UNIVERSITY OF TROMSØ UIT

FACULTY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF GEOLOGY

POST-PRECAMBRIAN MAGMATISM IN EASTERN FINNMARK, NORWAY: MANTLE SOURCES, POSSIBLE ORIGINS AND DIAMOND POTENTIAL

Glenn Martin Dagsvold Eriksen

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Being a geologist is for me purely a matter of interest. I love exploration, and because I have been able to do what I love I have been able to keep doing my best.

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-Glenn

Abstract

Mantle sources under the Eastern Finnmark Region (EFR) appears to have inherited small scale heterogeneity from Precambrian geodynamics.
Compositions varying from depleted and slightly enriched (similar to N-MORB and E-MORB), to enriched (similar to OIB type), are present in the EFR.
Geochemical trends also indicates that some mantle sources has been to some extent influenced by subducting sediments, likely from an Early Paleozoic convergent margin.
Some of the mantle sources under Sør-Varanger area are geochemically similar to deep mantle sources capable of producing kimberlitic and related magmas, and indeed exotic and potentially diamondiferous rock suites has been identified and classified from the large number of samples collected during field work in Sør-Varanger area.
This combined with previously documented ideal crustal and mantle conditions for diamond emplacement in the Fennoscandian Shield gives the Sør-Varanger region a very good diamond potential.

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1 Introduction

1.1 Main Objectives

The primary goals for this thesis are to:

- Document alkaline mafic and ultramafic volcanism in eastern Finnmark.
- Observe possible source heterogeneity and metasomatism beneath eastern Finnmark based on geochemistry of volcanic rocks.
- Discuss potential link to diamond genesis.

1.2 Geographical Location of Study Area

The area of interest in this project, Sør-Varanger (SV) municipality, is situated in Eastern Finnmark, Northern Norway.
SV municipality covers an area of 3967 km^2 and is very close to The Archangel diamond province in NW Russia, and the new emerging diamond province in Eastern Finland.

1.3 The Geology of Eastern Finnmark Region

Age of Bedrock:
The bedrock in Eastern Finnmark as well as the bordering areas of Kola peninsula and Finland are included in the East European Craton (EEC), the bulk of which was formed during the archean period (earlier than 2,5 Ga).
A recent U-Pb isotope study (results not published), on zircons found in the bedrock of Sør-Varanger conducted by Kimberlitt AS in collaboration with the Geological Survey of Finland have revealed crustal components up to 3,69 Ga, as well as crustal formation events at 3,2 Ga and 2,8 Ga, coinciding with major episodes of diamond formation in the Earth's mantle (Kepezhinskas, P., 2011).

Event	Interpretation	Geologic Correlations
3.69 billion years	Oldest North Atlantic crust and oldest continental crust component in Norway	Correlates well with Amitsoq Gneiss of Greenland and Early Archean crustal terraines in Canada which hosts world class mines
3.2 billion years	Worldwide formation of peridoitic or P-type diamonds	Diamond mines in South Africa, Siberia, Canada and Arkhangelsk
2.9 to billion years	Major episode of crustal formation within North Atlantic cratons and worldwide formation of eclogitic or E-type diamonds	Major crustal production, TTG formations and assemblage of basement granite-gneiss terraines throughout the East European craton – Finland, Kola Peninsula, Karelia, Baltic States, and Ukraine
2.5 billion years	Continental crust consolidation and granitic magmatism, final amalgamation of cratonic terraines	Widespread crustal consolidation episode throughout the East European craton
1.5 billion years	Magmatism, metamorphism and migmatization of the older continental crust	Massive crustal deformation and granitic magmatism within western part of the East European craton, Danopolonian orogeny

Table 1.3.1. Data and interpretations after Kepezhinskas (2011), Gorbatschev and Bogdanova (1993), Bogdanova et al. (2008).

Early Proterozoic Rifting of the Craton:

In early Proterozoic the EEC underwent great rifting, splitting the plate into several blocks. Volcanic and sedimentary deposits that filled these rifts are today visible as greenstone belts oriented approximately NW-SE. (Ramberg *et al.*, 2007).

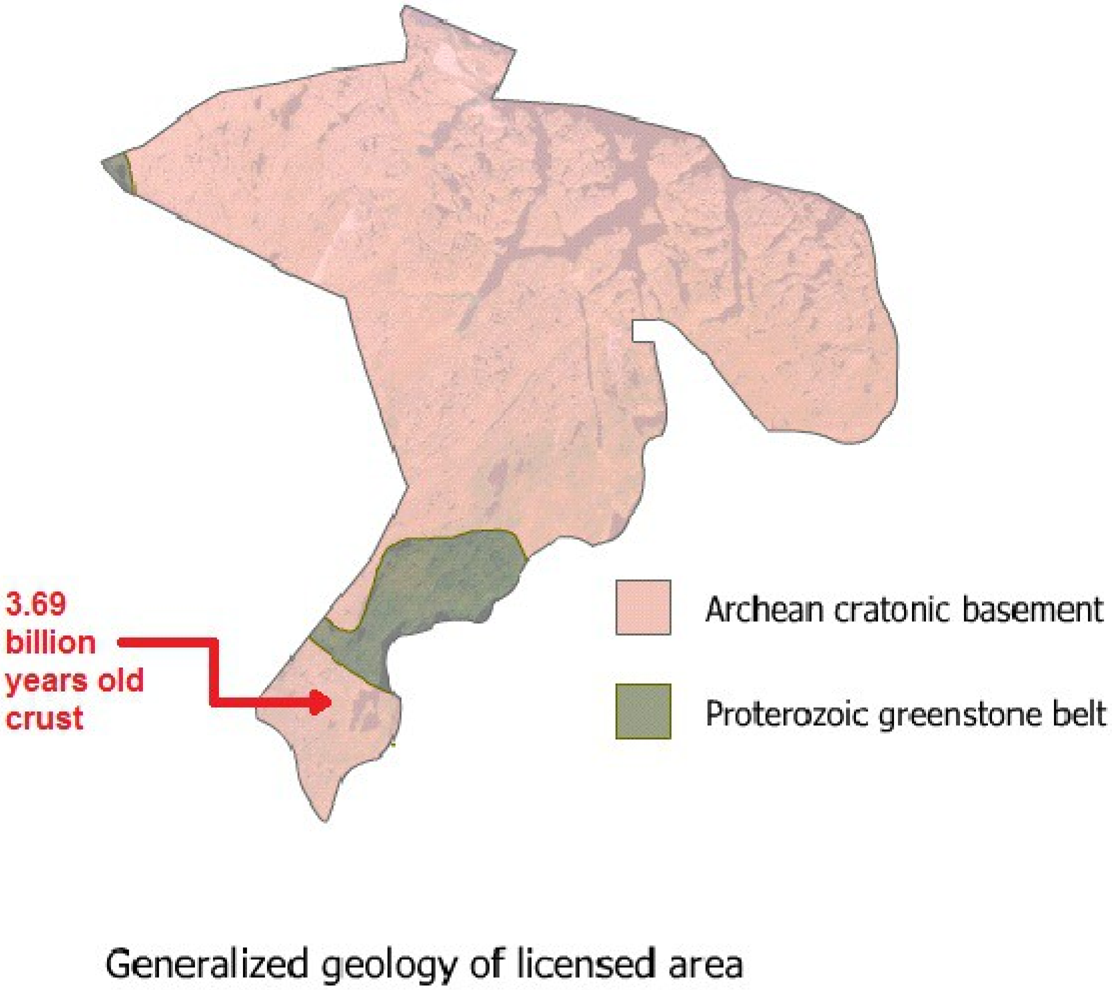

Figure 1.3.1. Simplified geology of the Sør-Varanger area.

Greenstone Belt in Pasvik Valley:

Pasvik valley (in SV) is split into two blocks by one of the greenstone belts starting in Polmak going through northern Finland, continuing across Pasvik valley, and on into the Kola peninsula (see figure 1.3.2. for visual representation, and figure 1.3.1. for outline) . The Northern division is the Sørvaranger-Kola block, and the southern is the Inari Block. (Ramberg *et al*., 2007).

Figure 1.3.2. Pillow-textured ultramafic lava (komatiite) from Pasvik greenstone sequence (Early Proterozoic supracrustal greenstone terrain).

Bjørnevann Iron Deposit:

The intrusives in SV was eroded, and during late Archean was made the base of several types of younger extrusives.

The greenstone belt at Bjørnevann south of Kirkenes are of special economic interest because it contains magnetite iron- ore in banded iron formation (BIF), and similar deposits are to be found on Russian side of the border at Oleneogorsk. (Ramberg *et al*., 2007).

General Composition of the Bedrock:

The Archean bedrock in northern SV is completely exposed, and predominately consists of TTG gneisses (see figures 1.3.3. and 1.3.4 for visual representation).

Figure 1.3.3. The Neiden gneiss wall in Sør-Varanger are a good illustration of the general makeup of the basement in the region. The dark rock in the middle of the wall is a boudinaged ultramafic sill, now part of basement.
Chemical makeup of the boudine are documented as sample kim09-2162.

The bedrock at Grense Jakobselv area (GJA) the eastern part of SV have been through an orogenic metamorphic reaction at high p/T (amphibolite to granulite facies), and the gneisses here have also been migmatised (migmatisation of gneisses also documented in western part of SV). There are also quite a lot of garnet rich granite bodies possibly formed by melting crustal rock.

The same area also contains some low-quartz granodiorites, monzonites, and syenites all younger than the local gneisses.

These rocks have a relatively high magnesium content implying that they were formed by melting of mantle-derived source rock. Similar rock bodies have been described nearby in both Northern Finland, and Russia. These are presumed to be from old ocean crust subducted into the mantle. (Ramberg *et al.*, 2007).

Figure 1.3.4. Trondhjemitic gneiss (granodiorite) in basement rock. General chemical makup of the dark sills in this picture are documented as sample kim09-2162A.

1.4 Previous Work(s) and Ideas on Volcanic Rocks in the Region

Beckinsale *et al*. (1975):

Distinguished between different principal dike ages in Tanafjorden-Varangerfjorden Region (N-NW of Sør-Varanger). Based on K-Ar results it was concluded that the age of intrusives in Kongsfjorden (schisted metadolerites) ranged from c. 945 Ma to c. 1945 Ma (uncertain/uncomfirmed). (Approximate location: black circle on figure 1.4.1.)

The age of intrusives in Båtsfjorden area (less schisted metadolerites) was determined to be c. 650 Ma. (Approximate location: orange circle on figure 1.4.1.)

The age of intrusives in eastern part of Varanger Peninsula was determined to be c. 360 Ma. both north and south of the Trollfjorden-Komagelva Fault Zone (TKFZ). (Approximate location: blue circle on figure 1.4.1.)

Guise *et al.* (2002):

Performed $^{40}Ar/^{39}Ar$ age dating on three geographically distinct but geochemically comparable dolerite dikes at eastern Varanger Peninsula. The dikes located at Finnvika, Komagnes, and Store Ekkerøya was found to have intruded during late Devonian-age (~370 Ma).

(Approximate locations: blue and purple circle on figure 1.4.1.)

The dike ages fits into a known pattern of Mid-Devonian to Early Carboniferous rifting with sporadic magmatism reported from adjacents parts of Kola Peninsula and neighbouring areas along the northeastern margin of the Fennoscandian Shield.

Roberts (2011):

Updated previous age determinations on Hamningberg dolerite dike (Varanger Peninsula, north of Sør-Varanger), and similar unmetamorphosed dikes in the region. Previous age determination of this dike, and similar nearby dikes, was interpreted based on discordant U- Pb ages on zircons, to be of Vendian (Ediecaran) age.

The new interpretation based on field, geochemical, and $^{40}Ar/^{39}Ar$ or K/Ar age characteristics shared with other Devonian-age dikes in NE Norway and NW Russia, concluded that the Hamningberg dike (and similar nearby un-metamorphosed dikes) are most likely of late Devonian age (~370 Ma).

(Approximate location: purple circle on figure 1.4.1.)

Lee M.J. e*t al.* (2003):

Published a petrographic and geochemical study of Devonian ultramafic lamprophyres at Sokli (eastern Finland).

The Sokli ultramafic lamprophyres (UML's) was found to have various modal proportions of Mg-Olivine and Ti-phlogopite phenocrysts and/or xenocrysts in calcite rich groundmass. Low SiO_2 and Al_2O_3, high Cr, Ni and MgO contents. They were therefore classified as aillikites (in accordance with Nicholas Rock, Lamprophyres, 1991).

The geochemistry of the Sokli aillikites indicated that they were derived from a depleted hazburgitic source. However the Sokli aillikites was found to have lower magnesium content and weaker HREE depletion compared to those of Kola Terskii coast kimberlites, which are considered to be derived from asthenospheric hazburgitic mantle, and this indicates a shallower melting depth of the Sokli aillikite source compared to the Kola Terskii kimberlites.

The Sokli aillikites was also found to be highly enriched in incompatible elements and REEs, indicating influence from an additional enriched metasomatic source (magma mixing). (Approximate location: black triangle on figure 1.4.1.)

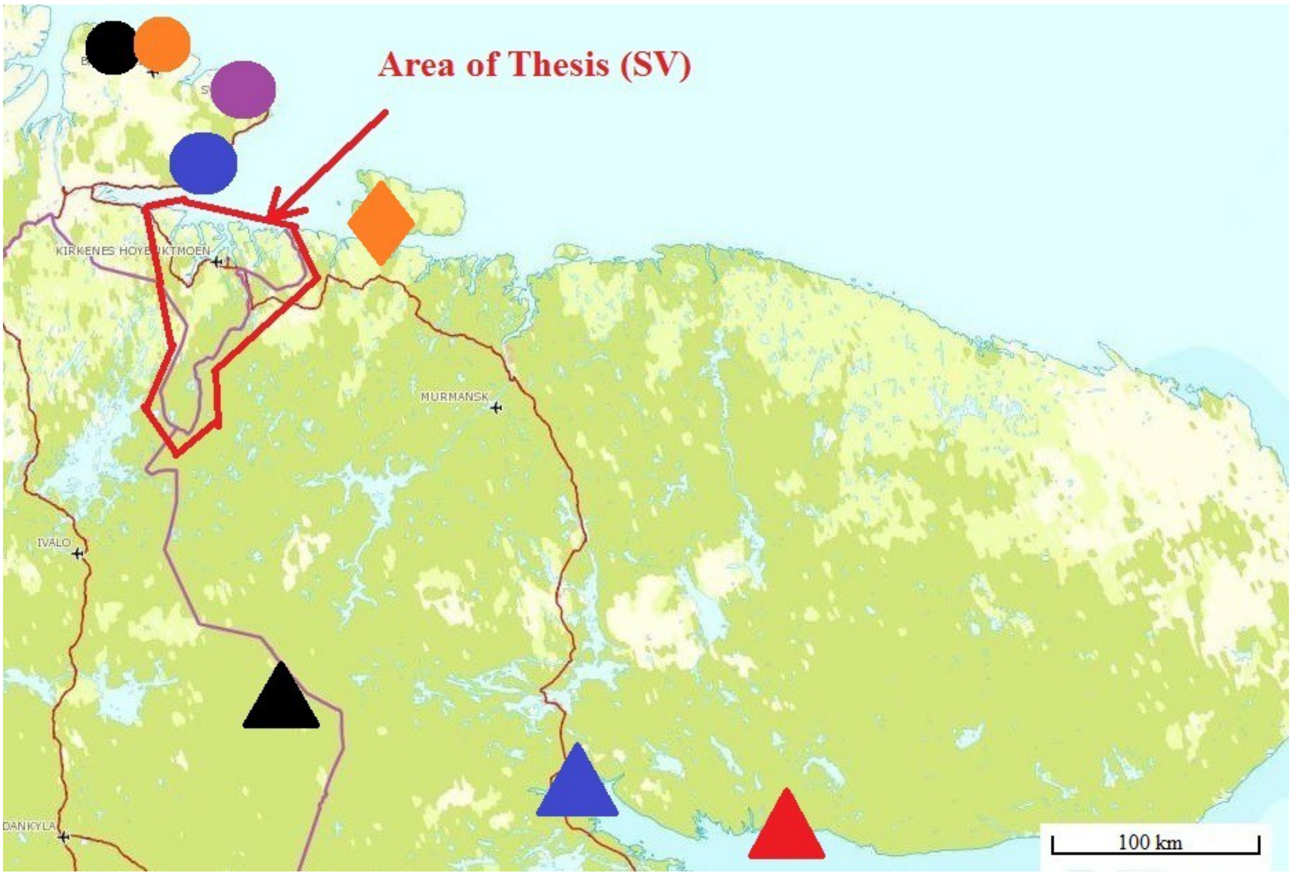

Figure 1.4.1. Overview of locations for some of the previous work and described volcanic rocks in region. The relative location of the thesis area is marked by outline.

Downes *et al.* (2005):

Published a review on the magmatism in the Kola region (NW Russia and Eastern Finland). They classified igneous rocks of the Kola Alkaline Carbonatite Province (SE of thesis area) into four groups: a) primitive mantle-derived silica-undersaturated silicate magmas; b) evolved alkaline and nepheline syenites; c) cumulate rocks; d) carbonatites and phoscorites.

It was determined that all four types are petrogenetically linked as there is no obvious age difference (360-380 Ma, late devonian) between these various groups and they were formed within a relatively restricted area.

The genetic process for all four magma types was theorized to have been triggered by the arrival of hot material (mantle plume?) beneath the Archean/Proterozoic lithosphere of the northern Baltic Shield, resulting in melting of the carbonated garnet peridotite upper mantle (source of all late Devonian magmatism in the region).

The primitive magma group listed by Downes (a) have varied compositions, and have been classified and described in several locations, of which most important are as follows:

Kimberlites, melilitites and Olivine-melilite neka-nephelinites at Terskii coast and Turiy. (Approximate location: red triangle on figure 1.4.1).

Aillikites at Sokli. (Approximate location: black triangle on figure 1.4.1.)

Damkjernites, Olivine-phlogopite melilitites and Ultramafic lamprophyres at Kandalaksha area. (Approximate location: blue triangle on figure 1.4.1).

Fedotov (2005):

Made a presentation on behalf of the Geological Institute at Kola Science Centre RAS, of some of the mafic dykes in the Kola region where he mentions some of the magmatism at Rybachi Peninsula and nearby areas. The Rybachi dolerite dike swarm have been dated through K-Ar and Sm-Nd methods, which has indicated that the dolerites was emplaced at around 600 Ma. (Approximate location: orange diamond on figure 1.4.1).

Rice *et al.* (2004):

Describes the dolerite dikes at Rybachi Peninsula, and compares them to the Båtsfjorden dikes (Approximate loaction: orange circle on figure 1.4.1.).

In age of emplacement they are described as relatively comparable, however the geochemistry of the dikes are different. Rybachi Peninsula dikes are in composition more related to the younger dikes at eastern part of Varanger Peninsula.

(Approximate location: blue circle on figure 1.4.1).

2 Sampling & Methods

2.1 Collecting Samples

In all 114 samples of volcanic intrusives were collected from mostly the northern part of SV. Typically chilled margin was collected if possible because it most closely represents the original magma source before crystallization fractionation.

In some cases both chilled margin and main body of intusive was collected and analyzed.

Figure 2.1.1. Large outcrop (sill) of High-Mg thoeliite basalt, sample kim09-3094.
Adult human male of medium height as scale in lower left corner.

Figure 2.1.2. Basalt dikes, kim09-2170 (left) & kim09-2170A (right).
Adult human male of medium height as scale directly in front of one of the dikes.
The dikes might be of different ages, oldest to the left.
A dike of ultramafic lamprophyre (kim09-2170b) was also found to the right of this picture.

Figure 2.1.3. Alkaline lamprophyre dike, sample kim09-1122. Standard brick hammer as scale in center of the picture.

Figure 2.1.4. Schisted/boudinaged glimmerite dike, sample kim09-2128A. Large GPS (Garmin Montana 600) as scale.

Figure 2.1.5. Picrite sill, lower half of outcrop not exposed. Sample R13-05.
Young human male of medium height as scale on top of outcrop.
Also observable, this sill has been through some hydrothermal intrusions (see figure 3.3.13).

2.2 Documenting Samples

The main objective when collecting samples of magmatic rocks in 2009 was to establish the presence of widspread alkaline magmatism in Eastern Finnmark, therefore no special concern was taken to consistently document everything for a thesis.

As a result there are some gaps in sample descriptions for some samples, but the important samples have all been well documented by further field seasons in 2011 and 2013.

The photographs from the field were taken with different cameras under different conditions, so quality may vary.

Also, due to the high number locations, only a few samples have been documented with a photo in this thesis.

2.3 Geochemical Data – Analytical Procedures

All rock samples collected were pulverized and put through XRF and ICP-MS analysis at Acme Analytical Laboratories in Vancouver, Canada.
Descriptions of analytical procedures below has been gathered from communications with the lab.

The major elements of the samples were analyzed by first mixing a portion of the sample pulp together with Li-tetraborate ($Li_2B_4O_7$) then analyzed with the help of X-ray fluorescence (XRF).
Loss of ignition (LOI) was then determined by igniting a sample split then measuring the weight loss.

For the trace elements analysis some of the sample pulp was mixed with $LiBO_2/Li_2B_4O_7$ flux, and fused in a furnance. The resulting bead was cooled before dissolved in ACS grade nitric acid and analyzed by inductively coupled plasma mass spectrometry (ICP-MS).
Because this method is very sensitive for potential contaminants, great care have been taken to avoid this through the entire process.

See appendix 3 for statement of sample quality.

2.4 Gechemical Data – Plotting and Data Treatment

All geochemical data has been plotted with the GCDkit (version 3.00) tool, except for the CIPW Norm calculations. Values below detection limit has been set as half of detection limit before plotting.

2.5 CIPW Norm Calculations

Calculated mineral norm has been used in this thesis as a tool for more easily displaying general composition of samples, and for making pseudo mineralogical classifications.

The norm of a rock may be substantially different from the observed mineralogy (the mode). Calculations assume that the magma is anhydrous, so no minerals such as micas or amphiboles are permitted.

Also it is assumed in the calculations that the Fe/Mg ratio of all ferromagnesian minerals are the same, and no account is taken of the minor solid solution of elements such as Ti and Al in ferromagnesian minerals. (Rollinson, H., 1993).

The calculation of CIPW norm for this thesis was performed with excel spreadsheet prepared by Kurt Hollocher. The following data was used for caluclation: Wt% of SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5.

Ppm of Sr, Ba, Ni, Zr.

Fe^{3+}/(Total Iron) value of zero.

2.6 Thin Sections

Thin section for this thesis has been prepared by the geological department at the University of Tromsø, and was lacquered instead of polished.

The photos of thin sections have been taken with a Canon EOS 650D camera mounted on a Leica polarization microscope, and minerals and structures in thin sections has been identified visually from determination of physical properties observed in a simple polarization microscope, using basic methods.

Scale was determined with use of a glass plate with relative scale (micrometer).

2.7 Classification Methods (for table 3.2.1)

- **Visual classification** has been made for most samples in field. Visual classifications are based on texture and visible mineral mode. Lamprophyres are easy to identify visually because of it's porphyritic texture with euhedral to subhedral phenocrysts of mica and/or amphibol (Mitchell 1994).

- **Rock (1987).** Nicholas Rock, also known as Mr. Lamprophyre made an overwiev of major petrological contrasts in lamprophyres, separating them into four main branches: calc-alkaline lamprophyres (CAL), alkaline lamprophyres (AL), ultramafic lamprophyres (UML), and lamproites (LL).
His classification schemes has been used for any sample identified as lamprophyre in chapter 3.

- **Total alkali versus silica (TAS) table.** Have been used as a simple classification scheme for all samples of a suitable basic basaltic makeup.

    TAS classifications are not suitable for:
    - Potash-rich rocks.
    - Highly magnesian rocks.
    - Weathered, altered or metamorphosed rocks.
    - Rocks with obvious signs of crystal fractionation.

    (Rollinson, H., 1993).

- **Jensen (1976).** Classification table for subalkaline volcanic rocks using total Fe + Ti vs. Al vs. Mg cation percentages. Has been used to classify any subalcalic rock not lamprophyric, with visible indications of crystal fractionation, and/or with rock samples with documented visble alteration. This classification scheme has the advantage of using elements with relative stability in low grade metamorphism. (Rollinson, H., 1993).

- **Geochem.** Used mostly for classification of picrites, as after major oxide values described in The Great Soviet Encyclopedia (1979). Described as an olivine rich rock with whole rock composition 20-29 wt% MgO, 38-41 wt% SiO_2 and 5-10 wt% Al_2O_3

3 Field Relations & Rock Descriptions

3.1 Introduction

The purpose of this chapter is to give a closer insight into the data used in the main part of this thesis. This chapter can also be used as a quick reference for the quality of samples and their individual characteristics. Sample numbers have also been coloured for quick reference to mantle source type as categorized by method in plot figure 4.2.7:

Sample genesis from enriched mantle source.

Sample genesis from mixed mantle source.

Sample genesis from subduction influenced mantle source.

Due to the great number of samples represented, not every sample has been described in detail, however the second half of this chapter contains thin sections of 18 of the most important samples described at greater depth.

Mineral Abbreviations Used:

Ab: Albite
An: Anorthite
Am: Amphibole
Aug: Augite
Bt: Biotite
Cb: Carbonate mineral
Chl: Chlorite
Cpx: Clinopyroxene
Crn: Corondum
Di: Diopside
Ep: Epidote
Hbl: Hornblende
Hem: Hematite
IDD: Iddingsite
Mca: Mica
Ol: Olivine
Opx: Orthopyroxene
Or: Orthoclase
Phl: Phlogopite
Pl: Plagioclase
Qtz: Quartz
Rt: Rutile
Srp: Serpentine
Ttn: Titanite

3.2 Observations of Individual Samples

Sample	Occurence	Texture	Type	Classification method	Strike	Size* /width**	Calculated CIPW Norm (vol% above 5)
1117	Dike	Equigranular	Metamorph Calc-alkaline lamprophyre	Visual + Rock (1987)	N/S	>0,5m	22% Ab 20% Or 15% Opx 12% Di 9% Hem
1118	Sill	Not observed	Dolerite	Visual + TAS table	None visible	30-50m	28% An 23% Ab 10% Qtz 10% Di 9% Opx 9% Hem 8% Or
1119	Dike	Not observed	Basalt	TAS Table	NW/SE	~1m	31% An 22% Ab 17% Di 8% Opx 7% Qtz 6% Hem
1120	Dike	Porphyritic	Alkaline Lamprophyre	Visual + Rock (1987)	N/S	~2,5m	35% Ab 21% An 10% Di 9% Hem 9% Opx 7% Or 6% Ttn
1120A	Dike	Porphyritic	Alkaline Lamprophyre	Visual + Rock (1987)	E/W	<0,5m	27% An 21% Ab 14% Di 13% Qtz 11% Hem 7% Opx
1122	Dike	Porphyritic	Alkaline lamprophyre w/ biotite	Visual + Rock (1987)	NE/SW	~5m	24% An 24% Ab 15% Qtz 10% Hem 8% Di 7% Opx 6% Or 6% Ttn

Sample	Occurence	Texture	Type	Classification method	Strike	Size* /width**	Calculated CIPW Norm (vol% above 5)
1122A	Sill	Porphyritic	Alkaline Lamprophyre w/ biotite phenocrysts	Visual + Rock (1987)	NW/SE	<5m	24% Opx 21% Ab 14% Di 11% Hem 10% An 7% Or 7% Ttn
1123	Sill	Not observed	Basalt	TAS table	NW/SE	No data	27% Ab 21% An 14% Qtz 11% Hem 8% Di 7% Ttn 7% Opx 5% Or
1143	Sill	Not observed	Basalt	TAS table	NE/SW	<0,5m	28% An 23% Ab 15% Di 10% Qtz 8% Hem 8% Opx 5% Or
1219	Dike	Porphyritic	Ultramafic Lamprophyre	Visual + Rock (1987)	N/S	2-3m	34% Opx 23% An 16% Hem 15% Ttn 6% Ab
2126A	Dike	Schistose w/ remains of plagioclase phenocrysts	Metamorph high-Fe tholeiite basalt	Visual + Jensen (1976)	N-NW/S-SE	<0,5m	24% An 21% Ab 13% Qtz 11% Di 10% Hem 8% Or 6% Opx
2127A	Dike	Not observed	Andesite	TAS table	W-SW/E-NE	>0,5m	28% An 24% Qtz 18% Ab 12% Opx 9% Or
2127B	Dike	Porphyritic	Metamorph Calc-alkaline Lamphrophyre	Visual + Rock (1987)	N/S	>0,5m	22% Opx 20% An 14% Di 13% Or 10% Ab 10% Qtz 8% Hem

Sample	Occurence	Texture	Type	Classification method	Strike	Size* /width**	Calculated CIPW Norm (vol% above 5)
2127C	Dike	Not observed	Basaltic andesite	TAS table	NE/SW	>0,5m	28% Ab 22% An 18% Qtz 10% Di 7% Hem 7% Or 5% Opx
2127D	Dike	Porphyritic	Metamorph komatiitic basalt w/ plagioclase phenocrysts	Visual + Jensen (1976)	NW/SE	~0,5m	25% Opx 21% Or 16% Di 14% An 8% Hem 6% Ab 6% Qtz
2128A	Dike	Schistose	Glimmerite	Visual	NE/SW	~1m	25% Or 20% Di 17% Opx 15% Ol 11% An 6% Hem
2128B	Dike	Not observed	Basalt	TAS table	No data	No data	26% An 25% Ab 11% Qtz 11% Opx 10% Di 9% Hem 6% Or
2128C	Dike	Not observed	Basalt	TAS table	No data	No data	31% An 19% Ab 15% Di 10% Opx 10% Qtz 7% Hem 6% Or
2128D	Dike	Not observed	Basalt	TAS table	No data	No data	27% An 24% Ab 14% Di 11% Qtz 9% Hem 8% Opx 5% Or

Sample	Occurence	Texture	Type	Classification method	Strike	Size*/width**	Calculated CIPW Norm (vol% above 5)
2128E	Dike	Not observed	Basalt	TAS table	No data	No data	28% An 22% Ab 14% Di 11% Qtz 9% Hem 8% Opx 5% Or
2128F	Dike	Not observed	Basalt	TAS table	No data	No data	29% An 18% Ab 15% Di 13% Qtz 9% Hem 8% Opx 6% Or
2129	Dike	Not observed	Basaltic andesite	TAS table	No data	No data	25% Ab 22% Di 16% An 14% Opx 8% Qtz 7% Hem 5% Or
2130	Dike	Not observed	Dolerite	Visual + TAS table	W-NW/E-SE	No data	28% Ab 20% An 15% Qtz 10% Hem 10% Di 7% Or 5% Opx
2130A	Dike	Porphyritic	Calc-alkaline lamprophyre w/ hornblende phenocrysts	Visual + Rock (1987)	W-NW/E-SE	No data	28% An 22% Ab 12% Opx 12% Hem 11% Qtz 9% Or 5% Ttn
2131	Dike	Porphyric	High-Fe tholeiite basalt w/ plagioclase phenocrysts	Visual + Jensen (1976)	NW/SE	No data	28% An 23% Ab 11% Di 10% Opx 9% Hem 9% Qtz 6% Or

Sample	Occurence	Texture	Type	Classification method	Strike	Size*/width**	Calculated CIPW Norm (vol% above 5)
2132	Dike	Porphyritic	Metamorph ultramafic lamprophyre w/ garnet and amphibole phenocrysts + chlorite	Visual + Rock (1987)	NW/SE	~1m	39% Opx 23% An 14% Di 10% Hem 5% Ab
2132A	Dike	Not observed	Basaltic andesite	TAS table	No data	No data	26% An 25% Ab 12% Qtz 11% Di 10% Opx 9% Or 6% Hem
2133	Dike	Not observed	Dolerite	Visual + TAS table	NW/SE	~4m	27% An 24% Ab 11% Di 10% Opx 9% Qtz 9% Hem 8% Or
2133A	Dike	Schistose	Metamorph komatiite	Visual + Jensen (1976)	NW/SE	<0,5m	40% Opx 31% Di 13% An 7% Qtz 5% Hem
2134	Dike	Porphyritic	High-Fe tholeiite basalt w/ plagioclase phenocrysts	Visual + Jensen (1976)	NW/SE	~2m	28% An 27% Ab 14% Di 8% Opx 7% Hem 7% Or 7% Qtz
2134A	Dike	Not observed	Metamorph high-Fe tholeiite basalt	Visual + Jensen (1976)	No data	No data	33% An 23% Ab 15% Opx 8% Hem 7% Or 7% Di
2134B	Dike	Porphyritic	Calc-alkaline lamprophyre w/ hornblende phenocrysts	Visual + Rock (1987)	No data	No data	28% Ab 21% An 14% Qtz 11% Di 10% Hem 5% Or

Sample	**Occurence**	**Texture**	**Type**	**Classification method**	**Strike**	**Size* /width****	**Calculated CIPW Norm (vol% above 5)**
2134C	Dike	Not observed	Basalt	TAS table	No data	No data	27% An 24% Ab 13% Di 11% Qtz 9% Hem 9% Opx
2135	Dike	Porphyritic	Calc-alkaline lamprophyre w/ amphibolite phenocrysts	Visual + Rock (1987)	NW/SE	~3m	29% An 16% Qtz 14% Ab 14% Di 10% Hem 7% Or 7% Opx
2135A	Dike	Aphyric	Komateiitic basalt	Jensen (1976)	NW/SE	<0,5m	24% Opx 24% Di 22% An 12% Or 7% Ab 6% Hem
2135B	Dike	Not observed	Dolerite	Visual + TAS table	NW/SE	<0,5m	25% An 24% Ab 15% Di 10% Qtz 10% Hem 7% Opx
2136	Dike	Not observed	Dolerite	Visual + TAS table	NW/SE	No data	25% Ab 23% An 16% Qtz 10% Hem 10% Di 6% Opx 5% Or
2136A	Dike	Not observed	Basaltic andesite	TAS table	NW/SE	No data	38% Ab 21% An 14% Qtz 8% Hem 8% Or 6% Di
2138	Dike	Not observed	Basalt	TAS table	NW/SE	No data	27% An 21% Ab 16% Qtz 12% Di 9% Hem 7% Opx 5% Or

