A hut on the hill: a multi-proxy microbotanical and micro-algae approach to a Pictish roundhouse floor at Cairnmore, Aberdeenshire.

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Abstract

Early medieval architecture is notably difficult to trace in northern Britain. The fortuitous survival of an intact floor of a building located just outside a ringfort at Cairnmore, a high-status early medieval ringfort enclosure in Aberdeenshire, Northeast Scotland, allowed the targeted deployment of a paleoethnobotanical approach that utilized microbotanical (i.e., phytoliths) and micro-algae residues (e.g., diatom frustules) to illuminate the character of the unusual survival of an early medieval building in Scotland. This research revealed novel data on the architecture of the early medieval roundhouse floor in this poorly documented region and era for settlement remains, securely identifying the use of turf for wailing in an early medieval lowland building. Evidence for roofing material was also preserved in the phytolith signature. Moreover, the microbotanical assemblage from Cairnmore was found to represent a use of a variety of ecological niches providing important evidence for landscape use. The presence (and absence) of particular microbotanical indicators also allowed interpretation of the possible uses of the structure. The results from this research demonstrate that microbotanical approaches can be critical in understanding architecture in regions where settlement survival is poor, highlighting the merits of microbotanical and micro-algae analyses in northern environments. The article concludes by advocating for the in-tandem assessment of these proxies in archaeological investigations where macrobotanical and other organic residues are poorly preserved.

Keywords: paleoethnobotany, phytolith, floor layer, Pictland, diatom

Introduction

Paeoethnobotanical approaches to archaeological deposits have provided valuable insights into how people in the past interacted with plant communities. Several recent studies have demonstrated the value of these approaches to illuminate past landscapes, foodways, and spatial activities (e.g., Borderie et al. 2020; Dal Corso et al. 2017; Juhola et al. 2019; Wade et al. 2021). Within northern British archaeological contexts, highly acidic soil conditions along with later land use (Ralston 1997; Hunter 2007:48–50; Noble et al. 2019ba; Noble et al. 2020:328) often inhibit the preservation of macrobotanical residues, floors, artifacts and structural remains, leading to poor understanding of settlement and early landscape use. These limitations are particularly evident for early medieval Scotland where our knowledge of architectural traditions is notably limited (Ralston 1997:24; Noble et al. 2020:320, 327–328). While in Scotland handfuls of early medieval structures are known in lowland contexts, in neighbouring areas such as early medieval Ireland or England, tens of thousands of sites are known (e.g., Hamerow 1993, 2012; O’Sullivan 2008, O’Sullivan et al. 2014:47–138; Carver 2019:139–303). Thus, in areas where settlement remains are sparse, such as Scotland, our knowledge of architecture is notably deficient compared to that of contemporary nearby cultural groups. For early medieval Scotland, the dearth in settlement architecture may have partly been due to a shift towards using material such as turf, and architectural traditions where earth-fast structural elements were less common in the late and post-Roman era, though these assumptions are often based on absence of evidence rather than direct attestation (Ralston 1997:24; Noble et al. 2020:320, 327–328).
Where preservation is poor, microbotanical methods can provide crucial insights into settlement traditions where other evidence is lacking. Microbotanical analyses target more durable residues such as phytoliths (plant microfossils), and such analyses are often effective where macrobotanical remains (such as seeds) are limited in the archaeological record (Pearsall 2015:253; Piperno 2006:1; Shillito 2013:72).

This study shows the efficacy of procuring phytoliths and other durable microstructures (e.g., diatom frustules) from archaeological deposits in challenging preservation contexts – such as within a floor layer from an early medieval site in northeast Scotland.

