	1970237.25
Sc	1068.75	1345.12	846.32	631.89	805.19	1038.64	1058.16	770.34	37.99	50.69	69.57	73.60	382.83	106.81	90.99	40.16	41.62	46.12	747.39	274.53	2029.75	467.32	675.96	861.66	644.73	268.09
Ti	1246621.00	974809.06	1220018.50	1046342.31	1342546.75	1683637.63	2235287.25	729041.50	2060.18	2259.13	3417.28	3378.89	2320.62	1818.91	1772.11	2836.92	3058.62	2065.44	1295797.25	886860.06	1325159.75	932608.44	1493781.25	1214398.00	1538945.00	1933009.25
V	2092.02	2002.08	1820.40	1579.08	2126.82	10148.32	4346.89	1432.43	1435.21	1386.47	1627.36	1850.90	2338.44	2168.23	1969.65	1636.43	1607.75	1733.85	6892.14	4351.90	1898.04	3100.34	5212.70	3798.71	8337.98	12300.09
Cr	205.74	208.12	282.85	162.89	331.30	295.58	494.74	146.85	183.10	137.67	104.01	102.89	933.04	707.90	659.56	924.68	900.58	753.21	364.25	268.36	227.74	251.77	350.34	322.72	288.46	1360.55
Mn	10910.07	8244.60	11273.31	10432.21	14663.54	20959.02	215760.95	8460.00	4885.18	5009.39	5939.60	6792.78	12418.33	5404.65	5711.45	6001.44	6845.67	5017.50	10334.43	5727.90	11333.02	9053.35	18925.23	11087.31	24731.01	17680.64
Fe	60853.21	70049.98	62302.22	63860.83	125479.01	71226.66	263846.53	68858.49	57962.18	60557.78	75584.23	72788.61	75424.10	53603.62	59602.44	75477.05	72883.29	51727.65	65475.23	45501.86	72508.91	53051.98	117538.16	66333.95	75319.95	77291.67
Zn	14.15	18.02	28.93	27.11	92.11	41.96	84.57	61.02	293.75	293.54	362.23	397.36	410.62	601.12	283.68	436.42	419.14	347.96	21.18	1133.65	11.67	27.30	282.12	17.24	77.23	46.24
Ga	78.06	74.33	67.51	79.02	92.71	135.69	120.75	128.96	242.18	258.73	383.34	363.99	443.39	330.71	300.51	312.92	312.16	342.32	87.51	71.12	73.28	154.62	118.62	82.12	138.39	117.38
Ge	250.22	219.64	275.87	262.20	311.70	477.40	443.82	195.84	194.66	207.60	230.02	293.09	235.74	189.92	180.80	218.07	219.74	207.09	313.34	202.45	233.21	176.86	305.24	245.24	221.05	378.66
Sr	1805.68	638.10	691.16	772.20	1590.87	4144.34	3788.59	796.78	1816.13	1850.67	3292.88	2861.81	2935.38	2820.44	2569.37	2249.88	1970.50	2225.36	1359.26	1062.25	962.89	1292.50	2575.19	897.70	1311.75	2843.22

Zr	4108.16	936.11	2134.49	1711.97	1998.61	2062.85	3091.93	1758.43	5.74	4.49	9.84	11.71	16.77	8.43	8.13	8.75	6.56	9.01	1442.60	1575.96	7822.53	4019.95	4111.60	2489.54	1807.47	1892.29
Ba	70.26	97.58	53.58	59.92	185.90	239.24	377.81	637.03	381.58	631.41	2111.75	1508.61	2222.05	894.83	662.33	984.30	930.39	1287.87	61.09	120.31	45.19	1468.02	173.39	64.92	20.43	149.12
La	7068.66	2869.09	2872.24	3916.51	8382.95	20525.14	10659.59	3055.63	41621.35	41876.16	47375.60	59980.05	43362.11	33896.32	34756.74	49657.34	49875.05	42151.50	4614.80	5097.72	3880.43	5237.92	12341.45	5465.73	1754.92	13288.90
Ce	14180.91	8282.74	10956.64	12445.13	20129.97	47207.84	29985.92	7715.57	56906.24	59222.04	66921.77	85710.83	54663.37	44087.79	46078.08	63959.36	64276.16	56977.45	13833.38	10897.70	10243.05	10193.06	20027.01	13297.34	4091.33	29236.27
Pr	1786.51	1224.04	1763.08	1856.89	2697.98	6197.39	4780.93	1054.20	4613.98	4791.36	5493.36	7097.68	4579.19	3579.66	3672.32	5125.01	5153.70	4798.82	2251.85	1787.33	1238.22	1165.52	2294.81	1636.54	486.61	3995.79
Nd	7506.78	6220.52	7910.83	7944.85	10110.83	24183.67	21031.38	5608.85	13489.31	14084.44	16317.20	20865.70	13970.58	10471.17	11071.81	14539.20	14988.27	13370.83	10094.65	8545.21	4281.48	4210.53	7985.55	5707.84	1822.19	15451.51
Sm	2720.33	2737.66	1574.23	1894.38	1458.77	3483.12	4927.22	2882.10	866.97	943.68	1084.16	1486.11	883.77	696.83	728.45	957.39	987.04	924.60	2067.33	1960.08	522.20	603.94	1018.88	786.29	229.59	2440.77
Eu	721.25	758.03	858.74	909.68	504.70	660.13	1071.64	687.91	122.81	125.08	148.17	178.64	135.34	119.77	128.52	140.29	147.05	129.52	730.60	470.64	101.88	134.47	221.18	314.27	56.24	568.47
Gd	4273.95	4344.49	1423.22	2213.14	1051.45	2393.83	5483.38	5087.96	392.73	412.78	505.05	625.24	399.64	302.20	319.73	426.75	433.20	394.85	1852.57	1490.41	273.85	362.18	638.95	499.16	138.24	1537.56
Tb	980.77	983.40	253.36	457.70	165.50	352.53	1086.89	1257.51	21.23	23.12	31.47	34.24	21.13	17.40	17.17	21.02	22.19	21.37	318.80	212.80	32.40	44.30	74.39	67.73	16.26	190.40
Dy	7401.78	7718.32	1824.93	3424.39	1095.26	2296.18	7681.24	9927.66	58.54	65.06	98.47	93.73	66.28	49.95	49.99	56.91	64.53	64.68	2256.05	1199.33	143.73	237.92	391.06	351.83	69.82	983.69
Ho	1649.07	1797.81	413.70	760.53	240.00	496.43	1705.41	2341.48	7.80	8.79	13.49	11.14	9.49	6.90	7.20	7.08	7.55	7.60	483.00	226.61	23.31	45.08	68.42	72.74	13.09	165.63
Er	4800.66	5370.86	1279.05	2294.45	733.63	1436.89	4861.69	7111.52	14.05	16.47	30.74	19.86	18.17	12.87	14.26	12.66	14.09	14.09	1432.43	587.90	53.83	114.24	162.65	210.93	33.40	398.32
Tm	715.22	838.74	211.84	390.31	128.13	226.96	729.34	1130.47	1.58	1.98	3.78	1.99	2.02	1.68	1.56	1.55	1.77	1.60	223.70	87.92	8.43	16.67	24.85	35.90	3.97	57.74

Yb	4760.05	5922.11	1668.93	2942.26	945.52	1605.39	4869.97	7769.89	9.55	12.58	23.44	15.84	14.60	12.82	12.73	10.92	11.19	10.03	1552.53	632.43	66.46	110.00	172.52	354.26	34.27	395.10
Lu	638.80	820.95	247.07	443.39	138.07	222.46	621.68	1077.67	1.65	2.18	4.02	2.86	2.33	2.03	1.87	1.63	1.74	1.60	226.63	91.36	9.80	13.67	22.87	72.43	3.86	54.40
Pb	63.54	49.18	54.78	75.25	109.00	161.55	114.37	199.34	229.65	287.25	353.78	386.88	275.82	249.62	269.47	384.90	372.53	313.06	74.07	33.58	51.11	67.97	105.29	101.48	40.71	61.75
Th	848.74	690.93	657.06	1070.28	1146.42	1468.11	897.56	2749.56	3485.38	3731.18	5524.38	7675.92	4843.58	4120.00	4128.37	5836.54	5874.58	5432.09	991.66	276.21	649.32	855.68	491.59	1661.83	140.67	717.40
U	905.32	987.68	1052.85	1809.47	2083.23	1307.88	1130.62	8532.46	209.65	300.34	266.63	235.90	176.49	204.90	189.26	159.41	166.75	180.55	1575.32	763.89	1334.17	1015.55	1432.11	3790.63	1235.09	1191.68

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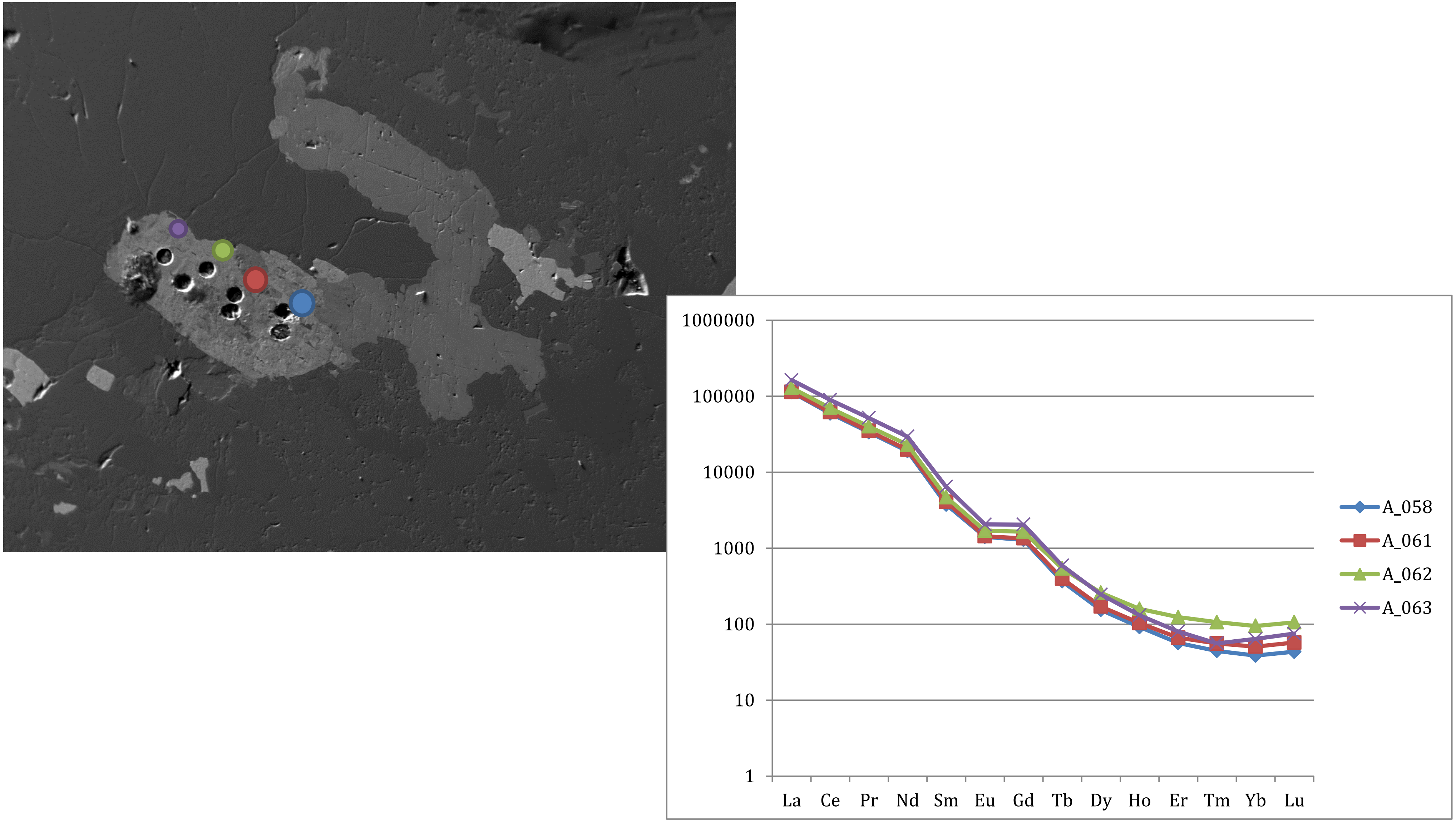
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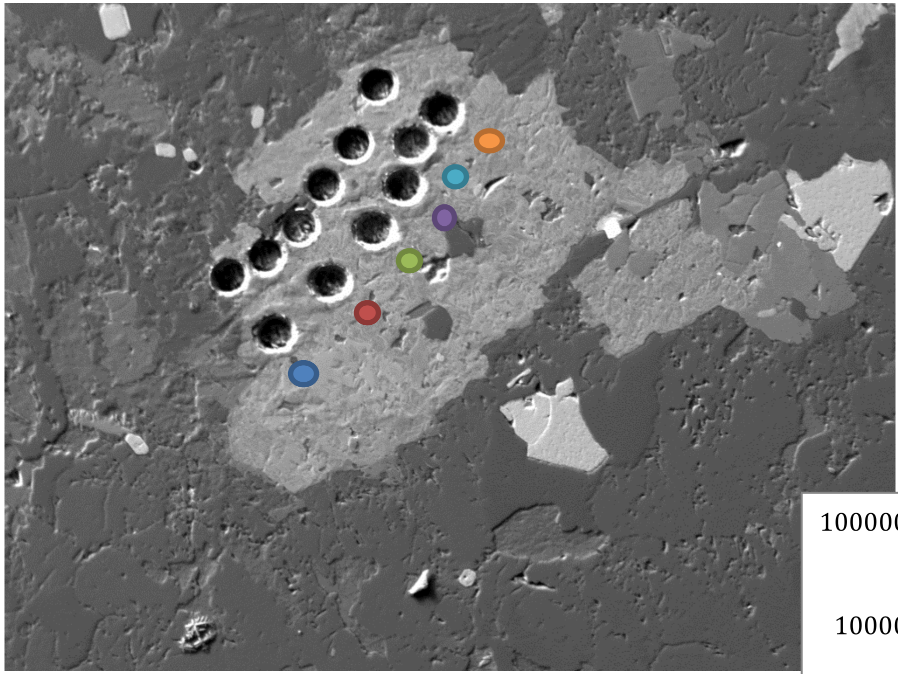

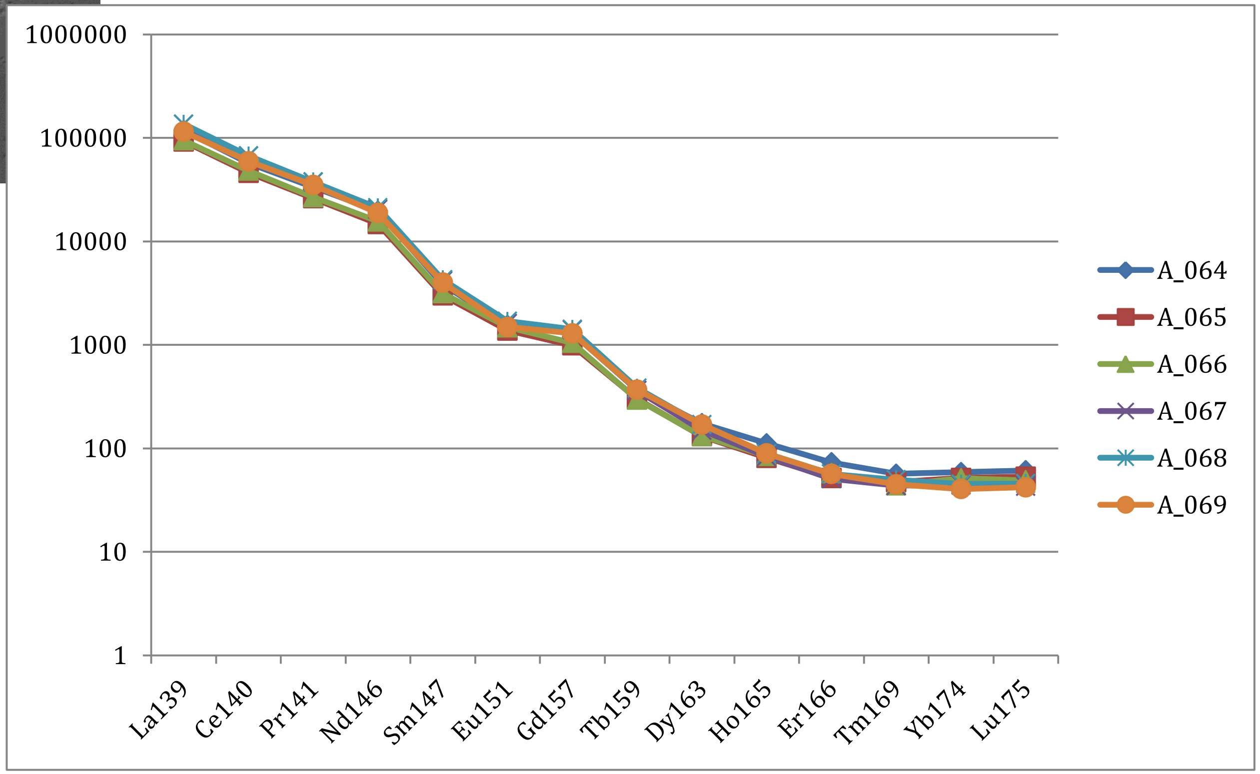
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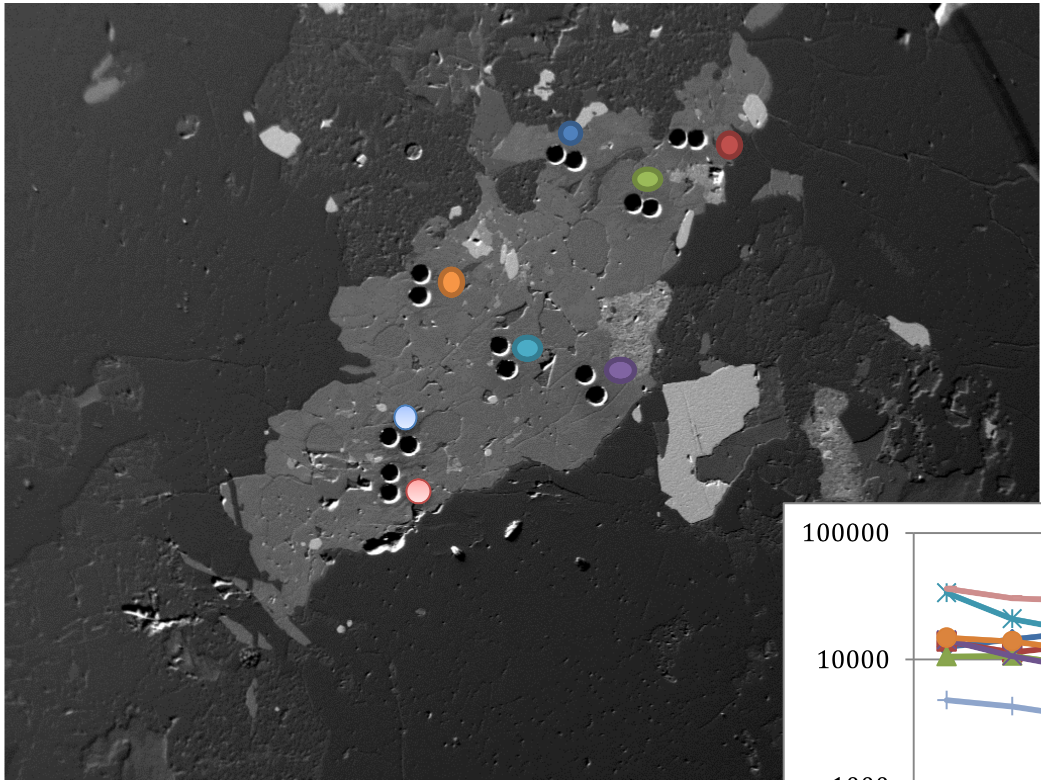