Sample	**Occurence**	**Texture**	**Type**	**Classification method**	**Strike**	**Size*/width****	**Calculated CIPW Norm (vol% above 5)**
2139	Dike	Porphyric	Calc-alkaline lamprophyre w/ amphibole phenocrysts and sulphide	Visual + Rock (1987)	N-NW/S-SE	No data	24% An 23% Ab 15% Qtz 11% Hem 9% Di 7% Or 6% Opx
2139A	Dike	Schistose	Metamorph ultramafic lamprophyre w/ amphibolite and phlogopite	Visual + Rock (1987)	N-NW/S-SE	No data	27% Di 24% Opx 21% Or 9% An 7% Ol 5% Ab
2141	Sill	Porphyritic	Metamorph high-Al lamproite	Visual + Rock (1987)	NE/SW	20-30m	35% Or 23% An 18% Opx 10% Hem 9% Qtz
2141A	Dike	Not observed	Dolerite	Visual + TAS table	N-NE/S-SW	~2m	29% An 21% Ab 12% Opx 9% Hem 9% Di 8% Or 8% Qtz
2142	Dike	Not observed	Basalt	TAS table	W/E	No data	28% An 22% Ab 13% Qtz 12% Di 9% Hem 7% Opx 5% Or
2144	Dike	Not observed	Dolerite	Visual + TAS table	W/E	No data	27% An 24% Ab 15% Di 11% Qtz 9% Hem 7% Opx
2144A	Dike	Not observed	Dolerite	Visual + TAS table	W/E	No data	28% An 24% Ab 16% Di 10% Qtz 8% Hem 8% Opx

Sample	**Occurence**	**Texture**	**Type**	**Classification method**	**Strike**	**Size*/width****	**Calculated CIPW Norm (vol% above 5)**
2145	Dike	Not observed	Dolerite	Visual + TAS table	N-NE/S-SW	No data	27% An 23% Ab 14% Di 10% Qtz 9% Opx 9% Hem
2146	Dike	Not observed	Dolerite	Visual + TAS table	W/E	~1m	27% An 22% Ab 14% Di 12% Qz 9% Hem 8% Opx 5% Or
2146A	Sill	Not observed	High-Fe tholeiite basalt	Jensen (1976)	No data	>4m	28% An 24% Ab 13% Di 11% Qtz 9% Opx 8% Hem
2146B	Chilled margin of 2146A (sill)	Not observed	Basalt	Visual + TAS table	No data	No data	25% Ab 21% Opx 20% Qtz 13% Or 8% Hem 6% An 5% Crn
2147	Dike	Porphyritic	High-Mg tholeiite basalt w/ pyroxene phenocrysts	Visual + Jensen (1976)	N/S	~6m	30% Ab 20% An 13% Di 12% Hy 12% Opx 7% Hem 6% Or
2148	Dike	Not observed	Dolerite	Visual + TAS table	W/E	No data	29% An 20% Ab 14% Qtz 12% Di 9% Hem 8% Opx
2148A	Dike	Not observed	Dolerite	Visual + TAS table	W/E	No data	27% An 15% Ab 14% Or 13% Di 13% Qtz 9% Hem 7% Opx

Sample	Occurence	Texture	Type	Classification method	Strike	Size*/width**	Calculated CIPW Norm (vol% above 5)
2149	Dike	Porphyritic	High-Fe tholeiite basalt w/ plagioclase phenocrysts	Visual + Jensen (1976)	N-NW/S-SE	~20m	24% Ab 23% An 17% Or 12% Di 9% Opx 8% Hem 6% Qtz
2150	Dike	Not observed	Dolerite	Visual + TAS table	N-NW/S-SE	~10m	27% An 23% Ab 11% Opx 10% Di 9% Qtz 8% Hem 8% Or
2151	Dike	Schistose	Metamorph high-Mg tholeiite basalt	Visual + Jensen (1976)	N-NE/S-SW	No data	26% Ab 22% An 17% Opx 10% Di 8% Hem 7% Qtz 5% Or
2152	Dike	Not observed	Basalt	TAS table	N-NE/S-SW	~10m	25% An 23% Ab 17% Opx 10% Qtz 10% Or 9% Hem
2152A	Dike	Schistose	Metamorph high-Fe tholeiite basalt	Visual + Jensen (1976)	N-NE/S-SW	<0,5m	27% Opx 20% Qtz 19% An 12% Hem 9% Ab 6% Crn 6% Or
2153	Dike	Not observed	Basaltic andesite	TAS table	W/E	~1m	23% An 23% Or 17% Opx 14% Qtz 14% Ab 7% Hem
2155	Dike	Not observed	Dolerite	Visual + TAS table	NW/SE	~10m	33% An 26% Ab 18% Di 7% Hem 6% Opx 5% Or

Sample	Occurence	Texture	Type	Classification method	Strike	Size* /width**	Calculated CIPW Norm (vol% above 5)
2156	Dike	Porphyritic	Alkaline basalt w/ plagioclase phenocrysts	Visual + TAS table	NW/SE	No data	27% An 26% Ab 15% Di 15% Or 7% Hem 7% Opx
2156A	Dike	Not observed	Metamorph high-mg tholeiite basalt w/ chlorite	Visual + Jensen (1976)	NW/SE	No data	22% An 22% Opx 20% Or 14% Qtz 11% Ab 9% Hem
2158	Dike	Not observed	Basaltic andesite	TAS table	NE/SW	~15m	27% An 25% Ab 15% Di 13% Qtz 7% Opx 6% Hem 5% Or
2159	Sill	Phaneritic	Gabbro with high-Fe tholeiite basalt composition	Visual + Jensen (1976)	NW/SE	~50m	28% An 23% Ab 14% Di 11% Qtz 9% Hem 8% Opx
2159A	Chilled margin of 2159 (Sill)	Aphyric	Gabbro w/ basaltic composition	Visual + TAS table	NW/SE	No data	27% An 19% Ab 17% Qtz 10% Hem 10% Di 7% Opx 5% Or
2162	Boudine	Schistose	Metamorph komatiitic basalt	Visual + Jensen (1976)	E-NE/W-SW	~3-5m	31% Opx 21% An 15% Ab 13% Di 12% Or 6% Hem
2162A	Sill	Not observed	Metamorph komatiitic basalt	Visual + Jensen (1976)	No data	No data	26% An 25% Opx 19% Ab 13% Di 6% Hem 6% Or

Sample	Occurence	Texture	Type	Classification method	Strike	Size*/width**	Calculated CIPW Norm (vol% above 5)
2164	Dike	Not observed	Dolerite	Visual + TAS table	W/E	No data	26% An 24% Ab 17% Di 9% Opx 8% Or 8% Hem
2165	Dike	Not observed	Komatiitic basalt	Jensen (1976)	W-NW/E-SE	~10m	28% Opx 23% An 19% Ab 13% Di 7% Or 6% Hem
2166	Dike	Schistose	Metamorph komatiitic basalt	Jensen (1976)	NW/SE	5-10m	32% Opx 21% Qtz 15% Hem 9% Crn 9% Ab 9% An
2166A	Dike	Not observed	Basaltic andesite	TAS table	N-NW/S-SE	~5m	25% Ab 25% An 16% Qtz 11% Di 8% Hem 6% Or 6% Opx
2169	Dike	Porphyritic	Ultramafic lamprophyre	Visual + Rock (1987)	NE/SW	~0,5m	32% Opx 18% An 13% Ab 12% Di 12% Hem 6% Ttn
2170	Dike	Not observed	Basalt	TAS table	W-NW/E-SE	~2m	28% An 24% Ab 12% Qtz 11% Di 9% Hem 9% Opx
2170A	Dike	Not observed	Basalt	TAS table	W-NW/E-SE	<0,5m	31% An 19% Ab 15% Qtz 12% Opx 9% Hem 8% Di

Sample	**Occurence**	**Texture**	**Type**	**Classification method**	**Strike**	**Size*/width****	**Calculated CIPW Norm (vol% above 5)**
2170B	Dike	Porphyritic	Ultramafic lamprophyre	Visual + Rock (1987)	N-NE/S-SW	~2m	42% Opx 22% An 13% Hem 10% Ab 6% Ttn
2175	Dike	Porphyritic	Ultramafic lamprophyre	Visual + Rock (1987)	N-NW/S-SE	~0,5m	34% Opx 17% An 14% Ab 12% Hem 11% Di 6% Ttn
2177	Dike	Not observed	Komatiitic basalt	Jensen (1976)	N/S	No data	24% Opx 23% Ab 16% An 15% Di 10% Hem 5% Or 5% Ttn
2220	Dike	Not observed	Alkaline foidite	TAS table	N/S	~1m	35% An 22% Opx 14% Ol 13% Hem 9% Ttn
2266	Dike	Not observed	Metamorph high-Fe tholeiite basalt	Visual + Jensen (1976)	NE/SW	~15m	31% An 22% Ab 18% Di 9% Opx 8% Hem 8% Qtz
2267	Dike	Not observed	Dolerite	Visual + TAS table	NW/SE	~15m	26% Ab 24% An 14% Qtz 12% Di 10% Hem 6% Opx
2275	Dike	Phaneritic	Microgabbro	Visual + TAS table	W/E	~0,5m	27% Ab 24% An 17% Di 9% Hem 7% Or 7% Opx 5% Qtz

Sample	Occurence	Texture	Type	Classification method	Strike	Size*/width**	Calculated CIPW Norm (vol% above 5)
2275A	Dike	Not observed	Dolerite	Visual + TAS table	NW/SE	~1m	26% An 25% Ab 17% Di 9% Hem 8% Qtz 7% Or 6% Opx
2275B	Dike	Not observed	Dolerite	Visual + TAS table	NW/SE	~1m	23% Ab 23% An 12% Or 11% Di 11% Qtz 9% Hem 7% Opx
2275C	Boudine	Schistose	Metamorph komateiitic basalt w/ secondary phlogopite	Visual + Jensen (1976)	No data	1-2m	31% Di 19% Opx 15% An 13% Ab 13% Or 8% Hem
2282	Dike	Porphyritic	High-Fe tholeiite basalt w/ plagioclase phenocrysts	Visual + Jensen (1976)	W-NW/E-SE	~5m	25% An 23% Ab 14% Qtz 11% Di 10% Hem 7% Opx
2288	Dike	Porphyritic	High-Fe tholeiite basalt w/ plagioclase phenocrysts	Visual + Jensen (1976)	N/S	>1m	27% Ab 22% An 12% Qtz 10% Hem 9% Di 9% Or 8% Opx
2291	Dike	Not observed	Dolerite	Visual + TAS table	W/E	>1m	27% Ab 24% An 11% Qtz 10% Hem 10% Opx 8% Di 6% Or

Sample	Occurence	Texture	Type	Classification method	Strike	Size* /width**	Calculated CIPW Norm (vol% above 5)
2341	Dike	Not observed	Basaltic andesite	TAS table	NW/SE	~3m	23% An 22% Ab 17% Qtz 12% Or 9% Di 8% Hem 7% Opx
2363	Dike	Not observed	Komatiitic basalt	Jensen (1976)	W-SW/E-NE	>8m	24% Ab 20% Opx 19% Di 15% An 9% Hem 5% Qtz
3019	Dike	Phaneritic	Gabbro	Visual + TAS table	W/E	>3m	28% An 26% Ab 20% Opx 18% Di
3024	Boulder	Schistose	Metamorph komatiitic basalt w/ phlogopite	Visual + Jensen (1976)	No orientation	~1m	26% Opx 19% An 15% Di 12% Ab 12% Hem 8% Ttn 7% Qtz
3066	Boulder	Porphyritic	Ultramafic high-Al lamproite	Visual + Rock (1987)	No orientation	~0,5m	26% Hem 25% Or 16% Opx 10% Crn 9% Qtz 7% Ab 6% An
3068	Sill	Porphyritic	Komatiite w/ pyroxene phenocrysts	Visual + Jensen (1976)	No data	>2m	32% Opx 30% Ol 16% An 9% Di 7% Hem 5% Ab
3068A	Sill	Porphyritic	Komatiite w/ pyroxene phenocrysts	Visual + Jensen (1976)	No data	>2m	35% Opx 20% An 15% Ol 11% Di 9% Ab 8% Hem

Sample	Occurence	Texture	Type	Classification method	Strike	Size*/width**	Calculated CIPW Norm (vol% above 5)
3069	Dike	Porphyritic	Picrite w/ phlogopite and cr-diopside mineralization	Visual + geochem	NW/SE	~2m	35% Opx 21% An 13% Di 12% Ab 9% Ol 7% Hem
3082	Dike	Not observed	Basalt	TAS table	No data	>2m	29% An 24% Ab 15% Di 11% Opx 8% Hem 7% Qtz
3082A	Dike	Not observed	Basaltic andesite	TAS table	No data	>2m	31% An 23% Ab 12% Di 11% Opx 8% Qtz 8% Or 6% Hem
3082B	Dike	Not observed	Basaltic andesite	TAS table	No data	>2m	30% An 25% Ab 14% Di 9% Qtz 8% Opx 7% Or 6% Hem
3094	Sill	Not observed	High-Mg thoeliite basalt	Jensen (1976)	No data	>7m	30% An 19% Ab 17% Opx 17% Di 6% Qtz 5% Hem 5% Or
3153	Dike	Not observed	Basalt	TAS table	No data	>1m	29% An 21% Ab 18% Opx 11% Qtz 8% Hem 7% Or
3212	Dike	Not observed	Basaltic andesite	TAS table	W/E	~1m	36% Qtz 24% An 10% Hem 10% Opx 8% Ab 7% Or

Sample	Occurence	Texture	Type	Classification method	Strike	Size*/width**	Calculated CIPW Norm (vol% above 5)
3212A	Dike	Not observed	Alkaline foidite	TAS table	W/E	~1m	66% An 17% Di 9% Hem
3224	Dike	Not observed	Dolerite	Visual + TAS table	N-NE/S-SW	>1m	26% An 26% Ab 13% Di 10% Qtz 9% Hem 8% Opx 5% Or
3224A	Dike	Not observed	Basaltic andesite	TAS table	W/E	>1m	26% Ab 23% An 16% Qtz 9% Hem 8% Or 7% Di 6% Opx
3225	Dike	Not observed	Basalt	TAS table	N-NW / S-SE	>1m	31% An 15% Di 13% Qtz 13% Ab 9% Hem 8% Opx 8% Or
3225A	Dike	Not observed	Basalt	TAS table	NW/SE	>1m	39% Ab 19% An 10% Qtz 10% Hem 9% Opx 7% Di
3245	Dike	Porphyritic	High-Fe tholeiite basalt w/ unidentified red phenocrysts	Visual + Jensen (1976)	W-NW / E-SE	~1m	26% Or 23% Qtz 18% Opx 10% Ab 9% Hem 7% An 6% Crn
R11-01	Boulder	Brecciated	Ultra-sodic / metasomatose calc-alkaline lamprophyre	Visual + Rock (1987)	No orientation	~2m	37% Ab 26% An 14% Opx 8% Di 8% Hem

Sample	**Occurence**	**Texture**	**Type**	**Classification method**	**Strike**	**Size*/width****	**Calculated CIPW Norm (vol% above 5)**
R13-05	Sill	Porphyritic	Picrite	Visual + geochem	No data	>1m	37% Opx 20% An 15% Ol 10% Di 9% Ab 7% Hem
R13-08	Dike	Porphyritic	Metamorph ultramafic lamprophyre w/ phlogopite phenocrysts	Visual + Rock (1987)	No data	>2m	36% Opx 17% An 16% Di 12% Ab 9% Hem
R13-12	Dike	Porphyritic	Metamorph high-Fe tholeiite basalt	Visual + Jensen (1976)	N/S	~0,5m	27% An 25% Ab 14% Di 11% Qtz 9% Hem 7% Opx
S375	Outcrop	Porphyritic	Ultramafic lamprophyre w/ some phlogopite phenocrysts	Visual + Rock (1987)	No data	No data	28% Opx 21% Ttn 18% An 15% Hem 10% Ab
S376	Boulder	Porphyritic	Metamorph komatiite	Visual + Jensen (1976)	No orientation	~2m	49% Opx 19% An 14% Di 8% Ab 7% Hem
S388	Boulder	Porphyritic	Calc-alkaline lamphrophyre w/ phlogopite and hornblende phenocrysts	Visual + Rock (1976)	No orientation	~1m	31% An 16% Di 14% Ab 13% Qtz 9% Hem 8% Opx 7% Or

Table 3.2.1. Sample overview and descriptions.
Some sample names has been shortened for better presentation (kim09-xxxx).
The term metamorph used in the classification description does not describe the degree of metamorphism, it only indicates that some sign of alteration has been observed. This can mean everything from slight seritization of plagioclases to completely schisted and structurally altered rock.
**indicates average diamater of loose boulders or boudines.*
*** indicates measured width of dike or sill.*

3.3 Description of Thin Sections

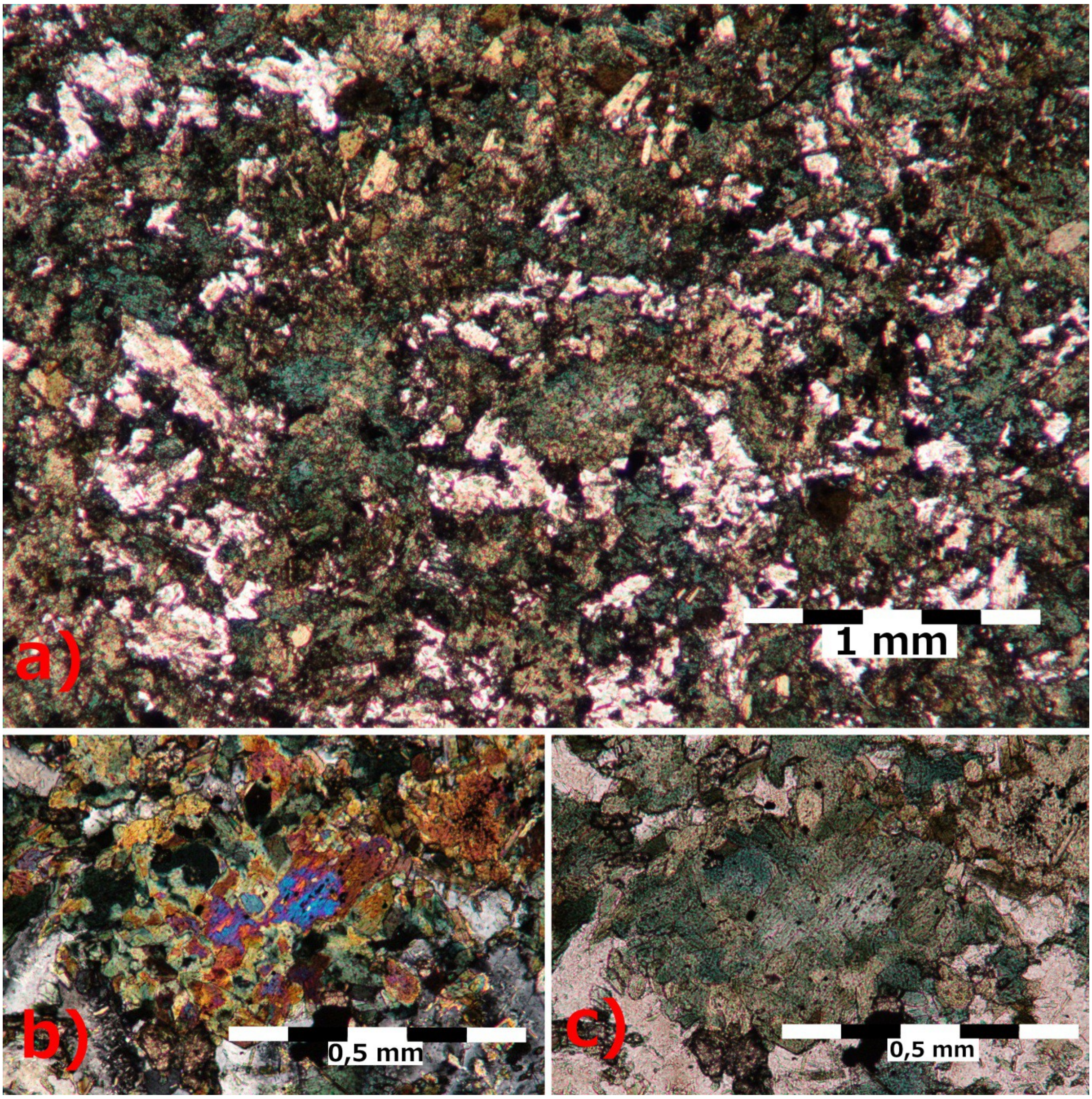

Figure 3.3.1: Thin section of kim09-1117. A metamorphosed calc-alkaline lamprophyre with only remains of its original porphyritic texture visible. a) Plane polarized view that shows how the rock is primarily made up of secondary minerals like chlorite and secondary amphiboles together with plagioclases. Some primary hornblendes also seem to be present in the rock, possibly as remains of its former phenocrysts. b) Cross polarized view of one of the larger cpx grains that has been almost completely altered to chlorite. The plagioclase in this picture has also been seritized heavily. c) Plane polarized view of altered clinopyroxene and surrounding minerals. Hornblende in top right corner.

Calc-alkaline lamprophyres (CAL) have a crustal influenced genesis, are most common in orogenic settings or Precambrian greenstone belts, are never found occurring in an oceanic setting, and are typically connected with nearby granite plutonism.

CAL's typically have a potassic whole rock chemistry composition with: 46-57 wt% SiO_2, 11-18 wt% Al_2O_3, 3-10 wt% MgO, 4-9 wt% CaO, 1,5-4% Na_2O, 3-7 wt% K_2O, and 1-5 wt% CO_2.

The minerals most commonly found in CAL's are quartz, alkali feldspars, plagioclase, carbonate minerals, epidote, amphiboles (hastingsite; tschermakite; Mg-riebeckite/arfvedsonite), and Al-bearing diopsidic augites with minor zoning. (Rock N.M.S., 1986).

CAL's were not typically associated with economic diamond potential until the discovery of the Wawa lamprophyres in Ontario (Canada). In 1991 the first documented discovery of diamonds in k-rich variety of calc-alkaline lamprophyre sparked a mining rush in the area. The Wawa lamprophyres further distinguish themselves from typical diamond bearing rocks by being one of the oldest known primary diamondiferous rocks (Archean emplacement age). (Lefebvre et al., 2005).

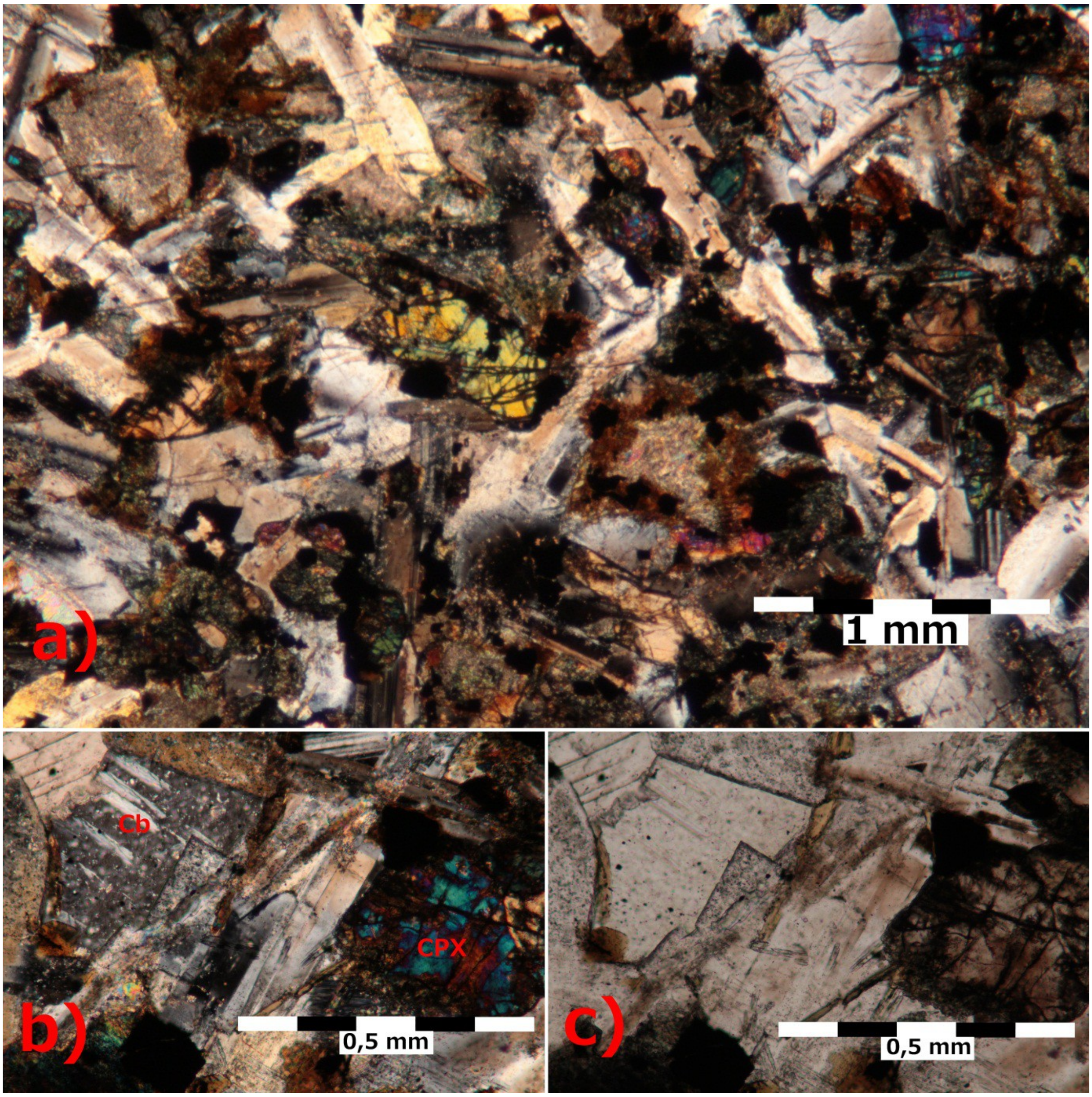

Figure 3.3.2: Thin section of an alkaline lamprophyre dike, kim09-1120 show presence of calcite, olivine, cpx, plagioclase and spinel. Some olivine grains are almost completely replaced by iddingsite. Typical grain size is approximately 0,5 mm. a) An xpl photo of the thin section with visible clinopyroxene, olivine with alteration, and slightly seritized plagioclases. b) Xpl photo showing among other things carbonate mineral and cpx. c) Same photo as b, shown in plane polarized light.

Alkaline lamprophyres (AL) are most typically found in connection with continental cratons and rift valleys. They are mostly associated with alkaline rock – carbonatite complexes (like in nearby Kola Alkaline Carbonatite Province), but also with Alkaline syenite-gabbro complexes.

Some AL's grade into basaltic rocks (camptonitic basalts) with similar bulk composition through gradual loss of amphibole + biotite and globular texture.

Al's typically have a sodic whole rock composition with: 36-46 wt% SiO_2, 10-16 wt% Al_2O_3, 4-10 wt% MgO, 7-15 wt% CaO, 2-5 wt% Na_2O, 1-3 wt% K_2O.

Biotite and albite are common minerals found in alkaline lamprophyres, together with strongly zoned augites.

There is a diamondiferous alkaline lamprophyre deposit in Wandagee (west Australia). (Rock N.M.S., 1986).

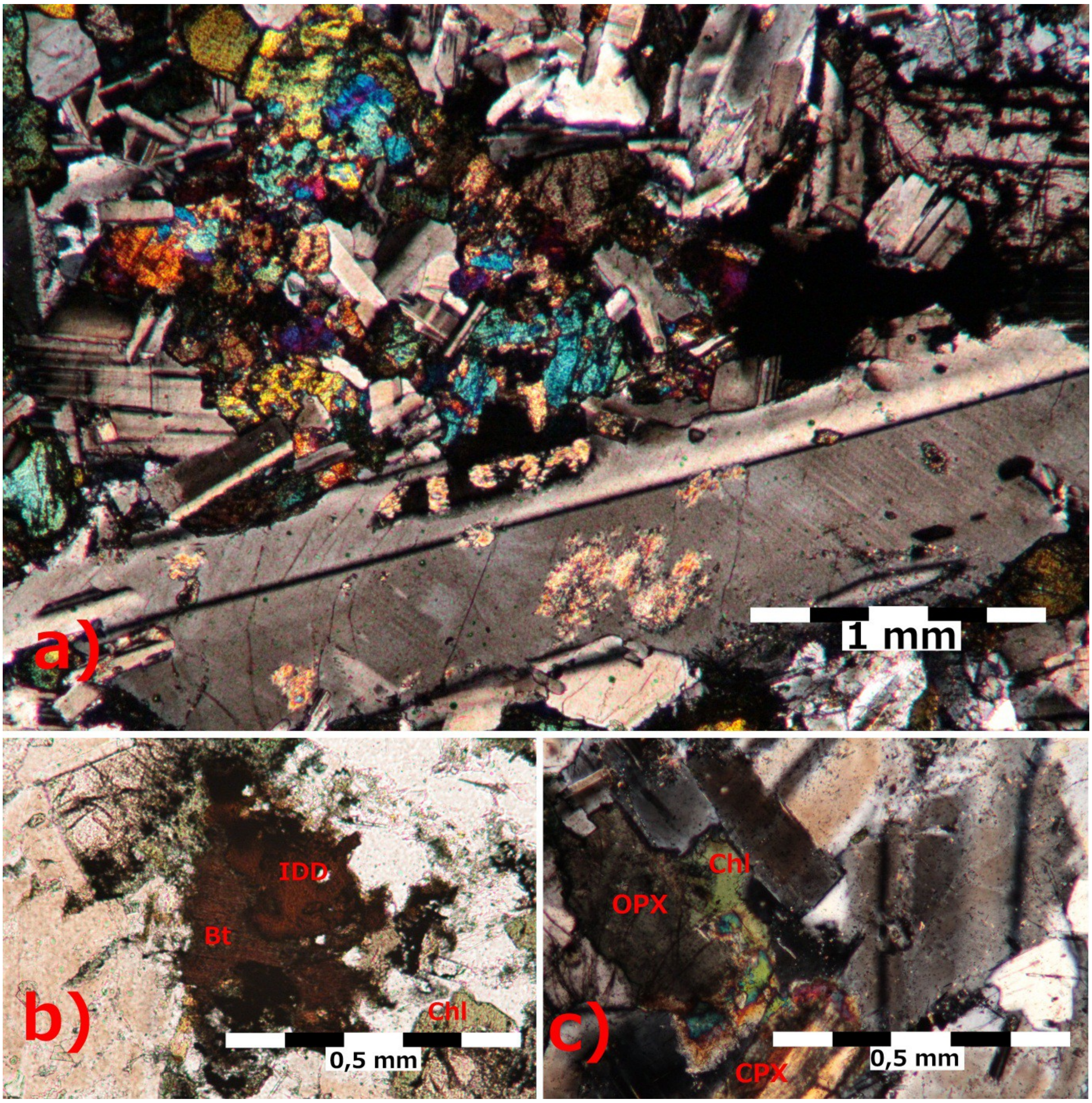

Figure 3.3.3: Thin section of kim09-1122A, an alkaline lamprophyre with high magnesium and iron content. Most grains up to 1 mm in size, but with some few abnormally large (megacrysts) plagioclase grains up to 7 mm in size showing spots of sericite that are not so common, but still present in the smaller grains. Several of the plagioclase grains also show zoning, indicating multi-staged crystallization in a crystal magma chamber before emplacement. Augite (cpx), opx and amphibole show some chlorite alteration along the edges. a) An xpl photo of the thin section, showing general mineral makeup, and relative size of grains. In this picture is also one of the larger plagioclase megacrysts. b) Photo with plane polarized light showing biotite, iddingsite alteration, and chlorite alteration. c) In this xpl photo both clinopyroxene and orthopyroxene are visible altered somewhat. Also present is plagioclase with some zoning visible.

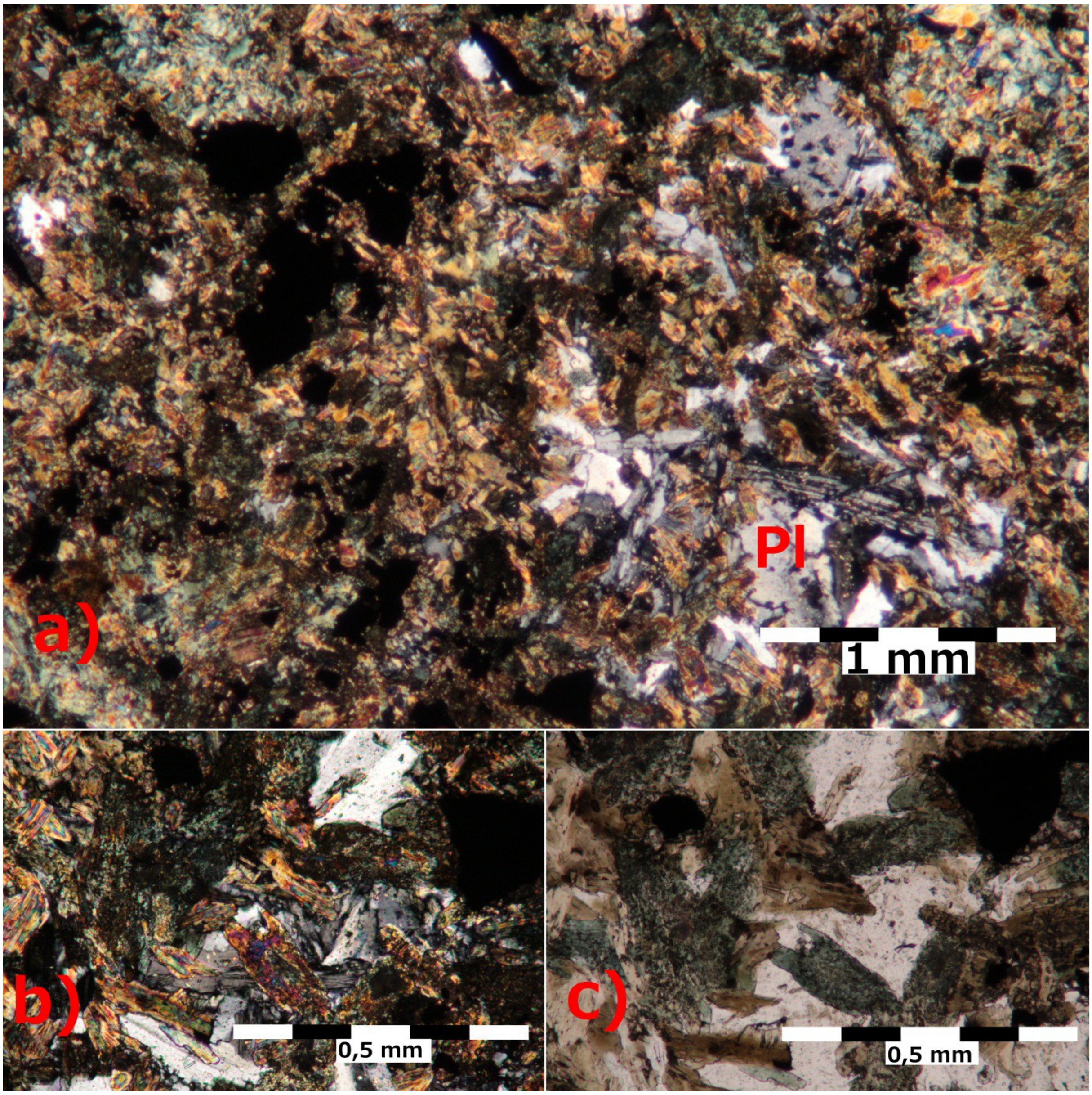

Figure 3.3.4: Thin section of kim09-1219, an ultramafic lamprophyre, very rich in iron, magnesium and titanium. Thin section shows the rock is metasomatic, and it contains chlorite, and other micas as well as secondary amphiboles. The rock is porphyritic, and have globular structures with carbonate minerals, and some larger opaque minerals, probably magnetite. The primary amphibole phenocrysts seem to have been mostly altered into hydromica. a) An xpl photo showing general composition. Also marked are one of the larger anhedral plagioclases, and right above it a melilite b) Chlorite, phlogopite and plagioclase are quite visible in this xpl photo of the thin section. c) A ppl photo of the same section, confirming makeup of the rock.

