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Abbreviated title: Pit Houses in Viking Age Iceland

Word Count: 13, 411

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*The small semi-subterranean buildings (*jarðhús*) that are found on many Viking Age farmsteads in Iceland (late 9th-11th century) have been subject to very wide ranging interpretations, from short-lived, expedient dwellings to saunas, women's workrooms, the houses of Slavic settlers, and in one case a cult building. This paper tests these hypotheses by making a thorough revaluation of pit house dates, architectural forms, internal structural features and artefacts, and presents new geoarchaeological evidence from the pit house at Hofstaðir, northeast Iceland, which lends strong support to the interpretation that they were women's workrooms. Although food was consumed in pit houses and they could have been used as dwellings by a few individuals, their primary function was for the production of woollen textiles by the female members of the household. Far from being short-lived, temporary dwellings, most pit houses were in use for a considerable period of time and must have represented an integral social and economic space on Viking Age farmsteads. Their abandonment in the later 10th and 11th centuries represents a dramatic shift in the organisation of household production and gendered household spaces, a shift that may be interpreted in the light of changing religious beliefs and social structures, the growing importance of homespun cloth as a valuable export commodity, and the rise in status of the women who made it.*

In Viking Age and medieval Iceland, the main arenas for everyday living, economic activities and social interactions were the buildings and outdoor activity areas contained within the homefields of dispersed farmsteads. In addition to the main dwelling house (Icelandic *skáli*), which has often been called a ‘longhouse’ in English due to its oblong shape, each homefield contained a number of smaller ‘outbuildings’ (*útihús*), as well as outdoor activity areas located between the buildings.[[2]](#endnote-2) Several different kinds of outbuildings have been excavated, including cattle byres, hay barns, sheep houses, smithies, structures of unknown function that have been interpreted as storage buildings, and, more rarely, corn-drying kilns, lavatories, and buildings containing hearths or cooking pits that appear to be specialised cooking buildings.[[3]](#endnote-3) On Viking Age farmsteads, it is also common to find one or more semi-subterranean buildings, known as *jarðhús* in Icelandic (literally ‘earth houses’) – a term that has variously been translated in the Icelandic archaeological literature as ‘pit houses’, ‘sunken huts’, or ‘sunken-featured buildings’ (Fig 1). These small, rectangular or near-square buildings always contain a stone-built hearth or oven (*ofn*) against a wall or in a corner, and it is clear from the artefacts and floor deposits found inside them that they were dwellings or work places for people, rather than animal houses or agricultural storage buildings.

Pit houses found on Icelandic farmsteads are restricted in date to the late 9th-11th century (Table 1; Fig 2). Semi-subterranean buildings rather different in form from the pit houses on farms continued to be used into later medieval and post-medieval periods at seasonal trading sites such as Gásir, in north Iceland,[[4]](#endnote-4) but pit houses on farmsteads were out of use by the 12th century, suggesting that on a country-wide scale household activities, including any economic activities that took place inside the buildings, underwent widespread reorganisation during the late 10th-11th century. An understanding of this restructuring of socio-economic space on farms, and the possible relationship between this farm-level reorganisation and wider social and economic changes occurring in Iceland, relies on a good understanding of how pit houses were used, and by whom. However, as will become clear in the section that follows, interpretations of these buildings have been very wide-ranging and often mutually exclusive. Following a brief review of the various interpretations that have been put forward to date, this paper presents the results of an interdisciplinary study of Icelandic pit houses, including a reassessment of all the archaeological evidence and new geoarchaeological and microrefuse data from the pit house excavated at Hofstaðir, in Mývatnssveit, in order to shed new light on the activities that took place in these buildings and their roles as social and economic spaces for Viking Age households.

Former Interpretations of the Functions of Pit Houses

When the first pit houses in Iceland were found by Thorsteinn Erlingsson[[5]](#endnote-5) and Þór Magnússon,[[6]](#endnote-6) they interpreted the buildings as *baðstofa* (literally ‘bathrooms’) based on the presence of ovens and heated stones, which could have had water thrown on them to create steam. This interpretation was heavily influenced by the unique description of a sunken building used as a steam sauna in the 13th-century *Eyrbyggja saga*,[[7]](#endnote-7) and there is no other literary or historical evidence to suggest that bathing was done in a specialised building, let alone a sunken one. In her review of references to *baðstofa* and bathing in medieval Icelandic texts, Nanna Ólafsdóttir argued convincingly that the term *baðstofa* referred to a livingroom rather than a specialised bathroom, and that ‘bathing’ in the modern sense of a full-body bath or a steam bath probably never took place in these rooms.[[8]](#endnote-8) While many archaeologists now dismiss the bath house theory in light of the finds and animal bones that are commonly found in pit houses,[[9]](#endnote-9) others have continued to suggest that bathing could still have been one function of pit houses.[[10]](#endnote-10)

One of the earliest explanations for the small size and semi-subterranean character of pit houses, and the one which is still favoured by many archaeologists, is that they were the first, temporary dwellings built by the earliest settlers. This was first proposed by Kristján Eldjárn following his excavation at Gjáskógar, where the pit house was found below a later longhouse.[[11]](#endnote-11) Other archaeologists have argued that pit houses are associated with the earliest settlement phases, and that their small size, simple design, and semi-subterranean character would have made them relatively quick and easy to build compared to the larger, ground-level dwelling houses.[[12]](#endnote-12) The argument follows that they were only occupied for a short period of time, and were later put to more peripheral use, or left to collapse, while their original function as a dwelling was replaced by the larger longhouses.[[13]](#endnote-13)

The arguments related to the stratigraphic phasing and short duration of use of pit houses will be revaluated below, but it should be noted from the outset that the internal organisation of the buildings differs markedly from the main residential buildings: they are not simply smaller, temporary versions of the larger houses. The most striking difference between them is the form of the fireplace and its location. While longhouses have long, central, open hearths, pit houses have fireplaces against one wall or in a corner, and these are almost always enclosed ovens made from upright stone slabs. Since the type of heating facility and its location in a building has a profound effect on how space is used and the nature of the social interactions that take place there, the unique presence of corner ovens has suggested to some scholars that either the functions of the buildings differed, or they were dwellings for different groups of people who had different ideas about how their living space should be organised and used.

It is this latter idea – that pit houses were so strikingly different from Viking Age houses that they may have been the dwellings of a distinct cultural group – that has recently been at the forefront of the pit house debate. The Polish archaeologist Przemysław Urbańczyk, noting similarities in the design of Icelandic pit houses and Slavic dwellings, suggested that Icelandic pit houses were built by a first generation of Slav settlers before they were culturally assimilated by the dominant Norse population.[[14]](#endnote-14) He argued that Icelandic pit houses are so similar to Slavic houses, and so different from contemporary ‘Germanic’ pit houses (German *Grubenhäuser*, Danish *grubehuse*, Norwegian and Swedish *grophus*), that they can only have been built by Slavs, or people who had grown up among Slavs and were accustomed to building and living in such dwellings.

Urbańczyk’s suggestion is problematic on several fronts. Although it is certainly true that Icelandic pit houses have many characteristics in common with Slavic pit houses, the Slavic versions date to the 6th-8th centuries, they were squarer than Icelandic pit houses, and the ovens were frequently capped not by a lintel stone but by several layers of small stones fashioned into a sort of vault.[[15]](#endnote-15) Moreover, since pit houses with stone-built corner ovens have indeed been found in northern Germany and Scandinavia from the 7th-8th century AD onward**s,**[[16]](#endnote-16) this building type need not have reached Iceland via Slavic immigrants. Slavs and southern Scandinavians were in contact well before the Viking Age, and these contacts intensified with trade across the Baltic during the 8th- 9th centuries, so Slavic pit houses may well have been the forerunners of the Scandinavian pit houses, as suggested by Holger Schmidt.[[17]](#endnote-17) Bjarni Einarsson has also drawn attention to the Sami Iron Age (AD 1-1700) pit houses in Finmark, some of which have a hearth in one corner.[[18]](#endnote-18) Whether the influence for this building type came from the far north or from south of the Baltic, it is clear that by the late 9th century when Iceland was being settled this building type was part of a repertoire being used throughout Scandinavia. While it is feasible that there was a small Slavic element in the population that settled in Iceland, pit houses are such a common feature on Icelandic Viking Age farms that if this building type were attributed to Slavic immigrants, it would indicate the presence of a Slav on at least 50% of farms. Considering that there has so far been a complete lack of Slavic material culture in Iceland, and there are no Slavic place names or personal names mentioned in the literary sources, it remains very unlikely that there were more than a few stray Slavs in Iceland.

The idea that Icelandic pit houses may have functioned as women’s work places was first put forward by Guðmundur Ólafsson following his excavation of the pit houses at Grelutóttir and Hjálmsstaðir, which contained many spinning and weaving implements.[[19]](#endnote-19) He concluded that the pit house functioned primarily as a *dyngja*, an Old Norse term for a women’s work place or dwelling where textile production was carried out. Barbara Crawford and Beverley Ballin Smith came to the same conclusion in their review of Icelandic pit houses, and attributed the same interpretation – and the same name – to the sunken building that they had excavated at the site of the Biggings, on Papa Stour, Shetland.[[20]](#endnote-20) This interpretation was heavily influenced by 13th- 14th-century Icelandic sagas and Norwegian farm inventories, where the term *dyngja* refers to the women’s quarters of a household – either a separate room in the house or a separate building – which was used for daily work such as weaving and sewing, as well as for bathing.[[21]](#endnote-21) Their physical appearance is rarely mentioned, but they are sometimes described as being dug down into the ground, and as having windows and stools.[[22]](#endnote-22) There are unfortunately no references to *dyngja* in older sources, so we cannot be certain that these rooms existed in the Viking Age. The term does not occur at all in Old Norse Eddic poetry, and although a ‘women’s room’ was named in a poem by the Norwegian *skáld* Þorbjörn hornklofi, dated to c AD 900, there is no indication of what this room was like, other than the fact that it had a fireplace.[[23]](#endnote-23)

The most recent interpretation of pit houses is Bjarni Einarsson's proposal that the pit house at Hólmur, in southeast Iceland, was a *blót* house where pagan cult activities took place.[[24]](#endnote-24) Einarsson noted that the building at Hólmur appeared to be a 'typical' pit house and his interpretation of the building as a *blót* house was based primarily on its context: its close proximity to a Viking Age grave and other features and deposits representing the remains of ritual activities. However, the building appears to have been stratigraphically *below* the cultural layers associated with the nearby cult activities,[[25]](#endnote-25) and as will become more evident below, in its form, internal features, the types of artefacts found in it, and the nature of its floor deposits, the pit house at Hólmur bears such a close resemblance to all the other pit houses that have been found on Viking Age farmsteads that the *blót* house interpretation seems difficult to justify. The interpretation of this pit house as a pagan cult building was heavily influenced by the mention of buildings called *blóthus*, *hof*, or *hörgur* in the Icelandic sagas and Eddic poetry, where activities associated with offerings, worship, and sacrifice took place,[[26]](#endnote-26) but this interpretation would have been difficult to deduce from the archaeological evidence alone.

