TECTONICS AND GEOARCHAEOLOGY OF SOME METAULTRAMAFIC ROCKS IN THE SOUTHERN APPALACHIANS

by

NICOLE MARIE DUHAMEL

(Under the Direction of Sam Swanson)

ABSTRACT

Metaultramafic rocks are wide-spread in the Appalachian Orogen and have been used in tectonic reconstructions. The Tugaloo Terrane extends from Alabama to Maryland containing two belts of ultramafic rocks, one in the Blue Ridge and one in the Inner Piedmont; Hess first described the belts. Normative mineralogy and comparison to various ophiolite sections shows that Blue Ridge rocks are related to arc volcanism and Piedmont rocks formed in a fore-arc setting.

Ancient Native Americans have quarried the metaultramafic rock soapstone. An inherent assumption in soapstone provenance studies is the homogeneity of soapstone mineralogy on the outcrop scale. Joseph Bond Quarry (18HO1) was used to test this assumption. Mineralogy proved uniform except for differences in talc and chlorite compositions between amphibole-bearing and amphibole-free assemblages. In future applications of soapstone mineralogy it will be important to take into account the roles of different assemblages in explaining variations in mineral compositions.

INDEX WORDS: Hess, Tugaloo Terrane, CIPW, soapstone, Joseph Bond Quarry, EMPA

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DEDICATION

I dedicate this to my family. I couldn't have done this without your belief and support in me and for always being there when I needed you and even when I didn't. Even though you could not be here in person I knew you were always with me. Thank you for the solid foundation of always telling me that no matter what happens you are proud of me.

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INTRODUCTION

Soapstone and other ultramafic rocks provide information on the tectonic history of mountain systems. Soapstone, together with other ultramafic rocks, occurs as small, rootless lenses and bodies in the Appalachians Orogen. Hess (1955) noted these ultramafic lenses were aligned in two belts in the Appalachian (and other) orogen. He likened the tectonic emplacement of these rocks into the crust as "watermelon seeds" slipped into the deforming orogeny. Hess further related each belt of ultramafic rock to the closing of an ocean basin. Plate tectonic models (e.g. Moores and MacGregor 1972) incorporate Hess's earlier ideas on the role of these ultramafic rocks in orogens. The ultramafic belts occur within the Blue Ridge and the Piedmont physiographic provinces. Chapter 1 explores the composition of rocks in the two belts and the tectonic significance of these belts.

Soapstone/steatite is composed of talc and chlorite with variable amounts of amphibole and FeCr oxides. It is the product of medium grade metamorphism of mafic/ultramafic rocks. Soapstone is a soft rock easily carved by bone and stone tools. This made steatite much sought-after by the Native Americans. For a short time period, soapstone bowls were made and widely distributed from soapstone quarry sites in eastern North America (Truncer 2004). Though steatite bowl technology was short lived, soapstone artifacts occur in archeological sites all along the east coast. Bowls have been found at sites that are not located near any known soapstone outcrops (Truncer 2004). Because soapstone is resistant to chemical weathering, artifacts are preserved, making this rock type ideal for study and interpretation (Truncer 2004). Chapter 2 reviews the archaeological setting of soapstone in the Appalachian Orogen.

Soapstone geoarchaeological studies started in the nineteenth century, but it wasn't until recent years that soapstone vessels received analytical attention. In the late 1800s, William Henry

Holmes of the Smithsonian Institution conducted surveys of known quarry sites in the area around Washington, D.C. and documented the steps of soapstone vessel manufacture (Holmes 1884). It wasn't until the mid-20th century that steatite vessels started to receive attention again, when radiocarbon dating became well established (Truncer 2004). The dates ranged from 3000-3330±160 BP (Shaffer 2008). This made soapstone vessels a key indicator for the Archaic Transitional Period (Truncer 2004). More recently, soapstone studies have focused on various geochemical techniques for sourcing the soapstone and the implications of those sources for understanding social/economic interactions of ancient Native American tribes (Schaffer 2008). Steatite outcrops and vessel quarries that are relatively unknown in terms of their mineralogy and geochemistry occur both in the Central and Southern Appalachians. Chapter 3 explores the mineralogy of a small soapstone quarry in Maryland, the Joseph Bond Quarry (18HO1), a soapstone quarry first described by Holmes (1890).

<u>CHAPTER 1</u>

PETROLOGICAL STATISTICAL ANALYSIS OF THE SOUTHERN APPALACHIANS ULTRAMAFIC BELTS WITHIN THE TUGALOO TERRANE

Hess Revisited

Harry H. Hess is considered the father of the study of the tectonic significance of Alpine-type ultramafic rocks in mountain belts. Hess (1955) noted that lenses of ultramafic rocks were aligned in two belts in the Appalachian (and other) orogenic systems (Figure 1). He noted that the lenses lacked evidence for igneous intrusion, such as chilled margins. He likened their emplacement into the upper crust as tectonic “watermelon seeds” slipped into the deforming orogen. Hess (1955) further related each belt of ultramafic rock to the closing of an ocean basin. Hess noticed the occurrence of these rocks in mountain systems. The term “Alpine-type” ultramafic rocks describe these tectonically emplaced bodies of ultramafic rock.

Hess started out as a prospector for a mining company for a few years then went back to school. He worked under an economics professor at Princeton on a nearby soapstone deposit (Moores and Vine 1988). This sparked his interest in ultramafic rocks and is where he first noted the linear distribution of ultramafic rocks in the Appalachians. He worked for several years with F. A. Vening Meinesz to study Caribbean marine geology and geophysics. This ended when he was asked to be active again in the US Navy during WWII. He worked on the USS Cape Johnson and by leaving on the depth sounder he provided a lot of data used to map the Pacific sea floor (Moores and Vine 1988). The new images of the sea floor led Hess to study seamounts for a few years which later renewed his interest in tectonics and alpine ultramafic rocks.

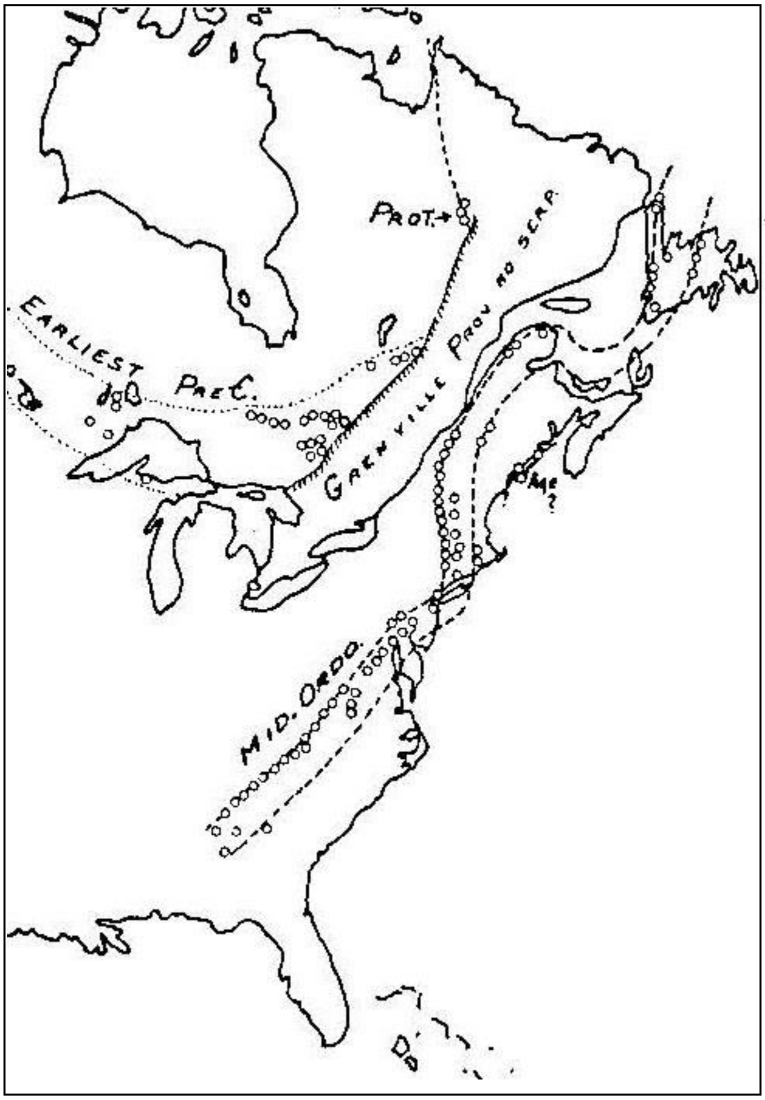

Figure 1: Hess's map of the serpentinite (ultramafic) belts of North America (Hess 1955).

Hess (1955) was the first to recognize the importance of ultramafic rocks in the study of mountain chains. He noted the main rock-type was serpentinite; however he did recognize that these bodies of serpentine were alteration products of olivine- and pyroxene-rich rocks. Although at first skeptical, he eventually recognized that peridotites and dunites were exposures of the

Earth's mantle based on new evidence from colleagues and his own research in Italy and Greece (Moores and Vine 1988). Once he recognized that ultramafic rocks are part of ophilolites, he noted their significance in the formation of orogenic belts (Hess 1955, Moores and Vine 1988). Hess noticed as he was studying these rocks around the world that the pods and bodies of ultramafic rocks lined up to form "belts" along the length of the mountain chains. His further investigation into this phenomena showed that the belts usually occurred in pairs, one belt on either side of the axis of the mountain belt. With his knowledge of marine geology and geophysics, he deduced that these belts were an indicator for closing of an ocean basin and accretion of an island arc as part of the formation of Alpine-type orogens (Moores and Vine 1988). He believed that an understanding of how his "serpentine belts" were emplaced would lead to a much better understanding of the formation of Alpine-type mountains (Hess 1955). One such mountain belt where Hess focused his research is the Appalachian Mountains along the eastern margin of North America.

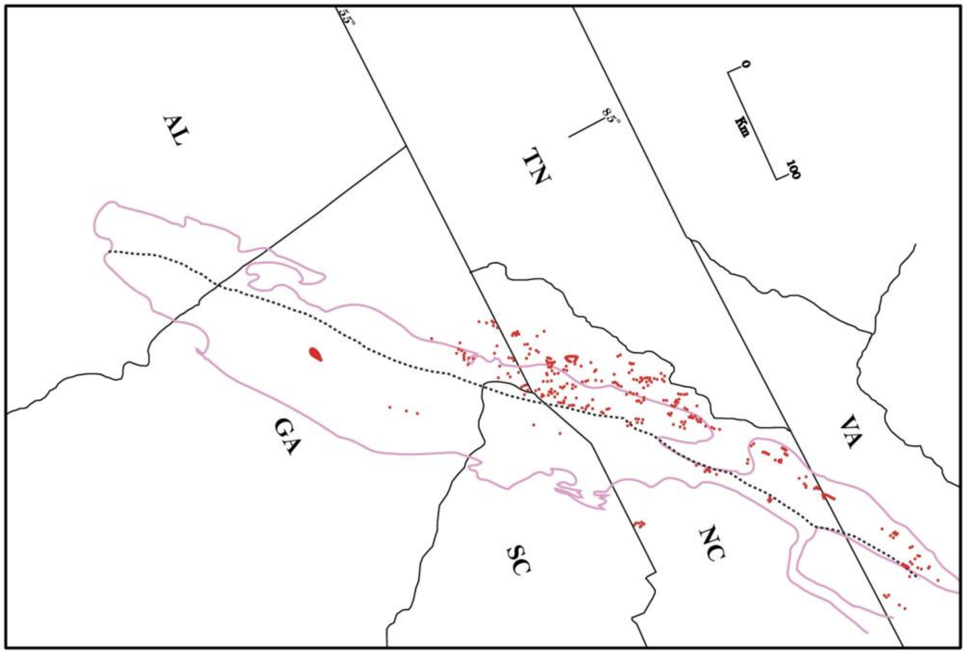

Figure 2: Outline of the Tugaloo Terrane in purple, Brevard Zone as the dashed line (Merschat et al 2010) and locations of known ultramafic rocks outcrops as red dots (Larrabee 1966).

As stated previously, Hess (1955) termed the belts “serpentine belts” but recognized the occurrence of several other types of ultramafic and mafic rocks (Hatcher et al. 1984, Butler 1989). Larrabee (1966) compiled a more detailed map of the location of the ultramafic and mafic bodies in the Appalachian orogen (Figure2). Both Larrabee’s and Hess’s maps show similar patterns; both show a greater abundance of ultramafic bodies in the west (Blue Ridge). Hess believed the serpentine bodies were emplaced with fluidity, as hydrous peridotite magma (Hess 1955). As stated earlier, Hess later conceded that the ultramafic bodies were emplaced tectonically as solid blocks (Moores and Vine 1988). Hatcher et al. (1984) emphasized that the ultramafic bodies and associated mafic rocks in the southern Appalachians formed a package. They acknowledged the fluid emplacement model of Hess’s “squeezed in watermelon seeds,” but also speculated that emplacement occurred as faulted blocks, which they termed as “punctured basketballs” (Hatcher et al. 1984). The tectonic significance of these rocks is still debated (Moores and MacGregor 1972, Hatcher 2010). This study will focus on the ultramafic rocks within the Tugaloo Terrane (Figure 3). The Tugaloo Terrane was defined by Hatcher (2002) based on the rocks with a similar geologic history. This terrane is the only one that contains portions of both ultramafic belts (Figure 2).

Ultramafic Belts

The ultramafic rocks of the Appalachian orogen are concentrated in two physiographic provinces, the Piedmont and Blue Ridge. Characteristics of Alpine-type ultramafic rocks include occurrences as irregular-elliptical deformed masses, isoclinal folds, minerals with high magnesium numbers, and fault contact with enclosing rocks. Alpine-type mafic and ultramafic rocks are commonly serpentinized hence Hess's emphasis on serpentine (Moores and MacGregor 1972).

Blue Ridge Belt

The Blue Ridge is the western-most province of crystalline rock in the Appalachian orogen. The western Blue Ridge is composed of low grade Laurentia margin metasediments deformed during accretion of rocks to the east. The eastern Blue Ridge is composed of medium to high grade schists, gneisses and amphibolites that were accreted and deformed during the Taconic orogeny (Hatcher 2010). The Blue Ridge runs from Newfoundland to Alabama, about 1100 km. It is dotted with small-large bodies of ultramafic rocks with a strong concentration within North Carolina and Georgia (Figure 2). Most of the ultramafic rocks are metadunites (Hatcher et al. 1984). Other ultramafic and mafic rocks within the Blue Ridge are metagabbros, amphibolites, metaperidotites, soapstone and serpentinites (Moores and MacGregor 1972, Mirsa and Keller 1978). The Blue Ridge has more ultramafic and mafic bodies creating a more "continuous" belt than the Piedmont throughout the Southern Appalachians (Figure 2).

Bodies of ultramafic rocks form elongate lenses lengthwise parallel to regional foliation of the enclosing metamorphic rock (Mirsa and Keller 1978). Most ultramafic bodies have a metasomatic reaction or “black-wall,” composed of chlorite-talc-amphibole schist. The black-wall indicates the ultramafic rocks were emplaced prior to regional metamorphism (Trommsdorff and Evans 1974).

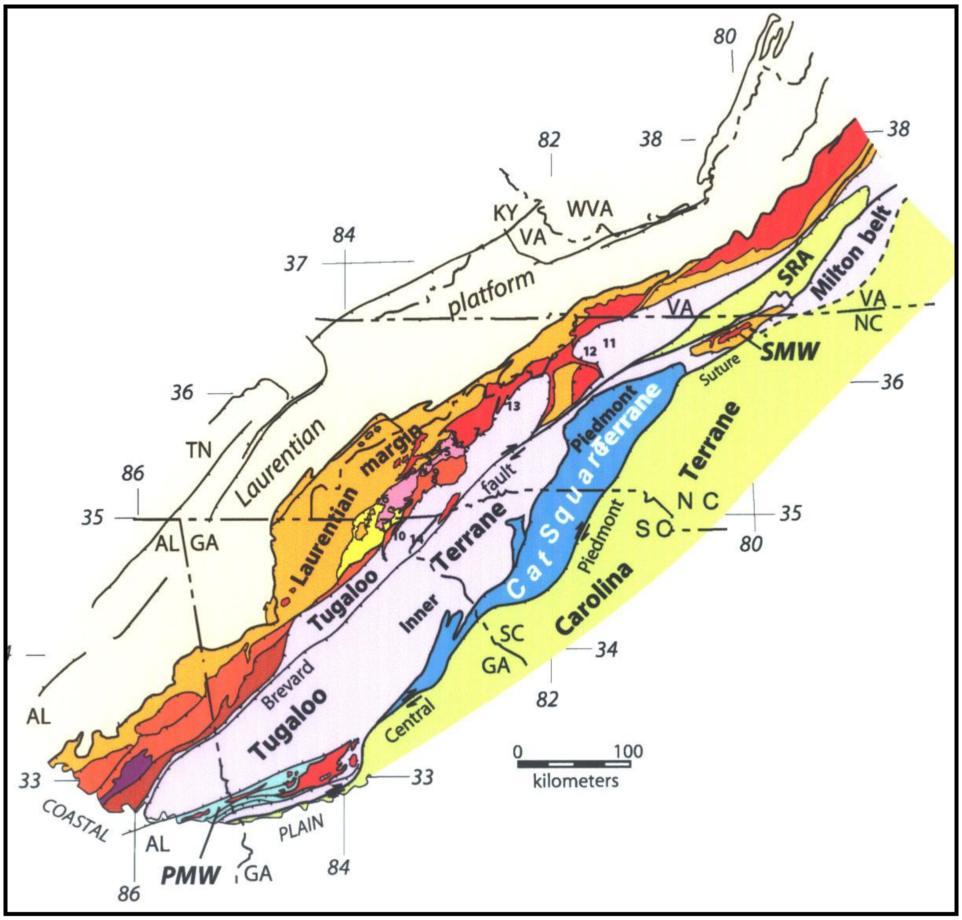

Figure 3: Hatcher’s map of the different terranes of the Southeastern United States (Hatcher 2002)

Piedmont Belt

The Piedmont province stretches from Maine to Alabama. It is split into the following belts based on degree of metamorphism and structural elements: Inner Piedmont, Kings Mountain, Charlotte, Carolina Slate, Raleigh, and Pine Mountain belts. The Inner Piedmont is part of the Tugaloo Terrane and contains fewer bodies of ultramafic rocks than the Blue Ridge (Mirsa and Keller 1978). The Inner Piedmont is composed of medium to high grade metamorphic rocks (Mittwede 1989). Local areas of greenschist facies associated with isoclinal folds are composed of muscovite sericite schist, phyllite, felsic to mafic metavolcanic and plutonic rocks (Butler 1991). Ultramafic rocks in the Inner Piedmont occur as sill-like bodies of ultramafics enclosed in the schists and gneisses. The small lenses of mafic and ultramafic rocks are conformable to foliation. The metadunites and metaperidotites lenses are up to 200m long and less than 100m thick with the outer edges composed of talc-rich rock (Butler 1989).

Tectonic History

The Appalachian Orogen records a history of ocean basin opening and closing (a Wilson cycle) from the late Precambrian through the Paleozoic (Hatcher 2010). The early super continent of Rodinia was rifted apart beginning in the late Precambrian. Breakup was initiated along the eastern margin of Laurentia. A new ocean basin, complete with subduction-related island arcs and associated fore arc subduction-related deposits, formed as a result of continental breakup. Beginning in the Ordovician, the new ocean basin began to close. The Taconic Orogeny resulted from the collision of island arc complexes with the Laurentia margin, closing of the Iapetus Ocean basin, and overthrusting of the island arc package of rocks onto the passive margin sediments of Laurentia (Hatcher 2010). Continued closing of the ocean basin produced the accretion of the Carolina superterrane in the Acadian-Neoacadian Orogeny in the Late

Devonian to the Mississippian. The ocean basin was finally closed at the end of the Paleozoic in the Alleghanian Orogeny in the assembly of Pangea (Hatcher 2010). Each of the three orogenies produced deformation and recrystallization in the southern Appalachian Orogen, but the Taconic Orogeny is associated with the highest metamorphic grades.

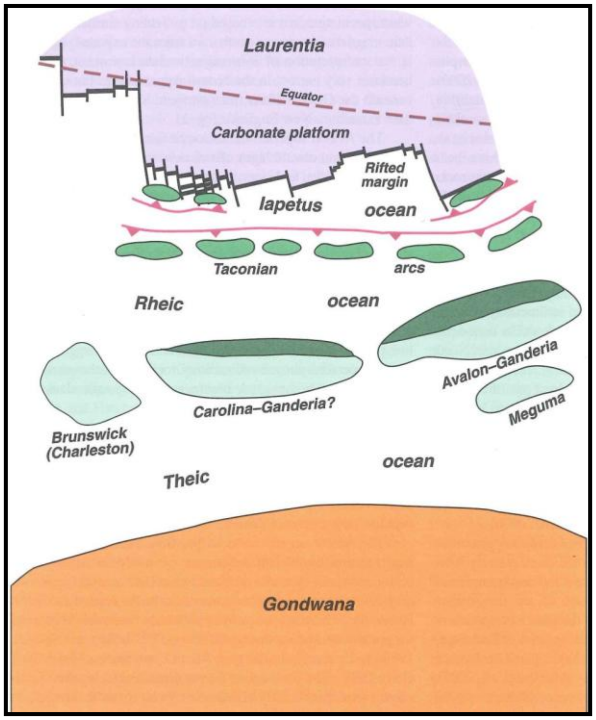

Figure 4: A representation of the different landmasses that were accreted to form the Appalachian Mountains (Hatcher 2010).

Tugaloo Terrane

Geologic terranes are defined by zircon age dates. Physiographic provinces such as the Blue Ridge and Piedmont are defined by earth surface topography. The Blue Ridge is defined as high-elevation areas northwest of the Brevard zone while the Piedmont is the low lying area southeast of the Brevard zone and northwest of the Coastal Plain. Terranes are groups of rocks that have similar zircon age dates (thus similar geologic histories) for their depositions and deformation. The Tugaloo terrane (Figure 3) is a package of island arc and subduction-related fore arc/back arc rocks emplaced along the Laurentia margin during the Taconic orogeny (Hatcher 2010). What makes this terrane unique is that it includes parts of the Blue Ridge and Piedmont provinces. The Brevard zone separates the two physiographic provinces, but it is not a terrane boundary (Hatcher et al. 1984). The Tugaloo Terrane (Figure 3) extends from Alabama, along the Appalachian trend, to equivalent rocks (e.g. Milton Chopawamsic-Potomac terranes) in Virginia and Maryland (Hatcher 2010). The Tugaloo Terrane contains the two belts of ultramafic and associated mafic rocks defined by Hess (1955) and Larrabee (1966) (Figure 2). The interesting issue of the Tugaloo Terrane is the existence of 2 ultramafic/mafic belts in one terrane. Models of ultramafic rock emplacement defined a plate boundary, yet two belts are within the same terrane. Tugaloo provides a unique opportunity to understand if these belts do represent plate boundaries and why are they is incorporated within one terrane.

Methods

As stated previously, one goal of this study is to understand the origins of the ultramafic and mafic bodies of the southern Appalachians. To understand how these bodies were emplaced, it is important to know how these rocks were first formed. These rocks have gone through multiple phases of high grade metamorphism/alteration and deformation making the determination of the protoliths difficult. Protolith determination is usually done through analysis of thin sections, however most of these rocks are completely recrystallized and any evidence of original minerals and/or fabrics are sparse. Another method to decipher the protolith of a metamorphic rock is to use the bulk geochemistry. This study summarized geochemical data from several sources (Appendices 1.1a and 1.2a) and calculated the CIPW normative mineralogy. The data were later analyzed through the statistical program R (R Development Core Team 2011) to see if there were differences between Blue Ridge and Piedmont rocks.

Data gathering

There have been many studies of the ultramafic and mafic bodies of the southern Appalachians. Studies that reported geochemical compositions of the ultramafic and mafic rocks (Hunter 1941, Kulp and Brobst 1954, Butler and Ragland 1969, Hatcher 1970, Carpenter and Chen 1978, Dribus et al 1982, Hatcher et al. 1984, Mittwede and Zupan 1985, Conte 1986, Warner et al. 1986, Higgins et al 1988, Warner et al. 1989, Mittwede 1989, Raymond et al 2001, Warner 2001, Staphor et al 2010, Chaumba 2012, Sam Swanson (unpublished)) were divided by locality (Blue Ridge versus Piedmont). The geochemical data were sorted to include only localities within the Tugaloo Terrane. Results of the compilation include 166 samples from the Blue Ridge in Appendix 1.1a and 97 samples from the Piedmont in Appendix 1.2a. The uneven distributions of bulk rock data between the Blue Ridge and the Piedmont was noted by other authors (Hatcher et al. 1984, Mirsa and Keller 1978).

The ophiolite concept has greatly changed since being related to plate tectonics in the early 1970's (Moores and Vine 1988, Dilek and Furnes 2011). Ophiolites are slices of ancient oceanic crust that have been thrust onto the continental crust. They contain sections, in order, of sediment, pillow basalts, sheeted dikes, leucogabbro, gabbro, layered ultramafic rocks and mantle rocks. Each kind of ophiolite follows this pattern and presence/absence of each unit is what distinguishes the ophiolites from different settings (Moores et al. 2000). The type of ophiolites considered were Mid-Ocean Ridge, Suprasubduction Zone (SSZ)-backarc to forearc, and a Volcanic Arc. The SSZ is considered to be the most common ophiolite type (Dilek and Furnes 2011). Fresh igneous rocks representative of each kind of ophiolite were gathered

(Lippard et al. 1986, Kurth-Velz et al. 2004). The mantle section is variably represented in the ophiolite sections. To be consistent none of the mantle sections were included in the data compilation. The ophiolite crustal rock-type data were normalized and the results were complied into pie graphs (Figure 8). Ophiolite sections with ratios of ultramafic rocks to mafic rocks closest to the ratios of Blue Ridge and Piedmont were used for this study.

CIPW norm

The geochemical data for each sample were normalized to 100% on an anhydrous basis. In the early 1900s, Cross et al. (1902) proposed a calculation process that converts bulk rock analyses (weight percents of the oxides) to normative mineralogy, referred to here as the CIPW norm. The complied geochemical data for Blue Ridge and Piedmont portions of the Tugaloo Terrane were then used to calculate normative mineralogy using the program **norm**4.xls. The calculated normative mineralogy is typically quite different from the rock mineralogy aka the "mode." Normative mineralogy can be used to classify the protoliths of the metamafic and metaultramafic rocks.

Recasting the chemical data as normative mineralogy allows for the determination of the protolith. The absence/presence of a normative mineral can indicate if the protolith was enriched or depleted in a particular component. An example is the presence or absence of quartz. If there is normative quartz, then the protolith was silica enriched (oversaturated) and modal quartz is expected in the protolith. Anhydrous norms were interpreted as protolith mineralogy and this calculated mineralogy was used to assign rock names to the protoliths. The percentages of protolith rock types were complied into pie graphs (Figure 5) for easy comparison between the Blue Ridge and the Piedmont.

Limitations of Normative Mineralogy

There are some limitations that must be kept in mind when using the CIPW normative system. The CIPW normative calculation was designed to reproduce the anhydrous mineralogy of the basaltic magma. This means that there are no hydrous minerals in CIPW norms. The second disadvantage of the CIPW normative system is how it deals with non-ideal components in normative minerals. For example, clinopyroxene from ultramafic rocks often contains Al and Na (Deer et al. 1966), yet normative clinopyroxene is calculated without Al or Na. This can result in the erroneous appearance of plagioclase in the protolith mineralogy.

Statistical Analysis

The statistical program used for statistical analysis was "R Project for Statistical Computing" or R for short (R Development Core Team 2011). It provides a wide variety of statistical (linear and nonlinear modeling, classical statistical tests, time-series analysis, etc.) and graphical techniques. R is available as Free Software under the terms of the Free Software Foundation's GNU General Public License in source code form (R Development Core Team 2011).

Principal Component Analysis (PCA) was done on the geochemical data. A PCA is type of discriminant function analysis, a statistical method to distinguish groups within a set of data. The approach is to create new axes that will take into account as much of the variance between all of the variables as possible. The new axes are called Principal Components (PCs) (Holland 2011). In the process, a PCA eliminates any variables that do not have a significant value (Garrison 2003). Before the PCA can be accomplished the data must have a normal distribution. As a result, any column or row that has zeros, any outliers and anything under or above a specific range of a main variable needs to be eliminated. In this study, samples that fell outside the range of 41-54% SiO_2 were not included in the analysis. As a result, the number of PCs created is equal to the number of variables that are still in the data tables. In essence, PCA is an approach for multi-variant data in which the data are continually rotated with each new axis so that each successive axis shows decreasing amount of variance between the variables (Garrison 2003, Holland 2011). To run a successive PCA, the data must be reduced so that any variable or sample that has zeros must be removed. After this is done, the data need to be checked for any outliers and to make sure that the data have a normal distribution by using the pairs() function. Any outliers need to be removed and since the Blue Ridge-Piedmont data were right-tail skewed for some of the variables, a log transform was done to get a more normal distribution.

However, the same number of PCs remain as variables and the point of this approach is to "reduce the dimensionality" of the data (Holland 2011). So, the last step before plotting the data on the new axes is to ignore any PCA that shows very little variance. The cut-off point is arbitrary. The cut off point for this study was any PC that showed less than 12.5% of the variance between the variables. Since there were 8 PC's, if each showed equal amount of variance, the variance for each would have been 100/8 =12.5. So, anything under 12.5 would not have any effect on the data. The result was the cut-off point was at 3. The final step of the PCA was to create graphs until all PCs were graphed between each other. Since only 3 PCs were used, only three graphs were needed.

Geochemistry of Mafic and Ultramafic Rocks in the Tugaloo Terrane

Bulk compositions of the ultramafic and mafic rocks provide clues to tectonic setting. The CIPW norms were used to determine the protoliths of the metamafic and metaultramafic rocks of the Tugaloo Terrane. The PCA of the data were used to determine if Blue Ridge rocks and Piedmont rocks are separable via the geochemistry of the samples.

CIPW bulk analyses

The CIPW normative mineralogy was used to compare Blue Ridge and Piedmont rocks and to define the possible protoliths. Since only a portion of the data reported loss on ignition (LOI), water had to be taken out of consideration. To account for Al and Na content of clinopyroxene, calculated norms with up to 15% normative plagioclase were considered ultramafic rocks. The normative mineralogy portrayed as protolith rock types are displayed as pie diagrams (Figure 5).

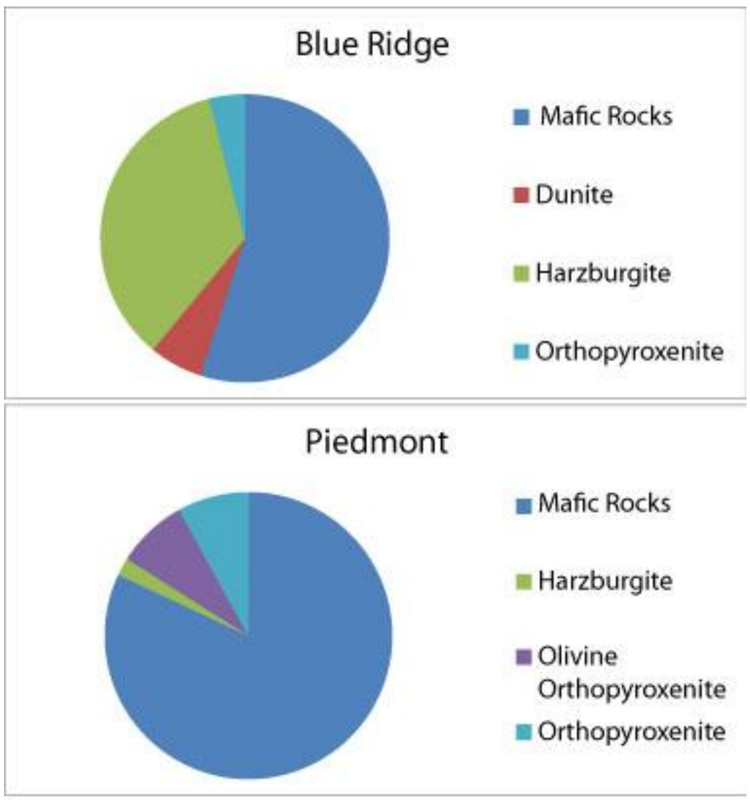

Figure 5: Abundance of the mafic and ultramafic rocks of the Piedmont and Blue Ridge based on calculated normative mineralogy

The Blue Ridge and the Piedmont have a surprisingly different proportion of mafic and ultramafic rocks (Figure 5). The term mafic rocks are used for any rock with more than 15% plagioclase in its norm. There rocks are mostly amphibolites and metagabbros. The ratio of ultramafic to mafic rocks is close to 50-50 in the Blue Ridge while the Piedmont consists of about 80% mafic and the 20% ultramafic rocks. The proportions of ultramafic rocks are also different in the Blue Ridge and Piedmont suites. Ultramafic rocks of the Piedmont are mostly olivine-poor pyroxenites, whereas olivine-rich dunites and harzburgites dominate the Blue Ridge suite (Figure 5).

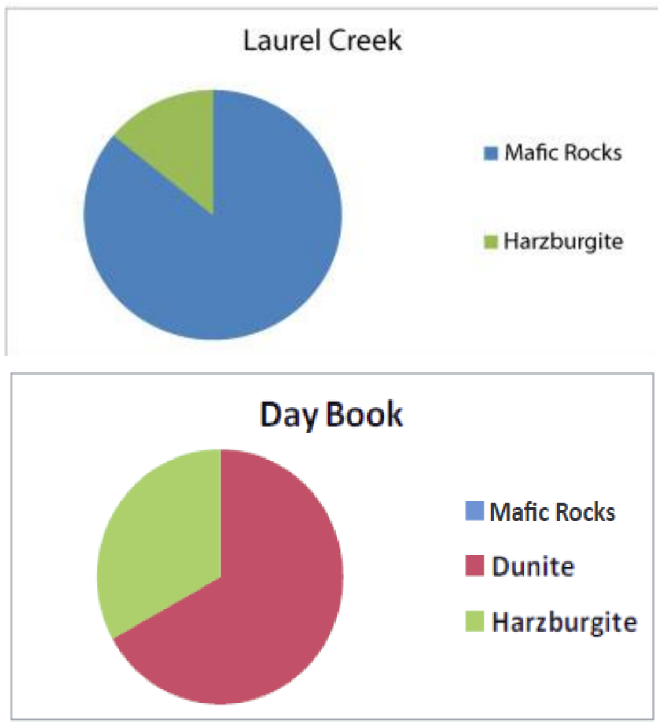

Figure 6: Portions of mafic and ultramafic rocks from representative areas within the Blue Ridge (based on the analyses in Appendix 1.1a and 1.2a)

One possible explanation of the high proportions of ultramafic rocks in the Blue Ridge, relative to the Piedmont, may come from the over-sampling of the ultramafic rock, relative to mafic rocks in the Blue Ridge. The Blue Ridge ultramafic rocks were mined for a variety of industrial minerals including olivine (Hunter 1941), asbestos (Conrad et al. 1963), chromite (Hunter et al. 1942), corundum (Pratt and Lewis 1905), and vermiculite (Murdock and Hunter 1946). The economic reports often include analyses of the ultramafic rocks that host the ore deposits, but ignore the associated mafic rocks. For example, the Day Book body (Swanson 1981) is composed of metadunite and metaharzburgite and was mined for olivine, chromite and vermiculite. The ultramafic rock is enclosed in amphibolite. The area of the amphibolite outcrop is several times larger than the ultramafic rocks (Brobst 1962, Swanson 1981), yet the mafic rocks are not represented by analyses (Figure 6). In contrast, a study of the Laurel Creek body (Hatcher et al. 1984) more accurately represents the proportions of mafic and ultramafic rocks (Figure 6). The proportion of mafic to ultramafic rocks of Laurel Creek is similar to the rock distribution in the Piedmont (Figure 5).

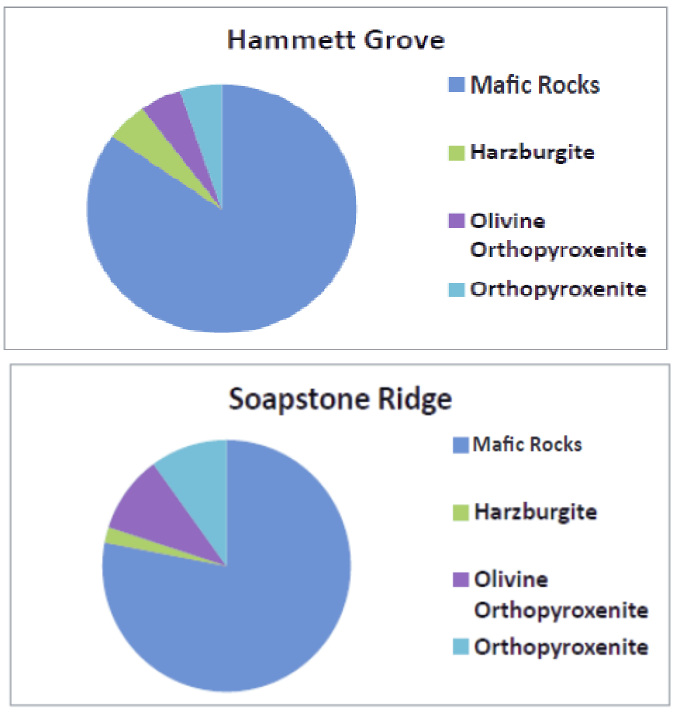

Figure 7: Proportion of mafic and ultramafic rocks from representative areas within the Piedmont (Appendices 1.1b and 1.2b)

Ultramafic rocks of the Piedmont were not exploited for mineral commodities in historic times. Thus the suite of Piedmont samples does not suffer from the selective over-sampling of the ultramafic rocks. Two bodies of Piedmont mafic/ultramafic rocks, Soapstone Ridge and

Hammett Grove (Figure 7) show the same pattern, where mafic rocks are much more abundant that the ultramafic rocks. Allowing for the over-sampling of Blue Ridge ultramafic rocks suggests the proportion of mafic to ultramafic rocks at Laurel Creek (Figure 6) is probably a better representation of the actual outcrop pattern of these rocks in the Blue Ridge.

Consideration of just the ultramafic rock types may provide a better comparison of various ophiolite settings to the Blue Ridge and Piedmont rocks. The proportion of various ultramafic rock types do not suffer the selective samplings discussed earlier for Blue Ridge ultramafic rocks and thus provide a better comparison to ophiolite types.

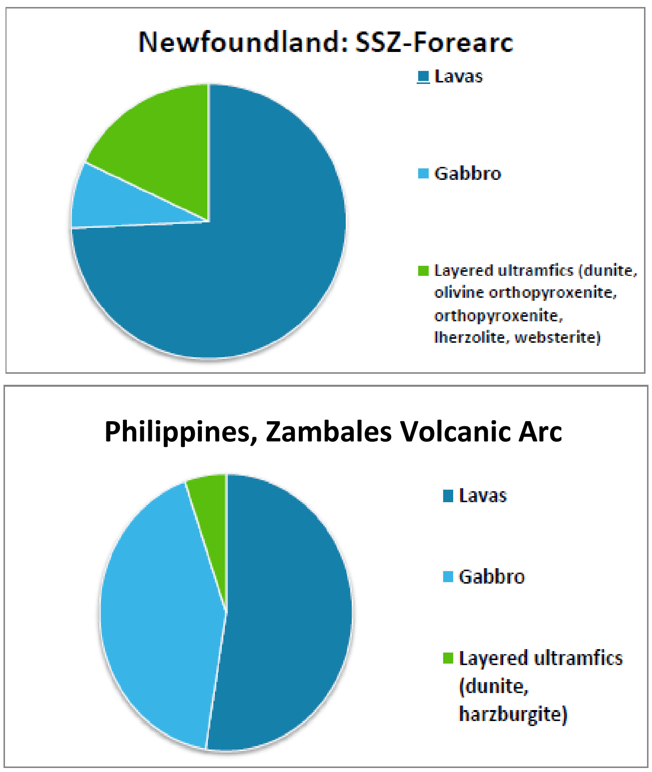

Figure 8: Proportion of different ophilolites units based on published stratigraphic sections

Comparison of the Laurel Creek (proxy for the Blue Ridge) and Piedmont data (Figure 5 and 7) to mafic/ultramafic rocks in sections of ophiolite from suprasubduction zone-fore arc and volcanic arc settings (Figure 8) shows the overall dominance of mafic rocks. Based upon the comparison of the ratio of mafic to ultramafic rocks (Figure 6 and 7) to the representative ophiolite types (Figure 8), both the Piedmont the Blue Ridge data resemble the ratio of mafic/ultramafic rock types of SSZ-forearc ophiolite (Newfoundland, Figure 8).

Consideration of the ultramafic rock petrology provides a way around the problems associated with the absolute abundance of various rock types. Ultramafic rocks of the Blue Ridge are olivine-rich (dunite and harzburgite, Figures 5 and 6) while ultramafic rocks of the Piedmont are more pyroxene-rich (pyroxenites, Figure 5 and 7). Comparison to ophiolite sections shows the olivine-rich ultramafic rocks are typical of ultramafic rocks in volcanic arc ophiolites (Figure 8). Pyroxene-rich ultramafic rocks are more typical of SSZ fore-arc (Figure 8). Upon this consideration, having the Blue Ridge ultramafic rocks being possibly derived from a volcanic arc and Piedmont ultramafic rocks being derived from a fore-arc setting (SSZ) setting in consistent with Hess's model of an island arc accretion and the closing of an ocean basin. The Tugaloo Terrane represents remnants of the volcanic arc and fore-arc, back-arc rocks (Hatcher 2010).

Geochemical statistics

A PCA shows a very distinct separation between Blue Ridge and Piedmont samples (Figure 9). As a check, the total variance covered by PC 1-3 was calculated. The variance came to about 87%, which means that any patterns shown the PCs are very representative of the data. To understand the PCA plots, the variables that most influence each PC are needed. The principal components and corresponding variables are as follows: PC 1 represents Si and Mg, PC 2 represents both Fe valences and Mn and PC 3 represents Ti, Al and Ca. When looking at the graphs there is a very clear clustering/separation of the points between the Blue Ridge and the Piedmont along the PC1 axis. The data also show clear clustering along the PC 3 axis as well, though the Blue Ridge data are more spread out than the Piedmont samples. PC 2, however, shows more of a mixing of the data. This analysis demonstrates that the Blue Ridge and the Piedmont rock compositions are separable by Mg and Si along with Ti, Al and Ca to a lesser extent (Figure 9). This is consistent with information shown on Figures 6-8. Overall, the clear separations of PCA results for the Piedmont and Blue Ridge support the hypothesis that the two belts represent two different tectonic settings (volcanic arc and seafloor).

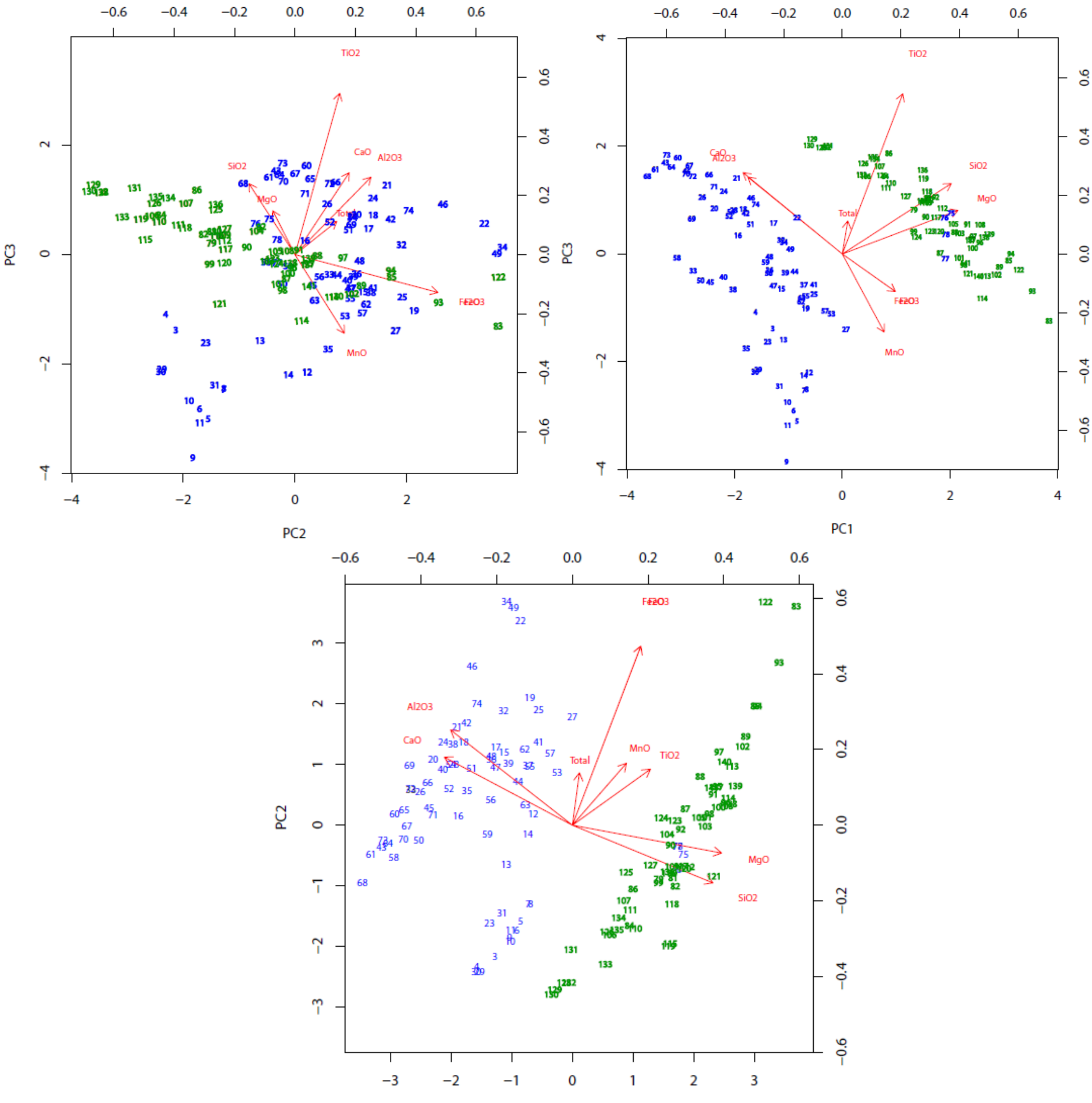

Figure 9: The PCA graphs show the distribution of the Blue Ridge samples in blue and Piedmont in green, PC1 (Si, Mg), PC2 (Fe, Mn) and PC3 (Ti, Al, Ca) as the axes

CHAPTER 2

GEOLOGICAL AND ARCHAEOLOGICAL BACKGROUND OF STEATITE IN THE SOUTHEASTERN APPALACHIAN MOUNTAINS

Soapstone Background

Steatite (soapstone) is a white to green to grey hydrous magnesium silicate rock with easy carvability. The terms “steatite” and “soapstone” are interchangeable because archaeology and geology use different terms. An archaeologist will refer to this magnesium silicate rock as “steatite while a geologist will refer to it as “soapstone.” Soapstone/steatite is easy to carve because it is composed of large amounts of soft minerals: talc, chlorite and serpentine. This rock type can either form a smooth fine-grained texture during low grade metamorphism or an aggregate coarse-grained texture during medium grade metamorphism (Chidester et al. 1964). Since the main emphasis of this study is geological, this rock type will be called soapstone.

Soapstone mineralogy is mainly talc (90-75%) and chlorite (5-15%) with lesser amounts of other minerals. Common accessory minerals in soapstone include magnetite, amphiboles (tremolite, cummingtonite and anthophyllite), serpentine, dolomite/magnesite along with relicts of olivine and pyroxene (Truncer et al. 1998, Greene 1995). The caravability of a soapstone outcrop is dependent on the percentage of amphiboles present. Higher amounts of amphibole make soapstone more difficult to carve. The misconception is that almost all soapstone is composed of talc and chlorite (Garrison 2003). However, most soapstone contains talc, chlorite and a varying amount of amphibole (Figure 10). How the mineral assemblage is derived depends on the composition of the protolith and the metamorphic grade.

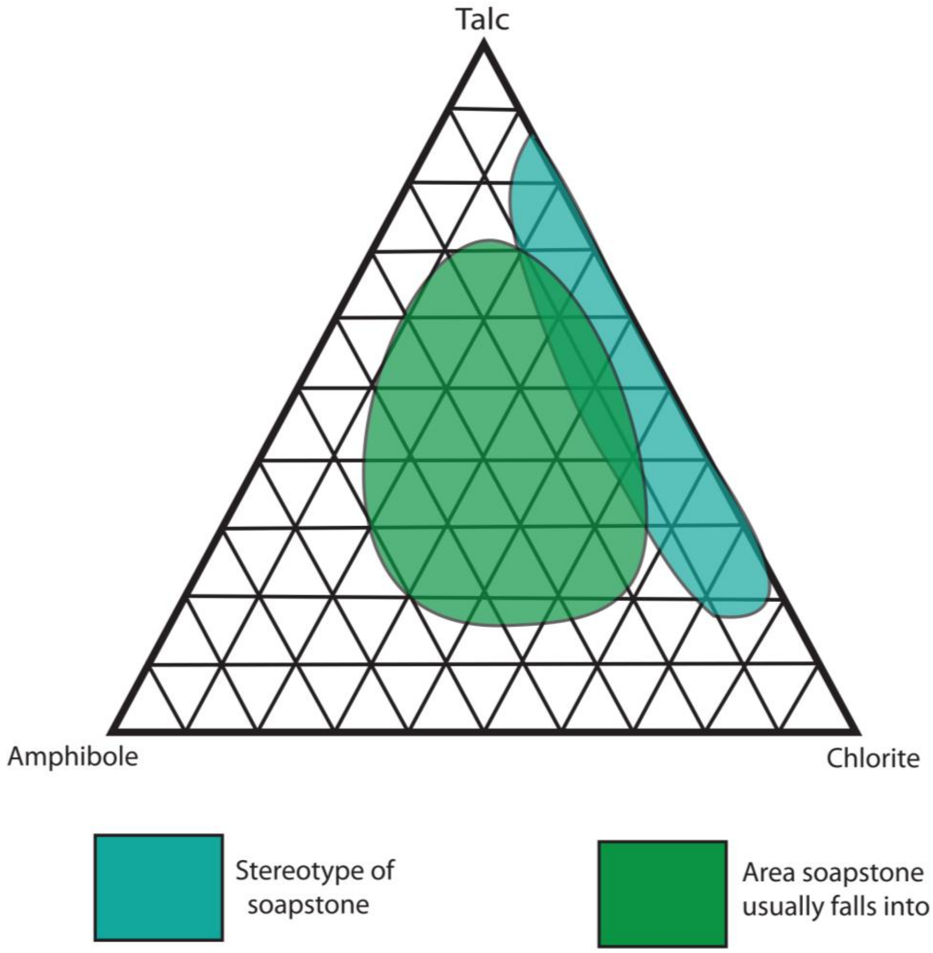

Figure 10: Tertiary diagram demonstrating the misconception and the actual mineralogy of soapstone

Origin of Soapstone

Soapstone has two protoliths, ultramafic rocks or dolomitic limestone (Greene 1995, Chidester et al. 1964). Dolomitic rocks that produce soapstone upon metamorphism occur in northwest Georgia, in western Virginia and in New England (Larrabee 1966, Greene 1995).

Ultramafic Protolith

The best known source of soapstone is the metamorphism of ultramafic igneous rocks (Greene 1995). Before the rocks can be turned into soapstone, they have to go through serpentization. Serpentinite can be transformed to soapstone by the addition of silica from hydrothermal fluids. Serpentinization usually accompanies a regional metamorphism event (Greene 1995, Evans 1977). This type of soapstone commonly forms in a pods and lens within the protolith. The pods are variable in size from meters to kilometers in length. This type of soapstone is typical found throughout the Appalachians, but is most abundant in the Blue Ridge Province (Chidester et al. 1964, Larrabee 1966, Mirsa and Keller 1978). A metasomatic "blackwall," rich in chlorite, typically forms between the soapstone and schist (Figure 11).