Ultramafic lamprophyres (UML), like AL's are most typically found in connection with continental cratons and rift valleys. They are mostly associated with alkaline rock – carbonatite complexes (like in nearby Kola Alkaline Carbonatite Province).
UML's typical whole rock composition are sodipotassic, and with: 20-35 wt% SiO_2, 2-12 wt% Al_2O_3, 8-20 wt% MgO, 10-20 wt% CaO, <3 wt% Na_2O, 1-3 wt% K_2O and 2-12 wt% CO_2. Nepheline and melilite are common minerals found in UML. Volatile poor (dry) UML's are often classified as simply nephelinites or melilitites (Rock N.M.S., 1986).

Ultramafic lamprophyres can in themselves contain Diamonds, but are also commonly genetically connected with Kimberlites (e.g. Downes *et al.* 2005)

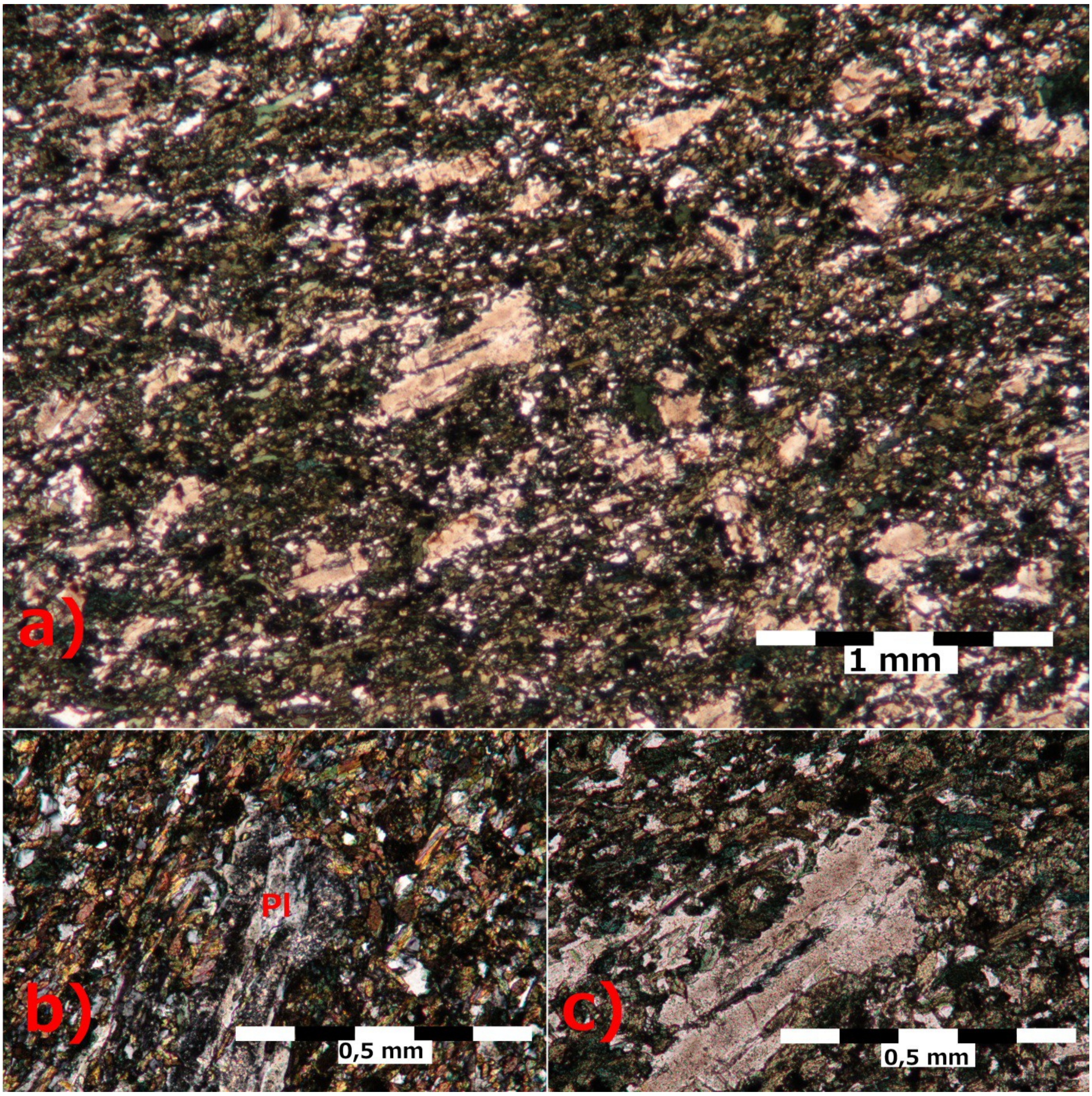

Figure 3.3.5: Thin section of 2126A, a meta-dolerite (or possible former Al-rich lamroite) showing some preferred orientation of grains. Very fine grained, main mineral present is chlorite, largest mineral grains are former phenocrysts of plagioclase, severely seritized. a) General view of thin section in ppl. Preferred orientation of plagioclase is most apparent. b) Close up of thin section in xpl. Central in photo is severely seritized plagioclase grain. c) A ppl view of thin section showing chlorite grains oriented around larger plagioclase grain.

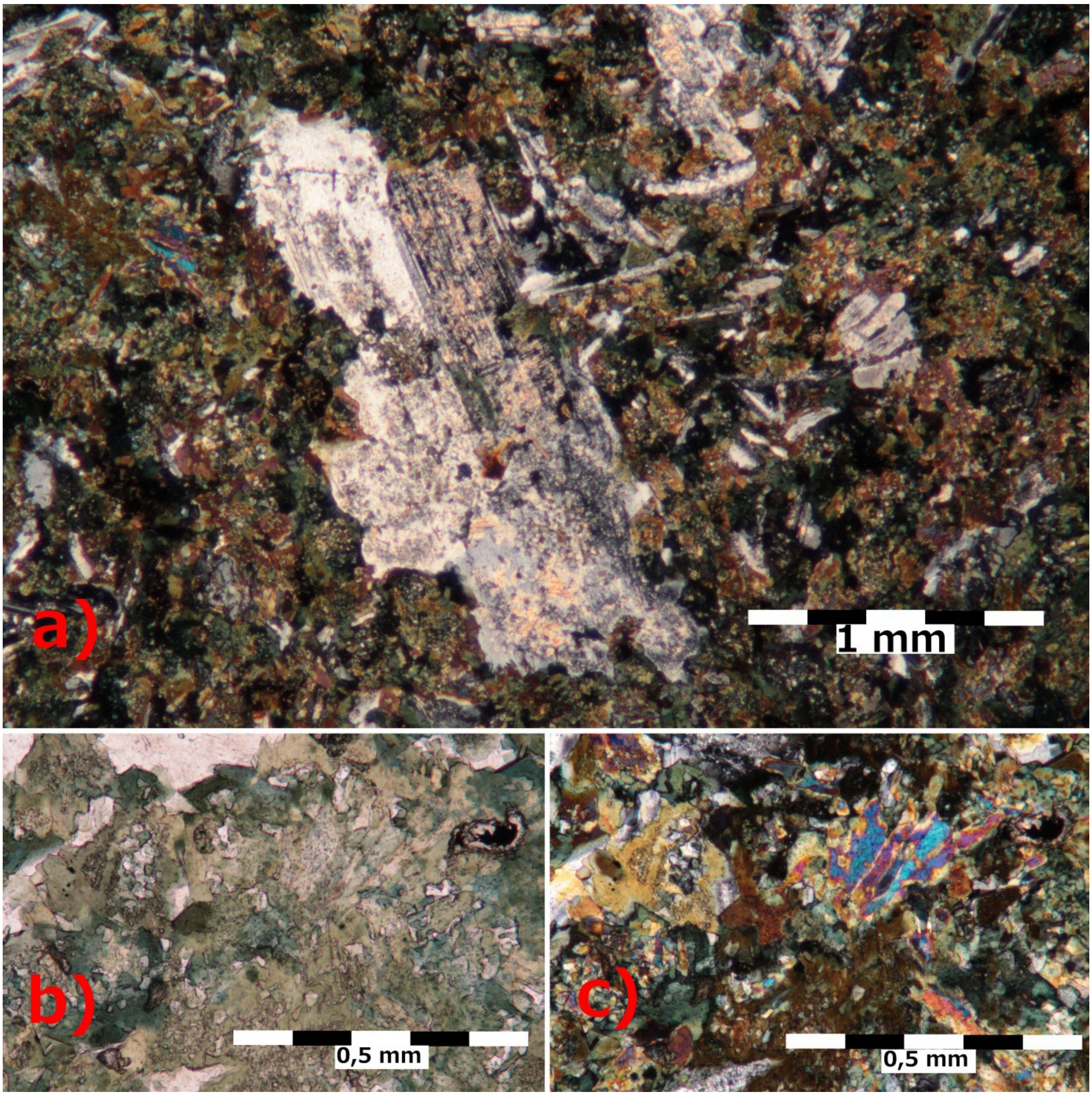

Figure 3.3.6: Thin section of kim09-2127D, a metasomatized komatiitic basalt containing laths and megacrysts of heavily seritized plagioclase, remains of opaque minerals, some secondary amphiboles, and micas. a) Large xpl view of one of the seritized plagioclase megacrysts surrounded by a groundmass containing cpx, amphibole and mica. b) Plane polarized view of part of the thin section showing that secondary minerals like chlorite and tremolite are dominant. c) Cross polarized view of the same section as in b.

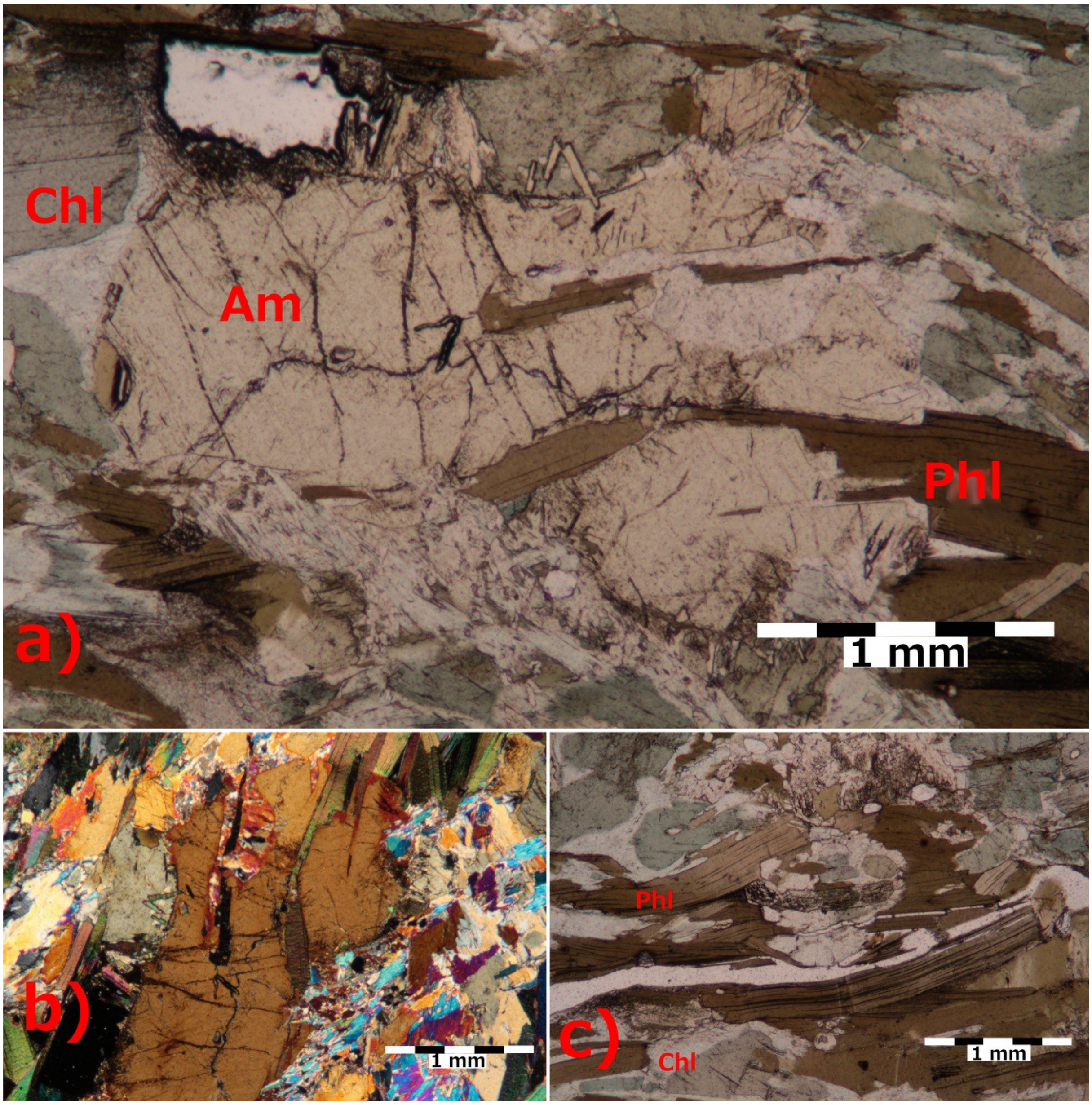

Figure 3.3.7: Thin section of kim09-2128A, a schisted/altered glimmerite, containing a lot of well crystallized mica including phlogopite. Grains are showing directional preference, and are especially rich in certain zones/bands in the rock. a) A plane polarized light photo of the thin section showing a large amphibole that seems to have grown around several phlogopite grains, indicating the phlogopite is definitely primary for the rock, while other minerals have been grown secondary. b) A cross polarized light photo of phlogopite partially intergrown into amphibole. c) A zone/layer of almost pure phlogopite in the rock. Several of these are visible in the thin section.

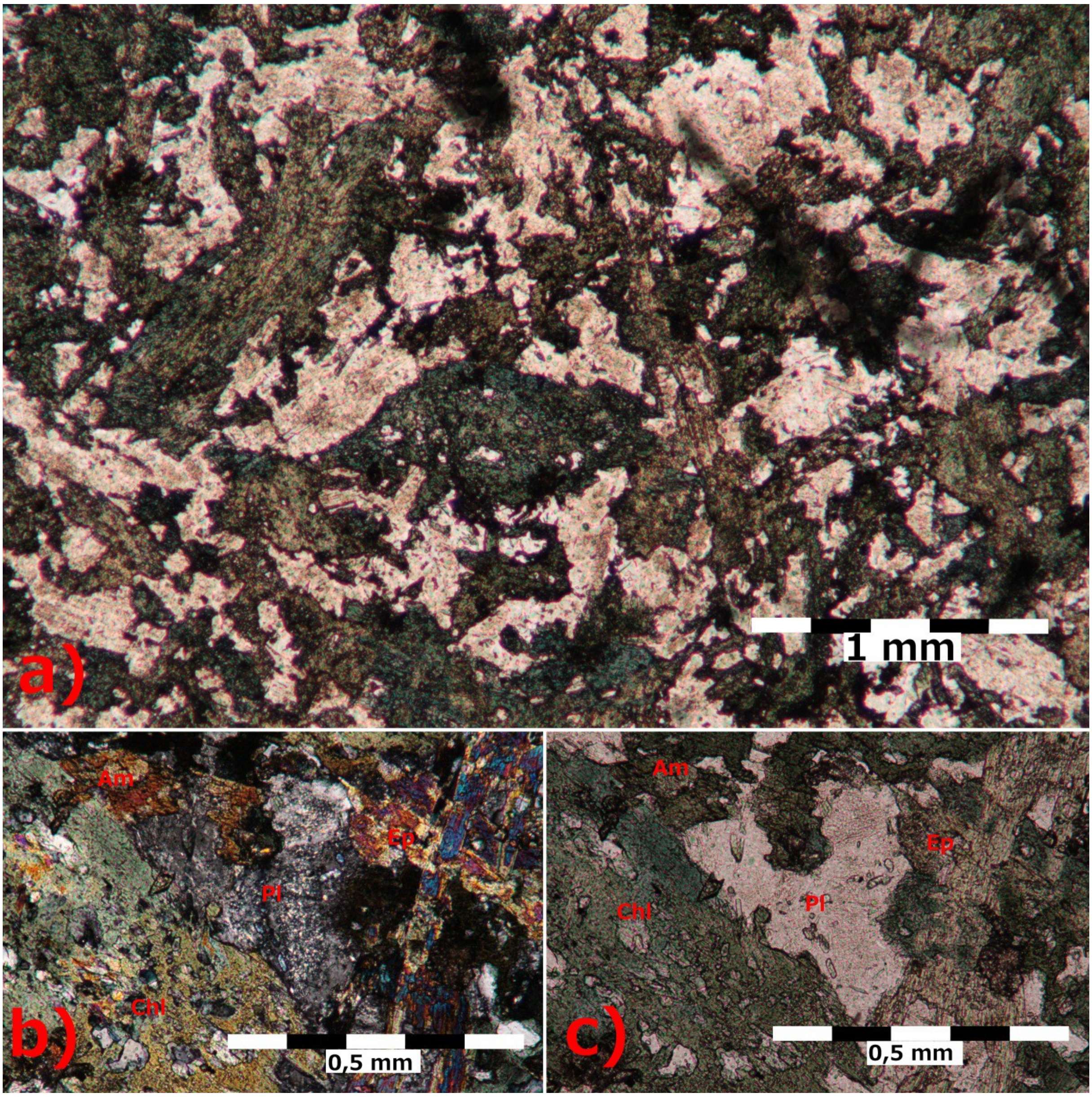

Figure 3.3.8: Thin section of kim09-2132, a metamorphosed ultramafic lamprophyre containing secondary amphiboles, chlorites, epidotes, and plagioclase altered almost completely to sericite. Everything is more or less equigranular, and the rock also contains very few opaque minerals. a) General view of the thin section in plane polarized light, showing the altered nature of the rock. b) An xpl view of the rock showing some of the minerals. c) A further look on the minerals in plane polarized light.

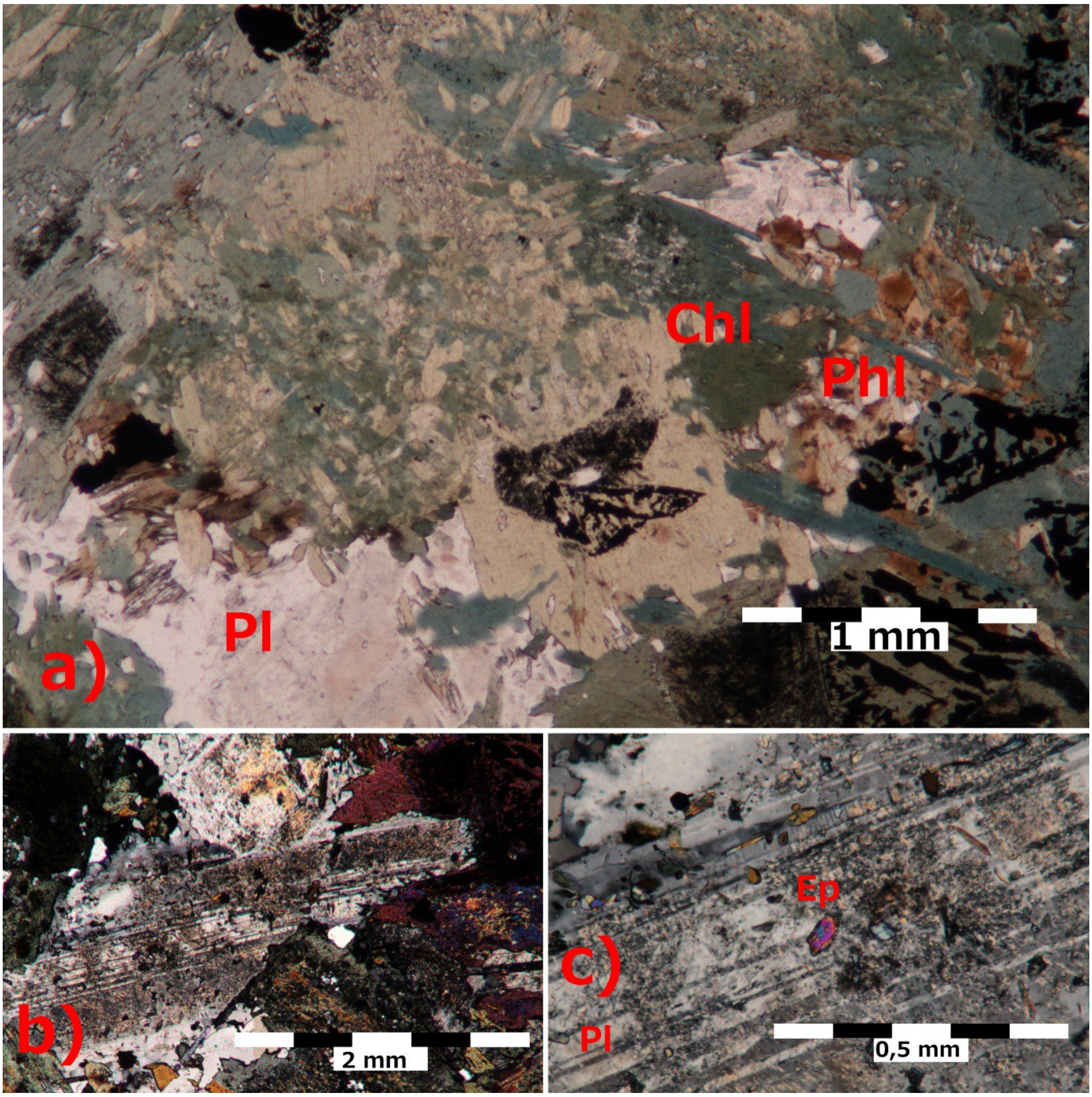

Figure 3.3.9: Thin section of kim09-2141, a metamorphosed high-Al lamproite with large laths of phlogopite almost completely replaced by hydromica and antigorite. Large amphibolite megacrysts with abundant layers of spinel inclusions.Big plagioclase crystals almost completely covered with sericite. a) A plane polarized light view of the thin section showing the metasomatized minerals, and spinel layers in large amphiboles. b) A cross polarized view of one of the large seriticed plagioclases; also visible in picture is one of the amphiboles at top right in picture. Also small subhedral mica grains in the lower portion of the photograph. c) A close up photo of alteration in plagioclase.

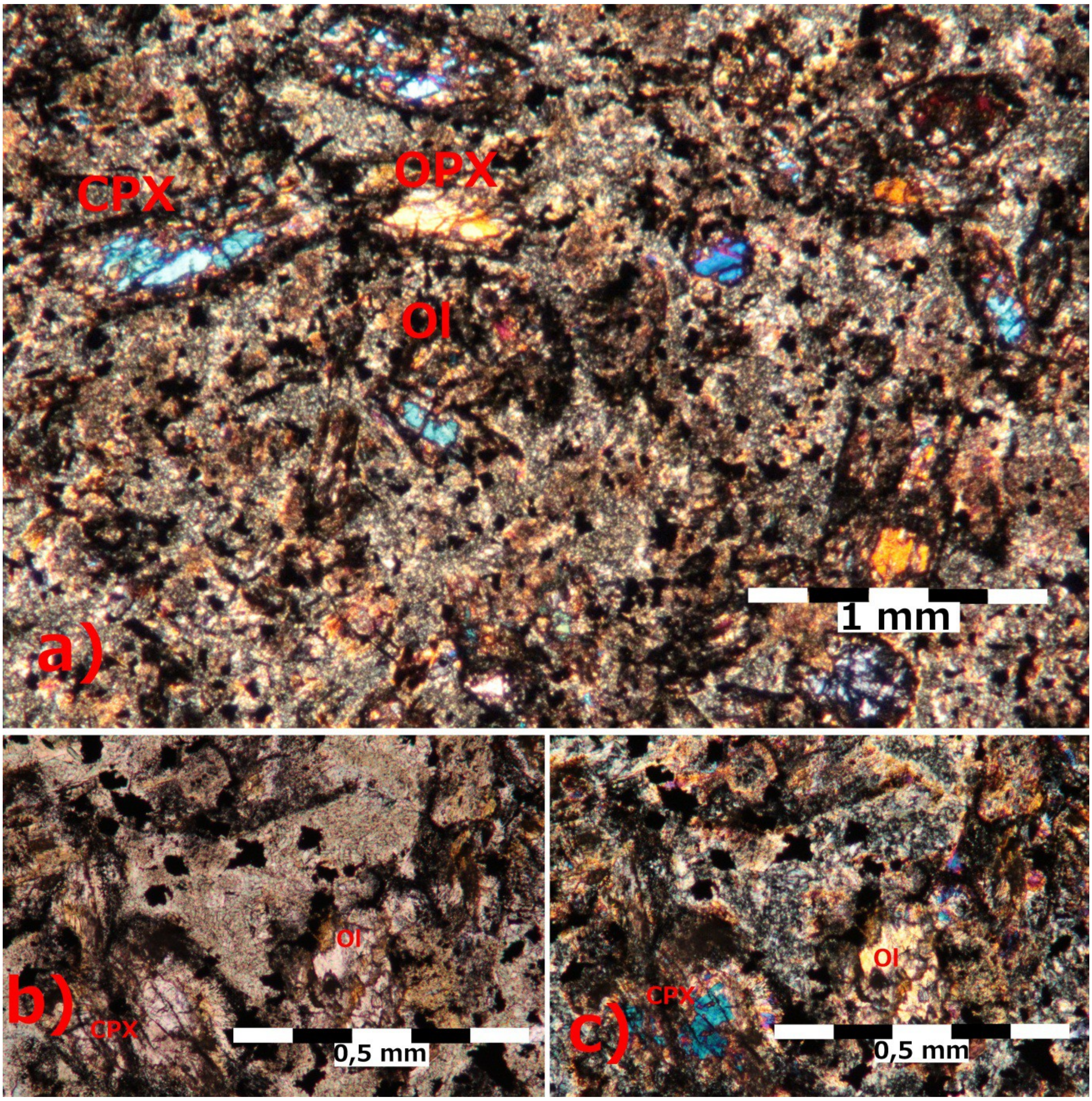

Figure 3.3.10: Thin section of kim09-2175, an ultramafic lamprophyre containing olivine, opx, cpx and amphibole. Olivine is partially resorbed suggesting disequilibrium conditions for olivine during emplacement in the upper crust, but also might indicate that the origin of this rock is in the deep mantle. a) General xpl view of the thin section, showing some of the most important minerals present, and their state. b) Plane polarized view of thin section and its alterations. c) Cross polarized close view of thin section showing a serpentinized groundmass, indicating high magnesian silicate minerals.

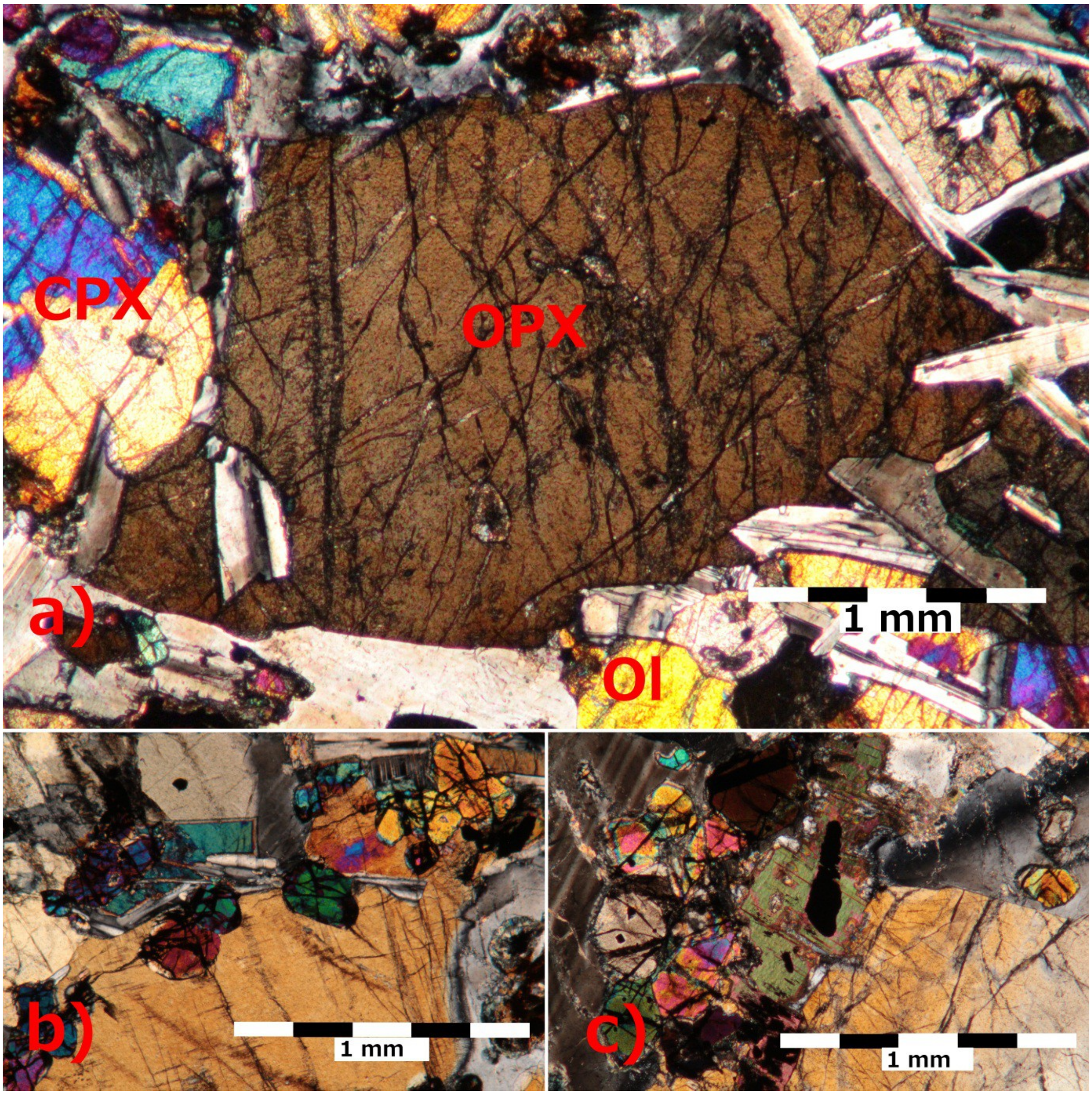

Figure 3.3.11: Thin section of kim09-3069, a very coarse grained mica picrite (Proto-kimberlite?) with presence of opx, cpx, phlogopite, plagioclase, amphibole, olivine, and spinel. Subhedral to euhedral spinel present as inclusions in both primary (sub-liquidus) mica and olivine, very typical of kimberlitic melts (Mitchell, 1995).a)General view of the thin section in xpl, with focus on opx as it is the largest type of mineral visiblein this thin section. b) Olivine and other types of smaller mineral grains apparently included into the orthopyroxenes in this rock. Indicates opx grew after olivine.c) Axpl view of phlogopite and olivine with spinel present as inclusions.

Historically mica rich picrite like kim09-3069 (figure 3.3.11) was the first diamond related rock found in the nearby Archangelsk diamond province (the so-called Mela sills), kimberlites were found later in the same area(s) (Beard et al., 2000).

Mahotkin et al. (1999) published a paper about micaceous alkaline picrites in the Arkhangelsk region where they described these as proto-kimberlites, closely related to diamondiferous kimberlite.

A genetic model was proposed where sub-lithospheric convecting mantle produced enriched magma, and during uprising through a ~200 km thick lithosphere some of the magma reacted with fusible lithospheric components to produce micaceous alkaline picrites and diamondiferous kimberlites.

