Lost Context: elemental analysis of unprovenienced 15th and 16th century Vietnamese jarlets using pXRF

By

William Cowling
Bachelor of Archaeology

Thesis
Submitted to Flinders University
for the degree of

Master of Archaeology and Heritage Management
College of Humanities, Arts and Social Sciences
20/12/2024

TABLE OF CONTENTS

ABSTRACT

This thesis investigates the potential for interpreting secondary and tertiary depositional contexts of unprovenienced cargo through the application of pXRF as an analytical technique. This study focuses on a set of 55 Vietnamese blue and white high-fired stoneware small jars known as jarlets. These jarlets form a small part of a much larger ceramics collection housed at the Southeast Asia Ceramic Archaeology Lab (SEACAL) at Flinders University. The ceramics of this collection are considered ‘grey/orphaned’ objects, which lack archaeological context, as they were salvaged from shipwrecks within Indonesian territorial waters.

Currently there are no recorded examples of similar ceramics found from shipwrecks within Indonesian waters. Examples of these ceramics have been found in Southeast Asia, mainly from shipwrecks within territorial waters of both Vietnam and the Philippines. This has led to the hypothesis that the Vietnamese blue and white jarlets were salvaged from an unidentified shipwreck in Indonesia.

This study aims to evaluate the effectiveness of pXRF as an analytical method in identifying significant compositional differences between both Vietnamese jarlets and a selection of comparable Vietnamese and Chinese ceramics. pXRF was used in conjunction with principal component analysis and hierarchical cluster analysis to group the ceramics based on their elemental composition. The results demonstrate that pXRF is a viable analytical technique for identifying significant differences. The Vietnamese jarlets exhibit characteristics, mainly in relation to the motif, which differ from traditional understandings. This distinction is most prominent in the absence of manganese found in the ceramic motifs, which varies with the high manganese content found in other Vietnamese blue and white stoneware ceramics. This variation arises from the cobalt used, as it contained traces of manganese. The pXRF results, along with the lack of known examples in Indonesia, result in the hypothesis that these ceramics differ from the comparable Vietnamese blue and white ceramics, and the conclusion that came from an unidentified shipwreck.

DECLARATION

I certify that this thesis:

1. does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university

2. and the research within will not be submitted for any other future degree or diploma without the permission of Flinders University; and

3. To the best of my knowledge and belief, does not contain any material previously published or written by another person except where due reference is made in the text.

Signed...

Date.................20 /12/24....................

ACKNOWLEDGEMENTS

I would first like to acknowledge and thank my supervisor Martin Polkinghorne who has provided consistent knowledge, feedback and support throughout the whole postgraduate process. I would like to thank Catherine Morton for teaching me the ins and outs of using the pXRF and elemental analysis, whilst also providing feedback on my methods and results. I would also like to thank Daryl Wesley and Heather Burke as topic coordinators and for the support they provided.

I would like to thank Nia Naelul Hasanah and Zainab Tahir for their support and overwhelming knowledge of Southeast Asian ceramics. I would like to thank Jarrad Kowlessar for his help with understanding statistical analysis and also for suggesting possible methods and software. I would like to thank Susan Arthure for her support and advice around writing a thesis. I would also like to thank all the members of SEACAL who have all provided support for me.

Finally, I would like to thank my friends and family who have all supported me through this process. I am especially thankful to my parents, who have always been supportive over the last two years.

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 Introduction

The Maritime Silk Route, also known as the Silk Routes, refers to the sailing routes that connected Asia to Europe along with Eastern Africa and the Arabian Peninsula. Despite this the Maritime Silk Route is a modern term used to describe the trade exchange routes between these continents (Polkinghorne et al. 2024:2; Winter 2022:4). Indonesia was at the centre of the ‘Maritime Silk and Spice Route’ as it was the main the centre of the maritime routes that connect the South China Sea and the Indian Ocean (Polkinghorne et al. 2024:3–4). Due to this factor, Indonesia became a hub within the Maritime Silk Route. Indonesia contains vast coastlines along with more sea than land with the second largest coastline in the world. Indonesia would become a hub of trade and exchange where goods, religion, ideas and language were exchanged (Heng 2022:215).

Figure removed due to copyright restriction.

Figure 1: Map depicting the location of known shipwrecks in Indonesia. Map and data courtesy of the Kementerian Kelautan dan Perikanan (KKP).

Indonesia as a hub and important destination within the Maritime Silk Route led to the Indonesian waters containing a vast array of shipwrecks. Over 700 shipwrecks are currently known to exist within Indonesian territorial waters, depicted in Figure 1. Of the known shipwrecks, only 170 shipwrecks have been surveyed. A large quantity of these ships had cargos that contain ceramics (Polkinghorne et al. 2024:3). Ceramics were one of the main traded goods along the Maritime Silk Route. This has led to the salvage of these shipwrecks. These ceramics would then end up on the antiquity market where they would be sold and dispersed across the world (Polkinghorne et al. 2024:3). These objects were dispersed without any form of archaeological recording or consideration. By removing these ceramics without archaeological recording, they are considered to be 'grey' or 'orphaned' objects. This creates multiple difficulties when working with these objects. Objects taken from shipwrecks without proper recording, lack provenience and context (Polkinghorne et al. 2024:3). The Reuniting Orphaned Cargos project aims to work with a collection of these 'grey' ceramics and develop the context of the object by using an array of different methods. The project includes ceramics from two collections, one at SEACAL at Flinders University and the other is the KKP Collections in Indonesia (Polkinghorne et al. 2024:3).

This thesis has considered the unknown context of Vietnamese blue and white jarlets from the 15th and 16th century. These ceramics pose interesting questions as there is a lack of known recorded shipwrecks in Indonesia that contain these ceramics. This extends to the KKP Collection, which does not contain any examples of these Vietnamese jarlets (Kikuchi 2021:182; Zainab Tahir, pers. comm. 2024). The major sites that are known to carry these blue and white Vietnamese ceramics from the 15th and 16th century are the Chàm Islands, the Pandanan Island and the Lena Shoal shipwrecks (Kikuchi 2021:182–186). These factors establish the hypothesis that the ceramics in this study came from an unidentified shipwreck in Indonesian territorial waters.

1.2 Research Question

This thesis aims to evaluate whether pXRF is an applicable method for classifying Vietnamese ceramics based on their elemental composition. This method will be applied to a collection of 55 blue and white stoneware jarlets produced in Vietnam during the 15th and 16th century. The principal question for this research is: Can elemental analysis of 15th and 16th century Vietnamese stoneware jarlets inform interpretations of the secondary and tertiary depositional contexts of unprovenanced cargo? The aim is to identify the characteristics that the pXRF can classify and to understand how these characteristics reveal insights into the production process, location of production, and the shipwreck from which they were salvaged.

1.3 The Collection

The 55 Vietnamese jarlets that are the centre piece for this research project are part of the collection featured at the Southeast Asian Ceramics Archaeology Laboratory (SEACAL), at Flinders University. The collection features over 2300 ceramics manufactured in China and Southeast Asia and salvaged from Indonesian territorial waters. The collection was donated by Mr Michael Abbott AO KC. Michael Abbott purchased these ceramics from the antiques market and dealers within Indonesia from the early 1960s to the 2010s. This collection presents a complex issue that is front and centre in the ‘Reuniting Orphaned Cargoes’ project. This project aims to connect and trace the provenience, or archaeological contexts, of ‘grey’ underwater cultural heritage in conjunction with the collection of underwater cultural heritage in Indonesia (Polkinghorne et al. 2024:1–2).

The ceramics in this collection are considered ‘grey/orphaned’ underwater cultural heritage as the ceramics were removed from the underwater site without records nor in an unethical manner. Polkinghorne et al. (2024:3) define ‘grey/orphaned’ as, ‘cultural objects that have been recovered unethically, illegally, or in some other problematic way’. The *Presidential Decree No. 25 of 1992* was an agreement between the Indonesian government and salvaging companies regarding the ownership and sale of culturally and historically valuable objects. The decree stated that the Indonesian government had ownership of culturally significant objects, whilst objects that were deemed not to have any cultural significance could be sold. Objects salvaged from these shipwrecks would be distributed equally between the government and the salvaging company. Despite the restrictions of the decree, no formal definitions of what qualifies as cultural heritage were stated. Salvaging of shipwrecks in this manner occurred from 1989 to 2010 (Polkinghorne et al. 2024:5; Suryokumoro 2017:191-192). *Law No.11 of 2010* concerning Cultural Conservation acted as a significant advancement for underwater cultural heritage in Indonesia despite its complexities. The law determined the criteria for underwater cultural heritage to be classified as cagar budaya, or culturally significant. Difficulties are present due to the ambiguity of the criteria. This has also led to difficulties when determining the value of non-Indonesian objects as the criteria states that they must hold cultural significance for national identity (Pearson 2022:393; Polkinghorne et al. 2024:5). *Law No.11 of 2010* concerning Cultural Conservation stated within Article 1 that the significance be determined through a process carried out by a panel chosen by the Ministry of Education and Culture. Sites and the objects within those sites are ranked by the cultural significance they hold. This ranking is determined according to the sites and objects meeting the criteria, then determining their importance at a national, provincial and regency/municipal level. This assessment determines if the sites and/or the objects obtain a cultural heritage status (Pearson 2022:394; Polkinghorne et al. 2024:5). Objects that are deemed not ‘significant’ can be salvaged and purchased on the antiques market. These ‘non-significant’ objects have lost provenience as the information from where they were salvaged was lost through the sale (Polkinghorne et al. 2024:3–10).

Working with ‘grey’ ceramics presents multiple issues relating to the ethics surrounding the ceramics. These issues are created as the ceramics were salvaged without consideration for good archaeological practices. It is difficult for ‘grey’ objects to be separated from the monetary value that has been associated with them. This stigma around the ceramics has led to the opinion that archaeologists cannot work with ‘grey’ objects due to the difficulties present (Polkinghorne et al. 2024:5–7). Research with the ‘grey’ objects can be seen as a form of validation for commercial and illegal salvaging and emphasises the financial aspects of the objects. However, the ‘Reuniting Orphaned Cargoes’ proposes the idea that ‘grey’ underwater cultural heritage can have positive impacts in the field and states that research is the ‘greatest opportunity to effect positive change (Polkinghorne et al. 2024:5–6). Without further research into understanding the objects and the unethical practices around them, underwater cultural heritage will continue to be salvaged and sold within the antique market.

The collection in SEACAL contains ceramics without provenience from China, Thailand, Vietnam, Indonesia, Cambodia and Myanmar. Among these objects without known provenience are the Vietnamese jarlets. These objects are significant within the collection due to all 55 objects containing varying levels of marine accretions. This factor concludes that all these jarlets share similar archaeological context in terms of deposition. Based on interviews with Abbott, it is stated that these Vietnamese jarlets were most likely bought in Sulawesi, with some being bought in Bali. Abbott notes that these were bought in 2002 (Michael Abbott, pers. comm. 2022). This provides information on the story of the objects and their point of sale; however, further verification is required to see if this provides insight into the location of salvage.

1.4 Historical Background

The jarlets that form the core part of this thesis were produced in Vietnam during the 15th and 16th century. They are blue and white stoneware, a ceramic style that was commonly produced during this period. The production of these ceramics occurred following the Ming invasion of Đại Ngu, modern day northern Vietnam. The invasion took place during 1406 and 1407 (Taylor 2013:178–179). The Ming rule over Đại Ngu ended in 1427 with the introduction of the Lê dynasty. Despite the end of Chinese rule, the effects of the invasion continued to be felt, and this can be seen within ceramic production. The Ming Invasion also coincided with the Ming ban on exports. This started in the late 14th century and would continue into the 15th century. Due to the ban on exports, which included ceramics, Vietnamese ceramic production began to increase and fill the hole in the market left by the pause in Chinese ceramic exports (Brown 1988:25). This period marked the beginning of Vietnam's mass production of ceramics for foreign markets. The ceramics that are the focal point of this study are presumed to have been produced for the South-East Asian market; however, similar objects appear in Japan, most notably in Okinawa (Kikuchi 2021:188; Guy 1986:46–47).

During this period, there was an increase in blue and white ceramic production. The style and decoration of the ceramics were inspired by Chinese ceramics, which was a result of the earlier Ming Invasion, as well as emulating Chinese designs to fill the market. Common motifs would include lotus flowers, floral designs, along with animals such as birds (Brown 1988:25–26). The major kiln sites during this time for blue and white Vietnamese ceramics were located in the Hai Hung province. Major kiln sites in the province are the Chu Đâu and the Mỹ Xá kiln sites. These kiln sites were major producers of blue and white Vietnamese ceramics, with other kiln sites in the same area produced similar ceramics whilst also being labelled as Chu Đâu ceramics (Kikuchi 2021:30–35).

1.5 Known Shipwrecks

There is a lack of known shipwrecks in Indonesia that contain Vietnamese blue and white ceramics from the 15th and 16th century, along with no examples of Vietnamese blue and white ceramics in the KKP Collections in Indonesia (Kikuchi 2021:182; Zainab Tahir, pers. comm. 2024). The main known shipwrecks in Southeast Asia that contained Vietnamese blue and white ceramics are the Cù Lao Chàm shipwreck, also known as the Hội An shipwreck, the Pandanan Island shipwreck in the Philippines, and the Lena Shoal shipwreck in the Philippines (Kikuchi 2021:182–186). These shipwrecks contained blue and white Vietnamese ceramics from Northern Vietnam. The most famous of these shipwrecks, the Cù Lao Chàm shipwreck contained large quantities of Vietnamese ceramics. Approximately 300,000 Vietnamese ceramics were found. The Chu Đâu kilns were the main source for ceramics present at the Cù Lao Chàm shipwreck (Colomban et al. 2004:125–126). The shipwreck was stated to have sunk between the latter part of the 15th century to the first half of the 16th century. The Pandanan shipwreck is located off the Pandanan Island in the Philippines. Approximately 4722 ceramics were salvaged, with the majority being from Central and Northern Vietnam (Kikuchi 2021:185). The blue and white ceramics found at the site have been attributed to the Chu Đâu kilns. It is assumed that the shipwreck is from the mid-15th century. The Lena Shoal shipwreck is located off the north side of Palawan Island in the Philippines. Approximately 3000 ceramics were excavated; however, only 28 were blue and white ceramics from Northern Vietnam. These ceramics, like the other ships, are considered to be products of the Chu Đâu kilns (Kikuchi 2021:186).

There is an absence of shipwrecks in Indonesia that contain 15th and 16th century blue and white Vietnamese ceramics (Zainab Tahir, pers. comm. 2024). This suggests that they came from an unidentified shipwreck. The presence of marine accretions on the ceramics suggests that they came from a marine context. Due to the lack of examples for comparison, however, difficulties arise when establishing their provenience without further research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter discusses the research of pXRF in archaeology, the applications, and best practices of elemental analysis on ceramics, whilst also discussing the literature on Vietnamese ceramics. Over the last 20 years, pXRF as a technique for elemental analysis has developed significantly. Due to these developments, pXRF has become an increasingly accessible technique to use within archaeology. With these developments has come a greater understanding of the best applications and limits of the technology in archaeology and, more specifically, the analysis of ceramics in archaeological contexts (Shuger and Mass 2012:17).

2.2 pXRF in Archaeology

pXRF, as a technique for elemental compositional analysis is becoming increasingly popular within archaeology. This is due to pXRF offering flexibility, accessibility, and the ability to study the elemental composition of artefacts in situ and in a non-destructive manner. These factors also allow for large quantities of artefacts to be analysed in a shorter period of time and in a considerably cheaper manner, in comparison to other analytical techniques (Tanasi et al. 2017:222; Shuger and Mass 2012:17). During the late 2000s, pXRF had gained attention and popularity, a rise which Ellery Frahm and Roger C.P. Doonan described as a revolution (Frahm and Doonan 2013:1425). This attention led to debates around the analytical capabilities of pXRF. Frahm and Doonan (2013:1425) state that ‘few other recent instrumental developments have generated such debate’. Most of these debates take place within ‘informal’ settings, such as conferences (Frahm and Doonan 2013:1425). M. Steven Shackley (2010) recalls a 2009 meeting in Atlanta and when the topic of pXRF was mentioned it was as if two ‘seemingly opposing sides’ had suddenly appeared. Shackley (2010:17) puts forward that archaeology as a field may have not been ready nor prepared ‘intellectually’ for pXRF. Handheld and portable XRFs were available in forms and used in research for a number of years (Shakely 2010:17). An early example of early pXRF use is in 1995 by P. J. Potts who assessed the analytical performance on a field-portable X-ray fluorescence instrumentation (Potts et al. 1995:1273). Due to developments in the technology, handheld pXRF has become increasingly accessible and less expensive. As handheld pXRF becomes more readily available, a mindset or stereotype has developed centred around the ‘point and shoot’ nature of the pXRF. Interpretation of the results is key when using pXRF (Shuger and Mass 2012:17–18). Aaron N. Shugar and Jennifer L. Mass (2012:18) state that for interpreting the results of your data you ‘still require a detailed understanding of the principles of X-ray spectrometry’. Handheld pXRF was seen as a solution to problems that require elemental analysis and that it can answer the questions directly based on the results. This can lead to a misunderstood view of what is possible to achieve and the limits of the data that can be collected (Shuger and Mass 2012:18).

Handheld pXRF is a technology that allows for almost instantaneous qualitative data and results, through that can lead to a misunderstanding surrounding what can be achieved without understanding the principles and the calibrations of the machine. Issues occur because there is a lack of understanding of the principles, and this can lead to further problems with analysis. This revolves around the expectations of the results and the belief that the results will directly solve archaeological problems. Due to the ‘point and shoot’ nature that is associated with pXRF, the rigorous scientific protocols that are used by other lab-based techniques can at times be ignored (Frahm and Doonan 2013:1427; Shuger and Mass 2012:18). Shakley (2010) notes that keeping to strict analytical protocols are a requirement when using pXRF in research, especially when pXRF is used in relation to field work (Shakely 2010:19).

Calibrations are a key component of conducting replicable and creditable research when using pXRF. Despite their importance, they are often overlooked (Frahm 2024:14–15; Johnson et al. 2024:158). Over time the electronics of the pXRF can drift, which leads to incorrect measurements. In newer models of pXRF, this is preformed automatically using pre-installed software. E. Frahm (2024:104831) states that ‘without this calibration, it is possible that the spectrum will drift and that X-ray peaks will shift enough to be measured erroneously’. There are two types of calibrations: energy calibrations and quantifications calibrations. The energy calibration is the x-ray spectra energy that is produced, while the quantification calibration is the counts to concentration (Frahm

2024:104831). Corrections are commonly mistaken as being similar to calibrations. Corrections relate to the detection of x-ray fluorescence. Frahm (2024:104831) states that ‘interactions between the primary X-ray beam and the atoms which emit characteristic X-rays introduce biases into the spectrum’. Due to this factor, corrections are required for the unequal fluorescence efficiency. The most common method for correction is the fundamental parameters approach. Calibrations and corrections form an important part of the using pXRF in way which promotes reproducibility and credibility of research.

Shakely (2010:19) stresses the importance of using standards when using pXRF in archaeology. Nathan Goodale and associates (2012:883) come to a similar conclusion in that international geological standards need to be used. The standards need to be regularly tested and be internationally available. Frahm and Doonan (2013:1430) concludes that the majority of pXRF papers published up to 2013 are mainly conducted within laboratory settings. The paper notes that 18% of the handheld pXRF papers are conducted on-site or at excavations and/or surveys. Along with excavation/site settings, only 43% of pXRF papers at that point were conducting research using a handheld pXRF. Handheld pXRF at that point was still mostly a lab-based technique and hence followed the protocols that were associate with lab-based settings. The paper challenges the perceptions at the time that archaeologists were going to sites and excavations and were just ‘pointing and shooting’ at anything on site. They continue and state that the majority of pXRF equipment never leaves a museum or laboratory setting (Frahm and Doonan 2013:1430).

More recent papers around the performance and reliability of handheld pXRF are less general and more focused on its use in specific areas or on specific materials. Jean-Baptiste LeMoine and Christina T. Halperin (2021) compares the analytical ability of Instrumental Neutron Activation Analysis (INAA) and pXRF when analysing Mayan ceramics. The research using the pXRF was conducted in a laboratory setting at two different laboratories in Guatemala (LeMoine and Halperin 2021:1–4). LeMoine and Halperin (2021) concludes that whilst pXRF does not have the analytical precision of data that INAA offers, its can still offer the precision needed to make conclusions around the provenance of ceramics in a large regional sense. This suggests that pXRF can classify the regional origin of the ceramics if the regions have varying geological characteristics (LeMoine and Halperin 2021:1–4). When variances in the geological characteristics are present, the pXRF is a reliable tool to be used and the results can be interpreted with a level of confidence. However, pXRF cannot analysis at the level of INAA based on the range of elements that pXRF can analyse. LeMoine and Halperin (2021) note that when identifying the origin of ceramics based on a subregional level, the pXRF cannot achieve this. Despite the differences in accuracy and precision, the pXRF offers non-destructible analysis of the ceramics and offers a less labour demanding alternative to INAA (LeMoine and Halperin 2021:3–9). This refers to the process of taking samples from the object, as INAA is classed as a semi-destructive analysis process. This can work with smaller sample sets, however, becomes an issue when working with larger sample sets. In the situation of LeMoine and Halperin (2021), they were not using whole ceramics from a museum or collection and instead were using sherds where semi-destructive analysis was permitted (LeMoine and Halperin 2021:8).

Junkyu Kim and coauthors (2023) study demonstrates the precision of pXRF. The study aimed to test the accuracy and precision of pXRF on prehistoric and early historical Korean ceramics, along with the process to select reproducible elements for analysis (Kim et al. 2023:1). They draw similar conclusions based on the analysis of ceramics to that of LeMoine and Halperin (2021). pXRF can have varied results or anomalies due to non-homogeneous characteristics. They stress the importance of selecting and filtering elements to increase the reliability of the study. Emmitt and team (2018) state the importance of choosing small selections of elements when conducting sourcing analysis of ceramics (Emmit et al 2018:430; Kim et al. 2023:10). However, Kim and their coauthors (2023) note the difficulty that is present when selecting or removing elements due to unknown factors. Systematic errors can be reduced through calibration of the pXRF based on the data collected. One of the methods of reducing systematic errors is through the process of selecting and removing elements. Errors caused by the matrix of the ceramics surface provide problems that are out of the control of the researcher when in a scenario of non-destructive analysis. They expand on this the issues of the method by stating that one of the problems present with pXRF is that of non-destructive analysis, as it presents problems or errors that cannot be removed, only reduced (Kim et al. 2023:10). Baxter and Jackson (2001) note the importance of selecting elements through careful consideration and that applying selected elements to other studies without evaluation, or that lack similar context, can lead to issues (Baxter and Jackson 2001:253–264).

2.3 pXRF in Analysing Ceramics

It is becoming increasingly common to use handheld pXRF as a tool to analyse ceramics. Handheld pXRF offers a non-destructive method of analysis, accessibility and the ability to analyse large groups of objects in a shorter period of time. Understanding the elemental composition of ceramics can give a wealth of information about the object and its manufacturing process (Shuger and Mass 2012:17). Handheld pXRF and other elemental composition analysis techniques are becoming frequently used to analysis the elemental composition of ceramics from Southeast Asia. An early example of research into the elemental composition of Vietnamese porcelain was conducted by Philippe Colomban et al. (2004), which used XRF and EDX to classify the elemental composition of sherds of Vietnamese 15th century porcelain and stoneware. These samples were excavated from the Chu Đâu–Mỹ Xá kiln sites and from the Cu Lao Chàm shipwreck. The samples were located at the Museum of Hải Dương and the Museum of Quảng Nam respectively. The research discusses the differences in the elemental composition based on the colour/type of the ceramic's motif (Colomban et al. 2004:125–127).

Fischer and Hsieh (2017) assess whether pXRF is a viable method of comparing Chinese 16th–17th century blue and white porcelain from two different kiln sites. The aim was to determine if pXRF could differentiate the difference between porcelain production at Jingdezhen and Zhangzhou kiln sites (Fischer and Hsieh 2017:14–15). Wenpeng Xu and their coauthors (2019) had similar aims in testing if pXRF could differentiate the kiln sites of Chinese porcelain dating to the 12th and 13th century from the Java Sea Shipwreck (JSW). This was done by comparing samples from the JSW and samples of porcelain from four kiln sites. Similar to the findings of Fischer and Hsieh (2017), Xu and team (2019:57) state that pXRF is a viable method for identifying the potential sources for overseas cargos found distant from production contexts for Chinese porcelains. Both of these articles use similar methods and analytical protocols for analysing the ceramics. Analysing the methods of both articles can help to determine the best analytical protocols that can then be applied to this study on Vietnamese blue and white porcelain (Fischer and Hsieh 2017:14; Xu, Niziolek and Feinman 2019:57).

Shankly (2010) stressed the importance of standards for analytical protocols. Standards act as a form of calibration for the pXRF and allow for elements to be removed from datasets when exceeding a deviation threshold. Without the use of standards and routinely testing those standards, the research you are conducting with pXRF delves into a 'trust me' state (Shakely 2010:19). Fischer and Hsieh (2017) and Xu and their team (2019) use a Thermo Niton XL3t GOLDD + portable X-ray fluorescence spectrometer with a silver (Ag) anode tube. Along with using the same handheld pXRF, both use a standard to determine the deviation of the pXRF and allow for elements to be excluded from the data set if they exceed a certain threshold (Fischer and Hsieh 2017:17; Xu et al. 2019:61). Fischer and Hsieh (2017) use the Corning Archaeology glass standard due to the standard sharing similar properties with the glaze's composition, whilst also containing minimal cobalt (Fischer and Hsieh 2017:19). Xu and coauthors (2019) used the Ohio Red Clay standard. 28 elements were removed from the dataset as they fell below the limit of detection (LOD), whilst a further 3 elements (calcium, sulphur, and zinc) were removed as the elements had a deviation of over 20% (Xu et al. 2019:62).

2.4 Key Elements in Vietnamese Blue and White Ceramics

To classify the characteristics of the ceramics, the key elements must be understood. This study will be analysing Vietnamese blue and white ceramics from the 15th and 16th century. This can help to distinguish between different types of Vietnamese blue and white, whilst also revealing how these characteristics differ from Chinese ceramics. This section will focus on the glaze and motif, as they are central in this thesis.

Zirconium (Zr) is one element in the glaze that can differ between Vietnamese and Chinese ceramics. Zirconium in the glaze is thought to come from the zircon crystals (Simsek et al. 2015:167). The zircon crystals remain after the firing process. Colomban and coauthors (2003:192) note that the remains act as a ‘fingerprint’ of the kiln and ‘a careful examination of any phase is a good way of learning if the same raw materials were used over a long period, if unsolved technical problems occurred, or if there were any modifications of production capabilities’ (Colomban et al. 2003:192). Vietnamese ceramics typically exhibit higher traces of zirconium compared to both Chinese and modern Japanese ceramics. The presence of zircon crystals is stated to be present from ceramics produced at the kilns in Chu Đâu (Colomban et al. 2003:192; Simsek et al. 2015:167). The highest quantity of zirconium measured in Vietnamese ceramics comes from Central Vietnam (Simsek et al. 2015:167).

The relationship between calcium (Ca) and potassium (K) can differentiate if a ceramic is of Vietnamese or Chinese origin. Vietnamese ceramics have higher amounts of Ca compared to K. Chinese ceramics have higher amounts K than Ca. Both Ca and K have been used as the main fluxing agent for the glaze. Ca and K have different characteristics as a fluxing agent. Ca is considered to be the more effective of the two fluxing agents in relation to the glaze, but has inconsistencies around the viscosity of the glaze which can create problems during the stinting phase, and can cause the glaze to buildup and become deposited (Colomban et al 2003:191). Ca is commonly found in shell, chalk and vegetable ash. K is rarer in comparison to Ca with some vegetable ash providing K along with feldspar being used to source the K. Vietnamese ceramics used K as the fluxing agent in the body, mixed with a combination of Ca and Na, whilst Ca was used as the fluxing agent for the glaze of the ceramic (Colomban et al. 2003:190–192). This is important in helping to distinguish between Vietnamese and Chinese ceramics. Whilst it is known that the ceramics are from Vietnam based on the style and motif, it is important to understand the characteristics that define them as Vietnamese ceramics.

