# The Compilation of a British Lowland Heathland and Agricultural Grassland Phytolith Reference Database and its application at the archaeological site of Wytch Farm, Poole Harbour, Dorset

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## Abstract

Phytoliths are inorganic, microscopic silica bodies formed within and between living plant cells. They can be used to identify plants to different taxonomic levels and have been utilised to address archaeobotanical and palaeoecological questions in multiple regions of the world. Phytoliths are rarely utilised as a proxy within British archaeology and that makes this project unique as it explores how phytoliths can be incorporated into archaeobotanical research frameworks. The project attempts to do so by building a foundation with the creation of a habitat related photographic phytolith database.

The aim of this project was to compile the photographic phytolith reference database for comparative purposes and then apply the database and additional proxies as an analytical tool on a Late Anglo-Saxon archaeological site, Wytch Farm. The site investigated at Wytch Farm is a small promontory jutting out into the Poole Harbour area, Isle of Purbeck, Dorset, southwest England. The archaeological excavation at Wytch Farm had revealed salt working hearths and brine tanks. Three British Isle habitats, agricultural grassland, lowland heathland, and an experimental agricultural field, were used for the phytolith reference collection. Plants collected from these habitats in late autumn led to the compilation of a website that shows the plant's phytoliths (httms://phynd.online). The website and phytolith soil analysis conducted were then combined to interpret the 1000-year-old soil deposit (baulk), accumulated, and overlying the late Anglo-Saxon saltern site. Additional proxies were used: pollen analysis, geochemical analyses using portable x-ray spectroscopy (pXRF), magnetic susceptibility, soil pH and loss on ignition. The combined analysis has led to methodological observations on the extraction of phytoliths from British native plants and an interpretation of the Wytch Farm soil deposits and anthropogenic use of the site during and beyond the Late Anglo-Saxon period.

As the baulk contains modern A horizon soil samples from across the field, an experiment was conducted at the Wytch farm site to establish the link between the site's vegetation and the phytoliths detected in the modern A horizon soil. This investigation did not prove successful, and the results did not improve when pollen data was added.

Most of the archaeological soil samples analysed contained many single phytoliths. The analysis suggested that due to a lack in multicell phytolith numbers in all soilsamples the identification to plant species is difficult. The dry ashing process of the modern plants used for the reference data base showed that plants did produce multicells. The pXRF results showed that silica is available in the Wytch Farm soil, and therefore multicells should be expected within the soil samples. A possible answer to this discrepancy might be a weaker silicification of

phytoliths due to low transpiration rates within a temperate climate zone. This means that post depositional taphonomic conditions account for the lack of multicelled forms preserved in the archaeological samples.
Due to the lack in multicells the analysis used the available single phytoliths and concentrated on a broader interpretation related to plant parts. This application of single phytolith counts at the Wytch Farm site over time and through different contexts (core samples and micromorphology block subsamples) together with the other environmental proxies pointed to a site that since Late Anglo-Saxon times has been used for agricultural and industry related activities (salt production and metal working) and did not revert back to a lower heathland landscape over that 1000-year time period. Agricultural practices that could be inferred were grazing and cereal production. There was clear indication for a water edge clearing event right at the start of the saltern production site and the presence of repeated flooding events for the lowest soil strata. A rise in burnt phytoliths in certain areas together with the magnetic susceptibility results seems to indicate areas with high temperature burning processes.
Using phytoliths and the accompanying phytolith database has proved a successful proxy at a site where, apart from pollen and charcoal, no other organic remains could be detected due to the acidic and well aerated nature of the soil.

## Acknowledgement

Archaeology is a team effort and while the project itself and the execution was done solely by myself, I could not have achieved any of it without the help and support of the following people and institutions:

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## 1. Introduction

On a global scale phytoliths have been used effectively for archaeological research. In preparation for an undergraduate project proposal in 2019, literature related to phytolith research and publications within British archaeological projects was looked at. It was found that phytoliths are a poorly represented proxy (Appendix 1). The reason given is the lack of a phytolith plant database for British flora which would help with plant part and species identification (Powers-Jones 1994).

Wytch Farm, the farmland, not to be confused with the nearby crude oil extraction area with the same name, is located on the western side of Poole Harbour. Various archaeological and historical research projects have established that Poole Harbour has been visited by humans and settled since pre-historic times (Cox and Hearne 1991; Hearne and Cox 1991; Ladle and Woodward 2009; Dyer and Darvill 2010). It has been the location for many industrial processes and trade networks since then such as pottery production, Purbeck stone extraction and distribution, the late medieval alum and copperas industry, trade with continental Europe as early as the late Iron Age and beyond such as the Newfoundland salted cod trade network in the 18$^{th}$ and 19$^{th}$ century (Woodward 1987; Cox and Hearne 1991; Hearne and Cox 1991; Wessex Archaeology 1991; Wilkes 2007; Ladle and Woodward 2009; Dyer and Darvill 2010; Bellamy et al. 2014; Jones 2017; Pitman 2020; Pike 2021).

The Wytch Farm archaeological site investigated for this project is surrounded by Corfe River on its northern side, borders the harbour on its eastern and southern side and connects to the mainland by a narrow causeway. This causeway was created over the last 100 years by recent generations of tenant farmers. The farmland is part of the larger Rempstone Estate, Isle of Purbeck, Dorset (pers.

Comm. D. Pitman). An excavation conducted by Bournemouth University in 2018 and 2019 revealed upstanding hearth features and with the help of radiocarbon dating from six charcoal samples showed a date range from cal AD 723 (95%) to cal AD 1216 (95%). Most of the dated samples placed within the 11th and 12th century AD (Appendix 2). The excavation area has been interpreted as a late Anglo-Saxon salt working site. As the soil at the site has an acidic pH and is well aerated, there were few organic finds during either of the two excavation periods in 2018 and 2019 (pers. Comm; Osborne 2019; Barrass et al. 2019; Pike 2021). Phytoliths are inorganic plant remains and survive well within an acidic soil environment (English Heritage 2011). To explore the possibility of applying these inorganic plant remains to archaeological interpretations of the site the creation of a site related open access British phytolith database was suggested. This database would then be applied to the phytoliths extracted from modern A horizon and archaeological soil samples.

This introductory chapter will explain what phytoliths are and how they are currently used within British archaeological research. It will describe the archaeological site of Wytch Farm and its current interpretation and list the aims and objectives for the project itself.

## 1.1 Phytoliths

Phytoliths are microscopic silica particles that are formed from silicon dioxide, mostly within stem, leaf, husks, and seed rind (Piperno 2006). Once deposited the silicon is silicified in and around the plant cells forming replicas of the cells and intercellular spaces (Piperno 2006). Phytoliths are not formed in all plants. One reason being that silica is not present in the local soil and therefore it cannot be taken up with water during the plant's transpiration process (Piperno 2006). The other reason that it has not been part of the plants' evolutionary adaptation (Piperno 2006). The plants' silica compounds are non-organic, therefore phytoliths survive, even when the organic part of the plant decomposes. Phytoliths exist in all soil types and do not have to be charred or preserved in waterlogged conditions. They can be found in acidic soils and soils with a pH of up to 8.5 (Environmental Archaeology 2011). As plant decomposition is located where a plant dies, phytolith bodies settle in the soil within the vicinity of plant decomposition and remain there (Hart 2011). If this soil moves, due to human, alluvial, colluvial or strong wind activity, then the phytoliths will be displaced (Piperno 2006). Phytoliths are categorised into single cell types (single phytoliths) and through these can be grouped into larger botanical categories such as monocotyledons (grasses), eudicots (e.g., herbaceous perennials and trees), sub families, for example C3 Pooideae and C4 Panicoidae, and also plant constituent parts such as stems, leaves, or husks (Smith 1996) (Fig.1). Conjoined phytoliths (multicell phytoliths) can be identified to genus and sometimes to species (Fig.2). If plants are used anthropogenically and therefore represent human activity, then the phytoliths left behind in the archaeological sediment can inform about people's actions such as plant use for wattle and daub or cereal preparation processes (Harvey and Fuller 2005; Jenkins et al. 2017).

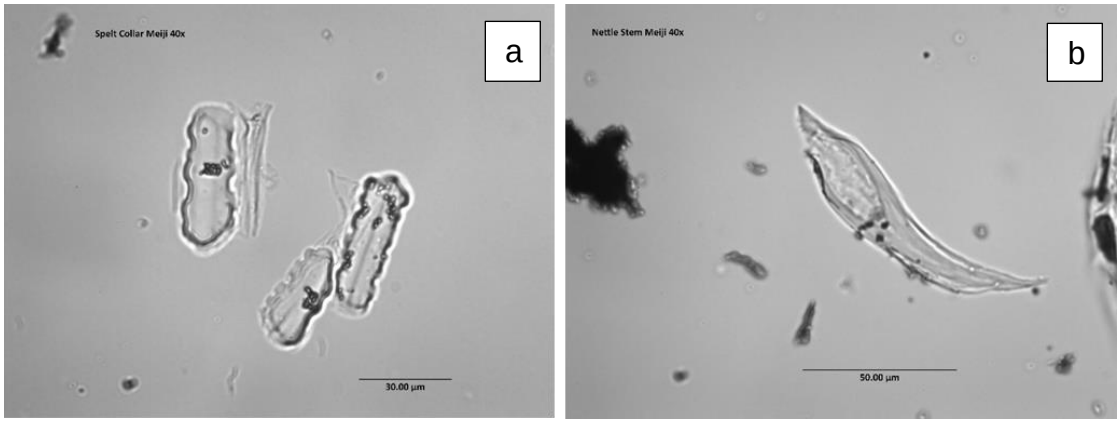



***Figure 1*** *Two examples of single phytolith types, a. crenate, Spelt, b. acute bulbosus, Nettle, (Osborne 2022)*

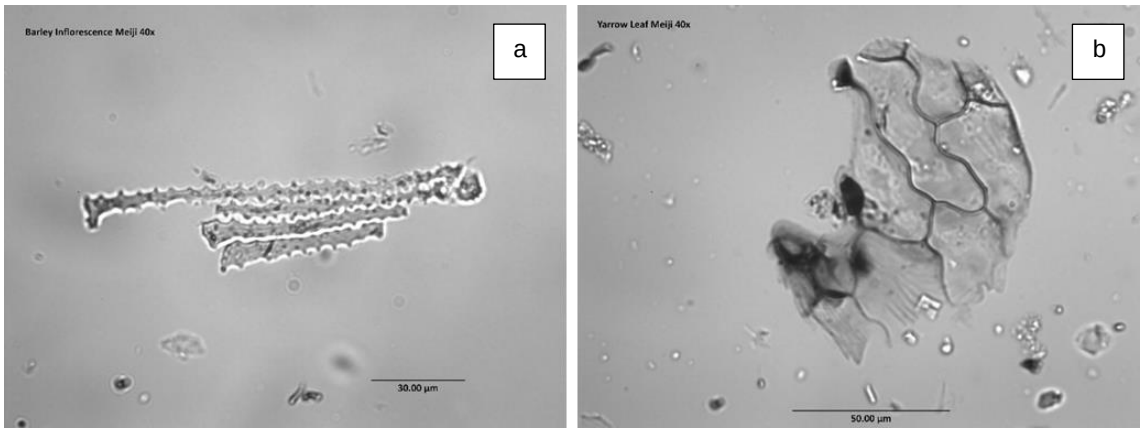



***Figure 2*** *Two examples of phytolith multicells (cojoined phytoliths), a. Barley, spikelet fork, b. Yarrow, leaf, (Osborne 2022)*

The presence of phytoliths in plants has been known since the 19th century, but their use within science and specifically archaeology has only been highlighted since the 1970s. The most prominent application of phytolith analysis is in South America, the Tropics, the Fertile Crescent and China and the focus is agriculture and crop domestication. For example, research by Dolores Piperno for the assessment of the presence of possible plant domesticates, such as maize and squashes in tropic soils, especially in South America, (Piperno 2006), and by Arlene Rosen for the assessment of cereal domestication, such as wheat and barley, in the Fertile Crescent (Rosen 2008). Phytoliths are also frequently used within Asian

plant research, especially in China on the domestication of millet and rice (Zhang et al. 2018). There have been international collaborative papers (Liu et al. 2002) but Asian and especially Chinese research papers are not always available to a Western audience due to language and publication barriers. Because of the intense study within all these localities, various identification catalogues and plant species specific phytolith picture websites are available through open access, such as Phytolith.missouri.edu or phytcore.org.

From 1970 onwards and with Piperno's (1988) publication, phytoliths have become a more widely used proxy within archaeology and more studies involving phytoliths and much wider research questions and applications have developed such as the investigation of midden and pit deposits (Powers-Jones 1994; Shillito and Ryan 2015), habitation floors (Rosen 2005), dung analysis (Portillo et al. 2019) and dark earth investigations (Vrydaghs et al. 2017).

However, when examining phytolith research in northwestern Europe and in particular Britain, research papers are limited (Appendix 1). The papers related to British phytolith research usually point out the advantage of the proxy, but acknowledge that more needs to be done, especially in terms of building up a plant species specific phytolith photographic database, aimed at British and Northern European flora (Powers-Jones 1994; Banerjea et al. 2015; McParland 2016; Radini et al. 2018; Wade et al. 2019; Banerjea et al. 2021; Kahlenberg 2021). Phytolith forms detected within British and northern European research can be linked to already existing databases with plant specific identification from other more temperate regions. This might not identify the exact plant species within Britain, but can help, with for example cereal recognition. Modern studies and plant phytolith reference collections exist for west Asia and southeast Asia and South America but are currently lacking within Europe, probably due to other archaeobotanical proxies, such as pollen and macro remains, perceived to fulfil

research queries' requirements and the potential of phytolith as an additional proxy not having been resolved. It is therefore important to build up a data base of phytoliths produced by plants from Britain. Phytoliths for the database can be extracted from current plant species which can be linked back to past environments (Tsartsidou et al. 2007). This MRes thesis will help fill this knowledge gap by enabling the creation of a photographic phytolith reference collection for British lowland heathland flora collected at a site on the Isle of Purbeck, Dorset, an agricultural grassland flora collected from the Wytch Farm field situated on the Isle of Purbeck and bordering Poole harbour, Dorset and some heritage agricultural cereal crops collected from Butser Ancient Farm, Hampshire and a modern barley crop from Abbey Farm in Gloucestershire.

## 1.2 Wytch Farm

Wytch Farm is a tenanted farm belonging to the Rempstone Estate. It is situated between the Purbeck Ridge and Poole Harbour in Dorset (Cox and Hearne 1991) (Fig.3 and Fig.4).

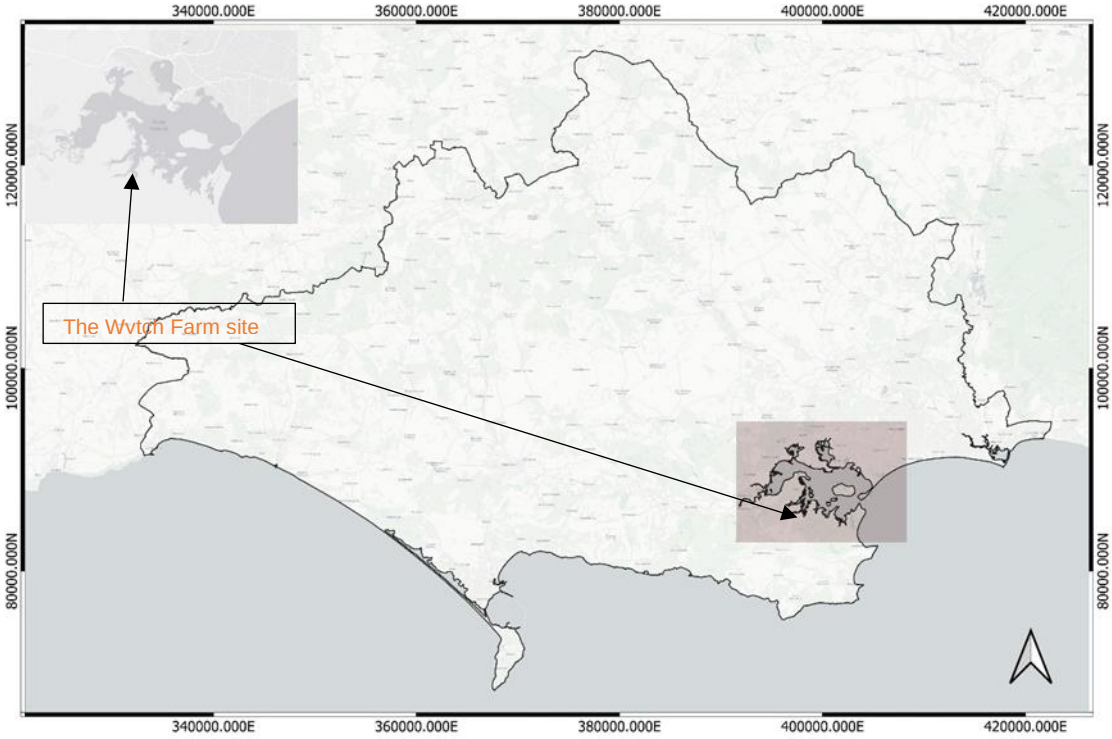



***Figure 3*** *The county of Dorset, the map insert depicts Poole Harbour*

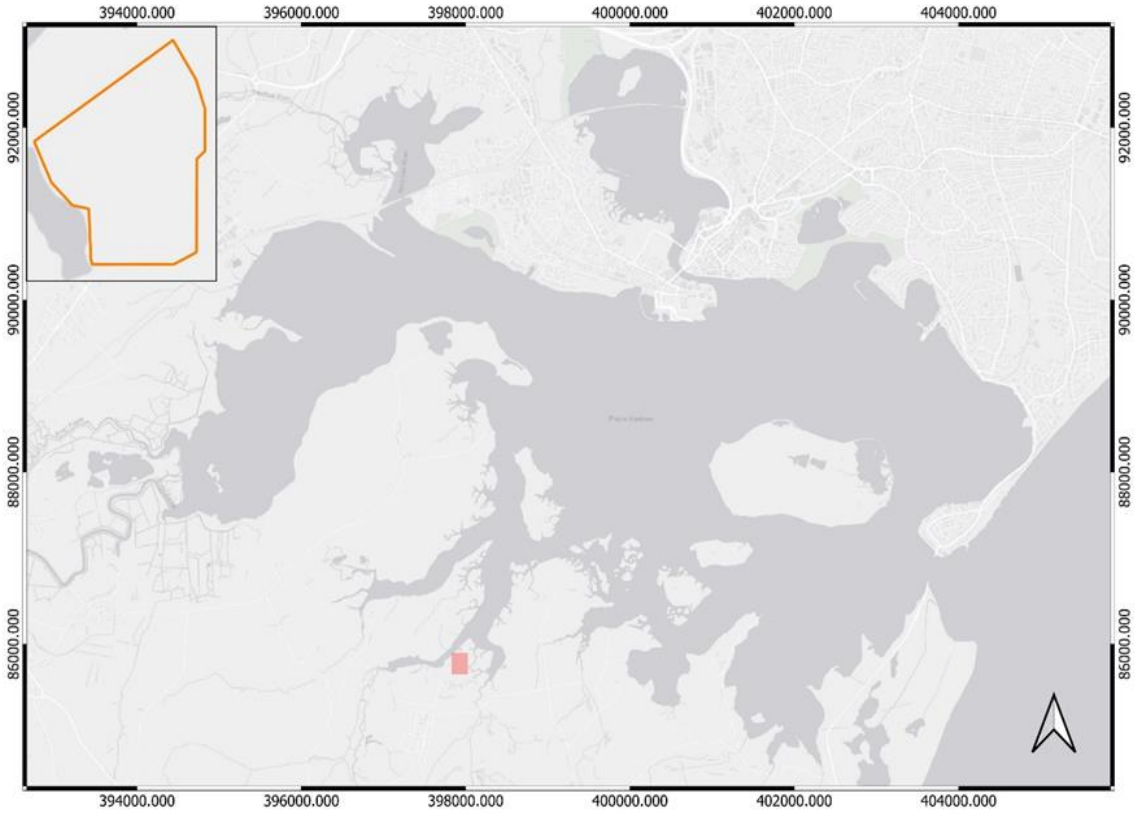



***Figure 4****Poole Harbour showing the location and outline of the Wytch Farm site*

Poole Harbour has a long history of trade and industry, such as the late Iron Age production of shale bracelets and a trade link with the continent in salted pig meat during the late Iron Age (Maltby 2006; Wilkes 2007; Dyer and Darvill 2010). A few other prominent industry and trade network examples are, the mass production and usage of the local late Iron Age black burnished ware after the Roman invasion and its distribution along the routes taken by the Roman army, the mentioning of 'salterns' on historic maps, the medieval alum copperas production to aid the textile industry, the usage and shipping of Purbeck stone since medieval times, trade in white ball clay with the Wedgewood factories in the 18th century and the salted cod trade with Newfoundland (Treswell Map 1586; Woodward 1987; Jarvis 1993; Ladle and Woodward 2009; Dyer and Darvill 2010;

Bellamy et al. 2014; Jones 2017; Pitman et al. 2020). Archaeological literature concerned with the Wytch Farm farmland gives an overview of a heathland landscape used for grazing and agriculture, historical industry processes such as a Roman pottery kiln, and there are some environmental studies related to pollen (Cox and Hearne 1991; Hearne and Cox 1991).

The soils in the Wytch Farm area are described as podzols. Podzols are predominantly formed from gravels, sand, and clay with a soil pH of 3.5 to 5.5. (Jordanova 2017; Podzol 2021) This soil type, typical of the Purbeck landscape, has been managed by people throughout history (Wessex Archaeology 1991). Due to it being so nutrient poor it was most often used for grazing animals, such as cattle and sheep (Wessex Archaeology 1991). Grazing on podzols forms heathland habitat dominated by heather and gorse (Hawkins 2004). Podzols can be used for agriculture, rye being the most tolerant grain for this type of soil, but fertilisation must be part of a regular soil conditioning scheme, as otherwise crop growth will be impeded drastically, and cannot be sustained for many growing seasons (Behre 1992). If left unmanaged podzols will revert to woodland characterised by pine, birch and after some time oak and hazel (Hawkins 2004). All these tree species cope well with the acidic and nutrient poor conditions of a podzolic soil (Hearne and Cox 1991). Apart from grazing and agriculture, heathland turves and gorse faggots have been cut and used throughout history as a source of fuel. They can produce high kiln temperatures which would have been an important factor around Purbeck and Poole, which is famous for its white ball clay and pottery industry, which was at its height between the late 18$^{th}$ and the mid-20$^{th}$ century (Hearne and Cox 1991; Dyer and Darvill 2010).

At Wytch Farm itself the soil is currently covered with grassland but within living memory has been used for agricultural crops such as clover, barley, turnips, and sugar beet (pers. comm. R. Pitman, Appendix 3). Considering the acidic nature of

the soil the current grassland cover should fit into one of the four acid grassland habitats which have been defined for the county of Dorset (Dorset Acid Grassland Inventory 2001). There are no published research reports for the Wytch Farm excavation at present but there is a poster presentation displayed at Bournemouth University and an unpublished undergraduate dissertation which focuses on the analysis of vitreous material (slag) found at the excavation site and within the Wytch Farm soil (Barrass et al. 2019; pers. comm. D. Pitman; Pike 2021). The current view is that the hearths found on the site were used for salt working while the vitreous material is a remnant of metal smelting processes either on the site or nearby (pers. comm. D. Pitman; Pike 2021) (Fig.5). The build-up of the soil profile above the excavation strata (baulk) is attributed to soil being deliberately moved to the site and becoming an additional agricultural resource as a grazing and crop production area (per. comm. D. Pitman) (Fig.6).

***Figure 5****One of two trenches from the 2019 excavation showing two hearths and postholes for a possible roof structure (Osborne 2019)*

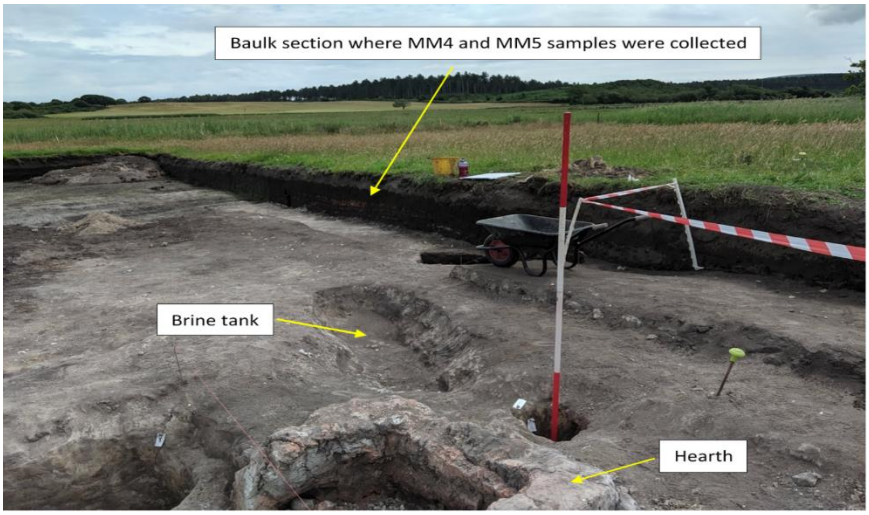



***Figure 6*** *View of the excavation area with the baulk, location for micromorphology samples MM4 and MM5 (Osborne 2019)*

***Figure 7*** *Some of the 2019 excavated features filled up with rainwater (Osborne 2019)*

During the 2019 excavation each student produced a fieldwork diary (Osborne 2019). Re-reading this diary shows a site that easily flooded during a rainy day and

***Figure 8****Plan view and section view of 2019 excavation showing undulating red sediment deposition, (Osborne 2019)*

was often wet underfoot, especially near the modern salt marsh, created through *Spartina* accumulation from the late 18th century onwards and adjacent to the site (Humphreys and May 2005). At this water's edge location small postholes indicated some form of hurdle fencing had been employed during the late Anglo-Saxon use of the salterns. It was noted that darker soil layers were interspersed with bright orange rubble layers that seemed to have been deposited in long lines or small heaps (Fig.7 and Fig.8).

There was a large amount of vitreous material found throughout the soil layers at the site and below that stratigraphy lay a very white sandy layer which was termed as the 'natural' and non-anthropogenic (Osborne 2019). It was possible to undertake radiocarbon dating on charcoal from small, burnt wooden branches found near some of the hearths. The earliest of the date ranges is from one sample and was calculated to cal AD 723-739 (95%), while the most recent dates from another sample range from cal AD 1118-1216 (95%). The other four samples range from cal AD 1017 (95%) to cal AD 1186 (95%) (Appendix 2).

Literature research revealed that Wytch Farm and its environs and large parts of the Isle of Purbeck were ecclesiastical landholdings (Sherborne, Cerne, and Milton Abbey are all mentioned in relation to differing areas of the Isle of Purbeck) until

the dissolution of the monasteries under Henry VIII (Wessex Archaeology 1991). Wessex Archaeology (1991) states that Cerne Abbey held the Wytch farm grounds. Cerne Abbey was given its status by Aethelmaer in a charter in AD 987 but there is an indication that a monastic group existed at Cerne before that date (https://www.dorsetcouncil.gov.uk/documents/35024/283356/Cerne_Abbas_Part_5.1_and_5.2_Saxon_and_medieval_February_2011.pdf/0273f7cf-9a5f-7486-7e36-4e8c16b9c6da).

This project's aim is to understand the Wytch Farm site baulk formation processes and whether the modern and archaeological soil deposits overlying the excavation site (micromorphology blocks) and the adjacent field (cores) are used for agricultural purposes or reverted back to heathland (Fig.10). It will attempt to identify different historical agricultural management practices within the soil profile such as the possibility of its use for grazing animals and whether and when crops were grown on the field throughout its history.

## 1.3 Aims

This project has two aims:

1. To create a phytolith database for British flora related to the site of Wytch Farm, Isle of Purbeck, Dorset.
2. To apply the phytolith database to modern soils, and archaeological soils to obtain an insight into anthropogenic usage of the Wytch Farm site from the late Anglo-Saxon excavation horizon to the present day.

## 1.4 Objectives

1. Establish a phytolith database for:

a. plants growing on the Wytch Farm site

b. plants from the surrounding lowland heathland landscape

c. crops grown on the Wytch Farm site within living memory.

2. Establish the phytolith signature for the modern A horizon from the Butser experimental crop growing field. This will provide a comparative tool for the modern A horizon soil analysed at Wytch Farm and possibly for the site's archaeological soil samples.

3. Compare vegetation samples with modern A horizon soil samples at Wytch Farm and establish the phytolith signature of these samples. This may provide a representative comparison tool that can be applied to the archaeological soil samples from the site.

4. Analyse archaeological soil samples from two sampling strategies used during the excavations:

a. Core samples collected from across the whole site. Part of this analysis will align with a project undertaken by Harry Manley who is investigating the soil build

up and possible anthropogenic heat industry related signatures left within the core soil samples

b. Two micromorphology blocks cut into the soil deposits (baulk) overlying the excavation site

# 2 Methodology

The methodology for this project has been aligned with laboratory training received when supporting phytolith research in the Bournemouth University laboratories and through fieldwork experience gained during two recent pilot projects, one at Farlington Marshes, Hampshire, UK, in the summer of 2020 and the other in the Wytch Farm and Hartland Moor environs, Dorset, UK, in the summer of 2021 (Karoune 2020; Davies and Elliott 2021).

The methodology protocols have been divided into four areas: fieldwork (2.1), plant identification (2.2), laboratory processes (2.3) and analysis (2.4).

## 2.1 Fieldwork

Three main locations were chosen for the collection of the modern plant specimen, which once dry ashed became the foundation for the database website (PhyND.online). The first location, Butser Ancient Farm, located in Hampshire, contains an experimental crop growing field where heritage cereal crops are cultivated. These are more likely to correspond to late Anglo Saxon cereal crops rather than modern cereal species which have been adapted and changed over many years. As the Wytch Farm site is situated within the lower heathland landscape of the Isle of Purbeck, the SSSI site of Hartland Moor was chosen as the second location. Hartland Moor reflects the lower heathland ecosystem and contains many of its characteristic flora. The Wytch Farm site itself was the third collection site. Plants were collected from across the field.

In order to supplement a crop not found at Butser, *Hordeum vulgare* (Barley), was collected from Abbey Home Farm, an organic landholding, in Gloucestershire.

The fieldwork and plant collecting at Butser Ancient Technology Farm in Hampshire, Wytch Farm in Dorset and a barley field at Abbey Farm in Gloucestershire was undertaken in August 2021. Additional fieldwork took place at

Hartland Moor in September 2021 with further plants collected from the same site by A. Diaz in October 2021. Each site was visited for one day apart from Wytch Farm where a repeat visit took place in April 2022. This additional visit was undertaken to assess the grassland classification for the Wytch Farm site. The weather for the fieldwork at Wytch Farm, Hartland Moor and in Gloucestershire was sunny and warm with the occasional cloud, while at Butser there were a few light rain showers interspersed with sunny skies.

### 2.1.1 Botanical survey and plant collection

To establish recent crop and agricultural management at the site of Wytch Farm a questionnaire was sent to the tenant farmer (Appendix 3). Many of the crops indicated on this questionnaire were sampled (Table 1).

**Table 1** Crops at Wytch Farm (50 Years)

| Crop grown at Wytch Farm over last 50 years | Equivalent crop for phytolith extraction collected from | Identification Number | Phytoliths identified |
|---|---|---|---|
| Barley | Field in Gloucestershire | M032-M038 | Yes |
| Clover | Wytch Farm site (Red Clover) | M046-M049 | Yes |
| Fodder Beet | Could not be sourced | - | - |
| Fodder Maize | Could not be sourced | - | - |
| Grass | Wytch Farm site | M065-M070 M140-M144 | Yes |
| Kale | Could not be sourced | - | - |
| Turnip | Could not be sourced | - | - |
| Wheat | Butser (Emmer, Einkorn) | M001-M014 | Yes |

These crop samples were collected from Butser Ancient Farm in Hampshire, the vegetation cover at the Wytch Farm site, and from Abbey Home Farm, an organic farm in Gloucestershire. It was not possible to source all the modern crops (Appendix 10)

As the silica take up within plants and the deposition into plant cell walls takes time it was decided to conduct the fieldwork in all locations towards the end of the summer (Piperno 1988; Pearsall 2000; Archer 2003). Most of the plants collected were still in flower and contained various plant parts (e.g., leaf, stem). Some had just started setting seed, but all plants collected had had time to accumulate and deposit silica to form phytoliths. With Wytch Farm being surrounded by heathland and with the typical acidic podzol soil for the area assumed, modern plants were collected from the site itself and from Hartland Moor, a heathland area under SSSI protection and managed by the National Trust (Appendix 5). Due to its protection status plants collected at Hartland Moor were sampled from above ground whereas at Butser, Abbey Home Farm in Gloucestershire and at Wytch Farm the landowners/managers were happy for the plants to be collected with their roots attached.

Wytch Farm had initially been classed within an acid grassland ecosystem (Dorset Acid Grassland Inventory 2001) but the site had been intensively managed for agricultural processes within living memory. Therefore, with the help of an experienced BSBI (Botanical Society of Britain and Ireland) recorder, a fieldwalking and plant identification survey was carried out in the spring of 2022. This compared the data identifying acid grassland with the actual plant data present on the site (Dorset Acid Grassland Inventory 2001, Appendix 11).

Plant identification was conducted in the field using existing knowledge gained during horticultural training and in addition there was support from a trained ecologist (Anita Diaz), a trained horticulturist/arboriculturist (Andrew Osborne) and a trained BSBI recorder (Robin Walls). In the field an app called ‘Leaf’ was used. ‘Leaf’ allows the user to take a picture of a plant part (leaf, flower, or seed/fruit being the most common). The app then suggests possible plant specimen matches for the uploaded plant features.

### 2.1.2 Modern soil samples

Although the main aim for this project concerns itself with the archaeological soil samples, some modern A horizon soil samples were taken at Butser and at the Wytch Farm site. The Butser A horizon soil from the experimental agricultural field was analysed for phytoliths to discern how the soil phytolith signature of this agricultural field would compare to the one at Wytch Farm. In addition, the Wytch Farm A horizon soil was used to compare the soil's phytolith signature to the site's vegetation cover.

A horizon soil samples were collected from two bays within the experimental crop growing area at Butser (Fig.7). The A horizon soil at Wytch Farm was taken from three quadrant samples (Fig.10 to Fig.14).

#### *2.1.2.1 Butser: modern A horizon soil samples*

As the experimental field at Butser had not been harvested, a random area was selected within the two bays chosen (Fig.11). One soil sample was taken from each of the two bays. The plant cover was moved to one side and an archaeological trowel, which had been wiped clean, was used to scoop some of the A horizon soil into a clean plastic container. The container was placed and kept in a fridge on arrival to the Bournemouth University laboratories before being processed.


**Figure 7** Soil sample collection at Butser, a. Bay 1; b. Bay 7

The samples collected from the Butser experimental crop growing area were dark brown to grey black in colour with no visible large inclusions. It was soil that held together when compressed but fell apart on drying.

### *2.1.2.2 Wytch Farm: modern quadrant A horizon soil samples*

Three 50 cm x 50 cm quadrant spaces were chosen randomly by throwing a quadrant grid frame (Fig.10 and Fig.12). It was decided to throw the first grid frame in the central area of the field where the soil had been disturbed due to the 2018/2019 excavation activities (Quadrant 1), the second quadrant close to and towards the wooded area (Quadrant 2) and the third from the wooded area back into the open field onto an area which had seen no disturbance by the excavations (Quadrant 3) (Fig.10 and Fig.12). For each quadrant the vegetation cover contained within was recorded and the percentage of plant coverage within the quadrant noted (see 3.1.3 and Table 6). A soil sample was then taken from within each quadrant using a 1m Eijkelkamp gouge augur (Fig.12). Only the top layer of soil up

to a depth of 14 cm was taken for analysis. The soil samples from each quadrant were placed into a plastic collection bag and deposited and kept in the fridge at the Bournemouth University laboratory until they were processed.

The quadrant sample soil was dark grey black in colour,  loose in consistency but the inclusions varied between the samples. Sample 2, which was collected nearest the tree line (Fig.10), contained leaf litter and tree debris (such as twigs or fruit) and would not hold shape when compressed. Sample 3, collected from undisturbed grassland (Fig10), held shape when compacted but fell apart easily, even before drying. Sample 1, which came from ground disturbed by the archaeological excavation processes (Fig.10), contained various grain size sandy inclusions as well as smaller stones no more than 5 mm in size.

### 2.1.3 Archaeological soil samples

Two different sampling techniques were used for the archaeological soil samples. The core samples had been taken during the excavations in 2018 and 2019 (Fig.13) and soil subsamples from two micromorphology blocks, extracted from the deposits upwards of the sandy (natural) sample overlying the excavation horizon during the 2019 excavation (Fig.6, Fig.10, Fig.11 and Fig.14).

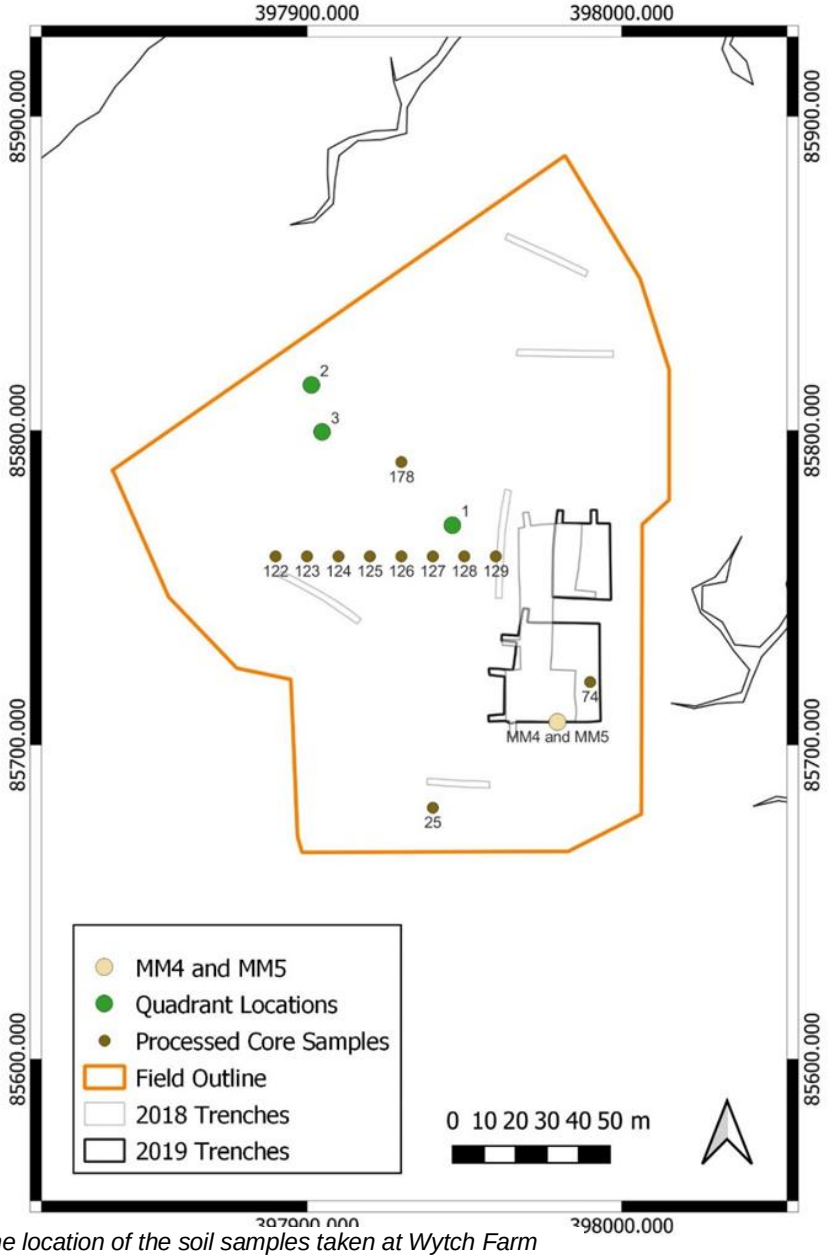



***Figure 10*** *Map showing the location of the soil samples taken at Wytch Farm*


***Figure 11*** *MM4 and MM5 micromorphology block sample sampling (Elliott 2019)*

***Figure 12*** *Collecting soil from Quadrant 1, August 2021 (A.Osborne 2021)*


***Figure 13*** *Core sample collection, fieldwork diary 24th June 2019 (Osborne 2019)*

### *2.1.3.1 Wytch Farm: the archaeological core soil samples*

The 262 core samples were taken using a 10m grid covering the whole Wytch Farm field. The grid was laid out using GIS and British National Grid coordinates. The sample location data was uploaded to a Leica differential GNSS (positional accuracy of +/-3cm) (Harry Manley pers. comm.). An Eijkelkamp 1m gouge augur was used to extract the sediment cores. Each core extracted was recorded in the field using visual colour and texture observations and then divided into a top, middle, and bottom sample (Fig.12). The depth of the core was recorded in relationship to where the sandy (natural) sediment was met. Closer to the water's edge of the site this sandy sediment was often not observed, and a layered sedimentation process could not be detected by the time 1 m had been reached. Further inland the sandy layer was replaced by a sterile alluvial clay layer (natural). The core samples for location 178 had been processed in 2019 as trial samples to assess whether phytolith work at Wytch Farm would be a viable option (Appendix 6).