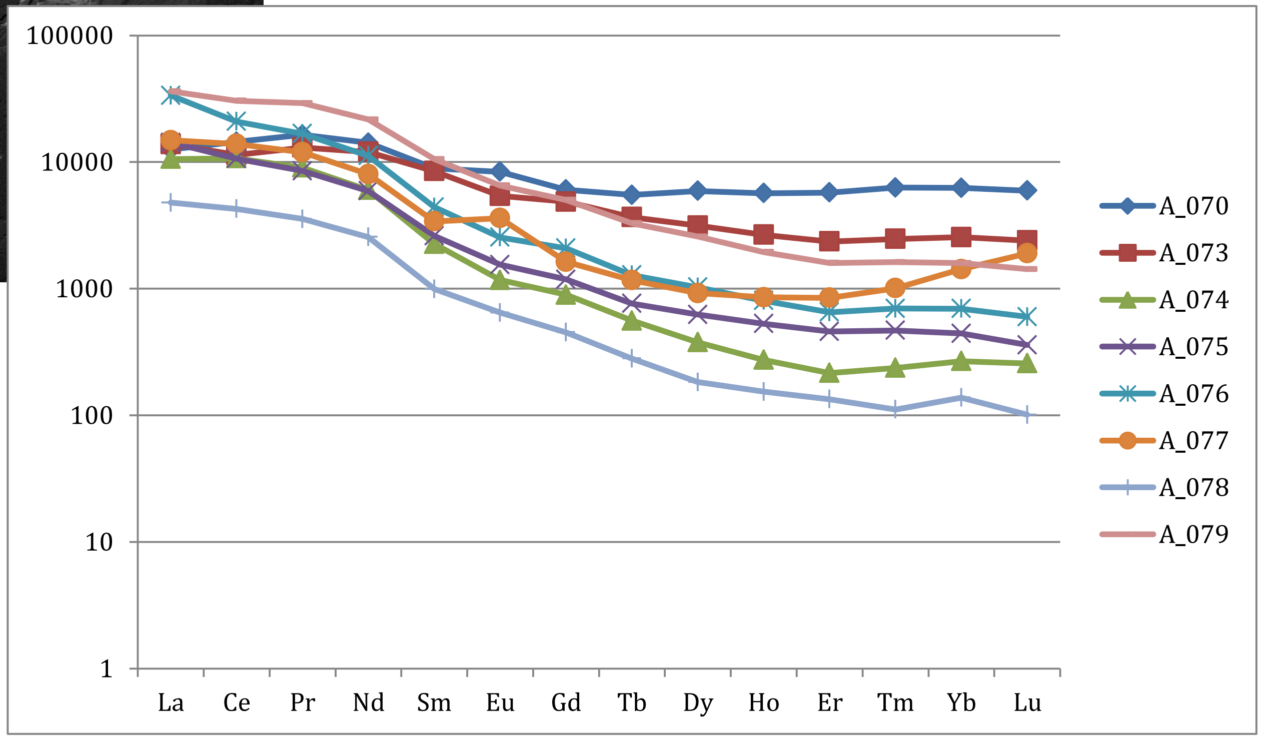
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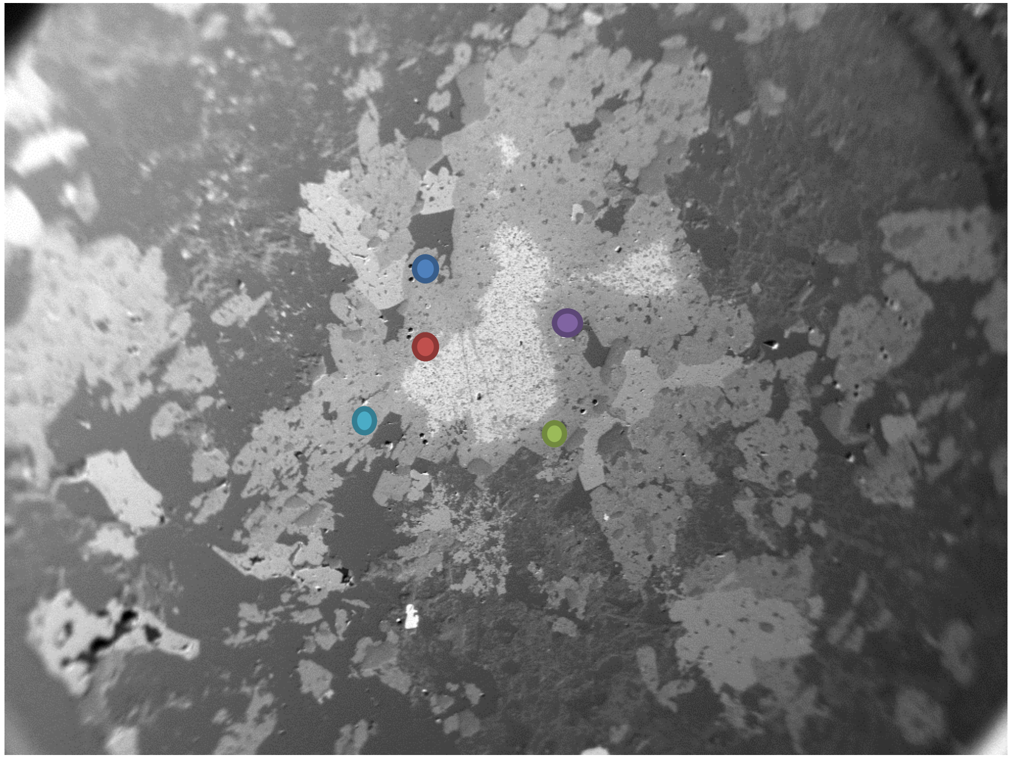
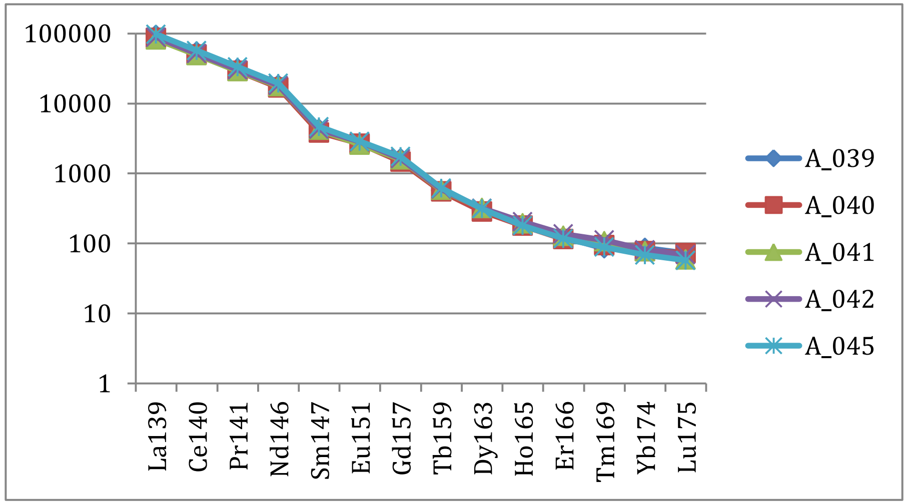
2.2 BB+400

	BB+400 156.6													
Sample	**A_034**	**A_035**	**A_036**	**A_037**	**A_038**	**A_039**	**A_040**	**A_041**	**A_042**	**A_045**	**A_046**	**A_047**	**A_048**	**A_049**
Al	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56
P	40.38	44.37	89817.35	143.81	42.16	43.05	41.18	40.76	41.28	44.30	43.67	41.16	39.42	39.49
Ca	107900.39	96352.23	322091.41	98115.60	81998.37	83883.65	98288.59	89474.77	87873.19	88844.93	84392.16	88088.52	79460.73	82399.94
Sc	6.40	8.87	14.91	12.82	9.19	8.78	10.34	8.59	9.13	8.07	12.37	8.82	10.45	19.90
Ti	767.05	2022.99	1358.07	1286.33	1584.98	1555.92	1494.75	1309.13	1425.74	1879.96	1568.92	1807.04	1775.30	1920.75
V	388.51	1699.36	1542.45	1690.46	3043.90	3179.12	1955.35	1204.54	2204.23	1662.48	1581.20	2319.74	1995.49	2715.01
Cr	1.15	4.06	2.14	15.43	1.71	1.70	1.68	2.02	4.64	5.17	6.76	4.31	8.21	8.81
Mn	3415.50	5375.70	5223.39	3239.20	6050.72	5346.97	6229.81	2980.98	4741.70	4200.48	5729.22	4706.51	4555.57	4674.65
Fe	71402.81	76118.52	64758.84	61138.14	56607.87	54853.70	66514.83	64736.32	57519.25	65090.91	66685.77	58815.62	61630.34	55512.88
Zn	356.29	475.04	402.71	326.14	467.27	395.16	385.73	232.03	308.26	362.69	366.56	343.73	257.29	289.69
Ga	207.58	273.44	249.11	266.97	296.68	352.61	250.77	234.24	296.19	258.24	239.77	302.78	273.72	296.04
Ge	157.41	241.00	212.94	192.83	207.60	211.93	179.43	193.09	203.63	212.43	203.71	221.64	214.06	207.67
Sr	6174.92	3163.28	5753.73	3645.27	2002.11	1962.92	2757.39	2932.79	2175.06	3034.47	2914.38	2285.79	2516.19	2816.19
Zr	15.18	13.08	13.49	14.49	11.25	8.50	12.59	14.27	8.83	9.41	13.05	8.88	6.90	17.79
Ba	205.40	324.02	265.31	260.47	301.21	286.55	250.44	244.90	257.80	281.45	271.10	281.14	260.64	296.39
La	26099.37	39466.23	28816.14	30299.49	30629.19	34741.30	31822.00	30207.08	32530.02	35785.63	30722.21	35207.73	31432.96	29898.22
Ce	39102.97	61572.34	47060.98	46915.94	48999.02	52429.66	48056.94	46892.71	49226.28	54431.43	48720.59	54988.69	50150.76	47965.14
Pr	3227.92	5362.16	4263.42	4079.72	4224.66	4351.26	3999.20	3972.53	4149.35	4569.24	4204.15	4688.43	4234.58	4157.78
Nd	10042.85	15797.81	13875.27	12530.72	13129.39	13064.22	12070.02	12608.70	12834.15	13832.08	13180.57	14213.88	12963.87	12975.50
Sm	685.05	1201.15	1199.73	946.16	1025.62	1000.45	891.17	970.38	981.60	1076.19	998.55	1063.77	1013.47	1017.67
Eu	156.83	280.17	323.73	236.39	255.36	231.57	231.56	224.44	247.29	249.12	260.25	245.16	222.85	257.98

Gd	300.80	584.74	673.95	478.67	531.65	498.77	453.10	486.04	497.06	531.01	478.90	511.63	482.14	502.57
Tb	14.99	36.15	60.43	34.34	39.96	33.20	32.16	33.77	34.42	35.80	31.62	34.13	32.83	36.17
Dy	29.49	109.29	292.59	135.14	157.19	112.78	108.97	121.97	121.41	119.40	109.85	121.48	120.59	129.14
Ho	2.08	13.52	54.72	18.99	22.54	15.22	15.25	16.47	17.33	15.24	15.45	16.83	16.72	17.30
Er	2.33	24.68	134.26	39.41	44.68	30.55	28.66	31.98	34.01	29.16	29.32	31.67	31.41	35.51
Tm	0.20	2.50	15.99	3.87	4.79	3.02	3.35	3.82	3.97	3.16	3.33	4.03	4.11	4.10
Yb	0.49	16.22	77.02	26.43	31.04	21.35	19.27	19.20	20.14	16.96	18.94	23.29	21.07	25.31
Lu	0.06	1.87	9.27	2.65	4.25	2.76	2.77	2.25	2.63	2.18	2.41	3.02	2.74	3.51
Pb	31.36	34.17	42.78	31.55	36.30	29.23	29.58	23.74	24.61	28.43	33.51	31.38	28.34	37.99
Th	238.24	358.17	353.55	317.03	306.05	310.27	250.66	255.99	260.20	292.21	360.99	412.32	374.36	383.57
U	305.93	248.72	409.35	454.81	339.29	330.82	258.92	407.10	343.41	272.94	228.58	383.43	330.71	1399.18

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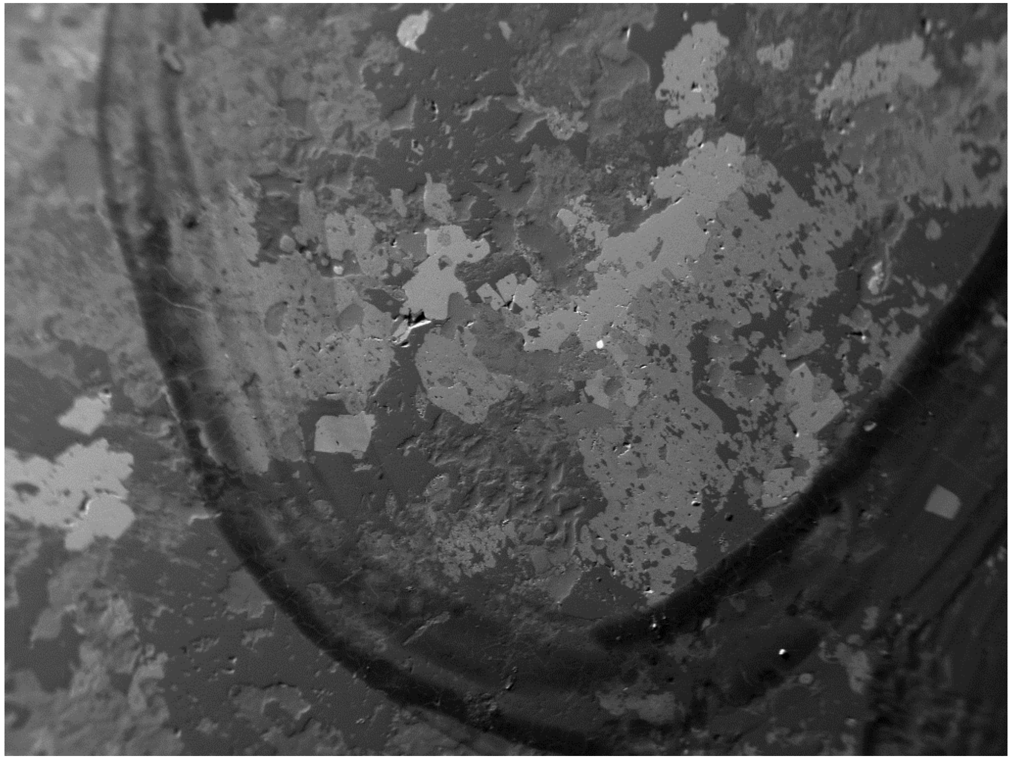

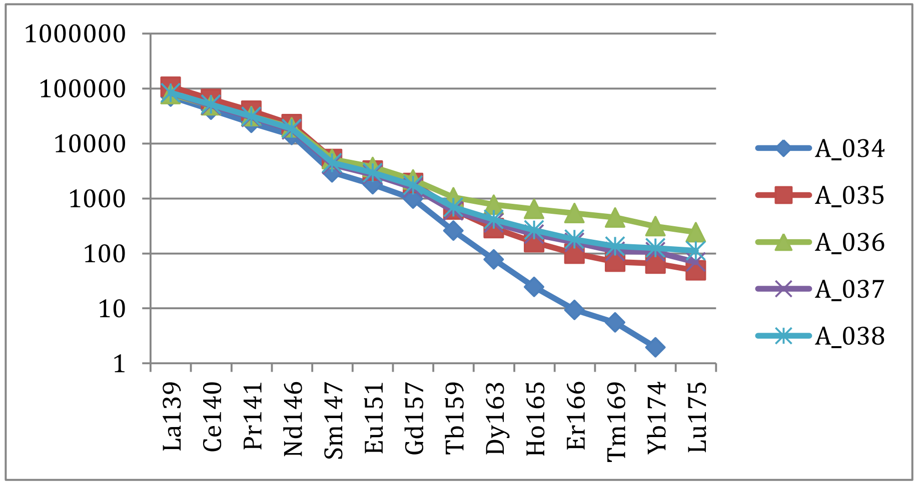
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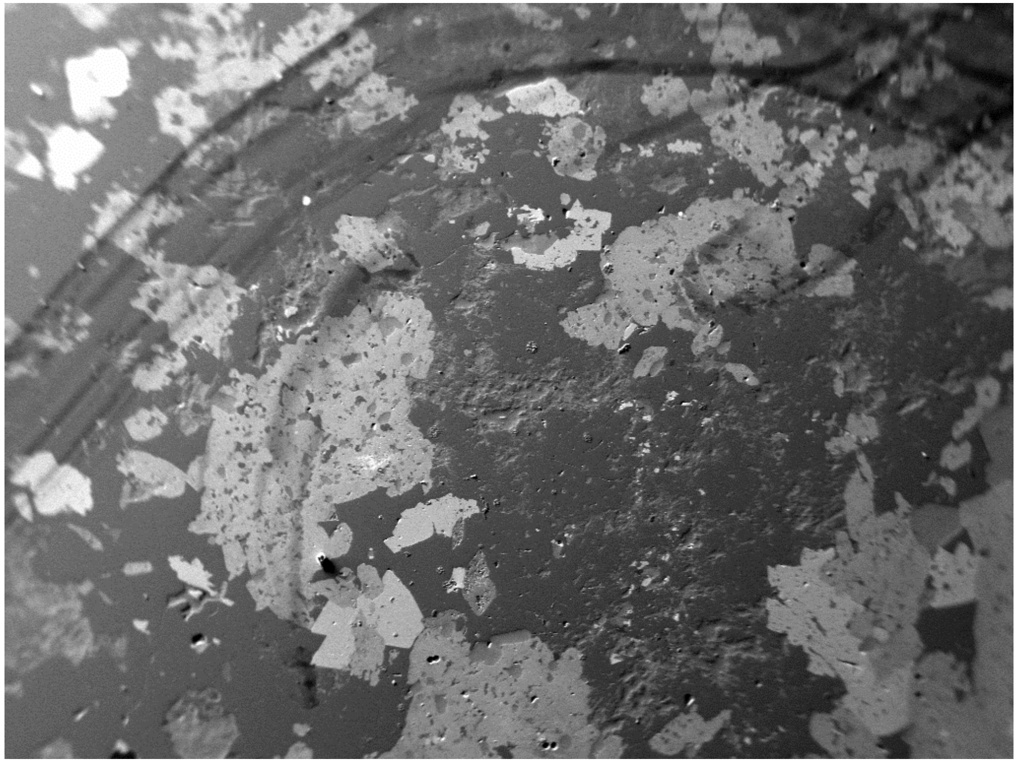

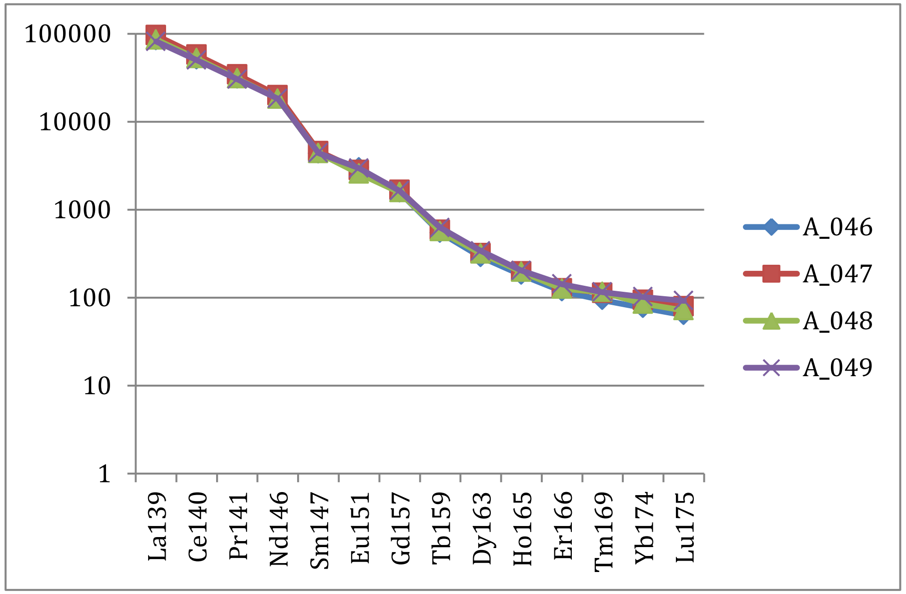
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BB+400 90

