Residue Analysis of Pre-Contact Small and Miniature Pottery: A Multi-Proxy Approach

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Abstract

Small and miniature pottery vessels are common in North American archaeological sites, although they have rarely been the focus of study. These vessels are variously interpreted to be mortuary or ceremonial vessels, practice pots, toys, bowls, cups, and are often believed to be associated with children. The majority of studies conducted on pottery rely on visual examinations, while this thesis combined visual techniques with organic residue analysis for a more comprehensive study. Using multiple analytical techniques on vessels from three collections, biochemical residues were located and extracted, and then analyzed to infer possible function of the vessels. This process also takes into account cross-contamination from curatorial processes. The techniques used include microscopic examination, scanning electron microscopy (SEM), microfossil starch and phytolith analysis, and gas chromatography coupled mass spectrometry (GC-MS). This research design is non-destructive, and tailored to address the fact that many specimens have been curated and held in museums for some time. Many adjustments to the methodological approach were made to account for the various difficulties and limitations that arise when working with pottery. Results from the analysis indicate that the methodology used had a limited success rate. While a small number of results were successful in suggesting possible functions of vessels, the majority of results were indicative of contamination, although these were easily ruled out as non-archaeological. Overall it was determined that the combination of these methods, especially if further testing was performed, could be a feasible route of analysis for unique samples where standard destructive methods are not suitable, but where further analysis is desired.

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Chapter 1: Introduction to Organic Residue Analysis and Using a Multi-Proxy Approach

"The problem of function is perhaps one of the most difficult faced by those studying archaeological ceramics" (Orton et al. 1993)

1.1 Introduction

Archaeological artifacts are frequently categorized and defined based on their functions, rendering interpretations challenging for artifacts lacking an obvious function. The majority of archaeological studies which analyze pottery focus on analyses of their physical attributes. While this data can be informative, it can be limiting, and the addition of residue analysis provides further insight into the possible function of these vessels by allowing researchers to analyze aspects of artifacts that are often overlooked, or unable to be seen. Analyzing residues from pottery vessels is not a new methodology, but standard methods of analyzing these residues are extremely destructive, and since the majority of the sample vessels used for this study are from museum collections, non-destructive techniques were developed to suit this unique sample type. This project looks at small and miniature Woodland pottery as a whole, including an analysis of the current body of literature and an examination of the physical attributes of sample vessels in addition to residue analysis in hopes of providing a more complete picture of their past uses.

1.2 Multi-Proxy Approach

Archaeological residues act as an important record of information concerning diet, subsistence, and general resource use, and can be studied in a multitude of ways. When residues preserve on the exterior or within the matrix of pottery vessels, they are representative of substances that were processed or stored, and possibly consumed during the pots' use (Boyd et al. 2008). These residues can be analyzed for botanical and biochemical proxies, they can be dated, and the various stylistic characteristics of sherds can often be associated with specific cultural groups (Boyd et al. 2008). The use of organic residue analysis to study pre-contact cultures has provided important insights into past lifeways. However, few studies analyzing pottery have used a multi-proxy approach. More recent literature calls for the use of multiple lines of evidence as standard regarding residue analysis (see Boyd et al. 2008; Hart et al. 2007). The combination of methods such as the ones used in this study, including incident and transmitted light microscopy, along with SEM, microfossil starch and phytolith analysis, and GC-MS allows for a greater recovery of information than each method would alone.

All of the vessels used for analysis were previously excavated or surface collected from sites within Boreal Forest regions in northern Manitoba and Northwestern Ontario. Archaeological research within boreal forest environments is limited due to the size of the region and its "challenging depositional environments" (Hamilton 2006). The preservation of organics is rare in these environments due to podzolic soils, which rapidly degrade them (Hamilton 2006; Meyer and Russell 1987). Additionally, Boreal Forest sites are prone to taphonomic disturbance which can result in mixed or compressed stratigraphy (Hamilton 2006). Despite these limitations, the last decade has seen an increase in organic residue analysis from these regions which have successfully identified residues extracted from stone tools from sites dating to the Early Pre-Contact Period, many of which were conducted out of Lakehead University (see Bouchard 2017; Cook 2015; Hodgson 2016). In addition to attempting to further understand small and miniature pottery vessels, this project also serves as an introduction to multi-analytical pottery analysis and testing non-destructive residue methodologies on pottery. This thesis demonstrates that analyzing absorbed residues from pottery vessels with limited to no visible residue on their surface can overcome taphonomic limitations inherent in Boreal Forest sites.

1.3 Sampling

Sample vessels were loaned by The Manitoba Museum, Lakehead University, and an avocational archaeologist (Brad Hyslop). These specific collections were selected due to their availability and ease of access. Vessels within each collection were carefully selected, and included searching through databases for vessels that were catalogued using terms such as 'miniature,' 'small,' 'toy,' 'cup,' 'juvenile,' and 'mortuary.' Overall a total of thirty-five small/possible small vessels, twelve miniature/possible miniature vessels, and thirty-six full-sized vessels from fifteen archaeological sites were selected for analysis. The number of samples analyzed differed for each methodological approach depending on the specific requirements of each technique.

1.4 Thesis Organization

This thesis is divided into seven chapters. Chapter 2 reviews the current body of literature that exists for small and miniature pottery vessels, and provides a background on this little understood type of material culture while also challenging the prominent belief of a connection between small objects and children. The current terminology used to describe small and miniature vessels is discussed in this chapter, and a new more concise terminology is presented. Chapter 3 explores the origins of the organic residue methodologies used for analysis as well as their strengths and weaknesses when analyzing residues on pottery. In Chapter 4, the archaeological sites from which the sample vessels were collected are discussed. Chapter 5 outlines the methodological procedures used to analyze the sample vessels, including the in-depth cataloguing and documentation of physical attributes, as well as the various residue techniques which included: *in-situ* reflected light microscopy, transmitted light microscopy, scanning electron microscopy (SEM), gas chromatography coupled mass spectrometry (GC-MS), and microfossil starch and phytolith analysis. Chapter 6 presents the results from the various analytical approaches, including those from the documentation of the vessels' physical attributes, as well as the results from residue analyses. Finally, Chapter 7 discusses the results presented in Chapter 6 and provides interpretations concerning the larger picture of small and miniature pottery and the overall success of the chosen methodologies.

Chapter 2: Literature Review of Small and Miniature Pottery

2.1 Introduction

Pottery technology became widespread in several parts of North America during the Woodland or Late period (1000BCE-1000CE), and is frequently found in archaeological sites. Small and miniature-sized vessels are a unique type of pottery found in archaeological sites around the world, although they have rarely been the focus of in-depth examination. Within a North American context, these vessels have been variously interpreted as mortuary/ceremonial vessels, practice pots, toys, bowls, cups, or even incorrectly labelled as pipes (see Bagwell 2002; Baxter 2005a, 2005b; Buchner 1996; Crown 1999, 2001, 2002; Ellis 1994; Finney 1983; Fisher-Carroll 2001; Holmes 1903; Hodges 1968; Hutson 2006; Judd 1954; Kamp et al. 1999; Kamp 2002; Lillehammer 1989; Martin 1991; Moeller 1980; Nesbitt 1938; Pearce 1978; Roosa 1977; Saylor 1999; Smith 1998; Storck 1988). While searching archaeological collections for miniature and small vessels for this study, it became apparent that numerous past cultures made vessels of this kind. While the vessels themselves may be prevalent, research concerning them is not, and most of the literature that does exist points to a lack of understanding concerning this type of material culture and the role it may have played. Carey (2006:1) states that this lack of knowledge, coupled with the small size of these vessels, has resulted in the dismissal of these artifacts as "unexplainable curiosities rather than functioning components of culture." This chapter discusses some of the roles pottery served during the Woodland period, and brings together existing literature concerning the use and manufacture of miniature and small pottery vessels. It also discusses the array of terminology used to describe small and miniature vessels, and seeks to clarify and define the most appropriate terms. Finally, one of the most prevalent themes within the literature concerning these vessels is their suggested connection with children. Throughout this chapter this theme will be analyzed to determine its appropriateness for the study area.

2.2 Pottery & the Woodland Period

The Woodland period of North America, which lasted from approximately 1000BCE-1700CE depending on the geographic area, is characterized mainly by the manufacture and use of pottery. Other significant attributes of this period include the use of food-storage pits, the adoption of the bow-and-arrow, the introduction of horticulture in specific regions, and the use of mound building and other mortuary rituals in certain areas (Hamilton et al. 2011; Neusius and Gross 2007; Syms 2014). The focus of this section is on the adoption of pottery and the different functions it may have served, with an emphasis on the potential uses of small and miniature pottery vessels and their presence in the archaeological record. Pottery making traditions relevant to the sample vessels are discussed as well. Due to the significant lack of literature on miniature pottery specifically, some of the articles and ethnographic sources cited deal with other categories of miniature artifacts.

2.2.1 Pottery Traditions & Time Period

Pottery traditions or styles of vessels are assessed primarily on physical attributes. The fragmentary nature of many of the sample vessels rendered assigning pottery traditions difficult, and led to many "undetermined" vessel identifications. In addition to this, the definitions and names of pottery styles are frequently changed and adapted, and there is often debate regarding the specifics of categorizations. Literature on pottery from Boreal Forest regions describes multiple variations in style that occur at different sites, as well as significant similarities between many pottery traditions and many hybrid versions of styles (Arzigian 2008; Meyer and Hamilton 1994). However, for researchers studying a specific region, the ability to recognize the styles of pottery and other material culture of that region is essential. While there are limitations, this familiarity can help researchers identify timelines and other important affiliations. Despite these difficulties, sample vessels have been attributed to three pottery traditions: Laurel, Blackduck, and Selkirk (specifically vessels from the Kame Hills and Clearwater Lake Complexes). The most common characteristics and traits for each pottery style are briefly described below, as well as how many sample pots were attributed to each. Since some vessels were not able to be categorized, an undetermined vessel category is discussed as well. The majority of vessels sampled for this thesis date to the Late Woodland period.

2.2.1.1 Laurel

Laurel pottery was first defined as part of the "Rainy River Focus" by Wilford in 1937 from sites in northern Minnesota (Arzigian 2008; Wilford 1937). The definition was later revised as the "Laurel Focus" in 1941 and has since been described by many researchers in Minnesota and other parts of North America (see Arzigian 2008; Anderson 1979; Budak 1985, 1998; Lugenbeal 1976; Stoltman 1973; Syms 1977; Wilford 1943). Ranging in age from approximately 150 BCE to 1000 CE, the typical Laurel pottery style of the larger Laurel Composite is characterized by thin, coil-made, straight necked, conical vessels with plain, smoothed body surfaces (Arzigian 2008; Hamilton 2013; Peach et al. 2006; Wilford 1943). Decorative attributes consist of punctates, bosses, dentate stamps, pseudo-scallop shell impressions, drag stamps, and incising on the upper shoulder and rim (Hamilton 2013; Peach et al. 2006; Syms 1977). Since being recovered from sites in Minnesota, Laurel pottery has been excavated or surface collected from sites in Michigan, Wisconsin, Saskatchewan, Manitoba, and Northwestern Ontario (Hamilton 2013; Peach et al. 2006). According to some researchers, there are many different types of Laurel ware, this includes stylistic variations such as Laurel dentate, Laurel incised, Laurel punctate amongst others, though this thesis simply categorizes them as Laurel (Arzigian 2008; Meyer and Hamilton 1994; Peach et al. 2006). Two sample vessels have been assessed as Laurel: a possible miniature vessel from The Pas Reserve Site (FkMh-5), and one possible small vessel from the Thomas Site (GgLl-03).

2.2.1.2 Blackduck

Blackduck pottery occurred as part of the larger Blackduck complex which stretched across parts of the eastern Subarctic, Aspen Parkland, Boreal Forest, and northeastern Plains of North America from approximately 500-1700 CE (Hamilton et al. 2011, Warrick 2013). Initially defined by Wilford in 1937, there is ongoing debate regarding whether Blackduck pottery styles developed from the Laurel Focus, or whether these styles and later styles, including Rainy River and Selkrik traditions, were made by the same cultural groups (Dyck and Morlan 2001; Lenius and Olinyk 1990; Meyer and Hamilton 1994). Additional debates regarding terminology for Blackduck pottery argue for splitting early and late pottery styles, and include a variety of subgroups, including some that group later variations with Selkirk and Duck Bay styles (Arzigian 2008). Distinctive Blackduck vessels are generally thin-walled globular vessels with constricted necks, flared rims, and thickened lips (Arzigian 2008; Dyck and Morlan 2001; Hamilton et al. 2011;

Meyer and Hamilton 1994; Syms 1977). The exterior body of vessels generally exhibits a vertically oriented textile impression, as a result of being formed in a textile bag or with a cord-wrapped paddle (Meyer and Hamilton 1994, Syms 1977). Vertical combing is sometimes seen on the exterior of vessels as well (Hamilton et al. 2011; Lenius and Olinyk 1990). The exterior rim and neck portions are often elaborately decorated, with decorations consisting of cord-wrapped tool impressions, punctates, and bosses (Syms 1977; Hamilton et al. 2011; Meyer and Hamilton 1994). Interior rim decorations do occur sometimes as well (Dyck and Morlan 2001). Three small and one possible miniature vessel from the sample were identified as Blackduck vessels, all from the McCluskey Site (DbJm-2).

2.2.1.3 Selkirk

Selkirk assemblages were first described from pottery found in Southeast Manitoba in the 1950s (Meyer and Russell 1987). Since then, several regional Selkirk variations have been recognized (Meyer and Russell 1987). The pottery from two such variations, the Kame Hills Complex, and the Clearwater Lake Complex will be discussed. Typical Selkirk vessels are globular, with constricted necks and excurvate rims and a smoothed textile impression over the body (Meyer and Hamilton 1994). It has been argued that Selkirk assemblages originated from Blackduck and Laurel Occupations (Meyer and Russell 1987). Five vessels studied for this thesis were simply identified as 'Selkirk.'

Pottery styles occurring in the Kame Hills Complex were discovered during the Churchill Diversion Archaeological Project in Northern Manitoba and named after the Kame Hills Site where the pottery was recovered (Meyer and Russell 1987). Vessels occurring in this complex are thin-walled, globular vessels with constricted necks and excurvate rims (Dickson 1980; Malasiuk 2001). Vessel temper consists of sand and is present in small to moderate quantities (Dickson 1980). Typical designs include multiple rows of external punctates, and interior bosses (Dickson 1980). Rim decorations include cord impressions, incised designs, fabric-impressing which often extends over the lip and into the interior, and even designs which incorporate spruce twig stamping, while some vessels have plain exteriors (Meyer and Russell 1987). Eleven sample vessels were assessed as occurring in the Kame Hills Complex vessels; one small vessel from the Burntwood River Burial Site (GjLs-2), two small and one possible small vessel from the Fire Island Site (HfLp-11), three small and one miniature vessel from the Kame Hills Site (HiLp-1), two small vessels from the Isthmus site (HiLp-3), and one small vessel from the Blueberry Surprise Site (HlLv-6).

Clearwater Lake Punctate (CWLP) vessels are defined as having a medium to coarse paste that is often laminated (Dickson 1983). The temper used in CWLP vessels is coarse, sometimes the size of pebbles, and usually consist of granite, quartz, mica, and sand, with crushed granite temper being the most common (Dickson 1983). Pots of this variety are generally manufactured through bag molds or paddle-and-anvil techniques, and smaller vessels are hand-molded out of lumps of clay (Dickson 1983). Vessels are globular or slightly elongated, with rounded or no shoulders, and constricted necks (Dickson 1983). Regarding decorations, the exterior surface of vessels generally consists of smoothed fabric impressions, and they generally have 1 to 3 rows of punctates which consist of 4 types: ovoid, crescentic, rectangular, and round (MacNeish 1958; Meyer and Russell 1987). Fabric impressions may be found on the lip surface, and other lip decorations can include cord wrapped object impressed, incised lines, or linear stamps (Dickson 1983). CWLP vessels found in northern Manitoban sites are often decorated with only a single row of punctates (Dickson 1983; Meyer and Russell 1987). Undecorated vessels are uncommon (Dickson 1983). Four sample vessels were assessed as Clearwater Lake Punctate vessels, one small vessel from the Kame Hills Site (HiLp-1), two small vessels from the Isthmus Site (HiLp-3), and one small vessel from the Raspberry Site (HjLp-7).

2.2.1.4 Undetermined

The vast majority of sample vessels were fragmented, often consisting of a single broken sherd. While sherds can be informative, they give a limited view of what the entire pot would have looked like and depending on how fragmented it is, it is sometimes too difficult to attribute it to a specific pottery tradition. Furthermore, while some decorative motifs are indicative of certain pottery types, miniature and small vessels do not necessarily follow the typical design patterns. Additionally, certain designs are known to appear on many pottery styles which further renders associations challenging. Twenty-one sample vessels were assessed to be undetermined. This includes: one possible miniature vessel from the McLeod Site (GfLm-7), all ten vessels from the EcJw-1 site which includes two small, four possible small vessels, one miniature, and three possible miniature vessels (although all were determined to be from the Late Woodland Period), as well as nine small vessels, one possible small vessel, and four possible miniature vessels from the McCluskey Site (DbJm-2).

2.2.2 Origins and Uses of Pottery

The manufacture of pottery vessels in North America allowed for new ways to carry, store, and cook food. While some forms of pottery were being created during the earlier Middle period (commonly referred to as Archaic), many common cooking methods during that time (i.e. rock-filled pits or slab-lined hearths) were indirect heating methods, and the containers used to heat food were made of organic materials which do not preserve well over time (Neusius and Gross 2007). The adoption of pottery has also been cited as evidence of a sedentary lifestyle, as the heavy, breakable pots made of fired clay are not nearly as efficient for a mobile lifestyle as skin bags or vessels made of bark (Neusius and Gross 2007).

Pottery is an extremely important interpretive tool for archaeologists as it preserves well in the archaeological record and can illustrate a direct link between past peoples and food preparation activities. In addition to this, pottery comes in different shapes and styles, and was made with varying materials and decorations. This plasticity encourages considerable variation, resulting in the definition of styles thought to be characteristic of specific cultures or complexes, and indicative of cultural developments over time. The variability of pottery styles speaks to the complexity of this period and its cultures. There are a multitude of cultures associated with the Woodland period, many with their own unique pottery styles, and many of which created small and miniature vessels in addition to full-sized ones.

While full-sized vessels served different functions, they are generally treated as food preparation or storage vessels in the archaeological literature. There have been multiple studies on full-sized vessels detailing ways in which to determine their specific function. Hally (1986) discusses archaeologists abilities to identify pottery function, and mentions both full-sized and smaller vessels. Hally's (1986) study is based on vessels from the Barnett phase in Georgia. Like many other such studies, Hally attempted to assess the function of specific pots based on morphological factors, including general physical characteristics, use wear, and surface decorations. Such studies propose that a pot's physical characteristics determine its functional limits. For example, assessing a pot's ability to stand upright or withstand thermal stress will determine its potential to hold liquids or utility for storage, cooking, or boiling (Hally 1986). Hally's interpretations of the vessels he studied were primarily food related, for both full-sized and miniature vessels.

Gibson (1994) offers functional explanations of full-sized vessels from Bushfield West (FhNa-10), a large pre-contact Selkirk site near Nipawin, Saskatchewan. Gibson's interpretations are based largely on the visibility of residues as well as physical characteristics, and he identifies three vessel functions. He suggests that cooking vessels exhibit thick, black carbonized residue on the interior or exterior, while boiling vessels have evidence of staining and little carbonized residue. The third type, utility vessels, do not illustrate evidence of having been used in or over a fire (1994). Gibson also suggests that these vessels with differing function also vary in shape and size. Cooking pots are generally large, thin, and well-made, with long excurvate rims. Boiling pots are smaller, with short, vertical rims, while utility pots, moderate in size, can vary in height, and have excurvate or flared rims (Gibson 1994). These interpretations of the function of pots are common in the literature and are extremely useful. To some extent, of course, the function of pots can be determined based on physical characteristics, and interpretations are strengthened when visible residues are present. However, additional interpretive venues are required to further illustrate the larger picture of true vessel function.

While it can be assumed that the primary function of pottery vessels is to contain various substances, we can rarely tell what those substances were or why the vessel was used. In contrast to full-sized vessels that are commonly linked to food preparation and storage, miniature and small pots have been found in both burial and ceremonial contexts, tentatively indicative of other, non-food preparatory uses. While significant research has been performed on larger pottery vessels, comparatively less has focused on miniature and small-sized vessels. As a result, the role they played amongst past cultural groups is little understood.

2.2.3 Miniature and Small Pots in the Archaeological Record

Miniature-sized artifacts are prevalent in the archaeological record of North America and elsewhere in the world. Many miniature artifact categories are well documented; however, as previously mentioned, small and miniature pottery vessels have been largely neglected in North American archaeology. The regular presence of miniature and small pottery vessels in archaeological collections was noted earlier in this chapter, and this seems to signify some level of importance or at least their common manufacture and use in the past. While a large number of miniature and small vessels have been recovered, they are often only briefly mentioned in archaeological reports and are far outweighed in recoveries and research by full-sized vessels. For example, K.C.A. Dawson's (1974), report on the McCluskey site (DbJm-2) in Northwestern Ontario, a site included in this study, barely mentions the 40 rim sherds from small and miniature vessels recovered, and all of the sherds are interpreted as "mortuary" vessels. Many other archaeological reports mention miniature and small vessels without detailed description or explanation. For example, Hamilton (1981) describes a small vessel from the Wenesaga Rapids site (EdKh-1), Hanna and Pentney (1998) recorded finding miniature Clearwater Lake Punctate vessels at a site near Brabant Lake in Saskatchewan, while Brandzin (1997) mentions a miniature Selkirk vessel from the Spruce Rapids site (GdMo-5) in Saskatchewan. Hanna (1976) mentions three burial mounds from the Moose Bay Burial Mound site (EdMq-3) in Saskatchewan that contained small pottery vessels and sherds.

While the above reports make little mention of the small and miniature vessels found in archaeological sites, there are some sources which offer diverse explanations and theories of their use. One popular explanation regarding the use of miniature artifacts, including miniature pottery vessels, is that they are associated with children. Two specific functional roles are associated with the supposed children's pots. The first is that they were children's toys, created by or for children. The second is that they are practice pots, created by children learning how to make pottery. There are multiple archaeological reports that identify miniature objects found at sites as children's toys (see Baxter 2005a, 2005b; Buchner 1996; Crown 1999, 2001, 2002; Fisher-Carroll 2001; Holmes 1903; Hodges 1968; Hutson 2006; Judd 1954; Martin 1991; Moeller 1980; Nesbitt 1938; Pearce 1978; Roosa 1977; Saylor 1999; Smith 1998; Storck 1988). Similarly, several ethnographic sources describe cases of children using smaller versions of tools and other objects made of stone, wood, bone, and clay as toys (see Calvert 1992; Kidd 1906; Park 1998; Santina 2001; Shipbeck 1968; Vanstone 1985). Baxter (2005a, 2005b) explains that this archaeological interpretation has been common for decades, and the assumption is based on the size of the object, whether it is 'crudely' made, and whether they are used as toys in modern cultures (see also Carey 2006; Smith 1998). Overall, it would appear that size is the main determining factor in assessing objects as toys, based largely on the assumption that small size equals small people (Baxter 2005a, 2005b; Carey 2006). Alternatively, it has been suggested that miniature and small pots might have been practice vessels, created by children to learn the skill of pottery making, perhaps in preparation of future adult roles (see Ellis 1994; Bagwell 2002; Crown 1999, 2001, 2002; Hutson 2006; Kamp et al. 1999; Kamp 2002; Lillehammer 1989).

While the association of miniature vessels with children is common, a number of reports challenge this idea and suggest alternatives. One such alternative focuses on the inclusion of these vessels in mortuary or ceremonial activities, as they are often found in association with burials and mounds. Contrary to simpler vessels often associated with children, many of the pots discussed in these reports are described as well made. The mortuary practices of the Devils Lake-Sourisford (DLS) complex are well documented, and the complex is known to have used small pottery vessels as burial goods. In his report on the DLS Burial Complex, Syms (1979) describes how distinctive small pottery vessels have been found in burial mounds on the Northeastern Plains for over a century. He suggests these vessels might have been created for "individuals who underwent particular religious experiences during their lifetime" (Syms 1979: 291). Job (2009) discusses small Devils Lake-Sourisford complex pottery with salamander designs and how they might represent an ideological relationship between salamanders and the indigenous group that created the pot. Job (2009) suggests that the salamander motif on the vessels, which were found in a burial, is possibly representative of renewal or rebirth. Hanna (1976) describes several small pottery vessels, some with turtle decorations, from burial mounds on Crooked Lake in Saskatchewan.

Martin (1991) and Orr (1951) discuss large quantities of miniature vessels from the Kincaid Mounds site in Illinois (11MX2-11; 11PO2-10), and suggest they have been used for mortuary rituals. Jackson (1992), suggests miniatures found at the Ables Creek site (3DR214) in Arkansas, a pre-contact cemetery, might represent an unidentified mortuary assemblage. In an early report, Holmes (1903), suggests that miniature vessels found in graves were created specifically for mortuary use. Meyer (2015), discusses a well-made, unique small pink coloured pot from Saskatchewan that can be assigned to the Mortlach phase, and is believed to have been used for ceremonial purposes. There are multiple other archaeological and ethnographic reports that link miniature and small objects with rituals. Hally (1986), interprets a small pot as having possibly been used to hold coals for fire, likely for ceremonial purposes. Swanton's (1942) ethnographic research on the Caddoan Indigenous group reports the use of small pots as fat and tobacco incense burners in ritual contexts. Other reports cite the use of small artifacts in medicine bundles, as charms and divinatory devices, and in other ritualistic or symbolic contexts (Baxter 2005a, 2005b; Ellis 1994; Harrington 1914; Harrod 1987; Lillehammer 1989; Skinner 1913; Speck 1935; Wildshut 1975).

While associations with children or ceremonial purposes are the more popular explanations, there are other suggestions that consist of more domestic related activities. Finney (1983) describes eight miniature vessels found at the Mund Site in the American Bottom, as drinking cups or rain scoops, while Fortier (1983) suggests the Mund Site miniatures were used as scoops for seeds or for storage. Baxter (2005a, 2005b) discusses how small pots have been documented ethnographically and archaeologically as containers for herbs, seeds, and pigments. Another interesting example of the function of small pots comes from the Chatawba group of

North Carolina, a contemporary Indigenous group known for their pottery, who often make miniature pots simply for the challenge of it (Blumer 2004). Creating pottery is an ancient practice amongst the Chatawba, and skilled potters will create miniature pots of any shape or style, using the same techniques as larger vessels to showcase their skill (Blumer 2004). In summary, according to the archaeological and ethnographic literature, miniature and small vessels might be the result of children making toys or practice vessels, while others appear to have played a significant role in domestic, ritual, and ceremonial purposes.

2.3 Pottery Terminology

The lack of terminological standardization used to describe small-scale vessels is addressed in this section. This inconsistency is noted in journal articles, books, archaeological reports, and even museum catalogues. This includes more generic terms such as miniature or small, as well as more specific terms including juvenile, toy, cup, bowl, or even the incorrect label of pipe bowls. The varying terminology is problematic and inconsistent, causing confusion regarding the function of the vessels, and leading to cataloguing errors. While some of the terminologies seem apt, others are superfluous and do not allow for any sort of uniformity amongst researchers. Lack of research and differing theoretical perspectives and assumptions concerning their creation and use are some of the reasons for varying terminology. Essentially, this section will explain and clarify the terminology regarding this type of pottery, discuss theoretical perspectives surrounding the different designations, and give definitions of the most appropriate terms.

2.3.1 'Small' and 'Miniature' Vessels

Several reports use the terms 'small' and/or 'miniature' to define pottery, including Kamp (2002), Menon and Varma (2011), and Baxter (2005a, 2005b). According to Kamp (2002) the distinction between what is meant by 'miniature' and 'small' vessels is quite clear, albeit there is some overlap. She describes miniature vessels as "very tiny ceramics, sometime no larger than the end of a thumb," which are unusable for any regular activities (Kamp 2002:437). Small vessels consist of those of a much more usable size, although still significantly smaller than full-sized vessels (Kamp 2002). They are also often lumped into the miniature category when catalogued in museum collections and in various reports. Baxter (2005a, 2005b) who associates miniature objects with children, generally interpreted as toys, describes miniatures of various types of artifacts as small versions of full-sized objects which are differentiated from the larger object through size, as well as lacking the same function. Baxter then goes on to say that objects without a larger counterpart should not be considered miniatures. However, there are studies that illustrate miniature artifacts serving the same or similar purpose as their larger counterparts (Park 2006). Baxter (2005a, 2005b) then explains that small objects (ie. objects that do not have a larger counterpart and are therefore not considered miniatures under her definition) should not necessarily be associated with children and referred to as toys. Rather, such small objects have been documented as having a multitude of other functions (see Baxter 2005a, 2005b; Blumer 2004; Finney 1983; Ellis 1994; Harrington 1914; Harrod 1987; Lillehammer 1989; Skinner 1913; Speck 1935; Wildshut 1975). Unlike Kamp (2002) who suggests miniature and small should be viewed as different categories based largely on size, Baxter (2005a, 2005b) appears to lump them all together, and instead differentiates between the different terms based on whether the object has a larger counterpart.

In addition to size, there is also debate over definitions of the vessels based on the manufacturing technique. Miniatures are often described as being formed through a pinching technique, and are often referred to as 'pinchpots' in the literature (Finney 1983; Carey 2006). However, Carey (2006) distinguishes miniature vessels from pinchpots, explaining that pinchpots are often crude, with unfinished surfaces, no temper, and a lack of appendages and decorations. Alternatively, she defines miniature vessels as those containing temper, often produced through a coiling method, and often exhibiting appendages and decorations (Carey 2006). It is unclear if Carey is referring to a specific size of vessel within her discussion, and whether or not she is grouping both miniature and small pots together as did Baxter (2005a, 2005b). Regarding the manufacture of small pots, Kamp (2002) states that they generally illustrate additional forming and the use of decorative traits, characteristics that she believes miniatures are often lacking.

Instead of having endless categories to describe vessels of the same stature, Menon and Varma (2011), suggest that the term 'miniature' be used for pots that are the smallest within a range of sizes, regardless of their use and function. This seems to be the most sensible solution, and allows for more pots to be lumped together instead of unnecessarily splitting them into multiple categories based on differing functions. As such, the definition that will be used throughout this thesis of what is meant by a <u>miniature</u> vessel is essentially *a very tiny pot, sometimes miniature versions of full-sized pots, with or without a similar function, created through different manufacturing techniques, with or without decorations*. Similarly, the definition for <u>small</u>

pottery vessels is essentially *vessels that are significantly smaller than full-sized vessels, larger than miniatures and of a more usable size, created through different manufacturing techniques, with or without decorations, that can be used for a variety of purposes*. The terms 'miniature' and 'small' have been selected for this thesis as they are more objective and easy to understand, unlike subjective terms such as 'toy' and 'juvenile,' which lack easily observable characteristics. This is further discussed below.

2.3.2 'Juvenile' and 'Toy'

The term 'juvenile' is used to describe any vessel of a small stature which is assumed to have been made by children. In Smith's (1998) master's thesis, she used this term to describe the vessels she studied. Her research focused on Huron children through the analysis of pottery production and assumed a connection between small vessels and children. Smith (1998) defines the category of juvenile vessels based on three criteria: their small size, their basic forms, and their basic decorations. Many reports use the 'juvenile' and 'toy' terminologies to discuss vessels assumed to be associated with children (Smith 1998, Pearce 1978; Wright 1973). Similar to the term 'juvenile,' the term 'toy' is used to define vessels that have an association with children as a type of plaything. Reports use similar criteria to assess an artifact as a toy as they do for a juvenile vessel, including discussions of 'crudeness' and their small size, with the addition that toys might also have similarities to modern day toys (Baxter 2005a, 2005b). Vessels described as toys are believed to have been made by or for children, meaning they could have been made by adults as well (Smith 1998). However, often the literature that uses the toy terminology implies that children were making the toy vessels themselves (Ellis 1994). The main determining factor in defining a vessel as juvenile or toy has to do with its apparent 'crudeness,' although other factors such as the spatial distribution of the pots within a site can also lead researchers to make this interpretation (Ellis 1994). There are some clear and obvious issues with these terminologies; small and miniature vessels appear to have been created for a variety of purposes, and as such, these terms might not always be accurate. As discussed below, it can be difficult to assess who made a vessel as the size and quality of a vessel does not necessarily indicate its maker, further rendering these terminologies imprecise. As already noted, it seems more appropriate to identify a vessel by its size and style, otherwise there is a possibility of ending up with countless categories for pots that could easily be grouped together. Similarly, there is a potential to misidentify a pot and attribute a function to it that it might not have had.

2.3.3 'Ceremonial,' 'Mortuary,' and Other Terminologies

Two of the other most popular terms for small and miniature vessels are 'ceremonial' and 'mortuary,' especially when they are found in a burial context. Similar to juvenile and toy, these terms invoke a specific function. Some of the literature suggests that mortuary vessels be categorized differently as they serve a different purpose than other vessels of similar or smaller stature (Kamp 2002). It is suggested that pots found in a burial context might illustrate variability regarding form, decorative traits, and overall quality considering their specialized context (Kamp 2002). While this is often true, and the significance of these vessels is important to note, vessels found in a mortuary context are often miniature or small vessels, and it seems unnecessary to give them a separate term based on a different function. As such, similar to 'juvenile' and 'toy' and all the other terms, it seems appropriate to categorize vessels found in a mortuary context as miniature or small, and assign their function or description as mortuary or ceremonial so as to not diminish their importance.

Other terminologies include descriptions of vessels as cups, bowls, jars, medicinal vessels, holders for pigment, holders for fire, vessels for food preparation, or even as a challenge for more skilled potters to show their craftsmanship. In his discussions of the pottery from the Kame Hills site (HiLp-1) in northern Manitoba, Dickson (1980) categorizes pottery vessels into different functional categories, including: pots, bowls, cups, and plates. Dickson defines pots as vessels with slight constricted openings with similar height to diameter ratios (1980). Comparatively, he defines bowls as deep plates with round or elliptical openings that have curved or straight sides and heights smaller than the mouth diameter (Dickson 1980). Cups, according to Dickson, are deep bowls that have vertical sides and a circular opening with a similar depth or height to the length of the diameter (1980). One miniature vessel from the Kame Hills site (Vessel 49) was categorized by Dickson as a pipe bowl. This function specific terminology is reflected within museum catalogues as well, where the same miniature sample vessel from the Kame Hills site had been catalogued as a pipe bowl before being re-evaluated. It is apparent that there is overlap between many categories, and that the form and function of many pots could likely fit into several. However, as already suggested, it seems more appropriate to use the small and miniature terminology as that will allow for standardization, especially when the pots' past function is unclear. If enough context or other factors are present that can allow for further identification as to the specific use of a vessel, then its function can still be attributed as such, but the vessel would still fall within the 'small' or 'miniature' category. There are currently no standards regarding how to define or assess these types of vessels and quite often it is too difficult to tell what kind of pot researchers are referring to as so many of the terms are used interchangeably. As such, it is proposed that the terms 'miniature' and 'small' be used when referring to all vessels of this nature. They are two separate but similar categories, differentiated by size, which can be easily applied without confusion.

2.4 Small and Miniature Pottery: Do Small Pots Equal Small People?

The study of children through material culture is a recent development within archaeology. An offshoot of feminist and gender archaeological perspectives, it has become a popular research topic within the last decade (Menon and Varma 2011). Bioarchaeological data, as well as attempts at identifying artifacts made by or for children are some of the ways archaeologists are rendering children visible (Menon and Varma 2011). It is apparent that there are countless theoretical ideas surrounding the use and function of small and miniature pottery vessels and small and miniature artifacts in general, and quite often the most common idea is that they are somehow related to children. However, as previously mentioned there are sometimes issues around associating children with certain artifacts. This section will discuss general theoretical ideas surrounding this association, including the quality and size of pottery vessels, and some studies undertaken to try and assess the presence of children within craft production. The spatial distribution of small and miniature artifacts within a site and its association with children will be discussed as well. While both small and miniature vessels will be discussed here, it should be noted that most of the literature that associates pots with children talks about miniature ones, or at least use that term specifically, as it seems that small pots are believed to have been used for a greater variety of activities.

2.4.1 Size & Quality

One of the first interpretations of miniature vessels by scholars in the late nineteenth and early twentieth centuries, was that they were children's toys (Carey 2006). Since then, the small size of these vessels has led to them being constantly interpreted as material culture associated with children, either made by, or for them. According to Carey (2006:5) the long-standing concept of "small pots equal small people" may derive from them being essentially interpreted as a pre-contact version of a tea-set. Western ideals have perpetuated this assumption, with the underlying idea that children play instead of contributing to society in any sort of meaningful way (Arden 2006; Deverenski 2000). As already noted, there are multiple reports that associate miniature artifacts with children. Most of these interpretations are based on assumptions that since children are smaller than adults, they are the only ones interacting with small objects (Deverenski 2000). Smith (1998) explains that the assumptions behind children making these pots stems from three different traditional criteria, including their small size, 'crude' manufacture, and basic decorations. In other words, miniature pots are expected to be of basic form, lacking in symmetry, with inconsistencies in thickness and overall manufacture and decoration (Carey 2006; Kamp 2002, 2006; Smith 1998). It is thought that children lack the necessary motor skills and hand-eye co-ordination to make large vessels or finely made vessels of any size, and instead can only create pinchpots which are considered one of the easier forms that children as young as four can create (Carey 2006; Golomb 1993; Kamp 2002, 2006; Smith 1998). It has also been suggested that children lack abstract thinking skills needed to carry out the proper design and layout of a pot, and that vessels decorated by children should illustrate uneven spacing, poorly executed designs, and ones that differ from other vessels from the same area or complex (Carey 2006; Smith 1998). An example of this type of interpretation comes from Hodges (1968) who describes a miniature pottery vessel from a Saskatchewan site that has unique decorations and shows a lack of uniformity in thickness and the shape of the neck. He likens the vessel to a "prized possession" of a young girl being tutored in her future duties (Hodges 1968). Similar interpretations are prevalent within the literature concerning this type of material culture, but studies that challenge this idea are becoming more common as well.

Smith's (1998) examination of miniature pottery within the context of the visibility of children in archaeology, sought to provide definitive examples of how to study and include children when interpreting the archaeological record. Smith's justification for focusing on small pots resonates within the current literature in that this type of small artifact should, in theory, provide direct access to children due to its size (Smith 1998). Smith's study examined the role of children in archaeology by looking at their involvement in 'juvenile' pottery production in pre-contact Huron society. Smith compared the assumed Huron juvenile pots with more sophisticated 'adult' pots through the use of three measurements. The categories are explained in depth in Chapter 5, but consist of measurements used to assess the general quality and manufacture of vessels and include: the crudity index, the curvature consistency index, and the motif application index (Smith 1998). Smith's results found that the assumed juvenile vessels tended to be more poorly made compared with the adult ones, indicating that there is possibly some validity to traditional assumptions that associate children with more basic vessels. Carey (2006), used the criteria outlined in Smith's thesis to assess the potential manufacturers of Mississippian miniature vessels. The results from Carey's examinations of 212 Mississippian miniature vessels revealed that the majority of the vessels were made by adults rather than by or for children. Carey suggests that previous associations of miniatures as being the toys or practice pots of children may not be as strong as originally believed. Rather, these types of vessels should be evaluated as potentially of adult manufacture and use, and not always assumed to have been made by children (Carey 2006). Carey suggests that many of the assumptions surrounding miniature vessels and children stem from a lack of knowledge regarding miniature vessels and believes that the tendency of researchers to group miniature pots into a category associated with children has "resulted in an inaccurate picture of their place within the ceramic assemblage" (2006:61).

The literature contains many conflicting ideas and studies concerning the relationship of size and manufacturer. However, the small size of a vessel does not always indicate its maker, rather just that the vessel itself is small. There are multiple possibilities as to why smaller vessels may have been made. They could be created for use in a ceremony or placed in a burial. It is possible that children may have made small vessels because larger vessels were too challenging and they lacked the necessary motor skills, or they may have only been given a certain amount of clay to work with (Smith 1998). Additionally, children may have been attempting to make smaller versions of the vessels their parents were making (Smith 1998). There is the possibility that some small-sized vessels could have been made as toys, but these could have been made by either children or adults. It has also been suggested that even if a pot is more basic that it could still have been made by an adult as a type of artistic "baby talk," suggesting that at times adults have made vessels differently and of lower quality for children (DeBoer 1975; Kamp 2002; Smith 1998). Regarding decorations thought to be unique or poorly executed, Smith (1998) suggests that decorations that deviate from full-sized or other vessels in a site or complex do not necessarily represent a lack of abilities, but might reflect innovation by a child potter. Further adding to the difficulties of determining who made a vessel, standards for assessing quality can vary crossculturally and often relate to the function of each individual item (Kamp 2002). Bagwell (2002) suggests that an adult may intentionally choose to not put effort into a vessel, or that they may be limited due to injury, disease, or old age, or not begin to create pottery until adulthood. Overall, it is often simply an assumption that children were the ones making miniature and small vessels, and not verifiable fact (Smith 1998).

2.4.2 Children and Craft Production

There are multiple studies that explore the stages of craft production and the role that children played within it. In many cultures, craft production is something continuously passed down from one generation to the next, and most of the literature on pottery discusses how craft production is likely a sequential activity that represents a gradual learning process progressing from poorly made miniatures, to well-made full-sized vessels (Menon and Varma 2011). The visibility of children within craft making can be difficult to see in many ways. There are multiple ethnographic reports that describe the involvement of children within various aspects of pottery production. Some reports suggest they were directly involved in the manufacturing process, while others suggest they performed tasks such as clay procurement and preparation, or decorating previously formed vessels (Hutson 2006; Menon and Varma 2011). When involved in the manufacture, novice and beginner potters are unable to create large, even vessels, and lack the skills needed to properly prepare, temper, or fire the clay (Menon and Varma 2011). According to Menon and Varma (2011), identifiers of a novice potter include the small size of vessels, the use of a pinchpot technique, and the presence of asymmetry, uneven thickness, rough finishes, and cracks. Signs of an expert potter include larger vessels that are coiled and well put together, symmetrical, even, smoothed, and without cracks (Menon and Varma 2011). Bagwell (2002) discusses how children go through various developmental stages and suggests that children at each stage of development are only capable of certain aspects of vessel creation, allowing for researchers to determine the minimum age at which a child would have been capable of creating certain vessels. In addition, some attributes of pottery making are more variable and sensitive, and lack of experience or underdeveloped motor skills could lead to many issues (Bagwell 2002). These include the symmetry of the vessel's form, producing an identifiable form, the ability to form a pot through pinching vs. coiling, and finishing the vessel (ie. smoothing any cracks) (Bagwell 2002). Kamp (2002) also discusses the skill progression of children as craft producers and how their learning experience begins by making clay figurines and miniature vessels as toys, progresses to small but still usable pots, and then larger, full-sized vessels. She also addresses how the latter stage can occur while still in childhood (Kamp 2002). While many articles associate children with the more basic, novice-made pots, not all novices are children which can lead to difficulties with trying to differentiate between a pot made by a child, or one simply made by an older novice potter. As such, the involvement of children within pottery making communities can be very difficult to see archaeologically.

Kamp et al. (1999) conducted a study that measured fingerprint ridge breadth found on pottery in an attempt to identify the age of the potter. The study analyzed quantitative measurements and qualitative attributes of fingerprints left on pottery and compared them with a modern population in hopes of determining the age of the individuals who made the vessels (Kamp et al. 1999). These results were then compared with pots and clay figurines dated from 1100-1250CE from the Sinagua region of northern Arizona. It was found that this method can predict the average age of potters within a group of pottery makers with a 95 percent level of confidence with a margin of error of less than a year (Kamp et al. 1999). However, for this method to be applied, a significant proportion of the sample needs to exhibit obvious and measurable fingerprints, something which is not often possible.

In a similar fashion to Smith (1998) and Carey (2006), Bagwell compared vessels made by adults with more basic miniature vessels believed to have been made by children (2002). Smith's (1998) study found that the small vessels she examined were more poorly made than the full-sized ones and therefore potentially made by children, and Carey's study (2006) found that the majority of the vessels were created by adults. Bagwell's (2002) results fell somewhere in between, as they indicated that both children and adults were making the miniature vessels within her sample. Bagwell proposes a technique that measures key attributes that reflect skill and the age of the potter that would be associated with certain skills. This considered construction technique, symmetry of the maximum dimension, evenness and thickness of the rim, consistent wall angle, how well the base held the vessel flat and even, the presence of any cracks, and the observation of recognizable forms. Interestingly, Bagwell did not assess decorative motifs due to the possibility that the person decorating the vessel might differ from the individual who manufactured the vessel. Each different attribute was assigned a score based on skill levels assumed to correspond to increasing levels of experience as well as age (Bagwell 2002). Scores were then totaled to achieve a final "skill score" (Bagwell 2002). Bagwell studied 78 pots in various capacities, ranging from size to quality of manufacture, and overall she found that most scored high on the scale. Bagwell proposed three hypotheses regarding vessel manufacture: that the large, full-sized vessels were made by skilled adult potters and show evidence of use as cooking or storage vessels; that small vessels were used as toys or practice pots and illustrated a low level of skill and were thus made by children; and that small vessels for ritual contexts were made by adults (2002). In a similar study by Kamp (2002), pottery made by the Sinagua people, a pre-Columbian cultural group that occupied a large portion of central Arizona, was assessed. Overall examination of the vessel attributes suggest that full-sized vessels were generally well made, miniature ones were of poor quality, and that small vessels were variable in terms of quality, ranging from very well made to poor quality (Kamp 2002). Kamp (2002), argues that these observations suggest that miniature vessels are probably the result of novices, specifically child novices, while full-sized vessels are made by more sophisticated potters of any age, and that small vessels range from being made by beginners, to more expert potters. These studies illustrate varying involvement of children within craft production activities amongst different societies.

Overall, there are multiple studies that illustrate the involvement of children with pottery manufacturing in a variety of cultures. Some of these studies view children as active participants, while others suggest involvement was limited to superfluous activities such as the collecting and preparation of materials. Archaeologically, their involvement in past societies can be difficult to see, but many researchers believe that regardless of their type of involvement, children were innovative and served as "repositories of sacred knowledge and power" and their participation should at least be considered (Ardren 2006:246).

2.4.3 Spatial Distribution

Spatial distribution is also used in interpreting miniature artifacts that are believed to relate to children, however, there are conflicting ideas about what the spatial distribution patterns should look like. Archaeological literature that links children to the distribution of artifacts within a site began in the 1970s, and consists of ethnographic observation and experimental studies (Baxter 2005b). Much of the early literature has led to the assumption that children's artifacts are randomly distributed throughout sites (Baxter 2005b). Ellis (1994) echoes the idea of children having a randomizing effect on distribution, and suggests that there should be little to no clustering of children's objects in a site. Ellis believes that if these artifacts are found in a cluster, they would appear away from adult domestic activities, essentially "away from areas of intense activity" (Ellis 1994:262). Alternatively, Baxter (2005b) explains that the way space is used is influenced by cultural factors, and that the way children interact with their environment is something taught as part of their social development. As such, Baxter believes children would not have been using space in a random fashion, and instead, their behaviour and artifact distribution within a site should demonstrate regular patterning that reflects the social guidelines for the use of space amongst a specific cultural group. Furthermore, Baxter (2005b) suggests that the patterning of children's objects should differ from those used in other contexts, such as in rituals, burials, or ones used for storage. Baxter (2005b) examined five different domestic sites which were cross examined with historic and ethnographic accounts, and found identifiable patterns of children's objects in four of the five cases, which generally illustrate clustering of children's artifacts near domestic spaces. Carey (2006) echoes Baxter's study, and suggests that if vessels were used as toys, they would be found archaeologically in domestic areas where children could be supervised while playing. Therefore, broken sherds of toy vessels are expected to have been discarded along with domestic refuse, while something like practice pots are more likely to be found in habitation zones (Carey 2006). There is clearly conflict between researchers concerning how spatial distribution patterns are to be applied when trying to determine the association of artifacts with children, rendering it difficult to make that association even when there is a known context.

2.5 Conclusion

There is a common theme running through much of the literature that miniature and small vessels are unique, and that they differ from regular-sized vessels in more than just size. While larger vessels are almost always linked with food preparation or storage, it is interesting to note that small and miniature vessels are much less commonly associated with those activities, and when they are, it is generally with the assumption that they were used for food preparation during a ceremony or ritual. Meyer echoes the idea that these vessels are special, explaining that small pots are a characteristic aspect of pottery assemblages in the Boreal Forest and on the Canadian Plains, describing them as "revered sacred paraphernalia" (Meyer 2015:27). However, the literature illustrates that these pots might have had multiple functions, and may not have only been used for ceremonial purposes or as toys or practice pots as is often suggested. As will be discussed further in later chapters, the function of small and miniature pottery vessels appears to be difficult to discern based solely on physical traits. This could be the reason there are so many differing terminologies and interpretations in the literature as to their use and manufacture in the past. Small and miniature vessels should not necessarily be assumed to have been made by children, although it appears that when vessels are less refined in form and decoration the possibility of manufacture by a child is something to consider. It is suggested that miniature and small vessels be evaluated case by case, as there could be many reasons behind the creation of these types of vessels. While the physical assessment of pottery is important, the context in which a vessel is found is also something to consider when determining its function. Typically, additional analyses are needed to truly determine artifact function. Oral histories from Indigenous groups and discussions with contemporary Indigenous potters would also serve as an important source of knowledge that should be incorporated when permitted. Results from residue analysis and the physical assessment of the vessels used for this study will be compared with the ideas put forth in this chapter. This comparison will examine similarities or differences observed between the results and the ideas discussed previously, as well as offer additional theoretical input where necessary.

Chapter 3: A Brief History of Archaeological Residue Analysis

3.1 Introduction

Organic residue analysis can provide insights into past lifeways that would otherwise remain invisible. Organic residue analysis originated with biomolecular and forensic studies, as well as organic chemistry (Evershed 2008). Archaeological application of these techniques has allowed for information recovery regarding resource use, diet, and subsistence practices unattainable through conventional archaeological methods. This chapter explores the organic residue methodologies used for analysis by briefly outlining how they work, as well as their origins and contexts of use. It also discusses methodological strengths and weaknesses relevant to this study, specifically the challenges associated with analyzing residues on pottery. Analyses to be discussed include: low-powered and high-powered transmitted light microscopy and incident light microscopy, gas chromatography coupled mass spectrometry (GC-MS), scanning electron microscopy (SEM), and microfossil phytolith and starch research. Some of these methods are plant specific, while others can find traces of both plants and animals. Several of these methods can be applied to archaeological residues from various contexts, including soil, lithics, and even human dentition, but the analytic emphasis is on organic residues found on pottery surfaces or absorbed within its matrix. Pottery can be a challenging material for residue analysis due to its irregular shapes and porosity, as such the various strengths and limitations of each technique is discussed as well.

3.2 A History of Organic Residue Analysis

North American archaeological research addressing resource use and subsistence practices has primarily focused on big game hunting, while plants and other less visible remains have been generally ignored and undervalued (Syms et al. 2014). Organic residue research has begun to bridge this gap by studying residues found in various archaeological contexts in order to better understand past societies and their lifeways. Researchers have been exploring these relationships in a more direct way by analyzing residues from pottery, tools, bone, and features from a multitude of sites throughout Canada, the United States, and internationally. Residue analysis on pottery assemblages has become increasingly popular over the last few decades, especially once the capacity of pottery to preserve residues became better known (Stacey 2009). It should be noted that this present analysis of small and miniature pottery vessels presents a more complicated subject matter since their use and function may extend beyond simple subsistence practices. This section discusses each of the methods implemented during this study, describes their application within archaeological research, and the reasons behind why each method was selected for this analysis.

Residue analysis can help determine the origins of amorphous and degraded archaeological residues that are often unanalyzable using traditional techniques (Evershed 2008; Hodgson 2016; Stacey 2009). Residue analysis techniques are based on the principle that all living systems are made up of organic compounds that have specific biomarkers that can sometimes be identified down to family, genus, or even species (Loy 1997). These compounds include carbohydrates (sugar, starch), fatty acids (fat, oil, wax), and proteins (amino acids), amongst others (Brown and Brown 2011; Evershed 2008; Loy 1997). The field of residue analysis is continuously growing, and there are various techniques that can be applied to the diverse material cultures present in the archaeological record. Methods such as GC-MS and SEM amongst others are being used frequently to provide more in-depth information about archaeological artifacts and residues. Additionally, it is becoming more common for techniques to be used in conjunction with one another to maximize the types of information and breadth of data that can be collected. The following sections detail the methods selected to analyze the complicated material type of small and miniature pottery, and how the growing field of residue analysis has allowed for the recovery of information from pottery that would otherwise remain invisible.

3.3 Strengths and Limitations of Analyzing Pottery Assemblages for Residues

Identifying what was held in a pottery vessel provides evidence for how and why the vessel was used (Taché 2018). Organic residues found on pottery vessels can be deposited in several ways, ranging from the remnants of the contents that the vessel originally held or the accumulation of multiple uses, or in the form of certain decorations, sealants and adhesives, or even from repairs (Beck et al. 1989; Charters et al. 1993; Connan et al. 2004; Heron and Pollard 1988; Stacey 2009; Steele et al. 2008; Urem-Kotsou et al. 2006). While pots are rarely found still containing their original contents, there are examples of this occurring (see Charrie-Duhaut et al. 2007; Condamin et al. 1976; Garnier et al. 2003; Serpico and White 1996). The most visible form of pottery residue is carbonized material that adhered to the vessel through cooking (Stacey 2009). However, the presence of charred residues is completely dependent on how plants were being processed and consumed (Surette 2008). Plant remains from food encrustations only represent one component of past diet, as only plants cooked through boiling in pottery vessels will be identified from plant microfossils extracted from carbonized residues (Boyd et al. 2014). As such, plants which were eaten raw or cooked in different ways such as roasting, or pottery vessels simply used for storage or other means will not have visible charred residue (Boyd et al. 2014). However, one of the major strengths of analyzing organic residues from pottery is that even sherds without carbonized residues that appear 'clean,' often have invisible absorbed residues (Stacey 2009). Absorbed residues are the most common type of residue found on pottery due to the porosity of pottery microstructure, and are typically better preserved than surface residues (Evershed 2008; Stacey 2009). The preservation of residues on or within pottery is unpredictable, and there are many factors which can lead to their degradation in an archaeological context (Stacey 2009). While unpredictable, residues have been extracted and identified from pottery samples that date to more than 14,000 years old (Craig et al. 2013; Lucquin 2016; Stacey 2009).

While methods for analyzing residues from stone tools developed comparatively quickly, initial attempts with pottery proved more difficult to analyze, and achieved minimal success rates (Skibo 2013). For example, researchers did not initially know what affects soil from archaeological sites had on pottery, whether heat altered residues, which portion of vessels was the best for analysis, and how to extract residues efficiently (Evershed 2008; Skibo 2013). While these questions are now generally able to be addressed, certain limitations still arise when working with pottery. The porosity of pottery and its irregular shapes can make residue extractions and certain analytical techniques challenging. Although difficult to work with, pottery is an ideal material for the preservation of organic residues, as residues can become adhered to the exterior surface in the form of carbonized food residue, or absorbed within the matrix of the vessel (Evershed 1993; Malainey et al. 1999). Many techniques that analyze residues from pottery are destructive, either requiring the entire sherd, or part of the sherd to be ground up, cored, thin-sectioned or coated prior to analysis. While many of these destructive methods were selected for this analysis, the techniques were altered so as to not damage the sample vessels. The specific ways in which techniques were altered will be discussed in Chapter 4.

The focus of most of the initial pottery residue work was on lipids, such as waxes, fats, and sterols, as they proved to have higher success rates (Skibo 2013). Many of these initial studies extracted residues by grinding up the base portion from sample vessels with the assumption it would contain the highest concentration of absorbed residues; this proved to be false as the residues in this portion of a vessel can become degraded from being heated (Skibo 2013). However, when selecting sherds for residue analysis it is important to consider which portion of a vessel might provide the best chance of extracting residues (Evershed 2008; Skibo 2013). The challenging aspect of selecting sherds, especially those from small and miniature vessels, is that in order to select sherds, some idea of function is required. Whether vessels were used for cooking or storage and whether or not heat was a factor all contribute to where residues will be preserved within the vessel (Evershed 2008; Skibo 2013). The suggestions of selective sampling from certain parts of vessels is not always possible. Regarding small and miniature vessels, determining their function is part of what is trying to be analyzed by identifying residues and what they might mean regarding how the vessel may have been used.