Phytoliths and diatom frustules are microfossils composed of biogenic silica, and the morphology of these silicious cell walls can be taxonomically diagnostic (Pearsall 2015:253; Piperno 2006; Smol and Stoermer 2010; Stone and Yost 2020). Microscopic algae are often present in archaeological samples that target phytoliths and other microbotanical structures; however, these microscopic residues are rarely examined together in archaeological investigations (e.g., Vuorela et al. 1996). Other types of multi-proxy archaeological approaches, often termed “piggy-back” approaches, have targeted phytoliths, starch grains, calcareous spherulites and other microscopic residues together (Canti and Nicosia 2018:32; Portillo and Albert 2011), but diatoms and other micro-algae are rarely incorporated into these studies beyond a count of specimens present in archaeological samples (Stone and Yost 2020:23). This hesitancy toward targeting diatoms and other micro-algae specimens in archaeological investigations is presumably a response to the skill required for accurate identification of these silicious microstructures as diatom species are incredibly diverse (Battarbee 1988; Stone and Yost 2020:23). However, like phytoliths, diatoms can provide detailed information about their environmental contexts when retrieved from in situ archaeological deposits (Juggins and Cameron 2010; Mannion 1987; Smol and Stoermer 2010:3). The presence of diatom residues (i.e., frustules) allows archaeologists to investigate the aquatic and semi-aquatic components of human-environment relationships, such as the collection and movement of aquatic and semi-aquatic resources (e.g., turf, drinking water, clay, etc.) (Beneš et al. 2022; Flower 2006; Hill et al. 2019; Juggins and Cameron 2010; Rippon 2000).
Figure 1. Location of Cairnmore (Aberdeenshire, Scotland) and contemporaneous site Burghead, both located to the west of the city of Aberdeen; a) plan of the double-walled ringfort at Cairnmore with b) small roundhouse structure located just outside the outermost rampart (the structure is the subject of analysis of this article).

Cairnmore, Scotland

In this article we assess phytoliths, diatom frustules, and chrysophycean cysts procured from a single roundhouse floor layer within the complex at Cairnmore (Aberdeenshire, Scotland). Cairnmore is an unusual and rare complex bivallate fort that overlooks the Upper Strathbogie Valley, where at Rhynie, a high status early medieval settlement enclosure, metalworking area, and cemetery have been found over the course of six seasons of excavation (Noble et al. 2019b). Cairnmore sits on the shoulder of a hill and comprises two rubble rampart walls that were strengthened by a complex post revetment (Noble et al. 2019c; Noble et al. 2019c). At both Rhynie and Cairnmore, settlement remains were poorly represented in the centre of the settlements where later cultivation had removed the majority of floor layers. These later agricultural activities left behind only fragmentary postholes and other architectural features, as is the case with nearly all lowland early medieval settlements in eastern Scotland (Ralston 1997). However, at Cairnmore the collapse of the outer ramparts had fortuitously preserved the floor layer of a better preserved structure, located beside the outermost enclosure wall (Fig. 1). This building survived under extensive stone spread from rampart decay and was located abutting the outermost rampart wall.

The floor layer for the structure comprised a deposit over 6 m in diameter and up to 0.12 m thick (Fig.1 & 2) and consisted of a dark brown clayey silt with burnt bone and charcoal incorporated throughout the deposit (Noble et al. 2022). The floor layer appeared to form part of a circular roundhouse structure, though only one part of the floor was excavated as the rest underlay or was truncated by a later
stone boundary wall. A small number of artifacts were recovered from the floor layer, including a
fragment of a shale bracelet and a small iron object (Fig. 1). Three pit features were present within the
floor layer, potentially representing hearths (Noble et al. 2022). Macrobotanical remains included
charcoal fragments of oak (Quercus sp.) and birch (Betula sp.), along with charred plant seeds from black
mustard (Brassica nigra), ribwort plantain (Plantago lanceolata) and sedges (Carex sp.) (Niehaus 2021).
No structural features such as postholes or evidence of roofing were preserved to give any indication of
the appearance or form of the building. Radiocarbon dating suggests the floor layer is of 5th – 6th century
AD date, and was therefore contemporary with the ringfort settlement, the dates for which span the 5th to
7th centuries AD.

The objectives of this paleoethnobotanical study were to 1) evaluate the effectiveness of
microbotanical analysis for archaeological investigations in areas where these techniques have rarely been
attempted such as Scotland, 2) assess if this microbotanical assemblage could address the nature of the
Cairnmore structure and illuminate the architectural details of a rare roundhouse building in a region with
a very limited settlement record, and 3) assess the spatialization of activities within the building and wider
landscape use (both terrestrial and aquatic environments).

