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Floor formation processes and the interpretation of site activity areas: An ethnoarchaeological study of turf buildings at Thverá, northeast Iceland

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ABSTRACT

The importance of identifying activity areas on archaeological sites has focussed much ethnoarchaeological and geoarchaeological research on floor formation processes, especially the cultural practices and preservation conditions affecting the distributions of artefacts, organic residues, and elements. In order to broaden the understanding of site formation processes in northern regions, an ethnoarchaeological study integrating geoarchaeological methods was conducted at abandoned 19th- and early 20th-century turf buildings at the farm of Thverá, northeast Iceland. Micromorphological analysis of the floor deposits in different rooms, compared to the former resident's descriptions of how space had been used and how floors had been maintained, revealed that only a few activities resulted in the accumulation of residues that were diagnostic of how space had been used on a daily basis. Instead, floor layers were dominated by residues associated with maintenance events, such as the intentional spreading of ash, and the laying of fresh turf. This study highlighted the fact that "dirty", "clean", "comfortable", and "waste", are socially constructed concepts that have a significant impact on the composition of occupation surfaces and must be given careful consideration by archaeologists attempting to spatially analyse residues in floor deposits to interpret site activity areas.

Introduction

The interpretation of site activity areas, and the differentiation between the residues of the past use of space and other processes that may have affected the composition of occupation surfaces, is a key problem faced by all archaeologists who are engaged with research on settlement sites and are interested in how households organised their daily lives and economic activities. The methodological challenge of answering these questions is significant, because in the absence of obvious features such as hearths, cooking pits, storage pits or sleeping platforms, the interpretation of activity areas is normally dependent on a clear understanding of the agents and processes behind the observed patterns in the distributions of artefacts, microrefuse, organic residues, and/or elements that accumulated on presumed occupation surfaces (e.g. Metcalfe and Heath, 1990; Middleton and Price, 1996; Sampietro and Vattuone, 2005; Smith et al., 2001; Sullivan and Kealhofer, 2004; Vizcaíno and Cañabate, 1999). However, the composition of occupation surfaces is determined by variable and complex sets of interactions between a wide range of processes (Carr, 1984; Gé et al., 1993; LaMotta and Schiffer, 1999; Wandsnider, 1996). Most floor formation processes are cultural: intentional or accidental human actions that result in the deposition and/or removal of particular artefacts and residues – especially larger objects, which tend to be removed, dumped, redistributed or cached when activity areas or buildings are being cleaned or abandoned (Lange and Rydberg, 1972; Sakaguchi, 2007; Stevenson, 1982; Tani, 1995; Tomka, 1993). But there is also a range of natural processes that can alter the composition of occupation deposits with the passage of time, as they become subject to the same physical, chemical, and biological processes that affect local landforms and soils (Brink, 1977; Johnson and Hansen, 1974; Rolfsen, 1980; Schiffer, 1996; Stein, 1983; Wood and Johnson, 1978). It is therefore essential to develop a rigorous framework for detecting and interpreting activity areas – not merely for analysing spatial patterns in the composition of occupation deposits, but for detecting the possible palimpsest of cultural and natural floor formation processes that may also have affected this composition.

For over three decades, ethnoarchaeological, ethnohistoric and experimental studies of the formation processes affecting occupation surfaces have been making an important contribution to the development of methodologies used by archaeologists to sample, analyse, and interpret spatial data with relation to site activity areas (e.g. Bartram et al., 1991; Binford, 1978; Brochier et al., 1992; Deal, 1985; Fernández et al., 2002; Gifford-Gonzalez et al., 1985; Hayden and Cannon, 1983; Hutson et al., 2007; Murray, 1980; Nielsen, 1991; Simms, 1988; Shahack-Gross et al., 2003,

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2004). Increasingly wary about the reliability of artefact distributions, especially artefacts over 1–2 cm in size, which are most likely to be removed during cleaning events or dumped or cached during abandonment events, the trend has increasingly been to analyse the spatial distributions of the most minute residues: microrefuse (bones and artefacts under 1–2 mm in size), phytoliths, organic residues, elements (especially P and Ca), and stable isotopes (especially N and C), and to use multiple overlapping datasets whenever possible (e.g. Fladmark, 1982; Metcalfe and Heath, 1990; Middleton and Price, 1996; Sanchez Vizcaíno and Cañabate, 1999; Sampietro and Vattuone, 2005; Shahack-Gross et al., 2008; Sherwood et al., 1995; Smith et al., 2001; Stein and Teltser, 1989; Sullivan and Kealhofer, 2004; Terry et al., 2004; Wilson et al., 2005, 2008).

Although most archaeologists are conscious of the fact that occupation deposits are commonly palimpsests, and may therefore be made up of the artefacts and residues of multiple, super-imposed events (e.g. Ascher, 1968; Carr, 1987; Kroll and Isaac, 1984; Malinsky-Buller et al., 2011), the most common method of sampling continues to involve scooping loose bulk samples into a polythene bag, which inevitably homogenises any super-imposed events and produces time-averaged results. In comparison to the analysis of artefact distributions or bulk samples, the taking of undisturbed block samples for impregnation with resin, thin sectioning, and micromorphological analysis with petrologic microscopes remains surprisingly rare, even though the ability of soil micromorphology to distinguish minute lenses (i.e. events) and changes in the composition of occupation deposits over time has been well attested since the late 1980s (e.g. Boivin, 2000; Courty et al., 1989; Davidson et al., 1992; Goldberg and Macphail, 2006; Macphail et al., 2004; Macphail and Crowther, 2007; Matthews, 1995; Matthews et al., 1997; Milek and French, 2007; Shahack-Gross et al., 2005).

Compared to more southern regions, particularly Latin America and the Near East, only a few ethnoarchaeological studies integrating geoarchaeological techniques have been conducted in the northern regions of Europe and North America, and these have focussed on the ability of multi-element analysis of soils to detect site activity areas (e.g. Knudson et al., 2004; Wilson et al., 2005, 2008). There has been a lack of ethnoarchaeological research on cultural and natural floor formation processes in northern regions, particularly in buildings constructed of turf or sod: the surface soil held together by the roots of grasses and other plants, which was the main building material until the mid-20th century in northern regions lacking good building timber. In addition to being abundant, and easy to cut and to build with, turf is an ideal construction material in cool northern climates due to its excellent insulating properties and the ability of living grass on the roof to absorb rain water and melting snow (Gestsson, 1982; Sigurðardottir, 2008; Urbanczyk, 1999). However, turf floor materials are subject to wear and turf walls and roofs are prone to degradation when they are penetrated by water and frost, and must be repaired regularly (Fenton, 1978, p. 110; and see below). In order to investigate cultural and natural site formation processes particular to turf buildings, and to develop an analytical and interpretive framework that would be relevant to a larger project on the use of space in Viking Age Scandinavian buildings (Milek, 2006), an ethnoarchaeological study integrating geoarchaeological methods was conducted on recently abandoned 19th- and early 20th-century turf buildings at the farm of Thverá (*Þverá*), in northeast Iceland.

The results of the ethnoarchaeological study at Thverá are presented here, beginning with general observations about the site formation processes associated with turf buildings: the residues that may become integrated into floor deposits during the building, use and repair of turf buildings, how turf buildings decay and collapse, and how they – and the floor deposits within them – ultimately become incorporated into the archaeological record. These general observations are followed by the results of a soil micromorphological study of the floor sediments in the main dwelling house and a sheephouse at Thverá, which permitted the composition of the occupation deposits to be compared to the former resident's descriptions of the original functions of the rooms and how their floors had been maintained. The discussion section assesses which activity areas at Thverá could be detected archaeologically, and compares the floor formation processes observed on this farm to those recorded in Icelandic ethnographic archives and in other world-wide ethnoarchaeological and experimental studies. This integrated study provides new insights into environmentally and culturally contingent space use and floor maintenance practices, with important implications for cross-cultural Middle Range Theory pertaining to floor formation processes and archaeological research on site activity areas.

The Study Site: Thverá, Laxárdalur, Northeast Iceland

The farm of Thverá is located in Laxárdalur in northeast Iceland (Fig. 1). The farm has recently been by-passed by the modern road system, but in the past it was in a favourable location at the crossroads of the main north-south route through the Laxá river valley, an important ford across the Laxá river, and the upland track that crossed the mountain of Hvítafell to the west (Olesen and Kjær, 1972). The 19th-century house that was the main subject of this study is located on top of a c. 2 m high artificial mound, which suggests a long settlement history on the site, but the mound has not been excavated, and the precise date of its foundation is not known. A burial that was accompanied by a horse, dating to AD 900–1000, was found at the southern border of the farm, and it is therefore likely that the farm has been occupied since the Viking Age (Eldjárn and Friðriksson, 2000, p. 204; Friðriksson, 1999).

The turf dwelling house at Thverá was built in 1852 and was continuously occupied until its abandonment in 1960, when the last residents of the house moved into a modern concrete building c. 70 m to the south. The house was then used in a limited way as a storage building until it was taken into the care of the National Museum of Iceland in 1965. At that time, the parts of the house that had fallen into disrepair (e.g. the smithy) were rebuilt, and the debris that had accumulated since abandonment was cleaned out. The farmer who had been born in the bedroom of the turf house in 1938 and who had lived there until 1960, Áskell Jónasson, was commissioned by the National Museum to undertake the necessary upkeep of the walls and the roof, but otherwise to disturb the house as little as possible. He laid fresh strips of turf over the earthen floors of the house in order to "make them nice" for visitors, which had the beneficial effect of sealing the floors and protecting them from further disturbance. Although the house is open to the public, visitation is low because the farm is far from a major road, and visitors have probably had a negligible impact on the house and its floor deposits. The likelihood that the floor sediments were well preserved, and the availability of a reliable informant who was willing to talk about what daily life had been like inside the turf house, made the site ideal for the investigation of floor formation processes.

Research methods

Field work was carried out over the course of 14 years, from 1997 to 2010, during which time numerous interviews were conducted with Áskell Jónasson, and he answered two questionnaires that further clarified issues related to the use of space inside the house and floor maintenance practices. A geoarchaeological sampling programme was conducted from 1997-1999, and visits to

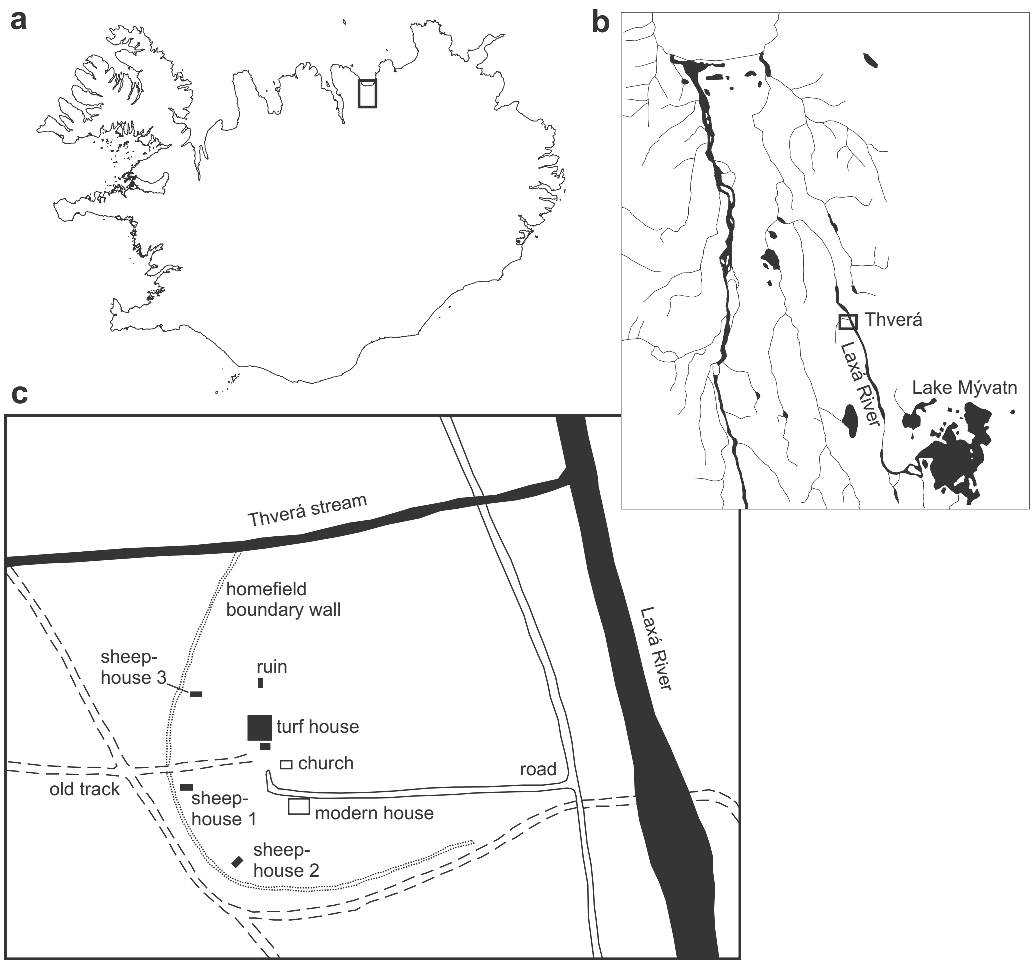

Fig. 1. Location of Thverá: (a) map of Iceland, showing the location of Laxárdalur; (b) map of Laxárdalur, showing the location of Thverá; (c) plan of Thverá, showing the locations of all the buildings discussed in the text (adapted from Olesen and Kjær, 1972, p. 24).

the farm continued until 2010 to record turf construction and repair events, and to monitor the processes of decay and collapse of the outbuildings in the farm's homefield, some of which were in active use until 2009 (sheephouse 1 and attached hay barn), some of which had been abandoned for 50–80 years and were in various stages of collapse (sheephouses 2 and 3, and a storage building), and some of which had been abandoned for 100–150 years and were low grassy mounds well on their way to becoming archaeological sites (ruin) (Figs. 1 and 2).