In 2018 and 2019 the core samples were described by students on A4 sheets in the field during the collection process (Fig.13; Osborne 2019). They were part of a 2019/20 undergraduate's independent research project which was not completed. Although some records for the core depths are available the soil descriptions were not digitised, and the former student did not respond to attempts at retrieving this information (pers. Comm. Harry Manley and personal attempts). This has made the creation of a section drawing which related the core depths to the excavation site impossible.

### *2.1.3.2 Wytch Farm: the micromorphology block samples*

During the 2019 excavation micromorphology block samples were taken by Dr. S Elliott, using prefabricated galvanised steel tins (fig.14). Two of the blocks were taken from the soil overlying the excavation site (baulk, Feature 1002) and inclusive of the underlying sandy sediment (natural) (Fig.6 and Fig.14). No section drawing for feature 1002 is currently available.

The tin size for sample MM4 was 30x10x10 cm and for sample MM5 was 13x7.5x5 cm. The baulk area sampled was lightly cleaned using a trowel and the tins inserted, marked to show top and bottom, wrapped in blue cloth (WYPALL L20 sheet size 28x38 cm) and sealed using duct tape. They were taken back to Bournemouth University and stored in a laboratory fridge until subsampling took place in January 2022.

The micromorphology sample soil description was undertaken in the Bournemouth University laboratory in 2021 (Table 2). No description was undertaken during the sampling process in the field (pers. comm. S.Elliott). The two micromorphology blocks were divided into subsamples. Sample MM4-SS9 overlaps stratigraphically with MM5-SS1. MM4-SS1 represents the sandy sediment (natural) below the excavation site and the lowest stratigraphic layer. MM5-SS4 represents the topmost baulk sample and is the lower part of the topsoil which was unstratified due to modern ploughing within recent management practices on the field (Appendix 3). All 13 subsamples are described (Table 2).


***Figure 14*** *MM4 and MM5 micromorphology sample blocks*

**Table 2** *Description of subsample MM4 and MM5 soil*

| Sample Number | Sample | Description |
|---|---|---|
| 1 | MM4-SS1 | Sandy layer, beige-white, pure sand |
| 2 | MM4-SS2 | Striated layer, striation of orange transitioning to brown, not homogenous |
| 3 | MM4-SS3 | Grey layer, flecks of charcoal, more consolidated |
| 4 | MM4-SS4 | Brown layer, paler at lower edge, darker at upper edge, flecks of charcoal |
| 5 | MM4-SS5 | Thinner layer, white/grey and orange striation, white pin head sandy patches, flecks of charcoal |
| 6 | MM4-SS6 | Brown layer, flecks of charcoal, flecks of orange and white (not sand) |
| 7 | MM4-SS7 | Orange striations and brown humic ones, flecks of charcoal, larger flecks of orange and white |
| 8 | MM4-SS8 | Like MM4-SS7 but divided by band of brown, whole layer slopes to the right side, orange striation more consolidated |
| 9 | MM4-SS9 | Dark brown, holding together, larger patches of sandy inclusions |
| 10 | MM5-SS1 | Brown layer at lower end, overall orange layer |
| 11 | MM5-SS2 | Brown layer, flecks of charcoal, sporadic small grit like stone inclusions, pieces of slag |
| 12 | MM5-SS3 | Orange layer with white, chalk like inclusions and stand out orange inclusions |
| 13 | MM5-SS4 | Brown layer, loose and sandy, sandy quartz inclusions, small flecks of orange and charcoal |

Apart from the white sandy sediment of MM4-SS1 all other layers were either brown, grey, or orange. There were observations of charcoal inclusions and small sandy inclusions. Slag (vitreous material) and possible fired clay like material was recovered from some of the subsamples.

## 2.2 Plant identification and project herbarium

After an initial identification in the field all the collected plants were dried. The dried plant specimens were compared to Kew Herbarium samples using the RBG Kew Herbarium online catalogue. In addition, various identification guides were used to determine the specimen's botanical classification (Rose 2006; Stace 2010; BSBI website). A project herbarium was created using A3 herbarium mounting paper and fixing the plants with Arcare gummed lined tape and B303 botanical mounting paste. (Press et al. 1981; Parry-Crooke 1993; Cope and Gray 2009; RBG Edinburgh online). The herbarium sheets were placed in two acid free boxes and have formed part of the physical archive for this project which is stored with the Wytch Farm excavation archive at Bournemouth University (Appendix 15 and Appendix 16).

## 2.3 Laboratory processes

The following section will detail the two methods used to process for phytoliths within this project. The first method, the dry ashing protocol, was developed by Jenkins et al. (2011) and it was used to extract the phytoliths from the collected and dried modern plant specimen (see 2.3.1.1). The second method, a phytolith soil processing protocol adapted from Rosen (1999), was used for the modern A horizon soil samples from Butser and Wytch Farm and for the archaeological soil from the cores and micromorphology block samples (see 2.1.1.2).

Additional analytical methods were used on all or some of the soil samples. Loss on ignition (LOI) was used on all soil samples to determine the soil's organic content (see 4.2 and 4.3). All soil samples had their pH analysed to establish potential phytolith degradation due to soils being too alkaline (see 4.2 and 4.3). As the project progressed other techniques were included to enhance the phytolith findings and in response to observations made. The micromorphology block samples had their geochemical composition determined using pXRF (portable X-Ray spectroscopy) (see 4.3.2.4). This was to check for silica within the soil and to see if any other elements could help with the phytolith interpretation. An additional and comparative botanical proxy, pollen analysis, was employed to investigate the three Wytch Farm quadrant soil samples (see 4.2.2.3). During the phytolith analysis diatoms were revealed in some of the archaeological soil samples. Diatoms are non-phytolith silica remains attributed to microalgae. This observation was noted and investigated further (see 4.3.1.5 and 4.3.2.5). All the additional analytical proxies enhanced and helped to underpin some of the project's interpretations.

An attempt was made to analyse slides obtained from the whole of the micromorphology blocks (micromorphology section slides) to assess these

archaeological soil samples for presence or absence of faecal spherulites or visible signs of trampling. Funding was procured from a Bournemouth University research fund in January 2022 to process the micromorphology blocks into micromorphology slides. This process was undertaken by an external contractor and finished in September 2022. As the Master thesis hand in deadline was in June 2022 it was not possible to include this proxy. The micromorphology slides are held with the physical archive for this project at Bournemouth University.

### 2.3.1 Phytolith extraction

Phytoliths were extracted from the modern plants and from both the modern and archaeological soils.

#### *2.3.1.1 Dry Ashing the Modern Plant Specimen*

Initial research into dry ashing indicated various protocols (Piperno 1988; Pearsall 2000; Archer 2003; Jenkins et al. 2011; Boston University online). Based on experience, and the complexity and time requirement for the other protocols identified, the Jenkins et al. (2011) methodology was selected for the plants analysed in this study. This project has evaluated the method by Jenkins et al. (2011) for its suitability of dry ashing the modern British flora (see 3.1.4).

After collection in the field and drying the plants between newspaper sheets and in a plant press, the plants were washed three times in distilled water and placed on baking paper sheets and dried overnight in a Heraeus oven at 50˚C (Fig.15).


***Figure 15*** *Preparation of dried plants for dry ashing*

Before the washing process and after each plant specimen the sink was cleaned and rinsed with distilled water to avoid cross contamination. Once dried the plant specimens were divided into their parts (such as leaf, stem, root, etc.) sometimes using a scalpel, scissors or a sharp knife on a glass cutting board. Most often it was possible to separate the parts by breaking them apart. Individually numbered crucibles were weighed before the plant parts were added and then once again when they had been filled (Fig.16).

***Figure 16*** *Separating and weighing the plant specimen*

Between each plant specimen the tools and surface areas worked on were cleaned with 'Biocleanse' to avoid cross contamination and full crucibles were covered over in a tray with a sheet of aluminium to avoid plant parts accidentally becoming mixed. Once 24 crucibles had been processed, they were placed in a cold muffle furnace and the temperature was set to 550˚C and then fired for two hours and forty-five minutes. The muffle furnace was then switched off and allowed to cool overnight. The content of each crucible was transferred into a numbered 15 ml plastic tube, and a 6 ml 10% Hydrochloride (HCl) solution was added to each tube and then left to stand for 5 minutes. After those 5 minutes 10 ml distilled water was added to the tube and placed in a centrifuge at 2000 rpm for 5 minutes. The extra solution was then poured off and more distilled water to 10 ml was added. This process was repeated twice. Numbered and empty 5 ml

glass beakers were weighed. Once the 15 ml tubes had been through the centrifuge and pouring process a pipette was used, a separate one for each tube, to transfer the ash containing the phytoliths from the 15 ml tube into the corresponding numbered 5 ml glass beaker, using drops of distilled water if needed. The 5 ml beakers were then placed in the Heraeus oven at 50˚C until all the distilled water had evaporated. After cooling the full beakers were weighed individually and each ash sample had a maximum of 0.0010 g sample placed on a microscope slide and mounted using Entellan and a 22x22 mm cover slip.

#### *2.3.1.2 Phytolith processing from soil (modern and archaeological soil samples)*

A pilot study had already been conducted on core 178 in 2019 using the adapted Rosen (1999) protocol to extract the phytoliths. As this trial had not shown any problems it was decided to continue using the protocol to ensure consistency.

Due to centrifuge and muffle furnace space availability the work was done in batches of 24 samples. The soil was sieved using a 500-micron mesh and 2 g of the soil which had passed through the sieve was weighed into 40 ml plastic centrifuge tubes. To remove carbonates 10 ml of 10% Hydrochloride (HCL) was added to each tube and shaken. Then the tubes were filled to the 40 ml mark with distilled water and placed into a centrifuge at 2000 rpm for five minutes. The solution was then poured off and the tubes refiled to 40 ml with distilled water and placed back into the centrifuge. This was repeated twice. After the third centrifuge run and pouring off the liquid once more, the remaining soil was placed into 400 ml glass beakers. Each beaker had 20 ml of 5% Sodium Hexametaphosphate added to begin the clay removal process. Each beaker was then filled to the 8 cm mark, stirred, and left to settle for 75 minutes. Then the water was carefully poured off without disrupting the sediment in the bottom of the beaker and the beaker refilled to the 8 cm mark with distilled water and left to stand for 60 minutes. Then it was poured off again and the last step repeated until the water was clear after the 60-minute settling period. This was then poured off and the remaining sediment transferred into crucibles and dried in a drying oven at 50˚C. Once dry the crucibles were transferred into a cold muffle furnace and set to 500˚C and left for three hours. The muffle furnace was then switched off and allowed to cool overnight. The sediment was transferred to 15 ml plastic tubes and 3 ml of Sodium metatungstate (SPT), calibrated to a 2.3 density, was added to each tube, and shaken. The tubes were then placed in a centrifuge at 800 rpm for

10 minutes. The supernatant containing the phytoliths was poured into a corresponding numbered empty 15 ml tube and distilled water added to the 10 ml mark. Each tube was shaken and placed in the centrifuge at 2000 rpm for 5 minutes, the extra solution poured off and filled up to the 10 ml mark with distilled water and then placed into the centrifuge. This process was repeated twice more. Numbered and empty 5 ml glass beakers were weighed. Once the 15 ml tubes had been through the centrifuge and pouring process a pipette was used, a separate one for each tube, to transfer the ash containing the phytoliths from the 15 ml tube into the corresponding numbered 5 ml glass beaker, using drops of distilled water if needed. The 5 ml beakers were then placed in the Heraeus oven at 50˚C until all the distilled water had evaporated. After cooling the full beakers were weighed individually and then each ash sample had a maximum of 0.0020 g sample placed on a microscope slide and mounted using Entellan and a 22x22 mm cover slip.

### 2.3.2 Other laboratory processes used within the project

The additional proxies were undertaken on the modern A horizon and archaeological soil samples. Loss on ignition and pH determination was done for all soil samples. Portable x-ray fluorescent spectroscopy was done on the archaeological micromorphology samples. Pollen processing and analysis was undertaken with the Wytch Farm quadrant soil samples. The magnetic susceptibility investigations were undertaken by Mark Johnson and Harry Manley but are briefly mentioned within this methodology as they have an impact on interpretation of the burnt phytoliths and charcoal found in the core archaeological samples (see 4.3.1.3).

#### *2.3.2.1 Loss on Ignition (LOI) (modern and archaeological soil samples)*

The Wytch Farm core samples had already been dried and had been sieved with a 4 mm sieve to analyse them for magnetic susceptibility. The quadrant samples and micromorphology samples had been dried but no sieving had taken place.

Empty crucibles were weighed, then a small spatula of dried sample soil added, and the full crucible weighed again. The crucibles containing the sample soil were then put in a Memmert drying oven for 12 to 16 hours (overnight) at 105 ˚Celsius, cooled in a desiccator and then weighed. After weighing they were put in a cold muffle furnace set to 550 ˚Celsius for two- and three-quarter hours, the furnace was allowed to cool for about an hour and then the crucibles were taken out and cooled in a desiccator and then re-weighed.

#### *2.3.2.2 pH (modern and archaeological soil samples)*

The Wytch Farm core samples had already been dried and sieved with a 4mm sieve in order to analyse them for magnetic susceptibility. The quadrant samples and micromorphology samples had been dried but no sieving had taken place.

All pH samples were analysed using a pH metre except for core sample 178. This had been processed as a trial sample in 2019 and litmus paper had been used to test the pH and therefore the results for sample 178 are less precise pH values.

With the exception of core sample 178, for all other soil samples 10 mg of soil was weighed into 40 ml plastic tubes. The tubes were filled to the 25 ml mark with ultra-pure water and then shaken on an orbital shaker for 15 minutes at 150 rpm and at room temperature. The pH was tested using a Jenway 3510 pH Meter.

### *2.3.2.3 Portable x-ray fluorescent spectroscopy- pXRF (micromorphology block samples only)*

***Figure 17*** *Preparing the micromorphology soil samples for the pXRF analysis*

For the preparation of the samples, gloves were worn, and a Kimtech Science wipe used to prepare the samples on (Fig.17). After each sample was labelled, and filled the Kimtech wipe was discarded, and the bench cleaned with 'Biocleanse' to avoid cross contamination between samples. The soil subsamples were prepared by pouring the sample soil into 31 mm open ended x-cells which had an xrf (x-ray fluorescent) thin film (polypropylene, TF-240-255, 63.5 mm) clamped between the container and the outer ring. If there was not enough sample the container was filled with the addition of wadding material. The larger vitreous and clay like material were added to the pXRF without container.The portable Nitron XL3t GOLDD+ XRF Analyser with the Bournemouth University identification number No. SN113932 was used for the analysis. The handheld device was clamped into a

stand within the appropriate laboratory space within the university. Both stand, and device were connected to the affiliated laptop computer linked to the analysis programme (Fig.18). The set up was Mining, Cu/Zn, Standard: 20, 40, 60, 80 with a maximum time of 200 seconds. Helium was off and at the beginning of the process a system check was performed. After the system check was successful three of the standards supplied with the device were analysed first. They were NIST 2709aPP, RCR APP 09121903 and Si02 99.995% PP. These three standards were reanalysed once all the soil samples, vitreous materials and the clay like material had been scanned. This informed on the performance of the device and allowed for errors to be detected.


***Figure 18*** *The pXRF analysis set up*

#### *2.3.2.4 Pollen (Quadrant samples only)*

The pollen, which was processed using the modern A horizon soil collected from the quadrants at Wytch Farm, was processed in the laboratories of the University of Reading under the guidance and with support from Jon Badger, a Laboratory Technician at QUEST, Quaternary Scientific, a commercial, university affiliated unit. The protocol used at Reading is adapted from a method by Moore et al. (1994) (Appendix 9). Gloves were worn throughout all processes. 4 g of sediment was weighed into a 40 ml glass beaker. 20 ml Sodiumpyrophosphate was added to the beaker and a Licopodium tablet (Batch No. 100320201) added to the solution. The beaker was covered with aluminium foil and then heated to 80˚C on a hot plate and left to simmer for 30 minutes. The solution was poured through a 125 µm sieve and then sieved through a 10 µm sieve. The remaining residue was poured into a rounded 15ml plastic centrifuge tube and spun at 2500 rpm for 5 minutes, with the break on. The liquid was poured off and 6 ml of SPT added to the tubes, the tubes shaken on a vortex mixer (lab dancer) and then placed in the centrifuge at 2500 rpm with the break off for 20 minutes. The pollen was in suspense at the top of the SPT. This top layer and about 4 ml of SPT was poured into a conical 15 ml plastic centrifuge tube. The tube was filled to the 15 ml mark with de-ionised water and mixed using the lab dancer. It was spun in the centrifuge at 2500 rpm for 5 minutes with the brakes on. The liquid was poured off and the tube filled to 15 ml with de-ionised water, mixed and then spun again. The process was repeated once more and then the liquid was poured off. Acetic Acid 99% was poured into a 60 ml glass beaker under the fume hood. In the fume hood 10 ml of acetic acid was added to each tube and the solution mixed using the lab dancer. It was spun in the centrifuge at 2500 rpm for 5 minutes with the brake on before being poured off into the sink inside the fume cupboard. While the acetic acid was being spun in the centrifuge a 1 l glass beaker was filled with

de-ionised water covered with aluminium foil and placed on a hot plate and heated to 80/90˚C. Meanwhile Acetic Anhydrite 97% and Sulphuric Acid were mixed at a ratio of 9:1 in the fume cupboard. The Acetic Anhydrite was measured out first and poured into a glass flask then the Sulphuric Acid was measured and added slowly and bit by bit. 4.5 ml of this mixture was added to each tube and the tubes were placed in the hot water bath for 3 minutes. They were taken out and placed in the centrifuge at 2500 rpm for 5 minutes with the brakes on. The liquid was poured off into the sink in the fume cupboard and topped up with de-ionised water to the 15 ml mark, mixed on the vortex mixer (lab dancer) and then spun at 2500 rpm for 5 minutes with the brakes on. The last step was repeated two more times before the liquid was poured off. A small amount of Safranin was placed on the side of a micro centrifuge tube and the pollen transferred from the conical 15 ml tube tip into the micro centrifuge tube using a 5 ml plastic pipette. The microcentrifuge was used to spin the tubes at 2500 rpm for 5 minutes with the breaks on. Glycerol was heated in a hot water bath on the hot plate until it was liquid, and a small amount transferred into each micro centrifuge tube. After gently stirring the glycerol and pollen with a wooden stick the mixture was transferred, eight to ten drops per slide, onto a microscope slide and a rectangular cover plate added. The slide was left to dry for a minimum of 30 minutes before being assessed. Licopodium being present on the slide indicated successful pollen processing.

#### *2.3.2.5 Magnetic susceptibility*

In the summer of 2021, all the core samples had been processed by Mark Johnson for magnetic susceptibility and the results analysed and mapped using QGis by Harry Manley at Bournemouth University (Manley et al., forthcoming). These results were made available for this project and integrated with the core sample's burnt phytolith analysis (see 4.3.1.3).

## 2.4 Analysis

The modern plant phytoliths were photographed and a data base set up (PhyND.online) while the soil phytoliths were counted and compared with the modern plant pictorial data base (PhyND.online).

### 2.4.1 Modern plant phytolith photography

The single phytolith types and multicells found on each slide were photographed using an Infinity 1 Camera attached to a Meiji MT6520 polarising microscope. The Infinity Camera computer package allowed for the photos to be annotated with the colloquial plant name, plant part, microscope name and magnification used. This was done to prevent mix ups and misidentification in the future. The International Code for Phytolith Nomenclature 2.0 (2019) was used to identify single phytolith types and their descriptive terminology. Each photo with a magnification of 40x had a scale bar added. In addition, photos with annotations of specific phytolith types were sometimes taken, often zoomed out at a magnification of 10x and 20x.

### 2.4.2 Modern plant phytolith data base

A data master file was constructed using Excel which listed vernacular and botanical plant names, the plant parts, the various phytolith nomenclature types, a link to the herbarium specimen photo and links to all the phytolith photos taken during this project. The website itself was coded by Joshua Osborne using sveltekit and the code is hosted on GitHub. The data base is open access and will continue to be monitored and improved by investigating ease of access and the possibility of more data being added. It will be maintained by Sigrid and Joshua Osborne. The website can be found under https://phynd.online.

### 2.4.3 Soil phytolith analysis (modern and archaeological samples)

The modern A horizon and archaeological samples' microscope slides, in accordance with phytolith analysis protocols (Piperno 2006), were counted using a Meiji MT6520 polarising microscope to 250 single and 100 multicell phytoliths. For the count a magnification of 40x was used. Once 250 single phytoliths had been counted the remainder of the slide was checked for multicell phytoliths at a magnification of 20x. A count sheet was produced using the International Code for Phytolith Nomenclature 2.0 (ICPT 2019; ICPN 2019) (Appendix 8). Photographs were taken throughout the count process using an Infinite 1 Camera mounted onto the polarising Meiji MT6520 microscope. The camera programme allowed for annotations to be added in the same way as for the modern plants.

### 2.4.4 Pollen analysis (quadrant samples only)

The three Wytch Farm quadrant microscope slides were assessed thirty minutes after the pollen had been mounted. Licopodium was visible on all three slides which indicated that the pollen processing had been successful. The pollen was counted using the Meiji MT6520 polarising microscope and with the aid of the online identification guide provided by the Global Pollen Project (Online). The slides were counted until 250 pollen had been found and identified.

# 3 Botanical Results

This results section will represent the botanical fieldwork results (3.1) and the dry ashing results (3.2) for all the collected plants which were used to build the PhyND.online database.

## 3.1 Botanical survey for all locations

In total 53 plants were collected from Wytch Farm, Butser, Hartland Moor and Abbey Home Farm. Two plant specimens (*Calluna vulgaris* and *Molinia caerulea*) were collected twice from Hartland Moor, once by S. Osborne and again by A.Diaz. Therefore, the number of plant species processed was 51 (Table 3).

**Table 3** *Plants collected for the project*

| Site, Month, Year | Number of plants collected | Monocotyledon (Angiosperm) | Eudicot (Angiosperm) | Gymnosperm | Pteridophyte | Dried by |
|---|---|---|---|---|---|---|
| Butser, August 2021, A. and S. Osborne | 6 | 4 | 2 | 0 | 0 | S. Osborne |
| Wytch Farm, August 2021, A. and S. Osborne | 26 | 3 | 22 | 0 | 1 | S. Osborne |
| Farm in Gloucestershire, August 2021, S. Osborne | 1 | 1 | 0 | 0 | 0 | S. Osborne |
| Hartland Moor, September 2021, A. and S. Osborne | 12 | 3 | 8 | 1 | 0 | S. Osborne |
| Hartland Moor, October 2021, A. Diaz | 8 | 5 | 3 | 0 | 0 | A. Diaz |

An attempt was made to collect and include the crops grown at Wytch Farm which had been indicated by the farmer (Table 1, Appendix 3). These crop plants were collected from various locations (Table 1). It was not possible to source fodder beet, kale, turnip, or fodder maize in time for the phytolith dry ashing processes (Appendix 10).

### 3.1.1 Wytch Farm: plant collection and grassland assessment

After the initial plant collection on the Wytch Farm site in August 2021 another visit was arranged for April 2022 to test the assumption that the Wytch Farm grassland is an acid grassland. A plant survey was undertaken at the site under the guidance of R. Walls, BSBI recorder for the Dorset area (Table 4). Some plants were identified from their vegetative state while others were in flower. R. Walls used Ellenberg and CSR scores to infer that "the environment around the edge (of the field) is wetter, less open, more nutritious, less acidic and more saline." And "In terms of classification and the NVC, … it is not clear. It certainly does not fit an acid or calcifugous grassland. The best description is probably a derelict ryegrass-clover ley, MG7. The excavations will be the cause of this by creating piles of bare soil and disturbed subsoil." (Pers. Comm. R. M. Walls 2022; Appendix 11). The April survey confirmed the presence of all the plants that had been collected the previous August with 35 additional plants being identified (Table 4).

**Table 1** *All plants collected and identified at Wytch Farm*

| Fieldwork 18 August 2021 | Plants collected for dry ashing | | Fieldwork 23 April 2022 (List by R. M. Walls) Plants observed | |
|---|---|---|---|---|
| **Index Number** | **Botanical Name** | **Vernacular Name** | **Botanical Name** | **Vernacular Name** |
| M061-M064 | *Achillea millefolium* | Yarrow | *Achillea millefolium* | Yarrow |
| M140-M144 | *Agrostis stolonifera* | Creeping Bent | *Agrostis capillaris* | Common Bent |
| M129-M132 | *Anthemis cotula* | Stinking Chamomile | *Agrostis stolonifera* | Creeping Bent |
| M086-M089 | *Anthriscus sylvestris* | Cow Parsley | *Allium vineale* | Wild Onion |
| M078-M081 | *Cerastium fontanum* | Mouse-ear Chickweed | *Anisantha sterilis* | Barren Brome |
| M090-M092 | *Cirsium arvense* | Creeping Thistle | *Anthoxanthum odoratum* | Sweet Vernal-grass |
| M093-M096 | *Echium vulgare* | Viper's Bugloss | *Anthriscus sylvestris* | Cow Parsley |
| M137-M139 | *Hedera helix* | Ivy | *Arctium minus* | Lesser Burdock |
| M116-M120 | *Hypericum humifisum* | Trailing St John's Wort | *Cerastium fontanum* | Common Mouse-ear |
| M056-M060 | *Hypochaeris radicata* | Catsear | *Cerastium glomeratum* | Sticky Mouse-ear |
| M113-M115 | *Ilex sp.* | Holly | *Chenopodium album* | Fat-hen |
| M039-M042 | *Jacobaea vulgaris, Senecio jacobaea* | Ragwort | *Cirsium arvense* | Creeping Thistle |
| M133-M136 | *Plantago lanceolata* | Ribwort | *Cirsium palustre* | Marsh Thistle |
| M145-M148 | *Plantago major* | Broadleaf Plantain | *Conopodium majus* | Pignut |
| M050-M55 | *Poa pratensis subsp. pratensis* | Sweet Meadow Grass | *Crataegus monogyna* | Hawthorn |
| M110-M112 | *Prunus spinosa* | Blackthorn | *Dactylis glomerata* | Cock's-foot |
| M071-M072 | *Pteridium* | Bracken | *Digitalis purpurea* | Foxglove |
| M105-M109, M211-M216 | *Quercus* | Oak | *Festuca rubra* | Red Fescue |
| M121-M124 | *Ranunculus repens* | Buttercup | *Ficaria verna* | Lesser Celandine |
| M082-M085 | *Rubus sp.* | Bramble | *Galium aparine* | Cleavers |
| M125-M128 | *Rumex acetosella* | Sheeps's Sorrel | *Geranium molle* | Dove's-foot Crane's-bill |
| M073-M077 | *Taraxacum officinale* | Dandelion | *Hedera hibernica* | Atlantic Ivy |
| M046-M049 | *Trifolium pratense* | Red Clover | *Holcus lanatus* | Yorkshire-fog |
| M065-M070 | *Trisetum flavesence* | Yellow Oat Grass | *Hyacinthoides non-scripta* | Bluebell |
| M043-M045 | *Urtica dioica* | Nettle | *Hypochaeris radicata* | Cat's-ear |

| Fieldwork 18 August 2021 | Plants collected for dry ashing | | Fieldwork 23 April 2022 (List by R. M. Walls) Plants observed | |
|---|---|---|---|---|
| **Index Number** | **Botanical Name** | **Vernacular Name** | **Botanical Name** | **Vernacular Name** |
| M149-M152 | *Veronica chamaedrys* | Germander Speedwell | *Ilex aquifolium* | Holly |
| | | | *Juncus effusus* | Soft-rush |
| | | | *Lapsana communis* | Nipplewort |
| | | | *Lepidium didymum* | Lesser Swine-cress |
| | | | *Lolium perenne* | Perennial Rye-grass |
| | | | *Oenanthe crocata* | Hemlock Water-dropwort |
| | | | *Ornithopus perpusillus* | Bird's-foot |
| | | | *Phragmites australis* | Common Reed |
| | | | *Plantago lanceolata* | Ribwort Plantain |
| | | | *Plantago major* | Greater Plantain |
| | | | *Poa annua* | Annual Meadow-grass |
| | | | *Potentilla reptans* | Creeping Cinquefoil |
| | | | *Prunus spinosa* | Blackthorn |
| | | | *Pteridium aquilinum* | Bracken |
| | | | *Quercus robur* | Pedunculate Oak |
| | | | *Ranunculus repens* | Creeping Buttercup |
| | | | *Rubus fruticosus agg.* | Bramble |
| | | | *Rumex acetosella* | Sheep's Sorrel |
| | | | *Rumex obtusifolius* | Broad-leaved Dock |
| | | | *Sagina procumbens* | Procumbent Pearlwort |
| | | | *Salix cinerea* | Grey Willow |
| | | | *Senecio jacobaea* | Common Ragwort |
| | | | *Senecio vulgaris* | Groundsel |
| | | | *Sonchus oleraceus* | Smooth Sow-thistle |
| | | | *Stachys sylvatica* | Hedge Woundwort |
| | | | *Stellaria media* | Common Chickweed |
| | | | *Stellaria pallida* | Lesser Chickweed |

**Fieldwork 23 April 2022 (List by R. M. Walls) Plants observed**

| Botanical Name | Vernacular Name |
|---|---|
| *Taraxacum officinale agg.* | Dandelion |
| *Trifolium fragiferum* | Strawberry Clover |
| *Trifolium repens* | White Clover |
| *Tripleurospermum inodorum* | Scentless Mayweed |
| *Urtica dioica* | Common Nettle |
| *Veronica arvensis* | Wall Speedwell |
| *Veronica chamaedrys* | Germander Speedwell |
| *Veronica serpyllifolia* | Thyme-leaved Speedwell |
| *Viola riviniana* | Common Dog-violet |

### 3.1.2 Butser: botanical results

The experimental crop growing area at Butser is divided into seven bays, marked by the fencing posts of the perimeter fence. Bay 1 was the outermost bay and the plants identified within the area are listed in Table 5.

***Table 5*** *List of plants identified as growing within Bay 1, Butser experimental crop growing field (list compiled by A. Osborne).*

| **Bay area** | **Scientific plant name** | **Vernacular plant name** |
|---|---|---|
| 1 | *Triticum monococcum* | Einkorn |
| 1 | *Avena fatua* | Wild Oat Grass |
| 1 | *Scorzoneroides autumnalis* | Autumn Hawkbit |
| 1 | *Rumex crispus* | Curly Dock |
| 1 | *Taraxacum officinale* | Dandelion |
| 1 | *Senecio vulgaris* | Common Groundsel |
| 1 | *Odontite vulgaris* | Red Bartsia |
| 1 | *Papaver rhoeas* | Poppy |
| 1 | *Helminthotheca echioides* | Bristly Oxtongue |
| 1 | *Heracleum mantegazzianum* | Common Hogweed |
| 1 | *Argentina anserina* | Silverweed |
| 1 | *Mentha arvensis* | Wild Mint |
| 1 | *Anthemis cotula* | Stinking Chamomile |
| 1 | *Hypericum perforatum* | Perforated St. John's Wort |
| 1 | *Verbascum nigrum* | Black Mullein |
| 1 | *Circium arvense* | Creeping Thistle |
| 1 | *Senecio vulgaris* | Ragwort |
| 1 | *Dipsacus sylvestris* | Wild Teasel |

### 3.1.3 Wytch Farm: the quadrants botanical results

The following table shows each quadrant, which plants were seen growing and the percentage of ground covered by each plant within the quadrant square (Table 6).

**Table 6** *Plant presence within each quadrant at Wytch Farm*

| Scientific name | Vernacular name | Quadrant 1 | % | Quadrant 2 | % | Quadrant 3 | % |
|---|---|---|---|---|---|---|---|
| *Triticum sp.* | Clover | Yes | 2 | No | | Yes | 8 |
| *Hypocharis radicata* | Catsear | Yes | 50 | Yes | 10 | No | |
| *Achillea millefolium* | Yarrow | Yes | 20 | Yes | 50 | Yes | 20 |
| *Plantago sp.* | Plantain | Yes | 2 | No | | No | |
| *Echium vulgare* | Buglossus | Yes | 2 | No | | No | |
| *Veronica sp.* | Speedwell | Yes | 1 | No | | No | |
| *Agrostis sp.* | Agrostis | Yes | 20 | No | | No | |
| | Other grass | Yes | 1 | No | | No | |
| *Elymus repens* | Couch grass | No | | Yes | 9 | Yes | 60 |
| *Hedera helix* | Ivy | No | | Yes | 1 | No | |
| *Prunus spinosa* | Blackthorn | No | | Yes | 10 | No | |
| *Cerastium sp.* | Mouse ear chickweed | No | | No | | Yes | 10 |
| *Taraxacum officinale* | Dandelion | No | | No | | Yes | 2 |
| | Leaf litter | No | | Yes | 20 | No | |
| | Bare soil | No | 2 | No | | No | |

Each quadrant shows a variation in plant cover and there are bare soil patches in Quadrant 1 and leaf litter covering some of Quadrant 2. The plant present in all three quadrants is Yarrow (*Achillea millefolium*).

### 3.1.4 Dry ashing results

The dry ashing results of the 51 modern plant specimens collected are represented in three separate plant groups (clade). One group representing the monocotyledons (grasses, sedges, bulbous plants), one the eudicots (annuals, perennials, shrubs, trees) and the last group the pteridophytes (ferns). The additional group of gymnosperms, represented by the Scots Pine (Pinus sylvestris) has been discussed within the eudicot category. Table 4 details each of these three clades and breaks the dry ashing results into different categories. Within each plant part and clades dry ashed it was noted whether phytoliths were detected, whether contamination was observed on the microscope slide, whether charcoal was present on the slide and how much dried plant material was used on average for each group to achieve enough microscope slide mounting material (Table 7, Appendix 12 and 13).

**Table 7** *Clades, their plants parts and processing observations*

| **Monocotyledons** | **Plants processed within the clades** | **Plant parts processed from the clades plants' collected** | **Plant parts that showed phytoliths after processing** | **Plant parts that did not show phytoliths** | **Plant parts that did not produce material to mount onto a slide** | **Plant parts that showed charcoal on the slide ~** | **Plant parts with contamination on the slide** |
|---|---|---|---|---|---|---|---|
| | 15 * | | | | | | |
| **Root** | | 9 | 8 | 1 | 0 | 1 | 9 |
| **Leaf** | | 15 | 12 | 2 | 1 | 2 | 5 |
| **Internode** | | 7 | 7 | 0 | 0 | 2 | 0 |
| **Node** | | 7 | 7 | 0 | 0 | 3 | 1 |
| **Collar** | | 7 | 6 | 0 | 1 | 1 | 1 |
| **Awn** | | 4 | 4 | 0 | 0 | 0 | 0 |
| **Spikelet** | | 9 | 8 | 1 | 0 | 0 | 1 |
| **Stolon** | | 1 | 1 | 0 | 0 | 0 | 1 |
| **Stem** | | 5 | 2 | 2 | 1 | 3 | 0 |
| **Inflorescence** | | 4 | 2 | 0 | 2 | 1 | 0 |
| **Eudicots** | | | | | | | |
| | 35^ | | | | | | |
| **Root** | | 18 | 6 | 10 | 2 | 6 | 16 |
| **Leaf** | | 39 | 18 | 8 | 13 | 9 | 11 |
| **Stem** | | 34 | 7 | 14 | 13 | 15 | 7 |
| **Flower/Inflorescence** | | 25 | 4 | 13 | 8 | 10 | 13 |
| **Tuber** | | 2 | 0 | 2 | 0 | 2 | 2 |
| **Twig** | | 5 | 1 | 1 | 3 | 1 | 0 |

| **Monocotyledons** | **Plants processed within the clades** | **Plant parts processed from the clades plants' collected** | **Plant parts that showed phytoliths after processing** | **Plant parts that did not show phytoliths** | **Plant parts that did not produce material to mount onto a slide** | **Plant parts that showed charcoal on the slide ~** | **Plant parts with contamination on the slide** |
|---|---|---|---|---|---|---|---|
| **Bark** | | 9 | 3 | 1 | 5 | 0 | 4 |
| **Other>** | | 12 | 1 | 3 | 8 | 4 | 3 |
| **Pteridophyte** | | | | | | | |
| | 1 | | | | | | |
| **Stem** | | 1 | 1 | 0 | 0 | 0 | 0 |
| **Frond** | | 1 | 1 | 0 | 0 | 0 | 0 |

^19 annual/biennial or perennial, 10 shrubs, 5 trees, 1 climber
*1 bulbous plant, 4 sedges, 10 grasses
~for monocotyledons: 2 plant parts that had not produced phytoliths contained charcoal; for Eudicots: 35 plant parts that had not produced phytoliths contained charcoal
>fruit, acorn, bean, come, needles, thorn, node

All 51 plant species were processed and analysed/photographed. Contamination with soil minerals, other phytoliths and fibres from the blue cloth (see 2.3.1.1) used during processing was highest in the root parts: 25 of the 27 root parts from both monocotyledons and eudicots (and *Pinus sylvestris*) were contaminated. Leaf showed the next highest contamination rate for the monocotyledons while in the eudicots (and *Pinus sylvestris*) the flower/inflorescence was the second highest contaminated part followed by leaf and then stem. Having possible contamination from other plant part phytoliths could pose a problem for the photographic database accuracy.

While preparing the plant parts the dried plant material used at the beginning of the process was weighed. On average 0.09 g of dried plant material was processed for the monocotyledons, 0.13 g for the eudicots (and *Pinus sylvestris*) and 0.11 g for the pteridophytes.

Out of 68 monocotyledon plant parts, 57 showed phytoliths on the microscope slides and were subsequently photographed (PhyND.online). Of the six plant parts which did not show any phytoliths on the microscope slide two contained charcoal, meaning that they had not been completely ashed and required a higher temperature rather than the 500˚C used. Five monocotyledon plant parts (stem, collar, leaf, and inflorescence) did not produce any material for mounting onto a microscope slide. For the 144 plant parts from the eudicots (and *Pinus sylvestris*) 40 showed phytoliths on the microscope slide and were recorded through photography (PhyND.online). Of the 52 eudicot (and *Pinus sylvestris*) plant parts which did not display phytoliths on their microscope slide, 40 contained charcoal. This can be seen on the PhyND.online website as these plant parts do not show any photographs. Fourty eudicot (and *Pinus sylvestris*) plant parts (all apart from tuber) did not produce any material for mounting onto microscope slides. Both

pteridophyte plant parts contained phytoliths and the pictorial data was added to the website (PhyND.online).

For some plants (*Quercus robur, Myrica gale, Calluna vulgaris, Agrosis curtisii* and *Molinia caerulea*) the plants were processed twice either due to being collected twice or as a small experiment to see whether increasing the plant material processed would have a relationship with the phytoliths detected on a slide (Table 8).

**Table 8** Comparison: quantity of dry ashing material versus phytolith detection

| Index Number | Botanical Name | Vernacular Name | Plant Part | Plant Material After dry ashing | Phytoliths Y/N | Index Number | Botanical Name | Vernacular Name | Plant Part | Plant Material After dry ashing | Phytoliths Y/N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| First Ashing | First Ashing | First Ashing | First Ashing | First Ashing | First Ashing | Second Ashing | Second Ashing | Second Ashing | Second Ashing | Second Ashing | Second Ashing |
| M189 | *Agrostis curtisii* | Bristle Bent | Stem/Leaf | 0.0338 | Y | M210 | *Agrostis curtisii* | Bristle Bent | Leaf | 0.0425 | Y |
| M172 | *Calluna vulgaris* | Heather | Leaf | 0.1073 | No Slide | M200 | *Calluna vulgaris* | Heather | Leaf | 0.1532 | Y |
| M173 | *Calluna vulgaris* | Heather | Stem | 0.2787 | No Slide | M201 | *Calluna vulgaris* | Heather | Stem | 0.4631 | N |
| M174 | *Calluna vulgaris* | Heather | Inflorescence | 0.0956 | No Slide | M202 | *Calluna vulgaris* | Heather | Inflorescence | 0.0416 | N |
| M169 | *Molinia sp.* | Molinia | Leaf | 0.0776 | N | M204 | *Molinia caerulea* | Purple Moor Grass | Leaf | 0.106 | Y |
| M170 | *Molinia sp.* | Molinia | Stem | 0.1903 | N | M205 | *Molinia caerulea* | Purple Moor Grass | Stem | 0.1066 | No Slide |
| M171 | *Molinia sp.* | Molinia | Inflorescence | 0.063 | Y | M206 | *Molinia caerulea* | Purple Moor Grass | Inflorescence | 0.0058 | Y |
| M190 | *Myrica gale* | Bog Myrtle | Leaf | 0.1021 | No Slide | M207 | *Myrica gale* | Bog Myrtle | Leaf | 0.0938 | No Slide |
| M191 | *Myrica gale* | Bog Myrtle | Stem | 0.1446 | No Slide | M208 | *Myrica gale* | Bog Myrtle | Stem | 0.2722 | N |
| M192 | *Myrica gale* | Bog Myrtle | Inflorescence | 0.0729 | N | M209 | *Myrica gale* | Bog Myrtle | Inflorescence | 0.1144 | N |
| M105 | *Quercus robur* | Oak | Leaf | 0.1156 | Y | M212 | *Quercus robur* | Oak | Leaf | 0.5107 | Y |
| M106 | *Quercus robur* | Oak | Stem | 0.0982 | No Slide | x | *Quercus robur* | Oak | x | X | x |
| M107 | *Quercus robur* | Oak | Bark | 0.3029 | No Slide | M213 | *Quercus robur* | Oak | Bark | 0.8123 | N |
| M108 | *Quercus robur* | Oak | Acorn Case | 0.0828 | Y | M215 | *Quercus robur* | Oak | Acorn Case | 0.3003 | No Slide |
| M109 | *Quercus robur* | Oak | Acorn | 0.0654 | No Slide | M216 | *Quercus robur* | Oak | Acorn | 0.3448 | N |

Two of the monocotyledon's plant parts and one of the eudicot's plant parts had already shown phytoliths at a lower dried plant weight. For two eudicot plant parts there was no change detected between the lower and higher weights and in one eudicot (*Calluna vulgaris,* inflorescence) the higher weight had produced no material to mount onto a slide, but the lower dried plant weight did produce a slide. Of the remaining two monocotyledon plant parts and six eudicot plant parts there was a change from the lower to the higher weight. Three plant parts contained phytoliths on the slide processed from the higher weight and five produced enough material to mount onto a slide. The slides produced usually contained charcoal.

