A STROLL THROUGH THE PARK: EVALUATING THE USEFULNESS OF PHYTOLITH AND STARCH REMAINS FOUND ON MEDIEVAL SHERDS FROM WICKEN, NORTHAMPTONSHIRE, ENGLAND

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TABLE OF CONTENTS

3. METHODS

4. COMPARATIVE COLLECTION RESULTS

5. ARCHAEOLOGICAL RESULTS AND DISCUSSION

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

ABSTRACT

Survey artifacts are used by a variety of archaeologists studying any number of interesting topics. The focus of this masters thesis is to test the usefulness of paleoethnobotanical remains found on artifacts recovered during archaeological survey and to study food consumption and production patterns in medieval England. Specifically phytolith and starch grain analysis was used to determine the level of environmental contamination on fieldwalking and excavated artifacts from the medieval period in the parish of Wicken, Northamptonshire, England. In addition, a comparative collection of phytolith and starch grains found in medieval foods and weeds was created. Particular emphasis was placed upon looking for wheat, barley, oats, rye, and legume phytoliths and starch grains. The usefulness and level of contamination was determined by comparing survey artifacts and surface soil samples from Wicken with non-contaminated excavated artifacts from nearby Wyton, Cambridgeshire. The microremains from the artifacts and soil samples were examined under a microscope using standardized processing and counting methods devised at the MU paleoethnobotany lab. In addition, the phytoliths and starch grains found in the soils and artifacts from Wicken and Wyton were compared to the medieval historical records for Northamptonshire and Cambridgeshire so as to better understand human consumption patterns in medieval England. Finally, the residues from the survey artifacts will be used to gain a better understanding of the relationship between the manuring hypothesis proposed by R. Jones and the development of the open-field system.

The results of this study indicate that survey artifacts have undergone some degree of contamination because the phytoliths and starch grains found on the artifacts match those found in the surrounding soil. However, the results are inconclusive because the origins of the residues on the artifacts cannot be determined with absolute certainty. The historical record for medieval Northamptonshire does not match the microfossil record found at Glebe Cottage in Wicken, Northamptonshire. The historical record for Cambridgeshire does match the microfossil record found on the artifacts from Durley Cottage, Cambridgeshire. The end result illustrates that although the historical record can be used to interpret overall food production patterns in a region, subtle variations still exist as seen with the plant microfossil record. Unfortunately, because it could not be determined if the survey artifacts were contaminated by their environment, the manuring hypothesis could not be tested. An interesting side result of this study was to demonstrate that land use practices influence phytolith taphonomy and the overall phytolith assemblage. Soils that are constantly farmed and undergo bioturbation were found to have mostly broken and redundant phytolith types. Soils that did not undergo extreme bioturbation, such as those protected by a collapsed building, contained fragile and often diagnostic types.

CHAPTER 1 : INTRODUCTION

Introduction and Research Questions

The transition from Anglo-Saxon to Norman England is one of the most crucial periods in English history and has been studied extensively by historians, linguists, and archaeologists. From the initial invasion of the Anglo-Saxons in 410 A.D. (Arnold 1984) to the arrival of the Bubonic plague in the 14th century (Ottaway 1992), England underwent widespread cultural changes including such notable events as the development of the English language (Fulk and Cain 2003) and the rise of the nucleated village (Hall 1981). Throughout all of these changes both production and consumption of food has played a crucial role in the development of English society. One of the best ways to examine the role of food in medieval England is through the use of archaeological remains.

Archaeologists use a wide variety of methods to understand food patterns and food ways including both faunal (Grant 1977) and floral analysis (Perry et. al. 2006), isotope analysis (Privat et al. 2002), and trace element analysis (Delgado et. al. 2005). Macrobotanical analysis of charred seeds, fruits, nuts, wood, roots, and tubers has been successfully used by scientists and archaeologists since the late nineteenth century to better understand diet in both the New and Old Worlds (Pearsall 2000). The past 30 years of research have seen remarkable strides in the use of plant microfossils such as phytoliths (Pearsall et. al 2004), and more recently starch grains (Torrence and Barton 2006), to explore topics ranging from the origins of agriculture to the development of state level societies (Piperno 2006). The most recent application of phytolith and starch

grain analysis has been to examine artifact residues to answer questions related to tool use and food production and consumption patterns.

Artifact residues, specifically phytoliths and starch grains, are unique because they represent a link between plants and past tool use. Because these microfossils are found on the artifacts surface, they are directly associated with the tool therefore they are representative of past activities (Chandler-Ezell and Pearsall 2003). Sometimes, they can play a crucial role in an archaeological study if the macrobotanical record is sparse. Similar to phytoliths and starch grains found in the soils, artifact residues can be used to address a wide array of important anthropological issues such as plant domestication and ritualized activities (Pearsall 2000).

Some archaeologists use residue analysis to understand what foods were processed and consumed. For example, Chandler-Ezell et. al. (2006) discovered some of the earliest examples of manioc, arrowroot, and llerén processing in coastal Ecuador on stone tools from the Real Alto site. In addition, they were able to determine whether or not foods were cooked or consumed raw as well as what part of the plant was processed (Chandler-Ezell et. al 2006). Other archaeologists may use residue analysis to get at tool function and the range of tool use (Babot 2003; Barton et al 1998; Atchinson et. al. 2005). Some archaeologists have even gone so far as to use residues to understand the relationship between tool use and social activities (Barton and White 1993) or tool use and gender roles (Binford and Binford 1969). Other examples of starch and phytolith residue analyses include: Barton (2005); Barton, H., R. Torrence, and F. Fullagar (1998); Crowther, A. (2005); Denham, T. P., S. G. Haberle, C. Lentfer, R. Fullagar, J. Field, M. Therin, N. Porch, and B. Winsborough (2003); Fullagar, R., F. Furby, and B. Hardy

(1996); Fullagar, R., and J. Field (1997); Fullagar, R., J. Field, T. Denham, and C. Lentfer (2005); Fullagar, R. with R. Jones (2004); Hall, J., S. Higgins, and R. Fullagar (1989).

Similar to some of the projects mentioned above, the goal of this master's thesis is to use phytolith and starch grain residues to gain a better understanding of food processing and consumption patterns in medieval England and how this can be represented in the archaeological record. In order to address this complex topic, I studied artifacts and soils from medieval contexts in Northamptonshire and Cambridgshire, England associated with the Whittlewood project and the Higher Education Field Academy (HEFA) Currently Occupied Rural Settlement (CORS) project.

The Whittlewood project is an intensive investigation by the Medieval Settlement Research Group into the rise and fall of nucleated villages in south central England ranging from the Roman to later medieval periods. The project is designed to "explain the origin and survival of contrasting nucleated villages and of dispersed settlements" in eleven counties around the Whittlewood area (The Whittlewood Project: 2005 electronic document). The Higher Education Field Academy is a program run by the Cambridge University Archaeology Department and is designed get local students and historical societies actively involved in archaeological and historical investigations. Both of these projects have conducted extensive archaeological research resulting in large quantities of artifacts collected from excavated units and from the surface during survey work. However, only those artifacts collected during excavation are considered useful for paleoethnobotanical research, i.e. starch grain and phytolith residue analysis. The artifacts collected while surveying are not normally included in such a study because they are not

associated with a specific context and may be contaminated with residues not associated with original tool use.

This thesis uses some of the artifacts and soils gathered from these projects to test whether or not artifacts collected during survey work, as opposed to those collected during excavations, can be used to answer questions related to medieval food processing and consumption patterns through residue analysis.

It is within this historical and cultural context that the four main research goals of this project are set. These goals are: 1) the creation of a comparative phytolith and starch grain collection of common medieval foods and field weeds found in archaeological settings and listed in historical texts; 2) testing to see if artifacts collected during an archaeological survey can be used for paleoethnobotanical analysis; 3) comparing the archaeobotanical results with historical record of the area; and 4) if the survey artifacts can be used for paleoethnobotanical analysis, analyzing how the food residues from the survey artifacts can be used to better understand the development of the medieval open-field system. The specific research questions are:

1. Are phytoliths and starch grains that may be present on survey artifacts as useful archaeologically as the remains found on excavated artifacts?
2. How do the archaeobotanical results from the artifacts and soils sampled in Wicken and Wyton compare with the historical record for each county? What can these results tell us about the medieval food patterns in these two villages?
3. If the residues on survey artifacts are related to original use and do not show evidence of environmental contamination, what can this tell us about the

artifact and how it relates to the development of the open field system in Anglo-Saxon/Medieval England?

Research Design and Methods

Comparative Phytolith and Starch Grain Study

A comparative collection of phytoliths and starch grain types was created based on historical and archaeological records that detailed a number of foods encountered in the medieval peasant diet. These plants were selected because they were a good representation of what could be found in the local fields and gardens or acquired through trade. Some of these plants included those that were commonly grown in nearby fields such as wheat (*Triticum* sp L.), barley (*Hordeum* sp. L.), oats (*Avena* sp. L), rye (*Secale* sp. L.), and legumes. Other plants included those may be commonly found in a small backyard garden such as celery (*Apium graveolens*), cabbage (*Brassica oleracea*), and beets (*Betas vulgaris*). Finally, some rare plants that were acquired through trade, such as apples (*Malus pumila*), poppy seeds (*Papaver somniforum*), and grapes (*Vitis vinifera*), were also included.

In addition, important weeds that were common to fallow fields were included in the study so as to account for possible "confusor" types of phytoliths and starch grains (Chandler-Ezell et al 2006). The overall list of food and weedy plants was based on the research conducted by various historians and archaeologists such as M. A. Monk (1977); M. Jones (1981); F. J. Green (1981, 1984); F.A. Roach (1985); A. Hagan (1992); I. G. Simmons (2001); and S. Pollington (2003).

Due to time and availability constraints, not every possible type of food item or weedy plant was included in this study. A total of 57 species and their associated parts

were examined for their diagnostic potential. The methods and procedures for processing the collection are found in chapter 3 while the results and discussion of the comparative collection are found in chapter 4. The diagnostic phytoliths and starch grains were carefully analyzed and compared with established types such as those created by Terry Ball, Arlene Rosen, and E. T. Reichert (Ball et. al. 1999; Ball et al. 1993; Ball et. al. 1996; Cummings 1992; Kaplan et. al. 1992; Piperno 2006; Portillo et. al. 2006; Rosen 1987, 1992; Rosen and Weiner 1994; Tubb et. al. 1993; Piperno et. al. 2004; Reichert 1913, 1919).

Phytolith residues can be identified using a diagnostic or assemblage based approach. In the diagnostic approach, phytoliths are identified by comparing the morphology of an unknown phytolith with a known diagnostic phytolith type. A diagnostic phytolith is defined by Pearsall as one that "can be used to distinguish among plant taxa in a given flora" (2000: 376). Typically, a diagnostic phytolith is one that has a unique morphology that can be used to identify that particular phytolith to the family, genus, or even species level. However, not every phytolith is diagnostic around the world and may only be diagnostic in certain contexts (Pearsall 2000).

Diagonstic phytoliths can have limited, regional , and universal context. Some diagnostics types can only be used in specific "limited contexts", such as human teeth or fecal matter, because the type would be redundant in any other environmental or archaeological situations. Other phytoliths are diagnostic at the regional level because they are unique in certain ecological and environmental conditions but may be redundant at a global scale. Examples of a regional diagnostic type would be domesticated grasses in colder environments where very few wild grass types exist. Finally, universal

diagnostic phytoliths are those, such as the Arecaceae family, that have a morphology unique to that family, genus, or species and cannot be confused with other phytoliths found around the world (Pearsall 2000). Examples of the diagnostic approach can be seen with Pearsall and Pipernos's work related to Teosinte and maize phytolith types (Pearsall 2000; Piperno 2006). The diagnostic approach was used in this study because of its simplicity and ease of use. However, not every plant produces a unique phytolith type that can be matched to that particular family, genus, or species. In this situation, an assemblage based approach may be necessary to identify the plant remains.

An assemblage based approach for phytolith identification suggests that instead of having a one to one match between a type and a particular species, suites of phytoliths are characteristic of a plant and which can only be determined through statistical analysis. Plants produce many different types of phytoliths that, when studied together, have unique assemblages that can be used to identify that plant to the family, genus, or species level. Thus, instead of having one type of phytolith that can be used to identify the presence of a plant, a whole collection of phytoliths is necessary to determine its presence. Examples of this type of approach can be seen with the morphometric studies conducted by Terry Ball et al. (1993, 1996, 1999). This approach was not used in this study due to time and technological constraints.

Evaluating Survey Artifact Usefulness for Residue Analysis

The question of artifact usefulness is directly related to the issue of artifact contamination. Are the residues that you find on an artifact associated with its original use? Or, have the artifacts undergone some degree of contamination? Do plant residues, i.e. phytoliths and starch grains, found in the soil become deposited on artifacts immersed

in the soil? Conversely, can residues from an artifact be deposited in the surrounding soil? Artifact residues can be divided into primary and secondary residues. Primary residues are defined as those associated with original tool use. Secondary residues are defined as those associated with post depositional processing. Therefore, artifact contamination is the deposition of any residue that is not associated with the original use of an artifact, i.e. the primary residues (Chandler-Ezell and Pearsall 2003). Artifact contamination is in turn linked with the topic of plant microfossil movement within the environmental and archaeological settings.

The movement of phytoliths in the environment and in the soil has been extensively studied by researchers such as Piperno (2006), Pearsall (2000), Rosen (1992), and others. Indeed, research has shown that by-and-large, phytoliths typically stay in the same location where they were originally deposited because of the chemical bonding with the surrounding soil particles (Pearsall 2000; Piperno 2006). Does this mean that the chemical bonds between phytoliths and soils will prevent them from become stuck to buried artifacts or vice versa? As of right now there has been very little research conducted to answer this specific question. Preliminary research by Chandler-Ezell and Pearsall (2003) indicates that the majority of phytoliths remain with their soils because of their strong chemical bonds. These phytoliths should remain with the soils if they are systematically removed from an artifact's surface. However, this is not to say that some transfer of phytoliths along the soil/artifact interface has not occurred. The question of artifact contamination has been addressed more extensively by researchers studying starch grains.

Similar to phytoliths, starch grains can undergo some degree of movement around the landscape but are most often associated with their original deposition. Therin (1998) showed that the majority of starch grains will remain *in situ* despite vertical movement of water through the soil column. Two interesting studies by Attenbrow et. al. (1998) and Barton et. al (1998) provide evidence that artifacts can pick up residues from the surrounding soils. In the Attenbrow et. al. study, artifacts that were buried in a shell midden containing shell residues not associated with the original tool use. These residues were different from the primary residues and closely matched the residues found in the surrounding shell midden (Fullagar 2006). Barton et. al. found starch grains on both unmodified pieces of stone and obsidian artifacts from a site in Papua New Guinea. The presence of these grains indicated that some of the starch grains from the surrounding environment had transferred onto the artifacts and non-artifacts alike (Barton and Matthews 2006; Fullagar 2006).

In contrast, Williamson (2006) conducted a controlled experiment where she placed clean or recently used artifacts in direct contact with a variety of materials such as meats, leathers, and vegetables in the soil. Her preliminary results demonstrated that although some plants such as potatoes can provide a source of starch contamination, the starch grains do not "arbitrarily adhere to artifact surfaces, except in small quantities" (Williamson 2006: 90). Thus, in her study, the majority of artifacts still contained intact primary deposition with little secondary deposition from nearby contaminants. Clearly, however, there is still much work to be done to answer the complex question of artifact residue contamination.

Three Part Design

To try and address this complex issue, I employed a three part research design. In the first part, I compared the microfossil residues found on freshly collected, unwashed survey artifacts with their surrounding soils taken from a field (field number WI-13) near Wicken, Northamptonshire. This comparison was made to see if any microfossils had made their way from the soils onto the artifacts themselves.

For the second part of the project, I compared the surface artifacts to the artifacts found in a sealed context such as those found preserved under the floorboards at Durley Cottage, Cambridgeshire. By comparing these two sets of artifacts, I could address the question of usefulness by means of having a control sample. The artifacts from Durley Cottage served as the control sample because they have been protected from environmental forces and had not undergone the same types of bioturbation as the artifacts collected from the field. Therefore, if the results from the Williamson study hold true, the Durley Cottage artifacts should not have any evidence of environmental contamination and should serve as baseline of comparison for what a non-contaminated artifact should look like.

The phytoliths and starch grains found in the soil samples and excavated artifacts would be compared to those found in the surveyed artifacts and help determine which residues were primary and which were secondary in origin. The residues, along with the soil samples, were chemically processed to separate the starch grains and phytoliths from the soil and residue matrices. It is important to note that the artifact residues were divided into three samples.

The third part of the research design is a cross artifact/soil comparison of all three sediments. Each one of the artifacts underwent series of controlled cleanings where various methods were used to essentially peel back the layers of residue. Three steps were used to separate primary from secondary residue deposition resulting in sediments 1, 2, and 3 samples. Primary residues are those residues associated with original tool use while secondary residues are associated with post-depositional processes. Sediment 1 samples were associated with the secondary depositions and were supposed to closely match the surrounding environmental soil. Sediment 2 samples were a mix of both primary and secondary depositions. Finally, sediment 3 samples represented primary depositions associated with tool use (Chandler-Ezell and Pearsall 2003). For specific artifact processing details, see chapter 3.

The microremains were examined under a research microscope and identified by comparing them to the newly created phytolith and starch grains comparative collections of medieval foods and field weeds. Particular emphasis was placed upon looking for crop residues such as wheat, barley, oats, rye, and legume phytoliths and starch grains.

The initial hypotheses for this investigation are as follows:

A) If the sediment 2 and 3 residues from the survey artifacts closely match the residues found in the soil samples but differ from the sediments 2 and 3 in the excavated samples, then there has been environmental contamination, i.e. secondary residues were deposited on the artifacts. Specifically, I looked for diagnostic starch grains or phytoliths that would be associated with weeds found in a field during the fallow period but not associated with food practices.

B) If sediments 2 and 3 recovered from the survey artifacts do not match residues in the soil samples, then I can hypothesize that there has not been environmental contamination and the residues are primary in origin.

Comparisons to Historical Record

The questions related to the historical record and the development of the open field system were addressed by examining the phytoliths and starch grains found in artifacts and residues from nearby excavated units at Glebe Cottage in the town of Wicken in addition to those discovered while examining the artifact contamination issue. The results from the excavated and survey artifacts and the excavated soils were compared with the known historical records for Wicken, Northamptonshire and Wyton, Cambridgeshire.

Significance

The world of starch grain and phytolith analysis is continually changing with new studies and comparative collections developing all the time. The creation of a comparative collection for medieval Britain would help expand the body of knowledge by reaffirming or revaluating existing types and suggesting new possible diagnostic types for further research. Secondly, one commonly understudied aspect of the archaeological record is the use of survey artifacts in paleoethnobotanical research. Survey artifacts are commonly encountered during archaeological investigations and are often used for determining site location and, as with the case of medieval England, used for understanding past farming activities. If survey artifacts prove to be useful for paleoethnobotanical analysis, it would provide archaeologists with another avenue for examining past tool use and subsistence practices. In addition, by comparing the archaeological and historical records, a better

picture of medieval food practices may emerge. Finally, if the survey artifacts prove to be useful and their distribution in the agricultural fields are the result of manuring practices associated with the development of the open-field system, they would provide an excellent glimpse into the dietary patterns of the peasant population of medieval Wicken and Wyton.

Structure of the Thesis

The results of this study are presented in the next five chapters. Chapter two provides an overview of phytolith and starch grain analysis in archaeology, discusses Anglo-Saxon foodways, the formation of open-field systems and the manuring hypothesis, and presents the archaeological and historical background of Wicken, Northamptonshire and Wyton, Cambridgeshire. The third chapter reviews the methods used to process the comparative collection along with the methods used to process and analyze phytoliths and starch grains found on artifact residues and soil samples. A short discussion of artifact type and their historical importance is also included in this chapter. Chapter four presents the results of the comparative collection study and discusses its implications for research. Chapter five presents the results of the artifact and soil samples, addresses the questions posed above, and discusses problems and future research. Chapter six presents the conclusions for this project. Raw data for the comparative section of this study is located in Appendix I. Appendix II contains the raw data from the phytoliths and starch grains found in the soils and artifacts studied.

CHAPTER 2: BACKGROUND

Phytolith and Starch Grain Analysis in Archaeology

History of Phytolith Analysis

The term phytolith, a Greek word meaning "plant stone", is used to describe two different types of mineral concretions that form diagnostic shapes within plant systems (Piperno 1988). Calcium phytoliths are composed of calcium oxalate crystals that can be produced in almost every section of a plant. These phytoliths exist in a variety of plant species such as olives and grapes yet are also found sporadically in soil contexts. Because these phytoliths occur infrequently in the soil and are very hard to extract, most phytolith research has focused on phytoliths composed of silica (Pearsall 2000; Rapp and Mulholland 1992).

The first stage of opal silica phytolith research began with Loeuwenhoek's 1675 discovery of the previously mentioned calcium phytoliths during the early years of light microscopy (Rapp and Mulholland 1992). Many years passed without any advances until in 1835, a German botanist named Struve observed silica phytoliths in living plant tissue. One year later, C.G. Ehrenberg, another German scientist, began his study of phytoliths in plants and soil sediments. In his reports, he developed the first classification system and recognized differences in phytolith morphology in relation to plant families (Piperno 2006). However, aside from these initial discoveries, phytolith research was sporadic during the 19th century.

The beginning of the 20th century brought with it the study of plant anatomy and physiology in relation to phytolith production. From 1900 until 1936, German scientists

such as F. Netolitzky dominated the field of phytolith studies (Rapp and Mulholland 1992) and produced many reports relating to production, taxonomy, intraspecific variation, and dispersion techniques. Most of their studies involved the analysis of phytoliths in the grass family as well as a few other monocotyledons. However, the onset of World War II halted phytolith research in Germany and the rest of Europe (Piperno 2006). The third phase of phytolith research did not begin until sometime after the end of the Second World War

Piperno describes this third stage as "The Period of Ecological Phytolith Research" in which, from the mid 1950s until 1975, botanists, soils scientists, and others used phytoliths in soils to index past environmental histories. The focus of phytolith research had shifted out of Germany and was now centered in the United Kingdom, the United States, and Japan. This renewed interest in phytoliths lead to a series of important discoveries. The previous view that phytoliths lasted only one thousand years and that they could only be found in certain contexts was disproved by a number of studies. These studies illustrated that silica bodies lasted millions of years. In addition, they were found in varied contexts, for example, Wisconsin-age loess and till, deep sea cores, and atmospheric dusts. Studies during this time also included investigations into the chemical and physical properties of phytoliths. In their attempt to investigate past ecosystems, scientists expanded their research into nonmoncotyledenous species such as those of the coniferous and deciduous trees. Finally, one of the most important studies of this period was the Twiss et al. (1969) study in which the authors developed a classification system for the three subfamilies of grasses that is still used today (Piperno 1988, 2006). By the

mid 1970s the focus of phytolith research was shifting once again in a new, more archaeological based direction.

Modern phytolith research, dating from the mid 1970s to the present, has focused on the creation and application of phytolith typologies for archaeological and paleoecological use. Paleoethnobotanists were particularly interested in areas of the world where other archaeobotanical data, such as pollen and seeds, were lacking. Consequently, detailed classification systems have emerged from studies in Eastern North America and the tropics. The proper application of these studies, such as those conducted by Pearsall (1978), Piperno (1984), and Rovner (1971), paved the way for phytoliths to emerge as a major tool in archaeological and paleoethnobotanical reconstruction.

History of Starch Grain Analysis

Starch grains represent one of the newest microfossils to be incorporated into the ever expanding sphere of paleoethnobotany. In addition to macroremains, pollen, and phytoliths, archaeologists now use starch grains to identify the presence of certain plants that would otherwise be absent in the fossil record. Starch grains are spherical bodies of starch that serve as an energy storage device for plants. Starch is originally produced in the chloroplast cells via specialized organs called amyloplasts. During photosynthesis, when sunlight hits the chloroplast cells the light energy is converted into a sugar compound called glucose. Some of the glucose is transported to amylosplasts whereupon the glucose is converted into reserve or storage starch grains (Gott et. al. 2006)

Starch grains are found in almost every type of plant tissue including leaves, fruit, roots, stems, seeds, etc. Their overall morphology is genetically determined, however,

their size and shape can be modified by internal and external factors. Two types of starch are commonly produced by plant cells, storage and transient. Transient starches are very small, typically about one micrometer in diameter, extremely numerous grains that are found throughout the plant. Unfortunately, because of their size and redundancy, they are not useful for identifying plant species. In contrast, storage starch grains are quite diverse in their size and shape and are usefully archaeologically (Gott. et al 2006). It is the presence of absence of specific starch characteristics such as overall granule shape; position and form of the hilum; presence or absence and shape of a fissure; presence or absence of lamellae; number and characteristics of pressure facets; and the size and morphology of the extinction cross that makes these starch grains useful diagnostically (Torrence 2006b).

Archaeological starch grain analysis is a very young field having only recently developed over the past twenty years. Prior to this period, starch grains were periodically studied by botanists, chemists, and biologists such as Greenish and Collin (1904), Reichert (1913, 1919), and Wallis (1957), and Seidemann (1966) (Torrence 2006b). Systematic use of starch grains for archaeological research was pioneered by Donald Ugent in 1981. Subsequent studies by Ugent (Ugent et. al. 1982, 1983, 1984, 1986, 1987, Ugent 1994, 1997) served to strengthen the argument for starch grains as a valid archaeological tool (Torrence 2006b). The next major development in starch grain research came with the chipped stone studies in Australia by Tom Loy (et al. 1992, 1994) and Richard Fullagar (1998) and the studies conducted by Dolores Piperno and Irene Holst (1998, 2004; Piperno et. al. 2000) in the New World (Torrence 2006b). Since these major studies, starch grain research has gained credibility as a major research tool and

has resulted in the formation of the Ancient Starch Research Group in 1998 and numerous studies such as those conducted by Chandler-Ezell et al. (2004), Korstanje (2003), Halsam (2004), Fullagar et al (2005), Piperno et al.(2004), and Denham et al. (2003).

Culture History of the Anglo-Saxons and Medieval England

Introduction

The contemporary villages of Wicken, Northamptonshire and Wyton, Cambridgeshire have long histories dating back to before the Norman invasion of 1066 A. D. Archaeological and historical evidence indicates that these villages were founded sometime during the middle Anglo-Saxon period and thrived throughout the later medieval periods. Even though the artifacts used in this study were produced during the middle medieval period (1066-1300), the common peasant farmer could trace his or her cultural heritage back to the earlier Anglo-Saxons. Despite the fact that the ruling class and aristocracy of the middle medieval period was predominately of Norman French descent, the English peasant populations shared more in common culturally with their Germanic or in some cases Viking ancestors than they did with their Norman overlords. Therefore, in order to understand medieval tool use and associated food production and consumption patterns, one must look at the earlier Anglo-Saxon period to get a true perspective on the medieval peasant populations of Northamptonshire and Cambridegshire.

Brief History of the Anglo-Saxons and Their Environment

The term ‘Anglo-Saxon’ is used to describe the material culture associated with Germanic populations who migrated to eastern England during the early 5th and 6th

centuries A.D. (Arnold 1984). This migration was preceded by the gradual departure of the Romans during the 4th and 5th centuries A.D. Whether large populations of Roman citizens actually left England, leaving a somewhat open and abandoned landscape, is still hotly contested among scholars. Instead, some suggest that the majority of the population, which had been Romanized, remained and it was only the military and elite Roman officials who departed England. Regardless as to the number of people who left, archaeologically the Roman artifacts and features gradually disappear from the soil record after 410 A.D.

The immigrant Germanic population was composed of many groups that originated in northern Germany, Scandinavia, and other parts of mainland Europe. The generic term 'Anglo-Saxon' is therefore used to describe a collection of peoples such as the Angles, Saxons, Jutes, Frisians, and Franks. Most of these subcategorizations correspond with the hypothesized region of origin such as the Saxons from Saxony and the Jutes from Jutland in Denmark (Harke 2002). The language of the Anglo-Saxons was Old English; a language originally developed in Germany. One of the best known examples of this language is the epic poem *Beowulf* written sometime before the 10th century A.D. (Fulk and Cain 2003). Artifacts found with the Anglo-Saxons bear a resemblance to contemporaneous Germanic artifacts found on the European mainland. In addition, a new form of funerary rite, cremation, was introduced to the island. Those individuals who were not cremated but buried instead were closer morphologically to their continental cousins than to the native populations of Britain (Harke 2002). All of this evidence points to the emergence of a new population on the landscape.[i]

Anglo-Saxons maintained political and military control through the establishment of kingdoms in England. However, the end of the Anglo-Saxon period is characteristically defined by the invasion of the Norman duke, William the Conqueror (sometimes referred to as William the Bastard) in 1066. The defeat of the Saxon King, Harold, at the Battle of Hastings stifled the spread of Germanic traditions found in England and ushered in the French Norman medieval period (Hills 1999)[ii]. It is important to note that the term 'Anglo-Saxon' does not mean the same time period or culture as 'medieval'.

The term 'medieval' is often liberally applies to a wide range of temporal and cultural contexts in Britain. The 'medieval' period in this project stretches from the Anglo-Saxon invasion to well beyond the Norman invasion of 1066. 'Anglo-Saxon' will be used exclusively for the Germanic populations living in England from 410 to 1066 A.D. Other terms, such as 'Saxon' and 'Jute', are all considered part of the Anglo-Saxon cultural family. Having loosely defined the Anglo-Saxon identity, it is important to understand the landscape and environment they encountered when first arriving in England.

An examination of the environment in which the Anglo-Saxons and their later decedents lived is important because it defines the parameters of what can be produced by the landscape for consumption. The environment and climate of the area are major factors that influence what crops can be sown and what livestock can be maintained. The Anglo-Saxons that appeared on the shores of Britain encountered a landscape that had been modified by humans for thousands of years. Britain itself rests in the temperate zone of the Northern Hemisphere but, in contrast to the European neighbors, has a warmer

climate due to the moderating effects of the North Atlantic drift. The basic geology of Britain, which includes the countries of Scotland, England, and Wales, holds that the oldest rocks are to be found in the northern and western regions, such as the Scottish highlands. The youngest material, which are also typically the most fertile, are the softer strata found in the southern and eastern sections of England (Simmons 2001). To facilitate an understanding of the level of modification the Anglo-Saxons encountered, one must have a mental image of the environment before human contact.

Humans have been modifying Britain for over 10,000 years with the arrival of hunter-gatherers in south east England. Great Britain during this section of the Pleistocene was still connected with mainland Europe though a land bridge to what is now modern France (Simmons 2001). The landscape before the arrival of humans was covered mostly in forests and tundra. Most of Scotland, north Wales, and some sections of England consisted of a tundra ecosystem complete with low shrubs and small trees such as willow (*Salix* spp) and dwarf birch (*Betula nana*). The rest of England and Wales was dense woodland consisting of oaks (*Quercus*), lime (*Tilia*), beech (*Fagus*), hazel (*Corylus*), pine (*Pinus*), and birch (*Betula*). The frequency and density of these species was dependent upon their proximity to the tundra. The fauna found on the tundra was dominated by the reindeer (*Rangifer tarandus*) and wild horse. Certain type of forests favored the moose (*Alces alces*) while the wild ox also found a home amongst the trees. Other local fauna included the red (*Cervus elaphus*) and roe (*Capreolus capreolus*) deer, the wild pig (*Sus scrofa*) and the beaver (*Castor fiber*). The chief predators of the time were wolves (*Canis lupus*) and bears (*Ursus arctos*) (Simmons 2001). The environment

encountered by arriving Anglo-Saxon populations was very different from this pristine Pleistocene image.

When the Anglo-Saxons arrived to England in the mid 400's A.D., they encountered a landscape that had been modified by humans since at least 8,000 B.C. Sometime around 3,500 B.C. farming communities emerged and began clearing the land for their own use (Megaw and Simpson 1979). The Iron Age and subsequent Roman occupation period had seen widespread land clearance for agricultural use. Starting in the 5th century B.C., forests were disappearing at an unprecedented rate and scale in response to the increasing demands of a growing population (Turner 1981). These clearances had a ripple affect that altered several environments found in Britain.

The clearance and conversion of woodlands in the pre-Anglo-Saxon time periods caused widespread ecological changes throughout the realm. The opening of the forests caused the creation of new habitats and permitted the spread of new types of flora and fauna, such as the bluebell grass (*Campanula rotundifolia*) and the fox (*Vulpes*). For example, in the Lake District of England, land that had been cleared for farm use quickly suffered from erosion and consequently changed into grasslands, heaths, or bogs. Much of the moorland that exists today in Britain is the direct result of these early clearances (Turner 1981; Simmons 2001). Another consequence of the land clearances was the diminished numbers or disappearance of species, such as the wild boar and wild cattle, that could not survive the ecological pressures induced by the increase in both the human population and deforestation (Simmons 2001).

The clearing of forests was so extensive that upon their arrival, there was little need for the Anglo-Saxons to carve farms out of the already depleted woodlands of

England. In fact, the pollen record shows that during the early stages of the Anglo-Saxon occupation, there was a slight regeneration of the forests in certain areas (Turner 1981). The pollen diagrams also indicate that there was no significant ecological change in England following the end of Roman rule (Sawyer 1978). Thus, even though the Romans had left Britain, the Anglo-Saxons were not forced to hack out a living in what some historians had seen as a plague-stricken, abandoned wilderness. Instead, the Anglo-Saxons adapted to their new environment and utilized many of the resources made available to them by earlier populations (Cleary 1995). In time, their impact on the English environment would manifest itself in the intensification of farming practices in existing fields rather than the clearance of vast tracts of forest for cultivation.

Food Production and Consumption Patterns in Medieval England

Food Production

One of the most important choices the Anglo-Saxons were forced to make upon their arrival was where to establish farms and later villages. Finding and settling the most fertile lands to produce the needed food was crucial to their early form of subsistence agriculture (Arnold 1988). The location of these rural settlements depended upon the availability and quality of factors, for instance water, fuel, arable land, pasture, and suitable defensive terrain. Because the Anglo-Saxons were moving into an already occupied landscape, they were also forced to deal with other considerations such as land tenure issues and the rural economy (Arnold 1988; Steane 1984). The archaeological and historical evidence points to some interesting trends in site locations.

The general area of occupation of England is best illustrated by the distribution of cemeteries and mound structures. These sites, although they do not always coincide with

a farmstead, provide the best overall picture of Anglo-Saxon settlement patterns (Fowler 1976). One of the strongest determinants for farm locations was the availability of water. Farms were frequently located near springs, wells and shallow ponds rather than the flood plains of a river (Steane 1984). Steane points out that

> In many areas of the county, we find lines of settlements (found either through aerial photography, field walking, or excavation of impermanent features), strung out like beads along springlines where water gushed out at the junction between permeable sandes, chalk or limestones, and impermeable clays [1984:144].

Fowler (1976) agrees that the idea of water was a key determinant but argues also that the farms were found close to the rivers and tended to avoid Roman roads. However, the variations seen in farm spatial arrangement may be the result of regional and local differences in the environment rather than underlying cultural trends (Arnold 1988). The size and shape of the farm buildings found on the landscape varied with the economic prosperity of each farmer.

The farms found throughout England during the Anglo-Saxon period can be categorized into four basic groups: earlier farms, enclosed farms, composite farms, and large settlements. These four categories are based on the spatial arrangements of specific types of buildings found on each farm or farmstead (Arnold 1984, 1988). The size of an Anglo-Saxon farm ranged from an individual farm to a nucleated farmstead composed of multiple buildings run by multiple families (Sawyer 1978).

The first category, which has been referred to as “earlier farms” consists of a few isolated buildings that are associated with pre-Anglo-Saxon structures. Examples of earlier structures may include the abandoned Roman villa or a late prehistoric enclosure.

An enclosed farm is a collection of small buildings that are associated with a fenced enclosure or paddock and may be associated with 'Celtic' field systems. Composite farms are larger settlements that include different quantities of both earlier farms and enclose farms. Finally, there are simple large settlements that represent one very large farm and are not subdivided into smaller sections (Arnold 1997). On these farms there were two essential types of structures; what Arnold calls sunken buildings and rectangular structures (Arnold 1984).

During the 5th century A.D., sunken buildings and rectangular structures were erected over earlier farms and associated fields. Examples of this replacement approach can be seen at the Bishopstone site in county Sussex (Arnold 1988). A sunken building is an awkward term used to describe any small structure that was erected over a subrectangular or square pit in the ground (Arnold 1988). Structures similar to this building can be seen in contemporaneous sites in Holland, Germany, and Denmark. These buildings had a utilitarian purpose and would house grain supplies, livestock, and people sometimes under the same roof (Harvey 1970). Eventually, after their usefulness had subsided, these buildings sometimes served as a garbage pit (Arnold 1984).

Many Anglo-Saxon farms, particularly the wealthier estates, included rectangular structures sometimes referred to as a hall or long house. These buildings, built at the ground level, varied in size but were always larger than nearby sunken buildings (Arnold 1988). 'Halls' were essentially rectangular timber structures who can be found in the archaeological record by the presence of post holes, post molds, and beam-slots. Most 'halls' are divided into two size categories on the basis of floor area. The floor area and associated category may reflect the economic status of the farm settlement (Arnold

1988). The design of the 'hall' was very general and would be built to suit the specific needs of the farm. Some of these rectangular structures were built for the storage and processing of grain (Harvey 1970). The overall picture of an Anglo-Saxon farm is one of a combination of different impermanent structures that were modified to suit the needs of its inhabitants.

Shift From Celtic to Open Field Systems

During the Anglo-Saxon period, a new style of farming known as the "open-field system" emerged and is linked to the development of that decidedly medieval entity known as the nucleated village. These villages in turn formed the basis of stereotypical medieval life in many parts of England. How the new farming system and village developed is still hotly debated with theories ranging from population pressure to political pressure as the chief cause. Yet despite the differences between the Celtic and open-field systems, they are both heavily dependent upon field shape.