Material and methods
The paleoethnobotanical approach for this study was oriented to address the often shallow (e.g., < 0.3 m)
archaeological deposits at Pictish sites and to interpret the spatial deposition of microarchaeological
residues from the roundhouse. The sampling and laboratory procedures outlined below follow standard
protocols for phytolith analysis and were successful in isolating microbotanical and micro-algae
specimens.

Sampling
Twenty-one samples were taken from the floor layer using a horizontal sampling technique and “pinch”
sampling method (Fig. 2 & 3). Horizontal sampling allows for variation in plant taxa to be seen more
clearly and can be used to identify activity areas and assess architectural features (Lennstrom and Hastorf
1992; Pearsall 2015:275). The floor area was sampled by establishing a 1 m x 1 m sampling grid and the
“pinch” sampling method was employed for each unit within the grid. Several pinches of sediment (~ 1
Tbsp each) were taken within and across each unit which created a composite sample that amounted to
approximately 200 grams from each unit. Two samples were procured from areas believed to be outside
the floor layer context (samples 18 and 21) to examine ‘natural’ signatures of microbotanical and
microalgae residues for comparison with the floor layer.
Figure 2. Pinch sampling grid and sample numbers of the roundhouse floor context

Figure 3. Pinch sampling diagram
Laboratory Processing

Samples were sent to the McMaster Paleoethnobotanical Research Facility (MPERF) where they were processed following MPERF protocols for extracting phytoliths from sediments (Piperno 2006; Morell-Hart 2018). This process involves soil sterilization, deflocculating samples in water, dividing soils into A/B and S fractions, clay removal, microwave chemical digestion and flotation of phytoliths. For the Cairnmore context, processing took twenty-six days for the batch of 21 samples.

As the samples were processed outside of Scotland, soils were first sterilized in a muffle furnace at 200 degrees Celsius for six hours to remove the risk of soil borne-contamination. The samples were then transferred to 1000mL beakers, and 2 Tbsp of sodium bicarbonate was added, then beakers were filled with hot water and stirred every 15 minutes to break up clumps of soil. Next, the samples were divided into sand (S), larger sediments (D) and fine/coarse sediments (A/B) using U.S.A. Standard Testing sieves No. 35, No. 60, No. 270, and base pan. S fractions were collected from sieve No. 270 into 50mL centrifuge tubes, and A/B fractions from the base pan were each transferred to a 1000mL beaker. These A/B fractions required a clay removal step and so the samples were stirred, allowed to sit for one hour, slowly poured off the upper 400mL, re-added hot water, then repeated until the water was clear of suspended clay for all samples. Once clear, the A/B samples were transferred to 50mL centrifuge tubes.

Samples were centrifuged for 5 minutes at 1000rpm to concentrate the sample at the base of the centrifuge tube, and excess water was poured off, leaving a damp sediment plug in the tube. Ten grams of each sediment plug was weighed into 600mL beakers for the chemical digestion process, using 3mL of hydrochloric acid (10% aqueous solution), 5mL of nitric acid (68 –70% aqueous solution) and 1mL of hydrogen peroxide (30% aqueous solution). Once all three chemicals were added, samples were transferred to microwave vessels tubes and heated in the MARS 6 microwave digestion system for 130 minutes. Samples were allowed to sit in the microwave overnight after processing, then transferred from microwave tubes into 50mL centrifuge tubes and centrifuged at 3000rpm for 5 minutes. The chemical supernatant from each tube was poured off, then samples were subject to two rinses using ultra-pure water.