The average increase in dried plant material for the plant parts which showed a change was 0.16 g. The lowest weight increase resulting in a change was 0.03 g and the highest 0.51 g.

Due to time constraints no experiment was conducted to adjust the muffle furnace temperature to re-ash some of the charcoal produced to see whether a higher ashing temperature would burn it off and enable the detection of phytoliths masked by the charcoal.

# 4 Soil analysis results

In order to highlight the overall phytolith results this section will start with a general description of the phytolith types found within all the soil samples (4.1) before looking at each of the modern A horizon and archaeological soil samples separately (4.2 and 4.3).

## 4.1 Phytolith description and nomenclature

The International  Phytolith Nomenclature lists the descriptions of currently accepted terms for specific phytolith types and a set way for the description of any new types (ICPN 2.0 2019; ICPT 2.0 2019). Applying this code to all the phytoliths observed revealed that the most numerous types within the modern A horizon and archaeological soil samples belong to the elongate entire, bilobate, blocky and silica aggregate. The following table lists all phytolith types found within all soil samples and which plants (either family or clades) they represented within the photographic phytolith database created for this project (Table 9; PhyND.online).

This gives an indication on how representative the current database is in determining the vegetation from the soil analysis.

**Table 9** *Phytolith types found in the soil samples and what plant groups they identify with on the PhyND.online website*

| Phytolith types observed on the microscope slides | Grass (Monocotyledon) | Grass Crop (Monocotyledon) | Sedge (Monocotyledon) | Bulb (Monocotyledon) | Annual | Biennial | Perennial | Shrub (Eudicot) | Tree | Climber | Fern (Pteridophyte) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bilobate | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elongate entire | 5 | 5 | 0 | 0 | 2 | 0 | 10 | 0 | 2 | 1 | 1 |
| Blocky | 5 | 5 | 0 | 0 | 1 | 0 | 4 | 0 | 1 | 0 | 1 |
| Silica aggregate | 0 | 0 | 0 | 0 | 2 | 1 | 7 | 0 | 2 | 0 | 0 |
| Crenate | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rondel | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Acute bulbosus | 4 | 5 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 |
| Bulliform flabellate | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bulliform fusiform | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| Bulliform crenate | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Polylobate | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trapezoid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Saddle | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elongate dendritic | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **Phytolith types observed on the microscope slides** | **Grass** | **Grass Crop** | **Sedge** | **Bulb** | **Annual** | **Biennial** | **Perennial** | **Shrub** | **Tree** | **Climber** | **Fern** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elongate dentate | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| Elongate sinuate | 4 | 4 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| Sheet | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Puzzle | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| Ridged phytolith | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sclerid | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Papillate | 2 | 3 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 |
| Cork | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elongate with hole | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

Elongate entire and blocky phytolith types represent the most range of plants within the monocotyeledon and eudicot (and *Pinus sylvestris*) groups. Bilobate, crenate, rondel and polylobate are represented by monocotyledon plants, as are cork, sheet and bulliform flabellate. Phytolith types that have been found in the Wytch farm soil samples but are currently not represented on the PhyND.online website are trapezoid, cross, saddle and the ridged phytoliths (not part of current Nomenclature 2.0 terminology but have been termed as such for this project, see 4.1). The types represented by eudicots (and Pinus *sylvestris*) are silica aggregate, bulliform crenate, puzzle and sclerid. All other types are represented by both monocotyledons and eudicots (and *Pinus sylvestris*). The phytolith types found for the pteridophyte are elongate entire, blocky, puzzle and elongate with hole.

Single phytolith types observed within the soil samples have been linked to certain phytoliths extracted from the modern plants. In particular, the elongate entire with hole was linked to the Bracken, the only plant representing the pteridophytes, while dentate single phytoliths in form and shape have some strong similarities with the single dentate extracted for Spelt leaf (*Triticum spelta*), Emmer Wheat node and internode (*Triticum dicoccon*), Wild Oat spikelet (*Avena fatua*) and Black Bog Rush inflorescence (*Schoenus nigricans*).

When analysing and classifying the phytolith types for this project Nomenclature 2.0 was used (ICPN 2.0 2019; ICPT 2.0 2019). Some other phytolith types which are not part of Nomenclature 2.0 were observed. Of those some are mentioned in other nomenclature literature such as puzzle, sheet and sclerid, while the term ridged, elongate with hole, bulliform fusiform and bulliform ovate were termed for this project (Piperno 2006). Using Nomenclature 2.0 the following best describes the four phytoliths with their project specific terms: ridged- irregular with rectilinear features and an axial raised ridge (Fig. 19), elongate with hole- elongate with a hollow at one end, bulliform fusiform- oval in shape with one end

convex and broad and the other compressing towards a pointed tip (Fig.20) and bulliform crenate- oval with one end with a wider concave side in comparison to the other end. The observation of blocky, bulliform flabellate and elongate entire phytolith types in a multicell structure with silica aggregate was noted for this project (Fig.21).

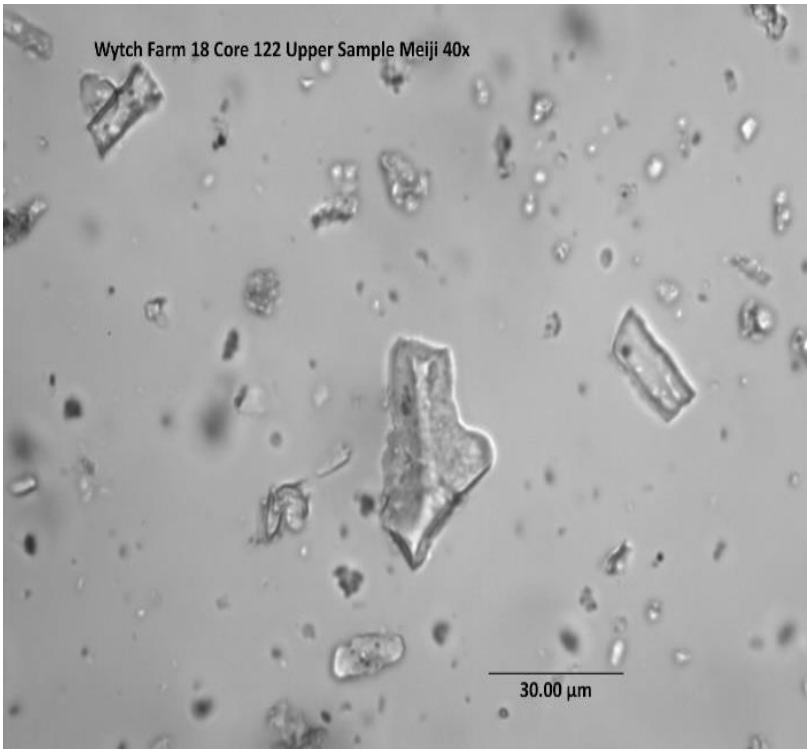



***Figure 19*** *Ridged phytolith*

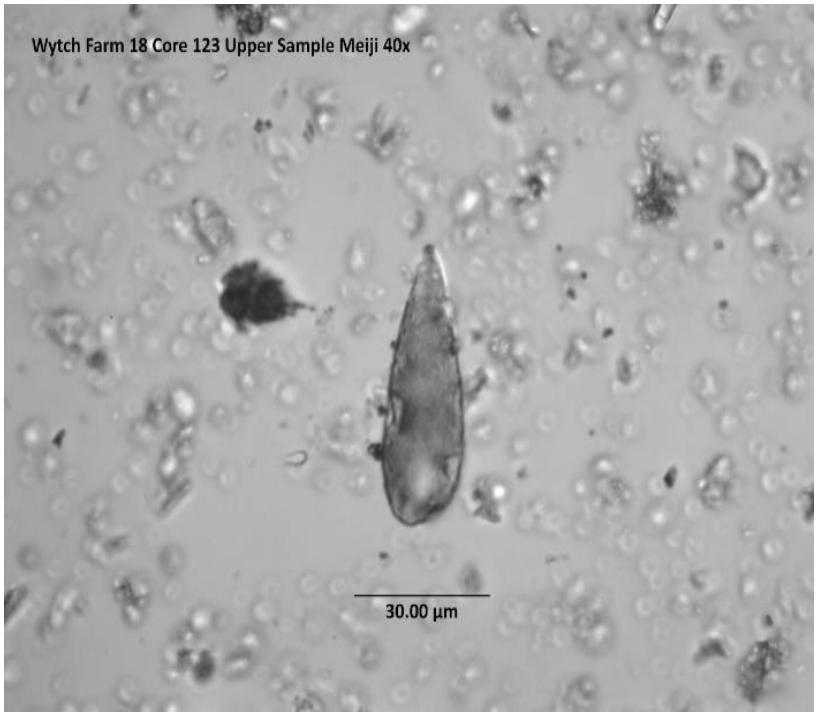



***Figure 20*** *Bulliform fusiform phytolith*

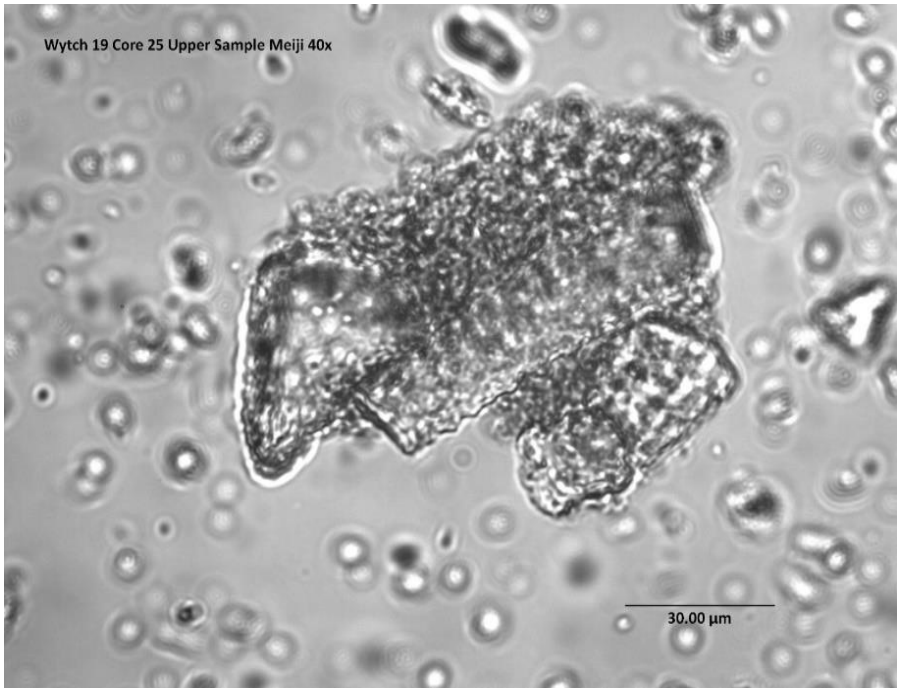



***Figure 21*** *Multicell showing bulliform flabellate and blocky phytoliths embedded within silica aggregate*

## 4.2 Modern soil samples

The Butser A horizon soil phytolith results are used to compare this agricultural crop growing area to the modern agricultural soil phytolith signature at the Wytch Farm site. The modern A horizon soil from the Wytch Farm quadrants was also used to establish the relationship between the Wytch Farm vegetation cover and phytolith signature within the Wytch Farm sample soil.

### 4.2.1 Butser results

This section will show the botanical research results, phytolith counts and any additional proxy used for the Butser modern A horizon soils.

#### *4.2.1.1 Butser: phytolith counts*

Soil from the A horizon was collected at Butser from two different locations, Bay 1, and Bay 7 (Fig.7). Although both soil samples were processed only Bay 1 has been counted for single and multicell phytoliths (Fig.22).

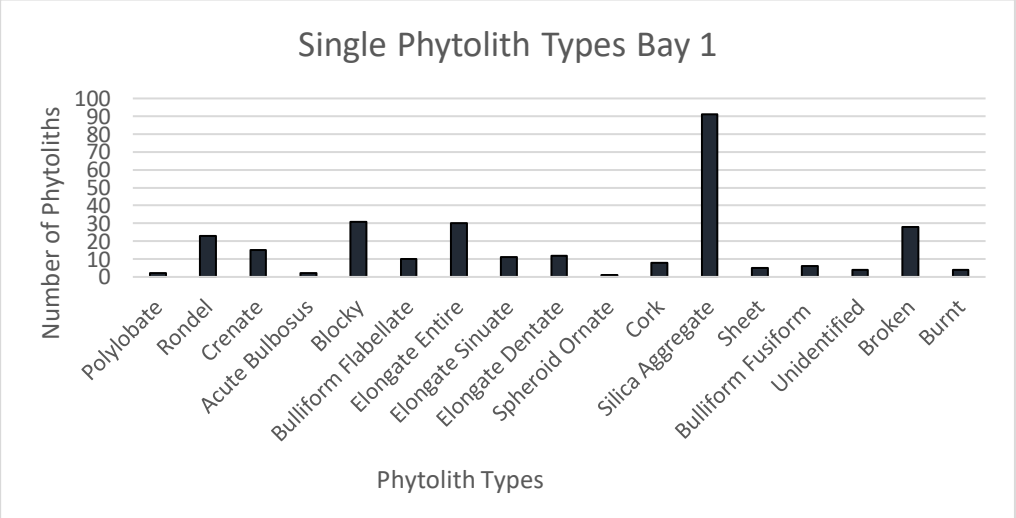
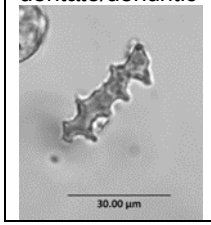



***Figure 22*** *Phytolith types counted for the Bay 1 modern A horizon soil*

Although the main crop planted within Bay 1 was a cereal crop which can be indicated by the presence of crenate, rondel and polylobate phytolith types, silica

aggregates, which are more likely to indicate eudicots is the largest phytolith type present for this count (Fig.22 and Table 10). Overall, 283 single phytoliths were counted in three of the 22 rows.

**Table 10** *Butser, Bay 1, Percentage of different phytolith types within the single phytolith count results, the pictures were taken from this soil sample (Osborne 2022)*

| **Phytolith types typical for Monocotyledon** | **Percentage within the sample count (%)** | **Phytolith types typical for Eudicot** | **Percentage within the sample count (%)** | **Phytolith types, not cades specific** | **Percentage within the sample count (%)** | **Phytolith types represented with less than 5%** | **Overall percentage within the sample count** | **Other (burnt, degraded or broken phytoliths)** | **Percentage within the sample count (%)** |
|---|---|---|---|---|---|---|---|---|---|
| Rondel | 8 | Silica aggregate | 32 | Blocky | 11 | Phytolith types: polylobate, acute bulbosus, bulliform flabellate, bulliform fusiform, elongate sinuate, cork, sheet, unidentified | 18 | Burnt and broken | 11 |
| Crenate | 5 | | | Elongate entire | 11 | | | | |
| Elongate dentate/dendritic   | 4 | | | | | | | | |

A phytolith count aims to count 100 multicells on a slide. Having counted the whole slide for Bay 1 only 37 multicells were found and within them various individual phytolith types could be counted (Fig.23). Overall, the 37 multicells contained 106 individual phytoliths. The largest number of individual phytolith types within the multicells belonged to the elongate entire closely followed by the elongate dentate types.

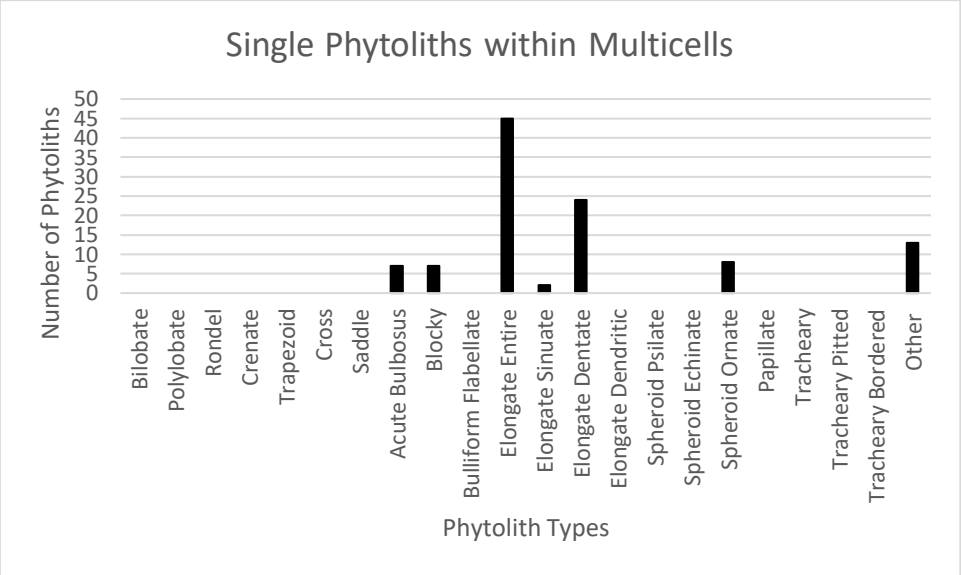



***Figure 23*** *Phytolith types observed within the multicells counted for Bay 1*

### *4.2.1.2 Butser: other proxy: pH*

The only other proxy used for the Butser A horizon soil was pH. The pH for the A horizon in Bay 1 was 7.8 and 7.73 for Bay 7. Both levels are below >8.5, which is the level at which phytolith degradation might make it a less viable analytical proxy (English Heritage 2011).

### 4.2.2 Wytch Farm: the quadrants

In order to analyse the modern A horizon soil for the three quadrants sampled at Wytch Farm botanical results, phytolith count results, additional proxies used and the relationship between vegetation cover, pollen and phytolith counts are listed in this section.

#### *4.2.2.1 Wytch Farm: quadrants phytolith counts*

All three quadrants were counted for phytoliths. Quadrant 1 produced a count of 290 single phytoliths in two rows and four multicells on the whole slide, Quadrant 2 showed 314 single phytoliths in three rows and one multicell on the whole slide and the Quadrant 3 count was 293 single phytoliths in one row and one multicell for the whole slide. None of the multicells were indicative of a specific plant but the single phytoliths indicate the presence of monocotyledons and eudicots (Fig.24, Table 11). The four phytolith types most represented in all three quadrants are elongate entire, blocky, silica aggregate and bilobate closely followed by rondel and crenate.

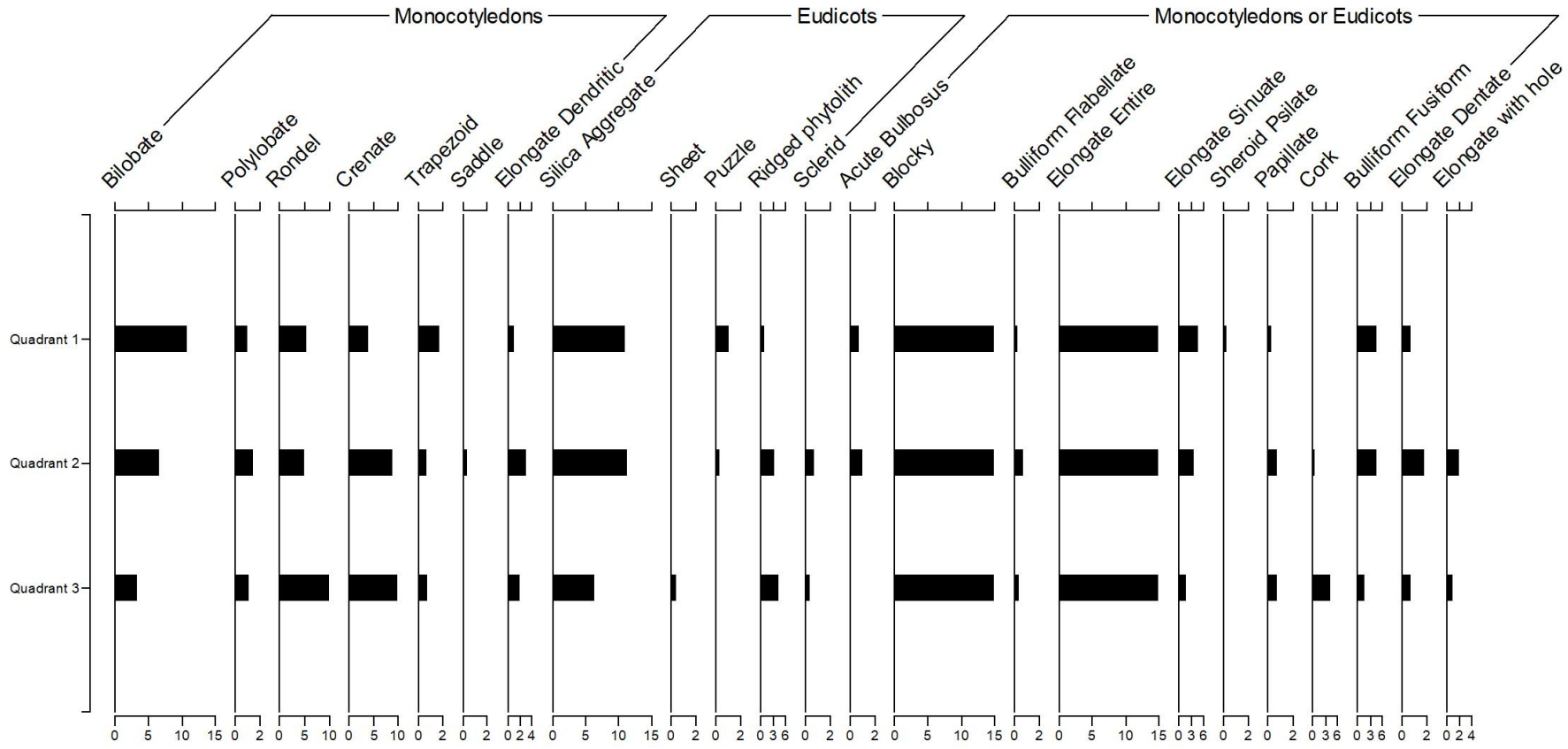
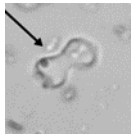
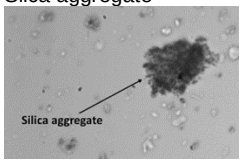
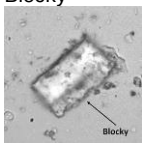
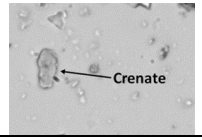
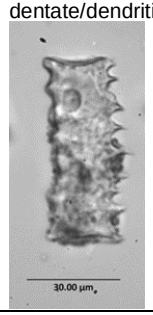
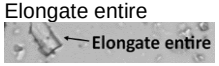



***Figure 24*** *Single phytolith type distribution for Quadrant 1-3*

**Table 2** *Wytch Farm, Quadrant 1-3, phytolith types in percentage, photos taken from the corresponding soil samples (Osborne 2022)*

| Quadrant | Phytolith types typical for Monocotyledon | Percentage within the sample count (%) | Phytolith types typical for Eudicot | Percentage within the sample count (%) | Phytolith types, not cades specific | Percentage within the sample count (%) | Phytolith types represented with less than 5% | Overall percentage within the sample count | Other (burnt, degraded or broken phytoliths) | Percentage within the sample count (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Bilobate  | 10 | Silca aggregate   | 10 | Blocky   | 26 | Polylobate, trapezoid, acute bulbosus, elongate sinuate, spheroid psilate, papillate, bulliform fusiform, cork,puzzle, ridged | 16 | Burnt, degraded and broken | 6 |
| 1 | Rondel | 5 | | | Elongate entire | 21 | | | | |
| 1 | Crenate   | 4 | | | | | | | | |
| 1 | Elongate dentate/dendritic   | 2 | | | | | | | | |

| Quadrant | Phytolith types typical for Monocotyledon | Percentage within the sample count (%) | Phytolith types typical for Eudicot | Percentage within the sample count (%) | Phytolith types, not cades specific | Percentage within the sample count (%) | Phytolith types represented with less than 5% | Overall percentage within the sample count | Other (burnt, degraded or broken phytoliths) | Percentage within the sample count (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Crenate | 8 | Silica aggregate | 10 | Elongate entire   | 24 | Polylobate, rondel, trapezoid, saddle, acute bulbosus, bulliform flabellate, bulliform fusiform, elongate sinuate, papillate, cork, puzzle, bulliform ovate, ridged, sklerid | 22 | Broken, degraded and burnt | 11 |
| 2 | Bilobate | 6 | | | Blocky | 14 | | | | |
| 2 | Elongate dentate/dendritic | 5 | | | | | | | | |
| **Quadrant** | **Phytolith types typical for Monocotyledon** | **Percentage within the sample count (%)** | **Phytolith types typical for Eudicot** | **Percentage within the sample count (%)** | **Phytolith types, not cades specific** | **Percentage within the sample count (%)** | **Phytolith types represented with less than 5%** | **Overall percentage within the sample count** | **Other (burnt, degraded or broken phytoliths)** | **Percentage within the sample count (%)** |
| 3 | Rondel | 11 | Silica aggregate | 6 | Elongate entire | 26 | Bilobate, polylobate, trapezoid, bulliform flabellate, elongate sinuate, papillate, cork, sheet, bulliform fusiform, | 18 | Broken | 10 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | bulliform ovate, ridged | | | |
| | Crenate | 11 | | | Blocky | 15 | | | | |
| | Elongate dentate/dendritic | 3 | | | | | | | | |

### *4.2.2.2 Wytch Farm: quadrants: pH*

The pH results are represented in the graph below (Fig.25)

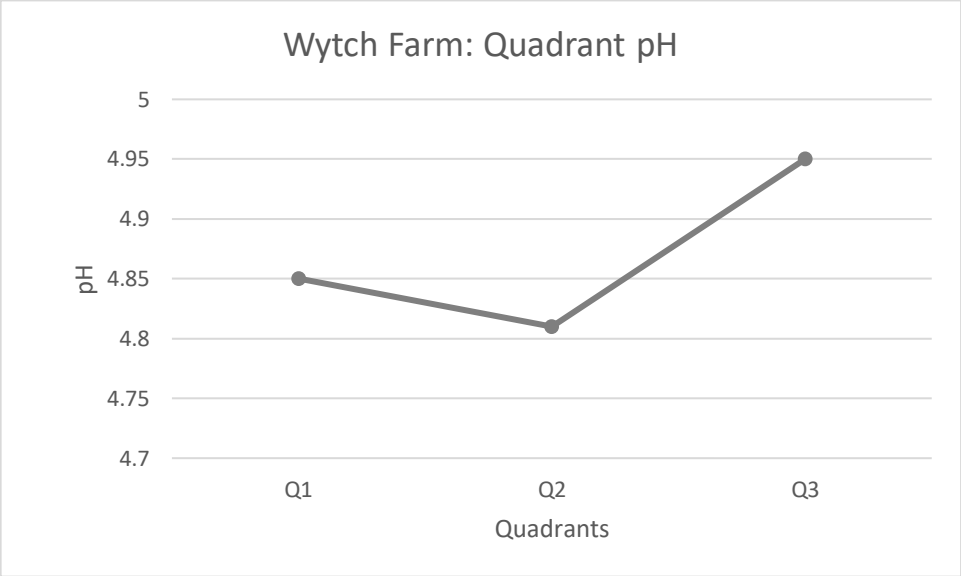



***Figure 8*** *pH results for the three modern soil quadrant A horizon*

The pH for all three quadrants lay between 4.8 and 4.95 and falls within the acid spectrum.

### *4.2.2.3 Wytch Farm: quadrants: pollen results*

For the pollen analysis it was decided to identify the pollen for the specific plants that had been observed in each quadrant and to then see if this represented the percentages (Table 12).

**Table 3** *Pollen count for Quadrant 1-3*

| | Quadrant 1 Pollen | Quadrant 2 Pollen | Quadrant 3 Pollen |
|---|---|---|---|
| Lycopodium | 113 | 58 | 45 |
| Unidentified | 235 | 207 | 220 |
| White Clover | 1 | 0 | 0 |
| Cats Ear | 2 | 4 | 1 |
| Yarrow | 1 | 8 | 1 |
| Plantago | 18 | 4 | 14 |
| Speedwell | 8 | 6 | 5 |
| Couch Grass | 0 | 10 | 5 |
| Blackthorn | 7 | 5 | 5 |
| Ivy | 2 | 3 | 4 |
| Dandelion | 1 | 7 | 5 |
| Mouse Ear Chickweed | 1 | 0 | 0 |
| Total pollen | 276 | 254 | 260 |
| Sum of identified pollen | 41 | 47 | 40 |
| Percentage identified of total of all pollen found | 14.86 | 18.50 | 15.38 |

The plants which had been identified as growing within the quadrants could be identified through the pollen on the slides although all quadrants showed pollen of plants not seen within the vegetation and some of the pollen identified is not reflected in the plant list for that quadrant (Table 10). Out of all the pollen observed in each quadrant 14.86% represented the plants growing within Quadrant 1, 18.5% represented the ones within Quadrant 2 and 15.38% for Quadrant 3.

### *4.2.2.4 Wytch Farm: vegetation cover versus pollen/phytolith in soil*

The percentage of monocotyledons and eudicots which could be detected through the phytoliths was calculated and compared to the monocotyledon and eudicot percentages obtained from the original plant count and the pollen analysis (Table 13). For Table 13 only single phytoliths that could be representative of either monocotyledons or eudicots were included as were only pollen types that had been identified as belonging to a plant growing within the quadrant. An average between all three quadrants was used as the overall percentage figure for each proxy.

**Table 4** *Monocotyledon and Eudicot percentage for each quadrant proxy*

| | Plants observed | Phytoliths | Pollen |
|---|---|---|---|
| Monocotyledons | 32% | 67% | 12% |
| Eudicots | 68% | 33% | 88% |

Although pollen and plant cover show the same weighting, eudicots being the largest group of plants, the ratio is not the same. Within the phytoliths the monocotyledons outweigh the eudicots in reverse order to the actual plant cover, since monocotyledon phytoliths are prevalent in larger amounts compared to eudicot ones (Piperno 2006).

## 4.3 Wytch Farm: archaeological soil samples

This section has been divided into the core sample (4.3.1) and micromorphology block sample results (4.3.2).

### 4.3.1 Wytch Farm: core samples

Apart from the single and multicell phytolith counts, additional proxies, pH, loss on ignition and diatoms were applied to the core samples. As these samples aligned with the research question into heat signatures detected through the magnetic susceptibility (see 1.4 and 2.3.2.5) a separate section details the magnetic susceptibility results and burnt phytolith and charcoal count (Harry Manley pers. comm.)

Loss on ignition and pH, two additional proxies, were used to establish the suitability of phytolith analysis for the soil pH (English Heritage 2011) and to establish the assumption that the soil was poor in organic remains (loss on ignition).

### *4.3.1.1 Core samples: other proxy: pH*

All of the seven cores (21 individual samples) and seven background samples were analysed for pH (Fig.26 and Fig.27)

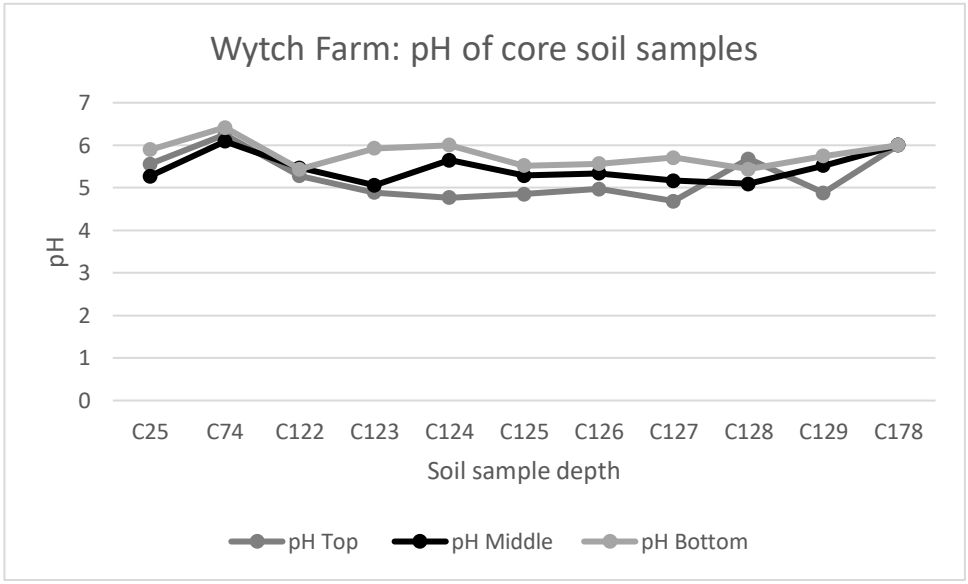



***Figure 26*** *pH for the soil core samples arranged by depth*

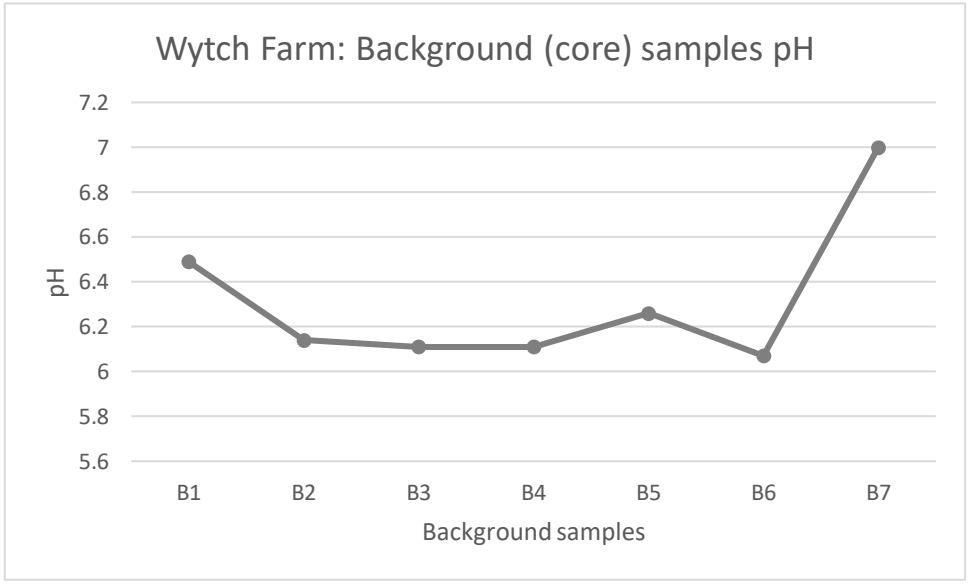



***Figure 27*** *pH of background (core) samples*

Although there are fluctuations all samples lie between a pH of above 4.5 and 6.5 except for one background sample with a reading of 7. The anomaly of all three

readings converging on one result for 178 can be explained by the sample's pH being analysed using litmus paper rather than the pH metre. The lower core samples are much closer in pH to the background samples while the pH decreases, becomes more acidic, for the middle and once again for the upper soil cores. This trend is different for core 25, 74 and 128 where the upper sample pH is higher and for core 178 where the pH is the same for all three core depths.

### *4.3.1.2 Core samples: other proxy: loss on ignition*

The following chart details the loss on ignition results for all the core and core background samples (Fig.28).

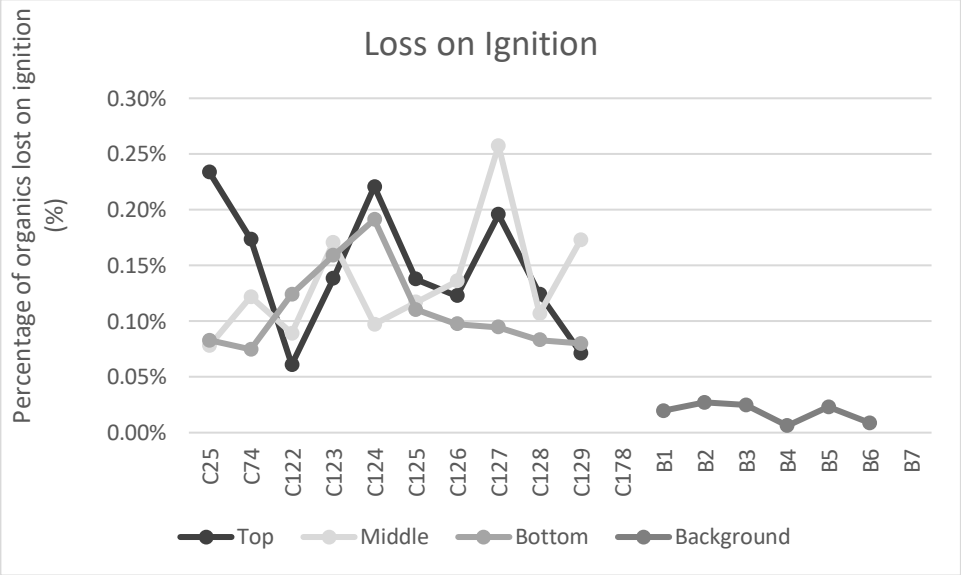



***Figure 28*** *Loss of ignition for all core and background samples*

The percentages for organics on loss on ignition is higher than the background samples for all the core samples investigated. Cores 122 to 124 of the lower samples have a higher LOI percentage while the other lower cores are similar. Both the middle and top cores display larger fluctuations with core 25, 122, 124 and 128 showing similar percentages for the middle of the core samples. For the top core samples cores 123, 125, 126 and 128 are comparable in their percentage.

### *4.3.1.3 Core samples: charcoal and burnt phytoliths*

It is possible to detect burning in phytoliths and processed phytolith microscope slides can contain microscopic charcoal particles (Fig.29). All the charcoal (Fig.29) and burnt phytoliths (Fig.30) found on each of the core sample microscope slides were counted (Fig.31).

