2009

Crystal-Chemical Relationships in Kimberlitic and Non-kimberlitic Garnets and Ilmenites

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Spine Title: Crystal-Chemical Trends in Garnets and Ilmenites

Thesis Format: Integrated-Article

By

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Graduate Program: Geology

A thesis submitted in partial fulfillment
of the requirements for the degree of Master of Sciences

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Abstract

A detailed investigation of the relationship between crystal structure and chemical composition was conducted for a suite of kimberlitic garnets, and kimberlitic and non-kimberlitic ilmenites. The results for garnet showed clear trends of increasing unit cell with increasing calcium and chromium contents. Increases in unit cell occurred parallel to the divisions between major garnet types, making unit cell ineffective as a discrimination tool for diamond exploration, although it could have application to skarn exploration. Kimberlitic and non-kimberlitic ilmenites did not follow well defined trends and the two sources could not be distinguished by their unit cell dimensions.

This work also outlines several issues concerning the footprint of the incident X-ray beam of the Brüker D8 Discover at low glancing angles, and makes recommendations for future studies. In addition, a new method is reported that allows partially automated thin section mapping, providing modal mineralogy and 2D maps of the thin section.

Keywords: garnet, ilmenite, crystal structure, X-ray diffraction, diamond, kimberlite, exploration, modal analysis, mapping.

Acknowledgements

First, I would like to thank Dr. R. Flemming for her support and guidance. She made my Masters a memorable experience.

I would also like to thank my lab-mates, Matt Izawa and Candace Freckleton, for being sources of fresh ideas and critical thinking. Thanks to Duane Petts and Ivan Barker, whose technical help was most appreciated for magnetic separation and SEM analysis.

Thanks to Brian Hart (Surface Science Western) who helped me collect SEM-EDX data, and Jim Renaud (Renaud Geological Consulting), who provided quick, reliable EPMA analyses.

I would also like to acknowledge Dr. T. Nowicki, Dr. H. Helmstaedt, Dr. D. Schulze and De Beers Canada, who graciously donated samples.

Thanks also to Patti, for her moral support, and for helping me create the programs and scripts that were used throughout my thesis. Without her help the micro-XRD mapping method would not have been as effective.

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Chapter 1: Introduction and Literature Review

Kimberly mine, Kimberly, South Africa, 1872 (shortly after discovery). Source: De Beers (http://www.debeersgroup.com/en/Global/display-image/?imageID=1273).

1.1 Overview

Garnet is an important mineral in metamorphic and high-pressure rocks. Several major elements are compatible in the garnet crystal structure and it forms a wide range of solid solutions which reflect the composition of the host rock. As a consequence of their importance in the rock forming minerals, garnets, particularly pyrope, almandine and grossular, have received a great deal of interest from both academia and the exploration industry. The academic world has been particularly interested in the thermodynamics and crystal structure of garnet, principally to resolve the pressure-temperature (P-T) history of the rocks that host it (e.g. Grütter *et al.*, 2006). The diamond exploration industry uses the chemical composition of garnet and other minerals to establish whether or not a kimberlite (the major primary source of diamonds) has the potential to host diamonds (Gurney *et al.*, 2005). These minerals have been termed "kimberlite indicator minerals" or KIMs. In addition to its use as a KIM, garnet is used as a thermobarometer to establish the geothermal gradient in the crust and upper mantle (Ravna, 2000; Grütter *et al.*, 2006). This is of particular importance for diamond exploration, as the geothermal gradient is used to determine whether or not a kimberlite passed through rocks that lie within the diamond stability field.

Initial research into the relationship between crystal structure and major element chemistry for garnet (Chmielová *et al.*, 1997; Flemming and Hollis, 2003; Harwood, 2005) showed a positive linear trend of unit cell dimension with both calcium and chromium content. The research presented here builds on those studies and examines ilmenite, another common KIM. Ilmenite is rhombohedral (unlike garnet which is cubic), so an initial study was conducted in order to test the response of a non-cubic crystal structure to chemical substitution.

To date, no research has been conducted that ties the research on garnet or ilmenite crystal structures with the geochemical trends used by the diamond exploration industry. This study will examine the relationship between the crystal structure and major element chemistry of a suite of natural garnets and ilmenites, from several kimberlites worldwide. The long term goal of this line of research is to develop a technique for classifying different KIMs using crystal structural information rather than chemical composition.

This chapter introduces the concepts important to diamond exploration, including: deposit types, diamond stability and sources, transport of diamond to the surface, KIMs and the current methods used to classify them. It will also introduce the important aspects of the garnet and ilmenite crystal structures, as they relate to this study.

1.2 Diamond Exploration

Diamonds form deep within the Earth at the base of large, thick, stable cratons. They can be transported to the surface by both igneous and tectonic processes, although the latter has never produced any economic diamond deposits (Gurney *et al.*, 2005). Kimberlites and lamproites are the only two primary igneous rock types that have ever produced economic grades of diamonds, but even these are exceedingly low grade (generally < 3 g/ton). In the past, secondary deposits were the largest contributors to worldwide diamond recovery, although their role is beginning to diminish. These deposits, which include fluvial/alluvial, marine, wind-borne and paleoplacer deposits, are created by erosion of primary diamondiferous rocks (Gurney *et al.*, 2005). The present research is concerned with primary kimberlitic deposits, so other diamond sources will be excluded from the following review. Figure 1.1 is a simplified schematic of an Archean craton. Kimberlites are found on stable Archean cratons and surrounding Proterozoic orogenic belts (Mitchell, 1993). Diamondiferous kimberlites have only been found on the cratons themselves; although rare exceptions do occur where deep Archean roots are thought to exist beneath Proterozoic belts (e.g. Schulze *et al.*, 2006). The majority of kimberlites do not contain diamonds, at least at grades high enough to mine, so the discovery of a kimberlite, or even a cluster of them, is only the first step toward determining whether or not diamonds are present.

Kimberlites are easily eroded, both physically and chemically (McClenaghan *et al.*, 2000). As a result, diamond exploration focuses on finding the more resistant minerals which originate within them. These include constituents of the kimberlite itself but several of the resistant minerals are actually xenocrysts, entrained by the kimberlite magma during its passage through the lithospheric mantle and crust. Depending on the geographic location of a particular kimberlite, resistant minerals can get concentrated in fluvial/alluvial deposits, or dispersed by glaciers in till dispersal trains.

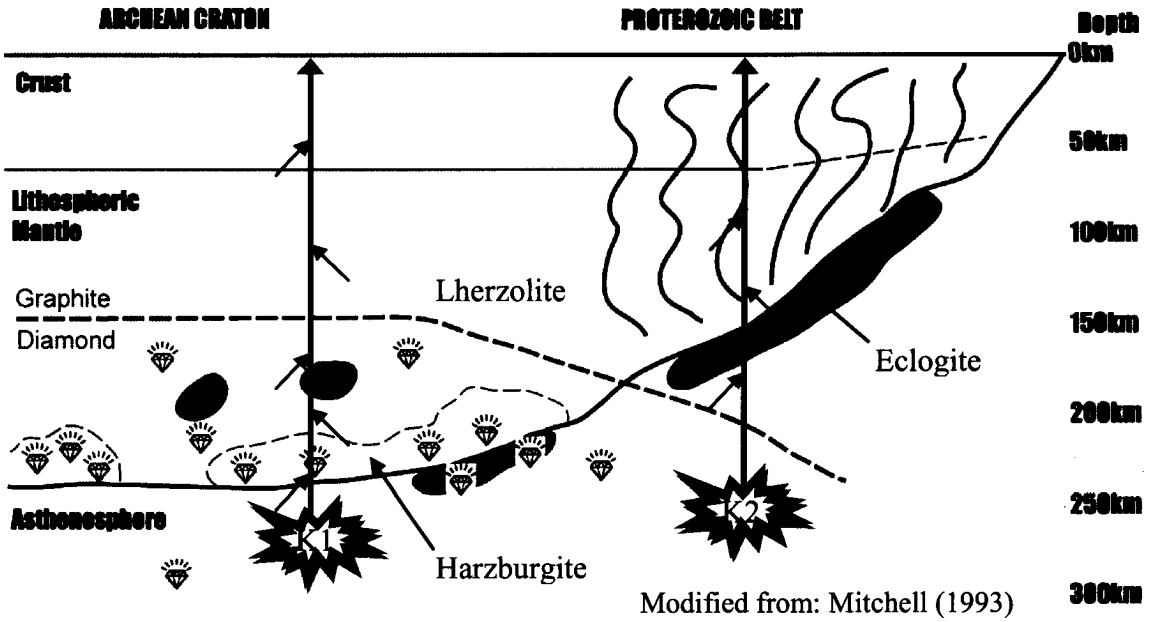


Figure 1.1: A simplified schematic of an Archean craton, showing how two kimberlites (K1 and K2) might sample the lithospheric mantle and crust. The diamond symbols indicate regions which might contain diamonds. The graphite-diamond phase boundary has been marked (dashed line).

Most of the resistant minerals have a high density, so samples collected by stream or till sampling programs can be sorted into "heavy mineral concentrates." These are then sorted visually into mineralogical groups and analyzed using Electron Probe Micro-Analysis (EPMA). The major and trace element chemistry is then used to determine whether the minerals being sampled indicate the presence of kimberlite, and in some cases, diamond itself.

1.2.1 Kimberlite Indicator Minerals (KIMs)

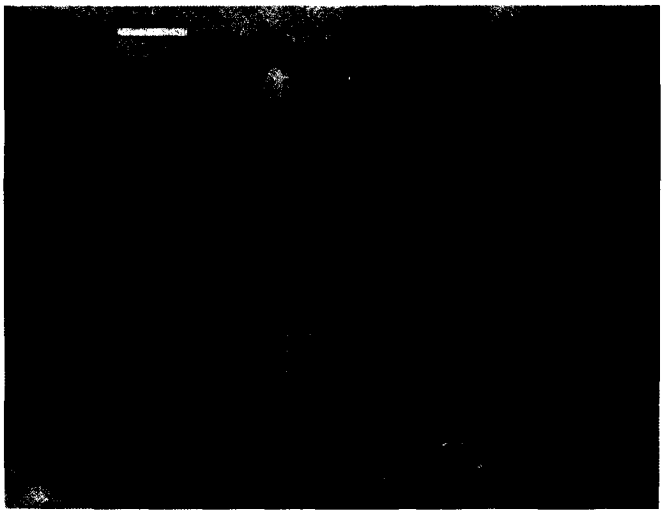
Sampling unconsolidated sediments for key indicator minerals is the most commonly used method for kimberlite exploration. The indicator minerals include peridotitic and eclogitic garnets, Cr-diopside, Mg-ilmenite and chromite (Figure 1.2; Helmstaedt, 2006). Other minerals, such as zircon, olivine and phlogopite can be useful indicator minerals but are also present in non-kimberlitic rocks; olivine and phlogopite are easily weathered which further limits their utility.

Garnets are generally considered to be the best indicator of kimberlite (and diamond), because calcium-poor, chromium-rich pyropes are the most common minerals found as inclusions within diamonds (Gurney *et al.*, 2005). The compositions and

sources of these garnets will be discussed in detail in Section 1.2.3 and in Chapters 3 and 4. Mg-ilmenite, or picroilmenite, is another useful KIM which almost always originates from outside the diamond stability field.

Ilmenites recovered from kimberlite are derived from a variety of sources, becoming entrained in the kimberlite magma during its ascent through the lithospheric mantle and crust. The sources include the megacryst suite (similar to pegmatite, but with mantle mineralogy), ilmenites formed by metasomatic processes, MARID suite ilmenites (Mica-Amphibole-Rutile-Ilmenite-Diopside), and ilmenite phenocrysts and groundmass in the host kimberlite (Dawson and Smith, 1977; Wyatt *et al.*, 2004). None of these sources are known diamondiferous assemblages. Ilmenites ($FeTiO_3$) form extensive solid solutions with geikielite ($MgTiO_3$) and hematite (Fe_2O_3). The presence of high MgO in ilmenite, along with low hematite content, represent relatively reducing conditions in the kimberlite magma, which would favour preservation of diamonds en route to the surface (Helmstaedt, 2006).

The KIMs outlined above are recovered exclusively from kimberlite and/or diamond-related mantle lithologies. Therefore, the presence of even a few KIMs in a sampling program is evidence of the presence of a kimberlite and warrants further reconnaissance (Helmstaedt, personal communication). However, the presence of KIMs does not guarantee that *diamondiferous* kimberlites are present, even if the compositions of garnet are known to be derived from within the diamond stability field (see Section 1.2.2).



Source: Helmstaedt, (2006)

Figure 1.2: Examples of several different types of kimberlite indicator mineral.

1.2.2 Diamonds: Stability and Sources

In order to understand why only specific rock types host diamonds, one must be familiar with the types of rock which make up the asthenospheric and lithospheric mantle, and the roots of the cratonic lithosphere. The major rock types that will be discussed in this research have been briefly described in Appendix 1. Diamonds are associated with the thick roots of continents, which may extend up to 400 km depth (Bijwaard *et al.*, 1998). Continental crust under a craton tends to have a maximum thickness of 60 km and is underlain by 100-400 km of lithospheric mantle (Figure 1.1). This region is depleted in komatiitic and basaltic components and is composed principally of spinel- or garnet-bearing lherzolites, harzburgites, and dunite (Mitchell, 1993). In some cases it may be underplated by eclogitic material, which is thought to be a remnant of subducted oceanic crust. The asthenosphere is located between the lithospheric mantle and the lower transition zone (~400-660 km depth). It is a relatively homogeneous zone of convecting material (Bijwaard *et al.*,1998; Mitchell, 1993).

Dating of diamonds, diamond inclusions, and diamond bearing xenoliths from around the world has shown that the majority of diamonds were formed in the Archean and Proterozoic; peridotitic diamonds typically date at ~3.0 Ga, and eclogitic diamonds between 1 and 1.5 Ga (Helmstaedt, 2006; Nixon *et al.*, 1987). Most kimberlites were emplaced within the last 500 Ma, although notable exceptions do occur. The large gap between the ages of diamonds and kimberlites has been used as evidence that diamond is a xenocryst in the kimberlite magma (Mitchell, 1993). Kimberlite melts occasionally passed through diamondiferous horizons en route to the surface, assimilating some of the country rock as they did so. The abundance of xenoliths from both the lithospheric mantle and lower crust in kimberlites is evidence that they can sample these regions.

Studies of large suites of inclusions in diamonds have shown that the dominant host rocks for diamond are harzburgites and eclogites (Gurney *et al.*, 2005). Lherzolite can also host diamonds occasionally (Helmstaedt, 2006). Harzburgites are a residual rock, created by partial melting of lherzolite. They are Ca-depleted, moderately Cr-enriched, and do not contain clinopyroxene. Harzburgite is scattered throughout the lowest parts of the lithospheric mantle, often at the transition between the lithospheric mantle and the asthenosphere (Gurney *et al.*, 2005). Eclogite is also most common at the transition

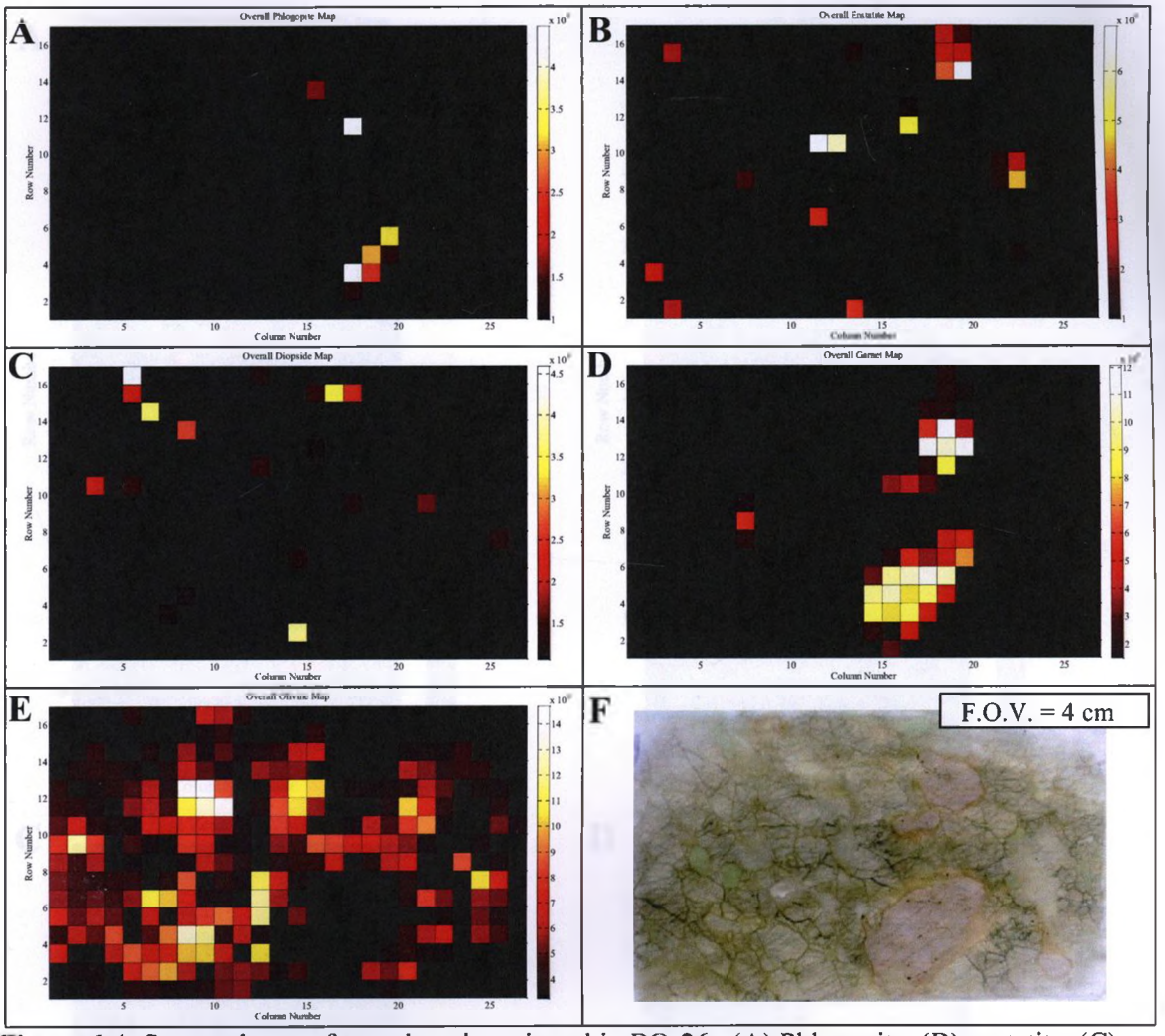


Figure 6.4: Summed maps for each major mineral in BO-26. (A) Phlogopite, (B) enstatite, (C) diopside, (D) garnet, (E) olivine. The thin section image has been included in (F) for comparison. Note: the map appears continuous but there was a 1 mm gap between the spots. The background has been removed from these maps, so that all cells below the threshold value appear black. Coloured regions indicate the presence of the mineral in question, regardless of intensity.

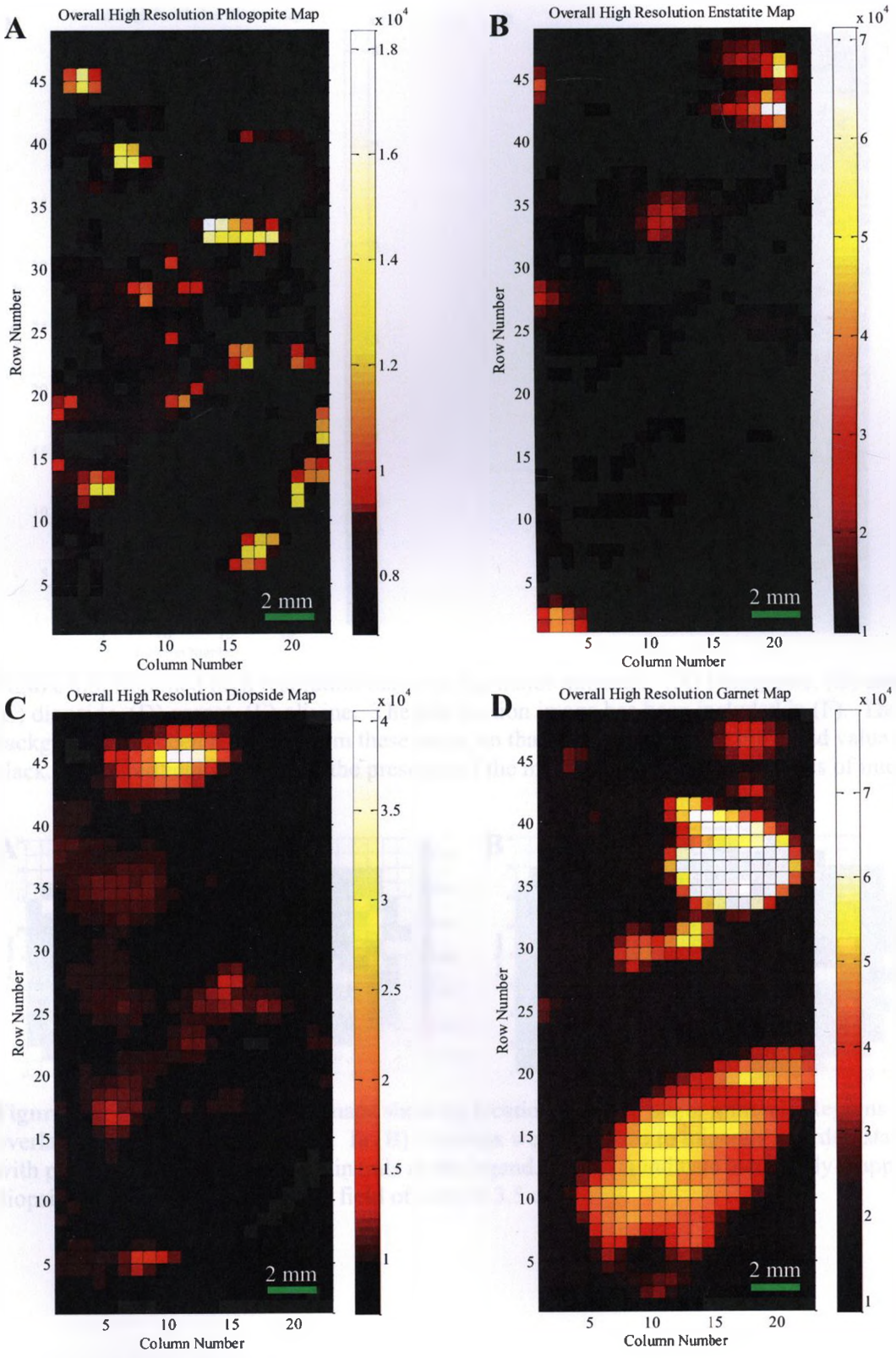


Figure 6.5: See caption overleaf.

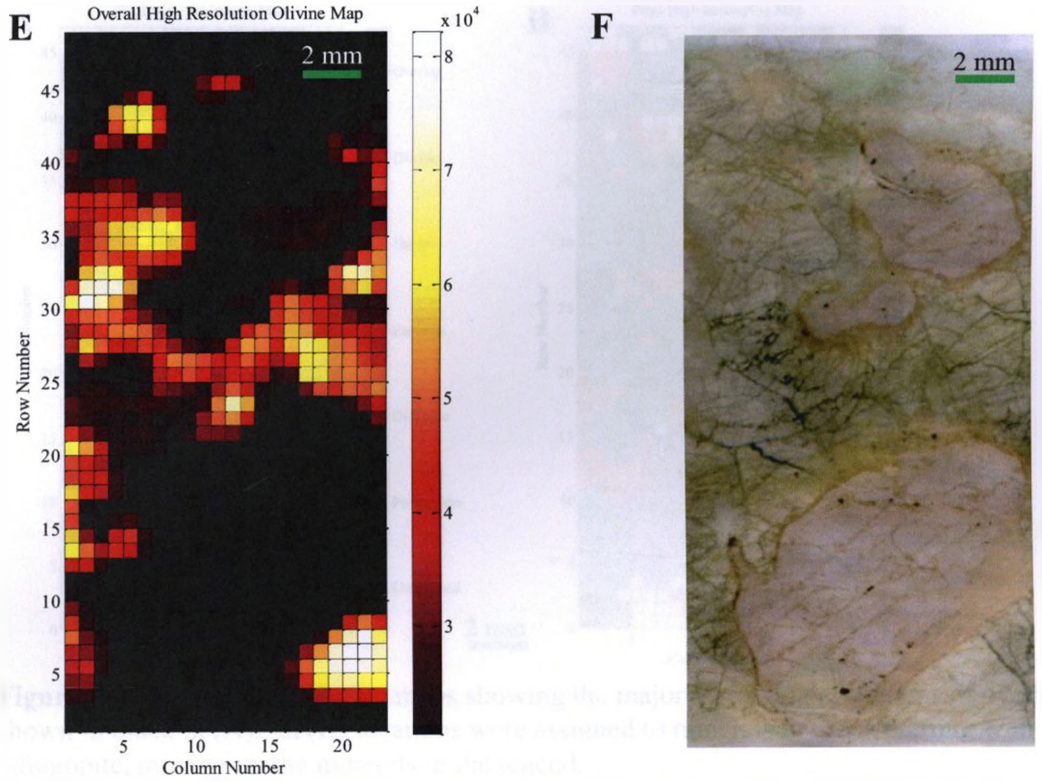


Figure 6.5: Summed high resolution maps for the major minerals. (A) Phlogopite, (B) enstatite, (C) diopside, (D) garnet, (E) olivine. The thin section image has been included in (F). The background has been removed from these maps, so that all cells below the threshold value appear black. Coloured regions indicate the presence of the mineral in question, regardless of intensity.

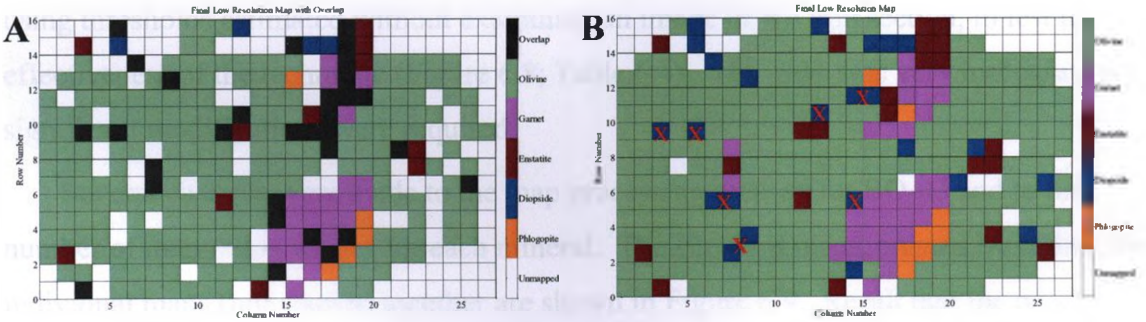


Figure 6.6: Final low resolution maps showing locations of each major mineral. Regions of overlap are shown in black in (A). In (B) locations were assigned to minerals in order, starting with phlogopite, moving up the minerals in the legend. Red X's indicate incorrectly mapped diopside grains. In both maps the field of view is 3.5 cm.

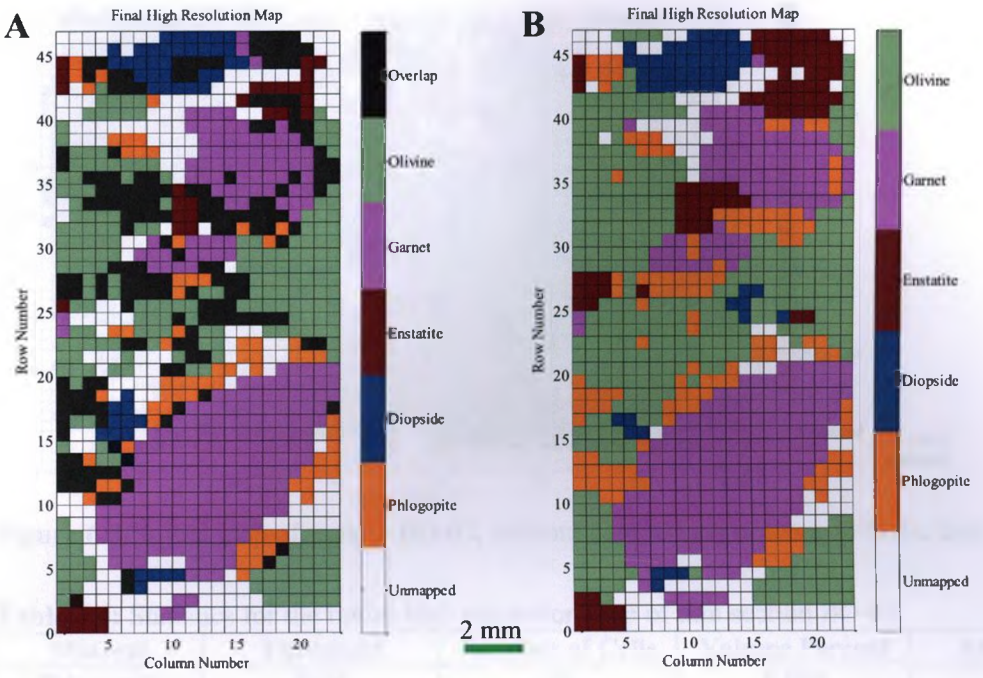


Figure 6.7: Final high resolution maps showing the major mineralogy. Regions of overlap are shown in black in (A). In (B) locations were assigned to minerals in order, starting with phlogopite, moving up the minerals in the legend.

6.3.2 BO-03

A "trial" version of the final map was created using the same method as BO-26, using thresholds estimated without examining an image of the thin section, to test the effectiveness of the technique (Figure 6.8; Table 6.4). This map was very inaccurate and significant modifications were required.

Several changes were made to the map processing method for BO-03 and to the number of integration ranges for each mineral. The summed maps, created by adding the individual maps (not shown) together are shown in Figure 6.9. Recall that the revised method subtracted background from the individual maps, so the values in each cell of Figure 6.9 indicate the number of individual maps that mapped the mineral. Any cell containing a non-zero value was considered to contain the mineral under examination. The final map, created by assigning minerals to cells based on the summed maps, is shown in Figure 6.10. For BO-03, overlap was not considered as the modal proportions determined by point counting were accurately reproduced in the map with no overlap.

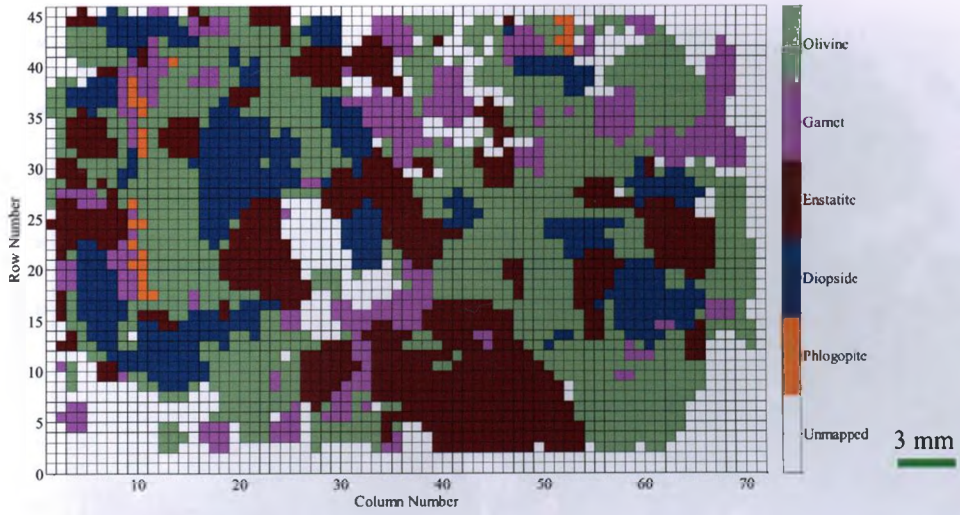


Figure 6.8: Initial map of sample BO-03, without comparison of the map to the thin section.

Table 6.4: Statistics for the initial high resolution map of thin section BO-03.

Mineral	Threshold	Number of Cells	Volume Percent	Area (mm^2)
Phlogopite	3100	26	0.908	6.50
Diopside	1400	428	14.9	107
Enstatite	4400	642	22.4	160
Garnet	4700	343	12.0	86.0
Olivine	6100	1089	38.0	272
Unassigned	-	334	11.8	83.5

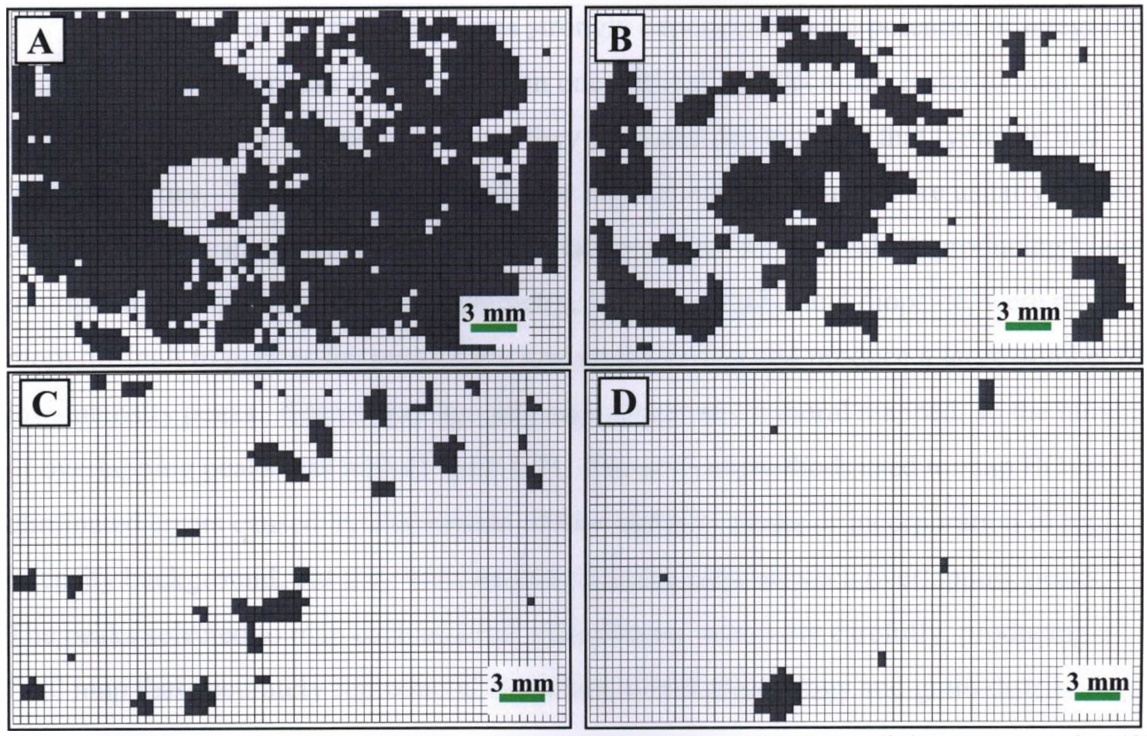


Figure 6.9: Summed maps for BO-03 using the revised methods for (A) olivine, (B) enstatite, (C) garnet and (D) phlogopite. Dark gray areas outline the areas occupied by each mineral.

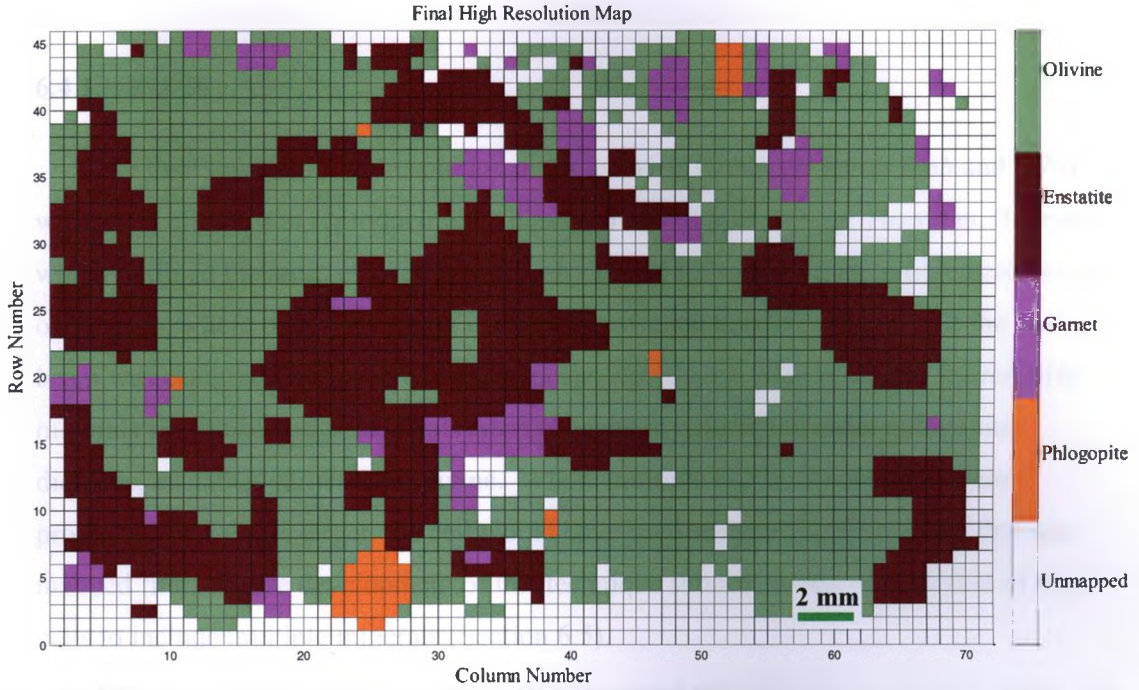


Figure 6.10: Final high resolution map of BO-03 created using the revised methods. The unassigned cells at the margins of the map were not counted in the modal proportions.