Manganese (Mn) and its relationship with iron (Fe) and cobalt (Co) is important in distinguishing the source of the cobalt used in the blue motif (Simsek et al. 2015:167). It is understood that the cobalt used in Vietnamese blue and white ceramics during the 15th and 16th century did not originate from Vietnam (Kikuchi 2021:188). The cobalt sourced from China has higher traces of Mn. This is due to the cobalt coming from a manganese ore. This gives the motif a darker design opposed to cobalt sourced for from the Middle East, which has lower traces of manganese. Ceramics found at the Chu Đâu kiln sites exhibit this characteristic and have higher amounts of Mn (Simsek et al. 2015:167). Despite this, it is noted that Vietnamese ceramics have exhibited many different ratios between Mn and Co. This shows that various different pigment types were used in Vietnamese blue and whites (Colomban et al 2021:14).

2.5 Vietnamese Ceramic Production

Vietnam has a long history of ceramic production. From excavating early ceramics along with stone axes and burial sites, archaeologists have identified multiple early cultures of Vietnam which produced ceramics, such as the Phùng Nguyên culture (first half of the second millennium BCE), Đồng Đậu culture (second half of the second millennium BCE), Gò Mun culture (c.1100–700 BCE), and the Dong Son culture (700 BCE) (Kim 2015:106–110). These early cultures had distinct ceramic traditions. These ceramics had evidence of colours ranging from yellows and reds, along with darker grey. In conjunction with the ceramics found, evidence is present for workshops locations. This indicates dedicated ceramic productions (Kim 2015:106–110; Khoach 1980:33). From the bronze age in northern Vietnam, distinct styles of ceramics would appear. These styles of ceramics would be different from other ceramics found in other regions; however, these styles transitioned over time. During the Phùng Nguyên culture, ceramics produced had thinner walls due to the use of fine clay, fine temper and organic temper. Thin-walled ceramics would be phased out for heavier and thick-walled ceramics during the Đồng Đậu culture. Ceramics produced during the Bronze Age in Northern Vietnam would become the foundation for Vietnamese ceramic production (Chinh and Van Tien 1980:56–57).

During the late 2nd century BCE, the Han Dynasty arrived in the region and began to increase political control of the area, and later annexation (Kim 2022:533). The Han Chinese introduced closed firing techniques that allowed for higher temperatures to be reached within the kilns. This increase in sustained temperature allowed for ceramics of better quality to be produced (Fang 2023:151). The main production sites that were introduced during this period were the Thanh Hóa, Bim Son and Chí Linh kilns. During this period the Chinese influence could be seen as elements of cities were beginning to 'copy' aspects from Han Dynasty China. This is especially evident in the architectural elements such as ceramic roof tiles (Demandt 2020:179–180)

Ceramic export trade in Vietnam expanded under the Ming Emperor Hongwu's restriction on trade during the 14th century, following the war that expelled the Mongols in 1368. Roxana Brown (1988:23) notes that another reason for the beginning of export was the Chinese refugees settling and applying their trade in Northern Vietnam. However, Brown (1988:23) continues and states that this changed with the expansion of production following the trade ban by Emperor Hongwu.

The Red Delta River region in Northern Vietnam was a hub for ceramic producing communities. Sites included Trầm Điền, Huong Canh, Thổ Hà and Phù Lãng (Kikuchi 2021:24–28). Along with these sites there were also two ceramic complexes, Tức Mặc and Cồn Chè. These two sites were located within the royal complex, and now on the edge of modern-day Nam Định City (Kikuchi 2021:25). The 14th century saw the beginning of mass production of Vietnamese ceramics. The beginnings of blue and white ceramics production in Vietnam would be seen during this period which aimed to replicate the look of Yuan blue and white porcelain. Kikuchi (2021) stated that the Vietnamese were taking advantage of the Chinese maritime trade routes through Southeast Asia to export ceramics (Kikuchi 2021:149). Examples of exported Vietnamese wares from the Tran dynasty can be found in the Nikai-den sector of Shuri Castle in Okinawa, Japan. Approximately 545 sherds were found, which indicated that there was a minimum of 105 individual Vietnamese ceramics (Kikuchi 2021:11,152–153).

Whilst mass production and export of Vietnamese ceramics began during the late Tran dynasty, the late 13th and 14th century were also a period of decline for the Tran dynasty. The late 13th and early 14th century were plagued by natural disasters, such as droughts and floods, which lead to crop failures, along with political tension due to wars in what is modern day Laos and internal clashes (Taylor 2013:137–138). In 1361, the Kingdom of Champa began invasions and wars due to the decline that was facing the Tran dynasty. The Tran dynasty would come to an end in 1400 after Ho Quy Ly, born Le Quy Ly, would take the throne.

The Ho Dynasty would only last from 1400 to 1407, due to the Ming Invasion of Dại Ngu. The Ming occupied Northern Vietnam from 1407 to 1427. Keith Taylor (2013:179) states, in relation to the destruction of Vietnamese literature, that 'writings by the Vietnamese before the 15th century are rare'. Vietnam went through a period of strong Chinese influence on many facets of life, and this included ceramics. The Ming occupation of Vietnam had impacts on the style and type of ceramics produced (Taylor 2013:179).

These impacts would continue beyond the Ming occupation which ended in 1427. It is not exactly known when cobalt was introduced to Vietnamese ceramics. Blue and white designs before the introduction used an iron black design to imitate the blue and white of Chinese designs (Brown 1988:25). When cobalt was introduced, the iron black designs along with monochromatic ceramics would begin to slow down in production and become much less common. Evidence does exist for overlapping production of both cobalt and iron black designs as Brown (1988:25) states that ceramics produced during this period sometimes featured both the cobalt blue and iron black. Chinese design motifs also started to become more common following the introduction of cobalt. Following the earlier blue and white designs that shared similarities with earlier wares, Vietnamese blue and white ceramics shared increasingly more similarities with Chinese designs. This included both the motifs of the ceramics and their shapes. Brown (1988:25) describes this and the following periods as a 'total break from the past'.

The cobalt used in ceramics is presumed to not have originated from Vietnam but was instead introduced. One explanation for this is that it was introduced during the Ming occupation. Despite this explanation, evidence suggests that cobalt blue and white designs were most likely introduced in the latter half of the 14th century or at the latest, the first quarter of the 15th century. This is explained by Vietnamese ceramics that were found in Japan (Kikuchi 2021:188). John Guy (1986:46) states that a blue and white Vietnamese ceramic was found on Okinawa and has a similar flower motif to that of underglaze iron ceramics and that the blue and white ceramic would have reached the Okinawa no later than 1416 as this is when the site where the sherds were found from was destroyed (Guy 1986:46–47).

The Lê dynasty followed the Ming occupation of Vietnam. During this period, there was an increase in ceramic production due to the Ming Gap. The Ming Gap is a term that refers to the lack of Chinese blue and white wares from the 14th to 15th century due to the trade ban imposed by the Ming Dynasty (Brown 2004:6–7; Tai 2012:85–86). As there was a gap within the ceramic's exports market within Southeast Asia, Vietnam filled the gap left by Chinese ceramics. During the Lê dynasty, blue and white ceramics produced would have similar characteristic to the jarlets in this study, or possibly in the following Mạc dynasty which lasted from the end of the Lê dynasty in 1527 until 1592 (Kikuchi 2021:29).

The production of blue and white Vietnamese ceramics centred in Hải Hưng province, which later divided into two provinces now known as Hải Dương and Hưng Yên. Kilns in the Nam Sách Region in Hải Hưng province included the Chu Đâu kilns, the Mỹ Xá kilns, and the Hùng Thắng kilns. The Chu Đâu kilns and Mỹ Xá kilns are commonly referred to as the same due to being connected by a levee (Kikuchi 2021:30). The blue and white ceramics that the area produced were known collectively as Chu Đâu wares. It is important to note that Vietnamese blue and white ceramics were produced at other kiln sites. Kikuchi (2021) notes that the blue and white ceramics, such as Chu Đâu, were the main trade export during the Lê dynasty (Kikuchi 2021:35). The quality of these ceramics improved greatly during the mid-15th century. Brown (1986) states that the best Vietnamese blue and white ceramics were produced during this period, through the quality was still present in the 16th century. There were five excavations of the Chu Đâu kilns between 1986 and 1991. Tăng Bá Hoành, one of the researchers on the excavation, noted that the ceramics found at the Chu Đâu kilns were of higher quality. The increase in quality of the Chu Đâu ceramics has been attributed to trade ban imposed by the Ming Dynasty (Kikuchi 2021:30–31). The region, however, would decline in the 17th century following conflicts between the Lê dynasty and the Mạc dynasty that occurred during the 16th century (Kikuchi 2021:11).

2.6 The Chàm Islands Shipwreck

The Chàm Islands shipwreck, previously known as the Hội An shipwreck, contained one of the largest deposits of Vietnamese blue and white stoneware from the 15th century (Kikuchi 2021:183). The shipwreck is located off the coast of Cù lao Chàm, known as the Chàm Islands, near the city of Hội An. The shipwreck was first discovered by fisherman during the mid-1990s and was excavated from 1997 to 1999. The excavation was conducted by the Vietnamese Institute of Archaeology and the National Museum of Vietnamese History. The excavations were also conducted in conjunction with the Malaysian salvage company Saga Horizon (Guy 2005:107–108). A significant portion of the ceramics

Figure removed due to copyright restriction.

Figure 2: Vietnamese blue and white stoneware from the Museum of Trade Ceramics, Hội An, Vietnam. Photo courtesy of M. Polkinghorne.

excavated were sold by the US auction house Butterfields in 2000. The ceramics were sold due to the need for funding. The site is estimated to have contained approximately 250,000 ceramics with over 150,000 being intact (Brown 2004:9; Guy 2005:107–108). The Chàm Islands shipwreck is significant not only for the large quantity of Vietnamese blue and white stoneware ceramics, but also due to the significant number of styles present. Brown (2004:10) noted that the shipwreck displayed the stylistic evolution of Vietnamese ceramics as the site contained all the known styles dating to the 15th and 16th century within a single assemblage. Examples of the Vietnamese blue and white ceramics from the Chàm Islands shipwreck are seen in Figure 2. The Vietnamese blue and white ceramics from the shipwreck are attributed to the Chu Đậu kilns and the surrounding kilns in the area of the Hải Dương province (Kikuchi 2021:183).

2.7 The Pandanan Island Shipwreck

The Pandanan Island shipwreck is located off the coast of Pandanan Island, Palawan, Philippines. The shipwreck contained large quantities of Vietnamese ceramics along with Chinese and Thai ceramics. The shipwreck was first located by pearl divers accidentally and was examined initially by the National Museum in 1993. Excavations of the site would begin in 1995 with 4,722 artefacts being recovered. The artefacts excavated included ceramics as well as coins, metal, stone and glass artefacts (Dizon 2003:9–10). Eusebio Z. Dizon (1996:70) stated that 70% of the ceramics came from Vietnam, with the ceramics originating from both central and northern Vietnam. Similarly to the Chàm Islands shipwreck, the blue and white stoneware came from the Chu Đậu kilns. The Pandanan Island shipwreck is dated to around the mid-15th century due to the majority of the porcelain found at the site dating to this period (Kikuchi 2021:185).

2.8 The Lena Shoal Shipwreck

The Lena Shoal shipwreck was located to the north of Palawan Island, Philippines. The site was found by local spear fisherman and the was excavated in 1997 by the Philippine National Museum. Approximately 3,000 ceramics and other artefacts were excavated from the site (Kikuchi 2021:185). The ceramics excavated came from China, Vietnam, Thailand and Myanmar. Unlike the Chàm Islands shipwreck and the Pandanan shipwreck, most of the ceramics were not Vietnamese. Approximately 3,000 ceramics were excavated from the shipwreck. However, only 28 blue and white stoneware ceramics from Northern Vietnam were excavated from the site. Despite the small quantity of Vietnamese blue and white, they assumed to have been produced at the Chu Đậu. The shipwreck is dated to the end of the 15th century based to the Thai jars from the site (Dizon 2003:11–12; Kikuchi 2021:185).

CHAPTER 3: SAMPLES AND METHODS

3.1 Introduction

This chapter details the vessels and methods that were used in this study. The methods section of this chapter discuses the process to analyse these ceramics and the interpretations of the results. It also discusses how the methods were chosen and similarities present to other studies.

3.2 Vessels

The samples for this research date to the 15th and 16th century, and they comprise of Vietnamese blue and white porcelain jarlets. All 55 jarlets are from the SEACAL lab at Flinders University. All samples are complete vessels, not sherds. Based on the marine growth on the ceramics, the 55 vessels came from a submerged environment. These 55 ceramics are classed as ‘grey’ artefacts, as they were salvaged without archaeological protocols and purchased on the antiques market. The shipwreck or shipwrecks from which the ceramics were recovered are unknown. The purpose of this research is to understand if pXRF can be used as a method of understanding ‘grey’ ceramics provenance. From the interviews conducted with Michael Abbott, the jarlets are considered to have been bought in Sulawesi with other being bought in Bali. The jarlets come in three different shapes with associated decorative designs.

The 55 jarlets form the main set in this study and will be referred to as the ‘main set’ throughout the methods, results and discussion. This is to avoid repetitiveness when discussing the vessels as a group. The 23 other Vietnamese and Chinese ceramics will be referred to as the ‘comparative set’ unless otherwise specified.

The ceramics separated into these categories based on their shape. This is for convenience when interpreting and displaying the results. The different in shape are not believed to imply a difference in context between the vessels. By grouping the vessels based on shape, it is not inferring that vessels grouped are from the same production site or depositional context. The vessels are purely grouped based on the shape and motif. The same metric is extended to the comparative set.

The first shape is the cylindrical shape. 14 cylindrical shaped jarlets are present within the main set. The body of the ceramic is cylindrical in shape with slight tapering on the shoulders with a small rim. It also has a rimmed base that occasionally features the brown paint of the base that is sometimes referred to as a ‘chocolate’ base. Overall, there is insignificant variation in shape and size for the cylindrical jarlets. The main blue motif that surrounds the body consists of lotus flowers with a floral/plant design surrounding the flowers. A lotus flower design wraps around the shoulder of the vessel. All the cylindrical ceramics feature the same design with small variations in the thickness of the design and intensity of the blue colour, however the difference in intensity of colour may be due to post-depositional damage. All the cylindrical jarlets have some degree of marine growth as well as salts and abrasions present.

The second shape is the globular shape. The globular shape jarlets were the most common in the main set, with a total of 38 vessels. The globular shape consists of rounded broad shoulders with a tapered body. The shape has varied lip height with a small amount not having distinct lips. The globular shape has varied bases with approximately half of the ceramics having flat bases whilst the remainder have a rimmed base, like that of the cylindrical shape. Again, similarly to the cylindrical design, the bases on certain samples have the ‘chocolate’ base. The motif of the globular shape is very similar to that of the cylindrical design. The main body has the floral design with lotus flowers on the body of the ceramic and the around the shoulders of the ceramic. The design and motif are all the same across all the globular shapes. Like the cylindrical shape, the globular jarlets are predominantly the same size and shape overall. There is more variance when compared to the cylindrical shape.

The last shape present is the hexagonal shaped jarlet. Only 3 hexagonal shaped jarlets were in the main set. These jarlets have a six-sided body with an angled shoulder that leads to the lip. All the hexagonal shaped jarlets have a rimed base with the ‘chocolate’ base. The motif design of the hexagonal jarlets is different to that of the cylindrical and globular jarlets. The only similarity is the lotus petal design above the shoulder that goes around the rim. The six sides that make the body feature a plant design with the shoulders having an alternating lined and floral pattern.

To assist with contextualising the elemental data attained from the jarlets, an additional group of Vietnamese and Chinese blue and white ceramics was used. The comparison set is used as a point of comparison to highlight the differences that are present in the elemental composition of the jarlets. The ceramics used for this set are all blue and white ceramics from both Vietnam and

China. The Vietnamese ceramics were used in both the analysis of the glaze and the motif while the Chinese ceramics were only used in the analysis of the motif in order to see how the glaze compares to other Vietnam ceramics, not the glaze on the Chinese ceramics. The comparison set consisted of 11 Vietnamese and 12 Chinese ceramics. The Vietnamese ceramics included 4 covered boxes (ABT1268, ABT1261, ABT0869, ABT0870), 4 small cups (ABT1060, ABT1088, ABT1102, ABT1854), 2 jars (ABT0274, ABT1224) and 1 hexagonal jarlet (ABT1214) that shares similarities with the hexagonal jarlets of the main set. This jarlet was original considered part of the main set but was excluded due to lacking marine accretions (making post-depositional history uncertain), the size being large and the darker colour of the motif. The 12 Chinese ceramics included 4 Batavia ware cups (ABT1048, ABT1062, ABT1068, ABT1084), 4 Chinese jarlets (ABT1235, ABT1243, ABT1265, ABT1267), 2 Chinese covered boxes (ABT0867, ABT0876) and 2 small jars with lids (ABT1220, ABT1226).

3.3 Methods pXRF

3.3.1 Overview

This thesis used a Bruker 5i in laboratory bench setup in an upright position whilst being plugged into a 120v wall outlet. The Bruker emitted an 8mm beam diameter using the provided collimator. Samples were scanned for 60s using the preinstalled GeoExplorer2022, which operates at 40 kV, 20 µA using the Ti:25/Al:300 wheel for 30s in the first phase then 10 kV, 65 µA with no filter for 30s in the second phase. Each sample was scanned three time in the same spot for the glaze, motif and paste. Samples include 55 Vietnamese blue and white jarlets in three varying shapes. Each shape has a similar size and weight. In addition to the main set and total of 25 Vietnamese and Chinese ceramics were also scanned as part of the comparison set. The same configuration was used to analyse the comparison set. No filters were used; no vacuum or helium chamber were used. Neutron Activation Analysis (NAA) and National Institute of Standards and Technology (NIST) samples were used as a point of comparison. The results from the NAA and NIST will be used to compare against the results of the pXRF. (Johnson et al. 2024:160).

3.3.2 Calibration Modes

Analysis conducted with the Bruker 5i instrument utilised two calibration modes. The two modes that were used are the GeoExploer2020 and the GeoMining modes. GeoExplorer2020 has two phases whilst GeoMining has three phases. GeoExplorer gives how the results of the compounds MgO, Al2O3, SiO2 and K2O. Previous studies have used two different modes in their studies. Both

Speakman et al. (2011) and Fischer and Hsieh used both a ‘soil’ mode and a ‘mining mode’ (Speakman et al. 2011:46; Fischer and Hsieh 2017:17). However, for this study only one mode in GeoExplorer2020 was used, as this study was less concerned with using the compound results.

3.3.3 Acquisition Time

The acquisition time of the Bruker Tracer 5i can be set manually. The acquisition time was 60 seconds. From our findings, little variance was found by increasing the acquisition time. Based on the results from other articles using pXRF to analysis ceramics, large variances in acquisition time were found, ranging from 60s to 200s. Increasing the acquisition time improves the ‘peak-to background ratio’ (da Silva et al. 2023:3). However, it has been stated that increasing the acquisition time beyond 60s has little impact on the results (Sinnesael et al. 2018:22). Matthias Sinnesael (2018:22) add that 60s ‘was sufficient for Time of Stable Reproducibility (TSR) and Time of Stable (TSA) to be reached for individual point spectra for all elements considered in this study’. Niels J. de Winter et. al. (2017) state similar findings on trace element analysis of carbonates using pXRF. They note when increasing the acquisition time beyond a large number, 60s, the increases in precision are negligible or non-existent (de Winter et al. 2017:1216). Despite these findings, pXRF articles that analyse ceramics set acquisition times of above 60s. Fischer and Hsieh (2019) state that they use an acquisition time of 90s whilst Xu et. al. (2021) state that they used an acquisition time of 120s. It is not elaborated further as to why these acquisition times were chosen in these studies; however, it shows that there is variance present in studies. It is also worth stating that these studies used a different manufacturer of pXRF so that could be a factor present when deciding what acquisition time to use (Fischer and Hsieh 2019:17; Xu et al. 2021:5). de Winter et. al. (2017) and Sinnesael et. al. (2018) used an older Bruker model of pXRF. Da Silva et. al. (2022) also used an acquisition time of 60s on a Bruker model pXRF (Da Silva et al 2023:2; de Winter et al. 2017:1216; Sinnesael et al. 2018:22). Due to these factors, an acquisition time of 60s was used when the jarlets were analysed in this study.

3.3.4 Collimator

For this study, the 8mm collimator was used. A collimator is used to determine the size of the x-ray beam used when taking results as it is used to widen or narrow the X-ray beam. The Bruker Tracer 5i, is equipped with two options, an 8mm and a 3mm collimator. The 8mm collimator was chosen, as it was found that the results of the 3mm collimator had more variance in the results than the 8mm collimator. Although the 3mm beam size would have been beneficial for this study, due to factors such as marine growth. The 8mm was used due to the variances.

3.3.5 Acquisition Area

This study collected results from three different locations on each ceramic. Results were taken from the glaze and motif. This study aims to test the applicability of using pXRF as a method to classify and develop the context of the chosen ceramics, mainly the area of production and the shipwreck from which they were salvaged. This is an important distinction to make, as pXRF is not a reliable tool to do quantification analysis of the ceramic's elemental composition (Xu et al. 2019:63). The concern for this study was focused on the ability the pXRF has to link ceramics based on similarities opposed to getting exact elemental composition. Other methods such as neutron activation analysis or inductively coupled plasma mass spectrometry are better suited to the task quantitative analysis (Xu et al. 2019:63). As the focus was on finding the provenience, the glaze and motif were the chosen areas of acquisition. The study used a 'single spot' strategy. This means results were taken each of the two sections from one area. This is opposed to a 'multi spot' strategy where results for each of the three areas are taken from different spots (de Winter et al. 2017:1213). There were multiple factors as to why a single spot strategy was use. The first being that marine growth affects the ability to scan from certain areas. On all 55 of the samples in the main set, marine growths were present. Certain ceramics had more marine growth than others. Due to the marine growth present on the artefact, difficulties were present when placing the sensor against the surface of the ceramic. Air in the atmosphere can affect the results and a helium purge was not used which would require the pXRF to be connect to a helium tank when in use. The air between the surface that is being tested and the sensor of the pXRF will absorb some of the low energy x-rays. Any gap between the surface and the sensor can affect the results negatively (Fischer and Hsieh 2019:63). Another reason for doing a single spot strategy is that not all the ceramics had multiple areas large enough to test. There also not multiple areas that filled the 8mm test area, or in the case of the glaze, multiple 8mm areas where there was no motif. This was problematic when testing the cylindrical jarlets, as the motif design was thinner and more densely compacted compared to the globular shape jarlets. For these reasons it was decided to use a single spot strategy.

Despite choosing to use a single spot, a small number of ceramics were tested using a multiple spot strategy. This was to determine the differences that are present between the two strategies. Multi spot has benefits due to the fact the surface or glaze of a ceramic is not homogenous. The elemental composition of the ceramics surface will not be the same in different locations. A multiple spot strategy aims to average the elemental composition of each different area to determine a theoretical overall surfaces average of the elemental composition. By comparing the different methods, the aim was to determine which method provided more precise results and which of the two would be better for further and expanded research. de Winter et. al. (2017:1215) in their research comparing the different methods for pXRF found that a multiple spot strategy had the lowest precision of the two methods (de Winter et al. 2017:1215). This study used three samples from a single spot, then averaged the three results to improve the variability. The aim by following this method was to improve the overall accuracy of the tests. In theory this could also improve the replicability of this study. Each of these three tests were taken from in the same spot one after another. The three samples were averaged. This was done to increase the precision of the results, whilst also trying to remove any possible outliers in the data.

From conducting the analysis, it was determined that the focus would be on the glaze and motif results, excluding the samples of the paste. This was due to the gap are present between the surface of the paste and the base rim of the object. This was the only area of the jarlet where a sample of the paste could be taken. Due to this, the pXRF was unable to be directly against the surface of the paste, meaning that the results would be affected by the air that was present between the detector of the pXRF and surface of the paste. This greatly affected the results. For this reason, the paste results were excluded from the study. This is expanded upon in the limitations section of this chapter.

3.3.6 NAA and NIST Comparison

The NAA and NIST sample were used as a comparison to the pXRF. Two different types of standards were used. The first being conducting NAA on a ceramic that has a similar matrix to the jarlets. Ceramic sample ABT1087 was analysed via k_0-NAA at the Australian Nuclear Science and Technology Organisation. The surface glaze was removed to ensure only the ceramic fabric was analysed; this also eliminates any potential post depositional contamination (Glascock 1992:13; Polkinghorne et al. 2019:8). A Dremel with a tungsten carbide high-speed burr was used to remove the outer surface of the ceramic (Glascock 1992:13; Polkinghorne et al. 2019:8). This was conducted inside a customised Perspex box to contain dust and limit the possibility of contamination. Deionized water was used to rinse the sample which was then dried in a laboratory oven at 110°C. The dried sample was then crushed into a homogenised powder with a Brazilian agate mortar and pestle. Approximately 100 mg of the powdered sample was sent to ANSTO for k_0-NAA and the remaining powder was placed in a pXRF sample capsule with a one-micron thick plastic cover on one side which was used to take results from using pXRF.

By comparing the results of both the NAA and pXRF, it was determined what elements should be removed from data. Elements were removed if they fell below the limits of detection or exceeded. Along with the NAA data, another point of comparison was. The second point of comparison was from the National Institute of Standards and Technology in the United States. The sample used was 98b Plastic Clay. The Plastic Clay has the exact elemental composition of the clay and can be used to compare with the pXRF results.

3.3.7 MURRAP Statistical Routines and GAUSS Runtime

For the analysis of the data, MURRAP Statistical Routines and GAUSS Runtime was used. MURRAP Statistical Routines and GAUSS Runtime is a program in development from the Archaeometry Laboratory at the University of Missouri Research Rector which turns the data into log 10. The software is a public domain statistical analysis software that was last updated in November 2022. The program is used for principal component analysis which can create hierarchical clusters and biplots from the data collected. By doing principal component analysis, it can group the jarlets by similarities of elements. Doing so allows to classify possible groupings and the characteristics that define those groups. The aim of the project is to determine if pXRF can classify significant differences in the elemental composition of the ceramics. By grouping the objects, this can then lead further understanding of the production along with the secondary and tertiary depositional contexts. This is a program that has been used in pXRF and NAA studies previously (Fischer and Hsieh 2019:63).

3.3.8 Principal Component Analysis

Principal component analysis, or PCA, is a statistical method of showing the relationships between the data of the samples. This helps to group the data of the results by transforming and plotting them on a coordinate system. By plotting the principal components, it demonstrates the variability between the samples and the elements which are contributing to that variability (Glascock et al 2004:98–100). PCA plots the first principal component against the second principal component. The first principal component of the data will include the highest amount of variability whilst the second principal component will depict the majority of the remaining variability. PCA was used in this study to depict the variability between the ceramics of both the main set and the comparison set. PC1 and PC2 of the data for both the glaze and motif were plotted on biplots with vectors which depicted the elements which caused the highest variability amongst the ceramics (Bland 2019:381). The PCA was conducted using the aforementioned MURRAP Statistical Routines and GAUSS Runtime which turns the data in the base-10 logarithms. The use of base-10 logarithms compensates for the large variability between the major elements and the trace elements. Due to ceramics having a combination of major, minor and trace elements, the major elements can overpower the data due to PCA being scale dependent. The use of base-10 logarithms compensates for the difference present between the major and trace elements. The summary of the variability of each biplot is stated within the results (Glascock et al. 2004:100; Bland 2019:381).

3.3.9 Hierarchical Cluster Analysis

Hierarchical cluster analysis is a form of cluster analysis that groups samples based on the similarities between them. Hierarchical cluster analysis depicts the similarities between the samples by displaying the groups using a dendrogram (Glascock et al. 2004:98). Hierarchical cluster analysis was used in this study to group the ceramics of the main set as well as the comparison set. All hierarchical cluster analysis data in this study has been displayed using a dendrogram.

3.4 Limitations

Multiple limitations were present that would affect the outcome of the results. These limitations were caused by the shapes of the jarlets, as well as the marine accretions, interfering or hindering the sensor of the pXRF.