3.3.1 Incident Light Microscopy & Transmitted Light Microscopy

Incident light microscopy can be used to view residues *in-situ* (also referred to as *in-situ* reflected light microscopy), while transmitted light microscopy requires residues be removed and placed on a slide. Both methods have gained momentum since the 1970s when they were used to analyze plant and animal residues from stone tools (Briuer 1976). Magnifications vary from low-powered (10x to 100x) to high-powered (100x to 1000x). Microscopy has been the standard approach for analyzing residues on stone tools (Petraglia et al. 2012). Incident light microscopy is often used as a preliminary or screening step in lithic residue analysis, as its implementation can allow researchers to target certain surfaces for removal and avoid the use of solvents that might alter or remove diagnostic residues (Van Gijn 2014). As residue analysis continued to emerge, the use of microscopy to analyze other residues such as blood and microfossils, including starch and phytoliths, became increasingly popular (Boyd et al. 2014; Fullagar et al. 2006; Loy 1983; Loy et al. 1992; Newman and Julig 1989; Piperno 1990; Piperno 2006; Shafer and Holloway 1979; Zarillo and Kooyman 2006). Other studies have positively identified resins used for hafting stone tools and many plant and woody tissues (Fullagar and Jones 2004; Lombard 2006; Lombard and Wadley 2006; Mazza et al. 2006; Wadley et al. 2004).

Both low- and high-powered transmitted and incident light microscopy are commonly employed in current residue research (Bouchard 2017; Hodgson 2016). The field of archaeological microscopy continues to grow; at present, its applications are geographically diverse and it has been used to examine material that extends as far back as over 1,000,000 years (Hardy and Rogers 2001). However, when searching for studies that use incident light microscopy for residue analysis, it was found that the vast majority of studies were related to lithic analysis rather than pottery. One of the few studies that references the use of low-powered microscopy to analyze sherds was conducted in Belize on worked sherds that had been used as 'tools' to make pottery (López Varela et al. 2002). A study by Crowther (2005) used incident light microscopy to analyze Lapita sherds from New Ireland. The study identified *in-situ* starch grains and raphides which were believed to offer evidence of on-site plant processing (Crowther 2005). Transmitted light microscopy is used more frequently to analyze residues from pottery, especially with the emergence of mircrofossil analysis as will be discussed further below. It is apparent that there is a lack of studies that analyze residues *in-situ* on pottery. As discussed in this chapter, many studies utilize a multi-proxy approach when analyzing archaeological residues from pottery. However, the use of microscopy within these methodological approaches, especially incident light microscopy, is still uncommon. While it does add significantly more labour during a study, it can act as an initial screening step, and can also help corroborate residues that are found through the use of other methods.

While incident light microscopy enables analysis of residues that are *in-situ* on an artifacts surface, transmitted light microscopy requires the residue be removed and placed on a glass slide prior to analysis. One of the benefits of using transmitted light microscopy is that when residues are placed on a slide, it eliminates the depth of field issues that are prevalent when conducting incident light microscopy. The placement of the light source varies with both approaches; the light source is located above the artifact for incident light microscopy, and below for transmitted light microscopy. Having the light source located above allows the object to be manipulated and examined at different angles, allowing for shadows which can make important features visible (Hodgson 2016). Microscopy has been used to identify diagnostic features or residues such as hair fibres, starch, phytoliths and pollen; however, using microscopy alone to identify residues is limiting. Often residues present on an archaeological artifact are amorphous in nature, and are not identifiable by appearance alone (Petraglia et al. 2012). During the initial microscopic examination, residues are observable with magnifications lower than 100X, although higher magnification is typically required to accurately characterize and identify the residue. However, when amorphous residues are present, their classification is typically limited to powerful microscopic imaging. Overall, visual identifications of residues that are not corroborated with other techniques should be interpreted cautiously as it is difficult to positively identify residues based on morphological structures alone (Hodgson 2016; Petraglia et al. 2012).

The irregular shapes of pottery sherds make incident light microscopy challenging. These physical limitations can lead to depth of field issues, or the complete inability for sherds to be observed under a microscope if there is not enough space between the optical lens and the stage where the objects are placed for observation. Irregularly shaped objects that lack flat surfaces can be problematic, requiring multiple images to be taken of a surface in order to create one clear image of the surface or residue. While these images can be compiled using image stacking software, this inevitably requires additional time and effort. At times, an object such as a glass or plastic mount can be placed underneath the sherd in order to manipulate the angle at which it rests. However, this only works in certain situations as it can also further limit the space between the lens and the microscope stage.

3.3.2 Scanning Electron Microscopy (SEM)

SEM is capable of two broad functions: imaging and gathering compositional information (Fraham 2014; Froh 2004). SEM allows for the acquisition of highly magnified images of the surface of an object and has much greater magnification capabilities than other types of microscopy (Fraham 2014). Within an SEM, there are two condenser lenses that work to focus light on a small, concentrated area through an objective lens (Froh 2004). An SEM emits a focused electron beam at an object within a vacuum (Fraham 2014). SEM works on the basic principle that fewer electrons will create darker images, while more electrons allow for whiter images, and a combination of both is what allows researchers to see the image in 3D within the machine (Froh 2004). For imaging, an SEM takes photos pixel by pixel. Depending on the model, magnification can range from 5X to over 200,000X, and SEMs have an increased depth of field, allowing the surface of objects to appear in focus without needing to take multiple photos and stack them into one composite image (Fraham 2014). In addition to highly magnified images, an SEM can measure the elemental composition of a specimen by the use of X-rays that are emitted under electron bombardment (Fraham 2014; Froh 2004). Over its more than five-decade history of use within archaeology, this technique has been applied to a vast array of archaeological material where helpful information can be derived from magnified images of an artifact or through a breakdown of its composition (Fraham 2014).

One of the first studies that used SEM to analyze archaeological material was published in 1968, and identified pollen to aid with the ecological reconstruction of a site environment (Pilcher 1968). The following year, Brothwell (1969) published a study that discussed the application of SEM for examining a variety of archaeological material, including: teeth, bone, fibres, botanical remains, and stone tools (Fraham 2014). The last few decades have seen improvements to both the hardware and performance capabilities of the SEM (Fraham 2014). Within archaeology the technique is used to study both organic and inorganic materials. Its applications are varied, and range from studies trying to determine the raw material sources of objects, to differentiating between paints and slips on pottery surfaces, to identifying macrobotanicals, amongst others. One study which analyzed obsidian was able to chemically match the stone to a specific volcanic eruption (Fraham 2014). SEM can also be used for use-wear analysis by obtaining magnified images of the working edge of tools (Bouchard 2017; Fedje 1979; Knutsson et al. 1986; Kooyman 2000; Olle 2014). Microbotanical evidence has been photographed with an SEM to aid with environmental and dietary reconstructions through identifications of pollen, charcoal, and other material (Barton 2007; Boyd et al. 2008; Haslam 2006). Teeth, bone, and even human skin and organs have been analyzed with the use of an SEM to determine ancient dental techniques or pathologies amongst other applications (Brothwell 1969; Coppa et al. 2006; Hess et al. 1998; Williams et al. 1995). Bikiaris et al. (2000) used SEM as a means to characterize the composition of ochre to allow for different types of ochre to be identified.

SEM allows for inclusions in pottery, such as temper, to be characterized and potentially even sourced (Fraham 2014). A study by Ownby et al. (2004) used SEM to look at schist present in the temper of Hohokam pottery and were able to distinguish between naturally occurring schist in sand, and schist that had been intentionally crushed and used as temper. Charalambous et al. (2010) used an SEM to identify thin glazes on Byzantine pottery surfaces. Similarly, Stewart et al. (1999) analyzed paints on pottery with the use of SEM. Broekmans et al. (2004) analyzed the chemical composition and mineralogy of pots that had been used for cooking in order to make inferences regarding the manufacture and firing techniques of pots from the third millennium BCE in Syria. A study by Velraj et al. (2009) used an SEM to analyze the internal morphology of pots to study the firing temperature of pots from three different sites in India. There are also studies that look at surface topography of pottery (Ravishnakar and Carter 1999). The technique has also used to analyze residues from pottery. Shislina et al. (2007) employed SEM to view phytoliths from residues removed from Bronze Age pottery from the northwestern Caspian steppe, while Cartwright (2002) analyzed charred plant remains associated with pottery from a site in Jordan.

Teodor et al. (2014) used an SEM to successfully differentiate between vessels that had experimentally been filled with wine and those that had not.

While SEM offers a versatile methodology, it has several limitations, especially when it comes to pottery. Many SEM models require non-conductive (ie. non-metal) samples to be coated in a thin layer of gold or carbon to prevent an electric charge from building up which will prevent proper analysis and potentially damage the machine (Fraham 2014; Froh 2004). While these coatings can sometimes be removed, often they cannot be which is not a viable option for non-destructive studies (Fraham 2014). More recent machines have reduced vacuums which allow samples to be analyzed without the use of a coating (Fraham 2014; Froh 2004). However, due to the porosity of pottery there are often technical issues with the vacuum when analyzing un-coated sherds, as will be discussed further in Chapter 4. Similar to other forms of microscopy, there are also size restrictions when using an SEM, as the object being analyzed needs to fit on the platforms that are inserted into the chamber as well as within the chamber itself. As such, only small sherds with a relatively flat surface can be analyzed with this technique.

3.3.3 Gas Chromatography coupled Mass Spectrometry (GC-MS)

GC-MS is used in order to determine the chemical signatures of residues, including both plant and animal biomarkers. The emergence of GC-MS methods to study residues down to the molecular level began in the 1950s and 1960s, when gas chromatography (GC) and mass spectrometry (MS) were used together, allowing molecular components of biological and environmental materials to be separated and identified (Evershed 2008). The GC-MS process is based on separating molecules as they travel through the gas chromatography column in a gaseous state, which is followed by characterization of the separated components by a mass spectrometer (Brown and Brown 2011; Malainey 2011). Results are then checked against a comparative database to allow for identification. GC-MS has the ability to separate and characterize individual components that make up mixtures that were present in pottery vessels, as well as to identify modern or environmental contaminants (Evershed 2008).

First developed in the field of chemistry, GC-MS now has a broad range of applications. It has been implemented in archaeology in order to analyze residues from soils and sediments, from human and animal remains, and from tools and pottery amongst other contexts (Evershed 2008). This technique has allowed for the positive identification of countless archaeological residues including: resins, waxes, alkaloids, amino acids, carbohydrates, and hydrocarbons (Columbini et al. 2005; d'Errico et al. 2012; Evershed et al. 1997, Evershed 2008). In addition to successfully identifying residues found in plants and animals, GC-MS can also identify synthetic compounds found in plastics and natural compounds that are used industrially which can easily contaminate archaeological samples (Petraglia et al. 2012). It is sometimes possible to determine the origins of these compounds, and cautious results interpretation readily allows identification of contamination (Petraglia et al. 2012). GC-MS can be used to study pottery residues from several contexts, including *in-situ*, visible surface residues, and absorbed residues (Evershed 2008). *In-situ* residues are rare, however, there are circumstances where they have been recovered. For example, Charrié-Duhaut et al. (2007) analyzed the contents of Canopic jars from an Egyptian tomb. Absorbed and surface residues are much more common in an archaeological context (Evershed 2008). These residues derive from the processing of plant and animal products in the pot during its life-cycle which are then absorbed into the pottery, or are left on the interior or exterior surfaces of vessels (Evershed 2008). Studies from all over the world have been able to trace the sources of various residues from archaeologically significant pottery including aquatic animal biomarkers (Farrell et al. 2014; Copley et al. 2005), beeswax (Heron et al. 1994), vegetable oils (Kimpe et al. 2002) and many more.

Various methods of residue removal are possible to prepare samples for the GC-MS, including physical removals and chemical removals, or sometimes a mixture of both. The most common removal techniques from pottery are destructive, and require the sherd to be ground up prior to soaking in a chemical solution (see Correa-Ascencio and Evershed 2014; Dunne et al. 2018; Evershed 2008; Evershed et al. 1990; Evershed et al. 1991; Evershed et al. 1995a; Evershed et al. 1995b; Hansel et al. 2011; Lucquin et al. 2016; Mileto et al. 2017). In order to extract residues for GC-MS analysis, a sample must be exposed to a chemical solution. Chemical solutions can be used to directly remove residues from an artifact, or to soak residues in post physical removal. There have been a variety of solutions used for residue removal, including: water, ethanol, methanol, chloroform, acetonitrile, ethyl ether, and methyl chloride (see Table 3.1). The selection of a solution is often based on the types of residues expected to be present in the sherds; however, solutions which target a variety of residues are gaining in popularity as opposed to more selective solutions (Bouchard 2017; Cook 2014; Crowther et al. 2015; Hodgson 2016). In addition to the challenges of selecting solvents, there are often difficulties in finding glass vessels that are the appropriate size and shape to accommodate the object being subjected to residue removal.

Table 3. 1: Organic Solvents Used in Archaeological Residue Extractions

Solvents	Ratio	Targeted Compound	Reference
Chloroform/Methyl Esters	N/A	Fatty acids, various	Mazzia and Glegenheimer 2014
Chloroform/Methanol	2:1	Fatty acids	Copley et al. 2005
Chloroform/Methanol	2:1	Fatty acids, beeswax	Evershed et al. 2003
Chloroform/Methanol	2:1	Cholesterol	Stott and Evershed 1996
Dichloromethane		Resin acids	Ribechini et al. 2008
Ammonium hydroxide		Amino acids	Barnard et al. 2007
Acetonitrile		Fatty acids	Barnard et al. 2007
Dichloromethane/methanol	1:1	Resin acids, fatty acids	Charrie-Duhaut et al. 2007
Dichloromethan/methanol	1:1	Resin acids	Regert et al. 2008
Dichloromethan/methanol	2:1	Resin acids, fatty acids	Reviewers comment
Dichloromethane		Resin acids	Stern et al. 2003
Dichloromethane			Hogberg et al. 2009
Methanol/water/acetic acid	9:9:2	Polyphenols	Romanus et al. 2009
Methanol		Resin acids	Findeisen et al. 2007
Chloroform/methanol/ citrate buffer	1:2:0.8	Various	Fbuonasera et al. 2005
Acetonitrile/ethanol/water	1:1:1	Various	Crowther et al. 2015; Hodgson 2016; Bouchard 2017

Adapted from Hodgson 2016

Contamination is a concern when analyzing archaeological residues with GC-MS. Contamination deriving from soils and the general depositional environment is comparatively minimal and often easily ruled out (Skibo 2013; Stacey 2009). Contamination is of greater concern during the processing phase as the improper handling of artifacts could lead to contamination from oils found on fingertips or soaps, creams or other modern hygiene products (Evershed 1993; Skibo 2013; Stacey 2009). Skibo (2013) suggests that, ideally, sherds or other artifacts should be selected for analysis in the field, and proper handling and storage procedures should be incorporated in order to prevent adding possible contaminants. In the lab, samples should be handled while wearing gloves, and the use of sterile or new lab materials should be used (Skibo 2013). Additionally, Skibo (2013) suggests that samples should not be washed as this can lead to the loss or alteration of residues that are soluble in water (Morton 1989; Oudemans and Boon 1991). However, good results have been obtained from samples that were previously washed (Stacey 2009). Plasticizers such as phthalates, which are commonly found in industrial products such as plastic bags used to store artifacts and pipette tips can also contaminate samples, although these modern contaminants are easily ruled out (Cook 2014; Skibo 2013; Stacey 2009). Skibo (2013) recommends using glass or other lab and storage materials that will not absorb into the pottery matrix. However, these procedural suggestions are not applicable when it comes to collections that have been curated and stored for extended periods of time and that have been handled extensively.

The interpretation of GC-MS results is one of its major challenges. In general, the best results will come from pure samples, which is not possible with the highly degraded and complex mixtures present in archaeological residues (Skibo 2013). These complex mixtures are also subject to hundreds or even thousands of years of degradation that can occur in archaeological contexts (Skibo 2013). Even when preservation of residues is good, interpretation of residue origin is usually limited to broad categories such as faunal, floral, or marine (Stacey 2009). However, specific biomarkers indicative of residues from certain origins have been positively identified, allowing for more precise interpretations to be made (Stacey 2009). When interpreting GC-MS results, a cautious approach is suggested, especially when dealing with mixed and degraded archeological residues (Petraglia et al. 2012; Stacey 2009).

3.3.4 Microfossil Research

Microfossil research involves the analysis of starch grains and phytoliths; microscopic particles which form in plants and have diagnostic features allowing for specific plant identification. Certain aspects of microfossil research have been around since the 1800s, with the first report on phytoliths published in 1835 by a German botanist (Piperno 2006; Struve 1835). Microfossil analyses were used in archaeological research in parts of Europe as early as the 1900s; however, they were only recently applied in North American archaeology beginning in the 1960s, before flourishing to a greater extent during the 1980s and 1990s (Pearsall 2000). Archaeologically significant phytoliths and starch grains can be found in soils and sediments from sites, in dental calculus, coprolites, cooking residues on pottery vessels, as well as on tools used for plant processing. These methods have been used in studies all over the world, including South America, Asia, Europe, Australia, Africa, and North America.

Phytoliths and starch grains extracted from dental calculus can be indicative of diet as well as non-consumption activities such as preparing fibres for use in textile making (see Chinique de Aramas et al. 2015; Fox et al. 1996; Hardy et al. 2009; Piperno 2006; Weslowski et al. 2010). When extracted from stone tools they can help to identify tool use and function as well as providing insight into diet and food preparation (see Barton et al. 1998; Fullagar and Field 1997; Pearsall et al. 2004; Piperno et al. 2000, 2004). Extracting starch and phytoliths from carbonized food residue on pottery is another method that shows direct evidence of diet and food processing activities. Residues from pottery were first examined in the early 1900s where remains of rice, wheat, and barley were found to have been incorporated into pots either through intentional or unintentional processes (Piperno 2006). In recent years, analyzing food residues from pots has become more common, and has been yielding important information regarding diet, and the use and spread of plants (see Boyd 2010; Boyd and Surette 2010; Boyd et al. 2006, 2008, 2014; Lints 2012)

Current research is using microfossil methods to address fundamental archaeological research questions, specifically those regarding food procurement choices, transitions between foraging and farming, development of agriculture in the Americas, trade, use of wild plants versus domesticated ones, and many more (Boyd et al. 2014). Pioneering research by Bozarth (1986, 1987, 1990, 1992, 1993), and Mulholland (1982, 1989, 1993) applied microfossil analysis to research questions in a North American context (Piperno 2006). Their research concentrated on building reference collections essential to this form of work, as well as identifying diagnostic phytoliths which would allow for specific and accurate plant identification of many plant species. This research has helped to establish the use of these methods in North America, where hundreds of sites and thousands of samples have currently been analyzed using microfossil methods. In North America, researchers have been exploring the relationship between pre-contact Indigenous societies and plants from a multitude of artifacts and sites, spanning from southern Ontario to Alberta, stretching into the United States (see Boyd 2010; Boyd and Surette 2010; Boyd et al. 2006, 2008, 2014; Lints 2012; Surette 2008; Zarillo 2008; Zarillo and Kooyman 2006). This research provides direct evidence of plant use in areas where previously there was almost no archaeological evidence for this.

Analyses of macroremains have been more widely applied than microfossil research since materials are easily visible and identifiable under low-power magnification (Pearsall 2000). However, in sites with poor preservation of both macroremains and microfossils such as pollen, microfossil starch and phytolith analyses has enhanced data recovery regarding human and plant interactions (Pearsall 2000). While macrofossil analyses are extremely beneficial, preservation of macrofossils and pollen are only possible in certain conditions, rendering microfossil analyses of starch and phytoliths vital due to their good preservation under many conditions (Surette 2008). Microfossils also have high rates of production, which when coupled with their exceptional preservation, renders them an ideal means for identifying plants from archaeological materials (Dincauze 2000). Starch grains and phytoliths can help inform us about the extent to which past societies made use of certain plants, and can give us information regarding particular environments as well. In recent decades, microfossil research has undergone rapid development and is beginning to gain much wider use and acceptance (Pearsall 2000). Phytoliths and starch grains preserve well in the archaeological record and offer direct information regarding human and plant relations in the past (Dincauze 2000; Pearsall 2000). However, as previously stated, charred residues are only present when pottery vessels are used to prepare plants in certain ways. As such, the number of sherds in a collection with carbonized residues is extremely variable and can limit the sample size available for study.

Microfossil research in North America has been focused heavily on identifying the source and spread of domesticated plants (Boyd et al. 2006, 2008; Boyd and Surette 2010; Bozarth 1987, 1990; Hart et al. 2007; Pearsall et al. 2004; Pearsall 2002; Piperno et al. 2004, 2009; Staller and

Thompson 2002; Thompson 2000; Zarrillo and Kooyman 2006). One study by Boyd et al. (N.D.), presents the first evidence for ancient food production in the North American Boreal Forest area which represents one of the most northern examples of pre-contact horticulture in North America. This study illustrates evidence for much more widespread food production in North America than what archaeologists have traditionally recognized (Boyd et al. N.D.). An extensive study by Boyd and Surette (2010) that looked at microfossils from preserved carbonized food residue found that maize was consumed by every pottery producing culture spanning the central Boreal Forest and Canadian Prairies as far north as the subarctic climate zone by approximately AD 500. Overall, microfossil research from North American sites has revealed the use of wild and domestic plants, and includes hundreds of plant species, including maize, wild rice, squash, and bean amongst others (Boyd et al. 2006; Lints 2012; Zarillo 2008; Zarillo and Kooyman 2006).

3.4 Conclusion

Pottery presents a number of challenges for archaeological residue analysis due to its porosity, and the many difficulties presented by its irregular shapes and sizes. Analyzing small and miniature pottery vessels offers further challenges since their past functions are not as well understood as their full-sized counterparts. Although difficult to work with, it is also clear that pottery is an ideal material for the preservation of organic residues, as residues can adhere to the surface as carbonized food residue, or be absorbed within the matrix of the vessel (Evershed 1993; Malainey 1999). Additionally, pottery is an important and often abundant material in archaeological sites, and can reveal important information regarding past resource use, especially when analyzed using a multi-proxy approach.

The combination of techniques selected for this analysis work well together, as limitations of certain techniques can often be overcome through the use of another method. Incident light microscopy is an excellent screening tool for archaeological residues. It can help identify *in-situ* residues and contaminants, and can aid with interpretations of chemical analyses. Transmitted light microscopy is a useful tool to view removed residues without depth of field issues prevalent with incident light microscopy. However, the use of these microscopic methods alone to identify residues is limiting as residues are often amorphous, requiring further analysis to be positively identified. This is why the additional techniques of SEM, GC-MS, and microfossil analysis were chosen for this study. SEM allows for much higher magnification than other forms of microscopy, and in addition to being able to take highly magnified and detailed images, it allows researchers to conduct elemental analysis on a specific area of an object. While the previous methods are limited to visible residues, GC-MS permits analysis of absorbed or 'invisible' residues and can help identify the source of archaeological residues as well as contamination. Microfossils preserve extremely well in the archaeological record, and although this analysis is limited to vessels which exhibit carbonized residue, the analysis of starch and phytoliths can be informative regarding past plant use when present. Overall, a multi-proxy approach to residue analysis, especially when analyzing pottery, is essential and will allow for the recovery of more in-depth information than using a single method.

Chapter 4: Archaeological Sites and Collections

4.1 Introduction

This chapter discusses archaeological sites from which the sample vessels were collected, how many vessels were analyzed from each site, and whether they can be associated with one of the specific pottery traditions outlined in Chapter 2. The sample collection includes a total of thirty-five small/possible small vessels, twelve miniature/possible miniature vessels, and thirty-six full-sized vessels from fifteen archaeological sites (see Figure 4.1). They were loaned by The Manitoba Museum, Lakehead University, and an avocational archaeologist (Brad Hyslop). The archaeological sites discussed below were chosen based on whether small and miniature vessels were recovered, and whether the vessels were available for analyses.

4.2 The Manitoba Museum Collection

A total of thirty-one small, miniature, and full-sized vessels from eleven archaeological sites (see Figure 4.2) were loaned by the Manitoba Museum. The pots included Laurel and Selkirk vessels, and several vessels with undetermined affiliations that are mostly from the Late Woodland. They ranged from very well made small vessels, to more simply made miniature ones. In total, there were twenty small/possible small vessels, three miniature/possible miniature vessels, and eight full-sized vessels for comparative purposes (see Figures A.1, A.2, A.3). Each site and its corresponding vessels will be briefly discussed in this section.

Figure 4. 1: Overview of Site Locations

4.2.1 Carrot River (FlMh-1)

FlMh-1 is a disturbed Late Woodland site on a point of land immediately west of the Carrot and Saskatchewan River confluence (see Figure 4.2) (HRB 2016). Surface collections and test excavations down to 1.5 metres were carried out in the late 1960s, and the site contained four hearths and a concentration of burned bones (HRB 2016). Pottery, flakes, and eight bone awls were also recovered (HRB 2016). Based on these recoveries, the site was designated as a campsite (HRB 2016). The radiocarbon date for lab sample A-1196 yielded a normalized age of 490 ± 110 BP (1451 ± 115 CE) (CARD; HRB 2016). One almost complete small vessel (vessel 1) from the site was used for analysis (see Figure A.2). The small vessel is a Selkirk pot with no decorations but it had a very small amount of carbonized residue present on the exterior rim.

4.2.2 The Pas Reserve (FkMh-5)

The Pas Reserve site is located on the north bank of the Saskatchewan River directly across from The Pas, Manitoba (see Figure 4.2). The site was first recorded during the Glacial Lake Agassiz Archaeological Survey in 1967, although it had been known locally prior to this (Tamplin 1977). The site is described as a stratified campsite with 4 components consisting of Selkirk, Avonlea, Laurel, and Duncan, although they are not well stratigraphically separated (CARD). The Selkirk occupation was a thin layer near the surface, and was excavated in eight one-metre by two-metre units, and twenty-six two-metre by two-metre units (Tamplin 1977). A burial with artifacts was found at the site, as well as hearths, and both surface collections and test excavations were conducted in 1967, 1968, and 1972 (HRB 2016; Tamplin 1977). Twelve radiocarbon dates were obtained from the site and lab samples A-1369 and A-1183 range in normalized age from 3190 ± 60 BP to 280 ± 110 BP (1474 ± 53 BCE to 1652 ± 144 CE) (HRB 2016). A large number of artifacts was recovered, including lithics, bones, and pottery (HRB 2016). The site has been destroyed due to vandalism, building construction, cultivation, and erosion (HRB 2016). The site was revisited in 1994 by G. Hill, who wrote about having to clean up the 'mess' left by prior untrained excavators, and there is little written information regarding the previous excavations (Hill 1994). One Middle Woodland vessel (vessel 54) described as a possible "toy pot" was analyzed (Tamplin 1977). This vessel is a possible miniature Laurel pot, with minimal decoration that consists of punctates and bosses (see Figure A.1).

4.2.3 Mcleod Site (GfLm-07)

The Mcleod site is a Late Woodland site located on a clay beach along the eroding eastern shoreline of the waterway draining into Bruneau Lake (see Figure 4.2) (HRB 2016). The Mcleod site is one of several sites in the Sipiwesk Lake area surveyed by HRB and Northern Lights Heritage Services Inc (NLHS) over the course of four years, beginning in 2006. The archaeological survey was requested by Manitoba Hydro and Cross Lake First Nation due to severe erosion. This had occurred because of past Hydro-Electric developments in the 60s and 70s which had led to site deterioration (HRB Bruneau 2007). A controlled surface survey was conducted, and finds included pottery, lithics, and flakes (HRB 2016). No absolute dates have been procured, but the site ranges in age from 1100 CE to 1750 CE, based on interpretations of the variety of diagnostic artifacts found on site (HRB 2016). During the 2006 surveys, GPS points were obtained for the location of the artifacts, however, as most of the recoveries were surface finds there is little relevant contextual information. On a per site basis, this site yielded more precontact pottery than any of the other sites examined during the 2006 survey. While the site was never formally assigned a site-type, it was potentially used as a campsite or a short-term settlement based on the type of recoveries. Overall, 304 pottery sherds, including vessels that occur in the Clearwater Lake Complex and other Selkirk varieties were found. Findings included one possible miniature vessel (vessel 20) with no decorations which was used for this analysis (see Figure A.1). The vessel had been previously catalogued in the Manitoba Museum system as a 'miniature bowl.'

4.2.4 Maria Ross Site (GfLm-10)

The Maria Ross site is a Late Woodland site located on a south facing shoreline of an eroding clay beach on the channel connecting Sipiwesk Lake to Bruneau Lake, and is one of the sites surveyed by HRB and NLHS during the 2007 field season (see Figure 4.2) (NLHS 2008; HRB 2016). Concentrations of lithics and pottery were recovered at 4 locations within the site, that spans 100-metres and is situated on a clay beach of the eroding shoreline (HRB 2016). Controlled surface survey and subsurface testing was conducted, and the site was determined to be a campsite (HRB 2016). Seven shovel tests were conducted at the site during the 2007 field season (NLHS 2008). Five contained pottery and lithics to a depth of 4cm (NLHS 2008). At a depth of 7cm, the soil was saturated with water, and the site was deemed a low priority as cultural remains had been dislodged from their original context (NLHS 2008). Three vessels from the site were analyzed for this thesis (vessels 10, 17, and 25). The vessels have minimal decoration with vessel 10 exhibiting only textile impressions on the exterior, and vessels 17 and 25 only exhibiting notching on the lips. Vessel 10 is a small pottery vessel (see Figure A.2), vessel 17 is a possible small (see Figure A.2), and vessel 25 is a possible miniature vessel (see Figure A.1). The presence of Late Woodland fabric-impressed pottery was used to date the site to approximately 750 CE to 1650 CE (NLHS 2008; HRB 2016).

4.2.5 Thomas Site (GgLl-03)

The Thomas site is located on the north shore of Bruneau Lake on a low sand beach of an eroding shoreline (see Figure 4.2) (HRB 2016). It is a multicomponent campsite believed to have been used for many generations (NLHS 2008). The site stretches 40 metres east to west, and 20 metres north to south (HRB 2016). When the site was surveyed in 2007 by NLHS and HRB, five test pits were put in and the site was found to contain a mix of pre-contact and historic artifacts including pottery, lithics, a musket ball, buttons, and a pocket watch fragment (HRB 2016). Pottery finds included Laurel, Selkirk, Plains Woodland, Clearwater Lake, Bird Lake, and Sipiwesk (NLHS 2008). The site has been dated to approximately 1CE to 800CE based on the styles of pottery found (HRB 2016). No radiocarbon dates were obtained. One possible small Middle Woodland Laurel vessel (vessel 2) was analyzed (see Figure A.2). The vessel exhibits right oblique cord wrapped impressions, as well as at least four lines of parallel horizontal pseudo-scallop shell impressions. This vessel was catalogued as a 'miniature bowl' in the Manitoba Museum system.

4.2.6 Burntwood River Burial (GjLs-2)

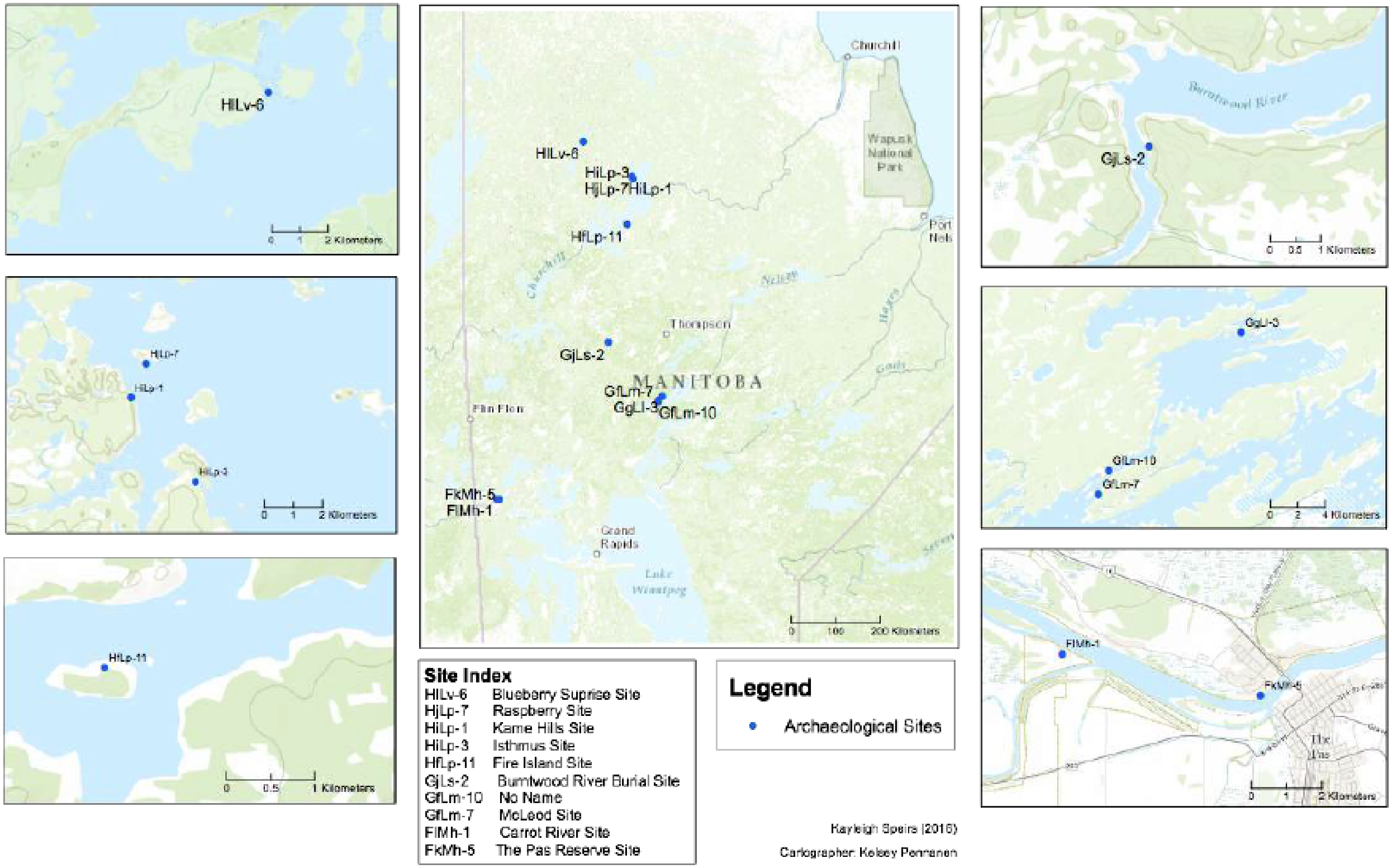
The Burntwood River Burial site is a Late Woodland site located on a mud beach on the east bank of the upper Burntwood River (see Figure 4.2) (HRB 2016, Malasiuk 2001). The

Burntwood River Burial site was surveyed and excavated as a part of The Churchill River Diversion Archaeological Project (CRDAP). This burial site is associated with an extensive campsite (HRB 2016). CRDAP was initiated in 1969 in order to conduct archaeological investigations of lake and river shorelines in north-central Manitoba expected to be disturbed by proposed hydro-electric developments (Malasiuk 2001). Both surveys and excavations were conducted at sites along these shorelines until 1976 when the hydro-electric developments which diverted the Churchill River were completed (Malasiuk 2001). The project was renewed in the early 90s following the discovery of a burial on South Indian Lake, which led to the discovery of multiple burials along eroding shorelines in the region (Malasiuk 2001). The CRDAP has led to the discovery of over 700 sites, spanning thousands of years (Malasiuk 2001). The CRDAP crew was actually informed of the existence of the GjLs-2 site by a community member (Malasiuk 2001). The sites in the area contained vast amounts of pottery including vessels that occur in the Kame Hills Complex, as well as many post-contact artifacts (Malasiuk 2001). Malasiuk (2001) discusses the diversity of decorative traits seen on pottery from the Burntwood River Burial site, believing it might hint at the large number of individual vessels that were left at the site and other surrounding sites (Malasiuk 2001). Malasiuk explains that the size, spacing, shape, and angle of impression of the punctates varies from pot to pot, with some exhibiting a lunate (crescent moon-shaped) punctate, a rare but not totally unknown design on vessels occurring in the Kame Hills Complex. This site was quite rich, with more than 200 surface collections of which the majority were Kame Hills varieties of pottery (Malasiuk 2001). No radiocarbon dates were obtained from the site, but recoveries of Plains Woodland pottery and post-contact artifacts reflects a multi-component site spanning hundreds or even thousands of years. Surface collections were conducted, as well as the removal of human remains (HRB 2016). The burial, dated to the mid-20th century based on associated finds, was recovered from the eroding shoreline following a ceremony, and has since been reburied in Nelson House by the community there (Malasiuk 2001). One well-made small Selkirk vessel (vessel 1) with textile impressions on the exterior was analyzed (see Figure A.2). The vessel was catalogued as a 'bowl' in the Manitoba Museum system and in Malasiuk's report.

4.2.7 Fire Island (HfLp-11)

The Fire Island site is a Late Woodland site located on the south/southeast side of Fire Island (see Figure 4.2) (HRB 2016). The site was first recorded in 1974 when artifacts were observed after a fire (Kroker 1990). The site has since been destroyed by flooding (HRB 2016). Artifacts spanned an area nearly 750 metres long and 60 metres wide, and concentrations of pottery and burnt bone were recovered through surface collecting and excavations in the late 1980s (HRB 2016; Kroker 1990). Samples were sent for radiocarbon dating and the normalized age from lab sample S-965 was 380 ± 170 BP (1598 ± 180 CE) (HRB 2016). Three Selkirk vessels from this site were analyzed (vessels 2, 3, and 7). Vessel 2 exhibited an encircling ring of punctates on the exterior rim, with bosses on the interior. This is a small vessel and is part of an online exhibit by the Canadian Museum of History where it is identified as a small pot or cup (see Figure A.2) (Exhibit Specimen 6 2017). Vessel 3 is a small pot with an encircling row of punctates on the rim, with bosses on the interior of the vessel and an obliterated textile impression on the exterior (see Figure A.2). Vessel 7 has no decorations and is a possible small vessel (see Figure A.2).

Figure 4. 2: Manitoba Archaeological Sites



4.2.8 Kame Hills Site (HiLp-1)

The Kame Hills area is located on the northwestern side of Southern Indian Lake in northern Manitoba (see Figure 4.2) (Dickson 1983). An archaeological survey in 1971 revealed several sites in the area which were subsequently excavated over the following four years (Dickson 1983). Overall, twelve sites were recorded in the Kame Hills area, most of which yielded large amounts of pottery (Dickson 1983). In fact, pottery was the most prominent artifact type found at the majority of sites in the region, and almost all vessels found have been catalogued as Selkirk pottery (Dickson 1983). The Kame Hills site is a large settlement site that has recently been destroyed by flooding deriving from the construction of a hydro-electric dam (HRB 2016). At least twenty hearths were uncovered through surface collecting, test excavations, and formal excavation (HRB 2016). Fifteen radiocarbon dates were analyzed and lab samples S-1077 and GaK-6061 yielded normalized ages of 3590 ± 90 BP and 210 ± 130 BP respectively (1953 ± 134 BCE to 1721 ± 172 CE) (CARD; HRB 2016). The site contained a substantial number of artifacts, with more than 20,000 artifacts having been recovered. Finds ranged from pottery, to projectile points, other formal tools, flakes, and historic artifacts (HRB 2016). Overall, 132 individual pottery vessels were recovered from the site; 129 were identified as Selkirk, one as Blackduck, and two as Laurel (Dickson 1980). In the site reports, pottery from the site is variously interpreted to be pots, plates, bowls, cups and even pipe bowls (Dickson 1980). There were many interesting pottery pieces found at the Kame Hills site, including a variety of flat, plate-like pieces possibly used as lamps (Dickson 1980; MacLean 1995). Dickson's definitions of the varying types of vessels can be found in Chapter 2. Five vessels from this site were used for analysis (vessels 25, 28, 49, 51, and 121). Dickson (1980) refers to vessel 49 as a pipe bowl, but he does state that it has no stem or obvious opening for inserting a stem. This miniature vessel was recovered from level one and was found in association with fourteen Clearwater Lake Punctate vessels, consisting of “8 plates, 4 pots, 1 bowl, and 1 cup” (Dickson 1980). Vessel 49 is a miniature Selkirk vessel; it is a simple pinch-pot style vessel, with two rows of uneven punctates on the exterior and bosses on the interior (see Figure A.1). Vessels 51, 25, and 28 are referred to as cups by Dickson (1980) while vessel 121 is referred to as a bowl. These four are all small vessels, with similar styles of decoration consisting of some type of notching or CWOI on the lip, one to two rows of punctates on the exterior with bosses on the interior, and textile impressions on the body (see Figure A.2).

4.2.9 The Isthmus Site (HiLp-3)

The Isthmus site is located in the Kame Hills region approximately 1.5 kilometers southeast of the Kame Hills Site, on a narrow sand bar connected to the main shore (see Figure 4.2) (Dickson 1983). The site has been destroyed due to flooding (HRB 2016). Surface collections, as well as test pitting and a formal excavation in 1972 were conducted at the site, and finds included pottery concentrations, a pipe bowl fragment, gun parts, and lithics (Dickson 1983). A large quantity of daub was recovered from the site, which indicates the possibility that vessels were manufactured on site (Dickson 1983). This, coupled with the other types of material culture found, led to the site being assessed as a settlement (HRB 2016). No radiocarbon dates were obtained but the site has pre-contact Woodland period artifacts and post-contact components. At least eighteen Selkirk pots were identified from the site, four of which were analyzed for this project (vessels 8, 11, 23, and 24). All 4 vessels have been identified as Selkirk based on stylistic traits, and all four are small vessels (see Figure A.2). These vessels are similarly decorated, with all of them having one to two rows of punctates on the exterior, with bosses on the interior, textile or obliterated textile impressions on the body, and vessels 23 and 24 have the addition of notching on the lip.

4.2.10 The Raspberry Site (HjLp-7)

The Raspberry Site is located on the west bank of the Churchill River, on the southern point of a large island in Southern Indian Lake in the Kame Hills area (see Figure 4.2) (HRB 2016). The site has been destroyed by flooding and a fire in the early 1960s (Dickson 1983; HRB 2016). The site was surface collected, test pitted, and fully excavated by ARC in 1971 and revealed pottery and lithics (Dickson 1980). No radiocarbon dates were obtained for this site, but it has a mixture of pre-contact and post-contact artifacts. The site also contained orange rock piles and fire-cracked rock (Dickson 1980). In recent times, a fishing camp was located on the site and remains of one structure are still visible, as well as a scattering of historic artifacts (Dickson 1983). The site was determined to be a settlement (HRB 2016). Two vessels from this site were analyzed (vessels 17 and 18). Both are Selkirk vessels, and 17 is a small vessel, while 18 is a possible small (see Figure A.2). Both vessels have one row of punctates on the exterior, bosses on the interior, and a smooth surface finish on the body.

4.2.11 The Blueberry Surprise Site (HlLv-6)

The Blueberry Surprise Site is a Late Woodland and post-contact site located in the Kame Hills area (see Figure 4.2). The site was destroyed by a fire in 1982 and has also suffered from the effects of erosion. Surface collections were conducted at the site and pottery similar to that from other sites on Southern Indian Lake were found (HRB 2016). Radiocarbon dates were not obtained for the site, rather, the site antiquity is estimated to be around 800CE-1850CE based upon the recovery of diagnostic material (HRB 2016). Findings include pottery, a stone adze, and a metal fishing tool (HRB 2016). The site is believed to be a campsite (HRB 2016). One vessel (vessel 4) from this site was used for analysis. The pot is a small, well made Late Woodland vessel like those occurring in the Kame Hills Complex, with CWO impressions, punctates and bosses, and textile impressions (see Figure A.2). This vessel is the only one in the sample to contain interior decorations other than bosses.

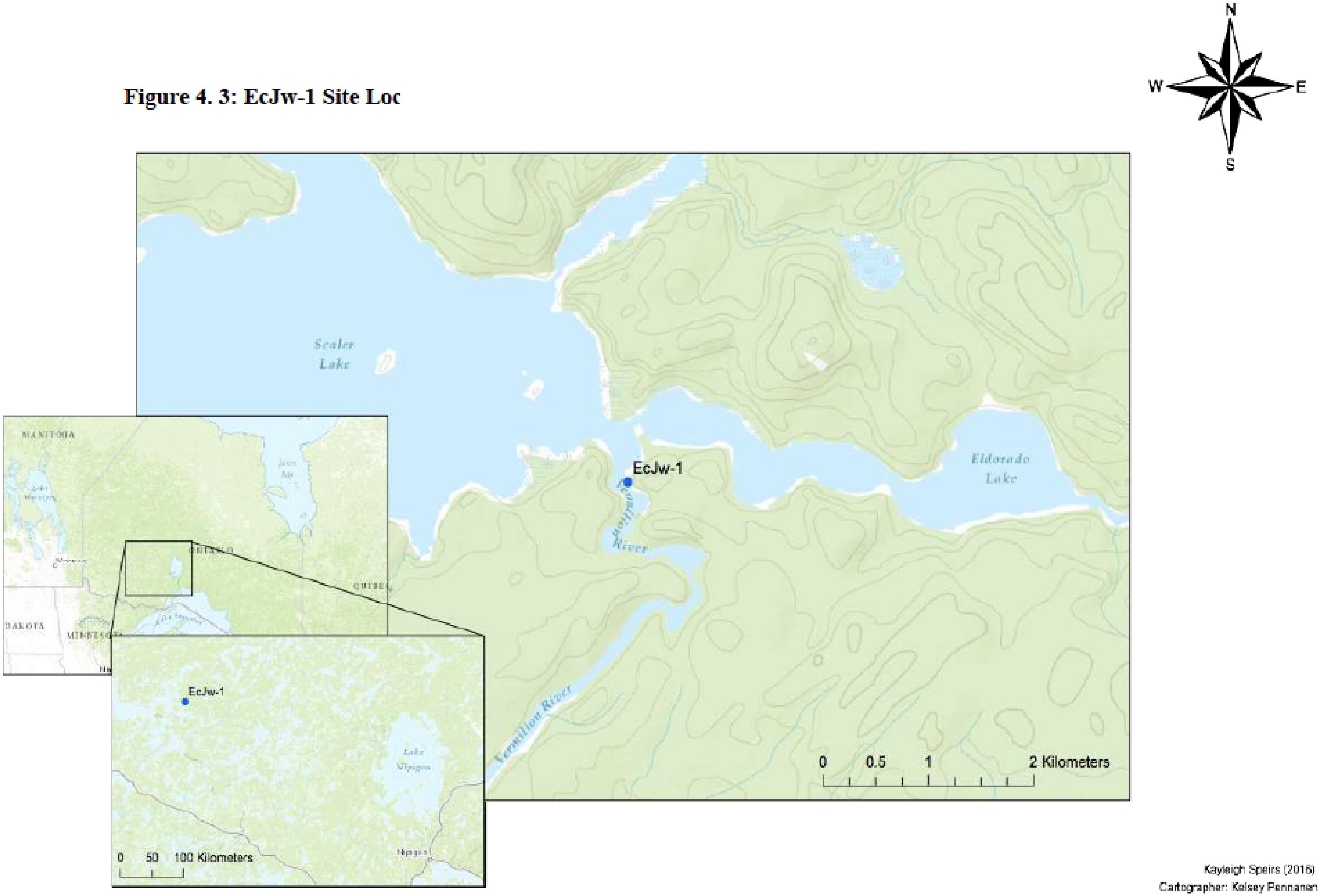
4.3 Brad Hyslop Collection (Lac Seul, Ontario)

Pottery sherds from the EcJw-1 site (see Figure 4.3) in Northwestern Ontario were borrowed from avocational archaeologist, Brad Hyslop. The sherds consisted of four miniature/possibly miniature vessels, six small/possibly small vessels, and ten rim sherds from full-sized vessels, as well as a soil sample from the site for comparative purposes (see Figures A.1, A.2, A.3). In total, twenty vessels consisting of twenty-eight sherds underwent analysis.

4.3.1 EcJw-1

The EcJw-1 site is located on Scaler Lake in Northwestern Ontario. The site consists of a single hearth on an eroded and highly disturbed shoreline (Hyslop 2012). Due to the disturbance

Figure 4. 3: EcJw-1 Site Loc



the context in which the pots were found has little value and the vertical separation of artifacts was not recorded (Hyslop 2012). While the site is extremely disturbed, a vertical profile of a 1.5-metre-long hearth could be seen along the southern wall of one of the squares dug into it, revealing three distinct layers (Hyslop 2012). Many rim sherds were found during the excavations conducted in 2010, which represent a variety of different vessels; however, the majority of pottery found at the site was unclassifiable (Hyslop 2012). Both Laurel and Late Woodland artifacts were found mixed together (Hyslop 2012). Excavations of the area revealed 1606 artifacts which consisted of 206 lithics, 842 pottery pieces, and 558 bone fragments (Hyslop 2012). No radiocarbon dates have been obtained from the site, but the material culture dates the site from the Middle to Late Woodland period. There was a large amount of miniature and small vessels recovered from the hearth feature. As previously mentioned, a total of twenty vessels were analyzed from this collection. This consisted of four miniatures/possible miniatures, six smalls/possible smalls, and ten full-sized vessels, as well as a soil sample. The vessels were attributed numbers from 1 to 20 based on the order they were catalogued in. Vessels 1 to 10 represent the miniature and small pots, while 11 to 20 are the full-sized vessels (see Figures A.1, A.2, A.3). Many of the small and miniature vessels had little to no decoration, although some exhibited some interesting markings such as crescentic-shaped stamps. The regular-sized vessels generally exhibited similar decorations consisting of (CWO) impressions and punctates.

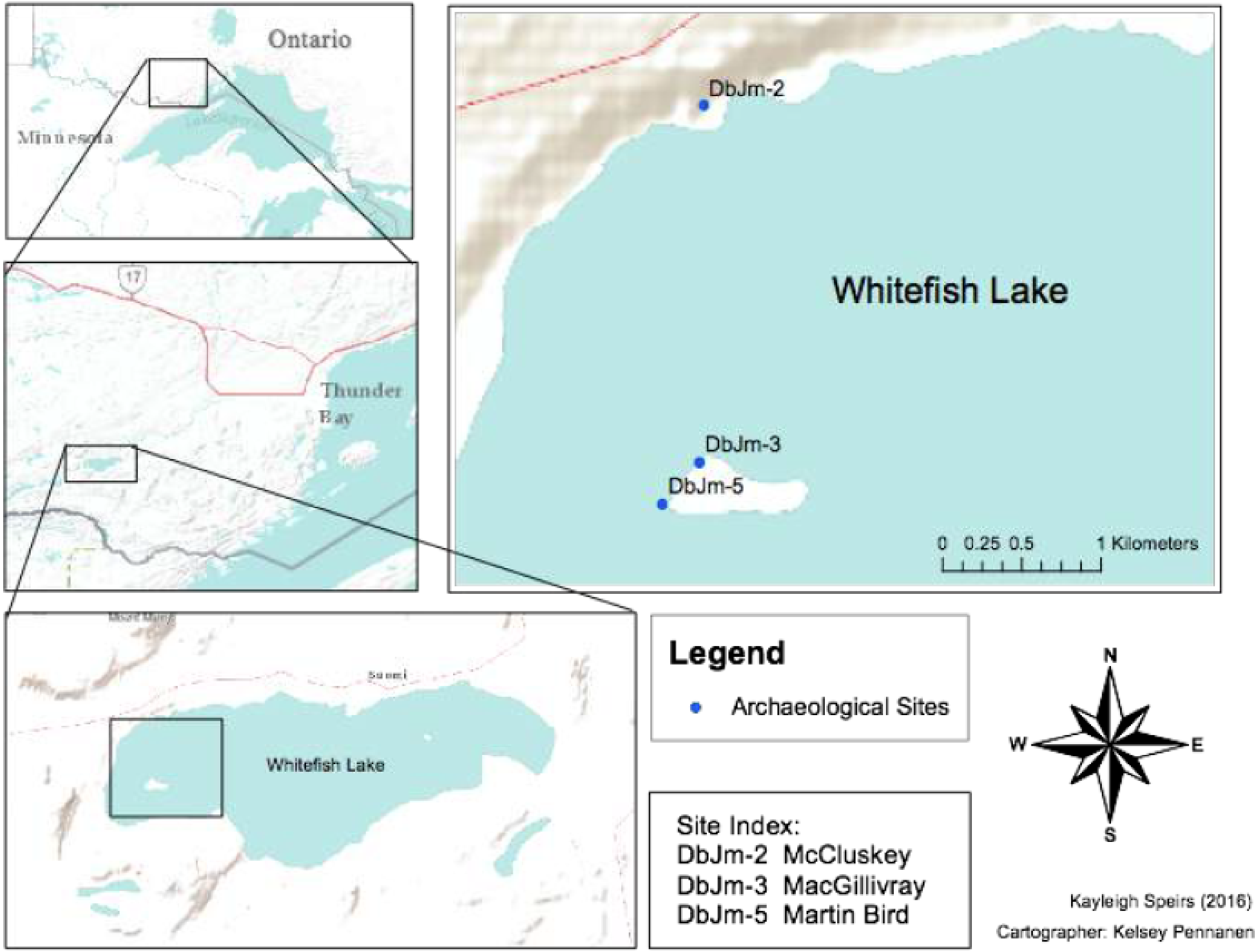
4.4 Lakehead University Collection

Thirty-two vessels from three sites were chosen for analysis from the Lakehead University collection. These samples consisted of nine small vessels, five miniature/possible miniature vessels, as well as eighteen full-sized vessels and several soil samples for comparative analysis (see Figures A.1, A.2, A.3). These sites are located on Whitefish lake in Northwestern Ontario (see Figure 4.4). The Macgillivray and Martin-Bird sites are located on Macgillivray Island at the west side of the lake, while the McCluskey site is located to the north of the island on the mainland. While the majority of the data used for this study was collected during past excavations, several soil samples were collected from the Macgillivray site during the 2016 field season and analyzed as part of this project.

4.4.1 Martin-Bird (DbJm-5)

The Martin-Bird site is located on Macgillivray Island in Whitefish Lake in northwestern Ontario (see Figure 4.4). The site was first discovered in 1964, surveyed in 1966, and initial excavations took place in 1970 and 1987 by K. C. A. Dawson. The burial mounds on site had also been subjected to years of looting prior to being excavated, and there were many post-contact artifacts from that time period found on the island as well (Boyd 2013). According to Dawson, the Martin-Bird site is a multi-component habitation site, with features including a Blackduck burial and a Laurel mound, and is believed to have been occupied for over 700 years (1987). Dawson obtained 10 radiocarbon dates from the Martin-Bird site and lab samples S-773 and S-774 yielded normalized ages of 3480 ± 70 BP and 180 ± 140 BP respectively (1806 ± 87 BCE to 1738 ± 169 CE) (CARD). In his report, Dawson discusses three separate areas of the site, Area A, Area B, and Area C. In all three of the areas Dawson reported finding "juvenile" vessels. Area A, which is located on a clay terrace west of the shore and near the northwestern point of the island had ten units opened. One unit had "juvenile" vessels in the first level surrounding a hearth, along with

Figure 4. 4: Whitefish Lake Sites



Blackduck and Laurel pottery. Level two in the same area revealed "juvenile" rim sherds along with more Blackduck and Laurel pottery, lithics, and post-contact artifacts (Dawson 1987). Nine units were opened in Area B, which is located north of the south shore of the island, and east of Area A (Dawson 1987). The first level of one unit revealed three "juvenile" rim sherds in association with other types of pottery. Area C, a natural ridge 10m east of Area A, had a two-foot-wide trench opened up (Dawson 1987). A burial was found in this area, and three "juvenile" vessels were found in association with the burial. In 2009 and 2010, further excavations to expand upon Dawson's work were undertaken at the Martin-Bird site by an archaeological team from Lakehead University (Boyd 2013; Hamilton 2011). Their excavations were focused upon addressing micro-botanical remains from domestic plants, specifically maize, recovered from carbonized residues on pottery vessels collected by Dawson and whether Indigenous groups traded for such domesticated plants, or if small-scale gardening took place on the island (Boyd 2013; Hamilton 2011). The 2009 investigations consisted of shovel tests, mapping, and geophysical remote sensing (Hamilton 2011). Based on information obtained in the 2009 field season, a small block excavation of a burned rock complex was conducted in 2010 (Boyd 2013). Archaeobotanical analysis was conducted, and results indicated this feature was likely used as a "drying or parching surface for on-site processing of maize and perhaps wild rice" (Boyd 1:2013). Other residue analysis was conducted on grinding stones as well as carbonized food residues from potery sherds and results strongly indicate the site was used for maize horticulture during the Late Woodland period (Boyd 2013). Further research on the island has been conducted in the 2015, and 2016 field seasons. Six full-sized vessels were randomly selected from the Martin-Bird collection to act as comparisons for small and miniature vessels analyzed from the McCluskey (DbJm-2) site (see Figure A.3). The vessels are all Blackduck or likely Blackduck, with most exhibiting textile and cord-wrapped object impressions. Two of the vessels have more detailed motifs, including stamping on the rim or neck.