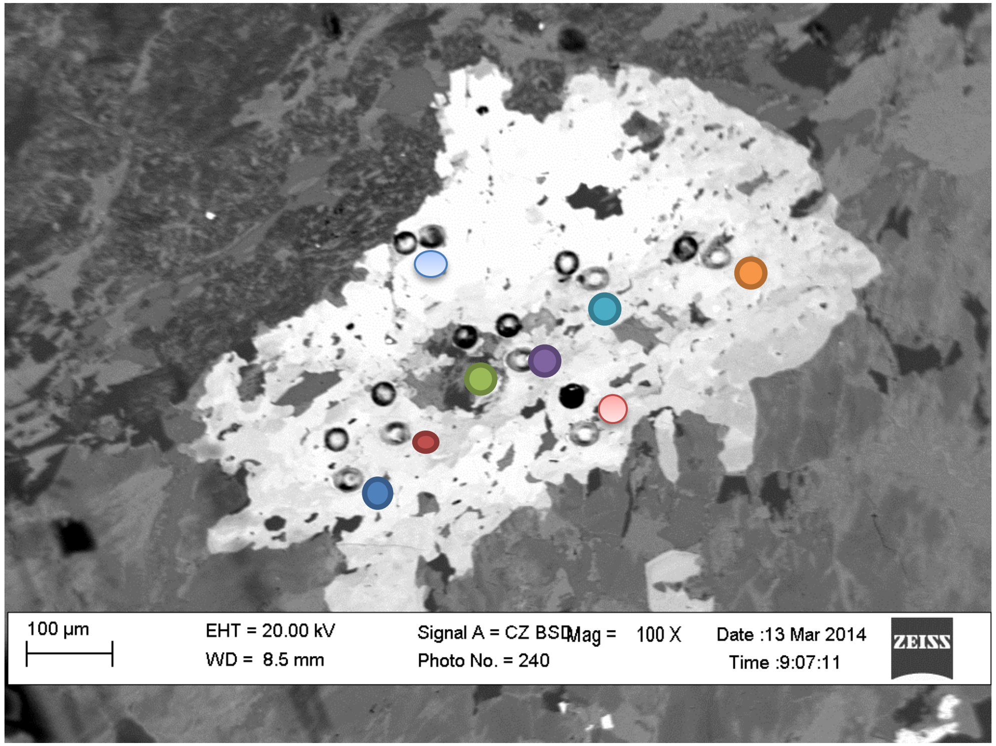
Sample	A_080	A_081	A_082	A_085	A_086	A_087	A_088	A_089	A_090	A_091	A_092	A_093	A_094	A_097	A_098	A_099	A_100
Al	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56
P	3394.78	46.89	40.94	39.55	95.18	41.00	43.00	40.48	36.61	36.71	37.16	40.57	40.92	40.88	34.71	39.77	40.87
Ca	104703.21	92754.06	98062.60	96877.91	93615.84	105590.95	95508.21	100442.08	89009.37	95928.93	93382.77	99633.93	83702.70	90228.52	79503.67	104538.29	102524.62
Sc	25.08	46.13	12.14	8.59	23.45	16.23	38.51	18.38	12.74	18.00	24.58	56.54	42.62	77.94	15.87	10.26	38.87
Ti	4983.60	5371.77	1967.84	1149.24	2862.18	2095.55	3142.11	1687.60	1507.62	3014.99	3938.29	4824.58	6057.73	5015.75	3269.67	1994.87	3916.20
V	1181.29	1278.61	698.22	778.03	980.77	680.78	989.72	692.66	482.18	1302.50	1110.24	1139.06	1205.04	1274.08	1415.63	455.05	799.82
Cr	20.21	16.94	17.53	17.48	27.58	23.35	21.47	9.43	17.10	25.11	20.23	36.23	33.50	27.54	21.79	14.59	37.07
Mn	10818.92	10111.51	3351.26	3803.68	8837.35	11832.72	11781.92	6796.60	6365.32	5360.71	6782.74	15473.66	20441.88	24492.68	7123.41	3211.68	9244.65
Fe	118334.95	108221.63	87680.80	86927.64	91203.34	110470.57	97094.25	80147.92	81162.58	91834.95	101914.92	123744.26	125433.79	116370.60	77277.08	102411.69	127412.11
Zn	622.72	446.15	250.82	245.28	655.25	3665.36	678.39	502.78	462.28	403.62	486.25	651.47	653.31	565.69	438.59	1329.11	1246.45
Ga	318.11	308.01	248.96	230.04	266.86	301.52	290.34	232.97	230.58	269.12	268.93	283.52	346.95	319.38	248.30	220.40	274.93
Ge	343.27	318.63	210.54	200.78	269.05	300.94	279.72	203.95	186.74	236.49	279.67	336.98	290.89	331.19	249.84	283.76	314.93
Sr	7053.98	3941.86	6293.61	4362.54	5235.19	5613.97	4031.44	4338.49	5595.86	3840.13	6159.41	4882.61	3396.88	2252.32	4611.39	8763.36	5764.91
Zr	11.72	9.75	15.34	12.37	800.32	11.15	18.19	23.28	18.90	15.53	4.92	8.04	4.04	1.38	17.17	17.40	13.00
Ba	906.39	569.30	372.64	305.28	442.10	588.24	478.50	433.73	434.80	388.79	494.96	640.97	708.26	642.59	415.81	410.11	556.73
La	57961.00	67638.59	44696.11	38364.77	50206.91	63143.41	61231.22	40130.57	39397.05	50110.75	60265.44	80426.98	93752.75	85501.67	46887.83	47180.51	69194.81
Ce	91411.16	102128.16	64322.05	57441.14	77746.40	96009.23	92222.89	61656.94	57157.57	74352.70	90553.59	116483.02	124031.80	121216.10	71664.27	78203.08	104575.23
Pr	7749.58	8209.87	5135.02	4725.04	6272.20	7689.01	7270.51	4931.45	4521.69	5927.92	7100.64	8988.62	8544.53	9087.25	5770.87	6611.89	8264.18
Nd	22874.06	22951.96	14757.44	13981.12	17937.52	21425.65	19844.15	14258.58	12844.28	16597.92	19254.95	24550.61	20590.04	23995.67	16431.69	19570.16	22646.40
Sm	1597.66	1500.04	964.82	922.11	1128.32	1124.70	1204.52	923.10	734.00	1129.12	1176.64	1497.28	997.89	1528.55	1053.70	1222.95	1248.71
Eu	384.77	375.66	235.30	242.09	283.09	252.36	275.11	234.57	185.65	333.16	275.40	331.65	271.52	402.63	277.00	263.98	235.38
Gd	695.11	702.30	437.41	384.01	522.70	459.44	519.01	407.20	326.82	564.36	552.64	662.52	509.84	754.09	464.85	478.79	503.23
Tb	42.03	44.51	24.89	22.57	32.67	19.37	28.00	23.28	16.50	37.89	34.08	37.83	27.34	48.96	28.85	21.44	24.45
Dy	152.94	156.89	87.20	69.47	120.32	42.09	85.27	69.72	46.72	137.65	132.03	128.65	92.19	199.87	104.28	51.97	64.12

Ho	24.28	24.33	12.40	8.80	17.55	5.42	11.89	8.83	5.22	19.45	20.60	19.89	16.26	33.10	15.16	6.04	8.76
Er	59.69	57.45	24.33	16.14	41.68	9.73	24.88	17.18	7.61	38.67	51.07	44.29	41.61	89.13	38.55	10.74	18.90
Tm	7.63	7.64	2.18	1.51	4.99	1.50	3.61	2.05	0.95	3.62	7.15	6.44	6.05	14.92	4.78	1.17	2.52
Yb	47.94	51.96	12.51	7.24	32.56	9.54	26.29	14.07	4.73	19.84	41.92	47.35	51.83	110.38	32.65	9.26	18.48
Lu	6.38	7.24	1.43	0.87	4.23	1.57	4.01	1.70	0.68	2.09	5.70	6.61	6.99	16.49	4.18	1.35	2.85
Pb	30.48	27.53	16.15	23.44	30.90	35.74	27.04	20.77	17.97	21.83	25.83	31.78	28.74	30.65	25.66	41.92	35.96
Th	361.43	252.36	195.65	215.87	270.67	300.54	219.49	178.26	186.67	227.20	245.59	267.71	225.80	248.03	245.33	224.86	276.87
U	76.92	150.19	157.20	223.38	131.26	34.64	41.65	147.23	124.31	106.74	90.57	81.79	26.79	47.64	65.85	40.80	32.61

BB+400 90 continued

Sample	A_101	A_102	A_103	A_104	A_105	A_106	A_109	A_110	A_111	A_112	A_113	A_114	A_115	A_116	A_117	A_118	A_121	A_122	A_123	A_124	A_125	A_126	A_127	A_128	A_129	A_130	A_131
Al	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56
P	41.64	41.14	40.08	47.65	44.87	39.10	37.23	31.56	35.63	36.68	37.89	133.57	36.53	36.81	34.21	37.59	122.47	2112.38	35.02	314.64	104237.32	34.30	38.09	38.95	38.43	36.9	36.89
Ca	105824.80	105861.98	161304.67	89671.97	105089.86	99941.32	101156.98	96171.66	93246.99	97736.91	101420.53	94906.34	99980.08	94950.41	97142.43	90772.47	94902.62	119116.62	81404.41	94488.62	382754.72	95424.07	125607.71	92954.55	93088.59	94814.48	95322.70
Sc	37.10	30.87	12.09	13.64	14.38	9.01	5.07	4.73	5.03	5.99	6.68	5.18	4.95	5.82	4.24	9.61	11.31	29.94	17.16	25.97	11.82	53.37	11.49	8.91	10.23	22.94	15.00
Ti	4676.45	4606.57	3226.35	14255.53	5838.22	1717.22	1357.21	1162.20	1161.45	1100.26	1423.55	1693.56	1753.54	1661.83	747.47	2632.73	2549.58	1413.71	1866.35	4483.14	2119.12	7245.37	2845.15	2695.11	3323.60	5118.04	2217.05
V	436.02	1139.23	579.16	2263.18	1333.02	317.35	792.12	837.70	988.32	801.06	741.75	492.55	671.31	880.00	406.63	897.33	1674.33	568.38	623.89	1130.25	2575.81	1196.06	1089.34	876.59	1352.08	1010.57	926.56
Cr	20.19	11.54	1.91	15.12	12.73	1.77	5.85	8.02	12.19	9.53	12.31	14.89	11.85	5.40	1.60	38.17	34.40	13.74	18.43	15.60	13.30	10.33	33.57	45.67	13.41	16.55	25.91
Mn	8056.79	12711.99	8985.75	40531.26	15195.04	3004.85	4205.97	3698.91	4359.83	4692.63	5496.85	4731.10	3564.87	3413.98	2900.72	5540.54	5251.53	18420.95	8519.52	8420.65	5348.84	10452.10	9970.66	7887.92	7913.75	4012.98	7264.48
Fe	128004.14	125169.62	93124.83	132758.05	107271.21	98795.86	93099.08	71007.62	74532.77	83861.17	93038.55	103005.44	91863.93	90004.59	66140.73	94516.80	90696.45	153006.80	119171.92	120987.34	84465.09	129591.35	106760.55	107789.42	120701.43	110171.60	108677.66
Zn	1446.01	1254.48	780.68	1311.83	1198.42	1314.68	309.32	286.76	351.30	298.43	398.89	502.46	167.10	262.79	290.57	494.02	411.77	299.20	360.09	602.03	353.50	539.39	554.06	618.36	485.71	425.98	558.69
Ga	288.07	272.87	149.65	297.14	262.21	204.84	239.55	242.51	301.79	220.31	250.26	236.27	241.12	266.67	224.98	293.58	295.93	389.76	253.13	335.64	338.35	371.32	302.38	261.71	269.69	286.16	288.87
Ge	337.81	348.64	192.08	470.82	294.32	252.42	200.16	167.18	190.25	169.93	201.90	200.24	214.32	222.91	145.95	251.40	241.42	169.75	198.46	326.81	359.76	406.85	256.00	228.19	231.13	296.22	267.55
Sr	5473.02	6142.96	6709.21	2975.99	6894.00	8521.21	4636.77	4841.12	3488.22	5564.85	4738.59	5260.99	5213.52	4895.45	5946.60	4952.03	4412.06	5436.84	4954.39	4319.23	7919.00	3747.69	4413.49	5081.15	5171.10	4810.52	5654.54
Zr	8.54	13.06	67.94	4.35	20.46	20.57	16.07	30.84	25.89	13.44	12.35	12.60	13.10	18.72	17.08	9.91	14.87	20.55	18.14	10.56	48.37	3.49	10.18	16.71	9.51	19.61	17.83
Ba	600.88	570.41	264.86	724.74	537.14	393.68	312.06	306.24	318.21	235.96	366.76	579.69	362.48	338.36	249.64	430.41	397.13	3240.71	720.55	637.07	583.40	666.24	478.30	558.88	650.60	490.88	434.21
La	76981.95	72775.96	25072.24	88160.23	55984.25	44751.50	38597.10	28721.60	33924.02	28584.24	38191.46	38593.57	42217.73	43265.02	27067.90	51901.52	45906.59	28981.73	36878.07	76131.69	44425.39	86717.66	57440.48	46195.67	44355.71	62492.46	48662.86
Ce	112517.57	110255.92	44867.00	140871.44	86341.73	74437.59	58232.83	43999.29	50842.59	43328.36	57294.77	57374.09	63252.41	64854.45	40774.42	77478.05	68490.17	44294.28	54802.86	109136.64	75000.72	123395.12	81975.74	68089.22	65518.12	94180.60	72725.77
Pr	8670.31	8934.70	4012.23	11812.96	7132.57	6384.44	4857.63	3676.14	4270.05	3570.85	4787.42	4732.00	5245.41	5353.88	3394.39	6206.79	5604.72	3876.68	4564.62	8704.86	7131.75	9929.62	6384.70	5547.93	5321.15	7737.45	6046.03