One limitations present was that the rim around the base of the jarlet made it difficult to obtain results from the paste. The pXRF required the sensor to touching against the sample in order to reduce the effect of air on the beam. This problem led to the results from the paste being excluded as over half the ceramics have a rim. There is the possibility of taking samples from the rim itself. However, this had its own difficulties as a quarter of the rim's diameter is covered by the glaze. This would interfere with the results would detect both the paste and the glaze.

Similar difficulties were present due to marine growth on the ceramics. The marine growth prevents a sample being taken as either, there is not enough surface area, or the marine growth prevents the sample being directly against the sensor when the results are taken (Fischer and Hsieh 2017:16; Xu, Niziolek and Feinman 2019:62). The problem with preventing the sensor from being directly in contact with the surface of the ceramic occurs as there is air between the beam's path and the surface of the test sample. This is due to the argon present in the air which causes a gradual loss in flux intensity, or attenuation, of lower atomic number elements (Kuzmanovic et al

2021:5). The elements that make up the main components of the elemental composition of stoneware fall into the low energy x-ray lines. This includes elements such as silicon, magnesium, aluminium, and potassium (Bezur and Casadio 2012:253).

The hexagonal shaped jarlets presented difficulties due to the marine accretion and the shape of the motif. Issues were present when taking results from the ceramic due to the marine accretion. This made it difficult to get the sample area directly against the sensor of the pXRF due to the marine growth. The cobalt motif design on the hexagonal jarlets is thinner and which led to the motif not filing the 8mm sensor size of the pXRF. This means that when taking samples, the result would also feature the glaze when analysing the motif. These difficulties were also present due to the marine growth covering the areas where is motif is at its thickest.

The marine accretions present on the ceramics and the issues around the thinness of the motif were the reasons it was decided that a single spot strategy would be used. Three samples would be taken from a single spot instead of multiple spots. This was due to the lack of available spots to sample due to the marine accretion preventing the sensor from coming in contact with the surface.

There are complications when taking a sample from a curved or uneven surface using a pXRF. Most of the glaze area on the ceramics tested are not flat and usually have a curve (Fischer and Hsieh 2017:18–19). A solution that is used to create a flat surface is to take powder sample from the ceramic and press the sample into a pellet. This creates the flat surface whilst also homogenizing the sample (Emmitt et al. 2018:423). Another solution is to analysis the cross section of the ceramic, again offering a flat surface. However, both these solutions are time and labour consuming whilst also being destructive to the ceramic. In scenarios where keeping the ceramic whole is a priority, or when the ceramic is in a museum or collection, these solutions are not viable options (LeMoine and Halperin 2021:3). Fischer and Hsieh (2017:19) tested the difference between the results of flat versus curved surfaces and note that ‘data for light elements measured with pXRF in non-ideal conditions should be taken and interpreted cautiously’. Within their own research they labelled aluminium and silicon as ‘semi-qualitive’ and was only used when discussing the general trends of the ceramics

CHAPTER 4: RESULTS

4.1 Introduction

The chapter presents the results of the pXRF analysis of the 55 Vietnamese blue and white stoneware jarlets, and the comparison set. It discusses detail the comparison between the pXRF and the NAA and NIST samples, the results of analysis of the glaze and the analysis of the motif. The analysis of the glaze and motif was carried out with the use of both principal component and hierarchical cluster analysis.

4.2 Neutron Activation Analysis (NAA) Comparison

Neutron Activation Analysis (NAA) was conducted on object ABT1087 as a point of comparison between pXRF and NAA. This would determine the difference of the values produced by the two methods and the elements that be removed from the study or included as semi-quantitative. ABT1087 was chosen due to having a similar matrix to that of our objects. ABT1087 is a Batavia ware porcelain small cup. Table 1 shows the results from the NAA and pXRF of ABT1087. The results are given in Parts Per Million (PPM). Fifteen elements were compared, Al, K, Ca, Cr, Mn, Fe, Co, Zn, Ga, As, Rb, Ce, Hf, Th and U. The results show that pXRF results for Cr, Mn, Zn, As, Rb, Hf, Th and U were higher than NAA. Cr, Th, Hf and U were significantly higher with Cr having a difference of 75.72 PPM, Th having a difference of 32.19 PPM, Hf having a difference of 4.414 and U having a difference of 480.94 PPM. All four elements have a high percentage difference between the NAA and pXRF. Due to the NAA having higher accuracy then the pXRF, elements with large discrepancies could be removed. Cr, Th, Hf and U were excluded from further analysis within study. Th would also inconstantly fall below the limits of detection. The pXRF results for Al is significantly lower compared to the NAA results however it will be kept in the main study despite the low accuracy due to Al being one of the core components of clay. Lighter elements measured in inconsistent environments must be interpreted within the study with caution. This study measured the objects in air which created an inconsistent environment. Caution was used when using Al to form conclusions in this study. The same caution must also be applied to K as it also falls significantly below the NAA measurement. The remainder of the elements fall within an acceptable area of similarity between the pXRF and the NAA results.

Table 1: NAA v pXRF ABT1087

ABT 1087	Al	K	Ca	Cr	Mn	Fe	Co	Zn	Ga	As	Rb
NAA	135800.000	25410.000	11730.000	2.280	1616.000	6819.000	258.800	31.560	37.660	7.797	431.700
pXRF	73132.000	17657.000	9829.000	78.000	1799.000	5205.000	188.000	49.000	8.000	15.000	477.000
Difference	62668.000	7753.000	1901.000	-75.720	-183.000	1614.000	70.800	-17.440	29.660	-7.203	-45.300

4.3 NIST Material 98b Comparison

The NIST material 98b was used for comparison for the pXRF. Al, K, Ca, Ti, Cr, Mn, Fe, Li, Mg, Na and Sr were compared between the 98b sample and the pXRF. Table 2 shows the results from the comparison. The results are given in PPM. The results showed that the pXRF results for Al was significantly lower than the NIST sample. The pXRF result for Al is 102709 PPM with the NIST sample being 143000 PPM. However this result is similar to the NAA sample, this has reinforced the decision to keep Al as a semi-qualitive element. This is due to the difficulty of measuring lighter elements been inconsistent to measure and that the element is part of the basic make up of clay. K and Fe pXRF result fell below the NIST sample however not by a significant amount. Ti pXRF result was also under the result for the NIST sample, however not to the extent that it needs to be removed from the study. The pXRF result for Ca was also significantly higher than the NIST result. Similarly to Al, calcium is a core component of the clay and glaze. Caution will be taken when forming opinion based of the Ca results from the objects. Cr, Mn and Sr pXRF results were higher than the NIST result. Cr had already been excluded the results due to the significant difference between the NAA and pXRF results. The results for Mn and Sr were higher however not by a significant amount that would exclude them for the results. The pXRF was not able to pick up results for Li, Mg and Na. This was due to the model of pXRF used in the study not being able to sense Li and Na. Mg was detected using the pXRF used in this study, however the error was high. This meant that the Mg result fell below the limits of detection. It must be noted when forming opinions from the Mg results that the error is quite high and could affect the results.

Table 2: NIST 98b vs pXRF

98b	Al	K	Ca	Ti	Cr	Mn	Fe	Sr
NIST PPM	143000.000	28100.000	759.000	8090.000	119.000	116.000	11800.000	189.000
pXRF PPM	102709.000	24324.000	1316.000	5764.000	147.000	168.000	10288.000	223.000
Difference	40291.000	3776.000	-557.000	2326.000	-28.000	-52.000	1512.000	-34.000

5.4 Glaze Composition

21 elements were chosen for this analysis, Mg, Al, Si, S, K, Ca, Ti, Mn, Fe, Co, Zn, Ga, As, Rb, Sr, Zr, Nb, Mo, Pd, Sn and Ce. The results for the glaze were taken from the 55 objects along with 11 other ceramics from Vietnam from the comparison set. These 11 ceramics acted as a point of comparison to the main objects within the dataset. The glaze was analysed with principal component analysis and hierarchical clusters.

Table 3: Summary of the first 10 principal components for Figure 3 with variation and cumulative

PC	Variance %	Cumulative %
1	41.34	41.34
2	15.3	56.64
3	8.44	65.08
4	7.14	72.22
5	5.62	77.84
6	5.33	83.17
7	4.55	87.72
8	3.13	90.85
9	2.3	93.15
10	1.94	95.09

Table 3 and Table 4 display the summary of the first 10 principal components for Figure 3 and Figure 4 respectively. The PCA for Figure 3 could account for 95.09% variability within the first 10 PCAs. The PCA for Figure 4 could account for 98.37% variability from the first 10 PCAs. The Figure 3 and Figure 4 are biplots of principal components 1 and 2 based on the composition of the glaze. Figure 3 shows the pXRF results when taking one sample from each object. Figure 4 shows the results when three sample are taken from each object then averaged to mitigate the variance that can be found. Figures 3 and 4 only show the results from the main 55 objects in the study. By averaging the results, the overlap between the results were shown.

Table 4: Summary of the first 10 principal components for Figure 4 with variation and cumulative

PC	*Variance %*	*Cumulative %*
1	68.22	68.22
2	7.96	76.18
3	6.34	82.53
4	5.11	87.64
5	3.55	91.19
6	2.68	93.88
7	2.02	95.90
8	1.08	96.98
9	0.78	97.75
10	0.61	98.37

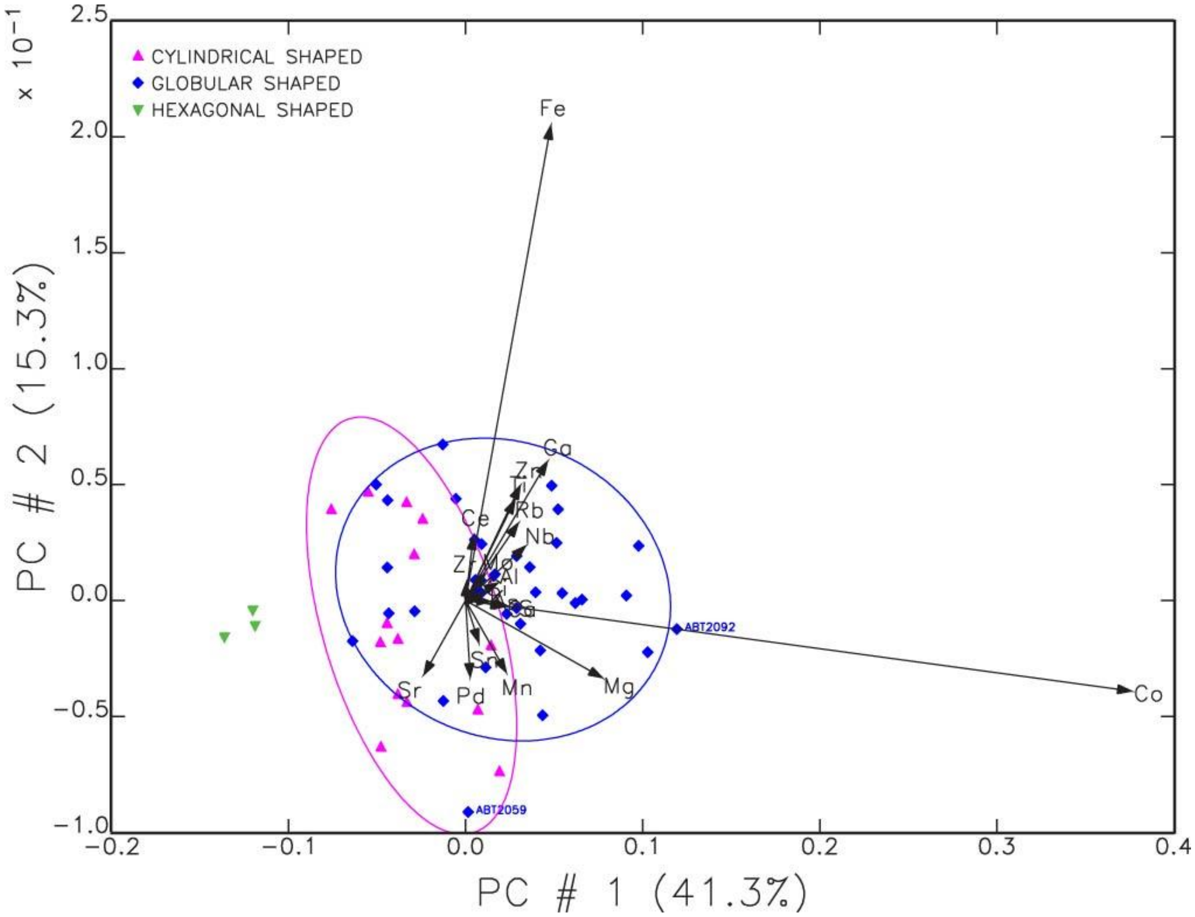


Figure 3: Biplot of the principal components 1 and 2 based on the averages of three samples from the glaze

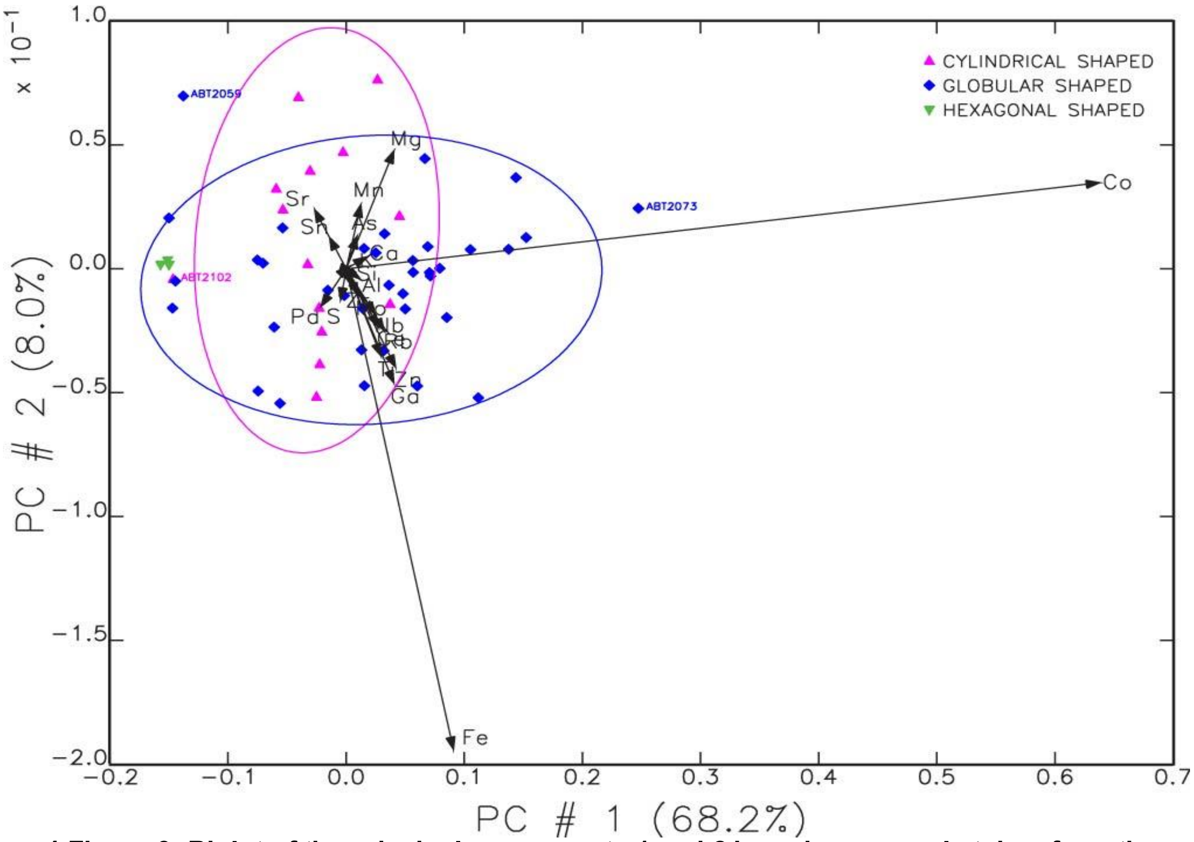


Figure 4:Figure 3: Biplot of the principal components 1 and 2 based one sample taken from the glaze

This is most evident in the hexagonal shaped ceramics. They were completely separate from the other two shapes in Figure 3; however, they overlap in Figure 4. Figure 4 displays that the elements that causing the most variation within the main set of ceramics are Fe and Co. The highest Co value of the ceramics is 53.66 PPM whilst the lowest is 0 which is the value for 21 of the 55 objects. The variance is most likely attributed to ceramics where part of the motif was picked up by the pXRF. This was mentioned in the limitations where certain ceramics didn't have a large enough area of glaze to fill the test area of the pXRF. Fe was the other element causing the highest variance with the lowest being 481.66 PPM and the highest being 5535 PPM. Overall, there is a large overlap between the three different shapes that are found in the main set.

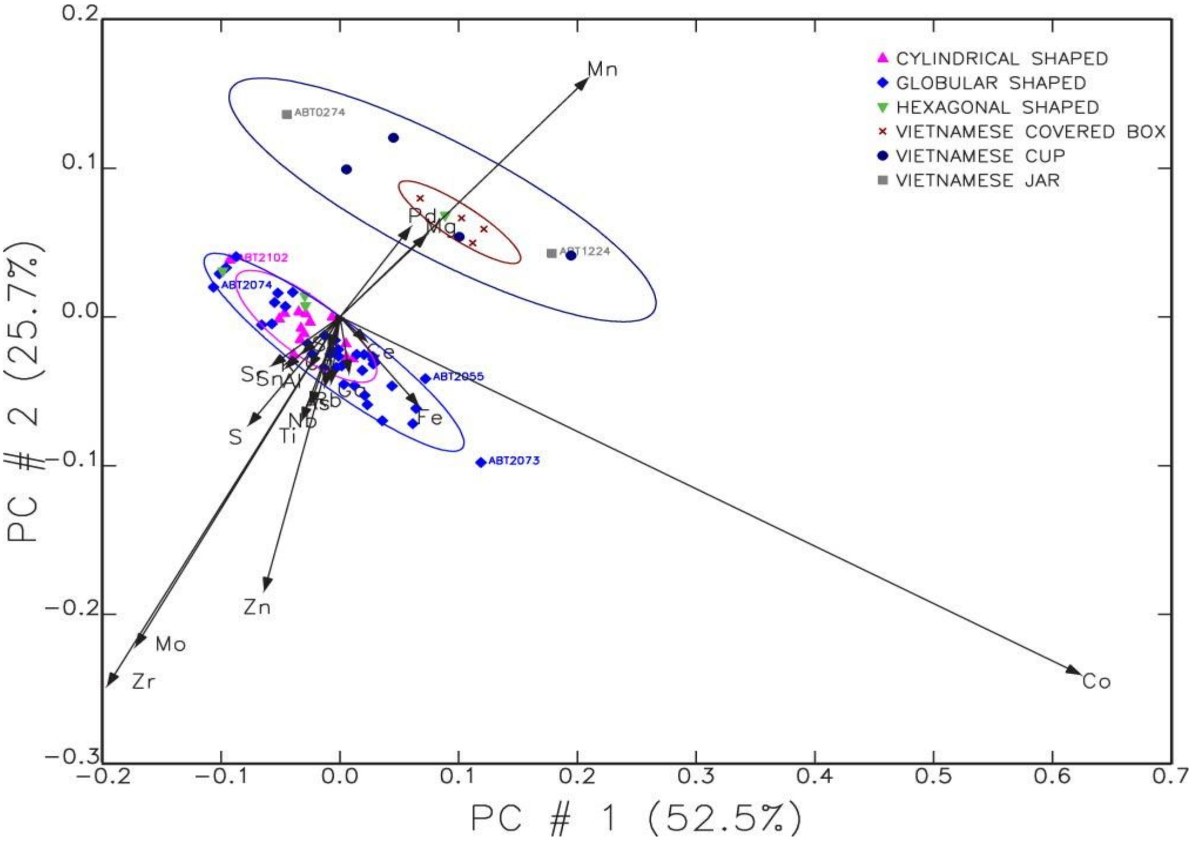


Figure 5: Biplot of the principal components 1 and 2 based on the sample averages of the glaze from the main set and the comparative set.

Table 5 display the summary of the first 10 principal components for Figure 5. The PCA for Figure 5 could account for 98.02% variability within the first 10 PCAs. Figure 5 is a biplot of the principal components 1 and 2 of the glaze composition of the main 55 Vietnamese jarlets along with 11 other Vietnamese blue and white ceramics. This adds 4 Vietnamese covered boxes, 4 Vietnamese small cups, 2 Vietnamese jars along with 1 other Vietnamese hexagonal jar. These 11 examples are also blue and white stoneware from the 15th and 16th century, the same as the main ceramics. The one added hexagonal jarlet (ABT1214) is similar to the other three hexagonal jarlets from the main dataset. It lacks the marine accretions that are present on the main examples of hexagonal jars along with being larger with the body being denser. It has the same pattern and motifs as the other examples, but the colour of the motifs is darker, closer to black compared to blue. It was originally part of the main dataset however it was removed due to these differences. Figure 5 shows a clear difference between the main jarlets in the dataset and the 11 other ceramics. It must be noted that the biplot shows more variant between the comparison ceramics which is to be expected as there is a small quantity with 4 different types. Similar to the biplot without the comparison ceramics, Co is shown to have the largest relative difference between the two sets of objects. Mn, Zn, Mo and Zr are causing the largest difference between the object groups. The difference between these objects is reinforced by Figure 6 which shows a hierarchical cluster showing both sets of ceramics. Based on Figure 6, the cluster is showing two clear groupings. It is showing that pXRF can differentiate between different groups of ceramics, as can clearly been seen in the hierarchical cluster.

All the other Vietnamese ceramics have a higher amount of Mn except for one Vietnamese jar (ABT0274). The main set of jarlets have significantly higher amounts of Zr. 926 PPM is the lowest quantity the jarlets (ABT2101) whilst the highest amount found in the comparison set is 242.66 PPM (ABT1854). It must be noted that there is variance amongst the Zr results for the main set, with the lowest being 926 PPM (ABT2101) whilst the highest being 1850 PPM (ABT2053). The results for Mo follow a similar pattern with the lowest of the main set having trace of 35.66 PPM whilst the highest of the comparison set being 15.66 PPM. Zn was another element that had large variance however not to the extent of the other groups. The range of Zn for the main set was 151.66 PPM–695.33 PPM and the range for the comparison set was 46 PPM–174.33 PPM. The overlap between the groups was minimal with only one jarlet (ABT2069) from the main set falling below the highest from the comparison set.

Table 5: Summary of the first 10 principal components for Figure 5 with variation and cumulative

PC	*Variance %*	*Cumulative %*
1	52.48	52.48
2	25.74	78.21
3	5.11	83.32
4	4.28	87.60
5	3.38	90.98
6	2.59	93.57
7	1.84	95.42
8	1.34	96.78
9	0.70	97.45
10	0.62	98.02

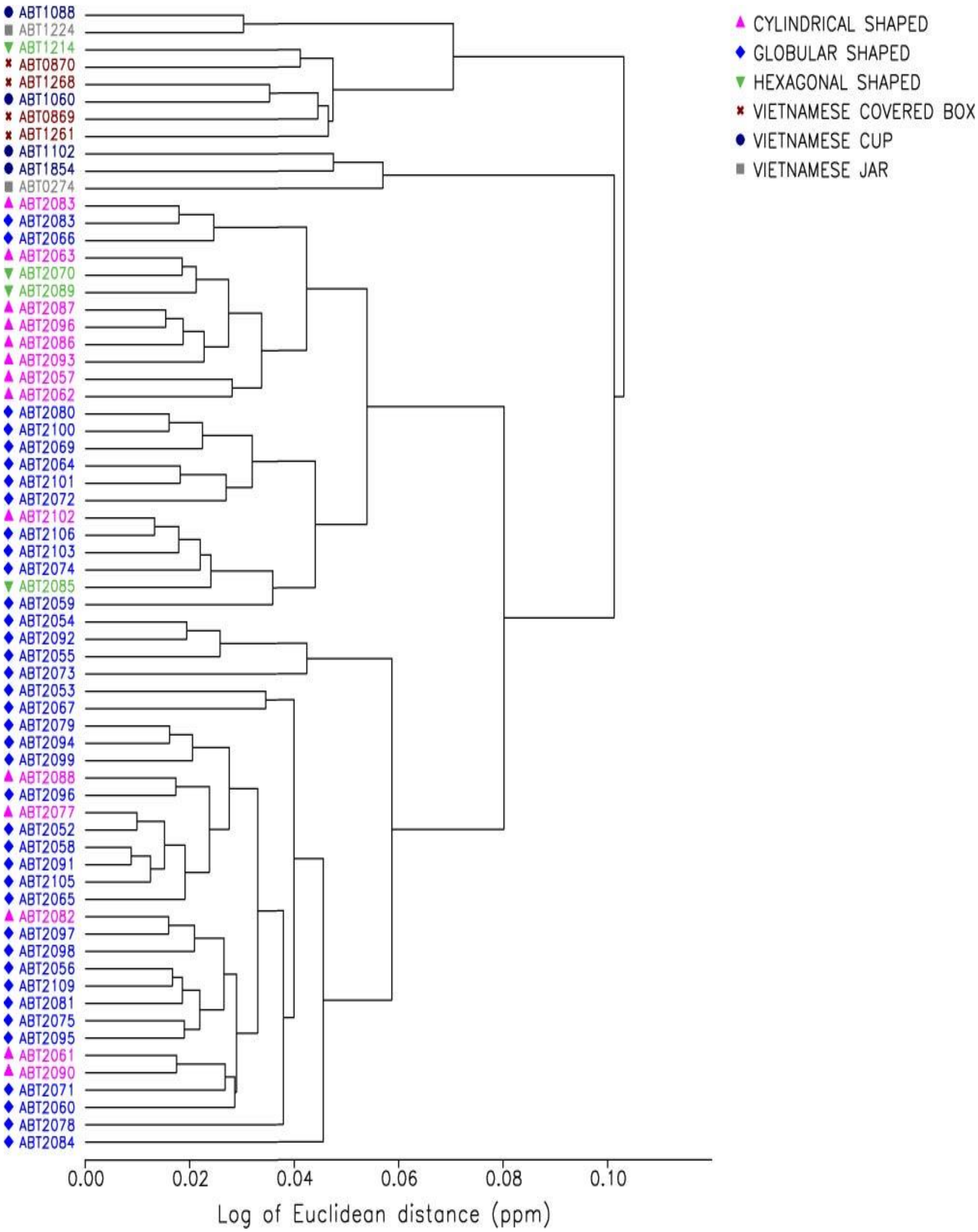


Figure 6: Hierarchical cluster analysis of the glaze composition of the main set and the comparative set.

Table 6: Summary of the first 10 principal components for Figure 7 with variation and cumulative.