4.4.2 McCluskey (DbJm-2)

The McCluskey site is located on the north shore of Whitefish Lake in northwestern Ontario (see Figure 4.4). Pottery had been recorded at the site as early as 1882, however, the site was not officially designated until 1960 (Dawson 1974; Winchell 1911). Excavations began at the site in 1962, followed by a few years of surface collecting, and further excavations in 1964 (Dawson 1974). The site is believed to have been occupied seasonally for approximately 2000 years, and saw an exploitation of both aquatic and faunal resources. The site, which had a burial mound, has since been destroyed by the construction of buildings and a road. In addition to the mound, the site had two hearths and a roasting pit. Although the site was generally un-stratified, the northwest edge of the mound where a cluster of pottery was found exhibited some intact stratigraphic context. Dawson obtained one radiocarbon date which placed the normalized age of the site at 1990 ± 90 BP (12 ± 109 BCE), although this date was considered to be older than expected and could be the result of contaminated carbon from a forest fire (CARD). Lithics, as well as Blackduck pottery and a small quantity of Laurel pottery have been excavated from the site, including forty rims from approximately thirty-one small "mortuary" vessels (Dawson 1974). The "mortuary" vessels were uncovered in an area adjacent to the mound from the periphery of a roasting pit (Dawson 1974). Dawson suggested the small and large Blackduck vessels served as cooking vessels due to carbonized material adhering to the interior of many of the rim sherds (Dawson 1974). Regarding the small vessels, Dawson describes them as typical of Blackduck vessels in form, but "quite small in size," and he refers to them all as mortuary vessels due to their proximity to the mound (1974:37). In searching through the collection it was difficult to confidently identify some of the sherds as miniature or small due to their fragmented nature, and as such, only twenty-one sherds out of the apparent forty vessels were selected for analysis. Of these, ten are small vessels, four are possible miniatures, and seven are regular-sized vessels (see Figures A.1, A.2, A.3). In his report, Dawson analyzed the small vessels according to categories established for the full-sized ones, although he does note that "their small fragmented nature makes the classification imprecise" (1974:37). Four of the small and miniature pots are Blackduck vessels, while the rest have been classified as undetermined, although they are likely Blackduck vessels as well. Several of the pots exhibited no decorative motifs, and the most common motifs were punctates, bosses, and some form of cord-wrapped-object impressions.

4.4.3 Macgillivray (DbJm-3)

The Macgillivray site (DbJm-3) is located on Macgillivray Island in Whitefish Lake in northwestern Ontario (see Figure 4.4). It is a primarily Laurel habitation site with Late Woodland and post-contact components (Boyd 2013; Dawson 1980). Dawson obtained two radiocarbon dates, one was dismissed as likely being contaminated from a forest fire, and the other was obtained from a wood feature within the mound (CARD). The dates place the age of the burial mound at 1930 ± 200 (58 ± 240 CE) (GaK-1492), while the habitation areas are associated with the Late Woodland (CARD). Initial surveys of the site took place in 1964, and in 1966 the site was surveyed further and partially excavated (Dawson 1980). Dawson and his team laid out the site into a five-foot grid pattern and opened thirty-five units (1980). Eight of the units cross-sectioned the burial mound and the remaining were opened in habitation areas. In addition to the units, thirty-eight test pits were opened as well. Features included hearths, pits, and the burial mound (Dawson 1980). Artifacts were generally recovered from level three, with levels being excavated in two-inch intervals. Some artifacts found in lower levels where found in association with features (Dawson 1980). Findings included pottery, lithics, and both human and animal bone (Dawson 1980). A significant amount of Laurel pottery was recovered from the site, and one Selkirk vessel was recovered as well. One rim from a small vessel, which Dawson defines as a possible "mortuary" vessel with a plain body and an incised and decorated exterior and lip was found (1980). During the summer of 2016, a team of archaeologists from Lakehead University surveyed the site and opened up test-pits. This research was conducted with similar goals to projects conducted at the Martin Bird site in 2009, 2010, and 2015. The site was mapped, and artifact findings included pottery, lithics, several hearths, and post-contact surface finds. Multiple soil samples were collected from test-units during the 2016 season as well, to act as a control for the data obtained from analyzing pottery sherds. Five full-sized vessels from the Macgillivray site were randomly selected from the Lakehead University collection to act as comparisons for the small and miniature pottery analyzed in this area (see Figure A.3). The pots chosen are mostly Laurel, and most exhibit punctates and bosses, with some having additional motifs consisting of stamping.

4.5 Conclusion

The sites described in this chapter span a wide geographic area within the Boreal Forest environments of Manitoba and Northwestern Ontario, and consist of campsites, burials, and settlements which sometimes contain multiple occupations. While the sites differ in many ways, one unifying feature is the recovery of morphologically similar small and miniature pottery vessels. Several of the vessels were affiliated with Laurel and Selkirk types; however, the majority of the small and miniature vessels recovered from these sites could not be affiliated with a specific pottery tradition due to their fragmented state. The full geographic extent of small and miniature vessels is currently unknown as these vessels are rarely the object of intensive study. However, as explored in Chapter 2 and demonstrated in this chapter, these vessels have been recovered from sites across North America and elsewhere in the world. As previously noted, the sites selected for this study were based on the availability of material for analysis. Overall, these sites represent only a small portion of North American sites known to have small and miniature pottery vessels. This thesis represents one of the first studies to analyze a large quantity of these vessels. The site information presented in this chapter will be used to aid interpretations of the results obtained through residue analysis in order to better understand this complicated material culture.

Chapter 5: Methodology

5.1 Introduction

This chapter reviews methodological procedures used to analyze the sample vessels. Prior to residue analysis, in-depth cataloguing took place that included photography, measurements, and documentation of other important features. The residue analysis included *in-situ* reflected light microscopy, transmitted light microscopy, scanning electron microscopy (SEM), gas chromatography coupled mass spectrometry (GC-MS), and microfossil starch and phytolith analysis. These methods were employed sequentially, allowing samples to be tested in as many ways as possible without impinging on one another. During data collection, issues were encountered that required some techniques to be modified, including the introduction of additional preparatory steps in order to adequately prepare the pottery vessels for analysis. This included steps to avoid contamination and deal with previously contaminated samples.

5.2 Pottery Attributes

The morphology of a pottery vessel which includes its shape, size, and form, can be an important factor in determining its stylistic affiliation. These features, along with information regarding vessel surface finish and paste composition, amongst others, can be used to infer intended function. While the morphology of pottery vessels can be described and classified in various ways, there is currently no standard guideline for classifying miniature and small vessels, making it important for researchers to choose relevant features that are appropriate for each assemblage or vessel. Pottery attributes chosen for cataloguing were based on Syms and Dedi's (2006) museum cataloguing guideline. However, their guideline is extremely detailed and not all of it was applicable to the unique category of miniature and small pottery vessels. Overall, 19 attributes were chosen (see Table B.1), ranging from the shape and thickness of the neck, lip, and base, to vessel decorations, to some unique categories tailored specifically for small and miniature vessels. Smith's (1998) thesis provided a guideline for specific measurements of small and miniature pottery which assess the quality (ie. thickness, consistency, shape, and decorations) of each vessel to determine the possibility of their manufacture by children.

5.2.1 Miniature and Small Vessels

There are no standardized size ranges or approach to use in order to determine which category the sample vessels belonged to. Instead, sample pots were determined to be either small or miniature based on the definitions presented in Chapter 2, which included measurements of their height and estimations of circumference when these were able to be taken. Observations of their general size and curvature were taken into account as well. Many of the circumference estimations were based on measurements of diameter assessed with a diameter estimation sheet (see Figure B.1). Assessing the rim diameter using a chart often resulted in finding the 'best fit,' as opposed to an exact match due to the irregularity of many of the vessels as well as generally only having a small rim portion to assess (Collett 2012). Results of these measurements and estimates are discussed in Chapter 6.

5.2.2 Vessel Profile, Neck, Rim, Lip, Shoulder, and Base Shape

Visual examination of the vessel enables documentation of its profile shape that encompasses the portion of the neck, rim, lip, shoulder, and base that are available. At present, there are no definitive standards and guidelines to follow when cataloguing pottery, although many museums or universities have developed guidelines reflecting their own collections. While the Canadian Heritage Information Network has a detailed and publicly available book of nomenclature for museum cataloguing, it is extremely broad and defines objects such as pottery based on function rather than physical descriptions. As already mentioned, the pottery attributes used for this study derives from documentation provided by Syms and Dedi (2006). This guideline provides figures and descriptions for defining regionally relevant pottery attributes. Basic definitions of the attributes chosen are discussed here, and more detailed descriptions with figures can be found in Appendix B.

The profile of a vessel refers to its overall shape in cross-section. Vessel profiles can range from globular, conical, and cylindrical, to more intricate anthropomorphic shapes amongst others (see Figure B.2). Since the majority of the vessels are represented by fragments, only a small proportion of the assemblage could be assigned a vessel shape. Comparatively more sample vessels were able to have their neck shape documented as there were a significant number of rim sherds in the sample. Documenting the neck portion of the sample vessels consisted of a description of the upper portion of the vessel ranging from just below the neck to the lip (Syms and Dedi 2006). Syms and Dedi's guide presents fourteen different neck shapes, including excurvate, straight, and converging (see Figure B.3 for images and descriptions). Lip shape refers to the general shape of the lip portion of a vessel. There are thirteen variations of lip shape described in Syms and Dedi's manual, including rounded, squared, and pointed which were used to categorize the sample vessels (see Figure B.4). Shoulder and base shapes are much less variable, with only five shoulder shapes and four base shapes described in Syms and Dedi's manual that were used to define the sample vessels (see Figures B.5 and B.6). There were few sample vessels that were able to have their shoulder or base described as typically these portions of the vessels were not present. Results from all of these visual assessments are summarized in Chapter 6.

5.2.3 Paste Composition and Surface Finish

Analysis of the vessel surface finish included both the exterior and interior. Descriptive terms used to define surface finish include: smoothed, textile-impressed, and obliterated (see Figure B.7). Most of the sample vessels were sufficiently intact to allow description of surface finish. The paste composition of a pot includes the clay, temper, and any other material used to fabricate the vessel. The temper of the sample vessels was analyzed using either a magnifying glass or under low-magnification using a Nikon SMZ800 microscope, and was characterized by particle size and type (see Table B.2). Results of both analyses are discussed in Chapter 6.

5.2.4 Decorative Motifs

Analysis of pottery vessels commonly divides the vessel visually into upper and lower portions; the former consisting of the neck and rim, and the latter making up the larger body of the vessel (Marois 1984). The two sections are connected by a shoulder junction, unless the pot has particularly vertical sides (Marois 1984). Decoration is usually concentrated on the upper vessel portion, making rim sherds particularly useful. Pottery decoration is often viewed as ornamental, and their addition or absence typically does not affect their functionality (Marois 1984). However, analysis of decorative motifs is a primary means of assigning vessels into different pottery traditions, and they can provide insight into craftsmanship and artistic abilities. Additionally, decorations can reflect socially mediated information expressed by artisans spanning large geographic areas and time periods, which could have significant meaning to the groups who used these vessels. In order to analyze decorative motifs visible on the sample vessels, the interior and exterior of all vessels and sherds were inspected for decorations, and the motifs and their locations were described in detail. These descriptions are discussed in Chapter 6.

5.2.5 General Measurements

When assessing and cataloguing pottery, it is common to take measurements from various portions of vessels to determine their overall size or carrying capacity, as well as to determine maximum thickness and height amongst others for comparative purposes and to explore craftsmanship. Analyzing measurements is sometimes considered easier and more accurate by comparing mathematical representations of a pots' shape and its features rather than relying on visual examinations (Orton and Hughes 2013). In fact, measurement based classifications were developed to allow for more universal ways of describing and classifying pottery vessels (Skibo 2013). Measurements used for this study included the maximum thickness of the body, rim, and lip of each vessel or sherd, as well as the vessel height and circumference when possible (see Table B.1). These measurements are discussed further in Chapter 6. Due to the fragmented nature of many of the sample vessels, not all measurements were appropriate for each pot. In addition to these measurements, three measurements developed specifically for small and miniature pottery were also taken, which will be discussed further below (see Table B.1). Measurements were taken with digital calipers and represent the maximum and average thicknesses.

5.2.6 'Juvenile' Vessel Measurements

Smith's (1998) thesis outlines and tests three different measurements created to evaluate the quality of 'juvenile' pottery. As outlined in Chapter 2, small and miniature pottery vessels are often assumed to be made by children because of their small size, basic manufacture, and lack of or less detailed decorations (Ellis 1994; Bagwell 2002; Crown 1999, 2001, 2002; Hutson 2006; Kamp et al. 1999; Kamp 2002, 2006; Lillehammer 1989; Smith 1998). Smith (1998) created measurements to serve as a more objective way of evaluating pots by providing a system created specifically for variables within the 'juvenile' pot category that assess the skill level of the manufacturer and the pots' overall quality. Smith's criteria are used for this study, and include the *Crudity Index*, the *Curvature Consistency Index*, and the *Motif Application Index*. These measures will be discussed below. Measurements were taken with digital calipers, as well as the aid of rulers when necessary. Not all measurements could be calculated for each vessel as many sample vessels were fragmentary and eroded and were left out of these analyses.

5.2.6.1 The Crudity Index

The *Crudity Index* (CI) assesses the quality of the construction of a vessel by taking thickness measurements at two points on a vessel and creating a ratio between the thickest and thinnest points (Smith 1998). In theory, Smith explains that the closer the ratio is to '1,' the better the manufacture of the pot and therefore, the better the potter and the more likely the pot was not manufactured by a child. If the vessel consists of a single sherd (or non-reconstructed sherds), then the two points chosen for measurement must be on the same plane, but on opposite sides of the sherd. These measurements can be taken from any type of sherd (ie. rim, body, shoulder) as long as both points are taken from the same zone as different areas might vary in thickness on purpose (Smith 1998). If the vessel is whole, the thickness measurements are to be taken from the rim as it is too difficult to gather measurements from other areas (Smith 1998). Once measurements were taken, the crudity index was determined by dividing the thicker value into the thinner, and results were divided into three categories: 'crude,' 'fair', and 'fine' which are thought to represent varying motor abilities (Smith 1998). The fine category includes results that fall between 0.81-1, and indicate high motor skills (Smith 1998). The fair category includes results falling between 0.61-0.80 and reflects adequate ability, while the 'crude' category contains results ranging between 0-0.6 and represents poor motor abilities (Smith 1998).

5.2.6.2 Curvature Consistency Index

Similar to the CI, the *Curvature Consistency Index* (CCI) evaluates a pots manufacture, however, CCI assesses the curve of a vessels wall instead of its thickness. Smith (1998) created this index to further determine whether a link could be made between poor motor skills and pots made by children. The technique for assessing the CCI differs depending on whether the vessel is complete or just a sherd. To assess CCI for a sherd, it is placed with the interior side facing down on a flat surface and the length of the interior curve is measured with a ruler; the one quarter mark from either side is found, and then depth measurements are taken from each point to the top of the interior curve using calipers (Smith 1998). A ratio is then calculated for the two points. For complete vessels, a ruler is placed with its edge down on the opening of the vessel from one side to the other, the quarter mark from each side is found, and depth measurements are taken and then divided to get a ratio (Smith 1998). Similar to calculating the crudity index, the pots were then separated into crude (0-0.6), fair (0.61-0.80), and fine (0.81-1) categories.

5.2.6.3 Motif Application Index

As with CI and CCI, the *Motif Application Index* (MAI) assesses the motor skills of a potter, but it does so arbitrarily by analyzing decorative motifs. This index is qualitative while the other indices are quantitative. Smith (1998) explains that this index provides a way to examine the consistency of motif application by breaking it down into different categories which are then assigned a certain score. The four categories include: consistency in impression depth (are they pressed into the clay at equal depths), relative length of motif elements, width of motif elements, and spacing of motif elements (are they equally spaced in relation to each other (Smith 1998). Each category is assigned a numerical value of 1-3 ranging from crude to fine. These values are then added up, and divided by four which then yields the MAI. Deciding which score to give a particular trait is subjective and decisions are made in relation to the other motifs being analyzed. In order for the MAI to be calculated, the vessels being analyzed must have repetition of elements (ie. multiple punctates, bosses, incised lines etc.) (Smith 1998). If a vessel is plain or too broken to illustrate a repetition of elements, they were excluded from analysis. Once the MAI has been determined, values were again grouped into the three categories of crude (1-1.5), fair (1.6-2.5), and fine (2.6-3).

5.3 Laboratory Procedures

5.3.1 Contamination Control

Great care was taken to eliminate any possibility of contaminating pottery vessels during analysis. Non-powdered gloves were worn when artifacts were handled to avoid adding further oils from human hands and cornstarch present in powdered gloves. Whenever possible, new lab materials were used, including disposable pipette tips, GC-MS vials and lids, and centrifuge tubes. To further ensure sterility, all non-disposable materials such as the glassware used for GC-MS residue extractions were thoroughly cleaned and autoclaved prior to use. Cross-contamination was avoided by storing each vessel collection separately, and each vessel or sherd was kept in its own individual bag or box. To assess the purity of the solvents used during GC-MS extractions, blanks of the tri-mixtures used to extract residue were sent for analysis along with the archaeological samples.

Contamination is an issue with all of the sample collections since many had been held in museums or university collections for decades. As such, they have been handled extensively, and had visible contamination including white-out, glue, and ink from labelling and reconstruction. The vessels from the Manitoba Museum as well as the ones from EcJw-1 were confirmed to have previously been cleaned using a wet brush and tap water. It is likely the samples from Lakehead had been washed as well. While cleaning artifacts is not ideal for residue analysis, it does allow for the potential removal of surface contamination. Since it is known that contaminants are present in the sample vessels (i.e. hand oils, white-out etc.), this can aid with interpretations as contaminants are more easily ruled out when they are known to be present in the results. As such, cautious interpretations of results were conducted and any possible contaminants were excluded from interpretations as will be discussed in Chapters 6 and 7.

5.3.2 In-Situ Reflected Light Microscopy

Microscopy was used to locate any visible residues and contamination on the surface of the sample vessels. Each vessel was examined using a Nikon SMZ800 microscope under magnification ranging from 15X to 64X. Interior and exterior surfaces were scanned, and any possible residues or sources of contamination were photographed and documented, along with their location on the vessel. Vessels with areas of interest were then examined under an Olympus BX51 microscope at 100X-500X magnification which allowed for more detailed images to be obtained. Residues were described based on their basic morphology and colour and are discussed in Chapter 6.

The physical form of many pottery vessels proved to be problematic for microscope examination. Many of the reconstructed vessels could not be examined due to their large size and irregular shape. Vessels that were examined often exhibited physical irregularities (i.e., the curve of the vessel, depth of decorative motifs) rendering it challenging to capture a single, detailed image as a flat surface was nearly impossible to create. As such, only very small slivers of the field of view could be focused on at a time. In order to capture an image of the entire area of interest, multiple photographs of the same area were taken by adjusting the focus to allow for each aspect in the field of view to be in focus. These photographs were then 'stacked' using ImageJ software into a single composite image.

Following physical and chemical residue removals, the surfaces of vessel sherds were re-examined under the Olympus BX51 microscope. This was done to see whether changes to the surfaces were visible and to discern whether residues were successfully removed. This step can also help determine whether further extractions are possible or necessary, and if the method of removal was effective or required additional testing. Results of these examinations are discussed in Chapter 6.

5.3.3 Transmitted Light Microscopy

As discussed in Chapter 3, transmitted light microscopy requires residues be removed and placed on a slide prior to examination. When chemical removals from the sample vessels was done to enable GC-MS analysis, a portion was placed on slides for microscopy. To prepare slides, 75 mL of the residue solution were pipetted onto each slide, allowed to dry, and then slide covers were mounted using Entellan new rapid mounting medium. Slides were then examined under an Olympus BX51 microscope at varying magnification to determine whether the residue removals had been successful and to see what types of residues were present. Documentation of residues followed a similar pattern as for reflected light microscopy, which included descriptions of morphology and colour. This was conducted with the objective of corroborating or adding to the identified compounds found using the other approaches. Descriptions of the residues are discussed further in Chapter 6.

5.3.4 Scanning Electron Microscopy (SEM)

As discussed in Chapter 3, SEM uses a focused electron beam to conduct detailed analysis of an artifact's surface, as well as analysis of what elements are present at a specific surface point. Since the SEM operates within a vacuum chamber, the porous nature of pottery sherds requires that they be prepared prior to use (Fraham 2014). Typically, samples will be coated in a conductive material such as gold or carbon to allow for proper functioning of the machine, however, this was not desirable for this study as it would damage the sample sherds. As such, preliminary tests to prepare the samples for SEM analysis were conducted in an effort to reduce moisture trapped within the porous pottery matrix. Tests first consisted of placing the sherds in clean, glass dishes and heating them inside a drying oven at 40-45° Celsius for a minimum of 48 hours. However, this proved to be ineffective at adequately preparing the samples. Drying samples in a desiccator was attempted next, and this proved to be moderately more effective. Drierite desiccant was first heated to 175° Celsius and then added to the base of the desiccator. Pottery samples were then placed on top in individual glass vials. Air was vacuumed out of the desiccator using a pump, and samples were left to dry for up to five days prior to SEM analysis. Even with this preparatory step, the vacuum took thirty minutes on average to reach the required level to even turn on the SEM for analysis.

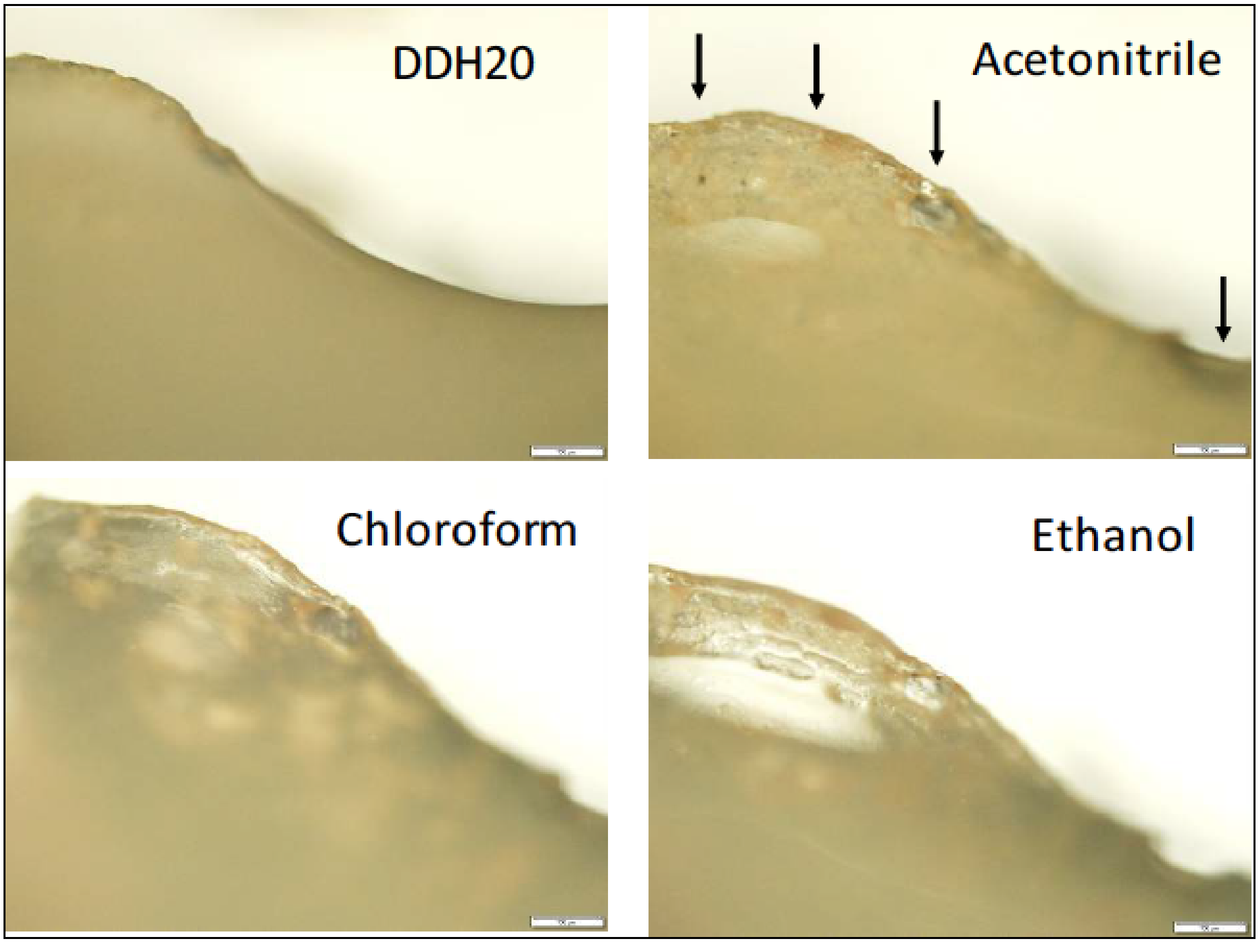
Use of the SEM was limited since few of the sample sherds were small enough to fit within the machine. Unfortunately, sherds which exhibited visible carbonized residues were amongst those too large to fit within the SEM, and as such, sherds exhibiting orange staining on their surfaces were analyzed instead. SEM analysis was used to photograph and take elemental analysis of the orange staining to see whether its components could be identified and assessed as either diagenetic staining or possible intentional ochre staining. Studies by Ownby et al. (2004), Charalambous et al. (2010), and Broekmans et al. (2004) which analyzed the composition of pottery paste as well as surface glazes were used as guides. To prepare the samples for entry into the SEM they were secured to a metal plate with carbon tape. Small pieces of copper tape were placed on two to three edges of the sherd and the plate to further secure the sherd as any movement will cause images to appear blurred. Once the sherds where placed within the machine, the vacuum was turned on and once it reached the appropriate level, the SEM was turned on and the surface of each sherd was scanned in a grid-like pattern. Multiple images of interesting features were captured, and elemental analysis was carried out. For the elemental analysis, three areas with visible orange staining and three areas without were analyzed for comparative purposes on each sherd. The elemental analysis was carried out by AZtecEnergy EDS software which was integrated within the SEM. It allowed for the elements in a specific area to be scanned and presented on a spectrum. Results are discussed in Chapter 6.

5.3.5 Residue Extraction

5.3.5.1 Solvent Selection & Solubility Tests

A solubility test on the glue present on the reconstructed sample vessels was conducted in order to select solvents for residue removal. This was done to prevent these vessels from being subjected to unnecessary damage during the extraction phase. A test was run on a small glue sample obtained from one of the reconstructed vessels from the Manitoba Museum. The glue used to reconstruct the vessels is believed to be Elmer's White Glue (Kevin Brownlee, personal correspondence). A small portion of glue was carefully removed using tweezers, placed in a glass petri dish, and viewed through an Olympus BX51 microscope. A series of chemicals were pipetted onto the glue and any changes to the glue were documented (see Figure 5.1). The chemicals tested

Figure 5. 1: Solubility Test



included: acetonitrile, anhydrous ethyl alcohol, DDH_20, chloroform, dicloromethane, and acetone. It was found that acetonitrile had an immediate and significant thinning effect on the glue, acetone had a slight thinning effect, and the rest of the chemicals had little to no effect. Following this test, two different solvent mixtures consisting of three chemicals each were selected. The tri-mixture for single sample sherds and non-reconstructed vessels consisted of acetonitrile, DDH_20, and anhydrous ethyl alcohol. Chloroform was selected as a replacement for acetonitrile for removals on reconstructed vessels, which were soaked in a tri-mixture of chloroform, DDH_20, and anhydrous ethyl alcohol so as to not affect the glue holding the sherds together. The effectiveness of each selected solvent is discussed below.

In addition to selecting solvents to accommodate the glue present on the reconstructed vessels, solvent selection for residue removal is dependent upon the targeted residues (ie. starches, carbohydrates, proteins etc.) as well as the category of artifact being analyzed (ie. pottery, lithic etc.). Utilizing a mixture of solvents that target various residues allows for a broader range of residues to be extracted (Evershed 2008; Loy 1997; Pearsall et al. 2004). Since the past use of small and miniature pottery vessels is largely unknown, the scope of this study was kept broad, allowing for the potential removal of all categories of residues that could be present with the use of a tri-mixture. As such, both tri-mixtures were selected to allow for removals to be effective at removing a variety of residues. Both acetonitrile and ethanol have been proven effective at removing hydrophobic compounds including lipids when mixed with water (Lin et al. 2007). When water is added to a mixture of solvents, it increases the polarity of the mixture which ensures the solubility of compounds damaged by oxidation (Brown and Brown 2011). While chloroform is not miscible with water and has been proven to be less effective than acetonitrile at removing residues (see Lin et al. 2007), it has been used successfully as a solvent to remove residues in multiple studies (Copley et al. 2005; Evershed et al. 2003; Fbuonasera et al. 2005; Mazzia and Glegenheimer 2014; Stott and Evershed 1996). Coupled with the results from the solubility test, chloroform was selected as a replacement for acetonitrile on reconstructed vessels. Ethanol is effective at dissolving resin acids (Cheng et al. 2013; Malarvizhi and Ramarkrishnan 2011). Unlike chloroform, acetonitrile is miscible with water and is proven to dissolve fatty acids and amino acids (Barnard et al. 2007).

5.3.5.2 Chemical and Physical Removals

There are various physical and chemical techniques for extracting residues, several of which were applied for this study. All sample vessels were subjected to a chemical removal while only three were subjected to a physical residue removal. Chemical removals can be conducted in a few ways. For lithics, the common technique is to soak and sonicate the working edge of the tool in a solvent within a glass vessel (Bouchard 2017; Cook 2014; Hodgson 2016). Alternatively, the standard methodology for extracting absorbed residues from pottery is destructive, requiring the sherd to be ground up or for a sample to be cored prior to being soaked in a solvent (Skibo 2013). The surface of the sherd is often ground off and discarded initially to get rid of possible surface contaminants (Skibo 2013). Chemical solvents are then added to the ground-up sherd and soaked before preparation for GC-MS analysis. A non-destructive methodology for extracting absorbed residues from pottery was developed for this project. This process closely follows the process used to extract residues from lithics although there are several differences as will be discussed below.

Prior to extracting residues, glass vessels and GC vials were autoclaved to ensure sterility. The extraction technique varied depending on the morphology, size, and fragility of each vessel, as well as whether the sample was reconstructed or not. Single sherds or reconstructed vessels that fit within one of the glass vessels were placed with the surface targeted for removal facing down. One of the tri-mixtures consisting of either double distilled water (ddH20), ethanol (EtOH), and acetonitrile (ACN) or ddH20, EtOH, and chloroform (CHCL) (1:1:1 v/v/v) was then pipetted into the vial to submerge the targeted surface area. Since vessels had been previously washed, a water sonication prior to residue removal, a common step in the literature (Cook 2014), was deemed unnecessary. As discussed earlier, these solvents are proven effective at breaking down a variety of organic residues, rendering them ideal for non-targeted residue removals to test the feasibility of this study.

If the glass container used to soak the sherds fit within the sonicator, the samples were sonicated for fifteen minutes. Typical studies following similar methodologies sonicate samples anywhere from five minutes up to an hour with the majority conducting longer sonication times (Bouchard 2017; Cook 2014; Hodgson 2016). However, due to the fragility of pottery and the feasibility-testing nature of this study, a shorter sonication time was selected to observe the effects sonication had on the samples, as well as to avoid complete removal of residues. Larger reconstructed vessels that did not fit within a glass vessel were instead carefully positioned on top of the vessel. The tri-mixture was pipetted onto the targeted removal area and allowed to soak into the area until it was saturated enough that the solvent would drip into the base of the glass vessel for collection. These samples could not be sonicated.

Physical removals were conducted on three sherds. In each instance, there was an extremely small amount of visible carbonized residue present on the surface of the sherds. Removals were conducted under a Nikon SMZ800 microscope using a scalpel and followed the removal procedure outlined in Surette's (N.D.) lab manual. The residue was carefully removed from the surface of the vessel and filtered into a glass GC vial using a clean funnel. Then, 1ml of tri-mixture consisting of ddH20, EtOH, and ACN was added to the vials which were then sonicated in order to agitate the carbonized residue within the solvent mixture. Soil samples analyzed for comparative purposes for this study were prepared using a similar approach. Soil was transferred into glass GC vials, saturated with tri-mixture, and sonicated.

Following removals, the residue solutions from chemical removals were placed into sterile 2ml glass GC vials with crimp-tops and left to evaporate at room temperature to a quantity of 1-2ml to avoid dilution. The liquid from the chemical and physical removals was then carefully transferred into new vials so as to not transfer any particulate matter. The vials were then frozen, and freeze-dried. In order to prepare the samples for entry to the GC-MS, 0.08-1ml of acetonitrile was added to the vials along with 0.1ml of BSTFA which derivatives the samples (a process which chemically changes the samples so that its properties are more suitable for a particular type of analysis) (Sellers 2010). The vials were then purged with nitrogen and crimp lids were tightly clamped on. Samples were then heated on a block heater at 121° degrees for thirty minutes. Samples were then ready to be run through the GC-MS.

There were many challenges that arose during the chemical residue removals. In addition to having an effect on the glue used in reconstructions, the acetonitrile also completely removed the nail polish, ink, and white-out present on multiple sample sherds in the form of labels. As it was often impossible to avoid extracting from areas without labels, permission was obtained from Kevin Brownlee, the curator of the Manitoba Museum collection, to continue with extracting from these sherds as new labels would be created at a later time. The porosity of the pottery sherds rendered them extremely absorbent, and a significant amount of the tri-mixture was required to adequately saturate the sherds and remove residues. Additionally, the porosity rendered it extremely challenging to target specific areas or surfaces as a significant amount of the solvents became absorbed within the pottery matrix. As such a large amount of tri-mixture was used in order to saturate the sherds to allow for at least 100ml of solvent with removed residue to be collected.

5.3.6 Gas-Chromatography Coupled Mass-Spectrometry (GC-MS)

Following residue removals, samples were prepared for analysis in the GC-MS as described above. GC-MS analysis was conducted in a Varian model 450 gas chromatograph coupled to a Varian model 300-MS quadruple mass spectrometer with a FactorFourTM capillary column. Samples were introduced with an autosampler in splitless mode at an injection port with a temperature of 270°C with helium as the carrier gas. The column temperature was for two minutes at 50°C at the input, and then increased to 155°C at 8°C a minute. Following this, the temperature was increased further to 275°C at 40°C a minute which was held for nine minutes. The ion source was set at 200°C under electron ionization conditions which produced ionization energy of 70eV. The GC-MS interface temperature was set to 266°C and a scan range of 40-500 m/z was used. Altogether, 153 residue samples were analyzed in the GC-MS. The results were analyzed using Varian MS Workstation (Version 6) and the NIST98 Mass Spectral Database. Peaks above the general background static were recorded and compared with the comparative library. Some studies use a minimum threshold and only record peaks above it which have a higher probability of being identified and matching components in the comparative library (see Cook 2014). This was not done for this study due to a mixture of samples from sites with podzolic soils, and to test the success of the residue removal technique by collecting even small amounts of potentially authentic or informative data. Relevant peaks were compared and matched with compounds from the database, or examined further if no match was found. Chemicals that were identified as likely deriving from a contaminant were noted and excluded from archaeological interpretations. The results from the GC-MS analysis are discussed in Chapter 6.

5.3.7 Starch and Phytolith Analysis

As there was a lack of carbonized residues on the miniature and small vessels from the three collections, limited microfossil analysis was conducted. There were three sample vessels with carbonized residue. The residues from all three vessels were physically removed with a scalpel as described above. Following GC-MS analysis, the residues were prepared for microfossil analysis. However, it was found that only one of the samples, HiLp-1 V.28 had enough residue to process for microfossils (only 5.1mg). The procedure to extract microfossils from the sample followed the lab manual adapted by Surette (N.D.) which was originally based on Chandler-Ezell and Pearsall (2003) and Horrocks (2005). Due to the limited amount of residue, the sample was only processed for starch grains. However, phytoliths often end up being extracted using this approach as well. To process the sample, the residue was placed in a 50mL centrifuge tube and 5ml of a 6% solution of hydrogen peroxide (H_20_2) was added. The solution is used to extract starch and the diluted solution is used to reduce the possibility of starch destruction. The sample was then placed in an orbital shaker at 1400 rpm for ten minutes. The sample was then filled to the 50 mL line with water and centrifuged for five minutes at 3000 rpm. The supernatant was carefully removed without disturbing the residue. This step was repeated twice more to ensure the removal of the hydrogen peroxide. The sample was then sieved through 118µm nitrex cloth to filter starch grains from the remaining carbonized material. Phytoliths, pollen, and other microfossils may also pass through the cloth, allowing them to be noted and analyzed when viewing the sample under a microscope. The sample was then placed in a microcentrifuge tube, filled with ethanol, and then mounted onto a slide for analysis. Analysis of microfossil slides took place under an Olympus BX51 microscope and identifications were made using Surette (2008); Lints (2012), and Brown (1984). Potential starch grains were viewed under both plane and cross-polarized light.

5.4 Conclusion

Pottery is a challenging material type to work with. Its porosity and irregular shapes and sizes required multiple adjustments to the methodology and prevented many sample vessels from being analyzed with certain techniques. There were additional challenges presented by this particular sample as well, including the general fragmented nature of the vessels, high amounts of contamination, and the lack of visible residues. These challenges coupled with the non-destructive nature of this study rendered the data collection phase extremely labor-intensive and time-consuming. While non-destructive techniques are essential when working with unique objects, especially ones from museum collections, they are also limiting. Creating or altering techniques to accommodate a sample is not always possible for studies with limited resources. However, the ability to analyze a material type that has never previously been the focus of intensive study through a comparison of its physical attributes and organic residue analysis is unique, and allows this study to focus on both the results of the analysis as well as the feasibility of the methodology. The results of this intensive data collection will be discussed in Chapter 6.

Chapter 6: Results

6.1 Introduction

This chapter presents results from the various approaches used to analyze the sample vessels. The results are separated into two sections, with the first discussing the results from documenting the physical attributes of the vessels, and the second presenting the results of the residue analysis techniques. The sample collections are discussed together, and comparisons are made between all sample vessels, including the three different vessel categories. While the focus of the results is on small and miniature vessels, full-sized vessels are discussed when comparisons are necessary.

6.2 Pottery Attributes

This section discusses results from the documentation of physical attributes of the sample vessels during the initial cataloguing phase as described in Chapter 5. Each vessel was catalogued and descriptions included nineteen attributes and categories of information (see Table B.1), which loosely followed Syms and Dedi's (2006) museum cataloguing guidelines. Features selected for the small and miniature vessels included both quantitative and qualitative attributes ranging from the shape and thickness of the neck, lip, and base, to vessel decorations, to capturing unique measurements tailored specifically for small and miniature vessels (Smith 1998). Pottery vessel attributes will be discussed in categories, and the various collections will be discussed together based on similarities of their results.

6.2.1 Miniature and Small Vessels

Overall, twelve sample vessels were assessed as miniature or possible miniature, while thirty-five were assessed as small or possible small vessels (see Table B.2). The circumference measurements for miniature and small vessels from this sample range from 9.42cm to 13.18cm, and 15.7cm to 40.82cm respectively (Tables D.1 and D.2). Comparatively, the circumference of full-sized sample vessels ranges from 37.68cm-136cm (Table D.3). Much greater variation is seen in the small and full-sized vessel categories. There is overlap between the small and full-sized ranges, which illustrates the importance of incorporating other factors and measurements, such as height, when trying to assess vessels as the circumference alone could be misleading. As discussed in Chapter 2, miniatures are extremely small vessels, and there is much less variability in their size when compared to small vessels that have a much wider range. As such, it is typically quite obvious when a vessel falls into the miniature category, with the exception of fragmented single sherds. Items that are identified as "possible" miniature or small vessels were assessed as such due to their fragmented nature; the majority of which consist of a single broken sherd. While it can often be ascertained that the sherd does not belong to a full-sized vessel, it is sometimes difficult to be certain whether the sherd is from a miniature vessel or a small one. However, at times, the circumference or diameter measurements can help distinguish between the two categories. Due to this, these vessels were associated with the category deemed most likely. This sample represents a fraction of the number of vessels of this kind that exist in the archaeological record of North America, although it should be noted that these types of vessels are vastly outnumbered by the recovery of regular sized vessels. With thirty-five vessels making up 74% of the sample, small vessels are much more prominent in the sample than miniature vessels which consist of twelve vessels, or 25% of the sample (see Table C.1).

6.2.2 Vessel Form and Finish

6.2.2.1 Vessel Profile, Neck, Rim, Lip, Shoulder, and Base Shape

The profile of a vessel refers to its overall shape. One miniature vessel was found to have a conical shape (see Table C.2). Six small vessels had enough of the vessel present to have their profiles documented, of which four were globular in shape, one was conoidal, and one was a mix of globular and conoidal (see Table C.3). None of the full-sized vessels allowed for profile assessments as all were fragmented sherds (see Table C.4).

Documenting the neck portion of a vessel consists of a description of the upper portion of the vessel ranging from just below the neck to the lip (Syms and Dedi 2006). Straight necks were represented the most in the small and miniature categories, with six miniature vessels and sixteen small vessels exhibiting this type of neck shape (see Tables C.2 and C.3). Comparatively fewer full-sized vessels had straight necks, with only four falling into this category (see Table C.4). Excurvate necks were also well represented, with three miniatures, thirteen small vessels, and eleven full-sized vessels exhibiting this form of neck (see Tables C.2, C.3, and C.4). Additionally, seven full-sized vessels had slightly excurvate necks, making excurvate the most represented shape for full-sized vessels (Table C.4). One small vessel had a convex shape, one miniature had a straight but slightly convex neck shape, and one was straight but slightly converging inward (see Tables C.2 and C.3).

Lip shape refers to the general shape of the lip portion of a vessel. The lip shape of several of the miniature and small vessels were challenging to put into categories as many of them exhibited some type of lip decoration (i.e. notching) which affects the overall shape. Four miniature vessels had squared lips (two of which were affected by decorations), five had rounded lips, and two had rounded edges and a squared surface (see Table C.2). Rounded lips were the most prominent shape for the small sample vessels with nineteen of the vessels exhibiting this form, five of which were slightly skewed by decorations (see Table C.3). Eight of the small vessels had squared lips, two of which had decoration, one slightly sloped down, and one was squared but slightly angled forward (see Table C.3). Similar to the miniature vessels, there were several small vessels that exhibited a hybrid squared and rounded lip. Four had rounded edges but a squared top, and two had squared edges with a rounded top (see Table C.3). The lip shapes of full-sized sample vessels were more variable than the other two vessel types. Four full-sized vessels had rounded lips (two of which had decoration), one had squared edges with a pointed top, six were squared (two were affected by decoration), three exhibited exterior wedging, three were squared with exterior wedging, two had rounded edges but with a squared top, and two had in-sloped lips, of which one was affected by decoration (see Table C.4).

Due to the fragmented state of the majority of the sample vessels, there were significantly fewer sherds and vessels with an intact base or shoulder to be observed. Shoulder shape is a description of the amount of angular inflection, and slight or no rounding was the most exhibited form represented in the sample (Syms and Dedi 2006). One miniature vessel, nine small vessels, and one full-sized vessel had slight to no rounding on the shoulder area (see Tables C.2, C.3, and C.4). One miniature vessel and two small vessels had marked rounding, and one small vessel had a concave shoulder (see Tables C.2 and C.3). Regarding base shape, rounded was the only type represented for the sample vessels, with one miniature and five small vessels exhibiting a round base (see Tables C.2 and C.3).

6.2.2.2 Paste Composition and Surface Finish

The surface finishes for the sample vessels from all three categories are relatively similar, with smooth and textile impressed surfaces being the most prominent along with fine or medium grit temper. The eight miniature vessels that were able to be assessed for surface finish all had a smooth finish, and all miniature vessels had a fine grit temper ranging from low to high densities (see Table C.5). The surface finish of small vessels ranged from smooth, to obliterated, to textile impressed finishes, and temper ranged from natural to coarse grit (see Table C.6). Smooth surface finishes were the most predominant on the small vessels, along with a fine grit temper. Almost all the full-sized vessels had a textile impressed surface finish, and the majority had a fine or medium temper (see Table C.7).

6.2.3 Decorative Motifs

The most common lip decoration on miniature vessels was notches, particularly fingernail notches (see Table C.8). The lip portion of small sample vessels were also predominantly decorated with notches as well as CWOI (see Table C.9). Notches and CWOI were the predominant decoration on the lip portion of full-sized sample vessels as well (Table C.10).

Typically, the most highly decorated portion of a vessel is the rim area. On the small and miniature vessels, this area was predominantly decorated with punctates, stamps, and CWOI (Tables C.8 and C.9). Similarly, full-sized vessels did not deviate from this trend, as the predominate decorations on full-sized rims were also punctates, stamps, and CWOI (see Table C.10). Other rim and neck decorations included pseudo-scallop shell impressions and incised lines. Different shapes of stamps, such as oval, crescentic, square, rectangular, and some irregular shapes were present on the vessels as well (see Tables C.8, C.9, C.10).

All of the miniature sample vessels that had visible body portions had a smooth finish, while small vessels had almost equal amounts of smooth and textile-impressed finishes (Tables C.8 and C.9). Comparatively, the vast majority of full-sized vessels that had visible body portions were textile-impressed (see Table C.10).

Interior decorations were present on pots in all three categories of vessels. Bosses, which generally corresponded with exterior punctates, were the most common interior decoration for all size categories (Tables C.8, C.9, C.10). A few small vessels had what appeared to be brush marks or striations of some kind, which could be the result of the manufacturing process. The most unique interior decorations were seen on vessel HlLv-6 V.4 which had 2 interior rows of bosses and textile impressions throughout the rest of its interior. Full-sized vessels had a few additional interior decoration types as well. Vessel EcJw-1 V.15 had interior punctates, and vessel DbJm-5 V.4 had interior right, parallel, oblique stamps.

Not including surface finish, which may have been a result of the manufacturing process, five miniature vessels, nine small vessels, and eleven full-sized vessels had no visible decorations (Tables C.8, C.9, C.10). There were also several vessels that had unique decorative traits. The exterior lip portion of one of the miniature vessels (DbJm-2 V.2) was pinched to form a ridge, something that was not seen on sample vessels from any of the other categories. Several sample vessels from the EcJw-1 site had crescent-shaped stamps, which included miniature vessels and one small vessel. It is possible that these vessels had been decorated using the same tool. Vessels HfLp-11 V.3 and HiLp-1 V.25 (both small vessels) had a similar irregularity on their rim and neck portions. Both vessels had encircling rows of punctates with one additional punctate that was situated slightly lower but in close proximity to the row of punctates. Both vessels were broken in the same area, directly adjacent to the lone punctate, but it is possible that the missing portions would have had further punctates. A few vessels from the EcJw-1 site had stamps with an interior impression consistent with some type of pronged instrument being used to make the motif. This was seen on small and full-sized vessels from this site.

Without including surface finish, the maximum number of motifs seen on the miniature vessels was six, although only one vessel featured this amount of decoration (DbJm-2 V.2). One miniature vessel had four motifs, while the rest of the vessels that were decorated had no more than two or three designs (Table C.8). The maximum number of decorations seen on small vessels was four, although the majority of small vessels were decorated with two to three different types (Table C.9). Comparatively, there was a larger number of full-sized vessels with more than four decorative motifs, with the maximum amount of decorations seen on these vessels being five (Table C.10).

6.2.4 General Measurements

The average thickness of the body portion of miniature vessels is 7.265mm and measurements range from 4.68mm to 9.31mm (Table D.4). The small vessels have an average body thickness of 6.81mm and range from 3.67mm to 10.78mm (Table. D.5). Comparatively, the average thickness of the body portion of the full-sized vessels from the sample is 5.86mm and measurements range from 4.05mm to 8.79mm (Table D.6). The average thickness of full-sized vessels is thinner than both the small and miniature vessels, and significant variation in thickness is seen within all three categories.

Rim thickness measurements for miniature vessels range from 3.38mm to 7.29mm with an average thickness of 5.63mm (Table D.4). The average rim thickness for small vessels is 5.94mm and measurements range from 3.06mm to 10.56mm (Table D.5). 6.77mm is the average rim thickness for full-sized vessels, and measurements range from 4.2mm to 8.84mm (Table D.6). In this instance, miniature vessels have the smallest average rim thickness, and the average increases with each vessel type.

Average lip thickness for miniature vessels is 4.61mm, and measurements range from 2.54mm to 6.29mm (Table D.4). Measurements for small vessels range from 3.19mm to 9.38mm with an average of 5.54mm (Table D.5), while full-sized vessels have an average lip thickness of 8.41mm and range from 5.1mm to 13.02mm (Table D.6). Similar to rim thickness, the average lip thickness measurements are smallest for the miniature vessels and increase in both remaining vessel types.

The average height of miniature vessels is 35.35mm and 78.33mm for small vessels (Tables D.4 and D.5). None of the full-sized vessels allowed for this measurement to be taken as all full-sized sample vessels consisted of sherds. It should be noted that the miniature vessel measurement is based on one vessel, while the small vessel average is based on four vessels, and therefore it is difficult to make any accurate conclusions pertaining to these measurements.

6.2.5 Crudity Index, Curvature Consistency Index, and Motif Application Index

Forty-three out of forty-nine sample vessels were able to be assessed for their Crudity Index (CI) (see Table D.7). Thirty-four of the vessels fell under the 'fine' category, eight fell under the 'fair' category, while only one vessel was assessed as 'crude.' Twenty-one vessels were assessed for their Curvature Consistency Index (CCI) (see Table D.8). Sixteen vessels were assessed as 'fine,' four as 'fair,' and only one as 'crude.' A total of twenty-seven vessels were able to have their Motif Application Index (MAI) assessed. Results differ from both the CI and CCI as only four vessels were assessed to be 'fine,' while fourteen were found to be 'fair,' and nine were 'crude' (Table D.9).

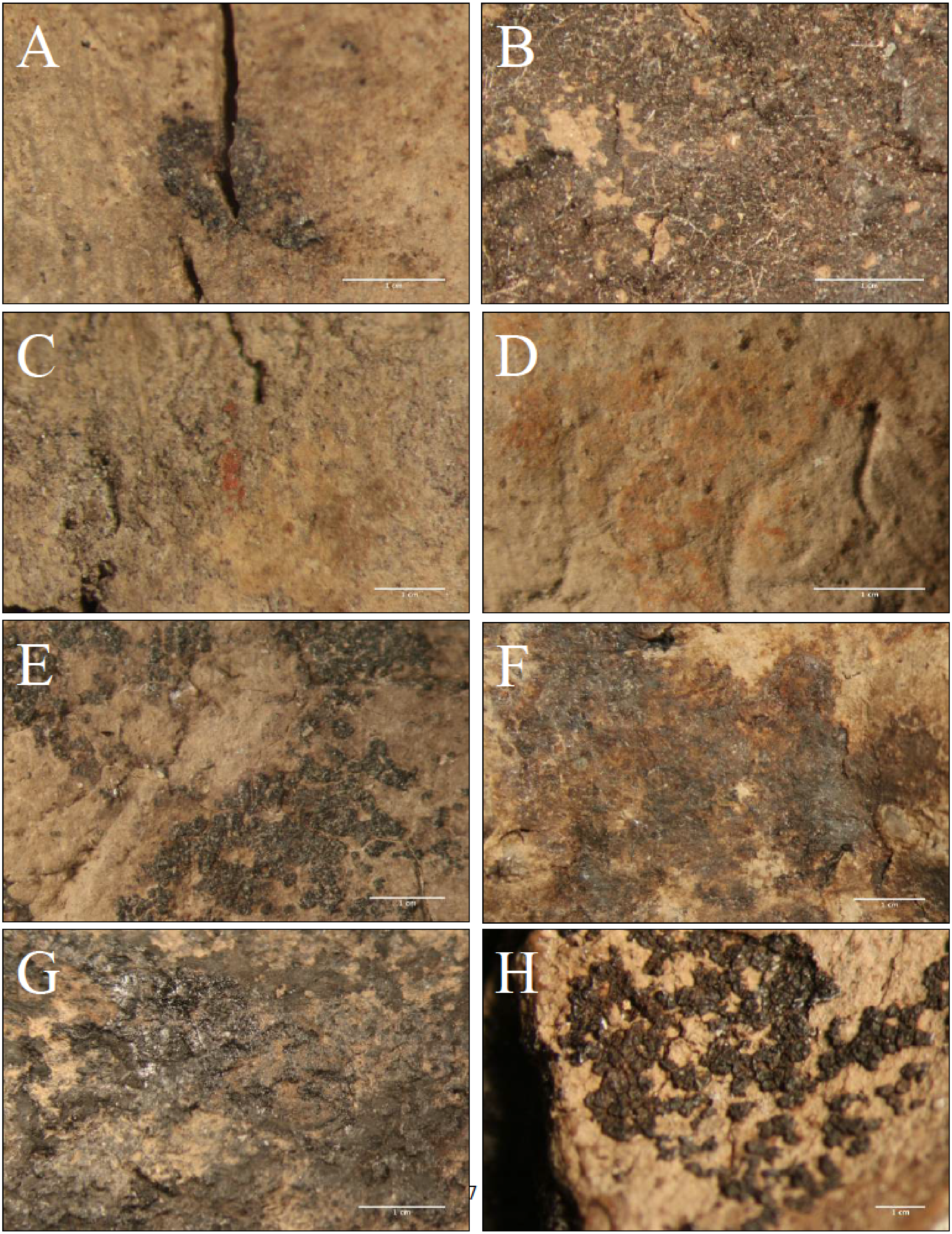
6.3 Results of Organic Residue Analysis

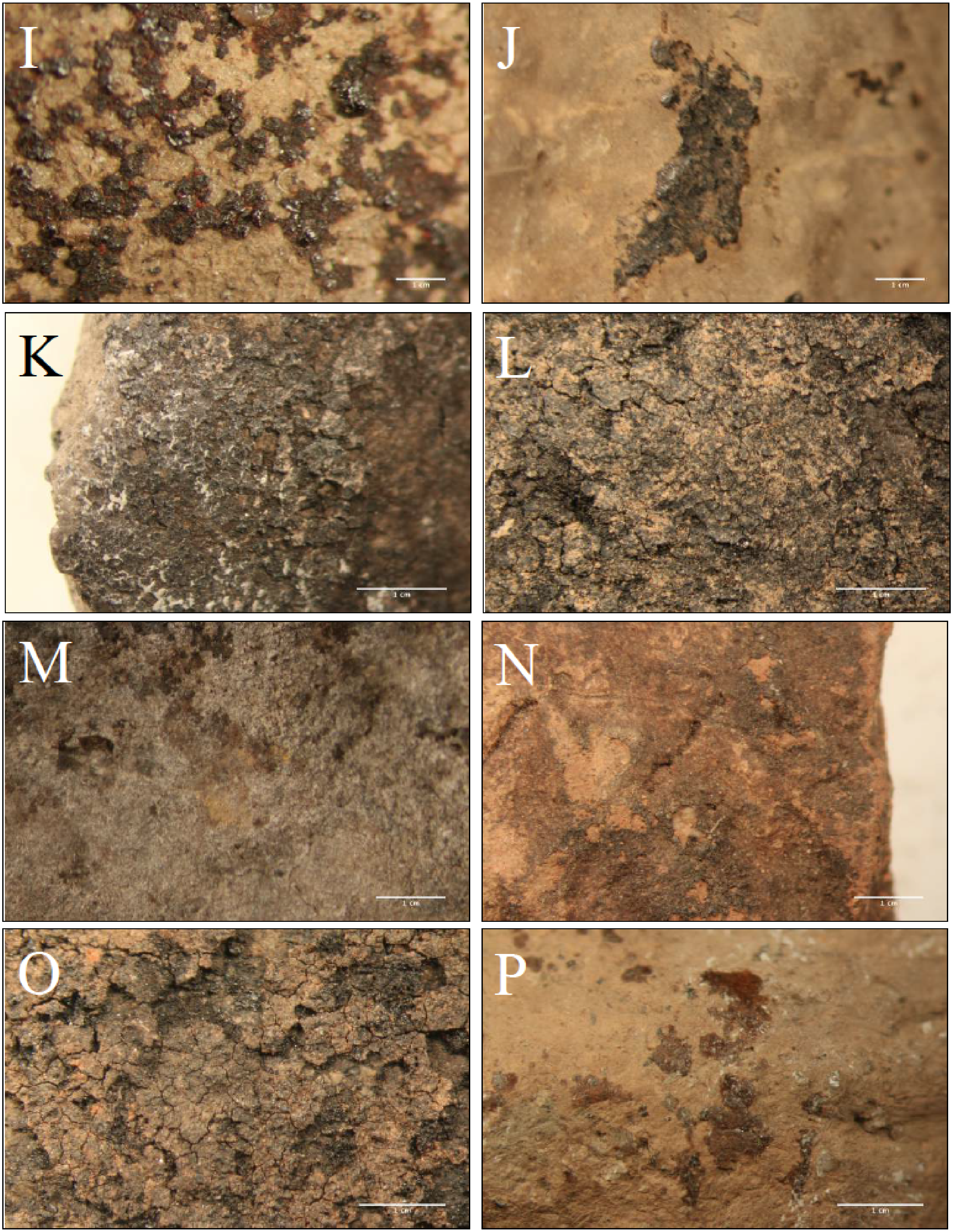
This section discusses results from the suite of residue analysis conducted on the sample vessels, including findings from *in-situ* reflected light microscopy, transmitted light microscopy, scanning electron microscopy, gas chromatography coupled mass spectrometry, and microfossil starch and phytolith analysis. Certain methods were found to be more successful than others, and each method's applicability to the sample is briefly discussed. Contamination as well as potential archaeologically significant findings are discussed, including the challenges of distinguishing between the two.