Following chemical digestion and rinsing, the samples were floated using heavy liquid (sodium polytungstate solution). This solution was added to each 50mL centrifuge tube sample, agitated, then centrifuged for 5 minutes at 1000rpm to allow phytoliths to rise to the surface of the tube. Phytoliths were extracted using a pipet to skim the surface of each sample and transferred to a 15mL centrifuge tube. This process was repeated for two extractions total from each sample. The samples were then isolated by removing the heavy liquid by filling the 15mL tube with ultra-pure water, centrifuged for 10 minutes at 1000 rpm and poured off. This process was repeated for a total of three washes until the sample was clear. After the final pour off, approximately 3mL of acetone was added to the sample, centrifuged for 10 minutes at 1500rpm and poured off. Samples were uncapped, covered with parafilm, and placed under a fume hood for one week to dry completely. Once dry, the samples were mounted onto glass microscope slides using a pipet, covered with 1–3 drops of immersion oil and a glass coverslip.

Analyses

Tabulation and analysis were conducted at the MPERF using a Zeiss microscope for transmitted light microscopy (200x, 400x and 630x magnifications). Primary analysis involved identifying and tabulating diagnostic phytolith morphotypes to a minimum of 200 counts per sample (A/B and S fractions) following recommended practice (Albert et al. 1999; Albert and Weiner 2001; Pearsall 2015).

Morphotypes were identified using the International Code for Phytolith Nomenclature (ICPN) 1.0 and 2.0 when possible (Madella et al. 2005; Neumann et al. 2019). Micro-algae such as diatoms and chrysophytes were counted separately (although synchronously) from the phytoliths, and were tentatively identified using ICPN 2.0, Jüttner et al. (2022), Spaulding et al. (2022) and Stone and Yost (2020).

Secondary analyses included calculating 1) the relative prominence of ecological indicators (e.g., wetland taxa), 2) the relative prominence of human activities (e.g., grain processing), 3) the ubiquity of
major plant groups (e.g., monocots and dicots) and micro-algae, and 4) the richness of plant taxa within
the roundhouse floor layer. All secondary analyses were carried out using Excel pivot tables.

Results
Microbotanical results
The procedure for extracting phytoliths from archaeological soil samples successfully isolated phytoliths,
diatoms, chrysophycean cysts, and microcharcoal from the Cairnmore roundhouse. Some phytoliths
appeared partially dissolved or weathered which likely reflects the acidic soil conditions. Degraded
phytoliths were not counted, but many were of the elongate entire and scutiform morphotypes.
Monocotyledonous plant taxa, which germinate with a single embryonic leaf (typical of grasses), were the
most commonly represented in all of the samples and phytoliths from the grass family (Poaceae) had the
highest total counts for this assemblage. This is unsurprising as the grass family is known as one of the
highest producers of phytoliths (Delhon 2010; Delhon et al. 2020:231; Morell-Hart 2019:236; Twiss
1992). Within this sampling context the Panicoideae (characteristically xerophytic – thriving in dry
environments) (Morell-Hart 2019:236) and Pooideae (characteristically temperate – consisting of pasture
and cereal grasses) subfamilies of the grass family are the most prominent, with rarer occurrences of
likely Arundinoideae (as evidenced by the bulliform morphotype). The Chlorideae subfamily may also be
represented by these bulliform specimens; however, Arundinoideae is more likely given the climate and
plant communities known for this region. Overall, the grass family is represented at Cairnmore through
bilobate, polylobate, trapeziform, and elongate morphotypes (Fig. 4). Phytoliths representative of cereal
inflorescence bracts (i.e., elongate dendritic and papillae phytoliths) were also recovered in trace
quantities (see discussion). Sedge family (Cyperaceae) cones were occasionally identified, indicating the
presence of sedges (Carnelli et al. 2004: 51; Morris et al. 2009; Ollendorf 1992) and occasional acicular
morphotypes appear very similar to those present in common club-rush (Schoenoplectus lacustris) (Fig.
5). The presence of sedges can be used to infer resource procurement from wetland ecological niche
zones as these plants thrive in areas with wet and inundated soils.