PC	*Variance %*	*Cumulative %*
1	54.80	54.80
2	12.49	67.29
3	10.14	77.43
4	6.26	83.69
5	4.01	87.70
6	3.09	90:79
7	2.76	93.55
8	2.13	95.68
9	1.23	96.92
10	0.73	97.65

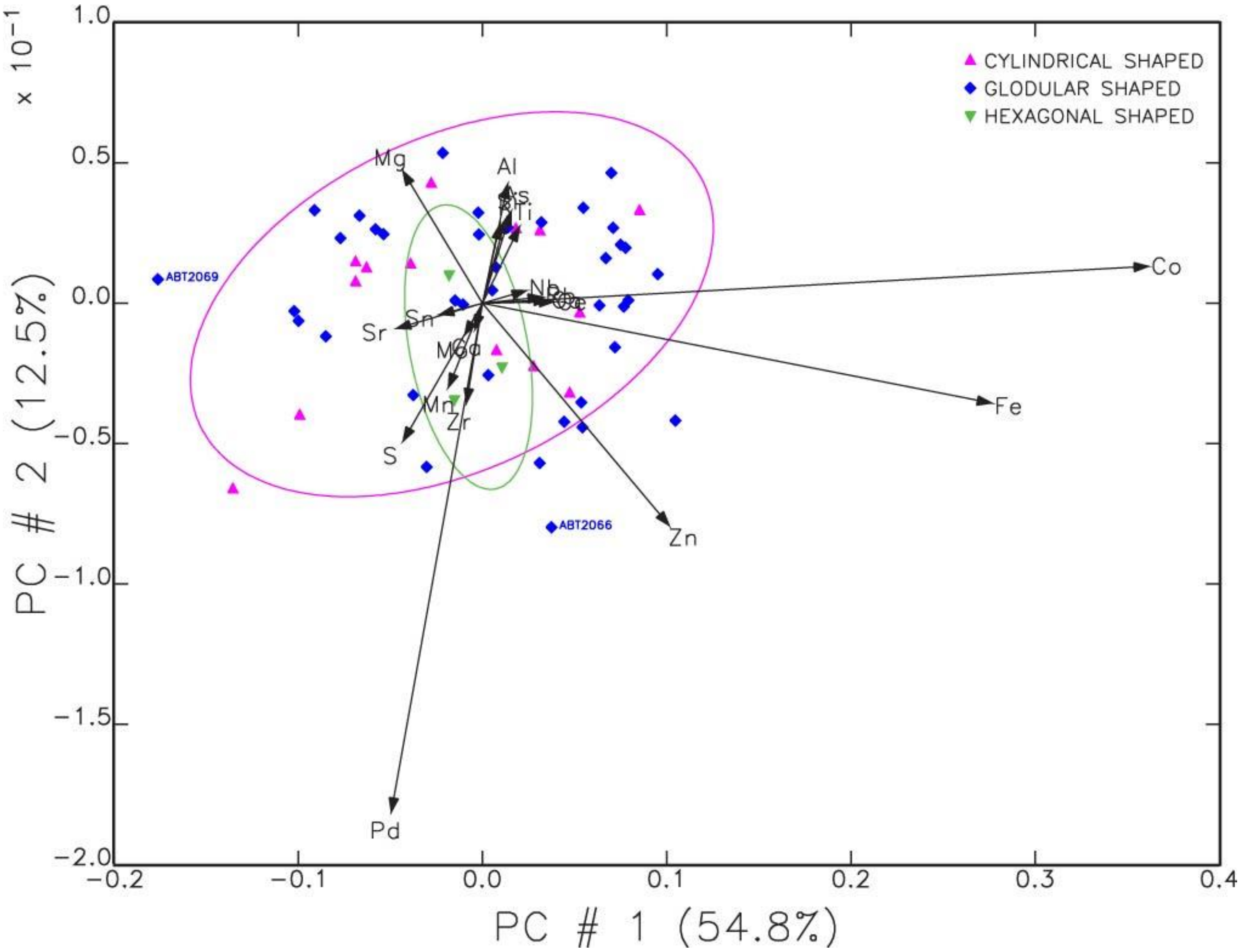


Figure 7: Biplot of principal components 1 and 2 based on the motif.

4.3 Motif Composition

The same 21 elements were used for the analysis of the motif: Mg, Al, Si, S, K, Ca, Ti, Mn, Fe, Co, Zn, Ga, As, Rb, Sr, Zr, Nb, Mo, Pd, Sn and Ce. The same 55 ceramics with 11 other Vietnamese ceramics were used along with 12 Chinese blue and white ceramics. These include 4 Batavia ware cups, 4 Chinese jarlets, 2 Chinese jars with lids and 2 Chinese covered boxes. The aim of including the Chinese ceramics was to state the differences and possibilities of the Co in the motif. The results were taken only of the motif; however, it must also be mentioned that glaze was detected in the results. This was an issue that was mentioned in the limitations chapter of the methods. Table 6 displays the summary of the first 10 principal components for Figure 7. The PCA for Figure 7 could account for 97.86% variability within the first 10 PCAs. Figure 7 shows a biplot of the principal components 1 and 2 of the main set of jarlets. The results show that the composition of the motif across all three shapes is very similar. The elements creating the variance are Co, Fe, Zn and Pd. Zn did not cause much variation in the glaze; however, it is assumed that the Zn found in the results is mainly from the glaze. This is assumed due to little change between the results of the glaze and the motif. Fe was also one of the major causes of variation of the glaze for the main set. A similar difference is present in the motif however, some ceramics featured a drastically higher amount of Fe in the motif than the glaze, whilst others the results were lower for the motif than the glaze. Examples of this can be seen in ABT2055, which had a Fe content of 2185.33 PPM for the glaze, whilst the motif had a Fe content of 8285.66 PPM. ABT2102 had a Fe total of 1488 PPM for the glaze but only a total of 515 PPM for the motif. Despite the difference, there is a large difference between the Fe contents of the motif across the main set, with the highest being 8285.66 PPM and the lowest being 515 PPM. A possible explanation for this difference is that the ceramics could have been made during the period when iron-based motifs were transitioned into cobalt motifs. It is also important to note that during this transition, kiln sites would use a mix of both iron and cobalt to create the motif. A similar trend is present in the Co content of the motif. This is due to the high disparity between the Co results for the main set. The highest Co reading in the main set is 2808.66 PPM, whilst the lowest is 47.68 PPM. This is a large difference between the highest and the lowest.

Table 7: Summary of the first 10 principal components for Figure 8 with variation and cumulative

PC	*Variance %*	*Cumulative %*
1	62.68	62.68
2	12.94	75.62
3	8.41	84.04
4	4.87	88.90
5	2.70	91.60
6	2.07	93.67
7	1.87	95.54
8	1.02	96.56
9	0.90	97:46
10	0.66	98.67

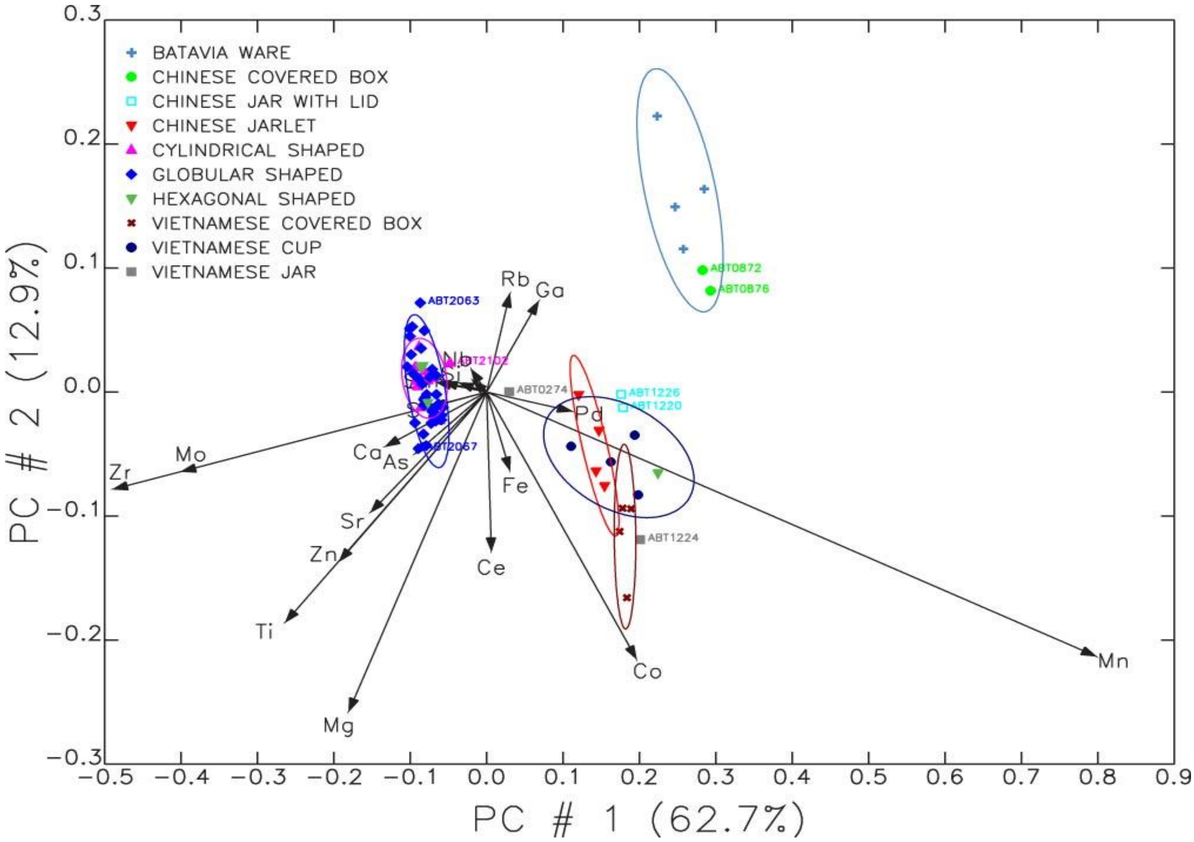


Figure 8: Biplot of principal components 1 and 2 based on the motif of the main set and the comparative set.

Table 7 displays the summary of the first 10 principal components for Figure 8. The PCA for Figure 6 could account for 98.67% variability within the first 10 PCAs. Figure 8 is a biplot of the principal components 1 and 2 of both sets of ceramics. This includes the main set and the Vietnamese and Chinese blue and white ceramics. From the biplot it can be seen that the comparison sets do not group with the main set. The Batavia ware cups, and the Chinese covered boxes group together, whilst the Chinese jarlets and the Chinese jars with lids group together with the Vietnamese comparison ceramics. However, the Vietnamese jars appear to be outliers. One of the main contributing factors to this is Mn. Mn has been identified as an important element when determining the origin of the cobalt used in the ceramic (Simsek et al. 2015:167). The Mn contents for the main set are significantly lower than that of both the Chinese and Vietnamese ceramics. The range for the main set of jarlets is 109.66 PPM–582.66 PPM. Whilst the range of the Vietnamese and Chinese ceramics is 2841.66 PPM–55947.33 PPM. Despite having a large range of Mn readings across the 23 comparison ceramics, it is clear that these ceramics have significantly higher Mn readings than the main set. It must be noted that one of the Vietnamese jars, ABT0274, has a Mn reading of 346.66 PPM. This is the one major outlier within the comparison set. This is reinforced in Figure 9, which shows that ABT0274 is closer to the main set than the comparison set. Figure 7 shows the grouping of the two sets based on the Mn and Fe contents. Zr is another element where there is a clear difference between the main set and the comparison set. The ceramics in the main set exhibit higher traces of Zr, whilst the comparison pieces all have lower traces. The highest value of Zr in the comparison set is 263.66 PPM. The lowest value for the main set is 952.66 PPM, with the highest being 1987 PPM.

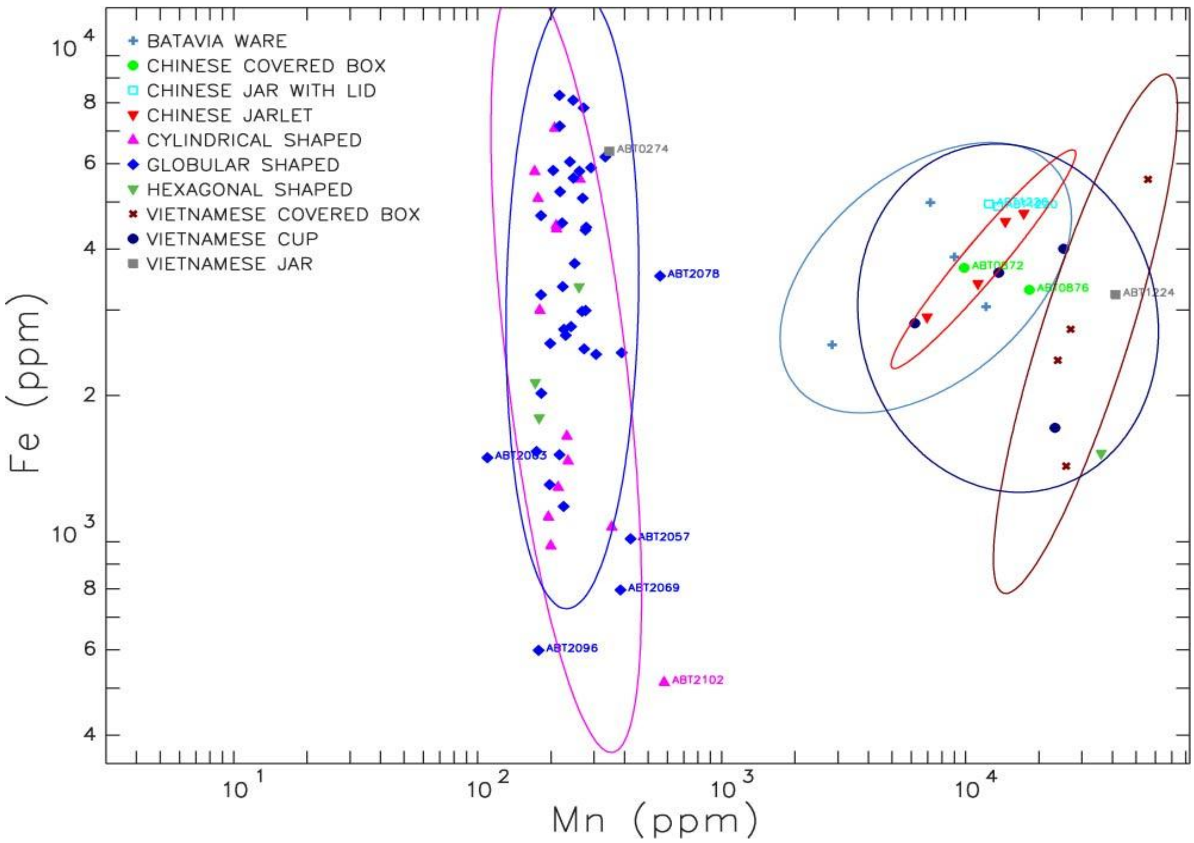


Figure 9: Mn-Fe bivariate plot of the motif from the main set and the comparative set.

From the results of the motif, it can be seen that the elemental composition of the jarlets in the main set varies from that of the other Vietnamese and Chinese comparison ceramics. Figure 10 shows the clear clustering for the two groups based on the motif, with the one Vietnamese jar having more similarities with the jarlets of the main set. The hierarchical cluster shows that the other Vietnamese ceramics used in the study have a similar elemental composition to the Chinese ceramics than to the main set.

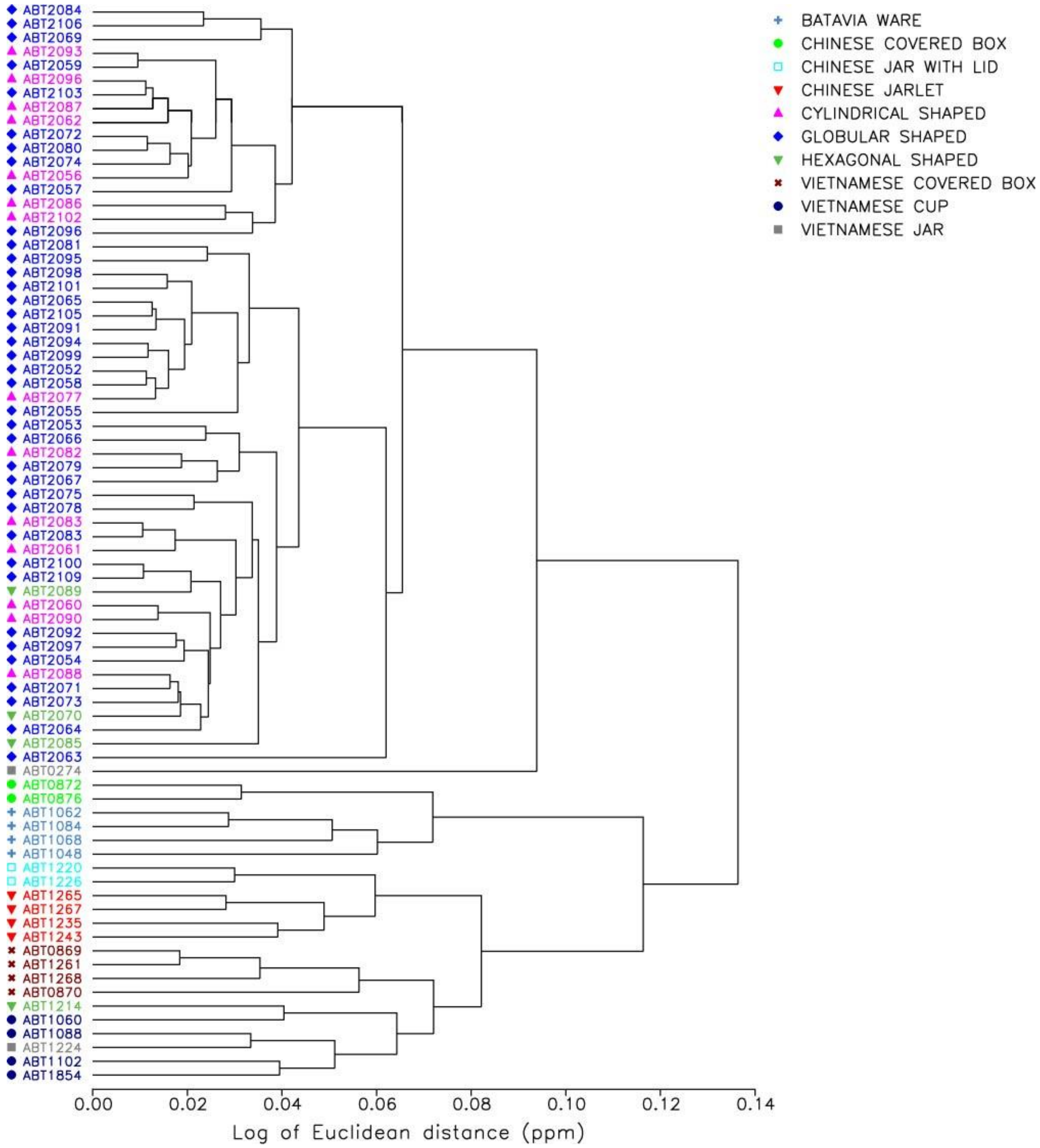


Figure 10: Hierarchical cluster analysis of the motif composition of the main set and the competitive set.

CHAPTER 5: DISCUSSION

5.1 Introduction

The chapter discusses the results of the elemental composition of the main set of jarlets in this study. It will detail the results for the glaze of the ceramics, along with how they compare to the other Vietnamese ceramics. It will examine at the composition of the motif and how the differences could imply that the cobalt used in the jarlets could have been sourced from a different location when compared than the Vietnamese and Chinese ceramics in the comparison set. This chapter then discusses the possible kiln sites of origin and the lack of known shipwrecks in Indonesia that carry Vietnamese blue-and-white ceramics from the 15th and 16th century.

5.2 Discussion on the Glaze

The results for the glaze show that there is a difference in the elemental composition between the jarlets of the main set and the Vietnamese ceramics used in the comparison set. The other Vietnamese ceramics were produced in a similar time period to that of the main set, from the 15th and 16th century. Mn, Zn, Mo, Zr along with Co, were the elements that caused the largest difference between the two sets.

As stated in the results, for select ceramics there are traces of Co in the glaze. 45 of the combined 66 Vietnamese ceramics contained Co in the glaze, with seven having amounts at or less than 1 PPM. There are two main reasons for Co to be in the glaze. The first being that when the results were taken, a small section of the motif was present. This limitation occurred because there were only small areas of glaze where there was not any motif. This was an issue, especially with the cylindrical shaped and hexagonal shaped jarlets. This occurred because the areas where the motif was not present were small, and not easily accessible for the pXRF due to the shape. The shape caused a problem as the pXRF had to be flat against the surface. This meant that the result had to be taken near the motif. This was not a problem for the globular shaped jarlets, as results could easily be taken from the lower body which did not typically have a design apart from a ring motif. Despite the limitations associated with the cylindrical and hexagonal shaped jarlets, the ceramic shape that contained the most traces of Co was the globular shape. The globular shaped jarlets comprised the majority of the main set, with 38. With 25 of these containing traces of Co. However, 4 contained 1.33 PPM or less. This is compared to six of the 14 cylindrical shaped ceramics containing Co, with two containing less than or equal to 1 PPM and the highest being 9 PPM. Only one of the three hexagonal shaped jarlets contain traces of Co in the glaze and it was less than 1 PPM. One possible explanation for this is that during production Co was being used in the glaze. It has been recorded that it is possible that traces Co was added to the glaze to give the Vietnamese blue and white stoneware the further look of being porcelain (Colomban et al. 2021:16). Whilst it is difficult to determine the cause for the traces of Co in the glaze, it was important to state the possibilities due to the large variance that is present in the main set of jarlets, and the comparison set. This can be seen in Figure 3 as Co is shown to be one of the largest contributors to the differences.

Zr is a large contributor to the difference between the main set and the comparison set. Zr for Vietnamese ceramics is assumed to come from the Zircon, which has been tested and found at Vietnamese kilns such as Chu Đâu (Colomban et al 2003:192). The main set of jarlets exhibited higher traces of Zr than that of the comparison set. The comparison set had a range of 170.66 PPM to 242.66 PPM. The main set of jarlets had a range of 926 PPM to 1850 PPM. Zr can be used to help identify Vietnamese ceramics. Both Chinese and modern Japanese blue and whites show lower values of Zr compared to Vietnamese ceramics, which exhibit higher levels of Zr. Simsek et al. (2015:167) states that, 'The highest content is measured for the glaze of shards from Central Vietnam. A large level of zirconium is measured in modern Bát Tràng porcelain body'. Despite the fact that Vietnamese ceramics contain higher traces of Zr, the Vietnamese ceramics of the comparison set of ceramics exhibit a lower quantity of Zr in the glaze when compared to the jarlets in the main set. This raises an interesting question surrounding the ceramics. Whilst the comparison set includes only a small quantity of Vietnamese ceramics of varying types, it is interesting that they all have lower quantities of Zr when the main set of jarlets all exhibit higher quantities, albeit across a wide range of values. Despite the lower quantities in the comparison set it is known that they originate from Vietnam, based on the motifs and shapes of the ceramics. This poses interesting questions around whether the difference in quantities of Zr relates to differences in time period, kiln site or some other factor or issue. It asks if this is a possible indication that they were made at different kiln site or regions. Simsek et al. (2015:167) states that it can be an indication, however pXRF analysis would be required on Vietnamese blue and white from known kiln sites to be able to make conclusions. Difficulties are created when working with 'grey' objects, as access to objects from known sites or productions sites to make comparisons is not possible.

Mo is another element that exhibits higher traces in the main set than the comparison set. This was also observed in Zn. However, one of the Vietnamese covered boxes exhibits higher traces of Mo and Zn. There was a vast difference in the amount of Mn between the two sets. Mn followed a similar pattern as was mentioned for the motif, where the main set of jarlets exhibited lower quantities of Mn whilst the comparison set contained higher quantities. However, one of the Vietnamese jars (ABT0274) had lower traces of Mn compared to the other comparison set. This is the same jar that had closer similarities to the main set for the motif. Mn in the glaze can create a pink colour, but it also gives the glaze a darker colour based on the atmosphere of the kiln as well as the percentage of Mn used (Karasu and Turan 2002:1448). It is unsure how the high amounts of Mn in the glaze of some of the comparison ceramics is affecting the glaze. Three of the comparison pieces, ABT0896, ABT1214 and ABT1088, exhibit significantly higher amounts of Mn compared to both the comparison set and the main set. It is unsure what the significance is for this high Mn reading. However, it can be stated that the main set feature lower amounts of Mn, whilst the comparison set have higher amounts, apart from the one outlier. The aforementioned elements, along with Mg and Pd, are the main factors for the difference in the glaze between the groups based on principal component analysis. This is reflected in Figure 5. The ceramics used in both the main set and the comparison set also follow conventions of Vietnamese glazes set out by previous studies.

The ratio between Ca and K can indicate if a ceramic is Vietnamese opposed to Chinese. Vietnamese glazes exhibit a higher Ca contents and lower K contents. Chinese glazes exhibit lower Ca contents and higher K contents (Simsek et al 2015:167). This ratio of higher Ca and lower K is present in both the main set and the Vietnamese ceramics in the comparison set. The range of K for both sets is from 16285 PPM to 28955 PPM. The range for Ca for both sets is 52206.33 PPM to 131755 PPM. This is important to note as both Ca and K were being used as the main fluxing agent for the glaze. Both have different characteristics, with Ca being noted as the more effective of the two fluxing agents but defects could occur during the stinting process leading to a buildup of glaze (Colomban et al. 2003:192). Ca was used as the fluxing agent for the glaze of Vietnamese ceramics. This is reflected in the Vietnamese ceramics of both the main set and the comparison set. Colomban et al (2003:192) state that ‘glaze compositions of the 15th century Chu Đâu-Mỹ Xá and Hop Lê ceramics are close to those of the Song productions (China)’.

Studying the glaze of the ceramics from the two sets of Vietnamese ceramics, it can be seen that they exhibit the assumed characteristics of Vietnamese ceramics. Despite this they have differences that causes the PCA to group them differently. This comes from the traves of Co, Zr, Mo, Zn, Mn, Mg and Pd, along with other minor differences. The differences of the elemental composition of the glaze could imply different sourcing of clay or temper, different kiln sites or changes through time. Based on the differences of the glaze when comparing the main set and the comparison set, it can be hypothesised that different types or sourcing of clay was used between the main set and the comparison set. However, from the results it can be seen that pXRF can classify differences between different groups. It also detects the known elements that can differentiate between Vietnamese production and other places of production. However, the comparison set exhibited lower traces of Zr compared to the main set which deviates from the norm.

5.3 Discussion on the Motif

The results from the motif of both the main set and the Vietnamese and Chinese comparison set show that there is a difference between the two. This is possibly indicating that the cobalt used in the motif for the main set was sourced from somewhere different to the Vietnamese blue and white ceramics in the comparison set. This is mainly attributed to the difference in Mn exhibited between the two groups. It shows how the motif of the jarlets in the main set differ from both the Chinese and the Vietnamese ceramics in the comparison set.

Mn is an important element when determining the source of cobalt for Asian ceramics. The is due to cobalt being found within manganese ore. The main set of ceramics had lower traces of Mn. The range of the Mn found in the main set was from 109.66 PPM to 582.66 PPM. The Vietnamese and Chinese ceramics of the comparison set had a range of Mn from 2841.66 PPM to 55947.66 PPM. The Vietnamese ceramics in the comparison set had, on average, higher amounts of Mn than the Chinese ceramics. This is shown in Figure 9 which displays the Vietnamese comparison ceramics grouping closer to the Chinese ceramics, apart from one Vietnamese jar which is similar to the main set. This leads on to the possible sourcing of the Mn.

It has been known that for Vietnamese ceramics and Chinese ceramics from certain production areas such as Yunnan. The cobalt used in the motifs sourced from regions of Northern Vietnam and Yunnan exhibit high Mn contents (Simsek et al. 2015:167). It is most likely that the cobalt was sourced from a manganese ore that contained minor amounts of Co. It has been noted that locally sourced cobalt was used predominantly from the Xuande era,1425–1435, during Ming Dynasty, as before they were using predominantly imported cobalt ore mainly from the Middle East (Colomban et al. 2021:9). The imported cobalt ore was arsenical. This cobalt ore contained higher trace of Fe whilst the Chinese cobalt ore contained higher Mn. However, it must be noted that high Fe cobalt ore is found in China, but no evidence exists that it was commonly used in the production of blue and white ceramics (Wen et al. 2007:109). Wen et al. (2007:109) state that this was especially the case ‘around the time of the origins of blue-and-white porcelain in China (before the early 15th century)’. This is also the same for Mn rich cobalt existing in the Middle East and Europe. The Chinese kilns in Jingdezhen would have begun using the Mn high cobalt in the Xuande period during the Ming Dynasty. Despite, Mn rich cobalt being used during earlier periods at folk kilns.

This is most likely due to the fact that these folk kilns would not have been able to afford the imported cobalt, so they would have used locally sourced cobalt (Wen et al. 2007:111). It is important to note that this transition from imported cobalt to locally sourced cobalt would not have been a sudden transition but most likely would have occurred over a period of time.

The exact source of cobalt used in Vietnamese blue and white is not known. Kikuchi (2021:188) stated that Vietnam did not produce cobalt during this time and that the cobalt would have come from China, mainly for the Yunnan Province. The Co used in Vietnamese ceramics is traditionally high in Mn. This is due to the Co being sourced from a manganese ore (Simsek et al. 2015:167; Kikuchi 2021:188). However, this is not a pattern that the jarlets of the main set follow. As stated previously within the results and the discussion, the Mn exhibited in the main jarlets was significantly lower than that of the comparison set, this includes both the Vietnamese and Chinese comparison ceramics. Based on the grouping from the results and the difference in Mn exhibited in the ceramics, the hypothesis is that the cobalt used in the main set was sourced from a different location than the Vietnamese ceramics in the comparison set. It is known that the ceramics from Chu Đâu along with the blue and white ceramics found on the Cù Lao Chàm shipwreck exhibit higher amounts of Mn in the blue motif. While the main set does not reflect the same characteristics as the Chu Đâu and Mỹ Xá kilns, it may not be an indicator that that were not produced at this site (Simsek et al. 2015:160).