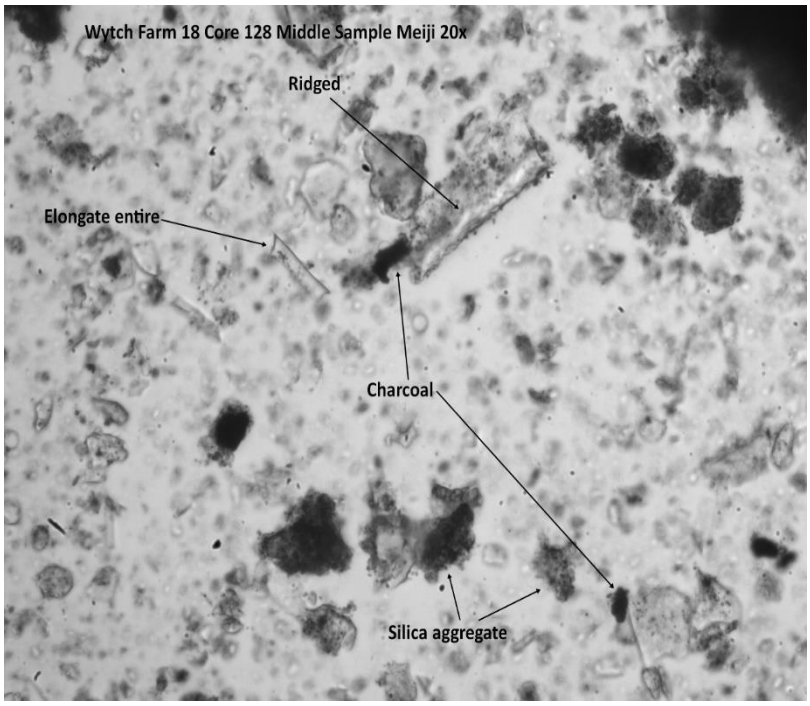



***Figure 29*** *Annotated zoomed out photo showing charcoal and phytoliths*

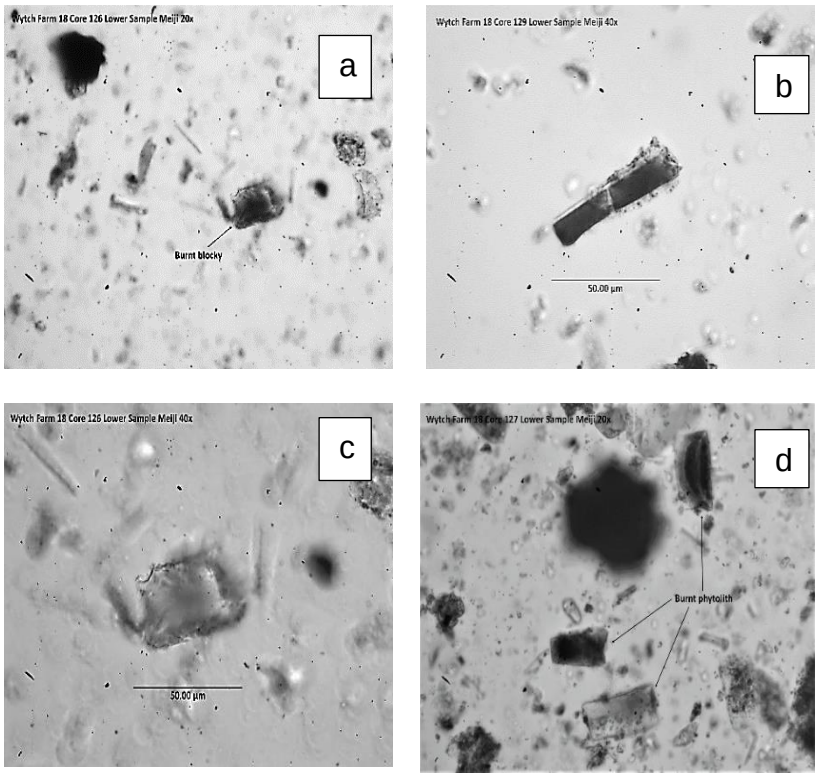



***Figure 30*** *Burnt phytoliths; a. blocky; b. multicell; c. blocky; d. blocky*

The graph below (Fig.31) shows that the most common burnt phytoliths were blocky and bulliform flabellate types, especially for the upper and middle core samples. In the lower core samples elongate entire and bilobate burnt phytolith types were observed as well.

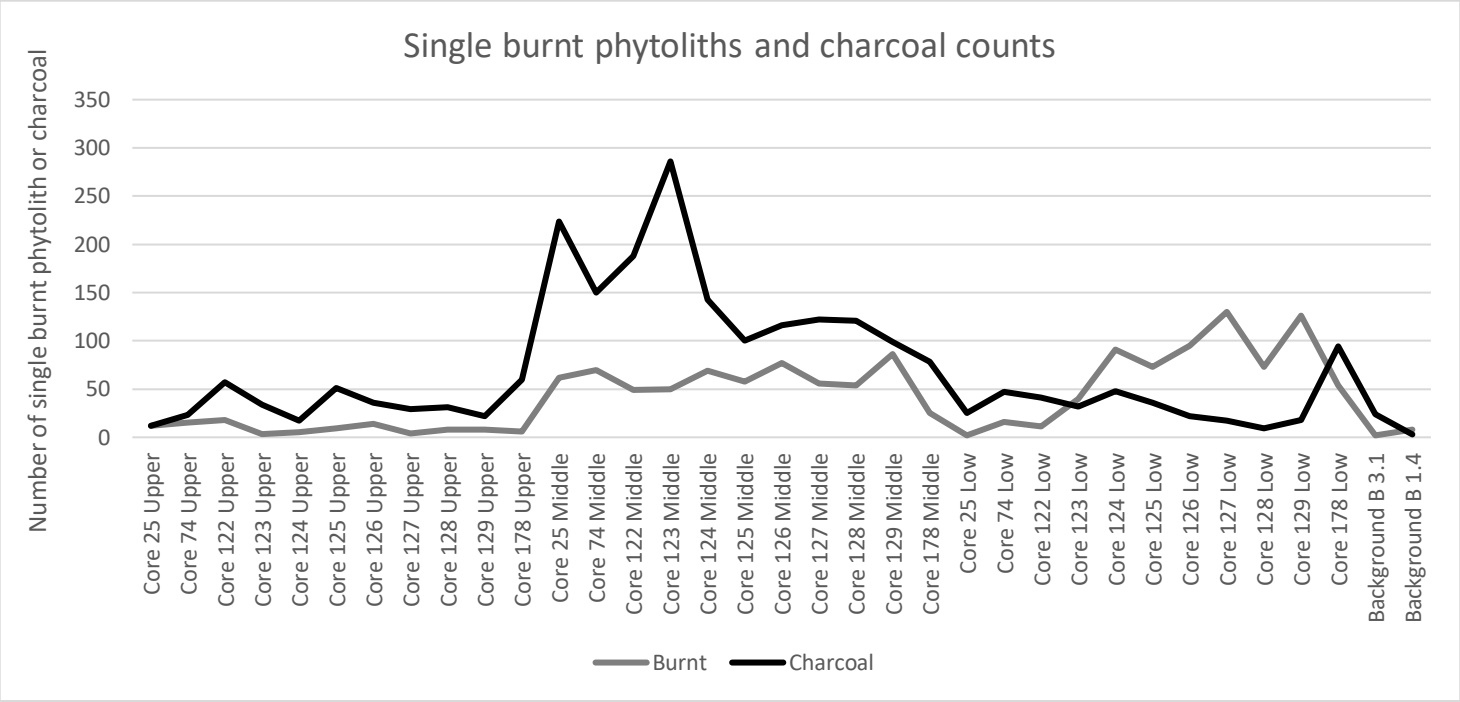



***Figure 31*** *Burnt phytoliths and charcoal, background samples collected from the sandy soil below the salterns*

For the upper and middle of the core samples burnt phytoliths remain below the charcoal count. This changes for the transect cores in the lower core samples where from core 123 to core 129 the burnt phytoliths exceed the charcoal count. The highest charcoal count is seen at the middle core samples and while the burnt phytoliths also increase for the middle core samples they go above this increase in the transect core samples for the lower core samples.

Magnetic susceptibility measurements were taken for all core samples by M. Johnson in the autumn of 2021 and the data entered and analysed using QGis by H. Manley (Fig.29).

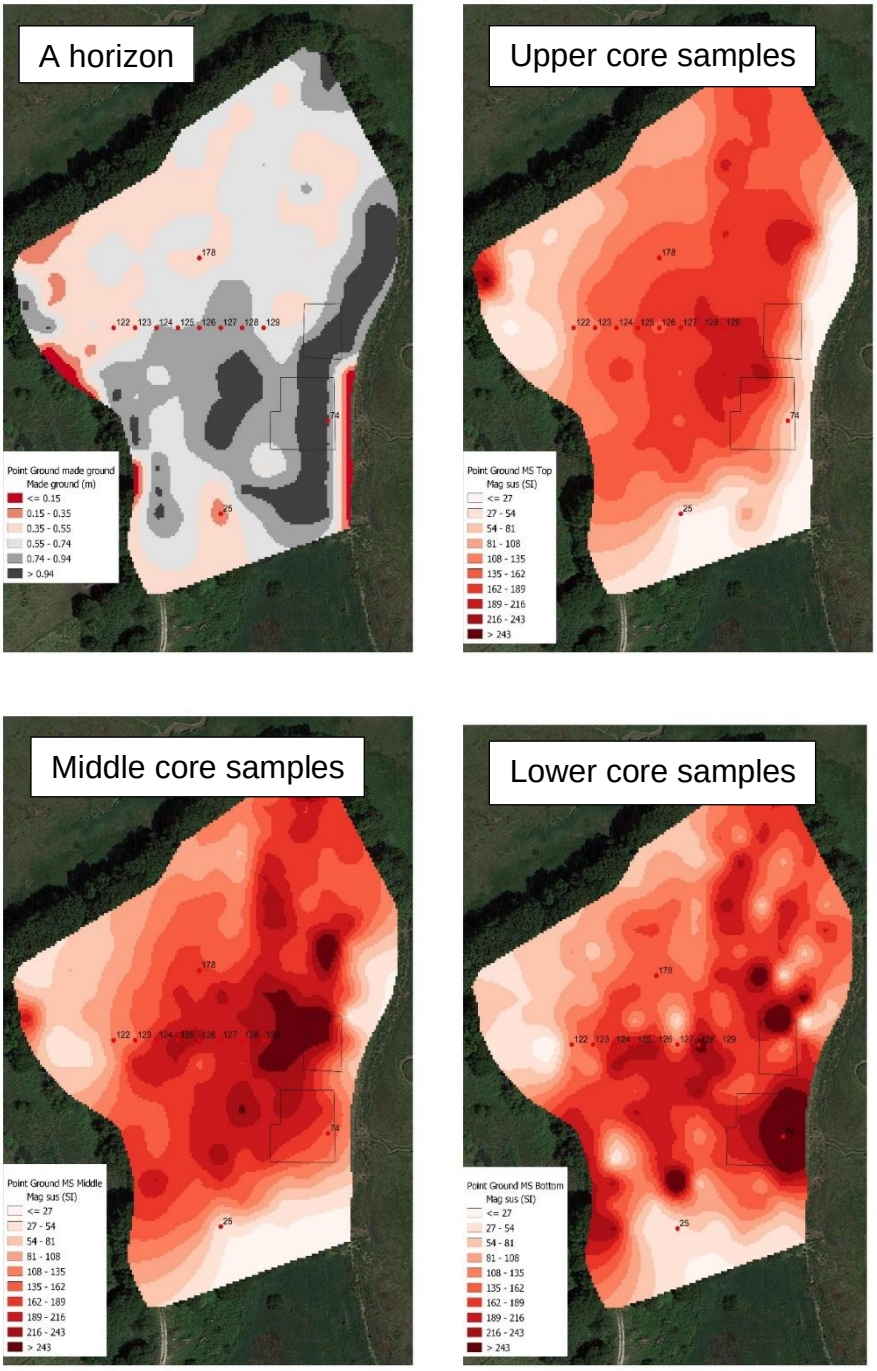



***Figure 32*** *Magnetic susceptibility results for the core samples (H. Manley 2022)*

The map in Figure 32, 'A horizon', shows the soil build up and depth from the A horizon to the 'natural' sandy and clay silt background on the site while the map 'Upper core samples' shows the magnetic susceptibility results for those core

samples. The map, ‘Middle core samples’ shows the middle and the ‘Lower core samples’ the respective core samples’ magnetic susceptibility. All four maps indicate the core sample locations analysed for phytoliths (Fig.10). The highest and largest area for magnetic susceptibility is bordering the harbour front in the lower cores with three smaller spots more inland. The largest and one of those smaller areas overlap with the excavation areas of 2018/19. In the middle cores the area with the highest magnetic susceptibility has shifted and there is only one other larger area with the same readings. By the upper cores there is no pronounced area with high susceptibility, but the pattern of the underlying middle core samples can be detected. For the most part the areas with the highest level of magnetic susceptibility sit in the zones where there is less soil build up. The one exception is the large magnetic susceptibility area bordering the harbour in the lower core samples.

#### *4.3.1.4 Core samples: phytolith counts*

The phytolith counts (excluding burnt single phytoliths) for all the core samples and including two background samples achieved an average count of 303 single phytoliths within an average of two rows of the 22 microscope rows. On average 14 multicells were observed when counting all 22 microscope rows and these 14 multicells contained an average of 34 bonded single phytoliths. An additional count was conducted to determine the amount of single phytoliths within each multicell and how many multicells contained silica aggregate (Fig.32).

##### 4.3.1.4.1 Core samples: Multicell counts

The following chart shows how many individual phytoliths were bonded together into a multicell and which ones contained silica aggregate (Fig.33).

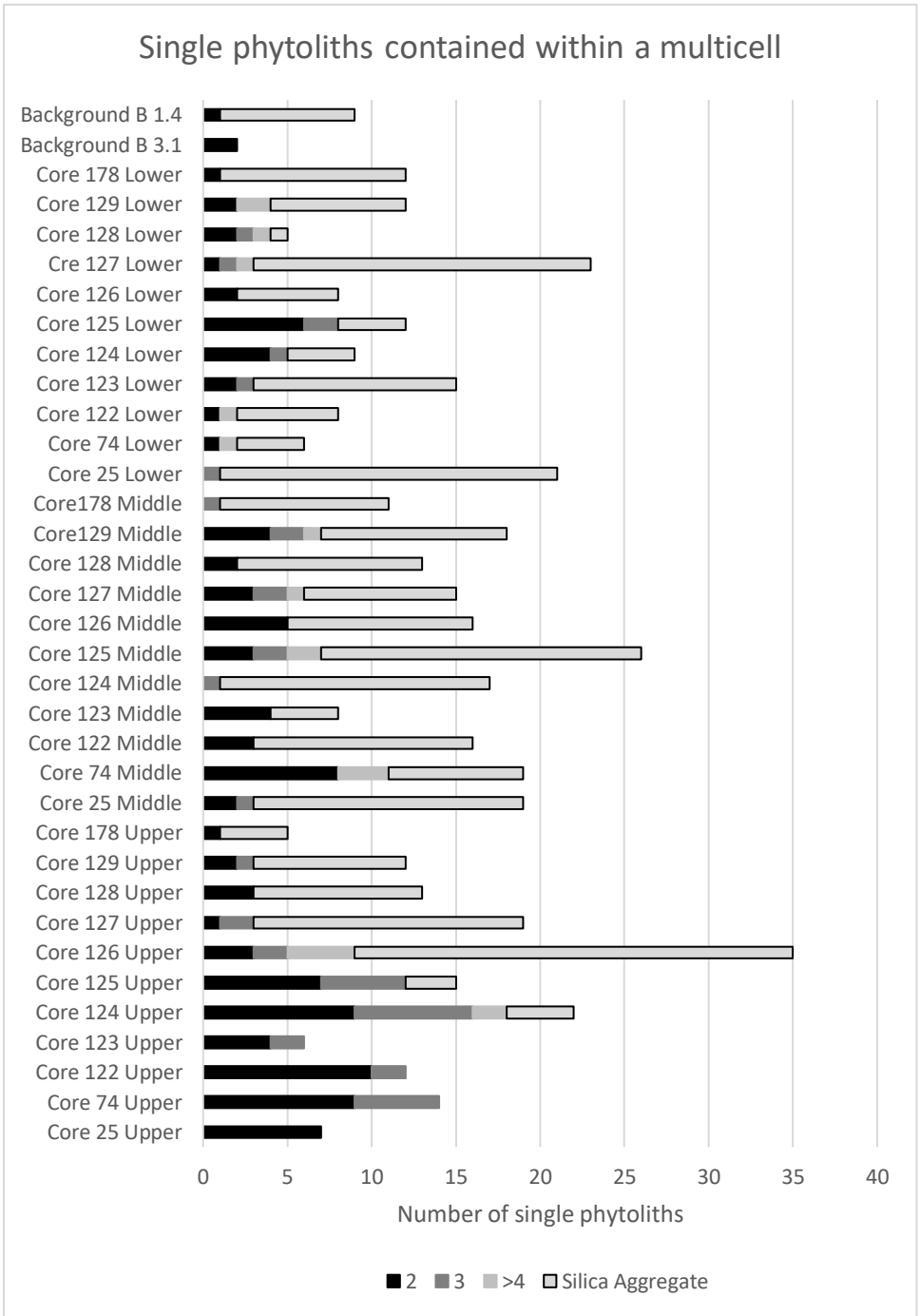
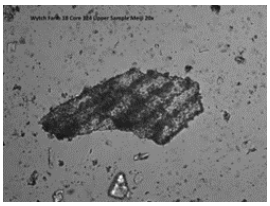
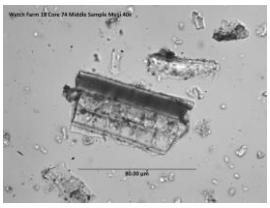
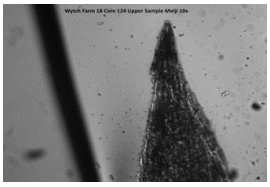
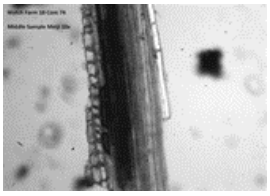
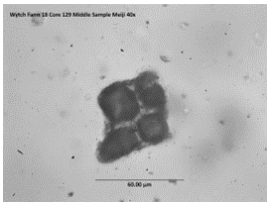
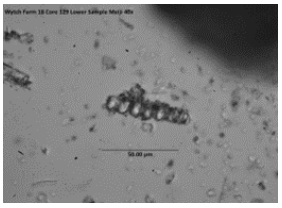



***Figure 33*** *Number of single phytoliths within each multicell*

An observation was made when looking for multicells. Some very distinct phytolith types, such as elongate entire or blocky types were embedded within silica aggregate (see Fig.21). It was decided to class these as multicells. Although often surrounding or encasing single phytolith types the silica aggregate itself was counted as a single unit. For most of the cores these multicells containing silica aggregate are the largest type of multicell. These multicells usually bonded with two other phytolith types. Some contained blocky and others elongate entire phytoliths and usually one blocky or one elongate entire was joined with the silica aggregate. On average the core sample microscope slides held three multicells containing two single phytoliths, one multicell containing three single phytoliths, less than one multicell containing more than four single phytoliths and seven multicells made up of silica aggregate and another phytolith type. Table 14 shows multicells which were identified to specific plant parts, and some which are potentially identifiable to plant species.

**Table 5** *Multicells observed and possible identification to plant species (PhyND.onine)*

| Multicell observed | Where detected | General information | Specific identification |
|---|---|---|---|
|  | Core 124 Upper | Made up of elongate entire<br>Most likely indicates a leaf or stem plant part for any cades | Leaf or stem |
|  | Core 74 Middle | Signs of burning<br>Made up of elongate entire, two containing spheroid psilate phytolith types | Potential for species identification but currently no match to any plant on PhyND.online |
|  | Core 124 Upper | | Most probably *Achillea millefolium* (Yarrow) (PhyND.online) |
|  | Core 74 Middle | | Potential for species identification but currently no match to any plant on PhyND.online |
|  | Core 129 Middle | Signs of burning<br>Made up of spheroid psilate, blocky and bulliform phytolith types | Potential for species identification but currently no match to any plant on PhyND.online |
|  | Core 129 Lower | | Most probably *Eriophorum angustifolium*<br>(Common Cotton Grass)(PhyND.online) |

Some currently unidentified multicells have the potential for further identification if more British flora phytolith data becomes available.

#### 4.3.1.4.2 Core samples: Single phytolith counts

The single phytolith counts were grouped and arranged into a graph to illustrate any changes within the core samples at their different depths (Fig. 34 and Table 15).

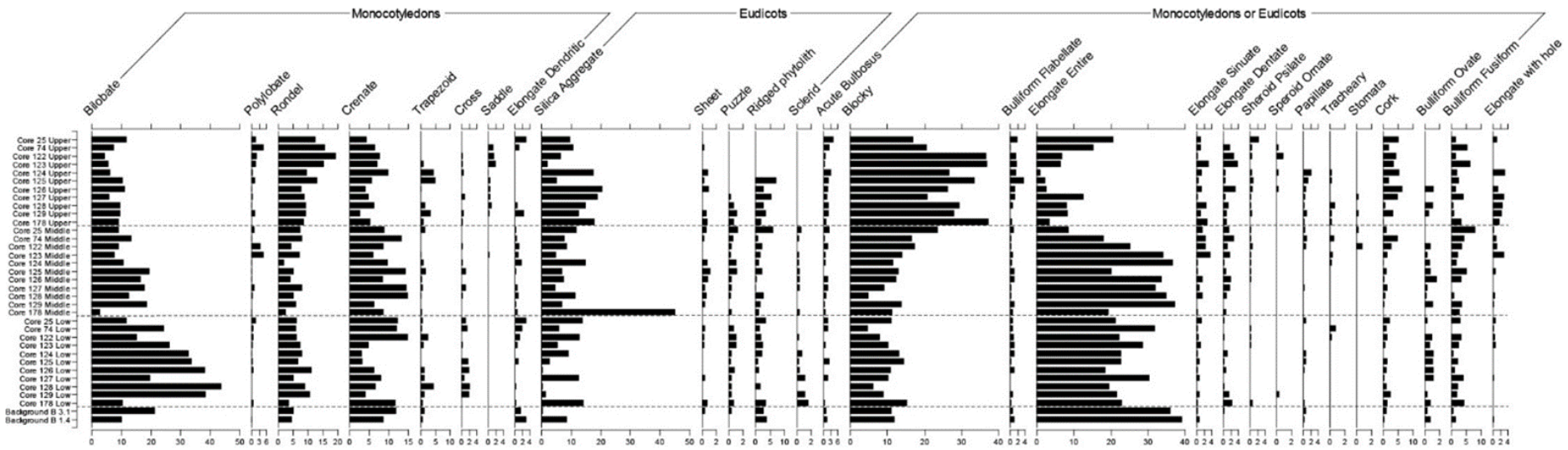
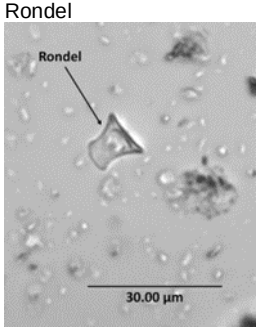
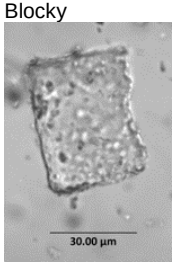
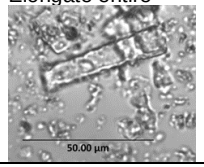
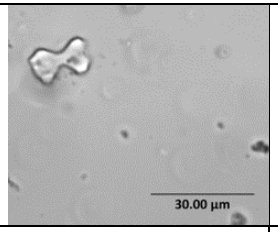
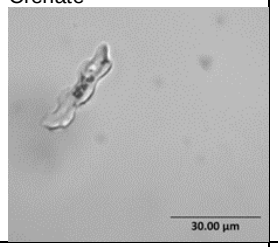
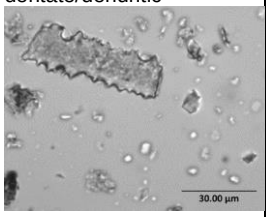
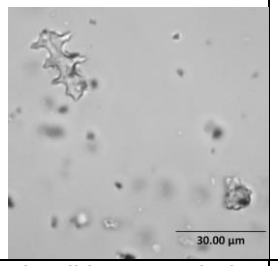
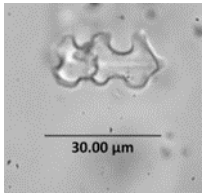
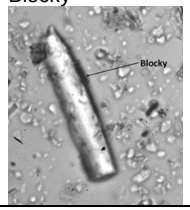


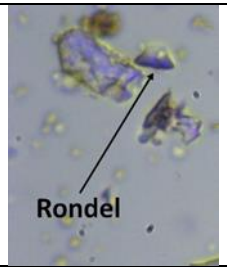
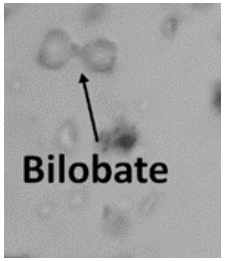
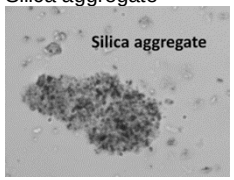
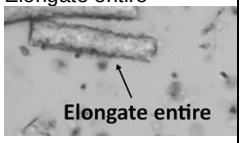

***Figure 34*** *Core samples: single phytolith counts*

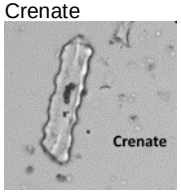
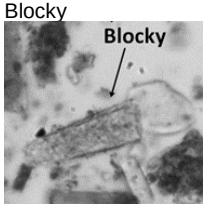
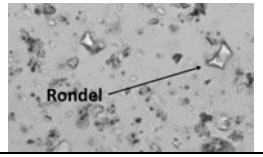
**Table 6** *Core samples phytolith types and percentages*

| Core depth | Phytolith types typical for Monocotyledon | Percentage within the sample count (%) | Phytolith types typical for Eudicot | Percentage within the sample count (%) | Phytolith types, not cades specific | Percentage within the sample count (%) | Phytolith types represented with less than 5% | Overall percentage within the sample count | Other (burnt, degraded or broken phytoliths) | Percentage within the sample count (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper | Rondel   | 11 | Silica aggregate | 11 | Blocky   | 25 | Polylobate, trapezoid, cross, saddle, acute bulbosus, bulliform flabellate, bulliform fusiform, bulliform ovate, elongate sinuate, spheroid psilate, spheroid ornate, papillate, tracheary, stomata, cork, sheet, puzzle, ridged, with hole, sklerid, unidentified | 21 | Broken, degraded and burnt | 11 |
| Upper | Bilobate | 7 | | | Elongate entire   | 7 | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| |  | | | | | | | | | |
| Upper | Crenate  | 5 | | | | | | | | |
| Upper | Elongate dentate/dendritic   | 2 | | | | | | | | |
| **Core depth** | **Phytolith types typical for Monocotyledon** | **Percentage within** | **Phytolith types typical for Eudicot** | **Percentage within** | **Phytolith types, not cades specific** | **Percentage within** | **Phytolith types** | **Overall percentag** | **Other** | **Percentage within** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **the sample count (%)** | | **the sample count (%)** | | **the sample count (%)** | **represented with less than 5%** | **e within the sample count** | **(burnt, degraded or broken phytoliths)** | **the sample count (%)** |
| Middle | Bilobate   | 9 | Silica aggregate   | 9 | Elongate entire | 20 | Polylobate, trapezoid, cross, saddle, acute bulbosus, bulliform flabellate, bulliform fusiform, bulliform ovate, elongate sinuate, spheroid psilate, spheroid ornate, papillate, tracheary, stomata, cork, sheet, puzzle, ridged, with hole, sklerid, unidentified | 19 | Broken, degraded and burnt | 25 |
| Middle | Crenate   | 8 | | | Blocky   | 10 | | | | |
| Middle | Rondel | 4 | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| |  | | | | | | | | | |
| Middle | Elongate dentate/dendritic | 2 | | | | | | | | |
| **Core depth** | **Phytolith types typical for Monocotyledon** | **Percentage within the sample count (%)** | **Phytolith types typical for Eudicot** | **Percentage within the sample count (%)** | **Phytolith types, not cades specific** | **Percentage within the sample count (%)** | **Phytolith types represented with less than 5%** | **Overall percentage within the sample count** | **Other (burnt, degraded or broken phytoliths)** | **Percentage within the sample count (%)** |
| Lower | Bilobate  | 19 | Silica aggregate  | 5 | Elongate entire  | 17 | Polylobate, trapezoid, cross, acute bulbosus, bulliform flabellate, bulliform fusiform, bulliform ovate, elongate sinuate, spheroid psilate, spheroid ornate, papillate, tracheary, cork, sheet, puzzle, ridged, with hole, sklerid | 10 | Broken, degraded and burnt | 30 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Lower | Crenate   | 6 | | | Blocky   | 7 | | | | |
| Lower | Rondel   | 5 | | | | | | | | |
| Lower | Elongate dentate/dendritic | 1 | | | | | | | | |
| **Average percentage of all core samples with phytolith counts** | **Phytolith types typical for Monocotyledon** | **Percentage within the sample count (%)** | **Phytolith types typical for Eudicot** | **Percentage within the sample count (%)** | **Phytolith types, not cades specific** | **Percentage within the sample count (%)** | **Phytolith types represented with less than 5%** | **Overall percentage within the sample count** | **Other (burnt, degraded or broken phytoliths)** | **Percentage within the sample count (%)** |
| | Bilobate | 11 | Silica aggregate | 8 | Blocky | 14 | As above | 19 | Broken, degraded and burnt | 21 |
| | Crenate | 6 | | | Elongate entire | 14 | | | | |
| | Rondel | 6 | | | | | | | | |
| | Elongate dentate/dendritic | 2 | | | | | | | | |

The most common phytolith types, and this was consistent for all the core soil samples, were bilobate (Fig. 35, e), elongate entire (Fig. 35, a, and b) and blocky (Fig. 35, c). Other types which were more pronounced were rondel (Fig. 35, e) silica aggregate (Fig. 35, f) followed by crenate (Fig. 35, d). Two other phytolith types, which were not counted in large amounts but are important for interpretative purposes are elongate dentate (Fig. 35, g) and elongate dendritic (Fig. 35, h).

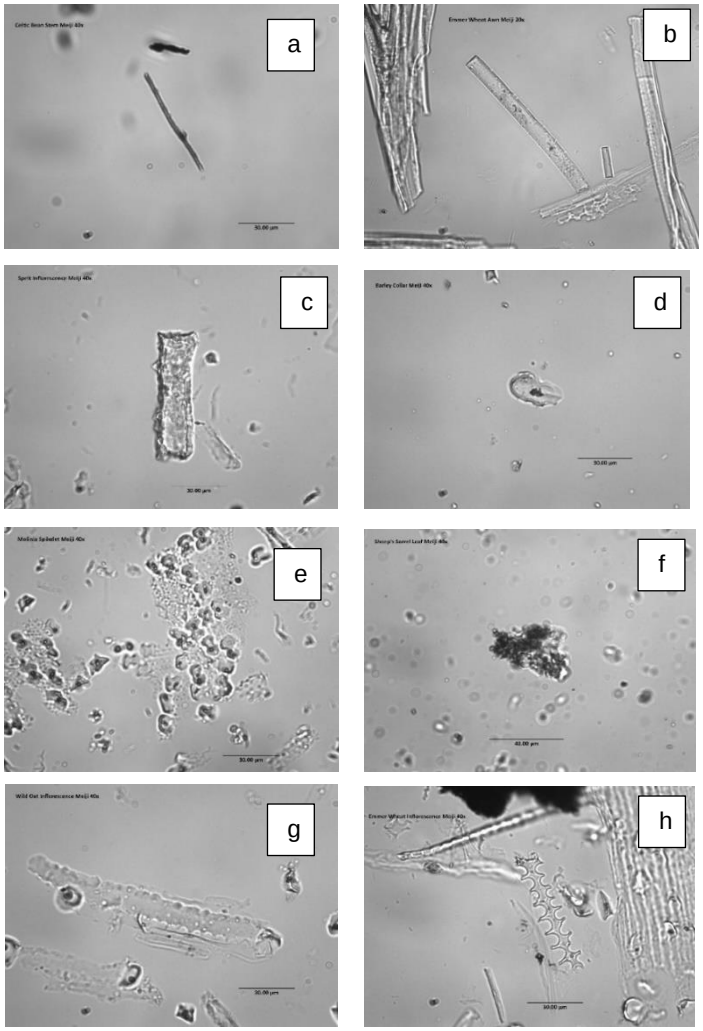



***Figure 35*** *Phytolith types used within the results and discussion a.Celtic Bean, stem, b. Emmer Wheat, awn, c. Spelt , spikelet fork, d. Barley, collar, e. Molinia, inflorescence, f. Sheep's Sorrell, leaf, g. Wild Oat, inflorescence, h. Emmer Wheat, spikelet fork*

When looking at the background samples, lower, middle, and upper core samples within their grouping a decrease in bilobates is seen from the lower to the upper core samples, crenate types seem to be at their highest level within the middle core samples, there is an increase in blocky within the upper sample with a corresponding decrease in the elongate entire types. The silica aggregates show one very high spike in the middle sample of core 178 and although there are core fluctuations there is an overall increase towards the upper core samples. Other types which seem to increase towards the upper samples are cork, elongate with hole, spheroid psilate, elongate sinuate and elongate dentate and polylobate.

### *4.3.1.5 Core samples: non-phytolith silica remains*

Sponge spicules and diatoms were observed in the core samples but mainly two diatom types were seen (Fig.36)

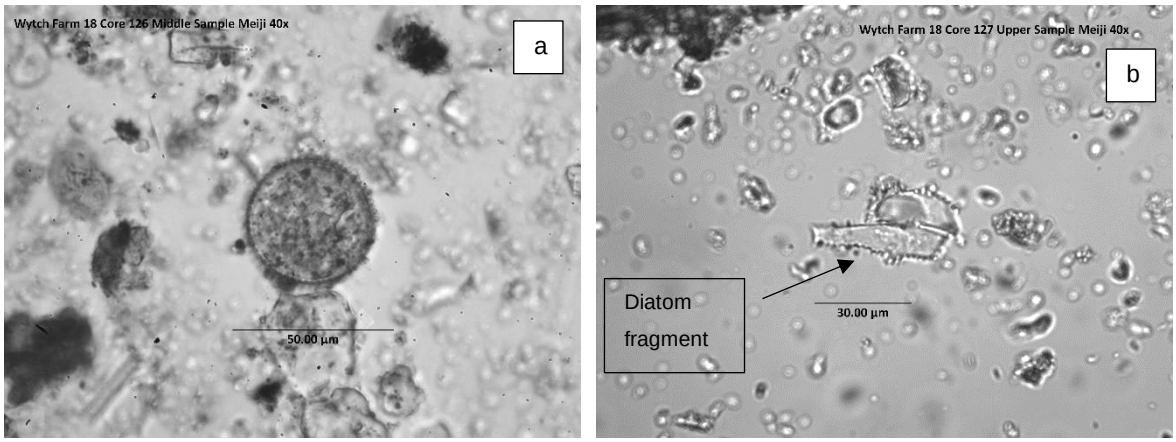



***Figure 36*** *The two diatom types seen in the core samples*

The types of diatoms observed within the core samples were circular in shape (Fig. 36, a) and broken pieces (Fig. 36, b). The following graph shows the diatoms and

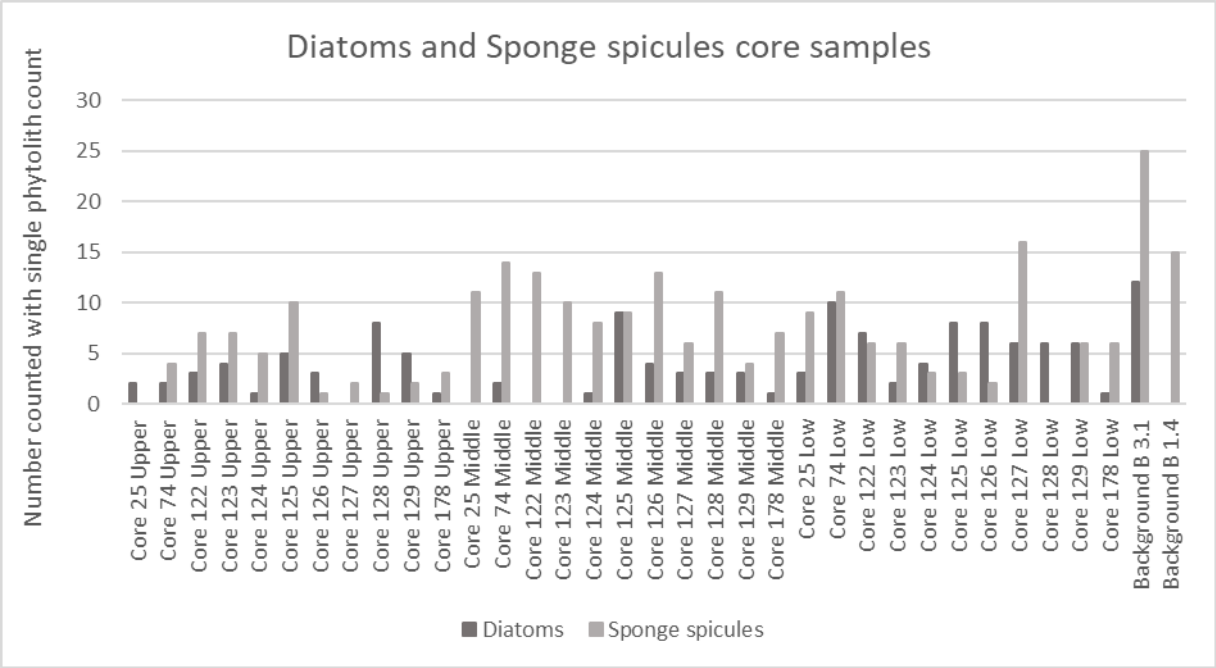



***Figure 37*** *Diatoms and sponge spicules in core sample single phytolith count*

sponge spicules observed while counting the single phytoliths for the core samples (Fig. 37).

It was noted that sponge spicules and diatoms are present throughout the core samples, but the amount seems to decline somewhat towards the upper core samples and there are some middle cores which hardly contain any diatoms.

### 4.3.2 Wytch Farm: micromorphology block subsamples

The following section will show the phytolith, pH, loss on ignition and pXRF results for the micromorphology block subsamples (4.3.2.1 to 4.3.2.4). In addition, it will describe the non-silica phytolith (diatom and sponge spicule) observations for the same samples (4.3.2.5).

#### *4.3.2.1 Wytch Farm: micromorphology block subsamples phytolith results*

The phytolith analysis of the micromorphology subsamples produced the following results: to obtain a minimum count of 250 single phytoliths 20 rows were counted for MM4-SS2 while looking at the whole 22 rows resulted in a count of eight phytoliths for MM4-SS1 (Fig. 39). For all the other subsamples an average of 289 single phytoliths was counted within one row. MM4-SS1 and MM4-SS2 did not contain any multicell phytoliths while on average 18 multicells containing a combined count of on average 54 individual bonded phytolith types were counted for the remaining subsamples. A breakdown of the amount of bonded single phytoliths contained within each multicell was undertaken (Fig.38).

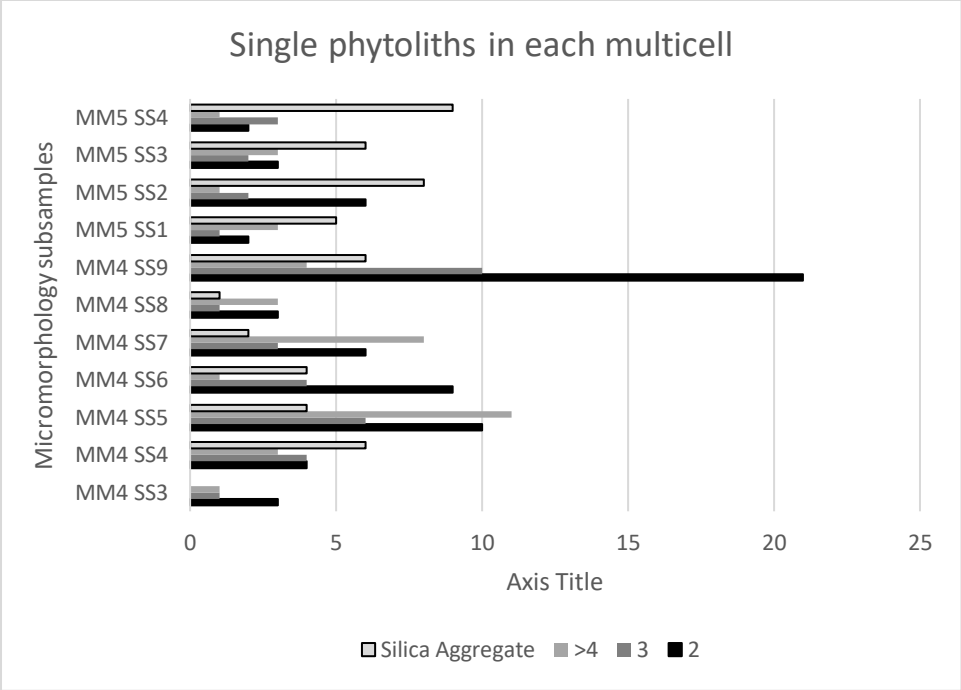



***Figure 38*** *Amount of single phytoliths within each multicell*

The largest amounts and tallest spike for two single phytolith making up a multicell is seen in MM4-SS9. This is not reflected in MM5-SS1 which overlaps MM4-SS9. Overall multicells made up with silica or with two bonded single phytoliths are dominating the assemblages.

For the single phytolith counts a graph was produced which shows the changes from the lowest stratigraphic layer to the highest (Fig.39 and Table 16).