The geoarchaeological sampling programme involved the excavation of shallow trenches (c. 20 cm wide and 20 cm deep) in all of the main rooms and corridors of the main dwelling house and sheephouse 2 in order to expose the floors in section (Figs. 3 and 4). After written and photographic records were made of the exposed sections, undisturbed block samples for soil micromorphological analysis were taken from the floors and underlying soils using 9 × 6 × 5 cm aluminium sampling tins, following the method outlined by Courty et al. (1989). Thin sections were manufactured at the Department of Archaeology at the University of Cambridge, UK. The samples were dried using acetone replacement of water, impregnated with crystic polyester resin, and thin sectioned following the method described by Murphy (1986). Thin sections were first studied at a scale of 1:1, scanned using a flatbed scanner, and then analysed with petrographic microscopes at magnifications ranging from x4 to x250 with plane-polarized light (PPL), cross-polarized light (XPL), and oblique-incident light (OIL).

Micromorphological analysis permits the identification of the mineral, organic, and anthropogenic components of soils and sediments, including ash, charcoal, organic matter in various stages of decomposition, minute artefacts, and bones. In thin section it is also possible to observe the physical organisation of these components, and the microscopic structures of soils and sediments, which are affected by sedimentary processes such as mode of deposition, pedological processes such as bioturbation and leaching, and mechanical processes such as compaction by trampling and truncation events (Courty et al., 1989). Micromorphological descriptions followed the international standards in Bullock et al. (1985) and Stoops (2003), and utilised additional reference works such as FitzPatrick (1993) and Canti (1999). Only information directly relevant to the discussion of floor formation processes is provided here.

The lifecycle of turf buildings: construction, use, maintenance, collapse

The organisation of space in the buildings at Thverá was typical for Iceland in the 19th- and early 20th-century (Ágústsson, 1987), but many aspects of their lifecycle, the living conditions inside them, and floor formation processes, are likely to be similar to turf/sod buildings throughout northern regions. The walls of the buildings at Thverá were 1.5–2.0 m thick, with inner cores of turf, outer stone linings containing 5–10 courses of undressed basalt stones, and a capping of numerous courses of turf laid grass-side down (Fig. 2; Video 1). Most turf walls were constructed of long strips of turf, known in Icelandic as *strengur*, but the smaller, brick-like *kvíahnaus* was also used (Ólafsson and Ágústsson, 2003, pp. 6–7; see Fig. 2i). The turf had been cut from a low-lying, wet area

Fig. 2. Turf buildings at Thverá: (a) front of the main house; (b) back of the main house, showing light shafts protruding through the turf roof; (c) roofs of sheephouse 1 (right) and attached hay barn (left) under repair, showing turf strips being laid over a mat of birch brushwood; (d) sheephouse 2 in 1998, c. 40 years after it was abandoned, with an outer skin of stones beginning to peel away; (e) interior of sheephouse 2 in 2002, with the turf roof starting to collapse onto the floor; (f) interior of sheephouse 2 in 2010, with much of the roof collapsed, and the interior exposed to sunlight, rain, and soil formation processes; (g) sheephouse 2 in 2010, showing the collapsing roof, the progressive slumping of the stone and turf walls, and the living turf growing down over the exterior of the walls; (h) a storage building 70–80 years after abandonment, with a fully collapsed roof and slumping walls; (i) sheephouse 3 70–80 years after abandonment, showing shrinkage and cracking of the exposed turf being weathered by rain and frost; note the living turf overgrowing the top of the wall and the locations of bones (1, 3) and ceramics (2) protruding from the turf.

close to the Laxá river, within the homefield of the farm, and it had an organic content of 40–60% as determined by loss-on-ignition at 550 °C. Icelanders consider wetland turf to be the best building material because the dense root mat and the high organic content relative to mineral content give it more coherence, make it more water absorbent, and give it better insulating properties than dry turf (Gestsson, 1982; Steinberg, 2004). In the turf cutting area at Thverá it was possible to cut two layers of turf: a surface layer with a very dense root mat and a subsurface layer, which had fewer roots and a higher mineral content. These two types of turf had different

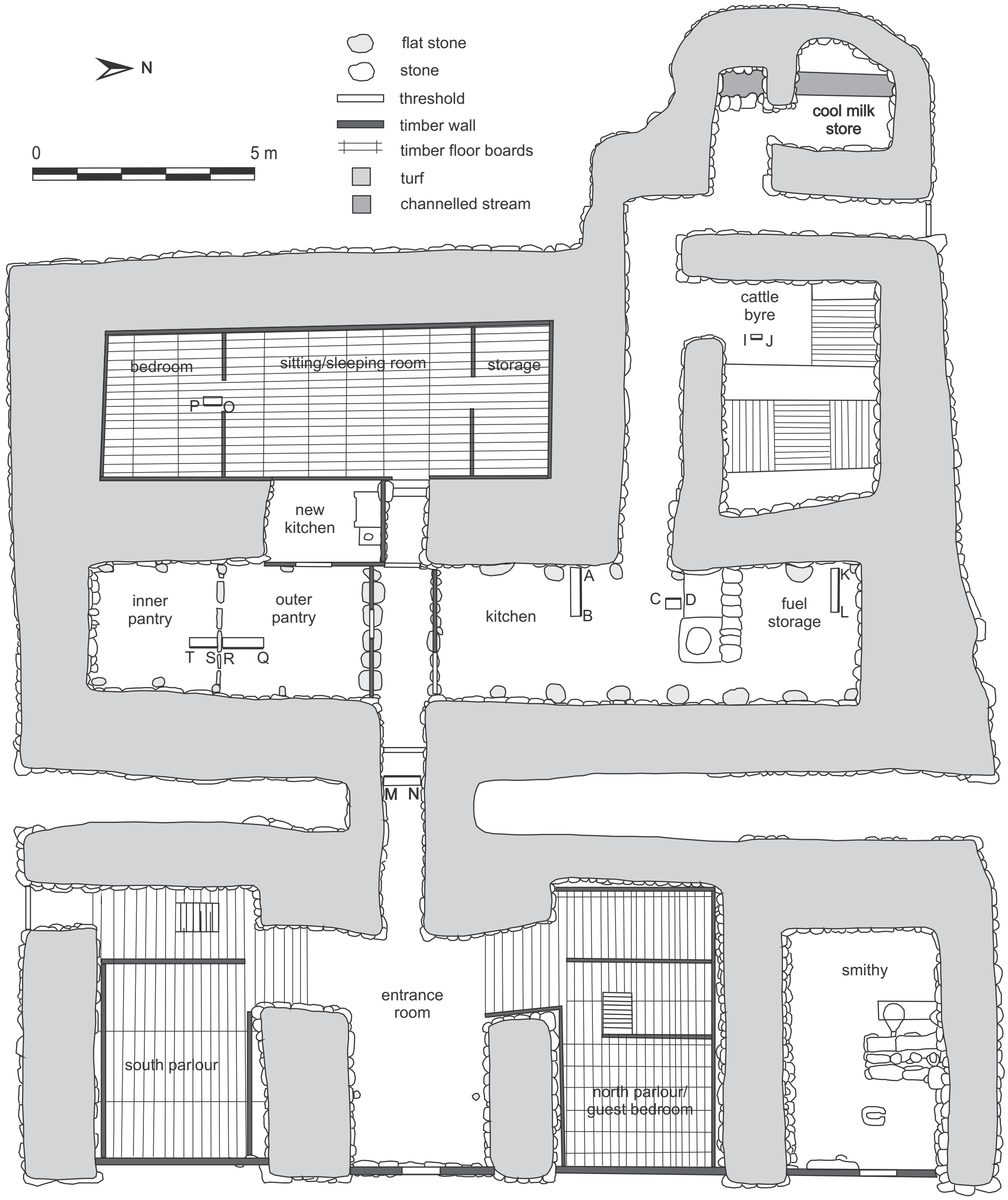

Fig. 3. Plan of the house as it appeared in 1997–1999, showing room functions and the locations of the sampling trenches discussed in the text (adapted from Oleson and Kjær, 1972, p. 25). Where floorboards were present (indicated by horizontal and vertical lines), samples were taken below the floor boards.

structural qualities, which influenced their use as building materials. The tangle of the root mat just under the grass made the surface turf layer more coherent than the subsurface turf; however, the less organic subsurface turf shrank less upon drying and was better at retaining its size and shape. Roofs were always constructed of the grassy, more waterproof upper turf, while walls could be constructed of either type. This potential difference in the organic content of turf roofs and walls could be evident archaeologically.

It is important to note that turf cut in the vicinity of human dwellings may contain artefacts and bones that had previously been spread around as a result of waste disposal, soil amendment, animal trampling, or playing children (see also McIntosh, 1974), and the ceramics and bones found embedded in the turf wall of sheephouse 3 show that this process was active at Thverá (Fig. 2i). Eventually, when these walls finally collapse, the older, residual artefacts will end up in the layer of wall collapse, above the occupation deposits – a reminder that archaeologists should avoid using the artefacts found in turf collapse layers for dating the occupation of a building or interpreting its function.

As could clearly be seen when the roof of sheephouse 1 was being repaired, the roof was covered by large strips of slightly overlapping turf, 40 × 150 cm in size, which were pegged into a mat of birch brushwood overlying a framework of wooden roof timbers (Fig. 2c). The timber framework of the roof was supported by wooden posts resting on rows of stone post pads placed along the inner edges of the walls (Fig. 3). With the grass facing upwards, the roof turves absorbed the rainfall and the grass remained living (Fig. 2b–d; Video 1). The pitch of the roof was normally adjusted to the amount of rainfall received in a particular area, with a pitch of lower than 45° in drier regions and higher than 45° in rainy areas, where it helped to promote runoff (Gestsson, 1982). The grass growing on the roofs at Thverá was cut with a scythe and added

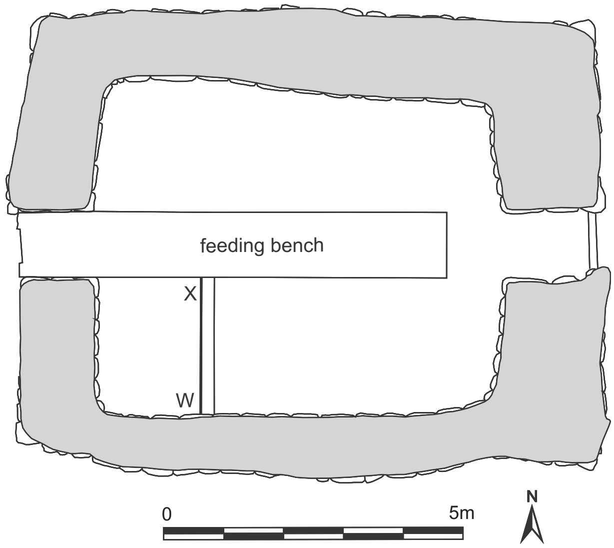

Fig. 4. Plan of sheephouse 2, showing the locations of the sample trench discussed in the text.

to the homefield's hay crop, a practice that was also recorded by 19th-century travellers to Iceland (e.g. Henderson, 1818).