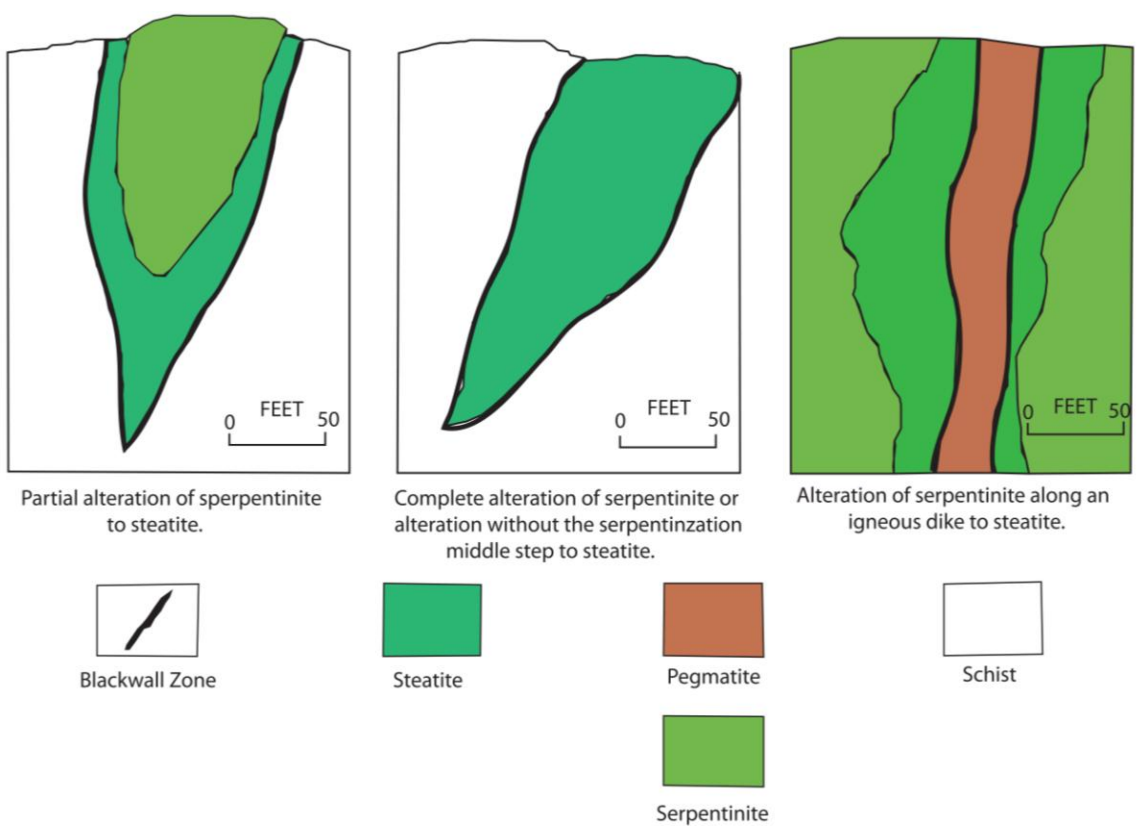

Figure 11: This diagram represents the different formation avenues for soapstone from ultramafic rocks, revised from Chidester et al. (1964)

Carbonate Protolith

Soapstone can form from dolomite by metasomatic enrichment of silica from hydrothermal fluids. The silica in the hydrothermal fluid is usually provided from nearby siliceous rocks when an intrusion heats pore water and the rocks next to it (Greene 1995). The soapstone bodies can form in a range of shapes and sizes representing the original stratification (Figure 12) (Chidester et al. 1964, Mirsa and Keller 1978).

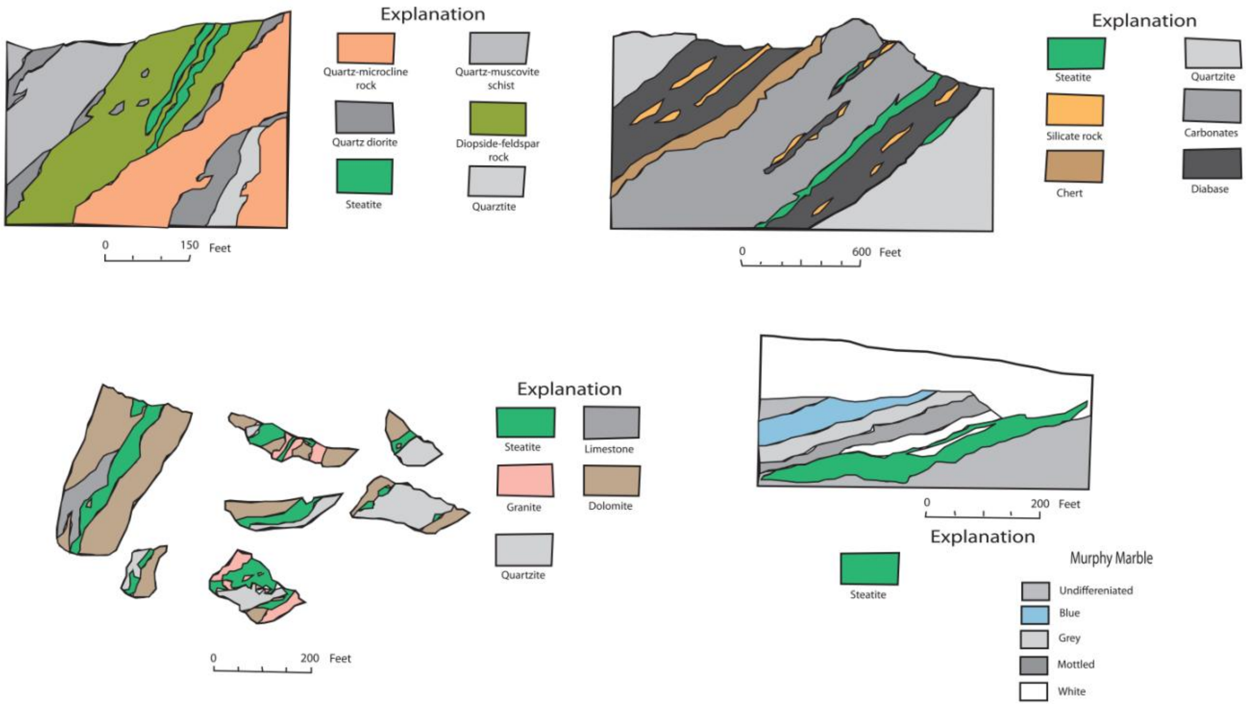

Figure 12: Idealized cross-sections of the rock type the soapstone is derived the nearby source of silica from which enriches the hydrothermal fluids, revised from Chidester et al. (1964).

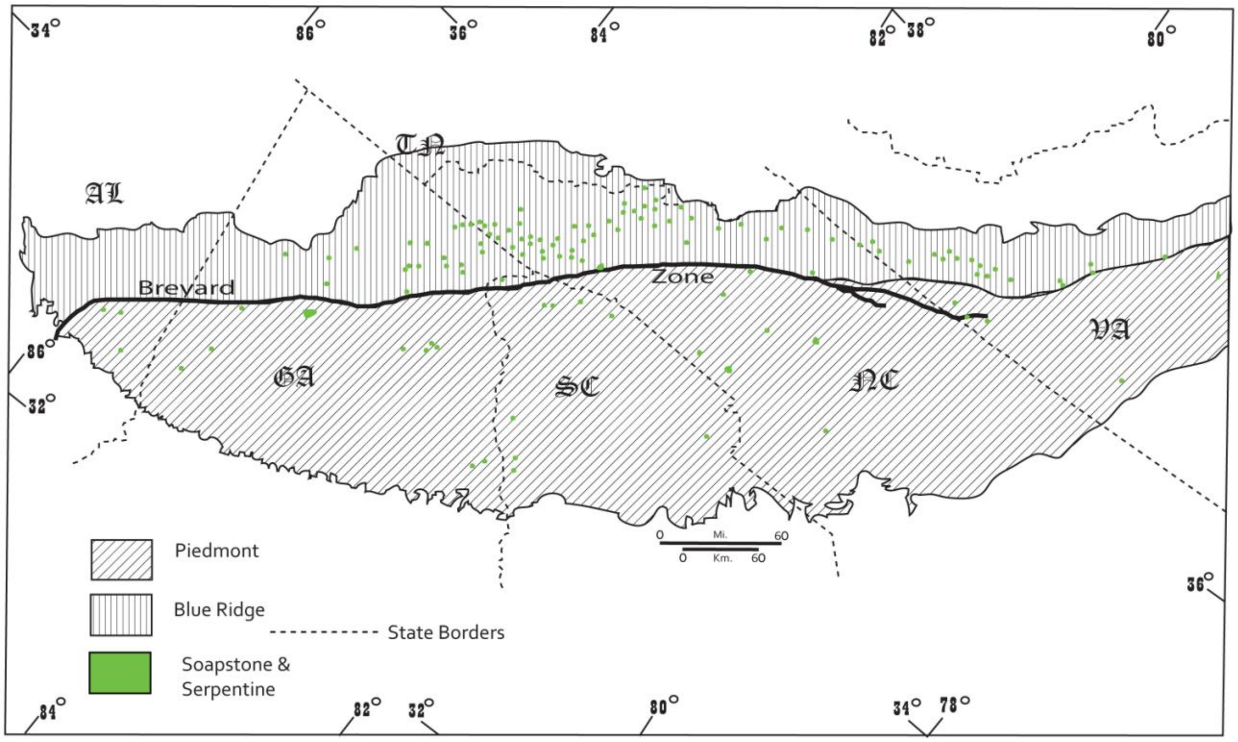

Figure 13: Mirsa and Keller (1978) map of the distribution of soapstone and serpentine outcrops between the Piedmont and the Blue Ridge separated by the Brevard Zone

Soapstone Archaeological Background

Soapstone artifacts have attracted the attention of archeologists on and off for the past century. When North American archaeologists were excavating Native American ancient homes, these vessels were found but were ignored (Truncer 2004). However, as more information was gathered about soapstone vessels, they became a clue into deciphering the human history of the Appalachian region. One of the prime reasons for interest in soapstone was these vessels appear to mark a previously unrecognized transitional period between the Archaic and Woodland periods. Even though they have been studied for over a century, very little is known about the soapstone vessels and the people who carved them.

Steatite and Southeastern Appalachian Ancient Native Americans

Uses and Distributions

The frequencies of where each form/shape of soapstone vessels are commonly found may shed insight into their functions. The first hypothesis was that soapstone vessels were used for cooking purposes (Truncer 2004). Ward and Custer (1988) looked into this assumption in Pennsylvania-Maryland. They noted that the type of outcrop delineated the shape and size of the soapstone vessels. The physical characteristics of the outcrops controlled the size and shape of the bowls made. Grooves found in outcrops delineated the shape of the vessels. Ward and Custer (1988) suggested that the artisans chose different shape and size for different cooking styles. The variability in the styles could also represent the formality of the uses of the vessels i.e. everyday/common or ceremonial use (Ward and Custer 1988). Dixon (1987) also looked into the frequencies of the different shapes of soapstone vessels in Rhode Island. He noted that the deeper and rounder/oval shapes were the most common. The non-round shapes were the least common. Dixon speculated that the common shapes represented household use for cooking and storage while the less common shapes were for ceremonial uses, even burials (Dixon 1987). Recent studies (Truncer 2004) have used Thermoluminescence (TL) to determine whether soapstone bowls were once heated. This may prove that some styles have been used for cooking. This is also an age dating technique by which one can determine the time that the soapstone bowls were heated over a fire (Garrison 2003).

Truncer (2004) also studied the distribution of soapstone quarries and the amount of artifacts found compared to the distribution of styles. A transverse from northern to southern New England shows a trend of increasing number of steatite artifacts to the south. The highest frequency of vessels is in southern Massachusetts. The mid-Atlantic region has the highest count of steatite vessels with the largest number of vessels found in the New Jersey-Maryland-District of Columbia area (Truncer 2004). In the southern Appalachians, North Carolina has a large number of soapstone quarries along its border with Tennessee. South Carolina has a tight large cluster of soapstone quarries near its border with North Carolina. Georgia and Alabama have fewer and more wide-spread steatite quarries. However, Georgia has the most steatite artifacts found in this region. Yet, the Southern Appalachians collectively have the least amount of soapstone artifacts within the Appalachians.

Mark of Transitional Period

Soapstone is considered to be the marker for the Transitional Archaic Period around 2700-1500 BC (Snow 1980, Stewart 1994, Truncer 2004). Radiocarbon dating techniques have been updated so that smaller amounts of sample can be analyzed using an Accelerated Mass Spectrometer (AMS). Tiny amounts of soot scrapings from the bottoms of steatite vessels are useful for dating. This dating of artifact firing is important because before only larger objects that were stratigraphically located could be dated (Snow 1980). Thermoluminescence (TL), as stated earlier, is another technique that dates the heating of a soapstone bowl (Truncer 2004). This technique may prove to be more reliable than dating soot because it dates the time the bowl was hot. Truncer's (2004) compiled age and location maps of other studies and his own dates demonstrating the ages varied between the different regions of the Appalachian Mountains. The range of dates for the Appalachians is 3730–690 BC (Snow 1980, Stewart 1994, Truncer 2004).

History of Steatite Research

When steatite vessels were first discovered, they were mainly overlooked as unimportant (Truncer 2004). Archaeologists were more interested in understanding the earthen mounds left by ancient Native Americans. Artifacts were described first on an individual basis and then in groups to help decipher the earthen mounds in which they were found. The issue arose that soapstone vessels were found primarily at non-mound habitation sites. As time went on, more steatite quarries were discovered. These quarries started to receive more attention for the understanding the "mining" techniques of the ancient Native Americans (Truncer 2004).

The soapstone pioneer: W. H. Holmes

William Henry Holmes work on steatite vessels (Holmes 1890) is still cited by researchers. W.H. Holmes worked at the Smithsonian Institute initially as a scientific illustrator. Later, Holmes became interested in geology when he was sent out on a geological survey of the western territories. Holmes later became a geologist for the United State Geological Society (USGS) when it was first formed. The head of the USGS, John Wesley Powell, put Holmes in charge of investigating "The Paleolithic American" (Truncer 2004). The first site he went to was the Piney Branch in the Potomac Valley. What sparked his interest were the carved bowl scars in the soapstone outcrops faces and fragments of completed bowls. This soapstone quarry was where Holmes became interested in deciphering the steps of soapstone vessel manufacture. He also did a survey of soapstone quarries form New England to South Carolina (Holmes 1890). Due to his very detailed artwork and report, his work became the fundamental study on soapstone vessel manufacture (Truncer 2004).

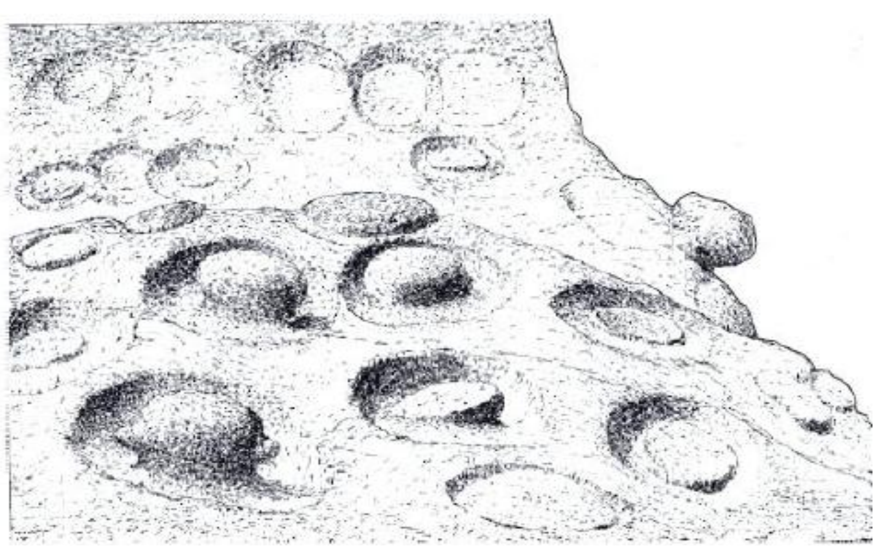

Figure 14: Sketch of the soapstone bowl scars Holmes noted on soapstone outcrop as indicators for quarrying in the area (Holmes 1884). Individual scars are 30-50 cm in diameter.

Even though steatite is very easy to carve, it is very chemical resistant allowing for details of how steatite vessels were quarried and manufactured to still clearly being evident. These preserved details allowed Holmes to establish the steps in steatite vessel manufacture. The faces of the outcrops still had remnants of vessels in various stages of production (Figure 14). There were scars where bowls were removed and pieces that had yet to be totally cut away. Pieces were chiseled and shaped until they were the right size and shape and then the bowl blanks were undercut out of the rock face. Blanks were usually oval in shape with a flat top and bottom. A middle round "nucleus" was roughly chiseled out of the blank and from there, working towards the rim and down the sides, the bowl part was slowly cut out. As the center was being chiseled the two handles were carved out on the sides (Figure 15). Holmes categorized different bowl shapes from the refuse of broken vessels and tools found at the quarry. The tools were sharply pointed quartzite shards in different shapes and sizes depending on their role during the manufacturing process. When chronology became the focal point of soapstone studies, Holmes was in the camp that the Native Americans who carved the bowls belonged to the tribes that met the first European settlers (Holmes 1884).

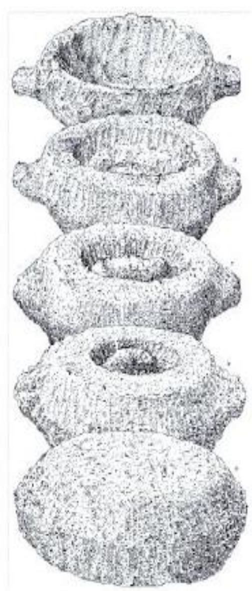

Figure 15: Holmes's representation of the different phases of bowl manufacture after the desired piece is carved out of the outcrop working from the center and the outside simultaneously with final bowl length of 25-50 cm (Holmes 1884).

Chronology of Soapstone Bowls

The 19th century saw the rise of chronological studies in soapstone archaeology by the introduction of "seriation" at the beginning of the century. Seriation was a technique developed in Egypt by Sir Flinders Petrie for Archaic ceramics of the Old Kingdom (Garrison 2003). This method uses decorations on the artifacts to set up a timeline of how the style of decoration changed over time and is used to establish relative time (Garrison 2003). The initial chronological studies created a renewed interest in understanding soapstone vessels. Parker (1922) became interested in determining steatite artifact and quarrying tool frequencies throughout the state of New York. Parker stated it was important to study the strata of a habitation site to set up a timeline (Parker 1922). However, he was dismissed due to the rise of popularity for the hypothesis (hyper-short chronology) that all archaeological artifacts and habitation sites pre-European arrival belonged to known historic groups (Truncer 2004). Cross (1956) averaged time depth of soapstone and ceramic artifacts across 40 excavation site throughout New Jersey by the assumption the ground surface as a baseline. Cross presumed that any artifact found at/near the surface was recent in age without taking into account of any erosional differences (Cross 1956). David Bushnell, Jr. (1940) discovered a possible colonial document that placed soapstone with a tribe that the Europeans interacted with (Truncer 2004).

The hyper-short chronology dropped out of favor due to the advent of radiocarbon dating. Ritchie (1969) and Coe (1964) were the first researchers to apply radiocarbon dating to soapstone bowls (Truncer 2004). Ritchie did his study on soapstone vessels in Long Island, New York while Coe did his study on soapstone in North Carolina but both used charcoal from hearths in relation to the soapstone artifacts (Coe 1964, Ritchie 1969). The dating results suggested even though soapstone bowl manufacture was widespread it was a short lived process (Truncer 2004). This lead to the usage of using soapstone bowls as a key marker for the period Witthoft (1953) coined as the "Late Archaic Transitional Period" (Hoffman 1998).

Soapstone/Ceramic Timeline Debate

Many researchers in the soapstone/ceramic debate stuck to the idea that soapstone came before early ceramics. The sequence that was derived was based upon the existence of Marcey Creek ceramics found in the Mid-Atlantic region of the Appalachians. Marcey Creek ceramics are bowls that follow soapstone bowl shapes and are tempered with soapstone. Many researchers believe the sequence was soapstone to soapstone-tempered ceramics to crushed-stone tempered ceramics (Klein 1997, Hoffman 1998). Ritchie's (1969) radiocarbon dates and Truncer's (2004) radiocarbon and thermoluminescense dates are used to back up this timeline.

A few researchers believe that early ceramics pre-date soapstone bowls. Radiocarbon dates gathered by Sassaman (1993, 1997) and Hoffman (1998) of early ceramic artifacts in the Southeastern region and southern portion of the Mid-Atlantic region demonstrate that soapstone tempered ceramics appeared roughly a century before soapstone vessels appeared and continued to be used at the same time as the soapstone (Sassaman 2006). A few researchers think that soapstone bowls were used primarily as a status objects and a little for cookware (Snow 1980, Sassaman 1993, Hoffman 1998, Sassaman 2000). A possible explanation is that the Southern cultures developed differently from the Northern cultures due to a lack of inter-regional trade compared to the strong trade within the regions (Snow 1980). This is still a highly debated issue for understanding soapstone bowls (Truncer 2006, Sassaman 2006).

Provenance

Interest in reconstruction of trade routes has renewed in the past 25 years (Tykot 2004). Provenance studies can provide information needed to reconstruct patterns of exchange systems and trade routes. Provenance studies are based on the assumption that there are defining and demonstrable physical and/or chemical characteristics between sources that are retained within the final product (Rapp and Hill 1998). For a successful provenance study all possible sources need to be located and physically characterized, one or more properties of the sources need to be homogeneous, and the possible defining characteristics have measurable differences using suitable analytical techniques (Herz and Garrison 1998).

In the past 30 years, improvements of analytical techniques and instruments have opened a number of new possibilities for archaeological research. When choosing a technique a researcher must consider bulk or surface composition, the destructive or non-destructive nature, precision/ accuracy and availability/cost of that method (Tykot 2004). Such practical considerations as cost and access often determines an analytical routine (Tykot 2004, Herz and Garrison 1998).

Previous Soapstone Provenance Studies

Soapstone provenance studies utilized rare earth elemental (REE) patterns collected by instrumental neutron activation analysis (INAA) method. The technique was first developed and applied by Allen et al. (1975) on soapstone from southern Virginia. Artifact and source REE characteristics were defined by INAA and then were compared to each other. Initially the findings were seen as promising, however a later study conducted by Allen and Pennell (1978) proved that many REE levels in soapstone fell below the detection limits of the INAA method (Allen and Pennell 1978). Truncer (et al. 1998) applied the methodology of the studies by Allen and Pennell (1978) by analyzing REE along with minor elements, such as transition metals, on Virginia soapstones using INAA. The transition metal concentrations proved to always be over detection limits and Truncer proposed that transition metals could provide the chemical fingerprint of soapstones instead of REE. However, he was only able to match 6 out of 133 artifacts to an appropriate quarry. Truncer's study was later applied by Jones et al. (2007) in the Shetland and Crete Islands. They analyzed REE and transition metals but they used INAA in tandem with ICP-MS (inductively-coupled plasma mass spectrometry). This technique got lower detection limits for REE and transition metals which resulted in successfully characterizing/differentiating three Shetland sources. However, they were able to distinguish only three out of 12 known sources in the Shetland and Crete Islands.

The Drawbacks of REE Methods on Soapstone

The drawbacks to INAA analysis of REE in soapstone are illustrated by the study of Moffat and Butler (1986). Moffat and Butler did their study on the Shetland Islands, where Jones et al. (2007) worked. However, Jones did not take into account the problems that Moffat and Butler stated with characterization of soapstone. Moffat and Butler (1986) concluded that the REE distributions were too inconsistent between sources for there to be high confidence in characterization of the artifact sources. Their supplementary conclusion was the observation that soapstone outcrops are heterogeneous in terms of the mineralogy.

A New Approach

As stated previously, soapstone is a complex rock type. Not only is it coarse grained with a range of possible mineralogies, it is geochemically complex as well. As shown by Moffat and Butler (1986), not only does bulk composition vary on an outcrop scale, but so does the chemistry of the minerals themselves. However, this is where the coarse grained nature of soapstone becomes an asset instead of a liability. Turnbaugh and Keifer (1979) proposed to look at the mineralogy of soapstone as a possible tool for characterizing soapstone for provenance. However, this was not picked up until Ige and Swanson (2008) took a new approach on how to chemically fingerprint soapstone. They did a petrologic study in tandem with an EMPA (electron microprobe analysis) of the chemical make-up of the individual soapstone minerals. Not only did their study prove to be largely successful, their study revealed outcrops had homogeneous mineral compositions. As stated by Tykot (2004), a successful provenance study needs one or two physical characteristics between sources/artifacts that are homogeneous. The Ige and Swanson (2008) study demonstrated that mineral compositions are different between sources but they are homogenous within the sources. By widening the scope to include the geological aspects of soapstone, Ige and Swanson's new approach covered all the aspects needed for a successful provenance study.

The methodology of Ige and Swanson (2008) was later applied to the study of soapstone quarries and bowl shards in the Southeastern Appalachian Mountains Radko (2011). He gathered samples from two quarries in Soapstone Ridge, GA and one quarry from Hammett Grove, SC. A suite of artifacts from south Georgia were analyzed. He analyzed his samples with the EMPA along with X-Ray Diffraction (XRD) of powders made from samples. He concluded that the artifacts could not be uniquely identified to the quarries that he sampled. It is possible that the artifacts are from numerous other quarries in the area. However, he does conclude that even though there is some overlap, he could see distinction between the different quarries. The best separation was seen with the compositions of low-Ca amphiboles and ilmenite (Radko 2011). This study is a test of the hypothesis that the soapstone outcrops are homogeneous.

CHAPTER 3

A MINERALOGICAL STUDY OF THE JOSEPH BOND QUARRY: IMPLICATIONS FOR THE FUTURE OF STEATITE PROVENANCE

Joseph Bond Quarry: 18HO1

This study was done to test the hypothesis that the mineralogy of soapstone is uniform on a small scale. The Joseph Bond Soapstone Quarry (18HO1) is ideal to test this hypothesis. The Joseph Bond Quarry consists of three disconnected outcrops thus providing an opportunity to test the mineralogical variations not only between outcrops but within small outcrops as well. Samples from the outcrops were collected during archaeological investigation preceding the building of the Duckett Reservoir (Inashima and Clark 2003). The Joseph Bond Quarry was one of the first sites described by Holmes when he began to study soapstone bowl manufacture (Holmes 1890, Inashima and Clark 2003). The bowl making scars on the outcrops demonstrate that the outcrops were once used by the ancient Native Americans.

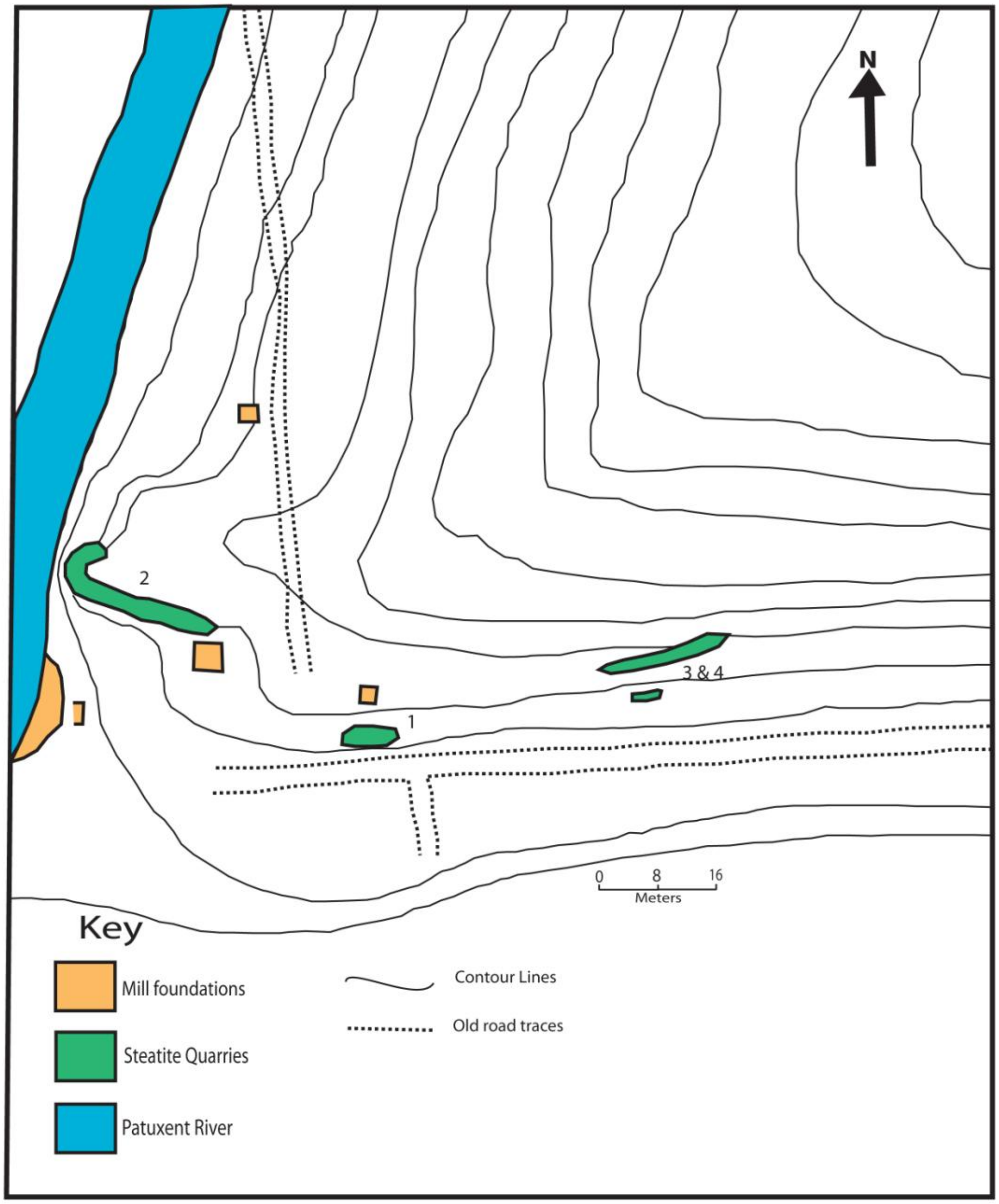

Figure 16: Joseph Bond Quarry (site 18HOI) showing the three outcrops that were sampled, revised from Inashima and Clark (2003)

Regional Geology

The soapstone of the Joseph Bond Quarry occurs as isolated bodies of ultramafic rock in the Potomac composite terrane, first defined by Drake (1989). The Potomac composite terrane consists of packages of mélange units metamorphosed at medium to high grades. Metagreywacke and quartz mica schist are the most common rocks and represent the mélange matrix. Exotic blocks of other metasedimenatary rocks and mafic and ultramafic rocks are included within the mélange units (Drake 1989, Southworth et al. 2006, Horton et al. 2010). The mélanges are intruded by Ordovician granitoid plutons (Aleinikoff et al. 2002; Sinha et al. 2012) and are thought to represent Neoproterozoic to Cambrian fore-arc rocks accreted to North America during the Taconic orogeny (Southworth et al. 2006, Sinha et al. 2012). Hatcher (2010) correlated the Potomac Terrane with the Tugaloo Terrane (see Ch. 1) further south (Figure 17).

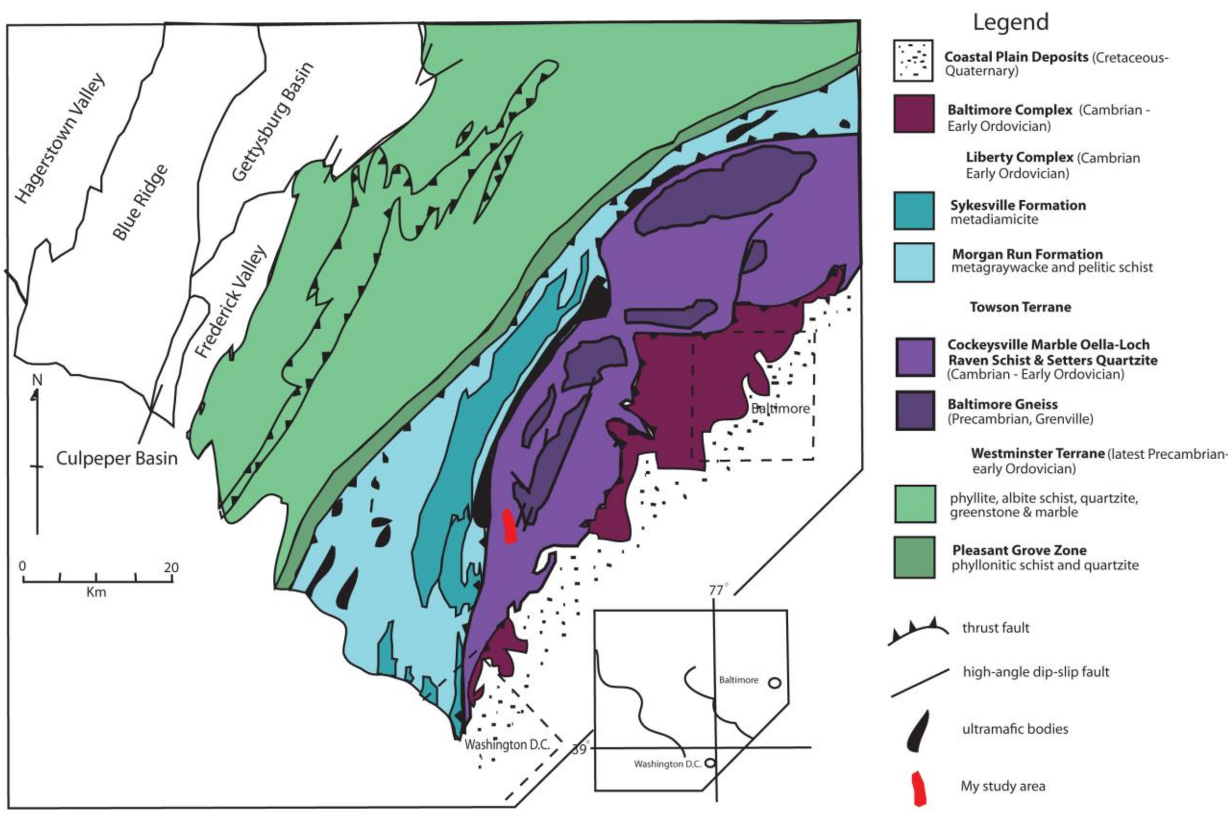

Figure 17: Simplified geologic map for location of study area, revised from Muller et al. 1989

Methods

There were several stages to the study of the soapstone samples from 18HO1. Joseph Bond Quarry's three outcrops (1, 2, and 34) were sampled. Samples were labeled by outcrop (1, 2, 34) with multiple samples per outcrop as A, B, C, etc. by Paul Inashima, an archaeologist working for the Washington Suburban Sanitary Commission. The first stage was identification of the minerals and determination of the modal percentages of each mineral using a petrographic microscope. Polished thin sections were commercially prepared for each sample. The petrographic microscope was also used to locate minerals/locations for further study on the electron microprobe.

The electron microprobe provided analyses of the minerals. The weight percent data were reduced using the spreadsheets provided by Tindle (http://www.open.ac.uk/earth-research/tindle/AGTWebPages/AGTSoft.html). Review of the data and comparison to representative analyses from Deer et al. (1966) revealed some of the data were poor (low totals, nonstoichometric formulas). Poor data were removed from the data set. Unfortunately, this results in complete removal of some of the samples from some of the data sets. Viable results were represented on variation diagrams and tested for significant variability using the R program.

Petrographic Microscope

The microscope that was used was a Leica DM 750 provided by the UGA Geology department. The modal percentages were calculated via point counting using an attachable stage and a Clay Adam Laboratory Counter. The spacing between the points was 1mm, generally larger than the soapstone grain size. Approximately 300 points were measured per sample. The thin section modal analyses are represented in Table 1.

Electron Microprobe

The instrument used was a JEOL JXA-8600 electron microprobe (EMP) located in the basement of the Geology-Geography Building at UGA. The analytical conditions were an accelerating voltage of 15 KV, a 15nA beam current, and a beam diameter of approximately 1 um. The Energy Dispersive Spectrometer (EDS) and Wavelength Dispersive Spectrometers (WDS) were both used. The EDS was automated and provided X-ray spectra that allowed for a quick check of elemental abundances for targeting minerals. Minerals/sites for microprobe analysis were marked on top of the carbon coating using a fine point Sharpie. This allowed for the circles to show on the electron backscatter imaging of the electron microprobe. The minerals were analyzed in three separate groups, sheet silicates (talc and chlorite), amphiboles, and FeCrTi oxides. The EDS was also used to generate X-ray maps for major elements in mineral grains. The WDS was automated with Bruker Quantax software and provided the quantitative measurements of the elemental oxides present in each mineral analyzed. Natural minerals were used for standards. Each quantitative analysis was done by Armstrong's PRX matrix and these analyses were used to compute the initial empirical formulas of the minerals. These analyses were further analyzed using the Tindle spreadsheets and a R statistical routine.

Further analysis of the microprobe data was done using the freeware Excel spreadsheets provide by Tindle (http://www.open.ac.uk/earth-research/tindle/AGTWebPages/AGTSoft .html). Andy Tindle, senior officer of the microprobe at the Earth Sciences Department of Open University, UK, has devised Excel spreadsheets that apportion the total iron measured by the EMP to the appropriate Fe2+/Fe3+ based on stoichiometry. The electron microprobe is unable to distinguish between the different iron oxidation states. Redistributions of total iron to Fe^{2+} and Fe^{3+} provide more accurate weight percent totals and empirical formulas.

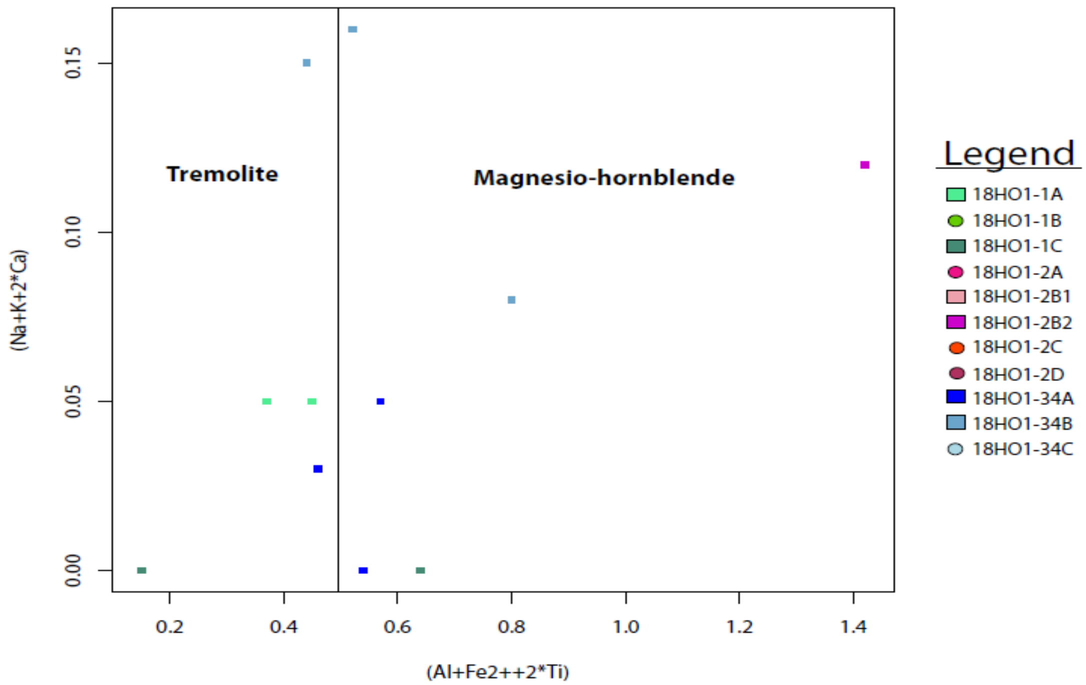

Figure 18: Hawthorne et al. (2012) classification graph for Ca-amphiboles.

The final analyses were compared to representative analyses per mineral type from Deer et al. (1966). This comparison was first used to classify the iron and chromium oxides. Titanomagnetites are defined as spinels with TiO_2 higher than 5 wt. %, magnetite contains less than 4 wt. % Cr_2O_3, chromian magnetite falls between 4-50 wt. % Cr_2O_3 and chromite has greater than 50 wt. % Cr_2O_3. The “tremolites” corresponded with tremolites for Deer et al. (1966). However, a new classification by Hawthorne et al. (2012) classifies some of the tremolites as magnesio-hornblende (Figure 18). This term “high calcium amphiboles” is used to describe the amphiboles. Different criteria were adopted for quality assurance of the mineral compositions. For talc, any analysis that fell lower than 60 wt. % SiO_2, 91 total weight percent or 5.8 for the sum of the octahedral site was eliminated. Analyses that had lower than 27 wt. % SiO_2, 83 total weight percent or 11.7 for the octahedral site for chlorite were discarded. High calcium amphiboles with lower than 52% SiO_2, 95 total weight percent or less than 5 for the sum of the C site were discarded. Cummingtonite criteria include analyses lower than 54 wt. % SiO_2, 93 total weight percent or less than 5 for the C site. Iron and chromium oxides with less than 94 total weight percent or less than 23 stoichimetric total were eliminated. Lastly, ilmenite and rutile were eliminated if totals were lower than 97 total weight percent.

Variation diagrams were generated using the statistical program, R. Different symbols and colors were used to designate the different outcrops and different shades of those colors for differentiating the different thin sections. The thin sections of 1A-3A were assigned shades of green, those of 2A-2D were assigned shades of red/orange and thin sections labeled 34A- 34C were assigned shades of blue. Not all of the samples contained amphiboles. Samples that contained amphiboles were distinguished from those that did not. The sections with amphibole (1A, 1C, 2B1, 2B2, 34A and 34B) are designated with squares while those that do not contain amphibole are circles. The chlorites were also mapped on a tertiary diagram of Zane and Weiss (1998) to distinguish the variety of chlorite in the samples.

Mineralogy of Joseph Bond Quarry

Overall, the modal mineralogy of the samples is relatively similar. The range in modal percentages of each mineral (Table 1) differ only on a small margin. The outcrops are similar to each other based on the modal analysis. Yet, most notable, not all of the samples contain amphibole. So, the main difference between samples is which type of amphibole and oxide is dominant within the sample. Outcrop 1 contains mostly high-Ca amphiboles with small inclusions of cummingtonite, ilmenite being the main oxide phase. Sample 1B lacks amphibole. Outcrop 2 is distinguished by the dominance of the cummingtonite with some inclusions of calcic amphibole with chromian magnetite and ilmenite as the main oxides. The amphibole bearing samples (2B1, 2B2) are the only samples with chromian magnetite rims on chromite cores and ilmenite rims with rutile cores (Figure 19 and 20). Outcrop 34 also has variable amounts of amphibole (Table 1). The main oxide phase is magnetite and it is the only outcrop that has grains (34A) that are magnetite rim with chromian magnetite core. Despite these minor differences, the overall mineralogy of the 3 outcrops is quite similar. Amphibole-bearing and amphibole-free rocks occur in all outcrops (Table 1).

Sample	Talc	Chlorite	High Ca-Amphi-boles	Cummi ng - tonite	Oxides modal %	Chromian Magnetite	Mag-netite	Chro-mite	Ilmenite	Rutile
1A	32	18	20	11	19	major	0	0	minor	0
1B	35	45	0	0	20	minor	major	0	major	0
1C	37	34	9	6	14	minor includes titano	minor	0	major	0
2A	58	15	0	0	27	major	0	0	minor	0
2B1	26	17	10	39	8	rim, major	0	core, minor	rim, major	core, minor
2B2	40	17	11	25	6	rim, major	0	core, minor	rim, major	core, minor
2C	40	35	0	0	26	0	minor	0	major	0
2D	42	33	0	0	25	minor	major	0	trace	0
34A	34	29	10	12	15	Core, major	Rim, minor	0	minor	0
34B	33	16	17	21	13	major	0	0	minor	0
34C	45	40	0	0	15	0	major	0	minor	0

Table 1: The modal percentages for each thin section from petrographic microscope analysis and the distinction of the oxides based upon EMPA.

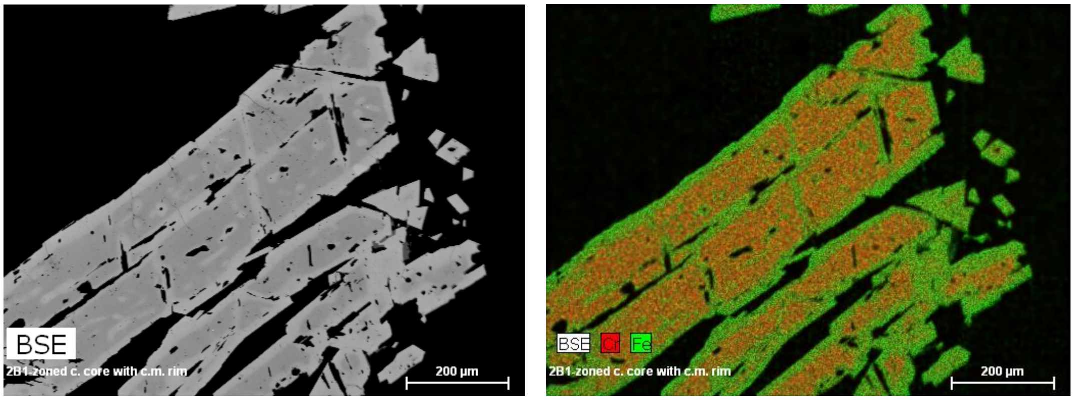

Figure 19: Probe photos of grains with chromite core and chromian magnetite rims. The photo on the left is a electron backscatter image and the photo on the right is colored by the location of the different element as show in the bottom left hand corner of the picture.

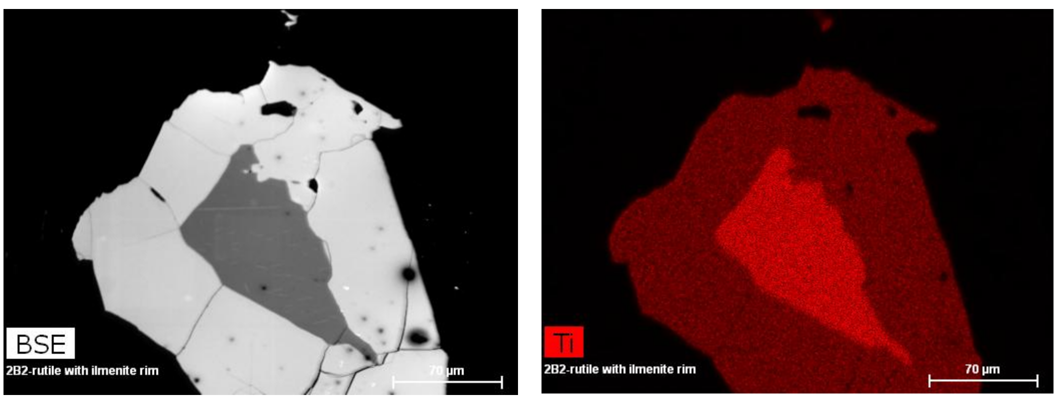

Figure 20: Probe photos of a grain with a rutile core and an ilmenite rims. The photo on the left is an electron backscatter image and the photo on the right is colored by the location of titanium as show in the bottom left hand corner of the picture.

Mineral Chemistry

Sheet Silicates

Sheet silicates (also known as phyllosilicates) are characterized by their flaky and platy habit. This is due to their sheet-like crystal structure. The sheets are comprised of two types, the octahedral (O) and the tetrahedral (T) sheets. The O sheet is characterized by divalent or trivalent cations bonded between two layers of OH^- anions. The OH^- anions are what make sheet silicates hydrous and give sheet silicates their characteristic softness (Nesse 2000). The O sheets are characterized as either trioctahedral or as dioctahedral sheets. Trioctahedral sheets are composed of cations that are divalent, e.g. Mg^{2+} and Fe^{2+}, and all three octahedral sites are filled. In dioctahedral sheets are when the cations are trivalent, e.g. Al^{3+} and Fe^{3+}, and only two of the three octahedral sites are filled. Even though dioctahedral sheets have empty sites the net charge is still zero like the trioctahedral sheets. A characteristic that differentiates sheet silicates is what type of O sheet is present in the structure. There is only one kind of tetrahedral site whose composition can be surmised as T_2O_5. The cations that fill the T site, e.g. Si^{4+}, Al^{3+} and less commonly Fe^{3+}.

Talc

The name talc is derived from the Arabic word “talq” meaning “mica” (Chesterman and Lowe 1979). This talc forms from the hydrothermal alteration of Mg-rich igneous rocks by CO_2-rich hydrous fluids and the alteration of dolomite-rich rocks with silica rich fluids. The formula for talc is $Mg_3Si_4O_{10}(OH)_2$. Minor substitutions of Fe^{2+} or Mn^{2+} for Mg^{2+} and Al^{3+} and Ti^{4+} for the Si are possible (Deer et al. 1992).

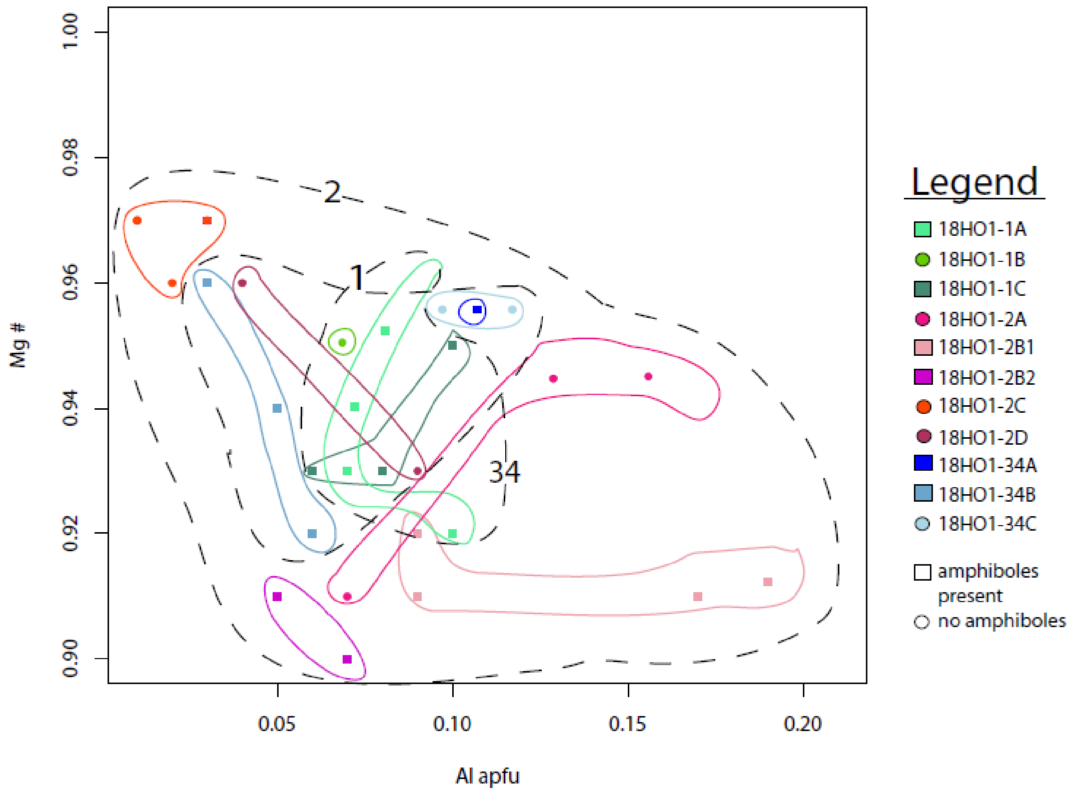

Figure 21: Talc probe data plot of Mg # (Mg/Mg+Fetot) versus Al atoms per formula unit (apfu) with corresponding colored circles per thin section and black dashed numbered lines for outcrops

The mineral chemistry of talc shows overlap of the outcrops (Figure 21). Samples from outcrop 1 do not overlap each other, but the range of variation is small. Outcrop 2 samples show more scatter than samples from Outcrop 1. They are more scattered, perhaps because there are more samples. Outcrop 34 is similar to outcrop 1 and shows little variation between the three samples. Overall, talc shows little compositional variation and the three outcrops are quite similar.

Chlorite

The Greek word "chloros" meaning "green" is the root word for chlorite (Chesterman and Lowe 1979). Chlorite occurs in low- to medium-grade metamorphic mafic and pelitic rocks as well in low-grade greenschist rock in which it is the main constituent. Chlorite has trioctahedral sheets like talc, but it differs in that the interlayer is filled with an additional octahedral layer aka TOT + 1. The basic chemical formula for chlorite, $(Mg,Fe,Al)_3(Si,Al)_4O_{10}(OH)_2$, shows the possibility of substitutions in both tetrahedral and octahedral sites. Chlorite that is dominated by Mg is called clinochlore, chlorite that is Fe-rich is called chamosite and Al-rich chlorite is called sudoite. Mg^{2+} and Fe $^{(2+ \text{ or } 3+)}$ are the major substitutions but minor level of Al^{4+} can be substituted by Mn^{2+}, Cr^{3+} and Ni^{2+}. The tetrahedral sheet can also have alternate substitutions as well of Ti^{4+} for the Si^{4+} or Al^{3+} (Nesse 2000, Deer et. al. 1992). This range in composition is represented in Figure 22.

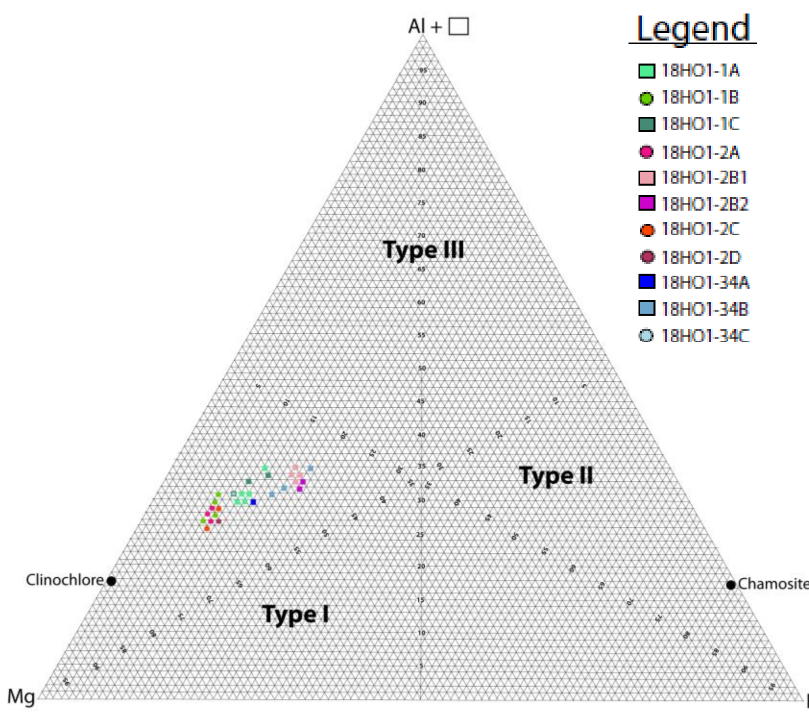

Figure 22: Chlorite analyses plotted on Zane and Weiss's (1998) chlorite identification ternary diagram.