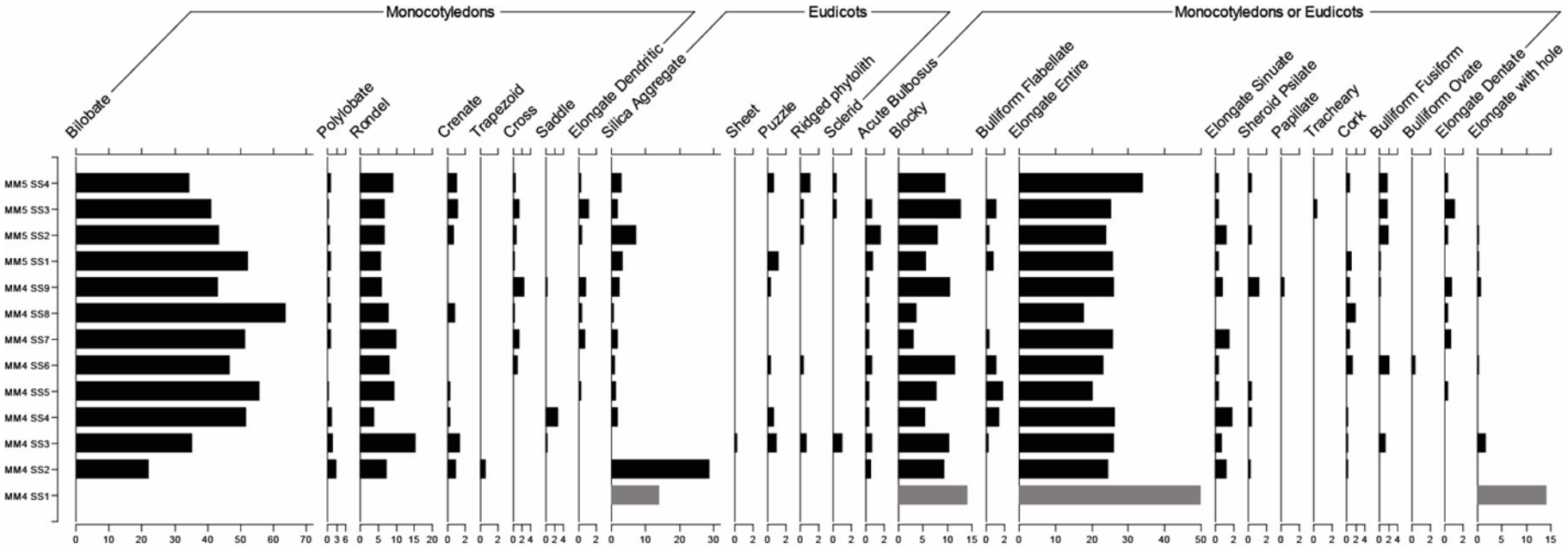
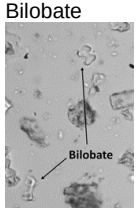
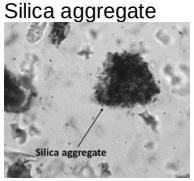
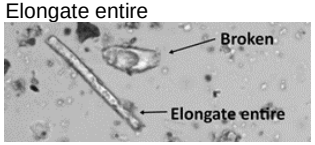
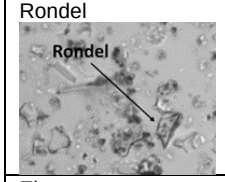
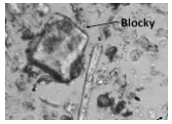
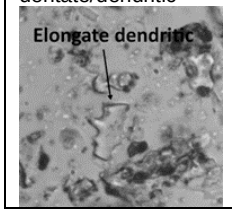



***Figure 39*** *Single phytolith type counts for the micromorphology subsamples*

*The black bars indicate a count of over 250 single phytoliths per sample slide, the grey bars indicate an overall count of 8 single phytoliths on the whole sample slide

**Table 7** *Micromorphology samples averages for phytolith types and percentages for all 14 micromorphology subsamples*

| **Phytolith types typical for Monocotyledon** | **Percentage within the sample count (%)** | **Phytolith types typical for Eudicot** | **Percentage within the sample count (%)** | **Phytolith types, not cades specific** | **Percentage within the sample count (%)** | **Phytolith types represented with less than 5%** | **Overall percentage within the sample count** | **Other (burnt, degraded or broken phytoliths)** | **Percentage within the sample count (%)** |
|---|---|---|---|---|---|---|---|---|---|
| Bilobate   | 37 | Silica aggregate   | 4 | Elongate entire   | 24 | Polylobate, crenate, trapezoid, saddle, acute bulbosus, elongate sinuate, cork, bulliform fusiform, bulliform ovate, ridged, sklerid | 8 | Broken and degraded | 12 |
| Rondel   | 7 | | | Blocky   | 8 | | | | |
| Elongate dentate/dendritic   | >1 | | | | | | | | |

MM4-SS1 is different to the other subsamples as it only produced eight phytoliths on the whole slide which belonged to elongate with hole, blocky, elongate entire and silica aggregate. MM4-SS2 shows a large amount of silica aggregate. The dominant phytolith type for the remaining micromorphology subsamples is bilobate. This is closely followed by all subsamples with elongate entire and then blocky. The types which are seen to increase towards the higher layers are cross, elongate dendritic, and elongate dentate. All three of these forms are not present in the lowest subsample layers.

### *4.3.2.2 Wytch Farm: micromorphology block subsamples other proxy: pH*

The pH results for the micromorphology block subsamples are displayed below (Fig.40).

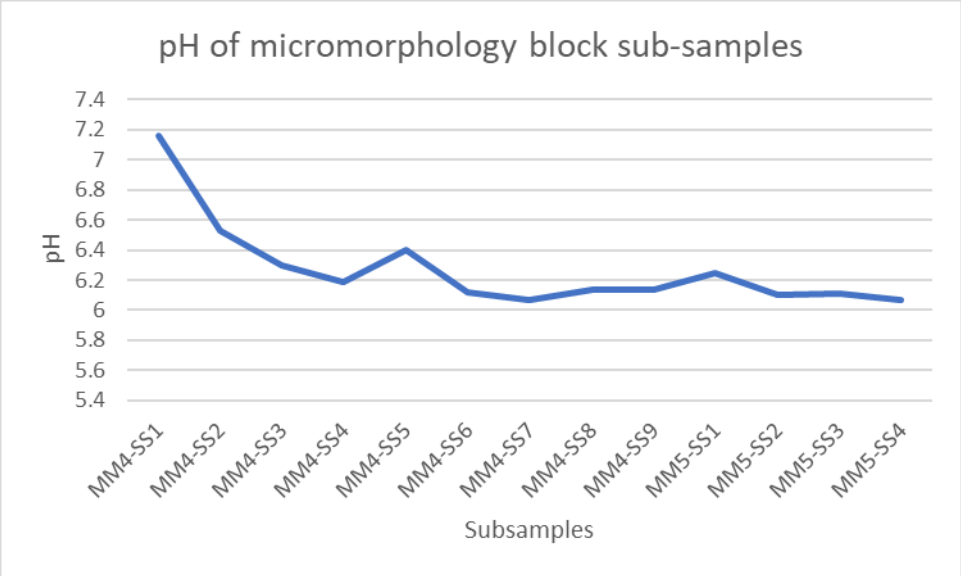



***Figure 40*** *pH results for the micromorphology subsamples*

The pH ranges from 7.2 at the lowest stratigraphic subsample to just above 6 for the highest stratigraphic subsample. There is a slight pH rise for MM4-SS5 followed by a fall and then a steady small rise again towards MM5-SS1 after which it goes back to the lowest level of MM4-SS7.

### *4.3.2.3 Wytch Farm: micromorphology block subsample other proxy: loss on ignition*

The loss on ignition for the micromorphology subsamples are displayed in the graph below (Fig.41)

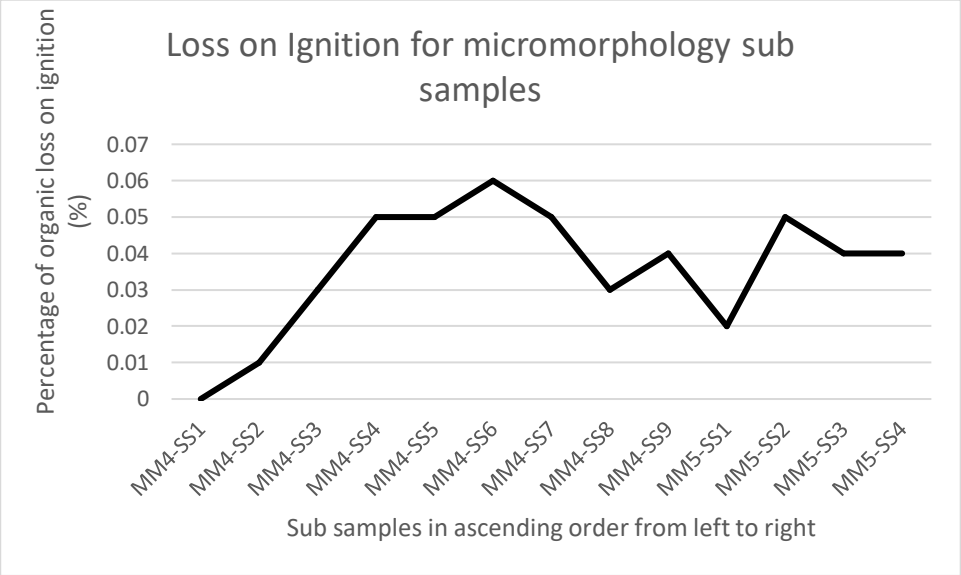



***Figure 41*** *Loss on ignition for the micromorphology subsamples*

Overall, the organic content is below 0.06% with the lowest level for the 'natural', sandy MM4-SS1 layer then a steep rise towards MM4-SS6 with a fall and fluctuation and another rise to MM5-SS2 before levelling out towards the highest layer of MM5-SS4.

### *4.3.2.4 Wytch Farm: micromorphology block subsamples other proxy: pXRF*

The portable x-ray florescence results have been analysed in two different groupings and with different element related queries. The micromorphology subsample soil was investigated for silica (Si), to establish whether it is present within the Wytch Farm soil, potassium (K), which is indicative of organic plant

material, phosphate (P), which can indicate faecal matter, calcium (Ca) which is a main component of bone, and lead (Pb), copper (Cu) and zinc (Zn) which can be an indicator of anthropogenic activity (Fig. 41 to Fig. 45). The vitreous (slag) and high fired clay like material recovered from some of the subsamples were compared with an x-ray florescence elements table compiled by J. Pike (2021) as part of her investigation of the vitreous material found during the Wytch Farm excavations (Fig.46 and Fig.47).

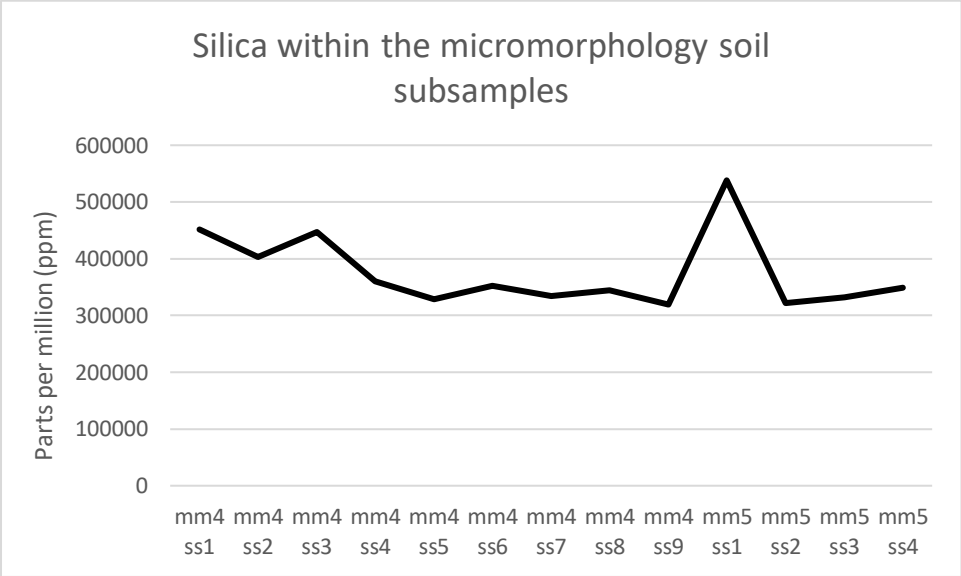



***Figure 42*** *Silica results for pXRF analysis of the micromorphology soil subsamples*

The silica (Si) levels decrease from MM4-SS3 and then level out until there is a spike at MM5-SS1 from where it goes back to the previous levels.

There is a large increase in potassium (K) to MM4-SS3 where the highest overall peak occurs. It then falls towards MM4-SS4 only to rise for MM4-SS5 and SS6 and then to fall again for MM4-SS7 before levelling out for the next subsample layers. Phosphate (P) rises towards MM4-SS5 then falls and levels out until rising again to the same level at MM5-SS1 before another fall and gentle rise.

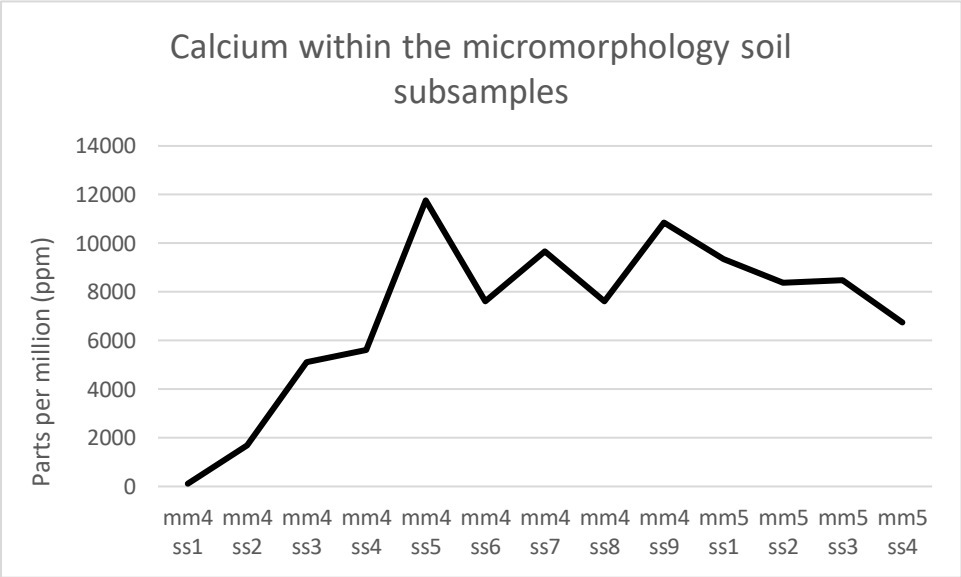



***Figure 44*** *Calcium results for the micromorphology soil subsamples*

Calcium (Ca) rises to its highest peak at MM4-SS5 and then fluctuates down and up until reaching its second highest peak at MM4-SS9 before a decline but remaining above levels reached for MM4-SS4.

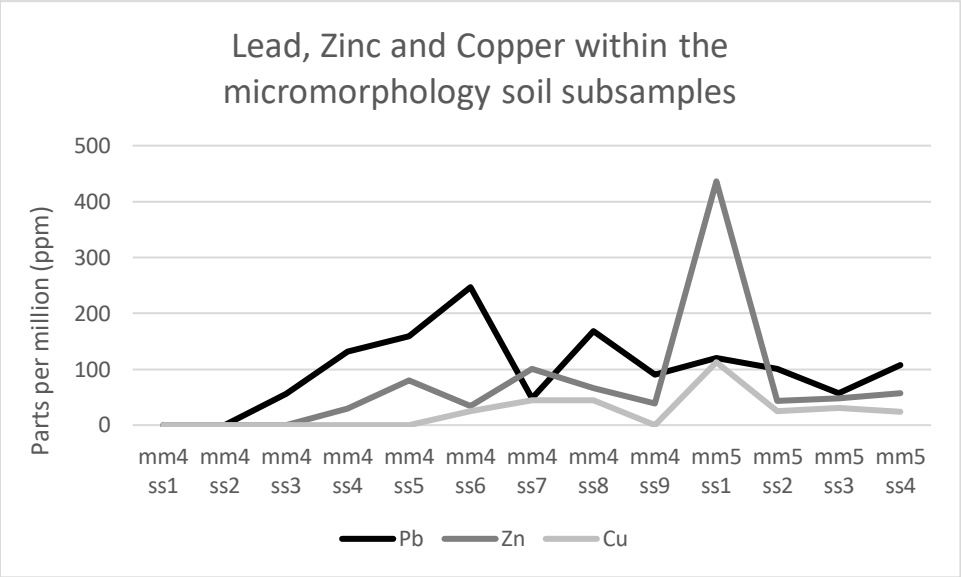



***Figure 45*** *Lead, zinc and copper results for the micromorphology soil subsamples*

Lead (Pb) has its highest peak at MM4-SS6 while zinc (Zn) and copper (Cu) both have theirs at MM5-SS1. Copper (Cu) did not register in the pXRF analysis for MM4-SS1 to MM4-SS5 and for MM4-SS9. Both lead (Pb) and zinc (Zn) are presented in higher values than copper (Cu). Apart from the large spike at MM5-SS1 zinc (Zn) is level whereas lead (Pb) fluctuates more widely.

J. Pike (2021) separated the vitreous material into two groups. The first one had a high SiO2 and a low Fe2O3 content. This group is represented through its average elemental results and is called Average 1. The second group was identified as having lower levels of SiO2 and higher levels of Fe2O3. This group is represented by its average elemental results and is called Average 2. The following two graphs compare Pike's (2021) two elemental group results with the vitreous inclusions (slag) and the other inclusion (possibly high fired clay) (Fig.46 and Fig.47).

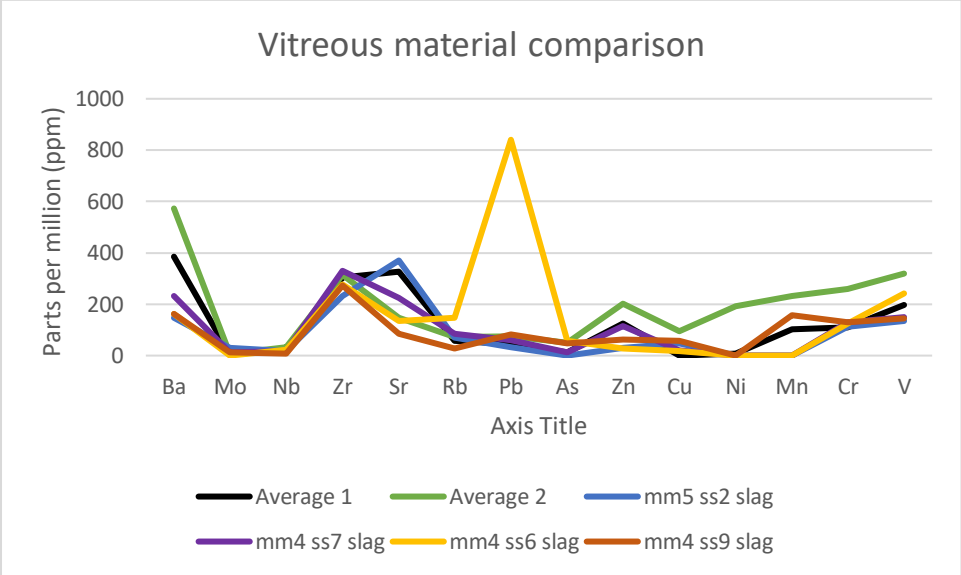



***Figure 46*** *Comparison of vitreous material elements*

Apart from the spike in lead (Pb) and the low count for manganese (Mn) for MM4-SS6 all the vitreous material samples collected from the micromorphology soil subsamples closely follow the two curves of averages established in Pike's (2021) Wytch Farm analysis.

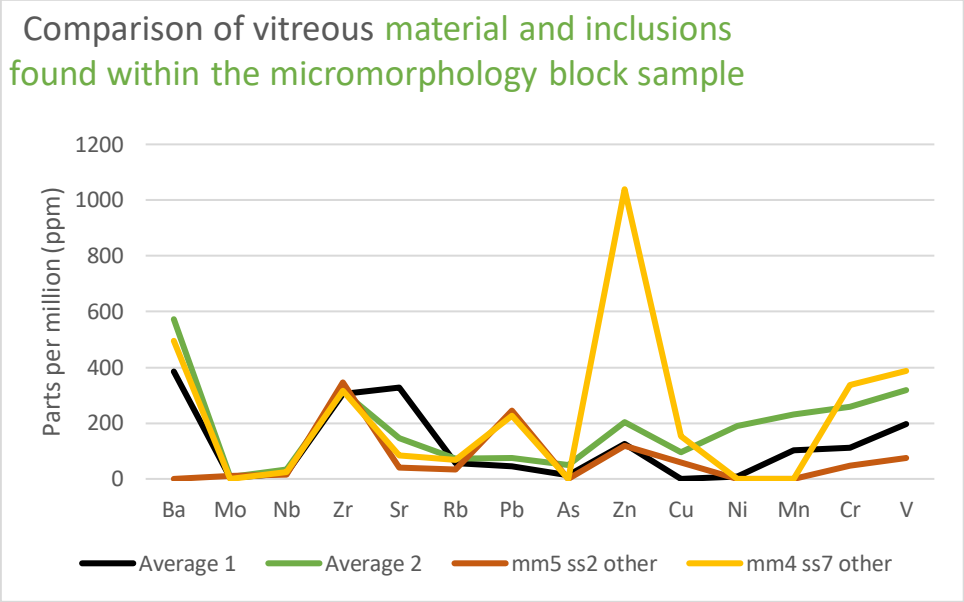



***Figure 47*** *Vitreous material and the other inclusion observed within the subsamples broken down into their elements*

Although some elements show similarities between the vitreous and other material there are differences in Sr (strontium), Pb (lead), Mn (manganese), Cr (chromium) and V (vanadium). There is a large zinc (Zn) spike for the MM4-SS7 sample.

### *4.3.2.5 Wytch Farm: micromorphology subsamples: non-phytolith silica forms*

While counting phytoliths the slide often contained other silica remains. Two of these were diatoms (microalgae) and sponge spicules. These can indicate wet ground conditions and are usually included within the count. It was noted that apart from sponge spicules many other types of diatoms were represented on the microscope slides of the subsamples (Fig.48)

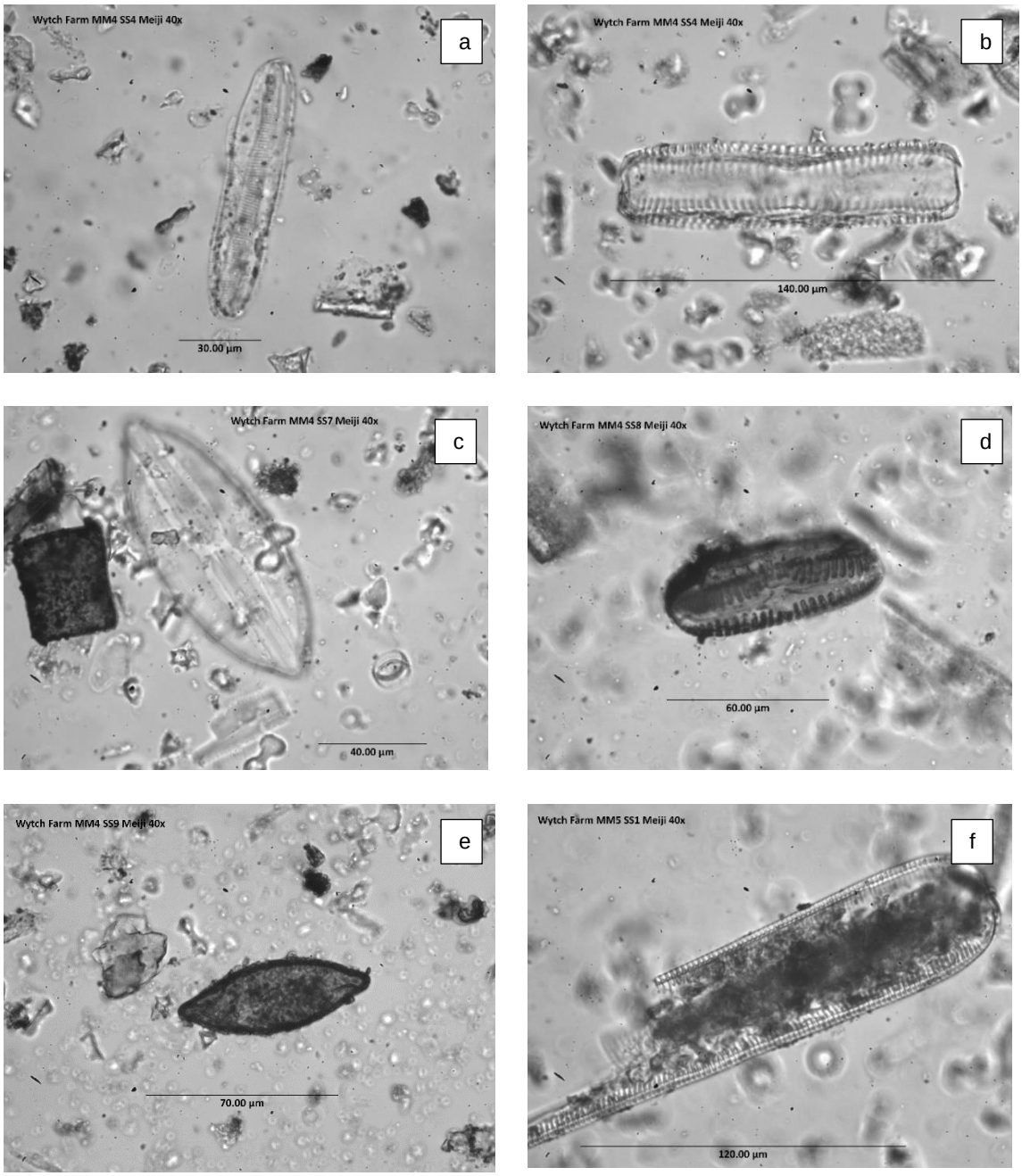



***Figure 48*** *Various diatoms observed on the micromorphology subsample microscope slides*

Many of the diatoms found were whole (Fig. 48, a-e) although some were broken (Fig. 48, f). A graph was compiled with all the diatoms and sponge spicules found although this count only represents what was found while counting single

phytoliths, this means in one row for subsample MM4-SS3 through to MM5-SS4. The counts for MM4-SS1 and MM4-SS2 encompassed the whole microscope slide (Fig. 49).

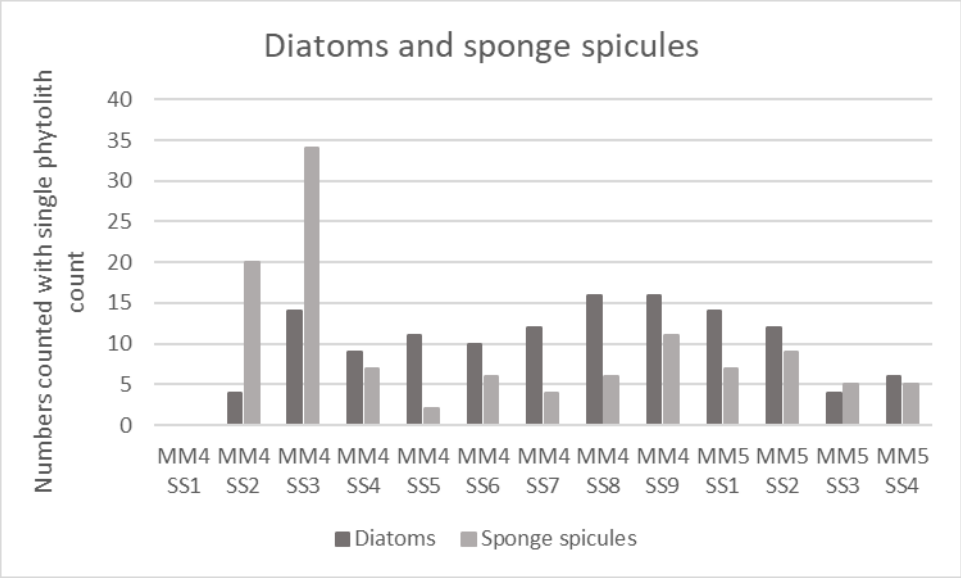



***Figure 49*** *Diatoms and sponge spicules in micromorphology subsample single phytolith count*

MM4-SS1 has no diatoms or sponge spicules while in MM4-SS2 and MM4-SS3 there are more sponge spicules than diatoms. This changes from MM4-SS4 until from MM5-SS3 diatoms and sponge spicules are on a similar level but also at their lowest count overall.

# 5 Project Archive and Data Storage

The 2019 fieldwork diary, all microscope slides produced for this project, two herbarium boxes, left over dry ashing material and the laboratory notebook (containing all fieldworking and laboratory notes) and count sheets have been added to the physical Wytch Farm archive held at Bournemouth University.

All photographs and Excel sheets with the data collected are held on a memory stick with the physical Wytch Farm archive at Bournemouth University and in addition all data and the project, once approved, will be uploaded onto the open access online BoRDAR archive at Bournemouth University and a link to GIT HUB established.

# 6 Discussion

The aim of this project was to examine phytoliths extracted from soil samples at the Wytch Farm site with the help of a pictorial phytolith reference database. This discussion chapter will look at the phytolith analysis and how this informs the interpretation of anthropogenic processes at the Wytch Farm site and occasionally including additional proxy results to further the argument. It will then evaluate the data base and phytolith processing methodology before a closer look is taken at the additional proxies.

## 6.1 Phytolith analysis

This section will divide the phytolith discussion into multicell and single phytoliths. It will firstly examine the multicells to try to understand why there are so few within both the modern and the archaeological soil samples. Secondly it will use the single phytolith counts for all soils to understand what they can tell us about the Wytch Farm site.

### 6.1.1 Multicells from all locations

During the counting of the phytoliths it became apparent that none of the slides prepared from the modern and archaeological soil samples contained enough multicells to achieve a count of 100 which is the preferred number for a microscope slide phytolith count (Piperno 2006)(see 4.2.1 to 4.3.2)(Fig.23, Fig.32). Most of the multicells observed were either made up of elongate entire (Table 14), or a combination of elongate entire and bulliform within a silica aggregate (Fig.21). Although not diagnostic to species, Table 7 shows that elongate entire phytolith types are present in most of the modern plants processed for the data base and when broken down into plant parts are representing the stem (including collar, node, and internode), root (including stolon and tuber), leaf and are also found in the inflorescence (including awn and spikelet). Silica aggregate, although

a mass of silicified phytoliths, is usually counted as a single phytolith type, as its appearance cannot be broken down into individual phytolith types (Fig.21). It is mostly found in eudicots, especially the herbaceous eudicots. We can infer from the presence of the silica aggregate in the multicells paired with elongate entire or blocky, that these multicells originated in eudicots (Fig.21).

The results of the data base findings show only a very few multicells were indicative of a potential plant species and these either related to eudicots which are from biennial or perennial plants or possibly a rush (monocotyledon) which could not be identified. As the unidentified potential rush species (Table 14) shows, it must be acknowledged that the PhyND.online database is currently incomplete and does not represent all possible British Flora plant species or plants having grown on the site in the past.

The pXRF analysis of the soil (see 3.3.2.4) showed the presence of silica within the soil (Fig.41). The abundance of single phytoliths within the soil and of multicells within the dry ashed modern plants showed that phytolith formation took and is taking place within the plants on the site and that multicells are being formed. It is therefore hypothesised that the silicification between the individual phytoliths is weaker and taphonomic processes are more likely to break the multicells into their constituent single phytoliths. This can be indicated by research carried out by Rosen and Weiner (1994) where they investigated multicells in relation to water availability in arid regions in the Middle East. They grew a comparison crop in the temperate zone of West Germany and noted that there was a lack of multicells within the crop plants and the multicells present contained a smaller number of single phytoliths in comparison to the ones from the arid regions' crops. They linked this to the lower transpiration rate leading lesser silicification of the multicell. An additional contributing factor to the break down in multicells could be the acidic soil itself. Jenkins (2011) in her comparison of dry ashing versus wet

ashing (a method which uses acids as a main component), showed that the acid processes used during the wet ashing led to the breakdown in multicells. If the silicification in temperate zones is already weaker, and the multicells themselves are made up of a smaller number of single phytoliths, the deposition in acidic soil might very well contribute to further multicell deterioration.

### 6.1.2 Single Phytoliths from all locations

As the multicells proved more elusive and therefore the identification of specific plant species using the limited database data available is currently not possible, the interpretation of the site with the aid of the single phytolith counts became the main focus. The first part of this section will detail the outcome of the comparison between the quadrant vegetation cover and the modern A horizon soil samples from the same areas (see 1.5 Objective 3). The second part will deal with the main aim of this thesis by using the counts and database to inform on interpretations that can be made on the Wytch Farm site (see 1.4).

## 6.2 Wytch Farm: A horizon soil samples and vegetative cover

The experiment conducted using the three quadrants at Wytch Farm failed to indicate any relationship between the phytolith counts for the soil samples and the percentage of plants growing above ground (see 3.2.2.2.3.2). When combining the phytolith and pollen analysis there was no relationship between plants grown in the quadrants to the proxies extracted from the soil beneath. It would improve the experiment if the percentage count for the plants growing above ground had been dry ashed and investigated as a whole assemblage to see if this would change the overall picture. However, this small experiment confirmed two statements that are made about phytolith and pollen proxies. Firstly, phytoliths recovered from the soil are represented in larger amounts from monocotyledons compared to the eudicots and gymnosperms. Secondly, pollen does represent

what is growing in situ, but the largest pollen extracted from the soil samples has originated from somewhere else, most probably through wind dispersal. The current approach taken by Kahlenberg (2021) using computer modelling which looks into the identification of specific plant ecosystems and linking those to a specific soil phytolith signature might lead to some better results. It will be interesting to see how the modelling will help improve recognition of phytolith composition from vegetative cover compared to the soil phytolith assemblages.

## 6.3 Interpretations

The following section will look at the Butser and Wytch Farm quadrant modern A horizon soil and the archaeological core and micromorphology subsample single phytolith type graphs and by comparison suggest interpretations for anthropogenic processes at the Wytch Farm site (Fig.22, Fig.24, Fig.33, Fig.38, Table 9, Table 11, Table 15 and Table 16).

### 6.3.1 Comparison of the modern agricultural soil phytolith type signature

The Butser bay 1 sample has been used to compare an unrelated modern agricultural crop growing area with the most recent and known agricultural signature of the Wytch Farm site. Although the soil samples were collected at these different sites with differing soil conditions (see 3.2.2.1.3 compared to 3.2.2.2.3.1), they show a similar single phytolith signature (Fig.22 and Fig.24). For both Butser bay 1 and the quadrant soil samples from Wytch Farm a detailed plant list exists (Table 8 and Table 10). At Butser the cereals were growing interspersed with many herbaceous plants (eudicots) and at Wytch Farm the quadrants contained predominantly herbaceous plants a few climbers and small tree saplings (all eudicots) as well as bare patches and leaf litter. Although neither botanical result reflected the actual vegetation cover changes of the whole year it

gave a good indication of two areas where grasses and grass crops were growing together with predominantly herbaceous perennials (as also seen through the few identifiable multicells Fig.33). The phytolith type signature for Butser and the Wytch Farm quadrants seen together show a dominance of blocky and elongate phytoliths with silica aggregates fluctuating but being well represented. This is closely followed by bilobate, rondel and crenate phytolith types. Within the archaeological soil samples collected at Wytch Farm the upper core samples and subsample MM5-SS4 overlap with the modern quadrant A horizon soil samples. It has to be noted that these archaeological samples display the same phytolith type signature as the Butser and Wytch Farm quadrant samples. Seen together with the Kahlenber's (2021) hypothesis of certain ecosystems displaying a specific phytolith signature it could be argued that this is exemplified for the Butser bay 1, Wytch Farm quadrant and the archaeological upper core samples and subsample MM5-SS4. This common signature might reflects the ecosystem of an agricultural landscape which at Wytch Farm has recently been managed through a rotation of lower maintenance years (grazing and no weeding) with high maintenance crop growing practices and with some of the crops being herbaceous (sugar beet, clover) rather than cereal crops (Appendix 3, Table 3). Butser's bay 1 soil indicates a less well managed agricultural management style as the experimental area does not get cultivated every year and does not receive extensive weeding between the cereal crops sown (pers. comm).

### 6.3.2 The archaeological soil interpretation

When looking at the archaeological Wytch Farm core and micromorphology block samples it can be noted that there is fluctuation within the prominent phytolith types from the top/upper to the middle and lower core and microorphology samples but the overall dominance in composition made up of elongate entire, blocky, bilobate, silica aggregate, rondel and crenate as already observed for the

modern soil samples does not change and no other phytolith type becomes prevalent. This can be seen as the presence of a similar plant cover throughout the 1000-year time period of the baulk with variations in phytolith type numbers occurring due to changes in anthropogenic practices on the site. Some of these numerical phytolith type changes will be explored and tied in with specific agricultural practices.

The first phytolith type to be examined is the crenate type. An argument can be made that the increase in crenate phytolith types in the middle core samples indicates a change (see 3.2.3.1.3.2). Some of the changes towards a crenate increase are already visible in a few of the lower core samples. Thirsk (1985) through her study of historical records notes that there was a change in agriculture within the 16th and 17th century and that landowners often tried new management methods in marginal areas of their land. De Pard (2010) comments on the intentions to drain some of Poole Harbour for agricultural land gain in 1673-74. Although no dating for the baulk exists and radiocarbon dating for the last 500 years is not a viable option, this time of agricultural experimentation and expansion into the fenlands and other land bordered by rivers and the sea, might be reflected in the small changes detected within the crenate phytolith types (Thirsk 1985). The crenate phytolith type is represented in many of the processed cereal crops (PhyND.online). Other phytolith types such as the bilobates which indicate grassland rather than crops (PhyND.online) decrease at the same time as the crenates increase. Other, less dominant phytolith types (elongate dentate and dendritic), indicate a rise in awns and grass inflorescence towards the middle and upper samples for both the cores and micromorphology subsamples. It can therefore be inferred that cereal crops were grown at the Wytch Farm site. Returning to the crenate phytolith type it can be observed that the modern soil, disturbed by the Wytch Farm archaeological excavation an collected for this thesis

in quadrant 1, produced the lowest count of crenate types while the modern soil of quadrant 3, from the area of the site which has been managed by a rotation of grazing and crop growing, produced the highest crenate count. This could be an indication that the lower core and micromorphology subsamples were frequently disturbed while the middle core sample soil was less disturbed. The disturbance and lowering in crenate numbers for the upper core samples could be attributable to the known ploughing activities of more recent years.

The second phytolith type, together with some insights gained from the diatom distribution within the samples and geochemical analysis will lead to another interpretation. As discussed in section 4.3.2, the evidence from the non-phytolith silica bodies (e.g. diatoms) found within the lower micromorphology block samples and overlying the archaeological features, indicate that the site was frequently under water. This can be substantiated by the fieldschool diary observations of hurdles alongside the coastline and clay like and vitreous material rubble being added to the shoreline, all anthropogenic interventions to remedy water saturated surface conditions. The phytolith counts, particularly the micromorphology block subsamples, revealed the presence of plants along this water's edge. The dominance of bilobate phytolith types indicates the presence of grasses (PhyND.online). In contrast to the bilobates the phytolith types representing flowering grass parts (elongate dendritic and dentate) are not well represented for these lower sections. Grasses vary in their flowering seasons and some grass species can flower as early as January, but others will flower as late as September. Although it can be argued that the continued wet conditions prevented the formation of grass husks, another explanation could be the removal of these through grazing or grass cutting. As the micromorphology slides were unavailable when this project was completed it was not possible to check for dung

or indications of trampling which should show up in the micromorphology layers to support a grazing hypothesis.

The last phytolith type used for the Wytch Farm interpretation is silica aggregate (although made up of more than one phytolith, due to its appearance this is counted as a single phytolith type). Again, when looking at the water's edge and the micromorphology block samples it was established during the excavation that MM4-SS1 (the natural, sandy sediment) was positioned right below an anthropogenic soil and underlying the areas on which the saltern hearths had been constructed. It is interesting to note that the subsample MM4-SS2 overlying MM4-SS1 has a large spike in silica aggregate phytoliths. As the micromorphology block was sampled near to the water's edge it can be argued that this shoreline, as can often be observed alongside stretches of coast, nowadays had a coverage of possibly rushes, sedges and other saltwater tolerant plant species. As these would have prevented access to the sea water needed to extract the salt, it would have been in the interest of the salt producers to remove such a cover and keep the area free of larger marginal plants. And for the micromorphology subsamples from MM4-SS3 upwards this is clearly the case with a much-diminished count for silica aggregates.

## 6.4 Database and Methodology Assessment

The website and photographic database will be assessed on how it has been utilised for this project. The use of the dry ashing methodology protocol devised by Jenkins (2011) and the time management for the project can be fully evaluated and suggestions made to improve the outcome.

### 6.4.1 Database

The photographic database accompanying this project has been turned into a website and is accessible (PhyND.online). The advantages of such an open access approach were highlighted when other proxies were integrated into this project, for example pollen and diatoms. It was relatively easy, even for someone not used to pollen analysis, to find the appropriate pollen when accessing 'The Global Pollen Project' online (Appendix 14). From there, identification of the pollen on the quadrant pollen microscope slides was possible. The same approach was taken in order to research the diatoms found on the phytolith microscope slides (Fig.35, Fig. 36, Fig.47 and Fig.48) and various websites were accessed (naturalhistory.museumwales online; nhbs.com online). Although S. Davies (Appendix 15) recommended literature and website links, research into diatoms and whether they were typical for British terrestrial, coastal or maritime environments proved much more difficult, as none of the books were available in the Bournemouth University library and the online websites were not as easy to use or as helpful as the pollen website had been (diatoms.org online; naturalhistory.museumwales online; nhbs.com online). It must be acknowledged that PhyND.online currently only deals with British flora related to this project, but saltwater plants and British native tree parts were collected at Farlington Marsh and within the Poole vicinity in 2020 and 2021 and have been dried and are awaiting further processing (Karoune 2020). Previous work using phytoliths have

already produced photos and these, with permission from the respective researchers, could be incorporated into the database and placed onto the website in a similar fashion as 'The Global Pollen Project' , which contains pollen images from many different research projects and researchers (Powers Jones 1994; Smith 1996; Hart 2011; Mc Parland 2016; Radini et al. 2018; The Global Pollen Project online). For the project itself. the pictorial phytolith database has proved useful as it was possible to determine certain plant species through the few multicells that were found and to understand which plant parts were represented by what phytolith types at the Wytch Farm site (Table 8). This in turn supported interpretations on the site, continuity and changes in plant coverage and gave an insight into anthropogenic processes and plant usage (see 4.1.2).