The cobalt used could have come directly from the Chinese sourced cobalt in Yunnan, or from Middle Eastern traders in China, or directly from merchant ships as they head towards Southern China. However, Colomban et al (2021:41) notes that various cobalt pigments were used with ‘very different amounts of Mn’. This makes determining the source difficult based on the differences present in the motif without a known example from a kiln site. This is also made more difficult when it has been recorded that the sources of cobalt were mixed together. This can give varying results in the motif and make it difficult to determine if the cobalt was locally sourced or imported.

A defect that affects the blue motif appears to be present in some of the jarlets from the main set and from the comparison set. Dendrites occur in the motif during the cooling phase when the motif is solidifying. This creates dark spots throughout the motif (Colomban et al. 2021:41). Originally, it was assumed that the cause for these darker spots could be that the motif continued higher trace of Co. Currently it is not known if the dark spots present on the ceramics in this study, are dendrites. Dendrites have been noted to occur in both Vietnamese and Chinese ceramics. This can occur in ceramics produced in the Chu Đâu kilns. Dendrites are Fe rich (Colomban et al. 2021:41). Dendrites could possible be a cause for high Fe contents in the motifs for some of the ceramics. Further research is needed to understand if dendrites are present in the motifs and how they will affect the elemental composition of the motif.

From the results and discussion of the elemental composition of the motif, it can be concluded that pXRF can detect the differences between the main set and the comparison set. The Mn contents in the motif has led to the hypothesis that the jarlets in the main set differ from the norm based on the use of Mn rich Co in the blue décor of the motif. Traditionally the Co came from around the Yunnan province in China, however the locally sourced cobalt used had higher levels of Mn. This presents questions about the sourcing of the cobalt used. The type of cobalt used could imply at which kiln sites they were produced. Further research is required around the Mn in the motif and comparison with similar objects from known kiln sites in Northern Vietnam.

5.4 Shipwreck Sites Containing Vietnamese Ceramics

There is a lack of known shipwrecks sites in Indonesian waters that were containing Vietnamese blue-and-white ceramics (Kikuchi 2021:182; Zainab Tahir, pers. comm. 2024). Previous research notes that examples of major shipwrecks that contain Vietnamese blue-and-white ceramics are the Cù Lao Chàm shipwreck site, also known as the Hội An shipwreck, the Pandanan Island shipwreck in the Philippines, and the Lena Shoal shipwreck in the Philippines (Kikuchi 2021:182–186). These shipwrecks contain large quantities of Vietnamese blue and white ceramics. With the lack of known shipwrecks in Indonesian waters containing these ceramics, it raises questions about how the ceramics were located in the Indonesian antiques market. All of the 55 blue and white jarlets in this study all contain some form of marine accretion on the ceramic. This would indicate that the ceramics would have come from a marine context. The KKP Collections in Indonesia, which is a collection of 'grey' ceramics in Indonesia from shipwrecks, contains little to no examples of blue and white Vietnamese ceramics of this nature. From interviews it is known that the ceramics were purchased in both Sulawesi and Bali (Michael Abbott, pers. comm. 2022). This presents questions around how they arrived in Indonesia. Were they from a shipwreck in Vietnam or the Philippines and made there way to Indonesia through salvaging, or were they removed or salvaged from a shipwreck in Indonesian waters? The available evidence would imply that the jarlets were from an unidentified shipwreck within Indonesian territorial waters. This presents many future avenues of research into the possible shipwrecks from which they were removed.

CHAPTER 6: CONCLUSION

6.1 Conclusion

The aim of the study was to determine if pXRF is a viable method of grouping ceramics that lack context due to being 'grey/orphaned' cargo based on the elemental composition. The aim was to determine if certain characteristics of a group of ceramics could be classified to infer possible production sites or shipwrecks which they could be related to. This project is part of a wider Reuniting Orphaned Cargo project at SEACAL which aims to determine methods that can be used to provided provenience for 'grey/orphaned' ceramics which lack context. This thesis aimed to provide the characteristics that can be used to differentiate between blue and white Vietnamese jarlets from the 15th and 16th century that can be found using pXRF as the main method of identification. The findings of this thesis present further research into these ceramics that can possible answer the questions surrounding their production and the shipwreck that they could possibly originate from. The findings of this study have found that pXRF can classify the groupings of the glaze and motif of the ceramics. The other major finding is that the main set of ceramics in this study exhibit different characteristics than the comparison set, whilst also being different from previous research on similar objects.

The question at the centre of this project aimed to answer the question: can elemental analysis of 15th and 16th century Vietnamese stoneware jarlets inform interpretations of the secondary and tertiary depositional contexts of unprovenanced cargo? The aim was to understand what the elemental composition can tell us in relation to diagnostic features of the ceramics and how those features can push forward further research.

This study looked at the glaze and motif of 55 Vietnamese blue and white jarlets across three shapes. A comparison set of 26 Vietnamese and Chinese blue and white ceramics from the SEACAL collection were used to compare the data with the main set of 55 jarlets. This study wanted to utilise the non-destructive and portable nature of pXRF. pXRF presents many positives when working with large collections. However, pXRF comes with downsides that must be understood and addressed to maximise its capabilities. This mainly relates to pXRF being a qualitive form of analysis and lacks the accuracy of other methods such as INAA. However, understanding the negatives of pXRF is required to understand how this form of analysis can be used. This was a core concept within this study as the aim was to maximise the effectiveness of the technology. Due to these factors, the methods of this project were crucial for the outcomes. This centred around following established good practices, such as the use of standards. Despite this, the methods used could be improved for future studies, especially in relations to the use of calibrations, custom calibrations specifically for blue and white stoneware/porcelain as well as taking samples from multiple different areas across the ceramics. Calibrations are a key part of using pXRF in scientific studies. The use of calibrations adds further credibility to the research as well as adding to the reproducibility of research. Future research would require the use of both standards and calibrations. Custom calibrations could be used in future research to maximise the precision of the pXRF, specifically for stoneware/porcelain. This would improve the reproducibility and the precision of the results. Taking samples from multiple locations across the ceramic would increase the credibility of research results due to the non-homogeneous nature of ceramics. In this study three samples were taken from the same area and then averaged. However, it would be more effective to take three samples from different locations. This is important because the elemental composition of the ceramics surface is not homogenous. This would be an important consideration for future research.

The findings from this study found that the jarlets grouped differently when compared to other Vietnamese ceramics of a similar type The was evident in both the glaze and the motif. The findings around the motif pose interesting questions about the object. This mainly in relation to the lower Mn contents exhibited in the cobalt motif. This implies that the cobalt used was not the same as was used traditionally in Vietnamese blue and white stoneware. The higher Mn content, which is expected to be seen, was present in the both the Vietnamese and Chinese ceramics used for comparison. These follow the pattern of Chinese sourced cobalt whilst the main set deviated from this. From this it can be hypothesised that the lower Mn in the motif could imply that the cobalt used was sourced from a different location. However, it is not conclusive if these factors affect what the possible kiln sites were. From the literature, it was assumed that the ceramics were produced in Northern Vietnam in the Hải Dương province with the most famous kiln being the Chu Đâu. Further research is required about the implications of the cobalt in the possible production sites.

From the findings of the study, it was hypothesised that the 55 blue and white jarlets were salvaged from an unidentified shipwreck in Indonesian waters. This is due to the similarities that are consistent across the collection of 55 ceramics. The inference from these similarities is that they were produced at the same kiln site and are assumed to have been shipped together. The ceramics indicate that the shipwreck is assumed to be located in Indonesia due to their point of sale.

6.2 Future Research

The findings of this thesis have raised questions for future research. These mainly surround the results of the ceramic but also the location of the shipwreck they were from. The jarlets themselves require further research to explore how these differences relate to the production of these jarlets. Future studies would be able to build upon the findings of this thesis. This refers to the findings of the pXRF itself and the shipwrecks that carry Vietnamese blue and white ceramics.

Based on the findings, it would indicate that the cobalt used in the jarlets is different to that used in both the Vietnamese and the Chinese comparison ceramics. Based on the findings of the study, the differences in the elemental composition. Conducting further analysis would require the jarlets be compared to other blue and white ceramics from kiln sites in Vietnam. The lack of comparison to other Vietnamese blue and whites of known origin is a flaw within this study. This comparison would vastly improve the outcomes of the research. This would provide opportunity for further understanding about how to interpret the differences found in the jarlets. Further research would build upon knowledge of best use of pXRF. Future studies would need to consider the limitations and flaws indicated around the use of pXRF and improve the creditability of the study. Further research would hope to gain further understanding of the relation these ceramics have with other Vietnamese ceramics from this time.

Further research is required on the shipwrecks in Southeast Asia that carried Vietnamese ceramics. From our findings it indicates a lack of known shipwrecks in Indonesia. This presents questions about how the ceramics arrived oat the Indonesian antiquity market. Despite this, the hypothesis of the study believes that the shipwreck an unidentified shipwreck in Indonesia. By looking at the shipwrecks, a better understanding can be gained of the story these objects have post-deposition.

REFERENCES

Baxter, M.J. and C. M. Jackson 2001 Variable Selection in Artefact Compositional Studies. Archaeometry 43(2):253–268.

Bezur, A. and F. Casadio 2012 The analysis of porcelain using handheld and portable X-ray fluorescence spectrometers. In A.N Shugar and J.L. Mass (eds), Handheld XRF for Art and Archaeology, pp.17–36. Leuven: Leuven University Press.

Bland, C. 2017 2500 Years of Pottery: A Multidisciplinary Approach to the Investigation of Domestic Ceramic Production at Caleta Vitor Archaeological Complex, Northern Chile. Unpublished PhD thesis, College of Humanities, Arts and Social Sciences, Flinders University, Adelaide.

Brown, R.M. 1988 *The Ceramics of South-East Asia: Their Dating and Identification*. Oxford: Oxford University Press.

Brown, R.M. 2004. The Ming Gap and Shipwreck Ceramics in Southeast Asia. Unpublished Ph.D. dissertation, UCLA History Department, University of California, Los Angeles.

Chinh, H. X. and Van Tien, B. 1980 The Dongson Culture and Cultural Centers in the Metal Age in Vietnam. Asian Perspectives 23(1):55–65.

Colomban, P., N.Q. Liem, G. Sagon, H.X. Tinh and T.B. Hoành 2003 Microstructure, composition and processing of 15th century Vietnamese porcelains and celadons. *Journal of cultural heritage* 4(3):187–197.

Colomban, P., G. Sagon, L.Q. Huy, N.Q. Liem and L Mazerolles 2004 Vietnamese (15th century) blue-and-white, Tam Thai and lustre porcelains/stonewares: Glaze composition and decoration techniques. Archaeometry 46(1):125–136.

Colomban, P., B. Kırmızı and G.S. Franci 2021 Cobalt and Associated Impurities in Blue (and Green) Glass, Glaze and Enamel: Relationships between Raw Materials, Processing, Composition, Phases and International Trade. *Minerals* 11(6):1–42.

Da Silva, A. C., A. Triantafyllou and N. Delmelle 2023 Portable x-ray fluorescence calibrations: Workflow and guidelines for optimizing the analysis of geological samples. *Chemical geology* 623:1–22.

de Winter, N.J., M. Sinnesael, C. Makarona, S. Vansteenberge and P. Claeys 2017 Trace element analyses of carbonates using portable and micro-X-ray fluorescence: performance and optimization of measurement parameters and strategies. *Journal for Analytical Atomic Spectrometry* 6(32):1211–1223.

Demandt, M. H. S. 2020 Reaching 'the Southern Wilderness': Expansion and the Formation of the Lingnan Transportation Network during the Qin and Han Dynasties. *Journal of the economic and social history of the Orient* 63(2):157–194.

Dizon, E. Z. 2003 Underwater and maritime archaeology in the Philippines. *Philippine quarterly of culture and society* 31(1/2):1–25.

Dizon, E. Z. 1996 Anatomy of a Shipwreck: Archaeology of the15th-century Pandanan Shipwreck. In C. Loviny (eds) *The Pearl Road*: *Tales of Treasure Ships in the Philippines*, pp.62–93. Makati: Asia Type Comp.

Doonan, R.C.P. and E. Frahm 2013 The technological versus methodological revolution of portable XRF in archaeology. *Journal of Archaeological Science* 40(2):1425–1434.

Emmitt, J.J., A.J. McAlister, R.S Phillipps and S. Holdaway 2018 Sourcing without sources: Measuring ceramic variability with pXRF. *Journal of Archaeological Science: Reports* 17:422–432.

Fang, L. & L. Ma 2023 *The history of Chinese ceramics*. Singapore: Springer.

Fischer, C. and E. Hsieh 2017 Export Chinese blue-and-white porcelain: Compositional analysis and sourcing using non-invasive portable XRF and reflectance spectroscopy. *Journal of Archaeological Science* 80:14 – 26.

Frahm, E. 2024 Protocols, pitfalls, and publishing for pXRF analyses: From ‘know how’ to ‘best practices’. *Journal of archaeological science, reports* 60:104831.

Glascock, M.D. 1992 Characterization of archaeological ceramics at MURR by neutron activation analysis and multivariate statistics. In H. Neff (ed.), *Chemical Characterization of Ceramic Pastes in Archaeology, Monographs in World Archaeology*, pp.11–26. Madison: Prehistory Press,

Glascock, M.D., H. Neff and K.J. Vaughn 2004 Instrumental neutron activation analysis and multivariate statistics for pottery provenance. *Hyperfine Interactions* 154:95–105.

Goodale, N., D.G. Bailey, G.T. Jones, C. Prescott, E. Scholz, N. Stagliano and C. Lewis 2012 pXRF: A study of inter-instrument performance. Journal of Archaeological Science 39(4):875–883.

Guy, J. 1986 *Oriental Trade Ceramics in South-East Asia, Ninth to Sixteenth Centuries: With a Catalogue of Chinese, Vietnamese and Thai Wares in Australian Collections*. Singapore: Oxford University Press.

Guy, J 2005 The Hội An (Cu Lao Cham) Shipwreck Cargo and Asian Ceramic Trade. In P. Cheng, G, Li and C.K. Wan (eds), Proceedings of the International Conference: Chinese Export Ceramics and Maritime Trade, 12th –15th Centuries, pp.105–125. Hong Kong: City University of Hong Kong.

Heng, D. 2022 Urban Demographics along the Asian Maritime Silk Road: Archaeological Small Finds and Settlement Patterns at Premodern Port-Settlements of the Malay Region. In F. Billé, S. Mehendale and J. W. Lankton (eds.), *The Maritime Silk Road: Global Connectivities, Regional Nodes, Localities,* pp. 215–241. Amsterdam: Amsterdam University Press.

Johnson, K., C.P. Quinn, N. Goodale and R. Conrey 2024 Best Practices for Publishing pXRF Analyses. *Advances in archaeological practice: a journal of the Society of American archaeology* 12(2):156–162.

Karasu, B. and Turan, S. 2002 Effects of cobalt, copper, manganese and titanium oxide additions on the microstructures of zinc containing soft porcelain glazes. *Journal of the European Ceramic Society* 22(10):1447–1455.

Khoach, N. B. 1980 Phung Nguyen. *Asian Perspectives 23*(1):23–53.

Kikuchi, Y. 2021 *A History of Maritime Trade in Northern Vietnam, 12th to 18th Centuries: Archaeological Investigations in Vandon and Phohien.* Singapore: Springer.

Kim, J. J.W. Park, H. Kim, Y. Oh, J. Park, M Conte and J. Kim 2023 Selecting reproducible elements in non-destructive portable X-ray fluorescence analysis of prehistoric and early historical ceramics from Korea. Journal of Archaeological Science, Reports 47:1–12.

Kim, N.C. 2022 The Dong Son culture of Vietnam. In C.F.W. Higham and N.C. Kim (eds), The Oxford Handbook of Early Southeast Asia, pp. 532–543. Oxford: Oxford University Press.

Kuzmanovic, M., A. Stancalie, D. Milovanovic, A. Staicu, L. Damjanovic-Vasilic, D. Rankovic ND J. Savovic 2021 Analysis of lead-based archaeological pottery glazes by laser induced breakdown spectroscopy. *Optics and laser technology* 134:106599.

LeMoine, J.-B. and C.T. Halperin 2021 Comparing INAA and pXRF analytical methods for ceramics: A case study with classic Maya wares. *Journal of Archaeological Science: Reports* 36:1–13.

Pearson, N. 2022 Resisting Internationalism?: The Evolution of Indonesia's Shipwreck Legislation. *Bijdragen Tot de Taal-, Land- En Volkenkunde* 178(4):379–409.

Polkinghorne, M., C. Morton, A. Roberts, R.S. Popelka-Filcoff, Y. Sato, V. Vuthy, P. Thammapreechakorn, A. Stopic, P. Grave, D. Hein & L. Vitou 2019 Consumption and exchange in Early Modern Cambodia: NAA of brown-glaze stoneware from Longvek, 15th-17th centuries. *PLoS ONE* 14(5):e0216895

Polkinghorne, M., N. Pearson, W. van Duivenvoorde, W. Nayati, Z. Tahir, N.N.H. Ridwan, C. Forrest, N.H. Tan, R. Popelka-Filcoff, C. Morton, J. Kowlessar and M. Staniforth 2024 Reuniting orphaned cargoes: Recovering cultural knowledge from salvaged and dispersed underwater cultural heritage in Southeast Asia. *Marine Policy* 163:1–13.

Medley, M. 1976 The Chinese Potter: A Practical History of Chinese Ceramics. New York: Cornell University Press

Potts, P.J., O. Williams-Thorpe and P.C. Webb 1995 Analysis of silicate rocks using field-portable X-ray fluorescence instrumentation incorporating a mercury (II) iodide detector: A preliminary assessment of analytical performance. *The Analysist* 120(5):1273–1278.

Shackley, M.S. 2010 Is their reliability and validity in portable x-ray fluorescence spectrometry (PXRF)? *The SAA Archaeological Record* 10(5):17–20.

Shugar, A.N. and J.L. Mass 2012 Introduction. In A.N Shugar and J.L. Mass (eds), *Handheld XRF for Art and Archaeology*. Leuven: Leuven University Press.

Simsek, G., P. Colomban, S. Wong, B. Zhao, A. Rougeulle and N.Q. Liem 2015 Toward a fast non-destructive identification of pottery: The sourcing of 14th-16th century Vietnamese and Chinese ceramic shards. *Journal of cultural heritage* 16(2):159–172.

Sinnesael, M., N.J de Winter, C. Snoeck, A. Montanari and P. Claeys 2018 An integrated pelagic carbonate multi-proxy study using portable X-ray fluorescence (pXRF): Maastrichtian strata from the Bottaccione Gorge, Gubbio, Italy. *Cretaceous research* 91:20–32.

Speakman, R.J., N.C. Little, D. Creel, M.R. Miller and J.G. Iñañez 2011 Sourcing ceramics with portable XRF spectrometers? A comparison with INAA using Mimbres pottery from the American Southwest. *Journal of Archaeological Science* 38:3483–3496.

Suryokumoro, H. 2017 The Implications of ASEAN Economic Community (Aec) to the Regulation of Cooperative Supervision by the Government Under Law Number 25/1992 on Cooperative. *Brawijaya Law Journal 4*(2):189-218.

Tai, Y. S. 2012 Ming Gap and the Revival of Commercial Production of Blue and White Porcelain in China. Bulletin of the Indo-Pacific Prehistory Association 35:85–92.

Tanaka, K. and E.Z. Dizon 2011 Shipwreck Site and Earthenware Vessels in the Philippines: Earthenware Vessels of the Pandanan Shipwreck Site. *In Proceedings of the Asia-Pacific Regional Conference on Underwater Archaeological Heritage.* Manila: Museum of Underwater Archaeology.

Tanasi, D., R.H. Tykot, F. Pirone and E. McKendry 2017 Provenance study of prehistoric ceramics from Sicily: A comparative study between pXRF and XRF. *Open Archaeology* 3(1):222–234.

Taylor, K.W. 2013 *A History of the Vietnamese*. Cambridge: Cambridge University Press.

Wen, R., C.S. Wang, Z.W. Mao, Y.Y Huang and A.M. Pollard 2007 The chemical composition of blue pigment on Chinese blue-and-white porcelain of the Yuan and Ming dynasties (AD1271–1644). *Archaeometry* 49(1):101–115.

Wade, G. 2008 Engaging the South: Ming China and Southeast Asia in the Fifteenth Century. *Journal of the economic and social history of the Orient* 51(4):578–638.

Winter, T. 2022 *The silk road:* connecting histories and futures. Oxford: Oxford University Press.

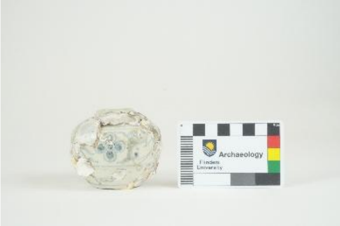
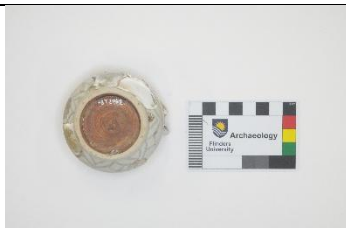
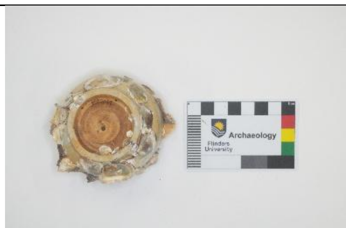
Xu, W., L.C. Niziolek and M. and G.M. Feinman 2019 Sourcing Qingbai porcelains from the Java Sea Shipwreck: Compositional analysis using portable XRF. *Journal of Archaeological Science* 103:57–71.

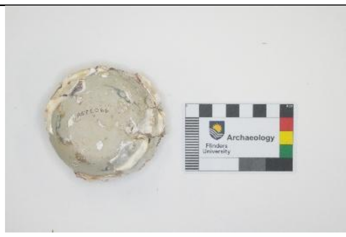
Xu, W., Z. Yang, L. Chen, J. Cui, L. Dussubieux and W. Wang 2021 Compositional analysis below the production region level: A case study of porcelain production at Dehua, Fujian, China. *Journal of Archaeological Science* 135:1–15.

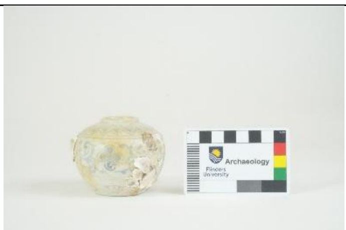
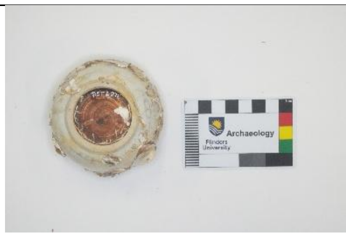
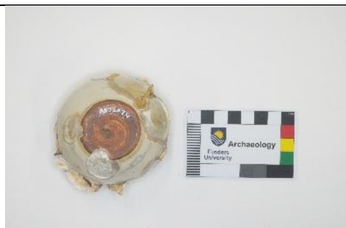
APPENDICES

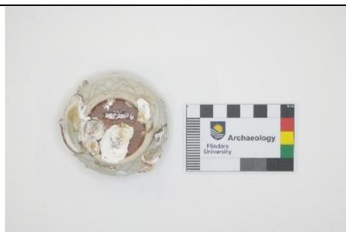
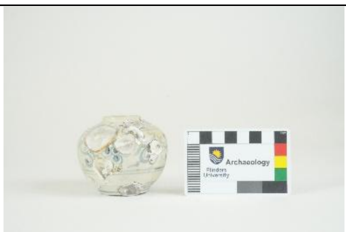
Appendix A: Jarlets

ID Number	Side	Bottom	Top
ABT2052			
ABT2053			
ABT2054			
ABT2055			
ABT2056			
ABT2057			

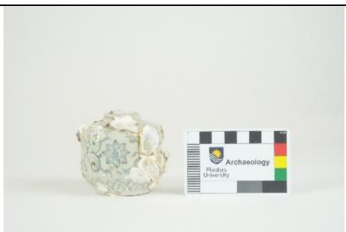
ABT2058			
ABT2059			
ABT2060			
ABT2061			
ABT2062			
ABT2063			

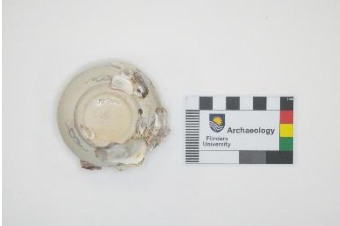
ABT2064			
ABT2065			
ABT2066			
ABT2067			
ABT2068			
ABT2069			

ABT2070			
ABT2071			
ABT2072			
ABT2073			
ABT2074			
ABT2075			

ABT2076			
ABT2077			
ABT2078			
ABT2079			
ABT2080			
ABT2081			

ABT2082			
ABT2083			
ABT2084			
ABT2085			
ABT2086			
ABT2087			

ABT2088			
ABT2089			
ABT2090			
ABT2091			
ABT2092			
ABT2093			

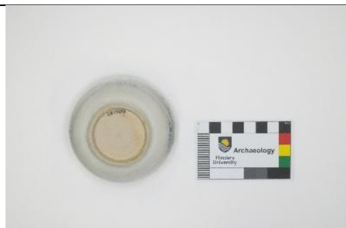
ABT2094			
ABT2095			
ABT2096			
ABT2097			
ABT2098			
ABT2099			

ABT2100			
ABT2101			
ABT2102			
ABT2103			
ABT2105			
ABT2106			

ABT2109			

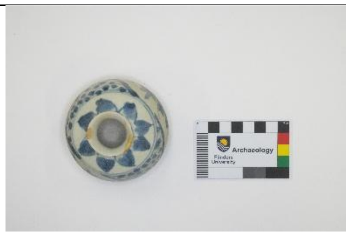
Appendix B: Vietnamese Comparison Ceramics

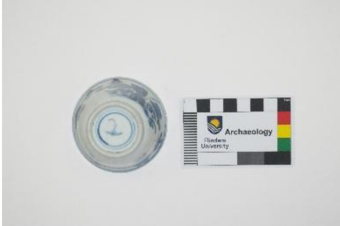
ID Number	Side	Bottom	Top
ABT0869			
ABT0870			
ABT1261			
ABT1268			