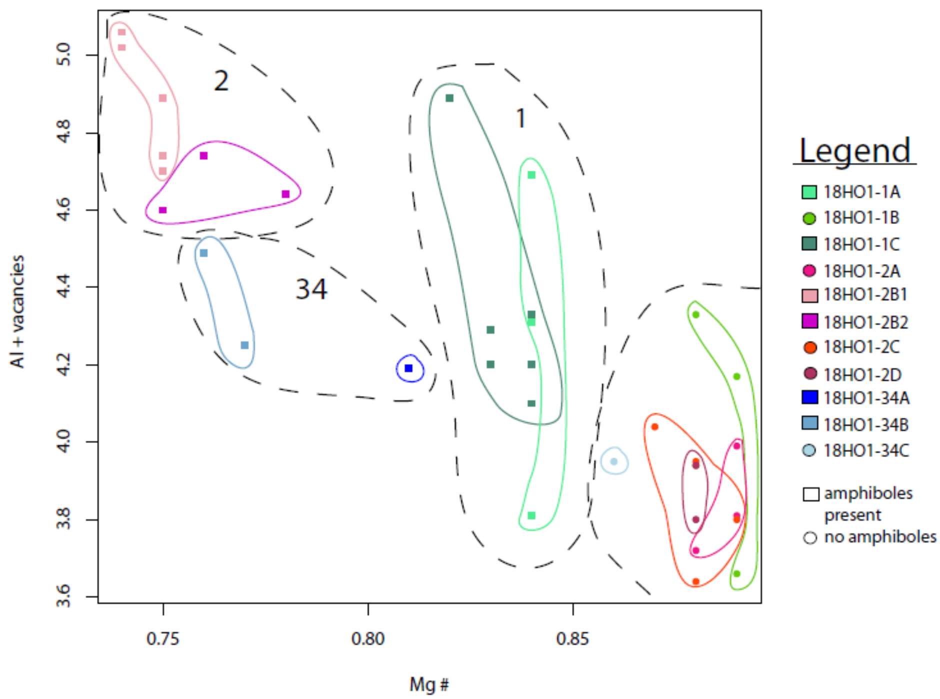

Figure 23: Chlorite plot of Al plus vacancies in the B site versus Mg # (Mg/Mg+Fetot) with corresponding colored circles per thin section and black dashed numbered for outcrops

Chlorite analyses from thin sections that contain amphibole (squares) are more Fe-rich (lower Mg #) than chlorite from amphibole-free samples (circles). Chlorite compositions from amphibole-bearing samples plot together (Figure 23) as do the chlorite of the amphibole-free samples. There is separation by outcrop for the amphibole-bearing chlorite compositions, but the chlorite from amphibole-free samples is very uniform. This demonstrates both heterogeneity internally and between the outcrops with the amphibole-bearing samples. Samples without amphiboles all overlap and plot in the same small area. This shows homogeneity within and between the sections without amphibole.

Amphiboles

Amphiboles are chain silicates. Their structure is comprised of two chains of silicon tetrahedra. The chains run parallel to the c-axis and are "stacked in alternating fashion" to produce five different octahedral sites. The amphiboles are characterized by how the formula $A_{0-1}B_2C_5T_8O_{22}(OH)_2$ is filled. The A site represents the larger 1+ or 2+ cations, B has the M4 octahedral site cations, C is for the M1, M2 and M3 octahedral cations. The T site houses the tetrahedral cations Si^{4+} and Al^{4+}. The amphiboles are split into groups based primarily on the cations that fill the B site. These groups are iron-magnesium, calcic, sodic-calcic and sodic (Nesse 2000, Deer et. al. 1992). The M1, M2 and M3 site cations bond within the chains to produce a structure similar to the TOT stacks in sheet silicates. The cations in M4 and A bond these stacks together which is also the locations of the weakest bonds creating the cleavage planes found with amphiboles.

High Ca-Amphiboles

Ca-amphiboles are called calcic amphiboles because the B site is dominated by Ca^{2+}. The basic formula for tremolite is $Ca_2(Mg, Fe)_5Si_8O_{22}(OH)_2$. The common substitutions are Al^{3+} for Si^{4+} in the T site and Al^{3+} for Mg^{2+} and $Fe^{(3+ \text{ or } 2+)}$. The less common substitutions are Na^{2+} for Ca^{2+}, Mn^{3+} for Mg^{2+} and Fe^{2+} Ti^{4+} for Si^{4+}. Tremolite can be replaced by retrograde talc and carbonates or chlorite.

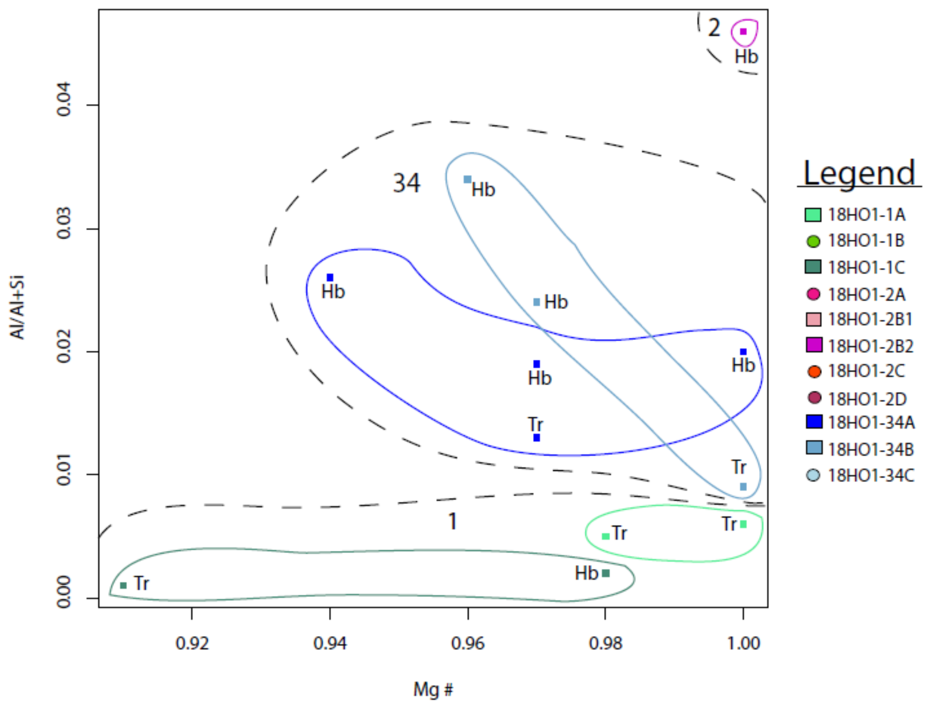

Figure 24: High Ca-amphiboles of Al # (Al/Al+Si) vs Mg # with corresponding colored circles per thin section and black dashed numbered for outcrops

The data for calcic amphiboles show distinct fields for each of the outcrops (Figure 24). The individual outcrops are distinctive from one another. There is enough heterogeneity within the outcrops that individual samples form separate groups from other samples of that outcrop (Figure 24).

Cummingtonite (Low Ca-Amphibole)

Cummingtonite is a low-Ca iron-magnesium amphibole. Cummingtonite, and its polymorph anthophyllite, occur in regionally metamorphosed ultramafic and mafic rocks in which they are commonly associated with Fe/Mg-rich oxides. The basic formula for these minerals is $(Mg, Fe)_2(Mg,Fe)_5Si_8O_{22}(OH)_2$. The common substitutions are Ca^{2+} in the B site, Mg^{3+} in both B and C sites and Al^{4+} in the T site. Less common substitutions are Ti^{4+} and Fe^{3+} in the T site. Cummingtonite can commonly alter to chlorite, talc and in some case oxides (Nesse 2000).

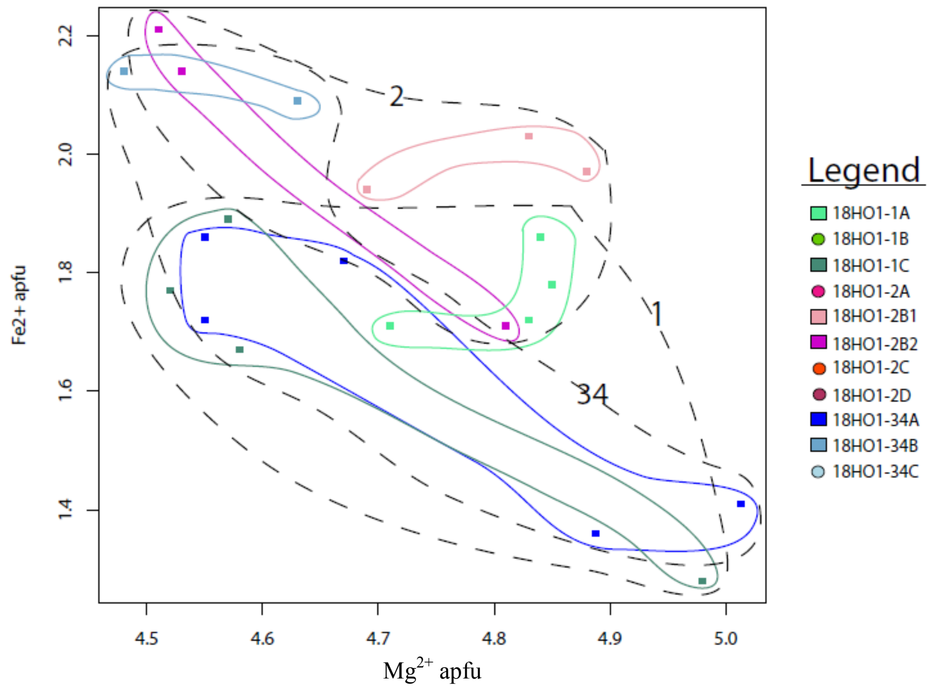

Figure 25: Cummingtonite data plotted Fe^{2+} apfu and Mg apfu with corresponding colored circles per thin section and black dashed numbered for outcrops

Cummingtonite compositions are variable; some samples show almost as much variation as the entire data set (Figure 25). Individual samples largely plot separate from other samples from the same outcrop. This demonstrates that the outcrops are heterogeneous internally. However, the data show a large amount of overlap between the three outcrops (Figure 25) Cummingtonite analyses are similar to talc analyses (Figure 20); there is almost a complete overlap of the outcrops.

Oxide Minerals

The oxide minerals are composed of Fe, Mn, Ti and Cr bonded to oxygen in cubic or hexagonal packing. These minerals are distinguished by metal content. Magnetite and chromite have the basic formula of XY_2O_4 of the spinel group. Magnetite and chromite differ in the metal that fills the Y site of the formula. Chromite has Cr^{3+} while magnetite has Fe^{3+}. Common substitutions in these minerals are Mn, Mg and Al for the octahedral iron. Magnetite accommodates Ti in the octahedral site at high temperature. Hematite is in a solid solution with ilmenite which is characterized by the basic formula of X_2O_3. Ilmenite differs from hematite in that both iron and titanium occupy the X site while hematite just has iron. Common substitutions for ilmenite are Mg and Mn for the Fe. Ilmenite can be associated with rutile. Rutile is part of the XO_2 family of oxides. Rutile is usually pure titanium oxide, but can have small substitutions of iron and, less commonly, chromium and vanadium. Oxides are formed during magmatic crystallization, metamorphic recrystallization and weathering. This results in a complex pattern of zoning and replacement (e.g. Swanson and Raymond 2010).

Magnetite and ilmenite occur in all the samples. Original chromite shows various stages of recrystallization to magnetite (Swanson and Raymond, 2010). Magnetite composition varies from nearly pure magnetite to chromian magnetite. Samples from outcrop 2 contain magnetite overgrowths on cores of chromite. Titanomagnetite occurs in sample 18HO1-1C (Table 1). Ilmenite occurs as overgrowths on rutile grains in samples 18HO1-2B1 and 18HO1-2B2. The ilmenite is nearly pure, but does contain a few percent MnO (Appendix 2.6).

Discussion

Variation in the mineralogy of samples is apparent on a variety of scales (Table 1). All three outcrops have some samples that contain amphibole and some samples that do not. One of the thin sections has zones that contain amphibole and areas that lack amphibole. The amphibole in outcrop 2 is mostly low-Ca cummingtonite; subequal amounts of high- and low-Ca amphiboles occur in outcrops 1 and 34 (Table 1). Inclusions of low-Ca amphibole occur in high-

Ca amphibole in outcrop 1, while outcrop 34 has inclusions of high-Ca amphibole in low-Ca amphibole. Amphiboles of outcrop 2 lack inclusions of other amphiboles.

The probe data disprove the hypothesis that the individual outcrops are homogenous. Variation in mineral assemblages (± amphibole) occurs even at the scale of a thin section. Compositions of talc and chlorite change with changes in mineral assemblage (Figure 23). This amount of variability of internal chemistry of the soapstone outcrops demonstrates that techniques such as INAA that use very small powdered samples are not viable for soapstone provenance. Radko (2011) found that small XRD samples did not accurately describe soapstone mineralogy.

This study has also demonstrated that EMPA still has potential to be used successfully in sourcing soapstone bowls. Cummingtonite, talc, and chlorite (from amphibole-free rocks) show overlapping patterns of variation (Figures 21, 23, 25) and suggest homogeneity of the outcrops and quarry. Relatively few analyses of Ca-rich amphiboles are reported (Appendix 2.3) and they do not define a consistent pattern. Chlorite in amphibole-bearing assemblages (Figure 25) also shows a wider pattern of variation than chlorite in amphibole-free assemblages (Figure 25). Mineralogy of the oxide phases seems dependant on local (thin section scale) alteration and is thus not useful in distinguishing the quarry.

CONCLUSIONS

Overall, this study has shown that ultramafic rocks are important in interpreting tectonic and human history. The unique chemical make-up of ultramafic rocks can be used as a "fingerprint" to source the origins of these rock types and to source artifacts to quarry sites. The relatively small number of mineral analyses per sample reported in this study is inadequate to characterize the mineralogy of individual thin sections. More analyses should be done to test the hypothesis of mineral compositional variability at the outcrop scale. However, the data set is adequate to characterize the mineralogy of the Bond Quarry. The appearance of two different mineral assemblages (± amphibole) in each outcrop was a surprise and produced systematic changes in the composition of talc and chlorite. Future studies of soapstone mineralogy need to be aware of potential changes in mineral composition related to changes in mineral assemblage, even in the same thin section.

Statistical analysis of mafic and ultramafic rocks within the Tugaloo Terrane revealed systematic differences between rocks in the Piedmont and Blue Ridge. The protolith of ultramafic rocks within these two provinces is also different. The Blue Ridge contains olivine-rich ultramafic rocks (dunite and harzburgite) while the Piedmont contains more pyroxene-rich rocks (pyroxenites of various kinds). Comparison to relatively unaltered ophiolite sections from different tectonic settings indicate that the Blue Ridge suite of ultramafic rocks aligns with island arc assemblages and the Piedmont pyroxenites are more like SSZ (fore-arc and back-arc) rocks. The Tugaloo Terrane represents an island arc assemblage, complete with arc-related and fore arc/back arc assemblages. This study took a different approach to test Hess's hypothesis about the origin of serpentine belts. In the end, my conclusions support the Hess model that paired serpentine belts represent an island arc accreted to a continental margin during the closing of an ocean basin. Further study of the mafic rock chemistry in light of this model is a logical continuation of this study.

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Appendix 1.1a: Tugaloo Blue Ridge Normalized	Paper	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
LC-95	R.D. Hatcher 1984	49.89	0.54	14.36	12.24	0	0.18	12.86	10.28	0.53	0.17	0.11	0	101.16
normalized		49.74	0.54	14.32	3.66	7.69	0.18	12.82	10.25	0.53	0.17	0.11	0	100.01
LC-179B	R.D. Hatcher 1984	47.15	1.93	14.23	13.49	0	0.19	10.64	10.97	0.94	0.2	0	0	99.74
normalized		47.73	1.95	14.40	4.1	8.6	0.19	10.77	411.1	0.95	0.2	0	0	99.99
LC-152	R.D. Hatcher 1984	51.20	1.54	15.21	13.03	0	0.18	7.6	10.62	0.83	0.27	0.21	0	100.69
normalized		51.31	1.54	15.24	3.92	8.23	0.18	7.62	10.64	0.83	0.27	0.21	0	99.99
LC-138	R.D. Hatcher 1984	48.61	2.29	14.48	12.88	0	0.17	7.4	9.59	1.51	0.47	0	0	97.4
normalized		50.37	2.37	15.01	4	8.41	0.18	7.67	9.94	1.56	0.49	0	0	100
LC-240	R.D. Hatcher 1984	49.14	0.41	9.01	15.50	0	0.18	15.05	6.72	1.23	0.07	0.23	0	97.54
normalized		50.95	0.43	9.34	4.82	10.12	0.19	15.6	6.97	1.28	0.07	0.24	0	100.1
LC-239B	R.D. Hatcher 1984	50.12	0.52	6.34	15.13	0	0.22	19.73	5.45	0.44	0.05	0.05	0	98.05
normalized		51.68	0.54	6.54	4.68	9.83	0.23	20.34	5.62	0.45	0.05	0.05	0	100.01
LC-161	R.D. Hatcher 1984	48.61	1.38	12.47	13.58	0	0.18	12.80	10.17	1.29	0.16	0.13	0	100.77
normalized		48.7	1.38	12.49	4.08	8.57	0.18	12.82	10.19	1.29	0.16	0.13	0	99.99
LC-140	R.D. Hatcher 1984	51.93	0.85	16.05	11.01	0	0.18	8.64	9.48	0.73	0.19	0.27	0	99.33
normalized		52.69	0.86	16.28	3.35	7.04	0.18	8.77	9.62	0.74	0.19	0.27	0	99.99
LC-14	R.D. Hatcher 1984	52.69	1.25	12.08	12.03	0	0.19	7.73	10.05	0.94	0.24	0.25	0	97.45
normalized		54.54	1.29	12.5	3.74	7.84	0.2	8	10.4	0.97	0.25	0.26	0	99.99
LC-242	R.D. Hatcher 1984	49.85	0.05	2.66	10.38	0	0.11	32.2	0.24	2.71	0.06	0.18	0	98.44
normalized		51.02	0.05	2.72	3.19	6.69	0.11	32.95	0.25	2.77	0.06	0.18	0	99.99

LC-34	R.D. Hatcher 1984	46.76	0	1.66	8.89	0	0.11	39.93	0.13	2.77	0.06	0.19	0	100.5
normalized		46.82	0	1.66	2.67	5.61	0.11	39.98	0.13	2.77	0.06	0.19	0	100
LC-142	R.D. Hatcher 1984	51.83	0.28	2.9	17.43	0	0.13	21.71	1.44	2.77	0.06	0.2	0	98.75
normalized		53.14	0.29	2.97	5.36	11.26	0.13	22.26	1.48	2.84	0.06	0.21	0	100
LC-2	R.D. Hatcher 1984	47.66	0.25	6.22	17.34	0	0.13	16.99	5.49	3.07	0.06	0.32	0	97.53
normalized		49.48	0.26	6.46	5.4	11.34	0.13	17.64	5.7	3.19	0.06	0.33	0	99.99
BRQ3	Mittwede 1984	53	0.05	2.96	7.54	4.75	0.08	30.5	0.05	0.03	0.009	0.009	0	98.98
normalized		53.75	0.05	3	3.9	8.19	0.08	30.93	0.05	0.03	0.01	0.01	0	100
BRQ4	Mittwede 1984	51.9	0.06	3.79	7.77	4.9	0.07	30.3	0.03	0.02	0.009	0.02	0	98.869
normalized		31.73	0.04	2.32	15.26	32.04	0.04	18.52	0.02	0.01	0.01	0.01	0	100
BRQ5	Mittwede 1984	53.1	0.05	3.02	8.47	5.34	0.15	29.7	0.03	0.01	0.009	0.009	0	99.888
normalized		53.38	0.05	3.04	4.34	9.12	0.15	29.86	0.03	0.01	0.01	0.01	0	100
BRQ6	Mittwede 1984	54.7	0.04	2.15	8.18	5.16	0.14	29.9	0.06	0.009	0.009	0.009	0	100.357
normalized		54.72	0.04	2.15	4.18	8.77	0.14	29.91	0.06	0.01	0.01	0.01	0	100
RM106	Raymond et al	41.48	0.02	0.42	0	8.35	0.11	48.57	0.08	0.009	0.03	0.02	0.3	99.389
Wet(FeRatio=0.3)		41.48	0.02	0.42	2.78	5.85	0.11	48.57	0.08	0.009	0.03	0.02	0.3	99.669
(Wet)normalized		41.62	0.02	0.42	2.79	5.87	0.11	48.73	0.08	0.01	0.03	0.02	0.3	100
Dry(FeRatio=0.3)		41.48	0.02	0.42	2.78	5.85	0.11	48.57	0.08	0.009	0.03	0.02	0	99.369
(Dry)normalized		41.74	0.02	0.42	2.8	5.88	0.11	48.88	0.08	0.01	0.03	0.02	0	99.99
RM109	Raymond et al	44.83	0.02	0.57	0	9.73	0.15	42.95	0.16	0.03	0.03	0.09	0.7	99.26
Wet(FeRatio=0.3)		44.83	0.02	0.57	3.24	6.81	0.15	42.95	0.16	0.03	0.03	0.09	0.7	99.58
(Wet)normalized		45.02	0.02	0.57	3.25	6.84	0.15	43.13	0.16	0.03	0.03	0.09	0.7	99.99
Dry(FeRatio=0.3)		44.83	0.02	0.57	3.24	6.81	0.15	42.95	0.16	0.03	0.03	0.09	0	98.88
(Dry)normalized		45.09	0.02	0.58	3.3	6.92	0.15	43.63	0.16	0.03	0.03	0.09	0	100
RM116	Raymond et al	41.46	0.02	0.98	0	8.56	0.1	46.9	0.13	0.07	0.03	0.05	1	99.39
Wet(FeRatio=0.3)		41.46	0.02	0.98	2.85	5.99	0.1	46.9	0.13	0.07	0.03	0.05	1	99.58

(Wet)normalized		41.63	0.02	0.98	2.86	6.02	0.1	47.1	0.13	0.07	0.03	0.05	1	99.99
Dry(FeRatio=0.3)		41.46	0.02	0.98	2.85	5.99	0.1	46.9	0.13	0.07	0.03	0.05	0	98.58
(Dry)normalized		42.05	0.02	0.99	2.89	6.08	0.1	47.57	0.13	0.07	0.03	0.05	0	99.98
HC-4	Carpenter & Chen 1978	41.5	0.05	0.34	1.33	5.9	0.13	49.26	0.06	0	0	0	0.98	99.55
Wet(FeRatio=0.3)		41.5	0.05	0.34	2.37	4.97	0.13	49.26	0.06	0	0	0	0.98	99.66
(Wet)normalized		41.64	0.05	0.34	2.38	4.99	0.13	49.43	0.06	0	0	0	0.98	100
Dry(FeRatio=0.3)		41.5	0.05	0.34	2.37	4.97	0.13	49.26	0.06	0	0	0	0	98.68
(Dry)normalized		42.06	0.05	0.34	2.40	5.03	0.13	49.92	0.06	0	0	0	0	99.99
HC-5	Carpenter & Chen 1978	41.72	0.07	0.42	2.31	5.9	0.12	46.96	0.08	0	0	0	2.05	99.63
Wet(FeRatio=0.3)		41.72	0.07	0.42	2.66	5.59	0.12	46.96	0.08	0	0	0	2.05	99.67
(Wet)normalized		41.86	0.07	0.42	2.67	5.61	0.12	47.12	0.08	0	0	0	2.06	100.01
Dry(FeRatio=0.3)		41.72	0.07	0.42	2.66	5.59	0.12	46.96	0.08	0	0	0	0	97.62
(Dry)normalized		42.74	0.07	0.43	2.73	5.72	0.12	48.11	0.08	0	0	0	0	100
HC-6	Carpenter & Chen 1978	42.24	0.06	0.43	1.31	6.14	0.11	46.7	1.44	0	0.01	0	1.04	99.48
Wet(FeRatio=0.3)		42.24	0.06	0.43	2.44	5.12	0.11	46.7	1.44	0	0.01	0	1.04	99.59
(Wet)normalized		42.41	0.06	0.43	2.45	5.14	0.11	46.89	1.45	0	0.01	0	1.04	99.99
Dry(FeRatio=0.3)		42.24	0.06	0.43	2.44	5.12	0.11	46.7	1.44	0	0.01	0	0	98.55
(Dry)normalized		42.86	0.06	0.44	2.48	5.2	0.11	47.39	1.46	0	0.01	0	0	100.01
D	Carpenter & Chen 1978	41.86	0.08	1.07	2.73	5.45	0.31	43.6	0.47	0	0.06	0	4.18	99.81
Wet(FeRatio=0.3)		41.86	0.08	1.07	2.64	5.53	0.31	43.6	0.47	0	0.06	0	4.18	99.8
(Wet)normalized		41.94	0.08	1.07	2.65	5.54	0.31	43.69	0.47	0	0.06	0	4.19	100
Dry(FeRatio=0.3)		41.86	0.08	1.07	2.64	5.53	0.31	43.6	0.47	0	0.06	0	0	95.62
(Dry)normalized		43.78	0.08	1.12	2.76	5.79	0.32	45.6	0.49	0	0.06	0	0	100
F-1	Carpenter & Chen 1978	41.18	0.03	0.97	2.95	4.87	0.31	44.6	0.09	0	0.02	0	4.72	99.74
Wet(FeRatio=0.3)		41.18	0.03	0.97	2.51	5.27	0.31	44.6	0.09	0	0.02	0	4.72	99.7
(Wet)normalized		41.3	0.03	0.97	2.52	5.29	0.31	44.73	0.09	0	0.02	0	4.73	99.99
Dry(FeRatio=0.3)		41.18	0.03	0.97	2.51	5.27	0.31	44.6	0.09	0	0.02	0	0	94.98
(Dry)normalized		43.36	0.03	1.02	2.64	5.55	0.33	46.96	0.09	0	0.02	0	0	100

F-2	Carpenter & Chen 1978	42.04	0.02	1.05	3.61	4.02	0.29	41.38	0.09	0	0.01	0	7.56	100.07
Wet(FeRatio=0.3)		42.04	0.02	1.05	2.42	5.09	0.29	41.38	0.09	0	0.01	0	7.56	99.95
(Wet)normalized		42.06	0.02	1.05	2.42	5.09	0.29	41.4	0.09	0	0.01	0	7.56	99.99
Dry(FeRatio=0.3)		42.04	0.02	1.05	2.42	5.09	0.29	41.38	0.09	0	0.01	0	0	92.39
(Dry)normalized		45.5	0.02	1.14	2.62	5.51	0.31	47.74	0.1	0	0.01	0	0	100
F-3	Carpenter & Chen 1978	42.64	0.01	0.56	3.13	4.88	0.32	44.25	0.09	0	0	0	3.97	99.85
Wet(FeRatio=0.3)		42.64	0.01	0.56	2.57	5.39	0.32	44.25	0.09	0	0	0	3.97	99.8
(Wet)normalized		42.73	0.01	0.56	2.58	5.4	0.32	44.34	0.09	0	0	0	3.98	100.01
Dry(FeRatio=0.3)		42.64	0.01	0.56	2.57	5.39	0.32	44.25	0.09	0	0	0	0	95.83
(Dry)normalized		44.37	0.01	0.58	2.67	5.61	0.33	46.33	0.09	0	0	0	0	99.99
F-4	Carpenter & Chen 1978	42.04	0.07	1.14	2.68	5.65	0.3	43.65	0.52	0	0.02	0	4.13	100.2
Wet(FeRatio=0.3)		42.04	0.07	1.14	2.69	5.64	0.3	43.65	0.52	0	0.02	0	4.13	100.2
(Wet)normalized		41.96	0.07	1.14	2.68	5.63	0.3	43.56	0.52	0	0.02	0	4.12	100
Dry(FeRatio=0.3)		42.04	0.07	1.14	2.69	5.64	0.3	43.65	0.52	0	0.02	0	0	96.07
(Dry)normalized		43.76	0.07	1.19	2.8	5.87	0.31	45.44	0.54	0	0.02	0	0	100
F-5	Carpenter & Chen 1978	43.16	0.04	0.73	2.5	5.13	0.28	43.8	0.63	0	0.02	0	3.64	99.93
Wet(FeRatio=0.3)		43.16	0.04	0.73	2.46	5.17	0.28	43.8	0.63	0	0.02	0	3.64	99.93
(Wet)normalized		43.19	0.04	0.73	2.46	5.17	0.28	43.83	0.63	0	0.02	0	3.64	99.99
Dry(FeRatio=0.3)		43.16	0.04	0.73	2.46	5.17	0.28	43.8	0.63	0	0.02	0	0	96.29
(Dry)normalized		44.82	0.04	0.76	2.56	5.36	0.29	45.49	0.65	0	0.02	00	0	99.99
F-6	Carpenter & Chen 1978	41.6	0.04	0.88	2.81	5.03	0.3	44.26	0.5	0	0.01	0	5.1	100.53
Wet(FeRatio=0.3)		41.6	0.04	0.88	2.52	5.29	0.3	44.26	0.5	0	0.01	0	5.1	100.5
(Wet)normalized		41.36	0.04	0.88	2.51	5.26	0.3	44.01	0.5	0	0.01	0	5.07	99.94
Dry(FeRatio=0.3)		41.6	0.04	0.88	2.52	5.29	0.3	44.26	0.5	0	0.01	0	0	95.4
(Dry)normalized		43.61	0.04	0.92	2.64	5.55	0.31	46.39	0.52	0	0.01	0	0	99.99
Day Book Dunite	Butler and Ragland 1969	40.7	0.01	3.1	7.72	0	0.12	46.5	0.37	0.1	0.02	0	0	98.64
normalized		41.49	0.01	3.16	2.36	4.96	0.12	47.4	0.38	0.1	0.02	0	0	100

1	Kulp and Brobst 1954	40.67	0.01	0.75	1.15	6.56	0.12	48.77	0	0	0.03	0.02	1.46	99.54
Wet(FeRatio=0.3)		40.67	0.01	0.75	2.53	5.32	0.12	48.77	0	0	0.03	0.02	1.46	99.68
(Wet)normalized		40.8	0.01	0.75	2.54	5.34	0.12	48.93	0	0	0.03	0.02	1.46	100
Dry(FeRatio=0.3)		40.67	0.01	0.75	2.53	5.32	0.12	48.77	0	0	0.03	0.02	0	98.22
(Dry)normalized		41.41	0.01	0.76	2.58	5.41	0.12	49.65	0	0	0.03	0.02	0	99.99
8	Kulp and Brobst 1954	40.93	0	1.32	7.6	0	0	48.77	0.29	0.13	0	0	0	99.04
normalized		41.55	0	1.34	2.31	4.86	0	49.51	0.29	0.13	0	0	0	99.99
7A	Dribus et al 1982	41.9	0	0	8.92	0	0.2	42.92	0.2	0	0	0	0	94.14
normalized		44.81	0	0	2.86	6.01	0.21	45.9	0.21	0	0	0	0	100
12	Dribus et al 1982	41.6	0	0	9.75	0	0.14	45.67	0.17	0	0	0	0	97.33
normalized		43.04	0	0	3.03	6.35	0.14	47.25	0.18	0	0	0	0	99.99
17	Dribus et al 1982	41.2	0	0	9.63	0	0.14	46.69	0.17	0	0	0	0	97.83
normalized		42.41	0	0	2.97	6.24	0.14	48.06	0.17	0	0	0	0	99.9
18A	Dribus et al 1982	41.1	0	0	9.34	0	0.16	46.7	0.15	0	0	0	0	97.45
normalized		42.46	0	0	2.89	6.08	0.17	48.25	0.15	0	0	0	0	100
20L	Dribus et al 1982	39.9	0	0	8.49	0	0.14	47.3	0.14	0	0	0	0	95.97
normalized		41.84	0	0	2.67	5.61	0.15	49.59	0.15	0	0	0	0	100.01
21	Dribus et al 1982	41.6	0	0	7.84	0	0.13	46.68	0.14	0	0	0	0	96.39
normalized		43.41	0	0	2.45	5.15	0.14	48.71	0.15	0	0	0	0	100.01
24A	Dribus et al 1982	42.1	0	0	8.47	0	0.14	46.85	0.12	0	0	0	0	97.68
normalized		43.36	0	0	2.62	5.5	0.14	48.26	0.12	0	0	0	0	100
25	Dribus et al 1982	42.7	0	0	8.95	0	0.15	46.53	0.17	0	0	0	0	98.5
normalized		43.63	0	0	2.74	5.76	0.15	47.54	0.17	0	0	0	0	99.99

28C	Dribus et al 1982	43.8	0	0	9.59	0	0.15	47.25	0.2	0	0	0	0	100.99
normalized		43.66	0	0	2.87	6.02	0.15	47.1	0.2	0	0	0	0	100
28Q	Dribus et al 1982	43.4	0	0	9.97	0	0.15	47.06	0.14	0	0	0	0	100.72
normalized		43.39	0	0	2.99	6.28	0.15	47.05	0.14	0	0	0	0	100
31	Dribus et al 1982	43.5	0	0	10.42	0	0.15	45.76	0.23	0	0	0	0	100.06
normalized		43.79	0	0	3.15	6.61	0.15	46.07	0.23	0	0	0	0	100
33	Dribus et al 1982	44.2	0	0	10.05	0	0.15	44.65	0.11	0	0	0	0	99.16
normalized		44.89	0	0	3.06	6.43	0.15	45.35	0.11	0	0	0	0	99.99
E2	Dribus et al 1982	41.9	0	0	8.8	0	0.14	46.99	0.13	0	0	0	0	97.96
normalized		43.04	0	0	2.71	5.69	0.14	48.27	0.13	0	0	0	0	99.98
E3	Dribus et al 1982	43.2	0	0	8.81	0	0.15	47.29	0.14	0	0	0	0	99.59
normalized		43.65	0	0	2.67	5.61	0.15	47.78	0.14	0	0	0	0	100
Long Creek Soapstone	Hatcher 1970	51.41	0.34	6.69	7.42	0	0	24.5	1.3	0	0	0	0.5	92.16
Wet(FeRatio=0.3)		51.41	0.34	6.69	2.23	4.67	0	24.5	1.3	0	0	0	0.5	91.64
(Wet)normalized		56.1	0.34	7.3	2.43	5.1	0	26.74	1.42	0	0	0	0.5	99.93
Dry(FeRatio=0.3)		51.41	0.34	6.69	2.23	4.67	0	24.5	1.3	0	0	0	0	91.14
(Dry)normalized		56.41	0.37	7.34	2.44	5.13	0	26.88	1.43	0	0	0	0	100
1	Mittwede and Zupan 1985	49.39	0.68	6.67	10.92	0	0.19	17.79	11.1	0.53	0.27	0.05	1.31	98.9
Wet(FeRatio=0.3)		49.39	0.68	6.67	3.28	6.88	0.19	17.79	11.1	0.53	0.27	0.05	1.31	98.14
(Wet)normalized		50.33	0.69	6.8	3.34	7.01	0.19	18.13	11.31	0.54	0.27	0.05	1.33	99.99
Dry(FeRatio=0.3)		49.39	0.68	6.67	3.28	6.88	0.19	17.79	11.1	0.53	0.27	0.05	0	96.83
(Dry)normalized		51.01	0.7	6.89	3.38	7.1	0.2	18.37	11.46	0.55	0.28	0.05	0	99.99
2	Mittwede and Zupan 1985	44.74	0.4	5.86	12.7	0	0.23	21.33	8.17	0.15	0.08	0.03	4.59	98.28
Wet(FeRatio=0.3)		44.74	0.4	5.86	3.81	8	0.23	21.33	8.17	0.15	0.08	0.03	4.59	97.39

(Wet)normalized		45.93	0.41	6.01	3.91	8.21	0.23	21.9	8.39	0.15	0.08	0.03	4.71	99.96
Dry(FeRatio=0.3)		44.74	0.4	5.86	3.81	8	0.23	21.33	8.17	0.15	0.08	0.03	0	92.8
(Dry)normalized		48.21	0.43	6.31	4.11	8.62	0.25	22.9	8.8	0.16	0.09	0.03	0	100
3	Mittwede and Zupan 1985	58.98	0.03	1.05	5.33	0	0.05	26.28	0.05	0.06	0.1	0.1	1.98	94.01
Wet(FeRatio=0.3)		58.98	0.03	1.05	1.6	3.36	0.05	26.28	0.05	0.06	0.1	0.1	1.98	93.64
(Wet)normalized		62.99	0.03	1.12	1.71	3.59	0.05	28.06	0.05	0.06	0.11	0.11	2.11	99.99
Dry(FeRatio=0.3)		58.98	0.03	1.05	1.6	3.36	0.05	26.28	0.05	0.06	0.1	0.1	0	91.66
(Dry)normalized		64.35	0.03	1.15	1.74	3.66	0.05	28.67	0.05	0.07	0.11	0.11	0	99.99
2-4	Staphor et al 2010	45.84	0.65	6.19	13.85	0	0.19	26.69	0.26	0.05	0.03	0.1	6.72	100.57
Wet(FeRatio=0.3)		45.84	0.65	6.19	4.16	8.72	0.19	26.69	0.26	0.05	0.03	0.1	6.72	99.6
(Wet)normalized		46.02	0.65	6.21	4.18	8.76	0.19	26.8	0.26	0.05	0.03	0.1	6.75	100
Dry(FeRatio=0.3)		45.84	0.65	6.19	4.16	8.72	0.19	26.69	0.26	0.05	0.03	0.1	0	92.88
(Dry)normalized		49.36	0.7	6.66	4.47	9.39	0.2	28.73	0.28	0.05	0.03	0.11	0	99.98
168	Staphor et al 2010	45.88	0.59	7.3	12.7	0	0.17	25.03	3.19	0.06	0.02	0.06	5.7	100.7
Wet(FeRatio=0.3)		45.88	0.59	7.3	3.81	8	0.17	25.03	3.19	0.06	0.02	0.06	5.7	99.81
(Wet)normalized		45.97	0.59	7.31	3.82	8.01	0.17	25.08	3.2	0.06	0.02	0.06	5.7	99.99
Dry(FeRatio=0.3)		45.88	0.59	7.3	3.81	8	0.17	25.03	3.19	0.06	0.02	0.06	0	94.11
(Dry)normalized		48.75	0.63	7.76	4.05	8.5	0.18	26.6	3.39	0.06	0.02	0.06	0	100
122B	Staphor et al 2010	47.11	0.55	5.99	13.6	0	0.2	24.23	4.22	0.12	0.03	0.07	4.5	100.62
Wet(FeRatio=0.3)		47.11	0.55	5.99	4.08	8.57	0.2	24.23	4.22	0.12	0.03	0.07	4.5	99.67
(Wet)normalized		47.27	0.55	6.01	4.09	8.6	0.2	24.31	4.23	0.12	0.03	0.07	4.5	99.98
Dry(FeRatio=0.3)		47.11	0.55	5.99	4.08	8.57	0.2	24.23	4.22	0.12	0.03	0.07	0	95.17
(Dry)normalized		49.5	0.58	6.29	4.29	9	0.21	25.46	4.43	0.13	0.03	0.07	0	99.99
120F	Staphor et al 2010	46.39	0.39	6.48	12.97	0	0.21	20.81	8.07	0.19	0.05	0.07	5.33	100.96
Wet(FeRatio=0.3)		46.39	0.39	6.48	3.89	8.17	0.21	20.81	8.07	0.19	0.05	0.07	5.33	100.05
(Wet)normalized		46	0.39	6.43	3.86	8.1	0.21	20.64	8	0.19	0.05	0.07	5.29	99.23
Dry(FeRatio=0.3)		46.39	0.39	6.48	3.89	8.17	0.21	20.81	8.07	0.19	0.05	0.07	0	94.72
(Dry)normalized		48.98	0.41	6.84	4.11	8.62	0.22	21.97	8.52	0.2	0.05	0.07	0	99.99

120D	Staphor et al 2010	44.33	0.54	6.47	12.86	0	0.19	22.48	6.28	0.14	0.05	0.09	5.95	99.38
Wet(FeRatio=0.3)		44.33	0.54	6.47	3.86	8.1	0.19	22.48	6.28	0.14	0.05	0.09	5.95	98.48
(Wet)normalized		45.01	0.54	6.57	3.92	8.23	0.19	22.83	6.38	0.14	0.05	0.09	6.04	99.99
Dry(FeRatio=0.3)		44.33	0.54	6.47	3.86	8.1	0.19	22.48	6.28	0.14	0.05	0.09	0	92.53
(Dry)normalized		47.91	0.58	6.99	4.17	8.47	0.21	24.3	6.79	0.15	0.05	0.1	0	100
48A	Staphor et al 2010	47.6	0.54	5.33	11.71	0	0.22	22.16	8.71	0.17	0.05	0.1	3.31	99.9
Wet(FeRatio=0.3)		47.6	0.54	5.33	3.51	7.38	0.22	22.16	8.71	0.17	0.05	0.1	3.31	99.08
(Wet)normalized		48.04	0.54	5.38	3.54	7.45	0.22	22.37	8.79	0.17	0.05	0.1	3.34	99.99
Dry(FeRatio=0.3)		47.6	0.54	5.33	3.51	7.38	0.22	22.16	8.71	0.17	0.05	0.1	0	95.77
(Dry)normalized		49.7	0.56	5.57	3.67	7.7	0.23	23.14	9.09	0.18	0.05	0.1	0	99.99
48B	Staphor et al 2010	44.45	0.51	8.3	12.96	0	0.2	20.83	7.5	0.21	0.07	0.06	4.22	99.31
Wet(FeRatio=0.3)		44.45	0.51	8.3	3.89	8.16	0.2	20.83	7.5	0.21	0.07	0.06	4.22	98.4
(Wet)normalized		45.17	0.51	8.4	3.95	8.29	0.2	21.17	7.62	0.21	0.07	0.06	4.29	99.94
Dry(FeRatio=0.3)		44.45	0.51	8.3	3.89	8.16	0.2	20.83	7.5	0.21	0.07	0.06	0	94.18
(Dry)normalized		47.2	0.54	8.81	4.13	8.67	0.21	22.12	7.96	0.22	0.07	0.06	0	99.99
228C1	Staphor et al 2010	48.51	0.08	11.47	9.31	0	0.17	16.6	10.38	1.35	0.15	0.05	5.57	103.64
Wet(FeRatio=0.3)		48.51	0.08	11.47	2.79	5.86	0.17	16.6	10.38	1.35	0.15	0.05	5.57	102.98
(Wet)normalized		47.11	0.08	11.14	2.71	5.69	0.17	16.12	10.08	1.31	0.15	0.05	5.41	100.02
Dry(FeRatio=0.3)		48.51	0.08	11.47	2.79	5.86	0.17	16.6	10.38	1.35	0.15	0.05	0	97.41
(Dry)normalized		49.8	0.08	11.77	2.87	6.02	0.17	17.04	10.66	1.39	0.15	0.05	0	100
191B	Staphor et al 2010	47.43	0.07	9.52	10.4	0	0.16	19.45	9.27	0.83	0.06	0.02	3.49	100.7
Wet(FeRatio=0.3)		47.43	0.07	9.52	3.12	6.55	0.16	19.45	9.27	0.83	0.06	0.02	3.49	99.97
(Wet)normalized		47.44	0.07	9.52	3.12	6.55	0.16	19.46	9.27	0.83	0.06	0.02	3.49	99.99
Dry(FeRatio=0.3)		47.43	0.07	9.52	3.12	6.55	0.16	19.45	9.27	0.83	0.06	0.02	0	96.48
(Dry)normalized		49.16	0.07	9.87	3.23	6.79	0.17	20.16	9.61	0.86	0.06	0.02	0	100
126A	Staphor et al 2010	46.17	0.13	11.14	12.42	0	0.19	16.01	9.38	1.5	0.11	0.03	2.26	99.34
Wet(FeRatio=0.3)		46.17	0.13	11.14	3.73	7.82	0.19	16.01	9.38	1.5	0.11	0.03	2.26	98.47

(Wet)normalized		46.89	0.13	11.31	3.79	7.94	0.19	16.26	9.53	1.52	0.11	0.03	2.3	100
Dry(FeRatio=0.3)		46.17	0.13	11.14	3.73	7.82	0.19	16.01	9.38	1.5	0.11	0.03	0	96.21
(Dry)normalized		47.99	0.14	11.58	3.87	8.13	0.2	16.64	9.75	1.56	0.11	0.03	0	100
126B	Staphor et al 2010	43.13	0.08	13.67	11.51	0	0.17	17.07	9.45	1.13	0.11	0.03	3.59	99.94
Wet(FeRatio=0.3)		43.13	0.08	13.67	3.45	7.25	0.17	17.07	9.45	1.13	0.11	0.03	3.59	99.13
(Wet)normalized		43.51	0.08	13.79	3.48	7.31	0.17	17.22	9.53	1.14	0.11	0.03	3.62	99.99
Dry(FeRatio=0.3)		43.13	0.08	13.67	3.45	7.25	0.17	17.07	9.45	1.13	0.11	0.03	0	95.54
(Dry)normalized		45.14	0.08	14.31	3.61	7.59	0.18	17.87	9.89	1.18	0.12	0.03	0	100
19A	Staphor et al 2010	46.7	0.72	8.93	12.42	0	0.23	18.57	7.81	0.58	0.06	0.1	3.1	99.22
Wet(FeRatio=0.3)		46.7	0.72	8.93	3.73	7.82	0.23	18.57	7.81	0.58	0.06	0.1	3.1	98.35
(Wet)normalized		47.48	0.73	9.08	3.79	7.95	0.23	18.88	7.94	0.59	0.06	0.1	3.15	99.98
Dry(FeRatio=0.3)		46.7	0.72	8.93	3.73	7.82	0.23	18.57	7.81	0.58	0.06	0.1	0	95.25
(Dry)normalized		49.03	0.76	9.38	3.91	8.21	0.24	19.5	8.2	0.61	0.06	0.1	0	100
225A	Staphor et al 2010	47.22	0.09	10.83	11.31	0	0.18	17.72	9.03	1.11	0.1	0.02	3.33	100.94
Wet(FeRatio=0.3)		47.22	0.09	10.83	3.39	7.12	0.18	17.72	9.03	1.11	0.1	0.02	3.33	100.14
(Wet)normalized		47.15	0.09	10.81	3.39	7.11	0.18	17.7	9.02	1.11	0.1	0.02	3.33	100.01
Dry(FeRatio=0.3)		47.22	0.09	10.83	3.39	7.12	0.18	17.72	9.03	1.11	0.1	0.02	0	96.81
(Dry)normalized		48.77	0.09	11.19	3.5	7.36	0.19	18.3	9.33	1.15	0.1	0.02	0	100
221F	Staphor et al 2010	43.81	0.04	7.31	12.75	0	0.19	22.68	6.8	0.14	0.07	0.07	4.66	98.52
Wet(FeRatio=0.3)		43.81	0.04	7.31	3.83	8.03	0.19	22.68	6.8	0.14	0.07	0.07	4.66	97.63
(Wet)normalized		44.87	0.04	7.49	3.92	8.22	0.19	23.23	6.97	0.14	0.07	0.07	4.77	99.98
Dry(FeRatio=0.3)		43.81	0.04	7.31	3.83	8.03	0.19	22.68	6.8	0.14	0.07	0.07	0	92.97
(Dry)normalized		47.12	0.04	7.86	4.11	8.64	0.2	24.4	7.31	0.15	0.08	0.08	0	99.99
97	Staphor et al 2010	52.51	0.93	14.83	8.77	0	0.15	7.5	12.65	1.83	0.34	0.09	1.29	100.89
Wet(FeRatio=0.3)		52.51	0.93	14.83	2.63	5.52	0.15	7.5	12.65	1.83	0.34	0.09	1.29	100.27
(Wet)normalized		52.37	0.93	14.79	2.62	5.51	0.15	7.48	12.62	1.83	0.34	0.09	1.29	100.02
Dry(FeRatio=0.3)		52.51	0.93	14.83	2.63	5.52	0.15	7.5	12.65	1.83	0.34	0.09	0	98.98
(Dry)normalized		53.05	0.94	14.98	2.66	5.58	0.15	7.58	12.78	1.85	0.34	0.09	0	100

273F	Staphor et al 2010	50.71	1.08	15.17	10.42	0	0.15	7.34	11.44	3.06	0.36	0.12	0.83	100.68
Wet(FeRatio=0.3)		50.71	1.08	15.17	3.13	6.56	0.15	7.34	11.44	3.06	0.36	0.12	0.83	99.95
(Wet)normalized		50.74	1.08	15.17	3.13	6.56	0.15	7.34	11.45	3.06	0.36	0.12	0.83	99.99
Dry(FeRatio=0.3)		50.71	1.08	15.17	3.13	6.56	0.15	7.34	11.44	3.06	0.36	0.12	0	99.12
(Dry)normalized		51.16	1.09	15.3	3.15	6.62	0.15	7.41	11.54	3.09	0.36	0.12	0	99.99
273B	Staphor et al 2010	50.66	0.88	14.38	9.11	0	0.15	9.55	12.51	2.22	0.31	0.1	1.05	100.92
Wet(FeRatio=0.3)		50.66	0.88	14.38	2.73	5.74	0.15	9.55	12.51	2.22	0.31	0.1	1.05	100.28
(Wet)normalized		50.52	0.88	14.34	2.72	5.72	0.15	9.52	12.48	2.21	0.31	0.1	1.05	100
Dry(FeRatio=0.3)		50.66	0.88	14.38	2.73	5.74	0.15	9.55	12.51	2.22	0.31	0.1	0	99.23
(Dry)normalized		51.05	0.89	14.49	2.75	5.78	0.15	9.62	12.61	2.24	0.31	0.1	0	99.99
274	Staphor et al 2010	49.98	1.13	13.96	9.32	0	0.16	9.29	10.87	2.93	0.3	0.11	0.85	98.9
Wet(FeRatio=0.3)		49.98	1.13	13.96	2.8	5.87	0.16	9.29	10.87	2.93	0.3	0.11	0.85	98.25
(Wet)normalized		50.87	1.15	14.21	2.85	5.97	0.16	9.46	11.06	2.98	0.3	0.11	0.86	99.98
Dry(FeRatio=0.3)		49.98	1.13	13.96	2.8	5.87	0.16	9.29	10.87	2.93	0.3	0.11	0	97.4
(Dry)normalized		51.32	1.16	14.33	2.87	6.03	0.16	9.54	11.16	3.01	0.31	0.11	0	100
52B2	Staphor et al 2010	48.06	1.1	11.18	12.16	0	0.19	12.44	11.43	0.99	0.41	0.07	2.62	100.65
Wet(FeRatio=0.3)		48.06	1.1	11.18	3.65	7.66	0.19	12.44	11.43	0.99	0.41	0.07	2.62	99.8
(Wet)normalized		48.16	1.1	11.2	3.66	7.68	0.19	12.46	11.45	0.99	0.41	0.07	2.63	100
Dry(FeRatio=0.3)		48.06	1.1	11.18	3.65	7.66	0.19	12.44	11.43	0.99	0.41	0.07	0	97.18
(Dry)normalized		49.46	1.13	11.5	3.75	7.88	0.2	12.8	11.76	1.02	0.42	0.07	0	99.99
52B1	Staphor et al 2010	49.61	1.14	13.87	10.71	0	0.16	8.64	10.13	2.68	0.65	0.12	3.01	100.72
Wet(FeRatio=0.3)		49.61	1.14	13.87	3.21	6.75	0.16	8.64	10.13	2.68	0.65	0.12	3.01	99.97
(Wet)normalized		49.62	1.14	13.87	3.21	6.75	0.16	8.64	10.13	2.68	0.65	0.12	3.01	99.98
Dry(FeRatio=0.3)		49.61	1.14	13.87	3.21	6.75	0.16	8.64	10.13	2.68	0.65	0.12	0	96.96
(Dry)normalized		51.17	1.18	14.31	3.31	6.96	0.17	8.91	10.45	2.76	0.67	0.12	0	100.01
51B	Staphor et al 2010	46.33	1.17	11.38	12.5	0	0.23	12.07	11.02	1.29	0.33	0.04	4.44	100.8
Wet(FeRatio=0.3)		46.33	1.17	11.38	3.75	7.87	0.23	12.07	11.02	1.29	0.33	0.04	4.44	99.92