The roof of the house at Thverá was pierced by wooden shafts to provide some air circulation and light (Fig. 2b, Video 1), but these also let out heat and let in rain and snow, and during cold or wet weather these could be blocked. Rain falling through these shafts splashed onto the floor below, creating damp patches that could become muddy if the rainfall was heavy or if there was little or no wind. However, the strong winds and "horizontal rain" that are typical of Iceland result in little rain falling through the shafts. Besides the light shafts, most rooms were provided with a window (Fig. 2b, Video 1), but overall the light levels in the house remained low by modern standards, and the interior corridors were very dark (Video 2). During the night and during the long northern winter, when there is little daylight, the main source of light was oil lamps and candles, and the house was even darker. Since people will normally only pick up objects that they can see, the low level of lighting in these and other houses in northern regions will have had a profound effect on floor formation, since it will result in less hand-retrieval of dropped objects, more accidental loss, and more and larger objects being left on the floors in their primary position.

Regardless of the rain that occasionally fell through the roof shafts, and the occasional leaky roof, the interior of the house was of course relatively dry, and the turf making up the interior walls gradually dried out and became more crumbly. When people or animals brushed up against these dry turf walls, small amounts of fine soil material and fragments of organic matter fell to the floor, or rose for a while as air-borne dust, which eventually settled. For this reason, there was always a gradual accumulation of turf-derived silt and organic matter on the floors of turf houses. Other sources of material that accumulated on the floors – often much more rapidly – will be discussed in greater detail below.

As the buildings at Thverá prove, a well built and maintained turf structure could last for over 100 years (Nilsson, 1943, p. 293). However, such longevity requires regular replacement of the turf in the walls and roofs, which are susceptible to weathering by repeated cycles of wetting and drying, freezing and thawing, as well as repairs to roof timbers, which succumb to rot. Both turf and timbers have to be replaced every 10–20 years. At Thverá, episodes of roof repair resulted in the deposition of organic turf fragments, brushwood, and soil on the floors of the buildings, material which was subsequently trampled into the occupation deposits, even if the larger fragments were picked up by hand or swept away. A large midden of discarded turf and brushwood also accumulated next to buildings while their roofs were being repaired, which was then partially or completely redistributed as manure for the fields, burnt as fuel, or used as levelling material,

There were several buildings at Thverá that had been abandoned over the past 150 years, which provided insights into how turf buildings collapse. After abandonment, the first major change to the buildings was either the removal (for reuse) or the gradual rotting of the roof-supporting posts, which resulted in the inward collapse of the roof onto the floor of the building (Figs. 2e and f). If the posts were left in place, it took around 50 years for the roof to collapse, although this time could be reduced if the posts were already very old and starting to rot when the building was abandoned. While the roof was still intact, it protected the floor from rain and sunlight, and thereby prevented plant growth. The eventual collapse of the roof sealed the floor with a substantial layer of turf and protected it from major disturbance, but from that point onwards the interior of the building was exposed to sunlight and rainwater and became subject to soil-formation processes, such as plant growth, bioturbation by earthworms and plant roots, leaching, and freeze-thaw processes (Fig. 2f). The roof sometimes collapsed straight downwards, leaving the timber, brushwood, and turf layers in their original stratigraphic position. However, it was much more common to observe only parts of the roof collapsing inwards at any one time, leaving fragments of turf, brushwood, and timber dangling from holes in the roof until they too eventually fell, becoming inverted and mixed (Fig. 2e).

Turf walls remained upstanding for decades after the roof collapsed, creating a concave ruin that acted as a trap for windblown sand, silt, and household rubbish (Fig. 2h). With no roof cover, the upper layer of turf on the walls was exposed to sunlight and rain, and the grass began to grow again (Fig. 2h and i). However, the organic matter in the underlying turves gradually decayed, causing them to shrink and crack, and they were further degraded by repeated cycles of wetting and drying, and freezing and thawing (Fig. 2i). As the exposed walls gradually lost coherence, stacks of turf on either the inner or outer faces sometimes separated from the core of the wall and leaned outwards, eventually tumbling under the weight of gravity (e.g. the back wall in Fig. 2h). Over time, the walls continued to slump and flow outwards, leaving only the inner core *in situ* (Fig. 2h). Once the walls had been reduced to the point that former structures were merely low mounds, and the living turf had fully grown over them, the ruins stabilised as upstanding earthworks, and from that point only gradually lost height due to decomposition of organic matter, shrinkage, and compaction over time. However, ruined walls with exposed edges could remain vulnerable to wind erosion or abrasion by animals (especially sheep), which sometimes rubbed against them while using them as wind shelters.

Spatial organisation and floor formation at Thverá

The house at Thverá is of the "passage house" type, named after the central passageway that gave access to the main rooms of the house – a form that developed in Iceland in the 14th century (Ágústsson, 1987). The house faces east, towards the Laxá river, and its back rooms are set slightly into an east-facing slope. The floor surfaces therefore rested partly on natural soil and partly on older building remains and occupation debris. During its 110 year use-life the house underwent several alterations and additions, and as new materials became available in the 20th century they were incorporated into the structure. The front rooms, which included an entrance room, a south parlour and a north parlour/guest bedroom with overhead lofts, small storage spaces and a smithy with its own outside entrance, were added to the original house in the 1870s. These rooms followed the late

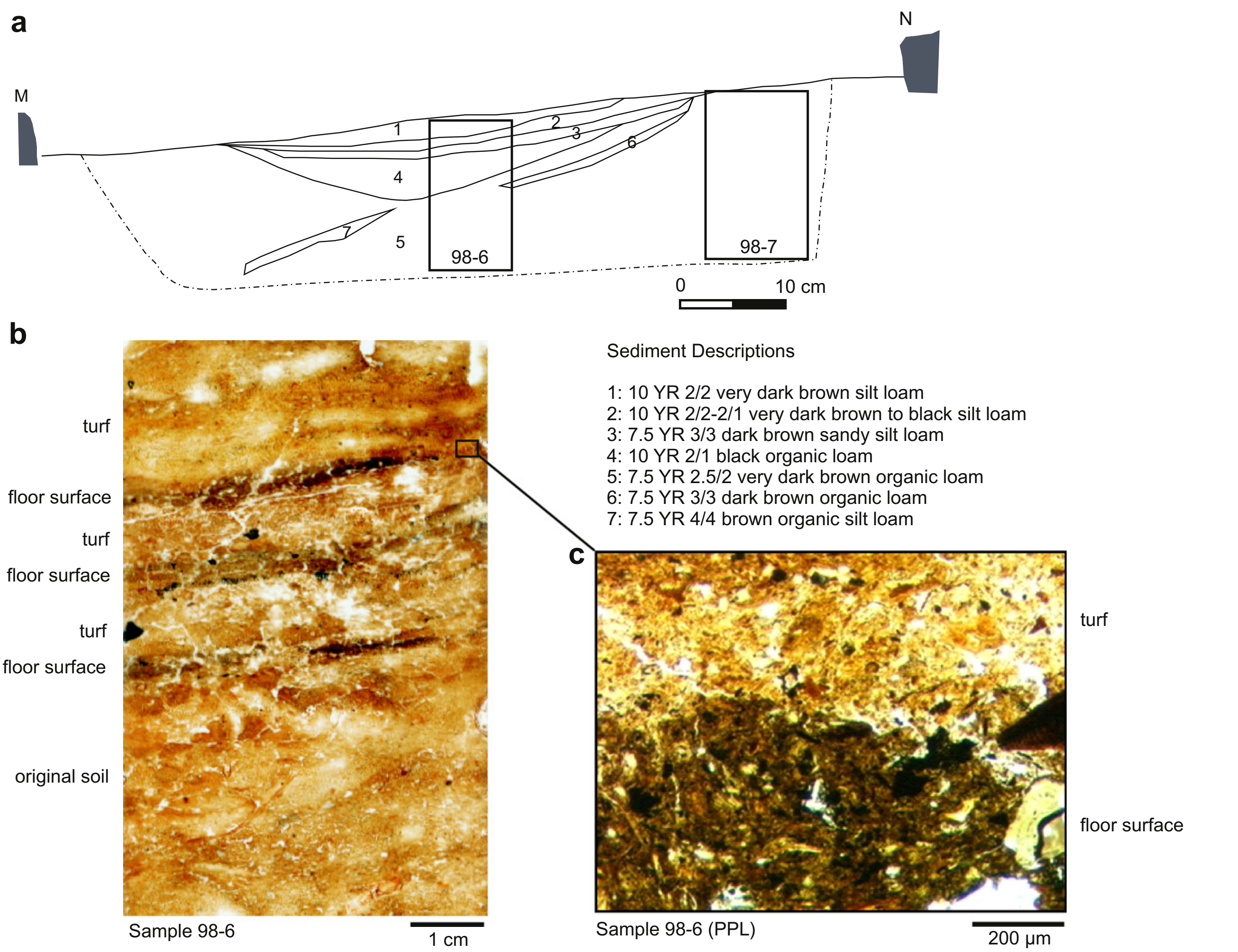

Fig. 5. Floor sediment in the central corridor: (a) drawing of section M-N, with sediment descriptions and the locations of the micromorphology samples; (b) Sample 98–6, from the centre of the corridor, with alternating lenses labelled; (c) detail of the boundary between the "dirty", trampled floor surface and the clean layer of turf on top of it.

19th-century fashion of having front-facing gables constructed of wooden planks, and, in the case of the "good" rooms (i.e. parlours and guest bedroom), floors made of well-joined wooden floorboards (Figs. 2a and 3; Lucas, 2009a). These rooms were not included in the geoarchaeological study, but were photo-documented along with the rest of the house (Video 2).

The smithy went out of use shortly after 1940, after which it was used as a store room for agricultural implements and riding tack until the roof collapsed. Because it had an earthen floor the smithy was originally intended for sampling, but during the course of this investigation it became clear that when it was cleaned out and repaired in the 1960s the floor had been truncated to a level lower than when it was in use, which unfortunately eliminated the potential of this building for archaeological study. The geo-ethnoarchaeological study therefore concentrated on the earthen floor deposits of the original 1852 house, as well as sheephouse 2, which was built in the early 20th century (the precise date is not known) and abandoned in the 1950s, after which it had only been used occasionally during the lambing season and had not been cleaned out (Figs. 3 and 4). Sheephouse 2 was sampled in 1999, 1 year before the roof started to collapse.

Entrance room and central corridor

The floors of the front entrance room and the central corridor were described by Áskell Jónasson as a "hard-trodden earth floor", and these floors had been subjected to heavy foot traffic, compaction, and wear. There was, however, significant difference in the level of compaction across these floors, and along the walls, out of reach of foot traffic, loose sediment had accumulated. In front of the entrance the floor had frequently become wet, which brought the sediment closer to its plastic limit (the point at which the water content made it mouldable) and facilitated its compaction. A number of different methods had been used to maintain the floors in these areas. If the floors in the entrance room became too wet, ash from the kitchen hearth was sprinkled over them and stamped down in order to absorb the water and dry them out. If the floors in the entrance or corridor became worn and uneven, the depressions were sometimes filled with a mixture of soil and ash, and it was also customary to cover the floors in these areas with a fresh layer turf on a yearly basis. Sometimes, but not always, the old turf floor was spaded out first in order to prepare the surface for fresh turf.