These five different interpretations of Icelandic pit houses, all of which are problematic in their own way, suggest that either buildings of a very similar form had wide-ranging functions, or that the interpretations require some reassessment in light of new archaeological evidence. In the following sections, a multi-disciplinary, comparative approach is used to evaluate these interpretations – first by looking at the complete corpus of buildings excavated to date, several of which have not yet been published – and then by applying geoarchaeological and microrefuse analyses to the detailed study of one recently excavated pit house.

Distribution and Archaeological Contexts

A total of 22 pit houses have now been found on 15 different sites in Iceland; each of these sites contained one to five pit houses. Although their distribution is concentrated in the west, southwest, and northeast parts of the country, where the majority of excavations have taken place as part of large-scale research projects or in advance of modern development, it is clear from the distribution map (Fig 1) that they are not restricted to any one region, or to coastal or inland areas, and they appear to have been fairly common throughout Iceland. Of the 25 farm sites in Iceland where 'longhouses' have been at least partially excavated, and that can with certainty be dated to the Viking Age,[[27]](#endnote-27) 12 have pit houses. All the farmsteads apparently lacking pit houses have been only partially excavated, either because research concentrated on the large dwelling houses, or because rescue excavations exposed only a fraction of the farm. The recently discovered pit houses at Vatnsfjörður, Sveigakot, and Hrísheimar had been infilled and were therefore invisible on the ground surface; they would never have been found if the excavators had not been using open area excavation methods, which are a fairly recent introduction to Icelandic archaeology. Until more Viking Age farmsteads are fully excavated, the evidence suggests that most 9th- to 11th-century farmsteads in Iceland probably included a pit house.

The majority of pit houses –14 out of the 22 – were located on farm sites with large dwelling houses that were probably contemporary. Although some archaeologists have argued that where pit houses and longhouses have been found on the same site, the pit houses predated the construction of the larger dwellings and should therefore be interpreted as temporary shelters associated with the first colonisation of the site,[[28]](#endnote-28) it is not common for such a sequence to be demonstrable stratigraphically. Only two pit houses, Gjáskógar and Hvítárholt X, are directly surmounted by a large Viking Age dwelling house. Of these two, the one at Hvítárholt could easily have been contemporary with one of the other large dwelling houses on the site, of which there were three. The Viking Age middens that infill several pit houses, at Hofstaðir, Sveigakot, and Hrísheimar, for example, provide dates that span the late 10th-11th centuries, and can only verify that the pit houses were definitely abandoned by that date, not that they were constructed as the temporary dwellings of Iceland's first settlers in the late 9th or early 10th centuries (Table 1). The typological and radiocarbon dates of material recovered from the occupation deposits in the pit houses consistently overlap with those of the large dwelling houses on the same site. At the sites of Hjálmstaðir, Hrísheimar, Ljótólfsstaðir, and Stóraborg, where no large dwelling houses contemporary with the pit houses were investigated, the pit houses’ seemingly isolated position can be attributed to the incomplete survival or excavation of the sites. The vast majority of pit houses were not isolated buildings, but were located on Viking Age farms, where they were merely one of several outbuildings.

There are three apparent exceptions to this rule: the pit houses at Gjáskógar, Háls, and Hólmur, which have been interpreted as being outside the context of a farm site, although Gjáskógar and Háls did become farms in the high medieval period.[[29]](#endnote-29) Gjáskógar and Háls were upland sites, and based on the pit houses’ association with slag and charcoal, their excavators argued that the pit houses were periodically inhabited by one or two people from nearby farms who were sent out to these sites during the iron extraction season in order to exploit the available woodland and to produce the charcoal needed to smelt bog iron. Since neither of these pit houses were fully recorded, it is not possible to take their interpretation any further, but it is proposed here that the pit house at Hólmur was constructed before the site began to be used for burials and other cult activities, and that it functioned rather like Gjáskógar and Háls. The slag and iron bloom found on the cult site, interpreted by the excavator as offerings, suggest that iron sources were available close by and continued to be exploited.

PIT HOUSE FORMS, Associated FEATURES AND FINDS

Construction Methods

Of the 22 pit houses that have been excavated in whole or in part, 20 have been recorded in sufficient detail to make it possible to compare their size, form, and internal features (Table 2, Figs 3-8). The pits themselves reached depths of 0.3-1.2 m from the original ground surface, and in a couple of cases had been built into a slope so that one end of the structure was slightly deeper than the other (Eiríksstaðir and Hrísheimar H). Granastaðir 3 is so far the only pit house to have a narrow turf-built revetment wall on the inside of the cut (Fig 4c).[[30]](#endnote-30) However, at Vatnsfjörður, where the pit house had to be dug into underlying gravels, strips of turf had been placed along the edges of the cut – seemingly to prevent the gravel from slumping, and at Hvítárholt I and Ljótólfsstaðir stone slabs were propped up against the walls, presumably for the same purpose (Fig 4e).[[31]](#endnote-31)

In the vast majority of cases, turf walls were not found in association with pit houses, suggesting that timber walls were the norm. Pit house 6A at Háls, the only one to have a turf wall rising above the edges of the pit, has already been discussed as anomalous because it was not located on a farm. The turf ring wall surrounding Hofstaðir G could not have functioned as a structural wall because it was set back 0.5-1.0 m from the edge of the pit; the pit house was essentially a sunken timber building ringed by a sheltering turf wall (Fig 8a). This construction method is in marked contrast to the walls of the main dwelling houses on Icelandic farmsteads, which are invariably constructed of turf c 1.5 m thick, sometimes with a stone lining at their base. The tendency for pit houses to have timber walls cannot be coincidental – other small outbuildings at Vatnsfjörður have turf walls, for example – and it must be related in some way to the function of the building. Since timber walls are much less insulating than turf, but make it possible to have windows, it is proposed here that windows for light and/or air circulation were needed for the tasks carried out in the buildings.

Since most of the pits were 0.5-1.0 m deep, the structures were semi-subterranean, and it can be assumed that their walls rose 1.5 m or more above the edges of the pits. At Granastaðir 3, Sveigakot T1, and Hrísheimar H access into the pit was gained via a short ramp, for which a cut had been made in one corner of the house. In all other pit houses – 85% of cases – there was no cut for the entrance, and access into the pit must have been gained via wooden steps descending from a door at ground level. The ring wall around Hofstaðir G did not have a gap for an entrance, so access must have been gained by walking *over* the low turf wall via steps, through a door in a timber wall, and down another flight of steps or a short ladder into the pit.

In comparison with the main dwelling houses pit houses were very small buildings, but their dimensions did vary. The vast majority had an internal area of 8-16 m2 and the smallest pit houses, at Hólmur and Stóraborg, reached sizes of only 4.4 and 4.8 m2 respectively (Table 2; Fig 7). If these buildings were ever used as dwellings (see discussion below), it could only have been for a very small number of people – one or two at the most. Most pit houses were rectangular in shape, with width to length ratios of 1:1.3 to 1:1.9. However, the pit houses at Eiríksstaðir and Hólmur were square, and those at Granastaðir, Ljótólfstaðir and Stóraborg were nearly so. As will become clear below, variations in the sizes and shapes of pit houses does not appear to be related to the internal features or functions of the buildings.

The interior skeleton of roof-supporting posts varied considerably, but in most cases the interior edges of the pits were lined with posts set in post holes or on post pads, which would have supported sill beams and the wooden staves or panels used for the timber wall construction. Interior posts were also common, and several pit houses appear to have their interior space divided between three aisles, the boundaries of which were marked by posts, in common with the central living spaces of the larger dwelling houses. The buildings must have had pitched roofs, but end posts for the direct support of the ridgepieces can only be identified with certainty at Grelutóttir II, Hrísheimar H, Sveigakot T1, Hvítárholt I and IV and Vatnsfjörður 10. The fact that the floors of most pit houses are sealed by turf collapse layers indicates that their roofs were commonly covered with turf.

Pin holes

In addition to post holes, 72% of the pit houses whose floors were fully excavated also contained very small holes, 1-3 cm in diameter, called ‘stake holes’ or ‘pin holes’ (Icelandic *pínhólur*) in the literature. These holes tended to be lined or filled with dark, charcoal-rich floor sediment, making them impossible to see until the floor was fully excavated (as it often was not in earlier excavations). Pin holes were sometimes present in extraordinarily high numbers: Hofstaðir G had 77, Hrísheimar C had 87, Granastaðir 3 contained at least 50, and the earlier phase of the pit house at Hjálmsstaðir had no less than 200. These small holes were not evenly spaced across the floor,[[32]](#endnote-32) but tended to occur in clusters. When these small holes first began to appear in pit houses, they were interpreted as the remains of supports for platforms or benches along the walls.[[33]](#endnote-33) Considering their erratic and clustered distribution, however, this interpretation seems highly unlikely.

It is most likely, as Mjöll Snæsdóttir and Guðmundur Ólafsson[[34]](#endnote-34) have suggested, that the pin holes were created by an activity that involved narrow rods being pressed into the floor. Few artefacts found in the Viking Age archaeological record are of a size or shape that could conceivably have made such holes. One possibility, though few have been found, are the rod-shaped iron stands with open baskets at the top to hold lamps; these had tapered shafts that would have been set upright in an earth floor.[[35]](#endnote-35) Alternatively, based on images of women spinning in medieval manuscripts,[[36]](#endnote-36) Guðmundur Ólafsson argued that the pin holes were made by the end of a long distaff, a narrow rod that was braced by the knees or pushed into the ground, and used to hold raw wool fibres during spinning.[[37]](#endnote-37) Most Viking Age distaffs identified as such in the archaeological record are wooden and only 0.3-0.4 m in length.[[38]](#endnote-38) Rather than being set into the ground, these short distaffs are thought to have been held in one hand, or tucked under an arm or fixed to a belt, leaving both hands free to draw out the fibres and twist the yarn around the spindle. However, many 0.75-1.04 m long staffs have been found in women's graves in Scandinavia, made of either iron or wood (where preservation conditions permitted survival), with 1-2 cm thick square shafts that taper to a point at one end and have open-work ‘handles’ and/or suspension rings at the other end. Although it has been convincingly argued on the basis of archaeological and literary evidence that these long staffs – particularly the iron ones – were probably used as staffs of sorcery by female magic-workers,[[39]](#endnote-39) it has recently been pointed out that this special use could be derived from the concept that magic and fate were spun, and the *seiðr* staffs were probably symbolic distaffs.[[40]](#endnote-40) It does seem most likely that the pin holes commonly found in Icelandic pit houses were created by the tapered end of a long distaff (perhaps made of iron but more probably wood) and that spinning was a common activity in these buildings.

Furnishings

In 60% of pit houses it was possible to identify furnishings along at least one wall. Raised platforms constructed of earth or turf, preserved up to a maximum height of 30 cm, were found at Grelutóttir I, Stóraborg, Hvítárholt V and VII, Sveigakot T1 phases 3 and 4, and Vatnsfjörður 10. In other pit houses, 0.5-1.5 m wide areas along the edges of the pit where floor deposits were either absent, unusually thin, or loose, have been interpreted by the excavators as the likely locations of wooden platforms, although any type of floor covering would have produced the same effect (Figs 3-6). Like the similar platforms in the side isles of the larger dwelling houses, these areas were probably used for sitting and working, and although such a function could never be proven, they could also have been slept on by one or two people.