(Wet)normalized		46.37	1.17	11.39	3.75	7.88	0.23	12.08	11.03	1.29	0.33	0.04	4.44	100
Dry(FeRatio=0.3)		46.33	1.17	11.38	3.75	7.87	0.23	12.07	11.02	1.29	0.33	0.04	0	95.48
(Dry)normalized		48.52	1.23	11.92	3.93	8.25	0.24	12.64	11.54	1.35	0.35	0.04	0	100.01
10B	Staphor et al 2010	50.44	1.07	15.93	10.11	0	0.18	6.38	10.55	1.84	0.14	0.11	4.12	100.87
Wet(FeRatio=0.3)		50.44	1.07	15.93	3.03	6.37	0.18	6.38	10.55	1.84	0.14	0.11	4.12	100.16
(Wet)normalized		50.36	1.07	15.9	3.03	6.36	0.18	6.37	10.53	1.84	0.14	0.11	4.11	100
Dry(FeRatio=0.3)		50.44	1.07	15.93	3.03	6.37	0.18	6.38	10.55	1.84	0.14	0.11	0	96.04
(Dry)normalized		52.52	1.11	16.59	3.16	6.63	0.19	6.64	10.98	1.92	0.15	0.11	0	100
2-6	Staphor et al 2010	51.58	1	14.51	9.41	0	0.15	8.43	10.41	3.01	0.75	0.1	1.49	100.84
Wet(FeRatio=0.3)		51.58	1	14.51	2.82	5.93	0.15	8.43	10.41	3.01	0.75	0.1	1.49	100.18
(Wet)normalized		51.49	1	14.48	2.81	5.92	0.15	8.41	10.39	3	0.75	0.1	1.49	99.99
Dry(FeRatio=0.3)		51.58	1	14.51	2.82	5.93	0.15	8.43	10.41	3.01	0.75	0.1	0	98.69
(Dry)normalized		52.26	1.01	14.7	2.86	6.01	0.15	8.54	10.55	3.05	0.76	0.1	0	99.99
168	Staphor et al 2010	50.71	1.11	10.3	10.13	0	0.16	11.45	11.09	2.02	0.42	0.1	1.69	99.18
Wet(FeRatio=0.3)		50.71	1.11	10.3	3.04	6.38	0.16	11.45	11.09	2.02	0.42	0.1	1.69	98.47
(Wet)normalized		51.5	1.13	10.46	3.09	6.48	0.16	11.63	11.26	2.05	0.42	0.1	1.71	99.99
Dry(FeRatio=0.3)		50.71	1.11	10.3	3.04	6.38	0.16	11.45	11.09	2.02	0.42	0.1	0	96.78
(Dry)normalized		52.4	1.15	10.64	3.14	6.59	0.17	11.83	11.46	2.09	0.43	0.1	0	100
123	Staphor et al 2010	49.26	1.12	16.84	9.48	0	0.16	7.65	10.79	3.12	0.23	0.11	2.18	100.94
Wet(FeRatio=0.3)		49.26	1.12	16.84	2.84	5.97	0.16	7.65	10.79	3.12	0.23	0.11	2.18	100.27
(Wet)normalized		49.13	1.12	16.79	2.83	5.95	0.16	7.63	10.76	3.11	0.23	0.11	2.17	99.99
Dry(FeRatio=0.3)		49.26	1.12	16.84	2.84	5.97	0.16	7.65	10.79	3.12	0.23	0.11	0	98.09
(Dry)normalized		50.22	1.14	17.17	2.9	6.09	0.16	7.8	11	3.18	0.23	0.11	0	100
122A	Staphor et al 2010	50.82	0.55	17.09	7.51	0	0.16	7.73	11.13	3.24	0.23	0.13	0.74	99.33
Wet(FeRatio=0.3)		50.82	0.55	17.09	2.25	4.73	0.16	7.73	11.13	3.24	0.23	0.13	0.74	98.8
(Wet)normalized		51.44	0.56	17.3	2.28	4.79	0.16	7.82	11.27	3.28	0.23	0.13	0.75	100.01
Dry(FeRatio=0.3)		50.82	0.55	17.09	2.25	4.73	0.16	7.73	11.13	3.24	0.23	0.13	0	98.06
(Dry)normalized		51.82	0.56	17.43	2.3	4.82	0.16	7.88	11.35	3.3	0.23	0.13	0	99.98

120A	Staphor et al 2010	49.56	0.83	9.32	10.85	0	0.24	16.31	12.46	1.39	0.33	0.05	0.07	101.41
Wet(FeRatio=0.3)		49.56	0.83	9.32	3.26	6.83	0.24	16.31	12.46	1.39	0.33	0.05	0.07	100.65
(Wet)normalized		49.24	0.82	9.26	3.24	6.79	0.24	16.2	12.38	1.38	0.33	0.05	0.07	100
Dry(FeRatio=0.3)		49.56	0.83	9.32	3.26	6.83	0.24	16.31	12.46	1.39	0.33	0.05	0	100.58
(Dry)normalized		49.27	0.83	9.27	3.24	6.79	0.24	16.22	12.39	1.38	0.33	0.05	0	100.01
120B	Staphor et al 2010	48.32	0.75	14.91	8.49	0	0.16	11.93	12.52	2.26	0.32	0.13	0.9	100.69
		48.32	0.75	14.91	2.55	5.35	0.16	11.93	12.52	2.26	0.32	0.13	0.9	100.1
(Wet)normalized		48.27	0.75	14.9	2.55	5.34	0.16	11.92	12.51	2.26	0.32	0.13	0.9	100.01
		48.32	0.75	14.91	2.55	5.35	0.16	11.93	12.52	2.26	0.32	0.13	0	99.2
(Dry)normalized		48.71	0.76	15.03	2.57	5.39	0.16	12.03	12.62	2.28	0.32	0.13	0	100
120C	Staphor et al 2010	49.85	0.57	15.42	8.69	0	0.14	9.56	12.68	2.34	0.44	0.1	0.88	100.67
Wet(FeRatio=0.3)		49.85	0.57	15.42	2.61	5.47	0.14	9.56	12.68	2.34	0.44	0.1	0.88	100.06
(Wet)normalized		49.82	0.57	15.41	2.61	5.47	0.14	9.55	12.67	2.34	0.44	0.1	0.88	100
Dry(FeRatio=0.3)		49.85	0.57	15.42	2.61	5.47	0.14	9.56	12.68	2.34	0.44	0.1	0	99.18
(Dry)normalized		50.26	0.57	15.55	2.63	5.52	0.14	9.64	12.78	2.36	0.44	0.1	0	99.99
48	Staphor et al 2010	49.17	1.98	15.88	4.8	0	0.13	8.31	14.76	1.44	0.27	0.05	3.28	100.07
Wet(FeRatio=0.3)		49.17	1.98	15.88	1.44	3.02	0.13	8.31	14.76	1.44	0.27	0.05	3.28	99.73
(Wet)normalized		49.3	1.99	15.92	1.44	3.03	0.13	8.33	14.8	1.44	0.27	0.05	3.29	99.99
Dry(FeRatio=0.3)		49.17	1.98	15.88	1.44	3.02	0.13	8.31	14.76	1.44	0.27	0.05	0	96.45
(Dry)normalized		50.98	2.05	16.46	1.49	3.13	0.13	8.62	15.3	1.49	0.28	0.05	0	99.98
228B	Staphor et al 2010	46.54	1.98	13.51	14.12	0	0.23	6.32	11.66	1.32	0.39	0.12	4.34	100.53
Wet(FeRatio=0.3)		46.54	1.98	13.51	4.24	8.89	0.23	6.32	11.66	1.32	0.39	0.12	4.34	99.54
(Wet)normalized		46.76	1.99	13.57	4.26	8.93	0.23	6.35	11.71	1.33	0.39	0.12	4.36	100
Dry(FeRatio=0.3)		46.54	1.98	13.51	4.24	8.89	0.23	6.32	11.66	1.32	0.39	0.12	0	95.2
(Dry)normalized		48.89	2.08	14.19	4.45	9.34	0.24	6.64	12.25	1.39	0.41	0.13	0	100.01
191	Staphor et al 2010	46.37	0.12	11.15	13.65	0	0.19	15.47	9.3	1.53	0.17	0.04	2.57	100.56
Wet(FeRatio=0.3)		46.37	0.12	11.15	4.1	8.6	0.19	15.47	9.3	1.53	0.17	0.04	2.57	99.61

(Wet)normalized		46.55	0.12	11.19	4.12	8.63	0.19	15.53	9.33	1.54	0.17	0.04	2.58	99.99
Dry(FeRatio=0.3)		46.37	0.12	11.15	4.1	8.6	0.19	15.47	9.3	1.53	0.17	0.04	0	97.04
(Dry)normalized		47.79	0.12	11.49	4.22	8.86	0.2	15.94	9.58	1.58	0.18	0.04	0	100
126_{SE}	Staphor et al 2010	50.49	0.25	14.35	10.97	0	0.2	7.7	11.72	2.08	0.19	0.04	2.69	100.68
Wet(FeRatio=0.3)		50.49	0.25	14.35	3.29	6.91	0.2	7.7	11.72	2.08	0.19	0.04	2.69	99.91
(Wet)normalized		50.53	0.25	14.36	3.29	6.92	0.2	7.71	11.73	2.08	0.19	0.04	2.69	99.99
Dry(FeRatio=0.3)		50.49	0.25	14.35	3.29	6.91	0.2	7.7	11.72	2.08	0.19	0.04	0	97.22
(Dry)normalized		51.93	0.26	14.76	3.39	7.11	0.21	7.92	12.06	2.14	0.2	0.04	0	100.02
126_{NW}	Staphor et al 2010	48.4	1.27	14.2	17.39	0	0.26	6.53	8.93	2.56	0.28	0.1	1.03	100.95
Wet(FeRatio=0.3)		48.4	1.27	14.2	5.22	10.95	0.26	6.53	8.93	2.56	0.28	0.1	1.03	99.73
(Wet)normalized		48.53	1.27	14.24	5.23	10.97	0.26	6.55	8.95	2.57	0.28	0.1	1.03	99.98
Dry(FeRatio=0.3)		48.4	1.27	14.2	5.22	10.95	0.26	6.53	8.93	2.56	0.28	0.1	0	98.7
(Dry)normalized		49.04	1.29	14.39	5.29	11.1	0.26	6.62	9.05	2.59	0.28	0.1	0	100.01
19B	Staphor et al 2010	52.63	1.81	14.72	14.16	0	0.19	5.14	7.79	1.58	0.31	0.16	2.32	100.81
Wet(FeRatio=0.3)		52.63	1.81	14.72	4.25	8.92	0.19	5.14	7.79	1.58	0.31	0.16	2.32	99.82
(Wet)normalized		52.72	1.81	14.75	4.26	8.94	0.19	5.15	7.8	1.58	0.31	0.16	2.32	99.99
Dry(FeRatio=0.3)		52.63	1.81	14.72	4.25	8.92	0.19	5.14	7.79	1.58	0.31	0.16	0	97.5
(Dry)normalized		53.98	1.86	15.1	4.36	9.15	0.19	5.27	7.99	1.62	0.32	0.16	0	100
225	Staphor et al 2010	45.46	1.24	15.71	17.4	0	0.24	6.88	8.58	3.23	0.29	0.12	1.35	100.5
Wet(FeRatio=0.3)		45.46	1.24	15.71	5.22	10.96	0.24	6.88	8.58	3.23	0.29	0.12	1.35	99.28
(Wet)normalized		45.79	1.25	15.82	5.26	11.04	0.24	6.93	8.64	3.25	0.29	0.12	1.36	99.99
Dry(FeRatio=0.3)		45.46	1.24	15.71	5.22	10.96	0.24	6.88	8.58	3.23	0.29	0.12	0	97.93
(Dry)normalized		46.42	1.27	16.04	5.33	11.19	0.25	7.03	8.76	3.3	0.3	0.12	0	100.01
97	Staphor et al 2010	46.3	0.54	6.59	10.54	0	0.18	23.92	5.39	0.06	0.01	0.06	5.3	98.89
Wet(FeRatio=0.3)		46.3	0.54	6.59	3.16	6.64	0.18	23.92	5.39	0.06	0.01	0.06	5.3	98.15
(Wet)normalized		47.17	0.55	6.71	3.22	6.77	0.18	24.37	5.49	0.06	0.01	0.06	5.4	99.99
Dry(FeRatio=0.3)		46.3	0.54	6.59	3.16	6.64	0.18	23.92	5.39	0.06	0.01	0.06	0	92.85
(Dry)normalized		49.86	0.58	7.1	3.41	7.15	0.19	25.76	5.81	0.06	0.01	0.06	0	99.99

273_{North}	Staphor et al 2010	43.73	0.62	7.06	13.33	0	0.18	25.27	3.21	0.06	0.01	0.09	6.6	100.16
Wet(FeRatio=0.3)		43.73	0.62	7.06	4	8.4	0.18	25.27	3.21	0.06	0.01	0.09	6.6	99.23
(Wet)normalized		44.07	0.63	7.11	4.03	8.47	0.18	25.46	3.23	0.06	0.01	0.09	6.65	99.99
Dry(FeRatio=0.3)		43.73	0.62	7.06	4	8.4	0.18	25.27	3.21	0.06	0.01	0.09	0	92.63
(Dry)normalized		47.21	0.67	7.62	4.32	9.06	0.19	27.28	3.47	0.06	0.01	0.1	0	99.99
273_{South}	Staphor et al 2010	48.06	0.35	6.28	14.06	0	0.2	22.65	4.75	0.11	0.03	0.05	4.19	100.73
Wet(FeRatio=0.3)		48.06	0.35	6.28	4.22	8.86	0.2	22.65	4.75	0.11	0.03	0.05	4.19	99.75
(Wet)normalized		48.18	0.35	6.3	4.23	8.88	0.2	22.71	4.76	0.11	0.03	0.05	4.2	100
Dry(FeRatio=0.3)		48.06	0.35	6.28	4.22	8.86	0.2	22.65	4.75	0.11	0.03	0.05	0	95.56
(Dry)normalized		50.3	0.37	6.57	4.41	9.27	0.21	23.7	4.97	0.12	0.03	0.05	0	100
274D	Staphor et al 2010	47.39	0.53	5.86	12.64	0	0.18	25.59	2.77	0.02	0.01	0.07	5.07	100.13
Wet(FeRatio=0.3)		47.39	0.53	5.86	3.79	7.96	0.18	25.59	2.77	0.02	0.01	0.07	5.07	99.24
(Wet)normalized		47.75	0.53	5.9	3.82	8.02	0.18	25.79	2.79	0.02	0.01	0.07	5.11	99.99
Dry(FeRatio=0.3)		47.39	0.53	5.86	3.79	7.96	0.18	25.59	2.77	0.02	0.01	0.07	0	94.17
(Dry)normalized		50.32	0.56	6.22	4.03	8.45	0.19	27.17	2.94	0.02	0.01	0.07	0	99.98
274C	Staphor et al 2010	45.27	0.76	9.35	11.34	0	0.18	16.02	8.13	0.63	1.06	0.03	7	99.77
Wet(FeRatio=0.3)		45.27	0.76	9.35	3.4	7.14	0.18	16.02	8.13	0.63	1.06	0.03	7	98.97
(Wet)normalized		45.74	0.77	9.45	3.44	7.21	0.18	16.19	8.21	0.64	1.07	0.03	7.07	100
Dry(FeRatio=0.3)		45.27	0.76	9.35	3.4	7.14	0.18	16.02	8.13	0.63	1.06	0.03	0	91.97
(Dry)normalized		49.22	0.83	10.17	3.7	7.77	0.2	17.42	8.84	0.68	1.15	0.03	0	100.01
52B1	Staphor et al 2010	40.36	0.87	10.17	14.36	0	0.15	20.92	6.03	0.22	0.1	0.08	7.69	100.95
Wet(FeRatio=0.3)		40.36	0.87	10.17	4.31	9.04	0.15	20.92	6.03	0.22	0.1	0.08	7.69	99.94
(Wet)normalized		40.38	0.87	10.18	4.31	9.05	0.15	20.93	6.03	0.22	0.1	0.08	7.69	99.99
Dry(FeRatio=0.3)		40.36	0.87	10.17	4.31	9.04	0.15	20.92	6.03	0.22	0.1	0.08	0	92.25
(Dry)normalized		43.75	0.94	11.02	4.67	9.8	0.16	22.68	6.54	0.24	0.11	0.09	0	100
51A	Staphor et al 2010	46.85	0.6	5.96	13.97	0	0.22	24.93	2.49	0.04	0.01	0.06	5.19	100.32
Wet(FeRatio=0.3)		46.85	0.6	5.96	4.19	8.8	0.22	24.93	2.49	0.04	0.01	0.06	5.19	99.34

(Wet)normalized		47.16	0.6	6	4.22	8.86	0.22	25.1	2.51	0.04	0.01	0.06	5.22	100
Dry(FeRatio=0.3)		46.85	0.6	5.96	4.19	8.8	0.22	24.93	2.49	0.04	0.01	0.06	0	94.15
(Dry)normalized		49.76	0.64	6.33	4.45	9.35	0.23	26.48	2.64	0.04	0.01	0.06	0	99.99
10A	Staphor et al 2010	44.97	0.56	7.26	13.73	0	0.19	25	2.36	0.02	0.03	0.07	5.66	99.85
Wet(FeRatio=0.3)		44.97	0.56	7.26	4.12	8.65	0.19	25	2.36	0.02	0.03	0.07	5.66	98.89
(Wet)normalized		45.47	0.57	7.34	4.17	8.75	0.19	25.28	2.39	0.02	0.03	0.07	5.72	100
Dry(FeRatio=0.3)		44.97	0.56	7.26	4.12	8.65	0.19	25	2.36	0.02	0.03	0.07	0	93.23
(Dry)normalized		48.24	0.6	7.79	4.42	9.28	0.2	26.82	2.53	0.02	0.03	0.08	0	100.01
Day Book A-1	Hunter 1941	40.86	0	2.18	7.66	0	0	49.31	0	0	0	0	0.63	100.64
Wet(FeRatio=0.3)		40.86	0	2.18	2.3	4.82	0	49.31	0	0	0	0	0.63	100.1
(Wet)normalized		40.82	0	2.18	2.3	4.82	0	49.26	0	0	0	0	0.63	100.01
Dry(FeRatio=0.3)		40.86	0	2.18	2.3	4.82	0	49.31	0	0	0	0	0	99.47
(Dry)normalized		41.08	0	2.19	2.31	0	0	49.57	0	0	0	0		100
Day Book A-2	Hunter 1941	42.4	0	1.06	8.62	0	0	45.92	0	0	0	0	1.23	99.23
(Wet)normalized		42.4	0	1.06	2.59	5.43	0	45.92	0	0	0	0	1.23	98.63
Dry(FeRatio=0.3)		42.99	0	1.07	2.63	5.51	0	46.56	0	0	0	0	1.25	100.01
(Dry)normalized		42.4	0	1.06	2.59	5.43	0	45.92	0	0	0	0	0	97.4
Wet(FeRatio=0.3)		43.53	0	1.09	2.66	5.57	0	47.15	0	0	0	0		100
Newdale B-1	Hunter 1941	41.06	0	1.53	7.27	0	0	47.81	0.24	0	0	0	2.43	100.34
Dry(FeRatio=0.3)		41.06	0	1.53	2.18	4.58	0	47.81	0.24	0	0	0	2.43	99.83
(Dry)normalized		41.13	0	1.53	2.18	4.59	0	47.89	0.24	0	0	0	2.43	99.99
Wet(FeRatio=0.3)		41.06	0	1.53	2.18	4.58	0	47.81	0.24	0	0	0	0	97.4
(Wet)normalized		42.16	0	1.57	2.24	4.7	0	49.09	0.25	0	0	0		100.01
Democrat A-1	Hunter 1941	40.18	0	1.48	8.94	0	0	45.39	0	0	0	0	3.76	99.75
Wet(FeRatio=0.3)		40.18	0	1.48	2.68	5.63	0	45.39	0	0	0	0	3.76	99.12
(Wet)normalized		40.54	0	1.49	2.7	5.68	0	45.79	0	0	0	0	3.79	99.99
Dry(FeRatio=0.3)		40.18	0	1.48	2.68	5.63	0	45.39	0	0	0	0	0	95.36
(Dry)normalized		42.13	0	1.55	2.81	5.9	0	47.6	0	0	0	0		99.99
Number Nine A-1	Hunter 1941	38.94	0	1.36	10.88	0	0	47.5	0.08	0	0	0	0.89	99.65
Wet(FeRatio=0.3)		38.94	0	1.36	3.26	6.85	0	47.5	0.08	0	0	0	0.89	98.88
(Wet)normalized		39.38	0	1.38	3.3	6.93	0	48.04	0.08	0	0	0	0.9	100.01
Dry(FeRatio=0.3)		38.94	0	1.36	3.26	6.85	0	47.5	0.08	0	0	0	0	97.99

(Dry)normalized		39.74	0	1.39	3.33	6.99	0	48.47	0.08	0	0	0		100
Number Nine B-1	Hunter 1941	39.2	0	1.34	11.2	0	0	47.96	0.22	0	0	0	1.01	100.93
Wet(FeRatio=0.3)		39.2	0	1.34	3.36	7.05	0	47.96	0.22	0	0	0	1.01	100.14
(Wet)normalized		39.15	0	1.34	3.36	7.04	0	47.89	0.22	0	0	0	1.01	100.01
Dry(FeRatio=0.3)		39.2	0	1.34	3.36	7.05	0	47.96	0.22	0	0	0	0	99.13
(Dry)normalized		39.54	0	1.35	3.39	7.12	0	48.38	0.22	0	0	0		100
Laurel Creek A-1	Hunter 1941	43.92	0	1.4	8.94	0	0	42.17	0	0	0	0	3.94	100.37
Wet(FeRatio=0.3)		43.92	0	1.4	2.68	5.63	0	42.17	0	0	0	0	3.94	99.74
(Wet)normalized		44.03	0	1.4	2.69	5.64	0	42.28	0	0	0	0	3.95	99.99
Dry(FeRatio=0.3)		43.92	0	1.4	2.68	5.63	0	42.17	0	0	0	0	0	95.8
(Dry)normalized		45.84	0	1.46	2.8	5.88	0	44.02	0	0	0	0		100
As-4	Conte 1986	55.71	3.25	14.05	13.08	0	0.18	5.59	6.44	2.16	0.55	1.05	0	102.06
normalized		55.08	3.21	13.89	3.88	8.15	0.18	5.53	6.37	2.14	0.54	1.04		100.01
As-12	Conte 1986	47.89	3.23	12.88	16.44	0	0.21	6.13	9.79	2.92	0.27	0.44	0	100.2
normalized		48.35	3.26	13	4.98	10.45	0.21	6.19	9.88	2.95	0.27	0.44		99.98
As-14	Conte 1986	54.27	3.43	11.8	13.6	0	0.22	5.31	9.12	2.84	0.21	0.38	0	101.18
normalized		54.14	3.42	11.77	4.07	8.55	0.22	5.3	9.1	2.83	0.21	0.38		100
As-17	Conte 1986	48.06	2.26	13.82	15.39	0	0.22	7.99	8.88	3.23	0.19	0.16	0	100.2
normalized		48.49	2.28	13.94	4.66	9.78	0.22	8.06	8.96	3.26	0.19	0.16		100
As-27	Conte 1986	50.79	3.16	12.01	16.06	0	0.22	5.54	9.24	2.34	0.82	0.43	0	100.61
normalized		51.06	3.18	12.07	4.84	10.17	0.22	5.57	9.29	2.35	0.82	0.43		99.99
As-36	Conte 1986	49.28	2.87	14.31	14.29	0	0.19	6.23	9.59	2.96	0.25	0.24	0	100.21
normalized		49.67	2.89	14.42	4.32	9.07	0.19	6.28	9.67	2.98	0.25	0.24		99.98
As-62	Conte 1986	49.72	2.82	12.06	16.72	0	0.21	5.6	11.22	1.28	0.27	0.29	0	100.19
normalized		50.21	2.85	12.18	5.07	10.64	0.21	5.66	11.33	1.29	0.27	0.29		100
As-66	Conte 1986	50.93	3.4	13.78	15.03	0	0.2	4.31	6.76	2.25	2.39	0.84	0	99.89
normalized		51.53	3.44	13.94	4.56	9.58	0.2	4.36	6.84	2.28	2.42	0.85		100
As-96	Conte 1986	49.13	3.02	12.93	16.93	0	0.25	6.75	9.25	2.58	0.26	0.34	0	101.44
normalized		49.01	3.01	12.9	5.07	10.64	0.25	6.73	9.23	2.57	0.26	0.34		100.01
AB-3	Conte 1986	45.54	3.15	14.31	18.3	0	0.33	6.31	9.6	2.57	0.98	0.41	0	101.5
normalized		45.44	3.14	14.28	5.48	11.5	0.33	6.3	9.58	2.56	0.98	0.41		100
AB-4	Conte 1986	49.12	3.05	13.44	16.66	0	0.22	5.24	8.52	1.78	1.01	0.4	0	99.44
normalized		49.98	3.1	13.68	5.09	10.68	0.22	5.33	8.67	1.81	1.03	0.41		100

Ab-5	Conte 1986	50.04	3.06	13.15	16.66	0	0.23	5.69	8.13	1.9	0.97	0.39	0	100.22
normalized		50.52	3.09	13.28	5.05	10.59	0.23	5.74	8.21	1.92	0.98	0.39		100
AB-8	Conte 1986	50.24	3.13	13.81	16.56	0	0.21	5.01	8.17	2.04	0.92	0.39	0	100.48
normalized		50.58	3.15	13.9	5	10.5	0.21	5.04	8.23	2.05	0.93	0.39		99.98
AB-17	Conte 1986	49.52	2.85	13.45	15.41	0	0.18	5.66	11.01	2.23	0.35	0.51	0	101.17
normalized		49.48	2.85	13.44	4.62	9.7	0.18	5.65	11	2.23	0.35	0.51		100.01
As-9	Conte 1986	47.68	0.74	12.85	17.59	0	0.22	7.02	9.61	2.55	0.17	0.07	0	98.5
normalized		49.02	0.76	13.21	5.43	11.39	0.23	7.22	9.88	2.62	0.17	0.07		100
As-20	Conte 1986	51.69	0.15	12.28	12.89	0	0.15	8.83	11.64	1.28	0.19	0.02	0	99.12
normalized		52.63	0.15	12.5	3.94	8.27	0.15	8.99	11.85	1.3	0.19	0.02		99.99
As-24	Conte 1986	50.67	0.44	12.07	14.88	0	0.18	7.95	11.13	1.51	0.17	0.06	0	99.06
normalized		51.7	0.45	12.31	4.55	9.56	0.18	8.11	11.36	1.54	0.17	0.06		99.99
As-29	Conte 1986	48.09	0.54	13.5	15.9	0	0.19	7.36	9.88	2.99	0.32	0.05	0	98.82
normalized		49.22	0.55	13.82	4.88	10.25	0.19	7.53	10.11	306	0.33	0.05		99.99
As-37	Conte 1986	49.97	0.89	12.13	14.76	0	0.2	7.96	11.55	1.55	0.13	0.08	0	99.22
normalized		50.89	0.91	12.35	4.51	9.47	0.2	8.11	11.76	1.58	0.13	0.08		99.99
As-52	Conte 1986	51.66	0.35	12.62	14.42	0	0.15	7.03	10.48	1.6	0.16	0.02	0	98.49
normalized		53	0.36	12.95	4.44	9.32	0.15	7.21	10.75	1.64	0.16	0.02		100
As-53	Conte 1986	51.26	0.17	12.23	13.28	0	0.18	8.43	11.94	1.25	0.12	0.02	0	98.88
normalized		52.33	0.17	12.49	4.07	8.545	0.18	8.61	12.19	1.28	0.12	0.02		100
As-58	Conte 1986	52.83	0.23	11.51	16.27	0	0.2	5.95	10.36	1.14	0.08	0.04	0	98.61
normalized		54.2	0.24	11.81	5.01	10.51	0.21	6.1	10.63	1.17	0.08	0.04		100
As-61	Conte 1986	50.86	0.21	11.47	12.18	0	0.16	8.62	13.99	1.31	0.1	0.02	0	98.92
normalized		51.86	0.21	11.7	3.73	7.82	0.16	8.79	14.27	1.34	0.1	0.02		100
As-63	Conte 1986	49.44	0.96	12.79	15.21	0	0.16	7.38	10.44	2.35	0.23	0.09	0	99.05
normalized		50.46	0.98	13.05	4.66	9.78	0.16	7.53	10.65	2.4	0.23	0.09		99.99
As-64	Conte 1986	49.5	1.03	12.56	16.34	0	0.21	6.39	11.1	2.24	0.13	0.12	0	99.62
normalized		50.27	1.05	12.75	4.98	10.45	0.21	6.49	11.27	2.27	0.13	0.12		99.99
As-69	Conte 1986	51.19	0.85	12.94	12.78	0	0.14	5.75	15.86	0.91	0.18	0.29	0	100.89
normalized		51.19	0.85	12.94	3.83	8.05	0.14	5.75	15.86	0.91	0.18	0.29		99.99
As-71	Conte 1986	47.46	0.39	11.81	14.92	0	0.2	9.91	12.67	1.63	0.3	0	0	99.29
normalized		48.31	0.4	12.02	4.56	9.57	0.2	10.009	12.9	1.66	0.31	0		100.02
As-76	Conte 1986	44.89	1.3	13.3	18.07	0	0.22	7.89	10.91	2.36	0.13	0.18	0	99.25

normalized		45.81	1.33	13.57	5.53	11.62	0.22	8.05	11.13	2.41	0.13	0.18		99.98
As-92	Conte 1986	50.69	0.42	12.58	13.55	0	0.17	8	11.95	1.74	0.25	0.08	0	99.43
normalized		51.47	0.43	12.77	4.13	8.67	0.17	8.12	12.13	1.77	0.25	0.08		99.99
As-5	Conte 1986	50.21	1.02	17.71	8.42	0	0.1	7.4	10.97	3.23	0.15	0.21	0	99.42
normalized		50.8	1.03	17.92	2.56	5.37	0.1	7.49	11.1	3.27	0.15	0.21		100
As-6	Conte 1986	49.81	1.55	15.21	11.69	0	0.18	5.67	9.92	3.53	0.67	0.3	0	98.53
normalized		50.98	1.59	15.57	3.59	7.54	0.18	5.8	10.15	3.61	0.69	0.31		100.01
As-7	Conte 1986	50.94	1.8	15.67	11.08	0	0.17	6.05	8.33	4.47	0.2	0.36	0	99.07
normalized		51.82	1.83	15.94	3.38	7.1	0.17	6.16	8.47	4.55	0.2	0.37		99.99
As-8	Conte 1986	48.03	2.02	15.88	9.36	0	0.15	7.8	10.24	3.53	0.82	0.33	0	98.16
normalized		49.26	2.07	16.29	2.88	6.05	0.15	8	10.5	3.62	0.84	0.34		100
As-10	Conte 1986	43.09	0.55	7.62	13.47	0	0.22	28.33	4.03	0.47	0	0.14	0	97.92
normalized		44.43	0.57	7.86	4.17	8.75	0.23	29.21	4.16	0.48	0	0.14		100
As-15	Conte 1986	47.87	1.56	15.25	12.88	0	0.18	6.38	10.25	3.19	1.68	0.41	0	99.65
normalized		48.48	1.58	15.44	3.91	8.22	0.18	6.46	10.38	3.23	1.7	0.42		100
As-22	Conte 1986	49.97	0.75	13.68	13.14	0	0.17	9.98	7.12	3.04	0.09	0.08	0	98.02
normalized		51.46	0.77	14.09	4.06	8.52	0.18	10.28	7.33	3.13	0.09	0.08		99.99
As-31	Conte 1986	52.14	1.24	12.89	11.88	0	0.17	7.38	11	2.04	0.43	0.16	0	99.33
normalized		52.94	1.26	13.09	3.62	7.6	0.17	7.49	11.17	2.07	0.44	0.16		100.01
As-32	Conte 1986	50.04	1.84	13.44	12.48	0	0.19	8.21	10.18	2.72	0.15	0.15	0	99.4
normalized		50.79	1.87	13.64	3.8	7.98	0.19	8.33	10.33	2.76	0.15	0.15		99.99
As-39	Conte 1986	46.92	1.32	15.08	12.64	0	0.19	9.86	6.64	3.39	0.16	0.16	0	96.36
normalized		49.14	1.38	15.79	3.97	8.34	0.2	10.33	6.95	3.55	0.17	0.17		99.99
As-40	Conte 1986	48.32	1.78	13.98	14.03	0	0.19	7.2	10.75	2.58	0.39	0.27	0	99.49
normalized		49.05	1.81	14.19	4.27	8.97	0.19	7.31	10.91	2.62	0.4	0.27		99.99
As-43	Conte 1986	49.61	1.26	13.93	12.87	0	0.19	7.4	10.56	2.35	0.28	0.15	0	98.6
normalized		50.78	1.29	14.26	3.95	8.3	0.19	7.57	10.81	2.41	0.29	0.15		100
As-45	Conte 1986	49.1	1.36	15.94	11.72	0	0.17	6.52	10.37	2.81	0.44	0.16	0	98.59
normalized		50.22	1.39	16.3	3.6	7.55	0.17	6.67	10.61	2.87	0.45	0.16		99.99
As-47	Conte 1986	49.51	1.4	14.27	13.25	0	0.19	7.05	10	2.73	0.26	0.16	0	98.82
normalized		50.58	1.43	14.58	4.06	8.53	0.19	7.2	10.22	2.79	0.27	0.16		100.01
As-49	Conte 1986	49.31	1.29	16.2	10.66	0	0.16	7.35	9.38	3.61	0.25	0.17	0	98.38
normalized		50.51	1.32	16.59	3.28	6.88	0.16	7.53	9.61	3.7	0.26	0.17		100.01

As-56	Conte 1986	49.85	1.88	13.93	14.15	0	0.2	6.68	10.03	2.87	0.31	0.33	0	100.23
normalized		50.23	1.89	14.04	4.28	8.98	0.2	6.73	10.11	2.89	0.31	0.33		99.99
As-65	Conte 1986	47.64	1.19	13.48	13.48	0	0.17	8.55	12.09	2.09	0.41	0.18	0	99.28
normalized		48.45	1.21	13.71	4.11	8.63	0.17	8.69	12.29	2.13	0.42	0.18		99.99
As-67	Conte 1986	49.48	1.33	14.2	13.36	0	0.28	8.21	11.59	1.43	0.32	0.15	0	100.35
normalized		49.77	1.34	14.28	4.03	8.46	0.28	8.26	11.66	1.44	0.32	0.15		99.99
As-68	Conte 1986	47.86	1.49	15.42	12.2	0	0.19	7.88	11.91	2.27	0.47	0.11	0	99.8
normalized		48.37	1.51	15.58	3.7	7.77	0.19	7.96	12.04	2.29	0.48	0.11		100
As-73	Conte 1986	49.72	0.94	14.61	10.32	0	0.15	8.35	10.82	2.55	1.23	0.1	0	98.79
normalized		50.7	0.96	14.9	3.16	6.63	0.15	8.51	11.03	2.6	1.25	0.1		99.99
As-74	Conte 1986	51.98	1.12	17.08	9.64	0	0.1	5.32	7.72	3.59	0.86	0.22	0	97.63
normalized		53.61	1.16	17.62	2.98	6.26	0.1	5.49	7.96	3.7	0.89	0.23		100
As-77	Conte 1986	51.86	1.25	14.37	13.49	0	0.28	7.32	8.11	2.46	0.11	0.15	0	99.4
normalized		52.67	1.27	14.6	4.11	8.63	0.28	7.43	8.24	2.5	0.11	0.15		99.99
As-80	Conte 1986	48.68	1.24	15.28	11.98	0	0.21	8.63	9.75	3.04	0.22	0.25	0	99.28
normalized		49.45	1.26	15.52	3.65	7.67	0.21	8.77	9.9	3.09	0.22	0.25		99.99
As-81	Conte 1986	48.61	1.4	15.15	12.28	0	0.15	7.71	10.52	2.74	0.49	0.21	0	99.26
normalized		49.9	1.42	15.4	3.74	7.86	0.15	7.84	10.69	2.78	0.5	0.21		99.99
As-82	Conte 1986	51	1.43	14.14	12.15	0	0.17	7.22	10.32	2.78	0.29	0.27	0	99.77
normalized		51.56	1.45	14.29	3.68	7.74	0.17	7.3	10.43	2.81	0.29	0.27		99.99
As-85	Conte 1986	48.76	1.37	14.07	12.25	0	0.12	7.87	11.47	2.42	0.22	0.2	0	98.75
normalized		49.81	1.4	14.37	3.75	7.88	0.12	8.04	11.72	2.47	0.22	0.2		99.98
As-86	Conte 1986	50.31	1.26	14.12	11.33	0	0.14	7.92	12.21	2.41	0.16	0.18	0	100.04
normalized		50.69	1.27	14.23	3.42	7.19	0.14	7.19	12.3	2.43	0.16	0.18		99.99
As-87	Conte 1986	48.63	1.14	14.14	11.93	0	0.16	8.32	12.68	2.44	0.38	0.12	0	99.94
normalized		49.07	1.15	14.27	3.61	7.58	0.16	8.4	12.79	2.46	0.38	0.12		99.99
As-89	Conte 1986	50.96	0.74	13.97	9.5	0	0.14	9.49	12.26	1.45	0.25	0.07	0	98.83
normalized		51.91	0.75	14.23	2.9	6.1	0.14	9.67	12.49	1.48	0.25	0.07		99.99
As-90	Conte 1986	49.37	0.72	12.23	10.77	0	0.13	11.63	12.47	1.81	0.32	0.12	0	99.57
normalized		49.96	0.73	12.38	3.27	6.87	0.13	11.77	12.62	1.83	0.32	0.12		100
As-94	Conte 1986	45.92	0.53	7.37	13.11	0	0.27	23.77	5.29	0.76	0	0.09	0	97.11
normalized		47.74	0.55	7.66	4.09	8.58	0.28	24.71	5.5	0.79	0	0.09		99.99
As-95	Conte 1986	48.06	1.92	15.22	12.93	0	0.17	6.43	11.39	3.17	0.4	0.41	0	100.1

normalized		48.45	1.94	15.34	3.91	8.21	0.17	6.48	11.48	3.2	0.4	0.41		99.99
AB-1	Conte 1986	51.42	1.9	16.35	12.27	0	0.13	4.95	7.05	3.34	1.4	0.33	0	99.14
normalized		52.32	1.93	16.64	3.75	7.86	0.13	5.04	7.17	3.4	1.42	0.34		100
AB-2	Conte 1986	47.74	1.35	14.78	11.07	0	0.12	7	17.75	0.96	0.14	0.12	0	101.03
normalized		47.62	1.35	14.74	3.31	6.96	0.12	6.98	17.71	0.96	0.14	0.12		100.01
AB-7	Conte 1986	53.16	1.01	14.8	9.44	0	0.12	6.69	11.63	2.45	0.12	0.15	0	99.57
normalized		53.75	1.02	14.96	2.86	6.01	0.12	6.76	11.76	2.48	0.12	0.15		99.99
AB-9	Conte 1986	49.84	1.34	14.09	11.35	0	0.14	8.94	10.89	2.4	0.26	0.21	0	99.46
normalized		50.51	1.36	14.28	3.45	7.25	0.14	9.06	11.04	2.43	0.26	0.21		99.99
AB-10	Conte 1986	50.31	1.28	14.9	10.46	0	0.14	6.81	12.23	2.96	0.15	0.17	0	99.41
normalized		50.98	1.3	15.1	3.18	6.68	0.14	6.9	12.39	3	0.15	0.17		99.99
AB-11	Conte 1986	50.95	1.33	14.68	10.89	0	0.16	6.67	10.69	3.58	0.32	0.21	0	99.48
normalized		51.61	1.35	14.87	3.31	6.95	0.16	6.76	10.83	3.63	0.32	0.21		100
AB-12	Conte 1986	48.75	1.19	16.54	11.11	0	0.12	4.71	17.96	1	0.13	0.15	0	101.66
normalized		48.32	1.18	16.4	3.3	6.94	0.12	4.67	17.8	0.99	0.13	0.15		100
AB-13	Conte 1986	45.79	1.38	17.54	11.47	0	0.15	7.97	11.55	2.49	0.83	0.2	0	99.37
normalized		46.46	1.4	17.8	3.49	7.33	0.15	8.09	11.72	2.53	0.84	0.2		100.01
AB-14	Conte 1986	49.33	1.15	16.91	10.10	0	0.14	6.74	11.38	3.58	0.26	0.17	0	99.76
normalized		49.8	1.16	17.07	3.06	6.42	0.14	6.8	11.49	3.61	0.26	0.17		99.98
AB-15	Conte 1986	47.85	1.26	13.3	10.56	0	0.17	8.77	12.78	2.65	0.53	0.17	0	98.04
normalized		49.18	1.29	13.67	3.26	6.84	0.17	9.01	13.13	2.72	0.54	0.17		99.98
AB-16	Conte 1986	49.3	1.01	15.09	9.95	0	0.14	9.99	10.5	2.82	0.44	0.19	0	99.43
normalized		49.93	1.02	15.28	3.02	6.35	0.14	10.12	10.63	2.86	0.45	0.19		99.99

Appendix 1.1b: Tugaloo Blue Ridge Norms	Paper	Quartz	Plag	Orth	Neph	Corun	Diop	Hyp	Oliv	Acmite	Ilmen	Mag	Apa	Total
LC-95	R.D. Hatcher	3.45	40.68	1	0	0	11.17	37.12	0	0	1.03	5.31	0.25	100.01
LC-179B	R.D. Hatcher	1.71	42.48	1.18	0	0	16.56	28.42	0	0	3.7	5.94	0	99.99
LC-152	R.D. Hatcher	10.58	44.08	1.6	0	0	11.63	23.01	0	0	2.92	5.68	0.49	99.99
LC-138	R.D. Hatcher	6.42	45.71	2.9	0	0	13.57	21.12	0	0	4.5	5.8	0	100.02
LC-240	R.D. Hatcher	2.15	30.36	0.41	0	0	10.82	47.9	0	0	0.82	6.99	0.56	100.01
LC-239B	R.D. Hatcher	2.96	19.49	0.3	0	0	9.47	59.87	0	0	1.03	6.79	0.12	100.03
LC-161	R.D. Hatcher	0	38.73	0.95	0	0	17.53	33.91	0.04	0	2.62	5.92	0.3	100
LC-140	R.D. Hatcher	11.77	46.8	1.12	0	0	4.37	28.81	0	0	1.63	4.86	0.63	99.99
LC-14	R.D. Hatcher	14.62	37.22	1.48	0	0	16.89	21.31	0	0	2.45	5.42	0.6	99.99
LC-242	R.D. Hatcher	0	13.66	0.35	0	0	0.05	32.94	43.55	8.86	0.09	0.31	0.42	99.99
LC-34	R.D. Hatcher	0	8.2	0.35	0	0	0	13.67	68.22	7.72	0	0	0.44	100.1
LC-142	R.D. Hatcher	0	14.94	0.35	0	0	4.78	56.06	11.06	8.01	0.55	3.76	0.49	100
LC-2	R.D. Hatcher	0	30.12	0.35	0	0	18.47	18.08	23.88	0	0.49	7.38	0.76	99.98
BRQ3	Mittwede 1984	1.94	0.44	0.06	0	2.87	0	88.92	0	0	0.09	5.65	0.02	99.99
BRQ4	Mittwede 1984	0	0.12	0.06	0	2.28	0	27.66	47.66	0	0.08	22.13	0.02	100.01
BRQ5	Mittwede 1984	2.65	0.17	0.06	0	2.98	0	8773	0	0	0.09	6.29	0.02	99.99
BRQ6	Mittwede 1984	4.08	0.32	0.06	0	2.04	0	87.34	0	0	0.08	6.06	0.02	100
RM106(wet)	Raymond et al	0	0.35	0.18	0	0.27	0	10.33	84.44	0	0.04	4.05	0.05	99.71
(dry)		0	0.35	0.18	0	0.27	0	10.35	84.7	0	0.04	4.06	0.05	100
RM109(wet)	Raymond et al	0	0.46	0.18	0	0.41	0	34.76	58.52	0	0.04	4.71	0.21	99.29
(dry)		0	0.46	0.18	0	0.42	0	35.04	58.9	0	0.04	4.76	0.21	100.01
RM116(wet)	Raymond et al	0	0.91	0.18	0	0.72	0	13.08	79.81	0	0.04	4.15	0.12	99.01
(dry)		0	0.91	0.18	0	0.73	0	13.25	80.57	0	0.04	4.19	0.12	99.99
HC-4(wet)	Carpenter & Chen 1978	0	0.3	0	0	0.23	0	10.14	84.81	0	0.09	3.45	0	99.02
(dry)		0	0.3	0	0	0.23	0	10.28	85.61	0	0.09	3.48	0	99.99
HC-5(wet)	Carpenter & Chen 1978	0	0.4	0	0	0.27	0	15.95	77.33	0	0.13	3.87	0	97.95
(dry)		0	0.4	0	0	0.27	0	8.25	87.11	0	0.13	3.83	0	99.99

HC-6(wet)	Carpenter & Chen 1978	0	1.14	0.06	0	0	4.74	11.04	78.31	0	0.11	3.55	0	98.95
(dry)		0	1.17	0.06	0	0	4.76	11.17	79.15	0	0.11	3.6	0	100.02
D(wet)	Carpenter & Chen 1978	0	2.33	0.35	0	0.15	0	21.14	67.84	0	0.15	3.84	0	95.8
(dry)		0	2.43	0.35	0	0.16	0	22.11	70.79	0	0.15	4	0	99.99
F-1(wet)	Carpenter & Chen 1978	0	0.45	0.12	0	0.78	0	19.81	70.39	0	0.06	3.65	0	95.26
(dry)		0	0.45	0.12	0	0.83	0	20.84	73.88	0	0.06	3.83	0	100.01
F-2(wet)	Carpenter & Chen 1978	0	0.45	0.06	0	0.88	0	31.21	56.3	0	0.04	3.51	0	92.45
(dry)		0	0.5	0.06	0	0.95	0	33.74	60.92	0	0.04	3.8	0	100.01
F-3(wet)	Carpenter & Chen 1978	0	0.45	0	0	0.4	0	25.77	65.66	0	0.02	3.74	0	96.04
(dry)		0	0.45	0	0	0.42	0	26.86	68.36	0	0.02	3.89	0	100
F-4(wet)	Carpenter & Chen 1978	0	2.58	0.12	0	0.17	0	21.6	67.4	0	0.13	3.89	0	95.89
(dry)		0	2.68	0.12	0	0.19	0	22.53	70.3	0	0.13	4.06	0	100.01
F-5(wet)	Carpenter & Chen 1978	0	1.93	0.12	0	0	0.94	25.2	64.52	0	0.08	3.57	0	96.36
(dry)		0	2.01	0.12	0	0	0.95	26.17	66.95	0	0.08	3.71	0	99.99
F-6(wet)	Carpenter & Chen 1978	0	2.37	0.06	0	0	0.09	19.09	69.55	0	0.08	3.64	0	94.88
(dry)		0	2.48	0.06	0	0	0.08	20.21	73.26	0	0.08	3.83	0	100
Day Book Dunite	Butler and Ragland 1969	0	2.73	0.12	0	2.28	0	10.2	81.23	0	0.02	3.42	0	100
1(wet)	Kulp and Brobst 1954	0	0.18	0	0	0.72	0	8.18	85.75	0	0.02	3.68	0.05	98.58
(dry)		0	0	0.18	0	0.73	0	8.35	86.95	0	0.02	3.74	0.05	100.02
8	Kulp and Brobst 1954	0	2.54	0	0	0.6	0	5.66	87.85	0	0	3.35	0	100
7A	Dribus et al 1982	0	0	0	0	0	0.82	27.88	67.16	0	0	4.15	0	100.01

12	Dribus et al 1982	0	0	0	0	0	0.7	18.33	76.57	0	0	4.39	0	99.99
17	Dribus et al 1982	0	0	0	0	0	0.66	14.29	80.73	0	0	4.31	0	99.99
18A	Dribus et al 1982	0	0	0	0	0	0.58	14.22	81.01	0	0	4.19	0	100
20L	Dribus et al 1982	0	0	0	0	0	0.58	9.26	86.3	0	0	3.87	0	100.01
21	Dribus et al 1982	0	0	0	0	0	0.58	17.32	78.56	0	0	3.55	0	100.01
24A	Dribus et al 1982	0	0	0	0	0	0.47	18.08	77.65	0	0	3.8	0	100
25	Dribus et al 1982	0	0	0	0	0	0.66	20.26	75.1	0	0	3.97	0	99.99
28C	Dribus et al 1982	0	0	0	0	0	0.78	21.04	74.02	0	0	4.16	0	100
28Q	Dribus et al 1982	0	0	0	0	0	0.55	20.3	74.82	0	0	4.34	0	100.01
31	Dribus et al 1982	0	0	0	0	0	0.9	23.32	71.22	0	0	4.57	0	100.01
33	Dribus et al 1982	0	0	0	0	0	0.43	29.74	65.39	0	0	4.44	0	100
E2	Dribus et al 1982	0	0	0	0	0	0.51	16.71	78.83	0	0	3.93	0	99.98
E3	Dribus et al 1982	0	0	0	0	0	0.54	20.04	75.54	0	0	3.87	0	99.99
Long Creek Soapstone(wet)	Hatcher 1970	10.10	7.04	0	0	4.72	0	73.4	0	0	0.65	3.52	0	99.43
(dry)		10.18	7.09	0	0	4.74	0	73.75	0	0	0.7	3.54	0	100
1(wet)	Mittwede and Zupan 1985	0	19.9	1.6	0	0	32.11	37.6	1.19	0	1.31	4.84	0.12	98.67
(dry)		0	20.16	1.65	0	0	32.56	38	1.27	0	1.33	4.9	0.12	99.99
2(wet)	Mittwede and Zupan 1985	16.76	0.47	0	0	0	20.6	37.3	13.61	0	0.78	5.67	0.07	95.26

(dry)		0	17.59	0.53	0	0	21.62	39.03	14.38	0	0.82	5.96	0.07	100
3(wet)	Mittwede and Zupan 1985	18.01	0.51	0.65	0	0.9	0	75.11	0	0	0.06	2.48	0.25	97.97
(dry)		18.36	0.59	0.65	0	0.92	0	76.74	0	0	0.06	2.52	0.25	100.09
2-4(wet)	Staphor et al 2010	0	1.06	0.18	0	5.86	0	78.53	0.09	0	1.23	6.06	0.23	93.24
(dry)		0.02	1.09	0.18	0	6.3	0	84.33	0	0	1.33	6.48	0.25	99.98
168(wet)	Staphor et al 2010	0	15.99	0.12	0	1.52	0	61.26	8.61	0	1.12	5.54	0.14	94.3
(dry)		0	16.93	0.12	0	1.62	0	65.03	9.09	0	1.2	5.87	0.14	100
122B(wet)	Staphor et al 2010	0	16.79	0.18	0	0	3.77	60.1	7.51	0	1.04	5.93	0.16	95.48
(dry)		0	17.59	0.18	0	0	3.99	62.85	7.9	0	1.1	6.22	0.16	99.99
120F(wet)	Staphor et al 2010	0	18.15	0.3	0	0	18.03	42.69	8.27	0	0.74	5.6	0.16	93.94
(dry)		0	19.31	0.3	0	0	19.23	45.53	8.73	0	0.78	5.96	0.16	100
120D(wet)	Staphor et al 2010	0	18.34	0.3	0	0	11.04	43.47	13.9	0	1.03	5.68	0.21	93.97
(dry)		0	19.52	0.3	0	0	11.73	46.34	14.74	0	1.1	6.05	0.23	100.01
48A(wet)	Staphor et al 2010	0	15.21	0.3	0	0	23.12	43.19	8.44	0	1.03	5.13	0.23	96.65
(dry)		0	15.77	0.3	0	0	23.93	44.64	8.75	0	1.06	5.32	0.23	100
48B(wet)	Staphor et al 2010	0	23.55	0.41	0	0	12.43	37.75	14.68	0	0.97	5.73	0.14	95.66
(dry)		0	24.71	0.41	0	0	12.92	39.44	15.37	0	1.03	5.99	0.14	100
228C1(wet)	Staphor et al 2010	0	35.16	0.89	0	0	20.33	21.95	12.1	0	0.15	3.93	0.12	94.63
(dry)		0	37.19	0.89	0	0	21.54	23.17	12.79	0	0.15	4.16	0.12	100.01
191B(wet)	Staphor et al 2010	0	29.1	0.35	0	0	18.87	29.38	14.1	0	0.13	4.52	0.05	96.5
(dry)		0	30.17	0.35	0	0	19.56	30.45	14.61	0	0.13	4.68	0.05	100
126A(wet)	Staphor et al 2010		36.57	0.65	0	0	18.66	17.85	18.16	0	0.25	5.5	0.07	97.71