In the section excavated in the corridor, the central, trampled part of the floor was characterised by a concave depression that had been filled with fine, compact layers of alternating dark brown and brown silt loam (Fig. 5), while adjacent to the stone walls, the original ground surface was unaltered. In Sample 98-6 it was possible to see that all the layers in the centre of the corridor were composed of turf – that is, the A horizon of an andosol, containing an abundance of partially decomposed plant fragments. The uppermost 2 cm, which contained the clean, fresh turf that had been laid in the corridor prior to opening the house to the public, had lost the granular or subangular blocky microstructure of natural turf and had been compacted to a massive microstructure (no porosity). The brown and dark brown layers of the floor surfaces were clearly visible in thin section; the lowermost dark brown layer observed in the field turned out to be composed of two discrete layers, which were separated by another lighter brown one. The lighter brown layers consisted of "clean" turf that contained only occasional charcoal fragments. The darker brown layers, on the other hand, were stained by dark brown organic pigment and contained highly fragmented charcoal (c. 10%), nodules of iron that had been rubefied by heating in oxidizing conditions (derived from peat/turf ash; 5%), and rare pieces of burnt and unburnt bone, all under 2 mm in size (Fig. 5c). The lighter and darker brown layers also had differing microstructures, with the lower parts of the "clean" turf layers preserving the original subangular blocky structure of the turf and the "dirty" turf layers exhibiting either a prismatic or a platy structure – a clear indicator that they had been compacted by vertical pressure during trampling (Bresson and Zambaux, 1990; Courty et al., 1994, p. 259; Davidson et al., 1992, p. 62; Gé et al., 1993; Rentzel and Narten, 2000).

There was good correspondence between the characteristics of the floor sediments in the corridor and the floor use and maintenance practices detailed by the former resident of the house. The dark brown layers that contained organic staining, minute charcoal and bone fragments, and fragments of peat/turf ash, were heavily trampled surfaces, while the clean turf layers between them were created when the fresh turf was laid on the floor in order to fill the depression caused by compaction and wear. It is interesting to note that although fresh turf was said to have been laid on this floor surface nearly every year, only three trampled surfaces and two fresh turf layers were preserved, which indicates that the floor had at some point been truncated. This may have occurred through repeated wearing down by trampling or during a repair episode, when the old floor deposits were spaded out. The convex depression in the central part of the floor indicates, however, that wear by trampling probably played the most important role in the truncation of the floor deposit. In the past, heavily trampled floors are also likely to have been truncated in this way, which means that the depth of the floor sediment and the number of discrete, trampled surfaces observed in the field or in thin section *cannot* be used to estimate the rate or duration of floor formation.

Kitchen

North of the main corridor, accessed by stepping across a stone and wood threshold, and through a wooden partition wall, was the "old" kitchen, so-called because in 1880 a "new" kitchen had been created by removing part of a turf wall adjacent to the pantry and installing an iron stove (Fig. 3). Prior to the construction of the new kitchen the old kitchen was the only room in the house with a fireplace, and the only location where it was possible to cook. While Áskell lived in the house, the old kitchen had been used for food storage and preparation, and the two open stone hearths had mainly been used for doing the washing and making special foodstuffs, such as blood pudding. Ash was stored in a receptacle between the hearths until it was taken for spreading on the floors or to fertilise the fields. Behind the hearth was a low stone wall that separated the fire from the fuel storage area at the north end of the room. The walls of the kitchen had been lined with furnishings and containers (e.g. counters, barrels storing foodstuff in whey, butter churns) and meat and fish had been hung from the rafters, where it was gradually smoked, even though there was a small shaft above the hearth through which some smoke could escape. Due to the furnishings on the edges of the room, foot traffic was restricted to the centre of the room, and the floors there were purported to have been swept daily. If part of the floor became worn or wet (e.g. due to a spill or a leak in the roof, which was probably not uncommon; Magnússon, 2010, p. 53) ash was deposited on it and stamped down, and the floor was swept over. The floor thus became covered with ash deposits of uneven thickness. When this steadily accruing floor surface eventually caused the roof to become uncomfortably low, it was shovelled out, and the ashy sediment was spread on the fields.

Two sampling trenches were placed in the old kitchen, one in front of the hearth, and one that extended from the middle of the floor to the western wall (Fig. 3). In section, the kitchen floor was characterised by layers of pink and grey ash and charcoal, which covered an undulating soil surface (Fig. 6a and b). At 30–40 cm from the western wall, the black charcoal-rich layer contained several pieces (up to 5 cm) of ceramic from a single plate. Towards the centre of the floor the black charcoal layer was up to 5 cm thick, but it thinned out at c. 20 cm from the western wall, and the underlying soil surface on the edge of the wall took on a more greyish-brown aspect, perhaps because furnishings against the wall had prevented the direct build-up of floor sediment. In front of the hearth the floor sediment had accumulated on top of a flagstone, and was rich in ash and large pieces of charcoal (up to 2 cm in size).

In thin section, the black layer in the central part of the kitchen floor could be identified as coal ash, and the pink and grey layer below it was identified as peat ash (Fig. 6c). Below these deposits there was a 1 cm thick brown layer that had not been distinguished in the field: an organic silt loam, stained brown with organic pigment, which contained nodules of heat-oxidized iron, burnt tephra grains, and the occasional fragment of burnt bone (less than 1.1 mm). This layer originally had a well-developed platy microstructure, but 75% of it had been reworked by soil fauna (Fig. 6c). In thin section, the floor sediment in front of the hearth was characterised by abundant coal ash, wood charcoal, and calcitic wood ash, as well as frequent heat-oxidized iron nodules and occasional fragments of burnt and unburnt bone. Like the other central parts of the kitchen floor, this layer has a well-developed platy structure due to being compacted by trampling.

The sedimentary characteristics of the kitchen floor corresponded closely to the former maintenance practices, for the layers of pure ash and the large fragments of coal and charcoal must be the products of dumping events. However, it was not straightforward to detect the change in the use of the room that occurred in 1880, when it went from being the primary kitchen in the house to being used for storing food and washing laundry. A few minute burnt bone fragments were concentrated in the organic silt loam in the lower parts of the floor stratigraphy in the central part of the room, as would be expected, but in front of the hearth, where the floor consisted of only a single layer – presumably the last phase of floor before the house was abandoned – a few bone and unburnt bone fragments were also found, and were in association with the coal fragments that post-date 1880. This highlights the fact that the presence of burnt bone in a floor layer is not diagnostic of cooking, but merely indicates that bone waste was tossed into a fire, and was subsequently moved along with fuel ash that was accidentally or intentionally spread over the floor.

Fuel storage area

On the north end of the kitchen, behind a low stone wall that formed the back of the hearths, there was a space that was used for the storage of fuel, including sheep dung, peat, brushwood, and, after 1880, coal (Fig. 3). A small hatch had been installed in the roof in order to enable fuel to be dropped in more easily, and, as in other parts of the house, ash was sprinkled on the floors of this area if they became wet or worn.

Sampling trench K–L, which stretched from the middle of the floor to the western wall in the northwest corner of the fuel storage area, did not show any clear floor layers in the field (Fig. 7a). In thin section, however, it was clear that the uppermost sediment horizons in the middle of the storage area contained a moderately- to well-developed platy microstructure – good evidence of compaction by trampling (Fig. 7c). Most importantly, it was possible to identify residues of the fuels that had been stored in this area. These included a lens of fine coal fragments (Fig. 7d), wood fragments, an aggregate of herbivore dung, which contained highly fragmented and compacted grass fragments and abundant faecal spherulites (Fig. 7e; see Canti 1999), and lenses of peat, which contained horizontally bedded phytoliths. It is notable that the thin section taken adjacent to the west wall, Sample 98-1, did not exhibit any structural indicators of trampling and contained coal fragments up to 8 mm in size, while in the sample taken from the middle of the room, which did contain structural evidence for trampling, all the coal fragments were under 2 mm in size. This size sorting is probably a product of the "edge effect" noted by several ethnoarchaeologists and experimental archaeologists, where larger objects tend to be kicked out of areas of heavy foot traffic, and accumulate on the edges of the trampled areas (e.g. Bartram et al., 1991, p. 104; Gifford-Gonzalez et al., 1985, pp. 808–810; Nielsen, 1991, p. 491; Stockton, 1973; Wilk and Schiffer, 1979, p. 533). Trampling also helps to fragment objects and reduce their size (e.g. DeBoer and Lathrap, 1979, p. 133; Gifford-Gonzalez et al., 1985, p. 813; Nielsen, 1991, p. 493).

The floor sediments in the fuel storage area contained the residues of all of the fuels that had been used on the farm, and provided a good indication of what this space had been used for. The particular parts of the floor that were sampled did not contain any ash or other evidence of floor maintenance practices.

Pantry

To the south of the main corridor was the pantry, which was entered by stepping across a stone and timber threshold, through a wooden partition wall (Fig. 3). A wooden partition wall, now marked by a row of foundation stones, once stood in the middle of the pantry, dividing it into "inner" and "outer" rooms. The "inner" pantry (the one furthest in) had been used for storing the butter churn and various foodstuffs, most of which were contained in

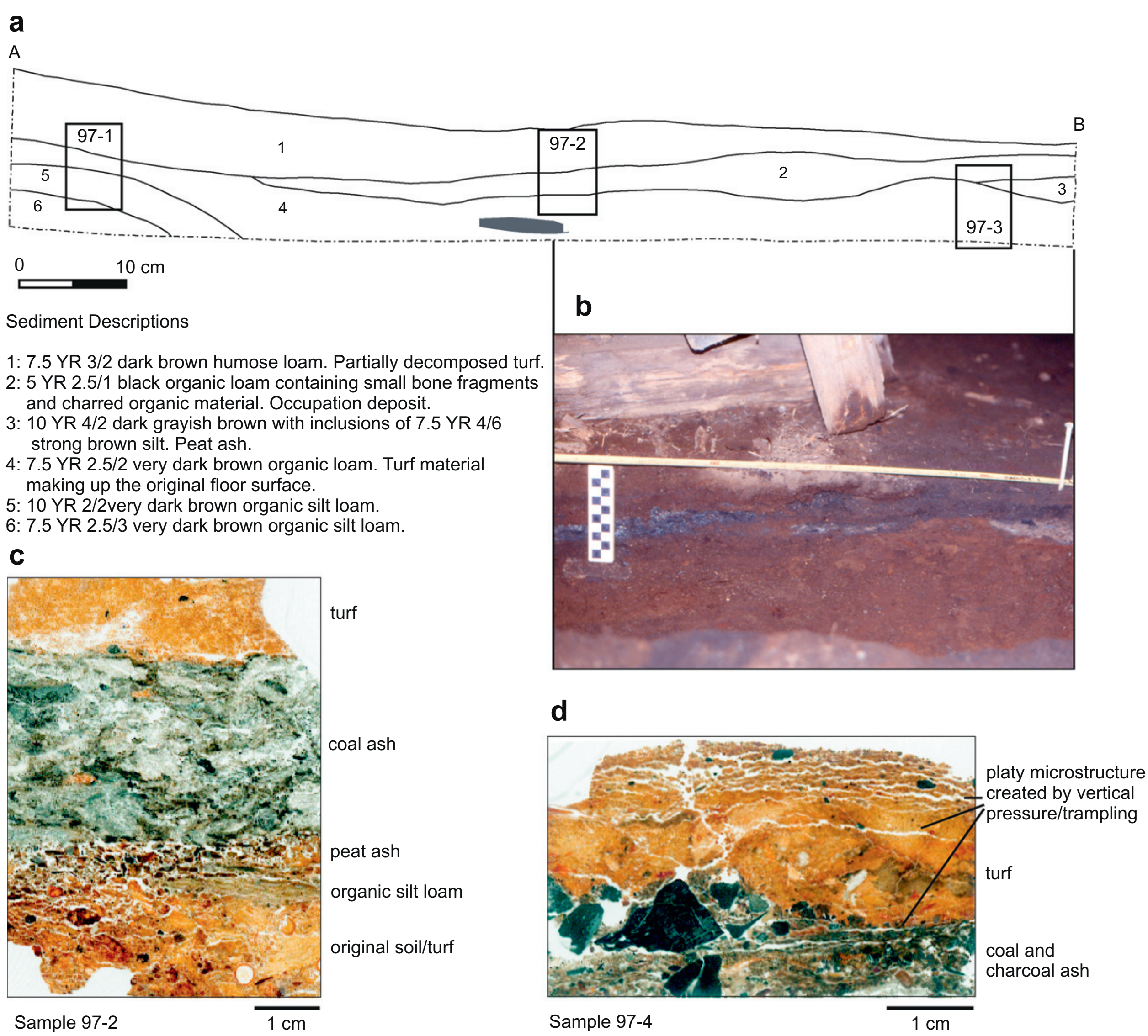

Fig. 6. Floor sediment in the kitchen: (a) drawing of section A-B, with sediment descriptions and the locations of the micromorphology samples; (b) photograph of the kitchen floor prior to sampling; (c) Sample 97–2, showing the thick coal ash layer, and underlying trampled and bioturbated floor surface; (d) Sample 97–4 from section C-D, in front of the hearth, showing the accumulation of large fragments of coal and charcoal.