The database had its limitations as it is currently incomplete. All plants for the database had been collected in late summer and autumn. As the spring 2022 revisit of Wytch Farm highlighted, not all plants growing throughout the year had been collected in the late summer 2021 fieldwork (Table 4). This has resulted in the soil phytoliths presenting some phytolith types which were not detected by the dry ashing process such as the ridged, saddle, cross and trapezoid phytoliths while some other phytolith types are only represented by one or two plants such as bulliform crenate, polylobate, sheet, sclerid and elongate with hole (Table 8). Therefore, assigning these specific phytolith types to just one plant species must be undertaken with caution until more data has been collected. Future projects with the aim of collecting plants from a set environment should therefore endeavour to collect plants at different parts of the year to represent the actual flora. The hypothesis that the Wytch farm site represented an acid grassland has been discredited (see 3.1.1) and this demonstrates that existing ecosystem classification needs to be checked for individual sites. The amount of plant species' parts that did not produce a slide containing phytoliths and sometimes

only showing charcoal (see 4.2.2) illustrates that there are potential phytolith types from the plants dry ashed within this project that need further investigation through an adaptation within the methodology (see 3.1.2, Table 5 and Table 6).

### 6.4.2 Microscope slide preparation

While processing the plants using the Jenkins 2011 protocol it was noted that some plants and plant parts did not produce phytoliths while other slides showed charcoal instead of phytoliths (Table 5). Contamination was present on a lot of the processed slides, most notable for the roots of all plants and the leaves for the eudicots (and *Pinus sylvestris*). Contaminants that were observed were blue cloth fibres from the disposable towels used during the processing, mineral particles, charcoal but also phytoliths that should not be seen in that plant part, such as a dendritic phytolith type in a slide for a root. Dendritic phytoliths only occur in inflorescent plant parts of monocotyledons.

The following will show each of these observations and how the methodology can be adapted or improved for better results in the future.

#### *6.4.2.1 Failed microscope slides*

The Boston University (pers. Comm E. Jenkins) dry ashing protocol stated that 0.1 g of plant material was sufficient to extract phytoliths. As seen in the results section (see 3.1.2) on average the plant material processed for monocotyledons, eudicots (and *Pinus sylvestris*) and the pteridophytes was approximately that recommended figure. Processing the eudicots (and *Pinus sylvestris*) most often resulted in no slides due to insufficient mounting material. The small experiment increasing plant material for some of these eudicots showed that even a small addition could result in mounting material (Table 6). It is therefore suggested that some further tests are done, especially with the eudicots (and gymnosperms) to establish whether an increase in plant material and how much increase will produce

phytoliths. Not all plants or plant parts will produce phytoliths and the whole area of eudicot, pteridophyte and gymnosperm phytolith research is still underrepresented within archaeological and botanical phytolith studies (Piperno 2006; An and Xie 2022). Further experiments along this line of inquiry might reveal whether certain eudicots, such as annuals or bulbous plants, due to their shorter life span, might be entirely devoid of phytoliths or whether certain eudicot and gymnosperm plant parts are more likely to produce phytoliths than others.

#### *6.4.2.2 Charcoal*

All the plant parts were dry ashed at a temperature of 500˚C with the failsafe cut off point set at 550˚C. The exception was the second batch of 24 plant parts (M025 to M049) as this batch contained barley (*Hordeum vulgare*). Jenkins had noted in a previous dry ashing experiment that barley phytoliths were distorted and damaged by the heat if 500˚C was used (Jenkins et all. 2011; Jenkins pers. comm.). Therefore, this batch was heated to 400˚C with a failsafe of 450˚C. It is interesting to note that of those 24 plant parts 12 produced charcoal with one slide (Ragwort, *Jacobaea vulgaris*, root) being entirely charcoal. The other 11 slides contained charcoal but in addition phytoliths could be detected and photographed. For all the processing which produced charcoal on their slides it is assumed that if a higher temperature was used, the charcoal would burn away while revealing the phytoliths currently masked by this charcoal. Although some plant parts which only produced slides with charcoal had some spare mounting material, which could be re-ashed at a higher temperature, due to time constraints this was not followed up with an appropriate experiment. This revealed a weakness in the project planning stages. All processes were done in blocks with the first block being the dry ashing (October until December 2021) and the photography block not taking place until mid-January and lasting until March 2022). If each batch had had a quick assessment for charcoal right after the slides

had been produced, this could have been picked up and temperature increase trials included within the dry ashing processing block. It should be possible to run this as a small separate investigative project before proceeding with more British flora dry ashing.

#### *6.4.2.3 Contamination*

As with the charcoal observation the contamination of the processed dry ashing material became apparent when the photographs were taken. Contamination with blue cloth fibres and charcoal were less problematic as they are easy to identify and have no real impact on phytolith recognition. Soil minerals are generally easy to separate from the phytoliths. The problems arose in plant parts where soil contamination was noted the most, such as in the roots, tubers, or stolon. In these plant parts, phytolith types that are only found in specific other plant parts, such as dendritic phytoliths, which only occur in the inflorescences of monocotyledons, were observed as well. It was therefore inferred that the washing process at the beginning will have to be improved, especially for the root parts. This could be undertaken by including a sonication stage into the dry ashing protocol (Pearsall 2000). Another potential for contamination pointed out by Buffington et al. (2021), is a chance of cross contamination during the muffle furnace process. They concluded that using 0.1g of plant material was preferrable to 0.2g and caused less contamination as less material combusted and mixed while settling back into the crucibles (Buffington et al. 2021). As on average only about 0.1g of plant material was used for this project, contamination within the muffle furnace should not have caused a problem within this project, but will need to be considered, if the amount is increased, especially when trialling a better phytolith outcome for Gymnosperms and Eudicots. There is the possibility of adding lids or a foil cover to the crucibles, which could prevent cross contamination, but this might require a small trial, as covering the crucibles could affect the ashing process. Equally it

might be of interest to explore another methodology, namely the microwave protocol trialled by Parr et. al (2001), when changing to larger sample sizes to avoid cross contamination. Looking at all these findings it is recommended that for future dry ashing, specifically for eudicots and gymnosperms, trials regarding washing, amount of plant material, muffle furnace temperature and the potential of using the microwave protocol are explored to guarantee an overall better outcome.

### 6.4.3 Other Proxies

The investigation into additional proxies for this project originated in proving certain assumptions for the Wytch Farm soil (acid soil with low organic content, acid grassland), observations throughout the project such as the presence of diatoms within all soil samples and vitreous material inclusions for the micromorphology soil subsamples. All additional proxies, especially for the pollen analysis of the three quadrants, were mainly used in order to investigate what they could tell us in connection with the phytolith findings, but by representing the data it might be possible for a specialist within these areas to draw more conclusions.

All the Wytch Farm soil samples were tested for loss on ignition and pH in order to ascertain the acidity of the soil and prove the low organic content within the soil.

#### *6.4.3.1 Loss on ignition (LOI)*

Figure 28 and Figure 40 clearly show that the organic content within the Wytch Farm soil was low, although it was markedly higher than the LOI for the respective background samples. This rise in LOI is clearly reflected in the phytolith presence observed in MM4-SS1 and the background samples collected with the core samples. Although there are fluctuations, at no point does the LOI return to the background sample values in any of the overlying soil samples and looking at this together with the phytolith counts it can be inferred that once plants established there was no phase over the following years up to the present day when the site was not covered by vegetation.

#### *6.4.3.2 pH*

All the archaeological Wytch Farm background samples examined for pH show a range of between 6 and 7 and are therefore closer to the neutral pH spectrum. It can be noted that for both the archaeological micromorphology block subsamples

and the bottom and middle core samples, the soil becomes more acidic the higher up the soil layer lies, and it is at its most acidic for the top core samples which reflect the soil overlying MM5-SS4, the topmost micromorphology subsample. There are elements that can influence pH levels and in particular phosphorus (P) and nitrogen (N) can play a part in this (Jordanova 2017; Purbasha et al. 2020). The pXRF analysis of the micromorphology subsamples shows how phosphorus (P) increases from MM4-SS1. It rises to over 1000 ppm at MM4-SS3 and at MM4-SS4 goes above 2000ppm around which it stays, with two fluctuations even reaching 3000 ppm (Fig.40). Phosphorus (P) can enter the soil from mammalian excrement and this large increase would certainly indicate that something containing phosphorus (P) was added to the soil. From the recent farming questionnaire, we learned that fertilizers were added as the soil needed this in order to produce a good crop yield over the last 50 years (Appendix 3). Purbarash et al. (2020) acknowledge that over time leaching of certain elements and high rainfall will increase the acidity of soil, but they state that fertilisation with nitrogen (N) and phosphorus (P) cause soil pH to turn more acidic. It can therefore be inferred that the Wytch Farm soil pH increase has the potential of being driven by anthropogenic processes related to fertilisation and animal husbandry and that together with natural acidification this might be the cause for the pH of the soil becoming more acidic over time.

#### *6.4.3.3 Diatoms*

As diatoms represent silica remains of microalgae and sponges, they show up on microscope slides processed for phytoliths as all silicic is extracted at a specific gravity of 2.3. Due to their preference to live in and near wet areas it is good practice to count them alongside the phytoliths. Both sponge spicules and diatoms were only counted until 250 phytoliths had been observed on each slide, which for most slides meant counting between one and four rows out of 22. Serieyssol

(2010/11) notes that between 300 to 600 diatoms are generally considered a representative count while stressing that if there is a larger diatom species variety then it is advised to count to 1000. Therefore, Figure 52 and Figure 54 do not represent an adequate scientific count protocol but nevertheless show their presence and some fluctuations between sponge spicules and the diatoms themselves. The photographs show the variety of diatoms observed, particularly for the lower core samples and micromorphology subsamples (Fig.36 and Fig.48). For these layers whole diatoms were present, while for the middle and top core samples most diatoms and sponge spicules, except for the circular diatoms (Fig. 36 and Fig.48), were highly fragmented and there were only two types of diatoms, circular and fragmented parts of a diatom like the one in Figure 35. According to Davis (pers. comm. Appendix 15) the diatoms in the lower samples can represent freshwater, coastal and maritime species. It is therefore possible to infer frequent coastal water flooding to the lower areas and this changes from the middle to the upper soil samples. The diatoms infer that the middle and upper samples are still wet in areas but more likely through rainwater sitting on top of a saturated soil. This can still be seen over the winter months and in early spring at the Wytch Farm site especially on its Eastern shoreline. It would be beneficial for the research at Wytch Farm to do some further diatom analysis conducted by a specialist.

#### *6.4.3.4 pXRF analysis for the Wytch Farm micromorphology blocks*

The pXRF analysis was undertaken to check the availability of silica within the Wytch Farm soil, because so few multicell phytoliths were identified within the core and micromorphology soil samples. Vitrified material was also noted within the subsamples and as an unpublished analysis for the vitrified material at Wytch Farm exists, it was possible to compare both materials and see if they were similar or different (Pike 2021).

#### 6.4.3.4.1 Micromorphology blocks: Silica and organic elements

LOI results already established an increase in organic material from the MM4-SS1 background sample for all the following subsample layers. At the same time as the organic matter increased the silica (Si), which is readily available within the Wytch Farm soil, decreased and remained level from MM4-SS4 onwards with one spike at MM5-SS1. This spike at MM5-SS1 is unexpected and as MM5-SS1 overlaps with MM4-SS9 it is surprising to see this huge difference. Potassium (K), which is an element indicating the presence of plants, rises rapidly from MM4-SS1 to MM4-SS2 and remains mostly between 4000 and 5000 ppm until a drop at MM4-SS7 to about 3000 ppm and then the values stay around that figure. The decrease of silica (Si) at the same time as the increase of organic material and rise in potassium (K) might indicate that silica is taken up by the plants to form phytoliths and that some of these plants disappear from the area and therefore deplete the silica (Si) presence (De Tombeur 2020). But as the silica (Si) curve remains mostly along the same level this can indicate that after some time there is an equilibrium between plant uptake and silica (Si) remaining within the soil. This same trend seems to be happening with the potassium (K) and phosphorus (P) curve and supports the interpretation of a more balanced soil element system. When looking at the description of MM9-SS4 and MM5-SS1, which are the same stratigraphic layer, they do differ in appearance and an overall orange layer is noticed for MM5-SS1. Clay contains silica (Si) in large amounts and can show up as an orange layer. Potentially the spike in the silica (Si) for MM5-SS1 can be explained by the presence of clay deposits within this layer and specifically for the subsample taken from it. When the elemental analysis described above is seen together with the phytolith results for the lower, middle, and top core samples and where the levelling out occurs within the micromorphology subsamples, it seems to indicate a change around the middle of the baulk overlay. Within the

middle samples, the phytolith analysis shows an increase in crenate phytoliths which, according to the PhyND.online database indicate two grasses but also five grass crops. Seen together, this supports the earlier hypothesis (see 4.1.2) of a change from grazing to a more managed agricultural crop growing area.

#### 6.4.3.4.2 Micromorphology blocks: other pXRF results

The other two pXRF results shown relate to calcium (Ca) and the combination of copper (Cu), lead (Pb) and zinc (Zn). Calcium (Ca) is released back into the soil when the soil contains decaying animal bone, microorganisms, and plants. The level of calcium (Ca) in the soil increases from nearly 0 in MM4-SS1 to just under 12000 ppm in MM4-SS5. It then fluctuates but never falls below 6000 ppm. It is beyond the scope of this project to follow this further, but it seems to indicate that something containing calcium (Ca) was added to the soil and it seems unlikely that it was solely the additional plant matter, as the phosphorus (P) indicates the presence of mammals as well.

Copper (Cu), lead (Pb), and zinc (Zn) are often seen as anthropogenic indicators (Socloff and Carter 1952; Davidson et al. 2007; Wilson et al. 2009; Bintliff and Degryse 2022) and there are interesting fluctuations. The large zinc (Zn) spike at MM5-SS1 which coincides with the silica spike for the same subsample will need further investigation and interpretation but reaches beyond this project.

Having undertaken the pXRF analysis for the subsamples, it has to be recognised that the pXRF for the top layer of the baulk (about 20-30cm) is only represented by the MM5-SS4 subsample layer. The top layer of the baulk constitutes our best understanding of recent agricultural practices, which means that an interpretation of elemental analysis and anthropogenic use could become more detailed. Therefore, it would have been beneficial to undertake pXRF on the core soil samples, especially the upper core samples, as well as on the modern A horizon

quadrant soils, as this would produce an even more nuanced interpretation and therefore understanding of the site formation processes due to anthropogenic usage.

#### *6.4.3.5 Vitreous material and indicators of high temperature processes*

Pike (2021) undertook the analysis of the vitreous material recovered during the Wytch Farm excavation and interpreted them as hammerscale debris. As Figure 46 and 47 show, the vitreous material found within the micromorphology subsamples is a close match to the material analysed by Pike in 2021 in three cases, with one sample varying only in the lead (Pb) content. It is interesting to note that all four samples had been found higher up. Looking at the magnetic susceptibility results and the relationship to high burning events and comparing it to the burnt phytoliths it can be noted that the lowest core samples have the highest amount of burning event areas while they also contain more burnt phytoliths compared to charcoal (Bellomo 1993). According to Parr (2006) darkly coloured phytoliths occur naturally in plants but are also an indicator of burning. Parr (2006) states that natural and burnt phytoliths can be differentiated as burnt phytoliths have a dull appearance, whereas naturally coloured phytoliths have a translucent appearance. This visual criterion was used when assessing the phytoliths throughout the counting process of the Wytch Farm core samples. Charcoal is formed when oxygen is excluded from the burning process of plant material and can occur at a temperature as low as 300˚C. As the dry ashing processes for this project showed, charcoal formed in the oxygen excluded muffle furnace environment at both 450˚C and 550˚C. Phytoliths, due to their silica structure are much more like glass in relationship to their burning properties and can withstand heat up to 900˚C. Therefore, burnt phytoliths are indicative of higher burning temperatures. Combining this knowledge with the magnetic susceptibility results it becomes clear that in the lower core samples some high burning event took place and that

this carried on into some areas for the middle core samples but then declined. Dong et al. (2022) suggests a more nuanced method of using carbon within phytoliths to prove fire activity. This could be a useful tool for future fire investigations at Wytch Farm to dispel any criticism of a purely visual assessment of phytoliths for burning and the fact that the core samples were unstratified, which indicates sample mixing between layers.

When using all the proxies, the fieldwork diary notes, the PhyND.online database and the phytolith analysis together, the Wytch Farm site emerges as a landscape that after being used in the late Anglo-Saxon times never reverted into a heathland landscape, but was a space where humans procured salt, worked on their metal utensils and tools, grazed their animals, experimented with agricultural land expansion and to this day produce cereal and other agricultural crops.

# 7 Conclusion

The aim of this project was to create a database related to the Wytch Farm archaeological site, analyse modern A horizon soils, and use these to help with the analysis of anthropogenic processes by applying phytolith and additional proxies to archaeological soil samples, giving an insight into events from the time the saltern hearths were built in the late Anglo-Saxon period until present day.

Although it has to be acknowledged that there are methodological issues related to the lack of phytolith multicells and the creation of the database, using PhyND.online has proved invaluable for interpreting the Wytch Farm site. The lack of multicell phytoliths, possibly due to reduced silicification related to phytolith formation in temperate zones, mostly prevented the identification of exact plant species at the site, but where multicells were found it was possible to use PhyND.online to link some to specific plants. Together with the single phytolith findings the identified multicells could be used to support the hypothesis that plant cover at Wytch Farm shows a continuation of a similar vegetation composition throughout the 1000 years represented by feature [1002] (the baulk sample) overlying the site and excavation areas. The single phytolith types, their specific link to certain plant parts, such as stems, or plant types, such as cereal crops, led to detailed interpretative observations. A relationship between the burnt phytoliths, charcoal and magnetic susceptibility results was identified as an indicator of high temperature burning events. Bilobate, elongate dendritic, elongate dentate, and silica aggregate phytolith types were used to interpret the wet areas, particularly for the lower levels of the baulk, and to link this into the possibility of showing a grazing regime to keep the vegetation low which would give better access to the sea water needed for the salterns. A link between the agricultural changes to land reclamation through drainage during the 16$^{th}$ and 17$^{th}$ centuries was inferred using the crenate phytolith type and its link to cereal crop

production and a differentiation between disturbed or undisturbed soil. This showed the potential of phytoliths as a proxy to investigated changes to agricultural areas.

This project involved the integration of other proxies either due to their identification in the samples, such as the diatoms and the vitreous material, or as a planned addition in order to investigate a known assumption and to test phytolith presence within plants and soil. Having collected this additional data and with this project being open access. it will be possible for specialists within some of those fields to use the data for their research and create a scientific discussion around the site's anthropogenic use. Combining these other proxies with the phytolith results has supported some of the inferences made through the phytolith analysis.

The application of historical records and the fieldwork diary notes have helped to move towards more detailed insights. For example, the formation of the salterns around the 10$^{th}$ century in response to the Wytch Farm site being part of the monastic Cerne Abbas landholding, and salt being a tax levied at tenant farmers. As already mentioned, the sites change from predominantly grazing to agricultural cereal crops potentially is a reflection of the agricultural changes sweeping through Britain during the 16th and 17th centuries with the increase in crop versatility and land reclamation projects. For the recent time period, i.e., the last 100 years, the use of fertilizers is known. For the upper and modern A horizon soil this might explain the increase in pH. The modern ploughing and diversification in crop rotation seems to have altered the phytolith signature, especially for the crenate type. With the knowledge gained through interviewing the farmer, a comparison between the known practice of rotating a grazing with a crop growing regime and the earlier agricultural practices could be contrasted and inferred through the phytolith and pXRF analysis.

Looking back on the 2019 field school statement that the well aerated acidic soil would not allow for many organic finds, this project has shown that while organic plant remains and bones were not recovered at the Wytch Farm site, by applying the use of inorganic plant remains and looking into chemical elements contained within the soil, traces of the organic signatures can be detected and used to assess changes and anthropogenic management practices.

Overall, this project utilised phytolith analysis and integrated other proxies to identify four key findings. Firstly, that, after an initial water's edge clearing event, the vegetation species remained the same over the 1000-year history of the baulk build up at Wytch Farm site. Secondly, that high temperature processes took place in various locations at the Wytch Farm site, mainly within the lower and therefore earliest baulk sections overlying the late Anglos Saxon salterns. Thirdly, the use of grazing to keep vegetation down is a suggestion for the stratigraphy overlying the salterns. And fourthly, the changes in agricultural management from grazing to cereal crop production for the middle core sample sections and a ploughing and fertilizing regime for the upper, most recent, baulk samples.

This project has demonstrated that creating a phytolith database for Britain is a great resource for the future. It benefits British research but could equally be used in European contexts as many of the plants which grow in Britain reflect some of the plants of Northern and sometimes even Southern Europe. Additional plants have already been collected and dried. An immediate start on processing saltwater species and trees known from prehistoric Britain up to the Anglo-Saxon times is therefore possible. With the insights obtained regarding the methodology for dry ashing, the next plant batches can be processed with the experiences and knowledges gained from this project. Although within this project phytoliths were used for a British archaeological interpretation, they are an equally valuable proxy used within paleoenvironmental, geological, botanical, and other research areas.

The continued building of an open access database and website would be a worthy undertaking for the future.

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# Appendices

## Appendix 1 Assessment of published literature related to phytoliths within British archaeology

Quick survey of literature that uses phytoliths for analysis within British archaeological sites (initial research in 2020-repeated/updated in June 2022)

| Source | Search parameters | Phytolith publications analysing British sites |
|---|---|---|
| ADS (Archaeological Data Services) | Phytoliths | None under 'Archives'<br>Four under 'Library' |
| Bournemouth University library | Britain and phytoliths | One related to Ireland |
| Bournemouth University library | Phytoliths and Scotland | None |
| Bournemouth University library | Phytoliths and England | One |
| Google Scholar | Phytoliths, archaeology and Great Britain | Five looking at the first 100 records |

Altogether there were 11 publications but some of these were the same articles, conference transcripts or parts of book publications but listed in each of the different sources

## Appendix 2 Radiocarbon Dates for Wytch Farm

| UBANo | Sample ID | Material Type | $^{14}C$ Age | ± | F14C | ± | mg Graphite |
|---|---|---|---|---|---|---|---|
| UBA-41041 | WYT19/PLACE19, C2057, S1 | charcoal | 908 | 23 | 0.8931 | 0.0026 | 0.888 |
| UBA-41042 | WYT19/PLACE19, C2074, S21 | charcoal | 890 | 27 | 0.8951 | 0.0030 | 0.512 |
| UBA-41043 | WYT19/PLACE19, C2018, S23 | charcoal | 972 | 23 | 0.8860 | 0.0026 | 0.960 |
| UBA-41044 | WYT19/PLACE19, C2076, S24 | charcoal | 935 | 24 | 0.8902 | 0.0027 | 0.948 |
| UBA-41045 | WYT19/PLACE19, C1128, S516 | charcoal | 1197 | 27 | 0.8616 | 0.0029 | 0.979 |
| UBA-41046 | WYT19/PLACE19, C1821, S13 | charcoal | 914 | 23 | 0.8924 | 0.0026 | 0.979 |

## Information about radiocarbon calibration

RADIOCARBON CALIBRATION PROGRAM*
CALIB REV7.0.1

*To be used in conjunction with:
Stuiver, M., and Reimer, P.J., 1993, Radiocarbon, 35, 215-230.
Annotated results (text) - -

41041
UBA-41041
Radiocarbon Age BP  908 +/-  23
Calibration data set: intcal13.14c  # Reimer et al. 2013

| % area enclosed | cal AD age ranges | relative area under probability distribution |
|---|---|---|
| 68.3 (1 sigma) | 1046- 1090 | 0.594 |
| | 1121- 1139 | 0.213 |
| | 1148- 1163 | 0.193 |
| 95.4 (2 sigma) | 1037- 1186 | 1.000 |

41042
UBA-41042
Radiocarbon Age BP  890 +/-  27
Calibration data set: intcal13.14c  # Reimer et al. 2013

| % area enclosed | cal AD age ranges | relative area under probability distribution |
|---|---|---|
| 68.3 (1 sigma) | 1051- 1082 | 0.361 |
| | 1128- 1134 | 0.052 |
| | 1151- 1192 | 0.507 |
| | 1197- 1205 | 0.080 |
| 95.4 (2 sigma) | 1043- 1104 | 0.368 |
| | 1118- 1216 | 0.632 |

41043
UBA-41043
Radiocarbon Age BP  972 +/-  23
Calibration data set: intcal13.14c  # Reimer et al. 2013

| % area enclosed | cal AD age ranges | relative area under probability distribution |
|---|---|---|
| 68.3 (1 sigma) | 1021- 1045 | 0.528 |
| | 1095- 1120 | 0.405 |
| | 1142- 1146 | 0.067 |
| 95.4 (2 sigma) | 1017- 1054 | 0.435 |
| | 1078- 1153 | 0.565 |

41044
UBA-41044
Radiocarbon Age BP  935 +/-  24
Calibration data set: intcal13.14c  # Reimer et al. 2013

| % area enclosed | cal AD age ranges | relative area under probability distribution |
|---|---|---|
| 68.3 (1 sigma) | 1040- 1052 | 0.164 |
| | 1080- 1110 | 0.375 |
| | 1115- 1152 | 0.461 |
| 95.4 (2 sigma) | 1032- 1156 | 1.000 |

41045
UBA-41045
Radiocarbon Age BP  1197 +/-  27
Calibration data set: intcal13.14c  # Reimer et al. 2013

| % area enclosed | cal AD age ranges | relative area under probability distribution |
|---|---|---|

```
  68.3 (1 sigma)     cal AD 775- 779                    0.059
                            788- 869                    0.941
  95.4 (2 sigma)     cal AD 723- 739                    0.033
                            767- 893                    0.963
                            933- 936                    0.004

41046
UBA-41046
Radiocarbon Age BP    914 +/-   23
Calibration data set: intcal13.14c               # Reimer et al. 2013
  % area enclosed       cal AD age ranges            relative area under
                                                   probability distribution
  68.3 (1 sigma)     cal AD 1046- 1092                  0.613
                            1121- 1140                  0.236
                            1147- 1160                  0.151
  95.4 (2 sigma)     cal AD 1034- 1169                  0.993
                            1177- 1182                  0.007

 References for calibration datasets:
Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE
Cheng H, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Haflidason H,
Hajdas I, HattÃ© C, Heaton TJ, Hogg AG, Hughen KA, Kaiser KF, Kromer B,
Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Turney CSM,
van der Plicht J.
IntCal13 and MARINE13 radiocarbon age calibration curves 0-50000 years calBP
Radiocarbon 55(4). DOI: 10.2458/azu_js_rc.55.16947

Comments:
* This standard deviation (error) includes a lab error multiplier.
** 1 sigma = square root of (sample std. dev.^2 + curve std. dev.^2)
** 2 sigma = 2 x square root of (sample std. dev.^2 + curve std. dev.^2)
where ^2 = quantity squared.
[ ] = calibrated range impinges on end of calibration data set
0* represents a "negative" age BP
1955* or 1960* denote influence of nuclear testing C-14

NOTE:  Cal ages and ranges are rounded to the nearest year which
       may be too precise in many instances.  Users are advised to
       round results to the nearest 10 yr for samples with standard
       deviation in the radiocarbon age greater than 50 yr.

<>
```

## Appendix 3 Questionnaire to tenant farmer of Wytch Farm site

*Thank you for answering these questions.*

*Hopefully I can discover some agricultural clues within the soil, that will show what previous generations grew or how they managed your field once it had ceased being used for obtaining salt.*

*Sigrid Osborne, June 2021*

**What crops do you remember growing on the field:**

Grass, Maize, Fodder Beat, Kale & Turnips, Clover, Barley, Wheat

**What fertilisers did you use and how often (manure, industrial fertiliser, mostly potassium and nitrate or anything else, yearly, twice yearly, other)**

Some years would be 4 times a year, but lately, nothing

Fertilised for the crop depending on what the crop needed

Would be mostly nitrogen, the ground would have been limed as well.

Quite heavily grazed at one point. Would have had extra organics manure.

**What cultivation methods did you use when growing crops or making silage/hay (ploughing, harrowing, ,…)**

Ploughing /Harrowing

You don’t cultivate to make hay that’s done on the surface

**Was there a particular time period between crop growing and grazing or using the grass for silage/as animal fodder which you employed:**

There is no set rotation.  It would be predominately grass, a crop would have been grown as a great crop before becoming grass again.

Grass may grow very well the first year, then less the next year and the next year and then very well again.

It depended on what we wanted in the field for that particular year.

**Anything else you would like to note down about the field (knowledge of use from previous generations, any stories or tales about this part of your land)**

Not really no. It wasn’t very accessible in the early days until we put a bank in to connect it to the main farm. It was pretty well cut off by the tides. My son Derek had his wedding there, archaeological digs have been carried out along with various other student experiments.

## Appendix 4 Report for Butser Ancient Farm about plant collecting and further work

# Fieldwork at Butser

### Who I am:

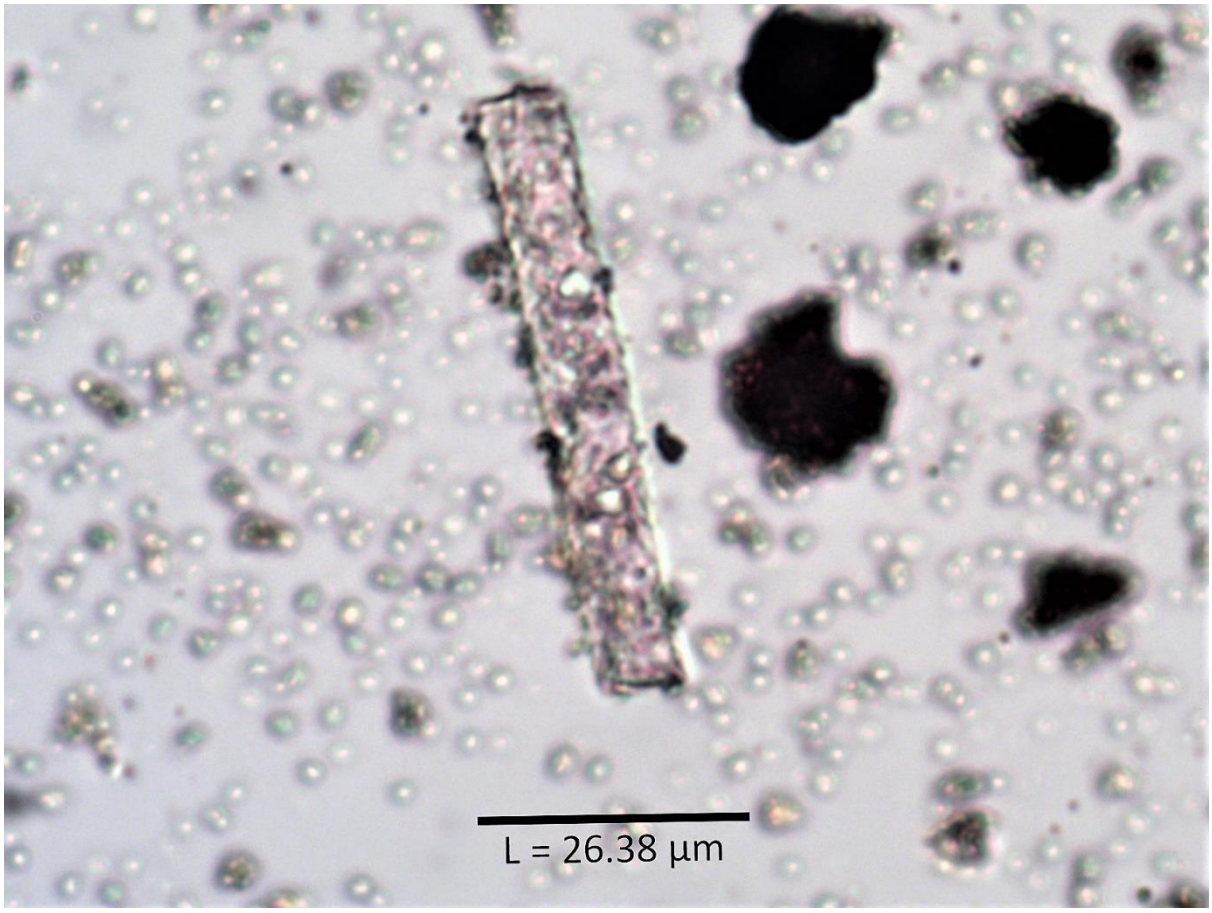
My name is Siggy (Sigrid) and I am a mature student at Bournemouth University with a background in horticulture. This summer I graduated with a degree in archaeology and am currently preparing for the start of a Master of Research, in the year beginning 20th September at Bournemouth University.

### What type of fieldwork:

While studying for my undergraduate degree, I volunteered to do some extracurricular work, and this gave me training and insight into archaeobotany and in particular, the study of phytoliths which are silicaceous, microscopic plant remains. If you would like to understand

phytoliths in more detail you can follow this link:

https://www.environmentalscience.org/phytoliths




*X 400 magnification; an elongate phytolith, these phytolith forms are usually found within leaf or stem parts of plants (S.Osborne 2021)*

## Why this fieldwork?

In the summer of 2019, Bournemouth University ran a field school at Wytch Farm, Poole Harbour. The soil at the excavation site is very acidic and this meant that organic materials did not survive. Phytoliths can be preserved in acidic soil and I suggested undertaking a project using them to see what grew on the site and whether agricultural practices could be detected. It was at this point that I realised that there is no phytolith identification guide for the British Flora.

*1000 years of soil accumulation at the Wytch Farm Fieldschool site, as it has been part of an agricultural area, what can this soil tell us about past agricultural management practices? (S. Osborne 2019)*

My Master of Research project aims to collect phytolith identification data for British plants within the Wytch Farm area and for common crops grown within an agricultural context in Britain. I will then attempt to identify these plants within the archaeological soil sampled at the site in 2018 and 2019. This might give an insight into changes such as woodland management, crop growing or grazing regimes.

## Why Butser Ancient Farm? And what I did on the day:

On emailing Fergus at Butser, I found out that various cereals are currently growing there, and I am hoping that I might detect some of them through their phytoliths within the soil at Wytch farm.

My husband, (who is a horticulturalist and arboriculturist) and I, recorded most of the plants we could see growing within the experimental crop growing area at Butser. I took some plants of Celtic Bean, Einkorn, Emmer, Spelt, Oat Grass and Flax. These are currently drying in a plant press at my house. I also took some soil just below the root horizon in the area where the Einkorn and Emmer wheat are growing.

*Drying the beans and plants collected at Butser (S.Osborne 2021)*

## What will be done next:

**Plants collected:**

When the plants are completely dry, they will be washed in distilled water to remove any contaminants. I will then cut them into very small pieces and separate them into their individual plant parts- seed, leaf, stem, root… These will then be ashed in a furnace at around 500 ˚C and after being mounted on a microscope slide, I can find the pytoliths associated with each plant and plant part and record them by taking a picture with a camera attached to the microscope. These pictures will form the basis of a British phytolith identification data base.

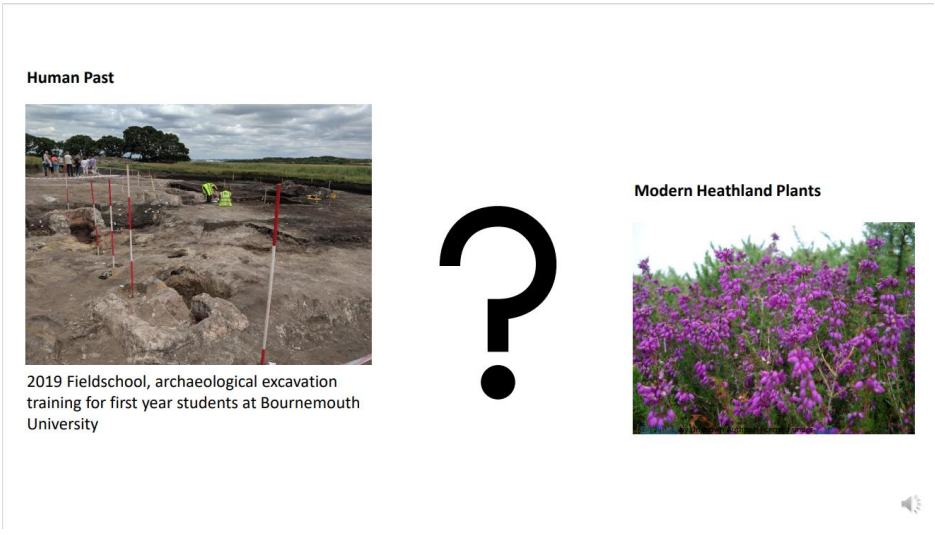
**Soil collected:**

After testing the soil pH, if the soil is too alkaline (above 8) phytoliths do not survive well, I will extract all the phytoliths present within the sample and analyse them under the microscope. This will show how many of the plants growing above ground actually end up being present in phytolith form within the soil.

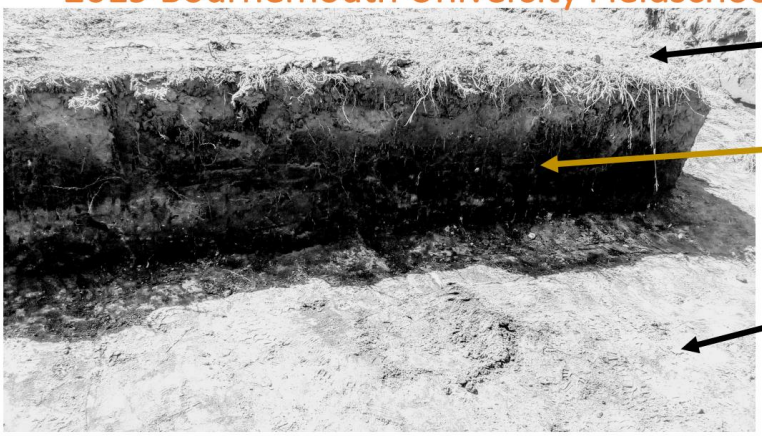
Both these processes can take up to two months. I am planning to start working on both the soil and plants from the end of September onwards and will let you know towards the end of this year what I have found.

If you have any questions, do contact me: s5117147@bournemouth.ac.uk

Appendix 5 Video Blog produced for the National Trust about fieldwork at Hartland Moor **(Powerpoint slides from the blog)**

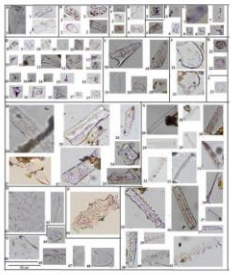
## 2019 Bournemouth University Fieldschool




## Archaeobotany = the study of plant remains from the past

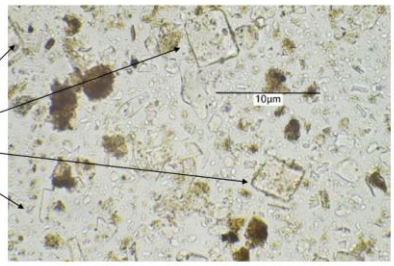
Working as a horticulturist (A. Osborne, 1994)

**Phytoliths** = microscopic plant indicators



Various different phytolith types (Picture from Internet Search, Sep. 2021)

Some of the phytoliths that can be seen on this microscope slide




Microscope slide showing phytoliths within the fieldschool excavation soil (S. Osborne 2019)

### Work done at Hartland Moor

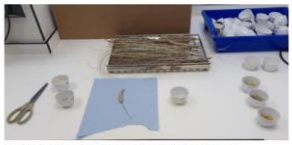
Identify Plants

Collect and press plants for drying

### Work done at home

More pressing and drying, changing the paper regularly to prevent the plants getting mouldy

### Work done in the university laboratories



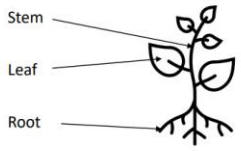
Taking the plants apart into stems, leaves, roots


Ashing the plant parts in a muffle furnace

After some other smaller processes involving chemicals the processed phytoliths are placed onto the microscope slides ready for photography and analysis

(All pictures taken by S. Osborne, 2021)

# Important!




- Not all plants produce phytoliths
- Some plants produce the same type of phytoliths
- Plants produce different types of phytoliths in different parts- some are specific for leaf or stem, some for roots etc.