(dry)		0	37.47	0.65	0	0	19.09	18.22	18.63	0	0.27	5.61	0.07	100.01
126B(wet)	Staphor et al 2010	0	41.83	0.65	0	0	11.87	8.6	28.16	0	0.15	5.05	0.07	96.38
(dry)		0	43.38	0.71	0	0	12.33	8.84	29.29	0	0.15	5.23	0.07	100
19A(wet)	Staphor et al 2010	0	26.94	0.35	0	0	13.35	43.33	5.75	0	1.39	5.5	0.23	96.84
(dry)		0	27.84	0.35	0	0	13.79	44.71	5.96	0	1.44	5.67	0.23	99.99
225A(wet)	Staphor et al 2010	0	33.61	0.59	0	0	16.23	26.86	14.25	0	0.17	4.92	0.05	96.68
(dry)		0	34.81	0.59	0	0	16.77	27.78	14.76	0	0.17	5.07	0.05	100
221F(wet)	Staphor et al 2010	0	20.79	0.41	0	0	11.53	36.73	19.89	0	0.08	5.68	0.16	95.21
(dry)		0	21.81	0.47	0	0	12.07	38.52	20.9	0	0.08	5.96	0.19	100
97(wet)	Staphor et al 2010	6.1	46.62	2.01	0	0	24.79	13.43	0	0	1.77	3.8	0.21	98.73
(dry)		6.22	47.22	2.01	0	0	25.08	13.62	0	0	1.79	3.86	0.21	100.01
273F(wet)	Staphor et al 2010	0	52.49	2.13	0	0	23.73	11.75	2.2	0	2.05	4.54	0.28	99.17
(dry)		0	52.96	2.13	0	0	23.92	11.78	2.29	0	2.07	4.57	0.28	100
273B(wet)	Staphor et al 2010	0	46.99	1.83	0	0	26.35	17.22	0.71	0	1.67	3.94	0.23	98.94
(dry)		0	47.52	1.83	0	0	26.65	17.31	0.77	0	1.69	3.99	0.23	99.99
274(wet)	Staphor et al 2010	0	49.73	1.77	0	0	23.69	12.56	4.8	0	2.18	4.13	0.25	99.11
(dry)		0	50.14	1.83	0	0	23.96	12.5	4.95	0	2.2	4.16	0.25	99.99
52B2(wet)	Staphor et al 2010	0.33	33.28	2.42	0	0	25.15	28.63	0	0	2.09	5.31	0.16	97.37
(dry)		0.32	34.19	2.48	0	0	25.86	29.4	0	0	2.15	5.44	0.16	100
52B1(wet)	Staphor et al 2010	0	46.57	3.84	0	0	20.56	16.59	2.31	0	2.17	4.65	0.28	96.97
(dry)		0	48.03	3.96	0	0	21.2	17.13	2.37	0	2.24	4.8	0.28	100.01
51B(wet)	Staphor et al 2010	0	34.23	1.95	0	0	24.15	21.61	4.88	0	2.22	5.44	0.09	95.57

(dry)		0	36.85	2.07	0	0	25.28	22.55	5.14	0	2.34	5.7	0.09	100.02
10B(wet)	Staphor et al 2010	7.48	50.28	0.83	0	0	13.6	17.03	0	0	2.03	4.39	0.25	95.89
(dry)		7.77	52.45	0.89	0	0	14.2	17.75	0	0	2.11	4.58	0.25	100
2-6(wet)	Staphor et al 2010	0	49.21	4.43	0	0	21.7	14.97	1.98	0	1.9	4.07	0.23	98.49
(dry)		0	49.98	4.49	0	0	22.06	15.06	2.1	0	1.92	4.15	0.23	99.99
168(wet)	Staphor et al 2010	1.26	35.44	2.48	0	0	29.6	22.64	0	0	2.15	4.48	0.23	98.28
(dry)		1.25	36.07	2.54	0	0	30.17	23.02	0	0	2.18	4.55	0.23	100.01
123(wet)	Staphor et al 2010	0	57.49	1.36	0	0	17.26	8.73	6.49	0	2.13	4.1	0.25	97.81
(dry)		0	58.8	1.36	0	0	17.64	8.93	6.65	0	2.17	4.2	0.25	100
122A(wet)	Staphor et al 2010	0	59.56	1.36	0	0	18.62	10.47	4.58	0	1.06	3.31	0.3	99.26
(dry)		0	59.99	1.36	0	0	18.73	10.66	4.55	0	1.06	3.33	0.3	99.98
120A(wet)	Staphor et al 2010	0	29.77	1.95	0	0	34.16	14.34	13.33	0	1.56	4.7	0.12	99.93
(dry)		0	29.8	1.95	0	0	34.18	14.34	13.35	0	1.58	4.7	0.12	100.02
120B(wet)	Staphor et al 2010	0	48.69	1.89	0	0	25.16	1.58	16.36	0	1.42	3.7	0.3	99.1
(dry)		0	49.12	1.89	0	0	25.39	1.67	16.47	0	1.44	3.73	0.3	100.01
120C(wet)	Staphor et al 2010	0	50.04	2.6	0	0	25.55	8.31	7.51	0	1.08	3.78	0.23	99.1
(dry)		0	50.51	2.6	0	0	25.76	8.42	7.58	0	1.08	3.81	0.23	99.99
48(wet)	Staphor et al 2010	3.27	48.36	1.6	0	0	28.93	8.56	0	0	3.78	2.09	0.12	96.71
(dry)		3.37	50.01	1.65	0	0	29.92	8.87	0	0	3.89	2.16	0.12	99.99
228B(wet)	Staphor et al 2010	4.67	41.16	2.3	0	0	22.34	14.94	0	0	3.78	6.18	0.28	95.65
(dry)		4.87	43.03	2.42	0	0	23.36	15.63	0	0	3.95	6.45	0.3	100.01
191(wet)	Staphor et al 2010	0	36.15	1	0	0	18.35	18.07	17.54	0	0.23	5.97	0.09	97.4

(dry)		0	37.1	1.06	0	0	18.85	18.48	18.07	0	0.23	6.12	0.09	100
126_{SE}(wet)	Staphor et al 2010	2.84	46.88	1.12	0	0	23.22	17.9	0	0	0.47	4.77	0.09	97.29
(dry)		2.9	48.19	1.18	0	0	23.9	18.36	0	0	0.49	4.92	0.09	100.03
126_{NW}(wet)	Staphor et al 2010	1.1	48.24	1.65	0	0	14.21	23.52	0	0	2.41	7.58	0.23	98.94
(dry)		1.15	48.73	1.65	0	0	14.36	23.78	0	0	2.45	7.67	0.23	100.02
19B(wet)	Staphor et al 2010	14.9	45.61	1.83	0	0	4.44	20.9	0	0	3.44	6.18	0.37	97.67
(dry)		15.24	46.69	1.89	0	0	4.61	21.34	0	0	3.53	6.32	0.37	99.99
225(wet)	Staphor et al 2010	0	55.22	1.71	0	0	11.81	2.73	16.89	0	2.37	7.63	0.28	98.64
(dry)		0	55.99	1.77	0	0	12.01	2.54	17.28	0	2.41	7.73	0.28	100.01
97(wet)	Staphor et al 2010	0	18.52	0.06	0	0	6.98	54.8	8.39	0	1.04	6.47	0.14	94.6
(dry)		0	19.58	0.06	0	0	7.39	57.93	8.84	0	1.1	4.94	0.14	99.98
273_{North}(wet)	Staphor et al 2010	0	15.94	0.06	0	1.34	0	53.48	15.27	0	1.2	5.84	0.21	93.34
(dry)		0	17.07	0.06	0	1.44	0	57.34	16.31	0	1.27	6.26	0.23	99.98
273_{South}(wet)	Staphor et al 2010	0	17.54	0.18	0	0	5.31	63.9	1.96	0	0.66	6.13	0.12	95.8
(dry)		0	18.31	0	0	0	5.59	66.65	2.06	0	0.7	6.39	0.12	100
274D(wet)	Staphor et al 2010	0	13.55	0.06	0	0.95	0	69.53	4.08	0	1.01	5.54	0.16	94.88
(dry)		0	14.3	0.06	0	1	0	73.3	4.26	0	1.06	5.84	0.16	99.98
274C(wet)	Staphor et al 2010	0	25.17	6.32	0	0	16.53	29.53	8.86	0	1.46	4.99	0.07	92.93
(dry)		0	27.05	6.8	0	0	17.79	31.89	9.47	0	1.58	5.36	0.07	100.01
Sample: Tugaloo-Blue Ridge	Paper	Quartz	Plag	Orth	Neph	Corun	Diop	Hyp	Oliv	Acmite	Ilmen	Mag	Apa	Total
52B1(wet)	Staphor et al 2010	0	28.36	0.59	0	0	2.3	28.06	24.9	0	1.65	6.25	0.19	92.3

(dry)		0	30.7	0.65	0	0	2.54	30.35	27.01	0	1.79	6.77	0.21	100.02
51A(wet)	Staphor et al 2010	0	12.4	0.06	0	1.5	0	70.22	3.21	0	1.14	6.12	0.14	94.79
(dry)		0	13.04	0.06	0	1.6	0	74.19	3.3	0	1.22	6.45	0.14	100
10A(wet)	Staphor et al 2010	0	11.57	0.18	0	3.1	0	65.09	7.06	0	1.08	6.05	0.16	94.29
(dry)		0	12.2	0.18	0	3.32	0	69.2	7.39	0	1.14	6.41	0.19	100.03
WGW-4(wet)	R.D.Warner &Others	0	22.08	0	0	0	5.89	16.53	44.38	0	0.84	5.73	0	95.45
(dry)		0	23.16	0	0	0	6.16	17.25	46.56	0	0.87	6	0	100
Day Book A-1(wet)	Hunter 1941	0	0	0	0	2.18	0	8.53	85.34	0	0	3.33	0	99.38
(dry)		0	0	0	0	2.19	0	8.59	85.87	0	0	3.35	0	100
Day Book A-2(wet)	Hunter 1941	0	0	0	0	1.07	0	21.98	71.9	0	0	381	0	98.76
(dry)		0	0	0	0	1.09	0	22.25	72.8	0	0	3.86	0	100
Newdale B-1(wet)	Hunter 1941	0	1.19	0	0	1.09	0	11.54	80.57	0	0	3.16	0	97.55
(dry)		0	1.24	0	0	1.12	0	11.81	82.6	0	0	3.25	0	100.02
Democrat A-1(wet)	Hunter 1941	0	0	0	0	1.49	0	15.42	75.37	0	0	3.91	0	96.19
(dry)		0	0	0	0	1.55	0	16	78.37	0	0	4.07	0	99.99
Number Nine A-1(wet)	Hunter 1941	0	0.4	0	0	1.23	0	3.82	88.87	0	0	4.78	0	99.1
(dry)		0	0.4	0	0	1.24	0	3.89	89.64	0	0	4.83	0	100
Number Nine B-1(wet)	Hunter 1941	0	1.09	0	0	0.94	0	2.28	89.81	0	0	4.87	0	98.99
(dry)		0	1.09	0	0	0.95	0	2.27	90.77	0	0	4.92	0	100
Sample: Tugaloo-Blue Ridge	Paper	Quartz	Plag	Orth	Neph	Corun	Diop	Hyp	Oliv	Acmite	Ilmen	Mag	Apa	Total
As-4	Conte 1986	18.51	42.92	3.19	0	0.69	0	20.57	0	0	6.1	5.63	2.41	100.02
As-12	Conte 1986	1.74	46.39	1.6	0	0	20.16	15.65	0	0	6.19	7.22	1.02	99.97

As-14	Conte 1986	12.48	42.74	1.24	0	0	19.37	10.9	0	0	6.5	5.9	0.88	100.01
As-17	Conte 1986	0	50.43	1.12	0	0	16.68	13.91	6.4	0	4.33	6.76	0.37	100
As-27	Conte 1986	7.8	39.85	4.85	0	0	19.07	14.37	0	0	6.04	7.02	1	100
As-36	Conte 1986	2.6	50.45	1.48	0	0	17.19	15.96	0	0	5.49	6.26	0.56	99.99
As-62	Conte 1986	10.73	37.56	1.6	0	0	22.71	13.98	0	0	5.41	7.35	0.67	100.01
As-66	Conte 1986	8.04	39.95	14.3	0	0	6.34	16.26	0	0	6.53	6.61	1.97	100
As-96	Conte 1986	3.74	44.64	1.54	0	0	16.87	19.37	0	0	5.72	7.35	0.79	100.02
AB-3	Conte 1986	0	46.24	5.79	0	0	16.62	8.14	8.35	0	5.96	7.95	0.95	100
AB-4	Conte 1986	8.33	41.48	6.09	0	0	11.64	18.25	0	0	5.89	7.38	0.95	100.01
Ab-5	Conte 1986	8.63	40.97	5.79	0	0	11.03	19.49	0	0	5.87	7.32	0.9	100
AB-8	Conte 1986	9	43.32	5.5	0	0	10.11	17.92	0	0	5.98	7.25	0.9	99.98
AB-17	Conte 1986	5.76	44.5	2.07	0	0	20.93	13.46	0	0	5.41	6.7	1.18	100.01
As-9	Conte 1986	0	45.95	1	0	0	20.4	22.17	1	0	1.44	7.87	0.16	99.9
As-20	Conte 1986	6.84	38.71	1.12	0	0	25.1	22.17	0	0	0.28	5.71	0.05	99.98
As-24	Conte 1986	6.17	39.2	1	0	0	24.32	21.71	0	0	0.85	6.6	0.14	99.99
As-29	Conte 1986	0	48.89	1.95	0	0	22	9.98	8.94	0	1.04	7.08	0.12	100
As-37	Conte 1986	5.25	39.59	0.77	0	0	25.74	20.18	0	0	1.73	6.54	0.19	99.99
As-52	Conte 1986	8.69	41.38	0.95	0	0	21.05	20.77	0	0	0.68	6.44	0.05	100.01
As-53	Conte 1986	6.88	38.81	0.71	0	0	26.31	21.02	0	0	0.32	5.9	0.05	100
As-58	Conte 1986	13.99	36.64	0.47	0	0	21.29	19.8	0	0	0.46	7.26	0.09	100
As-61	Conte 1986	4.67	36.95	0.59	0	0	36.5	15.43	0	0	0.4	5.41	0.05	100
As-63	Conte 1986	2.07	44.46	1.36	0	0	22.95	20.32	0	0	1.86	6.76	0.21	99.99
As-64	Conte 1986	3.5	43.42	0.77	0	0	25.44	17.37	0	0	1.99	7.22	0.28	99.99
As-69	Conte 1986	8.65	38.39	1.06	0	0	37.75	6.3	0	0	1.61	5.55	0.67	99.98
As-71	Conte 1986	0	38.48	1.83	0	0	32.1	12.76	7.48	0	0.76	6061	0	100.02
As-76	Conte 1986	0	46.22	0.77	0	0	23.12	5.91	13.01	0	2.53	8.02	0.42	100
As-92	Conte 1986	4.06	41.14	1.48	0	0	27.26	19.06	0	0	0.82	5.99	0.19	100
As-5	Conte 1986	0	61.44	0.89	0	0	15.96	11.24	4.31	0	1.96	3.71	0.49	100
As-6	Conte 1986	0	54.79	4.08	0	0	19.6	10.23	2.37	0	3.02	5.21	0.72	100.02
As-7	Conte 1986	0	60.98	1.18	0	0	13.86	10.97	3.77	0	3.48	4.9	0.86	100
As-8	Conte 1986	0	53.78	4.96	1.39	0	19.28	0	11.69	0	3.93	4.18	0.79	100
As-10	Conte 1986	0	23.35	0	0	0	0.34	29.88	38.98	0	1.08	6.05	0.32	100
As-15	Conte 1986	0	45.47	10.05	2.42	0	21.27	0	11.15	0	3	5.67	0.97	100

As-22	Conte 1986	0	50.62	0.53	0	0	9.45	30.46	1.4	0	1.46	5.89	0.19	100
As-31	Conte 1986	6.69	42.64	2.6	0	0	23.67	16.4	0	0	2.39	5.25	0.37	100.01
As-32	Conte 1986	1.62	47.74	0.89	0	0	20.86	19.47	0	0	3.55	5.51	0.35	99.99
As-39	Conte 1986	0	56.69	1	0	0	5.41	14.86	13.26	0	2.62	5.76	0.39	99.99
As-40	Conte 1986	0	47.95	2.36	0	0	21.6	17.33	0.5	0	3.44	6.19	0.63	100
As-43	Conte 1986	2.47	47.63	1.71	0	0	20.62	19.05	0	0	2.45	5.73	0.35	100.01
As-45	Conte 1986	0.12	54.55	2.66	0	0	17.3	17.13	0	0	2.64	5.22	0.37	99.99
As-47	Conte 1986	1.45	50.07	1.6	0	0	18.85	19.07	0	0	2.72	5.89	0.37	100.02
As-49	Conte 1986	0	59.2	1.54	0	0	15.06	8.83	7.73	0	2.51	4.76	0.39	100.02
As-56	Conte 1986	1.91	48.88	1.83	0	0	19.2	17.61	0	0	3.59	6.21	0.76	99.99
As-65	Conte 1986	0	44.63	2.48	0	0	26.87	11.91	5.43	0	2.3	5.96	0.42	100
As-67	Conte 1986	3.97	43.74	1.89	0	0	20.5	21.15	0	0	2.54	5.84	0.35	99.98
As-68	Conte 1986	0	50.19	2.84	0	0	22.77	10.01	5.71	0	2.87	5.36	0.25	100
As-73	Conte 1986	0	47.29	7.39	0	0	23.14	8.32	7.12	0	1.82	4.58	0.23	99.98
As-74	Conte 1986	2.74	60.15	5.26	0	0	7.42	17.38	0	0	2.2	4.32	0.53	100
As-77	Conte 1986	6.95	49.44	0.65	0	0	9.44	24.79	0	0	2.41	5.96	0.35	99.99
As-80	Conte 1986	0	53.97	1.3	0	0	15.85	12.87	7.73	0	2.39	5.29	0.58	99.98
As-81	Conte 1986	0	51.59	2.95	0	0	19.08	13.01	4.76	0	2.7	5.42	0.49	100
As-82	Conte 1986	2.78	49.3	1.71	0	0	19.8	17.69	0	0	2.75	5.34	0.63	100
As-85	Conte 1986	0.18	48.37	1.3	0	0	23.72	17.85	0	0	2.66	5.44	0.46	99.98
As-86	Conte 1986	1.31	48.01	0.95	0	0	26.12	15.82	0	0	2.41	4.96	0.42	100
As-87	Conte 1986	0	47.59	2.25	0	0	28.97	6.23	7.26	0	2.18	5.23	0.28	99.99
As-89	Conte 1986	4.29	43.97	1.48	0	0	24.07	20.39	0	0	1.42	4.2	0.16	99.98
As-90	Conte 1986	0	40.11	1.89	0	0	29.75	16.26	5.59	0	1.39	4.74	0.28	100.01
As-94	Conte 1986	0	24.04	0	0	0	7.41	39.9	21.47	0	1.04	5.93	0.21	100
As-95	Conte 1986	0	53.39	2.36	0	0	22.71	3.7	7.53	0	3.68	5.67	0.95	99.99
AB-1	Conte 1986	2.97	54.72	8.39	0	0	6.04	17.99	0	0	3.67	5.44	0.79	100.01
AB-2	Conte 1986	0.96	43.62	0.83	0	0	41.67	5.29	0	0	2.56	4.8	0.28	100.01
AB-7	Conte 1986	6.78	50.32	0.71	0	0	22.6	13.15	0	0	1.94	4.15	0.35	100
AB-9	Conte 1986	0.59	47.85	1.54	0	0	20.98	20.96	0	0	2.58	5	0.49	99.99
AB-10	Conte 1986	0.21	52.68	0.89	0	0	26.69	12.05	0	0	2.47	4.61	0.39	99.99
AB-11	Conte 1986	0	54.05	1.89	0	0	23.47	10.54	2.2	0	2.56	4.8	0.49	100
AB-12	Conte 1986	3.84	48.3	0.77	0	0	38.79	0.93	0	0	2.24	4.78	0.35	100

AB-13	Conte 1986	0	52.63	4.96	1.9	0	17.82	0	14.52	0	2.66	5.06	0.46	100.01
AB-14	Conte 1986	0	59.5	1.54	0.35	0	0	21.22	10.34	0	2.22	4.44	0.39	99.98
AB-15	Conte 1986	0	45.34	3.19	0.63	0	32.53	0	10.71	0	2.45	4.73	0.39	99.97
AB-16	Conte 1986	0	51.73	2.66	0	0	19.17	9.25	1043	0	1.94	4.38	0.44	100

Appendix 1.2a: Tugaloo Piedmont Normalized	Paper	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
Clemson	Warmet et. al.	45.2	0.3	7.1	2	10.7	0	28.3	6.1	0.3	0	0	0	100
normalized		45.1	0.3	7.08	4.16	8.73	0	28.24	6.09	0.3	0	0		100
Seneca	Warmet et. al.	44.2	0.3	5.7	3	11.7	0	30.8	4	0.2	0	0	0	99.9
normalized		44.16	0.3	5.7	4.8	10.07	0	30.78	4	0.2	0	0		100.01
Walhalla	Warmet et. al.	42.6	0.4	7	0	12.9	0	32.6	4.3	0.1	0	0	0	99.9
normalized		42.46	0.4	6.98	4.29	9	0	32.49	4.29	0.1	0	0		100.1
WGC-1	Warner et al 1986	42.34	0.30	6.98	13.11	0	0.26	27.42	5.7	0.2	0.01	0.01	0	96.33
normalized		44.38	0.31	7.32	4.12	8.65	0.27	28.74	5.97	0.21	0.01	0.01		99.99
WGC-1A	Warner et al 1986	42.47	0.29	7.68	13.35	0	0.24	26.92	5.94	0.36	0.01	0.01	0	97.27
normalized		44.09	0.3	7.97	4.16	8.73	0.25	6.17	0.37	0.37	0.01	0.01		100
WGC-2	Warner et al 1986	42.74	0.34	6.44	13.83	0	0.29	29.03	5.43	0.39	0.01	0.01	0	98.51
normalized		43.82	0.35	6.60	4.25	8.93	0.3	29.76	5.57	0.4	0.01	0.01		100

WGC-3	Warner et al 1986	42.5	0.31	6.39	13.63	0	0.29	27.98	5.93	0.2	0.01	0.01	0	97.25
normalized		44.14	0.32	6.64	4.25	8.92	0.3	29.06	6.16	0.21	0.01	0.01		100.02
WGC-4	Warner et al 1986	44.76	0.32	6.43	13.21	0	0	23.38	6.12	0.09	0.01	0	0	94.32
normalized		47.93	0.34	6.88	4.24	8.91	0	25.03	6.55	0.1	0.01	0		99.99
WGS-1	Warner et al 1986	42.59	0.31	6.54	14.9	0	0.3	29.59	4.42	0.29	0.03	0.01	0	98.98
normalized		43.49	0.32	6.68	4.56	9.58	0.31	30.21	4.51	0.3	0.03	0.01		100
WGS-4	Warner et al 1986	41.59	0.3	4.81	16.65	0	0	28.01	3.66	0.09	0.01	0	0	95.12
normalized		44.27	0.32	5.12	5.32	11.16	0	29.81	3.9	0.1	0.01	0		100.01
WGS-5	Warner et al 1986	41.68	0.24	5.11	15.48	0	0	29.35	4.34	0.09	0.01	0	0	96.3
normalized		43.77	0.25	5.37	4.88	10.24	0	30.83	4.56	0.09	0.01	0		100
64A	Mittwede 1987	53.48	0.01	1.68	4.22	2.66	0.07	25.51	0.9	0	0.26	0	0	88.79
normalized		60.37	0.01	1.9	2.43	5.1	0.08	28.8	1.02	0	0.29	0		100
64B	Mittwede 1987	50.48	0.14	3.85	6.77	4.26	0.09	23.98	2.34	0.06	0	0	0	91.97
normalized		55.09	0.15	4.2	3.77	7.91	0.1	26.17	2.55	0.07	0	0		100.01

161	Mittwede 1987	45.36	0.86	7.04	14.59	9.19	0.15	26.24	1.78	0.01	0	0.2	0	105.42
normalized		43.32	0.82	6.72	7.11	14.92	0.14	25.06	1.7	0.01	0	0.19		99.99
176A	Mittwede 1987	42.5	0.05	2.26	9.56	6.02	0.16	34.91	0.72	0	0	0	0	96.18
normalized		44.4	0.05	2.36	5.09	10.69	0.17	36.47	0.75	0	0	0		99.98
183	Mittwede 1987	57.97	0.05	2.21	6.28	0	0.08	27.18	0.26	0	0.15	0	0	94.18
normalized		61.84	0.05	2.36	2.01	4.22	0.09	29	0.28	0	0.16	0		100.01
82	Mittwede 1987	43.93	0.38	7.42	11.02	0	0.17	21.56	9.06	0.22	0	0	0	93.76
normalized		47.24	0.41	7.98	3.56	7.46	0.18	23.19	9.74	0.24	0	0		100
83	Mittwede 1987	41.87	0.2	8.03	13.3	0	0.18	24.76	6.74	0.36	0	0	0	95.44
normalized		44.29	0.21	8.5	4.22	8.87	0.19	26.2	7.13	0.38	0	0		99.99
85A	Mittwede 1987	46.27	0.2	12.25	9.46	0	0.12	20.84	9.82	0.64	0	0	0	99.6
normalized		46.77	0.2	12.38	2.87	6.02	0.12	21.06	9.93	0.65	0	0		100
123	Mittwede 1987	43.35	0.23	13.51	11.24	0	0.13	20.4	8.49	0.59	0.13	0	0	98.07
normalized		44.56	0.24	13.89	3.47	7.28	0.13	20.97	8.73	0.61	0.13	0		100.01
150	Mittwede	41.94	0.21	11.81	12.55	0	0.22	20.0	7.86	0.7	0	0	0	95.32

	1987							3						
normalized		44.41	0.22	12.51	3.99	8.37	0.23	21.21	8.32	0.74	0	0		100
117	Mittwede 1987	49.13	0.61	6.96	8.89	0	0.16	17.36	12.68	0.61	0.21	0	0	96.61
normalized		51.18	0.64	7.25	2.78	5.83	0.17	18.09	13.21	0.64	0.22	0		100.01
187	Mittwede 1987	47.07	0.41	7	8.12	0	0.14	18.54	12.53	0.83	0.23	0	0	94.87
normalized		49.91	0.43	7.42	2.58	5.42	0.15	19.66	13.29	0.88	0.24	0		99.98
194	Mittwede 1987	50.17	0.58	5.38	8.48	0	0.16	17.62	13.67	0.58	0.1	0	0	96.74
normalized		52.18	0.6	5.6	2.65	5.56	0.17	18.33	14.22	0.6	0.1	0		100.01
84	Mittwede 1987	48.34	0.36	12.65	6.99	0	0.13	13.49	15.85	0.55	0.49	0	0	98.85
normalized		49.15	0.37	12.86	2.13	4.48	0.13	13.71	16.11	0.56	0.5	0		100
85B	Mittwede 1987	44.66	0.27	15.33	6.74	0	0.11	12.85	13.67	0.76	0.2	0	0	94.59
normalized		47.45	0.29	16.29	2.15	4.51	0.12	13.65	14.52	0.81	0.21	0		100
86	Mittwede 1987	43.95	0.22	21	5.1	0	0.08	9.76	14.2	0.77	0.18	0	0	95.26
normalized		46.31	0.23	22.13	1.61	3.38	0.08	10.28	14.96	0.81	0.19	0		99.98
87A-1	Mittwede	48.71	0.58	17.7	7.88	0	0.14	10.2	13.9	1.04	0.3	0.06	0	100.6

	1987							6	8		4			9
normalized		48.64	0.58	17.68	2.36	4.96	0.14	10.25	13.96	1.04	0.34	0.06		100.01
87A-2	Mittwede 1987	47.67	0.49	19.69	6.91	0	0.11	9.94	14.26	0.69	0.18	0	0	99.94
normalized		47.93	0.49	19.8	2.08	4.38	0.11	9.99	14.34	0.69	0.18	0		99.99
103	Mittwede 1987	45.86	0.67	17.74	6.81	0	0.11	9.74	14.99	0.76	0.12	0	0	96.8
normalized		47.61	0.7	18.42	2.12	4.45	0.11	10.11	15.56	0.79	0.12	0		99.99
34	Mittwede 1987	49.98	1.88	17.55	11.9	0	0.2	5.61	11.54	2.37	0.22	0.14	0	101.39
normalized		50.05	1.18	17.58	3.58	7.51	0.2	5.62	11.56	2.37	0.22	0.14		100.01
WGW-4	R.D.Warner &Others	40.84	0.44	7.88	13.19	0	0	28.39	5.69	0.16	0	0	4.56	101.15
Wet(FeRatio=0.3)		40.84	0.44	7.88	3.96	8.31	0	28.39	5.69	0.16	0	0	4.56	100.23
(Wet)normalized		40.75	0.44	7.86	3.95	8.29	0	28.32	5.68	0.16	0	0	4.55	100
Dry(FeRatio=0.3)		40.84	0.44	7.88	3.96	8.31	0	28.39	5.69	0.16	0	0	0	95.67
(Dry)normalized		42.69	0.46	8.24	4.14	8.68	0	29.68	5.95	0.17	0	0		100.01
CW1	Sam Swanson, Unpublished	42.8	0.65	6.79	13.3	0	0.21	28.4	0.19	0.11	0.01	0.11	7.4	99.97

Wet(FeRatio=0.3)		42.8	0.65	6.79	3.99	8.38	0.21	28.4	0.19	0.11	0.01	0.11	7.4	99.04
(Wet)normalized		43.21	0.66	6.86	4.03	8.46	0.21	28.68	0.19	0.11	0.01	0.11	7.5	100.03
Dry(FeRatio=0.3)		42.8	0.65	6.79	3.99	8.38	0.21	28.4	0.19	0.11	0.01	0.11	0	91.64
(Dry)normalized		46.71	0.71	7.41	4.35	9.14	0.23	30.99	0.21	0.12	0.01	0.12		100
CW6	Sam Swanson, Unpublished	41.4	0.69	6.86	13.4	0	0.25	27.9	3.08	0.23	0.01	0.09	6	99.91
Wet(FeRatio=0.3)		41.4	0.69	6.86	4.02	8.44	0.25	27.9	3.08	0.23	0.01	0.09	6	98.97
(Wet)normalized		41.83	0.7	6.93	4.06	8.53	0.25	28.2	3.11	0.23	0.01	0.09	6.06	100
Dry(FeRatio=0.3)		41.4	0.69	6.86	4.02	8.44	0.25	27.9	3.08	0.23	0.01	0.09	0	92.97
(Dry)normalized		44.53	0.74	7.38	4.32	9.08	0.27	30.01	3.31	0.25	0.01	0.1		100
CW13	Sam Swanson, Unpublished	42.9	0.66	6.89	13.7	0	0.21	28.1	0.16	0.1	0.01	0.07	7.2	100
Wet(FeRatio=0.3)		42.9	0.66	6.89	4.11	8.63	0.21	28.1	0.16	0.1	0.01	0.07	7.2	99.04
(Wet)normalized		43.32	0.67	6.96	4.15	8.71	0.21	28.37	0.16	0.1	0.01	0.07	7.27	100
Dry(FeRatio=0.3)		42.9	0.66	6.89	4.11	8.63	0.21	28.1	0.16	0.1	0.01	0.07	0	91.84

(Dry)normalized		46.71	0.72	7.5	4.48	9.4	0.23	30.6	0.17	0.11	0.01	0.08		100.01
CW16	Sam Swanson, Unpublished	44.5	0.8	9.8	11.2	0	0.33	22.4	4.82	0.67	0.01	0.15	5.15	99.83
Wet(FeRatio=0.3)		44.5	0.8	9.8	3.36	7.05	0.33	22.4	4.82	0.67	0.01	0.15	5.15	99.04
(Wet)normalized		44.93	0.8	9.9	3.39	7.12	0.33	22.62	4.87	0.68	0.01	0.15	5.2	100
Dry(FeRatio=0.3)		44.5	0.8	9.8	3.36	7.05	0.33	22.4	4.82	0.67	0.01	0.15	0	93.89
(Dry)normalized		47.49	0.85	10.46	3.59	7.53	0.35	23.91	5.14	0.5	0.01	0.16		99.99
West1	Chaumba 2012	52.65	0.24	5.48	11.06	0	0.19	24.49	3.01	0.21	0.04	0.02	3.95	101.34
Wet(FeRatio=0.3)		52.65	0.24	5.48	3.32	6.97	0.19	24.49	3.01	0.21	0.04	0.02	3.95	100.57
(Wet)normalized		52.35	0.24	5.45	3.3	6.93	0.19	24.35	2.99	0.21	0.04	0.02	3.93	100
Dry(FeRatio=0.3)		52.65	0.24	5.48	3.32	6.97	0.19	24.49	3.01	0.21	0.04	0.02	0	96.62
(Dry)normalized		54.5	0.25	5.67	3.43	7.21	0.2	25.35	3.12	0.22	0.04	0.02		100.01
West2	Chaumba 2012	53.1	0.21	4.54	10.93	0	0.19	25.12	3.21	0.24	0.05	0.02	3.29	100.9
Wet(FeRatio=0.3)		53.1	0.21	4.54	3.28	6.88	0.19	25.12	3.21	0.24	0.05	0.02	3.29	100.13
(Wet)normalized		53.03	0.21	4.53	3.28	6.87	0.19	25.0	3.21	0.24	0.0	0.02	3.2	100.0

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Dry(FeRatio=0.3)		53.1	0.21	4.54	3.28	6.88	0.19	25.12	3.21	0.24	0.05	0.02	0	96.84
(Dry)normalized		54.83	0.22	4.69	3.39	7.11	0.2	25.94	3.31	0.25	0.05	0.02		100.01
Moore1	Chaumba 2012	53.58	0.35	3.76	10.69	0	0.19	25.51	3.35	0.1	0.06	0.1	3.19	100.88
Wet(FeRatio=0.3)		53.58	0.35	3.76	3.21	6.73	0.19	25.51	3.35	0.1	0.06	0.1	3.19	100.13
(Wet)normalized		53.51	0.35	3.76	3.21	6.72	0.19	25.48	3.35	0.1	0.06	0.1	3.19	100.02
Dry(FeRatio=0.3)		53.58	0.35	3.76	3.21	6.73	0.19	25.51	3.35	0.1	0.06	0.1	0	96.94
(Dry)normalized		55.13	0.36	3.87	3.38	7.1	0.2	26.25	3.45	0.1	0.06	0.1		100
Moore3	Chaumba 2012	52.35	0.77	5.28	11.48	0	0.21	19.73	8.39	0.58	0.1	0.11	1.61	100.61
Wet(FeRatio=0.3)		52.35	0.77	5.28	3.44	7.23	0.21	19.73	8.39	0.58	0.1	0.11	1.61	99.8
(Wet)normalized		52.45	0.77	5.29	3.45	7.24	0.21	19.77	8.4	0.58	0.1	0.11	1.61	99.98
Dry(FeRatio=0.3)		52.35	0.77	5.28	3.44	7.23	0.21	19.73	8.39	0.58	0.1	0.11	0	98.19
(Dry)normalized		53.31	0.78	5.38	3.51	7.36	0.21	20.09	8.54	0.59	0.1	0.11		99.98
BPL1	Chaumba 2012	43.7	0.53	7.33	11.83	0	0.18	27.78	3.43	0.18	0.06	0.04	6.3	101.36
Wet(FeRatio=0.3		43.7	0.53	7.33	3.55	7.45	0.18	27.7	3.43	0.18	0.0	0.04	6.3	100.5

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(Wet)normalized		43.47	0.53	7.29	3.53	7.41	0.18	27.63	3.41	0.18	0.06	0.04	6.27	100
Dry(FeRatio=0.3)		43.7	0.53	7.33	3.55	7.45	0.18	27.78	3.43	0.18	0.06	0.04	0	94.23
(Dry)normalized		46.38	0.56	7.78	3.77	7.91	0.19	29.48	3.64	0.19	0.06	0.04		100
BPL2	Chaumba 2012	43.86	0.59	7.96	11.43	0	0.19	26.76	4.23	0.04	0.04	0.06	6.11	101.27
Wet(FeRatio=0.3)		43.86	0.59	7.96	3.43	7.2	0.19	26.76	4.23	0.04	0.04	0.06	6.11	100.47
(Wet)normalized		43.65	0.59	7.92	3.41	7.17	0.19	26.63	4.21	0.04	0.04	0.06	6.08	99.99
Dry(FeRatio=0.3)		43.86	0.59	7.96	3.43	7.2	0.19	26.76	4.23	0.04	0.04	0.06	0	94.36
(Dry)normalized		46.48	0.63	8.44	3.63	7.63	0.2	28.36	4.48	0.04	0.04	0.06		99.99
WCT	Chaumba 2012	48.49	0.33	6.46	12.43	0	0.25	21.63	7.64	0.66	0.07	0.01	1.69	99.66
Wet(FeRatio=0.3)		48.49	0.33	6.46	3.73	7.83	0.25	21.63	7.64	0.66	0.07	0.01	1.69	98.79
(Wet)normalized		49.08	0.33	6.54	3.78	7.93	0.25	21.89	7.73	0.67	0.07	0.01	1.71	99.99
Dry(FeRatio=0.3)		48.49	0.33	6.46	3.73	7.83	0.25	21.63	7.64	0.66	0.07	0.01	0	97.1
(Dry)normalized		50.25	0.34	6.69	3.86	8.11	0.26	22.41	7.92	0.06	0.07	0.01		99.98
WCAT2	Chaumba	51.5	0.32	5.23	12.44	0	0.23	22.8	6.27	0.6	0.1	0.02	0.5	100.1

	2012							9			1		4	5
Wet(FeRatio=0.3)		51.5	0.32	5.23	3.73	7.84	0.23	22.89	6.27	0.6	0.11	0.02	0.54	99.28
(Wet)normalized		51.87	0.32	5.27	3.76	7.9	0.23	23.06	6.32	0.6	0.11	0.02	0.54	100
Dry(FeRatio=0.3)		51.5	0.32	5.23	3.73	7.84	0.23	22.89	6.27	0.6	0.11	0.02	0	98.74
(Dry)normalized		52.16	0.32	5.3	3.78	7.94	0.23	23.18	6.35	0.61	0.11	0.02		100
R.31	Higgins et al 1988	42	0.14	11.7	4.54	4.13	0.14	25.4	5.62	0.48	0.06	0.02	0	94.23
normalized		44.66	0.15	12.44	2.91	6.11	0.15	27.01	5.98	0.51	0.06	0.02		100
R.16	Higgins et al 1988	42.5	0.65	5.8	10.57	9.63	0.27	25.7	0.24	0.59	0.03	0.12	0	96.1
normalized		44.42	0.68	6.06	6.67	14	0.28	26.86	0.25	0.62	0.03	0.13		100
R.13	Higgins et al 1988	42.8	0.94	6.8	8.74	7.96	0.2	25.3	0.31	0.19	0.06	0.13	0	93.43
normalized		45.98	1.01	7.31	5.67	11.9	0.21	27.18	0.33	0.2	0.06	0.14		99.99
R.15	Higgins et al 1988	43.1	0.61	6.68	6.73	6.13	0.19	26.6	1.34	0.01	0.04	0.14	0	91.57
normalized		47.21	0.67	7.32	4.45	9.34	0.21	29.13	1.47	0.01	0.04	0.15		100
S.2	Higgins et al 1988	43.5	0.27	11.6	3.84	5.16	0.14	23.2	6.1	0.61	0.15	0.1	5.03	99.7
Wet(FeRatio=0.3		43.5	0.27	11.6	2.87	6.03	0.14	23.2	6.1	0.61	0.1	0.1	5.0	99.6

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(Wet)normalized		43.67	0.27	11.64	2.88	6.05	0.14	23.29	6.12	0.61	0.15	0.1	5.05	99.97
Dry(FeRatio=0.3)		43.5	0.27	11.6	2.87	6.03	0.14	23.2	6.1	0.61	0.15	0.1	0	94.57
(Dry)normalized		46	0.29	12.27	3.04	6.38	0.15	24.53	6.45	0.65	0.16	0.11		100.03
R.6	Higgins et al 1988	44.4	0.55	6.8	7.69	7.01	0.26	26.7	0.45	0.65	0.04	0.05	0	94.6
normalized		47.09	0.58	7.21	4.93	10.34	0.28	28.32	0.48	0.69	0.04	0.05		100.01
R.1	Higgins et al 1988	44.5	0.55	6.15	6.91	6.29	0.22	26.7	1.75	0.16	0.18	0.08	0	93.49
normalized		47.74	0.59	6.6	4.47	9.39	0.24	28.64	1.88	0.17	0.19	0.09		100
R.23	Higgins et al 1988	44.8	0.36	7.36	7.06	6.43	0.18	27.5	0.08	0.25	0.05	0.01	0	94.08
normalized		47.76	0.38	7.85	4.54	9.54	0.19	29.32	0.09	0.27	0.05	0.01		100
AR.35	Higgins et al 1988	44.8	0.31	7.43	7.12	6.48	0.21	24.9	3.97	0.09	0.01	0.12	0	95.44
normalized		47.08	0.33	7.81	4.52	9.48	0.22	26.17	4.17	0.09	0.01	0.13		100.01
R.3	Higgins et al 1988	44.8	0.54	7.11	6.02	5.49	0.2	23.3	7.11	0.45	0.06	0.06	0	95.14
normalized		47.12	0.57	7.49	3.83	8.05	0.21	24.55	7.49	0.47	0.06	0.06		99.99
R.29	Higgins et al	44.8	0.27	8.36	6.33	5.77	0.27	22.7	6.32	0.5	0.1	0.04	0	95.47

	1988										1			
normalized		47.05	0.28	8.78	4.01	8.43	0.28	23.84	6.64	0.53	0.12	0.04		100
R.8	Higgins et al 1988	45	0.43	5.08	9.16	8.35	0.25	25.7	0.11	0.46	0.04	0.11	0	94.69
normalized		47.71	0.46	5.39	5.86	12.31	0.27	27.25	0.12	0.49	0.04	0.12		100.02
AR.33	Higgins et al 1988	45.4	0.99	5.76	8.69	7.91	0.22	26	0.44	0.03	0.01	0.01	0	95.46
normalized		47.73	1.04	6.06	5.51	11.58	0.23	27.34	0.46	0.03	0.01	0.01		100
R.17	Higgins et al 1988	46	0.72	8.68	5.81	5.3	0.23	24.4	4.08	1.27	0.08	0.16	0	96.73
normalized		47.46	0.75	8.99	3.64	7.64	0.24	25.29	4.23	1.32	0.08	0.17		100.02
R.7	Higgins et al 1988	46.3	0.35	6.29	6.98	6.36	0.2	27.1	0.43	0.21	0.04	0.05	0	94.31
normalized		49.24	0.37	6.69	4.48	9.41	0.21	28.82	0.46	0.22	0.04	0.05		99.99
R.19	Higgins et al 1988	46.5	0.65	6.69	7.9	7.2	0.2	25.2	1.86	0.44	0.04	0.04	0	96.72
normalized		48.23	0.67	9.64	4.95	10.39	0.21	26.14	1.93	0.46	0.04	0.04		100
R.18	Higgins et al 1988	46.8	0.73	8.34	6.54	5.96	0.29	24.5	1.93	0.96	0.05	0.08	0	96.18
normalized		48.79	0.76	8.69	4.12	8.64	0.3	25.54	2.01	1	0.05	0.08		99.98
R.12	Higgins et al	47	0.29	6.27	6.49	5.91	0.26	26.2	2.6	0.34	0.0	0.01	0	95.42

	1988										5			
normalized		49.39	0.3	6.59	4.12	8.64	0.27	27.53	2.73	0.36	0.05	0.01		99.99
R.4	Higgins et al 1988	47	0.28	7.07	5.14	4.68	0.25	22.5	8.24	0.45	0.08	0.06	0	95.75
normalized		49.19	0.29	7.4	3.25	6.82	0.26	23.55	8.62	0.47	0.08	0.06		99.99
R.9	Higgins et al 1988	47.2	0.33	5.89	6.7	6.1	0.18	26.7	0.75	0.63	0.03	0.13	0	94.64
normalized		50.01	0.35	6.24	4.28	9	0.19	28.29	0.79	0.67	0.03	0.14		99.99
R.14	Higgins et al 1988	47.3	0.61	6	7.64	6.96	0.29	25.6	0.84	0.1	0.04	0.35	0	95.73
normalized		49.57	0.64	6.29	4.83	10.15	0.3	26.83	0.88	0.1	0.04	0.37		100
S.547	Higgins et al 1988	48.8	0.37	7.3	6.2	5.1	0.21	21.9	6.8	0.67	0.2	0.05	2.32	99.92
Wet(FeRatio=0.3)		48.8	0.37	7.3	3.56	7.48	0.21	21.9	6.8	0.67	0.2	0.05	2.32	99.66
(Wet)normalized		48.97	0.37	7.32	3.57	7.5	0.21	21.97	6.82	0.67	0.2	0.05	2.33	99.98
Dry(FeRatio=0.3)		48.8	0.37	7.3	3.56	7.48	0.21	21.9	6.8	0.67	0.2	0.05	0	97.34
(Dry)normalized		50.14	0.38	7.5	3.66	7.68	0.22	22.5	6.99	0.69	0.21	0.05		100.02
AR.32	Higgins et al 1988	48.9	0.38	3.52	6.59	6.01	0.2	25.5	3.91	0.01	0.01	0.17	0	95.2
normalized		51.51	0.4	3.71	4.19	8.8	0.21	26.86	4.12	0.01	0.01	0.18		100

R.11	Higgins et al 1988	49.3	0.63	4.95	7.12	6.48	0.17	26.6	0.15	0.07	0.04	0.01	0	95.52
normalized		51.77	0.66	5.2	4.51	9.47	0.18	27.93	0.16	0.07	0.04	0.01		100
S.20	Higgins et al 1988	49.7	0.86	7.7	4.7	4.6	0.16	15.4	12.3	0.7	0.25	0.12	2.4	98.89
Wet(FeRatio=0.3)		49.7	0.86	7.7	2.94	6.18	0.16	15.4	12.3	0.7	0.25	0.12	2.4	98.71
(Wet)normalized		50.35	0.87	7.8	2.99	6.26	0.16	15.6	12.46	0.71	0.25	0.12	2.43	100
Dry(FeRatio=0.3)		49.7	0.86	7.7	2.94	6.18	0.16	15.4	12.3	0.7	0.25	0.12	0	96.31
(Dry)normalized		51.6	0.89	7.99	3.06	6.42	0.17	15.99	12.77	0.73	0.26	0.12		100
AR.37	Higgins et al 1988	49.8	0.01	6.17	4.66	4.24	0.14	27.5	0.2	0.21	0.01	0.01	0	92.95
normalized		53.68	0.01	6.65	3.03	6.36	0.15	29.64	0.22	0.23	0.01	0.01		99.99
R.21	Higgins et al 1988	50	0.62	6.48	5.86	5.34	0.18	23.5	3.72	0.89	0.08	0.08	0	96.75
normalized		51.8	0.64	6.71	3.67	7.7	0.19	24.35	3.85	0.92	0.08	0.08		99.99
R.28	Higgins et al 1988	50	0.12	7.94	4.58	4.17	0.16	23.3	5.65	0.62	0.07	0.04	0	96.65
normalized		51.83	0.12	8.23	2.87	6.02	0.17	24.15	5.86	0.64	0.07	0.04		100
S.10	Higgins et al 1988	50.4	0.21	5.2	7.2	4.2	0.17	27.4	1.2	0	0	0.06	3.67	99.71

Wet(FeRatio=0.3)		50.4	0.21	5.2	3.56	7.48	0.17	27.4	1.2	0	0	0.06	3.67	99.35
(Wet)normalized		50.73	0.21	5.23	3.58	7.53	0.17	27.58	1.21	0	0	0.06	3.69	99.99
Dry(FeRatio=0.3)		50.4	0.21	5.2	3.56	7.48	0.17	27.4	1.2	0	0	0.06	0	95.68
(Dry)normalized		52.68	0.22	5.44	3.72	7.81	0.18	28.64	1.25	0	0	0.06		100
SS.RA	Higgins et al 1988	50.6	0.68	9	3.1	5.2	0.18	15.2	13	0.88	0.23	0.13	0.9	99.1
Wet(FeRatio=0.3)		50.6	0.68	9	2.66	5.59	0.18	15.2	13	0.88	0.23	0.13	0.9	99.05
(Wet)normalized		51.09	0.69	9.09	2.69	5.64	0.18	15.35	13.13	0.89	0.23	0.13	0.91	100.02
Dry(FeRatio=0.3)		50.6	0.68	9	2.66	5.59	0.18	15.2	13	0.88	0.23	0.13	0	98.15
(Dry)normalized		51.55	0.69	9.17	2.71	5.7	0.18	15.49	13.24	0.9	0.23	0.13		99.99
S.13	Higgins et al 1988	51.1	0.76	5.3	3.4	5.8	0.2	17.1	14.1	0.61	0.05	0.17	0.78	99.37
Wet(FeRatio=0.3)		51.1	0.76	5.3	2.95	6.2	0.2	17.1	14.1	0.61	0.05	0.17	0.78	99.32
(Wet)normalized		51.45	0.77	5.34	2.97	6.24	0.2	17.22	14.2	0.61	0.05	0.17	0.79	100.01
Dry(FeRatio=0.3)		51.1	0.76	5.3	2.95	6.2	0.2	17.1	14.1	0.61	0.05	0.17	0	98.54
(Dry)normalized		51.85	0.77	5.38	3	6.29	0.2	17.35	14.31	0.62	0.05	0.17		99.99
AR.34	Higgins et al	51.5	0.28	5.76	5.6	5.1	0.18	23.5	3.72	0.15	0.0	0.01	0	95.81

	1988										1			
normalized		53.88	0.29	6.03	3.54	7.42	0.19	24.58	3.89	0.16	0.01	0.01		100
R.20	Higgins et al 1988	51.7	0.3	5.35	7.22	6.58	0.31	24.7	1.12	0.55	0.04	0.06	0	97.93
normalized		52.95	0.31	5.48	4.47	9.37	0.32	25.3	1.15	0.56	0.04	0.06		100.01
R.22	Higgins et al 1988	51.8	0.33	5.11	6.97	6.34	0.32	24.4	1.1	0.41	0.06	0.02	0	96.86
normalized		53.63	0.34	5.29	4.35	9.14	0.33	25.26	1.14	0.42	0.06	0.02		99.98
AR.38	Higgins et al 1988	52.7	0.01	4.1	4.33	3.94	0.15	28.5	0.44	0.3	0.01	0.01	0	94.49
normalized		55.87	0.01	4.35	2.77	5.82	0.16	30.22	0.47	0.32	0.01	0.01		100.01
R.25	Higgins et al 1988	53	0.37	5.31	5.7	5.19	0.22	24	2.53	1.12	0.06	0.05	0	97.55
normalized		54.56	0.38	5.46	3.53	7.42	0.23	24.66	2.6	1.15	0.06	0.05		100
AR.36	Higgins et al 1988	53.4	0.38	4.81	5.07	4.61	0.18	25.2	1.72	0.44	0.01	0.01	0	95.83
normalized		55.84	0.4	5.03	3.2	6.71	0.19	26.35	1.8	0.46	0.01	0.01		100
R.24	Higgins et al 1988	54.1	0.26	4.91	5.81	5.3	0.22	23.5	2.07	0.6	0.06	0.02	0	96.85
normalized		55.99	0.27	5.08	3.63	7.63	0.23	24.32	2.14	0.62	0.06	0.02		99.99
R.27	Higgins et al	54.5	0.03	3.71	5.49	5	0.28	25.6	0.2	0.21	0.0	0.02	0	95.08

	1988										4			
normalized		57.45	0.03	3.91	3.49	7.33	0.3	26.9 9	0.21	0.22	0.0 4	0.02		99.99

Appendix 1.2b: Tugaloo Piedmont Norms	Paper	Quartz	Plag	Orth	Neph	Corun	Diop	Hyp	Oliv	Ilmen	Mag	Apa	Total
Clemson	Warmet et. al.	0	20.51	0	0	0	9.69	27.09	36.11	0.57	6.03	0	100
Seneca	Warmet et. al.	0	16.35	0	0	0	4.11	30.7	41.32	0.57	6.96	0	100.01
Walhalla	Warmet et. al.	0	19.44	0	0	0	2.12	20.54	50.93	0.76	6.22	0	100.01
WGC-1	Warner et al 1986	0	20.78	0.06	0	0	8.35	25.06	39.16	0.59	5.97	0.02	99.99
WGC-1A	Warner et al 1986	0	23.19	0.06	0	0	8.31	21.34	40.49	0.57	6.03	0.02	100.01
WGC-2	Warner et al 1986	0	19.57	0.06	0	0	9.01	19.62	44.89	0.66	6.16	0.02	99.99
WGC-3	Warner et al 1986	0	18.92	0.06	0	0	10.57	22.72	40.96	0.61	6.16	0.02	100.02
WGC-4	Warner et al 1986	0	19.14	0.06	0	0	11.26	46.44	16.29	0.65	6.15	0	99.99
WGS-1	Warner et al 1986	0	19.33	0.18	0	0	4.37	23.99	44.89	0.61	6.61	0.02	100
WGS-4	Warner et al 1986	0	14.34	0.06	0	0	4.65	35.42	37.22	0.61	7.71	0	100.01
WGS-5	Warner et al 1986	0	14.98	0.06	0	0	6.66	28.11	42.64	0.47	7.08	0	100
64A	Mittwede 1987	10.89	4.33	1.71	0	0	0.58	78.95	0	0.02	3.52	0	100
64B	Mittwede 1987	5.36	11.74	0	0	0	1.19	75.97	0	0.28	5.47	0	100.01
161	Mittwede 1987	0	7.28	0	0	4.07	0	59.74	16.6	1.56	10.31	0.44	100
176A	Mittwede 1987	0	3.72	0	0	1	0	47.71	46.08	0.09	7.38	0	99.98
183	Mittwede 1987	14.58	1.39	0.95	0	1.68	0	78.41	0	0.09	2.91	0	100.01
82	Mittwede 1987	0	22.73	0	0	0	21.88	28.78	20.67	0.78	5.16	0	100