Small areas paved with stones were found in seven pit houses, presumably used to manage muddy floor surfaces or to act as foundations for wooden furnishings. The only other clear examples of inbuilt furniture were the stacked stone constructions of unknown function that were found on the east gable walls of both of the Grelutóttir pit houses (Fig 3d-e). The alleged barrel pit in the northeast corner of Hrísheimar H (Fig 4e) may actually have had another function, since the bases of barrel pits are usually flat. Two shallow pits, both about 40 cm in diameter, were also found underlying the floor layer of Hofstaðir G, and were therefore associated with the first phase of the building (Fig 8a).[[41]](#endnote-41) The pit near the west side of the house was 10 cm deep, and contained a grey-blue clayey fill, which suggests that the soil had been gleyed by saturation with water. The pit close to the centre of the building was only 7 cm deep, and its basal fill was a thin layer of ash and charcoal; whatever this pit had contained, it was removed and infilled with ash prior to the accumulation of the upper floor deposit.

Corner or Side Ovens

All pit houses contained a fireplace, and without exception the fireplaces were positioned against a wall or in a corner of the structures. Nearly all of them were constructed using a particular technique, never seen in longhouses, in which three standing vertical stone slabs created a box that was surmounted by a horizontal lintel stone (Fig 6). There is also some evidence in the form of collapsed stone slabs, linear grooves, or curb stones on the inner side of the fireplaces that at least some of them had had a fourth vertical stone propped up against their front, which could have acted as a door.[[42]](#endnote-42) In those few cases where upright slabs were not recovered, such as at Háls 6A, Hrísheimar H, and phase 2b of Sveigakot T1, it is actually possible that the slabs were removed for reuse when the building was abandoned, as had clearly been done at Hofstaðir G and Hvítárholt VII.[[43]](#endnote-43) Fireplaces lined and capped with stone slabs would have been effective at containing heat, raising the temperature of the fire, and, perhaps most importantly, they would have contained sparks – even more so if a stone slab had been placed across the front of the feature. These enclosed fireplaces must have effectively functioned as ovens or stoves (Icelandic *ofn*), and would have been particularly suitable for such functions as roasting and baking, and/orradiating heat and therefore keeping pit houses warm and dry without the risk of sparks that comes with an open fire. Since this type of fireplace was restricted to pit houses, and has not yet been found in the larger dwelling houses, we may assume that its function was intimately related to the function of these buildings.

Occupation Deposits

The composition of the occupation deposits in pit houses gives further indication of what they had been used for and their duration of use. The floor deposits themselves varied in thickness, but they were only described as ‘thin’ in Hvítárholt V, VII, and X. In most pit houses, the thickness of the floor deposit was variable, depending on whether the measurement was taken in the centre of the building or near the edges, where there may have been wooden platforms or other floor coverings. Where the accumulations were thickest, they were recorded as being up to 2 cm (Gjáskógar, Hofstaðir G), 4 cm (Grelutóttir I, Hjálmsstaðir phase 2, Hvítárholt I), 5 cm (Stóraborg, Vatnsfjörður 10), 6 cm (Eiríksstaðir, Granastaðir, Hjálmsstaðir phase 1), 7 cm (Hólmur), and even up to 10 cm thick (Grelutóttir II). Moreover, several pit houses had multiple occupation phases. In parts of Hvítárholt V, for example, there were two floors, one on top of the other. The Hjálmsstaðir pit house also had two distinct occupation phases, each with a separate oven and a thick floor deposit, and there were two distinct phases of floors at Vatnsfjörður 10, the second of which was associated with a sitting platform and post pads that had been placed over earlier post holes. Overlapping post holes and post pads in both Vatnsfjörður 10 and Hofstaðir G indicate that the buildings experienced at least two episodes of post replacement and repair, and they must therefore have been occupied for a number of years – probably for several decades.[[44]](#endnote-44) The most extreme case of long-term occupation was Sveigakot T1, which had four distinct occupation phases, each with distinct floor deposits and associated fireplaces and sitting platforms.[[45]](#endnote-45) In most cases, therefore, the thickness of the accumulated floor deposits and the complexity of the lives of the structures are comparable to the larger dwelling houses, and do not support the interpretation that their occupation was short-term or temporary.

All the floor deposits were dark brown, black or dark grey in colour, and were mainly composed of organic matter and finely comminuted wood charcoal fragments, often with grey wood ash more predominant in and around the fireplaces. Unfortunately, archaeobotanical analysis has not been conducted on the deposits on floors or in ovens, with the exception of a brief assessment of the floor deposits in Hofstaðir G – an assessment that produced one charred barley grain (*Hordeum sativum*) and one seed of the vegetal weed *Spergula arvensis*[[46]](#endnote-46) – and it is therefore impossible to generalise about the types of charred plant remains that were produced in pit houses.

Significantly, the occupation deposits of over 90% of pit houses contained large numbers of ‘heated stones’: fist-sized stones which were blackened and/or fire-cracked from being heated in a fire. Stones heated in this way are thought to have been commonly used to roast meat in cooking pits or to heat liquids; in Iceland they were used for the latter as late as the 16th century.[[47]](#endnote-47) Since cooking pits were only found in the vicinity of one pit house (Hólmur, where they might not be contemporary), the heated stones commonly found in pit houses were almost certainly used to heat liquids.

Small fragments of bone and burnt bone were also commonly found embedded in pit house floor deposits (Table 3). They were recorded in 56% of pit houses, but considering that bone was not systematically collected or recorded during older excavations, the number of pit houses containing bones could well have been higher. It is impossible to know whether meat and fish were cooked in the pit houses or whether they were cooked elsewhere, but the presence of bones does indicate that they were at the very least consumed in pit houses. Cooking does not normally result in the burning of bones, and the presence of burnt bones in the floor deposits indicates that bones were occasionally discarded in the fire and were subsequently spread around the building along with fuel ash residues.

Artefacts

Few artefacts have been found in the floors of pit houses, suggesting that most usable objects were removed when the buildings were abandoned, but of the artefacts left behind it is clear that implements involved with textile production dominate (Table 3). The most common artefacts in pit houses are perforated stone weights used to stretch the warp threads of upright looms, which have been found in around 78% of pit houses. Several houses contained only one loomweight, which alone is not enough to suggest that a loom had once been in the building, but most contained three or more, and at Hólmur four loomweights were found directly adjacent to the house in addition to the one that was found in the floor.[[48]](#endnote-48) At Hrísheimar C, seven loomweights were found lying in a row, which strongly suggests the location of a dismantled upright loom,[[49]](#endnote-49) and equally convincing are Grelutóttir II and Hofstaðir G, which had 13 and 19 loomweights respectively.[[50]](#endnote-50) If it was common for weaving to take place in pit houses, as it seems to have been, this could explain the need for a good source of light, and the tendency for pit houses to have timber walls, which facilitate the construction of windows.

The second most common artefacts were spindle whorls, which were found in 33% of pit houses. Most pit houses contained only one, but Hofstaðir G and Granastaðir 3 contained two and three spindle whorls respectively. Viewed in conjunction with the pin holes that were probably created by distaffs, it would seem that spinning was an important activity in pit houses. Other tools that would have been used for textile production included a whalebone weaving sword, which was found in Hvítárholt IV, the iron tooth of a wool comb, which was found in the early phase at Hjálmsstaðir, and a pair of iron shears (scissors), which were found in the floor of Hvítárholt X.

Other objects commonly found in pit houses are iron nails, whetstones, iron knives and flint strike-a-lights, which unfortunately provide little additional information about how these buildings were used. Flint strike-a-lights would have been used in any structure where a fire was lit, and knives were multifunctional tools used in a very wide range of everyday tasks. Similarly, whetstones, which were found in Grelutóttir II and Hvítárholt I, are amongst the most common objects found on settlement sites, and they may be expected to be found wherever knives were used. Stone lamps, such as the one found in the early phase at Hjálmsstaðir, are much rarer in comparison, but they would have been useful in any building, especially during the dark Icelandic winters, and are not indicative of a specific activity. Besides the implements used in woollen textile production, the only objects found in pit houses that are diagnostic of a particular activity are the steatite pot fragments, which were only found in Hólmur and Hvítárholt X. Looking at the assemblage as a whole, therefore, it is striking that nearly every pit house contained heated stones that had probably been used to heat liquids, as well as objects that had been used in woollen textile production.

A Geoarchaeological and Microrefuse Study of Pit House G at Hofstaðir, Northeast Iceland

Rationale and Methodology

In light of the important role that artefact distributions have traditionally played in the interpretations of archaeological buildings and activity areas, it is important to note that world-wide ethnoarchaeological studies have shown that very few artefacts enter the archaeological record in the precise location where they were used. Objects may be discarded when they are broken or no longer useful, but discard usually takes place outside buildings, often in designated rubbish heaps.[[51]](#endnote-51) It is not common for refuse to be left on living floors while buildings are in use – especially if it is large, sharp or noxious – and objects that are accidentally dropped and broken are usually removed by hand if they are large enough to be seen.[[52]](#endnote-52) Larger objects also tend to be kicked or swept to one side of heavy traffic areas, causing them to accumulate in corners or against the edges of walls or furnishings, leaving only the smallest objects *in situ* where they were used.[[53]](#endnote-53) Discard practices do tend to change when a building is about to be abandoned, which may result in more rubbish accumulating on floors, but during the abandonment process the objects left behind tend to be the ones that were too heavy or not valuable enough to move, or that were intentionally placed or left in the building as part of a ‘closing deposit’.[[54]](#endnote-54) Archaeologists must therefore be aware that although the *presence* of artefacts on the floor of a building may be suggestive of the activities that took place there, the *precise locations* of larger artefacts (e.g. those over 1-2 cm in size) may be a less reliable source of information about the spatial organisation of activity areas than those of finer residues. For this reason, it is beneficial to study floor deposits using several different analytical techniques, including the distributions of microscopic residues and chemical properties, when trying to ascertain the locations of activity areas.[[55]](#endnote-55)

The use of artefact distributions to characterise the function of pit house G at Hofstaðir, in Mývatnssveit, was fraught with all the usual difficulties. There were few artefacts on the floor of the building, and almost all of them were loomweights: ten of them recovered with the occupation deposit, context 9, and a further five that had been resting on the floor and were recovered with the overlying collapse deposit, context 8.[[56]](#endnote-56) These loomweights were scattered close to the north, west, and south edges of the building (Fig 8a), but if these find spots represented their locations of use, there would have been a loom leaning against each of these walls, which cannot have been the case – at least not at the same time. It is most likely that a loom leaned against the northern wall of the pit house, where most of the loomweights were clustered, four of them in pairs, and where there was a row of shallow depressions that might represent the imprint of a loom's feet.[[57]](#endnote-57) The only other objects in the floor were a composite bone comb, a small iron loop, and a basalt stone interpreted as a hammerstone, all found close to the robbed-out fireplace in the northwest corner, which can provide little insight into the function of the building. A few objects also came from the primary collapse of the building, and are probably associated with the use of the building, including two spindle whorls, an iron hook, and a whetstone.