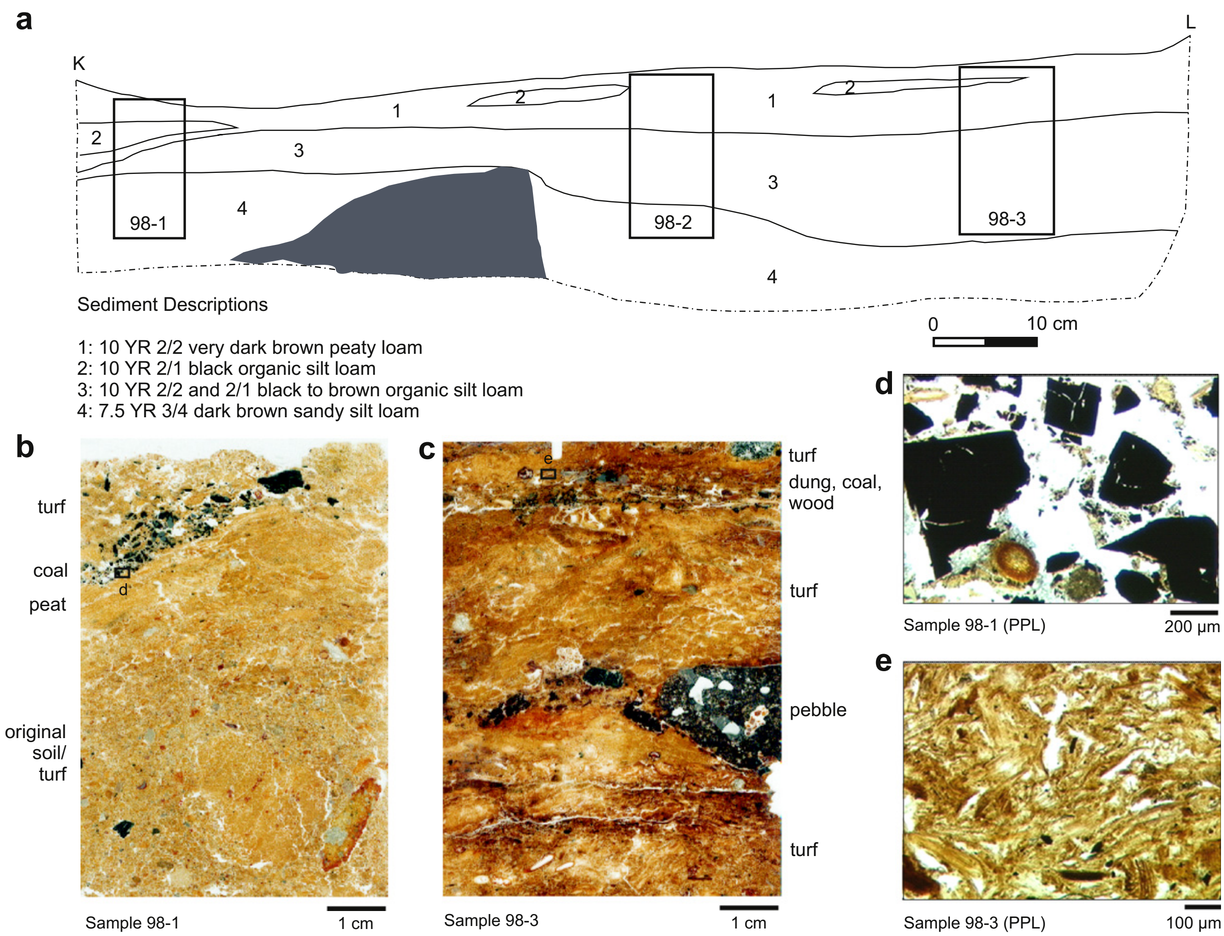

Fig. 7. Floor sediment from the fuel storage area: (a) drawing of section K-L, with sediment descriptions and the locations of the micromorphology samples; (b) Sample 98–1, showing lenses of coal and peat; (c) Sample 98-3, showing a lens of herbivore dung; (d) detail of the coal in Sample 98–1; (e) detail of the herbivore dung in Sample 98–3.

barrels, while the outer pantry (the one closest to the corridor), had been used more as a work area, especially for making dairy products. As in other parts of the house, the floors of the pantry were treated with ashes if they became wet, worn, or uneven, and were shovelled out onto the fields when they became too thick. In addition, the floors were sometimes covered with fresh turf, although Áskell did not remember this being done as often in the pantry as in the corridor and entrance room.

Sampling trenches were placed in both parts of the pantry (Fig. 3). In section Q–R, the floors appeared to consist of brown, reddish brown, and dark brown peaty turf (organic silt loam) layers, which interdigitated with uneven and discontinuous layers of charcoal and grey ash (Fig. 8a). In Sample 98-26, it could be seen that the dark brown colour of one silt loam layer in the outer pantry was due to organic pigmentation, an abundance of silt-sized organic residues, and the presence of highly fragmented charcoal and coal (less than 1.5 mm). In addition, this layer contained horizontally bedded plant tissues and amorphous organic matter, occasional heat-oxidized iron nodules and fragments of burnt bone (less than 2 mm), and one nut shell fragment. This layer had a very well-developed platy structure, and was undoubtedly a trampled occupation surface (Fig. 8b–c). Below this trampled surface there was a layer of large charcoal fragments up to 1.5 mm in size, which were too large to have been trampled into this room on the soles of feet, and must have been intentionally dumped. The trampled floor layer was capped by two layers of very peaty turf, which were distinguished by a sharp boundary and an abundance of red oxidized iron in the lower turf layer. These turf layers had clearly been intentionally laid and can be associated with the practice of periodic turf-laying that was described by Áskell.

In Sample 98-30, which was taken from section S–T in the inner pantry, three floor surfaces separated by layers of "clean" turf were distinguished (Fig. 8d). These were very similar to the trampled floor surface in the outer pantry, but the lower layer had been reworked by soil fauna and its original platy structure only survived in its lowermost part. There was also a fine lens of waterlain silt and clay at the bottom of this layer, which was not observed elsewhere in the house, but which must have been caused by a spill or a roof leak. The uppermost floor surface survived only as a small aggregate of around 5 mm in length. This aggregate had very sharp boundaries, was situated between two turf layers that also had sharp boundaries, indicating that it was the remnants of a truncated floor surface.

There is extremely good correspondence between the micromorphological characteristics of the floor sediments in the pantry and the information provided by Áskell about floor maintenance activities; namely, that fresh "carpets" of clean turf were occasionally laid over the floors, that floors were occasionally shovelled out, and that ash was sometimes sprinkled over the floors if they became wet. However, besides the nut shell fragment, there is no evidence of the food storage and preparation activities that used to take place in this room.

Sitting and sleeping rooms

The rooms used for sitting, eating, doing craftwork, and sleeping, were at the west end of the main corridor, up a short flight

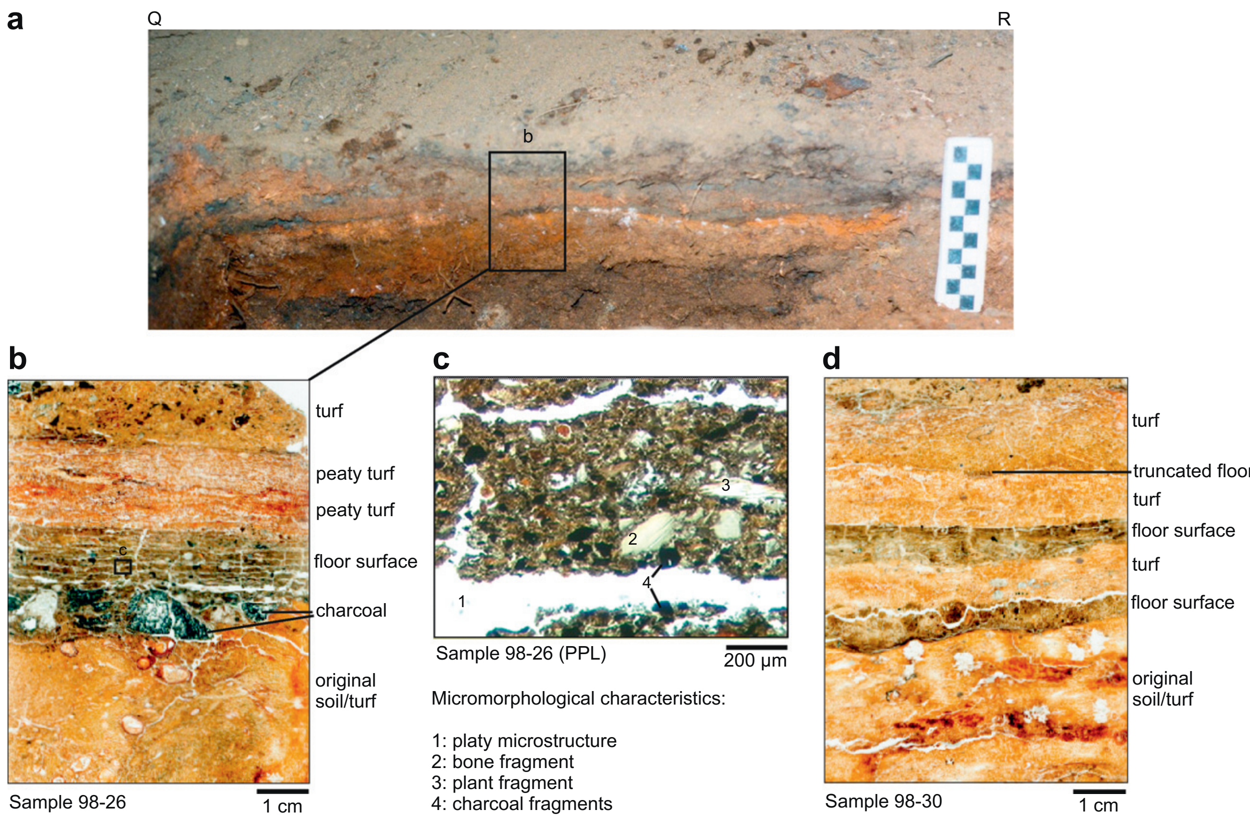

Fig. 8. Floor sediment in the pantry: (a) photograph of section Q-R, in the outer pantry, showing interdigitating layers of turf (orange-brown) and ash (grey) and the location of the micromorphology sample; (b) Sample 98–26, from the outer pantry, showing lenses of turf and a floor surface; (c) detail of the floor layer in Sample 98–26; (d) Sample 98-30, from section S-T in the inner pantry, showing alternating floor surfaces and layers of turf.

of steps (Fig. 3). They had wooden floor boards as well as wood panelling covering the turf walls, but the floorboards were not joined as well as those in the parlour and bedroom at the front of the house, and the gaps between them were up to 2 mm wide. The floor boards had occasionally been cleaned by sweeping and scrubbing them with sand.

Sampling trench O–P, which was placed below the floor boards just inside the entrance of the bedroom, contained very soft, loose silt and sand that had filtered down through the floor boards. There were two main layers, distinguished primarily by colour: a lower one that was a dark yellowish brown sandy silt loam, and an upper one that was a dark greyish brown sandy loam. In Samples 98-10, 11 and 12, from section O–P, it was clear that much of the fine silt had simply been trampled or airborne "dust" from the turf walls and earthen floors of the house. The uppermost, greyish layer also contained fine coal dust, and must mark the transition to the use of coal in 1880.

Cattle byre

From the "old" kitchen, a passageway lead to the cattle byre and the cool milk storage room in the northwest corner of the house, where a small stream had been channelled through the building (Fig. 3). The cattle byre had stalls for four cows and used to have room for a fifth, but one stall had been removed in c. 1900 to make way for the turf wall that replaced the original wooden partition wall between the byre and the passageway. Against the eastern wall of the byre there was a feeding trough that was built of turf and lined with wood, and in the middle of the byre there was a stone-lined channel for the collection of dung and urine. Where this ditch met the north wall of the byre a stone could be removed in order to make it easier to shovel out the dung. The floors of the stalls were covered with wooden floorboards, but when Áskell had been a child they had been covered with flag stones at the front and turf at the back. Like the turf floor coverings in the main part of the house, the turf bedding in the cattle byre could be easily cleaned out and replaced. The floors and dung channel had regularly been sprinkled with ash in order to absorb moisture and to mask odours.