The production of large scale crops throughout England was tied intimately with field shape which in turn influenced field systems. The term "field systems" is used here to define how a farmer manipulates the landscape to grow crops. The shape of the field was determined by several factors such as ploughing technique, land tenure, climate, elevation, local geography, and soil type. Field shape was also influenced indirectly by cultural and social factors such as kinship and inheritance practices (Monk 1977). All of these factors combined to influence the

Figure 2.1: Iron Age ard plow (BBC website: 2006)

type of field system employed by local populations. These same factors would eventually prove whether or not the farmers of a region were susceptible to nucleation (Lewis et al 1997). The appearance of the open-field system can only be understood when compared to its predecessor, the 'Celtic' or 'native' field system.

Throughout most of the prehistory and Roman occupation of Britain, all of the previously mentioned factors favored the use of the "Celtic," "closed," or 'native' field system. The farmers, who were unevenly distributed across the countryside, were responsible for tending their own individual plots of land and often enclosed their fields with some sort of marker such as a stone wall, bushes, or fencing. The fields, typically square, were farmed with a light ard plough (Figure 2.1) that cut a simple shallow furrow. In order to break up the soil properly, it was necessary for farmers to cross-cut the fields giving them a checkerboard appearance (Monk 1977; Loyn 1991; Fowler 1976). By the end of the early Anglo-Saxon period, changes in the field systems of England had begun.

Despite the departure of the Roman forces in 410 AD, the farming landscape did not undergo dramatic changes. The subsequent arrival of the Anglo-Saxons did little to change the way farms were run in these early years (Lewis et al 1997). Sometime during the 7th and 8th centuries A.D. a slow and gradual reorganization of the English landscape began to take shape. In small areas south of Yorkshire such as the counties of Buckinghamshire and Northamptonshire, scattered farms were deserted and a new 'open-field' system emerged. The individualized 'Celtic' field system was abandoned in favor of this new system that shared the land and responsibility of farming among many members of society. The overall result was a redistribution of property and the

abandonment of individual farmsteads in favor of new nucleated villages (Hall 1981; Arnold 1988; Loyn 1991).

The term open field system refers "…to all agricultural land, arable, pasture, and meadow, of a self-sufficient community which is worked and utilized according to a traditional pattern of communal activity" (Monk 1977: 244). An open field system is sometimes referred to as an infield-outfield system because of the way the fields are set up in relation to the nucleated village.

In the open field system, two types of fields surrounded each nucleated village, the infield and the outfield. The infield surrounded the immediate area of the village and consisted of smaller fields that were laid out in strips and actively cultivated. This field was vigorously farmed and received the bulk of the animal manure used for fertilization. The outfield was a series of outlying plots surrounding the infield and was brought under cultivation only for short periods of time. In addition to farmlands, pasture lands, grasslands, woodlands, and heaths were also considered part of the outfield (Steane 1984). Aside from the distinctive infield-outfield layout, an open field system can be characterized by four main features: crop rotation in two or three fields, ridge and furrow features, use of the mouldboard plough, and farmer cooperation.

One of the defining features of the open-field system was the use of two or three fields for crop rotation in the infield. If three fields were employed for farming, the first field was sown in the fall, the second field was sown in the spring, and the third field lay fallow (Monk 1977). Each one of the fields also corresponded with a specific type of crop. For example wheat may be grown in the first field, beans or some other legume in the second field, and wild grasses in the fallow field. The length of time each field was

used for each crop is unknown. However, each field would go through a rotation of different crops in order to maintain fertility. Thus, not only would the infield as a whole undergo crop rotation, each individual field would rotate through a grain, legume, and fallow cycle. The two field system employed a similar style of crop rotation (Simmons 2001). The fields themselves can still be seen today due to the ridge and furrow features that resulted from generations of ploughing in the same fashion.

Open field systems were typically ploughed in a clockwise manner with the furrows aligned down the steepest natural gradient of the landscape. The farmer would plow one lane then turn at the end and plow the adjacent lane. With time, soil would build up along the ridges and at the ends of each lane. As the generations passed, ridge and furrow features, sometimes called lynchets, were formed due to this ploughing technique (Hall 1981; Steane 1984). This characteristic feature of the Anglo-Saxon landscape would not have been possible without the advent of the mouldboard plough.

The intensification of the land through the use of the open field system was made possible by advances in technology such as the mouldboard plough. Like many things in the Anglo-Saxon period, the exact date of when the mouldboard plough first appeared is unknown. Archaeological evidence points to the 4th century A.D. while some of the earliest literary references are found in the 10th century (Monk 1977; Arnold 1984). The mouldboard plough was a heavy iron plough, sometimes depicted with wheels, pulled by oxen that allowed for more soil to be turned while farming. This new plough had several advantages over the earlier ard plough including that it could dig deeper, plough faster and required less physical energy from the farmer. In addition, this heavy plough facilitated the farming of unutilized heavier and harder soils (Lyon 1991). Open fields

would not have been possible however, if not for the cooperation of farming communities.

During the shift from Celtic to open field systems, farmers no longer functioned as solitary units but instead began working the land together. The open field system required that each farmer or tenant be responsible for his field or a portion of a field. The results of each harvest were shared by the community and often used to pay taxes. Because the open field system required cooperation between farmers, early scattered settlements were abandoned and instead small nucleated villages were formed in what has been termed by some as the “village moment”. The “village moment” was that point in English history in which new medieval villages emerged upon the English landscape. Indeed, both archaeological and historical evidence points to a strong relationship between the open-field system and the formation of nucleated villages (Hall 1981; Hooke 1995; Lewis et al 1997). The elusive question that archaeologists and historians have been chasing for years is; what caused the formation of the open-field system?

The invention of the mouldboard plow allowed for the intensification of the land use pratices such as farming to be sure. However, this plow did not cause individual farmers to abandon a tried and true method of agriculture and adopt a new method of shared production. Instead, a wide variety of theories have been put forth as why the open field system and nucleated villages appeared. The traditionalist view holds that the increase in both rural and urban populations necessitated more land to be cultivated so as to produce higher crop yields for the growing population. The open-field system was the response to this problem because more land was farmed communally then individually.

Therefore, when the open-field system emerged in different parts of England may reflect differences in population growth (Unwin 1988).

A revisionist view of this hypothesis states that the high population was necessary for the development of open-fields, because in order for the fields to work, a large labor force was needed to tend and manure the crops (Jones 2004). Brown and Foard hypothesize that the 'Great Replanning', i.e. the development of open fields was the result of increased sub-manorialization and the fragmentation of multiple large estates in the late Saxon period (Jones 2004). Another hypothesis suggests that the reorganization of the landscape was a response by lords to meet royal and ecclesiastical tax demands. The lords organized the fields and nucleated villages in an effort to increase crop yields and maintain stricter control over their tenants (Lewis et al. 1997; Unwin 1988). Larger political factors, such as the arrival of the Danish, the later assertion of English rule in the 10th century, and the harrying of the north by William the Conqueror in 1066-1067, are also seen as possible factors that led to open-field development (Lewis et al 1997). Finally, some have suggested that the development of this field system and village nucleation may not be as closely linked as others have hypothesized. As an alternative, the two events may have arisen separately due to different factors in different situations (Jones 2004). But how can the development of the open field system and village nucleation be tested in the archaeological record? The answer lies with manuring and artifact scatters.

Manuring hypothesis

Richard Jones of Leicester University has hypothesized that different farming strategies such as "infield/outfield cultivation, open-field farming, demesne blocks, and assarts can

all be characterized by the manuring strategies they deployed and identified from the signatures these have left in the ground"(2004:159). Jones goes on to suggest specifically that the creation of the open-field system in the Whittlewood area (which includes the town of Wicken) coincided with the development of a dual manuring strategy that used both livestock folding and inert domestic objects to help improve soil fertility of nearby fields (Jones 2004). Using the data collected during the Whittlewood Project, he tested this hypothesis.

One of the many ways that a farmer could improve soil fertility, aside from using a three-field system, crop rotations, and livestock waste, was to engage in farmstead manuring. Farmstead manuring was the intentional plowing of inert objects into the soil such as broken pot sherds and small pebbles. These objects would improve the soil by breaking up hard clays, increasing soil aeration and water flow, and provide additional nutrients if pot sherds from a local village were used (Jones 2004).

Prior to 850 A.D. some of the farmers in the Whittlewood area had simple Celtic fields that were fertilized in a number of ways including farmstead manuring. The archaeological result was the scattering of a few early pot sherd types in the fields close to the village. It was also during this period that new open fields were created. The creation of new, fertile fields along with crop rotation and the continued use of livestock dung resulted in a decreased need for domestic sources of manure. As a result, there is almost a complete drop in the number of pot sherd types found from this period (850-1100 A.D.) in the local fields of Whittlewood (Jones 2004).

As time progressed, the local population increased resulting in an increased demand for higher field productivity. In response, more and more fields were laid out and

eventually most of the area was under open-field system of cultivation. By 1100 A.D, in order to maintain soil fertility within the expansive open fields, and because the newer fields had subsequently lost much of their original fertility, a new dual manuring system had emerged. This system emphasized "the continual use of livestock folding and a return to the carting of domestic detritus and its spreading on to the land to supplement the restoration of the vital nutrients" (Jones 2004: 169). As a result, thousands of pot sherds specific to that period (1100-1300+A.D.) such as potterspuryware, early medieval sandyware, and medieval shellyware, are scattered in various concentrations around the current and abandoned medieval villages. Thus, Jones argues that the development of the open-field system can be linked with a change in manuring strategy and can be seen archaeologically through the use of scattered artifacts collected during survey work.

Crops grown

Despite the disappearance of Roman markets and their extensive trade networks in England during the 5th century A.D., the Anglo-Saxons and their descendents grew a wide variety of plants for consumption. Plants were grown in almost every context ranging from the large scale open fields to the small vegetable gardens found in towns and monasteries. Part of this diversity can be attributed to the continuity of species from the Roman and earlier periods. Many of the species cultivated from the Neolithic through the Roman periods were incorporated into the Anglo-Saxon repertoire. Because of the extensive archaeological and historical research that has been conducted, it is safe to say that the mainstay of the Anglo-Saxon diet, i.e. the grains, were typically grown in a farm setting. However, not enough information is known about the widespread cultivation of fruits and vegetables to form broad generalizations. Instead, I will take a wide approach

to food productions by including plants that may have been grown in other settings. Some of the most widespread plants encountered in both the archaeological and historical record fall into the broad category of grains.

Grains

The most popular and widespread of the grains harvested by the Anglo-Saxons was wheat. The presence of wheat (*Triticum sp*) can be traced back to the earliest settlements of the Neolithic age in southern England (Steane 1984). The genus is continually harvested throughout the Bronze and Iron ages but becomes dominant during Roman Britain (Fowler 1976). Anglo-Saxons continue this trend by harvesting a variety of wheats including spelt (*Triticum spelta*), bread (*Triticum aestivum*) and club (*Tritucum compactum*) wheats (Green 1981; Jones 1981). There is some debate as to which variety of wheat came to dominate Anglo-Saxon farming. Jones, Green and Arnold argue that by 700 A.D. bread wheat or club wheat was dominant and spelt was merely a contaminant grain (Green 1981; Jones 1981; Arnold 1988). Cleary argues to the contrary that spelt wheat was the dominant grain (Cleary 1995). Regardless of which species of wheat was sewn, this autumn planted crop was a major staple in farms across Anglo-Saxon England (Fowler 1976). Aside from wheat, barley was the second most widely planted crop.

Barley (*Hordeum* sp.) is another agrarian holdover from the earlier occupations of England. The most commonly harvested species of barley was the six row variety (*Hordeum vulgare*) and was used for consumption by both humans and livestock (Green 1981; Jones 1981; Fowler 1976). However, it is argued by some that there is an over representation of barley in the archaeological record (Jones 1981; Green 1981). Loyn even proposes that the lesser value of barley in comparison to grain has led to careless spilling

of barley chaffs and seeds thereby causing over representation (Loyn 1991). Of the remaining two major grains, oats and rye, neither play a dominant role in Anglo-Saxon culture.

Oats (*Avena sp*) and rye (*Secale cereale*) were two types of grains that were seen sporadically in the archaeological and historical record. Examples of oat and rye cultivation were widely scattered and were dependent on soil conditions. However, it was clear that by the time of the Norman Conquest, these two crops were grown as a supplementary source of food for humans or livestock (Green 1981; Jones 1981). The economic non-food crops included hops (*Linum lupulus*), woad (*Isatis tinctoria*), hemp (*Cannibis sativa*), and flax (*Linum ustatissumum*) (Green 1981; Jones 1981; Fowler 1976). Aside from the grains that were produced in the fields, vegetables may have also played a major role in the diet of the Anglo-Saxons.

Fruits and Vegetables

The exact role of vegetables in the Anglo-Saxon diet as well as how they were produced is unknown. Some vegetables were undoubtedly grown in the small backyard gardens of farms and towns. There have also been suggestions that vegetables were predominately produced in the Christian monasteries while others hypothesize that certain types of vegetables, such as legumes, played a key role in crop rotation (Green 1984, 1981).

Legumes, such as lentils (*Lens sp*), peas (*Pisum* sp.) and beans (*Vicia sp*) were probably some of the most important types of vegetables due to their high protein and vitamin content (Green 1981). All of these genera can be found in archaeological sites during the medieval period. Early evidence of the field pea (*Pisum sativum*) can be seen at the Iron Age site of Bishopstone and the Roman site of Owslebury (Jones 1981).

Historical evidence in the form of estate records from the later Saxon period point to the broad bean (*Vicia faba*) and the field pea (*Pisum sativum*) as being incorporated into village life (Green 1981, 1984; Steane 1984). In addition, historical accounts from the gardener Thomas Keynsham, who was in charge of several abbey gardens in Mells, Pilton, Marksbury, and Batcombe, showed gardens containing beans, leeks, onions, garlic and other vegetables (Steane 1984). Aside from legumes, archaeological evidence of beets (*Beta sp*), carrots (*Daucus carota*), and celery have been found in late Saxon sites in Wessex County (Green 1981). Some historical records indicate that turnips, radishes, parsnips, cabbage, and lettuce were grown in medieval gardens (Pollington 2003). Besides vegetables, a variety of fruits left over from the Roman occupation were still grown both wild and domestically.

The archaeological evidence for the active cultivation of fruits during the Anglo-Saxon period was rather scarce. Most of the information pertaining to fruits was found in historical documents. Archaeologically, hazelnuts and plum stones from the Plum family (*Rosaceae*) have been found in different Anglo-Saxon sites (Roach 1985). Other archaeological evidence pointed to the cultivation of sloe, bullace, strawberries, black berries, and raspberries in Wessex County during the Saxon period (Green 1981). Linguistic data from Old English indicated that the terms for mulberries (‘monbeam’), apples, pears (‘pirige’), blackberries (‘blaceberian’) and cherries (‘cirisbeam’) were common enough to be a part of the everyday lexicon (Roach 1985). Finally, there are many historical references to vineyards scattered throughout Anglo-Saxon England. The first of these references is made in Bede’s *A History of the English Church and People* in

731 A.D. These vineyards are often associated with Christian monasteries although others may have thrived in their original villa locations (Roach 1985).

Processing

The processing of grains collected from the harvest was divided into three tasks: drying, threshing, and milling. Sometime during the third and fourth centuries A.D. a new feature appeared on the farms of Romano-British England. This new feature was an additional room where grain was spread out on the floor for some sort of processing. The rooms frequently had an elongated form with a domed clay roof and were widely used throughout the Anglo-Saxon period. Some archaeologists argue that these new rooms were "corn driers" or drying kilns in which grains were hardened in preparation for threshing. Once the grain was hardened, it was easier to separate the grains into its components. However, experimental archaeological studies show that these rooms may also have been malting floors (Arnold 1984; Hagan 1992). It is important to note that both individual grain types such as wheat, barley, oats, rye, and combinations of grains such as meslin (wheat and rye), dredge (barley and oats), bereman corn (wheat and winter barley) and mixtillo (wheat and rye) were all processed separately. Once the grains were dried, they were transferred to another location for threshing.

Threshing was the process designed to break down the grains into small pieces in order to remove the husk, chaff, and other indigestible objects. Threshing was conducted throughout Anglo-Saxon England and was considered by some, such as pious St. Eistorwine who himself "threshed corn and winnowed it", to be a humble occupation (Hagan 1992). The process improved in efficiency once tribelum flints were added to the bottom of the wooden sledge and that dragged across the grains on the threshing floor.

Once threshed, the grains were subsequently passed through a series of sieves to remove impurities (Arnold 1984). After the grains were dried, threshed, and sieved, they were almost always sent to be milled. Milling in Anglo-Saxon England occurred at a variety of levels. Some milling was conducted by hand through the use of grinding stones, saddle and hand querns, mortar and pestles, or rotary handmills. By the seventh century A.D. larger human, water, or animal powered mills began to appear in the Anglo-Saxon landscape (Pollington 2003). These large mills took one of three forms: the horizontal, undershot, or overshot designs (Steane 1984). Once the grains were ground into flour they were often stored in large vessels finally ready to be cooked (Hagan 1992).

Cooking

Cooking in Anglo-Saxon England was centered on two main features, the oven and the hearth. The oven was an enclosed structure that could be as simple as an inverted pot covered with embers or a large communal oven that was part of a bake house. The oven was used for a variety of purposes but was most often associated with the baking of breads (Hagan 1992). The hearth was often a stone-lined fire pit that was located, depending on the design, in the center of a great hall. Some hearths were also located outside and were used when the weather was favorable. These pits were used for almost any cooking process that required heating. It was because of its utilitarian abilities that the hearth became the center of domestic life in the Anglo-Saxon household (Pollington 2003).

With these two cooking features available, Anglo-Saxons could cook foods in a wide variety of methods. Despite the numerous cooking possibilities provided by the oven and the hearth, the majority of Anglo-Saxon cuisine was based on boiling.

Historical and archaeological evidence showed that Anglo-Saxons were familiar with other styles of cooking such as roasting, frying, grilling, and baking in an oven. However, boiling was a technique that maximized nutritional return and provided a meal to many people at one sitting. The resulting gruel, stew, or broth was one of the most nutritious and efficient meals Anglo-Saxons produced. It is interesting to note that in many cultures, the boiling of foods is commonly associated with subsistence economies. As with Anglo-Saxon England, other cultures discovered that boiling was an efficient way to cook any type of food with extremely little effort allowing for cooks to conduct multiple chores at the same time. The Anglo-Saxon propensity to boil almost everything may be a reflection of their economic viability (Hagan 1992; Pollington 2003). This tendency to boil foods can be seen in some of the artifacts recovered from different sites.

Three types of cooking vessels were associated with the boiling of foods: cauldrons, earthenware pots, and soapstone bowls. Cauldrons were the largest of the cooking vessels and were often used for mass caterings. These metal pots were of particular importance because in addition to serving large quantities, they could also facilitate the boiling of large objects such as a boars head or leg of lamb. The most widely distributed cooking vessel was the earthenware pot. These pots were suited for cooking at low temperatures and for boiling smaller quantities of food. Finally, soapstone bowls were used because of their durability and heat distributive qualities (Hagan 1992)

Consumption

Determining the diet of past populations with little or no historical record is a daunting and challenging task. Archaeologically, it is almost impossible to tell with one hundred percent accuracy what cultures in the past have consumed without the use of coprolite

data. Even with coprolite data, the information gathered may represent consumption for medical rather than nutritional actions. With that being said, I am going to attempt to reconstruct the possible diet of the Anglo-Saxon peasant.

Historical records from the mid to late Anglo-Saxon period illustrate the extent of foods found by the wealthier portion of society. The rent records from one estate showed that they owed “ten vats of honey, three hundred loaves, twelve ambers of Welsh ale, thirty of cider ale, two full grown cots or ten wether, ten geese, twenty hens, ten cheese, an amber full of butter, five salmon, one hundred eels, and a quantity of fodder” (Sawyer 1978: 172). The meager diet of the peasant population would include some aspects of this list but not nearly to the same extent.

Although the possible combinations of food included in Anglo-Saxon diet were fairly extensive, the typical peasant meal was a combination of three key ingredients: meat; broth, gruel or stew; and bread. Broth, gruel, or stew, as discussed earlier, formed one of the core components of their cuisine and much of their diet revolved around this item. It was easy to make and could include almost anything that was available. According to one Anglo-Saxon reference, Athelstean’s ordinance, a destitute Englishman who lived on a royal estate was “to receive one amber of meal and shank of bacon or a wether worth four pence every month” (Hagan 1992: 71). In this situation, the combination of meat and stew were represented by the consumption of meal, which was a type of grain based gruel, and bacon or wether. Other combinations included bread and stew as well as bread and meat. Of course there was always the possibility that both bread and meat were dumped into the cauldron to form a part of the stew (Hagan 1992).

There were two styles of bread that were dominant in Anglo-Saxon cuisine, leavened and unleavened bread. Anglo-Saxons acquired the necessary yeast from a variety of sources and were therefore able to make both types of bread. Historical documents such as colorful illustrations, point to round loafs of large and small sizes (Hagan 1992; Pollington 2003). The Saxon population took pride in their 'hwaeten hlaf' or wheaten loaf because it was made with thoroughly sifted flour (Loyn 1991: 157). The grains used for the flour were mostly taken from wheat plants although oat, barley, and rye may have been used as well.

Grains, especially wheat, played a very important role in Anglo-Saxon cuisine because they formed the basis of both the bread and broth that was cooked. Wheat dominated the Anglo-Saxon cuisine not because it held social prestige, but because it was the most successful and easily grown crop of the four main grains. The flour produced from the grains wheat, barley, oats, and rye provided the body of substance for the stew. If the stew was made of only water and flour, it was then referred to as some form of porridge or gruel (Hagan 1992). Aside from the production of bread and stew, grains were also used in the creation of alcoholic beverages.

Depending on their social status, Anglo-Saxons may have had access to a wide range of alcoholic beverages to include in their diet. Monasteries frequently sold different types of wine produced from local vineyards. At the beginning of the ninth century A.D. historical evidence indicates that apples were used to ferment strong cider. The common peasant probably had easier access to ales from fermented wheat or barley grains (Fowler 1976; Roach 1985). Barley was important enough that Loyn argues "…that barley gave its name to the important institution of the berewick, the bere-wic, barley-wick, or

outlying farm, indicates the importance of the barley-crop both for food and for drink" (1991: 156).

As mentioned earlier, there is evidence for a wide variety of fruits and vegetables that may have been cultivated in Anglo-Saxon England. Most of these plants, such as cabbage and lettuce, would have been added to the stew pot. There is some evidence to suggest that the white pea was used to make a thick pottage while the green pea was used for green pottage. Some vegetables of the *Allium* family, such as the leek, onion, or garlic, were used to add flavor to meals. Another way to add flavor to a boring dish was through the use of coriander (*Cordiandum sativum*) and fennel (*Foeniculum vulgare*) (Green 1981; Hagan 1992; Steane 1984).

General Background

Archaeology and History of Wicken

The modern parish of Wicken in Northamptonshire was originally comprised of two smaller medieval parishes, Wyke Dyve and Wyke Hamon, which date back to 850 and 1086 A.D. respectively. Wyke Dyve was a carefully planned village comprised of common peasant tofts and crofts and truly began to expand sometime around 1100. By 1250, the village had reached its greatest extent but was in severe decline by the 1400s. The manor at Wyke dyve was supported by a small hamlet in nearby Dagnall which lasted well into the end of the medieval period (Jones 2004).

Unlike Wyke Dvye, Wyke Hamon was not founded during the Anglo-Saxon period and instead emerged sometime after the Norman invasion most likely between 1066 and 1086. This conclusion is supported by a complete lack of preconquest pottery at the village yet at the same time it was recorded in the Doomsday Book in 1086. Wyke

Hamon was initially smaller than its neighbor but would flourish between 1250 and 1450 and is considered by Jones to be “a fine example of a landscape of lordship, every element conceived and executed to display the power and wealth of its patron” (2004: 15). In addition, the village also had a second settlement center called Elm Green associated with the local manor. Elm Green was a fairly large settlement that would exist until about 1400.

The archaeology at Wicken is associated with the Whittlewood project which was designed to “explain the origin and survival of contrasting nucleated villages and of dispersed settlements” (The Whittlewood Projec website: 2005). The project selected 11 parishes in and around Whittlewood, England, where they conducted a series of surveys and excavations in an attempt to understand landscape use from the Roman to medieval periods. Between 2000 and 2004, Dr. Jones and others systematically surveyed local farmers fields and excavated shovel test pits and regular excavation units in Wicken and other counties. A total of over 16,000 pottery sherds were recovered while fieldwalking throughout the Whittlewood area and 58 test pits were excavated around the parish of Wicken including the hamlets of Elm Green and Dagnall (Jones 2004). In 2003, open area excavations were conducted at Glebe Cottage, Leckhampstead Road and is the source of the excavated artifacts analyzed in this study (Jones 2004). The excavations at this cottage revealed a well-made dovecote, floors, hearths, and robbed out walls typically found in brewhouses and bakehouses associated with seigniorial residences. The pottery and historical evidence indicates the site was occupied around the mid 13th century (Jones 2004).

Archaeology and History of Wyton

The modern village of Wyton and its close neighbor, Houghton were originally in the county of Huntingdonshire but were absorbed into Cambridgeshire in 1974. Unfortunately, sources for the history of Wyton and Houghton were hard to find or inaccessible for this project.

The artifacts used in this research project were collected in conjunction with the Higher Education Field Academy (HEFA) Currently Occupied Rural Settlement (CORS) project run by Dr. Carenza Lewis of Cambridge University during the fall of 2005. The Higher Education Field Academy is a project run by the Department of Archaeology at Cambridge University that is designed to get local students and historical societies actively involved in archaeological and historical investigations. HEFA is part of a larger national program interested in understanding the development of post-Roman Britain. In Wyton, Dr. Lewis and others excavated a series of one meter test pits looking for evidence of Roman, Anglo-Saxon, or later medieval occupations. At one of the sites, Durley cottage, artifacts were not only recovered in the two test pits in the backyard, but also from underneath the kitchen floorboards inside the house (Lewis, Carenza, personal communication; January 4, 2007, Houghton and Wyton Local History Society website; 2007). These artifacts constitute the bulk of my sample from Wyton and are important because they represent a set of artifacts that were sealed from potential environmental contamination. Unfortunately, the occupation history of Durley Cottage could not be obtained for this project. Knowing the history of the structure as well as how long the artifacts were sealed under the floorboars of the house would provide additional information that would present a clearer interpretation of the results.

CHAPTER 3: METHODS

Introduction

In this chapter, the methods used to collect, process, and analyze the archaeological soil and artifact samples and the comparative plant material will be discussed.

Collection of Samples

Artifacts and soils samples for this project were collected from several locations in Northamptonshire, Buckinghamshire, and Cambridgeshire England during the winter of 2006 (Figure 3.1). In Northamptonshire, with the help of Dr. Richard Jones of the University of Cardiff, basic survey work was undertaken in Wicken field #13 and nearby fields (Figures 3.2). Using sterile gloves and a clean trowel, medieval artifacts and associated soil samples were collected and placed in ziplock bags sealed with duct tape along with proper provinience information such as GIS coordinates. In order to test for the level of environmental contamination on the artifacts, soil samples were collected as close to the original artifact location as possible. With the trowel properly sterilized, soil samples were also collected from the medieval horizon of the north, south, east, and west

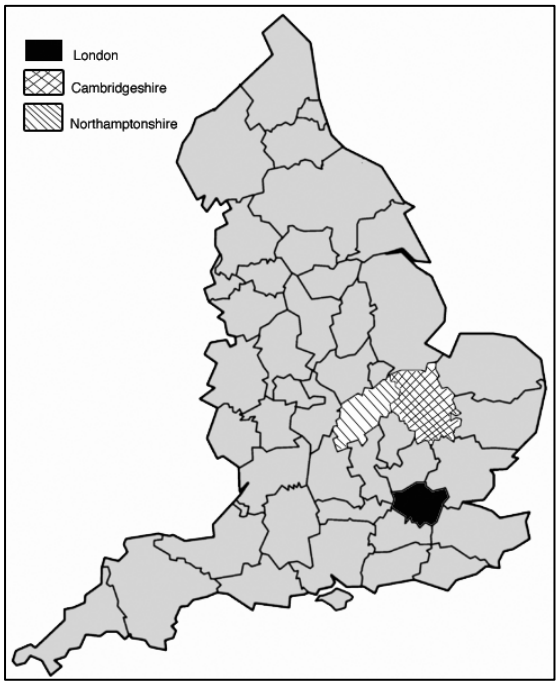


Figure 3.1 Counties of England (adapted from Wikipedia.com)

profiles and along the floor surface of an excavated unit from Glebe Cottage in the medieval village of Wicken. Further artifact samples from previous survey work and excavations at Wicken were collected from the Buckinghamshire county museum and placed in sealed bags for transport back to the United States.

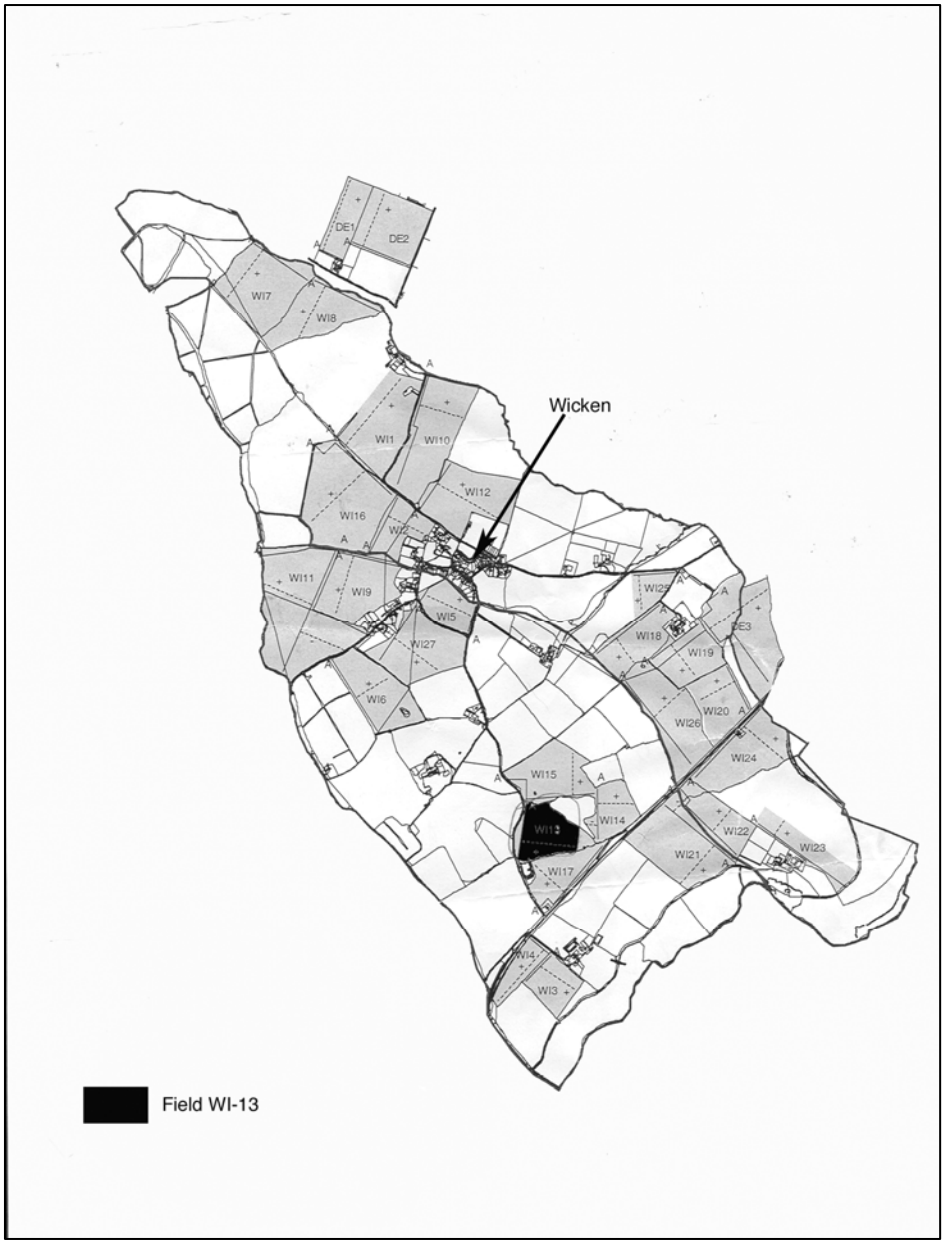


Figure 3.2 Field WI-13 and the village of Wicken in Northamptonshire (adapted from Whittlewood Project)

The control set of artifacts was originally discovered under the floorboards of Durley Cottage in Wyton, Cambridgeshire as part of the Higher Education Field Academy Currently Occupied Rural Settlement (CORS) project. These artifacts were collected at Cambridge University and placed in sealed bags for transport back to the United States.

Ceramic Types Collected

For this project, a total of eight artifacts were sampled belonging to three major ceramic types which include the following: early medieval sandyware, medieval shellyware, and potterspuryware. Three medieval sandyware sherds, three medieval shellyware sherds, and two potterspury ware sherds were collected from the field and museum settings. Ceramic identification for both the Wicken and Durley Cottage artifacts was completed by Paul Blinkhorm and classified via the Milton-Keynes and Northamptonshire pottery type series (Blinkhorn 2006).

Early medieval sandyware was produced between AD 1100 and 1400 in a wide variety of areas throughout southern England and is characterized by a hard fabric with quartz inclusions. Medieval shellyware was produced during the same period, but its production was limited to Northamptonshire and Bedfordshire. In order to give the fabric some added strength, the potters added small pieces of shell to the temper giving it a somewhat speckled appearance. Both early medieval sandyware and medieval shellyware were predominately used as cooking pots although bowl and jug forms also exist in small quantities (Blinkhorn 2006).

Potterspury ware was manufactured between AD 1250 and 1600 in Potterspury, Northamptonshire and is characterized by a pink, buff, or red paste with a slight sandy

texture and spots of green glaze. This type has a wide variety of forms associated with house or kitchen use but is most commonly found in jar, bowl, or jug forms (Blinkhorn 2006).

Processing of Archaeological Samples

For this project, phytoliths and starch grains were extracted from the excavated and surface soils as well as artifact residues. All of the samples were processed by the author at the paleoethnobotany laboratory at the Museum Support Center in Columbia, Missouri.

Soil Samples

Phytoliths were extracted from the soil matrix using the University of Missouri soil processing procedure (Pearsall 2000). Soil processing involves five major stages, initial preparation, the removal of carbonates and certain oxides, organic matter removal, dispersion, and heavy liquid flotation. During the initial preparation stage, the sample is dried, ground with a mortar and pestle, sieved to remove large particles, and immersed in water to test the pH. In the second stage, the samples are placed in a hot water bath and subjected to hydrochloric and mixed strong acid solutions in order to dissolve the carbonates and oxides. A strong hydrogen peroxide solution is used to remove the organic matter during the third step while Na_2H_2EDTA deflocculates the soil in the fourth major step. Finally, Zinc Iodide (ZnI_2) is used to float out the phytoliths from the soil matrix in the last stage (Pearsall 2000). The phytolith extracts were dried in test tubes and stored until they were mounted on a slide for analysis.

Starch grains were extracted from the soil matrix using an adapted procedure originally developed by Zarillo (2005) and Perry et al (2006) but later modified by

Duncan (2006). Starch extraction involves three major steps: disperson and pretreatment, oxidation, and flotation. The soils are initially sieved and dispersed through the use of a fine mesh screen and NaEDTA over several hours. After dispersion, the sample undergoes a brief oxidation through the use of dilute hydrogen peroxide and allowed to dry. Finally, cesium chloride is used to float the starch grains from the soil matrix.

In all, eight soil samples were processed for analysis. Five of the samples were from the excavated Glebe Cottage site in Wicken, from the north, south, east, and west profiles along with the floor while three were from field WI 13. The three samples from WI13 were associated with ceramics found while fieldwalking which included Potterspury ware, early medieval sandyware, and medieval shellyware.

Artifact samples

Artifact residues were processed via the standard MU "piggyback" method (K. Chandler-Ezell and Pearsall 2003; Pearsall et al. 2004). The piggyback method is designed to remove both phytolith and starch grains during the same processing period. If an artifact is unwashed, it will be comprised of three different sediment samples. In a sediment 1 sample, the artifact is placed in a sealable bag where it is brushed with a dry toothbrush and then removed. Distilled water is added and the brushed off soil is set aside for processing. The dry brushing removes any large clumps of soil and gives the artifact a very superficial cleaning only removing microfossils located on its outermost surface

A sediment 2 sample is obtained by scrubbing the artifact with a wet toothbrush inside a new bag. The distilled water acts as both a lubricant and solvent and, along with

the scrubbing action, helps to remove phytoliths and starch grains from the surface, cracks, and pores.

Finally, the artifact is placed into a water filled bag in a sonicator for five minutes where sound waves loosen any remaining residues in the deeper pores and crevices. This constitutes the sediment 3 sample. If an artifact has already been washed or roughly cleaned, as was the case with the six artifacts borrowed from the Buckinghamshire museum and the three artifacts from Durley Cottage, only sediments 2 and 3 can be sampled.

In the "piggyback" method, because normal phytolith processing employs strong chemicals and high heat, the fragile starch grains are removed first. Once a starch grain sample is taken, either by removing an "unprocessed" sample or by floating it out using cesium chloride (CsCl), the phytoliths are extracted in the same way used in soil processing except with smaller volumes of chemicals (Chandler-Ezell and Pearsall 2003; Pearsall et al. 2004).

Slide mounting and scanning

All phytolith and starch grain analysis was conducted by using a Nikon labophot compound microscope at 400X or a Zeiss compound microscope at 313-500X magnification. Pictures were taken using a Nikon Coolpics 995 digital camera, Alchemy TV program and Adobe Photoshop program. The phytoliths and starch grains were mounted on slides separately.