Nd	23566.06	25861.60	12995.48	34434.51	20961.13	18809.90	14461.31	11434.80	12964.53	11124.50	13814.52	14025.26	15380.67	15706.95	10490.64	17563.93	16050.44	11204.67	13759.80	24481.57	24535.62	28942.51	17505.00	16005.63	15359.30	22213.49	17485.21
Sm	1265.27	1620.22	960.41	2230.08	1437.25	1221.09	932.44	732.99	878.04	707.82	905.07	906.21	944.12	972.11	726.49	1071.61	994.30	723.65	878.57	1300.27	2462.47	1826.38	990.60	914.38	923.63	1389.22	1085.32
Eu	227.87	348.45	236.79	537.80	363.57	288.55	241.02	195.66	279.84	183.81	231.27	195.29	200.47	252.68	226.81	243.07	272.68	182.09	209.81	275.18	778.85	448.72	239.02	206.62	200.16	310.87	230.71
Gd	511.11	641.89	388.49	917.73	580.99	475.88	390.99	328.82	399.26	297.46	366.46	352.88	373.24	415.70	269.65	434.04	403.98	301.66	368.20	523.46	1318.56	806.37	403.31	360.24	357.75	570.88	408.18
Tb	22.20	32.46	23.83	55.28	31.98	23.38	25.26	20.11	23.49	16.62	20.50	18.67	19.48	24.46	12.72	21.46	23.04	19.54	20.97	23.63	104.61	47.41	20.59	18.58	18.50	32.01	19.91
Dy	53.43	84.58	73.93	152.09	95.53	59.32	88.26	72.54	65.65	53.41	63.60	50.69	59.47	85.14	27.18	63.79	73.94	69.49	62.09	56.38	438.49	162.29	62.43	49.12	55.14	100.31	45.69
Ho	6.16	10.38	9.10	19.94	13.10	6.42	11.75	8.88	7.88	7.26	7.01	6.06	8.29	12.46	2.80	8.50	11.63	10.95	8.27	6.91	72.76	22.26	8.08	6.54	7.01	13.21	4.91
Er	11.90	22.06	17.16	38.19	27.30	12.16	25.93	15.29	12.14	14.04	12.53	8.84	15.19	23.66	4.37	16.45	26.29	20.58	17.24	12.92	173.07	47.71	17.95	12.13	13.95	28.05	9.40
Tm	1.48	3.25	2.14	5.19	3.21	1.61	2.61	1.34	1.13	1.48	1.17	0.72	1.74	2.11	0.38	1.80	3.03	2.59	1.93	1.36	21.28	4.94	1.96	1.43	1.48	3.50	1.14
Yb	10.50	24.70	13.45	34.83	23.71	9.35	13.17	7.32	6.04	7.59	5.53	3.47	7.41	10.83	2.17	10.94	16.50	12.49	10.41	8.70	105.49	26.76	11.02	6.58	9.78	19.94	4.86
Lu	1.53	4.43	1.81	5.92	3.69	1.49	1.24	0.72	0.79	0.63	0.67	0.39	0.87	1.24	0.27	1.41	1.74	1.41	1.30	1.12	10.80	2.89	1.40	0.66	1.32	2.36	0.59
Pb	43.29	40.14	24.24	55.87	50.23	38.38	33.46	32.12	29.70	31.88	29.67	35.94	21.39	25.06	24.27	33.96	39.55	23.97	29.75	36.80	187.91	50.35	35.36	29.78	27.05	32.10	34.51
Th	307.60	274.82	113.94	499.76	346.61	194.30	363.69	227.17	276.85	213.50	271.18	276.32	315.01	323.30	194.98	305.01	357.70	240.41	297.42	417.06	832.96	628.35	258.68	272.34	262.21	417.39	351.37
U	22.94	17.78	52.59	148.71	92.21	58.23	270.99	249.78	316.17	309.12	255.61	209.50	149.44	184.32	296.46	460.51	263.77	241.80	209.92	41.69	1409.22	63.94	146.99	154.36	93.99	388.58	123.98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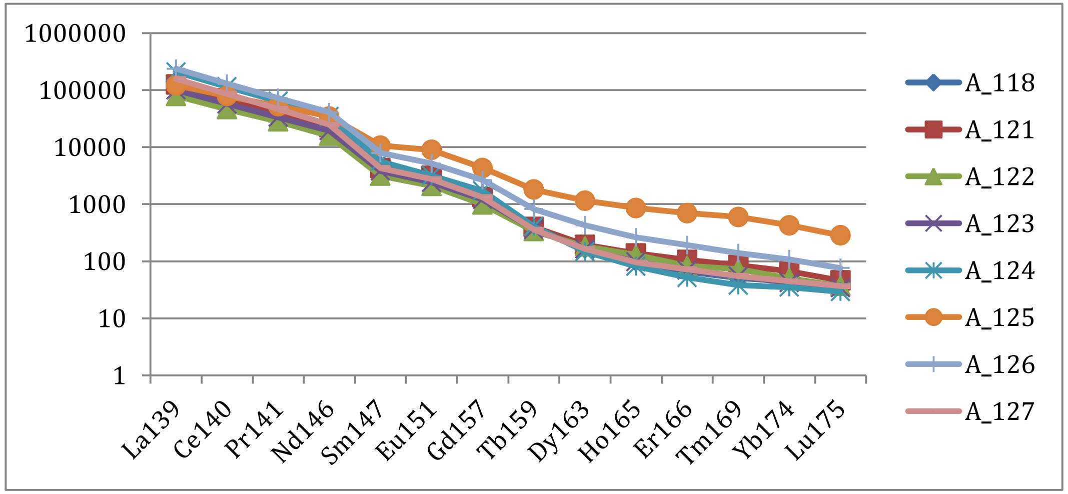
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A_122
A_123
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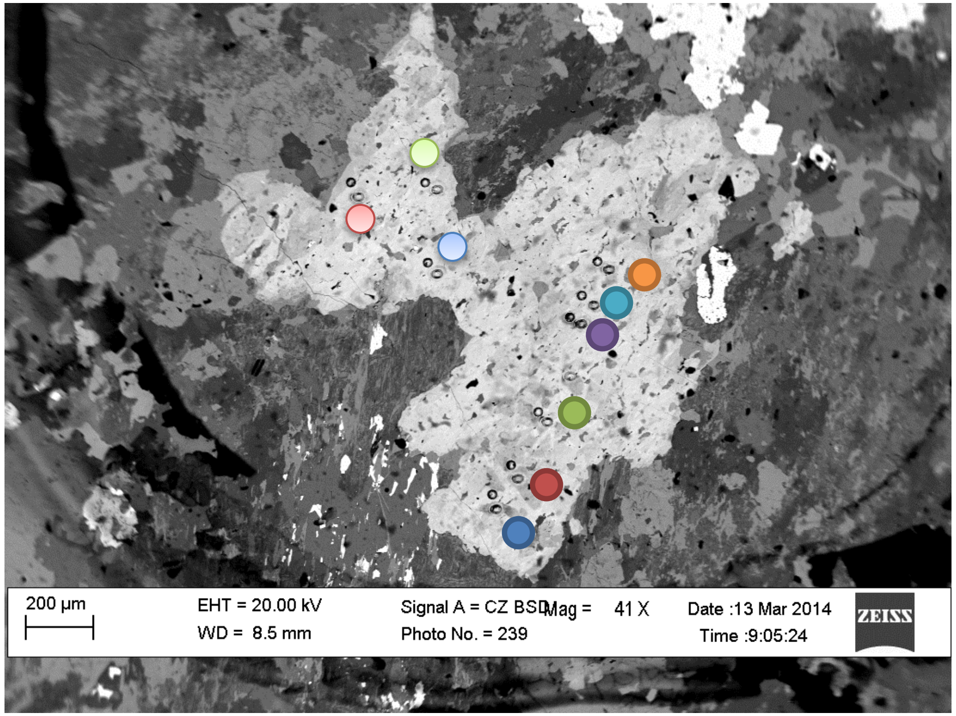
A_127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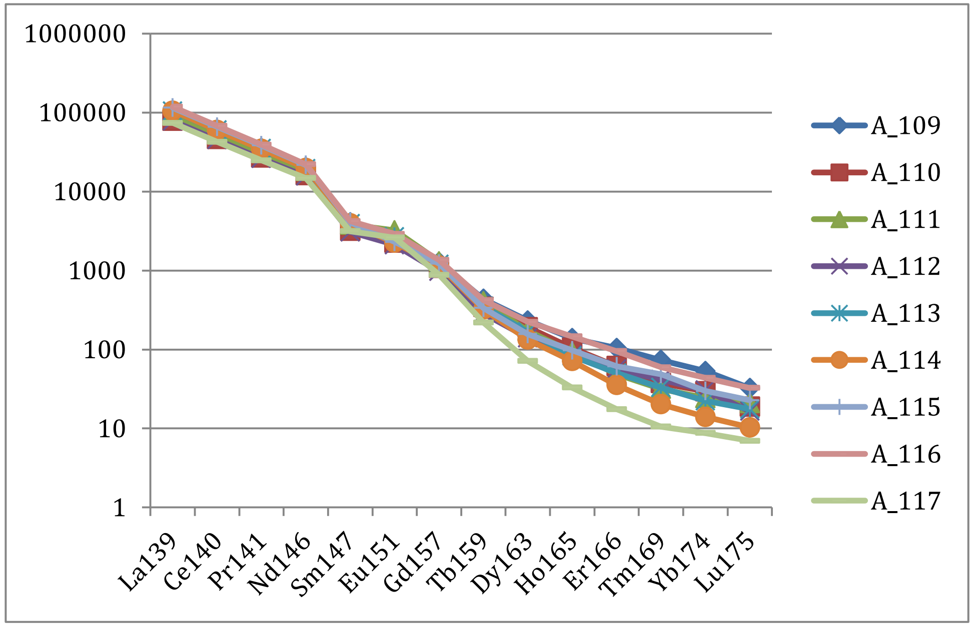
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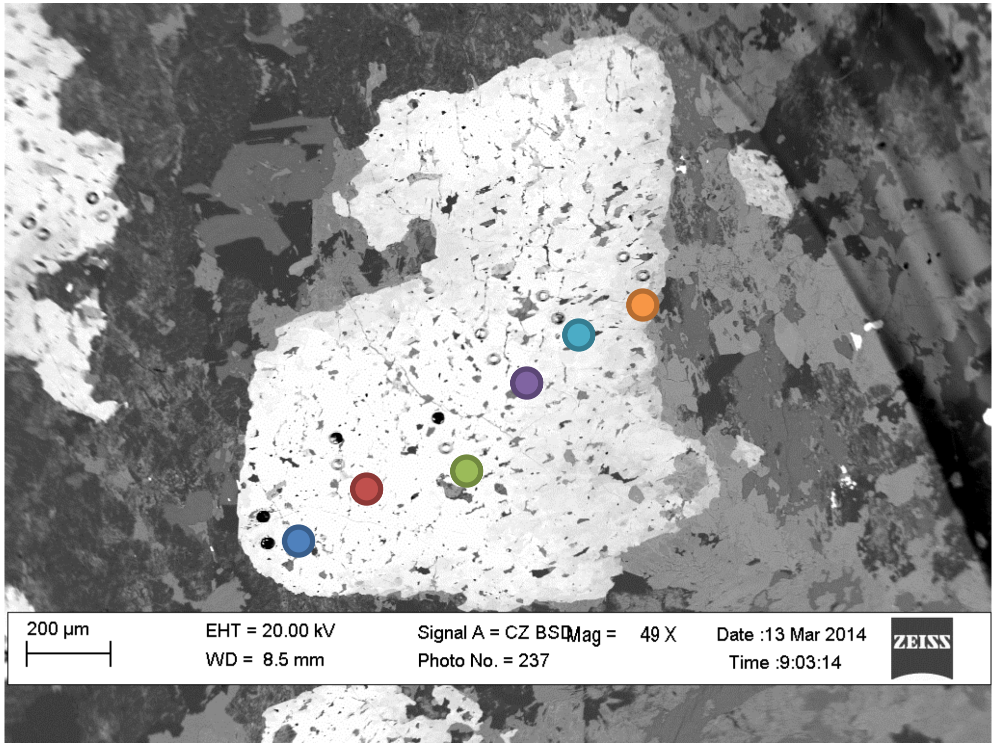
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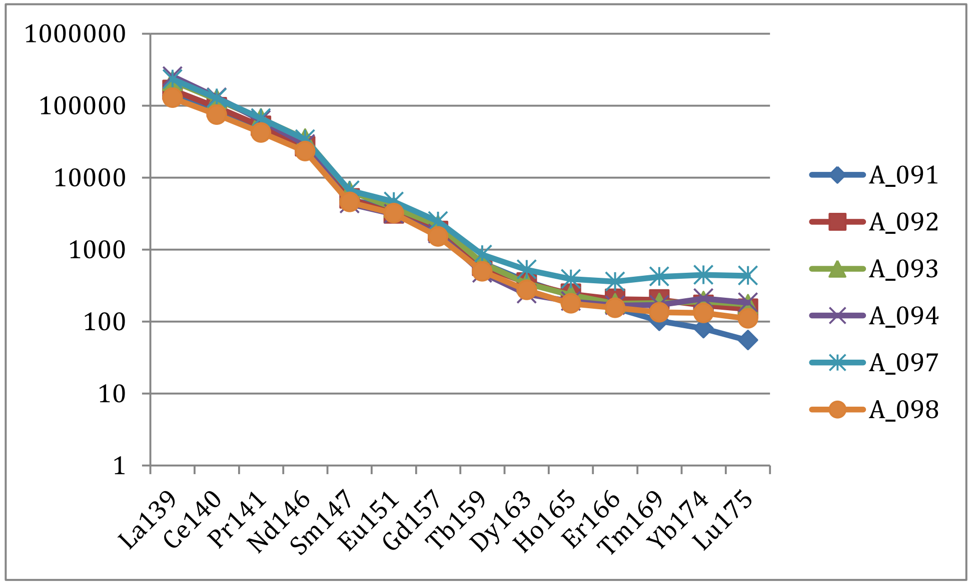
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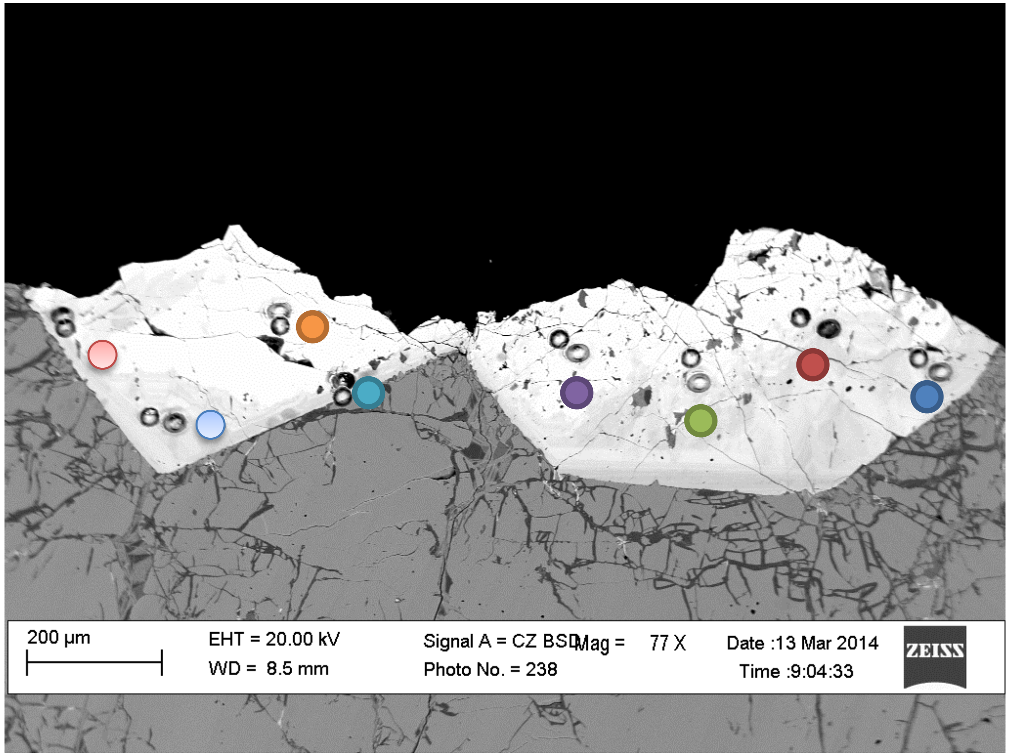
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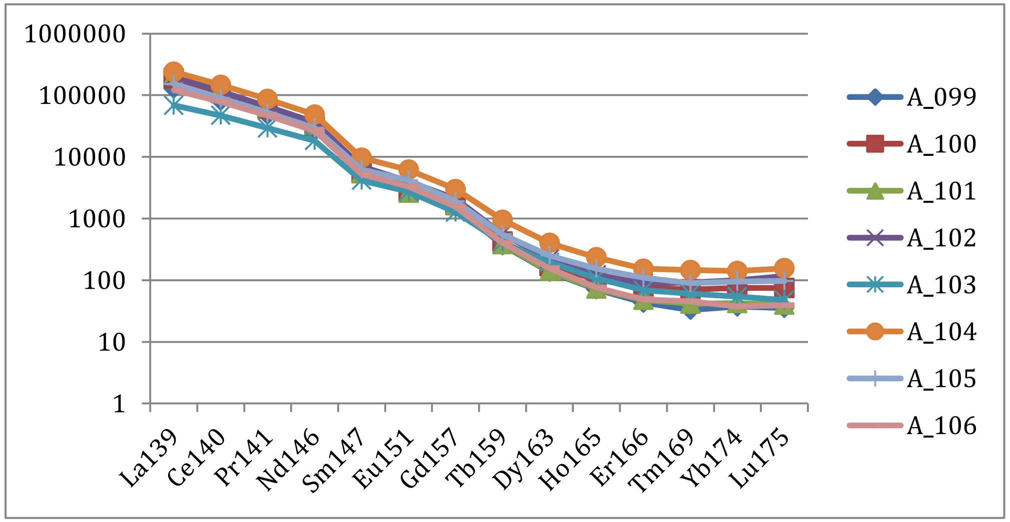
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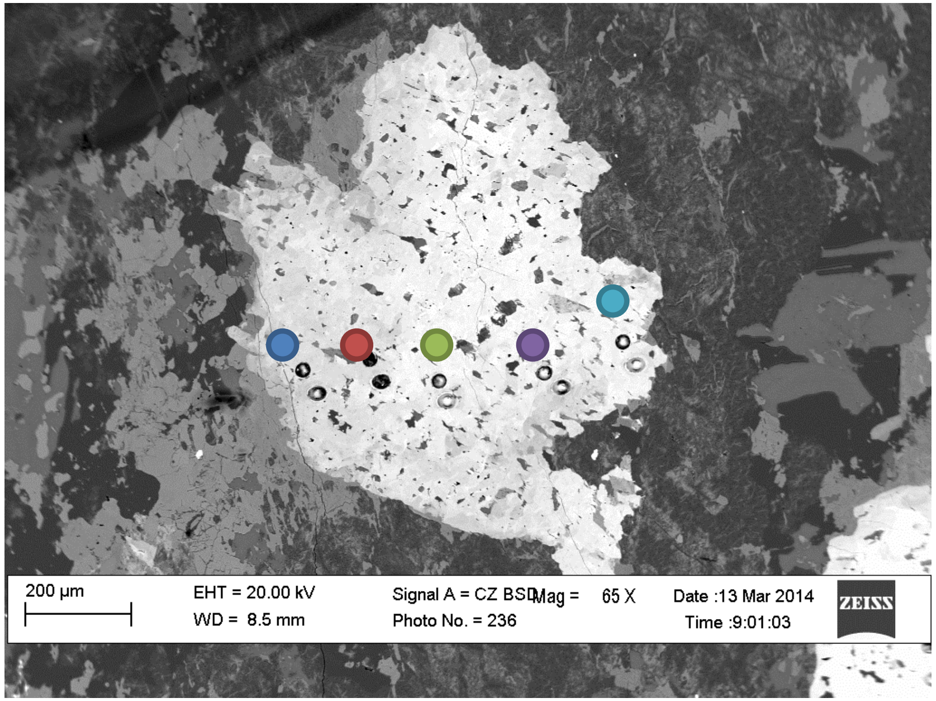
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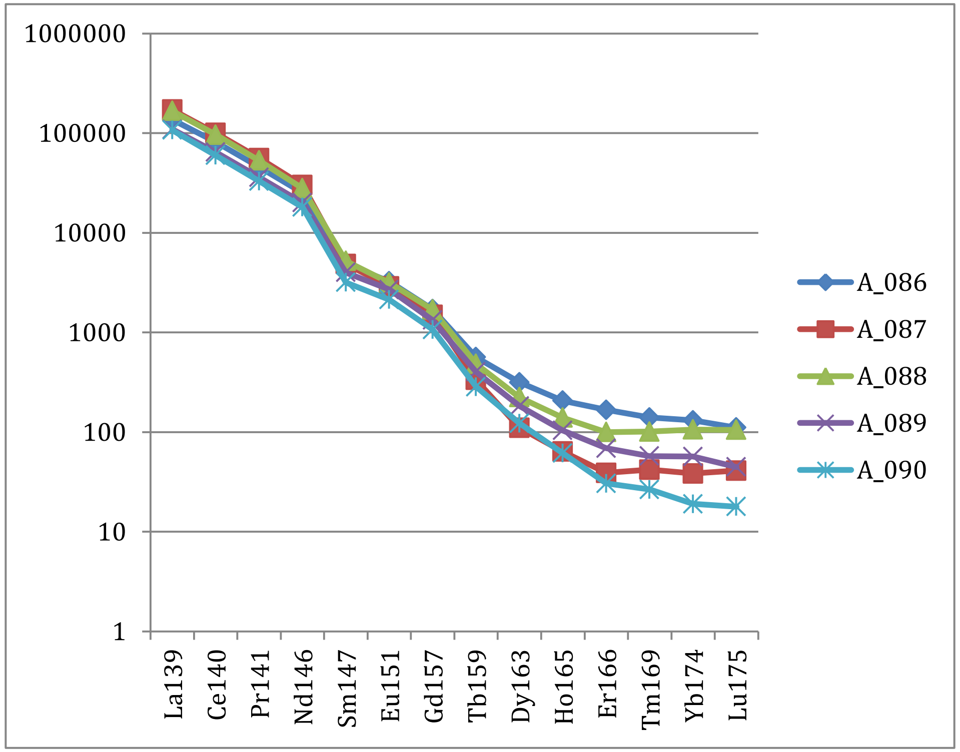
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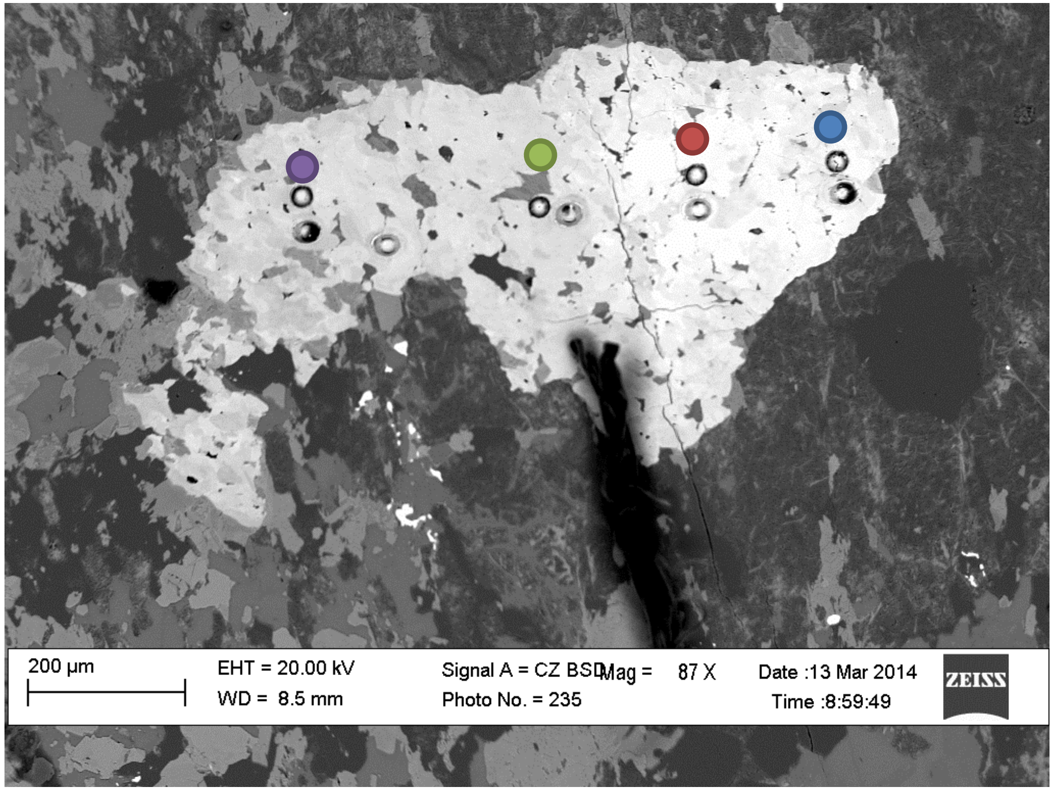
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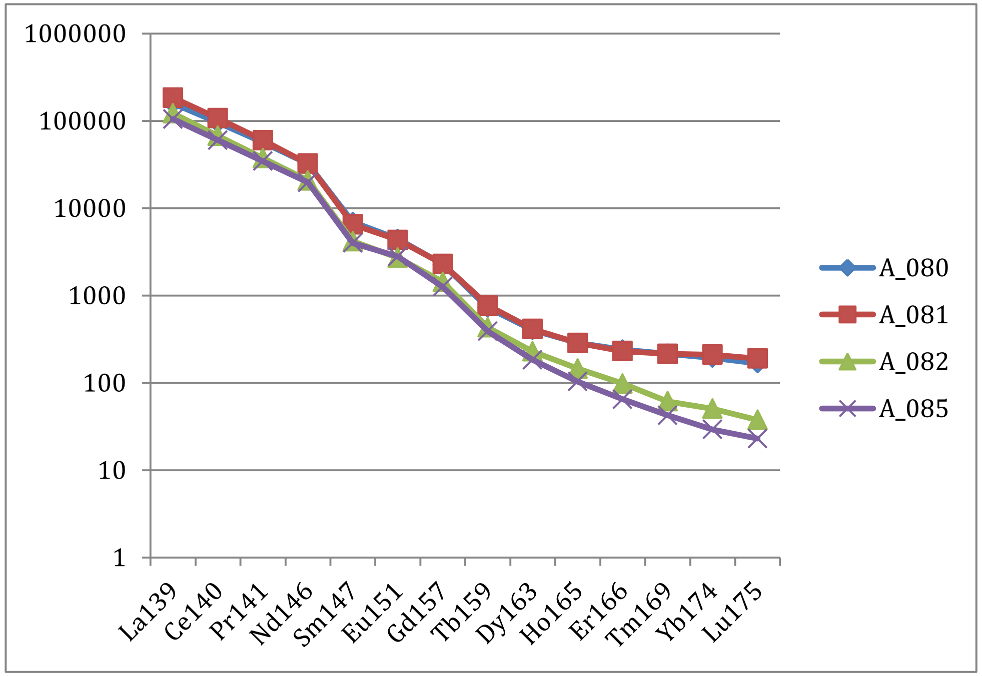
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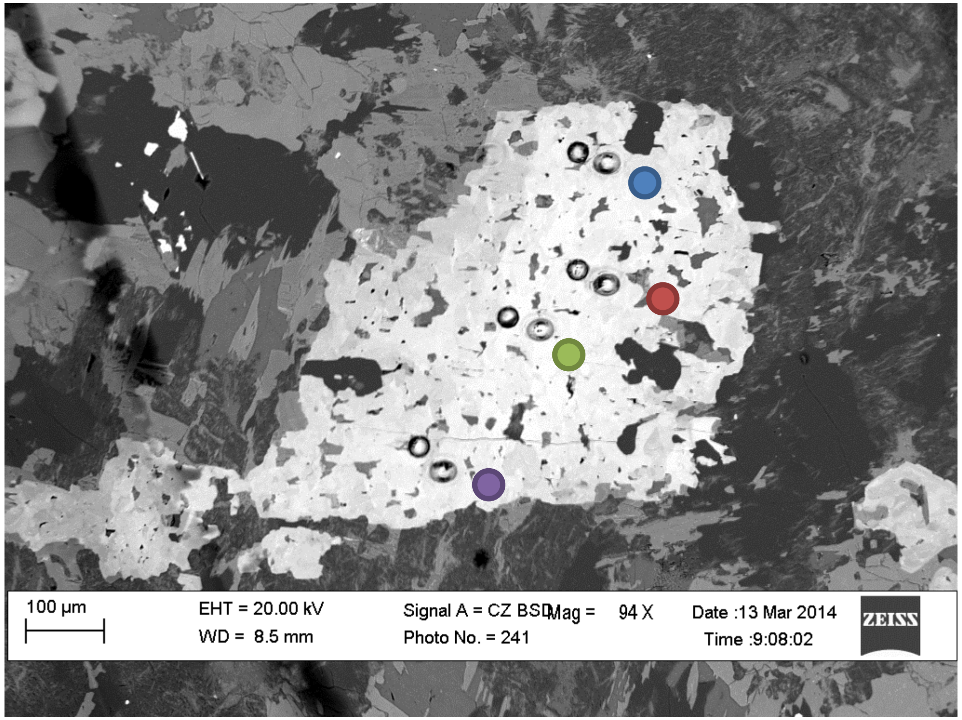
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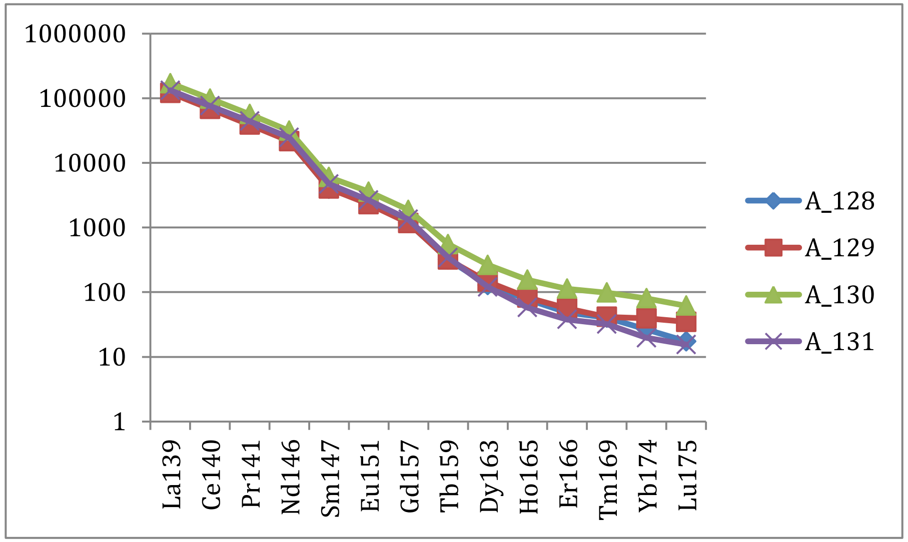
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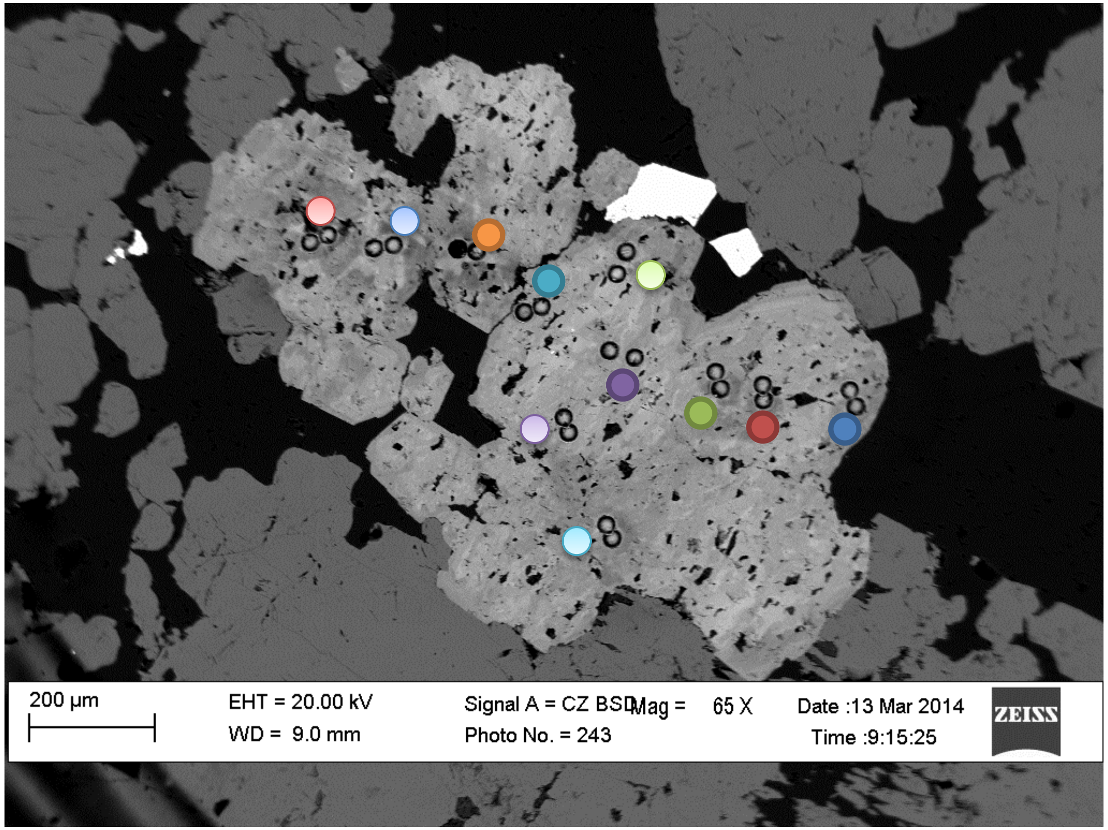
Tm169
Yb174
Lu175
A_128
A_129
A_130
A_131