Sampling trench I–J, which was placed in the part of the byre not covered with floor boards, revealed a floor composed of highly compacted, multi-layered, silty organic sediment, which came away in hard, thin, platy aggregates during excavation. A well-developed platy microstructure and localised massive microstructure was also observed in the thin section taken from this profile, Sample 98-23. Experiments have shown that such structures are created by heavy compaction under moist conditions (Bresson and Zambaux, 1990), which may be expected in a cattle byre. The fine layers observed in thin section were composed of dung, long strands of partially decomposed plant tissue (hay), coal ash, peat ash, and very dark brown, organic silt loams composed of mixtures of the above (Fig. 9b). Rare fragments (less than 1%) of burnt and unburnt bone were found associated with the ash layers and the mixed, loamy layers, and had clearly entered the floor deposit along with the ash.

Discrete dung lenses were readily identifiable and consisted of herbaceous plant tissues and associated phytoliths embedded in amorphous organic matter (Fig. 9c). The plant tissues varied in length, but many had a distinctly truncated, 'chopped' appearance, often with broken, squared ends. The shorter plant tissues were randomly oriented, but longer strands were predominantly horizontally or sub-horizontally aligned. Hay layers consisted of long strands of horizontally bedded plant tissues and associated phytoliths embedded in amorphous organic matter, and in some

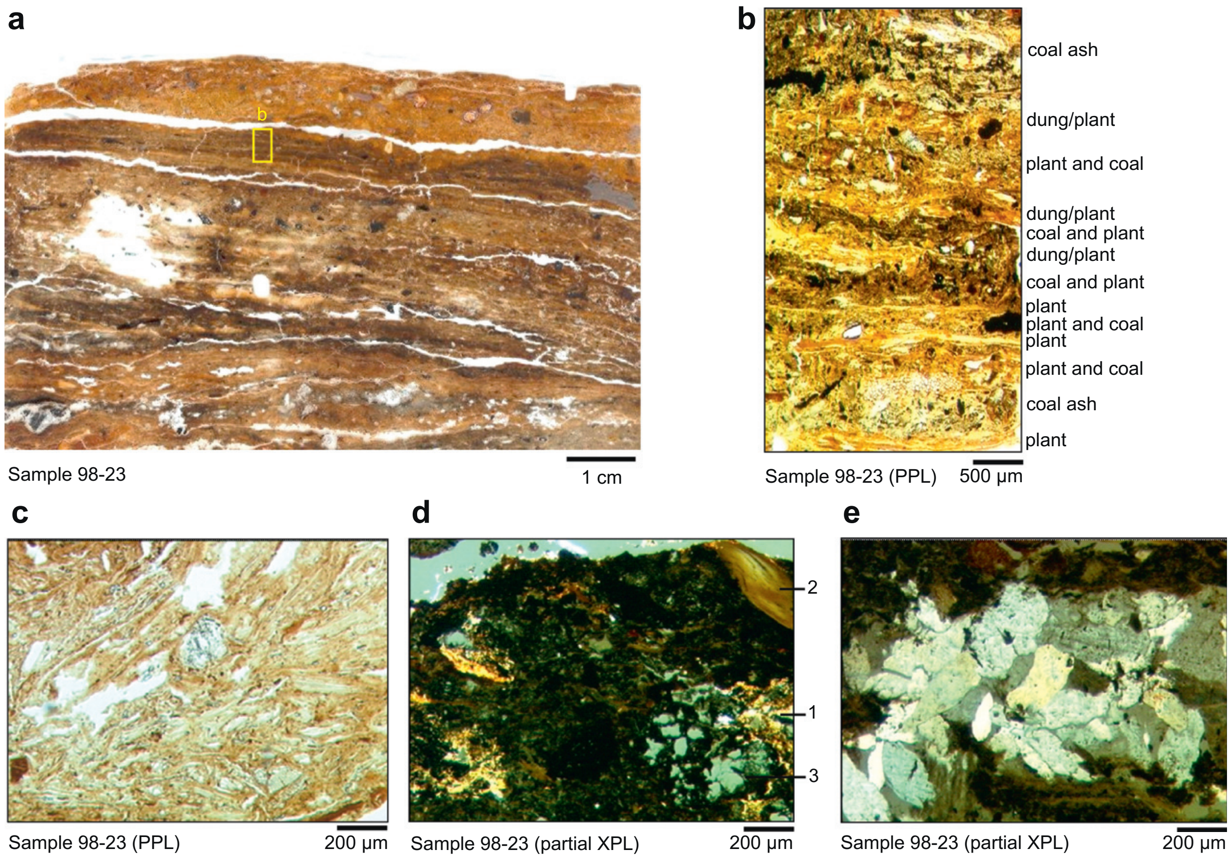

Fig. 9. Floor sediment in the cattle byre: (a) Sample 98–23, showing the microlaminated, highly compacted floor deposit; (b) detail of the microlaminations, composed of coal ash, plant material (hay) and dung; (c) detail of a dung lens, showing long and short/truncated plant fragments, articulated phytoliths, and amorphous organic matter; (d) detail of micritic calcium carbonate coatings and crystal intergrowths (1), a bone fragment (2), and a vesicular globule of non-metallurgical slag (3) in a lens dominated by coal ash and amorphous organic matter; (e) detail of hypidiotopic gypsum infilling of a planar void near the bottom of the cattle byre floor sequence.

severely compacted layers it was difficult to tell if the horizontally bedded plant matter was derived from cattle dung, hay, or a combination of the two, a difficulty also noted by Heathcote (2004).

Minute calcareous spherulites (monohydrocalcite, $CaCO_3{\cdot}H_2O$), which are often present in cattle dung (Brochier, 1996; Canti, 1999), were not present in the floor deposits in the cattle byre. It is possible that the cattle kept at Thverá did not produce spherulites, but if faecal spherulites had originally been present, they did not survive in the highly organic, acidic environment of the byre, where they would have been frequently doused with liquid excreta. In the middle of the floor sequence there was localised reprecipitation of silt-sized calcium carbonate (micrite) in the form of coatings around platy peds and intergrowths in the groundmass, and it is possible that this secondary calcium carbonate was derived from dissolved faecal spherulites (Fig. 9d). It is interesting to note that calcium carbonate mobilisation and redistribution has also been observed in modern stabling deposits in England, where faecal spherulites had been expected, but were not observed in thin section (Heathcote, 2000, 2004).

At the bottom of the floor sequence in the cattle byre, the long, horizontal planar voids that separated the platy peds were infilled with gypsum ($CaS0_4{\cdot}2H_2O$; Fig. 9e). Secondary gypsum formation is normally associated with arid conditions and to the author's knowledge this is the first time it has been observed in stabling deposits in a moist, temperate environment. Like the secondary calcium carbonate, these gypsum infillings are likely to derive from calcium and sulphur that was dissolved higher up the profile and carried downwards by a water or urine. There are abundant sources of calcium in these deposits, including plant matter, ash, and possibly faecal spherulites (Cook and Heizer, 1965), and the sulphur would have derived from the coal ash (Matthew Canti, pers. comm.).

There is very close correspondence between the use and maintenance of the cattle byre and the floor sediment characteristics observed in thin section. The housing and feeding of cattle in this space was evident in the highly compacted lenses of dung and herbaceous plant tissues (hay). In addition, the practice of regularly sprinkling the byre floor with ash in order to absorb moisture and odours resulted in the dung and hay layers being interbedded with lenses of coal and peat ash.

Sheephouse

When sheephouse 2 was in use, the dung and hay that accumulated on the floor had been shovelled out and spread over the infield on an annual basis. Áskell Jónasson reported that sometimes ash had been sprinkled over the floor surface in order to make it easier to shovel out the litter that accumulated over the following year. Since its abandonment the building had been used only occasionally, mainly during the lambing season, and it had not been cleaned out.

Two sections were excavated in the floor of the sheephouse, one at the front entrance, and one between the central feeding bench and the southern wall (Fig. 4). The floor of the sheephouse contained a 10–17 cm thick deposit of horizontally bedded dark brown organic matter, which still included visible strands of hay. The sediment lifted off in thin plates but was not as compact as the floor layer in the cattle byre. In Sample 99-1, which was taken from section W–X, this deposit was seen to consist of a sequence of layers of dung and horizontally bedded grass tissues, as well as organic silt loams made up of soil mixed with partially decomposed plant tissues (Fig. 10a). The deposit had a well-developed platy microstructure, which was probably a result of compaction by the trampling of animals as well as of the desiccation and shrinkage of the horizontally bedded organic matter.

The sequence contained a clear discontinuity, which was marked by a large horizontal planar void, below which the sediment was compacted to a depth of 1–2 mm. The organic sediment below the discontinuity had been subjected to much more reworking by soil fauna (50–70%) than the layers above (5–10%), and the faunal channels did not cross the upper boundary of this layer. It would therefore appear to represent an older accumulation of dung and hay, dating to before 1950, when the sheephouse was still in regular use. The discontinuity may represent the last time dung and hay was shovelled out of the sheephouse before it was abandoned and relegated to only occasional use.

The layers of sheep dung did not contain any faecal spherulites, but were readily identifiable on the basis of their organic composition: short segments of truncated plant tissues and associated silica phytoliths, which were randomly oriented and embedded in amorphous organic matter (Fig. 10b). As in the cattle byre, the layers that consisted of very long, horizontally bedded plant tissues were easily identified as hay, but the plant tissues in more reworked layers could have been derived from either dung or hay.

A number of unusual crystalline pedofeatures were observed in the sheephouse sediments. A layer of organic silt loam in the middle of the sequence contained several clusters of spherulitic siderite: very small crystals of iron carbonate ($FeCO_3$), only 5–10 μm in diameter, which appear reddish due to their iron content and which have an extinction cross in XPL due to their spherulitic shape (Fig. 10c). Spherulitic siderite forms in reducing conditions, and is common in bogs and waterlogged occupation deposits where there is abundant iron in the soil (Gebhardt and Langohr, 1996; Landuydt, 1990). Its presence in the sheephouse at Thverá indicates that localised reducing conditions occurred in the floors, either because they were occasionally saturated by urine, or because bacterial decomposition of the organic matter had used up the available oxygen.

One localised area in the floor sequence also contained vivianite ($Fe_3(PO_4)2{\cdot}8H_2O$), a compound that forms under reducing conditions when there is an abundance of available iron and phosphorus. The vivianite crystals were readily identifiable on the basis of their blue colour and pleochroism in plane-polarized light, and they formed discontinuous hypocoatings around large planar voids and crystal intergrowths in the organic groundmass (Fig. 10d). Vivianite is commonly found in bogs, and in archaeological contexts it is usually associated with waterlogged cess deposits and organic-rich occupation deposits subjected to periodic or prolonged waterlogging (e.g. Gebhardt and Langhor, 1999; Landuydt, 1990; Milek, 1997). Its formation in the sheephouse at Thverá was a result of the abundance of phosphate-rich sheep dung and plant matter, and is further evidence that localised reducing conditions occurred in the floor deposits. Since the farm buildings at Thverá were located on a well-drained slope, these reducing conditions must have been created by the build-up of organic matter on the floor of the sheephouse and the input of urine during the winter months when the sheep were housed there.