6.4 Discussion

The accuracy of the final maps was strongly dependent on the potential of integration windows to overlap peaks from more than one mineral. It was much easier to map minerals with higher symmetry because they produced fewer peaks that typically had high intensities. The intensities of peaks for high-symmetry minerals are usually higher because the d-spacings of several different lattice planes are equivalent, producing high multiplicities. Minerals with low symmetry, such as enstatite and diopside, were much more difficult to map as the peaks have low multiplicities and produce a large number of low-intensity peaks. Garnet was the only high-symmetry mineral mapped, so the number of overlapping peaks was high (Figure 6.3). The revised methods used to map BO-03 eliminated errors caused by elimination of low intensity peaks or incorporation of high-intensity background, but they were unable to distinguish between overlapping peaks. The peaks selected to map each mineral were chosen extremely carefully, producing a final map that accurately reproduced the actual modal mineralogy and grain distribution.

6.4.1 BO-26

The final low- and high-resolution maps ignoring overlap (Figures 6.6*b* and 6.7*b*) were most effective at reproducing the observed modal mineralogy. However, the maps which outlined the areas of overlap were very useful for outlining the problematic areas of the map, where cells were being incorrectly assigned to other minerals. If the X-ray beam was centered on a grain boundary, peaks would have been produced for multiple minerals simultaneously. Minerals were assigned to cells in the order phlogopite, diopside, enstatite, garnet then olivine. Where multiple diffraction patterns were produced for a single target, the cell would have been assigned to the mineral that was mapped first. Future development of this technique should involve subdivision of map cells to include multiple minerals (Section 6.5).

The low-resolution map of sample BO-26 agreed with the point count to within ± 4% (Table 6.3; Figure 6.11). Phlogopite and diopside were least accurately mapped, both in terms of their abundance and spatial distribution. The numbers of peaks used to map the two minerals (two for phlogopite, three for diopside) were insufficient to provide clear signal-to-noise ratios, resulting in poor definition of the areas containing each mineral. Phlogopite was commonly fine grained, bordering garnet in kelyphite rims and was rarely detected in the low-resolution map. The high-resolution map of BO-26 was much more effective at representing the phlogopite surrounding garnet. Several diopside grains were mapped where no diopside was present, a consequence of the low signal-to-noise ratio which made background subtraction difficult. In addition, the two diopside grains labeled (i) in Figure 6.1*a* were not mapped and the cells labeled (x) in Figure 6.6*b* did not contain diopside. Some of the grains mapped as diopside appeared to be enstatite, so there was probably some peak overlap between the two minerals for at least one integration window. The small grain size of diopside was also a problem as some grains fell in the space between the targets of the low-resolution map. Diopside was mapped more effectively in the high-resolution map, although some incorrectly mapped grains were present.

The proportions of olivine, garnet and enstatite matched very closely (± 1%) with the point count for the low-resolution map. The general shapes and distributions of the three

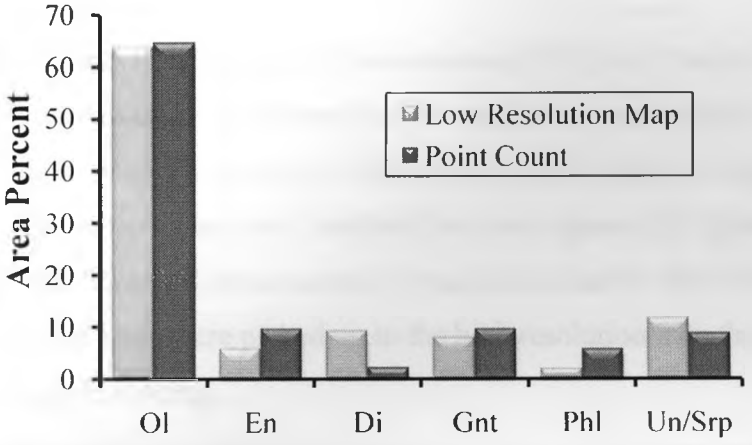


Figure 6.11: Comparison of the modal proportions determined from the low-resolution μXRD map and a point count. Ol = Olivine, En = Enstatite, Di = Diopside, Gnt = Garnet, Phl = Phlogopite, Un = Unassigned (μXRD map only), Srp = Serpentine (point count only).

minerals matched well with a visual inspection of the thin section image, bearing in mind the limits imposed by the map resolution.

The high-resolution maps of BO-26 (Figure 6.7) were much more accurate than the low resolution ones, especially for resolving the grain shapes. The amount of overlap between minerals in the high-resolution map (Figure 6.7*a*; Table 6.2*c*) was significant, and could not be reduced without making large areas of the map remain unassigned. Overlap was typically between olivine and one of the other minerals. The map which ignored overlap (Figure 6.7*b*; Table 6.2*d*) provided a better estimate of the mineral distribution. The locations containing minor minerals were mapped correctly, although, as with the low resolution map, the actual size of the grains was not always correct. For example, phlogopite was continuous along the entire lower edge of the large garnet, and not broken into three grains, as represented by the map.

To facilitate statistical comparison between the low- and high-resolution maps, a second set of low resolution maps (Figure 6.12) were created which covered columns 12 to 20 of the original maps, the same approximate area as the high resolution map. The numbers of cells, area percents and areas of each mineral were tabulated and included in Table 6.2*e-f*. The starting and ending columns of the low-resolution map were estimated visually and the region was approximately 1.5 columns wider than the high resolution map. As this would have affected the modal percentages and areas of the minerals, the

values in Table 6.2*e-f* were recalculated by omitting column 12 and halving the cells in column 20.

Figure 6.13 is a graphical comparison of Table 6.2*c* and *e* and Table 6.2*d* and *f*. Agreement was good between the two resolutions, particularly for the maps that did not include overlap. A larger percentage of the map remained unassigned using the high-resolution map. This could partially be a consequence of the shorter scan times, which degraded the signal-to-noise ratio; it was also possible that several small, poorly crystalline areas were picked up in the high resolution map that were missed by the 1.5mm grid spacing.

The choice between using the low- vs. high-resolution maps depends on the desired results. If a basic estimate of the modal mineralogy and the general mineral distribution is all that is required, the low resolution map would be the best choice. If accuracy and spatial distribution are important, it would be better to take the time to produce a high resolution map.

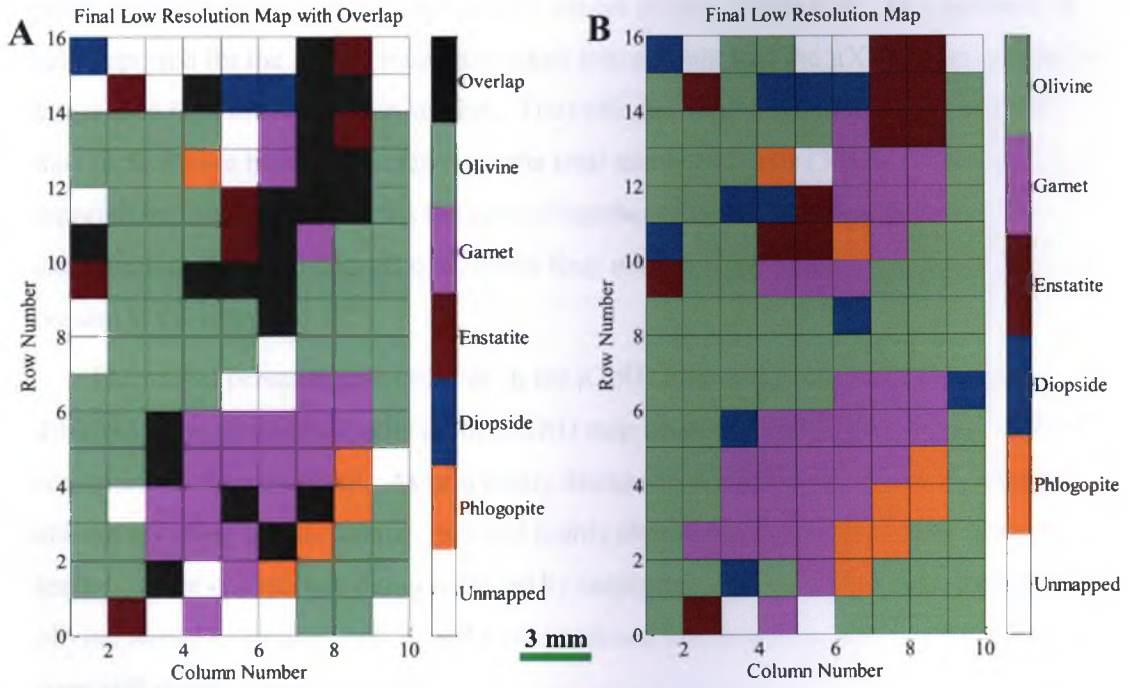


Figure 6.12: Final low resolution maps, covering the approximate area of the high resolution map. (A) With overlapping cells in black and (B) with overlapping cells ignored.

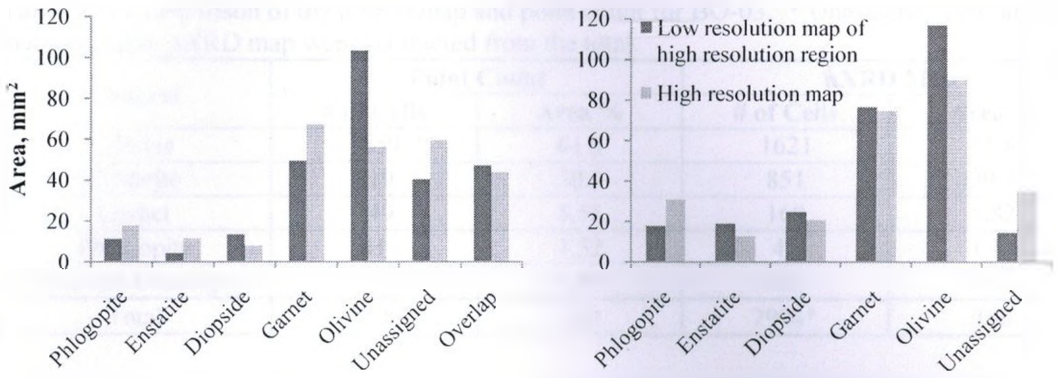


Figure 6.13: Calculated areas for each mineral (including overlap and unassigned cells) for the high-resolution and small low-resolution maps. (A) With overlap included, (B) excluding previously assigned cells.

6.4.2 BO-03

The revised method used to map BO-03 was much more effective than the original method used to map BO-26. The final μXRD map of BO-03 (Figure 6.10) agreed with a point count to within ±1% for all minerals except olivine (Table 6.5). The numbers of cells reported for the μXRD map have taken into account that the μXRD map covered a larger area than the actual thin section. The cells that were beyond the margins of the thin section have been subtracted from the total number of cells (3312), so that the value reported in Table 6.5 represents the correct number of cells. This was done by visual examination of the unassigned cells in the final map so some unassigned cells were still present at the margins.

The modal percentages of olivine in the μXRD map and point count were quite different. The unassigned cells in the μXRD map account for the 5.5% olivine and 1.4% serpentine that were absent. As previously discussed, serpentine could not be mapped effectively using this technique. Several highly altered regions were present in the thin section where olivine was being replaced by serpentine. In these areas the remnants of olivine were fine grained and would have produced low-intensity XRD peaks, but they were still point counted as olivine.

The majority of peaks selected to map BO-26 were used to map BO-03, but several additions and deletions of peaks were required to eliminate erroneous cell assignments.

Table 6.5: Comparison of the μXRD map and point count for BO-03. * Unassigned cells at the margins of the μXRD map were subtracted from the total.

Mineral	Point Count		μXRD Map	
	# of Cells	Area %	# of Cells	Area %
Olivine	1659	61.3	1621	55.8
Enstatite	819	30.3	851	29.3
Garnet	149	5.51	169	5.82
Phlogopite	41	1.52	41	1.41
Serpentine/Unassigned	38	1.40	222	7.64
Total	2706	100	2904*	100

For example, comparison of Figures 6.8 to 6.10 shows that a large proportion of the cells were incorrectly assigned prior to modification of the mapping parameters. As a result, at this stage of method development it is still necessary to compare the final map produced using this technique to a thin section image. After comparison to the thin section image and adjustment of the map parameters the final map was very accurate.

Improvements made to the data collection and map generation scripts, and to the MATLAB programs used to interpret the maps produced significant time savings, in terms of user input and data processing, compared to the map of BO-26. One of the most significant improvements was to the initial map generation in GADDSMap. The revised method used a script to generate all of the maps with one command, whereas each map had to be produced separately with the original method.

6.5 Recommendations for Future Study

One of the simplest improvements to the technique would be to include multiple minerals in single map cells. The raw μXRD data detected all of the minerals that were present within the X-ray beam diameter. Minor minerals were assigned to cells first, to avoid their being masked by more abundant phases, such that once a cell had been assigned to a mineral it wasn't re-assigned. It would be fairly simple to split the cells in the final map to include more than one mineral, when multiple minerals were present. The loss of resolution in the final map created by assignment of cells to a single mineral did not produce a significant difference relative to the point count. However, if the crosshairs were located at (or close to) a grain boundary only one mineral was counted.

As a result, inclusion of multiple minerals in the μXRD map should improve the resolution over the point count, unless a similar technique was used to point count.

One of the major limitations of this technique was that individual peaks had to be mapped separately. There is no automatic diffraction pattern recognition currently included with the GADDS or GADDSMap software. Development of a program that could automatically select the closest matching diffraction pattern from a set of user defined reference patterns (e.g. ICDD powder diffraction files) would greatly improve the map accuracy. This would also eliminate the most difficult step in the mapping process – selection of the integration ranges corresponding to peaks for each mineral. Automatic integration of the raw GADDS data is a simple task. Development of a program in MATLAB that could identify the peaks in the integrated intensity vs. 2θ data and compare those peaks to ICDD cards should allow the whole diffraction pattern for each mineral to be taken into account. Using this technique it should be easy to map more complex mineralogies, provided the minerals were known beforehand. For example, serpentine could not be mapped using the current technique due to poor intensity and overlap with other minerals, but if the whole diffraction pattern was taken into consideration, it should be possible to identify the peaks. Mapping unknown minerals would be a far more complex task, as the Search/Match software provided by Brüker is only effective for powdered samples. Extension of a general search into MATLAB would be a very difficult task.

Once the problems associated with mineral identification have been resolved, to the point that comparison to a thin section image is no longer necessary, it will be possible to use a larger variety of sample formats. One of the simplest formats would be cut rock sections, as there is still a flat surface to map. Using a 1 mm beam diameter, rather than the 0.5 mm beam used in this study, large areas could be mapped in very short time periods. Splitting the map cells to show multiple minerals in each cell would minimize the loss of resolution from the larger beam size, and would still allow minor minerals to be mapped. The larger beam also has a much higher intensity, which reduces the amount of time required for data collection at each target (less than 20 seconds would be sufficient).

The GADDS software has an automatic focusing function that could be adapted to map uneven sample surfaces. This would extend the range of sample surfaces that could be mapped to include rounded or uneven surfaces. For example, weathered surfaces or the surfaces of rounded meteorites could be mapped. Mapping meteorites in this manner would be especially advantageous as no sample preparation would be required. This is important as many meteorites are exceedingly rare and valuable, or belong to private collectors.

It is also possible to quantify strain using micro X-ray diffraction, as strained crystals produce diffraction spots that are streaked along the Debye ring, rather than producing round spots (Flemming, 2007). For example, the mineral(s) in Figure 6.2 all show a low to moderate amount of streaking along Debye rings. The length of the streak produced by diffraction off a strained lattice plane indicates the amount of strain-related mosaicity, so it can be quantified and mapped using a method similar to that presented in this chapter. Development of this method could be extremely useful for mapping strain across shear zones or for materials science applications (e.g. mapping residual stress in metals).

6.6 Conclusions

Mineralogical mapping using μXRD was effective at reproducing the modal proportions determined by conventional point counting, with the additional advantage of spatial representation of the data. The technique is also useful when different mineral polymorphs could be encountered, or when studying the hydration states of minerals. This is its strength over SEM-based techniques, which rely on changes in chemical composition and cannot distinguish between minerals that have very similar compositions. Furthermore, μXRD can be used to map larger samples than SEM.

The map of sample BO-26 was less effective at reproducing the actual mineral distribution than the map of BO-03. The primary difference was the improvement made to the method prior to mapping BO-03. Changes to the way in which background intensity was removed from the initial maps greatly improved the spatial accuracy of all of the minerals mapped.

Improvements to the method and development of new mapping applications, such as quantification of strain, would make μXRD mapping advantageous over more conventional SEM-based maps for a variety of purposes. μXRD is compatible with a wide range of sample formats and mapping the mineralogy of samples that cannot be altered (e.g. meteorites) would be especially useful.

6.7 References

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Chapter 7: General Discussion and Conclusions

7.1 Micro X-ray Diffraction as a Diamond Exploration Tool

The diamond exploration industry uses a variety of "kimberlite indicator minerals" (KIMs) to vector exploration efforts. These minerals are typically weathered and transported out of the host kimberlite by fluvial or glacial processes, and can commonly be traced back to their source. The most common minerals used as KIMs are Cr-pyrope, Mg-ilmenite, chromite and Cr-diopside. Other minerals, such as olivine and phlogopite, can also be used as KIMs, but they are rapidly weathered and are only recovered near the source kimberlite. All of these target minerals are classified as "kimberlitic" or "non-kimberlitic" based on their composition. In most cases, major element chemistry, determined by electron probe micro-analysis (EPMA), is sufficient to identify the source but, in some cases, trace element compositions can also be useful. For example, the nickel concentration in garnet can be used as a relative geothermometer (Griffin *et al.* 1989), which, combined with the chromium content, provides an extremely useful geothermobarometer that can be used to determine whether or not a garnet originated within the diamond stability field (Ryan *et al.*, 1996; Grütter *et al.*, 2004).

Single crystal and powder X-ray diffraction studies have shown that there is a direct correlation between changes in unit cell size and substitution of differently-sized cations into a crystal lattice. For example, substitution of calcium for magnesium in garnets (along the pyrope-grossular join) results in a linear change in the unit cell dimension (a_0) from 11.456 Å in pyrope to 11.849 Å in grossular (Novak and Gibbs, 1971). This is a very large change that is easily measured using X-ray diffraction. This example represents a simple binary solid solution, where a_0 can be directly related to the composition of the sample. In upper mantle garnets, however, the solid solutions are much more complex, involving several cations, and the size difference between them is not always so pronounced. Solid solution between calcium, magnesium and iron is extensive in the X-site, and a significant amount of chromium can substitute for aluminum in the Y-site.

In ilmenites, the difference in size between ferrous iron ($R^{[6]} = 0.75$) and magnesium ($R^{[6]} = 0.86$) is fairly small (0.11 Å in 6-fold coordination), and Fe – Mg substitution has little effect of on the unit cell (Shannon and Prewitt, 1970). Chromium, which is

relatively large ($R^{[6]}$ = 0.76 Å), and ferric iron ($R^{[6]}$ = 0.69 Å) can also substitute into the ilmenite crystal structure, but chromite is very similar in size to titanium ($R^{[6]}$ = 0.74 Å), which it replaces in the B-site (Shannon and Prewitt, 1970). Ferric iron could have an effect on the size of the unit cell as it can occur in larger concentrations in the B-site and is smaller than both titanium and chromium.

Modern micro X-ray diffraction (μXRD) techniques use X-ray beams that are collimated to a narrow diameter, allowing rapid analysis of submillimeter-sized samples. Use of a two-dimensional detector provides excellent spatial resolution and eliminates the need to powder samples. The primary advantages of μXRD over EPMA are that intact rocks or loose crystals can be analyzed, minimizing sample preparation, and moreover, data collection times are relatively short (2 – 4 minutes). Unit cell refinements can be performed in approximately two to four minutes per sample (depending on the user), and this could be drastically reduced by automatic identification of major peaks.

The research presented in this thesis examined the applicability of μXRD as a new tool for characterization of garnet and ilmenite in terms of diamond exploration. This research builds towards a long-term goal of characterizing all major KIMs using μXRD, by examining changes in unit cell size as they relate to changes in composition.

We have shown that, although well-defined linear correlations were observed for Ca – Mg substitution in the X-site of garnet and for Cr – Al substitution in the Y-site, these changes did not allow sufficient differentiation between upper mantle garnets. The primary difficulty with the use of the unit cell as a classification tool was that variation in a_0 occurred parallel to the compositional dividing lines used to classify several garnet types. As a result, garnets from very different sources, each with a different composition, could all have the same unit cell. For example, a "diamond-indicating" G10D garnet could have the same unit cell dimension as a G9 "non-diamond-indicating" garnet, as well as a G3 "eclogitic" garnet. Compositionally, these three garnet types become progressively more calcium-rich (which increases a_0) and less chromium-rich (which decreases a_0) simultaneously, such that the effects of each substitution cancel each other out.

As discussed in detail in Section 4.5, this technique could have applicability in a different area of mineral exploration, where the composition of garnet is used to vector exploration. In several types of skarn deposits, garnets from the binary solid-solution grossular – andradite solid solution are used to direct exploration, where the andradite component increases with proximity to the deposit. In this case the solid solution is dominated by two end members which have a very large size difference, avoiding the compositional complexity associated with upper mantle garnets.

Ilmenites crystallize in the rhombohedral crystal system, such that changes to both a_0 and c_0 are possible. The major differences between kimberlitic and non-kimberlitic ilmenites are magnesium and chromium contents, both of which have higher concentrations in samples recovered from kimberlites. However, the radii of magnesium and ferrous iron are similar, and the range of substitution between them was not sufficient to cause statistically significant changes in either a_0 or c_0, although weakly defined trends may be present.

Ferric iron is smaller than ferrous iron, so that reduction of ilmenite (increasing the Fe_2O_3 content) should result in a decrease in the size of the unit cell. The concentration of ferric iron is typically 5 – 10 wt % in kimberlitic ilmenites, but it can reach approximately 20 wt %, which should have been enough to reduce the size of the unit cell. However, the observed trends of Fe^{3+} vs. a_0 and Fe^{3+} vs. c_0 contradicted each other; the former lay on a weakly defined negative trend, the latter lay on a weakly defined positive trend. As the two trends were very poorly defined, it is likely that the changes to a_0 and c_0 were not caused by Fe^{3+} alone.

Definition of crystal-chemical trends that reflected cation substitutions was probably complicated by the presence of secondary phases in many of the ilmenites, most of which resulted from subsolidus oxidation or reduction. These processes can leach cations from the host ilmenite, forming alteration haloes proximal to the secondary phases. In some cases the altered areas were large enough to be detected by μXRD, which could have affected the unit cell refinement.

To be effective as a diamond exploration tool, it would be necessary to distinguish between KI and NKI ilmenites by their a_0 and c_0 lengths. However, Figures 4.7 to 4.10

show that this was not the case, as there was a large amount of overlap between KIs and NKIs for both a_0 and c_0.

7.2 Beam Overlap

In the course of the research presented in this thesis some important methods were developed to minimize beam overlap between closely spaced targets. In-situ analysis of single crystals using μXRD requires an omega scan, where the X-ray source and GADDS detector are rotated around the sample, through an angle omega. In order to maximize the amount of data collected for a sample, it is usually best to use the full range of rotation of the source and detector. The result is that the X-ray beam has a very large footprint at low incident angles, which decreases rapidly as the incident angle increases. A large beam footprint is a major problem when samples are mounted close together, as the X-ray beam can overlap onto the neighbouring grain. There are two options to minimize this problem: higher incident X-ray beam angles can be used, or the X-ray beam can be collimated to a smaller diameter. The downside to increasing the incident angle is that less data is collected. Decreasing the beam diameter decreases the intensity of the X-ray beam, making data collection take longer. The best approach to minimizing the size of the footprint depends on the requirements of the study, but ideally the targets would be located further apart, thus eliminating the problem. In the case of prepared grain mounts, the solution is to mount the grains > 1 mm apart whenever possible. For footprints larger than 1 mm the intensity of the X-ray beam attenuates very rapidly.

7.3 Thin Section Mapping using μXRD

A new method for mapping thin sections was developed during this research. The goal was to be able to reproduce the modal mineralogy determined using a point count. The method was advantageous over a point count because human input could be minimized using automation scripts, although the data collection and map generation processes were fairly time consuming. The thin section maps produced using μXRD were successful at reproducing the modal mineralogy, in addition to creation of a 2D map of the thin section at 0.5 mm resolution.

Several recommendations were made that would greatly improve the method. These include subdivision of map cells to include more than one mineral; each X-ray target detected all minerals under the X-ray beam, so it would be possible to include each mineral detected, rather than just one. Another important improvement would be to use entire diffraction patterns to map minerals. The current method used individual peaks corresponding to a specific mineral, and some errors were introduced due to overlapping peaks from different minerals. Implementation of these and other minor improvements would reduce the amount of user input and improve the quality of the final map.

7.4 References

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Appendices

Appendix 1: Glossary of Lithologies

Rock Name	Basic Mineralogy
Basalt	Plagioclase, olivine, pyroxene and minor accessory minerals
Komatiite	Olivine, pyroxene and chromite
Kimberlite	Olivine, pyrope garnet, Cr-diopside, Mg-ilmenite and spinel (± phlogopite).
Eclogite	Omphacite, garnet (calcic almandine-pyrope) and accessory minerals
Peridotite	General term to describe lherzolite, harzburgite and dunite (plus other minor rock types)
Dunite	Olivine plus accessory phases
Harzburgite	Olivine, Cr-pyrope garnet and enstatite
Lherzolite	Olivine, pyrope garnet (changes to spinel or plagioclase at lower pressures), diopside and enstatite

Appendix 2: Data Collection and Processing Scripts

Run Script

```
!*************************************************************************
!*  In Command Prompt (GADSS Window: press CTRL and K) type:             *
!*       @run <Data File Name> <Number of Spots> <Scan Time (in sec)>     *
!*  i.e. @run %1 %2 %3    where %1,%2,%3 are handles used by GADDS        *
!*  For example: @run AT-P1- 5 480                                        *
!*    %1 is Data File Name (AT-P1-),                                      *
!*    %2 is the number of picked targets (5),                             *
!*    %3 is number of seconds for an 8 minute run (480)                   *
!*************************************************************************
! Run 2 omega-scan frames for one by one spots
#let %R = 001
#while ('%R' <= %2) do
! Multitarget run, 1st Frame: set Theta1, Theta2 and omega
SCAN /multitargets 1 /THETA1=6.0 /THETA2=38.5 /AXIS=2-Om /WIDTH=34 &
/SCANTIME=%3 '%1'Fr1 /TITLE="Frame 1" /SAMPLE="0" /NUMSAMPLE=2 &
/DISPLAY=63 /REALTIME /CLEAR /startrun=%R /endrun=%R &
/MODE=Scan /VIDEO

! Multitarget run, 2nd Frame: set Theta1, Theta2 and omega
SCAN /multitargets 1 /THETA1=25.5 /THETA2=45 /AXIS=2-Om /WIDTH=24.5 &
/SCANTIME=%3 '%1'Fr2 /TITLE="Frame 2" /SAMPLE="0" /NUMSAMPLE=1 &
/DISPLAY=63 /REALTIME /CLEAR /startrun=%R /endrun=%R &
/MODE=Scan
! Increment %R for next sample and continue loop
#inc %R
#wend
!*************************************************************************
```

Integrate Script

```
*************************************************************************
!* GADDS Syntax: > @integrate %1 %2                                     *
!* %1 = filename                                                        *
!* %2 = # of samples to integrate                                       *
!* Filename is the string used as %1 in run.slm                         *
*************************************************************************
! Check Octogon for first frame
MASK /OCTAGON 2. 202. 2. 824. 1018. 1840. 1020. 820.
#let %R = 001
#while ('%R' <= %2) do
! Load Frame 1
DISPLAY /NEW "'%1'Fr1_'%R'_000.gfrm"
! Integrate chi for the specified parameters (2th and chi)
INTEGRATE /CHI 26.60 61.30 -118.70 -61.20 /NORMAL=5 /STEPSIZE=0.050
INTEGRATE /WRITE "AW-P1-'%R'" &
 /FILENAME='%1'-'%R' /FORMAT=DIFFRAC-AT &
 /APPEND /SCALE=1.0
! Increment %R and continue to next sample
#inc %R
#wend
! Check Octogon for second frame
MASK /OCTAGON 2. 202. 2. 824. 1018. 1840. 1020. 820.
#let %R = 001
#while ('%R' <= %2) do
! Load Frame 2
DISPLAY /NEW "'%1'Fr2_'%R'_000.gfrm"
```

```
! Integrate chi for the specified parameters (2th and chi)
INTEGRATE /CHI 52.70 87.30 -109.600 -70.500 /NORMAL=5 /STEPSIZE=0.050
INTEGRATE /WRITE "AW-P1-'%R'"  &
 /FILENAME='%1'-'%R' /FORMAT=DIFFRAC-AT &
 /APPEND /SCALE=1.0
! Increment %R and continue to next sample
#inc %R
#wend
! Merge the 2 Frames
#let %R = 001
#while ('%R' <= %2) do
SYSTEM "MERGE /B /S '%1'-'%R'.raw '%1'-'%R'M.raw"
! Increment %R and continue to next sample
#inc %R
#wend
!*****************************************************************************
```

Input File Generation

The following program was used to create input files for "Unit Cell;" a similar program was used to create input files for LSUCRIPC.

Maketext.m

```
% Program to produce a tab delimited text file for Unit Cell refinement
import = xlsread('E:\X Docs\School\MSc\Analysis\AT-P1\AT-P1 Dsp 70percent
 cutoff.xls','AT-P1 70percent');
% Create an array from the first 3 columns of the input array for hkl values
hkl = [import(:,1),import(:,2),import(:,3)];
% Create the headers and footer for the ouptut text file (change based on min.)
header1 = 'BH AT-P1';
% create d-spacings matrix from import matrix
for i = 4:(length(import(1,:)))
    dsp(:,i-3) = import(:,i);
end
% concatenate the hkl matrix and the column in question from dsp, ignoring
% blanks:
for i = 1:(length(dsp(1,:)))
    % merge hkl array with the dspacing (dsp) values for grain (i)
    temp = cat(2,hkl,dsp(:,i));
    % create output matrix excluding NaN values
    index = 1;
    for j = 2:length(temp)
        if ~isnan(temp(j,4))
            for k = 1:4
                output(index,k) = temp(j,k);
                %output(index,5) = 0;
                %output(index,6) = 0.0;
                %output(index,7) = 0;
            end
            index = index+1;
        end
    end
    % Put it all together
    file = strcat(num2str(i),'.dat');
    outputstr = num2str(output);
    x = strvcat(header1,outputstr);
    dlmwrite(file,x,'delimiter','','newline','pc');
end
```

Appendix 3: Major Element Chemistry and Unit Cell Parameters

Part 1: Garnet Analyses

Table 1: Attawapiskat, mount AW-P1 (MT1/1-100). No sodium EPMA results were included with the samples.

Sample	Weight Percent (wt %) Oxides (EPMA)									Atoms Per Formula Unit (APFU)									
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Unit cell (Å)	Standard Deviation
1	41.89	0.03	22.59	2.87	8.22	19.20	0.63	4.58	100.01	3.00	0.00	1.91	0.16	0.49	2.05	0.04	0.35	11.5297	0.0058
2	42.14	0.00	22.40	2.97	8.59	18.37	0.61	5.46	100.54	3.01	0.00	1.89	0.17	0.51	1.96	0.04	0.42	11.5384	0.0044
3	41.41	0.06	20.65	5.24	8.32	17.55	0.53	6.22	99.98	3.01	0.00	1.77	0.30	0.51	1.90	0.03	0.48	11.5580	0.0031
4	42.38	0.04	20.68	4.57	7.24	19.41	0.39	5.23	99.94	3.05	0.00	1.75	0.26	0.44	2.08	0.02	0.40	11.5456	0.0051
5	41.51	0.03	20.79	4.83	8.30	17.65	0.63	6.25	99.99	3.01	0.00	1.78	0.28	0.50	1.91	0.04	0.49	11.5532	0.0047
6	41.38	0.03	17.51	9.00	6.99	18.25	0.49	6.99	100.64	3.01	0.00	1.50	0.52	0.42	1.98	0.03	0.54	11.5861	0.0057
7	41.63	0.01	21.96	3.61	8.08	19.05	0.55	4.95	99.84	2.99	0.00	1.86	0.21	0.49	2.04	0.03	0.38	11.5334	0.0047
8	41.81	0.02	21.96	3.97	8.13	18.88	0.59	4.87	100.23	3.00	0.00	1.86	0.23	0.49	2.02	0.04	0.37	11.5334	0.0065
9	41.16	0.13	19.29	6.95	7.61	19.18	0.53	5.34	100.19	2.98	0.01	1.64	0.40	0.46	2.07	0.03	0.41	11.5562	0.0074
10	41.37	0.12	19.92	6.44	7.11	19.33	0.49	5.26	100.04	2.99	0.01	1.69	0.37	0.43	2.08	0.03	0.41	11.5517	0.0053
11	41.04	0.15	18.31	8.00	6.99	19.12	0.48	5.67	99.76	2.99	0.01	1.57	0.46	0.43	2.08	0.03	0.44	11.5571	0.0046
12	41.56	0.14	21.18	4.52	7.43	20.08	0.45	4.73	100.09	2.97	0.01	1.79	0.26	0.44	2.14	0.03	0.36	11.5370	0.0038
13	41.45	0.07	19.74	6.44	7.38	19.06	0.41	5.48	100.03	3.00	0.00	1.68	0.37	0.45	2.05	0.03	0.42	11.5371	0.0079
14	41.99	0.01	21.95	3.28	8.06	18.76	0.61	5.30	99.96	3.02	0.00	1.86	0.19	0.48	2.01	0.04	0.41	11.5361	0.0068
15	41.50	0.30	18.78	7.52	7.62	18.80	0.35	5.51	100.38	3.01	0.02	1.60	0.43	0.46	2.03	0.02	0.43	11.5598	0.0037
16	41.55	0.05	21.10	4.89	8.04	19.27	0.56	4.84	100.30	2.98	0.00	1.79	0.28	0.48	2.06	0.03	0.37	11.5383	0.0030
17	41.69	0.18	18.69	7.17	7.14	19.16	0.51	5.64	100.18	3.02	0.01	1.59	0.41	0.43	2.07	0.03	0.44	11.5607	0.0033
18	41.32	0.04	20.76	5.05	8.32	17.68	0.60	6.04	99.81	3.00	0.00	1.78	0.29	0.51	1.92	0.04	0.47	11.5467	0.0045
19	40.96	0.35	17.84	8.35	7.44	18.55	0.41	5.73	99.63	3.00	0.02	1.54	0.48	0.46	2.03	0.03	0.45	11.5693	0.0030
20	42.08	0.10	20.23	5.70	6.55	19.98	0.39	5.31	100.34	3.01	0.01	1.71	0.32	0.39	2.13	0.02	0.41	11.5490	0.0076
21	41.55	0.12	19.57	6.79	7.57	18.91	0.11	5.29	99.91	3.01	0.01	1.67	0.39	0.46	2.04	0.01	0.41	11.5524	0.0047
22	41.32	0.17	18.49	7.51	7.38	18.83	0.42	5.90	100.02	3.00	0.01	1.58	0.43	0.45	2.04	0.03	0.46	11.5670	0.0048
23	41.60	0.14	20.30	5.96	7.40	19.22	0.48	5.28	100.38	2.99	0.01	1.72	0.34	0.45	2.06	0.03	0.41	11.5491	0.0063
24	40.89	0.15	18.14	8.35	7.40	18.87	0.51	5.90	100.21	2.97	0.01	1.55	0.48	0.45	2.04	0.03	0.46	11.5658	0.0055
25	42.11	0.20	20.54	5.57	6.56	19.87	0.34	4.98	100.17	3.02	0.01	1.74	0.32	0.39	2.12	0.02	0.38	11.5430	0.0056
26	41.72	0.19	18.99	6.94	6.70	19.67	0.38	5.34	99.93	3.01	0.01	1.62	0.40	0.40	2.12	0.02	0.41	11.5601	0.0041
27	41.69	0.13	19.79	6.37	6.90	19.86	0.46	4.91	100.11	3.00	0.01	1.68	0.36	0.42	2.13	0.03	0.38	11.5489	0.0059
28	41.32	0.21	18.55	7.84	7.10	19.40	0.50	5.23	100.15	2.99	0.01	1.58	0.45	0.43	2.10	0.03	0.41	11.5614	0.0044
29	41.62	0.34	20.26	5.43	7.63	20.07	0.45	4.15	99.95	2.99	0.02	1.72	0.31	0.46	2.15	0.03	0.32	11.5369	0.0033
30	41.38	0.22	19.63	6.69	7.39	19.44	0.37	4.83	99.95	2.99	0.01	1.67	0.38	0.45	2.10	0.02	0.37	11.5481	0.0046
31	41.06	0.29	19.50	6.78	7.41	19.36	0.50	5.31	100.21	2.96	0.02	1.66	0.39	0.45	2.08	0.03	0.41	11.5569	0.0042