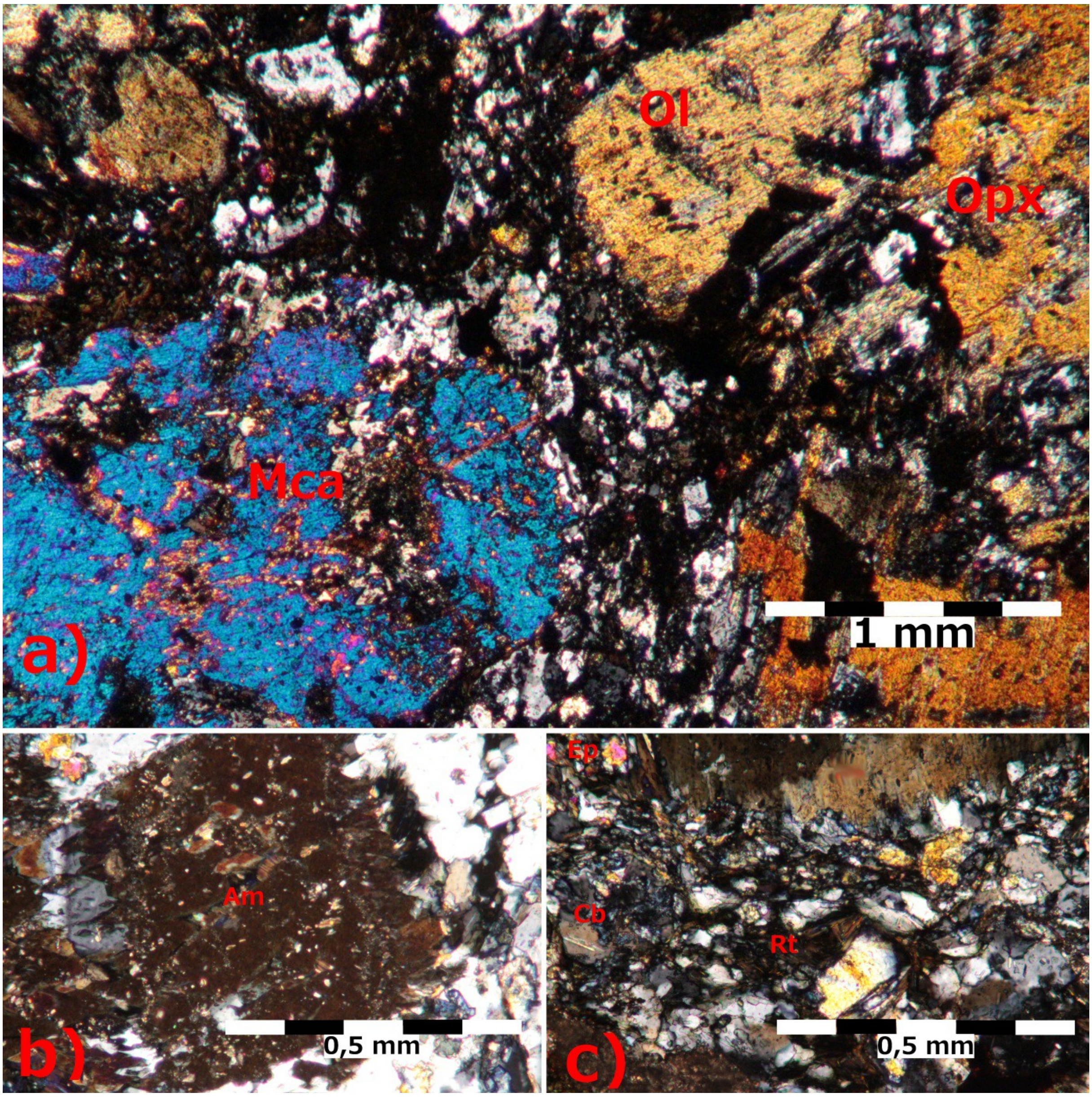

Figure 3.3.12: Thin section of r11-01, a brecciated ultra-sodic, calc-alkaline lamprophyre with mica, olivine, amphiboles, pyroxenes, epidote, spinel, carbonate minerals, very little plagioclase, and also seems to contain some Ti-oxides. Large subhedral mica phenocryst suggests high water content in parental melt. Euhedral to subhedral mica, and olivine is also included in amphibolite and pyroxene megacrysts, probably from an early phase. a) Cross polarized view of thin section showing some of the important minerals present, and their relative size and state. Most of the minerals have been heavily fractured, likely as a result of eruption. b) Close up cross polarized view of one of the amphiboles in the thin section, some inclusions visible. c) Cross polarized view of groundmass that seems to contain some rutile or similar mineral (ilmenite ?).

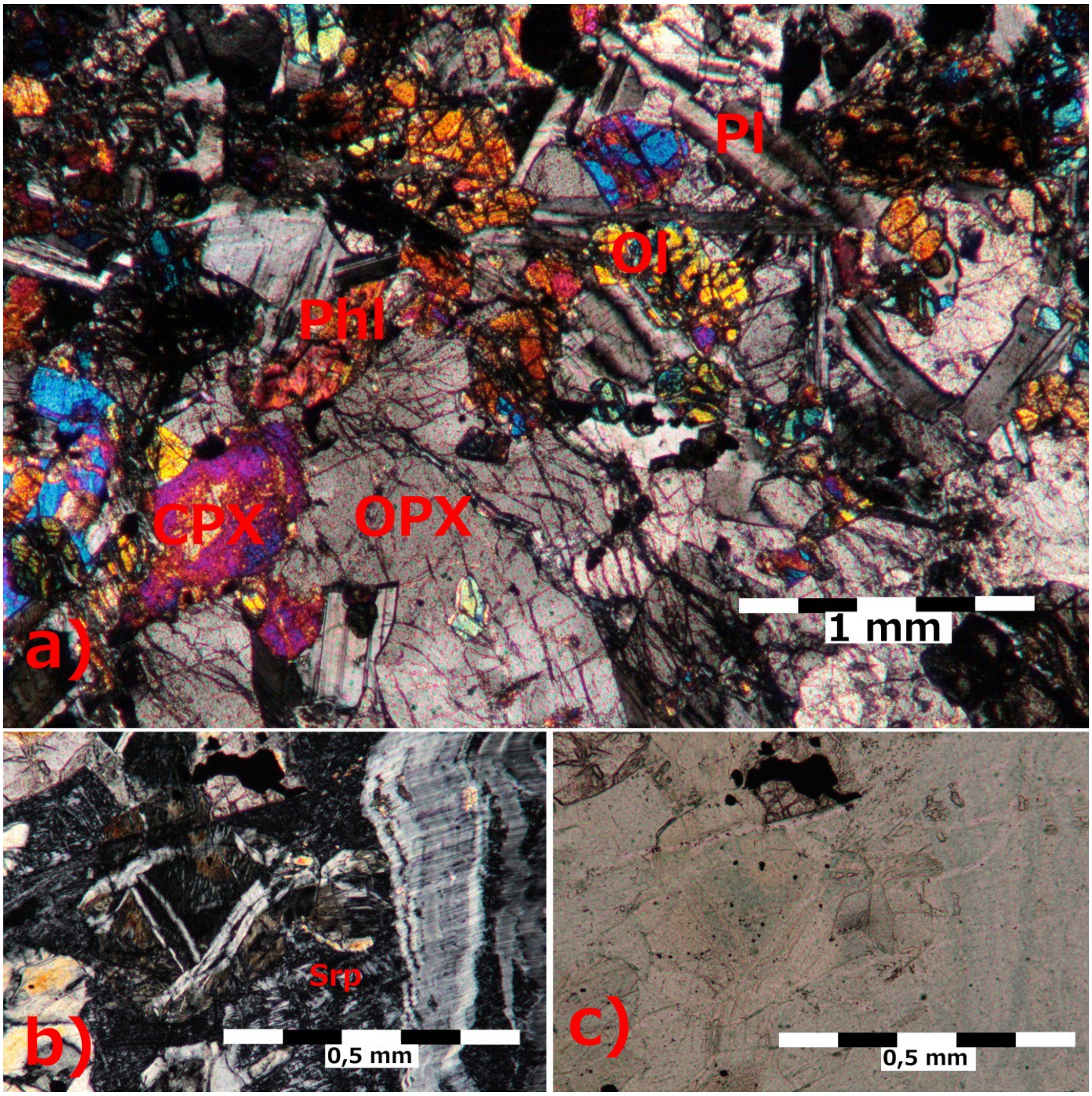

Figure 3.3.13: Thin section of r13-05, a partially serpentinized coarse grained micaeous picrite with presence of phlogopite, plagioclase, olivine, amphibole and pyroxene. Alteration (serpentization) is strongest closest to hydrothermal vein in rock, and dissipates significantly further from it. a) Cross polarized view of one of the most unaltered parts of the thin section. b) Cross polarized view of area closest to hydrothermal vein. c) Plane polarized view of same area as in b.

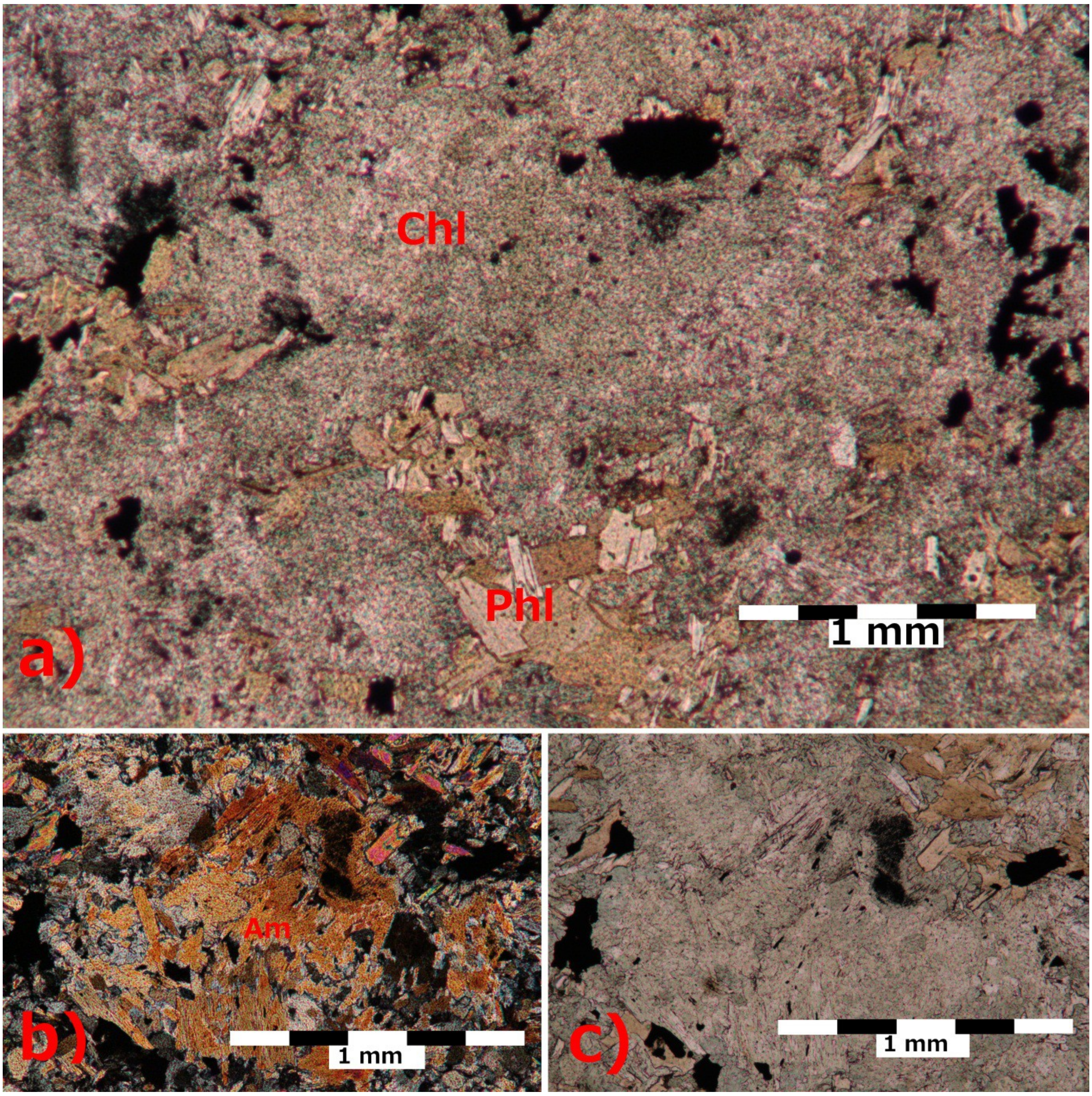

Figure 3.3.14: Thin section of r13-08, a metamorphosed ultramafic lamprophyre with both primary and secondary amphibole. Also present is phlogopite and chlorite. a) Plane polarized view of the thin section showing clusters of phlogopite in a mostly chlorite groundmass. b) Cross polarized view of one of the altered amphiboles. c) Plane polarized view of same section as in b

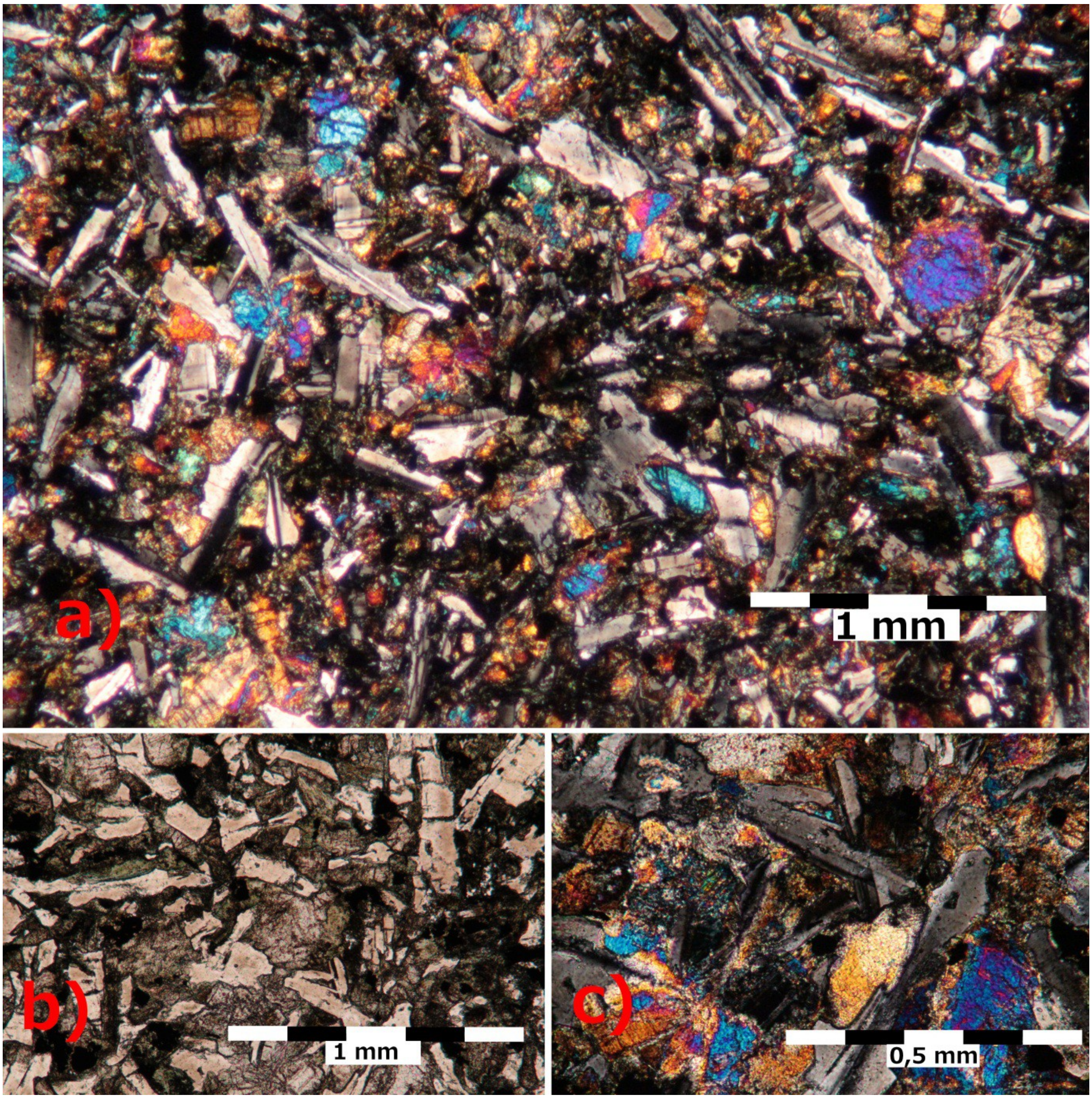

Figure 3.3.15: Thin section of r13-12, a slightly chloritized high-Fe tholeiite basalt dike where main mineral are laths of plagioclase, typical in appearance for volcanic igneous rocks, some chlorite alteration in other minerals like cpx and opx. a) Cross polarized view of thin section showing the structure of the rock as primary, seemingly unaltered since deposit. b) Plane polarized view of the thin section where alteration is visible around the plagioclases. c) Cross polarized view of the thin section showing remains of pyroxenes, and some alteration in the plagioclases.

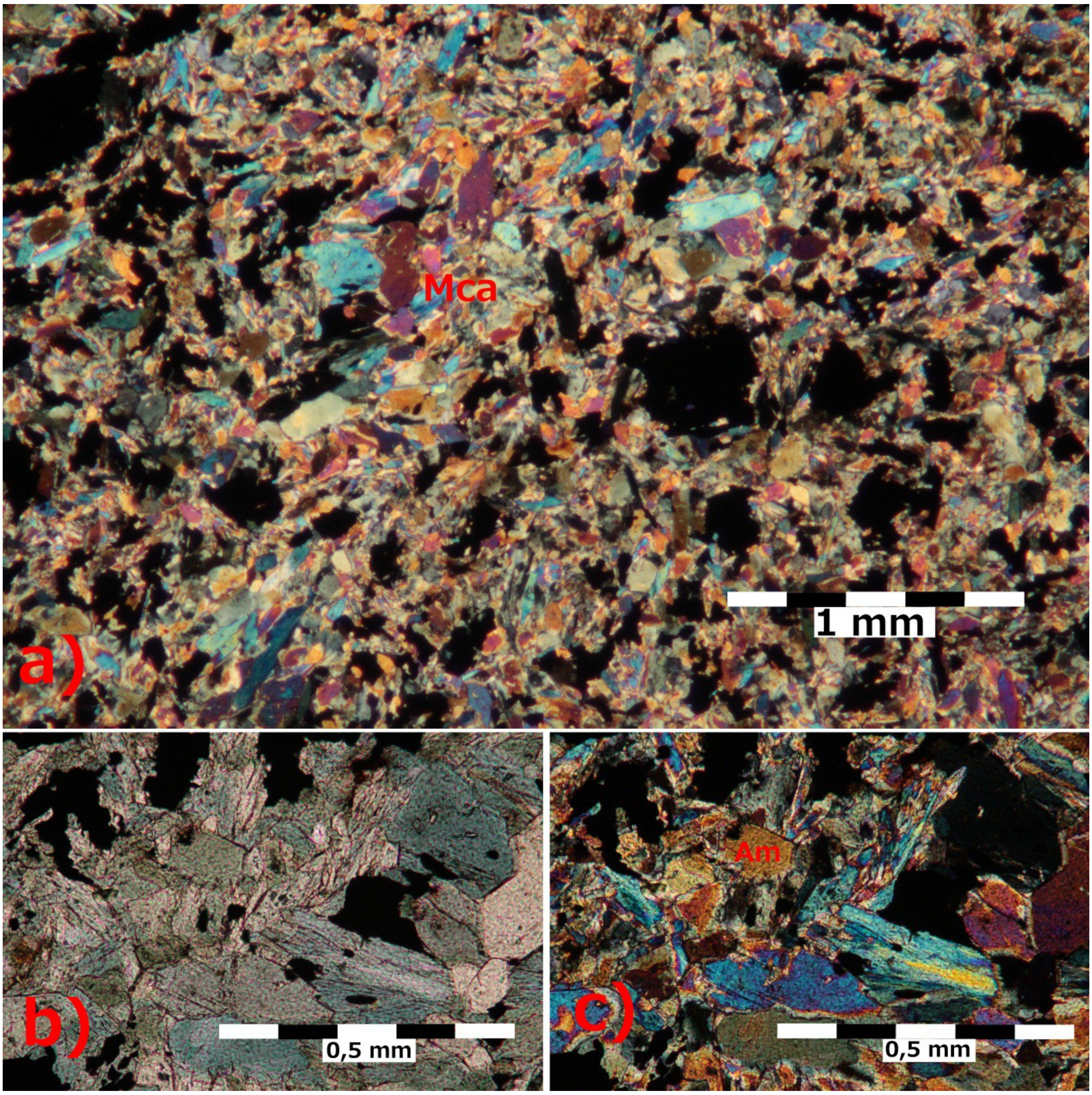

Figure 3.3.16: Thin section of s375, a titanium, iron, and magnesium rich rock, most likely a ultramafic lamprophyre. a) Wide view of thin section shows a lot of opaque minerals, some mica and secondary amphiboles. The rock is fine grained and mostly equigranular, except for some clusters of larger grains (porphyritic mica?), and the opaque minerals. b) Plane polarized view of thin section showing chlorites and secondary amphiboles. c) Cross polarized view of thin section with amphibole marked in center. Cleavage is also visible for surrounding minerals, and many of them seem to have prefect cleavage in one direction only. There is also a distinct lack of plagioclases.

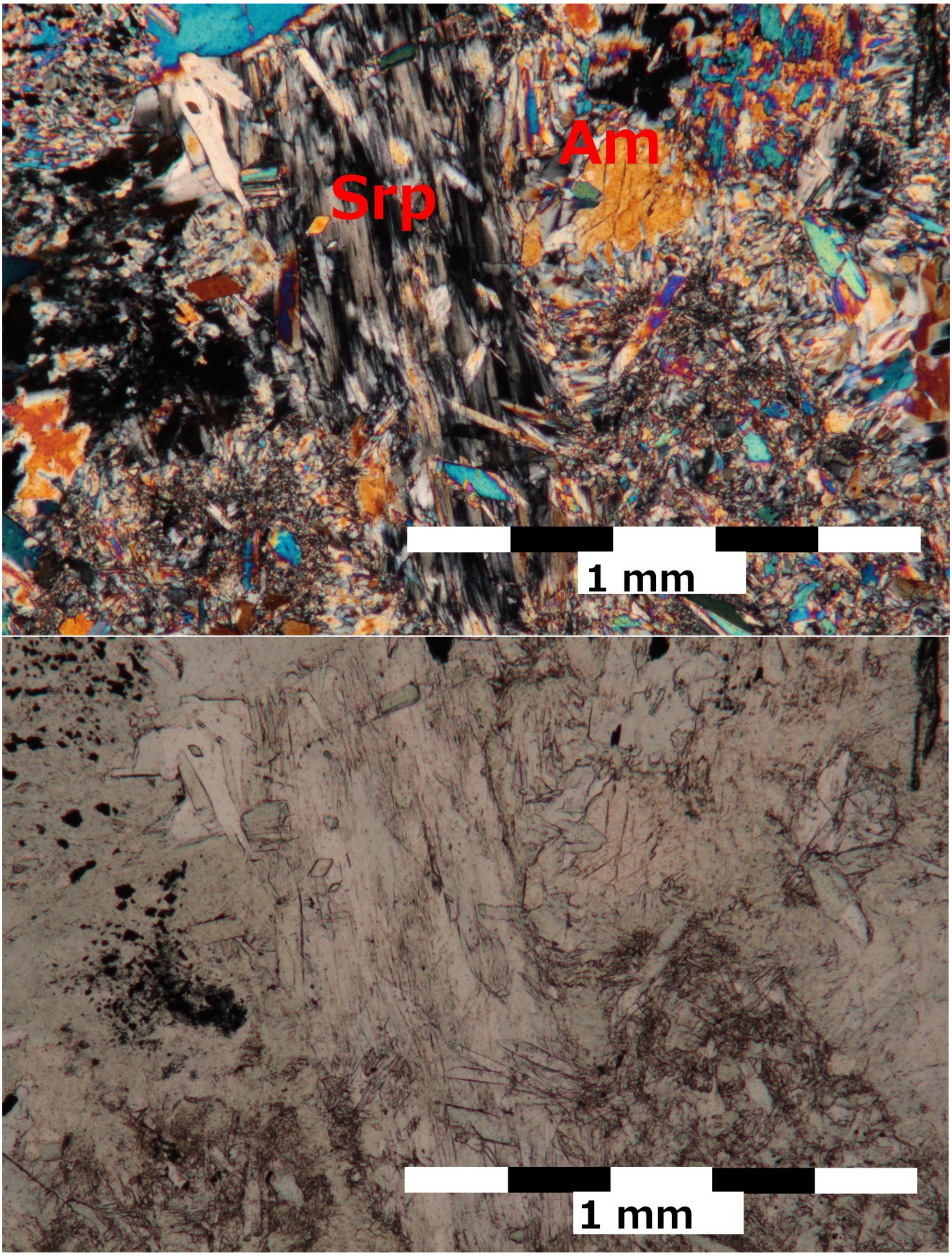

Figure 3.3.17: Thin section of s376, a metamorphosed komatiite with secondary amphiboles and hydromica. There is also quite a lot of serpentine present, reflecting its magnesium rich nature. Top photo shows a cross polarized view of the thin section, and bottom photo shows a plane polarized view.

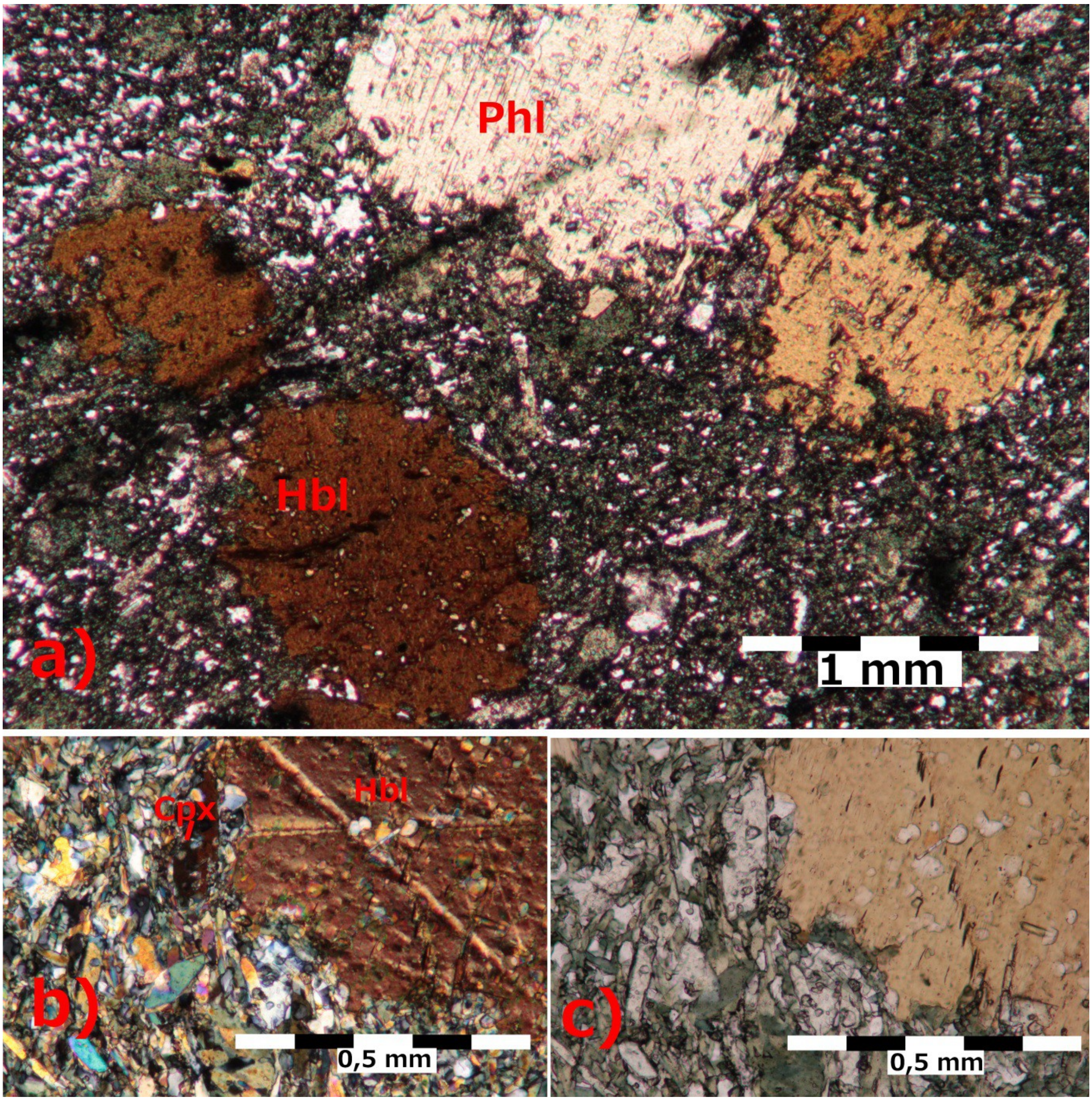

Figure 3.3.18: Thin section of s388, a calc-alkaline lamprophyre with phlogopite and hornblende phenocrysts. Matrix is dominated by cpx and contains mica, also included into amphiboles. a) Plane polarized view of large phlogopite and hornblende megacrysts. b) Cross polarized view of one of the hornblendes with mica inclusions, also visible is the larger clinopyroxenes in the matrix. c) Plane polarized view of same section as in b showing the alterations of magnesium rich minerals in the groundmass.

4 Petrology & Geochemistry

4.1 Introduction

Results presented in this chapter have been interpreted using GCDkit. Several plots has been made to visually present the large number of samples and interpretation of trends seen in the distribution of geochemical data.

4.2 Major & Trace Geochemistry of Samples

General Fractionation Trends as Shown by Simple Bivariate Plots:

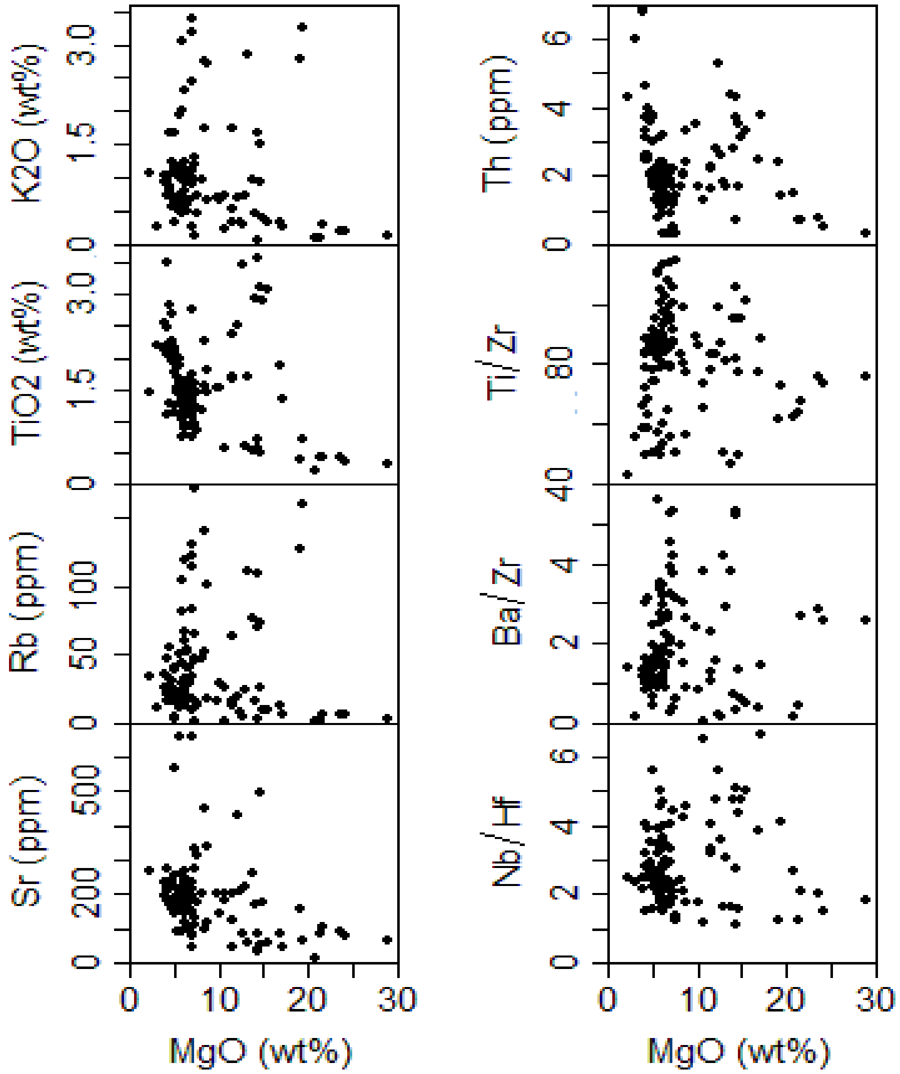

Fig. 4.2.1. Bivariate plots with selection of LILE, HFSE, and elemental ratios (ppm) vs. magnesium (ppm) for the mafic-ultramafic rock association in Sør-Varanger. The different fractionation trends visible suggest multiple magmatic suites are present in the area.

Bivariate plots are useful in showing variation between samples and to identify trends. The element plotted along the x-axis are selected to show either the maximum variability between samples or to illustrate a particular geochemical process.
For basic igneous rocks it is best to use magnesium or MgO as x-axis because it shows the greatest range and is the most appropriate element/oxide to use as it is an important component of the solid phases in equilibrium with mafic melts. (Rollinson, H., 1993).

Some interpretations can be made from position of plots in plate of bivariate plots such as figure 4.2.2.
Very high magnesium values are typical for picrites and komateiitic basalts.
High magnesium and potassium values together with enriched values of incompatible elements are very typical for ultramafic lamprophyres and related rock suites such as kimberlites.
High values of potassium and incompatible elements together with relatively low values of magnesium are typical for alkali basalts and related rock suites.

Sample Alteration and its Affect on Mobile Elements:

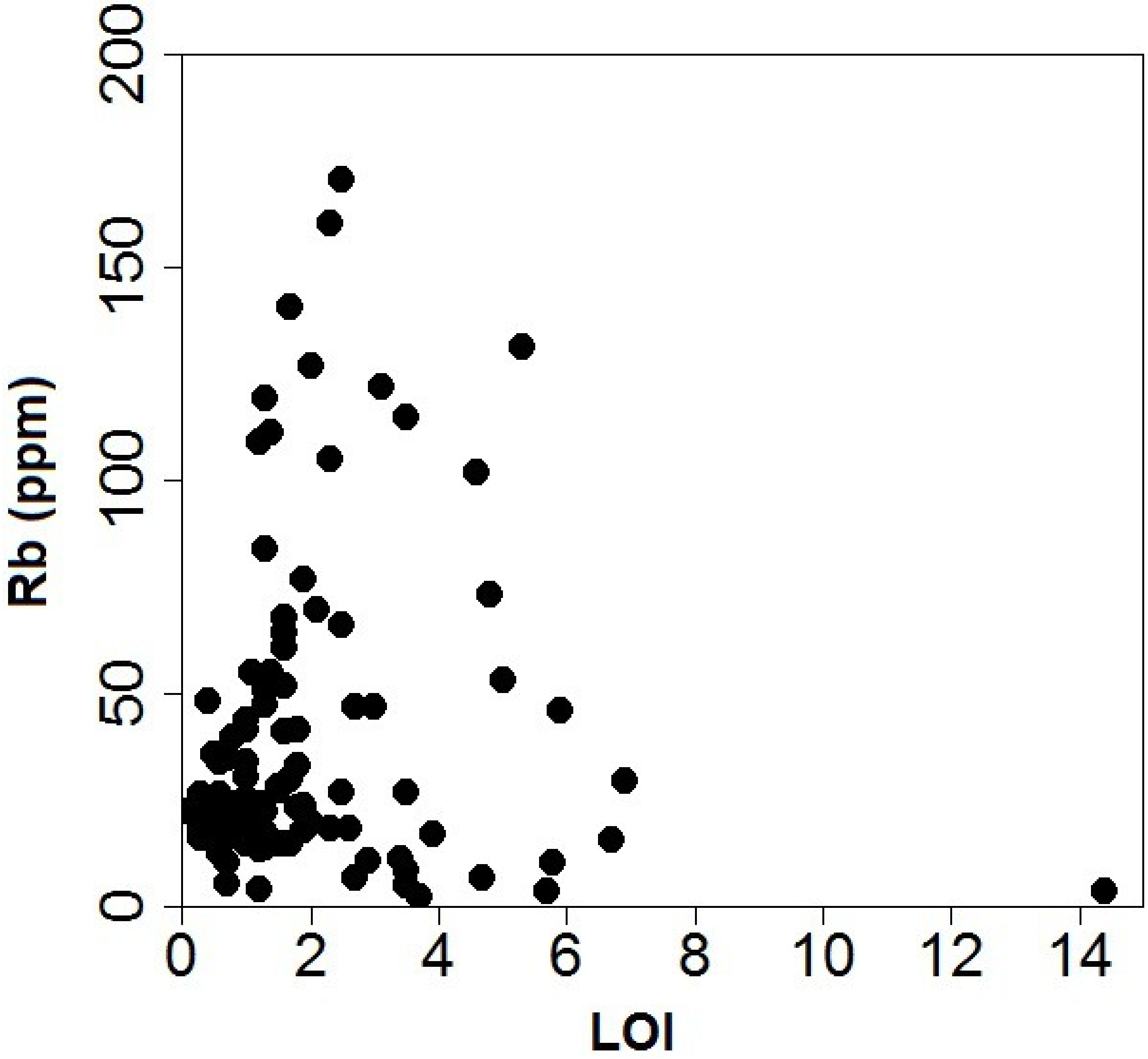

Figure 4.2.2. The use of mobile large-ion lithophile elements (LILE) in interpreting geochemical data is risky if there has been too much alteration. However this loss of ignition (LOI) vs Rb plot shows no significant correlation between loss of ignition and Rb, also the highest LOI value (14+) shows very low Rb content, indicating that the Rb content of samples from the study area has not been significantly affected by secondary alteration, but are likely caused by crustal contamination.