As in the cattle byre, the flow of liquid through the floors of the sheephouse resulted in the mobilisation of calcium and the localised re-precipitation of secondary calcium carbonate in the form

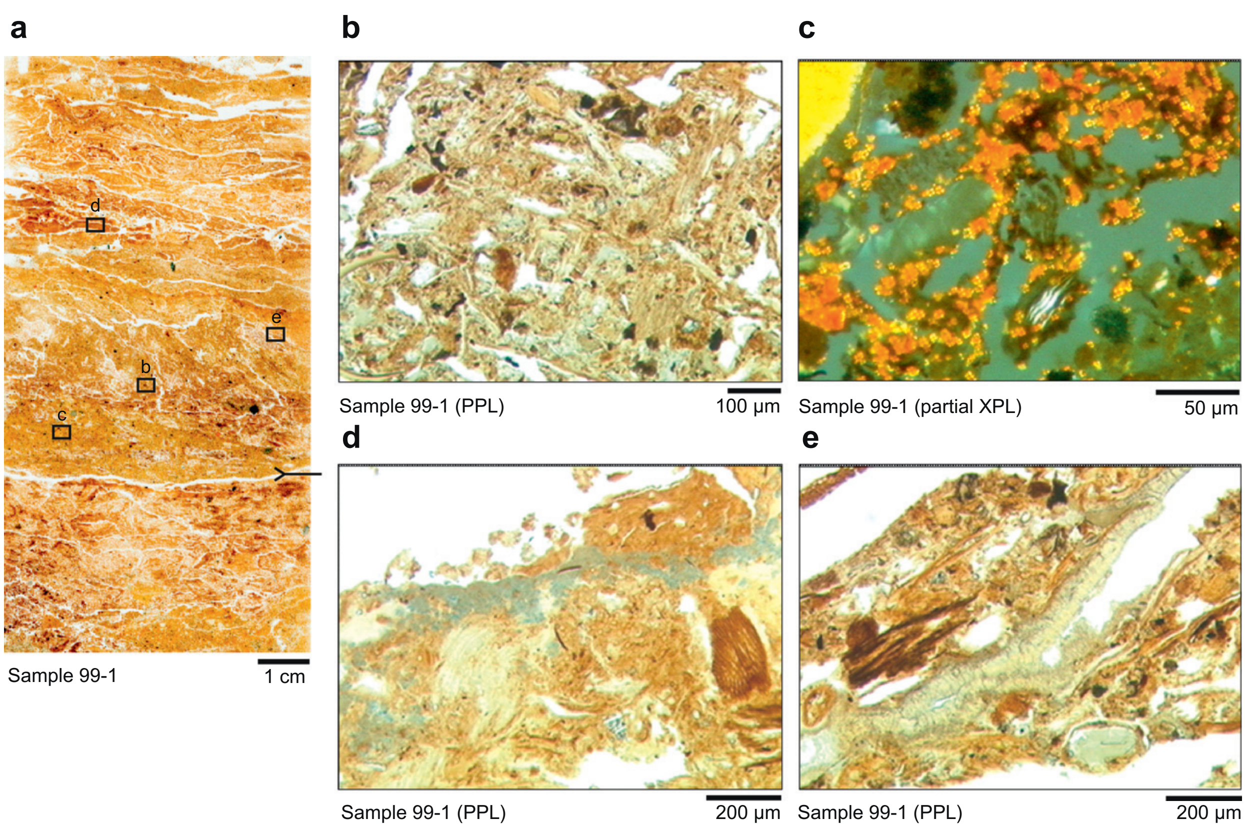

Fig. 10. Floor sediment in the sheephouse: (a) Sample 99–1, showing the deep sequence of dung, hay, and soil deposits, and a clear discontinuity (arrow); (b) detail of sheep dung, showing randomly oriented plant tissues, often with truncated, squared ends, and associated phytoliths; (c) siderite spherulites; (d) hypocoating and intergrowths of vivianite (small blue crystals); (e) calcium carbonate infilling.

of coatings and infillings in voids. In the sheephouse, however, the crystals were not only in the form of micrite, but were sometimes larger, lathe-shaped, and oriented perpendicular to the walls of the voids (Fig. 10e). The calcium could have derived from either the plant material in the bedding (i.e. hay) or the animal excreta, or both (Cook and Heizer, 1965, p. 19).

The function of the sheephouse was readily identifiable from the composition of the floor deposits, and the evidence for reducing conditions within the building. No ash was observed in thin section, but the practice of shovelling out the floors was clearly observed in the form of a sharp discontinuity in the sequence. From the archaeological point of view, this practice meant that most of the material that had accumulated during the life of the sheephouse had been removed, and it would not be possible to judge the longevity of the building on the basis of the thickness of its occupation deposits. The severe reworking of the lower third of Sample 99-1 by soil fauna is not surprising in such organic-rich, palatable deposits, and it would be realistic to expect the same of organic-rich sediments in the archaeological record, especially those associated with animal stabling areas. In such cases it would be difficult to distinguish horizontal bedding in the field, and it would probably require a high resolution technique such as thin section micromorphology to identify the original organisation and composition of the sediment.

Discussion

The ethnoarchaeological study of the turf houses at Thverá revealed a diverse set of processes that had affected the final composition and structure of the floor deposits. Many floor formation processes were detectable by careful observation in the field, but the additional details provided by micromorphological analysis were often essential for the correct identification of past activities, particularly periodic wetting and its associated redistribution of elements (Table 1). Areas of heavy and light foot traffic were readily identifiable in the field and in thin section. Heavily trampled, compacted floor sediments were characterised by platy, prismatic, or massive microstructures, and highly fragmented inclusions (under 2 mm), while untrampled areas tended to have more porous, granular microstructures and larger inclusions. At Thverá, the mode of deposition could also be inferred from the sedimentary structure of the floor deposit, with micro-laminations and the horizontal orientation of inclusions signifying a gradually accruing surface, and thicker layers with randomly oriented inclusions indicating that deposition occurred in a single dumping event.

The observed reduction in the porosity of heavily trampled, compacted floor sediments would have significantly reduced the available oxygen and made it much more difficult for earthworms and other soil fauna to penetrate them, substantially increasing the potential for the recovery of uncharred organic materials. This potential has occasionally been observed on archaeological sites (e.g. uncharred seeds on the floors of a house at Bessastaðir, southwest Iceland, which were radiocarbon dated to the 10th century; Nelson and Takahashi, 1999), but has not been fully exploited. Uncharred plant remains and insects found on well-drained sites are often attributed to modern contamination, but the creation of localised anaerobic conditions within well-compacted floors, especially in animal buildings, where there was also liquid excreta, means that

Table 1
Floor formation processes at Thverá and their archaeological visibility.

Formation Process	Frequency and location	Archaeological evidence	Micromorphological evidence
Trampling	Heaviest in byre	Sediment very firm and platy. Concave depressions where the floor is compressed and worn	Platy or prismatic structure.
	Very heavy in entrance room, main corridor	Artefacts highly fragmented. Loose sediment and larger objects accumulate on the edges of walls and furniture	Artefacts mainly less than
	Heavy in centre of kitchen, centre of pantry, sheephouse		2 mm and are embedded in floor sediment.
Wetting	Frequent in byre, sheephouse	Compact, platy structure	Well-developed platy or massive microstructure.
	Often in entrance room, main corridor	Depletion of Fe and formation of Fe nodules or pans	Depletion of Fe and formation of Fe nodules or pans.
	Periodic throughout the house, due to roof leaks and spills		Depletion of $CaCO_3$. Secondary $CaCO_3$ pedofeatures. Presence of siderite and/or vivianite.
Sweeping	Daily throughout house	Size sorting, with larger objects swept away or to the side	Size sorting, with well-swept areas having artefacts less than 2 mm in size.
	Periodically as needed following the deposition and stamping of ash	Loose sediment and larger objects accumulate on the edges of walls and furniture	
Ash deposition	Periodically throughout the house and byre	Layers of pure ash or charcoal	Lenses of pure ash or charcoal.
	Annually in the sheephouse after shovelling out the floors in the spring	Ash/charcoal present in parts of the house where ash could not have spread accidentally by sweeping or trampling (i.e. not adjacent to hearth)	
Turf deposition	Annually in entrance room and central corridor. Every few years in pantry	"Clean" sediment layers between trampled floor surfaces.	"Clean" turf layers, which may contain evidence of original soil microstructure, between trampled floor surfaces with compaction microstructures.
Raw fuel deposition	Frequently in fuel storage area	Not identified	Layers of wood tissues, peat, coal crumbs, dung crumbs.
Dung deposition	Frequently in byre and sheephouse.	Layers of very dark brown, very compacted, highly organic sediment, but requires micromorphological id.	Layers of herbivore dung identifiable on the basis of truncated plant tissues, phytoliths.
Shovelling out	As needed throughout the house, byre, and sheephouse.	Abrupt boundaries between stratigraphic layers.	Knife-edge truncation boundaries/discontinuities. Relict slivers of truncated floors.
Turf/soil deposition during roof/wall repair	Every 10-20 years throughout the house, byre, and sheephouse	Not identified.	Potentially distinguishable as a lens of mixed turf, soil, and organic matter, but may be difficult to distinguish from intentionally laid turf.

even on well-drained sites, uncharred plant remains and insects may be ancient and worthy of study.

The practice of shovelling out floor layers when they got too thick, which left discontinuities in floor sequences, could be seen in the field in the form of very sharp boundaries between layers, but it was easier to identify truncation events in thin section, where knife-edge boundaries and sometimes slivers of the truncated floor deposits could be seen more clearly. The periodic truncation of floors effectively eliminated the possibility of recovering full floor sequences, and meant that the depth of the floor sediment or the number of discrete surfaces in it can never be used to infer the intensity or duration of occupation of a building. Turf roof and wall repair events were reported to leave irregular deposits of turf and organic matter on the floors of turf buildings, but these were not identified in the restricted views of the floors obtained during this particular sampling programme.

Many floor formation processes that were observed at Thverá are similar to those observed in ethnoarchaeological and experimental studies conducted in other parts of the world, and a collective survey of these processes provides an invaluable interpretive framework for archaeologists attempting to use the composition, compaction, and structure of floor deposits to infer site activity areas (Table 2). An important implication of these studies is that artefact distributions are more closely related to the effects of trampling, cleaning, and abandonment processes (which are in turn related to artefact size, weight, and robustness) than to their primary deposition in floor deposits, and that it is essential to study and consider all of these factors before incorporating artefacts into activity area analyses. But perhaps the most salient lesson that can be drawn from these studies, and which was brought to the foreground by the research at Thverá, is the degree of cultural contingency in the quantity and type of materials

Table 2
Cultural floor formation processes observed in world-wide ethnoarchaeological and experimental studies.

Process	Observed trends	References
Deposition of material on floors during occupation		
Primary deposition	Objects often deliberately stored out of the way of heavy foot traffic (e.g. along walls, in corners, under furniture) Primary refuse deposition tends to be of smaller items (less than 2 cm) Types and patterns of primary refuse depends on culturally specific habits, beliefs, taboos, and perceptions of comfort and cleanliness	Bartram et al. (1991, p. 103), Binford (1978, p. 346), Bulmer (1976, pp. 178–179), Deal (1985, pp. 254–258), Fladmark (1982), Gifford (1980, pp. 98–100), Hayden and Cannon (1983), McKellar (1983), cited in Schiffer (1996, pp. 62–63), Murray (1980), O'Connell (1987, pp. 92–95) and this study.
Secondary deposition	Types and distributions of natural materials and secondary refuse will depend on culturally specific habits, beliefs, taboos, and perceptions of comfort and cleanliness	Boivin (2001, pp. 73–111), Moore (1982), Sinclair (1953, p. 22) and this study.
Alteration of floors during occupation		
Trampling (compression, kicking, scuffing)	Vertical displacement of objects: Greater depth penetration of smaller artefacts Large, blocky particles tend to rise to the surface Greater depth penetration on looser, more permeable floor sediments (up to 16 cm in sand)	Bartram et al. (1991, p. 104), Gifford (1978, pp. 81–83, 1980, pp. 101–102), Gifford-Gonzalez et al. (1985, pp. 808–810), Hayden and Cannon (1983), Hitchcock (1987, p. 417), Lewarch and O'Brien (1981, p. 308), Nielsen (1991, p. 489), O'Connell et al. (1991, p. 67), Stockton (1973, p. 116) and Villa and Courtin (1983, pp. 275–277)
	Horizontal displacement of objects: Greater displacement of larger and lighter artefacts Greater displacement on more compact floor sediments, where there is less chance of artefact burial	Bartram et al. (1991, p. 104), Gifford-Gonzalez et al. (1985, pp. 808–810), Nielsen (1991, p. 491), Stockton (1973), Villa and Courtin (1983, p. 277), Wilk and Schiffer (1979, p. 533) and this study
	Fragmentation of objects: More breakage of larger and less robust artefacts and bones (e.g. thinner, less dense) More breakage on harder, more compact floor surfaces	DeBoer and Lathrap (1979, p. 133), Gifford-Gonzalez et al. (1985, p. 813), Kirkby and Kirkby (1976, p. 237), Nielsen (1991, p. 493), Villa and Courtin (1983, p. 278) and this study
Cleaning (sweeping and hand removal)	Frequent cleaning may result in complete removal of primary or secondary deposits Hard-to-reach places can act as artefact traps More common displacement of larger, lighter objects Greater displacement on more compact floor sediments More displacement of sharp or noxious objects, objects that pose a hindrance to movement, and objects with little value or recycling potential More displacement where there is greater spatial constraint on living space More displacement where cultural ideology dictates cleanliness More displacement where the individual(s) responsible for cleaning have more inclination and more time to clean	Arnold (1990), Binford and Bertram (1977, p. 95), Boivin (2001, p. 119), Cribb (1991, p. 128), Deal (1985, p. 260), DeBoer and Lathrap (1979, pp. 128–129), Fladmark (1982), Hayden and Cannon (1983), Hitchcock (1987, p. 416), McKellar (1983, cited in Schiffer (1996, pp. 62–63), Murray (1980, p. 497), O'Connell (1987, p. 95), O'Connell et al. (1991, p. 66), Simms (1988, p. 204) and this study
Alteration of floors during abandonment		
Interruption of normal discard and cleaning practices	Immediately prior to abandonment refuse may be allowed to accumulate on floors Building may be used for storage of usable objects if residents move nearby or if they plan to return Abandoned structures may be used as refuse dumps Objects may be placed on the floors of abandoned buildings in a meaningful or symbolic way	Deal (1985, pp. 264–267), Hayden and Cannon (1983), Joyce and Johannessen (1993, p. 150), LaMotta and Schiffer (1999), Stevenson (1982) and this study.
Removal of usable objects and features	Objects and features (e.g. hearths, posts) are more likely to be removed if abandonment is planned and gradual, if there is no plan to return, if residents move nearby, if objects are portable, and there is a means of transport The removal of certain objects and not others may be dependent on the perceived value of certain items, cultural habits, beliefs, and taboos	Deal (1985), Gekas and Phillips (1973), Graham (1993, p. 37), Lange and Rydberg (1972, p. 430), Moore (1982, p. 76), Simms 1988, p. 208), Smith (1996), Stevenson (1982, p. 241), Tomka (1993) and this study