Sample	Weight Percent (wt %) Oxides (EPMA)									Atoms Per Formula Unit (APFU)									
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Unit cell (Å)	Standard Deviation
32	41.07	0.17	18.58	7.94	7.40	18.71	0.52	5.86	100.25	2.98	0.01	1.59	0.46	0.45	2.03	0.03	0.46	11.5641	0.0047
33	41.19	0.18	18.33	8.06	7.00	19.01	0.52	5.67	99.96	3.00	0.01	1.57	0.46	0.43	2.06	0.03	0.44	11.5639	0.0041
34	41.90	0.26	20.04	5.89	6.66	20.08	0.46	5.15	100.44	3.00	0.01	1.69	0.33	0.40	2.14	0.03	0.39	11.5489	0.0036
35	41.88	0.33	19.96	5.83	7.32	19.54	0.43	4.84	100.13	3.02	0.02	1.69	0.33	0.44	2.10	0.03	0.37	11.5500	0.0059
36	41.62	0.00	21.87	3.79	8.19	18.33	0.62	5.71	100.13	2.99	0.00	1.85	0.22	0.49	1.97	0.04	0.44	11.5458	0.0056
37	41.65	0.00	22.23	3.63	8.06	18.75	0.60	5.10	100.02	2.99	0.00	1.88	0.21	0.48	2.01	0.04	0.39	11.5337	0.0037
38	41.70	0.05	18.73	7.33	6.92	18.75	0.44	6.17	100.09	3.02	0.00	1.60	0.42	0.42	2.03	0.03	0.48	11.5719	0.0044
39	41.35	0.07	19.05	7.16	7.08	18.91	0.44	6.12	100.18	2.99	0.00	1.62	0.41	0.43	2.04	0.03	0.47	11.5660	0.0034
40	41.10	0.19	17.95	8.48	7.87	18.29	0.44	6.08	100.40	2.99	0.01	1.54	0.49	0.48	1.99	0.03	0.47	11.5731	0.0047
41	40.89	0.39	17.69	8.45	7.18	18.68	0.56	6.07	99.91	2.99	0.02	1.52	0.49	0.44	2.03	0.03	0.47	11.5764	0.0034
42	41.65	0.27	20.44	5.44	7.98	19.29	0.44	4.94	100.45	2.99	0.01	1.73	0.31	0.48	2.07	0.03	0.38	11.5468	0.0112
43	41.40	0.25	19.74	6.32	7.00	19.70	0.46	5.02	99.89	2.99	0.01	1.68	0.36	0.42	2.12	0.03	0.39	11.5517	0.0062
44	41.17	0.09	19.35	6.88	7.16	19.03	0.44	6.11	100.23	2.97	0.00	1.65	0.39	0.43	2.05	0.03	0.47	11.5608	0.0071
45	41.06	0.20	17.91	9.02	7.06	18.48	0.41	6.06	100.20	2.99	0.01	1.54	0.52	0.43	2.01	0.03	0.47	11.5741	0.0035
46	41.60	0.27	19.94	5.56	7.35	19.76	0.49	4.73	99.70	3.00	0.01	1.70	0.32	0.44	2.13	0.03	0.37	11.5422	0.0034
47	41.46	0.13	20.36	5.44	7.25	19.91	0.29	4.67	99.51	2.99	0.01	1.73	0.31	0.44	2.14	0.02	0.36	11.5412	0.0039
48	41.83	0.23	19.82	6.20	7.28	19.46	0.48	5.02	100.32	3.01	0.01	1.68	0.35	0.44	2.09	0.03	0.39	11.5513	0.0044
49	41.53	0.06	21.57	4.27	7.98	19.46	0.49	4.71	100.07	2.98	0.00	1.82	0.24	0.48	2.08	0.03	0.36	11.5375	0.0046
50	41.30	0.19	18.46	7.88	6.96	19.20	0.54	5.58	100.11	3.00	0.01	1.58	0.45	0.42	2.08	0.03	0.43	11.5642	0.0047
51	42.01	0.32	19.45	6.22	7.11	19.85	0.43	4.86	100.25	3.02	0.02	1.65	0.35	0.43	2.13	0.03	0.37	11.5505	0.0025
52	41.86	0.33	21.34	3.47	7.74	19.71	0.48	4.90	99.83	3.00	0.02	1.80	0.20	0.46	2.11	0.03	0.38	11.5386	0.0061
53	41.93	0.16	21.12	4.59	7.47	19.89	0.53	4.65	100.34	3.00	0.01	1.78	0.26	0.45	2.12	0.03	0.36	11.5438	0.0047
54	42.19	0.28	21.80	3.62	7.43	20.02	0.41	4.48	100.23	3.01	0.02	1.83	0.20	0.44	2.13	0.02	0.34	11.5349	0.0042
55	41.62	0.23	20.51	5.32	7.75	19.34	0.40	5.07	100.24	2.99	0.01	1.74	0.30	0.47	2.07	0.02	0.39	11.5460	0.0041
56	41.44	0.26	20.38	5.33	7.69	19.21	0.53	5.00	99.84	2.99	0.01	1.74	0.30	0.46	2.07	0.03	0.39	11.5332	0.0047
57	42.20	0.06	20.89	5.19	6.95	20.56	0.35	4.31	100.51	3.01	0.00	1.75	0.29	0.41	2.18	0.02	0.33	11.5345	0.0045
58	41.18	0.23	18.88	7.20	7.75	18.87	0.44	5.49	100.04	2.99	0.01	1.62	0.41	0.47	2.04	0.03	0.43	11.5586	0.0037
59	41.86	0.20	22.24	3.03	7.83	19.96	0.45	4.53	100.10	2.99	0.01	1.87	0.17	0.47	2.12	0.03	0.35	11.5428	0.0030
60	41.78	0.24	21.83	3.37	7.69	20.08	0.43	4.54	99.96	2.99	0.01	1.84	0.19	0.46	2.14	0.03	0.35	11.5285	0.0072
61	41.46	0.44	21.19	3.56	8.51	19.99	0.39	4.25	99.79	2.98	0.02	1.79	0.20	0.51	2.14	0.02	0.33	11.5417	0.0043
62	41.51	0.19	21.18	4.08	7.08	20.59	0.32	4.64	99.59	2.97	0.01	1.79	0.23	0.42	2.20	0.02	0.36	11.5341	0.0057
63	41.39	0.38	21.40	3.62	7.88	20.04	0.45	4.50	99.66	2.97	0.02	1.81	0.21	0.47	2.14	0.03	0.35	11.5330	0.0040
64	41.22	0.19	21.16	4.77	7.52	19.73	0.51	4.73	99.83	2.96	0.01	1.79	0.27	0.45	2.11	0.03	0.36	11.5408	0.0103
65	40.99	0.35	19.73	6.20	7.37	19.84	0.47	5.18	100.13	2.95	0.02	1.67	0.35	0.44	2.13	0.03	0.40	11.5533	0.0042
66	41.31	0.19	20.98	4.53	7.69	19.81	0.34	5.11	99.96	2.96	0.01	1.77	0.26	0.46	2.12	0.02	0.39	11.5402	0.0066
67	41.77	0.27	21.48	3.75	8.06	20.08	0.45	4.44	100.30	2.98	0.01	1.81	0.21	0.48	2.14	0.03	0.34	11.5324	0.0067

Sample	Weight Percent (wt %) Oxides (EPMA)									Atoms Per Formula Unit (APFU)									
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Unit cell (Å)	Standard Deviation
68	41.56	0.19	21.57	3.90	7.14	20.39	0.45	4.60	99.80	2.97	0.01	1.82	0.22	0.43	2.17	0.03	0.35	11.5305	0.0041
69	41.59	0.25	22.56	2.68	7.26	20.67	0.41	4.45	99.87	2.96	0.01	1.89	0.15	0.43	2.19	0.02	0.34	11.5296	0.0056
70	41.90	0.17	21.59	3.70	7.45	20.47	0.42	4.74	100.44	2.98	0.01	1.81	0.21	0.44	2.17	0.03	0.36	11.5281	0.0075
71	41.16	0.22	21.91	3.09	7.96	20.25	0.43	4.87	99.89	2.94	0.01	1.84	0.17	0.48	2.16	0.03	0.37	11.5374	0.0036
72	41.25	0.45	20.48	4.93	7.45	19.91	0.44	5.16	100.07	2.96	0.02	1.73	0.28	0.45	2.13	0.03	0.40	11.5473	0.0040
73	41.34	0.28	21.94	3.39	8.08	19.79	0.42	4.67	99.91	2.96	0.02	1.85	0.19	0.48	2.11	0.03	0.36	11.5281	0.0043
74	41.36	0.16	21.67	3.71	7.68	19.87	0.44	4.99	99.88	2.96	0.01	1.83	0.21	0.46	2.12	0.03	0.38	11.5380	0.0028
75	41.06	0.41	18.57	6.78	7.42	19.46	0.32	5.66	99.68	2.98	0.02	1.59	0.39	0.45	2.11	0.02	0.44	11.5635	0.0021
76	41.90	0.45	21.47	3.66	8.19	19.88	0.41	4.43	100.39	2.99	0.02	1.81	0.21	0.49	2.12	0.02	0.34	11.5341	0.0095
77	41.37	0.46	21.07	3.89	8.83	18.87	0.45	4.97	99.91	2.99	0.02	1.79	0.22	0.53	2.03	0.03	0.38	11.5457	0.0050
78	41.71	0.52	21.09	3.30	8.56	19.93	0.40	4.37	99.88	2.99	0.03	1.78	0.19	0.51	2.13	0.02	0.34	11.5329	0.0057
79	41.10	0.54	20.61	4.16	8.52	19.77	0.46	4.61	99.77	2.96	0.03	1.75	0.24	0.51	2.12	0.03	0.36	11.5416	0.0035
80	42.13	0.46	21.14	3.36	8.78	20.04	0.36	4.36	100.63	3.00	0.02	1.78	0.19	0.52	2.13	0.02	0.33	11.5294	0.0054
81	41.75	0.39	21.50	2.51	9.29	19.27	0.42	4.72	99.85	3.00	0.02	1.82	0.14	0.56	2.07	0.03	0.36	11.5417	0.0035
82	41.79	0.52	21.36	3.14	8.43	19.84	0.44	4.50	100.02	2.99	0.03	1.80	0.18	0.51	2.12	0.03	0.35	11.5387	0.0033
83	41.61	0.40	21.26	3.56	8.50	19.76	0.43	4.30	99.82	2.99	0.02	1.80	0.20	0.51	2.12	0.03	0.33	11.5355	0.0061
84	41.66	0.51	21.24	3.89	8.46	19.65	0.41	4.42	100.24	2.99	0.03	1.79	0.22	0.51	2.10	0.02	0.34	11.5359	0.0059
85	42.32	0.36	22.48	2.12	7.76	20.42	0.42	4.33	100.21	3.00	0.02	1.88	0.12	0.46	2.16	0.03	0.33	11.5210	0.0120
86	41.58	0.35	21.49	3.06	9.31	19.13	0.44	4.86	100.22	2.98	0.02	1.82	0.17	0.56	2.05	0.03	0.37	11.5444	0.0034
87	41.48	0.41	21.76	2.75	9.07	19.27	0.35	4.60	99.69	2.99	0.02	1.85	0.16	0.55	2.07	0.02	0.35	11.5369	0.0038
88	41.65	0.46	21.22	3.16	8.71	20.21	0.35	4.04	99.80	2.99	0.02	1.79	0.18	0.52	2.16	0.02	0.31	11.5262	0.0046
89	42.14	0.44	21.54	3.38	8.52	19.93	0.39	3.95	100.29	3.01	0.02	1.81	0.19	0.51	2.12	0.02	0.30	11.5275	0.0046
90	42.17	0.46	22.07	2.41	8.45	20.15	0.37	4.20	100.28	3.00	0.02	1.85	0.14	0.50	2.14	0.02	0.32	11.5245	0.0029
91	41.25	0.52	21.06	3.41	8.84	19.76	0.51	4.50	99.85	2.97	0.03	1.78	0.19	0.53	2.12	0.03	0.35	11.5342	0.0036
92	41.20	0.39	22.01	2.70	9.13	19.15	0.47	4.80	99.85	2.96	0.02	1.86	0.15	0.55	2.05	0.03	0.37	11.5383	0.0052
93	41.94	0.34	21.96	2.61	7.82	20.69	0.38	4.47	100.21	2.98	0.02	1.84	0.15	0.46	2.19	0.02	0.34	11.5318	0.0059
94	42.21	0.35	21.71	3.09	7.33	20.63	0.36	4.28	99.96	3.01	0.02	1.82	0.17	0.44	2.19	0.02	0.33	11.5349	0.0045
95	41.56	0.47	20.69	3.70	8.88	19.72	0.46	4.32	99.80	2.99	0.03	1.76	0.21	0.53	2.12	0.03	0.33	11.5357	0.0054
96	41.82	0.40	21.52	3.11	8.34	19.97	0.36	4.09	99.61	3.00	0.02	1.82	0.18	0.50	2.14	0.02	0.31	11.5316	0.0035
97	42.08	0.47	20.28	4.69	8.35	19.58	0.38	4.63	100.46	3.02	0.03	1.71	0.27	0.50	2.09	0.02	0.36	11.5411	0.0040
98	42.11	0.36	20.84	4.23	7.71	20.49	0.44	4.36	100.54	3.00	0.02	1.75	0.24	0.46	2.18	0.03	0.33	11.5328	0.0045
99	41.79	0.49	20.92	3.55	8.69	19.81	0.36	4.42	100.03	3.00	0.03	1.77	0.20	0.52	2.12	0.02	0.34	11.5327	0.0072
100	42.00	0.45	20.37	4.59	7.90	19.37	0.35	4.91	99.94	3.03	0.02	1.73	0.26	0.48	2.08	0.02	0.38	11.5440	0.0052

Table 2: Attawapiskat, mount AW-P2 (MT1/1-20). No sodium EPMA results were included with the samples.

Sample	Weight Percent (wt %) Oxides (EPMA)									Atoms Per Formula Unit (APFU)									
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Unit Cell (Å)	Standard Deviation
1	42.10	0.25	18.99	7.07	6.75	19.94	0.40	4.74	100.24	3.03	0.01	1.61	0.40	0.41	2.14	0.02	0.37	11.5491	0.0030
2	41.92	0.36	19.78	5.93	7.26	19.79	0.34	5.17	100.55	3.01	0.02	1.67	0.34	0.44	2.12	0.02	0.40	11.5501	0.0053
3	41.70	0.28	20.30	5.08	7.14	20.08	0.55	4.77	99.90	3.00	0.02	1.72	0.29	0.43	2.15	0.03	0.37	11.5419	0.0042
4	42.39	0.27	21.57	3.14	7.42	20.36	0.37	4.57	100.09	3.02	0.01	1.81	0.18	0.44	2.16	0.02	0.35	11.5341	0.0046
5	42.30	0.34	22.30	1.38	9.52	19.98	0.41	3.86	100.09	3.02	0.02	1.87	0.08	0.57	2.12	0.02	0.29	11.5249	0.0034
6	42.10	0.26	20.35	4.85	7.10	19.78	0.48	4.86	99.78	3.03	0.01	1.73	0.28	0.43	2.12	0.03	0.37	11.5428	0.0030
7	41.68	0.25	19.91	5.94	6.70	20.09	0.46	4.94	99.97	3.00	0.01	1.69	0.34	0.40	2.15	0.03	0.38	11.5450	0.0062
8	41.98	0.24	20.49	4.70	7.60	19.69	0.36	5.09	100.15	3.01	0.01	1.73	0.27	0.46	2.11	0.02	0.39	11.5459	0.0032
9	42.87	0.35	21.74	1.55	9.16	19.85	0.52	4.01	100.05	3.06	0.02	1.83	0.09	0.55	2.11	0.03	0.31	11.5214	0.0053
10	42.40	0.30	22.00	1.75	9.54	19.33	0.44	4.14	99.90	3.04	0.02	1.86	0.10	0.57	2.07	0.03	0.32	11.5292	0.0049
11	42.17	0.00	21.74	3.60	7.63	19.76	0.52	4.78	100.20	3.01	0.00	1.83	0.20	0.46	2.10	0.03	0.37	11.5298	0.0041
12	42.95	0.26	22.57	1.04	9.11	19.85	0.48	4.30	100.56	3.05	0.01	1.89	0.06	0.54	2.10	0.03	0.33	11.5259	0.0031
13	42.01	0.04	21.32	4.23	7.78	19.68	0.51	4.57	100.14	3.01	0.00	1.80	0.24	0.47	2.10	0.03	0.35	11.5311	0.0056
14	42.37	0.12	20.58	4.76	7.53	19.83	0.47	4.60	100.26	3.04	0.01	1.74	0.27	0.45	2.12	0.03	0.35	11.5385	0.0046
15	42.52	0.32	19.77	5.45	7.14	19.57	0.37	5.27	100.41	3.05	0.02	1.67	0.31	0.43	2.09	0.02	0.41	11.5539	0.0036
16	41.89	0.13	21.51	3.52	7.63	20.03	0.47	4.82	100.00	2.99	0.01	1.81	0.20	0.46	2.13	0.03	0.37	11.5361	0.0036
17	41.88	0.29	19.92	5.77	7.17	19.97	0.53	4.83	100.36	3.00	0.02	1.68	0.33	0.43	2.14	0.03	0.37	11.5468	0.0037
18	42.30	0.49	21.00	3.34	8.60	19.86	0.42	4.26	100.27	3.03	0.03	1.77	0.19	0.51	2.12	0.03	0.33	11.5358	0.0064
19	41.84	0.18	20.37	4.79	7.61	20.15	0.47	4.63	100.04	3.00	0.01	1.72	0.27	0.46	2.15	0.03	0.36	11.5425	0.0039
20	42.81	0.19	21.84	2.57	7.40	20.61	0.38	4.37	100.17	3.04	0.01	1.83	0.14	0.44	2.18	0.02	0.33	11.5275	0.0038

Table 3: Attawapiskat, mount AW-P3 (MT1/2-20).

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
1	41.56	0.23	20.03	5.97	7.01	19.77	0.43	5.30	0.02	100.32	2.98	0.01	1.69	0.34	0.42	2.12	0.03	0.41	0.00	11.5357	0.0047
2	42.03	0.51	20.19	4.63	7.63	19.99	0.39	4.71	0.02	100.10	3.02	0.03	1.71	0.26	0.46	2.14	0.02	0.36	0.00	11.5305	0.0051
3	41.36	0.43	20.49	4.72	8.01	20.20	0.46	4.46	0.02	100.15	2.97	0.02	1.73	0.27	0.48	2.16	0.03	0.34	0.00	11.5392	0.0040
4	41.10	0.09	23.45	0.05	14.77	16.02	0.46	4.02	0.03	99.99	2.99	0.00	2.01	0.00	0.90	1.74	0.03	0.31	0.00	11.5241	0.0029
5	41.72	0.42	21.76	3.08	8.94	19.18	0.44	4.60	0.03	100.17	2.99	0.02	1.84	0.17	0.54	2.05	0.03	0.35	0.00	11.5341	0.0026
6	42.56	0.45	21.42	3.12	8.56	19.43	0.48	4.38	0.03	100.43	3.04	0.02	1.80	0.18	0.51	2.07	0.03	0.34	0.00	11.5369	0.0074
7	No data available																				

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
8	41.36	0.03	18.88	7.15	7.12	18.61	0.45	6.33	0.03	99.96	3.00	0.00	1.62	0.41	0.43	2.01	0.03	0.49	0.00	11.5679	0.0040
9	41.96	0.33	21.81	2.82	8.19	20.05	0.43	4.24	0.02	99.85	3.00	0.02	1.84	0.16	0.49	2.14	0.03	0.32	0.00	11.5289	0.0054
10	41.74	0.26	19.87	5.95	7.29	19.73	0.51	5.13	0.02	100.50	2.99	0.01	1.68	0.34	0.44	2.11	0.03	0.39	0.00	11.5500	0.0045
11	42.07	0.20	21.05	4.20	7.85	19.25	0.46	4.84	0.02	99.94	3.03	0.01	1.78	0.24	0.47	2.06	0.03	0.37	0.00	11.5379	0.0038
12	41.68	0.05	20.94	4.83	7.81	19.36	0.51	4.85	0.02	100.05	3.00	0.00	1.77	0.27	0.47	2.07	0.03	0.37	0.00	11.5326	0.0027
13	41.73	0.40	20.36	5.03	7.60	19.76	0.55	5.02	0.02	100.47	2.99	0.02	1.72	0.28	0.46	2.11	0.03	0.39	0.00	11.5486	0.0045
14	41.92	0.09	20.39	4.85	7.57	19.24	0.38	5.36	0.02	99.82	3.02	0.00	1.73	0.28	0.46	2.07	0.02	0.41	0.00	11.5453	0.0050
15	41.80	0.17	20.12	5.06	7.72	19.98	0.38	4.76	0.02	100.01	3.00	0.01	1.70	0.29	0.46	2.14	0.02	0.37	0.00	11.5438	0.0031
16	41.67	0.21	19.06	6.68	7.16	19.48	0.49	5.14	0.02	99.91	3.02	0.01	1.63	0.38	0.43	2.10	0.03	0.40	0.00	11.5481	0.0046
17	42.46	0.06	21.43	3.49	8.63	18.64	0.61	5.17	0.02	100.51	3.04	0.00	1.81	0.20	0.52	1.99	0.04	0.40	0.00	11.5346	0.0034
18	42.37	0.42	20.71	3.13	8.80	19.76	0.43	4.12	0.02	99.76	3.05	0.02	1.76	0.18	0.53	2.12	0.03	0.32	0.00	11.5328	0.0037
19	41.35	0.38	17.55	7.96	7.61	18.49	0.50	6.01	0.02	99.87	3.02	0.02	1.51	0.46	0.47	2.01	0.03	0.47	0.00	11.5698	0.0031
20	42.47	0.43	20.03	4.52	8.06	19.77	0.42	4.43	0.02	100.15	3.05	0.02	1.70	0.26	0.48	2.12	0.03	0.34	0.00	11.5343	0.0037

Table 4: Aultman, mount AT-P1.

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
AT-P1-R0	41.46	0.62	22.44	0.65	10.45	19.29	0.19	5.01	0.05	100.16	2.96	0.03	1.89	0.04	0.62	2.05	0.01	0.38	0.01	11.5324	0.0035
AT-P1-R1	40.90	0.84	22.05	0.74	10.80	19.44	0.23	5.26	0.05	100.31	2.92	0.04	1.86	0.04	0.64	2.07	0.01	0.40	0.01	11.5368	0.0039
AT-P1-R2	41.31	1.08	21.84	1.07	10.79	18.77	0.22	5.35	0.10	100.53	2.96	0.06	1.84	0.06	0.65	2.00	0.01	0.41	0.01	11.5458	0.0027
AT-P1-R3	41.46	1.21	21.85	0.56	10.64	18.69	0.23	5.75	0.08	100.47	2.97	0.07	1.84	0.03	0.64	1.99	0.01	0.44	0.01	11.5523	0.0029
AT-P1-R4	41.43	0.11	24.27	0.15	11.11	19.58	0.17	3.39	0.05	100.26	2.94	0.01	2.03	0.01	0.66	2.07	0.01	0.26	0.01	11.4797	0.0049
AT-P1-01	40.03	0.21	22.36	2.15	11.00	18.46	0.29	5.34	0.04	99.87	2.88	0.01	1.90	0.12	0.66	1.98	0.02	0.41	0.01	11.5407	0.0063
AT-P1-02	41.32	0.13	23.38	1.30	9.75	18.81	0.28	5.30	0.02	100.28	2.95	0.01	1.97	0.07	0.58	2.00	0.02	0.40	0.00	11.5293	0.0042
AT-P1-03	41.44	0.18	20.17	5.00	6.69	20.56	0.24	5.83	0.00	100.10	2.96	0.01	1.70	0.28	0.40	2.19	0.01	0.45	0.00	11.5441	0.0029
AT-P1-04	41.11	0.12	23.31	1.45	9.15	19.43	0.27	5.36	0.03	100.23	2.92	0.01	1.95	0.08	0.54	2.06	0.02	0.41	0.00	11.5271	0.0054
AT-P1-05	41.98	0.14	22.64	1.07	9.67	19.16	0.16	5.24	0.00	100.06	3.00	0.01	1.91	0.06	0.58	2.04	0.01	0.40	0.00	11.5233	0.0033
AT-P1-06	41.42	0.14	22.91	1.31	10.73	18.26	0.31	5.27	0.02	100.37	2.97	0.01	1.93	0.07	0.64	1.95	0.02	0.40	0.00	11.5268	0.0056
AT-P1-07	40.98	0.22	18.79	6.41	8.04	18.64	0.24	6.54	0.04	99.89	2.98	0.01	1.61	0.37	0.49	2.02	0.01	0.51	0.01	11.5638	0.0038
AT-P1-08	40.57	0.03	19.83	5.80	7.35	19.79	0.27	6.30	0.01	99.96	2.92	0.00	1.68	0.33	0.44	2.12	0.02	0.49	0.00	11.5545	0.0025
AT-P1-09	41.22	0.01	19.80	5.46	7.24	20.29	0.23	6.34	0.00	100.58	2.94	0.00	1.66	0.31	0.43	2.16	0.01	0.48	0.00	11.5531	0.0040
AT-P1-10	41.80	0.10	22.18	1.29	10.17	18.97	0.29	5.19	0.05	100.03	2.99	0.01	1.87	0.07	0.61	2.02	0.02	0.40	0.01	11.5312	0.0031
AT-P1-11	41.00	0.09	16.13	9.98	7.01	17.56	0.26	8.24	0.01	100.28	3.01	0.01	1.39	0.58	0.43	1.92	0.02	0.65	0.00	11.6003	0.0039
AT-P1-12	41.29	0.14	22.79	1.21	10.53	19.02	0.33	5.22	0.01	100.54	2.94	0.01	1.91	0.07	0.63	2.02	0.02	0.40	0.00	11.5304	0.0055
AT-P1-13	40.99	0.23	19.41	5.90	8.19	19.01	0.33	6.13	0.06	100.23	2.96	0.01	1.65	0.34	0.49	2.05	0.02	0.47	0.01	11.5567	0.0051

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
AT-P1-14	41.35	0.03	23.42	0.69	10.66	19.92	0.24	3.95	0.04	100.30	2.94	0.00	1.96	0.04	0.63	2.11	0.01	0.30	0.01	11.5126	0.0026
AT-P1-15	41.34	0.00	19.03	6.43	8.25	19.08	0.26	6.16	0.03	100.58	2.98	0.00	1.62	0.37	0.50	2.05	0.02	0.47	0.00	11.5578	0.0036
AT-P1-16	40.65	0.10	21.37	3.33	10.01	19.02	0.36	5.60	0.04	100.47	2.91	0.01	1.80	0.19	0.60	2.03	0.02	0.43	0.01	11.5459	0.0058
AT-P1-17	41.35	0.00	20.93	4.34	7.93	20.69	0.26	4.70	0.04	100.24	2.95	0.00	1.76	0.24	0.47	2.20	0.02	0.36	0.00	11.5354	0.0050
AT-P1-18	41.88	0.14	19.93	5.43	6.18	20.95	0.17	5.83	0.01	100.52	2.98	0.01	1.67	0.31	0.37	2.22	0.01	0.44	0.00	11.5325	0.0061
AT-P1-19	41.56	0.15	23.25	1.35	9.59	19.08	0.21	5.34	0.01	100.54	2.95	0.01	1.95	0.08	0.57	2.02	0.01	0.41	0.00	11.5310	0.0027
AT-P1-20	40.29	0.61	22.95	1.08	10.48	19.43	0.27	5.31	0.02	100.43	2.87	0.03	1.93	0.06	0.62	2.06	0.02	0.41	0.00	11.5285	0.0055
AT-P1-21	41.23	0.09	22.76	1.42	9.52	19.42	0.19	5.14	0.01	99.79	2.95	0.01	1.92	0.08	0.57	2.07	0.01	0.39	0.00	11.5280	0.0043
AT-P1-22	40.81	0.40	18.62	6.42	8.54	19.38	0.26	5.74	0.07	100.23	2.95	0.02	1.59	0.37	0.52	2.09	0.02	0.44	0.01	11.5598	0.0043
AT-P1-23	41.62	0.22	18.09	7.96	6.71	19.13	0.23	6.42	0.05	100.42	3.01	0.01	1.54	0.45	0.41	2.06	0.01	0.50	0.01	11.5712	0.0029
AT-P1-24	40.51	0.90	13.55	11.26	7.83	17.62	0.24	8.54	0.05	100.50	2.99	0.05	1.18	0.66	0.48	1.94	0.02	0.68	0.01	11.6264	0.0057
AT-P1-25	40.06	0.05	17.84	8.20	7.99	18.67	0.29	6.61	0.02	99.71	2.93	0.00	1.54	0.47	0.49	2.03	0.02	0.52	0.00	11.5723	0.0027
AT-P1-26	40.78	0.21	23.08	1.44	10.17	18.62	0.21	5.27	0.02	99.81	2.93	0.01	1.95	0.08	0.61	1.99	0.01	0.41	0.00	11.5305	0.0031
AT-P1-27	41.22	0.08	19.97	5.32	8.60	19.38	0.22	5.39	0.06	100.23	2.97	0.00	1.69	0.30	0.52	2.08	0.01	0.42	0.01	11.5505	0.0044
AT-P1-28	41.37	0.40	18.96	6.50	7.80	19.20	0.23	6.07	0.06	100.59	2.98	0.02	1.61	0.37	0.47	2.06	0.01	0.47	0.01	11.5646	0.0042
AT-P1-29	41.32	0.05	23.16	1.42	9.56	19.08	0.21	5.01	0.01	99.81	2.96	0.00	1.95	0.08	0.57	2.04	0.01	0.38	0.00	11.5210	0.0041
AT-P1-30	41.62	0.15	23.04	1.40	10.31	18.66	0.22	5.11	0.01	100.51	2.97	0.01	1.94	0.08	0.61	1.99	0.01	0.39	0.00	11.5103	0.0037
AT-P1-31	41.41	0.19	20.45	4.84	8.18	19.89	0.27	5.35	0.02	100.59	2.96	0.01	1.72	0.27	0.49	2.12	0.02	0.41	0.00	11.5435	0.0042
AT-P1-32	40.92	0.17	22.78	1.89	9.38	19.64	0.19	4.79	0.04	99.79	2.93	0.01	1.92	0.11	0.56	2.09	0.01	0.37	0.01	11.5280	0.0035
AT-P1-33	40.64	0.09	23.54	1.25	9.91	19.25	0.27	4.92	0.03	99.90	2.90	0.00	1.98	0.07	0.59	2.05	0.02	0.38	0.00	11.5243	0.0028
AT-P1-34	41.88	0.06	21.01	4.71	7.58	21.30	0.26	3.75	0.02	100.56	2.97	0.00	1.76	0.26	0.45	2.25	0.02	0.28	0.00	11.5037	0.0046
AT-P1-35	41.31	0.30	18.52	7.03	8.17	18.44	0.28	6.30	0.05	100.40	3.00	0.02	1.58	0.40	0.50	1.99	0.02	0.49	0.01	11.5683	0.0031
AT-P1-36	40.98	0.06	22.90	1.25	10.10	19.29	0.16	5.11	0.01	99.85	2.93	0.00	1.93	0.07	0.60	2.06	0.01	0.39	0.00	11.5266	0.0040
AT-P1-37	40.96	0.07	23.02	1.15	10.23	18.98	0.21	5.20	0.05	99.88	2.93	0.00	1.94	0.07	0.61	2.03	0.01	0.40	0.01	11.5173	0.0051
AT-P1-38	40.87	0.02	22.76	1.42	10.90	18.94	0.26	5.22	0.05	100.44	2.92	0.00	1.91	0.08	0.65	2.02	0.02	0.40	0.01	11.5215	0.0034
AT-P1-39	40.90	0.08	19.01	6.58	7.57	19.01	0.22	6.34	0.01	99.73	2.97	0.00	1.63	0.38	0.46	2.06	0.01	0.49	0.00	11.5660	0.0032
AT-P1-40	40.82	0.16	22.48	2.12	10.66	18.80	0.23	5.08	0.02	100.38	2.92	0.01	1.90	0.12	0.64	2.01	0.01	0.39	0.00	11.5323	0.0046
AT-P1-41	42.20	0.00	20.38	5.08	6.89	21.13	0.26	4.20	0.01	100.16	3.01	0.00	1.71	0.29	0.41	2.25	0.02	0.32	0.00	11.5249	0.0039
AT-P1-42	41.65	0.27	21.16	3.56	8.82	19.68	0.24	5.12	0.02	100.53	2.97	0.01	1.78	0.20	0.53	2.09	0.01	0.39	0.00	11.5397	0.0023
AT-P1-43	42.01	0.41	17.56	7.64	5.99	19.46	0.19	6.74	0.03	100.04	3.04	0.02	1.50	0.44	0.36	2.10	0.01	0.52	0.00	11.5762	0.0038
AT-P1-44	41.74	0.18	23.18	1.34	8.01	21.37	0.26	4.06	0.05	100.18	2.94	0.01	1.93	0.07	0.47	2.25	0.02	0.31	0.01	11.5142	0.0033
AT-P1-45	40.94	0.05	23.27	1.46	10.63	18.77	0.26	4.89	0.02	100.30	2.93	0.00	1.96	0.08	0.64	2.00	0.02	0.37	0.00	11.5154	0.0060
AT-P1-46	41.46	0.00	20.79	4.61	7.70	19.35	0.25	6.26	0.01	100.42	2.97	0.00	1.75	0.26	0.46	2.06	0.02	0.48	0.00	11.5347	0.0055
AT-P1-47	41.47	0.03	20.64	4.62	8.17	19.36	0.28	5.49	0.03	100.08	2.98	0.00	1.75	0.26	0.49	2.07	0.02	0.42	0.00	11.5250	0.0045
AT-P1-48	41.56	0.50	16.80	8.29	6.75	19.72	0.21	6.65	0.03	100.52	3.00	0.03	1.43	0.47	0.41	2.12	0.01	0.52	0.00	11.5811	0.0041
AT-P1-49	41.29	0.09	22.60	1.49	10.04	18.97	0.31	5.14	0.02	99.96	2.96	0.00	1.91	0.08	0.60	2.03	0.02	0.39	0.00	11.5220	0.0036

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
AT-P1-50	41.42	0.13	18.56	7.02	7.79	17.93	0.24	6.94	0.02	100.04	3.02	0.01	1.59	0.40	0.47	1.95	0.01	0.54	0.00	11.5741	0.0030
AT-P1-51	41.89	0.46	19.95	4.68	6.65	20.24	0.21	5.94	0.05	100.07	3.00	0.02	1.68	0.26	0.40	2.16	0.01	0.46	0.01	11.5574	0.0031
AT-P1-52	41.23	0.14	22.71	1.47	10.75	18.35	0.26	4.96	0.01	99.86	2.97	0.01	1.93	0.08	0.65	1.97	0.02	0.38	0.00	11.5280	0.0056
AT-P1-53	41.70	0.12	21.95	3.20	7.65	19.32	0.25	5.66	0.03	99.88	2.99	0.01	1.85	0.18	0.46	2.06	0.02	0.43	0.00	11.5399	0.0026
AT-P1-54	41.27	0.12	19.00	7.40	6.76	19.10	0.25	6.10	0.03	100.04	2.99	0.01	1.62	0.42	0.41	2.06	0.02	0.47	0.00	11.5630	0.0035
AT-P1-55	41.86	0.22	20.34	4.75	8.23	19.35	0.28	4.95	0.03	100.01	3.01	0.01	1.73	0.27	0.50	2.08	0.02	0.38	0.00	11.5374	0.0057
AT-P1-56	42.62	0.04	20.29	5.48	7.31	20.21	0.22	4.24	0.06	100.46	3.04	0.00	1.71	0.31	0.44	2.15	0.01	0.32	0.01	11.5125	0.0068
AT-P1-57	42.78	0.13	21.88	3.62	7.30	20.70	0.20	3.64	0.05	100.29	3.04	0.01	1.83	0.20	0.43	2.19	0.01	0.28	0.01	11.5112	0.0064
AT-P1-58	41.91	0.21	22.80	1.85	9.36	18.81	0.18	4.83	0.06	100.01	3.00	0.01	1.92	0.10	0.56	2.01	0.01	0.37	0.01	11.5233	0.0041
AT-P1-59	41.38	0.24	19.52	6.33	7.08	20.58	0.24	4.96	0.08	100.42	2.96	0.01	1.65	0.36	0.42	2.19	0.01	0.38	0.01	11.5491	0.0033
AT-P1-60	40.95	1.06	21.69	3.93	7.58	20.48	0.25	4.56	0.03	100.53	2.91	0.06	1.82	0.22	0.45	2.17	0.02	0.35	0.00	11.5299	0.0040
AT-P1-61	42.08	0.63	19.91	5.03	5.90	20.92	0.14	5.35	0.04	99.99	3.00	0.03	1.68	0.28	0.35	2.23	0.01	0.41	0.01	11.5418	0.0038
AT-P1-62	41.28	0.82	22.07	3.02	8.25	19.72	0.24	4.75	0.05	100.20	2.95	0.04	1.86	0.17	0.49	2.10	0.01	0.36	0.01	11.5244	0.0047
AT-P1-63	41.86	0.91	21.90	0.81	9.70	19.41	0.14	4.99	0.07	99.79	3.00	0.05	1.85	0.05	0.58	2.07	0.01	0.38	0.01	11.5268	0.0057
AT-P1-64	41.78	0.23	21.10	4.14	7.57	19.15	0.27	5.52	0.06	99.82	3.00	0.01	1.79	0.24	0.46	2.05	0.02	0.43	0.01	11.5204	0.0051
AT-P1-65	41.32	0.04	17.00	8.63	7.02	18.50	0.22	7.35	0.00	100.09	3.01	0.00	1.46	0.50	0.43	2.01	0.01	0.57	0.00	11.5807	0.0040
AT-P1-66	40.70	0.09	22.43	1.61	10.80	18.67	0.25	5.28	0.01	99.83	2.93	0.00	1.90	0.09	0.65	2.00	0.01	0.41	0.00	11.5268	0.0029
AT-P1-67	41.68	0.00	22.99	1.44	9.70	18.90	0.25	5.16	0.02	100.13	2.98	0.00	1.94	0.08	0.58	2.01	0.01	0.39	0.00	11.5243	0.0044
AT-P1-68	41.35	0.20	22.33	1.90	10.88	18.31	0.28	5.14	0.01	100.40	2.97	0.01	1.89	0.11	0.65	1.96	0.02	0.40	0.00	11.5275	0.0023
AT-P1-69	41.82	0.02	22.87	1.58	9.79	18.87	0.21	5.15	0.01	100.32	2.99	0.00	1.92	0.09	0.58	2.01	0.01	0.39	0.00	11.5262	0.0061
AT-P1-70	41.72	0.07	23.05	1.40	9.98	18.81	0.31	5.23	0.03	100.59	2.97	0.00	1.93	0.08	0.59	2.00	0.02	0.40	0.00	11.5274	0.0029
AT-P1-71	41.29	0.13	22.50	1.57	9.75	19.36	0.30	5.37	0.03	100.29	2.94	0.01	1.89	0.09	0.58	2.06	0.02	0.41	0.00	11.5277	0.0041
AT-P1-72	41.05	0.28	17.46	7.83	8.49	18.94	0.22	6.23	0.04	100.54	2.98	0.02	1.49	0.45	0.51	2.05	0.01	0.48	0.01	11.5702	0.0023
AT-P1-73	41.87	0.33	18.20	5.68	8.21	19.08	0.25	6.49	0.06	100.17	3.03	0.02	1.55	0.32	0.50	2.06	0.02	0.50	0.01	11.5410	0.0056
AT-P1-74	41.29	0.06	22.12	1.50	10.13	19.40	0.25	5.42	0.02	100.19	2.95	0.00	1.86	0.08	0.60	2.06	0.01	0.41	0.00	11.5323	0.0050
AT-P1-75	40.91	0.19	22.73	1.23	10.30	19.42	0.27	5.47	0.02	100.54	2.91	0.01	1.91	0.07	0.61	2.06	0.02	0.42	0.00	11.5267	0.0031
AT-P1-76	40.72	0.14	22.86	1.43	10.52	18.89	0.29	5.14	0.00	99.99	2.92	0.01	1.93	0.08	0.63	2.02	0.02	0.39	0.00	11.5140	0.0028
AT-P1-77	41.16	0.17	22.96	1.34	10.19	19.01	0.27	5.30	0.03	100.42	2.93	0.01	1.93	0.08	0.61	2.02	0.02	0.40	0.00	11.5191	0.0056
AT-P1-78	41.00	0.00	19.43	5.98	8.46	18.24	0.35	6.81	0.02	100.30	2.97	0.00	1.66	0.34	0.51	1.97	0.02	0.53	0.00	11.5511	0.0047
AT-P1-79	41.18	0.21	21.74	2.71	10.85	18.74	0.23	4.76	0.05	100.46	2.95	0.01	1.84	0.15	0.65	2.00	0.01	0.37	0.01	11.5323	0.0026
AT-P1-80	41.94	0.02	20.26	4.72	6.32	20.59	0.16	6.03	0.00	100.03	2.99	0.00	1.70	0.27	0.38	2.19	0.01	0.46	0.00	11.5398	0.0039
AT-P1-81	41.00	0.03	22.57	1.51	10.74	18.86	0.31	5.32	0.03	100.37	2.93	0.00	1.90	0.09	0.64	2.01	0.02	0.41	0.00	11.5240	0.0041
AT-P1-82	41.07	0.04	21.55	3.97	7.39	20.90	0.29	4.73	0.02	99.97	2.92	0.00	1.81	0.22	0.44	2.22	0.02	0.36	0.00	11.5164	0.0038
AT-P1-83	40.81	0.61	21.02	3.42	7.33	21.08	0.17	5.46	0.05	99.95	2.90	0.03	1.76	0.19	0.44	2.24	0.01	0.42	0.01	11.5452	0.0043
AT-P1-84	41.93	0.00	21.06	4.37	7.32	22.08	0.21	2.82	0.00	99.78	2.98	0.00	1.77	0.25	0.44	2.34	0.01	0.21	0.00	11.5050	0.0052
AT-P1-85	41.68	0.23	18.92	6.39	7.15	19.56	0.26	6.15	0.05	100.38	3.00	0.01	1.60	0.36	0.43	2.10	0.02	0.47	0.01	11.5379	0.0051