Dicotyledonous morphotypes (representing plants that germinate with two embryonic leaves)
such as opaque perforated plates were also frequent within the roundhouse floor context, and likely
indicated the aster family (Asteraceae) (Fig. 4 G-H). However, several perforated plate morphotypes also
resemble the heather family (Ericaceae) forms identified by Carnelli et al. (2004) and others appear
similar to vascular tissues, potentially from tubers (Fig. 4I). Research on phytolith production in the
Ericaceae family is limited (e.g., Bujan 2013; Thorn 2006), and further investigations should focus on
identifying diagnostic morphotypes for this family of plants. This would be especially useful for northern
European phytolith research as this family of plants is well represented in temperate European
environments and within Scotland specifically (e.g., Calluna vulgaris). Lastly, tabular and spheroid
morphotypes were also present in the floor layer and these morphotypes were counted as dicot specimens
(Albert et al. 1999; Danu et al. 2020:7; Delhon et al. 2020:232). Overall, dicotyledonous morphotypes
were less represented in the floor layer than monocotyledonous morphotypes; however, this follows the
general pattern observed in archaeological investigations (Carnelli et al. 2004; Dal Corso et al. 2017:15;
Tsartsidou et al. 2007).

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Table 1. Results of microbotanical and micro-algae residues from roundhouse floor samples

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<td>4</td>
<td>411</td>
</tr>
<tr>
<td>21</td>
<td>S</td>
<td>presumed ‘natural’ outside floor layer feature</td>
<td>9</td>
<td>102</td>
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<td>169</td>
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Micro-algae: diatoms and chrysophycean cysts

Diatom frustules and chrysophycean cysts were present throughout the roundhouse floor samples and were counted synchronously alongside the phytoliths in each sample. These aquatic microstructures are essential for illuminating the presence of semi-aquatic and aquatic environments. Accurate identification of diatom frustules can be challenging as diatoms are the most diverse protists (Spaulding et al. 2022; Stone and Yost 2020:23); however, this presents interdisciplinary opportunities for paleoethnobotanists and microbiologists (among other specialists) to work together on environmental archaeology research to aid future identification. Within the context of the floor samples, tentative identifications were assigned for several complete diatoms with redundant morphotypes (Fig. 6). All diatoms were pennate in form, and included araphid pennate and raphid pennate examples. The provisional identifications include the genera *Achnanthidium, Hantzschia, Pinnularia, Eunotia and Navicula*. Following Jütter et al. (2022), Spaulding et al. (2022), Stone and Yost (2020) and Denys (1991) it appears that most of these diatoms are...
freshwater species and lived within subaerial and terrestrial environments. Chrysophytes largely consisted of small spherical forms (Fig. 6G) and stomatocysts with smooth and rugose ornamentation (Fig. 6H & I). The round chrysophyte specimens appear similar to the *C. pseudodiachloros* and *C. elegans* forms recovered from peat bogs by Cambra (2010) in Spain. However, verification from diatomists is needed to fully confirm these identifications.

**Contexts**

Overall, the counts of diatoms and chrysophycean cysts were often higher around the edge of the floor layer, within the assumed ‘natural’ units (18 and 21), and within units with pit/hearth features. Although the taxonomic identification of these specimens is unverified, their presence indicates concentrations of damp or inundated deposits where these micro-algae were present.

**Discussion**

This multiproxy study provides robust data to interpret the architectural features of the Cairnmore roundhouse such as the wall and roof materials. This data also contributes to our knowledge of the use of space within the roundhouse and activities associated with the Cairnmore complex more broadly.

**Architecture – walls and roof**

Intact floor layers uncovered during excavation allow archaeologists to examine the use of space, architectural details, activities and site formation processes (Borderie et al. 2020:151; Macphail et al. 2004; Milek 2012; Robertson and Roy 2019). However, *in situ* floor deposits are rare for lowland structures within Britain (e.g., for prehistoric roundhouses see Ghey et al. 2007; Webley 2007) and exceptionally uncommon in early medieval eastern Scotland (Ralston 1997; Noble et al. 2020:320). Initial observations by the excavators noted that this structure was potentially constructed of turf or other earthen materials (Noble et al. 2022), as has been suggested for other early medieval lowland structures (e.g., Ralston 1997:24; Noble et al. 2020:320), and this hypothesis is supported by the absence of postholes and stakeholes surrounding the floor layer which could have supported an earthfast timber structure to brace the walls and roof. One of the aims of this study was to test the hypothesis for turf walling by examining
the microbotanical and micro-algae assemblages present in and around the floor of this structure that lay just outside the ringfort.