making their way into floor sediments as either primary or secondary deposits. Culturally specific habits, beliefs, taboos, and perceptions of what is "comfortable" or "clean" have an all-important effect on what is accidentally or intentionally incorporated into floor deposits, and is allowed to remain there throughout the building's use and abandonment.

The study at Thverá demonstrated that in Icelandic turf houses it was floor maintenance practices rather than how space was used on an everyday basis that had the greatest impact on the final composition and appearance of floor deposits. This was particularly the case in the pantry, where the floors were composed of deliberately deposited ash and turf intended to keep the floors "clean" and dry, but contained little evidence of food storage or dairy processing. The kitchen did contain the thickest ash layers, as well as fine bone fragments and a broken ceramic plate, but since ash and small fragments of burnt bone were found throughout the house, it is clear that this material is not diagnostic of cooking activities but of intentional hearth waste deposition – a practice that was intended to absorb moisture, mask odours, or fill depressions in the floor, and had nothing to do with the function of the space. At Thverá it was only the fuel storage area, where the floor contained raw fuel residues, and the cattle byre and sheephouse, where the floors contained dung and hay, which provided uncontroversial evidence for room function.

The results of this ethnoarchaeological study place renewed emphasis on how important it is for archaeologists engaged in the spatial analysis of artefacts, organic remains, and/or chemical residues in occupation deposits to consider first and foremost their modes of arrival (see Hillman, 1991, p. 35, for similar observations regarding the interpretation of seed assemblages). As a case in point, it is clear that the spatial distributions of charred plant materials and burnt bone fragments on occupation surfaces *do not* provide information about the locations of their original processing, use, or consumption – the spatial analysis of burnt materials can only provide information about the redistribution of materials that have been taken from a fireplace. In order to have a good understanding of the full range of taphonomic processes involved in floor formation at a particular site, from the mode and frequency of deposition to the physical and/or chemical alteration of floor deposits during the use or maintenance of the space, or after its abandonment, it will be necessary to integrate analyses such as soil micromorphology.

Information held in questionnaires and interviews in the ethnographic archives at the National Museum of Iceland make it clear that the methods used to maintain even, dry, debris-free and salubrious earthen floors at Thverá were common throughout Iceland in the early 20th century (Table 3). The most common maintenance practices were sweeping and the deposition of ash when floors became wet or uneven. Ash was commonly mixed with refuse in byres, since this prevented it from flowing, made it a better fertiliser, and made it easier to work with when putting it on the fields. The archives also brought to light other acceptable floor maintenance practices, such as the use of sheep dung to fill holes in the floor, which was again covered with ash in order to mask its odour. Sand could also be intentionally spread on floors, and stones were laid down in heavily trampled passages if they became muddy. The problem of dust rising off dry floors and the desirability of making them as hard- packed as possible was frequently mentioned, and until the floors were hard enough, some households sprinkled water on them to keep the dust from rising. Once the floors were well hardened they could be swept, and sweeping with birds' wings or straw brooms was often described as a daily activity.

Similar floor maintenance practices have been noted elsewhere in the North Atlantic region, where climates were similarly cool and damp, and turf and peat were used as construction materials.

Table 3
Cultural floor formation processes in turf houses discussed in replies to Questionnaire 64: Cleaning and Laundry, Ethnography Department, National Museum of Iceland.

Manuscript no.	Reference to cultural floor formation processes
Deposition of ash, turf, sand, water, and stones	
7835	"We used to put ash on the floors when they got wet, and after a while the floors got so thick that they had to be shovelled out."
7844	"Until the floors were hard-packed it was necessary to sprinkle water on them to keep the dust from rising."
7871	"We sometimes spread sand on the earthen floor and then swept it."
7874	"Ash was used on turf floors, since if they had ash on them, they were less dusty."
	"We always used ash on the floor of cattle byres."
7933	"If the earthen floor got wet, we spread ash over the wet spot, and after a while we swept the floor."
8065	"Ash was especially used on the floor inside the main entrance since it got especially wet there."
8077	"In the entrance of grandfather's farmhouse they put turf down."
8188	"If the dog made holes in the floor, they put sheep dung in it, and ash over that, to keep the smell away."
8225	"Ash was used in cattle byres and also on turf floors inside houses when they got wet."
	"Earthen floors were usually dry and hard-stamped, but when it had been raining for a long time it became necessary to lay stones down in the passages to walk on."
	"Also, dogs dug holes into the floor, and my mother filled up the holes with ash."
8227	"Turf floors were swept, and if they were a bit wet, dry ash was put on them before they were swept because then they became dry."
Sweeping	
7844	"If the earthen floors were good and old the surfaces were so dry and hard that they could be swept."
7861	"Earthen floors were swept."
7870	"The earthen floor was so hard it was as though it was wooden, and it was swept every day."
7877	"We had wooden floors in part of the house and earthen floors in part of the house. The earthen floor was stamped hard and kept dry so that it did not muck up the wooden floors."
7882	"The wings of birds were used to sweep the earthen floor."
7953	"Earthen floors were swept."
8021	"Floors were swept with birds' wings."
	"Wooden floors were cleaned by scrubbing them with ash or sand."
8188	"We swept the earthen floors with the wing of a swan and later with a broom."
8227	"Turf floors were swept and if they were a bit wet, dry ash was put on them before they were swept because then they became dry."
Removal of floor	
7835	"We used to put ash on the floors when they got wet, and after a while the floors got so thick that they had to be shovelled out."
7903	"When the roof leaked, they shovelled away the wet earthen floor."
8086	"Earthen floors were shovelled out when they got too thick because of all the ash that was put on them."

In the Western Isles of Scotland, 19th- and early 20th-century travellers noted the intentional spreading of ash, calcareous sand, and dry, powdered peat on earthen floors, as well as the shovelling out of floor sediments and their use as manure on fields (Gordon, 1937, p. 19; Kissling, 1943, p. 86; MacKenzie, 1905, p. 402). In the Northern Isles of Scotland, 18th- to early 20th-century travellers and administrative documents recorded the use of turf, peat, dry soil, turf ash and peat ash as bedding in byres in order to soak up animal wastes (see Fenton 1978, pp. 195 and 281). Layers of dung, grass, ashes, and dry soil could build up to thicknesses of 1–1.5 m before they were shovelled out and moved to an outdoor dung midden in order to continue the composting process, before being used to manure the fields.

Throughout the North Atlantic region, therefore, dried, charred, or ashed organic matter appears to have been selected and used as flooring materials due to its ability to absorb liquids and adsorb organic compounds, including those that cause odours (Byrne and Marsh, 1995; Cheremisinoff and Morresi, 1980). In this cool and damp northern context, ash in particular was perceived as a "clean" substance – not a "waste" to be thrown away, but a useful material, retained and valued for its potential use as a hygienic flooring material and its ability to promote comfortable and healthy living conditions in the dwellings of humans and animals. It is impossible to know how long Icelanders and other inhabitants of the North Atlantic region have been using the floor maintenance practices observed at Thverá, but it may not be a coincidence that charcoal and ash has commonly been found covering the floors of turf buildings in Iceland and Scotland from the Viking Age through the post-Medieval Period (e.g. Edvardsson and McGovern, 2005; Lucas, 2009a, p. 78; Lucas, 2009b; Milek, 2003; Smith et al., 2001). Especially when substantial deposits of ash and burnt bone are found in rooms that do not contain a hearth, or are too distant from the hearth to have been introduced into the floor by accidental spillage, it is very possible that the floors were not "dirty", but, on the contrary, were being well maintained.

Conclusion

In conclusion, new ethnographic research on floor formation processes, especially when integrating geoarchaeological methods such as soil micromorphology, can provide important insights into both universal and culturally contingent site formation processes, and are therefore invaluable to archaeologists attempting to reconstruct how past societies organised their daily lives and economic activities. The results of the ethnographic and micromorphological study of the floor deposits at Thverá have far-reaching implications for the study and interpretation of site activity areas, for they suggest that only a few activities, such as animal stabling and the storage of organic materials (e.g. fuels) directly on a floor surface, have genuine potential to create diagnostic residues in floor deposits. Although certain kinds of craft activities might also leave diagnostic residues, archaeologists cannot take it for granted that the spatial distributions of artefacts, organic residues, ashes, charred remains, or their associated elements are a direct result of the use of a particular space. In fact, floor layers may be dominated by residues resulting from maintenance practices, which have no relation to the daily or economic activities that used to take place there.

Methodologically, the use of soil micromorphology proved to be essential for the identification of a wide range of floor formation processes. The level of detail soil thin sections can provide about the precise composition of floor deposits, the nature and origin of the organic matter, the size and sorting of inclusions, the degree of compaction, the alteration of the sediment's chemistry and structure due to wetting, the number of layers in the floor sequence (some of which might be minutely thin), the presence of discontinuities (truncation events), and the affects of soil formation processes, meant that micromorphological analysis was indispensable for studying the activities and floor maintenance practices that took place in all of the activity areas investigated at Thverá. In general, archaeologists engaged with research on site activity areas should consider integrating soil micromorphological analysis into their research design whenever possible.

Although some of the floor formation processes observed in Icelandic turf buildings followed trends recorded elsewhere in the world, many had not previously been noted, and these will be of particular interest to archaeologists working in northern regions. The ethnoarchaeological study at Thverá highlighted a number of floor maintenance practices, such as the intentional spreading of ash and laying of fresh turf on floors that are damp, worn, or uneven, that appear to be particularly suitable for cool, damp northern environments where turf is a common building material and ash production is abundant. In this cultural and environmental context, ash and top soil are not "waste" materials or "dirty", but clean and absorbent substances that can keep floor surface well maintained, dry, comfortable and hygienic. It is important for archaeologists to remember that the concepts of "maintenance", "cleanliness", and "waste" are socially constructed, and that these cultural perceptions can have a significant impact on the composition of occupation deposits. Archaeologists attempting to spatially analyse residues in floor deposits in order to infer site activity areas need to pay special attention to all of the possible origins of these residues as well as the possible reasons for their deposition.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jaa.2011.11.001.

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