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
AT-P1-86	41.01	0.39	15.93	9.15	6.90	19.81	0.20	6.58	0.03	99.99	2.99	0.02	1.37	0.53	0.42	2.15	0.01	0.51	0.00	11.5706	0.0031
AT-P1-87	40.55	0.04	15.49	9.98	7.55	18.43	0.17	7.78	0.01	100.00	2.98	0.00	1.34	0.58	0.46	2.02	0.01	0.61	0.00	11.5859	0.0039
AT-P1-88	40.72	0.43	19.79	5.46	7.91	20.38	0.25	5.25	0.06	100.25	2.92	0.02	1.67	0.31	0.47	2.18	0.01	0.40	0.01	11.5405	0.0025
AT-P1-89	41.44	0.67	21.21	0.75	11.09	19.48	0.23	5.15	0.07	100.09	2.97	0.04	1.79	0.04	0.66	2.08	0.01	0.39	0.01	11.5154	0.0050
AT-P1-90	40.93	0.12	18.88	6.62	7.79	19.00	0.29	6.78	0.04	100.45	2.95	0.01	1.60	0.38	0.47	2.04	0.02	0.52	0.01	11.5402	0.0059
AT-P1-91	40.53	0.18	19.94	5.76	8.42	19.37	0.30	5.46	0.05	100.02	2.93	0.01	1.70	0.33	0.51	2.08	0.02	0.42	0.01	11.5426	0.0025
AT-P1-92	41.44	0.14	20.31	4.97	8.01	19.77	0.34	5.45	0.04	100.46	2.97	0.01	1.71	0.28	0.48	2.11	0.02	0.42	0.01	11.5429	0.0031
AT-P1-93	41.11	0.15	22.97	1.89	9.67	18.83	0.34	5.06	0.03	100.05	2.94	0.01	1.94	0.11	0.58	2.01	0.02	0.39	0.00	11.5270	0.0043
AT-P1-94	40.95	0.08	22.89	1.63	9.69	19.55	0.37	5.20	0.01	100.34	2.91	0.00	1.92	0.09	0.58	2.07	0.02	0.40	0.00	11.5234	0.0063
AT-P1-95	40.22	0.02	16.63	9.16	7.04	18.44	0.28	8.16	0.00	99.96	2.94	0.00	1.43	0.53	0.43	2.01	0.02	0.64	0.00	11.5870	0.0025
AT-P1-96	41.78	0.15	22.70	2.53	7.56	20.97	0.26	4.50	0.05	100.50	2.95	0.01	1.89	0.14	0.45	2.21	0.02	0.34	0.01	11.5209	0.0031
AT-P1-97	40.83	0.09	21.47	4.09	7.97	20.09	0.28	5.07	0.03	99.92	2.92	0.00	1.81	0.23	0.48	2.14	0.02	0.39	0.00	11.5221	0.0037

Table 5: Bobbejaan, mount BB-P1.

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
BB-P1-R1	40.64	0.10	22.89	1.64	10.23	19.29	0.28	5.20	0.02	100.29	2.90	0.01	1.92	0.09	0.61	2.05	0.02	0.40	0.00	11.4944	0.0072
BB-P1-R2	41.90	0.11	23.76	0.13	11.27	18.94	0.23	3.98	0.03	100.35	2.99	0.01	2.00	0.01	0.67	2.01	0.01	0.30	0.00	11.5090	0.0035
BB-P1-R3	41.73	0.19	23.95	0.34	12.29	18.16	0.20	3.59	0.06	100.52	2.98	0.01	2.02	0.02	0.74	1.94	0.01	0.28	0.01	11.4853	0.0052
BB-P1-R4	41.72	0.41	23.84	0.14	7.95	20.46	0.14	5.04	0.03	99.74	2.95	0.02	1.99	0.01	0.47	2.16	0.01	0.38	0.00	11.5002	0.0039
BB-P1-R5	41.34	0.78	22.07	0.68	10.80	18.79	0.16	5.15	0.04	99.81	2.97	0.04	1.87	0.04	0.65	2.01	0.01	0.40	0.01	11.5350	0.0041
BB-P1-01	41.67	0.00	20.71	4.94	6.51	20.89	0.27	4.73	0.03	99.73	2.98	0.00	1.74	0.28	0.39	2.23	0.02	0.36	0.00	11.5348	0.0039
BB-P1-02	41.84	0.00	20.61	5.36	6.61	20.60	0.20	4.50	0.03	99.75	3.00	0.00	1.74	0.30	0.40	2.20	0.01	0.35	0.00	11.5377	0.0054
BB-P1-03	42.20	0.03	20.31	5.37	7.18	20.39	0.29	4.69	0.04	100.51	3.01	0.00	1.71	0.30	0.43	2.17	0.02	0.36	0.01	11.5355	0.0028
BB-P1-04	41.64	0.03	21.23	4.39	7.21	20.44	0.27	4.80	0.00	100.01	2.97	0.00	1.79	0.25	0.43	2.18	0.02	0.37	0.00	11.5244	0.0042
BB-P1-05	41.85	0.04	20.29	5.78	6.35	20.12	0.26	5.13	0.04	99.84	3.00	0.00	1.72	0.33	0.38	2.15	0.02	0.39	0.01	11.5437	0.0046
BB-P1-06	42.19	0.01	21.08	5.02	6.87	20.17	0.23	4.93	0.01	100.50	3.01	0.00	1.77	0.28	0.41	2.14	0.01	0.38	0.00	11.5364	0.0054
BB-P1-07	42.73	0.00	22.02	3.84	5.87	23.51	0.18	1.76	0.00	99.90	3.01	0.00	1.83	0.21	0.35	2.47	0.01	0.13	0.00	11.4943	0.0025
BB-P1-08	41.78	0.01	20.19	5.75	7.43	19.45	0.26	5.52	0.02	100.40	3.00	0.00	1.71	0.33	0.45	2.08	0.02	0.42	0.00	11.5400	0.0045
BB-P1-09	42.02	0.02	21.48	4.62	6.77	20.46	0.20	4.84	0.01	100.40	2.99	0.00	1.80	0.26	0.40	2.17	0.01	0.37	0.00	11.5228	0.0036
BB-P1-10	41.73	0.00	20.35	5.54	7.19	19.97	0.18	5.59	0.01	100.56	2.98	0.00	1.71	0.31	0.43	2.13	0.01	0.43	0.00	11.5400	0.0048
BB-P1-11	42.68	0.04	20.93	4.88	6.36	23.51	0.15	1.97	0.01	100.53	3.00	0.00	1.73	0.27	0.37	2.46	0.01	0.15	0.00	11.4961	0.0031
BB-P1-12	42.09	0.09	21.10	4.25	6.66	20.66	0.29	4.85	0.00	99.99	3.00	0.00	1.77	0.24	0.40	2.20	0.02	0.37	0.00	11.5215	0.0040
BB-P1-13	41.59	0.00	20.21	5.31	6.75	20.25	0.25	5.33	0.02	99.71	2.99	0.00	1.71	0.30	0.41	2.17	0.02	0.41	0.00	11.5392	0.0027
BB-P1-14	41.45	0.03	20.08	5.74	6.91	20.46	0.25	4.98	0.05	99.94	2.97	0.00	1.70	0.33	0.41	2.19	0.01	0.38	0.01	11.5381	0.0030

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
BB-P1-15	41.00	0.00	19.38	6.31	7.42	19.39	0.26	6.49	0.02	100.26	2.95	0.00	1.64	0.36	0.45	2.08	0.02	0.50	0.00	11.5454	0.0041
BB-P1-16	41.95	0.07	21.01	4.43	6.96	20.93	0.19	4.77	0.00	100.31	2.98	0.00	1.76	0.25	0.41	2.22	0.01	0.36	0.00	11.5284	0.0052
BB-P1-17	41.90	0.11	19.53	6.67	6.42	19.67	0.17	5.74	0.04	100.24	3.01	0.01	1.65	0.38	0.39	2.11	0.01	0.44	0.00	11.5525	0.0036
BB-P1-18	41.90	0.05	19.50	6.26	7.42	19.39	0.28	5.44	0.02	100.25	3.02	0.00	1.65	0.36	0.45	2.08	0.02	0.42	0.00	11.5510	0.0034
BB-P1-19	41.85	0.03	21.20	4.53	6.51	21.49	0.32	4.01	0.02	99.95	2.98	0.00	1.78	0.25	0.39	2.28	0.02	0.31	0.00	11.5092	0.0035
BB-P1-20	42.13	0.03	20.81	4.70	6.69	20.93	0.20	4.93	0.01	100.41	2.99	0.00	1.74	0.26	0.40	2.22	0.01	0.37	0.00	11.5299	0.0045
BB-P1-21	41.73	0.00	21.07	4.29	7.07	20.76	0.21	4.81	0.02	99.94	2.98	0.00	1.77	0.24	0.42	2.21	0.01	0.37	0.00	11.5353	0.0025
BB-P1-22	42.14	0.00	21.15	4.69	6.40	21.57	0.26	4.28	0.04	100.53	2.98	0.00	1.76	0.26	0.38	2.27	0.02	0.32	0.01	11.5212	0.0028
BB-P1-23	42.27	0.00	20.77	4.80	6.94	20.41	0.28	5.08	0.00	100.54	3.01	0.00	1.74	0.27	0.41	2.16	0.02	0.39	0.00	11.5224	0.0049
BB-P1-24	41.93	0.14	20.13	5.32	6.65	20.40	0.18	5.12	0.04	99.91	3.00	0.01	1.70	0.30	0.40	2.18	0.01	0.39	0.01	11.5449	0.0046
BB-P1-25	40.83	0.26	19.71	5.15	9.98	18.29	0.36	5.74	0.03	100.34	2.96	0.01	1.68	0.30	0.60	1.98	0.02	0.45	0.00	11.5463	0.0043
BB-P1-26	41.63	0.00	20.78	4.42	7.00	21.00	0.27	4.64	0.02	99.76	2.97	0.00	1.75	0.25	0.42	2.24	0.02	0.36	0.00	11.5323	0.0055
BB-P1-27	41.48	0.04	19.87	5.70	6.69	20.08	0.24	5.82	0.03	99.95	2.98	0.00	1.68	0.32	0.40	2.15	0.01	0.45	0.00	11.5476	0.0040
BB-P1-28	42.10	0.00	20.68	4.73	7.16	20.64	0.20	5.03	0.02	100.57	2.99	0.00	1.73	0.27	0.43	2.19	0.01	0.38	0.00	11.5259	0.0034
BB-P1-29	41.94	0.02	21.62	3.46	8.39	19.44	0.24	5.37	0.02	100.50	2.99	0.00	1.82	0.20	0.50	2.07	0.01	0.41	0.00	11.5217	0.0050
BB-P1-30	41.82	0.02	20.81	4.75	7.43	21.07	0.25	4.08	0.02	100.26	2.98	0.00	1.75	0.27	0.44	2.24	0.02	0.31	0.00	11.5262	0.0036
BB-P1-31	41.70	0.06	20.80	4.61	7.14	20.46	0.33	5.03	0.03	100.16	2.98	0.00	1.75	0.26	0.43	2.18	0.02	0.38	0.00	11.5300	0.0061
BB-P1-32	41.41	0.05	19.49	6.19	7.24	19.22	0.23	6.44	0.02	100.30	2.98	0.00	1.65	0.35	0.44	2.06	0.01	0.50	0.00	11.5552	0.0044
BB-P1-33	41.43	0.08	18.61	6.32	9.98	17.63	0.29	6.23	0.02	100.59	3.01	0.00	1.60	0.36	0.61	1.91	0.02	0.49	0.00	11.5640	0.0034
BB-P1-34	41.13	0.06	20.85	4.86	7.54	21.11	0.21	4.17	0.03	99.95	2.94	0.00	1.75	0.27	0.45	2.25	0.01	0.32	0.00	11.5308	0.0041
BB-P1-35	41.05	0.11	18.77	6.51	9.34	16.70	0.37	7.64	0.01	100.51	3.00	0.01	1.61	0.38	0.57	1.82	0.02	0.60	0.00	11.5817	0.0065
BB-P1-36	41.00	0.09	20.44	5.12	7.27	20.71	0.27	4.93	0.02	99.83	2.94	0.00	1.73	0.29	0.44	2.21	0.02	0.38	0.00	11.5345	0.0055
BB-P1-37	41.38	0.01	20.93	4.31	8.11	19.65	0.35	5.75	0.01	100.50	2.96	0.00	1.76	0.24	0.48	2.09	0.02	0.44	0.00	11.5428	0.0039
BB-P1-38	40.86	0.09	17.90	8.27	6.69	22.34	0.24	3.45	0.03	99.86	2.93	0.00	1.51	0.47	0.40	2.39	0.01	0.27	0.00	11.5314	0.0051
BB-P1-39	41.28	0.04	20.15	5.61	6.88	20.40	0.26	5.37	0.01	99.98	2.96	0.00	1.70	0.32	0.41	2.18	0.02	0.41	0.00	11.5381	0.0033
BB-P1-40	41.38	0.00	20.86	4.81	7.07	20.81	0.24	5.15	0.04	100.35	2.94	0.00	1.75	0.27	0.42	2.21	0.01	0.39	0.01	11.5372	0.0072
BB-P1-41	41.81	0.18	20.16	5.50	6.88	19.78	0.30	5.78	0.03	100.41	2.99	0.01	1.70	0.31	0.41	2.11	0.02	0.44	0.00	11.5403	0.0034
BB-P1-42	41.50	0.04	20.98	4.76	7.26	20.56	0.20	5.00	0.01	100.30	2.96	0.00	1.76	0.27	0.43	2.18	0.01	0.38	0.00	11.5335	0.0043
BB-P1-43	41.50	0.02	21.04	5.05	7.28	20.22	0.22	5.21	0.02	100.57	2.95	0.00	1.77	0.28	0.43	2.15	0.01	0.40	0.00	11.5433	0.0040
BB-P1-44	41.44	0.14	20.19	5.76	6.91	20.52	0.23	5.27	0.04	100.50	2.96	0.01	1.70	0.32	0.41	2.18	0.01	0.40	0.00	11.5424	0.0025
BB-P1-45	41.75	0.01	20.11	5.45	7.20	19.72	0.24	6.05	0.02	100.55	2.98	0.00	1.69	0.31	0.43	2.10	0.01	0.46	0.00	11.5407	0.0050
BB-P1-46	41.86	0.00	22.06	4.08	7.23	21.20	0.22	3.73	0.02	100.39	2.97	0.00	1.84	0.23	0.43	2.24	0.01	0.28	0.00	11.5210	0.0041
BB-P1-47	41.19	0.00	21.61	4.35	7.03	20.90	0.21	4.97	0.01	100.26	2.93	0.00	1.81	0.24	0.42	2.21	0.01	0.38	0.00	11.5345	0.0034
BB-P1-48	42.03	0.01	21.07	4.57	7.08	21.08	0.26	4.36	0.06	100.51	2.98	0.00	1.76	0.26	0.42	2.23	0.02	0.33	0.01	11.5284	0.0048
BB-P1-49	40.48	0.05	18.95	6.76	9.11	17.22	0.36	7.48	0.02	100.43	2.95	0.00	1.63	0.39	0.55	1.87	0.02	0.58	0.00	11.5756	0.0041
BB-P1-50	41.80	0.00	20.05	5.85	6.96	19.42	0.24	6.02	0.03	100.37	3.00	0.00	1.69	0.33	0.42	2.08	0.01	0.46	0.00	11.5528	0.0034

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
BB-P1-51	41.83	0.01	21.80	4.17	6.79	20.85	0.17	4.84	0.04	100.50	2.96	0.00	1.82	0.23	0.40	2.20	0.01	0.37	0.01	11.5232	0.0054
BB-P1-52	41.63	0.01	20.69	5.25	7.09	20.42	0.22	5.25	0.04	100.59	2.96	0.00	1.74	0.30	0.42	2.17	0.01	0.40	0.01	11.5368	0.0032
BB-P1-53	40.85	0.01	20.18	5.33	9.04	18.35	0.28	5.89	0.03	99.94	2.96	0.00	1.72	0.31	0.55	1.98	0.02	0.46	0.00	11.5536	0.0047
BB-P1-54	41.32	0.00	20.64	5.03	7.06	20.45	0.23	5.31	0.01	100.05	2.95	0.00	1.74	0.28	0.42	2.18	0.01	0.41	0.00	11.5398	0.0042
BB-P1-55	41.17	0.06	20.24	5.34	7.84	19.92	0.27	5.42	0.01	100.28	2.95	0.00	1.71	0.30	0.47	2.13	0.02	0.42	0.00	11.5450	0.0033
BB-P1-56	41.39	0.02	21.36	4.59	6.86	21.07	0.26	5.02	0.01	100.58	2.93	0.00	1.78	0.26	0.41	2.22	0.02	0.38	0.00	11.5307	0.0045
BB-P1-57	41.75	0.07	20.45	5.25	7.12	20.43	0.18	5.25	0.02	100.52	2.97	0.00	1.72	0.30	0.42	2.17	0.01	0.40	0.00	11.5430	0.0039
BB-P1-58	41.51	0.14	21.12	4.48	6.91	20.64	0.22	5.29	0.03	100.34	2.95	0.01	1.77	0.25	0.41	2.19	0.01	0.40	0.00	11.5343	0.0043
BB-P1-59	41.30	0.19	16.35	10.40	6.75	18.81	0.22	6.44	0.07	100.53	3.01	0.01	1.40	0.60	0.41	2.04	0.01	0.50	0.01	11.5858	0.0023
BB-P1-60	41.52	0.14	20.18	5.63	6.94	20.19	0.23	5.46	0.03	100.32	2.97	0.01	1.70	0.32	0.42	2.15	0.01	0.42	0.00	11.5465	0.0039
BB-P1-61	41.54	0.07	20.11	5.95	7.05	20.09	0.25	5.45	0.01	100.51	2.97	0.00	1.69	0.34	0.42	2.14	0.02	0.42	0.00	11.5414	0.0048
BB-P1-62	41.56	0.02	20.56	5.24	6.86	20.02	0.27	5.88	0.04	100.44	2.97	0.00	1.73	0.30	0.41	2.13	0.02	0.45	0.01	11.5497	0.0038
BB-P1-63	41.42	0.03	20.80	5.14	6.87	20.92	0.28	4.42	0.04	99.91	2.96	0.00	1.75	0.29	0.41	2.23	0.02	0.34	0.01	11.5276	0.0034
BB-P1-64	41.61	0.00	20.15	5.14	6.95	20.87	0.20	4.79	0.05	99.74	2.98	0.00	1.70	0.29	0.42	2.23	0.01	0.37	0.01	11.5307	0.0037
BB-P1-65	41.43	0.00	20.54	5.53	7.85	19.62	0.31	5.18	0.03	100.50	2.97	0.00	1.73	0.31	0.47	2.09	0.02	0.40	0.00	11.5413	0.0033
BB-P1-66	41.47	0.04	22.03	3.55	7.62	20.42	0.22	5.23	0.02	100.58	2.94	0.00	1.84	0.20	0.45	2.16	0.01	0.40	0.00	11.5315	0.0050
BB-P1-67	41.83	0.04	20.54	5.16	6.92	19.80	0.19	5.25	0.03	99.76	3.01	0.00	1.74	0.29	0.42	2.12	0.01	0.40	0.00	11.5397	0.0037
BB-P1-68	41.82	0.00	19.58	5.96	8.22	18.75	0.30	5.85	0.03	100.51	3.01	0.00	1.66	0.34	0.50	2.01	0.02	0.45	0.00	11.5535	0.0047
BB-P1-69	41.49	0.03	21.22	4.35	6.95	20.60	0.22	4.82	0.03	99.72	2.97	0.00	1.79	0.25	0.42	2.20	0.01	0.37	0.00	11.5340	0.0042
BB-P1-70	41.31	0.00	21.09	4.72	7.41	20.41	0.27	4.97	0.02	100.21	2.95	0.00	1.77	0.27	0.44	2.17	0.02	0.38	0.00	11.5337	0.0027
BB-P1-71	41.55	0.03	21.02	4.58	6.94	21.30	0.24	4.53	0.02	100.20	2.95	0.00	1.76	0.26	0.41	2.26	0.01	0.34	0.00	11.5281	0.0039
BB-P1-72	41.73	0.16	20.66	5.22	6.85	20.47	0.15	5.08	0.03	100.34	2.98	0.01	1.74	0.29	0.41	2.18	0.01	0.39	0.00	11.5400	0.0054
BB-P1-73	41.19	0.05	20.20	5.62	7.42	19.99	0.24	5.45	0.01	100.17	2.95	0.00	1.71	0.32	0.45	2.14	0.01	0.42	0.00	11.5331	0.0033
BB-P1-74	41.62	0.01	20.43	5.01	7.01	20.68	0.22	5.11	0.01	100.10	2.97	0.00	1.72	0.28	0.42	2.20	0.01	0.39	0.00	11.5409	0.0038
BB-P1-75	41.03	0.05	20.46	5.67	7.05	20.21	0.20	5.27	0.03	99.97	2.94	0.00	1.73	0.32	0.42	2.16	0.01	0.41	0.00	11.5431	0.0043
BB-P1-76	41.15	0.11	18.55	5.71	10.27	17.84	0.38	6.23	0.05	100.28	3.00	0.01	1.59	0.33	0.63	1.94	0.02	0.49	0.01	11.5607	0.0033
BB-P1-77	41.72	0.00	21.03	4.64	6.81	21.04	0.25	4.57	0.03	100.07	2.97	0.00	1.76	0.26	0.41	2.23	0.01	0.35	0.00	11.5251	0.0041
BB-P1-78	42.00	0.00	20.65	5.10	6.99	19.98	0.25	5.12	0.02	100.10	3.01	0.00	1.74	0.29	0.42	2.13	0.02	0.39	0.00	11.5286	0.0053
BB-P1-79	41.75	0.08	20.14	6.23	6.37	22.64	0.17	2.38	0.02	99.75	2.97	0.00	1.69	0.35	0.38	2.40	0.01	0.18	0.00	11.5023	0.0035
BB-P1-80	42.53	0.05	21.63	4.12	6.88	21.79	0.18	3.33	0.02	100.52	3.00	0.00	1.80	0.23	0.41	2.29	0.01	0.25	0.00	11.5039	0.0033
BB-P1-81	41.61	0.05	20.71	4.95	6.72	20.23	0.25	5.17	0.02	99.72	2.98	0.00	1.75	0.28	0.40	2.16	0.02	0.40	0.00	11.5286	0.0047
BB-P1-82	41.98	0.02	20.60	5.43	6.73	20.03	0.23	5.19	0.03	100.25	3.00	0.00	1.74	0.31	0.40	2.14	0.01	0.40	0.00	11.5247	0.0036
BB-P1-83	40.86	0.08	20.87	5.22	7.94	19.93	0.25	4.83	0.02	99.99	2.93	0.00	1.77	0.30	0.48	2.13	0.02	0.37	0.00	11.5172	0.0075
BB-P1-84	41.69	0.00	20.73	4.82	7.25	20.62	0.28	5.10	0.03	100.52	2.96	0.00	1.74	0.27	0.43	2.19	0.02	0.39	0.00	11.5364	0.0052
BB-P1-85	41.18	0.00	21.04	4.95	7.32	19.98	0.23	5.17	0.01	99.88	2.95	0.00	1.78	0.28	0.44	2.14	0.01	0.40	0.00	11.5189	0.0060
BB-P1-86	41.71	0.00	22.50	3.00	7.61	20.50	0.23	5.00	0.02	100.56	2.95	0.00	1.88	0.17	0.45	2.16	0.01	0.38	0.00	11.5295	0.0048

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
BB-P1-87	41.57	0.05	21.10	4.97	7.27	20.74	0.25	4.54	0.02	100.51	2.96	0.00	1.77	0.28	0.43	2.20	0.01	0.35	0.00	11.5332	0.0029
BB-P1-88	41.58	0.04	20.46	5.35	7.23	20.08	0.24	5.49	0.00	100.46	2.97	0.00	1.72	0.30	0.43	2.14	0.01	0.42	0.00	11.5500	0.0041
BB-P1-89	40.67	0.00	22.37	3.08	8.42	19.43	0.28	5.64	0.02	99.90	2.91	0.00	1.89	0.17	0.50	2.07	0.02	0.43	0.00	11.5379	0.0045

Table 6: Jagersfontein, mount JF-P1.

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
JF-P1-R1	41.73	0.81	23.09	0.65	10.62	18.47	0.11	4.99	0.08	100.55	2.98	0.04	1.94	0.04	0.63	1.97	0.01	0.38	0.01	11.5340	0.0041
JF-P1-R2	41.69	0.09	23.24	0.60	10.48	18.71	0.19	4.80	0.02	99.82	2.99	0.00	1.96	0.03	0.63	2.00	0.01	0.37	0.00	11.5295	0.0041
JF-P1-R3	40.21	0.13	24.16	0.15	14.63	16.28	0.20	4.10	0.06	99.92	2.92	0.01	2.07	0.01	0.89	1.76	0.01	0.32	0.01	11.5069	0.0065
JF-P1-R4	41.14	0.28	23.07	1.28	9.55	19.44	0.25	5.09	0.02	100.11	2.93	0.01	1.94	0.07	0.57	2.07	0.02	0.39	0.00	11.5262	0.0058
JF-P1-R5	41.67	0.73	22.30	0.60	10.65	19.74	0.18	4.51	0.13	100.51	2.96	0.04	1.87	0.03	0.63	2.09	0.01	0.34	0.02	11.5349	0.0040
JF-P1-01	40.85	0.15	19.53	6.21	6.87	20.58	0.21	5.45	0.04	99.87	2.93	0.01	1.65	0.35	0.41	2.20	0.01	0.42	0.00	11.5525	0.0046
JF-P1-02	41.23	0.09	21.74	3.44	8.89	19.11	0.19	5.26	0.03	99.97	2.96	0.00	1.84	0.20	0.53	2.05	0.01	0.40	0.00	11.5333	0.0039
JF-P1-03	41.09	0.23	17.75	8.10	7.02	19.89	0.14	5.76	0.08	100.04	2.97	0.01	1.51	0.46	0.42	2.15	0.01	0.45	0.01	11.5745	0.0048
JF-P1-04	41.71	0.27	22.53	3.11	6.39	21.28	0.23	4.58	0.04	100.14	2.95	0.01	1.88	0.17	0.38	2.24	0.01	0.35	0.01	11.5258	0.0043
JF-P1-05	41.35	0.00	21.33	4.55	6.78	21.08	0.20	4.83	0.01	100.14	2.94	0.00	1.79	0.26	0.40	2.23	0.01	0.37	0.00	11.5280	0.0048
JF-P1-06	42.21	0.12	23.02	2.28	6.66	21.60	0.14	4.45	0.03	100.52	2.96	0.01	1.90	0.13	0.39	2.26	0.01	0.33	0.00	11.5015	0.0054
JF-P1-07	41.58	0.10	21.36	4.62	6.63	22.14	0.16	3.85	0.02	100.48	2.93	0.01	1.78	0.26	0.39	2.33	0.01	0.29	0.00	11.5165	0.0058
JF-P1-08	41.74	0.00	23.09	2.91	7.51	20.28	0.27	4.68	0.02	100.50	2.95	0.00	1.93	0.16	0.44	2.14	0.02	0.35	0.00	11.5302	0.0035
JF-P1-09	41.44	0.07	20.31	5.90	6.96	19.93	0.22	5.60	0.01	100.44	2.96	0.00	1.71	0.33	0.42	2.13	0.01	0.43	0.00	11.5512	0.0045
JF-P1-10	41.41	0.30	22.47	1.49	13.09	16.72	0.24	4.75	0.04	100.51	3.00	0.02	1.92	0.09	0.79	1.80	0.01	0.37	0.01	11.5373	0.0033
JF-P1-11	41.57	0.04	21.13	5.04	6.90	20.02	0.25	4.84	0.03	99.81	2.98	0.00	1.79	0.29	0.41	2.14	0.01	0.37	0.00	11.5394	0.0032
JF-P1-12	41.35	0.03	22.15	3.60	7.30	20.78	0.23	4.27	0.02	99.73	2.95	0.00	1.86	0.20	0.44	2.21	0.01	0.33	0.00	11.5163	0.0065
JF-P1-13	41.10	0.03	20.15	5.93	7.03	19.72	0.29	5.58	0.03	99.86	2.96	0.00	1.71	0.34	0.42	2.12	0.02	0.43	0.00	11.5484	0.0038
JF-P1-14	41.50	0.02	22.26	2.50	8.83	19.36	0.24	5.05	0.03	99.78	2.97	0.00	1.88	0.14	0.53	2.07	0.01	0.39	0.00	11.5187	0.0045
JF-P1-15	41.94	0.04	20.76	5.12	6.30	22.30	0.21	2.95	0.42	100.04	2.97	0.00	1.73	0.29	0.37	2.35	0.01	0.22	0.06	11.5225	0.0048
JF-P1-16	41.16	0.05	23.16	2.54	8.20	20.00	0.27	4.74	0.01	100.13	2.93	0.00	1.94	0.14	0.49	2.12	0.02	0.36	0.00	11.5302	0.0039
JF-P1-17	41.46	0.19	22.22	3.56	6.73	21.18	0.15	4.68	0.08	100.25	2.93	0.01	1.85	0.20	0.40	2.23	0.01	0.35	0.01	11.5296	0.0056
JF-P1-18	41.10	0.05	20.22	6.00	6.44	20.97	0.19	4.92	0.02	99.91	2.94	0.00	1.70	0.34	0.39	2.24	0.01	0.38	0.00	11.5519	0.0042
JF-P1-19	41.53	0.11	21.37	4.47	6.53	21.67	0.15	4.64	0.05	100.50	2.93	0.01	1.78	0.25	0.39	2.28	0.01	0.35	0.01	11.5325	0.0032
JF-P1-20	40.77	0.00	22.20	3.21	8.15	20.58	0.26	4.70	0.03	99.89	2.90	0.00	1.86	0.18	0.49	2.19	0.02	0.36	0.00	11.5248	0.0063
JF-P1-21	41.73	0.51	20.98	3.11	7.16	21.60	0.18	4.73	0.07	100.06	2.96	0.03	1.75	0.17	0.42	2.28	0.01	0.36	0.01	11.5388	0.0063
JF-P1-22	41.54	0.00	20.34	5.87	6.62	20.76	0.12	5.22	0.05	100.50	2.96	0.00	1.71	0.33	0.39	2.20	0.01	0.40	0.01	11.5463	0.0034
JF-P1-23	41.76	0.00	20.09	6.71	5.45	23.04	0.17	3.07	0.02	100.30	2.95	0.00	1.67	0.37	0.32	2.43	0.01	0.23	0.00	11.5233	0.0033

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
JF-P1-24	42.25	0.00	19.37	7.24	5.73	22.63	0.17	3.17	0.00	100.57	2.99	0.00	1.62	0.41	0.34	2.39	0.01	0.24	0.00	11.5136	0.0046
JF-P1-25	41.73	0.09	19.72	6.73	5.83	21.41	0.15	4.44	0.03	100.14	2.98	0.00	1.66	0.38	0.35	2.28	0.01	0.34	0.00	11.5460	0.0025
JF-P1-26	41.14	0.03	19.75	6.30	7.30	19.70	0.20	6.15	0.02	100.60	2.95	0.00	1.67	0.36	0.44	2.10	0.01	0.47	0.00	11.5559	0.0038
JF-P1-27	41.43	0.79	21.07	2.68	9.47	20.20	0.19	4.58	0.11	100.51	2.95	0.04	1.77	0.15	0.56	2.15	0.01	0.35	0.02	11.5380	0.0053
JF-P1-28	41.33	0.06	20.97	5.15	7.32	20.04	0.20	5.27	0.02	100.36	2.95	0.00	1.77	0.29	0.44	2.13	0.01	0.40	0.00	11.5463	0.0044
JF-P1-29	41.43	0.04	22.64	3.98	7.37	19.54	0.23	5.07	0.04	100.34	2.95	0.00	1.90	0.22	0.44	2.07	0.01	0.39	0.01	11.5314	0.0043
JF-P1-30	42.01	0.01	22.78	3.03	8.53	18.81	0.28	4.84	0.00	100.29	3.00	0.00	1.92	0.17	0.51	2.01	0.02	0.37	0.00	11.5171	0.0066
JF-P1-31	41.49	1.22	22.34	1.01	9.09	19.09	0.18	5.88	0.11	100.42	2.96	0.07	1.88	0.06	0.54	2.03	0.01	0.45	0.01	11.5563	0.0042
JF-P1-32	41.77	0.50	22.32	2.25	8.25	20.42	0.18	4.55	0.10	100.34	2.96	0.03	1.87	0.13	0.49	2.16	0.01	0.35	0.01	11.5317	0.0043
JF-P1-33	41.67	0.00	21.05	4.74	6.27	21.97	0.23	4.57	0.06	100.56	2.94	0.00	1.75	0.26	0.37	2.31	0.01	0.35	0.01	11.5366	0.0071
JF-P1-34	41.68	0.01	22.76	2.88	7.33	20.76	0.21	4.94	0.02	100.58	2.94	0.00	1.89	0.16	0.43	2.18	0.01	0.37	0.00	11.5241	0.0031
JF-P1-35	41.23	0.07	21.79	3.01	10.92	18.09	0.37	4.90	0.04	100.42	2.97	0.00	1.85	0.17	0.66	1.94	0.02	0.38	0.01	11.5312	0.0039
JF-P1-36	41.54	0.05	22.85	2.59	8.78	19.57	0.26	4.86	0.01	100.50	2.95	0.00	1.91	0.15	0.52	2.07	0.02	0.37	0.00	11.5309	0.0029
JF-P1-37	40.85	0.10	19.80	6.61	6.72	20.56	0.22	5.68	0.02	100.54	2.92	0.01	1.67	0.37	0.40	2.19	0.01	0.43	0.00	11.5476	0.0042
JF-P1-38	41.59	0.04	20.29	5.68	6.50	21.44	0.22	4.77	0.01	100.54	2.95	0.00	1.70	0.32	0.39	2.27	0.01	0.36	0.00	11.5427	0.0032
JF-P1-39	41.04	0.09	20.64	5.12	6.92	20.68	0.28	5.25	0.02	100.03	2.93	0.00	1.74	0.29	0.41	2.20	0.02	0.40	0.00	11.5410	0.0041
JF-P1-40	41.08	0.15	19.14	6.30	7.05	21.03	0.22	5.58	0.04	100.59	2.93	0.01	1.61	0.36	0.42	2.23	0.01	0.43	0.01	11.5582	0.0037
JF-P1-41	41.15	0.00	23.21	2.55	9.03	18.46	0.31	5.07	0.02	99.79	2.96	0.00	1.97	0.14	0.54	1.98	0.02	0.39	0.00	11.5268	0.0066
JF-P1-42	41.47	0.05	20.75	5.28	6.40	20.61	0.21	5.33	0.02	100.10	2.96	0.00	1.74	0.30	0.38	2.19	0.01	0.41	0.00	11.5395	0.0044
JF-P1-43	41.81	0.00	20.80	5.00	6.77	21.06	0.16	4.65	0.01	100.27	2.97	0.00	1.74	0.28	0.40	2.23	0.01	0.35	0.00	11.5379	0.0057
JF-P1-44	40.85	0.01	22.65	3.10	7.23	21.14	0.26	4.49	0.05	99.77	2.90	0.00	1.90	0.17	0.43	2.24	0.02	0.34	0.01	11.5172	0.0038
JF-P1-45	41.00	0.00	20.02	6.78	6.82	20.00	0.17	5.76	0.02	100.55	2.93	0.00	1.69	0.38	0.41	2.13	0.01	0.44	0.00	11.5361	0.0086
JF-P1-46	41.88	0.05	21.80	4.52	5.87	22.86	0.16	3.21	0.00	100.35	2.95	0.00	1.81	0.25	0.35	2.40	0.01	0.24	0.00	11.5158	0.0054
JF-P1-47	40.88	0.13	21.61	4.05	6.99	20.56	0.25	5.25	0.01	99.72	2.92	0.01	1.82	0.23	0.42	2.19	0.02	0.40	0.00	11.5389	0.0071
JF-P1-48	40.96	0.04	21.71	4.52	7.20	20.33	0.18	4.86	0.00	99.78	2.93	0.00	1.83	0.26	0.43	2.17	0.01	0.37	0.00	11.5298	0.0048
JF-P1-49	41.10	0.00	22.72	2.66	7.66	20.60	0.19	4.79	0.04	99.76	2.92	0.00	1.90	0.15	0.46	2.18	0.01	0.37	0.01	11.5120	0.0064
JF-P1-50	41.51	0.04	23.66	1.94	8.66	19.74	0.24	4.70	0.01	100.48	2.94	0.00	1.98	0.11	0.51	2.09	0.01	0.36	0.00	11.5065	0.0076

Table 7: Jagersfontein, mount JF-P4.