6.3.1 In-Situ Reflected Light Microscopy

As discussed in Chapter 5, microscopy was used to locate any visible residues and evidence of contamination. A small amount of potentially authentic residues and a large number of contaminants were located (see Table E.1 and Figures 6.1 and 6.3). Overall, there was a significant lack of identifiable organic residues located, with the majority being amorphous in appearance, or likely the result of contamination (Table 6.21, Figures 6.1 and 6.3). There were multiple vessels with a prominent, unidentified orange staining, including several from EcJw-1 (Vessels 8, 7, 9, 13, 14, 17, 20), two from Martin Bird (Vessels 1 and 2) and two from McCluskey (Vessels 2 and 19) which included small and regular sized vessels (see Figure 6.1). Four of these sherds were further examined with an SEM and results of this examination will be discussed below. One small vessel (FlMh-1 V.1) had a very limited amount of carbonized residue, while small vessel (HiLp1 V.25) had traces of possible carbonized residue (see Figure 6.1). A small vessel from McCluskey had an amorphous residue on its surface (Vessel 4) (Figure 6.1). Possible miniature vessel (FkMh-5 Vessel 54), and small vessels (HiLp-1 V.28, HiLp-3 V.24) had similar types of possibly organic residue present on their surfaces; however, this could be traces of soil adhering to their surfaces as well (see Figure 6.1). Three comparative full-sized vessels from EcJw-1 had possible organic residue material, including an amorphous looking residue and some grey, ashy

Figure 6. 1: Possible Residues

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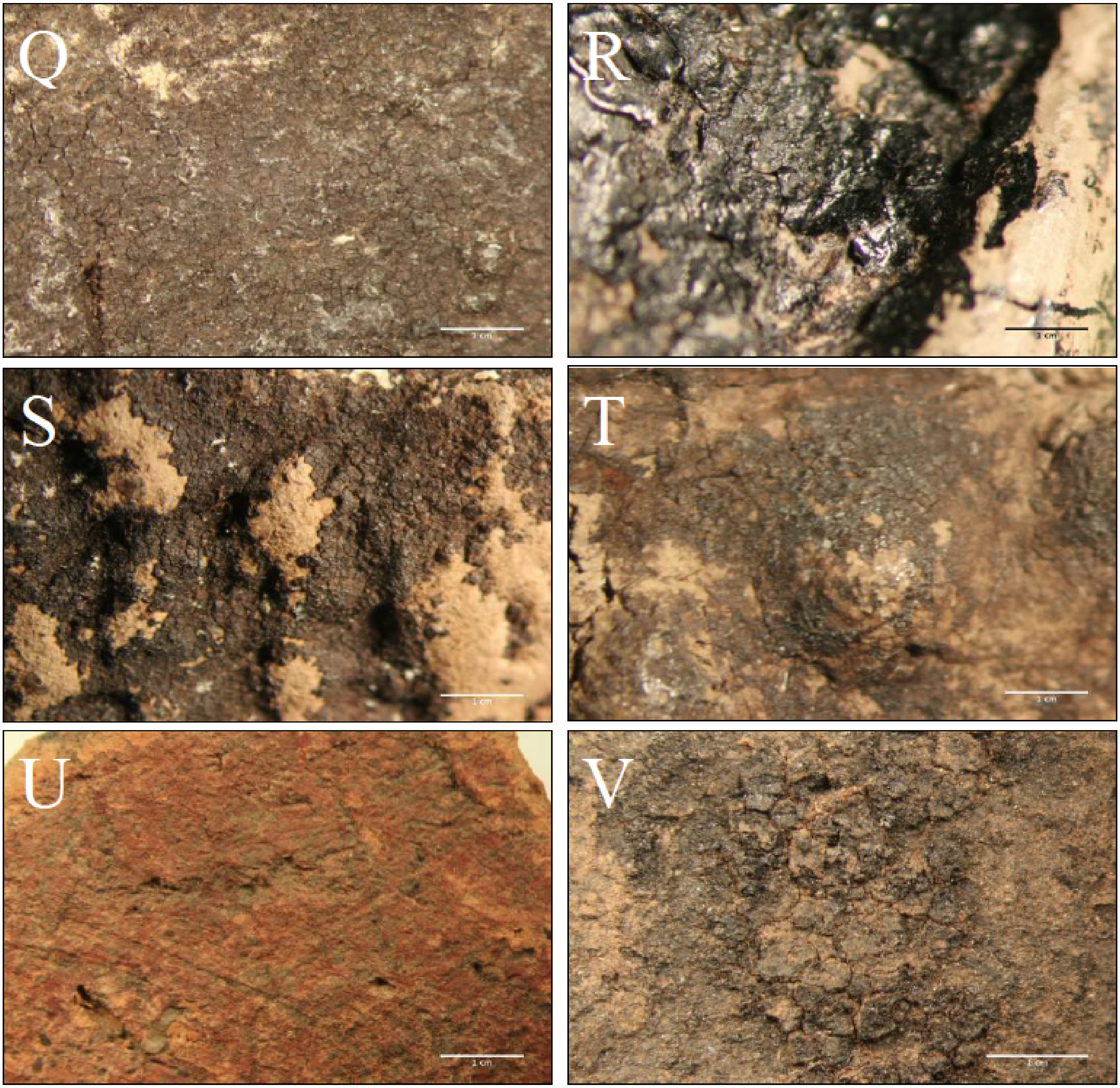
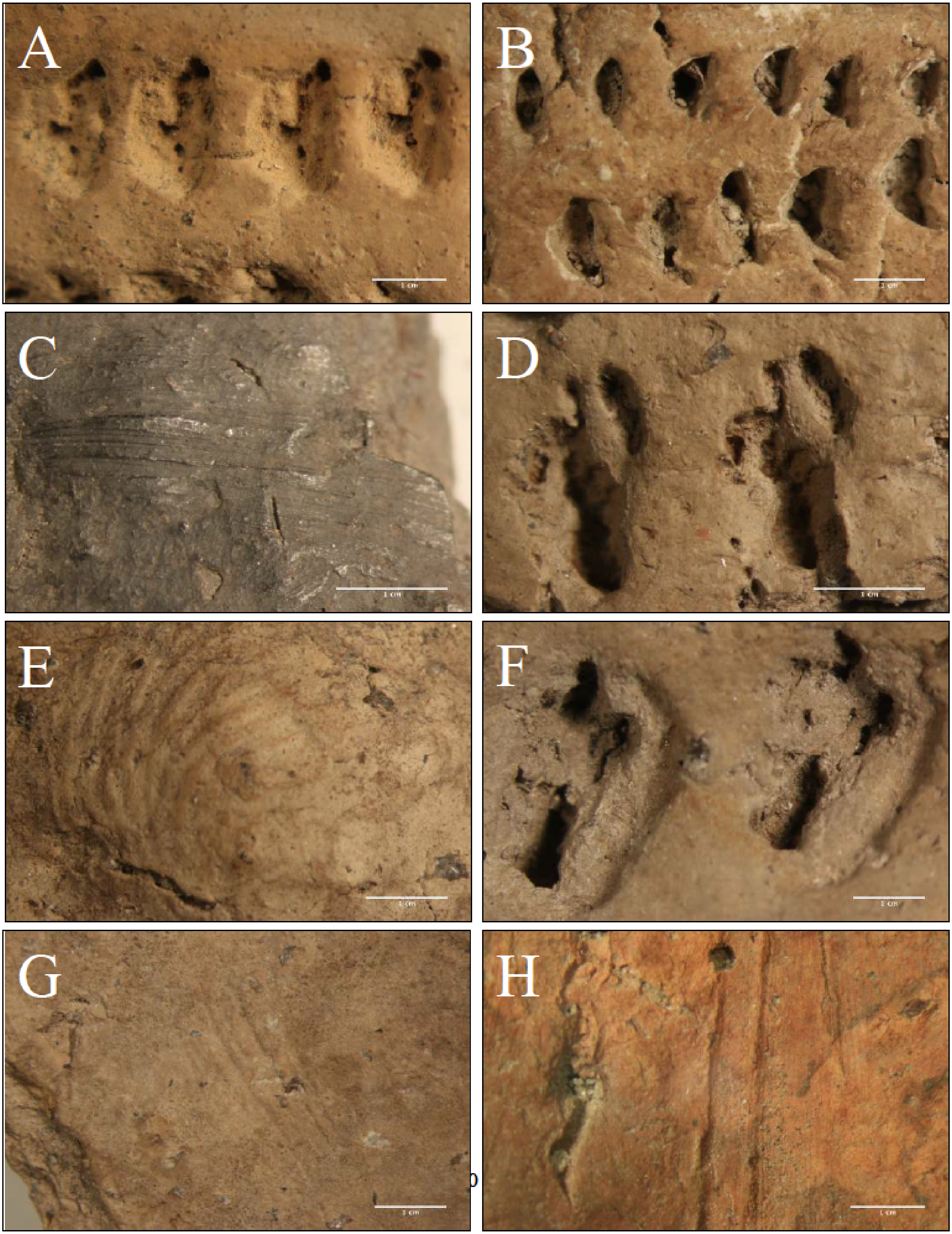
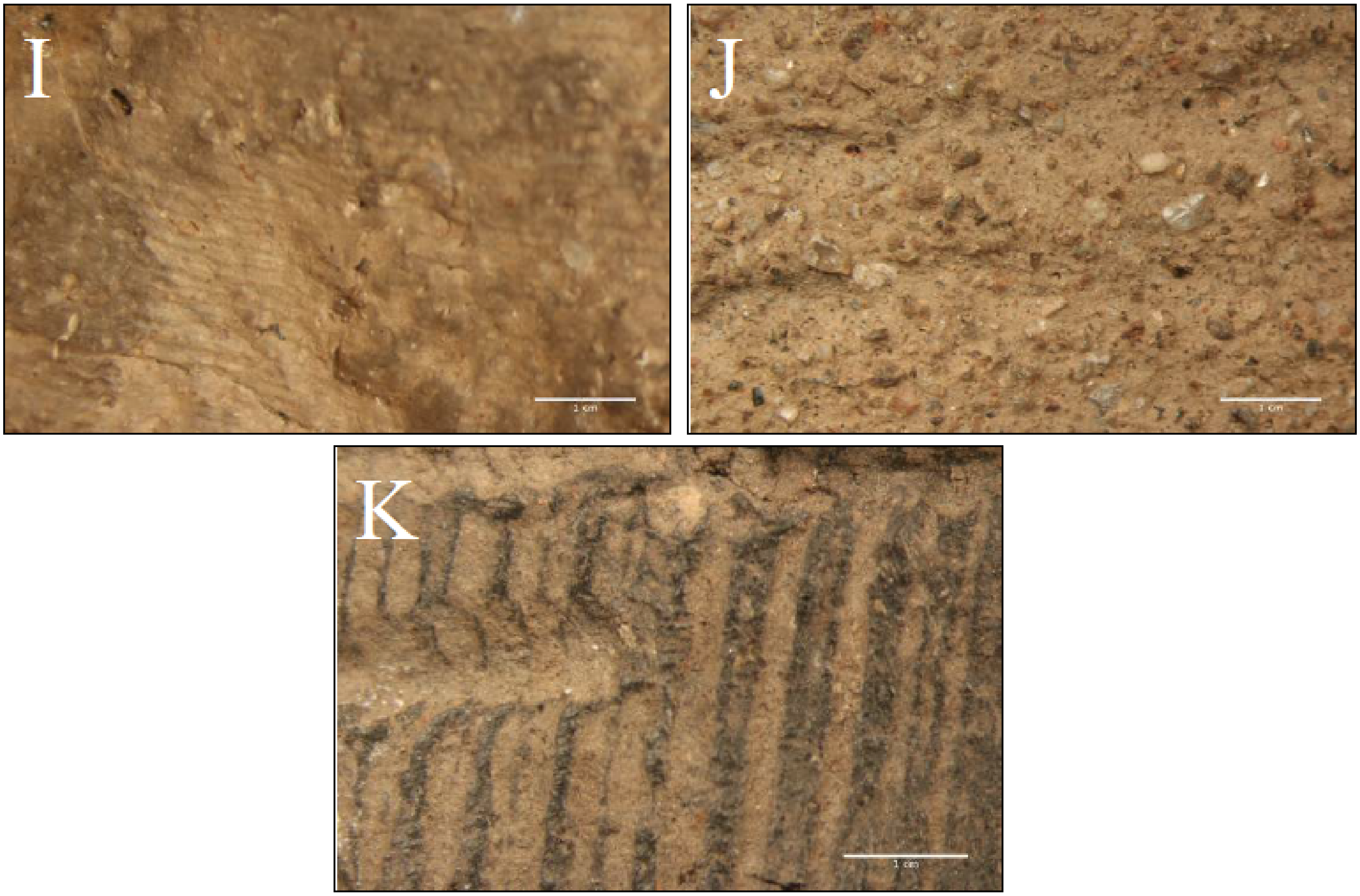


(A): Possible residue on FkMh-5 V.54; (B): Residue on HiLp-3 V.24; (C): Amorphous red/orange residue on EcJw-1 V.8; (D): Orange staining on surface of EcJw-1 V.9, likely due to weathering or oxidation when the vessel was fired; (E): Possible carbonized residue on surface of EcJw-1 V.15; (F): Amorphous residue or staining on surface of EcJw-1 V.18; (G): Residue on DbJm-2 V.16; (H): Residue on HiLp-1 V.25; (I): Carbonized residue covering red amorphous residue on HiLp-1 V.25; (J): Black amorphous residue on HfLp-11 V.3; (K): Possible organic residue on DbJm-2 V.15; (L): Possible organic residue on DbJm-2 V.17; (M): Ashy residue on EcJw-1 V.16; (N): Possible residue on DbJm-5 V.2; (O): Possible organic residue on DbJm-5 V.6; (P): Amorphous residue on DbJm-2 V.4; (Q): Possible residue on HiLp-1 V.28; (R): Carbonized residue on FlMh-1 V.1; (S): Possible residue on HiLp-1 V.28; (T): Possible residue on HiLp-1 V.25; (U): Orange staining/oxidation on DbJm-5 V.1; (V): Possible residue on DbJm-5 V.5

Figure 6. 2: Decorative Motifs



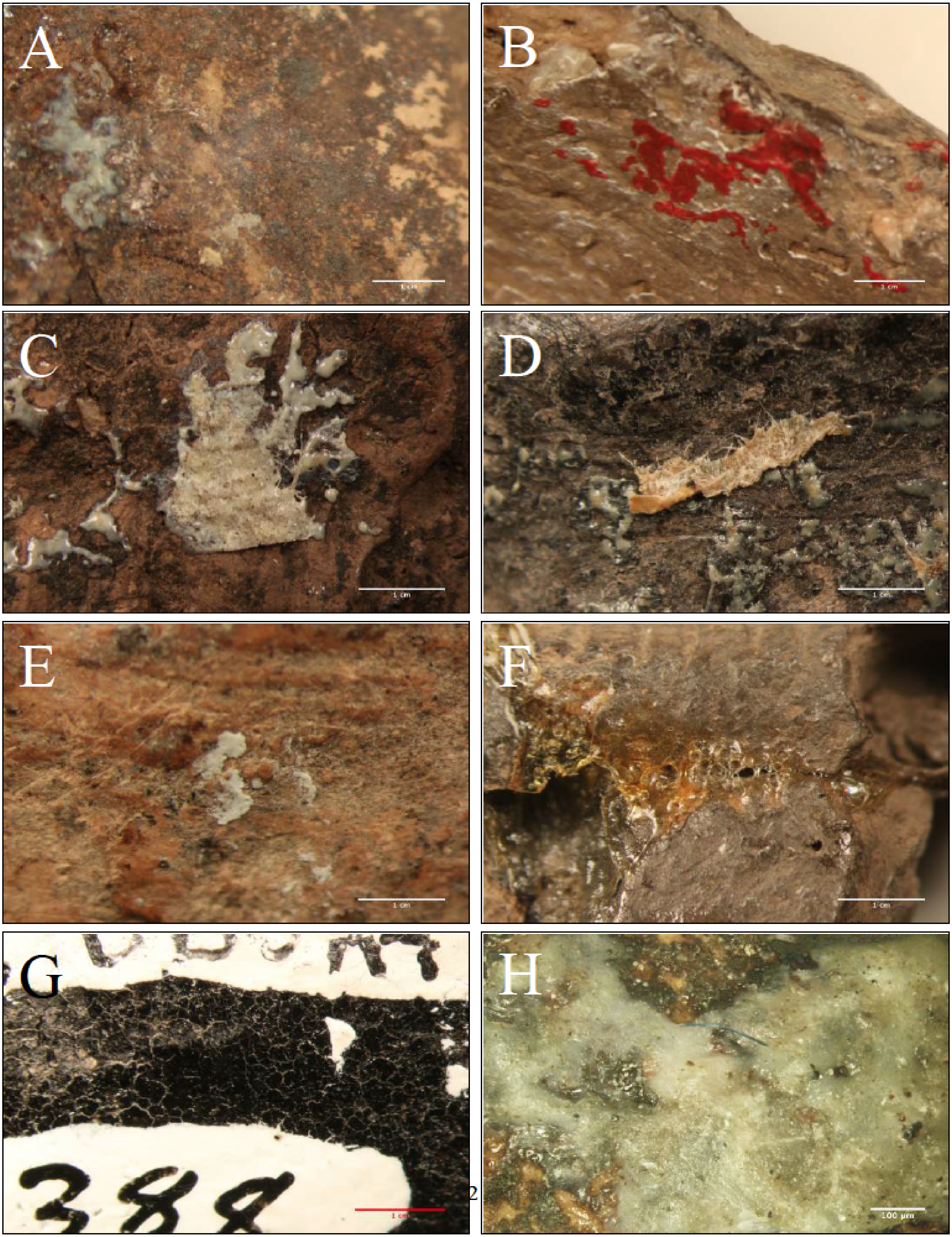


(A): Unique punctate markings on EcJw-1 V.1; (B): Crescentic (half-moon) shaped punctates on EcJw-1 V.3; (C) Striations on the interior of vessel EcJw-1 V.10; (D): Unique punctate markings, similar to ones in image A, vessel EcJw-1 V.12; (E): Fingerprint on vessel EcJw-1 V.13; (F): More unique punctate markings on EcJw-1 V.14; (G): Striations on surface of EcJw-1 V.19; (H): Striations and orange staining on EcJw-1 V.20; (I): Striations on surface of GjLs-2 V.1; (J): High concentration of temper on vessel DbJm-3 V.2; (K): Decorations and discolouration on DbJm-2 V.10

residue (see Figure 6.1). Three regular sized vessels from Martin Bird had visible residues on their surfaces (Vessels 2, 5, 6), and three full-sized vessels from McCluskey had carbonized residue (Vessels 15, 16, 17) (Figure 6.1).

A significant number of sample vessels, including small, miniature, and full-sized vessels had one or more forms of modern contamination (Table 6.3). Contamination from the cataloguing

Figure 6. 3: Examples of Contamination



(A): Glue on HiLp-1 V.121; (B): Amorphous red residue, the result of some kind of modern contamination on GjLs-2 V.1; (C): Glue on DbJm-5 V.3; (D): Glue and fibres on DbJm-2 V.1; (E): Contamination on DbJm-2 V.6; (F): Glue on DbJm-2 V.1; (G): Whiteout, ink, and nail polish on DbJm-2 V.15 (was potentially placed over residue); (H): Glue and blue fibre on HiLp-1 V.121

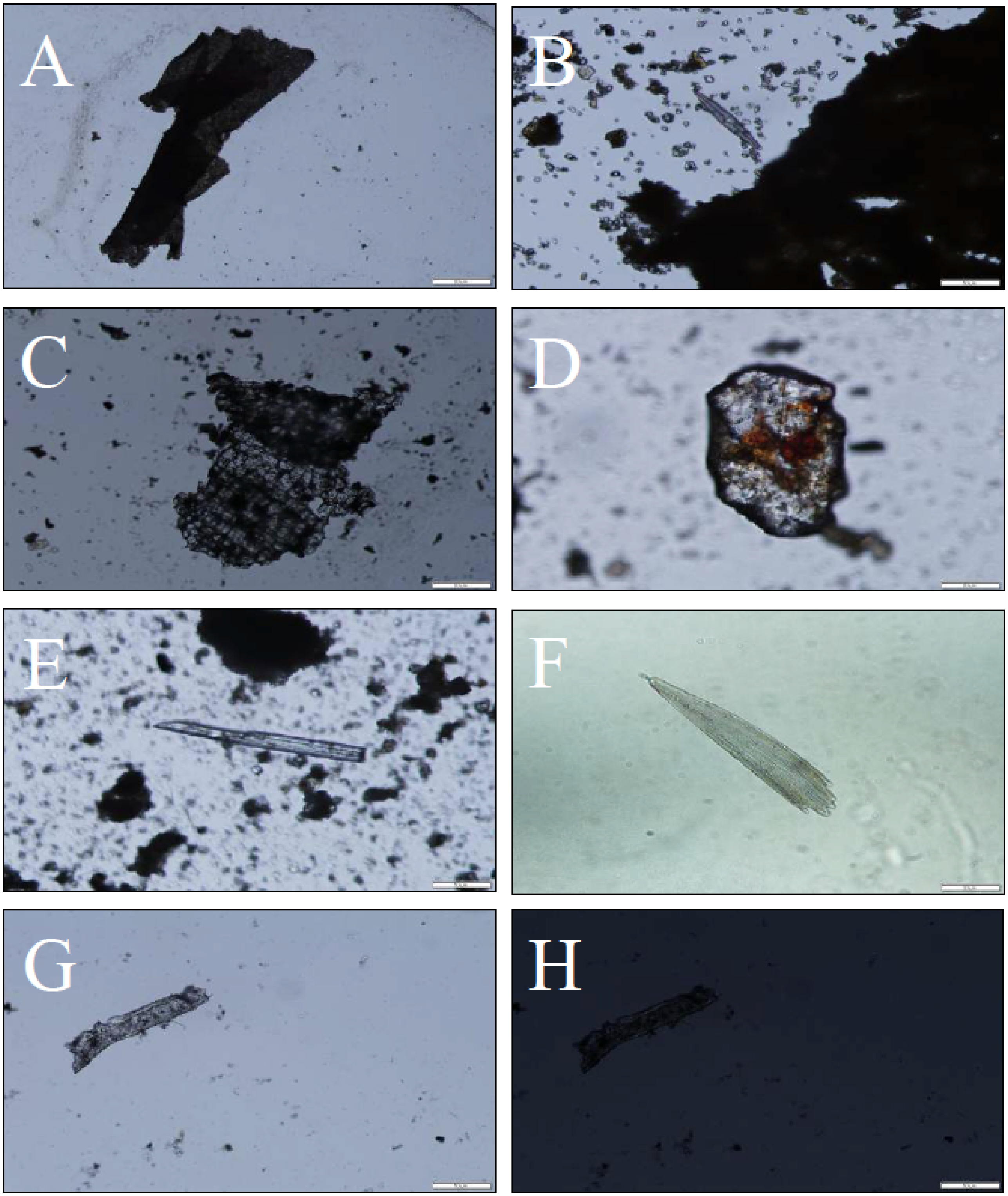
process was prominent, and included the presence of glue, white-out, ink, and nail polish (see Table E.1 and Figure 6.3). Other forms of contamination, such as homogenous and amorphous red and gray substances were located on several vessels (including GjLs-2 V.1 and DbJm-2 V.6), likely from plasticine used to take molds of a sherds' surface (see Figure 6.3).

As there was a significant lack of identifiable organic residues present, vessels with unique attributes, such as striations or distinct decorative motifs were documented as well. Vessels EcJw-1 V.1, EcJw-1 V.12, and EcJw-1 V.14 had unique punctate markings and may have all been decorated using the same tool (Figure 6.2). Several vessels had deep striation or brushing marks on the interior or exterior which could have occurred during the fabrication process, during use, or in post-deposition (Figure 6.2). This included two vessels from EcJw-1 (Vessels 19 and 20), and vessel GjLs-2 V.1 (see Figure 6.2).

6.3.2 Transmitted Light Microscopy

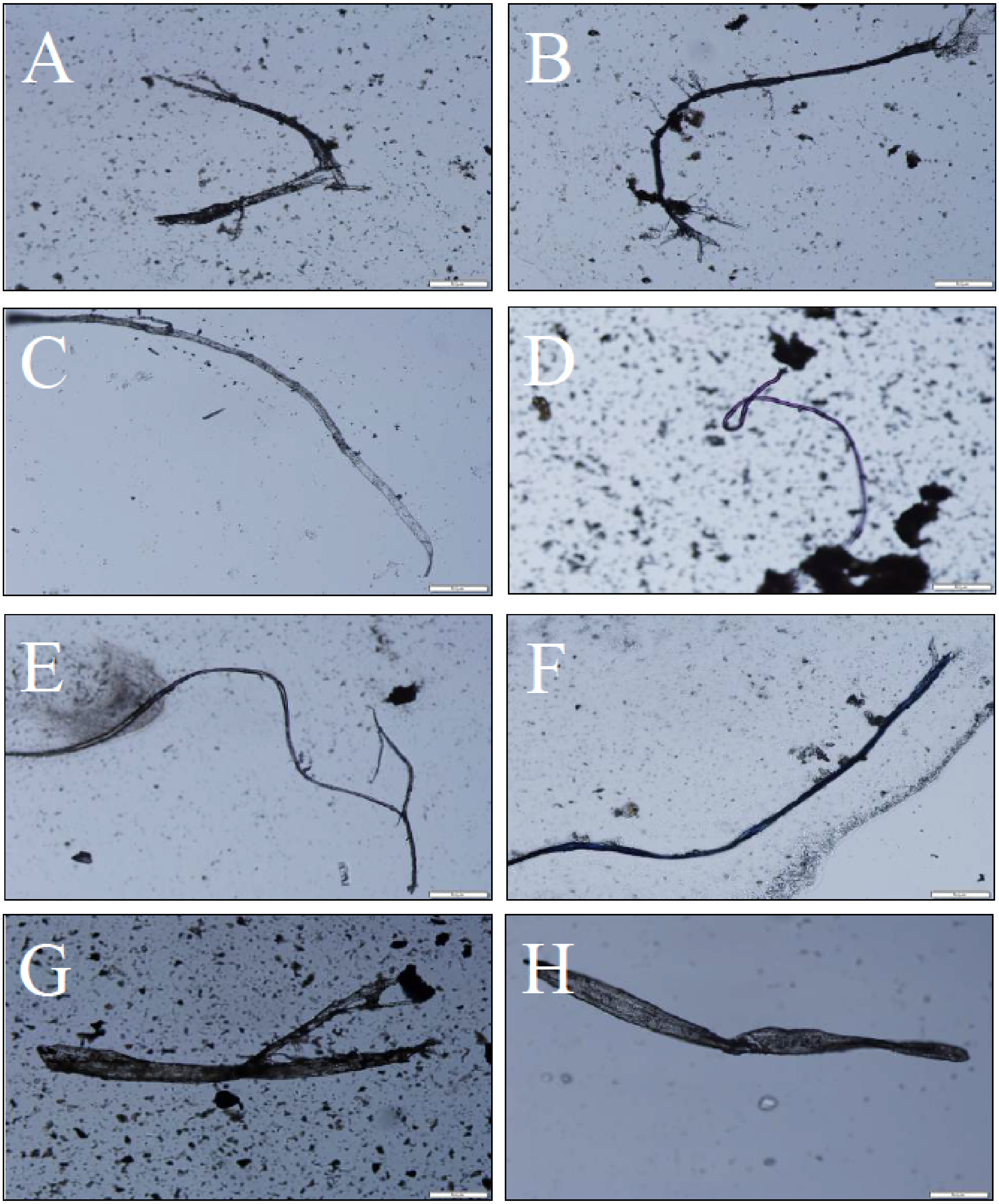
Documenting residues and particulate materials found when analyzing slides with transmitted light microscopy included descriptions of morphology, colour, and size (see Table E.2 for the full list of results). Significant amounts of contamination were documented, as well as many unidentifiable fibres, amorphous residues, and possible organic residues. Results from each collection are discussed together based on similar results and due to limited findings.

Figure 6. 4: Examples of Possible Plant Material



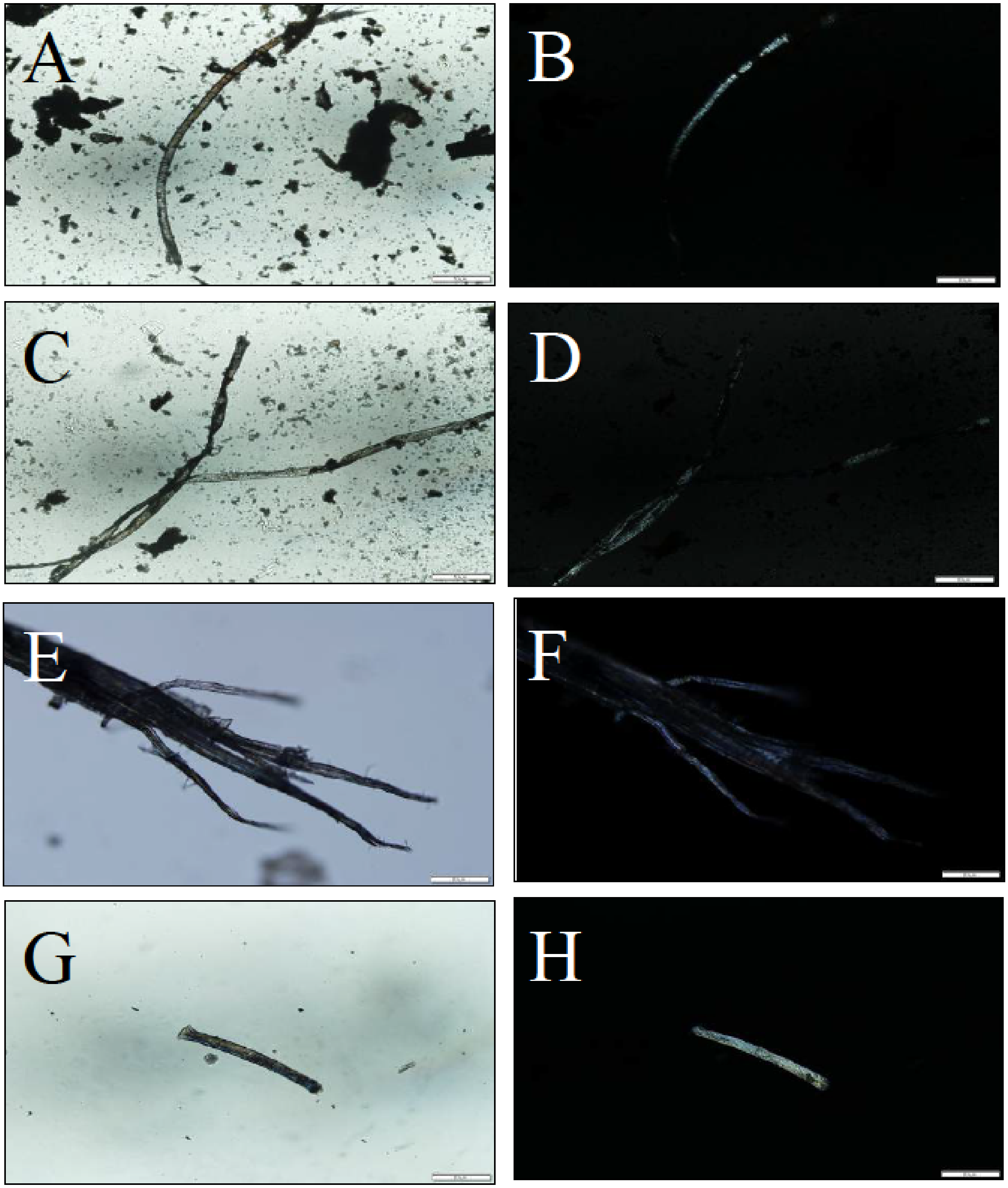
(A): Unidentified fibrous material from EcJw-1 V.12; (B): Fresh water diatom from EcJw-1 V.1; (C): Organic fibrous material from EcJw-1 V.17; (D): Unidentified material from DbJm-3 V.3; (E): Possible sponge spicule from EcJw-1 V.3; (F): Unidentified organic material on DbJm-2 V.6; (G) & (H): Unidentified fibre on EcJw-1 V.5 in plane and cross-polarized light

Figure 6. 5: Examples of Fibres



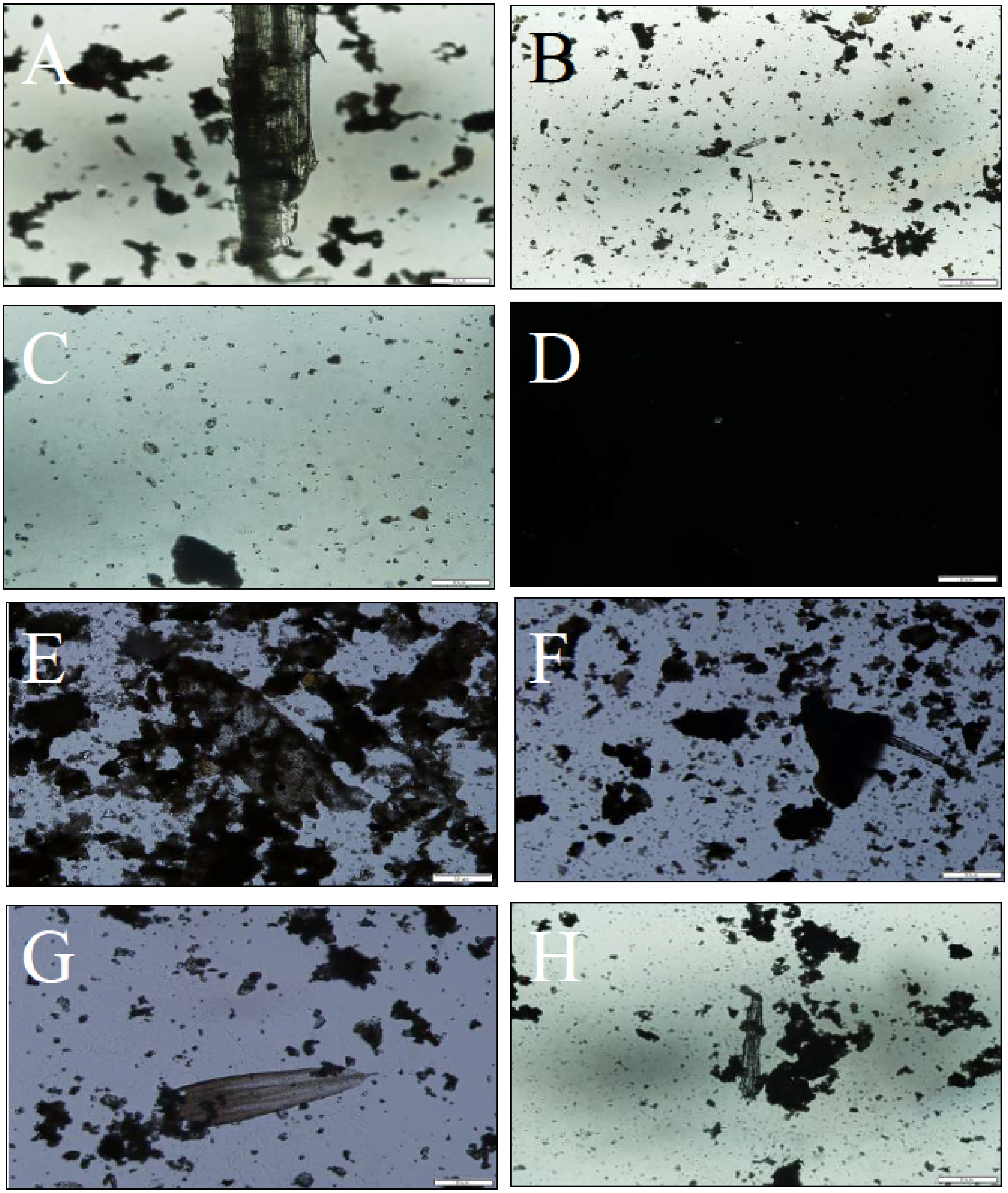
(A): Unidentified fibre from EcJw-1 V.6; (B): Degraded fibre from the exterior of EcJw-1 V.10; (C) Fibre from EcJw-1 V.1; (D): Purple fibre, likely contamination EcJw-1 V.1; (E): Blue fibre, likely contamination from EcJw-1 V. 2; (F): Blue fibre, likely contamination from EcJw-1 V.3; (G): Damaged fibre from DbJm-3 V.5; (H): Fibre from exterior of HiLp-3 V.23

Figure 6. 6: Examples of Fibres



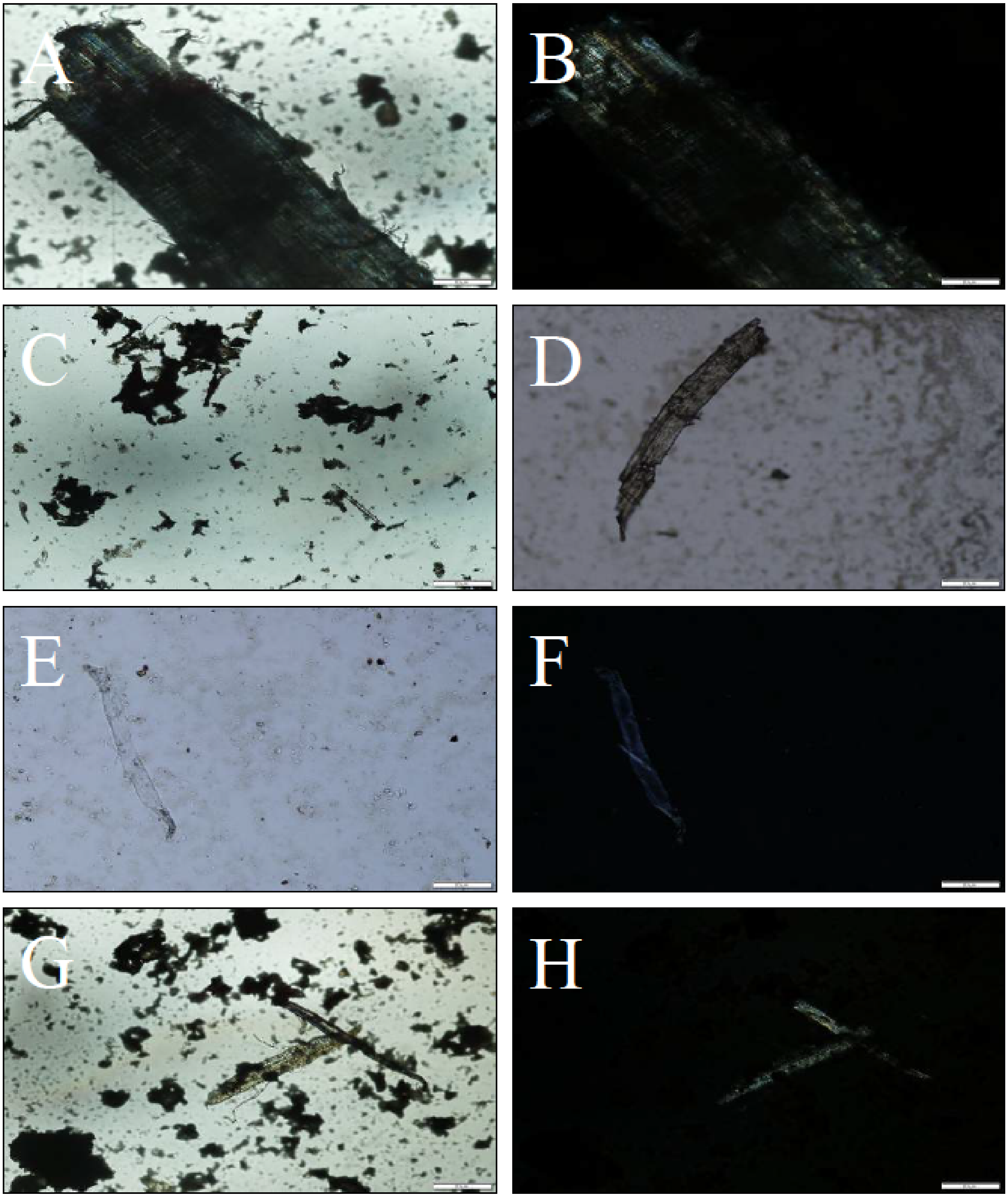
(A) & (B): Fibre or hair from the exterior surface of DbJm-2 V.2; (C) & (D): Fibre in plane and cross-polarized light from DbJm-2 V.3; (E) & (F): Fibre in plane and cross-polarized light from exterior of HiLp-3 V.3; (G) & (H): Fibre in plane and cross-polarized light from HfLp-11 No des.

Figure 6. 7: Examples of Possible Plant Material



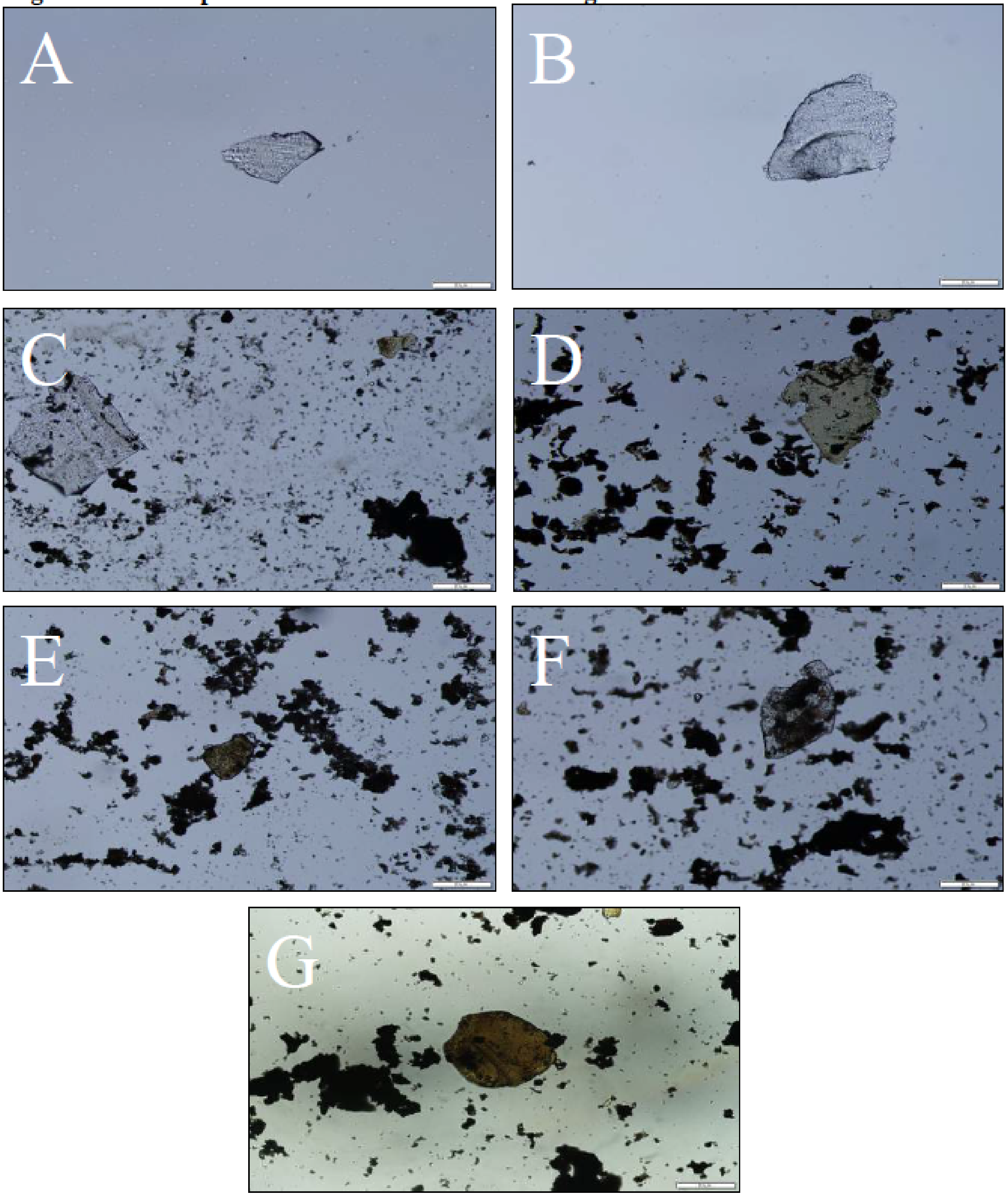
(A): Fibrous material from DbJm-2 V.12; (B): Phytolith from DbJm-2 V.12; (C) & (D): Starch grain in plane and cross-polarized light from DbJm-2 V.21; (E): Fibrous material from DbJm-2 V.13; (F): Organic material from DbJm-2 V.5; (G): Organic material from exterior of HfLp-11 V.7; (H): Organic material from DbJm-2 V.8

Figure 6. 8: Examples of Possible Plant Material



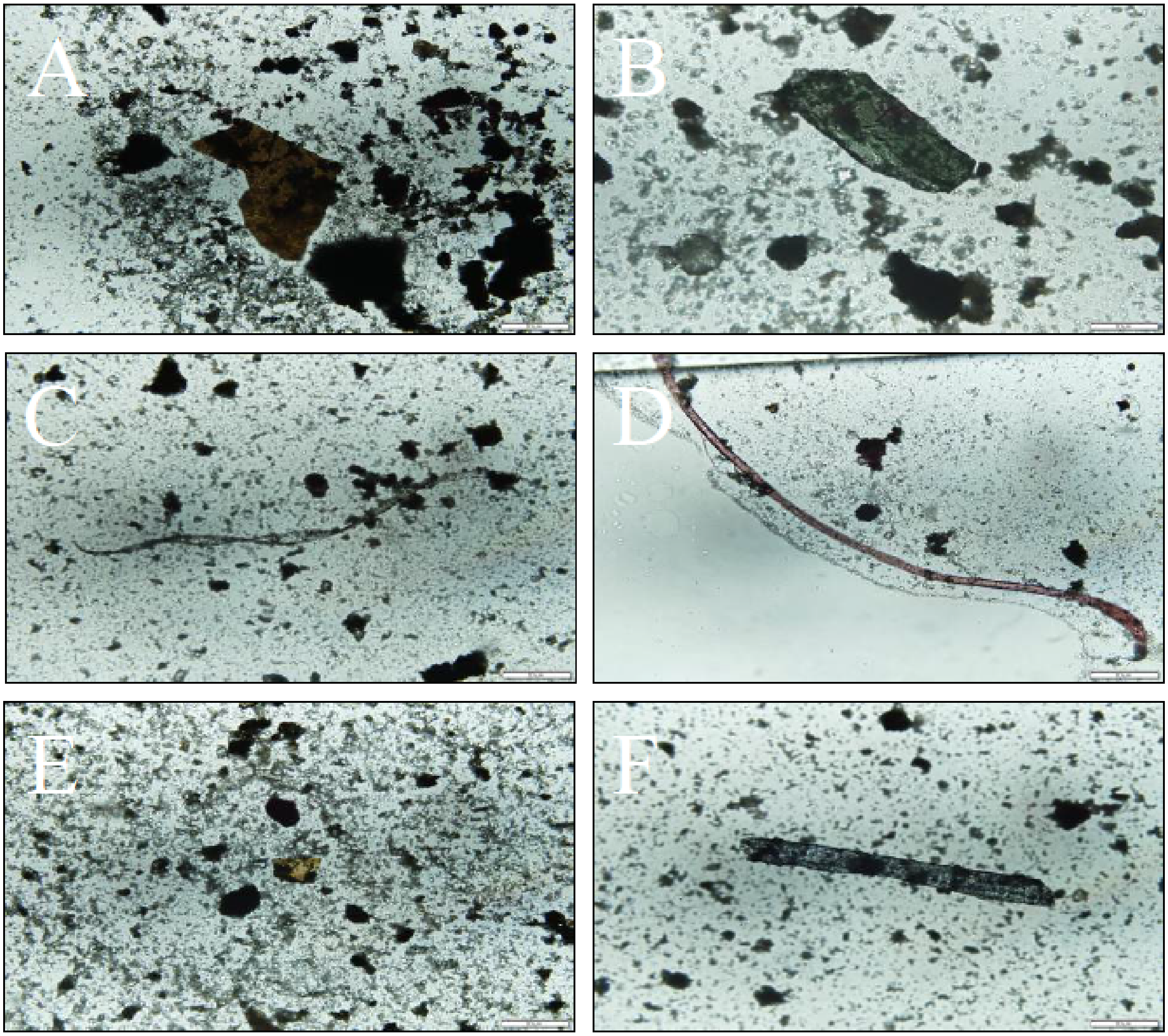
(A) & (B): Fibrous material in plane and cross-polarized light from exterior surface of DbJm-2 V.2; (C): Possible phytolith from DbJm-2 V.20; (D): Fibrous material from exterior of GfLm-7 V.20; (E) & (F): Transparent fibrous material from EcJw-1 V.15; (G) & (H): Damaged fibre in plane and cross-polarized light on DbJm-2 V.10

Figure 6. 9: Examples of Possible Lithic and Shell Fragments



(A): Possible lithic fragment from EcJw-1 V.5; (B): Possible lithic fragment from EcJw-1 V.9; (C): Possible stone or shell fragment from EcJw-1 V. 16; (D) Unidentified yellow particulate material from DbJm-2 V.17; (E): Unidentified yellow particulate matter from EcJw-1 V.13; (F): Particulate material from exterior of DbJm-3 V.2; (G): Amber coloured particulate material on DbJm-2 V.17

Figure 6. 10: Examples of Material from Soil Samples



(A): Organic material from Macgillivray soil sample (S-1); (B): Greenish-blue lithic material from Macgillivray soul sample (S-1); (C): Fibre from Macgillivray soil sample (S-3); (D): Purple fibre, likely contamination from Macgillivray soil sample (S-4); (E): Yellow particulate material from Macgillivray soil sample (S-4); (F): Unidentified organic fibre from Macgillivray soil sample (S-5)

A significant number of slides had fibrous material (see Figure 6.4, 6.5, 6.6, 6.8). Often the fibres were the result of modern contamination such as synthetic and dyed fibres found on vessels EcJw-1 V.1 and EcJw-1 V.3 (see Figure 6.5). However, possible fibrous plant material was located as well (vessels DbJm-2 V.2, EcJw-1 V.1-, EcJw-1 V.12, DbJm-5 V.3) (see Figures 6.6, 6.7, 6.8).

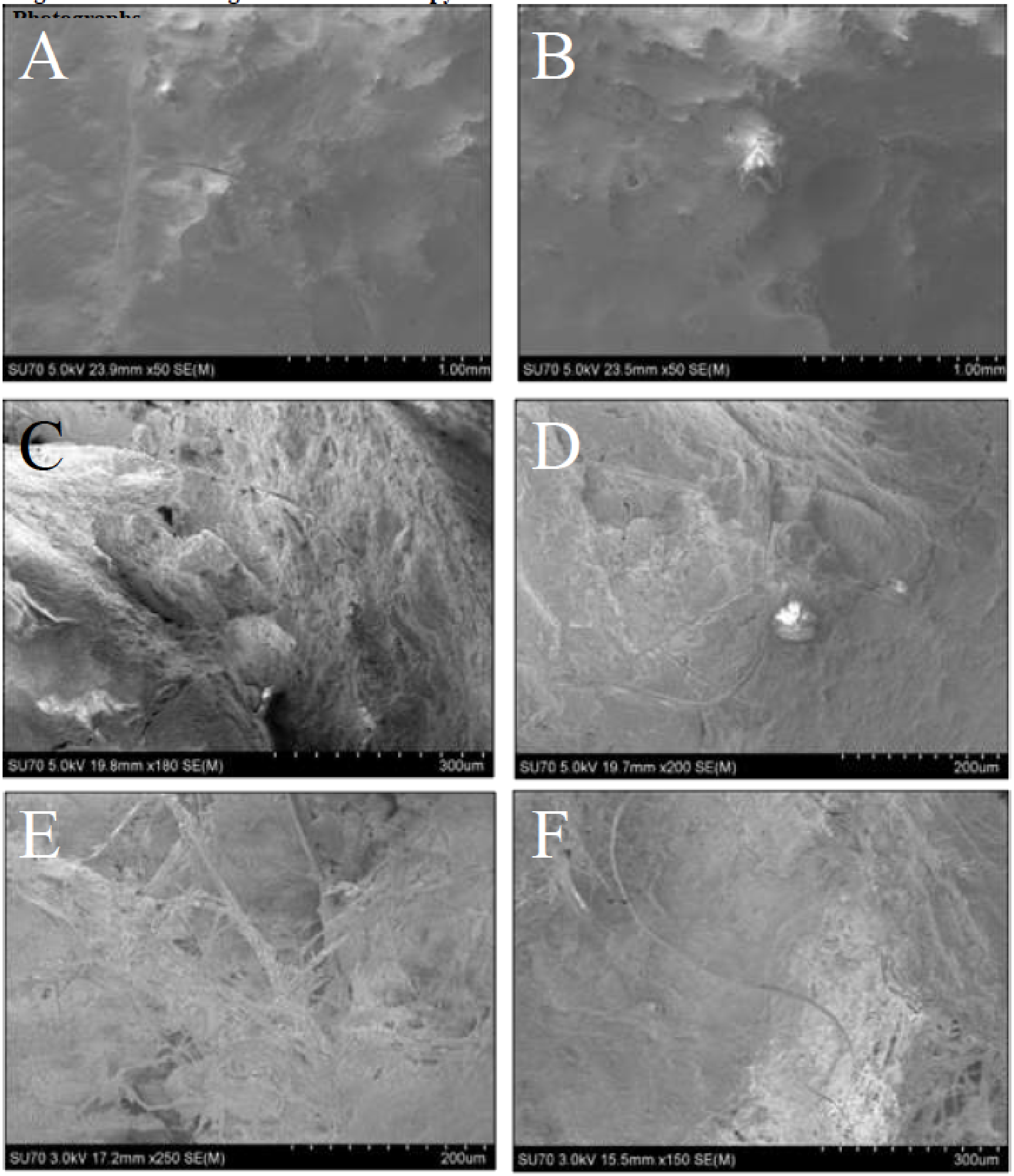
There was also a possible shell fragment on vessel EcJw-1 V.16 (see Figure 6.9) as well as several possible lithic fragments, most notable being yellow lithic material that was found on multiple slides (see Figure 6.9). A possible phytolith (DbJm-2 V.12) as well as a few starch grains (DbJm-2 V.21) were located as well, although they were not identifiable (see Figures 6.7, 6.8). A fresh water diatom was located on vessel EcJw-1 V.1 (Figure 6.4).

6.3.3 Scanning Electron Microscopy

Use of the SEM was limited as few of the pottery sherds could fit within the machine. Four sherds exhibiting orange staining found during microscopy were chosen, as ones with potential organic residues were too large for the machine. The surfaces of the four sherds (HiLp-3 V. 23, GfLm-10 V.25, GfLM-10 V.17, GfLm-10 V.10) were scanned, and elemental analysis was carried out on areas with visible orange staining and areas without for comparison (see Figures G.1-G.14).

When strategically scanning the surfaces of the sherds, there were no visible residues or unique attributes noted, instead photographs taken included general surface images, as well as images of fibres and temper (see Figure 6.11). Overall, results from analyses, including elemental analysis, illustrate homogeneity between the majority of the pottery surfaces, with most being composed of major elements commonly found in oxidized materials and sediments (see Figures G.1-G.14).