In order to improve the understanding of how Hofstaðir G was used, a detailed geoarchaeological and microrefuse study was conducted on its floor deposits. When the pit house was excavated, the floor layer was exposed in opposing quadrants, and the resulting sections, which ran through the two main axes of the building, were used for the collection of undisturbed block samples for micromorphological analysis (Fig 8b).[[58]](#endnote-58) After being impregnated with resin and thin sectioned, the micromorphology samples were analysed on petrographic microscopes at magnifications ranging from x5 to x250,[[59]](#endnote-59) which made it possible to quantify the mineral, organic, and artefactual components of each microstratigraphic layer in the floor sediment, to detect differences in compaction across the floor (i.e. areas of heavier and lighter foot traffic), and to detect any truncation episodes or post-depositional processes such as leaching or bioturbation.

Once fully exposed, the entire floor deposit was collected on a 0.5 m grid totalling 64 sampling squares (Fig 8b).[[60]](#endnote-60) The first samples to be taken were c 300 ml bulk samples for the quantification of organic content, pH, electrical conductivity (a proxy for soluble salt content), magnetic susceptibility, and multiple elements.[[61]](#endnote-61) The remaining sediment in each grid square, if any, was used for microrefuse analysis; its volume was measured, it was wet-sieved, and its contents were analysed to the 1 mm size fraction in order to study the concentrations of minute fragments of bones, burnt bones and artefacts in each litre of sediment. The geochemical and microrefuse values were plotted on the plan of the house using ArcView GIS and analysed to determine if there were any activity areas – perhaps not visible in the field – that were characterised by peaks or falls in the quantities of particular microresidues.

Field Description of the Occupation Deposits in Hofstaðir G

The floor deposit in Hofstaðir G was given two context numbers in the field, 9a and 9b, which reflected the variation in its character and composition, and were thought to relate to how space had been used in different parts of the building.[[62]](#endnote-62) The floor was 10-15 mm thick in the centre of the building, increasing to a thickness of 80-100 mm around the fireplace in the northwest corner, where part of it had been cut away when the stone slabs of the fireplace were removed (Fig 8a). In this central part of the building and around the fireplace the floor deposit (context 9a) appeared pitch-black, compact, and greasy. The disturbed fill of the fireplace itself was a mixture of charcoal-rich soil and grey ash, and underneath this mixed sediment the natural subsoil had been reddened by heat. Along the east side of the pit house and in the southwest corner the floor deposit was very thin and patchy (2-5 mm thick), and consisted of a smear of fine charcoal with some thin patches of cream-yellow-green material that appeared to be decomposed organic matter (context 9b). The boundary between contexts 9a and 9b in the eastern third of the pit was closely associated with a post pad and several post pad depressions, suggesting to the excavators that the space in the eastern third of the building might have been covered with a wooden bench or platform.[[63]](#endnote-63) A thin iron pan had formed under the thin floor deposits on the east side and southwest corner of the pit house; it became thicker on the eastern edge of the building where it coated the insides of the post holes. Upon the removal of the floor layer, 77 small depressions, most c 10 mm in diameter, were found scattered across the floor everywhere except for the eastern side of the building. Gavin Lucas interpreted these holes as indicative of moveable furniture, though he did not suggest what this furniture might have been.[[64]](#endnote-64) These match the description of the *pínholur* found in many pit houses, which were interpreted by Guðmundur Ólafsson as the result of distaffs being pressed into the floor.

Microrefuse Analysis

The distribution of burnt and unburnt bones in the floor deposits of Hofstaðir G revealed some interesting patterns (Fig 9). The largest unburnt bones in the microrefuse samples were only 4-10 mm in size and all of them were fish. These were concentrated within two sampling squares on the eastern edge of the central floor deposit, context 9a, directly opposite the fireplace. It is most likely that these bones were dropped while fish were being consumed or hammered to soften them prior to consumption, and that this spot, facing the fireplace, was a favoured sitting place. Since ethnographic and experimental work on trampling has shown that larger objects tend to accumulate against physical barriers, either because they get kicked out of the paths of heavy traffic, or because they are protected there from trampling and further breakage (the so-called ‘fringe effect’),[[65]](#endnote-65) it is also possible that the fish bones accumulated in this location because they had come to rest at the edge of a piece of furniture. Either way, the results support the excavator's suggestion that the boundary between the thick, black central floor deposit and the thin, patchy deposits on the east side of the building represents the edge of a wooden bench or platform.

Bone fragments under 4 mm in size were concentrated within and immediately around the fireplace in the northwest corner of the building; almost none were found in the southern half of the pit house (Fig 9). It therefore seems that the area around the hearth was the focal point for activities involved with the processing and/or consuming of fish and animal foods. The presence of bones in the fireplace itself indicates that they were intentionally tossed into the fire to dispose of them and/or to feed the fire, and this is further supported by the high concentration of burnt/calcined bones – both fish and mammal – in and around the hearth. The largest burnt bones, up to 20 mm in size, were mainly concentrated within the fireplace itself, but there was also a small concentration 1 m south of the fireplace, on the west side of the building. This same sampling square also exhibited an elevated magnetic susceptibility value (Fig 10; see discussion below), and viewed together it is highly likely that this represents the location of a dump of burnt bones, soil, and ash resulting from cleaning out or dismantling the fireplace. The highest concentrations of 1-2 mm and 2-4 mm burnt bone fragments were immediately east of the fireplace, in a location also marked by elevated potassium, calcium, and related pH values (Figs 9-10), which are commonly associated with wood ash.[[66]](#endnote-66) This multi-layered evidence suggests that this was where ash and burnt bones were swept out of the fireplace, and probably indicates the location of the ‘front door’ of the oven. From this spot, spreading south along the central axis of the building, there was a consistent presence of minute burnt bones, most under 2 mm in size. These burnt bone fragments must have reached the southern half of the pit house either by being trampled, swept, or intentionally spread there with ashes from the fireplace – a common practice in Iceland in the 19th-20th century.[[67]](#endnote-67) The highly fragmented state of the bones in the central floor area is suggestive of a zone of heavy trampling,[[68]](#endnote-68) a view supported by the micromorphology of the sediments in this area, which will be discussed further below.

Geoarchaeological Analyses

The field descriptions of the occupation deposits in Hofstaðir G were strongly supported by subsequent geoarchaeological analyses, but this analytical work also permitted the identification of activity areas that had not been observed in the field. The sediments within and adjacent to the dismantled fireplace in the northwest corner of the building had elevated magnetic susceptibility values (Fig 10), which can only be due to the effects of heating on the underlying soils, and contradicts the excavator's hypothesis that the fire burned on top of the oven's lintel stone, rather than inside the fireplace.[[69]](#endnote-69) The sediments in and around the fireplace also contained high concentrations of the elements commonly associated with wood ash, including phosphorus, calcium, potassium, and magnesium (Fig 10).[[70]](#endnote-70) The high pH of the sediments in the fireplace is linked to the concentration of the alkaline elements calcium, potassium, and magnesium, and more specifically to the presence of fine-grained calcium carbonate, which had been visible in the field as grey, silty wood ash.

In a 1 m-wide area around the hearth and in the strip of floor running through the north-south axis of the building (context 9a) loss-on-ignition revealed elevated levels of organic matter (Fig 10). There were also elevated levels of a series of elements that tend to be taken up by and stored in plants (phosphorus, barium, strontium, copper, and zinc) and which will therefore rise to above-average concentrations where plant tissues or their ash residues have been deposited (Figs 10-11). Although loss-on-ignition at 550ºC cannot distinguish between charred and uncharred organic matter, the four micromorphology samples taken around the hearth and in the central floor area showed that both charred wood and uncharred herbaceous plant material were major components of floor deposit 9a (Fig 13a-d).

Moreover, the microstratigraphy visible in thin section indicated that context 9a had at least two phases, which were characterised by different relative concentrations of charcoal and herbaceous plant material (contexts 9a.1, 9a.2 and 9a.3; see Fig 12 and Table 5). The uppermost phase, context 9a.1, was characterised by minute horizontal lenses under 1 mm in thickness, which contained 40-70% compacted, highly fragmented charcoal (concentrations varied slightly in different thin sections), most of which was under 1 mm in size (Fig 13a-b). It was this high concentration of charcoal that had given context 9a its distinctive black colour in the field. Context 9a.1 also contained around 2-5% amorphous organic matter – plant material so highly decomposed that its cell structure was no longer apparent and it could not be identified – and it is this decomposed organic matter that was responsible for the so-called ‘greasy’ consistency of the floor layer. Some of this decomposed organic matter was intimately mixed with the fine mineral material and charcoal in the floor, but some of it was still *in situ*, visible as long, narrow, pale-brown strands, or was partially infilling the voids being left behind as it shrank (Fig 13b). The burnt and unburnt bone fragments that had been recovered in the microrefuse samples could be observed *in situ* in the micromorphology samples, where they were present in quantities of 0.5-2%. As can be seen in Figs 13a-b, these bone fragments often occurred together in micro-lenses, where the elongated fragments were invariably horizontally or sub-horizontally oriented, indicating that they had come to rest on a compacted, gradually accruing surface.

With the exception of the amorphous organic matter, the bulk of the material making up context 9a.1 derives from the oven in the northwest corner of the pit house, and its high level of fragmentation is indicative of a high level of trampling, though some of the silt-sized charcoal may also have originated as air-borne soot that settled on the floor surface. Compaction by trampling was also evident in the low porosity of the floor layers relative to the layers of turf collapse above them (context 8) and the natural soils below them (context 3), and from the presence of horizontal planar voids, which are created by vertical pressure, and are commonly observed in silt-textured or loamy floor sediments (Table 4).[[71]](#endnote-71) Context 9a.1 had an extremely sharp lower boundary, which must have been created by a truncation event such as the floor being shovelled out – a practice that was common in turf houses in Iceland until the mid-20th century.[[72]](#endnote-72)

Below this black floor horizon there was a 4-8 mm thick layer, context 9a.2, which contained much less silt-sized charcoal (only around 5%), but much higher concentrations of amorphous organic matter, reaching up to 20-30% in Sample HST99-8 in the southern part of the pit house (Fig 13c-d, Table 4). In areas where this layer had not been heavily bioturbated (a problem exacerbated by the palatability of this organic-rich layer to soil fauna), long strands of herbaceous plant matter were still visible, often accompanied by the rod-shaped phytoliths typical of grasses (present in quantities of 2-5%). The micromorphological evidence therefore suggests that this earlier phase of the floor represents a period of use in which activities taking place in the building resulted in the deposition of grasses and other herbaceous plant materials. This could have involved, for example, the processing of plant foods, and in this context it is interesting to note that a charred grain of six-rowed, hulled barley (*Hordeum sativum*) and a charred seed of the segetal weed *Spergula arvensis* were found in the floor and were interpreted as indicative of food preparation in the pit house.[[73]](#endnote-73) It is also possible that grass or straw was intentionally strewn on the floor in order to ‘sweeten’ it and to keep it dry. If this were the case, the shovelling out of this organic-rich layer and the subsequent increase in charcoal and ash deposition would suggest a change in floor maintenance practices during the life of the house.