Figure 4. Common phytolith morphotypes from roundhouse floor samples (viewed at 400x). (A) cylindrical polylobate – Poaceae, (B) bilobate – Poaceae, (C) elongate entire – Poaceae (D – E) elongate dendritic [inflorescence bract] – Poaceae, (F) Cyperaceae cones, (G – H) Asteraceae or possibly Ericaceae opaque perforated plates, (I) Vascular tissue, possibly from a tuber.
Figure 5. (A) Acicular hair morphotype from modern *Schoenoplectus lacustris* viewed at 100x (Prado 2022) and (B) acicular hair from roundhouse floor, viewed at 400x.

Figure 6. Diatoms and chrysophycean cysts extracted from roundhouse floor (viewed at 400x). All identifications are unverified by a diatomist (A) cf. *Achnanthidium* sp., (B) cf. *Hantzschia* sp., (C) cf. *Pinnularia* sp., (D) cf. *Eunotia* sp., (E) cf. *Pinnularia* sp., (F) possible burnt fragment of *Navicula* sp., (G – I) chrysophycean cysts.

The phytolith evidence indicates a consistent presence of wetland plant taxa (e.g., Cyperaceae sp.) in the Cairnmore floor deposit. Although present in lower quantities than Poaceae morphotypes, above average counts of Cyperaceae cones were retrieved from 54% of the outer floor units where the wall of a superstructure may be expected. This is a remarkable finding as Cyperaceae phytoliths are considered to have relatively low visibility (Dal Corso et al. 2017:16; Novello and Barboni 2015; Ollendorf 1992). The micro-algae assemblage, consisting of diatoms and chrysophycean cysts, was also ubiquitous across the floor, often in similar counts and concentrations to the Cyperaceae cones. Although these microfossils were retrieved from 90% of the sampling area (each present in 20 out of 21 units), elevated counts around the edge of the floor deposit and from supposed ‘natural’ units (18 and 21) indicate wetland plants and algae were concentrated around the edge of the structure.

The most likely explanation of this pattern is that the wetland indicator species come from a turf/peat wall, with turfs cut from a wetland context the likely source. Analogous construction techniques are also known from Viking Age and later historical turf structures in Iceland, where turf was typically cut from lowland bogs and transported to the uplands for house construction (Bathurst et al. 2010; van Hoof and van Dijken 2008). Several diatom genera from the roundhouse floor at Cairnmore appear to overlap with the findings of Bathurst et al. (e.g., *Achnanthes*, *Eunotia*, *Navicula* and *Pinnularia*) and these
taxa are notably often found in peat-bogs (Bathurst et al. 2010:2925). The study by Bathurst et al. is an excellent example of the advantages of targeting micro-algae residues in archaeological research; however, this is a rare case as most archaeological approaches to past environments, especially in northern regions, do not prioritize the recovery of diatom frustules. Within northern environments there are very few studies that analyze microbotanical and micro-algae residues in tandem (e.g., Vuorela et al. 1996) and to our knowledge, no archaeological studies have targeted chrysophycean cysts for analysis.

Wetland turf has often been a preferred material over grassland turf because of its denser root mat and wet climates (Milek 2012:120–122; van Hoof and van Dijken 2008:1026). The practice of targeting wet environments for turf extraction has been attributed to areas across the northern hemisphere including Scotland, Iceland, Greenland, the Faroe Islands, Germany, Ireland, the Netherlands, and Norway (Huisman and Milek 2017: 113). Within Scotland, turf was often procured from wet environments such as sedge marshes, peat bogs, and heathlands (Huisman and Milek 2017:113; Walker 2006:7–8) as these environments yield turf with deep root systems which results in a robust building material. Within Scotland, Cyperaceae plants are mostly found in wet environments including fen, heathland, and marsh environments. The phytolith signature in the Cairnmore floor deposit containing Cyperaceae and Asteraceae (possibly Æricaceae) forms could therefore reflect turfs procured from a variety of wet environments. Few Cyperaceae plant species grow in drier locales within Scotland as most sedges thrive in wet and inundated soils (Preston et al. 2002). Coupled with the micro-algae evidence, we suggest that the sedges in this floor deposit are unlikely to originate from dry environments. Overall, the phytoliths, diatom frustules, and chrysophycean cysts retrieved from the Cairnmore floor signature suggest that the turfs procured for this structure came from wet environments, likely peat bogs and other wet locales (e.g., heathland and fens).