Figure 6. 11: Scanning Electron Microscopy Photographs



(A): Fibre on surface of GfLm-10 V.17; (B): Close up of temper on GfLm-10 V.17; (C): Fibre in crack on sherd GfLm-10 V.25; (D): Fibres on GfLm-10 V.25; (E) & (F): Fibres on HiLp-3 V.23

6.3.4 Gas Chromatography Coupled Mass Spectrometry

As discussed in Chapter 5, typical GC-MS procedures involving pottery are extremely destructive, requiring sherds to be ground up for analysis. Due to the uniqueness of the sample vessels, an alternative non-destructive technique was developed to remove residues for GC-MS analysis. GC-MS results were highly variable, with some samples demonstrating strong peaks on their chromatographs while others were comparatively weak, or had no readable peaks at all. Archaeologically significant components were rare, and typically only signified residues that contained general "plant" or "animal" biomarkers. Overall, twenty-seven samples showed the presence of possible plant material (six miniatures, seventeen smalls, four full-sized), nine had presence of possible animal material (three miniatures, two smalls, and four full-sized), and forty had insufficient results (six miniatures, sixteen smalls, and eighteen full-sized) (Tables F.1, F.2, F.3). More specific components found included the presence of alkaloids, resin acids, hydrocarbons, and acetylsalicylate acid (see Tables F.1, F.2, F.3). One miniature vessel, HiLp-1 V.49, showed a combination of resin acids such as dehydroabietic acid (see Figure 6.12), a plant exudate found in conifers (Mills and Whilte 1977), and acetylsalicylate acid (see Figure 6.13 and Table 6.23). Another interesting component included the presence of hentriacontane (Figure 6.14), a possible derivative from black elderberries and beeswax which was found on two small vessels (HiLp-1 V.51 and HiLp-3 V.8). HiLp-1 V.51 also showed the presence of dehydroabietic acid (Figure F.2). A complete list of results can be seen in Tables F.1, F.2, and F.3. Contamination was also prominent in a number of sample results. A significant number of samples illustrated strong hexadecanoic and octadecanoic acid peaks; components commonly found in human sweat and modern consumer products respectively (Croxton *et al.* 2010; Gunstone et al 2007; Helwig *et al.*

Figure 6. 12: GC-MS peak showing dehydroabietic acid

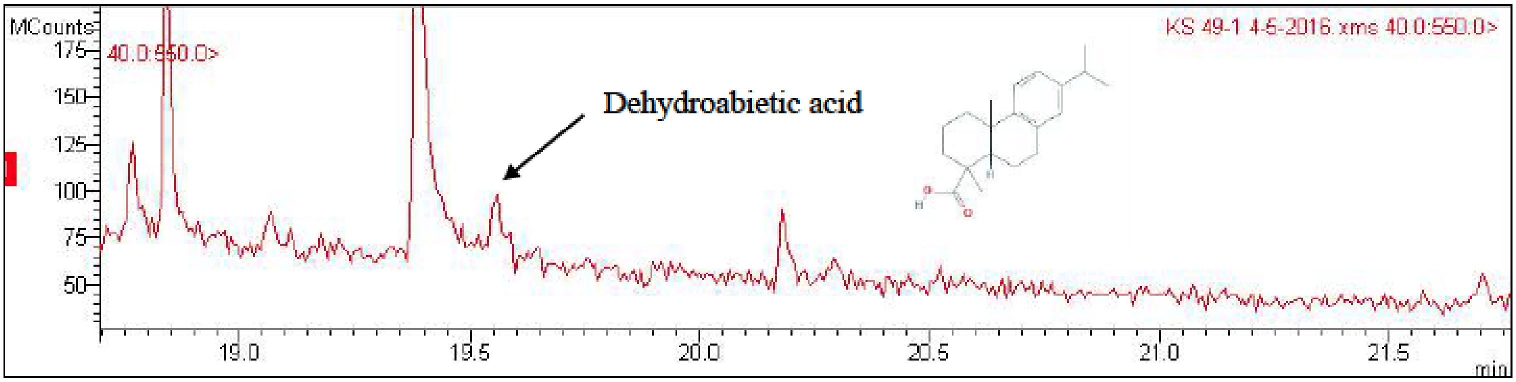


Figure 6. 13: GC-MS peak showing acetylsalicylate acid

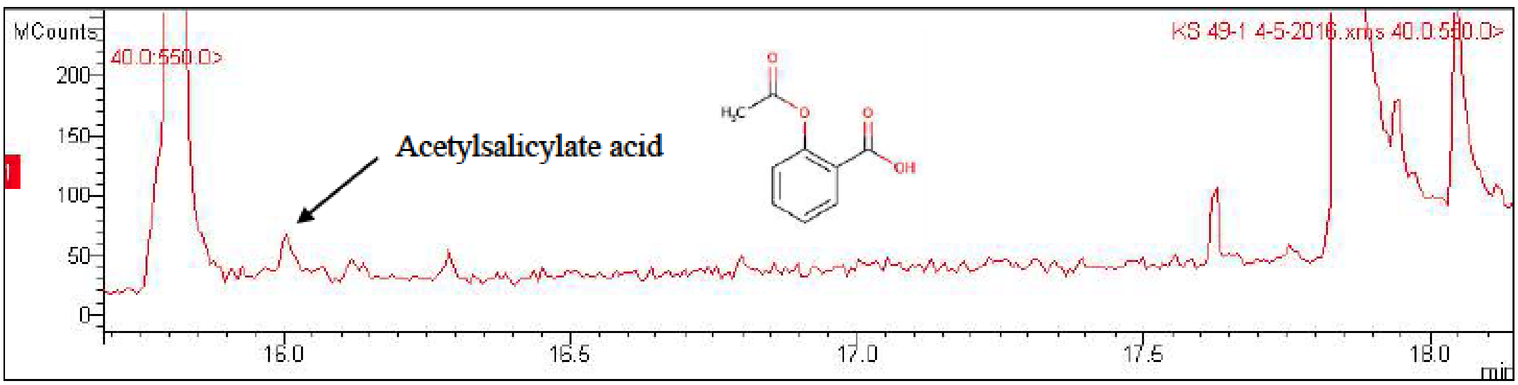
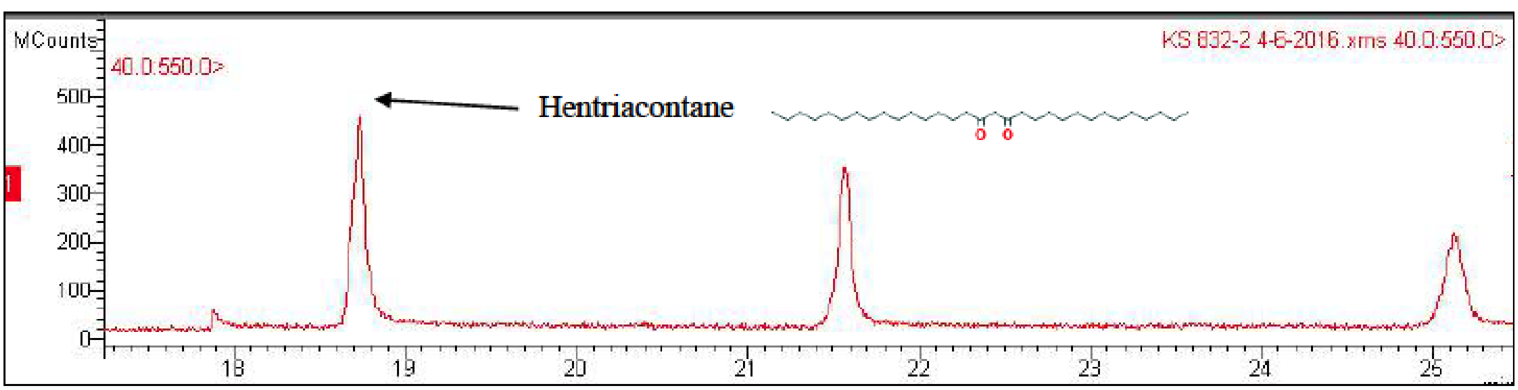


Figure 6. 14: GC-MS peak showing hentriacontane



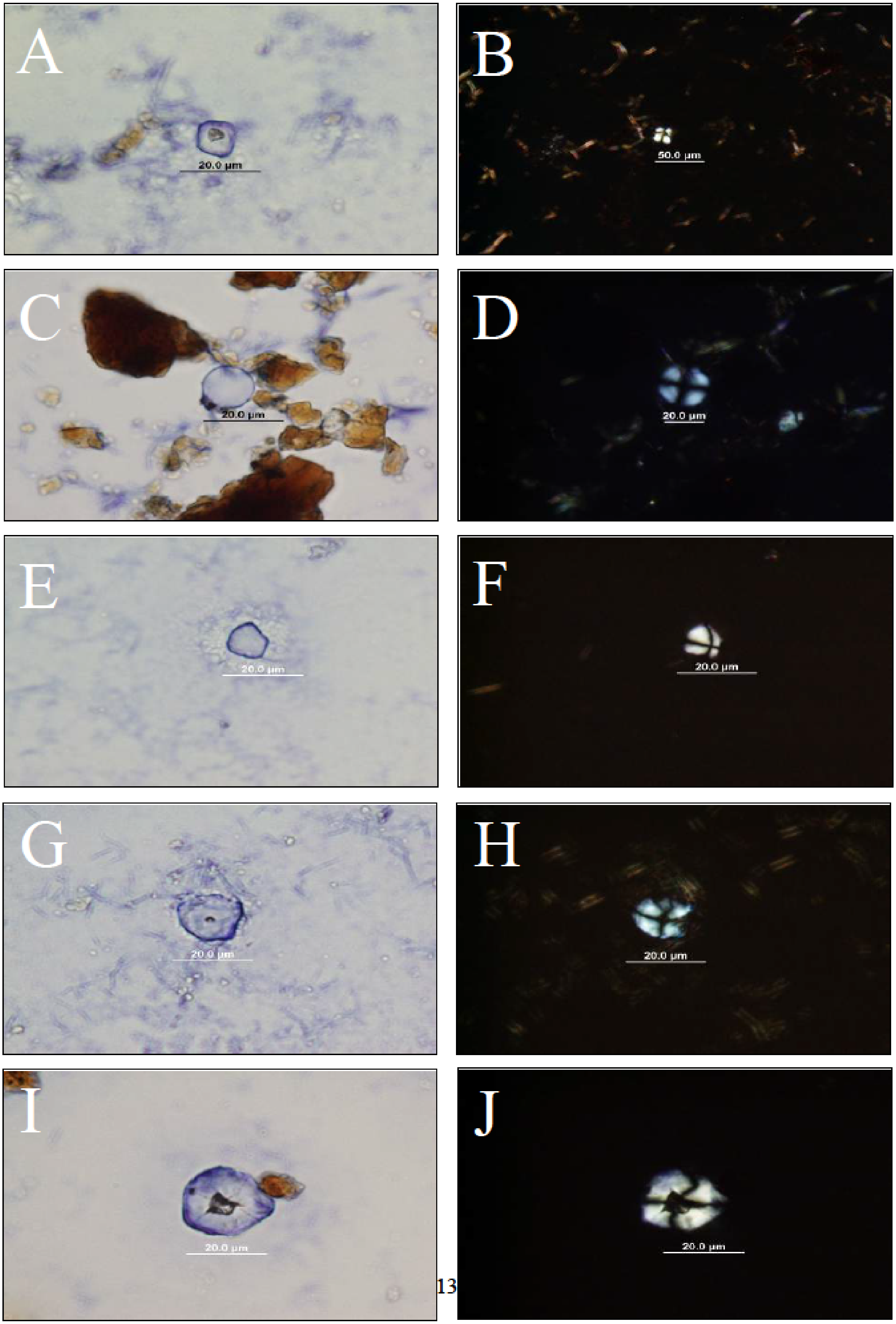
2014; Malainey 1999, Magg 1984; Regert *et al.* 2001). Additionally, eighteen samples (two miniatures, eleven smalls, and five full-sized) were found to have significant Benadryl peaks, a common modern antihistamine that is likely contamination. Other sources of contamination included acetamide and phthalic acid, common components in plastics (Lorz *et al.* 2007), and benzoic acid, which is commonly found in plants as well as plastics (Lang and Stanhope 2001). Additionally, many components found in modern cosmetics such as etocrylene, diethyl phthalate, and cyclohexasiloxane were present on sample vessels (Tables F.1, F.2, F.3).

During residue extraction several attempts were made to sample directly from the interior or exterior of a pottery sherd. Twenty-four small and miniature vessels and seven full-sized vessels were sampled from their exterior and interior surfaces. It became apparent that for the majority of pots sampled this attempt at a specific removal was not possible as sherds quickly absorbed the chemical solvent which would often soak through to the opposite side. While the challenges of this attempt have already been detailed in Chapter 5, GC-MS results from a few samples did illustrate different spectra's when the extractions from the interior and exterior of a sherd were compared. For example, the results from vessel FkMh-5 V.54, a possible miniature vessel, illustrates completely different spectra between the interior and exterior extractions (Table F.1). Other samples illustrated noticeable differences between their interior and exterior spectra's as well, including HiLp-1 V.49, GfLm-10 V.17, HiLp-1 V.121 (Table F.1, F.2). It was noted that the spectra representing exterior surfaces often illustrated fewer peaks than their interior counterparts.

6.3.5 Microfossil Analysis

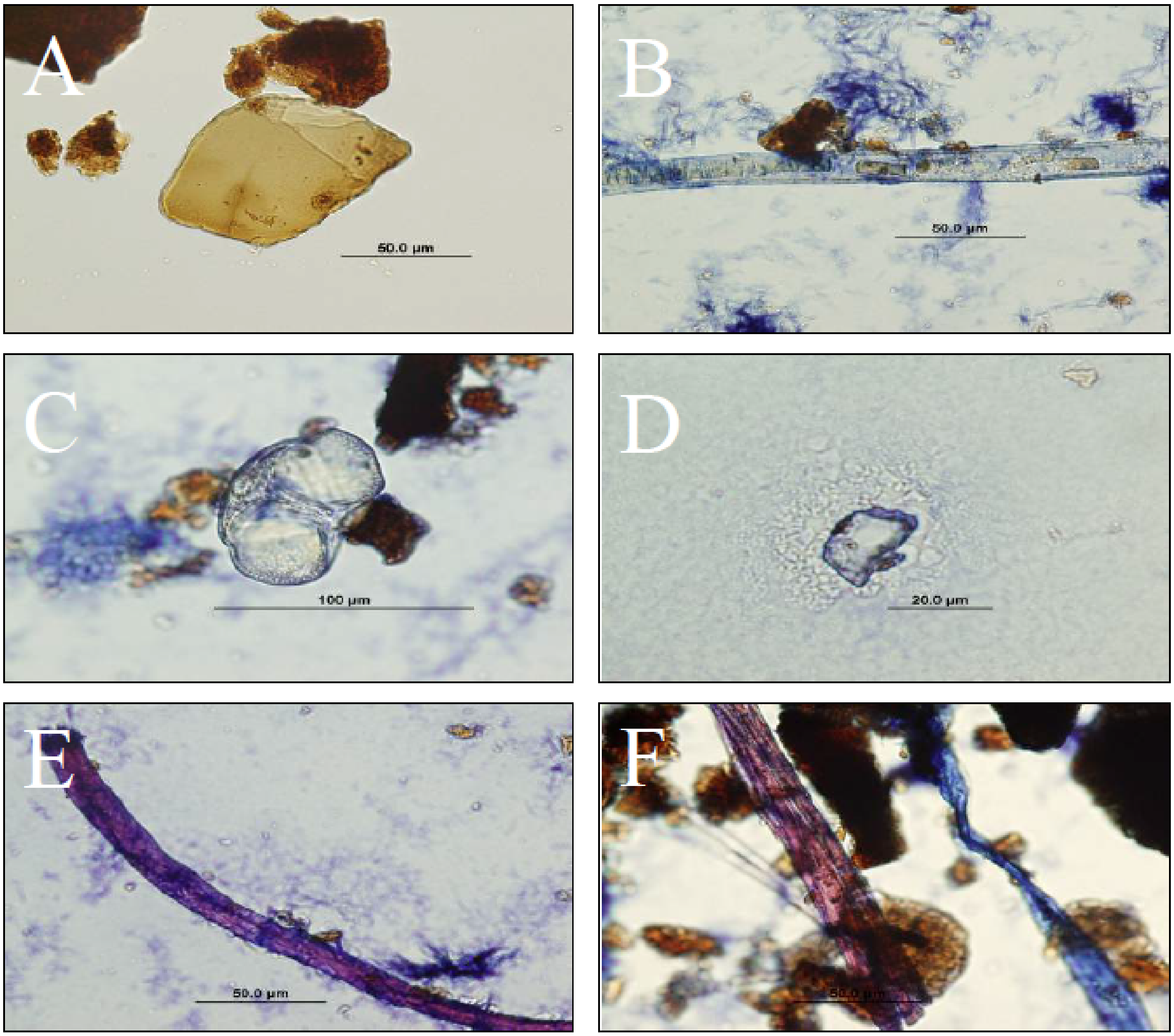
Physical removals were conducted on three vessels that had visible carbonized residue, however, only one vessel had enough material to be processed and analyzed for microfossils. Vessel HiLp-1 V.28 (sherd M9749) was scraped and the removed residue was processed for starch and phytloliths as described in Chapter 5. Results were limited and while phytoliths and starch grains were located, none were identifiable. There were a few starch grains that appeared to be

Figure 6. 15: Possible starch grains from HiLp-1 V.28



(A) & (B): Starch grain in plane and cross-polarized light; (C) & (D): Possible algal spore or starch grain in plane and cross-polarized light; (E) & (F): Starch grain in plane and cross-polarized light; (G) & (H): Starch grain in plane and cross-polarized light; (I) & (J): Starch grain in plane and cross-polarized light

Figure 6. 16: Possible plant material HiLp-1 V.28



(A): Possible plant cuticle; (B): Possible fungi or algal; (C): Possible black spruce pollen grain; (D): Possible grass phytolith; (E) & (F): Possible synthetic fibres slightly gelatinized due to their irregular extinction cross shapes (Figure 6.15). Figure 6.15 images A and B, and I and J are possibly degraded maize starch but positive identifications were not possible. Figure 6.15 image C and D is a possible algal spore. Figure 6.16 image A is a possible plant cuticle, image B is possible fungi or algae, image C is a possible black spruce pollen grain, image D is a possible grass phytolith, and images E and F appear to be some kind of modern synthetic contamination.

6.4 Conclusion

Results from analyzing physical attributes and conducting residue analysis on small and miniature pottery vessels were variable, although some homogeneity was found. Similarities were seen between all three vessel categories, especially regarding their physical characteristics where uniformity was seen between many of the traits that were assessed. The majority of sample vessels were fragmented which rendered interpretations of their physical attributes challenging as significant portions of a vessel were often missing. This resulted in many "undetermined" assessments. Overall, results from residue analysis indicated a high presence of contamination and unidentifiable residues, although some potentially archaeologically significant results were found as well. These variable results were in part due to a lack of visible residues on the sample vessels, and contamination from the cataloguing and curation process. These aspects affected results from microfossil, microscopy, and SEM analysis which did not produce significantly identifiable results. The results from GC-MS analysis were significantly greater than from the other methodologies; while they also illustrated high rates of contamination, there were also possible archaeologically significant residues located as well, a much rarer result in the other forms of analysis. The identification of potential archaeological residues is significant, and illustrates that some of the methodologies used, including the non-destructive method for removing residues for GC-MS analysis were successful. This study was as much a methodology test as it was an attempt to provide further insight into the function of small and miniature pottery vessels. While many of the methods did not produce significant results on their own, the combination of them all has provided insight into suitable methods for future analysis of small and miniature pottery vessels. Interpretations of the results from all methodologies and comparisons between them can be seen in Chapter 7.

Chapter 7: Interpretations & Discussion

7.1 Introduction

This chapter discusses the results presented in Chapter 6 and how they may be interpreted concerning the function of small and miniature pottery vessels. Interpretations from the various types of analysis are discussed separately as well as in relation to one another. Archaeological sites where the sample vessels were collected are discussed when relevant information concerning context and site type is pertinent to the overall discussion. An examination and assessment of the methodologies used is provided, as well as suggestions for future studies that focus on similar topics. Finally, the importance of this study and its results are explored.

7.2 Pottery Attribute Interpretations

Skibo (2013) and other researchers suggest there is a link between a vessel's form and its function. However, the majority of studies which approach interpretations from this standpoint are focused on full-sized vessels. When assessing the various pottery attributes on the sample of small and miniature vessels, it was found that the results were largely homogenous with similarities seen between all three vessel categories regarding overall vessel form and decorative motifs. The majority of sample vessels were fragmented, which rendered interpretations of their physical attributes challenging as significant portions were often missing. This resulted in many "undetermined" assessments throughout the categories analyzed, and made further interpretations challenging. This section discusses whether any interpretations regarding function were able to be made through analysis of the physical attributes.

7.2.1 Vessel Form and Finish

Results from analyzing the form and finish of the sample vessels were limited due to the fragmented nature of the sample vessels, and were largely consistent across the three categories. Similarities between profiles, neck, lip shoulder, and base shape were common, and primarily aided with interpretations of which pottery tradition and time period the vessels belonged to as opposed to information related to function. The most defining trait and morphological feature that unites small and miniature vessels is their size. However, based on size alone these pots present a dilemma when trying to assess their function. They are not practical with regards to cooking like their larger counterparts, rendering their specific intended functions largely unknown. Existing studies that analyze vessels based on their morphology examine full-sized vessels, and their approaches are not applicable to these unique vessel types. It should also be noted that none of the sample vessels studied had obvious functional attributes such as spouts or handles and there is little to no indication of the function of these vessels based solely on visual examinations alone. Overall, results from examining the physical attributes of the sample vessels revealed similarities among the majority, with pots from all size categories illustrating similar shapes and finishes. While many similarities between vessels can be seen in addition to size, including many overlapping decorative motifs, similar temper types, and all being from sites in Boreal Forest regions, these could be attributed to sampling bias, a relatively small sample size, and geographical limitations rather than function.

7.2.2 Decorative Motifs

Similar to analyses of the vessel forms, the decorative motifs were largely consistent across vessel categories. For example, the most common decorations that appeared on sample vessels from all categories were punctates, stamps, and CWOI. A handful of vessels deviated from this trend with the inclusion of pseudo-scallop shell impressions, incised lines, or unique stamp shapes, as well as a few vessels that had interior decorations. Several vessels from EcJw-1 illustrated the same crescent-shaped stamp, while several others had been stamped using the same three-pronged object. The EcJw-1 site, a single hearth site located on Scaler Lake, contained one of the largest concentrations of small and miniature vessels of all the sites discussed for this study. However, it is difficult to make any inferences regarding the large number of vessels excavated as the site was highly disturbed and eroded. There was also a significant number of sample vessels from a variety of sites that had no visible decoration.

One area where the vessel categories deviated was the decoration present on the body of the vessels. All of the miniature sample vessels that had visible body portions had a smooth finish, while small vessels had almost equal amounts of smooth and textile impressed finishes, and comparatively, the vast majority of full-sized vessels that had visible body portions were textile impressed. The larger amount of textile-impressed full-size sherds could be due to larger Blackduck and Selkirk vessels often being made in bag molds, while some of the small and miniature vessels may have been hand-crafted without the use of a mold (Carey 2006; Golomb 1993; Kamp 2002; Smith 1998).

When the number of decorations on each vessel was counted, it was interesting to note that the sample vessel with the largest number of decorations present was a miniature vessel (DbJm-2

V.2). This deviates from traditional beliefs that these kinds of vessels will lack or have fewer detailed decorations than their full-sized counterparts (Ellis 1994; Bagwell 2002; Crown 1999, 2001, 2002; Hutson 2006; Kamp et al. 1999; Kamp 2002, 2006; Lillehammer 1989; Smith 1998). This vessel was from the McCluskey Site (DbJm-2), which contained a burial mound (Dawson 1974). The miniature vessel was discovered adjacent to the mound in the periphery of a roasting pit, and as such may have been created specifically for ceremonial or burial contexts (Dawson 1974). In his report, Dawson (1974) describes all the small and miniature vessels as "mortuary" vessels. The Martin Bird Site (DbJm-5), located in close proximity to the McCluskey Site was also found to have direct association between highly decorated small pottery vessels and a burial mound which could suggest some type of burial ceremonialism in the region (Dawson 1974, Dawson 1987). Pottery decorations are often viewed as strictly ornamental, although there are many studies which explore decorations as a means of reflecting socially mediated ideas and information (Braun 1991). As such, it is important to note that there could be deeper social meaning regarding why many of the small and miniature sample vessels were decorated, and why vessel DbJm-2 V.2 was decorated so extensively.

7.2.3 General Measurements & Juvenile Measurements

When comparing the average thickness of the body portion of the sample vessels, it was found that despite their overall smaller size, the miniature vessels on average had thicker walls than the small vessels. Comparatively, the full-sized vessels were thinner than both the small and miniature vessels. This could be an indication of inferior quality, as the thinness of a vessel is often associated with superior manufacture (Gibson 1994, Skibo 2013). However, the rim and lip thickness measurements yielded contradictory results, with miniature vessels having the thinnest measurements on average in each category, with the average thickness increasing in both the small and full-sized vessel categories.

According to the results of the Crudity Index (CI), the majority of sample vessels appear to be well-made, while only one would be considered to possibly have been made by a child, HiLp-1 V.121. In his report on the Kame Hills Site (HiLp-1) Dickson (1980) refers to vessel 121, a small pottery vessel, as a "bowl." Pottery was the most prominent artifact found at the Kame Hills Site, a large settlement site on Southern Indian Lake in northern Manitoba. Similarly, the results from assessing the Curvature Consistency Index (CCI) again show that the majority of vessels are well-made, while only one vessel, vessel EcJw-1 V.10, has the potential to have been made by a child, according to Smith's definitions. The Motif Application Index (MAI) had more variable results than the other two indexes, which could be the result of inconsistent motif applications on the sample vessels, or the possibility that pots were made by adults and subsequently decorated by children, or due to the subjective nature of the MAI amongst other reasons. Overall, the results of the 'juvenile' pot measurements indicate that sample vessels are generally well-made, and would not be considered to have been made by children.

When comparing the general measurements to the 'juvenile' measurements, the results were largely complimentary. While the body thickness measurements indicate the miniature vessels could be of inferior quality, the rim and lip measurements show the opposite. These results coupled with the juvenile measurement results which show that none of the small or miniature vessels would be considered to have been made by children provides evidence contrary to standard beliefs that these vessels are expected to be of basic form, lacking symmetry, with inconsistencies in thickness and overall manufacture and decoration (Carey 2006; Kamp 2002; Smith 1998). This calls into question the validity of making assumptions about craftsmanship, skill level, and function based solely on physical traits, measurements, and size without further analysis.

7.3 Organic Residue Analysis Interpretations

As discussed in Chapter 2, the primary function of pottery vessels is to contain various substances. However, we can rarely tell what those substances were or why the vessel was used in certain ways. Unlike full-sized vessels that are commonly linked to food preparation and storage, miniature and small pots have been found in a variety of contexts, including both burial and ceremonial contexts, which is suggestive of other, non-food preparatory uses. The methodological approach was selected in an attempt to identify residues on small and miniature vessels to see whether inferences could be made regarding their past use. Identifying what was held in a pottery vessel can provide insight into how and why a vessel was used, which is especially important for a material type such as small and miniature vessels where an obvious function is not discernible based on physical examinations alone. The research design was non-destructive, and tailored to address the fact that many specimens had been curated and held in museums for some time. Many adjustments to the methodological approach were made to account for the various difficulties and limitations that arise when working with pottery, including its porosity, irregular shapes, and the amount of contamination from the cataloguing process. This section discusses interpretations from the results from each methodological approach, and whether the method provided new insights.

7.3.1 *In-situ* Reflected Light Microscopy & Transmitted Light Microscopy

A small amount of potentially authentic residues and a large number of contaminants were located during *in-situ* reflected light microscopy. While there were traces of carbonized residue and several amorphous residues located on sherds, these could not be identified due to their amorphous nature. Overall, contamination was the most prominent finding which reflected the fact that the majority of these sherds had been catalogued and curated in museums for long periods of time. Additionally, all of the sample vessels had previously been cleaned using a wet brush and tap water, a step which may have removed water soluble residues adhering to the surfaces of the sherds. While not implemented often when conducting residue analysis on pottery, the documentation of residues and their location on stone tools prior to residue removal has aided in the interpretation of lithic tool function when results from the two analyses are compared (Bouchard 2017; Hodgson 2016; Lombard 2006). However, the lack of identifiable residues on the sample sherds makes comparisons between methodologies challenging.

Similarly, there were no significant or diagnostic residues found during transmitted light microscopy. High amounts of contamination were documented, as well as many unidentifiable fibres, and amorphous residues. Many of the fibres present on slides were identified as modern synthetic and dyed fibres, the result of contamination from clothing or other fabrics. While there were possible plant fibres located, these could not be identified further. The lithic and shell material that was located on several slides is possibly the result of temper particulates or soil that may have adhered to the vessels.

Overall, there were no significant or diagnostic residues located during either microscopic analysis. However, it should be noted that not all vessels were able to be examined microscopically as their size and shapes did not permit this method of analysis. Contamination was the most prominent type of residue present on the sample vessels. While there was limited residue of archaeological significance, there were trace amounts found on a few small vessels, including several amorphous residues and a small amount of carbonized residue. The lack of visible residue does not indicate that these vessels were not used, rather, that their methods of use might not have left visible traces on their surfaces. This form of microscopy, while an important and beneficial step when conducting a thorough analytical process, is extremely time consuming and did not produce significant results for this study.

7.3.2 Scanning Electron Microscopy

Results from analyses illustrate homogeneity between the majority of the pottery surfaces, with most being composed of major elements commonly found in oxidized materials and sediments. While there is no indication that staining is from a modern source, there is also no evidence that staining was deliberately applied, given the lack of a distinguishable motif, although this cannot be confirmed without further examination with image processing software. The most conservative explanation is that the staining is the result of weathering derived from the matrix or oxidation in the process of firing the vessel.

7.3.3 Gas Chromatography Coupled Mass Spectrometry

7.3.3.1 Possible Archaeological Residues

As discussed in Chapter 6, the GC-MS results were highly variable. The presence of diagnostic compounds was rare. However, there were components identifiable as plant and animal biomarkers. Unfortunately, the majority of these compounds would only allow for general interpretations which were not able to be narrowed down to family or species. Overall, twenty-seven samples showed the presence of possible plant material (six miniatures, seventeen smalls, four full-sized), nine had presence of possible animal material (three miniatures, two smalls, and four full-sized), and forty had insufficient results (six miniatures, sixteen smalls, and eighteen full-sized). Compounds indicative of possible plant material were the most prominent GC-MS result, which suggests that at some point during the pots use it came into contact with plant material. With all residue analysis it is difficult to assess the authenticity of results, especially when analyzing archaeological objects where depositional and taphonomic factors could potentially contaminate samples. However, as previously discussed, studies have illustrated that contamination deriving from soils and depositional environments is often minimal, although interpretations remained cautious due to the number of known contaminants (Skibo 2013; Stacey 2009). Similarly, the vessels with possible animal compounds illustrate the potential that these vessels came into contact with animal substances at some point during their use. The general nature of these results does not provide much indication of function or how the compounds were absorbed into the vessels' matrix, rather that the vessels may have come into contact with plant or animal material at some point during the duration of their use. The forty vessels that had insufficient results for GC-MS interpretation make up a significant portion of the sample vessels. While this could indicate issues with the residue removal process, it could also suggest that the majority of the sample vessels were not produced in order to be used like their larger counterparts, or at least not in ways that left significant residues that were able to be identified.

There was a small number of sample vessels whose results were indicative of more specific compounds than simply 'plant' or 'animal.' HiLp-1 V.49, a miniature vessel from the Kame Hills Site (HiLp-1), showed a combination of resin acids such as dehydroabietic acid, a plant exudate found in conifers (Mills and Whilte 1977), and acetylsalicylic acid which can naturally be found in willow bark (Mahdi 2010). These results are indicative of possible medicinal plant use. This result is interesting as the miniature vessel it was found on is one of the more basic and plainly decorated sample vessels and would not have been able to hold much. The GC-MS results for this vessel provide an interpretation that significantly deviates from how the vessel may have been interpreted through physical assessments alone, again providing evidence for the benefit of using a multi-proxy approach.

7.3.3.2 Contamination

Similar to results from microscopy, GC-MS results illustrated the presence of many contaminants, including a variety of synthetic and organic compounds common in modern substances such as cosmetics, as well as fatty acids potentially deposited through human contact, the presence of derivatization product, and even contamination from another student's project. However, the majority of contaminants were easily located during interpretations as many appeared as significant peaks on their chromatographs and had high probability matches with modern compounds. Additionally, any compound that was a potential contaminant was excluded from interpretations.

A significant number of samples produced strong hexadecanoic and octadecanoic acid peaks; components commonly found in human sweat and modern consumer products respectively (Croxton *et al.* 2010; Gunstone et al 2007; Helwig *et al.* 2014; Malainey 1994, Magg 1984; Regert *et al.* 2001). The prevalence of hexadecanoic acid is likely the result of the sample vessels being handled and curated in museums for long periods of time. While some studies have used the ratio between the two acids to distinguish between different sources of animal fats, they were largely ruled out as contamination due to their prevalence in a large number of samples, and their presence in common contaminants (Evershed 2008). Other sources of contamination included acetamide and phthalic acid, common components in plastics (Lorz *et al.* 2007), and benzoic acid, which is commonly found in plants as well as plastics (Lang and Stanhope 2001). Again, the presence of compounds from plastics is likely the result of the curation process.

Eighteen samples (two miniatures, eleven smalls, and five full-sized) were found to have significant Benadryl peaks, a common modern antihistamine. Due to its presence in a large number of the sample results, as well as how significant the peaks were, its presence was interpreted as contamination and was ruled out of interpretations. This was confirmed when it was found that another student working in the same lab was using Benadryl as part of their study, and had contaminated portions of the lab.

7.3.4 Microfossil Analysis

While microfossil starch and phytolith analysis was limited in this study due to a lack of carbonized residue, there have been studies where microfossils were successfully analyzed from carbonized residue on similar small pottery vessels. For example, Boyd et al. (2018) analyzed microfossil starch and phytoliths from a small pottery vessel from the Martin Bird site DbJm-5, and successfully identified traces of maize, wild rice, and bean. However, it should be noted that unless carbonized residues are present on small and miniature vessels, this type of analysis should not be undertaken. Alternatively, in order to use this type of analysis, special care should be taken to locate sample vessels with carbonized residues.

7.4 Methodological Approach Evaluation & Suggestions for Future Research

Results from residue analysis indicated a high presence of contamination and unidentifiable residues, although some potentially archaeologically significant results were found as well. These variable results were in part due to a lack of visible residues on the sample vessels, and contamination from the cataloguing and curation process. These aspects effected results from all the methodological techniques, and largely prevented microfossil analysis, microscopy, and SEM from having significant results. The results from GC-MS analysis were greater than from the other methodologies; while they also illustrated high rates of contamination, there were also possible archaeologically significant residues located as well, a much rarer result in the other forms of analysis. The identification of potential archaeological residues is significant, and illustrates that some of the methodologies used, including the non-destructive method for removing residues for

GC-MS analysis showed moderate levels of success. This study was as much a methodology test as it was an attempt to provide further insight into the function of small and miniature pottery vessels. While many of the methods did not produce significant results on their own, the combination of them all has provided insight into suitable methods for future analysis of small and miniature pottery vessels, as wells as ways in which methods could be modified and adapted.

While incident light microscopy can be used as a screening tool for archaeological residues, it did not provide much insight concerning residues on the sample vessels other than to illustrate the high prevalence of contamination. Additionally, there were depth of field challenges when working with the irregular shape of pottery sherds, while other vessels were too large to even fit under the microscope. Transmitted light microscopy removed depth of field issues, however, there were not significant or archaeological residues identified during this step. These methods would likely provide more successful results from samples where sherds are selected based on the presence of residues rather than on samples without anything visible. Additionally, the use of these microscopic methods alone to identify residues is limiting as residues are often amorphous, requiring further analysis to be positively identified.

It is extremely difficult to conduct SEM analysis in a non-destructive manner on pottery. Typically, samples analyzed with an SEM would be coated in a layer of carbon or gold to prevent an electric charge from building up which will prevent proper analysis and potentially damage the machine (Fraham 2014; Froh 2004). More recent machines have reduced vacuums which allow for samples to be analyzed without the use of a coating, but other complications can arise (Fraham 2014; Froh 2004). For example, the porosity of the sample pottery led to technical issues with the vacuum which was a challenging issue to overcome. Additionally, few sample vessels were able to fit within the small vacuum chamber, preventing more desired samples from being analyzed.

The previous methods are limited to analyzing visible residues and not all sample vessels were able to be examined. All the sample vessels were able to be analyzed using GC-MS, which permits analysis of absorbed or 'invisible' residues. While the analytical side of GC-MS has major advantages, it is the residue removal process to prepare samples for analysis that could use further refinement. This thesis developed the methodology for non-destructive removal from pottery as all other techniques are extremely destructive. While the results from GC-MS analysis had moderate success as some potentially archaeological residues were identified, the removal process could benefit from further testing and refinement. For example, longer soaking and sonication times could be tested. It should be noted that while the residue removal process could use some adjustments, it is a possible route for researchers to take when analyzing residues from unique pottery vessels where traditional methods are not appropriate but where additional information is desired.

As already discussed, the results from microfossil starch and phytolith analysis were limited, and this technique should only be applied to samples where visible carbonized residues are present. However, selecting samples with carbonized residues can be challenging, as it requires intensive visual examination to select sherds that have residue. Additionally, as discussed extensively throughout this thesis, small and miniature vessels were not always used in the same way as their full-sized counterparts. The presence of carbonized residues on pottery only occurs when food was prepared in a certain way.

A theme explored extensively in this thesis is that pottery is a challenging material type to work with. Its porosity and irregular shapes and sizes required multiple adjustments to the methodology and prevented many sample vessels from being analyzed with certain techniques. There were additional challenges presented by this particular sample as well, including the general fragmented nature of the vessels, high amounts of contamination, and the lack of visible residues. These challenges coupled with the non-destructive nature of this study rendered the data collection phase extremely labor-intensive and time-consuming. While non-destructive techniques are essential when working with unique objects, especially ones from museum collections, they are also limiting. Creating or altering techniques to accommodate a sample is not always possible for studies with limited resources.

Results from the suite of analyses indicate that the methodology used had a limited success rate. While a small number of results were successful in indicating the presence of possible archaeological residues on vessels, the majority of results were indicative of contamination, although these were easily ruled out as non-archaeological. Overall it was determined that the combination of these methods, especially if further testing was performed, could be a feasible route of analysis for unique samples where standard destructive methods are not suitable, but where further analysis is desired. This study proves that non-destructive variations of traditional methods can be successfully conducted on absorbed residues found in pottery. While further testing would be required to render the chemical removal method more effective, there were multiple positive results where archaeological residues were able to be identified. Non-destructive techniques allow for a multi-proxy approach whereas studies that use traditional techniques that are destructive are limited in the number of techniques they can use. Archaeological residue analysis is still a young field, with the earliest studies taking place in the early twentieth century, and only gaining momentum in the 70s and 80s (Stacey 2009). Over time, the techniques and equipment have evolved significantly, as have the expectations of researchers and the types of studies being conducted. Even when considering the various challenges presented when analyzing pottery, it is important to recognize that even minor information can shed light on our limited understanding of the past. There are multiple research avenues and methodological techniques that could be applied to future analyses of small and miniature pottery that were not able to be utilized in this study. This includes the selection of samples where visible residues are present, analyzing a larger sample size, utilizing other organic residue methodologies, and incorporating oral histories from Indigenous groups and discussions with contemporary Indigenous potters.

7.5 Conclusion

For centuries, archaeologists have examined artifacts, including pottery vessels and made interpretations about past cultures. A great deal can be inferred from analyzing pottery, such as a basic understanding of craftsmanship, diet, population movement, trade patterns and more. However, more recently researchers have recognized that the significance of the types of material culture that are left behind by past-cultures would likely not be shared by the cultures who created them (Skibo 2013). While it is true that artifacts do not necessarily reflect the identities of their makers, invaluable information can still be gained by conducting in-depth analyses, especially ones that delve further than simple visual examinations. While documenting the shape and taking measurements of pots during cataloguing is extremely important, these variables alone cannot always determine the actual function of a vessel, especially small and miniature ones which stray from standard styles and usages. This thesis presented a comprehensive review of the archaeological literature concerning small and miniature pottery in North America, while also conducting a methodological test of non-destructive residue analysis techniques. It was noted in this study that small and miniature vessels are a surprisingly common material type found in sites across North America. However, as opposed to their full-sized counterparts, these vessels are treated as oddities and curiosities, and are rarely the focus of in-depth analysis. Studies that do analyze them are typically focused on their possible connection with children or ceremony, and only examine their physical characteristics. For these reasons the appropriateness of applying organic residue methods to this material culture becomes apparent; what better approach than applying techniques which provide insights into the invisible than on a material culture that in many ways has been rendered invisible itself. While results proved to be limited, they still shed some insight onto this little understood material type, and it is hoped that future projects will continue to analyze these unique vessels.

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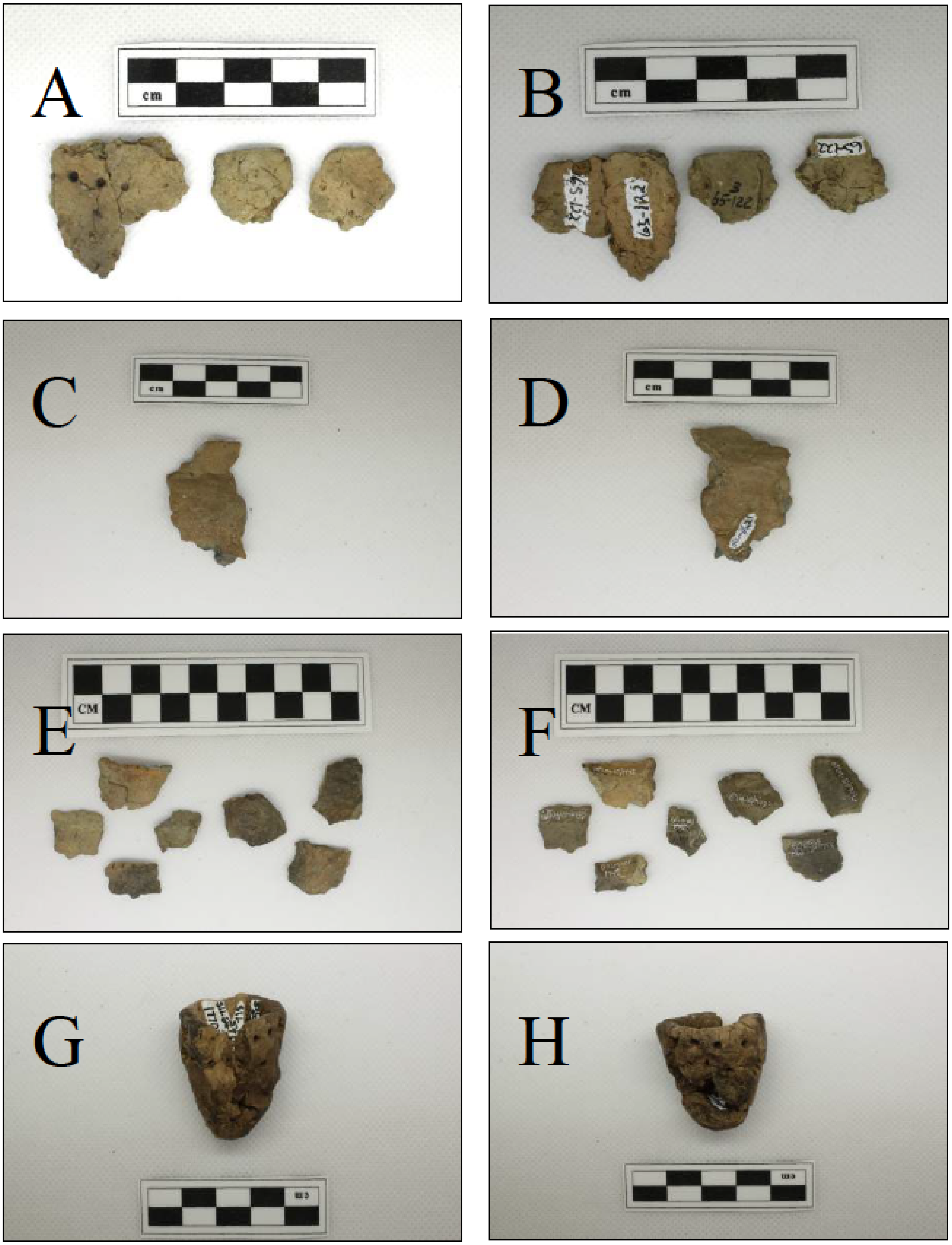
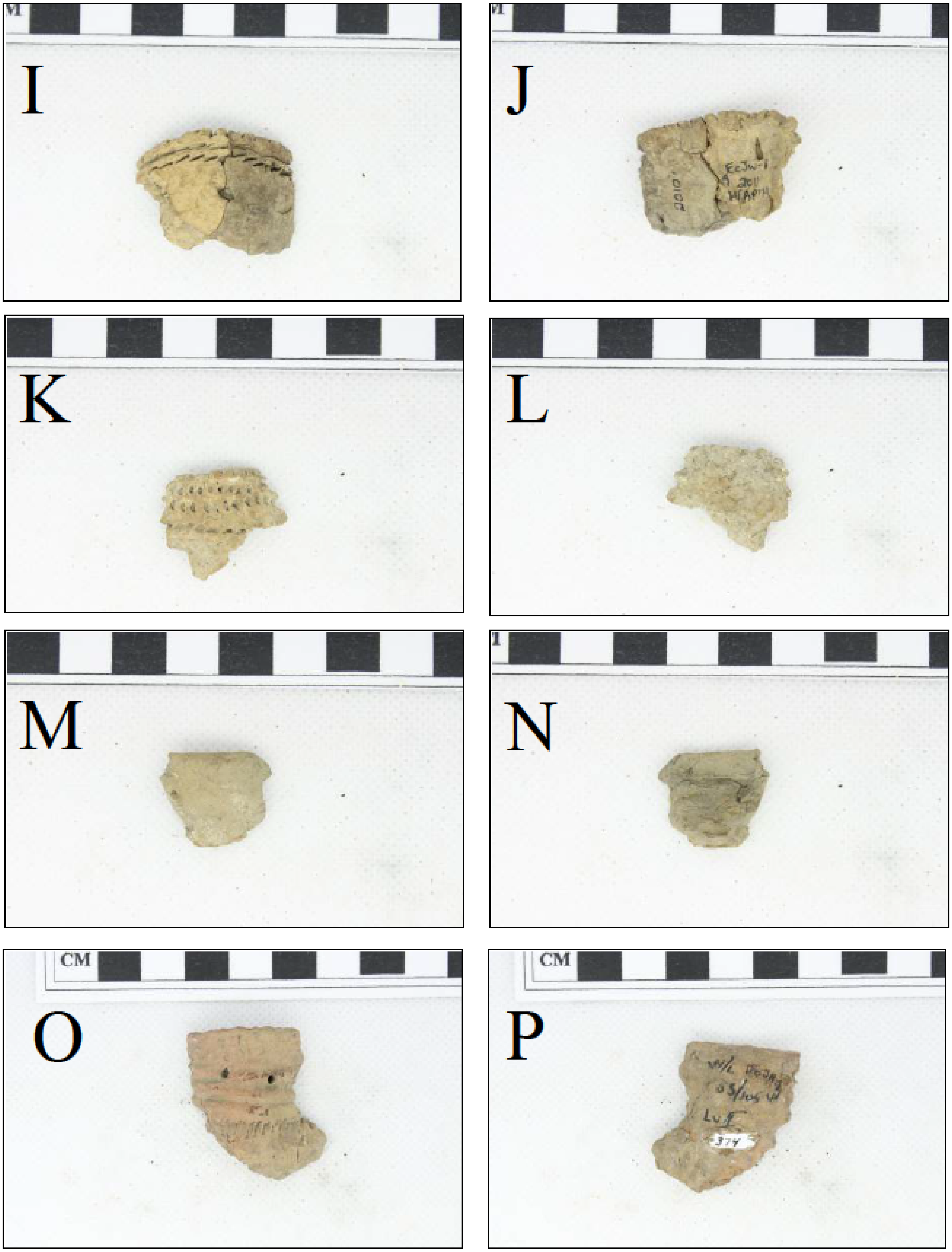
Appendix A: Sample Vessel Images

Figure A. 1: Sample Miniature Vessels

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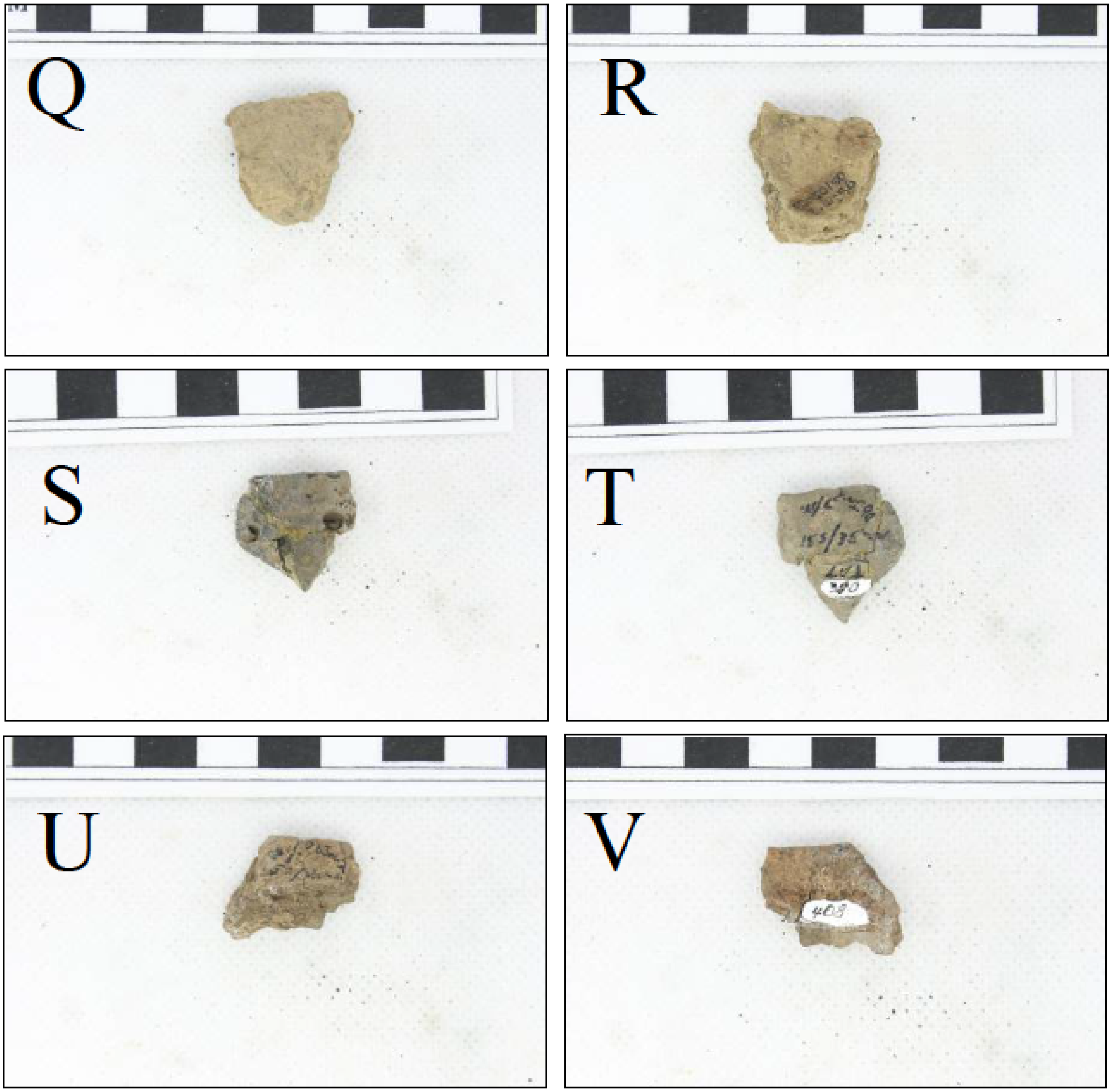
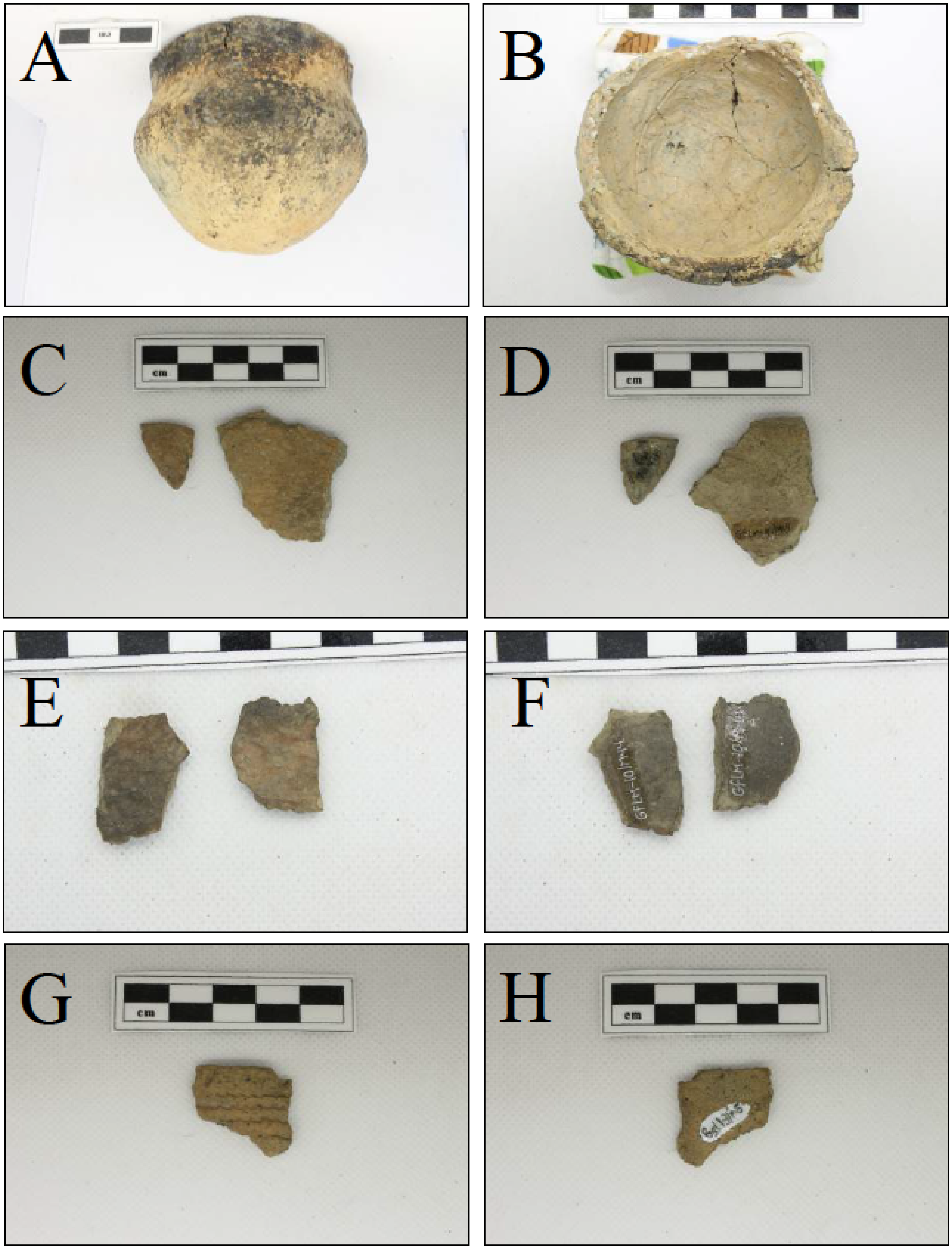


A & B: FkMh-5 V.54 (Possible Miniature); C & D: GfLm-7 V.20 (Possible Miniature); E & F: GfLm-10 V.25 (Possible Miniature); G & H: HiLp-1 V.49 (Miniature); I & J: EcJw-1 V.2 (Miniature); K & L: EcJw-1 V.3 (Possible Miniature); M & N: EcJw-1 V.4 (Miniature); O & P: DbJm-2 V.2 (Possible Miniature); Q & R: DbJm-2 V.7 (Possible Miniature); S & T: DbJm-2 V.11 (Possible Miniature); U & V: DbJm-2 V.8; Not pictured: EcJw-1 V.9 (no photo available)