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
JF-P4-01	41.30	0.05	22.10	3.56	7.63	20.84	0.30	4.48	0.00	100.26	2.93	0.00	1.85	0.20	0.45	2.21	0.02	0.34	0.00	11.5251	0.0060
JF-P4-02	41.37	0.15	20.63	4.58	6.34	21.26	0.13	5.40	0.02	99.87	2.95	0.01	1.73	0.26	0.38	2.26	0.01	0.41	0.00	11.5424	0.0087
JF-P4-03	41.29	0.20	20.54	4.97	6.74	20.97	0.16	5.06	0.04	99.98	2.95	0.01	1.73	0.28	0.40	2.23	0.01	0.39	0.01	11.5355	0.0042
JF-P4-04	41.21	0.12	21.30	4.13	6.55	21.21	0.21	5.12	0.00	99.85	2.93	0.01	1.79	0.23	0.39	2.25	0.01	0.39	0.00	11.5434	0.0050

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
JF-P4-05	40.95	0.04	22.65	2.72	9.17	19.95	0.18	4.86	0.02	100.53	2.91	0.00	1.90	0.15	0.54	2.11	0.01	0.37	0.00	11.5290	0.0040
JF-P4-06	41.89	0.00	21.21	5.38	6.42	21.33	0.18	3.99	0.01	100.41	2.97	0.00	1.77	0.30	0.38	2.26	0.01	0.30	0.00	11.5256	0.0045
JF-P4-07	41.46	0.20	21.90	3.91	7.51	20.41	0.14	5.04	0.02	100.58	2.94	0.01	1.83	0.22	0.45	2.16	0.01	0.38	0.00	11.5275	0.0056
JF-P4-08	41.39	0.01	23.67	1.74	8.47	19.79	0.21	4.83	0.04	100.14	2.94	0.00	1.98	0.10	0.50	2.09	0.01	0.37	0.01	11.5303	0.0051
JF-P4-09	41.50	0.27	20.78	5.28	6.63	20.95	0.20	4.85	0.04	100.49	2.95	0.01	1.74	0.30	0.39	2.22	0.01	0.37	0.00	11.5348	0.0040
JF-P4-10	41.20	0.08	20.95	5.13	6.93	20.18	0.19	5.22	0.02	99.91	2.95	0.00	1.77	0.29	0.42	2.16	0.01	0.40	0.00	11.5398	0.0055
JF-P4-11	41.45	0.21	20.25	5.64	7.29	20.50	0.18	4.82	0.05	100.38	2.96	0.01	1.70	0.32	0.44	2.18	0.01	0.37	0.01	11.5448	0.0049
JF-P4-12	41.89	0.00	21.34	3.74	7.89	20.43	0.26	4.75	0.03	100.34	2.98	0.00	1.79	0.21	0.47	2.17	0.02	0.36	0.00	11.5234	0.0051
JF-P4-13	41.54	0.04	21.26	5.27	6.79	20.36	0.18	4.74	0.02	100.19	2.96	0.00	1.79	0.30	0.41	2.17	0.01	0.36	0.00	11.5389	0.0056
JF-P4-14	40.99	0.00	20.62	4.52	9.32	19.93	0.22	4.12	0.06	99.78	2.95	0.00	1.75	0.26	0.56	2.14	0.01	0.32	0.01	11.5425	0.0063
JF-P4-15	41.98	0.08	20.55	5.00	6.40	20.75	0.25	5.50	0.02	100.52	2.98	0.00	1.72	0.28	0.38	2.20	0.01	0.42	0.00	11.5466	0.0041
JF-P4-16	41.80	0.23	21.55	3.46	6.55	21.59	0.17	4.74	0.02	100.11	2.96	0.01	1.80	0.19	0.39	2.28	0.01	0.36	0.00	11.5330	0.0060
JF-P4-17	41.50	0.02	22.38	2.43	8.66	19.93	0.28	4.97	0.01	100.18	2.96	0.00	1.88	0.14	0.52	2.12	0.02	0.38	0.00	11.5354	0.0035
JF-P4-18	41.88	0.00	22.59	2.41	7.64	20.75	0.24	4.83	0.02	100.37	2.96	0.00	1.88	0.13	0.45	2.19	0.01	0.37	0.00	11.5273	0.0040
JF-P4-19	41.57	0.00	22.67	2.15	9.11	19.99	0.25	4.85	0.01	100.60	2.95	0.00	1.89	0.12	0.54	2.11	0.01	0.37	0.00	11.5284	0.0039
JF-P4-20	41.42	0.04	22.30	3.04	7.72	20.86	0.29	4.83	0.04	100.54	2.93	0.00	1.86	0.17	0.46	2.20	0.02	0.37	0.01	11.5288	0.0050
JF-P4-21	41.83	0.01	21.87	3.62	7.56	20.22	0.23	5.07	0.03	100.45	2.97	0.00	1.83	0.20	0.45	2.14	0.01	0.39	0.00	11.5341	0.0045
JF-P4-22	41.17	0.06	21.74	3.77	8.09	19.87	0.27	5.51	0.02	100.49	2.93	0.00	1.82	0.21	0.48	2.11	0.02	0.42	0.00	11.5382	0.0044
JF-P4-23	41.28	0.09	19.71	5.92	6.77	20.83	0.15	5.29	0.03	100.07	2.95	0.00	1.66	0.34	0.41	2.22	0.01	0.41	0.00	11.5493	0.0030
JF-P4-24	41.77	0.35	19.02	5.71	7.00	20.61	0.22	5.38	0.03	100.09	3.00	0.02	1.61	0.32	0.42	2.20	0.01	0.41	0.00	11.5513	0.0033
JF-P4-25	40.88	0.00	22.48	2.76	8.57	19.89	0.33	4.84	0.00	99.75	2.92	0.00	1.90	0.16	0.51	2.12	0.02	0.37	0.00	11.5102	0.0080
JF-P4-26	41.09	0.00	22.67	2.76	9.03	19.47	0.34	4.70	0.01	100.05	2.94	0.00	1.91	0.16	0.54	2.08	0.02	0.36	0.00	11.5327	0.0038
JF-P4-27	41.37	0.32	21.86	3.26	8.57	20.06	0.21	4.54	0.06	100.24	2.95	0.02	1.84	0.18	0.51	2.13	0.01	0.35	0.01	11.5366	0.0039
JF-P4-28	42.21	0.03	21.61	3.91	6.49	20.71	0.17	4.96	0.03	100.10	3.00	0.00	1.81	0.22	0.39	2.19	0.01	0.38	0.00	11.5345	0.0047
JF-P4-29	41.71	0.06	21.05	4.92	7.01	20.00	0.21	5.53	0.04	100.53	2.97	0.00	1.77	0.28	0.42	2.12	0.01	0.42	0.01	11.5426	0.0031
JF-P4-30	42.05	0.05	20.84	5.34	6.33	20.42	0.20	4.85	0.02	100.12	3.00	0.00	1.75	0.30	0.38	2.17	0.01	0.37	0.00	11.5385	0.0032
JF-P4-31	41.69	0.02	20.62	4.97	6.64	20.07	0.16	5.60	0.01	99.76	2.99	0.00	1.74	0.28	0.40	2.15	0.01	0.43	0.00	11.5457	0.0098
JF-P4-32	41.61	0.06	22.70	2.88	7.96	20.12	0.25	4.86	0.01	100.43	2.95	0.00	1.90	0.16	0.47	2.13	0.01	0.37	0.00	11.5265	0.0043
JF-P4-33	41.71	0.12	20.34	5.60	6.82	20.18	0.18	5.32	0.05	100.30	2.98	0.01	1.71	0.32	0.41	2.15	0.01	0.41	0.01	11.5450	0.0046
JF-P4-34	41.87	0.00	21.47	4.34	6.19	21.64	0.22	4.63	0.04	100.38	2.96	0.00	1.79	0.24	0.37	2.28	0.01	0.35	0.00	11.5308	0.0038
JF-P4-35	41.73	0.16	20.11	4.69	7.24	20.73	0.20	5.41	0.04	100.31	2.97	0.01	1.69	0.26	0.43	2.20	0.01	0.41	0.01	11.5492	0.0035
JF-P4-36	41.74	0.08	21.05	4.69	6.99	21.39	0.23	4.25	0.02	100.44	2.96	0.00	1.76	0.26	0.41	2.26	0.01	0.32	0.00	11.5242	0.0039
JF-P4-37	41.11	0.01	22.88	2.38	8.51	20.09	0.26	4.68	0.02	99.93	2.93	0.00	1.92	0.13	0.51	2.13	0.02	0.36	0.00	11.5249	0.0048
JF-P4-38	41.55	0.20	20.64	5.34	6.52	21.05	0.20	5.05	0.02	100.56	2.95	0.01	1.73	0.30	0.39	2.23	0.01	0.38	0.00	11.5423	0.0042
JF-P4-39	41.47	0.08	21.15	3.07	9.35	19.76	0.32	4.92	0.02	100.12	2.97	0.00	1.79	0.17	0.56	2.11	0.02	0.38	0.00	11.5408	0.0065
JF-P4-40	41.13	0.12	21.02	4.69	6.82	20.63	0.26	5.68	0.02	100.35	2.92	0.01	1.76	0.26	0.41	2.19	0.02	0.43	0.00	11.5465	0.0060

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
JF-P4-41	41.80	0.86	19.05	5.54	6.90	20.57	0.13	5.13	0.09	100.07	3.00	0.05	1.61	0.31	0.41	2.20	0.01	0.39	0.01	11.5600	0.0033
JF-P4-42	40.93	0.10	19.59	6.62	7.02	20.27	0.19	5.62	0.06	100.40	2.93	0.01	1.65	0.37	0.42	2.16	0.01	0.43	0.01	11.5552	0.0045
JF-P4-43	41.12	0.09	20.10	4.91	6.65	21.05	0.20	5.64	0.00	99.76	2.94	0.00	1.69	0.28	0.40	2.24	0.01	0.43	0.00	11.5435	0.0045
JF-P4-44	41.42	0.00	22.91	2.41	8.51	20.39	0.25	4.65	0.03	100.57	2.93	0.00	1.91	0.13	0.50	2.15	0.01	0.35	0.00	11.5290	0.0043
JF-P4-45	41.12	0.11	22.42	3.13	8.98	18.81	0.32	5.37	0.05	100.31	2.94	0.01	1.89	0.18	0.54	2.01	0.02	0.41	0.01	11.5342	0.0055
JF-P4-46	41.38	0.08	20.31	5.65	6.78	21.09	0.23	4.97	0.02	100.52	2.94	0.00	1.70	0.32	0.40	2.24	0.01	0.38	0.00	11.5440	0.0034
JF-P4-47	41.36	0.24	20.14	5.67	7.08	20.16	0.23	5.69	0.02	100.59	2.95	0.01	1.69	0.32	0.42	2.15	0.01	0.44	0.00	11.5545	0.0017
JF-P4-48	41.76	0.09	21.22	4.80	6.61	20.75	0.12	5.21	0.02	100.59	2.96	0.00	1.77	0.27	0.39	2.19	0.01	0.40	0.00	11.5368	0.0040
JF-P4-49	41.68	0.08	20.87	4.87	6.49	19.65	0.21	5.90	0.07	99.82	2.99	0.00	1.76	0.28	0.39	2.10	0.01	0.45	0.01	11.5476	0.0036
JF-P4-50	41.20	0.02	22.31	3.51	8.71	19.00	0.35	5.33	0.01	100.44	2.94	0.00	1.88	0.20	0.52	2.02	0.02	0.41	0.00	11.5451	0.0082
JF-P4-51	41.07	0.21	18.39	8.53	5.65	19.94	0.15	5.87	0.06	99.85	2.97	0.01	1.57	0.49	0.34	2.15	0.01	0.45	0.01	11.5620	0.0026
JF-P4-52	41.50	0.03	22.66	2.74	8.37	19.39	0.29	4.95	0.02	99.95	2.97	0.00	1.91	0.15	0.50	2.07	0.02	0.38	0.00	11.5443	0.0052
JF-P4-53	41.63	0.00	19.52	7.23	6.18	23.78	0.21	1.98	0.00	100.53	2.94	0.00	1.62	0.40	0.37	2.50	0.01	0.15	0.00	11.5184	0.0040
JF-P4-54	40.95	0.23	20.35	5.31	7.34	20.55	0.18	5.18	0.06	100.14	2.93	0.01	1.71	0.30	0.44	2.19	0.01	0.40	0.01	11.5515	0.0057
JF-P4-55	41.67	0.04	21.08	4.94	6.63	21.74	0.17	4.24	0.04	100.55	2.95	0.00	1.76	0.28	0.39	2.29	0.01	0.32	0.01	11.5275	0.0044
JF-P4-56	41.25	0.04	20.10	6.24	6.61	21.15	0.20	4.68	0.03	100.29	2.94	0.00	1.69	0.35	0.39	2.25	0.01	0.36	0.00	11.5411	0.0034
JF-P4-57	41.18	0.15	20.14	5.88	6.64	20.59	0.24	5.43	0.06	100.31	2.94	0.01	1.69	0.33	0.40	2.19	0.01	0.42	0.01	11.5507	0.0033
JF-P4-58	40.93	0.26	19.68	6.29	6.25	20.53	0.24	5.84	0.04	100.06	2.93	0.01	1.66	0.36	0.37	2.19	0.01	0.45	0.01	11.5518	0.0048
JF-P4-59	41.33	0.02	22.22	2.72	9.00	19.92	0.31	5.04	0.01	100.56	2.94	0.00	1.86	0.15	0.53	2.11	0.02	0.38	0.00	11.5338	0.0099
JF-P4-60	41.38	0.06	21.27	4.56	6.68	21.28	0.18	5.07	0.02	100.51	2.93	0.00	1.77	0.26	0.40	2.25	0.01	0.38	0.00	11.5310	0.0097
JF-P4-61	41.21	0.00	22.18	3.44	7.73	20.34	0.28	5.09	0.00	100.26	2.93	0.00	1.86	0.19	0.46	2.16	0.02	0.39	0.00	11.5329	0.0052
JF-P4-62	40.56	0.06	19.05	6.78	7.17	20.44	0.25	5.60	0.04	99.96	2.92	0.00	1.62	0.39	0.43	2.19	0.02	0.43	0.01	11.5559	0.0030
JF-P4-63	40.87	0.00	20.92	4.84	6.54	20.89	0.19	5.62	0.02	99.88	2.91	0.00	1.76	0.27	0.39	2.22	0.01	0.43	0.00	11.5388	0.0042
JF-P4-64	41.80	0.05	22.29	2.27	8.81	19.98	0.21	4.79	0.03	100.22	2.98	0.00	1.87	0.13	0.52	2.12	0.01	0.37	0.00	11.5262	0.0037
JF-P4-65	40.57	0.08	19.91	6.40	6.91	19.94	0.19	5.83	0.03	99.86	2.92	0.00	1.69	0.36	0.42	2.14	0.01	0.45	0.00	11.5604	0.0054
JF-P4-66	40.59	0.12	21.34	4.79	6.60	20.95	0.13	5.15	0.03	99.70	2.90	0.01	1.80	0.27	0.39	2.23	0.01	0.39	0.00	11.5377	0.0047
JF-P4-67	41.22	0.00	22.37	3.14	8.51	19.82	0.27	5.24	0.02	100.59											
JF-P4-68	41.11	0.00	22.77	3.02	8.49	19.32	0.28	4.93	0.02	99.95	2.94	0.00	1.92	0.17	0.51	2.06	0.02	0.38	0.00	11.5357	0.0045
JF-P4-69	40.58	0.21	20.22	6.04	7.50	20.10	0.15	5.70	0.06	100.54	2.90	0.01	1.70	0.34	0.45	2.14	0.01	0.44	0.01	11.5553	0.0036
JF-P4-70	41.53	0.05	23.10	2.81	8.43	19.07	0.25	5.07	0.02	100.34	2.96	0.00	1.94	0.16	0.50	2.03	0.02	0.39	0.00	11.5297	0.0040
JF-P4-71	41.50	0.10	20.93	4.87	7.01	19.27	0.22	5.94	0.04	99.88	2.98	0.01	1.77	0.28	0.42	2.06	0.01	0.46	0.01	11.5503	0.0025
JF-P4-72	41.29	0.00	20.24	6.03	6.97	19.45	0.23	5.52	0.04	99.78	2.98	0.00	1.72	0.34	0.42	2.09	0.01	0.43	0.01	11.5513	0.0047
JF-P4-73	40.93	0.00	22.18	3.90	7.30	20.11	0.24	5.29	0.01	99.95	2.92	0.00	1.87	0.22	0.44	2.14	0.01	0.40	0.00	11.5404	0.0039
JF-P4-74	40.98	0.08	20.92	4.99	6.99	20.11	0.13	5.55	0.01	99.75	2.94	0.00	1.77	0.28	0.42	2.15	0.01	0.43	0.00	11.5486	0.0038
JF-P4-75	40.91	0.01	20.18	5.96	6.40	21.47	0.15	4.78	0.01	99.86	2.92	0.00	1.70	0.34	0.38	2.29	0.01	0.37	0.00	11.5403	0.0035
JF-P4-76	41.75	0.00	20.56	4.60	7.14	20.65	0.14	5.66	0.02	100.51	2.97	0.00	1.72	0.26	0.42	2.19	0.01	0.43	0.00	11.5459	0.0039

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)									Unit Cell (Å)	Standard Deviation
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na		
JF-P4-77	41.39	0.06	23.09	2.29	8.62	20.49	0.25	4.37	0.02	100.57	2.93	0.00	1.92	0.13	0.51	2.16	0.02	0.33	0.00	11.5219	0.0047
JF-P4-78	40.95	0.12	20.46	5.43	7.08	20.68	0.21	5.60	0.02	100.54	2.91	0.01	1.72	0.31	0.42	2.19	0.01	0.43	0.00	11.5501	0.0037
JF-P4-79	41.53	0.00	22.10	3.14	8.02	20.38	0.30	5.02	0.03	100.50	2.94	0.00	1.85	0.18	0.48	2.15	0.02	0.38	0.00	11.5316	0.0025
JF-P4-80	41.42	0.30	20.93	4.34	6.63	21.77	0.16	4.92	0.05	100.53	2.93	0.02	1.74	0.24	0.39	2.29	0.01	0.37	0.01	11.5351	0.0027
JF-P4-81	40.55	0.29	18.62	6.82	6.89	20.83	0.30	5.57	0.04	99.92	2.92	0.02	1.58	0.39	0.41	2.23	0.02	0.43	0.01	11.5558	0.0038
JF-P4-82	41.30	0.06	22.83	2.92	7.55	20.32	0.23	4.64	0.06	99.89	2.94	0.00	1.91	0.16	0.45	2.16	0.01	0.35	0.01	11.5281	0.0048
JF-P4-83	40.65	0.23	19.43	6.17	7.01	19.86	0.24	6.11	0.04	99.74	2.93	0.01	1.65	0.35	0.42	2.14	0.01	0.47	0.01	11.5594	0.0038
JF-P4-84	41.01	0.10	20.20	5.48	7.08	20.50	0.25	5.69	0.00	100.32	2.93	0.01	1.70	0.31	0.42	2.18	0.02	0.44	0.00	11.5488	0.0045
JF-P4-85	41.11	0.04	19.95	5.52	7.18	20.63	0.22	5.52	0.03	100.19	2.94	0.00	1.68	0.31	0.43	2.20	0.01	0.42	0.00	11.5521	0.0036
JF-P4-86	41.80	0.00	21.29	3.62	8.53	19.51	0.31	5.37	0.00	100.44	2.99	0.00	1.79	0.20	0.51	2.08	0.02	0.41	0.00	11.5442	0.0051
JF-P4-87	41.58	0.35	22.17	2.80	6.63	21.49	0.22	4.90	0.03	100.16	2.94	0.02	1.85	0.16	0.39	2.26	0.01	0.37	0.00	11.5319	0.0043
JF-P4-88	41.29	0.09	19.80	5.83	6.65	21.35	0.25	5.28	0.03	100.56	2.93	0.00	1.66	0.33	0.40	2.26	0.01	0.40	0.00	11.5480	0.0027
JF-P4-89	41.47	0.04	21.35	4.79	6.87	20.24	0.23	5.20	0.02	100.20	2.96	0.00	1.79	0.27	0.41	2.15	0.01	0.40	0.00	11.5413	0.0036
JF-P4-90	40.97	0.06	21.03	5.06	6.92	20.49	0.20	5.03	0.04	99.80	2.93	0.00	1.77	0.29	0.41	2.19	0.01	0.39	0.01	11.5330	0.0047
JF-P4-91	41.49	0.03	20.87	5.84	6.06	22.40	0.23	2.85	0.02	99.79	2.95	0.00	1.75	0.33	0.36	2.38	0.01	0.22	0.00	11.5189	0.0047
JF-P4-92	41.29	0.06	20.91	4.66	6.66	21.27	0.18	5.04	0.01	100.09	2.94	0.00	1.75	0.26	0.40	2.25	0.01	0.38	0.00	11.5388	0.0034
JF-P4-93	41.09	0.01	22.48	2.78	8.79	19.48	0.28	5.23	0.05	100.18	2.93	0.00	1.89	0.16	0.52	2.07	0.02	0.40	0.01	11.5349	0.0065
JF-P4-94	40.67	0.00	22.56	2.63	8.87	19.83	0.25	4.94	0.01	99.76	2.91	0.00	1.90	0.15	0.53	2.11	0.01	0.38	0.00	11.5278	0.0062
JF-P4-95	41.25	0.12	21.25	4.82	6.37	20.63	0.16	5.65	0.02	100.27	2.93	0.01	1.78	0.27	0.38	2.19	0.01	0.43	0.00	11.5472	0.0033
JF-P4-96	40.96	0.24	21.29	3.64	7.79	21.28	0.20	4.92	0.03	100.35	2.90	0.01	1.78	0.20	0.46	2.25	0.01	0.37	0.00	11.5424	0.0054
JF-P4-97	41.10	0.10	21.99	3.51	7.50	20.90	0.25	4.93	0.02	100.29	2.91	0.01	1.84	0.20	0.44	2.21	0.01	0.37	0.00	11.5349	0.0047
JF-P4-98	41.53	0.03	19.52	6.36	6.67	21.08	0.24	5.04	0.06	100.52	2.96	0.00	1.64	0.36	0.40	2.24	0.01	0.38	0.01	11.5449	0.0070
JF-P4-R1	41.81	0.08	23.14	1.02	9.73	18.22	0.13	6.38	0.03	100.53	2.98	0.00	1.94	0.06	0.58	1.94	0.01	0.49	0.00	11.5425	0.0036
JF-P4-R2	40.37	0.12	23.67	0.35	14.51	16.58	0.21	4.27	0.04	100.13	2.93	0.01	2.02	0.02	0.88	1.79	0.01	0.33	0.01	11.5303	0.0066
JF-P4-R3	41.44	0.95	21.52	0.76	10.79	19.59	0.17	5.25	0.04	100.50	2.96	0.05	1.81	0.04	0.64	2.08	0.01	0.40	0.01	11.5401	0.0045
JF-P4-R4	41.24	0.83	22.28	0.67	10.66	19.55	0.16	5.04	0.09	100.52	2.93	0.04	1.87	0.04	0.63	2.07	0.01	0.38	0.01	11.5426	0.0033
JF-P4-R5	41.69	0.81	23.48	0.15	9.01	20.63	0.15	4.39	0.06	100.36	2.94	0.04	1.95	0.01	0.53	2.17	0.01	0.33	0.01	11.5271	0.0049

Table 8: Koala, mount KO-D2.

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)									Unit Cell (Å)	Standard Deviation
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na		
1	42.20	0.36	22.59	0.12	10.40	19.29	0.48	5.02	0.00	100.46	3.00	0.02	1.89	0.01	0.62	2.05	0.03	0.38	0.00	11.5216	0.0036
2	42.20	0.36	22.59	0.12	10.40	19.29	0.48	5.02	0.00	100.46	3.00	0.02	1.89	0.01	0.62	2.05	0.03	0.38	0.00	11.5274	0.0044
3	41.99	0.31	22.77	0.36	8.99	20.20	0.49	3.95	0.06	99.12	3.01	0.02	1.92	0.02	0.54	2.16	0.03	0.30	0.00	11.5091	0.0041
4	42.23	0.34	22.73	0.20	9.00	20.36	0.54	3.98	0.05	99.41	3.01	0.02	1.91	0.01	0.54	2.17	0.03	0.30	0.00	11.5208	0.0032
5	38.99	0.12	22.26	0.08	23.90	8.95	0.58	6.05	0.00	100.93	2.95	0.01	1.99	0.00	1.51	1.01	0.04	0.49	0.00	11.5553	0.0049

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)									Unit Cell	Standard
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	(Å)	Deviation
6	41.01	0.56	21.36	0.69	14.03	16.64	0.61	4.54	0.08	99.51	3.01	0.03	1.85	0.04	0.86	1.82	0.04	0.36	0.00	11.5338	0.0043
7	40.75	0.11	23.48	0.09	11.75	14.00	0.35	9.39	0.06	99.98	2.97	0.01	2.02	0.01	0.72	1.52	0.02	0.73	0.00	11.5699	0.0044
8	42.26	0.28	23.81	0.24	8.97	20.11	0.42	3.88	0.06	100.03	3.00	0.01	1.99	0.01	0.53	2.13	0.03	0.29	0.00	11.5132	0.0049
9	41.82	0.42	23.01	0.43	9.53	19.53	0.63	4.23	0.06	99.67	2.99	0.02	1.94	0.02	0.57	2.08	0.04	0.32	0.00	11.5222	0.0034
10	41.35	0.45	22.74	0.63	10.92	18.92	0.52	4.35	0.07	99.95	2.97	0.02	1.92	0.04	0.66	2.02	0.03	0.33	0.00	11.5246	0.0041
11	43.10	0.03	22.84	0.47	6.62	18.19	0.33	7.54	0.05	99.18	3.09	0.00	1.93	0.03	0.40	1.95	0.02	0.58	0.00	11.5298	0.0042
12	41.13	0.47	23.19	0.05	10.38	12.92	0.21	12.39	0.08	100.83	2.98	0.03	1.98	0.00	0.63	1.40	0.01	0.96	0.00	11.6055	0.0050
13	40.96	0.28	23.62	0.04	8.87	9.16	0.15	18.01	0.10	101.20	2.99	0.02	2.03	0.00	0.54	1.00	0.01	1.41	0.01	11.6618	0.0044
14	42.11	0.28	22.87	0.31	10.44	18.64	0.35	5.37	0.03	100.39	3.00	0.02	1.92	0.02	0.62	1.98	0.02	0.41	0.00	11.5333	0.0040
15	42.08	0.35	23.42	0.10	9.13	19.90	0.39	4.61	0.04	100.02	2.99	0.02	1.96	0.01	0.54	2.11	0.02	0.35	0.00	11.5232	0.0041
16	40.78	0.34	23.11	0.00	15.67	14.03	0.56	6.41	0.07	100.96	2.97	0.02	1.99	0.00	0.96	1.53	0.03	0.50	0.00	11.5578	0.0045
17	39.65	0.02	21.48	0.00	15.65	5.66	0.46	16.74	0.12	99.78	3.02	0.00	1.93	0.00	1.00	0.64	0.03	1.37	0.01	11.6027	0.0032
18	43.40	0.03	23.24	0.14	6.08	18.32	0.40	7.71	0.06	99.38	3.10	0.00	1.96	0.01	0.36	1.95	0.02	0.59	0.00	11.5220	0.0055
19	42.53	0.38	23.95	0.08	8.93	19.84	0.45	4.73	0.06	100.96	2.99	0.02	1.99	0.00	0.53	2.08	0.03	0.36	0.00	11.5124	0.0044
20	41.91	0.50	23.00	0.11	12.50	15.92	0.43	7.02	0.08	101.48	3.00	0.03	1.94	0.01	0.75	1.70	0.03	0.54	0.00	11.5497	0.0062
21	40.77	0.00	23.58	0.04	12.92	14.72	0.40	7.54	0.04	100.02	2.97	0.00	2.03	0.00	0.79	1.60	0.02	0.59	0.00	11.5517	0.0051
22	42.00	0.40	23.62	0.13	9.18	19.29	0.49	4.51	0.06	99.68	3.00	0.02	1.99	0.01	0.55	2.05	0.03	0.35	0.00	11.5219	0.0043
23	40.34	0.83	21.89	0.09	13.84	12.02	0.42	10.74	0.11	100.27	2.98	0.05	1.91	0.01	0.86	1.32	0.03	0.85	0.01	11.6004	0.0067
24	41.54	0.42	22.79	0.08	11.22	17.72	0.37	5.63	0.03	99.79	3.00	0.02	1.94	0.00	0.68	1.90	0.02	0.43	0.00	11.5374	0.0057
25	42.32	0.49	23.60	0.22	9.95	19.69	0.54	4.08	0.06	100.95	2.99	0.03	1.97	0.01	0.59	2.07	0.03	0.31	0.00	11.5197	0.0059
26	40.36	0.51	22.97	0.06	16.98	13.32	0.54	6.10	0.19	101.02	2.96	0.03	1.99	0.00	1.04	1.46	0.03	0.48	0.01	11.5482	0.0057
27	39.13	0.03	21.48	0.05	15.51	5.83	0.54	16.72	0.11	99.41	2.99	0.00	1.94	0.00	0.99	0.66	0.03	1.37	0.01	11.5998	0.0048
28	42.26	0.39	23.10	0.21	10.11	19.06	0.41	5.24	0.04	100.81	3.00	0.02	1.93	0.01	0.60	2.02	0.02	0.40	0.00	11.5285	0.0043
29	41.81	0.35	23.82	0.06	9.02	19.67	0.53	4.82	0.08	100.15	2.97	0.02	1.99	0.00	0.54	2.08	0.03	0.37	0.00	11.5220	0.0046
30	39.40	0.13	22.22	0.03	20.19	7.46	0.63	9.92	0.02	100.00	3.01	0.01	2.00	0.00	1.29	0.85	0.04	0.81	0.00	11.5832	0.0066
31	43.34	0.02	23.41	0.09	5.98	18.86	0.46	7.05	0.05	99.28	3.09	0.00	1.97	0.01	0.36	2.01	0.03	0.54	0.00	11.5175	0.0054
32	42.10	0.30	23.96	0.10	9.06	19.40	0.64	5.03	0.05	100.63	2.98	0.02	2.00	0.01	0.54	2.05	0.04	0.38	0.00	11.5263	0.0028
33	41.54	0.33	23.61	0.10	10.84	18.01	0.53	5.34	0.09	100.39	2.97	0.02	1.99	0.01	0.65	1.92	0.03	0.41	0.00	11.5301	0.0044
34	41.88	0.40	22.92	0.12	8.58	20.28	0.39	4.39	0.03	98.99	3.00	0.02	1.93	0.01	0.51	2.16	0.02	0.34	0.00	11.5251	0.0032
35	42.30	0.34	24.01	0.10	9.00	19.89	0.43	4.78	0.07	100.92	2.98	0.02	1.99	0.01	0.53	2.09	0.03	0.36	0.00	11.5325	0.0044
36	40.67	0.35	23.84	0.00	10.44	10.85	0.32	14.26	0.09	100.83	2.97	0.02	2.05	0.00	0.64	1.18	0.02	1.12	0.00	11.6310	0.0062
37	40.68	0.36	23.42	0.00	8.77	9.24	0.17	17.95	0.09	100.70	2.98	0.02	2.02	0.00	0.54	1.01	0.01	1.41	0.00	11.6613	0.0041
38	39.45	0.03	21.85	0.00	15.66	5.75	0.49	16.61	0.11	99.94	3.00	0.00	1.96	0.00	1.00	0.65	0.03	1.35	0.01	11.6033	0.0043
39	40.37	0.03	22.05	0.05	11.73	9.43	0.40	16.27	0.14	100.46	2.99	0.00	1.92	0.00	0.73	1.04	0.03	1.29	0.01	11.5881	0.0052
40	41.84	0.38	23.68	0.12	8.97	20.15	0.32	4.08	0.05	99.59	2.98	0.02	1.99	0.01	0.53	2.14	0.02	0.31	0.00	11.5064	0.0049
41	41.85	0.49	23.25	0.23	9.47	19.52	0.52	4.49	0.07	99.89	2.99	0.03	1.96	0.01	0.57	2.08	0.03	0.34	0.00	11.5230	0.0053
42	39.03	0.17	21.81	0.06	18.80	6.45	0.59	13.03	0.11	100.05	2.98	0.01	1.96	0.00	1.20	0.73	0.04	1.07	0.01	11.5937	0.0066