ABT1060			
ABT1088			
ABT1102			
ABT1854			
ABT0274			
ABT1224			

ABT1214			

Appendix C: Chinese Comparison Ceramics

ID Number	Side	Bottom	Top
ABT1235			
ABT1243			
ABT1265			
ABT1267			

ABT1048			
ABT1062			
ABT1068			
ABT1084			
ABT0872			
ABT0876			

ABT1220			
ABT1226			

Appendix D: Glaze 1 Results

File #	ABT Numbe	Area	Mg	Al	Si	S	K	Ca	Ti	Cr	Mn	Fe	Zn	Zn Err	Ga	As	Rb	Sr	Y	Zr	Nb	Mo	Pd	Sn	Ce	Hf	U
1530	ABT 2102	Glaze	7528	89618	337792	1847	25474	84315	723	95	267	1488	262	12	2	45	153	319	0	1302	17	57	22	150	29	42	102
1539	ABT 2084	Glaze	11971	80388	306057	7476	23185	131618	845	85	219	2475	235	13	2	25	163	397	6	1449	17	54	48	181	22	41	97
1551	ABT 2059	Glaze	9316	98276	361025	2102	26676	94534	690	102	272	479	185	9	2	39	147	312	0	1265	17	56	13	252	22	40	99
1560	ABT 2090	Glaze	5976	92947	342997	1656	24735	89764	959	97	129	2997	314	12	3	31	166	279	0	1430	17	60	28	214	34	48	130
1569	ABT 2054	Glaze	8081	99894	362398	1633	25011	100232	813	93	223	1363	361	12	3	42	185	260	0	1424	18	59	20	204	23	48	123
1578	ABT 2081	Glaze	14086	96823	362714	1853	27390	91148	844	123	214	1493	439	14	3	46	190	213	0	1651	20	72	19	243	32	55	120
1605	ABT 2080	Glaze	5077	94613	351363	2299	27467	86991	829	110	202	1567	179	9	2	44	149	346	0	1236	14	55	20	264	26	29	86
1614	ABT 2067	Glaze	13538	99335	320323	3443	20746	98996	1770	169	386	4033	404	13	4	42	195	241	0	1833	18	75	39	283	37	38	118
1624	ABT 2053	Glaze	6620	93342	348227	2131	25583	91945	1066	101	183	5572	392	14	3	39	202	232	0	1863	20	87	22	295	22	37	119
1633	ABT 2064	Glaze	7400	96431	350111	3960	27098	85261	1021	98	194	2839	422	14	4	50	186	270	0	1451	21	64	19	170	31	40	127
1642	ABT 2057	Glaze	12130	78145	315336	3326	23894	83966	1076	110	372	910	304	14	2	33	154	312	0	1421	20	49	38	287	19	42	97
1651	ABT 2073	Glaze	8244	102700	365377	1655	26818	90227	1276	121	153	2301	290	10	3	43	187	277	0	1461	17	68		136	34	43	115
1660	ABT 2096	Glaze	12771	92927	337501	2150	23975	98181	877	90	225	991	279	12	2	42	148	324	0	1314	18	54	30	287	23	36	80
1671	ABT 2089	Glaze	7042	80466	315246	2059	22129	87442	956	98	209	1300	327	14	2	38	132	329	0	1271	11	47	41	188	26	31	88
1680	ABT 2098	Glaze	7429	102937	363867	2435	25717	94825	1115	89	223	1734	315	11	3	62	194	245	0	1067	20	46		138	23	47	140
1689	ABT 2097	Glaze	9896	98630	354923	2374	26564	90092	1049	83	210	1731	380	13	4	44	205	263	0	1530	20	69	22	191	30	46	166
1698	ABT 2100	Glaze	8635	88453	344593	2167	26006	85111	918	98	242	1725	258	12	2	44	146	333	0	1277	13	54	21	299	26	26	87
1707	ABT 2092	Glaze	10451	94555	360333	1714	24681	119676	776	119	189	1976	272	11	4	30	200	237	0	1574	24	73	17	152	17	41	139
1716	ABT 2056	Glaze	10271	95544	354277	1970	27297	93146	1073	84	214	2213	326	12	4	50	183	296	0	1632	19	81	23	274	38	37	104
1725	ABT 2101	Glaze	7903	96286	351559	4396	24906	91890	1066	93	174	3680	359	13	3	39	183	241	0	943	21	39	21	167	22	46	103
1734	ABT 2087	Glaze	9938	94623	354423	2359	26348	92375	772	95	231	1040	292	12	3	42	170	285	0	1346	19	60	24	193	23	38	109
1851	ABT 2071	Glaze	8368	86452	334234	2735	26501	84871	1176	90	333	3410	333	14	3	33	180	305	0	1405	19	59	41	219	24	41	109
1860	ABT 2055	Glaze	9107	97295	350774	1581	25704	90405	1062	108	276	2164	362	13	4	51	188	257	0	940	18	34	22	178	28	45	138
1869	ABT 2109	Glaze	10057	89826	350135	1691	26863	85455	900	93	188	2058	277	12	3	47	163	318	0	1367	16	60	16	330	28	31	114
1878	ABT 2105	Glaze	7195	91944	343354	1959	25428	83956	688	104	291	2108	433	15	3	41	180	247	0	1063	22	51	28	172	27	39	133
1888	ABT 2062	Glaze	6422	77140	309159	2231	23619	78688	757	105	229	502	348	15	3	40	145	310	3	1622	12	51	39	270	29	37	99
1898	ABT 2078	Glaze	10022	75290	307806	2968	23620	105977	726	123	334	2006	694	22	3	61	186	288	6	1602	16	64	63	288	30	39	143
1907	ABT 2058	Glaze	9664	98774	355682	2159	25849	86281	1100	121	186	1787	355	12	3	52	184	258	0	1066	18	42	19	201	31	46	130
1916	ABT 2099	Glaze	7541	99765	364089	1614	28011	86946	1155	91	163	2105	502	14	3	48	206	215	0	1571	20	63	15	223	30	44	119
1925	ABT 2085	Glaze	4016	84026	317647	2532	25451	75252	951	102	229	877	429	16	3	47	164	279	0	1467	15	51	32	162	27	34	123
1934	ABT 2086	Glaze	8299	85082	331137	2878	24813	88223	799	107	218	793	336	14	2	40	151	315	0	1541	21	69	27	195	20	37	77
1944	ABT 2083	Glaze	4306	79700	318098	1296	22318	80359	472	98	193	3728	431	16	3	22	173	236	0	1561	23	68	51	156	23	29	117
1953	ABT 2052	Glaze	7755	97855	353502	2812	26297	85531	882	85	225	2151	395	13	3	52	187	238	0	1062	15	35	21	183	22	35	119
1962	ABT 2072	Glaze	11349	92764	351765	4082	25094	98741	866	81	165	2476	242	11	2	25	170	294	0	1562	17	80	23	301	30	32	106
1971	ABT 2091	Glaze	8984	96802	356391	2410	26413	85687	1002	107	206	2091	394	13	3	48	189	243	0	1065	24	44	17	182	28	49	132
1980	ABT 2103	Glaze	8035	90723	344487	2006	25314	93204	840	88	213	834	322	13	2	36	162	299	0	1562	16	75	28	214	27	34	101
1989	ABT 2066	Glaze	4651	77501	321869	1444	23362	95946	788	101	172	1753	642	20	3	26	182	233	0	1587	19	73	51	276	16	34	114
1998	ABT 2074	Glaze	5881	92643	345346	3625	27155	82073	1045	103	129	1302	283	12	3	43	168	298	0	1395	23	63	24	205	29	40	99
2012	ABT 2060	Glaze	8521	95942	355099	1773	25828	95519	985	101	192	3890	192	10	3	35	183	287	0	1473	22	70		211	29	32	126
2021	ABT 2083	Glaze	4689	76996	312152	1293	21806	78794	702	96	149	3388	406	16	3	20	166	255	2	1550	14	54	41	199	20	32	84
2030	ABT 2079	Glaze	8195	92804	344539	2645	27841	90742	1007	85	247	2414	645	18	4	47	217	231	0	1653	23	70	26	195	22	47	178
2039	ABT 2096	Glaze	16466	88881	325184	2298	23983	98127	578	77	333	1206	323	13	2	35	149	340	0	1349	18	63	39	202	20	36	85
2048	ABT 2061	Glaze	8442	88712	334105	1534	24437	87605	798	106	273	2368	311	13	3	37	159	291	0	1382	20	61	26	270	28	37	84
2057	ABT 2070	Glaze	3411	64230	271567	1559	20894	66761	311	93	229	1166	292	15	2	32	122	351	25	1272	14	41	54	152	23	23	77
2066	ABT 2069	Glaze	10066	97982	358001	1834	26936	86816	784	94	230	1726	154	8	2	34	132	358	0	1120	17	47		289	16	29	66
2076	ABT 2088	Glaze	11760	81538	325165	2200	23123	95125	644	91	247	1308	415	16	3	29	168	255	0	1525	16	51	26	117	22	35	110
2085	ABT 2082	Glaze	8774	102818	360366	2127	26013	91619	1302	90	106	2030	357	12	4	52	213	268	0	1535	21	58	25	235	25	45	153
2094	ABT 2093	Glaze	7129	90612	340898	1841	24953	91902	805	98	148	532	232	11	2	39	151	303	0	1392	17	67	28	239	20	39	78
2103	ABT 2106	Glaze	7703	94618	358085	2047	25955	95279	922	101	276	1366	270	11	3	37	173	288	0	1367	17	59	17	209	22	42	98
2112	ABT 2094	Glaze	8321	102737	363201	2437	27623	87784	918	93	252	1827	451	13	3	55	212	233	0	1553	23	70	17	186	31	44	150
2121	ABT 2063	Glaze	5151	76670	307049	1670	24388	79529	478	92	217	1563	353	15	2	42	153	320	5	1507	17	66	41	223	21	40	85
2130	ABT 2075	Glaze	5052	90998	341553	2272	26874	86710	620	75	389	1851	370	14	3	45	186	302	0	1724	22	78	32	228	28	40	115
2139	ABT 2065	Glaze	13178	94546	346151	3872	26309	84470	672	103	342	2207	439	14	2	44	191	249	0	1096	18	39	29	253	29	44	124
2148	ABT 2077	Glaze	3732	89154	340744	2776	24877	83134	834	99	192	2015	466	16	3	50	187	236	0	1104	17	38	21	93	29	42	118
2157	ABT 2095	Glaze	6392	94666	353033	1631	26808	101912	916	116	375	1704	394	14	3	60	193	249	0	1682	20	72	23	338	24	44	89

Appendix E: Glaze Average Results

ANID	Area	Shape	Mg	Al	Si	S	K	Ca	Ti	Mn	Fe	Co	Zn	Ga	As	Rb	Sr	Zr	Nb	Mo	Pd	Sn	Ce
ABT 2052	Glaze	Globe-shaped	7952.333	98079	352674	2831.667	26211	85223.67	924	220	2117	8.666667	394	3.666667	51	188.3333	237	1057	18	40.33333	23.33333	168	28.66667
ABT 2053	Glaze	Globe-shaped	7300.333	94222.33	348353	2130	25665.33	92004	990.6667	201	5535	0	388	3	39.33333	202.6667	232.6667	1850	21	83.33333	25	311.6667	28.33333
ABT 2054	Glaze	Globe-shaped	8745.667	99454.67	362625.7	1748	25065.33	100345.3	795.3333	228	1342.667	49.33333	370.3333	3	44	183.3333	261.6667	1434.667	17.66667	60.33333	17.5	157.3333	26.66667
ABT 2055	Glaze	Globe-shaped	9097	96022.33	351618.7	1590	25638	90402	1038.667	301.3333	2160.333	0	371	4	52	187	256.6667	927	20	36.33333	22.66667	146.6667	27.33333
ABT 2056	Glaze	Globe-shaped	9044	96291.67	353685.3	1925.333	27303	92955.33	768	291.6667	2217	7	325.3333	3.333333	47	182	297.3333	1630	20.66667	78.33333	22.66667	239	36
ABT 2057	Glaze	Cylinder-shaped	13444.33	79661	316599	3352	23906	84154.67	923.3333	407.3333	899.6667	4.333333	300	2.333333	34	155	310.6667	1411	18.66667	47.66667	42.33333	275.3333	22.66667
ABT 2058	Glaze	Globe-shaped	8645.333	98571	356373	2109	25852.33	86374.33	950.3333	215.3333	1780.333	13	357.3333	3	51	181.6667	257.6667	1044.667	19.33333	39	20.66667	169.6667	27
ABT 2059	Glaze	Globe-shaped	9620	98065	361384.3	2064	26709	94412.67	612.6667	269	481.6667	0	188	2	39	148	309.6667	1269	17.66667	56.66667	12.66667	276	20
ABT 2060	Glaze	Globe-shaped	8003	96089.33	354779	1778.333	25885.67	95274.33	928	212.6667	3883.667	0	193.6667	3	34.66667	183	285.3333	1446.667	23.66667	66	15	223	28
ABT 2061	Glaze	Cylinder-shaped	8927	89308.67	334533.7	1519	24498.33	87577	985.3333	240	2398.667	0	305.3333	2.333333	36.66667	161.3333	293.3333	1385	17	54.33333	28.33333	215	30.33333
ABT 2062	Glaze	Cylinder-shaped	7649.333	76398.67	310047	2138.333	23707.67	78550.67	609.3333	243.6667	523.6667	8.333333	350.3333	2.333333	39.33333	145	307.3333	1586.667	14	52	40.66667	293	21
ABT 2063	Glaze	Cylinder-shaped	4311.667	76063	307125.3	1643	24374	79230.67	637.6667	195	1568	0	356.3333	2	43.33333	151.6667	324	1524	16.66667	57.33333	41.33333	241	21.66667
ABT 2064	Glaze	Globe-shaped	6678.333	97323	351538.3	3938.333	27184.67	85888	1072.667	189.3333	2851.667	0	418.3333	3.333333	49	185.6667	272.3333	1459	17.33333	55.66667	21	184	26.33333
ABT 2065	Glaze	Globe-shaped	11801	94502	347109.7	3865.333	26298.67	84702.33	879.6667	294.6667	2185.333	12.66667	433.6667	3	43.33333	189.6667	252	1083	20.33333	45.33333	28.66667	235	30
ABT 2066	Glaze	Globe-shaped	4485.667	77577.33	322641.7	1484.333	23304.67	96071.33	782	161	1774	5.333333	642	3	27.33333	179.3333	235.6667	1614	19.33333	66.66667	48	250.3333	16.66667
ABT 2067	Glaze	Globe-shaped	13210.67	100259	321233.7	3457	20683.67	98999	1864.667	362.3333	4039	9	397	4	43.33333	195.6667	238.6667	1822	21.33333	78.33333	39	305	38.66667
ABT 2069	Glaze	Globe-shaped	7846.667	98452.67	358405.3	1787.667	26926.33	86878.33	769.3333	223	1695.667	0	151.6667	2.333333	37	131.3333	360.6667	1116.333	15	46.33333	11	281	19.33333
ABT 2070	Glaze	Hexagonal-shaped	3794.333	64110.67	273216.3	1521	20921.67	66984.67	526	185.6667	1137.667	0	299	2	31.66667	122.6667	347.6667	1286.333	15	36	53.66667	218.3333	25
ABT 2071	Glaze	Globe-shaped	9102.667	85911.67	333391.7	2803.333	26432.67	84742.33	898	392.6667	3406.667	0	343	3	33.33333	180	306.3333	1430.667	19	61.66667	36.33333	203.6667	27.66667
ABT 2072	Glaze	Globe-shaped	10952.67	92052	351993	4078.667	25160	98903.67	886.3333	178.6667	2453	0	241	2.666667	28	172	298	1587	17.66667	72	23.33333	305	27
ABT 2073	Glaze	Globe-shaped	7981	103768.7	366000.7	1614.667	26841.33	90340.67	1049.333	197	2272.667	0	285	3	42	188.6667	274.3333	1434.333	18.66667	67.66667	15	194.6667	28.33333
ABT 2074	Glaze	Globe-shaped	6618.667	93321	346582.3	3554.667	27310.67	82258	997	133	1331	0.333333	279.6667	3	44	170.6667	297	1379.667	18.33333	61.66667	25	213.6667	23.66667
ABT 2075	Glaze	Globe-shaped	7004.667	91060	342441	2300	26935.67	86866	894	341.3333	1882	3	367.3333	3	43	186.3333	296.6667	1697.333	19.66667	74.66667	26.33333	278.3333	27
ABT 2077	Glaze	Cylinder-shaped	6277	89911	341759.3	2742.333	25013.67	83488.33	923.3333	188	2020	7.333333	465	3	49.33333	187	237	1087.667	19.66667	42	25	152	32
ABT 2078	Glaze	Globe-shaped	10572.33	75888	309209.7	3000	23638	106358.3	507.6667	361	2016.667	10.33333	695.3333	2.666667	59.66667	184.6667	286.6667	1607.667	16.33333	59.66667	54	219.3333	26.33333
ABT 2079	Glaze	Globe-shaped	8292.333	91864.33	344469.3	2715.333	27961.33	90541.67	934.6667	241	2393.667	15.33333	652.6667	4	49.33333	215	233.3333	1645	21.66667	68	25.33333	179.6667	25.66667
ABT 2080	Glaze	Globe-shaped	6347.333	95582.67	351899.3	2321.667	27577.67	87101	915.3333	179.6667	1580.333	0	176.3333	2.666667	43.33333	146.6667	346.6667	1238.667	16	59.66667	22.33333	270.6667	22.66667
ABT 2081	Glaze	Globe-shaped	12773.67	97436	363413	1899.667	27324	91265	786	229.3333	1506	6.666667	436.3333	3	45.66667	190.6667	214.6667	1651.333	18.66667	72.33333	18	233.3333	27.33333
ABT 2082	Glaze	Cylinder-shaped	7412.333	102625.7	360174.7	2207	25997.67	91777	1182.667	126.3333	1992.667	0	356	4	50.66667	210.6667	265.6667	1535.333	21	60.66667	23	227	28
ABT 2083	Glaze	Globe-shaped	5055.667	79580.33	318176.3	1249.667	22352.67	80505	588.6667	185.3333	3764.333	5	429.3333	3	22	172.3333	238	1588	19.66667	57.66667	41	219	23
ABT 2083	Glaze	Cylinder-shaped	3663	77938.33	312942.3	1296.333	21921.33	79024	694.3333	157	3414.667	1	399	2.666667	19.33333	164.3333	251.3333	1540	14.66667	56.66667	43	182.3333	22.66667
ABT 2084	Glaze	Globe-shaped	12166.33	80887.67	306050	7440	23151.67	131755	852.3333	220.6667	2452	0	232	2	25.33333	164	397.3333	1458	17.66667	55	43.66667	215.6667	28
ABT 2085	Glaze	Hexagonal-shaped	4755	82464.67	316148.3	2595.333	25427.67	75156.67	905.6667	238.3333	887.3333	0.333333	438.3333	2.333333	47.66667	164	278.6667	1453.333	15.33333	48.66667	37.33333	177.6667	27.33333
ABT 2086	Glaze	Cylinder-shaped	7588	85514.67	331747.3	2893	24714.67	88148.33	838.6667	204	802	1.666667	327	2.333333	40.33333	152	312.6667	1552.333	19.66667	64.33333	30.33333	182.3333	22.33333
ABT 2087	Glaze	Cylinder-shaped	12114	95479	355527	2331.333	26316	92360.33	964.3333	192	1024.667	1.666667	281.6667	3	42	168.3333	282.6667	1347	17.66667	58.33333	21.66667	207.6667	26
ABT 2088	Glaze	Cylinder-shaped	11471	83225.33	325755	2205	23099.33	95151.67	749.3333	225.3333	1343.333	9	404	3	29.66667	170.6667	255.3333	1513.333	17	55.66667	30	199	27.33333
ABT 2089	Glaze	Hexagonal-shaped	7784.667	81850.67	315664.7	2138.667	22169.33	87441.67	591	253.3333	1320	0	321.3333	2	36.66667	136.3333	326.3333	1278.333	13.33333	54	37.66667	182	27
ABT 2090	Glaze	Cylinder-shaped	6300	93623.33	343835.7	1601	24721.67	89931	930.6667	129	2998	0	307.3333	3	31	168.3333	280.6667	1428.667	17.33333	58.66667	28.66667	225.6667	24.66667
ABT 2091	Glaze	Globe-shaped	10252	96762.33	356477.7	2424.333	26522	85644.33	908	233	2085.333	10	397.3333	3	47.66667	190.6667	242.6667	1060.333	20	39.66667	21	177.6667	28.66667
ABT 2092	Glaze	Globe-shaped	9641	95780.67	360778.7	1738.333	24621.67	119658.7	1022.667	141.3333	1955.667	53.66667	263.6667	3.333333	29.66667	199	236	1586	22.33333	72	16.66667	161.6667	26.33333
ABT 2093	Glaze	Cylinder-shaped	7259	90032	341148.3	1838	24998	91873.67	603.3333	186.6667	534	0	230.3333	2	37.66667	148.3333	300.6667	1385.333	15.66667	60.33333	27.33333	264	21
ABT 2094	Glaze	Globe-shaped	8695	102485	362741.3	2463.333	27688.33	87821.33	1044	244.6667	1854.667	14.33333	453	3.666667	55	210.3333	236	1544.667	21.66667	65.33333	14.33333	196.6667	28
ABT 2095	Glaze	Globe-shaped	8804.667	93489.67	352784	1548.333	26751	101546	902.6667	378.3333	1704	5	407	3	60.33333	194	250	1678	18.33333	70.33333	19.33333	333	22.66667
ABT 2096	Glaze	Cylinder-shaped	13116.67	93454.33	338366	2138.667	24077.67	98600	935.3333	221.6667	1012.667	0	279.6667	2	39.33333	148.6667	324	1315	18	49.33333	23.33333	235.6667	21
ABT 2096	Glaze	Globe-shaped	14814.33	88394	325656	2311	23881.33	98161.67	853.6667	269	1213.333	13.66667	324	2	37.66667	150	337.3333	1354.667	18	51.33333	29	187.3333	25.33333
ABT 2097	Glaze	Globe-shaped	7398.333	100297.7	356506.7	2315.667	26673	90049.67	1044.333	214.6667	1716.333	3.666667	367	4	44.66667	207.3333	261.3333	1529	20.33333	65.66667	18.33333	170.3333	27.33333
ABT 2098	Glaze	Globe-shaped	6979.333	102747	363553.7	2401.333	25755	94642	1049.333	247.3333	1714	4	317.6667	3.333333	63	195.3333	246.3333	1061.333	21	45.66667	13	148.6667	25.66667
ABT 2099	Glaze	Globe-shaped	6231	100258	365039.7	1561.667	27983	87220.33	995.6667	185.3333	2114.667	8.666667	496.6667	3.666667	46.66667	205.6667	216.3333	1557	20	60	14.66667	218.3333	27.66667
ABT 2100	Glaze	Globe-shaped	8099.333	88299.33	345511.7	2161.333	26064.33	85250.33	679	278.6667	1750.333	0	255.6667	2.333333	45	147	330	1286.667	14	56.33333	25.66667	314.3333	22
ABT 2101	Glaze	Globe-shaped	7688.667	96933.33	352458.3	4393.333	24936	91863.33	973.6667	187.3333	3643.667	1.333333	359	3	40	181.3333	239.3333	926	21	35.66667	19.33333	154.6667	25.66667
ABT 2102	Glaze	Cylinder-shaped	8411.333	89508.33	338330.3	1810.333	25399.67	84382.67	734.3333	255	1488	0.333333	266.6667	2.333333	44.66667	151.6667	316	1301.667	18.33333	55.66667	24.33333	165.6667	22.33333
ABT 2103	Glaze	Globe-shaped	8868	91049.33	345291.7	1988.667	25189.33	93180.33	797.3333	216.3333	834.6667	0.333333	319.6667	2.333333	37.66667	158.6667	298.3333	1550	18.66667	66.66667	24.66667	253	24.66667
ABT 2105	Glaze	Globe-shaped	7446.333	92980	344960.7	1994.333	25579.67	84188.33	914.6667	250.6667	2080.667	13.33333	427	3	41	179.6667	246.3333	1059.333	20.33333	44	27.66667	220	27.66667
ABT 2106	Glaze	Globe-shaped	7920.667	95234.67	358098.3	2093.333	25943.33	95647	936.6667	269.6667	1358	0.333333	263.3333	3	40	172.6667	288	1375.333	19	56.66667	16.33333	188.3333	20
ABT 2109	Glaze	Globe-shaped	8514.333	91434.33	350973.3	1715.333	26798.33	85402.67	790	213.3333	2054	0	267.3333	2.333333	46.66667	159.3333	316.3333	1360	16.33333	59	19.33333	300.6667	27.33333