Figure A. 2: Sample Small Vessels

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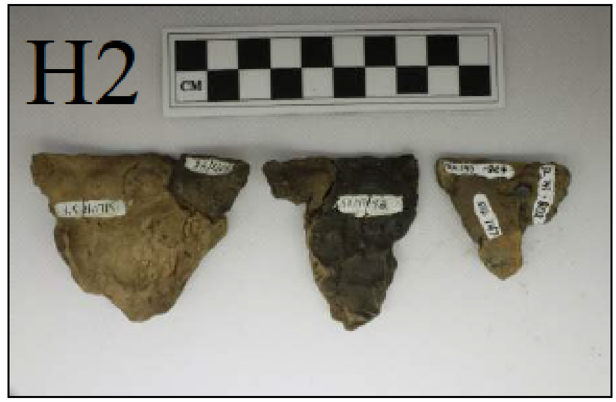
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J2
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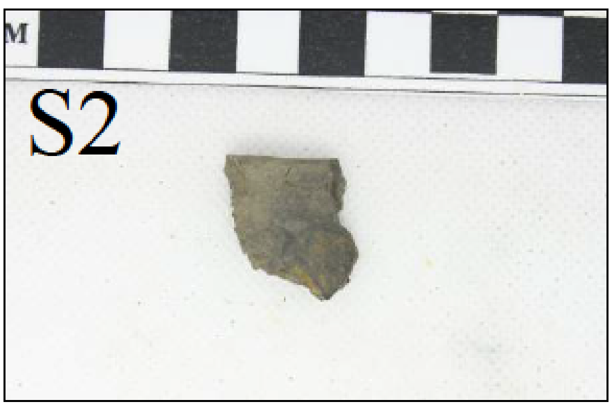
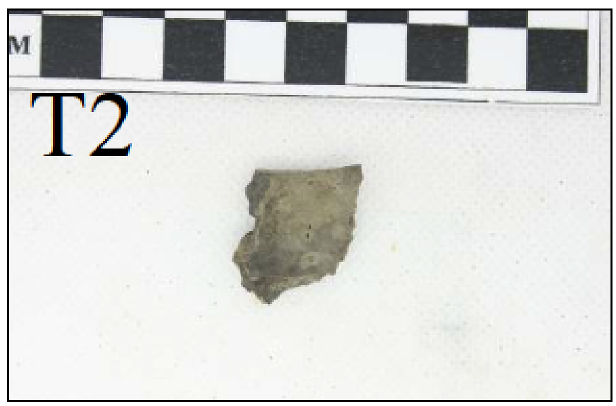

S2

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U2

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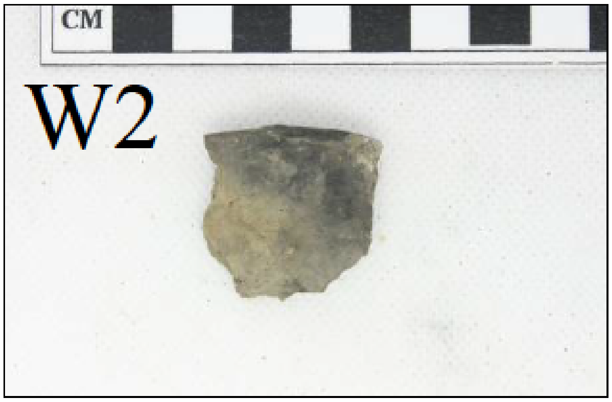
V2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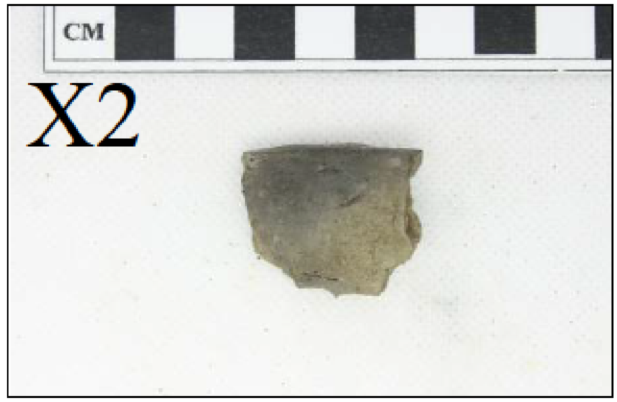

CM
X2


CM
Y2


CM
Z2


A3


B3


C3


D3


E3

F3

G3

H3

I3

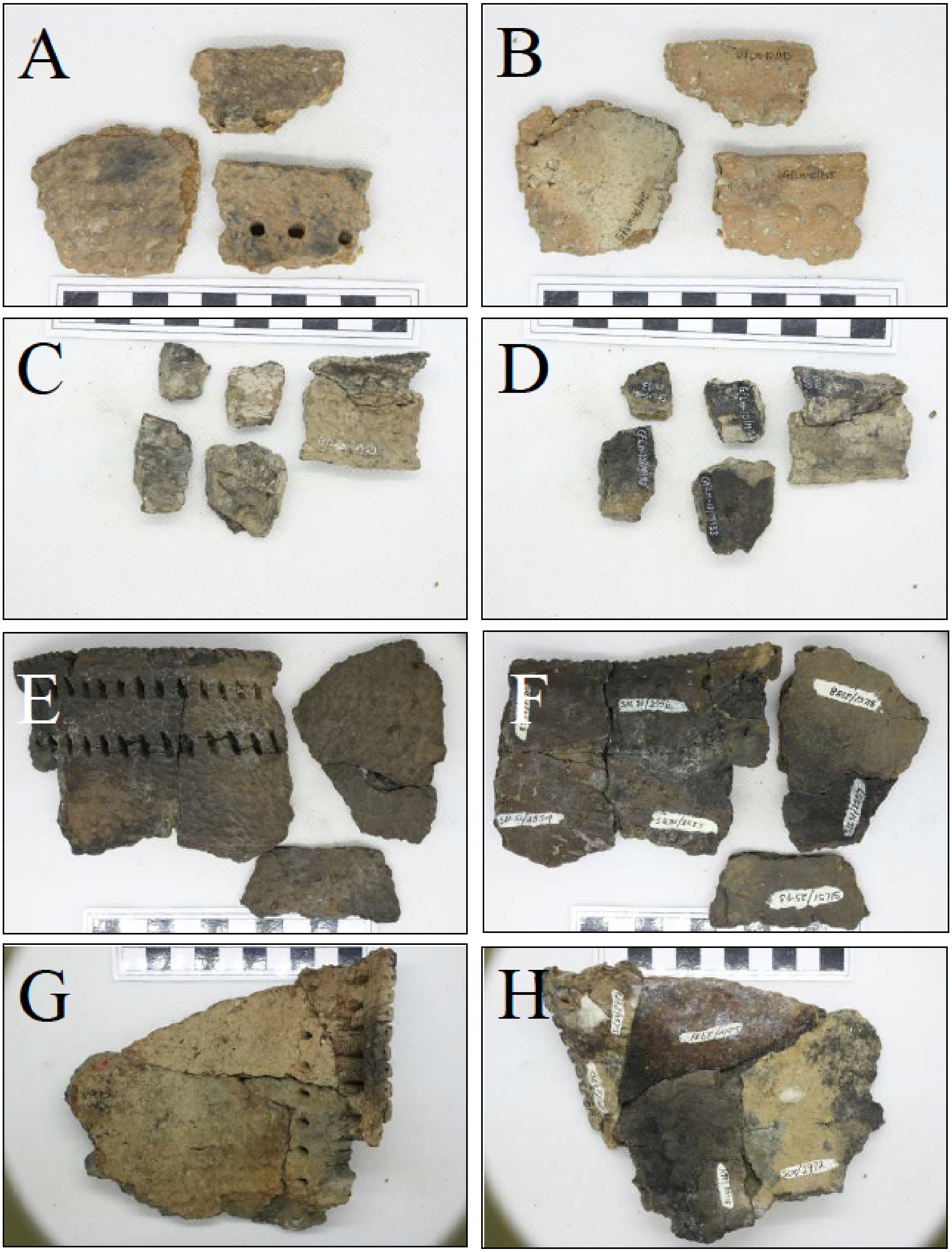
J3

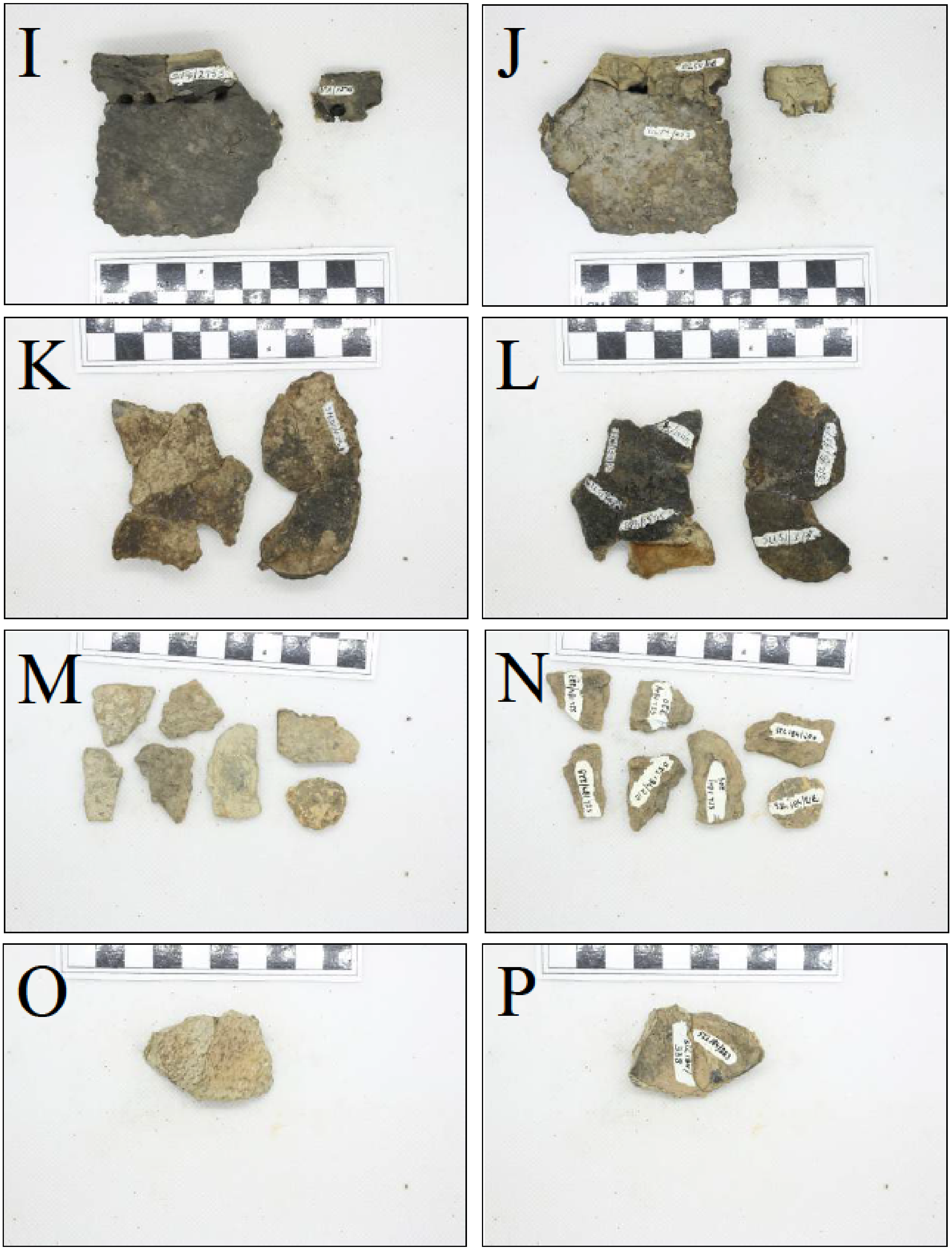
K3

L3

A & B: FlMh-1 V. 1 (Small); C & D: GfLm-10 V.10 (Small); E & F: GfLm-10 V.17 (Possible Small); G & H: GgLl-3 V.2 (Possible Small); I & J: GjLs-2 V.1 (Small); K & L: HfLp-11 V.2 (Small); M & N: HfLp-11 V.3 (Small); O & P: HfLp-11 V.7 (Possible Small); Q & R: HiLp-1 V.25 (Small); S & T: HiLp-1 V.28 (Small); U & V: HiLp-1 V.51 (Small); W & X: HiLp-1 V.121 (Small); Y & Z: HiLp-3 V.8 (Small); A2 & B2: HiLp-3 V.11 (Small); C2 & D2: HiLp-3 V. 23 (Small); E2 & F2: HiLp-3 V.24 (Small); G2 & H2: HjLp-7 V.17 (Small); I2 & J2: HjLp-7 V. 18 (Possible Small); K2 & L2: HlLv-6 V.4 (Small); M2 & N2: EcJw-1 V.1 (Small); O2 & P2: EcJw-1 V.5 (Small); Q2 & R2: EcJw-1 V.6 (Possible Small); S2 & T2: EcJw-1 V.7 (Possible Small); U2 & V2: EcJw-1 V.8 (Possible Small); W2 & X2: EcJw-1 V.10 (Small); Y2 & Z2: DbJm-2 V.1 (Small); A3 & B3: DbJm-2 V.3 (Possible Small); C3 & D3: DbJm-2 V.4 (Small); E3 & F3: DbJm-2 V.5 (Small); G3 & H3: DbJm-2 V.6 (Small); I3 & J3: DbJm-2 V.9 (Small); K3 & L3: DbJm-2 V.10 (Small); M3 & N3: DbJm-2 V.12 (Small); O3 & P3: DbJm-2 V.13 (Small); Q3 & R3: DbJm-2 V.14 (Small)

Figure A. 3: Sample Full-Sized Vessels

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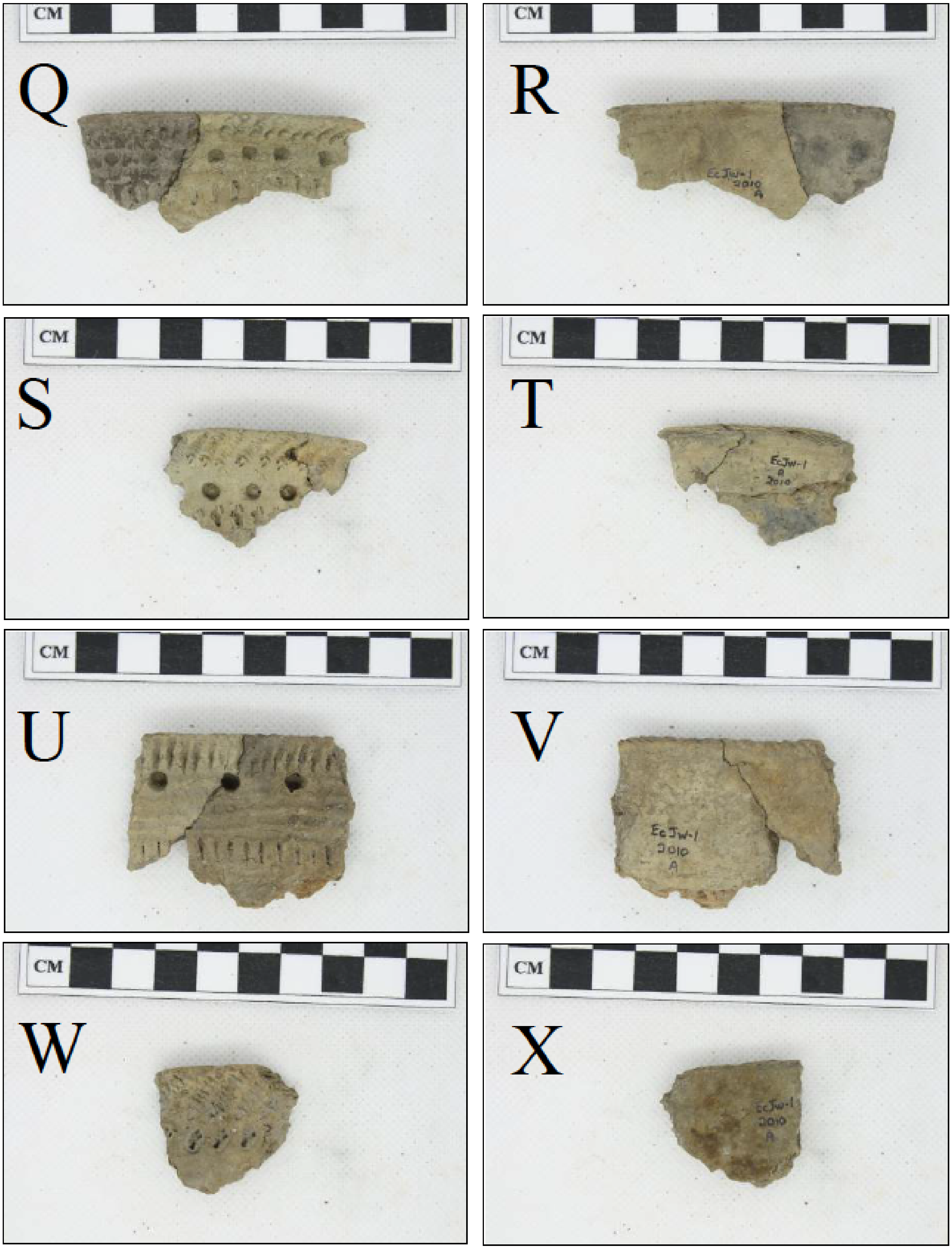
CM
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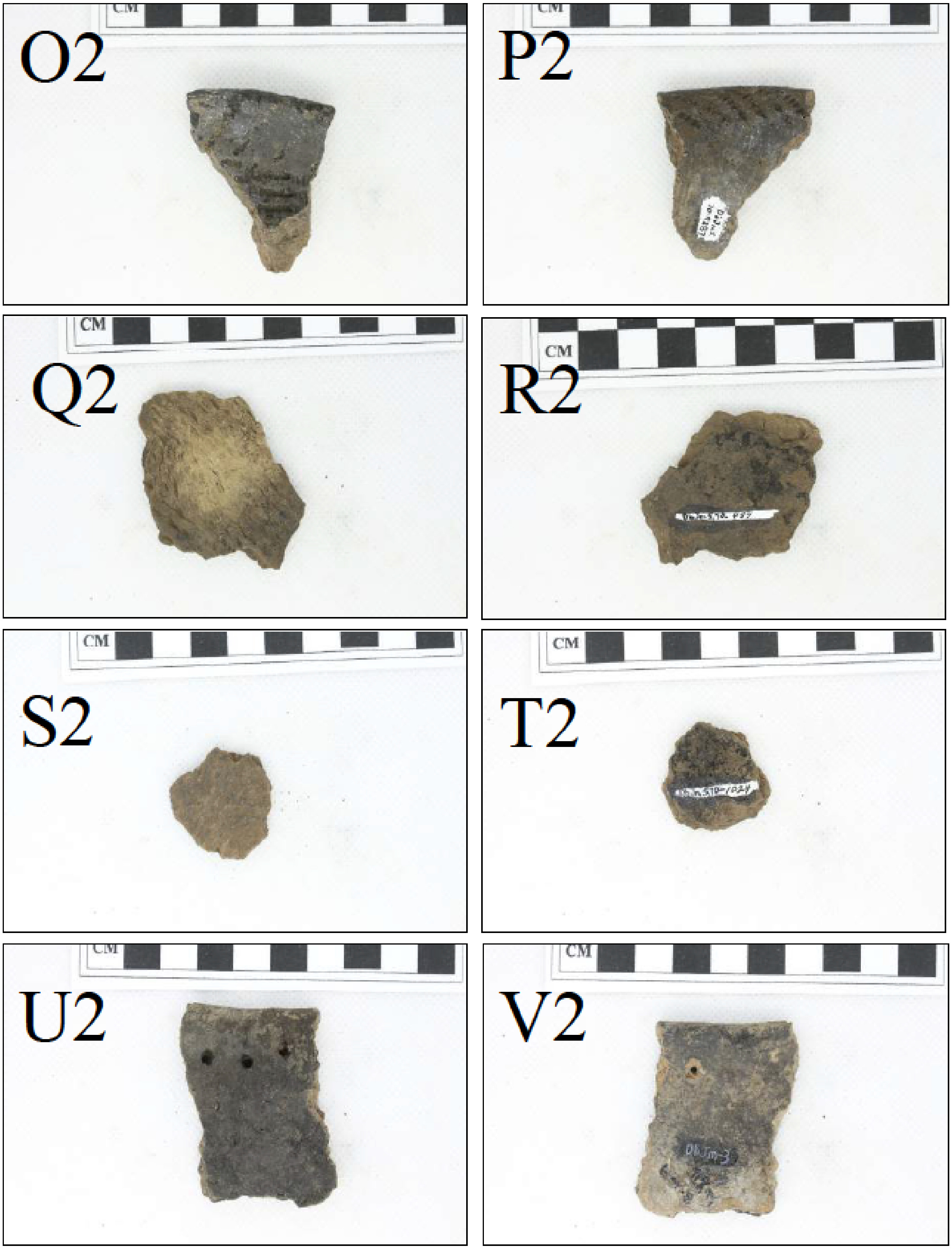
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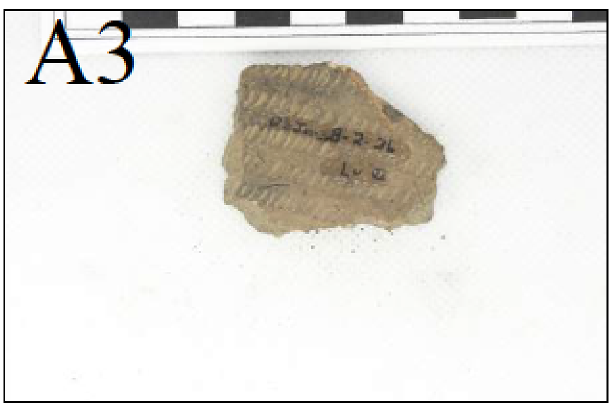
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G3

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H3

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I3

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J3

K3

L3

A & B: GfLm-10 V.2; C & D: GfLm-10 V.9; E & F: HiLp-3 V.1; G & H: HiLp-1 V.120; I & J: HiLp-1 V.14; K & L: HiLp-3 V.3; M & N: HfLp-11 No des.; O & P: HfLp-11 V.1; Q & R: EcJw-1 V.11; S & T: EcJw-1 V.12; U & V: EcJw-1 V.13; W & X: EcJw-1 V.14; Y & Z: EcJw-1 V.15; A1 & B1: EcJw-1 V.16; C1 & D1: EcJw-1 V.17; E1 & F1: EcJw-1 V.18; G1 & H1: EcJw-1 V.19; Not pictured EcJw-1 V.20 (no picture available); I1 & J1: DbJm-5 V.1; K1 & L1: DbJm-5 V.2; M1 & N1: DbJm-5 V.3; O1 & P1: DbJm-5 V.4; Q1 & R1: DbJm-5 V.5; S1 & T1: DbJm-5 V.6; U1 & V1: DbJm-3 V.1; W1 & X1: DbJm-3 V.2; Y1 & Z1: DbJm-3 V.3; A2 & B2: DbJm-3 V.4; C2 & D2: DbJm-3 V.5; E2 & F2: DbJm-2 V.15; G2 & H2: DbJm-2 V.16; I2 & J2: DbJm-2 V.17; K2 & L2: DbJm-2 V.18; M2 & N2: DbJm-2 V.19; O2 & P2: DbJm-2 V.20; Q2 & R2: DbJm-2 V.21

Appendix B: Pottery Attribute Figures and Descriptions

Figure B. 1 :Diameter Estimation Sheet (Syms and Dedi 2006)

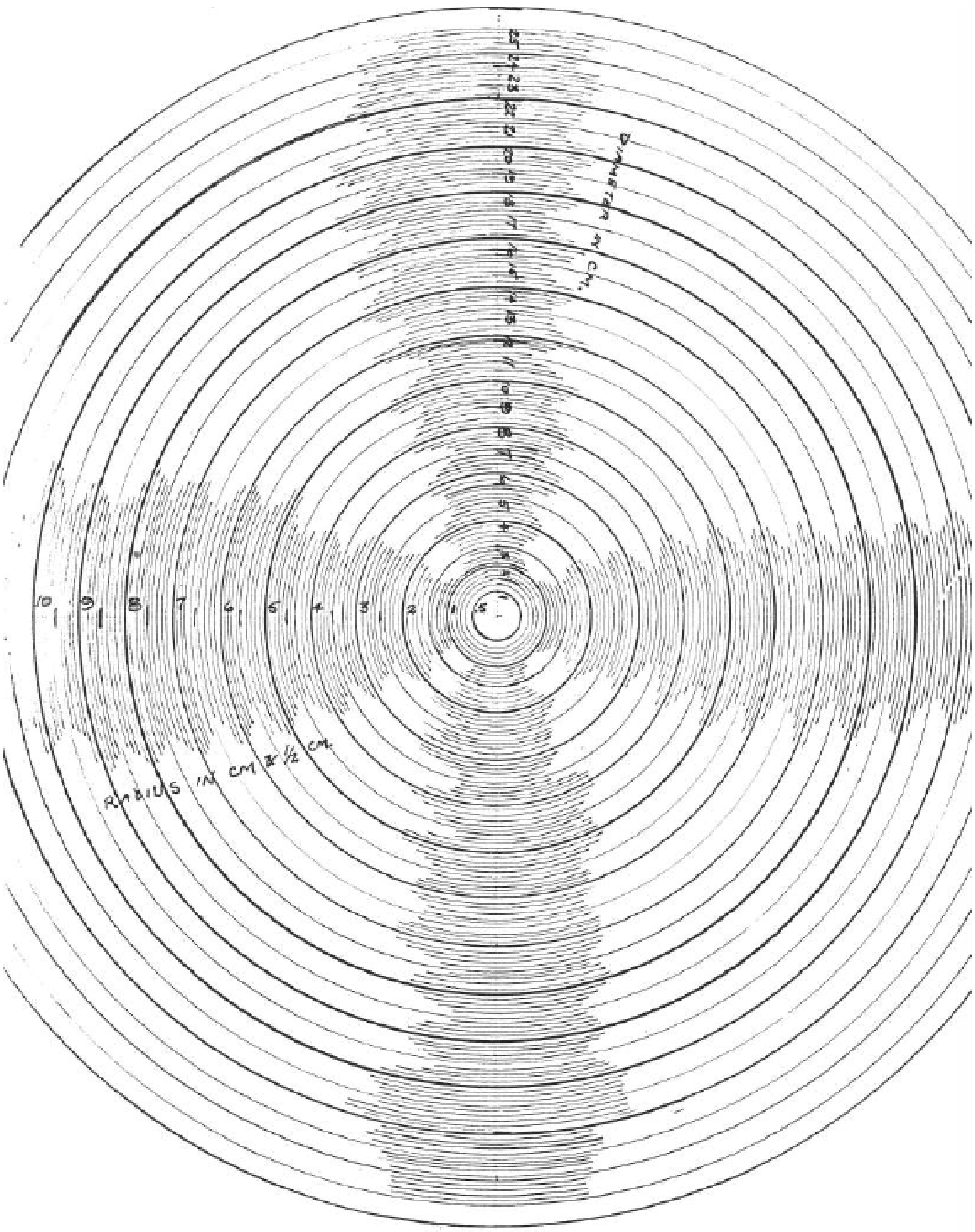


Figure B. 2: Vessel Form (Adapted from Syms and Dedi 2006)

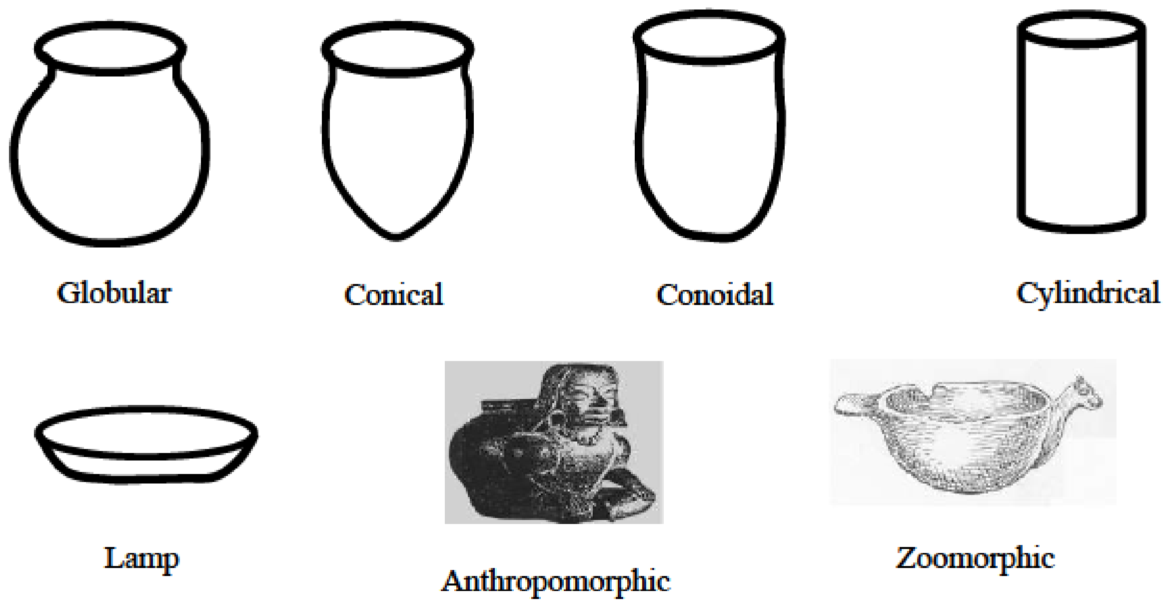
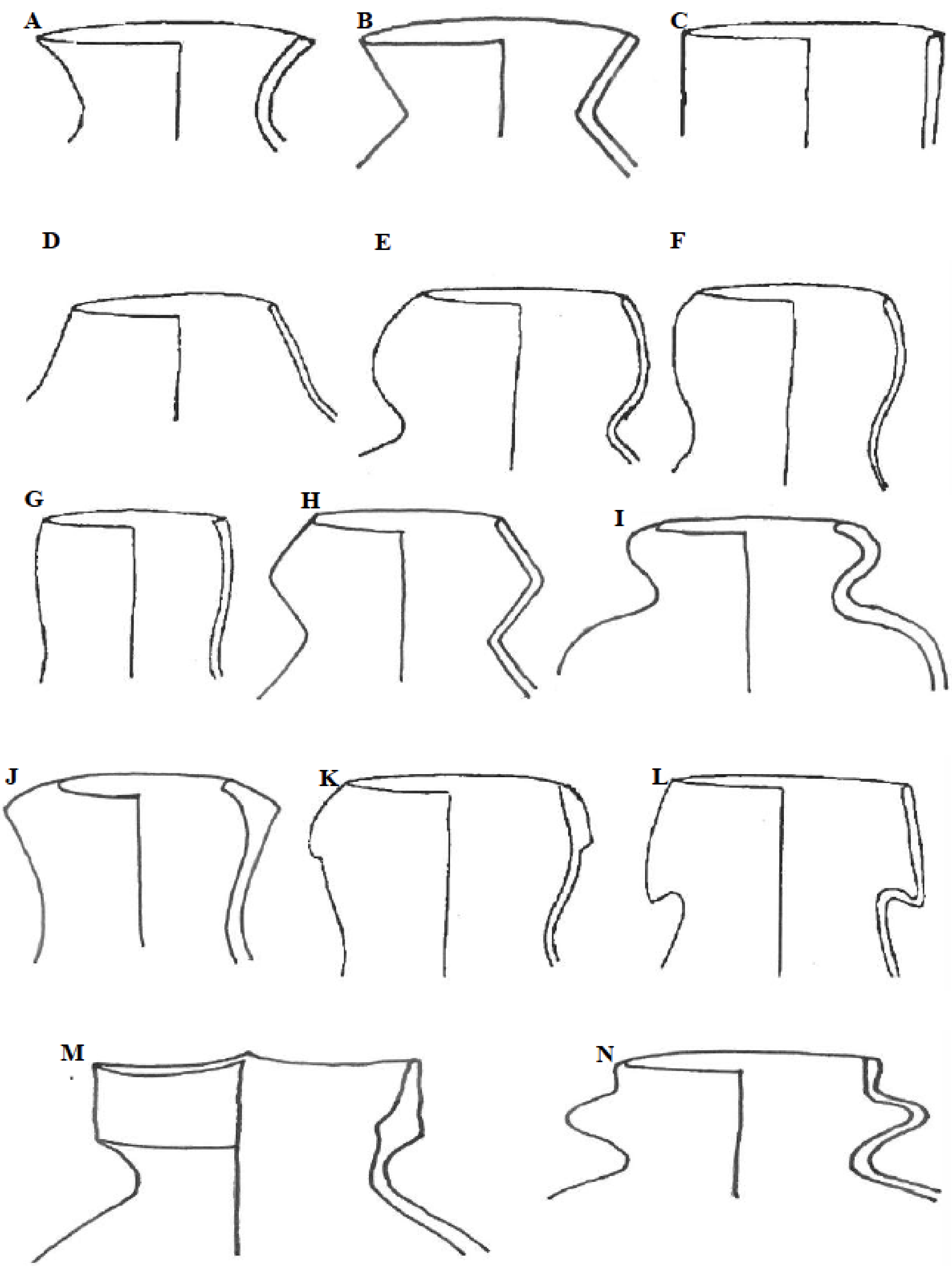
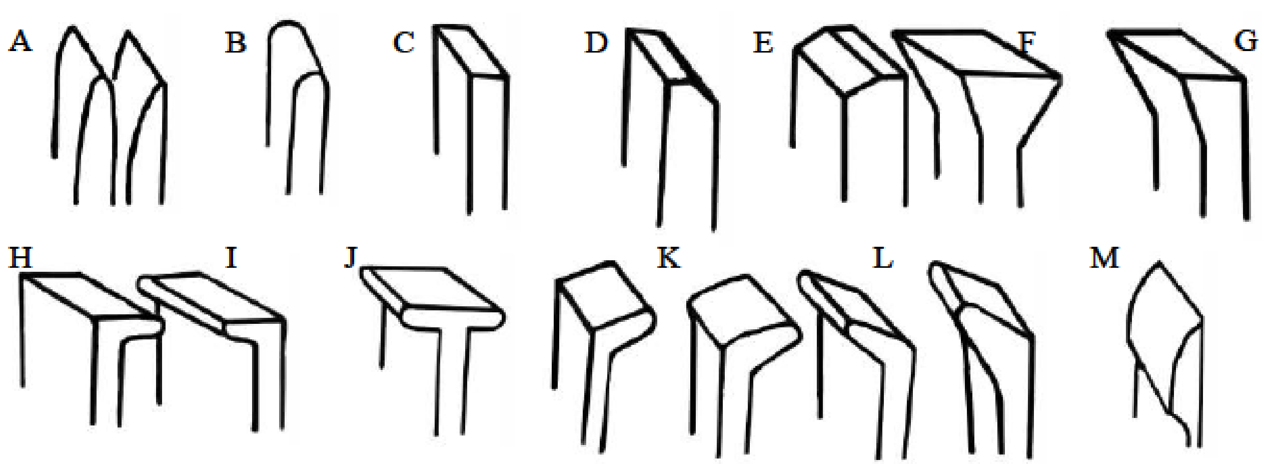


Figure B. 3: Neck Form (Adapted from Syms and Dedi 2006)



A) Excurvate Rim: curves outward from the most constricted portion of the neck to the lip
B) Straight Out-flared Rim: flares out form the most constricted portion of the neck to the lip without curvature
C) Straight Rim: no curvature, straight-walled cylinder
D) Converging Rim: straight-line slope from neck to lip with lip diameter smaller than neck diameter
E) S-Rim: sharp concave curvature between the lip and point of inflection (widest portion of the neck) and reverse curvature below to the most constricted portion of the neck expanding again to the shoulder. Curvature ratio is greater than 1.5
F) Shallow S-Rim: gradual curvature with a ratio between 0.6 and 1.5
G) Incipient S-Rim: very gentle curvature of 0.1 to 0.8 with most values below 0.6
H) Angular S-Rim: an S-profile displaying angular bends rather than curvatures
I) Crimped S-Rim: an S-Rim, but curvatures are short and close
J) Wedged Rim: Slight curvature outward from neck then angling inward and thickening just under and towards lip
K) Braced Rim: has a thickened band made by adding an extra layer of clay to below the exterior below the lip
L) Collared Rim: an exaggerated angular S-profile in which the bottom of the exterior point of inflection is lower than the interior curvature (Plains form)
M) Collared Rim: Southern Ontario vessel form
N) Composite: Rim profile composed of angles and curvatures

Figure B. 4: Lip Form (Adapted from Syms and Dedi 2006)



- Pointed: converges to a point, symmetric or asymmetric
- Rounded: rounded apex
- Square: square edges and the top surface is perpendicular to the profile
- In-sloped: planar surface oblique to profile starting to the interior of the vessel
- Out-sloped: planar surface oblique to profile starting (beveled) to the exterior of the vessel

- Wedged: pronounced widening of lip resembling an inverted triangle; other terms used include splayed or flared. Do not use term for specimens that have slight thickening to due to small amounts of excess clay pushed over the edge when the lip was flattened
- Exterior Wedged: pronounced widening of the lip (from the neck up to a flattened lip surface) on the exterior only (a wedged lip occurring on the exterior only)
- L-shaped interior: definite ridge projecting into the interior of the vessel (resembling an inverted capital L)
- L-shaped exterior: definite ridge projecting over the exterior of the vessel (resembling an inverted capital L)
- T-shaped: definite ridges projecting over both interior and exterior (resembling a capital T)
- Beveled interior: resembling an L-shaped lip except the ridge is oriented obliquely to the profile, slanting over the interior of the vessel
- Beveled exterior: resembling an L-shaped lip except the ridge flares obliquely away from the vessel
- Braced: has a thickened portion where an extra strip has been added. Upper portion is pointed asymmetrically to the interior

Figure B. 5: Shoulder Form (Adapted from Syms and Dedi 2006)

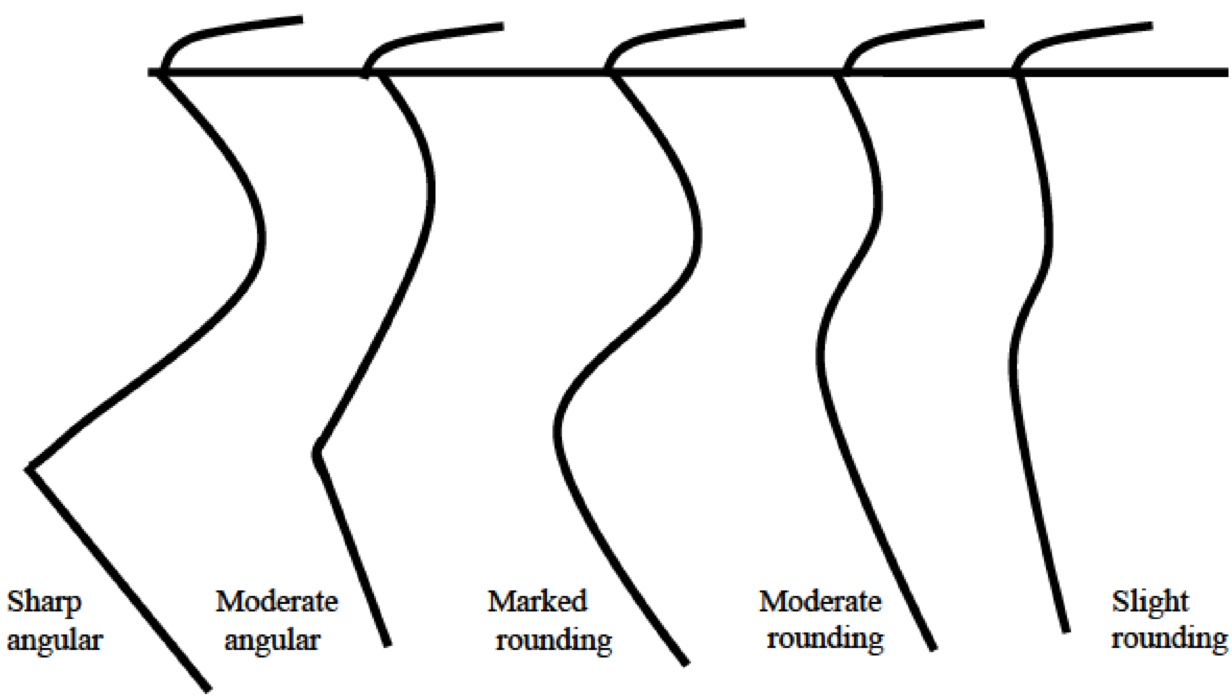


Figure B. 6: Base Form (Adapted from Syms and Dedi 2006)

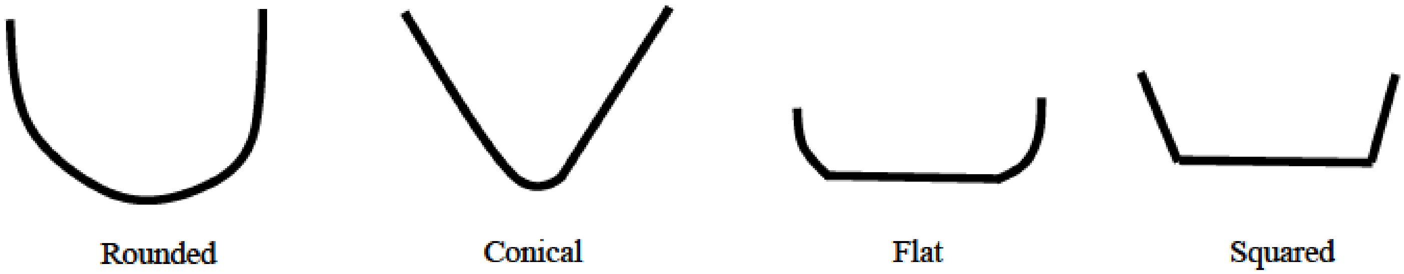


Figure B. 7: Surface Finish (Adapted from Syms and Dedi 2006)

Smoothed: surface has no visible pattern

Textile Impressed

Obliterated: primary surface finish is obscured

Table B. 1: Pottery Attribute Descriptions

Attribute	Description
Vessel Type	Is the vessel miniature, small, full-sized or other
Pottery Tradition	Does the vessel have attributes that would allow it to be characterized as a certain pottery tradition (ie. Laurel, Blackduck, Selkirk etc.)
Time Period	What time period is the vessel or sherd associated with (ie. Early, Middle, or Late Woodland etc.)
Vessel Profile	The overall shape of a vessel (ie. conical, globular, conoidal, cylindrical etc.)
Neck Shape	The upper portion of the vessel ranging from just below the neck to the lip (ie. straight, excurvate, convex, converging etc.)
Lip Shape	Shape of the lip portion of a vessel (ie. squared, rounded, angled, pointed, wedged etc.)
Shoulder Shape	The amount of angular inflection visible on a vessel (ie. rounding, concave etc.)
Base Shape	Shape of the base of a vessel (ie. rounded, conical, flat, squared)
Surface Finish	Description of the interior and/or exterior surface of the vessel (ie. smooth, textile-impressed, obliterated etc.)
Paste Composition	Description of the size, density, and type of temper included in the paste of the vessel
Decorative Motifs	Description of the decorations visible on a pottery sherd or vessel
Diameter	Measurement of the opening of a vessel which can be used to determine its circumference
Maximum Thickness (Body)	What is the maximum thickness of the body of the vessel or sherd
Maximum Thickness (Rim)	What is the maximum rim thickness of the vessel or sherd

Maximum Thickness (Lip)	What is the maximum lip thickness of the vessel or sherd
Vessel Height	What is the maximum height of the vessel
Crudity Index	The crudity index assesses the quality of the construction of a vessel by taking thickness measurements at two points on a vessel and creating a ratio between the thickest and thinnest points
Curvature Consistency Index	The curvature consistency index evaluates a pots manufacture by measuring the curve of a vessels wall
Motif Application Index	The motif application index assesses the motor skills of a potter by analyzing decorative motifs

Table B. 2: Temper (Adapted from Syms and Dedi 2006)

Type:

1) Natural – use of coarse sand or very small pebbles as temper (ie. Natural quartz inclusions)
2) Grit – consisting of specically prepared temper such as broken granite, quartz, feldspar, mica, garnet, basalt etc.
3) Added bone, shell, grog, crushed ceramic
4) Plant fibres

Size:

1) Fine – particles up to 1 mm diameter
2) Medium – particles range from 1-3 mm diameter
3) Coarse particles greater than 2 mm diameter

Appendix C: Pottery Attribute Results

Table C. 1: Sample Distribution of Miniature and Small Vessels

Vessel Type	Number of Vessels	% of Sample
Small/Possible Small	35	74%
Miniature/Possible Miniature	12	25%

Table C. 2: Miniature Vessel Form

Vessel	Profile	Neck	Lip	Shoulder	Base
FkMh-5 V.54	N/A	Straight	Squared	Slight rounding	N/A
GfLm-07 V.20	N/A	Excurvate	Rounded	Marked rounding	N/A
GfLm-10 V.25	N/A	Excurvate	Squared/rounded	N/A	N/A
HiLp-1 V.49	Conical	Straight	Squared/rounded	N/A	Rounded
EcJw-1 V.2	N/A	Straight/slightly convex	Rounded (decorated)	N/A	N/A
EcJw-1 V.3	N/A	Straight	Squared (decorated)	N/A	N/A
EcJw-1 V.4	N/A	Straight	Rounded	N/A	N/A
EcJw-1 V.9	N/A	Straight/converging in	Rounded	N/A	N/A
DbJm-2 V.2	N/A	Excurvate	Squared (decorated)	N/A	N/A
DbJm-2 V.7	N/A	N/A	N/A	N/A	N/A
DbJm-2 V.8	N/A	Straight	Rounded	N/A	N/A
DbJm-2 V.11	N/A	Straight	Squared	N/A	N/A

Table C. 3: Small Vessel Form

Vessel	Profile	Neck	Lip	Shoulder	Base
FlMh-1 V.1	Globular	Excurvate	Squared	Marked rounding	Rounded
GfLm-10 V.10	N/A	Straight	Rounded	N/A	N/A
GfLm-10 V.17	N/A	Excurvate	Squared	N/A	N/A
GgLl-03 V. 2	N/A	Straight	Rounded	N/A	N/A
GjLs-2 V.1	Globular	N/A	N/A	Slight rounding	Rounded
HfLp-11 V.2	Conoidal/globular	Excurvate	Rounded	Slight rounding	Rounded
HfLp-11 V.3	N/A	Excurvate	Rounded	Slight rounding	N/A
HfLp-11 V.7	N/A	N/A	N/A	N/A	N/A
HiLp-1 V.25	N/A	Straight	Rounded (decoration)	Light/no rounding	N/A
HiLp-1 V.28	N/A	Straight	Rounded (decoration)	Slight/no rounding	N/A
HiLp-1 V.51	Conoidal	Straight	Squared	Slight/no rounding	Rounded
HiLp-1 V.121	N/A	Straight	Rounded	N/A	N/A
HiLp-3 V.8	Globular	Excurvate	Rounded/squared	Slight rounding	Rounded
HiLp-3 V.11	N/A	Straight	Squared/rounded	Slight/no rounding	N/A
HiLp-3 V.23	N/A	Straight	Squared/rounded	N/A	N/A
HiLp-3 V.24	N/A	Straight	Rounded	N/A	N/A
HjLp-7 V.17	N/A	Straight	Rounded	N/A	N/A
HjLp-7 V.18	N/A	N/A	Rounded	N/A	N/A
HlLv-6 V.4	Globular	Excurvate	Rounded	Slight rounding	N/A
EcJw-1 V.1	N/A	Converging/excurvate	Rounded/slightly squared	N/A	N/A
EcJw-1 V.5	N/A	Straight	Squared	N/A	N/A
EcJw-1 V.6	N/A	N/A	Squared (decorated)	N/A	N/A

EcJw-1 V.7	N/A	Straight	Rounded	N/A	N/A
EcJw-1 V.8	N/A	Straight	Rounded/squared	N/A	N/A
EcJw-1 V.10	N/A	Straight	Rounded	N/A	N/A
DbJm-2 V.1	N/A	Excurvate	Rounded	N/A	N/A
DbJm-2 V.3	N/A	Excurvate	Rounded/slightly squared	N/A	N/A
DbJm-2 V.4	N/A	Convex	Rounded	N/A	N/A
DbJm-2 V.5	N/A	Excurvate	Rounded (decorated)	N/A	N/A
DbJm-2 V.6	N/A	Straight	Squared/slopes down	N/A	N/A
DbJm-2 V.9	N/A	Excurvate	Squared (decorated)	N/A	N/A
DbJm-2 V.10	N/A	Straight	Rounded	N/A	N/A
DbJm-2 V.12	N/A	Excurvate	Squared/angled forward	Concave	N/A
DbJm-2 V.13	N/A	Excurvate	Rounded (decorated)	N/A	N/A
DbJm-2 V.14	N/A	Excurvate	Rounded (decorated)	Marked rounded	N/A

Table C. 4: Full-sized Vessel Form

Vessel	Profile	Neck	Lip	Shoulder	Base
GfLm-10 V.2	N/A	Straight	Rounded	N/A	N/A
GfLm-10 V.9	N/A	Excurvate	Squared/pointed	N/A	N/A
HiLp-3 V.1	N/A	Slightly excurvate	Squared (decoration)	N/A	N/A
HiLp-1 V.120	N/A	Excurvate	Rounded (decoration)	N/A	N/A
HiLp-1 V.14	N/A	Excurvate	Squared	Slight rounding	N/A
HiLp-3 V.3	N/A	N/A	N/A	N/A	N/A
HfLp-11 No des.	N/A	N/A	N/A	N/A	N/A
HfLp-11 V.1	N/A	N/A	N/A	N/A	N/A
EcJw-1 V.11	N/A	Excurvate	Exterior wedged	N/A	N/A
EcJw-1 V.12	N/A	Excurvate	Exterior wedged	N/A	N/A
EcJw-1 V.13	N/A	Straight/excurvate	Squared	N/A	N/A
EcJw-1 V.14	N/A	Straight/excurcate	Slight exterior wedging	N/A	N/A
EcJw-1 V.15	N/A	Straight	Squared	N/A	N/A
EcJw-1 V.16	N/A	Straight	Squared/exterior wedging	N/A	N/A
EcJw-1 V.17	N/A	Straight/excurvate	Squared/exterior wedging	N/A	N/A
EcJw-1 V.18	N/A	Slightly excurvate	Exterior wedged	N/A	N/A
EcJw-1 V.19	N/A	Straight/excurvate	Squared/exterior wedged	N/A	N/A
EcJw-1 V.20	N/A	N/A	N/A	N/A	N/A
DbJm-5 V.1	N/A	N/A	N/A	N/A	N/A
DbJm-5 V.2	N/A	N/A	N/A	N/A	N/A
DbJm-5 V.3	N/A	N/A	N/A	N/A	N/A
DbJm-5 V.4	N/A	Excurvate	Rounded/squared	N/A	N/A

DbJm-5 V.5	N/A	N/A	N/A	N/A	N/A
DbJm-5 V.6	N/A	N/A	N/A	N/A	N/A
DbJm-3 V.1	N/A	Straight/slight excurvate	Rounded/squared	N/A	N/A
DbJm-3 V.2	N/A	Straight	Rounded	N/A	N/A
DbJm-3 V.3	N/A	Excurvate	Squared	N/A	N/A
DbJm-5 V.4	N/A	N/A	N/A	N/A	N/A
DbJm-3 V.5	N/A	N/A	N/A	N/A	N/A
DbJm-2 V.15	N/A	Excurvate	Rounded (Decorated)	N/A	N/A
DbJm-2 V.16	N/A	Excurvate	In-sloped	N/A	N/A
DbJm-2 V.17	N/A	N/A	N/A	N/A	N/A
DbJm-2 V.18	N/A	Excurvate	In-sloped (decorated)	N/A	N/A
DbJm-2 V.19	N/A	N/A	N/A	N/A	N/A
DbJm-2 V.20	N/A	N/A	N/A	N/A	N/A
DbJm-2 V.21	N/A	Excurvate	Squared (Decorated)	N/A	N/A

Table C. 5: Surface Finish and Temper Miniature Vessels

Vessel	Surface Finish	Temper
FkMh-5 V.54	Smooth	Fine grit
HiLp-1 V.49	Smooth	Natural to fine grit
GfLm-10 V.25	Smooth	Fine grit
GfLm-7 V.20	Smooth	High fine grit
EcJw-1 V.2	Smooth	Low fine grit
EcJw-1 V.3	N/A	Fine grit
EcJw-1 V.4	Smooth	Fine grit
EcJw-1 V.9	Smooth	Fine grit
DbJm-2 V.2	Smooth	None to Low natural
DbJm-2 V.7	Undetermined	Fine grit
DbJm-2 V.8	N/A	Low natural
DbJm-2 V.11	N/A	Fine grit

Table C. 6: Surface Finish and Temper Small Vessels

Vessel	Surface Finish	Temper
FlMh-1 V.1	Smooth	Heavy fine grit
GfLm-10 V.10	Smooth and textile impressed	Fine to medium grit
GfLm-10 V.17	Textile impressed	Fine grit
GgLl-03 V. 2	N/A	Fine grit
GjLs-2 V.1	Textile impressed	Fine to medium grit

HfLp-11 V.2	Textile impressed	Medium grit
HfLp-11 V.3	Obliterated	Medium to coarse grit
HfLp-11 V.7	Smooth	Natural to fine grit
HiLp-1 V.25	Textile impressed	Medium to coarse grit
HiLp-1 V.28	Textile impressed (some obliterated)	Natural to fine grit
HiLp-1 V.51	Textile impressed (some obliterated)	Low natural
HiLp-1 V.121	Textile impressed	Fine grit
HiLp-3 V.8	Textile impressed	Medium grit
HiLp-3 V.11	Obliterated	Low fine to medium grit
HiLp-3 V.23	Obliterated	Fine grit
HiLp-3 V.24	Obliterated	Fine grit
HjLp-7 V.17	Smooth	Fine grit
HjLp-7 V.18	Smooth	Low natural to fine grit
HlLv-6 V.4	Semi-obliterated (interior textile impressed)	Fine to medium grit
EcJw-1 V.1	Smooth	Low fine grit
EcJw-1 V.5	Smooth	Fine grit
EcJw-1 V.6	N/A	Fine grit
EcJw-1 V.7	Smooth	Fine grit
EcJw-1 V.8	Smooth	Fine grit
EcJw-1 V.10	Smooth	Fine grit
DbJm-2 V.1	Smooth	None to Low natural
DbJm-2 V.3	Smooth	Medium grit
DbJm-2 V.4	Smooth	Fine grit

DbJm-2 V.5	Smooth	Low fine grit
DbJm-2 V.6	Smooth	None to low natural
DbJm-2 V.9	N/A	Low fine grit
DbJm-2 V.10	N/A	Fine to medium grit
DbJm-2 V.12	Textile impressed	Medium grit
DbJm-2 V.13	N/A	None to low natural
DbJm-2 V.14	Smooth	Fine grit

Table C. 7: Surface Finish and Temper Full-Sized Vessels

Vessel	Surface Finish	Temper
GfLm-10 V.2	Textile impressed	Medium grit
GfLm-10 V.9	Textile impressed	Medium grit
HiLp-3 V.1	Textile impressed	Medium to coarse grit
HiLp-1 V.120	Textile impressed	Fine to medium grit
HiLp-1 V.14	Textile impressed	Medium to coarse grit
HiLp-3 V.3	Obliterated	Low fine grit
HfLp-11 no des.	Textile impressed	Low fine grit
HfLp-11 V.1	Textile impressed	Low fine grit
EcJw-1 V.11	N/A	Fine grit
EcJw-1 V.12	N/A	Fine grit
EcJw-1 V.13	Textile impressed	Fine grit
EcJw-1 V.14	Textile impressed	Fine to medium grit