In a couple of samples context 9a.2 also contained a significant proportion of large charcoal fragments (1-10 mm) and in the southern part of the central floor deposit larger charcoal fragments embedded in the amorphous organic matter reached concentrations of 20-30% (Fig 13c, Table 4). The lowermost lens in Sample HST99-8, context 9a.3, contained 5-10% charcoal fragments, some of which reached 8 mm in size, as well as 10-20% finely comminuted charcoal under 1 mm in size (Fig 13c). So far from the fireplace, the large charcoal fragments in these lower phases of the floor deposit could only have been the result of intentional dumping. There is also ample evidence in the form of low porosity and the presence of horizontal planar voids in and immediately below contexts 9a.2 and 9a.3 that in this earlier phase the central floor area was heavily compacted by trampling (Fig 13c-d; Table 4). Throughout its life, therefore, the central aisle of the building appears to have served as a corridor for foot traffic: the main route by which people moved from one end of the building to the other.

 In contrast, the southwest corner and the eastern side of Hofstaðir G, where the thin and patchy floor context 9b was located, appear to be quite distinct activity areas, and the geochemical results provided some interesting insights into what might have been done in these areas. Most of the southwest corner of the pit house had levels of organic matter and associated elements that were far below the mean (Figs 10-11). However, one 50x50 cm sample square in this area had highly elevated values of phosphorus, calcium, potassium, magnesium, barium, strontium, copper, zinc, and sodium, which are closely associated with organic matter and its ash. Since these elements did not accumulate with organic matter (in which case the area would have had high loss-on-ignition values as well), they must have infiltrated the soil in solution, and accumulated in the pores or impregnated the fine soil material. A solution of water and wood ash, which would have high concentrations of all of these elements, would be an alkaline lye, historically commonly used for cleaning and bleaching.[[74]](#endnote-74)

In the context of this discussion, it is also worth considering the possible function of the 10 cm deep pit found next to the west wall of the pit house, at the boundary between the ash-rich deposit, 9a, and the thin floor deposit under consideration here (Fig 8a). This pit had clearly belonged to an early phase of the pit house, since it was cut by six small pin holes and covered by a thin floor deposit. The fill of this pit was unlike any other sediment on the site: it was a grey-blue, clayey gleyed soil – one which had been saturated by water and in which reducing conditions had caused the mobilisation and leaching of iron. The occurrence of such localised gleying suggests the location of a container holding a liquid that was made of a slowly permeable substance, such as wood or coarse-grained stone. Considering both sources of evidence for liquid entering the floor deposits in the southwest corner of the building – some of it rich in elements associated with lyes – it is proposed that washing was one of the activities that took place in this corner of the pit house.

The eastern side of Hofstaðir G, which also had a very thin floor layer (context 9b), and which was thought by the excavators to have been covered by a wooden bench or platform, had a unique geochemical signature in the form of exceptionally high electrical conductivity values: 3000-4000 times higher than in other parts of the pit house (Fig 11). The survival of such high concentrations of soluble salts indicates that the eastern third of the pit house was the location of a distinct activity. In order to determine which salts were responsible for these elevated levels of electrical conductivity, statistical correlation analyses[[75]](#endnote-75) were conducted and the distribution map of electrical conductivity values was visually compared to all of the element distributions (Table 5, Figs 10-11). This revealed that only the elements sodium, aluminium and iron were positively correlated with the enhanced soluble salt content on the eastern side of the pit house. Iron and aluminium, the dominant elements in the local andisols and the main components of the iron pan that was underlying the thin floors, are unlikely to be derived from human activities. However, the high sodium levels on the eastern side of the pit house must be a result of activities taking place in this area. It is also possible – even likely – that the electrical conductivity levels were enhanced by the presence of elements not detectable by ICP-AES, such as nitrogen and chlorine, which have common salt-forming ions: ammonium (NH4+), nitrate (NO3-), nitrite (NO2-), and chloride (Cl-).

The substances with significant salt content that could conceivably have been present on a Viking Age farm in Iceland are seawater, precipitated sea salt, seaweed and urine, and one or more of these substances must have been present in significant quantities on the eastern side of the pit house. 85% of the salt-forming ions in solution in seawater are sodium (Na+) and chloride (Cl-), but it also contains smaller quantities of sulphate (SO42-), magnesium (Mg2+), calcium (Ca2+), potassium (K+) and bicarbonate (HCO3-). When seawater evaporates, the solid salts that are precipitated include sodium chloride, potassium chloride, and calcium sulphate (gypsum). Sea salt, whether obtained by evaporating seawater or by burning seaweed, could have been used as a preservative for meat, fish, or butter.[[76]](#endnote-76) In addition, sea water and the alkaline solution (lye) created by mixing seaweed ash with water could be used for activities such as cleansing, bleaching or dyeing, which requires salt as a mordant. However, neither seaweed nor seawater were readily available at the inland site of Hofstaðir.

Urine, on the other hand, would have been abundant and could easily have been stored in barrels. Chemically, urine is composed of nitrogen-rich urea (2%), ammonia (0.05%), and uric acid (0.03%), in addition to c 2% dissolved salts, of which the most common are chloride, potassium, sulphate, phosphate and sodium. Micromorphology sample HST99-4, which was taken close to the western edge of context 9b in the eastern third of the pit house, did not contain any optically visible salts in the form of crystalline pedofeatures. This means that the ions or ionic compounds responsible for the high electrical conductivity values were not present in the form of crystals such as sodium chloride or calcium sulphate (gypsum), common precipitates of seawater. Rather, they must have been bonded with fine mineral or organic materials in the matrix of the soil, where they remained optically invisible. This suggests that they were derived from urine rather than sea salts, for solutions that contain many different ions, including urine, rarely form defined salts after the evaporation of the water.

In thin section it was possible to see that the thin, patchy smears of dark-coloured floor sediment on the eastern side of the pit house were mainly composed of 2-5% minute charcoal fragments under 1 mm in size, but there were also localised concentrations of dark brown fungal spores (Table 4, Fig 13e-f). Fungal sclerotia and fungal spores were present in trace amounts in all the thin sections examined, but this is the only place where the fungal spores reached a frequency of 0.5-1%. This is likely to be significant, for although thin sections from all the Viking Age buildings at Hofstaðir have been studied, the only other context where large numbers of fungal spores were present was the cess pit in the lavatory, structure E2. Concentrations of fungal spores indicate conditions favourable for the growth of fungus in this part of the pit house, which could be linked to nitrogen enrichment and the presence of urine. The storage and spillage of urine on the eastern side of the pit house would also account for the cream-yellow-greenish staining of the floor in this area, which had been noted in the field.

Why would urine have been stored on the eastern side of the pit house? Although seemingly noxious to our 21st-century sensibilities, urine has been stored and used as a cheap and readily available cleansing and dyeing agent for wool and woollen textiles from at least the Roman period until the early 20th century in continental Europe, the British Isles and Iceland.[[77]](#endnote-77) While fresh urine is slightly acidic (pH 6.0), when it is left standing for some time the urea is converted by the bacterium *Micrococcus ureoe* into ammonia and carbon dioxide, and the resulting 4% ammonium carbonate solution is a strong alkali. The reaction of grease (lanolin) in wool with the alkali in the urine, which can be promoted by agitating the liquid, creates a frothy, soap-like scum that effectively removes greasy dirt, insects and ectoparasites.[[78]](#endnote-78) The practice of washing wool is not mentioned in medieval Icelandic literature, but in 19th- and 20th-century Iceland it was still common practice to use gently heated stale urine and water to wash sheep fleeces.[[79]](#endnote-79) In addition, wool cloth could be fulled by soaking and pressing it in a mixture of stale urine and hot water, which had the effect of shrinking and tightening the cloth, making it stronger and warmer and better suited for coats and hoods.[[80]](#endnote-80) It is therefore proposed that the soluble salts concentrated on the eastern side of the pit house were from spilt urine, and that it had been stored and used in this area for cleaning, fulling and possibly dyeing wool. The heat-blackened and fire-cracked stones found in Hofstaðir G could very well have been used for heating urine and water for this purpose.

Reconstruction of the Use of Space in Hofstaðir G

Although Hofstaðir G was a small, single-roomed building, the space within this room was organised into five distinct activity areas. Based on the integrated macroscale and microscale evidence, these activity areas are interpreted as follows: 1) a heavily trampled central corridor where herbaceous organic matter and hearth refuse accumulated, which had clearly been cleaned out (truncated) at least once; 2) a weaving area with a standing loom against the northern wall; 3) an area around the oven in the northwest corner where fish and animal foods were eaten and possibly also prepared, and where stones were heated for the heating of liquids such as water and urine; 4) a 'wet' area in the southwest corner, where there had been a washing basin that at least occasionally contained lye; and 5) a raised wooden platform on the eastern side of the pit house, used for sitting, possibly sleeping one or two people, and where urine barrels were at least sometimes stored for the washing, fulling, and possibly dyeing of wool (Fig 14). The clusters of pin holes in the floor everywhere except for the areas occupied by the wooden platform and the oven are most likely to be the product of distaffs and lamps being pressed into the floor, and are evidence for the spinning of wool. The detailed study of Hofstaðir G highlights the possibility that pit houses could well have been used for all stages of woollen textile production, from the initial cleaning of fleeces to weaving and dyeing. Although meals must have been consumed in Hofstaðir G and other pit houses where burnt bones were found, and it is possible that one or two people could have slept on the platform (though this seems unlikely if it was frequently used for the storage of urine), the evidence certainly does *not* support the view that pit houses were smaller, simpler and more temporary versions of the larger dwelling houses.

Discussion

Although multi-functional to the extent that meals were consumed in them during the course of the working day, this survey of pit houses, accompanied by the detailed study of the occupation deposits in pit house G at Hofstaðir, have shown that woollen textile production is likely to have been the primary function of the pit houses that have been found on Viking Age farmsteads in Iceland. Viewed in this light, the heated stones that are so abundant in pit houses were probably used to heat water and/or urine for washing, fulling, and possibly dyeing wool, and the use of enclosed ovens rather than open hearths might well have been a measure to reduce the risk of flying sparks that could have damaged the valuable commodity. Due to the small size of pit houses, and the fact that most have only one sitting platform, it is unlikely that more than one or two people could have used these buildings as sleeping places. The small size of the buildings would also have had an impact on the size of the looms in them. No warp-weighted looms survive in the archaeological record, but if Viking Age looms were similar in size to the ethnographic examples preserved in Iceland, the Faroes and Norway, the horizontal beams could have been anywhere from 1.90 to 2.40 m long,[[81]](#endnote-81) and in the smallest of the pit houses such a loom would have taken up most of a wall.

The fact that the walls of pit houses were constructed of timber rather than turf, which would have made it easier to have windows, must have been connected to the need for good light for the various activities involved with the production of woollen textiles. The semi-subterranean character of the buildings would have helped to reduce the entry of draughts at floor level, and would have helped to keep them warmer. However, the sunken character of the buildings seems to have had little other functional purpose. Unlike linen-weaving, for which the warp threads have to remain damp in order to remain workable,[[82]](#endnote-82) a humid environment was not advantageous for the weaving of woollen textiles, and at any rate the radiating heat from the corner or side ovens would have helped to keep the houses warm and dry. However, it is interesting to note that as the only buildings on Viking Age farmsteads with timber walls and sunken access, the semi-subterranean character of pit houses must have meant and communicated something about the functions of the buildings and who used them. Since Viking Age pit houses in mainland Scandinavia were commonly used for weaving as well,[[83]](#endnote-83) Icelandic pit houses represented the continuation of a very long-standing cultural tradition that the appropriate space for textile production was a semi-subterranean building.