- Phytolith research used a lot in Middle East, Asia and South America and catalogues for the plants for those regions exist, for example: https://www.researchgate.net/publication/339399581_Illustrated_catalog_of_Phytoliths_from_the_Galapagos_Islands_Economic_species_of_San_Cristobal_Island_Catalogo_ilustrado_de_Fitolitos_de_las_Islas_Galapagos_Especies_economicas_de_la_Isla_San_Cristoba

Image taken from the internet (Sep. 2021)

- There is no phytolith catalogue for British plants at the moment, so archaeologists who would like to use phytoliths in Britain find it hard to analyse. They cannot identify many of the phytoliths found within the soil and link them to specific plants

## Masters by Research Project 2021/22

Bournemouth University

- Extract phytoliths from modern plants and produce a catalogue
- Use the catalogue to identify plants within the fieldschool excavation soil profile
- Can I detect: meadow and grazing plants, agricultural crops, burning of certain plants = different agricultural management processes over time

# More information

https://www.environmentalscience.org/phytoliths

## What happens next

Dry ashing and mounting onto microscope slides from end of September 2021 onwards

Analysis and photographing the phytoliths found

Production of the catalogue

Get in touch: s5117147@bournemouth.ac.uk

Feedback about phytolith results from plants at Hartland Moor should be ready from March 2022 onwards

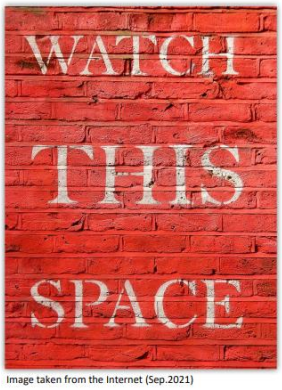
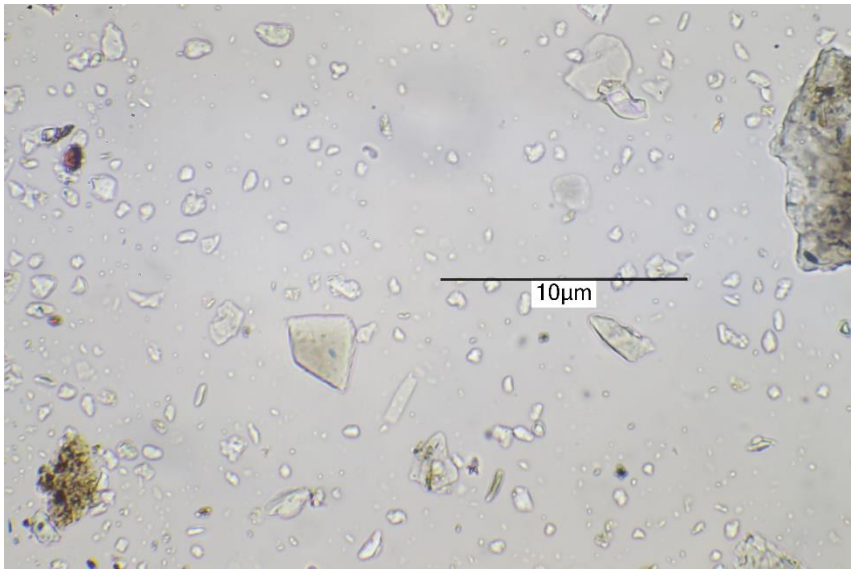



Image taken from the Internet (Sep.2021)

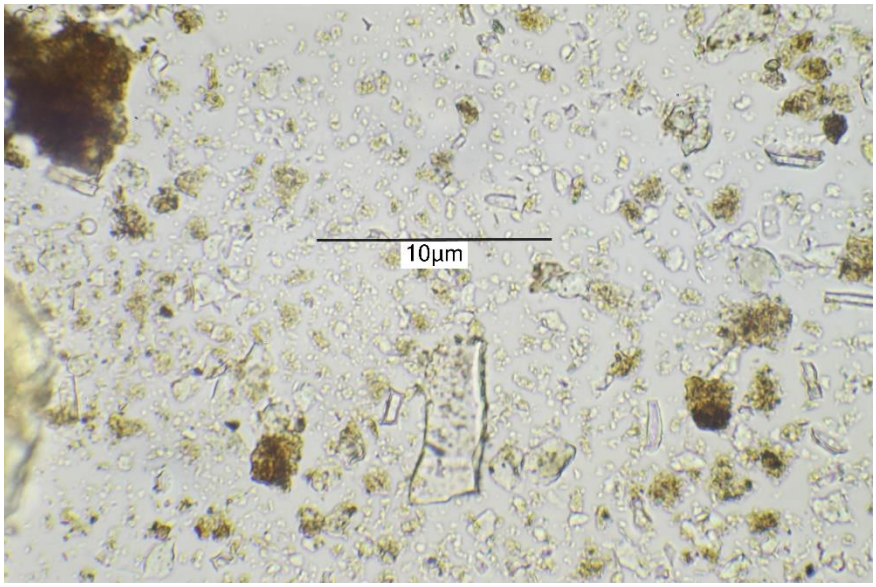
## Appendix 6 Samples processed in 2019 to assess viability of phytolith processing at the Wytch Farm site

Photographs taken of phytoliths on microscope slides processed from core sample 178 and background sample, collected at Wytch Farm during 2018 excavation. Samples provided by Harry Manley and processed late November 2019 following the 10 step protocol mentioned in the methodology of this paper. About 10g of original sample soil were processed to obtain 0.0020g of phytoliths for mounting onto the microscope slides.

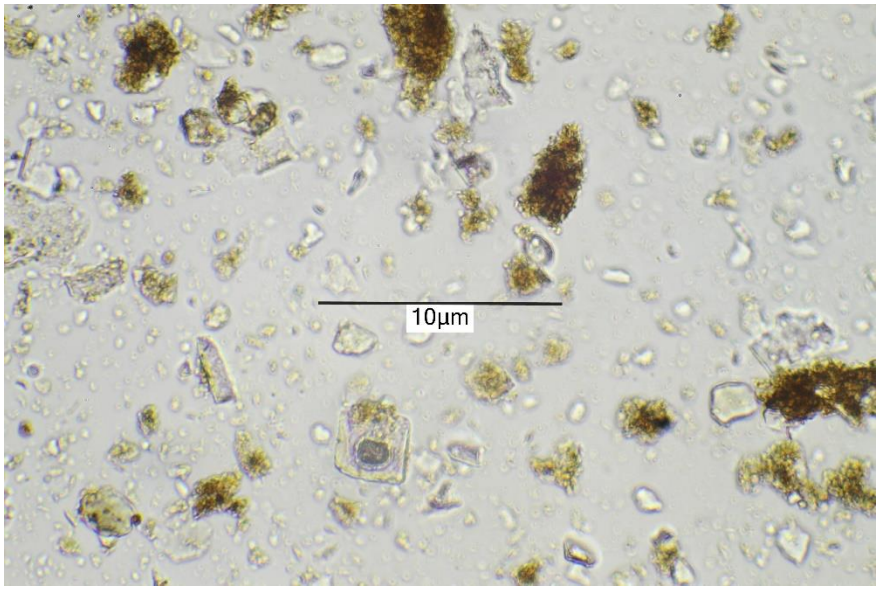
Background Sample:
A few phytoliths are present in this sample



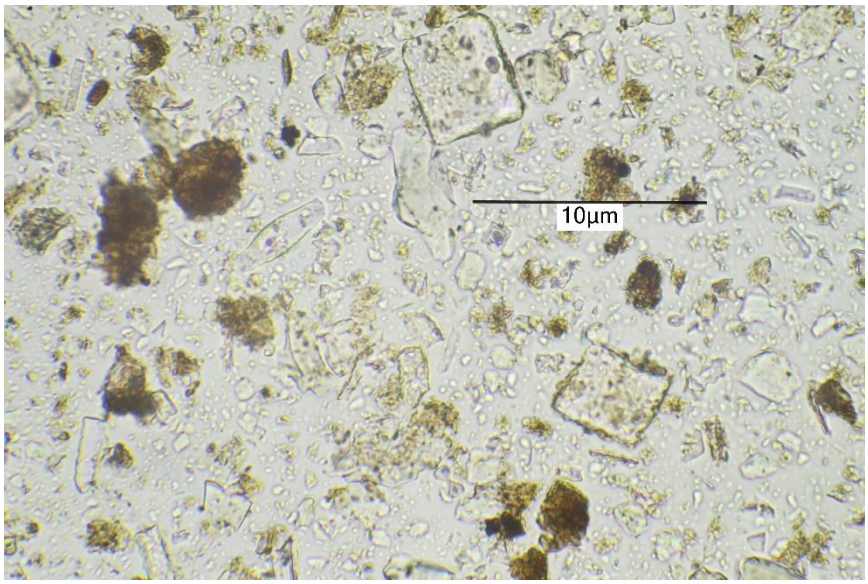

Core 178 Top core sample
Diatoms, monocot and dicot phytoliths can be seen in this sample




Core 178 Middle core sample
Monocot and dicot phytoliths can be seen, different in size, somewhat in type and in distribution compared to 178 top or 178 bottom core sample, a burnt phytolith can be seen in this picture




Core 178 bottom core sample
Monocot and dicot phytoliths are present, different in size, in type and in distribution to core 178 middle sample or core 178 top sample




A phytolith count and detailed analysis of forms and percentages of phytolith types has not been done on these samples. The pictures were taken in the centre part of the mounted phytolith slides' cover plate.

S

# Appendix 7 Nomenclature 2.0 sheet used for phytolith terminology

# Nomenclature for Phytoliths

Annals of Botany 124: 189–199, 2019 doi: 10.1093/aob/mcz064, available online at www.academic.oup.com/aob

International Code for Phytolith Nomenclature (ICPN) 2.0 International Committee for Phytolith Taxonomy (ICPT) (Katharina Neumann*1, Caroline A. E. Strömberg2 , Terry Ball3 , Rosa Maria Albert4,5 , Luc Vrydaghs6 and Linda Scott Cummings7



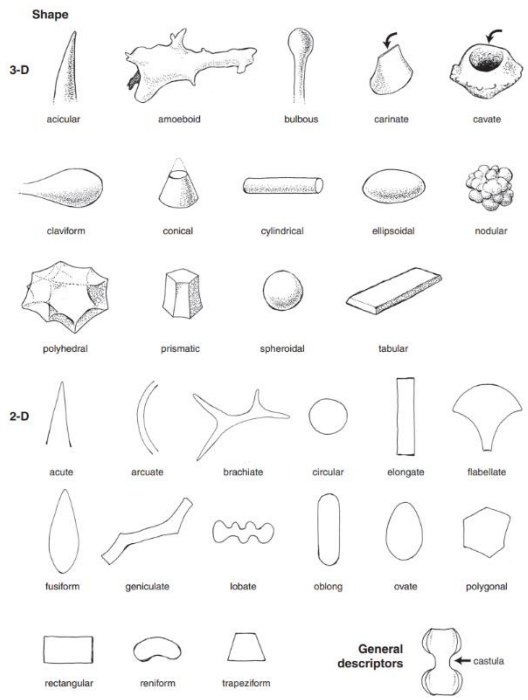
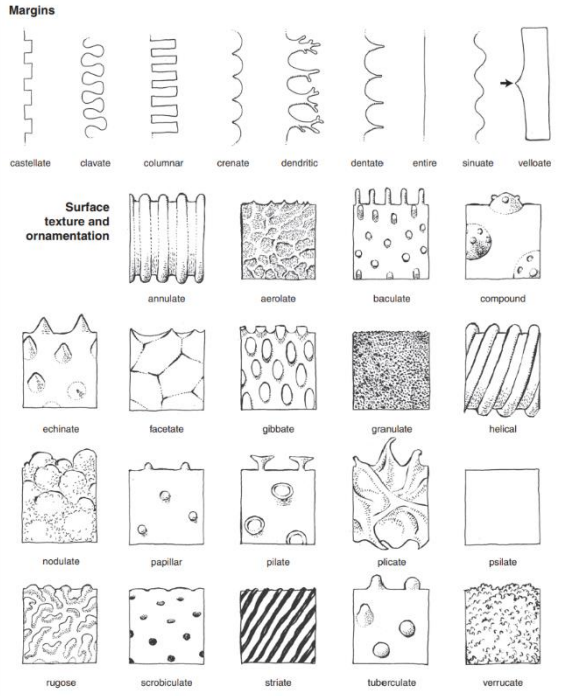



Fig. 1A. Line drawings illustrating important shape and general descriptors. Drawings by C.A.E. Strömberg.








1. 1B. Line drawings illustrating important phytolith descriptors for margins, surface, texture and ornamentation. Drawings by C.A.E. Strömberg.

**Current Standard Morphotypes**

Spheroid Psilate

Spheroid Echinate

Spheroid Ornate

Acute Bulbosus (Hair)

Papillate

Blocky (bulliform)

Bulliform Flabellate (keystone)

Elongate Entire

Elongate Sinuate

**Grass Silica Short Cell Phytoliths**:

Saddle

Bilobate

Polylobate

Cross

Rondel

Crenate

Trapezoid

t

Elongate Dentate

Elongate Dendritic

Tracheary, Tracheary Pitted, Tracheary Bordered

# Appendix 8 Count Sheets produced for this project

| Count Sheet | |
|---|---|
| Site | |
| Sample | |
| Rows Counted | |
| Single | |
| Multicell | |
| Burnt | |
| Degraded | |
| Charcoal | |
| | |
| Bilobate | |
| Polylobate | |
| Rondel | |
| Crenate | |
| Trapezoid | |
| Cross | |
| Saddle | |
| | |
| Acute Bulbosus | |
| Blocky | |
| Bulliform Flabellate | |
| Elongate Entire | |
| Elongate Sinuate | |
| Elongate Dentate | |
| Elongate Dendritic | |
| Sheroid Psilate | |
| Sheroid Echinate | |
| Spheroid Ornate | |
| Papillate | |
| Tracheary | |
| Tracheary Pitted | |
| Tracheary Bordered | |
| | |
| Stomata | |
| Papillae | |
| Cork | |
| Silica Aggregate | |
| | |
| Other (use Nomenclature destriptors) | |

| | |
|---|---|
| | |

Multicell Count Sheet

| Site | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | MulticellCount | | Identification | Bilobate | Polylobate | Rondel | Crenate | Trapezoid | Cross | Saddle | AcuteBulbosus | Blocky | BulliformFlabellate | EnongateEntire | ElongateSinuate | ElongatedDentate | ElongatedDendritic | SheroidPsilate | SheroidEchinate | SpheroidOrnate | Papillate | Trachea ry | TrachearyPitted | TrachearyBordered | Other (use Nomenclature descriptors) |
| | | | | | | | | | | | | | | | | | | | | | | | | |
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# Appendix 9 Pollen Processing at Reading University (Quest)

*Figure . Filter set up for pollen processing, 125 micronmetre sieve at the top, 10 micronmetre sieve at the bottom*

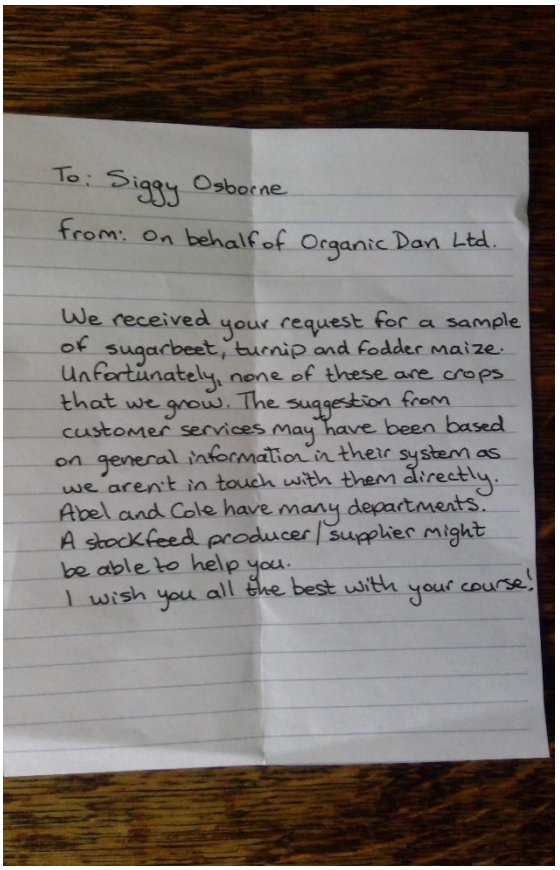

*Figure . 4g of sediment mixed with Sodiumpyrophosphate and one Licopodium tablet added and heating at 80 degrees Celcius on the hotplate*

*Figure . Fume cupboard set up for cellulose removal stage*

## Appendix 10 Sourcing crops grown on the Wytch Farm field

The farmer himself did not grow any of the crops anymore

An enquiry was made through the researchers vegetable box provider: ‘Abel and Cole’ who suggested contacting two of their suppliers. One was contacted by e-mail, the other via a written letter. There was no response to the e-mail but a letter was received.



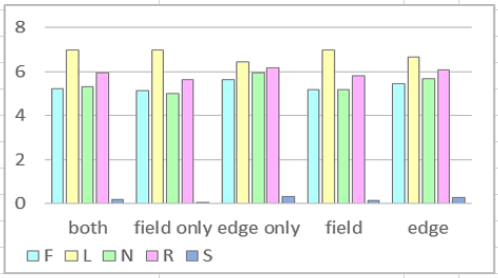
To: Siggy Osborne

From: On behalf of Organic Dan Ltd.

We received your request for a sample of sugarbeet, turnip and fodder maize. Unfortunately, none of these are crops that we grow. The suggestion from customer services may have been based on general information in their system as we aren't in touch with them directly. Abel and Cole have many departments. A stockfeed producer / supplier might be able to help you.
I wish you all the best with your course!

# Appendix 11 Botanical assessment of the Wytch Farm site by Robin Walls

| Ellenberg scores | Ellenberg scores | Niche vect | ASPT both | ASPT field only | ASPT edge only | ASPT field | ASPT edge |
|---|---|---|---|---|---|---|---|
| wetness | wetness | F | 5.21 | 5.14 | 5.64 | 5.18 | 5.47 |
| openness | openness | L | 7.00 | 7.00 | 6.46 | 7.00 | 6.68 |
| nutrient level | nutrient level | N | 5.32 | 5.00 | 5.96 | 5.18 | 5.70 |
| base richness | base richness | R | 5.95 | 5.64 | 6.18 | 5.82 | 6.09 |
| salinity | salinity | S | 0.21 | 0.07 | 0.32 | 0.15 | 0.28 |
| | | no.spp | 19 | 14 | 28 | 33 | 47 |




| Plant strategy | Strategy vector | field | edge |
|---|---|---|---|
| competitor | C | 0.396 | 0.388 |
| stress tolerant | S | 0.146 | 0.206 |
| ruderal | R | 0.457 | 0.405 |
| | no.spp | 33 | 44 |
| | strategy | CR/CSR | CR/CSR |

**Robin Walls**
to me

Apr 24, 2022, 1:29 PM

Siggy
A very enjoyable day and hopefully useful for you.

Attached is a list of all the species I wrote down and the ones from the pond that I remember. The records are all on Living Record. Let me know of any additions.

As I said, I've put the data into my spreadsheet to work out the Ellenberg and CSR scores. No need for you to bother about this unless it is relevant to your project. I'm pleased to say that it indicates what we might expect: the environment around the edge is wetter, less open, more nutritious, less acidic and more saline. If you need to understand this I can explain.

In terms of classification and the NVC, as I suspected it is not clear. It certainly does not fit an acid or calcifugous grassland. The best description is probably a derelict ryegrass-clover ley, MG7. The excavations will be the cause of this by creating piles of bare soil and disturbed subsoil.

Robin

## Appendix 12 Contamination description

| Index Number | ColloquialPlant Name | Latin | Plant Part | Contamination |
|---|---|---|---|---|
| M001 | Einkorn | Triticum monococcum | Root | Yes, soil |
| M002 | Einkorn | Triticum monococcum | Leaf, Blade and Sheaf | None noted |
| M003 | Einkorn | Triticum monococcum | Leaf, Collar (B&S partly) | None noted |
| M004 | Einkorn | Triticum monococcum | Stem, Internode | None noted |
| M005 | Einkorn | Triticum monococcum | Stem, Node (I partly) | None noted |
| M006 | Einkorn | Triticum monococcum | Awn | None noted |
| M007 | Einkorn | Triticum monococcum | Spikelet | None noted |
| M008 | Emmer Wheat | Triticum dicoccon | Root | Yes, soil |
| M009 | Emmer Wheat | Triticum dicoccon | Leaf, Blade and Sheaf | None noted |
| M010 | Emmer Wheat | Triticum dicoccon | Leaf, Collar (B&S partly) | A few inclusions, globular, small |
| M011 | Emmer Wheat | Triticum dicoccon | Stem, Internode | None noted |
| M012 | Emmer Wheat | Triticum dicoccon | Stem, Node (I partly) | None noted |
| M013 | Emmer Wheat | Triticum dicoccon | Awn | None noted |
| M014 | Emmer Wheat | Triticum dicoccon | Spikelet | None noted |
| M015 | Flax | Linum usitatissimum | Roots | Yes, soil |
| M016 | Flax | Linum usitatissimum | Leaf | Yes, soil |
| M017 | Flax | Linum usitatissimum | Stem, including bast/flax fibre outer layer | |
| M018 | Flax | Linum usitatissimum | Flower, all parts | A few, blue towel and mineral/soil |
| M019 | Spelt | Triticum aestivum | Root | Yes, soil |
| M020 | Spelt | Triticum aestivum | Leaf, Blade and Sheaf | None noted |

| | | | | |
|---|---|---|---|---|
| M021 | Spelt | Triticum aestivum | Leaf, Collar (B&S partly) | None noted |
| M022 | Spelt | Triticum aestivum | Stem, Internode | None noted |
| M023 | Spelt | Triticum aestivum | Stem, Node (I partly) | None noted |
| M024 | Spelt | Triticum aestivum | Spikelet | None noted |
| M025 | Wild Oat | Avena fatua | Root | Yes, soil |
| M026 | Wild Oat | Avena fatua | Leaf, Blade and Sheaf | Yes, dendritic multicell |
| M027 | Wild Oat | Avena fatua | Leaf, Collar (B&S partly) | None noted |
| M028 | Wild Oat | Avena fatua | Stem, Internode | None noted |
| M029 | Wild Oat | Avena fatua | Stem, Node | None noted |
| M030 | Wild Oat | Avena fatua | Awn | None noted |
| M031 | Wild Oat | Avena fatua | Spikelet (2 outer only) | None noted |
| M032 | Barley | Hordeum vulgare | Root | Yes, soil |
| M033 | Barley | Hordeum vulgare | Leaf, Blade and Sheaf | None noted |
| M034 | Barley | Hordeum vulgare | Leaf, Collar (B&S partly) | None noted |
| M035 | Barley | Hordeum vulgare | Stem, Internode | None noted |
| M036 | Barley | Hordeum vulgare | Stem, Node | None noted |
| M037 | Barley | Hordeum vulgare | Awn | None noted |
| M038 | Barley | Hordeum vulgare | Spikelet (hard to peel) | None noted |
| M039 | Ragwort | Jacobaea vulgaris | Root | Yes quartz |
| M040 | Ragwort | Jacobaea vulgaris | Leaf, with stalk to stem | Yes quartz |
| M041 | Ragwort | Jacobaea vulgaris | Stem with pith | None noted |
| M042 | Ragwort | Jacobaea vulgaris | Flower, all parts and seed | Yes quartz |
| M043 | Nettle | Urtica dioica | Leaf | None noted |
| M044 | Nettle | Urtica dioica | Stem, with stalk to stem | None noted |
| M045 | Nettle | Urtica dioica | Flower, all parts | None noted |
| M046 | Red Clover | Trifolium pratense | Root | Yes, soil |

| | | | | |
|---|---|---|---|---|
| M047 | Red Clover | Trifolium pratense | Leaf | Yes, rondel, grass |
| M048 | Red Clover | Trifolium pratense | Stem (to flower, leaf and central) | None noted |
| M049 | Red Clover | Trifolium pratense | Flower, all parts | Yes fibres |
| M050 | Sweet Meadow Grass | Poa pratensis subsp. pratensis | Root | Yes quartz |
| M051 | Sweet Meadow Grass | Poa pratensis subsp. pratensis | Leaf, Blade and Sheaf | None noted |
| M052 | Sweet Meadow Grass | Poa pratensis subsp. pratensis | Leaf, Collar (B&S partly) | No slide |
| M053 | Sweet Meadow Grass | Poa pratensis subsp. pratensis | Stem, Internode | None noted |
| M054 | Sweet Meadow Grass | Poa pratensis subsp. pratensis | Stem, Node | None noted |
| M055 | Sweet Meadow Grass | Poa pratensis subsp. pratensis | Spikelet with stalk | None noted |
| M056 | Catsear | Hypochaeris radicata | Root | Yes, soil |
| M057 | Catsear | Hypochaeris radicata | Leaf | Yes, soil |
| M058 | Catsear | Hypochaeris radicata | Stem (main and to flower) | No slide |
| M059 | Catsear | Hypochaeris radicata | Stem, Node | No slide |
| M060 | Catsear | Hypochaeris radicata | Flower, all parts | Yes some inclusions, transparent all glow |
| M061 | Yarrow | Achillea millefolium | Root and Tuber | Yes, soil |
| M062 | Yarrow | Achillea millefolium | Leaf with Midrib | None noted |
| M063 | Yarrow | Achillea millefolium | Stem with Node | None noted |
| M064 | Yarrow | Achillea millefolium | Flower (with short stalks and seed) | Diatoms perhaps |
| M065 | Yellow Oat Grass | Trisetum flavesence | Root | Yes, some quartz and silica aggregate, soil, but sparse |
| M066 | Yellow Oat Grass | Trisetum flavesence | Leaf, Blade and Sheaf | None noted |

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| | | | | |
|---|---|---|---|---|
| M067 | Yellow Oat Grass | Trisetum flavesence | Leaf, Collar (B&S partly) | None noted |
| M068 | Yellow Oat Grass | Trisetum flavesence | Stem, Internode | None noted |
| M069 | Yellow Oat Grass | Trisetum flavesence | Stem, Node | Other plant parts |
| M070 | Yellow Oat Grass | Trisetum flavesence | Spikelet | None noted |
| M071 | Bracken | Pteridium | Stem | None noted |
| M072 | Bracken | Pteridium | Font with cental rib | None noted |
| M073 | Dandelion | Taraxacum officinale | Root | Yes, soil |
| M074 | Dandelion | Taraxacum officinale | Leaf with Midrib | None noted |
| M075 | Dandelion | Taraxacum officinale | Flower all parts | Yes quartz |
| M076 | Dandelion | Taraxacum officinale | Stem to Flower | Yes quartz |
| M077 | Dandelion | Taraxacum officinale | Tuber | Yes, soil |
| M078 | Mouse-ear Chickweed | Cerastium fontanum | Root | Yes, soil |
| M079 | Mouse-ear Chickweed | Cerastium fontanum | Stem (including leaf and flower node) | Yes, soil |
| M080 | Mouse-ear Chickweed | Cerastium fontanum | Leaf | Yes quartz |
| M081 | Mouse-ear Chickweed | Cerastium fontanum | Flower all parts | Yes quartz |
| M082 | Bramble | Rubus sp. | Leaf with stalk and midrib | None noted |
| M083 | Bramble | Rubus sp. | Stem | No slide |
| M084 | Bramble | Rubus sp. | Thorns | No slide |
| M085 | Bramble | Rubus sp. | Fruit (Green) | None noted |
| M086 | Cow Parsley | Anthriscus sylvestris | Root | Yes soil |
| M087 | Cow Parsley | Anthriscus sylvestris | Stem to Flower and Leaf | None noted |
| M088 | Cow Parsley | Anthriscus sylvestris | Leaf | None noted |
| M089 | Cow Parsley | Anthriscus sylvestris | Tuber | Yes, soil |
| M090 | Creeping Thistle | Cirsium arvense | Root | Yes, soil |
| M091 | Creeping Thistle | Cirsium arvense | Leaf | None noted |
| M092 | Creeping Thistle | Cirsium arvense | Stem | Yes, soil |

| | | | | |
|---|---|---|---|---|
| M093 | Viper's Bugloss | Echium vulgare | Root | Yes, soil |
| M094 | Viper's Bugloss | Echium vulgare | Leaf | None noted |
| M095 | Viper's Bugloss | Echium vulgare | Stem | No slide |
| M096 | Viper's Bugloss | Echium vulgare | Node | Yes, quartz? |
| M097 | Celtic Bean | Vicia faba | Leaf with midrib | Yes, not sure, some quartz, diatom |
| M098 | Celtic Bean | Vicia faba | Stem | None noted |
| M099 | Celtic Bean | Vicia faba | Bean pod | Yes, quartz? |
| M100 | Celtic Bean | Vicia faba | Bean, outer rind and some inner starch | No slide |
| M101 | Walnut Tree | Juglans sp. | Leaf | None noted |
| M102 | Walnut Tree | Juglans sp. | Leaf stem | No slide |
| M103 | Walnut Tree | Juglans sp. | Bark | No slide |
| M104 | Tree | Juglans sp. | Twig | No slide |
| M105 | Oak | Quercus | Leaf | None noted |
| M106 | Oak | Quercus | Stem | No slide |
| M107 | Oak | Quercus | Bark | No slide |
| M108 | Oak | Quercus | Acorn, outer | Yes quartz? |
| M109 | Oak | Quercus | Acorn, rind, starch gone due to insect | No slide |
| M110 | Blackthorn | Prunus spinosa | Leaf | No slide |
| M111 | Blackthorn | Prunus spinosa | Twig | No slide |
| M112 | Blackthorn | Prunus spinosa | Bark | No slide |
| M113 | Holly | Ilex sp. | Leaf | Yes quartz? |
| M114 | Holly | Ilex sp. | Bark | No slide |
| M115 | Holly | Ilex sp. | Twig | None noted |
| M116 | Trailing St John's Wort | Hypericum humifisum | Root | Yes, soil |
| M117 | Trailing St John's Wort | Hypericum humifisum | Leaf | No slide |
| M118 | Trailing St John's Wort | Hypericum humifisum | Stem | No slide |
| M119 | Trailing St John's Wort | Hypericum humifisum | Flower | No slide |
| M120 | Trailing St John's Wort | Hypericum humifisum | Fruit/Seed | No slide |
| M121 | Buttercup | Ranunculus repens | Root | Yes, soil |

| | | | | |
|---|---|---|---|---|
| M122 | Buttercup | Ranunculus repens | Leaf | Yes, soil |
| M123 | Buttercup | Ranunculus repens | Stem | None noted |
| M124 | Buttercup | Ranunculus repens | Flower | No Slide |
| M125 | Sheeps's Sorrel | Rumex acetosella | Root | No Slide |
| M126 | Sheeps's Sorrel | Rumex acetosella | Leaf | Yes, soil |
| M127 | Sheeps's Sorrel | Rumex acetosella | Stem | None noted |
| M128 | Sheeps's Sorrel | Rumex acetosella | Flower | No Slide |
| M129 | Stinking Chamomile | Anthemis cotula | Root | Yes, soil |
| M130 | Stinking Chamomile | Anthemis cotula | Leaf | No Slide |
| M131 | Stinking Chamomile | Anthemis cotula | Stem | No Slide |
| M132 | Stinking Chamomile | Anthemis cotula | Flower | No Slide |
| M133 | Ribwort | Plantago lanceolata | Root | Yes, soil |
| M134 | Ribwort | Plantago lanceolata | Leaf | No Slide |
| M135 | Ribwort | Plantago lanceolata | Stem | No Slide |
| M136 | Ribwort | Plantago lanceolata | Flower | No Slide |
| M137 | Ivy | Hedera helix | Root | Yes, soil |
| M138 | Ivy | Hedera helix | Leaf | No Slide |
| M139 | Ivy | Hedera helix | Stem | No Slide |
| M140 | Creeping Bent | Agrostis stolonifera | Root | Yes, soil |
| M141 | Creeping Bent | Agrostis stolonifera | Leaf | None noted |
| M142 | Creeping Bent | Agrostis stolonifera | Internode and node | None noted |
| M143 | Creeping Bent | Agrostis stolonifera | Stolon | Yes, quartz? |
| M144 | Creeping Bent | Agrostis stolonifera | Spikelet | Yes, possibly starch |
| M145 | Broadleaf Plantain | Plantago major | Root | Yes, soil |
| M146 | Broadleaf Plantain | Plantago major | Leaf | Yes, soil |

| | | | | |
|---|---|---|---|---|
| M147 | Broadleaf Plantain | Plantago major | Stem | None noted |
| M148 | Broadleaf Plantain | Plantago major | Inflorescence | None noted |
| M149 | Germander Speedwell | Veronica chamaedrys | Root | Yes, soil |
| M150 | Germander Speedwell | Veronica chamaedrys | Leaf | None noted |
| M151 | Germander Speedwell | Veronica chamaedrys | Stem | No Slide |
| M152 | Germander Speedwell | Veronica chamaedrys | Inflorescence (with seeds) | No Slide |
| M153 | Dwarf Furze | Ulex galii | Leaf/Thorns | None noted |
| M154 | Dwarf Furze | Ulex galii | Stem | None noted |
| M155 | Dwarf Furze | Ulex galii | Flower | None noted |
| M156 | Scots Pine | Pinus sylvestris | Needles | No Slide |
| M157 | Scots Pine | Pinus sylvestris | Stem | Yes |
| M158 | Scots Pine | Pinus sylvestris | Bark | Yes, quartz?, bilobe seen |
| M159 | Scots Pine | Pinus sylvestris | Cone | No Slide |
| M160 | Compact rush | Juncus conglomeratus | Stem | None noted |
| M161 | Compact rush | Juncus conglomeratus | Inflorescence | No Slide |
| M162 | Round-fruited rush | Juncus compressus | Stem | None noted |
| M163 | Round-fruited rush | Juncus compressus | Sheaf and 'leaf' | Yes |
| M164 | Round-fruited rush | Juncus compressus | Inflorescence (with seeds and stalks) | No Slide |
| M165 | Birch | Betula sp. | Leaf | No Slide |
| M166 | Birch | Betula sp. | Twig | None noted |
| M167 | Birch | Betula sp. | Bark | No Slide |
| M168 | Birch | Betula sp. | Catkins (with seeds) | Yes, quartz |
| M169 | Molinia | Molinia sp. | Leaf (sheaf and blade) | Yes |
| M170 | Molinia | Molinia sp. | Stem | None noted |
| M171 | Molinia | Molinia sp. | Spikelet with stalk | None noted |
| M172 | Heather | Calluna vulgaris | Leaf | No Slide |
| M173 | Heather | Calluna vulgaris | Stem | No Slide |
| M174 | Heather | Calluna vulgaris | Inflorescence | No Slide |
| M175 | Crossleaf Heather | Erica tetralix | Leaf | No Slide |

| | | | | |
|---|---|---|---|---|
| M176 | Crossleaf Heather | Erica tetralix | Stem | Yes |
| M177 | Crossleaf Heather | Erica tetralix | Inflorescence | None noted |
| M178 | Dorset Heather | Erica ciliaris | Leaf | Yes, blue roll fibre, some quartz? |
| M179 | Dorset Heather | Erica ciliaris | Stem | No Slide |
| M180 | Dorset Heather | Erica ciliaris | Inflorescence | Yes, quartz? |
| M181 | Willow | Salix caprea | Leaf (with stalk and midrib) | No Slide |
| M182 | Willow | Salix caprea | Stem | Not much on slide |
| M183 | Willow | Salix caprea | Bark | Yes, quartz? |
| M184 | Dwarf Gorse | Ulex minor | Leaf (spine/thorn) | No Slide |
| M185 | Dwarf Gorse | Ulex minor | Stem | Yes, quartz? |
| M186 | Dwarf Gorse | Ulex minor | Inflorescence | No Slide |
| M187 | European Gorse | Ulex europaeus | Leaf (spine/thorn) | None noted |
| M188 | European Gorse | Ulex europaeus | Stem | None noted |
| M189 | Bristle Bent (unwashed) | Agrostis curtisii | Stem/Leaf | Yes, quartz? |
| M190 | Bog Myrtle (unwashed) | Myrica gale | Leaf | No Slide |
| M191 | Bog Myrtle (unwashed) | Myrica gale | Stem | No Slide |
| M192 | Bog Myrtle (unwashed) | Myrica gale | Inflorescence | Yes, some blue roll tissue strands |
| M193 | Black Bog Rush | Schoenus nigricans | Stem | None noted |
| M194 | Black Bog Rush | Schoenus nigricans | Inflorescence with spike | None noted |
| M195 | Bog Asphodel | Narthecium ossifragum | Root and Tuber | Yes, quartz? |
| M196 | Bog Asphodel | Narthecium ossifragum | Leaf | No Slide |
| M197 | Bell Heather | Erica cinerea | Leaf | No Slide |
| M198 | Bell Heather | Erica cinerea | Twig | No Slide |
| M199 | Bell Heather | Erica cinerea | Inflorescence | Yes, blue roll fibres and mineral inclusions |

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|---|---|---|---|---|
| M200 | Heather | Calluna vulgaris | Leaf | None noted |
| M201 | Heather | Calluna vulgaris | Twig/Stem | Yes a few bit |
| M202 | Heather | Calluna vulgaris | Inflorescence | Yes a few bits |
| M203 | Common Cotton Grass | Eriophorum sp. | Leaf (sheaf and blade) | None noted |
| M204 | Purple Moor Grass | Molinia caerulea | Leaf (node, sheaf and blade) | None noted |
| M205 | Purple Moor Grass | Molinia caerulea | Stem | No Slide |
| M206 | Purple Moor Grass | Molinia caerulea | Inflorescence with stalks | None noted |
| M207 | Bog Myrtle | Myrica gale | Leaf | No Slide |
| M208 | Bog Myrtle | Myrica gale | Twig/Stem | Yes |
| M209 | Bog Myrtle | Myrica gale | Inflorescence | Yes |
| M210 | Bristle Bent | Agrostis curtisii | Leaf | Yes |
| M211 | English Oak (Test) | Quercus robur | Leaf with Galls | None noted |
| M212 | using more material | Quercus robur | Leaf | None noted |
| M213 | English Oak (Test) | Quercus robur | Bark | Yes quartz? |
| M214 | English Oak (Test) | Quercus robur | Bark with Lichen | Yes, soil |
| M215 | English Oak (Test) | Quercus robur | Acorn Case | No slide |
| M216 | English Oak (Test) | Quercus robur | Acorn inside case | None noted |