EcJw-1 V.15	N/A	Fine grit
EcJw-1 V.16	N/A	Fine grit
EcJw-1 V.17	Textile impressed (some obliterated)	Fine grit
EcJw-1 V.18	Textile impressed (some obliterated)	Fine grit
EcJw-1 V.19	N/A	Fine grit
EcJw-1 V.20	Textile impressed	Fine grit
DbJm-5 V.1	Textile impressed (some obliterated)	Medium grit
DbJm-5 V.2	Textile impressed	Medium grit
DbJm-5 V.3	Textile impressed	Fine to medium grit
DbJm-5 V.4	N/A	Fine to medium grit
DbJm-5 V.5	Textile impressed	Fine to medium grit
DbJm-5 V.6	Textile impressed	Fine to medium grit
DbJm-3 V.1	Smooth	Low fine grit
DbJm-3 V.2	N/A	Heavy fine grit
DbJm-3 V.3	N/A	Low fine grit
DbJm-3 V.4	N/A	Medium grit
DbJm-3 V.5	Smooth/Obliterated	Fine to medium grit
DbJm-2 V.15	Textile impressed	Fine grit
DbJm-2 V.16	Textile impressed	Low fine grit
DbJm-2 V.17	Textile impressed	Medium to coarse grit
DbJm-2 V.18	N/A	Fine grit
DbJm-2 V.19	Textile impressed	Fine to medium grit
DbJm-2 V.20	Obliterated	Medium grit

DbJm-2 V.21	N/A	Low fine grit

Table C. 8: Decorative Motifs of Miniature Vessels

Vessel	Lip	Rim/Neck	Body	Interior Decoration
FkMh-5 V.54	N/A	Punctates	Smooth	Bosses
HiLp-1 V.49	N/A	2 rows of punctates on rim	Smooth	Bosses
GfLm-10 V.25	Fingernail notches	Possible incised lines	Smooth	N/A
GfLm-7 V.20	N/A	N/A	Smooth	N/A
EcJw-1 V.2	Fingernail notches	1 irregular, horizontal dragged incised line and 1 right, oblique incised line or stamp	Smooth	N/A
EcJw-1 V.3	Thick with thin, parallel notches	2 rows of crescent shaped stamps, 1 row of horizontal, oval stamps	N/A	N/A
EcJw-1 V.4	N/A	N/A	Smooth	N/A
EcJw-1 V.9	N/A	N/A	Smooth	Possible bosses
DbJm-2 V.2	Fingernail or CWO notches, exterior has been pinched to form ridge	3 horizontal rows of CWO, row of punctates in between first and second CWO rows, underneath are vertical incised lines	Smooth	Bosses
DbJm-2 V.7	N/A	N/A	Undetermined	N/A
DbJm-2 V.8	N/A	N/A	N/A	N/A
DbJm-2 V.11	Right parallel finger notches	Right parallel oblique CWO, 2 rows of CWO, punctates	N/A	Bosses

Table C. 9: Decorative Motifs of Small Vessels

Vessel	Lip	Rim/Neck	Body	Interior Decoration
FlMh-1 V.1	N/A	N/A	Smooth	N/A
GfLm-10 V.10	N/A	N/A	Textile impressed	Brush marks
GfLm-10 V.17	Notches	N/A	Textile impressed	N/A
GgLl-03 V. 2	N/A	Right oblique CWOI, at least 4 parallel rows of pseudo-scallop shell impressions	N/A	N/A
GjLs-2 V.1	N/A	N/A	Textile impressed	N/A
HfLp-11 V.2	N/A	Encircling row of punctates (some go straight through to interior)	Textile impressed	Bosses
HfLp-11 V.3	N/A	Encircling row of punctates. 1 additional Punctate below row (similar to HiLp-1 V. 25). On both pots it appears that there were additional punctates beside this lone one, but they are broken/missing.	Obliterated	Bosses
HfLp-11 V.7	N/A	N/A	Smooth	N/A
HiLp-1 V.25	Fingernail notches or CWOI	Encircling row of punctates. 1 additional Punctate below row (similar to HfLp-11 V. 3). On both pots it appears that there were additional punctates beside this lone one, but they are broken/missing.	Textile impressed	Bosses

HiLp-1 V.28	Notches	1 row of small punctates, 1 row of larger punctates (both encircle rim), left oblique pattern	Textile impressed	Bosses, left oblique pattern, brush marks
HiLp-1 V.51	CWOI	Encircling row of punctates, possible incised line	Textile impressed	Bosses, possible incised line
HiLp-1 V.121	CWOI	Punctates encircling rim	Textile impressed	Bosses
HiLp-3 V.8	N/A	Punctates encircling rim (some go all the way through)	Textile impressed	Bosses
HiLp-3 V.11	N/A	Encircling row of punctates	Obliterated	Bosses
HiLp-3 V.23	Notches, mostly angled left, but some are right and left	2 rows of encircling punctates	Obliterated	Bosses, striations
HiLp-3 V.24	Notches	2 rows of encircling punctates, some are elongated	Obliterated	Bosses
HjLp-7 V.17	N/A	1 row of large punctates	Smooth	Bosses
HjLp-7 V.18	N/A	Large punctates	Smooth	Bosses
HlLv-6 V.4	CWOI	2 rows of punctates	Semi-obliterated textile impressed	2 rows of bosses, textile impressed
EcJw-1 V.1	CWOI	3 or more rows of irregular right oblique stamping or CWOI (slightly oval, had small circular impressions near top, like object had ‘prongs’)	Smooth	N/A

EcJw-1 V.5	Slightly 'L' shaped	N/A	Smooth	N/A
EcJw-1 V.6	Thick with parallel thin notches (notches crisscross near broken edge)	Exfoliated, 1 row of stamping (possibly half-moon stamps)	N/A	N/A
EcJw-1 V.7	N/A	N/A	Smooth	N/A
EcJw-1 V.8	Notches	1 encircling horizontal incised line	Smooth	N/A
EcJw-1 V.10	N/A	N/A	Smooth	N/A
DbJm-2 V.1	N/A	N/A	Smooth	N/A
DbJm-2 V.3	Possible CWO (very worn)	N/A	Smooth	N/A
DbJm-2 V.4	N/A	N/A	Smooth	N/A
DbJm-2 V.5	Right parallel oblique CWOI	Row of CWOI (worn), 2 rows of square stamps (very spaced out)	Smooth	N/A
DbJm-2 V.6	N/A	N/A	Smooth	N/A
DbJm-2 V.9	Right parallel oblique CWOI (obliterated)	Parallel oblique CWOI, horizontal row of CWO and row of punctates	N/A	N/A
DbJm-2 V.10	Possible CWOI	Vertical drag and stamp impressions, row of CWOI or incised line	N/A	N/A

DbJm-2 V.12	N/A	Textile impressions. Possible cross hatching design	Textile impressed	N/A
DbJm-2 V.13	Right parallel oblique CWOI	Right parallel oblique CWOI, at least 2 rows of horizontal CWOI and punctates	N/A	Bosses
DbJm-2 V.14	Left parallel oblique finger notches	Vertical chevron design and punctates	Smooth	Bosses

Table C. 10: Decorative Motifs of Full-Sized Vessels

Vessel	Lip	Rim/Neck	Body	Interior Decoration
GfLm-10 V.2	Notches	1 row of punctates	Textile impressed	Bosses
GfLm-10 V.9	N/A	Punctates	Textile impressed	Bosses
HiLp-3 V.1	Fingernail notches	2 rows of slightly oblique "punctates" (thinner horizontal stamps?)	Textile impressed	Bosses
HiLp-1 V.120	Notches, small holes on each section between notches	1 row of large, rectangular punctates, 1 row of smaller circular punctates	Textile impressed	Bosses
HiLp-1 V.14	N/A	1 row of punctates	Textile impressed	Bosses
HiLp-3 V.3	N/A	N/A	Obliterated	N/A
HfLp-11 no des.	N/A	N/A	Textile impressed	N/A
HfLp-11 V.1	N/A	N/A	Textile impressed	N/A
EcJw-1 V.11	CWOI	Right parallel oblique CWOI, 1 row of punctates, 1 row of rectangular stamps	N/A	Bosses
EcJw-1 V.12	CWOI	Right parallel oblique CWOI, 1 row of Punctates, 1 row of irregular stamp	N/A	Bosses
EcJw-1 V.13	Right parallel CWOI	Slight right oblique CWOI, 5 horizontal rows of cord impressions, rows of punctates Between first and third CWO rows, 1 row	Textile impressed	N/A

EcJw-1 V.14	Slightly obliterated left parallel CWOI	Of vertical incised lines/stamps Right parallel oblique CWOI, row of irregular stamps/impressions (3 pronged object)	N/A	N/A
EcJw-1 V.15	Obliterated CWOI	Vertical/slightly right oblique stamps, at least 3 rows of pseudo-scallop shell (pss) lines, bosses between first and second rows of pss lines	N/A	Punctates
EcJw-1 V.16	Vertical stamps	Vertical stamps, punctates, row of stamps (3 pronged), exfoliated	N/A	Bosses
EcJw-1 V.17	Left parallel CWOI	Right parallel CWOI, row of oval stamps, Punctates/circular stamps	Textile impressed	N/A
EcJw-1 V.18	Left parallel oblique CWOI	Right parallel CWOI, 3 horizontal rows of CWOI, 1 row of vertical incised lines	Textile impressed	N/A
EcJw-1 V.19	Right parallel CWOI	Right parallel CWOI, 4 horizontal lines of stamps or CWOI, in between the first two rows of stamps/CWOI there are rows of smaller but deeper stamps, and one row of bow-tie shaped stamps	N/A	N/A
EcJw-1 V.20	N/A	N/A	Textile impressed	N/A
DbJm-5 V.1	N/A	N/A	Textile impressed obliterated in areas	N/A
DbJm-5 V.2	N/A	N/A	Textile impression, pattern goes in different directions	Orange/pink staining

DbJm-5 V.3	N/A	Stamps, row of CWOI	Textile impressed	N/A
DbJm-5 V.4	Smoothed (may have had motif)	Left parallel oblique (obliterated) stamps or CWOI, possibly alternating between CWOI and stamps, 3 rows of horizontal Parallel CWO or stamp	N/A	Right parallel oblique stamps
DbJm-5 V.5	N/A	N/A	Textile impressed	N/A
DbJm-5 V.6	N/A	N/A	Textile impressed pattern that goes in different direction	N/A
DbJm-3 V.1	N/A	Bosses, in between bosses are shallow punctates/stamps	Smooth	Punctates
DbJm-3 V.2	N/A	Exfoliated left parallel oblique stamps, row of small punctates, several rows of parallel pseudo-scallop shell impressions	N/A	Bosses
DbJm-3 V.3	N/A	Left parallel oblique incised lines/stamps, below is a row of rectangular punctates, possible textile impressions	N/A	Bosses
DbJm-3 V.4	N/A	At least 5 rows of stamps (rocker stamped?)	N/A	N/A
DbJm-3 V.5	N/A	Punctates, CWO or pseudo-scallop shell impressions (damaged)	Smooth/obliterated	N/A
DbJm-2 V.15	Notches (deep CWOI)	Deep right parallel oblique CWOI, punctates, at least 3 rows of CWOI,	Textile impressed	Bosses

		Dragged stamped lines over exterior		
DbJm-2 V.16	"V" shaped stamps	Right parallel oblique CWOI, 2 rows of stamps, 1 row of rectangular stamps	Textile impressed	N/A
DbJm-2 V.17	N/A	N/A	Textile impressed	N/A
DbJm-2 V.18	Right parallel oblique CWOI	Right parallel oblique CWOI, possible punctates	N/A	N/A
DbJm-2 V.19	N/A	N/A	Textile impressed	N/A
DbJm-2 V.20	N/A	N/A	Obliterated?	N/A
DbJm-2 V.21	N/A	Deep right parallel oblique CWOI, at least 5 rows of CWOI (last row is deeper and more pronounced than the previous ones), 1 row of punctates in the second row of CWOI	N/A	Bosses

Appendix D: Pottery Measurements

Table D. 1: Size Measurements of Miniature Vessels

Vessel	Diameter	Circumference	Height
HiLp-1 V.49	3cm	9.42cm	35.35mm
GfLm-10 V.25	4cm	12.56cm	N/A
EcJw-1 V.2	4.2cm	13.18cm	N/A
DbJm-2 V.2	4cm	12.56cm	N/A
DbJm-2 V.8	3cm	9.42cm	N/A
DbJm-2 V.11	4cm	12.56cm	N/A

Table D. 2: Size Measurements of Small Vessels

Vessel	Diameter	Circumference	Height
GgLl-03 V.2	6cm	18.84cm	N/A
HiLp-1 V.25	8cm	25.12cm	N/A
HfLp-11 V.2	6cm	18.84cm	70mm
HiLp-1 V.28	7cm	21.98cm	N/A
HiLp-1 V.51	7cm	21.98cm	63.08
FlMh-1 V.1	7.5cm	23.55cm	65mm
HfLp-11 V.3	8cm	25.12cm	N/A
HiLp-3 V.11	7cm	21.98cm	N/A
HjLp-7 V.17	8cm	25.12cm	N/A

HlLv-6 V.4	12cm	37.68cm	N/A
HiLp-3 V.8	13cm	40.82cm	115mm
HiLp-1 V.121	9cm	28.26cm	N/A
HjLp-7 V.18	12cm	37.68cm	N/A
EcJw-1 V.1	7.25cm	22.76cm	N/A
EcJw-1 V.5	6.5cm	20.41cm	N/A
EcJw-1 V.10	10.4cm	32.65cm	N/A
DbJm-2 V.1	9cm	28.26cm	N/A
DbJm-2 V.3	5cm	15.7cm	N/A
DbJm-2 V.4	5cm	15.7cm	N/A
DbJm-2 V.5	7cm	21.98cm	N/A
DbJm-2 V.6	8cm	25.12cm	N/A
DbJm-2 V.9	10cm	31.4cm	N/A
DbJm-2 V.10	10cm	31.4cm	N/A
DbJm-2 V.13	8cm	25.12cm	N/A
DbJm-2 V.14	5cm	15.7cm	N/A

*Circumference represents estimations calculated using ** from Dedi and Syms**
**Diameter estimated using scale chart (see Figure ** in appendix).
***Height only calculated for vessels with intact lip and base.

Table D. 3: Size Measurements of Full-Sized Vessels

Vessel	Diameter	Circumference	Height
GfLm-10 V.2	18cm	56.52cm	N/A

HiLp-3 V.1	18cm	56.52cm	N/A
HiLp-1 V.14	16cm	50.24cm	N/A
EcJw-1 V.11	20.7cm	65cm	N/A
EcJw-1 V.12	42.8cm	134.4cm	N/A
EcJw-1 V.13	15.7cm	49.3cm	N/A
EcJw-1 V.16	43.3cm	136cm	N/A
DbJm-5 V.4	24cm	75.36cm	N/A
DbJm-3 V.1	22cm	69cm	N/A
DbJm-3 V.2	21.5cm	67.61cm	N/A
DbJm-3 V.3	22cm	69cm	N/A
DbJm-2 V.15	22cm	69cm	N/A
DbJm-2 V.16	17cm	53.38cm	N/A
DbJm-2 V.18	12cm	37.68cm	N/A
DbJm-2 V.21	18cm	56.52cm	N/A

Table D. 4: General Measurements of Miniature Vessels

Vessel	Body	Rim	Lip	Height
FkMh-5 V.54	4.68mm	5.38mm	4.23mm	N/A
GfLm-07 V.20	7.13mm	3.38mm	2.54mm	N/A
HiLp-1 V.49	7.94mm	6.76mm	5.33mm	35.35mm
EcJw-1 V.2	N/A	4.51mm	3.83mm	N/A
EcJw-1 V.3	N/A	N/A	6.16mm	N/A
EcJw-1 V.4	N/A	N/A	3.64mm	N/A
EcJw-1 V.9	N/A	7.29mm	3.55mm	N/A
DbJm-2 V.2	N/A	5.80mm	4.93mm	N/A
DbJm-2 V.3	N/A	6.4mm	6.29mm	N/A
DbJm-2 V.7	9.31mm	N/A	N/A	N/A
DbJm-2 V.8	N/A	5.16mm	4.70mm	N/A
DbJm-2 V.11	N/A	6.00mm	5.48mm	N/A
Average	**7.265mm**	**5.63mm**	**4.61mm**	**35.35mm**

-Measurements represent maximum thickness/height.
-N/A signifies vessel was too fragmentary or exfoliated for measurement to be taken

Table D. 5: General Measurements of Small Vessels

Vessel	Body	Rim	Lip	Height
FlMh-1 V.1	N/A	5.76mm	4.89mm	65.09mm
GfLm-10 V.10	5.92mm	4.54mm	3.56mm	N/A
GfLm-10 V.17	4.39mm	4.42mm	4.24mm	N/A

GfLm-10 V.25	3.67mm	4.28mm	3.68mm	N/A
GgLl-03 V.2	6.16mm	5.24mm	4.15mm	N/A
GjLs-2 V.1	6.07mm	N/A	N/A	N/A
HfLp-11 V.2	7.03mm	6.32mm	4.27mm	70.17mm
HfLp-11 V.3	N/A	7.72mm	6.52mm	N/A
HfLp-11 V.7	9.04mm	N/A	N/A	N/A
HiLp-1 V.25	10.78mm	7.5mm	5.77mm	N/A
HiLp-1 V.28	6.33mm	5.81mm	4.56mm	N/A
HiLp-1 V.51	N/A	5.76mm	4.35mm	63.08mm
HiLp-1 V.121	6.74mm	6.8mm	5.82mm	N/A
HiLp-3 V.8	6.16mm	10.56mm	9.38mm	114.98mm
HiLp-3 V.11	8.44mm	6.15mm	5.19mm	N/A
HiLp-3 V.23	7.59mm	5.28mm	4.91mm	N/A
HiLp-3 V.24	7.97mm	7.30mm	7.21mm	N/A
HjLp-7 V.17	9.28mm	9.03mm	7.01mm	N/A
HjLp-7 V.18	7.46mm	6.21mm	5.35mm	N/A
HlLv-6 V.4	5.04mm	6.87mm	5.79mm	N/A
EcJw-1 V.1	N/A	6.85mm	6.83mm	N/A
EcJw-1 V.5	N/A	5.47mm	5.84mm	N/A
EcJw-1 V.6	N/A	N/A	7.17mm	N/A
EcJw-1 V.7	N/A	4.91mm	5.25mm	N/A
EcJw-1 V.8	N/A	3.8mm	3.19mm	N/A
EcJw-1 V.10	N/A	5.3mm	6.01mm	N/A

DbJm-2 V.1	N/A	7.54mm	7.41mm	N/A
DbJm-2 V.4	N/A	8.16mm	6.14mm	N/A
DbJm-2 V.5	N/A	5.04mm	6.42mm	N/A
DbJm-2 V.6	N/A	3.06mm	4.88mm	N/A
DbJm-2 V.9	N/A	4.63mm	5.92mm	N/A
DbJm-2 V.10	N/A	3.71mm	3.33mm	N/A
DbJm-2 V.12	6.45mm	7.81mm	6.48mm	N/A
DbJm-2 V.13	N/A	4.39mm	7.22mm	N/A
DbJm-2 V.14	4.96mm	4.07mm	4.17mm	N/A
Average	**6.81mm**	**5.94mm**	**5.54mm**	**78.33mm**

-Measurements represent maximum thickness/height.
-N/A signifies vessel was too fragmentary or exfoliated for measurement to be taken

Table D. 6: General Measurements of Full-Sized Vessels

Vessel	**Body**	**Rim**	**Lip**	**Height**
EcJw-1 V.11	N/A	4.20mm	10.92mm	N/A
EcJw-1 V.12	N/A	6.16mm	11.22mm	N/A
EcJw-1 V.13	N/A	7.22mm	10.63mm	N/A
EcJw-1 V.14	N/A	7.03mm	9.41mm	N/A
EcJw-1 V.15	N/A	6.45mm	5.62mm	N/A
EcJw-1 V.16	N/A	6.59mm	9.4mm	N/A
EcJw-1 V.17	N/A	6.99mm	10.2mm	N/A
EcJw-1 V.18	N/A	6.6mm	9.74mm	N/A

EcJw-1 V.19	N/A	6.16mm	7.22mm	N/A
EcJw-1 V.20	4.05mm	N/A	N/A	N/A
DbJm-5 V.1	5.28mm	N/A	N/A	N/A
DbJm-5 V.2	4.99mm	N/A	N/A	N/A
DbJm-5 V.3	6.41mm	N/A	N/A	N/A
DbJm-5 V.4	N/A	7.67mm	7.92mm	N/A
DbJm-5 V.5	5.07mm	N/A	N/A	N/A
DbJm-5 V.6	4.72mm	N/A	N/A	N/A
DbJm-3 V.1	N/A	7.10mm	5.58mm	N/A
DbJm-3 V.2	N/A	8.43mm	5.12mm	N/A
DbJm-3 V.3	N/A	7.77mm	5.10mm	N/A
DbJm-3 V.4	7.16mm	N/A	N/A	N/A
DbJm-3 V.5	8.79mm	N/A	N/A	N/A
DbJm-2 V.15	N/A	6.01mm	6.79mm	N/A
DbJm-2 V.16	N/A	6.3mm	5.89mm	N/A
DbJm-2 V.17	6.02mm	N/A	N/A	N/A
DbJm-2 V.18	N/A	8.84mm	13.02mm	N/A
DbJm-2 V.19	6.91mm	N/A	N/A	N/A
DbJm-2 V.20	5.04mm	N/A	N/A	N/A
DbJm-2 V.21	N/A	5.53mm	9.27mm	N/A
Average	**5.86mm**	**6.77mm**	**8.41mm**	**N/A**

Table D. 7: Crudity Index

Vessel	Thick	Thin	Crudity Index	Result
FlMh-1 V.1	3.53	4.26	0.83	Fine
FkMh-5	5.18	5.6	0.92	Fine
GfLm-07 V.20	6.19	7.08	0.87	Fine
GfLm-10 V.10	4.28	5.2	0.82	Fine
GfLm-10 V.17	3.74	3.95	0.95	Fine
GfLm-10 V.25	2.76	3.28	0.84	Fine
GgLl-03 V.2	4.69	5.63	0.83	Fine
GjLs-2 V.1	5.71	6.03	0.95	Fine
HfLp-11 V.2	3.39	4.38	0.77	Fair
HfLp-11 V.3	5.38	5.76	0.93	Fine
HfLp-11 V.7	6.3	7.12	0.88	Fine
HiLp-1 V.25	4.15	5.15	0.81	Fine
HiLp-1 V.28	3.75	5.04	0.74	Fair
HiLp-1 V.49	4.94	6.08	0.81	Fine
HiLp-1 V.51	3.94	4.42	0.89	Fine
HiLp-1 V.121	4	6.62	0.60	Crude
HiLp-3 V.8	5.05	6.98	0.72	Fair
HiLp-3 V.11	7.27	7.88	0.92	Fine
HiLp-3 V.23	5.38	5.82	0.92	Fine
HiLp-3 V.24	5.54	7.83	0.71	Fair
HjLp-7 V.17	6.56	7.51	0.87	Fine

HjLp-7 V.18	4.7	6.33	0.74	Fair
HlLv-6 V.4	5.27	5.79	0.91	Fine
EcJw-1 V.1	5.72	6	0.95	Fine
EcJw-1 V.2	3.62	4.67	0.77	Fair
EcJw-1 V.5	4.8	5.14	0.93	Fine
EcJw-1 V.7	3.82	4.46	0.86	Fine
EcJw-1 V.8	3.6	3.8	0.95	Fine
EcJw-1 V.10	4.74	4.82	0.98	Fine
EcJw-1 V.9	5.93	7.71	0.77	Fair
DbJm-2 V.1	6.91	7.12	0.97	Fine
DbJm-2 V.2	4.3	6.59	0.65	Fair
DbJm-2 V.3	5.69	5.9	0.96	Fine
DbJm-2 V.4	5.5	5.56	0.991	Fine
DbJm-2 V.5	6.1	7.12	0.86	Fine
DbJm-2 V.6	3.96	4.04	0.98	Fine
DbJm-2 V.8	5.16	5.51	0.94	Fine
DbJm-2 V.9	5.42	6.32	0.86	Fine
DbJm-2 V.10	2.38	2.89	0.82	Fine
DbJm-2 V.11	5.29	5.45	0.97	Fine
DbJm-2 V.12	7.72	7.92	0.97	Fine
DbJm-2 V.13	6.88	6.95	0.99	Fine
DbJm-2 V.14	3.39	3.79	0.89	Fine

Fine =0.81-1; Fair =0.61-0.8; Crude =0-0.6

Table D. 8: Curvature Consistency Index

Vessel	Depth 1	Depth 2	Curvature Consistency Index	Result
FlMh-1 V.1	17.59	17.96	0.98	Fine
GfLm-10 V. 25	2.55	2.86	0.89	Fine
HfLp-11 V.2	7.94	9.94	0.798	Fair
HfLp-11 V.3	10.71	10.78	0.99	Fine
HiLp-1 V.25	4.85	7.6	0.64	Fair
HiLp-1 V.28	21.25	21.67	0.98	Fine
HiLp-1 V.49	6.79	8.36	0.81	Fine
HiLp-1 V.51	27.09	29.45	0.92	Fine
HiLp-3 V.11	2.29	2.3	0.995	Fine
HjLp-7 V.17	8.41	8.5	0.99	Fine
HlLv-6 V.4	16.48	16.5	0.998	Fine
EcJw-1 V.1	2.66	2.99	0.89	Fine
EcJw-1 V.2	3.91	4.17	0.94	Fine
EcJw-1 V.5	1.1	1.35	0.81	Fine
EcJw-1 V.10	0.54	0.98	0.55	Crude
DbJm-2 V.1	2.66	2.8	0.95	Fine
DbJm-2 V.2	2.39	3.13	0.76	Fair
DbJm-2 V.4	1.35	1.88	0.72	Fair
DbJm-2 V.5	4.83	5.09	0.95	Fine
DbJm-2 V.6	1.33	1.48	0.898	Fine
DbJm-2 V.14	3.73	3.97	0.94	Fine

Crude (0-0.6); Fair (0.61-0.80), and fine (0.81-1)

Table D. 9: Motif Application Index

Vessel	Depth	Length	Width	Spacing	Total/Result
HfLp-11 V.2	1	1	1	1	1 Crude
HiLp-3 V.8	1	1	1	1	1 Crude
HiLv-6 V.4	3	3	3	2	2.75 Fine
HiLp-1 V.51	3	2	2	2	2.25 Fair
HfLp-11 V.3	2	1	1	1	1.25 Crude
HiLp-1 V.25	1	2	2	1	1.5 Crude
FkMh-5 V.54	2	2	2	2	2 Fair
HiLp-3 V.24	3	2	2	2	2.25 Fair
GfLm-10 V.25	1	2	1	1	1.25 Crude
GFLm-10 V/17	2	2	3	2	2.25 Fair
HiLp-1 V.121	2	2	2	1	1.75 Fair
GgLl-3 V.2	2.5	3	3	2.5	2.75 Fine
HiLp-1 V.28	1	1.5	2	2	1.62 Fair
HiLp-3 V.11	2	3	3	2.5	2.62 Fine
HiLp-3 V.23	1.5	2	1.5	2	1.75 Fair
HiLp-1 V.49	1	1	1.5	1	1.12 Crude
HjLp-7 V.18	2.5	1.5	2		1.5 Crude
HjLp-7 V.17	2.5	2	2.5	2	2.25 Fair
EcJw-1 V.1	3	3	2.5	2.5	2.75 Fine
EcJw-1 V.2	1	1.5	2	1.5	1.5 Crude
EcJw-1 V.3	2	2	2	2	2 Fair

DbJm-2 V.2	2.5	2	2	1.5	2 Fair
DbJm-2 V.5	2.5	2.5	2	2	2.25 Fair
DbJm-2 V.9	2	2.5	2	2	2.12 Fair
DbJm-2 V.11	2	2	2	2	2 Fair
DbJm-2 V. 13	2	1.5	1.5	1.5	1.62 Fair
DbJm-2 V. 14	1.5	1	1	1	1.12 Crude

1-1.5=crude; 1.6-2.5=fair; 2.6-3=fine
1=crude; 2=moderate; 3=fine

Appendix E: Reflected & Transmitted Light Microscopy Results

Table E. 1: In-Situ Reflected Light Microscopy Results

Vessel	Size	Residue Description
EcJw-1 V.9	Possible Miniature	Orange staining (likely due to weathering or oxidation when the vessel was fired)
FkMh-5 V.54	Possible Miniature	Unidentified black residue
HiLp-3 V.24	Small	Unidentified brown residue
HiLp-1 V.25	Small	Carbonized residue; carbonized residue over red amorphous residue
HfLp-11 V.3	Small	Black amorphous residue
DbJm-2 V.4	Small	Brown amorphous residue
HiLp-1 V.28	Small	Carbonized residue
FlMh-1 V.1	Small	Carbonized residue
HiLp-1 V.121	Small	Glue; Glue and blue fibre
GjLs-2 V.1	Small	Amorphous red residue, the result of some kind of modern contamination
DbJm-2 V.1	Small	Glue and fibres
DbJm-2 V.6	Small	Grey amorphous residue, the result of some kind of modern contamination
EcJw-1 V.8	Possible Small	Amorphous red/orange residue
EcJw-1 V.15	Full-Sized	Possible carbonized residue
EcJw-1 V.16	Full-Sized	Grey, ashy residue
EcJw-1 V.18	Full-Sized	Amorphous brown residue or staining
DbJm-2 V.16	Full-Sized	Possible carbonized residue
DbJm-2 V.15	Full-Sized	Possible carbonized residue

DbJm-2 V.17	Full-Sized	Possible carbonized residue
DbJm-5 V.2	Full-Sized	Possible carbonized residue
DbJm-5 V.6	Full-Sized	Possible carbonized residue
DbJm-5 V.1	Full-Sized	Orange staining/oxidation
DbJm-5 V.5	Full-Sized	Grey ashy residue – possible carbonized residue
DbJm-5 V.3	Full-Sized	Glue
DbJm-2 V.15	Full-Sized	Whiteout, ink, nail polish (possible residue underneath)

Table E. 2: Transmitted Light Microscopy Results

Vessel	Size	Residue Description
EcJw-1 V.2	Miniature	Blue fibre (likely contamination)
EcJw-1 V.3	Possible Miniature	Possible plant material; blue fibre (likely contamination)
DbJm-2 V.2	Possible Miniature	Fibre or possible hair; fibrous material
DbJm-2 V.8	Possible Miniature	Organic material
GfLm-7 V.20	Possible Miniature	Fibrous material
EcJw-1 V.9	Possible Miniature	Possible lithic fragment
EcJw-1 V.1	Small	Fresh water diatom; fibre; purple fibre (likely contamination)
DbJm-2 V.6	Small	Unidentified organic material
EcJw-1 V.10	Small	Degraded fibre
HiLp-3 V.23	Small	Fibre

DbJm-2 V.12	Small	Fibrous material; phytolith
DbJm-2 V.13	Small	Fibrous material
DbJm-2 V.5	Small	Organic material
DbJm-2 V. 10	Small	Damaged fibre
DbJm-2 V.3	Possible Small	Fibre
EcJw-1 V.5	Possible Small	Unidentified fibre
EcJw-1 V.6	Possible Small	Unidentified fibre
HfLp-11 V.7	Possible Small	Organic material
EcJw-1 V.5	Possible Small	Possible lithic fragment
EcJw-1 V.12	Full-Sized	Unidentified fibrous material
EcJw-1 V.17	Full-Sized	Organic fibrous material
DbJm-3 V.3	Full-Sized	Unidentified material
DbJm-3 V.5	Full-Sized	Damaged fibre
HiLp-3 V.3	Full-Sized	Fibre
HfLp-11 No des.	Full-Sized	Fibre
DbJm-2 V.21	Full-Sized	Starch grain
DbJm-2 V.20	Full-Sized	Possible phytolith
EcJw-1 V.15	Full-Sized	Transparent fibrous material
EcJw-1 V.16	Full-Sized	Possible lithic or shell fragment
DbJm-2 V.17	Full-Sized	Yellow lithic material
EcJw-1 V.13	Full-Sized	Yellow lithic material
DbJm-3 V.2	Full-Sized	Particulate material
DbJm-2 V.17	Full-Sized	Amber coloured particulate/lithic material

S-1	Soil Sample	Organic material; green/blue lithic material
S-3	Soil Sample	Fibre
S-4	Soil Sample	Purple fibre, likely contamination; yellow lithic material
S-5	Soil Sample	Unidentified organic fibre

Appendix F: GC-MS Results

Table F. 1: GC/MS Results of Miniature Vessels

Vessel	Size	GC/MS Result
FkMh-5 V.54	Possible miniature	Interior: Benadryl, propanoic acid, hexadecanoic acid, benzoic acid (possible plant source or modern food preservative)
FkMh-5 V.54	Possible miniature	Exterior: Hexanoic acid (fatty acid found in animal oils and fats), benzoic acid (possible plant source or modern food preservative)
GfLm-7 V.20	Possible miniature	Interior: Propanoic acid, hexanoic acid (fatty acid found in animal oils and fats), benzoic acid (possible plant source or modern food preservative)
GfLm-7 V.20	Possible miniature	Exterior: No identifiable peaks
GfLm-7 V.20	Possible miniature	Interior: Etocrylene (UV absorber in cosmetics and sunscreen), benzoic acid (possible plant source or modern food preservative), hexanoic acid (fatty acid found in animal oils and fats), hexadecanoic acid
GfLm-10 V. 25	Possible miniature	Exterior: Hexadecanoic acid, octadecanoic acid
GfLm-10 V. 25	Possible miniature	Interior: Acetamide (plasticizer, industrial solvent), dodecanoic acid (antiseptic, coatings, painting materials, plastics
HiLp-1 V. 49	Miniature	Interior: Trimethylsilyl acetylsalicylate (possible medicinal plant source), Tetradecoic acid (fatty acid common in plant oils), benadryl, Dibutyl phthalate (plastic contamination), Palmitelaidic acid (fatty acid), hexadecanoic acid, octadecanoic acid, plant diturpenoid (linolenic acid), Dehydroabietic acid (plant exudate found in conifers), Benzoic acid (possible plant source or modern food preservative)

HiLp-1 V. 49	Miniature	Exterior: Benzoic acid (possible plant source or modern food preservative), hexadecanoic acid, octadecanoic acid
EcJw-1 V.2	Miniature	Exterior: Propanoic acid, isoxazole (anti-inflammatory), acetamide (plasticizer, industrial solvent), cyclohexadiene (natural derivative of terpinene, a component of pine oil)
EcJw-1 V.2	Miniature	Interior: Benzenepropanoic acid (a fixative agent or preservative in flavouring, food additive, spices, fragrance, and medicine), quinolone (flavouring ingredient), cyclohexanol (used in the production of lacquers, paints, varnishes, plastics, soaps, and more), acetamide (plasticizer, industrial solvent)
EcJw-1 V.3	Possible miniature	Interior: Acetamide (plasticizer, industrial solvent)
EcJw-1 V.4	Miniature	Interior: Phenyl (antiseptic, cleaning products), desmethyldoxepin (ingredient in antidepressants), benzimidazole (ingredient in antifungal, antiviral, antihistamine etc.)
EcJw-1 V.9	Miniature	Interior: Acetamide (plasticizer, industrial solvent)
EcJw-1 V.9	Miniature	Exterior: Cyclohexasiloxane (modern cosmetics ingredient)
DbJm-2 V.2	Miniature	Interior: No identifiable peaks
DbJm-2 V.2	Miniature	Exterior: No identifiable peaks
DbJm-2 V.7	Miniature	Interior: No identifiable peaks
DbJm-2 V.7	Miniature	Exterior: No identifiable peaks
DbJm-2 V.8	Miniature	Interior: Dibutyl phthalate (plasticizer)
DbJm-2 V.11	Miniature	Interior: No identifiable peaks

Table F. 2: GC/MS Results of Small Vessels

Vessel	Size	GC/MS Result
FlMh-1 V.1	Small	Residue: Hexadecanoic acid, octadecanoic acid
FlMh-1 V.1	Small	Interior: No identifiable peaks
FlMh-1 V.1	Small	Exterior: Hexadecanoic acid, octadecanoic acid
FlMh-1 V.1	Small	Interior: Diethyl phthalate (binder in cosmetics, fragrances, plasticizers), phthalic acid (modern chemical in dyes and perfumes), azelaic acid (produced by yeast and found in wheat, barley, rye, also used in cosmetics), sebacic acid (plasticizers, cosmetics etc.), dodecanoic acid (antiseptic, coatings, painting materials, plastics)
GfLm-10 V.10	Small	Exterior: Benzoic acid (possible plant source or modern food preservative), hexadecanoic acid, octadecanoic acid
GfLm-10 V.10	Small	Interior: Hexadecanoic acid, octadecanoic acid
GfLm-10 V.17	Possible small	Exterior: No identifiable peaks
GfLm-10 V.17	Possible small	Interior: Tenamfetamine (amphetamine derivative – a hallucinogen), diethyl phthalate (binder in cosmetics, fragrances, and plasticizers), phtalic acid (product in chemicals and consumer products), dodecanoic acid (antiseptic, coatings, painting materials, plastics)
GgLl-3 V. 2	Possible small	Interior: Benadryl, propanoic acid, hexanoic acid, trisiloxane (sunscreen ingredient), benzoic acid (possible plant source or modern food preservative), narceine

		(common in opium poppy)
GgLl-3 V.2	Possible small	Exterior: Benadryl
GjLs-2 V. 1	Small	Interior: Propanoic acid (human sweat/hand oils)
GjLs-2 V. 1	Small	Exterior: Propanoic acid, hexadecanoic acid, octadecanoic acid
GjLs-2 V. 1	Small	Interior: Acetamide (plasticizer, industrial solvent), cyclobarbital (barbiturate derivative)
HfLp-11 V.2	Small	Interior: Benzoic acid (possible plant source, could be modern food preservative), benadryl
HfLp-11 V.3	Small	Exterior: Hexadecanoic acid, octadecanoic acid
HfLp-11 V.3	Small	Interior: Benzoic acid (possible plant source or modern food preservative), benadryl
HfLp-11 V. 7	Possible small	Interior: Propanoic acid, hexadecanoic acid, benadryl, Benzoic acid (possible plant source or modern food preservative)
HfLp-11 V. 7	Possible small	Exterior: Hexadecanoic acid, octadecanoic acid
HiLp-1 V. 25	Small	Interior: Alanine (amino acid), Benzoic acid (possible plant source or modern food preservative)
HiLp-1 V. 25	Small	Exterior: Benzoic acid (possible plant source or modern food preservative), hexadecanoic acid, octadecanoic acid
HiLp-1 V. 25	Small	Interior: No identifiable peaks
HiLp-1 V. 28	Small	Residue: Cycloheptasiloxane (modern cosmetics ingredient), Benadryl, Benzoic acid (possible plant source or modern food preservative)

HiLp-1 V. 28	Small	Interior: Acetamide (plasticizer, industrial solvent), Ethene (plastics, antifreeze, solvents), cyclobarbital (barbiturate derivative)
HiLp-1 V. 28	Small	Exterior: No identifiable peaks
HiLp-1 V. 51	Small	Interior: Benadryl, Benzoic acid (possible plant source or modern food preservative), hexadecanoic acid, octadecanic acid, Hentriacontane (possible black elderberry or beeswax source),), Dehydroabietic acid (a plant exudate found in conifers), Trisiloxane (sunscreen ingredient)
HiLp-1 V. 121	Small	Interior: Narceine (common in opium poppy), Benzoic acid (possible plant source or modern food preservative), Cyclohexasiloxane (modern cosmetics ingredient)
HiLp-1 V. 121	Small	Exterior: No identifiable peaks
HiLp-3 V. 8	Small	Residue: Hexadecanoic acid, octadecanoic acid
HiLp-3 V. 8	Small	Interior: Benadryl, propanoic acid, benzoic acid (possible plant source or modern food preservative), Cyclohexasiloxane (modern cosmetics ingredient), Hentriacontane (possible black elderberry or beeswax source), Pentacosane (naturally occurring wax)
HiLp-3 V. 11	Small	Interior: Benadryl, propanoic acid, hexanoic acid (fatty acid found in animal oils and fats), Cyclohexasiloxane (modern cosmetics), Benzoic acid (possible plant source or modern food preservative)
HiLp-3 V. 23	Small	Exterior: Hexadecanoic acid, octadecanoic acid
HiLp-3 V. 23	Small	Interior: Acetamide (plasticizer, industrial solvent), phthalic acid (modern

		chemical in dyes and perfumes)
HiLp-3 V. 24	Small	Interior: Benadryl, propanoic acid, Benzoic acid (possible plant source or modern food preservative)
HiLp-3 V. 24	Small	Exterior: Benzoic acid (possible plant source or modern food preservative), Benadryl, hexadecanoic acid
HiLp-3 V. 24	Small	Interior: Propanoic acid, octadecanoic acid, nonanoic acid (saturated fatty acid from plants), phtalic acid (product in chemicals and consumer products), hexadecanoic acid
HjLp-7 V. 17	Small	Exterior: Octanal dimethyl acetal (flavour and fragrance agent), cannabinol (found in aged cannabis), Acetamide (plasticizer, industrial solvent)
HjLp-7 V. 17	Small	Interior: Benzenepropanoic acid (ingredient in cosmetics, food additives, and pharmaceuticals)
HjLp-7 V. 18	Possible small	Interior: Narceine (common in opium poppy), hexanoic acid (fatty acid found in animal oils and fats), benzoic acid (possible plant source or modern food preservative)
HlLv-6 V. 4	Small	Interior: Hexadecanoic acid, octadecanoic acid
HlLv-6 V. 4	Small	Exterior: Benzoic acid (possible plant source or modern food preservative), hexadecanoic acid, octadecanoic acid
EcJw-1 V.1	Small	Interior: Propanoic acid, octadecanoic acid
EcJw-1 V.5	Possible small	Interior: No identifiable peaks
EcJw-1 V.5	Possible small	Exterior: No identifiable peaks
EcJw-1 V.6	Possible small	Interior: No identifiable peaks

EcJw-1 V.7	Possible small	Interior: Acetamide (plasticizer, industrial solvent)
EcJw-1 V.8	Possible small	Interior: Acetamide (plasticizer, industrial solvent), benzaldehyde (ingredient in dyes, perfumes, flavourings and pharmaceuticals)
EcJw-1 V.10	Small	Interior: Acetamide (plasticizer, industrial solvent)
EcJw-1 V.10	Small	Exterior: No identifiable peaks
DbJm-2 V.1	Small	Interior: Dibutyl phthalate (plasticizer)
DbJm-2 V.3	Possible small	Interior: Dibutyl phthalate (plasticizer)
DbJm-2 V.4	Small	Interior: Dibutyl phthalate (plasticizer)
DbJm-2 V.4	Small	Exterior: No identifiable peaks
DbJm-2 V.5	Small	Interior: Dibutyl phthalate (plasticizer)
DbJm-2 V.5	Small	Exterior: No identifiable peaks
DbJm-2 V.6	Small	Interior: Propanoic acid, phthalic acid (modern chemical in dyes and perfumes)
DbJm-2 V.9	Small	Interior: No identifiable peaks
DbJm-2 V.10	Small	Interior: No identifiable peaks
DbJm-2 V.12	Small	Interior: No identifiable peaks
DbJm-2 V.13	Small	Interior: No identifiable peaks
DbJm-2 V.14	Small	Interior: No identifiable peaks

Table F. 3: GC/MS Results of Full-Sized Vessels

Vessel	Size	GC/MS Result
GfLm-10 V.2	Full-sized	Interior: Pentanoic acid (found naturally in the perennial flowering plant valerian)
GfLm-10 V.2	Full-sized	Exterior: No identifiable peaks
GfLm-10 V.9	Full-sized	Interior: No identifiable peaks
HiLp-3 V.1	Full-sized	Interior: No identifiable peaks
HiLp-1 V.120	Full-sized	Interior: No identifiable peaks
HiLp-1 V.14	Full-sized	Interior: No identifiable peaks
HiLp-1 V.14	Full-sized	Exterior: No identifiable peaks
HiLp-3 V.3	Full-sized	Interior: No identifiable peaks
HiLp-3 V.3	Full-sized	Exterior: No identifiable peaks
HfLp-11 no des.	Full-sized	Interior: No identifiable peaks
HfLp-11 V.1	Full-sized	Interior: No identifiable peaks
HfLp-11 V.1	Full-sized	Exterior: No identifiable peaks
EcJw-1 V.11	Full-sized	Interior: Propanoic acid, cyclohexasiloxane (modern cosmetics ingredient)
EcJw-1 V.12	Full-sized	Interior: Acetamide (plasticizer, industrial solvent)
EcJw-1 V.13	Full-sized	Interior: Cyclohexasiloxane (modern cosmetics ingredient), tetradecanoic acid (common saturated fatty acid derived from nutmeg and found in palm kernel oil, cocounut oil, butter fat and is a minor component of many other animal fats), octadecanoic acid
EcJw-1 V.14	Full-sized	Interior: benzoic acid (possible plant source or modern food preservative), benadryl, hexadecanoic acid, octadecanoic

		acid
EcJw-1 V.14	Full-sized	Exterior: Benzenebutanoic acid (drug used to treat sickle cell anemia and other conditions), nonadecanoic acid (monounsaturated fatty acid), propiophenone (used in the synthesis of pharmaceuticals and in perfumes)
EcJw-1 V.15	Full-sized	Interior: Phthalic acid (modern chemical in dyes and perfumes), diethyl phthalate (plasticizer, cosmetics ingredient)
EcJw-1 V.16	Full-sized	Interior: Octadecanoic acid, cathine (used in psychoactive drugs, found naturally in the shrub *Catha edulis*), narceine (common in opium poppy), propadiene (used in fuel), heptadecanoic acid (saturated fatty acid, it occurs as a trace component of the fat and milkfat of ruminants)
EcJw-1 V.17	Full-sized	Interior: Cyclohexasiloxane (modern cosmetics ingredient), hexadecanoic acid, octadecanoic acid
EcJw-1 V.17	Full-sized	Exterior: Acetamide (plasticizer, industrial solvent)
EcJw-1 V.18	Full-sized	Interior: Cyclohexasiloxane (modern cosmetics ingredient), octadecanoic acid
EcJw-1 V.19	Full-sized	Interior: Cathinone (monoamine alkaloid found in the shrub *Catha edulis),* acetamide (plasticizer, industrial solvent)
EcJw-1 V.20	Full-sized	Interior: Cyclohexasiloxane (modern cosmetics ingredient), hexadecanoic acid, octadecanoic acid, benzene (industrial chemical)
DbJm-5 V.1	Full-sized	Interior: Acetamide (plasticizer, industrial solvent), Cyclohexasiloxane (modern cosmetics ingredient)
DbJm-5 V.2	Full-sized	Interior: Propanoic acid, cyclohexasiloxane (modern cosmetics ingredient), Benadryl, narceine (common in opium poppy),

		hexadecanoic acid, octadecanoic acid, benzaldehyde (ingredient in dyes, perfumes, flavourings and pharmaceuticals)
DbJm-5 V.3	Full-sized	Interior: Acetamide (plasticizer, industrial solvent), propanoic acid, hexadecanoic acid, cyclohexasiloxane (modern cosmetics ingredient), octadecanoic acid
DbJm-5 V.4	Full-sized	Interior: Acetamide (plasticizer, industrial solvent), cyclohexasiloxane (modern cosmetics ingredient)
DbJm-5 V.5	Full-sized	Exterior: Propanoic acid, hexadecanoic acid
DbJm-5 V.5	Full-sized	Interior: Propanoic acid, acetamide (plasticizer, industrial solvent), cyclohexasiloxane (modern cosmetics ingredient), hexadecanoic acid
DbJm-5 V.6	Full-sized	Interior: Acetamide (plasticizer, industrial solvent), cyclohexasiloxane (modern cosmetics ingredient)
DbJm-3 V.1	Full-sized	Interior: Acetamide (plasticizer, industrial solvent), cyclohexasiloxane (modern cosmetics ingredient)
DbJm-3 V.2	Full-sized	Interior: Propanoic acid, trisiloxane (sunscreen ingredient), mandelic acid (popular alpha hydroxyl acid derived from bitter almonds; popular in skincare), hexanedioic acid (used in the production of nylon), isoquinoline (ingredient in anesthetic, antihypertension, antifungal, disinfectant; also used in dyes, paints, insecticides or as a solvent to extract resins and terpenes), valine (amino acid), tetradecanoic acid (common saturated fatty acid derived from nutmeg and found in palm kernel oil, cocounut oil, butter fat and is a minor component of many other animal fats), dodecanedioic acid (dicarboxylic acid mainly used in antiseptics, top-grade coatings, painting materials, corrosion inhibitors, surfactants, and engineering plastics), phthalic acid (modern chemical in

		dyes and perfumes), Benadryl, octadecanoic acid, hexadecanoic acid
DbJm-3 V.2	Full-sized	Exterior: Nonanoic acid (saturated fatty acid from plants), Benadryl, dibutyl phthalate (plasticizer), hexadecanoic acid, octadecanoic acid
DbJm-3 V.3	Full-sized	Interior: Acetamide (plasticizer, industrial solvent), propanoic acid, octadecanoic acid, acetylicitric acid (citric acid), dodecanoic acid, tetradecanoic acid (common saturated fatty acid derived from nutmeg and found in palm kernel oil, cocounut oil, butter fat and is a minor component of many other animal fats), phthalic acid (product in chemicals and consumer products), hexadecanoic acid, octadecanoic acid
DbJm-3 V.4	Full-sized	Interior: Hexanoic acid (fatty acid found naturally in various animal fats and oils, component in vanilla, used in artificial flavours), pentanoic acid (derived from valerian plant, used in perfumes and cosmetics), acetamide (plasticizer, industrial solvent), hexadecanoic acid, octadecanoic acid
DbJm-3 V.5	Full-sized	Interior: Butanedioic acid (ingredient in polyester, resins, polymers, food additives, supplements, flavouring agents), cyclotrisiloxane (cosmetics ingredient)
DbJm-2 V.15	Full-sized	Interior: No identifiable peaks
DbJm-2 V.16	Full-sized	Interior: No identifiable peaks
DbJm-2 V.17	Full-sized	Interior: No identifiable peaks
DbJm-2 V.17	Full-sized	Exterior: No identifiable peaks
DbJm-2 V.18	Full-sized	Interior: No identifiable peaks
DbJm-2 V.19	Full-sized	Interior: Benadryl, benzene (industrial chemical)
DbJm-2 V.20	Full-sized	Interior: No identifiable peaks

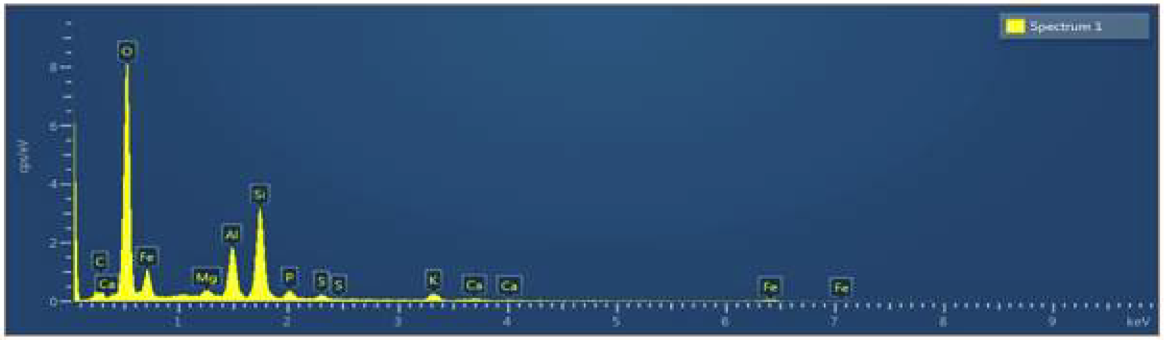
DbJm-2 V.21	Full-sized	Interior: No identifiable peaks

Table F. 4: GC/MS Results of Soil Samples

Soil ID	GC/MS Result
DbJm-3 July 22/16, Test Pit, 510N 540E	Penicillamine (medication), acetamide, Bupropion (medication)
DbJm-3, July 26/16, Test pit, 525N 510 E	Mexiletine (medication), cyclotrisiloxane (cosmetics ingredient)
DbJm-3, Test pit, 515N 545 E	Penicillamine (medication), acetamide, benzaldehyde (ingredient in dyes, perfumes, flavourings and pharmaceuticals)
DbJm-3. July 23/16, 505N 535E, 15-20cm	Acetamide, octodrine (stimulant)
DbJm-3. July 25/16, 510N 525E	No identifiable pea

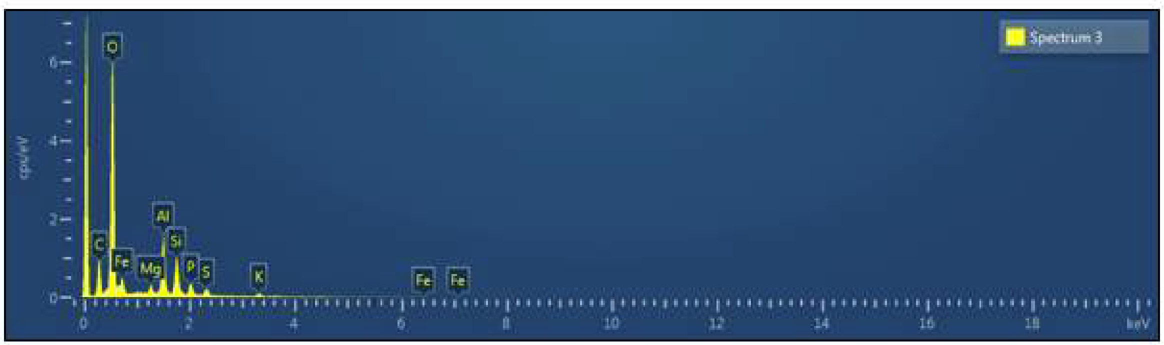
Appendix G: SEM Results

Figure G. 1: HiLp-3 V.23 Control Scan, Spectrum 1-3



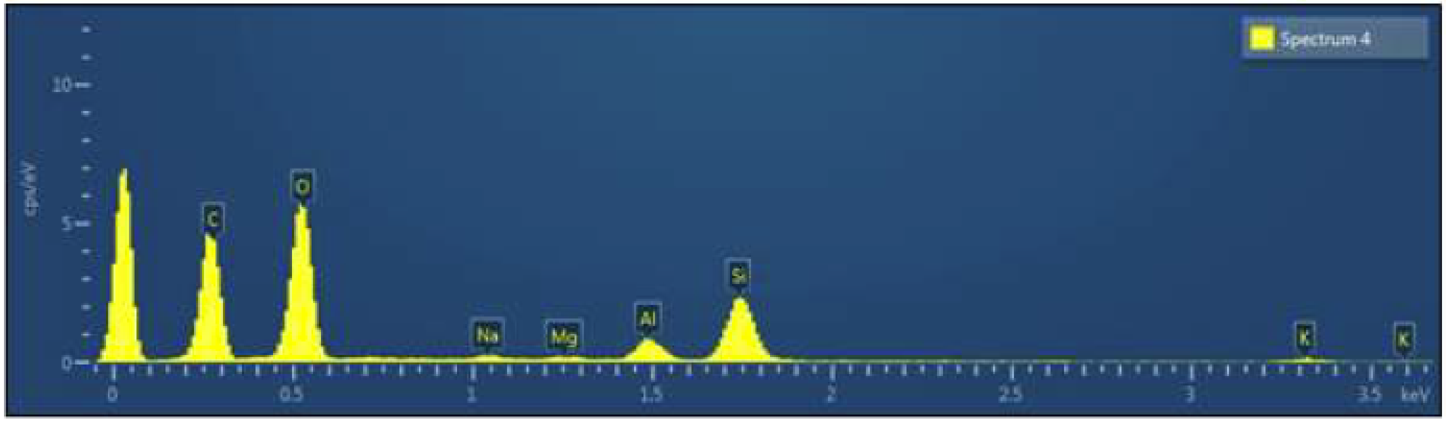
Element	Atomic %
O	62.54
Na	0.30
Mg	1.13
Al	8.63
Si	17.37
P	1.87
S	1.02
K	2.60
Ca	0.70
Fe	3.85

Element	Atomic %
O	62.54
Na	0.30
Mg	1.13
Al	8.63
Si	17.37
P	1.87
S	1.02
K	2.60
Ca	0.70
Fe	3.85