2.3 E-200

E-200 86.66

Sample	A_007	A_008	A_009	A_010	A_011	A_012	A_015	A_016	A_017	A_018	A_019	A_020	A_021	A_022	A_023	A_024	A_027	A_028	A_029	A_030	A_031	A_032	A_033	A_034	A_035	A_036
Al	83621.58	83621.57	83621.58	83621.58	83621.58	83621.58	83621.57	83621.58	83621.57	83621.57	83621.57	83621.57	83621.57	83621.57	83621.57	83621.57	83621.57	83621.57	83621.58	83621.57	83621.57	83621.57	83621.57	83621.57	83621.58	83621.57
P	720.07	36.28	43.45	47.41	42.17	41.73	51.69	43.64	38.74	40.45	38.31	37.07	41.39	36.85	54.74	37.63	42.28	35.95	37.31	36.97	37.59	36.07	37.28	35.78	34.05	36.88
Ca	3125199.75	141121.36	92031.51	91955.73	122383.48	88926.31	88275.34	100155.23	92173.45	97274.70	90046.49	90521.22	87672.67	92914.89	125966.93	87669.24	89932.55	88903.26	105681.16	88228.66	83849.12	86707.53	93158.55	90564.59	88225.66	90125.73
Sc	91.94	4.95	3.34	3.54	4.43	3.36	3.33	3.67	3.48	3.22	3.14	2.97	3.52	3.10	3.72	3.00	3.14	2.76	2.78	3.01	3.32	2.83	2.92	3.26	2.75	2.73
Ti	2723.84	1245.13	1412.53	1415.08	1245.19	2101.18	2281.74	2374.81	2297.33	1957.32	2468.60	2307.57	2714.61	2532.14	2169.28	2430.78	2134.17	1780.42	1945.59	2140.51	1473.80	1977.21	2686.54	3317.54	1980.28	2344.84
V	1395.11	730.95	624.87	584.00	613.49	419.18	471.09	337.37	245.18	471.26	482.33	304.63	343.97	380.80	426.44	567.74	573.52	534.54	534.88	581.00	539.92	560.22	602.32	735.23	519.94	565.29
Cr	777.02	1.20	1.44	1.54	1.36	1.36	1.70	1.45	1.33	1.39	1.33	1.29	2.40	25.27	4.77	3.30	1.45	1.29	1.36	1.31	1.34	9.11	4.35	1.33	1.27	3.41
Mn	512707.38	12558.41	3306.08	4349.15	9545.72	3655.61	4549.81	4468.92	4413.41	4153.00	4305.32	4600.05	3796.72	4046.82	5005.39	2795.07	2994.49	2299.17	2833.27	2810.49	3299.69	2575.44	4017.49	3959.02	2549.48	2722.62
Fe	2545537.50	103761.54	69663.30	76592.14	100070.15	75442.43	93387.64	75192.52	69078.55	84011.75	83453.73	77729.15	71094.68	77901.00	85752.10	69621.42	72178.16	62438.19	67478.76	67479.18	77334.34	66163.35	81433.62	88058.23	69002.91	69945.77
Zn	15693.37	503.14	288.20	303.68	485.86	380.16	511.50	637.05	832.14	460.07	462.38	645.46	583.61	593.49	695.88	429.87	433.32	417.20	442.24	394.04	347.16	402.88	456.07	455.16	388.80	406.65
Ga	388.42	293.46	299.59	306.69	307.40	319.88	367.51	359.74	313.70	353.90	328.55	333.94	344.13	353.53	353.27	287.59	302.88	279.48	292.15	287.96	284.63	285.08	303.02	324.12	283.72	302.61
Ge	686.86	182.67	164.11	162.64	171.69	168.72	160.02	121.88	105.94	188.69	161.16	109.76	127.48	136.84	157.59	151.23	157.92	147.30	145.43	143.26	133.14	147.53	167.91	195.88	139.99	150.57
Sr	12832.87	4163.81	4728.46	3920.71	3579.58	5994.47	5767.76	7455.93	10311.60	5182.31	6867.14	8802.67	8142.04	7250.09	5693.09	6267.32	5038.85	5235.52	5257.87	5543.28	4490.12	5689.98	5655.30	5313.71	6125.34	5944.30
Zr	29.56	10.95	10.25	8.51	11.93	7.07	7.51	4.55	3.95	6.90	6.77	3.43	4.96	5.02	6.52	5.91	8.21	8.08	7.31	6.51	8.16	6.46	6.22	5.89	4.92	5.11
Ba	471.66	290.35	251.32	252.03	252.06	301.32	342.80	308.08	305.37	335.69	331.41	299.92	297.22	312.53	414.85	278.69	284.45	251.88	261.09	263.86	243.14	255.05	366.39	349.13	274.84	281.74
La	40936.03	46268.26	50318.28	52038.97	48719.97	64423.96	79141.26	75979.25	72350.17	66692.85	72868.54	72874.14	69623.69	74710.79	70432.17	60830.16	61796.87	54373.38	56110.13	57695.88	49017.86	55268.33	66144.93	76910.02	57693.46	61370.32
Ce	35904.24	40815.62	43240.19	45006.23	42858.51	51694.15	57746.63	48322.86	45953.14	55079.20	54883.79	44137.63	47179.05	50076.13	53046.42	47996.20	49158.89	43790.84	44873.87	45054.25	38657.02	44543.31	51797.25	60249.63	44361.99	48335.13