## Appendix 13 showing plant parts, phytolith presence, charcoal presence and contamination sorted into Monocotyledons, Eudicots (one Gymnosperm) and Ferns

| Monocots Index Number | Botanical Name | Vernacular Name | Category | Plant Part | Phytoliths Y | Phytoliths N | No Slide | Charcoal | Contamination |
|---|---|---|---|---|---|---|---|---|---|
| M189 | *Agrostis curtisii* | Bristle Bent (unwashed) | Grass | Leaf | Y | | | N | Y |
| M210 | *Agrostis curtisii* | Bristle Bent | Grass | Leaf | Y | | | N | Y |
| M140 | *Agrostis stolonifera* | Creeping Bent | Grass | Root | Y | | | N | Y |
| M141 | *Agrostis stolonifera* | Creeping Bent | Grass | Leaf | Y | | | N | N |
| M142 | *Agrostis stolonifera* | Creeping Bent | Grass | Internode and node | Y | | | N | N |
| M143 | *Agrostis stolonifera* | Creeping Bent | Grass | Stolon | Y | | | N | Y |
| M144 | *Agrostis stolonifera* | Creeping Bent | Grass | Spikelet | | N | | N | Y |
| M025 | *Avena fatua* | Wild Oat | Grass | Root | Y | | | Y | Y |
| M026 | *Avena fatua* | Wild Oat | Grass | Leaf | Y | | | Y | Y |
| M027 | *Avena fatua* | Wild Oat | Grass | Collar | Y | | | N | N |
| M028 | *Avena fatua* | Wild Oat | Grass | Internode | Y | | | Y | N |
| M029 | *Avena fatua* | Wild Oat | Grass | Node | Y | | | Y | N |
| M030 | *Avena fatua* | Wild Oat | Grass | Awn | Y | | | N | N |
| M031 | *Avena fatua* | Wild Oat | Grass | Spikelet | Y | | | N | N |
| M203 | *Eriophorum sp.* | Common Cotton Grass | Sedge | Leaf | Y | | | Y | N |
| M032 | *Hordeum vulgare* | Barley | Grass | Root | Y | | | N | Y |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M033 | *Hordeum vulgare* | Barley | Grass | Leaf | Y | | | N | N |
| M034 | *Hordeum vulgare* | Barley | Grass | Collar | Y | | | N | N |
| M035 | *Hordeum vulgare* | Barley | Grass | Internode | Y | | | Y | N |
| M036 | *Hordeum vulgare* | Barley | Grass | Node | Y | | | Y | N |
| M037 | *Hordeum vulgare* | Barley | Grass | Awn | Y | | | N | N |
| M038 | *Hordeum vulgare* | Barley | Grass | Spikelet | Y | | | N | N |
| M162 | *Juncus compressus* | Round-fruited rush | Sedge | Stem | Y | | | Y | N |
| M163 | *Juncus compressus* | Round-fruited rush | Sedge | Leaf | | N | | N | Y |
| M164 | *Juncus compressus* | Round-fruited rush | Sedge | Inflorescence (with seeds and stalks) | | | No Slide | No Slide | No Slide |
| M160 | *Juncus conglomeratus* | Compact rush | Sedge | Stem | | N | | Y | N |
| M161 | *Juncus conglomeratus* | Compact rush | Sedge | Inflorescence | | | No Slide | No Slide | No Slide |
| M204 | *Molinia caerulea* | Purple Moor Grass | Grass | Leaf and Node | Y | | | N | N |
| M205 | *Molinia caerulea* | Purple Moor Grass | Grass | Stem | | | No Slide | No Slide | No Slide |
| M206 | *Molinia caerulea* | Purple Moor Grass | Grass | Inflorescence | Y | | | N | N |
| M169 | *Molinia sp.* | Molinia | Grass | Leaf | | N | | No phytoliths observed on slide | Y |
| M170 | *Molinia sp.* | Molinia | Grass | Stem | | N | | Y | N |
| M171 | *Molinia sp.* | Molinia | Grass | Spikelet | Y | | | N | N |
| M195 | *Northeciu m ossifragum* | Bog Asphodel | Bulbous Plant | Root and Tuber | | N | | N | Y |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| M196 | *Nartheciu m ossifragum* | Bog Asphodel | Bulbous Plant | Leaf | | No Slide | No Slide | No Slide |
| M050 | *Poa pratensis subsp. pratensis* | Sweet Meadow Grass | Grass | Root | Y | | N | Y |
| M051 | *Poa pratensis subsp. pratensis* | Sweet Meadow Grass | Grass | Leaf | Y | | N | N |
| M052 | *Poa pratensis subsp. pratensis* | Sweet Meadow Grass | Grass | Collar | | No Slide | No slide | No slide |
| M053 | *Poa pratensis subsp. pratensis* | Sweet Meadow Grass | Grass | Internode | Y | | N | N |
| M054 | *Poa pratensis subsp. pratensis* | Sweet Meadow Grass | Grass | Node | Y | | N | N |
| M055 | *Poa pratensis subsp. pratensis* | Sweet Meadow Grass | Grass | Spikelet | Y | | N | N |
| M193 | *Schoenus nigricans* | Black Bog Rush | Sedge | Stem | Y | | N | N |
| M194 | *Schoenus nigricans* | Black Bog Rush | Sedge | Inflorescence | Y | | N | N |
| M065 | *Trisetum flavesence* | Oat Grass Yellow | Grass | Root | Y | | N | Y |
| M066 | *Trisetum flavesence* | Oat Grass Yellow | Grass | Leaf | Y | | N | N |
| M067 | *Trisetum flavesence* | Oat Grass Yellow | Grass | Collar | Y | | Y | N |
| M068 | *Trisetum flavesence* | Oat Grass Yellow | Grass | Internode | Y | | N | N |
| M069 | *Trisetum flavesence* | Oat Grass | Grass | Node | Y | | N | Y |

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|---|---|---|---|---|---|---|---|
| M070 | *Trisetum flavesence* | Yellow Oat Grass | Grass | Spikelet | Y | N | N |
| M019 | *Triticum aestivum* | Spelt | Grass | Root | Y | N | Y |
| M020 | *Triticum aestivum* | Spelt | Grass | Leaf | Y | N | N |
| M021 | *Triticum aestivum* | Spelt | Grass | Collar | Y | N | N |
| M022 | *Triticum aestivum* | Spelt | Grass | Internode | Y | N | N |
| M023 | *Triticum aestivum* | Spelt | Grass | Node | Y | Y | N |
| M024 | *Triticum aestivum* | Spelt | Grass | Spikelet | Y | N | N |
| M008 | *Triticum dicoccon* | Emmer Wheat | Grass | Root | Y | N | Y |
| M009 | *Triticum dicoccon* | Emmer Wheat | Grass | Leaf | Y | N | N |
| M010 | *Triticum dicoccon* | Emmer Wheat | Grass | Collar | Y | N | Y |
| M011 | *Triticum dicoccon* | Emmer Wheat | Grass | Internode | Y | N | N |
| M012 | *Triticum dicoccon* | Emmer Wheat | Grass | Node | Y | N | N |
| M013 | *Triticum dicoccon* | Emmer Wheat | Grass | Awn | Y | N | N |
| M014 | *Triticum dicoccon* | Emmer Wheat | Grass | Spikelet | Y | N | N |
| M001 | *Triticum monococcum* | Einkorn | Grass | Root | Y | N | Y |
| M002 | *Triticum monococcum* | Einkorn | Grass | Leaf | Y | N | N |
| M003 | *Triticum monococcum* | Einkorn | Grass | Collar | Y | N | N |
| M004 | *Triticum monococcum* | Einkorn | Grass | Internode | Y | N | N |
| M005 | *Triticum monococcum* | Einkorn | Grass | Node | Y | N | N |
| M006 | *Triticum monococcum* | Einkorn | Grass | Awn | Y | N | N |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M007 | *Triticum monococcum* | Einkorn | Grass | Spikelet | Y | | N | | N |

Eudicots (and one Gymnosperm-*Pinus sylvestris*)

| Index Number | Botanical Name | Vernacular Name | Category | Plant Part | Phytoliths Y | Phytoliths N | No Slide | Charcoal | Contamination |
|---|---|---|---|---|---|---|---|---|---|
| M061 | *Achillea millefolium* | Yarrow | Perennial | Root and Tuber | Y | | | Y | Y |
| M062 | *Achillea millefolium* | Yarrow | Perennial | Leaf | Y | | | N | N |
| M063 | *Achillea millefolium* | Yarrow | Perennial | Stem | Y | | | N | N |
| M064 | *Achillea millefolium* | Yarrow | Perennial | Flower | Y | | | N | Y |
| M129 | *Anthemis cotula* | Stinking Chamomile | Perennial | Root | Y | | | N | Y |
| M130 | *Anthemis cotula* | Stinking Chamomile | Perennial | Leaf | | | No Slide | No Slide | No Slide |
| M131 | *Anthemis cotula* | Stinking Chamomile | Perennial | Stem | | | No Slide | No Slide | No Slide |
| M132 | *Anthemis cotula* | Stinking Chamomile | Perennial | Flower | | | No Slide | No Slide | No Slide |
| M086 | *Anthriscus sylvestris* | Cow Parsley | Perennial | Root | | N | | Y | Y |
| M087 | *Anthriscus sylvestris* | Cow Parsley | Perennial | Stem | | N | | Y | N |
| M088 | *Anthriscus sylvestris* | Cow Parsley | Perennial | Leaf | | N | | Y | N |
| M089 | *Anthriscus sylvestris* | Cow Parsley | Perennial | Tuber | | N | | Y | Y |
| M165 | *Betula sp.* | Birch | Tree | Leaf | | | No Slide | No Slide | No Slide |
| M166 | *Betula sp.* | Birch | Tree | Twig | | N | | Y | N |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M167 | *Betula sp.* | Birch | Tree | Bark | | | No Slide | No Slide | No Slide |
| M168 | *Betula sp.* | Birch | Tree | Flower and Fruit | | N | | Y | Y |
| M172 | *Calluna vulgaris* | Heather | Shrub | Leaf | | | No Slide | No Slide | No Slide |
| M173 | *Calluna vulgaris* | Heather | Shrub | Stem | | | No Slide | No Slide | No Slide |
| M174 | *Calluna vulgaris* | Heather | Shrub | Inflorescence | | | No Slide | No Slide | No Slide |
| M200 | *Calluna vulgaris* | Heather | Shrub | Leaf | Y | | | Y | N |
| M201 | *Calluna vulgaris* | Heather | Shrub | Stem | | N | | N | Y |
| M202 | *Calluna vulgaris* | Heather | Shrub | Inflorescence | | N | | Y | Y |
| M078 | *Cerastium fontanum* | Mouse-ear Chickweed | Perennial | Root | | N | | None found | Y |
| M079 | *Cerastium fontanum* | Mouse-ear Chickweed | Perennial | Stem | | N | | Y | Y |
| M080 | *Cerastium fontanum* | Mouse-ear Chickweed | Perennial | Leaf | | N | | No phytoliths seen | Y |
| M081 | *Cerastium fontanum* | Mouse-ear Chickweed | Perennial | Flower | | N | | Y | Y |
| M090 | *Cirsium arvense* | Creeping Thistle | Perennial | Root | | | No Slide | N | Y |
| M091 | *Cirsium arvense* | Creeping Thistle | Perennial | Leaf | Y | | | N | N |
| M092 | *Cirsium arvense* | Creeping Thistle | Perennial | Stem | Y | | | Y | Y |
| M093 | *Echium vulgare* | Viper's Bugloss | Biennial | Root | | N | | Y | Y |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M094 | *Echium vulgare* | Viper's Bugloss | Biennial | Leaf | Y | | | N | N |
| M095 | *Echium vulgare* | Viper's Bugloss | Biennial | Stem | | | No Slide | No slide | No slide |
| M096 | *Echium vulgare* | Viper's Bugloss | Biennial | Node | | N | | Y | Y |
| M178 | *Erica ciliaris* | Dorset Heather | Shrub | Leaf | | N | | Y | Y |
| M179 | *Erica ciliaris* | Dorset Heather | Shrub | Stem | | | No Slide | No Slide | No Slide |
| M180 | *Erica ciliaris* | Dorset Heather | Shrub | Inflorescence | | N | | Y | Y |
| M197 | *Erica cinerea* | Bell Heather | Shrub | Leaf | | | No Slide | No Slide | No Slide |
| M198 | *Erica cinerea* | Bell Heather | Shrub | Twig | | | No Slide | No Slide | No Slide |
| M199 | *Erica cinerea* | Bell Heather | Shrub | Inflorescence | | N | | N | Y |
| M175 | *Erica tetralix* | Crossleaf Heather | Shrub | Leaf | | | No Slide | No Slide | No Slide |
| M176 | *Erica tetralix* | Crossleaf Heather | Shrub | Stem | | N | | Y | Y |
| M177 | *Erica tetralix* | Crossleaf Heather | Shrub | Inflorescence | | N | | N | N |
| M137 | *Hedera helix* | Ivy | Woody Climber | Root | Y | | | Y | Y |
| M138 | *Hedera helix* | Ivy | Woody Climber | Leaf | | | No Slide | No Slide | No Slide |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M139 | *Hedera helix* | Ivy | Woody Climber | Stem | | | No Slide | No Slide | No Slide |
| M116 | *Hypericum humifisum* | Trailing St John's Wort | Perennial | Root | | N | | N | Y |
| M117 | *Hypericum humifisum* | Trailing St John's Wort | Perennial | Leaf | | | No Slide | No slide | No slide |
| M118 | *Hypericum humifisum* | Trailing St John's Wort | Perennial | Stem | | | No Slide | No slide | No slide |
| M119 | *Hypericum humifisum* | Trailing St John's Wort | Perennial | Flower | | | No Slide | No slide | No slide |
| M120 | *Hypericum humifisum* | Trailing St John's Wort | Perennial | Fruit | | | No Slide | No slide | No slide |
| M056 | *Hypochaeris radicata* | Catsear | Perennial | Root | | N | | N | Y |
| M057 | *Hypochaeris radicata* | Catsear | Perennial | Leaf | Y | | | N | Y |
| M058 | *Hypochaeris radicata* | Catsear | Perennial | Stem | | | No Slide | No slide | No slide |
| M059 | *Hypochaeris radicata* | Catsear | Perennial | Node | | | No Slide | No slide | No slide |
| M060 | *Hypochaeris radicata* | Catsear | Perennial | Flower | | N | | Y | Y |
| M113 | *Ilex sp.* | Holly | Shrub | Leaf | Y | | | N | Y |
| M114 | *Ilex sp.* | Holly | Shrub | Bark | | | No Slide | No slide | No slide |
| M115 | *Ilex sp.* | Holly | Shrub | Twig | Y | | | N | N |
| M039 | *Jacobaea vulgaris, Senecio jacobaea* | Ragwort | Biennial | Root | | N | | Y | Y |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M040 | *Jacobaea vulgaris, Senecio jacobaea* | Ragwort | Biennial | Leaf | Y | | | N | Y |
| M041 | *Jacobaea vulgaris, Senecio jacobaea* | Ragwort | Biennial | Stem | Y | | | N | N |
| M042 | *Jacobaea vulgaris, Senecio jacobaea* | Ragwort | Biennial | Flower | | N | | Y | Y |
| M101 | *Juglans sp.* | Walnut Tree | Tree | Leaf | Y | | | N | N |
| M102 | *Juglans sp.* | Walnut Tree | Tree | Stem | | | No Slide | No slide | No slide |
| M103 | *Juglans sp.* | Walnut Tree | Tree | Bark | | | No Slide | No slide | No slide |
| M104 | *Juglans sp.* | Walnut Tree | Tree | Twig | | | No Slide | No slide | No slide |
| M015 | *Linum usitatissimum* | Flax | Annual | Roots | Y | | | N | Y |
| M016 | *Linum usitatissimum* | Flax | Annual | Leaf | Y | | | N | Y |
| M017 | *Linum usitatissimum* | Flax | Annual | Stem | | N | | Y | |
| M018 | *Linum usitatissimum* | Flax | Annual | Flower | Y | | | N | Y |
| M190 | *Myrica gale* | Bog Myrtle (unwashed) | Shrub | Leaf | | | No Slide | No Slide | No Slide |
| M191 | *Myrica gale* | Bog Myrtle (unwashed) | Shrub | Stem | | | No Slide | No Slide | No Slide |
| M192 | *Myrica gale* | Bog Myrtle (unwashed) | Shrub | Inflorescence | | N | | N | Y |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M207 | *Myrica gale* | Bog Myrtle | Shrub | Leaf | | | No Slide | No Slide | No Slide |
| M208 | *Myrica gale* | Bog Myrtle | Shrub | Stem | | N | | Y | Y |
| M209 | *Myrica gale* | Bog Myrtle | Shrub | Inflorescence | | N | | Y | Y |
| M156 | *Pinus sylvestris* | Scots Pine | Tree | Needles | | | No Slide | No Slide | No Slide |
| M157 | *Pinus sylvestris* | Scots Pine | Tree | Stem | Y | | | N | Y |
| M158 | *Pinus sylvestris* | Scots Pine | Tree | Bark | Y | | | N | Y |
| M159 | *Pinus sylvestris* | Scots Pine | Tree | Cone | | | No Slide | No Slide | No Slide |
| M133 | *Plantago lanceolata* | Ribwort | Perennial | Root | | N | | N | Y |
| M134 | *Plantago lanceolata* | Ribwort | Perennial | Leaf | | | No Slide | No Slide | No Slide |
| M135 | *Plantago lanceolata* | Ribwort | Perennial | Stem | | | No Slide | No Slide | No Slide |
| M136 | *Plantago lanceolata* | Ribwort | Perennial | Flower | | | No Slide | No Slide | No Slide |
| M145 | *Plantago major* | Broadleaf Plantain | Perennial | Root | | N | | N | Y |
| M146 | *Plantago major* | Broadleaf Plantain | Perennial | Leaf | Y | | | Y | Y |
| M147 | *Plantago major* | Broadleaf Plantain | Perennial | Stem | | N | | N | N |
| M148 | *Plantago major* | Plantain | Perennial | Inflorescence | | N | | N | N |
| M110 | *Prunus spinosa* | Blackthorn | Tree | Leaf | | | No Slide | No slide | No slide |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M111 | *Prunus spinosa* | Blackthorn | Tree | Twig | | | No Slide | No slide | No slide |
| M112 | *Prunus spinosa* | Blackthorn | Tree | Bark | | | No Slide | No slide | No slide |
| M105 | *Quercus* | Oak | Tree | Leaf | Y | | | N | N |
| M106 | *Quercus* | Oak | Tree | Stem | | | No Slide | No slide | No slide |
| M107 | *Quercus* | Oak | Tree | Bark | | | No Slide | No slide | No slide |
| M108 | *Quercus* | Oak | Tree | Acorn Case | Y | | | N | Y |
| M109 | *Quercus* | Oak | Tree | Acorn | | | No Slide | No slide | No slide |
| M211 | *Quercus robur* | English Oak (Test) using more material | Tree | Leaf with Galls | Y | | | N | N |
| M212 | *Quercus robur* | English Oak (Test) | Tree | Leaf | Y | | | N | N |
| M213 | *Quercus robur* | English Oak (Test) | Tree | Bark | | N | | N | Y |
| M214 | *Quercus robur* | English Oak (Test) | Tree | Bark with Lichen | | N | | N | Y |
| M215 | *Quercus robur* | English Oak (Test) | Tree | Acorn Case | | | No Slide | No slide | No slide |
| M216 | *Quercus robur* | English Oak (Test) | Tree | Acorn | | N | | Y | N |
| M121 | *Ranunculus repens* | Buttercup | Perennial | Root | | N | | N | Y |
| M122 | *Ranunculus repens* | Buttercup | Perennial | Leaf | Y | | | N | Y |
| M123 | *Ranunculus repens* | Buttercup | Perennial | Stem | | N | | Y | N |
| M124 | *Ranunculus repens* | Buttercup | Perennial | Flower | | | No Slide | No Slide | No Slide |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M082 | *Rubus sp.* | Bramble | Shrub | Leaf | | N | | Y | N |
| M083 | *Rubus sp.* | Bramble | Shrub | Stem | | | No Slide | No slide | No slide |
| M084 | *Rubus sp.* | Bramble | Shrub | Thorns | | | No Slide | No slide | No slide |
| M085 | *Rubus sp.* | Bramble | Shrub | Fruit | | N | | Y | N |
| M125 | *Rumex acetosella* | Sheeps's Sorrel | Perennial | Root | | | No Slide | No Slide | No Slide |
| M126 | *Rumex acetosella* | Sheeps's Sorrel | Perennial | Leaf | Y | | | N | Y |
| M127 | *Rumex acetosella* | Sheeps's Sorrel | Perennial | Stem | | N | | Y | N |
| M128 | *Rumex acetosella* | Sheeps's Sorrel | Perennial | Flower | | | No Slide | No Slide | No Slide |
| M181 | *Salix caprea* | Willow | Tree | Leaf | | | No Slide | No Slide | No Slide |
| M182 | *Salix caprea* | Willow | Tree | Stem | Y | | | Y | N |
| M183 | *Salix caprea* | Willow | Tree | Bark | | N | | N | Y |
| M073 | *Taraxacum officinale* | Dandelion | Perennial | Root | Y | | | N | Y |
| M074 | *Taraxacum officinale* | Dandelion | Perennial | Leaf | | N | | Y | N |
| M075 | *Taraxacum officinale* | Dandelion | Perennial | Flower | | N | | Y | Y |
| M076 | *Taraxacum officinale* | Dandelion | Perennial | Stem | | N | | Y | Y |
| M077 | *Taraxacum officinale* | Dandelion | Perennial | Tuber | | N | | Y | Y |
| M046 | *Trifolium pratense* | Red Clover | Perennial | Root | | N | | Y | Y |
| M047 | *Trifolium pratense* | Red Clover | Perennial | Leaf | Y | | | Y | Y |
| M048 | *Trifolium pratense* | Red Clover | Perennial | Stem | Y | | | Y | N |
| M049 | *Trifolium pratense* | Red Clover | Perennial | Flower | Y | | | Y | Y |
| M187 | *Ulex europaeus* | European Gorse | Shrub | Leaf and Thorns | | N | | Y | N |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| M188 | *Ulex europaeus* | European Gorse | Shrub | Stem | N | | Y | N |
| M153 | *Ulex galii* | Dwarf Furze | Shrub | Leaf and Thorns | N | | Y | N |
| M154 | *Ulex galii* | Dwarf Furze | Shrub | Stem | N | | Y | N |
| M155 | *Ulex galii* | Dwarf Furze | Shrub | Flower | N | | Y | N |
| M184 | *Ulex minor* | Dwarf Gorse | Shrub | Leaf and Thorns | | No Slide | No Slide | No Slide |
| M185 | *Ulex minor* | Dwarf Gorse | Shrub | Stem | N | | Y | Y |
| M186 | *Ulex minor* | Dwarf Gorse | Shrub | Inflorescence | | No Slide | No Slide | No Slide |
| M043 | *Urtica dioica* | Nettle | Perennial | Leaf | Y | | N | N |
| M044 | *Urtica dioica* | Nettle | Perennial | Stem | Y | | N | N |
| M045 | *Urtica dioica* | Nettle | Perennial | Flower | Y | | N | N |
| M149 | *Veronica chamaedrys* | Germander Speedwell | Perennial | Root | Y | | N | Y |
| M150 | *Veronica chamaedrys* | Germander Speedwell | Perennial | Leaf | N | | N | N |
| M151 | *Veronica chamaedrys* | Germander Speedwell | Perennial | Stem | | No Slide | No Slide | No Slide |
| M152 | *Veronica chamaedrys* | Germander Speedwell | Perennial | Inflorescence | | No Slide | No Slide | No Slide |
| M097 | *Vicia faba* | Celtic Bean | Annual | Leaf | Y | | N | Y |
| M098 | *Vicia faba* | Celtic Bean | Annual | Stem | Y | | Y | N |
| M099 | *Vicia faba* | Celtic Bean | Annual | Bean pod | N | | Y | Y |

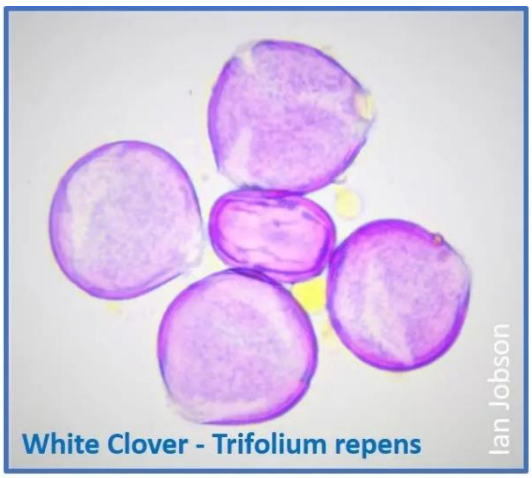
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| M100 | | *Vicia faba* | Celtic Bean | Annual | Bean rind | | | No Slide | No slide | No slide |

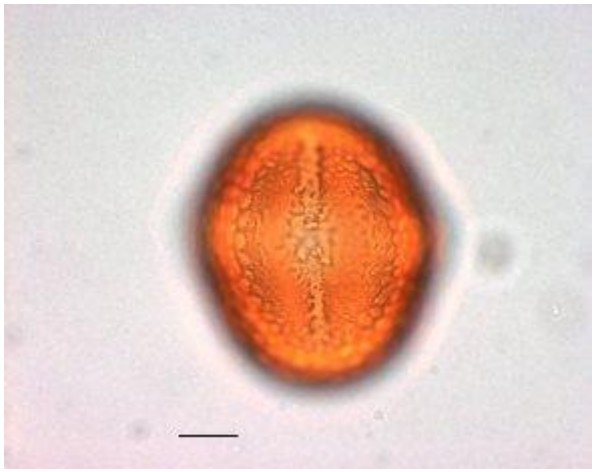
Pteridophyta

| **Index Number** | **Botanical Name** | **Vernacular Name** | **Category** | **Plant Part** | **Phytoliths Y** | **Phytoliths N** | **No Slide** | **Charcoal** | **Contamination** |
|---|---|---|---|---|---|---|---|---|---|
| M071 | *Pteridium* | Bracken | Fern | Stem | Y | | | N | N |
| M072 | *Pteridium* | Bracken | Fern | Frond | Y | | | N | N |

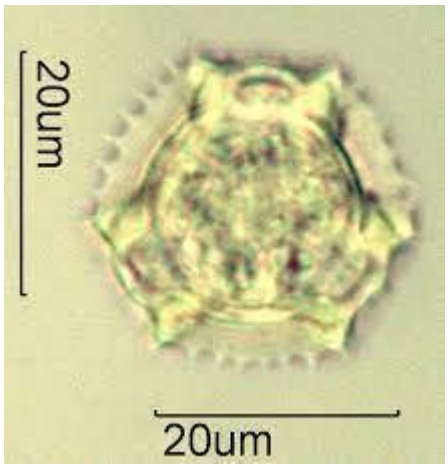
## Appendix 14 Pollen Identifiers for Wytch Farm **(The Global Pollen Project online)**

Trifolium-Clover

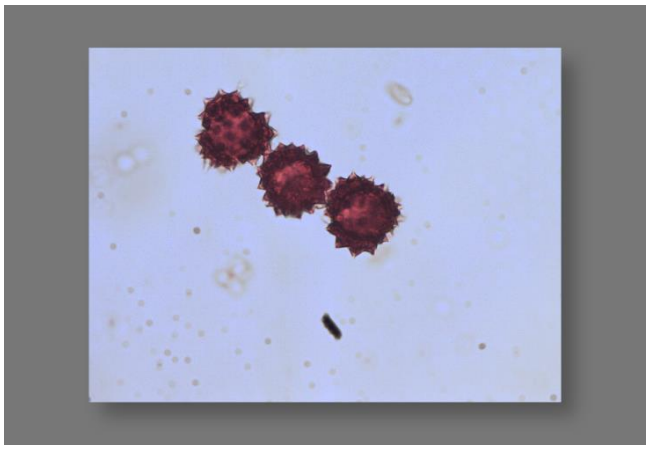


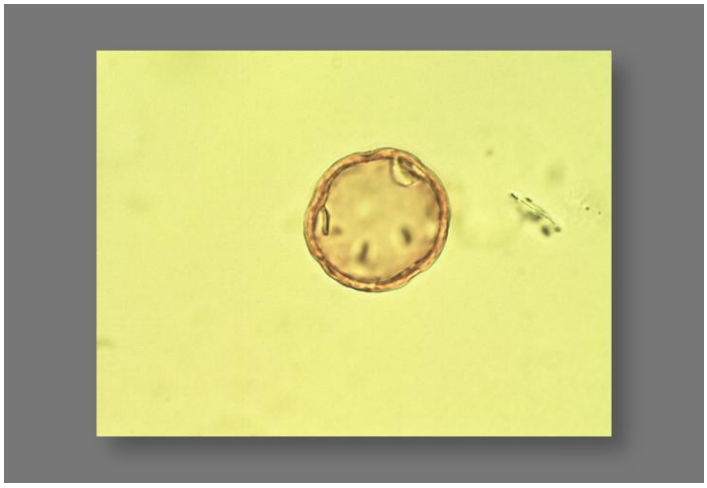
Hypochaeris radicata-Cats Ear



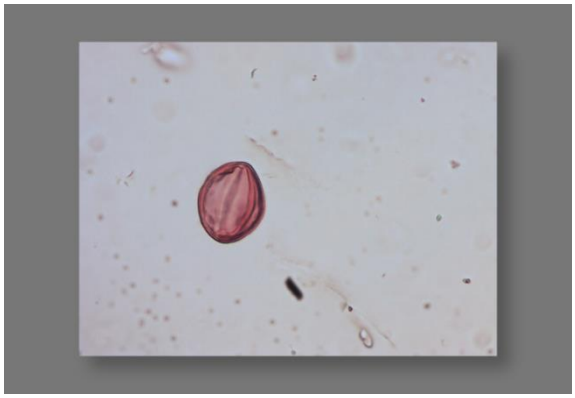

Achillea millefolium-Yarrow



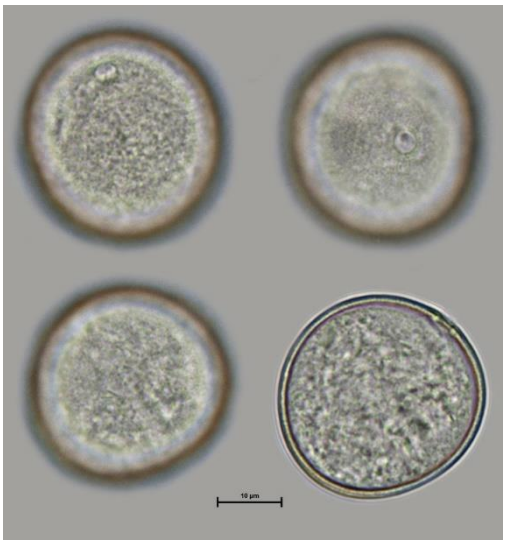
Plantago-Plantain



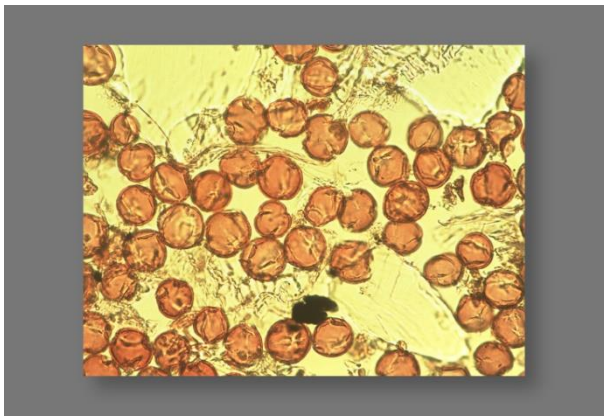
Veronica chamaedrys-Speedwell



Elymus repens-Couch Grass

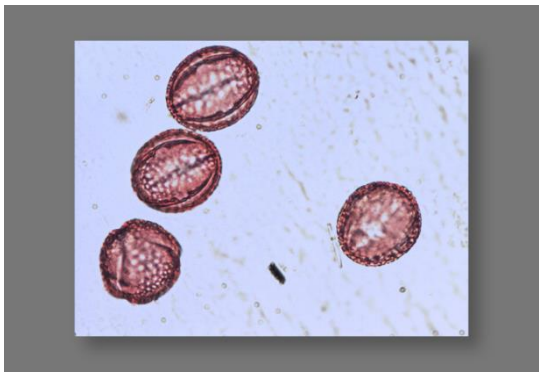


Prunus spinosa-Blackthorn

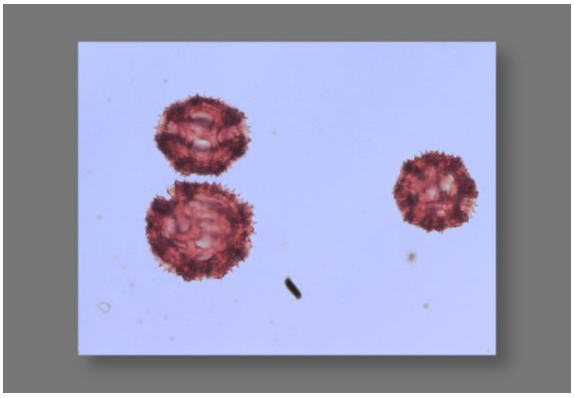


aaa

Hedera helix-Ivy

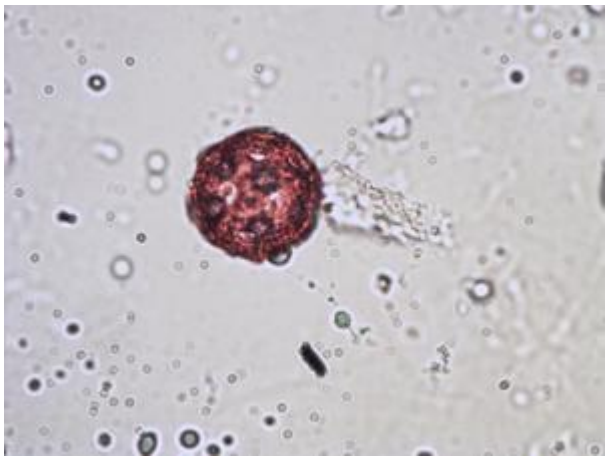


Taraxacum-Dandelion



Cerastium-Mouse Ear Chickweed

bbb



Licopodium


ccc

## Appendix 15 Communication with S. Davies about diatoms found in slides

Hi Siggy

Thanks for your email. Interesting pictures...

Are these from different samples or the same sample? It looks like you have a bit of a mix here. I can see Pinnularia (both in valve and girdle view) - that is a freshwater genus but some species are more aerophilous, occuring in bogs. The distinctive (lemon shaped) diatom you have looks like Lyrella lyra (coastal) but I think would need further investigation as there may be freshwater species within the Lyrella genus as well (a number of species were transferred into this new genus from Navicula and I can't remember whether it is exclusively marine or has freshwater species).

Finding a good taxonomic guide for coastal diatoms is a bit of a challenge. I've used Hendy and Ingram (1964) An introductory account of the smaller algae of British coastal waters and Cleve-Euler (1952) - Die Diatomeen von Schweden und Finland. Whilst the taxonomy may need updating in places they have been invaluable as references as most taxonomic books are focused wholly on freshwaters. Vos and De Wolf (1993) is also good.

This book is also useful - species are arranged alphabetically and an indication given as to whether they are fresh, marine or brackish.https://www.nhbs.com/an-atlas-of-british-diatoms-book

This is a good online guide for the UK but is focused entirely on freshwater: https://naturalhistory.museumwales.ac.uk/diatoms/
You could also try this https://diatoms.org/ US online database.

I hope this helps - if you have any other queries, please do get in touch, I'm always happy to look at diatom pictures!

Sarah

ddd

## Appendix 16 Physical Archive Storage

The physical archive for this project is held at Bournemouth University and is kept by Dr. Derek Pitman.
It contains two storage boxes and two herbarium specimen boxes
Content of storage boxes: Box 1: any spare dry plant material; Box 2: All microscope slides, all spare processed, ashed and phytolith soil material, micromorphology slides for MM4 and MM5, a memory stick containing all raw data
Content list for herbarium specimens for the herbarium boxes are in Appendix

## Appendix 17 Plant Lists for Herbarium Boxes

Plant list for the box containing herbarium specimen collected at Butser Ancient Technology Farm in Hampshire, Abbey Home Farm in Gloucestershire, and Hartland Moor on the Isle of Purbeck- in alphabetical order

| **Plant (Scientific Name)** | **Project Identification Number** | **Clades** |
|---|---|---|
| *Agrostis curtisii* | M189 and M210 | Monocotyledon (Grass) |
| *Avena fatua* | M025-031 | Monocotyledon (Grass) |
| *Betula species* | M165-168 | Eudicot (Tree) |
| *Calluna vulgaris* | M172-174 and M200-202 | Eudicot (Shrub) |
| *Erica cilliaris* | M178-180 | Eudicot (Shrub) |
| *Erica cinerea* | M197-199 | Eudicot (Shrub) |
| *Erica tetralix* | M175-177 | Eudicot (Shrub) |
| *Eriophorium angustifolium* | M203 | Monocotyledon (Grass) |
| *Hordeum vulgare* | M032-038 | Monocotyledon (Grass-cereal) |
| *Juncus compressus* | M162-164 | Monocotyledon (Rush) |
| *Juncus conglomeratus* | M160-161 | Monocotyledon (Rush) |
| *Linum usitatissimum* | M015-018 | Eudicot (Bi-annual) |
| *Molinia caerulaea* | M169-171 and M204-206 | Monocotyledon (Grass) |
| *Myrica gale* | M190-192 and M207-209 | Eudicot (Shrub) |
| *Narthesium ossifragum* | M195-196 | Monocotyledon (Bulb) |
| *Pinus sylvestris* | M156-159 | Gymnosperm |
| *Salix caprea* | M181-183 | Eudicot (Tree) |
| *Schoenus nigricans* | M193-194 | Monocotyledon (Sedge) |
| *Triticum aestivum* | M019-024 | Monocotyledon (Grass-cereal) |
| *Triticum dicoccan* | M008-014 | Monocotyledon (Grass-cereal) |
| *Triticum monococcum* | M001-007 | Monocotyledon (Grass-cereal) |
| *Ulex europaeus* | M187-188 | Eudicot (Shrub) |
| *Ulex galii* | M153-155 | Eudicot (Shrub) |
| *Ulex minor* | M184-186 | Eudicot (Shrub) |
| *Vicia faba* | M097-100 | Eudicot (Annual) |

Plant List for the box containing herbarium specimen collected at Point Ground, Wytch Farm, Isle of Purbeck- in alphabetical order (?= might need further identification)

| **Plant (Scientific Name)** | **Project Identification Number** | **Clades** |
|---|---|---|
| *Achillea millefolium* | M061-64 | Eudicot (Perennial) |
| *Agrostis stolonifera* | M140-144 | Monocotyledon (Grass) |
| *Anthemis cotula ?* | M129-132 | Eudicot (Annual) |
| *Anthriscus sylvestris ?* | M086-089 | Monocotyledon (Grass) |
| *Cerastium fontanum* | M078-081 | Eudicot (Perennial) |
| *Cirsium arvense* | M090-092 | Eudicot (Perennial) |
| *Echium vulgare* | M093-096 | Eudicot (Perennial) |
| *Hedera helix* | M137-139 | Eudicot (Climber) |
| *Hypericum humifisum* | M116-120 | Eudicot (Perennial) |
| *Hypocharis radicata* | M056-060 | Eudicot (Perennial) |
| *Ilex aquifolium* | M113-115 | Eudicot (Shrub) |
| *Jacobaea vulgaris* | M039-042 | Eudicot (Perennial) |
| *Plantago lanceolata* | M133-136 | Eudicot (Perennial) |
| *Plantago major* | M145-148 | Eudicot (Perennial) |
| *Poa pratensis subsp. pratensis* | M050-055 | Monocotyledon (Grass) |
| *Prunus spinosa* | M110-112 | Eudicot (Tree) |
| *Pteridium aquilinum* | M071-072 | Tracheophyte (Fern) |
| *Quercus robur* | M105-109 and M211-216 | Eudicot (Tree) |
| *Ranunculus repens* | M121-124 | Eudicot (Perennial) |
| *Rubus species* | M082-085 | Eudicot |
| *Rumex acetosella* | M125-128 | Eudicot (Perennial) |
| *Taraxacum officinale* | M073-077 | Eudicot (Perennial) |
| *Trifolium pratense* | M046-049 | Eudicot (Perennial) |
| *Trisetum flavense* | M065-070 | Monocotyledon (Grass) |
| *Urtica dioica* | M043-045 | Eudicot (Perennial) |
| *Veronica chamaedrys* | M149-152 | Eudicot (Perennial) |

# 9 Glossary and Abbreviations

(Encyclopaedia Britannica online)

Annual: any plant that completes its life cycle in a single growing season

**Biennial**: Any plant that completes its life cycle in two growing seasons. During the first growing season biennials produce roots, stems, and leaves; during the second they produce flowers, fruits, and seeds, and then die

**Clade**: to a single lineage (clade) composed of the common ancestor and all of its descendants

**Eudicot**: differentiated from dicotyledons by recent re-classification due to DNA research into plant evolution- within this project encompasses all dicotyledons such as annuals, biennials, herbaceous perennials and deciduous trees, shrubs and climbers

**Gymnosperm**: any vascular plant that reproduces by means of an exposed seed, or ovule—unlike angiosperms, or flowering plants, whose seeds are enclosed by mature ovaries, or fruits. The seeds of many gymnosperms (literally, “naked seeds”) are borne in cones and are not visible until maturity

**Loss on ignition** (LOI): Loss on Ignition measures the weight of a dried soil before and after burning away its organic matter. (https://www.exploresoils.org.uk/explore/soil-organisms/exploring-soil-organisms-loss-of-ignition/)

**Magnetic susceptibility** (Mag Sus): quantitative measure of the extent to which a material may be magnetized in relation to a given applied.

**Monocotyledon**: one of the two great groups of flowering plants, or angiosperms, the other being the eudicotyledons (eudicots)

**Panicoideae**: Most members of the two subfamilies Chloridoideae and Panicoideae tolerate relatively warm and dry habitats through special adaptations for photosynthesis. Both subfamilies are concentrated in the tropics

**Perennial**: any plant that persists for several years, usually with new herbaceous growth from a part that survives from season to season

**pH**: quantitative measure of the acidity or basicity

**Pollen**: a mass of microspores in a seed plant appearing usually as a fine dust. Each pollen grain is a minute body, of varying shape and structure, formed in the male structures of seed-bearing plants and transported by various means (wind, water, insects, etc.) to the female structures, where fertilization occurs. In angiosperms, pollen is produced by the anthers of the stamens in flowers. In gymnosperms, it is formed in the microsporophylls of the microstrobili (male pollen cones).

**Pooideae**: This subfamily contains almost 3,300 species and is clearly defined by various features, including the absence of the distinctive two-celled hairs found on the leaf epidermis in the rest of the family. The Pooideae reigns in temperate climates.

**Portable x-ray fluorescence** (pXRF): X-ray Fluorescence is a technique for chemical compositional measurement in which X-rays of a known energy are directed towards a target or sample, causing the atoms within the material to emit "fluorescent" X-rays at energies characteristic of its elemental composition. (https://www.fieldmuseum.org/science/special-projects/elemental-analysis-facility/portable-x-ray-fluorescence-pxrf)

**Pteridophyte**: any of the spore-bearing vascular plants, including the ferns, club mosses, spike mosses, quillworts, horsetails, and whisk ferns.