Both the archaeological and the literary evidence point to the fact that textile production in Viking Age Iceland was primarily carried out by women. In furnished burials in Scandinavia and the North Atlantic region, the most common implements found in women’s graves were related to textile production, including wool combs, spindle whorls, loomweights, weaving swords, weaving tablets, needles, glass linen smoothers and whalebone smoothing boards.[[84]](#endnote-84) Although some of these implements have also been found in a few male graves in Scandinavia, this is extremely rare, and in Iceland, all the furnished burials that contained textile implements were sexed as female on the basis of skeletal evidence or the presence of oval brooches.[[85]](#endnote-85) In the Old Norse poems that mention spinning and weaving, these activities are conducted exclusively by females.[[86]](#endnote-86) In the 13th- and 14th-century sagas, there are also numerous references to women weaving, sewing, and making clothing, indicating that this work was in the women’s domain in the immediate post-Viking period, and in Iceland it remained so until the introduction of the horizontal loom in the 19th century.[[87]](#endnote-87) All of the evidence therefore points to the pit houses on Viking Age farmsteads in Iceland as the women’s workrooms, or *dyngja*, that are mentioned in Old Norse literary sources as the places where textiles were made.

Women of all status, from housewives and their daughters to servants and slaves would have been involved in textile production, and it is likely that this work was predominantly done in pit houses. These buildings must have represented an integral and distinctively female space on Viking Age farmsteads in Iceland, and should perhaps be seen in opposition to smithies and ironworking activities, which archaeological and literary sources associate solely with men.[[88]](#endnote-88) Indeed, the 10th-century poem by Þorbjörn hornklofi makes it clear that *dyngja* were exclusively places for women and children, and in the Icelandic sagas bad things tended to happen when men overheard conversations that took place in *dyngjur*, which they were not supposed to hear.[[89]](#endnote-89) Pit houses should be viewed as strongly gendered spaces, and the fact that all pit houses in Iceland were abandoned in the later 10th or 11th century points to a dramatic and meaningful shift in the organisation of these gendered spaces and the household production of homespun wool.

From the 12th century onwards the space for women’s textile work can be found deep inside the main dwelling houses. On12th- and 13th-century farms, such as the later phases of Sveigakot, Stöng, Þórarinsstaðir, and Sámstaðir, the size and organisation of space in the main dwelling houses had changed, and many of the same elements associated with textile production, including corner ovens, heated stones, pin holes in the floor, loomweights and other implements associated with spinning and weaving, had been relocated to the so-called *stofa* – rooms that had to be accessed via the central livingrooms.[[90]](#endnote-90) If the distribution of spinning and weaving implements is anything to go by, these activities had certainly taken place in the central livingrooms of longhouses before this date, making it clear that timber walls and windows were not absolute requirements. However, the universal abandonment of pit houses and the construction of new rooms for textile production deep in the main dwelling house by the turn of the 12th century must point to wider social and economic changes in Icelandic society.

It might not be a coincidence, for example, that during the late 10th and 11th century, when pit houses were being abandoned, Iceland was converting to Christianity. It is proposed here that the lack of a good functional reason for the semi-subterranean character of pit houses may be related to a more symbolic significance of the building form, one that was related to pagan religious beliefs and women’s magic. In Old Norse mythological sources, the fates of men were frequently determined by *nornir*, female supernatural beings who lived below ground, next to the roots of the mythical world tree, Yggdrasil, and in the poem *Helgakviða Hundingsbana I* they manipulated fate by twisting threads.[[91]](#endnote-91) In the poem *Darraðarljóð*, in *Njal’s saga*, valkyries in a *dyngja* wove the battle-fate of warriors on a gruesome loom that had men's entrails for threads and loomweights fashioned from heads.[[92]](#endnote-92) In addition, the art of *seiðr*, the magic performed by women and occasionally ‘unmanly men’ in Old Norse literary sources, seems to have involved the symbolic spinning of a mind emissary or snare, probably with the aid of a real or symbolic distaff of the kind found in some female burials and interpreted as staffs of sorcery.[[93]](#endnote-93) Another common motif in the saga literature is supernaturally protective or harmful shirts and banners that have been woven and embroidered by female magic workers.[[94]](#endnote-94) If these written sources are true reflections of world-views and practices in Viking Age Iceland, there may very well have been a cognitive association between pagan religious beliefs, women's magic, and the semi-subterranean spinning and weaving spaces on farmsteads. If pit houses were perceived as real or potential places of women's magic, which appears to have been associated at times with the practices of spinning and weaving, this other-worldly character of the spaces could also explain why they were originally set apart from the main dwelling house. Once Icelanders began converting to Christianity around AD 1000 and over the course of the following century, separate, semi-subterranean spinning and weaving spaces would have been rendered redundant, or were perhaps considered polluted by pagan beliefs and practices, and this could be why textile production shifted to the main dwelling house. It is clear from Christian commentators on the continent that practicing magic at the loom was still occasionally done by women in the 11th-century, but it was considered a sin and efforts were being made to stamp out the practice.[[95]](#endnote-95)

Although in Iceland as a whole the timing of the adoption of Christianity and the abandonment of pit houses seem to have roughly coincided, it is clear that there was not a simple or direct correlation between Christian conversion and the abandonment of pit houses at the level of individual households. At some farms, such as Hofstaðir and at Hólmur, for example, the abandonment of pit houses actually marked the start of a new or intensified phase of cult activity: the ritual slaughter of cattle in the case of Hofstaðir, and burial rites in the case of Hólmur.[[96]](#endnote-96) In addition, in some cases the very act of closing and sealing the pit house seems to have been done within the context of pagan beliefs. Most abandoned pit houses were used as dumping grounds for household wastes such as ashes and animal bones – undoubtedly a practical measure of rubbish disposal, but one that also infilled the pits and made them invisible from the ground surface, which might not have been an accident. However, at Vatnsfjörður, where the pit was only 0.3 m deep, an animal building was constructed directly on top of the pit house soon after it was abandoned. A stone pavement was placed in the entrance of the new building, a central stone pavement was laid along the original long axis of the pit house, and two large flag stones were deliberately placed over the ruins of the corner oven.[[97]](#endnote-97) Stone pavements are common in animal buildings in Viking Age and medieval Iceland,[[98]](#endnote-98) but the choice in this case may have been intentional. The laying of stones over the floor and oven of the pit house recalls the large stones placed on top of at least two iron staffs in burials in Norway and Denmark, which, it has been suggested, could represent symbolic killings of objects used in the art of *seiðr*, just as in the sagas sorcerers were often killed by stoning.[[99]](#endnote-99) The animal building at Vatnsfjörður was larger and more square than the pit house it concealed, and its turf walls were set out further than the edges of the pit, but before its eastern wall was constructed, a foundation deposit of ten large rounded cakes of refined iron bloom was placed on the ground surface.[[100]](#endnote-100) Representing around 35 kg of unused iron, this was a very valuable deposit, and it is proposed here that its intention was to neutralize the female space – which might have been associated with female magic – before the space was completely eradicated by the construction of the animal building. It was suggested above that pit houses and the textile production activities that took place inside them might have had a counterweight in smithies and activities associated with ironworking, which the burial record and literary sources indicate were in the male domain. This could explain the choice of iron blooms as a foundation deposit: it was material that had been converted from raw material to usable iron by men, and may therefore have been an appropriate agent to neutralize the female space where raw wool was converted to textiles, before the pit house was closed and covered over by an animal building.

In addition to the conversion to Christianity, which must have had a profound effect on many aspects of daily life, historical sources point to other significant social and economic changes that were occurring in Iceland during the 11th century: the abandonment of the institution of slavery,[[101]](#endnote-101) and the growing importance of homespun wool (*vaðmál*) as a commodity for barter, export, and the making of legal payments.[[102]](#endnote-102) So important did homespun wool become for the Icelandic economy, that lengths (ells) of wool replaced silver bullion as the standard against which all other products were valued.[[103]](#endnote-103) In c AD 1096, for example, when Bishop Gizurr persuaded Icelanders to accept the tithe tax to support the new Icelandic church, people had to assess their property in lengths of homespun, and ells of cloth were the currency specified for most payments.[[104]](#endnote-104) The economic importance of homespun wool for barter, the payment of taxes and as a commodity that could be exchanged by farmers for imported barley, timber, bronze brooches, schist whetstones, glass beads, antler combs and other foreign goods must have also increased the economic power and the status of the women who produced it – including women who had formerly been slaves. The movement of woollen textile production from pit houses to women's workrooms deep inside the main dwelling houses may therefore be linked to the increased status of this important work, and a desire to keep a watchful and protective eye on the workspace, the product, and the women who were making it.

Conclusion

This interdisciplinary study of pit houses on Viking Age farmsteads in Iceland, which included for the first time a detailed analysis of the microrefuse, geochemistry and micromorphology of floor sediments, has provided a unique insight into the functions of these buildings. Far from being short-lived, temporary dwellings, specialised saunas, or the houses of ethnic Slavs, this revaluation of the archaeological record has made it clear that pit houses were long-lasting, integral social and economic spaces, as they had been in mainland Scandinavia, and that there was probably at least one on every Icelandic farmstead until this type of building was abandoned altogether in the 11th century. Key to the interpretation of the function of these buildings was the geoarchaeological evidence from the pit house at Hofstaðir, which firmly demonstrated that these semi-subterranean buildings functioned primarily as work rooms for all stages of woollen textile production, from the washing of raw wool through the spinning of yarn and the weaving of cloth. The geoarchaeological work lent strong support to interpretations derived from the survey of the artefactual evidence from pit houses, which showed unequivocally that the buildings were dominated by textile-working implements and stones for heating liquids. These new insights into the role of pit houses as centres for textile production on farmsteads also dovetail well with what we now know about their unique architectural features: the timber walls that enabled the installation of windows, and the enclosed corner ovens that could heat small buildings without endangering them with sparks. Perhaps more interestingly, the geoarchaeological work presented here adds a new layer of detail, including the fact that urine and lye were used for cleaning, fulling, and possibly dyeing wool in pit houses. Since all the literary and burial records indicate that textile production was exclusively women’s work, we must regard pit houses as strongly gendered spaces with an important role on Viking Age farmsteads as the place where women interacted socially and worked on all stages of the production of homespun wool cloth, a valuable commodity that was essential for daily life and as a means of exchange, trade, and payment of taxes.

To understand why these textile workrooms were kept separate from the main dwelling house, and why they were semi-subterranean, we must seek more than functional explanations. The recent excavation of the pit house at Vatnsfjörður, which revealed an interesting sequence of ritualised ‘closing’ events, as well as the deliberate infilling of many pit houses after their abandonment, were interpreted here in light of new research on women’s magic and its association with the actions of spinning, weaving, and twining threads in Old Norse literary sources. The conclusion is that pit houses were not only strongly gendered spaces, but were likely to have been symbolically charged and were probably linked – at least cognitively, if not actually – with pagan beliefs and practices. The shift in textile production to rooms deep inside the main dwelling house by the 12th-13th century is probably reflective of the fact that spinning and weaving had by this time lost this association with pagan practices, and had instead become a most valued economic activity. As a means of paying the tithe and as the most important trade item in Iceland during the high medieval period, homespun wool was an immensely valuable commodity, and the meaning and significance of the shift in the location of textile production is almost certainly related to the value placed on this work space and the women who used it.