Pr	2879.26	3150.62	3260.10	3345.21	3267.03	3625.75	3756.33	2850.52	2685.08	4100.35	3687.81	2580.16	2885.91	3178.93	3546.20	3376.42	3473.07	3129.03	3180.56	3180.81	2731.29	3180.15	3664.00	4301.37	3104.35	3428.51
Nd	8571.73	9575.73	10010.02	10047.38	10056.49	10265.34	10042.70	6757.96	6299.08	12213.20	10231.75	5819.33	7178.55	7932.06	9817.74	9606.06	10058.72	9005.61	9408.00	9143.26	7832.47	9183.32	10658.19	12424.69	9035.94	9841.74
Sm	707.26	770.82	787.78	771.28	763.03	707.68	643.28	356.98	264.49	837.05	680.19	257.47	394.44	451.12	643.71	637.58	686.05	629.08	646.64	624.49	544.56	643.23	721.42	861.62	587.34	669.07
Eu	228.83	284.09	289.83	298.75	282.94	285.64	305.86	201.88	133.29	292.56	271.67	143.42	184.79	210.60	271.85	215.85	242.40	217.13	226.90	212.65	205.91	218.87	241.82	298.64	209.96	224.29
Gd	311.13	371.43	384.22	380.09	369.07	360.49	350.49	212.36	159.86	385.97	326.93	155.12	210.65	240.82	322.95	292.75	307.66	282.42	294.64	294.07	258.80	289.94	314.32	386.57	273.80	303.54
Tb	21.85	24.68	25.44	24.63	24.78	21.81	21.35	12.52	7.05	23.04	18.97	7.55	11.06	13.38	18.44	15.58	18.08	15.80	16.61	15.78	15.15	16.73	18.02	22.85	15.18	16.78
Dy	72.83	83.24	80.40	77.18	79.63	69.47	65.97	35.74	19.37	66.64	58.51	19.53	33.68	38.15	61.22	43.09	52.43	45.40	45.62	45.45	44.81	46.24	46.82	63.58	44.51	45.14
Ho	10.35	10.59	10.52	9.29	10.47	8.50	8.23	4.49	2.09	7.55	7.40	2.53	4.21	4.53	7.41	4.73	5.98	4.51	5.37	4.78	4.77	4.85	4.91	6.94	4.37	4.72
Er	15.04	15.03	15.19	14.19	14.27	11.29	11.75	6.36	3.39	9.74	10.47	3.92	6.26	6.60	10.04	5.49	6.83	5.63	6.01	5.85	7.03	5.35	7.00	7.91	5.95	6.05
Tm	0.95	0.96	1.14	0.90	1.14	0.71	0.62	0.26	0.15	0.52	0.49	0.25	0.44	0.23	0.50	0.24	0.51	0.36	0.39	0.42	0.48	0.40	0.46	0.45	0.37	0.25
Yb	9.29	2.27	3.43	1.92	1.91	1.20	0.96	0.52	0.48	1.28	1.33	0.57	0.81	0.43	1.12	0.87	1.11	1.11	1.00	1.39	1.86	0.82	0.96	1.32	0.78	0.89
Lu	0.67	0.18	0.10	0.15	0.12	0.07	0.09	0.02	0.00	0.06	0.05	0.01	0.06	0.08	0.01	0.00	0.06	0.06	0.13	0.10	0.06	0.08	0.04	0.06	0.06	0.01
Pb	50.43	1.20	10.36	8.97	12.00	6.39	21.68	6.79	9.72	14.05	9.88	8.18	8.34	7.14	7.72	11.91	11.22	9.24	10.81	10.33	8.66	12.41	12.01	11.49	9.16	11.04
Th	21.75	25.94	25.30	22.58	28.11	9.36	6.23	1.37	2.11	24.23	13.55	2.24	3.62	5.26	15.94	19.34	20.62	18.82	17.26	18.07	15.94	19.82	19.95	23.61	15.30	19.28
U	300.62	333.14	274.20	252.94	250.93	186.98	119.91	116.02	65.50	125.94	198.42	114.46	98.08	109.59	105.87	201.04	225.12	221.00	212.77	222.63	210.54	214.13	176.72	144.46	211.95	199.94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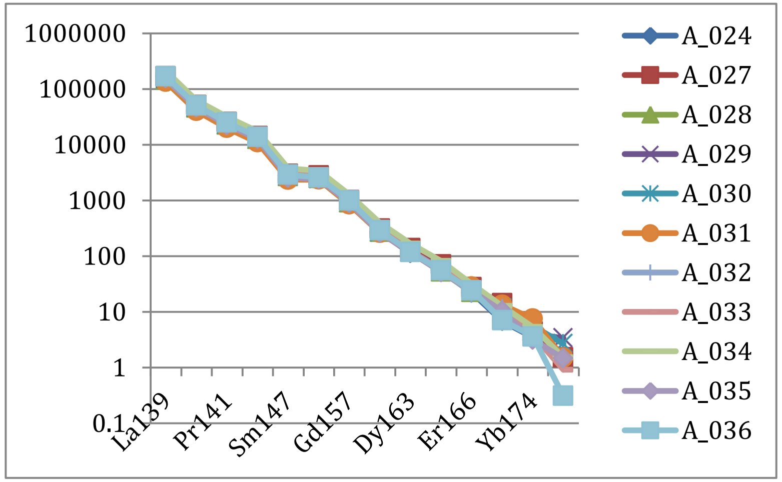
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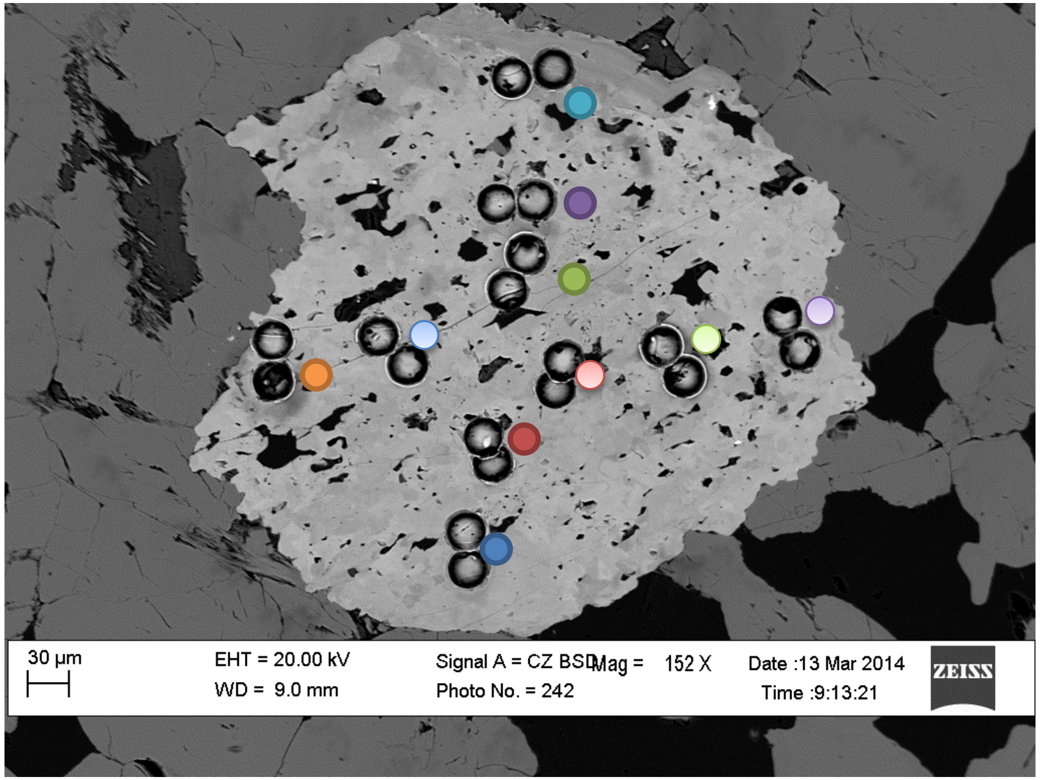
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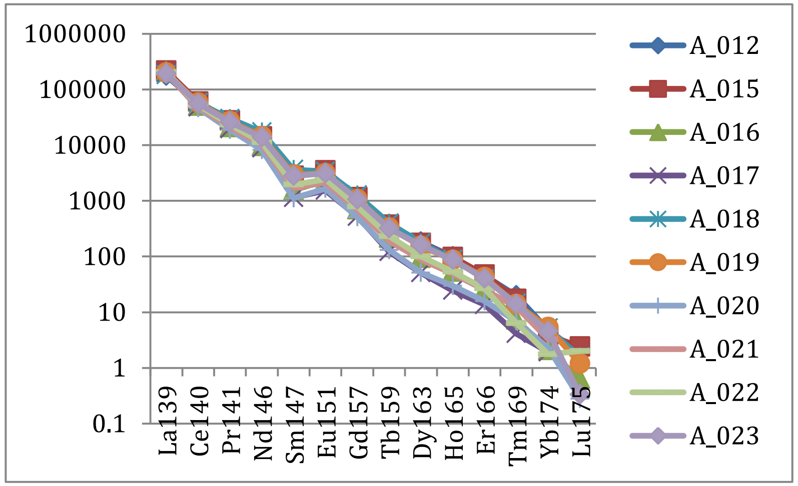
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Tm169
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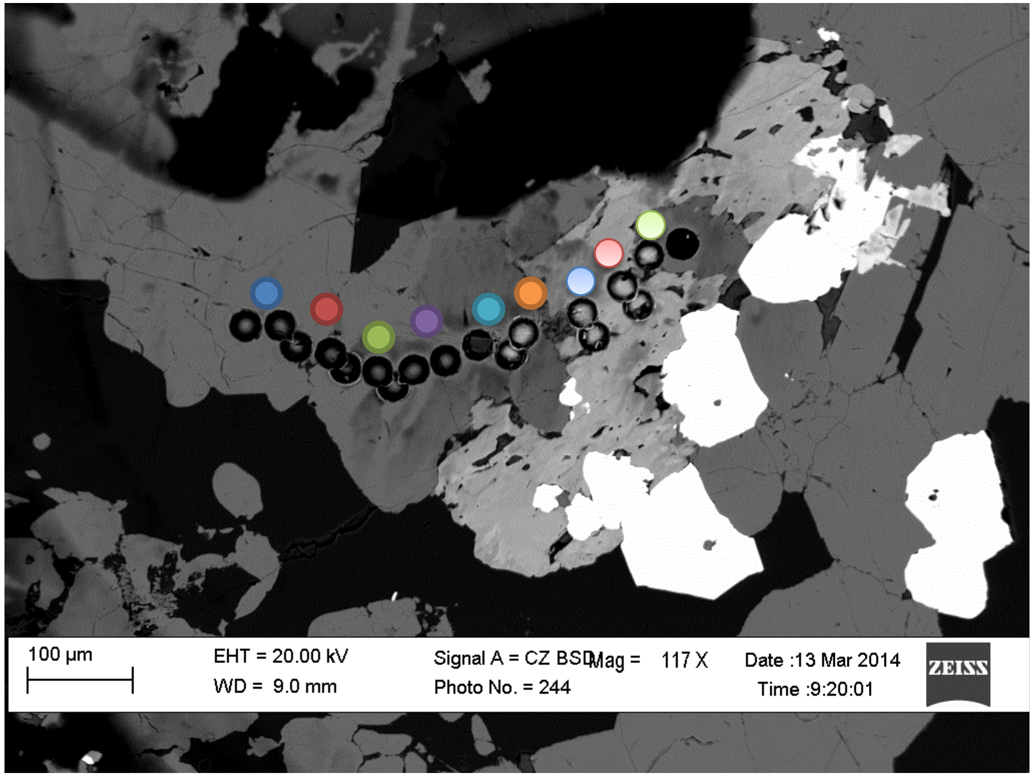
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WD = 9.0 mm
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Date :13 Mar 2014
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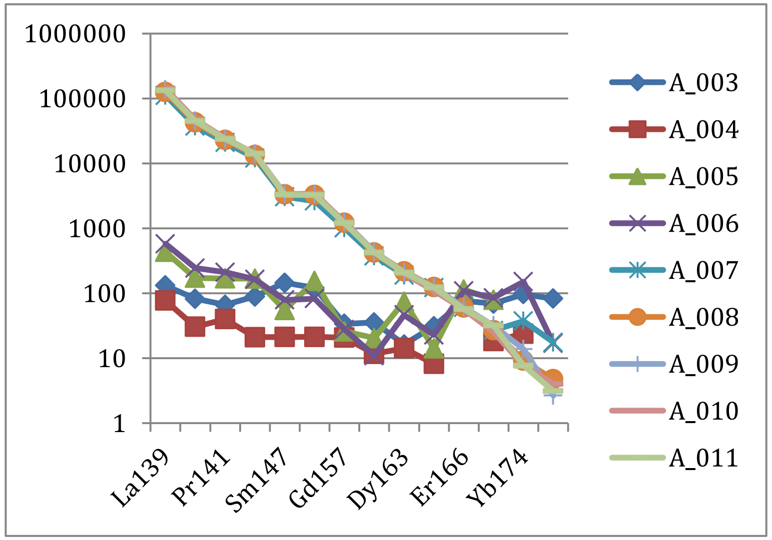
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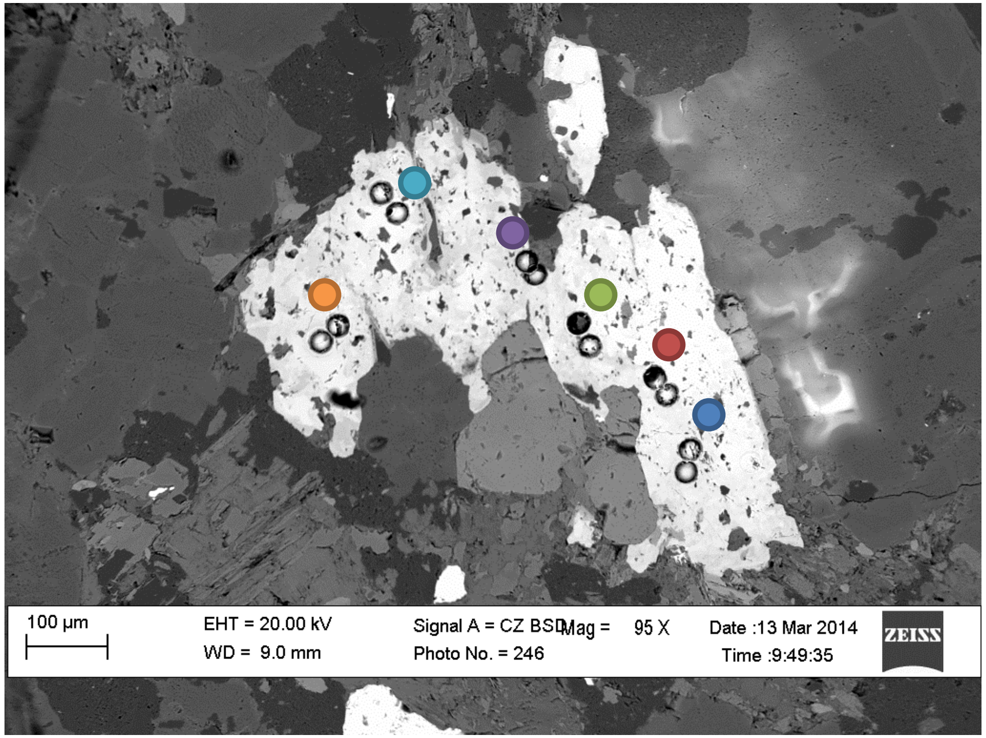
	E-200 304																
Sample	**A_039**	**A_040**	**A_041**	**A_042**	**A_043**	**A_044**	**A_045**	**A_046**	**A_047**	**A_048**	**A_051**	**A_052**	**A_053**	**A_054**	**A_055**	**A_056**	**A_057**
Al	83621.57	83621.57	83621.58	83621.56	83621.57	83621.57	83621.57	83621.57	83621.57	83621.57	83621.57	83621.56	83621.57	83621.57	83621.57	83621.56	83621.57
P	134.18	119.82	133.64	42.88	70811.63	43.61	36.59	114.15	44.15	2679.94	2199.42	981.79	2225.34	2346.57	1163.42	473.38	38.86
Ca	1027016.25	885418.63	979765.88	100060.15	142924.13	101742.07	63640.75	108185.68	94790.72	2064079.25	1993340.88	2255821.25	3202343.75	3554029.50	1609207.50	95143.02	91964.97
Sc	75.95	53.05	51.85	166.50	171.68	144.08	105.11	226.62	297.75	2211.99	538.61	1034.28	3104.98	1332.53	389.85	73.15	269.15
Ti	811351.88	748504.69	781059.19	12290.32	10785.00	10382.69	2639.81	13019.24	11991.97	2729875.00	1927795.50	2183079.00	3429521.50	4635778.50	1566042.50	2138.20	3646.09
V	13325.00	11790.82	12876.71	1110.05	1152.34	1146.87	597.29	1525.99	1049.44	6998.63	6824.65	6589.35	8552.92	11314.29	12590.50	1756.53	411.25
Cr	183.56	383.60	353.83	131.73	<3.95	41.84	25.64	40.12	17.53	1122.37	408.46	794.27	1397.11	1416.08	551.62	233.00	57.63
Mn	13607.32	2836.54	15754.70	6065.40	8344.99	7917.08	6825.26	9757.66	11199.99	381995.31	19316.73	30123.53	63205.45	325526.47	17021.47	4910.71	5872.01
Fe	52833.04	44790.38	64827.92	114404.61	125519.19	140394.55	105596.09	167021.67	139894.27	398756.09	112766.08	134120.44	269009.69	893244.56	99696.94	75684.38	82427.34
Zn	15.50	14.20	17.74	331.20	384.18	1401.33	266.14	514.20	356.75	151.37	38.28	27.19	465.38	2934.38	293.11	251.64	360.95
Ga	67.59	50.64	69.36	236.96	439.81	238.84	150.55	278.49	252.49	130.24	77.49	91.43	304.26	123.29	81.43	218.02	170.93
Ge	216.75	179.86	184.71	501.44	1087.99	480.00	209.82	630.65	518.48	285.46	932.91	912.04	762.24	604.49	295.53	250.89	367.24
Sr	2003.40	766.80	1845.32	1693.73	1993.45	2096.34	2141.41	1482.70	2242.91	9747.95	763.40	2842.69	19718.82	10851.52	6133.56	3926.02	3509.10
Zr	7155.40	4603.04	3242.30	4.09	4.47	8.60	9.37	4.20	10.43	3326.87	3793.26	2816.02	12590.44	5854.78	1283.29	11.18	7.15
Ba	150.45	17.50	217.78	625.97	1485.30	694.00	251.30	812.12	826.40	656.11	272.28	326.13	1569.07	204.12	103.07	821.03	508.69
La	924.98	723.48	917.46	66240.09	161296.03	62648.24	27898.39	85635.22	67858.37	12814.71	12652.32	17537.22	64095.28	14900.52	7227.04	35900.50	45932.03
Ce	4533.02	3711.15	4068.79	124452.14	294157.44	119174.08	51007.61	161387.45	126525.66	23709.77	62509.27	72987.08	122493.32	40158.38	16533.18	58615.11	83690.43
Pr	1049.38	892.14	874.15	12333.61	28064.55	11657.12	4990.16	16174.81	12596.53	2345.81	13285.97	13435.50	12736.90	4981.17	2562.29	5497.65	8563.51
Nd	7743.01	6348.23	5614.91	39533.25	86430.11	37050.80	15759.16	51031.40	40847.73	7660.21	70990.52	64917.43	38888.77	17217.96	11446.65	17462.20	28723.22

Sm	3478.29	2719.56	2181.50	3854.51	7731.07	3413.83	1462.05	5006.04	4122.63	832.66	18507.86	14993.90	3702.50	2055.63	2522.45	1448.75	3225.32
Eu	833.48	746.09	612.84	301.48	823.65	291.97	150.49	445.50	366.81	229.25	3177.06	3393.58	512.39	304.70	636.00	245.35	301.00
Gd	3058.56	2250.17	1859.58	1670.20	3487.49	1408.14	605.71	2113.63	1823.26	566.64	14518.79	11815.30	2221.09	1208.01	1890.55	569.48	1324.89
Tb	410.48	306.34	257.58	129.62	292.79	99.88	44.18	164.45	151.64	83.34	2200.52	1979.03	311.85	169.09	279.96	36.80	98.22
Dy	2276.01	1699.75	1414.62	423.37	1124.68	315.00	132.90	545.52	552.08	481.03	13365.16	12207.95	1887.69	1072.58	1556.46	106.15	319.18
Ho	423.21	306.35	266.72	53.27	162.11	41.43	16.25	70.38	73.52	102.52	2574.52	2483.68	380.36	219.26	286.93	13.79	37.95
Er	1118.19	794.82	687.12	101.33	335.75	72.42	27.59	132.63	142.82	280.66	6766.23	6765.33	1013.17	659.47	758.11	24.45	66.01
Tm	145.43	106.21	97.15	11.52	35.77	8.38	3.10	14.20	17.07	52.81	919.17	935.96	155.33	97.52	99.23	2.55	8.18
Yb	889.69	603.04	598.07	75.90	170.35	55.06	18.25	89.38	118.72	387.58	4972.38	5436.90	953.72	663.36	588.57	16.13	48.27
Lu	86.50	60.19	58.04	10.52	18.29	7.92	2.52	12.55	16.44	48.91	463.38	579.01	122.43	68.96	64.64	2.68	7.51
Pb	19.65	12.41	295.45	386.85	575.15	207.73	94.31	247.54	249.16	183.84	141.56	141.00	274.59	125.20	51.30	395.59	193.48
Th	179.25	185.42	195.91	4309.03	11544.14	3383.71	1418.01	3797.34	4304.64	615.23	2363.72	1830.05	3948.02	195.25	298.15	7085.62	3507.33
U	1610.08	887.83	861.21	92.78	302.66	56.34	68.80	90.50	108.06	7784.95	1040.51	1775.75	2888.47	577.23	1192.55	309.34	59.30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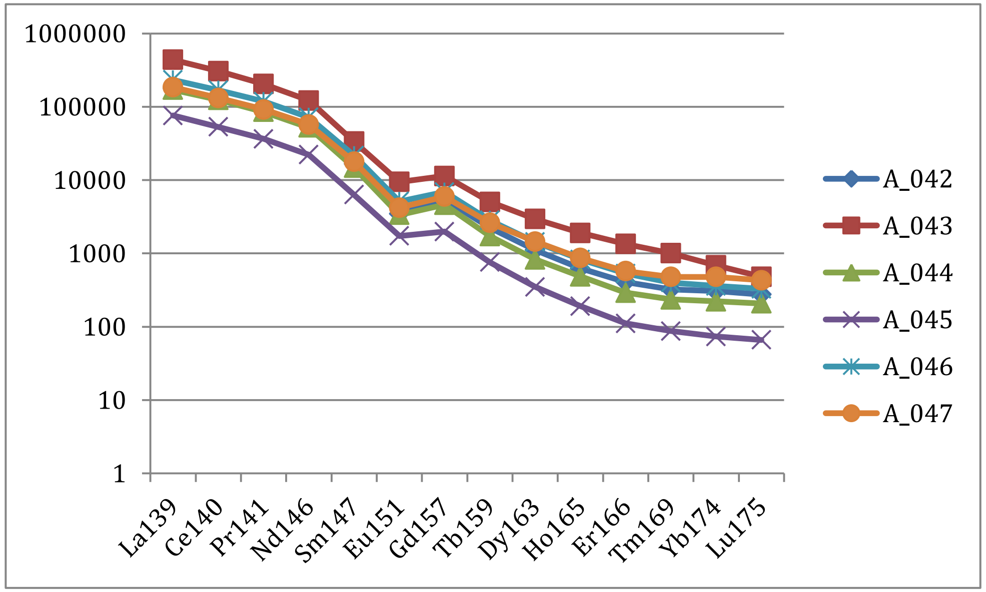
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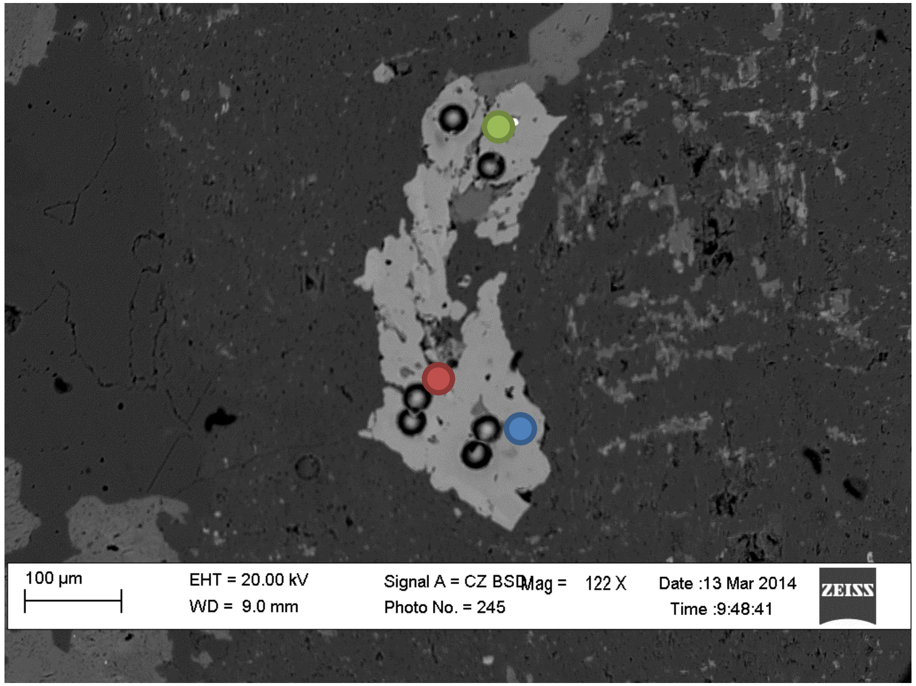
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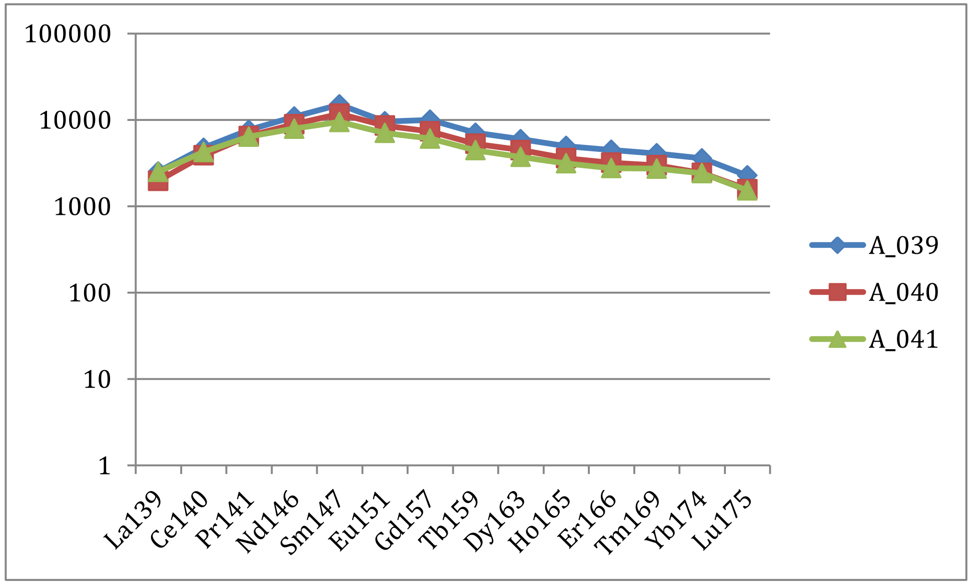
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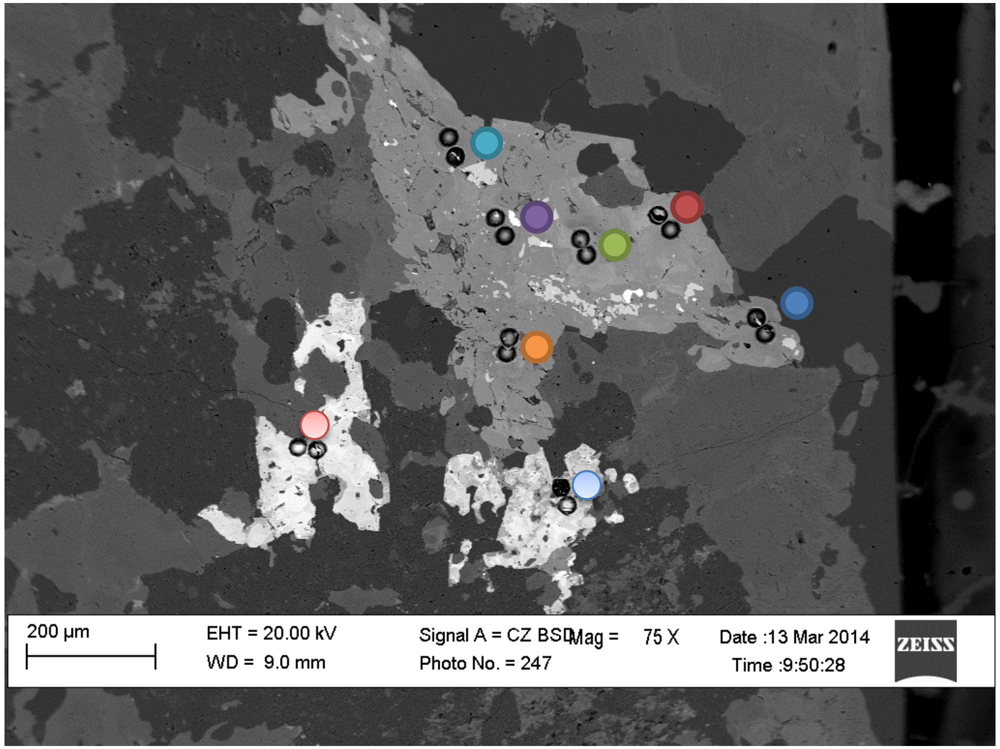
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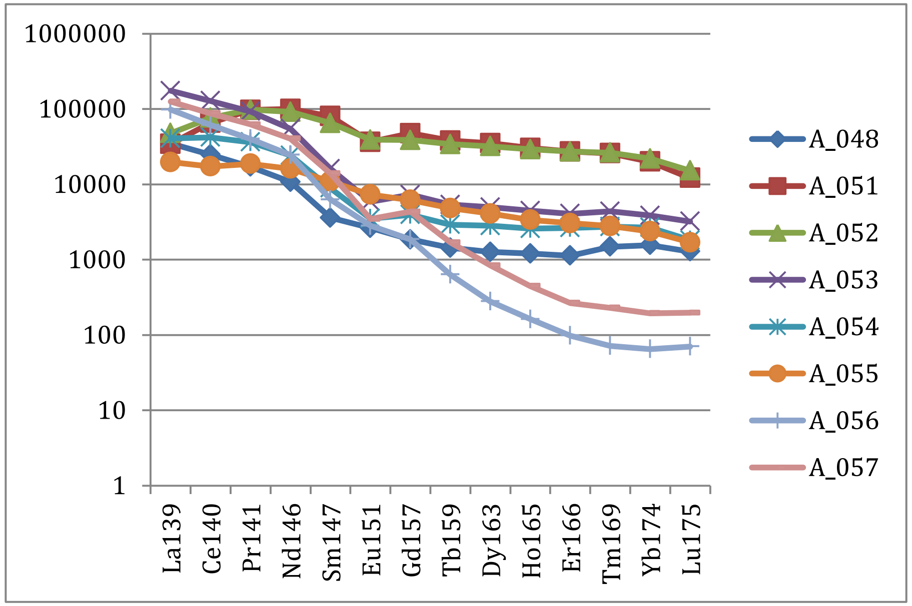
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A_057