83	Mittwede 1987	0	24.7	0	0	0	11.01	20.36	37.4	0.4	6.12	0	99.99
85A	Mittwede 1987	0	36.36	0	0	0	14.55	20.91	23.64	0.38	4.16	0	100
123	Mittwede 1987	0	39.94	0.77	0	0	6.77	16.5	30.55	0.46	5.03	0	100.02
150	Mittwede 1987	0	37.07	0	0	0	8.32	16.91	31.5	0.42	5.79	0	100.01
117	Mittwede 1987	0	21.68	1.3	0	0	39	29.08	3.72	1.22	4.03	0	100.03
187	Mittwede 1987	0	23.03	1.42	0	0	39.78	15.5	15.69	0.82	3.74	0	99.98
194	Mittwede 1987	0	17.37	0.59	0	0	46.06	30.38	0.62	1.14	3.84	0	100
84	Mittwede 1987	0	35.84	2.95	0	0	38.66	10.83	7.93	0.7	3.09	0	100
85B	Mittwede 1987	0	47.05	1.24	0	0	25.23	9.24	13.58	0.55	3.12	0	100.01
86	Mittwede 1987	0	63.04	1.12	0	0	14.28	7.08	11.68	0.44	2.33	0	99.97
87A-1	Mittwede 1987	0	51.37	2.01	0	0	20.95	18.51	2.51	1.1	3.42	0.14	100.01
87A-2	Mittwede 1987	0	56.24	1.06	0	0	16.5	20.95	1.29	0.93	3.02	0	99.99
103	Mittwede 1987	0	53.04	0.71	0	0	24.5	13.13	4.21	1.33	3.07	0	99.99
34	Mittwede 1987	2.72	56.73	1.3	0	0	16.13	15.38	0	2.24	5.19	0.32	100.01
WGW-4(wet)	R.D.Warner &Others	0	22.08	0	0	0	5.89	16.53	44.38	0.84	5.73	0	95.45
(dry)		0	23.16	0	0	0	6.16	17.25	46.56	0.87	6	0	100
CW1(wet)	Sam Swanson, Unpublished	0	1.15	0.06	0	6.59	0	63.72	13.66	1.25	5.84	0.25	92.52
(dry)		0	1.27	0.06	0	7.11	0	68.88	14.75	1.35	6.31	0.28	100.01
CW6(wet)	Sam Swanson, Unpublished	0	16.79	0.06	0	1.1	0	35.9	32.67	1.33	5.89	0.21	93.95
(dry)		0	17.88	0.06	0	1.18	0	38.18	34.8	1.41	6.26	0.23	100
CW13(wet)	Sam Swanson, Unpublished	0	1.18	0.06	0	6.66	0	64.74	12.63	1.27	6.02	0.16	92.72
(dry)		0	1.25	0.06	0	7.19	0	69.8	13.66	1.37	6.5	0.19	100.02
CW16(wet)	Sam Swanson, Unpublished	0	28.93	0.06	0	0.28	0	41.14	17.61	1.52	4.92	0.35	94.81

(dry)		0	28.69	0.06	0	0.66	0	47.97	15.43	1.61	5.21	0.37	100
West1(wet)	Chaumba 2012	3.98	15.59	0.24	0	0	0.71	70.27	0	0.46	4.78	0.05	96.08
(dry)		4.14	16.23	0.24	0	0	0.78	73.14	0	0.47	4.97	0.05	100.02
West2(wet)	Chaumba 2012	3.71	13.17	0.3	0	0	3.68	70.67	0	0.4	4.76	0.05	96.74
(dry)		3.83	13.64	0.3	0	0	3.77	73.1	0	0.42	4.92	0.05	100.03
Moore1(wet)	Chaumba 2012	4.88	10.48	0.35	0	0	5	70.57	0	0.66	4.65	0.23	96.82
(dry)		4.92	10.78	0.35	0	0	5.16	72.92	0	0.68	4.9	0.23	99.99
Moore3(wet)	Chaumba 2012	3.53	16.44	0.59	0	0	23.33	47.76	0	1.46	5	0.25	98.36
(dry)		3.59	16.73	0.59	0	0	23.72	48.53	0	1.48	5.09	0.25	99.98
BPL1(wet)	Chaumba 2012	0	18.18	0.35	0	0.82	0	41.69	26.47	1.01	5.12	0.09	93.73
(dry)		0	19.4	0.35	0	0.88	0	44.53	28.21	1.06	5.47	0.09	99.99
BPL2(wet)	Chaumba 2012	0	20.83	0.24	0	0.3	0	42.56	23.78	1.12	4.94	0.14	93.91
(dry)		0	21.92	0.24	0	0.31	0	43.99	26.44	1.18	5.79	0.14	100.01
WCT(wet)	Chaumba 2012	0	20.3	0.41	0	0	18.78	41.93	10.73	0.63	5.48	0.02	98.28
(dry)		0	18.29	0.41	0	0	17.03	54.56	3.43	0.65	5.6	0.02	99.99
WCAT2(wet)	Chaumba 2012	0	16.44	0.65	0	0	15.75	58.63	1.89	0.61	5.45	0.05	99.47
(dry)		0	16.56	0.65	0	0	15.84	58.9	1.92	0.61	5.48	0.05	100.01
R.31	Higgins et al 1988	0	33.85	0.35	0	0.71	0	22.54	37.99	0.28	4.22	0.05	99.99
R.16	Higgins et al 1988	0	5.64	0.18	0	4.86	0	56.69	21.37	1.29	9.67	0.3	100
R.13	Higgins et al 1988	0	2.41	0.35	0	6.65	0	71.4	8.7	1.92	8.22	0.32	99.97
R.15	Higgins et al 1988	0	6.4	0.24	0	4.95	0	68.11	12.24	1.27	6.45	0.35	100.01
S.2(wet)	Higgins et al 1988	0	33.74	0.89	0	0	0.89	25.97	28.52	0.51	4.18	0.23	94.93
(dry)		0	35.59	0.95	0	0	0.94	27.2	30.14	0.55	4.41	0.25	100.03

R.6	Higgins et al 1988	0	7.89	0.24	0	5.28	0	61.41	16.83	1.1	7.15	0.12	100.02
R.1	Higgins et al 1988	0	10.18	1.12	0	2.91	0	62.23	15.75	1.12	6.48	0.21	100
R.23	Higgins et al 1988	0	2.67	0.3	0	7.21	0	72.57	9.94	0.72	6.58	0.02	100.01
AR.35	Higgins et al 1988	0	20.6	0.06	0	0.38	0	53.53	17.96	0.63	6.55	0.3	100.01
R.3	Higgins et al 1988	0	22.13	0.35	0	0	14.75	33.15	22.84	1.08	5.55	0.14	99.99
R.29	Higgins et al 1988	0	25.71	0.71	0	0	9.09	35.1	22.95	0.53	5.81	0.09	99.99
R.8	Higgins et al 1988	0	4.15	0.24	0	4.54	0	71.71	9.78	0.87	8.5	0.28	100.07
AR.33	Higgins et al 1988	0	2.74	0.06	0	5.19	0	79.25	3.05	1.98	7.99	0.02	100.01
R.17	Higgins et al 1988	0	29.54	0.47	0	0	1.19	34.86	28.86	1.42	5.28	0.39	100.01
R.7	Higgins et al 1988	0	3.82	0.24	0	5.57	0	77.9	5.15	0.7	6.5	0.12	100
R.19	Higgins et al 1988	0	13.21	0.24	0	2.73	0	65.1	10.19	1.27	7.18	0.09	100.01
R.18	Higgins et al 1988	0	17.91	0.3	0	3.53	0	58.96	11.69	1.44	5.97	0.19	99.99
R.12	Higgins et al 1988	0	16.52	0.3	0	1	0	62.18	13.42	0.57	5.97	0.02	99.98
R.4	Higgins et al 1988	0	21.82	0.47	0	0	19.41	37.03	15.86	0.55	4.71	0.14	99.99

R.9	Higgins et al 1988	0	8.67	0.18	0	4	0	71.83	8.12	0.66	6.21	0.32	99.99
R.14	Higgins et al 1988	1.55	2.97	0.24	0	5.37	0	80.98	0	1.22	7	0.86	100.01
S.547(wet)	Higgins et al 1988	0	22.04	1.18	0	0	13.59	44.83	10.02	0.7	5.18	0.12	97.66
(dry)		0	22.59	1.24	0	0	13.96	45.69	10.4	0.72	5.31	0.12	100.03
AR.32	Higgins et al 1988	0	10.13	0.06	0	0	7.3	73.73	1.53	0.76	6.08	0.42	100.01
R.11	Higgins et al 1988	3.38	1.32	0.24	0	4.77	0	82.48	0	1.25	6.54	0.02	100
S.20(wet)	Higgins et al 1988	1.49	23.37	1.48	0	0	34.66	30.32	0	1.65	4.34	0.28	97.59
(dry)		1.48	23.93	1.54	0	0	35.56	31.08	0	1.69	4.44	0.28	100
AR.37	Higgins et al 1988	3.38	2.97	0.06	0	5.88	0	83.26	0	0.02	4.39	0.02	99.98
R.21	Higgins et al 1988	0	21.73	0.47	0	0	3.67	62.68	4.73	1.22	5.32	0.19	100.01
R.28	Higgins et al 1988	0	24.79	0.41	0	0	7.45	56.56	6.31	0.23	4.16	0.09	100
S.10(wet)	Higgins et al 1988	2.25	5.61	0	0	3.17	0	79.53	0	0.4	5.19	0.14	96.29
(dry)		2.36	5.81	0	0	3.31	0	82.58	0	0.42	5.39	0.14	100.01
SS.RA(wet)	Higgins et al 1988	0.58	27.66	1.36	0	0	35.01	28.99	0	1.31	3.9	0.3	99.11
(dry)		0.58	27.92	1.36	0	0	35.31	29.29	0	1.31	3.93	0.3	100
S.13(wet)	Higgins et al 1988	0.85	16.85	0.3	0	0	45.7	29.37	0	1.46	4.31	0.39	99.23

(dry)		0.84	17	0.3	0	0	46.08	29.58	0	1.46	4.35	0.39	100
AR.34	Higgins et al 1988	3.91	17.06	0.06	0	0	2.79	70.48	0	0.55	5.13	0.02	100
R.20	Higgins et al 1988	3.34	10.05	0.24	0	2.57	0	76.61	0	0.59	6.48	0.14	100.02
R.22	Higgins et al 1988	4.88	9.08	0.35	0	2.51	0	76.16	0	0.65	6.31	0.05	99.99
AR.38	Higgins et al 1988	3.99	4.97	0.06	0	2.98	0	83.95	0	0.02	4.02	0.02	100.01
R.25	Higgins et al 1988	1.21	19.29	0.35	0	0	2.38	70.8	0	0.72	5.12	0.12	99.99
AR.36	Higgins et al 1988	5.75	12.76	0.06	0	1.01	0	75	0	0.76	4.64	0.02	100
R.24	Higgins et al 1988	6.36	15.73	0.35	0	0.15	0	71.57	0	0.51	5.26	0.05	99.98
R.27	Higgins et al 1988	10.34	2.77	0.24	0	3.17	0	78.31	0	0.06	5.06	0.05	100

```
setwd("C:\\Documents and Settings\\midnite25\\Desktop")
#to set the working directory to files on the desktop
blueRidge <- read.csv(file="blue ridge tugaloo.csv")
blueRidge
piedmont <- read.csv(file="piedmont tugaloo.csv")
piedmont

attach(blueRidge)
#for easy access
dev.new()
#to call up a new graphing window
pairs(blueRidge[,3:10], gap=0, cex.labels=0.7)
#[rows, columns]
#a test to find any outliers and the distribution of the data
dev.new()
plot(SiO2~CaO)
blueRidge[2,10] <- 4.11
blueRidge[2,]
CaO
CaO[2] <- 4.11
CaO
#Above steps are to correct data entry
plot(SiO2~CaO)
which(CaO>15)
 # locating problem point(s) so they can be dropped
which(SiO2<35)
which(SiO2>63)
dev.new()
pairs(blueRidge[,3:10], gap=0, cex.labels=0.7)
plot(SiO2~FeO)
which(FeO>30)
blueRidge.edited <- blueRidge[c(1:13,15:32,34:62,64:77),]
#to run the set without the problem samples
pairs(blueRidge.edited[,3:10], gap=0, cex.labels=0.7)
pairs(blueRidge.edited[,3:10], gap=0, cex.labels=0.7)
logBlue <- log(blueRidge.edited[,c(3:4)])
#when the data is right skewed (a tail on the right side)
blueRidge.edited[,c(3:4)] <- logBlue
dev.new()
pairs(blueRidge.edited[,3:10], gap=0, cex.labels=0.7)
MgO.edited <- blueRidge.edited[,c(9)]
CaO.edited <- blueRidge.edited[,c(10)]
logMgO <- log(MgO.edited)
plot(logMgO~CaO.edited)
dev.new()
blueRidge.edited[,c(9)] <- logMgO
pairs(blueRidge.edited[,3:10], gap=0, cex.labels=0.7)
```

```
attach(piedmont)
dev.new()
pairs(piedmont[,3:10], gap=0, cex.labels=0.7)
CaO <- piedmont[,10]
dev.new()
plot(MgO~CaO)
plot(MgO~CaO)
which(MgO<9)
which(MgO>35)
plot(SiO2~TiO2)
which(SiO2>60)
which(TiO2>1.1)
plot(Al2O3~MnO)
which(Al2O3>20)
which(MnO>0.33)
plot(CaO~MgO)
piedmont.edited <- piedmont[c(3:5,7:8,11:20,22:24,26:28,30:77),]
pairs(piedmont.edited[,3:10], gap=0, cex.labels=0.7)
dev.new()
logAlAndCa <- log(piedmont.edited[,c(5,10)])
piedmont.edited[,c(5,10)] <- logAlAndCa
pairs(piedmont.edited[,3:10], gap=0, cex.labels=0.7)

blueRidge.piedmont <- merge(blueRidge.edited, piedmont.edited, all=TRUE)
blueRidge.piedmont[2:11]
#needed step for a pca

blue.pied.pca <- prcomp(blueRidge.piedmont[2:141,2:10], retx=TRUE, center=TRUE, scale.=TRUE)
#running the actual pca on the data, the TRUEs are to make the all variables to have equal effects
sd <- blue.pied.pca$sdev
#to separate the standard deviations results from the pca
loadings <- blue.pied.pca$rotation
rownames(loadings) <- colnames(blueRidge.piedmont[,2:10])
#to bring out the loadings
scores <- blue.pied.pca$x
rownames(scores) <- rownames(blueRidge.piedmont[2:141,])
#to bring out the scores
write.table(loadings, file="BluePiedLoading.txt")
write.table(scores, file="BluePiedScore.txt")
write.table(sd, file="BluePiedSd.txt")
#have the data separated in easy accessible files
```

```
dev.new()
plot(blue.pied.pca, xlab="PC")
#plots the variances of the principles components
dev.new()
plot(sd, xlab="PC", ylab="var", type="b", pch=16)
#plots the variances of the standard deviations of the PCs, another way to look at how to reduce the number of PC to look at
var <- sd^2
var.percent <- var/sum(var)*100
var.percent[1:4]
# to look at if 4 should be included (since so close to 3) we can look at the variance numerically and we want PCs that explain more than 12.5% due to 100%/8 (number of PCs) we get 12.5% and since 4 is less than 12.5 the focus will remain on 1-3
sum(var.percent[1:3])
#for reporting and to see how much is left unaccounted for
loadings[,1:3]
#to look at which variables are represented in each PC
#PC1 = SiO and MgO, PC2 = Fe2O3, FeO and MnO, PC3 = TiO, Al2O3 and CaO

dev.new()
biplot(scores[2:77,c(1,2)], loadings[,c(1,2)], cex=0.7)
#biplots are for to see how the samples are plotted in the new spaces with the PCs which is done until all PCs have been plotted versus each other, in this case there is only a need for 3
# just blue ridge
dev.new()
biplot(scores[78:140,c(1,2)], loadings[,c(1,2)], cex=0.7)
# just piedmont

dev.new()
biplot(scores[2:77,c(1,3)], loadings[,c(1,3)], cex=0.7)
dev.new()
biplot(scores[78:140,c(1,3)], loadings[,c(1,3)], cex=0.7)

dev.new()
biplot(scores[2:77,c(2,3)], loadings[,c(2,3)], cex=0.7)
dev.new()
biplot(scores[78:140,c(2,3)], loadings[,c(2,3)], cex=0.7)
```

Appendix 1.4: Data used for PCA

Sample: Tu	Paper	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Total	Label
LC-95	R.D. Hatche	49.74	0.54	14.32	3.66	7.69	0.18	12.82	10.25	100.01	B
LC-179B	R.D. Hatche	47.73	1.95	14.4	4.1	8.6	0.19	10.77	411.1	99.99	B
LC-152	R.D. Hatche	51.31	1.54	15.24	3.92	8.23	0.18	7.62	10.64	99.99	B
LC-138	R.D. Hatche	50.37	2.37	15.01	4	8.41	0.18	7.67	9.94	100	B
LC-240	R.D. Hatche	50.95	0.43	9.34	4.82	10.12	0.19	15.6	6.97	100.1	B
LC-239B	R.D. Hatche	51.68	0.54	6.54	4.68	9.83	0.23	20.34	5.62	100.01	B
LC-161	R.D. Hatche	48.7	1.38	12.49	4.08	8.57	0.18	12.82	10.19	99.99	B
LC-140	R.D. Hatche	52.69	0.86	16.28	3.35	7.04	0.18	8.77	9.62	99.99	B
LC-14	R.D. Hatche	54.54	1.29	12.5	3.74	7.84	0.2	8	10.4	99.99	B
LC-242	R.D. Hatche	51.02	0.05	2.72	3.19	6.69	0.11	32.95	0.25	99.99	B
LC-142	R.D. Hatche	53.14	0.29	2.97	5.36	11.26	0.13	22.26	1.48	100	B
LC-2	R.D. Hatche	49.48	0.26	6.46	5.4	11.34	0.13	17.64	5.7	99.99	B
BRQ3	Mittwede 1	53.75	0.05	3	3.9	8.19	0.08	30.93	0.05	100	B
BRQ4	Mittwede 1	31.73	0.04	2.32	15.26	32.04	0.04	18.52	0.02	100	B
BRQ5	Mittwede 1	53.38	0.05	3.04	4.34	9.12	0.15	29.86	0.03	100	B
BRQ6	Mittwede 1	54.72	0.04	2.15	4.18	8.77	0.14	29.91	0.06	100	B
RM106	Raymond e	41.74	0.02	0.42	2.8	5.88	0.11	48.88	0.08	99.99	B
RM109	Raymond e	45.09	0.02	0.58	3.3	6.92	0.15	43.63	0.16	100	B
RM116	Raymond e	42.05	0.02	0.99	2.89	6.08	0.1	47.57	0.13	99.98	B
HC-4	Carpenter &	42.06	0.05	0.34	2.4	5.03	0.13	49.92	0.06	99.99	B
HC-5	Carpenter &	42.74	0.07	0.43	2.73	5.72	0.12	48.11	0.08	100	B
HC-6	Carpenter &	42.86	0.06	0.44	2.48	5.2	0.11	47.39	1.46	100.01	B
D	Carpenter &	43.78	0.08	1.12	2.76	5.79	0.32	45.6	0.49	100	B
F-1	Carpenter &	43.36	0.03	1.02	2.64	5.55	0.33	46.96	0.09	100	B
F-2	Carpenter &	45.5	0.02	1.14	2.62	5.51	0.31	47.74	0.1	100	B
F-3	Carpenter &	44.37	0.01	0.58	2.67	5.61	0.33	46.33	0.09	99.99	B
F-4	Carpenter &	43.76	0.07	1.19	2.8	5.87	0.31	45.44	0.54	100	B
F-5	Carpenter &	44.82	0.04	0.76	2.56	5.36	0.29	45.49	0.65	99.99	B
F-6	Carpenter &	43.61	0.04	0.92	2.64	5.55	0.31	46.39	0.52	99.99	B
Day Book D	Butler and	41.49	0.01	3.16	2.36	4.96	0.12	47.4	0.38	100	B
1	Mittwede a	51.01	0.7	6.89	3.38	7.1	0.2	18.37	11.46	99.99	B
2	Mittwede a	48.21	0.43	6.31	4.11	8.62	0.25	22.9	8.8	100	B
3	Mittwede a	64.35	0.03	1.15	1.74	3.66	0.05	28.67	0.05	99.99	B

4-Feb	Staphor et	49.36	0.7	6.66	4.47	9.39	0.2	28.73	0.28	99.98	B
168	Staphor et	48.75	0.63	7.76	4.05	8.5	0.18	26.6	3.39	100	B
122B	Staphor et	49.5	0.58	6.29	4.29	9	0.21	25.46	4.43	99.99	B
120F	Staphor et	48.98	0.41	6.84	4.11	8.62	0.22	21.97	8.52	99.99	B
120D	Staphor et	47.91	0.58	6.99	4.17	8.47	0.21	24.3	6.79	100	B
48A	Staphor et	49.7	0.56	5.57	3.67	7.7	0.23	23.14	9.09	99.99	B
48B	Staphor et	47.2	0.54	8.81	4.13	8.67	0.21	22.12	7.96	99.99	B
228C1	Staphor et	49.8	0.08	11.77	2.87	6.02	0.17	17.04	10.66	100	B
191B	Staphor et	49.16	0.07	9.87	3.23	6.79	0.17	20.16	9.61	100	B
126A	Staphor et	47.99	0.14	11.58	3.87	8.13	0.2	16.64	9.75	100	B
126B	Staphor et	45.14	0.08	14.31	3.61	7.59	0.18	17.87	9.89	100	B
19A	Staphor et	49.03	0.76	9.38	3.91	8.21	0.24	19.5	8.2	100	B
225A	Staphor et	48.77	0.09	11.19	3.5	7.36	0.19	18.3	9.33	100	B
221F	Staphor et	47.12	0.04	7.86	4.11	8.64	0.2	24.4	7.31	99.99	B
97	Staphor et	53.05	0.94	14.98	2.66	5.58	0.15	7.58	12.78	100	B
273F	Staphor et	51.16	1.09	15.3	3.15	6.62	0.15	7.41	11.54	99.99	B
273B	Staphor et	51.05	0.89	14.49	2.75	5.78	0.15	9.62	12.61	99.99	B
274	Staphor et	51.32	1.16	14.33	2.87	6.03	0.16	9.54	11.16	100	B
52B2	Staphor et	49.46	1.13	11.5	3.75	7.88	0.2	12.8	11.76	99.99	B
52B1	Staphor et	51.17	1.18	14.31	3.31	6.96	0.17	8.91	10.45	100.01	B
51B	Staphor et	48.52	1.23	11.92	3.93	8.25	0.24	12.64	11.54	100.01	B
10B	Staphor et	52.52	1.11	16.59	3.16	6.63	0.19	6.64	10.98	100	B
168	Staphor et	52.4	1.15	10.64	3.14	6.59	0.17	11.83	11.46	100	B
123	Staphor et	50.22	1.14	17.17	2.9	6.09	0.16	7.8	11	100	B
122A	Staphor et	51.82	0.56	17.43	2.3	4.82	0.16	7.88	11.35	99.98	B
120A	Staphor et	49.27	0.83	9.27	3.24	6.79	0.24	16.22	12.39	100.01	B
120B	Staphor et	48.71	0.76	15.03	2.57	5.39	0.16	12.03	12.62	100	B
120C	Staphor et	50.26	0.57	15.55	2.63	5.52	0.14	9.64	12.78	99.99	B
48	Staphor et	50.98	2.05	16.46	1.49	3.13	0.13	8.62	15.3	99.98	B
228B	Staphor et	48.89	2.08	14.19	4.45	9.34	0.24	6.64	12.25	100.01	B
191	Staphor et	47.79	0.12	11.49	4.22	8.86	0.2	15.94	9.58	100	B
126SE	Staphor et	51.93	0.26	14.76	3.39	7.11	0.21	7.92	12.06	100.02	B
126NW	Staphor et	49.04	1.29	14.39	5.29	11.1	0.26	6.62	9.05	100.01	B
19B	Staphor et	53.98	1.86	15.1	4.36	9.15	0.19	5.27	7.99	100	B
225	Staphor et	46.42	1.27	16.04	5.33	11.19	0.25	7.03	8.76	100.01	B
97	Staphor et	49.86	0.58	7.1	3.41	7.15	0.19	25.76	5.81	99.99	B
273North	Staphor et	47.21	0.67	7.62	4.32	9.06	0.19	27.28	3.47	99.99	B

273South	Staphor et	50.3	0.37	6.57	4.41	9.27	0.21	23.7	4.97	100 B
274D	Staphor et	50.32	0.56	6.22	4.03	8.45	0.19	27.17	2.94	99.98 B
274C	Staphor et	49.22	0.83	10.17	3.7	7.77	0.2	17.42	8.84	100.01 B
52B1	Staphor et	43.75	0.94	11.02	4.67	9.8	0.16	22.68	6.54	100 B
51A	Staphor et	49.76	0.64	6.33	4.45	9.35	0.23	26.48	2.64	99.99 B
10A	Staphor et	48.24	0.6	7.79	4.42	9.28	0.2	26.82	2.53	100.01 B
WGC-1	Warner et a	44.38	0.31	7.32	4.12	8.65	0.27	28.74	5.97	99.99 P
WGC-1A	Warner et a	44.09	0.3	7.97	4.16	8.73	0.25	6.17	0.37	100 P
WGC-2	Warner et a	43.82	0.35	6.6	4.25	8.93	0.3	29.76	5.57	100 P
WGC-3	Warner et a	44.14	0.32	6.64	4.25	8.92	0.3	29.06	6.16	100.02 P
WGS-1	Warner et a	43.49	0.32	6.68	4.56	9.58	0.31	30.21	4.51	100 P
64A	Mittwede 1	60.37	0.01	1.9	2.43	5.1	0.08	28.8	1.02	100 P
64B	Mittwede 1	55.09	0.15	4.2	3.77	7.91	0.1	26.17	2.55	100.01 P
161	Mittwede 1	43.32	0.82	6.72	7.11	14.92	0.14	25.06	1.7	99.99 P
176A	Mittwede 1	44.4	0.05	2.36	5.09	10.69	0.17	36.47	0.75	99.98 P
183	Mittwede 1	61.84	0.05	2.36	2.01	4.22	0.09	29	0.28	100.01 P
82	Mittwede 1	47.24	0.41	7.98	3.56	7.46	0.18	23.19	9.74	100 P
83	Mittwede 1	44.29	0.21	8.5	4.22	8.87	0.19	26.2	7.13	99.99 P
85A	Mittwede 1	46.77	0.2	12.38	2.87	6.02	0.12	21.06	9.93	100 P
123	Mittwede 1	44.56	0.24	13.89	3.47	7.28	0.13	20.97	8.73	100.01 P
150	Mittwede 1	44.41	0.22	12.51	3.99	8.37	0.23	21.21	8.32	100 P
117	Mittwede 1	51.18	0.64	7.25	2.78	5.83	0.17	18.09	13.21	100.01 P
187	Mittwede 1	49.91	0.43	7.42	2.58	5.42	0.15	19.66	13.29	99.98 P
194	Mittwede 1	52.18	0.6	5.6	2.65	5.56	0.17	18.33	14.22	100.01 P
84	Mittwede 1	49.15	0.37	12.86	2.13	4.48	0.13	13.71	16.11	100 P
85B	Mittwede 1	47.45	0.29	16.29	2.15	4.51	0.12	13.65	14.52	100 P
86	Mittwede 1	46.31	0.23	22.13	1.61	3.38	0.08	10.28	14.96	99.98 P
87A-1	Mittwede 1	48.64	0.58	17.68	2.36	4.96	0.14	10.25	13.96	100.01 P
87A-2	Mittwede 1	47.93	0.49	19.8	2.08	4.38	0.11	9.99	14.34	99.99 P
103	Mittwede 1	47.61	0.7	18.42	2.12	4.45	0.11	10.11	15.56	99.99 P
34	Mittwede 1	50.05	1.18	17.58	3.58	7.51	0.2	5.62	11.56	100.01 P
CW1	Sam Swans	46.71	0.71	7.41	4.35	9.14	0.23	30.99	0.21	100 P
CW6	Sam Swans	44.53	0.74	7.38	4.32	9.08	0.27	30.01	3.31	100 P
CW13	Sam Swans	46.71	0.72	7.5	4.48	9.4	0.23	30.6	0.17	100.01 P
CW16	Sam Swans	47.49	0.85	10.46	3.59	7.53	0.35	23.91	5.14	99.99 P
West1	Chaumba 2	54.5	0.25	5.67	3.43	7.21	0.2	25.35	3.12	100.01 P
West2	Chaumba 2	54.83	0.22	4.69	3.39	7.11	0.2	25.94	3.31	100.01 P

Moore1	Chaumba 2	55.13	0.36	3.87	3.38	7.1	0.2	26.25	3.45	100	P
Moore3	Chaumba 2	53.31	0.78	5.38	3.51	7.36	0.21	20.09	8.54	99.98	P
BPL1	Chaumba 2	46.38	0.56	7.78	3.77	7.91	0.19	29.48	3.64	100	P
BPL2	Chaumba 2	46.48	0.63	8.44	3.63	7.63	0.2	28.36	4.48	99.99	P
WCT	Chaumba 2	50.25	0.34	6.69	3.86	8.11	0.26	22.41	7.92	99.98	P
WCAT2	Chaumba 2	52.16	0.32	5.3	3.78	7.94	0.23	23.18	6.35	100	P
R.31	Higgins et a	44.66	0.15	12.44	2.91	6.11	0.15	27.01	5.98	100	P
R.16	Higgins et a	44.42	0.68	6.06	6.67	14	0.28	26.86	0.25	100	P
R.13	Higgins et a	45.98	1.01	7.31	5.67	11.9	0.21	27.18	0.33	99.99	P
R.15	Higgins et a	47.21	0.67	7.32	4.45	9.34	0.21	29.13	1.47	100	P
S.2	Higgins et a	46	0.29	12.27	3.04	6.38	0.15	24.53	6.45	100.03	P
R.6	Higgins et a	47.09	0.58	7.21	4.93	10.34	0.28	28.32	0.48	100.01	P
R.1	Higgins et a	47.74	0.59	6.6	4.47	9.39	0.24	28.64	1.88	100	P
R.23	Higgins et a	47.76	0.38	7.85	4.54	9.54	0.19	29.32	0.09	100	P
AR.35	Higgins et a	47.08	0.33	7.81	4.52	9.48	0.22	26.17	4.17	100.01	P
R.3	Higgins et a	47.12	0.57	7.49	3.83	8.05	0.21	24.55	7.49	99.99	P
R.29	Higgins et a	47.05	0.28	8.78	4.01	8.43	0.28	23.84	6.64	100	P
R.8	Higgins et a	47.71	0.46	5.39	5.86	12.31	0.27	27.25	0.12	100.02	P
AR.33	Higgins et a	47.73	1.04	6.06	5.51	11.58	0.23	27.34	0.46	100	P
R.17	Higgins et a	47.46	0.75	8.99	3.64	7.64	0.24	25.29	4.23	100.02	P
R.7	Higgins et a	49.24	0.37	6.69	4.48	9.41	0.21	28.82	0.46	99.99	P
R.19	Higgins et a	48.23	0.67	9.64	4.95	10.39	0.21	26.14	1.93	100	P
R.18	Higgins et a	48.79	0.76	8.69	4.12	8.64	0.3	25.54	2.01	99.98	P
R.12	Higgins et a	49.39	0.3	6.59	4.12	8.64	0.27	27.53	2.73	99.99	P
R.4	Higgins et a	49.19	0.29	7.4	3.25	6.82	0.26	23.55	8.62	99.99	P
R.9	Higgins et a	50.01	0.35	6.24	4.28	9	0.19	28.29	0.79	99.99	P
R.14	Higgins et a	49.57	0.64	6.29	4.83	10.15	0.3	26.83	0.88	100	P
S.547	Higgins et a	50.14	0.38	7.5	3.66	7.68	0.22	22.5	6.99	100.02	P
AR.32	Higgins et a	51.51	0.4	3.71	4.19	8.8	0.21	26.86	4.12	100	P
R.11	Higgins et a	51.77	0.66	5.2	4.51	9.47	0.18	27.93	0.16	100	P
S.20	Higgins et a	51.6	0.89	7.99	3.06	6.42	0.17	15.99	12.77	100	P
AR.37	Higgins et a	53.68	0.01	6.65	3.03	6.36	0.15	29.64	0.22	99.99	P
R.21	Higgins et a	51.8	0.64	6.71	3.67	7.7	0.19	24.35	3.85	99.99	P
R.28	Higgins et a	51.83	0.12	8.23	2.87	6.02	0.17	24.15	5.86	100	P
S.10	Higgins et a	52.68	0.22	5.44	3.72	7.81	0.18	28.64	1.25	100	P
SS.RA	Higgins et a	51.55	0.69	9.17	2.71	5.7	0.18	15.49	13.24	99.99	P
S.13	Higgins et a	51.85	0.77	5.38	3	6.29	0.2	17.35	14.31	99.99	P

AR.34	Higgins et a	53.88	0.29	6.03	3.54	7.42	0.19	24.58	3.89	100	P
R.20	Higgins et a	52.95	0.31	5.48	4.47	9.37	0.32	25.3	1.15	100.01	P
R.22	Higgins et a	53.63	0.34	5.29	4.35	9.14	0.33	25.26	1.14	99.98	P
AR.38	Higgins et a	55.87	0.01	4.35	2.77	5.82	0.16	30.22	0.47	100.01	P
R.25	Higgins et a	54.56	0.38	5.46	3.53	7.42	0.23	24.66	2.6	100	P
AR.36	Higgins et a	55.84	0.4	5.03	3.2	6.71	0.19	26.35	1.8	100	P
R.24	Higgins et a	55.99	0.27	5.08	3.63	7.63	0.23	24.32	2.14	99.99	P
R.27	Higgins et a	57.45	0.03	3.91	3.49	7.33	0.3	26.99	0.21	99.99	P

Appendix 2.1: Talcs
Thin Section: 18H01-1A

Analysis		1A-1	1A-2	1A-5	1A-6
Weight %	MDL				
SiO_2	0.011	61.70	62.47	62.48	63.02
TiO_2	0.018	0.03	0.02	0.03	0.02
Al_2O_3	0.014	0.49	0.10	0.36	0.18
FeO	0.076	3.71	3.13	2.66	3.69
MnO	0.081	0.00	0.00	0.00	0.09
MgO	0.012	28.42	28.90	28.60	28.83
NiO	0.086	0.00	0.28	0.20	0.20
Cr_2O_3	0.08	0.13	0.00	0.11	0.00
Total		94.42	95.00	94.47	96.01
Formula units based on 22 Oxygen					
Si		7.99	8.00	8.00	8.00
Al^{IV}		0.01	0.00	0.00	0.00
SumT		8.00	8.00	8.00	8.00
Al^{VI}		0.07	0.05	0.10	0.06
Ti		0.00	0.00	0.00	0.00
Cr		0.01	0.00	0.01	0.00
Mg		5.49	5.54	5.49	5.48
Fe^{2+}		0.40	0.34	0.29	0.39
Ni		0.00	0.03	0.02	0.02
Mn		0.00	0.00	0.00	0.01
Sum O		5.97	5.95	5.91	5.96
Total		13.97	13.95	13.91	13.96
Mg #		0.93	0.94	0.95	0.93

Thin Section: 18H01-1B

Analysis		1B-5
Weight %	MDL	
SiO_2	0.011	62.05
TiO_2	0.018	0.04
Al_2O_3	0.014	0.05
FeO	0.076	2.06
MnO	0.081	0.00
MgO	0.012	28.26
NiO	0.086	0.09
Cr_2O_3	0.08	0.00
Total		92.48
Formula units based on 22 Oxygen		
Si		8.00
Al^{IV}		0.00
SumT		8.00
Al^{VI}		0.13
Ti		0.00
Cr		0.00
Mg		5.51
Fe^{2+}		0.23
Ni		0.01
Mn		0.00
Sum O		5.88
Total		13.88
Mg #		0.96

Thin Section: 18H01-1C

Analysis		1C-1	1C-2	1C-4	1C-6
Weight %	MDL				
SiO_2	0.011	60.75	61.39	62.47	60.88
TiO_2	0.018	0.08	0.03	0.02	0.06
Al_2O_3	0.014	0.40	0.11	0.16	0.43
FeO	0.076	3.83	3.52	3.06	4.04
MnO	0.081	0.13	0.00	0.11	0.00
MgO	0.012	28.06	27.95	26.89	27.32
NiO	0.086	0.15	0.15	0.10	0.00
Cr_2O_3	0.08	0.00	0.00	0.00	0.00
Total		93.45	93.17	92.64	92.67
Formula units based on 22 Oxygen					
Si		7.97	8.00	8.00	8.00
Al^{IV}		0.03	0.00	0.00	0.00
SumT		8.00	8.00	8.00	8.00
Al^{VI}		0.03	0.07	0.21	0.10
Ti		0.01	0.00	0.00	0.01
Cr		0.00	0.00	0.00	0.00
Mg		5.49	5.47	5.25	5.38
Fe^{2+}		0.42	0.39	0.34	0.45
Ni		0.02	0.02	0.01	0.00
Mn		0.02	0.00	0.01	0.00
Sum O		5.98	5.94	5.83	5.93
Total		13.98	13.94	13.83	13.93
Mg #		0.93	0.93	0.94	0.92

Thin Section: 18H01-2A

Analysis		2A-1	2A-3	2A-4
Weight %	MDL			
SiO_2	0.011	61.52	63.92	65.30
TiO_2	0.018	0.00	0.06	0.00
Al_2O_3	0.014	0.02	0.07	0.05
FeO	0.076	1.55	2.04	2.08
MnO	0.081	0.00	0.00	0.00
MgO	0.012	28.59	29.20	29.01
NiO	0.086	0.08	0.20	0.12
Cr_2O_3	0.08	0.00	0.00	0.17
Total		91.88	95.44	96.71
Formula units based on 22 Oxygen				
Si		8.00	8.00	8.00
Al^{IV}		0.00	0.00	0.00
SumT		8.00	8.00	8.00
Al^{VI}		0.10	0.12	0.17
Ti		0.00	0.01	0.00
Cr		0.00	0.00	0.02
Mg		5.61	5.52	5.41
Fe^{2+}		0.17	0.22	0.22
Ni		0.01	0.02	0.01
Mn		0.00	0.00	0.00
Sum O		5.89	5.89	5.83
Total		13.89	13.89	13.83
Mg #		0.97	0.96	0.96

Thin Section: 18H01-2B1

Analysis		2B1-1	2B1-2	2B1-3	2B1-4
Weight %	MDL				
SiO_2	0.011	60.88	63.21	61.61	61.32
TiO_2	0.018	0.04	0.05	0.00	0.06
Al_2O_3	0.014	0.38	0.58	0.58	1.06
FeO	0.076	5.00	4.45	4.90	4.97
MnO	0.081	0.00	0.00	0.00	0.00
MgO	0.012	26.97	27.02	28.15	27.07
NiO	0.086	0.23	0.00	0.14	0.14
Cr_2O_3	0.08	0.11	0.09	0.13	0.09
Total		93.52	95.55	95.57	94.75
Formula units based on 22 Oxygen					
Si		8.00	8.00	7.94	7.96
Al^{IV}		0.00	0.00	0.06	0.04
SumT		8.00	8.00	8.00	8.00
Al^{VI}		0.07	0.18	0.03	0.13
Ti		0.00	0.01	0.00	0.01
Cr		0.01	0.01	0.01	0.01
Mg		5.29	5.16	5.41	5.24
Fe^{2+}		0.55	0.48	0.53	0.54
Ni		0.03	0.00	0.01	0.01
Mn		0.00	0.00	0.00	0.00
Sum O		5.96	5.83	6.00	5.94
Total		13.96	13.83	14.00	13.94
Mg #		0.91	0.92	0.91	0.91

Thin Section: 18H01-2B2

Analysis		2B2-1	2B2-2	2B2-4	2B2-5
Weight %	MDL				
SiO_2	0.011	60.89	60.04	60.35	60.40
TiO_2	0.018	0.04	0.03	0.04	0.05
Al_2O_3	0.014	0.44	0.45	0.44	0.35
FeO	0.076	4.48	5.60	5.47	5.13
MnO	0.081	0.00	0.13	0.00	0.00
MgO	0.012	27.01	27.60	27.33	28.03
NiO	0.086	0.31	0.24	0.15	0.30
Cr_2O_3	0.08	0.08	0.00	0.00	0.12
Total		93.32	94.12	93.83	94.41
Formula units based on 22 Oxygen					
Si		8.00	7.91	7.95	7.91
Al^{IV}		0.00	0.07	0.05	0.05
SumT		8.00	7.98	8.00	7.96
Al^{VI}		0.09	0.00	0.02	0.00
Ti		0.00	0.00	0.00	0.01
Cr		0.01	0.00	0.00	0.01
Mg		5.30	5.42	5.37	5.47
Fe^{2+}		0.49	0.62	0.60	0.56
Ni		0.03	0.03	0.02	0.03
Mn		0.00	0.01	0.00	0.00
Sum O		5.93	6.08	6.01	6.08
Total		13.93	14.05	14.01	14.05
Mg #		0.92	0.9	0.9	0.91

Thin Section: 18H01-2C

Analysis		2C-1	2C-2	2C-3	2C-4
Weight %	MDL				
SiO_2	0.011	61.73	61.92	60.89	62.14
TiO_2	0.018	0.00	0.00	0.06	0.03
Al_2O_3	0.014	0.04	0.08	0.03	0.06
FeO	0.076	1.54	2.16	1.88	1.84
MnO	0.081	0.13	0.09	0.00	0.00
MgO	0.012	29.66	29.65	30.19	29.83
NiO	0.086	0.28	0.11	0.04	0.16
Cr_2O_3	0.08	0.00	0.00	0.00	0.00
Total		93.33	93.90	93.14	93.95
Formula units based on 22 Oxygen					
Si		8.00	8.00	7.95	8.00
Al^{IV}		0.00	0.00	0.01	0.00
SumT		8.00	8.00	7.95	8.00
Al^{VI}		0.03	0.02	0.00	0.03
Ti		0.00	0.00	0.01	0.00
Cr		0.00	0.00	0.00	0.00
Mg		5.74	5.72	5.87	5.74
Fe^{2+}		0.17	0.23	0.21	0.20
Ni		0.03	0.01	0.00	0.02
Mn		0.01	0.01	0.00	0.00
Sum O		5.98	6.00	6.09	5.99
Total		13.98	14.00	14.04	13.99
Mg #		0.97	0.96	0.97	0.97

Thin Section: 18H01-2D

Analysis		2D-1	2D-2
Weight %	MDL		
SiO_2	0.011	60.28	60.89
TiO_2	0.018	0.07	0.03
Al_2O_3	0.014	0.07	0.06
FeO	0.076	1.86	1.96
MnO	0.081	0.00	0.00
MgO	0.012	29.53	28.89
NiO	0.086	0.35	0.00
Cr_2O_3	0.08	0.00	0.10
Total		92.13	91.89
Formula units based on 22 Oxygen			
Si		7.96	8.00
Al^{IV}		0.01	0.00
SumT		7.97	8.00
Al^{VI}		0.00	0.04
Ti		0.01	0.00
Cr		0.00	0.01
Mg		5.81	5.68
Fe^{2+}		0.21	0.22
Ni		0.04	0.00
Mn		0.00	0.00
Sum O		6.06	5.96
Total		14.04	13.96
Mg #		0.97	0.96

Thin Section: 18H01-34A

Analysis		34A-3
Weight %	MDL	
SiO_2	0.011	60.00
TiO_2	0.018	0.03
Al_2O_3	0.014	0.44
FeO	0.076	3.62
MnO	0.081	0.00
MgO	0.012	27.14
NiO	0.086	0.00
Cr_2O_3	0.08	0.00
Total		91.23
Formula units based on 22 Oxygen		
Si		8.02
Al^{IV}		0.00
SumT		8.02
Al^{VI}		0.09
Ti		0.00
Cr		0.00
Mg		5.44
Fe^{2+}		0.41
Ni		0.00
Mn		0.00
Sum O		5.94
Total		13.97
Mg #		0.93

Thin Section: 18H01-34B

Analysis		34B-1	34B-2	34B-4
Weight %	MDL			
SiO_2	0.011	61.01	60.00	60.39
TiO_2	0.018	0.02	0.05	0.00
Al_2O_3	0.014	0.19	0.31	0.39
FeO	0.076	4.32	3.14	4.25
MnO	0.081	0.00	0.00	0.00
MgO	0.012	26.89	27.84	28.08
NiO	0.086	0.21	0.21	0.21
Cr_2O_3	0.08	0.00	0.00	0.00
Total		92.76	91.60	93.47
Formula units based on 22 Oxygen				
Si		8.00	8.00	7.95
Al^{IV}		0.00	0.00	0.05
SumT		8.00	8.00	8.00
Al^{VI}		0.10	0.05	0.01
Ti		0.00	0.01	0.00
Cr		0.00	0.00	0.00
Mg		5.30	5.53	5.51
Fe^{2+}		0.48	0.35	0.47
Ni		0.02	0.02	0.02
Mn		0.00	0.00	0.00
Sum O		5.90	5.96	6.00
Total		13.90	13.96	14.00
Mg #		0.92	0.94	0.92

Thin Section: 18H01-34C

Analysis		34C-1	34C-2	34C-3
Weight %	MDL			
SiO_2	0.011	61.82	60.75	62.00
TiO_2	0.018	0.07	0.04	0.03
Al_2O_3	0.014	0.14	0.16	0.20
FeO	0.076	2.22	1.96	2.52
MnO	0.081	0.00	0.00	0.00
MgO	0.012	29.63	28.25	28.25
NiO	0.086	0.00	0.00	0.17
Cr_2O_3	0.08	0.00	0.12	0.08
Total		94.03	91.35	93.13
Formula units based on 22 Oxygen				
Si		7.99	8.00	8.00
Al^{IV}		0.01	0.00	0.00
SumT		8.00	8.00	8.00
Al^{VI}		0.02	0.09	0.11
Ti		0.01	0.00	0.00
Cr		0.00	0.01	0.01
Mg		5.71	5.59	5.49
Fe^{2+}		0.24	0.22	0.28
Ni		0.00	0.00	0.02
Mn		0.00	0.00	0.00
Sum O		5.97	5.91	5.91
Total		13.97	13.91	13.91
Mg #		0.96	0.96	0.95

Appendix 2.2: Chlorites

Thin Section: 18H01-1A

Analysis		1A-1	1A-2	1A-3	1A-4	1A-5	1A-6
Weight %	MDL						
SiO_2	0.012	29.47	30.41	30.29	29.38	30.34	29.81
TiO_2	0.018	0.04	0.06	0.07	0.00	0.03	0.06
Al_2O_3	0.014	17.92	17.18	17.27	20.57	18.87	18.50
Fe2O3	N/A	0.00	0.68	0.96	1.28	0.38	0.48
FeO	0.083	9.86	8.65	8.35	8.76	9.68	8.85
MnO	0.081	0.09	0.09	0.00	0.12	0.00	0.14
MgO	0.013	27.66	27.51	27.01	25.63	27.89	27.54
Cr_2O_3	0.083	0.23	0.31	0.21	0.54	0.64	0.38
NiO	0.087	0.23	0.21	0.16	0.35	0.34	0.16
Total		85.51	85.11	84.32	86.62	88.18	85.92
Formula units based on 28 Oxygen							
Si		5.87	6.05	6.07	5.76	5.86	5.88
Al^{IV}		2.14	1.95	1.93	2.24	2.15	2.12
SumT		8.00	8.00	8.00	8.00	8.00	8.00
Al^{VI}		2.07	2.08	2.16	2.51	2.15	2.18
Ti		0.01	0.01	0.01	0.00	0.01	0.01
Cr		0.04	0.05	0.03	0.08	0.10	0.06
Fe^{3+}		0.00	0.10	0.14	0.19	0.05	0.06
Mg		8.21	8.17	8.08	7.49	8.02	8.10
Fe^{2+}		1.64	1.44	1.40	1.43	1.57	1.47
Ni		0.04	0.03	0.03	0.06	0.05	0.02
Mn		0.02	0.02	0.00	0.02	0.00	0.02
Sum O		12.01	11.90	11.85	11.79	11.94	11.93
Total		20.01	19.90	19.85	19.79	19.94	19.93
Mg #		0.83	0.84	0.84	0.82	0.83	0.84
Fetot/(Mg+Fetot)		0.26	0.25	0.25	0.28	0.26	0.25
Al/(Al+Fetot+Mg)		0.32	0.32	0.32	0.37	0.33	0.33
Al+vacancies		4.20	4.10	4.20	4.89	4.29	4.33
Variety		clinochlore	clinochlore	clinochlore	clinochlore	clinochlore	clinochlore

Thin Section: 18HO1-1B

Analysis		1B-1	1B-3	1B-4	1B-7
Weight %	MDL				
SiO_2	0.012	30.41	29.84	30.23	31.68
TiO_2	0.018	0.03	0.07	0.08	0.05
Al_2O_3	0.014	18.09	17.89	17.05	15.84
Fe2O3	N/A	0.95	0.29	0.01	0.24
FeO	0.083	6.10	6.36	7.29	6.53
MnO	0.081	0.10	0.00	0.00	0.00
MgO	0.013	28.46	29.32	29.68	30.72
Cr_2O_3	0.083	0.28	0.43	0.26	0.13
NiO	0.087	0.25	0.25	0.17	0.24
Total		84.68	84.45	84.78	85.44
Formula units based on 28 Oxygen					
Si		6.01	5.91	5.98	6.19
Al^{IV}		1.99	2.09	2.02	1.81
SumT		8.00	8.00	8.00	8.00
Al^{VI}		2.22	2.08	1.95	1.84
Ti		0.01	0.01	0.01	0.01
Cr		0.04	0.07	0.04	0.02
Fe^{3+}		0.14	0.03	0.00	0.04
Mg		8.38	8.65	8.75	8.95
Fe^{2+}		1.01	1.07	1.21	1.06
Ni		0.04	0.04	0.03	0.04
Mn		0.02	0.00	0.00	0.00
Sum O		11.86	11.95	11.98	11.95
Total		19.86	19.95	19.98	19.95
Mg #		0.88	0.89	0.88	0.89
Fetot/(Mg+Fetot)		0.20	0.18	0.20	0.18
Al/(Al+Fetot+Mg)		0.34	0.33	0.32	0.30
Al+vacancies		4.33	4.17	3.94	3.66
Variety		clinochlore	clinochlore	clinochlore	clinochlore

Thin Section: 18H01-1C

Analysis		1C-1	1C-3	1C-5
Weight %	MDL			
SiO_2	0.012	29.61	29.31	30.76
TiO_2	0.018	0.07	0.09	0.04
Al_2O_3	0.014	18.49	19.63	15.81
Fe2O3	N/A	0.16	0.99	0.51
FeO	0.083	9.16	8.39	9.13
MnO	0.081	0.00	0.00	0.00
MgO	0.013	28.01	26.47	27.83
Cr_2O_3	0.083	0.11	0.36	0.00
NiO	0.087	0.00	0.10	0.00
Total		85.62	85.33	84.08
Formula units based on 28 Oxygen				
Si		5.85	5.81	6.19
Al^{IV}		2.15	2.19	1.81
SumT		8.00	8.00	8.00
Al^{VI}		2.15	2.40	1.94
Ti		0.01	0.01	0.01
Cr		0.02	0.06	0.00
Fe^{3+}		0.02	0.02	0.06
Mg		8.25	7.82	8.35
Fe^{2+}		1.51	1.52	1.55
Ni		0.00	0.02	0.00
Mn		0.00	0.00	0.00
Sum O		11.97	11.84	11.90
Total		19.97	19.84	19.90
Mg#		0.84	0.84	0.84
Fetot/(Mg+Fetot)		0.25	0.26	0.26
Al/(Al+Fetot+Mg)		0.33	0.35	0.30
Al+vacancies		4.31	4.69	3.81
Variety		clinochlore	clinochlore	clinochlore

Thin Section: 18H01-2A

Analysis		2A-2	2A-3	2A-5
Weight %	MDL			
SiO_2	0.012	30.91	29.93	30.37
TiO_2	0.018	0.03	0.06	0.04
Al_2O_3	0.014	16.26	16.14	17.01
Fe2O3	N/A	0.01	0.26	0.75
FeO	0.083	7.16	6.49	5.97
MnO	0.081	0.00	0.00	0.16
MgO	0.013	30.36	29.15	28.80
Cr_2O_3	0.083	1.71	1.57	1.17
NiO	0.087	0.34	0.34	0.30
Total		86.77	83.92	84.56
Formula units based on 28 Oxygen				
Si		6.00	6.00	6.03
Al^{IV}		2.00	2.00	1.97
SumT		8.00	8.00	8.00
Al^{VI}		1.73	1.81	2.00
Ti		0.01	0.01	0.01
Cr		0.26	0.25	0.18
Fe^{3+}		0.00	0.04	0.11
Mg		8.79	8.71	8.52
Fe^{2+}		1.16	1.09	0.99
Ni		0.05	0.05	0.05
Mn		0.00	0.00	0.03
Sum O		12.00	11.96	11.89
Total		20.00	19.96	19.89
Mg#		0.88	0.89	0.89
Fetot/(Mg+Fetot)		0.19	0.19	0.19
Al/(Al+Fetot+Mg)		0.30	0.31	0.32
Al+vacancies		3.72	3.81	3.99
Variety		clinochlore	clinochlore	clinochlore