Indications of Tectonic Environment:

"*The use of immobile elements like Ti, Zr, Nb and Y for distinguishing between basalt types is ideal because of their relative stability in metasomatic events*". (Rollinson, H., 1993).

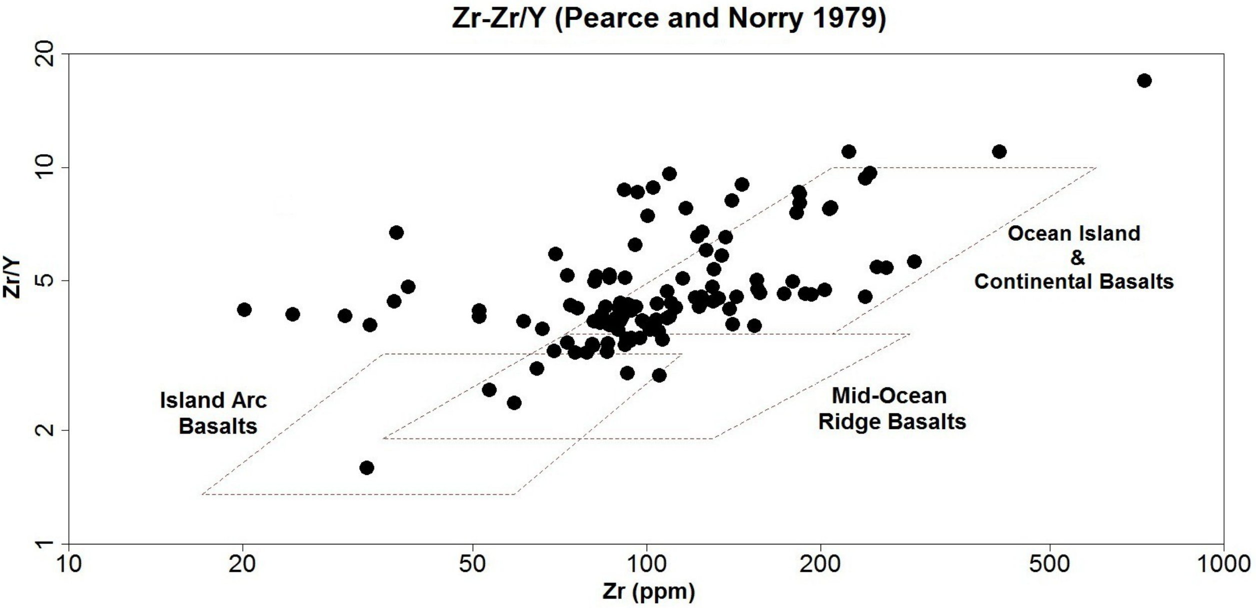

Figure 4.2.3. Adapted Zr-Zr/Y geotectonic plot by Pearce and Norry (1979) indicating that most of the samples from the study area plots in or near enriched mantle source (OIB).

Pearce and Norry (1979) noted that within plate basalts (renamed to Ocean island & Continental basalts in figure 4.2.3.) have a high Zr/Y ratio due to (fluid controlled) source heterogeneities, and are alkalic in composition.

Indications of Mantle Source Heterogeneity:

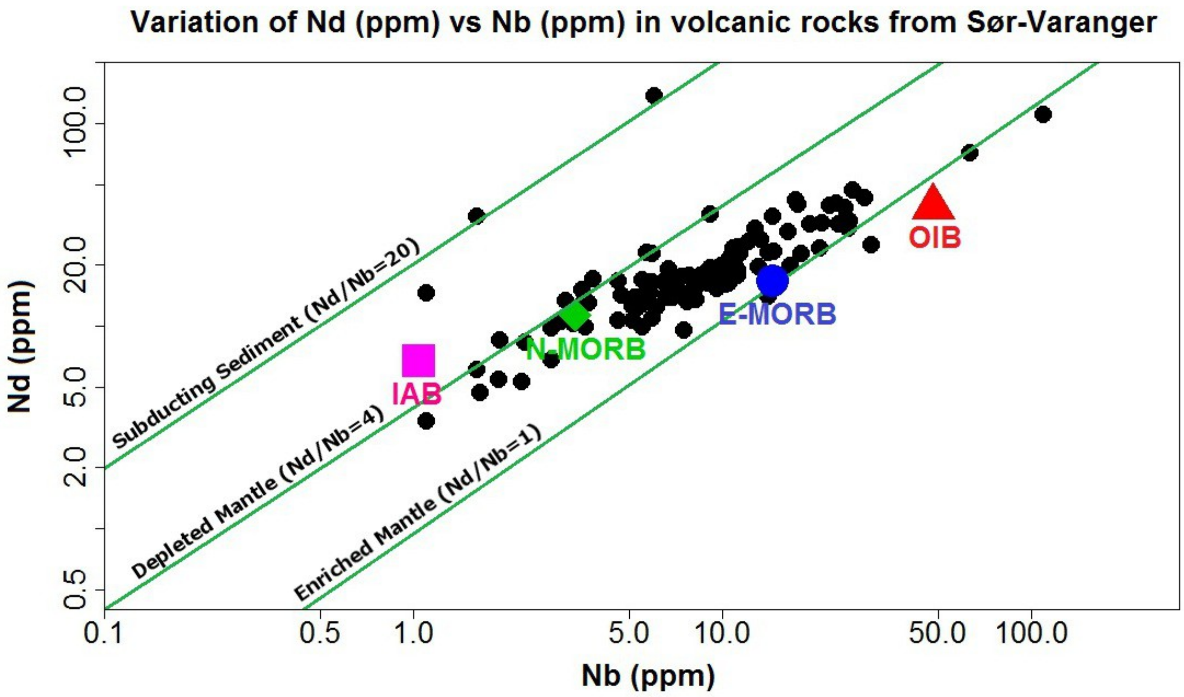

Figure 4.2.4. Customized diagram showing variation of Nd (ppm) versus Nb (ppm) in volcanic rocks from the study area.
Data sources: Average Nd and Nb values for island arc basalts (IAB), normal mid-ocean ridge basalts (N-MORB), enriched mid-ocean ridge basalts (E-MORB) and ocean island basalts (OIB) are from Niu and O'Hara (2003). Nd and Nb values for depleted mantle (DM) are from Workman and Hart (2005) and for enriched mantle – from Carlson & Boyet (2008). Trace element contents in subducting sediment represented by clay sediment of Tonga trench are after Plank and Langmuir (1998).

The chemical composition of typical kimberlite and kimberlite related source rock are mostly plotted in the area of OIB (Le Roex et al., 2003). However some deviant trace element values are found when the source rock has been influenced by multiple components.
One such example are the Siddanpalli kimberlites from Southern India (figure 4.2.5) where a possible involvement of a subducted component in their mantle source region displaced their chemical composition relative to typical kimberlites. (Chalapathi Rao et al. 2010).
A similar situation are indicated in Sør-Varanger with the displacement trend seen in the mafic-ultramafic rock association (figure 4.2.5).
The wide distribution of chemical compositions also supports mantle source heterogeneity in source rock under SV.

Indications of Mantle Source Metasomatism:

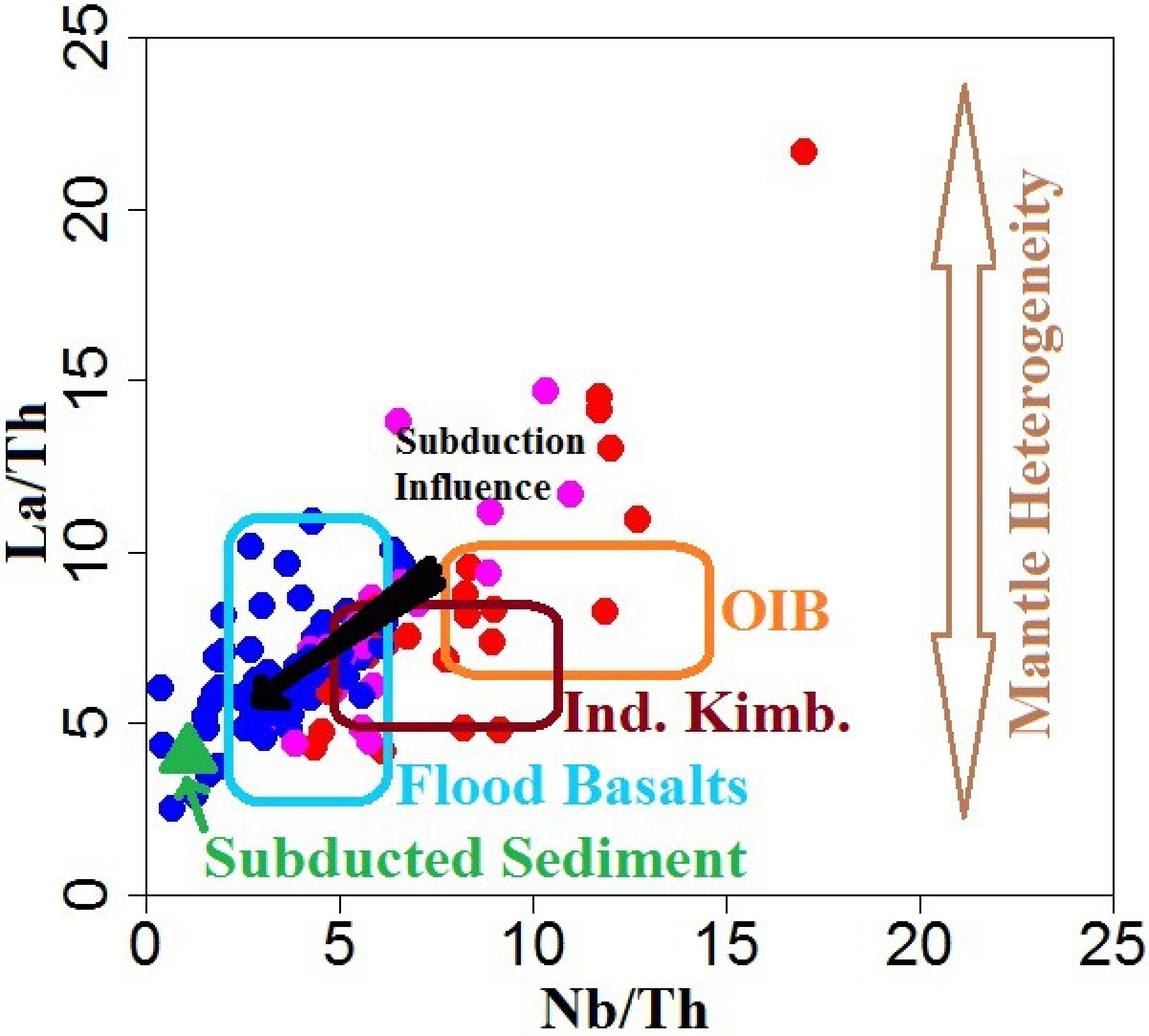

Figure 4.2.5. Customised La/Th versus Nb/Th graph for post-Precambrian igneous rocks in Sør-Varanger.
Fields for ocean island basalts (OIB), Indian kimberlites from eastern Dharwar Craton (Ind. Kimb.) and flood basalts are from Chalapathi Rao et al. (2010).
Average subducted sediment value (GLOSS – Global Subducted Sediment) is after Plank and Langmuir (1998).

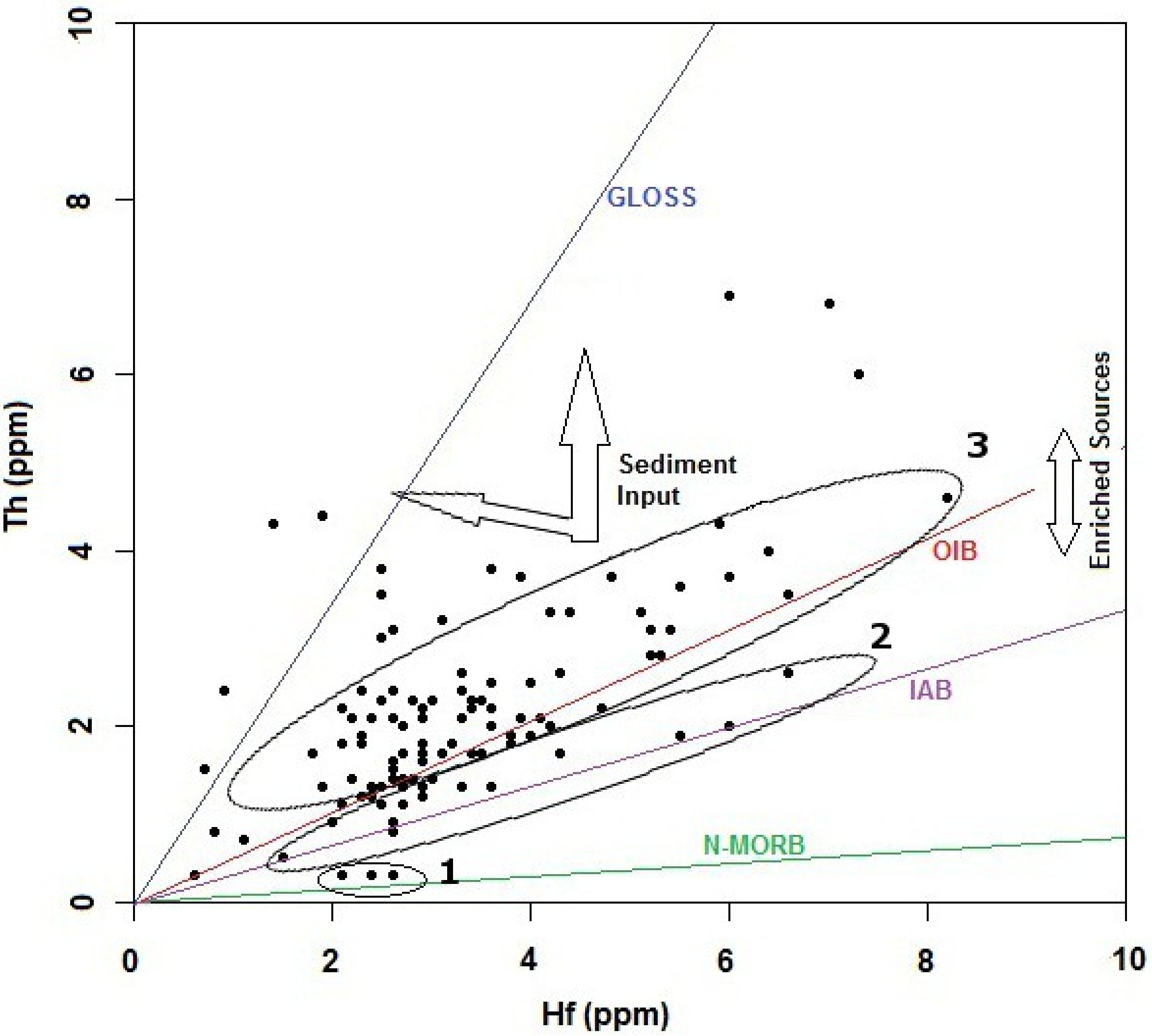

Figure 4.2.6. Th (ppm) versus Hf (ppm) for post- precambrien igneous rocks from SV area. Th/Hf ratios and related equilines for normal (depleted) mid-ocean ridge basalt (N-MORB), island arc basalt (IAB), and enriched mantle (OIB) are from Niu and O'Hara (2003). Global subducting sediment (GLOSS) value is after Plank and Langmuir (1998). Fields 1-3 are for SV volcanic rocks: 1- Depleted compositions, 2-Subduction modified compositions, 3-Enriched compositions (mantle sources compatible with kimberlite generation model of Le Roex et al., (2003)).

The chemical composition of the mafic-ultramafic rock association in Sør-Varanger are varied, and a large number of samples show enriched mantle source compositions.
Sediment input is indicated by the apparent chemical displacement towards GLOSS (figure 4.2.6). This is probably due to an earlier subduction event.

Mantle Source Determination:

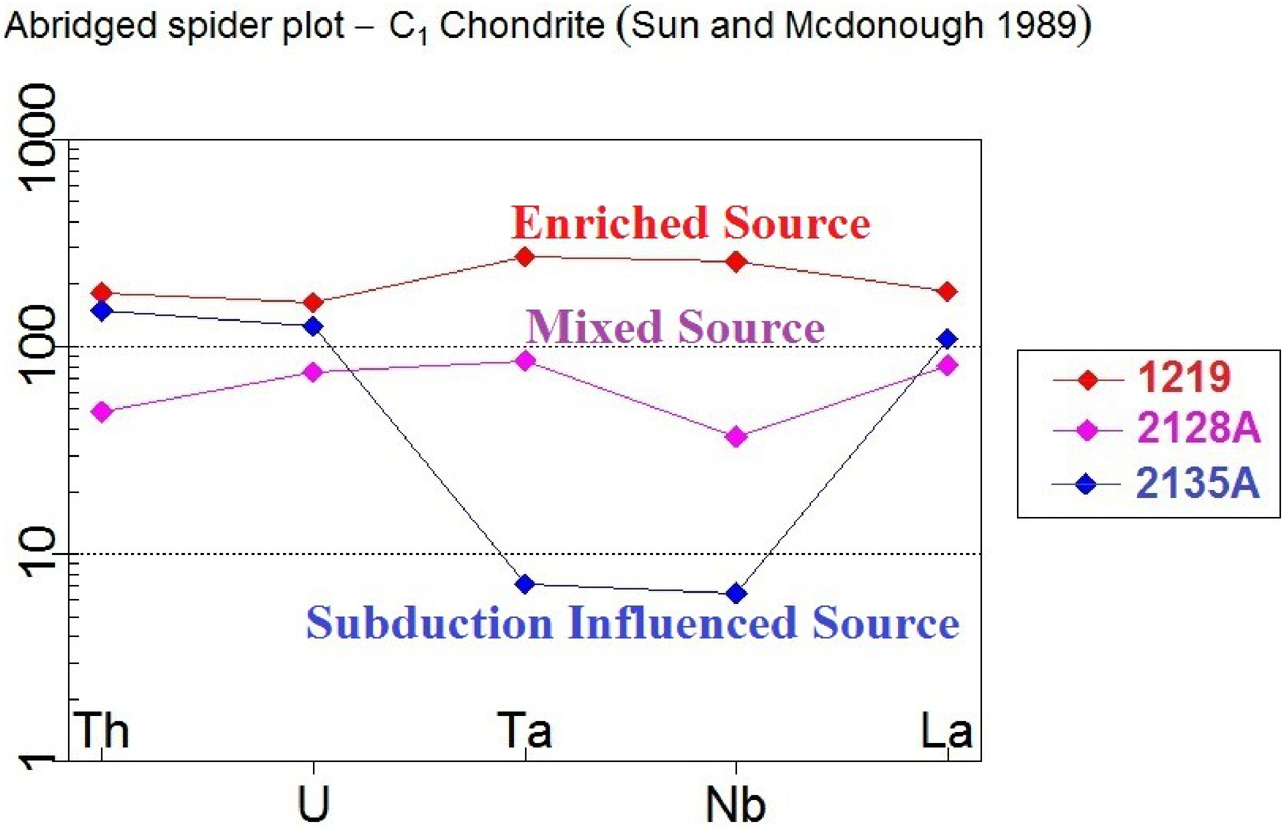

Figure 4.2.7: Plot showing determination of mantle sources. Samples 1219, 2128A, and 3135A are good examples of each mantle source type respectively. Visual representation of all samples categorized this way is impractical due to the high number of samples. Data from this mantle source classification of samples have been used in other plots and tables throughout this thesis. See appendix 2 for relative distribution of mantle source samples.

Indications for Subduction Enrichment:

It is widely recognized (e.g., Saunders et al., 1980) that calc-alkaline magmas erupted above subduction zones characteristically display relatively low abundance of some high field-strength elements (HFSE) such as niobium (Nb) and tantalum (Ta) as compared to other incompatible elements such as uranium (U), thorium (Th) and lanthanum (La).

Several geochemical profiles (figure 4.2.7) show such subduction-related values, however this does not necessarily imply subduction was the cause of magmatism.
The lithospheric mantle can inherit a subduction related signature (chemical overprint) from earlier tectonic events. (e.g. Goodenough et al., 2002; Ringwood, 1990).
These inherited subduction enrichment trends can be observed in the geochemistry of the Sør-Varanger mafic-ultramafic rock suites, as demonstrated in figures 4.2.8 to 4.2.11.

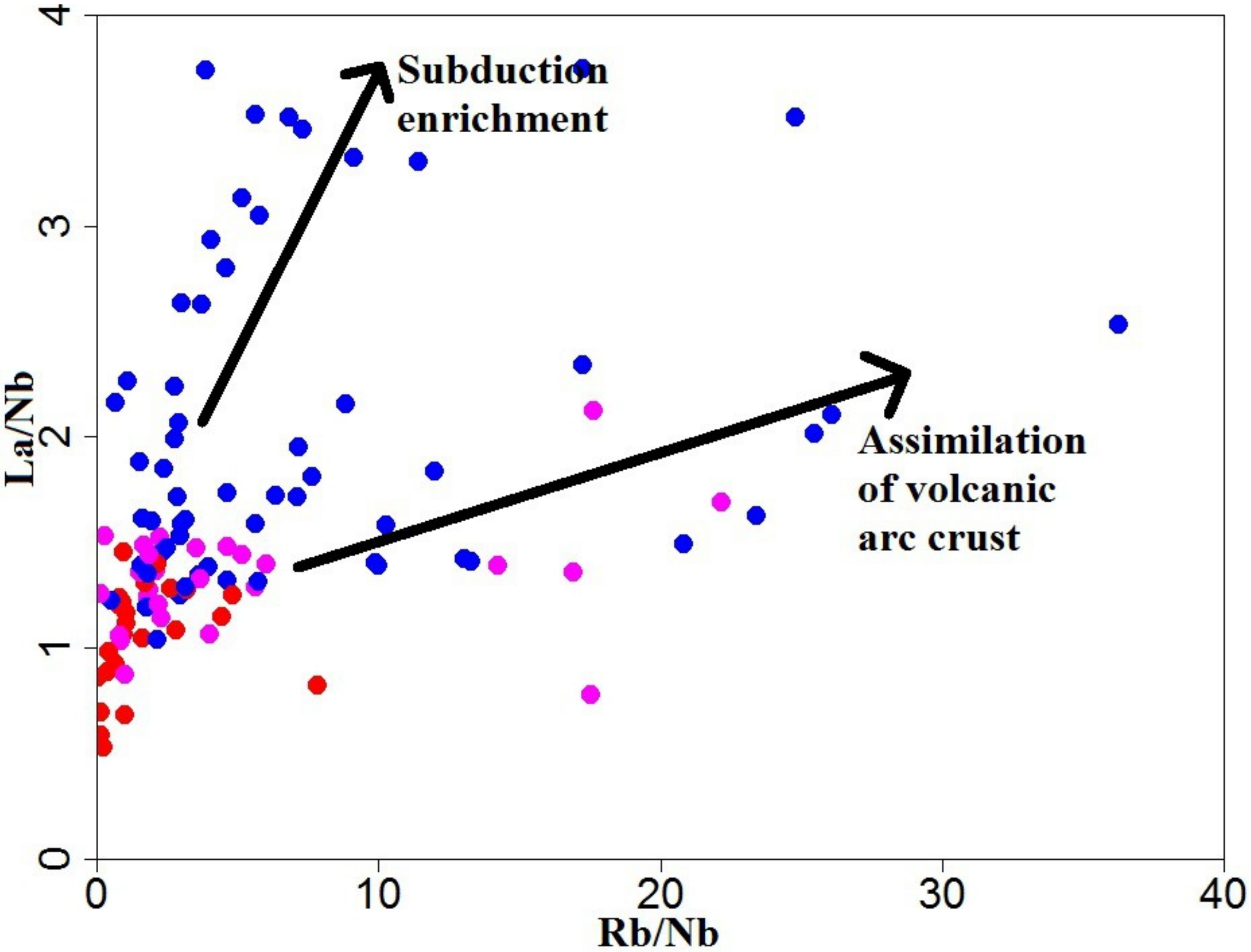

Figure 4.2.8. Chemical overprint visible in trends for La/Nb vs Rb/Nb diagram of Post-Precambrian rocks from SV. Volcanic arc crust has low HFSE contents, high LILE contents, elevated LILE/HFSE ratios. Any metasomatism happening due to assimilation of volcanic arc crust will reflect these values.(e.g. Michelfelder et al. 2013). *Lower trend (assimilation of volcanic arc crust) might alternatively be due to secondary alteration observed in some samples.*

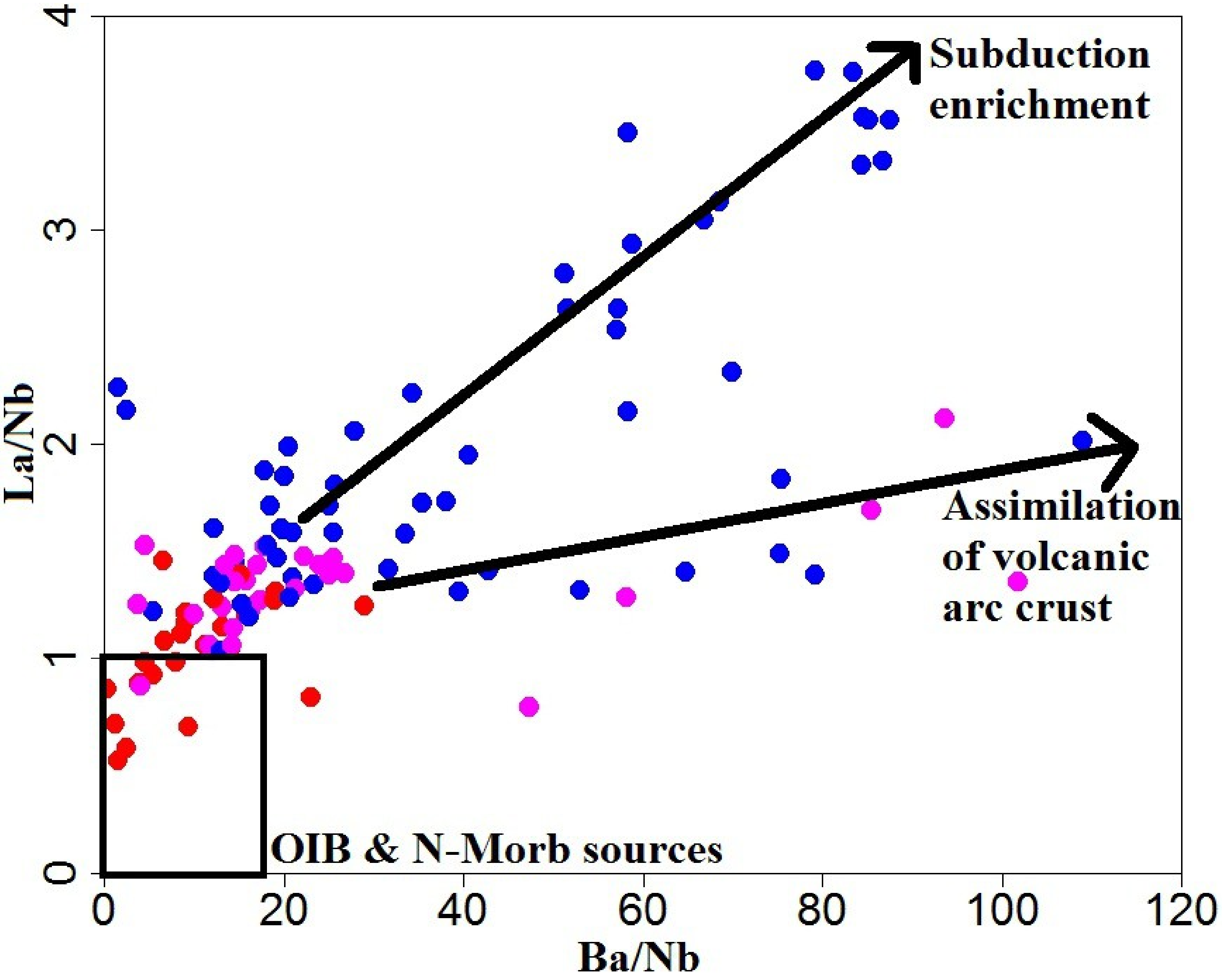

Figure 4.2.9. Chemical overprint of primary OIB and N-MORB sources visible in trending for La/Nb vs Ba/Nb plots for Post-Precambrian rocks from SV. Volcanic arc crust has low HFSE contents, high LILE contents, elevated LILE/HFSE ratios. Any metasomatism happening due to assimilation of volcanic arc crust will reflect these values. (e.g. Michelfelder et al. 2013). Lower trend (assimilation of volcanic arc crust) might alternatively be due to secondary alteration observed in some samples.

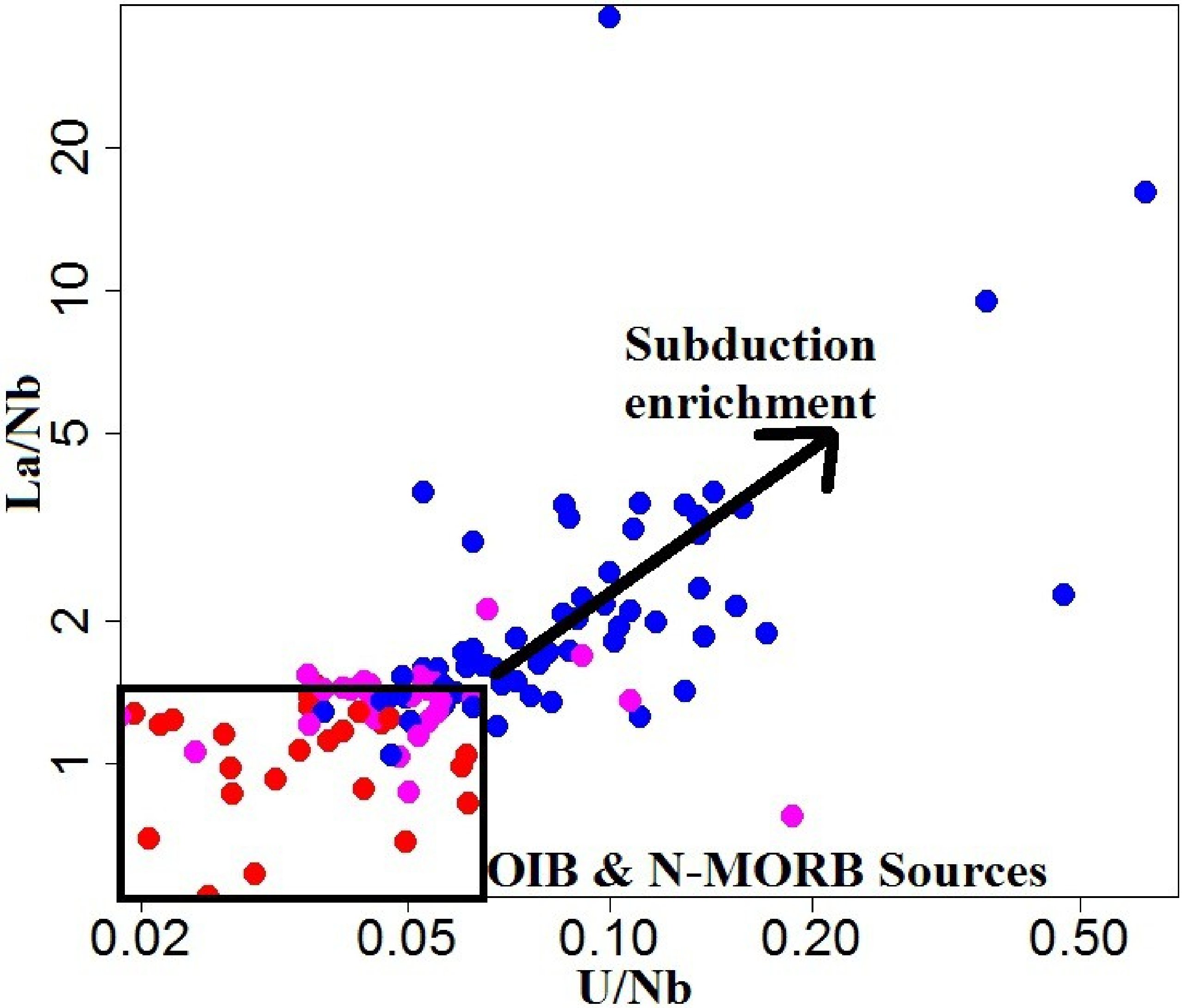

Figure 4.2.10. Chemical overprint of primary OIB and N-MORB sources visible in La/Nb vs U/Nb plot of Post-Precambrian rocks from SV.