Appendix F: Glaze Average Comparison Results

ANID	Area	Shape	Mg	Al	Si	S	K	Ca	Ti	Mn	Fe	Co	Zn	Ga	As	Rb	Sr	Zr	Nb	Mo	Pd	Sn	Ce
ABT 0274	Glaze	1. Vietanmese Jar	17272.67	87109	368738.7	1016	28956	81109.33	584	369.3333	904.3333	0.333333	58.33333	3	32.66667	174	170.6667	180.6667	14.33333	11.33333	19.66667	184	24.33333
ABT 0869	Glaze	2. Vietnamese Covered Box	16604	71115.33	310546.7	1376.667	18871.33	71813	749.6667	2273.333	3563.667	29	174.3333	2	49.33333	141.3333	212.3333	190	13	11.33333	53	204.6667	31.66667
ABT 0870	Glaze	2. Vietnamese Covered Box	16068.67	69210.67	300136.3	2100.333	17986.67	80807.33	274.6667	747	2027.333	8	112.3333	2	47.66667	135	162.3333	227	15	10.66667	70.66667	177	29
ABT 1060	Glaze	3. Vietnamese Cup	7531.667	78979.67	339241	1089.333	16285	95060.33	665.6667	560	1844.333	27	64.66667	3	53.66667	121.6667	292.6667	230.3333	14.33333	10.66667	43	154.6667	23.66667
ABT 1088	Glaze	3. Vietnamese Cup	18257	69663	334228.3	937.3333	19829	72223	788	4023.333	4830.667	191.3333	116	2.666667	23.66667	153.6667	152.3333	226	16.66667	9	44	111	27
ABT 1102	Glaze	3. Vietnamese Cup	15202	80266	352326.7	870.3333	25334	92741.33	659.3333	743	2240.333	3	46	3	8.666667	138.6667	127.6667	172.3333	8.333333	8.666667	23.33333	102.6667	22.66667
ABT 1214	Glaze	Hexagonal-shaped	6540	58860.33	299119.3	1145.667	21407	52206.33	417	799.3333	1218	16.33333	136	2.666667	14.66667	166	158.6667	233	17	10	64.33333	162.3333	29.66667
ABT 1224	Glaze	1. Vietanmese Jar	19385	69436.33	340951.7	919	18990	98716.33	500	2656.333	2054	155.6667	125.3333	3	18.66667	129	213.3333	172	11.33333	13.33333	29.66667	160	29
ABT 1261	Glaze	2. Vietnamese Covered Box	8942.667	55065	285536.3	1707	16662.33	60855.67	488.3333	763.3333	1089.333	22	324.6667	2	76.33333	117.3333	171.6667	170.6667	7.333333	5	62.33333	187.6667	21
ABT 1268	Glaze	2. Vietnamese Covered Box	12209.67	72020.67	347616.3	891.6667	20015	72409	516.3333	911.3333	808.6667	36.33333	123.3333	2	102.6667	138.6667	190	187.6667	13.66667	15.66667	35.66667	167.3333	26
ABT 1854	Glaze	3. Vietnamese Cup	21614.67	71469.33	315799	1549.333	17499.33	116866	749.6667	712.6667	2313	1.333333	140.6667	3	20.33333	141.6667	246	242.6667	15.66667	13.66667	53.33333	138.6667	26.33333
ABT 2052	Glaze	Globe-shaped	7952.333	98079	352674	2831.667	26211	85223.67	924	220	2117	8.666667	394	3.666667	51	188.3333	237	1057	18	40.33333	23.33333	168	28.66667
ABT 2053	Glaze	Globe-shaped	7300.333	94222.33	348353	2130	25665.33	92004	990.6667	201	5535	0	388	3	39.33333	202.6667	232.6667	1850	21	83.33333	25	311.6667	28.33333
ABT 2054	Glaze	Globe-shaped	8745.667	99454.67	362625.7	1748	25065.33	100345.3	795.3333	228	1342.667	49.33333	370.3333	3	44	183.3333	261.6667	1434.667	17.66667	60.33333	17.5	157.3333	26.66667
ABT 2055	Glaze	Globe-shaped	9097	96022.33	351618.7	1590	25638	90402	1038.667	301.3333	2160.333	0	371	4	52	187	256.6667	927	20	36.33333	22.66667	146.6667	27.33333
ABT 2056	Glaze	Globe-shaped	9044	96291.67	353685.3	1925.333	27303	92955.33	768	291.6667	2217	7	325.3333	3.333333	47	182	297.3333	1630	20.66667	78.33333	22.66667	239	36
ABT 2057	Glaze	Cylinder-shaped	13444.33	79661	316599	3352	23906	84154.67	923.3333	407.3333	899.6667	4.333333	300	2.333333	34	155	310.6667	1411	18.66667	47.66667	42.33333	275.3333	22.66667
ABT 2058	Glaze	Globe-shaped	8645.333	98571	356373	2109	25852.33	86374.33	950.3333	215.3333	1780.333	13	357.3333	3	51	181.6667	257.6667	1044.667	19.33333	39	20.66667	169.6667	27
ABT 2059	Glaze	Globe-shaped	9620	98065	361384.3	2064	26709	94412.67	612.6667	269	481.6667	0	188	2	39	148	309.6667	1269	17.66667	56.66667	12.66667	276	20
ABT 2060	Glaze	Globe-shaped	8003	96089.33	354779	1778.333	25885.67	95274.33	928	212.6667	3883.667	0	193.6667	3	34.66667	183	285.3333	1446.667	23.66667	66	15	223	28
ABT 2061	Glaze	Cylinder-shaped	8927	89308.67	334533.7	1519	24498.33	87577	985.3333	240	2398.667	0	305.3333	2.333333	36.66667	161.3333	293.3333	1385	17	54.33333	28.33333	215	30.33333
ABT 2062	Glaze	Cylinder-shaped	7649.333	76398.67	310047	2138.333	23707.67	78550.67	609.3333	243.6667	523.6667	8.333333	350.3333	2.333333	39.33333	145	307.3333	1586.667	14	52	40.66667	293	21
ABT 2063	Glaze	Cylinder-shaped	4311.667	76063	307125.3	1643	24374	79230.67	637.6667	195	1568	0	356.3333	2	43.33333	151.6667	324	1524	16.66667	57.33333	41.33333	241	21.66667
ABT 2064	Glaze	Globe-shaped	6678.333	97323	351538.3	3938.333	27184.67	85888	1072.667	189.3333	2851.667	0	418.3333	3.333333	49	185.6667	272.3333	1459	17.33333	55.66667	21	184	26.33333
ABT 2065	Glaze	Globe-shaped	11801	94502	347109.7	3865.333	26298.67	84702.33	879.6667	294.6667	2185.333	12.66667	433.6667	3	43.33333	189.6667	252	1083	20.33333	45.33333	28.66667	235	30
ABT 2066	Glaze	Globe-shaped	4485.667	77577.33	322641.7	1484.333	23304.67	96071.33	782	161	1774	5.333333	642	3	27.33333	179.3333	235.6667	1614	19.33333	66.66667	48	250.3333	16.66667
ABT 2067	Glaze	Globe-shaped	13210.67	100259	321233.7	3457	20683.67	98999	1864.667	362.3333	4039	9	397	4	43.33333	195.6667	238.6667	1822	21.33333	78.33333	39	305	38.66667
ABT 2069	Glaze	Globe-shaped	7846.667	98452.67	358405.3	1787.667	26926.33	86878.33	769.3333	223	1695.667	0	151.6667	2.333333	37	131.3333	360.6667	1116.333	15	46.33333	11	281	19.33333
ABT 2070	Glaze	Hexagonal-shaped	3794.333	64110.67	273216.3	1521	20921.67	66984.67	526	185.6667	1137.667	0	299	2	31.66667	122.6667	347.6667	1286.333	15	36	53.66667	218.3333	25
ABT 2071	Glaze	Globe-shaped	9102.667	85911.67	333391.7	2803.333	26432.67	84742.33	898	392.6667	3406.667	0	343	3	33.33333	180	306.3333	1430.667	19	61.66667	36.33333	203.6667	27.66667
ABT 2072	Glaze	Globe-shaped	10952.67	92052	351993	4078.667	25160	98903.67	886.3333	178.6667	2453	0	241	2.666667	28	172	298	1587	17.66667	72	23.33333	305	27
ABT 2073	Glaze	Globe-shaped	7981	103768.7	366000.7	1614.667	26841.33	90340.67	1049.333	197	2272.667	0	285	3	42	188.6667	274.3333	1434.333	18.66667	67.66667	15	194.6667	28.33333
ABT 2074	Glaze	Globe-shaped	6618.667	93321	346582.3	3554.667	27310.67	82258	997	133	1331	0.333333	279.6667	3	44	170.6667	297	1379.667	18.33333	61.66667	25	213.6667	23.66667
ABT 2075	Glaze	Globe-shaped	7004.667	91060	342441	2300	26935.67	86866	894	341.3333	1882	3	367.3333	3	43	186.3333	296.6667	1697.333	19.66667	74.66667	26.33333	278.3333	27
ABT 2077	Glaze	Cylinder-shaped	6277	89911	341759.3	2742.333	25013.67	83488.33	923.3333	188	2020	7.333333	465	3	49.33333	187	237	1087.667	19.66667	42	25	152	32
ABT 2078	Glaze	Globe-shaped	10572.33	75888	309209.7	3000	23638	106358.3	507.6667	361	2016.667	10.33333	695.3333	2.666667	59.66667	184.6667	286.6667	1607.667	16.33333	59.66667	54	219.3333	26.33333
ABT 2079	Glaze	Globe-shaped	8292.333	91864.33	344469.3	2715.333	27961.33	90541.67	934.6667	241	2393.667	15.33333	652.6667	4	49.33333	215	233.3333	1645	21.66667	68	25.33333	179.6667	25.66667
ABT 2080	Glaze	Globe-shaped	6347.333	95582.67	351899.3	2321.667	27577.67	87101	915.3333	179.6667	1580.333	0	176.3333	2.666667	43.33333	146.6667	346.6667	1238.667	16	59.66667	22.33333	270.6667	22.66667
ABT 2081	Glaze	Globe-shaped	12773.67	97436	363413	1899.667	27324	91265	786	229.3333	1506	6.666667	436.3333	3	45.66667	190.6667	214.6667	1651.333	18.66667	72.33333	18	233.3333	27.33333
ABT 2082	Glaze	Cylinder-shaped	7412.333	102625.7	360174.7	2207	25997.67	91777	1182.667	126.3333	1992.667	0	356	4	50.66667	210.6667	265.6667	1535.333	21	60.66667	23	227	28
ABT 2083	Glaze	Globe-shaped	5055.667	79580.33	318176.3	1249.667	22352.67	80505	588.6667	185.3333	3764.333	5	429.3333	3	22	172.3333	238	1588	19.66667	57.66667	41	219	23
ABT 2083	Glaze	Cylinder-shaped	3663	77938.33	312942.3	1296.333	21921.33	79024	694.3333	157	3414.667	1	399	2.666667	19.33333	164.3333	251.3333	1540	14.66667	56.66667	43	182.3333	22.66667
ABT 2084	Glaze	Globe-shaped	12166.33	80887.67	306050	7440	23151.67	131755	852.3333	220.6667	2452	0	232	2	25.33333	164	397.3333	1458	17.66667	55	43.66667	215.6667	28
ABT 2085	Glaze	Hexagonal-shaped	4755	82464.67	316148.3	2595.333	25427.67	75156.67	905.6667	238.3333	887.3333	0.333333	438.3333	2.333333	47.66667	164	278.6667	1453.333	15.33333	48.66667	37.33333	177.6667	27.33333
ABT 2086	Glaze	Cylinder-shaped	7588	85514.67	331747.3	2893	24714.67	88148.33	838.6667	204	802	1.666667	327	2.333333	40.33333	152	312.6667	1552.333	19.66667	64.33333	30.33333	182.3333	22.33333
ABT 2087	Glaze	Cylinder-shaped	12114	95479	355527	2331.333	26316	92360.33	964.3333	192	1024.667	1.666667	281.6667	3	42	168.3333	282.6667	1347	17.66667	58.33333	21.66667	207.6667	26
ABT 2088	Glaze	Cylinder-shaped	11471	83225.33	325755	2205	23099.33	95151.67	749.3333	225.3333	1343.333	9	404	3	29.66667	170.6667	255.3333	1513.333	17	55.66667	30	199	27.33333
ABT 2089	Glaze	Hexagonal-shaped	7784.667	81850.67	315664.7	2138.667	22169.33	87441.67	591	253.3333	1320	0	321.3333	2	36.66667	136.3333	326.3333	1278.333	13.33333	54	37.66667	182	27
ABT 2090	Glaze	Cylinder-shaped	6300	93623.33	343835.7	1601	24721.67	89931	930.6667	129	2998	0	307.3333	3	31	168.3333	280.6667	1428.667	17.33333	58.66667	28.66667	225.6667	24.66667
ABT 2091	Glaze	Globe-shaped	10252	96762.33	356477.7	2424.333	26522	85644.33	908	233	2085.333	10	397.3333	3	47.66667	190.6667	242.6667	1060.333	20	39.66667	21	177.6667	28.66667
ABT 2092	Glaze	Globe-shaped	9641	95780.67	360778.7	1738.333	24621.67	119658.7	1022.667	141.3333	1955.667	53.66667	263.6667	3.333333	29.66667	199	236	1586	22.33333	72	16.66667	161.6667	26.33333
ABT 2093	Glaze	Cylinder-shaped	7259	90032	341148.3	1838	24998	91873.67	603.3333	186.6667	534	0	230.3333	2	37.66667	148.3333	300.6667	1385.333	15.66667	60.33333	27.33333	264	21
ABT 2094	Glaze	Globe-shaped	8695	102485	362741.3	2463.333	27688.33	87821.33	1044	244.6667	1854.667	14.33333	453	3.666667	55	210.3333	236	1544.667	21.66667	65.33333	14.33333	196.6667	28
ABT 2095	Glaze	Globe-shaped	8804.667	93489.67	352784	1548.333	26751	101546	902.6667	378.3333	1704	5	407	3	60.33333	194	250	1678	18.33333	70.33333	19.33333	333	22.66667
ABT 2096	Glaze	Cylinder-shaped	13116.67	93454.33	338366	2138.667	24077.67	98600	935.3333	221.6667	1012.667	0	279.6667	2	39.33333	148.6667	324	1315	18	49.33333	23.33333	235.6667	21
ABT 2096	Glaze	Globe-shaped	14814.33	88394	325656	2311	23881.33	98161.67	853.6667	269	1213.333	13.66667	324	2	37.66667	150	337.3333	1354.667	18	51.33333	29	187.3333	25.33333
ABT 2097	Glaze	Globe-shaped	7398.333	100297.7	356506.7	2315.667	26673	90049.67	1044.333	214.6667	1716.333	3.666667	367	4	44.66667	207.3333	261.3333	1529	20.33333	65.66667	18.33333	170.3333	27.33333
ABT 2098	Glaze	Globe-shaped	6979.333	102747	363553.7	2401.333	25755	94642	1049.333	247.3333	1714	4	317.6667	3.333333	63	195.3333	246.3333	1061.333	21	45.66667	13	148.6667	25.66667
ABT 2099	Glaze	Globe-shaped	6231	100258	365039.7	1561.667	27983	87220.33	995.6667	185.3333	2114.667	8.666667	496.6667	3.666667	46.66667	205.6667	216.3333	1557	20	60	14.66667	218.3333	27.66667
ABT 2100	Glaze	Globe-shaped	8099.333	88299.33	345511.7	2161.333	26064.33	85250.33	679	278.6667	1750.333	0	255.6667	2.333333	45	147	330	1286.667	14	56.33333	25.66667	314.3333	22
ABT 2101	Glaze	Globe-shaped	7688.667	96933.33	352458.3	4393.333	24936	91863.33	973.6667	187.3333	3643.667	1.333333	359	3	40	181.3333	239.3333	926	21	35.66667	19.33333	154.6667	25.66667
ABT 2102	Glaze	Cylinder-shaped	8411.333	89508.33	338330.3	1810.333	25399.67	84382.67	734.3333	255	1488	0.333333	266.6667	2.333333	44.66667	151.6667	316	1301.667	18.33333	55.66667	24.33333	165.6667	22.33333
ABT 2103	Glaze	Globe-shaped	8868	91049.33	345291.7	1988.667	25189.33	93180.33	797.3333	216.3333	834.6667	0.333333	319.6667	2.333333	37.66667	158.6667	298.3333	1550	18.66667	66.66667	24.66667	253	24.66667
ABT 2105	Glaze	Globe-shaped	7446.333	92980	344960.7	1994.333	25579.67	84188.33	914.6667	250.6667	2080.667	13.33333	427	3	41	179.6667	246.3333	1059.333	20.33333	44	27.66667	220	27.66667
ABT 2106	Glaze	Globe-shaped	7920.667	95234.67	358098.3	2093.333	25943.33	95647	936.6667	269.6667	1358	0.333333	263.3333	3	40	172.6667	288	1375.333	19	56.66667	16.33333	188.3333	20
ABT 2109	Glaze	Globe-shaped	8514.333	91434.33	350973.3	1715.333	26798.33	85402.67	790	213.3333	2054	0	267.3333	2.333333	46.66667	159.3333	316.3333	1360	16.33333	59	19.33333	300.6667	27.33333

Appendix G: Motif Average Results

ANID	Area	Shape	Mg	Al	Si	S	K	Ca	Ti	Mn	Fe	Co	Zn	Ga	As	Rb	Sr	Zr	Nb	Mo	Pd	Sn	Ce
ABT 2067	Motif	Globe-shaped	10310.33	89556	298696.7	2670.667	19125	93445.67	1938.333	292	5879.333	882.3333	499.6667	3	41	183.6667	228	1899.667	19.66667	74.66667	50.66667	276.3333	42
ABT 2052	Motif	Globe-shaped	6048.667	94403	349351	1441	25690.33	87713.33	931	217.6667	5255.333	1519.333	463	3	42	168	256.6667	1140	16.33333	40.33333	17.33333	142	26.33333
ABT 2053	Motif	Globe-shaped	8789.333	83918.67	315932	5282.333	24565	114597	1208	271.6667	7807	567.6667	538.3333	3	31.33333	203.6667	285	1987	21	74.66667	44.66667	226.6667	34.33333
ABT 2054	Motif	Globe-shaped	6596.667	96350	362232.3	1779.333	24792.67	98394.33	967	229.6667	2661.333	1074	389.3333	2.666667	43	170.3333	261.6667	1450.667	20.66667	63.66667	15.66667	192	24
ABT 2055	Motif	Globe-shaped	7150.333	82250.33	350767.7	856.6667	21499.33	115590	945.6667	216.3333	8285.667	1611.667	593	2.333333	33.33333	165	256	1037	18.66667	36.66667	19.66667	189	28.33333
ABT 2056	Motif	Cylinder-shaped	6528.333	96609	347682.3	3123.667	27110	97759	857	232.3333	1654	370.6667	320	3	44.66667	176.6667	299.6667	1666	16	69.33333	19.33333	285.3333	28.33333
ABT 2057	Motif	Globe-shaped	12244	91889.67	349682.3	1926	25428	90722.33	871.3333	423.6667	1014	189.6667	238.3333	3	38	158.3333	297.3333	1381.333	16	56	18.66667	231.6667	22.66667
ABT 2058	Motif	Globe-shaped	8215.667	97351	353395.7	1929.333	25462.67	89407	1066.333	247	5605	1414.333	432.3333	3	40	164.6667	266	1099.333	19	45.66667	15.33333	155.6667	28.33333
ABT 2059	Motif	Globe-shaped	9708.667	100867.3	365979.7	2085.667	27198.67	93895	865.3333	216.3333	1511.667	681.3333	201.6667	2	39.66667	149	295.6667	1312	14.66667	59.33333	14	322	26.66667
ABT 2060	Motif	Cylinder-shaped	7083.667	95184.67	352220.3	2110.333	25379	98868.33	1168	171.3333	5792	542.3333	217	2.333333	33.66667	167.6667	312	1387.667	16.33333	59.33333	17.33333	213.3333	30
ABT 2061	Motif	Cylinder-shaped	5399	79717.67	315573.3	1370.333	22398.67	81711.67	673.6667	210.3333	4413.333	756.3333	383.6667	2.333333	34.33333	151.6667	280.6667	1440.667	18.66667	53	37.33333	177.6667	24.66667
ABT 2062	Motif	Cylinder-shaped	6164.667	89923	336360	2104	25411	85442.33	657	199.6667	984	305.6667	288.3333	2	40.33333	149	307.3333	1516.667	16	56.66667	27	255.3333	26
ABT 2063	Motif	Globe-shaped	1475	62280	264003	1159.667	19923	64501	671	109.6667	1490.333	441	417.6667	2	37	131.3333	285	1606.333	13.33333	53	68.66667	194.6667	19
ABT 2064	Motif	Globe-shaped	7106	98989.33	353636	2232	27115.67	88557	908.6667	223.3333	3350	421.6667	404.3333	3	68	176.6667	284	1424.333	16.33333	57.66667	16	188.6667	24.33333
ABT 2065	Motif	Globe-shaped	7299.667	89298	344120	2949.333	25510.33	91264.33	889	261	5783.333	1548.333	527	2.666667	39.66667	175	258	1142.333	18.33333	41	28.66667	172.3333	28.33333
ABT 2066	Motif	Globe-shaped	11061	73441.33	281999.7	5593.667	20330.67	179360.7	869.6667	333.3333	6195.333	954.3333	641.6667	2.666667	29.33333	178	433.3333	1687	18.33333	61.66667	64.33333	267	27
ABT 2069	Motif	Globe-shaped	11973	84293.67	322439.3	2489.667	23377.33	113745	877.6667	385	796.6667	47.66667	154.6667	2	34.33333	122.6667	432.3333	1173	15	53.33333	32	272	19.66667
ABT 2070	Motif	Hexagonal-shaped	7258.667	89742.67	334755	1973.667	24989.33	83807.67	858.6667	172.3333	2124	533	280.3333	2	39	151	316.6667	1294	17.33333	46.33333	27.33333	163	20
ABT 2071	Motif	Globe-shaped	6446.333	91258.33	341263	2129.667	26326.67	89916	743.3333	273.3333	2492.667	511.3333	331.6667	3	46.33333	170.6667	303	1460	16.66667	60.66667	26.66667	217.3333	26.66667
ABT 2072	Motif	Globe-shaped	10915.67	92352.67	346515.3	2793.333	25322.33	101562.7	945.3333	198.3333	2559.667	224.6667	243	2.333333	38	154.6667	319.6667	1580.667	17	62.66667	18	298.3333	24.33333
ABT 2073	Motif	Globe-shaped	7937	90387.33	337631.3	1765	24556.67	96683	1208.333	182	3224.333	374.6667	310.3333	3	40.66667	172	298	1472.333	18.33333	57	30.66667	173	25
ABT 2074	Motif	Globe-shaped	6252.333	96912.67	349984.7	2746.667	27022.67	86955.67	874	174.3333	1535	177	237.6667	2.666667	43.66667	166.6667	309.3333	1372	19.33333	63	19.66667	237.6667	20.66667
ABT 2075	Motif	Globe-shaped	9283.667	83853	320730.7	3083.667	25908.67	99850	812.6667	390	2448	321.6667	403.3333	3	40.33333	180.3333	339.3333	1739	20.66667	70.66667	40.66667	280	26.33333
ABT 2077	Motif	Cylinder-shaped	6587.667	95244	356284	2018	25742	92181.33	909	263	5588	1801.667	465	3	58.33333	177	253	1152.333	18	44	12.66667	169	31
ABT 2078	Motif	Globe-shaped	7787.667	88170.33	340118	2056.333	25413.33	89701.33	694.3333	559.3333	3523	493.6667	566.6667	3	52.66667	181.6667	251	1546.667	19.66667	70	31.66667	246.3333	23.33333
ABT 2079	Motif	Globe-shaped	8173.667	82957.33	321659	2662.333	25595.33	115570	919.6667	276.6667	4379.333	1281.333	680	3	47	197	314	1685	18.33333	73	37.66667	243.6667	29.66667
ABT 2080	Motif	Globe-shaped	8300	93358.67	346395.7	2285.667	26553.33	86149	983.3333	182.3333	2022.667	241	210	2.333333	43.66667	149.6667	327.6667	1347.667	16.66667	64	21	278.6667	24.66667
ABT 2081	Motif	Globe-shaped	7010.667	89547.33	352520	1616.333	26345.33	85203	522	239	6053.333	1785	429	2.333333	46.66667	169	218.6667	1587	19.33333	75	22.33333	303.3333	28.33333
ABT 2082	Motif	Cylinder-shaped	7433	94884.33	351050	1833.667	26321.67	89613	1030.667	210	4483.667	1046.667	525.3333	3.666667	49.33333	209	217	1639	21.33333	66.66667	26.66667	193.3333	29
ABT 2083	Motif	Globe-shaped	4533.333	74296.33	321668.7	1176.333	21933	86536.67	559.6667	217.3333	7167.333	828	567	3	24.66667	166	235.6667	1571.333	17.66667	55	40.33333	211.6667	24
ABT 2083	Motif	Cylinder-shaped	5717.667	82589.67	331367.7	1582	23664.33	88013	619.3333	207	7113	737.6667	526.3333	3	26.66667	179.6667	233.3333	1610.333	17.66667	63	33.33333	221	24
ABT 2084	Motif	Globe-shaped	9042	87064	334748.3	3682.333	23640.33	125829.7	798.3333	225.6667	2735.333	80	227	2.333333	27	161.6667	340.6667	1414	18.66667	66.66667	26	184.6667	28
ABT 2085	Motif	Hexagonal-shaped	4851.667	79997.33	308201.3	4883.333	24141.67	75656	771.6667	179	1796.333	592.6667	482.3333	2.333333	46.66667	159.3333	260	1554.667	16.33333	49.33333	39	201.3333	25.66667
ABT 2086	Motif	Cylinder-shaped	9246	74891.33	294366	3489.333	21590.33	112411.3	755	354.6667	1075	170.3333	396.6667	2.333333	38.33333	139.6667	387.6667	1631.667	15	53.33333	48.66667	228.6667	23
ABT 2087	Motif	Cylinder-shaped	9577.667	92899	347476.3	2364.667	24965.67	89865.33	926	214.3333	1297	265	343	2.333333	48.66667	154.6667	286.3333	1359	20.33333	58.33333	25.66667	215.6667	25
ABT 2088	Motif	Cylinder-shaped	7420.667	85208.33	329147	1963.667	23201.33	101483.3	731.3333	180	3003	622.3333	461	3	33.66667	165.3333	267	1499.333	18.33333	54.66667	33.33333	194	25.33333
ABT 2089	Motif	Hexagonal-shaped	6826.333	83153.33	319525.7	3307.333	22485.33	115872.3	923	260.3333	3342.333	741	402.3333	2	37.66667	149	338	1367.667	16	55.66667	32.66667	226.3333	25.33333
ABT 2090	Motif	Cylinder-shaped	7629	99133.67	356560	1782	24831	94836.67	952	176.6667	5097.667	678.3333	332.3333	3	32.33333	170.6667	272.3333	1452.333	18	62	15.66667	237.3333	29.33333
ABT 2091	Motif	Globe-shaped	8699.667	89203.67	341626.7	2081.333	25184.33	82939	1045.667	222.3333	4527.667	1516.667	480	3	50.66667	164.3333	251.6667	1119.333	17.33333	41	28.66667	212	29
ABT 2092	Motif	Globe-shaped	11065.33	95831.67	354471	1093.333	24591.67	115021.7	913	241.3333	2772.333	759.3333	308.3333	3	30	185.6667	241	1577.333	19.33333	69.33333	20.33333	187	25.66667
ABT 2093	Motif	Cylinder-shaped	10431.33	92798.33	351032.7	1932	25505	93252.33	697.6667	235	1470.667	611.6667	235	2	37.66667	143.6667	299.3333	1378.667	14.33333	55.66667	15.66667	265	22
ABT 2094	Motif	Globe-shaped	7923.333	98930.33	362041.7	1838	27599.67	88432.67	789.3333	278.6667	4435.667	1555.667	477	2.666667	52.33333	194.3333	235.3333	1568.667	18.33333	65.33333	18	221.6667	31
ABT 2095	Motif	Globe-shaped	3871.667	76486	322218	2387.333	23255.33	89648.33	612	246.3333	8093	2808.667	461.3333	2	35.66667	148.3333	244.3333	1643	15.33333	63	37	259.6667	26.33333
ABT 2096	Motif	Cylinder-shaped	10927.67	91171.33	336857.3	2159.667	24020	97825	746	195.3333	1127.667	294.6667	288.6667	2	41	139.6667	329	1302.333	14.33333	52.66667	27	226	27
ABT 2096	Motif	Globe-shaped	7142.333	73116.67	287460	1536.333	19723.33	82014.67	744	177.6667	598.3333	316.6667	351	2	34	124.3333	310.3333	1395.667	14.33333	45	43.66667	203	22.33333
ABT 2097	Motif	Globe-shaped	10495.33	99070.33	351211.7	1763.333	25475	92113.67	1166.667	305.6667	2432	574.6667	348.3333	3	43.33333	182	276.6667	1560	20	63.66667	16.33333	204.3333	25.66667
ABT 2098	Motif	Globe-shaped	8578.667	100317	358274.7	2903.333	24757.33	98940.33	1064.667	249.6667	3735.667	1453.333	377	3	58.66667	179	260.6667	1146.333	19	44	14.5	199	25
ABT 2099	Motif	Globe-shaped	5506.667	94719	360474	1657.667	27397.67	88450	888.3333	269.3333	5094	1577.333	532.3333	3	46.66667	189.3333	235.6667	1544.333	19	58.33333	14.5	196	26.33333
ABT 2100	Motif	Globe-shaped	10113.67	86130	337255.7	2244	25806	85576.67	724.3333	277.3333	2992	813.6667	242.6667	2	47.33333	135.3333	343.6667	1263.667	15.33333	53	25.33333	253	34.33333
ABT 2101	Motif	Globe-shaped	7881.667	100003.7	363937.3	2761	24771.67	98044.33	1102.667	181.6667	4692	1594.667	372	2.666667	38.33333	167	257	952.6667	22	40.33333	11	159	28.33333
ABT 2102	Motif	Cylinder-shaped	8970.333	51347.33	228304	2726.333	16888	86107	544.3333	582.6667	515	151	366	2	32.33333	120.3333	332	1508.333	12.66667	42.66667	81.66667	176.6667	21.33333
ABT 2103	Motif	Globe-shaped	11041.33	95022	354646	1938.667	25190.33	97262	945	225	1182.333	282.6667	268	2	41.66667	158.3333	295.6667	1527.667	15.66667	61	20	258	26.66667
ABT 2105	Motif	Globe-shaped	5538	95052.33	353714.3	2099.667	26750.33	89186.33	1038.333	204	5805.333	1549.333	465.3333	3	38.66667	174.6667	257.6667	1108.333	19	43.66667	24.66667	187	32.66667
ABT 2106	Motif	Globe-shaped	7651.333	88976	346872.3	3763.667	24042.67	110222	738.6667	197.3333	1311.667	134.3333	250.3333	2.333333	33	155	325.3333	1346.667	21	58	28.66667	231.3333	17
ABT 2109	Motif	Globe-shaped	9264.667	82878.67	329199.7	2208	24940.67	82966.33	593.3333	268.3333	2977.667	839.3333	250	2	44.33333	135	346.6667	1281	14.33333	52.66667	27.66667	306.6667	23