All archaeological phytolith samples were mounted using a standardized amount (.001g) in Canada Balsam. Initially, on each phytolith soil slide a quick scan was conducted so as to get a general idea of the types that will be encountered. Based on the

comparative types found in the author's collection along with establish comparative types established by Rosen (1987, 1992), Rosen and Weiner (1994), Ball et al. (1993, 1996, 1999), Portillo et al. (2006), Kaplan et al. (1992), and Cummings (1992), a phytolith quick scan sheet was created. This quick scan sheet specifically was comprised of the cereal grain types established by Kaplan et al (1992); a column for papillae; a column for wavy long cells; columns for general environmental indicators such as chloridoid simple short cells, lobed complex short cells, rondel/square complex short cells, saddle complex short cells, diatoms; and columns for diagnostic types from this comparative collection such as the scrutiform lacunos prickle, tabular lacunose prickle, large armed hair cell, short armed hair cell, ovate dense irregular epidermal cells, parallelepipedal irregular vascular tissue, acute silicifed hair cell, spinulose spheres, and blunted hair cell. Each row was then scanned until 200 short cells or diagnostic phytoliths were found or until redundancy was reached. Once 200 phytoliths or redundancy was reached, the rest of the slide was scanned quickly for any unusual or unique types. In addition, 30 long cell fragments were counted separately and preliminarily classified to the wheat, barley, oats, rye, or wild grass categories.

For each of the artifact samples every other row, typically about 8-10 rows, was scanned and the number and type of phytoliths counted. Starch slides were mounted using a 50:50 ratio of glycerol and extract water and scanned using polarized light. Because of the meagerness of the starch soil and artifact residues, every row was scanned and each individual starch grain was counted, described, and photographed. However, because starch grains are heat sensitive, each slide could only be scanned for about a 30 minutes at a time.

Processing of Comparative Plant Samples

A total of 57 plant species from 24 different families was studied for this project. Based on historical documentation and the archaeological record, 36 species of food plants were chosen for this study (Table 3.1). The list ranges from commonly found species such as wheat, *Triticum sp*, to rarer species such as date palms, *Phoenix dactylifera*. In addition, in order to make sure that there were no confuser phytolith or starch grain types that could be mistaken for a food type, 21 historically known wild weed species were studied (Table 3.2). These weeds were included in this study because they were commonly listed in the historical record as "problem weeds" that were often found in medieval fields (Simmons 2001).

Table 3.1 Comparative Food Species

Family	**Scientific name**	**Common name**
Apiaceae	*Anethum graveolens*	Dill
Apiaceae	*Apium graveolens*	Celery
Apiaceae	*Coriandrum satirum*	Coriander
Apiaceae	*Daucus carota*	Cultivated Carrot
Apiaceae	*Foeniculuum vulgare*	Fennel
Apiaceae	*Pimpinella anisum*	Anise
Arecaceae	*Phoenix dactylifera*	Date palm
Brassicaceae	*Brassica oleracea*	Cabbage
Brassicaceae	*Brassica* sp.	Mustard
Chenopodiaceae	*Betas vulgaris*	Beets
Cucurbitaceae	*Cumuis sativus*	Cucumber
Fabaceae	*Cicer arietinum*	Chickpeas
Fabaceae	*Lens culinaris*	Lentils
Fabaceae	*Pisum sativum*	Peas (green, field, or garden)
Fabaceae	*Vicia ervilia*	Biter vetch
Fabaceae	*Vicia faba*	Faba (broad) beans
Liliaceae	*Allium cep*	Onion
Liliaceae	*Allium porrum*	Leek
Liliaceae	*Allium sativum*	Garlic

Table 3.1 Comparative Food Species continued		
Family	**Scientific name**	**Common name**
Moraceae	*Ficus carica*	Fig
Oleaceae	*Olea europea*	Olive
Papaveraceae	*Papaver somniforum*	Opium poppy
Pinaceae	*Pinus pinea*	Pine nut (Stone pine)
Poaceae	*Avena sativa*	Oats
Poaceae	*Hordeum vulgare*	2 Row malted Barley
Poaceae	*Hordeum vulgare*	6 Row malted Barley
Poaceae	*Hordeum vulgare*	Barley
Poaceae	*Secale cereale*	Rye
Poaceae	*Triticum* sp.	Whole Wheat
Poaceae	*Triticum spelta*	Spelt Wheat
Rosaceae	*Fragaria* sp.	Strawberries
Rosaceae	*Malus pumila*	Apple
Rosaceae	*Prunus avium*	Sweet Cherry
Rosaceae	*Prunus domestica*	European plum
Rosaceae	*Pyrus communis*	Pear
Vitaceae	*Vitis vinifera*	Grape

Table 3.2 Comparative wild species		
Family	**Scientific name**	**Common name**
Asteraceae	*Anthemis cotula*	Stinking mayweed
Asteraceae	*Sonchus arvensis*	Field Milk Thistle
Brassicaceae	*Sinapis arvensis*	Charlock
Campanulaceae	*Campanula rotundifolia*	Blue bell grass
Caryophyllaceae	*Agrostemma githago*	Corncockle
Caryophyllaceae	*Arenaria serpyllifolia*	Thyme-leaved sandwort
Caryophyllaceae	*Silene inflate*	Bladder Campion
Chenopodiaceae	*Chenopodium album*	Fathen
Dipsacaceae	*Knautia arvensis*	Cornflower
Euphorbiaceae	*Euphorbia helioscopia*	Sunspurge
Fabaceae	*Vicia hirsuta*	Hairy vetch
Lamiaceae	*Lamium purpureum*	Red Dend-nettle
Lamiaceae	*Stachys bullata*	California Hedgenettle
Orchidaceae	*Orchis latifolia L.*	Marsh Orchid
Poaceae	*Agropyron inerme*	Beardless wheat grass

Table 3.2 Comparative wild species continued		
Family	**Scientific name**	**Common name**
Poaceae	*Alopecurus carolinianus*	Carolina foxtail
Poaceae	*Alopecurus pratensis*	Meadow Foxtail
Polygonaceae	*Polygonum convolvulus*	Black Binwood
Primulaceae	*Primula veris*	Cowslip
Rosaceae	*Filipendula ulmaria(occidentalis)*	Meadow Sweet
Rubiaceae	*Galium aparine*	Goose grass

Food plants, such as lentils (*Lens culinaris*) and plums (*Prunus domestica*) were purchased at local grocery stores and local health food markets. Weedy plants such as stinking mayweed (*Anthemis cotula*) and blue bell grass (*Campanula rotundifolia)* were sampled from the University of Missouri herbarium. When possible, leaf, stem, and inflorescence components were collected for each species or genus.

For phytolith processing, each plant part was washed with detergent and sonicated to remove possible contaminants. The samples were then dry ashed according to established MU protocol (Pearsall 2000). A 0.001g sample of the extract was added to immersion oil, covered with a cover slip, and sealed with nail colored polish on a clean slide for each specimen. Overall, 94 phytolith comparative samples were scanned (See appendix I for details).

Starch grain comparative processing does not require any ashing and is as follows:

1. Make two labels, one for left over materials and one for the slide
2. Clean all instruments by heating with butane torch
3. Label slide: SC ####

   Family

Species

Tissue

Herbarium/Specimen #

4. Take sample and put into plastic bag, put plastic bag between paper towels, pound sample in plastic bag with heavy object. May also need to cut up specimens with knife/razor blade.
5. Place some of ground sample into labeled small vial
6. On slide, using nail polish paint two thin lines on slide larger than a cover slip
7. Place 2 drops of a 1:1 glycerol/water mix between the two lines.
8. Add small amount of sample to glycerol and stir toothpick.
9. Add cover slip and seal with nail polish.
10. Let slides dry flat, checking over next several days. Repair "bubbles or leaks" with nail polish.

(MU paleoethnobotany laboratory document 2006)

For each phytolith comparative sample, the leaf, stem, and inflorescence were examined where available. Comparative phytolith slides were scanned using a Nikon Labophot and a Zeiss compound microscope at 313-500X magnification. Every row of each slide was scanned and possible diagnostic phytoliths were recorded and photographed using the same techniques as discussed with the archaeological phytolith soil extracts. The comparative phytoliths were then compared with known types and assemblages created by experts such as Rosen (1987, 1992, 1994), Ball et al. (1993, 1996, 1999), Portillo et al. (2006), Kaplan et al. (1992), and Cummings (1992).

For each of the starch grain comparatives, the part of the plant most likely to produce large quantities of starch, such as the root or tuber, was examined. The slides were also scanned, recorded, and photographed using a Nikon Labophot compound microscope and Zeiss compound microscope. Starch grains were noted for their abundance as well as the extinction cross characteristics, granule shape and size, hilum, fissures, double wall, surface texture, and lamellae. When available, these results were compared to published types such as those found in *The Differentiation and Specificity of Starches in Relation to Genera*, *Species*, *Etc* by E.T. Reichert. A total of 47 starch grain samples were studied (Appendix I).

CHAPTER 4: COMPARATIVE COLLECTION RESULTS

Introduction

Of the 57 plant species from 24 plant families, 96 phytolith comparative and 47 starch grain comparative samples were studied. Each plant species was given a "diagnostic", "limited", or "not diagnostic or doesn't produce" designation in terms of phytolith and starch grain diagnostic capabilities. A diagnostic phytolith or starch grain must have a unique morphology that can be matched with a particular plant taxa either at a one-to-one level or by measuring multiple morphological variables (Pearsall 2000). In phytoliths for example, epidermal wavy long cells can be diagnostic because of the combination of their unique wave pattern and the height of the wave itself. In order for a starch grain to be considered diagnostic, it must show a unique combination of morphological features such as variations in type of extinction cross, hilum, shape, size, angularity, lamellae, fissures, surface texture, protuberances, and the outer wall. In addition, the microfossil, either starch grain or phytolith, must be found repeatedly throughout the plant specimen.

Phytoliths and starch grains that are considered to have limited diagnostic value are those that may be produced in extremely small quantities or may have a very generic morphology. Silicified vascular tissue found only in roots and fruits, such as those described by Chandler-Ezell et al (2003), could be considered to have a limited value because even though the phytolith may not correspond with a specific species, it is indicative of activities involving root or fruit products. If a plant specimen only has one or two small starch grains of redundant morphology in the sample, this plant would be

considered of limited diagnostic value. Finally, plants that either do not produce phytoliths or starch grains or produce types that are commonly found throughout the plant kingdom fall into the “not diagnostic or doesn’t produce” category.

Interestingly, some of the species with well documented phytoliths, such as the Arecaceae family have very little available starch grain data. Conversely, some plant species do not have large starch storage organs such as roots and tubers and as a result they were not examined for diagnostic starch grains. Therefore, both starch grain and phytolith comparative samples may not have been created for every single plant species (See appendix tables I and II).

Phytoliths

Overall, the majority of the food plants examined for phytoliths either produced phytoliths of little diagnostic value or did not produce phytoliths at all. In total, twenty-two food plants and seven weedy plants fell into this category. Seven food and seven weedy plants had limited diagnostic value in that they produced phytoliths found in the vascular, rooty, or fruity tissues which may only be useful in specific contexts. Finally, eight species of food plants, seven Poaceae and one Arecaceae species, and seven weedy species produced diagnostic phytoliths.

Diagnostic

Table 4.1 Diagnostic phytolith species		
Food species		
Family	**Species**	**Common name**
Arecaceae	*Phoenix dactylifera*	Date palm
Poaceae	*Avena sativa*	Oats
Poaceae	*Hordeum distichon*	2 Row malted Barley
Poaceae	*Hordeum vulgare*	6 Row malted Barley
Poaceae	*Secale cereale*	Rye
Poaceae	*Triticum* sp.	Whole Wheat
Poaceae	*Triticum spelta*	Spelt Wheat
Weedy species		
Family	**Species**	**Common name**
Asteraceae	*Anthemis cotula*	Stinking mayweed
Caryophyllaceae	*Silene inflate*	Bladder Campion
Euphorbiaceae	*Euphorbia helioscopia*	Sunspurge
Poaceae	*Agropyron inerme*	Beardless wheat grass
Poaceae	*Alopecurus carolinianus*	Carolina foxtail
Poaceae	*Alopecurus pratensis*	Meadow Foxtail
Rubiaceae	*Galium aparine*	Goose grass

Food Plants Producing Diagnostic Phytoliths. Arecaceae-Phoenix dactylifera- Date palm. The Arecaceae family is regarded by some phytolith analysts to be one of the few plant families to produce diagnostic universals (Pearsall 2000). In general, the subfamilies in this family can be divided into two separate groups, those that produce spheres, i.e. Arecoid, Borassoid, Cocoid, Lepidocayoid, Phytelaphantoid, and Sabaloid, and those that produce hat-shaped bodies such as Bactoid, Chamedoroid, Iratoid, and Nypoid (Pearsall 2000). As a member of the Arecoid subfamily, *Phoenix dactlifera* produces spiny spheres that can be found in rows and range in size from less than 10 microns to about 25 microns in size. These spherical bodies are found throughout the

plant ranging from the body of the tree to the fruit to the leaves (Cummings 1992; Rosen 1992).

Unfortunately for this study problems were encountered when ashing this sample for the comparative collection. No diagnostic spheres were encountered in this study. However, this is not to say that the diagnostic phytoliths are not produced as found by Cummings (1992). The spinulose spheres encountered in her study ranging from 10 to about 25 microns in size. No other diagnostic types were found.

Food Plants Producing Diagnostic Phytoliths- Poaceae. The Poaceae family of foods provided the most number of diagnostic species out of any family included this study. Wheat (*Triticum spp*), Barley (*Hordeum spp.*) and to a lesser extent Oat (*Avena spp*) phytoliths have been studied extensively by Rosen (1987, 1992, 1994), Ball et al. (1993, 1996, 1999), Portillo et al. (2006), Kaplan et al. (1992), Tubb et al. (1993), and Cummings (1992). Aside from the Kaplan et. al. (1992) study, domesticated Rye (*Secale cereale*) remains one of the last major grains left to be analyzed thoroughly for its phytolith content.

Food Plants Producing Diagnostic Phytoliths-Poaceae-Avena sativa-Oats. Aside from Kaplan et al. (1992) and Rosen (1992), the analysis of oat phytoliths has received very little attention until recently. Portillo et al. (2006) uses morphometric analysis to distinguish between two species of oats, *Avena sativa* L. and *Avena strigosa* Schreb. Their results show that the phytolith types differ in size enough that, when taken as a whole, they can be used to distinguish between the two species (Portillo et al. 2006). These phytolith types include, but are not limited to rondels, dendritic long cells, papillae, trichome bases, prickles, hair cells, stomata, elongate long cell echinate subepidermal, and finally elongate epidermal long cells (Portillo et. al. 2006). In 1992, Kaplan et. al. suggests that circular-base large prickle phytoliths and papillate-tipped small prickle phytoliths can be used to distinguish oats (*Avena sativa*) from other cereal grains (Kaplan 1992). Finally, although Rosen (1992) doesn't examine domesticated oats, she does examine wild oat grass (*Avena* sp) for diagnostic phytoliths. The diagnostic phytoliths for oat grass include wavy long cells that have waves that are "rod-like and straight, with thick rounded knobs at the crests", a wave height of 8.5 microns with thin waves, a wave

height of 16 microns with thick waves, papillae ranging from 15-50 microns in diameter and between 18 and 20 marginal pits present (Rosen 1992:136).

The majority of *Avena sativa* L. phytoliths found in this study were rondel short cells, epidermal wavy long cells, and papillae. Of those three types, only the wavy long cells and the papillae proved to be diagnostic. The shape of the waves was very similar to those found with the oat grass but were thick and ranged in height from 5-15 microns (Z1248).The papillae had an average diameter of 25-27.5 micrometers and anywhere between 10-14 marginal pits. The important feature to note about the wavy long cell is that the wave is well rounded with some projections sticking out from the wave wall (Figure 4.1).

Overall, the results from this study mirrored those findings from the published works of Portillo et al. (2006), Rosen (1992), and Kaplan et al (1992). In this study there was no significant variation from the types discussed in previous publications. The only major difference between this study and previous works was the documentation of the wave cell height and shape as well as papillae size and marginal pit number in this study. Because this project used a diagnostic approach as opposed to an assemblage approach for plant identification, the papillae, wavy long cells, circular-base large prickle phytoliths and

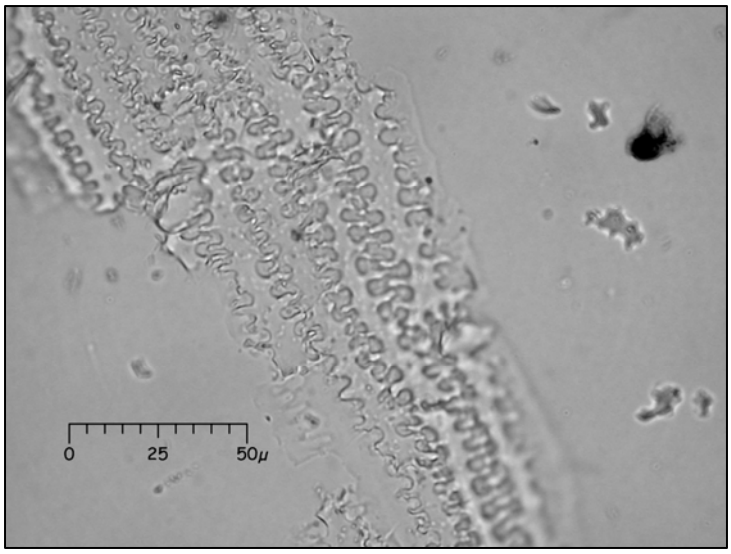


Figure 4.1 Diagnostic phytoliths; *Avena sativa* wavy long cells (Z1248)

papillate-tipped small prickle phytoliths were counted when scanning the artifact and soil samples.

Food Plants Producing Diagnostic Phytoliths-Poaceae-Hordeum spp- Barley. Barley is the second most commonly used grain during the old world Neolithic period in Europe. It comes in two varieties, two-row (*Hordeum distichum*) and six-row (*Hordeum vulgare*) with the former representing the more ancient species. Rosen (1992) established several diagnostic types based on her analysis of wavy long cells and papillae. The wavy long cells, both thick and thin, and broken trichome bases, also known as papillae, are characteristic of the genus. The thin cell walls are "serrated and end in sharp or knobbed points" while the thick cell walls "are often squarish and usually occur in waves of even amplitude" (Rosen 1992: 136). However, the shape of the wave is diagnostic of the genus and cannot be used to distinguish between the two species. Two rowed barley has wave height of 7 microns with thin waves and 10 microns with the thick waves. The trichome bases average in size from 18-25 microns with 10- 12 marginal pits present. Six rowed barley has exactly the same wave height and trichome base size but only has 7-9 pits (Rosen 1992).

Kaplan et al. discovered two important features of barley phytoliths during their study. The first feature was that the papillate tip (termed IIa2) phytolith that is widespread throughout the domesticated grasses, is noticeably absent from the 6-rowed barley. The absence of this type may prove to be useful in a study when paired with other microfossil data. Secondly, the trichome base that has an annular margin along at least two quadrants is only found in 6-row barley (Kaplan et al. 1992). Finally, Tubb et. al (1993) used pit number and papellae diameter to distinguish between the genera *Hordeum* (barley), *Aegilops* (goat grass), and *Triticum* (wheat) (Tubb et al 1993).

In this study, both two-row and six-row barley were examined for phytoliths. Aside from the occasional nondiagnostic hair cells and festucoid short cells, no new diagnostic types were discovered. All of the types examined in this study matched those already mentioned by Rosen (1992), Kaplan et al (1992), and Tubb et al (1993) in terms of both size and shape. The comparative types in this collection can be seen in Figure 4.2. The diagnostic barley types that were counted included the wavy long cells, trichome bases, and papillae.

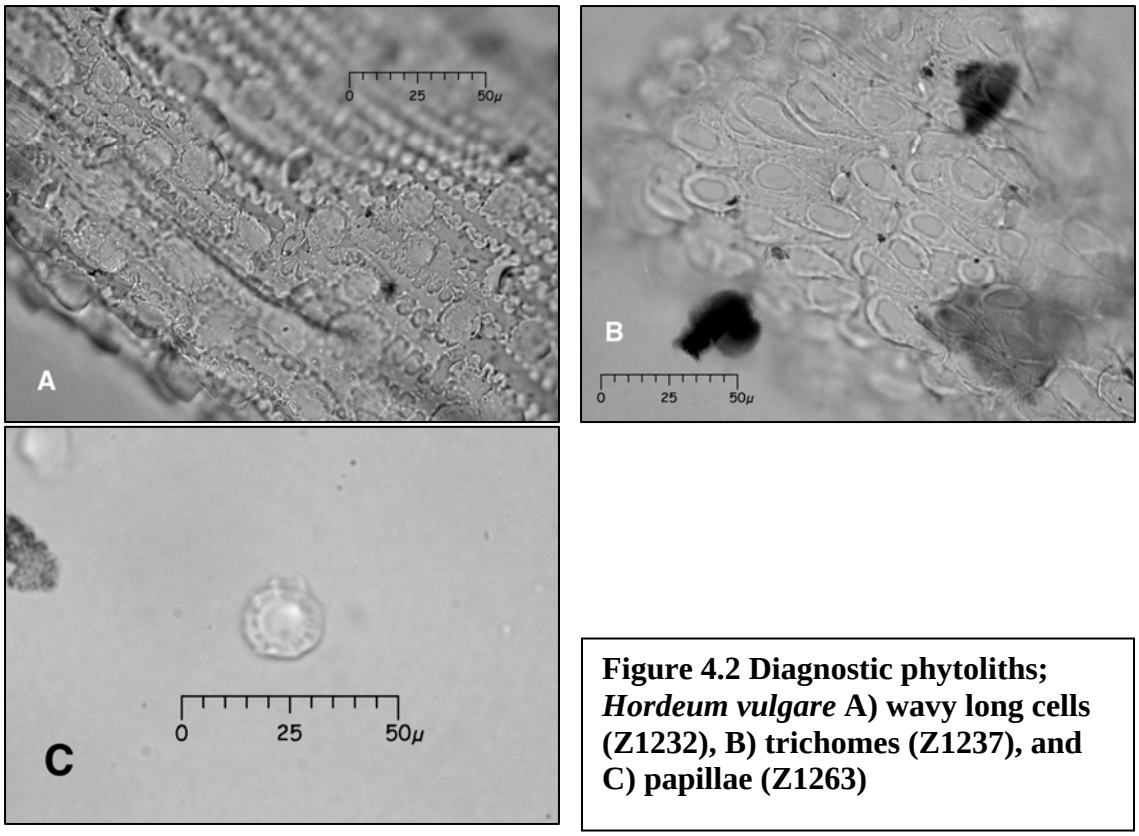


Figure 4.2 Diagnostic phytoliths; *Hordeum vulgare* A) wavy long cells (Z1232), B) trichomes (Z1237), and C) papillae (Z1263)

Food Plants Producing Diagnostic Phytoliths-Poaceae-Triticum spp- Wheat. Wheat was the most popular grain to emerge out of the Near Eastern agricultural revolution and is still a major part of human diet throughout the world today. Rosen (1998) studied three early species of wheat, *Triticum dicoccum, T. dicoccoides, and T. monococcum*, and discovered that although their trichome bases may vary in size (22-50 microns) and pit number slightly (10-12, 16-18, or 12-14), they all have the same long cell wave shape and wall wave heights. Wheat species have rounded to square waves and wave heights ranging from the thin 4 micron waves to the 5-8 micron thick micron waves on the lower part of the husk of the inflorescence. On the middle part of the husk, the thin waves are about 10 microns in height and the thick waves are about 15 microns in height and described as having "high rounded waves of irregular amplitude" (Rosen 1992: 143). In addition, Kaplan et. al. (1992) suggests that the sheet element with clavate protuberances (Kaplan type I2g) type can be used to separate wheat from oats, barley, and rye in the archaeological record (Kaplan et al. 1992).

Tubb, et al. (1993) analyzed the inflorescence papillae of *Triticum*, *Hordeum*, and *Aegilops* and discovered that not only were the papillae structurally different between *Hordeum* and *Triticum*, but counting the marginal pit number proved to be the best way to distinguish between the two genera (Tubb et al. 1993). Ball et al. (1993) used computer assisted image programs to conduct a morphometric analysis of the inflorescence bracts of three species of wheat, *Triticum monococcum*, *T. dicoccon* and *T. aestivum*. Ball et al. measured various morphological parameters of the phytoliths from each species and used discriminate analysis to separate the different types. The types that were studied included silica cell phytoliths, small prickle phytoliths, large prickle phytoliths, hair cell

phytoliths, trichome base phytoliths, stomata phytoliths, epidermal long cell phytoliths, dendriform phytoliths, sub-epidermal phytoliths, and papilla phytoliths. However, none of the types encountered were unique to each species and could only be separated using an assemblage based approach (Ball et al. 1996).

Two species of wheat were originally examined in this study, spelt wheat (*Triticum spelta*), and whole wheat or common wheat (*Triticum aestivum*). Unfortunately, due to some processing problems, the results of this genera are quite limited. The wave shape of spelt wheat was typically thick, rounded, and about 10 microns in height. The wave height and shape of spelt wheat was very similar to other types of wheat studied by Rosen (1992). However, the size of spelt papillae (10-15 microns) was only almost half the size of papillae found in other wheat species. Spelt papillae also had anywhere between 11-13 marginal pits (Figure 4.3)

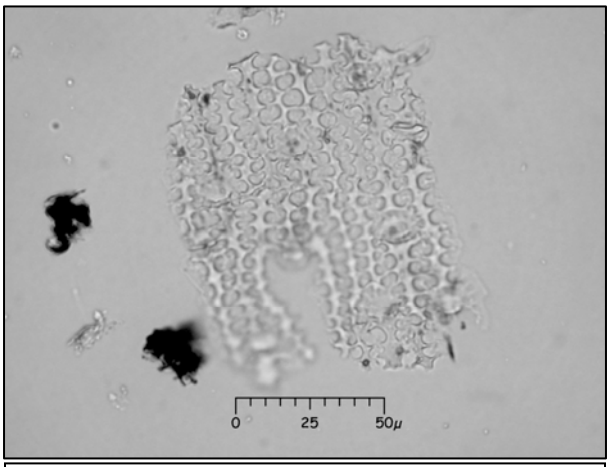


Figure 4.3 Diagnostic phytoliths; *Triticum spelta* wavy long cells (Z1264)

The processed common wheat species did not produce any useful phytoliths in this study. The results of this study should be viewed with caution due to the irregularities of both phytolith production and phytolith morphology in the wheat species. Specifically, the lack of other major phytoliths, either redundant or diagnostic types, may be the result of sampling errors.

Food Plants Producing Diagnostic Phytoliths-Poaceae-Secale cereale- Rye. Rye is one of the few remaining members of the domesticated plants out of the Near East to be examined for phytolith types. Kaplan, et. Al. included *Secale cereale* in their 1992 study and found that papillate-tipped small prickles could be used to distinguish between cultivated rye and oats.

The inflorescence of only one species of rye, *Secale cereale* was examined in this study. Two different types of wavy long cell patterns emerged. The thin waves have a height of about 10 microns and have a somewhat spiky or square pattern (N2085)**.** In contrast, the thicker waves are much shorter and about five microns in height with a low, blunted pattern (N2084). The papillae range from 15-20 microns and have between 9-14 marginal pits. See Figure 4.4 for details.

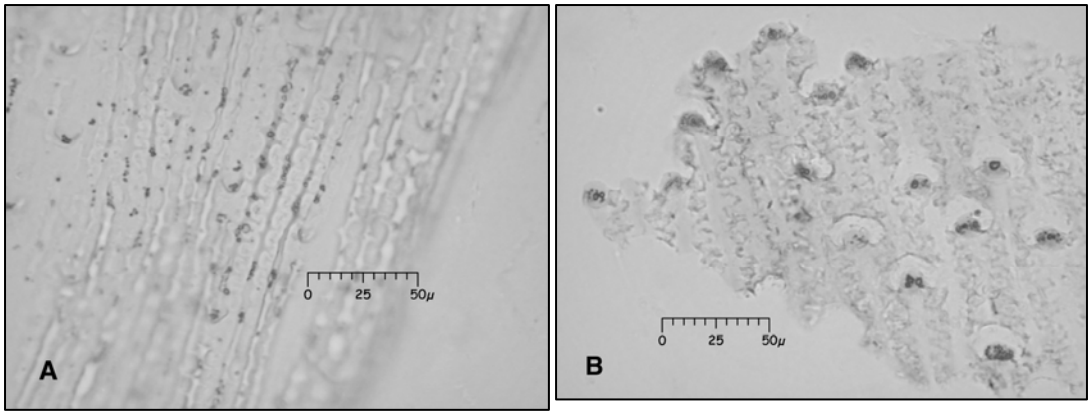


Figure 4.4 Diagnostic phytoliths; *Secale cereale* A) thick wavy long cells (N2084) and B) thin wavy long cells (N2085)

Diagnostic Weeds-Asteraceae-Anthemis cotula- Stinking mayweed. For this sample, the stem and leaf portions were studied together and the seed and flower parts were studied together. Most of the phytoliths produced in this species were nondescript with the exception of the wavy long cells attached to a unique hair tip found in the leaves and stem tissues. These long cells had a wave height between 5-10 microns and extended throughout most of the tissue (N1885). Several pointed phytolith types at least fifty microns in length were found at the tip of the hair (N1882). For comparative photos, see Figure 4.5.

The phytoliths from this specimen do not resemble any of the published types for Asteraceae such as the opaque perforated platelets and segmented hair cells (Bozarth 1992).

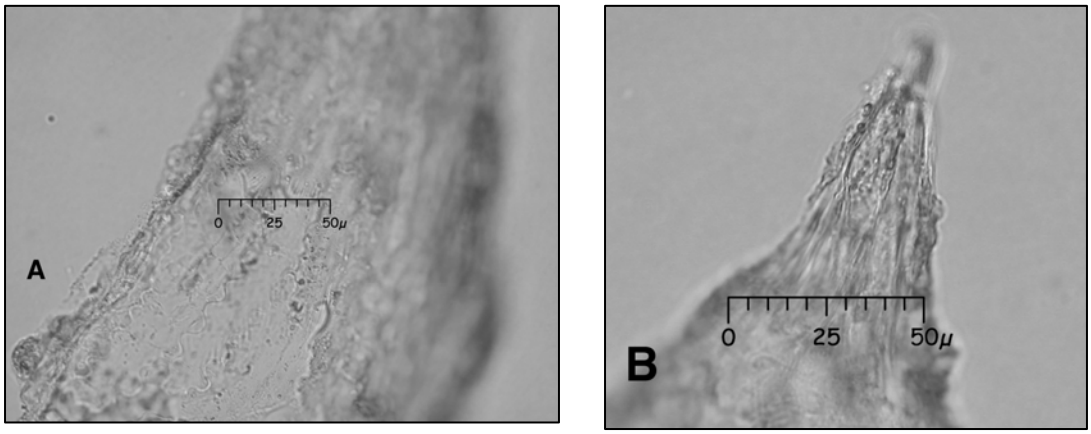


Figure 4.5 Diagnostic phytoliths; *Anthemis cotula* A) wavy long cells (N1885) and B) pointed phytolith types (N1882)

Diagnostic Weeds-Caryophyllaceae-Silene inflata- Bladder Campion. Two types of phytoliths were commonly found in the leaf and flower tissues of this species. In the flower tissues, epidermal long cells about 25 microns in length were common and held no diagnostic value. In contrast, a unique large parallelepipedal irregular vascular cell, affectionately termed the "feather-like" phytolith, was common in the leaf tissue (Figure 4.6). This phytolith was three dimensional and over 100 microns in length.

This phytolith type does not match any published types for the Caryophllaceae family, of which there are very few.

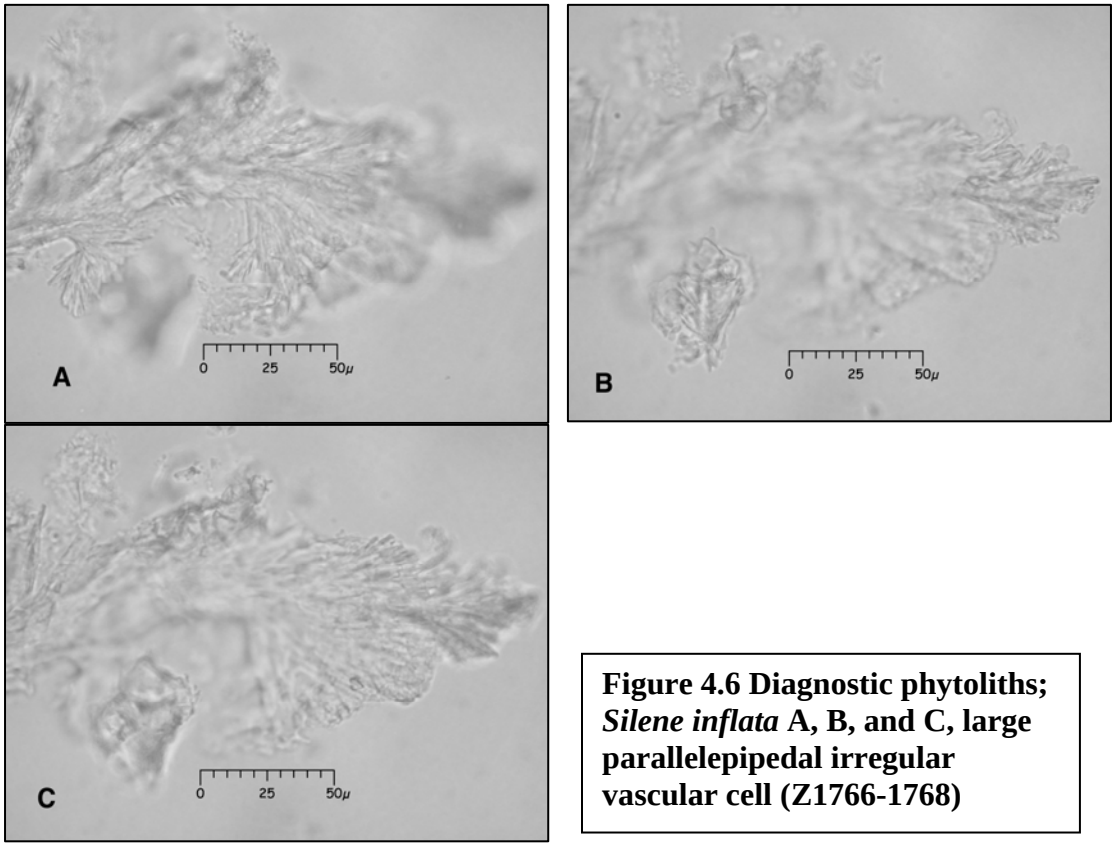


Figure 4.6 Diagnostic phytoliths; *Silene inflata* A, B, and C, large parallelepipedal irregular vascular cell (Z1766-1768)

Diagnostic Weeds-Euphorbiaceae-Euphorbia helioscopia- Sunspurge. Three different types of phytoliths are found in the leaf, flower, and seed tissue of the sunpurge plant. Common non-diagnostic trachiary phytoliths are found in the leaves and are about 10 microns in width. Another nondiagnostic phytolith type is found in the seed in the form of trachiary elements about 5 microns in width. The only diagnostic type found in this species was an ovate dense irregular epidermal cell, informally called the "scale-like" phytolith, which occurs in the flower. In this tissue, a series of ovate, flat phytoliths approximately 15 microns wide overlap each other (Figure 4.7).

This type does not match any of the published sources for the *Euphorbiaceae* family (Bozarth 1992).

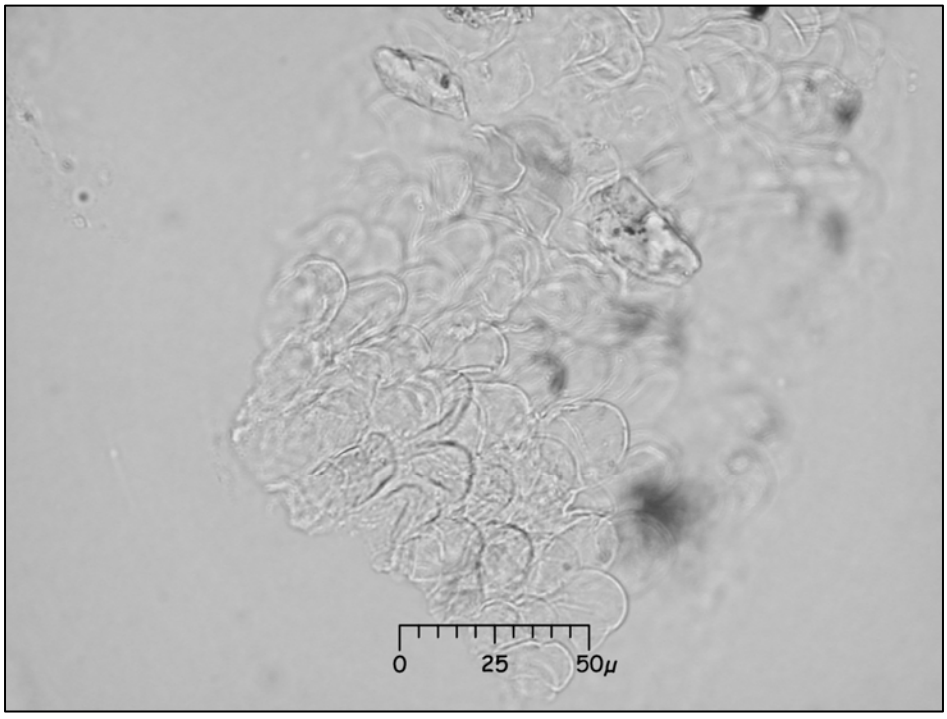


Figure 4.7 Diagnostic phytoliths; *Euphorbia helioscopia* ovate dense irregular epidermal cells (N1895)

Diagnostic Weeds-Poaceae. Much like the domesticated Old World grasses, one of the most common diagnostic phytoliths found in wild grasses continues to be the wavy long cell and trichome base.