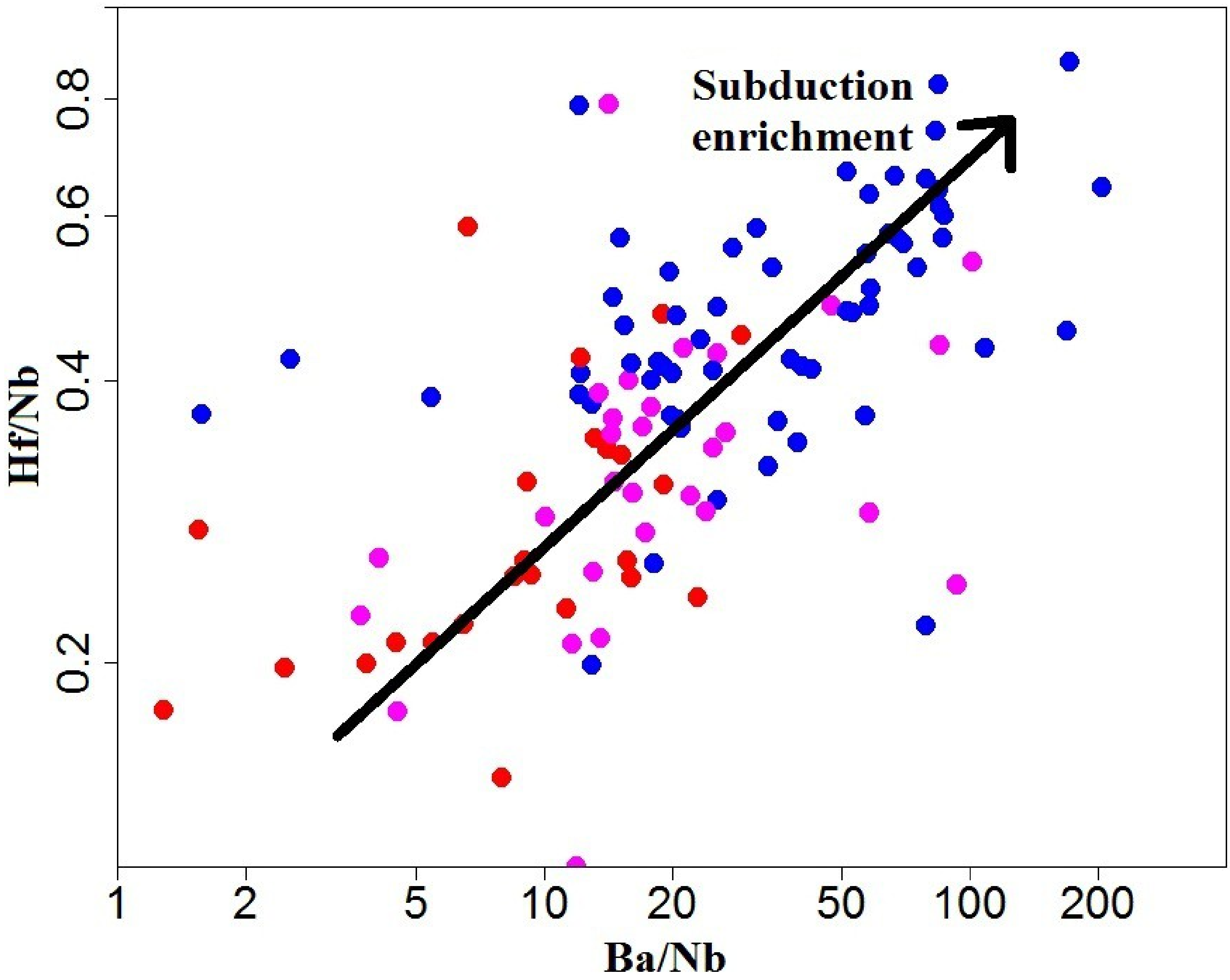

Figure 4.2.11. Trending indicating subduction enrichment of magma sources.

5 Discussion

5.1 Possible Scenarios for Origin of Mantle Heterogeneities

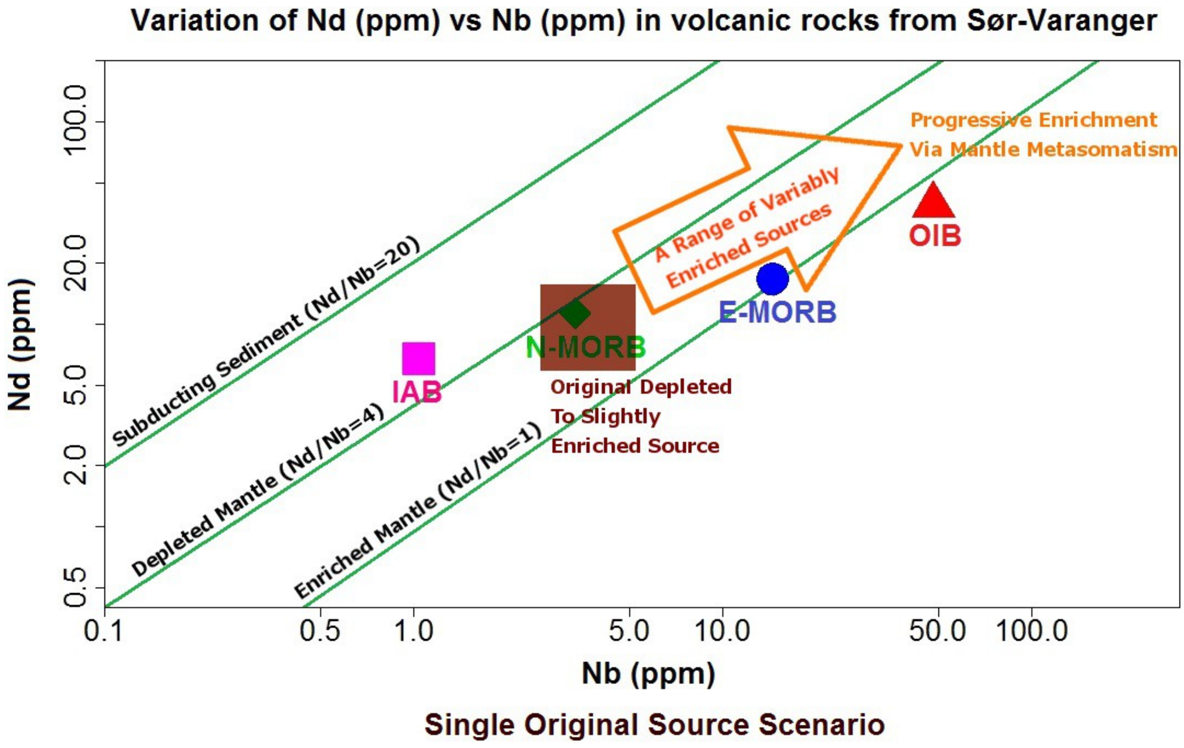

Figure 5.1.1. One explanation for the apparent mantle heterogeneity observed is the enrichment of a single original source, resulting in mantle heterogeneity.

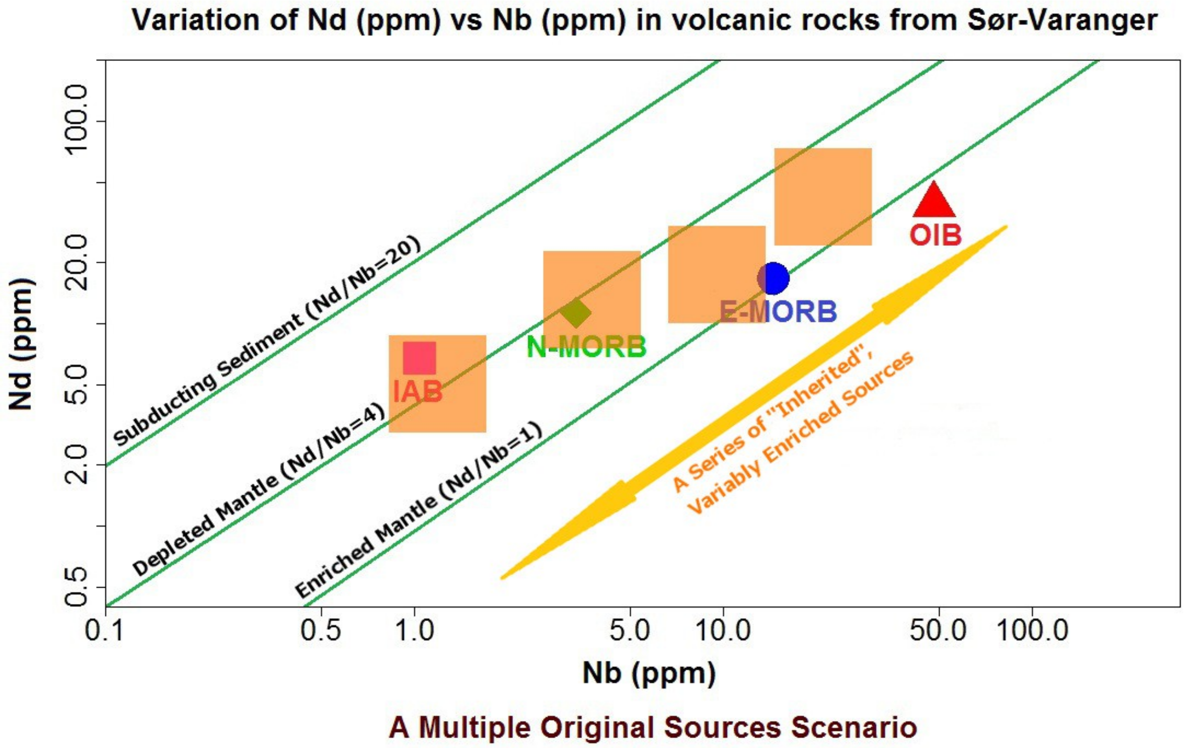

Figure 5.1.2. Alternatively there could have been multiple mantle sources inherited from Precambrian geodynamics. This scenario is most likely, and is indicated by the distribution of samples in figure 4.2.4.

5.2 Diamond Potential of Eastern Finnmark Region

Basics of diamond prospectivity:

The diamond prospectivity of any potential hard rock source of diamonds is dependant of two important factors. First, the underlying mantle source area must contain diamonds. Second, the magma must have come from a sufficient depth as to bring samples (as xenocrysts or xenoliths) of this diamondiferous mantle to the surface. (Woodard, J. 2010).

Source rock requirements for diamond production:

It has been theorized in several papers that diamonds can crystallise from redox reactions involving metasomatising carbonatite melts (e.g. Stachel *et al.* 2008; Araújo *et al.* 2009).

Crustal requirements for diamond stability:

Areas in which a thick lithospheric mantle, low geothermal gradient and Archean bedrock overlap are the most promising for diamond exploration. (O'Brien *et al.* 1999; Kukkonen *et al.* 2003).

Arguments for diamond prospectivity of Sør-Varanger:

There are several good indications of the diamond potential in Sør-Varanger area.

1) Presence of several types of exotic, potentially diamondiferous rock types such as (proto-kimberlites?), lamproites and lamprophyres (see chapter 3).
2) Volcanic rocks with OIB type geochemistry, indicating petrogenesis originated in sub-lithospheric mantle sources like kimberlites and relatives. (Le Roex et al. 2003).
3) Presence of thick crust (East European Craton) beneath Sør-Varanger area (Calcagnile 1982), making diamond genesis possible in local sub-lithospheric conditions (figure 5.2.1).
4) Archean bedrock present (see table 1.3.1) making diamond emplacement in Post-Precambriam magmatism possible.
5) Low geothermal gradient (Kukkonen *et al.* 1996), raising the diamond-graphite transition to shallower depths (see figure 5.2.1).
6) Mantle source beneath region subjected to carbonatite metasomatism during the Sveconfennian collision, giving good conditions for diamond crystallisation in source rock. (e.g. Andersson *et al.* 2006; Eklund *et al.* 1998).
7) Presence of diamonds in alluvial sediments from the Pasvik River valley (Reusch 1895; Strnad 1991).

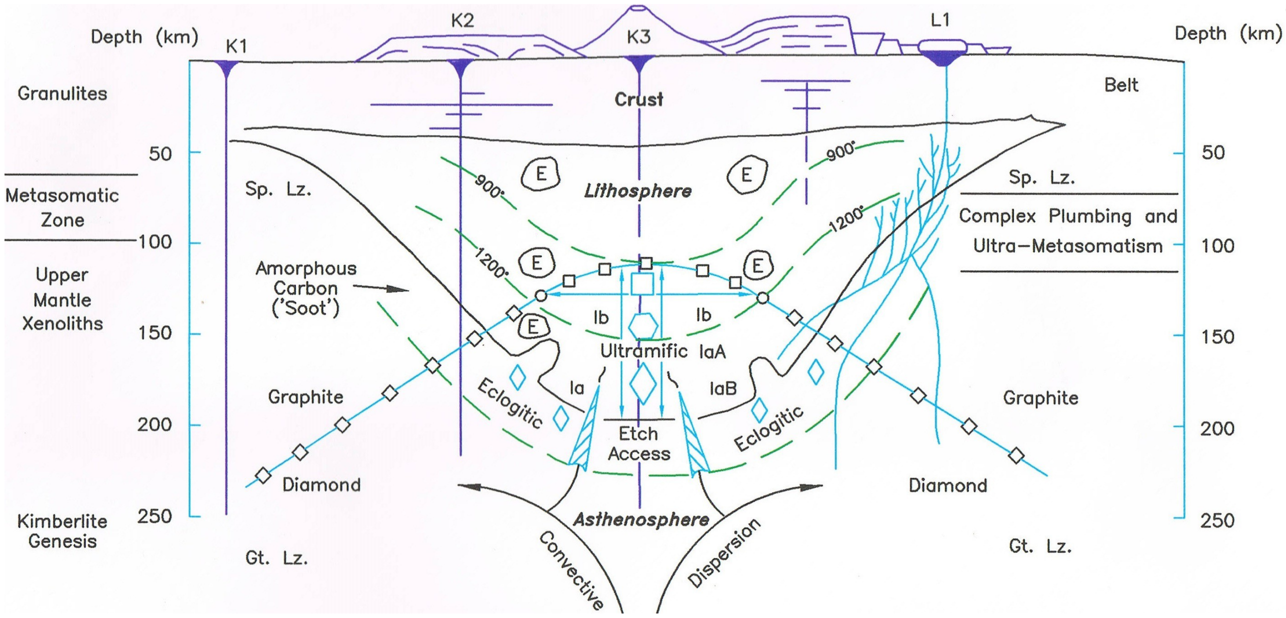

Figure 5.2.1: Subcratonic Lithosphere and Diamond Sources (After Haggerty, 1986)

6 Conclusions

- Original small-scale heterogeneity in mantle sources under SV varying from depleted and slightly enriched (similar to N- and E-MORB) to enriched (similar to OIB). Probably inherited from precambrian geodynamics.

- Subduction modification of some sources, most probably through accretion of subducted sediment to SV mantle at an Early Paleozoic (cambrian?) convergent margin.

- Some enriched sources under SV geochemically resemble deep mantle sources capable of producing kimberlitic and related magmas. Some of these melts can potentially carry diamond mineralization.

- Conditions for diamond mineralization and emplacement in Sør-Varanger are good, making the area a likely new diamond province, as of yet underdeveloped/poorly explored.

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Appendix 1. Whole rock chemical analysis, page 1

Analytical technics:	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF
Element:	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**Na_2O**	**K_2O**	**MnO**	**TiO_2**	**P_2O_5**	**LOI**	**SUM**
Unit:	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**
Method detection limit:	**0,1**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,1**	**0,01**
Kim09-1117	47,70	11,79	14,53	7,63	8,48	2,21	2,75	0,19	2,27	0,21	1,70	99,47
Kim09-1118	50,30	14,32	14,62	8,62	5,82	2,35	1,14	0,22	1,27	0,14	1,00	99,86
Kim09-1119	50,70	15,03	11,04	11,06	6,86	2,32	0,67	0,17	0,93	0,12	1,00	99,91
Kim09-1120	45,50	13,28	15,51	8,53	7,16	3,43	0,91	0,18	2,76	0,41	1,90	99,58
Kim09-1120A	48,90	12,61	17,68	9,75	5,63	2,09	0,50	0,24	1,99	0,16	0,40	99,97
Kim09-1122	50,30	12,78	16,67	8,70	4,50	2,40	0,86	0,23	2,85	0,34	0,30	99,90
Kim09-1122A	44,30	7,22	17,56	7,52	14,58	1,99	0,94	0,18	3,13	0,34	1,50	99,27
Kim09-1123	49,20	12,03	18,29	8,59	4,20	2,72	0,73	0,24	3,50	0,40	<0.1	99,99
Kim09-1143	50,10	13,69	14,35	9,99	6,13	2,34	0,71	0,20	1,32	0,12	0,80	99,72
Kim09-1219	35,80	7,61	23,35	8,57	12,39	0,49	0,34	0,33	6,75	0,61	3,50	99,76
Kim09-2126A	49,24	12,67	17,52	9,09	4,86	2,15	1,06	0,26	2,26	0,23	0,71	100,08
Kim09-2127A	56,30	13,88	12,21	6,04	5,03	1,85	1,22	0,13	1,13	0,16	1,80	99,80
Kim09-2127B	50,20	9,81	13,77	8,30	11,42	0,99	1,74	0,20	1,65	0,14	1,60	99,77
Kim09-2127C	55,40	13,35	13,03	7,86	4,28	2,90	0,98	0,16	1,09	0,16	0,60	99,85
Kim09-2127D	49,70	8,61	13,59	7,87	13,19	0,57	2,86	0,18	1,69	0,14	1,40	99,80
Kim09-2128A	47,10	7,79	10,55	7,82	19,23	0,37	3,25	0,17	0,72	0,30	2,30	99,58
Kim09-2128B	50,00	13,44	14,97	8,54	6,35	2,48	0,81	0,19	1,54	0,17	1,50	99,94
Kim09-2128C	50,50	14,30	12,36	10,43	7,16	1,89	0,89	0,19	1,07	0,11	1,00	99,93
Kim09-2128D	49,90	13,34	15,06	9,76	5,99	2,37	0,69	0,22	1,53	0,15	0,80	99,91
Kim09-2128E	50,10	13,44	14,89	9,94	6,20	2,18	0,69	0,21	1,46	0,14	0,70	99,98
Kim09-2128F	50,00	13,32	14,91	10,26	6,12	1,83	0,82	0,23	1,47	0,15	0,70	99,89
Kim09-2129	52,00	9,92	11,27	10,08	9,99	2,43	0,71	0,17	1,52	0,28	1,30	99,69
Kim09-2130	51,10	12,30	17,84	7,88	4,17	2,79	0,98	0,24	2,07	0,20	0,40	99,93
Kim09-2130A	46,00	13,64	19,24	6,83	4,89	2,13	1,25	0,21	2,68	0,23	2,50	99,66
Kim09-2131	48,50	13,93	15,41	9,06	6,26	2,32	0,80	0,24	1,53	0,12	1,80	99,94
Kim09-2132	44,60	7,89	14,96	8,13	17,07	0,46	0,27	0,24	1,35	0,27	4,70	99,92
Kim09-2132A	53,70	14,10	10,89	8,38	6,34	2,52	1,25	0,17	0,77	0,11	1,60	99,84
Kim09-2133	49,40	13,87	14,45	8,91	6,40	2,36	1,05	0,21	1,52	0,15	1,40	99,79
Kim09-2133A	51,50	4,44	8,68	9,84	20,77	0,25	0,09	0,23	0,21	0,01	3,70	99,81
Kim09-2134	50,00	14,69	12,76	9,53	6,24	2,71	0,99	0,20	1,13	0,10	1,60	99,92
Kim09-2134A	45,90	15,07	12,53	8,41	7,44	2,22	0,97	0,17	1,23	0,12	5,90	100,00
Kim09-2134B	50,70	12,38	17,83	8,40	4,27	2,85	0,74	0,24	2,11	0,20	0,10	99,82
Kim09-2134C	50,10	13,40	14,80	9,36	6,15	2,36	0,66	0,26	1,41	0,13	1,30	99,99
Kim09-2135	49,90	12,80	16,46	10,04	5,45	1,43	1,03	0,25	1,69	0,15	0,70	99,87
Kim09-2135A	49,10	10,06	9,67	10,98	14,30	0,67	1,67	0,25	0,70	0,44	2,10	99,98
Kim09-2135B	49,40	13,02	16,27	9,71	5,91	2,44	0,65	0,23	1,63	0,14	0,50	99,92
Kim09-2136	50,50	12,47	17,48	8,29	4,35	2,53	0,72	0,28	2,18	0,22	0,70	99,71
Kim09-2136A	54,20	14,65	14,01	6,83	2,33	3,93	1,08	0,18	1,45	0,32	0,70	99,75

Appendix 1. Whole rock chemical analysis, page 2

Analytical technics:	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF
Element:	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**Na_2O**	**K_2O**	**MnO**	**TiO_2**	**P_2O_5**	**LOI**	**SUM**
Unit:	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**
Method detection limit:	**0,1**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,1**	**0,01**
Kim09-2138	51,20	12,95	15,80	9,13	5,39	2,07	0,69	0,20	1,46	0,12	0,80	99,78
Kim09-2139	49,30	12,50	18,18	8,61	4,29	2,28	0,96	0,26	2,48	0,27	0,60	99,76
Kim09-2139A	50,40	6,75	8,07	9,15	19,19	0,49	2,79	0,12	0,38	0,20	2,00	99,56
Kim09-2141	47,10	14,93	16,85	4,28	7,30	0,26	4,79	0,20	1,48	0,15	2,50	99,88
Kim09-2141A	47,80	14,04	15,66	8,82	6,66	2,07	1,11	0,21	1,65	0,18	1,70	99,96
Kim09-2142	50,70	13,66	15,22	9,50	5,35	2,24	0,70	0,21	1,53	0,16	0,50	99,72
Kim09-2144	50,10	13,45	15,15	10,07	5,84	2,45	0,55	0,21	1,56	0,15	0,40	99,95
Kim09-2144A	50,10	13,81	14,24	10,30	6,22	2,41	0,57	0,21	1,43	0,12	0,40	99,87
Kim09-2145	49,20	13,21	15,67	9,68	6,59	2,28	0,60	0,22	1,58	0,16	0,80	99,98
Kim09-2146	50,60	13,40	15,30	9,55	5,86	2,26	0,70	0,26	1,39	0,12	0,50	99,97
Kim09-2146A	50,50	13,66	14,27	9,41	6,24	2,42	0,54	0,20	1,25	0,13	1,30	99,94
Kim09-2146B	52,00	14,43	12,70	1,29	8,44	2,38	1,74	0,04	1,57	0,17	5,00	99,77
Kim09-2147	54,10	12,24	11,44	7,77	7,61	3,00	0,75	0,13	0,85	0,13	1,70	99,68
Kim09-2148	50,40	13,47	15,69	9,59	5,68	2,01	0,60	0,24	1,53	0,12	0,60	99,95
Kim09-2148A	50,40	13,38	14,52	9,30	5,67	1,48	1,95	0,23	1,28	0,15	1,30	99,77
Kim09-2149	50,30	14,11	13,41	8,11	6,20	2,44	2,32	0,26	1,21	0,10	1,30	99,82
Kim09-2150	49,70	13,95	14,27	8,71	6,49	2,31	1,07	0,18	1,32	0,14	1,60	99,72
Kim09-2151	48,90	12,05	13,97	7,86	8,79	2,57	0,68	0,18	1,81	0,23	2,30	99,33
Kim09-2152	49,50	13,36	15,26	6,20	7,41	2,28	1,32	0,26	1,43	0,14	2,50	99,67
Kim09-2152A	43,80	14,13	18,36	3,18	10,00	0,80	0,68	0,22	1,51	0,15	6,90	99,68
Kim09-2153	51,50	14,57	12,59	4,40	6,92	1,35	3,18	0,12	1,31	0,14	3,50	99,68
Kim09-2155	48,40	16,01	12,26	11,48	6,06	2,63	0,70	0,18	1,03	0,09	1,00	99,90
Kim09-2156	48,20	15,32	12,33	9,49	5,93	2,64	2,02	0,32	1,07	0,10	2,30	99,74
Kim09-2156A	48,80	13,38	14,66	3,96	8,68	1,01	2,73	0,19	1,47	0,14	4,60	99,63
Kim09-2158	53,90	14,31	10,71	9,75	6,02	2,57	0,76	0,15	0,75	0,10	1,00	99,99
Kim09-2159	50,40	13,80	15,19	9,82	5,99	2,37	0,56	0,21	1,38	0,13	<0.1	99,82
Kim09-2159A	50,20	12,58	17,64	9,08	4,98	1,90	0,71	0,25	2,10	0,19	0,30	99,90
Kim09-2162	48,50	10,46	9,95	7,06	14,66	1,38	1,52	0,18	0,51	0,08	4,80	99,16
Kim09-2162A	50,80	12,33	10,49	8,59	12,98	1,90	0,75	0,16	0,61	0,11	1,20	99,90
Kim09-2164	49,10	13,85	13,30	10,18	7,11	2,43	1,11	0,20	1,15	0,09	1,30	99,87
Kim09-2165	50,30	11,72	10,18	7,87	13,81	1,92	0,98	0,16	0,54	0,10	1,90	99,44
Kim09-2166	41,00	14,30	21,13	1,51	11,51	0,77	0,35	0,17	2,36	0,12	6,70	99,89
Kim09-2166A	53,00	13,32	14,31	8,54	4,57	2,57	0,81	0,19	1,27	0,14	0,70	99,47
Kim09-2169	42,60	7,85	17,85	8,11	14,08	1,19	0,47	0,24	2,93	0,28	3,90	99,49
Kim09-2170	49,10	13,60	15,82	9,04	5,77	2,34	0,52	0,23	1,64	0,13	1,50	99,69
Kim09-2170A	49,80	13,65	14,66	8,44	6,37	1,92	0,51	0,21	1,42	0,13	2,60	99,74
Kim09-2170B	40,20	8,06	19,54	5,56	15,31	0,86	0,32	0,27	3,09	0,29	5,80	99,33
Kim09-2175	43,00	7,66	18,31	7,54	14,88	1,30	0,39	0,22	2,92	0,28	2,90	99,36

Appendix 1. Whole rock chemical analysis, page 3

Analytical technics:	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF
Element:	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**Na_2O**	**K_2O**	**MnO**	**TiO_2**	**P_2O_5**	**LOI**	**SUM**
Unit:	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**	**wt%**
Method detection limit:	**0,1**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,1**	**0,01**
Kim09-2177	45,40	9,07	16,24	8,38	12,16	2,14	0,69	0,18	2,53	0,27	2,00	99,13
Kim09-2220	31,30	9,34	17,62	8,56	14,28	0,07	0,08	0,22	3,57	0,35	14,4	99,79
Kim09-2266	49,00	13,90	13,55	11,22	7,07	2,21	0,27	0,18	1,50	0,10	0,70	99,72
Kim09-2267	50,50	12,88	16,65	9,15	4,76	2,58	0,58	0,23	1,96	0,16	0,30	99,70
Kim09-2275	48,40	13,44	15,43	9,89	6,13	2,73	0,97	0,22	1,50	0,14	0,70	99,53
Kim09-2275A	49,00	13,50	15,46	10,15	5,85	2,49	0,96	0,22	1,39	0,13	0,70	99,78
Kim09-2275B	49,60	12,81	15,80	8,41	4,99	2,24	1,66	0,21	1,90	0,16	1,60	99,43
Kim09-2275C	48,50	8,58	12,57	10,86	14,29	1,23	1,69	0,20	0,58	0,05	1,20	99,83
Kim09-2282	49,40	12,65	17,19	9,03	5,22	2,27	0,63	0,23	2,05	0,18	0,80	99,61
Kim09-2288	50,10	12,85	16,56	7,89	5,08	2,66	1,17	0,22	2,15	0,23	0,80	99,73
Kim09-2291	49,10	12,97	16,70	7,78	5,56	2,68	0,75	0,23	1,88	0,16	1,80	99,54
Kim09-2341	53,20	13,18	14,18	7,64	4,62	2,23	1,66	0,19	1,28	0,15	1,10	99,53
Kim09-2363	49,30	9,29	14,14	8,99	11,58	2,32	0,54	0,19	1,70	0,16	1,30	99,46
Kim09-3019	51,30	14,01	13,05	9,98	6,13	2,56	0,55	0,20	0,97	0,07	1,00	99,81
Kim09-3024	45,30	7,89	18,42	9,45	12,74	1,09	0,31	0,19	3,47	0,09	0,70	99,64
Kim09-3066	32,40	16,67	38,29	1,09	5,85	0,57	3,06	0,44	1,28	0,08	<0.1	99,81
Kim09-3068	42,50	5,59	11,25	4,76	28,79	0,47	0,14	0,14	0,31	0,04	5,70	99,74
Kim09-3068A	45,30	7,65	12,33	6,25	23,62	0,88	0,21	0,17	0,42	0,05	2,70	99,56
Kim09-3069	47,32	8,61	11,55	7,06	21,68	1,11	0,29	0,18	0,41	0,04	1,92	100,60
Kim09-3082	48,90	13,83	13,62	10,23	7,48	2,38	0,47	0,20	1,44	0,10	1,20	99,80
Kim09-3082A	52,50	15,54	10,08	9,62	7,07	2,38	1,15	0,15	0,76	0,09	0,60	99,95
Kim09-3082B	51,80	15,33	9,99	9,97	6,23	2,55	0,95	0,14	0,90	0,11	1,90	99,85
Kim09-3094	51,60	13,86	9,31	10,48	10,62	1,89	0,72	0,14	0,56	0,06	0,60	99,82
Kim09-3153	50,10	13,95	13,39	6,97	8,07	2,08	0,96	0,14	1,18	0,10	2,70	99,63
Kim09-3212	53,30	12,37	16,91	4,78	3,97	0,76	0,94	0,18	2,54	0,51	3,50	99,77
Kim09-3212A	36,00	21,28	14,46	18,37	3,19	0,09	0,28	0,18	2,21	0,43	3,40	99,98
Kim09-3224	50,10	13,58	15,10	9,42	5,79	2,57	0,70	0,22	1,58	0,15	0,70	99,99
Kim09-3224A	51,70	13,11	15,93	7,85	4,09	2,61	1,04	0,23	2,13	0,25	0,50	99,52
Kim09-3225	49,20	13,49	15,38	10,50	6,17	1,26	1,10	0,22	1,45	0,12	1,00	99,84
Kim09-3225A	49,70	12,67	15,74	6,54	5,02	3,78	0,34	0,21	1,76	0,14	3,50	99,43
Kim09-3245	50,80	14,33	14,09	1,28	7,16	0,99	3,38	0,12	1,72	0,13	5,30	99,34
R11-01	48,88	14,55	12,66	7,88	7,28	3,65	0,12	0,18	1,59	0,14	3,10	100,05
R13-05	45,36	7,57	11,76	5,81	24,14	0,84	0,20	0,18	0,37	0,04	3,60	100,37
R13-08	46,35	7,41	14,86	8,10	16,81	1,14	0,34	0,22	1,88	0,18	2,15	99,63
R13-12	49,98	13,52	15,89	9,78	5,84	2,51	0,47	0,23	1,62	0,12	-0,01	99,97
S375	35,80	6,81	22,61	10,52	10,72	0,89	0,25	0,41	8,94	1,07	0,90	98,99
S376	47,90	7,12	11,56	6,94	21,40	0,74	0,09	0,18	0,41	0,05	3,23	100,04
S388	49,94	13,48	14,59	10,54	6,46	1,42	1,02	0,22	1,09	0,09	0,95	99,80

Appendix 1. Whole rock chemical analysis, page 4

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Ba**	**Be**	**Co**	**Cs**	**Ga**	**Hf**	**Nb**	**Rb**	**Sn**	**Sr**	**Ta**	**Th**	**U**	**V**	**W**	**Zr**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Method detection limit:	**1**	**1**	**0,2**	**0,1**	**0,5**	**0,1**	**0,1**	**0,1**	**1**	**0,5**	**0,1**	**0,2**	**0,1**	**8**	**0,5**	**0,1**
Kim09-1117	413	1	67,3	6,9	22,7	4,2	17,9	140,5	2	453,2	1,1	2,0	1,1	335	1,4	137,2
Kim09-1118	244	<1	49,9	0,6	17,6	2,5	6,9	43,7	1	191,5	0,8	2,3	0,6	332	<0.5	89,2
Kim09-1119	235	<1	48,2	0,5	16,8	2,4	5,8	41,6	1	181,2	0,3	2,1	0,6	315	<0.5	86,3
Kim09-1120	359	2	65,5	0,4	22,3	5,5	22,3	17,5	2	660,9	1,4	1,9	0,5	316	<0.5	207,4
Kim09-1120A	369	2	63,8	0,3	21,3	6,0	23,4	17,6	2	657,0	1,4	2,0	0,5	312	<0.5	208,6
Kim09-1122	224	2	42,5	0,6	21,7	6,4	24,9	26,4	3	229,6	1,6	4,0	1,0	417	<0.5	250,3
Kim09-1122A	327	2	101,4	0,8	19,1	6,6	28,9	27,0	3	499,3	1,8	3,5	1,0	326	<0.5	243,5
Kim09-1123	240	2	48,8	0,7	22,7	8,2	26,3	23,1	3	218,6	1,7	4,6	1,2	469	<0.5	291,1
Kim09-1143	174	<1	50,7	0,4	16,9	2,9	6,8	24,1	<1	154,8	0,6	1,6	0,3	374	<0.5	92,2
Kim09-1219	81	5	112,6	0,7	27,5	11,2	63,0	8,4	5	211,1	3,8	5,3	1,3	588	0,7	407,6
Kim09-2126A	141	2	45,9	1,6	19,9	4,0	14,0	30,4	<1	219,9	0,8	2,0	0,5	390	0,9	157,4
Kim09-2127A	332	3	47,3	1,9	19,9	3,6	5,7	41,6	1	254,6	0,3	3,8	0,9	344	<0.5	134,8
Kim09-2127B	291	1	63,8	6,0	15,1	3,4	11,4	64,1	1	123,8	0,7	2,2	0,6	302	0,6	126,7
Kim09-2127C	394	<1	44,0	1,1	18,9	3,9	5,9	34,1	1	274,1	0,3	3,7	0,8	339	<0.5	130,8
Kim09-2127D	363	1	75,6	5,7	15,3	3,5	10,8	111,0	1	61,9	0,7	1,7	0,6	273	<0.5	125,0
Kim09-2128A	852	1	65,1	6,6	13,5	2,2	9,1	160,5	3	63,8	1,2	1,4	0,6	195	<0.5	59,0
Kim09-2128B	198	1	50,5	0,9	16,9	3,1	14,6	28,0	1	229,0	1,3	3,2	0,6	355	0,8	115,6
Kim09-2128C	162	<1	51,5	0,3	15,5	2,2	7,3	33,6	1	198,3	0,8	2,1	0,4	272	<0.5	81,3
Kim09-2128D	182	1	48,3	0,2	16,8	3,4	11,2	20,1	2	203,7	1,0	2,3	0,6	375	0,5	108,4
Kim09-2128E	189	<1	47,3	0,3	16,4	3,0	10,9	20,1	1	197,7	0,8	2,3	0,5	380	0,5	109,4
Kim09-2128F	147	<1	49,7	0,6	17,2	2,8	11,2	20,0	2	203,6	2,1	2,3	0,5	376	0,7	103,8
Kim09-2129	247	3	62,9	0,3	15,3	2,5	20,6	17,2	2	203,0	1,1	3,5	1,0	291	<0.5	102,5
Kim09-2130	254	1	51,8	0,4	20,6	4,3	12,1	48,0	2	236,7	0,7	2,6	0,6	429	<0.5	157,2
Kim09-2130A	230	<1	53,7	0,3	22,9	5,5	16,3	26,5	4	156,7	1,3	3,6	1,0	483	0,8	188,4
Kim09-2131	99	1	50,5	0,7	18,0	2,6	7,5	33,1	<1	268,1	0,5	0,9	0,2	316	<0.5	80,9
Kim09-2132	132	4	75,7	0,2	15,7	2,5	16,6	6,6	2	49,2	0,9	3,8	1,0	210	<0.5	91,6
Kim09-2132A	277	1	43,6	1,2	16,1	2,3	3,5	60,4	<1	239,2	0,2	1,9	0,5	251	<0.5	86,3
Kim09-2133	244	1	51,0	0,4	16,8	3,2	9,1	54,7	1	241,7	0,6	1,8	0,4	342	<0.5	108,6
Kim09-2133A	3	4	59,5	0,1	12,8	0,7	1,9	2,1	<1	15,0	0,2	1,5	0,9	75	<0.5	20,1
Kim09-2134	218	<1	43,6	0,4	16,3	2,1	5,1	67,7	1	249,7	0,3	1,1	0,3	304	<0.5	72,9
Kim09-2134A	303	<1	37,4	1,4	21,4	2,5	5,2	46,0	1	332,5	0,3	1,3	0,8	312	<0.5	80,8
Kim09-2134B	191	1	52,0	0,4	20,2	4,0	11,2	22,1	2	211,2	0,8	2,5	0,6	434	<0.5	143,1
Kim09-2134C	142	<1	49,0	0,5	17,6	2,7	6,1	22,2	1	144,0	0,4	1,3	0,5	362	<0.5	94,0
Kim09-2135	111	<1	50,3	0,4	17,5	3,3	7,2	21,4	1	95,0	0,4	1,3	0,8	418	<0.5	106,6
Kim09-2135A	274	2	54,6	2,6	12,3	1,4	1,6	69,5	1	85,5	0,1	4,3	1,0	221	0,5	51,3
Kim09-2135B	143	1	52,0	0,2	17,3	2,9	6,7	24,6	1	155,4	0,5	1,2	0,3	426	<0.5	93,4
Kim09-2136	132	2	50,5	0,4	19,6	4,4	10,8	17,2	2	186,1	0,6	3,3	0,7	418	<0.5	155,6
Kim09-2136A	290	1	32,9	0,5	21,3	5,9	14,5	34,7	2	269,2	1,0	4,3	2,0	169	<0.5	203,5