Wetland areas still exist close to Cairnmore today and turf could have been sourced nearby for the walls of the Cairnmore structure. The ubiquitous nature of wetland taxa across the roundhouse floor may have resulted from the redeposition and movement of wall detritus across the floor (e.g., through sweeping) and through decay from weathering and decomposition of the turf walls over time. The presence of elevated counts of chrysophycean cysts and diatom frustules in units 18 and 21, which were believed to be outside of the floor layer (and therefore were assumed to be ‘natural’ contexts), likely suggests the context of these units relates to the inner fabric of the turf wall. Therefore, it is recommended that sampling of ‘natural’ contexts should be targeted at a greater distance from an intact floor deposit to avoid sampling other unseen structural elements such as turf walling. Shovel test pits at a greater distance from excavated areas could potentially be useful for sampling ‘natural’ contexts. Although the samples from units 18 and 21 do not appear to be wholly ‘natural’ in derivation they were still useful for comparison with the floor layer as these signatures strongly contrasted with the floor signature (i.e., elevated counts of chrysophycean cysts and diatom frustules). This contrast also suggests that the signatures from the floor are not representative of ‘natural’ growth on the floor after the structure was abandoned.

In historical contexts turf walls could be reasonably thick, often comprising two ‘faces’ and a core, similar in form to our modern cavity walls, with turf constructed in two parallel lines with earth between (van Hoof and van Dijken 2008:1026–1027). Turf structures are thought to be relatively efficient in terms of time and labour investment required for their construction and upkeep (Loveday 2007) and are also excellent structures to use in areas where wood for building is scarce. Turf structures are also particularly valued in cold and wet regions as these structures have excellent insulation properties (Bathurst et al. 2010:2920; Milek 2012:120), a pertinent observation for the northern environments of northeast Scotland. The hillslope setting of Cairnmore would have been an exposed location and warmth and insulation would have been particularly valued in this context.

Interpreting the roof material of this turf walled structure is complicated as the samples in this study were procured from what may be a mixed context of floor and roof material. It is difficult to differentiate collapsed roof material from floor deposits in this context; therefore, to understand the character of the roof we compared the microbotanical signature with broader archaeological and
ethnographic evidence. Overall, we did not differentiate between floor materials and collapsed roof materials as this context was likely a mix of both; however, we have provided tentative interpretations for the roof structure below.

The low counts of reed type phytoliths (e.g., bulliform morphotypes) across the floor layer suggests that the roof, and the roundhouse structure broadly, did not significantly rely on these wetland plants, as has been argued for some prehistoric roundhouse structures in Britain (Ghey et al. 2007; Pope 2008:17). Instead, the high degree of grass family (Poaceae) and aster family (Asteraceae) phytoliths potentially suggest the roof was thatched using dried grasses and other wild plants (Morell-Hart 2019:236; Portillo and Albert 2011:3232). Aster family phytoliths and other dicot morphotypes were recovered across most of the floor layer, and prominent deposits of dicot residues were identified within several units (Fig. 7). Within the contemporary environment, aster family species include (but are not limited to) hawkweed, daisy, yarrow, knapweed and coltsfoot. However, further research is needed on Asteraceae phytoliths within northern Europe as some phytoliths recovered within this context were semi-translucent and resembled heather family (Ericaceae) microstructures identified by Carnelli et al. (2004:56). Ethnographic and historic research on Scottish shielings and other types of upland dwellings reference the use of heather (Calluna vulgaris) for thatched roofs (e.g., the blackhouses from the outer Hebrides and The Black Barn in Northumberland) (Dower 2015; Scott 2007; Walker 2006), and this could potentially explain the representation of Asteraceae and possible Ericaceae morphotypes recovered from this context.