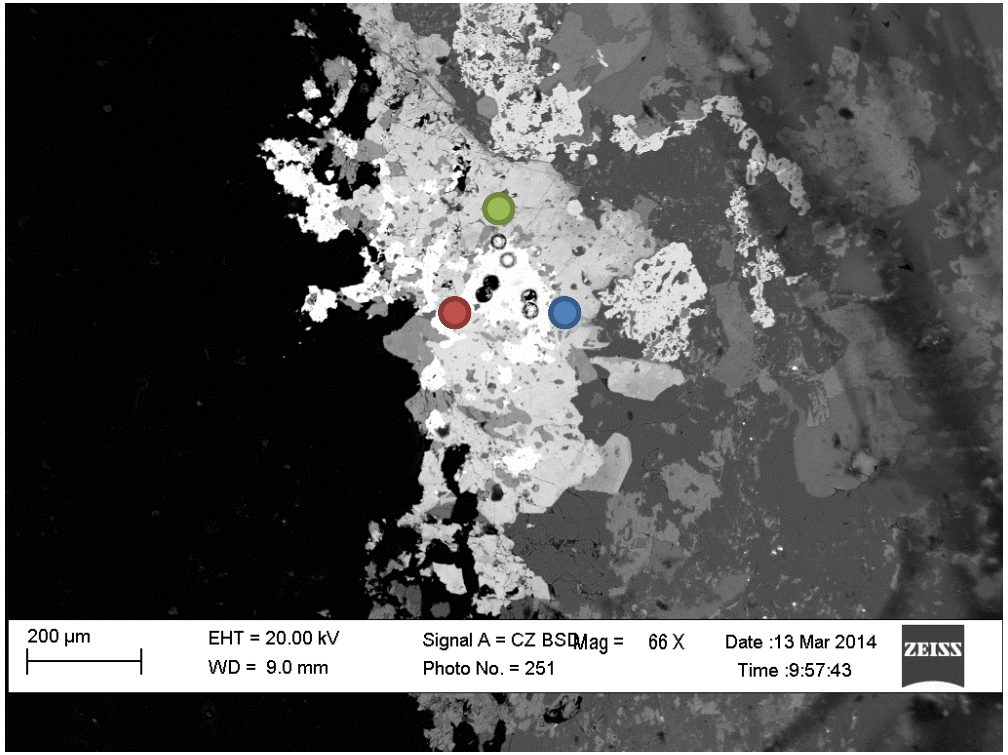
E-200 293

Sample	A_058	A_059	A_060	A_063	A_064	A_065	A_066	A_067	A_068	A_069	A_070	A_071	A_072	A_075	A_076	A_077	A_078	A_079	A_080	A_081
Al	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56	83621.56
P	32.82	38.20	42.06	39.67	36.42	42.27	34.57	34.99	90.20	33.11	48.86	36.54	43.07	36.44	42.21	34.80	32.14	34.84	37.10	39.70
Ca	88601.38	106035.77	120419.35	106873.04	115015.31	116384.97	99798.41	116963.33	102796.82	111368.66	100545.22	116207.48	105785.77	105858.27	109258.41	118556.92	116265.11	105447.48	89599.07	130816.03
Sc	6.26	5.22	4.93	6.24	5.40	6.24	5.34	4.60	6.73	54.11	320.19	145.05	23.43	12.54	19.75	35.48	11.73	6.30	5.39	5.65
Ti	1094.28	3001.71	3265.44	4691.22	1701.05	4255.40	3058.87	733.52	987.43	4447.55	13114.63	6360.42	2743.78	2265.24	5692.22	5428.02	640.26	1437.61	3674.46	5310.35
V	2082.42	2518.78	2525.77	3152.35	1984.16	2797.16	2409.23	933.29	1354.86	1021.46	5138.42	3279.15	2709.86	2270.22	3728.50	3347.68	573.76	2017.62	2254.51	3139.41
Cr	45.76	59.27	54.40	53.07	44.25	57.74	52.02	29.37	39.67	113.30	203.41	194.25	46.11	42.29	48.78	68.65	15.26	52.62	20.79	18.71
Mn	2908.76	5283.53	4612.15	9609.42	4039.81	6203.46	5423.03	2537.41	3550.12	3300.40	10979.67	7701.79	5483.21	6176.75	7282.76	7899.83	1864.56	4876.63	4007.99	6070.99
Fe	63097.93	116087.70	115848.34	135487.55	102447.56	133895.80	121154.88	79831.83	82148.74	82183.19	137237.38	109737.19	98777.92	98892.98	133710.61	106278.32	70802.98	87975.89	83787.86	141500.88
Zn	203.04	199.36	161.30	302.88	207.63	212.55	211.62	179.60	275.48	196.54	372.37	293.47	246.44	252.08	268.51	323.43	123.01	298.31	243.21	217.11
Ga	292.01	208.31	254.53	243.98	218.75	228.02	213.99	177.28	241.08	220.55	369.82	306.65	280.27	281.78	284.25	303.50	191.31	293.51	307.42	275.85
Ge	237.43	360.94	450.43	448.20	223.67	404.41	354.27	177.17	217.03	213.55	554.88	344.55	279.56	285.59	431.02	329.07	126.49	253.80	310.08	411.09
Sr	2141.52	2378.41	2920.29	659.07	3674.62	2470.17	2748.51	5305.05	3543.12	5459.48	810.12	2638.46	3528.11	2985.60	1837.90	2428.75	8694.01	3085.42	2630.78	2703.39
Zr	5.80	6.28	6.23	5.15	10.54	5.60	5.12	11.04	9.21	34.33	5.85	9.55	10.87	9.80	4.61	12.08	28.68	8.63	8.50	8.90
Ba	225.58	384.91	648.39	501.29	258.71	467.06	406.09	180.45	211.40	310.55	720.33	438.81	328.82	312.14	529.34	403.33	123.73	256.11	365.81	481.14
La	28336.92	47982.70	61707.01	63448.82	27551.35	57754.18	49992.29	20769.17	26573.03	27666.44	94952.34	57538.51	43518.63	40060.64	69871.27	53737.77	14940.60	33599.71	47965.04	65066.89
Ce	48038.54	80508.51	102673.59	104112.52	45701.23	95197.31	80869.05	34989.09	43589.11	46384.91	154399.88	90971.14	67819.19	64720.87	110630.40	82985.02	23615.65	54175.98	73890.33	99377.05
Pr	4686.03	7852.99	10268.85	10205.99	4370.74	9235.44	7783.19	3462.28	4300.51	4500.97	14092.92	8190.45	6250.24	6182.19	10487.24	7815.10	2199.54	5196.89	6982.29	9296.40
Nd	15795.20	26312.96	34266.83	33515.06	15010.62	30754.16	25845.50	12025.89	14287.60	14437.42	43047.34	24961.25	19326.03	19929.29	33750.59	22788.25	7087.36	17204.18	22865.97	29786.25
Sm	1374.23	2336.49	2982.31	2777.22	1342.41	2555.30	2157.34	1080.10	1261.23	1217.00	2935.28	1781.94	1442.88	1608.31	2591.95	1619.90	614.45	1536.98	1909.52	2421.90
Eu	201.44	346.64	444.38	377.21	233.41	365.45	312.94	204.13	209.21	190.37	308.03	242.47	228.20	262.62	333.24	255.24	163.72	264.21	296.65	365.67
Gd	567.62	892.24	1174.83	1027.97	544.99	961.61	813.48	439.99	474.45	464.14	993.39	644.38	552.97	632.50	930.54	620.83	255.09	645.64	773.41	954.53
Tb	36.85	57.48	74.00	61.40	37.27	61.37	52.39	32.79	29.99	29.36	57.58	39.31	35.25	41.12	52.20	40.32	21.19	44.20	50.96	58.33
Dy	113.93	177.42	233.83	185.14	121.43	185.98	151.92	109.98	81.60	85.51	164.15	123.47	120.40	131.51	149.87	136.66	72.20	133.87	160.20	177.20
Ho	14.17	21.01	28.69	22.02	15.70	22.02	19.26	13.78	9.20	11.22	21.44	16.71	16.59	16.17	17.26	19.45	9.48	16.52	19.47	23.78

Er	24.98	37.86	50.82	44.45	25.16	38.74	31.78	23.38	12.78	17.79	53.57	32.40	30.95	32.74	32.23	37.53	15.00	27.43	35.34	41.62
Tm	2.60	4.58	5.09	5.73	2.37	4.34	3.12	2.48	1.42	2.01	9.89	4.53	3.65	3.67	3.74	4.58	1.26	2.64	3.73	4.30
Yb	14.43	27.17	28.20	38.10	15.20	24.12	18.56	13.11	7.92	19.76	99.84	43.88	29.62	23.48	28.61	32.52	7.78	16.21	19.45	23.52
Lu	2.03	3.19	3.43	5.40	1.88	2.67	2.13	1.49	1.04	4.60	23.66	10.29	5.13	3.77	4.77	5.30	1.10	2.28	2.58	2.83
Pb	29.70	54.95	57.93	68.16	41.33	67.08	53.54	32.69	30.87	49.45	141.06	73.37	46.63	46.55	80.01	59.86	26.88	42.49	63.38	51.95
Th	449.15	822.58	1156.87	1016.24	464.74	1034.30	792.63	393.67	326.19	582.73	2324.14	1051.95	584.11	621.18	1222.55	880.94	236.84	470.34	661.60	720.87
U	311.23	161.21	418.85	127.48	293.97	256.02	190.11	375.41	253.11	448.43	82.76	254.89	351.74	335.68	110.85	342.98	501.47	279.28	309.53	896.16

	E-200 293 continued																
Sample	**A_082**	**A_083**	**A_084**	**A_105**	**A_106**	**A_107**	**A_108**	**A_111**	**A_112**	**A_113**	**A_114**	**A_115**	**A_116**	**A_117**	**A_118**	**A_119**	**A_120**
Al	83621.56	83621.56	83621.56	83621.55	83621.55	83621.55	83621.55	83621.55	83621.56	83621.55	83621.55	83621.55	83621.55	83621.55	83621.55	83621.55	83621.55
P	35.90	39.69	31.14	2033.45	1469.29	12824.89	31.22	31.68	37.17	31.47	37.27	26.52	25.76	28.66	29.57	70.35	27.58
Ca	110316.30	101287.66	89815.47	2691343.50	783127.00	218965.42	88401.63	99190.77	120632.77	87830.28	96367.52	54094.47	90174.16	84435.33	86742.52	100292.03	91202.87
Sc	5.27	5.69	6.55	658.64	242.22	27.00	4.81	4.86	5.12	5.00	4.69	4.04	5.53	5.31	4.90	5.06	5.60
Ti	3008.56	4019.34	3829.07	9579325.00	3167639.75	301141.91	4255.66	6479.24	5783.55	5200.32	3703.96	1096.22	1440.82	4777.21	4494.54	2912.00	5334.94
V	2432.68	2470.26	2199.53	66250.71	21190.31	4615.83	2376.56	2686.45	2765.70	2705.07	2261.54	1444.80	2063.54	2656.71	2594.80	2075.31	2661.09
Cr	43.17	35.86	39.73	3782.11	1445.65	149.51	55.94	54.31	64.07	65.30	73.42	33.08	58.65	62.79	69.29	43.90	67.03
Mn	5373.46	4498.05	5054.81	810162.94	301926.06	25955.48	3406.94	3887.88	5373.13	3959.34	3987.46	4883.13	2652.14	3458.60	3665.81	3507.61	3899.33
Fe	104166.97	103418.64	83001.70	6670712.00	2325894.75	282116.53	80215.74	87041.92	92325.73	91240.70	93994.00	102697.98	65921.23	90964.18	89882.09	77703.32	90892.91
Zn	227.44	189.91	196.37	5961.30	1403.51	394.08	225.98	211.67	237.44	264.80	231.90	174.62	223.70	210.45	231.94	268.58	239.44
Ga	254.47	225.69	213.98	27605.51	9634.72	1093.12	271.30	273.32	266.75	272.52	253.56	208.08	293.81	254.43	270.40	248.37	265.08
Ge	306.42	328.48	265.85	62736.28	21741.32	2247.86	296.57	336.67	344.01	351.21	306.32	157.32	252.59	318.47	329.80	261.99	356.03
Sr	2844.81	2643.84	2200.29	339234.38	111625.47	9153.97	1988.32	2049.04	1809.68	1790.50	2745.06	1954.40	2383.21	1477.43	2532.95	2832.70	1794.56
Zr	8.88	7.13	6.53	210496.67	83706.92	5653.26	5.73	6.81	5.35	5.27	8.29	4.52	6.81	5.93	5.48	6.64	5.24
Ba	342.32	426.15	332.84	88624.75	32259.34	3139.92	344.69	401.67	416.49	405.87	354.26	172.87	258.11	397.00	379.70	287.03	405.07
La	45081.66	53849.58	43573.15	0.00	4191304.00	403045.09	45248.45	51683.46	54509.55	53207.09	45741.41	19759.58	32739.69	51004.07	49732.98	36423.70	55432.06
Ce	71365.48	84151.03	66895.59	0.00	6424000.50	596715.69	72671.34	82370.40	87867.63	84566.75	72980.77	33314.85	53846.84	82522.16	81074.79	58353.45	84090.34