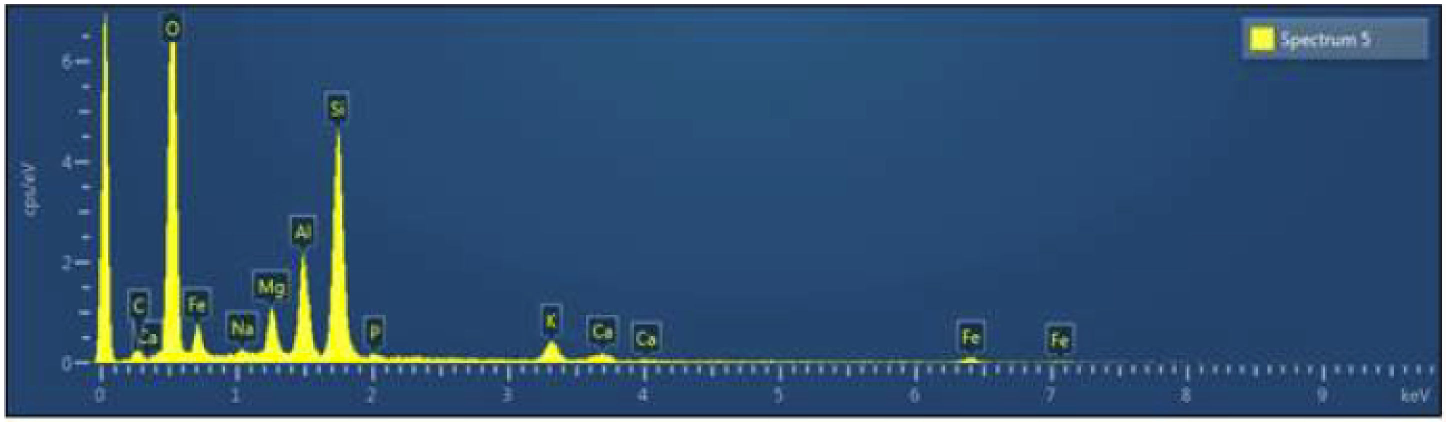


Element	Atomic %
O	63.50
Mg	1.98
Al	13.74
Si	10.02
P	4.17
S	2.36
K	1.72
Fe	2.51

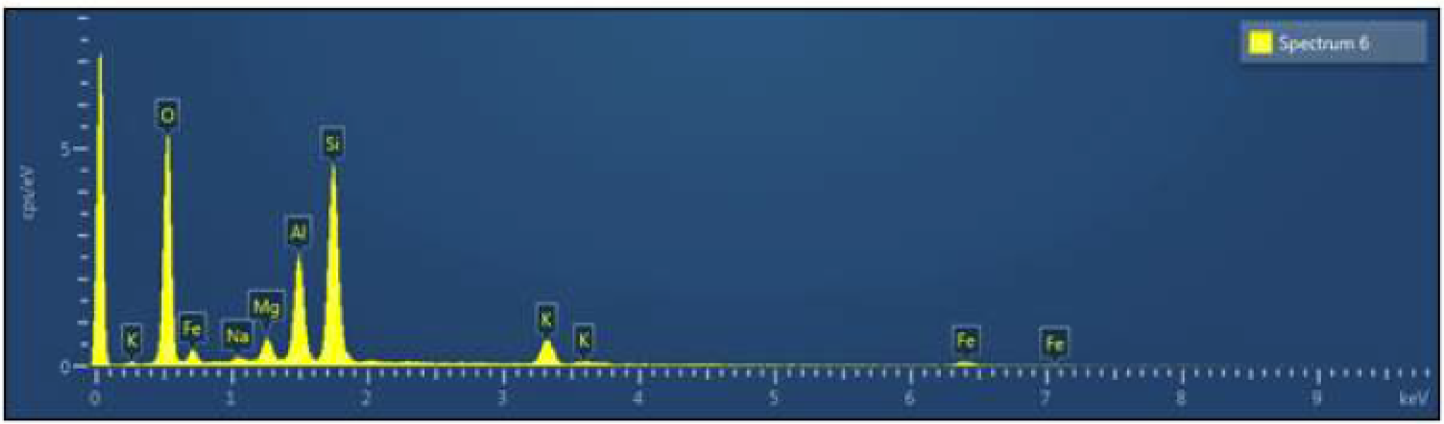
Figure G. 2: HiLp-3 V.23 Control Scan, Spectrum 4-6



Element	Atomic %
O	63.16
Na	1.50
Mg	0.97
Al	7.21
Si	24.70
K	2.45

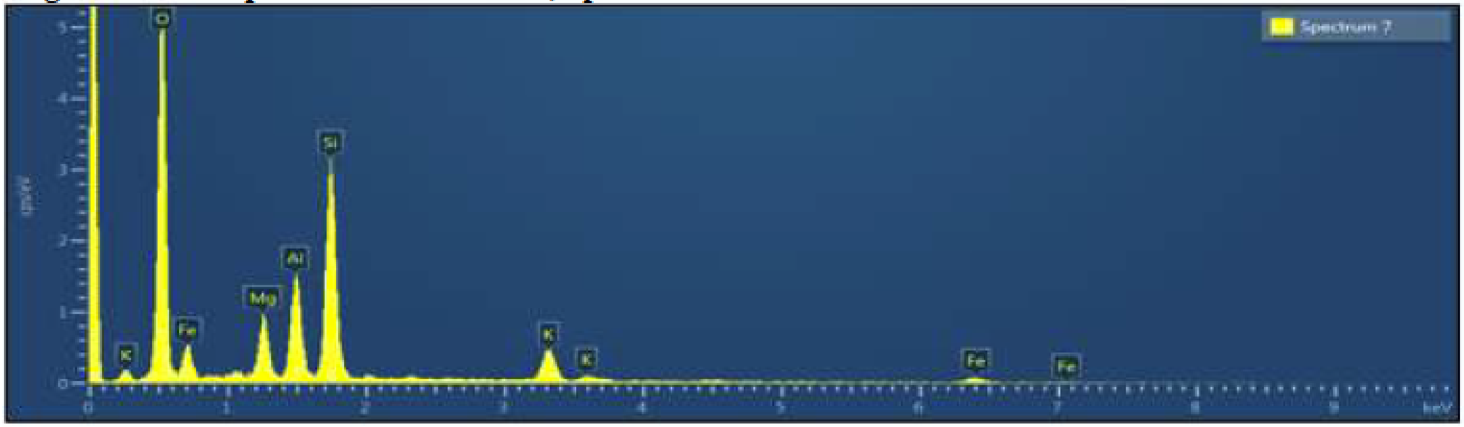


Element	Atomic %
O	61.14
Na	0.41
Mg	3.86
Al	7.64
Si	19.66
P	0.47
K	3.41
Ca	1.41
Fe	2.00

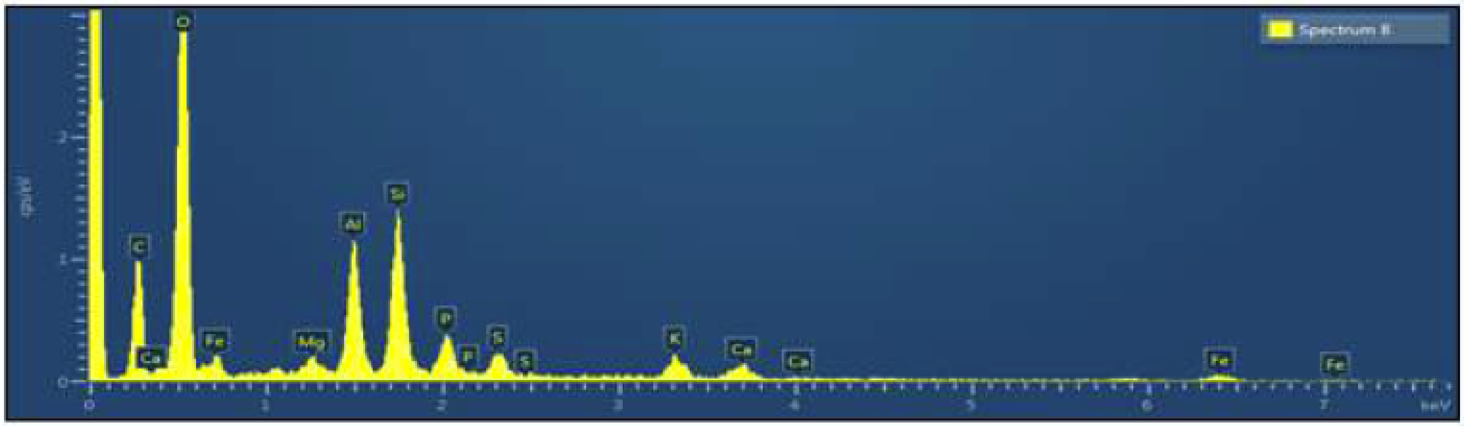


Element	Atomic %
O	61.07
Na	0.48
Mg	2.18
Al	9.60
Si	20.26
K	5.35
Fe	1.07

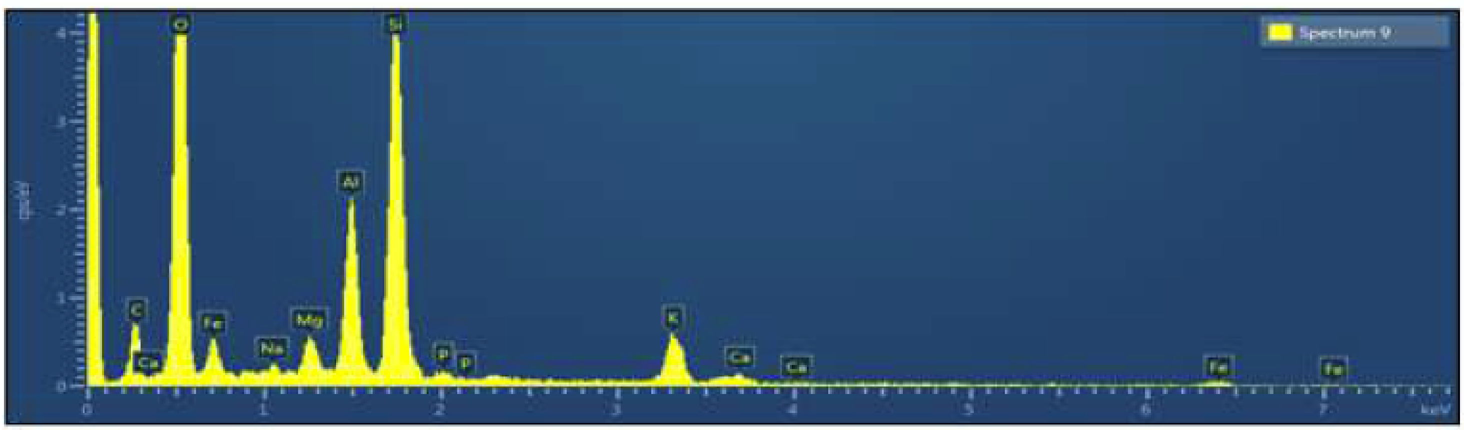
Figure G. 3: HiLp-3 V.23 Control Scan, Spectrum 7-9



Element	Atomic %
O	58.71
Mg	4.74
Al	6.86
Si	16.41
K	4.85
Fe	8.44

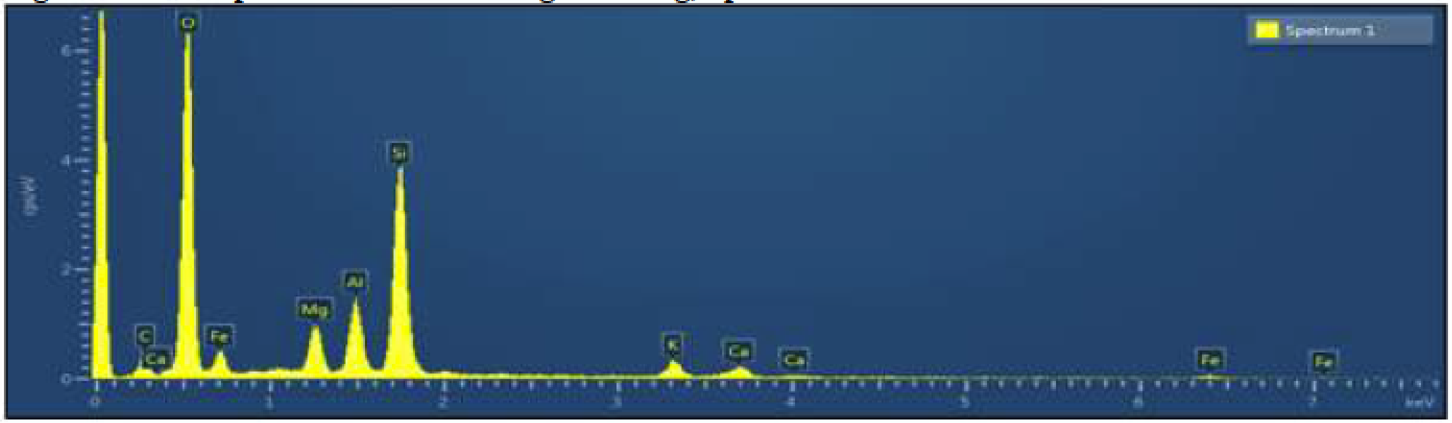


Element	Atomic %
O	62.18
Mg	1.10
Al	8.41
Si	11.77
P	3.49
S	2.35
K	3.13
Ca	2.41
Fe	5.16



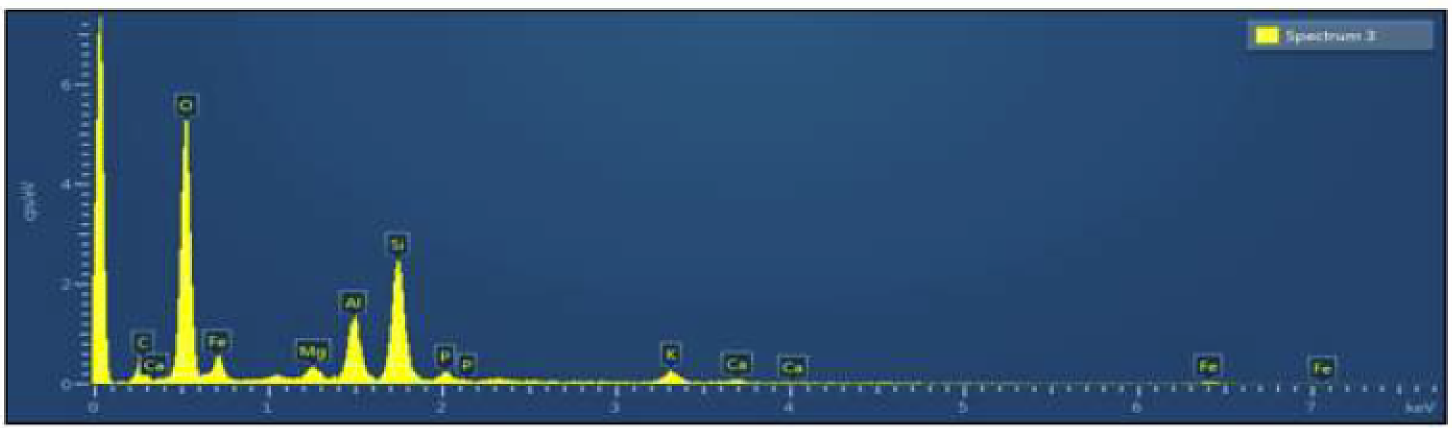
Element	Atomic %
O	59.99
Na	0.44
Mg	1.71
Al	7.34
Si	18.25
P	0.43
K	4.74
Ca	0.86
Fe	6.25

Figure G. 4: HiLp-3 V.23 Scan of Orange Staining, Spectrum 1-3



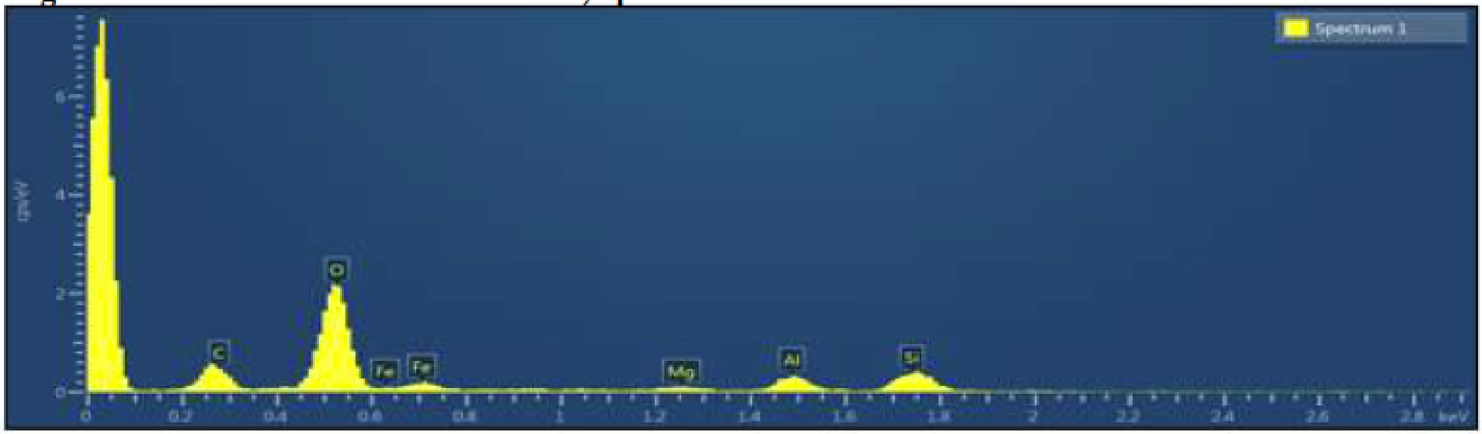
Element	Atomic %
O	59.82
Mg	4.28
Al	5.55
Si	18.20
K	2.69
Ca	2.05
Fe	7.42

Element	Atomic %
O	58.66
Mg	2.34
Al	7.09
Si	12.78
P	1.02
K	1.08
Ca	0.77
Fe	16.27



Element	Atomic %
O	60.08
Mg	1.68
Al	7.28
Si	15.89
P	1.29
K	2.59
Ca	0.85
Fe	10.35

Figure G. 5: GfLm-10 V.25: Control Scan, Spectrum 1-3

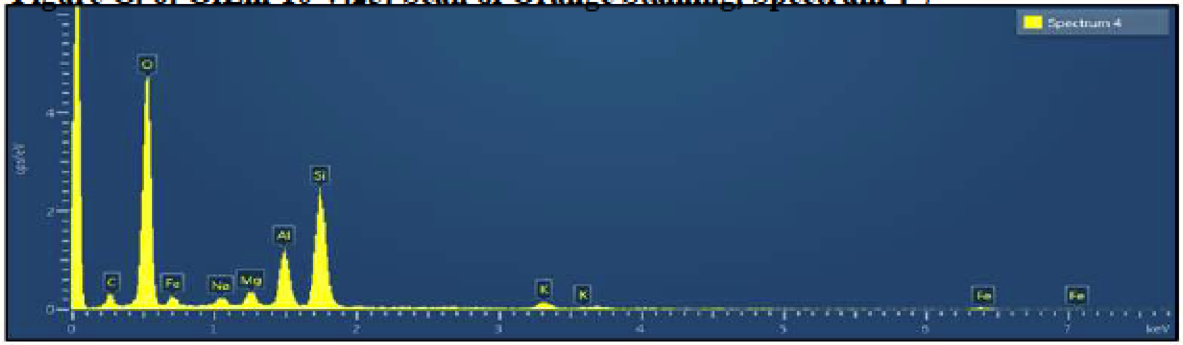


Element	Atomic %
O	60.86
Na	1.54
Mg	2.39
Al	8.28
Si	19.35
K	1.99
Fe	5.58

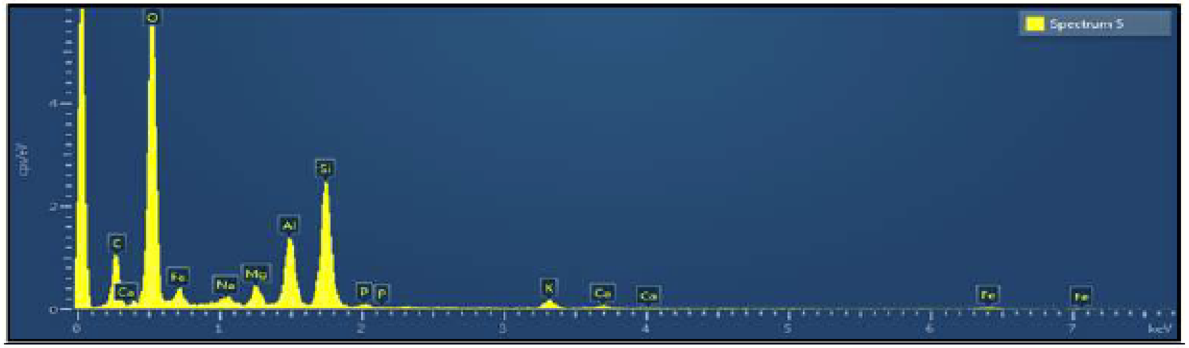
Element	Atomic %
O	60.17
Na	1.07
Mg	2.90
Al	9.73
Si	17.11
K	2.19
Fe	6.83

Element	Atomic %
O	61.63
Mg	1.55
Al	7.68
Si	20.92
K	3.00
Fe	5.22

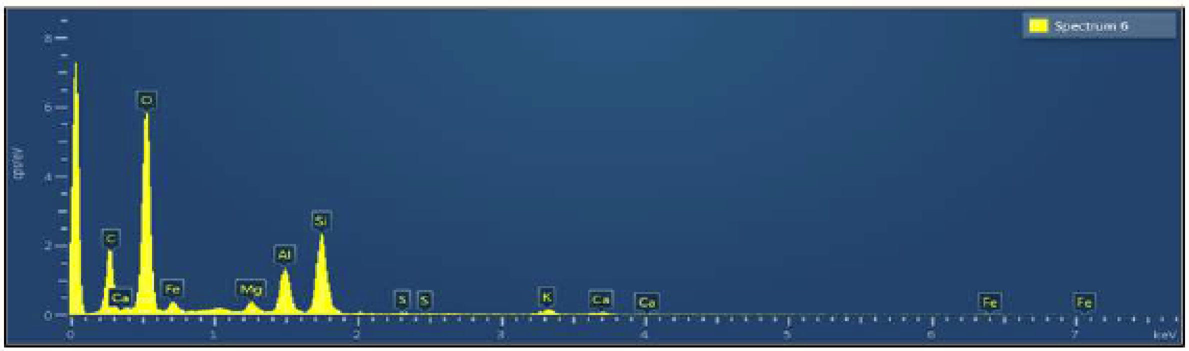
Figure G. 6: GfLm-10 V.25: Scan of Orange Staining, Spectrum 4-7



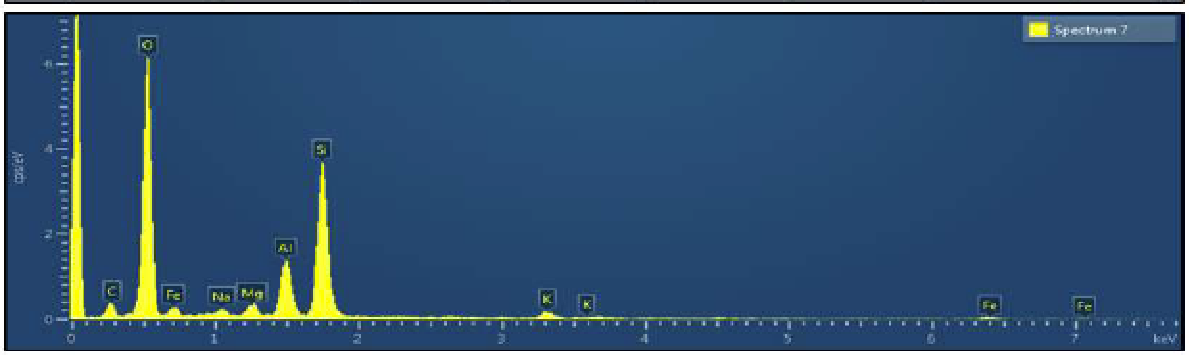
Element	Atomic %
O	60.86
Na	1.54
Mg	2.39
Al	8.28
Si	19.35
K	1.99
Fe	5.58



Element	Atomic %
O	60.02
Na	0.98
Mg	2.83
Al	8.13
Si	16.75
P	0.50
K	2.08
Ca	0.91
Fe	7.79

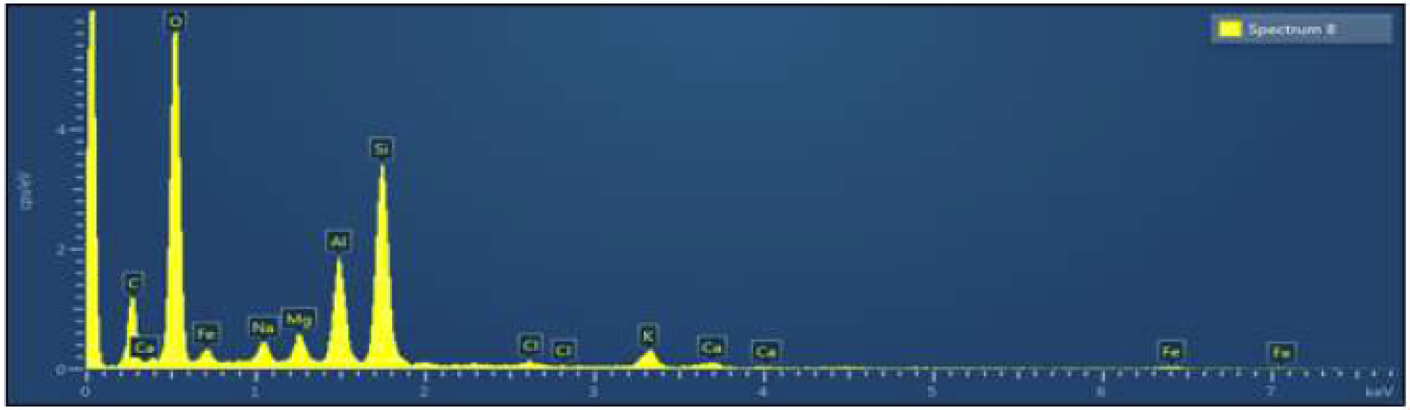


Element	Atomic %
O	60.76
Mg	2.32
Al	8.64
Si	17.17
S	0.48
K	1.83
Ca	1.27
Fe	7.54

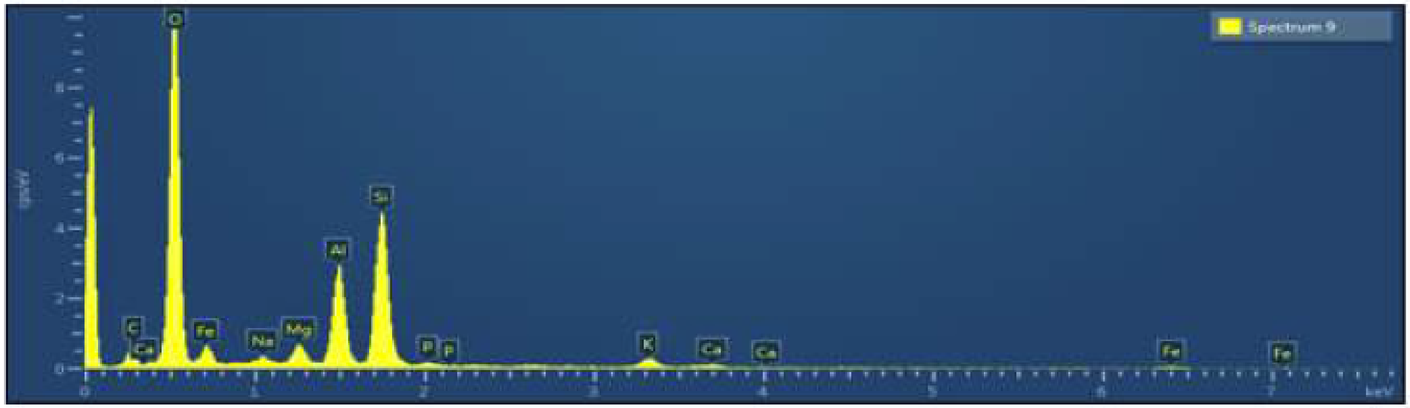


Element	Atomic %
O	62.21
Na	0.83
Mg	1.66
Al	6.86
Si	22.27
K	1.72
Fe	4.44

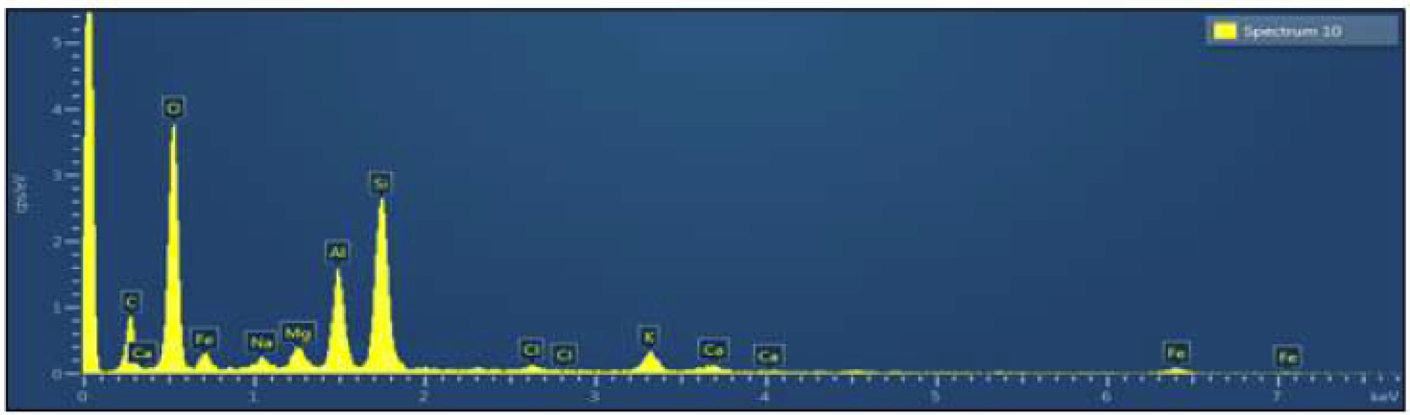
Figure G. 7: GfLm-10 V.25: Scan of Orange Staining, Spectrum 8-10



Element	Atomic %
O	59.72
Na	2.19
Mg	2.47
Al	8.19
Si	18.40
Cl	0.44
K	3.05
Ca	1.02
Fe	4.53



Element	Atomic %
O	60.54
Na	0.80
Mg	2.10
Al	9.58
Si	17.00
P	0.42
K	1.89
Ca	0.57
Fe	7.10

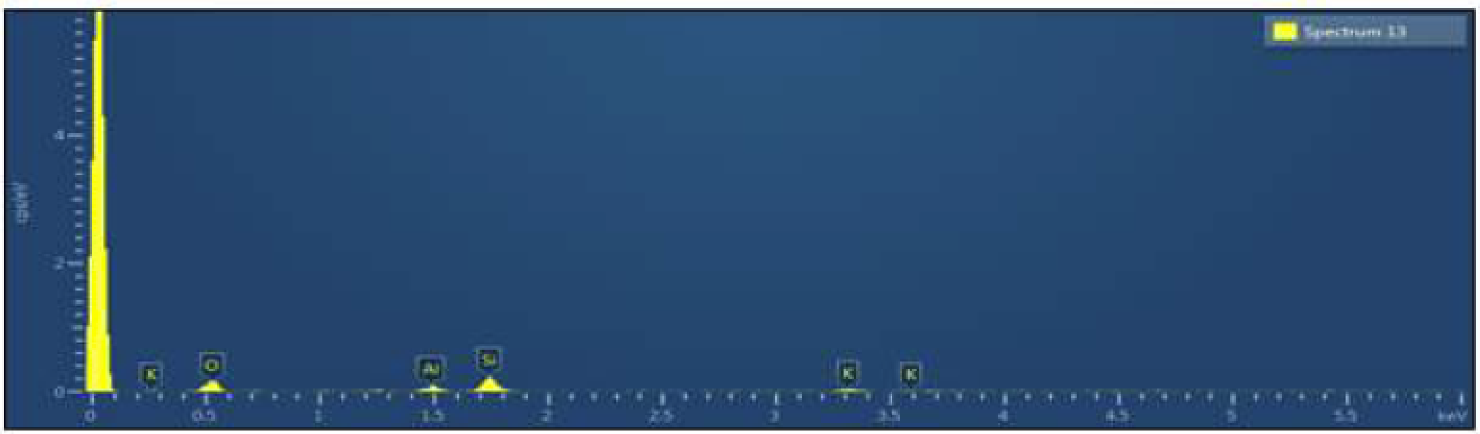


Element	Atomic %
O	59.30
Na	1.08
Mg	1.99
Al	8.58
Si	17.26
Cl	0.55
K	3.73
Ca	1.25

Figure G. 8: GfLm-10 V.25: Control Scan, Spectrum 11-13

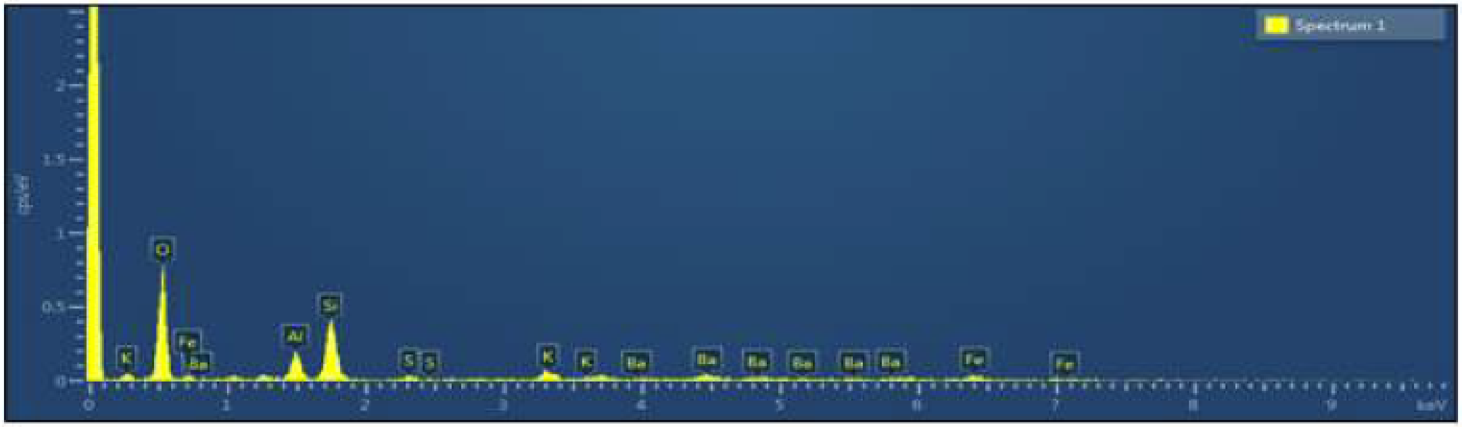
Element	Atomic %
O	61.09
Mg	2.09
Al	8.48
Si	20.64
K	5.38
Fe	2.32

Element	Atomic %
O	54.11
Al	16.43
Cu	29.46



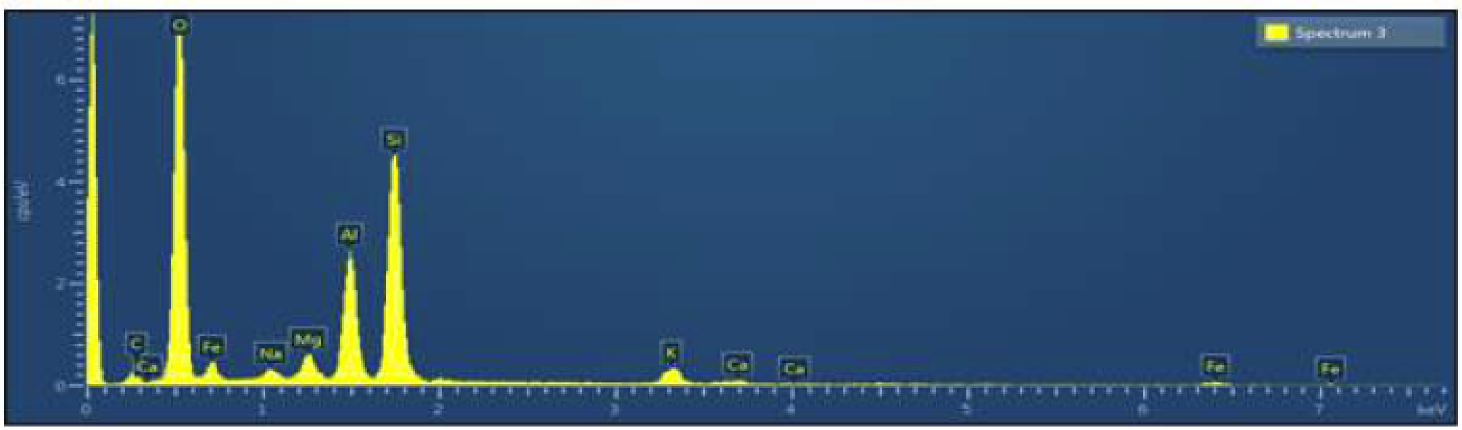
Element	Atomic %
O	61.05
Al	7.43
Si	22.76
K	8.76

Figure G. 9: GfLm-10 V.10: Scan of Orange Staining, Spectrum 1-3



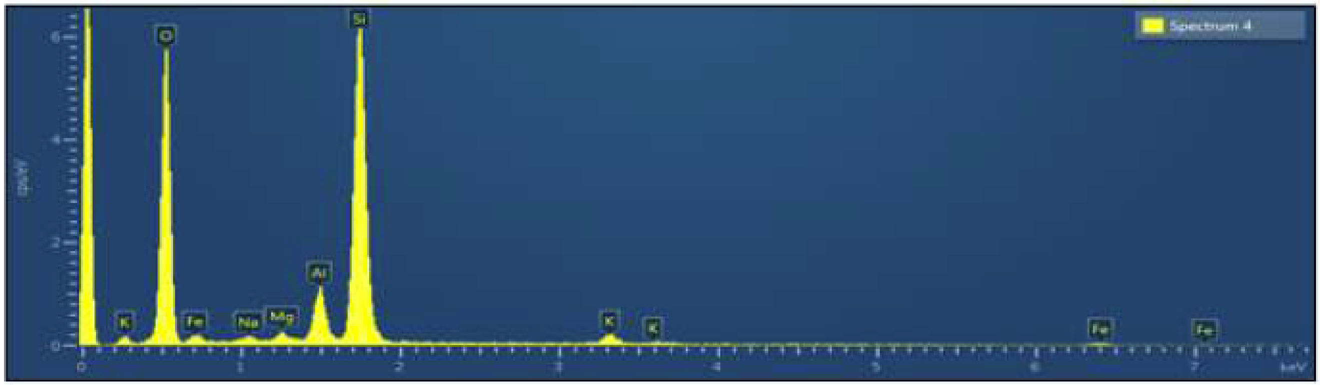
Element	Atomic %
O	60.89
Al	7.32
Si	17.60
S	1.46
K	4.78
Fe	4.01
Ba	3.93

Element	Atomic %
O	60.97
Na	0.75
Mg	1.98
Al	8.56
Si	18.97
K	2.93
Ca	1.09
Ti	0.52

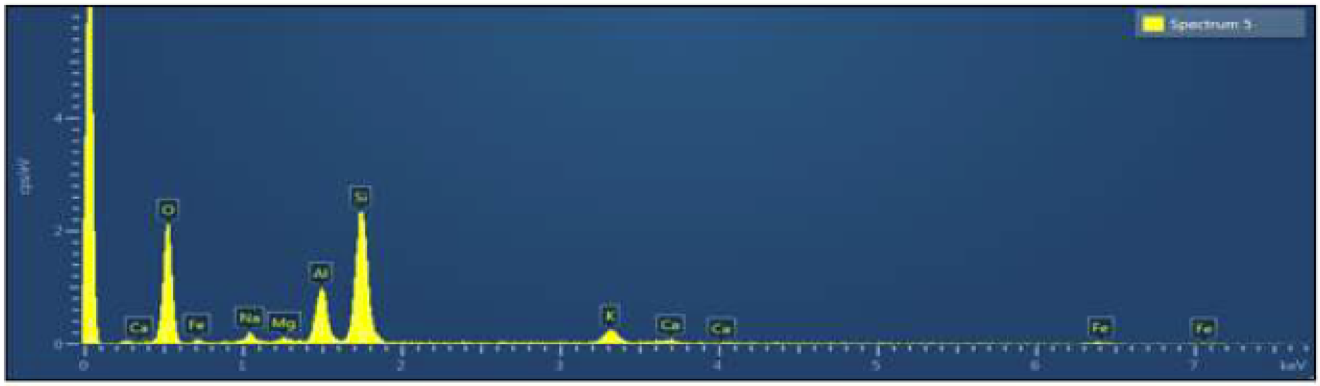


Element	Atomic %
O	60.87
Na	0.87
Mg	1.87
Al	8.92
Si	19.01
K	2.61
Ca	0.60
Fe	5.26

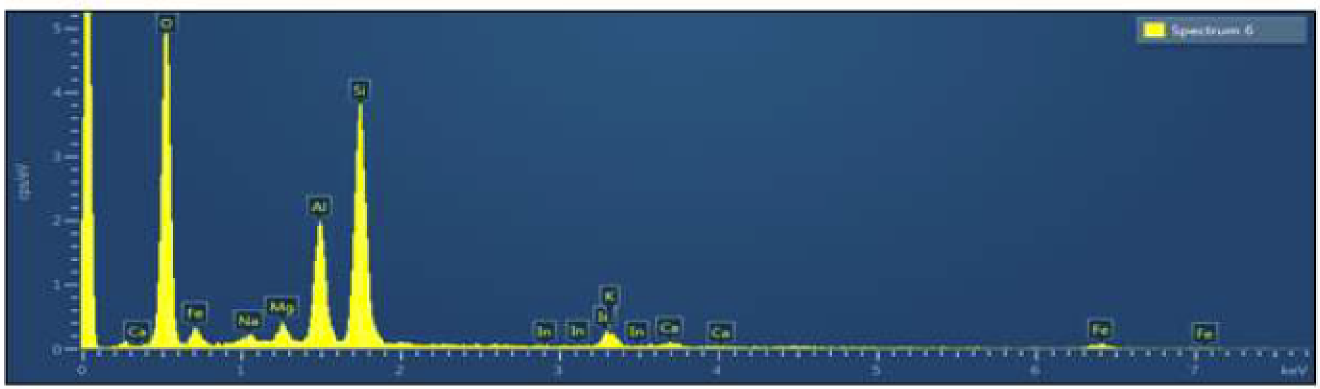
Figure G. 10: GfLm-10 V.10: Scan of Orange Staining, Spectrum 4-6



Element	Atomic %
O	64.17
Na	0.37
Mg	0.58
Al	3.88
Si	27.36
K	1.52
Fe	2.12



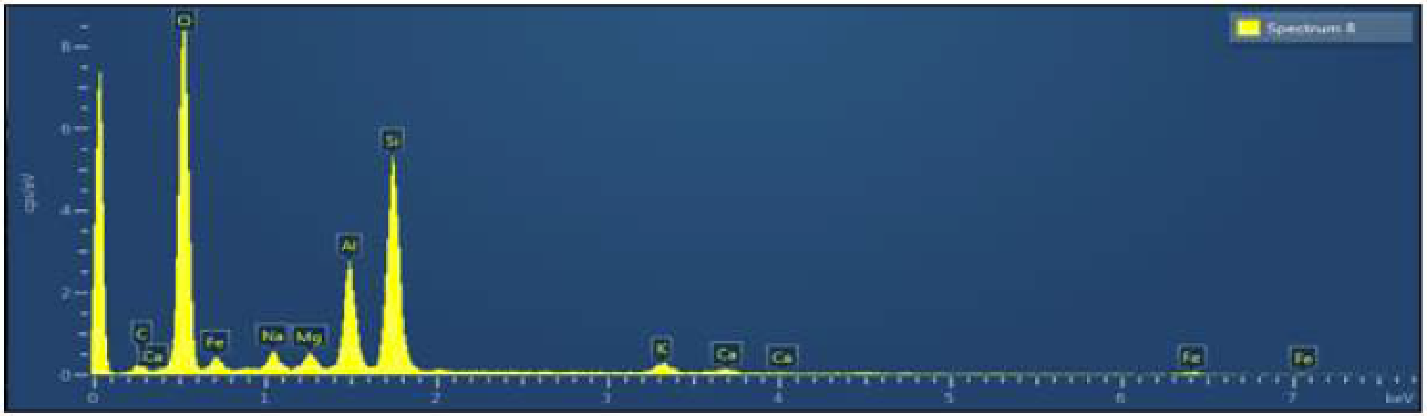
Element	Atomic %
O	61.35
Na	1.42
Mg	0.52
Al	7.75
Si	21.60
K	4.14
Ca	1.09
Fe	2.13



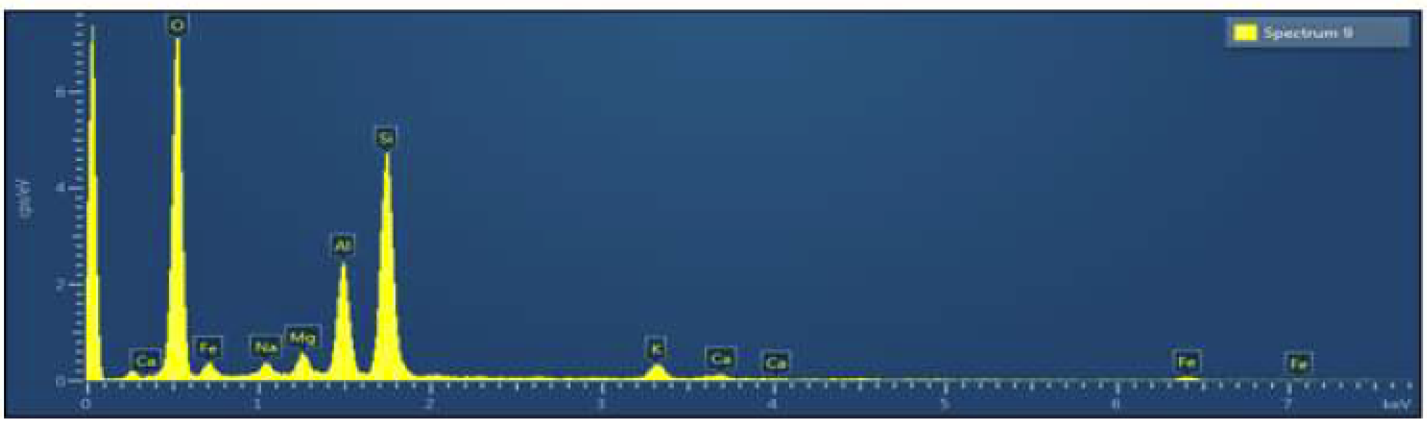
Element	Atomic %
O	61.51
Na	0.58
Mg	1.46
Al	8.54
Si	19.79
K	2.00
Ca	0.84
Fe	4.80
In	0.49

Figure G. 11: GfLm-10 V.10: Scan of Orange Staining, Spectrum 7-9

Element	Atomic %
O	64.72
Al	11.66
Si	23.62

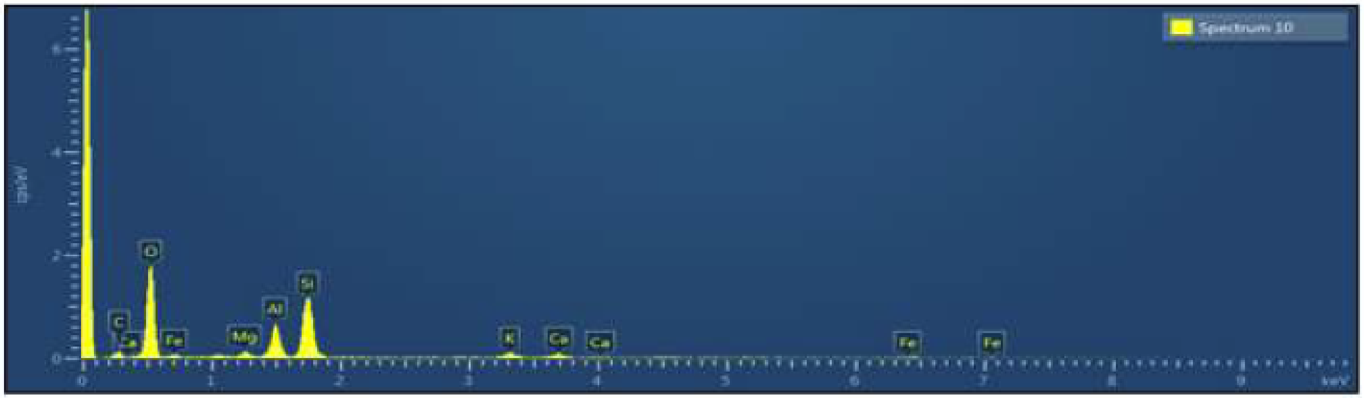


Element	Atomic %
O	61.09
Na	1.90
Mg	1.44
Al	8.46
Si	19.84
K	1.87
Ca	0.86
Fe	4.54



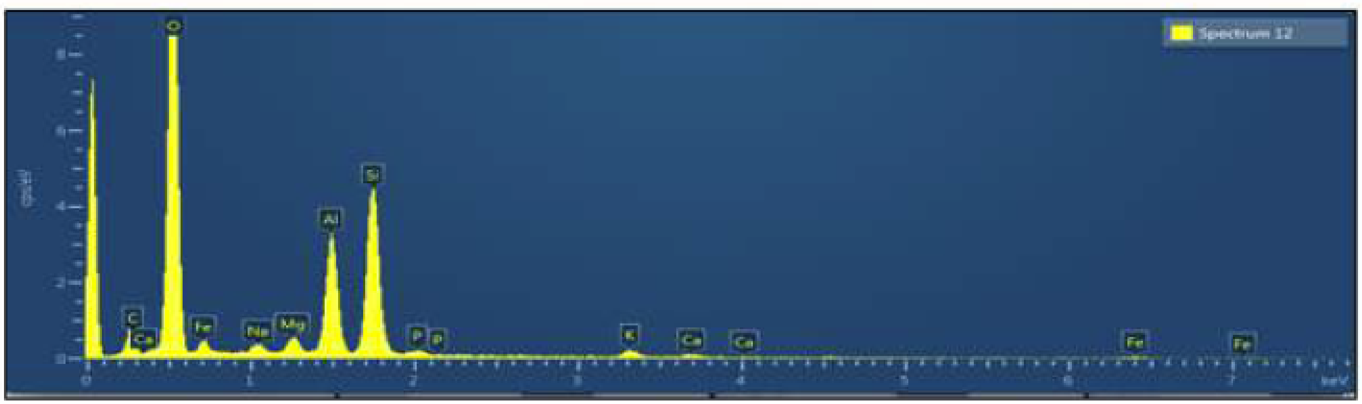
Element	Atomic %
O	61.12
Na	1.13
Mg	1.81
Al	8.65
Si	19.76
K	2.57
Ca	0.68
Fe	4.28

Figure G. 12: GfLm-10 V.10: Control Scan, Spectrum 10-13



Element	Atomic %
O	61.55
Mg	1.65
Al	8.50
Si	20.18
K	2.65
Ca	2.59
Fe	2.87

Element	Atomic %
O	61.89
Na	2.41
Mg	1.13
Al	7.26
Si	21.00
S	0.59
K	1.68
Ca	0.50
Fe	3.55

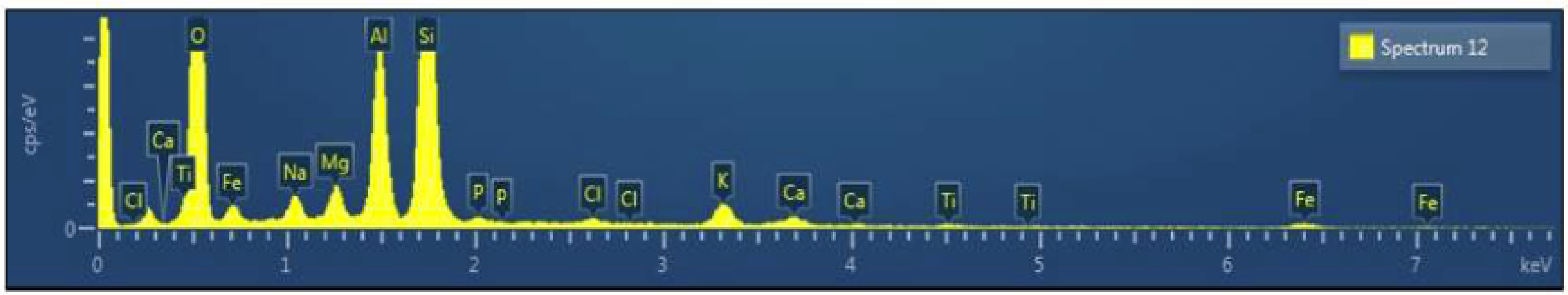


Element	Atomic %
O	61.48
Na	1.00
Mg	1.61
Al	10.64
Si	18.07
P	0.53
K	1.45
Ca	0.69
Fe	4.53

Figure G. 13: GfLm-10 V.17: Scan of Orange Staining, Spectrum 10-12

Element	Atomic %
C	34.56
O	52.40
Na	0.54
Mg	0.73
Al	3.01
Si	4.83
Cl	0.16
K	0.14
Fe	3.83

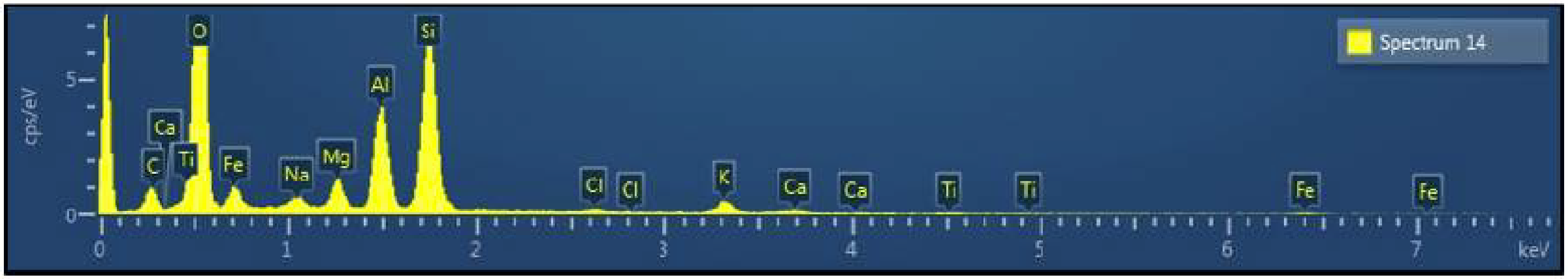
Element	Atomic %
C	18.77
O	55.59
Na	0.47
Mg	2.72
Al	4.72
Si	10.63
P	0.26
Cl	0.46
K	0.93
Ca	0.97
Ti	0.23
Fe	4.24



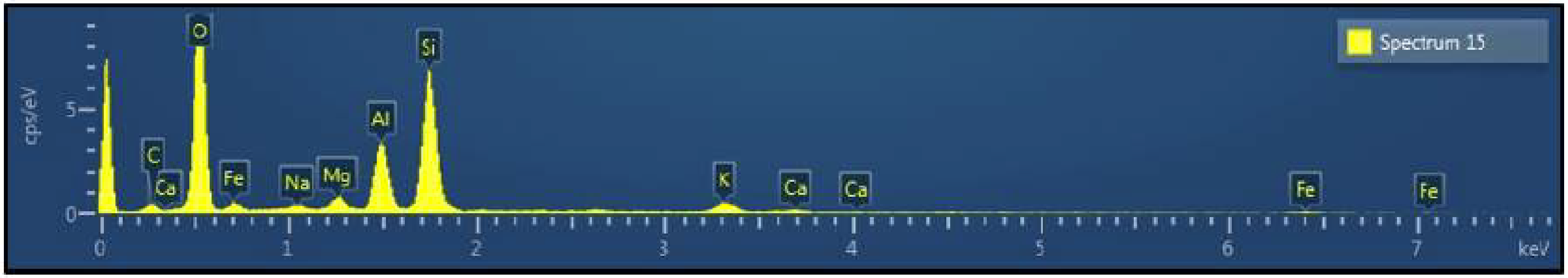
Element	Atomic %
O	60.99
Na	1.54
Mg	1.78
Al	8.63
Si	19.17
P	0.32
Cl	0.33
K	2.40
Ca	1.04
Ti	0.40
Fe	3.40

Figure G. 14: GfLm-10 V.17: Control Scan, Spectrum 13-16

Element	Atomic %
C	38.92
O	51.08
Mg	0.73
Al	1.84
Si	3.71
Fe	3.72



Element	Atomic %
C	11.10
O	61.28
Na	0.70
Mg	1.94
Al	5.77
Si	12.04
Cl	0.27
K	1.50
Ca	0.42
Ti	0.22
Fe	4.76



Element	Atomic %
C	5.89
O	61.30
Na	0.58
Mg	1.67
Al	7.07
Si	16.60
K	2.48
Ca	0.66
Fe	3.75