Appendix H: Motif Average Comparison Results

ANID	Area	Shape	Mg	Al	Si	S	K	Ca	Ti	Mn	Fe	Co	Zn	Ga	As	Rb	Sr	Zr	Nb	Mo	Pd	Sn	Ce
ABT 2102	Motif	Cylinder-shaped	8970.333	51347.33	228304	2726.333	16888	86107	544.3333	582.6667	515	151	366	2	32.33333	120.3333	332	1508.333	12.66667	42.66667	81.66667	176.6667	21.33333
ABT 2096	Motif	Globe-shaped	7142.333	73116.67	287460	1536.333	19723.33	82014.67	744	177.6667	598.3333	316.6667	351	2	34	124.3333	310.3333	1395.667	14.33333	45	43.66667	203	22.33333
ABT 2069	Motif	Globe-shaped	11973	84293.67	322439.3	2489.667	23377.33	113745	877.6667	385	796.6667	47.66667	154.6667	2	34.33333	122.6667	432.3333	1173	15	53.33333	32	272	19.66667
ABT 2062	Motif	Cylinder-shaped	6164.667	89923	336360	2104	25411	85442.33	657	199.6667	984	305.6667	288.3333	2	40.33333	149	307.3333	1516.667	16	56.66667	27	255.3333	26
ABT 2057	Motif	Globe-shaped	12244	91889.67	349682.3	1926	25428	90722.33	871.3333	423.6667	1014	189.6667	238.3333	3	38	158.3333	297.3333	1381.333	16	56	18.66667	231.6667	22.66667
ABT 2086	Motif	Cylinder-shaped	9246	74891.33	294366	3489.333	21590.33	112411.3	755	354.6667	1075	170.3333	396.6667	2.333333	38.33333	139.6667	387.6667	1631.667	15	53.33333	48.66667	228.6667	23
ABT 2096	Motif	Cylinder-shaped	10927.67	91171.33	336857.3	2159.667	24020	97825	746	195.3333	1127.667	294.6667	288.6667	2	41	139.6667	329	1302.333	14.33333	52.66667	27	226	27
ABT 2103	Motif	Globe-shaped	11041.33	95022	354646	1938.667	25190.33	97262	945	225	1182.333	282.6667	268	2	41.66667	158.3333	295.6667	1527.667	15.66667	61	20	258	26.66667
ABT 2087	Motif	Cylinder-shaped	9577.667	92899	347476.3	2364.667	24965.67	89865.33	926	214.3333	1297	265	343	2.333333	48.66667	154.6667	286.3333	1359	20.33333	58.33333	25.66667	215.6667	25
ABT 2106	Motif	Globe-shaped	7651.333	88976	346872.3	3763.667	24042.67	110222	738.6667	197.3333	1311.667	134.3333	250.3333	2.333333	33	155	325.3333	1346.667	21	58	28.66667	231.3333	17
ABT 1268	Motif	Vietnamese Covered Box	8184.667	58020.33	271911	1011.333	18018.67	54680.33	598	25812.33	1431.667	2691.667	390.6667	2	80.33333	103.6667	160.6667	186.6667	10.66667	6.666667	57.66667	157	38.66667
ABT 2093	Motif	Cylinder-shaped	10431.33	92798.33	351032.7	1932	25505	93252.33	697.6667	235	1470.667	611.6667	235	2	37.66667	143.6667	299.3333	1378.667	14.33333	55.66667	15.66667	265	22
ABT 2063	Motif	Globe-shaped	1475	62280	264003	1159.667	19923	64501	671	109.6667	1490.333	441	417.6667	2	37	131.3333	285	1606.333	13.33333	53	68.66667	194.6667	19
ABT 2059	Motif	Globe-shaped	9708.667	100867.3	365979.7	2085.667	27198.67	93895	865.3333	216.3333	1511.667	681.3333	201.6667	2	39.66667	149	295.6667	1312	14.66667	59.33333	14	322	26.66667
ABT 1214	Motif	Cylinder-shaped	2166.333	49764.33	249727.3	647	18959.67	41057.33	749	35991.67	1518.667	3359.333	185.6667	2	19.33333	120.3333	153.6667	225.6667	12	6	71	186.3333	68.33333
ABT 2074	Motif	Globe-shaped	6252.333	96912.67	349984.7	2746.667	27022.67	86955.67	874	174.3333	1535	177	237.6667	2.666667	43.66667	166.6667	309.3333	1372	19.33333	63	19.66667	237.6667	20.66667
ABT 2056	Motif	Cylinder-shaped	6528.333	96609	347682.3	3123.667	27110	97759	857	232.3333	1654	370.6667	320	3	44.66667	176.6667	299.6667	1666	16	69.33333	19.33333	285.3333	28.33333
ABT 1060	Motif	Vietnamese Cup	1332	57019.67	233484.7	1339.667	11901.67	58113.67	565.6667	23271.67	1717.333	2048	106.6667	2	30.33333	84	268.6667	263.6667	9.666667	7.333333	90.66667	84.33333	36
ABT 2085	Motif	Hexagonal-shaped	4851.667	79997.33	308201.3	4883.333	24141.67	75656	771.6667	179	1796.333	592.6667	482.3333	2.333333	46.66667	159.3333	260	1554.667	16.33333	49.33333	39	201.3333	25.66667
ABT 2080	Motif	Globe-shaped	8300	93358.67	346395.7	2285.667	26553.33	86149	983.3333	182.3333	2022.667	241	210	2.333333	43.66667	149.6667	327.6667	1347.667	16.66667	64	21	278.6667	24.66667
ABT 2070	Motif	Hexagonal-shaped	7258.667	89742.67	334755	1973.667	24989.33	83807.67	858.6667	172.3333	2124	533	280.3333	2	39	151	316.6667	1294	17.33333	46.33333	27.33333	163	20
ABT 0869	Motif	Vietnamese Covered Box	9588	65357.33	319851.3	3163	19939.67	59194.67	442	23851.33	2361.333	2383	664	2	0	120	158	161.6667	9	8.333333	45	175	28
ABT 2097	Motif	Globe-shaped	10495.33	99070.33	351211.7	1763.333	25475	92113.67	1166.667	305.6667	2432	574.6667	348.3333	3	43.33333	182	276.6667	1560	20	63.66667	16.33333	204.3333	25.66667
ABT 2075	Motif	Globe-shaped	9283.667	83853	320730.7	3083.667	25908.67	99850	812.6667	390	2448	321.6667	403.3333	3	40.33333	180.3333	339.3333	1739	20.66667	70.66667	40.66667	280	26.33333
ABT 2071	Motif	Globe-shaped	6446.333	91258.33	341263	2129.667	26326.67	89916	743.3333	273.3333	2492.667	511.3333	331.6667	3	46.33333	170.6667	303	1460	16.66667	60.66667	26.66667	217.3333	26.66667
ABT 1068	Motif	Batavia Ware	313.6667	75449.67	327683.3	1145	19781	49229.67	40.33333	2841.667	2544	226.6667	42.33333	7.333333	11.66667	354	51.66667	43	17.66667	4.333333	42.66667	163.3333	11
ABT 2072	Motif	Globe-shaped	10915.67	92352.67	346515.3	2793.333	25322.33	101562.7	945.3333	198.3333	2559.667	224.6667	243	2.333333	38	154.6667	319.6667	1580.667	17	62.66667	18	298.3333	24.33333
ABT 2054	Motif	Globe-shaped	6596.667	96350	362232.3	1779.333	24792.67	98394.33	967	229.6667	2661.333	1074	389.3333	2.666667	43	170.3333	261.6667	1450.667	20.66667	63.66667	15.66667	192	24
ABT 2084	Motif	Globe-shaped	9042	87064	334748.3	3682.333	23640.33	125829.7	798.3333	225.6667	2735.333	80	227	2.333333	27	161.6667	340.6667	1414	18.66667	66.66667	26	184.6667	28
ABT 1261	Motif	Vietnamese Covered Box	9116.333	63067.67	315862.3	3106.333	20094	56418	510.6667	26944.67	2737	2721.333	1166.333	2.666667	0	119	151.6667	161	10.33333	10.66667	41.33333	194.6667	44.33333
ABT 2092	Motif	Globe-shaped	11065.33	95831.67	354471	1093.333	24591.67	115021.7	913	241.3333	2772.333	759.3333	308.3333	3	30	185.6667	241	1577.333	19.33333	69.33333	20.33333	187	25.66667
ABT 1854	Motif	Vietnamese Cup	15574.67	67750.33	295559	1097	16888.33	100533	907.6667	6191.667	2813.667	545	144.3333	3.333333	14.66667	134.3333	227.6667	244.6667	16.33333	13	61.33333	123.3333	29
ABT 1267	Motif	Chinese Jarlet	11110	70085.33	328178	1098.333	25414.33	95808.33	175.6667	6952.333	2895.667	383.3333	92.66667	3.333333	6.666667	168	756.6667	210	21.66667	23.33333	28	166.3333	38
ABT 2109	Motif	Globe-shaped	9264.667	82878.67	329199.7	2208	24940.67	82966.33	593.3333	268.3333	2977.667	839.3333	250	2	44.33333	135	346.6667	1281	14.33333	52.66667	27.66667	306.6667	23
ABT 2100	Motif	Globe-shaped	10113.67	86130	337255.7	2244	25806	85576.67	724.3333	277.3333	2992	813.6667	242.6667	2	47.33333	135.3333	343.6667	1263.667	15.33333	53	25.33333	253	34.33333
ABT 2088	Motif	Cylinder-shaped	7420.667	85208.33	329147	1963.667	23201.33	101483.3	731.3333	180	3003	622.3333	461	3	33.66667	165.3333	267	1499.333	18.33333	54.66667	33.33333	194	25.33333
ABT 1048	Motif	Batavia Ware	107.6667	62076.33	317157.3	1013.667	18969	36673	49	12136.67	3047.333	1311.667	56.33333	6	47	303.6667	54.66667	44.33333	14.66667	5.333333	47	126.6667	11.66667
ABT 2073	Motif	Globe-shaped	7937	90387.33	337631.3	1765	24556.67	96683	1208.333	182	3224.333	374.6667	310.3333	3	40.66667	172	298	1472.333	18.33333	57	30.66667	173	25
ABT 1224	Motif	Vietnamese Jar	15634	69334.67	319023.3	987.6667	19730	73351.67	638.3333	41191	3226.667	4045	153.6667	2	23.33333	126.6667	191.3333	182	12.33333	12.66667	45	181	36.33333
ABT 0876	Motif	Chinese Covered Box	811.3333	58808	288990	2950	17093.33	24784	0	18293.67	3297.667	1991	136.3333	6.333333	10.66667	353.6667	52.66667	47.33333	15.33333	1.666667	69	213	13.66667
ABT 2089	Motif	Hexagonal-shaped	6826.333	83153.33	319525.7	3307.333	22485.33	115872.3	923	260.3333	3342.333	741	402.3333	2	37.66667	149	338	1367.667	16	55.66667	32.66667	226.3333	25.33333
ABT 2064	Motif	Globe-shaped	7106	98989.33	353636	2232	27115.67	88557	908.6667	223.3333	3350	421.6667	404.3333	3	68	176.6667	284	1424.333	16.33333	57.66667	16	188.6667	24.33333
ABT 1265	Motif	Chinese Jarlet	10982	72335.33	322926	1304.333	23617.67	89774	114.6667	11236.33	3395	929.3333	132.6667	3.666667	12	167.3333	731.3333	203	23	23.33333	37.33333	151	41.66667
ABT 2078	Motif	Globe-shaped	7787.667	88170.33	340118	2056.333	25413.33	89701.33	694.3333	559.3333	3523	493.6667	566.6667	3	52.66667	181.6667	251	1546.667	19.66667	70	31.66667	246.3333	23.33333
ABT 1102	Motif	Vietnamese Cup	13911.33	71899.67	314105.7	1921	22263.33	84895	696.6667	13698	3579	1321	68.66667	2.333333	12.33333	124	129.6667	196.3333	12.66667	8	43	168.3333	37
ABT 0872	Motif	Chinese Covered Box	0	52902	278868.7	3766.333	17858.33	20239	133	9878.333	3663.667	1455	148.6667	5	23	375	48.66667	49	18	0.666667	82.33333	150.6667	16
ABT 2098	Motif	Globe-shaped	8578.667	100317	358274.7	2903.333	24757.33	98940.33	1064.667	249.6667	3735.667	1453.333	377	3	58.66667	179	260.6667	1146.333	19	44	14.5	199	25
ABT 1062	Motif	Batavia Ware	1637	75361.33	341081.3	1529.333	21427.67	38703.67	46	8999.333	3854.333	911.6667	64	7	32.33333	340.6667	49.33333	41.33333	19.33333	3.333333	35.66667	200	14
ABT 1088	Motif	Vietnamese Cup	13902.67	61709.67	301174.3	473.6667	19471	60467.67	520.3333	25260	4008.333	2458.333	121	2	20.33333	117	164.6667	194	10.66667	4.666667	48	105	35.66667
ABT 2079	Motif	Globe-shaped	8173.667	82957.33	321659	2662.333	25595.33	115570	919.6667	276.6667	4379.333	1281.333	680	3	47	197	314	1685	18.33333	73	37.66667	243.6667	29.66667
ABT 2061	Motif	Cylinder-shaped	5399	79717.67	315573.3	1370.333	22398.67	81711.67	673.6667	210.3333	4413.333	756.3333	383.6667	2.333333	34.33333	151.6667	280.6667	1440.667	18.66667	53	37.33333	177.6667	24.66667
ABT 2094	Motif	Globe-shaped	7923.333	98930.33	362041.7	1838	27599.67	88432.67	789.3333	278.6667	4435.667	1555.667	477	2.666667	52.33333	194.3333	235.3333	1568.667	18.33333	65.33333	18	221.6667	31
ABT 2082	Motif	Cylinder-shaped	7433	94884.33	351050	1833.667	26321.67	89613	1030.667	210	4483.667	1046.667	525.3333	3.666667	49.33333	209	217	1639	21.33333	66.66667	26.66667	193.3333	29
ABT 2091	Motif	Globe-shaped	8699.667	89203.67	341626.7	2081.333	25184.33	82939	1045.667	222.3333	4527.667	1516.667	480	3	50.66667	164.3333	251.6667	1119.333	17.33333	41	28.66667	212	29
ABT 1243	Motif	Chinese Jarlet	11890.67	65388.33	303979.3	3459.667	22325.67	86730	156.3333	14544.67	4553.333	1348.667	138.6667	3.333333	39.66667	148	677.3333	198.3333	23.66667	35	45.66667	116	41.66667
ABT 2101	Motif	Globe-shaped	7881.667	100003.7	363937.3	2761	24771.67	98044.33	1102.667	181.6667	4692	1594.667	372	2.666667	38.33333	167	257	952.6667	22	40.33333	11	159	28.33333
ABT 1235	Motif	Chinese Jarlet	15044.67	70439	326816	1458	25983	85125	526.6667	17330.67	4732.667	1286.667	93	4	36.66667	185.3333	410.6667	158.3333	27.33333	20.33333	32.66667	185	50.33333
ABT 1220	Motif	Chinese Jar with Lid	4972.333	83385.33	370149.3	1183.333	35891	29773.33	188.3333	13612.67	4897.667	1769.333	98	4	27	212.3333	192.3333	148.6667	32.33333	20	13.33333	133	35.66667
ABT 1226	Motif	Chinese Jar with Lid	3916.333	86541	376582.7	497.3333	35376.33	31280.67	340.6667	12468.67	4955.333	1566	55.33333	5	14.66667	219.3333	199.3333	136	31.66667	28.33333	16	137.3333	35.33333
ABT 1084	Motif	Batavia Ware	889	76591.33	349423.3	1733.667	23382	35594	35.33333	7182.667	4988	689.6667	57	7	15.33333	388.6667	47.33333	42	17.33333	7	34	180.6667	10.33333
ABT 2099	Motif	Globe-shaped	5506.667	94719	360474	1657.667	27397.67	88450	888.3333	269.3333	5094	1577.333	532.3333	3	46.66667	189.3333	235.6667	1544.333	19	58.33333	14.5	196	26.33333
ABT 2090	Motif	Cylinder-shaped	7629	99133.67	356560	1782	24831	94836.67	952	176.6667	5097.667	678.3333	332.3333	3	32.33333	170.6667	272.3333	1452.333	18	62	15.66667	237.3333	29.33333
ABT 2052	Motif	Globe-shaped	6048.667	94403	349351	1441	25690.33	87713.33	931	217.6667	5255.333	1519.333	463	3	42	168	256.6667	1140	16.33333	40.33333	17.33333	142	26.33333
ABT 0870	Motif	Vietnamese Covered Box	9898.333	63958.67	233981	7996.333	14035.33	56148	829.6667	55947.33	5567.667	4968	764.3333	2	51.33333	113	164.6667	254.6667	14	19	87.66667	220	71.66667
ABT 2077	Motif	Cylinder-shaped	6587.667	95244	356284	2018	25742	92181.33	909	263	5588	1801.667	465	3	58.33333	177	253	1152.333	18	44	12.66667	169	31
ABT 2058	Motif	Globe-shaped	8215.667	97351	353395.7	1929.333	25462.67	89407	1066.333	247	5605	1414.333	432.3333	3	40	164.6667	266	1099.333	19	45.66667	15.33333	155.6667	28.33333
ABT 2065	Motif	Globe-shaped	7299.667	89298	344120	2949.333	25510.33	91264.33	889	261	5783.333	1548.333	527	2.666667	39.66667	175	258	1142.333	18.33333	41	28.66667	172.3333	28.33333
ABT 2060	Motif	Cylinder-shaped	7083.667	95184.67	352220.3	2110.333	25379	98868.33	1168	171.3333	5792	542.3333	217	2.333333	33.66667	167.6667	312	1387.667	16.33333	59.33333	17.33333	213.3333	30
ABT 2105	Motif	Globe-shaped	5538	95052.33	353714.3	2099.667	26750.33	89186.33	1038.333	204	5805.333	1549.333	465.3333	3	38.66667	174.6667	257.6667	1108.333	19	43.66667	24.66667	187	32.66667
ABT 2067	Motif	Globe-shaped	10310.33	89556	298696.7	2670.667	19125	93445.67	1938.333	292	5879.333	882.3333	499.6667	3	41	183.6667	228	1899.667	19.66667	74.66667	50.66667	276.3333	42
ABT 2081	Motif	Globe-shaped	7010.667	89547.33	352520	1616.333	26345.33	85203	522	239	6053.333	1785	429	2.333333	46.66667	169	218.6667	1587	19.33333	75	22.33333	303.3333	28.33333
ABT 2066	Motif	Globe-shaped	11061	73441.33	281999.7	5593.667	20330.67	179360.7	869.6667	333.3333	6195.333	954.3333	641.6667	2.666667	29.33333	178	433.3333	1687	18.33333	61.66667	64.33333	267	27
ABT 0274	Motif	Vietanmese Jar	20185.33	82229.67	342414.3	1245	26480.67	79724.67	680	346.6667	6365.667	1923	54	2.666667	42.33333	167.3333	177.6667	180.3333	13	16	36.33333	135.3333	25
ABT 2083	Motif	Cylinder-shaped	5717.667	82589.67	331367.7	1582	23664.33	88013	619.3333	207	7113	737.6667	526.3333	3	26.66667	179.6667	233.3333	1610.333	17.66667	63	33.33333	221	24
ABT 2083	Motif	Globe-shaped	4533.333	74296.33	321668.7	1176.333	21933	86536.67	559.6667	217.3333	7167.333	828	567	3	24.66667	166	235.6667	1571.333	17.66667	55	40.33333	211.6667	24
ABT 2053	Motif	Globe-shaped	8789.333	83918.67	315932	5282.333	24565	114597	1208	271.6667	7807	567.6667	538.3333	3	31.33333	203.6667	285	1987	21	74.66667	44.66667	226.6667	34.33333
ABT 2095	Motif	Globe-shaped	3871.667	76486	322218	2387.333	23255.33	89648.33	612	246.3333	8093	2808.667	461.3333	2	35.66667	148.3333	244.3333	1643	15.33333	63	37	259.6667	26.33333
ABT 2055	Motif	Globe-shaped	7150.333	82250.33	350767.7	856.6667	21499.33	115590	945.6667	216.3333	8285.667	1611.667	593	2.333333	33.33333	165	256	1037	18.66667	36.66667	19.66667	189	28.33333

Appendix I: Main Set Database Entries

INV#	vessel_form	group	shelf_location	country_of_manufacture	condition	date_of_creation	H (mm)	Rim D (mm)	Base D (mm)	Shoulder Circ	Paste Colour (munsell)	Glaze colour (munsell)	Motif/Decoration colour (munsell)	Weight (g)
ABT2052	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	61	28	36	245*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	75.6
ABT2053	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	71	28	37	250*	2.5Y 8/1	GLEY1 8/10Y	2.5PB 3/8	132.7
ABT2054	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	64	27	35	240	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	90.8
ABT2055	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	64	27	35	23	5Y 8/1	5Y 8/1	2.5PB 3/8	69.6
ABT2056	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	72	27	36	247*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	126.3
ABT2057	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	66	22	42	240*	2.5Y 8/1	5Y 8/1	2.5PB 3/8	113.9
ABT2058	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	63	27	35	235*	5Y 8/1	5Y 8/1	2.5PB 3/8	85.2
ABT2059	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	67	29	39	250*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	121.6
ABT2060	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	27	40	258*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	107.8
ABT2061	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	26	43	225	GLEY1 8/N	GLEY1 8/N	2.5PB 3/8	88.8
ABT2062	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	68	25	41	220*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	114.2
ABT2063	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	67	26	41	240*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	135
ABT2064	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	72	28	38	245	5Y 8/1	GLEY1 8/N	2.5PB 3/8	108.3
ABT2065	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	64	27	34	235	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	91.3
ABT2066	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	71	28	35	255*	GLEY1 8/N	GLEY1 8/N	2.5PB 3/8	145.3
ABT2067	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	66	28	39	255*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	145.4
ABT2068	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	72	27	38	258*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	132.6
ABT2069	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	73	28	37	250*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	125
ABT2070	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	73	24	37	235*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	116.8
ABT2071	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	64	26	34	236	5Y 8/1	GLEY1 8/N	2.5PB 3/8	106.4
ABT2072	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	64	27	35	240*	5Y 8/1	gLEY1 8/N	2.5PB 3/8	132.6
ABT2073	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	29	40	250	2.5Y 8/2	GLEY1 8/N	2.5PB 3/8	92.9
ABT2074	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	72	26	37	260*	5Y 8/1	5Y 8/1	2.5PB 3/8	126.2
ABT2075	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	72	29	35	252*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	145.4
ABT2076	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	68	25	41	230	5Y 8/1	GLEY1 8/N	2.5PB3/8	109.9
ABT2077	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	28	35	235	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	68.8
ABT2078	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	73	26	38	257*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	123.3
ABT2079	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	26	35	240*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	75.3
ABT2080	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	73	29	38	275*	2.5Y 8/1	5Y 8/1	2.5PB 3/8	145.4
ABT2081	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	67	26	40	223	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	124.3

INV#	vessel_form	group	shelf_location	country_of_manufacture	condition	date_of_creation	H (mm)	Rim D (mm)	Base D (mm)	Shoulder Circ	Paste Colour (munsell)	Glaze colour (munsell)	Motif/Decoration colour (munsell)	Weight (g)
ABT2082	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	64	26	36	240	5Y 8/1	GLEY1 8/N	2.5PB 3/8	97.8
ABT2083	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	66	26	42	218*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	101.4
ABT2084	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	72	28	40	250*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	125.6
ABT2085	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	74	24	38	24*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	100.4
ABT2086	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	25	42	223*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	113.7
ABT2087	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	66	25	42	217	5Y 8/1	GLEY1 8/N	2.5PB 3/8	112.4
ABT2088	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	68	25	44	228	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	107.7
ABT2089	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	74	25	36	233	2.5Y 7/1	GLEY1 8/N	2.5PB 3/8	119.7
ABT2090	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	25	42	230	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	103.3
ABT2091	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	63	28	34	240*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	93.1
ABT2092	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	27	40	250	2.5Y 8/1	5Y 8/1	2.5PB 3/8	113.2
ABT2093	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	68	25	41	220	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	123.9
ABT2094	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	63	26	37	243*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	85.2
ABT2095	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	29	39	248	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	134.8
ABT2096	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	25	43	222*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	93.9
ABT2097	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	64	27	35	242*	2.5Y 8/2	GLEY1 8/N	2.5PB 3/8	85.3
ABT2098	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	64	27	35	235*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	79.4
ABT2099	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	61	27	34	235*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	82.6
ABT2100	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	61	28	35	235*	5Y 8/1	5Y 8/1	2.5PB 3/8	96
ABT2101	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	62	27	35	245*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	68.6
ABT2102	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	72	27	36	270*	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	101
ABT2103	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	66	25	42	215	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	123.6
ABT2104	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	61	30	34	240	2.5Y 8/1	GLEY1 8/N	2.5PB 3/8	125.7
ABT2105	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	65	27	37	233	5Y 8/1	5Y 8/1	2.5PB 3/8	74.7
ABT2106	Jar - small	Vietnamese B&W jar	P2	Vietnam	Fair	14th - 16th century	72	28	38	246*	5Y 8/1	GLEY1 8/N	2.5PB 3/8	123.3

Appendix J: Comparison Set Database Entries

INV#	vessel_form	group	shelf_location	country_of_manufacture	condition	date_of_creation	H (mm)	Rim D (mm)	Base D (mm)	Shoulder Circ	Paste Colour (munsell)	Glaze colour (munsell)	Motif/Decoration colour (munsell)	Weight (g)
ABT0274	Jar - small	Vietnamese jarlett	P7	Thailand	Good	14th - 16th century	75	25	46	269	5Y 8/1	GLEY1 8/N	2.5PB 5/4	156.8
ABT0869	Covered box	Vietnamese B&W covered box	P7	Vietnam	Good	14th - 16th century	49	67	44	238	5Y 8/1	GLEY1 8/10Y	2.5PB 5/4	158.2
ABT0870	Covered box	Vietnamese B&W covered box	P7	Vietnam	fair	14th - 16th century	53	62	55	230	5Y 8/1	GLEY1 8/10Y	2.5PB 5/4	189
ABT0876	Covered box	Chinese B&W covered boxes	P8	China	Good	16th century	101	165	105	557	5Y 8/1	GLEY1 8/10GY	2.5PB 3/8	1010.4
ABT1048	Cup	Batavia ware cup B&W	P1	China	Good	18th century	42	71	38		GLEY1 8/N	GLEY1 8/N	2.5PB 3/8	49.3
ABT1060	Cup	Vietnamese B&W cup	p7	Vietnam	Good	14th - 16th century	56	90	41		5Y 8/1	GLEY1 8/N	GLEY1 3/5G	111.1
ABT1062	Cup	Batavia ware cup B&W	P1	China	Good	18th century	38	76	41		GLEY1 8/N	GLEY1 8/N	2.5PB 3/8	50.6
ABT1068	Cup	Batavia ware cup B&W	P1	China	Good	18th century	40	75	39		GLEY1 8/N	GLEY1 8/N	2.5PB 3/8	52.3
ABT1084	Cup	Batavia ware cup B&W	P1	China	Good	18th century	38	76	40		GLEY1 8/N	GLEY1 8/N	2.5PB 3/8	48.5
ABT1088	Cup	Vietnamese B&W cup	P7	Vietnam	Good	14th - 16th century	54	88	44		5Y 8/1	GLEY1 7/10Y	2.5PB 5/4	94
ABT1102	Cup	Vietnamese B&W cup	P7	Vietnam	good	14th - 16th century	53	88	41		GLEY1 8/N	GLEY1 8/N	2.5PB 5/4	96.2
ABT1214	Jar - small	Vietnamese B&W jar	P2	Vietnam	Good	14th - 16th century	85	27	52	250	2.5Y 8/1	GLEY1 8/N	2.5PB 5/4	191.9
ABT1220	Bottle	Chinese B&W bottle	P2	Vietnam	Good	14th - 16th century	96	28	61	265	GLEY1 8/5GY	GLEY1 8/10GY	2.5PB 5/4	234.9
ABT1224	Jar - small	Vietnamese B&W jar	P2	Vietnam	Good	14th - 16th century	83	33	60	300	GLEY1 8/10Y	GLEY1 8/N	2.5PB 5/4	256.8
ABT1226	Bottle	Chinese B&W bottle	P2	Vietnam	Good	14th - 16th century	102	26	64	270	5Y 8/1	GLEY1 8/10GY	2.5PB 5/4	243.4
ABT1235	Jar - small	Chinese B&W jar	P2	Vietnam	Good	14th - 16th century	78	35	54	260	2.5Y 8/1	GLEY1 8/10Y	2.5PB 5/4	227.1
ABT1243	Covered box	Chinese B&W jar	P7	Vietnam	Good	14th - 16th century	46	64	40	224	5Y 8/1	GLEY1 8/10Y	2.5PB 5/4	118.9
ABT1261	Covered box	Vietnamese B&W Covered Box	P7	Vietnam	Good	14th - 16th century	51	68	42	243	5Y 8/1	GLEY1 8/10Y	2.5PB 5/4	138.5
ABT1265	Jar - small	Chinese B&W jar	P2	Vietnam	Good	14th - 16th century	69	31	49	240	2.5Y 8/1	GLEY1 8/10Y	2.5PB 5/4	170.5
ABT1267	Jar - small	Chinese B&W jar	P2	Vietnam	Good	14th - 16th century	70	32	53	250	10YR 8/1	GLEY1 8/10Y	2.5PB 5/4	155.2
ABT1268	Covered box	Vietnamese B&W Covered Box	P7	Vietnam	Good	14th - 16th century	51	61	43	228	5Y 8/1	GLEY1 8/N	2.5PB 5/4	140.4
ABT1854	Cup	Vietnamese B&W cup	P7	Vietnam	Good	14th - 16th century	57	91	42		5Y 8/1	5Y 8/1	2.5PB 5/4	126.6