Thin Section: 18H01-2B1

Analysis		2B1-1	2B1-2	2B1-3	2B1-4	2B1-5
Weight %	MDL					
SiO_2	0.012	27.43	27.13	27.58	28.22	27.95
TiO_2	0.018	0.11	0.09	0.08	0.08	0.09
Al_2O_3	0.014	21.31	21.32	19.65	20.41	20.16
Fe2O3	N/A	0.46	0.25	0.07	0.89	0.23
FeO	0.083	14.10	14.26	14.15	13.26	13.98
MnO	0.081	0.14	0.10	0.00	0.00	0.19
MgO	0.013	22.97	22.88	23.68	23.11	23.68
Cr_2O_3	0.083	0.85	0.36	0.63	0.68	0.90
NiO	0.087	0.00	0.21	0.00	0.00	0.26
Total		87.37	86.61	85.82	86.65	87.44

Formula units based on 28 Oxygen					
Si	5.48	5.47	5.60	5.66	5.58
Al^{IV}	2.52	2.54	2.40	2.35	2.42
SumT	8.00	8.00	8.00	8.00	8.00
Al^{VI}	2.49	2.53	2.30	2.48	2.32
Ti	0.02	0.01	0.01	0.01	0.01
Cr	0.13	0.06	0.10	0.11	0.14
Fe^{3+}	0.07	0.04	0.01	0.13	0.03
Mg	6.84	6.87	7.16	6.90	7.05
Fe^{2+}	2.35	2.40	2.40	2.22	2.33
Ni	0.00	0.03	0.00	0.00	0.04
Mn	0.02	0.02	0.00	0.00	0.03
Sum O	11.93	11.96	11.98	11.85	11.97
Total	19.93	19.96	19.98	19.85	19.97
Mg#	0.74	0.74	0.75	0.75	0.75
Fetot/(Mg+Fetot)	0.39	0.39	0.38	0.38	0.38
Al/(Al+Fetot+Mg)	0.33	0.36	0.34	0.35	0.35
Al+vacancies	5.02	5.06	4.70	4.89	4.74
Variety	clinochlore	clinochlore	clinochlore	clinochlore	clinochlore

Thin Section: 18H01-2B2

Analysis		2B2-1	2B2-2	2B2-5
Weight %	MDL			
SiO_2	0.012	27.41	27.53	27.12
TiO_2	0.018	0.07	0.06	0.04
Al_2O_3	0.014	19.32	19.09	19.35
Fe2O3	N/A	0.06	0.00	0.57
FeO	0.083	15.13	14.26	12.50
MnO	0.081	0.00	0.12	0.00
MgO	0.013	22.91	23.51	22.90
Cr_2O_3	0.083	1.10	0.82	0.96
NiO	0.087	0.11	0.16	0.14
Total		86.11	85.56	83.57

Formula units based on 28 Oxygen			
Si	5.59	5.62	5.63
Al^{IV}	2.42	2.38	2.37
SumT	8.00	8.00	8.00
Al^{VI}	2.22	2.22	2.37
Ti	0.01	0.01	0.01
Cr	0.18	0.13	0.16
Fe^{3+}	0.01	0.00	0.09
Mg	6.96	7.16	7.09
Fe^{2+}	2.58	2.44	2.17
Ni	0.02	0.03	0.02
Mn	0.00	0.02	0.00
Sum O	11.98	12.00	11.90
Total	19.98	20.00	19.90
Mg#	0.78	0.75	0.76
Fetot/(Mg+Fetot)	0.40	0.38	0.36
Al/(Al+Fetot+Mg)	0.34	0.34	0.35
Al+vacancies	4.64	4.60	4.74
Variety	clinochlore	clinochlore	clinochlore

Thin Section: 18H01-2C

Analysis		2C-1	2C-2	2C-3	2C-5
Weight %	MDL				
SiO_2	0.012	30.55	31.54	29.70	29.94
TiO_2	0.018	0.03	0.04	0.06	0.05
Al_2O_3	0.014	16.15	15.74	17.04	16.74
Fe2O3	N/A	0.02	0.08	0.01	0.00
FeO	0.083	6.38	7.15	7.58	6.97
MnO	0.081	0.00	0.00	0.00	0.00
MgO	0.013	30.24	30.60	28.89	29.79
Cr_2O_3	0.083	0.10	0.00	0.00	0.00
NiO	0.087	0.18	0.16	0.23	0.10
Total		83.68	85.31	83.51	83.58

Formula units based on 28 Oxygen				
Si	6.09	6.19	5.98	5.99
Al^{IV}	1.91	1.81	2.02	2.01
SumT	8.00	8.00	8.00	8.00
Al^{VI}	1.89	1.83	2.02	1.93
Ti	0.01	0.01	0.01	0.01
Cr	0.02	0.00	0.00	0.00
Fe^{3+}	0.00	0.01	0.00	0.00
Mg	8.99	8.95	8.67	8.88
Fe^{2+}	1.07	1.17	1.28	1.17
Ni	0.03	0.03	0.04	0.02
Mn	0.00	0.00	0.00	0.00
Sum O	11.99	11.99	12.02	12.01
Total	19.99	19.99	20.02	20.01
Mg#	0.89	0.88	0.87	0.88
Fetot/(Mg+Fetot)	0.17	0.19	0.21	0.19
Al/(Al+Fetot+Mg)	0.31	0.29	0.32	0.31
Al+vacancies	3.80	3.64	4.04	3.95
Variety	clinochlore	clinochlore	clinochlore	clinochlore

Thin Section: 18H01-2D

Analysis		2D-1	2D-4
Weight %	MDL		
SiO_2	0.012	29.03	29.03
TiO_2	0.018	0.09	0.07
Al_2O_3	0.014	15.94	16.49
Fe2O3	N/A	0.00	0.00
FeO	0.083	7.39	7.44
MnO	0.081	0.19	0.13
MgO	0.013	30.15	29.40
Cr_2O_3	0.083	0.64	0.32
NiO	0.087	0.00	0.16
Total		83.43	83.04
Formula units based on 28 Oxygen			
Si		5.87	5.89
Al^{IV}		2.13	2.11
SumT		8.00	8.00
Al^{VI}		1.67	1.84
Ti		0.01	0.01
Cr		0.10	0.05
Fe^{3+}		0.00	0.00
Mg		9.09	8.89
Fe^{2+}		1.25	1.26
Ni		0.00	0.03
Mn		0.03	0.02
Sum O		12.16	12.10
Total		20.16	20.10
Mg#		0.88	0.88
Fetot/(Mg+Fetot)		0.20	0.20
Al/(Al+Fetot+Mg)		0.30	0.31
Al+vacancies		3.80	3.94
Variety		clinochlore	clinochlore

Thin Section: 18H01-34A

Analysis		34A-3
Weight %	MDL	
SiO_2	0.012	28.58
TiO_2	0.018	0.14
Al_2O_3	0.014	17.50
Fe2O3	N/A	0.00
FeO	0.083	10.80
MnO	0.081	0.12
MgO	0.013	26.46
Cr_2O_3	0.083	0.65
NiO	0.087	0.17
Total		84.42

Formula units based on 28 Oxygen	
Si	5.81
Al^{IV}	2.19
SumT	8.00
Al^{VI}	2.00
Ti	0.02
Cr	0.11
Fe^{3+}	0.00
Mg	8.02
Fe^{2+}	1.84
Ni	0.03
Mn	0.02
Sum O	12.02
Total	20.02
Mg#	0.81
Fetot/(Mg+Fetot)	0.29
Al/(Al+Fetot+Mg)	0.32
Al+vacancies	4.19
Variety	clinochlore

Thin Section: 18H01-34B

Analysis		34B-1	34B-2	34B-4
Weight %	MDL			
SiO_2	0.012	28.82	28.19	27.24
TiO_2	0.018	0.05	0.05	0.05
Al_2O_3	0.014	17.05	19.64	18.41
Fe2O3	N/A	0.72	1.94	0.00
FeO	0.083	11.97	11.43	13.45
MnO	0.081	0.10	0.00	0.14
MgO	0.013	23.96	21.50	23.99
Cr_2O_3	0.083	0.36	0.73	0.83
NiO	0.087	0.19	0.10	0.09
Total		83.21	83.57	84.21

Formula units based on 28 Oxygen			
Si	5.99	5.84	5.64
Al^{IV}	2.01	2.16	2.36
SumT	8.00	8.00	8.00
Al^{VI}	2.16	2.63	2.13
Ti	0.01	0.01	0.01
Cr	0.06	0.12	0.14
Fe^{3+}	0.11	0.30	0.00
Mg	7.42	6.64	7.40
Fe^{2+}	2.08	2.28	2.33
Ni	0.03	0.02	0.02
Mn	0.02	0.00	0.03
Sum O	11.89	11.99	12.04
Total	19.89	19.99	20.04
Mg#	0.77	0.74	0.76
Fetot/(Mg+Fetot)	0.35	0.38	0.36
Al/(Al+Fetot+Mg)	0.32	0.36	0.33
Al+vacancies	4.25	5.03	4.49
Variety	clinochlore	clinochlore	clinochlore

Thin Section: 18H01-34C

Analysis		34C-1
Weight %	MDL	
SiO_2	0.012	29.84
TiO_2	0.018	0.06
Al_2O_3	0.014	16.47
Fe2O3	N/A	0.37
FeO	0.083	7.99
MnO	0.081	0.00
MgO	0.013	28.05
Cr_2O_3	0.083	0.34
NiO	0.087	0.00
Total		83.11

Formula units based on 28 Oxygen	
Si	6.05
Al^{IV}	1.95
SumT	8.00
Al^{VI}	1.98
Ti	0.01
Cr	0.05
Fe^{3+}	0.06
Mg	8.48
Fe^{2+}	1.36
Ni	0.00
Mn	0.00
Sum O	11.93
Total	19.93
Mg#	0.86
Fetot/(Mg+Fetot)	0.23
Al/(Al+Fetot+Mg)	0.31
Al+vacancies	3.95
Variety	clinochlore

Appendix 2.3: High Ca-Amphiboles
Thin Section: 18H01-1A

Associated Cummingtonite*		1A-4	1A-5
Analysis		1A-1	1A-1
Mineral**		Mg-hr	Tr
Weight %	MDL		
SiO_2	0.01	57.42	57.93
TiO_2	0.02	0.02	0.03
Al_2O_3	0.01	0.55	0.50
Fe_2O_3	N/A	5.33	0.62
FeO	0.12	0.66	3.98
MnO	0.14	0.56	0.25
MgO	0.01	21.14	21.26
CaO	0.01	12.00	12.98
K_2O	0.02	0.00	0.00
Na_2O	0.02	0.16	0.11
Total		97.84	97.67
Formula units based on 23 Oxygen			
Si		7.99	8.00
Al^{IV}		0.01	0.00
SumT		8.00	8.00
Al^{VI}		0.08	0.08
Fe^{3+}		0.56	0.07
Ti		0.00	0.00
Mg		4.36	4.38
Fe^{2+}		0.00	0.46
Mn		0.00	0.01
Sum C		5.00	5.00
Mg		0.02	0.00
Fe^{2+}		0.07	0.00
Mn		0.07	0.02
Ca		1.79	1.92
Na		0.04	0.03
Sum B		1.99	1.97
Na		0.00	0.00
K		0.00	0.00
Sum A		0.00	0.00
Total		14.99	14.97
Mg#		0.98	0.91
^{A}(Na+K+2Ca)		0.00	0.00
^{C}(Al+Fe^{3+}+2Ti)		0.64	0.15

*- cummingtonites are small inclusions within the Ca-amphiboles
**Mineral abbreviations
Tr: Tremolite
Mg-hr: Magnesio-hornblende

Thin Section: 18H01-1C

Associated Cummingtonite*		1C-1	1C-4
Analysis		1C-1	1C-4
Mineral**		Tr	Tr
Weight %	MDL		
SiO_2	0.01	57.56	57.08
TiO_2	0.02	0.07	0.03
Al_2O_3	0.01	0.33	0.42
Fe_2O_3	N/A	3.72	4.20
FeO	0.12	0.68	0.00
MnO	0.14	0.00	0.43
MgO	0.01	22.61	22.59
CaO	0.01	12.90	12.31
K_2O	0.02	0.00	0.00
Na_2O	0.02	0.11	0.12
Total		97.97	97.18
Formula units based on 23 Oxygen			
Si		7.94	7.94
Al^{IV}		0.05	0.06
Ti		0.00	0.00
Fe^{3+}		0.00	0.00
SumT		8.00	8.00
Al^{VI}		0.00	0.01
Fe^{3+}		0.36	0.44
Ti		0.00	0.00
Mg		4.63	4.56
Fe^{2+}		0.00	0.00
Mn		0.00	0.00
Sum C		5.00	5.00
Mg		0.02	0.13
Fe^{2+}		0.10	0.00
Mn		0.00	0.05
Ca		1.91	1.83
Na		0.00	0.00
Sum B		2.02	2.01
Na		0.03	0.03
K		0.00	0.00
Sum A		0.03	0.03
Total		15.05	15.04
Mg#		0.98	1.00
^{A}(Na+K+2Ca)		0.05	0.05
^{C}(Al+Fe^{3+}+2Ti)		0.37	0.45

*- cummingtonites are small inclusions within the Ca-amphiboles
**Mineral abbreviations
Tr: Tremolite
Mg-hr: Magnesio-hornblende

Thin Section: 18H01-2B2

Analysis		2B2-1
Mineral**		Mg-hr
Weight %	MDL	
SiO_2	0.01	52.93
TiO_2	0.02	0.12
Al_2O_3	0.01	2.55
Fe_2O_3	N/A	12.06
FeO	0.12	0.00
MnO	0.14	0.46
MgO	0.01	18.13
CaO	0.01	10.41
K_2O	0.02	0.00
Na_2O	0.02	0.42
Total		97.08
Formula units based on 23 Oxygen		
Si		7.68
Al^{IV}		0.32
SumT		8.00
Al^{VI}		0.11
Fe^{3+}		1.28
Ti		0.01
Mg		3.60
Fe^{2+}		0.00
Mn		0.00
Sum C		5.00
Mg		0.33
Fe^{2+}		0.00
Mn		0.06
Ca		1.62
Na		0.00
Sum B		2.00
Na		0.12
K		0.00
Sum A		0.12
Total		15.12
Mg#		1.00
^{A}(Na+K+2Ca)		0.12
^{C}(Al+Fe^{3+}+2Ti)		1.42

**Mineral abbreviations
Tr: Tremolite
Mg-hr: Magnesio-hornblende

Thin Section: 18H01-34A

Associated Cummingtonite*		34A-1	34A-2		34A-4
Analysis		34A-1	34A-1	34A-2	34A-3
Mineral**		Tr	Mg-hr	Mg-hr	Mg-hr
Weight %	MDL				
SiO_2	0.01	56.76	56.24	55.18	55.85
TiO_2	0.02	0.09	0.06	0.10	0.09
Al_2O_3	0.01	0.74	1.01	2.27	1.49
Fe_2O_3	N/A	3.81	5.09	3.40	3.88
FeO	0.12	1.39	0.05	2.02	1.21
MnO	0.14	0.37	0.08	0.11	0.20
MgO	0.01	21.44	21.94	20.46	21.08
CaO	0.01	12.53	12.51	12.25	12.31
K_2O	0.02	0.00	0.00	0.00	0.00
Na_2O	0.02	0.19	0.21	0.50	0.26
Total		97.31	97.20	96.30	96.37
Formula units based on 23 Oxygen					
Si		7.92	7.86	7.78	7.86
Al^{IV}		0.08	0.14	0.22	0.14
SumT		8.00	8.00	8.00	8.00
Al^{VI}		0.04	0.02	0.16	0.11
Fe^{3+}		0.40	0.53	0.36	0.41
Ti		0.01	0.01	0.01	0.01
Mg		4.46	4.44	4.30	4.42
Fe^{2+}		0.09	0.00	0.17	0.05
Mn		0.00	0.00	0.00	0.00
Sum C		5.00	5.00	5.00	5.00
Mg		0.00	0.13	0.00	0.00
Fe^{2+}		0.07	0.01	0.09	0.09
Mn		0.04	0.01	0.01	0.02
Ca		1.87	1.87	1.85	1.86
Na		0.02	0.00	0.01	0.02
Sum B		2.00	2.02	1.96	1.99
Na		0.03	0.01	0.00	0.00
K		0.00	0.00	0.00	0.00
Sum A		0.03	0.01	0.00	0.00
Total		15.03	15.03	14.96	14.99
Mg#		0.97	1.00	0.94	0.97
^{A}(Na+K+2Ca)		0.03	0.05	0.00	0.00
^{C}(Al+Fe^{3+}+2Ti)		0.46	0.57	0.54	0.54

*- Ca-amphiboles are small inclusions within the cummingtonites
**Mineral abbreviations
Tr: Tremolite
Mg-hr: Magnesio-hornblende

Thin Section: 18H01-34B

Analysis		34B-1	34B-1	34B-2
Mineral**		Tr	Mg-hr	Mg-hr
Weight %	MDL			
SiO_2	0.01	56.43	55.17	54.86
TiO_2	0.02	0.01	0.11	0.01
Al_2O_3	0.01	0.54	3.37	1.79
Fe_2O_3	N/A	4.45	5.09	4.32
FeO	0.12	0.00	1.46	1.28
MnO	0.14	0.15	0.24	0.15
MgO	0.01	22.55	20.03	21.02
CaO	0.01	12.64	12.07	12.57
K_2O	0.02	0.00	0.00	0.00
Na_2O	0.02	0.18	0.51	0.36
Total		96.94	98.04	96.35
Formula units based on 23 Oxygen				
Si		7.89	7.69	7.77
Al^{IV}		0.09	0.31	0.24
Ti		0.00	0.00	0.00
Fe^{3+}		0.03	0.00	0.00
SumT		8.00	8.00	8.00
Al^{VI}		0.00	0.25	0.06
Fe^{3+}		0.44	0.53	0.45
Ti		0.00	0.01	0.00
Mg		4.56	4.16	4.44
Fe^{2+}		0.00	0.05	0.05
Mn		0.00	0.00	0.00
Sum C		5.00	5.00	5.00
Mg		0.14	0.00	0.00
Fe^{2+}		0.00	0.12	0.11
Mn		0.02	0.03	0.02
Ca		1.89	1.80	1.91
Na		0.00	0.05	0.00
Sum B		2.05	2.00	2.03
Na		0.05	0.08	0.10
K		0.00	0.00	0.00
Sum A		0.05	0.08	0.10
Total		15.09	15.08	15.13
Mg#		1.00	0.96	0.97
^{A}(Na+K+2Ca)		0.15	0.08	0.16
^{C}(Al+Fe^{3+}+2Ti)		0.44	0.80	0.52

**Mineral abbreviations
Tr: Tremolite
Mg-hr: Magnesio-hornblende

Appendix 2.4: Cummingtonites

Thin Section: 18H01-1A

Associated Ca-Amphibole*				1A-1	1A-1
Analysis		1A-1	1A-2	1A-4	1A-5
Weight %	MDL				
SiO_2	0.01	55.70	55.70	57.73	58.81
TiO_2	0.02	0.00	0.04	0.00	0.00
Al_2O_3	0.013	0.09	0.00	0.03	0.06
Fe_2O_3	N/A	0.00	0.00	0.00	0.00
FeO	0.12	15.49	14.40	14.12	10.92
MnO	0.134	1.67	2.17	1.96	1.08
MgO	0.013	21.04	20.65	21.66	23.82
CaO	0.014	0.65	0.68	1.01	0.64
K_2O	0.026	0.00	0.00	0.00	0.00
Na_2O	0.018	0.02	0.05	0.02	0.04
Total		94.66	93.70	96.52	95.36
Formula units based on 23 Oxygen					
Si		8.00	8.00	8.00	8.00
Al^{IV}		0.00	0.00	0.00	0.00
SumT		8.00	8.00	8.00	8.00
Al^{VI}		0.13	0.17	0.19	0.26
Fe^{3+}		0.00	0.00	0.00	0.00
Ti		0.00	0.01	0.00	0.00
Mg		4.57	4.52	4.58	4.74
Fe^{2+}		0.31	0.31	0.24	0.00
Mn		0.00	0.00	0.00	0.00
Sum C		5.00	5.00	5.00	5.00
Mg		0.00	0.00	0.00	0.24
Fe^{2+}		1.58	1.46	1.43	1.28
Mn		0.21	0.27	0.24	0.13
Ca		0.10	0.11	0.15	0.10
Na		0.01	0.01	0.01	0.01
Sum B		1.89	1.85	1.83	1.76
Na		0.00	0.00	0.00	0.00
K		0.00	0.00	0.00	0.00
Sum A		0.00	0.00	0.00	0.00
Total		14.89	14.85	14.83	14.76
Mg #		0.94	0.94	0.95	1.00

*- cummingtonites are small inclusions within the tremolites

Thin Section: 18H01-1C

Associated Ca-Amphibole*		1C-1			1C-4
Analysis		1C-1	1C-2	1C-3	1C-4
Weight %	MDL				
SiO_2	0.01	58.62	55.57	55.33	56.28
TiO_2	0.02	0.00	0.01	0.01	0.01
Al_2O_3	0.013	0.10	0.11	0.05	0.03
Fe_2O_3	N/A	0.00	0.19	0.29	0.00
FeO	0.12	14.83	15.47	14.79	14.38
MnO	0.134	1.84	1.57	1.92	2.04
MgO	0.013	22.90	22.61	22.52	22.64
CaO	0.014	1.27	0.68	0.83	0.70
K_2O	0.026	0.00	0.00	0.00	0.00
Na_2O	0.018	0.02	0.04	0.03	0.00
Total		99.57	96.24	95.76	96.09
Formula units based on 23 Oxygen					
Si		8.00	7.98	7.99	8.00
Al^{IV}		0.00	0.02	0.01	0.00
SumT		8.00	8.00	7.99	8.00
Al^{VI}		0.10	0.00	0.00	0.06
Fe^{3+}		0.00	0.02	0.03	0.00
Ti		0.00	0.00	0.00	0.00
Mg		4.71	4.84	4.85	4.83
Fe^{2+}		0.20	0.14	0.12	0.11
Mn		0.00	0.00	0.00	0.00
Sum C		5.00	5.00	5.00	5.00
Mg		0.00	0.00	0.00	0.00
Fe^{2+}		1.51	1.72	1.66	1.61
Mn		0.22	0.19	0.23	0.25
Ca		0.19	0.11	0.13	0.11
Na		0.01	0.00	0.00	0.00
Sum B		1.92	2.02	2.02	1.97
Na		0.00	0.01	0.01	0.00
K		0.00	0.00	0.00	0.00
Sum A		0.00	0.01	0.01	0.00
Total		14.92	15.03	15.02	14.97
Mg #		0.96	0.97	0.98	0.98

*- cummingtonites are small inclusions within the Ca-amphiboles

Thin Section: 18H01-2B1

Analysis		2B1-1	2B1-2	2B1-4
Weight %	MDL			
SiO_2	0.01	54.72	54.88	55.20
TiO_2	0.02	0.05	0.00	0.00
Al_2O_3	0.013	0.45	0.45	0.37
Fe_2O_3	N/A	0.00	0.07	0.47
FeO	0.12	15.77	16.24	16.43
MnO	0.134	0.82	0.60	0.55
MgO	0.013	21.36	22.56	22.48
CaO	0.014	0.25	0.31	0.50
K_2O	0.026	0.00	0.00	0.00
Na_2O	0.018	0.07	0.04	0.00
Total		93.36	94.99	95.84
Formula units based on 23 Oxygen				
Si		8.00	7.96	7.96
Al^{IV}		0.00	0.04	0.05
Ti		0.00	0.00	0.00
Fe^{2+}		0.00	0.00	0.00
SumT		8.00	8.00	8.00
Al^{VI}		0.13	0.04	0.02
Fe^{3+}		0.00	0.01	0.05
Ti		0.01	0.00	0.00
Mg		4.69	4.88	4.83
Fe^{2+}		0.18	0.08	0.10
Mn		0.00	0.00	0.00
Sum C		5.00	5.00	5.00
Mg		0.00	0.00	0.00
Fe^{2+}		1.76	1.89	1.93
Mn		0.10	0.07	0.12
Ca		0.04	0.05	0.08
Na		0.02	0.00	0.00
Sum B		1.92	2.01	2.13
Na		0.00	0.01	0.00
K		0.00	0.00	0.00
Sum A		0.00	0.01	0.00
		14.92	15.02	15.13
Mg #		0.96	0.98	0.98

Thin Section: 18H01-2B2

Analysis		2B2-2bright	2B2-2dark	2B2-4
Weight %	MDL			
SiO_2	0.01	54.16	55.41	55.26
TiO_2	0.02	0.01	0.00	0.05
Al_2O_3	0.013	0.18	0.41	0.36
Fe_2O_3	N/A	1.76	0.00	0.00
FeO	0.12	18.14	13.98	17.58
MnO	0.134	0.86	0.58	0.79
MgO	0.013	20.66	22.01	20.86
CaO	0.014	0.60	0.44	0.39
K_2O	0.026	0.00	0.00	0.00
Na_2O	0.018	0.02	0.04	0.03
Total		96.39	92.87	95.31
Formula units based on 23 Oxygen				
Si		7.92	8.00	8.00
Al^{IV}		0.03	0.00	0.00
Ti		0.00	0.00	0.00
Fe^{2+}		0.05	0.00	0.00
SumT		8.00	8.00	8.00
Al^{VI}		0.00	0.19	0.10
Fe^{3+}		0.19	0.00	0.00
Ti		0.00	0.00	0.01
Mg		4.51	4.81	4.53
Fe^{2+}		0.30	0.00	0.37
Mn		0.00	0.00	0.00
Sum C		5.00	5.00	5.00
Mg		0.00	0.00	0.00
Fe^{2+}		1.86	1.71	1.77
Mn		0.11	0.07	0.10
Ca		0.09	0.07	0.06
Na		0.00	0.01	0.01
Sum B		2.06	1.86	1.94
Na		0.01	0.00	0.00
K		0.00	0.00	0.00
Sum A		0.01	0.00	0.00
		15.07	14.86	14.94
Mg #		0.94	1.00	0.92

Thin Section: 18H01-34A

	MDL					
Associated Ca-Amphibole*		34A-1	34A-1		34A-3	
Analysis		34A-1	34A-2	34A-3	34A-4	34A-5
Weight %	MDL					
SiO_2	0.01	55.32	55.71	58.76	55.24	57.21
TiO_2	0.02	0.01	0.00	0.00	0.00	0.00
Al_2O_3	0.013	0.07	0.12	0.09	0.15	0.14
Fe_2O_3	N/A	0.00	0.00	0.00	0.00	0.00
FeO	0.12	14.99	14.21	11.58	15.16	11.88
MnO	0.134	2.18	2.37	1.69	2.08	1.63
MgO	0.013	21.55	21.08	23.40	20.84	23.65
CaO	0.014	1.03	2.09	0.50	0.66	0.54
K_2O	0.026	0.00	0.00	0.00	0.00	0.00
Na_2O	0.018	0.02	0.03	0.00	0.04	0.03
Total		95.03	95.41	95.91	94.03	94.97
Formula units based on 23 Oxygen						
Si		8.00	8.00	8.00	8.00	8.00
Al^{IV}		0.00	0.00	0.00	0.00	0.00
SumT		8.00	8.00	8.00	8.00	8.00
Al^{VI}		0.05	0.08	0.25	0.12	0.16
Fe^{3+}		0.00	0.00	0.00	0.00	0.00
Ti		0.00	0.00	0.00	0.00	0.00
Mg		4.67	4.55	4.75	4.55	4.85
Fe^{2+}		0.28	0.38	0.00	0.32	0.00
Mn		0.00	0.00	0.00	0.00	0.00
Sum C		5.00	5.00	5.00	5.00	5.00
Mg		0.00	0.00	0.14	0.00	0.17
Fe^{2+}		1.54	1.34	1.36	1.54	1.41
Mn		0.27	0.29	0.20	0.26	0.20
Ca		0.16	0.32	0.08	0.10	0.08
Na		0.01	0.01	0.00	0.01	0.01
Sum B		1.97	1.96	1.77	1.91	1.86
Na		0.00	0.00	0.00	0.00	0.00
K		0.00	0.00	0.00	0.00	0.00
Sum A		0.00	0.00	0.00	0.00	0.00
Total		14.97	14.96	14.77	14.91	14.87
Mg #		0.94	0.92	1.00	0.93	1.00

*- Ca-amphiboles are small inclusions within the cummingtonites

Thin Section: 18H01-34B

Analysis		34B-1	34B-2
Weight %	MDL		
SiO_2	0.01	55.20	55.95
TiO_2	0.02	0.02	0.00
Al_2O_3	0.013	0.11	0.08
Fe_2O_3	N/A	0.00	0.00
FeO	0.12	17.26	17.75
MnO	0.134	1.24	1.32
MgO	0.013	21.42	20.86
CaO	0.014	0.65	0.62
K_2O	0.026	0.00	0.00
Na_2O	0.018	0.00	0.03
Total		95.71	96.46
Formula units based on 23 Oxygen			
Si		8.00	8.00
Al^{IV}		0.00	0.00
SumT		8.00	8.00
Al^{VI}		0.02	0.07
Fe^{3+}		0.00	0.00
Ti		0.00	0.00
Mg		4.63	4.48
Fe^{2+}		0.34	0.45
Mn		0.00	0.00
Sum C		5.00	5.00
Mg		0.00	0.00
Fe^{2+}		1.75	1.69
Mn		0.15	0.16
Ca		0.10	0.10
Na		0.00	0.01
Sum B		2.01	1.95
Na		0.00	0.00
K		0.00	0.00
Sum A		0.00	0.00
Total		15.00	14.95
Mg #		0.93	0.91

Appendix 2.5: Chromium and Iron Oxides

Thin Section: 18H01-1A

Analysis		1A-1	1A-2	1A-1	1A-2	1A-3	1B-4
Mineral*		Cr-mt	Cr-mt	Mt	Mt	Mt	Mt
Weight %	MDL						
SiO_2	0.014	0.10	0.08	0.03	0.08	0.09	0.09
TiO_2	0.021	0.09	0.32	0.09	0.04	0.05	0.07
Al_2O_3	0.016	0.31	0.15	0.02	0.05	0.03	0.01
Cr_2O_3	0.08	7.59	6.18	3.98	2.94	2.73	1.08
Fe_2O_3	N/A	59.21	58.86	61.72	62.47	63.49	64.21
FeO	0.088	29.61	29.43	30.86	31.23	31.74	32.10
MnO	0.098	0.25	0.38	0.00	0.23	0.17	0.18
MgO	0.019	0.12	0.04	0.07	0.02	0.00	0.09
CaO	0.018	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.111	0.00	0.23	0.28	0.37	0.32	0.18
V_2O_3	0.023	0.48	0.46	0.47	0.37	0.40	0.38
Total		97.75	96.14	97.52	97.79	99.01	98.40
Formula units based on 32 Oxygen							
Si		0.04	0.03	0.01	0.03	0.04	0.03
Al		0.14	0.07	0.01	0.02	0.02	0.00
Cr		2.37	1.98	1.28	0.95	0.87	0.27
Fe^{3+}		13.92	14.14	14.70	14.88	14.93	15.21
Ti		0.03	0.10	0.03	0.01	0.01	0.02
Sum B		16.49	16.32	16.03	15.89	15.87	15.53
Mg		0.07	0.02	0.04	0.00	0.00	0.04
Fe^{2+}		7.73	7.86	8.17	8.27	8.30	8.45
Mn		0.09	0.13	0.00	0.08	0.06	0.05
Ca		0.00	0.00	0.00	0.00	0.00	0.00
Ni		0.00	0.07	0.09	0.12	0.10	0.05
V		0.08	0.07	0.08	0.06	0.06	0.05
Sum A		7.96	8.16	8.38	8.53	8.52	8.64
Total		24.46	24.48	24.40	24.42	24.39	24.16

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-1B

Analysis		1B-1	1B-1	1B-2	1B-3
Mineral*		Cr-mt	Mt	Mt	Mt
Weight %	MDL				
SiO_2	0.014	0.05	0.08	0.09	0.06
TiO_2	0.021	0.07	0.06	0.08	0.03
Al_2O_3	0.016	0.09	0.01	0.00	0.02
Cr_2O_3	0.08	4.77	2.16	0.68	2.18
Fe_2O_3	N/A	60.36	62.17	63.97	62.88
FeO	0.088	30.18	31.08	31.99	31.44
MnO	0.098	0.18	0.25	0.00	0.08
MgO	0.019	0.19	0.17	0.06	0.14
CaO	0.018	0.00	0.00	0.00	0.00
NiO	0.111	0.46	0.10	0.28	0.14
V_2O_3	0.023	0.47	0.49	0.34	0.48
Total		96.83	96.56	97.50	97.46
Formula units based on 32 Oxygen					
Si		0.02	0.03	0.04	0.03
Al		0.04	0.00	0.00	0.01
Cr		1.53	0.70	0.22	0.70
Fe^{3+}		14.48	14.96	15.32	15.00
Ti		0.21	0.02	0.03	0.01
Sum B		16.29	15.72	15.60	15.75
Mg		0.12	0.10	0.04	0.09
Fe^{2+}		8.04	8.32	8.51	8.33
Mn		0.06	0.09	0.00	0.03
Ca		0.00	0.00	0.00	0.00
Ni		0.15	0.03	0.92	0.05
V		0.08	0.08	0.06	0.08
Sum A		8.45	8.62	9.52	8.57
Total		24.74	24.33	25.12	24.33

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-1C

Analysis		1C-1	1C-1	1C-1	1C-2	1C-3
Mineral*		Cr-mt	Ti-mt	Mt	Mt	Mt
Weight %	MDL					
SiO_2	0.014	0.07	0.10	0.12	0.11	0.10
TiO_2	0.021	0.15	6.08	0.02	0.08	0.02
Al_2O_3	0.016	0.48	0.05	0.01	0.00	0.00
Cr_2O_3	0.08	11.71	0.10	0.50	0.30	0.64
Fe_2O_3	N/A	55.44	56.77	63.68	63.61	64.16
FeO	0.088	27.72	28.39	31.84	31.80	32.08
MnO	0.098	0.71	0.00	0.03	0.07	0.26
MgO	0.019	0.18	0.09	0.04	0.10	0.02
CaO	0.018	0.01	0.00	0.00	0.02	0.00
NiO	0.111	0.09	0.02	0.08	0.24	0.14
V_2O_3	0.023	0.90	0.72	0.63	0.54	0.61
Total		97.46	92.32	96.94	96.86	98.03
Formula units based on 32 Oxygen						
Si		0.03	0.04	0.04	0.04	0.03
Al		0.22	0.03	0.00	0.00	0.00
Cr		3.57	0.03	0.13	0.08	0.16
Fe^{3+}		12.98	13.90	15.30	15.32	15.27
Ti		0.04	1.87	0.01	0.02	0.00
Sum B		16.85	15.86	15.47	15.45	15.46
Mg		0.10	0.06	0.02	0.05	0.01
Fe^{2+}		7.21	7.72	8.50	8.51	8.48
Mn		0.23	0.00	0.01	0.02	0.07
Ca		0.00	0.00	0.00	0.09	0.00
Ni		0.03	0.00	0.02	0.06	0.04
V		0.14	0.12	0.08	0.07	0.08
Sum A		7.71	7.90	8.63	8.80	8.67
Total		24.56	23.76	24.10	24.25	24.13

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-2A

Analysis		2A-1	2A-2	2A-3	2A-1
Mineral*		Cr-mt	Cr-mt**	Cr-mt**	Mt
Weight %	MDL				
SiO_2	0.014	0.00	0.00	0.02	0.06
TiO_2	0.021	0.10	0.06	0.17	0.11
Al_2O_3	0.016	0.05	0.04	0.05	0.03
Cr_2O_3	0.08	4.50	3.10	3.51	2.93
Fe_2O_3	N/A	60.72	62.19	60.89	62.13
FeO	0.088	30.36	31.09	30.44	31.07
MnO	0.098	0.21	0.00	0.22	0.00
MgO	0.019	0.14	0.08	0.12	0.08
CaO	0.018	0.00	0.02	0.03	0.00
NiO	0.111	0.17	0.21	0.15	0.19
V_2O_3	0.023	0.27	0.28	0.28	0.29
Total		96.53	97.08	95.87	96.89
Formula units based on 32 Oxygen					
Si		0.00	0.00	0.01	0.02
Al		0.05	0.02	0.02	0.02
Cr		1.14	1.00	1.14	0.95
Fe^{3+}		14.59	14.90	14.74	14.90
Ti		0.10	0.02	0.05	0.04
Sum B		15.88	15.94	15.97	15.93
Mg		0.14	0.05	0.07	0.05
Fe^{2+}		8.11	8.28	8.19	8.28
Mn		0.21	0.00	0.08	0.00
Ca		0.00	0.01	0.01	0.00
Ni		0.18	0.07	0.05	0.06
V		0.27	0.05	0.05	0.05
Sum A		8.90	8.45	8.45	8.44
Total		24.78	24.39	24.42	24.37

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

**- Chromian magnetites have ilmenite (1& 2, respectively) inclusions

Thin Section: 18H01-2B1

Analysis		2B1-1	2B1-1	2B1-2	2B1-2	2B1-3	2B1-3
Mineral*		Cr-mt	Cr	Cr-mt	Cr	Cr-mt	Cr
Rim/Core		Rim1	Core1	Rim2	Core2	Rim3	Core3
Weight %	MDL						
SiO_2	0.014	0.07	0.04	0.10	0.15	0.13	0.07
TiO_2	0.021	0.13	0.25	0.09	0.18	0.22	0.35
Al_2O_3	0.016	0.51	1.74	0.46	1.70	0.79	3.00
Cr_2O_3	0.08	13.04	31.56	11.59	24.16	13.32	36.38
Fe_2O_3	N/A	54.40	41.87	54.90	46.50	54.34	35.94
FeO	0.088	27.20	20.94	27.45	23.25	27.17	17.97
MnO	0.098	0.58	1.35	0.22	0.34	0.43	1.26
MgO	0.019	0.00	0.10	0.05	0.08	0.13	0.20
CaO	0.018	0.00	0.00	0.00	0.00	0.03	0.00
NiO	0.111	0.17	0.06	0.12	0.00	0.29	0.13
V_2O_3	0.023	0.48	0.58	0.50	0.57	0.47	0.55
Total		96.58	98.50	95.48	96.92	97.33	95.84
Formula units based on 32 Oxygen							
Si		0.03	0.02	0.04	0.05	0.05	0.02
Al		0.24	0.71	0.21	0.72	0.36	1.20
Cr		4.00	8.58	3.62	6.88	4.03	9.76
Fe^{3+}		12.85	9.36	13.13	10.64	12.70	8.11
Ti		0.04	0.07	0.03	0.05	0.06	0.09
Sum B		17.15	18.73	17.03	18.35	17.21	19.18
Mg		0.00	0.05	0.03	0.04	0.07	0.10
Fe^{2+}		7.14	5.20	7.30	5.91	7.06	4.51
Mn		0.19	0.39	0.07	0.10	0.14	0.36
Ca		0.00	0.00	0.00	0.00	0.01	0.00
Ni		0.05	0.02	0.04	0.00	0.09	0.03
V		0.07	0.08	0.08	0.08	0.07	0.08
Sum A		7.46	5.74	7.52	6.14	7.45	5.08
Total		24.61	24.47	24.55	24.49	24.66	24.25

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-2B2

Analysis		2B2-1	2B2-1	2B2-2
Mineral*		Cr-mt	Cr	Cr-mt
Rim/Core		Rim1	Core1	Rim2
Weight %	MDL			
SiO_2	0.014	0.15	0.05	0.04
TiO_2	0.021	0.19	0.53	0.63
Al_2O_3	0.016	2.32	3.17	1.06
Cr_2O_3	0.08	15.03	35.14	16.33
Fe_2O_3	N/A	52.57	35.82	51.18
FeO	0.088	26.28	17.91	25.59
MnO	0.098	0.56	1.31	0.67
MgO	0.019	1.03	0.21	0.07
CaO	0.018	0.00	0.00	0.00
NiO	0.111	0.20	0.03	0.05
V_2O_3	0.023	0.47	0.53	0.43
Total		98.80	94.70	96.04
Formula units based on 32 Oxygen				
Si		0.06	0.02	0.02
Al		1.00	1.28	0.48
Cr		4.34	9.53	4.90
Fe^{3+}		11.90	8.16	12.01
Ti		0.05	0.14	0.18
Sum B		17.35	19.13	17.57
Mg		0.56	0.11	0.04
Fe^{2+}		6.61	4.54	6.67
Mn		0.17	0.38	0.22
Ca		0.00	0.00	0.00
Ni		0.06	0.01	0.01
V		0.07	0.07	0.07
Sum A		7.47	5.11	7.01
Total		24.82	24.24	24.58

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-2C

Analysis		2C-1	2C-2	2C-3	2C-4	2C-5
Mineral*		Mt	Mt	Mt	Mt	Mt
Weight %	MDL					
SiO_2	0.014	0.08	0.02	0.10	0.06	0.06
TiO_2	0.021	0.05	0.07	0.04	0.06	0.09
Al_2O_3	0.016	0.05	0.00	0.04	0.00	0.00
Cr_2O_3	0.08	1.10	0.90	0.66	0.22	0.83
Fe_2O_3	N/A	63.39	64.44	65.54	65.52	62.75
FeO	0.088	31.70	32.22	32.77	32.76	31.37
MnO	0.098	0.05	0.04	0.05	0.00	0.00
MgO	0.019	0.14	0.08	0.07	0.08	0.12
CaO	0.018	0.02	0.00	0.00	0.00	0.00
NiO	0.111	0.41	0.00	0.17	0.00	0.17
V_2O_3	0.023	0.50	0.55	0.51	0.58	0.55
Total		97.49	98.32	99.95	99.27	95.93
Formula units based on 32 Oxygen						
Si		0.03	0.01	0.03	0.02	0.02
Al		0.03	0.00	0.02	0.00	0.00
Cr		0.36	0.29	0.16	0.05	0.21
Fe^{3+}		15.18	15.26	15.29	15.37	15.24
Ti		0.01	0.02	0.01	0.02	0.02
Sum B		15.61	15.58	15.50	15.46	15.49
Mg		0.09	0.05	0.03	0.04	0.06
Fe^{2+}		8.43	8.48	8.49	8.54	8.47
Mn		0.02	0.01	0.01	0.00	0.00
Ca		0.01	0.00	0.00	0.00	0.00
Ni		0.13	0.00	0.04	0.00	0.04
V		0.08	0.09	0.06	0.07	0.07
Sum A		8.77	8.63	8.64	8.65	8.64
Total		24.38	24.21	24.14	24.11	24.13

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-2D

Analysis		2D-1	2D-1	2D-2	2D-3	2D-4	2D-5
Mineral*		Cr-mt	Mt	Mt	Mt	Mt	Mt
Weight %	MDL						
SiO_2	0.014	0.05	0.04	0.06	0.04	0.07	0.13
TiO_2	0.021	0.23	0.08	0.08	0.07	0.06	0.05
Al_2O_3	0.016	0.09	0.07	0.00	0.03	0.00	0.04
Cr_2O_3	0.08	6.56	3.62	2.11	3.00	0.61	1.87
Fe_2O_3	N/A	59.50	63.49	63.00	63.04	64.77	64.30
FeO	0.088	29.75	31.75	31.50	31.52	32.39	32.15
MnO	0.098	0.26	0.15	0.09	0.00	0.00	0.00
MgO	0.019	0.16	0.23	0.09	0.19	0.16	0.16
CaO	0.018	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.111	0.21	0.00	0.23	0.39	0.12	0.38
V_2O_3	0.023	0.44	0.42	0.42	0.36	0.39	0.39
Total		97.24	99.85	97.59	98.63	98.57	99.46
Formula units based on 32 Oxygen							
Si		0.02	0.02	0.02	0.02	0.03	0.05
Al		0.04	0.03	0.00	0.02	0.00	0.02
Cr		2.07	1.13	0.68	0.96	0.20	0.59
Fe^{3+}		14.13	14.73	15.03	14.88	15.31	15.07
Ti		0.07	0.02	0.02	0.02	0.02	0.01
Sum B		16.34	15.93	15.76	15.89	15.55	15.74
Mg		0.09	0.13	0.06	0.12	0.10	0.10
Fe^{2+}		7.85	8.18	8.35	8.27	8.51	8.37
Mn		0.09	0.05	0.03	0.00	0.00	0.00
Ca		0.00	0.00	0.00	0.00	0.00	0.00
Ni		0.07	0.00	0.07	0.13	0.04	0.12
V		0.07	0.07	0.07	0.06	0.06	0.06
Sum A		8.17	8.44	8.59	8.57	8.71	8.65
Total		24.50	24.37	24.35	24.45	24.26	24.39

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-34A

Analysis		34A-1	34A-1	34A-2	34A-3
Mineral*		Cr-mt	Mt	Cr-mt	Cr-mt
Rim/Core		Core1	Rim1		
Weight %	MDL				
SiO_2	0.014	0.06	0.07	0.07	0.08
TiO_2	0.021	0.42	0.09	0.10	0.18
Al_2O_3	0.016	0.88	0.07	0.10	0.22
Cr_2O_3	0.08	19.84	3.85	6.05	6.55
Fe_2O_3	N/A	51.00	62.70	60.00	60.86
FeO	0.088	25.50	31.35	30.00	30.43
MnO	0.098	1.23	0.08	0.44	0.44
MgO	0.019	0.20	0.05	0.10	0.07
CaO	0.018	0.02	0.02	0.00	0.00
NiO	0.111	0.21	0.21	0.27	0.00
V_2O_3	0.023	0.33	0.17	0.24	0.20
Total		99.69	98.66	97.35	99.02
Formula units based on 32 Oxygen					
Si		0.23	0.03	0.03	0.03
Al		0.38	0.03	0.05	0.10
Cr		5.69	1.22	1.92	2.03
Fe^{3+}		11.53	14.75	14.27	14.17
Ti		0.11	0.03	0.03	0.05
Sum B		17.94	16.06	16.29	16.38
Mg		0.11	0.03	0.06	0.04
Fe^{2+}		6.41	8.20	7.93	7.87
Mn		0.38	0.03	0.15	0.15
Ca		0.01	0.00	0.00	0.00
Ni		0.06	0.07	0.09	0.00
V		0.05	0.03	0.04	0.03
Sum A		7.01	8.35	8.26	8.09
Total		24.95	24.42	24.56	24.47

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-34B

Analysis		34B-1	34B-2	34B-1
Mineral*		Cr-mt	Cr-mt	Mt
Weight %	MDL			
SiO_2	0.014	0.07	0.07	0.12
TiO_2	0.021	0.13	0.09	0.11
Al_2O_3	0.016	0.17	0.02	0.02
Cr_2O_3	0.08	6.69	4.17	0.29
Fe_2O_3	N/A	61.22	61.92	65.74
FeO	0.088	30.61	30.96	32.87
MnO	0.098	0.12	0.28	0.12
MgO	0.019	0.08	0.03	0.02
CaO	0.018	0.02	0.00	0.04
NiO	0.111	0.08	0.00	0.00
V_2O_3	0.023	0.28	0.19	0.25
Total		99.48	97.74	99.58
Formula units based on 32 Oxygen				
Si		0.03	0.03	0.04
Al		0.08	0.01	0.01
Cr		2.07	1.33	0.07
Fe^{3+}		14.19	14.68	15.38
Ti		0.04	0.03	0.03
Sum B		16.40	16.08	15.52
Mg		0.05	0.02	0.01
Fe^{2+}		7.89	8.16	8.54
Mn		0.04	0.10	0.03
Ca		0.01	0.00	0.01
Ni		0.02	0.00	0.00
V		0.04	0.03	0.03
Sum A		8.05	8.30	8.63
Total		24.46	24.38	24.15

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Thin Section: 18H01-34C

Analysis		34C-1	34C-2
Mineral*		Mt	Mt
Weight %	MDL		
SiO_2	0.014	0.08	0.04
TiO_2	0.021	0.00	0.18
Al_2O_3	0.016	0.08	0.03
Cr_2O_3	0.08	1.23	3.84
Fe_2O_3	N/A	65.47	61.91
FeO	0.088	32.73	30.95
MnO	0.098	0.00	0.01
MgO	0.019	0.04	0.09
CaO	0.018	0.00	0.01
NiO	0.111	0.17	0.16
V_2O_3	0.023	0.32	0.27
Total		100.11	97.49
Formula units based on 32 Oxygen			
Si		0.03	0.02
Al		0.04	0.01
Cr		0.39	1.23
Fe^{3+}		15.24	14.73
Ti		0.00	0.06
Sum B		15.69	16.04
Mg		0.02	0.05
Fe^{2+}		8.47	8.18
Mn		0.00	0.00
Ca		0.00	0.00
Ni		0.05	0.05
V		0.05	0.04
Sum A		8.59	8.33
Total		24.29	24.38

*Mineral Abbreviations:
Cr-mt: Chromian magnetite
Ti-mt: Titano magnetite
Mt: Magnetite
Cr: Chromite

Appendix 2.6: Ilmenite

Thin Section: 18H01-1A

Analysis		1A-1
Weight %	MDL	
SiO_2	0.013	0.06
TiO_2	0.023	48.48
Al_2O_3	0.015	0.02
Cr_2O_3	0.08	0.28
Fe_2O_3	N/A	0.00
FeO	0.088	45.09
MnO	0.094	2.75
MgO	0.017	0.50
CaO	0.015	0.04
NiO	0.108	0.16
V_2O_3	0.024	0.00
Total		97.39
Formula units based on 6 Oxygen		
Ti		1.92
Si		0.00
Fe^{3+}		0.00
Cr		0.01
Al		0.00
V		0.00
Sum B		1.93
Fe^{2+}		1.98
Mg		0.04
Mn		0.12
Ca		0.00
Ni		0.01
Sum A		2.15
Total		4.08

Thin Section: 18H01-1B

Analysis		1B-1	1B-2	1B-3
Weight %	MDL			
SiO_2	0.013	0.05	0.05	0.09
TiO_2	0.023	49.16	50.47	49.53
Al_2O_3	0.015	0.00	0.02	0.00
Cr_2O_3	0.08	0.19	0.16	0.28
Fe_2O_3	N/A	0.00	0.00	0.00
FeO	0.088	44.98	43.93	45.22
MnO	0.094	1.92	2.13	1.70
MgO	0.017	1.56	1.53	1.50
CaO	0.015	0.00	0.01	0.01
NiO	0.108	0.04	0.12	0.00
V_2O_3	0.024	0.07	0.00	0.02
Total		97.96	98.39	98.31
Formula units based on 6 Oxygen				
Ti		1.91	1.95	1.92
Si		0.00	0.00	0.00
Fe^{3+}		0.00	0.00	0.00
Cr		0.01	0.01	0.01
Al		0.00	0.00	0.00
V		0.00	0.00	0.00
Sum B		1.92	1.96	1.93
Fe^{2+}		1.95	1.88	1.95
Mg		0.12	0.12	0.12
Mn		0.08	0.09	0.07
Ca		0.00	0.00	0.00
Ni		0.00	0.00	0.00
Sum A		2.15	2.09	2.14
Total		4.08	4.05	4.06

Thin Section: 18H01-1C

Analysis		1C-1	1C-2	1C-3	1C-4	1C-5
Weight %	MDL					
SiO_2	0.013	0.08	0.12	0.09	0.04	0.06
TiO_2	0.023	50.50	49.37	49.20	49.60	47.66
Al_2O_3	0.015	0.00	0.02	0.00	0.02	0.00
Cr_2O_3	0.08	0.03	0.03	0.17	0.00	0.02
Fe_2O_3	N/A	0.00	0.00	0.00	0.00	0.00
FeO	0.088	43.55	45.02	44.93	46.90	47.39
MnO	0.094	2.37	2.04	2.57	2.62	2.28
MgO	0.017	0.82	0.85	0.93	0.55	0.49
CaO	0.015	0.00	0.00	0.02	0.00	0.00
NiO	0.108	0.08	0.05	0.00	0.17	0.00
V_2O_3	0.024	0.00	0.02	0.07	0.00	0.00
Total		97.41	97.52	97.87	99.73	97.69
Formula units based on 6 Oxygen						
Ti		1.97	1.93	1.92	1.91	1.88
Si		0.00	0.00	0.00	0.00	0.00
Fe^{3+}		0.00	0.00	0.00	0.00	0.00
Cr		0.00	0.00	0.01	0.00	0.00
Al		0.00	0.00	0.00	0.00	0.00
V		0.00	0.00	0.00	0.00	0.00
Sum B		1.97	1.93	1.93	1.91	1.88
Fe^{2+}		1.89	1.96	1.95	2.01	2.08
Mg		0.06	0.07	0.07	0.04	0.04
Mn		0.10	0.09	0.11	0.11	0.10
Ca		0.00	0.00	0.00	0.00	0.00
Ni		0.00	0.00	0.00	0.00	0.00
Sum A		2.05	2.12	2.13	2.17	2.22
Total		4.02	4.05	4.06	4.08	4.11

Thin Section: 18H01-2A

Associated Chromian magnetite*		2A-4
Analysis		2A-2
Weight %	MDL	
SiO_2	0.013	0.01
TiO_2	0.023	51.14
Al_2O_3	0.015	0.00
Cr_2O_3	0.08	0.34
Fe_2O_3	N/A	0.00
FeO	0.088	38.50
MnO	0.094	5.62
MgO	0.017	1.97
CaO	0.015	0.00
NiO	0.108	0.04
V_2O_3	0.024	0.27
Total		97.88
Formula units based on 6 Oxygen		
Ti		1.96
Si		0.00
Fe^{3+}		0.00
Cr		0.01
Al		0.00
V		0.01
Sum B		1.99
Fe^{2+}		1.64
Mg		0.15
Mn		0.24
Ca		0.00
Ni		0.00
Sum A		2.04
Total		4.02