Diagnostic Weeds-Agropyron inerme- Beardless wheatgrass. In this interesting species, four phytolith types were discovered in the leaf tissues, three of which may prove to be diagnostic. The first diagnostic type is a rare elongated hair cell over 50 microns long and about 5 microns wide with a double wall, hollow interior, and blunted tip (N1903) (Figure 4.8). The wavy long cells in plate (N1905), were short and thin but rounded with a wave height of about 5 microns. *Agropyron inerme* also produces characteristic trichome cells about 13 microns across in diameter complete with between 11-13 papillae (Z1760). Finally, this species also produces stomata 20 microns by 40 microns that, although quite clearly silicified, is a very common phytolith type with no diagnostic value (N1907).

The possible diagnostic types found in *Agropyron inerme* overlap somewhat with established domesticated and wild grass types as well as some of the grass types analyzed in this study. The wavy long cell shape is unique to the species; however, the wave cell height overlaps with *Anthemis cotula*, *Alopecurus* spp, and the lower range of *Avena sativa*. In addition, the number of marginal pits on the papillae overlaps with *Avena sativa*, *Triticum spelta*, *T. dioccum*, and *T. monococcum*. The rare elongated cell doe not overlap with the published sources used in this study.

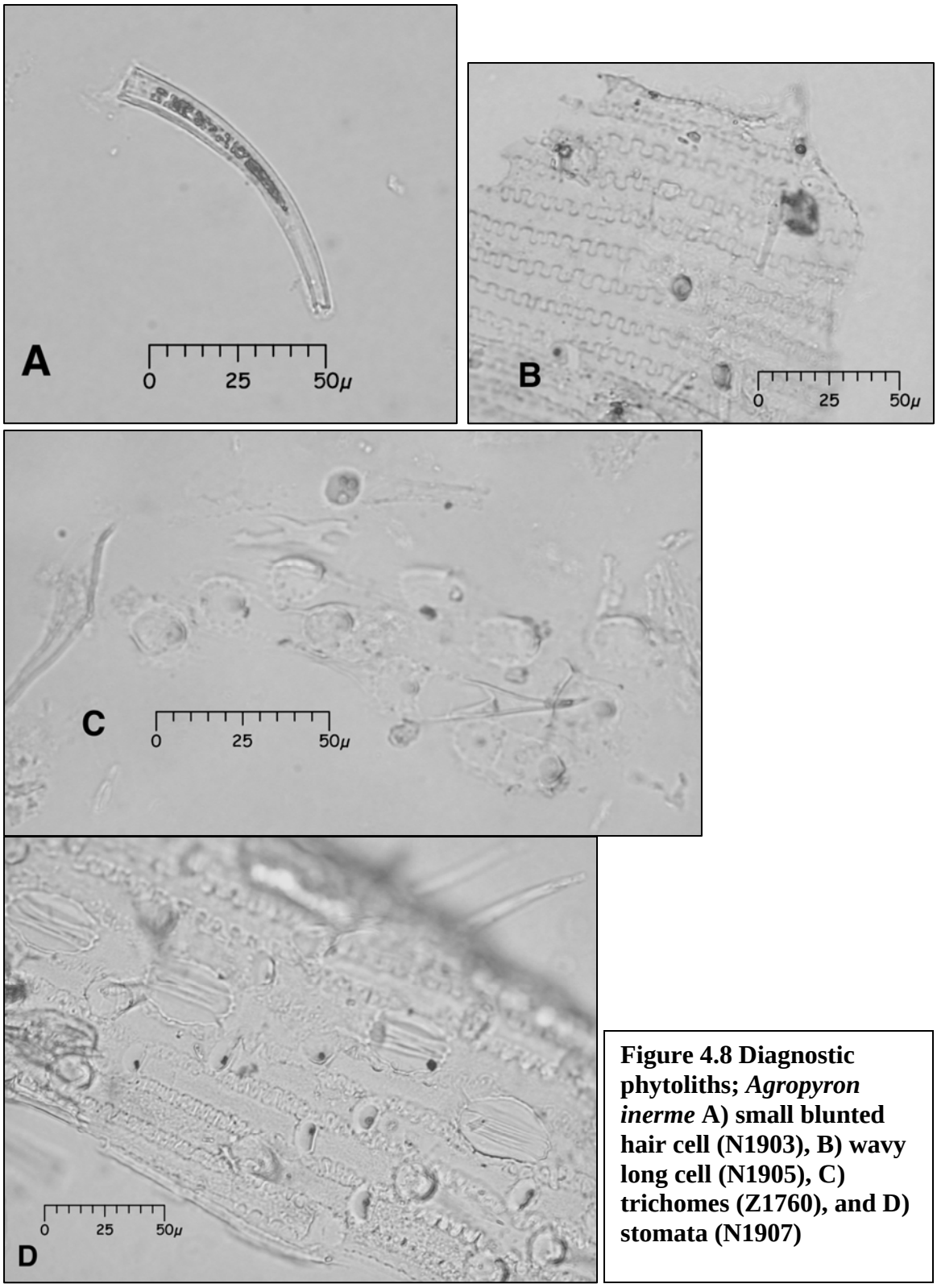


Figure 4.8 Diagnostic phytoliths; *Agropyron inerme* A) small blunted hair cell (N1903), B) wavy long cell (N1905), C) trichomes (Z1760), and D) stomata (N1907)

Diagnostic Weeds-Poaceae-Alopecurus carolinianus-Carolina foxtail and Alopecurus praetensis-Meadow foxtail. There was no discernable difference in phytolith types produced between these two species so the results of this study are specific to the genera *Alopecurus*. *Alopecurus* spp. produced a wide variety of diagnostic phytoliths in both the leaf and inflorescence tissues. In the leaf tissues, both armed hairs and wavy long cells can be found. The armed hairs as seen in Z1784, are about 40 microns in length with a hollow interior and protrude off the side of epidermal tissues. The wavy long cells are short, blunted, and thin with an average wave height of between 3-5 microns (Z1785). Finally, some trichomes can be seen in Z1785 however they had no visible papillae and measured about 10 microns across. The same phytolith types were found in the inflorescences.

The inflorescence tissues produce wavy long cells, trichomes, and long, somewhat heavily silicified, acute tipped hair cell. The waves found in these long cells are typically thick, measure about 4-5 microns in height, and are more rounded than those found in the leaf tissues (N1891). Trichomes of about 10 microns in diameter could be found throughout the samples yet most of them had few, if any visible papillae (N1890). Finally, long and narrow hair cells, approximately 5-7 microns in width, were present and are best noted for their heavily silicified tips (N1889). For examples, see Figure 4.9

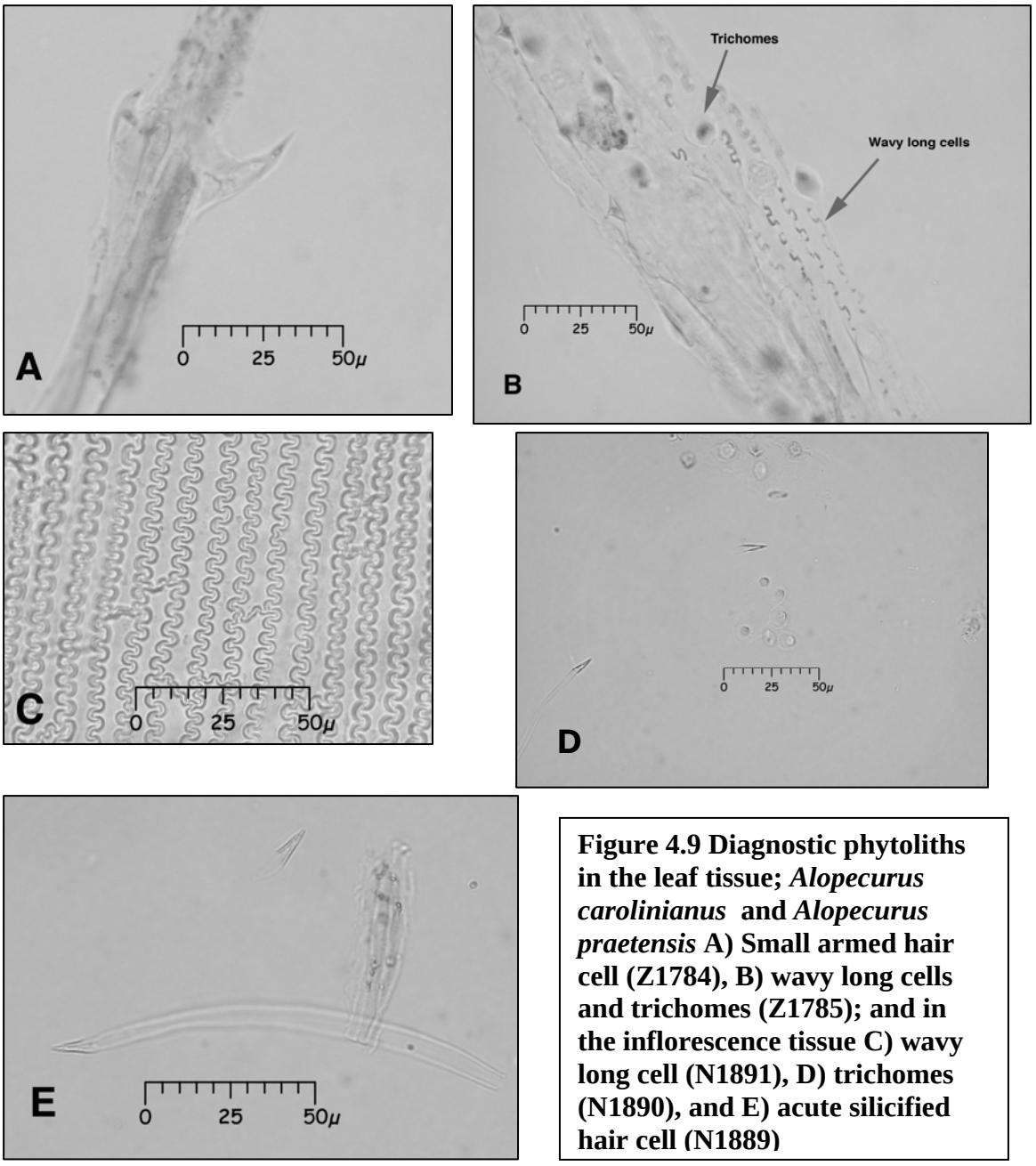


Figure 4.9 Diagnostic phytoliths in the leaf tissue; *Alopecurus carolinianus* and *Alopecurus praetensis* A) Small armed hair cell (Z1784), B) wavy long cells and trichomes (Z1785); and in the inflorescence tissue C) wavy long cell (N1891), D) trichomes (N1890), and E) acute silicified hair cell (N1889)

The wavy long cell shape is unique to *Alopecurus* spp however the wave height of the thick waves overlaps with *Agropyron inerme*, *Anthemis cotula*, *Secale cerale*, and *Avena sativa*. Both the armed and acute tipped hair cells do not match with any other types examined in this study or in the published literature used in this study. Comparisons to other established types should be conducted at a later date.

Diagnostic Weeds-Rubiaceae-Galium aparine-Goose grass. This species of weed produces an extremely large hair cell that is found in both leaf and seed tissues. The hair cell is over 100 microns in length with multiple inner layers and a curved tip (Z1769). The other types of phytoliths produced in this species are nondiagnostic vascular tissues and generalized stomata and epidermal tissues. For comparative photos, see Figure 4.10. This phytolith type does not match published types used for this study or any of the other plant species encountered during this study.

Figure 4.10 Diagnostic phytoliths *Galium aparine* large armed hair cell (Z1769).

Summary. The results of this study can be divided into two basic groups, wavy long cells and papillae, and non-wavy long cell and non-papillae phytoliths. The non-wavy long cell and papillae phytoliths are easy to distinguish because there is no overlapping amongst the types found in this study. These types are summarized in table 4.2

Table 4.2 Diagnostic Non-wavy long cell and non-papillae types

Species	**Phytolith type**
Galium aparine	Large armed hair cell
Alopecurus sp.	Acute silicified hair cell
Alopecurus sp.	Small armed hair cell
Agropyron inerme	Small blunted hair cell
Euphorbia helioscopia	Ovate dense irregular epidermal cell
Silene inflate	Large parallelepipedal irregular vascular cell
Phoenix dactlyifera	Spinulose spheres

The wavy long cells and papillae were distinguished from each other based on wave cell height, wave shape, papillae size, and number of marginal pits. The differences between *Avena sativa*, *Hordeum* sp., *Triticum* sp., *Secale cereale*, *Anthemus cotula*, *Agropyron inerme*, and *Alopecurus* sp. can be seen with the measurements compared in Table 4.3 and each individual wave cell drawing in Figure 4.11.It is important to note that proper identification of the wavy long cells requires both cell wall height measurements and the wave shape itself and that some wave height measurements may overlap between species and genera. Papillae identification requires both size and marginal pit number and may also overlap as well.

Table 4.3 Diagnostic wavy long cell and papillae measurements				
*** indicates adapted from Rosen (1992)**	**LC-Wall wave height**			
Measurements in microns	**Lower husk**	**Middle husk**	**Papillae Size**	**# pits**
Wheat (*Triticum*)				
Emmer (*T. dioccum*)*	4 thin	10 thin	22-30	10-12
	5-8 thick	15 thick		
Wild emmer (*T. dicoccoides*)*	4 thin	10 thin	21-43	16-18
	5-8 thick	15 thick		
Einkorn (*T. monococcum*)*	4 thin	10 thin	25-50	12-14
	5-8 thick	15 thick		
Spelt (*T. spelta*)	N/A	10 thick	10-15	11-13
Whole wheat (*T. aestivum*)	Processing problems	Processing problems	Processing problems	Processing problems
Barley (*Hordeum*)				
Two-row (*H. distichum*)*	7 thin	7 thin	18-25	10-12
	10 thick	10 thick		
Six-row (*H. vulgare*)*	7 thin	7 thin	18-25	7-9
	10 thick	10 thick		
Goat Grass (*Aegilops*)				
*Ae. Searsii**	N/A	8.5 thin	25-27	16-18
		15 thick		
*Ae. Bicornis**	N/A	10 thick	25-32	16-18
Oat Grass				
Avena sp*	N/A	8.5 thin	15, 50	18-20
		16 thin		
Avena sativa (Domesticated)	N/A	5-15 thick	25-27.5	10-14
Rye Grass				
Lolium sp*	N/A	7 thin	22	16-18
		8.5 thick		
Rye				
Secale cereale	N/A	10 thin	15-20	9-14
Other Weeds				
Anthemis cotula	N/A	5-10 thin	N/A	N/A
Agropyron inerme	N/A	5 thin	13	11-13
Alopecurus sp	N/A	3-5 thin	10	< 5
		4-5 thick		

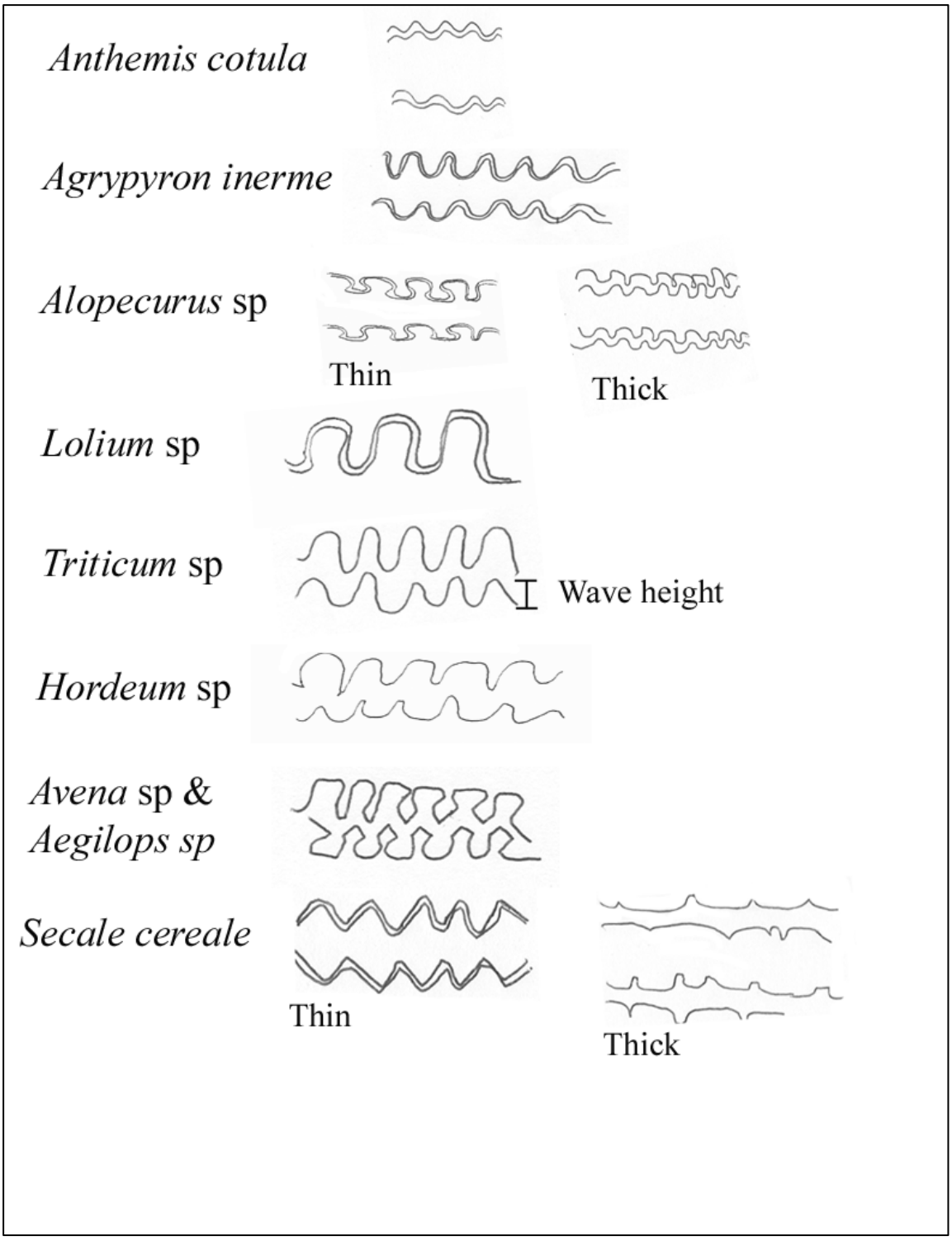


Figure 4.11 Wavy long cell drawings of diagnostic food and weedy species (Adapted from Rosen 1992)

Finally, some established types not encountered in this comparative study will be included when scanning archaeological samples. These diagnostic types, developed by Kaplan et al (1992) include the following (Table 4.4)

Table 4.4 Kaplan et al (1992) diagnostics included in this study
Note: Kaplan et al.(1992) type number in parenthesis

Type	**Species/genera**
Sheet elements having clavate protuberances over the entire surface (I2g)	*Tritcum* sp
Prickle, Papillate tip (IIa2)	Widespread, absent from *Hordeum vulgare*
Circular base, large prickle (IIb2)	*Secale cereale*/ *Avena sativa*
Macrohairs visbile with unaided eye or x5-10 (IIc1)	Absent from *Hordeum vulgare*/*Avena sativa*, present in *Triticum aestivum/Secale cereale*
Trichome base, annular margin entire along at least two quadrants (IIIa)	*Hordeum vulgare*
Trapezoid, length 2x width, margins alate, lobed (Va2)	Absent from *Secale cereale*

Limited

A few of the species examined in this comparative collection proved to have limited diagnostic capabilities because they produced generalized “rooty” or “fruity” phytolith types (Chandler-Ezell et al., 2006). These types include blocky parenchyma, multilobed parenchyma, straight transport tissue, and undulating transport elements Two great examples of rooty and fruity phytoliths can be seen with the strawberry (*Fragaria* sp.) and olive (*Olea europea*) samples. The *Fragaria sp* sample was mostly undifferentiated silica with the exception of some very large blocky epidermal cells measuring over 50 microns in some cases, found in the leaf tissue. *Olea europea* produces both ridged vascular tissue approximately ten microns in width found in the seeds as well as rectangular blocks between ten and twenty microns found in the fruit body .

Table 4.5 Limited diagnostic food phytolith species		
Family	**Species**	**Common name**
Apiaceae	*Foeniculuum vulgare*	Fennel
Brassicaceae	*Brassica* sp	Mustard
Cucurbitaceae	*Cumuis sativus*	Cucumber
Oleaceae	*Olea europea*	Olive
Rosaceae	*Fragaria* sp	Strawberries
Rosaceae	*Malus pumila*	Apple

Table 4.6 Limited diagnostic weedy phytolith species		
Family	**Species**	**Common name**
Campanulaceae	*Campanula rotundifolia*	Blue bell grass
Caryophyllaceae	*Arenaria serpyllifolia*	Thyme-leaved sandwort
Fabaceae	*Vicia hirsute*	Hairy vetch
Lamiaceae	*Lamium purpureum*	Red Dend-nettle
Lamiaceae	*Stachys bullata*	California Hedgenettle
Orchidaceae	*Orchis latifolia* L.	Marsh Orchid
Rosaceae	*Filipendula ulmaria(occidentalis)*	Meadow Sweet

Non-diagnostic

Below is a list of both the food and weedy plants that did not produce phytoliths or, if they did, they were redundant, nondiagnostic types (Table 4.7, 4.8).

Table 4.7 Non-diagnostic food phytolith species

Family	**Scientific name**	**Common name**
Apiaceae	*Anethum graveolens*	Dill
Apiaceae	*Apium graveolens*	Celery
Apiaceae	*Coriandrum satirum*	Coriander
Apiaceae	*Daucus carota*	Cultivated Carrot
Apiaceae	*Pimpinella anisum*	Anise
Brassicaceae	*Brassica oleracea*	Cabbage
Chenopodiaceae	*Betas vulgaris*	Beets
Fabaceae	*Cicer arietinum*	Chickpeas
Fabaceae	*Lens culinaris*	Lentils
Fabaceae	*Pisum sativum*	Peas (green, field, or garden)
Fabaceae	*Vicia ervilia*	Biter vetch
Fabaceae	*Vicia faba*	Faba (broad) beans
Liliaceae	*Allium cep*	Onion
Liliaceae	*Allium sativum*	Garlic
Liliaceae	*Allium porrum*	Leek
Moraceae	*Ficus carica*	Fig
Papaveraceae	*Papaver somniforum*	Opium poppy
Pinaceae	*Pinus pinea*	Pine nut (Stone pine)
Rosaceae	*Prunus avium*	Sweet Cherry
Rosaceae	*Prunus domestica*	European plum
Rosaceae	*Pyrus communis*	Pear
Vitaceae	*Vitis vinifera*	Grape

Table 4.8 Non-diagnostic weedy phytolith species		
Family	**Scientific name**	**Common name**
Asteraceae	*Sonchus arvensis*	Field Milk Thistle
Brassicaceae	*Sinapis arvensis*	Charlock
Caryophyllaceae	*Agrostemma githago*	Corncockle
Chenopodiaceae	*Chenopodium album*	Fathen
Dipsacaceae	*Knautia arvensis*	Cornflower
Polygonaceae	*Polygonum convolvulus*	Black Binwood
Primulaceae	*Primula veris*	Cowslip

Starch Grains

A total of 45 food and weedy plant species were examined for diagnostic starch grains. Only the major starch producing parts of the each plant, such as the seeds and storage organs, were analyzed. For this study, 11 characteristics of a starch grain were examined. These features include: extinction cross morphology, granule size, overall granule shape, granule angularity, presence or absence of lamellae, fissure morphology, position and form of the hilum, surface texture, protuberances, outer wall features, and if a starch grain is singular or compound (Adapted from Torrence 2006b). Each plant was given a diagnostic, semi-diagnostic, and nonproducing categorization as discussed at the beginning of the chapter. 13 species of food plants and 4 species of weeds were found to have diagnostic starch grains; 8 weedy plants and 8 food plants proved to be semi-diagnostic; and 13 food species and one weedy species did not produce diagnostic starch grains. The list of diagnostic starch grain species can be found in Table 4.9.

Diagnostic

Table 4.9 Diagnostic starch grain species **Food species**		
Family	**Species**	**Common name**
Apaceae	*Coriandrum satirum*	Coriander
Fabaceae	*Cicer arietinum*	Chickpeas
Fabaceae	*Pisum sativum*	Peas (green, field, or garden)

Table 4.9 Diagnostic starch grain species continued		
Family	**Species**	**Common name**
Fabaceae	*Vicia faba*	Faba (broad) beans
Fabaceae	*Lens culinaris*	Lentils
Poaceae	*Avena* sp	Oats
Poaceae	*Hordeum* sp	Barley
Poaceae	*Triticum* sp	Wheat
Poaceae	*Secale cereale*	Rye
Rosaceae	*Malus pumila*	Apple
Weedy species		
Family	**Species**	**Common name**
Fabaceae	*Vicia hirsuta*	Hairy vetch
Poaceae	*Alopecurus pratensis*	Meadow Foxtail
Poaceae	*Polygonum convolvulus*	Black Binwood
Rubiaceae	*Galium aparine*	Goose grass

The results of this study were compared with the results from Reichert (1913). The 1913 study by Reichert remains one of the most extensive examinations of starch grains found in both New World and Old World plants to date (Ugent 2006). The following species were compared with the results found in the Reichert study; *Pisum sativum*, *Vicia faba*, *Lens culinaris* (*Lens esculenta* in Reichert), *Avena* sp., *Hordeum* sp., *Triticum* sp., and *Secale cereale*.

Food plants producing diagnostic starch grains-Apiaceae- Coriandrum satirum-Coriander. The vascular tissue of this plant was examined for starch grains. The coriander sample in this study produced starch grains in the vascular tissues that have a spherical shape with round edges and range from 12.5 µ to 30µ in diameter with an average of about 20µ. The extinction cross is centric with straight, narrow arms at right angles. Lamellae are not visible in most cases while the hilum is slightly open and

centrically located or can not be seen at all. The granule has a smooth surface and a double outer wall. The starch grains had no protuberances and were singular in nature. Most lack fissures. The starch grain in Figure 4.12 exhibits some grinding damage as can be seen with the central fissures and is a rare type that contains lamellae.

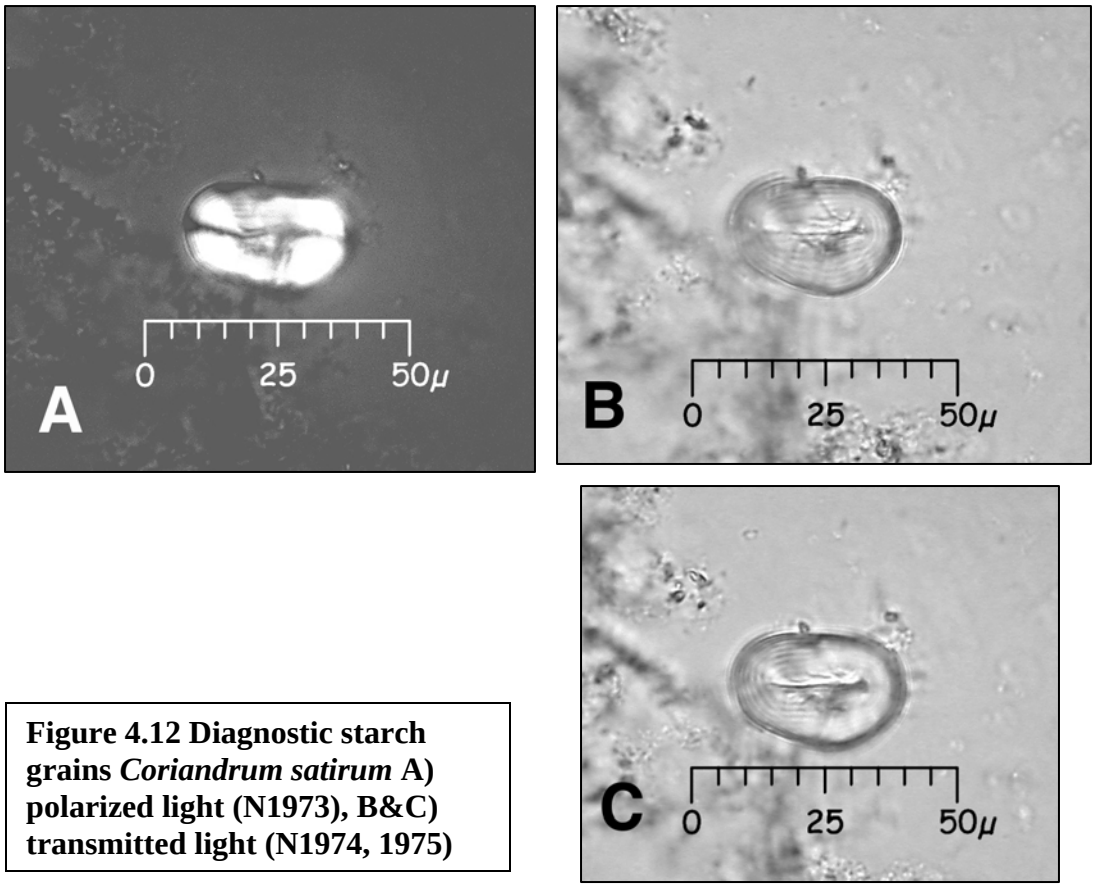


Figure 4.12 Diagnostic starch grains *Coriandrum satirum* A) polarized light (N1973), B&C) transmitted light (N1974, 1975)

No published sources exist for morphological comparisons.

Food plants producing diagnostic starch grains-Fabaceae-Cicer arietinum- Chickpeas. The legume seeds were examined for the following samples. The chickpea starch grains in this study range in size from 15µ to 30µ in diameter with an average size of 16µ by 20.5µ. They are mostly isolated, spherical to ovate grains with a round angularity, single outer wall, and smooth surface. While lacking fissures, the hilum is faint in most granules but open and centric in location. Half of the starch grains appeared to have extinction crosses greater or lesser than 90 degrees with bent, narrow arms. The half of the other starch grains had crosses with straight, narrow arms at a 90 degree angles and vacuoles. Both types had fine lamellae with four to eight concentric circles (Figure 4.13).

No published sources exist for morphological comparisons.

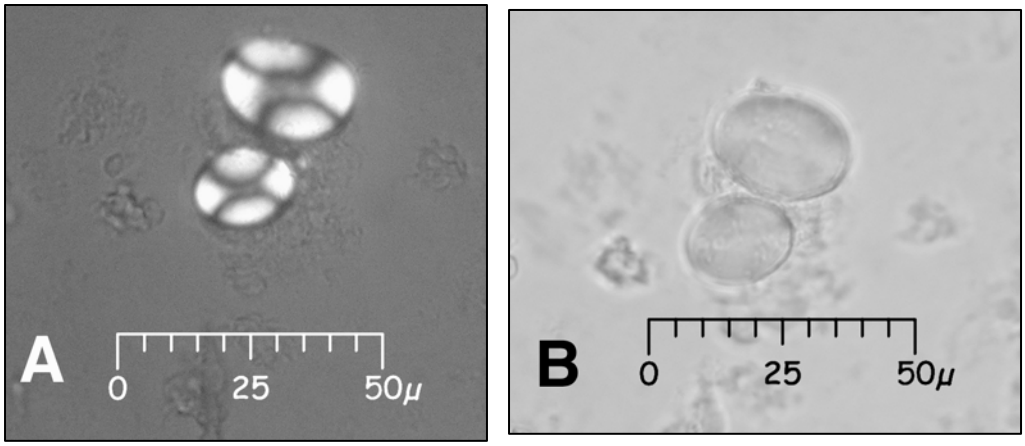


Figure 4.13 Diagnostic starch grains *Cicer arietinum* A) polarized light (N1603) and B) transmitted light (N1602)

*Food plants producing diagnostic starch grains-Fabaceae-Pisum sativum-Peas (green, field, or garden).*The majority of the starch grains found in this sample were spherical to ovate individual grains with rounded edges. There is no visible hilum while the average starch diameter is about 28µ. Some grains have fine lamellae. The extinction cross is fairly crisp in appearance and is composed of thin, straight arms at an angle greater than 90 degrees. Many of the starch grains have a deep linear fissure that divides the starch into two separate bodies. The surfaces were smooth and lacked any protuberances. The starch grain also had a double wall (Figure 4.14).

The results illustrated by Reichert (1913) showed a lot more variation than was seen in my sample. In his study, some of the starch grains were very small which he called the "broken down varieties" (Reichert 1913: 402-404). These small grains took a variety of shapes such as triangular, quadrilateral, or hemispherical. However, in contrast to Reichert's findings, the starch encountered in this study did have some lamellae and extinction crosses.

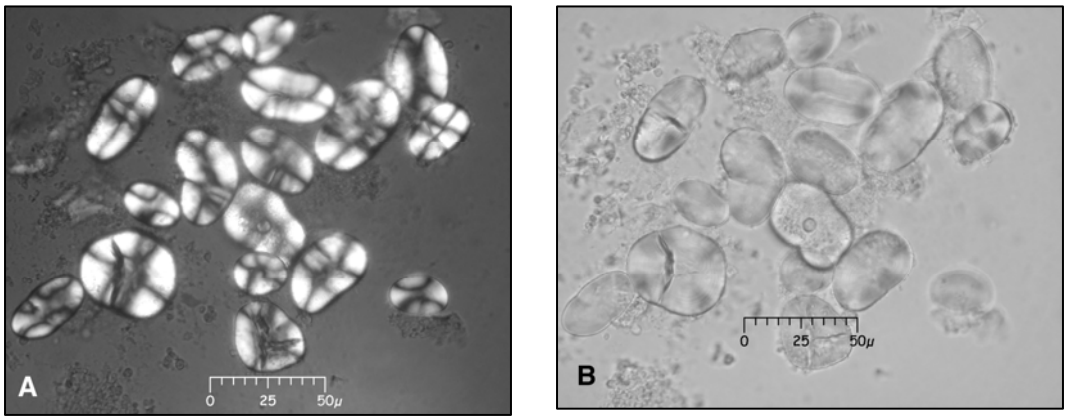


Figure 4.14 Diagnostic starch grains *Pisum sativum* A) polarized light (N1600) and B) transmitted light (N1599)

Food plants producing diagnostic starch grains-Fabaceae-Vicia faba- Faba (broad) beans. The faba bean starches are singular, with a spherical or ovate shape and a rounded angularity. They average approximately 29µ microns in size and have a small, open centric or slightly eccentric hilum that, in most forms, is accompanied by a simple linear fissure. The lamellae are very distinct but course and number between 6 to 8 rings. The extinction cross is centric or slightly eccentric and distinct with thin arms posed at a 90 degree angle. Some extinction crosses also contain a vacuole. The surface of the granule is smooth and the wall has a double outline. There are no protuberances (Figure 4.15).

Reichert originally described this starch grain as having a "bean shaped, elongated oval" shape which could vary in size from 4µ to 42µ in diameter (1913: 381-382). The range of shapes encountered by Reichert included reniform, pyriform, triangular, and quadrilateral. Overall, the results from this study match those discussed in Reichert (1913).

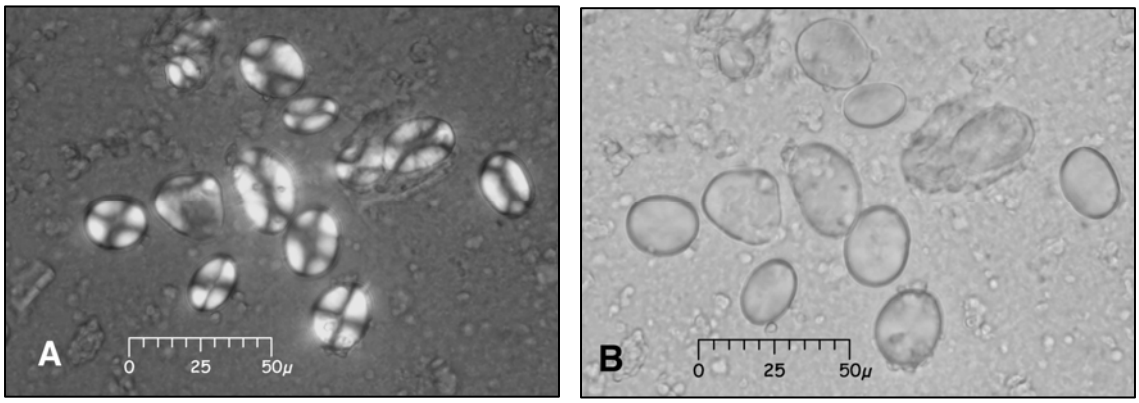


Figure 4.15 Diagnostic starch grains *Vicia faba* A) polarized light (N1594) and B) transmitted light (N1593)

Food plants producing diagnostic starch grains-Fabaceae-Lens culinaris (*Lens esculenta*)-*Lentils.* The starch grains encountered in this sample were singular ovate, spherical, or reniform in shape with average size of 13µ by 24µ. The edges of the granule were rounded. The hilum is centric to slightly eccentric and is often obscured by a simple linear fissure. The course lamellae number between 8 to 14 on the ovate starches and 6 to 10 on the spherical starches. They often have a smooth surface complete with a double outer wall. The extinction cross has thick, straight arms at a 90 degree angle and is sometimes accompanied by a dark vacuole. No protuberances were present (Figure 4.16).

Reichert describes this starch shape as "…ellipsoidal, rounded-oval, and reniform". In addition, some are "some ovoid, shield-shaped, heart-shaped, round pyriform, and irregular grains of indefinite form" (1913: 393). In his study they ranged in size from 4µ by 6µ to 22µ to 38µ. The descriptions from the Reichert study do not significantly vary from the results found in this study.