Appendix 1. Whole rock chemical analysis, page 5

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Ba**	**Be**	**Co**	**Cs**	**Ga**	**Hf**	**Nb**	**Rb**	**Sn**	**Sr**	**Ta**	**Th**	**U**	**V**	**W**	**Zr**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Method detection limit:	**1**	**1**	**0,2**	**0,1**	**0,5**	**0,1**	**0,1**	**0,1**	**1**	**0,5**	**0,1**	**0,2**	**0,1**	**8**	**0,5**	**0,1**
Kim09-2138	137	1	49,5	0,3	17,8	3,1	7,4	21,2	1	180,9	0,4	1,7	0,6	362	<0.5	99,4
Kim09-2139	180	2	47,1	0,7	20,9	5,2	21,0	21,6	2	183,0	1,4	3,1	0,8	349	<0.5	179,2
Kim09-2139A	640	<1	58,1	5,6	7,9	0,9	1,1	126,7	<1	157,6	<0.1	2,4	0,4	112	6,0	36,9
Kim09-2141	730	<1	44,6	4,2	30,4	2,9	6,7	170,7	2	272,5	0,4	2,2	0,6	343	<0.5	101,2
Kim09-2141A	244	<1	48,4	0,4	19,0	2,7	6,4	29,7	<1	155,6	0,4	1,4	0,4	360	<0.5	91,8
Kim09-2142	172	1	50,7	0,4	17,7	3,6	9,6	21,4	1	175,5	0,7	2,2	0,5	346	<0.5	123,2
Kim09-2144	127	1	49,3	0,4	18,2	3,2	8,0	16,6	1	208,9	0,5	1,8	0,5	347	<0.5	110,3
Kim09-2144A	111	<1	47,7	0,4	17,2	2,7	7,7	17,7	<1	213,5	0,4	2,0	0,4	331	<0.5	95,8
Kim09-2145	87	1	52,2	0,3	17,7	3,0	7,1	18,7	1	151,6	0,4	1,4	0,3	382	<0.5	97,4
Kim09-2146	281	1	51,0	0,2	18,4	2,5	5,3	24,4	<1	181,0	0,4	1,1	0,3	343	<0.5	83,1
Kim09-2146A	131	<1	48,7	0,3	16,9	2,6	4,7	13,7	<1	158,1	0,3	1,5	0,4	346	<0.5	85,8
Kim09-2146B	177	2	35,5	2,7	18,1	3,3	6,9	52,8	1	96,4	0,5	2,1	0,7	370	1,1	116,9
Kim09-2147	317	<1	56,0	0,5	16,3	2,8	3,8	14,6	<1	316,2	0,2	1,4	0,2	205	<0.5	100,5
Kim09-2148	77	<1	53,6	0,2	17,8	2,6	5,3	12,3	1	171,5	0,3	0,8	0,3	364	<0.5	83,5
Kim09-2148A	524	1	47,2	0,6	16,4	2,6	9,0	50,6	<1	160,6	0,6	1,6	0,5	350	<0.5	94,0
Kim09-2149	862	1	45,7	0,7	16,7	2,3	5,1	119,4	<1	150,6	0,3	1,2	0,4	339	<0.5	80,5
Kim09-2150	240	1	51,5	0,8	16,3	2,9	10,0	51,5	<1	187,5	0,5	1,8	0,4	376	0,6	90,9
Kim09-2151	124	1	60,0	1,2	17,3	4,2	19,1	18,1	1	340,8	1,2	3,3	0,7	237	0,6	140,4
Kim09-2152	415	1	51,8	0,6	17,2	2,9	5,5	65,9	1	133,7	0,5	1,7	0,4	386	0,8	98,2
Kim09-2152A	91	1	54,0	2,8	42,4	3,4	6,0	29,3	1	141,2	0,5	1,7	0,6	360	1,8	105,2
Kim09-2153	414	2	37,1	1,3	17,9	2,9	5,5	114,5	<1	88,3	0,4	1,8	0,4	372	0,9	91,8
Kim09-2155	185	<1	48,1	0,6	16,2	2,6	10,2	30,1	<1	256,0	0,7	2,1	0,5	280	<0.5	73,9
Kim09-2156	831	1	47,2	0,9	15,7	2,3	10,5	104,8	<1	205,4	0,6	2,4	0,8	276	<0.5	75,8
Kim09-2156A	413	2	48,8	0,8	20,5	3,3	5,9	101,6	<1	117,2	0,4	2,4	0,8	376	1,0	155,3
Kim09-2158	304	<1	43,9	0,3	15,9	2,3	3,6	20,3	<1	261,1	0,1	1,8	0,4	244	<0.5	86,2
Kim09-2159	189	<1	53,1	0,7	18,3	2,9	5,5	15,3	<1	172,4	0,4	2,1	0,5	377	<0.5	104,9
Kim09-2159A	166	<1	51,1	0,2	20,5	4,3	10,3	18,0	2	146,8	0,6	1,7	0,7	466	<0.5	140,9
Kim09-2162	572	1	61,1	1,8	12,2	1,8	2,8	73,1	<1	54,6	0,2	1,7	0,3	201	0,5	61,3
Kim09-2162A	306	<1	64,2	1,8	12,8	2,1	3,5	23,8	<1	220,0	0,2	1,8	0,3	189	<0.5	72,8
Kim09-2164	148	<1	48,7	0,9	15,5	2,0	5,9	83,9	<1	219,1	0,4	0,9	0,3	335	<0.5	69,1
Kim09-2165	264	<1	61,8	0,4	11,4	1,9	3,1	76,9	<1	258,7	0,2	4,4	0,4	193	<0.5	69,6
Kim09-2166	136	<1	71,5	1,1	24,7	2,9	9,3	15,6	<1	43,9	0,6	1,6	0,4	667	<0.5	104,2
Kim09-2166A	195	<1	46,6	0,5	17,8	3,6	9,8	19,1	1	172,7	0,6	2,5	0,6	335	0,5	129,9
Kim09-2169	138	2	113,2	1,1	19,3	5,3	25,2	16,9	2	170,7	1,6	2,8	0,8	391	<0.5	184,0
Kim09-2170	161	1	52,9	0,4	17,2	2,6	8,4	14,5	<1	200,9	0,5	1,4	0,3	447	<0.5	88,5
Kim09-2170A	128	2	52,3	0,5	18,0	2,8	8,4	18,0	<1	194,9	0,5	1,4	0,3	354	<0.5	90,0
Kim09-2170B	98	2	80,7	0,7	17,4	5,1	25,6	9,9	2	58,8	1,6	3,3	1,1	368	<0.5	183,6
Kim09-2175	116	1	107,0	0,6	18,7	5,4	25,7	10,4	2	178,1	1,8	3,1	0,7	372	<0.5	184,2

Appendix 1. Whole rock chemical analysis, page 6

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Ba**	**Be**	**Co**	**Cs**	**Ga**	**Hf**	**Nb**	**Rb**	**Sn**	**Sr**	**Ta**	**Th**	**U**	**V**	**W**	**Zr**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Method detection limit:	**1**	**1**	**0,2**	**0,1**	**0,5**	**0,1**	**0,1**	**0,1**	**1**	**0,5**	**0,1**	**0,2**	**0,1**	**8**	**0,5**	**0,1**
Kim09-2177	289	2	82,0	0,5	18,0	5,2	24,8	19,5	2	430,8	1,6	2,8	0,6	332	<0.5	181,8
Kim09-2220	75	3	109,6	0,9	20,7	6,0	30,4	3,6	2	39,3	1,8	3,7	0,9	433	<0.5	224,3
Kim09-2266	24	<1	49,5	0,2	19,9	2,1	3,6	10,1	<1	151,2	0,2	0,3	<0.1	450	<0.5	78,8
Kim09-2267	156	1	49,0	0,6	19,9	3,9	10,7	16,1	2	240,6	0,6	2,1	0,6	380	<0.5	133,4
Kim09-2275	97	<1	49,0	0,2	18,6	2,4	5,1	16,2	2	121,2	0,2	0,3	0,1	404	<0.5	92,5
Kim09-2275A	170	<1	51,8	0,3	16,2	2,6	13,1	23,4	<1	214,3	0,6	3,1	0,6	348	<0.5	92,8
Kim09-2275B	247	<1	47,6	0,2	19,8	3,8	8,5	41,1	2	176,3	0,5	1,8	0,4	409	2,4	124,3
Kim09-2275C	171	<1	68,4	2,2	12,1	1,1	3,0	108,8	3	34,0	0,3	0,7	0,3	236	<0.5	32,8
Kim09-2282	129	1	51,6	0,5	19,2	4,1	10,6	16,5	1	187,0	0,7	2,1	0,5	423	<0.5	139,1
Kim09-2288	279	1	49,0	0,3	20,4	4,8	13,3	39,8	2	225,7	0,8	3,7	0,9	361	<0.5	172,9
Kim09-2291	138	1	51,8	0,2	19,3	4,0	10,6	22,9	1	179,8	0,6	1,9	0,5	399	<0.5	130,5
Kim09-2341	379	1	45,7	0,7	17,2	3,3	9,6	54,8	1	168,2	0,5	2,6	0,6	326	<0.5	121,2
Kim09-2363	132	1	63,1	0,5	15,3	3,5	14,1	13,9	2	200,4	0,9	2,3	0,7	280	<0.5	122,4
Kim09-3019	91	<1	46,7	0,4	16,0	2,4	4,6	14,5	<1	207,1	0,3	1,2	0,3	291	<0.5	65,9
Kim09-3024	37	2	79,9	0,1	17,7	6,6	23,8	5,4	2	83,0	1,5	2,6	0,6	376	<0.5	239,2
Kim09-3066	531	<1	37,4	3,3	23,9	4,7	8,2	81,0	1	93,0	0,4	2,2	0,4	268	<0.5	153,7
Kim09-3068	63	<1	100,6	<0.1	6,3	0,6	1,1	3,3	<1	67,8	<0.1	0,3	<0.1	121	<0.5	24,4
Kim09-3068A	94	<1	95,7	0,4	8,4	0,8	1,6	6,5	<1	88,9	<0.1	0,8	0,1	162	<0.5	33,2
Kim09-3069	98	<1	83,5	0,1	9,0	0,9	1,9	7,1	<1	104,7	<0.1	0,7	<0.1	148	<0.5	36,4
Kim09-3082	47	<1	45,2	0,3	19,7	2,6	3,3	13,2	<1	175,4	0,2	0,3	<0.1	439	<0.5	75,3
Kim09-3082A	321	<1	43,2	0,5	15,0	2,1	3,7	33,7	<1	236,4	0,2	2,2	0,5	217	<0.5	81,9
Kim09-3082B	315	<1	45,9	0,6	17,3	2,6	4,6	23,7	1	237,8	0,3	2,4	0,5	250	<0.5	90,1
Kim09-3094	194	<1	46,6	0,2	12,7	1,9	2,3	26,2	<1	200,6	0,1	1,3	0,2	223	<0.5	51,3
Kim09-3153	165	<1	48,8	1,1	15,6	2,7	6,6	46,9	<1	202,8	0,4	1,7	0,4	320	0,5	85,0
Kim09-3212	313	1	39,3	0,3	23,1	7,0	17,5	26,5	2	232,7	1,0	6,8	3,0	66	0,5	260,2
Kim09-3212A	44	2	27,1	0,3	61,9	7,3	17,3	11,1	3	2230	1,0	6,0	1,7	279	<0.5	239,3
Kim09-3224	167	<1	48,4	0,5	19,0	3,6	8,7	21,5	1	214,5	0,5	2,0	0,6	359	<0.5	112,3
Kim09-3224A	263	2	40,2	0,9	21,2	6,0	12,8	35,5	2	196,1	0,8	6,9	1,5	351	<0.5	193,0
Kim09-3225	165	1	48,8	0,4	18,3	2,9	8,0	25,3	<1	195,6	0,4	1,3	0,3	377	<0.5	89,2
Kim09-3225A	54	<1	39,4	0,3	18,9	3,8	9,9	4,9	1	150,8	0,5	1,9	0,5	373	0,7	125,6
Kim09-3245	355	3	61,6	1,8	25,5	3,6	7,5	131,3	1	43,1	0,4	1,3	1,4	412	1,2	109,4
R11-01	40	1	47,8	<0.1	17,0	2,4	10,7	1,4	<1	331,2	0,7	1,2	0,2	252	0,8	95,2
R13-05	77	<1	87,6	1,0	7,8	1,0	1,5	6,9	<1	81,2	<0.1	0,5	<0.1	140	<0.5	30,1
R13-08	57	<1	78,4	0,6	13,3	3,6	13,9	13,8	1	85,1	1,0	2,5	0,7	223	0,8	145,2
R13-12	108	<1	50,5	0,5	18,9	3,1	8,0	15,0	<1	213,0	0,7	1,5	0,3	322	<0.5	107,5
S375	26	5	68,3	<0.1	35,1	16,7	109,2	2,1	5	185,5	6,3	8,6	3,0	627	1,0	731,5
S376	17	<1	80,1	0,2	7,7	1,1	1,4	1,1	<1	86,7	<0.1	0,7	<0.1	161	2,0	38,4
S388	98	3	56,1	2,6	16,6	1,8	3,1	40,4	<1	105,6	0,2	0,3	0,4	341	<0.5	63,8

Appendix 1. Whole rock chemical analysis, page 7

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Y**	**La**	**Ce**	**Pr**	**Nd**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Method detection limit:	**0,1**	**0,1**	**0,1**	**0,02**	**0,3**	**0,05**	**0,02**	**0,05**	**0,01**	**0,05**	**0,02**	**0,03**	**0,01**	**0,05**	**0,01**
Kim09-1117	21,0	14,7	34,9	4,87	22,6	5,17	2,70	5,44	0,83	4,30	0,80	2,01	0,27	1,63	0,23
Kim09-1118	24,1	11,9	28,1	3,53	16,2	3,41	1,13	4,12	0,70	4,16	0,88	2,64	0,37	2,43	0,38
Kim09-1119	22,6	11,3	26,3	3,37	14,6	3,21	1,08	3,71	0,65	3,83	0,80	2,44	0,35	2,26	0,34
Kim09-1120	26,7	27,6	67,3	8,91	39,1	7,89	2,54	7,38	1,09	5,68	0,99	2,50	0,35	2,04	0,28
Kim09-1120A	26,7	28,2	68,1	9,00	40,5	8,27	2,55	7,38	1,11	5,68	0,98	2,41	0,33	2,09	0,29
Kim09-1122	46,0	29,1	70,0	9,16	38,4	8,34	2,37	8,73	1,48	8,41	1,69	4,47	0,65	4,25	0,63
Kim09-1122A	25,2	30,7	73,4	9,69	43,0	8,52	2,70	7,82	1,13	5,72	0,94	2,25	0,28	1,59	0,21
Kim09-1123	51,9	32,0	75,5	10,23	46,8	9,87	2,64	10,12	1,70	9,68	1,89	5,22	0,79	4,92	0,72
Kim09-1143	26,3	10,0	24,1	3,24	14,9	3,49	1,11	4,27	0,74	4,50	0,94	2,85	0,41	2,80	0,42
Kim09-1219	37,1	43,8	113,7	15,40	71,7	14,92	5,04	13,86	1,92	9,31	1,41	3,12	0,38	2,06	0,24
Kim09-2126A	31,1	16,9	37,3	5,47	24,6	5,93	1,77	6,10	1,00	5,91	1,15	3,13	0,47	3,02	0,43
Kim09-2127A	23,1	19,7	44,0	5,45	23,1	4,28	1,10	4,12	0,69	4,15	0,83	2,43	0,37	2,43	0,38
Kim09-2127B	21,0	18,1	41,8	5,38	22,7	4,50	1,55	4,73	0,74	3,91	0,79	2,15	0,30	1,89	0,26
Kim09-2127C	24,4	18,0	41,3	5,11	22,7	4,31	1,23	4,13	0,71	4,12	0,87	2,54	0,38	2,52	0,38
Kim09-2127D	18,5	17,1	41,5	5,27	23,6	4,77	1,57	4,61	0,72	3,74	0,68	1,72	0,24	1,54	0,21
Kim09-2128A	24,9	19,3	53,8	7,81	35,7	7,29	1,63	6,08	0,89	4,46	0,86	2,21	0,35	2,15	0,32
Kim09-2128B	22,8	20,9	45,6	5,64	23,4	4,36	1,37	4,51	0,74	4,11	0,83	2,41	0,34	2,24	0,33
Kim09-2128C	16,3	10,8	25,1	3,26	14,6	3,07	0,95	3,12	0,54	2,90	0,59	1,73	0,26	1,62	0,23
Kim09-2128D	27,3	13,7	33,7	4,39	18,8	4,37	1,30	4,50	0,81	4,76	1,00	2,84	0,45	2,86	0,41
Kim09-2128E	27,2	13,9	33,7	4,32	19,7	4,17	1,27	4,60	0,80	4,78	0,99	2,93	0,44	2,77	0,42
Kim09-2128F	26,4	13,9	31,6	4,09	17,7	4,05	1,26	4,37	0,77	4,54	0,93	2,70	0,40	2,63	0,41
Kim09-2129	11,6	21,3	49,3	5,87	24,1	4,09	1,14	3,09	0,46	2,38	0,41	1,09	0,17	1,04	0,14
Kim09-2130	33,8	16,7	42,4	5,55	26,2	5,69	1,82	6,29	1,06	6,22	1,22	3,50	0,51	3,23	0,45
Kim09-2130A	40,7	17,0	45,8	6,20	29,1	6,96	2,38	7,61	1,32	7,49	1,53	4,38	0,63	4,00	0,57
Kim09-2131	20,7	8,6	22,1	3,07	14,0	3,47	1,23	4,12	0,69	3,91	0,79	2,17	0,32	1,94	0,29
Kim09-2132	10,5	16,3	37,4	4,90	19,8	3,93	1,11	3,25	0,45	2,16	0,37	1,01	0,14	0,93	0,13
Kim09-2132A	16,6	13,1	28,3	3,56	15,1	2,88	0,88	3,06	0,52	2,98	0,62	1,80	0,27	1,78	0,26
Kim09-2133	23,2	12,7	29,9	4,03	19,4	3,99	1,26	4,39	0,76	4,38	0,90	2,42	0,36	2,38	0,35
Kim09-2133A	4,8	4,3	12,4	1,88	8,5	1,76	0,35	1,45	0,19	0,90	0,15	0,44	0,06	0,45	0,06
Kim09-2134	21,3	7,2	17,5	2,40	10,7	2,89	0,95	3,31	0,60	3,93	0,79	2,30	0,33	2,12	0,33
Kim09-2134A	24,0	11,2	23,1	3,08	13,8	3,31	1,09	4,18	0,72	4,49	0,93	2,77	0,40	2,66	0,39
Kim09-2134B	31,5	16,1	38,6	5,32	24,4	5,61	1,72	6,32	1,03	5,96	1,15	3,48	0,49	3,08	0,43
Kim09-2134C	26,7	8,2	19,7	2,72	12,4	3,37	1,12	4,24	0,77	4,80	0,98	2,93	0,45	2,75	0,41
Kim09-2135	30,6	9,0	22,2	3,16	15,0	3,92	1,31	4,98	0,87	5,48	1,13	3,30	0,49	3,20	0,47
Kim09-2135A	12,8	25,8	59,1	7,85	34,9	6,50	1,79	5,03	0,61	2,94	0,44	1,06	0,16	0,98	0,15
Kim09-2135B	27,0	8,9	21,0	2,94	13,9	3,66	1,19	4,40	0,78	4,55	0,97	3,00	0,44	2,72	0,42
Kim09-2136	32,8	17,4	41,0	5,50	24,1	5,48	1,71	6,06	1,05	6,33	1,22	3,54	0,51	3,30	0,47
Kim09-2136A	43,0	26,8	62,0	8,14	34,9	7,73	2,36	8,30	1,39	7,98	1,61	4,55	0,66	4,08	0,61

Appendix 1. Whole rock chemical analysis, page 8

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Y**	**La**	**Ce**	**Pr**	**Nd**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Method detection limit:	**0,1**	**0,1**	**0,1**	**0,02**	**0,3**	**0,05**	**0,02**	**0,05**	**0,01**	**0,05**	**0,02**	**0,03**	**0,01**	**0,05**	**0,01**
Kim09-2138	25,7	12,7	29,1	3,86	17,5	3,96	1,27	4,62	0,77	4,41	0,94	2,67	0,39	2,52	0,37
Kim09-2139	36,0	23,4	55,6	7,42	32,0	7,08	2,10	7,26	1,18	6,95	1,32	3,74	0,52	3,24	0,48
Kim09-2139A	5,5	10,4	25,8	3,36	14,6	2,83	0,73	2,13	0,27	1,22	0,20	0,53	0,07	0,38	0,06
Kim09-2141	27,3	13,5	31,4	4,10	19,1	4,07	1,07	4,64	0,82	5,16	1,06	3,02	0,44	2,73	0,41
Kim09-2141A	27,2	11,1	25,1	3,47	16,5	3,83	1,30	4,60	0,81	4,89	1,03	2,76	0,44	2,86	0,42
Kim09-2142	28,9	14,6	33,7	4,47	19,2	4,52	1,32	5,01	0,85	5,14	1,06	2,97	0,46	2,90	0,44
Kim09-2144	25,3	10,9	27,1	3,74	16,9	4,00	1,25	4,53	0,78	4,58	0,93	2,61	0,39	2,50	0,34
Kim09-2144A	22,5	8,8	22,7	3,02	13,1	3,45	1,12	3,85	0,68	4,05	0,83	2,44	0,35	2,16	0,33
Kim09-2145	27,7	9,1	22,8	3,13	15,3	3,74	1,26	4,52	0,79	4,76	1,01	2,77	0,46	2,82	0,41
Kim09-2146	21,5	7,0	18,3	2,58	12,6	3,30	1,13	3,96	0,68	3,87	0,80	2,23	0,35	2,06	0,30
Kim09-2146A	25,2	9,7	23,8	3,22	14,1	3,40	1,14	4,03	0,71	4,29	0,96	2,63	0,40	2,57	0,40
Kim09-2146B	15,0	12,5	28,5	3,57	13,9	2,77	0,78	2,71	0,47	2,96	0,61	1,90	0,28	2,01	0,32
Kim09-2147	13,5	14,2	31,6	3,95	17,0	3,22	0,99	3,04	0,49	2,93	0,52	1,38	0,21	1,31	0,19
Kim09-2148	20,6	7,7	19,3	2,68	12,2	3,29	1,12	4,01	0,67	3,85	0,79	2,14	0,32	2,00	0,29
Kim09-2148A	22,6	11,6	28,0	3,53	16,2	3,62	1,09	3,88	0,70	4,09	0,87	2,49	0,39	2,54	0,39
Kim09-2149	23,7	8,3	20,1	2,62	12,5	2,89	0,94	3,56	0,65	3,85	0,86	2,51	0,38	2,41	0,35
Kim09-2150	22,5	14,4	31,8	4,03	17,3	3,42	1,10	3,70	0,64	3,73	0,79	2,41	0,33	2,28	0,35
Kim09-2151	17,2	27,8	65,7	8,03	31,7	5,61	1,80	4,69	0,68	3,37	0,62	1,72	0,22	1,43	0,21
Kim09-2152	25,0	10,1	23,2	3,05	12,8	3,33	1,00	3,95	0,73	4,42	0,90	2,76	0,39	2,81	0,43
Kim09-2152A	37,5	226,5	373,1	37,03	136,4	17,72	4,83	13,49	1,60	7,47	1,30	3,35	0,45	2,85	0,46
Kim09-2153	18,0	8,2	18,9	2,40	9,9	2,40	0,79	2,79	0,54	3,19	0,67	1,99	0,31	2,03	0,33
Kim09-2155	17,2	15,6	34,8	4,14	16,1	3,23	1,03	3,18	0,55	3,07	0,66	1,81	0,25	1,63	0,25
Kim09-2156	17,9	14,6	33,7	4,01	16,2	3,09	1,02	3,39	0,55	3,23	0,63	1,92	0,25	1,77	0,27
Kim09-2156A	30,9	13,8	29,5	3,78	16,4	4,03	1,38	4,87	0,87	4,98	1,03	3,10	0,44	2,93	0,47
Kim09-2158	16,9	12,7	28,8	3,47	13,4	2,86	0,83	2,66	0,50	2,84	0,60	1,78	0,25	1,75	0,28
Kim09-2159	28,5	12,3	29,9	3,91	16,9	3,84	1,27	4,61	0,81	4,87	1,03	3,12	0,45	2,90	0,47
Kim09-2159A	36,8	12,3	30,2	4,14	18,7	5,02	1,60	5,96	1,11	6,46	1,33	3,85	0,56	3,74	0,57
Kim09-2162	15,7	5,9	15,6	2,17	9,8	2,23	0,56	2,51	0,44	2,63	0,53	1,61	0,23	1,46	0,25
Kim09-2162A	14,1	12,3	27,5	3,28	12,7	2,50	0,74	2,42	0,42	2,39	0,51	1,45	0,21	1,43	0,22
Kim09-2164	21,2	8,2	18,5	2,48	10,9	2,79	0,95	3,28	0,61	3,66	0,77	2,23	0,33	2,07	0,33
Kim09-2165	11,8	10,9	27,2	3,47	13,3	2,67	0,66	2,36	0,37	2,19	0,41	1,22	0,18	1,14	0,18
Kim09-2166	24,0	13,8	29,8	3,76	16,6	3,95	1,37	4,69	0,80	4,31	0,89	2,56	0,34	2,23	0,34
Kim09-2166A	27,0	15,7	36,1	4,29	18,0	3,90	1,25	4,54	0,79	4,73	0,98	2,90	0,42	2,82	0,44
Kim09-2169	22,8	23,3	55,7	7,44	32,1	6,92	2,18	6,68	0,98	4,87	0,86	2,21	0,27	1,56	0,22
Kim09-2170	22,2	11,0	26,2	3,55	16,0	3,58	1,26	4,03	0,68	3,82	0,86	2,54	0,34	2,11	0,35
Kim09-2170A	23,0	11,7	26,5	3,65	16,7	3,49	1,21	3,95	0,69	3,80	0,83	2,34	0,33	2,14	0,32
Kim09-2170B	21,4	22,6	54,3	7,21	30,3	6,38	2,07	6,21	0,96	4,53	0,84	2,11	0,26	1,54	0,21
Kim09-2175	21,6	25,2	57,7	7,64	33,0	6,65	2,22	6,47	0,96	4,74	0,83	2,10	0,26	1,44	0,20

Appendix 1. Whole rock chemical analysis, page 9

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Y**	**La**	**Ce**	**Pr**	**Nd**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Method detection limit:	**0,1**	**0,1**	**0,1**	**0,02**	**0,3**	**0,05**	**0,02**	**0,05**	**0,01**	**0,05**	**0,02**	**0,03**	**0,01**	**0,05**	**0,01**
Kim09-2177	24,0	26,3	60,8	7,90	33,2	6,84	2,31	6,43	0,98	4,81	0,89	2,23	0,30	1,80	0,25
Kim09-2220	20,4	17,8	46,6	6,02	25,0	5,24	1,60	5,11	0,84	4,63	0,76	2,09	0,25	1,59	0,20
Kim09-2266	24,4	3,9	11,6	1,91	9,9	3,21	1,20	4,32	0,78	4,38	0,90	2,56	0,34	2,13	0,31
Kim09-2267	29,7	14,5	35,7	4,86	21,6	4,73	1,59	5,54	0,93	5,25	1,07	3,05	0,43	2,74	0,40
Kim09-2275	32,5	6,5	16,9	2,55	13,4	3,71	1,30	4,98	0,92	5,63	1,21	3,60	0,50	3,42	0,51
Kim09-2275A	21,5	17,7	39,8	4,92	19,6	3,96	1,23	4,12	0,69	4,11	0,80	2,29	0,33	2,07	0,32
Kim09-2275B	27,4	10,6	27,6	3,84	17,8	4,48	1,58	5,26	0,89	4,86	1,02	2,95	0,39	2,53	0,38
Kim09-2275C	20,6	7,6	20,2	2,48	10,5	2,44	0,76	2,85	0,54	3,17	0,68	2,05	0,30	2,01	0,30
Kim09-2282	33,1	14,7	36,4	4,91	21,6	5,11	1,68	5,98	1,03	5,79	1,16	3,47	0,49	3,08	0,45
Kim09-2288	37,4	21,1	48,6	6,39	26,8	5,95	1,82	6,58	1,13	6,28	1,34	3,78	0,53	3,43	0,50
Kim09-2291	29,6	11,0	28,6	3,87	17,4	4,38	1,56	5,27	0,93	5,13	1,09	3,14	0,43	2,65	0,41
Kim09-2341	26,9	12,6	29,4	3,61	15,2	3,39	1,16	4,19	0,75	4,35	0,95	2,91	0,40	2,76	0,41
Kim09-2363	18,7	9,6	24,1	3,24	14,0	3,62	1,27	3,97	0,67	3,60	0,70	1,88	0,24	1,56	0,24
Kim09-3019	17,7	7,4	18,3	2,47	10,7	2,45	0,89	3,06	0,53	3,07	0,62	1,91	0,27	1,75	0,27
Kim09-3024	25,6	12,5	37,4	6,12	31,9	7,80	2,33	7,74	1,16	5,71	0,98	2,48	0,31	1,80	0,23
Kim09-3066	40,4	11,5	26,0	3,37	13,5	3,48	0,52	5,02	1,06	6,92	1,55	4,59	0,67	4,70	0,67
Kim09-3068	6,0	2,9	6,9	0,86	3,4	0,82	0,29	1,02	0,17	1,02	0,22	0,64	0,10	0,62	0,10
Kim09-3068A	8,7	4,7	10,4	1,32	6,1	1,29	0,41	1,36	0,24	1,49	0,31	0,96	0,15	0,88	0,14
Kim09-3069	8,5	5,0	10,4	1,32	5,9	1,32	0,41	1,43	0,23	1,55	0,32	1,02	0,14	0,88	0,14
Kim09-3082	23,4	3,5	11,0	1,75	10,2	3,05	1,15	4,15	0,75	4,14	0,88	2,38	0,34	2,16	0,30
Kim09-3082A	15,9	12,3	27,9	3,32	13,0	2,64	0,81	2,65	0,48	2,72	0,56	1,68	0,25	1,65	0,24
Kim09-3082B	20,6	14,4	33,4	3,98	16,6	3,33	1,01	3,43	0,59	3,43	0,72	2,01	0,29	2,05	0,28
Kim09-3094	12,3	7,6	17,9	2,12	8,3	1,74	0,59	2,07	0,36	2,17	0,45	1,38	0,19	1,29	0,19
Kim09-3153	19,9	11,3	25,5	3,38	14,2	3,08	1,03	3,48	0,63	3,55	0,75	2,22	0,32	1,92	0,29
Kim09-3212	48,1	32,9	73,0	9,55	39,7	8,42	2,39	8,81	1,51	8,62	1,73	5,18	0,70	4,64	0,69
Kim09-3212A	52,8	37,4	81,1	10,17	41,7	9,24	2,57	10,18	1,65	8,91	1,91	5,36	0,74	4,75	0,72
Kim09-3224	26,5	12,8	31,6	4,13	18,0	4,27	1,36	4,93	0,82	4,68	1,01	2,76	0,38	2,49	0,37
Kim09-3224A	41,9	25,5	59,5	7,37	30,4	6,58	1,83	7,26	1,27	7,14	1,46	4,43	0,63	4,10	0,62
Kim09-3225	22,6	10,3	25,6	3,47	15,0	3,63	1,22	4,09	0,71	4,15	0,84	2,33	0,34	2,21	0,33
Kim09-3225A	28,4	12,1	29,3	4,23	19,8	4,67	1,38	5,14	0,88	5,20	1,04	2,98	0,41	2,71	0,38
Kim09-3245	11,4	5,8	17,2	2,21	9,5	2,12	0,66	2,18	0,41	2,32	0,44	1,29	0,20	1,48	0,20
R11-01	15,2	13,4	29,2	3,93	18,3	3,93	1,24	3,57	0,54	3,13	0,56	1,55	0,22	1,42	0,20
R13-05	7,6	4,2	8,7	1,11	5,0	1,02	0,36	1,17	0,20	1,24	0,31	0,81	0,13	0,93	0,11
R13-08	16,7	12,1	35,2	4,83	21,4	4,75	1,33	4,45	0,64	3,65	0,58	1,52	0,22	1,35	0,18
R13-12	21,5	11,5	24,9	3,51	16,2	3,87	1,27	4,17	0,70	4,32	0,83	2,16	0,34	1,93	0,31
S375	42,7	94,0	210,2	26,38	111,1	22,60	6,38	17,25	2,25	10,87	1,67	3,47	0,41	2,09	0,23
S376	8,3	5,7	11,9	1,47	6,4	1,29	0,40	1,44	0,22	1,37	0,28	0,78	0,13	0,83	0,12
S388	22,1	4,4	11,1	1,52	8,4	2,47	0,99	3,27	0,58	3,72	0,73	2,48	0,33	2,33	0,32