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)									Unit Cell	Standard
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	(Å)	Deviation
43	41.98	0.53	22.81	0.32	8.69	20.34	0.33	4.20	0.03	99.22	3.00	0.03	1.92	0.02	0.52	2.17	0.02	0.32	0.00	11.5245	0.0043
44	41.67	0.35	23.11	0.11	10.91	16.41	0.43	7.53	0.05	100.57	2.99	0.02	1.96	0.01	0.66	1.76	0.03	0.58	0.00	11.5446	0.0069
45	No data available																				
46	42.39	0.04	23.19	0.06	11.54	12.09	0.48	10.90	0.18	100.87	3.09	0.00	1.99	0.00	0.70	1.31	0.03	0.85	0.01	11.5580	0.0040
47	42.11	0.37	23.17	0.10	10.03	19.08	0.34	4.90	0.02	100.12	3.00	0.02	1.95	0.01	0.60	2.03	0.02	0.37	0.00	11.5281	0.0043
48	42.66	0.39	23.94	0.13	8.98	20.23	0.43	4.15	0.07	100.97	3.00	0.02	1.98	0.01	0.53	2.12	0.03	0.31	0.00	11.5210	0.0047
49	41.41	0.36	23.14	0.06	9.93	18.67	0.53	5.12	0.03	99.26	2.98	0.02	1.96	0.00	0.60	2.00	0.03	0.40	0.00	11.5321	0.0052
50	40.74	0.20	22.45	0.15	15.49	10.91	0.51	9.68	0.06	100.15	3.03	0.01	1.97	0.01	0.96	1.21	0.03	0.77	0.00	11.5654	0.0057
51	42.89	0.53	23.48	0.43	8.24	20.80	0.40	3.93	0.06	100.76	3.02	0.03	1.95	0.02	0.48	2.18	0.02	0.30	0.00	11.5185	0.0057
52	39.55	0.03	21.61	0.04	15.57	5.70	0.51	16.67	0.12	99.80	3.01	0.00	1.94	0.00	0.99	0.65	0.03	1.36	0.01	11.5633	0.0078
53	42.98	0.03	22.71	0.04	6.88	17.53	0.28	8.91	0.04	99.40	3.08	0.00	1.92	0.00	0.41	1.88	0.02	0.68	0.00	11.5363	0.0056
54	42.13	0.35	23.25	0.24	10.21	18.75	0.44	5.21	0.02	100.61	3.00	0.02	1.95	0.01	0.61	1.99	0.03	0.40	0.00	11.5365	0.0045
55	39.00	0.21	21.69	0.00	19.24	6.05	0.60	13.25	0.13	100.15	2.98	0.01	1.95	0.00	1.23	0.69	0.04	1.09	0.01	11.6011	0.0046
56	40.21	0.72	23.11	0.00	11.03	8.09	0.17	17.55	0.24	101.12	2.97	0.04	2.01	0.00	0.68	0.89	0.01	1.39	0.01	11.6735	0.0056
57	42.11	0.41	23.56	0.11	9.05	20.30	0.43	4.09	0.07	100.13	2.98	0.02	1.97	0.01	0.54	2.14	0.03	0.31	0.00	11.5193	0.0038
58	40.42	0.03	22.01	0.05	11.78	9.57	0.47	15.63	0.13	100.09	3.00	0.00	1.93	0.00	0.73	1.06	0.03	1.24	0.01	11.5831	0.0086
59	43.29	0.03	22.83	0.08	6.96	17.60	0.35	8.85	0.03	100.01	3.09	0.00	1.92	0.00	0.42	1.87	0.02	0.68	0.00	11.5302	0.0050
60	40.02	0.05	21.70	0.04	11.89	8.15	0.33	18.81	0.21	101.19	2.95	0.00	1.89	0.00	0.73	0.90	0.02	1.49	0.01	11.6064	0.0056
61	43.37	0.02	23.09	0.12	5.76	19.16	0.38	7.36	0.03	99.28	3.09	0.00	1.94	0.01	0.34	2.03	0.02	0.56	0.00	11.5252	0.0060
62	40.85	0.05	22.47	0.05	19.13	6.86	0.35	11.45	0.25	101.47	3.07	0.00	1.99	0.00	1.20	0.77	0.02	0.92	0.01	11.6156	0.0056
63	40.28	0.61	22.58	0.07	17.54	11.74	0.43	7.88	0.18	101.31	2.97	0.03	1.96	0.00	1.08	1.29	0.03	0.62	0.01	11.5759	0.0062
64	39.19	0.02	21.52	0.04	15.50	6.07	0.57	16.58	0.10	99.60	2.99	0.00	1.93	0.00	0.99	0.69	0.04	1.35	0.01	11.5989	0.0029
65	41.95	0.40	23.60	0.09	10.74	19.21	0.36	3.94	0.07	100.35	2.99	0.02	1.98	0.01	0.64	2.04	0.02	0.30	0.00	11.5190	0.0029
66	42.01	0.11	23.35	0.12	12.68	15.19	0.37	6.64	0.07	100.51	3.04	0.01	1.99	0.01	0.77	1.64	0.02	0.52	0.00	11.5333	0.0050
67	41.26	0.46	23.05	0.03	11.83	13.84	0.38	10.25	0.03	101.13	2.98	0.03	1.96	0.00	0.72	1.49	0.02	0.79	0.00	11.5922	0.0044
68	40.41	0.02	22.09	0.05	13.96	6.78	0.42	18.20	0.12	102.05	2.99	0.00	1.92	0.00	0.86	0.75	0.03	1.44	0.01	11.6007	0.0045
69	39.77	0.03	21.66	0.05	15.66	5.72	0.51	17.03	0.13	100.55	3.01	0.00	1.93	0.00	0.99	0.65	0.03	1.38	0.01	11.6046	0.0073
70	42.85	0.03	22.76	0.14	7.57	16.58	0.37	9.81	0.03	100.14	3.07	0.00	1.92	0.01	0.45	1.77	0.02	0.75	0.00	11.5366	0.0043
71	41.15	0.02	22.03	0.20	12.50	10.46	0.46	12.75	0.08	99.65	3.06	0.00	1.93	0.01	0.78	1.16	0.03	1.02	0.00	11.5721	0.0048
72	42.59	0.02	23.09	0.05	7.40	16.24	0.32	9.78	0.08	99.58	3.07	0.00	1.96	0.00	0.45	1.74	0.02	0.75	0.00	-	-
73	42.20	0.34	23.77	0.06	9.04	19.58	0.60	4.88	0.05	100.51	2.99	0.02	1.98	0.00	0.54	2.07	0.04	0.37	0.00	11.5268	0.0064
74	40.98	0.03	21.93	0.15	12.59	10.43	0.41	12.65	0.07	99.25	3.06	0.00	1.93	0.01	0.79	1.16	0.03	1.01	0.00	11.5715	0.0049
75	41.20	0.06	21.85	0.05	17.68	7.43	0.44	12.76	0.19	101.66	3.08	0.00	1.92	0.00	1.10	0.83	0.03	1.02	0.01	11.6302	0.0059
76	41.61	0.45	22.42	0.47	11.33	18.34	0.44	5.38	0.04	100.47	2.98	0.02	1.89	0.03	0.68	1.96	0.03	0.41	0.00	11.5357	0.0057
77	43.36	0.03	22.96	0.58	6.71	18.48	0.34	6.89	0.07	99.42	3.10	0.00	1.94	0.03	0.40	1.97	0.02	0.53	0.00	11.5187	0.0051
78	41.64	0.46	22.94	0.45	9.81	19.44	0.31	4.50	0.06	99.60	2.98	0.02	1.94	0.03	0.59	2.08	0.02	0.35	0.00	11.5276	0.0025
79	39.07	0.07	21.90	0.06	21.67	6.65	0.67	9.88	0.00	99.95	3.00	0.00	1.98	0.00	1.39	0.76	0.04	0.81	0.00	11.5809	0.0049

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)									Unit Cell (Å)	Standard Deviation
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na		
80	38.90	0.08	21.47	0.04	23.57	5.64	0.78	9.50	0.00	99.96	3.01	0.00	1.96	0.00	1.53	0.65	0.05	0.79	0.00	11.5736	0.0066
81	39.22	0.05	21.69	0.00	21.56	6.88	0.87	9.62	0.00	99.87	3.01	0.00	1.96	0.00	1.39	0.79	0.06	0.79	0.00	11.5693	0.0050
82	39.76	0.00	22.21	0.06	21.01	7.76	0.65	8.88	0.01	100.33	3.02	0.00	1.99	0.00	1.34	0.88	0.04	0.72	0.00	11.5708	0.0060
83	39.17	0.05	21.60	0.04	22.03	6.48	0.92	9.24	0.00	99.52	3.03	0.00	1.97	0.00	1.42	0.75	0.06	0.77	0.00	11.5691	0.0053
84	40.30	0.03	22.66	0.00	18.35	9.92	0.49	8.42	0.00	100.17	3.02	0.00	2.00	0.00	1.15	1.11	0.03	0.68	0.00	11.5557	0.0048
85	39.54	0.00	21.88	0.11	21.66	7.19	0.88	8.91	0.01	100.17	3.03	0.00	1.97	0.01	1.39	0.82	0.06	0.73	0.00	11.5709	0.0095
86	38.87	0.09	21.62	0.07	22.27	5.31	1.29	10.78	0.02	100.30	3.00	0.01	1.97	0.00	1.44	0.61	0.08	0.89	0.00	11.5902	0.0047
87	40.12	0.00	22.15	0.08	20.64	8.23	0.43	8.45	0.04	100.12	3.05	0.00	1.98	0.00	1.31	0.93	0.03	0.69	0.00	11.5714	0.0053
88	39.70	0.00	22.02	0.10	20.79	8.29	0.52	8.39	0.02	99.82	3.03	0.00	1.98	0.01	1.33	0.94	0.03	0.69	0.00	11.5648	0.0052
89	39.48	0.09	21.78	0.00	23.27	6.07	0.74	9.09	0.02	100.54	3.03	0.00	1.97	0.00	1.50	0.70	0.05	0.75	0.00	11.5756	0.0066
90	39.98	0.01	21.69	0.00	16.69	5.97	0.28	16.08	0.00	100.71	3.02	0.00	1.93	0.00	1.05	0.67	0.02	1.30	0.00	11.5996	0.0035

Table 9: Koala, mount KO-D4.

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
48	40.94	0.62	22.01	1.02	10.54	19.25	0.30	4.30	0.07	99.05	2.96	0.03	1.88	0.06	0.64	2.08	0.02	0.33	0.00	11.5100	0.0055
49	41.14	0.58	23.19	0.07	8.81	20.34	0.32	4.84	0.06	99.36	2.93	0.03	1.95	0.00	0.53	2.16	0.02	0.37	0.00	11.5018	0.0055
50	41.02	0.66	22.61	0.78	11.53	19.32	0.30	4.29	0.09	100.60	2.93	0.04	1.90	0.04	0.69	2.05	0.02	0.33	0.00	11.4978	0.0054
51	42.86	0.29	23.65	0.39	9.36	19.89	0.42	4.00	0.07	100.93	3.02	0.02	1.97	0.02	0.55	2.09	0.03	0.30	0.00	11.5025	0.0062
52	42.92	0.41	23.17	0.61	8.51	20.57	0.39	3.98	0.09	100.65	3.03	0.02	1.93	0.03	0.50	2.16	0.02	0.30	0.00	11.4974	0.0059
53	39.04	0.23	21.87	0.07	23.11	6.24	0.60	9.83	0.14	101.12	2.98	0.01	1.97	0.00	1.48	0.71	0.04	0.80	0.01	11.5028	0.0105
54	42.43	0.34	22.59	0.24	10.15	18.63	0.38	5.34	0.03	100.13	3.04	0.02	1.90	0.01	0.61	1.99	0.02	0.41	0.00	11.4983	0.0091
55	40.43	0.29	22.28	0.18	18.37	11.22	0.43	7.46	0.11	100.78	3.01	0.02	1.95	0.01	1.14	1.24	0.03	0.59	0.01	11.5901	0.0127
56	42.15	0.27	22.71	0.10	11.00	17.52	0.42	5.73	0.02	99.92	3.04	0.01	1.93	0.01	0.66	1.88	0.03	0.44	0.00	11.5274	0.0054
57	41.94	0.20	23.16	0.08	13.12	17.43	0.54	4.13	0.06	100.67	3.01	0.01	1.96	0.00	0.79	1.87	0.03	0.32	0.00	11.5250	0.0040
58	42.54	0.31	23.19	0.14	10.05	18.83	0.32	4.97	0.02	100.38	3.03	0.02	1.95	0.01	0.60	2.00	0.02	0.38	0.00	11.5153	0.0067
59	37.88	0.16	21.43	0.13	24.00	3.03	2.68	12.19	0.03	101.54	2.93	0.01	1.96	0.01	1.55	0.35	0.18	1.01	0.00	11.5171	0.0054
60	38.25	0.06	21.87	0.00	25.39	5.34	1.23	8.73	0.04	100.91	2.95	0.00	1.99	0.00	1.64	0.61	0.08	0.72	0.00	11.5763	0.0114
61	41.79	0.29	22.93	0.40	12.91	17.51	0.46	3.85	0.09	100.23	3.02	0.02	1.95	0.02	0.78	1.88	0.03	0.30	0.00	11.5090	0.0055
62	42.79	0.41	22.82	0.17	8.55	20.17	0.50	4.45	0.03	99.89	3.04	0.02	1.91	0.01	0.51	2.14	0.03	0.34	0.00	11.5081	0.0081
63	42.14	0.31	22.68	0.46	9.00	19.79	0.41	4.29	0.05	99.12	3.02	0.02	1.92	0.03	0.54	2.12	0.02	0.33	0.00	11.4995	0.0074
64	42.34	0.33	23.15	0.21	9.80	18.75	0.51	5.33	0.04	100.45	3.01	0.02	1.94	0.01	0.58	1.99	0.03	0.41	0.00	11.5164	0.0064

Table 10: Premier, mount PR-P1.

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
PR-P1-01	41.89	1.47	18.80	3.90	9.23	19.92	0.19	5.01	0.10	100.51	3.01	0.08	1.59	0.22	0.55	2.13	0.01	0.39	0.01	11.5613	0.0054
PR-P1-02	41.38	0.67	18.82	5.95	6.57	20.67	0.21	5.40	0.04	99.71	2.98	0.04	1.60	0.34	0.40	2.22	0.01	0.42	0.01	11.5572	0.0035
PR-P1-03	41.61	0.00	15.97	9.83	6.52	20.57	0.18	5.12	0.00	99.80	3.03	0.00	1.37	0.57	0.40	2.23	0.01	0.40	0.00	11.5669	0.0033
PR-P1-04	42.53	1.06	21.13	1.78	9.61	19.72	0.16	4.49	0.07	100.55	3.03	0.06	1.78	0.10	0.57	2.10	0.01	0.34	0.01	11.5370	0.0050
PR-P1-05	41.77	1.17	19.25	4.48	7.30	21.01	0.15	5.31	0.08	100.52	2.98	0.06	1.62	0.25	0.43	2.23	0.01	0.41	0.01	11.5583	0.0056
PR-P1-06	41.75	1.10	18.66	5.98	6.58	20.75	0.16	5.44	0.10	100.52	2.99	0.06	1.57	0.34	0.39	2.21	0.01	0.42	0.01	11.5687	0.0027
PR-P1-07	41.28	0.40	17.46	8.36	6.33	20.70	0.22	5.27	0.01	100.03	2.98	0.02	1.49	0.48	0.38	2.23	0.01	0.41	0.00	11.5617	0.0032
PR-P1-08	42.01	0.59	20.97	3.97	7.08	20.39	0.13	4.94	0.07	100.15	3.00	0.03	1.76	0.22	0.42	2.17	0.01	0.38	0.01	11.5457	0.0033
PR-P1-09	42.15	0.85	22.15	1.77	7.86	20.75	0.15	4.52	0.04	100.24	2.99	0.05	1.85	0.10	0.47	2.19	0.01	0.34	0.01	11.5376	0.0060
PR-P1-10	41.70	1.08	21.28	0.42	12.39	18.75	0.23	4.65	0.08	100.58	2.99	0.06	1.80	0.02	0.74	2.00	0.01	0.36	0.01	11.5452	0.0043
PR-P1-11	41.99	0.42	21.91	2.25	6.98	21.88	0.14	4.58	0.05	100.20	2.96	0.02	1.82	0.13	0.41	2.30	0.01	0.35	0.01	11.5290	0.0041
PR-P1-12	41.34	0.17	16.95	9.38	6.15	20.83	0.15	5.00	0.04	100.01	2.99	0.01	1.44	0.54	0.37	2.25	0.01	0.39	0.01	11.5598	0.0046
PR-P1-13	41.67	0.01	15.62	10.62	6.39	21.00	0.21	4.91	0.03	100.46	3.01	0.00	1.33	0.61	0.39	2.26	0.01	0.38	0.00	11.5681	0.0030
PR-P1-14	42.61	0.82	21.56	2.04	7.23	21.30	0.10	4.44	0.09	100.19	3.01	0.04	1.80	0.11	0.43	2.25	0.01	0.34	0.01	11.5353	0.0039
PR-P1-15	41.95	0.86	16.87	7.68	6.46	20.89	0.14	5.33	0.05	100.23	3.02	0.05	1.43	0.44	0.39	2.24	0.01	0.41	0.01	11.5657	0.0045
PR-P1-16	41.71	1.04	21.54	1.41	8.25	21.23	0.13	4.59	0.09	99.99	2.96	0.06	1.80	0.08	0.49	2.25	0.01	0.35	0.01	11.5346	0.0049
PR-P1-17	41.59	0.43	16.36	9.90	5.55	21.20	0.11	5.34	0.03	100.51	2.99	0.02	1.39	0.56	0.33	2.27	0.01	0.41	0.00	11.5728	0.0038
PR-P1-18	42.30	1.15	18.14	5.40	7.22	20.58	0.16	5.58	0.07	100.60	3.03	0.06	1.53	0.31	0.43	2.20	0.01	0.43	0.01	11.5648	0.0037
PR-P1-19	41.46	0.34	18.41	6.30	6.65	21.20	0.19	5.51	0.03	100.09	2.97	0.02	1.55	0.36	0.40	2.26	0.01	0.42	0.00	11.5551	0.0040
PR-P1-20	41.87	0.90	21.21	1.65	9.34	20.46	0.16	4.39	0.10	100.08	2.99	0.05	1.78	0.09	0.56	2.17	0.01	0.34	0.01	11.5371	0.0050
PR-P1-21	41.57	0.58	18.55	6.40	6.60	20.70	0.18	5.90	0.01	100.49	2.97	0.03	1.56	0.36	0.39	2.21	0.01	0.45	0.00	11.5617	0.0038
PR-P1-22	41.90	0.74	21.96	1.63	8.88	20.41	0.16	4.46	0.09	100.23	2.98	0.04	1.84	0.09	0.53	2.16	0.01	0.34	0.01	11.5385	0.0055
PR-P1-23	41.76	0.32	19.47	6.51	6.38	19.68	0.16	6.26	0.00	100.54	2.99	0.02	1.64	0.37	0.38	2.10	0.01	0.48	0.00	11.5657	0.0049
PR-P1-24	41.41	0.77	21.14	3.83	8.28	18.93	0.27	5.33	0.08	100.04	2.98	0.04	1.79	0.22	0.50	2.03	0.02	0.41	0.01	11.5558	0.0029
PR-P1-25	41.39	0.46	21.33	3.94	6.64	20.95	0.09	4.98	0.04	99.82	2.95	0.02	1.79	0.22	0.40	2.23	0.01	0.38	0.01	11.5380	0.0040
PR-P1-26	42.24	0.18	19.89	5.49	5.81	21.82	0.12	4.62	0.03	100.20	3.00	0.01	1.66	0.31	0.35	2.31	0.01	0.35	0.00	11.5398	0.0039
PR-P1-27	41.49	0.43	20.52	5.00	6.80	20.68	0.22	5.34	0.05	100.53	2.95	0.02	1.72	0.28	0.40	2.19	0.01	0.41	0.01	11.5500	0.0035
PR-P1-28	41.42	1.11	21.25	1.50	10.36	20.06	0.14	4.61	0.13	100.58	2.95	0.06	1.78	0.08	0.62	2.13	0.01	0.35	0.02	11.5417	0.0046
PR-P1-29	41.24	1.22	18.35	5.76	7.18	20.84	0.15	5.51	0.10	100.35	2.96	0.07	1.55	0.33	0.43	2.23	0.01	0.42	0.01	11.5664	0.0050
PR-P1-30	41.11	0.52	20.89	4.22	6.20	21.81	0.07	4.86	0.06	99.74	2.92	0.03	1.75	0.24	0.37	2.31	0.00	0.37	0.01	11.5404	0.0042
PR-P1-31	41.53	1.27	21.49	1.73	9.00	20.63	0.10	4.72	0.12	100.59	2.94	0.07	1.80	0.10	0.53	2.18	0.01	0.36	0.02	11.5431	0.0043
PR-P1-32	41.47	0.47	19.37	5.49	6.46	21.11	0.14	5.41	0.05	99.97	2.97	0.03	1.63	0.31	0.39	2.25	0.01	0.41	0.01	11.5476	0.0056
PR-P1-33	40.56	0.54	11.93	14.28	7.45	17.36	0.20	8.03	0.09	100.44	3.02	0.03	1.05	0.84	0.46	1.93	0.01	0.64	0.01	11.6316	0.0037

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
PR-P1-34	41.36	0.89	21.66	0.42	11.92	18.58	0.15	4.67	0.09	99.74	2.98	0.05	1.84	0.02	0.72	2.00	0.01	0.36	0.01	11.5443	0.0053
PR-P1-35	41.40	0.13	18.01	7.74	6.11	20.95	0.11	5.55	0.03	100.03	2.98	0.01	1.53	0.44	0.37	2.25	0.01	0.43	0.00	11.5606	0.0042
PR-P1-36	41.69	0.25	18.35	6.95	6.03	21.05	0.17	5.58	0.04	100.11	2.99	0.01	1.55	0.39	0.36	2.25	0.01	0.43	0.01	11.5595	0.0050
PR-P1-37	41.65	1.05	19.49	4.77	6.00	21.25	0.14	5.34	0.13	99.82	2.98	0.06	1.64	0.27	0.36	2.26	0.01	0.41	0.02	11.5572	0.0027
PR-P1-38	41.95	0.59	18.99	6.10	6.16	20.69	0.12	5.67	0.06	100.33	3.00	0.03	1.60	0.34	0.37	2.21	0.01	0.43	0.01	11.5564	0.0048
PR-P1-39	41.00	1.31	17.39	6.76	7.43	19.99	0.26	5.64	0.11	99.89	2.97	0.07	1.49	0.39	0.45	2.16	0.02	0.44	0.02	11.5788	0.0038
PR-P1-40	41.68	0.77	21.65	1.83	8.38	21.34	0.13	4.52	0.09	100.39	2.95	0.04	1.80	0.10	0.50	2.25	0.01	0.34	0.01	11.5367	0.0035
PR-P1-41	41.96	0.98	22.50	0.96	10.77	18.63	0.13	4.43	0.09	100.45	3.00	0.05	1.90	0.05	0.64	1.99	0.01	0.34	0.01	11.5388	0.0043
PR-P1-42	41.07	0.92	17.55	7.04	7.87	18.94	0.13	6.70	0.07	100.29	2.98	0.05	1.50	0.40	0.48	2.05	0.01	0.52	0.01	11.5916	0.0043
PR-P1-43	41.20	1.29	20.01	4.03	7.32	20.47	0.18	5.25	0.10	99.85	2.95	0.07	1.69	0.23	0.44	2.19	0.01	0.40	0.01	11.5444	0.0057
PR-P1-44	42.36	0.14	19.15	6.73	6.52	20.24	0.15	5.24	0.04	100.57	3.03	0.01	1.61	0.38	0.39	2.16	0.01	0.40	0.01	11.5500	0.0046
PR-P1-45	41.72	0.56	19.16	6.03	6.37	20.79	0.15	5.65	0.05	100.48	2.98	0.03	1.61	0.34	0.38	2.21	0.01	0.43	0.01	11.5565	0.0040
PR-P1-46	41.30	1.10	15.92	8.66	6.41	20.01	0.16	6.22	0.09	99.87	3.01	0.06	1.37	0.50	0.39	2.17	0.01	0.49	0.01	11.5899	0.0030
PR-P1-47	41.96	0.93	21.23	1.71	8.64	21.15	0.13	4.45	0.08	100.28	2.98	0.05	1.77	0.10	0.51	2.24	0.01	0.34	0.01	11.5367	0.0036
PR-P1-48	41.55	0.26	21.24	3.42	6.87	21.32	0.14	5.08	0.05	99.93	2.95	0.01	1.78	0.19	0.41	2.26	0.01	0.39	0.01	11.5360	0.0037
PR-P1-49	41.37	0.06	15.83	9.97	6.35	20.19	0.15	5.81	0.02	99.75	3.02	0.00	1.36	0.57	0.39	2.19	0.01	0.45	0.00	11.5729	0.0027
PR-P1-50	42.01	0.66	18.25	6.32	6.67	20.86	0.17	5.56	0.06	100.56	3.00	0.04	1.54	0.36	0.40	2.22	0.01	0.43	0.01	11.5637	0.0031
PR-P1-51	41.77	1.32	18.38	5.33	6.79	21.37	0.19	5.25	0.16	100.56	2.98	0.07	1.54	0.30	0.40	2.27	0.01	0.40	0.02	11.5649	0.0033
PR-P1-52	42.01	1.15	20.13	1.07	10.82	20.18	0.12	4.42	0.09	99.99	3.01	0.06	1.70	0.06	0.65	2.16	0.01	0.34	0.01	11.5445	0.0055
PR-P1-53	41.23	1.53	17.36	5.73	9.65	19.17	0.19	5.55	0.15	100.56	2.99	0.08	1.48	0.33	0.58	2.07	0.01	0.43	0.02	11.5836	0.0036
PR-P1-54	41.24	0.17	19.55	6.59	5.90	20.90	0.17	5.46	0.03	100.01	2.95	0.01	1.65	0.37	0.35	2.23	0.01	0.42	0.00	11.5546	0.0038
PR-P1-55	42.03	1.47	17.27	5.97	7.97	19.80	0.17	5.66	0.11	100.45	3.03	0.08	1.47	0.34	0.48	2.13	0.01	0.44	0.02	11.5835	0.0040
PR-P1-56	41.58	0.02	20.31	5.94	5.69	22.80	0.10	3.42	0.00	99.86	2.95	0.00	1.70	0.33	0.34	2.41	0.01	0.26	0.00	11.5149	0.0041
PR-P1-57	41.85	1.07	21.58	1.79	9.62	19.61	0.15	4.70	0.08	100.45	2.99	0.06	1.82	0.10	0.57	2.09	0.01	0.36	0.01	11.5466	0.0035
PR-P1-58	41.55	1.03	19.14	5.55	6.96	20.87	0.11	5.27	0.09	100.57	2.96	0.06	1.61	0.31	0.42	2.22	0.01	0.40	0.01	11.5601	0.0047
PR-P1-59	42.37	0.79	20.45	3.74	7.49	20.56	0.13	4.91	0.07	100.51	3.01	0.04	1.71	0.21	0.45	2.18	0.01	0.37	0.01	11.5442	0.0042
PR-P1-60	41.70	0.93	20.85	2.13	9.76	20.21	0.15	4.40	0.10	100.23	2.98	0.05	1.76	0.12	0.58	2.15	0.01	0.34	0.01	11.5428	0.0036
PR-P1-61	41.96	0.79	21.95	1.89	7.49	21.36	0.10	4.26	0.06	99.86	2.98	0.04	1.83	0.11	0.44	2.26	0.01	0.32	0.01	11.5310	0.0035
PR-P1-62	42.29	1.30	20.56	3.07	8.73	19.48	0.17	4.73	0.14	100.47	3.03	0.07	1.73	0.17	0.52	2.08	0.01	0.36	0.02	11.5571	0.0032
PR-P1-63	41.80	1.52	20.42	0.87	13.53	16.81	0.19	5.07	0.14	100.35	3.04	0.08	1.75	0.05	0.82	1.82	0.01	0.40	0.02	11.5638	0.0034
PR-P1-64	41.88	0.41	18.69	7.14	6.59	20.90	0.17	4.71	0.03	100.52	3.00	0.02	1.58	0.40	0.39	2.23	0.01	0.36	0.00	11.5506	0.0045
PR-P1-65	41.30	0.27	21.59	3.01	6.56	22.30	0.13	4.77	0.03	99.96	2.92	0.01	1.80	0.17	0.39	2.35	0.01	0.36	0.00	11.5323	0.0049

Table 11: Roberts Victor, mounts RV-P1, RV-P2, RV-P3 and RV-P5.

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
RV-P1-01	40.67	0.49	21.97	0.14	20.54	11.05	0.53	4.79	0.00	100.18	3.06	0.03	1.95	0.01	1.29	1.24	0.03	0.39	0.00	11.5436	0.0031
RV-P1-02	42.77	0.02	20.88	4.95	6.00	22.49	0.37	2.47	0.00	99.95	3.03	0.00	1.75	0.28	0.36	2.38	0.02	0.19	0.00	11.5187	0.0044
RV-P1-03	43.04	0.02	21.00	5.18	5.74	22.58	0.30	2.60	0.00	100.46	3.04	0.00	1.75	0.29	0.34	2.37	0.02	0.20	0.00	11.5494	0.0039
RV-P2-04	40.83	0.27	23.35	0.28	12.56	13.12	0.29	9.20	0.00	99.90	3.00	0.01	2.02	0.02	0.77	1.44	0.02	0.72	0.00	11.5506	0.0056
RV-P2-05	40.62	0.15	23.21	0.28	17.51	14.09	0.37	3.67	0.00	99.90	3.00	0.01	2.02	0.02	1.08	1.55	0.02	0.29	0.00	11.5250	0.0056
RV-P2-06	42.22	0.34	24.12	0.13	10.31	17.28	0.25	6.09	0.00	100.74	3.01	0.02	2.03	0.01	0.62	1.84	0.02	0.47	0.00	11.5461	0.0033
RV-P3-07	42.28	0.23	22.42	1.57	11.24	17.28	0.55	4.63	0.00	100.20	3.06	0.01	1.91	0.09	0.68	1.86	0.03	0.36	0.00	11.5317	0.0051
RV-P3-08	41.13	0.29	22.37	0.49	16.93	14.04	1.04	3.56	0.00	99.85	3.05	0.02	1.96	0.03	1.05	1.55	0.07	0.28	0.00	11.5292	0.0056
RV-P3-09	42.92	0.38	22.71	2.34	6.47	21.13	0.39	4.14	0.00	100.48	3.03	0.02	1.89	0.13	0.38	2.22	0.02	0.31	0.00	11.5224	0.0053
RV-P4	No data available																				
RV-P5-01	41.47	0.24	22.55	2.48	8.05	20.34	0.19	4.35	0.11	99.77	2.95	0.01	1.89	0.14	0.48	2.16	0.01	0.33	0.01	11.5203	0.0051
RV-P5-02	41.22	0.08	19.38	6.80	7.15	19.57	0.23	5.99	0.02	100.44	2.96	0.00	1.64	0.39	0.43	2.10	0.01	0.46	0.00	11.5494	0.0045
RV-P5-03	41.33	0.02	21.21	4.36	7.52	19.94	0.16	5.39	0.03	99.96	2.96	0.00	1.79	0.25	0.45	2.13	0.01	0.41	0.00	11.5366	0.0053
RV-P5-04	41.63	0.10	21.13	4.44	7.45	20.21	0.23	4.90	0.11	100.21	2.97	0.01	1.78	0.25	0.44	2.15	0.01	0.37	0.02	11.5364	0.0043
RV-P5-05	42.67	0.16	21.32	3.75	7.74	18.37	0.22	5.81	0.04	100.06	3.07	0.01	1.81	0.21	0.47	1.97	0.01	0.45	0.01	11.5516	0.0053
RV-P5-06	41.68	0.14	22.14	2.36	10.81	18.23	0.23	4.88	0.10	100.58	2.99	0.01	1.87	0.13	0.65	1.95	0.01	0.37	0.01	11.5341	0.0040
RV-P5-07	41.54	0.00	19.68	6.88	6.13	21.36	0.22	3.92	0.07	99.77	2.98	0.00	1.66	0.39	0.37	2.28	0.01	0.30	0.01	11.5373	0.0035
RV-P5-08	41.52	0.24	19.03	6.84	6.29	20.57	0.16	5.00	0.06	99.72	2.99	0.01	1.62	0.39	0.38	2.21	0.01	0.39	0.01	11.5560	0.0041
RV-P5-09	41.86	0.19	19.59	6.98	5.78	20.59	0.08	4.92	0.06	100.04	3.00	0.01	1.66	0.40	0.35	2.20	0.00	0.38	0.01	11.5570	0.0055
RV-P5-10	42.06	0.07	16.74	10.53	5.75	21.63	0.16	3.39	0.06	100.40	3.03	0.00	1.42	0.60	0.35	2.32	0.01	0.26	0.01	11.5461	0.0032
RV-P5-11	41.45	0.02	19.54	7.48	6.33	23.04	0.15	2.04	0.02	100.07	2.95	0.00	1.64	0.42	0.38	2.44	0.01	0.16	0.00	11.5165	0.0053
RV-P5-12	41.67	0.24	17.60	8.55	5.86	20.53	0.16	5.82	0.04	100.46	2.99	0.01	1.49	0.49	0.35	2.20	0.01	0.45	0.01	11.5699	0.0043
RV-P5-13	41.85	0.09	21.21	4.37	7.18	20.26	0.17	4.95	0.07	100.15	2.98	0.00	1.78	0.25	0.43	2.15	0.01	0.38	0.01	11.5490	0.0041
RV-P5-14	39.44	0.22	23.29	0.02	16.57	10.56	0.11	10.22	0.14	100.57	2.92	0.01	2.03	0.00	1.03	1.17	0.01	0.81	0.02	No Data Available	
RV-P5-15	40.68	0.10	24.36	0.05	11.44	15.98	0.06	7.51	0.15	100.32	2.93	0.01	2.06	0.00	0.69	1.71	0.00	0.58	0.02		
RV-P5-16	39.01	0.27	23.66	0.07	16.57	13.25	0.16	6.69	0.12	99.81	2.88	0.02	2.06	0.00	1.02	1.46	0.01	0.53	0.02		
RV-P5-17	40.77	0.23	23.03	1.01	15.59	14.74	0.26	4.48	0.12	100.21	2.99	0.01	1.99	0.06	0.96	1.61	0.02	0.35	0.02		
RV-P5-18	39.74	0.29	23.21	0.11	17.58	14.90	0.29	3.48	0.14	99.75	2.93	0.02	2.02	0.01	1.08	1.64	0.02	0.27	0.02		
RV-P5-19	39.39	0.26	23.51	0.11	18.30	14.13	0.15	3.81	0.10	99.76	2.91	0.01	2.05	0.01	1.13	1.56	0.01	0.30	0.01		
RV-P5-20	39.30	0.30	23.17	0.03	20.21	10.96	0.26	5.97	0.13	100.31	2.94	0.02	2.04	0.00	1.26	1.22	0.02	0.48	0.02		
RV-P5-21	40.00	0.09	24.67	0.15	13.01	18.63	0.21	3.19	0.04	99.97	2.87	0.00	2.08	0.01	0.78	1.99	0.01	0.24	0.00		
RV-P5-22	40.27	0.40	23.12	0.21	16.05	14.25	0.37	5.32	0.12	100.10	2.96	0.02	2.00	0.01	0.99	1.56	0.02	0.42	0.02		
RV-P5-23	40.99	0.21	24.33	0.43	9.50	20.10	0.22	3.86	0.08	99.72	2.91	0.01	2.04	0.02	0.56	2.13	0.01	0.29	0.01		

Sample	Weight Percent (wt %) Oxides (EPMA)										Atoms Per Formula Unit (APFU)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	Total	Si	Ti	Al	Cr	Fe	Mg	Mn	Ca	Na	Unit Cell (Å)	Standard Deviation
RV-P5-24	40.80	0.13	24.42	0.45	9.73	20.12	0.23	3.83	0.04	99.73	2.90	0.01	2.05	0.03	0.58	2.13	0.01	0.29	0.01		
RV-P5-25	40.74	0.29	21.03	4.61	7.41	20.34	0.28	4.95	0.08	99.71	2.92	0.02	1.78	0.26	0.44	2.17	0.02	0.38	0.01		

Part 2: Ilmenite analyses

Table 12: Sheiba ilmenites, mount SH-I. Std Dev = Standard Deviation. Missing samples in this table are included in Tables 13 and 14, which list the chromite and clinopyroxene samples from Sheiba. Niobium was not included in this list, but the Totals include it, so the niobium content can be determined if necessary.