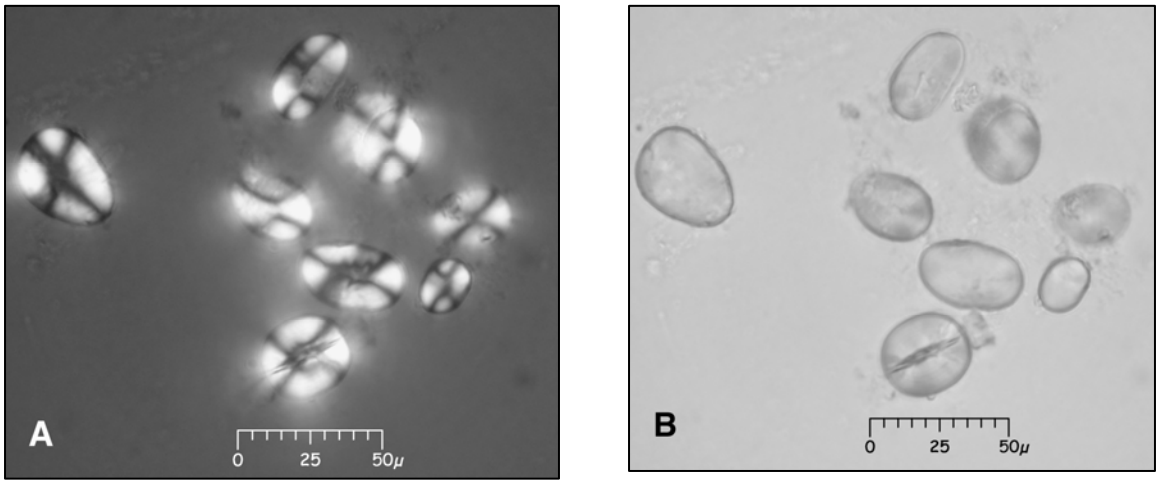


Figure 4.16 Diagnostic starch grains *Lens culinaris* (*Lens esculenta*) A) polarized light (N1597) and B) transmitted light (N1595)

Discussion of how to tell apart domesticated Fabaceae. The domesticated Fabaceae species are very hard to distinguish from one another based solely on measurable traits. There is much overlap in size range of each species with *Pisum sativum* and *Vicia faba* having the closest average granule size, 28µ and 29µ respectively. They all possess similar shapes and extinction crosses. *Cicer arietinum* can be distinguished from the others due to its single wall and absence of fissures. *Pisum sativum* may be distinguished from other Fabaceae species due to its lack of a hilum. Overall, the best way to properly identify the differences between these species is to study the comparative collection and internalize the characteristics of what each species should look like.

Food plants producing diagnostic starch grains-Poaceae- Avena spp- Oats. The seeds were examined for starch grains in the following samples. Starches produced by the Poaceae family are very different from those found in the Fabaceae family. The oat starches found in this sample are mostly spherical to ovate with a round angularity and an average size between 8µ and 10µ in diameter. The majority of the starch grains were isolated with a few compound granule exceptions. There is a single outer wall; the surface of the starch is smooth; and the hilum and lamellae are absent. A simple linear fissure runs through the center of most starch grains. The extinction cross is not distinct with thick, straight lines at 90 degree angles (Figure 4.17). No protuberances were seen.

Reichert observes that the grains sometimes occur in aggregates which can be as big as 40µ by 30µ in size with individual grains ranging in size from 2µ to 20µ. In contrast to this study, Reichert observes grains that are “polygonal, spindle-shaped…and irregular oval with one side either flattened or concave” (Reichert 1913: 374-375). The only major difference between this study and that of Reichert’s is that the extinction

crosses encountered in this study were far more distinct than those described by Reichert. Overall, the results from this study match those described by Reichert.

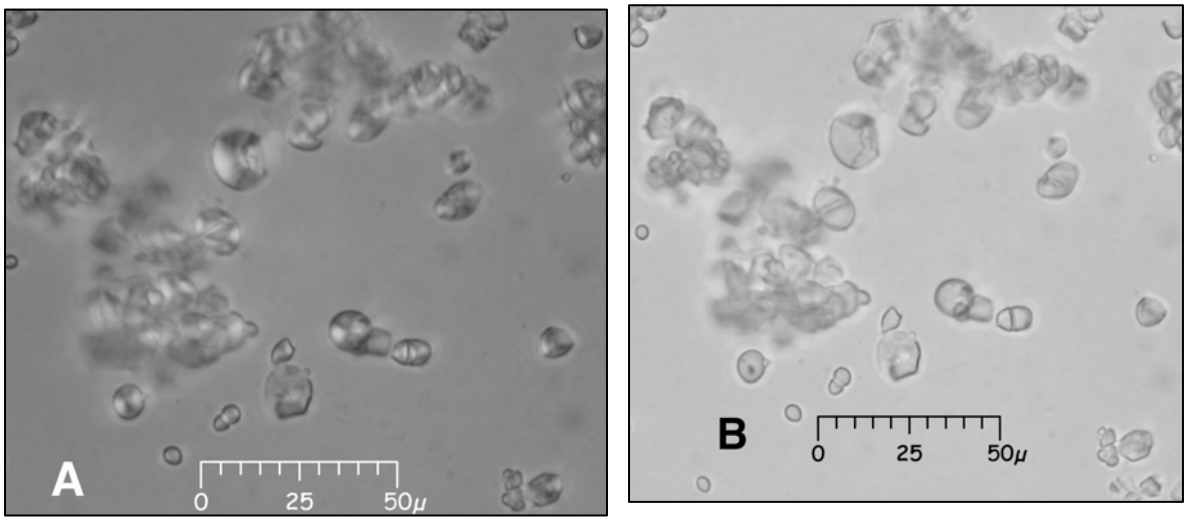


Figure 4.17 Diagnostic starch grains *Avena* spp A) polarized light (N1589) and B) transmitted light (N1588)

Food plants producing diagnostic starch grains-Poaceae-Hordeum spp- Barley. The barley starches in this study were singular and spherical to ovate in shape with rounded edges and a common size of about 19µ. The surface is smooth while the hilum is absent in most granules. A simple linear fissure can be seen when the starch grain is viewed from the side. The outer wall has a single layer and the lamellae are not visible in most cases. The extinction cross is comprised of broad, straight arms (although rarely bent) at a greater or less than 90 degree angle. No protuberances were seen (Figure 4.18).

In the study conducted by Reichert, he noted that the starch grains range in size from 2µ to 28µ while some types may be flattened, hemispherical, and dome shaped. Some compound starch grains do exist, but these are quite rare. These descriptions match those encountered in this study (Reichert 1913).

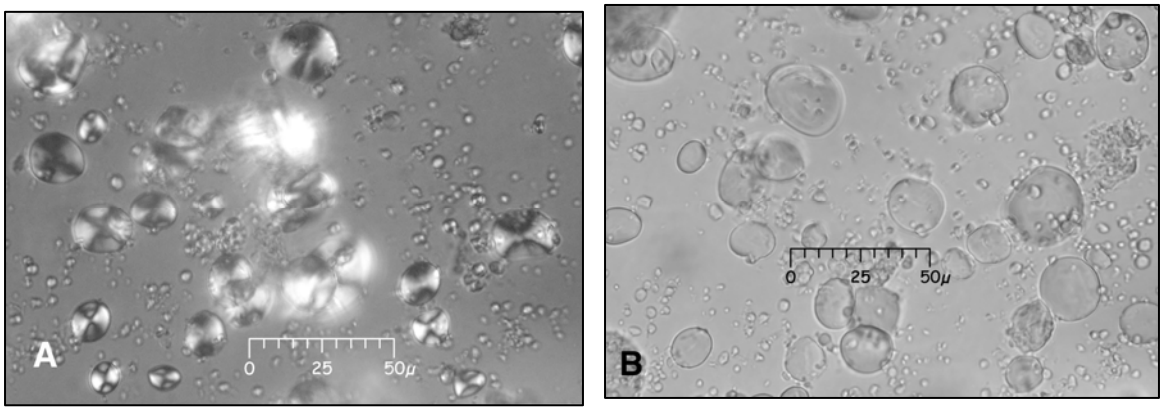


Figure 4.18 Diagnostic starch grains *Hordeum* spp A) polarized light (N1576) and B) transmitted light (N1573)

Food plants producing diagnostic starch grains-Poaceae-Triticum spp- Wheat. Wheat grains encountered in this study are typically singular with ovate to spherical shape with rounded edges and an average size of about 20µ in diameter. The lamellae and hilum are absent in most starch grains while a simple linear fissure can be seen when the starch grain is viewed from the side. The surface is smooth with a single, outer wall. The extinction cross is comprised of broad, straight arms at a 90 degree angle that are somewhat fuzzy and centered on a large vacuole. No protuberances were seen (Figure 4.19).

In addition, Reichert notes the starch grain in these genera can be divided into two basic size classes, large and small. The small starch grains, which are probably transient grains, average about 2µ by 2µ. Meanwhile, the large starch grains average between 20µ and 22µ but can be as large as 38µ by 34µ. Rare shapes noted by Reichert included "lenticular, spindle-shaped…bean-shaped, reniform, and hemispherical" (Reichert 1913: 364-368). The results from Reichert closely match those found in this study.

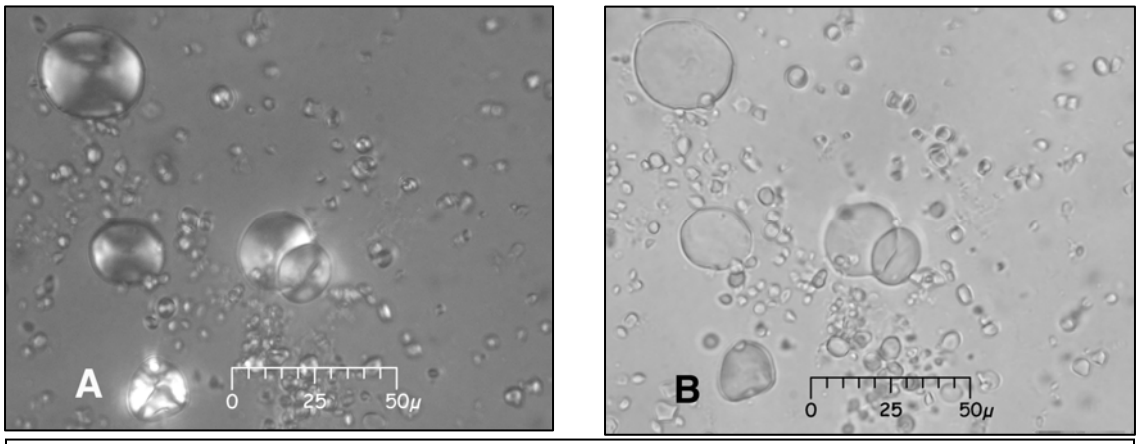


Figure 4.19 Diagnostic starch grains *Triticum* spp A) polarized light (N1580) and B) transmitted light (N1578)

Food plants producing diagnostic starch grains-Poaceae-Secale cereale- Rye. Rye starch grains are singular ovate to spherical in shape with round edges with and average size of 28µ in diameter. The lamellae are not visible however the hilum is open with a centric to slightly eccentric position. The grains have a single outer wall with a smooth surface but may have a simple linear fissure when viewed from the side. The extinction cross is not distinct in large grains but distinct in medium and smaller grains. It can be most characterized as having straight narrow arms at an angle other than 90 degrees. No protuberances were seen (Figure 4.20).

As with all the previous species, Reichert notes far more variation than is seen in this study. The sizes of the grains vary from 2µ to 48µ with some grains having a "bean-shaped, slightly polygonal, triangular with rounded angles, and a hemispherical" shape (Reichert 1913: 368-372). Aside from the increased variation seen in the Reichert study, the starch grains from this sample match those found by Reichert.

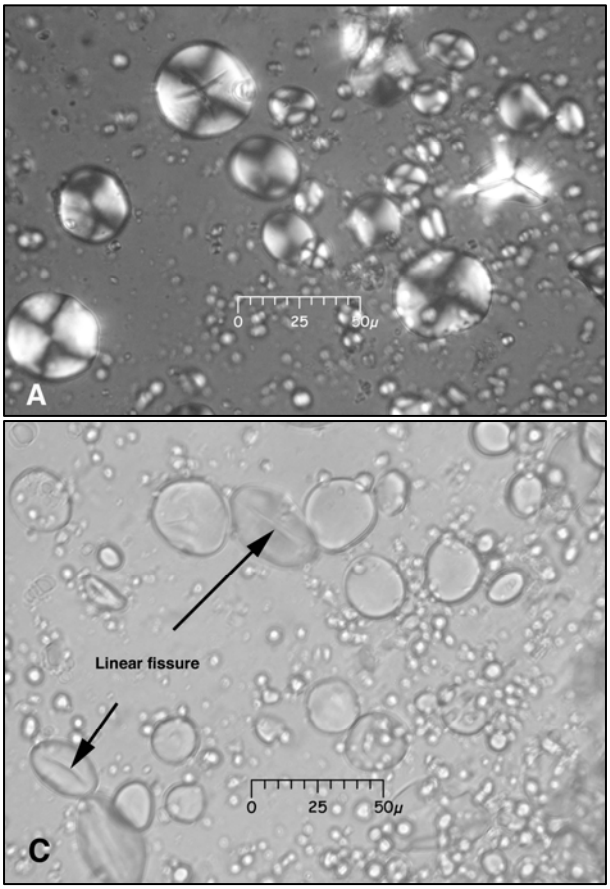


Figure 4.20 Diagnostic starch grains *Secale cereale* A) polarized light (N1571) and B&C) transmitted light (N1568 & N1569)

Discussion of how to tell apart domesticated Poaceae. The results of this study indicate that there are several ways to distinguish the four genera of Poaceae. Because the average shape of all the grains is spherical to ovate, one of the main distinguishing characteristics is average size. *Secale cereale* has the largest average size at 28µ, *Hordeum* spp and *Triticum* spp have an average size of 19µ and 20µ respectively, and the smallest starch grains are found with *Avena sativa* at 10µ by 8µ. The hilum is open and centric to slightly eccentric in *Secale cereale* while it is absent in the other three genera. The three other genera typically have extinction crosses with angles other than 90 degrees while *Avena sativa* has an extinction cross with right angle at 90 degree. Overall, it was found in this study that it is fairly easy to identify *Avena sativa* and *Secale cereale* however it is often hard to distinguish between *Hordeum* spp and *Triticum* spp. Reichert suggests that even though the extinction crosses are similar in both *Hordeum* spp. and *Triticum* spp, the extinction crosses in the large granules of *Hordeum* spp. are not as distinct and regular as the extinction crosses in the large granules of *Triticum* spp. Reichert also suggests that, in comparison to the *Triticum* spp., the large *Hordeum* spp starches are not quite as big as the *Triticum* spp. starches and are more reniform and bean shaped (Reichert 1913).

Food plants producing diagnostic starch grains-Rosaceae-Malus pumila- Apple. For this sample, both the mesocarp (fruity interior) and the exocarp (fleshy exterior) of the apple were examined. Apple starches found in the mesocarp average about 7.5µ in diameter and are singular and spherical with rounded edges. Some ovate and quadrilateral shaped starch exceptions are noted. It is interesting to note that there is very little variation in starch grain size for *Malus pumila*. In most cases the lamellae are not visible and the hilum is open with a centric or slightly eccentric location. Although quite rare, one or two starches with a closed hilum were encountered. Starches from this sample either have a single or double wall but always have a smooth surface. The extinction cross is narrow with straight arms at a right angle that are usually quite faint. No fissures or protubrances were encountered (Figure 4.21).

No published sources exist for morphological comparisons.

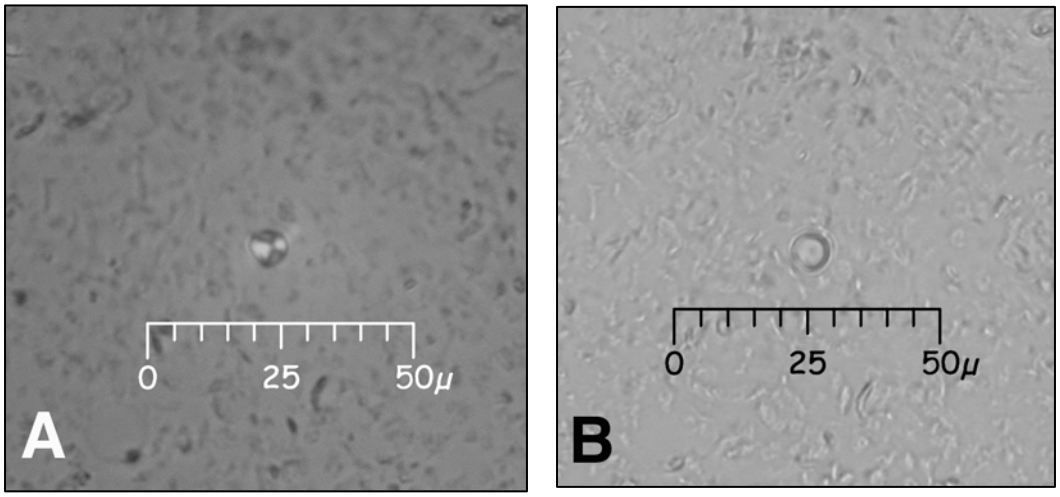


Figure 4.21 Diagnostic starch grains *Malus pumila* A) polarized light (N1608) and B) transmitted light (N1607)

Diagnostic Weed Plants. In contrast to the published works by Reichert (1913), there were no published works for the following species in order to form a basis for comparison.

Diagnostic Weed Plants- Fabaceae- Vicia hirsuta- Hairy vetch. The legume seed was examined for this family. The starch grains found in this species are spherical to ovate individual grains with rounded edges and range between 12.5µ and 35µ in diameter. The average size is 17.5µ by 22.5µ. The hilum is open and centric to slightly eccentric while the lamellae are not visible. All starch grains have a clear, double outer wall and a smooth surface. Some of the starches have a simple linear or a crossed fissure. No protuberances are visible. The extinction cross is has straight, narrow arms at a 90 degree angle with a vacuole in one or two examples. However, these vacuoles are most often associated with visible grinding or processing damage (Figure 4.22).

The starch grain characteristics from this species overlap with some of the starch grain characteristics encountered in other domesticated members of the Fabaceae family. The size and shape of *Vicia hirsuta* are well within the range of *Cicer arietinum, Pisum sativum, Vicia faba,* and *Lens culinaris*. The extinction crosses do not differ dramatically nor do the surface textures and granule angularity. However, the average size of *Vicia hirsuta* differs from the rest of the domesticated legumes and can be used to help distinguish the species. In addition, although *Pisum sativum*, *Vicia faba*, and *Lens culinaris* all have simple linear fissures to some degree, the presence of either simple linear and crossed fissures helps to distinguish *Vicia hirsuta* from its domesticated relatives. Finally, whereas the domesticated legumes generally have some sort of

lamellae, the absence of lamellae in *Vicia hirsuta* can be considered a defining characteristic.

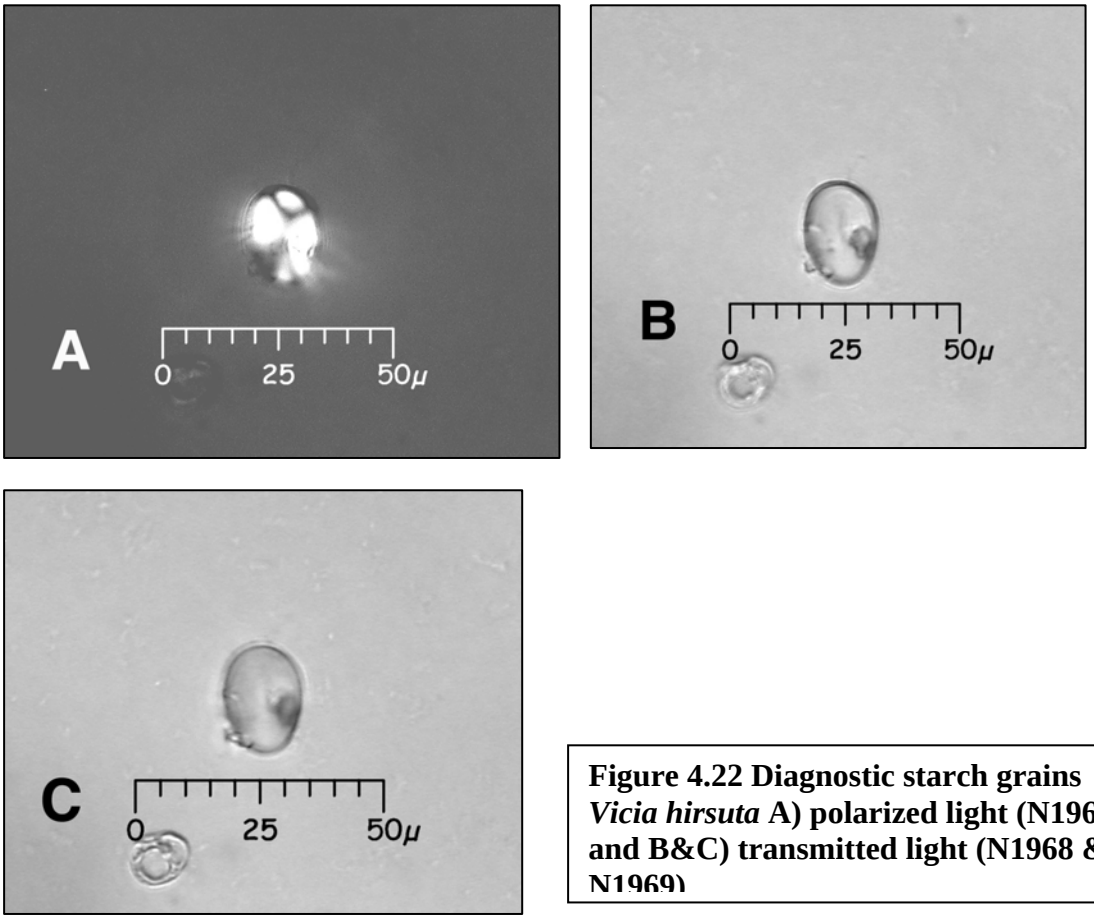


Figure 4.22 Diagnostic starch grains *Vicia hirsuta* A) polarized light (N1967) and B&C) transmitted light (N1968 & N1969)

Diagnostic Weed Plants-Poaceae-Alopecurus praetensis- Meadow Foxtail. The majority of the starch grains found in the seed of this species were very small, no bigger than 7.5µ and hard to analyze. However, there was one large starch grain that appeared to be a compound granule composed of many smaller starches sealed inside a double outer layer. This granule measured 17.5µ by 20µ and was spherical in shape with rounded edges. The hilum was absent along with any fissures or lamellae. The surface was bumpy but it did contain a double outer wall. It did not have a large extinction cross but instead each individual starch within the larger granule had its own extinction cross. These crosses had straight, narrow arms at right angles. The smaller starch grains measured less than 7.5µ. No protuberances were viewed (Figure 4.23).

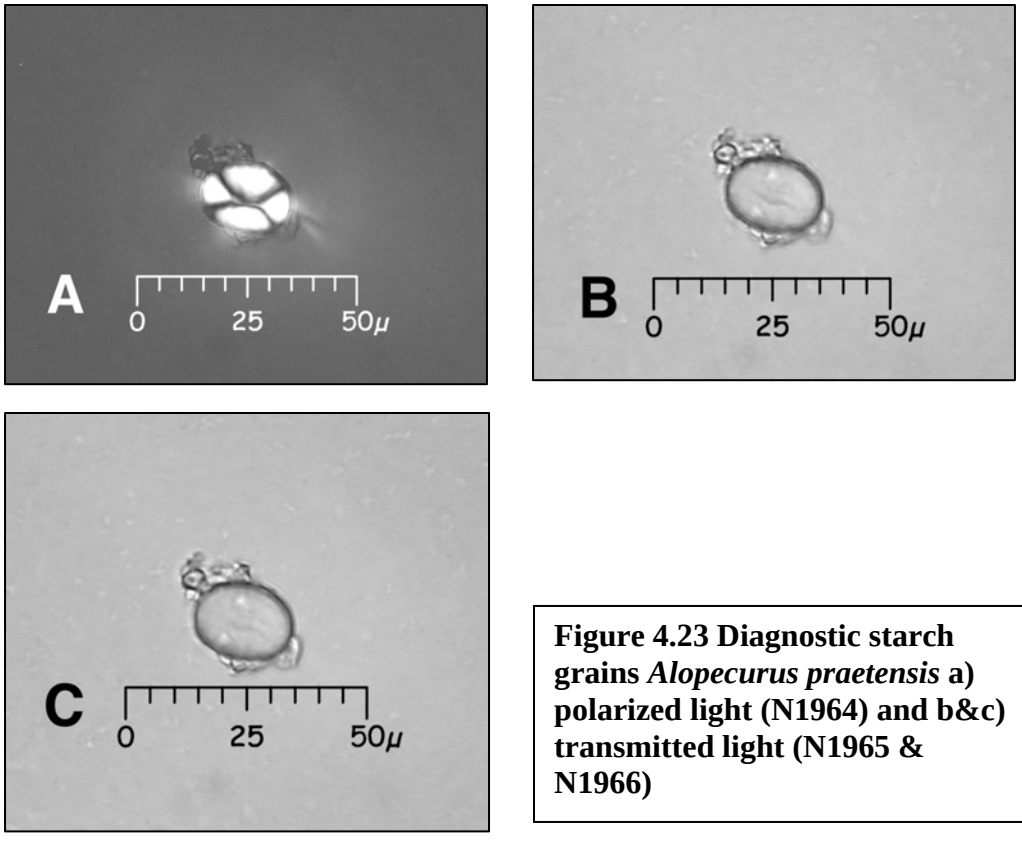


Figure 4.23 Diagnostic starch grains *Alopecurus praetensis* a) polarized light (N1964) and b&c) transmitted light (N1965 & N1966)

Diagnostic Weed Plants-Poaceae-Polygonum convolvulus- Black Binwood. The starch grains in this species were numerous but smaller when compared to their domesticated relatives and averaged about 12.5 microns in diameter. Each granule was spherical in shape but had rounded facets with simple linear fissures. The hilum was open and centric, the lamellae were absent, and the surface was bumpy with a double outer wall. The starch grains were often connected with one typically being slightly larger than the other forming a compound granule. The extinction cross had straight, narrow arms perched at a right angle. No protuberances were found (Figure 4.24).

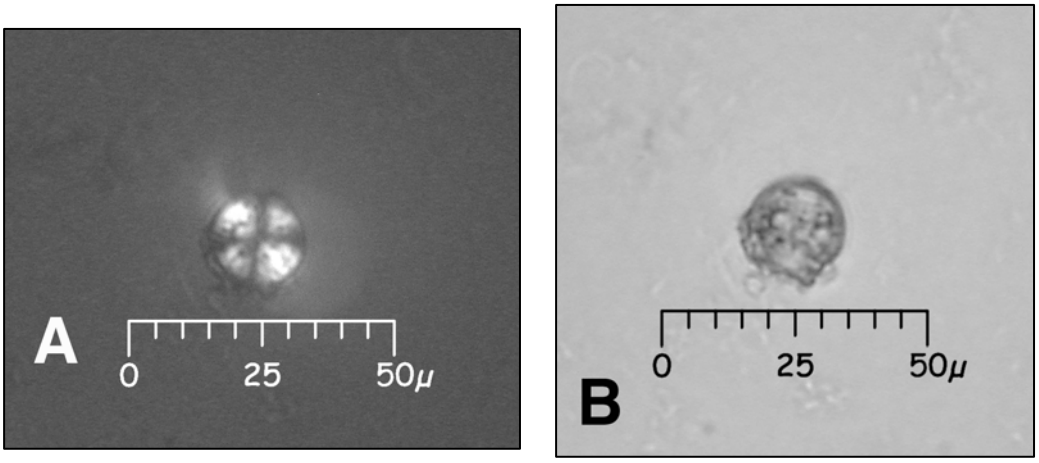


Figure 4.24 Diagnostic starch grains *Polygonum convolvulus* A) polarized light (N2158) and B) transmitted light (N2157)

Discussion of how to tell apart wild and domesticated Poaceae. There are several ways to distinguish between these two wild species of Poaceae. In terms of size and shape, the *Alopecurus pratensis* was either very small (<7.5µ) with generalized features such as a spherical shape and clear exctintion cross at a 90 degree angle or; it had a large compound granule about 17.5µ in size with numerous smaller starch grains contained within. In contrast, the *Polygonum convolvulus* was only about 12.5µ in size and had a faceted, spherical shape. In addition, the hilum was absent in *Alopecurus pratensis* but open and centric in *Polygonum convolvulus*. Finally, *Alopecurus pratensis* does not have a simple linear fissure while *Polygonum convolvulus* does.

It is fairly easy to distinguish the domesticated grasses from the wild, non domesticated grasses in this study. With the exception of *Avena sativa* the wild grasses in this study were much smaller on average than the domesticated grasses. The domesticated grasses all had similar individual, spherical to ovate shapes with smooth edges while the wild grasses could be compound (both species) or simple with a faceted edge (*Polygonum convolvulus*). Yet the most distinguishing difference between the domesticated and wild grasses was the presence of a granular surface on wild grass starches. All of these characteristics can be easily compared in Table 4.10

Diagnostic Weed Plants-Rubiaceae-Galium aparine- Goose grass. The seeds for this species were examined for starch grains. Most of the starch grains found in this species were single spherical grains ranging in size from 10µ to 22.5µ in diameter with an average size of about 15µ. The granules were rounded with no visible lamellae, a smooth surface, and a double outer wall. All of the granules had either a simple linear, crossed, or stellate fissure. The hilum was absent most of the time with a few exceptions having an open and centric hilum. Finally, the extinction crosses were not always clear and had straight, narrow arms at both 90 degree and other angles. No protuberances were observed (N2156, 2159).

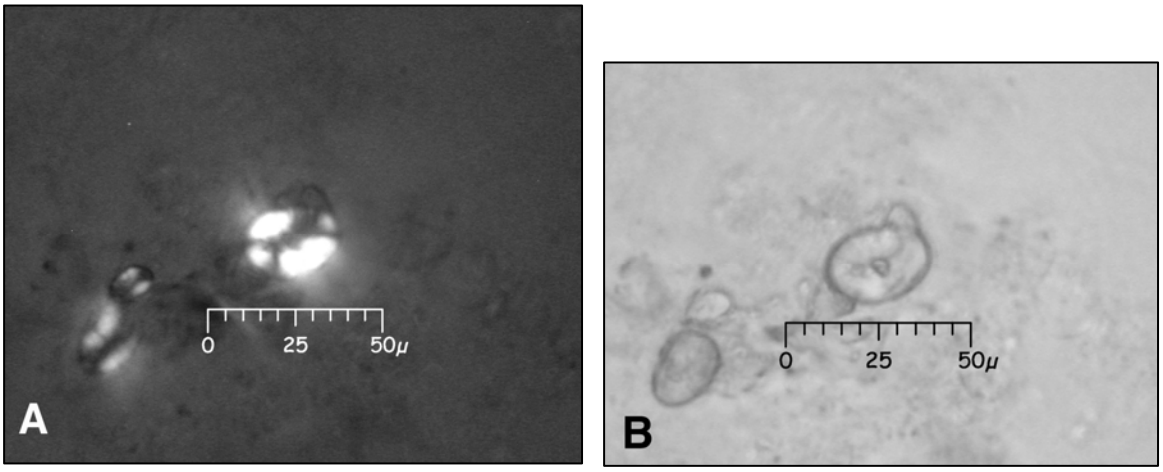


Figure 4.25 Diagnostic starch grains *Galium aparine* A) polarized light (N2159) and B) transmitted light (N2156)

Discussion of how to distinguish between diagnostic starch grains in this study. There are several overall trends that can be used to distinguish the different families and species in this study. When comparing the domesticated Fabaceae and Poaceae families, the domesticated Fabaceae species have the largest starch grains on average. The Fabaceae species also have fine or course lamellae as well as a double wall. In contrast, the domesticated Poaceae do not have lamellae and have single walls. They are also unique because, when viewed from the side, the domesticated Poaceae starch grains have a small but clear fissure. The wild Poaceae lack this unique fissure but these species can be distinguished by their relative small size, rough surface texture, and unique faceted shape or compound granular structure. The wild Fabaceae species is unique because, even though it may overlap in size with some of the domesticated Fabaceae species, it lacks any sort of lamellae and has a wider variety of fissure patterns. The three species not belonging to Fabaceae or Poaceae are not as easily identifiable.

The *Coriandrum satirum* may be hard to distinguish in certain situations because its features are found in many other genera, i.e. medium size, extinction cross at right angle, no lamellae, open hilum, smooth surface, and double wall. The most distinguishing characteristic of *Malus pumila* is its lack of morphological variation. The starch grains from this species are very small and uniform but if found in large quantities in a sample, may be diagnostic of the apple genus. Finally, whereas *Mauls pumila* starch grains were fairly regular, the *Galium aparine* starch grains contained a great deal of variability. The most diagnostic feature of this starch grain is its smaller size (15µ) paired with a fuzzy extinction cross and any number of fissures including simple linear, crossed, or stellate. For a full comparison of the features of these species, see Appendix IC

Limited

The following is a list of plant species that produced one or two generic starch grains per sample (Tables 4.10 & 4.11).

Table 4.10 Limited diagnostic food starches		
Family	**Species**	**Common Name**
Apiaceae	*Daucus carota*	Cultivated Carrot
Apiaceae	*Foeniculuum vulgare*	Fennel
Brassicaceae	*Brassica oleracea*	Cabbage
Brassicaceae	*Brassica* sp	Mustard
Chenopodiaceae	*Betas vulgaris*	Beets
Cucurbitaceae	*Cumuis sativus*	Cucumber
Oleaceae	*Olea europea*	Olive
Rosaceae	*Pyrus communis*	Pear

Table 4.11 Limited diagnostic wild starches		
Family	**Species**	**Common Name**
Asteraceae	*Anthemis cotula*	Stinking mayweed
Caryophyllaceae	*Agrostemma githago*	Corncockle
Caryophyllaceae	*Silene inflate*	Bladder Campion
Chenopodiaceae	*Chenopodium album*	Fathen
Euphorbiaceae	*Euphorbia helioscopia*	Sunspurge
Poaceae	*Alopecurus carolinianus*	Carolina foxtail
Poaceae	*Agropyron inerme*	Beardless wheat grass

Non-Diagnostic

These plants did not produce starch grains at all (Table 4.12 & 4.13).

Table 4.12 Non-producing food plants		
Family	**Species**	**Common Name**
Apiaceae	*Anethum graveolens*	Dill
Apiaceae	*Apium graveolens*	Celery
Arecaceae	*Phoenix dactylifera*	Date palm
Liliaceae	*Allium cep*	Onion
Liliaceae	*Allium porrum*	Leek
Liliaceae	*Allium sativum*	Garlic

Table 4.12 Non-producing food plants cont.		
Family	**Species**	**Common Name**
Moraceae	*Ficus carica*	Fig
Papaveraceae	*Papaver somniforum*	Opium poppy
Pinaceae	*Pinus pinea*	Pine nut (Stone pine)
Rosaceae	*Fragaria* sp	Strawberries
Rosaceae	*Prunus avium*	Sweet Cherry
Rosaceae	*Prunus domestica*	European plum
Vitaceae	*Vitis vinifera*	Grape

Table 4.13 Non-producing weedy plants		
Family	**Species**	**Common Name**
Brassicaceae	*Sinapis arvensis*	Charlock

CHAPTER 5: ARCHAEOLOGICAL RESULTS AND DISCUSSION

Are the Survey Artifacts Contaminated by Their Environment?

As was discussed in the introduction section, artifact contamination can be assessed by comparing the phytoliths and starch grains found in sediments 1, 2, and 3 of the survey artifacts with the microfossils found in the immediate surrounding soil and the microfossils found on a control set of artifacts. In the case of this project, three different sets of artifacts and soils were examined, i.e. potterspuryware, medieval shellyware, and early medieval sandyware. The three artifacts were collected from the freshly plowed field Wicken 13 and compared with their surrounding soils. In order to account for random variation, a control sample of contemporaneous artifacts was studied from Durley Cottage, Cambridgeshire, England and compared to those found in Wicken, Northamptonshire. It was hypothesized that artifact contamination occurred if weedy types of phytoliths and starch grains associated with fallow fields were found in the sediment 2 and 3 of the survey artifacts. If sediments 2 and 3 of the survey artifacts matched the microfossil assemblage from the surrounding soils but did not match the control sample, then secondary residues were deposited and artifact contamination occurred. In contrast, if the microfossils found in sediments 2 and 3 of the survey artifacts did not match the soil but matched the control sample, then secondary residues were not deposited and artifact contamination has not occurred.

Because the data are small, ubiquity was used to understand contamination instead of absolute counts. The raw counts were converted to simple x marks to represent the presence of a phytolith or starch grain type. Converting the numbers allowed for easy

ubiquity assessment via tables (Tables 5.1-5.6). Raw starch grain and phytolith counts can be seen in IIA-IIF in the appendix. Sediments 1, 2, and 3 were examined for the Wicken ceramics while sediments 2 and 3 were examined for the Durley cottage artifacts. Only sediments 2 and 3 were available for examination of the Durley Cottage artifacts because the artifacts did not contain enough loose soil on the surface to allow for a sediment 1 sample.

Phytolith Results

The phytolith data were scarce for each artifact and soil sample studied. Only 13 non-diagnostic and two diagnostic phytolith types were found with the potterspuryware sample. 11 non-diagnostic and four diagnostic types were associated with the medieval shellyware sample. 13 non-diagnostic types and two diagnostic types were encountered with the early medieval sandyware sample. Overall, only four types of diagnostic phytoliths were found in all three sample sets. These types included: I2g (sheet elements having clavate protuberances over the entire surface), Va2a (trapezoid, length 2x width, margins alate, lobed), wavy long cells, and papillae. Unfortunately, none of the weedy types studied in the phytolith comparative collection were found in the soil or artifact samples. The first set of artifacts to be examined is the single sherd of potterspuryware that was found in field WI-13 in Wicken.