Appendix 1. Whole rock chemical analysis, page 10

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Mo**	**Cu**	**Pb**	**Zn**	**Ni**	**As**	**Cd**	**Sb**	**Bi**	**Ag**	**Au**	**Hg**	**Tl**	**Se**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppb**	**ppm**	**ppm**	**ppm**
Method detection limit:	**0,1**	**0,1**	**0,1**	**1**	**0,1**	**0,5**	**0,1**	**0,1**	**0,1**	**0,1**	**0,5**	**0,01**	**0,1**	**0,5**
Kim09-1117	<0.1	33,0	2,6	131	127,6	<0.5	<0.1	<0.1	0,2	<0.1	0,9	<0.01	0,8	<0.5
Kim09-1118	0,3	153,0	3,6	32	22,7	<0.5	<0.1	<0.1	<0.1	<0.1	2,6	<0.01	<0.1	<0.5
Kim09-1119	0,4	120,2	2,3	45	28,9	<0.5	<0.1	<0.1	<0.1	<0.1	2,7	<0.01	<0.1	<0.5
Kim09-1120	0,9	121,1	2,8	65	170,3	<0.5	<0.1	<0.1	<0.1	<0.1	0,5	<0.01	<0.1	<0.5
Kim09-1120A	0,4	271,5	1,3	39	17,9	<0.5	<0.1	<0.1	<0.1	<0.1	3,3	<0.01	<0.1	0,8
Kim09-1122	1,0	393,0	2,6	56	16,1	<0.5	0,2	<0.1	<0.1	<0.1	2,6	<0.01	<0.1	0,9
Kim09-1122A	1,1	205,0	1,8	52	543,9	<0.5	<0.1	<0.1	<0.1	<0.1	1,4	<0.01	0,1	0,5
Kim09-1123	1,4	487,5	2,8	58	21,6	0,7	<0.1	<0.1	<0.1	0,1	1,3	<0.01	<0.1	0,9
Kim09-1143	0,3	247,6	1,6	28	14,3	<0.5	<0.1	0,4	<0.1	0,1	5,6	<0.01	<0.1	0,6
Kim09-1219	1,3	192,2	1,2	104	384,2	<0.5	<0.1	<0.1	<0.1	0,1	1,5	<0.01	<0.1	<0.5
Kim09-2126A	0,5	356,5	2,3	58	18,9	<0.5	<0.1	<0.1	0,2	0,3	5,0	<0.01	<0.1	1,3
Kim09-2127A	0,9	134,8	3,3	45	45,1	<0.5	<0.1	<0.1	0,2	0,1	1,4	<0.01	0,1	0,6
Kim09-2127B	0,5	94,7	1,2	53	174,8	<0.5	<0.1	<0.1	0,2	<0.1	1,1	<0.01	0,4	<0.5
Kim09-2127C	0,5	70,2	2,9	36	26,9	0,5	<0.1	<0.1	0,2	<0.1	2,3	<0.01	<0.1	<0.5
Kim09-2127D	0,6	163,5	1,0	64	261,2	<0.5	<0.1	<0.1	0,1	0,1	2,4	<0.01	0,6	<0.5
Kim09-2128A	<0.1	4,0	0,8	68	406,4	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0,9	<0.5
Kim09-2128B	0,5	309,1	1,4	38	23,5	<0.5	<0.1	<0.1	0,1	0,1	4,6	<0.01	<0.1	0,6
Kim09-2128C	0,2	148,7	1,9	20	19,5	<0.5	<0.1	<0.1	0,2	<0.1	1,4	<0.01	<0.1	<0.5
Kim09-2128D	0,4	312,9	2,0	33	31,4	<0.5	<0.1	0,2	0,3	0,2	3,4	<0.01	<0.1	0,7
Kim09-2128E	0,2	128,6	3,9	29	22,1	0,6	<0.1	<0.1	0,3	0,1	2,5	<0.01	<0.1	0,5
Kim09-2128F	0,3	152,1	1,4	38	23,6	<0.5	0,1	<0.1	0,2	0,2	4,9	<0.01	<0.1	<0.5
Kim09-2129	0,5	196,1	2,6	23	121,9	<0.5	<0.1	<0.1	0,1	<0.1	0,6	<0.01	<0.1	<0.5
Kim09-2130	0,6	210,0	3,2	41	11,7	<0.5	<0.1	<0.1	<0.1	0,1	1,6	<0.01	<0.1	0,7
Kim09-2130A	0,6	44,0	0,8	96	40,5	<0.5	<0.1	<0.1	<0.1	<0.1	0,5	<0.01	<0.1	<0.5
Kim09-2131	0,3	264,1	4,1	58	24,2	<0.5	<0.1	<0.1	0,2	0,2	3,8	<0.01	<0.1	<0.5
Kim09-2132	<0.1	0,9	0,5	322	428,8	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2132A	0,4	89,3	4,2	35	31,0	<0.5	<0.1	<0.1	<0.1	<0.1	2,9	<0.01	<0.1	<0.5
Kim09-2133	2,1	200,1	0,8	49	31,1	<0.5	<0.1	<0.1	<0.1	<0.1	1,0	<0.01	<0.1	<0.5
Kim09-2133A	<0.1	1,0	0,5	112	425,5	<0.5	<0.1	<0.1	<0.1	<0.1	0,6	<0.01	<0.1	<0.5
Kim09-2134	0,2	142,5	7,0	40	19,2	<0.5	<0.1	<0.1	<0.1	<0.1	1,1	<0.01	<0.1	<0.5
Kim09-2134A	0,3	130,0	2,4	65	35,8	<0.5	<0.1	<0.1	<0.1	<0.1	0,8	<0.01	<0.1	0,5
Kim09-2134B	0,6	202,5	1,7	44	17,8	<0.5	<0.1	<0.1	<0.1	<0.1	2,9	<0.01	<0.1	0,6
Kim09-2134C	0,4	189,8	1,1	35	21,3	<0.5	<0.1	<0.1	<0.1	<0.1	2,0	<0.01	<0.1	0,7
Kim09-2135	0,3	162,9	1,0	50	20,5	<0.5	<0.1	<0.1	<0.1	0,2	6,7	<0.01	<0.1	0,7
Kim09-2135A	<0.1	3,5	4,0	36	43,6	<0.5	<0.1	<0.1	0,2	<0.1	5,9	<0.01	0,3	<0.5
Kim09-2135B	0,1	86,0	1,1	25	9,9	<0.5	<0.1	<0.1	<0.1	<0.1	3,5	<0.01	<0.1	<0.5
Kim09-2136	0,6	239,2	1,6	52	23,7	<0.5	<0.1	<0.1	<0.1	<0.1	1,8	<0.01	<0.1	0,7
Kim09-2136A	0,7	171,1	8,6	56	8,6	0,5	<0.1	<0.1	1,2	<0.1	9,1	<0.01	<0.1	<0.5

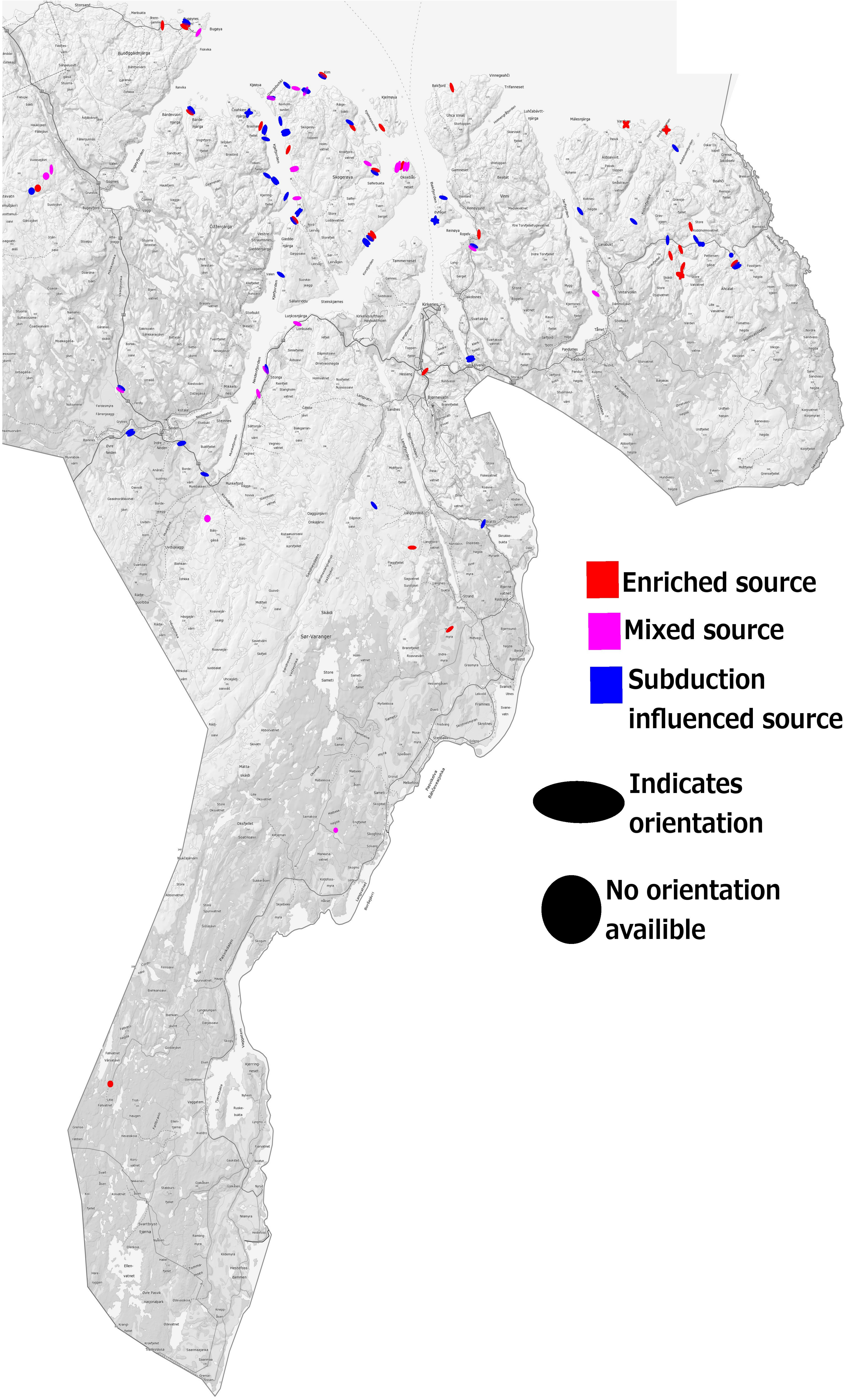
Appendix 1. Whole rock chemical analysis, page 11

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Mo**	**Cu**	**Pb**	**Zn**	**Ni**	**As**	**Cd**	**Sb**	**Bi**	**Ag**	**Au**	**Hg**	**Tl**	**Se**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppb**	**ppm**	**ppm**	**ppm**
Method detection limit:	**0,1**	**0,1**	**0,1**	**1**	**0,1**	**0,5**	**0,1**	**0,1**	**0,1**	**0,1**	**0,5**	**0,01**	**0,1**	**0,5**
Kim09-2138	0,2	258,2	2,6	40	15,3	<0.5	<0.1	<0.1	<0.1	<0.1	4,2	<0.01	<0.1	0,6
Kim09-2139	0,6	123,9	3,0	75	17,2	0,8	0,1	0,2	<0.1	0,1	1,6	<0.01	0,1	<0.5
Kim09-2139A	<0.1	3,0	1,3	33	156,5	<0.5	<0.1	<0.1	<0.1	<0.1	0,7	<0.01	0,5	<0.5
Kim09-2141	0,1	37,3	1,8	232	83,4	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0,9	<0.5
Kim09-2141A	0,4	118,5	6,5	56	48,6	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	0,5
Kim09-2142	0,4	173,5	2,2	35	16,2	<0.5	<0.1	<0.1	<0.1	<0.1	2,0	<0.01	<0.1	<0.5
Kim09-2144	0,4	171,9	2,7	28	16,9	<0.5	<0.1	<0.1	<0.1	<0.1	2,7	<0.01	<0.1	<0.5
Kim09-2144A	0,3	79,6	1,7	21	16,9	<0.5	<0.1	<0.1	<0.1	<0.1	2,5	<0.01	<0.1	<0.5
Kim09-2145	0,3	251,0	1,7	27	14,1	<0.5	<0.1	<0.1	<0.1	<0.1	2,9	<0.01	<0.1	<0.5
Kim09-2146	0,2	204,7	1,4	24	17,2	<0.5	<0.1	<0.1	<0.1	<0.1	4,2	<0.01	<0.1	<0.5
Kim09-2146A	<0.1	25,6	2,2	28	20,9	0,7	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2146B	0,3	111,4	1,4	44	72,1	<0.5	<0.1	<0.1	0,1	<0.1	0,5	<0.01	<0.1	<0.5
Kim09-2147	0,4	106,3	2,1	27	66,5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2148	0,2	238,7	1,7	30	25,3	<0.5	<0.1	<0.1	<0.1	0,1	3,6	<0.01	<0.1	0,6
Kim09-2148A	0,3	79,8	2,1	45	24,2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2149	0,3	153,8	6,6	65	29,0	<0.5	<0.1	<0.1	<0.1	<0.1	1,8	<0.01	<0.1	<0.5
Kim09-2150	0,2	260,6	1,4	40	25,8	<0.5	<0.1	<0.1	0,2	<0.1	2,2	<0.01	<0.1	<0.5
Kim09-2151	1,0	39,7	1,0	78	147,2	<0.5	<0.1	<0.1	0,1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2152	0,5	114,8	1,3	87	34,5	<0.5	<0.1	<0.1	0,1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2152A	0,3	13,2	1,9	187	100,9	0,9	<0.1	<0.1	0,4	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2153	0,3	41,2	1,3	75	53,6	<0.5	<0.1	<0.1	0,1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2155	0,4	151,1	1,3	34	21,3	0,9	<0.1	<0.1	<0.1	<0.1	1,4	<0.01	<0.1	<0.5
Kim09-2156	0,4	147,2	7,6	89	24,4	<0.5	<0.1	<0.1	<0.1	<0.1	2,4	<0.01	<0.1	<0.5
Kim09-2156A	0,3	109,6	1,9	129	73,9	<0.5	<0.1	<0.1	0,3	0,1	<0.5	<0.01	<0.1	<0.5
Kim09-2158	0,5	24,7	1,4	18	26,3	<0.5	<0.1	<0.1	<0.1	<0.1	1,1	<0.01	<0.1	<0.5
Kim09-2159	0,5	183,0	0,8	27	26,0	0,6	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	0,6
Kim09-2159A	0,5	238,8	1,6	50	21,5	<0.5	<0.1	<0.1	<0.1	0,1	5,8	<0.01	<0.1	<0.5
Kim09-2162	0,4	21,2	3,2	86	262,7	<0.5	<0.1	<0.1	<0.1	<0.1	0,5	<0.01	<0.1	<0.5
Kim09-2162A	0,2	83,4	3,0	21	176,3	0,7	<0.1	<0.1	<0.1	<0.1	1,0	<0.01	0,1	<0.5
Kim09-2164	0,3	168,6	1,9	15	14,0	0,7	<0.1	<0.1	<0.1	0,1	1,3	<0.01	<0.1	<0.5
Kim09-2165	0,4	103,0	3,2	19	101,8	1,4	<0.1	<0.1	<0.1	<0.1	0,9	<0.01	<0.1	<0.5
Kim09-2166	0,1	5,7	0,6	148	83,0	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2166A	0,5	114,6	1,1	37	26,3	0,6	<0.1	<0.1	<0.1	<0.1	1,6	<0.01	<0.1	<0.5
Kim09-2169	1,1	245,3	6,0	55	787,9	<0.5	<0.1	<0.1	<0.1	0,1	0,9	<0.01	<0.1	0,5
Kim09-2170	0,6	261,3	2,7	57	35,3	0,8	<0.1	<0.1	<0.1	<0.1	5,0	<0.01	<0.1	<0.5
Kim09-2170A	0,4	235,0	2,4	49	38,5	0,5	<0.1	<0.1	<0.1	0,1	3,9	<0.01	<0.1	0,8
Kim09-2170B	0,9	230,9	2,2	66	533,7	1,1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2175	1,0	213,7	3,3	42	590,8	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5

Appendix 1. Whole rock chemical analysis, page 12

Analytical technics:	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Element:	**Mo**	**Cu**	**Pb**	**Zn**	**Ni**	**As**	**Cd**	**Sb**	**Bi**	**Ag**	**Au**	**Hg**	**Tl**	**Se**
Unit:	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppb**	**ppm**	**ppm**	**ppm**
Method detection limit:	**0,1**	**0,1**	**0,1**	**1**	**0,1**	**0,5**	**0,1**	**0,1**	**0,1**	**0,1**	**0,5**	**0,01**	**0,1**	**0,5**
Kim09-2177	1,1	164,1	1,9	39	368,9	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2220	1,0	280,1	3,5	131	830,7	0,6	0,2	<0.1	<0.1	0,2	<0.5	<0.01	0,2	0,6
Kim09-2266	0,2	172,4	0,2	19	50,2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2267	0,5	180,4	1,0	36	21,1	<0.5	<0.1	<0.1	<0.1	<0.1	0,5	<0.01	<0.1	<0.5
Kim09-2275	0,3	195,6	1,2	30	37,5	<0.5	<0.1	<0.1	<0.1	0,1	<0.5	<0.01	<0.1	<0.5
Kim09-2275A	0,5	281,3	1,4	28	13,4	<0.5	<0.1	<0.1	<0.1	0,2	1,7	<0.01	<0.1	<0.5
Kim09-2275B	0,5	638,5	3,1	44	38,7	0,7	<0.1	<0.1	0,5	0,4	1,6	<0.01	<0.1	2,0
Kim09-2275C	59,1	4,0	1,3	43	217,0	0,6	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0,6	<0.5
Kim09-2282	0,6	275,2	1,2	56	35,0	0,5	0,1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2288	1,0	259,5	3,2	45	28,4	<0.5	<0.1	<0.1	<0.1	0,1	1,6	<0.01	<0.1	0,5
Kim09-2291	0,4	92,3	2,5	76	35,1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-2341	0,5	101,4	2,7	47	30,2	<0.5	<0.1	<0.1	<0.1	<0.1	1,0	<0.01	<0.1	<0.5
Kim09-2363	0,4	79,1	1,3	23	141,7	<0.5	<0.1	<0.1	<0.1	<0.1	0,9	<0.01	<0.1	<0.5
Kim09-3019	0,2	129,3	1,0	22	13,1	<0.5	<0.1	<0.1	<0.1	<0.1	2,8	<0.01	<0.1	<0.5
Kim09-3024	0,6	53,8	1,2	17	63,8	<0.5	<0.1	<0.1	<0.1	<0.1	1,8	<0.01	<0.1	<0.5
Kim09-3066	0,4	36,8	4,1	125	149,9	<0.5	<0.1	<0.1	<0.1	<0.1	1,1	<0.01	0,7	<0.5
Kim09-3068	0,1	46,1	0,9	31	1336	<0.5	<0.1	<0.1	<0.1	<0.1	1,4	<0.01	<0.1	<0.5
Kim09-3068A	0,2	68,6	1,3	27	797,7	<0.5	<0.1	<0.1	<0.1	<0.1	2,8	<0.01	<0.1	<0.5
Kim09-3069	0,2	78,5	0,9	32	790,8	<0.5	<0.1	<0.1	<0.1	<0.1	4,2	<0.01	<0.1	<0.5
Kim09-3082	0,2	163,8	1,3	22	42,2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
Kim09-3082A	0,4	87,3	1,6	25	23,5	<0.5	<0.1	<0.1	<0.1	<0.1	1,9	<0.01	<0.1	<0.5
Kim09-3082B	0,4	111,5	2,3	67	51,8	<0.5	0,2	<0.1	<0.1	<0.1	2,4	<0.01	<0.1	<0.5
Kim09-3094	0,3	62,6	1,8	11	48,5	<0.5	<0.1	<0.1	<0.1	<0.1	0,8	<0.01	<0.1	<0.5
Kim09-3153	0,3	203,4	2,2	54	32,3	<0.5	<0.1	<0.1	0,3	<0.1	4,7	<0.01	<0.1	<0.5
Kim09-3212	0,2	152,3	1,5	146	4,1	<0.5	<0.1	<0.1	0,1	<0.1	0,8	<0.01	<0.1	<0.5
Kim09-3212A	<0.1	107,2	7,3	86	5,1	<0.5	<0.1	<0.1	<0.1	<0.1	4,7	<0.01	<0.1	<0.5
Kim09-3224	0,4	214,8	2,6	36	18,4	<0.5	<0.1	<0.1	<0.1	0,1	3,2	<0.01	<0.1	<0.5
Kim09-3224A	0,8	217,6	3,7	95	15,9	<0.5	0,2	<0.1	<0.1	0,1	2,1	<0.01	0,1	<0.5
Kim09-3225	0,2	138,2	1,0	50	23,0	<0.5	<0.1	<0.1	<0.1	<0.1	3,6	<0.01	0,1	<0.5
Kim09-3225A	0,6	218,7	1,4	59	24,3	1,1	<0.1	<0.1	<0.1	<0.1	1,0	<0.01	<0.1	<0.5
Kim09-3245	0,6	132,1	12,5	61	91,7	4,1	<0.1	0,1	1,2	0,2	4,1	<0.01	0,2	<0.5
R11-01	0,3	54,7	1,1	66	43,4	33,2	<0.1	0,2	<0.1	<0.1	<0.5	<0.01	<0.1	0,8
R13-05	0,2	62,5	1,2	30	934,5	<0.5	<0.1	<0.1	<0.1	<0.1	2,8	<0.01	<0.1	0,5
R13-08	0,2	156,9	2,7	25	382,4	<0.5	<0.1	<0.1	<0.1	0,1	1,6	0,02	0,2	0,8
R13-12	0,4	214,2	1,1	23	27,4	1,0	<0.1	<0.1	<0.1	<0.1	5,2	<0.01	<0.1	<0.5
S375	2,5	85,8	2,3	18	119,0	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	0,7
S376	0,1	37,4	0,7	10	239,0	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
S388	0,2	135,0	0,8	35	42,2	<0.5	<0.1	<0.1	<0.1	<0.1	1,0	<0.01	0,2	1,2

Appendix 2: Relative position, orientation, and magma source of samples.



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STATEMENT OF QUALITY ASSURANCE / QUALITY CONTROL

Quality Management System and ISO Registration

Foreseeing the need for a globally recognized mark of quality in 1994, Acme began adapting its Quality Management System to an ISO 9000 model. Acme implemented a quality system compliant with the International Standards Organization (ISO) 9001 Model for Quality Assurance and ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories. On November 13, 1996, Acme became the first commercial geochemical analysis and assaying lab in North America to be accredited under ISO 9001. The laboratory has maintained its registration in good standing since then. Vancouver expanded the scope of it's registration to include the Smithers preparation facility in June of 2009.

In 2005 the Santiago, Chile laboratories received ISO 9001:2000 registration with the preparation facilities in Mendoza, Argentina and Georgetown, Guyana following in 2006. Acme's Lima, Peru facility completed its registration audit in 2009.

Both the Vancouver and Santiago hub laboratories are working toward ISO 17025:2005 accreditation and are expected to complete the accreditation process within the next year.

ISO 9001:2000
IRAM
GESTION
DE LA CALIDAD
RI-9000-1295
CERTIFIED IQNet MANAGEMENT SYSTEM

BSI
ISO 9001:2008
FM 63007

Acme has for many years regularly participated in the CANMET and Geostats round robin proficiency tests. Acme is recognized as a participant in the CALA Proficiency Testing Program and is registered by the BC Ministry of Water Land and Air Protection under the Environmental Data Quality Assurance (EDQA) Regulation.

All laboratories fall under the Quality Management Scope helping to ensure the same practices and procedures are followed throughout the organization.

Quality Control In Sample Testing

Samples submitted are analyzed with the strictest quality control. Blanks (analytical and method), duplicates and standard reference materials inserted in the sequences of client samples provide a measure of background noise, accuracy and precision. QA/QC protocol incorporates a granite or quartz sample-prep blank(s) carried through all stages of preparation and analysis as the first sample(s) in the job. Typically an analytical batch will be comprised of 34-36 client samples, a pulp duplicate to monitor analytical precision, a -10 mesh reject duplicate to monitor sub-sampling variation (drill core only), a reagent blank to measure background and an aliquot of Certified Reference Material (CRM) or Inhouse Reference Material to monitor accuracy. In the absence of suitable CRMs Inhouse Reference Materials are prepared and certified against internationally certified reference materials such as CANMET and USGS standards where possible and will be externally verified at a minimum of 3 other commercial laboratories. Using these inserted quality control samples each analytical batch and complete job is rigorously reviewed and validated prior to release.

Acme has always prided itself on providing the highest level of quality control data to its clients. Recent implementation of Acme new laboratory information management system (LIMS) and AcmeAccess provides clients with even greater access to quality control data.

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QUALITY CONTROL: DEFINITIONS AND GUIDELINES FOR INTERPRETATION

Acme Analytical Laboratories core product is analytical data. Therefore Acme has invested heavily into proprietary software and professional staff to ensure we produce the highest quality data. Acme uses a detailed and comprehensive quality system to minimize errors and maximize the reliability of our analytical results. This system applies a tiered approach to the application of quality systems in our laboratories. These tiers are layered in the following manner;

1. ISO 9001 and 17025 documentation, training and standard operating procedures. This forms the framework of the application of each specific method in the laboratory.
2. The use of instrument calibration standards. These solutions are analyzed before any other solutions to establish the factors required to convert raw instrument data into concentration values.
3. QC validation solutions. These solutions are analyzed with client samples to validate each run and to confirm that each analytical run has been performed correctly. These are typically inserted immediately before and immediately after client sample solutions.
4. Reference materials, replicates and blanks. These samples are inserted into randomly assigned positions within each rack as generated by our proprietary LIMS system so that they are analyzed with the client solutions. Their purpose is to provide a final verification of the entire sample handling process. These samples are made up of the following categories:
    - Sample preparation blank;
    - Sample preparation replicate;
    - Analytical blank;
    - Analytical replicate;
    - Certified Reference Material (CRM);
    - Internal Reference Material (IRM).
5. Data review and validation. This is the final layer that is made up of sophisticated proprietary software and professional personnel reviewing the data. The following steps are applied;
    a. Software validation. Proprietary software is used to review the data for specific problems and to perform a series of rational checks upon the data. Data values are flagged and given specific colors, red for fail and amber for warning. Operators must take action on failures and log their actions.
    b. Rack level validation is performed by the instrument operator that analyzed the samples. At Acme, this person is a Chemist or other person with substantial and equivalent experience. This can only occur when the data has passed the software validation. The operator reviews the rack QC and validates the rack of samples if all QC samples pass.
    c. Method level validation. This validation is performed by the senior department Chemist. This review examines all racks analyzed by a specific method. Its purpose is to identify any trends or unusual results that are not apparent when only looking at a single rack of data.
    d. Final Job validation. This is performed by a Certified Assayer or equivalent senior person. This person has access to all the data from multiple analytical methods to check and compare. This is the person that ultimately signs the final certificate.

This document provides a detailed description of Acme's application of Reference materials, Replicates and Blanks.

The Use of Analytical Blanks and Preparation Blanks

Acme uses two types of blanks in the sample analysis stream for drill and rock samples. The first is a preparation blank that is collected from the cleaning sand or rock used between each and every job to clean the crushing and pulverizing equipment prior to starting another client's samples. It also separates different jobs from the same client that may have been separated due to large differences in composition or grade. This blank appears as the first sample in each job, with results reported in the QC section of the certificate under the heading Prep Wash. The analytical results from this blank are used to monitor contamination during the preparation process. The second blank is an analytical blank which is inserted during analysis to monitor reagent contamination and is reported in the QC section of the certificate as BLK.

If the Client chooses to insert blank material, they must be previously certified by a minimum of 4 ISO 9001 accredited laboratories. The nominal maximum value for acceptance will be up to 1% of the preceding sample up to a maximum of 15ppb (preceding sample of 1,500ppb). For preceding samples above this range, additional cleaning rock must be run through equipment prior to these samples and repeat analysis will be at the cost of the client. In some cases, higher rates of contamination can occur. This is typically due to mineral types that contain higher levels of water of hydration (clay minerals). Our operators are trained to recognize this and use cleaning sand between such samples. Since this additional cleaning step carries an added cost, we do our best to contact the client to confirm these actions.

The Use of Replicates

Acme uses analytical and preparation replicates on drill samples to track reproducibility of the analytical and preparation processes. Data for both types of replicates is provided with each certificate at no charge. Replicate precision varies with concentration from 100% or greater error at or near the detection limit for the method, down to the method precision at concentrations greater than 10 times the detection limit.

If clients choose to submit blind replicates please note that replicates on drill samples may not meet the same reproducibility criteria as CRM's/IRM's because the drill samples may not be as homogeneous as an aggressively prepared and mixed standard.

The presence of native gold can also cause serious reproducibility problems. Where the presence of coarse gold is suspected, the parties should discuss more appropriate analytical and preparation techniques that can mitigate these problems.

The Use of Certified Standard Reference Materials (CRM's)

Acme uses CRM's whenever possible to track analytical accuracy and precision for each method. If a CRM is not available or of such high cost that they are not practical, Acme uses internal reference materials (IRM's) that are either synthetically made or certified by performing round robin analyses by several laboratories. If an IRM is used, Acme routinely validates their concentrations using CRM's when they are available.

For concentrations above 10 times the detection limit expected geochemical exploration sample precision is 15% for methods such as 1D and 1E. Ore grade expected precision is 7% at levels greater than 10 times the detection limit for methods such as 7AR and 7TD. Exact precision is method, element and standard quality dependent, so acceptance criteria for individual standard and method combinations are determined on a minimum of 30 replicates measured during the course of routine analyses at a single laboratory. It should be noted that the expected precision for gold in methods such as Group 3 and Group 6 are difficult to predict due to the heterogeneous distribution of gold in many materials.

Client Field Replicates

Field replicate precision is a measure of the sampling process and natural variability within the sample media; they are not suited for determining analytical precision.

Client's Use of Blind or Hidden Internal Standards

Acme encourages and strongly recommends the use of blind client standards and we recognize that their use is an important component of project data evaluation and acceptance. It is Acme's policy to reanalyze any sample batch that contains a failed customer standard, free of charge, under the following conditions;

- The client supplies Acme with the certification documentation for the standard or proof of certification parameters such as, but not limited to; method of analysis, number of participating laboratories, range of data in the round robin.
- Standards must come from an accredited manufacturer such as CANMET, CDN Labs, Ore Research, Rocklabs or WCM. Certification criteria/method of analysis should be considered before determining if a standard is applicable to a method.
- The analytical result falls outside 3 standard deviations of a population of no less than 30 values determined using a single analytical method (good laboratory practice indicates that 1 value between 2 and 3 SD's is acceptable, while 2 consecutive values will call for reanalysis. In the above description, Acme refers to the standard deviation of values determined over the course of these minimum 30 routine analytical measurements at a single lab, and not the value quoted in the certification sheet for the standard. This definition includes error associated with both the analytical technique, as well as error in the certified value, and is therefore a robust measure of a CRMs performance under a particular set of analytical conditions. In addition, individual standard values that fall outside 3 standard deviations but still lie within the certified error of the material will not be considered to have failed QC validation and costs for requested repeat analyses will be borne by client.
- The failed standard is brought to our attention within 90 days of the initial reporting of the analytical results.

If the reanalysis of a batch or rack is requested by the client due to a Standard failure and the only analytical result that changes significantly is the result for the Standard, the client will be charged for the reanalysis of the rack or batch as this indicates heterogeneity of the Standard itself. In addition, if both samples AND standards are unchanged upon reanalysis, the client will bear the cost of said reanalysis.

Some additional considerations should be noted;

- Variability of a standard material is additive to the analytical method error. Therefore, a poorly prepared standard will increase the total standard deviation realized.
- Selection of an appropriate standard that is both mineralogically and compositionally similar to the samples it is to be analyzed with is of critical importance.
    - If the standard has a different matrix then it would not be unusual if the only sample failing the performance criteria is the standard itself.
    - If the standard has a concentration that is not in a useful concentration range, then unexpected results can occur. For instance, if the concentration of the standard is too high, the laboratory may consistently reanalyze this standard under the assumption that the result is highly anomalous and therefore requires another check. This will waste money and time.

Determination of Method Confidence Limits to be Used for Pass/Fail Criteria

When referring to the Standard Certificate, neither the 95% confidence interval nor the standard deviation quoted in the certificate should be used to calculate control limits or to fail a batch of samples. The 95% confidence interval (normally appearing on the front page of a certificate) is a measure of the certainty of the accuracy of the recommended value. It does not relate to the expected precision during routine use. In addition, it does not account for variations controlled by the limitations imposed by a particular digestion method.

The control limits used to determine the passing or failing of batch data should be calculated from the data that is generated by the laboratory itself (see section “Client use of Blind or Hidden Internal Standards” above for details). Each laboratory provides Standards analyzed with each batch, for this purpose.

Whenever possible, the client should discuss their quality program with the laboratory prior to the start of the project. In this way, any difference in interpretation may be discussed and agreed to in advance.

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