![Roundhouse Floor: Monocot and Dicot Ubiquity](image)

Figure 7. Monocotyledon and dicotyledon ubiquity within the roundhouse floor

**Spatial analysis**

The microbotanical assemblage does not strongly indicate the division of space for specific activities, such as cooking, crop processing, or sleeping, though only part of the structure was revealed in excavation (Fig. 9). However, small concentrations of specific morphotypes were present. For example, dicot phytoliths and chrysophytes show a similar spatial pattern across the roundhouse floor with higher counts around the edges of the roundhouse and in the central units near the probable hearth features (i.e., units 9, 10, 11 & 15). Cabanes et al. (2010) discusses a similar pattern within late Mousterian cave occupations in Cantabria, Spain, where dicotyledonous residues were largely recovered from hearth deposits whereas monocotyledon residues surrounding hearth features were interpreted as bedding areas. The concentrations of chrysophytes related to probable hearth features may indicate that peat was also
being used for fuel within the roundhouse, a known practice from historical and ethnographic examples (Loveday 2007:87). Alternatively, perhaps some material from the wall and floor detritus was used to fill and close the hearths when abandoned or infiltrated what may have been sunken bowl-shaped hearths, through later processes of decay and dissolution of the turf superstructure.

Food processing may have been carried out in or in the vicinity of the building. Trace macrobotanical evidence from Cairnmore recovered granary weevils (Sitophilus granarius) from the roundhouse floor (Niehaus 2021:43), possibly indicating a crop processing area or storage facility located within or near the Cairnmore roundhouse. The microbotanical residues add more potential evidence for this. A small number of inflorescence bract phytoliths were retrieved, with the highest counts reaching 5 elongate dendritic forms in units 14 and 16 (Fig. 8). Grass inflorescences are typically formed in the later summer or early autumn and robust phytolith evidence of these foodstuffs is usually represented through articulated multicellular structures of elongate dendritic and papillae phytoliths (Delhon et al. 2020). Without multicellular forms or the use of morphometric analysis (Ball et al. 1996; Ball et al. 2009; Ball et al. 2016; Portillo, Ball and Manwaring 2006; Rosen 1992) it is challenging to interpret the taxa represented through these morphotypes. Many of these phytoliths were fragmented and were difficult to confidently match with reference examples in the McMaster Microbotanical Research Database (Prado 2022). However, the most likely identification is barley (Hordeum vulgare), the dominant crop type for the region in this period (Jones et al. 2021).

![Roundhouse Floor Inflorescence Bract Phytoliths](image.png)

Figure 8. Counts of inflorescence bract phytoliths within the roundhouse floor
In regard to function, the presence of a rare intact floor layer suggests that this structure was repeatedly used; however, the activities within the structure are challenging to interpret. As already discussed, only weak signatures indicating food processing or bedding areas were recovered from this context. Given the relative lack of such indicators it is possible the building was mainly an auxiliary vernacular structure such as a workshop or agricultural building, an interpretation that may chime with the presence of the structure outside of the ringfort. The use of this building as a domestic space cannot be fully dismissed however, as trace residues of food processing were recovered (e.g., elongate dendritic phytoliths) and the floor layer suggests some level of repeated use of the structure. Lastly, other forms of domestic evidence could have lain elsewhere in the building outside of the accessible sampling area.

<table>
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<th>Family</th>
<th>Number of units where present (max 21)</th>
<th>Frequency (%)</th>
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</thead>
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<td>21</td>
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<tr>
<td>Asteraceae</td>
<td>20</td>
<td>95</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>20</td>
<td>95</td>
</tr>
<tr>
<td>Poaceae (inflor. bracts)</td>
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<td>76</td>
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**Bibliography**


Pope, R. 2008. Roundhouses: 3,000 years of prehistoric design. *Current Archaeology* 222:14–21


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