For the potterspuryware sample in Wicken, sediments 1, 2, and 3 were analyzed for phytoliths along with the surrounding soil. After analyzing the data, several patterns emerged. Some of the phytoliths found in the soil were also found in sediments 1 and 3 of the artifact. Of the 15 phytolith types discovered, seven types, including the festucoid simple short cells, rondel/square complex short cells, I2g (sheet element, protuberances

clavate), Va2a (trapezoid, margins alate and lobed, ridged top), Vb2 (trapezoid, long, margins entire), and two new types, the scrutiform lacunose prickle, and the tabular lacunose prickle, were found in the sediment one, sediment two, and soil samples (Table 5.1). Two of the phytolith types, I2g and Va2a, held diagnostic value and were either characteristic of wheat (*Triticum* sp) (I2g) or generally characteristic of the cultivated old world grains except for rye (*Secale* sp) (Va2a).

In addition, because the four remaining phytolith types are produced in a wide variety of both domesticated and wild plants, they could be associated with either primary or secondary deposition.

In contrast, some phytoliths were found only in one sample type. For example, a redundant Va1b type (trapezoid, margins sinuous, 1-riged top), was found exclusively in the soil samples while panicoid and chloridoid simple short cells were found only in sediment 1 fraction (Table 5.1). The long cell, Ia (sheet element, margins sinuous), was found only in sediment 2. Unfortunately, potterspuryware was not found at the Durley Cottage and so cannot serve as a control mechanism for this sample. Finally, note that no economic phytoliths were recovered from sediment 3. In fact, no phytoliths of any kind were recovered from the sediment 3 sample.

Table 5.1 Presence vs. Absence of Economic Phytoliths found on Potterspuryware Sherd and in the Surrounding Soil from Wicken Field 13

Slide #	Context	Panicoid simple short cell	Festucoid simple short cell	Chloridoid Simple short cell	Rondel/Square complex short cell	Ia	Ib	I2g	Va1a	Va1b	Va1c	Va2a	Va2b	Vb1	Vb2	scrutiform lacunose prickle	tabular lacunose prickle	Papillae	Wavy long cells
2674 W	**Sed 1**	X	X	X	X		X	X	X			X	X	X	X	X	X		
2680 W	**Sed 2**		X		X	X		X				X			X	X	X		
2688 W	**Sed 3**																		
2982 W	**Soil**		X		X		X	X	X	X		X	X	X	X	X	X		

X= present

The second set of artifacts and soils studied was the medieval shellyware ceramic found in field WI-13, the soil surrounding it, and a medieval shellyware sherd recovered from under the floorboards at Durley Cottage. Most of the phytoliths found with the medieval shellyware sample in Wicken were found in the nearby soil. At WI-13, seven types were found exclusively in the soil, three types were found in the soil and in sediment 1 of the shellyware sherd, and two phytolith types were found in the soil and both sediments 1 and 2 (Table 5.2). With the exception of the type I2g, Va2a, and a wavy long cell, almost all of these types were redundant. Once again, no phytoliths were found in the sediment 3 sample.

Very few phytoliths were discovered on the medieval shellyware ceramics taken from Durley Cottage, including none from sediment 3. The only major phytolith type of any significance was the delicate papillae discovered in the sediment 2 sample. The significance of this find will be discussed below.

Table 5.2 Presence vs. Absence of Economic Phytoliths found on Two Early Medieval Sandyware Ceramics from Wicken Field 13 and Durley Cottage as well as from the Surrounding Soil from Wicken Field 13

Slide	Context	Panicoid simple short cell	Festucoid simple short cell	Chloridoid Simple short cell	Rondel/Square complex short	Ia	Ib	I2g	Va1a	Va1b	Va1c	Va2a	Va2b	Vb1	Vb2	scrutiform lacunose prickle	tabular lacunose prickle type	Papillae	Wavy long cells
	Ceramic 1 WI-13																		
2676W	**Sed 1**	X	X		X									X		X	X		
2682W	**Sed 2**		X									X				X			
2690W	**Sed 3**																		
2984	**Soil**	X	X	X	X		X	X	X			X	X		X	X	X		X
	Ceramic 2 Durl Cott																		
2719W	**Sed 2**																	X	
2727W	**Sed 3**																		

X= Present

The third and final set of artifacts used to study contamination was the early medieval sandyware sherd, its associated surface soil, and the early medieval sandyware sherd found at Durley Cottage. The majority of phytolith types found with this artifact type at WI-13 were associated with the nearby soil samples. Of the 15 phytolith types discovered, 11 were found only in the soil contexts (Table 5.3). Four phytolith types, including the diagnostic Va2a type, were found in both the sediment 2 and soils samples. One diagnostic I2g type was found exclusively in the soil. The Durley Cottage sherd once again produced very few phytoliths with only the scrutiform lacunose prickle type present in the sediment 3 sample.

Table 5.3 Presence vs. Absence of Economic Phytoliths found on Two Early Medieval Sandyware Ceramics from Wicken Field 13 and Durley Cottage and From the Surrounding Soil in Wicken Field 13

Slide	Context	Panicoid simple short cell	Festucoid simple short cell	Chloridoid Simple short cell	Rondel/Square complex short	Ia	Ib	I2g	Va1a	Va1b	Va1c	Va2a	Va2b	Vb1	Vb2	scrutiform lacunose prickle	tabular lacunose prickle	Papillae	Wavy long cells
	C-1																		
	WI-13																		
2675W	**Sed 1**																		
2681W	**Sed 2**		X		X							X				X			
2689W	**Sed 3**																		
2983	**Soil**	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		
	C-2																		
	Durley Cot																		
2686W	**Sed 2**																		
2694W	**Sed 3**															X			

X= present

Phytolith Discussion

The ubiquity data indicates that the phytoliths in the soil and from the surrounding environment may have contaminated the artifacts recovered during survey work. The original hypothesis suggests that if the residues, specifically sediments 2 and 3, found on the survey artifacts closely matched the microfossils found in the nearby soils but do not

match sediments 2 and 3 of the control artifacts, then secondary deposition, i.e. contamination, has occurred. Specifically, the presence of unique weedy type of phytoliths found in sediments 2 and 3 would indicate secondary residue deposition. Conversely, if the survey artifacts do not match the surrounding soils but match the control artifacts, then secondary deposition has not occurred. To rephrase the hypothesis, did sediments 2 and 3 from the survey artifacts match the soil microfossil assemblage? And, did the sediments 2 and 3 from the survey artifacts match the control sample? The answers to those questions are yes and no respectively.

In the potterspuryware sample, the residues found on the artifact closely matched those found in the nearby soil. Because there was no corresponding potterspuryware artifact at Durley cottage, that part of the hypothesis cannot be addressed. The potterspuryware sample may have had secondary deposition because most of the phytolith types found in the sediment 2 samples were also found in the sediment 1 and nearby soil samples. Of the 15 types found, 13 were found in both the soil and on the survey artifact.Two types were found only in the sediment 1 sample; 4 types were found in both the sediment 1 and the nearby soil sample; and 7 types were found in the sediments 1, 2, and soil (Table 5.1). Because the sediment 1 sample is the loose dirt on the artifact, the phytoliths contained therein are representative of the nearby soil. The sediment 2 sample should be more closely associated with artifact use and should have phytolith types not found in the soil or sediment 1. Instead, only one phytolith type was found exclusively in the sediment 2 sample, a redundant Ia type. The sediment 3 sample was completely devoid of phytoliths altogether. The overall picture of the phytoliths found with the potterspuryware is one of possible contamination for two reasons; 1)

because the phytoliths most closely associated with primary deposition (sediment 3) are absent and 2) almost all the phytoliths that are found in the sediment 2 sample, which is normally linked with tool use, are also found in the sediment 1 and soil samples. Thus, according to the hypothesis, some secondary residues may have been deposited on the potterspuryware ceramic.

The phytoliths found in the early medieval shellyware ceramics closely match those found in the soil and do not match those found on the control artifacts. Of the 15 types found, only three (festucoid simple short cell, Va2a, and scrutiform lacunose prickle) were found in the sediment 2 samples (Table 5.2). However, these types were not exclusively found in sediment 2 but were also found in the sediment 1 and soil samples. No phytolith types were found exclusively in the sediment 2 sample and no phytolith types at all were found in the sediment 3 sample. The one phytolith type that was found with the control sample at Durley Cottage, a papillae, was not found on the early medieval shellyware. The net result illustrating that the phytolith assemblage of the early medieval shellyware matches that of the surrounding that because there were no types found in sediment 3 sample and the types found in the sediment 2 samples were also found in the sediment 1 and soil sample, soil. The phytolith assemblage of this survey artifact does not match the assemblage at Durley Cottage.

The results of the early medieval sandyware ceramic were a little more difficult to interpret. The phytolith assemblage of the early medieval sandyware did match the soil phytolith assemblage. Four phytolith types found on the artifact were in the sediment 2 sample but were also found in the soil assemblage. Of the 15 types discovered, no types were found exclusively in the sediment 2 sample and no phytoliths at all were found in

the sediment 3 sample. Thus, phytoliths found on the early medieval sandyware match those found in the soil because the phytoliths found in the sediment 2 sample were also found in the soil sample thereby indicating possible secondary deposition according to the hypothesis. A problem arises when the results between the control and survey artifact are analyzed.

The early medieval sandyware artifact from Durley Cottage only had one phytolith type, a scrutiform lacunose prickle. The sediment 2 from the survey artifact also contained a scrutiform lacunose prickle type. Thus, the two artifacts appear to match because they share one phytolith type. This should indicate that there was no contamination on the survey artifact. Upon closer inspection, the phytolith type is found both on the sediment 2 sample and in the surrounding soil. Its presence in the sediment 2 sample could be argued as evidence of its status as a primary residue. However, sediment 2 samples sometimes contain secondary residues and the presence of this type in the soil sample raises doubt as the nature of its primary or secondary status. Therefore, this is not strong enough evidence to suggest that residues found on the early medieval sandyware artifact are primary in nature simply because they match one type found in the control sample. Overall, the phytolith residues from the sediment 2 sample of the early medieval sandyware match those found in the soil supporting the hypothesis that secondary deposition has occurred.

In general, the phytoliths found in the sediment 2 samples of the potterspuryware, medieval shellyware, and early medieval sandyware match those found in soil phytolith assemblages thereby supporting the first hypothesis for secondary residues deposition. However, the phytoliths on the medieval shellyware do not match those found in the

control sample but the phytoliths on the early medieval sandyware do match the control sample to a limited degree. This appears to both support the first and second hypotheses. Perhaps the starch grain data may shed light onto the perplexing subject of secondary residue deposition.

Starch Grain Results

The starch grain data were very sparse with only six starch grain types and 12 grains overall discovered. These types included the following: unknown grains, unidentifiable grains, *Triticum* sp or *Hordeum* sp, *Triticum* sp., *Alopecurus praetensis*, and *Hordeum vulgare*. Unknown grains are starch grains whose defining characteristics are easily viewed yet the granule does not match any of the types established in the comparative collection. Unidentifiable grains are granules whose features are obscured by such things as dirt or damage thereby rendering identification tenuous at best. In addition to the small number of grains recovered, no grains were found in the sediment 3 samples.

In the potterspuryware sample from field WI-13 in Wicken, starch grains were found in the sediment 1, and soil fractions (Table 5.4). The starch grain in the sediment 1 could not be properly identified and was placed in the unknown category. The grain itself was a single small, 7.5µ in diameter, had a spherical shape, round angularity, fine lamellae, a smooth surface, and a double outer wall. It lacked a hilum, fissures, protuberances, and an extinction cross (Figure 5.1). The surrounding soil contained probable *Hordeum vulgare* cf. starch grains because of its size (15µ by 15µ) and extinction cross. (Table 5.4).

Table 5.4 Potterspuryware Starch Grain Comparison

Slide #	Context	Unidentifiable	Unknown	Triticum or Hordeum	Triticum	Alopecurus praetensis	Hordeum vulgare (Poaceae for
SS 586	Sed 1		X				
SS 592	Sed 2						
SS 600	Sed 3						
SS 912	Soil						X

X=present

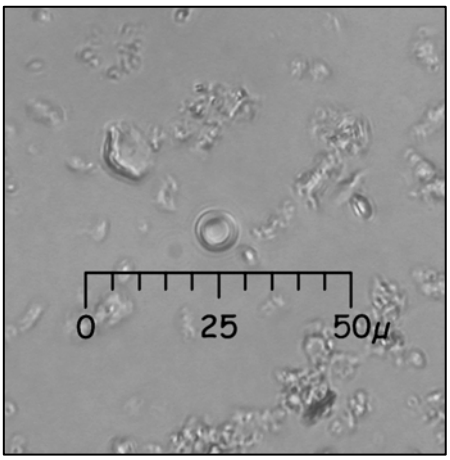


Figure 5.1 Unknown starch grain found on freshly collected survey Potterspuryware, transmitted light (N1692)

The medieval shellyware samples from WI-13 in Wicken contained an unidentifiable type found in the sediment 2 fraction of the medieval shellyware from Wicken, a wild type of grass, *Alopecurus praetensis* , in the soil sample from Wicken, and two unknown types in the sediment 2 sample from Durley Cottage (Table 5.5). The unidentifiable type from the sediment 2 sample in Wicken was a flat grain about 15µ in diameter, covered with dirt, and could only be spotted due to its damaged extinction cross (Figure 5.2) The two unknown types found in the sediment 2 sample from Durley Cottage are quite different from each other but both exhibited some form of central grinding damage. The first unknown grain was singular and measured 17.5µ by 15µ in diameter; had an extinction cross with a central vacuole and straight, narrow arms at a right angle; round angularity; smooth surface; and a double outer wall. The hilum, fissures, protuberances, and lamellae were absent. Unfortunately the granule shape could not be determined because it would not roll when examined on the slide (Figure 5.3).

The second unknown starch grain from the sediment 2 sample of Durley Cottage measured 17.5µ by 12.5µ, had a spherical shape with straight facets; no lamellae; an extinction cross with a vacuole and straight, narrow arms at a right angle; an open, centric hilum; crossed fissures; smooth surface; and a double outer wall. No protuberances were visible (Figure 5.4).

Table 5.5 Medieval Shellyware Starch Grain Comparison

Slide #	Context	Unidentifiable	Unknown	Triticum or Hordeum	Triticum	Alopecurus praetensis	Hordeum vulgare (Poaceae for sure)
	Ceramic 1						
	WI-13						
SS 588	**Sed 1**						
SS 594	**Sed 2**	X					
SS 602	**Sed 3**						
SS 914	**Soil**					X	
	Ceramic 2						
	Durley Cot						
SS 631	**Sed 2**		X				
SS 639	**Sed 3**						

X=present

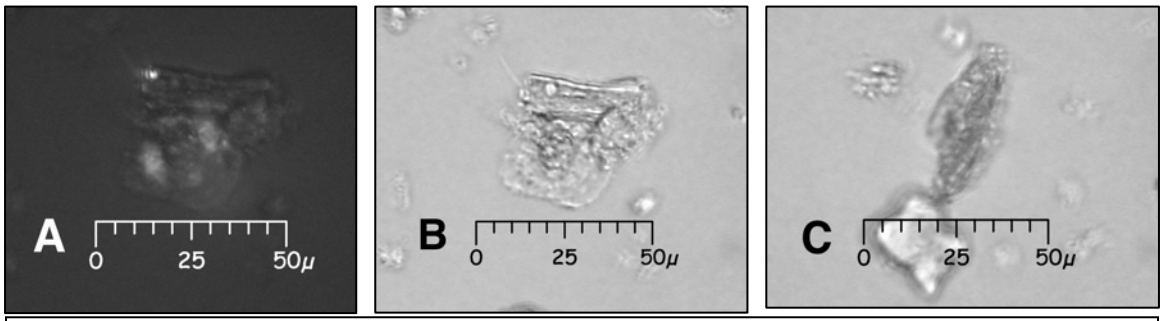


Figure 5.2 Unidentifiable starch grain found on freshly collected medieval shellyware A) polarized light (N2035) and B&C) transmitted light (N2036 & 2037)

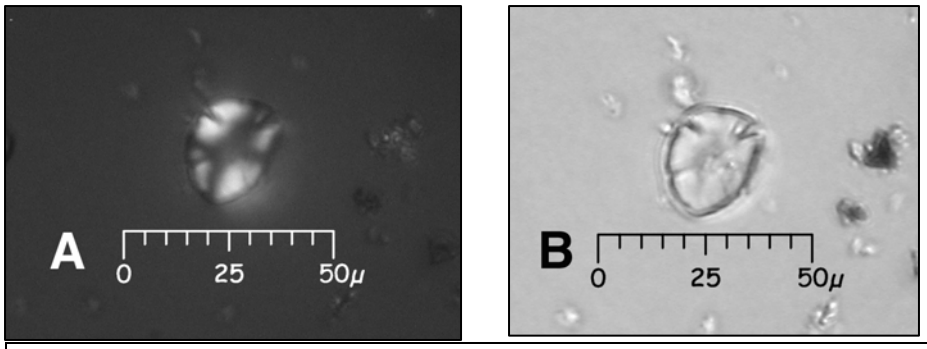


Figure 5.3 Unknown starch grain found on medieval shellyware from Durley Cottage A) polarized light (N2044) and B)transmitted light (N2045)

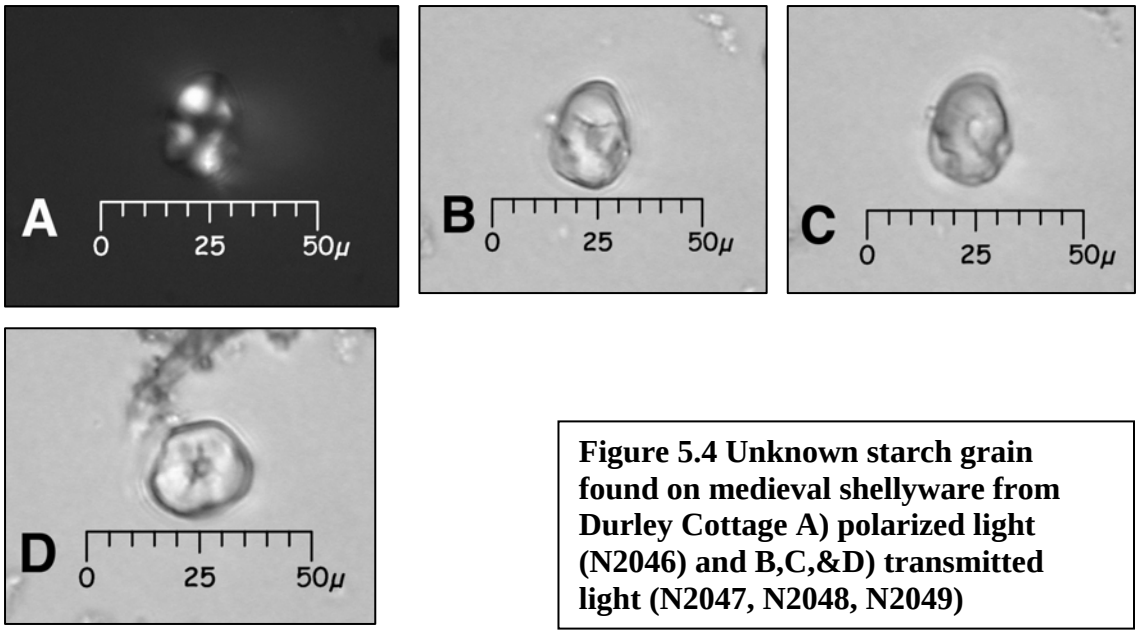


Figure 5.4 Unknown starch grain found on medieval shellyware from Durley Cottage A) polarized light (N2046) and B,C,&D) transmitted light (N2047, N2048, N2049)

Finally, a singular *Triticum* sp. or *Hordeum* sp was found in the sediment two of the early medieval sandyware from WI-13 in Wicken, and three *Triticum* sp. and an unidentifiable starch type were found in the soil sample (Table 5.6). The identification of the *Triticum/Hordeum* spp starch granule was based primarily on shape (spherical) and size (20µ by 17.5µ) because both fell within the range of variation for *Triticum* sp and *Hordeum* sp size and shape characteristics. The small starch grain (12.5µ by 10µ) found in the soil was unidentifiable because of its central damage and dirty appearance (Figure 5.5). The *Triticum* sp identification of the starches in the soil context was based on the size (20µ by 20µ) and broadness of the arms in the extinction cross. The early medieval sandyware sherd from Durley Cottage contained no starch grains (Table 5.6).

Table 5.6 Early Medieval Sandyware Starch Grain Comparison

Slide #	Context	Unidentifiable	Unknown	Triticum or Hordeum	Triticum	Alopecurus praetensis	Hordeum vulgare (Poaceae for sure)
	Ceramic 1 WI-13						
SS 587	**Sed 1**						
SS 593	**Sed 2**			X			
SS 601	**Sed 3**						
SS 913	**Soil**	X			X		
	Ceramic 2 Durley Cot						
SS 598	**Sed 2**						
SS 606	**Sed 3**						

X= present

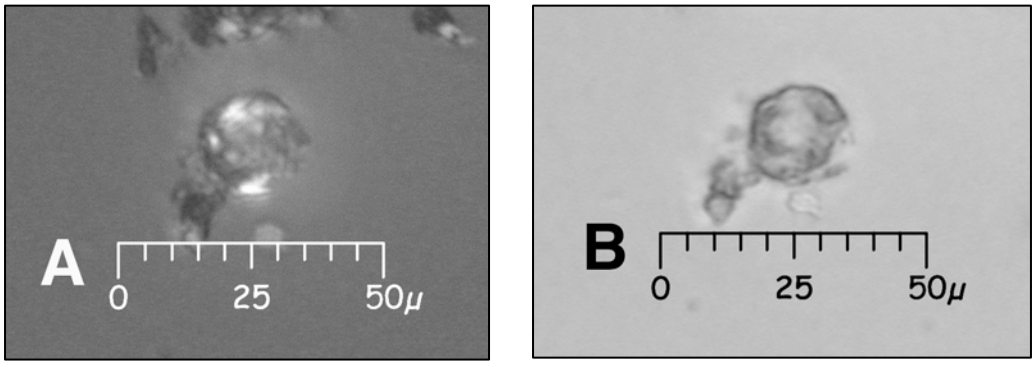


Figure 5.5 Unidentifable starch grain found in the soil near the early medieval sandyware ceramic A) polarized light (N2186) and B) transmitted light (N2185)

Starch grain discussion

Addressing the issue of artifact contamination through the use of starch grain analysis is a bit more problematic because of the small quantity of remains recovered. The data from the potterspuryware sample are inconclusive because no starch grains were recovered from sediments 2 and 3 (Table 5.4). One starch grain was recovered from the sediment 1 sample but because sediment 1's are not associated with primary residues, it cannot be used for comparative analysis.

The data from the medieval sandyware sample also proves to be inconclusive. In this instance, there is a single unidentifiable starch grain found in the sediment 2 sample from Wicken. However, because it is unidentifiable it cannot be used to determine if the residues from the artifact match with the weedy starch grain found in the soil sample (*Alopecurus praetensis*) or with the unknown starch grain found in the sediment 2 sample from the control set (Table 5.5). Therefore, the hypotheses cannot be confirmed or rejected using this data set.

Finally, the residues found in the sediment 2 sample from the early medieval sandyware ceramic in Wicken match those starch residues found in the soil. This assessment is tenuous at best because it is not a simple one-to-one match of starch grains. The sediment 2 sample contains a starch grain that is identified as *Triticum/Hordeum*. The soil samples contain unidentifiable and *Triticum* sp. starches (Table 5.6). If the sediment 2 starch grain belongs to the *Triticum* genus, then the artifact and the soils do match and the original hypothesis related to secondary residue deposition is confirmed. If however, the sediment 2 starch grain is truly *Hordeum* sp., then the artifact and the soils do not match and the hypothesis related to secondary deposition is rejected. The complete lack of starch grains in the sediment 3 sample from Wicken and the control sample from Durley Cottage do not strengthen or weaken the argument for secondary residue deposition. Thus, the only artifact that may exhibit possible starch secondary residue deposition is the early medieval sandyware ceramic

Conclusions

The results of this study indicate that the potterspuryware, medieval shellyware, and early medieval sandyware ceramics were contaminated by their environment Published research has demonstrated that when analyzing artifact residues, the sediment 1 sample is most closely associated with the microfossil assemblage of the surrounding soils, i.e secondary residues; the sediment 2 sample is associated with the primary residue with some possible secondary residue deposition, and the sediment 3 is closely associated with the artifact and primary residue deposition (Pearsall et al. 2004).

Because of the association between primary and secondary residues and where they may be found in a sediment fraction, the original hypothesis of this study stated that

if the phytoliths and starch grains in the sediment 2 and 3 samples matched the surrounding soil assemblages and did not match the control sample, then secondary residues have been deposited. Conversely, if the microfossils from the sediment 2 and 3 samples did not match the soil but did match the control sample, then secondary residues have not been deposited. The data supports the first hypothesis detailing artifact contamination.

In each one of the ceramics, secondary residues were deposited because the phytoliths found in the sediment 2 matched those found in the nearby soil. The potterspuryware shows some degree of contamination because the phytoliths found in the sediment 2 samples closely match those found in nearby soils. Unfortunately assessment is tenuous because no comparison to a potterspuryware ceramic in the control sample was possible and the starch grain data proved to be inconclusive. The early medieval sandyware ceramic had the most conclusive evidence because both the phytolith and starch grain assemblages matched the soil assemblage. The phytolith assemblage from this artifact also matched that of the control sample. However, because only one phytolith type, a redundant scrutiform lacunose prickle, was found in the control sample, the survey artifact, and the soil sample, it does not necessarily rule out the possibility of secondary residue deposition. Finally, the medieval shellyware also showed evidence of contamination because, even though the starch grains proved to be inconclusive, the phytolith assemblage matched the soil assemblage and did not match the control sample.

Further discussions

The overall results of this study bring up two very interesting questions: what happened to the sediment 3 residues? and how did the survey artifact microfossil assemblage come

to closely match the surrounding soil assemblage. Interpreting absence is always a hard task for any scientist. One must remember the old adage: absence of evidence is not evidence of absence. However, several possible explanations exist for the absence of any residues in the sediment 3 samples.

Absent sediment 3 residues

Two possibilities exist for explaining why the sediment 3 samples contained no microfossils. One possibility holds that while the survey artifacts rested in the fields, the original residues were completely scraped off during the plowing process. Eventually, with time, the primary residues were replaced by residues found in the surrounding environment. This scenario seems highly unlikely for several reasons. Sediment 3 samples represent microfossils that are embedded in the deepest cracks and crevices of an artifact and can only be removed through the use of water and sonic energy in the form of a sonicator. It seems highly unlikely the simple churning action of a plow could remove the deep microfossils from the surface of an artifact. Secondly, this scenario would also imply that all the primary residues from the survey artifacts, not just the sediment 3 samples, would have to be completely removed during the farming process leaving nothing behind, a very highly unlikely possibility. Finally, this scenario doesn't account for the lack of microfossils found in the sediment 3 samples of the control set of artifacts from Durley Cottage. It seems that the explanation for the missing sediment 3 samples is far simpler.

The simplest explanation for the absence of any sediment 3 microfossils may be that they were never there to begin with. The pathways in which phytoliths and starch grains end up on artifacts are long and complex. Perhaps the artifacts that were sampled

had been cleaned thoroughly before they were discarded thereby removing most of the residues. However, even after cleaning a tool, residues are sometimes still found on an artifact.

Some of the preliminary work conducted here at the MU paleoethnobotany laboratory has indicated that the depositional patterns of microfossils on artifacts may also be a factor. Unpublished experimental archaeological work here at MU has demonstrated that phytoliths and starch grains can become concentrated in certain areas of ceramics that correspond with different cooking methods. In this preliminary study, the phytoliths and starch grains form a concentrated ring around the top of the cooking vessel that relates to the height of the water used to cook gruel or stew. In both of these studies, the phytoliths and starch grains are not universally distributed across an artifact but instead are concentrated in specific areas. Perhaps the sherds that were sampled came from a section of the vessel where very few starch grains or phytoliths were deposited, i.e. the side portion of a cooking vessel.

Finally, the simplest explanation is that the artifacts were not used in food production and consumption. If that were the case, no primary sediment 3, or even sediment 2 residues would be expected. This explanation would certainly account for the lack of sediment 3 residues as well as the similarities between the survey artifact microfossil assemblage and the soil assemblage.

Phytolith and starch grain contamination and pathways

The results of this study show that some degree of environmental contamination has occurred on the three ceramics studied. The starch grains and phytoliths found in the sediment 2 samples match those found in the nearby soil and do not, for the most part, match those found in the control sample. Therefore it is entirely possible, as is evident with the study conducted by Barton et al. (1998) that the microfossils from the surrounding soil made their way onto the artifacts themselves. However, because there were no diagnostic weedy types found in the sediments 2 and 3 that could be used to pinpoint contamination, such as the types established in the comparative collection, alternative means of explanation for the similarities should be explored.

As stated above, there are many ways in which plant microfossils can become attached to the surface of an artifact. The generally assumed pathway of contamination is from the surrounding environment, such as the soil and nearby plant matter, to the artifact. However the movement of phytoliths and starch grains is not restricted to one direction i.e. from the soil to the artifact. Instead, it is possible that microfossils move in the reverse direction transferring from the artifacts to the surrounding soils.

Plant microfossils do not simply leap from the artifact into the soil at random. They require some sort of physical action to move them from one context to another. The rolling and tumbling associated with plowing a field provides the perfect opportunity for some of the residues to become dislodged from the artifact and be deposited in the nearby soils. If some of the residues were transferred from the artifact to the soil, the end result of this process would be similar microfossil assemblages in both the soil and artifact contexts.

Are there differences between archaeological and freshly plowed soil phytolith assemblages?

This question was not originally posed at the outset of this study but emerged as the soils from the survey and archaeological contexts were analyzed. As they were studied, major differences in phytolith taphonomy began to surface. Note, the patterns discussed in this section were found only with the recovered soil phytoliths but not with the recovered soil starch grains.

Phytolith Results

In this study, there appears to be a distinctive difference in the types of phytoliths found in the archaeological soils versus those found in the freshly farmed soils of WI-13 encountered during survey work. In the freshly farmed soils of Wicken, two new phytolith types, scrutiform lacunose prickle and tabular lacunose prickle phytoliths, are quite common (Figure 5.6). However, in the archaeological soils of an excavated manor in Wicken, these phytoliths, which are nondiagnostic and considered to be background types, are noticeably absent (Figure 5.7).

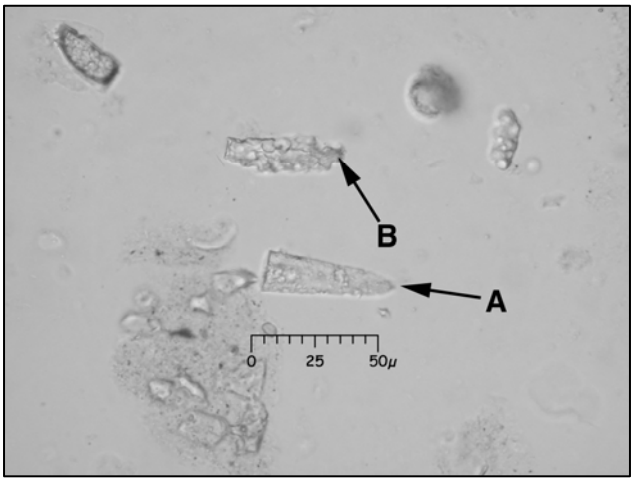
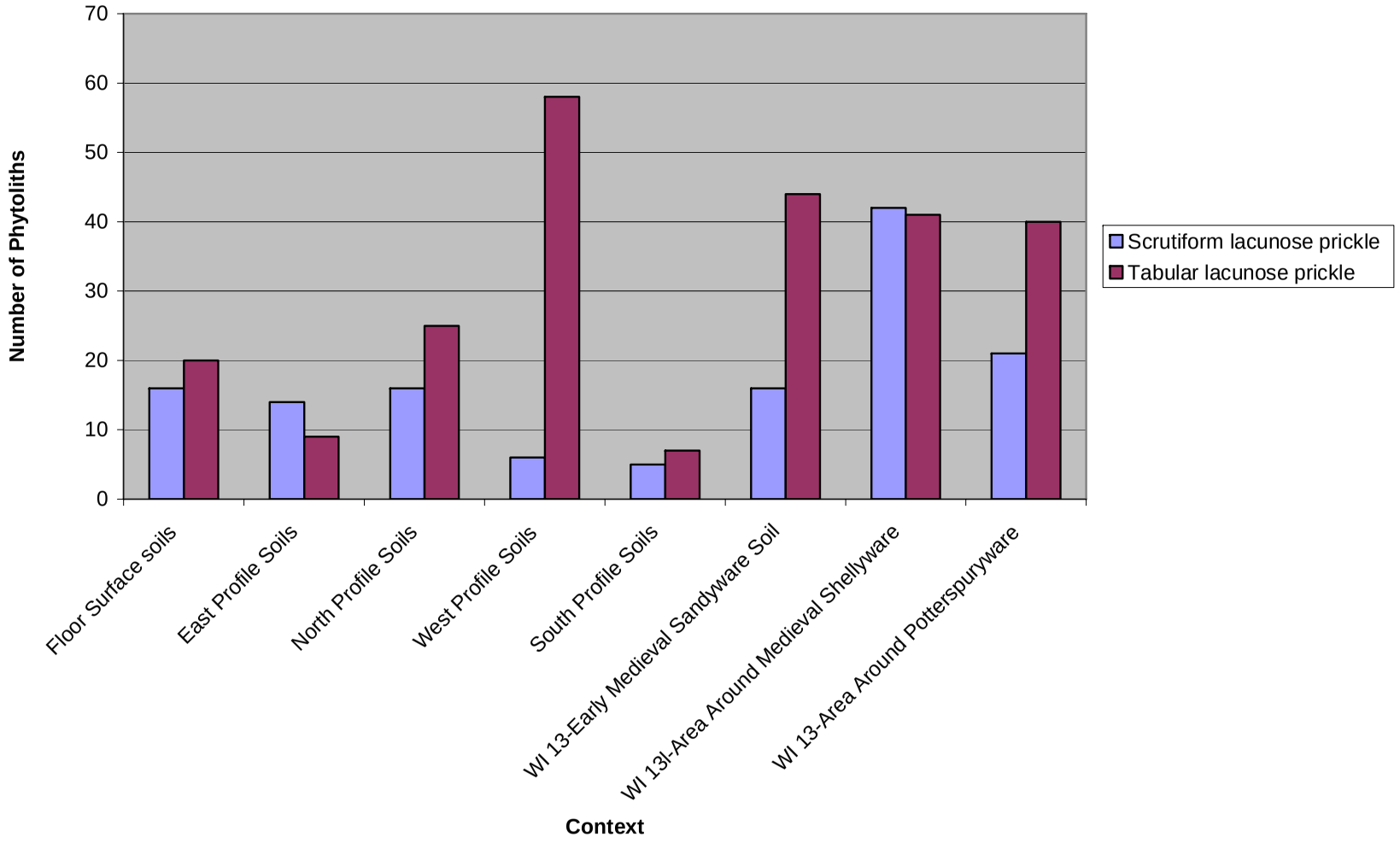


Figure 5.6 Unknown phytoliths A) scrutiform lacunose prickle and B) tabular lacunose prickle

Figure 5.7 Nondiagnostic Phytoliths in Excavated and Survey Soils in Wicken



In contrast, the excavated soils appear to have more rondel/square complex short cells (Figure 5.8) and fragile phytolith types such as wavy long cells and papillae (Figure 5.9) than do the field soils. Overall, the rondel/square complex short cells appear in higher percentages in the excavated soils than they do in the freshly plowed soils of field WI-13 (Figure 5.10). The higher quantity of rondel/square complex short cells may be a function of the activities of the abandoned house but the presence of fragile phytolith types such as papillae and complete wavy long cell sheets may provide insight into land use practices. For example, when combined with archaeological evidence, high quantities of domesticated phytolith grasses such as diagnostic papillae and complete wavy long cell sheets at a site would suggest that the site was used either for processing or storing grain supplies.