*- Ilmenites are small inclusions in the chromian magneites

Thin Section: 18H01-2B1

Associated Rutile*				2B1-2
Analysis		2B1-1	2B1-2	2B1-3
Weight %	MDL			
SiO_2	0.013	0.08	0.08	0.09
TiO_2	0.023	50.74	50.35	50.41
Al_2O_3	0.015	0.00	0.00	0.00
Cr_2O_3	0.08	0.53	0.40	0.24
Fe_2O_3	N/A	0.00	0.00	0.00
FeO	0.088	45.28	43.73	44.35
MnO	0.094	2.41	2.38	2.04
MgO	0.017	0.34	0.22	0.29
CaO	0.015	0.00	0.00	0.00
NiO	0.108	0.00	0.00	0.00
V_2O_3	0.024	0.00	0.20	0.02
Total		99.19	97.34	97.29
Formula units based on 6 Oxygen				
Ti		1.95	1.97	1.97
Si		0.00	0.00	0.00
Fe^{3+}		0.00	0.00	0.00
Cr		0.02	0.02	0.01
Al		0.00	0.00	0.00
V		0.00	0.00	0.00
Sum B		1.97	1.98	1.98
Fe^{2+}		1.93	1.90	1.93
Mg		0.03	0.02	0.02
Mn		0.10	0.11	0.09
Ca		0.00	0.00	0.00
Ni		0.00	0.00	0.00
Sum A		2.06	2.02	2.04
Total		4.03	4.00	4.02

* - Rutiles are thick cores of the ilmenites

Thin Section: 18H01-2B2

Associated Rutile*		2B2-1	2B2-2	2B2-3
Analysis		2B2-1	2B2-2	2B2-3
Weight %	MDL			
SiO_2	0.013	0.12	0.04	0.05
TiO_2	0.023	50.52	49.68	50.61
Al_2O_3	0.015	0.00	0.00	0.02
Cr_2O_3	0.08	0.08	0.32	0.38
Fe_2O_3	N/A	0.00	0.00	0.00
FeO	0.088	45.50	45.15	44.66
MnO	0.094	2.00	1.87	1.95
MgO	0.017	0.31	0.32	0.29
CaO	0.015	0.02	0.02	0.00
NiO	0.108	0.00	0.00	0.00
V_2O_3	0.024	0.10	0.16	0.07
Total		98.60	97.53	98.04
Formula units based on 6 Oxygen				
Ti		1.95	1.95	1.97
Si		0.01	0.00	0.00
Fe^{3+}		0.00	0.00	0.00
Cr		0.00	0.01	0.02
Al		0.00	0.00	0.00
V		0.00	0.00	0.00
Sum B		1.96	1.96	1.98
Fe^{2+}		1.96	1.97	1.93
Mg		0.02	0.02	0.02
Mn		0.09	0.08	0.09
Ca		0.00	0.00	0.00
Ni		0.00	0.00	0.00
Sum A		2.07	2.07	2.04
Total		4.03	4.03	4.02

* - Rutiles are thick cores of the ilmenites

Thin Section: 18H01-2C

Analysis		2C-1	2C-2	2C-3
Weight %	MDL			
SiO_2	0.013	0.06	0.07	0.07
TiO_2	0.023	50.17	48.87	49.21
Al_2O_3	0.015	0.00	0.02	0.00
Cr_2O_3	0.08	0.15	0.00	0.17
Fe_2O_3	N/A	0.00	0.00	0.00
FeO	0.088	43.67	45.67	45.70
MnO	0.094	3.28	2.02	1.95
MgO	0.017	1.35	1.21	1.48
CaO	0.015	0.00	0.00	0.00
NiO	0.108	0.00	0.10	0.07
V_2O_3	0.024	0.05	0.00	0.02
Total		98.73	97.84	98.64
Formula units based on 6 Oxygen				
Ti		1.93	1.91	1.91
Si		0.00	0.00	0.00
Fe^{3+}		0.00	0.00	0.00
Cr		0.01	0.00	0.01
Al		0.00	0.00	0.00
V		0.00	0.00	0.00
Sum B		1.94	1.91	1.92
Fe^{2+}		1.87	1.99	1.97
Mg		0.10	0.09	0.11
Mn		0.14	0.09	0.09
Ca		0.00	0.00	0.00
Ni		0.00	0.00	0.00
Sum A		2.12	2.17	2.17
Total		4.06	4.08	4.09

Thin Section: 18H01-2D

Analysis		2D-1	2D-2
Weight %	MDL		
SiO_2	0.013	0.06	0.06
TiO_2	0.023	46.27	49.31
Al_2O_3	0.015	0.00	0.00
Cr_2O_3	0.08	0.16	0.07
Fe_2O_3	N/A	0.00	0.00
FeO	0.088	47.28	45.63
MnO	0.094	2.12	2.47
MgO	0.017	1.43	1.49
CaO	0.015	0.01	0.00
NiO	0.108	0.12	0.00
V_2O_3	0.024	0.01	0.00
Total		97.46	98.88
Formula units based on 6 Oxygen			
Ti		1.84	1.90
Si		0.00	0.00
Fe^{3+}		0.00	0.00
Cr		0.01	0.00
Al		0.00	0.00
V		0.00	0.00
Sum B		1.85	1.90
Fe^{2+}		2.09	1.96
Mg		0.11	0.11
Mn		0.10	0.11
Ca		0.00	0.00
Ni		0.01	0.00
Sum A		2.31	2.18
Total		4.16	4.08

Thin Section: 18H01-34A

Analysis		34A-1
Weight %	MDL	
SiO_2	0.013	0.07
TiO_2	0.023	50.42
Al_2O_3	0.015	0.00
Cr_2O_3	0.08	0.05
Fe_2O_3	N/A	0.00
FeO	0.088	41.60
MnO	0.094	4.56
MgO	0.017	0.44
CaO	0.015	0.00
NiO	0.108	0.07
V_2O_3	0.024	0.00
Total		97.06
Formula units based on 6 Oxygen		
Ti		1.97
Si		0.00
Fe^{3+}		0.00
Cr		0.00
Al		0.00
V		0.00
Sum B		1.97
Fe^{2+}		1.81
Mg		0.03
Mn		0.20
Ca		0.00
Ni		0.00
Sum A		2.05
Total		4.02

Thin Section: 18H01-34B

Analysis		34B-1
Weight %	MDL	
SiO_2	0.013	0.00
TiO_2	0.023	49.67
Al_2O_3	0.015	0.00
Cr_2O_3	0.08	0.35
Fe_2O_3	N/A	0.00
FeO	0.088	46.06
MnO	0.094	2.20
MgO	0.017	0.31
CaO	0.015	0.02
NiO	0.108	0.00
V_2O_3	0.024	0.00
Total		98.38
Formula units based on 6 Oxygen		
Ti		1.93
Si		0.00
Fe^{3+}		0.00
Cr		0.01
Al		0.00
V		0.00
Sum B		1.95
Fe^{2+}		1.99
Mg		0.02
Mn		0.10
Ca		0.00
Ni		0.00
Sum A		2.11
Total		4.06

Thin Section: 18H01-34C

Analysis		34C-1	34C-2
Weight %	MDL		
SiO_2	0.013	0.02	0.04
TiO_2	0.023	53.31	49.90
Al_2O_3	0.015	0.00	0.01
Cr_2O_3	0.08	0.23	0.00
Fe_2O_3	N/A	0.00	0.00
FeO	0.088	44.68	44.31
MnO	0.094	3.56	3.13
MgO	0.017	0.84	0.78
CaO	0.015	0.00	0.02
NiO	0.108	0.01	0.04
V_2O_3	0.024	0.00	0.00
Total		102.39	98.11
Formula units based on 6 Oxygen			
Ti		1.97	1.94
Si		0.00	0.00
Fe^{3+}		0.00	0.00
Cr		0.01	0.00
Al		0.00	0.00
V		0.00	0.00
Sum B		1.98	1.94
Fe^{2+}		1.84	1.92
Mg		0.06	0.06
Mn		0.15	0.14
Ca		0.00	0.00
Ni		0.00	0.00
Sum A		2.05	2.11
Total		4.03	4.05

Appendix 2.7
Thin Section: 18H01-2B1

Associated Ilmenite*		2B1-3
Analysis		2B1-2
Weight %	MDL	
SiO_2	0.012	0.11
TiO_2	0.022	99.25
Al_2O_3	0.012	0.00
Cr_2O_3	0.09	0.50
Fe_2O_3	N/A	0.52
FeO	0.097	0.00
MnO	0.102	0.00
MgO	0.014	0.00
CaO	0.015	0.00
NiO	0.104	0.00
V_2O_3	0.024	0.22
Total		100.53
Formula units based on 2 Oxygen		
Ti		0.99
Si		0.00
Cr		0.01
Al		0.00
V		0.00
Fe^{3+}		0.01
Fe^{2+}		0.00
Mg		0.00
Mn		0.00
Ca		0.00
Ni		0.00
Sum B		1.01
Total		1.01

*- Ilmenites are thick rims around the rutiles

Thin Section: 18H01-2B2

	MDL			
Associated Ilmenite		2B2-1	2B2-2	2B2-3
Analysis		2B2-1	2B2-2	2B2-3
Weight %	MDL			
SiO_2	0.012	0.05	0.06	0.03
TiO_2	0.022	99.68	98.33	98.70
Al_2O_3	0.012	0.00	0.03	0.02
Cr_2O_3	0.09	0.38	0.23	0.59
Fe_2O_3	N/A	0.57	0.65	0.76
FeO	0.097	0.00	0.00	0.00
MnO	0.102	0.00	0.00	0.04
MgO	0.014	0.02	0.02	0.01
CaO	0.015	0.02	0.00	0.00
NiO	0.104	0.00	0.00	0.00
V_2O_3	0.024	0.12	0.39	0.30
Total		100.57	99.34	100.42
Formula units based on 2 Oxygen				
Ti		0.99	0.99	0.99
Si		0.00	0.00	0.00
Cr		0.00	0.00	0.01
Al		0.00	0.00	0.00
V		0.00	0.00	0.00
Fe^{3+}		0.01	0.01	0.01
Fe^{2+}		0.00	0.00	0.00
Mg		0.00	0.00	0.00
Mn		0.00	0.00	0.00
Ca		0.00	0.00	0.00
Ni		0.00	0.00	0.00
Sum B		1.00	1.00	1.01
Total		1.00	1.00	1.01

*- Ilmenites are thick rims around the rutiles

Appendix 2.8: R Code for Probe Data Graphs

```
talc <- read.csv(file="talcs.csv")
talc
attach(talc)

dev.new()
plot(FeO~MgO, xlab="MgO Wt. %", ylab="FeO Wt. %", type="n", main="Talc")
colors()[c(12,50,576,118,421,453,503,455,26,592,399)]
points(talc[c(1:4),7],talc[c(1:4),5], col="aquamarine4", pch=15, cex=0.7)
points(talc[c(5:6),7],talc[c(5:6),5], col="chartreuse3", pch=19, cex=0.7)
points(talc[c(7:10),7],talc[c(7:10),5], col="seagreen2", pch=15, cex=0.7)
points(talc[c(11:13),7],talc[c(11:13),5], col="deeppink2", pch=19, cex=0.7)
points(talc[c(14:17),7],talc[c(14:17),5], col="lightpink2", pch=15, cex=0.7)
points(talc[c(18:21),7],talc[c(18:21),5], col="magenta3", pch=15, cex=0.7)
points(talc[c(22:25),7],talc[c(22:25),5], col="orangered", pch=19, cex=0.7)
points(talc[c(26:27),7],talc[c(26:27),5], col="maroon", pch=19, cex=0.7)
points(talc[c(28),7],talc[c(28),5], col="blue", pch=15, cex=0.7)
points(talc[c(29:31),7],talc[c(29:31),5], col="skyblue3", pch=15, cex=0.7)
points(talc[c(32:34),7],talc[c(32:34),5], col="lightblue", pch=19, cex=0.7)

dev.new()
plot(FeO~Al2O3, xlab="Al2O3 Wt. %", ylab="FeO Wt. %", type="n", main="Talc")
points(talc[c(1:4),4],talc[c(1:4),5], col="aquamarine4", pch=15, cex=0.7)
points(talc[c(5:6),4],talc[c(5:6),5], col="chartreuse3", pch=19, cex=0.7)
points(talc[c(7:10),4],talc[c(7:10),5], col="seagreen2", pch=15, cex=0.7)
points(talc[c(11:13),4],talc[c(11:13),5], col="deeppink2", pch=19, cex=0.7)
points(talc[c(14:17),4],talc[c(14:17),5], col="lightpink2", pch=15, cex=0.7)
points(talc[c(18:21),4],talc[c(18:21),5], col="magenta3", pch=15, cex=0.7)
points(talc[c(22:25),4],talc[c(22:25),5], col="orangered", pch=19, cex=0.7)
points(talc[c(26:27),4],talc[c(26:27),5], col="maroon", pch=19, cex=0.7)
points(talc[c(28),4],talc[c(28),5], col="blue", pch=15, cex=0.7)
points(talc[c(29:31),4],talc[c(29:31),5], col="skyblue3", pch=15, cex=0.7)
points(talc[c(32:34),4],talc[c(32:34),5], col="lightblue", pch=19, cex=0.7)

dev.new()
plot(MgN~AlApfu, xlab="Al apfu", ylab="Mg #", type="n", main="Talc")
points(talc[c(1:4),11],talc[c(1:4),10], col="aquamarine4", pch=15, cex=0.7)
points(talc[c(5:6),11],talc[c(5:6),10], col="chartreuse3", pch=19, cex=0.7)
points(talc[c(7:10),11],talc[c(7:10),10], col="seagreen2", pch=15, cex=0.7)
points(talc[c(11:13),11],talc[c(11:13),10], col="deeppink2", pch=19, cex=0.7)
points(talc[c(14:17),11],talc[c(14:17),10], col="lightpink2", pch=15, cex=0.7)
points(talc[c(18:21),11],talc[c(18:21),10], col="magenta3", pch=15, cex=0.7)
points(talc[c(22:25),11],talc[c(22:25),10], col="orangered", pch=19, cex=0.7)
points(talc[c(26:27),11],talc[c(26:27),10], col="maroon", pch=19, cex=0.7)
points(talc[c(28),11],talc[c(28),10], col="blue", pch=15, cex=0.7)
points(talc[c(29:31),11],talc[c(29:31),10], col="skyblue3", pch=15, cex=0.7)
points(talc[c(32:34),11],talc[c(32:34),10], col="lightblue", pch=19, cex=0.7)
```

```
chlorite <- read.csv(file="chlorites.csv")
chlorite
attach(chlorite)


dev.new()
plot(FeO~NiO, xlab="NiO Wt. %", ylab="FeO Wt. %", type="n", main="Chlorite")
points(chlorite[c(1:6),10],chlorite[c(1:6),6], col="aquamarine4", pch=15, cex=0.7)
points(chlorite[c(7:10),10],chlorite[c(7:10),6], col="chartreuse3", pch=19, cex=0.7)
points(chlorite[c(11:13),10],chlorite[c(11:13),6], col="seagreen2", pch=15, cex=0.7)
points(chlorite[c(14:16),10],chlorite[c(14:16),6], col="deeppink2", pch=19, cex=0.7)
points(chlorite[c(17:21),10],chlorite[c(17:21),6], col="lightpink2", pch=15, cex=0.7)
points(chlorite[c(22:24),10],chlorite[c(22:24),6], col="magenta3", pch=15, cex=0.7)
points(chlorite[c(25:28),10],chlorite[c(25:28),6], col="orangered", pch=19, cex=0.7)
points(chlorite[c(29:30),10],chlorite[c(29:30),6], col="maroon", pch=19, cex=0.7)
points(chlorite[c(31),10],chlorite[c(31),6], col="blue", pch=15, cex=0.7)
points(chlorite[c(32:34),10],chlorite[c(32:34),6], col="skyblue3", pch=15, cex=0.7)
points(chlorite[c(35),10],chlorite[c(35),6], col="lightblue", pch=19, cex=0.7)

dev.new()
plot(AlVac~MgN, xlab="Mg #", ylab="Al + vacancies", type="n", main="Chlorite: Zane & Weiss")
points(chlorite[c(1:6),11],chlorite[c(1:6),13], col="aquamarine4", pch=15, cex=0.7)
points(chlorite[c(7:10),11],chlorite[c(7:10),13], col="chartreuse3", pch=19, cex=0.7)
points(chlorite[c(11:13),11],chlorite[c(11:13),13], col="seagreen2", pch=15, cex=0.7)
points(chlorite[c(14:16),11],chlorite[c(14:16),13], col="deeppink2", pch=19, cex=0.7)
points(chlorite[c(17:21),11],chlorite[c(17:21),13], col="lightpink2", pch=15, cex=0.7)
points(chlorite[c(22:24),11],chlorite[c(22:24),13], col="magenta3", pch=15, cex=0.7)
points(chlorite[c(25:28),11],chlorite[c(25:28),13], col="orangered", pch=19, cex=0.7)
points(chlorite[c(29:30),11],chlorite[c(29:30),13], col="maroon", pch=19, cex=0.7)
points(chlorite[c(31),11],chlorite[c(31),13], col="blue", pch=15, cex=0.7)
points(chlorite[c(32:34),11],chlorite[c(32:34),13], col="skyblue3", pch=15, cex=0.7)
points(chlorite[c(35),11],chlorite[c(35),13], col="lightblue", pch=19, cex=0.7)


dev.new()
plot(MgN~ SiApfu, xlab="Mg #", ylab=" Si apfu ", type="n", main="Chlorite: Zane & Weiss")
points(chlorite[c(1:6),14],chlorite[c(1:6),11], col="aquamarine4", pch=15, cex=0.7)
points(chlorite[c(7:10),14],chlorite[c(7:10),11], col="chartreuse3", pch=19, cex=0.7)
points(chlorite[c(11:13),14],chlorite[c(11:13),11], col="seagreen2", pch=15, cex=0.7)
points(chlorite[c(14:16),14],chlorite[c(14:16),11], col="deeppink2", pch=19, cex=0.7)
points(chlorite[c(17:21),14],chlorite[c(17:21),11], col="lightpink2", pch=15, cex=0.7)
points(chlorite[c(22:24),14],chlorite[c(22:24),11], col="magenta3", pch=15, cex=0.7)
points(chlorite[c(25:28),14],chlorite[c(25:28),11], col="orangered", pch=19, cex=0.7)
points(chlorite[c(29:30),14],chlorite[c(29:30),11], col="maroon", pch=19, cex=0.7)
points(chlorite[c(31),14],chlorite[c(31),11], col="blue", pch=15, cex=0.7)
points(chlorite[c(32:34),14],chlorite[c(32:34),11], col="skyblue3", pch=15, cex=0.7)
points(chlorite[c(35),14],chlorite[c(35),11], col="lightblue", pch=19, cex=0.7)
```

```
dev.new()
plot(AlN~MgN, xlab="Mg #", ylab="Al/(Al+Mg+Fetot)", type="n", main="Chlorite: Zane & Weiss")
points(chlorite[c(1:6),11],chlorite[c(1:6),12], col="aquamarine4", pch=15, cex=0.7)
points(chlorite[c(7:10),11],chlorite[c(7:10),12], col="chartreuse3", pch=19, cex=0.7)
points(chlorite[c(11:13),11],chlorite[c(11:13),12], col="seagreen2", pch=15, cex=0.7)
points(chlorite[c(14:16),11],chlorite[c(14:16),12], col="deeppink2", pch=19, cex=0.7)
points(chlorite[c(17:21),11],chlorite[c(17:21),12], col="lightpink2", pch=15, cex=0.7)
points(chlorite[c(22:24),11],chlorite[c(22:24),12], col="magenta3", pch=15, cex=0.7)
points(chlorite[c(25:28),11],chlorite[c(25:28),12], col="orangered", pch=19, cex=0.7)
points(chlorite[c(29:30),11],chlorite[c(29:30),12], col="maroon", pch=19, cex=0.7)
points(chlorite[c(31),11],chlorite[c(31),12], col="blue", pch=15, cex=0.7)
points(chlorite[c(32:34),11],chlorite[c(32:34),12], col="skyblue3", pch=15, cex=0.7)
points(chlorite[c(35),11],chlorite[c(35),12], col="lightblue", pch=19, cex=0.7)

calcAmph <- read.csv(file="Ca Amphiboles.csv")
calcAmph
attach(calcAmph)

dev.new()
plot(MgO~Al2O3, xlab="Al2O3 Wt. %", ylab="MgO Wt. %", type="n", main="High Ca Amphiboles")
points(calcAmph[c(1:2),4],calcAmph[c(1:2),8], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4),4],calcAmph[c(3:4),8], col="seagreen2", pch=15, cex=0.7)
points(calcAmph[c(5),4],calcAmph[c(5),8], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9),4],calcAmph[c(6:9),8], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12),4],calcAmph[c(10:12),8], col="skyblue3", pch=15, cex=0.7)

dev.new()
plot(SiO2~Al2O3, xlab="Al2O3 Wt. %", ylab=" SiO2 Wt. %", type="n", main=" High Ca Amphiboles ")
points(calcAmph[c(1:2),4],calcAmph[c(1:2),2], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4),4],calcAmph[c(3:4),2], col="seagreen2", pch=15, cex=0.7)
points(calcAmph[c(5),4],calcAmph[c(5),2], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9),4],calcAmph[c(6:9),2], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12),4],calcAmph[c(10:12),2], col="skyblue3", pch=15, cex=0.7)

dev.new()
plot(Fe2O3~Al2O3, xlab="Al2O3 Wt. %", ylab="Fe2O3 Wt. %", type="n", main=" High Ca Amphiboles ")
points(calcAmph[c(1:2),4],calcAmph[c(1:2),5], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4),4],calcAmph[c(3:4),5], col="seagreen2", pch=15, cex=0.7)
points(calcAmph[c(5),4],calcAmph[c(5),5], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9),4],calcAmph[c(6:9),5], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12),4],calcAmph[c(10:12),5], col="skyblue3", pch=15, cex=0.7)


dev.new()
plot(CaO~Na2O, xlab="Na2O Wt. %", ylab="CaO Wt. %", type="n", main=" High Ca Amphiboles ")
points(calcAmph[c(1:2), 11],calcAmph[c(1:2),9], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4), 11],calcAmph[c(3:4),9], col="seagreen2", pch=15, cex=0.7)
```

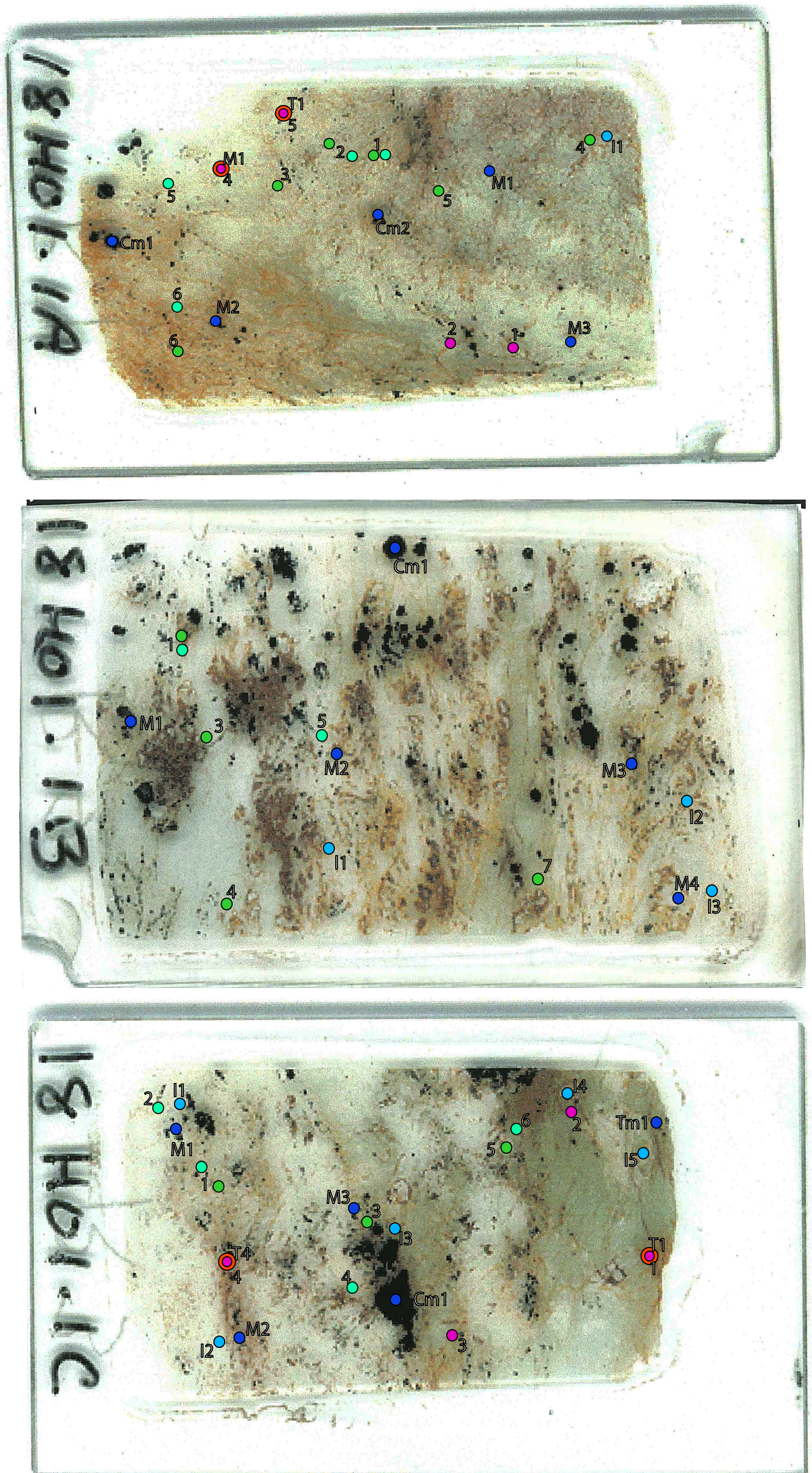
```
points(calcAmph[c(5), 11],calcAmph[c(5),9], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9), 11],calcAmph[c(6:9),9], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12), 11],calcAmph[c(10:12),9], col="skyblue3", pch=15, cex=0.7)

dev.new()
plot(CaO~MgO, xlab="MgO Wt. %", ylab="CaO Wt. %", type="n", main=" High Ca Amphiboles ")
points(calcAmph[c(1:2), 8],calcAmph[c(1:2),9], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4), 8],calcAmph[c(3:4),9], col="seagreen2", pch=15, cex=0.7)
points(calcAmph[c(5), 8],calcAmph[c(5),9], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9), 8],calcAmph[c(6:9),9], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12), 8],calcAmph[c(10:12),9], col="skyblue3", pch=15, cex=0.7)

dev.new()
plot(A~C, xlab="(Al+Fe2++2*Ti)", ylab="(Na+K+2*Ca)", type="n", main="Hawthorne Classification")
points(calcAmph[c(1:2), 14],calcAmph[c(1:2),13], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4), 14],calcAmph[c(3:4),13], col="seagreen2", pch=15, cex=0.7)
points(calcAmph[c(5), 14],calcAmph[c(5),13], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9), 14],calcAmph[c(6:9),13], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12), 14],calcAmph[c(10:12),13], col="skyblue3", pch=15, cex=0.7)


dev.new()
plot(MnO~MgN, xlab="Mg #", ylab="MnO Wt. %", type="n", main=" High Ca Amphiboles ")
points(calcAmph[c(1:2), 12],calcAmph[c(1:2),7], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4), 12],calcAmph[c(3:4),7], col="seagreen2", pch=15, cex=0.7)
points(calcAmph[c(5), 12],calcAmph[c(5),7], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9), 12],calcAmph[c(6:9),7], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12), 12],calcAmph[c(10:12),7], col="skyblue3", pch=15, cex=0.7)

dev.new()
plot(Al2~MgN, xlab="Mg #", ylab="Al/Al+Si", type="n", main=" High Ca Amphiboles ")
points(calcAmph[c(1:2), 12],calcAmph[c(1:2),15], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4), 12],calcAmph[c(3:4),15], col="seagreen2", pch=15, cex=0.7)
points(calcAmph[c(5), 12],calcAmph[c(5),15], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9), 12],calcAmph[c(6:9),15], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12), 12],calcAmph[c(10:12),15], col="skyblue3", pch=15, cex=0.7)

dev.new()
plot(MgN~SiApfu, xlab=" Si apfu", ylab="Mg #", type="n", main=" High Ca Amphiboles ")
points(calcAmph[c(1:2), 16],calcAmph[c(1:2),12], col="aquamarine4", pch=15, cex=0.7)
points(calcAmph[c(3:4), 16],calcAmph[c(3:4),12], col="seagreen2", pch=15, cex=0.7)
points(calcAmph[c(5), 16],calcAmph[c(5),12], col="magenta3", pch=15, cex=0.7)
points(calcAmph[c(6:9), 16],calcAmph[c(6:9),12], col="blue", pch=15, cex=0.7)
points(calcAmph[c(10:12), 16],calcAmph[c(10:12),12], col="skyblue3", pch=15, cex=0.7)


cummingtonite <- read.csv(file="cummingtonites.csv")
cummingtonite
```

```
attach(cummingtonite)


dev.new()
plot(MnO~MgN, xlab= "Mg #", ylab="MnO Wt. %", type="n", main="Cummingtonite")
points(cummingtonite[c(1:4),12],cummingtonite[c(1:4),7], col="aquamarine4", pch=15, cex=0.7)
points(cummingtonite[c(5:8),12],cummingtonite[c(5:8),7], col="seagreen2", pch=15, cex=0.7)
points(cummingtonite[c(9:11),12],cummingtonite[c(9:11),7], col="lightpink2", pch=15, cex=0.7)
points(cummingtonite[c(12:14),12],cummingtonite[c(12:14),7], col="magenta3", pch=15, cex=0.7)
points(cummingtonite[c(15:19),12],cummingtonite[c(15:19),7], col="blue", pch=15, cex=0.7)
points(cummingtonite[c(20:21),12],cummingtonite[c(20:21),7], col="skyblue3", pch=15, cex=0.7)

dev.new()
plot(MgN~SiApfu, xlab= " Si apfu", ylab="Mg #", type="n", main="Cummingtonite")
points(cummingtonite[c(1:4),13],cummingtonite[c(1:4),12], col="aquamarine4", pch=15, cex=0.7)
points(cummingtonite[c(5:8),13],cummingtonite[c(5:8),12], col="seagreen2", pch=15, cex=0.7)
points(cummingtonite[c(9:11),13],cummingtonite[c(9:11),12], col="lightpink2", pch=15, cex=0.7)
points(cummingtonite[c(12:14),13],cummingtonite[c(12:14),12], col="magenta3", pch=15, cex=0.7)
points(cummingtonite[c(15:19),13],cummingtonite[c(15:19),12], col="blue", pch=15, cex=0.7)
points(cummingtonite[c(20:21),13],cummingtonite[c(20:21),12], col="skyblue3", pch=15, cex=0.7)


ChTiMagnetite <- read.csv(file="chro and titan magnetites.csv")
ChTiMagnetite
attach(ChTiMagnetite)

dev.new()
plot(Fe2O3~V2O3, xlab="V2O3 Wt. %", ylab="Fe2O3 Wt. %", type="n", main="Chromian and Titanian
Magnetites")
points(ChTiMagnetite[c(1:2),12],ChTiMagnetite[c(1:2),6], col="aquamarine4", pch=15, cex=0.7)
points(ChTiMagnetite[c(3),12],ChTiMagnetite[c(3),6], col="chartreuse3", pch=19, cex=0.7)
points(ChTiMagnetite[c(4),12],ChTiMagnetite[c(4),6], col="seagreen2", pch=15, cex=0.7)
points(ChTiMagnetite[c(5),12],ChTiMagnetite[c(5),6], col="gray60", pch=15, cex=0.7)
points(ChTiMagnetite[c(6:8),12],ChTiMagnetite[c(6:8),6], col="deeppink2", pch=19, cex=0.7)
points(ChTiMagnetite[c(9:11),12],ChTiMagnetite[c(9:11),6], col="lightpink2", pch=15, cex=0.7)
points(ChTiMagnetite[c(12:13),12],ChTiMagnetite[c(12:13),6], col="magenta3", pch=15, cex=0.7)
points(ChTiMagnetite[c(14),12],ChTiMagnetite[c(14),6], col="maroon", pch=19, cex=0.7)
points(ChTiMagnetite[c(15:17),12],ChTiMagnetite[c(15:17),6], col="blue", pch=15, cex=0.7)
points(ChTiMagnetite[c(18:19),12],ChTiMagnetite[c(18:19),6], col="skyblue3", pch=15, cex=0.7)

magnetite <- read.csv(file="magnetites.csv")
magnetite
attach(magnetite)

dev.new()
plot(Fe2O3~V2O3, xlab="V2O3 Wt. %", ylab="Fe2O3 Wt. %", type="n", main="Magnetite")
points(magnetite[c(1:4),12],magnetite[c(1:4),6], col="aquamarine4", pch=15, cex=0.7)
points(magnetite[c(5:7),12],magnetite[c(5:7),6], col="chartreuse3", pch=15, cex=0.7)
```

```
points(magnetite[c(8:10),12],magnetite[c(8:10),6], col="seagreen2", pch=19, cex=0.7)
points(magnetite[c(11),12],magnetite[c(11),6], col="deeppink2", pch=19, cex=0.7)
points(magnetite[c(12:16),12],magnetite[c(12:16),6], col="orangered", pch=19, cex=0.7)
points(magnetite[c(17:21),12],magnetite[c(17:21),6], col="maroon", pch=19, cex=0.7)
points(magnetite[c(22),12],magnetite[c(22),6], col="blue", pch=15, cex=0.7)
points(magnetite[c(23),12],magnetite[c(23),6], col="skyblue3", pch=15, cex=0.7)
points(magnetite[c(24:25),12],magnetite[c(24:25),6], col="lightblue", pch=19, cex=0.7)

chromite <- read.csv(file="chromites.csv")
chromite
attach(chromite)

dev.new()
plot(Fe2O3~Cr2O3, xlab=" Cr2O3 Wt. %", ylab="Fe2O3 Wt. %", type="n", main="Chromite")
points(chromite[c(1:3),5],chromite[c(1:3),6], col="lightpink2", pch=15, cex=0.7)
points(chromite[c(4),5],chromite[c(4),6], col="magenta3", pch=15, cex=0.7)

dev.new()
plot(Fe2O3~V2O3, xlab="V2O3 Wt. %", ylab="Fe2O3 Wt. %", type="n", main="Chromite")
points(chromite[c(1:3),12],chromite[c(1:3),6], col="lightpink2", pch=15, cex=0.7)
points(chromite[c(4),12],chromite[c(4),6], col="magenta3", pch=15, cex=0.7)

CrFeCoreRim <- read.csv(file="chro and iron.csv")
CrFeCoreRim
attach(CrFeCoreRim)


dev.new()
plot(Fe2O3~Cr2O3, xlab=" Cr2O3 Wt. %", ylab="FeO Wt. %", type="n", main="Chromite Cores &
Chromian Magnetite Rims")
points(CrFeCoreRim[c(1:3),5],CrFeCoreRim[c(1:3),6], col="lightpink2", pch=19, cex=0.7)
points(CrFeCoreRim[c(4),5],CrFeCoreRim[c(4),6], col="magenta3", pch=19, cex=0.7)
points(CrFeCoreRim[c(5:7),5],CrFeCoreRim[c(5:7),6], col="lightpink2", pch=17, cex=0.7)
points(CrFeCoreRim[c(8),5],CrFeCoreRim[c(8),6], col="magenta3", pch=17, cex=0.7)


dev.new()
plot(Fe2O3~V2O3, xlab="V2O3 Wt. %", ylab="FeO Wt. %", type="n", main=" Chromite Cores & Chromian
Magnetite Rims ")
points(CrFeCoreRim[c(1:3),12],CrFeCoreRim[c(1:3),6], col="lightpink2", pch=19, cex=0.7)
points(CrFeCoreRim[c(4),12],CrFeCoreRim[c(4),6], col="magenta3", pch=19, cex=0.7)
points(CrFeCoreRim[c(5:7),12],CrFeCoreRim[c(5:7),6], col="lightpink2", pch=17, cex=0.7)
points(CrFeCoreRim[c(8),12],CrFeCoreRim[c(8),6], col="magenta3", pch=17, cex=0.7)

ilmenite <- read.csv(file="ilmenites.csv")
ilmenite
attach(ilmenite)
```

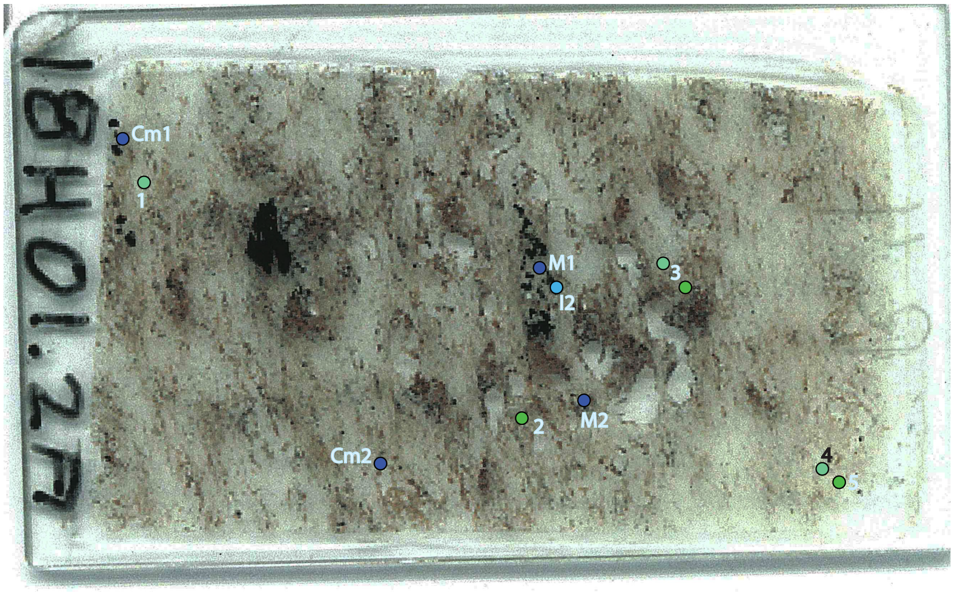
```
dev.new()
plot(FeO~MgO, xlab="MgO Wt. %", ylab="FeO Wt. %", type="n", main="Ilmenite")
points(ilmenite[c(1),9],ilmenite[c(1),7], col="aquamarine4", pch=15, cex=0.7)
points(ilmenite[c(2:4),9],ilmenite[c(2:4),7], col="chartreuse3", pch=19, cex=0.7)
points(ilmenite[c(5:9),9],ilmenite[c(5:9),7], col="seagreen2", pch=15, cex=0.7)
points(ilmenite[c(10),9],ilmenite[c(10),7], col="deeppink2", pch=19, cex=0.7)
points(ilmenite[c(11:13),9],ilmenite[c(11:13),7], col="lightpink2", pch=15, cex=0.7)
points(ilmenite[c(14:16),9],ilmenite[c(14:16),7], col="magenta3", pch=15, cex=0.7)
points(ilmenite[c(17:19),9],ilmenite[c(17:19),7], col="orangered", pch=19, cex=0.7)
points(ilmenite[c(20:21),9],ilmenite[c(20:21),7], col="maroon", pch=19, cex=0.7)
points(ilmenite[c(22),9],ilmenite[c(22),7], col="blue", pch=15, cex=0.7)
points(ilmenite[c(23),9],ilmenite[c(23),7], col="skyblue3", pch=15, cex=0.7)
points(ilmenite[c(24:25),9],ilmenite[c(24:25),7], col="lightblue", pch=19, cex=0.7)


rutile <- read.csv(file="rutiles.csv")
rutile
attach(rutile)

dev.new()
plot(Fe2O3~V2O3, xlab="V2O3 Wt. %", ylab="Fe2O3 Wt. %", type="n", main="Rutile")
points(rutile[c(1),12],rutile[c(1),6], col="lightpink2", pch=15, cex=0.7)
points(rutile[c(2:4),12],rutile[c(2:4),6], col="magenta3", pch=15, cex=0.7)

RcoreIrim <- read.csv(file="rutile and ilmenite.csv")
RcoreIrim
attach(RcoreIrim)


dev.new()
plot(TiO2~Cr2O3, xlab="Cr2O3 Wt. %", ylab="TiO2 Wt. %", type="n", main="Rutile Cores and Ilmenite
Rims")
points(RcoreIrim[c(1),5],RcoreIrim[c(1),3], col="lightpink2", pch=19, cex=0.7)
points(RcoreIrim[c(2:4),5],RcoreIrim[c(2:4),3], col="magenta3", pch=19, cex=0.7)
points(RcoreIrim[c(5),5],RcoreIrim[c(5),3], col="lightpink2", pch=17, cex=0.7)
points(RcoreIrim[c(6:8),5],RcoreIrim[c(6:8),3], col="magenta3", pch=17, cex=0.7)
```

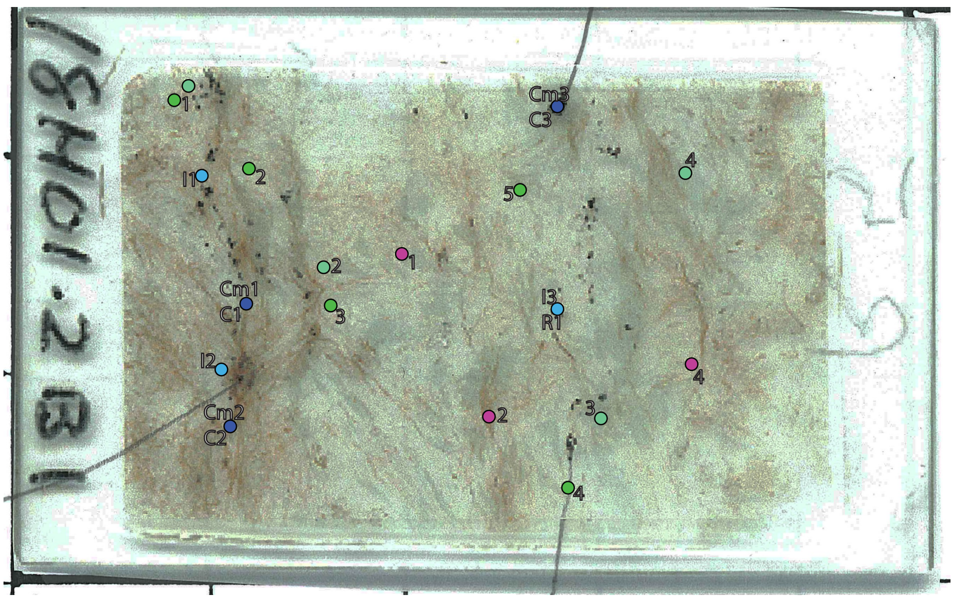
Appendix 3: Mapped acceptable analyses probe locations



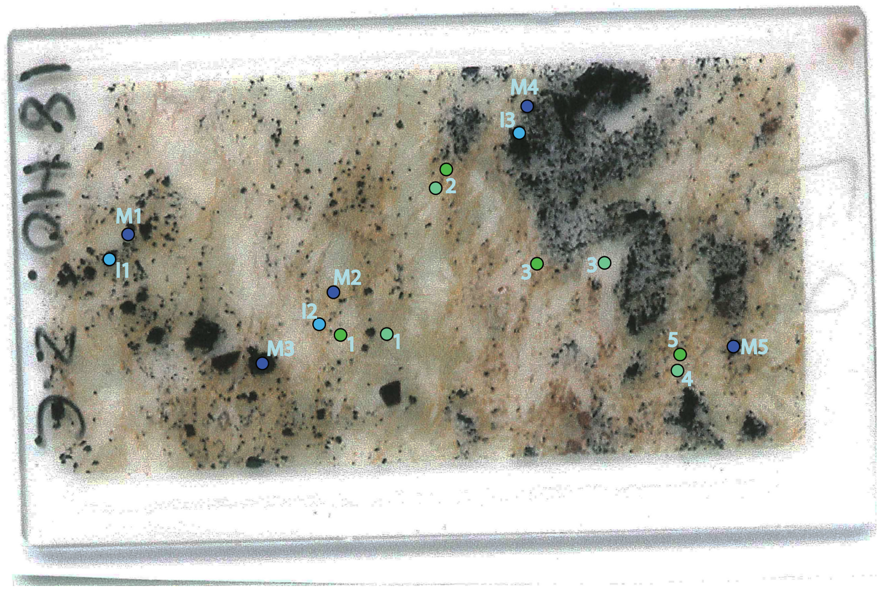
Legend

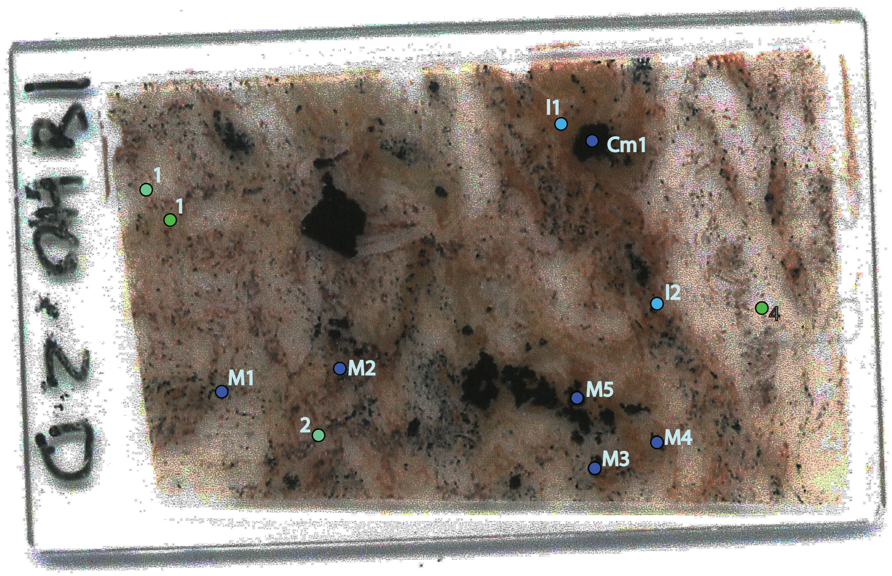
- Talc
- Chlorite
- High Ca-amphiboles
  - M = Maganesian hornblende
  - T = Tremolite
- Cummingtonite
- Fe-Cr Oxides
  - Cm = Chromian magnetite
  - Tm = Titanomagnetite
  - M = Magnetite
  - C = Chromite
- Ti (-Fe) Oxides
  - I = Ilmenite
  - R = Rutile

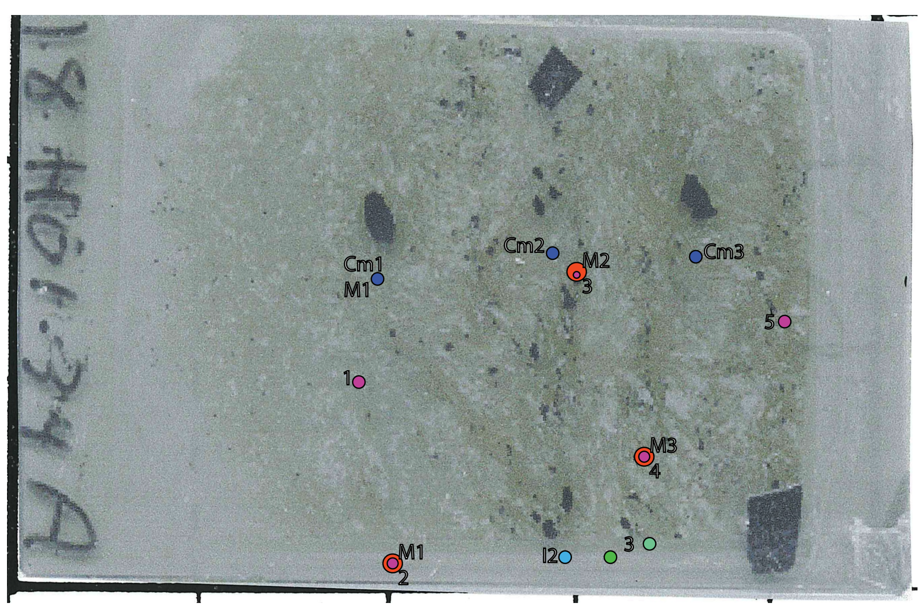

Cm1
1
M1
I2
3
2
M2
Cm2
4

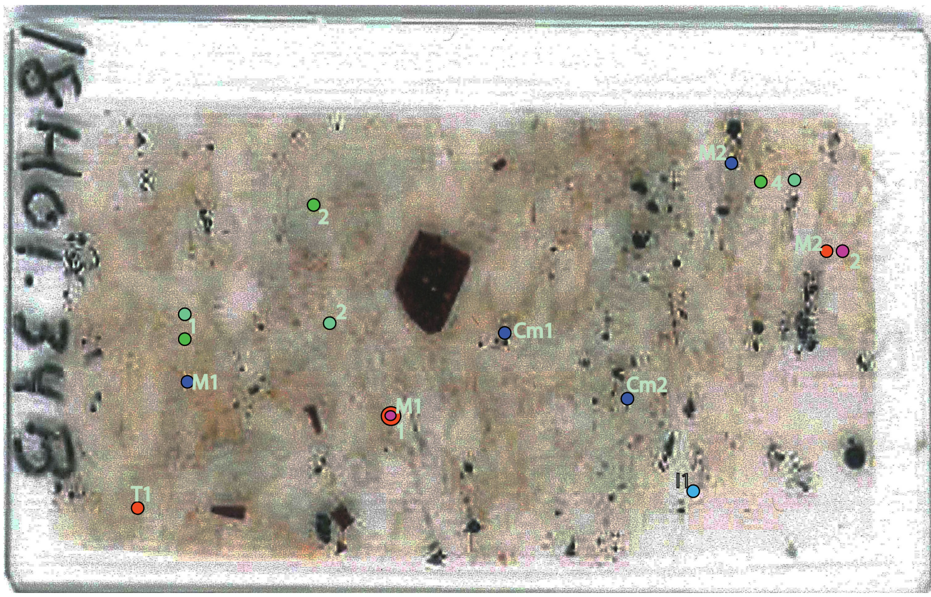

1
Cm3
C3
I1
2
4
5
1
2
Cm1
C1
3
I3
R1
I2
4
Cm2
C2
2
3
4


4
Cm1
C1
I2
R2
I3
R4
2
2
5
I1
R1
4
Cm2
1

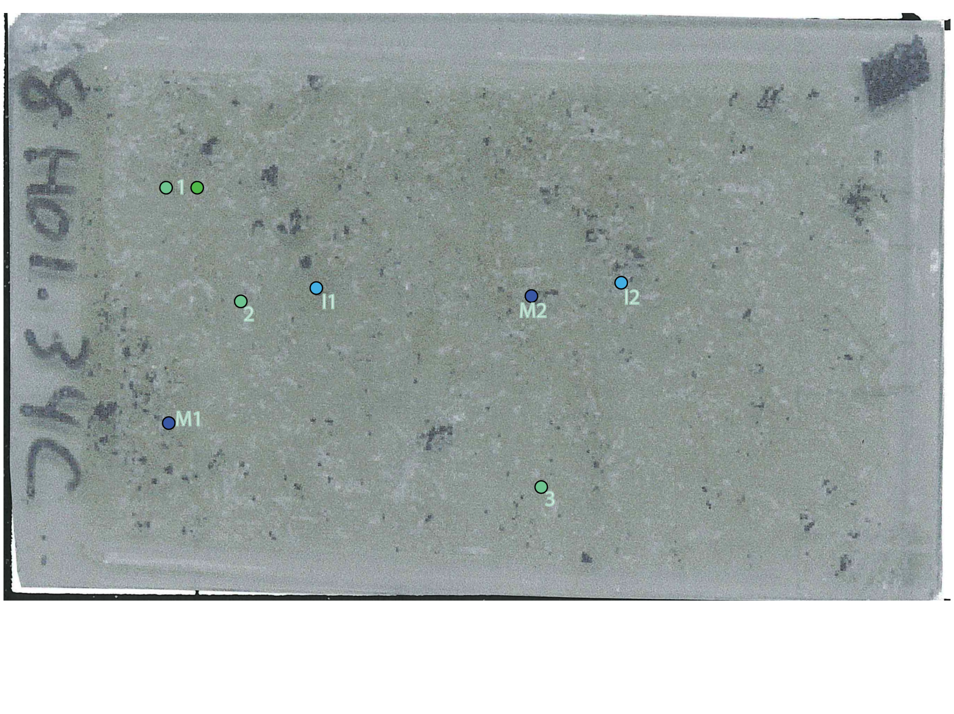

M4
I3
2
M1
I1
M2
I2
1
1
M3
3
3
5
4
M5


I1
Cm1
1
1
I2
4
M1
M2
M5
2
M4
M3


Cm2
M2
3
Cm3
Cm1
M1
5
1
M3
4
M1
2
I2
3



1840l:34B
M2
M2
2
2
2
1
Cm1
M1
M1
1
Cm2
I1
T1



1840l:34C
1
2
I1
M2
I2
M1
3