Sample	Weight Percent (wt %) Oxides (EPMA)											Atoms Per Formula Unit (APFU)													
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	ZnO	NiO	Total	Si	Ti	Al	Cr	Fe^{3+}	Fe^{2+}	Mn	Mg	Zn	Ni	a_0 (Å)	Std Dev	c_0 (Å)	Std Dev
SH-I-02	0.02	49.84	0.60	9.71	6.95	18.04	0.27	14.88	0.03	0.23	99.87	0.00	0.84	0.02	0.17	0.12	0.35	0.01	0.50	0.00	0.00	5.0645	0.0107	13.9067	0.0008
SH-I-03	0.04	51.02	0.29	5.40	9.45	18.61	0.23	14.43	0.04	0.32	99.05	0.00	0.87	0.01	0.10	0.17	0.36	0.00	0.49	0.00	0.00	5.0320	0.0105	13.9804	0.0079
SH-I-04	0.04	54.46	0.38	2.85	5.65	21.91	0.24	14.75	0.01	0.09	99.89	0.00	0.92	0.01	0.05	0.10	0.42	0.00	0.50	0.00	0.00	5.0693	0.0044	13.9464	0.0004
SH-I-05	0.02	51.46	0.28	6.01	7.58	20.70	0.14	13.92	0.00	0.16	99.60	0.00	0.88	0.01	0.11	0.13	0.40	0.00	0.47	0.00	0.00	5.0667	0.002	13.9542	0.0003
SH-I-06	0.05	50.92	0.64	6.36	9.00	19.21	0.17	14.54	0.02	0.22	100.31	0.00	0.86	0.02	0.11	0.16	0.37	0.00	0.49	0.00	0.00	5.0656	0.002	13.9368	0.0013
SH-I-07	0.00	51.95	0.38	7.22	7.37	15.67	0.36	16.74	0.00	0.22	99.26	0.00	0.87	0.01	0.13	0.13	0.30	0.01	0.56	0.00	0.00	5.0635	0.0018	13.9137	0.0003
SH-I-09	0.04	51.41	0.67	7.41	7.98	17.71	0.19	15.56	0.05	0.17	100.47	0.00	0.86	0.02	0.13	0.14	0.34	0.00	0.52	0.00	0.00	5.0617	0.0037	13.9295	0.0030
SH-I-10	0.00	51.37	0.35	2.02	10.71	24.13	0.14	11.91	0.05	0.10	99.82	0.00	0.89	0.01	0.04	0.19	0.48	0.00	0.41	0.00	0.00	5.0685	0.0044	13.9545	0.0011
SH-I-11	0.05	54.05	0.30	3.15	8.35	19.41	0.27	15.44	0.02	0.10	100.49	0.00	0.90	0.01	0.06	0.14	0.37	0.01	0.51	0.00	0.00	5.0706	0.0069	13.9353	0.0007
SH-I-12	0.00	53.46	0.30	2.74	8.62	20.37	0.19	14.65	0.00	0.12	99.78	0.00	0.90	0.01	0.05	0.15	0.39	0.00	0.49	0.00	0.00	5.0694	0.0033	13.9238	0.0014
SH-I-13	0.02	47.98	0.43	1.94	16.70	22.97	0.23	10.03	0.03	0.08	99.08	0.00	0.84	0.01	0.04	0.31	0.47	0.00	0.35	0.00	0.00	5.0179	0.0050	13.9495	0.0001
SH-I-14	0.02	52.74	0.28	5.02	7.39	20.88	0.23	14.26	0.05	0.24	100.48	0.00	0.89	0.01	0.09	0.13	0.40	0.00	0.48	0.00	0.00	5.0670	0.0030	13.9283	0.0004
SH-I-15	0.05	51.89	0.42	4.94	7.41	20.62	0.15	14.32	0.00	0.26	99.37	0.00	0.89	0.01	0.09	0.13	0.40	0.00	0.49	0.00	0.00	5.0670	0.0034	13.9021	0.0032
SH-I-17	0.04	51.60	0.36	5.88	8.32	20.11	0.22	13.92	0.07	0.17	100.00	0.00	0.88	0.01	0.11	0.14	0.39	0.00	0.47	0.00	0.00	5.0620	0.0015	-	-
SH-I-19	0.00	52.54	0.31	5.16	7.94	20.27	0.25	14.03	0.00	0.13	100.07	0.00	0.89	0.01	0.09	0.14	0.39	0.00	0.47	0.00	0.00	-	-	-	-
SH-I-20	0.03	51.17	0.35	5.82	8.37	19.81	0.25	14.12	0.04	0.18	99.41	0.00	0.87	0.01	0.10	0.15	0.39	0.00	0.48	0.00	0.00	5.0512	0.0048	13.9498	0.0006
SH-I-22	0.02	51.13	0.46	6.71	8.96	19.35	0.18	14.10	0.00	0.21	100.39	0.00	0.86	0.01	0.12	0.16	0.37	0.00	0.47	0.00	0.00	5.0653	0.0020	13.9676	0.0006
SH-I-23	0.03	53.43	0.38	3.41	7.21	21.77	0.22	14.12	0.00	0.10	100.08	0.00	0.91	0.01	0.06	0.12	0.42	0.00	0.47	0.00	0.00	5.0346	0.0272	13.9625	0.0021
SH-I-24	0.04	52.72	0.85	4.97	5.87	21.92	0.23	13.43	0.06	0.18	99.84	0.00	0.90	0.02	0.09	0.10	0.42	0.00	0.45	0.00	0.00	4.9796	0.0004	14.0939	0.0004
SH-I-26	0.02	53.40	0.29	2.84	8.49	19.67	0.28	14.65	0.06	0.16	99.27	0.00	0.91	0.01	0.05	0.15	0.38	0.01	0.49	0.00	0.00	5.0667	0.0056	13.9388	0.0006
SH-I-27	0.04	51.99	0.37	4.76	8.53	20.20	0.18	14.43	0.00	0.16	99.90	0.00	0.88	0.01	0.08	0.15	0.39	0.00	0.49	0.00	0.00	5.0679	0.0028	13.9273	0.0014
SH-I-30	0.00	49.02	0.13	0.09	8.08	41.13	0.14	1.61	0.09	0.03	99.51	0.00	0.92	0.00	0.00	0.16	0.88	0.00	0.06	0.00	0.00	5.0737	0.0096	14.0246	0.0005
SH-I-31	0.04	51.54	0.56	4.89	9.87	19.56	0.18	14.25	0.00	0.23	100.30	0.00	0.87	0.01	0.09	0.17	0.38	0.00	0.48	0.00	0.00	5.0621	0.0090	13.9273	0.0010
SH-I-32	0.04	53.44	0.32	3.85	6.97	21.12	0.18	14.73	0.00	0.11	100.15	0.00	0.90	0.01	0.07	0.12	0.41	0.00	0.49	0.00	0.00	5.0649	0.0048	13.9451	0.0004
SH-I-33	0.02	51.18	0.35	6.79	7.49	20.45	0.23	13.71	0.06	0.17	99.81	0.00	0.87	0.01	0.12	0.13	0.40	0.00	0.46	0.00	0.00	5.0750	0.0018	13.9190	0.0001

Sample	Weight Percent (wt %) Oxides (EPMA)											Atoms Per Formula Unit (APFU)													
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	ZnO	NiO	Total	Si	Ti	Al	Cr	Fe^{3+}	Fe^{2+}	Mn	Mg	Zn	Ni	a_0 (Å)	Std Dev	c_0 (Å)	Std Dev
SH-I-34	0.02	54.16	0.36	3.92	5.52	21.67	0.15	14.82	0.00	0.20	100.33	0.00	0.92	0.01	0.07	0.10	0.41	0.00	0.50	0.00	0.00	5.0624	0.0018	13.9486	0.0002
SH-I-36	0.04	49.37	0.43	8.23	9.05	18.66	0.14	13.98	0.05	0.19	99.32	0.00	0.84	0.01	0.15	0.16	0.36	0.00	0.47	0.00	0.00	5.0577	0.0124	13.9264	0.0008
SH-I-37	0.00	54.42	0.35	2.79	7.52	20.94	0.16	14.30	0.01	0.05	100.09	0.00	0.92	0.01	0.05	0.13	0.40	0.00	0.48	0.00	0.00	5.0624	0.0082	13.9556	0.0006
SH-I-38	0.29	53.46	0.24	4.51	5.23	21.40	0.26	14.21	0.05	0.17	99.45	0.01	0.91	0.01	0.08	0.09	0.41	0.01	0.48	0.00	0.00	5.0683	0.0022	13.9415	0.0002
SH-I-39	0.00	53.71	0.30	2.64	6.70	22.22	0.26	14.26	0.00	0.15	99.63	0.00	0.92	0.01	0.05	0.12	0.43	0.00	0.48	0.00	0.00	5.0679	0.0032	13.9468	0.0003
SH-I-40	0.05	52.52	0.37	4.28	9.45	18.77	0.24	14.71	0.04	0.14	99.89	0.00	0.89	0.01	0.08	0.16	0.36	0.00	0.49	0.00	0.00	5.0558	0.0121	13.9345	0.0011
SH-I-41	0.06	50.28	0.40	5.81	10.49	18.51	0.20	14.11	0.00	0.25	99.25	0.00	0.86	0.01	0.10	0.18	0.36	0.00	0.48	0.00	0.00	5.0650	0.0046	13.8947	0.0072
SH-I-42	0.05	54.64	0.34	2.68	7.26	21.12	0.17	14.45	0.11	0.10	100.45	0.00	0.92	0.01	0.05	0.12	0.40	0.00	0.48	0.00	0.00	5.0665	0.0029	13.8743	0.0019
SH-I-43	0.05	49.39	0.44	9.46	11.76	13.03	0.12	16.47	0.06	0.24	100.12	0.00	0.82	0.01	0.17	0.20	0.25	0.00	0.54	0.00	0.00	5.0709	0.0017	13.9550	0.0002
SH-I-45	0.03	51.68	0.32	5.44	9.36	19.46	0.19	14.24	0.00	0.20	100.18	0.00	0.87	0.01	0.10	0.16	0.38	0.00	0.48	0.00	0.00	5.0585	0.0034	13.9346	0.0041
SH-I-46	0.05	51.90	0.36	3.82	9.25	19.96	0.17	14.09	0.06	0.23	99.16	0.00	0.89	0.01	0.07	0.16	0.39	0.00	0.48	0.00	0.00	5.0678	0.0046	13.9291	0.0018
SH-I-48	0.03	52.66	0.36	4.30	8.63	20.43	0.17	14.29	0.00	0.14	100.33	0.00	0.89	0.01	0.08	0.15	0.39	0.00	0.48	0.00	0.00	5.0421	0.0085	13.9463	0.0005
SH-I-49	0.01	48.36	0.04	0.00	10.60	40.55	0.42	1.43	0.03	0.00	100.41	0.00	0.90	0.00	0.00	0.20	0.87	0.01	0.05	0.00	0.00	5.0886	0.0086	14.0151	0.0075
SH-I-50	0.03	52.33	0.39	4.28	9.80	19.60	0.15	14.47	0.00	0.10	100.37	0.00	0.88	0.01	0.08	0.17	0.38	0.00	0.48	0.00	0.00	-	-	13.9487	0.0007
SH-I-51	0.03	53.33	0.34	2.88	9.39	19.91	0.17	14.83	0.01	0.17	100.32	0.00	0.90	0.01	0.05	0.16	0.38	0.00	0.49	0.00	0.00	5.0692	0.0029	13.9068	0.0013
SH-I-52	0.07	52.24	0.38	4.45	9.47	19.62	0.14	14.11	0.06	0.12	99.98	0.00	0.88	0.01	0.08	0.16	0.38	0.00	0.47	0.00	0.00	5.0682	0.0078	13.9400	0.0005
SH-I-53	0.03	50.52	0.36	5.96	9.98	19.50	0.15	13.66	0.00	0.12	99.48	0.00	0.86	0.01	0.11	0.18	0.38	0.00	0.46	0.00	0.00	5.0677	0.0065	13.9252	0.0003
SH-I-54	0.03	49.72	0.67	6.99	12.23	16.25	0.20	14.92	0.00	0.19	100.23	0.00	0.83	0.02	0.12	0.21	0.31	0.00	0.50	0.00	0.00	5.0623	0.0090	13.9308	0.0009
SH-I-55	0.04	52.19	0.38	4.58	9.55	19.85	0.17	14.13	0.04	0.24	100.44	0.00	0.88	0.01	0.08	0.17	0.38	0.00	0.47	0.00	0.00	5.0532	0.0145	13.9639	0.0013
SH-I-56	0.04	51.64	0.64	6.03	8.10	19.83	0.14	14.37	0.00	0.16	100.26	0.00	0.87	0.02	0.11	0.14	0.38	0.00	0.48	0.00	0.00	5.0654	0.0052	13.9277	0.0005
SH-I-57	0.02	49.62	0.55	1.43	14.81	24.24	0.10	10.70	0.00	0.13	100.33	0.00	0.85	0.01	0.03	0.27	0.49	0.00	0.37	0.00	0.00	5.0340	0.0047	13.9870	0.0004
SH-I-58	0.04	51.22	0.44	6.35	9.30	19.28	0.16	14.34	0.00	0.20	100.55	0.00	0.86	0.01	0.11	0.16	0.37	0.00	0.48	0.00	0.00	5.0458	0.0109	13.9341	0.0010
SH-I-59	0.05	47.21	0.36	2.27	19.07	23.11	0.15	9.58	0.01	0.11	100.40	0.00	0.82	0.01	0.04	0.35	0.47	0.00	0.33	0.00	0.00	5.0796	0.0018	13.9459	0.0003
SH-I-60	0.03	52.77	0.38	3.95	9.83	19.48	0.21	14.36	0.02	0.15	100.48	0.00	0.89	0.01	0.07	0.17	0.37	0.00	0.48	0.00	0.00	5.0522	0.0116	13.9527	0.0002
SH-I-62	0.03	52.77	0.38	5.81	4.70	22.02	0.16	13.87	0.10	0.24	99.65	0.00	0.90	0.01	0.10	0.08	0.42	0.00	0.47	0.00	0.00	5.0589	0.0057	13.9378	0.0006
SH-I-63	0.05	52.56	0.43	6.02	5.68	19.24	0.14	14.97	0.07	0.29	99.01	0.00	0.90	0.01	0.11	0.10	0.37	0.00	0.51	0.00	0.00	5.0570	0.0043	13.9409	0.0004
SH-I-64	0.03	52.99	0.32	5.47	4.39	22.23	0.12	13.63	0.02	0.16	99.04	0.00	0.91	0.01	0.10	0.08	0.43	0.00	0.47	0.00	0.00	5.0670	0.0021	13.8781	0.0014
SH-I-65	0.04	54.59	0.40	3.35	5.10	22.00	0.22	13.98	0.00	0.11	99.52	0.00	0.93	0.01	0.06	0.09	0.42	0.00	0.47	0.00	0.00	5.0663	0.0021	13.9558	0.0003
SH-I-66	0.03	54.32	0.39	3.77	5.78	20.91	0.08	14.50	0.08	0.12	99.66	0.00	0.92	0.01	0.07	0.10	0.40	0.00	0.49	0.00	0.00	5.0706	0.0077	13.9288	0.0003
SH-I-67	0.04	48.70	0.60	1.52	15.46	23.62	0.14	10.20	0.00	0.12	99.16	0.00	0.85	0.02	0.03	0.28	0.48	0.00	0.35	0.00	0.00	5.0583	0.0163	13.9574	0.0040
SH-I-68	0.04	54.44	0.65	7.01	6.95	14.32	0.21	17.99	0.00	0.23	100.49	0.00	0.89	0.02	0.12	0.12	0.35	0.00	0.59	0.00	0.00	5.0869	0.0072	13.9074	0.0005
SH-I-68 *	0.05	85.94	0.03	2.35	5.88	14.99	0.04	5.11	0.02	0.04	100.40	Not Calculated													
SH-I-69 H	0.00	45.53	0.69	13.04	13.29	16.52	0.22	13.33	0.00	0.17	100.23	0.00	0.77	0.02	0.23	0.23	0.29	0.00	0.45	0.00	0.00	5.0509	0.0057	14.0340	0.0011
SH-I-69 L	0.02	46.43	0.63	11.62	11.48	18.04	0.19	13.20	0.00	0.28	99.45	0.00	0.79	0.02	0.21	0.20	0.33	0.00	0.45	0.00	0.00	Indistinguishable from host			

* Secondary rutile from SH-I-068. Also contained 1.77 wt % Nb_2O.

Table 13: Sheiba chromites, mount SH-I. Unit cells were not refined for non-ilmenite samples.

Sample	Weight Percent (wt %) Oxides (EPMA)									
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	ZnO	NiO	Total
SH-I-01	0.03	0.13	18.48	46.86	22.65	0.28	11.76	0.09	0.09	100.38
SH-I-08	0.02	3.85	1.79	53.78	30.52	0.33	9.50	0.04	0.12	99.95
SH-I-16	0.07	1.71	19.01	36.84	29.52	0.20	12.50	0.14	0.22	100.21
SH-I-18	0.12	2.15	4.78	56.77	24.10	0.27	10.74	0.05	0.13	99.10
SH-I-21	0.04	2.05	4.24	56.80	27.30	0.31	9.32	0.22	0.09	100.36
SH-I-23	0.67	8.11	4.65	50.18	22.53	0.19	13.23	0.05	0.20	99.80
SH-I-25	0.03	3.99	2.69	50.46	32.04	0.34	9.91	0.01	0.11	99.58
SH-I-28	0.08	0.15	5.59	63.34	18.82	0.28	11.68	0.11	0.16	100.22
SH-I-29	0.06	2.95	5.47	42.27	40.66	0.32	7.83	0.08	0.24	99.88
SH-I-35	0.08	3.52	5.99	50.85	28.68	0.24	10.95	0.02	0.16	100.49
SH-I-44	0.02	3.52	1.40	53.66	31.67	0.29	9.60	0.08	0.16	100.39
SH-I-47	0.04	2.62	2.75	54.88	29.19	0.23	9.78	0.09	0.13	99.69
SH-I-61	0.07	3.44	5.13	54.59	25.21	0.22	11.27	0.00	0.13	100.06

Table 14: Sheiba clinopyroxene, mount SH-I.

Sample	Weight Percent (wt %) Oxides (EPMA)										
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	K_2O	CaO	Na_2O	Total
SH-I-23	53.78	3.01	0.40	0.95	1.90	0.04	16.41	0.01	22.97	0.64	100.10

Table 15: Premier ilmenites, mount PR-I1.

Sample	Weight Percent (wt %) Oxides (EPMA)											Atoms Per Formula Unit (APFU)										a_0 (Å)	Std Dev	c_0 (Å)	Std Dev
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	ZnO	NiO	Total	Si	Ti	Al	Cr	Fe^{3+}	Fe^{2+}	Mn	Mg	Zn	Ni				
PR-I1-01	0.00	52.56	0.51	0.95	4.26	32.77	0.79	7.64	0.06	0.09	99.62	0.00	0.95	0.01	0.02	0.08	0.66	0.02	0.27	0.00	0.00	5.1017	0.012	14.0606	0.0005
PR-I1-02	0.00	56.55	0.58	0.64	2.96	25.39	0.17	14.37	0.00	0.03	100.79	0.00	0.96	0.02	0.01	0.05	0.48	0.00	0.48	0.00	0.00	5.0759	0.0076	14.0024	0.0014
PR-I1-03	0.04	53.50	0.77	1.41	5.69	26.35	0.18	12.22	0.07	0.19	100.53	0.00	0.92	0.02	0.03	0.10	0.51	0.00	0.42	0.00	0.00	5.095	0.0041	14.0821	0.0005
PR-I1-04	0.02	55.96	0.53	0.76	3.09	26.25	0.17	13.61	0.02	0.14	100.70	0.00	0.95	0.01	0.01	0.05	0.50	0.00	0.46	0.00	0.00	5.0854	0.0059	14.0928	0.0008
PR-I1-05	0.02	54.34	0.25	0.63	4.41	29.77	0.17	10.96	0.05	0.06	100.86	0.00	0.94	0.01	0.01	0.08	0.58	0.00	0.38	0.00	0.00	5.0388	0.0297	13.9844	0.0003
PR-I1-06	0.01	55.63	0.34	1.06	4.50	24.33	0.14	14.30	0.00	0.14	100.45	0.00	0.95	0.01	0.02	0.08	0.47	0.00	0.48	0.00	0.00	5.0904	0.002	14.0904	0.0005
PR-I1-07	0.03	54.28	0.55	1.50	3.82	28.34	0.15	11.62	0.00	0.10	100.51	0.00	0.94	0.02	0.03	0.07	0.55	0.00	0.40	0.00	0.00	5.0924	0.0022	14.0263	0.003
PR-I1-08	0.00	52.37	0.32	1.46	0.00	43.05	2.46	0.42	0.00	0.11	100.18	0.00	0.99	0.01	0.03	0.00	0.90	0.05	0.02	0.00	0.00	5.0978	0.0013	13.9795	0.0186
PR-I1-09	0.02	53.62	0.44	0.70	0.00	43.23	2.14	0.27	0.01	0.05	100.47	0.00	1.01	0.01	0.01	0.00	0.90	0.05	0.01	0.00	0.00	5.1012	0.0164	13.9704	0.0016
PR-I1-10	0.02	52.29	0.34	0.49	0.00	43.38	2.98	0.29	0.00	0.07	99.85	0.00	0.99	0.01	0.01	0.00	0.91	0.06	0.01	0.00	0.00	5.0715	0.0046	13.9644	0.0053
PR-I1-11	0.04	52.78	0.26	0.53	0.00	42.03	4.52	0.11	0.00	0.07	100.43	0.00	0.99	0.01	0.01	0.00	0.88	0.10	0.00	0.00	0.00	5.0913	0.0038	13.9793	0.0008
PR-I1-12	0.02	52.56	0.39	0.88	0.00	43.92	2.23	0.18	0.01	0.04	100.25	0.00	0.99	0.01	0.02	0.00	0.92	0.05	0.01	0.00	0.00	5.0312	0.0034	14.037	0.0004
PR-I1-13	0.03	52.09	0.60	0.63	0.00	43.24	2.26	0.40	0.14	0.12	99.56	0.00	0.99	0.02	0.01	0.00	0.91	0.05	0.02	0.00	0.00	5.0945	0.0024	13.9615	0.0014

Sample	Weight Percent (wt %) Oxides (EPMA)											Atoms Per Formula Unit (APFU)										a_0 (Å)	Std Dev	c_0 (Å)	Std Dev
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	ZnO	NiO	Total	Si	Ti	Al	Cr	Fe^{3+}	Fe^{2+}	Mn	Mg	Zn	Ni				
PR-I1-14	0.06	53.16	0.77	1.04	0.00	41.76	2.30	0.72	0.06	0.13	100.04	0.00	1.00	0.02	0.02	0.00	0.87	0.05	0.03	0.00	0.00	5.0953	0.0047	13.9389	0.0081
PR-I1-15	0.03	53.03	0.47	1.09	0.00	43.37	1.63	0.59	0.10	0.07	100.45	0.00	1.00	0.01	0.02	0.00	0.90	0.03	0.02	0.00	0.00	5.0074	0.0022	14.0802	0.0003
PR-I1-16	0.02	55.13	0.35	0.51	3.95	28.12	0.15	12.26	0.01	0.13	100.82	0.00	0.95	0.01	0.01	0.07	0.54	0.00	0.42	0.00	0.00	5.0756	0.0015	13.881	0.001
PR-I1-17	0.05	54.83	0.47	1.00	4.57	24.47	0.15	14.01	0.03	0.15	99.82	0.00	0.94	0.01	0.02	0.08	0.47	0.00	0.48	0.00	0.00	5.0621	0.0103	13.9911	0.0016
PR-I1-18	0.00	52.08	0.95	0.65	0.00	42.35	1.63	1.57	0.06	0.15	99.53	0.00	0.98	0.03	0.01	0.00	0.88	0.03	0.06	0.00	0.00	-	-	-	-
PR-I1-19	0.03	53.90	0.37	0.57	3.61	32.86	0.58	8.56	0.01	0.17	100.78	0.00	0.95	0.01	0.01	0.06	0.65	0.01	0.30	0.00	0.00	-	-	-	-
PR-I1-20	0.02	56.05	0.56	0.80	2.98	25.70	0.18	14.04	0.03	0.06	100.59	0.00	0.95	0.02	0.01	0.05	0.49	0.00	0.47	0.00	0.00	5.077	0.0092	13.9538	0.0066

Table 16: Premier ilmenites, mount PR-I2. Note that the oxides do not add up to 100% for PR-I2-19.

Sample	Weight Percent (wt %) Oxides (EPMA)											Atoms Per Formula Unit (APFU)										a_0 (Å)	Std Dev	c_0 (Å)	Std Dev
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	ZnO	NiO	Total	Si	Ti	Al	Cr	Fe^{3+}	Fe^{2+}	Mn	Mg	Zn	Ni				
PR-I2-01	0.03	52.21	0.05	0.55	3.20	36.97	0.97	5.26	0.00	0.07	99.43	0.00	0.96	0.00	0.01	0.06	0.76	0.02	0.19	0.00	0.00	5.0681	0.0054	14.0329	0.0006
PR-I2-02	0.03	54.78	0.64	0.94	0.00	37.23	5.45	0.04	0.00	0.08	99.26	0.00	1.05	0.02	0.02	0.00	0.77	0.12	0.00	0.00	0.00	-	-	-	-
PR-I2-03	0.03	51.75	0.57	0.74	1.73	38.90	1.67	3.54	0.04	0.08	99.20	0.00	0.96	0.02	0.01	0.03	0.81	0.03	0.13	0.00	0.00	5.0742	0.0051	13.9596	0.0054
PR-I2-04	0.01	53.94	0.61	1.58	5.04	25.19	0.13	13.12	0.05	0.15	99.93	0.00	0.93	0.02	0.03	0.09	0.49	0.00	0.45	0.00	0.00	5.0774	0.008	14.1885	0.0249
PR-I2-05	0.01	53.00	0.52	1.02	0.00	41.40	2.88	0.06	0.02	0.06	98.98	0.00	1.02	0.02	0.02	0.00	0.87	0.06	0.00	0.00	0.00	5.0764	0.0016	14.0346	0.0007
PR-I2-06	0.03	56.54	0.66	1.12	2.09	24.88	0.19	14.68	0.00	0.18	100.53	0.00	0.95	0.01	0.02	0.04	0.47	0.00	0.48	0.00	0.00	5.0904	0.002	14.0904	0.0005
PR-I2-07	0.01	53.87	0.30	0.57	4.63	29.64	0.22	10.69	0.03	0.06	100.18	0.00	0.94	0.02	0.03	0.08	0.58	0.00	0.40	0.00	0.00	5.0924	0.0022	14.0263	0.003
PR-I2-08	0.03	51.85	0.57	0.70	0.00	43.27	2.93	0.09	0.03	0.02	99.61	0.00	0.98	0.02	0.01	0.00	0.91	0.06	0.00	0.00	0.00	5.0902	0.0035	14.0297	0.0007
PR-I2-09	0.03	56.12	0.55	0.71	3.10	25.82	0.17	13.94	0.00	0.15	100.74	0.00	0.95	0.01	0.01	0.05	0.49	0.00	0.47	0.00	0.00	5.0813	0.0066	14.0815	0.0005
PR-I2-10	0.05	57.31	0.55	1.15	0.50	26.28	0.15	14.19	0.00	0.09	100.35	0.00	0.97	0.01	0.02	0.01	0.50	0.00	0.48	0.00	0.00	5.053	0.006	13.9679	0.0013
PR-I2-11	0.01	53.71	0.32	0.61	4.27	28.53	0.16	11.25	0.21	0.13	99.43	0.00	0.94	0.01	0.01	0.08	0.56	0.00	0.39	0.00	0.00	5.056	0.0107	13.963	0.001
PR-I2-12	0.02	51.70	0.63	1.64	3.42	35.59	1.07	5.56	0.00	0.11	99.78	0.00	0.94	0.02	0.03	0.06	0.73	0.02	0.20	0.00	0.00	5.0785	0.0296	14.0886	0.001
PR-I2-13	0.01	53.31	0.41	0.60	0.00	41.01	3.68	0.21	0.00	0.09	99.39	0.00	1.02	0.01	0.01	0.00	0.86	0.08	0.01	0.00	0.00	5.0795	0.0031	14.0435	0.0047
PR-I2-14	0.00	53.36	0.43	0.42	0.00	41.38	3.19	0.06	0.05	0.00	99.04	0.00	1.02	0.01	0.01	0.00	0.87	0.07	0.00	0.00	0.00	5.0847	0.0051	14.0279	0.0006
PR-I2-15	0.03	55.20	0.61	0.94	4.07	27.51	0.19	12.28	0.02	0.11	100.95	0.00	0.95	0.02	0.02	0.07	0.53	0.00	0.42	0.00	0.00	5.0723	0.003	14.0773	0.0052
PR-I2-16	0.01	54.85	0.56	0.77	4.80	23.86	0.16	14.37	0.00	0.10	99.58	0.00	0.94	0.01	0.01	0.08	0.46	0.00	0.49	0.00	0.00	5.0672	0.0013	13.971	0.0027
PR-I2-17	0.03	54.69	0.46	0.51	3.95	26.99	0.25	12.47	0.01	0.13	99.58	0.00	0.95	0.01	0.01	0.07	0.53	0.00	0.43	0.00	0.00	5.0693	0.0014	13.9763	0.0018
PR-I2-18	0.01	50.42	0.16	0.63	3.96	41.89	1.50	1.47	0.00	0.06	100.33	0.00	0.94	0.00	0.01	0.08	0.88	0.03	0.05	0.00	0.00	-	-	-	-
PR-I2-19	1.63	0.30	1.51	2.82	-	88.34	0.15	0.59	0.16	0.09	95.59	No data available													
PR-I2-20	0.01	53.92	0.16	0.60	4.39	30.84	0.20	9.88	0.00	0.09	100.15	0.00	0.95	0.00	0.01	0.08	0.61	0.00	0.34	0.00	0.00	5.0853	0.0016	14.0702	0.0004
PR-I2-21	0.04	52.57	0.49	0.78	0.00	41.16	3.20	1.37	0.09	0.10	99.93	0.00	0.99	0.01	0.02	0.00	0.86	0.07	0.05	0.00	0.00	5.0655	0.0037	13.9884	0.0002
PR-I2-22	0.05	53.33	0.87	0.49	0.00	42.16	1.82	0.74	0.04	0.09	99.59	0.00	1.01	0.03	0.01	0.00	0.88	0.04	0.03	0.00	0.00	5.0669	0.0021	13.9103	0.0006
PR-I2-23	0.02	52.76	0.49	0.55	0.00	42.27	2.55	0.12	0.00	0.05	98.82	0.00	1.01	0.01	0.01	0.00	0.89	0.06	0.00	0.00	0.00	5.0852	0.0033	14.0432	0.0004
PR-I2-24	0.01	52.60	0.38	0.81	0.00	41.78	3.51	0.20	0.00	0.08	99.36	0.00	1.00	0.01	0.02	0.00	0.88	0.08	0.01	0.00	0.00	5.0612	0.0247	14.079	0.0015

Appendix 4: Mapping GADDS Scripts and MATLAB Programs

GADDS Scripts

- Run.slm (Appendix 2)
  - The target lists for the two maps of BO-26 were created using the GUI version of the *GridTargets* command.
  - Run.slm was used to create the two maps of BO-26, using the target list created using *GridTargets*.
- Fullrun.slm
  - Target lists were created using Fullrun.slm for BO-03, where data collection was fully automated.
- Gntmap.slm and gntmap2.slm
  - An example of the *Mapping* function, used to generate the individual maps of each 2θ window (for sample BO-03) has been included for garnet. The method was identical for each other mineral.
  - These maps were created manually (one at a time) using the GUI interface in GADDS for sample BO-26.

Fullrun.slm

```
! Run 2fr omega scans of Lside and Rside of thin section
! SET UP FLAT SAMPLE PLANE:
GONIOMETER /FLATSAMPLE /X1=15.4390 /Y1=-1.6000 /Z1=13.7535 &
/X2=-7.0460 /Y2=-1.6000 /Z2=13.7635 &
/X3=5.1380 Y3=-17.2025 /Z3=13.7290
! SET UP GRID TARGETS LIST FOR FIRST SET OF SPOTS...
SCAN /GRIDTARGETS /XBEG=24.3745 /XEND=6.7105 /xINC=0.5 &
/YBEG=2.8105 /YEND=-19.7680 /YINC=0.5 /ORDER=YX
! RUN FIRST SET OF TARGETS
#let %R = 0001
#while ('%R' <= 1656) do
!Multirun First Frame: enter Theta1, Theta2 and Width for your first frame
SCAN /multitargets 1/THETA1=6.0 /THETA2=38.5 /AXIS=2-Om /WIDTH=34 /SCANTIME=60&
'BO-03_Lside_'Fr1 /TITLE="Frame 1" /SAMPLE="0" /NUMSAMPLE=2 &
/DISPLAY=15 /REALTIME /CLEAR /startrun=%R /endrun=%R &
/MODE=Scan /VIDEO
!Multirun Second Frame: enter Theta1, Theta2 and Width for your second frame
SCAN /multitargets 1/THETA1=25.5 /THETA2=45 /AXIS=2-Om /WIDTH=24.5
/SCANTIME=90&
'BO-03_Lside_'Fr2 /TITLE="Frame 2" /SAMPLE="0" /NUMSAMPLE=1 &
/DISPLAY=15 /REALTIME /CLEAR /startrun=%R /endrun=%R &
/MODE=Scan
#inc %R
#wend
! SET UP GRID TARGETS LIST FOR SECOND SET OF SPOTS...
SCAN /GRIDTARGETS /XBEG=6.7105 /XEND=-10.9535 /xINC=0.5 &
/YBEG=2.8105 /YEND=-19.7680 /YINC=0.5 /ORDER=YX
! RUN SECOND SET OF TARGETS
#let %R = 0001
#while ('%R' <= 1656) do
!Multirun First Frame: enter Theta1, Theta2 and Width for your first frame
SCAN /multitargets 1/THETA1=6.0 /THETA2=38.5 /AXIS=2-Om /WIDTH=34 /SCANTIME=60&
'BO-03_Rside_'Fr1 /TITLE="Frame 1" /SAMPLE="0" /NUMSAMPLE=2 &
/DISPLAY=15 /REALTIME /CLEAR /startrun=%R /endrun=%R &
/MODE=Scan /VIDEO
```

```
!Multirun Second Frame: enter Theta1, Theta2 and Width for your second frame
SCAN /multitargets 1/THETA1=25.5 /THETA2=45 /AXIS=2-Om /WIDTH=24.5
/SCANTIME=90&
'BO-03_Rside_'Fr2 /TITLE="Frame 2" /SAMPLE="0" /NUMSAMPLE=1 &
/DISPLAY=15 /REALTIME /CLEAR /startrun=%R /endrun=%R &
/MODE=Scan
#inc %R
#wend
```

Gntmap.slm

```
!** Analyze > Mapping for Garnet peaks  **
!** High-resolution version (001-999)   **
!** Written by Ben Harwood, 14.01.09    **
!** Creates 5 consecutive maps          **
! Frame 1
LOAD 'BO-03_Lside_'Fr1_001_000.gfrm /DISPLAY=15 /SCALE=-n /OFFSET=0.0
! Gnt_map_1
INTEGRATE /AREA 30.950 31.250 -110.800 -69.200
MAPPING 'BO-03_Lside_'Fr1_001_000.gfrm /FRAME=000 /RUN=999 Area &
 /SLAM="INTEGRATE /AREA 30.950 31.250 -110.800 -69.200"
! Gnt_map_2
INTEGRATE /AREA 34.700 35.100 -115.200 -65.000
MAPPING 'BO-03_Lside_'Fr1_001_000.gfrm /FRAME=000 /RUN=999 Area &
 /SLAM="INTEGRATE /AREA 34.700 35.100 -115.200 -65.000"
! Gnt_map_3
INTEGRATE /AREA 48.400 48.900 -112.200 -67.200
MAPPING 'BO-03_Lside_'Fr1_001_000.gfrm /FRAME=000 /RUN=999 Area &
 /SLAM="INTEGRATE /AREA 48.400 48.900 -112.200 -67.200"
!Frame 2
LOAD 'BO-03_Lside_'Fr2_001_000.gfrm /DISPLAY=15 /SCALE=-n /OFFSET=0.0
! Gnt_map_4
INTEGRATE /AREA 57.400 57.850 -104.800 -75.300
MAPPING 'BO-03_Lside_'Fr2_001_000.gfrm /FRAME=000 /RUN=999 Area &
 /SLAM="INTEGRATE /AREA 57.400 57.850 -104.800 -75.300"
! Gnt_map_5
INTEGRATE /AREA 59.900 60.200 -106.600 -73.400
MAPPING 'BO-03_Lside_'Fr2_001_000.gfrm /FRAME=000 /RUN=999 Area &
 /SLAM="INTEGRATE /AREA 59.900 60.200 -106.600 -73.400"
! Update number of characters in run number for targets 1000 to 1656
CONFIGURE /EDIT /USER="Herman Snerd" /SITE=SAXI$SITE /CALIBDIR=C:\frames &
 /MINCPS=25 /TIMEOUT=10 /NAMECHARS=28 /RUNCHARS=4 /RUNBASE=10 &
 /NUMCHARS=3 /NUMBASE=10 /TEMP=-1 /XBEAM=511.00 /YBEAM=511.00 &
 /FRAMESIZE=1024 /DISTANCE=12.000
! Execute mapping script for targets 1000 to 1656:
@gntmap2
```

Gntmap2.slm

```
!** Analyze > Mapping for Garnet peaks  **
!** High-resolution version (1000-1656) **
!** Written by Ben Harwood, 14.01.09    **
!** Creates 5 consecutive maps          **
! Frame 1
LOAD 'BO-03_Lside_'Fr1_1000_000.gfrm /DISPLAY=15 /SCALE=-n /OFFSET=0.0
! Gnt_map_1
INTEGRATE /AREA 30.950 31.250 -110.800 -69.200
MAPPING 'BO-03_Lside_'Fr1_1000_000.gfrm /FRAME=000 /RUN=1656 Area &
 /SLAM="INTEGRATE /AREA 30.950 31.250 -110.800 -69.200"
! Gnt_map_2
INTEGRATE /AREA 34.700 35.100 -115.200 -65.000
MAPPING 'BO-03_Lside_'Fr1_1000_000.gfrm /FRAME=000 /RUN=1656 Area &
```

```
 /SLAM="INTEGRATE /AREA 34.700 35.100 -115.200 -65.000"
! Gnt_map_3
INTEGRATE /AREA 48.400 48.900 -112.200 -67.200
MAPPING 'BO-03_Lside_'Fr1_1000_000.gfrm /FRAME=000 /RUN=1656 Area &
 /SLAM="INTEGRATE /AREA 48.400 48.900 -112.200 -67.200"
!Frame 2
LOAD 'BO-03_Lside_'Fr2_1000_000.gfrm /DISPLAY=15 /SCALE=-n /OFFSET=0.0
! Gnt_map_4
INTEGRATE /AREA 57.400 57.850 -104.800 -75.300
MAPPING 'BO-03_Lside_'Fr2_1000_000.gfrm /FRAME=000 /RUN=1656 Area &
 /SLAM="INTEGRATE /AREA 57.400 57.850 -104.800 -75.300"
! Gnt_map_5
INTEGRATE /AREA 59.900 60.200 -106.600 -73.400
MAPPING 'BO-03_Lside_'Fr2_1000_000.gfrm /FRAME=000 /RUN=1656 Area &
 /SLAM="INTEGRATE /AREA 59.900 60.200 -106.600 -73.400"
```

MATLAB Programs

Programs used to map BO-26.