Figure 5.8 Number of Rondel/Square Complex Short Cell Phytoliths Found in the Soils at the Excavated House and WI 13 in Wicken

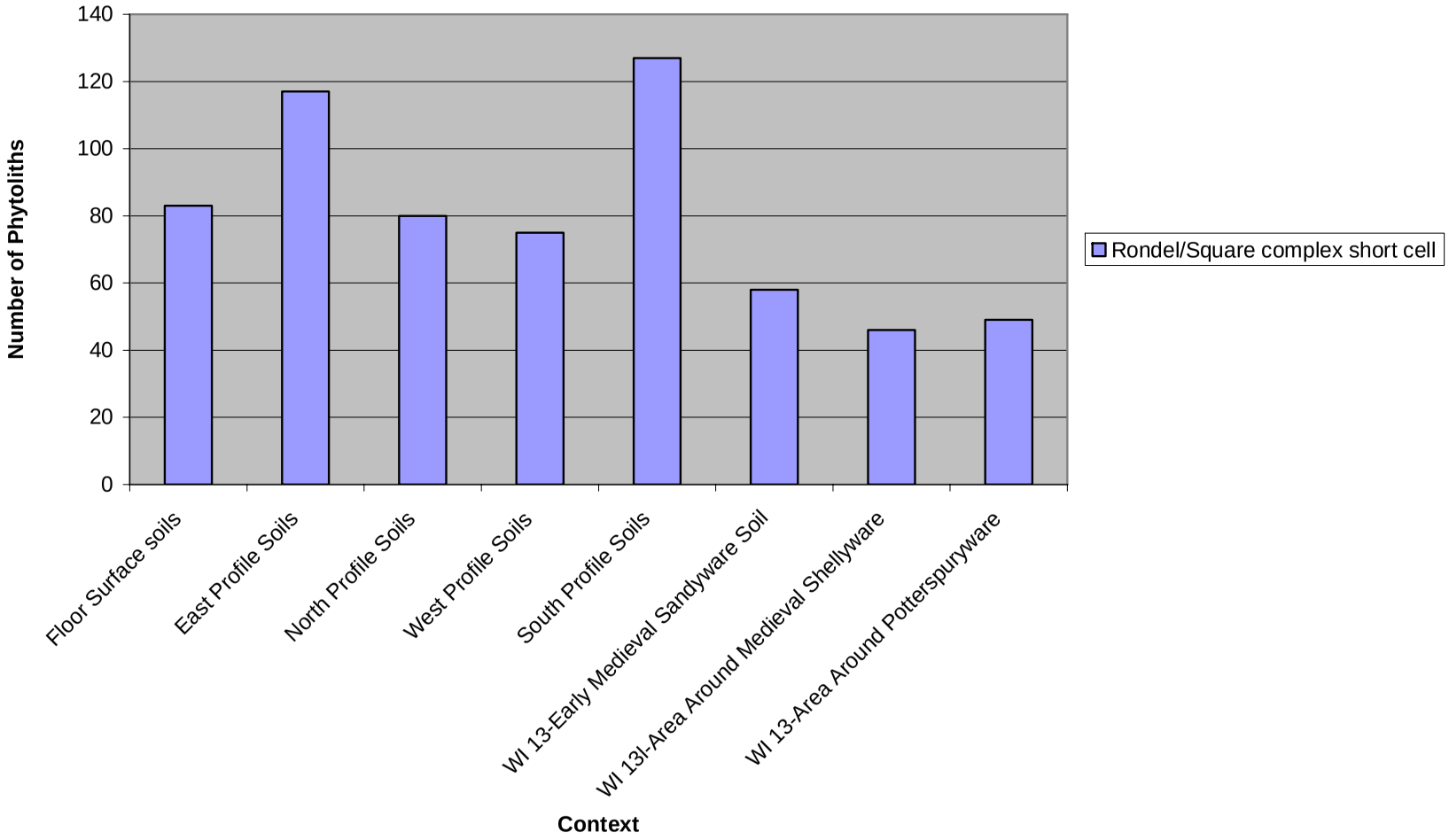


Figure 5.9 Number of Papillae and Wavy Long Cells Found in Excavated and Survey Soils in Wicken

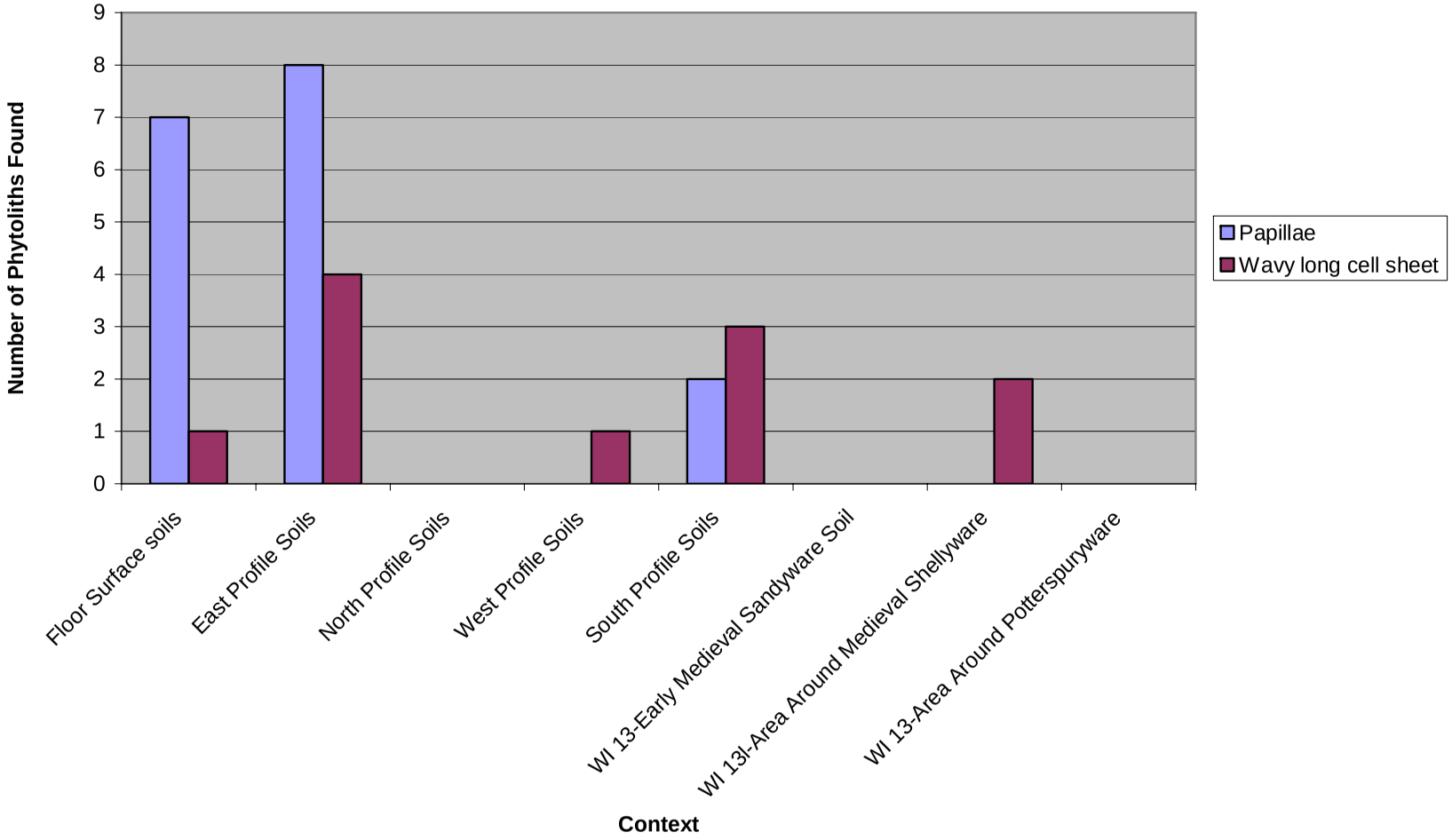
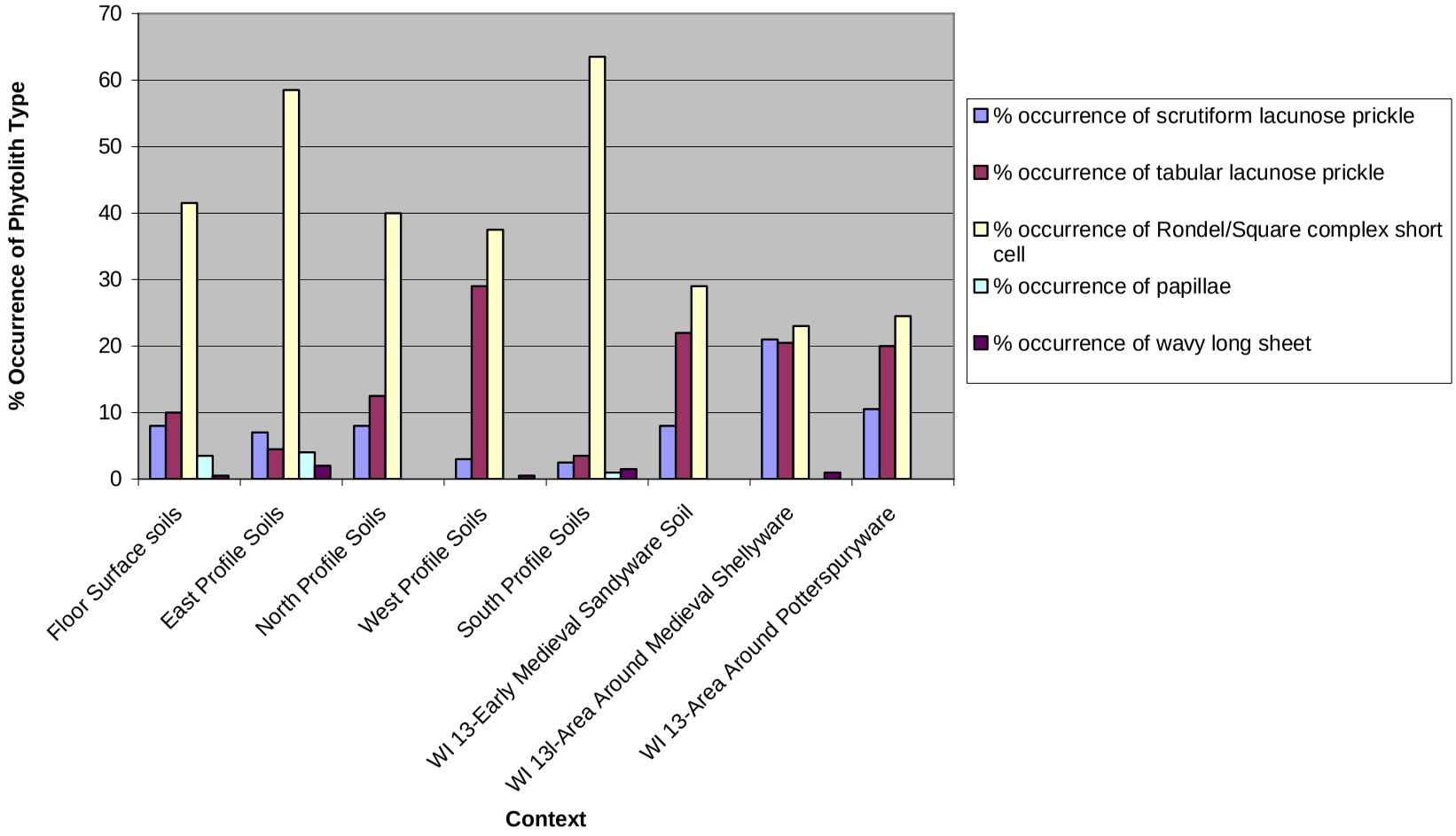


Figure 5.10 % Occurrence of Fragile vs. Nonfragile Phytolith Types in Excavated and Surface Soils



Phytolith Discussion

Soils contain a wide variety of information and can be interpreted in number of ways based upon the researcher and the questions being asked. Geoarchaeologists may study soil micromorphology to understand how changes in soil structure relate to changes in the landscape induced by human activity (Macphail et al. 1990). Archaeologists in the field will look at soil color and texture to identify changes in stratigraphy. Paleoethnobotanists can use phytoliths to determine land use practices. Some of the earliest and most influential studies done using phytolith analysis examined how assemblages taken from lake or estuary cores can be used to understand the past vegetation patterns and land use practices.

For example, Piperno's (1985) study of the sediment cores from Gutan Lake, Panama, showed how phytoliths, along with pollen, could be used to reconstruct past environments and environmental practices. In this particular instance, plant microfossil percentages and indicator species showed a history of undisturbed moist and seasonally dry tropical forests, marine and freshwater swamps, and later forest clearings associated with prehistoric agriculture. (Pearsall 2000; Piperno 2006).

Another example of how phytoliths can be used to understand land use practices can be seen in Kealhofer and Piperno's (1994) phytolith analysis in the Bang Pakong Valley, Thailand. In this study, changes in the phytolith assemblage, along with pollen and macrobotanical data, reflected the rise of rice cultivation along the coast of Thailand. The clearing of forests around 5300 BC was illustrated by a decrease in the number of tree type phytoliths while the eventual rise of rice (*Oryza* sp.) cultivation around 1650 BC

was illustrated through a subsequent increase in rice phytolith types (Pearsall 2000, 2006).

Very few phytolith studies related to understanding land use practices have been conducted in the British Isles. Powers and Gilbertson (1987) used the rocky soils of the Outer Hebrides, Scotland, to develop and refine a simple and cheap method for extracting phytoliths. More recently, Davidson et al. (2002) used phytoliths and micromorphology to help understand the close relationship between different soil horizons and faunal activity in Scotland.

The results presented here demonstrate that phytolith taphonomy can also provide insights into land use practices. Certain land use practices will have an impact on the microfossil record and will therefore alter the phytolith assemblage that can be recovered. The degree to which phytoliths are intact is a reflection of past and current activities on the landscape. Similar to previous studies, the soils collected from Wicken field 13 (WI-13) and the excavated house reflected local vegetational patterns and landscape use. However, taphonomy plays a key role in differentiating the two soils because modern farming practices have actively modified the phytolith assemblage of WI-13 while the soils of the excavated house were left relatively undisturbed following abandonment.

The results suggest that soils at the excavated house had a different phytolith assemblage from WI-13 because they were not constantly undergoing human induced bioturbation. Without the constant physical churning of the soils associated with modern farming, the phytoliths were left relatively intact and undamaged. This can be clearly seen with preservation of fragile phytolith types such as papillae and wavy long cells in the archaeological soils (Figure 5.5). The fragile nature of certain phytoliths is

acknowledged by Piperno that “at the other, less durable side of the spectrum, are eudicot epidermal and hair cell phytoliths from important crops, herbs, and trees that either do not survive at all over time or persist but in amount unrepresentative of their true importance and abundance in the past” (2006: 108). Thus, because these fragile phytoliths associated with important foods and plants came to rest in an area that was later covered by the ruins of a collapsed building, their presence in the archaeological record was preserved.

In contrast, although many phytoliths are quite durable, those that that were introduced into the soil while farming are subject to a higher degree of mechanical weathering and are much more likely to be broken into smaller fragments. The freshly farmed soils of WI-13 should contain diagnostic phytoliths related to crops such as papillae and wavy long cells. Instead, these types were notably absent (Figure 5.5). Sturdy generalized phytoliths such as the rondel/square complex short cells were also notably reduced in number (Figure 5.4) while generalized hardy background types such as the tabular lacunose prickle type were quite common (Figure 5.3). What emerges is a picture of two different phytolith assemblges affected by current land use practices.

The freshly farmed soil is rich in background and broken phytoliths but lacks complete fragile diagnostic phytoliths due to the physical destruction of complete phytolith types while plowing. The excavated soils associated with a small settlement may contain very few background phytoliths but several intact diagnostic fragile phytoliths due to the protected context. Thus, soils rich in broken phytoliths and background types may indicate a farming context while soils rich in fragile yet diagnostic types may represent a more protected context such as a house floor or backyard.

How do the archaeobotanical results compare with the historical record for each county? What can these results tell us about the medieval food patterns in Wicken and Wyton?

To answer the question of food production in Northamptonshire and Huntingdonshire, phytoliths and starch grains were examined from the excavated artifacts and excavated soils from Glebe Cottage, Wicken, and the excavated artifacts from Durley Cottage. The results from the first part of this project indicated that environmental contamination of microfossils can occur on artifacts collected during survey. As a result, the sediment 2 and 3 samples from the excavated artifacts of Glebe and Durley Cottages were examined while the survey artifacts and soils recovered from the fields surrounding Wicken were not. In addition, because of the limitations of the microfossils found on the survey artifacts, determining whether or not food residues associated with ceramics used in the manuring of medieval fields could not be determined.

Because the microfossil assemblage was so scarce on the artifact samples, ubiquity analysis was conducted to determine the presence or absence of microfossils found on the artifacts. A ubiquity analysis was also conducted for the starch grains found in the excavated soils from Glebe Cottage. In addition, a 200 phytolith count of the soil samples was conducted for the north, south, east, and west profiles, and the floor surfaces of the excavated units at Glebe Cottage. Economic types established in the comparative collection as well as some non-economic types found in published sources were included in both the phytolith and starch grain scans. The results were compared with historical sources of the period for each site.

Wicken Excavated Artifact Results

Overall, including both sediments 1 and 2 the study yielded only 10 phytoliths and five starch grains. Only two phytoliths found on the medieval shellyware ceramic were the Va2a (Trapezoid, length 2x width, margins alate, lobed) diagnostic type. The other eight phytolith types included the panicoid simple short cell, rondel/square complex short cell, Vb2, scrutiform lacunose prickle and tabular lacunose prickle. No diagnostic wavy long cell sheets or papillae were found. Four starch grains were found in the sediment 2 of the Potterspuryware ceramic and were comprised of the *Triticum* sp., unknown, and two *Avena* sp. types. The early medieval sandyware ceramic contained one *Triticum* sp. starch grain in its sediment 2/3 sample. Although some of the starch grains had distinct fissures, none of them had distinctive processing damage.

Durley Cottage Artifact Results

Six phytoliths including one unknown wavy long cell sheet, one *Hordeum vulgare* papillae, three cratered "projectile point" types, and one cratered square to rectangular type were discovered on the four artifacts. The wavy long cell sheet found in the sediment 2 sample of the medieval shellyware ceramic (2719 W) did not resemble any of the types found in the comparative collection. The *Hordeum vulgare* papillae was also found on this artifact. Three starch grains, including two unknowns (Figures 5.3 & 5.4) and one *Pisum sativum* type, were found in the sediment two samples of the medieval shellyware and Lyedon/Stanion "A" ware ceramics respectively.

Wicken Excavated Soils Results

When compared to the paltry remains found on the artifacts examined in this project, the excavated soils appear to have a plethora of phytoliths and starch grains. Overall, the

most dominant type of phytolith found in the 200 count was the rondel/square complex short cell. The variety in percentage of this type ranged from 36% in the western profile to 56.5% in the southern profile with all the rest falling somewhere in between. The second most common phytolith was another general grass type called the festucoid simple short cell. These phytoliths ranged from 7.5% in the eastern profile to 17.5% in the surface floor. Finally, four other phytolith types were found in moderate quantities in all five samples and included the two diagnostic indicators I2g and Va2a (Figures 5.11 and 5.12). Upon closer inspection, each individual soil sample has a unique combination of diagnostic starch grains and epidermal wavy cells and papillae phytoliths (Table 5.7).

Table 5.7 Diagnostic Phytoliths and Starch Grains Found in Excavated Soils

	Papillae			**Wavy long cells**			**Starch Grains**		
Context	**Wild**	**Domesticated**	**Unknown**	**Wild**	**Domesticated**	**Unknown**	**Wild**	**Domesticated**	**Unknown**
South profile	X (1)	X (1)		X (20)					
West Profile					X (1)				X (1)
East Profile		X (4)	X (2)	X (17)				X (1)	
North Profile								X (1)	
Floor		X (4)	X (3)	X (1)				X (1)	

X=present
Actual count in parentheses

Figure 5.11 Excavated Soil Phytolith Raw Count in Wicken

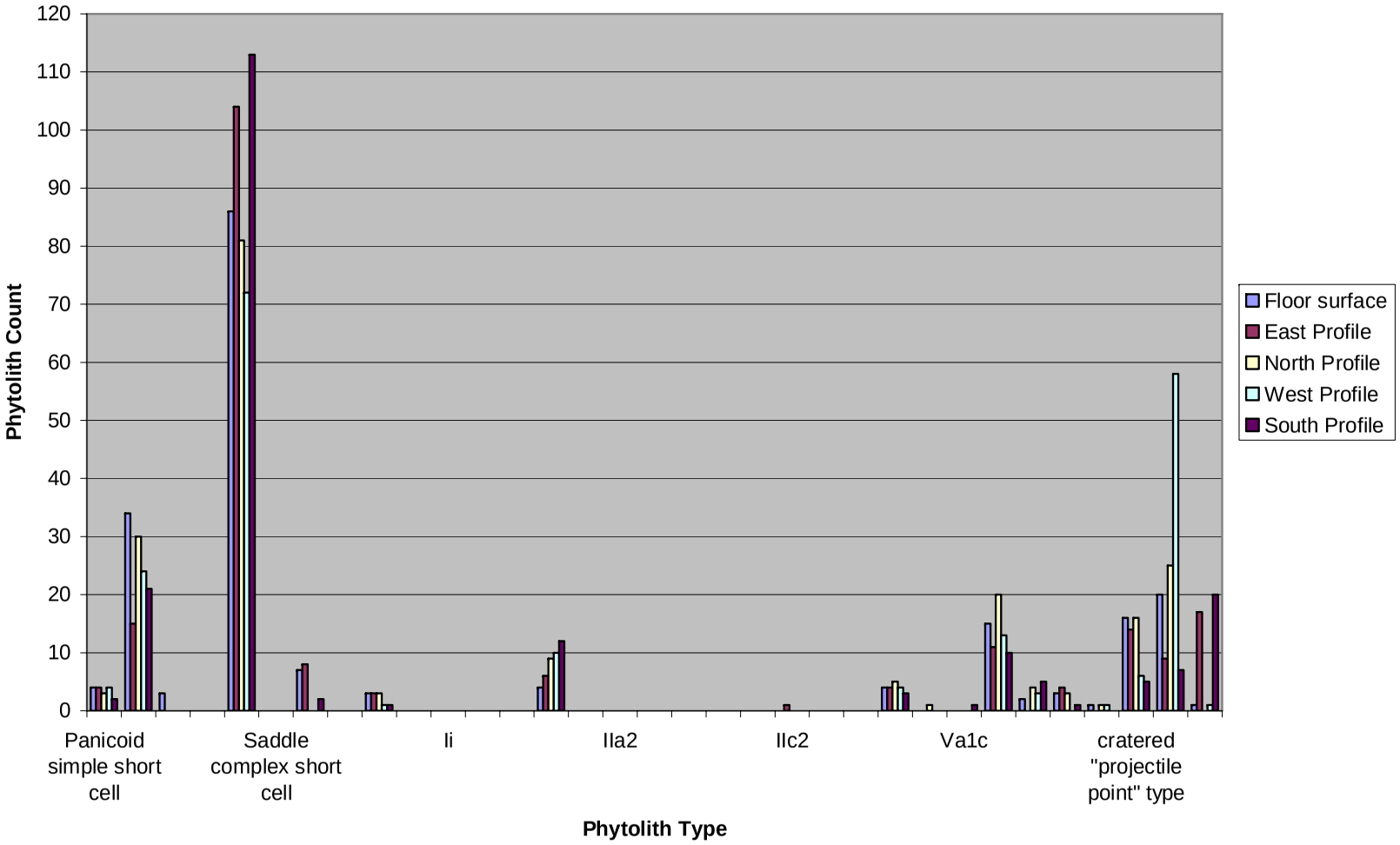
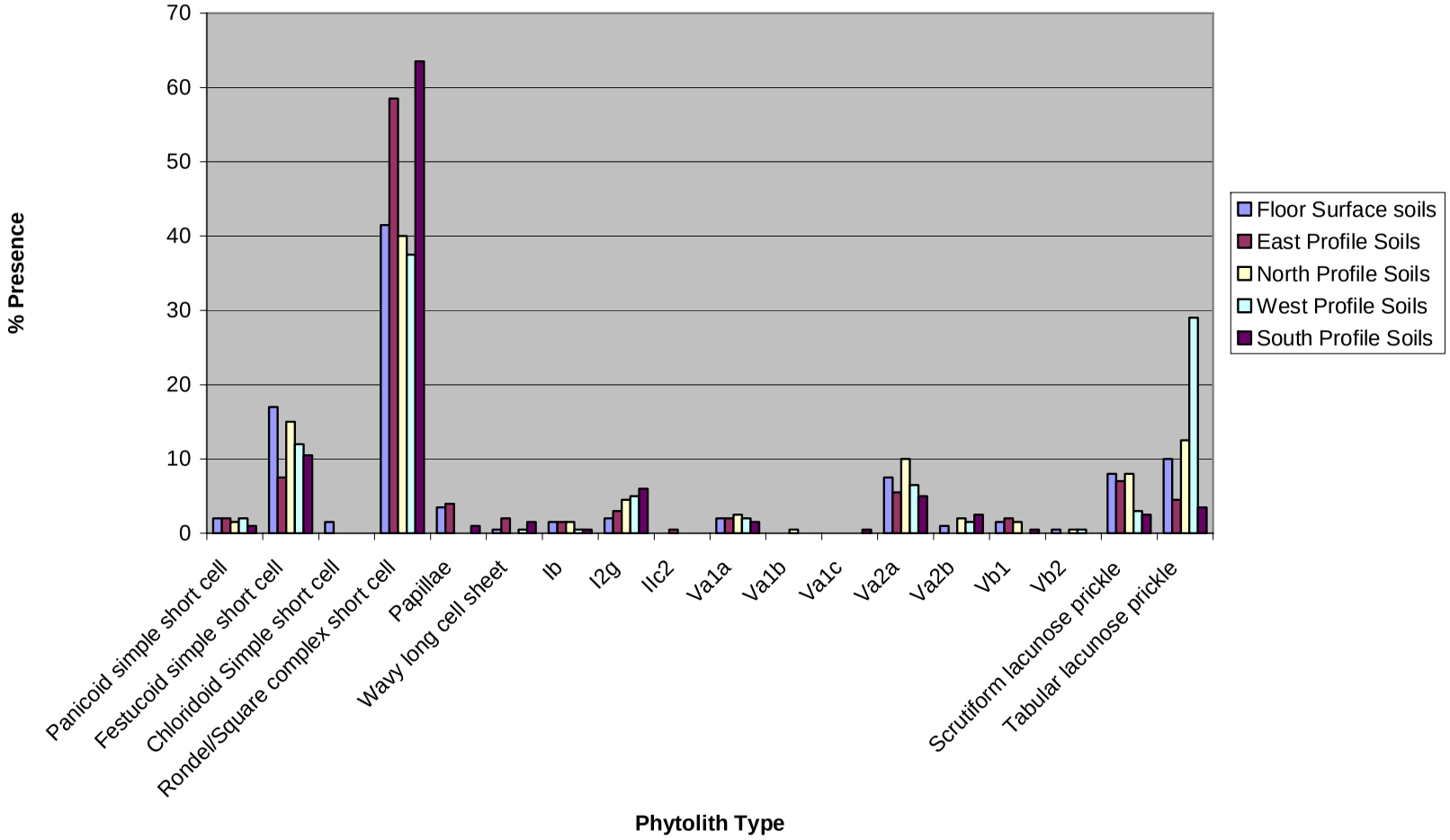


Figure 5.12 % of Economic Phytoliths Found (200 count) in Excavated Soils, Glebe Cottage, Wicken



Two papillae identified as a wild grass type and *Avena sp* were recovered from the southern profile. All of the complete epidermal sheets, as opposed to the small fragments encountered in the freshly tilled soils, were of the wild grass type. Six of these belonged to the genus *Alopecurus* and fourteen belonged to rye grass genus *Lolium* sp. No starch grains were found.

The western profile of the excavated unit did not contain any papillae but did contain one wavy long cell identified to the *Triticum* genus (Figure 5.13). In addition, one highly damaged unidentifiable starch grain with a bumpy, grainy surface was discovered (Figure 5.14). The northern profile does not have papillae or wavy long cells but does have a single starch grain that fits the size range for the *Fabaceae* family, and exhibits an extreme amount of processing damage (Figure 5.15).

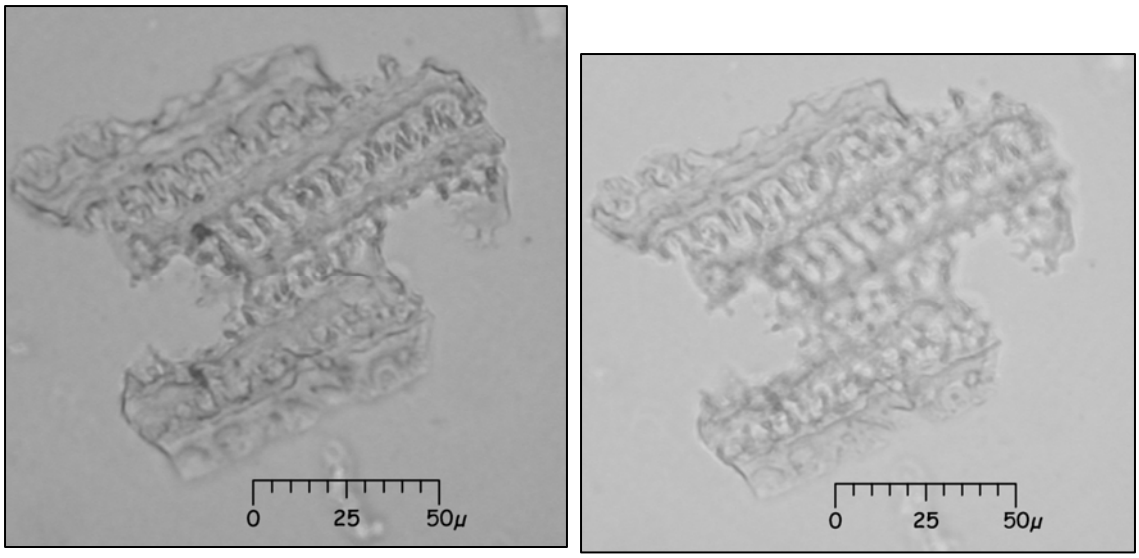


Figure 5.13 *Triticum* wavy long cell in western profile of excavated unit at Glebe Cottage, Wicken (N2110 & 2111)

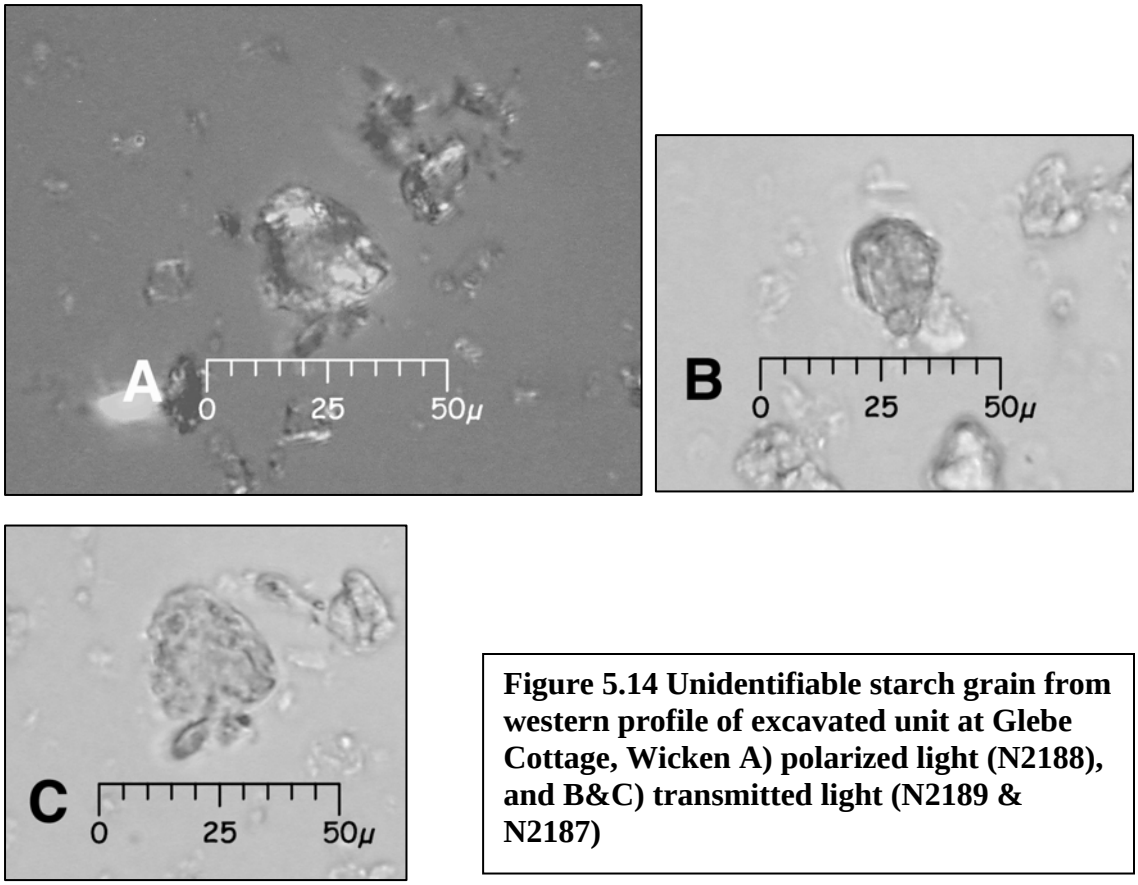


Figure 5.14 Unidentifiable starch grain from western profile of excavated unit at Glebe Cottage, Wicken A) polarized light (N2188), and B&C) transmitted light (N2189 & N2187)

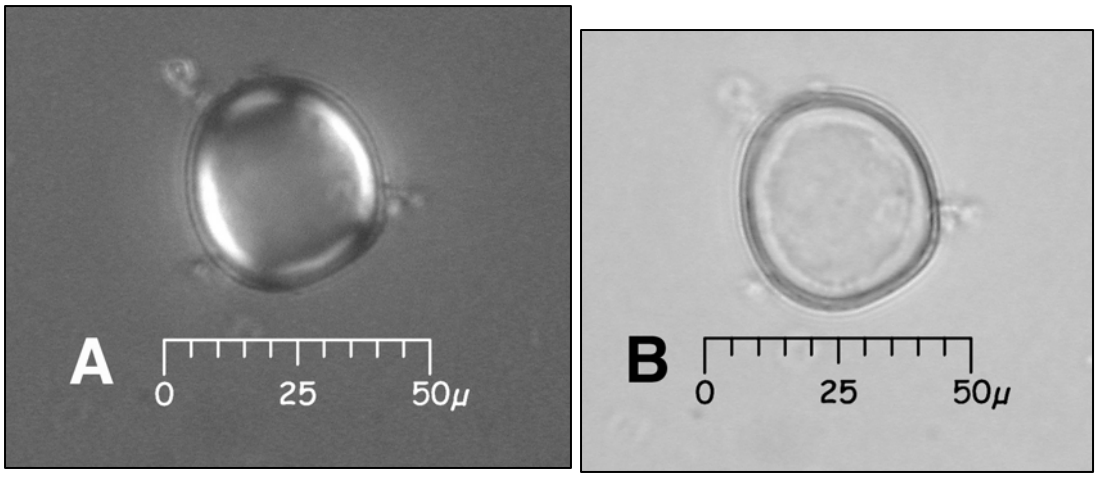


Figure 5.15 *Fabaceae* starch grain with extreme grinding damage from northern profile of excavated unit at Glebe Cottage, WickenA) polarized light (N2119) and B) transmitted light (N2110)

The eastern profile had a total of eight papillae, six of which could be tentatively identified. Because Einkorn and Emmer wheats were not grown in medieval England, any papillae that fell into this category can be classified as *Triticum* sp. Also, as discussed in chapter 4, some papillae are similar across several genus and thus must be assigned a multiple genera classification. For example, in this sample we have one papillae that can be classified as a *Triticum/Avena* and another papillae that can be classified as a *Triticum/Hordeum* papillae. A third papillae could belong to three different genera and is classified as a *Triticum/Hordeum/Avena* papillae. Finally, two papillae were classified as *Hordeum* sp., two as unknowns, and one solely as *Triticum* sp.

The eastern profile also contained 17 wavy long cell sheets, all of which were indicative of wild grass genera. Three *Alopecurus* sheets, five unknown weedy types, and nine *Agropyron* sheets were found (Figure 5.16). Finally, one highly dirty and slightly damaged *Fabaceae* starch grain was also present in the sample.

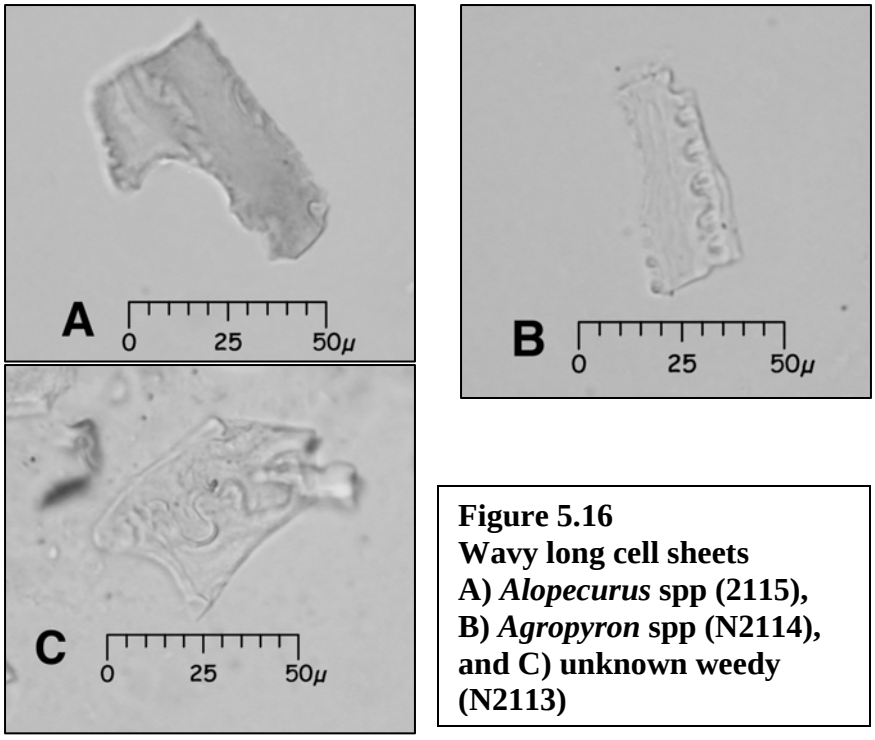


Figure 5.16
Wavy long cell sheets
A) *Alopecurus* spp (2115),
B) *Agropyron* spp (N2114),
and C) unknown weedy
(N2113)

The sample taken from the surface of the archaeological floor yielded mostly food phytoliths and starch grains. Seven papillae were counted, four of which were identifiable. Two of the papillae were of the *Triticum/Hordeum* variety and two were *Hordeum* sp. One wavy long cell sheet was identified as a wild *Alopecurus* sp. type and a single starch grain resembling *Lens esculenta*, based on size and extinction cross characteristics, was recovered.

Overall, several microfossil patterns emerge from the soils taken from the medieval horizon of the north, south, east, west profiles and the medieval floor surface. In all five samples, the majority of the intact wavy long cell sheets were the wild grass type, *Alopecurus* sp. In contrast, the majority of the papillae discovered belonged to domesticated grasses *Triticum* sp and *Hordeum* sp. The 200 phytolith count was dominated by rondel/square complex short cells which support the presence of large quantities of grass remains in the soil, wild or otherwise. The few starch grains that were found were often hard to identify because of their highly textured surface and battered appearance. The starch grains that were identified generally belonged to the *Fabaceae* family because of their size and extinction crosses.