Such a far-reaching and detailed interpretation of social space on Icelandic farmsteads would never have been possible without the integration of a very wide range of evidence gathered from the archaeological record, the geoarchaeology laboratory, and the Old Norse written sources. By providing important new insights into the gendered organisation of space on Viking Age households, and highlighting new ways of looking at domestic buildings that we used to think of as mundane work spaces, this study is a clear demonstration of how much further we can take our understanding of the archaeological, scientific, and written evidence when we line them up as equal partners, compare them against each other, and allow them to shed light on each other.

Acknowledgements

The author is indebted to Charles French and Catherine Hills, who supervised the PhD for which most of this research was conducted, and to Peter Jordan, Gordon Noble and Karen Bek-Pedersen, who provided valuable comments on an earlier version of this paper. Technical laboratory support for the geoarchaeological analyses was gratefully received from Julie and Steve Boreham, Phil Hughes, Chris Dixon and Stephen Reed at the University of Cambridge. I also owe a debt to Sophie Bergerbrant, Þórir Jónsson Hraundal, and Rasmus Gjedssø Bertelsen for help with Swedish and Icelandic translations. Gavin Lucas and Orri Vésteinsson at the University of Iceland, and Adolf Friðriksson and Garðar Guðmundsson at Fornleifastofnun Íslands, very kindly granted me access to geoarchaeological samples, site archives, and radiocarbon dates, and gave me permission to reproduce the plans of pit house G at Hofstaðir. Many thanks are owed to the archaeologists and publishers who gave me permission to reproduce plans and photographs of pit houses, and I would like to give particular thanks to those who permitted me to use unpublished plans and radiocarbon dates: Sigurður Bergsteinsson, Fornleifavernd (Bessastaðir), Guðmundur Ólafsson, National Museum of Iceland (Eiríksstaðir), Kevin P. Smith, Haffenreffer Museum of Anthropology, Brown University (Háls), Ragnar Edvardsson, Fornleifavernd and Thomas McGovern, City University of New York (Hrísheimar), and Orri Vésteinsson, University of Iceland (Sveigakot). Without their kindness, support, and patience, this work would not have been possible.

This research was funded by a Social Sciences and Humanities Research Council of Canada Doctoral Fellowship, a United Kingdom Overseas Research Studentship, a bursary from the Cambridge Commonwealth Trust, a Pelham Roberts Research Studentship, Muriel Onslow Research Studentships from Newnham College, Cambridge, and two Canadian Centennial Scholarships from the Canadian High Commission in London. The excavation at Hrísheimar was funded in part by the US National Science Foundation Office of Polar Programs Arctic Social Sciences Program grants 0851727, 0732327, 0352596, 0527732 and 0001026, and excavations at Vatnsfjörður have been generously supported by the government of Iceland and Fornleifasjóður. Finally, I would like to thank the Caledonian Research Fund and the Royal Society of Edinburgh for the Visiting European Research Fellowship that made it possible for me to do integrative research in Iceland and to excavate the pit house at Vatnsfjörður during the summer of 2010.

Figure captions

Fig 1

Map of Iceland, showing the locations of all pit houses excavated to date

Bessastaðir (1), Eiríksstaðir (2), Gjáskógar (3), Granastaðir (4), Grelutóttir (5), Háls (6), Hjálmsstaðir (7), Hofstaðir (8), Hólmur (9), Hrísheimar (10), Hvítárholt (11), Ljótólfsstaðir (12), Stóraborg (13), Sveigakot (14) and Vatnsfjörður (15).

Fig 2

Radiocarbon dates for pit houses in Iceland

Fig 3

Plans of Viking Age pit houses in Iceland

(a) Eiríksstaðir. *Drawing by Guðmundur Ólafsson,* © *Guðmundur Ólafsson*. (b) Gjáskógar. *Drawing by Kristján Eldjárn, © Árbók hins íslenzka fornleifafélags 1961*. (c) Granastaðir 3. *Drawing by Bjarni Einarsson, © Bjarni Einarsson 1992*. (d-e) Grelutóttir I and II respectively. *Drawings by the author after originals by Guðmundur Ólafsson,* *© Guðmundur Ólafsson and Árbók hins íslenzka fornleifafélags 1980*. (f) Háls 6A. *Drawing by* *the author after an original by Kevin P Smith,* © *Kevin P Smith. Used with permission.*

Fig 4

Plans of Viking Age pit houses in Iceland

(a-b) Hjálmstaðir phases 1 and 2 respectively. *Drawings by the author after originals by Guðmundur Ólafsson,* *©* *Guðmundur Ólafsson and Árnesingur 1992.* (c)Hólmur. *Drawing by Bjarni Einarsson, ©* *Bjarni Einarsson 2000.* (d-e) Hrísheimar C and H respectively. *Drawings by the author after originals by Ragnar Edvardsson, © Ragnar Edvardsson and Fornleifastofnun Íslands 2005*. (e-f) Hvítárholt I and IV respectively. *Drawing by the author after originals by Þór Magnússon, © Þór Magnússon and Árbók hins íslenzka fornleifafélags 1973*. *Used with permission.*

Fig 5

Plans of Viking Age pit houses in Iceland

(a-c) Hvítárholt V, VII and X respectively. *Drawings by the author after originals by Þór Magnússon, © Þór Magnússon and Árbók hins íslenzka fornleifafélags 1973*. (d) Stóraborg. *Drawing by Mjöll Snæsdóttir, © Mjöll Snæsdóttir and Árbók hins islenzka fornleifafélags 1992.* (e) Sveigakot T1 phase 3. *Drawing by the author after an original by Przemysław Urbańczyk © Fornleifastofnun Íslands 2002.* (f)Vatnsfjörður 10. *Drawing by the author,* *© the author and Fornleifastofnun Íslands 2010. Used with permission.*

Fig 6

Examples of Icelandic pit houses and their corner ovens

(a-b) Hvítárholt I and IV respectively, with heated stones and pin holes visible. *Photographs by Þór Magnússon,* © *Þór Magnússon and Árbok hins íslenzka fornleifafélags 1973.* (c) Vatnsfjörður 10 phase 2, with a stone-edged platform on the left side, a black charcoal-rich floor layer on the right side and the base of the oven in the far right corner. The oven had collapsed and the flat stones that had lined its sides were removed with other post-abandonment layers. *Photograph by the author, © the author and Fornleifastofnun Íslands 2010*. (d) Oven of Hjálmsstaðir phase 1. *Photograph by Guðmundur Ólafsson, © Guðmundur Ólafsson and Árnesingur 1992. Used with permission.*

Fig 7

Sizes of pit houses in Iceland

Fig 8

Plans of pit house G at Hofstaðir in Mývatnssveit

(a) Distribution of artefacts on the floor of Hofstaðir G. (b) Locations of micromorphology samples and the bulk sample grid. *Drawings by the author after an original by Gavin Lucas, © the author and Fornleifastofnun Íslands 2009.*

Fig 9

Distribution of bone and burnt bone fragments in Hofstaðir G floor context 9

Note that sampling squares without a dot represent those for which there was too little sediment to do microrefuse analysis.

Fig 10

Distribution of magnetic susceptibility, pH, loss-on-ignition, potassium, calcium, and total phosphorus values on the floor of Hofstaðir G

Fig 11

Distribution of barium, copper, zinc, sodium, iron, and electrical conductivity (a proxy for soluble salts) on the floor of Hofstaðir G

Fig 12

Three thin sections from the basal deposits of Hofstaðir G

Context numbers are divided into microstratigraphic units were necessary. Context 8: turf roof collapse, 9: floor deposit, 3: natural soils underlying the cut of the pit house.

Fig 13

Photographs of thin sections from Hofstaðir G

b: bone, bb: burnt bone, ch: charcoal, f: fungal spores, o: amorphous organic matter, pv: planar voids.

Fig 14

Interpretive plan of Hofstaðir G. *Drawing by the author after an original by Gavin Lucas, © the author and Fornleifastofnun Íslands 2009.*

Table Captions

Table 1

Dating evidence for pit houses in Iceland

Table 2

Dimensions of and features associated with pit houses in Iceland

Table 3

Finds in pit houses in Iceland

Table 4

Summary descriptions of three micromorphology samples from Hofstaðir G

Floor context 9a was split into microstratigraphic layers where necessary. Overlying turf collapse 8 and underlying natural soil 3 are shown in contrast.

Table 5

Spearman’s rho correlation coefficients (*rs*) for electrical conductivity (EC) and element values from floor context 9 in Hofstaðir G