- Makemap.m was re-run changing min_name, min_abbr and min_num to correspond to each of the minerals
- Colormins.m was used to take the maps created by makemap.m and create the final map

Makemap.m

```
% Program to re-order the intensity values from the .gmap file so that % they
have the correct map dimensions.  Also creates maps from each
% input file and a summed map by adding the individual maps together.
% Load file for colour map
load 'D:\X Docs\School\516b\Ben_516proj\Testing addition\mapcolors.txt'
% Variable mapping properties:
min_name = 'Phlogopite';
min_abbr = 'Phl';
min_num = 2;
% Setup a tweak to fix map edges
zx = zeros(1,26);
zx = zx + 5000;
zy = zeros(17,1);
zy = zy + 5000;
% Create the individual maps
for filenum = 1:min_num
     figure;
    % Define colormap
    colormap(mapcolors);
    % Load the excel file containing the raw GADDSMap values
    fileloc = 'D:\X Docs\School\516b\Ben_516proj\Testing addition\';
    map_name = strcat(min_abbr,'_map_',int2str(filenum));
    filename = strcat(fileloc,map_name,'.xls');
    import_file = eval(['xlsread(filename, map_name)']);
    % Re-order the values to fit the correct map dimensions
    [rows,cols] = size(import_file);
    col = 1;
    row = 1;
    for i = 1:rows
        % Store the current value in a temporary variable
        temp = import_file(i,:);
        for j = 1:length(temp)
            if ~isnan(temp(j))
```

```
                if col == 27
                    col = 1;
                    row = row+1;
                end
            % Store the current intensity value at the correct
            % location in the mineral map.
            min_map(row,col) = temp(j);
            col = col+1;
            end
        end
    end
    % Store the current map for later use
    % zx and zy fix the zeros off the margins of the map (for the plot)
    Mineral_maps{filenum} = [min_map;zx];
    Mineral_maps{filenum} = [Mineral_maps{filenum},zy];
    % Produce a map
    X = 1:27;
    Y = 17:-1:1;
    % Plot the current map as a surface in X-Y view
    surf(X,Y,Mineral_maps{filenum});
    colorbar;
    % Plot properties:
    title([min_name,' Map ',int2str(filenum)]);
    xlabel('Column Number');
    ylabel('Row Number');
    axis equal;
    axis([1 27 1 17]);
    % Create a total map which sums the cells from each individual
    % one:
    if filenum ~= 1
        tot_map = tot_map + Mineral_maps{filenum};
    else
        tot_map = Mineral_maps{filenum};
    end
end
% Plot the summed map
figure;
colormap(mapcolors);
surf(X,Y,tot_map);
colorbar;
% Plot properties
title(['Overall ',min_name,' Map']);
xlabel('Column Number');
ylabel('Row Number');
axis equal;
axis([1 27 1 17]);
```

Colormins.m

```
% Program to take "summed maps" from makemap.m and plot all of the
% minerals on a single map, based on user defined thresholds.  Also
% outputs the number of cells, the area % and the total area in mm^2
% occupied by each mineral. Output will either show overlapping
% minerals as black, or will define the cells based on the order they
% are stored in min_maps. In the latter case, minerals defined first
% will not be overwritten  by overlapping minerals.

% Load total maps for each mineral:
r = 1:48;
c = 1:22;
```

```
load 'tot_map_Gnt.mat';
tot_map_Gnt = tot_map(r,c);
load 'tot_map_Ol.mat';
tot_map_Ol = tot_map(r,c);
load 'tot_map_Phl.mat';
tot_map_Phl = tot_map(r,c);
load 'tot_map_En.mat';
tot_map_En = tot_map(r,c);
load 'tot_map_Di.mat';
tot_map_Di = tot_map(r,c);
clear min_map;
% Store the total maps in an array for easy access:
min_maps = {tot_map_Phl, tot_map_En, tot_map_Di, tot_map_Gnt, tot_map_Ol};
% Define thresholds for each mineral:
thresholds = [14600,23000,11000,25000,43000];
[rows,cols] = size(tot_map_Gnt);
% Define whether output will distinguish cells occupied by 2+ minerals
overlap = 'no';
% Create the Final Map, minerals defined by number according to the
% order in min_maps variable.
final_map = zeros(rows,cols);
for i = 1:length(min_maps)
    map = min_maps{i};
    for j = 1:rows
        for k = 1:cols
            if map(j,k) > thresholds(i);
                if final_map(j,k)==0
                    final_map(j,k) = i;
                else
                    if strcmp(overlap,'no')
                        continue;
                    elseif strcmp(overlap,'yes')
                        final_map(j,k) = 6;
                    end
                end
            else
                continue;
            end
        end
    end
end
% Determine number of cells occupied by each mineral:
phl = length(find(final_map==1));
en = length(find(final_map==2));
di = length(find(final_map==3));
gnt = length(find(final_map==4));
ol = length(find(final_map==5));
un = length(find(final_map==0));
no_cells = [phl;en;di;gnt;ol;un]
% Check all cells assigned, must = 1056:
tot_cells = sum(phl+en+di+gnt+ol+un);
% Calculate area %:
phl_pc = phl/tot_cells*100;
en_pc = en/tot_cells*100;
di_pc = di/tot_cells*100;
gnt_pc = gnt/tot_cells*100;
ol_pc = ol/tot_cells*100;
un_pc = un/tot_cells*100;
vol_percent = [phl_pc;en_pc;di_pc;gnt_pc;ol_pc;un_pc]
% Calculate total area occupied by each mineral:
cell_area = 0.5^2;
phl_area = cell_area*phl;
```

```
en_area = cell_area*en;
di_area = cell_area*di;
gnt_area = cell_area*gnt;
ol_area = cell_area*ol;
un_area = cell_area*un;
min_area = [phl_area;en_area;di_area;gnt_area;ol_area;un_area]
% Define colormap for no overlaps
if strcmp(overlap,'no')
    cmap = [1 1 1;
            1 0.50 0;
            0 0.25 0.50;
            0.50 0 0
            0.72 0.38 0.65;
            0.53 0.72 0.50];
% Define colormap for overlaps
elseif strcmp(overlap,'yes')
    cmap = [1 1 1;
            1 0.50 0;
            0 0.25 0.50;
            0.50 0 0;
            0.72 0.38 0.65;
            0.53 0.72 0.52;
            0 0 0];
end
colormap(cmap);
% Plot the final map using patch function
faces = [1 2 3 4];
count = 48;
for a = 1:rows
    for b = 1:cols
        % Define vertices:
       vertex = [b count-1; b count; b+1 count; b+1 count-1];
       patch('Vertices',vertex,'Faces',faces,'FaceVertexCData',
       final_map(a,b),'CDataMapping','scaled', 'Facecolor', 'flat');
    end
    count = count-1;
end
% Define colorbar properties:
if strcmp(overlap,'yes')
    colorbar('YTickLabel',{'Unmapped','Phlogopite','Enstatite','Diopside',
 'Garnet','Olivine','Overlap'});
else
    colorbar('YTick', [0.4165 1.2495 2.0825 2.9155 3.7485 4.5815],
     'TickLength', [0 0],'YTickLabel',{'Unmapped','Phlogopite',
     'Enstatite','Diopside','Garnet','Olivine'});
end
% Plot properties/titles:
title(['Final High Resolution Map']);
xlabel('Column Number');
ylabel('Row Number');
axis equal; % Forces square boxes
axis([1 23 0 47]);
```

Programs used to map BO-03 (revised methods)

- Makemap.m was modified to include the code required to merge the two runs (of the left and right sides of the thin section) and to correct the problem of two run number lengths on the left side. Also note changes to background removal. The updated filename was addmap.m
- Colormins.m was modified to match the changes to addmap.m (including thresholds and removal of diopside).

Addmap.m

```
% Program to re-order the intensity values from the .gmap file so that % they
have the correct map dimensions.  Also creates maps from each
% input file and an overall map by adding the individual maps together.
% The program also merges the maps for the three areas of the thin
% section to create one map for the entire thin section.
% Load file for colour map
load 'D:\X Docs\School\516b\BO03_map\Lside\mapcolors.txt'
% Variable mapping properties:
min_name = 'Phlogopite';
min_abbr = 'Phl';
min_num = 2;
% Determine the set of thresholds that correspond to the current
% mineral:
if strcmp(min_abbr,'Ol')
    threshold = [700,600,1200,600,1000,1000,800,2100]; % Olivine
elseif strcmp(min_abbr,'En')
    threshold = [1100,790,1100,1200,900]; % Enstatite
elseif strcmp(min_abbr,'Gnt')
    threshold = [5000,1900,2000,1800]; % Garnet
elseif strcmp(min_abbr,'Phl')
    threshold = [1900,800]; % Phlog
end
% Re-order a-side of Lside
for filenum = 1:min_num
    % Load the excel file containing the raw GADDSMap values
    fileloc = 'D:\X Docs\School\516b\BO03_map\Lside\a\';
    map_name = strcat(min_abbr,'_map_',int2str(filenum));
    filename = strcat(fileloc,map_name,'.xls');
    import_file = eval(['xlsread(filename, map_name)']);
    % Re-order the values to fit the correct map dimensions
    [rows,cols] = size(import_file);
    col = 1;
    row = 1;
    for i = 1:rows
        temp = import_file(i,:);
        for j = 1:length(temp)
            if ~isnan(temp(j))
                if col == 23
                    col = 1;
                    row = row+1;
                end
            % Store the current intensity value at the correct
            % location in the mineral map.
            min_map_a(row,col) = temp(j);
            col = col+1;
            end
        end
    end
    % Flip the map vertically and horizontally to get the correct
    % orientation
    min_map_a = fliplr(min_map_a);
    min_map_a = flipud(min_map_a);
    % Put the maps for each int area into an array:
    Lmaps_a{filenum} = [min_map_a];
end
% Re-order b-side of Lside
for filenum = 1:min_num
    % Load the excel file containing the raw GADDSMap values
```

```
    fileloc = 'D:\X Docs\School\516b\B003_map\Lside\b\';
    map_name = strcat(min_abbr,'_map_',int2str(filenum));
    filename = strcat(fileloc,map_name,'.xls');
    import_file = eval(['xlsread(filename, map_name)']);
    % Re-order the values to fit the correct map dimensions
    [rows,cols] = size(import_file);
    col = 1;
    row = 1;
    for i = 1:rows
        temp = import_file(i,:);
        for j = 1:length(temp)
            if ~isnan(temp(j))
                if col == 16
                    col = 1;
                    row = row+1;
                end
            % Store the current intensity value at the correct
            % location in the mineral map.
            min_map_b(row,col) = temp(j);
            col = col+1;
            end
        end
    end
    % Flip the map vertically and horizontally to get the correct
    % orientation
    min_map_b = fliplr(min_map_b);
    min_map_b = flipud(min_map_b);
    % Put the maps from each int area into an array:
    Lmaps_b{filenum} = [min_map_b];
end
for filenum = 1:min_num
    temp_a = Lmaps_a{filenum};
    temp_b = Lmaps_b{filenum};
    for k = 1:13
        temp_a(k,22) = temp_b(k,1);
    end
    temp_b1 = temp_b(:,2:15);
    Lmaps{filenum} = [temp_a temp_b1];
end
% Re-order R-side
for filenum = 1:min_num
    % Load the excel file containing the raw GADDSMap values
    fileloc = 'D:\X Docs\School\516b\B003_map\Rside\';
    map_name = strcat(min_abbr,'_map_',int2str(filenum));
    filename = strcat(fileloc,map_name,'.xls');
    import_file = eval(['xlsread(filename, map_name)']);
    % Re-order the values to fit the correct map dimensions
    [rows,cols] = size(import_file);
    col = 1;
    row = 1;
    for i = 1:rows
        temp = import_file(i,:);
        for j = 1:length(temp)
            if ~isnan(temp(j))
                if col == 37
                    col = 1;
                    row = row+1;
                end
            % Store the current intensity value at the correct
            % location in the mineral map.
            min_map_r(row,col) = temp(j);
            col = col+1;
```

```
            end
        end
    end
    % Flip the map vertically and horizontally to get the correct
    % orientation
    min_map_r = fliplr(min_map_r);
    min_map_r = flipud(min_map_r);
    % Put the maps from each int area into an array:
    Rmaps{filenum} = [min_map_r];
end
% Concatenate the left and right sides then produce the maps
for filenum = 1:min_num
    % Concatenate:
    BO_03_map{filenum} = [Lmaps{filenum} Rmaps{filenum}];
    % Produce individual maps using "patch" - for each integration
    % range
    figure;
    colormap(mapcolors);
    X = 1:72;
    Y = 1:1:46;
    map_temp = BO_03_map{filenum};
    faces = [1 2 3 4];
    count = 46;
    [r,c] = size(BO_03_map{filenum});
    for a = 1:r
        for b = 1:c
            % Define vertices:
            vertex = [b count-1; b count; b+1 count; b+1 count-1];
            patch('Vertices',vertex,'Faces',faces,'FaceVertexCData',
             map_temp(a,b),'CDataMapping','scaled', 'Facecolor',
             'flat');
        end
        count = count-1;
    end
    % Plot properties for the current individual map
    colorbar('FontName','times','FontSize',20);
    title(['High Resolution ',min_name,' Map ',
     int2str(filenum)],'FontName','times','FontSize',16);
    xlabel('Column Number','FontName','times','FontSize',20);
    ylabel('Row Number','FontName','times','FontSize',20);
    axis equal; % Square boxes
    axis([1 72 1 46]);
    axis off; % Hide numbers because they aren't useful
    % Define locations of each mineral based on thresholds
    intensity_temp = BO_03_map{filenum};
    for i = 1:46
        for j = 1:72
            if intensity_temp(i,j) > threshold(filenum)
                temp_map(i,j) = 1;
            else
                temp_map(i,j) = 0;
            end
        end
    end
    BO_03_map_a{filenum} = temp_map;
    % Create a "summed" map which sums the cells from each individual
    % one:
    if filenum ~= 1
        BO_tot_map = BO_tot_map + BO_03_map_a{filenum};
    else
        BO_tot_map = BO_03_map_a{filenum};
    end
```

```
end
% Plot the summed map for current mineral
figure;
colormap(mapcolors);
faces = [1 2 3 4];
count = 46;
[r,c] = size(BO_tot_map);
for a = 1:r
    for b = 1:c
        % Define vertices:
        vertex = [b count-1; b count; b+1 count; b+1 count-1];
        patch('Vertices',vertex,'Faces',faces,'FaceVertexCData',
         BO_tot_map(a,b),'CDataMapping','scaled', 'Facecolor', 'flat');
    end
    count = count-1;
end
% Plot properties for the summed map
colorbar('FontName','times','FontSize',16);
title(['BO-03 Summed ',min_name,' Map'],'FontName','times','FontSize',20);
xlabel('Column Number','FontName','times','FontSize',20);
ylabel('Row Number','FontName','times','FontSize',20);
axis equal;
axis([1 72 1 46]);
axis off;
```

Colormins.m

```
% Program to take "summed maps" from addmap.m and plot all of the
% minerals on a single map, based on user defined thresholds.  Also
% outputs the number of cells, the area % and the total area in mm^2
% occupied by each mineral. Output will either show overlapping
% minerals as black, or will define the cells based on the order they
% are stored in min_maps. In the latter case, minerals defined first
% will not be overwritten by overlapping minerals.
% Load total maps for each mineral:
r = 1:46;
c = 1:72;
load 'tot_map_Gnt.mat';
tot_map_Gnt = BO_tot_map(r,c);
load 'tot_map_Ol.mat';
tot_map_Ol = BO_tot_map(r,c);
load 'tot_map_Phl.mat';
tot_map_Phl = BO_tot_map(r,c);
load 'tot_map_En.mat';
tot_map_En = BO_tot_map(r,c);
clear min_map;
% Store the total maps in an array for easy access:
min_maps = {tot_map_Phl, tot_map_Gnt, tot_map_En, tot_map_Ol};
[rows,cols] = size(tot_map_Gnt);
% Define whether output will distinguish cells occupied by 2+ minerals
overlap = 'no';
% Create the Final Map, minerals defined by number according to the
% order in min_maps variable.
final_map = zeros(rows,cols);
for i = 1:length(min_maps)
    map = min_maps{i};
    for j = 1:rows
        for k = 1:cols
            if map(j,k) > 0;
                if final_map(j,k)==0
```

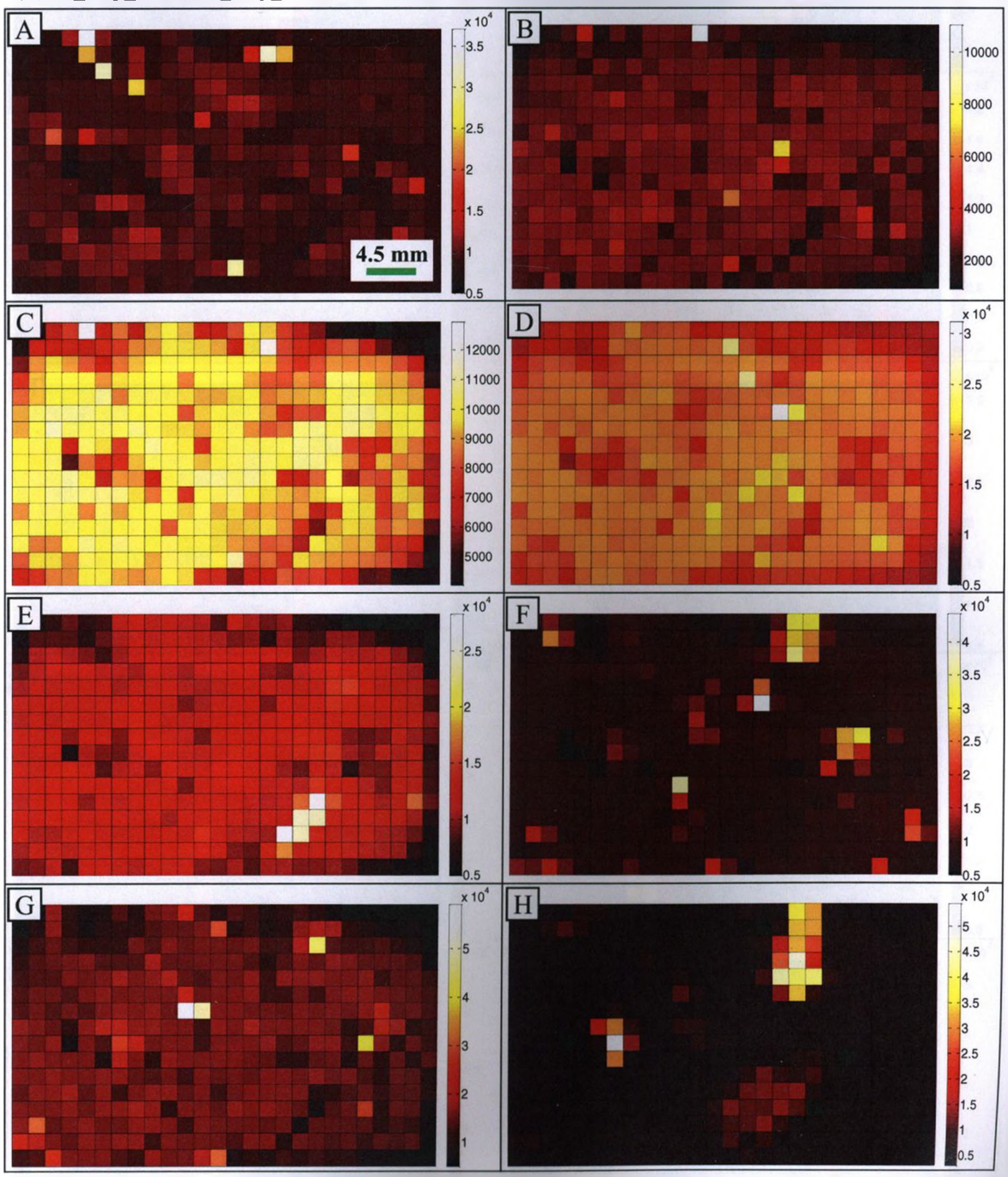
```
                    final_map(j,k) = i;
                else
                    if strcmp(overlap,'no')
                        continue;
                    elseif strcmp(overlap,'yes')
                        final_map(j,k) = 6;
                    end
                end
            else
                continue;
            end
        end
    end
end
% Flip the final map upside down...
final_map = flipud(final_map);
% Determine number of cells occupied by each mineral:
phl = length(find(final_map==1));
en = length(find(final_map==3));
gnt = length(find(final_map==2));
ol = length(find(final_map==4));
un_tot = length(find(final_map==0));
un = length(find(final_map==0))-(408);
off_map = 408;
no_cells = [phl;en;gnt;ol;un_tot;un;off_map]
% Check all cells assigned, must = 1056:
tot_cells = sum(phl+en+gnt+ol+un);
% Calculate area %:
phl_pc = phl/tot_cells*100;
en_pc = en/tot_cells*100;
gnt_pc = gnt/tot_cells*100;
ol_pc = ol/tot_cells*100;
un_tot_pc = un_tot/tot_cells*100
un_pc = un/tot_cells*100;
vol_percent = [phl_pc;en_pc;gnt_pc;ol_pc;un_tot_pc;un_pc]
% Calculate total area occupied by each mineral:
cell_area = 0.5^2;
phl_area = cell_area*phl;
en_area = cell_area*en;
gnt_area = cell_area*gnt;
ol_area = cell_area*ol;
un_area = cell_area*un;
min_area = [phl_area;en_area;gnt_area;ol_area;un_area];
% Define colormap for no overlaps
if strcmp(overlap,'no')
    cmap = [1 1 1;
            1 0.50 0;
            0.72 0.38 0.65;
            0.50 0 0;
            0.53 0.72 0.50];
% Define colormap for overlaps
elseif strcmp(overlap,'yes')
    cmap = [1 1 1;
            1 0.50 0;
            0 0.25 0.50;
            0.50 0 0;
            0.72 0.38 0.65;
            0.53 0.72 0.52;
            0 0 0];
end
colormap(cmap);
% Plot the final map using patch function
```

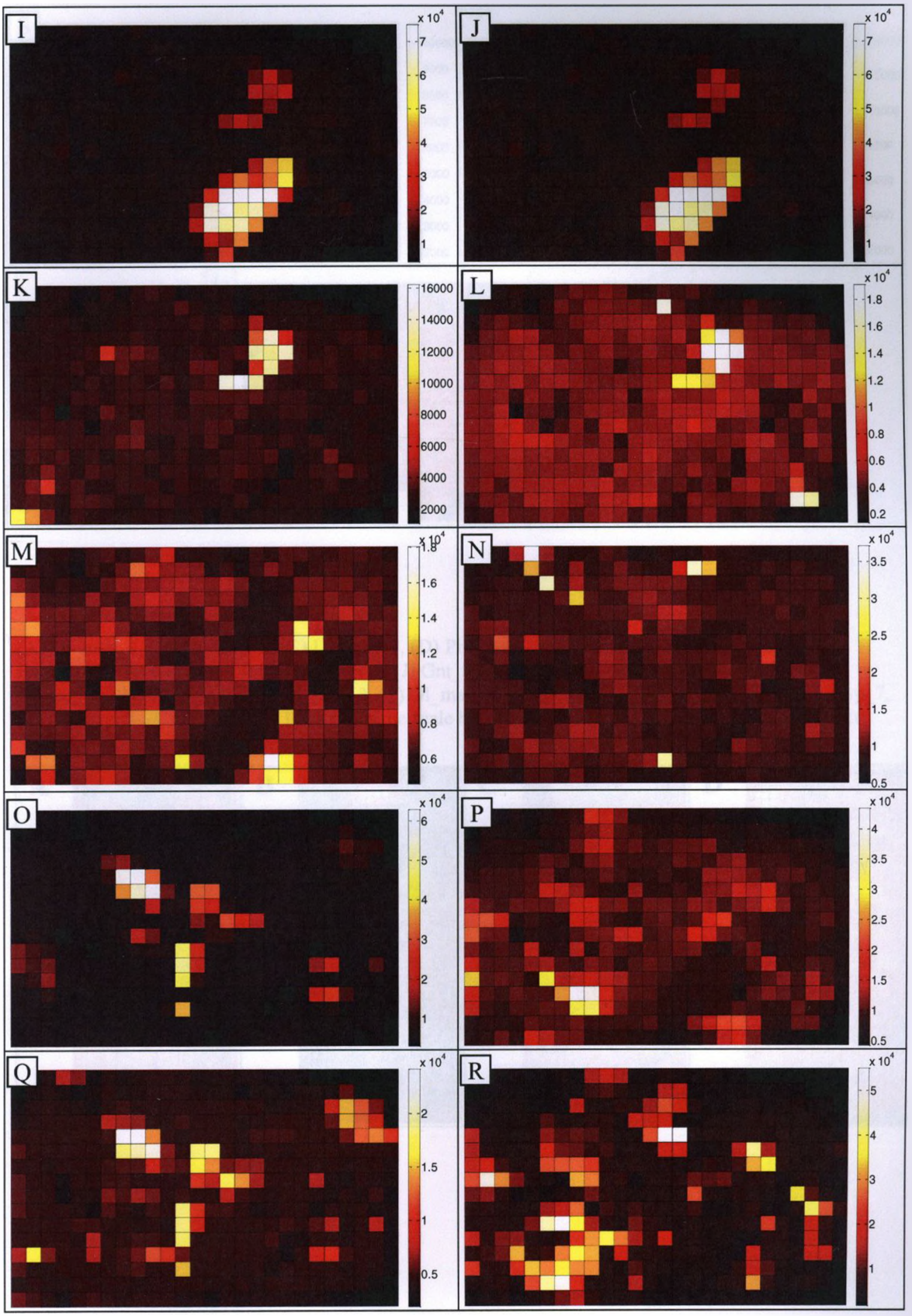
```
faces = [1 2 3 4];
count = 46;
for a = 1:rows
    for b = 1:cols
        % Define vertices:
        vertex = [b count-1; b count; b+1 count; b+1 count-1];
        patch('Vertices',vertex,'Faces',faces,'FaceVertexCData',
         final_map(a,b),'CDataMapping','scaled', 'Facecolor', 'flat');
    end
    count = count-1;
end
% Define colorbar properties:
if strcmp(overlap,'yes')
    colorbar('YTick', [0.4275 1.2825 2.1375 2.9925 3.8475 4.7025
     5.5575],'TickLength', [0 0],'YTickLabel',{'Unmapped','Phlogopite',
     'Diopside','Enstatite','Garnet','Olivine','Overlap'},
     'FontName','times','FontSize',16);
else
    colorbar('YTick', [0.4165 1.22 2.02 2.80 3.62],'TickLength', [0 0],
     'YTickLabel',{'Unmapped','Phlogopite','Garnet','Enstatite',
     'Olivine'},'FontName','times','FontSize',16);
end
% Plot properties/titles:
title(['Final High Resolution Map'],'FontName','times','FontSize',16);
xlabel('Column Number','FontName','times','FontSize',16);
ylabel('Row Number','FontName','times','FontSize',16);
axis equal; % Forces square boxes
axis([1 72 0 46]);
axis off;
```

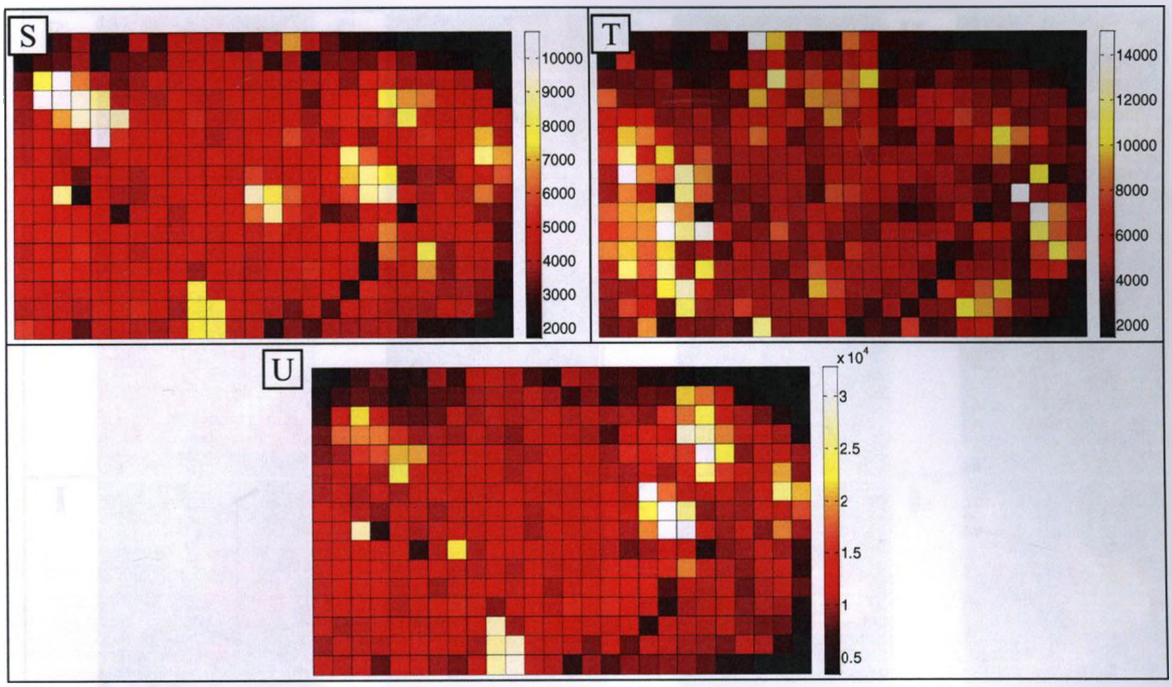
Appendix 5: Individual Maps

Low-resolution maps (BO-26)

(A) Di_map_1, (B) Di_map_2, (C) Di_map_3, (D) Phl_map_1, (E) Phl_map_2, (F) En_map_1, (G) En_map_2, (H) Gnt_map_1, (I) Gnt_map_2, (J) Gnt_map_3, (K) Gnt_map_4, (L) Gnt_map_5, (M) Ol_map_1, (N) Ol_map_2, (O) Ol_map_3, (P) Ol_map_4, (Q) Ol_map_5, (R) Ol_map_6, (S) Ol_map_7, (T) Ol_map_8, (U) Ol_map_9. In all cases the scale bar is the same as (A), where each box is 1.5 mm.

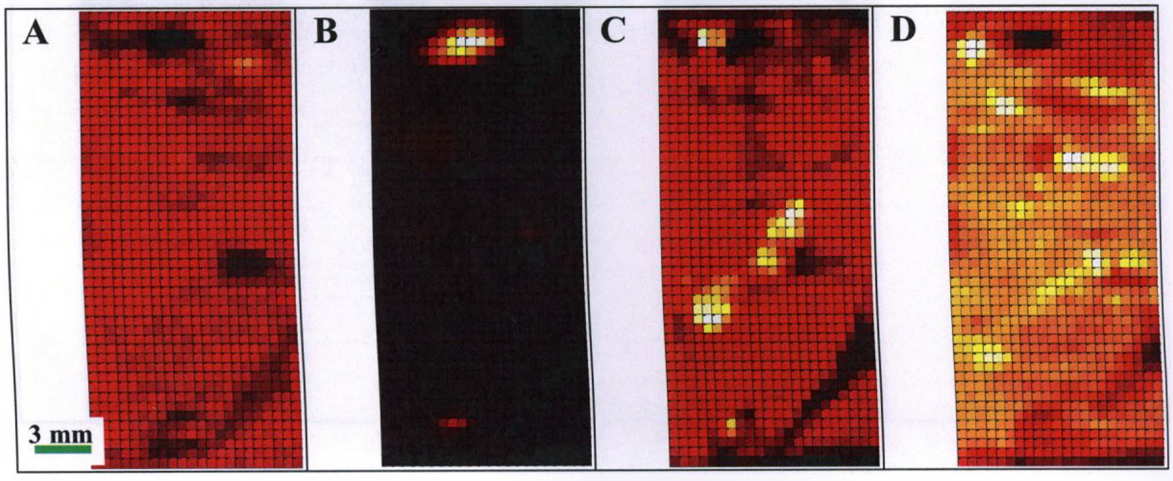


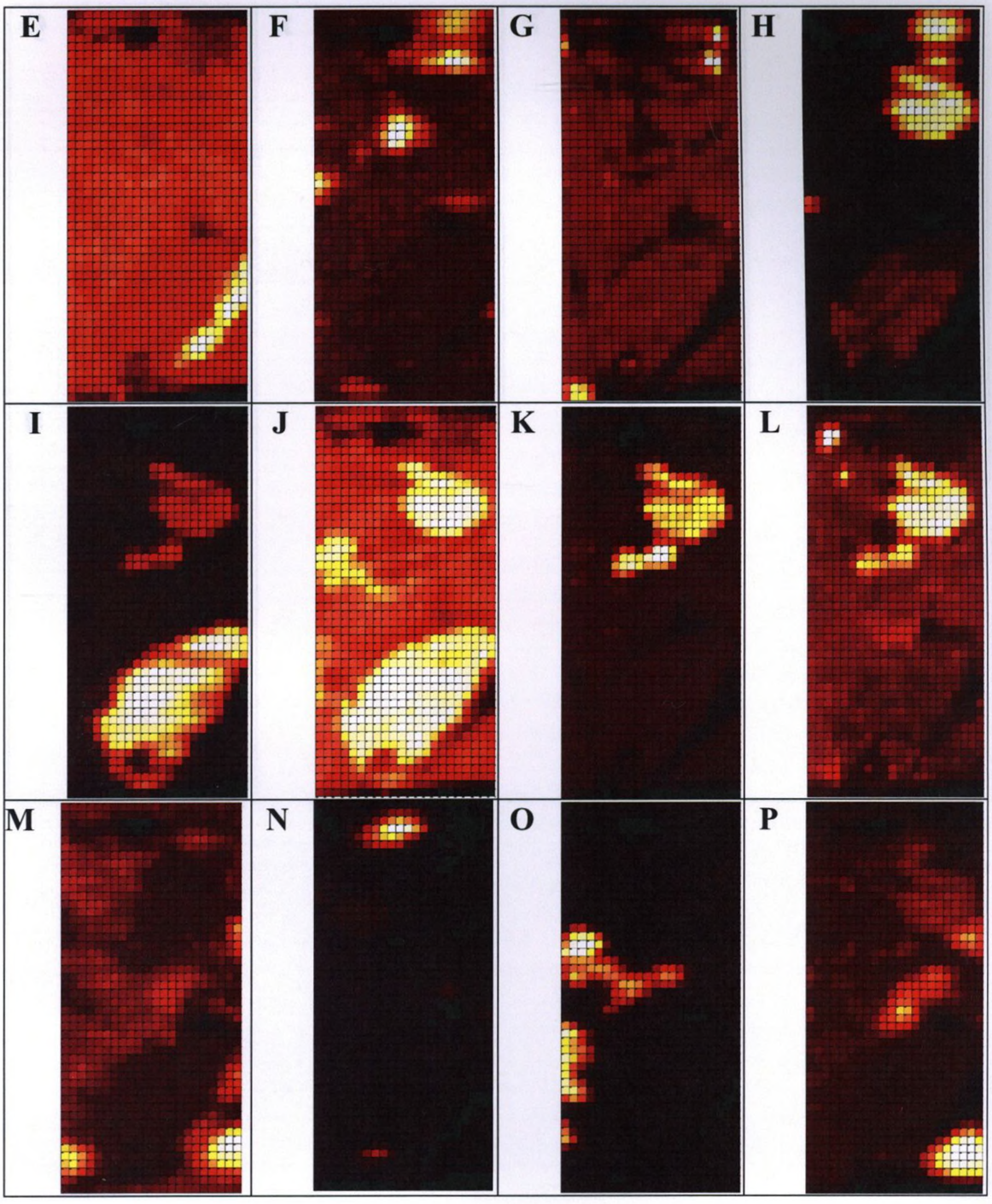

I
x 10^4
7
6
5
4
3
2
1
J
x 10^4
7
6
5
4
3
2
1
K
16000
14000
12000
10000
8000
6000
4000
2000
L
x 10^4
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
M
x 10^4
1.8
1.6
1.4
1.2
1
0.8
0.6
N
x 10^4
3.5
3
2.5
2
1.5
1
0.5
O
x 10^4
6
5
4
3
2
1
P
x 10^4
4
3.5
3
2.5
2
1.5
1
0.5
Q
x 10^4
2
1.5
1
0.5
R
x 10^4
5
4
3
2
1

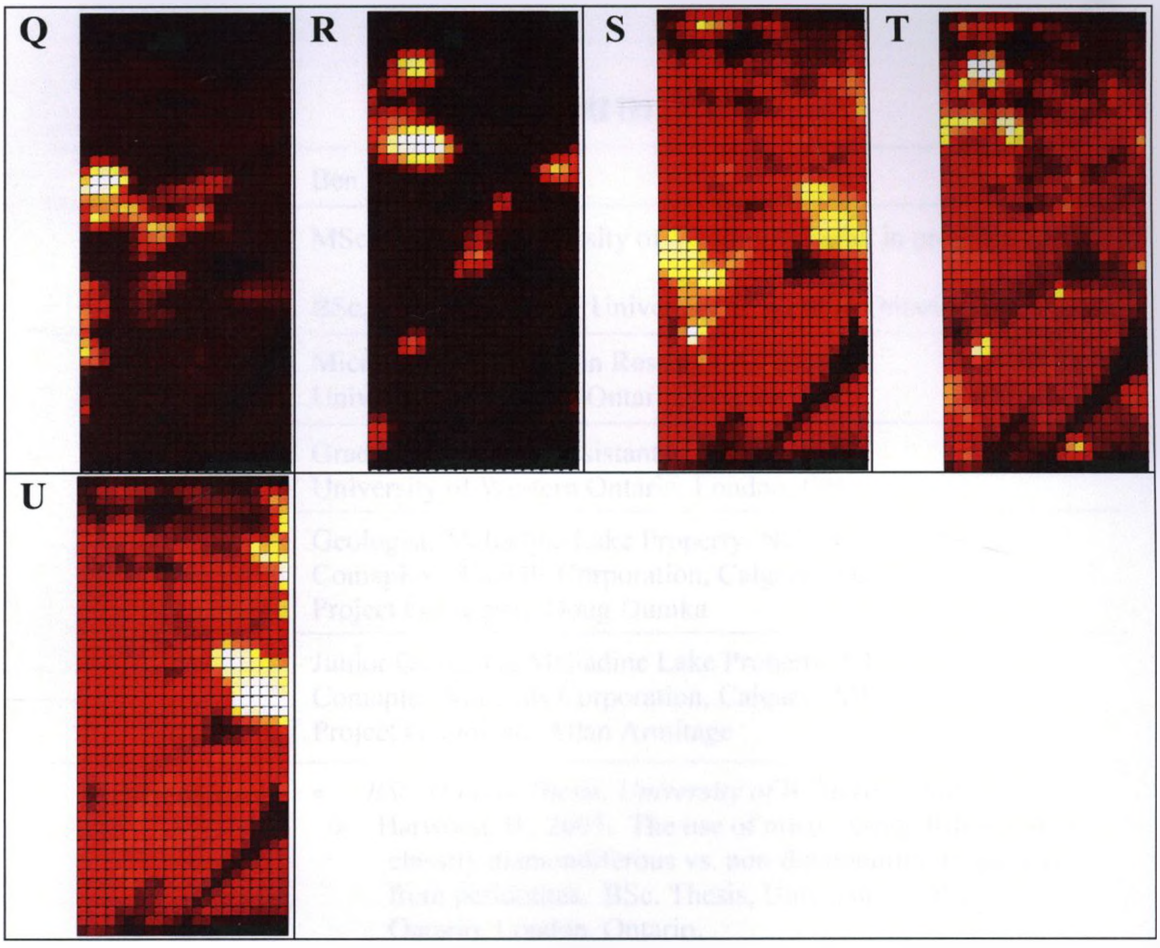


High-resolution map (BO-26)

(A) Di_map_1, (B) Di_map_2, (C) Di_map_3, (D) Phl_map_1, (E) Phl_map_2, (F) En_map_1, (G) En_map_2, (H) Gnt_map_1, (I) Gnt_map_2, (J) Gnt_map_3, (K) Gnt_map_4, (L) Gnt_map_5, (M) Ol_map_1, (N) Ol_map_2, (O) Ol_map_3, (P) Ol_map_4, (Q) Ol_map_5, (R) Ol_map_6, (S) Ol_map_7, (T) Ol_map_8, (U) Ol_map_9. In all cases the scale bar is the same as (A), where each box is 0.5 mm.




E
F
G
H
I
J
K
L
M
N
O
P


Q
R
S
T
U