Discussion

The historian H.E. Hallam (1981) reports that in rural England, from 1066 to 1348, dredge (a mixture of barley and oats), rye, and oats were the largest crops produced in Northamptonshire, while in medieval Huntingdonshire (which currently overlaps with modern Cambridgeshire, where Durley Cottage is located), wheat, barley, and legumes were the most important crops. Data from the limited sample studied here do not match

the historical data from Glebe Cottage, Wicken, Northamptonshire, while the remains from Durley Cottage in medieval Huntingdonshire do match the historical data.

Glebe Cottage, Wicken, Northamptonshire. The excavated artifacts from Wicken do not completely contradict the historical record but neither do they completely support it. The scant phytolith data only showed the presence of phytoliths that are found in most cereals except for rye, a widely produced crop according to the historical record. The starch grains did show evidence of oat cultivation which matched the records but also showed evidence of wheat cultivation, which was not described as a major crop in the historical record. Because of the similarities in wheat and barley starches, it not out of the realm of possibility that some of the wheat starches encountered are barley starches. If this is true, then the starch record would match the historical data. However, because the grains appear to be more "wheaty-like", there is some disparity between the archaeological and microfossil assemblages.

By far, the most useful data for comparing the archaeological and historical records came from the soils found at the excavation unit. Overall, the phytoliths and starch grains seemed to indicate processing at the site. Along the eastern profile we see high numbers of wild and domesticated grass phytoliths and some legume starch grains. The floor samples contained mostly domesticated grains and some legume starches such as *Lens esculenta*. The damaged starch grains present in the soil also support the suggestion that the site was used as a brew house or bake house associated with the nearby seigniorial residences.

What emerges from this data are a picture of a diet that included wheat, barley, and legumes. This collection of foods was common across much of medieval Europe and

formed the backbone of most peasant cuisines during this period (Hagan 1992). However, the archaeological data of wheat, barley, and legumes processing does not support the historical records of dredge, rye, and oat production in Northamptonshire.

Any number of reasons could exist for the disparity of the historical and archaeological data including sample size issues, taphonomic issues for archaeology, and inherent problems with any historical record. For example, wheat, although not necessarily a major crop produced in the area, may be produced as a minor crop at a small local scale. Perhaps it was only planted occasionally to supplement the major crops of the area therefore it wouldn't be recorded in the historical records. One must caution against over interpreting the absence of specific foods. Increasing the sample size of the study may reveal the presence of certain crops that were previously absent. Post depositional movement of microfossils at the site, either through bioturbation or water movement, may also influence which microfossils are recovered. However, there is the simple possibility that dredge, rye, and oats were in fact grown in the county but were traded for wheat, barley, and legumes that were then processed at Wicken site. If in fact this were the case, one would expect to find wheat, barley, and legume microfossils in the ancient field soils.

Durley Cottage, Wyton, Cambridgeshire. The archaeobotanical remains at Durley Cottage were scant; however, they do match up with the historical record. Like the rest of medieval England, wheat, barley, and legumes were commonly produced in the area. The barley papillae phytolith, the unknown wavy long cell, the unknown starch grains, and the pea starch grains found on the artifacts match both the common diet of the period as well as historical record for that county.

Limitations and Future Research Directions

The results from this study represent an examination of issues related to phytolith taphonomy, artifact residue deposition, and food consumption and production patterns in medieval England. Several limitations emerge from this project which impact interpretations and also provide an impetus for future research.

First and foremost is the issue of sample size. Whether it's the question related to artifact contamination, phytolith taphonomy in the soils, or food residues on medieval sherds, it would be desirable to increase the number of artifacts and soils examined beyond what could be accomplished in the framework of this research, which required study of a large comparative phytolith and starch collection. The number of samples used for all three questions is adequate for a preliminary examination of the issues but in order to answer the questions definitively, replicate samples should be examined, and other artifact classes included. It would also be useful to expand the research to nearby fields to see if the results are replicated. The unexpetedly low starch and phytolith counts on artifacts raise the question of whether this is characteristic of the artifacts and crops of this field, something that an expanded study should address.

Secondly, although the comparative collection used in this project was extensive, not every food and wild comparatives found in medieval England could be studied due to factors of time and availability. Millet (*Panicum miliaceum*) and mulberry fruit (*Morus* sp), for example, should be included in future studies. Further, not all of the wild types of possible "confusor" species for phytoliths and starch grains have been examined. Having said this, the project did include all the major comparatives and thus shows the potential and the limitations of microfossils for studying this place and time.

Future research topics might be to address the issues mentioned above and expand upon the original questions so as to better answer these interesting taphonomic and historical issues. If for example, one were to compare the phytolith and starch grain assemblages from less intensively disturbed environments such as an old growth forest or fields cultivated by hand instead of modern iron tipped plows, perhaps more primary residues would be present on the survey artifacts because they did not undergo intense bioturbation. Other future research topics might include: How does the diet of later medieval Wicken population, as seen through residue analysis, compare with the diet of the county's Roman and early Anglo-Saxon predecessors? Because the switch from the ard to mouldboard plough during the medieval period caused a corresponding shift in weed assemblages, how can this be seen in the archaeological record through the use of phytolith and starch grain analysis? Does the shift manifest itself into different phytolith and starch grain assemblages that can be seen in other archaeological sites?

CHAPTER 6: CONCLUSIONS

This study was originally designed to use phytolith and starch grain analysis to test to if artifacts collected during an archaeological survey could be used to understand the food production and consumption patterns of medieval Wicken, Northamptonshire, and Wyton, Cambridgeshire, England. The project had four main goals: the creation and analysis of a comparative collection of phytoliths and starch grains found in common medieval foods and weeds; determining the usefulness of survey artifacts for paleoethnobotanical research; comparing the historical and paleoethnobotanical data from excavated sites in Wicken and Wyton; and if possible, using the paleoethnobotanical data from the survey artifacts to gain a better understanding of the development of the open field system and how it relates to the manuring hypothesis proposed by Jones (2004).

Overall, of the 57 medieval food or weed species that were analyzed for their diagnostic starch grain and/or phytolith capabilities, few contained diagnostic microfossils. Most of the diagnostic phytoliths most belonged to the Poaeceae family. Seven food species including date palm (*Phoenix dactylifera*), oats (*Avena sativa*), 6-row and 2-row barley (*Hordeum vulgare*), spelt wheat (*Triticum spelta*), whole wheat (*Triticum aestivum*), and rye (*Secale cereale*), produced diagnostic phytoliths. Aside from the spinulose spheres found in the date palm samples, the diagnostic phytoliths found in the other six species were morphological variations of papillae and wavy long cells. Seven species of weeds that were found in fallow fields included the stinking mayweed (*Anthemis cotula*), bladder campion (*Silene inflata*), sunspurge (*Euphorbia helioscopia*), beardless wheatgrass (*Agropyron inerme*), Carolina foxtail (*Alopecurus carolinianus*),

meadow foxtail (*Alopecurus pratensis*), and goose grass (*Galium aparine*) also produced diagnostic phytoliths. These diagnostic types included a large armed hair cell, acute silicified hair cell, small armed hair cell, small blunted hair cell, ovate dense irregular epidermal cell, and a large parallelepipedal irregular vascular cell phytolith.

Most of the species that produced diagnostic starch grains in this comparative collection were members of the Poaceae or Fabaceae families. The following species of weeds and foods produced diagnostic starch grains; coriander (*Coriandrum satirum*), chickpeas (*Cicer arietinum*), peas (*Pisum sativum*), faba or broad beans (*Vicia faba*), lentils (*Lens culinaris*), oats (*Avena* spp), barley (*Hordeum* spp), wheat (*Triticum* spp), rye (*Secale cereale*), apple (*Malus pumila*), hairy vetch (*Vicia hirsuta*), meadow foxtail (*Alopecurus pratensis*), black binwood (*Polygonum convolvulus*), and goose grass (*Galium aparine*). A wide variety of plants were studied for this comparative collection and the species belonging to either the Poaceae or Fabaceae families typically produced some sort of diagnostic phytolith or starch grain. The creation of this type collection was crucial not only for this project, but will hopefully be of use for projects in the future.

The main bulk of this thesis was devoted to understanding the relationship between primary and secondary deposition of phytoliths and starch grains on artifacts. To try and understand this relationship, the microfossil assemblages from freshly collected survey artifacts were compared with their surrounding soil and contemporaneous artifacts recovered from a sealed context. The original hypothesis for this section of the project was that if the microfossil assemblage found on artifacts collected during survey matched the assemblages in the surrounding soil but not the microfossil assemblage of similar artifact from a protected environment, then the survey artifact must have undergone some

form of environmental contamination i.e. secondary deposition. The results of this study show seem to support the original hypothesis that contamination has occurred because the microfossil assemblages from the survey artifacts match the phytoliths and starch grains found in the nearby soils.

However, the results of this section should also be viewed with some degree of caution. The artifacts do match the surrounding soils and it is entirely possible that the phytoliths and microfossils on those artifacts were the product of secondary deposition, as is seen in the Barton et al. study (1998). This scenario is especially likely when considering the number of opportunities that microfossils from the soil can brush against an artifact due to the high degree of mechanical action associated with farming activities.

Conversely, because none of the phytoliths and starch grains found on the survey artifacts were exclusively found in fallow field setting, it was not possible to determine absolutely that microfossil contamination had occurred. Instead the similarities between artifact and soil microfossil assemblages could be due to artifact residues becoming deposited in the surrounding soil. Those same mechanical forces associated with plowing that could transfer secondary residues from the soil to the artifact could also be used to transfer primary residues from the artifact into the soil. Thus, despite the fact that the data appears to support the original hypotheses in this study, it is still unclear as to whether or not survey artifacts could be used for paleoethnobotanical research. Clearly more research needs to be conducted to gain a clearer understanding of the relationship between primary and secondary depositions, especially those in the field setting. This research could take the form of an expanded sample set, expanding the comparative

collection thereby increasing the possibility of discovering a weedy type that could be traced on the ceramics, or by sampling artifacts from nearby fields.

An unexpected result of this thesis was the discovery that phytoliths found in the freshly plowed soils of Wicken 13 had a distinctly different taphonomic signature than excavated soils from Glebe Cottage in Wicken. While analyzing the soils for the artifact contamination portion of this project and the soils for the medieval foodways portion of this project, certain patterns were noticed. The phytoliths from the freshly plowed fields were composed mostly of broken and non-diagnostic background phytoliths. In contrast, the phytolith assemblages from the excavated soils were rich in fragile phytolith types and diagnostic phytoliths associated with food processing. Using phytolith assemblages to determine land use practices is nothing. What emerges from this portion of the thesis is the demonstration that differences in phytolith taphonomy can be used in addition to differences in phytolith types to reconstruct past land use and environmental practices.

Finally, the phytoliths and starch grains in this study were used to reconstruct some of the diet encountered in Northamptonshire and medieval Huntingdonshire. The historical records from the period were compared with the microfossil assemblages found on the artifacts collected from Durley Cottage, Cambridgeshire (formerly part of medieval Huntingdonshire) and from the excavated artifacts and soils from Glebe Cottage in Wicken, Northamptonshire. The historical data from medieval Huntingdonshire matched the residues found on the Durley Cottage artifacts pointing towards a diet of wheat, barley, and legumes. The historical data from Northamptsonshire emphasizing the production of dredge (a mixture of oats and barley), rye and oats did not match the archaeological findings. The microfossils at Glebe Cottage suggested the

processing and consumption of plants similar to those found at Durley Cottage, i.e. the common medieval diet of wheats, barleys, and legumes. The results of this portion of the study illustrated that although a food may be widely produced in an area, so much so that it is recorded as the dominant crop in the historical record, localized food production and consumption patterns may be varied.

Unfortunately, the question related to survey artifacts, the manuring hypothesis, and the open-field system could not be addressed because of the mixed results from the analysis of primary and secondary residues found on survey artifacts. If the manuring hypothesis holds true, then the survey artifacts should have food residues on them because they were discarded by residents of nearby Wicken and then scattered on the infields. If subsequent studies can either separate the primary from secondary depositions on survey artifacts, or if they can show that survey artifacts do not have secondary deposition, then the artifacts collected could provide valuable insight into the medieval diet of the people living in Wicken. However, the results from the first part of this thesis prevented this topic from being studied.

The production and consumption of food is one of the most culturally dependent aspects of any society around the world. Its consumption can have incredible symbolic meaning while its production can heavily influence how a society is structured. Medieval England is no exception to this phenomenon. The artifacts recovered from the survey work of the Whittlewood project provide valuable insights into the formation of nucleated villages such as the town of Wicken. The role of food production and consumption is intimately tied with village nucleation and the development of the open-field systems. Yet it is through the use of microfossils such as phytoliths and starch grains

found on excavated and potentially, survey artifacts, which can provide direct information related to medieval food production and consumption patterns. Ultimately, it is through the use of plant microfossils that archaeologists will gain a much clearer picture of how food influenced the lives of people hundreds, if not thousands of years ago.

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Appendix IA Raw Starch Comparative Results

MU Starch #	Common Name	Family	Scientific Name	Part	Result
SC 93	Barley	Poaceae	*Hordeum vulgare*	Grains	Diagnostic
SC 94	Rye	Poaceae	*Secale cereale*	Grains	Diagnostic
SC 97	Oats	Poaceae	*Avena sativa*	Grains	Diagnostic
SC 157	Faba (broad) beans	Fabaceae	*Vicia faba*	Fruit/veg	Diagnostic
SC 158	Lentils	Fabaceae	*Lens culinaris*	Fruit/veg	Diagnostic
SC 159	Chickpeas	Fabaceae	*Cicer arietinum*	Fruit/veg	Diagnostic
SC 160	Peas (green, field, or garden)	Fabaceae	*Pisum sativum*	Fruit/veg	Diagnostic
SC 161	Wheats	Poaceae	*Triticum compactum*	Grains	Diagnostic
SC 178	Apple	Rosaceae	*Malus pumila*	Fruit/veg	Limited
SC 179	Apple	Rosaceae	*Malus pumila*	Fruit/veg	Diagnostic
SC 180	Strawberries	Rosaceae	*Fragaria* sp	Fruit/veg	No starch found
SC 181	Sweet Cherry	Rosaceae	*Prunus avium*	Fruit/veg	No starch found
SC 182	European plum	Rosaceae	*Prunus domestica*	Fruit/veg	No starch found
SC 183	Pear	Rosaceae	*Pyrus communis*	Fruit/veg	Limited
SC 184	Pear	Rosaceae	*Pyrus communis*	Fruit/veg	Limited
SC 185	Onion	Liliaceae	*Allium cep*	Fruit/veg	No starch found
SC 186	Leek	Liliaceae	*Allium porrum*	Fruit/veg	No starch found
SC 187	Garlic	Liliaceae	*Allium sativum*	Fruit/veg	No starch found
SC 188	Opium poppy	Papaveraceae	*Papaver somniforum*	Fruit/veg	No starch found
SC 189	Cucumber	Cucurbitaceae	*Cumuis sativus*	Fruit/veg	Limited
SC 190	Cucumber	Cucurbitaceae	*Cumuis sativus*	Fruit/veg	No starch found
SC 191	Beets	Chenopodiaceae	*Betas vulgaris*	Fruit/veg	Limited
SC 192	Cabbage	Brassicaceae	*Brassica oleracea*	Fruit/veg	Limited
SC 193	Dill	Apiaceae	*Anethum graveolens*	Fruit/veg	No starch found
SC 194	Anise	Apiaceae	*Pimpinella anisum*	Fruit/veg	N/A
SC 195	Date palm	Arecaceae	*Phoenix dactylifera*	Fruit/veg	No starch found
SC 196	Meadow Foxtail	Poaceae	*Alopecurus pratensis*	Weed	Diagnostic
SC 197	Hairy vetch	Fabaceae	*Vicia hirsuta*	Weed	Diagnostic
SC 198	Bladder Campion	Caryophyllaceae	*Silene inflata*	Weed	Limited
SC 199		Poaceae	*Alopecurus carolinianus*		Diagnostic
SC 200	Corncockle	Caryophyllaceae	*Agrostemma githago*	Weed	Limited
SC 201	Sunspurge	Euphorbiaceae	*Euphorbia helioscopia*	Weed	Limited
SC 202		Poaceae	*Agropyron inerme*		Diagnostic
SC 203	Fathen	Chenopodiaceae	*Chenopodium album*	Weed	Limited
SC 204	Goose grass	Rubiaceae	*Galium aparine*	Weed	Diagnostic
SC 205	Stinking mayweed	Asteraceae	*Anthemis cotula*	Weed	Limited
SC 206	Black Binwood	Polygonaceae	*Polygonum convolvulus*	Weed	Diagnostic
SC 207	Charlock	Brassicaceae	*Sinapis arvensis*	Weed	No starch found
SC 208	Celery	Apiaceae	*Apium graveoalens*	Fruit/veg	No starch found
SC 209	Coriander	Apiaceae	*Coriandrum satirum*	Fruit/veg	Diagnostic?
SC 210	Pine nut (Stone pine)	Pinaceae	*Pinus pinea*	Fruit/veg	No starch found
SC 211	Mustard	Brassicaceae	*Brassica* sp	Fruit/veg	Limited
SC 212	Fig	Moraceae	*Ficus carica*	Fruit/veg	No starch found
SC 213	Cultivated Carrot	Apiaceae	*Daucus carota*	Fruit/veg	Limited
SC 214	Fennel	Apiaceae	*Foeniculuum vulgare*	Fruit/veg	Limited
SC 215	Olive	Oleaceae	*Olea europea*	Fruit/veg	Limited
SC 216	Grape	Vitaceae	*Vitis vinifera*	Fruit/veg	No diagnostics

Appendix IB Phytolith Raw Comparative Results

MU Ptyto #	Plant Part	Common Name	Family	Scientific Name	Results
3048, 3049, 3050		Garlic	Liliaceae	*Allium sativum*	No phytos found
CP 2887	Seed	Spelt Wheat	Poaceae	*Triticum spelta*	Diagnostic epidermal cells
CP 2888	seed	Oats	Poaceae	*Avena sativa*	epidermal, hair, and festucoid cells
CP 2889	Seed	Whole Wheat	Poaceae	*Triticum compactum*	light epidermal cells
CP 2890, 3141	Seed	Rye	Poaceae	*Secale cereale*	None found
CP 2891	Seed	Barley	Poaceae	*Hordeum vulgare*	1 possible epidermal cell
CP 2924, 3140	Seed	Oats	Poaceae	*Avena sativa*	festucoid short cell, epidermal cells
CP 2925	Seed	6 Row malted barley	Poaceae	*Hordeum vulgare*	festucoid short cell, epidermal cells
CP 2926	Seed	Unmalted wheat for beer	Poaceae	*Triticum compactum*	1 unremarkable hair cell
CP 2927	Seed	Malted Rye	Poaceae	*Secale cereale*	None found
CP 2928	Seed	Oats	Poaceae	*Avena sativa*	festucoid short cell, epidermal cells
CP 2932	Seed	Malted 2 row barley	Poaceae	*Hordeum vulgare*	epidermal cells
CP 3030	Seed	Biter vetch	Fabaceae	*Vicia ervilia*	Produced silicified material, no unique phytos
CP 3031	Seed	Opium poppy	Papaveraceae	*Papaver somniforum*	Large chunks of silicified material, no diags
CP 3032	glumes/husk	Fennel	Apiaceae	*Foeniculuum vulgare*	Epidermal/vascular tissue, potentially diag
CP 3033	stem	Fennel	Apiaceae	*Foeniculuum vulgare*	Lightly silicified material, has "ribs"
CP 3034	base/root	Fennel	Apiaceae	*Foeniculuum vulgare*	circular tissue, "ribs"
CP 3035	Seed	Pine nut (Stone pine)	Pinaceae	*Pinus pinea*	No diagnostics, very little silica produced
CP 3036	stem	Apple	Rosaceae	*Malus pumila*	No phytos found
CP 3037	Fruit body	Apple	Rosaceae	*Malus pumila*	No phytos found
CP 3038	Seed	Apple	Rosaceae	*Malus pumila*	slide covered with small to medium sized rugulose spheres
CP 3039	stem	Pear	Rosaceae	*Pyrus communis*	contains raphids
CP 3040	Fruit body	Pear	Rosaceae	*Pyrus communis*	produced silicified material, no unique phytos, small #s of raphids
CP 3041	Seed	Pear	Rosaceae	*Pyrus communis*	No diagnostics, very little silica produced
CP 3042	stem	Sweet Cherry	Rosaceae	*Prunus avium*	No diagnostics, very little silica produced
CP 3043	Fruit body	Sweet Cherry	Rosaceae	*Prunus avium*	No diagnostics, large epidermal cells and silica fragments, raphids
CP 3045	leaf	Leek	Liliaceae	*Allium porrum*	silicificed vascular tissue
CP 3046	body	Leek	Liliaceae	*Allium porrum*	No diags, lots of extraneous silica
CP 3047	root	Leek	Liliaceae	*Allium porrum*	No diagnostics
CP 3051	fruit body	Olive	Oleaceae	*Olea europea*	Silicified blocks
CP 3052	seed	Olive	Oleaceae	*Olea europea*	vascular tissue, possible diag
CP 3053	Seed	Mustard	Brassicaceae	*Brassica sp*	Epidermal sheet, possible diag
CP 3054	Fruit body	Cucumber	Cucurbitaceae	*Cumuis sativus*	lots of silicified material, no diagnostics
CP 3055	Seed	Cucumber	Cucurbitaceae	*Cumuis sativus*	lots of silica, raphids, and faceted sphere
CP 3056	skin	Cucumber	Cucurbitaceae	*Cumuis sativus*	silica and raphids
CP 3057	stem	Fig	Moraceae	*Ficus carica*	lots of loose silica but nothing major
CP 3058	skin	Fig	Moraceae	*Ficus carica*	undifferentiated silica

CP 3059	leaf	Strawberries	Rosaceae	*Fragaria sp*	silicifed epidermal cells, possible
CP 3060	Fruit body	Strawberries	Rosaceae	*Fragaria sp*	small pieces of silica
CP 3061	Seed	Strawberries	Rosaceae	*Fragaria sp*	small amounts of raphids
CP 3062	Seed	Fig	Moraceae	*Ficus carica*	silicified material, no diags
CP 3063	Seed	Date palm	Arecaceae	*Phoenix dactylifera*	spheres, unsilicified materials
CP 3080	Fruit body	Date palm	Arecaceae	*Phoenix dactylifera*	smooth sphere
CP 3081		Cabbage	Brassicaceae	*Brassica oleracea*	No phytos found
CP 3082	Fruit body	European plum	Rosaceae	*Prunus domestica*	raphids, no diags
CP 3083	skin	European plum	Rosaceae	*Prunus domestica*	No diags, lots of extraneous silica
CP 3084	Seed	Faba (broad) beans	Fabaceae	*Vicia faba*	silicified material, no diags
CP 3085	Seed	Lentils	Fabaceae	*Lens culinaris*	mostly undifferentiated silica
CP 3086	Seed	Chickpeas	Fabaceae	*Cicer arietinum*	lightly silicified material, no diags
CP 3087	leaf	Charlock	Brassicaceae	*Sinapis arvensis*	No diags
CP 3088	seed	Charlock	Brassicaceae	*Sinapis arvensis*	No diagnostics
CP 3089	flower	Cowslip	Primulaceae	*Primula veris*	undifferentiated silica
CP 3090	leaf	Cowslip	Primulaceae	*Primula veris*	Large chunks of silicified material, no diags
CP 3091	leaf	Bladder Campion	Caryophyllaceae	*Silene inflata*	lightly silicified mass, "featherlike" phytos
CP 3092	leaf	Hairy vetch	Fabaceae	*Vicia hirsuta*	some silica, some vascular tissue, nothing unique
CP 3093	leaf		Poaceae	*Alopecurus carolinianus*	hairs, wavy long cells, diag
CP 3094	infl		Poaceae	*Alopecurus carolinianus*	hair cells, wavy epidermal tissue, bilobates,
CP 3095	flower/seed	Corncockle	Caryophyllaceae	*Agrostemma githago*	dark spheres that appear in sheets, nondiag
CP 3096	leaf		Caryophyllaceae	*Agrostemma githago*	sphere, no diagnostics
CP 3097	flower/seed	Stinking mayweed	Asteraceae	*Anthemis cotula*	No phytos found
CP 3098	leaf/stem	Stinking mayweed	Asteraceae	*Anthemis cotula*	unique tip with long cells, diag
CP 3099	leaf		Poaceae	*Agropyron inerme*	hair cells, wavy long cells
CP 3100	seed		Poaceae	*Agropyron inerme*	hair cells, trichomes, wavy long cells
CP 3101	leaf/flower	Thyme-leaved sandwort	Caryophyllaceae	*Arenaria serpyllifolia*	possible vascular tissue
CP 3102	seed	Sunspurge	Euphorbiaceae	*Euphorbia helioscopia*	possible vascular tissue
CP 3103	flower	Sunspurge	Euphorbiaceae	*Euphorbia helioscopia*	scale like phytos
CP 3104	leaf	Sunspurge	Euphorbiaceae	*Euphorbia helioscopia*	vascular tissue
CP 3105	seed	Fathen	Chenopodiaceae	*Chenopodium album*	no diag
CP 3106	leaf	Fathen	Chenopodiaceae	*Chenopodium album*	no diag
CP 3107	leaf	Blue bell grass	Campanulaceae	*Campanula rotundifolia*	no diag
CP 3108	flower	Blue bell grass	Campanulaceae	*Campanula rotundifolia*	no diag
CP 3109	leaf/flower	Red Dend-nettle	Lamiaceae	*Lamium purpureum*	epidermal round cells
CP 3110	leaf	Goose grass	Rubiaceae	*Galium aparine*	hair cell, hair cell base, vascular bundle, wavy quadrilateral
CP 3111	seed	Goose grass	Rubiaceae	*Galium aparine*	hair with hooked end
CP 3112	leaf	Black Binwood	Polygonaceae	*Polygonum convolvulus*	abundant undifferentiated spheres, some vascular tissue
CP 3113	seed	Black Binwood	Polygonaceae	*Polygonum convolvulus*	small round spheres, irregular nondiag spheres

CP 3114	leaf	Field Milk Thistle	Asteraceae	*Sonchus arvensis*	unahsed or partially ashed, no major diag
CP 3115	flower	Field Milk Thistle	Asteraceae	*Sonchus arvensis*	mostly undifferentiated plant parts, no diag
CP 3116	flower/seed	Bladder Campion	Caryophyllaceae	*Silene inflata*	some spheres, possible diag vascular tissue
CP 3117	leaf	Marsh Orchid (pfaf.org)	Orchidaceae	*Orchis latifolia L.*	vascular bundle?
CP 3118	flower	Marsh Orchid (pfaf.org)	Orchidaceae	*Orchis latifolia L.*	epidermal long cells
CP 3119	flower	California Hedgenettle (ibilio.o	Lamiaceae	*Stachys bullata*	mostly unashed plant material
CP 3120	flower	Meadow Sweet	Rosaceae	*Filipendula ulmaria(occidentali*	very light epidermal tissue
CP 3121	leaf	Meadow Sweet	Rosaceae	*Filipendula ulmaria(occidentali*	light hair cells, trainport elements, cystoliths, hair bases
CP 3122	leaf	California Hedgenettle (ibilio.o	Lamiaceae	*Stachys bullata*	strange epidermal cells, hair base
CP 3123	flower	Charlock	Brassicaceae	*Sinapis arvensis*	some unashed tissue, no unique phytos
CP 3124	seed	Hairy vetch	Fabaceae	*Vicia hirsuta*	small epidermal cells, no diag
CP 3125	leaf	Cornflower	Dipsacaceae	*Knautia arvensis*	spikey spheres, no diag
CP 3126	flower	Cornflower	Dipsacaceae	*Knautia arvensis*	green spikey spheres, no diag
CP 3127	leaf	Meadow Foxtail	Poaceae	*Alopecurus pratensis*	possible vascular tissue, chloridoid short cells, wavy long cells
CP 3128	seed	Meadow Foxtail	Poaceae	*Alopecurus pratensis*	papillae, hairs, wavy long cells
CP 3139	Seed	Barley	Poaceae	*Hordeum sp*	wavy long cells

Appendix IIA Soil Phytolith Raw Count

Site	Slide	Context	Panicoid simple short cell	Festucoid simple short cell	Chloridoid Simple short cell	Lobed complex short cell	Rondel/Square complex short cell	Saddle complex short cell	Papillae	Wavy long cell sheet	Ia	Ib	Ie	If	Ih	I2a	I2g	IIa1	IIa2	IIa3	IIb1	IIb2	IIc1	IIc2	IIIa	IIIb	IVa1a	IVa1b	IVa1c	IVa2a	IVa2b	IVb1	IVb2	Serrutiform lacunose prickle	Tabular lacunose prickle	Economic sum	Diatoms-hexagonal	Diatoms-Others
Glebe Cottage	2985	Floor Surface soils	4	34	3		83		7	1		3					4										4			15	2	3	1	16	20	200	1	
Glebe Cottage	2987	East Profile Soils	4	15			117		8	4		3					6							1			4			11		4		14	9	200		4
Glebe Cottage	2986	North Profile Soils	3	30			80					3					9										5	1		20	4	3	1	16	25	200	4	
Glebe Cottage	2989	West Profile Soils	4	24			75			1		1					10										4			13	3		1	6	58	200		
Glebe Cottage	2988W	South Profile Soils	2	21			127		2	3		1					12										3		1	10	5	1		5	7	200		6
Field WI 13	2983	WI 13-Early Medieval Sandyware Soil	1	23	1		58					7					6										8	4	2	19	4	2	5	16	44	200		9
Field WI 13	2984	WI 13l-Area Around Medieval Shellywar	2	30	1		46			2		4					1										10			17	3		1	42	41	200	1	2
Field WI 13	2982W	WI 13-Area Around Potterspuryware		14			49					5					6										16	1		37	2	7	2	21	40	200	1	1

Appendix IIB: Survey Phytolith Artifact Raw Count

Ceramic type	Sediment #	Slide	Panicoid simple short cell	Festucoid simple short cell	Chloridoid Simple short cell	Lobed complex short cell	Rondel/Square complex short cell	Saddle complex short cell	Papillae	Ia	Ib	Ie	If	Ih	I2a	I2g	IIa1	IIa2	IIa3	IIb1	IIb2	IIc1	IIc2	IIIa	IIIb	IVa1	IVa1b	IVa1c	IVa2a	IVa2b	IVb1	IVb2	Scrutiform lacunose prickle	Tabular lacunose prickle	Diatoms-hexagonal	Diatoms-Others
Early Medieval Sandyw	Sed 1	2675W																																		
Early Medieval Sandyw	Sed 2	2681W		13			1																						1				2		1	12
Early Medieval Sandyw	Sed 3	2689W																																		
Medieval Shellyware	Sed 1	2676W	1	2			3																								1		2	12		
Medieval Shellyware	Sed 2	2682W		1																									1				2		1	2
Medieval Shellyware	Sed 3	2690W																																	1	1
Potterspury ware	Sed 1	2674W	1	9	1		23				6					5										7			27	1	3	9	20	32		3
Potterspury ware	Sed 2	2680W		5			3			2						2													1			1	2	5		
Potterspury ware	Sed 3	2688W																																		

Appendix IIC: Durley Cottage Raw Phytolith Count

Ceramic type	Sediment #	Slide	Panicoid simple short cell	Festucoid simple short cell	Chloridoid Simple short cell	Lobed complex short cell	Rondel/Square complex short cel	Saddle complex short cell	Papillae	Ia	Ib	Ie	If	Ih	I2a	I2g	IIa1	IIa2	IIa3	IIb1	IIb2	IIc1	IIc2	IIIa	IIIb	Va1a	Va1b	Va1c	Va2a	Va2b	Vb1	Vb2	Scrutiform lacunose prickle	Tabular lacunose prickle	Wavy long cells	Diatoms-hexagonal	Diatoms-Others
Early Medieval Sandy Ware	2	2686W																															2				
Early Medieval Sandy Ware	3	2694W																																			
Grimston ware	2	2721W																															1	1		2	
Grimston ware	3	2729W																																			
Lyveden/Stanion 'A' Ware	2	2720W																																		1	
Lyveden/Stanion 'A' Ware	3	2728W																																	1		
Medieval Shelly Ware	2	2719W							1																										1	1	
Medieval Shelly Ware	3	2727W																																			

Appendix IID: Excavated Artifact Phytolith Raw Counts

Ceramic type	Sediment #	Slide	Panicoid simple short cell	Festucoid simple short cell	Chloridoid Simple short cell	Lobed complex short cell	Rondel/Square complex short cell	Saddle complex short cell	Papillae	Ia	Ib	Ie	If	Ih	I2a	I2g	IIa1	IIa2	IIa3	IIb1	IIb2	IIc1	IIc2	IIIa	IIIb	IVa1a	IVa1b	IVa1c	IVa2a	IVa2b	IVb1	IVb2	Scrutiform lacunose prickle	Tabular lacunose prickle	Diatoms-hexagonal	Diatoms-Others
Early Medieval Sandy Ware	2	2699W																														1		91	16
Medieval Shelly Ware	2	2700W																											2					10	
Potterspury Ware	2	2703W																																	
Medieval Shelly Ware	3	2708W	1																													2	2	1	>200
Potterspury Ware	3	2711W					1																												3
Early Medieval Sandy Ware	3	2707																														1			

Appendix II E: Excavated, Survey, and Durley Cottage Artifact Raw Starch Counts

MU #	Ceramic type	Sediment	Provenience	Results	Context
SS 578	Potterspury ware	Sed 2/3	GFW 04 101	No starch	Excavated
SS 579	Sandy ware	Sed 2/3	GFW 04 101	Triticum (1)	Excavated
SS 580	Shelly ware	Sed 2/3	GFW 04 101	No starch	Excavated
SS 586	Potterspury ware	Sed 1	WI 13- edge of occupatio	Unknown (1)	Survey
SS 587	Early Medieval Sandywar	Sed 1	WI 13	No starch	Survey
SS 588	Medieval Shellyware	Sed 1	WI 13	No starch	Survey
SS 592	Potterspury ware	Sed 2	WI 13- edge of occupatio	No starch	Survey
SS 593	Early Medieval Sandywar	Sed 2	WI 13	Triticum or Hordeum (1)	Survey
SS 594	Medieval Shellyware	Sed 2	WI 13	Unknown (1)	Survey
SS 598	Early Medieval Sandywar	Sed 2	Durley Cottage	No starch	Wyton
SS 600	Potterspury ware	Sed 3	WI 13- edge of occupatio	No starch	Survey
SS 601	Early Medieval Sandywar	Sed 3	WI 13	No starch	Survey
SS 602	Medieval Shellyware	Sed 3	WI 13	No starch	Survey
SS 606	Early Medieval Sandywar	Sed 3	Durley Cottage	No starch	Wyton
SS 611	Early Medieval Sandywar	Sed 2	GFW 04 080	No starch	Excavated
SS 612	Medieval Shellyware	Sed 2	GFW 04 045	No starch	Excavated
SS 615	Potterspury ware	Sed 2	GFW 04 101	Triticum (1), unknown (1), Avena sp (	Excavated
SS 619	Early Medieval Sandywar	Sed 3	GFW 04 080	No starch	Excavated
SS 620	Medieval Shellyware	Sed 3	GFW 04 045	No starch	Excavated
SS 623	Potterspury ware	Sed 3	GFW 04 101	No starch	Excavated
SS 631	Medieval Shellyware	Sed 2	Durley Cottage	Unknown (2)	Wyton
SS 639	Medieval Shellyware	Sed 3	Durley Cottage	No starch	Wyton

COMPARATIVE PLANT DATA

Appendix II F: Soil Starch Grain Raw Count

MU #	Ceramic type	Context	Location	Results
SS 915		GFW04	surface floor	Lens esculenta (1)
SS 916		GFW04	north profile	Unknown fabaceae (1)
SS 917		GFW04	east profile	Unknown fabaceae (1)
SS 918		GFW04	south profile	No starch found
SS 919		GFW04	west profile	Unknown (1)
SS 912	Potterspury Ware	WI13	SP 75038E	Hordeum vulgare (1) Poaceae for sure
			37978N	
SS 913	Early Medieval Sandy Ware	WI13	SP75038E	Triticum (3), Unknown (1)
			37978N	
SS 914	Medieval Shelly Ware	WI13	SP75015E	Alopecurus praetensis (1)
			38022N	

[i] The debate over the arrival of the Anglo-Saxons in England is primarily centered on the size and extent of the migration. In this debate it is suggested by some that large numbers of Germanic people left mainland Europe to conquer and settle new regions. Some of the earliest historical accounts make references to large waves of "pirates" who invading from the east during the 5th and 6th centuries. Others suggest that the migration was more gradual and that the Anglo-Saxons had already started settling the land during the Roman occupation. The Roman practice of hiring mercenaries to supplement their standing armies had introduced Germanic warriors to Britain well before the perceived Anglo-Saxon migration period. Therefore, the emergence of the Anglo-Saxons is viewed simply as an increase in migration of a population that was a small minority during the Roman occupation. Tied in with this is the question of the native population size in lieu of the Roman departure.

[ii] For the sake of simplicity, the influence of the Viking settlements and raids in north eastern England, starting with the 9th century A.D. has been ignored for this paper. The first Viking raids into Britain were recorded in 793 A.D. with the earliest English settlement emerging sometime around the 860s A.D. Viking raids throughout Britain undoubtedly disrupted the daily lives of the populations they attacked. Some sections of Britain were even included in the Danish king Knuts' short lived North Sea Empire in the first half of the 11th century. However, their impact on Anglo-saxon food and food production is unknown (Harke 2002: 157-161).