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2. Outdoor activity areas have rarely been excavated, but open area excavations at the 10th-century farm of Vatnsfjörður, in northwest Iceland, revealed hearths, cooking pits, smithying areas and sheet middens. [↑](#endnote-ref-2)
3. Berson 2002; Edvardsson and McGovern 2007; Hermanns-Auðardóttir 1989; Lucas 2010. [↑](#endnote-ref-3)
4. Harrison et al 2008; Roberts 2005. [↑](#endnote-ref-4)
5. at Eiríksstaðir and Ljótolfsstaðir; Erlingsson 1899, 57-99. [↑](#endnote-ref-5)
6. at Hvítárholt; Magnússon 1973. [↑](#endnote-ref-6)
7. Pálsson and Edwards 1989, 78; and see Guðmundsson 1889 for interpretations drawn from this description. [↑](#endnote-ref-7)
8. Ólafsdóttir 1974. [↑](#endnote-ref-8)
9. eg Einarsson 1992. [↑](#endnote-ref-9)
10. Ólafsson 1992. [↑](#endnote-ref-10)
11. Eldjárn1961; Eldjárn 1974. [↑](#endnote-ref-11)
12. Einarsson 1992; Friðriksson and Vésteinsson 1997; Vésteinsson 2000. [↑](#endnote-ref-12)
13. Vésteinsson 2000, 168. [↑](#endnote-ref-13)
14. Urbańczyk 2002a; Urbańczyk 2003b. [↑](#endnote-ref-14)
15. Donat 1980; Gojda 1991, 85-87; Ježeket al2002; Kobyliński 1997, 100; Kuna 2005; Ruttkay 2002; Takács 2002. [↑](#endnote-ref-15)
16. eg Kosel in Schleswig-Holstein, Uldal in Jutland, Vindinge and Margrethehåb in Zealand, Helgö, Löddeköpinge, Stora Köpinge, Valleberga, Vä and Sanda in Sweden, Övra Wannborga on Öland, Valum and Stedje in Norway; Åqvist 1992; Christensen 1990; Fallgren 1994; Göthberg 2000, 87; Hinz 1989, 80-83; Meier and Reichstein 1984; Mortensen 1997; Pilø 2005, 115; Rieck 1982; Schmidt 1994, 38. [↑](#endnote-ref-16)
17. Schmidt 1994, 161; Duczko 1997. [↑](#endnote-ref-17)
18. Einarsson 1992. [↑](#endnote-ref-18)
19. Ólafsson 1980; Ólafsson 1992. [↑](#endnote-ref-19)
20. Crawford and Ballin Smith 1999. [↑](#endnote-ref-20)
21. Crawford and Ballin Smith 1999, 213; Guðmundsson 1889, 244-5; Jochens 1995, 138; Magerøy 1958. [↑](#endnote-ref-21)
22. Guðmundsson 1889, 244; Magerøy 1958. [↑](#endnote-ref-22)
23. *Haralds saga hárfagra* chapter 15, Hollander 1964, 72; Bek-Pedersen 2008, 174; Kellogg 1988. [↑](#endnote-ref-23)
24. Einarsson 2008. [↑](#endnote-ref-24)
25. Einarsson 2008, 161, fig 12. [↑](#endnote-ref-25)
26. Einarsson 2008, 149-155. [↑](#endnote-ref-26)
27. Milek 2006; Milek forthcoming b. [↑](#endnote-ref-27)
28. Einarsson 1992; Eldjárn 1974; Friðriksson and Vésteinsson 1997; Vésteinsson 2000. [↑](#endnote-ref-28)
29. Eldjárn 1961; Smith 1995; Kevin Smith pers comm. [↑](#endnote-ref-29)
30. Einarsson 1992; Einarsson 1995. [↑](#endnote-ref-30)
31. Erlingsson 1899, 58; Magnússon 1973, 16. [↑](#endnote-ref-31)
32. contra Einarsson 1992. [↑](#endnote-ref-32)
33. Magnússon 1973; Ólafsson 1980. [↑](#endnote-ref-33)
34. Snæsdóttir 1992; Ólafsson 1992. [↑](#endnote-ref-34)
35. eg in the burials at Oseberg and Heinnum, Buskerud, Norway; Graham-Campbell 1980, 14, pl 25. [↑](#endnote-ref-35)
36. eg Björn 1974, 34; Wiklund and Diurson 1976, 57. [↑](#endnote-ref-36)
37. Ólafsson 1992 [↑](#endnote-ref-37)
38. eg at York, Oseberg, Hedeby and Bryggen. Andersson 2003, fig 63; Gardeła 2008, fig 2.1; Øye 1988, fig II.3; Walton Rogers 1997, fig 804. [↑](#endnote-ref-38)
39. Ingstad 1995; Lundström and Adolfsson 1995; Price 2002; Stenberger 1979,713. [↑](#endnote-ref-39)
40. Gardeła 2008; Heide 2006; Milek 2006. [↑](#endnote-ref-40)
41. Lucas 2009, 97. [↑](#endnote-ref-41)
42. Eg Magnússon 1973, 17. [↑](#endnote-ref-42)
43. Lucas 2009; Magnússon 1973, 38. [↑](#endnote-ref-43)
44. Lucas 2009, 94-95. [↑](#endnote-ref-44)
45. Urbańczyk 2002b; Urbańczyk 2003a. [↑](#endnote-ref-45)
46. Guðmundsson 2009, 328. [↑](#endnote-ref-46)
47. Foote and Wilson 1970, 164; O'Kelly 1954; Shetelig and Falk 1937, 310. [↑](#endnote-ref-47)
48. Einarsson 2008. [↑](#endnote-ref-48)
49. Edvardsson and McGovern 2007. [↑](#endnote-ref-49)
50. Lucas 2008; Ólafsson 1980. [↑](#endnote-ref-50)
51. Arnold 1990; Deal 1985; Gifford 1980; Murray 1980. [↑](#endnote-ref-51)
52. DeBoer and Lathtrap 1979; Hayden and Cannon 1983; LaMotta and Schiffer 1999; O'Connell 1987. [↑](#endnote-ref-52)
53. Bartram et al 1991; Wilk and Schiffer 1979. [↑](#endnote-ref-53)
54. Hayden and Cannon 1983; LaMotta and Schiffer 1999; Lang and Rydberg 1972; Simms 1988; Stevenson 1982. [↑](#endnote-ref-54)
55. Stein and Teltser 1989. [↑](#endnote-ref-55)
56. Lucas 2009, 99. [↑](#endnote-ref-56)
57. Lucas 2009, 100. [↑](#endnote-ref-57)
58. Micromorphology samples were taken by the author following the methods outlined in Courty et al 1989. [↑](#endnote-ref-58)
59. Thin sections were made and analysed by the author at the McBurney Geoarchaeology Laboratory, University of Cambridge, following the procedures detailed in Murphy 1986. [↑](#endnote-ref-59)
60. Bulk sampling was conducted by Orri Vésteinsson and Garðar Guðmundsson. [↑](#endnote-ref-60)
61. After air-drying for one week, samples were sieved in order to remove constituents over 2 mm and pulverised using a mortar and pestle. Organic content was estimated using loss-on-ignition at 550ºC, following the procedure of Nelson and Sommers 1996. pH and EC were tested using a 2:5 soil:deionized water suspension measured with a pHep 3 electronic pH meter and a DiST WP3 EC meter. Magnetic susceptibility was measured using a Bartington MS2 magnetic susceptibility meter with a low frequency sensor. Multi-element analysis by ICP-AES was conducted by ALS Chemex following procedure code ME-ICP41. [↑](#endnote-ref-61)
62. Lucas 2009, 96. [↑](#endnote-ref-62)
63. Lucas 2009, 95. [↑](#endnote-ref-63)
64. Lucas 2009, 100. [↑](#endnote-ref-64)
65. Wilk and Schiffer 1979. [↑](#endnote-ref-65)
66. Evans and Tylecote 1967; Pierce et al 1998. [↑](#endnote-ref-66)
67. Milek forthcoming a. [↑](#endnote-ref-67)
68. Gifford-Gonzalez et al 1985; Nielsen 1991. [↑](#endnote-ref-68)
69. Lucas 2009, 96. [↑](#endnote-ref-69)
70. Evans and Tylecote 1967; Pierce et al 1998. [↑](#endnote-ref-70)
71. Davidson et al 1992; Milek forthcoming a. [↑](#endnote-ref-71)
72. Milek forthcoming a. [↑](#endnote-ref-72)
73. Guðmundsson 2009, 328, 334. [↑](#endnote-ref-73)
74. Taylor and Singer 1956. [↑](#endnote-ref-74)
75. Although most data frequency distributions approximated the normal distribution curve, some frequency distributions were positively skewed, and for this reason both parametric tests (Pearson’s correlation coefficient (*r*)) and non-parametric tests (Spearman’s rho (*rs*)) were employed. The results of the analyses were nearly identical and only Spearman's rho is presented in Table 5. [↑](#endnote-ref-75)
76. Shetelig and Falk 1937, 311; Foote and Wilson 1970. [↑](#endnote-ref-76)
77. Buckland and Perry 1989; Shetelig and Falk 1937, 332, 336; Stead 1981; Stead 1982; Walton Rogers 1997, 1720. [↑](#endnote-ref-77)
78. Buckland and Perry 1989. [↑](#endnote-ref-78)
79. Jochens 1995, 135. [↑](#endnote-ref-79)
80. Jochens 1995, 140. [↑](#endnote-ref-80)
81. Hoffmann 1964. [↑](#endnote-ref-81)
82. Bender Jørgensen 1986; Zimmermann 1982. [↑](#endnote-ref-82)
83. Bender Jørgensen 1986; Mortensen 1997. [↑](#endnote-ref-83)
84. Jesch 1991, 19. [↑](#endnote-ref-84)
85. Friðriksson 2000. [↑](#endnote-ref-85)
86. eg *Rígsþula*, *Völundarkviða*, *Darraðarljóð*, *Helgakviða Hundingsbana I*, *Knútsdrápa* by Óttarr the Black; Bek-Pedersen 2008; Jesch 1991, 152; Larrington 1996, 114-115, 102, 248; Magnusson and Pálsson 1960, 349-351; Page 1995, 124, 150, 155. [↑](#endnote-ref-86)
87. Damsholt 1984; Jesch 1991, 192, 197; Jochens 1995, 134-160; Þorláksson 1991. [↑](#endnote-ref-87)
88. No smith’s tools have been found in Icelandic burials so far, but they were present in c 10% of male burials in Norway, and all the smiths in Old Norse literature were men or male dwarfs; eg *Rígsþula*, *Völundarkviða*, *Volsunga saga*; Barndon 2006; Byock 2004; Faulkes 1987, 101; Friðriksson 2000; Larrington 1996, 105-107, 249; Petersen 1951, 72. [↑](#endnote-ref-88)
89. Bek-Pedersen 2008, 174, 177; Þórólfsson and Jónsson 1943, 112. [↑](#endnote-ref-89)
90. Eldjárn 1949; Rafnsson 1977; Roussell 1943; Vésteinsson 2001. Note that the assertion by Bek-Pedersen 2008, 173, that in Iceland the *dyngja* was usually a separate room within the house, rather than a pit house as it was in mainland Scandinavia, can only be applied to houses from the 12th or 13th century onwards. [↑](#endnote-ref-90)
91. *Gylfagninning* chapter 15, Faulkes 1987, 18-19; *Helgakviða Hundingsbana I,* verses 2-4, Larrington 1996, 114-15, 278; Aðalsteinsson 1999, 47; Bek-Pedersen 2007; Bek-Pedersen 2011; Gardeła 2008; Heide 2006. [↑](#endnote-ref-91)
92. *Njál’s Saga* ch 157; Magnusson and Pálsson 1960, 349-351. [↑](#endnote-ref-92)
93. Gardeła 2008; Heide 2006; Price 2002. [↑](#endnote-ref-93)
94. eg *Orkneyinga saga* chapters 6, 11, 14, 17, 55, Pálsson and Edwards 1978; *Eyrbyggja saga* chapter 18, Pálsson and Edwards 1973; *Vatnsdæla saga* chapter 19, Jones 1944; *Njáls saga* chapter 157, Magnusson and Pálsson 1960; Bek-Pedersen 2009; Meaney 1981, 78-9. [↑](#endnote-ref-94)
95. eg *Corrector* of Burchard of Worms, c AD 1010, Meany1981, 185. [↑](#endnote-ref-95)
96. Einarsson 2008; Lucas and McGovern 2008; McGovern 2009, 236-249. [↑](#endnote-ref-96)
97. Milek 2010, 57-60. The interpretation of the building as an animal house is based on its organic-rich floor deposit and the identification of dung in micromorphology samples. [↑](#endnote-ref-97)
98. Berson 2002. [↑](#endnote-ref-98)
99. Gardeła 2009, 207-209. [↑](#endnote-ref-99)
100. Thomas Birch, pers comm, with further analysis of the iron in progress. [↑](#endnote-ref-100)
101. Agnarsdóttir and Árnason 1983; Foote 1977; Karlsson 2000, 52-53; Karras 1988. [↑](#endnote-ref-101)
102. Ingimundarson 1992; Jochens 1995, 134, 141-160; Thorláksson 2000, 185. [↑](#endnote-ref-102)
103. Jochens 1995, 141-160; Jóhannesson 1974, 331; Gelsinger 1981, 17-44. [↑](#endnote-ref-103)
104. *Íslendingabók*, chapter 10, Grønlie 2006, 11-12; *Grágás*, Dennis et al 1980, 32, 36-37, 246-47. [↑](#endnote-ref-104)