Pr	6816.45	7917.37	6303.66	1712299.25	601891.06	55341.35	6904.92	7844.35	8365.93	8027.53	7062.13	3352.48	5227.70	7927.14	7623.89	5785.43	8301.67
Nd	22288.31	25743.24	20210.82	5437465.50	1920890.00	176760.73	22907.00	25555.60	27480.71	26286.60	23345.86	10795.53	17682.26	26244.71	25380.80	19065.77	27277.21
Sm	1912.92	2120.83	1671.58	387957.66	139848.91	13582.87	1902.55	2063.88	2258.47	2172.52	1970.42	985.88	1625.33	2130.17	2101.23	1701.73	2205.06
Eu	291.12	314.41	255.86	66393.31	23833.05	2219.52	294.19	309.01	322.25	327.07	324.49	161.06	236.64	234.08	313.10	266.74	336.79
Gd	752.70	808.14	648.71	142529.50	51843.11	5320.34	710.59	781.59	823.33	793.27	751.80	386.68	653.94	779.87	810.53	653.39	822.82
Tb	50.41	52.54	42.04	8776.92	3270.60	371.88	43.76	46.91	50.17	49.13	47.84	28.00	42.85	46.44	50.03	42.29	48.42
Dy	156.88	163.84	125.10	27510.17	11179.96	1283.85	136.26	138.36	150.41	143.68	147.37	89.13	139.06	140.45	150.81	133.58	148.04
Ho	19.61	18.57	14.92	3820.24	1568.31	191.23	16.26	17.38	17.39	16.91	18.07	11.27	17.39	16.65	16.88	15.61	16.80
Er	37.00	36.13	27.77	8498.06	3793.69	449.47	32.26	29.81	32.03	29.99	30.91	19.15	28.99	30.89	33.38	27.58	31.27
Tm	3.65	4.01	2.88	1161.45	589.04	65.11	3.22	3.46	3.70	3.68	2.91	1.82	2.88	3.34	3.35	2.88	3.21
Yb	22.65	19.54	18.05	8115.08	4227.34	459.59	18.87	19.87	17.97	17.19	18.22	9.80	17.20	18.68	19.07	14.89	19.41
Lu	2.85	2.42	2.17	952.67	560.09	61.41	2.21	2.21	2.10	2.26	2.11	1.23	1.97	2.53	2.25	1.80	2.10
Pb	49.99	55.05	39.01	42872.63	16281.71	1014.69	40.33	43.59	54.01	45.55	48.01	46.23	35.17	46.80	47.23	37.48	52.64
Th	676.34	733.96	571.87	202651.03	93255.58	12695.43	675.30	664.14	767.62	693.49	661.37	314.32	494.04	819.78	736.70	553.52	799.10
U	225.60	183.49	111.30	110882.14	41830.39	5243.18	272.70	291.14	200.95	186.14	227.86	251.34	354.44	243.14	270.83	276.42	175.74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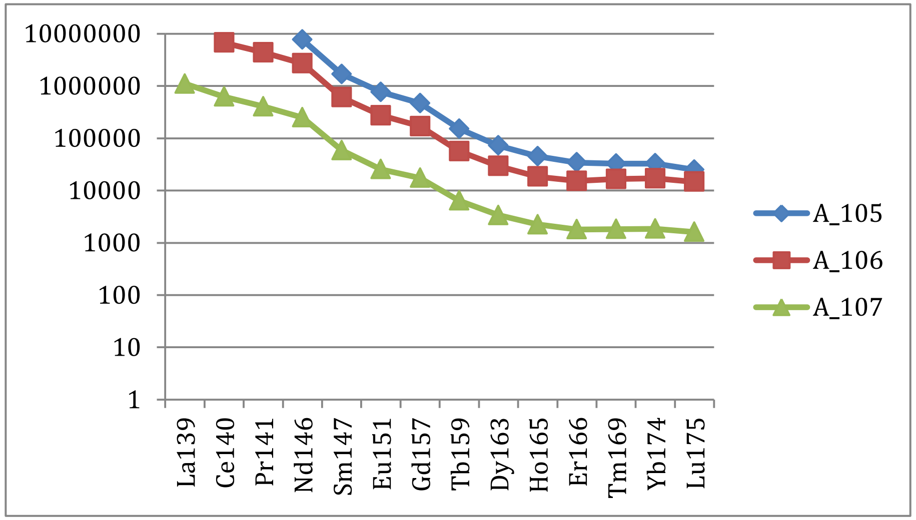
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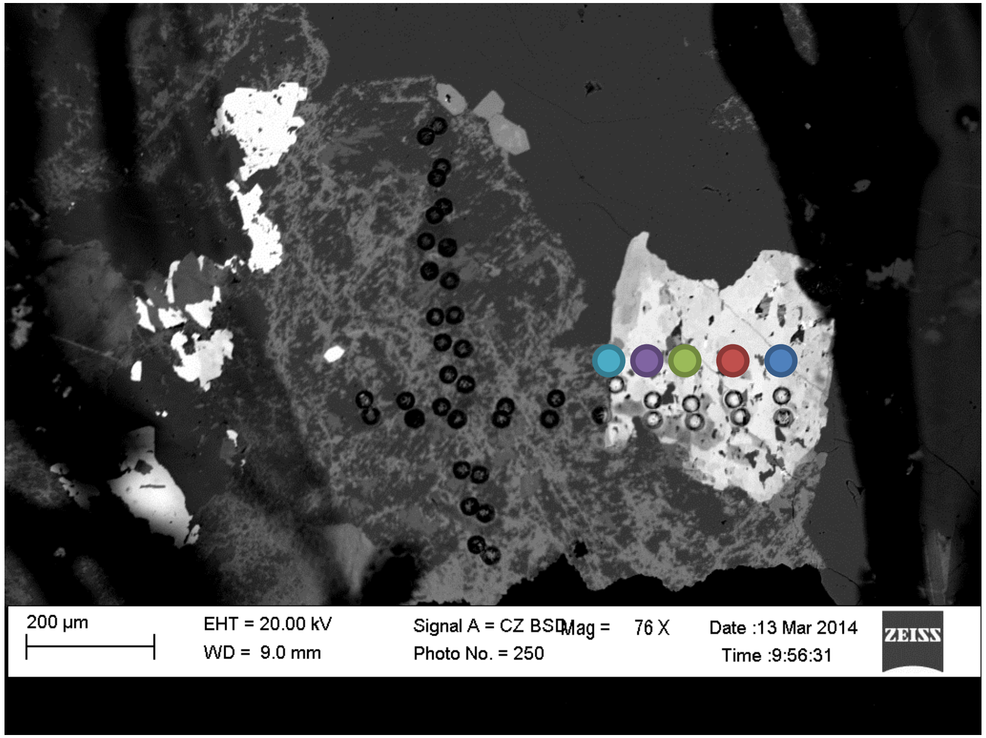
A_106
A_107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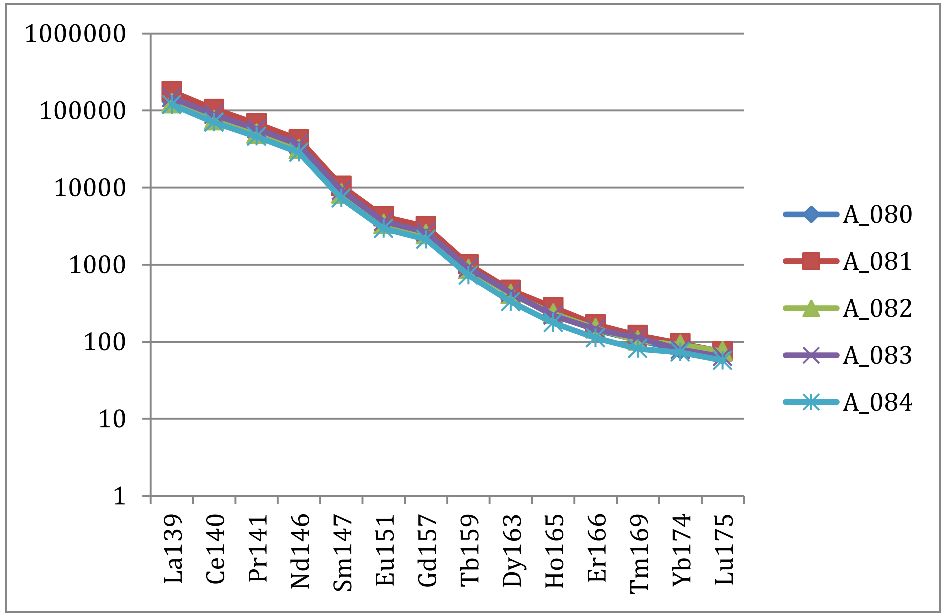
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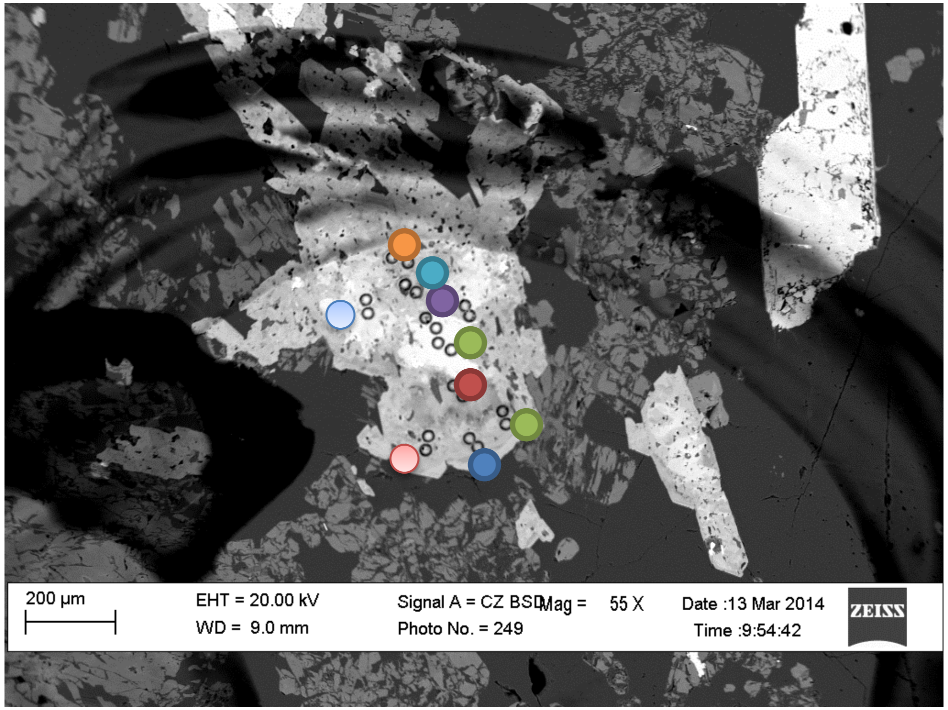
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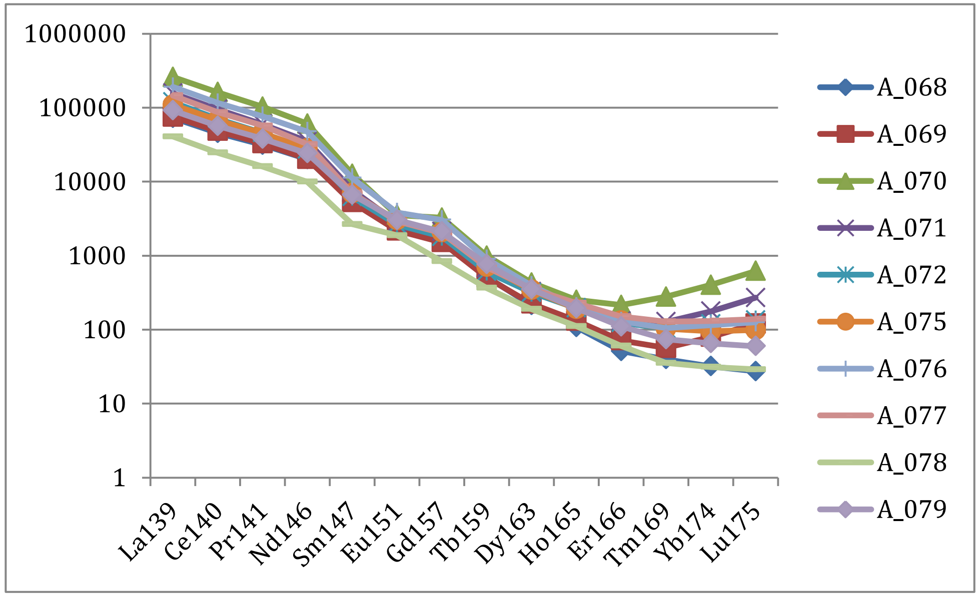
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Er166
Tm169
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A_071
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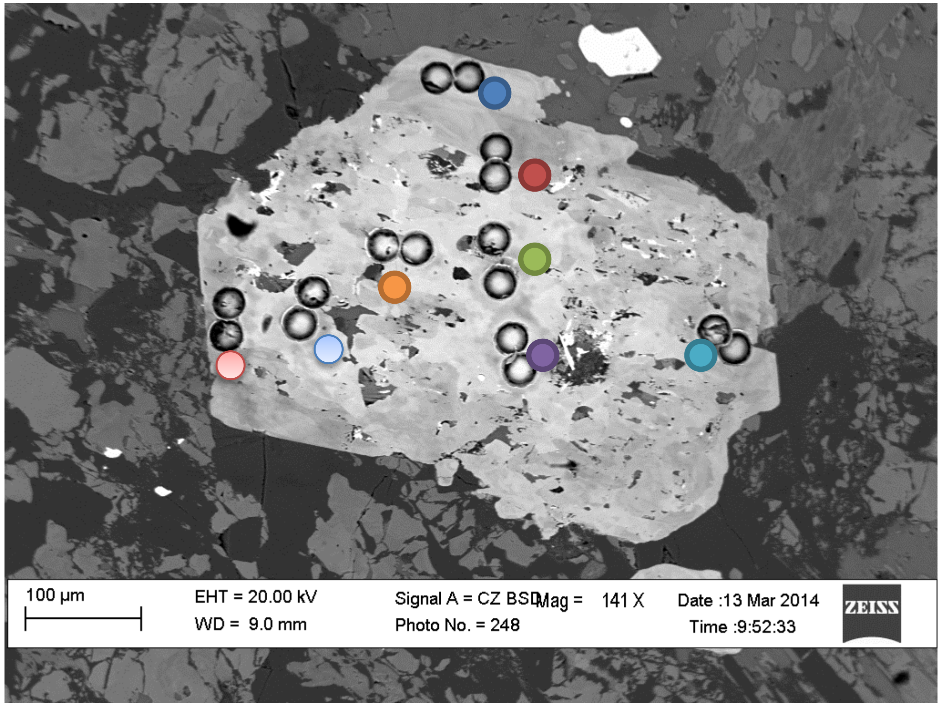
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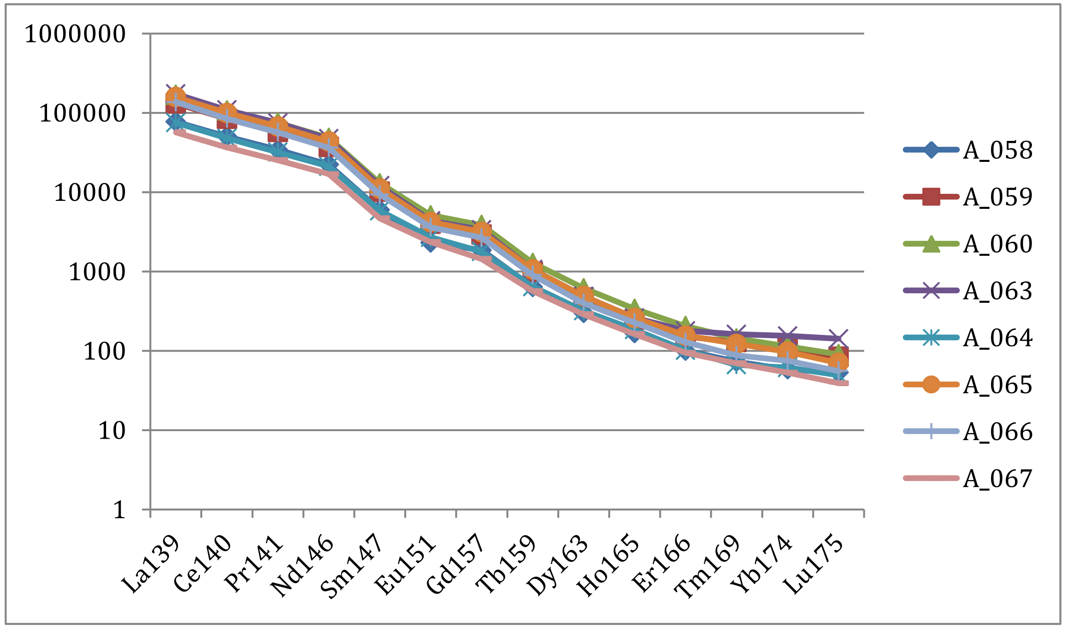
707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Yb174
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A_059
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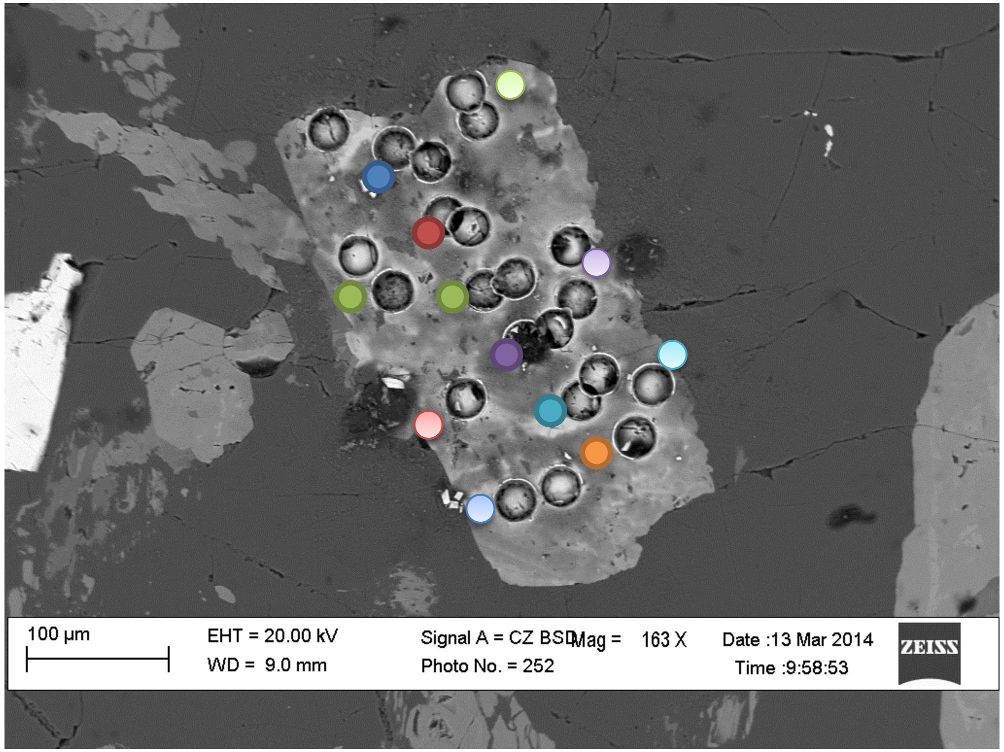
A_067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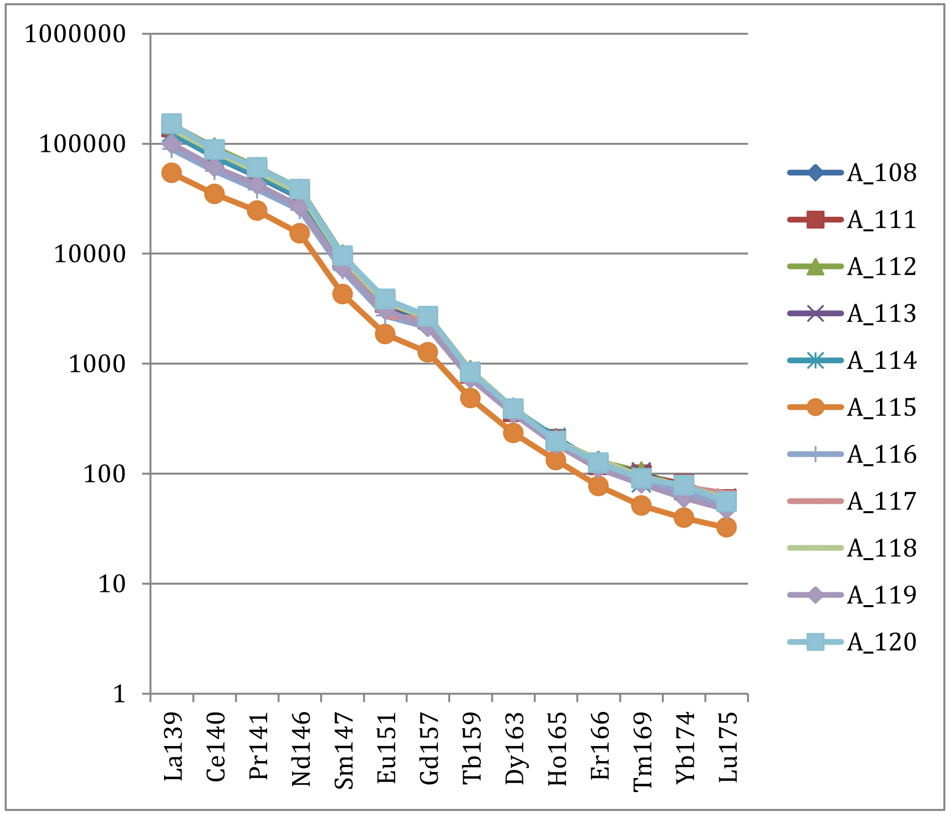
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Gd157
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Ho165
Er166
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Yb174
Lu175
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A_111
A_112
A_113
A_114
A_115
A_116
A_117
A_118
A_119
A_120